Depth of the thermocline changed drastically between stations B-20 and B-21 along the north-south section. Positions and thickness of mixing layers showed less significant change along the parallels, especially Line-A to D (Figures 5-5 and 5-6). In the southern part, the mixing layers were not always homogeneous along Line-E and F with drastic changes at Stations B-24 and B-29, except at the very coastal area along Line-G.

In short, the position of the themocline represented by 25℃ and the thickness of mixing layer showed significant north-south variation in the early phase of northeast monsoon season. East-west variation was found not to be remarkable in the waters north of Line-D, but significant along the southern lines. Salinity showed remarkable variation in the sea surface. Along Line-1, low salinity was observed at Stations B-19 and B-28, the lowest value appeared at B-19 (Figure 5-2). On Line-2, low salinity was observed at Station B-20 (Figure 5-3). In the low saline water, temperature was homogeneous, indicating existence of mixing layer, but gradient of salinity was appreciable. Vertical profile along Line-D connecting stations B-19 and B-21 of east-west section showed no thermal gradient, but a remarkable slope in salinity (Figure 5-6). A remarkable east-west salinity gradient was found in other profiles. Below the mixing layer, the haloclines were found at almost the same thermocline positions. Figure 5-9 shows fairly homogenous horizontal distribution of temperature at the subsurface layer of 10 m depth. Salinity was remarkably low to the north of Da Nang and at B-20 off Nha Trang. Low saline water found in quadrangles of 8° N to 9° N in the South Region might have reflected extrusion of waters from the Mekong River.

- ✧ The oceanographic conditions in the early phase of the northeast monsoon season are featured by a north-south change of mixing layers between Line-C, represented by stations B-17 and B-18, and Line-D, represented by stations B-24 and B-25, located at 12° N, thin in the north and thick in the south.
- ✧ Other features are the large north-south thermocline gradient between Line-C and D, shown by difference of depth of about 45 m.
- ✧ It is also noted that low saline water is present in the sub-surface layer in the waters north of Da Nang and B-20 off Nha Trang.

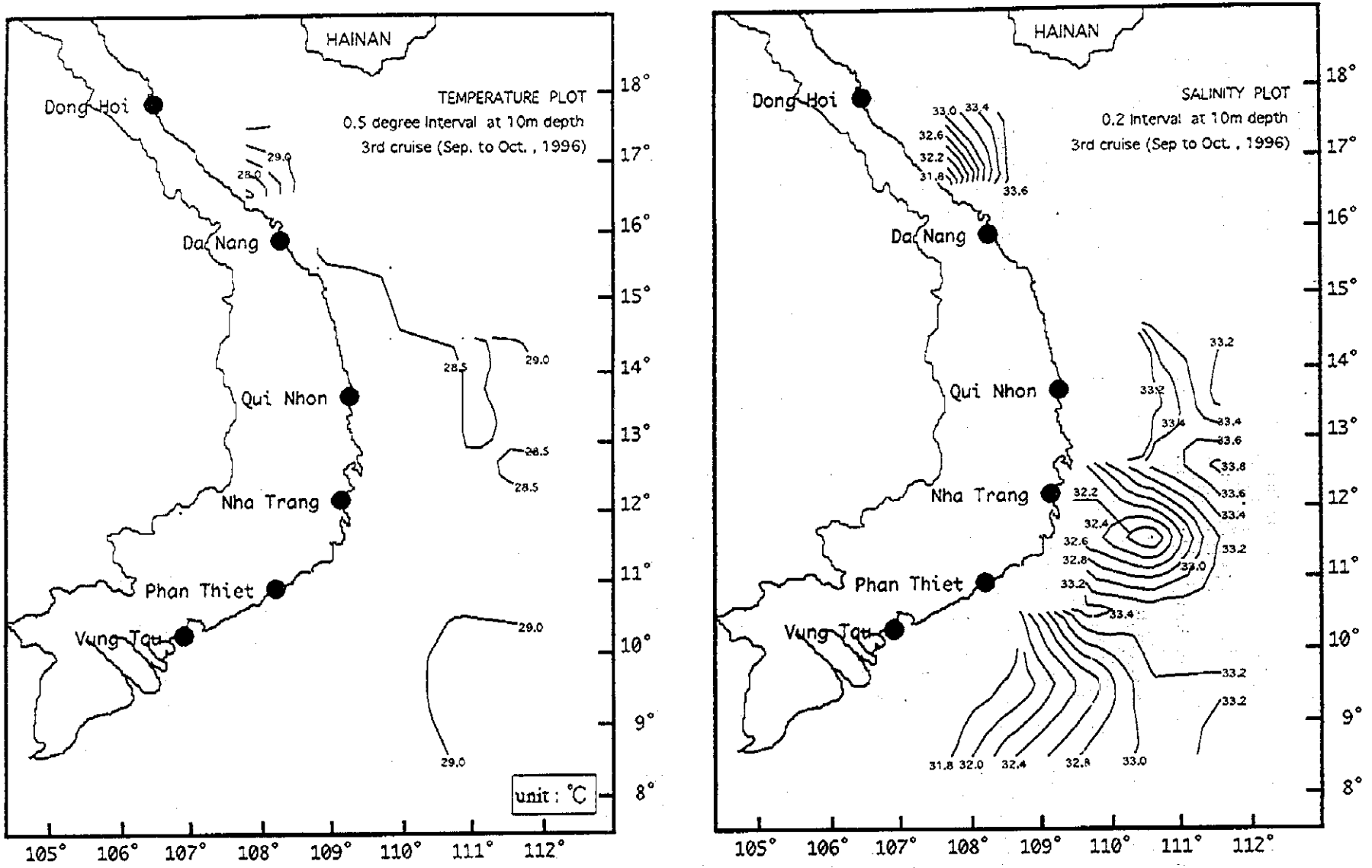
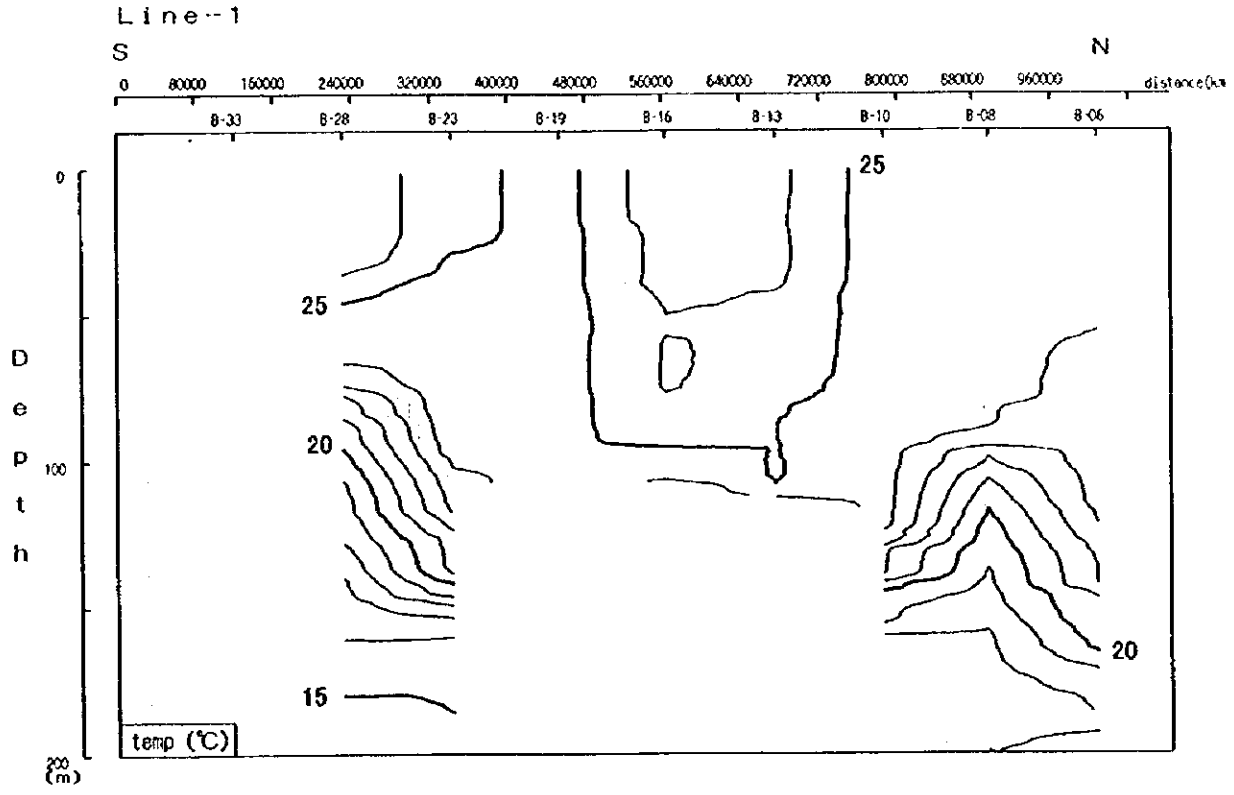


Figure5-9 Horizontal distribution of temperature (0.5℃ interval) and (0.2 interval)
(From Sept. to Oct. 1996, 3rd cruise)



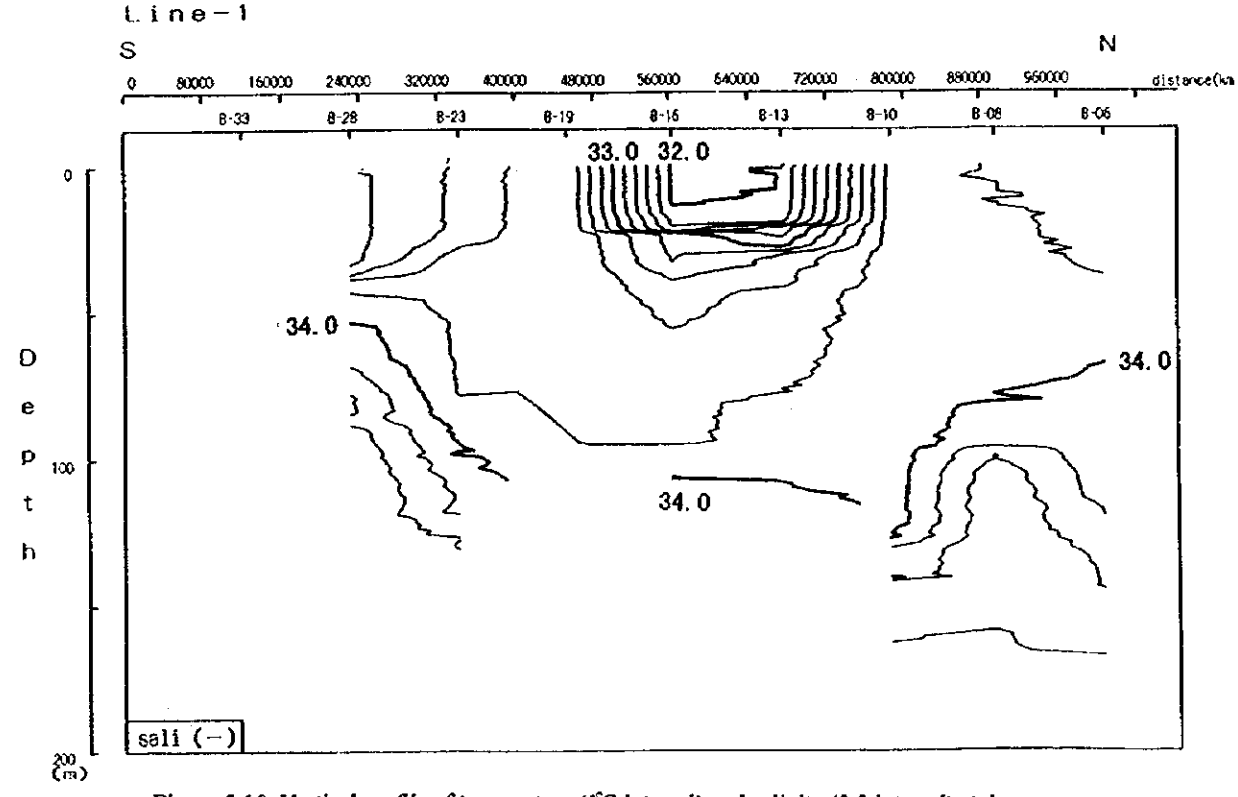
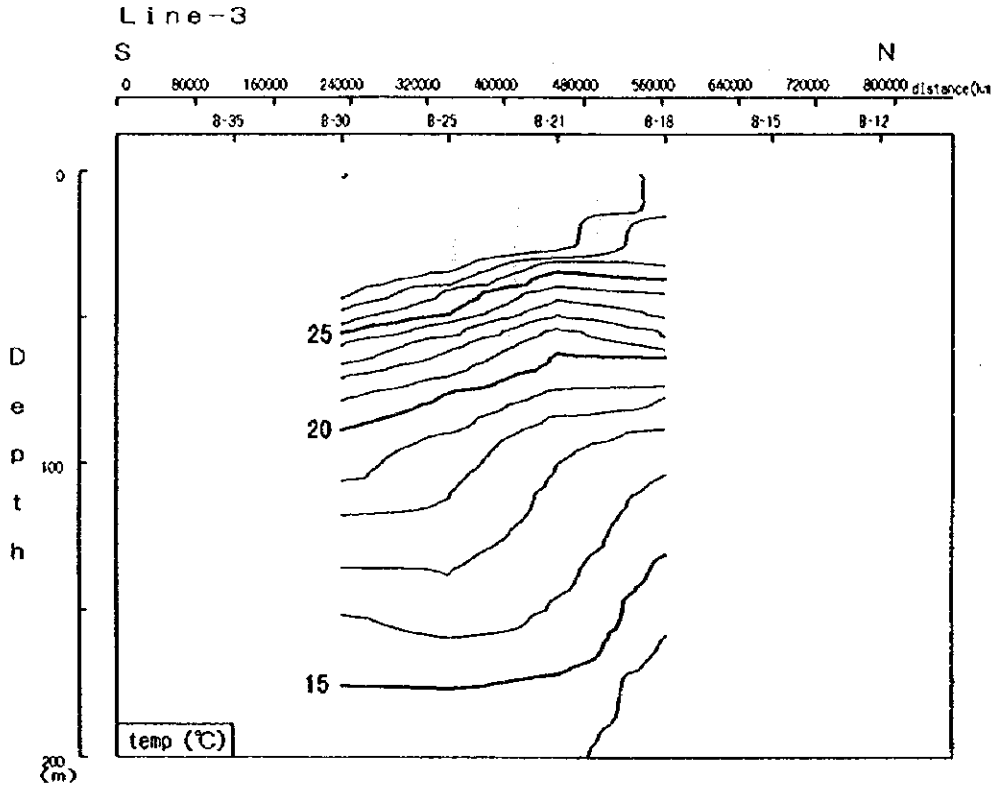


Figure 5-10. Vertical profile of temperature (1℃ interval) and salinity (0.2 interval) at the cross section of LINE-1. (From Nov. to Dec. 1995, 1st cruise)



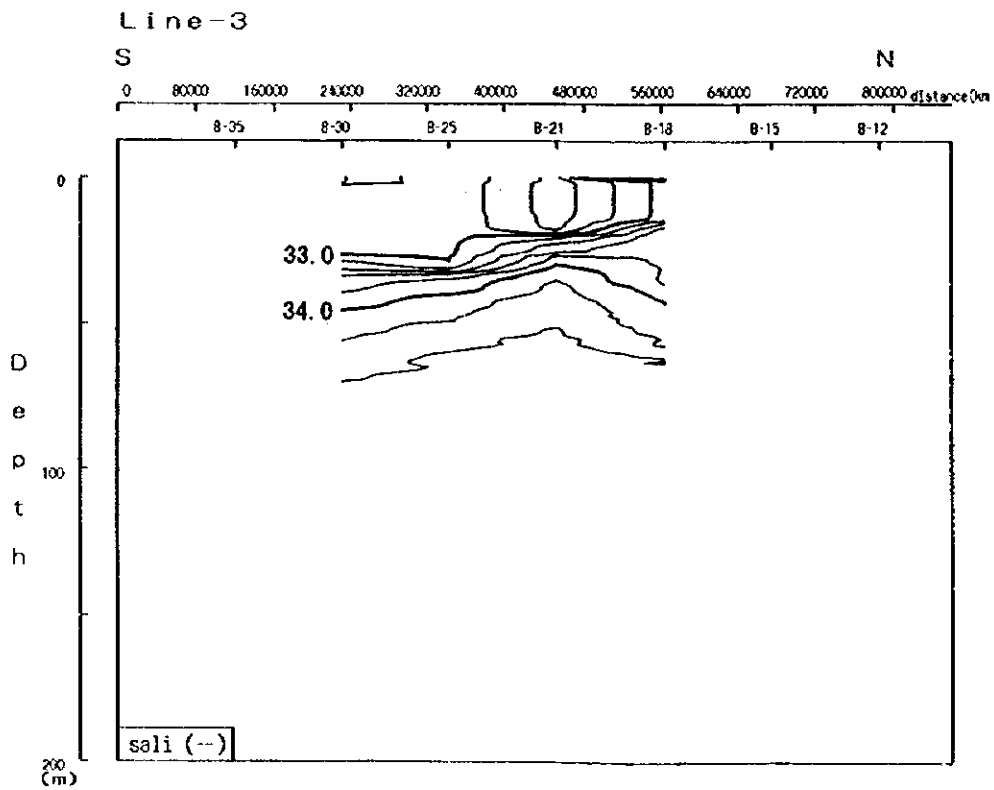


Figure 5-11. Vertical profile of temperature (1℃ interval) and salinity (0.2 interval) at the cross section of LINE-3. (From Nov. to Dec. 1995, 1st cruise)

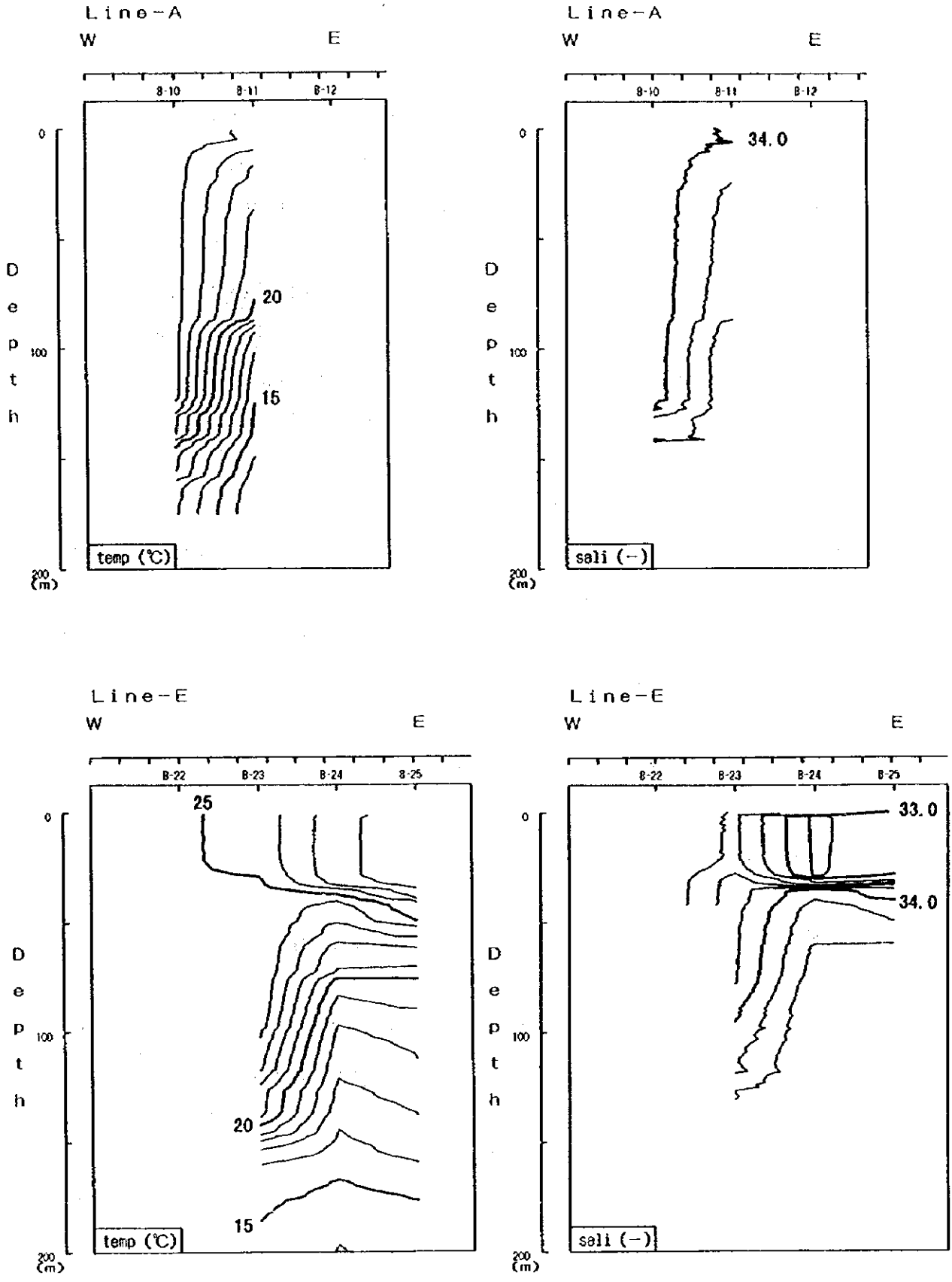


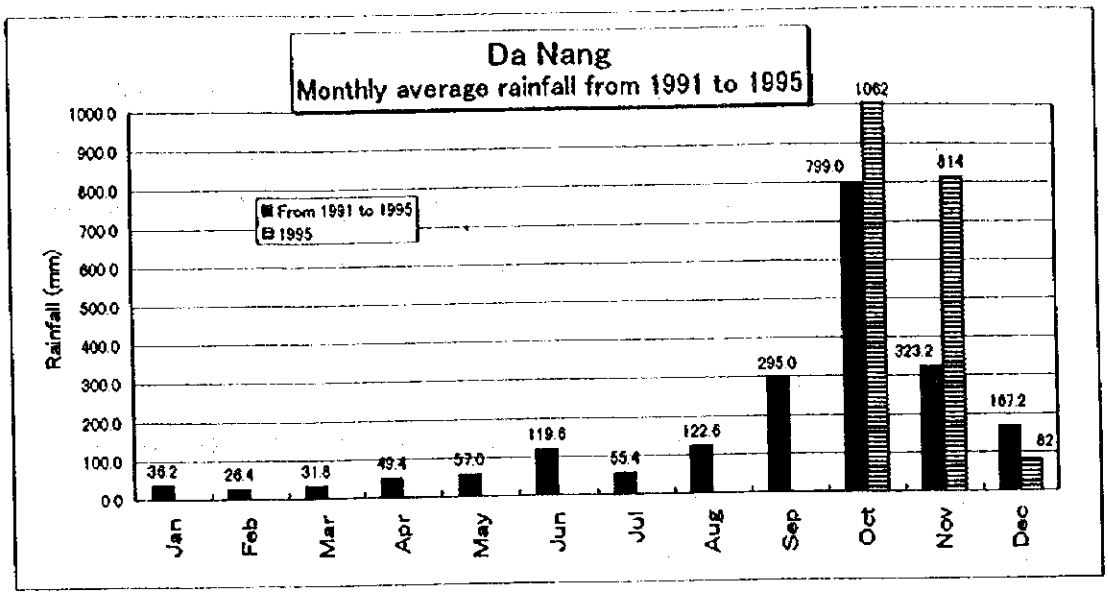
Figure 5-12. Vertical profile of temperature (1℃ interval) and salinity (0.2 interval) at the cross section of LINE-A and E. (From Nov. to Dec. 1995, 1st cruise)

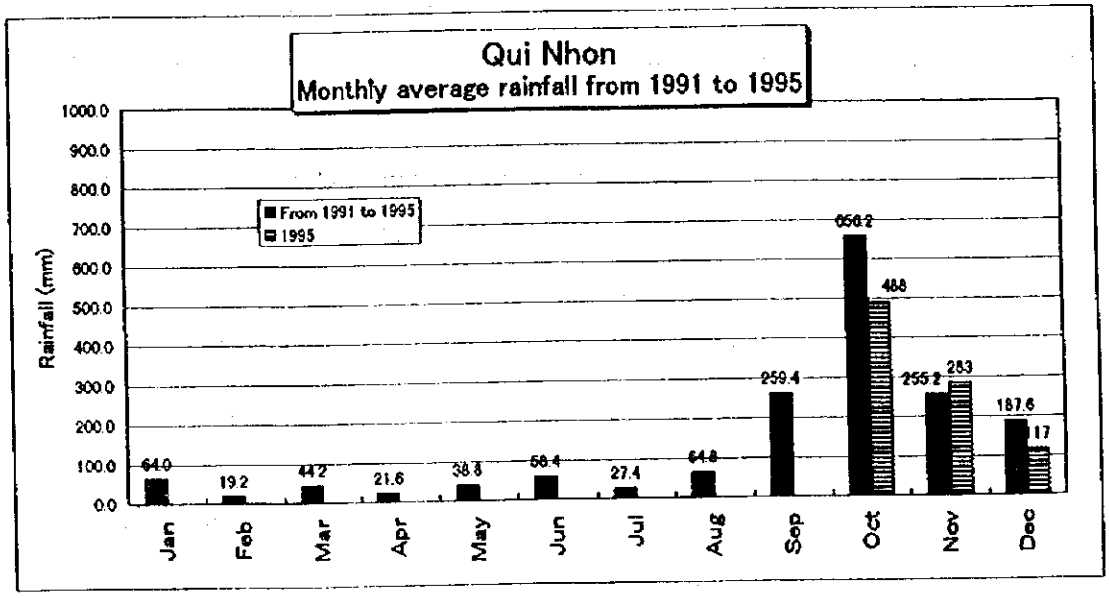
② Late phase

Vertical mixing proceeded with development of the monsoon in November and December. Along Line-1, the mixing layer reached as thick as about 100 m at Stations B-10 and B-19 (Figure 5-10). A thermocline represented by 25℃ occurred at around 100 m or deeper, and the positions changed between Stations B-06 and B-10 in the North Region and between Stations B-23 and B-28 in the South Region. Along Line-3, the mixing layer is thin reaching from sea surface to 30 or 40 m, and north-south thermal gradient was gentle (Figure 5-11). No mixing layer was found on vertical profile along Line-E (Figure 5-12). Thermocline of isotherms of 20℃ to 24℃ that occurred between Stations B-23 and B-24 was found at about 100 to 150 m depth on the west side of Station B-23, while 50 to 75 m on the east side of Station B-25. In addition to difference of depth of thermocline, near-surface temperature was high in the eastern waters but low in the western waters. Vertical mixing appeared to proceed in temperature along Line-1 and vertically homogeneous mixing layer was already formed. On the other hand, the salinity profile indicates the presence of low saline waters around Stations B-13 and B-16 on Line-1 resulting in a large salinity slope of 1.9 between Stations B-13 and B-10.

- ✧ Oceanographic conditions in the late phase are featured by a thick mixing layer of about 100 m in the coastal waters represented by Line-1 and thin mixing layer in the offshore waters represented by Line-3.
- ✧ North-south thermal gradient was steep in a deep layer about 100 m from the sea surface at both northern and southern ends of Line-1. Along Line-3, the thermal gradient was gentle.
- ✧ Low saline water occurred near the sea surface between Stations B-13 and B-16 located between Qui Nhon and Nha Trang, along Line-1, and at Station B-21 along Line-3. Throughout the northeastern monsoon season, the mixing layer developed quickly, especially in the waters near the continent.

Wide extension of low saline water in the surface layer of the coastal side on the Line-1, from Da Nang to Nha Trang, indicates the influence of rainfall in the central and southern Vietnam. As a matter of fact, average precipitation for five years





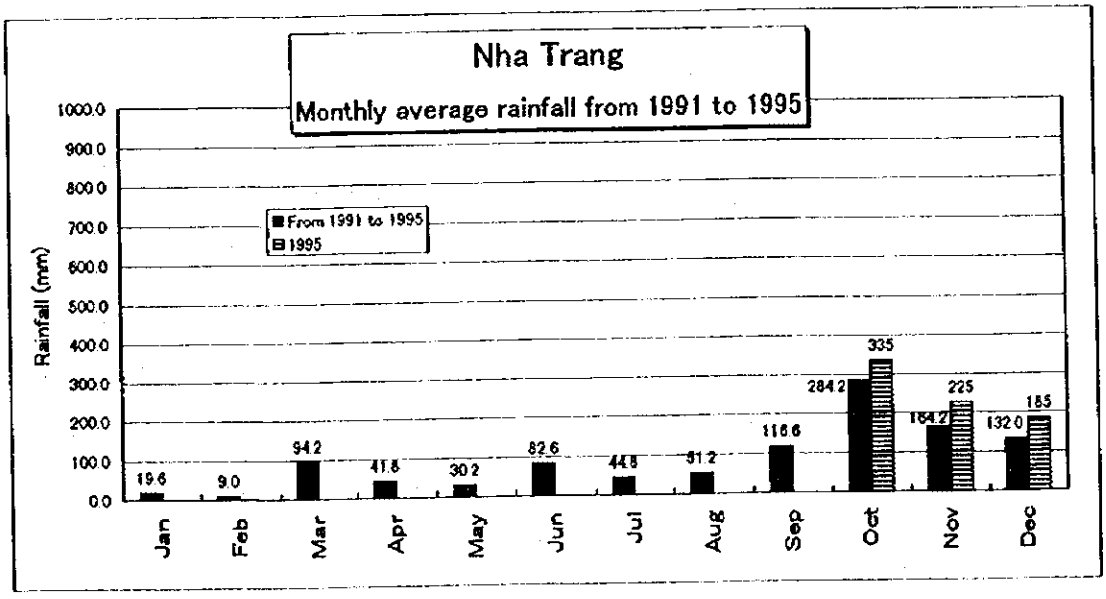


Figure 5-13. Monthly average rainfall form 1991 to 1995 at the center part of Viet Nam

from 1991 to 1995 shows rise of rain fall in October and November in the vicinity of Da Nang, Qui Nhon and Nha Trang (Figure 5-13). In other words, the area under survey is featured by decline of salinity in the surface layer due to heavy rain fall in the Central and South Regions, accompanied with wide horizontal variation of salinity.

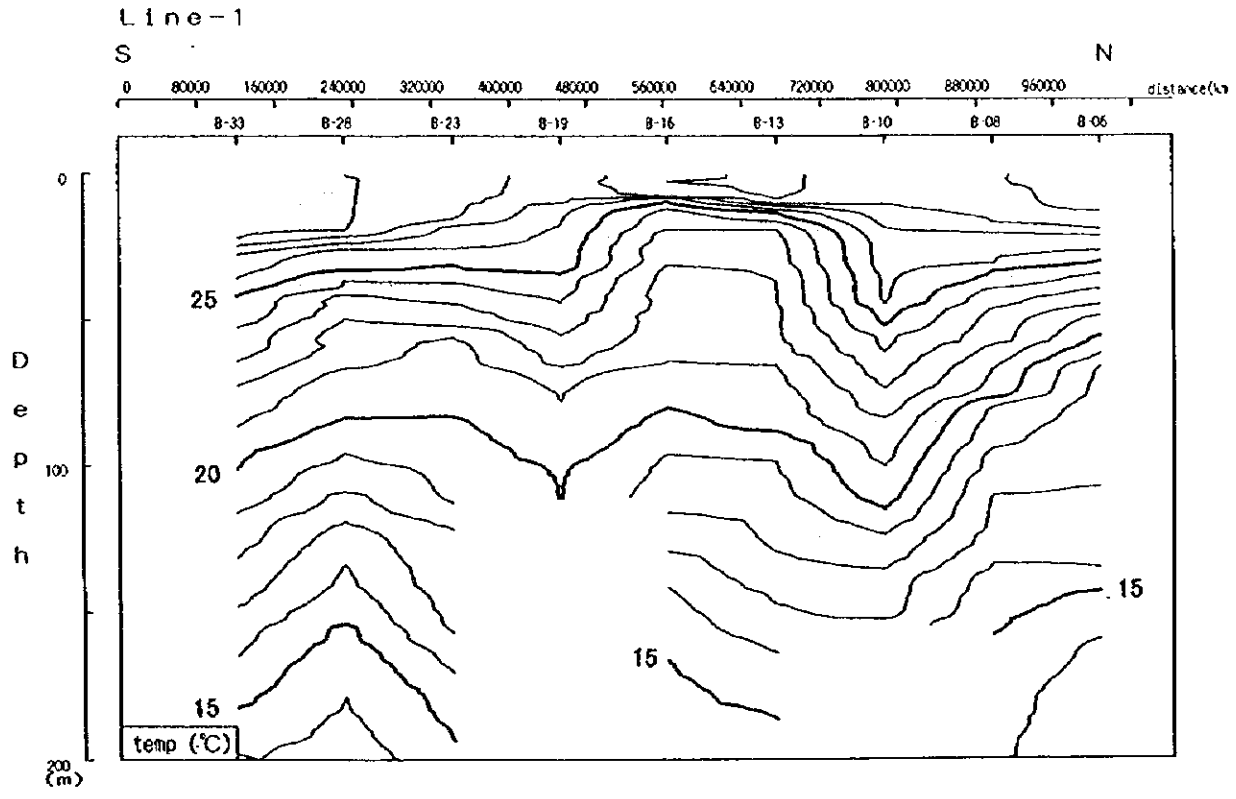
(b) Southwest monsoon season

The second and fourth surveys were executed in almost identical periods, May and June, of 1996 and 1997. Along Line-1 the thermal gradient showed drastic change between Stations B-10 and B-19, where low temperature elevated from mid layer to 10 m depth fig 5-13 (Figure 5-14). A similar vertical profile was found regarding salinity. Temperature was found low at the sea surface around Stations B-10 and B-19, and the salinity seems higher there than in the other part.

North-south thermal gradient was not found and thermocline kept almost constant depth and thickness along Line-2 and 3 (Figures 5-15 and 5-16). Mixing layer found there were very thin, only 20 m below the sea surface. Along the parallels, surface temperature tends to lower in the vicinity of Station B-23 on Line-E (Figure 5-19). Low salinity found at Station B-26 along Line-F is surmised to represent the influence of fresh water from the Mekong River (Figure 5-20).

Position of the thermocline changed remarkably on the parallel, and temperature seems to rise eastward (Figure 5-17 and 5-18). There appeared cold water in the vicinity of Stations B-11 on Line-A, B-16 and B-17 on Line-C, and B-22 on Line-E. East-west gradient was gentle for salinity, and salinity did not show steep east-west gradient found in distribution of temperature.

During the fourth cruise, thermocline and halocline, represented by 25℃ and 33.8, stayed at almost constant depth between Stations B-06 and B-16 along Line-1 (Figure 5-21). However, depth of thermocline and halocline showed significantly between Stations B-16 and B-19, and also between Stations B-23 and B-28 along the same line. Temperature and salinity showed steep gradient between Stations B-17 and B-20 along Line-2, indicating existence of oceanographic north-south homogeneity (Figure 5-22). A similar oceanographic structure was found also on Line-3, with steep



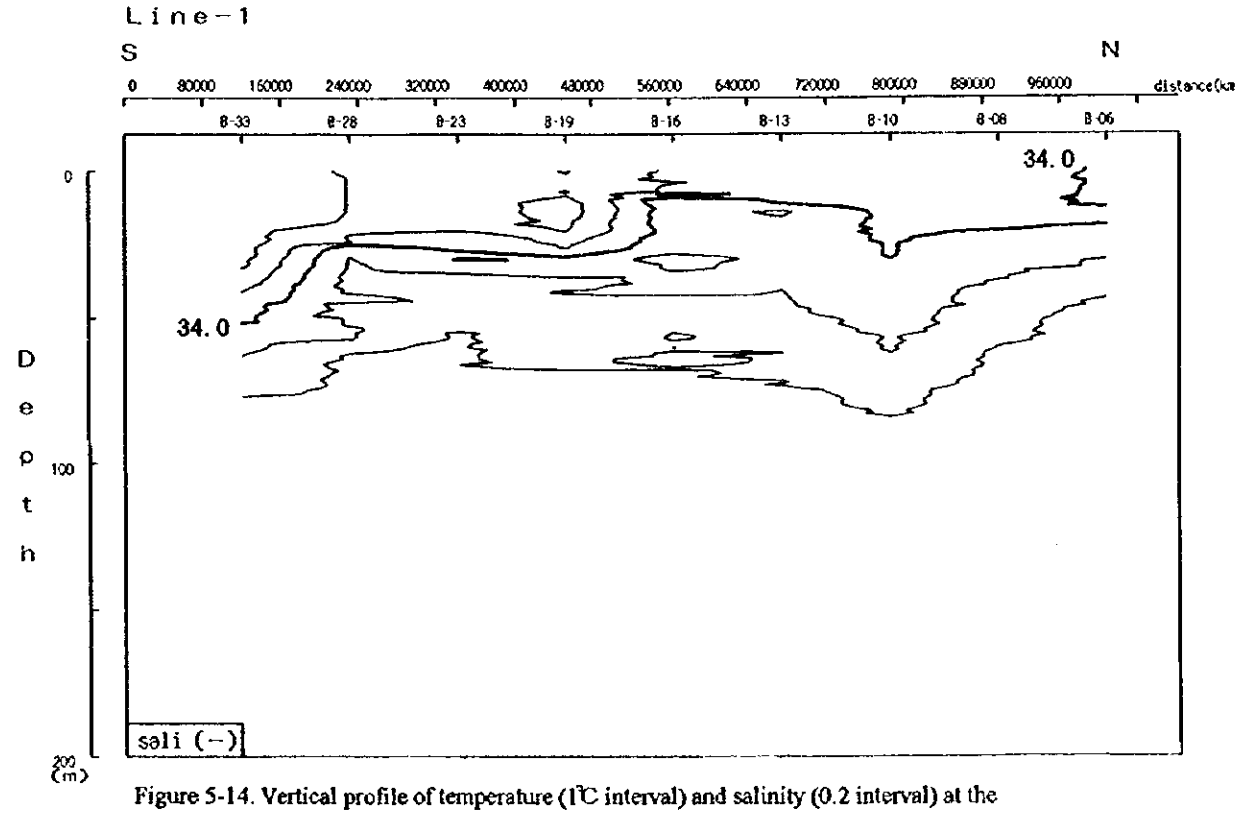


Figure 5-14. Vertical profile of temperature (1℃ interval) and salinity (0.2 interval) at the cross section of LINE-1. (From May to June 1996, 2nd cruise)

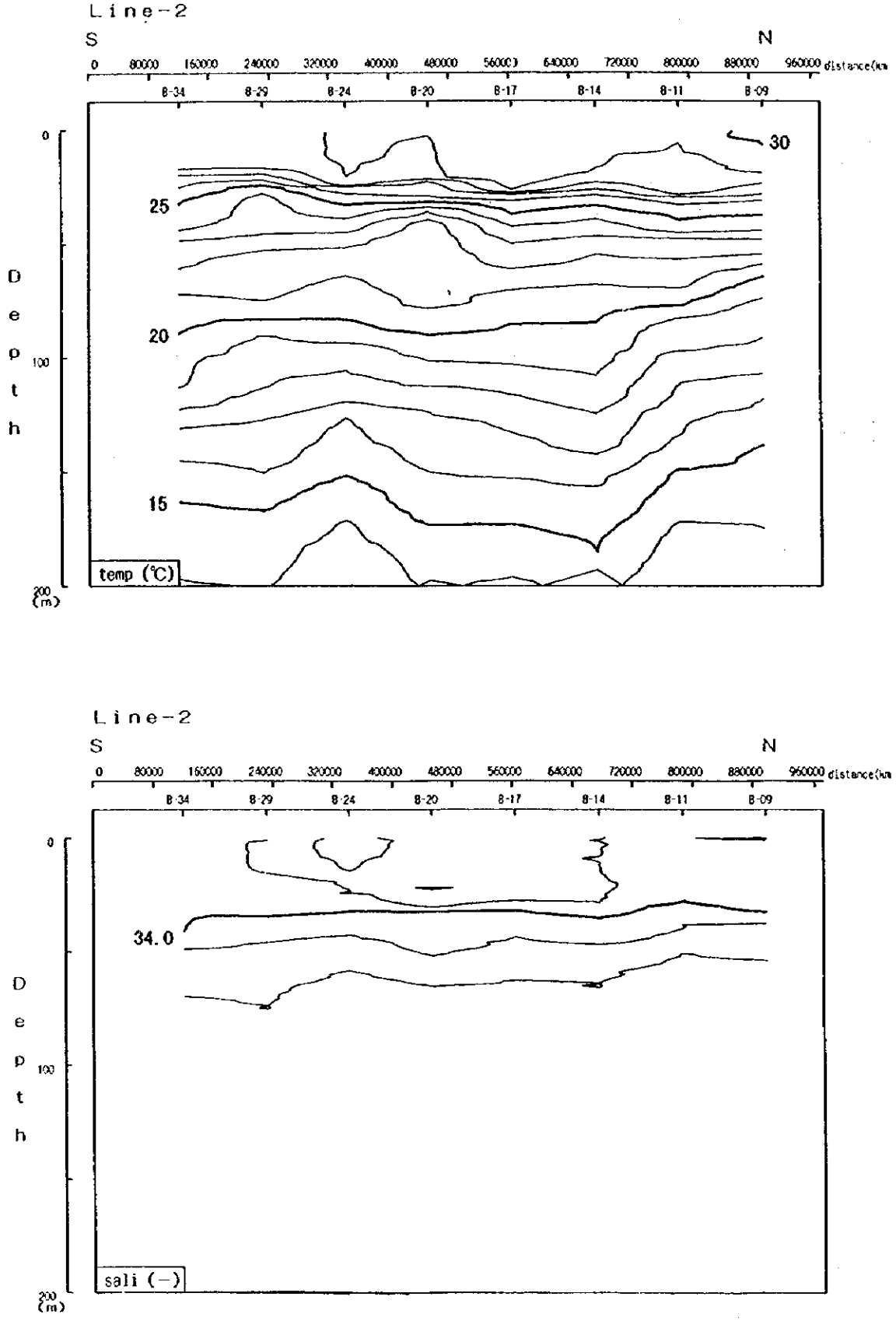
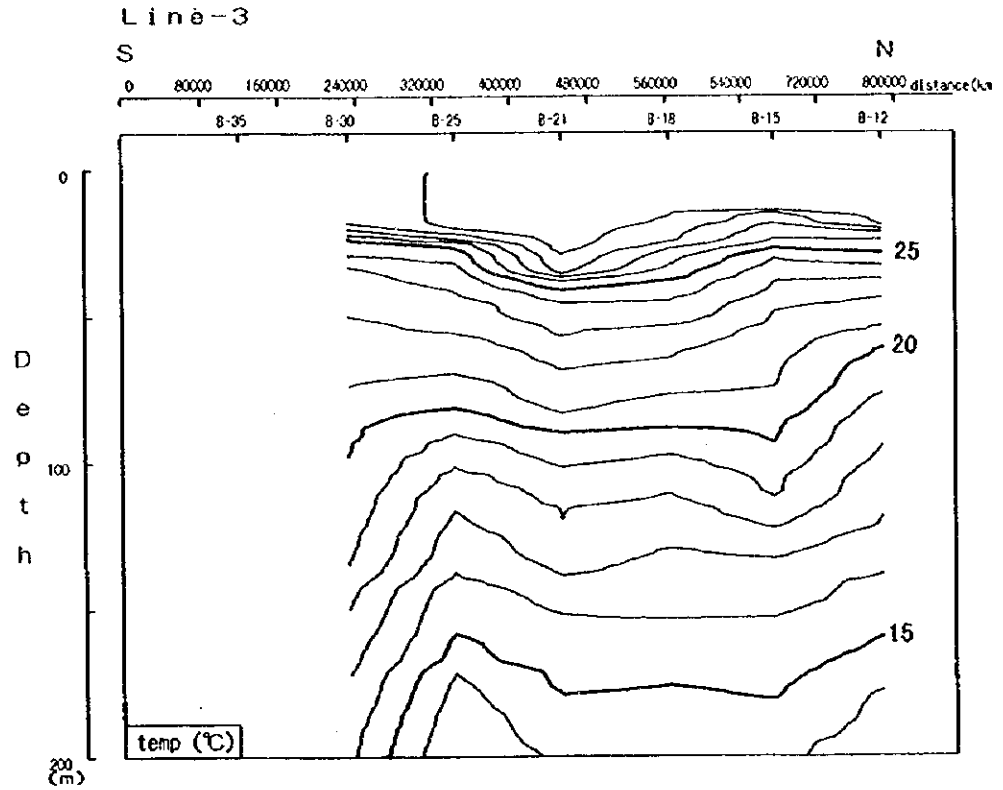


Figure 5-15. Vertical profile of temperature (1℃ interval) and salinity (0.2 interval) at the cross section of LINE-2. (From May to June 1996, 2nd cruise)



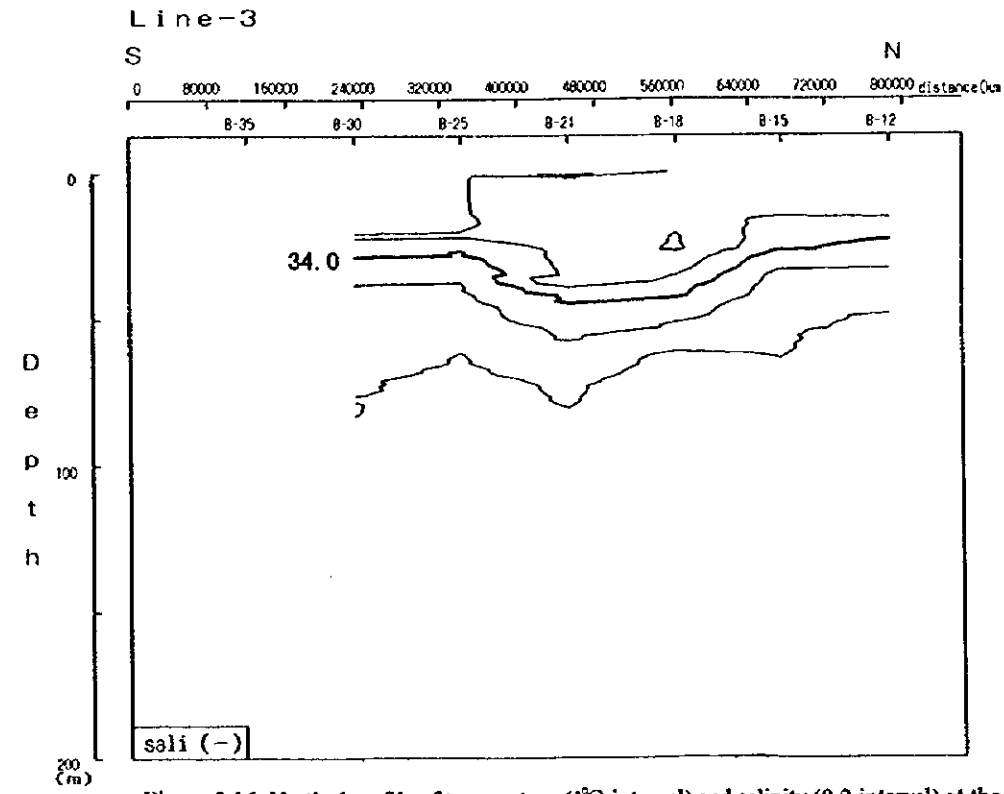


Figure 5-16. Vertical profile of temperature (1℃ interval) and salinity (0.2 interval) at the cross section of LINE-3. (From May to June 1996, 2nd cruise)

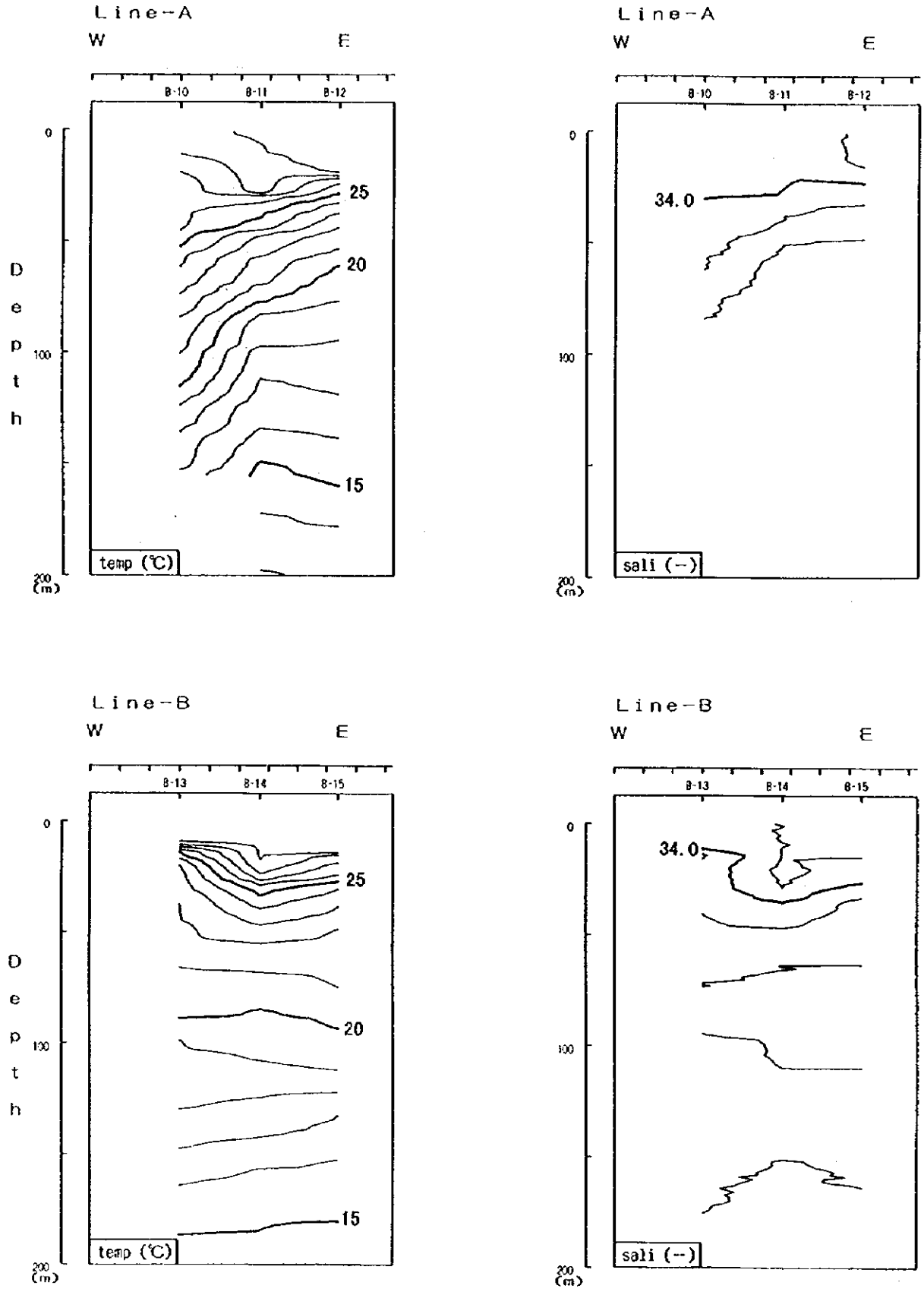


Figure 5-17. Vertical profile of temperature (1℃ interval) and salinity (0.2 interval) at the cross section of LINE-A and B. (From May to June 1996, 2nd cruise)

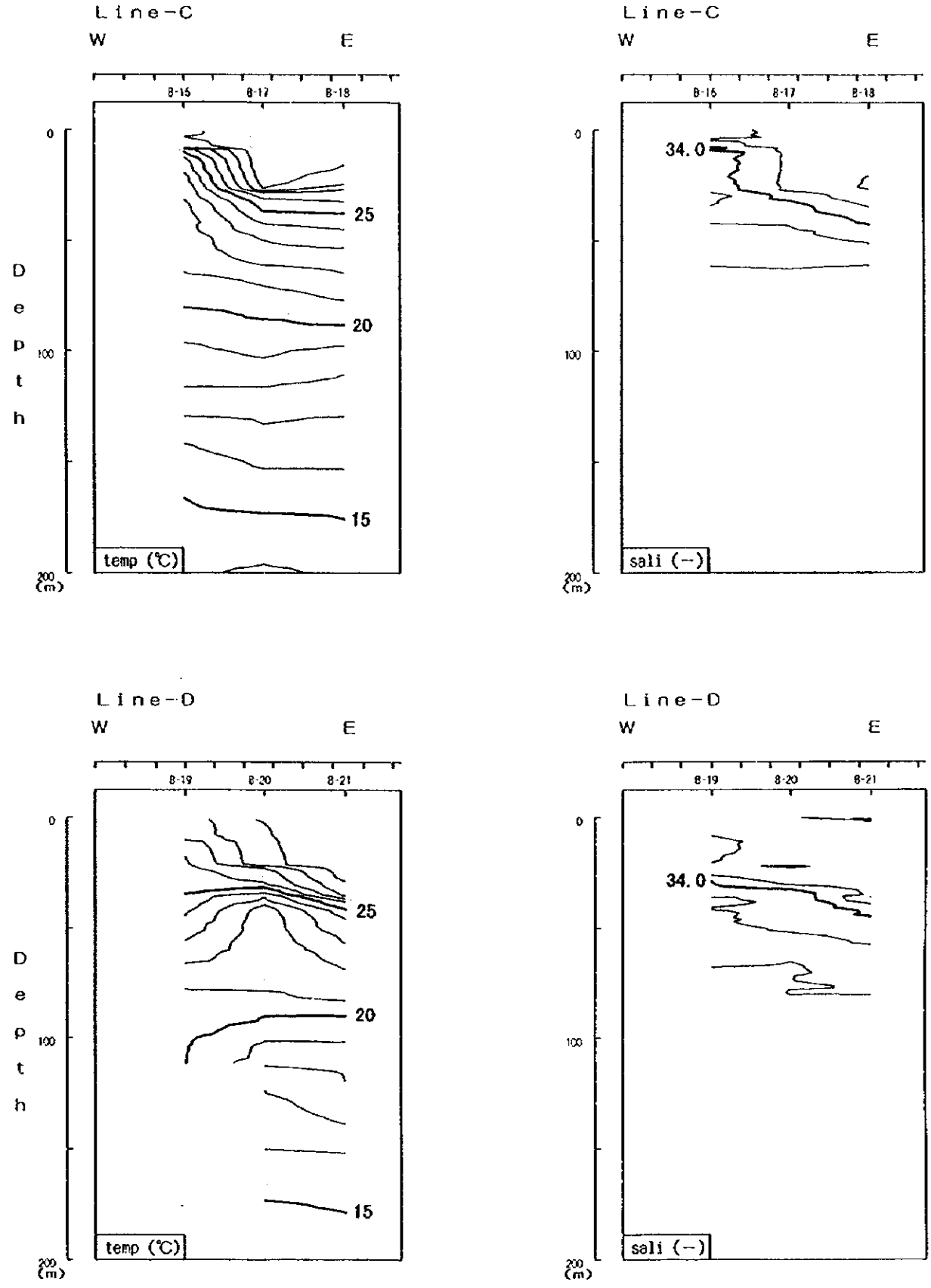
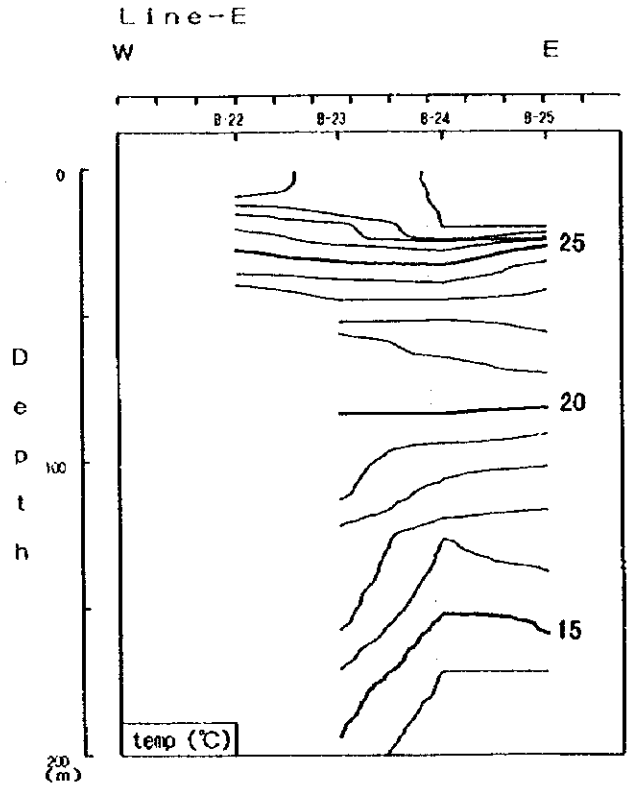


Figure 5-18. Vertical profile of temperature (1℃ interval) and salinity (0.2 interval) at the cross section of LINE-C and D. (From May to June 1996, 2nd cruise)



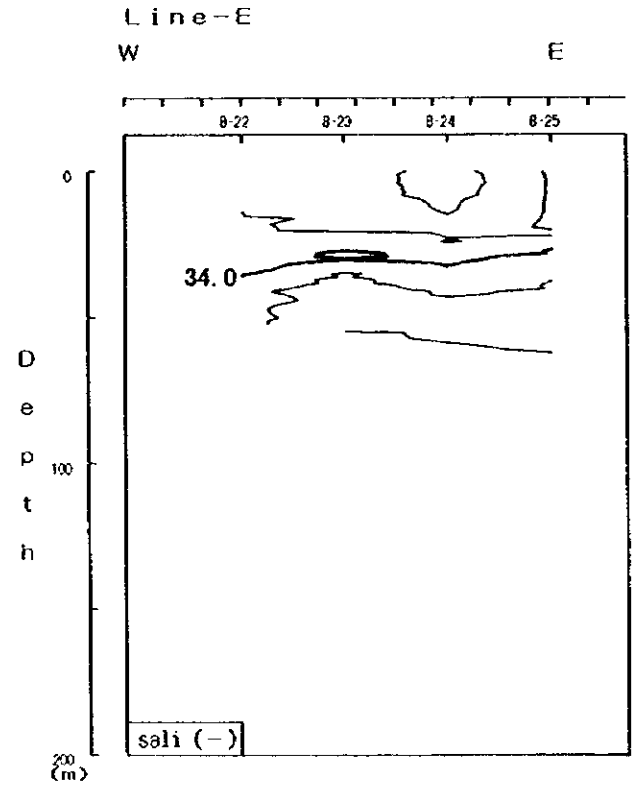


Figure 5-19. Vertical profile of temperature (1℃ interval) and salinity (0.2 interval) at the cross section of LINE-E. (From May to June 1996, 2nd cruise)

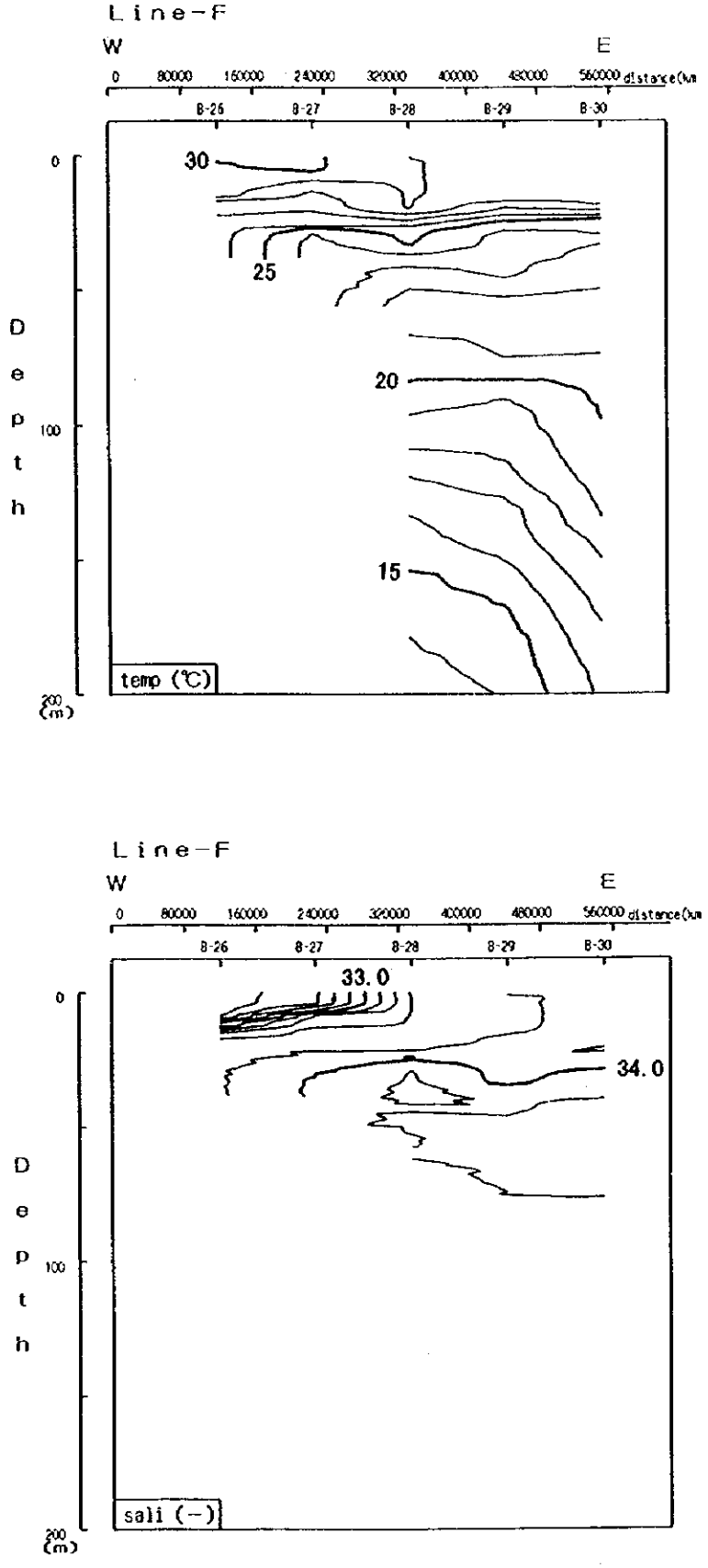
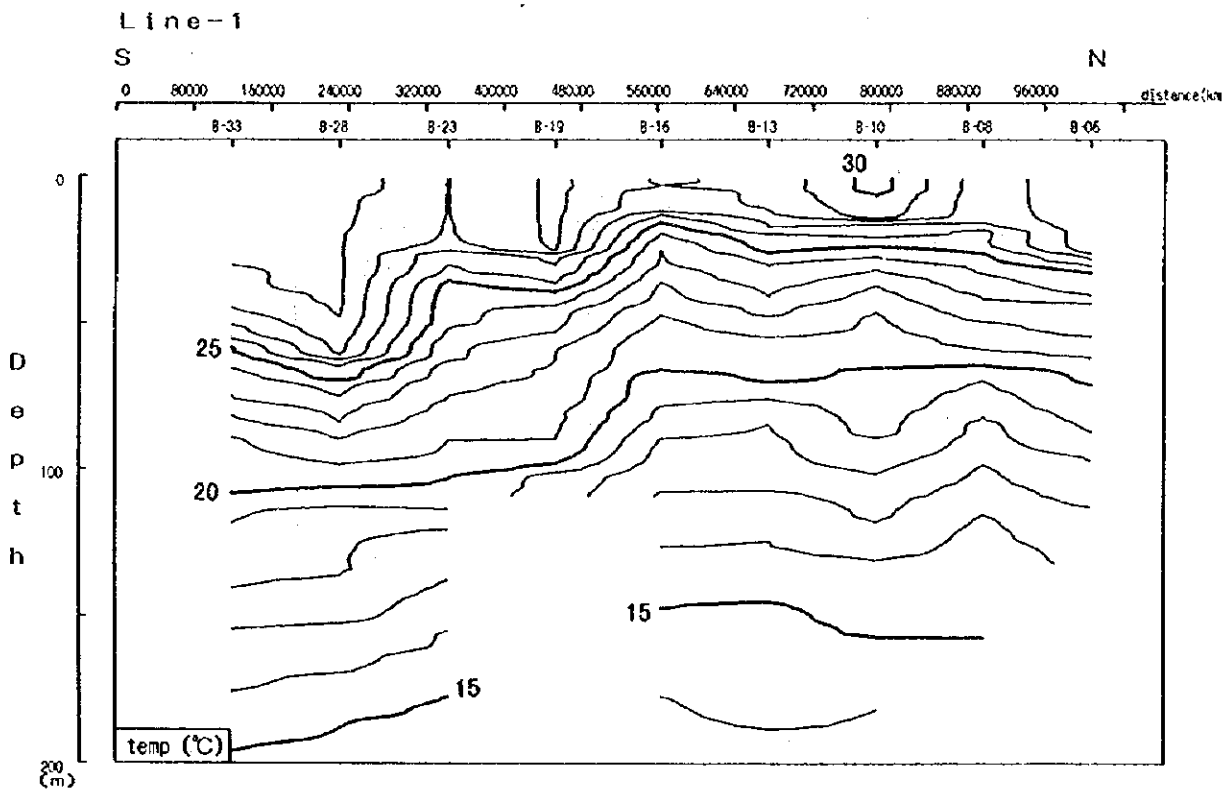


Figure 5-20. Vertical profile of temperature (1℃ interval) and salinity (0.2 interval) at the cross section of LINE-F. (From May to June 1996, 2nd cruise)



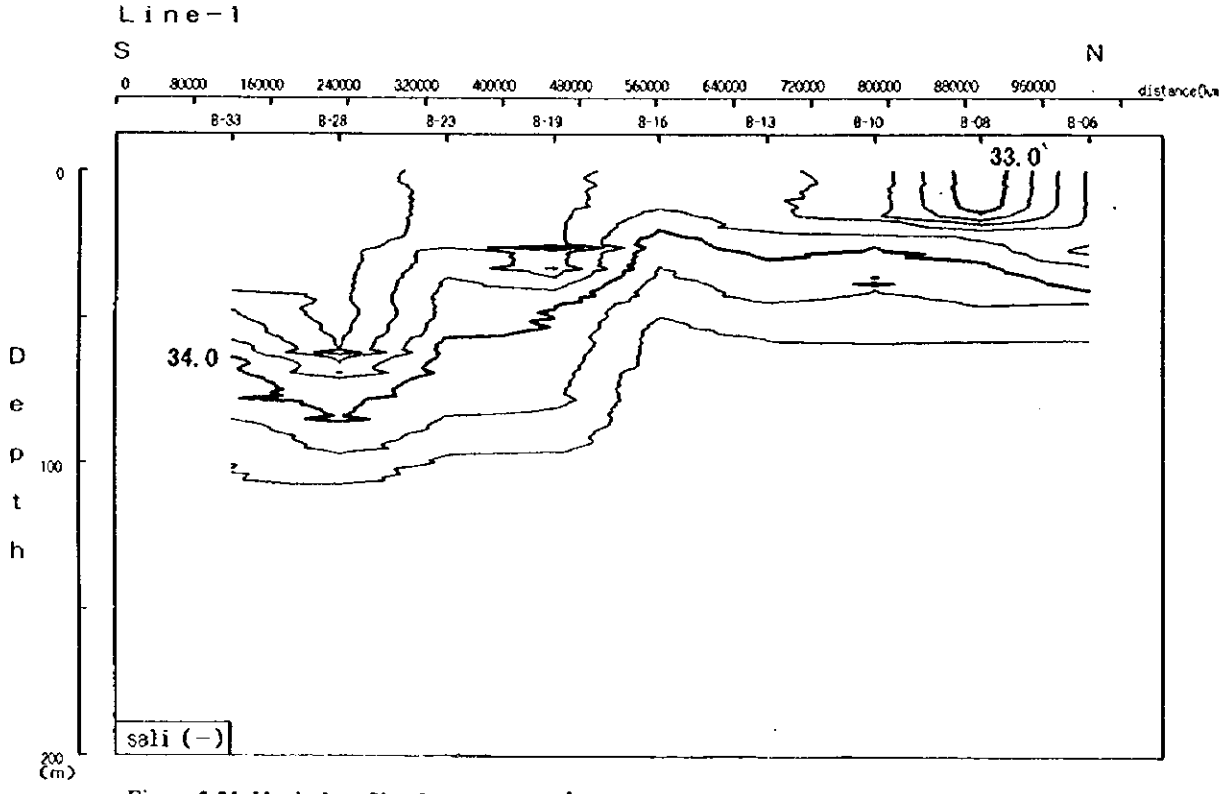
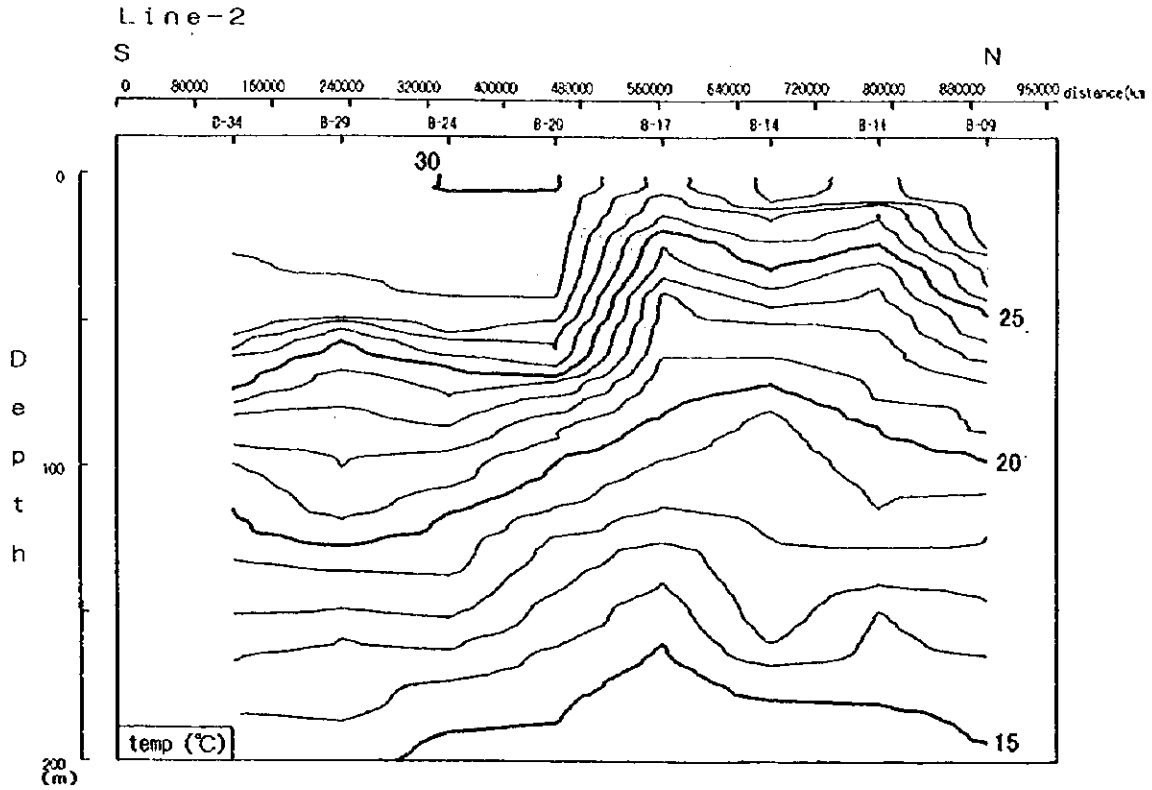


Figure 5-21. Vertical profile of temperature (1℃ interval) and salinity (0.2 interval) at the cross section of LINE-1. (From May to June 1997, 4th cruise)



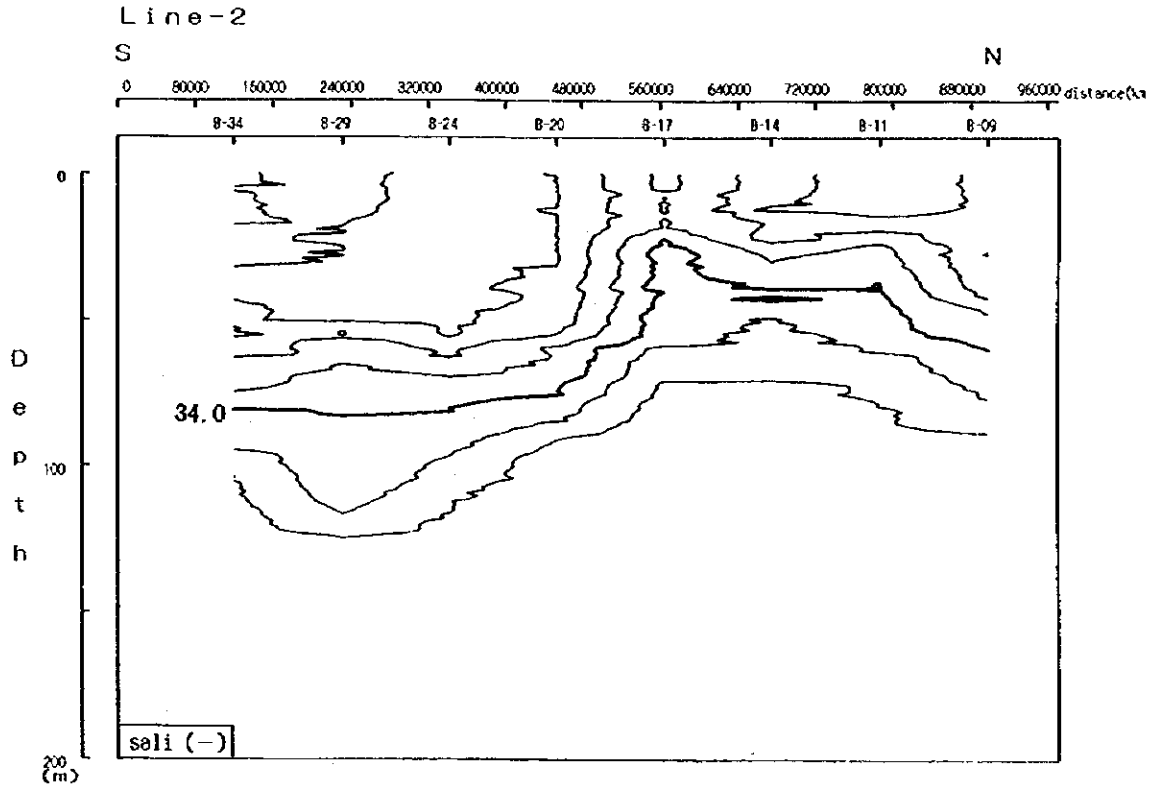
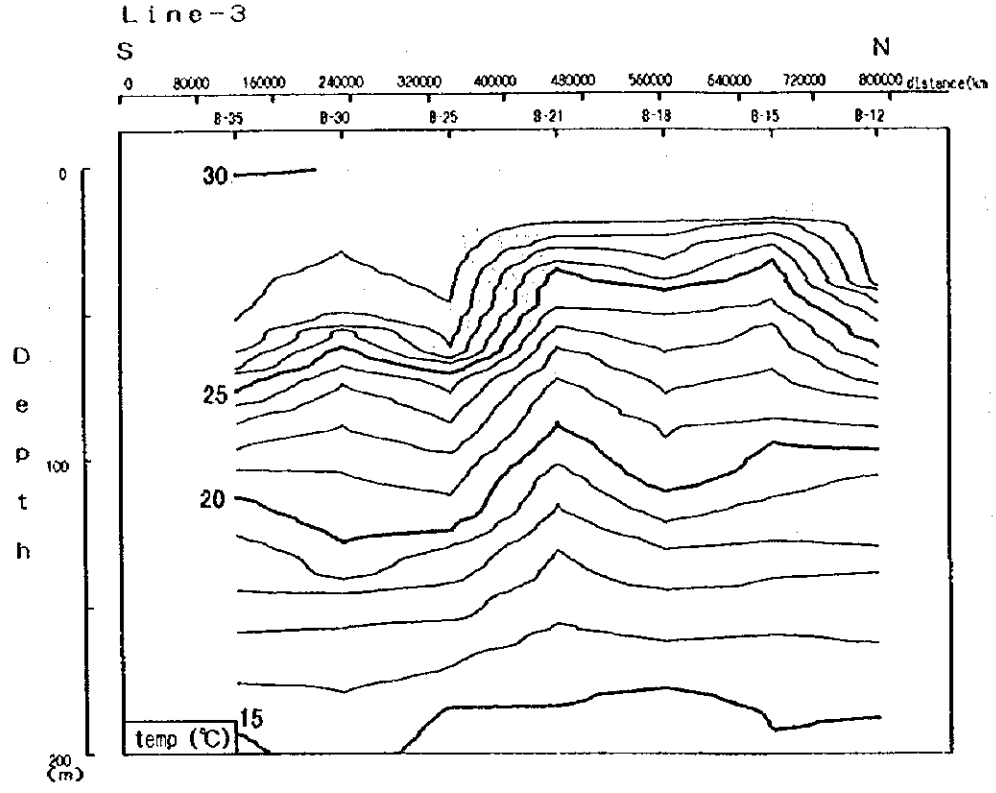


Figure 5-22. Vertical profile of temperature (1℃ interval) and salinity (0.2 interval) at the cross section of LINE-2. (From May to June 1997, 4th cruise)



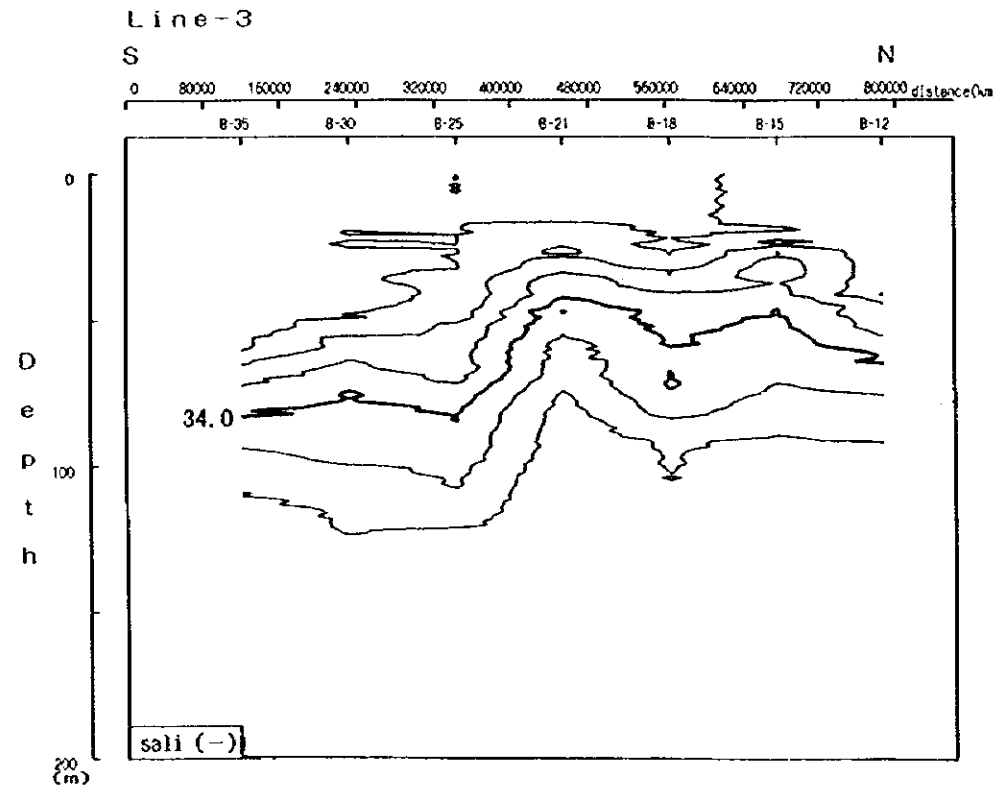


Figure 5-23. Vertical profile of temperature (1℃ interval) and salinity (0.2 interval) at the cross section of LINE-3. (From May to June 1997, 4th cruise)

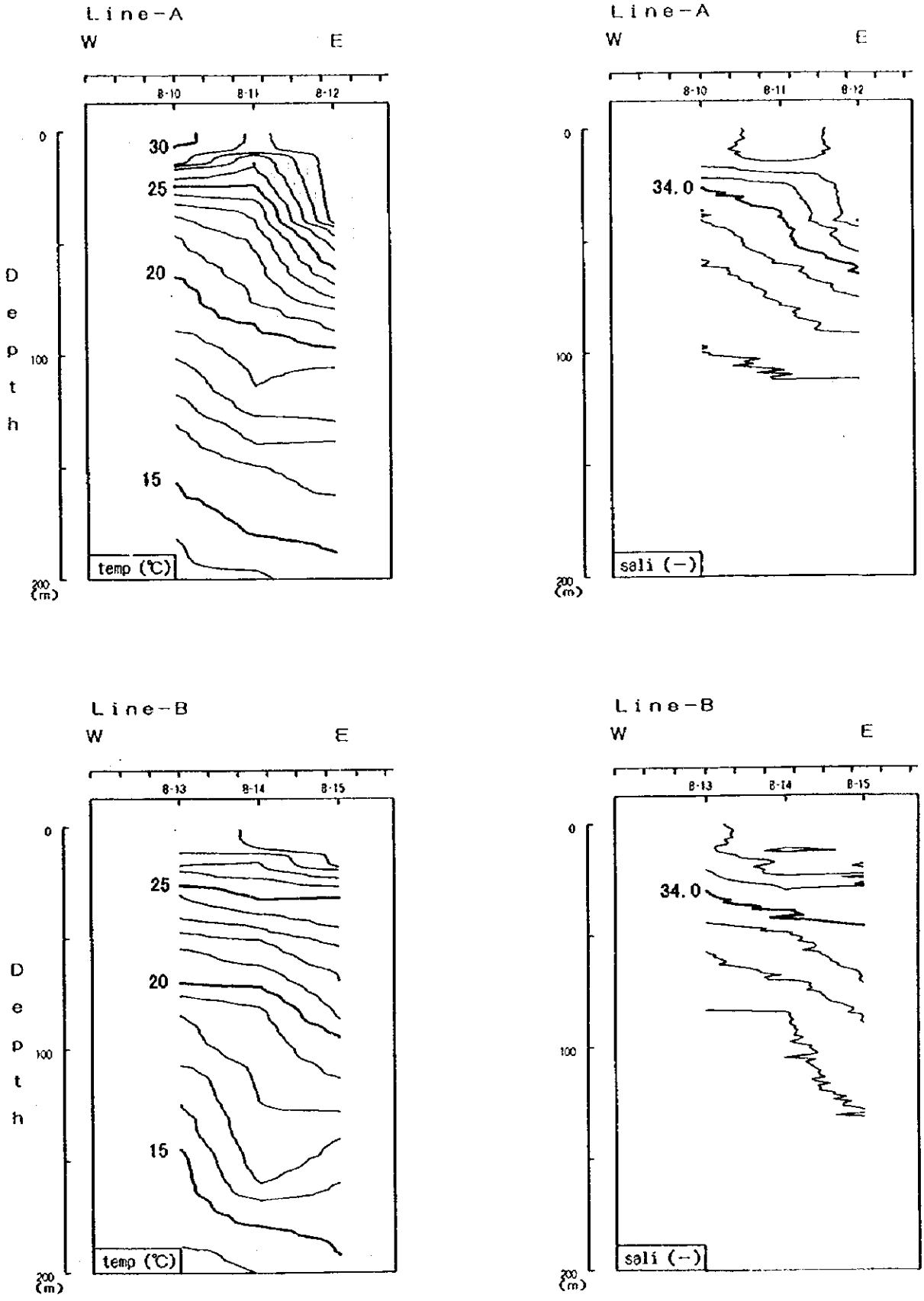


Figure 5-24. Vertical profile of temperature (1℃ interval) and salinity (0.2 interval) at the cross section of LINE-A and B. (From May to June 1997, 4th cruise)

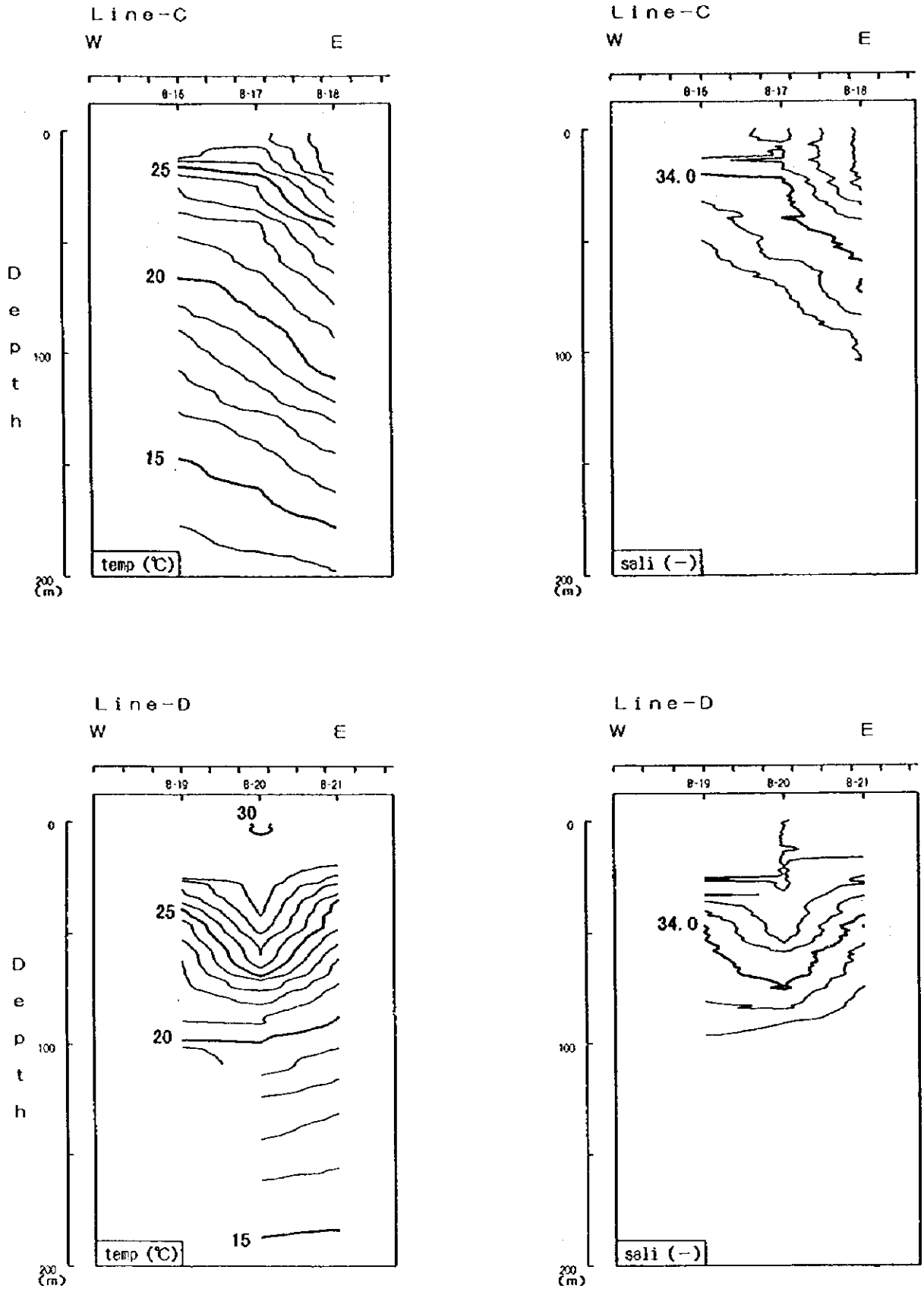
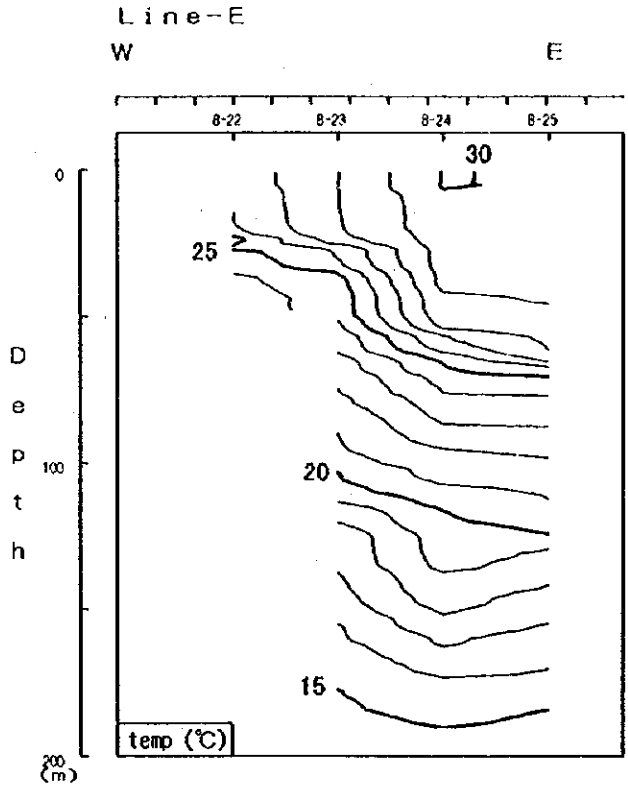


Figure 5-25. Vertical profile of temperature (1℃ interval) and salinity (0.2 interval) at the cross section of LINE-C and D. (From May to June 1997, 4th cruise)



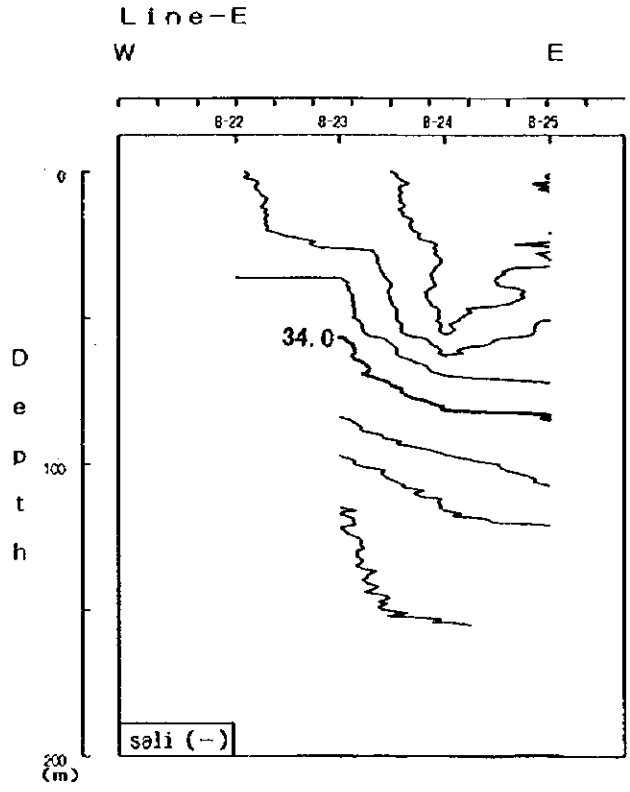


Figure 5-26. Vertical profile of temperature (1℃ interval) and salinity (0.2 interval) at the cross section of LINE-E. (From May to June 1997, 4th cruise)

gradient between Stations B-21 and B-25 (Figure 5-23). Mixing layer did not appear along Line-1, or limited south of Station B-20 on Line-2. Along Line-3, the mixing layer existed keeping the thickness almost constant between Stations B-12 and B-25, then increased the thickness southward. Vertical profiles along Line-A, C and E indicate that both thermocline and halocline tended to be shallow westward and deep eastward (Figures 5- 24 to 26). Mixing layer found on Line-D reached to the deepest layer at the Station B-20, and became shallower on both east and west sides. Low temperature and high salinity were found in the vicinity of Stations B-16, B-23 and B-17. In general, at deep layer the temperature is lower, and the salinity is higher than those at surrounding stations. This indicates existence of up-welling around the area in question.

Examination of data at sub-surface layer of 10 m depth indicates the low temperature and high salinity in the waters off north of Da Nang and Nha Trang in both 1996 and 1997 (Figures 5-27 and 5-28). Some oceanographic features differed between the same seasons of different years. Water mass of low temperature and high salinity was found off Phan Thiet at the 4th survey, but not at all at the 2nd survey. Existence of water mass with low temperature and high salinity found on horizontal distribution seems to be brought due to existence of up-welling. Horizontal isotherm contours appear close each other around the above cold areas. On the other hand, isohaline contours are widely spaced everywhere except in the vicinity of estuary of the Mekong River. Thus, temperature is a useful indicator to understand horizontal changes in the oceanographic conditions.

- ✧ During the southwest monsoon season, vertical profiles of temperature and salinity closely resemble with each other.
- ✧ Horizontal change is significant for temperature, but of only slightly effected on salinity. Both vertical profile and horizontal distribution of temperature and salinity indicate features inherent to the up-welling.
- ✧ Such features appeared at both 2nd and 4th surveys in the waters north of Da Nang and off Nha Trang.

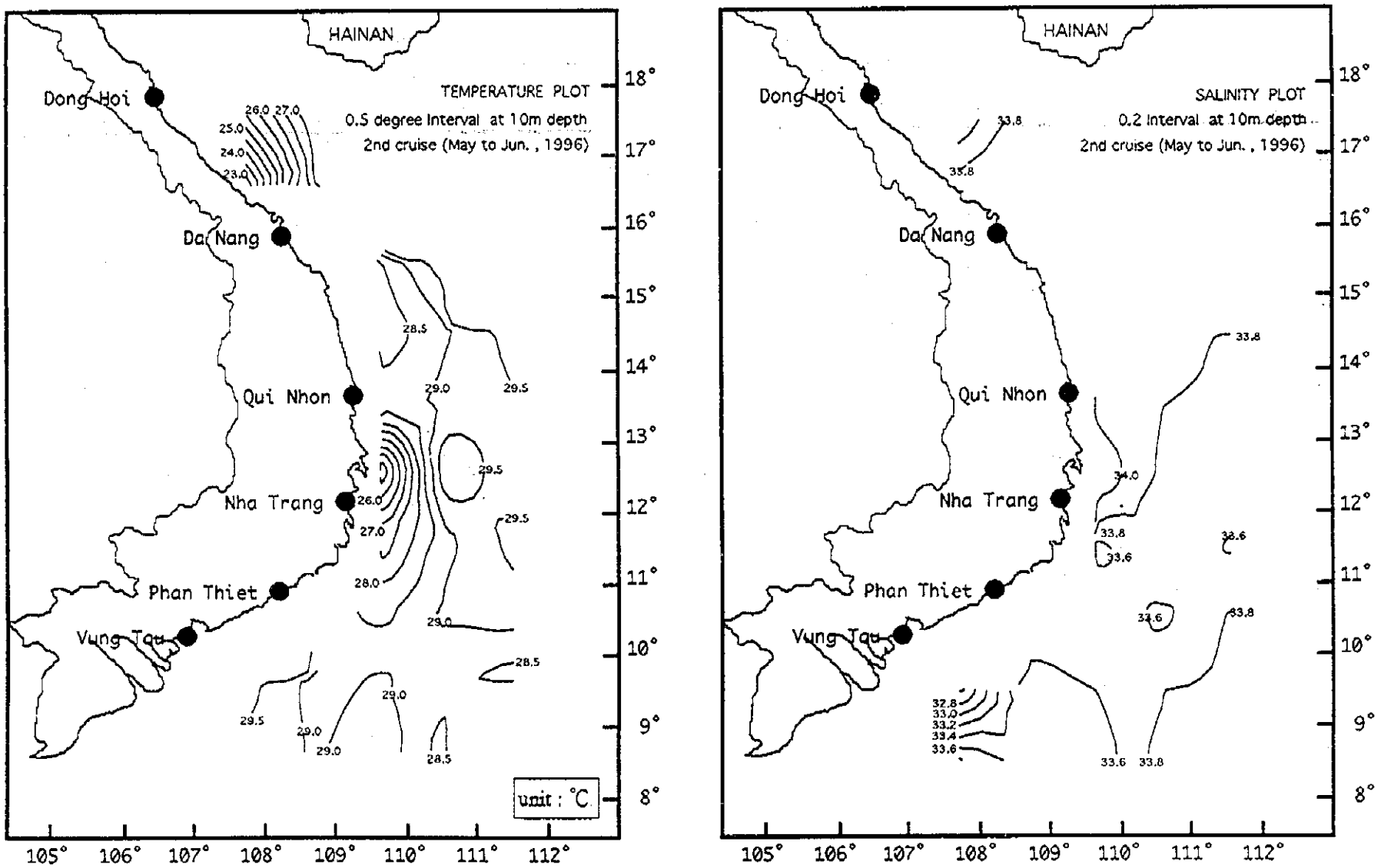


Figure5-27 Horizontal distribution of temperature (0.5℃ interval) and (0.2 interval)
(From May to June 1996, 2nd cruise)

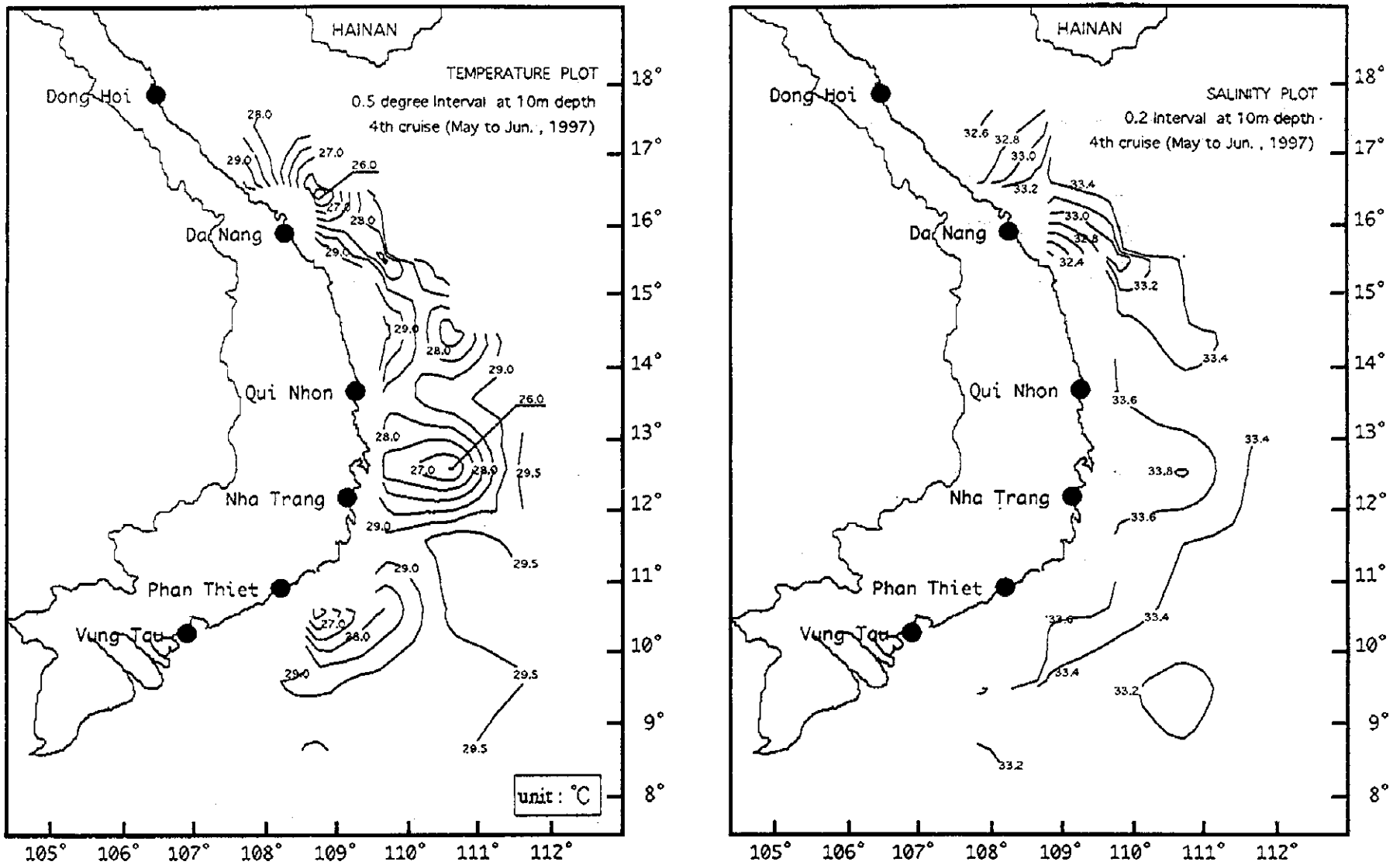


Figure5-28 Horizontal distribution of temperature (0.5℃ interval) and (0.2 interval) (From May to June 1997, 4th cruise)

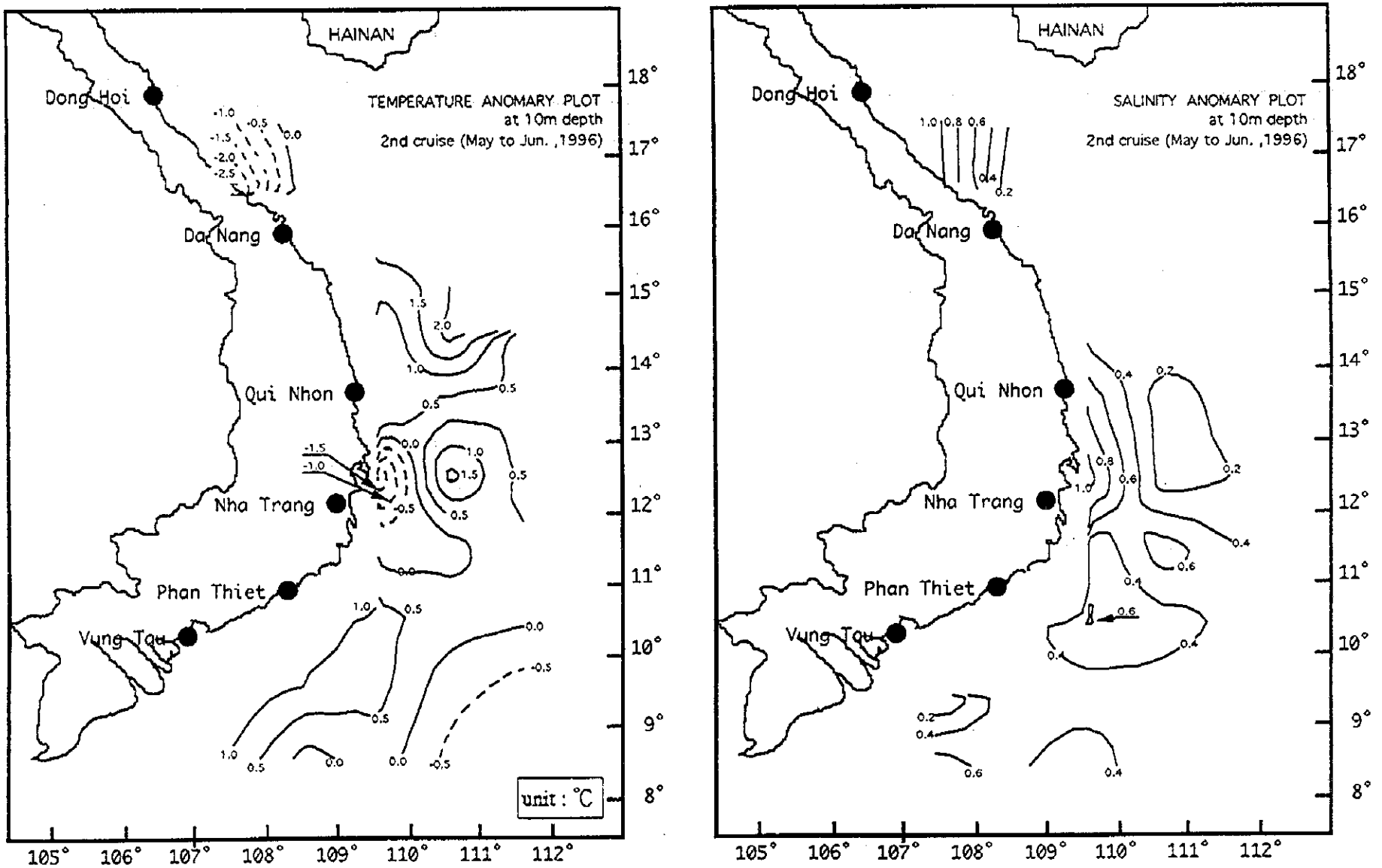


Figure 5-29A Horizontal distribution of temperature (0.5 ℃ interval) and salinity (0.2 ℃ interval) anomaly. (From May to June 1996, 2nd cruise)

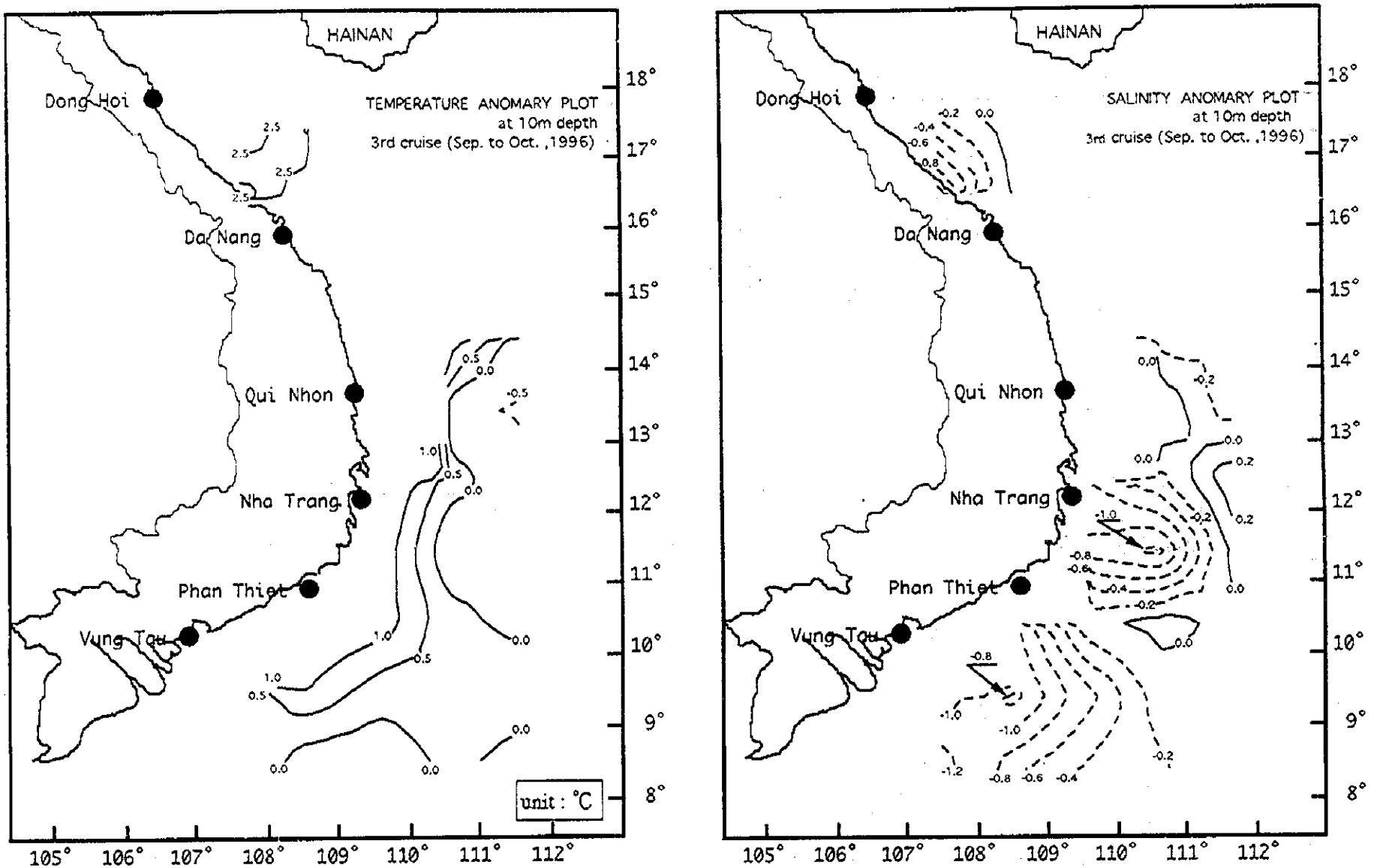


Figure 5-29B Horizontal distribution of temperature (0.5 ℃ interval) and salinity (0.2 ℃ interval) anomaly. (From Sept. to Oct. 1996, 3rd cruise)

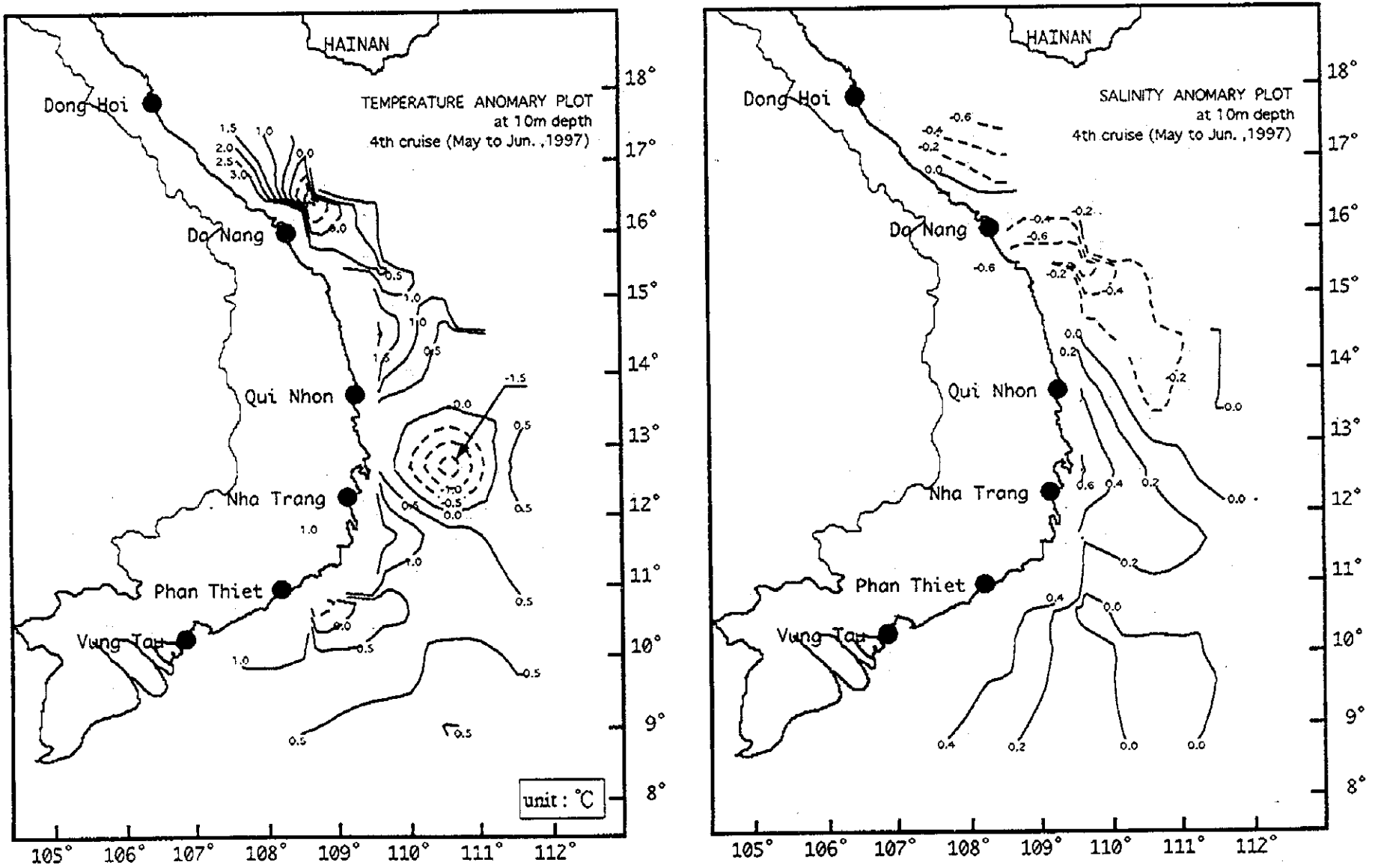


Figure 5-29C Horizontal distribution of temperature (0.5 ℃ interval) and salinity (0.2 ℃ interval) anomaly. (From May to June 1997, 4th cruise)

(c) Concluding remarks of analysis of temperature and salinity data

①Up-weling

Data for temperature and salinity were taken during four cruises which covered twice each southwest and northeast monsoon seasons. Examination of the data presents several oceanographic findings. First of all, the analysis indicates existence of up-welling in the southwest monsoon season. At the aim to show the up-welling more clearly, the "anomaly" was calculated at each station from an average of four measurements (Figures 5-29A to 5-29C). Tentative values of the present report may still provide some idea on the oceanography in this area. As already described in section 5-1, further oceanographic surveys are required for more accurate evaluation of the anomalies in order to assure precise discussion on changes of the environmental conditions of the valuable fish resources. In these figures, the anomalies were given at the intervals of 0.5℃ for temperature, and of 0.2 for salinity, and expressed by solid and dashed lines for positive and negative values, respectively.

During the early northeast monsoon season represented by data taken during the 3rd survey, this anomaly was as high as +2.5℃ in the waters off north of Da Nang to off Phan Thiet Absolute values found in the other sea areas were limited between 0℃ to 1.0℃. In the exceptionally warm area, there appeared low saline waters suggesting the influence of rainfall. Thermal anomaly in the southwest monsoon season covered by the 2nd and 4th surveys shows the existence of cold area off north of Da Nang and Nha Trang, where saline anomalies were positive. Positions of negative thermal anomalies and positive saline anomalies coincide with each other in the seasons of both 1996 and 1997. It is likely that up-welling has existed throughout the two cruise periods in the waters from north Da Nang to Phan Thiet.

② Seasonal and year-to-year changes of thermocline

A vertical boundary of two water masses appears as discontinuity layers for several environmental factors, e. g. thermocline of temperature and halocline of salinity. In sea areas with extensive seasonal changes of climate, thermoclines occur due to heating and cooling of water, and haloclines represent change of specific gravity

related to evaporation and precipitation, and the convective mixing layer even reaches down to 100-200m below the sea surface. The upper part characterized by such seasonal changes of oceanographic factors is called the seasonal zone against the non-seasonal zone where these abiotic factors stay within a limited range throughout the year.

Figure 5-30 shows the thermocline determined by vertical distribution of temperature and salinity measured at oceanographic stations covered by each of the first through fourth survey cruise. For reference, the depth of salinity contour of 34.0 is given in figure 5-31. Numerals for the missing stations are interpolated by the values found at the neighbor stations covered in the same cruise, and shown by parentheses in the attached tables. The depth of sea bottom is substituted at each station where the discontinuity layer was not identified due to development of a mixing zone.

(i) Late phase of northeastern monsoon season (November and December 1995)

No thermocline was observed in the coastal water shallower than 100m during the survey period when homogeneous water mass covered the whole depth range of the sea surface to the sea bottom. The overall average depth in the whole survey area was 76 m, the deepest value among the figures found in the four survey cruises. Extensive convection due to cooling of waters appears to have formed a single vertically homogeneous water mass from the sea surface to sea bottom in the coastal area shallower than 100 m. Thermoclines at the same latitude tend to be shallower in the offshore waters than those in the coastal zones, seemingly reflecting intrusion of the offshore water masses

expanding toward the coast

(ii) Southwestern monsoon season (May and June 1996)

Thermoclines found in the southwestern monsoon season appear to have been formed by the following procedure. The mild southwestern wind and rise of atmospheric temperature warmed the sea surface, then the mixing layer found in the northeastern monsoon season was replaced rapidly by the stratified layer, and so the thermocline shifted upward to 10 m - 30 m. Figure 5-30 indicates that the thermocline moved toward the sea surface over the whole survey area.

Cruise	Latitude Zone		15-16° N			14-15° N			13-14° N			12-13° N			11-12° N			10-11° N				09-10° N					08-09° N					Mean
	Duration	B06	B07	B08	B09	B10	B11	B12	B13	B14	B15	B16	B17	B18	B19	B20	B21	B22	B23	B24	B25	B26	B27	B28	B29	B30	B31	B32	B33	B34	B35	
1st	NE monsoon (Nov. ~ Dec. /95)	145	(120)	95	70	140	90	(40)	110	(80)	(50)	100	(70)	60	[100]	[55]	30	[45]	150	35	40	[40]	[75]	75	40	55	[50]	(85)	(80)	80	(85)	78
2nd	SW monsoon (May ~ June /96)	20	(30)	20	30	15	30	20	10	30	15	10	30	25	15	25	35	10	20	25	25	15	25	25	20	20	25	25	25	20	(20)	22
3rd	NE monsoon (Sept. ~Oct. /96)	(45)	(50)	55	(45)	50	35	25	(55)	30	20	60	30	20	60	55	60	35	55	85	75	30	55	50	60	60	30	70	55	65	75	50
4th	SW monsoon (May ~ Jun. /97)	30	(20)	20	25	15	10	40	20	10	20	15	20	40	25	70	35	20	30	55	65	35	35	65	50	55	55	75	55	60	70	39

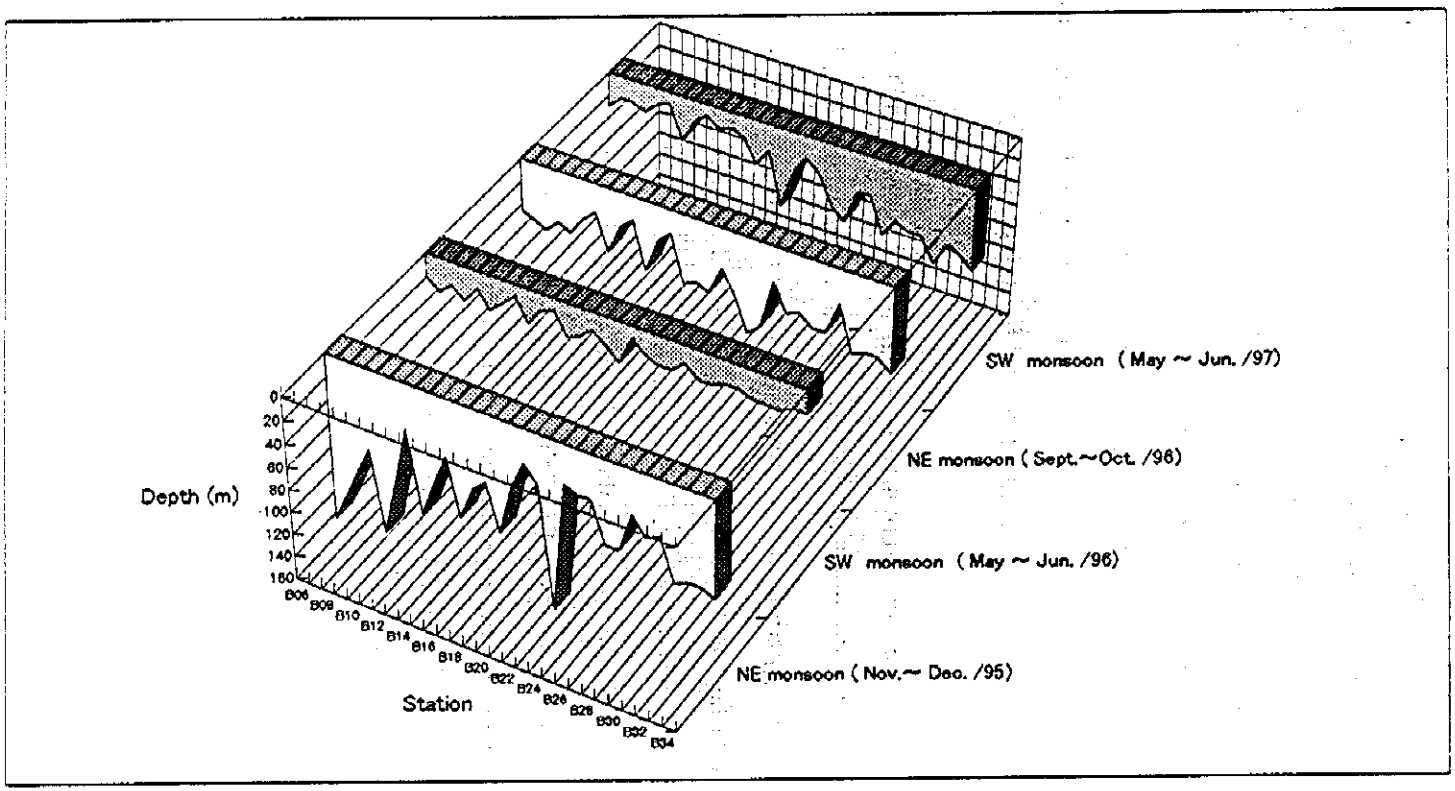


Figure 5-30 The distribution of thermocline determined by vertical profile of temperature and salinity measured at oceanographic stations covered by each of the 1st through 4th survey cruise.

Cruise	Latitude Zone		15-16° N			14-15° N			13-14° N			12-13° N			11-12° N			10-11° N				09-10° N					08-09° N					Mean
	Duration	B06	B07	B08	B09	B10	B11	B12	B13	B14	B15	B16	B17	B18	B19	B20	B21	B22	B23	B24	B25	B26	B27	B28	B29	B30	B31	B32	B33	B34	B35	
1st	NE monsoon (Nov. ~ Dec. /95)	70	(110)	80	55	130	10	(50)	110	(20)	(60)	110	(35)	40	[10]	(55)	30	[45]	100	35	40	[40]	[50]	55	45	45	[50]	(70)	(50)	55	(50)	63
2nd	SW monsoon (May ~ Jun. /96)	10	(10)	20	30	30	25	20	10	35	25	10	30	40	30	30	45	35	25	30	25	(30)	30	25	35	30	[50]	[40]	50	40	(45)	29
3rd	NE monsoon (Sept. ~ Oct. /95)	(40)	(40)	50	(35)	35	35	30	(40)	20	15	50	30	20	65	60	65	(35)	45	90	85	[40]	[50]	55	75	70	(50)	70	65	75	80	54
4th	SW monsoon (May ~ Jun. /97)	40	(20)	30	60	25	40	65	30	40	45	20	25	60	45	75	40	(35)	55	80	85	[40]	50	85	85	75	(50)	80	65	90	85	56

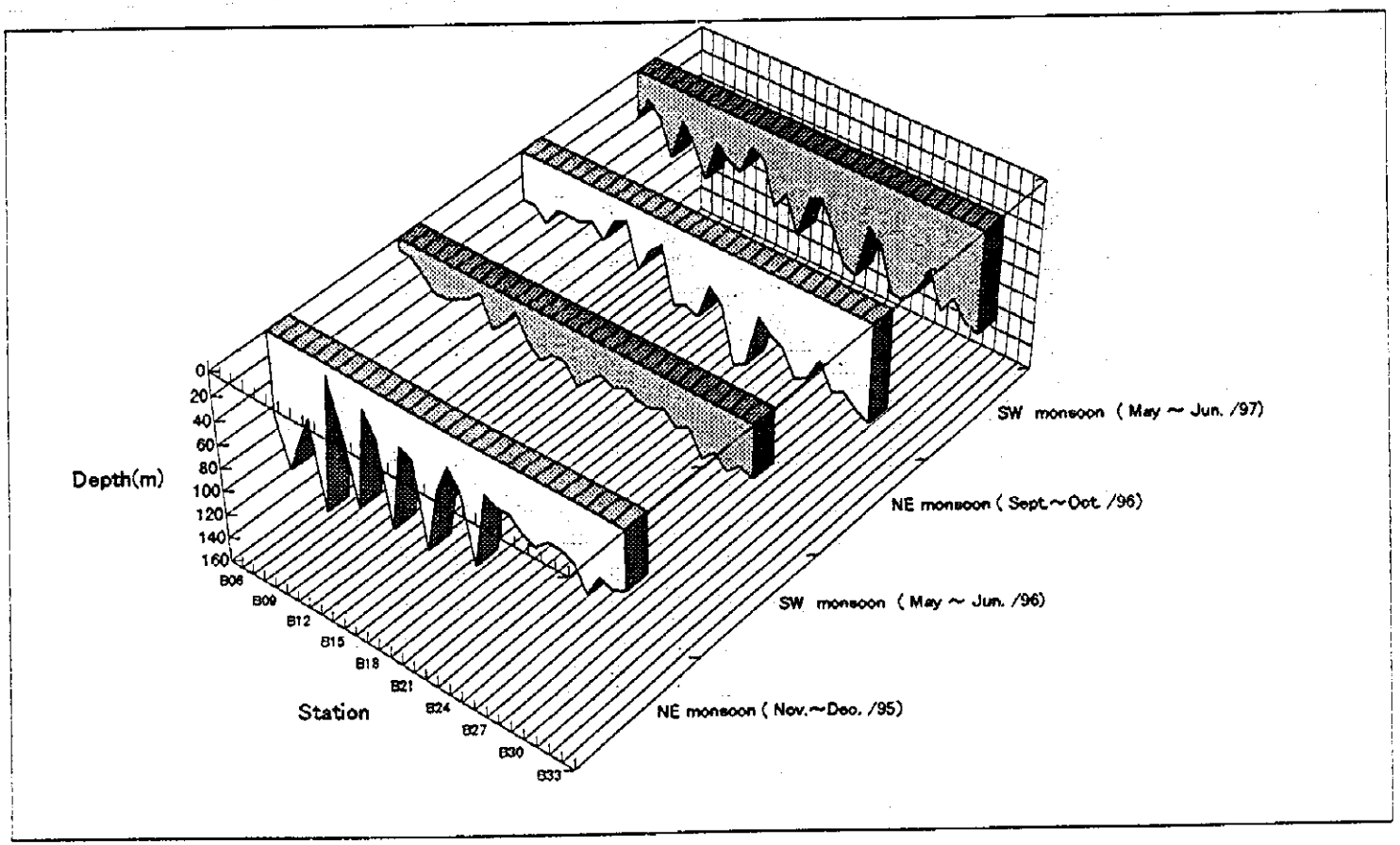


Figure 5-31 The distribution of salinity contour of 34.0 determined by vertical profile of salinity measured at oceanographic stations covered by each of the 1st through 4th survey cruise.

(iii) Early phase of northeastern monsoon season (September and October 1996)

The third survey was conducted about three months after the preceding cruise in the southwestern monsoon season. In the survey area, the northeastern monsoon began blowing, thus the prevailing northeastern wind and cooling of the surface water were resulted in the formation of a convection layer and so the thermocline was lowered by about 30 m on average in the whole survey area. The discontinuity layer was located at 50 m - 80 m depth in the South Region. On average over the whole survey area, thermoclines were about 25 m shallower in the season under discussion than in the late phase of northeastern monsoon of 1995.

(iv) Southwestern monsoon season (May and June 1997)

The fourth cruise covered the area about six months after the third cruise in the northeastern monsoon season, and about one year after the second cruise in the southwestern monsoon season. Distribution of thermocline was found to be remarkably different from that observed in the same months of the preceding year, thus disclosing considerable year-to-year variation of the oceanographic condition. Especially, the thermocline in the South Region appears to have been retained since late phase of northeastern monsoon season of the preceding year. The discrepancy between the two years was also found in the vertical distribution of salinity contour of 34.0. The findings indicate the possibility of remarkable variability among oceanographic structures represented by distribution of water masses due to year-to-year changes of meteorological conditions and adjacent water masses during the transitional period.

These findings summarized above indicate remarkable seasonal variation of oceanographic conditions, and considerable difference between year even in the same seasons. The oceanographic structure of water masses are determined by not only seasonal change of climate but also year-to-year variation of meteorological factors and oceanic currents in the offshore areas. Clarification of the distribution and movement of water masses and factors determining their formation are essential for the development of fisheries resource in the Vietnamese waters. It is necessary to accumulate oceanographic data through successive surveys.

(3) Horizontal distribution of apparent currents

Subsurface currents were identified on the basis of measurements by the Doppler's current meter. However, the data were collected during a long period extending over one and half months. In other words, each measure was obtained at different times, duration of which reaches to one and half-months at maximum, and it is possible to result in misunderstanding of the actual current patterns due to above-mentioned time lag.

In November during the first cruise, intensive southward currents were found to be driven by the northeast monsoon that developed along the coast of Vietnam. Another strong eastward current was identified on a line represented by 111° 30'E. There appeared currents of diverse directions including such movements toward the continent and northward in December.

The readings in May 1996 during the second cruise, indicated strong westward currents around Station B-14, which were already acknowledged in the NAGA Report. Other remarkable movements were a northwestward current in the vicinity of Station B-35, and northeastward current around Stations B-32 and B-33. Furthermore, there was some southward movement in this month, making the current patterns complicated. In June northward current appeared in the North Region, probably driven by the southwest monsoon. However, there still remained movements toward the coast and the south. Most readings in September of the third cruise showed only small velocity, except for significant northwestward current near 111° 30'E. The NAGA Report also noted that the oceanic currents are fading. The present survey also clarified that the southward current driven by the monsoon was weak. The monsoon became strong in October, and southward currents were developed, including such strong flow exceeding 160 cm/sec near the coast, developed suggesting considerable influence of the northeast monsoon.

In May 1997, under the fourth survey, the current patterns were complicated and did not coincide with findings of consistent west-ward movement in the second survey. The southwest monsoon showed strong influence toward the sea, resulting in intensive northward current off the coast of Vietnam in June.

(4) Zooplankton

Generally copepods constituted the major portion of zooplankton samples during the late phase of the northeast monsoon season of the first cruise (Figure 5-32). The dominating copepods were most abundant in the North Region. Nevertheless, the abundance was less compared to other seasons, and exceeded 7,000 individual per m^3, only at Stations B-01 and B-11 (Appendix table 7 to 15). Zooplankoton appeared most frequently in the Central Region, and also in the coastal and shallow waters in the early phase of the northeastern monsoon season, surveyed in 1996. Again copepods were dominant and more numerous in this phase rather than in the late phase (Figure 5-36).

In the southwest monsoon seasons of 1996 and 1997, zooplankton were found less in the South Region than in the Central and North Regions, especially in the vicinity of the mouth of the Mekong River, and in the shallow waters along Qui Nhon to Nha Trang (Figures 5- 34 and 38). In addition to copepods comprising major portion of samples at most stations, Ostracoda, Chaetognatha and Tunicata were frequently taken, replacing copepods that were found in reduced numbers at Station B-05 in both the second and fourth surveys.

(5) Phytoplankton

There appeared many species of phytoplankton of Bacillariacea and Dinoflagellata (Appendix table 16 to 22).

During the early phase of the northeast monsoon season in the third survey period, Bacillariacea constituted the major portion of samples taken in the North Region, but Dinoflagellata often exceeded the other in abundance in the shallow waters of the North Region and in the offshore waters of the South Region. Number of individuals was least in the waters between Lat. 13° N and 16° N (Figure 5-37).

Two surveys executed in the southwest monsoon seasons indicated change of species composition between years. Dinoflagellata was comparatively least at all stations in the second cruise (Figure 5-35), but portion of Dinoflagellata rose at Stations B-12,18,19 and B-33 in the fourth cruise (Figure 5-39).

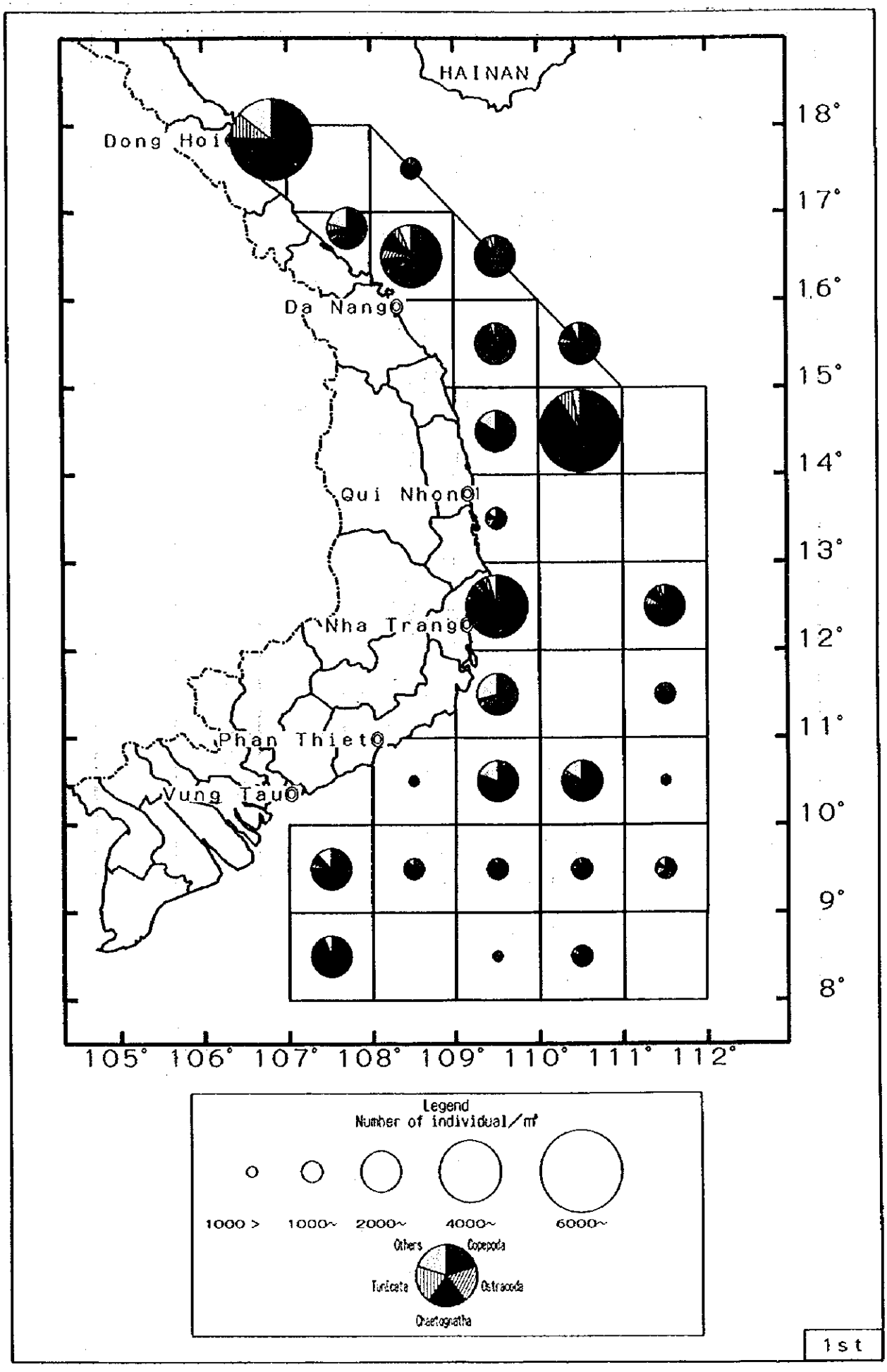


Figure 5-32 Distribution of zooplankton (From Nov. to Dec. 1995, 1st cruise)

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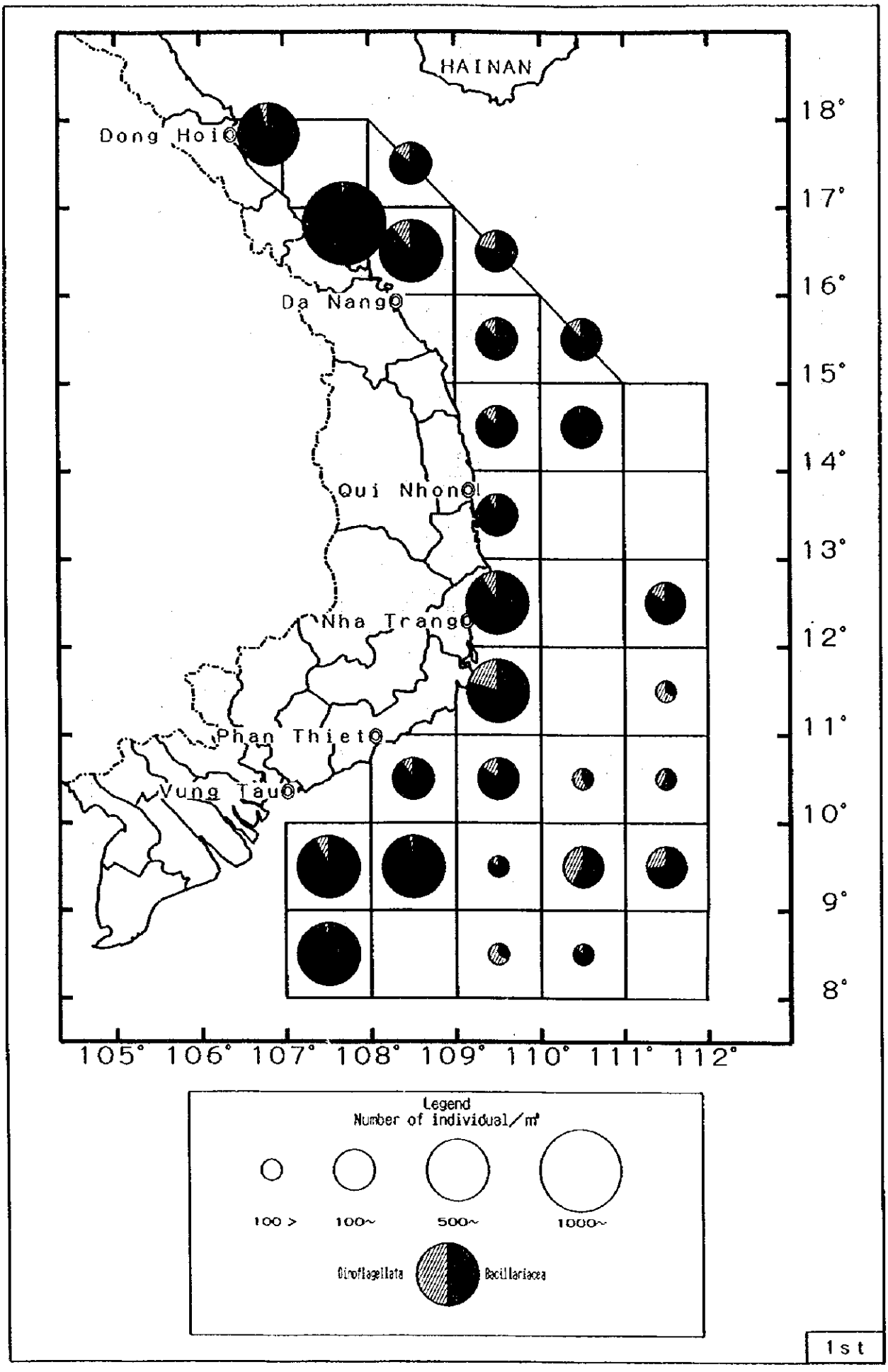

Figure 5-33 Distribution of phytoplankton (From Nov. to Dec. 1995, 1st cruise)

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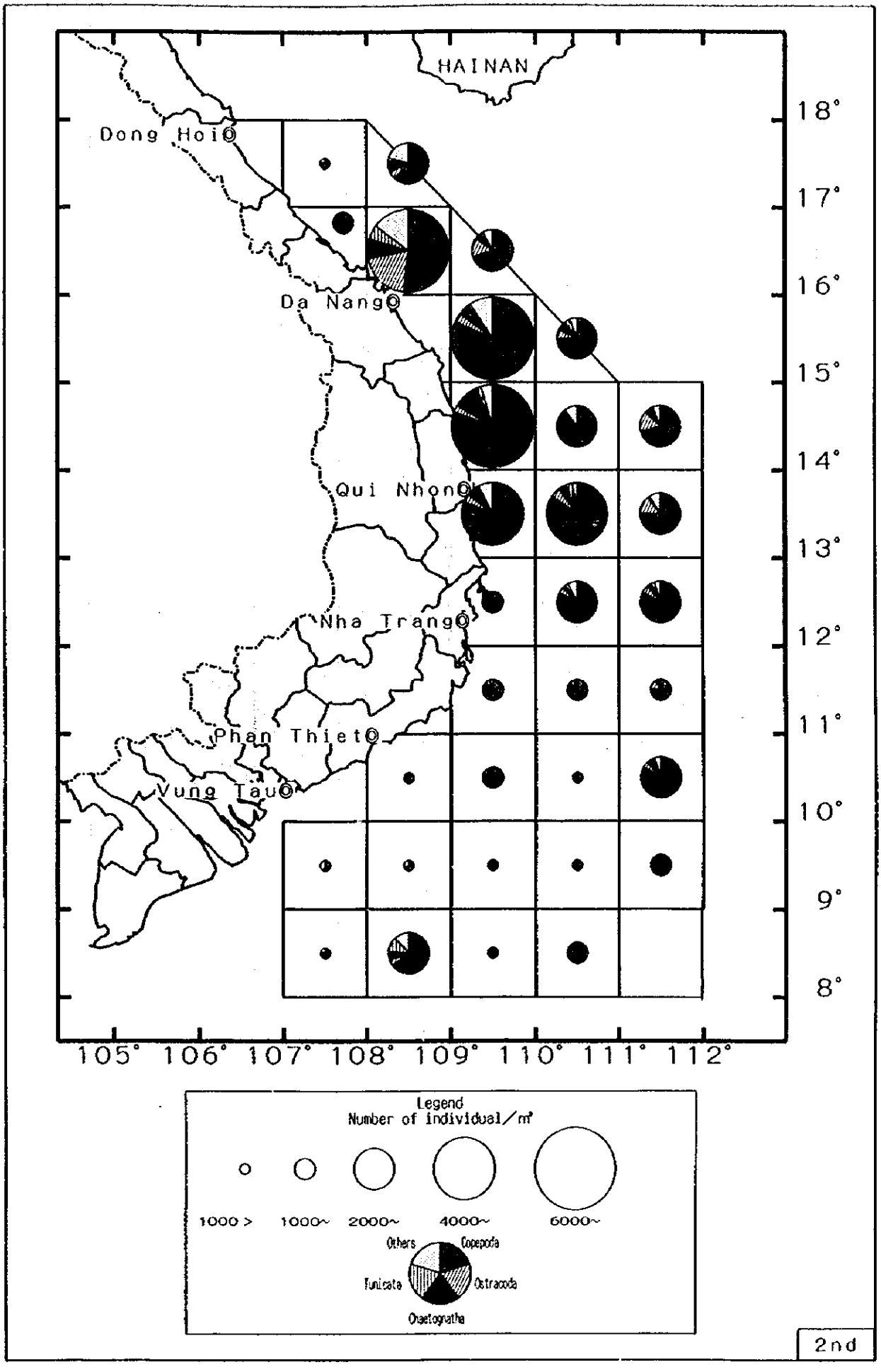

Figure 5-34 Distribution of zooplankton (From May to June 1996, 2nd cruise)

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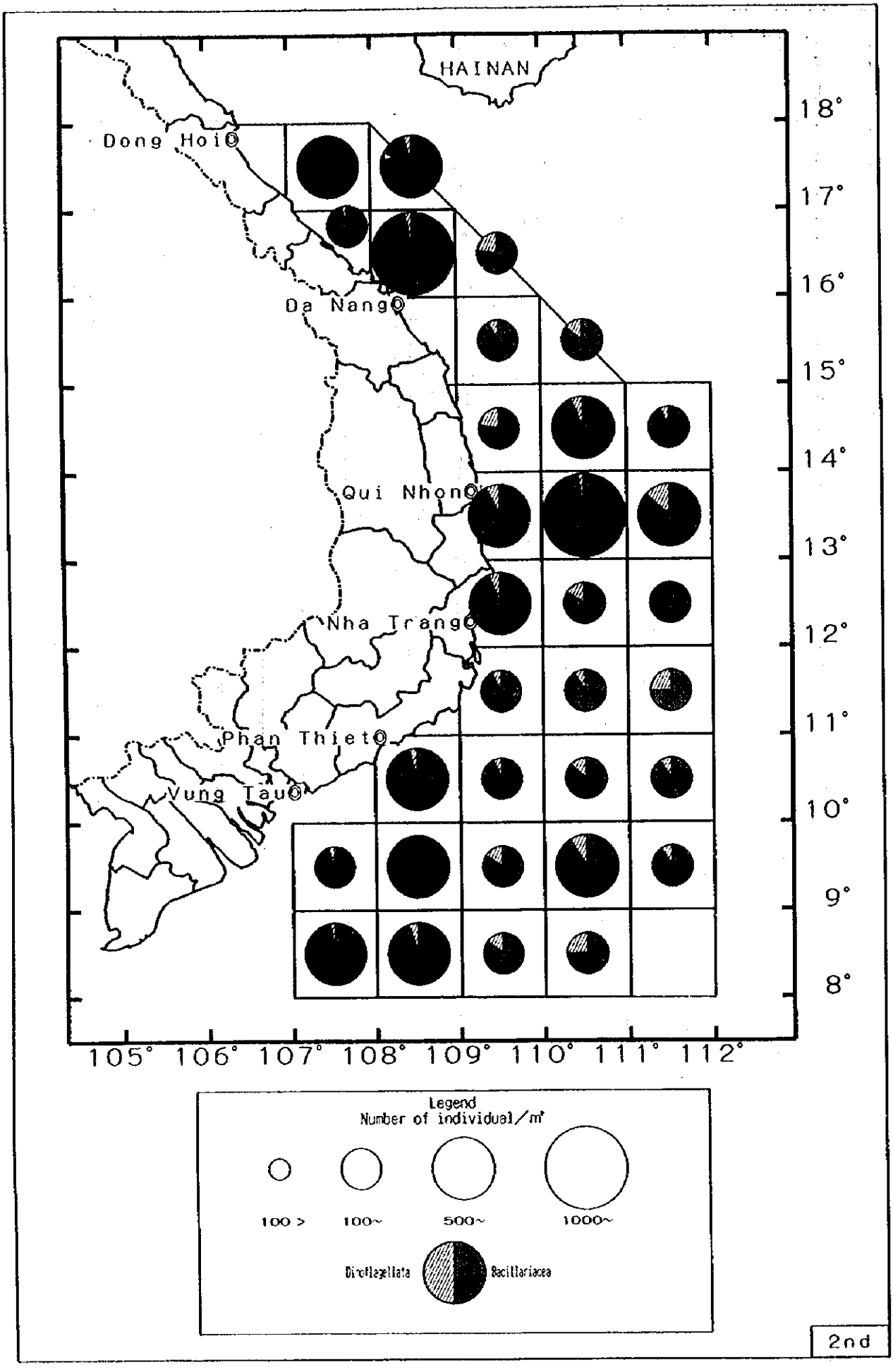

Figure 5-35 Distribution of phytoplankton (From May to June 1996, 2nd cruise)

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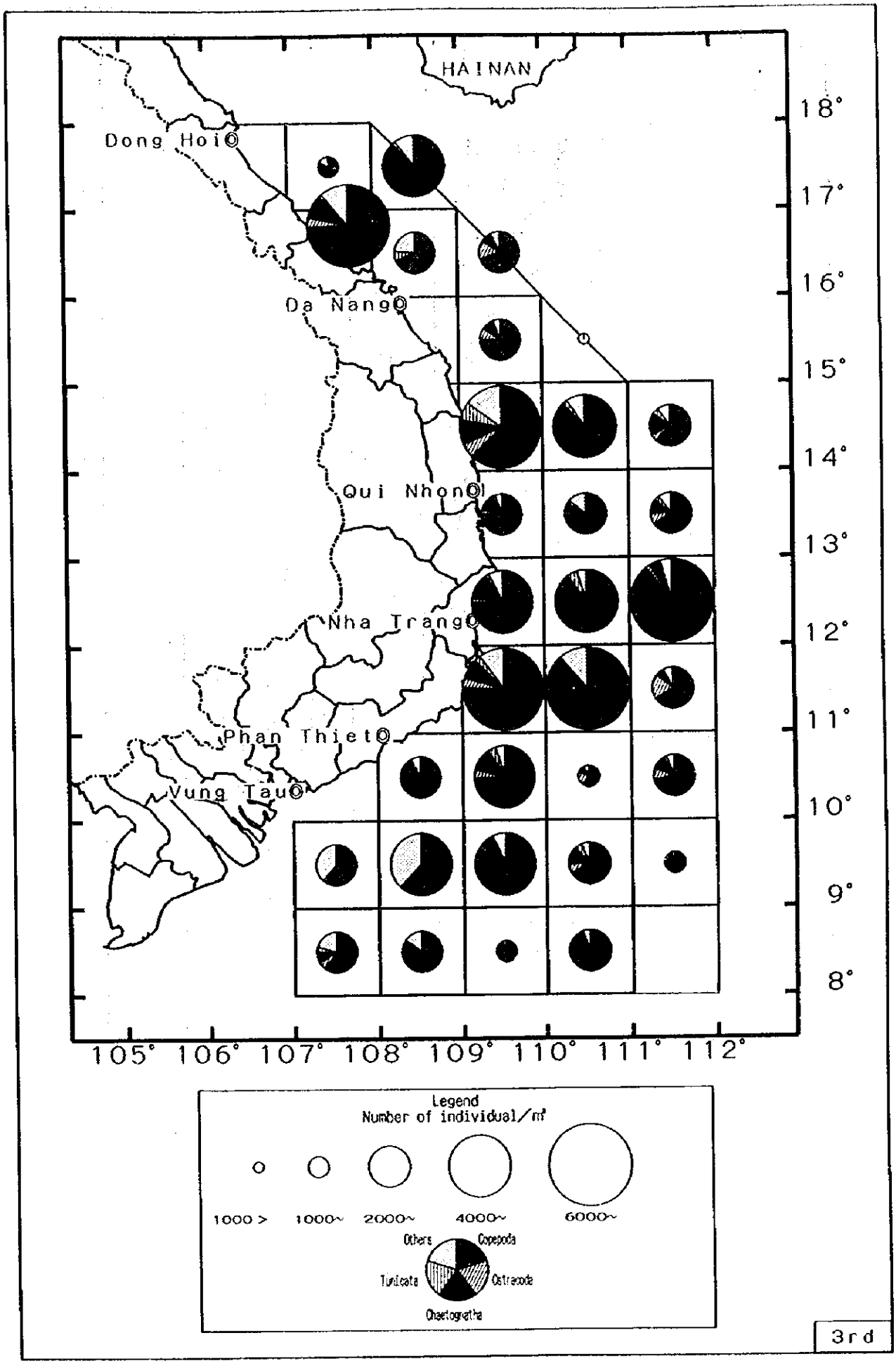

Figure 5-36 Distribution of zooplankton (From Sept. to Oct. 1996, 3rd cruise)

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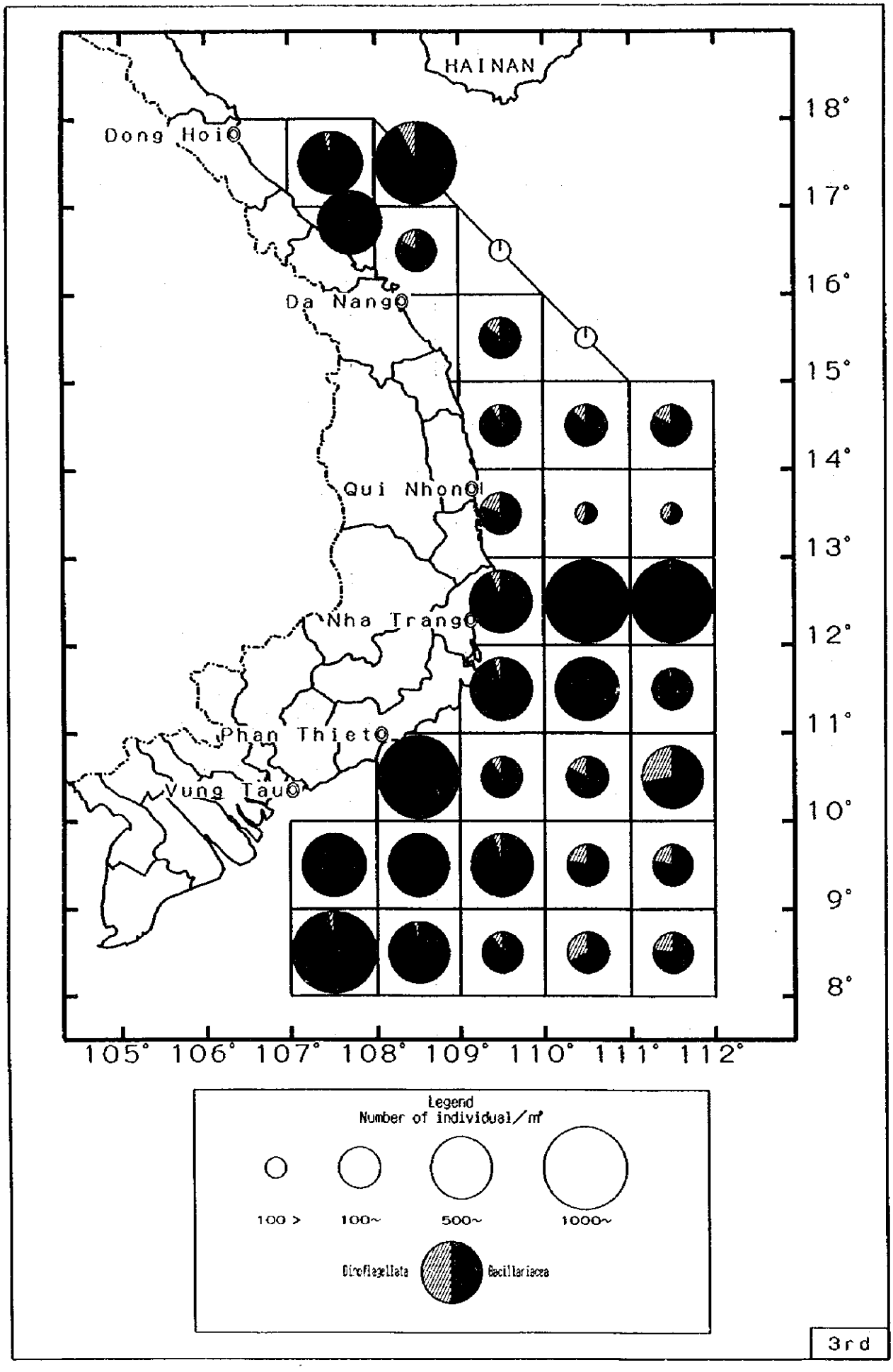

Figure 5-37 Distribution of phytoplankton (From Sept. to Oct. 1996, 3rd cruise)

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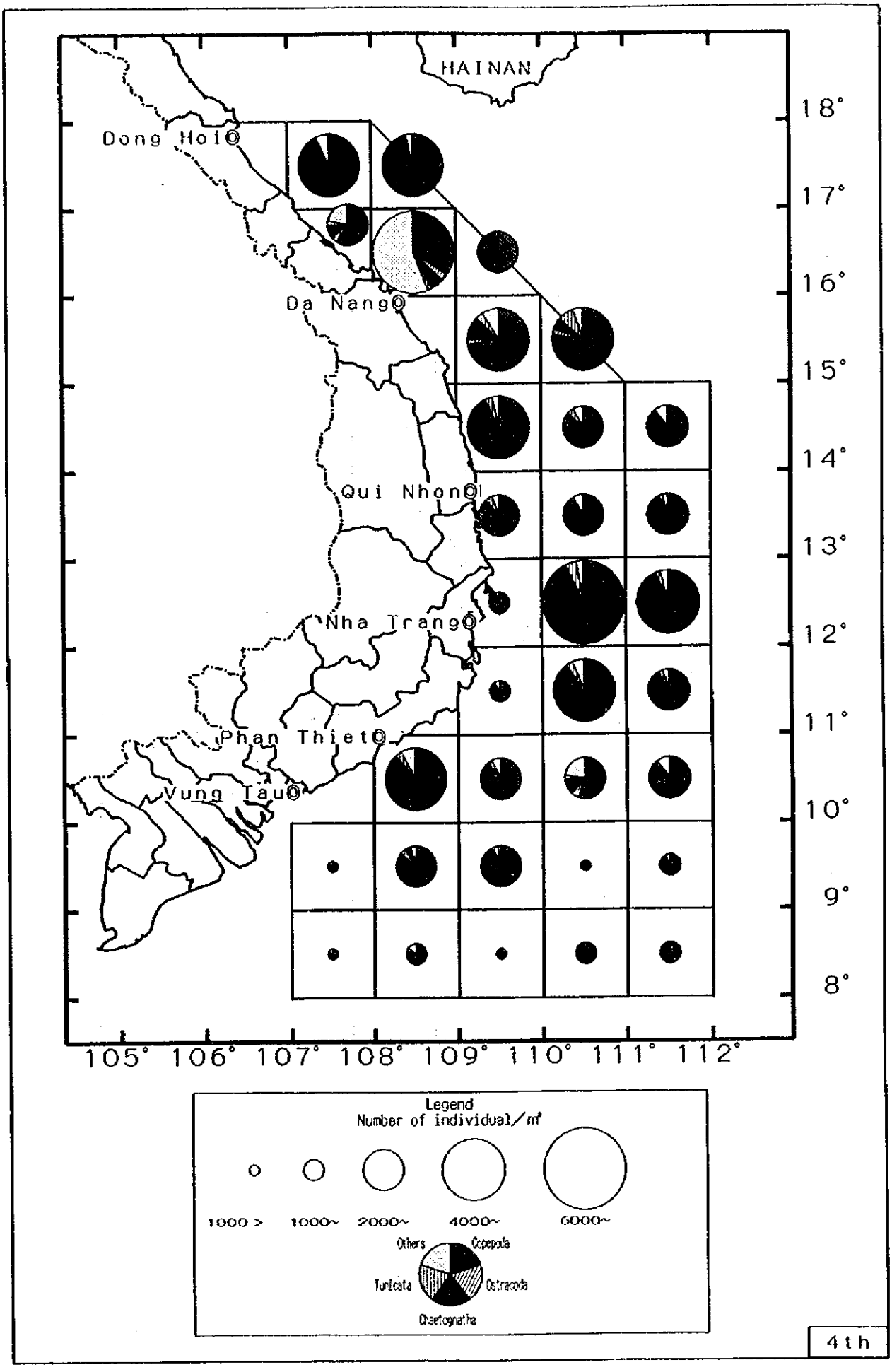

Figure 5-38 Distribution of zooplankton (From May to June 1997, 4th cruise)

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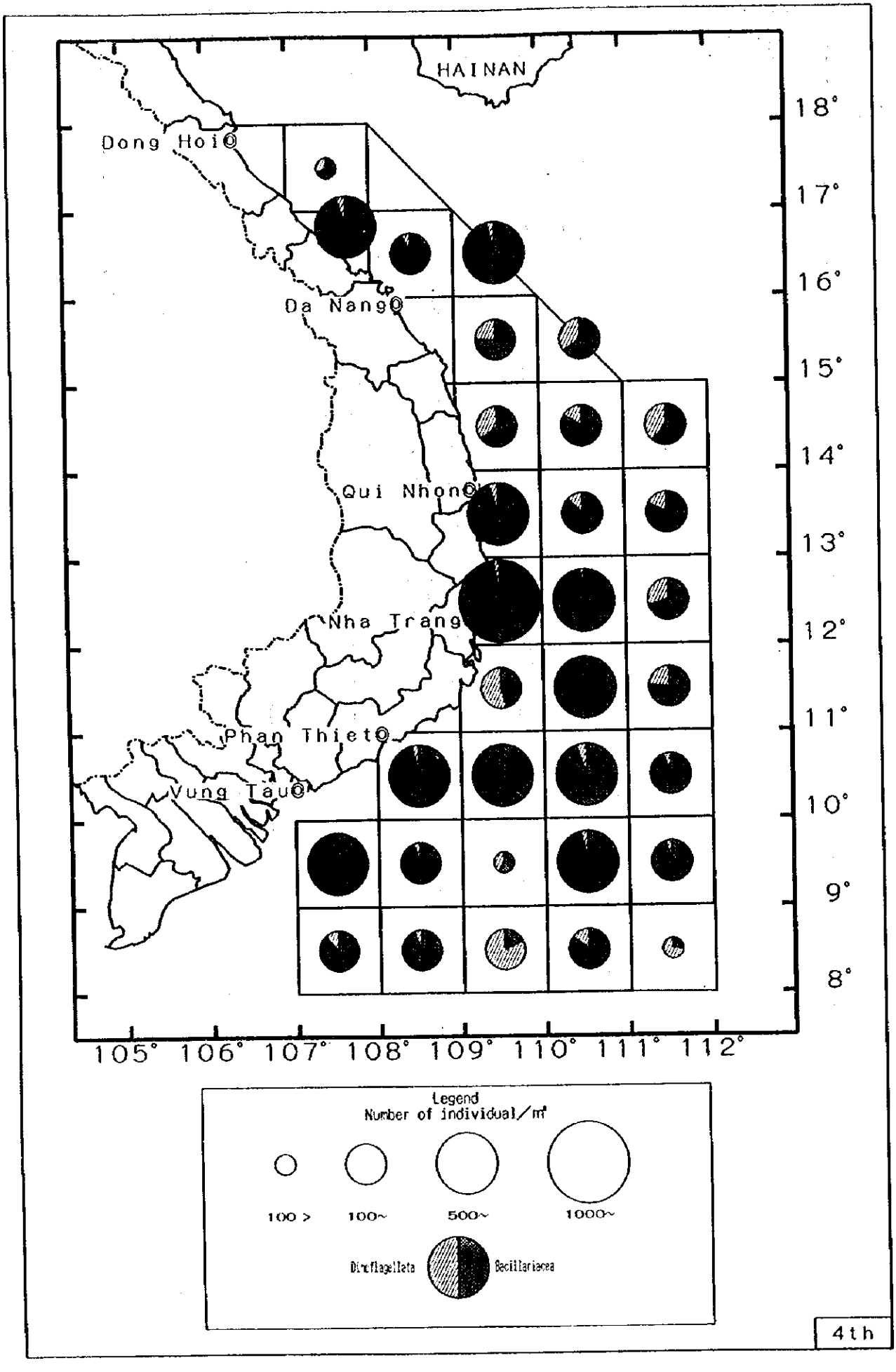

Figure 5-39 Distribution of phytoplankton (From May to June 1997, 4th cruise)

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5-2. Species composition of catches

(1) New findings on distribution of fishes

The catch of 95 test fishing operations of drift gillnets during the four research cruises consisted of fishes of 102 species of 33 families, and cephalopods of 3 species, each coming from different families. In addition, five species of dolphins (mammals) and three species of turtles were captured incidentally. A brown boody is the only sea bird taken during the research cruises (Table 5-3 & Table 5-4).

One of the significant biological findings is new records of many species in the Vietnamese waters, compared to the Check List of Marine Fishes on the Southeast Asian Region issued by the Southeast Asian Fisheries Development Center (hereinafter referred to as SEAFDEC) in 1996. To the right of the columns of Table 5-3 & 4, white and black circles indicate the presence and absence in the check list, respectively, for the whole South Asian waters and Vietnamese waters. Black circles, or new records count 21 species in the whole Southeast Asian waters, and 21 additional species in the Vietnamese waters. In other words, the existence of 42 species or slightly over two fifth of the 99 identified species were first confirmed in the Vietnamese waters. Taxonomy is not of primary interest to the present research, and further study is desirable in regard to assure the identification and scientific names. Appendix 3 shows description of species which occurrence were newly observed in Vietnamese waters.

(2) Definition of major species

Figure 5-40 & 5-41 indicate the catch composition of families of fishes and cephalopods in decreasing order of either, in terms of number of individual animals (Figure 5-40), or in terms of weight (Figure 5-41). The dominating five families in number are Scombridae, Coryphaenidae, Bramidae, Ommastrephidae and Carangidae, comprising 86 % of total catch. In term of weight, the heaviest catches are from Scombridae, Myliobatidae, Istiophoridae, Coryphaenidae and Bramidae, covering 89 % of the total. Large-sized species were upper rank in weight, though only few individuals appeared in the catch and only occasionally. Three families, Scombridae, Coryphanidae and Bramidae, appeared in the most abundant five in both number and weight,

comprising 74 % of total catch in number, and 48 % in weight.

Similarly, species of fishes and cephalopods were ranked in decreasing order of number and weight of catch (Table 5-5 & 5-6). In total 14 species entered into the most abundant 25 in both terms, and are listed, in the order of classification code given in Table 5-3 & 5-4, as follows: Coryphaena hippurus, C. equiselis, Brama orchini, Lobotes surinamensis, Auxis thazard, A. rochei, Euthynnus affinis, Katsuwonus pelamis, Thunnus tonggol, T. albacares, T. obesus, Istiophorus platypterus, Aluterus monoceros and Sthenoteuthis oualaniensis. In addition, four billfishes of Makaira indica, M. mazara, Tetrapterus audas and Xiphias gladius represent major catch in weight if not in number, and are added to 18 major species.

Table 5-3. A list of species caught in the 1995 - 1997 sea-borne survey - 1.

Presence ○ and Absence ● in the check list of marine fishes of SEAFDEC (1996).

Presence of the genus △ and Presence acknowledged by RIMP (1997.Dec.) □

No.	Latin Name	Code	Common Name	SE. ASIA	VIETNAM
1	Stegostoma fasciatum (Hermann)	911	zebra shark	○	○
2	Pseudocarcharias kamoharai (Matsubara)	941	crocodile shark	○	●
3	Galeocerdo cuvier (Perdo et Le Sueur)	1051	tiger shark	○	○
4	Prionace glauca Linnaeus	1052	blue shark	●	●
5	Carcharhinus sorrah (Valenciennes)	1074	spot-tail shark	○	□
6	Carcharhinus brevipinna (Muller et Henle)	1083	spiner shark	○	●
7	Carcharhinus falciformis (Bibron)	1092	silky shark	○	□
8	Sphyrna lewini (Griffith et Smith)	1102	scalloped hammerhead shark	○	○
9	Isistius brasiliensis (Quoy et Gaimard)	1194	(black shark)	●	●
10	Manta birostris (Donndorff)	1521	manta ray	○	●
11	Mobula japonica (Muller et Henle)	1522	devil ray	○	●
12	Chirocentrus dorab (Forsskal)	2103	dorab wolf herring	○	○
13	Saurida sp.	3090	lizardfish	△	△
14	Diaphus gigas Gilbert	3384	brightnose headlightfish	●	●
15	Diaphus watasei Jordan et Starks	3393	headlight fish, lantern-fish	○	●
16	Exocoetus volitans Linnaeus	4201	cosmopolitan flyingfish	○	○
17	Parexocoetus sp.	4210	sailfin flyingfish	●	●
18	Cypselurus sp.	4230	(coast flying fish)	△	△
19	Cypselurus atrisignis (Jenkins)	4232	greater spotted flyingfish	○	○
20	Cypselurus poecilopterus (Valenciennes)	4234	yellowfin flyingfish	○	○
21	Cypselurus cyanopterus (Valenciennes)	4242	margined flyingfish	●	●
22	Cypselurus spilonotopterus (Bleeker)	4243	(coast flying fish)	●	●
23	Cypselurus unicolor (Valenciennes)	4253	bigeye flyingfish	●	●
24	Cypselurus longibarbus (Parin)	4254	(coast flying fish)	○	○
25	Cypselurus naresii (Gunther)	4264	Uchida's flyingfish	●	●
26	Ablennes hians (Valenciennes)	4281	flat needlefish	○	●
27	Tylosurus acus melanotus (Bleeker)	4293	blackfin needlefish	●	●
28	Therapon jarbua (Forsskal)	6461	crescent perch	○	○
29	Priacanthus macracanthus Cuvier	6533	large-spined big-eye	○	○
30	Rachycentron canadum (Linnaeus)	6891	king fish	○	○
31	Parastromateus niger (Bloch)	6901	black pomfret	○	●
32	Elagatis bipinnulata (Quoy et Gaimard)	6902	rainbow runner	○	○
33	Naucrates ductor (Linnaeus)	6911	pilot fish	○	□
34	Serioline nigrofasciata (Ruppell)	6912	black band amberjack	○	□
35	Scomberoides commersonnianus Lacepede	6920	talang queenfish	○	●
36	Seriola rivoliana Valenciennes	6921	almaco jack	○	●
37	Scomberoides lysan (Forsskal)	6923	double dotted queenfish	○	○
38	Scomberoides tol (Cuvier)	6924	leatherskin queenfish	○	○
39	Trachinotus baillonii (Lacepede)	6931	black-spotted dart	●	●
40	Megalaspis cordyla (Linnaeus)	6934	hardtail scad	○	●
41	Decapterus russelli (Ruppell)	6941	slender scad	○	○
42	Decapterus macrosoma Bleeker	6942	layang scad	○	□
43	Decapterus maruadsi (Temminck et Schlegel)	6952	yellow tail rounded scad	○	□
44	Decapterus akaadsi Abe	6953	red-tail scad	●	●
45	Selar crumenophthalmus (Bloch)	6963	bigeye scad	○	○
46	Atule mate (Cuvier)	6971	slender-scaled scad	○	○
47	Alectis ciliaris (Bloch)	6993	threadfish trevally	○	○
48	Urapis helvola (Forster)	7002	whitemouth kingfish	○	○
49	Carangoides ferdau (Forsskal)	7031	blue trevally	○	□
50	Carangoides orthogrammus (Jordan et Gilbert)	7032	yellow-spotted crevalle	●	●
51	Coryphaena hippurus Linnaeus	7061	common dolphinfish	○	○
52	Coryphaena equiselis Linnaeus	7062	pompano dolphinfish	○	●
53	Mene maculata (Bloch et Schneider)	7063	moon-fish	○	□
54	Brama orcini Cuvier	7122	bigtooth pomfret	○	●
55	Lobotes surinamensis (Bloch)	7311	tripletail	○	●
56	Kyphosus vaigensis (Quoy et Gaimard)	7722	bass seachub	○	△

Table 5-4. A list of species caught in the 1995 - 1997 sea-borne survey - 2.

Presence ○ and Absence ● in the check list of marine fishes of SEAFDEC (1996).

Presence of the genus △ and Presence acknowledged by RIMP (1997.Dec.) □

No.	Latin Name	Code	Common Name	SE. ASIA	VIETNAM
57	Pseudocalliurichthys sp.	9930	variegated dragonet	●	●
58	Naso brevirostris (Valenciennes)	11221	spotted unicornfish	○	○
59	Lepidocybium flavobrunneum (Smith)	11361	escolar	●	●
60	Ruvettus pretiosus Cocco	11362	oilfish	●	●
61	Gempylus serpens Cuvier	11372	snake mackerels	○	●
62	Promethichthys prometheus (Cuvier)	11375	snake-mackerel, bermuda catfish	□	□
63	Rastrelliger kanagurta (Cuvier)	11431	chub mackerel	○	○
64	Scomber australasicus Cuvier	11442	blue mackerel	○	●
65	Auxis thazard (Lacepede)	11443	frigate tuna	○	○
66	Auxis rochei (Risso)	11444	bullet tuna	○	○
67	Sarda orientalis (Temminck et Schlegel)	11451	striped bonito	○	○
68	Euthynnus affinis (Cantor)	11453	eastern little tuna	○	○
69	Katsuwonus pelamis (Linnaeus)	11454	skipjack tuna	○	○
70	Thunnus tonggol (Bleeker)	11463	longtail tuna	○	○
71	Thunnus albacares (Bonnaterre)	11471	yellowfin tuna	○	○
72	Thunnus obesus (Lowe)	11472	bigeye tuna	○	○
73	Acanthocybium solandri (Cuvier)	11473	wahoo	○	○
74	Scomberomorus commerson (Lacepede)	11482	narrow-barred king mackerel	○	○
75	Istiophorus platypterus (Shaw et Nodder)	11491	Indo-Pacific sailfish	○	○
76	Makaira indica (Cuvier)	11492	black marlin	○	○
77	Makaira mazara (Jordan et Snyder)	11493	blue marlin	○	○
78	Tetrapterus audax (Philippi)	11494	striped marlin	○	●
79	Xiphias gladius Linnaeus	11502	broadbill swordfish	○	○
80	Psenes arafurensis Gunther	11532	Arafura eyebrow-fish	○	●
81	Psenes maculatus Lutken	11533	(blue eyebrowfish)	●	●
82	Psenes cyanophrys Valenciennes	11541	black driftfish	○	●
83	Cubiceps squamiceps (Lloyd)	11542	chunky fathead	●	●
84	Cubiceps pauciradiatus Gunther	11543	(chunky fathead)	○	●
85	Cubiceps baxteri McCulloch	11551	driftfish	○	●
86	Nomeus gronovii (Gmelin)	11552	man-of-war fish	●	●
87	Ariomma indica (Day)	11561	Indian drift fish	○	●
88	Remorina albescens (Temminck et Schlegel)	11581	white remora	●	●
89	Echeneis naucrates Linnaeus	11582	shark sucker	○	○
90	Remora remora (Linnaeus)	11592	remora	●	●
91	Melichthys vidua (Solander)	11993	pinktail triggerfish	●	●
92	Canthidermis maculata (Bloch)	12041	ocean triggerfish	○	○
93	Aluterus monoceros (Linnaeus)	12071	unicorn leatherjacket	○	○
94	Aluterus scriptus (Osbeck)	12072	leatherjacket	○	○
95	Lagocephalus sp.	12320	white-tail blowfish	△	△
96	Lagocephalus lagocephalus oceanicus Jordan et Fowl	12321	spotted smooth-backed blowfish	●	●
97	Diodon holocanthus Linnaeus	12341	freckled ballonfish	○	○
98	Diodon eydouxii Brissout et Barneville	12353	(porcupine fish)	●	●
99	Diodon hystrix Linnaeus	12354	(porcupine fish)	○	○
100	Sthenoteuthis oualaniensis Lesson	21198	flying squid		
101	Thysanoteuthis rhombus Troschel	21199	diamondback squid		
102	Tremoctopus violaceus Delle Chiaje	31222	(octopus)		
103	Globicephala macrorhynchus Gray	41148	short-finned pilot whale		
104	Stenella coeruleoalbus (Mayen)	41178	striped dolphin		
105	Stenella longirostris	41182	long-snouted spinner dolphin		
106	Stenella attenuata	41184	pantropical spotted dolphin		
107	Lagenodelphis hosei (Fraser)	41208	Fraser's dolphin		
108	Chelonica mydas	51522	green turtle		
109	Eretmochelys imbricata Linnaeus	51523	hawkbill turtle		
110	Lepidochelys olivacea Eschscholtz	51524	logger-head turtle		
111	Sula leucogaster	61749	brown booby		

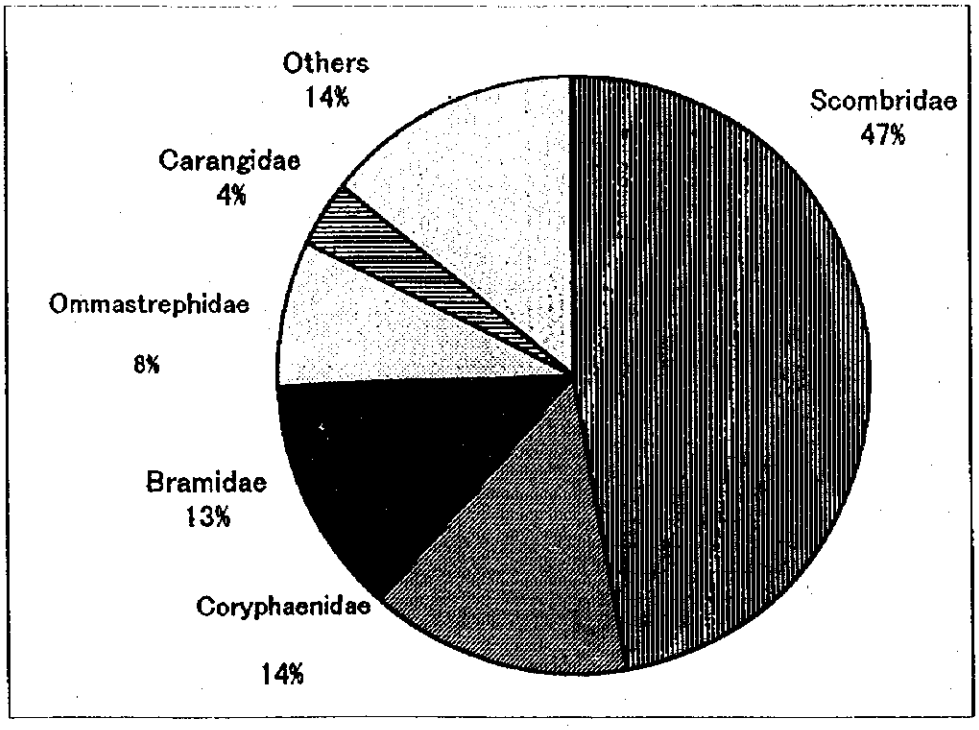


Figure 5-40. Composition of catch number of fish and cephalopod classified to families.

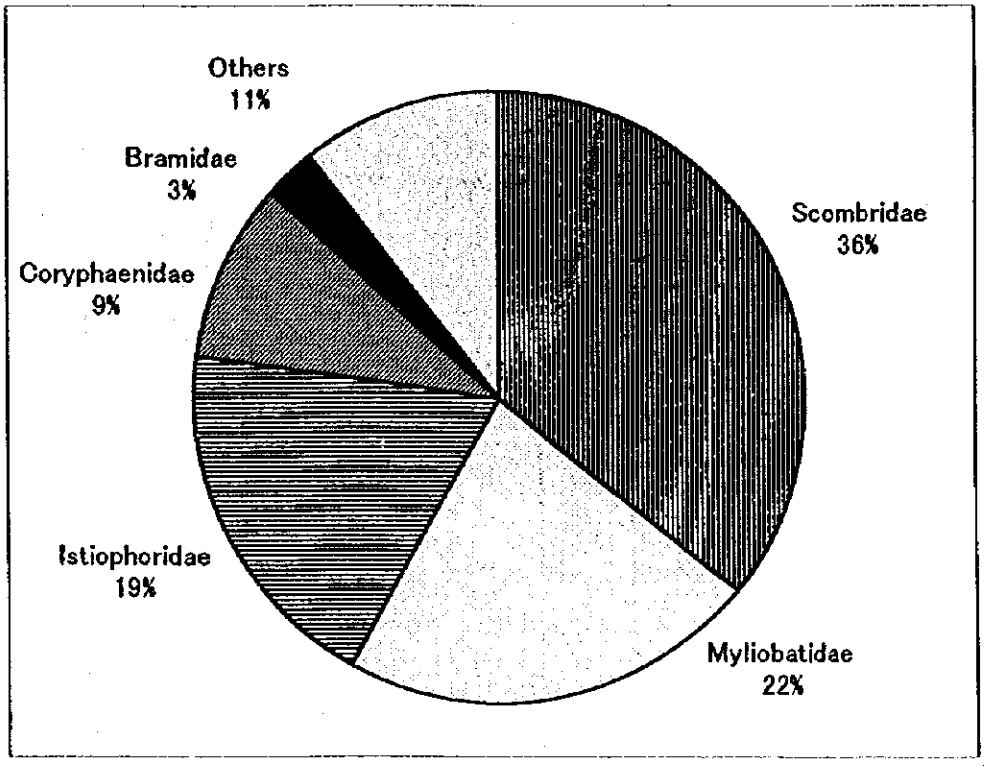


Figure 5-41. Composition of catch weight of fish and cephalopod classified to families.

Table 5-5. Species order of catch in number during sea-borne survey, 1995 - 1997.

Order	Species Name	Code	1st cruise 95.11-12	2nd cruise 96.5-6	3rd cruise 96.9-10	4th cruise 97.5-6	Total
1	*Auxis rochei*	11444		189	58	591	838
2	*Brama orcini*	07122	5	122	397	157	681
3	*Auxis thazard*	11443	2	127	242	289	660
4	*Katsuwonus pelamis*	11454	10	144	197	301	652
5	*Coryphaena hippurus*	07061	2	179	235	218	634
6	*Sthenoteuthis oualaniensis*	21198	9	76	144	163	392
7	*Aluterus monoceros*	12071	1	4	131	2	138
8	*Lobotes surinamensis*	07311	1	48	56	28	133
9	*Thunnus tonggol*	11463			40	71	111
10	*Coryphaena equiselis*	07062		13	33	63	109
11	*Thunnus obesus*	11472	1	15	4	59	79
12	*Euthynnus affinis*	11453		6	30	26	62
13	*Prlacanthus macracanthus*	06533		12	5	29	46
14	*Istiophorus platypterus*	11491		10	26	8	44
15	*Carangoides orthogrammus*	07032		4	13	24	41
16	*Cubiceps squamiceps*	11542			34		34
17	*Selar crumenophthalmus*	06963		5	11	10	26
18	*Scomber australasicus*	11442		3		23	26
19	*Cubiceps pauciradiatus*	11543		3		22	25
20	*Seriola rivoliana*	06921		13	4	6	23
21	*Psenes cyanophrys*	11541		8	4	8	20
22	*Thunnus albacares*	11471		1	11	7	19
23	*Diodon hystrix*	12354		1		18	19
24	*Canthidermis maculata*	12041		2	10	5	17
25	*Diodon eydouxii*	12353		3	7	7	17

Table 5-6. Species order of catch in weight during sea-borne survey, 1995 - 1997.

Order	Species Name	Code	1st cruise 95.11-12	2nd cruise 96.5-6	3rd cruise 96.9-10	4th cruise 97.5-6	Total
1	*Katsuwonus pelamis*	11454	12.20	518.76	537.25	709.70	1777.91
2	*Mobula japonica*	01522		593.00	371.00	225.00	1189.00
3	*Coryphaena hippurus*	07061	4.10	218.60	294.87	207.47	725.04
4	*Manta birostris*	01521		178.00	450.00		628.00
5	*Auxis thazard*	11443	1.35	154.01	240.40	227.45	623.21
6	*Makaira mazara*	11493		365.00	177.80		542.80
7	*Istiophorus platypterus*	11491		249.50	130.10	126.75	506.35
8	*Makaira indica*	11492		85.00	266.00		351.00
9	*Auxis rochei*	11444		58.08	14.28	166.89	239.25
10	*Brama orcini*	07122	1.70	45.48	128.68	38.18	214.04
11	*Lobotes surinamensis*	07311	0.55	83.10	67.60	41.50	192.75
12	*Tetrapterus audax*	11494				171.00	171.00
13	*Sthenoteuthis oualaniensis*	21198	3.95	36.91	56.00	70.53	167.39
14	*Thunnus albacares*	11471		12.60	67.45	5.30	85.35
15	*Prionace glauca*	01052		73.00			73.00
16	*Thunnus tonggol*	11463			36.40	30.15	66.55
17	*Euthynnus affinis*	11453		15.24	31.00	17.42	63.66
18	*Carcharhinus falciformis*	01092		16.08	21.90	14.85	52.83
19	*Coryphaena equiselis*	07062		6.33	18.15	23.65	48.13
20	*Sphyrna lewini*	01102				45.00	45.00
21	*Thunnus obesus*	11472	1.80	6.00	9.00	25.75	42.55
22	*Carcharhinus brevipinna*	01083		0.80	32.00		32.80
23	*Aluterus monoceros*	12071	0.40	1.90	29.04	0.23	31.57
24	*Xiphias gladius*	11502				24.00	24.00
25	*Galeocerdo cuvier*	01051		23.00			23.00

5-3 Relative Abundance of Major Species

5-3-1 CPUE of major species

General feature of the results of test fishing, mainly CPUE defined in Chapter 3 of major species, during the 2nd, 3rd and 4th cruises is set out. CPUE is expressed in number of individuals, except in the introductory part where the figure is also given in weight.

(1) The second sea-borne survey (5~6 /1996, SW monsoon season)

Catch at 32 test operations consisted of 71 species which comprised 1,895 of total CPUE in number and 2,902 of that in weight , except incidentally taken non target animals. Table 5-7 and Figure 5-42 show CPUE of the major species given in catch during 2nd survey, in terms of both number and weight, per 100 tans of 5-mesh size nets.

Table 5-7 Total CPUE, in terms of number and weight , of major species and other selected species taken during the 2nd survey, May and June 1996

Scientific name	English name	Catch	
		Total CPUE in number	Total CPUE in weight
Coryphaena hippurus	Common dolphinfish	506	437
Sthenoteuthis oualaniensis	Flying squid	268	127
Auxis rochei	Bullet mackerel	236	72
Brama orcini	Bigtooth pomfret	185	61
Katsuwonus pelamis	Skipjack tuna	135	448
Auxis thazard	Frigate mackerel	116	140
Lobotes surinamensis	Triple tail	54	83
Coryphaena equiselis	Pomoano dolphinfish	41	19
Thunnus obesus	Bigeye tuna	22	7
Istiophorus platypterus	Sail fish	11	244
Euthynnus affinis	Easter little tuna	7	14
Makaira mazara	Blue marlin	6	314
Makaira indica	Black marlin	4	64
Aluterus monoceros	Unicorn leatherjacket	4	2
Thunnus albacares	Yellowfin tuna	1	8
Thunnus tonggol	Longtail tuna	–	–
Tetrapterus audax	Striped marlin	–	–
Xiphias gladius	Broadbill swordfish	–	–
Total		1596	2040

Common dolphinfish was the most dominating species in terms of number, at 506. Other significant species, in decreasing order, were flying squid, bullet mackerel, bigtooth pomfret, skipkipjack tuna, frigate mackerel, all represented by more than 100. In terms of weight, skipjack tuna was most abundant, followed by common dolphinfish, blue marlin, sail fish frigate, mackerel, flying squid, each being heavier than 100 in combined mass. Triple tail, bullet mackerel, black marlin and bigtooth pomfret occupied

a significant share, though did not reach to 100. In the southwestern monsoon season, common dolphinfish, flying squid, bullet mackerel, bigtooth pomfret, skipjack tuna and frigate mackerel represented the most abundant group both in number and in weight.

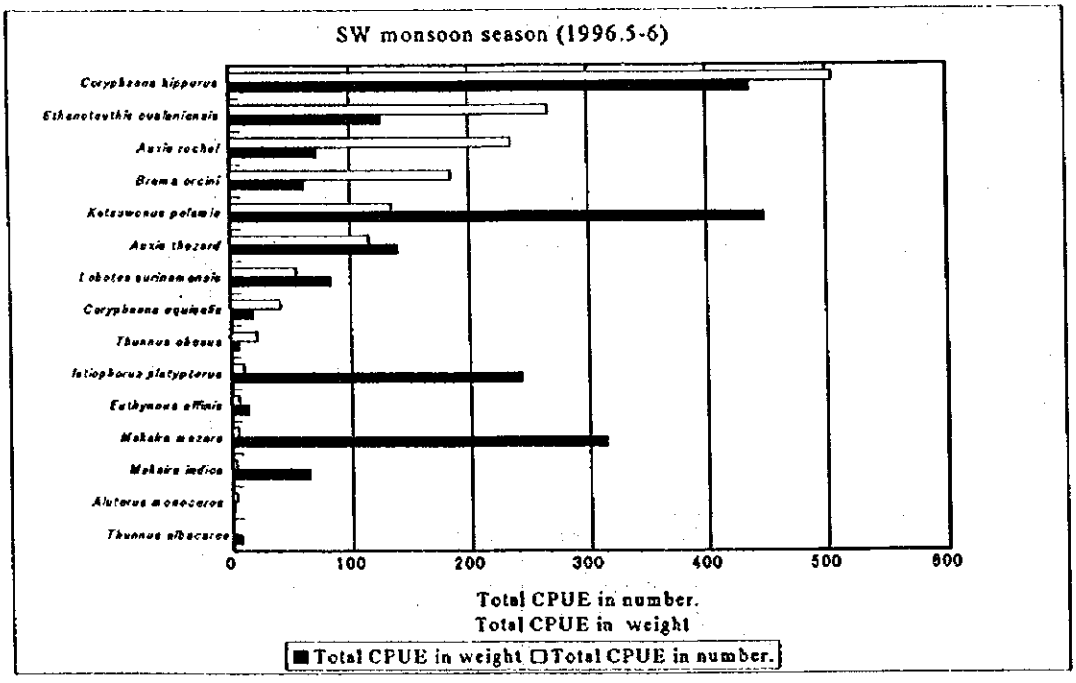


Figure 5-42 Total CPUE, in terms of number and weight, of major species and other selected species taken during the 2nd survey, May and June 1996

(2) The third sea-borne survey (9~10 /1996, NW monsoon season)

Total catch of 29 test operations consisted of 1,912 of CPUE in number and 3,134 in weight of 63 targeted species. Table 5-8 and Figure 5-43 show CPUE of the major species given in catch during 3rd survey, in terms of both number and weight, per 100 tans of 5-mesh size nets.

In terms of number, bigtooth pomfret was the dominant species, represented by 422. Other species exceeding 100 were common dolphinfish, frigate mackerel, skipjack tuna, flying squid and unicorn leatherjacket. In terms of weight, catch of skipjack tuna, 565, was the heaviest, followed by common dolphinfish, black marlin, frigate mackerel, blue marlin, bigtooth pomfret and sailfish, being each above 100.

Table 5-8 Total CPUE, in terms of number and weight, of major species and other selected species taken during the 3rd survey, Sept. and Oct. 1996

Scientific name	English name	Catch	
		Total CPUE in number	Total CPUE in weight
Brama orcini	Bigtooth pomfret	422	135
Coryphaena hippurus	Common dolphinfish	259	323
Auxis thazard	Frigate mackerel	234	231
Katsuwonus pelamis	Skipjack tuna	209	565
Sthenoteuthis oualaniensis	Flying squid	153	60
Aluterus monoceros	Unicorn leatherjacket	133	30
Auxis rochei	Bullet mackerel	58	14
Lobotes surinamensis	Triple tail	58	69
Thunnus tonggol	Longtail tuna	39	36
Coryphaena equiselis	Pomoano dolphinfish	36	20
Euthynnus affinis	Easter little tuna	29	30
Istiophorus platypterus	Sail fish	27	129
Thunnus albacares	Yellowfin tuna	11	70
Makaira mazara	Blue marlin	10	182
Makaira indica	Black marlin	8	268
Thunnus obesus	Bigeye tuna	4	10
Tetrapterus audax	Striped marlin	--	--
Xiphias gladius	Broadbill swordfish	--	--
Total		1690	2172

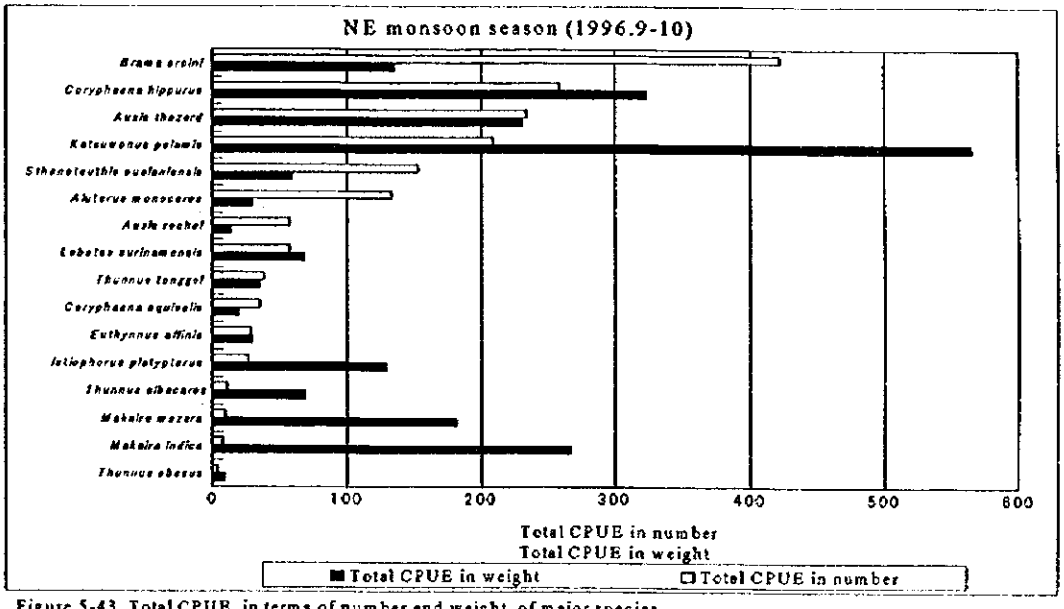


Figure 5-43 Total CPUE, in terms of number and weight, of major species and other selected species taken during the 3rd survey, Sept. and Oct. 1996

(3) The fourth sea-borne survey (5~6 /1997, SW monsoon season)

Total catch of 31 test operations consisted of 2,763 of CPUE in number and 2,926 in weight, for a total of 55 species. Table 5-9 and Figure 5-44 show CPUE of the major species given in catch during the 4th survey, in terms of both number and weight, per 100 tans of 5-mesh size nets.

In terms of number, bullet mackerel was again the most numerous species,

represented by 775 , as in the second survey, followed by frigate mackerel, big eye tuna, more than 100 were taken for each.

In terms of weight, the catch of skipjack tuna, 869, was the heaviest, followed by frigate mackerel, common dolphinfish, striped marlin, bullet mackerel, and sailfish, each being above 100.

Table 5-9 Total CPUE, in terms of number and weight, of major species and other selected species taken during the 4th survey, May and June 1997

Scientific name	English name	Catch	
		Total CPUE in number	Total CPUE in weight
Auxis rochei	Bullet mackerel	775	220
Auxis thazard	Frigate mackerel	385	296
Katsuwonus pelamis	Skipjack tuna	312	869
Coryphaena hippurus	Common dolphinfish	286	276
Sthenoteuthis oualaniensis	Flying squid	209	90
Brama orcini	Bigtooth pomfret	116	29
Thunnus tonggol	Longtail tuna	112	48
Thunnus obesus	Bigeye tuna	102	43
Coryphaena equiselis	Pomoano dolphinfish	77	29
Lobotes surinamensis	Triple tail	34	54
Euthynnus affinis	Easter little tuna	25	17
Thunnus albacares	Yellowfin tuna	11	7
Istiophorus platypterus	Sail fish	10	173
Tetrapterus audax	Striped marlin	4	237
Aluterus monoceros	Unicorn leatherjacket	2	0
Xiphias gladius	Broadbill swordfish	1	34
Makaira indica	Black marlin	–	–
Makaira mazara	Blue marlin	–	–
Total		2461	2422

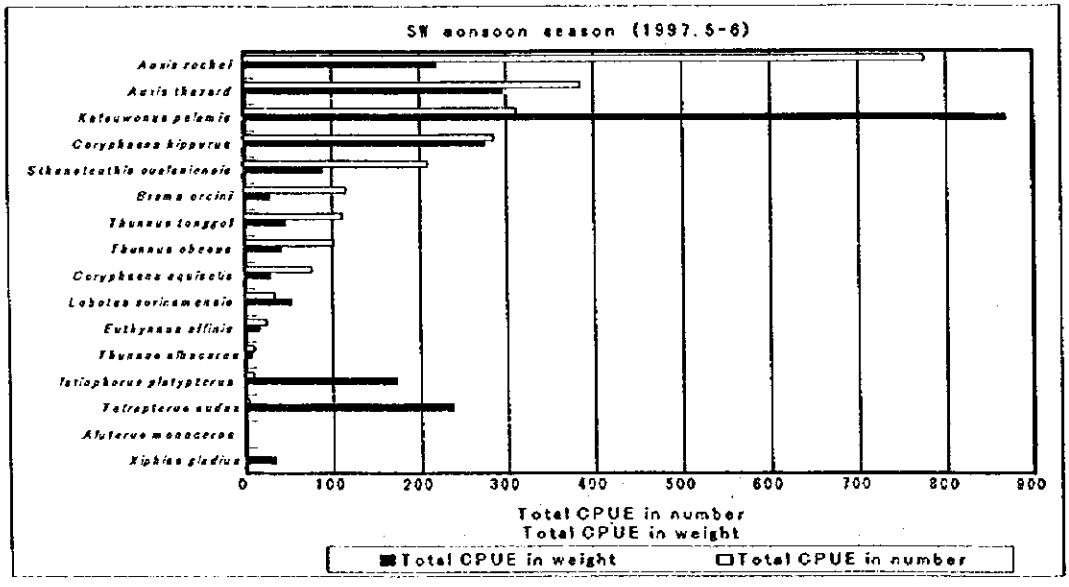


Figure 5-44 Total CPUE, in terms of number and weight, of major species and other selected species taken during the 4th survey, May and June 1997

(4) Seasonal change in abundance

If the second and third surveys could represent abundance in the southwestern and northeastern monsoon seasons, respectively, no remarkable change of major species was found between the two seasons. In terms of number, bullet mackerel at the first rank in the southwestern monsoon season declined to the 7th rank in the northwestern monsoon season, while unicorn leatherjacket rose from a very low ranking to 6th during the same duration. In weight, the most abundant species were skipjack tuna, common dolphinfish and frigate mackerel in both seasons. Except for billfishes, the 4th and 5th ranks were taken by flying squid and bigtooth pomfret in both seasons.

Catches in the northeastern monsoon season against that in the southwestern monsoon season (NE:SW) were 422:185 for bigtooth pomfret, 295:506 for common dolphinfish, 234:116 for frigate mackerel, 209:135 for skipjack tuna, 153:268 for flying squid and 133:4 for unicorn leatherjacket in terms of number, and weight for the most abundant six species, 135: 61 for bigtooth pomfret, 323:437 for common dolphinfish, 231:140 for frigate mackerel, 565:448 for skipjack tuna, 60:127 for flying squid and 30: 2 for unicorn leatherjacket. Four species out of six showed higher abundance in the northeastern monsoon season than in the southwestern monsoon season, except for common dolphinfish and flying squid.

6-3-2 Seasonal and year-to-year change of geographic distribution of relative abundance (CPUE) of major species.

Data from two survey cruises in the southwestern monsoon seasons of May to June 1996 and 1997 permit us to examine year-to-year change of CPUE in number of major species in each one-latitude-longitude-degree quadrangle in that season. The season-to-season comparison was conducted with the data taken in same year, during the 2nd survey cruise in southwestern monsoon season, and 3rd survey cruise in northeastern monsoon season from September to October in 1996.

(1) Common dolphinfish (*Coryphaena hippurus*)

① Southwestern monsoon season

Figure 5-45 compares CPUE in number of common dolphinfish in two southwestern monsoon seasons of 1996 and 1997. The sum of CPUE in number over the whole survey area was higher, 506 in 1996 than 286 in 1997, suggesting wide year-to-year fluctuation in distribution of CPUE. The fish are distributed widely over the whole survey area, but tend to aggregate in the coastal waters, especially in quadrangles of Lat. 15 degrees N to 18 degree N in the North Region. Other areas of concentration are found off the Mekong Delta in the South Region, as well as coastal waters of the Central Region.

② Northeastern monsoon season

Figure 5-46 indicates CPUE in number in the northwestern monsoon season, 1996. CPUE are 50 in the North Region, 140 in the Central Region and 69 in the South Region. Taking it into account that the test fishing was conducted at only three quadrangles out of nine in the North Region, and that CPUE might have been underestimated for abundance of stocks therein

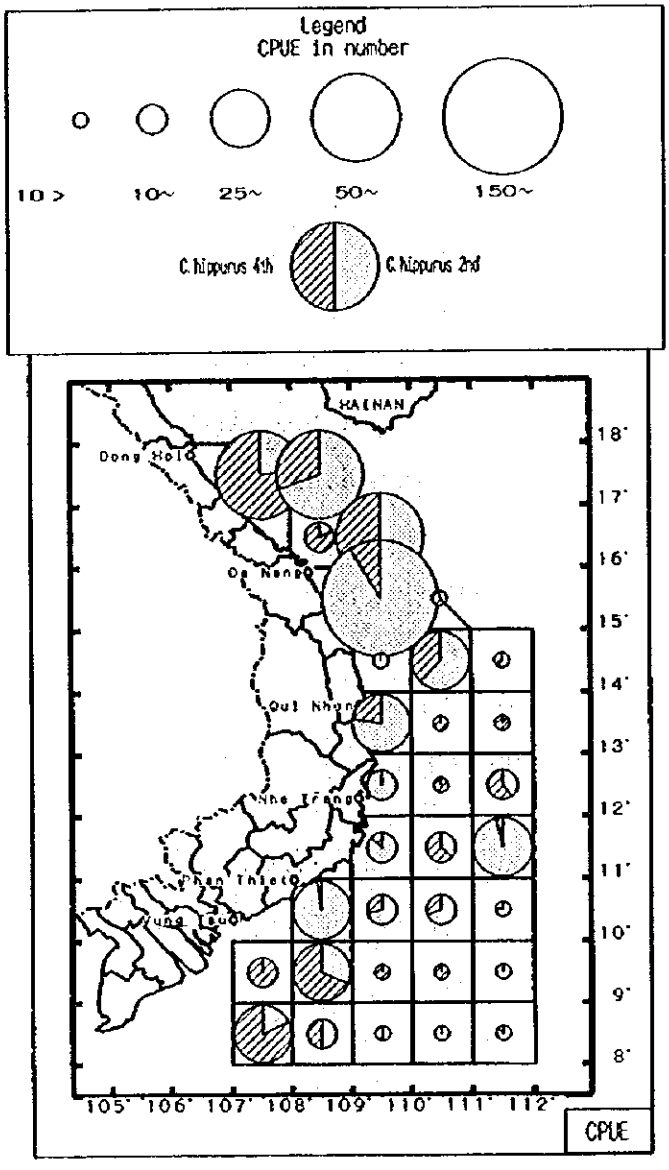


Figure 5-45 CPUE in number of common dolphinfish in SW monsoon season of 1996 and 1997.

③ Difference between seasons.

CPUE in number of common dolphinfish were illustrated for each cruise and for each quadrangle in Figure 5-47. Comparison of CPUE by quadrangle for each of three cruise cruises suggests that the distribution pattern resembles between the 3rd and 4th surveys, but not with the 2nd survey. The 2nd and 4th surveys in both southwestern monsoon seasons show a wide fluctuation in CPUE.

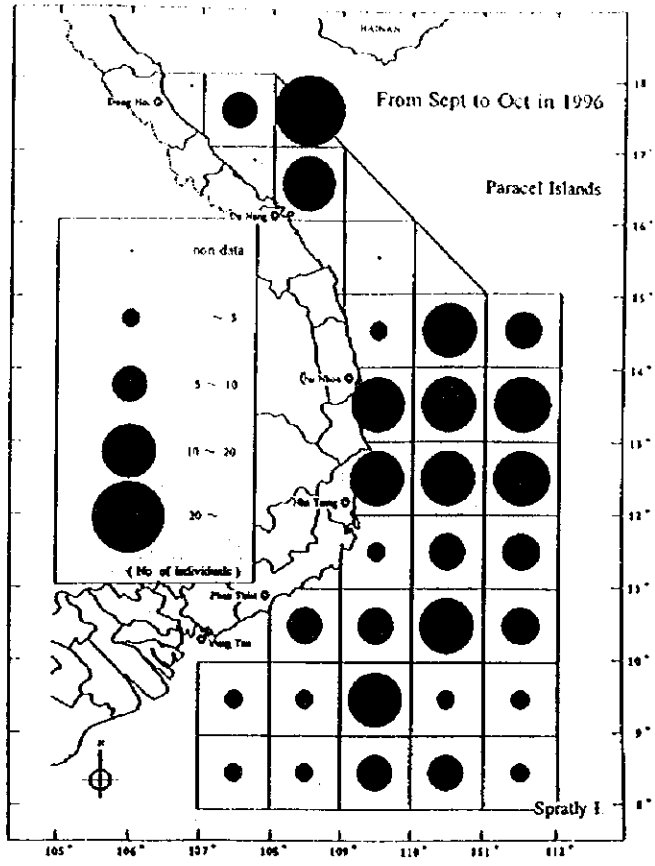
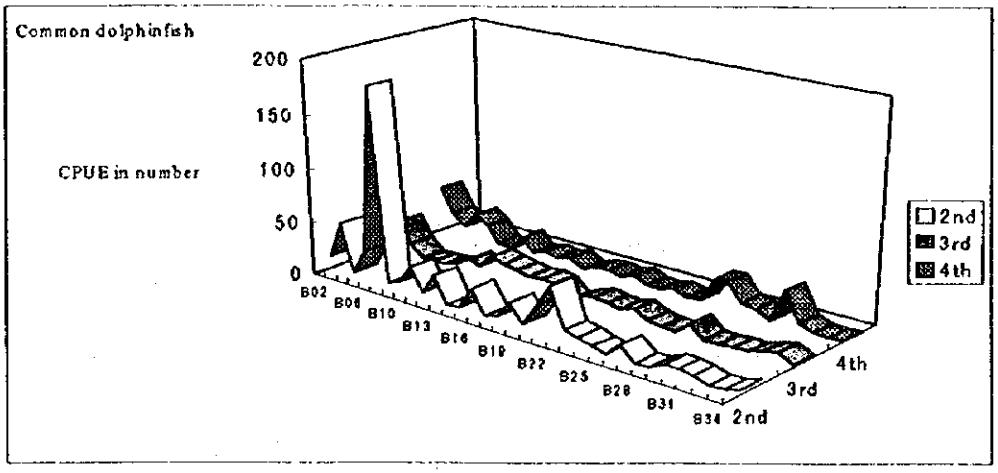


Figure 5-46 CPUE in number of common dolphinfish in NE monsoon season of 1996.



X-axis : serial number of survey quardrangles, Y-axis : serial number of survey cruises and Z-axis : CPUE in number in each quadrangles.

Figure 5-47 Distribution of CPUE in number of common dolphinfish by quadrangle in each of the three surveys of 1996 and 1997

(2) Pompano dolphinfish (*Coryphaena equiselis*)

① Southwestern monsoon season

Combined CPUE in number of the fish taken at the 2nd and 4th surveys is illustrated for each quadrangle in Figure 5-48. Total CPUE are 41 and 77 for the 2nd and 4th cruises, respectively, while number of positive quadrangles is 7 in 1996 and 18 in 1997. These values imply that catch of less abundant species would change widely from year to year. During the 2nd survey, pompano dolphinfish were taken in significant number of 10 to 20 individuals in entrance to the Gulf of Tongking, 17 degree N - 18 degree N, 108 degree E - 109 degree E, in the North Region, as well as off Nha Trang, 11 degree N - 12 degree N, 109 degree E - 110 degree E, in the Central Region. In spite of the increase of positive quadrangles for the 4th survey, more than double the preceding occasion, only one quadrangle, 9 degree N - 10 degree N, 109 degree E - 110 degree E, showed a high CPUE over 10. In the two surveys, pompano dolphinfish were only seldom found in some quadrangles such as 12 degree N - 14 degree N in the Central Region, and in 8 degree N - 9 degree N, 107 degree E - 112 degree E of the South Region. In general, pompano dolfinfish were found less than common dolphinfish in both CPUE and distribution range within the survey area.

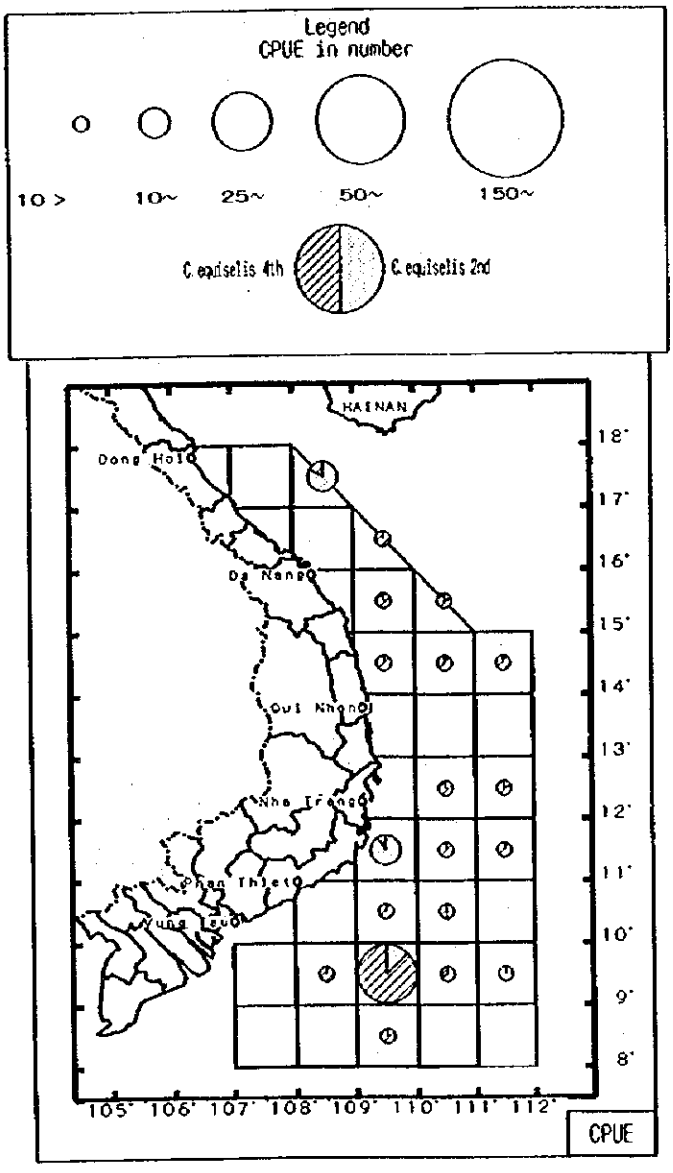


Figure 5-48 Distribution of CPUE in number of pompano dolphinfish in SW monsoon season of 1996 and 1997

② Northeastern monsoon season

Figure 5-49 shows distribution of CPUE in number in the northwestern monsoon season, 1996. The sum of CPUE over whole survey area is 36 , close to 41 that found in the 2nd cruise. The fish occurred only in quadrangles near the Gulf of Tongking, 17 degree N - 18 degree N, 108 degree E - 109 degree E, in the North Region and in the other limited quadrangles. CPUE is also very low everywhere under survey.

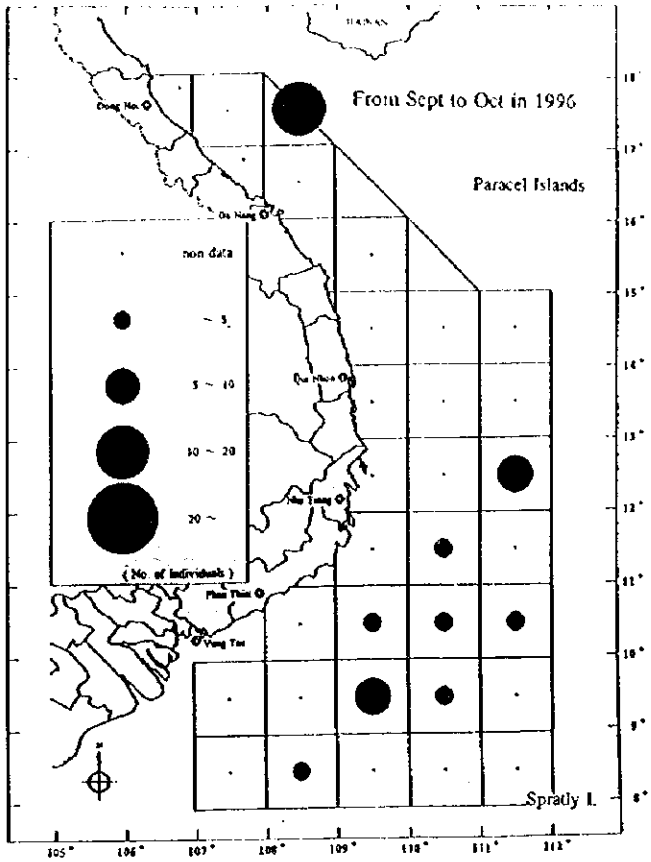


Figure 5-49 Distribution of CPUE in number of pompano dolphinfish in NE monsoon season of 1996

③ Difference between seasons

CPUE in number of the fish were illustrated for each cruise and for each quadrangle in Figure 5-50.

Comparison of CPUE by quadrangle for each of three cruises suggests that the distribution pattern has resemblance between the 3rd and 4th surveys, but not with the 2nd survey. Season-to-season change appears to be wider than year-to-year fluctuations.

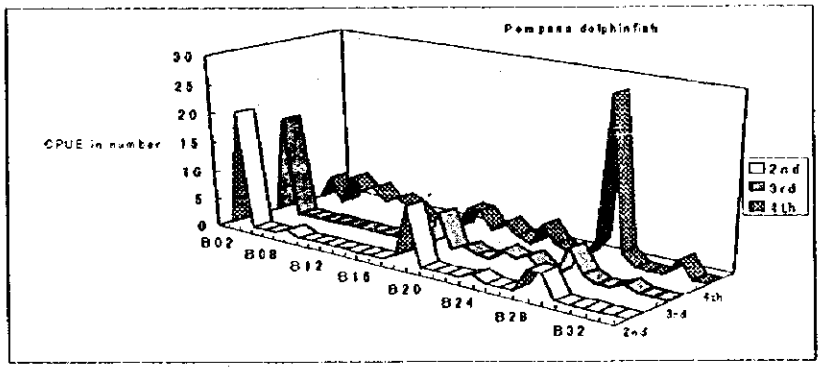


Figure 5-50 Distribution of CPUE in number of Pompano dolphinfish by quadrangle in each of the three surveys from 1996 to 1997.

(3) Bigtooth pomfret (*Brama orcini*)

① Southwestern monsoon season ,

Figure 5-51 presents CPUE in number of bigtooth pomfret in each quadrangle based on data from the 2nd and 4th cruises.

The sum of CPUE is 185 for 1996 and 116 for 1997. The fish appeared mainly in quadrangles, 12 degree N - 15 degree N, of the Central Region, 123 and 99, respectively, and, in less number, 56 and 16, in quadrangles, 8 degree N - 11 degree N, of the South Region.

It is likely that the major habitat of bigtooth pomfret in the southwestern monsoon season is located in the Central Region, especially two quadrangles of 14 degree N - 15 degree N, 109 degree E - 111 degree E, where CPUE in number was the highs; 45 in 1996 and 86 in 1997.

The fish did not appear near the Gulf of Tongking in the North Region, and near the Mekong Delta in the South Region. It seems probable to assume that the fish avoid low saline waters derived from large rivers.

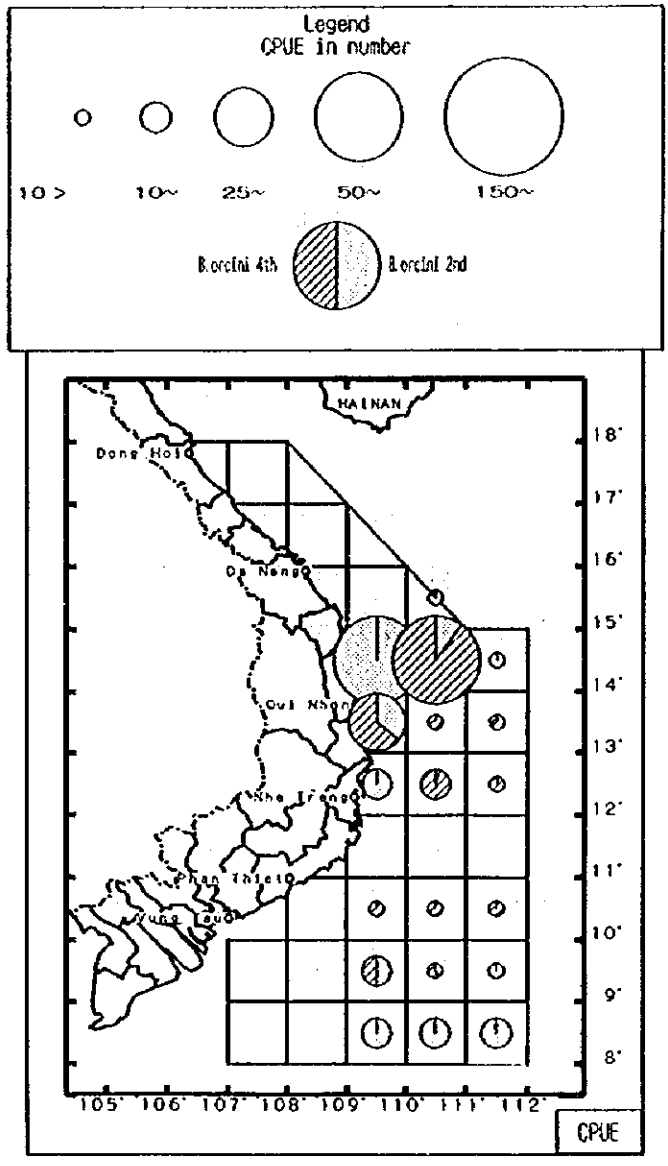


Figure 5-51 Distribution of CPUE in number of bigtooth pomfret in SW monsoon season of 1996 and 1997

② Northeastern monsoon season

Figure 5-52 presents CPUE in number of bigtooth pomfret in each quadrangle based on data from the 3rd cruise. CPUE of bigtooth pomfret based on data of the 3rd survey totaled 422 , as high as about three times of the figures in the southwest monsoon season. The geographical range expanded widely the Central and South Regions excluding coastal part of the latter. It is also noted that significant CPUE in number, 57 was found in the area of 11 degree N - 12 degree N, 109 degree E - 112 degree E, where the fish did not appear during the southwestern monsoon season.

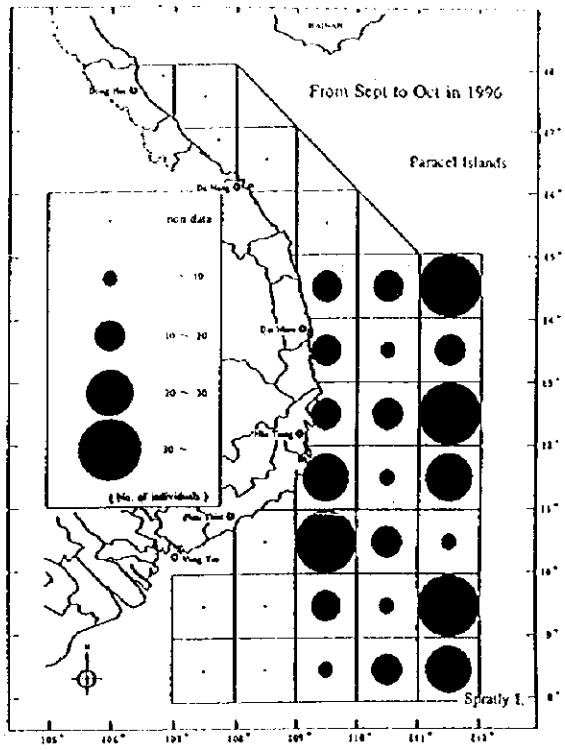


Figure 5-52 Distribution of CPUE in number of bigtooth pomfret in NE monsoon season of 1996

③ Difference between seasons.

CPUE in number of the fish were illustrated for each cruise and for eachquadrangle in Figure 5-53. Bigtooth pomfret showed fairly clear seasonal change in geographic distribution, and in availability to drift gill nets, more vulnerable in the northwestern monsoon season than in the other. It is also suggested that the fish seem to avoid the deep layer waters in addition to river waters.

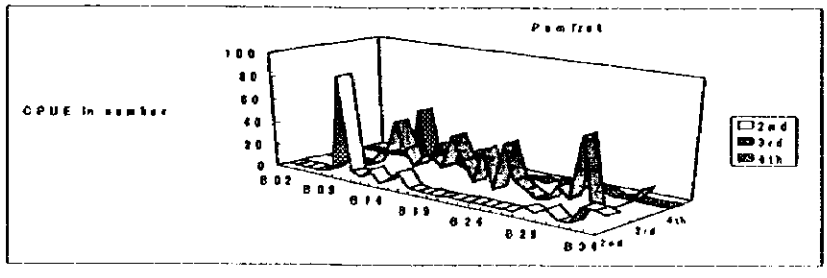


Figure 5-53 Distribution of CPUE in number of bigtooth Pomfret by quadrangle in each of the three surveys from 1996 to 1997.

(4) Triple tail (*Lobotes surinamensis*)

① Southwestern monsoon season

Figure 5-54 presents CPUE in number in each quadrangle based on data from the 2nd and 4th cruises. The sum of CPUE is 54 for 1996 and 34 for 1997. The fish is widely distributed in the survey area excluding coastal waters facing the Gulf of Tongking, 16 degree N - 18 degree N, 107 degree E - 108 degree E, of the North Region and coastal waters, 8 degree N - 11 degree N, 107 degree E - 109 degree E, of the South Region. The sum of CPUE in the 2nd and 4th surveys were 19 and 1 in the North Region, 17 and 17 in the Central Region, and 18 and 16 in the South Region. The wide year-to-year difference reflects a single high value of CPUE in number at a single station B-06 (16 degree N - 17 degree N, 109 degree E - 110 degree E), where the operation captured 18 of CPUE in number in 1996.

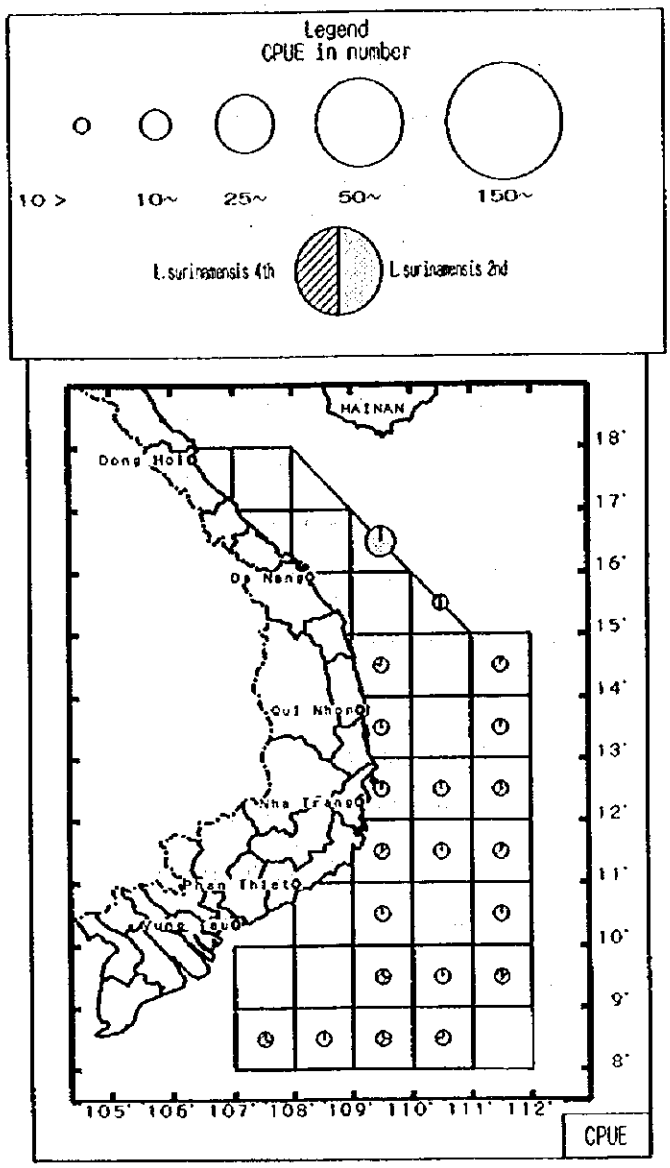


Figure 5-54 Distribution of CPUE in number of triple tail in SW monsoon season of 1996 and 1997

② Northeastern monsoon season

Figure 5-55 presents CPUE in number of triple tail in each quadrangle based on data from the 3rd cruise. Data taken during the northeastern monsoon season indicates CPUE 58 of in number. The fish appeared more frequently in the South Region with CPUE 34 of rather than in the Central Region, 18 and in the North Region, 6.

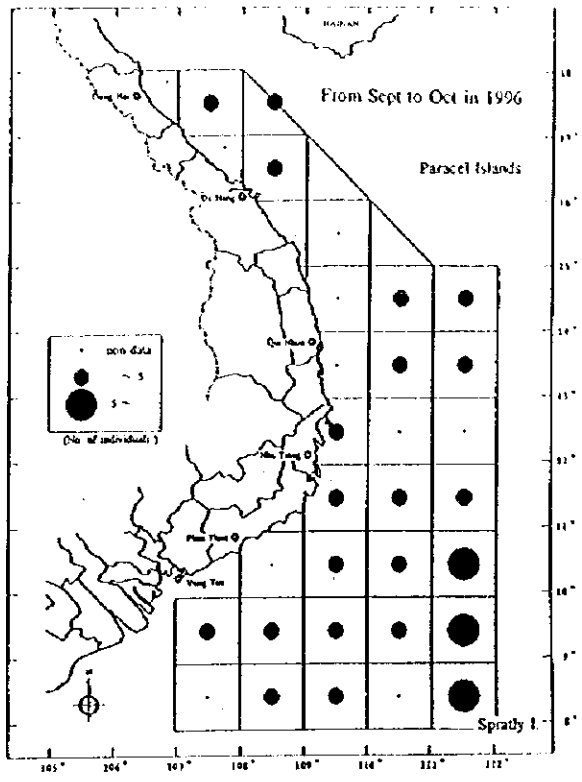


Figure 5-55 Distribution of CPUE in number of triple tail in NE monsoon season of 1996

③ Difference between seasons.

CPUE in number of Triple-tail were illustrated for each cruise and for each quadrangle in Figure 5-56. The fluctuation of CPUE in the North Region year-to-year appears to be wider than in other regions. Except for the North Region, season-to-season change appears to be small.

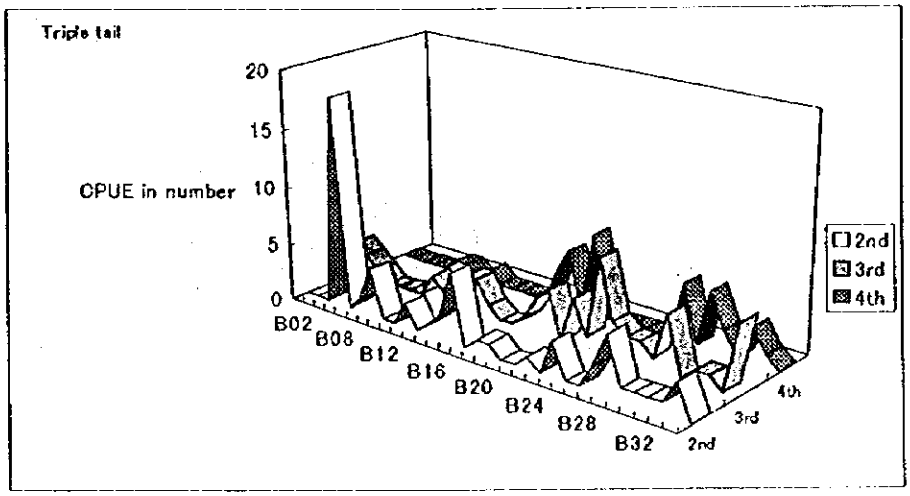


Figure 5-56 Distribution of CPUE in number of Triple tail by quadrangle in each of the three surveys from 1996 to 1997

(5) Frigate mackerel (*Auxis thazard*)

① Southwestern monsoon season

Figure 5-57 presents CPUE in number in each quadrangle based on data from the 2nd and 4th cruises. The sum of total CPUE in number for 1997 is 385, three times higher than 116 for 1996. CPUE in number was low in the Central Region, 9 in the 2nd survey and 3 in the 4th, compared to 72 in 1996 and 32 in 1997in the North Region and 35 and 350 in respective surveys in the South Region. It is also noted that the abundance showed remarkable year to year variation in quadrangles of the two prolific regions.

Except for offshore waters, 10 degree N - 11 degree N, 111 degree E - 112 degree E, in the South Region, high concentrations were found in the near coast areas.

The highest concentration was found in the quadrangle 16 degree N - 17 degree N, 109 degree E - 110 degree E in the North Region during the 2nd survey, or 9 degree N - 10 degree N, 107 degree E - 108 degree E in the South Region during the 4th survey. Especially, the figure in the most prolific quadrangle in 1997 comprises 90 % of the total.

In short, the fish are mainly distributed in the coastal waters of the North and South Regions in the southwestern monsoon season.

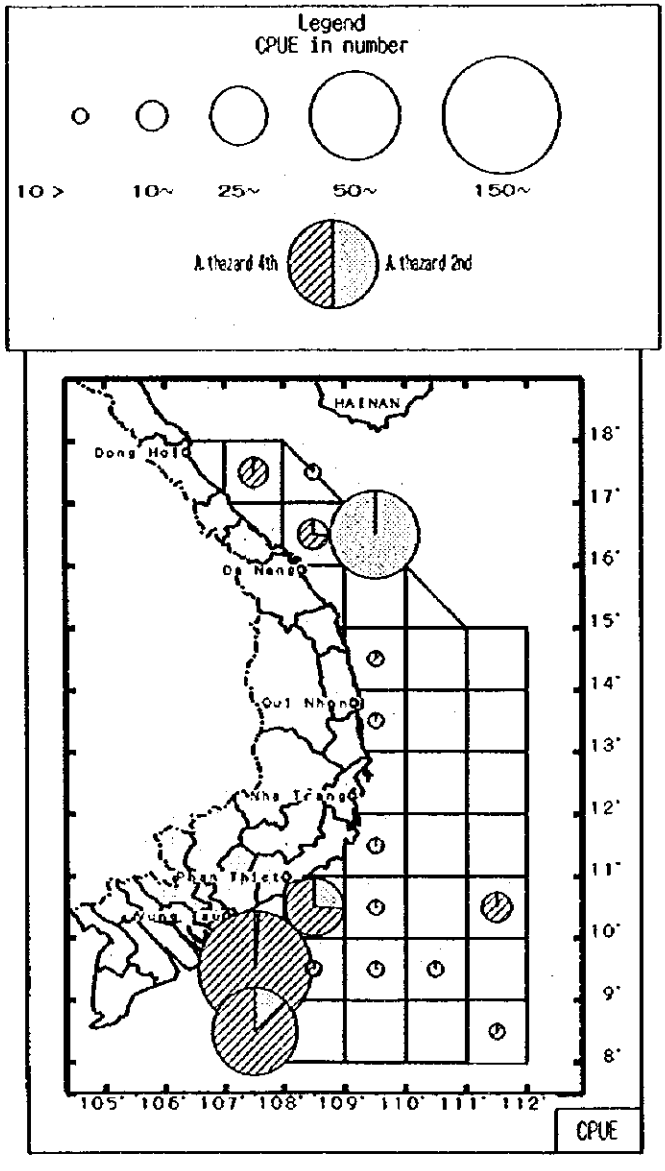


Figure 5-57 CPUE in number of frigate mackerel in SW monsoon season of 1996 and 1997

② Northeastern monsoon season

Figure 5-58 presents CPUE in number in each quadrangle based on data of the 3rd survey that totaled 234.
Of them 222 occurred in the South Region, and 10 in the North Region and only 2 in the Central Region. In the Central Region, the fish were taken in the offshore quadrangle.

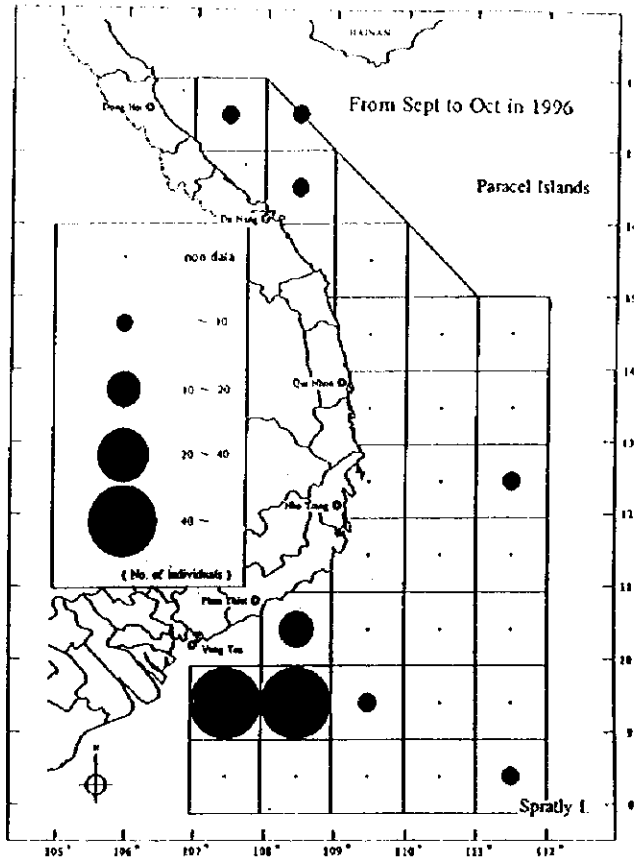


Figure 5-58 CPUE in number of frigate mackerel in NE monsoon season of 1996

③ Difference between seasons.

CPUE in number of frigate mackerel were illustrated for each cruise and for each quadrangle in Figure 5-59. It is noted that CPUE varied fairly significantly between years even in the same southwestern monsoon season.

During the 3rd and 4th cruisesconducted in different monsoon seasons, remarkably high values appeared in off shore waters represented by B-26 in the South Region.

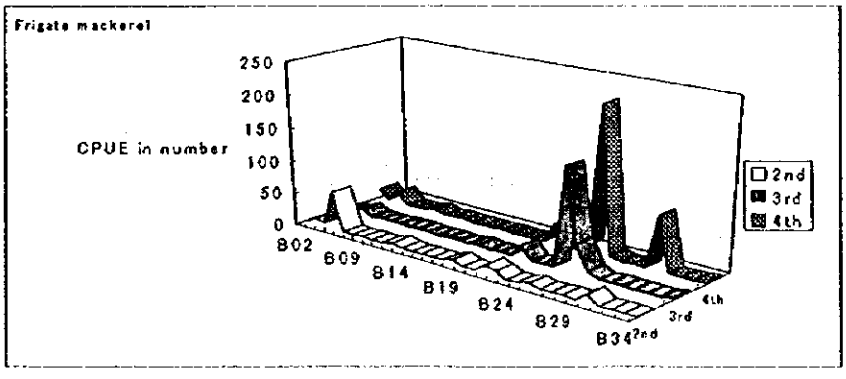


Figure 5-59 Distribution of CPUE in number of Frigate mackerel by quadrangle in each three surveys from 1996 to 1997.

(6) Bullet mackerel (*Auxis rochei*)

① Southwestern monsoon season

Figure 5-60 presents CPUE in number in each quadrangle based on data from the 2nd and 4th cruises. The sum of CPUE for 1997 is 775, over 3 times higher than the value for 1996.

CPUE in number varies widely from year to year, especially in prolific regions as 113 during the 2nd cruise and 266 during the 4th cruise in the North Region and 27 and 370, respectively, in the Central Region, but less significantly in the South Region as 96 in 1996 and 139 in 1997. The fish are mainly distributed in the waters near the coast, and less to the north of Lat. 16 degree N off Da Nang.

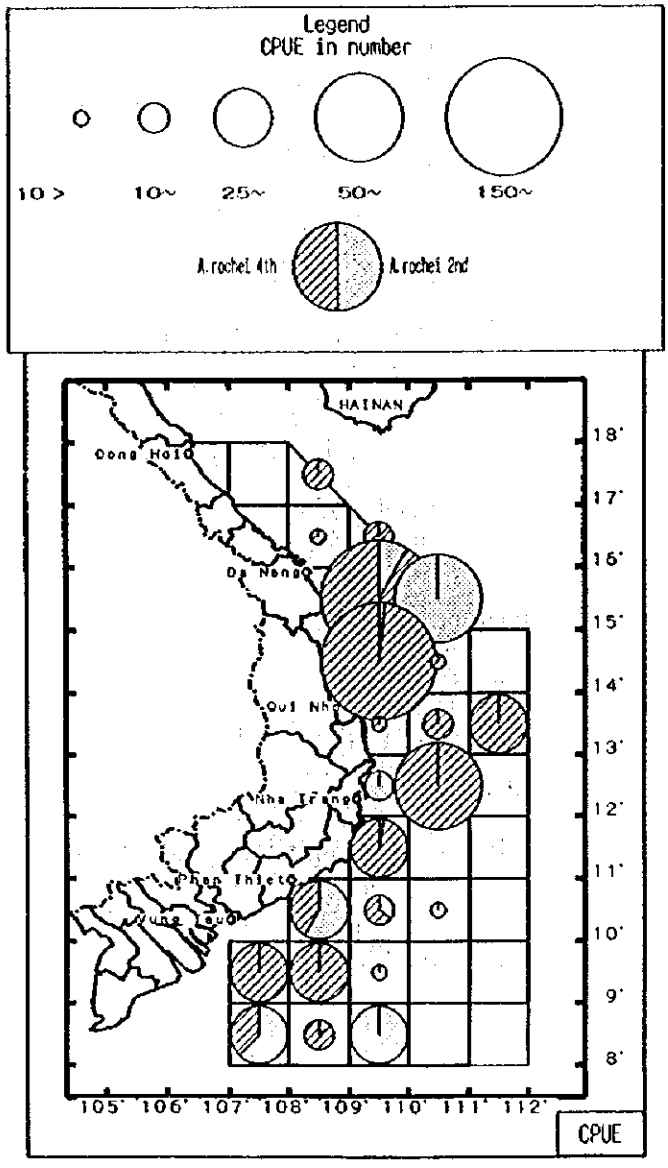


Figure 5-60 CPUE in number of bullet mackerel in SW monsoon season of 1996 and 1997

② Northeastern monsoon season

Figure 5-61 presents CPUE in number in each quadrangle based on data of the 3rd survey that totaled 58 individuals. The sums of CPUE in number by quadrangle were 1, 31 and 26 in the North, Central and South Regions, respectively. Only a single quadrangle, 12 degree N - 13 degree N, 111 degree E - 112 degree E, of the Central quadrangle represented 30 out of 31. The fish appeared over many quadrangles in the South Region.

③ Difference between seasons.

Figure 5-62 represents CPUE in number of bullet mackerel for each cruise and for each quadrangle. The fish were more frequently taken in the southwestern monsoon seasons than in the other season, but the CPUE showed fairly wide variation between years.

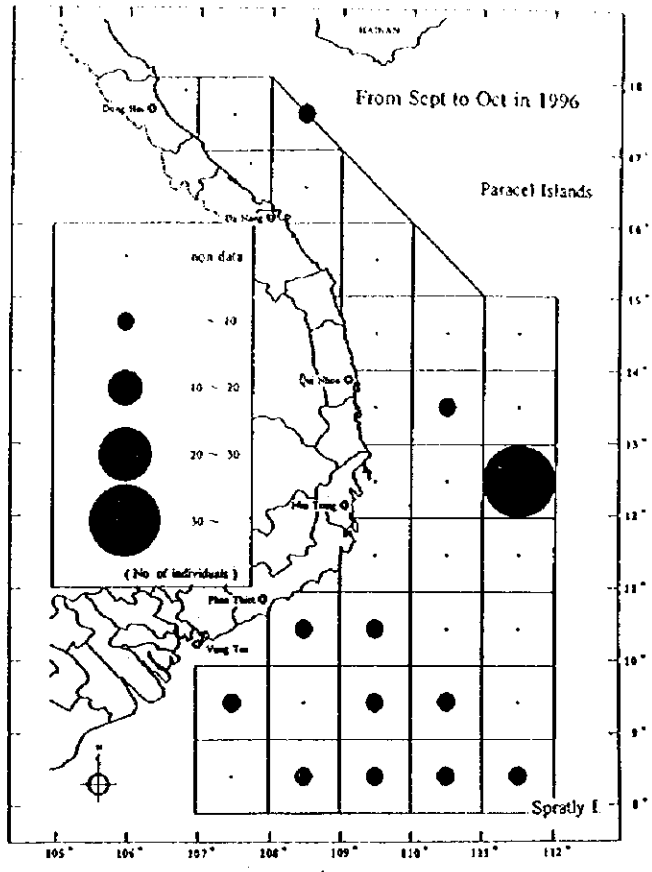


Figure 5-61 CPUE in number of bullet mackerel in NE monsoon season of 1996

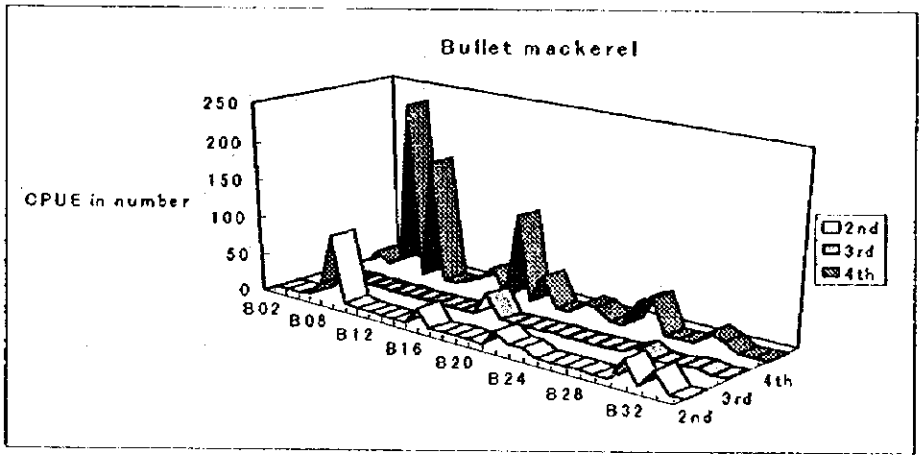


Figure 5-62 Distribution of CPUE in number of Bullet mackerel by quadrangle in each of the three surveys from 1996 to 1997.

(7) Eastern little tuna (*Euthynnus affinis*)

① Southwestern monsoon season

Figure 5-63 shows CPUE in number in each quadrangle based on the 2nd and 4th surveys. The fish did not appear at all in the Central Region. During the 2nd survey, only a nominal catch was taken either in offshore of the North Region, 16 degree N -17 degree N, 109 degree E - 110 degree E, or in coastal waters near the Mekong Delta, 9 degree N - 10 degree N, 107 degree E - 108 degree E, of the South Region.

During the 4th survey, the fish appeared only in the area around the Mekong Delta, 9 degree N - 10 degree N, 107 degree E - 108 degree E, at a fairly high value of 20. It is likely that the fish are distributed in two general areas of offshore waters in the North Region and the coastal waters in the South Region, more highly in the latter than in the former.

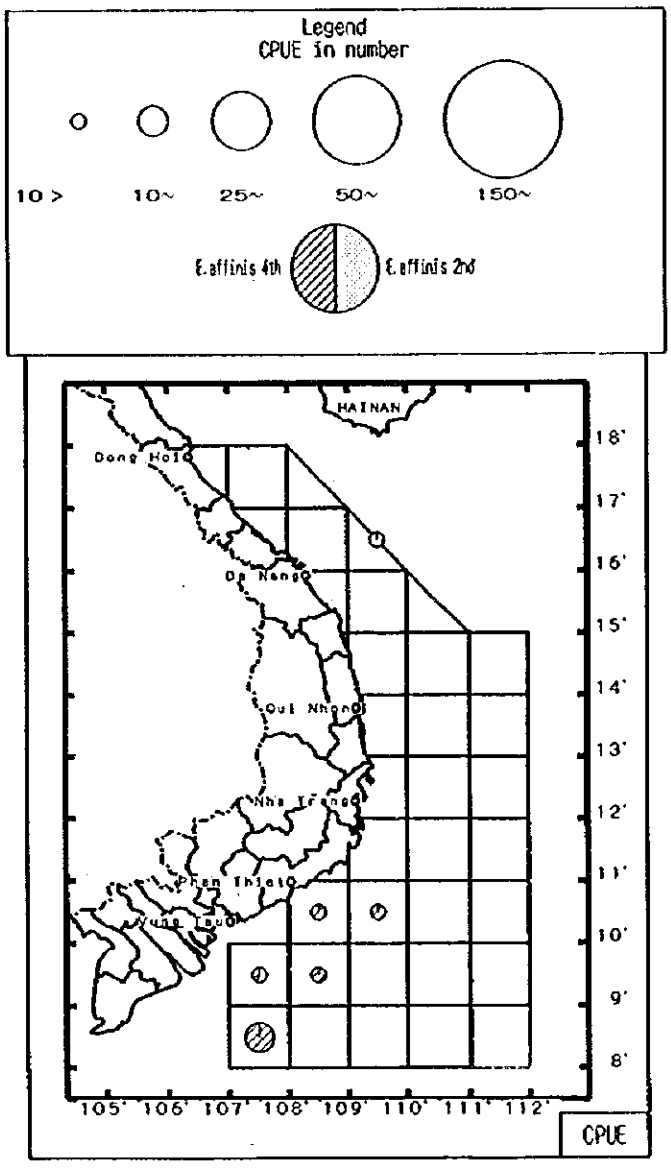


Figure 5-63 CPUE in number of eastern little tuna in SW monsoon season of 1996 and 1997

② Northeastern monsoon season

CPUE in number by quadrangle is given in Figure 5-64 drawn on the basis on data of the 3rd survey.

As seen in the Figure, the fish was dispersed over wide ranges including the waters around the Gulf of Tongking, 17 degree N - 18 degree N, 107 degree E - 108

degree E, of the North Region, in the offshore waters of the Central Region and in both coastal and offshore waters of the South Region.

③ Difference between seasons.

Figure 5-65 represents CPUE in number of bullet mackerel for each cruise and for each quadrangle. As pointed out in the above examination, little tuna is distributed in the coastal waters of the South and North Regions throughout the year, but found in the Central Region only in the northeastern monsoon season.

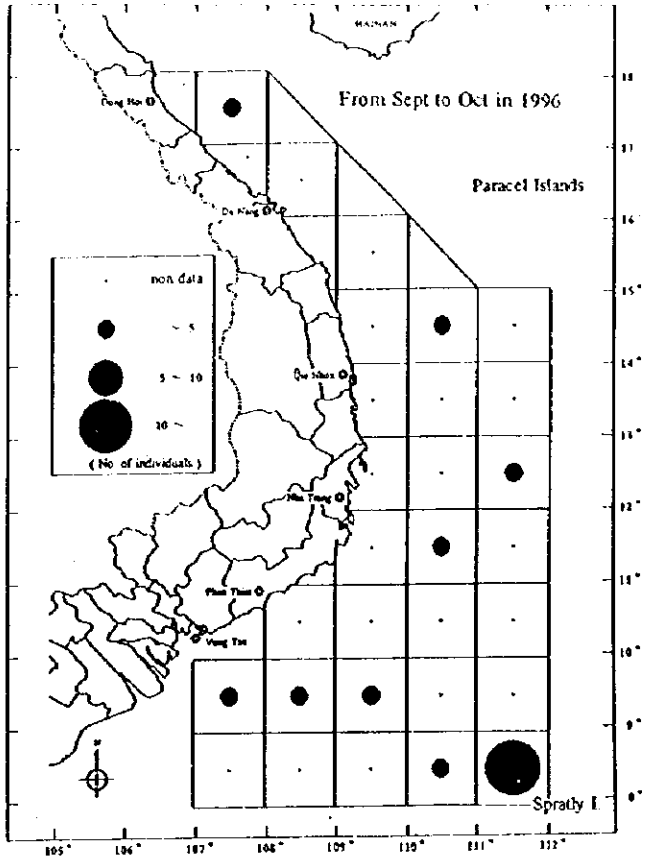


Figure 5-64 CPUE in number of eastern little tuna in NE monsoon season of 1996.

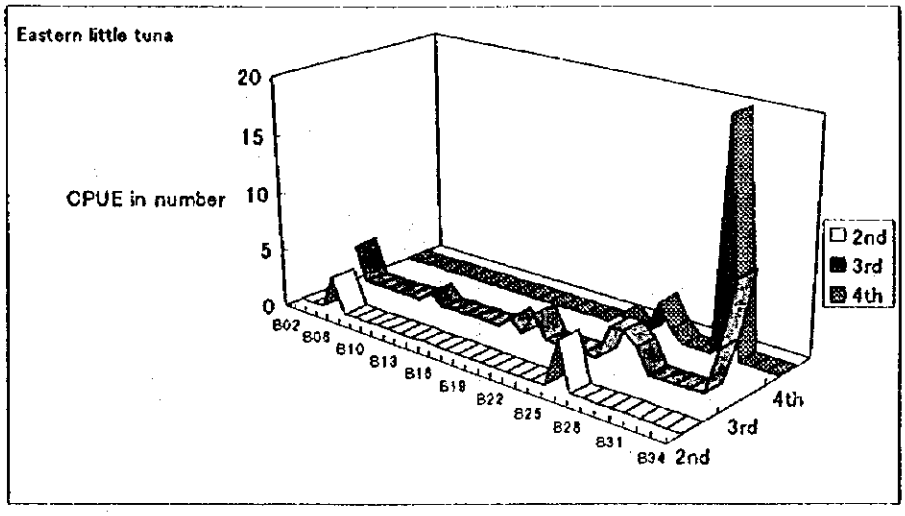


Figure 5-65 Distribution of CPUE in number of Eastern little tuna by quadrangle in each of the three surveys from 1996 to 1997.

(8) Skipjack tuna (*Katsuwonus pelamis*)

① Southwestern monsoon season

Figure 5-66 shows CPUE in number in each quadrangle based on the 2nd and 4th surveys. The Sum of CPUE in number differ between the two years, 135 in 1996 and 312 in 1997. The corresponding regional values are 15 and 25 in the North Region, 50 and 111 in the Central Region, and 70 and 176 in the South Region. The year-to-year variation was more remarkable in the two prolific southern regions than in the North Region. In the North Region, the fish occurred in the offshore waters throughout the cruises except only three fish taken in the entrance to the Gulf of Tongking, 17 degree N - 18 degree N, 107 degree E - 108 degree E, in 1997. Skipjack tuna were taken in wide geographic range from coastal to offshore waters, except a quadrangle of 12 degree N - 13 degree N, 109 degree E - 110 degree E near Nha Trang, in the Central Region.

The fish occurred in the entire the South Region, except for coastal quadrangle near the Mekong Delta, 8 degree N - 10 degree N, 107 degree E - 108 degree E, even though CPUE was low in coastal area and around the Spratly Islands.

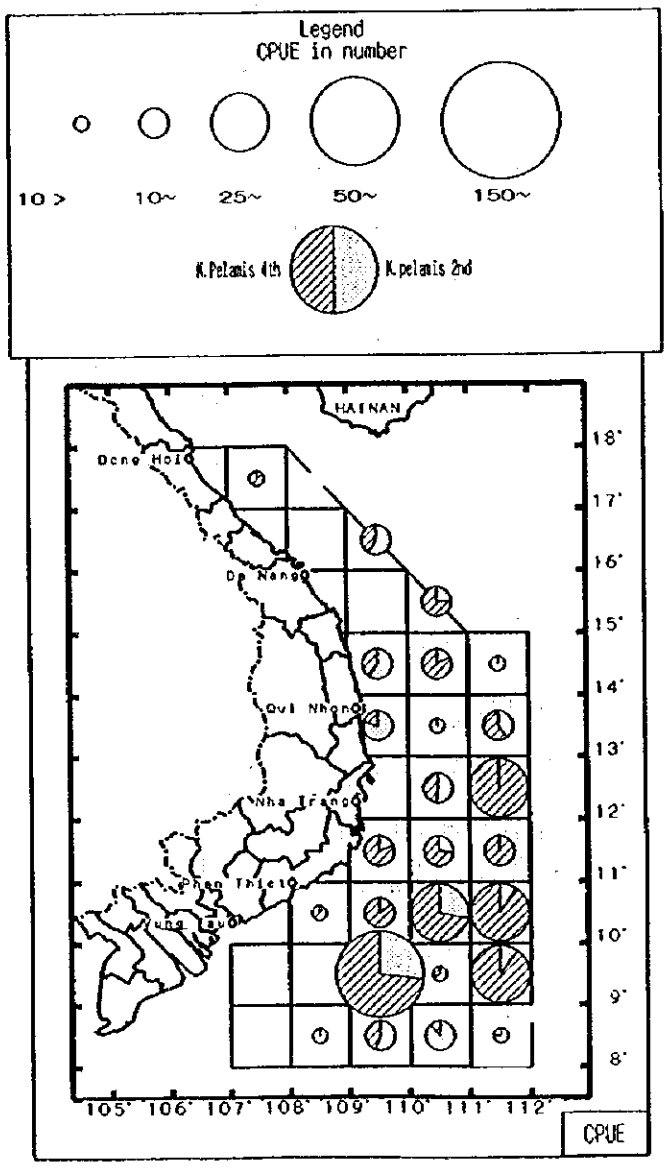


Figure 5-66 CPUE in number of skipjack tuna in SW monsoon season of 1996 and 1997

The two surveys revealedthe distribution range of skipjack tuna in the southwestern monsoon season, and fairly significant year-to-year variationsof CPUE.

② Northeastern monsoon season

CPUE in number by quadrangle is given in Figure 5-67 drawn on the basis of data taken by the 3rd survey. CPUE in number totaled 209, divided into 4, 123 and 82 in the North, Central and South Regions, respectively. Features of the seasonal distribution are high values in the Central Region, and low values in the offshore waters of the South Region. Unfortunately, occurrence of the fish in the North Region was not fully examined due to lack of test fishing in three quadrangles therein.

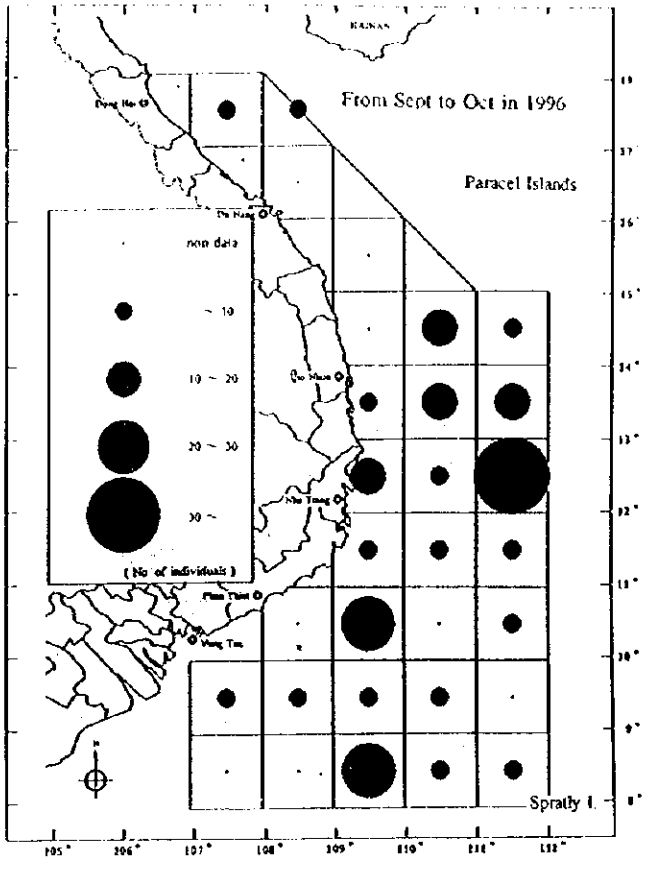


Figure 5-67 CPUE in number of skipjack tuna in NE monsoon season of 1996

③ Difference between seasons.

Figure 5-68 represents CPUE in number of skipjack tuna for each cruise and for each quadrangle. The fish were more frequently taken in the South Region in the southwestern monsoon season, while in the Central Region in the northeastern monsoon season. However, the CPUE showed fairly large year-to-year variation in the same southwestern monsoon season. However, distribution in the North Region needs further surveys in future, as a result of difficult weather conditions during test fishing in the 3 central quadrangles.

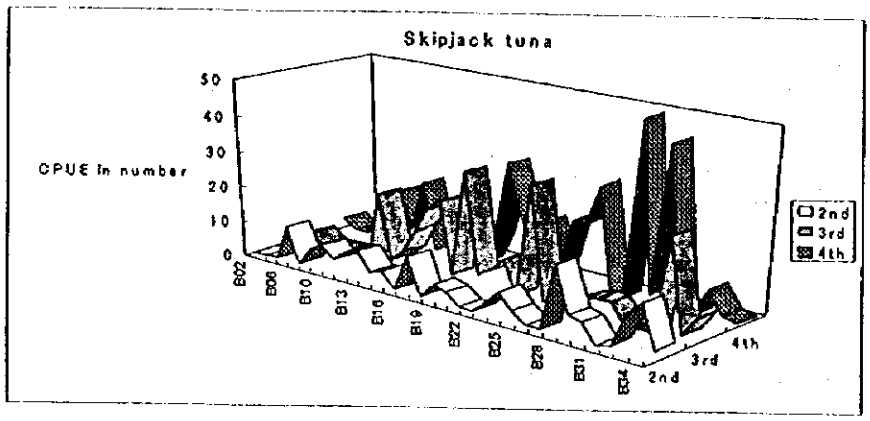


Figure 5-68 Distribution of CPUE in number of Skipjack tuna by quadrangle in each of the three surveys from 1996 to 1997.

(9) longtail tuna (*Thunnus tonggol*)

Figure 5-69 shows CPUE in number in each quadrangle based on data taken during the three surveys. Test operations caught long tail tuna in the 3rd and 4th surveys, but not in the 2nd survey. The fish appeared only in the coastal waters, 9 degree N - 11 degree N, 107 degree E - 109 degree E, near the Mekong Delta of the South Region. CPUE in number was higher, 112 in the southwestern monsoon season of 1997, than that of 39 in the northeastern monsoon season of 1996.

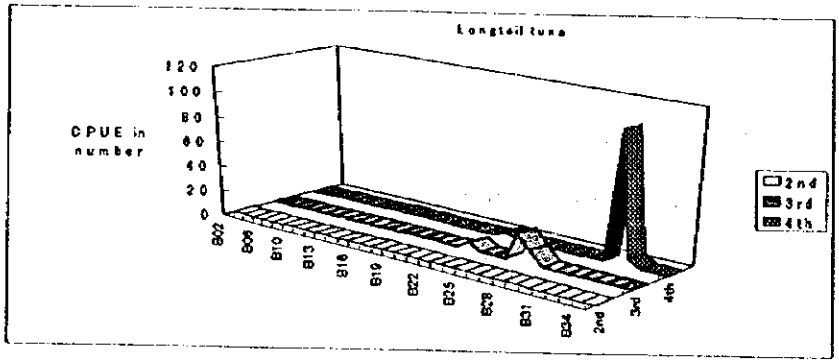


Figure 5-69 Distribution of CPUE in number of longtail tuna by quadrangle in each of the three surveys from 1996 to 1997.

(10) yellowfin tuna (Thunnus albacares)

Figure 5-70 shows CPUE in number in each quadrangle based on data taken during the three surveys. Unfortunately only a small number of the fish were collected by the test fishing, a single individual during the 2nd survey, and 11 individuals during in

each of the 3rd and 4th surveys. The fish occurred more frequently in the North Region during the southwestern monsoon season, while in the South Region during the northeastern monsoon season, rather than in the other regions.

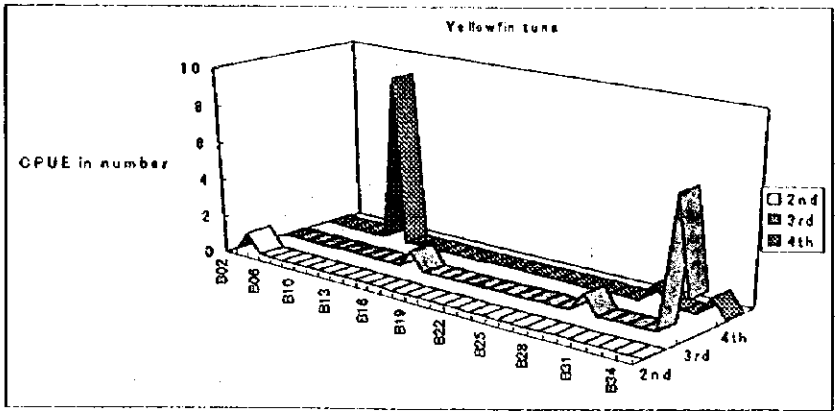


Figure 5-70 Distribution of CPUE in number of yellowfin tuna by quadrangle in each of the three surveys from 1996 to 1997.

(11) bigeye tuna (*Thunnus obesus*)

Figure 5-71 shows CPUE in number in each quadrangle based on data taken during the three surveys. The species was infrequent catch for the test fishing and the data failed show specific features of distribution.

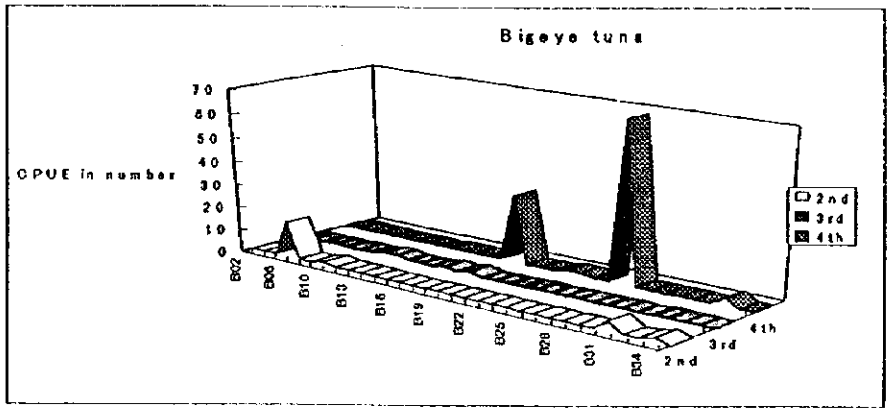


Figure 5-71 Distribution of CPUE in number of bigeye tuna by quadrangle in each of the three surveys in SW monsoon season.

(12) Sail fish (*Istiophorus platypterus*)

① Southwestern monsoon season

Figure 5-72 presents CPUE in number in each quadrangle based on data from the 2nd and 4th cruises. The sum of CPUE in number is 11 in 1996, and 10 in 1997.

Positive quadrangles appeared widely in the coastal waters, except for some concentration in the offshore waters at 8 degree N - 10 degree N, 110 degree E - 111 degree E, in 1997. The fish are distributed on the continental shelf, as well as shallow waters around the Spratly Islands.

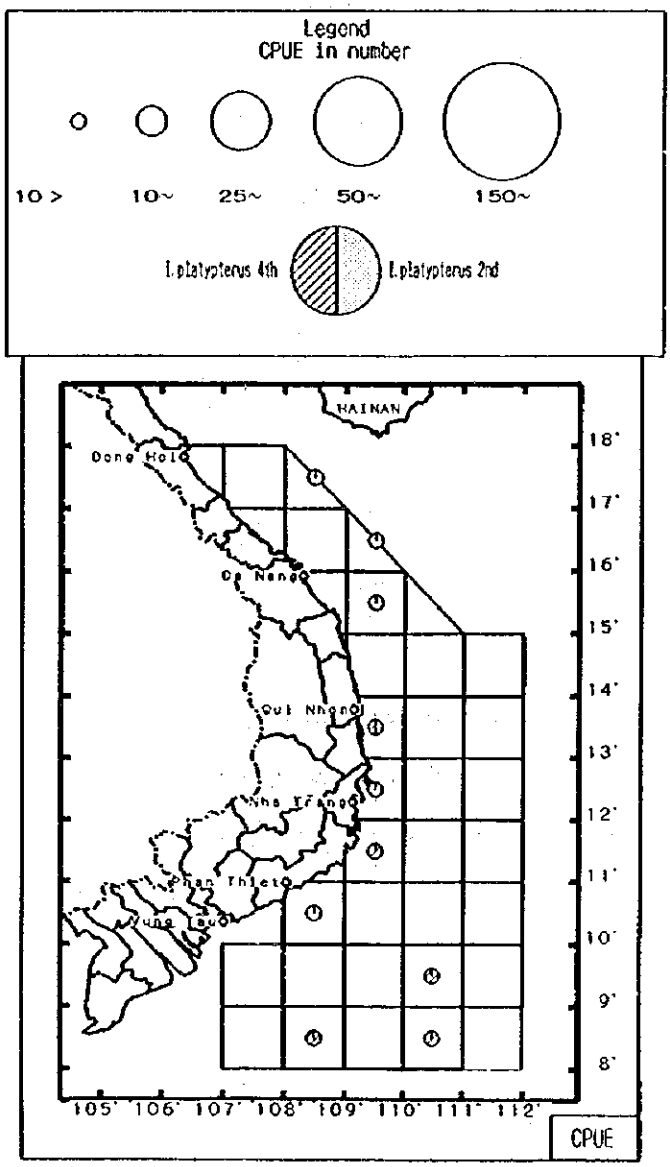


Figure 5-72 CPUE in number of sail fish in SW monsoon season of 1996 and 1997.

② Northeastern monsoon season

CPUE in number by quadrangle is given in Figure 5-73 drawn on the basis of data taken by the 3rd survey. The fish were not taken in the North Region, but occurred frequently in the offshore waters of the Central and South Regions, showed CPUE of 10 and 17 , respectively.

③ Difference between seasons.

Figure 5-74 shows CPUE in number in each quadrangle based on data taken during the three surveys. It is noted that CPUE rose in the coastal waters during the southwestern monsoon season, while in the offshore waters during the northeastern monsoon season. Biological data in p.5-132 indicate that size of fish differed between the fish taken in the two seasons, medium-sized fish in the southwestern monsoon season and small-sized fish in the northeastern monsoon season. This coincidence implies change of habitats of sailfish during their growth.

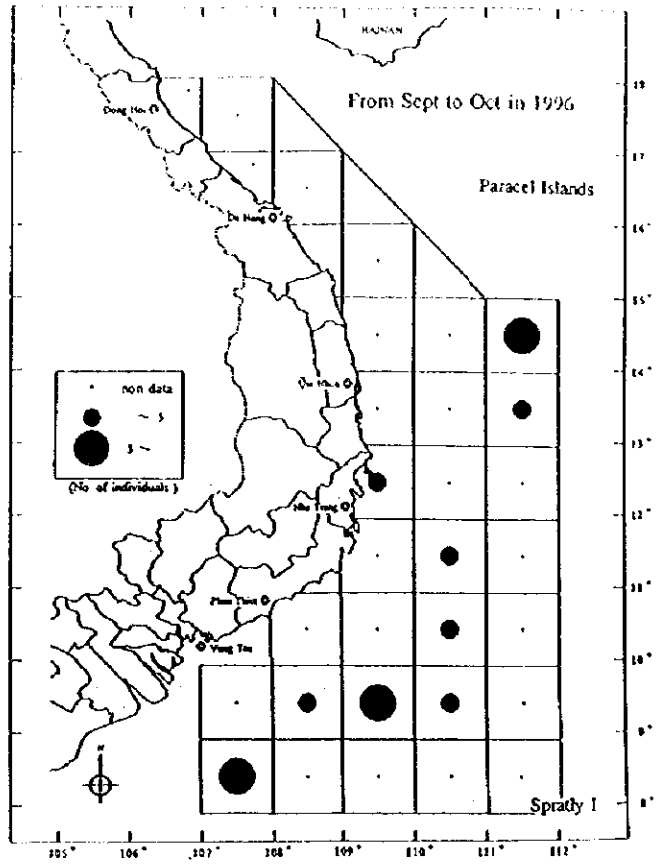


Figure 5-73 CPUE in number of sail fish in NE monsoon season of 1996

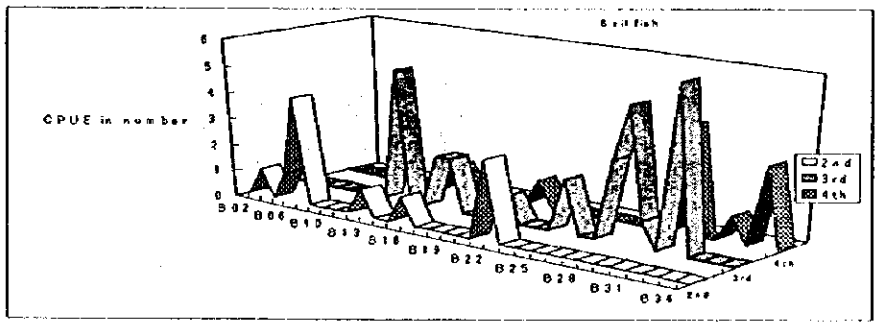


Figure 5-74 Distribution of CPUE in number of Sail fish by quadrangle in each of the three surveys from 1996 to 1997.

(13) Black marlin (*Makaira indica*)

Figure 5-75 shows CPUE in number in each quadrangle based on data taken

during the three surveys. Black marlin occurred in the North and South Regions during the 2nd and 3rd surveys, but not during the 4th survey, nor in the Central Region. The fish appeared in the shallow coastal waters including those around the Mekong Delta and the Gulf of Tongking.

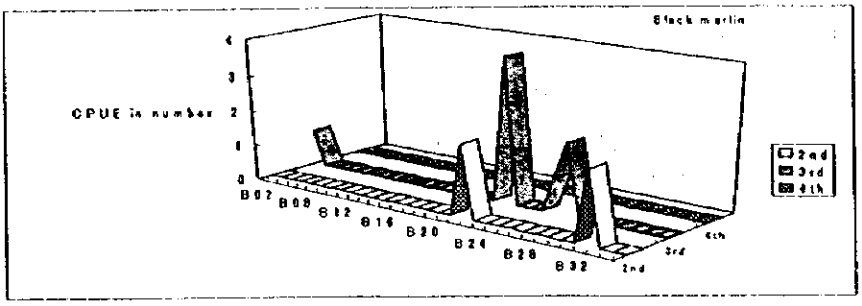


Figure 5-75 Distribution of CPUE in number of black marlin by quadrangle in each of the three surveys from 1996 to 1997.

(14) Blue marlin (*Makaira mazara*)

CPUE in number of blue marlin were illustrated for each cruise and for each quadrangle in Figure 5-76. In total, 6 and 10 were taken during the 2nd and 3rd surveys, respectively. Positive quadrangles scatter along the whole coastal waters during the southwestern monsoon season, but were confined to the southern waters during the northeastern monsoon season.

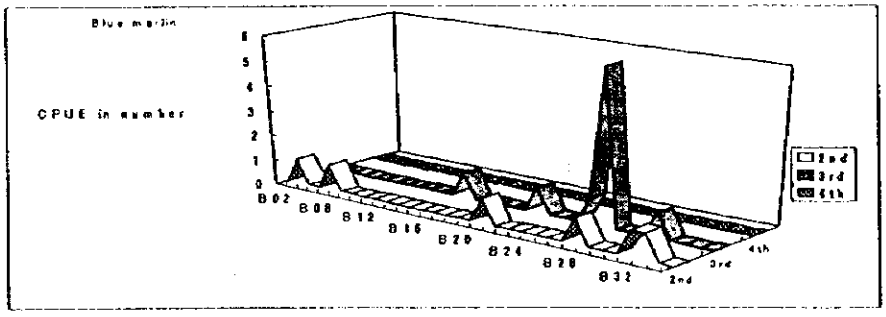


Figure 5-76 Distribution of CPUE in number of blue marlin by quadrangle in each of the three surveys from 1996 to 1997.

The fish appeared more frequently in the waters around the Mekong Delta, where the concentration of fish appeared near the Delta in the northeastern monsoon season, and seemed to have shifted offshore in the southwestern monsoon season. Blue marlin, as well as sailfish and black marlin, may migrate to the coastal waters where outflow of river waters might have attracted small-sized forage fishes.

(15) Striped marlin (*Tetrapterus audax*) and broadbill swordfish (*Xiphias gladius*)

Figure 5-77 and 78 shows CPUE in number of striped marlin and broadbill swordfish in each quadrangle based on data taken during the three surveys. Test fishing of the 4th survey incidentally caught 4 striped marlins in a quadrangle of 14 degree N - 15 degree N, 111 degree E - 112 degree E of the Central Region, and a single swordfish in another, 11 degree N - 12 degree N, 111 degree E - 112 degree E

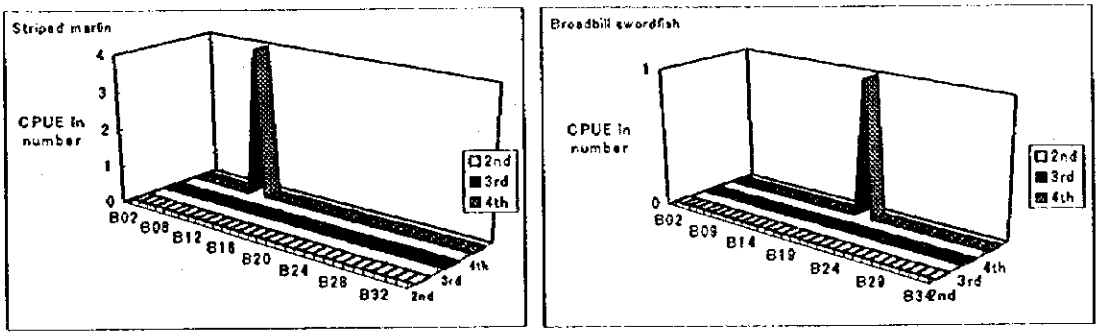


Figure 5-77 and 78 Distribution of CPUE in number of striped marlin and broadbill swordfish by quadrangle in each of the three surveys from 1996 to 1997.

(16) Unicorn leatherjacket (*Aluterus monoceros*)

Figure 5-79 shows CPUE in number in each quadrangle based on data taken during the three surveys. Test fishing in the southwestern monsoon season showed only 4 and 2, values of CPUE in number, in offshore waters of the Central Region during the 2nd and 4th surveys, respectively. On the other hand, 133 of CPUE , were taken during the 3rd survey, where the fish were found to be widely distributed. High concentrations appeared in the water near the Gulf of Tongking of the North Region and in the waters around the Spratly Islands, but not near the Mekong Delta in the South Region.

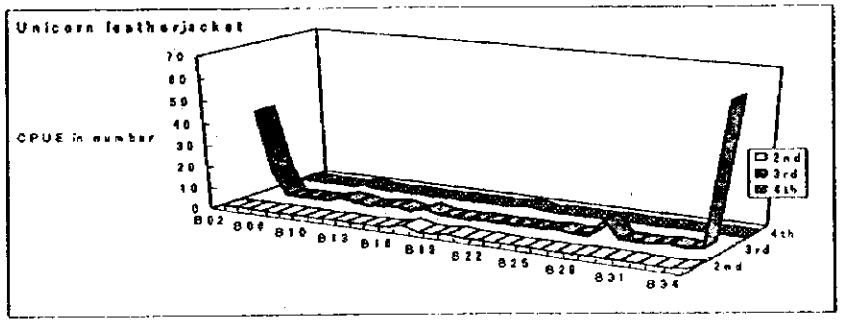


Figure 5-79 Distribution of CPUE in number of unicorn leatherjacket by quadrangle in each of the three surveys from 1996 to 1997.

(17) Flying squid (*Sthenoteuthis oualaniensis*)

① Southwestern monsoon season

Figure 5-80 shows CPUE in number of flying squid in each quadrangle based on the 2nd and 4th surveys. CPUE in number totaled to 268 and 209 , for the 2nd and 4th surveys, respectively, divided into 23, 134 and 111, and 34, 110 and 66, in each of the North, Central and South Regions.

The squid did not appear in the vicinity of the Gulf of Tongking nor of the Mekong Delta. Positive quadrangles are located in the offshore areas in the North and South Regions, but extended from the coast to offshore in the Central Region. CPUE exceeding 20 was not found in the North Region, but scattered in the Central and South Regions.

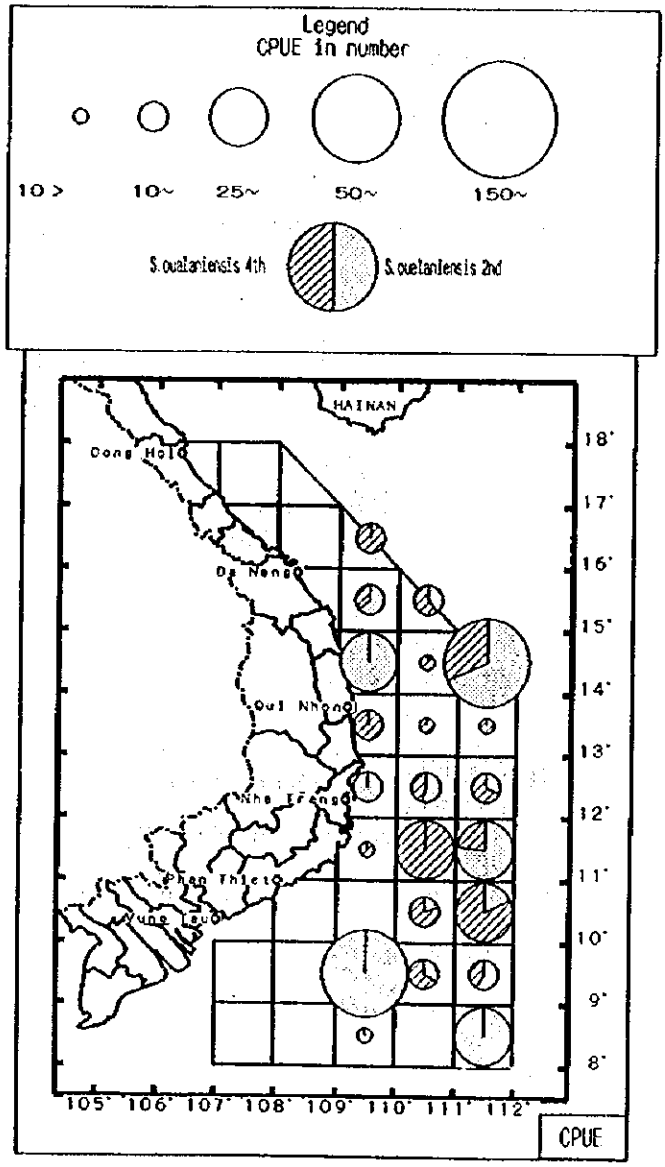


Figure 5-80 CPUE in number of flying squid in SW monsoon season of 1996 and 1997.

②North eastern monsoon season

CPUE in number by quadrangle is given in Figure 5-81 drawn on the basis of data taken by the 3rd survey. The sum of CPUE in number at all the operation sites was 153 including 128 in the Central Region and 25 in the South Region. No squid was found in the North Region during the 3rd survey, though three quadrangles were not investigated by test fishing .

③ Difference between seasons.

Figure 5-82 shows CPUE in number in each quadrangle based on data taken during the three surveys.

The values of CPUE at many quadrangle was found less in the northeastern monsoon season than in the southwestern monsoon season except in the Central Region. In the Central Region, the squid were more frequently recorded in the northwestern monsoon season, and values of CPUE and number of positive quadrangles were similar to that in the southwestern monsoon season. There was no recorded collection of the squid in the vicinity of the Mekong Delta. In short, flying squid is distributed in the Central Region covered by the oceanic waters during the rainy northeastern monsoon season.

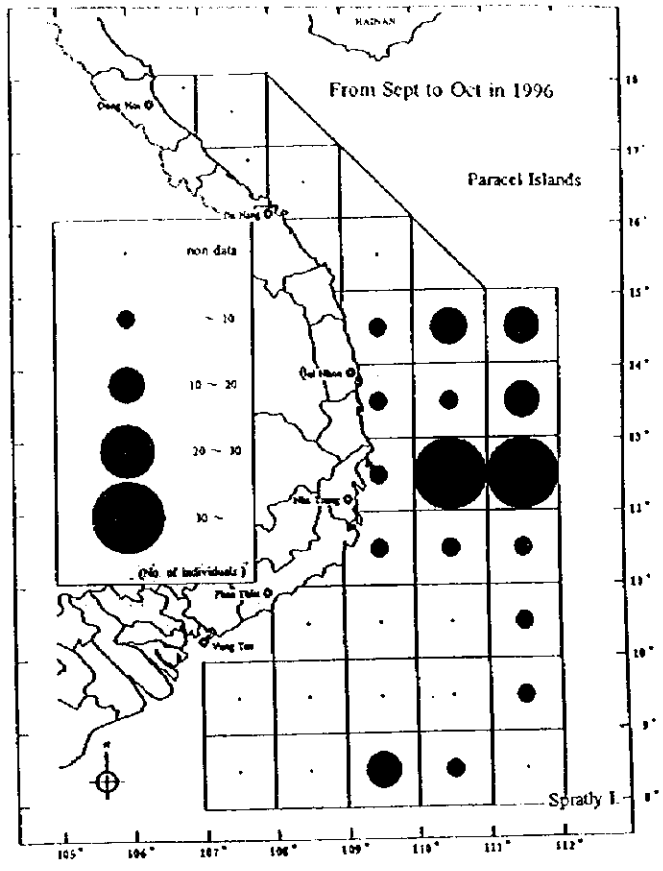


Figure 5-81 CPUE in number of flying squid in NE monsoon season of 1996.

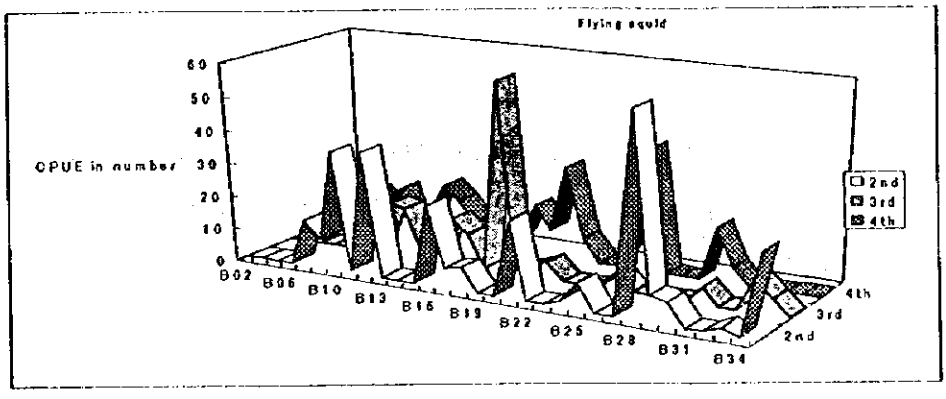


Figure 5-82 Distribution of CPUE in number of Flying squid by quadrangle in each of the three surveys from 1996 to 1997

5-4. Biological findings of the major species

Herein is described the general biological information on species of fisheries interest based upon data obtained through the test fishing. This chapter reviews general ichthyofauna found by gill netting in the sea area under survey for each monsoon season, and presents distribution, size of individuals, stomach contents and situation of gonads of 18 major species including a squid all as defined in the chapter 5-2-(2).

The area under survey is divided into 8 areas by sea depth for each of the North, Central and South Regions (Table 5-10). Length of body of individual specimens is expressed by standard length for tripletail and unicorn leatherjack, mantle length for flying squid, and fork length for the other 15 species. Length and weight frequencies were prepared with composition in number of individuals corrected by number of nets of different mesh sizes.

(1) Outline of general ichthyofauna in the survey area

Test fishing by surface gill nets during the three cruises caught 4,798 individuals of 99 species of interest to fisheries. Fishes of scombridae comprised 51.1% of the catch, followed by coryphaenidae 15.4 %, bramidae 14.1 % and carangidae 4.2 % (Figure 5-83). Bullet mackerel, frigate mackerel and skipjack tuna are the most frequently taken scombrids. The others are little tuna, longtail tuna, bigeye tuna and yellowfin tuna. Coryphenid catch consisted of two species, common and pompano dolphinfishes. The former comprises 85 % of this family. Only a species, pomfret, represented Bramidae. Most of fishes of these three families are listed to major species in this Report.

It is noted that fishes of Carangidae appeared frequently, representing 197 individuals of the 20 speices, although these fish of any single species were not numerous. Yellow-spotted travery appeared most frequently among carangids. The other significant species are almaco jack, bigeye scad, black band amberjack and talang queenfish (Table 5-11). Size of yellow spotted travery was 221.7 mm in mean fork length with a range of 117 to 258 mm and 250g in mean body weight

ranging between 50 and 400g. Averages of fork length and body weight of four other species were 246.0 mm and 300 g for almaco jack, 232.7 mm and 260 g for bigeye scad, 240.6 mm and 300 g for black band amberjack and 237.0 mm and 270 g for talang queenfish. In addition to fishes, the catch comprised three cephalopods inclusive of flying squid, diamondback squid and an octopus of *Tremoctopus violaceus*. Flying squid was the most abundant of the cephalopods, represented by 383 individuals or 7.5 % of target species, weighing 163.44kg. Incidentally taken animals were five species of dolphins and porpoise, three species of sea turtle and a single species of sea bird.

Figure 5-84 shows species composition of target species in terms of number of individuals. Among 18 major species, 95% of individuals were from 12 species including bullet mackerel, pompanos, frigate mackerel, skipjack tuna, common dolphinfish and flying squid. Only pomfret is a mid-layer species. The others are pelagic oceanic species, common in the warm waters including southern Japan stretching to the Ryukyu Archipelago (Matsubara,Ochiai and Iwai 1979, Ochiai and Tanaka 1986, Nakabo 1993). Flying squid is a typical oceanic cephalopod (Okutani 1995).

Figure 5-84 shows species composition of catch, in number, obtained during each of the three cruises. Test fishing in the southwest monsoon season of 1996 caught 1,010 fishes of 67 species and 77 squids of two species. Bullet mackerel was the most numerous species, followed by common dolphinfish, skipjack tuna, frigate mackerel, pomfret, flying squid and tripletail in decreasing order. These species comprised about 75 % of the catch, by number. During the northeast monsoon season of the same year, 1,693 fishes of 61 species and 144 flying squids were collected by the test fishing. Pomfret was the most numerous, and the other significant species were frigate mackerel, common dolphinfish, skipjack tuna, flying squid, unicorn leatherjacket, bullet mackerel and tripletail. Eight of theses species comprised 80 % of total catch by number. In the southwest monsoon of 1997, 2,095 fishes of 62 species and 164 squid were caught by drifting gillnets. Bullet

mackerel was the dominant species, followed by skipjack tuna, frigate mackerel, common dolphinfish, flying squid, pomfret, longtail tuna, pompano dolphifish and bigeye tuna, comprising some 85 % of the total catch.

Species composition of the catch changed significantly between seasons. Scombrids such as bullet mackerel, frigate mackerel and skipjack tuna dominated in the southwest monsoon seasons. The share of scombrids fewer and that of pomfret rose in the northeast monsoon season (Figure 5-84). The seasonal change was caused by catch of two species fluctuating significantly with bullet mackerel dominating in the southwest monsoon season and pompanos in the northeast monsoon season. Regional features of species composition will be described here in brief. In the North Region, common dolphifish and frigate mackerel were numerous in the inshore waters, while bullet mackerel and flying squid occurred on the continental slope. Common dolphinfish and frigate mackerel were again representative species in the inshore waters of the Central Region. Frequently caught species on the continental slope and offshore waters in the Region were pomfret, common dolphinfish, skipjack tuna, flying squid and tripletail. Significant species in the South Region were common dolphinfish, frigate mackerel and longtail tuna in the inshore waters and pomfret, skipjack tuna, common dolphinfish, flying squid and tripletail on the continental slope and offshore waters. Generally, frigate mackerel appeared mostly in the inshore waters, and the habitat of bullet mackerel extended to offshore throughout the country's waters. Longtail tuna was taken in the inshore waters of the South Region. The Continental slope and offshore waters appeared to yield pomfret, common dolphinfish, skipjack tuna, flying squid and tripletail.

Table 5-10. Classification of the survey areas based on the sea depth of location where the gillnet fishing was conducted.

Survey area	period	Inshore (less than 200m)	Continental slope(from 200 to about1000m)	Offshore(more than 1000m)
North Region	1996.May-June	B02, B03, B05, B06	B08, B09	-
	1996.Sep-Oct	B02, B03, B05	-	-
	1997.May-June	B02, B03, B05, B06	B08, B09	-
Central Region	1996.May-June	B19	B10, B13	B11, B12, B14, B15, B16, B17, B18, B20, B21
	1996.Sep-Oct	-	B10, B11	B12, B13, B14, B15, B16, B17, B18, B19, B20, B21
	1997.May-June	-	B10, B11, B13, B19	B12, B14, B15, B17, B18, B20, B21
South Region	1996.May-June	B22, B26, B27, B31, B32	B23	B24, B25, B28, B29, B30, B33, B34, B35
	1996.Sep-Oct	B22, B26, B27, B31, B32	B23, B28, B33	B24, B25, B29, B30, B34, B35
	1997.May-June	B22, B26, B27, B31, B32	B23	B24, B25, B28, B29, B30, B33, B34, B35

Table 5-11. Summary of carangid fish caught in the survey area.

	species	No.	Wt.(kg)
1	*Carangoides orthogrammus*	41	7.69
2	*Seriola rivoliana*	23	11.85
3	*Selar crumenophthalmus*	21	4.17
4	*Scomberoides commersonnianus*	15	3.79
5	*Seriolina nigrofasciata*	15	11.55
6	*Naucrates ductor*	14	3.75
7	*Scomberoides tol*	12	3.5
8	*Decapterus macrosoma*	10	0.98
9	*Decapterus akaadsi*	8	1.09
10	*Atule mate*	7	0.14
11	*Decapterus maruadsi*	5	1
12	*Megalaspis cordyla*	5	1.64
13	*Decapterus russelli*	4	1.13
14	*Parastromateus niger*	4	1.95
15	*Scomberoides lysan*	4	6.35
16	*Uraspis helvola*	4	1.1
17	*Trachinotus baillonii*	2	0.85
18	*Alectis ciliaris*	1	0.44
19	*Carangoides ferdau*	1	0.1
20	*Elagatis bipinnulata*	1	4.2
	Total:	197	67.27

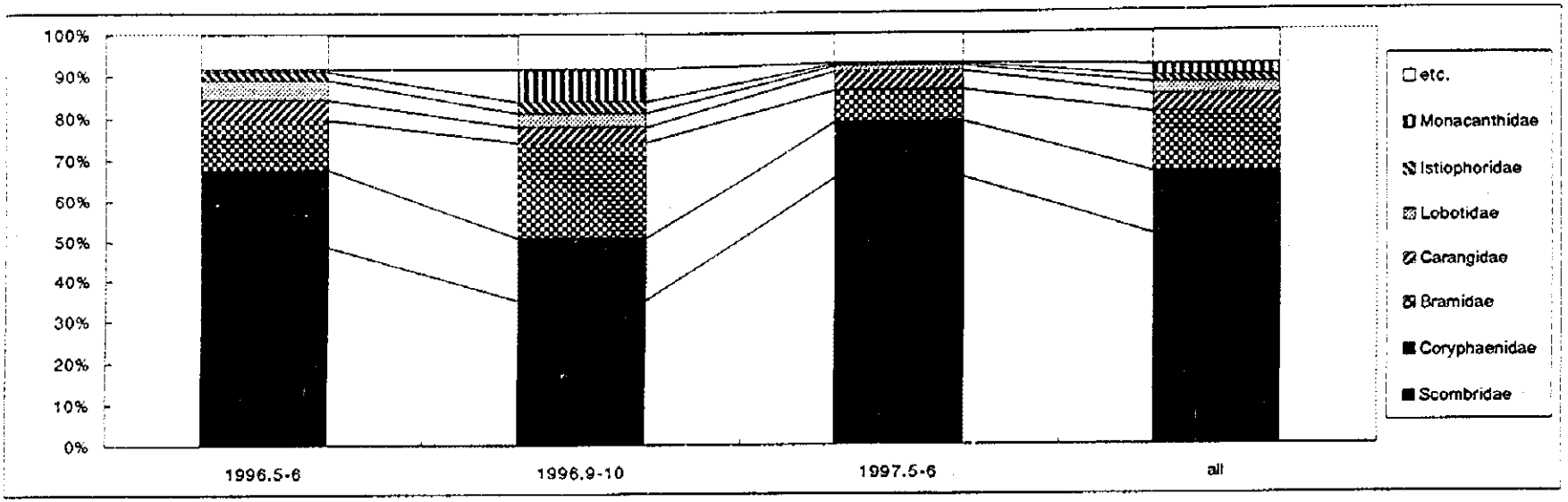


Figure 5-83. Composion of fish family caught by drift gillnets during each moonsoon season in the survey area.

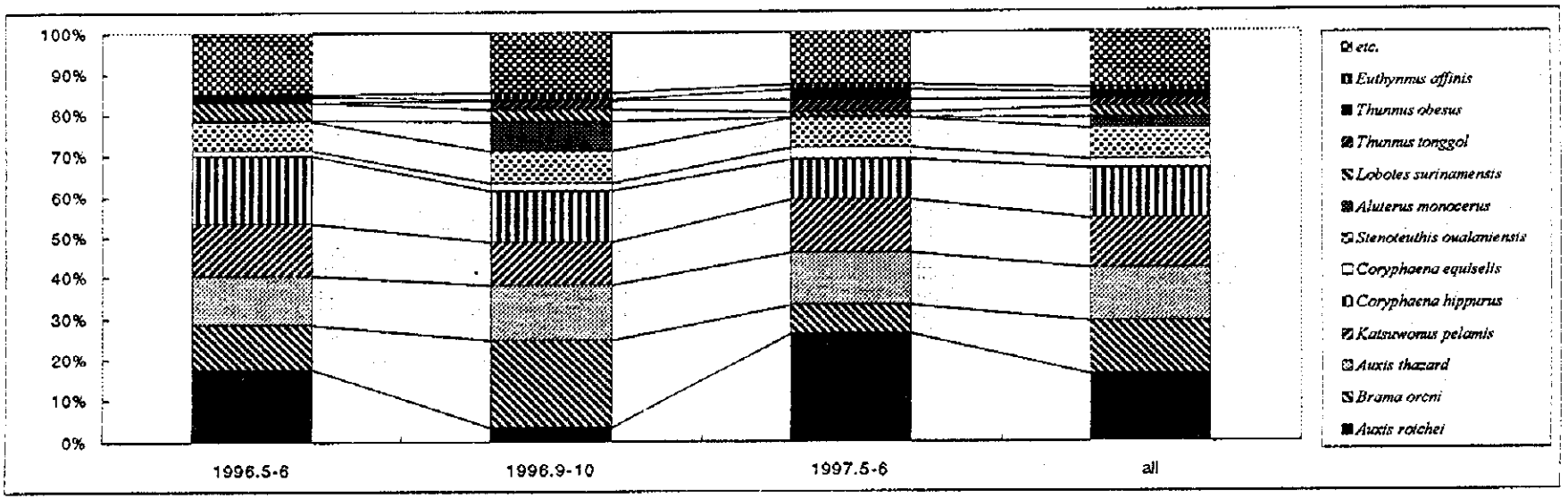


Figure 5-84. Species composion of a dominant fish caught during each moonsoon season in the survey area.

(2) Common dolphinfish (*Coryphaena hippurus*)

The distribution range of common dolphinfish was found to have covered almost the entire survey area. Sampled fish ranged between 225 and 1,125 mm in length with mode of 425 mm and mean of 448.5 mm, or between 0.5 kg and 12.25 kg in weight with mode of 0.75 kg and mean of 1.15 kg. The size of fish taken in different seasons and regions shows the following features. Fish caught in May and June of the 1996, south monsoon season, were 425 mm in modal length and 0.75 kg in modal weight. There was only slight difference of size of fish among regions except for frequent occurrence of slightly smaller individuals in the shore area of the North Region and offshore area of the South Region (Figures 5-85,88). During the survey in September and October 1996, representing the northeast monsoon season, the mode of common dolphinfish was 275 mm and 0.5 kg. The fish appeared more frequently in offshore areas of the Central and South Regions. Larger fish with modal length of 475 to 525 mm and modal weight of 1.25 kg occurred as common dolphifish were numerous in the shore areas of North and South Regions (Figures 5-86,89). Fish taken in the southwest monsoon season, May and June 1997 were 375 to 425 mm in modal length and 0.75 kg in modal weight. This size group dominated in most areas except the offshore area of the South Region (Figures 5-87,90). In short, medium sized fish of 375 to 425 mm in modal length dominated in the southwest monsoon season, while smaller fish of 275 mm were found distributed in the offshore waters of the Central and South Regions in the northeast monsoon season. According to studies on the materials taken in Japanese waters, common dolphinfish reach 20~25 cm in June and July of their first year of life, and then grow up to 38 cm at one year after birth, 68 cm at two years, 90 cm at three years, 108 cm at four years and 122 cm at five years (Ochiai and Tanaka 1986). Assuming the growth rate applicable to the Vietnamese stocks, major portion of samples taken in the southwest monsoon season are 1-age, and those in the northeast monsoon season are 0-age.

Stomach contents and gonads were investigated to learn feeding

habits and spawning activity of the fish in the area under study. Among five fish taken in the northeast monsoon season of 1996, three fish had empty stomachs, and the other two were found to have eaten squid, in spite of the previous reports that fishes are their major preys. Gonads were obtained in both southwest and northeast monsoon seasons of 1996. A fish of 430 mm taken in the southwest monsoon season was found with gonad a size of 9.2 g or 1.6 in GSI. Very primitive oocytes below 0.1 mm comprised half, and only few were 0.4 to 0.5 mm. In the northeast monsoon season, two fish of 491 and 625 mm were sampled for gonad inspection. Weight of gonads and GSI were small, 42.5 g and 206.5 g and 4.2 and 10.0, respectively. More than half of the ovarian eggs were less than 0.1 mm in diameter, and advanced ova of 0.4 to 0.5 mm comprised less than 10 %.

(3) Pompano dolphinfish (*Coryphaena equiselis*)

Test fishing captured pompano dolphinfish which were as large as 225 to 425 mm in length with a mode of 325 mm and mean of 309.0 mm, and 0.25 to 1.25 kg in weight with mode of 0.25 kg and mean of 0.44 kg. In the southwest monsoon season of 1996, fish of 325 mm and 0.25 kg represented the modal size. The mode of 325 mm appeared in all the sea areas including the most prolific inshore area of the North Region (Figures 5-91). The same modal size both in length and weight appeared for the fish taken in the northeast monsoon season of 1996 (Figure 5-92). The fish taken in the southwest monsoon season of 1997 were found with modes of 275 mm and 0.25 kg, and mostly distributed in the offshore areas of the Central and South Regions (Figures 5-93). In short, fish of 325 mm in modal length were major shoals taken in the inshore area of North Region in the two seasons of 1996, and smaller fish of 275 mm and 0.25 kg were taken mainly in the offshore area of Central and South Region in the southwest monsoon season of 1997.

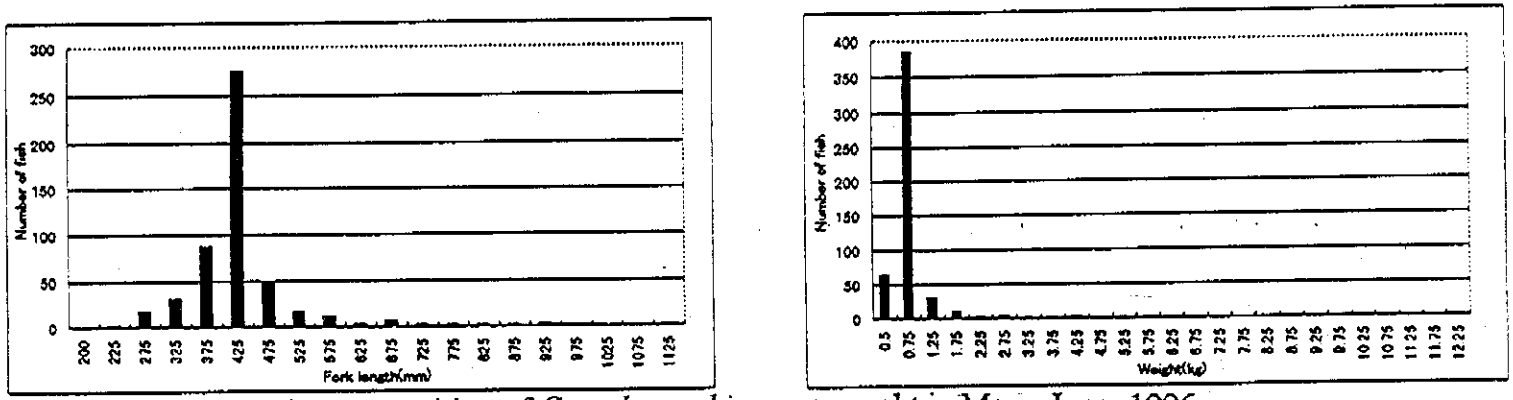


Figure 5-85 Body size composition of *Coryphaena hippurus* caught in May - June, 1996.

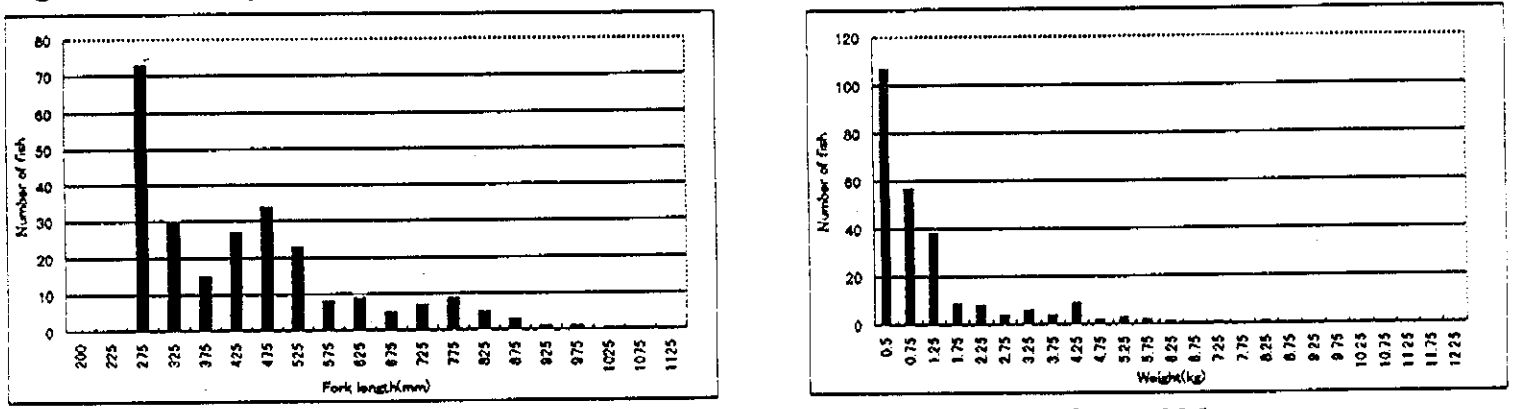


Figure 5-86 Body size composition of *Coryphaena hippurus* caught in Sept. - Oct., 1996.

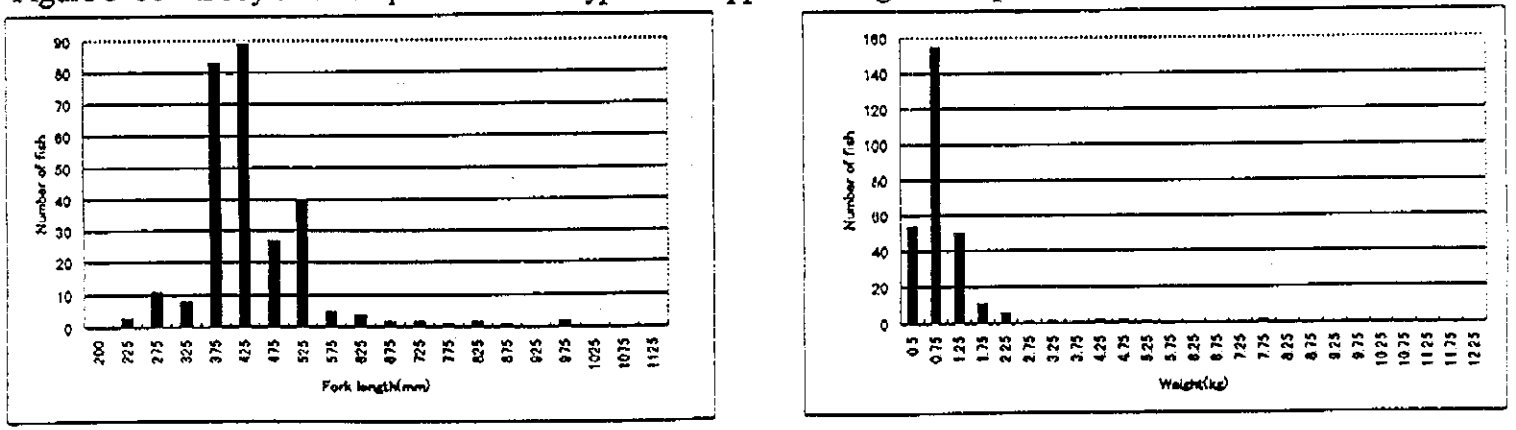


Figure 5-87 Body size composition of *Coryphaena hippurus* caught in May - June, 1997.

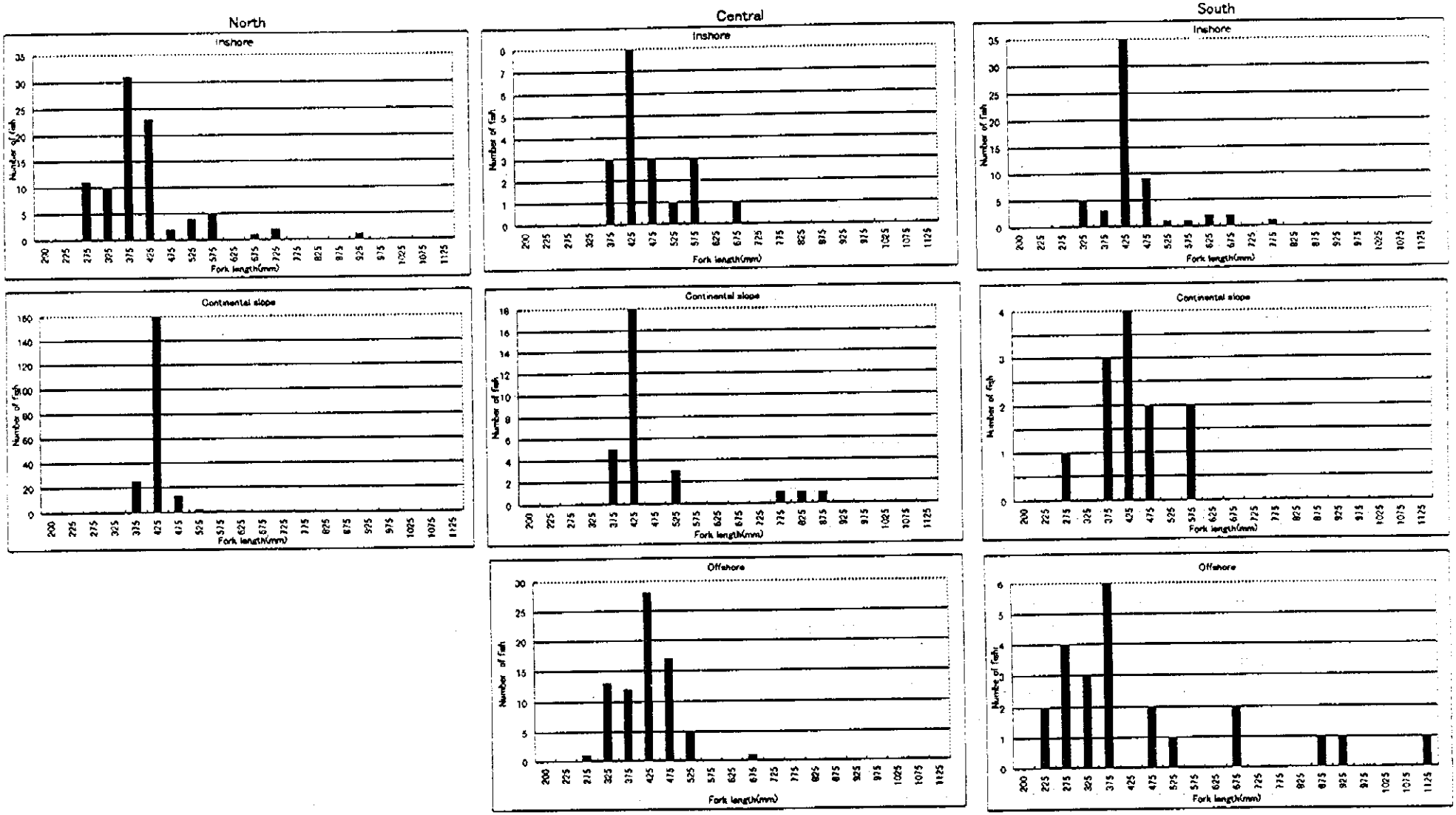


Figure 5-88. Fork length composition of *Coryphaena hippurus* caught at each area in May - June, 1996.

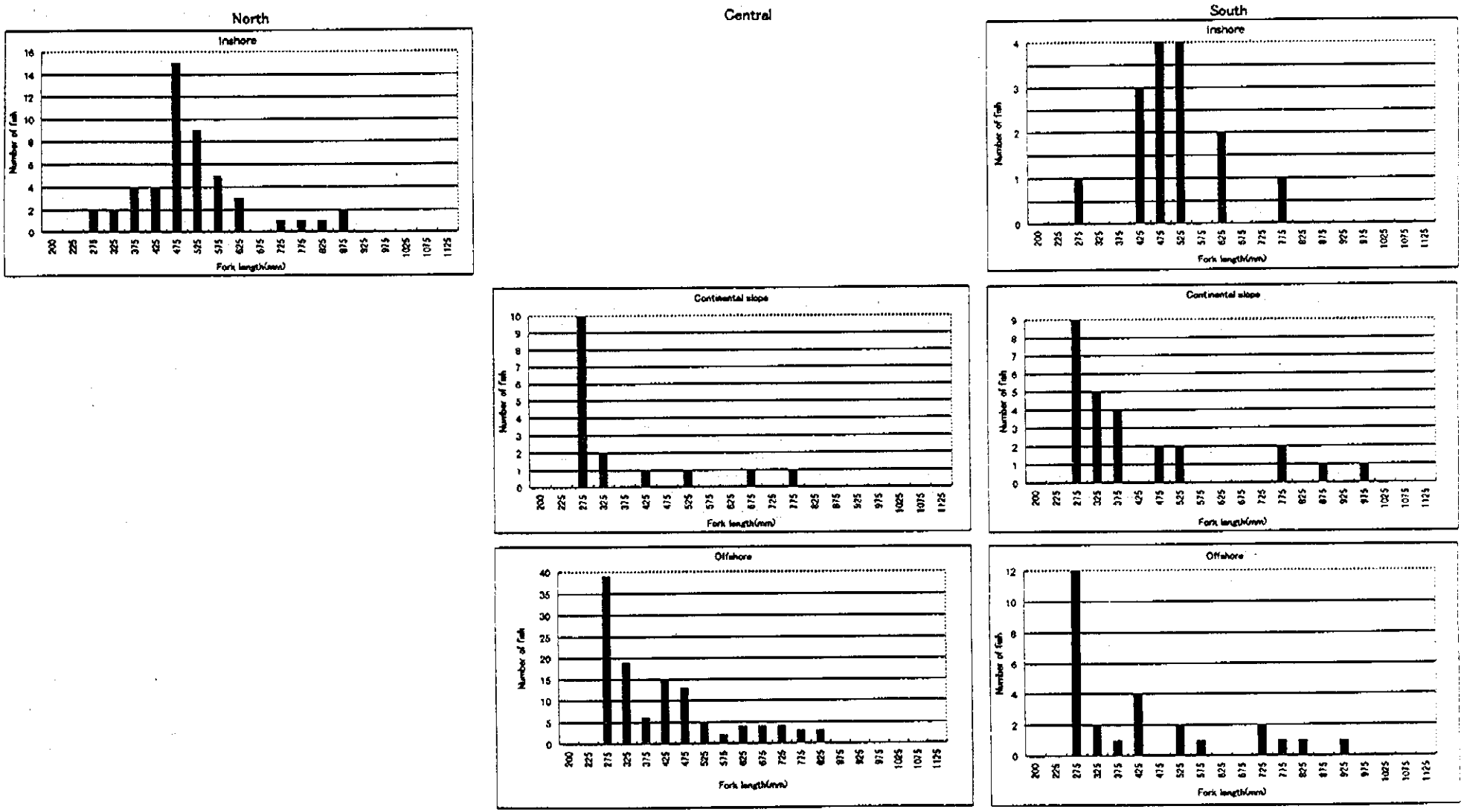


Figure 5-89. Fork length composition of *Coryphaena hippurus* caught at each area in Sept.- Oct., 1996.

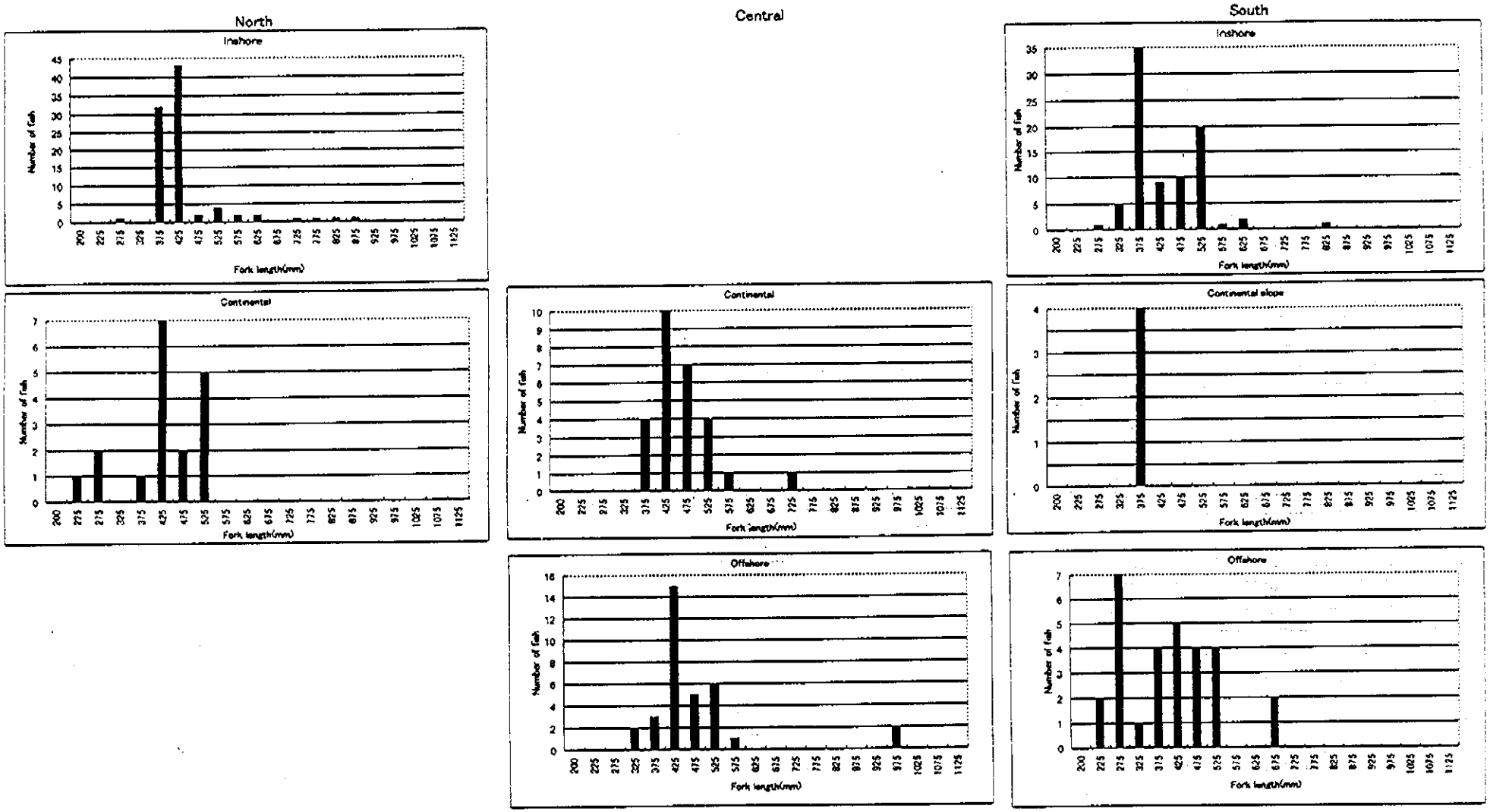


Figure 5-90. Fork length composition of *Coryphaena hippurus* caught at each area in May - June, 1997.

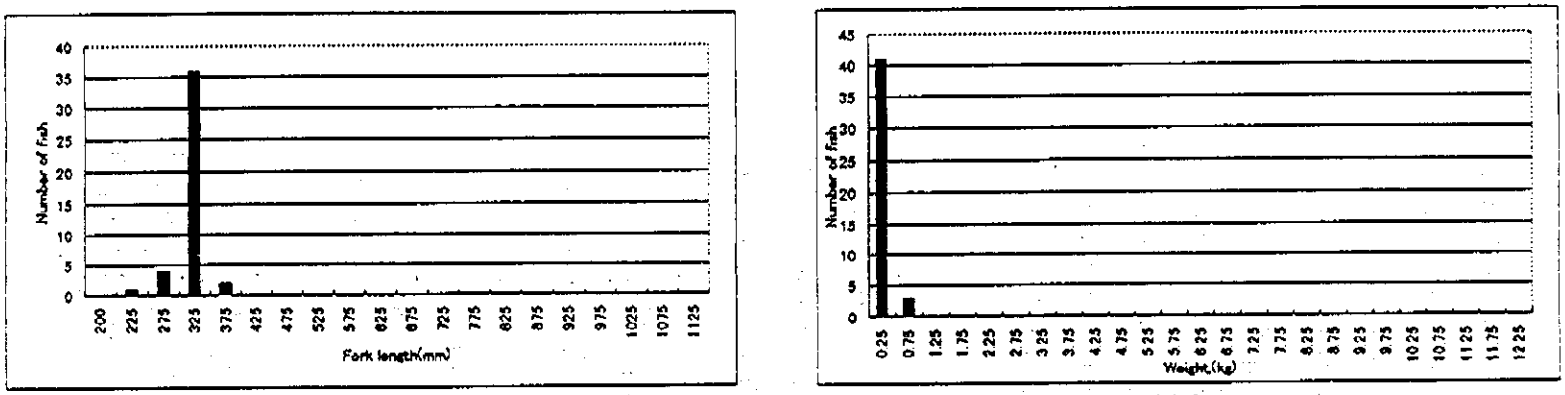


Figure 5-91. Body size composition of *Coryphaena equiselis* caught in May - June, 1996.

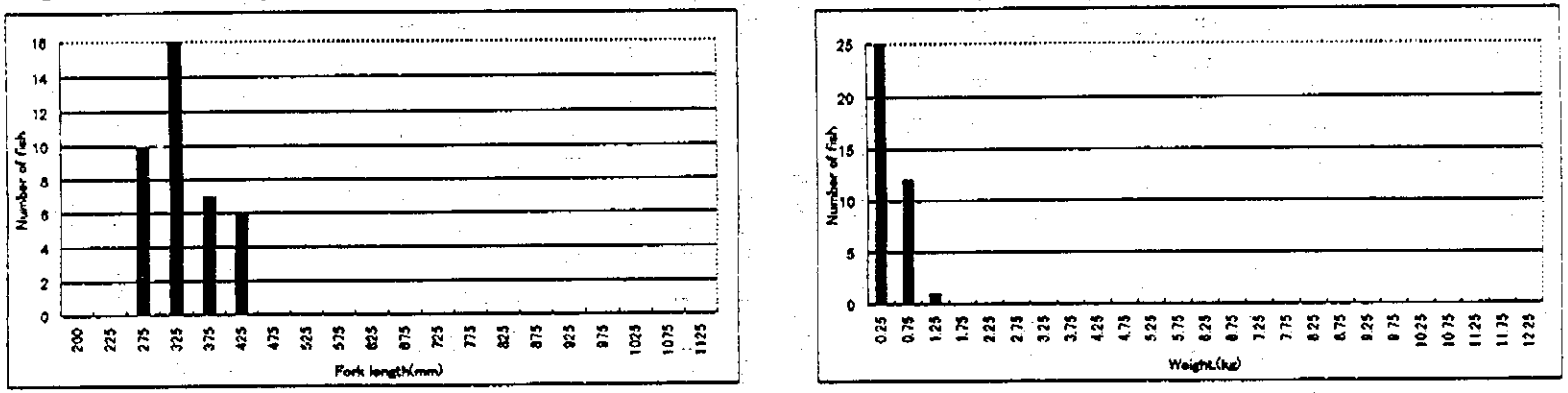


Figure 5-92. Body size composition of *Coryphaena equiselis* caught in Sept. - Oct., 1996.

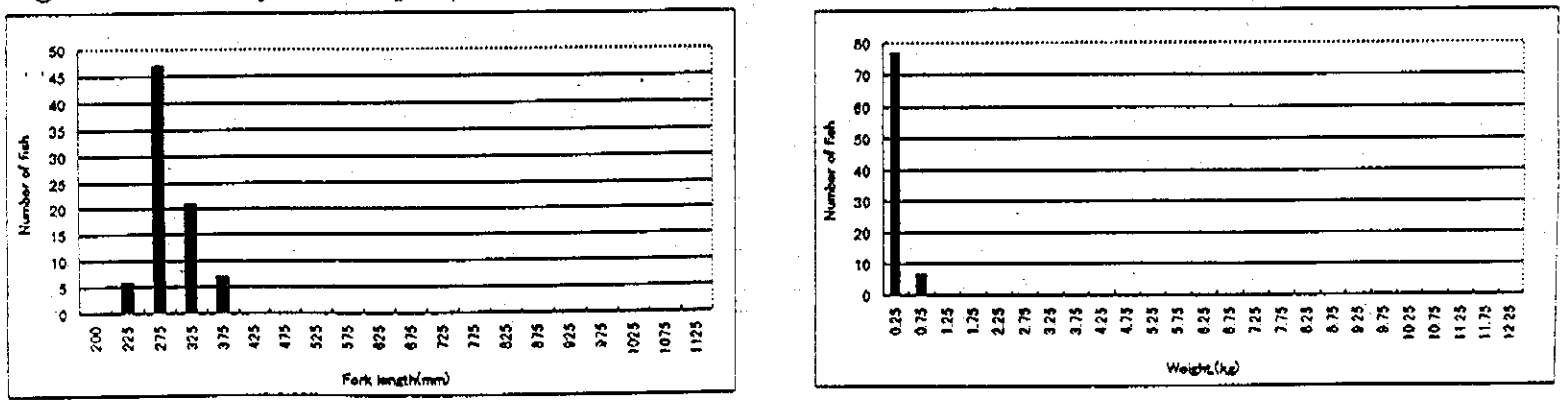


Figure 5-93. Body size composition of *Coryphaena equiselis* caught in May - June, 1997.

(4) Bigtooth Pomfret (*Brama orcini*)

There appeared a tendency that pomfret are distributed in the continental slope and offshore areas of Central and South Regions. Ranges of the fish taken during the four cruises were 110-390 mm in length and 0.05-1.15 kg in weight. Modes and means were 230 mm and 246.0 mm and 0.25 kg and 0.32 kg, respectively. The modes were found throughout the southwest monsoon season of 1996, specifically in the continental slope of North Region and Central Region, except the offshore area of South Region where bimodal group with 190 mm and 300 mm appeared (Figures 5-94,97). In the northwest monsoon season of 1996, modes appeared to be 250 mm and 0.25 kg. These values prevailed in the most abundant offshore area of South Region, except for slightly large fish of 270 mm in modal length. In the offshore area of the Central Region, additional modes were found in 230 mm or less and in 300 mm or above(Figures 5-95,98). In the southwest monsoon season of 1997, the dominant size group was 190 mm in modal length and 0.15 kg in modal weight, represented by those taken from most successful fishing ground of the continental slope of Central Region. Larger fish of modes of 230~250 mm and 0.25 kg were dominatnat in offshore areas (Figures 5-96,99). In general the fish of 190~230 mm in modal length occur in the continental slope area of the Central Region in the southwest monsoon season, while slightly larger fish with modal length of 250 mm are distributed in the offshore area of Central and South Regions during the northeast monsoon season. There is tendency that the small sized fish are distributed in the continental slope and the large sized fish live in the offshore area.

Stomach contents were investigated with four individuals taken in the northeast monsoon season of 1996 and 56 fish in the southwest monsoon season of 1997. Among 4 fish collected in 1996, one fish had unidentified fishes, two with squids, and the rest one with both fish of Genus Sardinella and squids. The fish collected in 1997 were found with shrimps, squids and fishes at almost same ratios, even though half of samples had already digested animals for identification of species

composition of stomach contents (Figure 5-100).

Samples of gonads were also obtained in the northeast monsoon season of 1996 and the southwest monsoon season of 1997. A fish of 31.7 in mean of GSI, 85.6 % of ovarian ova were smaller than 0.2 mm in diameter, and those over 0.5 mm comprised less than 10 % in the northeast monsoon season. On the other hand, there were heavy gonads of 22.1 to 34.8 in GSI in the southwest monsoon season. Specimens with ova less than 0.2 mm in diameter comprised less than 50 %, with increase representive more advanced ova of 0.4 to 1.4 mm in diameter.

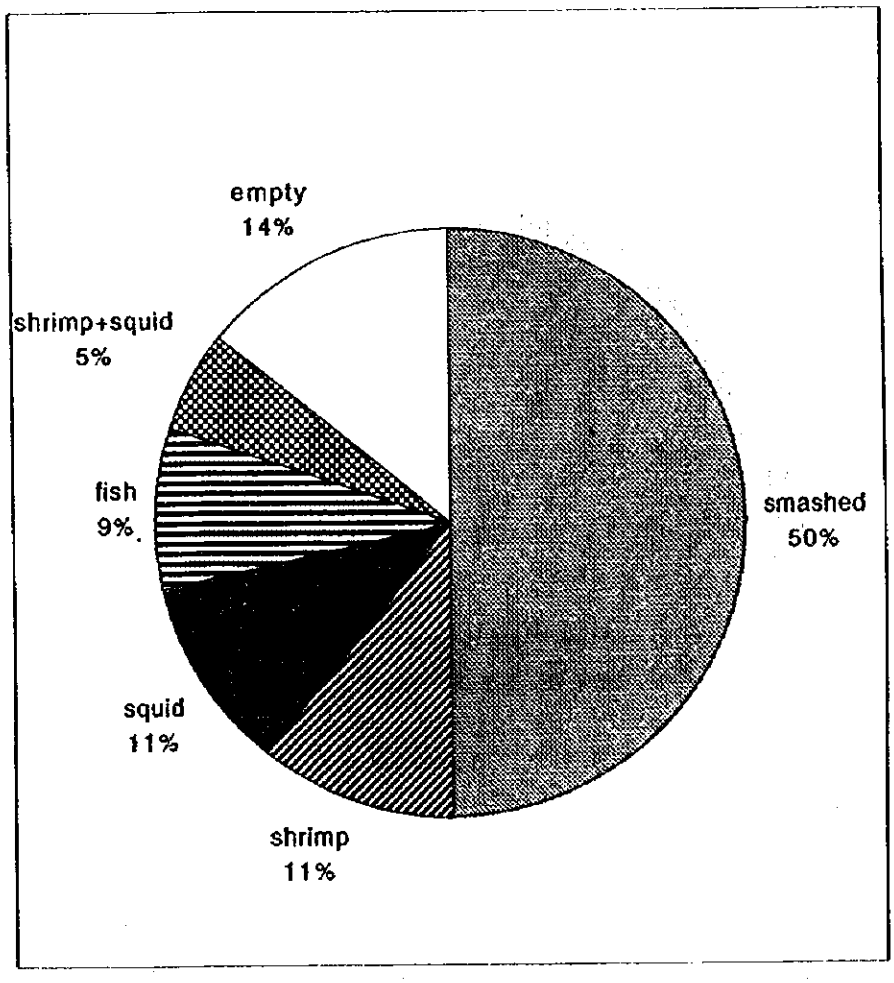
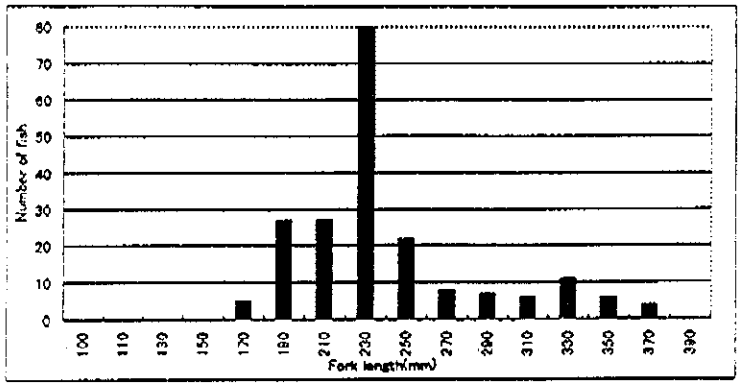


Figure 5-100. Composition of stomach contents of *Brama orcini* caught in May - June, 1997.



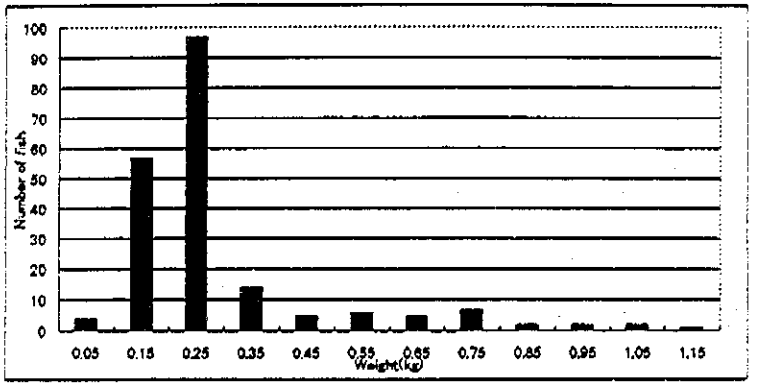
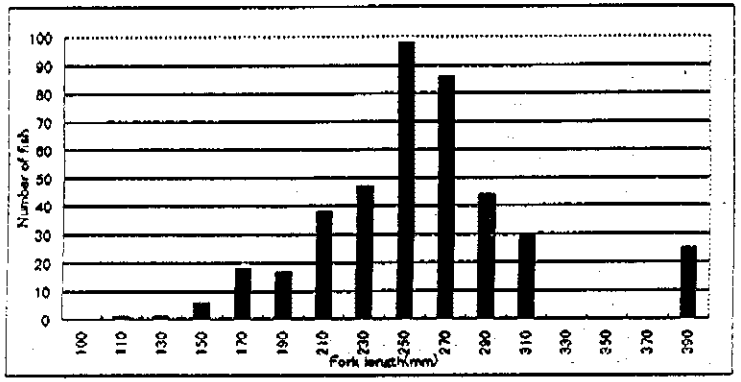


Figure 5-94. Body size composition of *Brama orcini* caught in May - June, 1996.



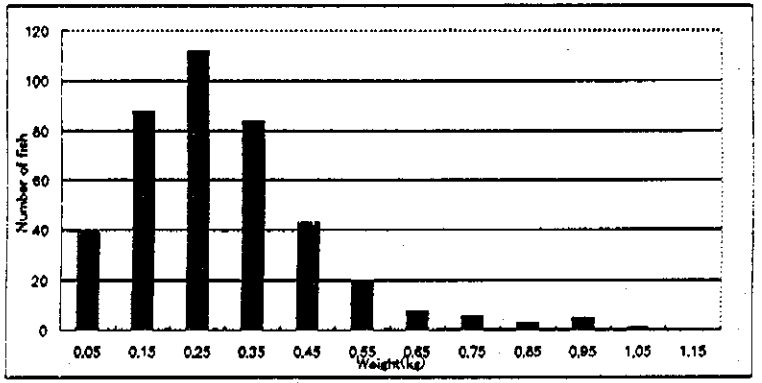
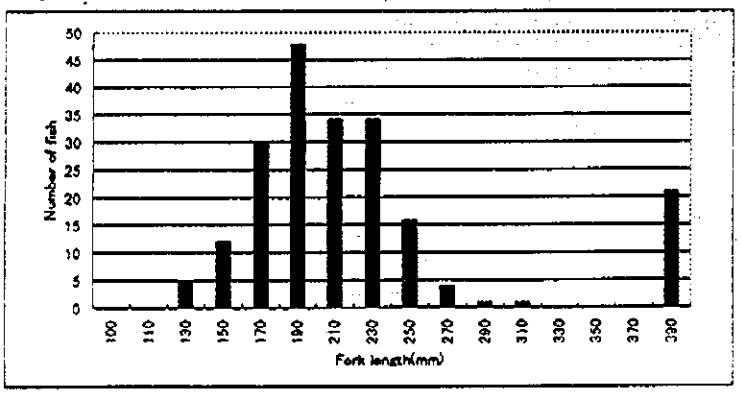


Figure 5-95. Body size composition of *Brama orcini* caught in Sept. - Oct., 1996.



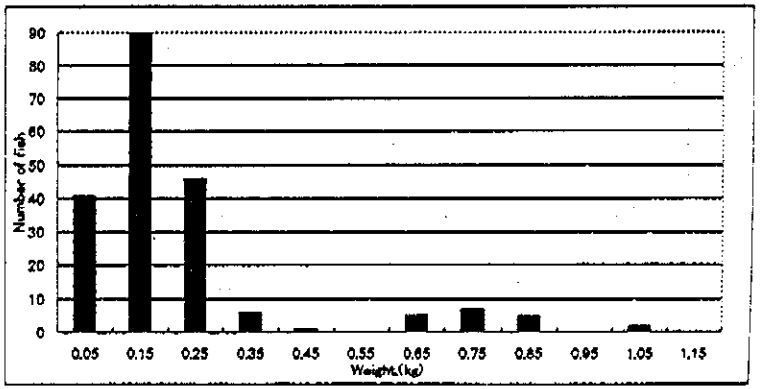


Figure 5-96. Body size composition of *Brama orcini* caught in May - June, 1997.

North

Central

South

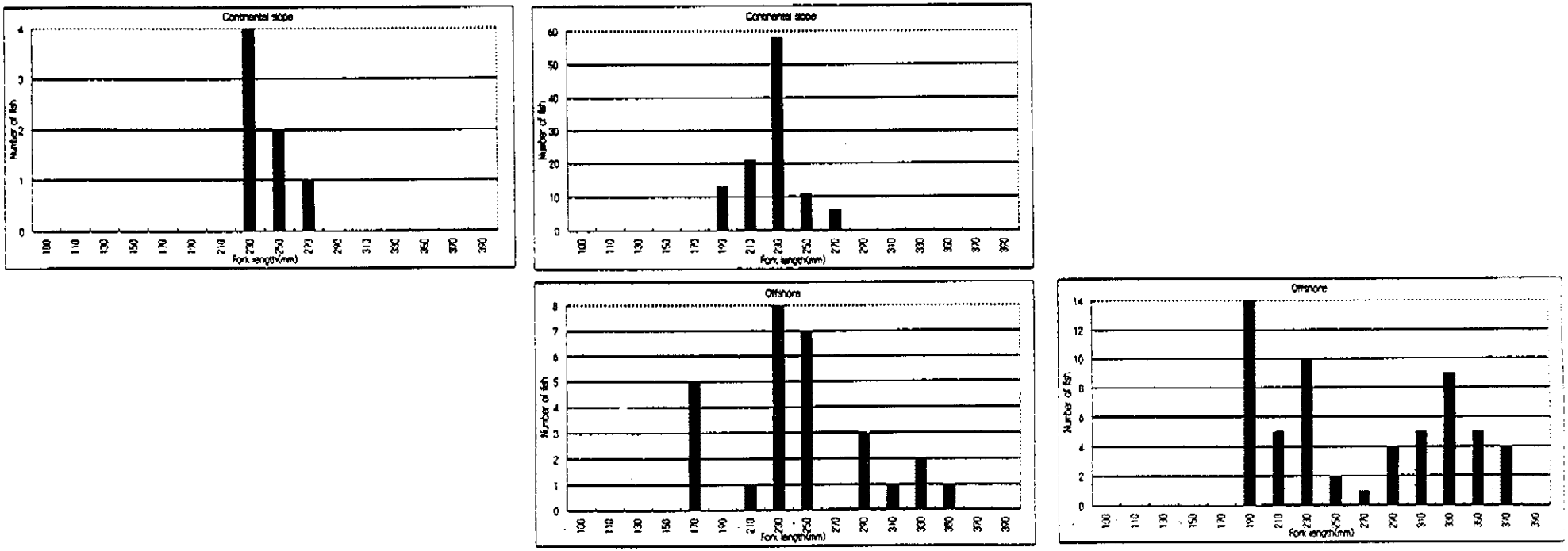


Figure 5-97. Fork length composition of *Brama orcini* caught at each area in May - June, 1996.

North Central South

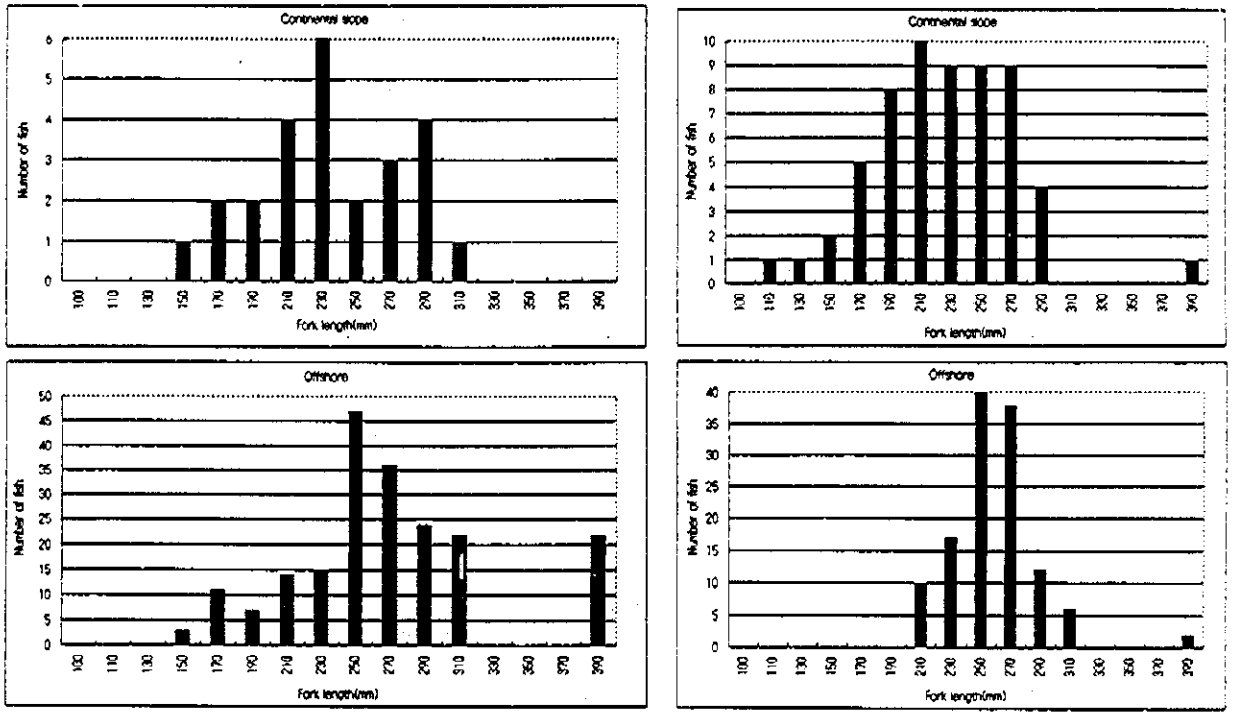


Figure 5-98. Fork length composition of *Brama orcini* caught at each area in Sept. - Oct., 1996.

North

Central

South

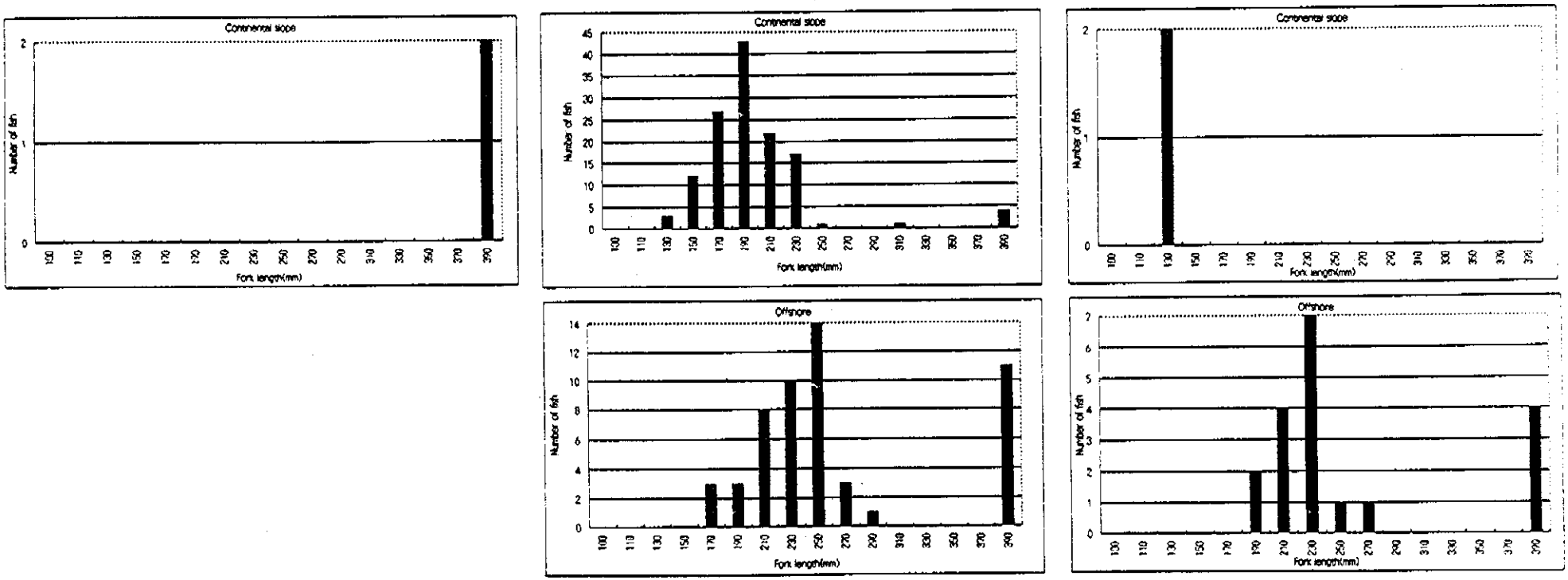


Figure 5-99. Fork length composition of *Brama orcini* caught at each area in May - June, 1997.