Mem. Fac. Fish., Kagoshima Univ.
Vol. 33, No. 1, pp. 33～42 (1984)

The Oceanographic Research in the Southern Region of the Hawaiian Islands-VII

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Abstract

The oceanographic observations and the tuna fishing experiments in the southern region of the Hawaiian Islands were carried out in May 1984. The results are summarized as follows:
1) The mean values of temperature and salinity were about 26.0 °C and 35.23 ‰ in the surface water, about 24.9 °C and 35.34 ‰ in the subsurface saline water, and about 7.6 °C and 34.14 ‰ in the subarctic intermediate water, respectively.
2) Salinity of the surface water being higher than usual was remarkable. It apparently suggests that the anticlockwise meso-scale vortex existed.
3) The highest catch of *marlin* was made on Nos. 1 and 5 hooks, and that of *albacore* on No. 3 hook.
4) The actual depths of Nos. 1 and 5 hooks ranged between 95 m and 115 m, Nos. 2 and 4 hooks between 100 m and 145 m, and No. 3 hook between 120 m and 205 m.
5) The good catches of *marlin* were estimated to be at the depths of 95 m − 105 m or less and that of *albacore* 180 m − 205 m or more.
6) The survey value was larger than the catenary value on No. 1 hook, while the former was smaller than the latter on Nos. 2 and 3 hooks.
7) Mean value of difference between the catenary and the survey values on each hook was −2.9 m on No. 1 hook, 20.6 m on No. 2 and 29.2 m on No. 3.

1. Introduction

The equatorial region of the Eastern North Pacific Ocean has been known to be abundant in the species of tuna. The investigation on the oceanic condition and the fish catches is of great importance mainly because it gives us the basic information for the exploitation of fishing ground. Results of studies concerning the oceanography and the fishery have been published by many researchers: CROMWELL (1953) GRAHAM (1941), KNAUSS (1960), MASUZAWA (1964) MONTGOMERY (1940), SVERDRUP *et al.* (1942), HANAMOTO (1974), HAMURO (1959), MORITA (1969) NAKAGOME (1961), NAKAMURA (1951, 1959), SAITO (1974), SUDA (1969), YAMANAKA (1965), and YOSHIHARA (1952, 1954).

Since 1978, the authors have been engaged in the studies on the oceanic condition and the biological aspect of the southern region of the Hawaiian Islands. In this report, the fishery oceanography of tuna is discussed based on the data obtained through the oceanographic observations and the tuna fishing experiments by the Keiten Maru of Kagoshima University.

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

2. Methods

From 15th through 24th, May 1984, oceanographic observation and tuna fishing experiment were carried out in the southern region of the Hawaiian Islands (between 163°W and 167°W along the latitude of about 20°N) by the Keiten Maru (G. T. 860 tons), a fisheries training and research ship of Kagoshima University, concurrently with the training of cadets.

The oceanographic observation was made by mean of the S. T. D. system (Plessy Model 9040). The temperature and salinity were recorded by the sensor of S. T. D. lowering from the surface

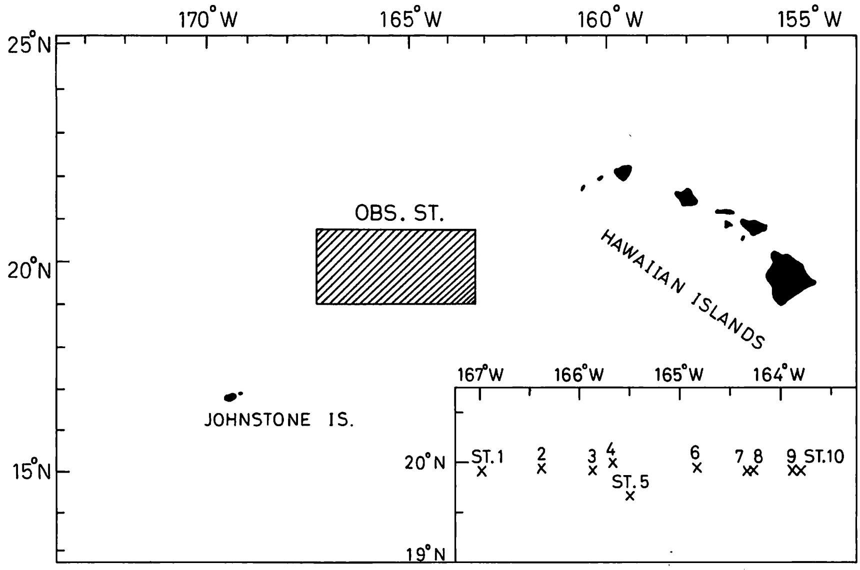

Fig. 1. Map showing the oceanographic stations of S. T. D observation

to 1200 m in depth at a rate of 90 m/min. The observation stations are shown in Fig. 1. The temperature and salinity values at each station are tabulated in the annexed table. The tuna fishing experiment was carried out making use of the tuna longline gear and the hook's depth of tuna longline was measured by using a self-registering depth meter (BS-04).

The construction of tuna longline gear per one unit is shown in Table 1.

Table 1. Construction of the tuna longline gear used in fishing experiment. (per one basket)

Name of part	Material	Length	No.**
Main line	Mansen (#58 Dia 6.5 mm)	330 m*	1
Branch line	Mansen (#9 Dia 5.2 mm)	15 m	4 (Nos.1,2,4,5 hook)
Branch line	Mansen (#9 Dia 5.2 mm)	40 m	1 (No.3 hook)
Sekiyama	M type (#28 3×3)	6 m	5
Hook wire	Steel wire (#28 3×3)	3 m	5
Hook	Steel		5
Float line	Mansen (#58 Dia 6.5 mm)	25 m	1

* Length per one basket. ** Number used for one basket

3. Results and Discussion

1) Oceanic Condition

The representative temperature-salinity curves are shown in Fig. 2. The mean values of

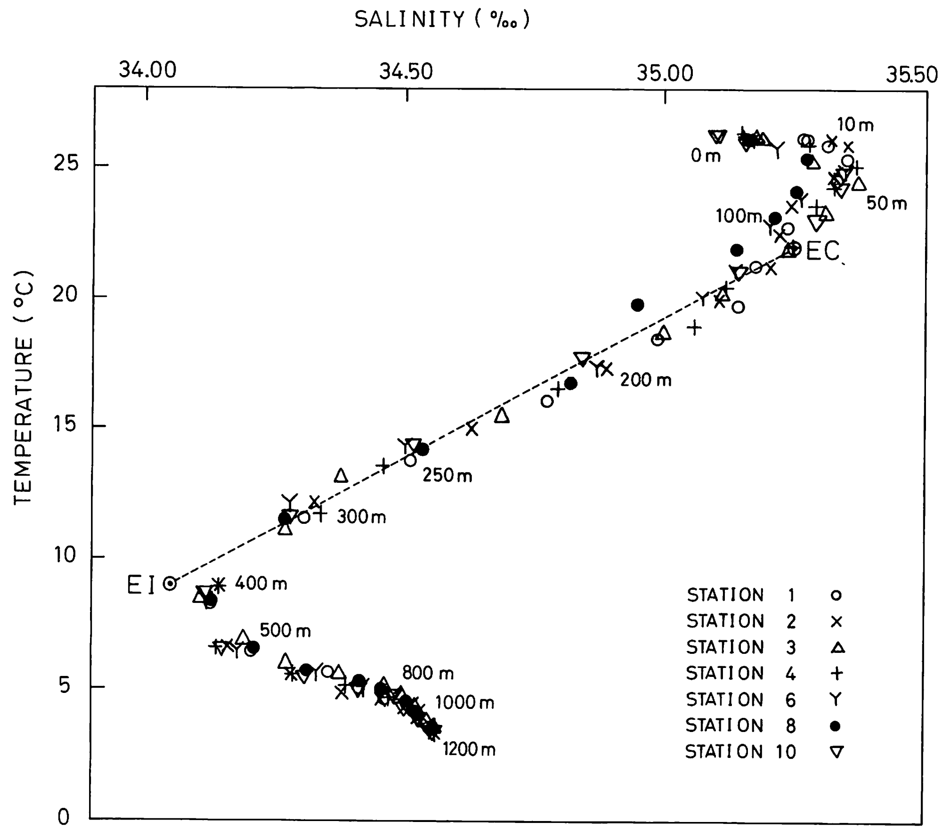

Fig. 2. The representative temperature-salinity curves. observing depth are entered (m)

temperature and salinity in the surface water were about 26.0°C and 35.23 ‰, respectively. The thermocline was found in a layer between about 30 m and 450 m in depth. The vertical gradient of temperature in the thermocline was about 0.05°C/m. The subsurface saline water was found at the depth of about 55 m and the mean values of temperature and salinity were about 24.9°C and 35.34 ‰. The values of temperature and salinity decreased with depth, and the salinity minimum water was found about 450 m in depth. The mean values of temperature and salinity minimum were about 7.6°C and 34.14 ‰, corresponding to the subarctic intermediate water. The EC-water and the EI-water defined by Yuwaki and Henmi (1981) were found about 150 m and 450 m in depth, respectively. The temperature-salinity curves between 200 m and 400 m coincide with a straight line passing through the EC-water and the EI-water, showing that the water in the layer was a mixture of the EC-water and the EI-water. The high salinity water in the surface layer was remarkable and it suggests the occurrence of the upwelling of water in this area. In 1981, the upwelling of lower water had clearly been found around 20°N, 163°W. These facts suggest the existence of the anti-clock-wise meso-scale vortex in this region as shown in Fig. 3.

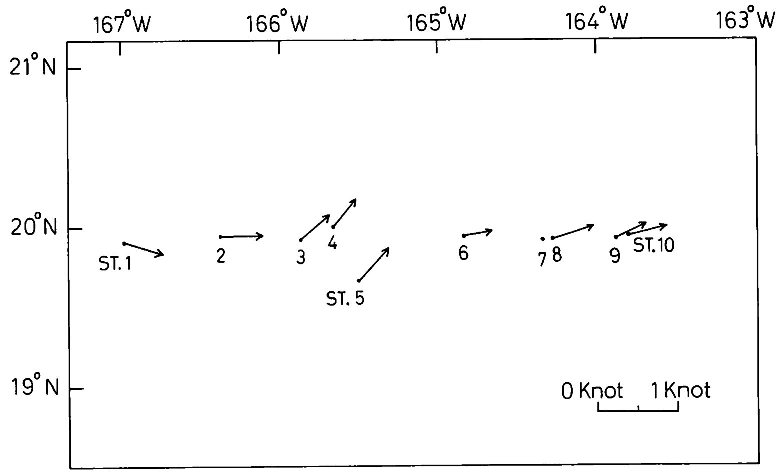

Fig. 3. The drifting direction and speed of tuna longline at each station

2) Fishing Condition

The tuna catches in this region were represented by the species of *marlin, albacore, yellowfin* and *bigeyed tunas*. The *marlin* and the *albacore* occupied the greater part of the fish catches and the proportion of them to the total catch in each case attains to about 45%, while those of the other tunas (yellowfin tuna and so on) were rather small. The proportions of catches of *marlin* and *albacore* on each hook are shown in Fig. 4. The convex-concave patterns were found in the

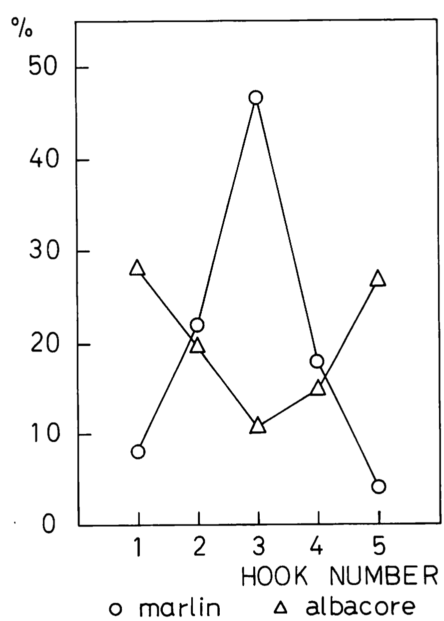

Fig. 4. The proportion of catches of marlin and albacore on each hook

Figure. The highest proportion of *marlin* is seen on Nos. 1 and 5 hooks, about 25% each. On the contrary, that of *albacore* is on No. 3 hook, about 50% of the total catches. Five hooks were generally attached on each unit of longline gear and these were serially numbered 1 through 5. Nos. 1 and 5 hooks were the shallowest, and No. 3 hook was the deepest as shown in Fig. 5.

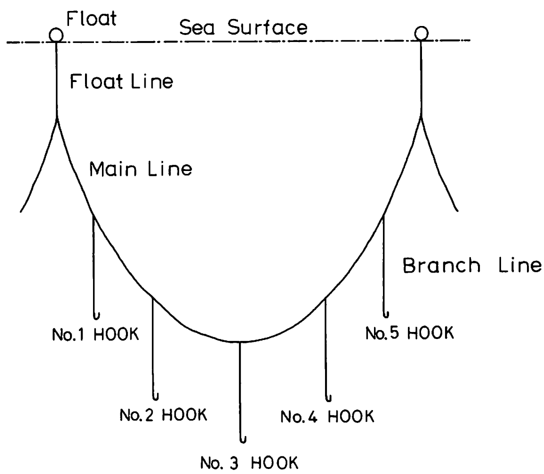

Fig. 5. Schematic diagram of tuna longline gear

The actual depths of each hook were measured with a depth meter in order to estimate the vertical distribution of the tuna species indirectly. The depth of Nos. 1 and 5 hooks ranged between 95 m and 115 m in depth, Nos. 2 and 4 hooks between 100 m and 145 m, and No. 3 hook between 120 m and 205 m, respectively (Fig. 6) The depth of No. 3 hook covered considerably wide range

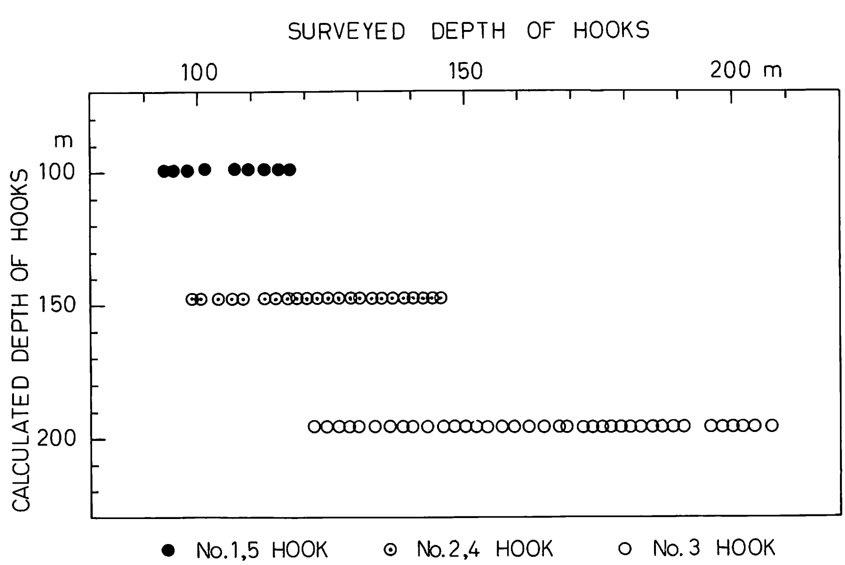

Fig. 6. Relationship between calculated and measured depths of hooks

● : Hook Nos. 1 and 5 ⊙ : Hook Nos. 2 and 4 O : Hook No. 3

in comparison with the others.

It is reasonably considered that the depth range of the good catches of *marlin* was to be 95 m – 105 m or less and that of *albacore* was 180 m – 205 m or more. Assuming that the main line take a form of catenary in sea water, the depth of any hook were calculated by using Yoshihara's expression to compare the calculated catenary value with the actual survey value.

The depth of hook at the deepest layer

$$= h_a + h_b + \ell\,(\sqrt{1 + cot^2\,\varphi_0} - cot\,\varphi_0)$$

The depth of respective hook

$$= h_a + h_b + \ell\,(\sqrt{1 + cot^2\,\varphi_0} - \sqrt{(1-2j/n)^2 + cot^2\,\varphi_0})$$

h_a : Length of branch line
h_b : Length of float line
ℓ : Length of onehalf of main line on one unit
j : Number of respective hook from the end of longline on one unit as shown in Fig. 7.

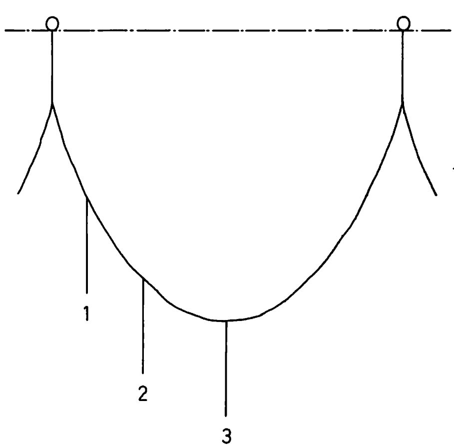

Fig. 7. No. of hook in one unit of longline

φ_0 : The angle between the main line point where the main line was tied to float line and the horizontal line, calculated by shortening rate
k : (ship's speed when longline is set) × (time passed while longline is set)/(length of main line on one unit) × (number of unit used a fishing experiment)

Frequencies of differences in hook's depth between the catenary value and the survey value are shown in Fig. 8. There happened to be difference between the calculated catenary value and the actual survey value. The dispersion of the differences was changed as the depth of water changes, i e : the survey value was larger than the catenary value on No. 1 hook but the survey value was smaller than the catenary value on Nos. 2 and 3 hooks. Mean value of differences between the catenary value and the survey value on each hook were –2.9 m on No. 1 hook, 20.6 m on No. 2

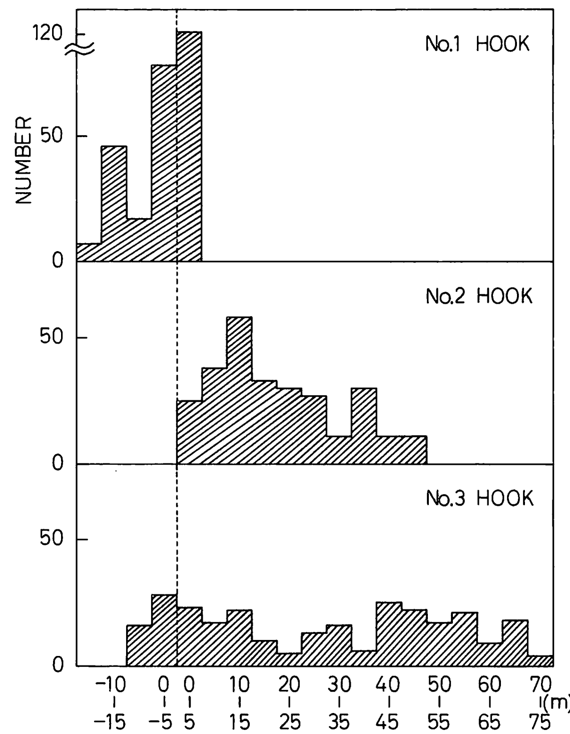

Fig. 8. Frequency on difference of hook's depth between catenary value and survey value (catenary value − survey value)

hook and 29.2 m on No. 3 hook, respectively. It was reported by Hamuro (1959) that the survey value being smaller than the catenary value usually happens when hook has been blow up by sea current or more frequently when angle between the direction of setting longline and that of sea current was from 0 degree to 90 degree.

It is presumed that the survey value being larger than the catenary value must be caused by the distance between neighbouring floats of longline becoming short or by the shortening rate becoming small.

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Annexed Table The Depth-temperature-salinity data at each station.

Depth (m)	Station 1 Lat. 19°-54'.8N Long. 166°-59'.1W May 15, 1984 Temp. (°C)	Salinity (‰)	Station 2 Lat. 19°-56'.6N Long. 166°-23'.0W May 16, 1984 Temp. (°C)	Salinity (‰)	Station 3 Lat. 19°-55'.3N Long. 165°-52'.3W May 17, 1984 Temp. (°C)	Salinity (‰)
0	26.18	35.269	26.09	35.321	26.18	35.176
10	26.17	35.275	26.09	35.322	26.12	35.187
20	25.88	35.313	26.07	35.322	25.27	35.284
30	25.34	35.352	25.88	35.349	24.92	35.346
50	24.58	35.333	24.70	35.325	24.46	35.370
75	22.76	35.239	23.59	35.243	23.29	35.306
100	21.28	35.179	22.52	35.221	21.89	35.237
125	19.80	35.145	21.26	35.205	20.16	35.114
150	18.54	34.992	19.97	35.106	18.70	35.000
200	16.10	34.778	17.33	34.891	15.42	34.686
250	13.77	34.514	15.02	34.630	13.10	34.375
300	11.58	34.307	12.20	34.327	11.09	34.268
400	8.27	34.129	8.94	34.145	8.42	34.107
500	6.45	34.207	6.62	34.161	6.80	34.190
600	5.65	34.354	5.55	34.283	5.90	34.270
700	5.04	34.414	4.88	34.382	5.50	34.375
800	4.63	34.464	4.65	34.456	5.10	34.460
900	4.42	34.509	4.31	34.502	4.80	34.495
1000	4.12	34.523	3.92	34.526	4.30	34.520
1200	3.50	34.552	3.36	34.561	3.70	34.545

Depth (m)	Station 4 Lat. 20°-00'.0N Long. 165°-39'.8W May 18, 1984 Temp. (°C)	Salinity (‰)	Station 5 Lat. 19°-40'.2N Long. 165°-30'.0W May 19, 1984 Temp. (°C)	Salinity (‰)	Station 6 Lat. 19°-56'.4N Long. 164°-50'.3W May 20, 1984 Temp. (°C)	Salinity (‰)
0	26.22	35.151	26.28	35.109	26.18	35.162
10	26.23	35.149	26.28	35.110	26.19	35.163
20	25.88	35.280	26.28	35.129	26.19	35.163
30	25.09	35.367	25.81	35.292	25.79	35.215
50	24.28	35.324	24.70	35.311	24.94	35.347
75	23.56	35.291	23.89	35.316	23.88	35.261
100	22.02	35.247	22.56	35.233	22.86	35.203
125	20.45	35.120	20.86	35.158	21.17	35.136
150	18.98	35.058	19.05	34.910	20.12	35.075
200	16.53	34.797	16.34	34.754	17.42	34.873
250	13.56	34.459	14.00	34.511	14.42	34.502
300	11.74	34.339	12.00	34.342	12.20	34.280
400	8.89	34.144	8.98	34.128	8.49	34.123
500	6.59	34.138	6.60	34.127	6.53	34.180
600	5.55	34.288	5.62	34.316	5.71	34.331
700	5.17	34.390	5.25	34.403	5.13	34.422
800	4.73	34.471	4.88	34.463	4.83	34.483
900	4.38	34.510	4.38	34.517	4.49	34.516
1000	3.98	34.533	4.01	34.538	4.15	34.534
1200	3.36	34.560	3.40	34.556	3.62	34.554

Depth (m)	Station 7 Lat. 19°-55′.0N Long. 164°-20′.0W May 21, 1984 Temp. (°C)	Salinity (‰)	Station 8 Lat. 19°-55′.4N Long. 164°-16′.5W May 22, 1984 Temp. (°C)	Salinity (‰)	Station 9 Lat. 19°-55′.3N Long. 163°-52′.7W May 23, 1984 Temp. (°C)	Salinity (‰)
0	26.26	35.115	26.14	35.162	26.15	35.171
10	26.26	35.133	26.14	35.163	26.16	35.174
20	26.25	35.144	26.14	35.166	26.16	35.174
30	26.19	35.182	26.14	35.165	26.16	35.175
50	26.20	35.212	25.37	35.272	25.58	35.266
75	24.70	35.262	24.18	35.253	24.68	35.318
100	23.20	35.167	23.18	35.215	23.41	35.312
125	21.60	35.087	21.93	35.141	22.03	35.192
150	20.20	35.032	19.77	34.950	20.27	35.054
200	16.71	34.765	16.72	34.822	17.24	34.808
250	14.34	34.587	14.21	34.536	14.75	34.561
300	12.15	34.337	11.57	34.270	11.83	34.261
400	8.53	34.126	8.31	34.128	8.35	34.095
500	6.64	34.133	6.52	34.212	6.55	34.109
600	5.72	34.331	5.73	34.315	5.88	34.285
700	5.23	34.439	5.34	34.415	5.26	34.401
800	4.85	34.493	5.02	34.458	4.88	34.477
900	4.51	34.506	4.54	34.506	4.39	34.507
1000	4.14	34.532	4.14	34.526	4.02	34.530
1200	3.57	34.555	3.49	34.555	3.45	34.563

Depth (m)	Station 10 Lat. 19°-56′.3N Long. 163°-48′.0W May 24, 1984 Temp. (°C)	Salinity (‰)
0	26.24	35.097
10	26.23	35.101
20	26.23	35.102
30	26.22	35.103
50	26.12	35.156
75	24.88	35.342
100	24.24	35.337
125	23.03	35.290
150	21.03	35.143
200	17.75	34.841
250	14.40	34.516
300	11.69	34.275
400	8.70	34.117
500	6.54	34.151
600	5.66	34.313
700	5.20	34.417
800	4.79	34.478
900	4.44	34.504
1000	4.05	34.532
1200	3.44	34.559