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The Oceanic Condition in the Region East of Kyushu— I Intensive Survey in September of 1984

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Abstract

Intensive oceanographic survey was carried out on Sept. 12 and 13 of 1984 in the region east of Kyushu. The CTD observations were made at 14 stations on the two parallel sections ESE of Hyuga and Nobeoka, ca 10 miles apart to each other. In addition, at 29 stations in a small triangular area in this region, the XBT observations were made. The distances of two adjacent CTD stations are mainly ca 5 miles and XBT ca 1 or 2 miles. The preliminary results are as follows.

Was found the down intrusion of less saline surface water to a depth of 30 m layer of a point ca 10 miles apart. The isolated saline water was detected on the subsurface layer near the coast. The geostrophic calculation refered to 1000 dbar revealed the existence of coastal counter current with the maximum SSW component of 55 cm/sec. The width of this counter current is more than 30 miles off Nobeoka (nouthern section) and less than 15 miles off Hyuga (southern section). The XBT results show that the widths of small scale cold cores and warm tongues are in the order of two miles.

1. Introduction

It is a well known fact that the Kuroshio flows northeastward in the offshore region east of Kyushu in general, and it changes the direction more or less eastwards in the region south of Cape Ashizurimisaki. In the coastal region east of Kyushu, the oceanographical observations have been performed once a month or two by the Ohita and Miyazaki Prefectural Fisheries Experiment Stations. From these routine observations, some complicate features, *i. e.*, the outflow of the Seto Inland Sea Water of less saline and low temperature into the Pacific through the western half of Bungo-suido passage, the coastal current flowing toward SSW, the horizontal intrusion of tonguelike warm water to coastal region, and the upwelling of cold saline water along 200 m isobath, are found to be largely affected in any case by the variation of distance of Kuroshio axis from the coast (these

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results are compiled by CHAEN[1]).

It can be expected that the interleaving thermohaline fine structures may exist in such an offshore region where the mixing or exchange of the Kuroshio water with the coastal water is prominent. However, the routine observations stated above are limited in the coastal region within 30 miles from the coast, besides the observation depth is less than 200 m, and furthermore, are reported the oceanographical data in only standard depths. Therefore, has not been clarified yet the three dimensional distribution of fine structure in the offshore region.

The fine structure in this region was investigated by NAGATA[2] for the first time and ICHIKAWA *et al.*[3] also. NAGATA[2] analysed many historical data of BT (Bathythermograph), showing that the occurrence frequency of shallow temperature inversion in this region is ca 20% and it increases in the Kuroshio region. Unfortunately, the horizontal scale of shallow temperature inversions in this region was not discussed by himself. ICHIKAWA *et al.*[3] suggested the possibility of intrusion of low salinity Seto Inland Sea Water to the subsurface layer of the Kuroshio region through the density frontal zone at Bungo-suido passage, though their conclusion is rather speculative because it is derived from the CTD (Conductivity, Temperature and Depth Meter) data at only one station. This problem in the region between the eastern coast of Kyushu and the Kuroshio itself deserves intensive study.

In order to clarify the three dimensional structure of mixing and exchange processes between the less saline and low temperature coastal water and the saline high temperature Kuroshio water, we carried out the CTD and XBT (Expendable Bathythermograph) observations intensively on Sept. 12 and 13 in 1984. The preliminary results of these observations are presented in this paper.

2. Observation

Fig. 1 shows the locations of our intensive CTD and XBT observations in the region east of Kyushu carried out on Sept. 12 and 13 in 1984 on board the training ship Kagoshima-maru of Faculty of Fisheries, Kagoshima University. The CTD observations were made sequentially at 14 stations on two parallel sections ESE off Hyuga and off Nobeoka, ca 10 miles apart to each other. These two sections were selected as a northern boundary region where the bottom topography and the configulation of coastal line are quite simple. The distances between two adjacent stations are ca 5 miles with a few exception (10 miles). The CTD casts were made to the maximum depth of 1000 dbar. The water temperature and conductivity for any pressure were obtained by a Neil Brown System Inc., Mark III CTD System and they were recorded directly on a computer compatible magnetic tape at every 250 milli-seconds, which corresponds to the vertical interval of ca 25 cm. The CTD date were checked, using the materials collected by a General Oceanics Inc., Rosset Multi-bottled Water Sampler at several depths, before and after the sequential 14 CTD casts. The interpolated values of water temperature and salinity, which are estimated from the running means of 5 points, are tabulated in Appendix 1 together with the station data.

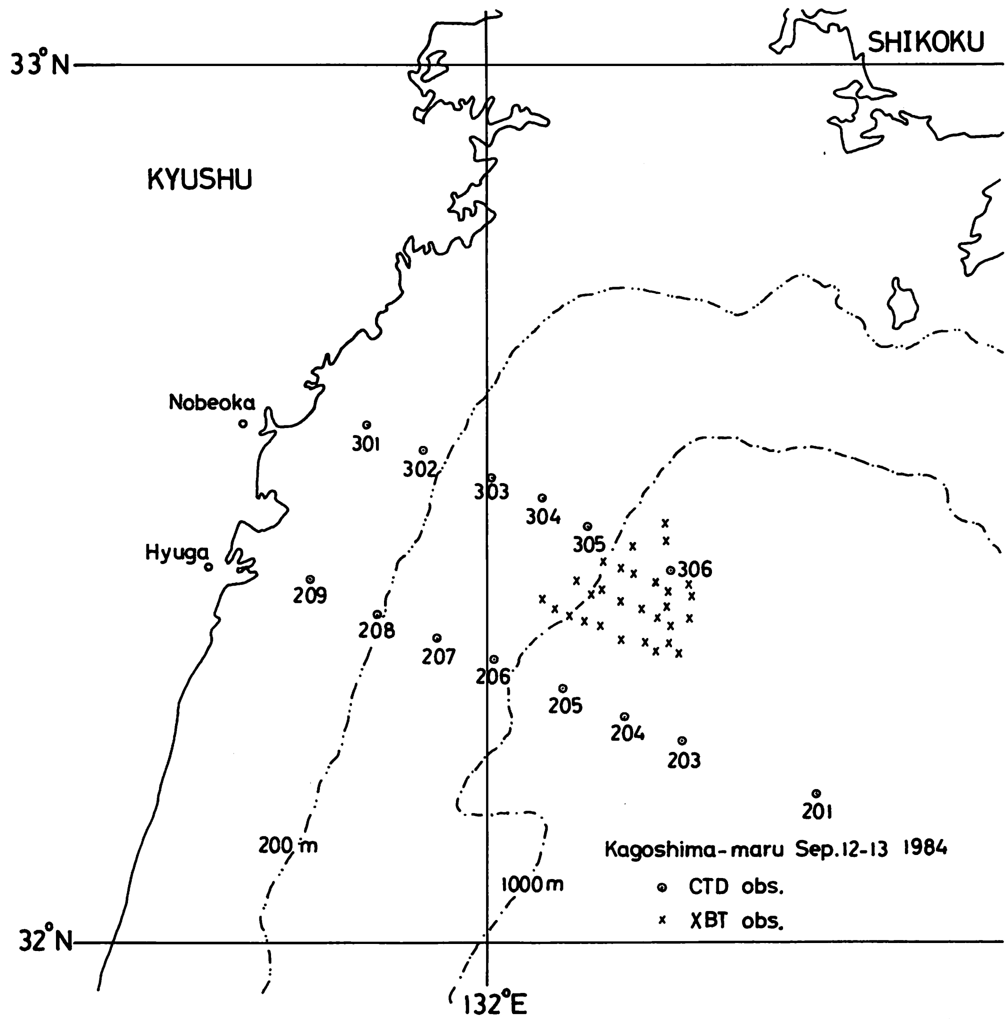

Fig. 1. The map showing the locations of CTD and XBT observations carried out on Sept. 12 and 13 of 1984.

At 29 stations in a triangular area shown in Fig. 1, the XBT observations were made on Sept. 13 of 1984, after all the CTD observations. This triangular area was selected on board, inspecting the continuous records of surface temperature and salinity, in order to examine precisely the structure of the water in a frontal region between the coastal and the Kuroshio waters. The distances of two adjacent XBT stations are ca 1 or 2 miles. The XBT data acquisition system used on board is Model SA-810 manufactured by Bathy System Inc. Continuous signal of output voltage from XBT probe is degitalized with the sampling frequency of 10 Hz with 12 bits binary resolution, which corresponds to the depth interval of ca 0.6 m and the temperature resolution of ca 0.02 ℃. The numerical values of water temperature obtained by XBT are tabulated in Appendix 2 with the station data.

3. Results and discussions

3.1 Vertical section of temperature and salinity

In Figs. 2 and 3 are shown the distributions of water temperature in the vertical section ESE of Hyuga (hereafter refered to as Section A) and that of Nobeoka (hereafter refered to as Section B), drawn from the data in Appendix 1. In Fig. 2 of Section A, a thermal front can be seen between Stns. 205 and 207. The highest temperature is 27.747 ℃ at 10 m deep of Stn. 201 inside the surface mixed layer above 27 ℃, which develops to a depth of ca 60 m at Stn. 201. The isotherm of 27 ℃ reaches up to sea surface near Stn. 204. On the other hand, the temperature of surface mixed layer in the onshore region is lower than 24 ℃ which is ca 4 ℃ lower than that in the offshore region.

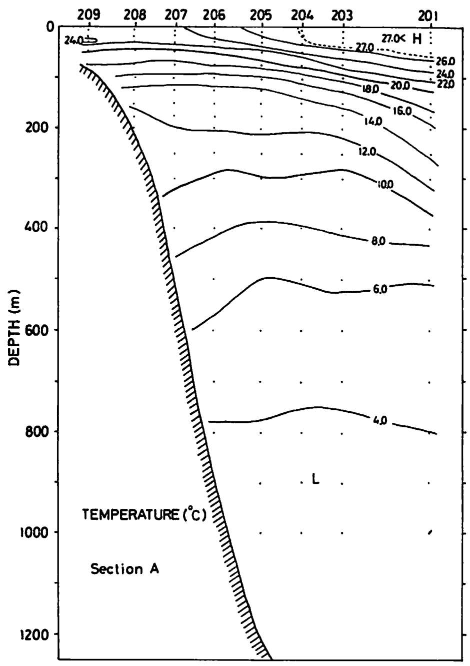

Fig. 2. Distribution of water temperature in the vertical section ESE of Hyuga on Sept. 12, 1984.

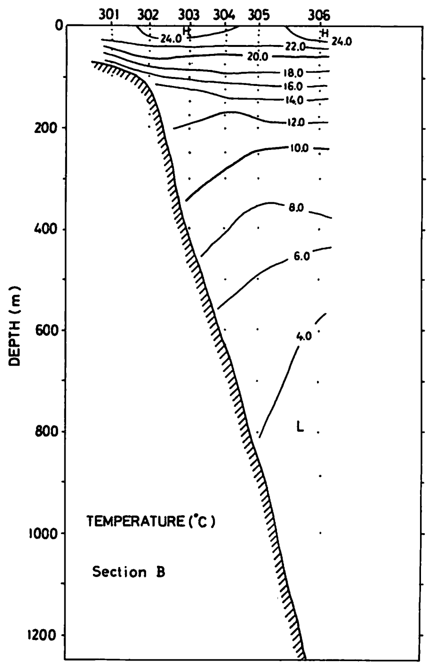

Fig. 3. Distribution of water temperature in the vertical section ESE of Nobeoka on Sept. 12 and 13, 1984.

In the subsurface layer, the isotherms from 14 to 22 ℃, which correspond to the thermocline, seem to extend rather horizontally on the onshore side of the thermal front stated above, while decline offshoreward on the offshore side. It must be emphasized that the isotherms from 10 to 14℃ sharply decline offshoreward in the offshore region from Stn. 203, while they decline onshoreward partly in the coastal region. It can be seen that only the isotherm of 12℃ declines offshoreward near the coast, showing the upwelling along 200 m isobath, as revealed by the routine observations.

In Fig. 3 of Section B, the highest temperature is 24.418 ℃ at a depth of 10 m on Stn. 303. The surface warm water higher than 24 ℃ is seen at two areas, *i. e.*, one is the region between Stns. 302 and 304, and the other is the offshore region around Stn. 306. This surface warm water seems to ride on the cold water in the range between 22 and 24 ℃ within the surface mixed layer. It must be remembered that the surface water lower than 24 ℃ in Section A is found only in the onshore region from Stn. 206. In other words, the temperature of the almost whole surface water in Section B equals to that of the coastal cold water in Section A.

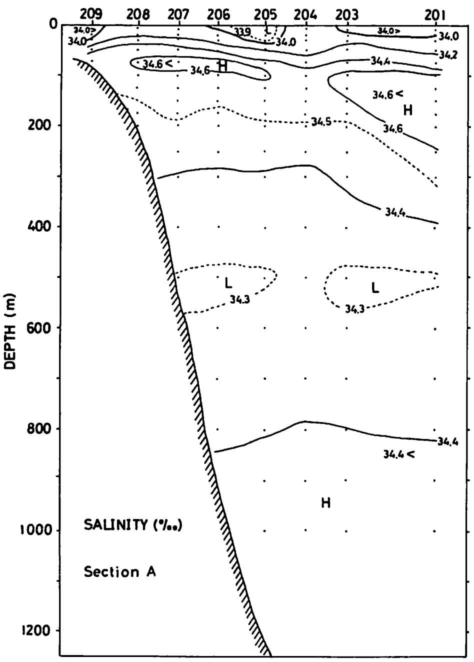

Fig. 4. Distribution of salinity in the vertical section ESE of Hyuga on Sept. 12, 1984.

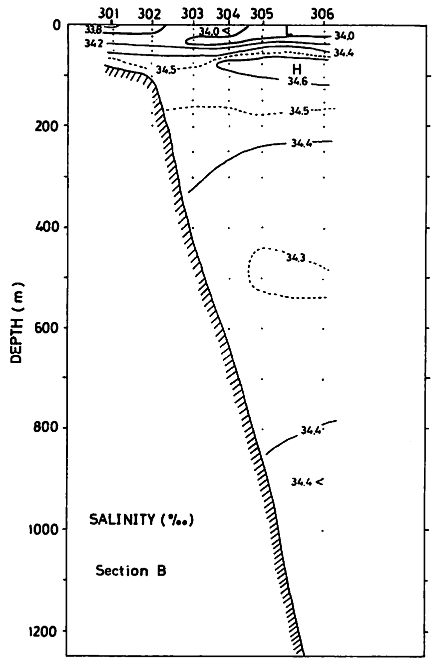

Fig. 5. Distribution of salinity in the vertical section ESE of Nobeoka on Sept. 12 and 13, 1984.

In the subsurface layer, the isotherms from 14 to 22 ℃ seem to be rather horizontal in the offshore region from Stn. 304, while they weakly decline offshoreward in the onshore region of Stn. 303. Below the subsurface layer, the sharp onshoreward declinations of all isotherms are seen in Section B, which is quite different from those in Section A.

The vertical distributions of salinity in Sections A and B shown in Figs. 4 and 5, are more complicated than those of temperature. In Fig. 4 of Section A, the lowest salinity is 33.839 ppt at a depth of 30 m on Stn. 209. The less saline surface water than 34.00 ppt is found at three areas, at the most nearshore region of Stn. 209, around the thermal front region between Stns. 206 and 205, and the offshore high temperature region from Stn. 203. The isoplet of 34.2 ppt is at the minimum of ca 30 m deep at Stns. 207 and 208, and at the maximum of ca 60 m deep at Stn. 204. These results suggest a process of downwelling along offshore edge of thermal front, and that of upwelling along onshore edge of thermal front.

In the subsurface layer, the saline waters higher than 34.6 ppt are found at two separate areas. One is located around ca 75 m deep with ca 30 m thick in some coastal area between Stn. 205 and Stn. 208 and the other in the more offshore region than Stn. 203. The latter increases in thickness according to the distance from the coast, *i. e.*, from ca 50 m thick at Stn. 203 to ca 150 m thick at Stn. 201. This result suggests that this offshore subsurface saline water originates from the more offshore region. It should be noticed that the depth of the central line through these saline waters nearly coincides to that of an isotherm of 18 ℃. Therefore, this saline water may be recognized as the Subtropical Subsurface Water. The maximum values of salinity in the two separated water described above are 34.619 ppt at 75 m deep of Stn. 208, the onshore end, and 34.696 ppt at 125 m deep of Stn. 201, the offshore end. This result indicates that the onshore subsurface saline water must be isolated from the offshore one. The isoplet of 34.5 ppt at Stns. 207 and 208 ascends onshoreward as same as the isotherm of 12 ℃ in Fig. 2, which shows the upwelling of saline water along 200 m isobath having been pointed from the routine observations.

The lowest value below the subsurface layer is 34.289 ppt at 500 m deep of Stn. 203. The less saline water than 34.3 ppt at 500 m deep are separated to two areas, similar to those subsurface saline water stated above, one is in the onshore region from Stn. 205, and the other is in the offshore region from Stn. 203. The depths of 34.4 ppt isoplets are shallowest at Stn. 204, corresponding to the isotherms lower than 10 ℃ in Fig. 2.

In Section B of Fig. 5, the lowest salinity is 33.770 ppt at sea surface of Stn. 301, the most onshore station, which is 0.069 ppt less than that in Section A. Therefore, it can be considered that the origin of coastal less saline water is the Seto Inland Sea Water flowing from the north. The less saline water than 34.0 ppt exists at the surface layer of onshore region from Stn. 302 and offshore region from Stn. 305. It must be noticed that the location of surface saline water higher than 34.0 ppt coincides to that of surface warm water higher than 24℃. Therefore, it can be conjectured that the origin of surface water at Stns. 303 and 304 is the Kuroshio water of high temperature and high salinity.

In the surface layer between Stns. 302 and 305, can be seen a certain patern of vertical circulation. The surface water of low salinity at Stn. 305 seems to intrude down obliquely to ca 30 m layer, extending over ca 10 miles to Stns. 303 and 304. On the other hand, the saline water at ca 30 m layer of Stn. 302 seems to intrude up to very surface of Stns. 303 and 304. The surface temperature at Stn. 305 is lower than those at either side of this point, *i. e.*, Stns. 304 and 306, indicating that a density maximum area exists around Stn. 305. Therefore, it can be recognized that the conjectured small scale vertical circulation is induced by the down intrusion of surface water along to the density front at Stn. 305.

In the surbsurface layer, the vertical gradients of salinity between 34.5 and 34.0 ppt in the offshore region from Stn. 304 is much larger than those in the onshore region from

Stn. 303. The highest salinity is 34.624 ppt at 100 m deep of Stn. 306. The saline water higher than 34.6 ppt can be seen in the offshore region of Stn. 304, centering on ca 80 m deep or the isotherm of 18 ℃. Below the subsurface layer, the less saline water than 34.3 ppt is found on 500 m deep of Stns. 305 and 306, and both of the isoplets of 34.4 ppt on ca 250 m deep and ca 800 m deep obviously decline onshoreward. These characteristics are

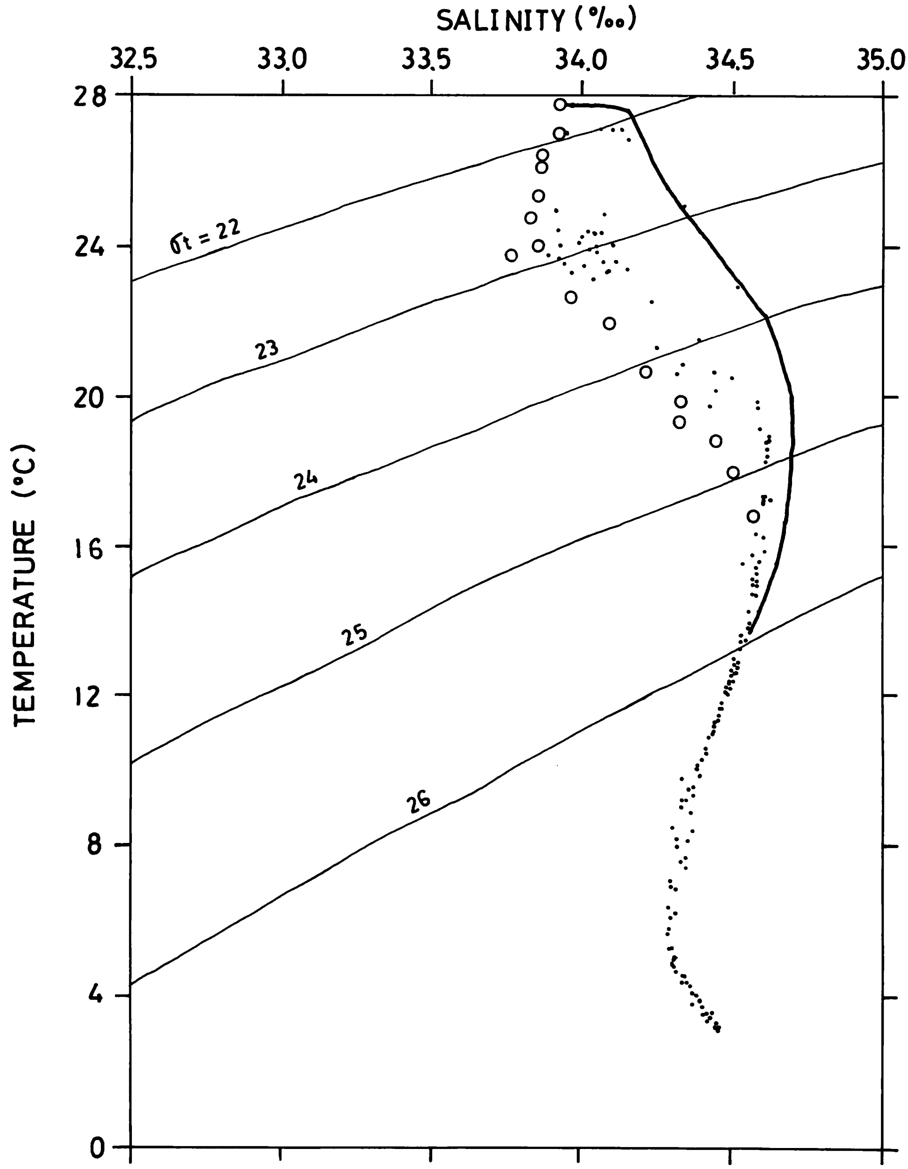

Fig. 6. Temperature-Salinity relation in the region east of Kyushu on Sept. 12 and 13, 1984. Thick line represents the TS-curve of Stn. 201, and open circles the lowest salinity water for each temperature.

similer to those of the vertical distribution of temperature in Section B or those of temperature and salinity on the onshore side of Stn. 204 in Section A. From these results, it may be concluded that the water types of all the sea waters on and below the subsurface layer in Section B and those in the onshore region of Section A are nearly equivalent to each other, as described in the next section.

3.2 Temperature salinity relation

In Fig. 6 is shown the temperature salinity relations at all depths of all stations obtained from the data given in Appendix 1. In this figure, the thick curve represents the TS-relation of Stn. 201, the most offshore station, and the open circles indicate the lowest salinity for each temperature, which are the values almost at Stns. 209 and 301, the most onshore stations in the two sections. The water corresponding to the maximum salinity of 34.69 ppt at 20 ℃ may be considered to be the Subtropical Subsurface Water, although this highest value is fairly lower than that of ca 34.9 ppt appropriate for far more offshore region. On the other hand, the water corresponding to the minimum salinity of ca 34.3 ppt at ca 6 ℃ may be considered to be the North Pacific Intermediate Water. Besides, the TS-curve of Stn. 201 is quite similar to the typical TS-curve in the Kuroshio region. Therefore, the water of Stn. 201 can be said to be the Kuroshio Water.

It is obvious from Fig. 6 that all the water mass colder than 12℃ has the same temperature salinity relation. On the other hand, the water types in the higher temperature range than ca 18℃ can be devided into three qroups according to salinity, *i. e.*, the most saline Kuroshio water represented by TS-curve of Stn. 201 (the first qroup), the lowest saline coastal water as represented by the water of Stn. 209 or Stn. 301 (the third qroup), and the mixture of the two, corresponding to a certain salinity in the transition range (the second group). The difference in salinity between the Kuroshio (the first group) and the least saline water (the third group) is more than ca 0.6 ppt for ca 24℃, showing significantly large value.

In Section A, not only the water of Stn. 201 but also the water in the upper 50 m layer of Stn. 203 and those in the upper 10 m layer of Stns. 204 and 205 seem to belong to the first group. On the other hand, no water type at all depths of all the stations in Section B belongs to the first group. It must be noticed here that the onshore subsurface saline water in Section A and the subsurface saline water in Section B are the same water type and both of them belong not to the first but to the second group.

3.3 Geostrophic current velocity

In Figs. 7 and 8 are shown the vertical distributions of geostrophic current velocity refered to 1000 dbar on Sections A and B, respectively. In these figures, the positive values indicate the NNE component of current velocity perpendiculer to the observational lines. Inspecting Fig. 7, it is obvious that the NNE component of current velocity is positive in the offshore side of Stn. 204, and negative in the onshore side of Stn. 205. This result suggests that the current field of Section A is devided by Stn. 204 into two areas, the offshore Kuroshio region and the onshore counter current region. On the other hand, is negative in Fig. 8 of Section B the current speed in the whole region. In other word, the whole Section B belongs to the onshore counter current region. It must be emphasized that the widths of the counter current in Sections A and B are ca 15 miles wide and more than 30 miles wide, respectively.

In Fig. 7, the positive values are found in the whole water column in the offshore Kuroshio region. The surface speed between Stns. 201 and 203 reaches up to the maximum positive value of 150 cm/sec. In the onshore counter current region of Section A, the region of negative current speed is limited below the surface layer. The maximum negative value of −45 cm/sec in Section A is found at a depth of ca 250 m between Stns. 205 and 206. On the other hand, the maximum negative value of ca −55 cm/sec in Section B is found not only on the depth of 175 m, which is ca 100 m shallower than Section A, but also on the sea surface between Stns. 303 and 304. The horizontal shear of current speed is fairly large at surface layer of Stn. 205, the thermal front region, and at subsurface layer of shelf edge of Stns. 207 and 303.

Comparing the vertical distributions of salinity with the current velocity, it can be concluded that the subsurface saline water in Section B flows toward SSW and appears in the onshore side of Stn. 205 in Section A as the onshore subsurface saline water.

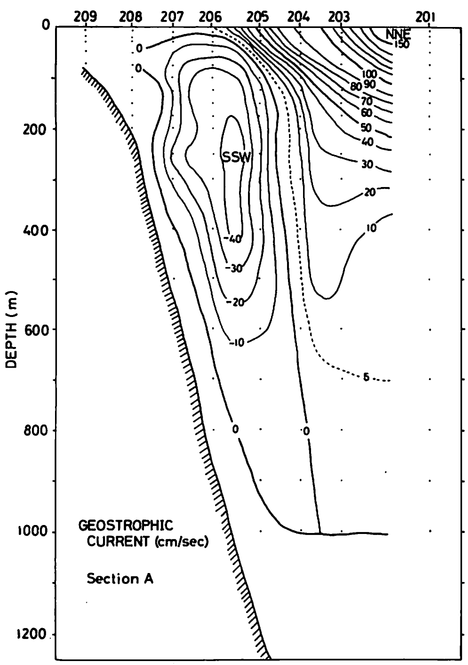

Fig. 7. Distribution of geostrophic current velocity refered to 1000 dbar in the vertical section ESE of Hyuga on Sept. 12. The postive values indicate the NNE component of current velocity.

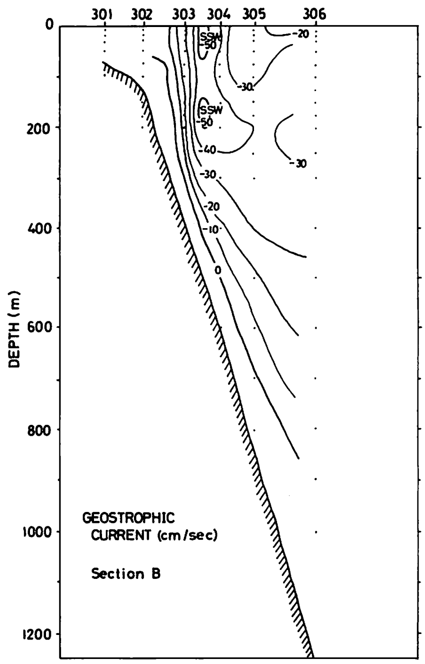

Fig. 8. Distribution of geostrophic current velocity refered to 1000 dbar in the vertical section ESE of Nobeoka on Sept. 12 and 13, 1984 (cf. the legend of Fig. 7).

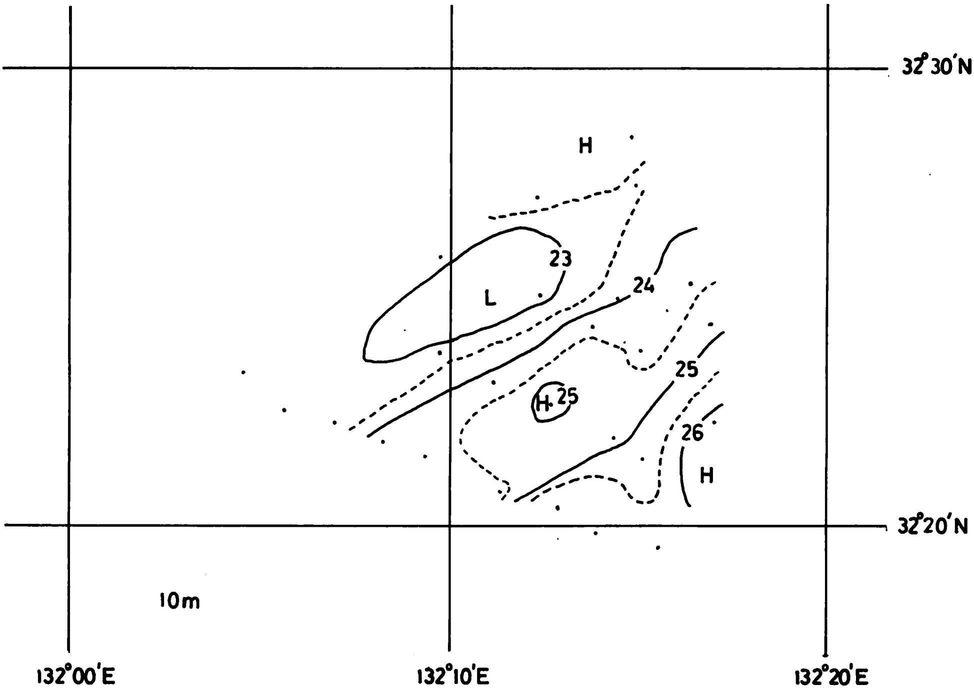

Fig. 9. Temperature distribution in fine horizontal scale on the depth of 10 m layer, Sept. 13 of 1984.

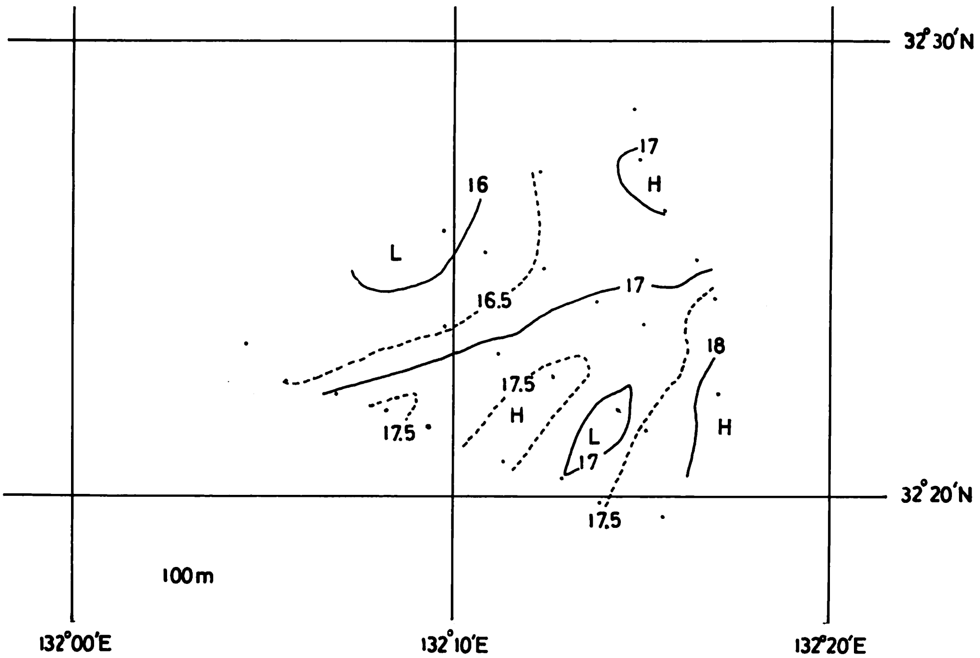

Fig. 10. Temperature distribution in fine horizontal scale on the depth of 100 m layer, Sept. 13 of 1984.

3.4 Temperature distribution in fine horizontal scale

In Figs. 9, 10, and 11 are shown the horizontal distributions of water temperature on the depths of 10, 100, and 400 m obtained from the XBT data given in Appendix 2, respectively. Inspecting Fig. 9 of 10 m layer, it is found that the isotherms of 24 and 25 ℃ run in the NE direction with small undulations and that the cold core lower than 23 ℃ with ca 2 miles wide and ca 4 miles long in NE direction exists centering on 32°-25′N, 132°-10′E. The highest temperature is 26. 24 ℃ at southeastern end of the triangular area of XBT observation and the lowest 22. 70 ℃ in the cold core.

In Fig. 10 of 100 m layer, the highest temperature is 18. 18 ℃ at the southeastern end of the highest temperature station on 10 m layer. The lowest temperature is 15. 69 ℃ at 32°-32′N, 132°-10′E, ca 1 mile NW of the lowest temperature station on 10 m layer. The isotherm of 17 ℃ runs in the ENE direction, rotating ca 25 degrees clockwise compared with 24 - 25 ℃ isotherms on 10 m layer. The temperature distribution in the northern region is rather simple than that in the southern region. The cold core found on 10 m layer seems to move northwestward and a warm region higher than 17 ℃ appears at 32°-27′N, 132°-15′E. In the southern region, are found two warm tongues higher than 17. 5 ℃, one of them is ca 1 mile wide and more than 3 miles long in NE direction, besides a cold core lower than 17 ℃ of ca 1 mile wide and 2 miles long in the same direction. On the eastern side of this small cold core, the isotherms of 17. 5 and 18 ℃ run in the NNE direction.

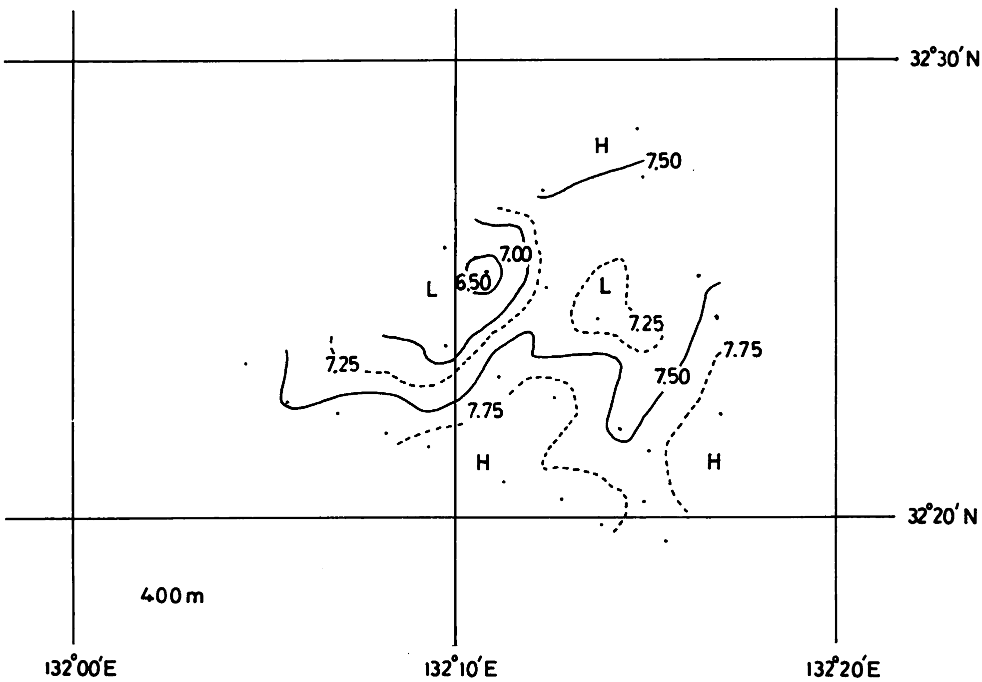

Fig. 11. Temperature distribution in fine horizontal scale on the depth of 400 m layer, Sept. 13 of 1984.

In Fig. 11 of 400 m layer, the highest and the lowest are found both at the same points on 10 m layer respectively, and the numerical values are 7.99 ℃ and 6.38 ℃. The isotherm of 7.5 ℃ runs to the east direction with large meander. The wave length and amplitude of this meander seem to be equal to each other of ca 1 mile. The warm tongue higher than 7.75 ℃ seems to intrude northeastward with a width of more than 3 miles.

4. Concluding remarks

Are presented in this paper the preliminary results of intensive oceanographical survey carried out on Sept. 12 and 13 of 1984 in the region east of Kyushu. From the interpolated values at standard depths of 14 CTD casts on two sections ESE of Hyuga and of Nobeoka, and 29 XBT casts in a triangular area, the following results are obtained.

1) The down intrusion of the less saline surface water into 30 m layer of a point ca 10 miles apart was found.

2) The saline subsurface water isolated from the offshore water was detected near the coast.

3) The water lower than 12 ℃ at all stations have nearly the same temperature salinity relations.

4) The geostrophic calculation refered to 1000 dbar revealed the existence in the whole water column of the coastal couter current with the maximum SSW component of 55 cm/sec. The width of this counter current is more than 30 miles off Nobeoka and less than 15 miles off Hyuga.

5) The widths of small scale cold cores and warm tongues are the order of two miles.

In order to clarify the mixing and/or exchange process between the less saline coastal water and the saline Kuroshio water, it is necessary to make a precise water mass analysis. However, in the present paper are made only the vertical sections of temperature, salinity and geostrophic current velocity, the temperature disributions in fine horizontal scale on several depths and the temperature salinity relations, all of which are obtained only from the oceanographical date on standard depths. The relation between the oceanographical condition of coastal region obtained by the routine survey and that of our intensive observations, and the three dimensional distribution of water mass, remain to be clarified.

Using the vertical profiles of temperature and salinity in high resolution of depth, we may be able to clarify the intrusion process of less-saline low-temperature water into saline high-temperature water. The precise discussions on the water mass exchange mechanism using the distribution of fine structures will be presented elsewhere.

Aknowledgement

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Appendix 1. Data of CTD observations, East of Kyushu, Sept. 12 and 13 of 1984, Kagoshima-maru, Kagoshima University.

Stn.	201	
DATE	9/12	
TIME	1516	
Lat.	32-10.2 N	
Long.	132-26.3 E	
DEPTH	1810m	
P	Temp.	Sal.
0	27.722	33.935
10	27.747	33.969
20	27.707	34.039
30	27.699	34.073
50	27.594	34.154
75	25.522	34.286
100	22.164	34.610
125	20.037	34.696
150	18.284	34.692
175	16.652	34.672
200	15.541	34.645
250	14.262	34.588
300	12.593	34.502
400	8.866	34.362
500	6.128	34.298
600	4.955	34.311
700	4.351	34.348
800	3.998	34.382
900	3.544	34.429
1000	3.241	34.446

Stn.	203	
DATE	9/12	
TIME	1757	
Lat.	32-14.0 N	
Long.	132-16.0 E	
DEPTH	1600m	
P	Temp.	Sal.
0	26.974	33.932
10	27.012	33.942
20	27.095	34.068
30	27.094	34.110
50	24.990	34.333
75	22.907	34.514
100	18.898	34.620
125	16.217	34.602
150	14.670	34.576
175	12.726	34.510
200	12.200	34.488
250	11.660	34.465
300	10.571	34.412
400	8.343	34.369
500	6.382	34.289
600	4.785	34.305
700	4.291	34.359
800	3.775	34.402
900	3.451	34.430
1000	3.176	34.454

Stn.	204	
DATE	9/12	
TIME	1940	
Lat.	32-15.6 N	
Long.	132-11.2 E	
DEPTH	1406m	
P	Temp.	Sal.
0	27.048	34.132
10	27.066	34.131
20	27.068	34.132
30	26.838	34.158
50	24.813	34.075
75	20.131	34.443
100	16.777	34.570
125	15.051	34.582
150	13.537	34.540
175	12.688	34.511
200	12.126	34.484
250	11.224	34.436
300	9.756	34.330
400	7.928	34.311
500	6.204	34.313
600	4.644	34.319
700	4.282	34.366
800	3.710	34.406
900	3.425	34.435
1000	3.177	34.458

Stn.	205	
DATE	9/12	
TIME	2210	
Lat.	32-17.6 N	
Long.	132-06.3 E	
DEPTH	1210m	
P	Temp.	Sal.
0	26.407	33.872
10	26.085	33.865
20	25.322	33.858
30	24.741	33.839
50	21.283	34.250
75	19.121	34.589
100	15.836	34.605
125	13.793	34.552
150	13.311	34.529
175	12.580	34.503
200	12.343	34.496
250	11.227	34.446
300	10.036	34.379
400	7.559	34.330
500	5.845	34.293
600	4.806	34.314
700	4.293	34.354
800	3.856	34.395
900	3.496	34.421
1000	3.270	34.449

Stn.	206	
DATE	9/12	
TIME	2330	
Lat.	32-19.5	N
Long.	132-00.9	E
DEPTH	890m	

P	Temp.	Sal.
0	24.921	33.916
10	24.316	34.050
20	24.017	34.106
30	23.381	34.153
50	20.464	34.493
75	18.220	34.611
100	15.008	34.577
125	13.476	34.531
150	12.714	34.505
175	12.248	34.488
200	12.113	34.483
250	11.194	34.441
300	9.459	34.358
400	8.110	34.319
500	7.054	34.293
600	5.273	34.305
700	4.522	34.335
800	3.889	34.385

Stn.	207	
DATE	9/13	
TIME	0050	
Lat.	32-21.0	N
Long.	131-55.9	E
DEPTH	538m	

P	Temp.	Sal.
0	23.908	34.031
10	23.902	34.034
20	23.557	34.071
30	22.503	34.232
50	19.833	34.583
75	17.277	34.607
100	14.217	34.558
125	13.538	34.542
150	13.150	34.531
175	12.582	34.503
200	12.015	34.480
250	10.955	34.433
300	10.281	34.399
400	9.151	34.343
500	6.899	34.298

Stn.	208	
DATE	9/13	
TIME	0215	
Lat.	32-22.5	N
Long.	131-51.0	E
DEPTH	206m	

P	Temp.	Sal.
0	23.902	34.056
10	23.894	34.053
20	23.846	34.048
30	21.485	34.390
50	19.704	34.582
75	18.123	34.619
100	15.750	34.567
125	13.542	34.531
150	12.240	34.486
175	11.458	34.455
200	11.165	34.441

Stn.	209	
DATE	9/13	
TIME	0307	
Lat.	32-25.0	N
Long.	131-46.0	E
DEPTH	86m	

P	Temp.	Sal.
0	23.925	33.855
10	23.950	33.860
20	24.015	33.930
30	23.567	34.116
50	19.834	34.336
75	17.959	34.506

Stn.	301	
DATE	9/13	
TIME	0438	
Lat.	32-35. 5 N	
Long.	131-50. 2 E	
DEPTH	80m	
P	Temp.	Sal.
0	23.743	33.770
10	23.774	33.894
20	23.330	34.099
30	21.978	34.096
50	19.292	34.336
75	15.500	34.537

Stn.	302	
DATE	9/13	
TIME	0513	
Lat.	32-33. 5 N	
Long.	131-55. 0 E	
DEPTH	123m	
P	Temp.	Sal.
0	24.131	33.991
10	24.139	33.991
20	24.129	34.009
30	23.912	34.072
50	21.405	34.386
75	19.451	34.426
100	15.069	34.561

Stn.	303	
DATE	9/13	
TIME	0558	
Lat.	32-31. 7 N	
Long.	132-00. 1 E	
DEPTH	405m	
P	Temp.	Sal.
0	24.394	34.026
10	24.241	34.008
20	24.033	34.000
30	22.630	33.974
50	20.679	34.218
75	18.773	34.450
100	16.800	34.568
125	13.722	34.563
150	12.825	34.514
175	12.259	34.490
200	11.730	34.467
250	11.435	34.456
300	10.901	34.428
400	8.475	34.304

Stn.	304	
DATE	9/13	
TIME	0642	
Lat.	32-30. 4 N	
Long.	132-04. 6 E	
DEPTH	611m	
P	Temp.	Sal.
0	24.331	34.068
10	24.367	34.072
20	23.437	34.015
30	23.248	33.969
50	20.571	34.318
75	18.457	34.621
100	16.260	34.585
125	14.926	34.583
150	13.420	34.546
175	11.674	34.464
200	11.299	34.449
250	10.458	34.416
300	9.504	34.374
400	8.107	34.352
500	6.885	34.317
600	4.996	34.313

Stn.	305	
DATE	9/13	
TIME	0734	
Lat.	32-28.5 N	
Long.	132-09.2 E	
DEPTH	845	
P	Temp.	Sal.
0	23.625	33.932
10	23.550	33.946
20	23.388	33.973
30	23.121	34.046
50	20.618	34.441
75	18.698	34.619
100	17.194	34.606
125	15.301	34.582
150	13.779	34.556
175	12.909	34.515
200	11.178	34.441
250	9.867	34.393
300	9.052	34.332
400	7.696	34.350
500	5.737	34.290
600	4.916	34.307
700	4.349	34.335
800	4.102	34.375

Stn.	306	
DATE	9/13	
TIME	0846	
Lot.	32-25.5 N	
Long.	132-15.2 E	
DEPTH	1810m	
P	Temp.	Sal.
0	24.412	33.926
10	24.418	33.926
20	24.409	33.928
30	24.048	34.005
50	20.812	34.334
75	18.228	34.620
100	17.162	34.624
125	15.511	34.590
150	13.891	34.559
175	12.335	34.493
200	11.125	34.444
250	10.139	34.382
300	9.367	34.372
400	7.474	34.344
500	5.306	34.297
600	4.547	34.342
700	3.841	34.375
800	3.583	34.408
900	3.385	34.428
1000	3.105	34.461

Appendix 2. Date of XBT observations, East of Kyushu, Sept. 13 of 1984, Kagoshima-maru, Kagoshima University.

St.	Time	Lat.	Long.	SFC-S	0m	10	20	30	50	75	100	125	150
	JST	N	E		200	250	300	350	400	500	600	800	1000
1	936	32-25.4	132-16.2	–	–	24.4	23.8	23.6	22.6	18.9	16.9	15.6	14.6
					11.2	10.0	9.1	8.1	7.5	5.2	4.3	3.3	2.8
2	1000	32-23.5	132-17.0	–	–	25.7	25.4	24.9	23.1	18.5	17.8	15.4	13.7
					10.8	10.2	9.3	8.3	7.6	5.5	4.4	3.4	3.0
3	1019	32-22.0	132-16.9	34.131	26.0	26.2	26.3	26.1	25.0	22.9	18.2	16.5	14.1
					11.7	10.5	9.7	8.9	8.0	5.3	4.6	3.5	3.0
4	1038	32-19.6	132-15.6	34.146	26.0	25.8	26.1	26.2	24.2	21.5	17.9	15.8	13.7
					11.7	10.5	9.5	87.3	7.6	5.7	4.7	3.5	3.2
5	1052	32.19.9	132-13.9	34.154	25.8	25.9	26.2	25.2	22.8	20.8	17.5	15.5	13.8
					11.4	10.2	9.7	8.8	7.8	5.5	4.6	3.4	3.0
6	1103	32-20.4	132-12.9	34.157	25.8	25.7	25.8	25.2	22.5	19.4	17.0	14.6	13.2
					11.4	10.2	9.5	8.5	7.9	5.6	4.5	3.4	3.0
7	1116	32-20.6	132-11.3	34.037	24.6	24.4	24.2	23.7	22.0	18.6	17.7	15.4	14.1
					11.5	10.6	9.2	8.5	7.8	5.6	4.4	3.6	3.0
8	1129	32-21.4	132-09.3	34.131	25.0	24.4	23.8	23.5	21.0	18.5	17.3	15.3	14.1
					11.5	10.0	8.9	8.3	7.8	5.5	4.7	3.4	3.0
9	1142	32-21.8	132-08.1	34.036	24.0	24.3	23.2	23.3	21.9	19.8	17.7	15.9	14.2
					11.6	10.0	9.0	8.2	7.7	5.4	4.8	3.8	3.1
10	1150	32-22.2	132-06.7	34.179	23.5	23.1	23.2	23.3	21.3	18.5	17.1	15.3	14.5
					11.9	10.1	8.9	8.1	7.6	5.5	4.7	3.8	3.1
11	1159	32-22.6	132-05.6	34.198	23.5	23.2	23.4	23.2	20.4	18.4	16.4	15.1	14.2
					11.7	9.9	9.2	8.3	7.5	5.7	4.9	3.8	3.1
12	1210	32-23.1	132-04.5	34.214	23.5	23.3	23.4	23.3	20.7	18.6	16.5	15.2	13.4
					11.7	9.9	8.9	8.6	7.9	6.2	5.0	3.8	–
13	1233	32-24.7	132-07.5	34.198	23.4	–	–	–	–	–	–	–	–
14	1247	32-23.6	132-08.3	34.125	23.3	–	–	–	–	–	–	–	–
15	1305	32-23.8	132-09.8	34.093	23.5	23.1	22.9	22.1	18.8	17.4	16.4	14.8	13.3
					10.4	9.3	8.4	7.9	6.9	5.0	4.1	3.3	–
16	1313	32-23.2	132-11.2	34.083	24.5	24.1	22.8	22.6	21.0	18.5	17.1	15.1	13.7
					11.2	9.7	9.0	8.5	7.6	5.4	4.4	3.5	3.0
17	1324	32-22.6	132-12.7	34.041	24.9	25.2	24.3	23.9	21.4	18.8	17.7	16.1	13.9
					12.0	10.1	9.3	8.7	8.0	5.8	4.6	3.6	3.2
18	1348	32-22.0	132-14.4	34.064	24.5	24.9	23.9	23.1	19.8	18.4	16.7	15.1	13.6
					10.7	9.6	9.1	8.1	7.5	5.2	4.4	3.5	3.1
19	1353	32-21.5	132-15.2	34.190	25.0	25.3	25.4	24.9	22.8	18.9	17.7	15.7	14.1
					11.3	10.2	9.2	8.4	7.7	5.5	4.7	3.5	3.0
20	1411	32-23.9	132-15.1	34.030	24.2	24.4	23.9	23.0	21.0	18.3	17.2	15.6	14.0
					11.2	10.0	9.0	8.5	7.2	5.5	4.6	3.5	3.0
21	1424	32-24.4	132-13.8	34.099	24.3	24.6	23.0	22.6	21.5	18.5	17.1	14.4	13.3
					10.7	9.7	8.5	8.1	7.1	5.3	4.4	3.3	2.8
22	1436	32-25.2	132-12.2	34.136	23.0	22.9	23.0	22.9	21.2	18.4	16.5	14.5	13.1
					11.0	9.4	8.9	8.4	7.4	5.5	4.4	3.3	2.8
23	1449	32-25.5	132-10.9	34.105	22.4	22.7	22.6	22.3	19.1	18.3	16.4	14.3	12.6
					10.4	9.2	8.4	7.8	6.4	5.2	4.2	3.3	–
24	1501	32-26.0	132-09.8	34.144	22.0	23.1	22.9	22.5	18.9	17.4	15.7	13.7	12.6
					10.6	9.2	8.5	7.6	6.7	5.1	4.2	3.4	–
25	1523	32-27.3	132-12.4	34.042	23.5	23.8	23.8	22.9	21.2	18.6	16.5	14.8	13.3
					11.6	9.9	8.8	8.4	7.5	5.8	4.9	3.6	3.1
26	1539	32-28.7	132-14.9	34.014	23.2	23.9	24.1	23.7	20.7	17.8	16.2	14.3	13.2
					11.2	10.0	9.1	8.3	7.6	5.5	4.7	3.9	3.2
27	1551	32-27.6	132-15.0	34.060	23.5	23.5	23.2	22.9	22.0	19.1	17.1	14.7	13.0
					10.9	9.6	8.8	8.0	7.4	5.5	4.6	3.6	2.9
28	1614	32-22.8	132-15.0	34.062	24.6	24.7	24.7	23.4	20.1	18.4	17.2	15.8	13.7
					11.4	10.0	9.4	8.8	7.7	5.8	4.9	3.8	3.2
29	1626	32-20.4	132-15.1	34.042	24.2	24.1	24.2	24.0	20.9	18.2	16.3	14.8	13.0
					11.7	10.2	9.6	8.7	7.9	5.9	4.7	3.6	3.0