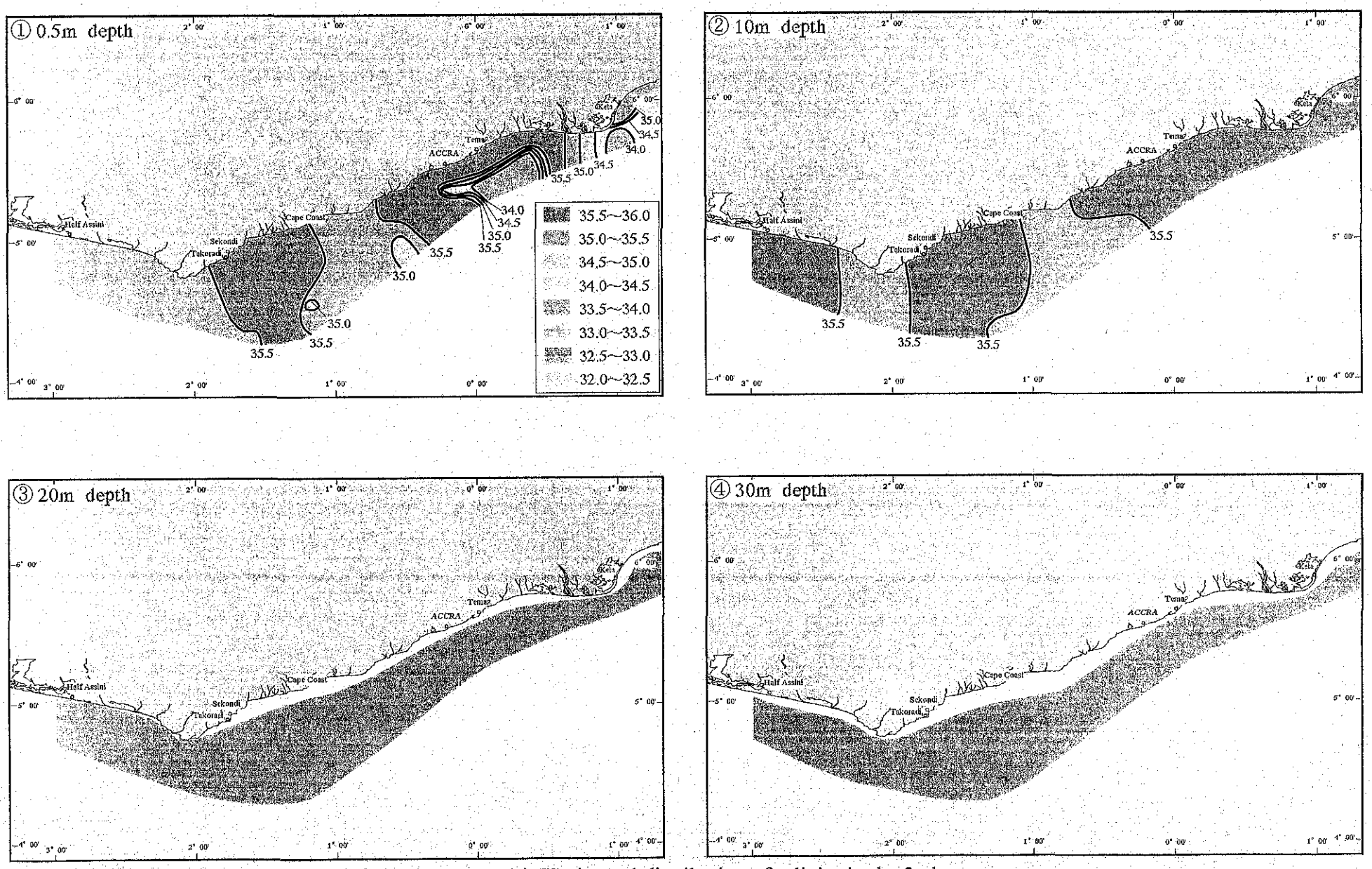


Figure 5-2-1-2 (1) Horizontal distribution of salinity in the 2nd survey

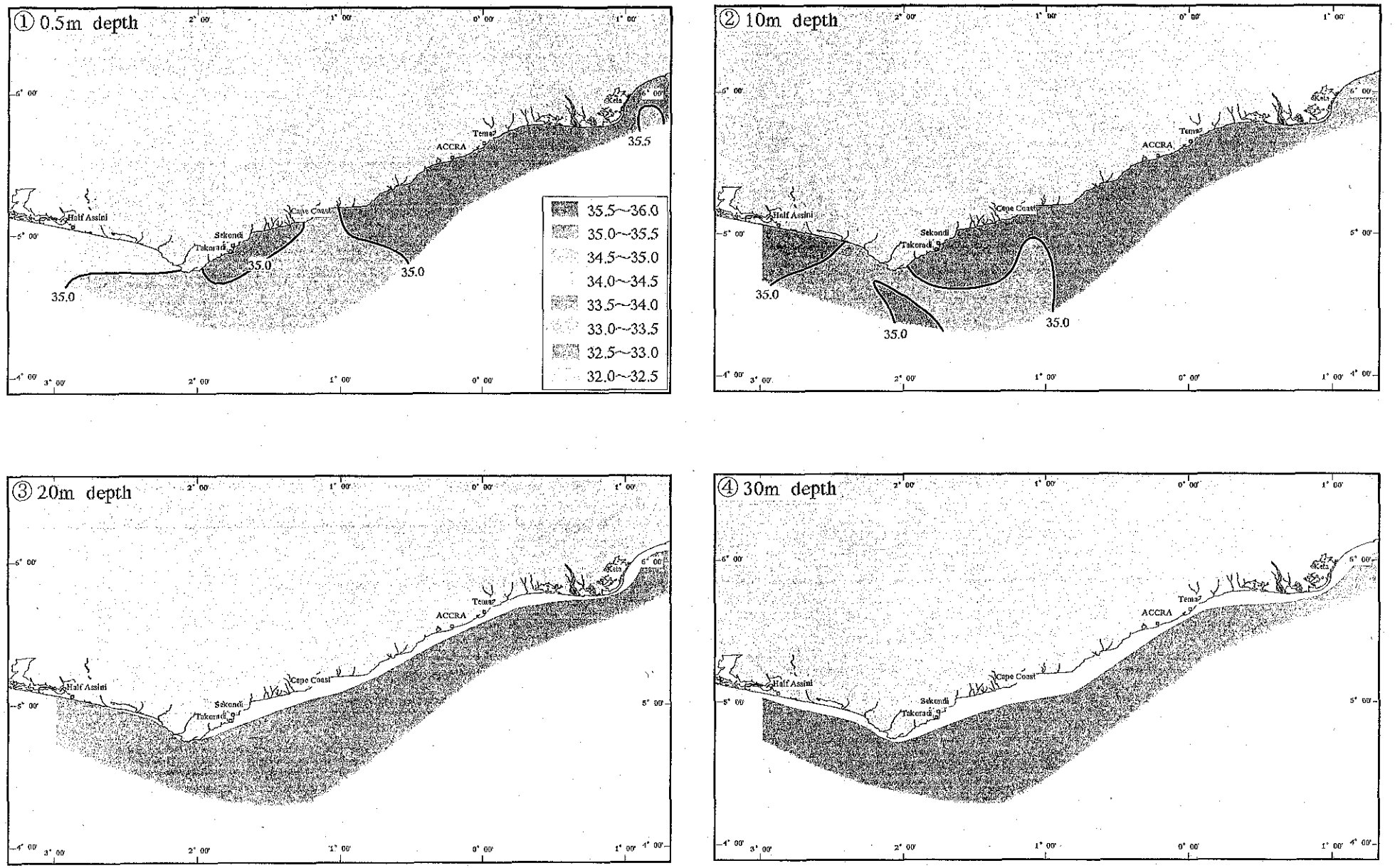


Figure 5-2-1-2 (2) Horizontal distribution of salinity in the 3rd survey

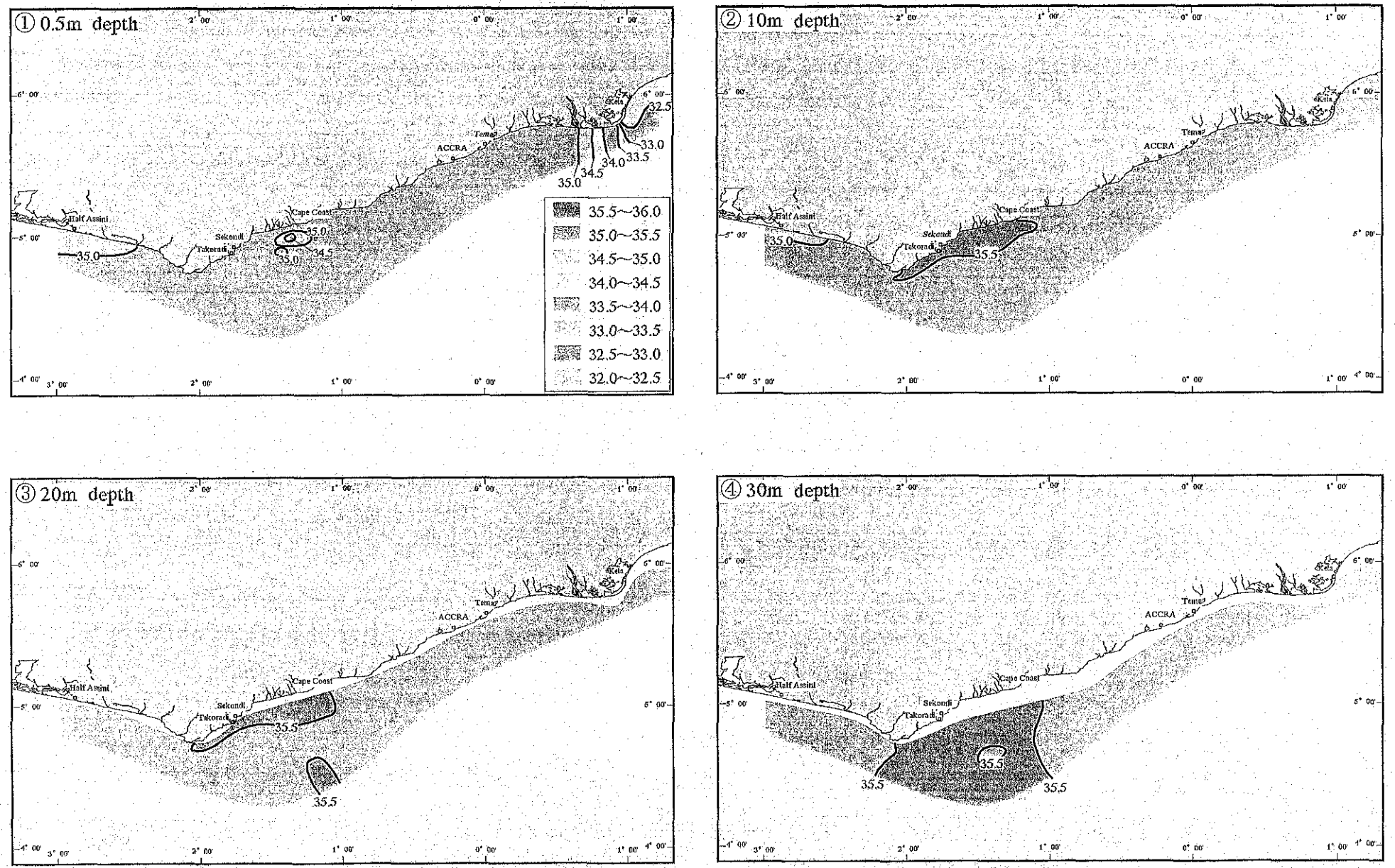


Figure 5-2-1-2 (3) Horizontal distribution of salinity in the 4th survey

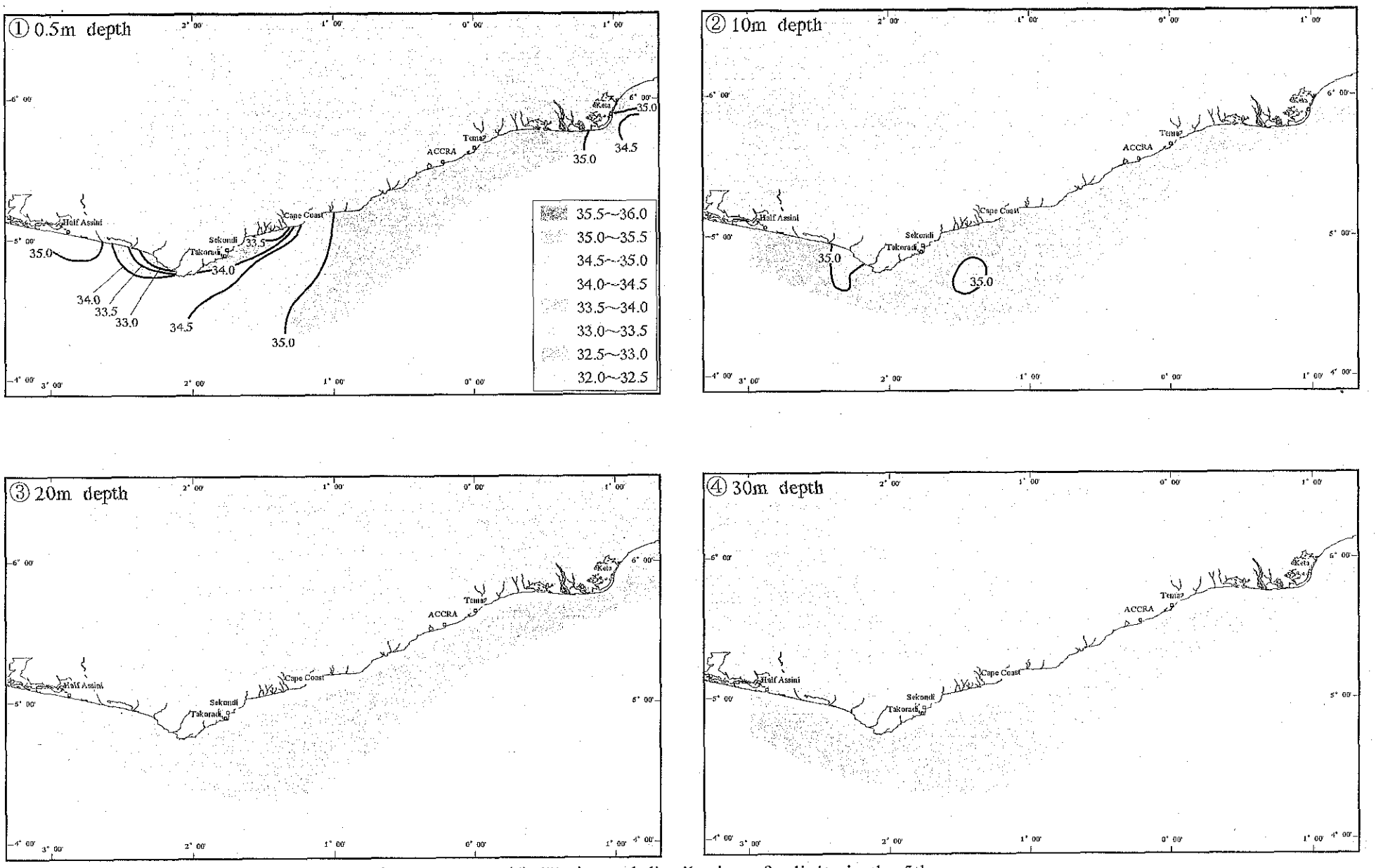


Figure 5-2-1-2 (4) Horizontal distribution of salinity in the 5th survey

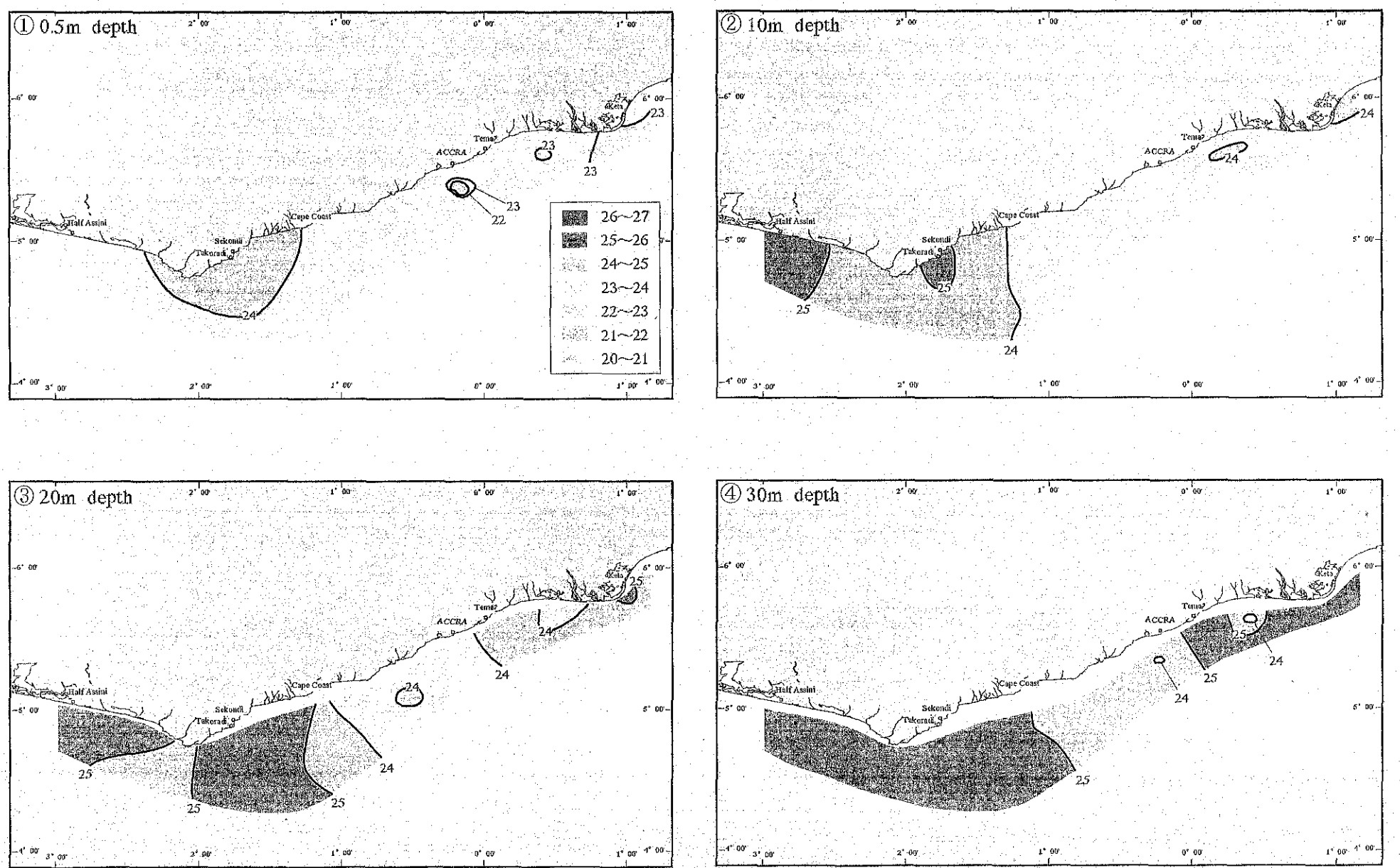


Figure 5-2-1-3 (1) Horizontal distribution of density in the 2nd survey

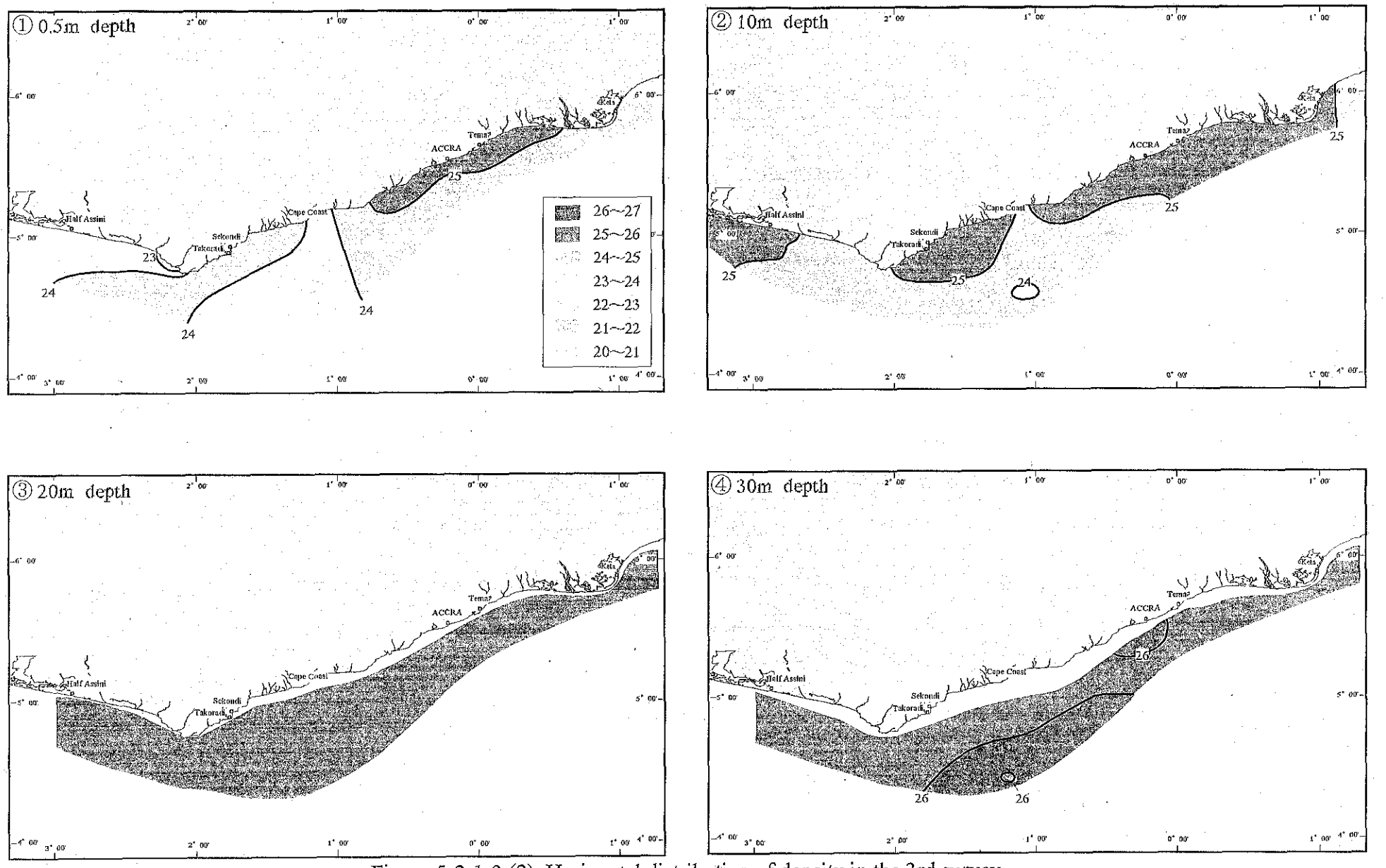


Figure 5-2-1-3 (2) Horizontal distribution of density in the 3rd survey

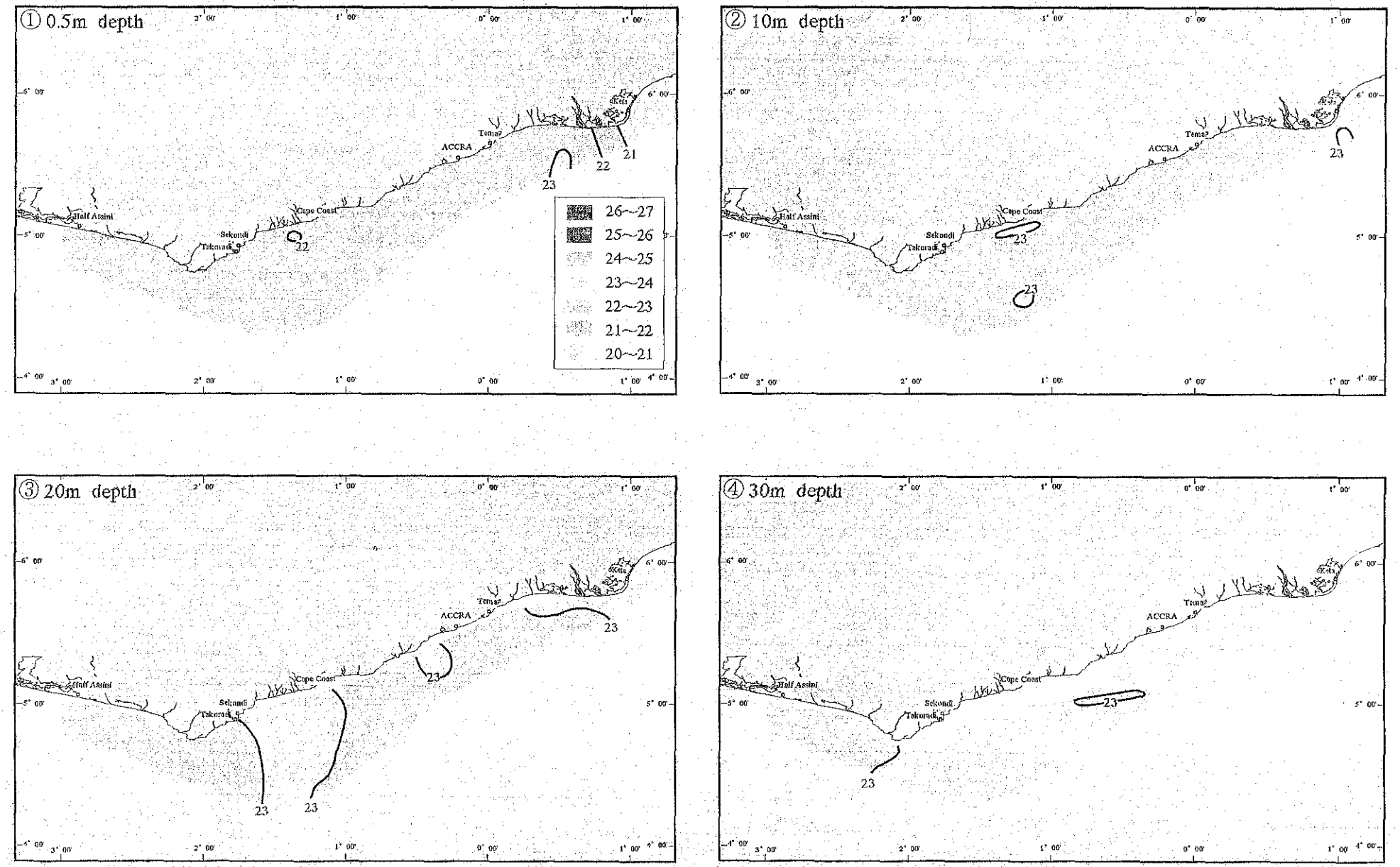


Figure 5-2-1-3 (3) Horizontal distribution of density in the 4th survey

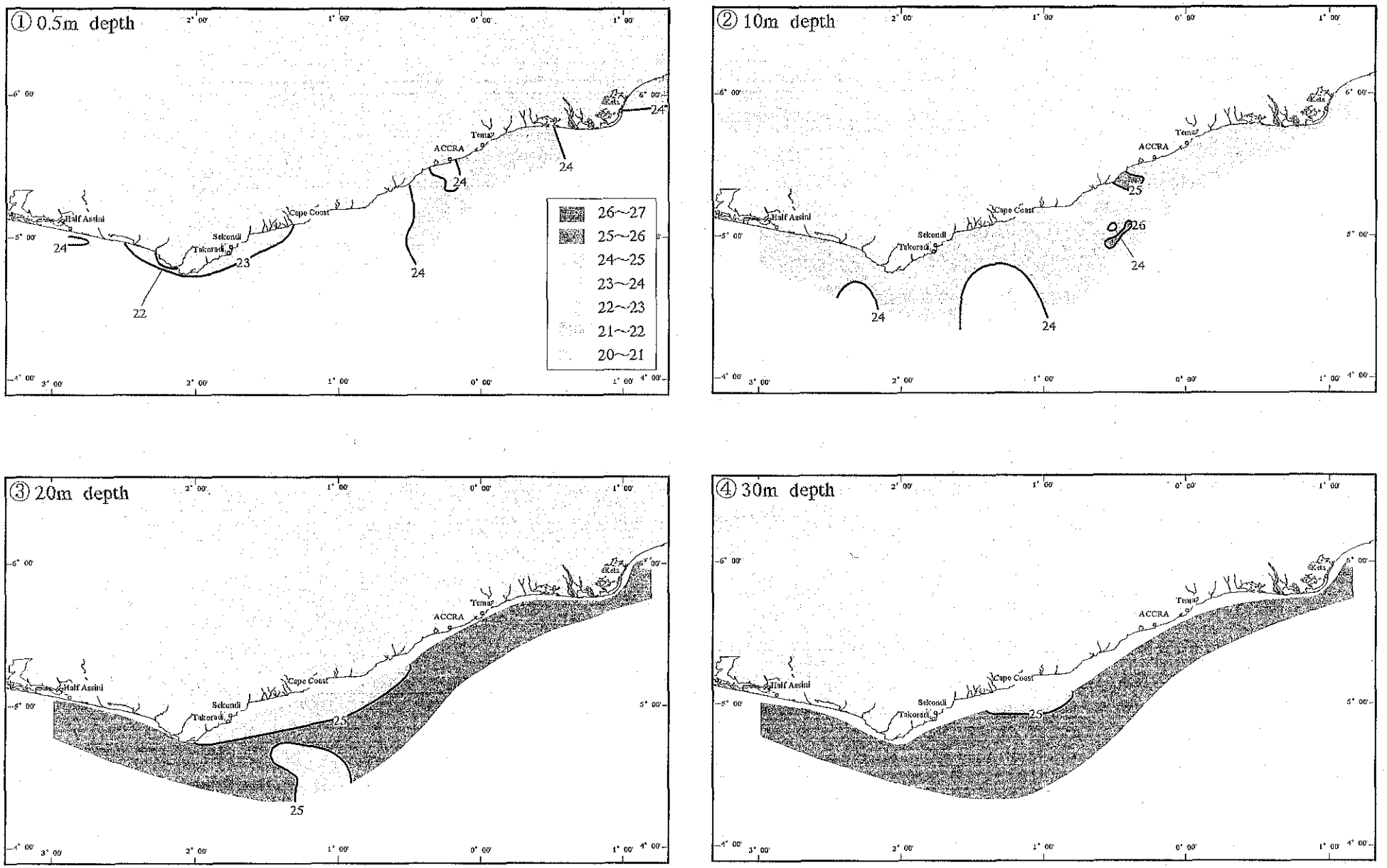


Figure 5-2-1-3 (4) Horizontal distribution of density in the 5th survey

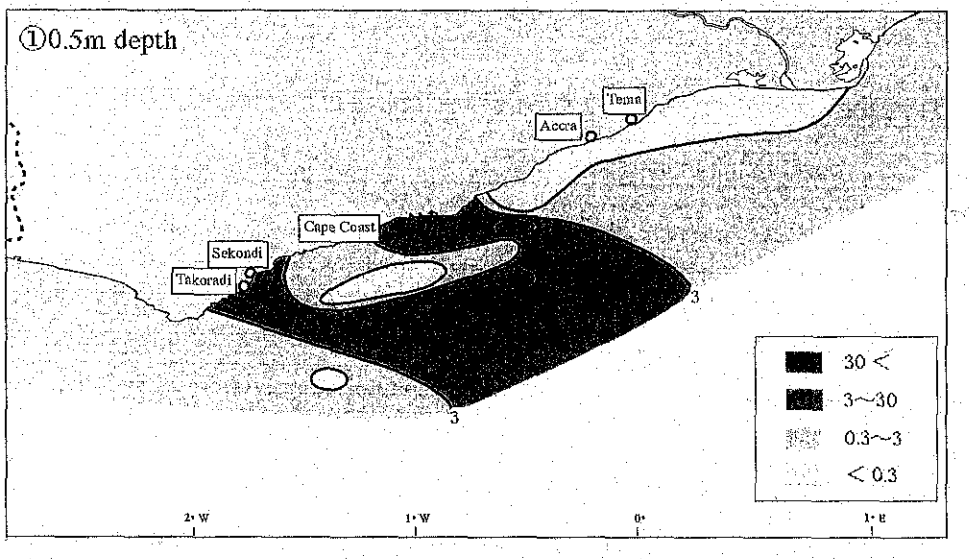


Figure 5-2-1-4 (1) Horizontal distribution of chlorophyll [ppb] in the 2nd survey

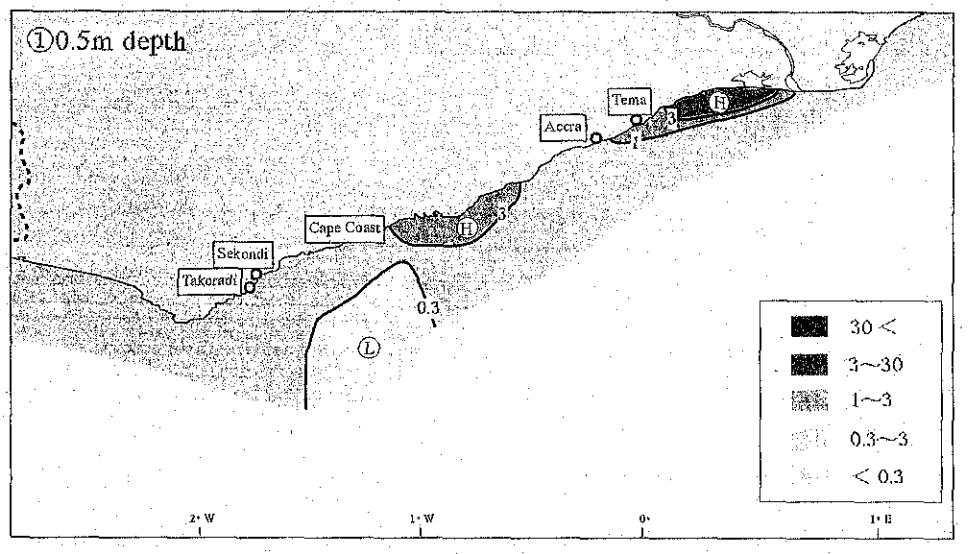


Figure 5-2-1-4 (2) Horizontal distribution of chlorophyll [ppb] in the 3rd survey

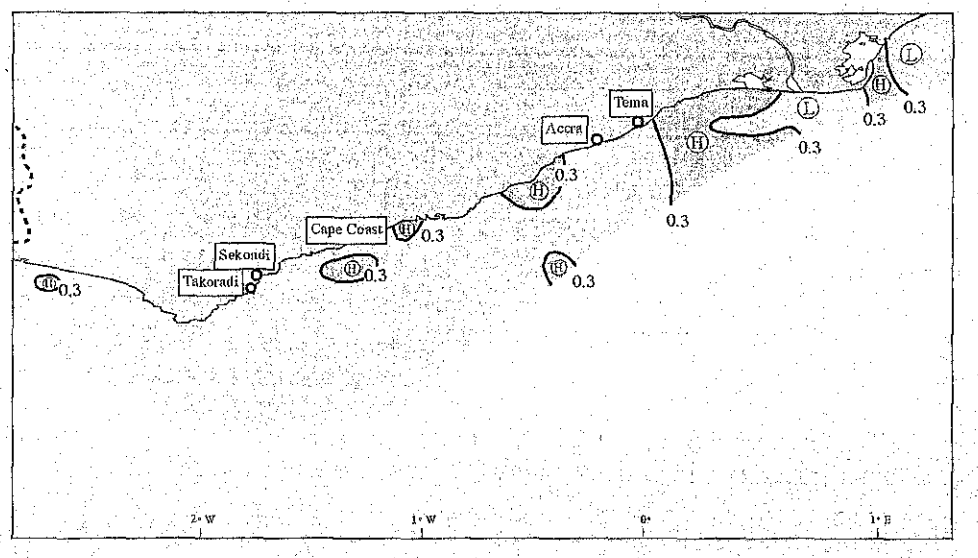


Figure 5-2-1-4 (3) Horizontal distribution of chlorophyll [ppb] in the 4th survey

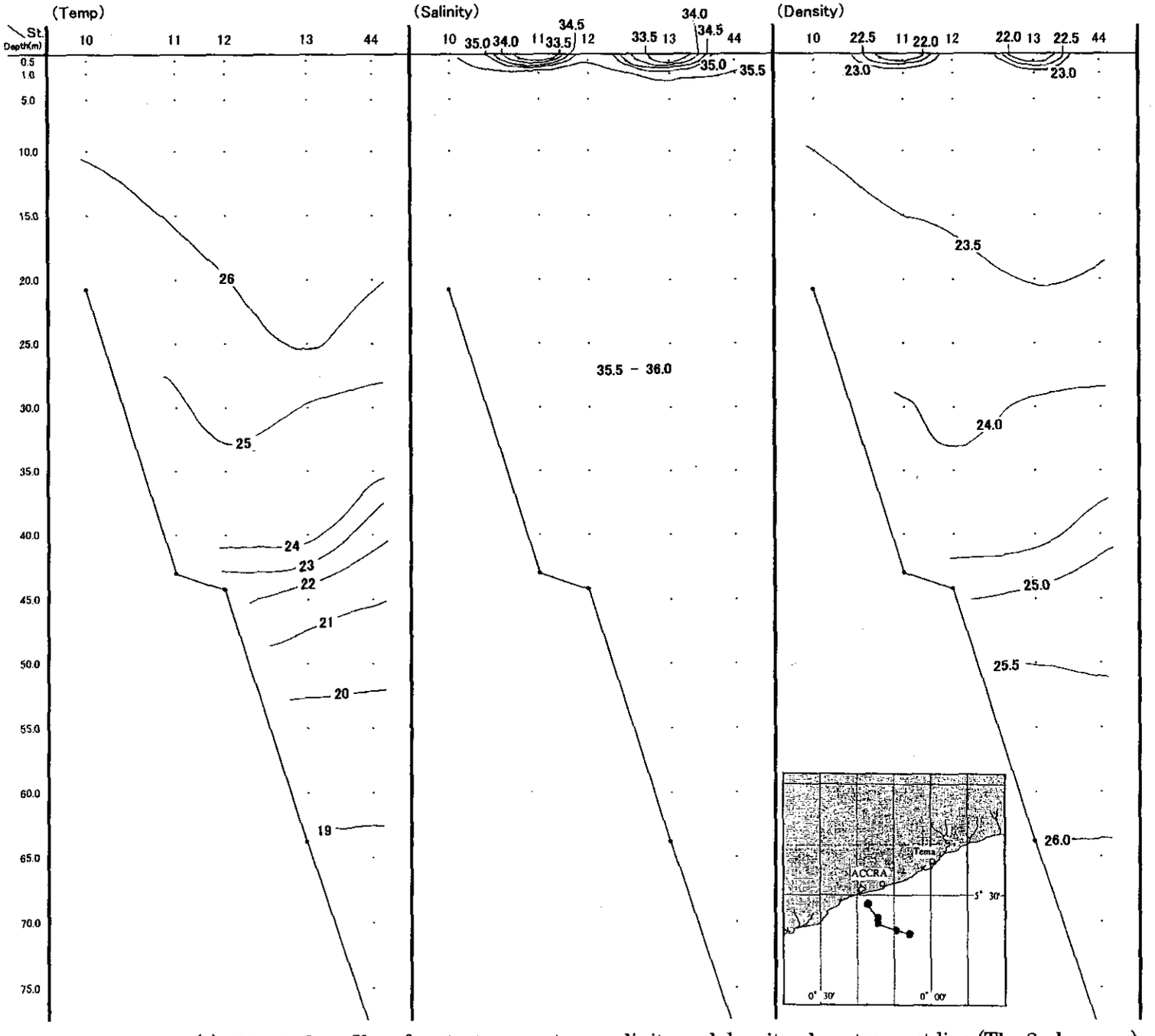


Figure 5-2-1-5 (1) Vertical profiles of water temperature, salinity and density along transect line (The 2nd survey)

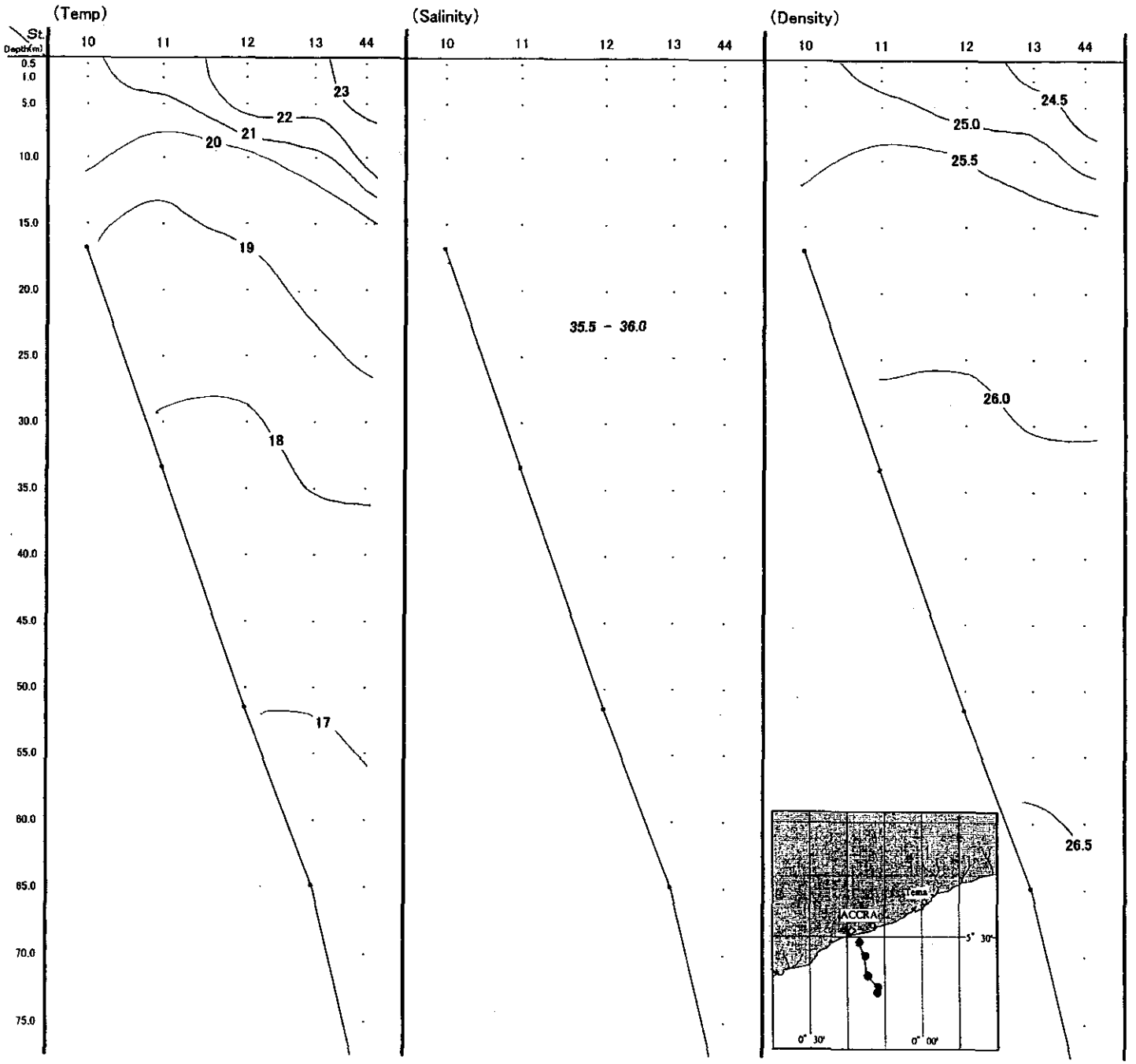


Figure 5-2-1-5 (2) Vertical profiles of water temperature, salinity and density along transect line (The 3rd survey)

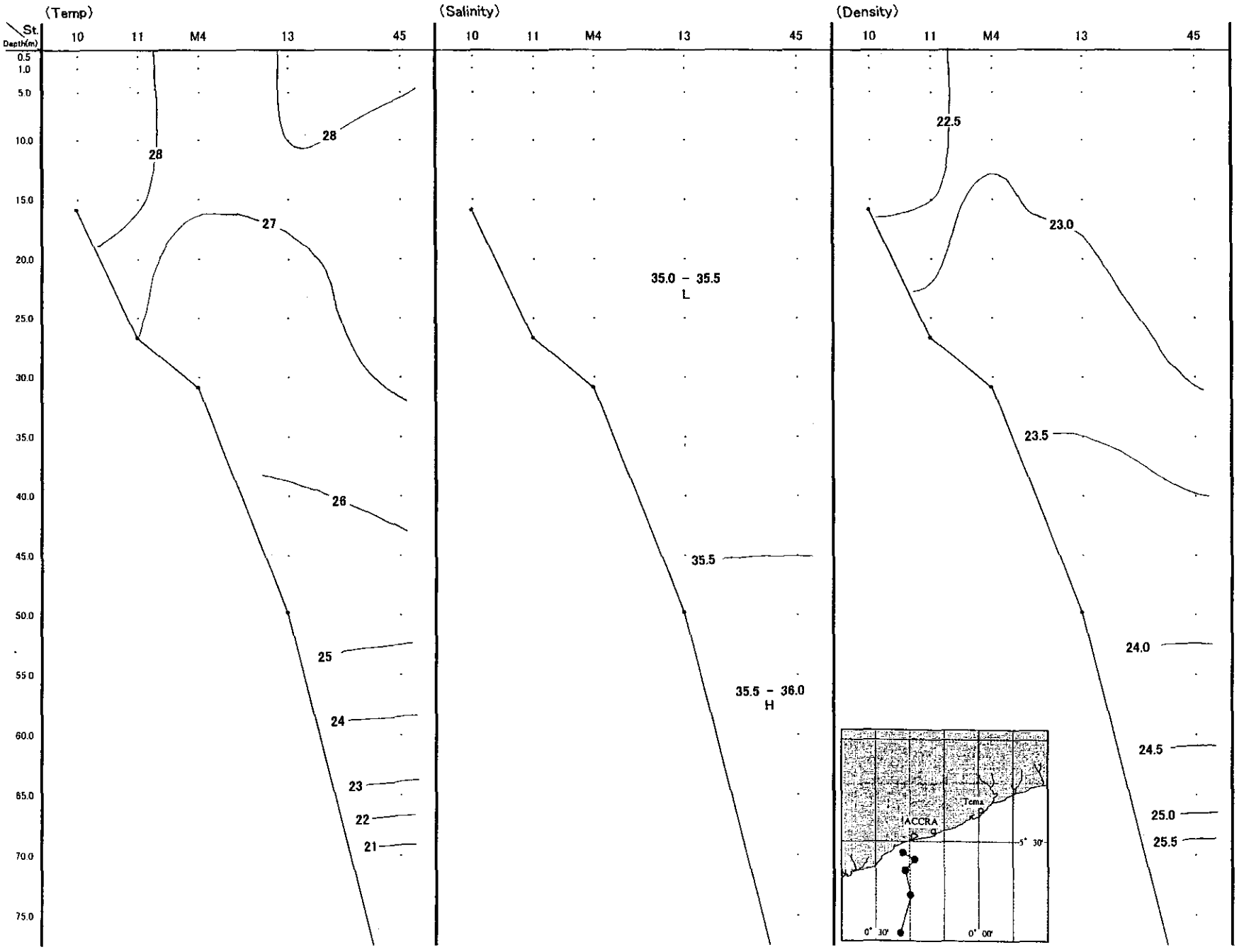


Figure 5-2-1-5 (3) Vertical profiles of water temperature, salinity and density along transect line (The 4th survey)

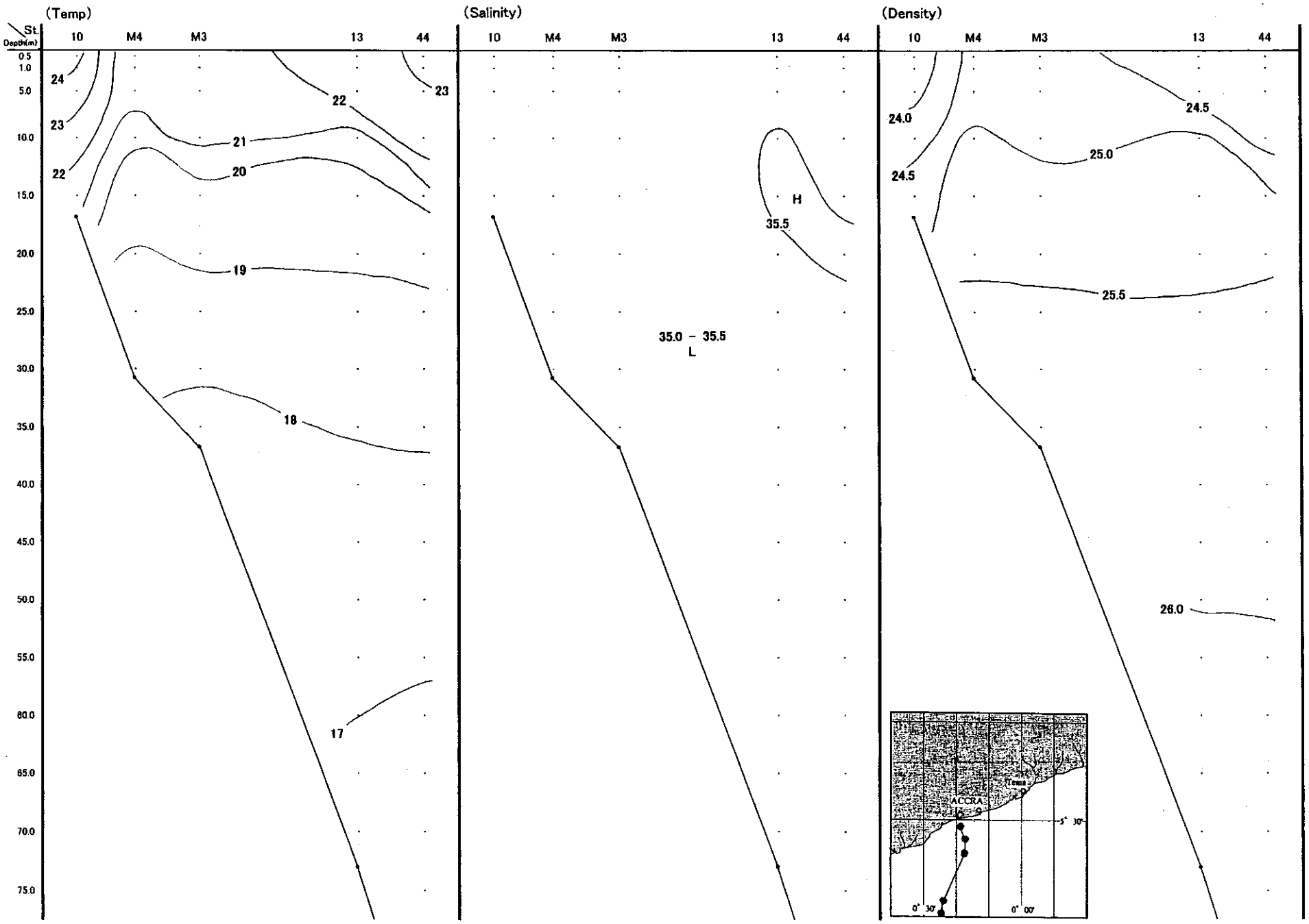
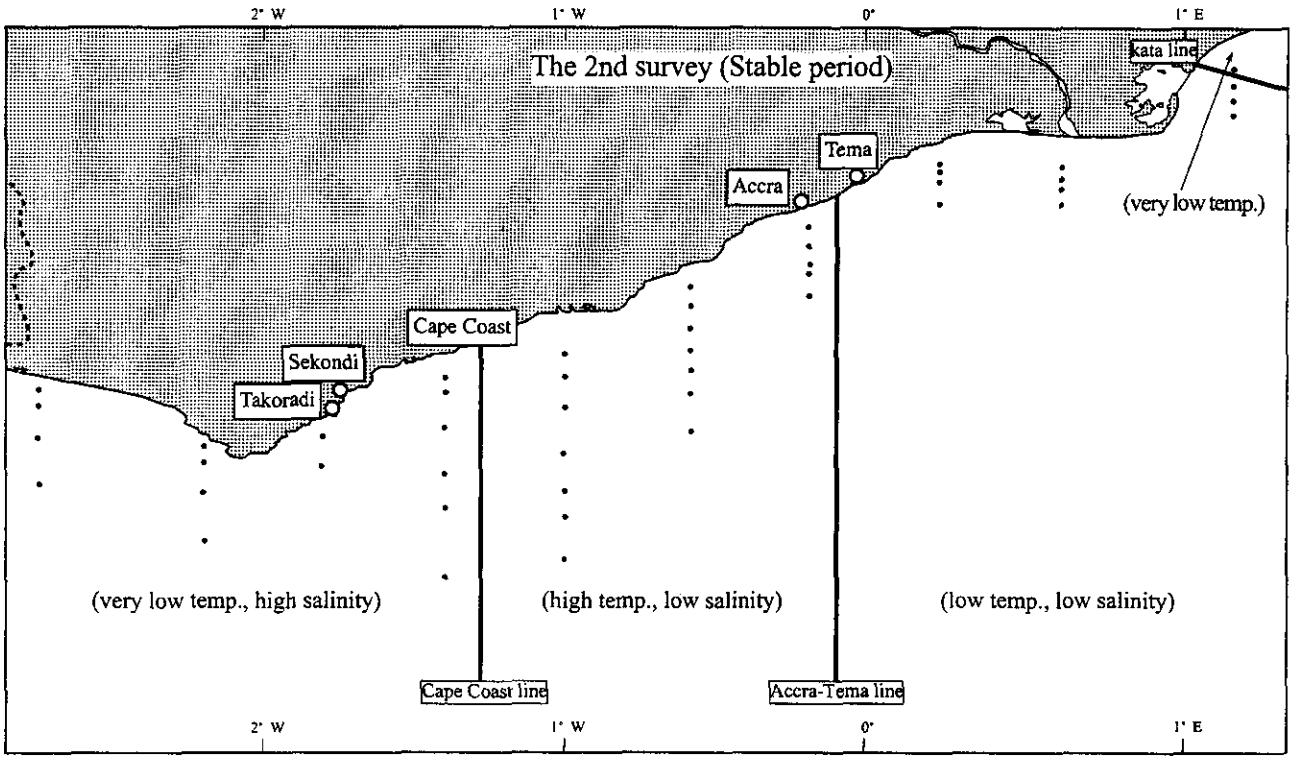


Figure 5-2-1-5 (4) Vertical profiles of water temperature, salinity and density along transect line (The 5th survey)



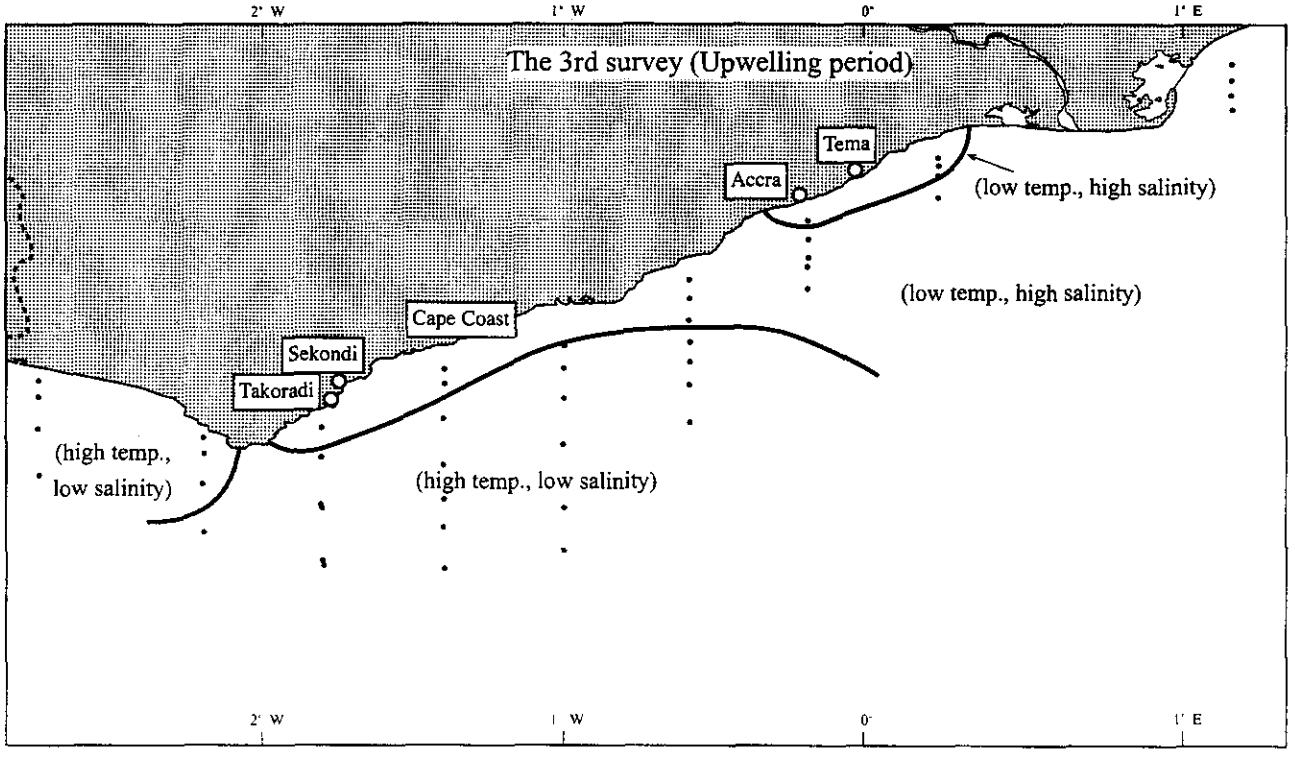
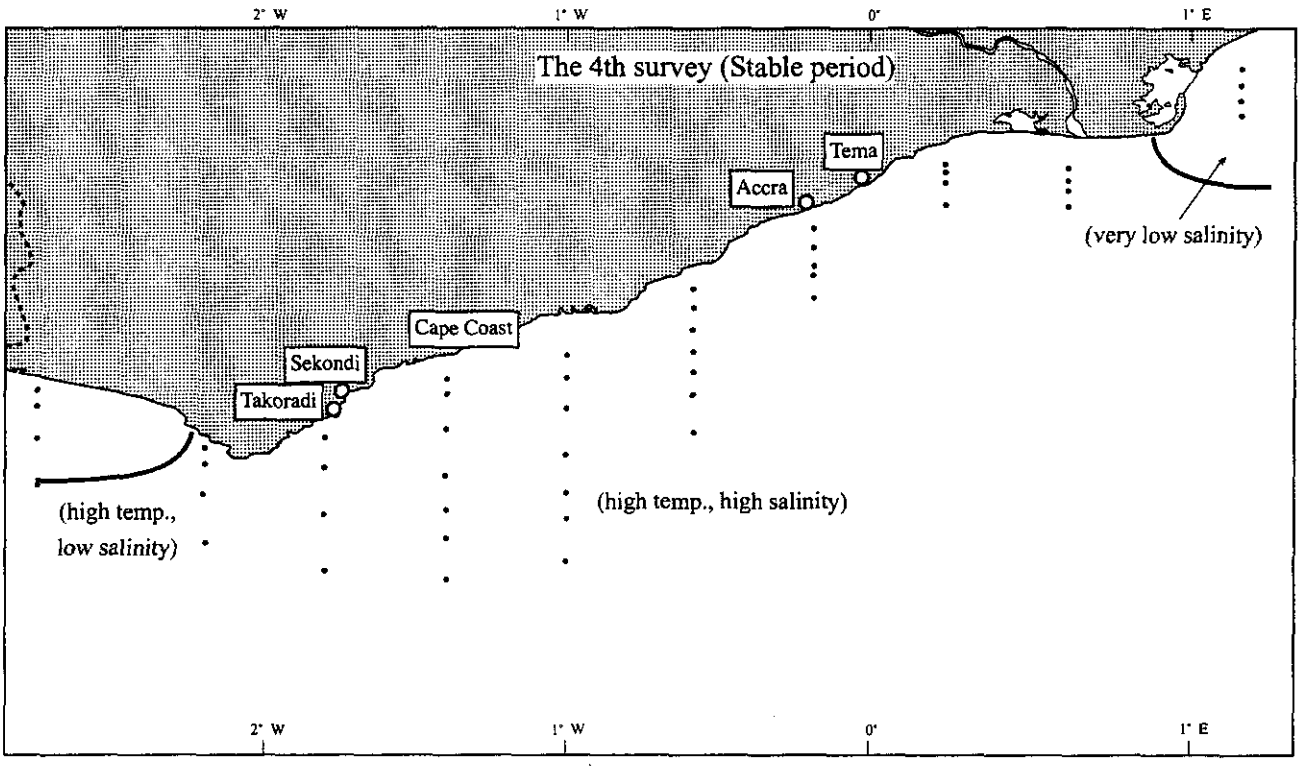


Figure 5-2-1-6 (1) Water mass structures in Ghanaian waters



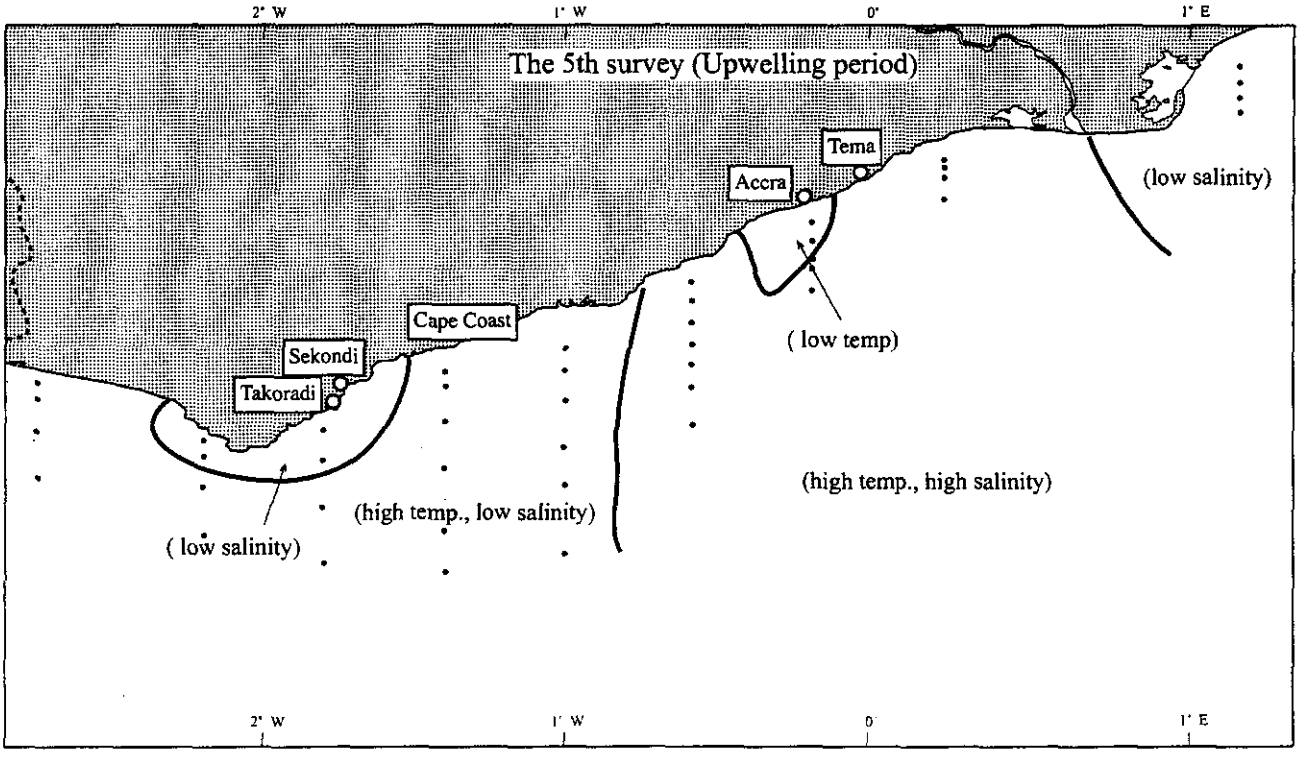


Figure 5-2-1-6 (2) Water mass structures in Ghanaian waters

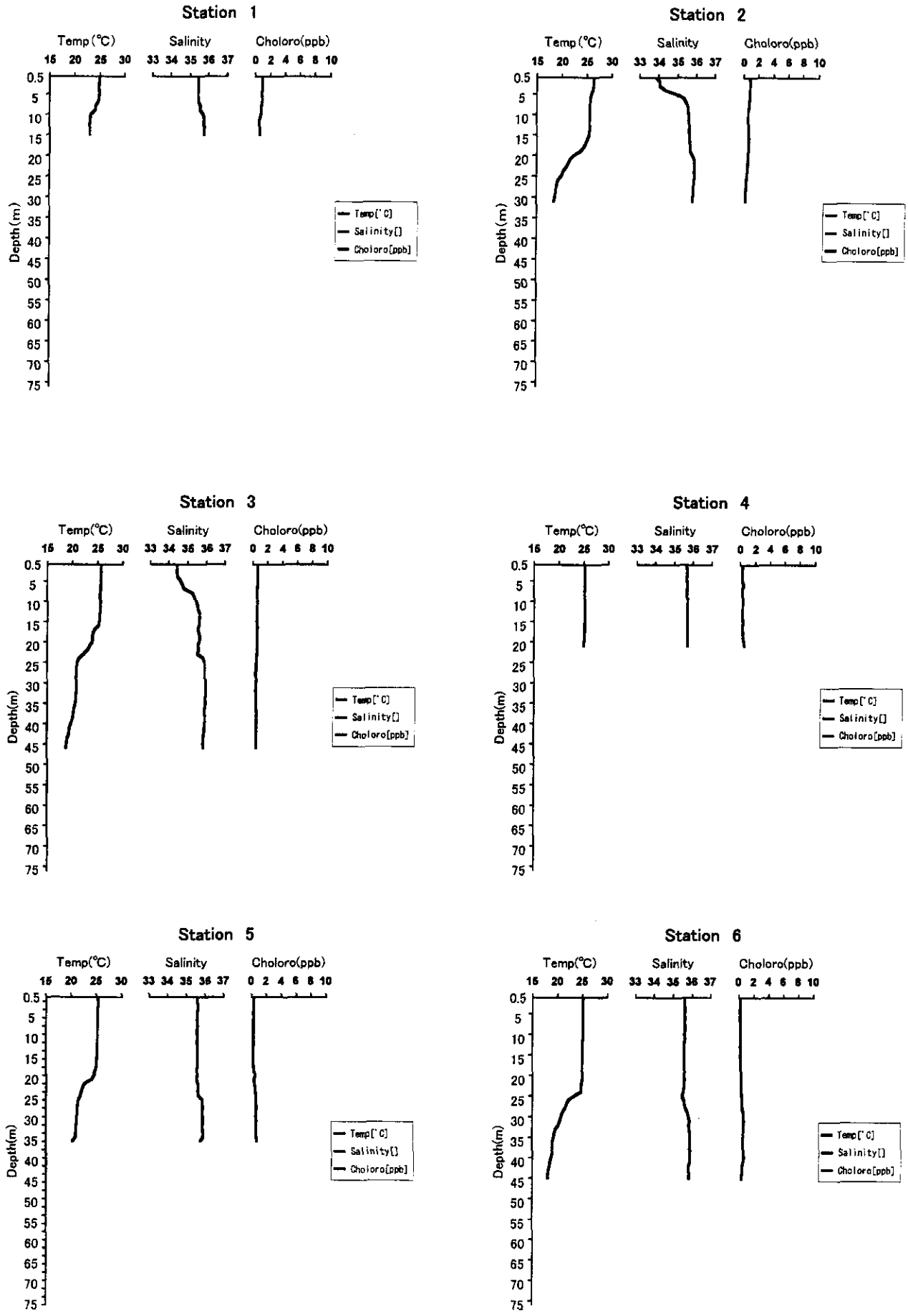


Figure 5-2-1-7 (1) Vertical profiles of water temperature, salinity and chlorophyll concentration (The 2nd survey)

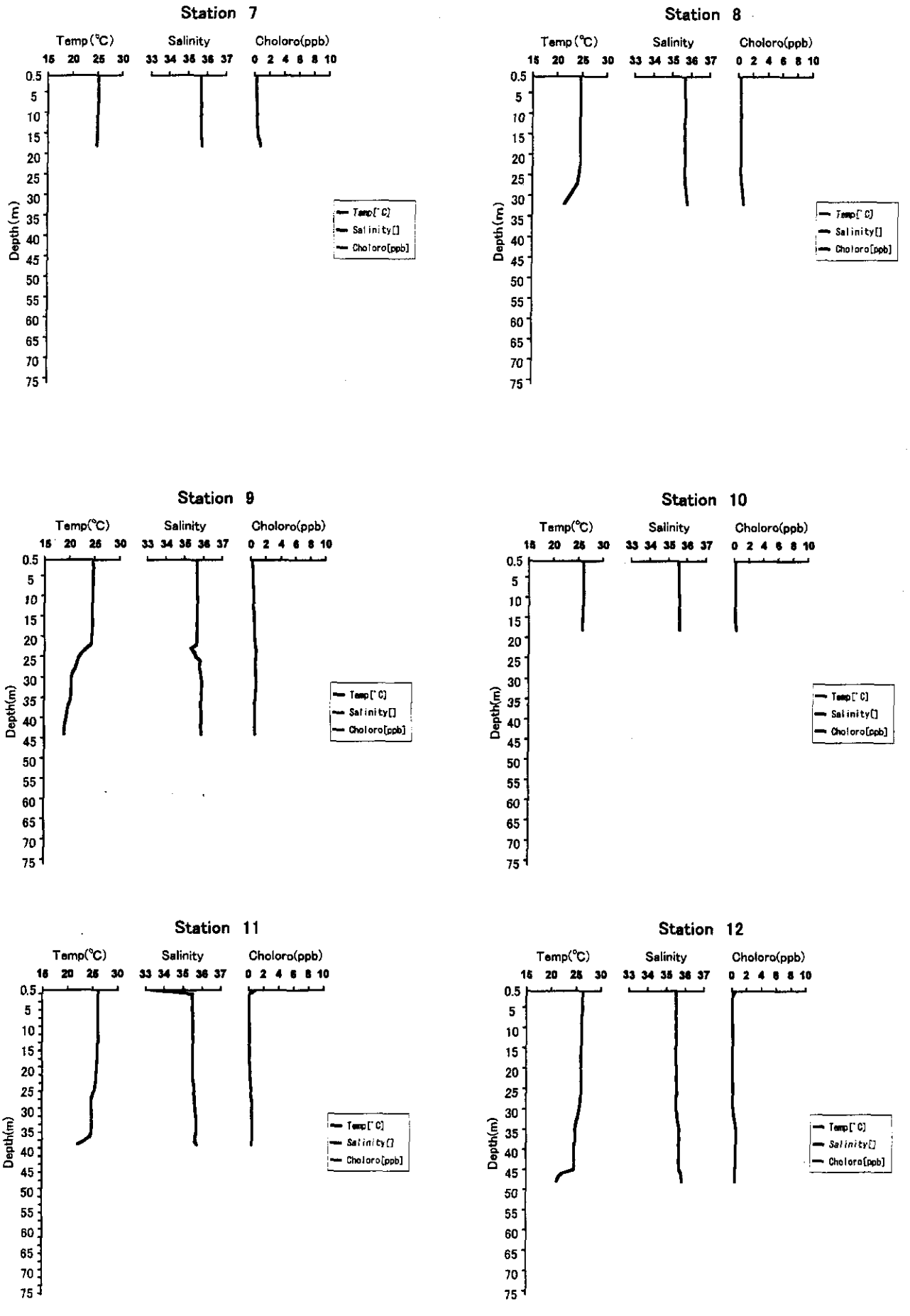
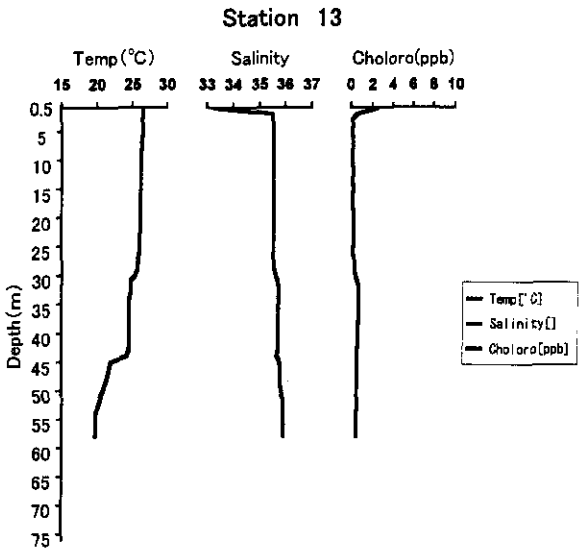
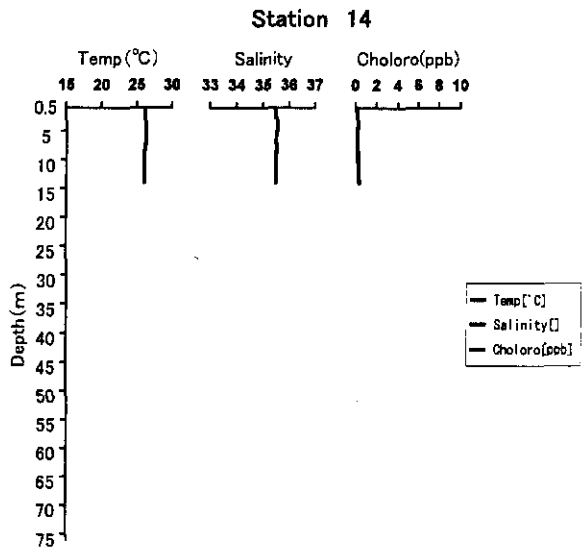
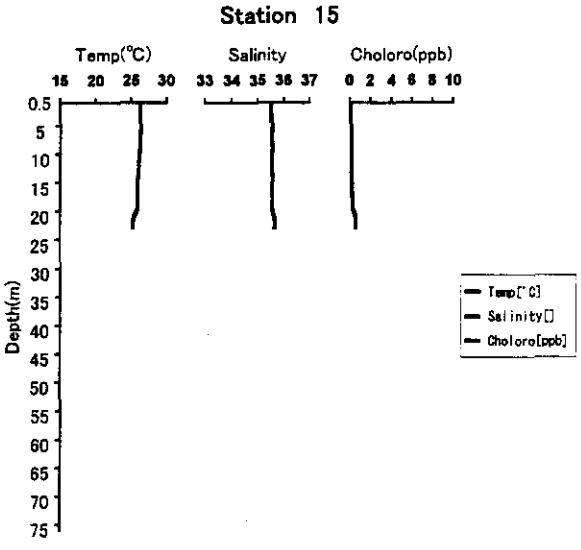
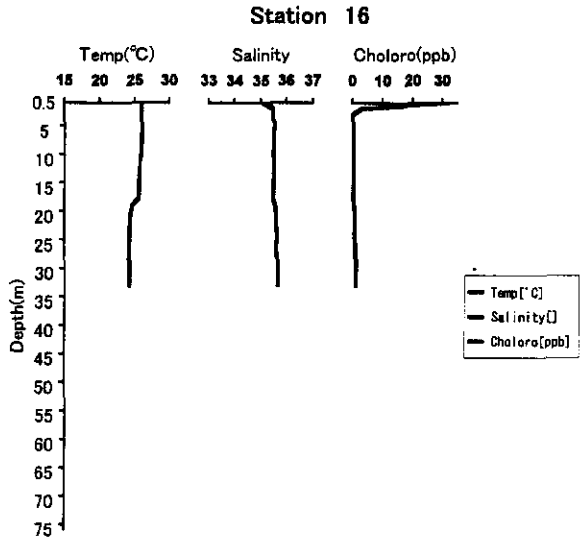


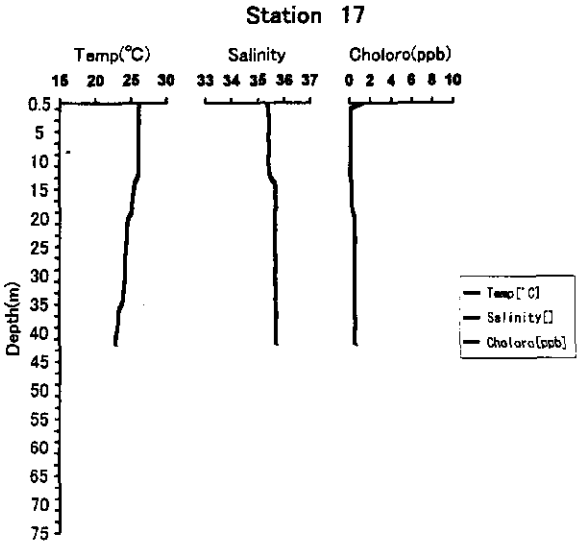
Figure 5-2-1-7 (2) Vertical profiles of water temperature, salinity and chlorophyll concentration (The 2nd survey)











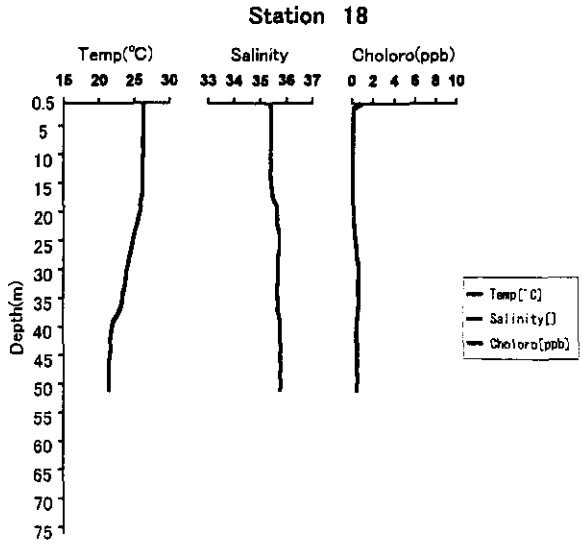


Figure 5-2-1-7 (3) Vertical profiles of water temperature, salinity and chlorophyll concentration (The 2nd survey)

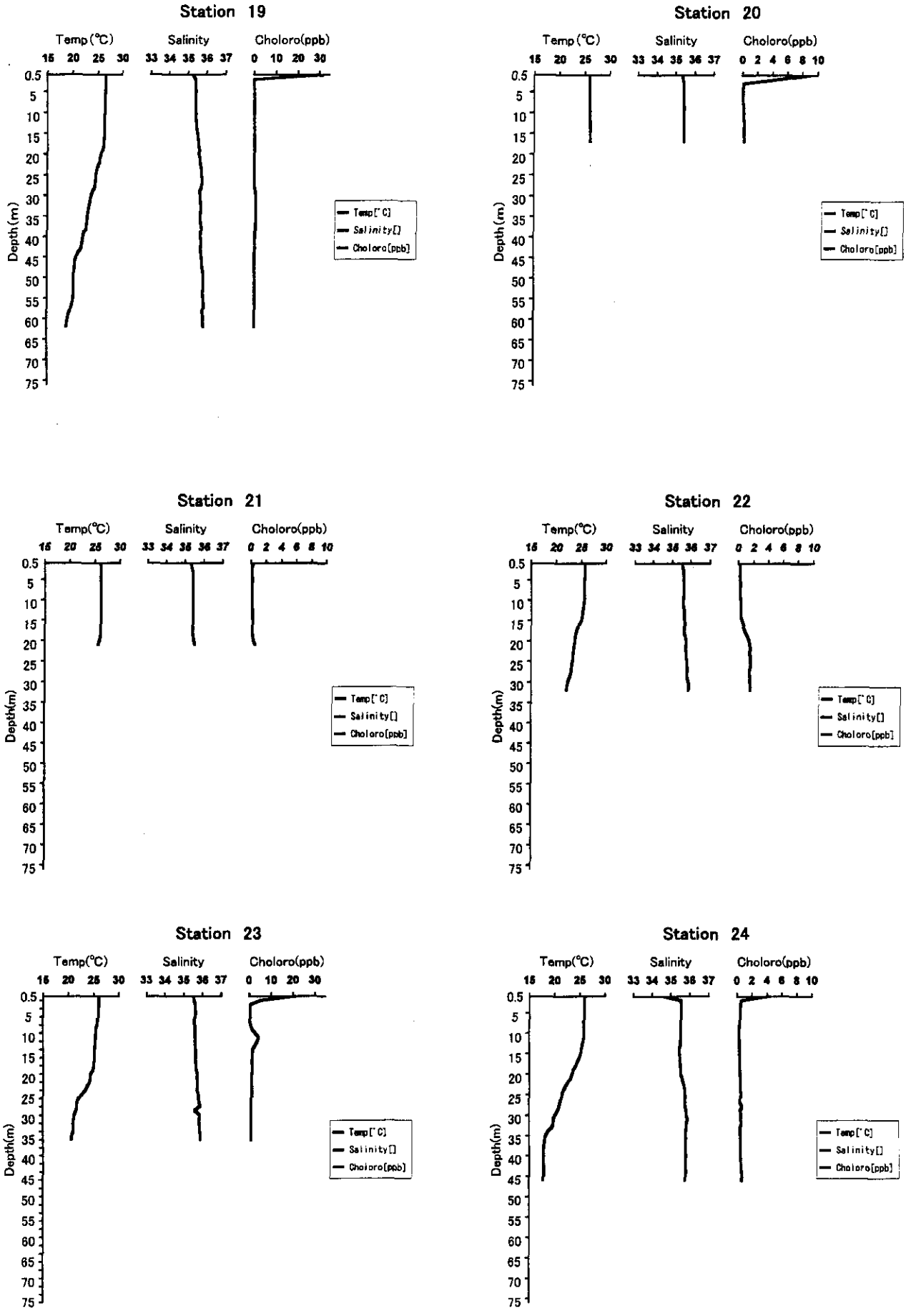


Figure 5-2-1-7 (4) Vertical profiles of water temperature, salinity and chlorophyll concentration (The 2nd survey)

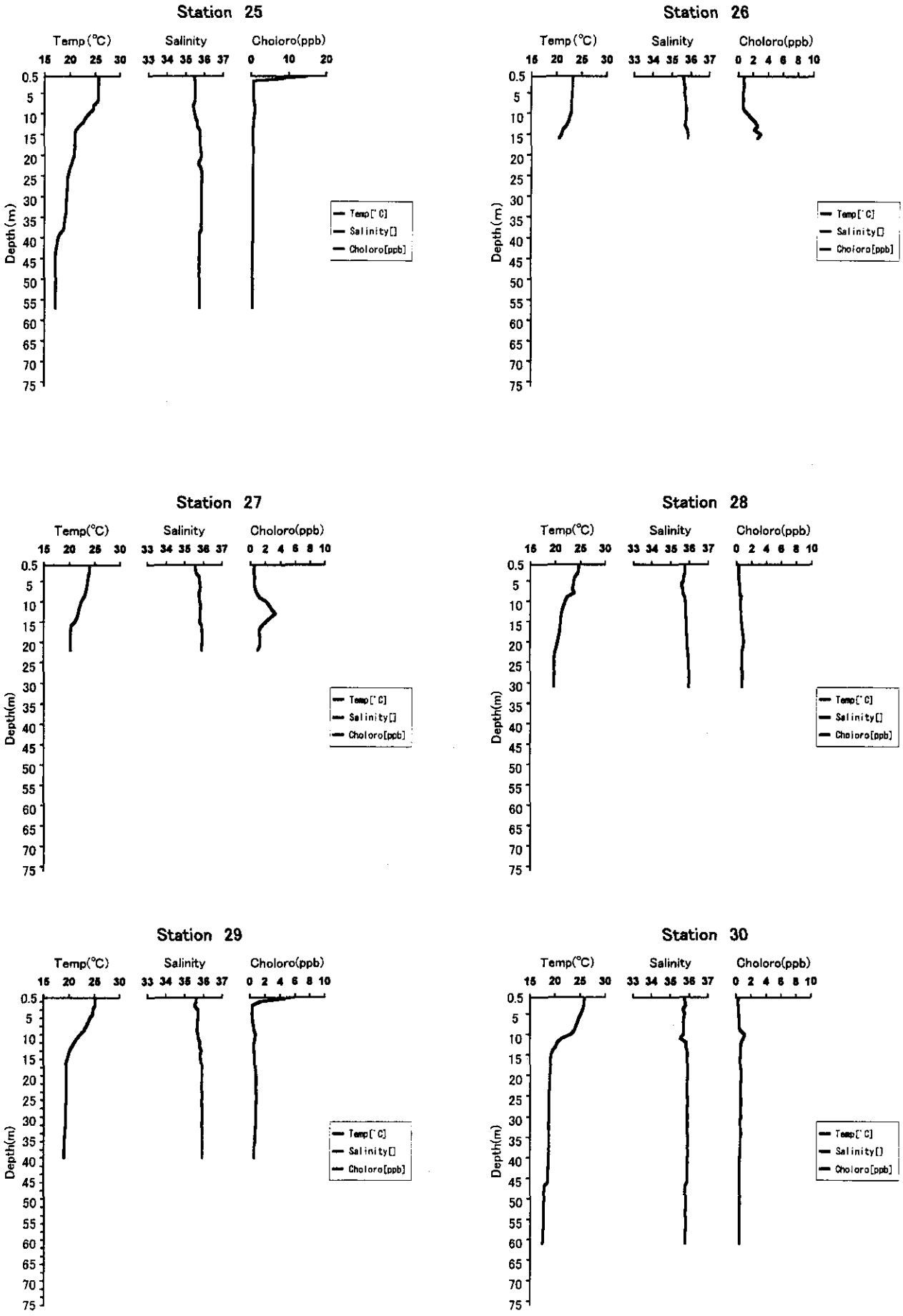


Figure 5-2-1-7 (5) Vertical profiles of water temperature, salinity and chlorophyll concentration (The 2nd survey)

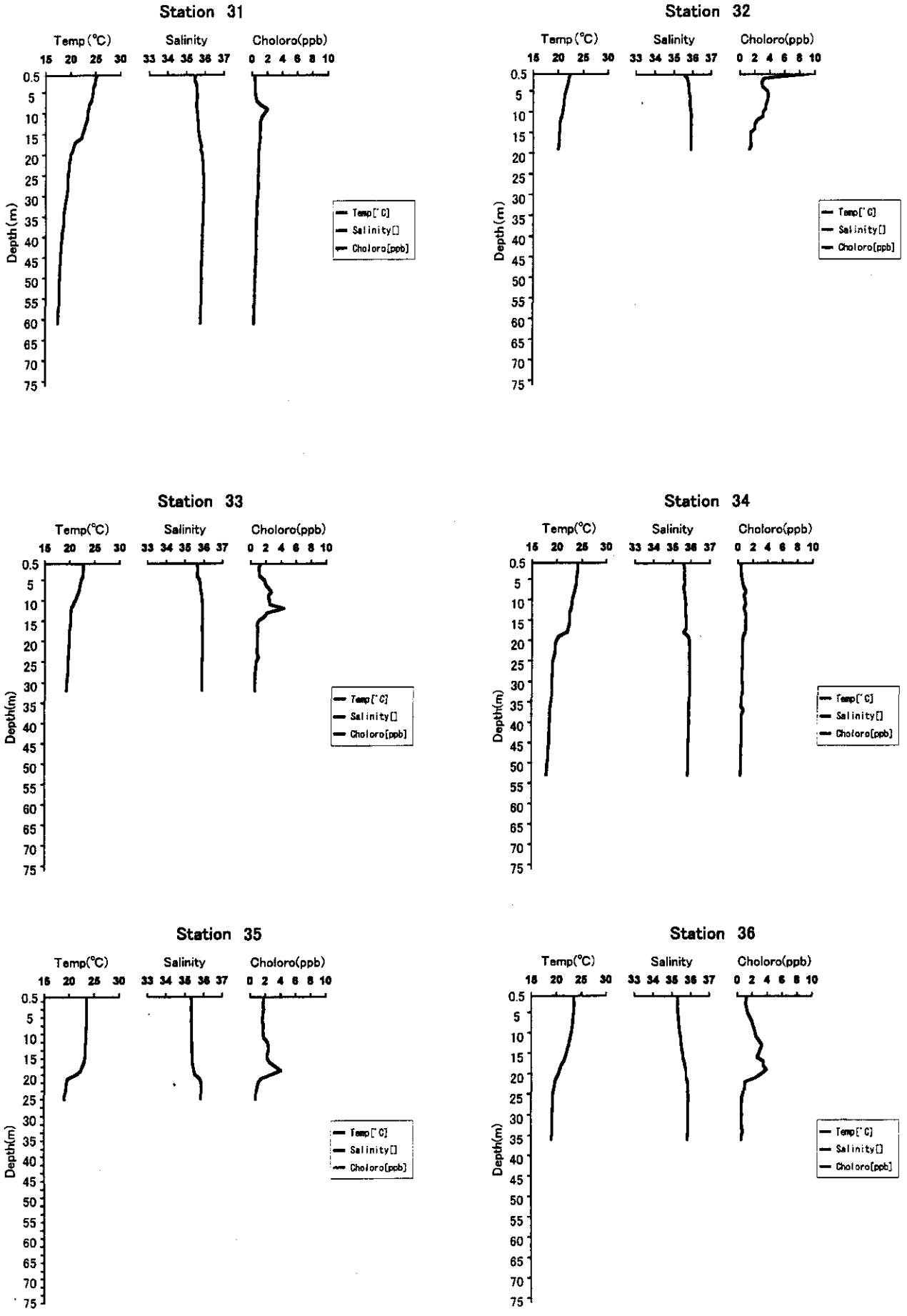


Figure 5-2-1-7 (6) Vertical profiles of water temperature, salinity and chlorophyll concentration (The 2nd survey)

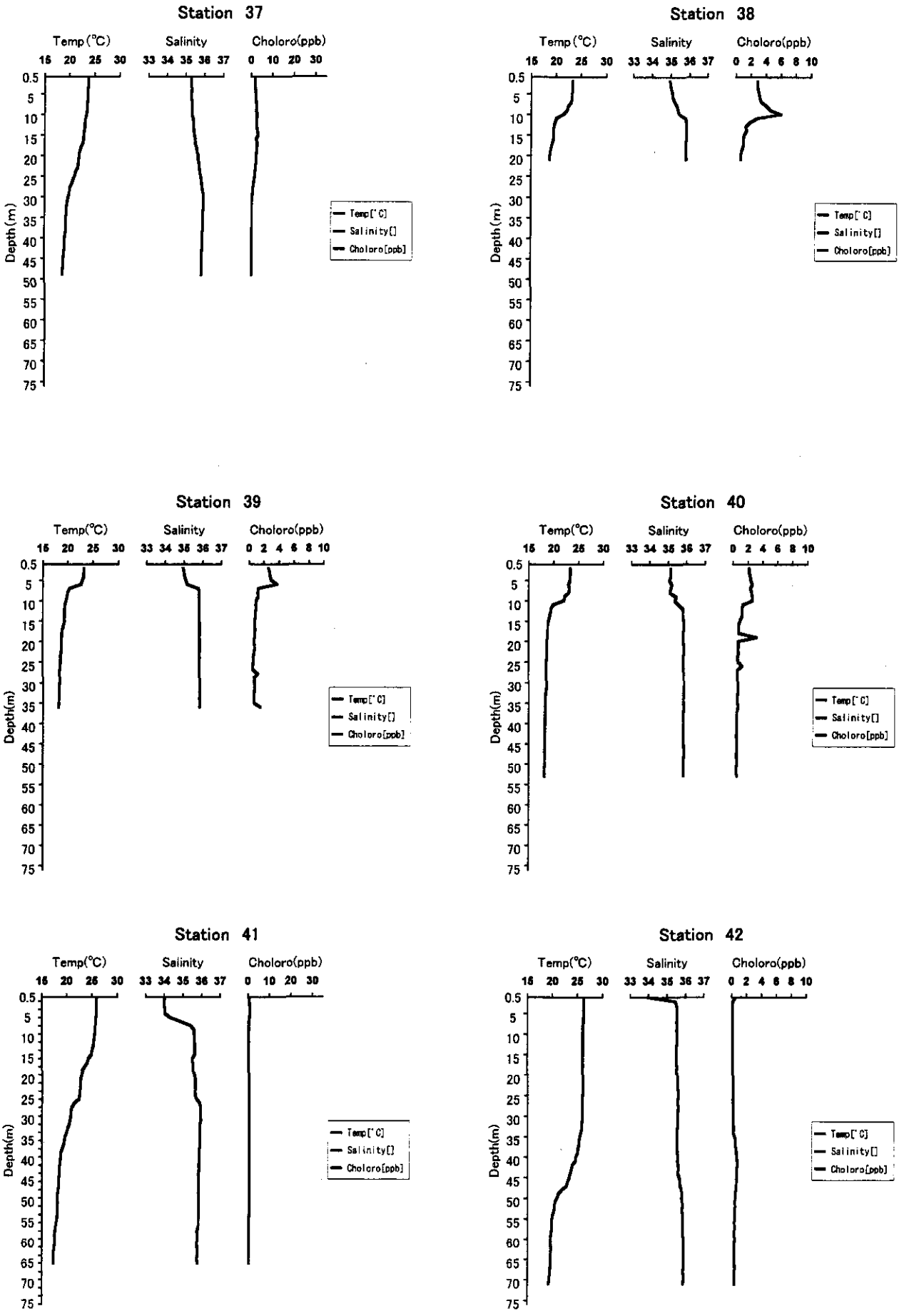


Figure 5-2-1-7 (7) Vertical profiles of water temperature, salinity and chlorophyll concentration (The 2nd survey)

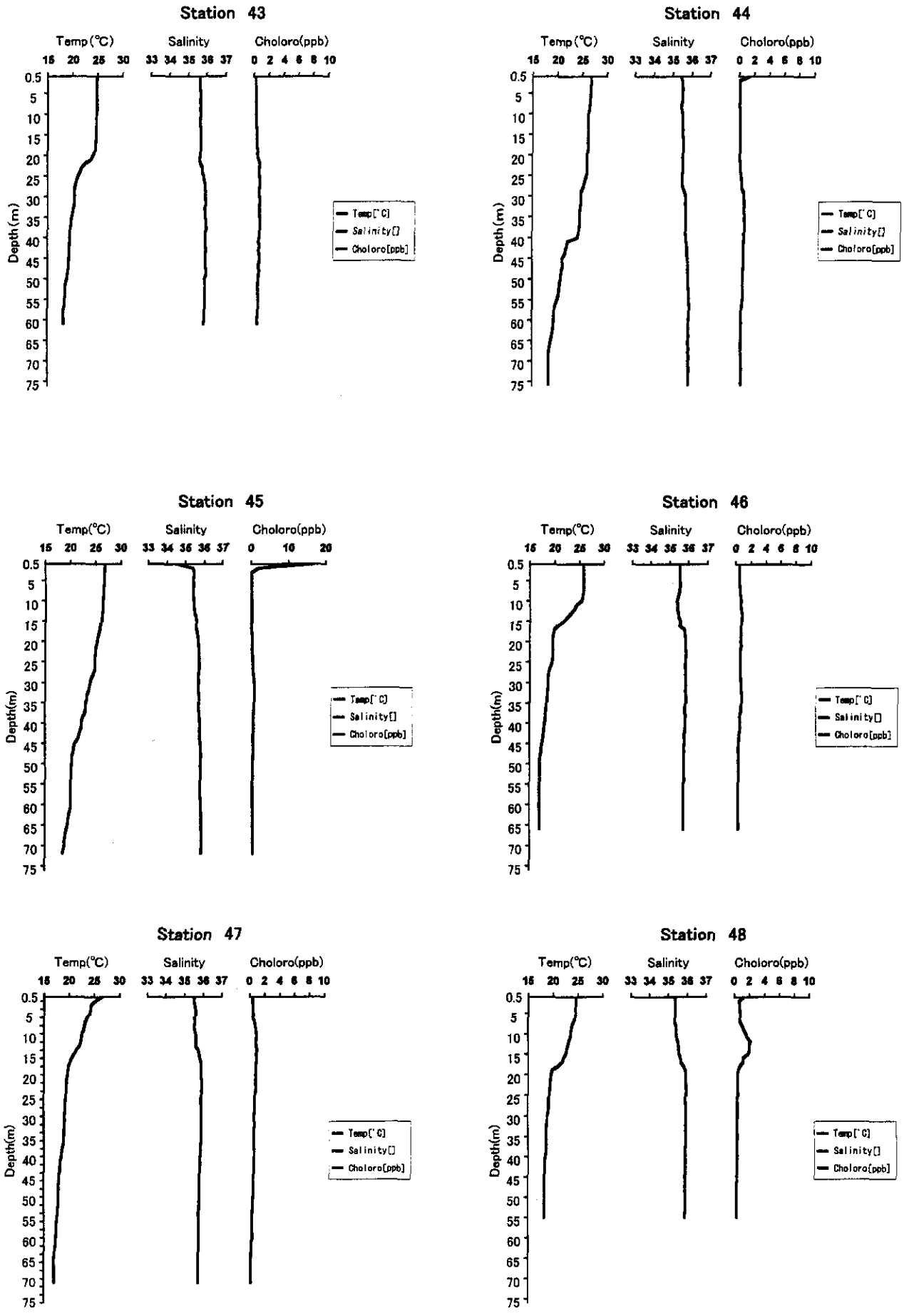


Figure 5-2-1-7 (8) Vertical profiles of water temperature, salinity and chlorophyll concentration (The 2nd survey)

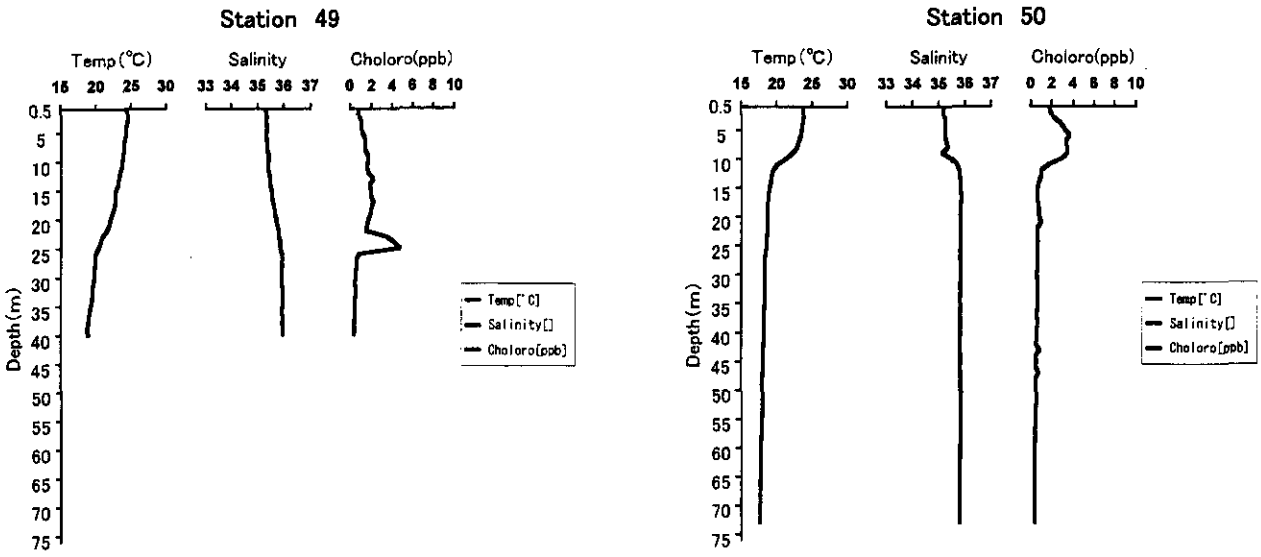


Figure 5-2-1-7 (9) Vertical profiles of water temperature, salinity and chlorophyll concentration (The 2nd survey)

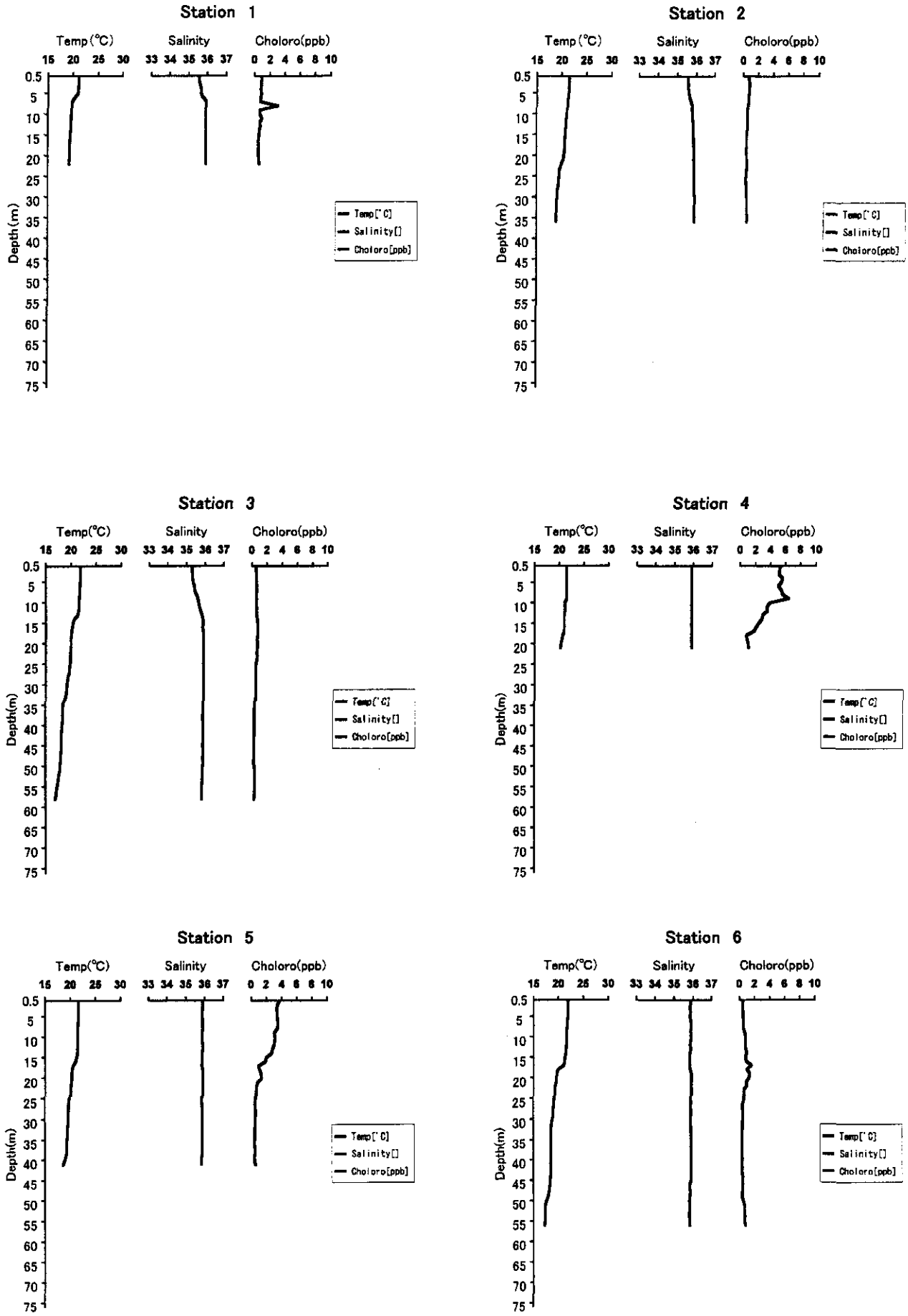


Figure 5-2-1-8 (1) Vertical profiles of water temperature, salinity and chlorophyll concentration (The 3rd survey)

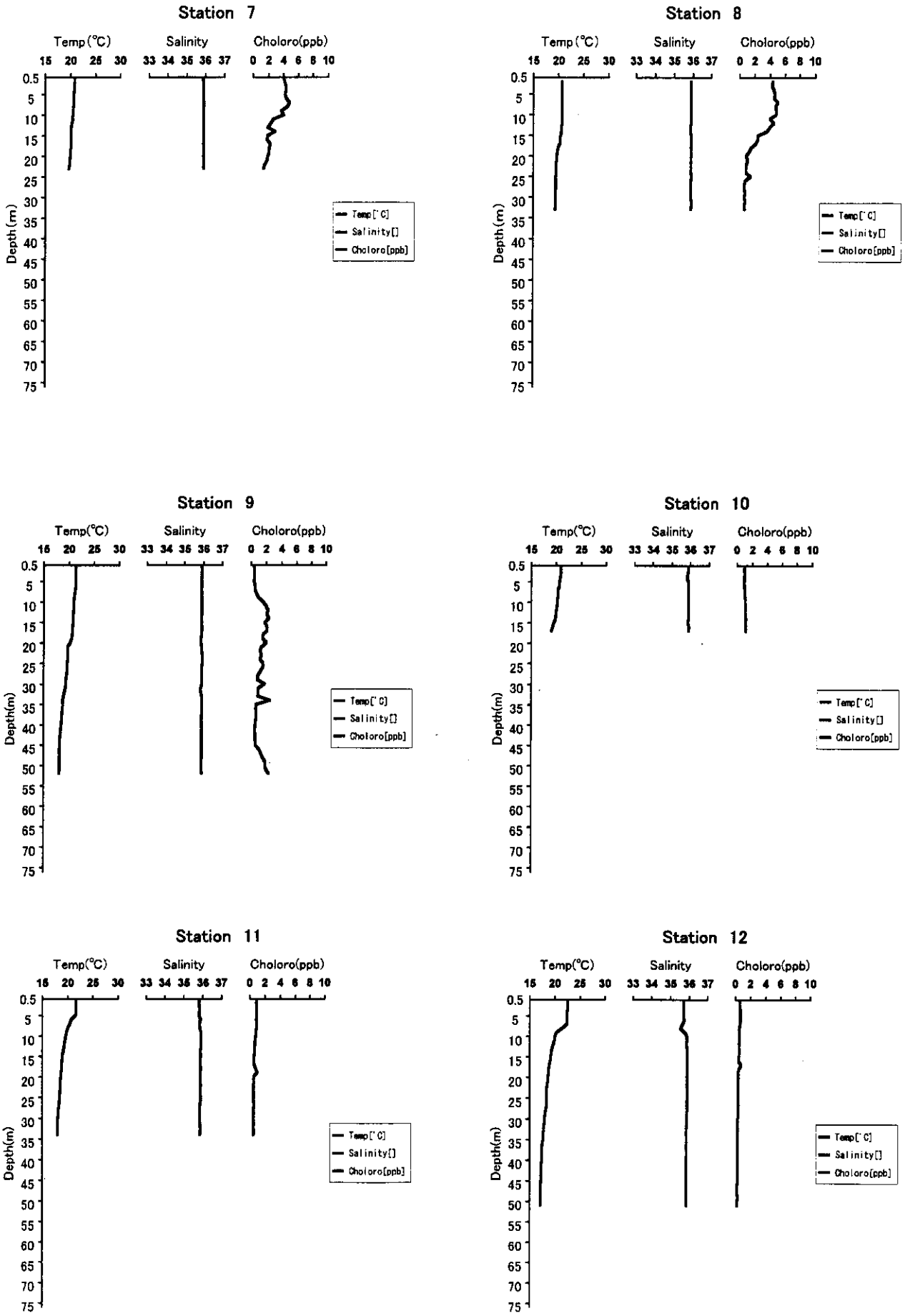


Figure 5-2-1-8 (2) Vertical profiles of water temperature, salinity and chlorophyll concentration (The 3rd survey)

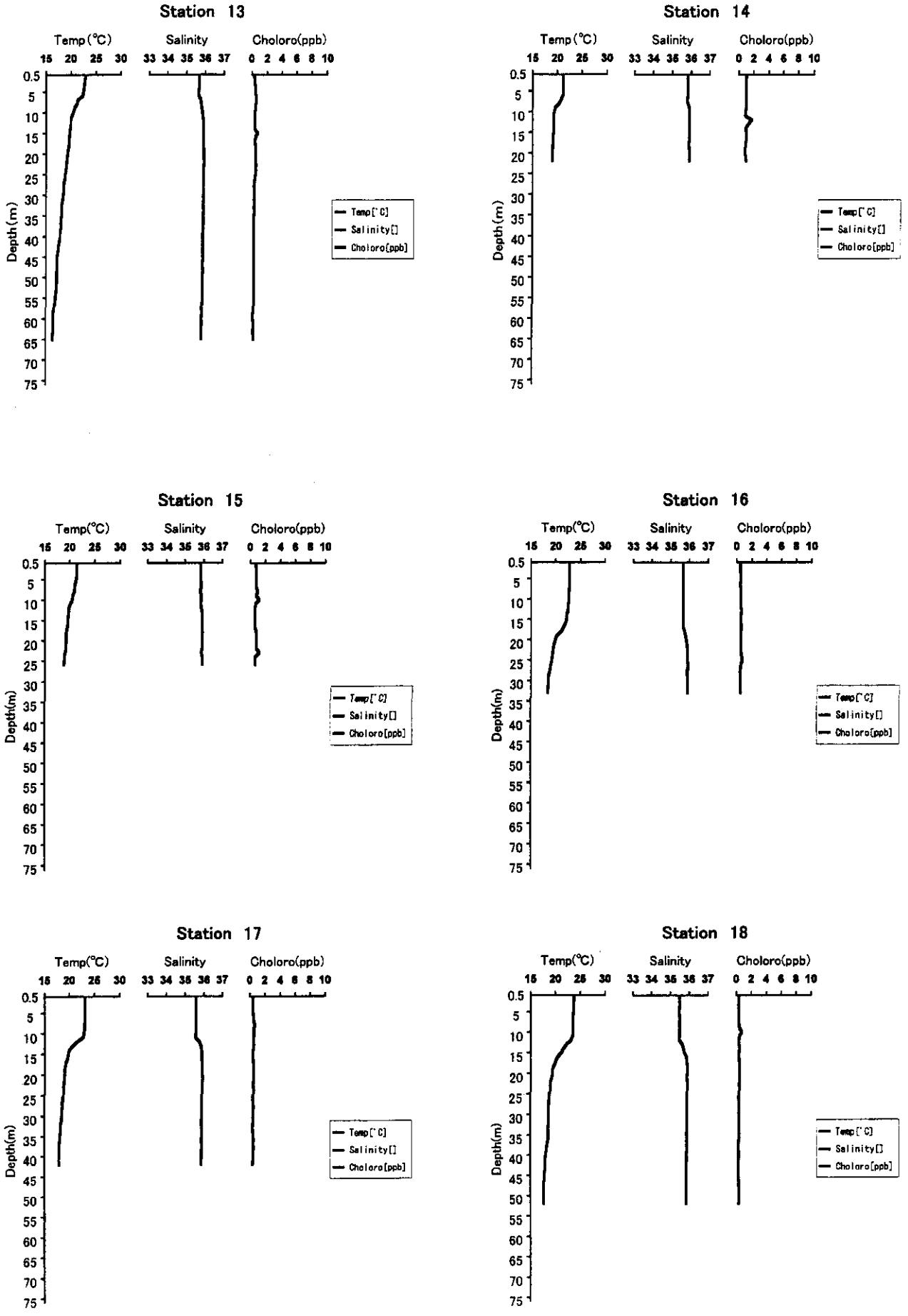


Figure 5-2-1-8 (3) Vertical profiles of water temperature, salinity and chlorophyll concentration (The 3rd survey)

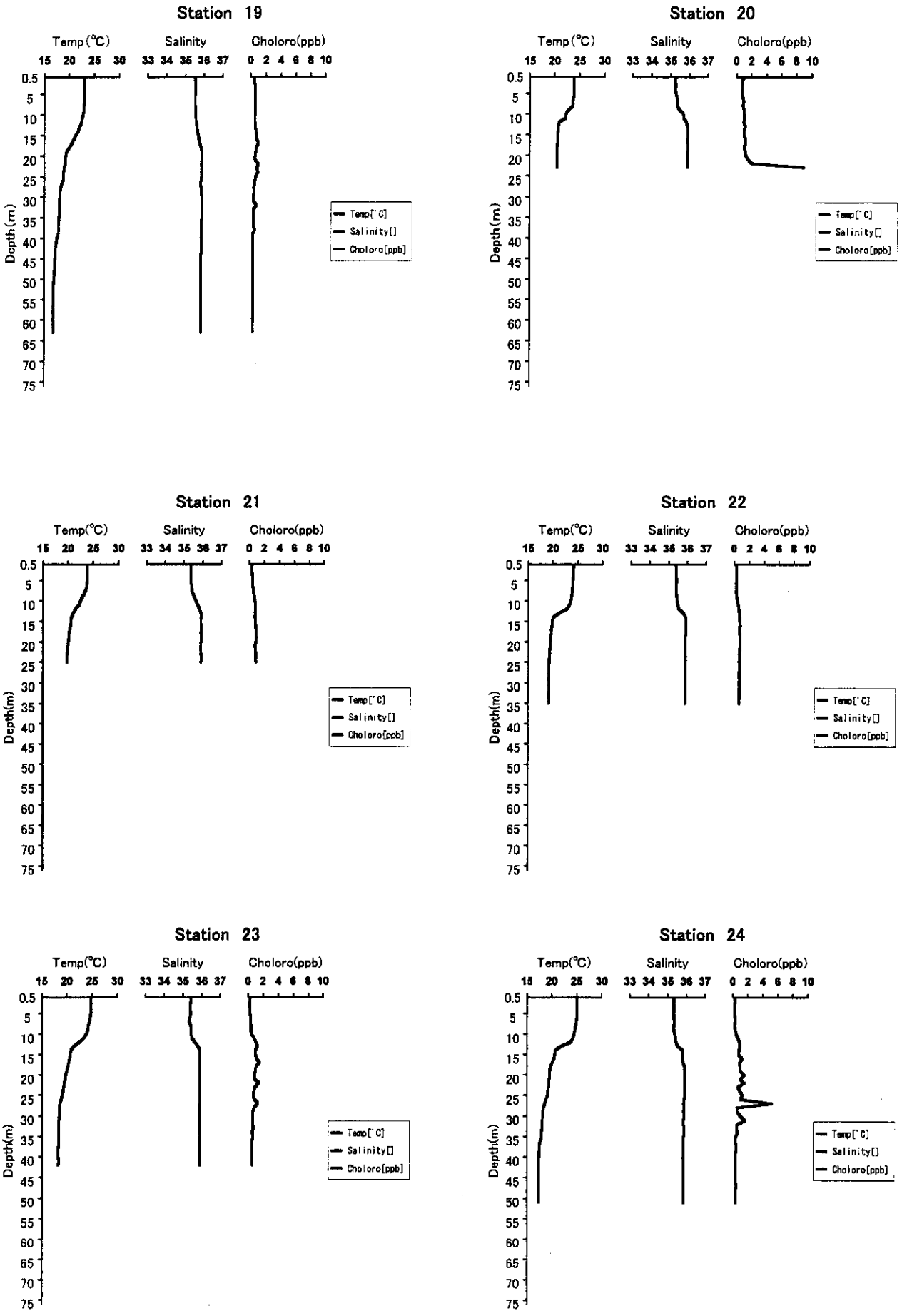


Figure 5-2-1-8 (4) Vertical profiles of water temperature, salinity and chlorophyll concentration (The 3rd survey)

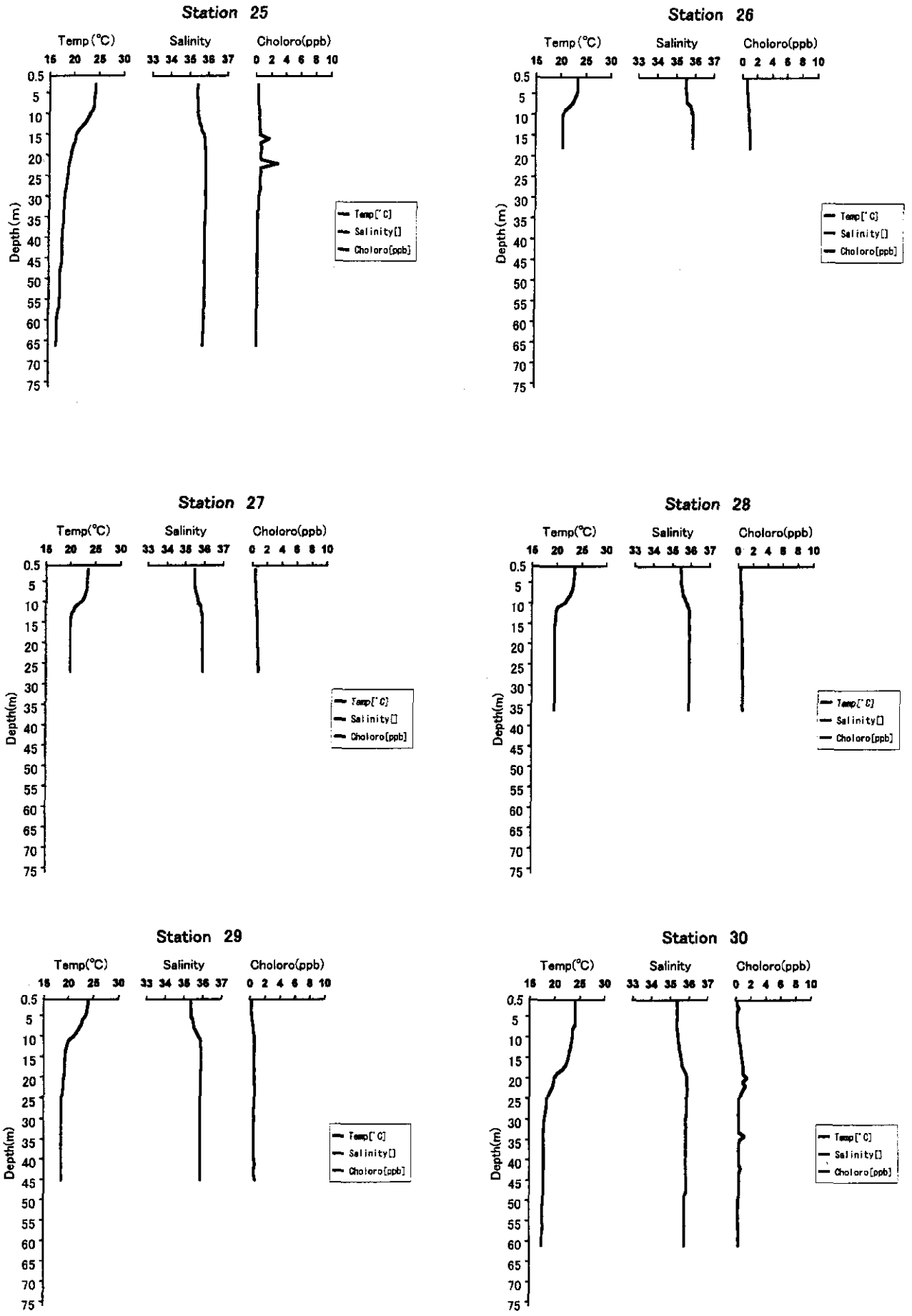


Figure 5-2-1-8 (5) Vertical profiles of water temperature, salinity and chlorophyll concentration (The 3rd survey)

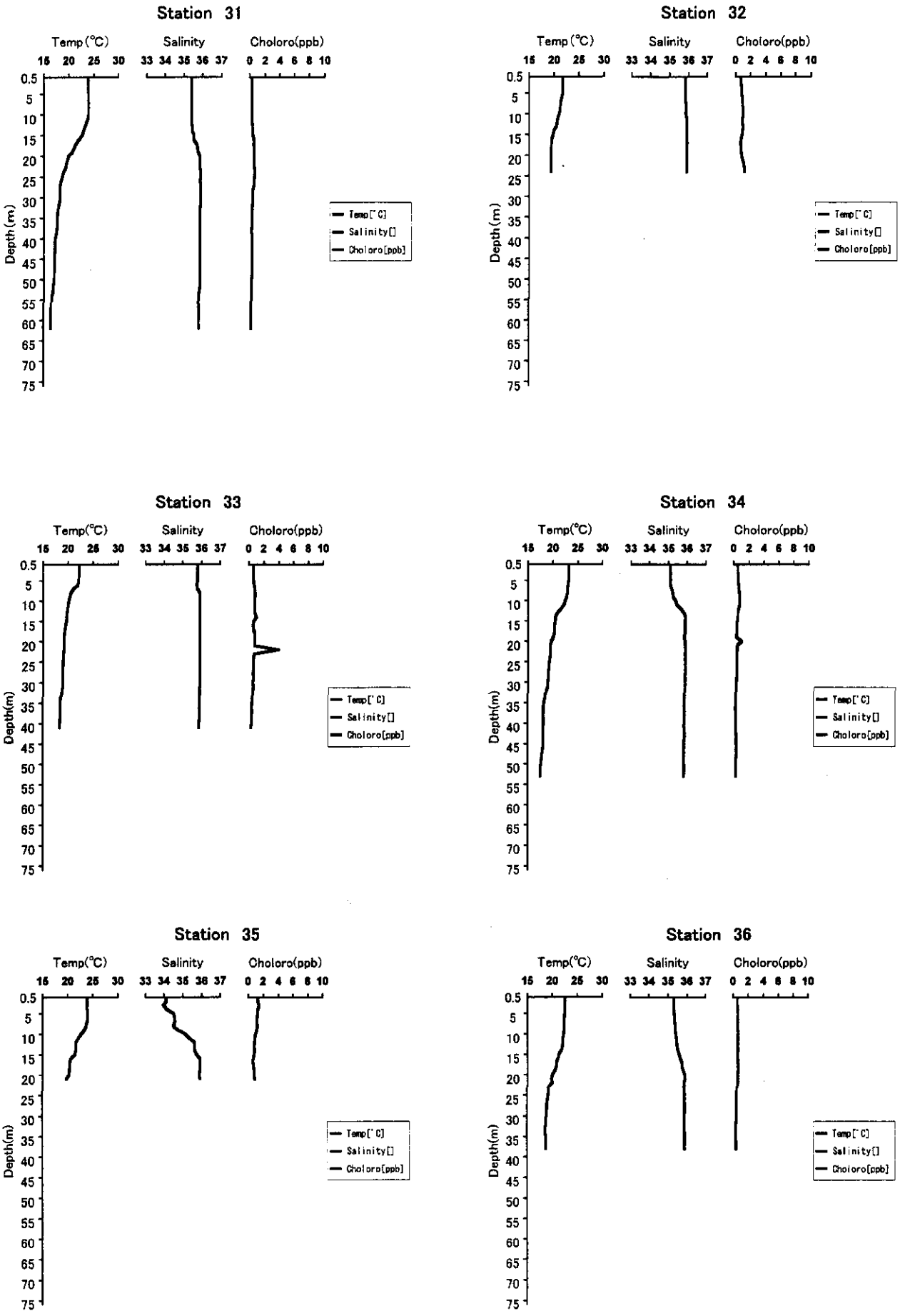


Figure 5-2-1-8 (6) Vertical profiles of water temperature, salinity and chlorophyll concentration (The 3rd survey)

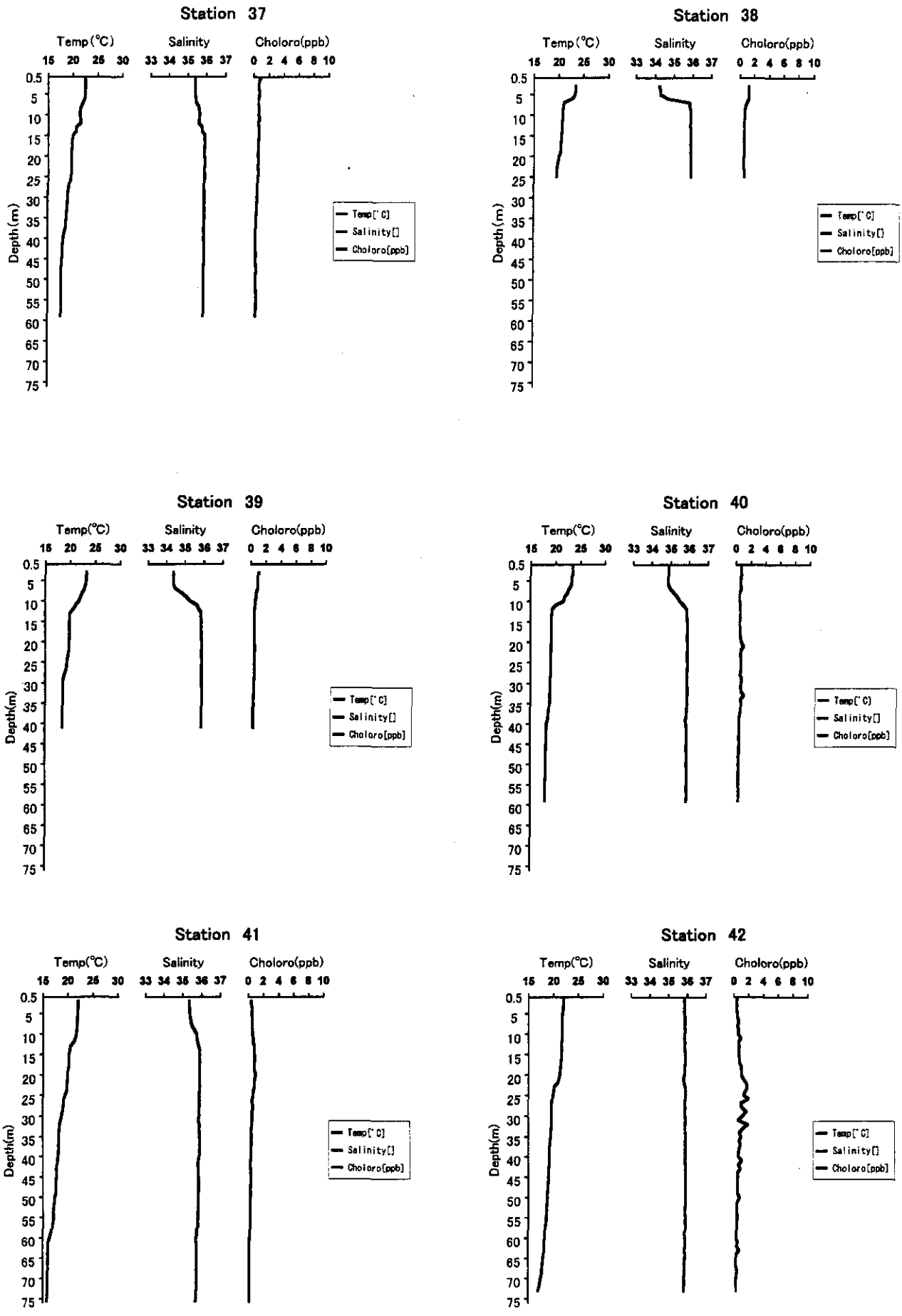


Figure 5-2-1-8 (7) Vertical profiles of water temperature, salinity and chlorophyll concentration (The 3rd survey)

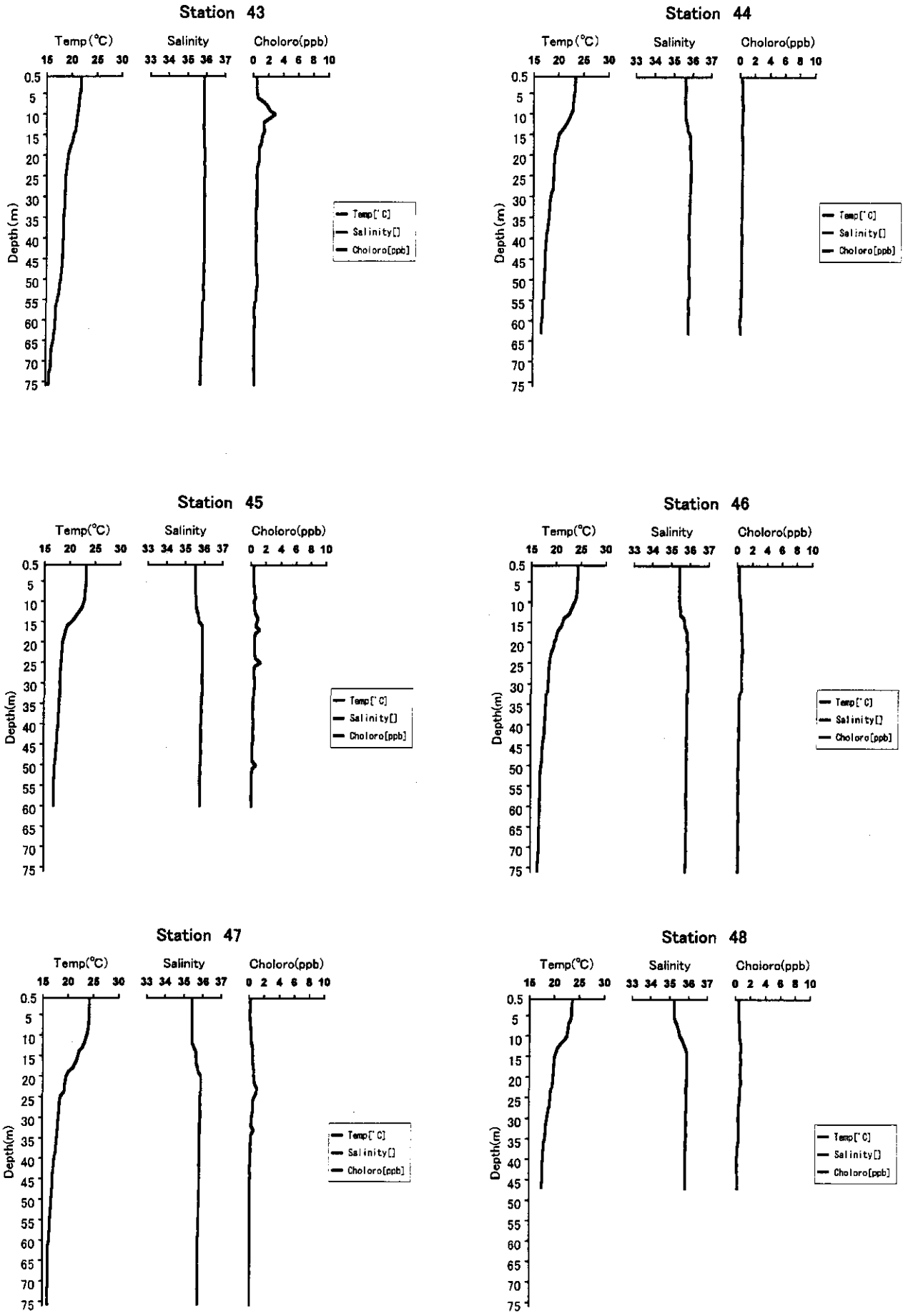


Figure 5-2-1-8 (8) Vertical profiles of water temperature, salinity and chlorophyll concentration (The 3rd survey)

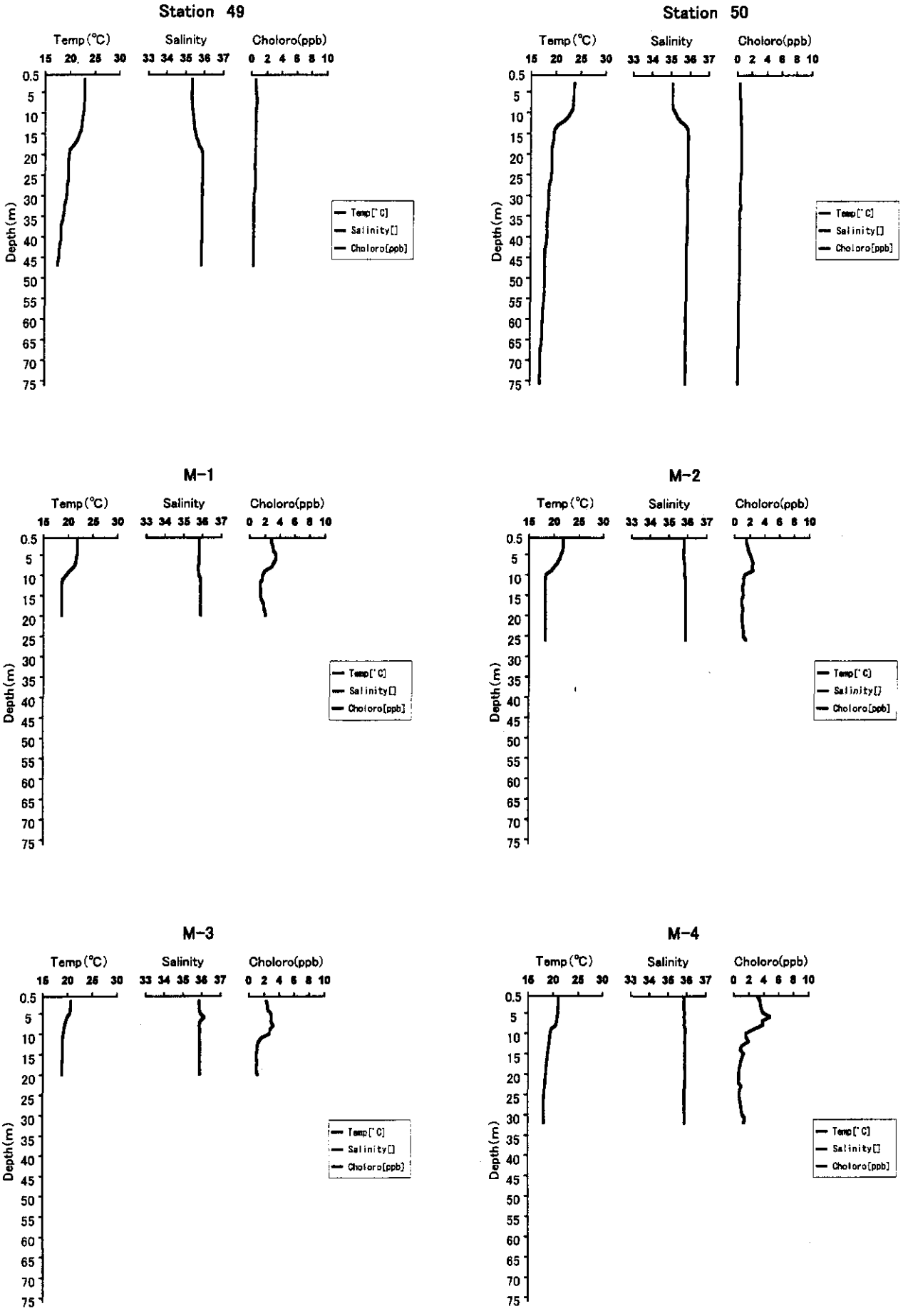


Figure 5-2-1-8 (9) Vertical profiles of water temperature, salinity and chlorophyll concentration (The 3rd survey)

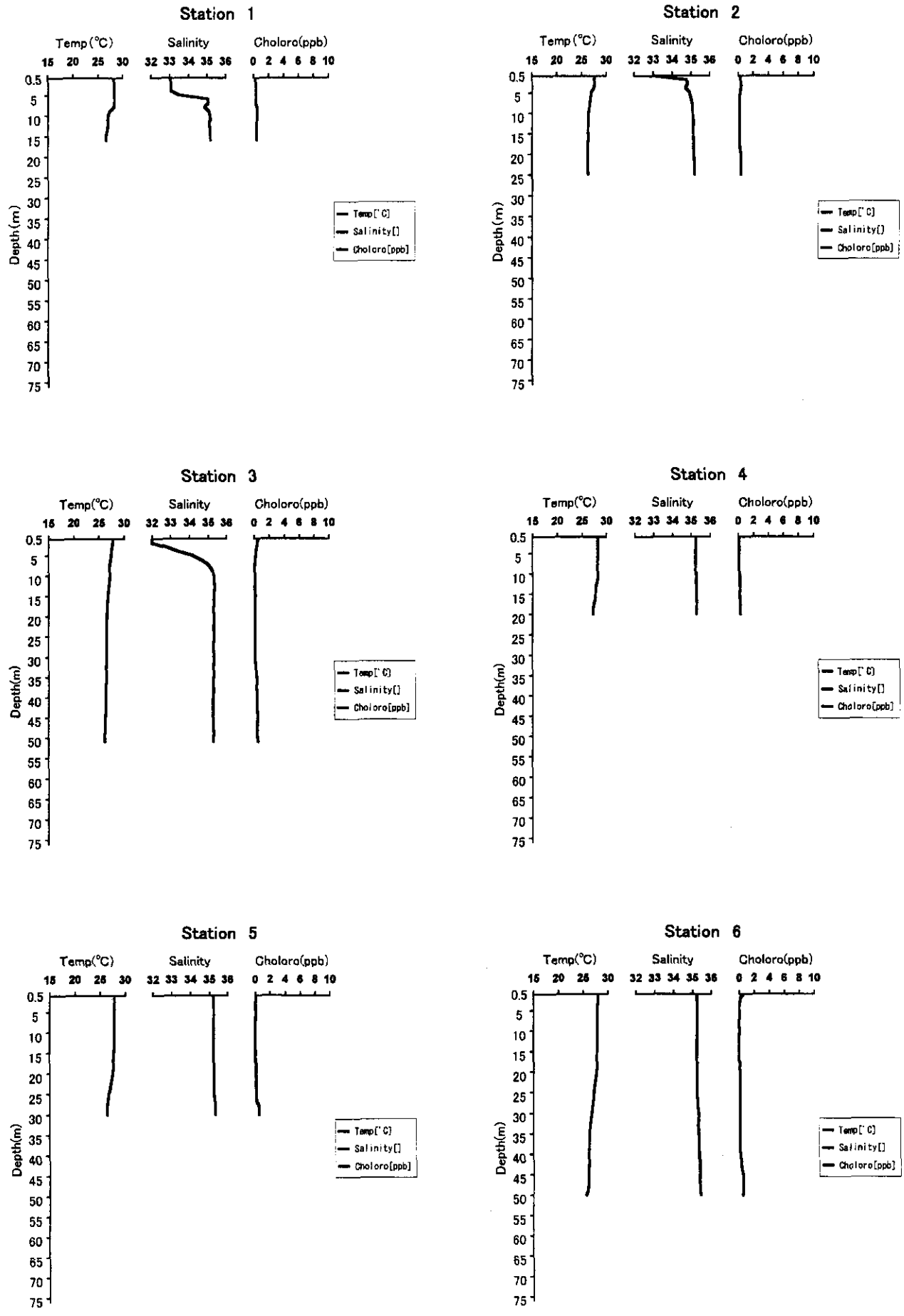


Figure 5-2-1-9 (1) Vertical profiles of water temperature, salinity and chlorophyll concentration (The 4th survey)

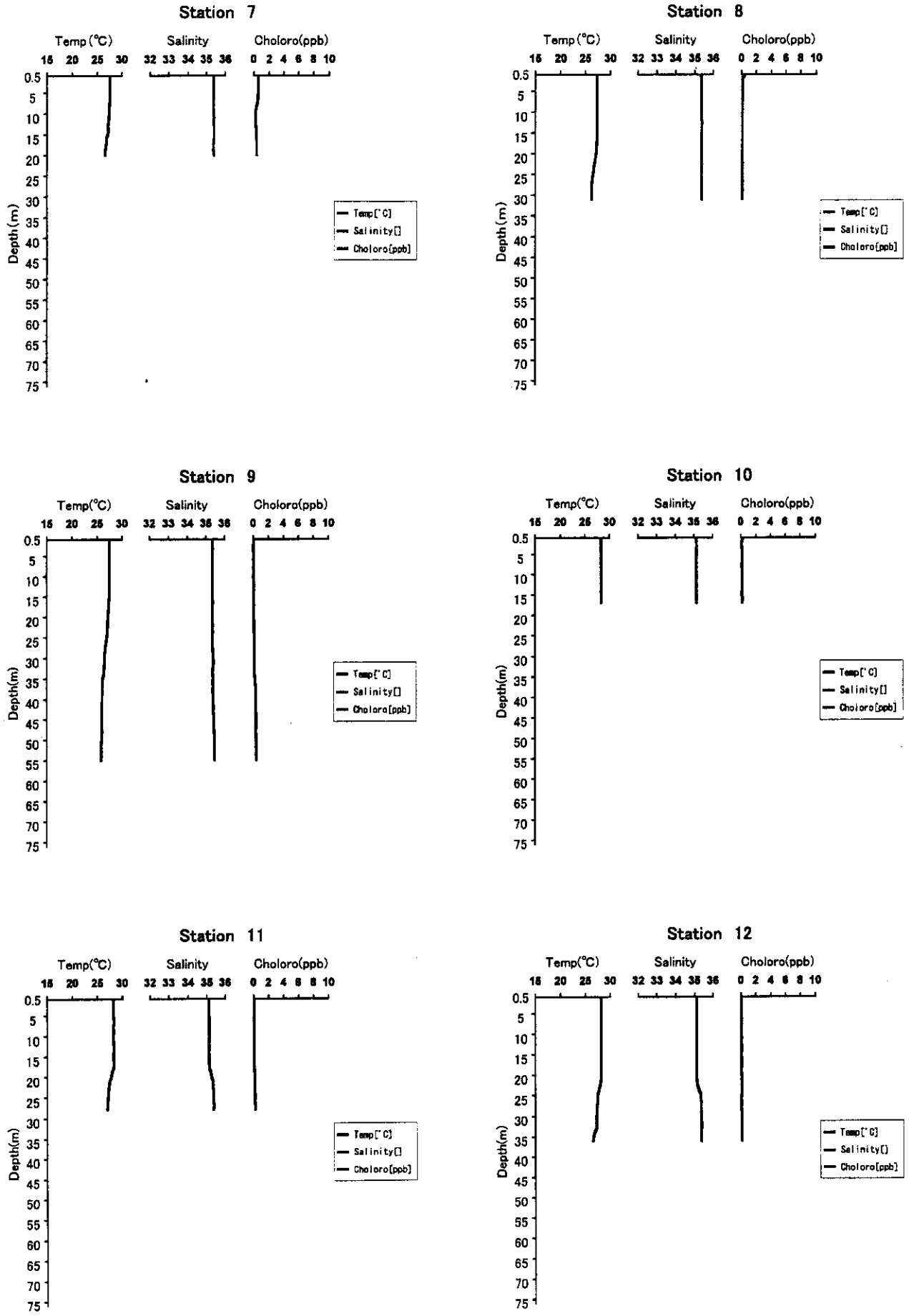


Figure 5-2-1-9 (2) Vertical profiles of water temperature, salinity and chlorophyll concentration (The 4th survey)

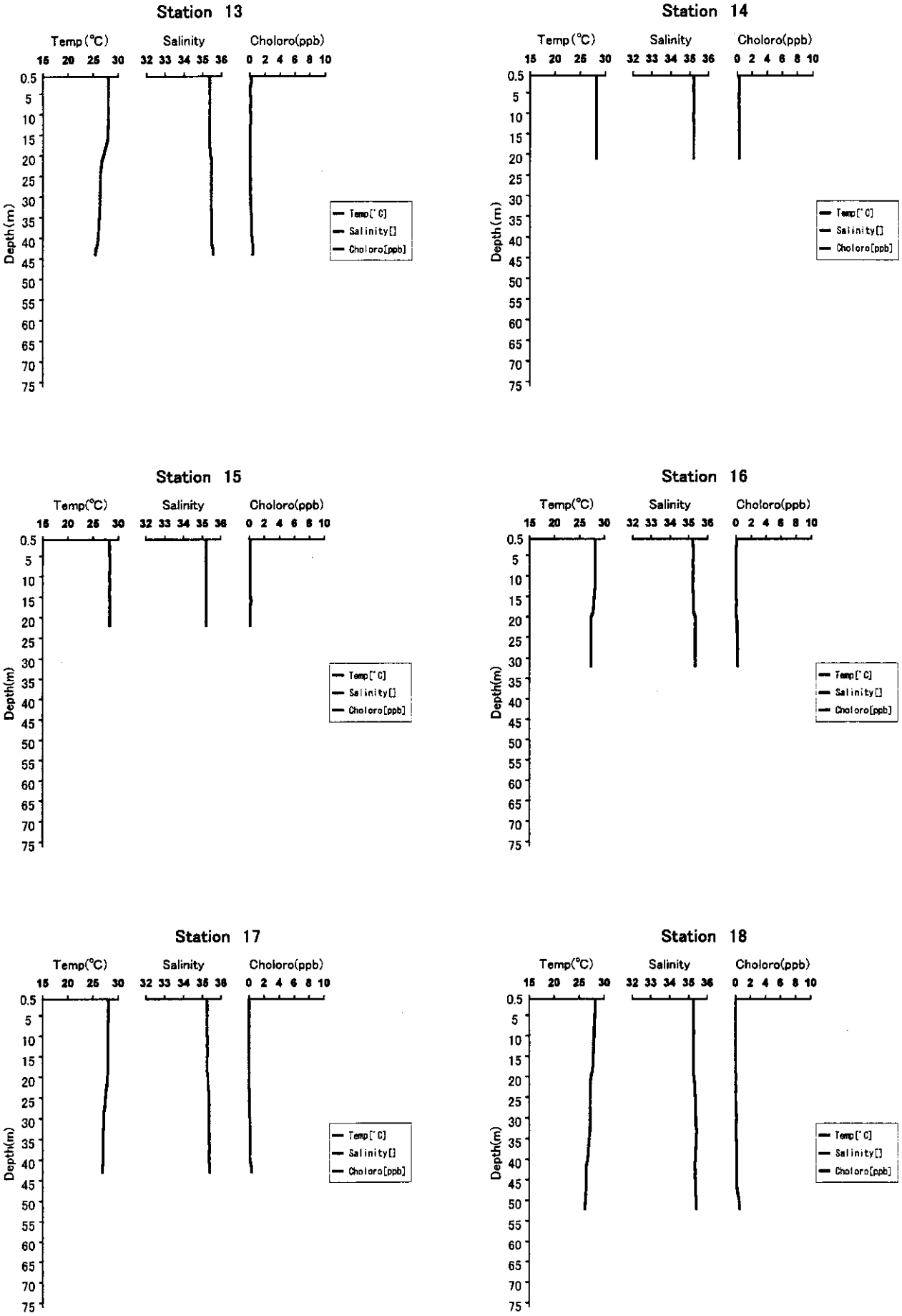


Figure 5-2-1-9 (3) Vertical profiles of water temperature, salinity and chlorophyll concentration (The 4th survey)

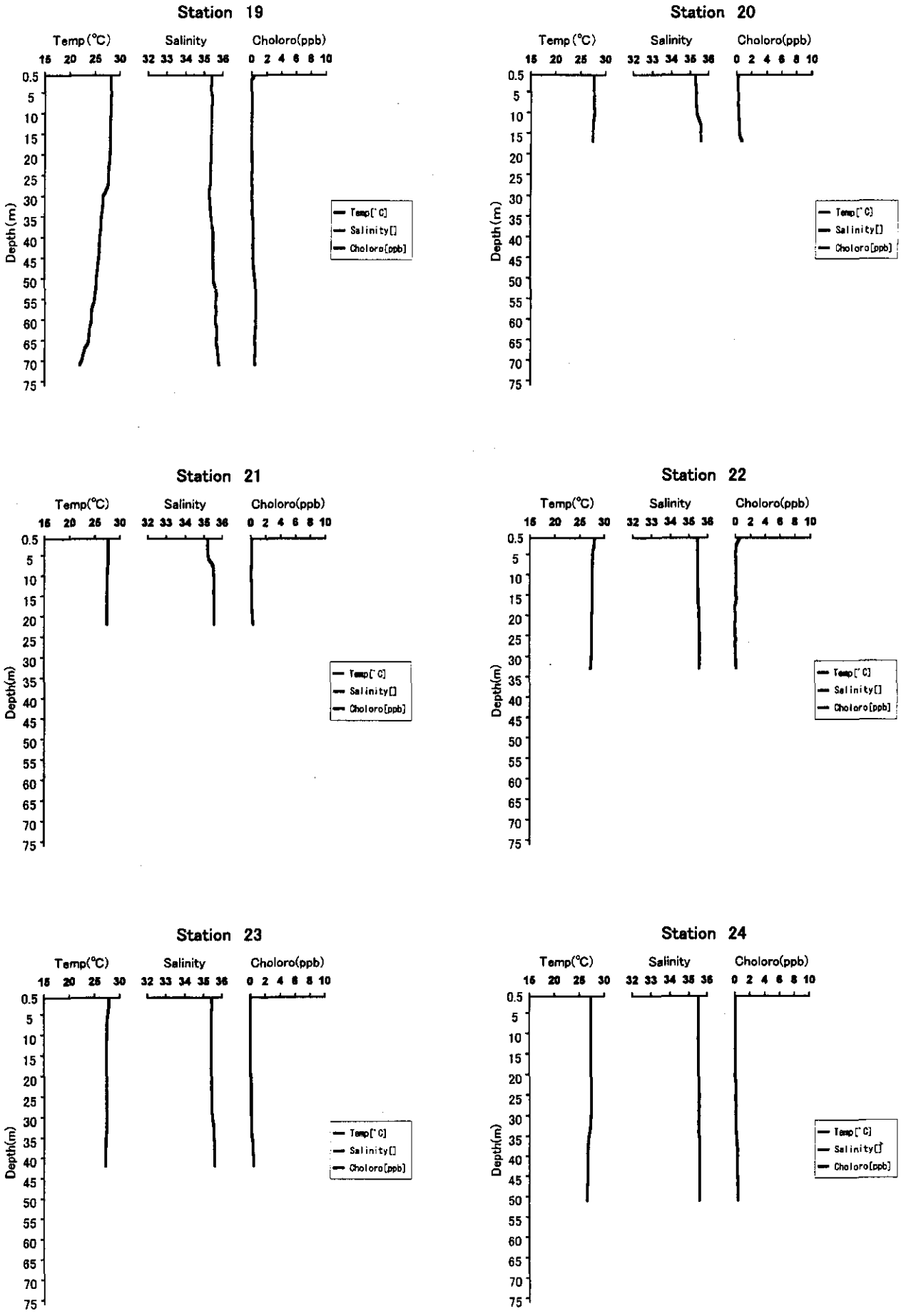


Figure 5-2-1-9 (4) Vertical profiles of water temperature, salinity and chlorophyll concentration (The 4th survey)

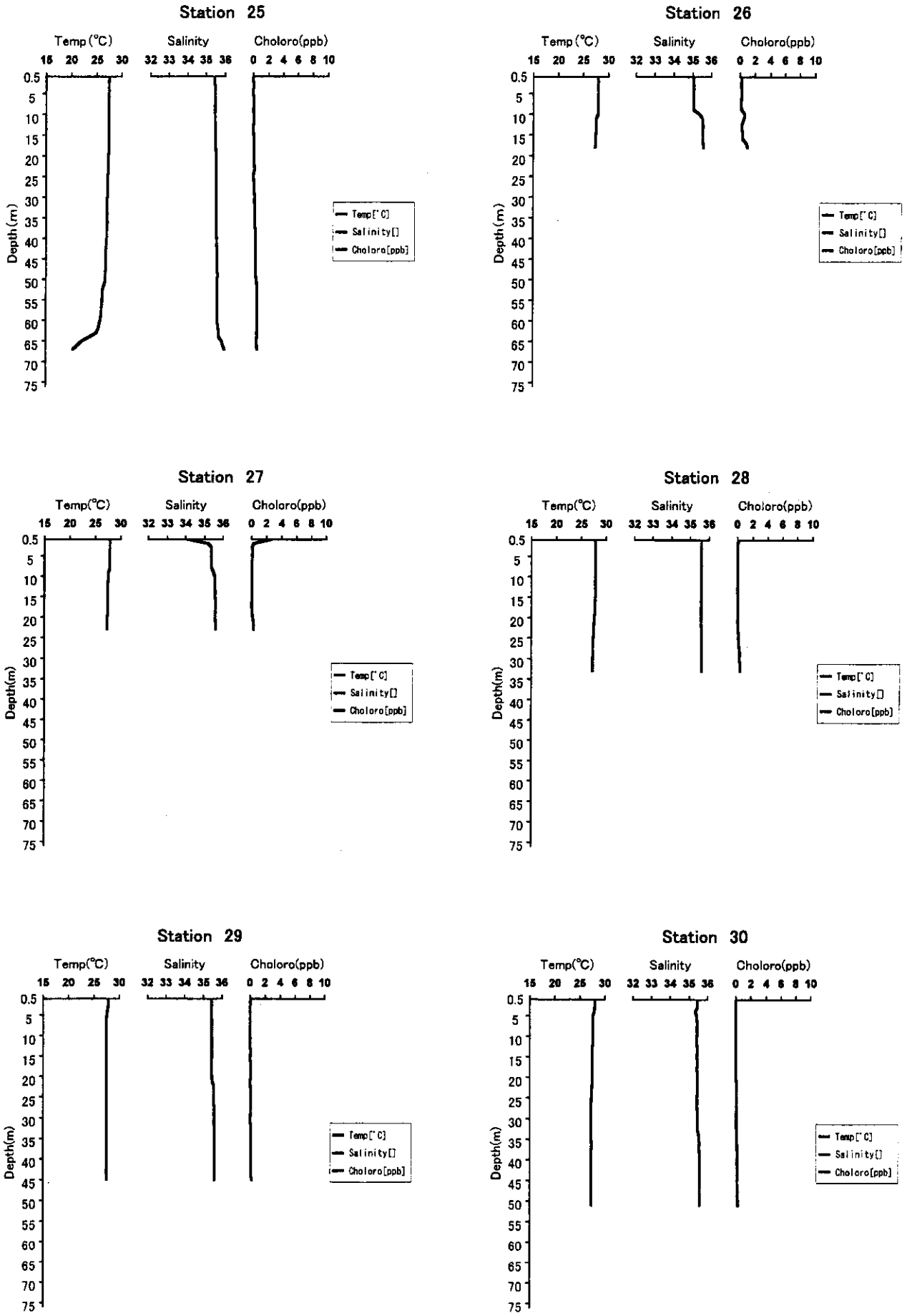


Figure 5-2-1-9 (5) Vertical profiles of water temperature, salinity and chlorophyll concentration (The 4th survey)

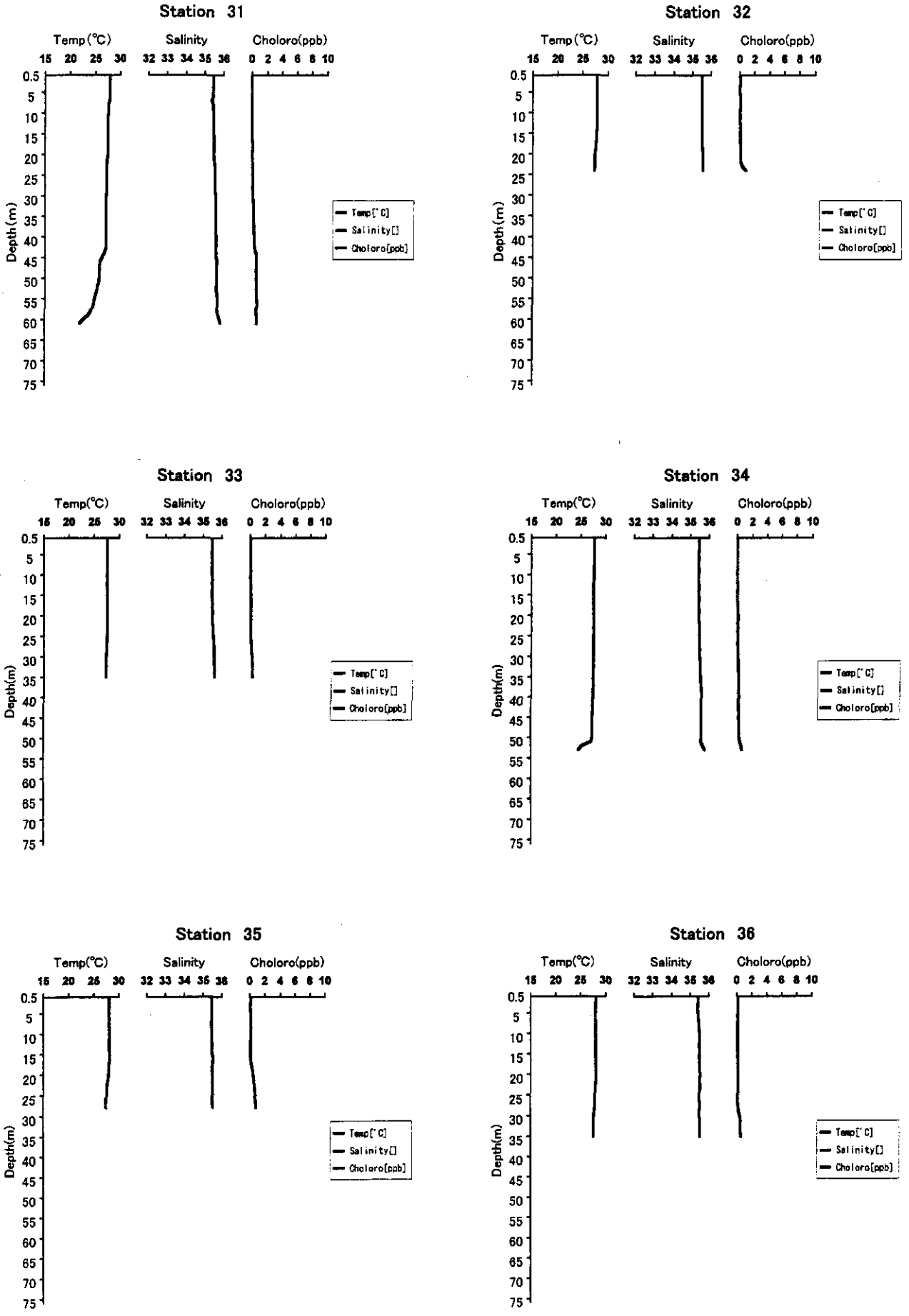


Figure 5-2-1-9 (6) Vertical profiles of water temperature, salinity and chlorophyll concentration (The 4th survey)

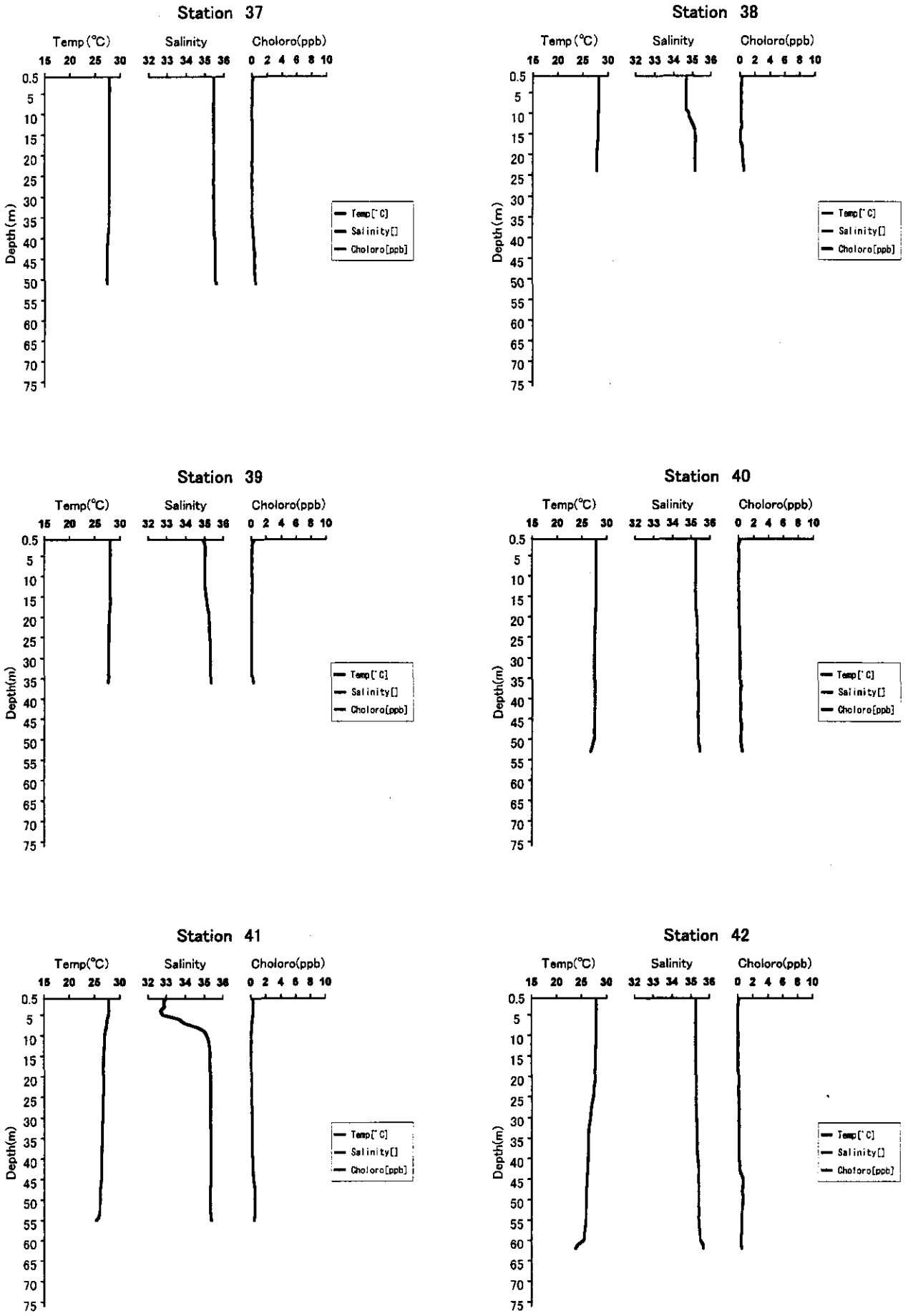


Figure 5-2-1-9 (7) Vertical profiles of water temperature, salinity and chlorophyll concentration (The 4th survey)

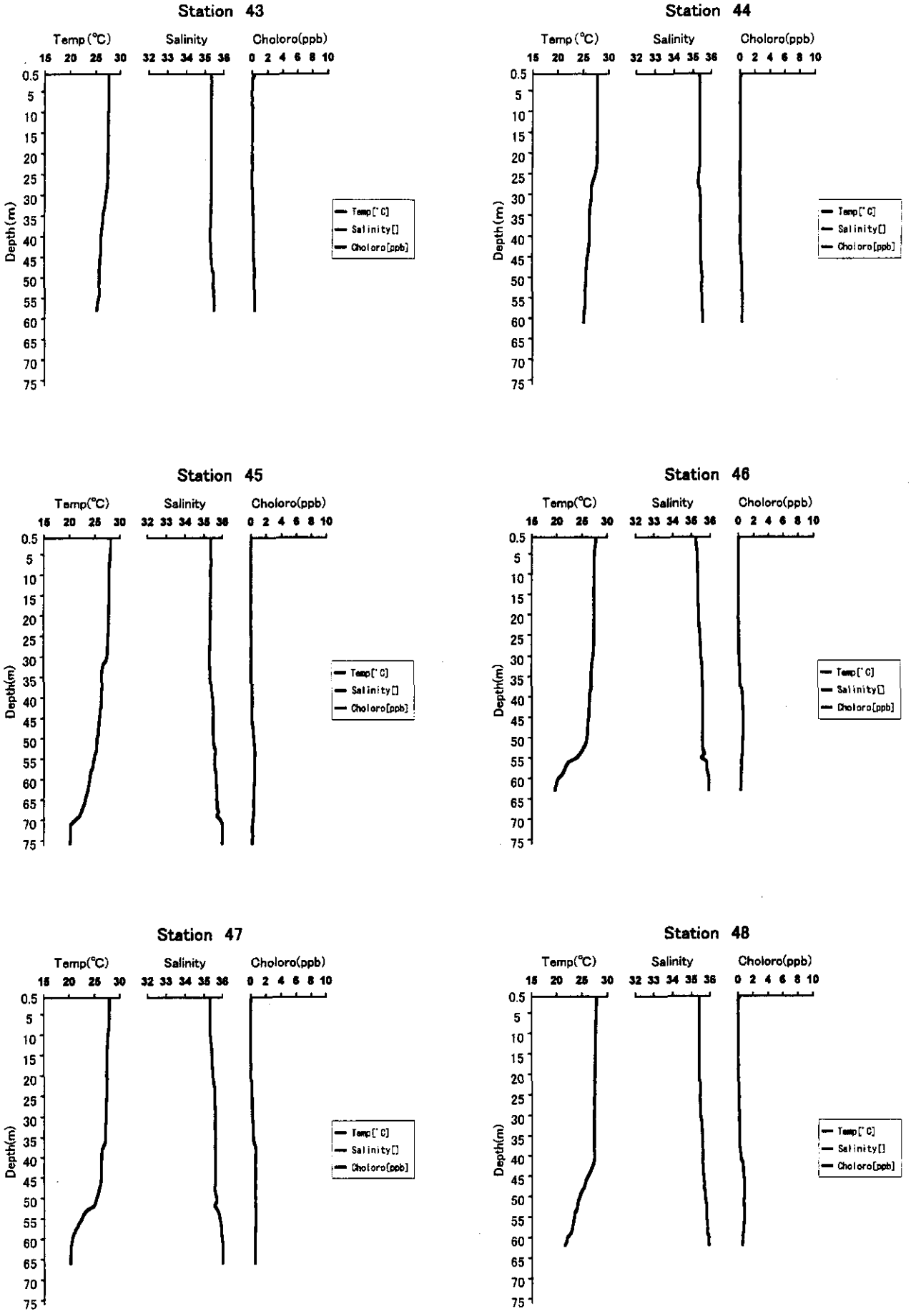


Figure 5-2-1-9 (8) Vertical profiles of water temperature, salinity and chlorophyll concentration (The 4th survey)

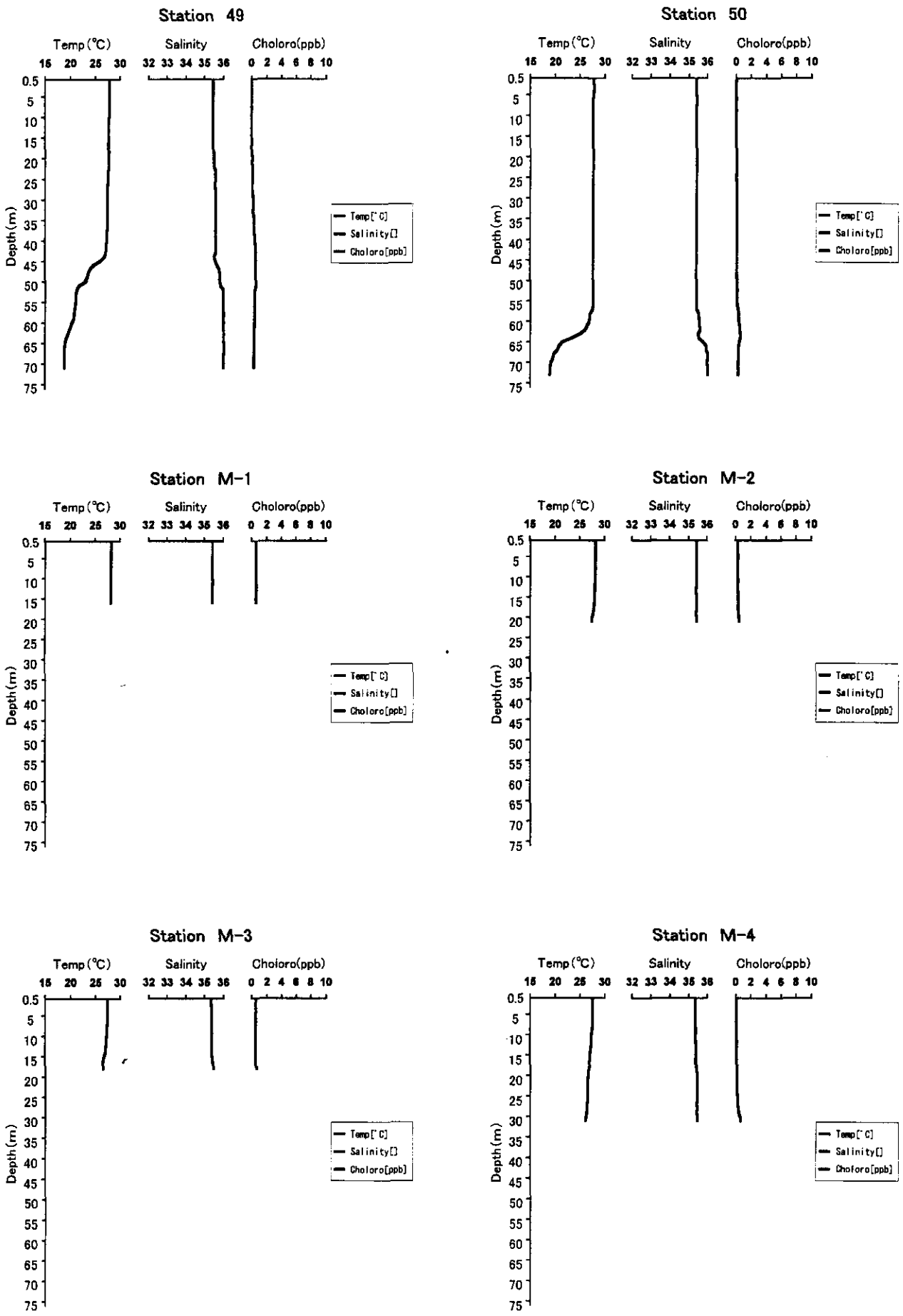


Figure 5-2-1-9 (9) Vertical profiles of water temperature, salinity and chlorophyll concentration (The 4th survey)

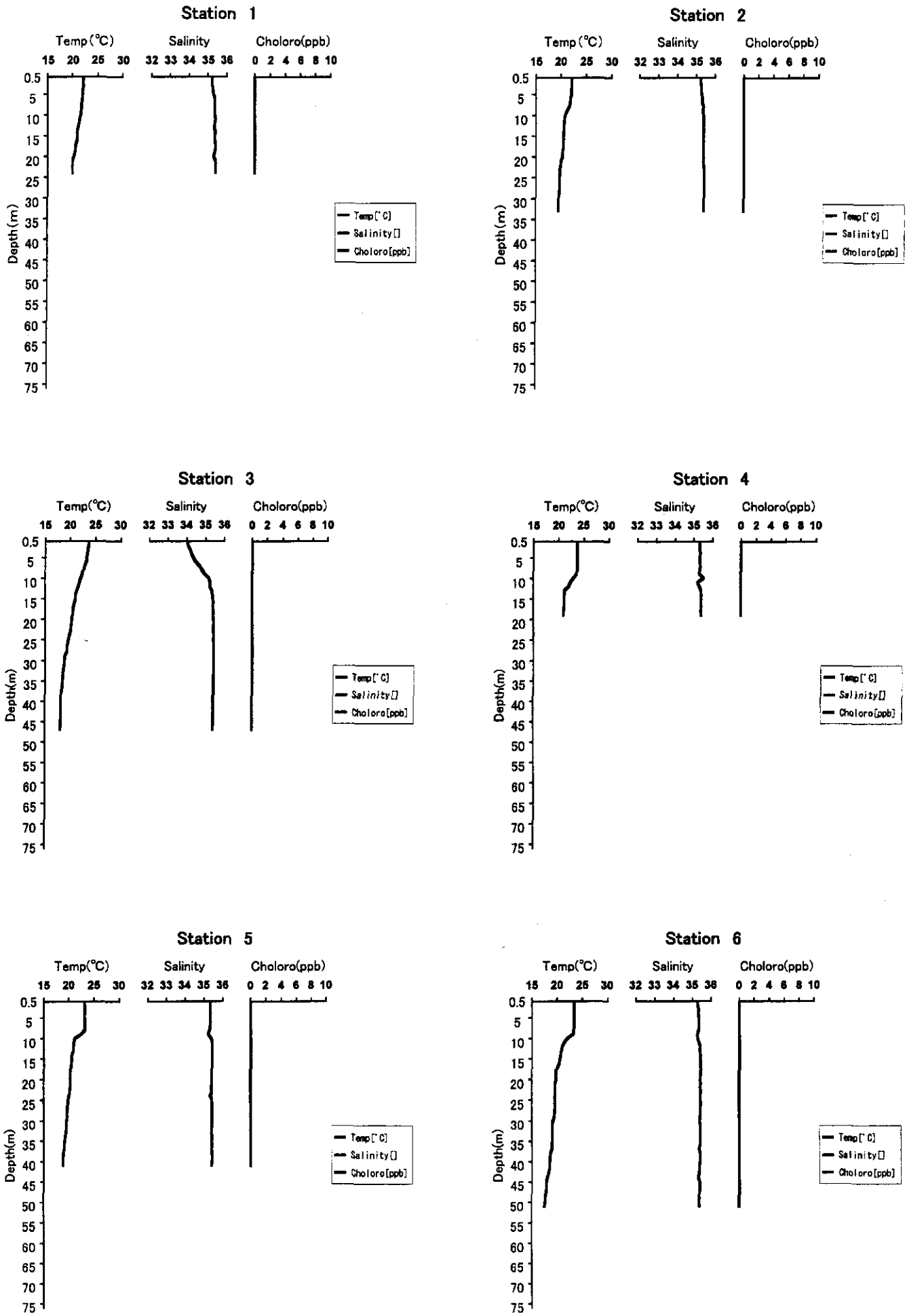


Figure 5-2-1-10 (1) Vertical profiles of water temperature, salinity and chlorophyll concentration (The 5th survey)

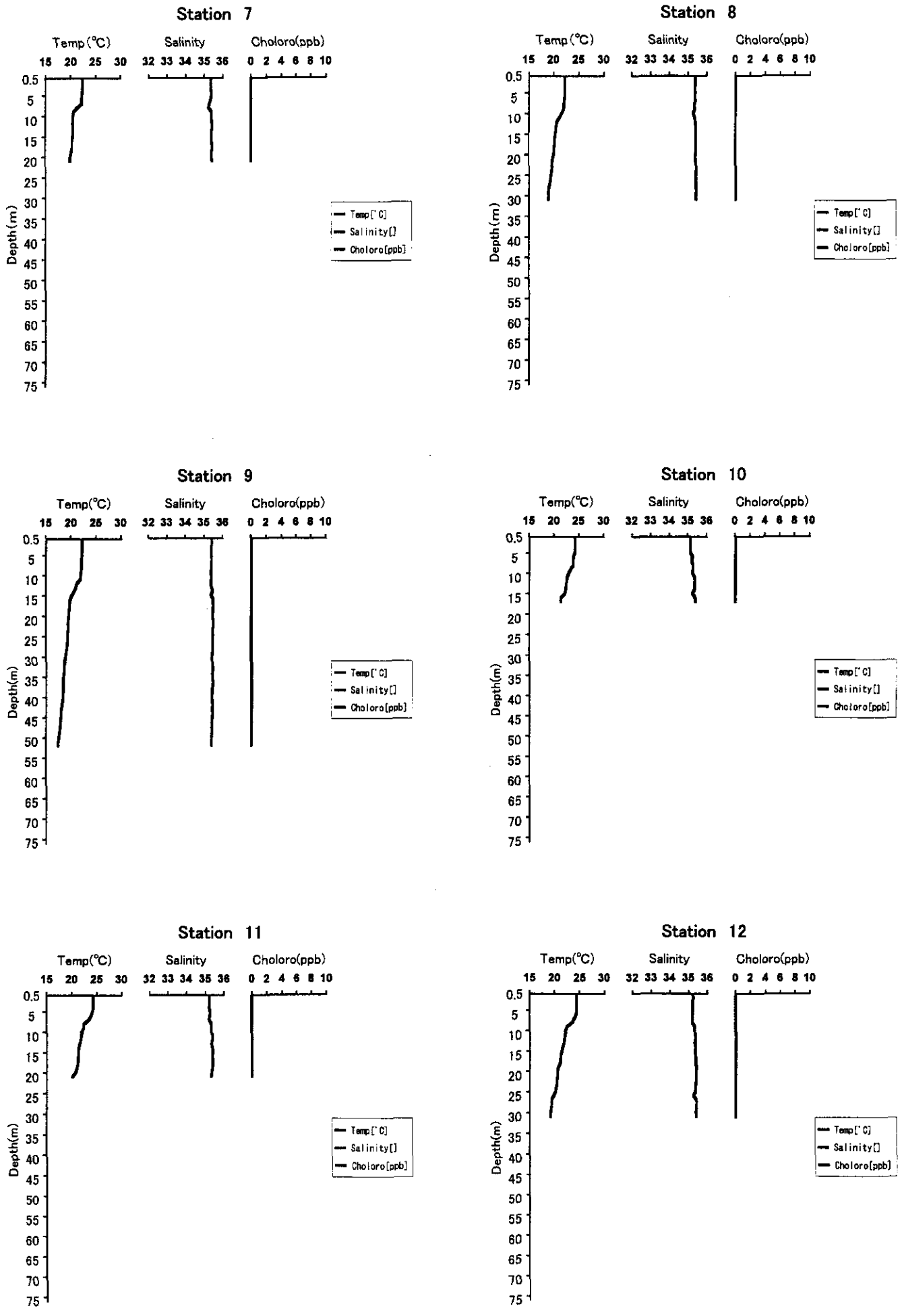


Figure 5-2-1-10 (2) Vertical profiles of water temperature, salinity and chlorophyll concentration (The 5th survey)

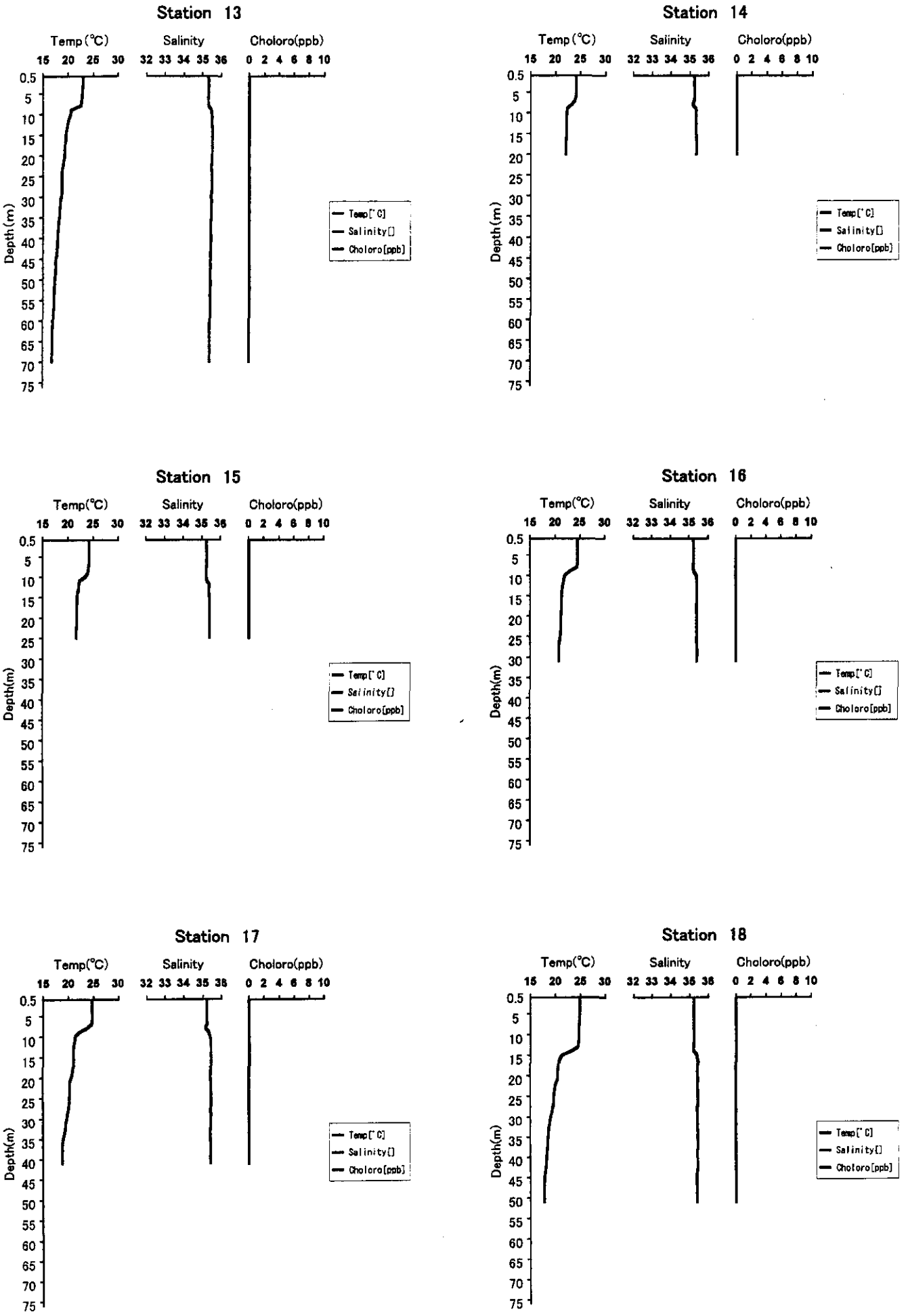
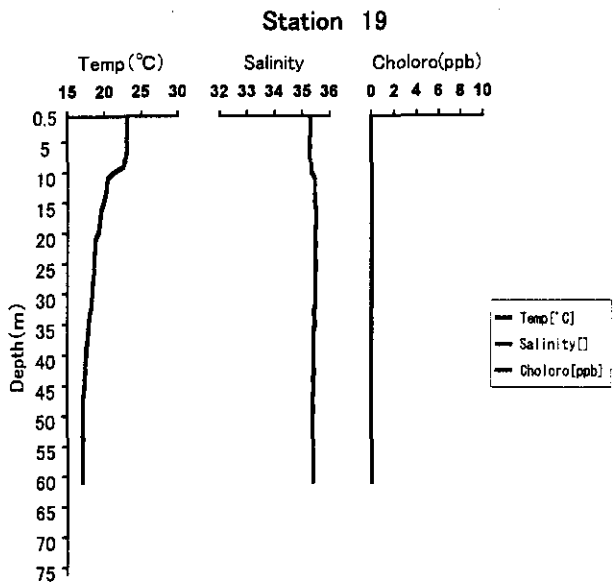
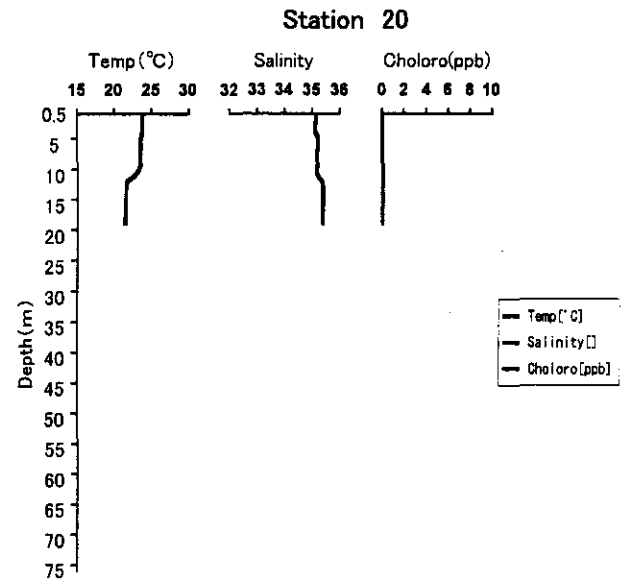
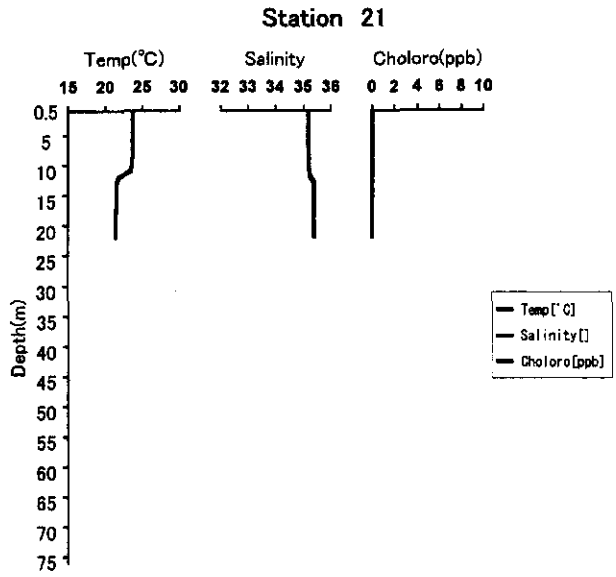
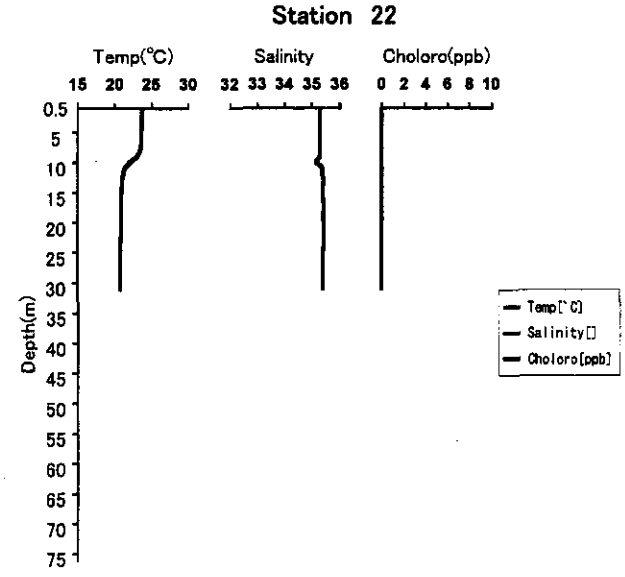


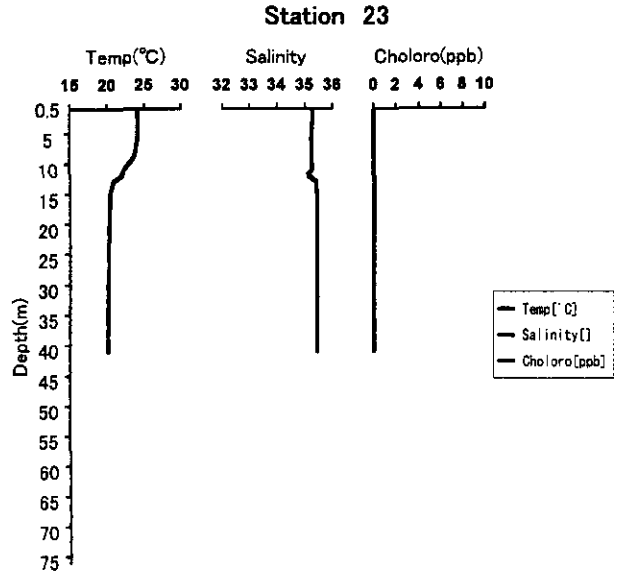
Figure 5-2-1-10 (3) Vertical profiles of water temperature, salinity and chlorophyll concentration (The 5th survey)











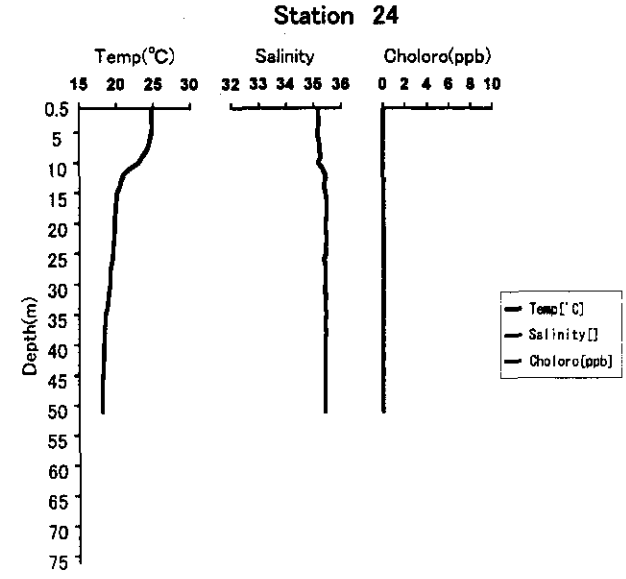
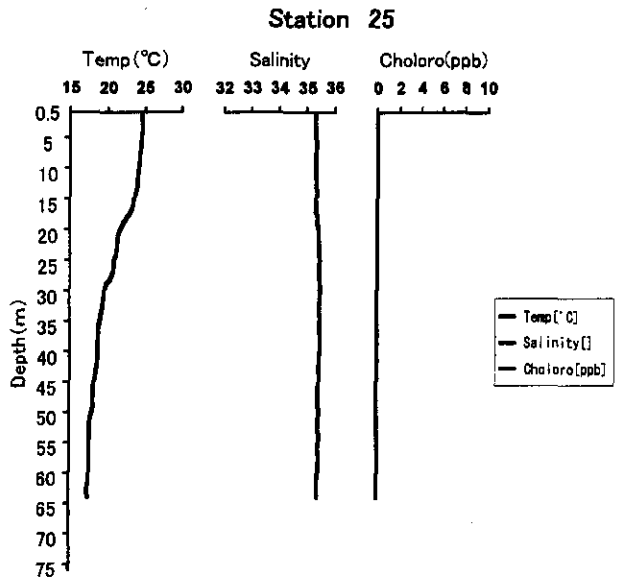
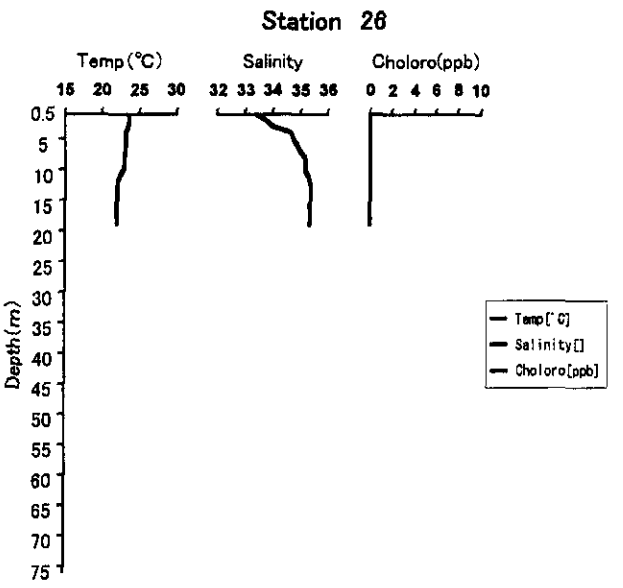
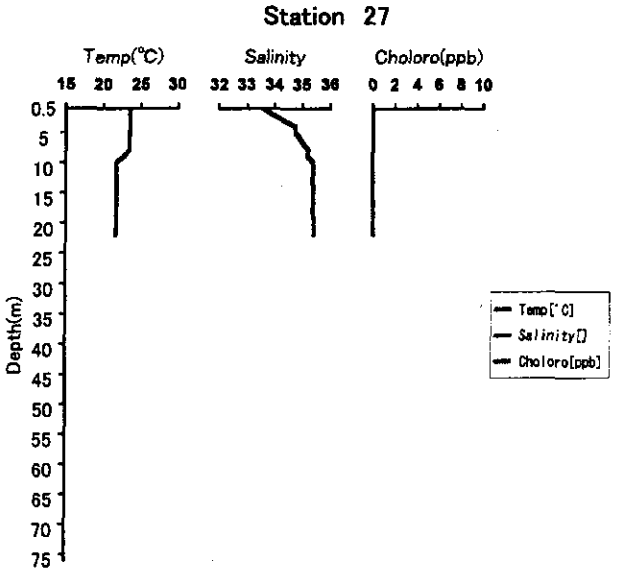
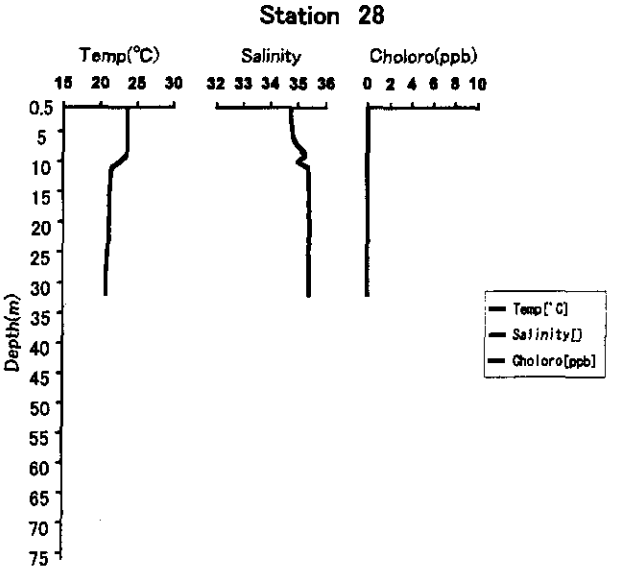


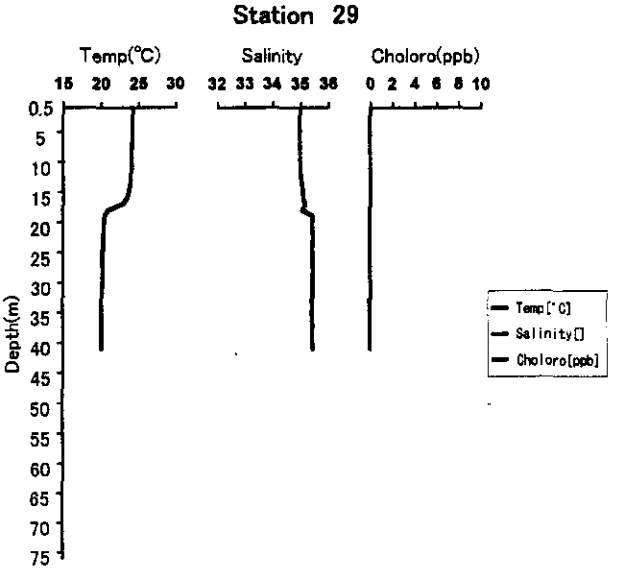
Figure 5-2-1-10 (4) Vertical profiles of water temperature, salinity and chlorophyll concentration (The 5th survey)











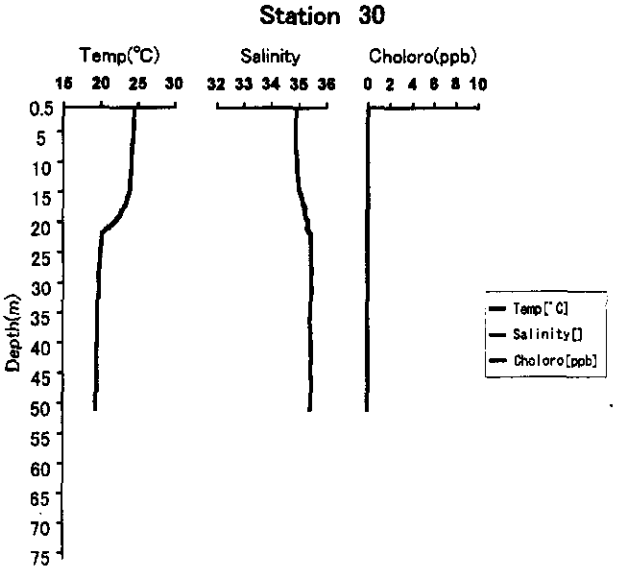


Figure 5-2-1-10 (5) Vertical profiles of water temperature, salinity and chlorophyll concentration (The 5th survey)

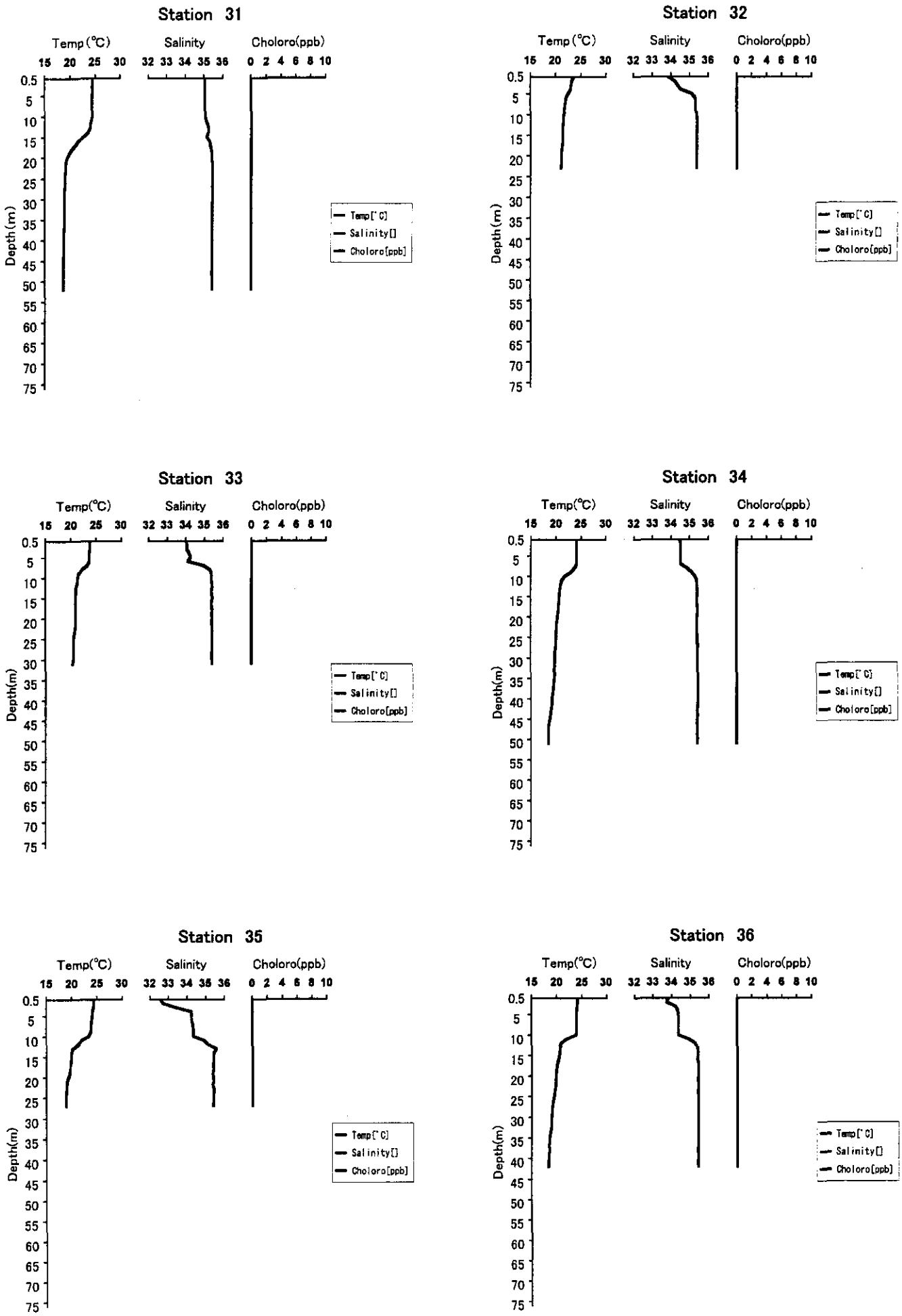


Figure 5-2-1-10 (6) Vertical profiles of water temperature, salinity and chlorophyll concentration (The 5th survey)

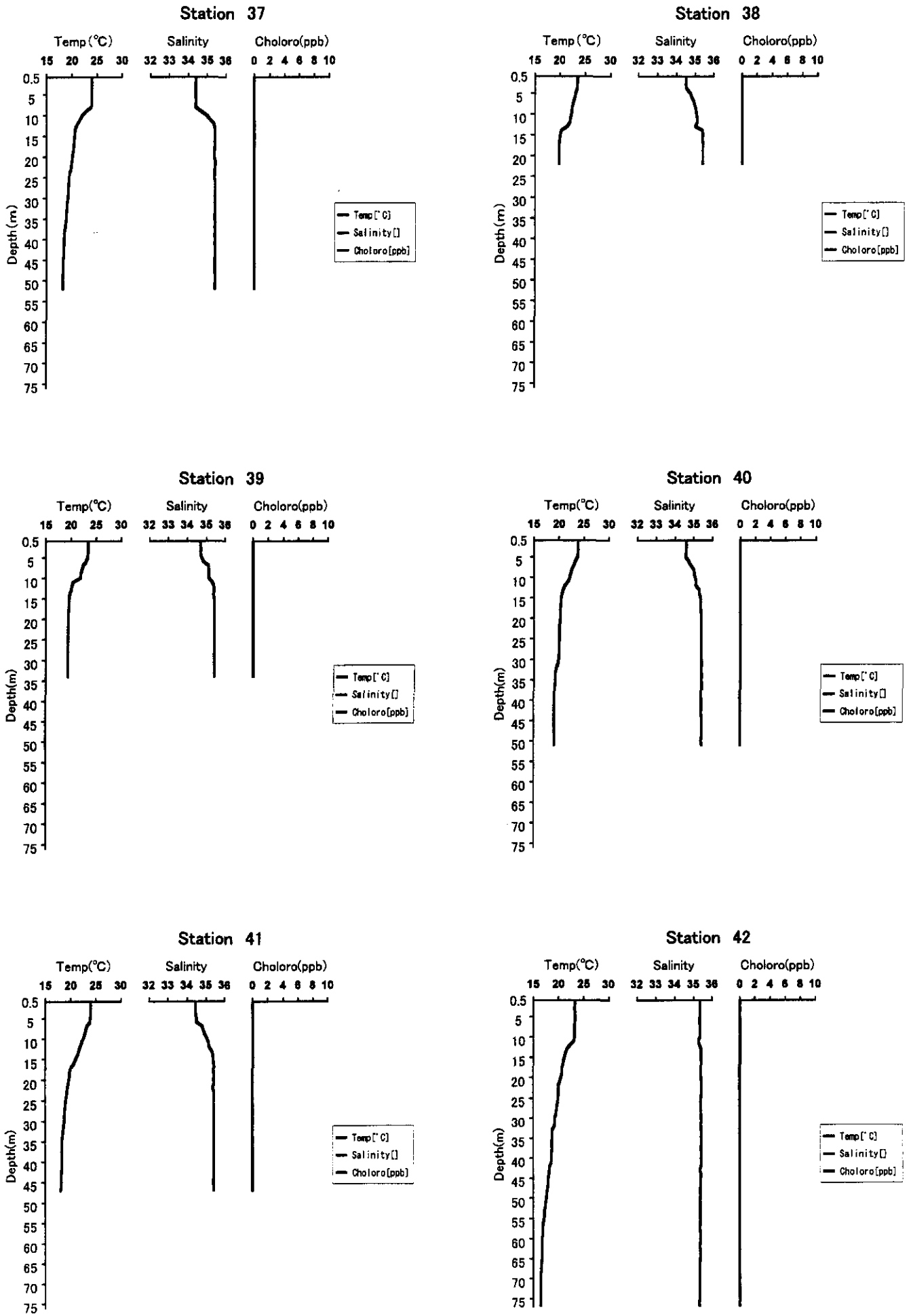


Figure 5-2-1-10 (7) Vertical profiles of water temperature, salinity and chlorophyll concentration (The 5th survey)

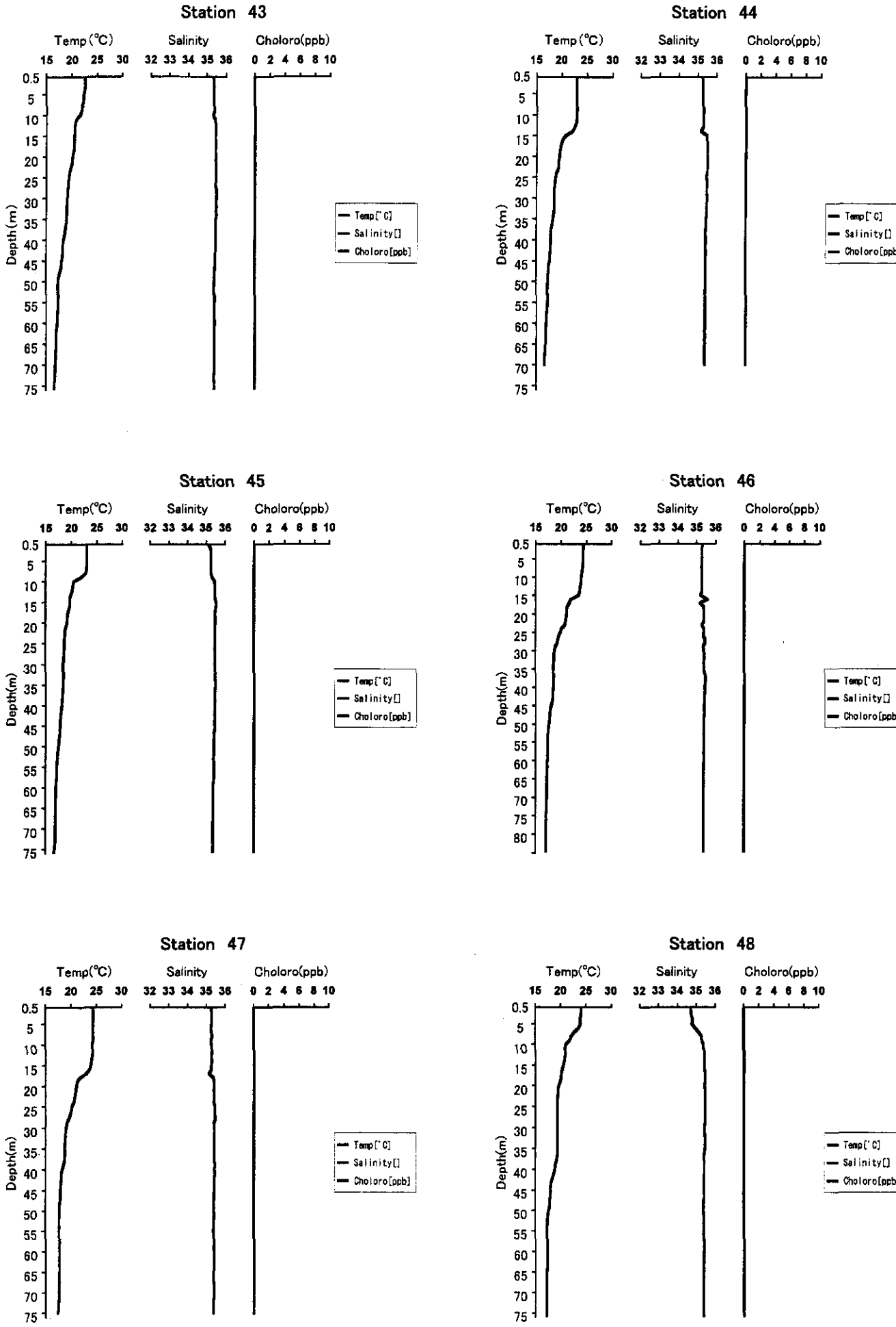


Figure 5-2-1-10 (8) Vertical profiles of water temperature, salinity and chlorophyll concentration (The 5th survey)

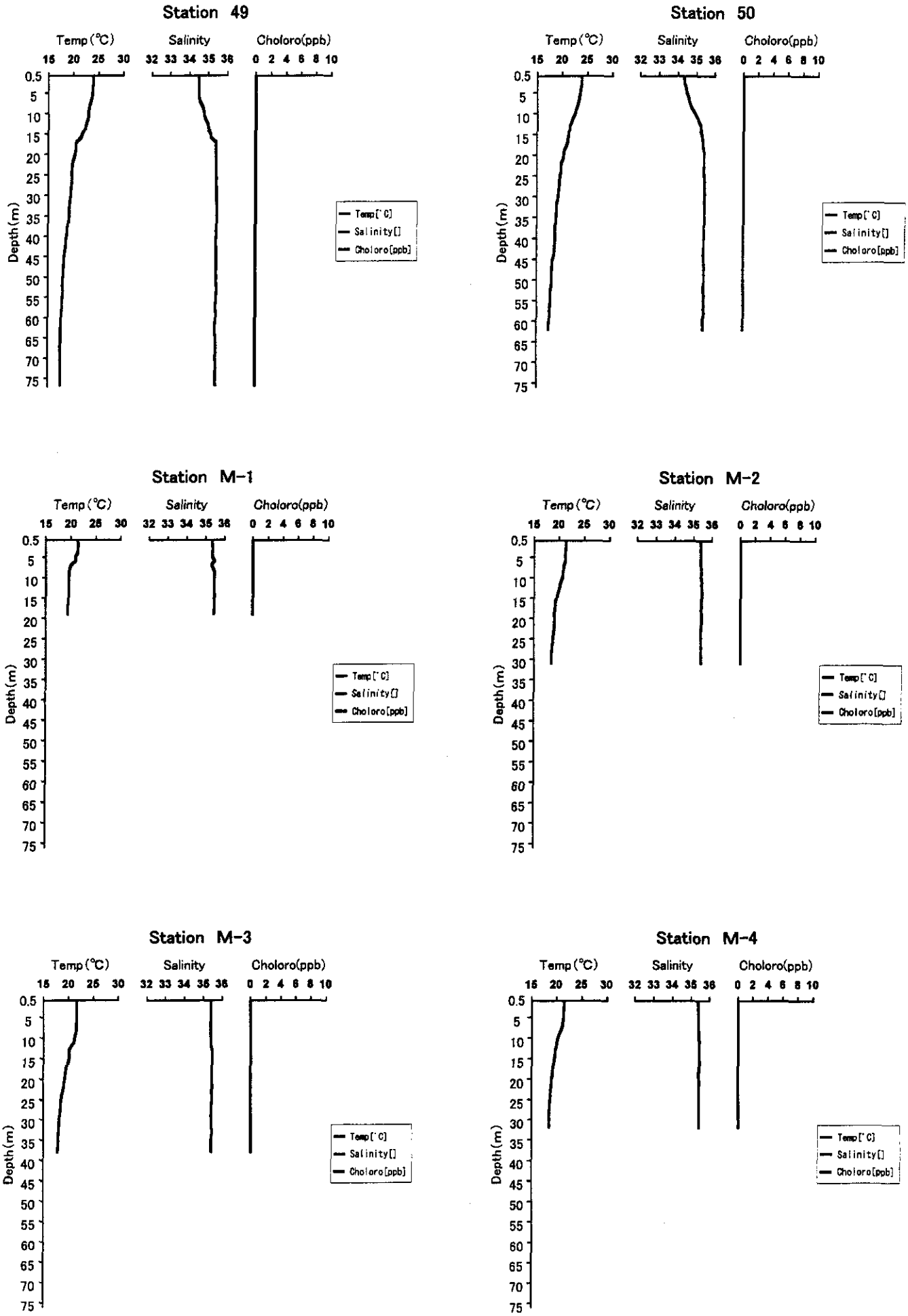


Figure 5-2-1-10 (9) Vertical profiles of water temperature, salinity and chlorophyll concentration (The 5th survey)

5-2-2. Trawl Survey

(1) Catches

Table 5-2-2-1 indicates a list of classified catches that were taken in the surveys. According to the table, catches are classified into 3 phyla (Vertebrata, Mollusca, Arthropod), 6 classes (Chondrichthyes, Osteichthyes, Reptilia, Gastropoda, Cephalopoda, Crustacea), 88 families, and 180 species. Of these classifications, Pisces consists of 72 families and 156 species. In our four time marine surveys, we always found 78 species of Pisces, 3 species of Mollusca, and 1 Crustacea. It seems natural that evaluation target species always appeared in the surveys because they are so important in fishery. Meanwhile, we observed 10 species, except *Lutjanus agennes*, of our 11 survey target species. *Lutjanus agennes* was added to our survey target species instead of *Lutjanus goreensis* and *Caranx hippos*, both of which had been target species in the preliminary survey and removed from the survey target species after consulting with the Fisheries Department. Since only two individuals of *Lutjanus agennes* were caught during our four times marine surveys, the species is not important in fisheries. The aforementioned two species had also similar results.

We have converted catch quantity (kg) per survey into catch quantity per hour (Table 5-2-2-2) to have relative values because towing hours at the survey stations were different. Accordingly, catch quantity at the second field survey (stable period) stood at 42 to 1,552 kg (average: 275 kg); 16 to 712 kg (average: 197 kg) at the third field survey (upwelling period); 35 to 2,184 kg (average: 343 kg) at the fourth field survey (stable period); and 22 to 1,280 kg (average: 306 kg) at the fifth field survey (upwelling period). Although catch quantity between the stable periods and upwelling periods varies from year to year, the stable periods tended to have catch quantity more than the upwelling periods. In the stable periods at the second and fourth field surveys, the evaluation target species had 124 kg (45%) and 155 kg (45%) of catch quantity respectively while the survey target species had 27 kg (10%) and 59 kg (17%) of catch quantity respectively. Meanwhile, in the upwelling periods at the third and fifth field surveys, the evaluation target species had 79 kg (40%) and 105 kg (34%) of catch quantity respectively while the survey target species had 37 kg (19%) and 63 kg

(20%) of catch quantity respectively. These surveys indicated that the stable periods had more catches of the evaluation target species. Catch quantity of both evaluation target species and survey target species in the stable and upwelling periods accounted for about 60% of the entire catch quantity, indicating the importance of the species selected for our surveys.

(2) Biological Measurement

Table 5-2-2-3 lists the numbers of individuals by items that we measured in our surveys. This section outlines a summary of the measurements, details of which are described later. Of the lengths of the evaluation target species caught in our mesh selectivity test fishing, the number of individuals measured with inner nets of 60-mm mesh size is added to the body length composition. However, the numbers of individuals measured with a 70-mm inner net and a 40-mm outer net are not included. Accordingly, the number of measured individuals in Table 5-2-2-3 and the number of individuals in the body length composition (Table 5-2-2-5) do not match with each other. For example, the number of measured individuals of *Pagellus bellottii* stood at 493 individuals at the third field survey and 187 individuals in the fourth field survey (Table 5-2-2-3). These figures include 215 individuals in the third field survey and 146 individuals in the fourth field survey, caught with a 70-mm inner net and a 40-mm outer net. Since these figures are not used for the body length composition, Table 5-2-2-5 shows the length compositions from 278 individuals and 41 individuals, respectively.

Body lengths and weights are data to deduce a length-weight relation formula (relative growth formula) while lengths lone are data to obtain an age composition. We have collected the target number of individuals of evaluation target species (250 individuals for each species) by the end of the third field survey. Thus, we did not measure the lengths and weights of individuals of the evaluation target species at the fourth and fifth field surveys, except for the species whose data were insufficient on growth and sex ratio. In the mesh selectivity tests, we measured the lengths of all of the evaluation target species caught until the fourth field survey. At the fifth field survey, we did not

measure the body lengths of the evaluation target species whose selectivity curve were obtained. Meanwhile, since we could not collect the target number of individuals of six survey target species (250 individuals for each species) by the end of the fourth field survey, we measured the body lengths and weights of all of the individuals caught at the fifth field survey. However, the catches of *Lutjanus agennes*, *Pomadasys jubelini*, *Epinephelus aeneus*, and *Drepane africana* were limited even at the fifth field survey. Thus, we could not collect the target number of individuals of these species by the end of the fifth field survey.

Data of sex and sexual gland indexes can be obtained by dissecting individuals to measure the weight of female sexual glands. We need these data by different age groups. At the third field survey, we knew no growth formulas, so we collected and measured throughout a range of species length. At the fourth field survey when we already knew growth formulas of almost all species, we tried collecting individuals of certain ages whose data were insufficient. As described later, we obtained data enough for stock analysis.

We took out the stomach contents of the species as soon as possible on board and froze them for analysis. As a result, we could find out most of the feeding habits of the evaluation target species by analyzing the stomach contents at the second and third field surveys. Accordingly, we did not collect the stomach contents at the fourth and fifth field surveys.

As age character, we collected their otoliths. Since examinations at the Tema laboratory were not satisfactory at the second field survey, we took those otoliths to Japan for grind and analysis. Based on the information obtained from this analysis, we carried out age determinations at the Tema laboratory at the third field survey. As a result, we found out ages of the major evaluation target species that we caught. We collected otoliths of two species, namely *Pseudupeneus prayensis* and *Brachydeuterus auritus* at the fourth field survey, and of *Decapterus rhonchus* at the fifth field survey, from width sample individuals because age data of these species were insufficient.

(3) Evaluation Target Species

Table 5-2-2-4 lists data of catch quantity by species while Table 5-2-2-5 lists a total length composition by survey stations. Figure 5-2-2-1 illustrates frequency distributions of total lengths of different species. However, in order to find out sex ratios by age group, data on total lengths obtained in the fifth field survey were based on the result of our measurement and analysis where we identified sexes of individuals of target age groups and measured their body lengths. Accordingly, since the total length data at the fifth field survey do not represent the entire image, Table 5-2-2-5 and Figure 5-2-2-1 do not include them.

Of our 10 evaluation target species, the species caught at more than a half of the survey stations are common to those caught in our four time surveys (second to fourth field surveys). They are five species, namely *Pagellus bellottii, Dentex canariensis, Sparus caeruleostictus, Pseudupeneus prayensis*, and *Sepia officinalis*. Since they were caught at more than 30 survey stations, we estimate that their living areas ranges along the entire coastal waters in Ghana. Also note that *Brachydeuterus auritus* were caught in our fourth and fifth field surveys at more than a half of our survey stations.

Total catch quantity per survey station of the above five species stood at 86 kg, 45 kg, 75 kg and 74 kg at the second, third, fourth and fifth survey, respectively. Since these weights account for 20 to 30% of the average total catch quantity of the corresponding survey time, namely 275 kg, 197 kg, 343 kg, and 306 kg, the five species are regarded as important species for trawl fishery in both stable periods and upwelling periods in Ghana. Meanwhile, we could catch *Galeoides decadactylus* only at 5, 13, 6 and 18 survey stations at the second, third, fourth and fifth survey, respectively. Similarly, we could catch *Pseudotholitus senegalensis* only at 4, 10, 5 and 11 survey stations at the second, third, fourth and fifth survey, respectively. The average catch quantity of both species stood at 1 kg, 2 kg and 3 kg at the second, third and fifth survey, respectively Although the average catch quantity of both species stood at 27 kg at the fourth field survey, the increase was attributable to 618 kg of catches of *Pseudotholithus senegalensis* at St.20. if this catches are removed from data, the

average catch quantity of both species stand at about 2 kg at the fourth field survey, which is similar to the quantity at the third field survey. From these data, we estimate that both species range in a narrow zone in low density. They are also unimportant target species for trawl fishery in stable periods and upwelling periods. The similar tendency is observed in the results of the field surveys by a research vessel, Dr. Fridtjof Nansen (Sigbjorn et al. 1999) (Table 5-2-2-4). Since Nansen carried out its field surveys during April through May, the significance of the above two species as fishing targets are considered unimportant throughout the year. The surveys by Nansen also revealed that the appearance rates of evaluation target species were generally low compared with those of our field surveys. For example, *Pagellus bellottii*, whose appearance rate is the highest in Nansen survey, occurs only at 25 stations of the 40 survey stations. Though we do not know the reason, this species might have had unique distributions during April through May.

Concerning depth distributions of species seeing from the body length composition, we found that small individuals of *Sepia officinalis* had a tendency to range in deep zones than shallow zones at the second and fourth surveys but the tendency was not observed at the third survey. This seems to indicate that *Sepia officinalis* has unique seasonal distributions. Other evaluation target species indicate no specific distributions (Table 5-2-2-5). When we focus on the body length composition of the aforementioned five evaluation target species which range over the entire coastal waters of Ghana, the lengths of *Pagellus bellottii* ranged between 115 to 275 mm at the second survey and 95 to 295 mm at the third survey. The lengths of *Dentex canariensis* respectively ranged between 95 to 515 mm and 105 to 525 mm at the second and third surveys. Similarly, the lengths of *Sparus caeruleostictus* stood at 115 to 375 mm and 85 to 375 mm at these surveys. The lengths of *Pseudupeneus prayensis* reached to 95 to 275 mm and 125 to 275 mm at these surveys. The mantle lengths of *Sepia officinalis* ranged between 35 to 295 mm and 55 to 295 mm at the second and third field surveys respectively (45 to 305 mm at the fourth field survey) (Table 5-2-2-5).

The towing hours at survey stations varied from point to point. Thus,

we revised the appearance frequencies of variety of body length into value per unit towing area and then into percentages of total length frequency distributions (Figure 5-2-2-1). As mentioned earlier, we tried to supplement insufficient data at the fourth and fifth field surveys. Therefore, in principle, we did not measure the body lengths of the species and age groups whose data were already at hand at these surveys. Based on the result of the third field survey indicating several species consisted of multiple year class groups and on the subsequent growth analysis described later, we also found that all of the evaluation target species consist of multiple year class groups.

In order to compare the total length composition mentioned above with the body length composition that Nansn obtained, we have to convert the total length (TL:mm) of several species into fork length (FL:mm). The relation formulas, obtained from the result of photo measurements, are listed below (including survey target species):

Brachydeuterus auritus	:	FL=0.847TL+16.9
Dentex canariensis	:	FL=0.847TL+11.7
Sparus caeruleostictus	:	FL=0.907TL−2.8
Pagellus bellottii	:	FL=0.991TL−15.4
Chroloscomburus chrysurus	:	FL=0.777TL+22.2
Galeoides decadactylus	:	FL=0.836TL+4.2

Using these relation formulas, we re-plotted Figure 5-2-2-1 according into the body length composition used for Nansen's surveys, and overlapped the figure with the results of Nansen's survey into Figure 5-2-2-2 (including survey target species). The specification of fishing gear used for the survey by Nansen is largely different from that of the fishing gear used for this survey. Since catchability coefficient vary, comparing the result of the survey by Nansen with the result of this survey is not reasonable. However, the result of the survey carried out by Nansen indicates a histogram in the ratio of trawl fishing per hour. Fig. 5-2-2-2 is made based on the ratios in the histogram visually estimated. The histogram in Fig. 5-2-2-1 and the histogram in Fig. 5-2-2-2, both of which are the results of this survey, are different because the latter histogram is made after converting the composition of total lengths into the composition of fork lengths.

The surveys by Nansen were carried out during April through May while our surveys were carried out from October. This six-months difference does not allow us to simply compare both data but guess growth degrees. For example, *Brachydeuterus auritus* consisted of at least two groups according to the result of Nansen's surveys; 85 mm *Brachydeuterus auritus* at peak could grow to 125 to 135 mm in two to three months (third field survey) and into 145 mm in six months (second field survey). Meanwhile, we hardly observed the growth of *Dentex canariensis*. Details of growth of different species are described later. Figure 5-2-2-3 illustrates relations between body lengths (total lengths) and weights. We are going to use the following length-weight relations of the all evaluation target species in Figure 5--2-2-3 from now on.

Pagellus bellottii : $W=0.00000811L^{3.09}$
Dentex canariensis : $W=0.0000186L^{2.94}$
Sparus caeruleostictus : $W=0.0000144L^{3.01}$
Pseudotolithus senegalensis : $W=0.0000106L^{3.02}$
Galeoides decadactylus : $W=0.00000803L^{3.05}$
Brachydeuterus auritus : $W=0.00000659L^{3.13}$
Pomadasys incisus : $W=0.0000168L^{2.96}$
Pseudupeneus prayensis : $W=0.00000359L^{3.23}$
Decapterus rhonchus : $W=0.00000510L^{3.12}$
Sepia officinalis : $W=0.000312L^{2.76}$

Table 5-2-2-6 shows results of sex ratios and maturities. The results are primarily based on the results of the second and third field surveys. Because at fourth and fifth surveys, we intensively tried surveying ages of individuals whose data on sex ratios by age were insufficient. Concerning the gonad index GI, we collected gonads extirpated out of fishes on board, kept them in plastic bags, and took them to the laboratory at Tema for measurement after getting off the boat. The gonad index was calculated by the weights of gonads. However, a number of the grown-up gonads broke in the plastic bags, which caused difficulty to measure their weights. Alternatively, we thought that visual inspection is more correct in determining the maturity of the gonads.

There are many different sex ratios observed. For example, there are species (*Pagellus bellottii*, *Dentex canariensis*, *Pomadasys incisus*) which hardly indicate any change in the sex ratio in the upwelling period (third survey) and in the stable period (second survey); species (*Decapterus rhonchus*, *Sparus caeruleostictus*, *Galeoides decadactylus*) whose sex ratio reverses between the upwelling and the stable period; and species (*Sepia officinalis*) whose sex ratio is one-sided. It was also observed that more females appeared for *Decapterus rhonchus*, *Pomadasys incisus*, *Brachydeuterus auritus*, etc. during the spawning season. Meanwhile, we have also observed that *Pagellus bellottii* and *Dentex canariensis* are almost equal in the number of males and females. Sex ratios by ages are described in Section 5-2-6.

There were five species which had mature eggs in the second survey (stable period). These include *Dentex canariensis* (total length: 225 mm or more), *Sparus caeruleostictus* (total length: 345 mm or more), *Galeoides decadactylus* (total length: 385 mm or more), *Pseudotholithus senegalensis* (total length: 235 mm or more), and *Pseudupeneus prayensis* (total length: 235 mm or more). Meanwhile, almost all species had mature eggs in the upwelling period, the third survey. In other words, there were two groups of species. One group of species, whose spawning season is in the upwelling period, includes *Decapterus rhonchus*, *Pomadasys incisus*, *Brachydeuterus auritus*, *Pagellus bellottii*, and *Sepia officinalis*. The other group of species, whose spawning seasons extend from the upwelling period to the stable period, includes *Dentex canariensis*, *Sparus caeruleostictus*, *Galeoides decadactylus*, *Pseudotholithus senegalensis*, and *Pseudupeneus prayensis*. We confirmed the spawning season of *Sepia officinalis* by collecting groups of eggs spawned during the third survey period (Plate 5-2-2-1), not by checking mature eggs of *Sepia officinalis*.

Table 5-2-2-7 lists results of feeding habits of species. Since we found feeding habits of species by the third field survey, we no longer surveyed feeding habits at the fourth and fifth surveys. Thus, Table 5-2-2-7 stems from the results of our second and third field surveys.

Decapterus rhonchus and *Brachydeuterus auritus* prey animals many of which do not live at the bottom substrata, such as cuttlefishes and Pisces. They do not have distinctive feeding habits as benthos feeder.

The other species prey Crustacea such as shrimps and crabs, Polychaete such as clamworms, and shells such as bivalves. In other words, these species have feeding habits as benthos feeder. However, since digestions speeds of fish vary very much depending on bait creatures, the survey result on feeding habits is susceptible to the time the survey was made. For example, since the chitin of Crustacea is hard to be digested, it remains in the stomach for a long time. Meanwhile Polychaete is easy to be digested, so identifying it becomes difficult soon after preyed. Thus, in general, Polychaete is classified simply into a digest. The fact that the ratio of digests is relatively high, as indicated in the result of this survey, should be understood as indicating an aspect that percentages in Table 5-2-2-7 should not be regarded as absolute assessment.

For age characteristics, the number of individual otolith listed in Fig. 5-2-2-3 were collected. In the second survey otolith were taken to Japan for sufficient examination, followed by processing with a grinder and whetstone to read their ages (Plate 5-2-2-2). Individual otolith were examined several times to read and determine their ages. Based on these age data, age determination of otolith was carried out as much as possible at the laboratory at Tema in the third survey. However, we do not know whether non-transparent and transparent areas are formed once a year. Based on a report on the comparison of otolith with growths of *Pagellus bellottii* (Research Division of the Japanese Fisheries Agency(RDJFA), 1989), we assumed that the transparent area and the non-transparent area are formed once a year, and that the number of ring spots is equal to the age. The result is indicated in Table 5-2-2-8, which is also used for growth analysis in Section 5-2-6. For details, see Section 5-2-6.

(4) Survey Target Species

Table 5-2-2-9 lists fish catches by different species while Table 5-2-2-10 lists a total length composition by survey stations. Figure 5-2-2-4 illustrates frequency distributions of total lengths of different species.

Among our 11 survey target species, no species was caught at more than a half of the survey stations. This is contrastive to the fact that 5

evaluation target species were caught at more than a half survey stations. At the second survey, we caught individuals of *Epinephelus aeneus* at 15 survey stations, which is largest in the number of survey stations, followed by *Chloroscombrus chrysurus* at 13 survey stations. At the third survey, we caught individuals of *Chloroscombrus chrysurus* at 20 survey stations, followed by *Balistes capriscus* at 15 survey stations. At the fourth survey, we caught individuals of *Chloroscombrus chrysurus* at 21 survey stations, followed by *Epinephelus aeneus* at 15 survey stations. At the fifth survey, we caught individuals of *Selene dorsalis* at 19 survey stations, followed by *Chloroscombrus chrysurus* at 17 survey stations. These survey results indicate that *Chloroscombrus chrysurus* are constantly found in broad areas among the survey target species. The catch quantity of the entire survey target species per survey station stood at 26 kg, 36 kg, 59 kg and 62 kg at the second, third, fourth and fifth survey, respectively. These weights account for only 9%, 18%, 17%, and 20% of the average of the entire fish catches for the second, third, fourth, and fifth field surveys, respectively. The tendency appears more eminent at Nansen's survey. The survey target species at Nansen's survey account for only 7% (=39 kg /535 kg x 100) at most.

Meanwhile, our evaluation target species include *Dentex canariensis, Sparus caeruleostictus,* and *Pagellus bellottii* of Sparidae while our survey target species include, besides these species, two Sparidae, namely *Dentex angolensis* and *Dentex congoensis*. As mentioned earlier, the evaluation target species in Sparidae were caught at more than a half survey stations (appearance rate: 65 to 96%) throughout our field surveys while the survey target species in Sparidae were caught at only 8 to 12 survey stations. However, the average catch quantity of the evaluation target species in Sparidae per survey station stood at about 60 kg, 30 kg, 48 kg and 45 kg at the second, third, fourth and fifth survey, respectively. On the other hand, the average catch quantity of the survey target species in Sparidae stood at 15 kg, 13 kg, 46 kg and 47 kg at the second, third, fourth and fifth survey, respectively. Although occurrences of the survey target species in Sparidae was small, they are considered as an important resource for the trawl fishery in Ghana. If catch quantity of these Sparidae is not

included in total catch quantity of the survey target species, the average catch quantity of the other nine survey target species per survey station at the third field survey accounted for 12% of the total catch quantity, the largest percentage among our field surveys. In other words, the remaining second, fourth, and fifth field surveys had only 4 to 5% of average catch quantity of these nine survey target species against the total fish catches. Thus, these nine survey target species are regarded as valuable only as by catch fishes. The similar tendency was also observed by Nansen's survey results (Table 5-2-2-9). Although the second and fourth field surveys respectively caught only one individual of *Lutjanus agennes* at St 14 and at St 17, the third and fifth field surveys caught no *Lutjanus agennes*. Nansen did not catch any of this species. From these facts, we can conclude that *Lutjanus agennes* has no value even as by catch fish.

As mentioned above, except for Sparidae, the survey target species can be positioned as by catch fishes throughout upwelling and stable periods.

We would like to introduce species with their body lengths, which were caught at 10 or more survey stations (appearance rate: 20% or more). They are *Epinephelus aeneus* ranging from 305 to 1095 mm at the second field survey, from 225 to 915 mm at the third field survey, from 175 to 845 mm at the fourth field survey, and from 175 mm to 1045 mm at the fifth field survey; *Lutjanus fulgens* respectively ranging from 185 to 415 mm, from 115 to 595 mm, and from 145 to 625 mm at our second, third, and fourth field surveys, except for the fifth field survey; *Dentex angolensis* respectively ranging from 85 to 255 mm and from 105 to 285 mm at our second and third field surveys; *Dentex congoensis* ranging from 65 to 185 mm and from 85 to 205 mm at our second and third field surveys; *Balistes capriscus* respectively ranging from 175 to 475 mm, from 135 to 505 mm, from 215 to 595 mm, and from 155 to 505 mm at our second, third, fourth, and fifth field surveys; and *Chroloscombrus chrysurus* respectively ranging from 45 to 305 mm and from 125 to 295 mm at our second and third field surveys (Table 5-2-2-9). Furthermore, although larger *Epinephelus aeneus* tended to appear in deep water, other species indicated no specific appearance tendencies.

As stated earlier, the time for trawling varied depending on the survey station. Catch frequencies of different body length ranges were adjusted to values per unit trawling area before they were converted into percentages, which are plotted in Fig. 5-2-2-4, indicating distributions of total length frequencies. However, we did not put *Lutjanus agennes* in the figure. This is because although we caught one individual of *Lutjanus agennes* at our second and fourth field surveys respectively, we caught no *Lutjanus agennes* at our third and fifth field surveys. When observing both surveys, other species indicate that they consist of multiple age class. Figure 5-2-2-3 illustrates length-weight relation formulas.