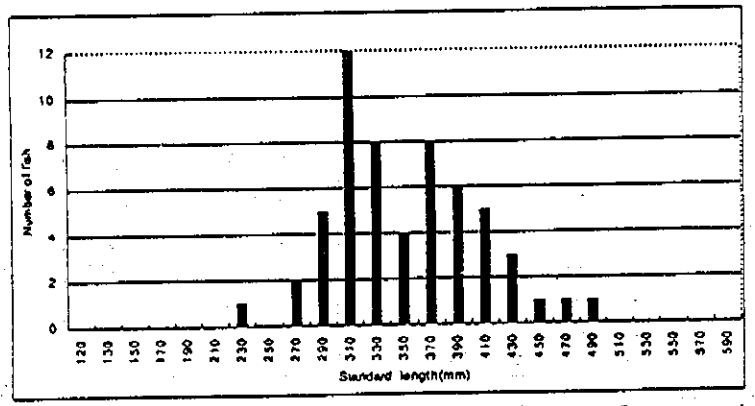
(5) Tripletail (*Lobotes surinamensis*)

Standard length of tripletail taken throughout the surveys ranged between 150 and 570 mm with a mean of 324.6 mm. Body weight of the fish varied from 0.1 kg to 4.5 kg, and was averaged 1.46 kg. The frequency distributions showed two modes of 310 mm and 390 mm and 0.5kg and 2.3 kg. Frequency distributions of samples collected in the southwest monsoon season of 1996 showed two modes at 310 mm and 370 mm, and at 1.1 kg and 2.1 kg. Most numerous samples taken in the inshore area of the North Region and offshore area of the South Region had two modes of 300 mm and 400 mm (Figures 5-101). The mode of samples taken in the northeastern monsoon season of 1996 was 230 mm and 0.5 kg. Samples were most frequently collected in the offshore areas of Central and South Regions, and mostly consisted of individuals from 150 mm to 250 mm, as well as large-sized fish exceeding 270 mm (Figures 5-102). Samples taken in the southwest monsoon season of 1997 showed modes of 350 mm and 1.1 kg, most frequently in the offshore areas of Central and South Regions. Fish from the South Region were larger at 390 mm and 2.3 kg, in comparison to those from the Central Region with modes of 270 to 290 mm and 0.9 kg (Figures 5-103). In short, tripletail are mainly distributed in the offshore areas of Central and South Regions. There is the possibility that size composition changes between seasons with large sized fish over 300 mm in the southwest monsoon season and small fish below 200 mm in the northeast monsoon season.

Samples of ovaries were taken in the southwest monsoon season of 1997. A female, 358 mm in length, had large gonad with GSI of 55. No ovum exceeded 0.5 mm in diameter. Ova less than 0.1mm comprised 62 % of the sample and those of 0.2 to 0.5 mm occupied 30.7 %. In case of an other female, 448 mm in length, small ova of 0.1 to 0.2 mm in diameter comprised 68 % and 23.6 % were large exceeding 0.5 mm. GSI of the fish was 9.8.



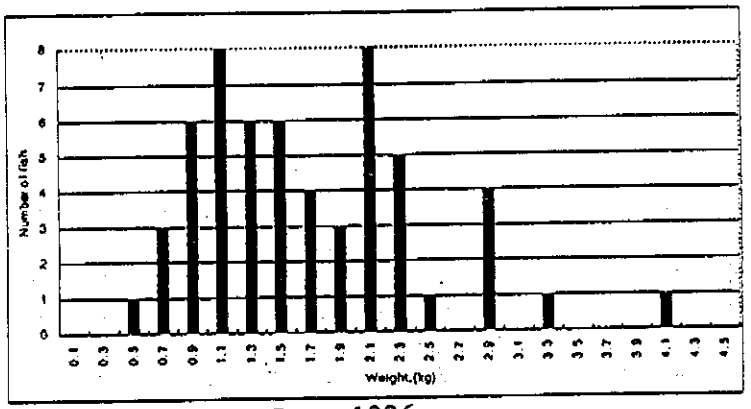
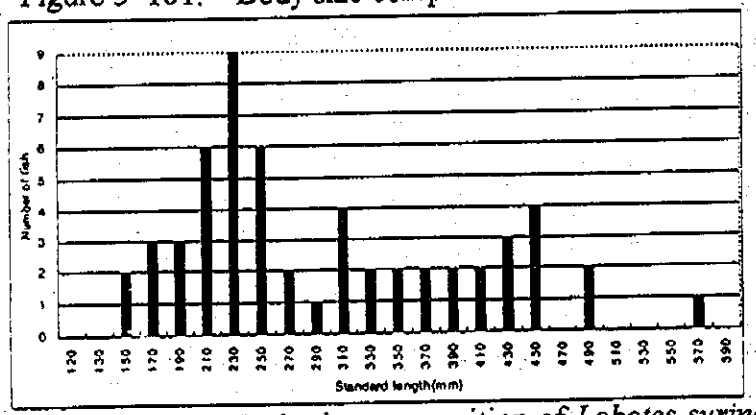


Figure 5-101. Body size composition of *Lobotes surinamensis* caught in May - June, 1996.



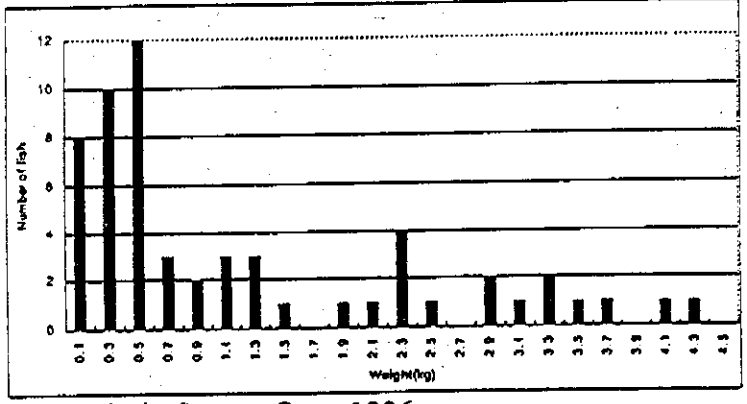
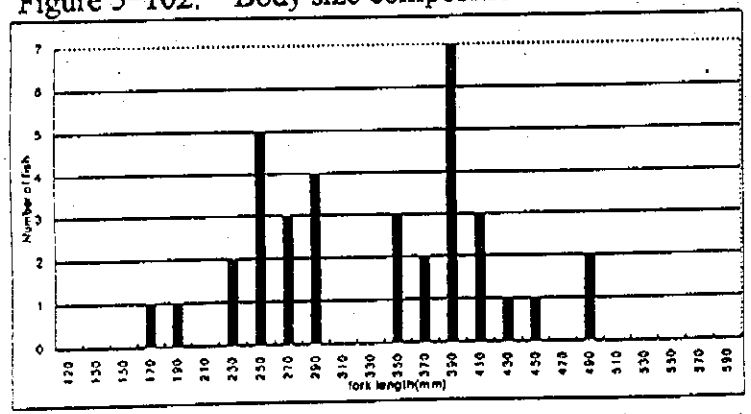


Figure 5-102. Body size composition of *Lobotes surinamensis* caught in Sept. - Oct., 1996.



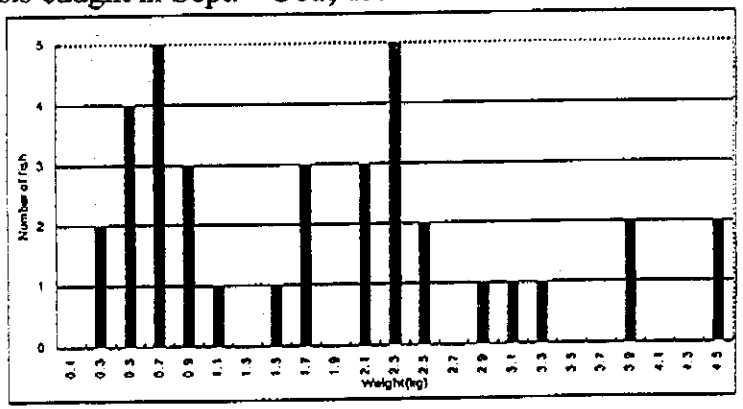


Figure 5-103. Body size composition of *Lobotes surinamensis* caught in May - June, 1997.

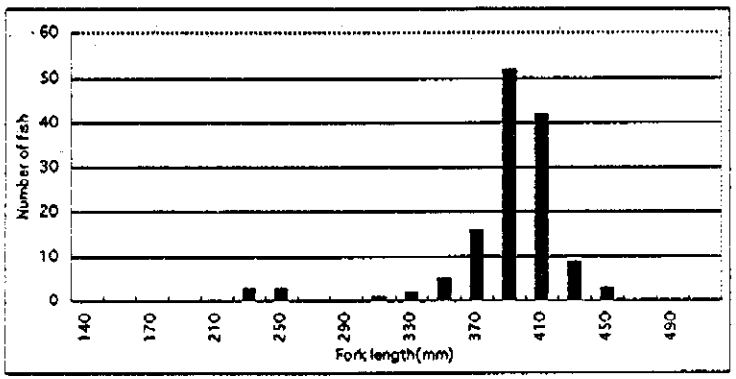
(6) Frigate mackerel (*Auxis thazard*)

The fish appeared more frequently in the North and South Regions, than in the Central Region. Sampled fish ranged from 230 to 450 mm in length and from 0.1 to 1.9 kg in weight. The modes were 350 mm and 0.9 kg, and the means were 360.6 mm and 0.95 kg. Modes of the fish taken in the southwest monsoon season of 1996 were 390 mm and 1.3 kg. The modes shifted slightly among areas, for instance 390 to 410 mm and 1.1 to 1.3 kg in the inshore areas of the North and South Regions (Figures 5-104,107). Almost the same modes of 390 mm and 1.1kg were found in the northeast monsoon season of 1996 when most samples came from the inshore area of the South Region (Figures 5-105,108). Samples taken in the southwest monsoon season of 1997 had modal length of 350 mm and modal weight of 0.9 kg. Size of fish differed between areas, and modes 330 mm and 0.9 kg in the inshore area of South Region, where the test fishing caught the most number of fish. Slightly larger fish of 390 mm and 1.3 kg were obtained in the inshore area of North Region (Figures 5-106,109).

Size as well as distribution range varied from season to season. In 1996, dominant groups were 370~90 mm in the inshore area during the southwest monsoon season, but 390 mm in the inshore area of South Region in the northeast monsoon season. The share of small sized fish at 330 mm was high in the inshore waters of the South Region in the southwest monsoon season of 1997.

Growth rate of frigate mackerel was evaluated with specimens from Gulf of Thailand as 26 cm at one year of age, 38 cm at two year of age and 47 cm at three year of age (Klinmuang 1979). Refering to the findings of Chu Tien Vinh (1994), estimated age of the frigate mackerel exploited off Viet Nam were mostly 1 to 2 year of age. His inference suggests that major catch consisted of 1 or 2 year of age fish in 1996 or simply one year in the southwest monsoon season of 1997.

A fish of 385 mm taken in the southwest monsoon season of 1997 had a GSI of 8.9, with very young ova of 0.2 mm or less comprising about 50 % and advanced ova of 0.5 mm or more about 30 %. Another fish of 441 mm showed



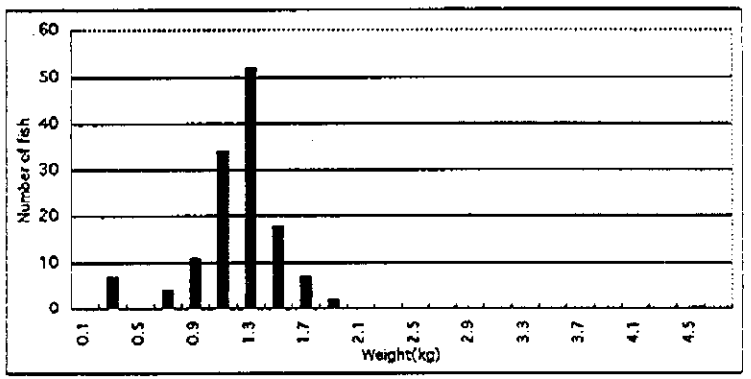
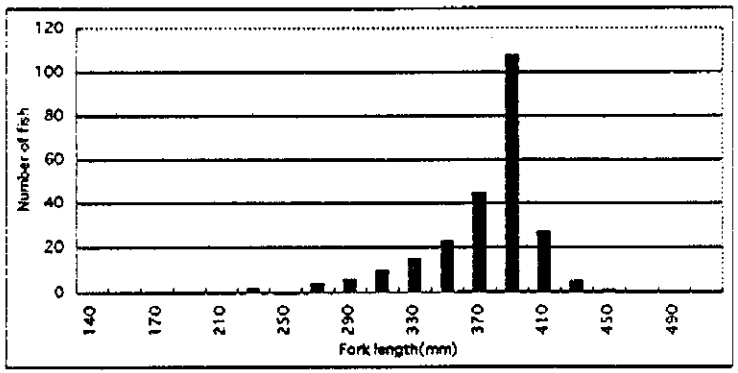


Figure 5-104. Body size composition of *Auxis thazard* caught in May - June, 1996.



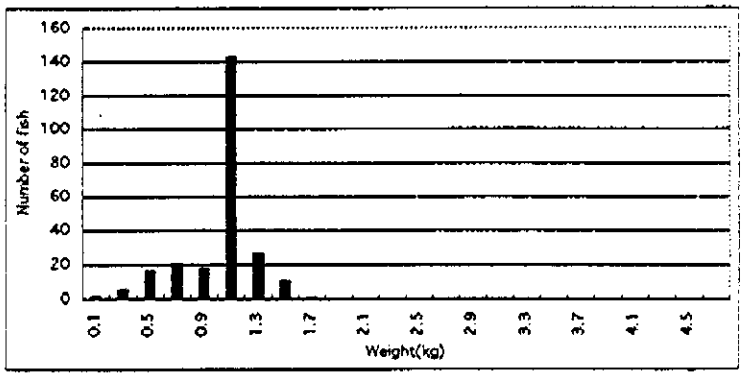
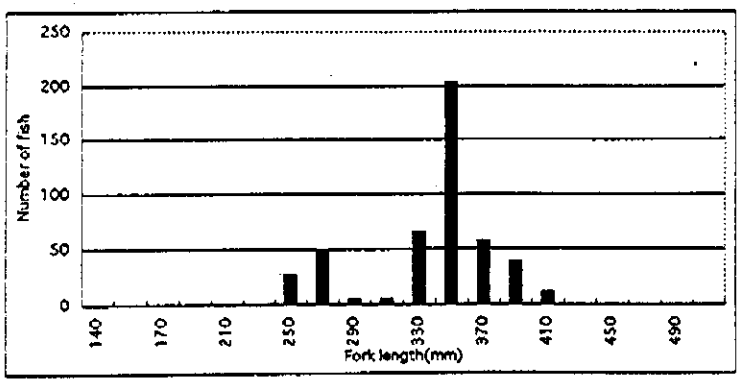


Figure 5-105. Body size composition of *Auxis thazard* caught in Sept. - Oct., 1996.



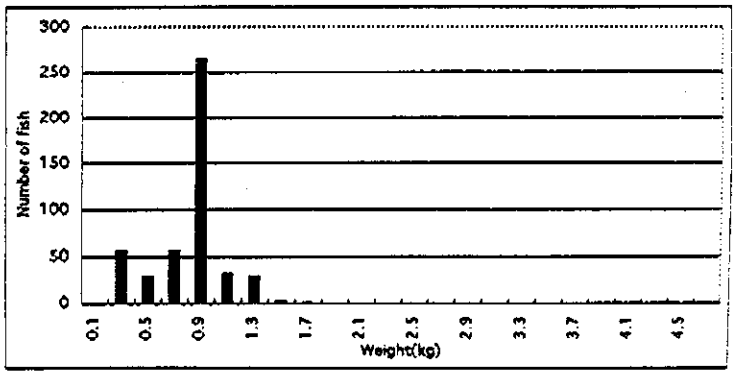


Figure 5-106. Body size composition of *Auxis thazard* caught in May - June, 1997.

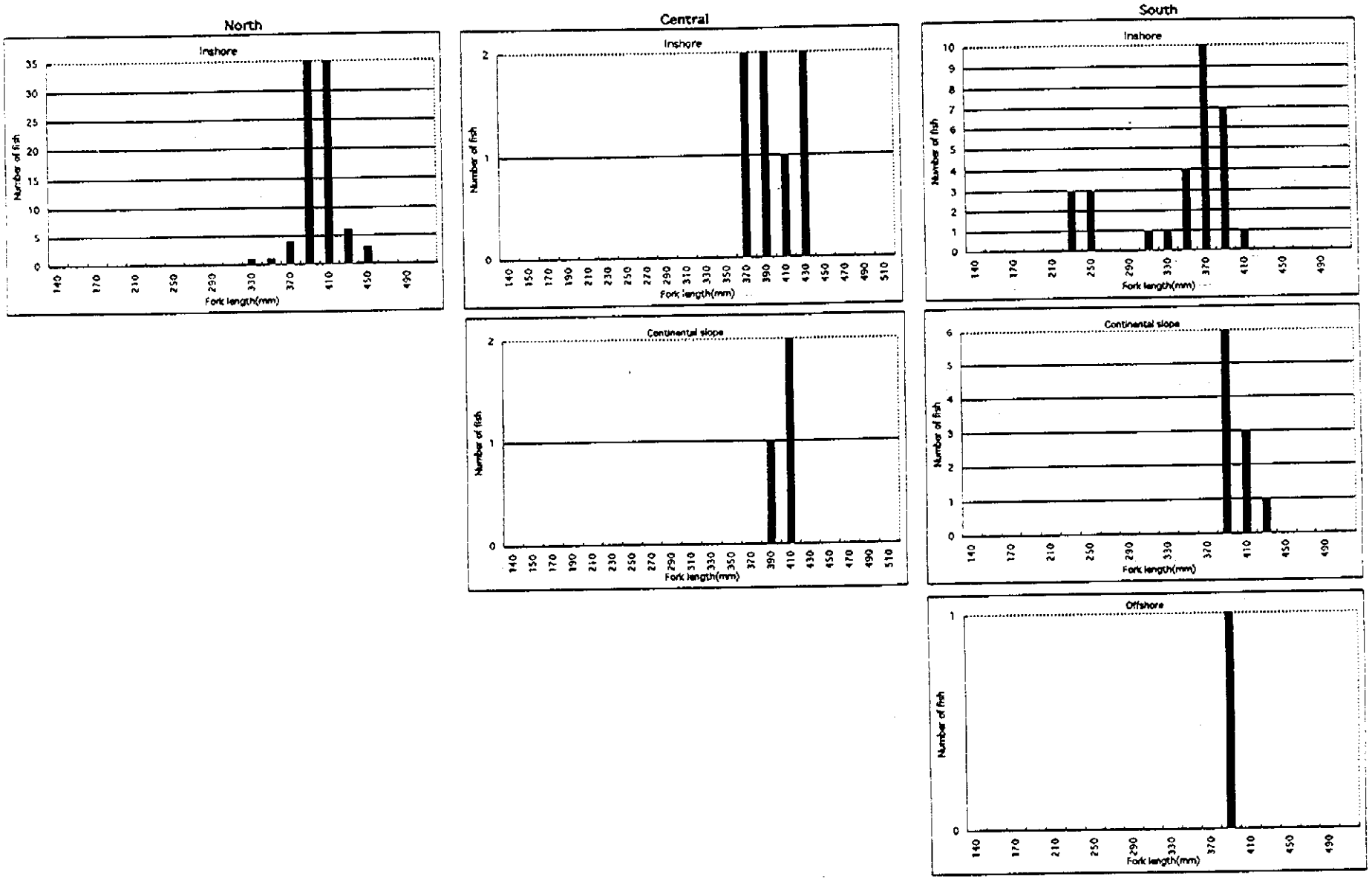


Figure 5-107. Fork length composition of *Auxis thazard* caught at each area in May - June, 1996.

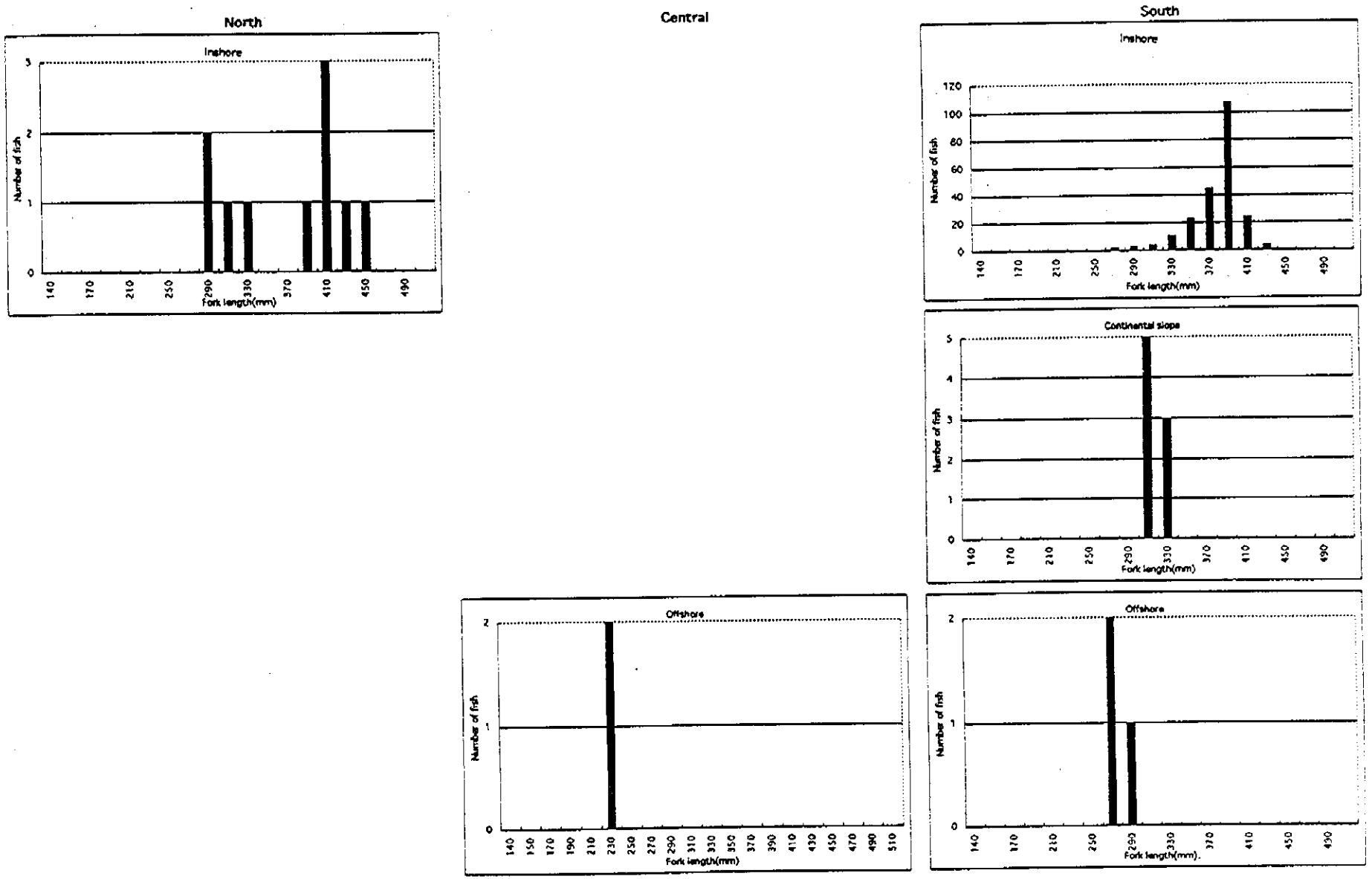


Figure 5-108. Fork length composition of *Auxis thazard* caught at each area in Sept. - Oct.,1996.

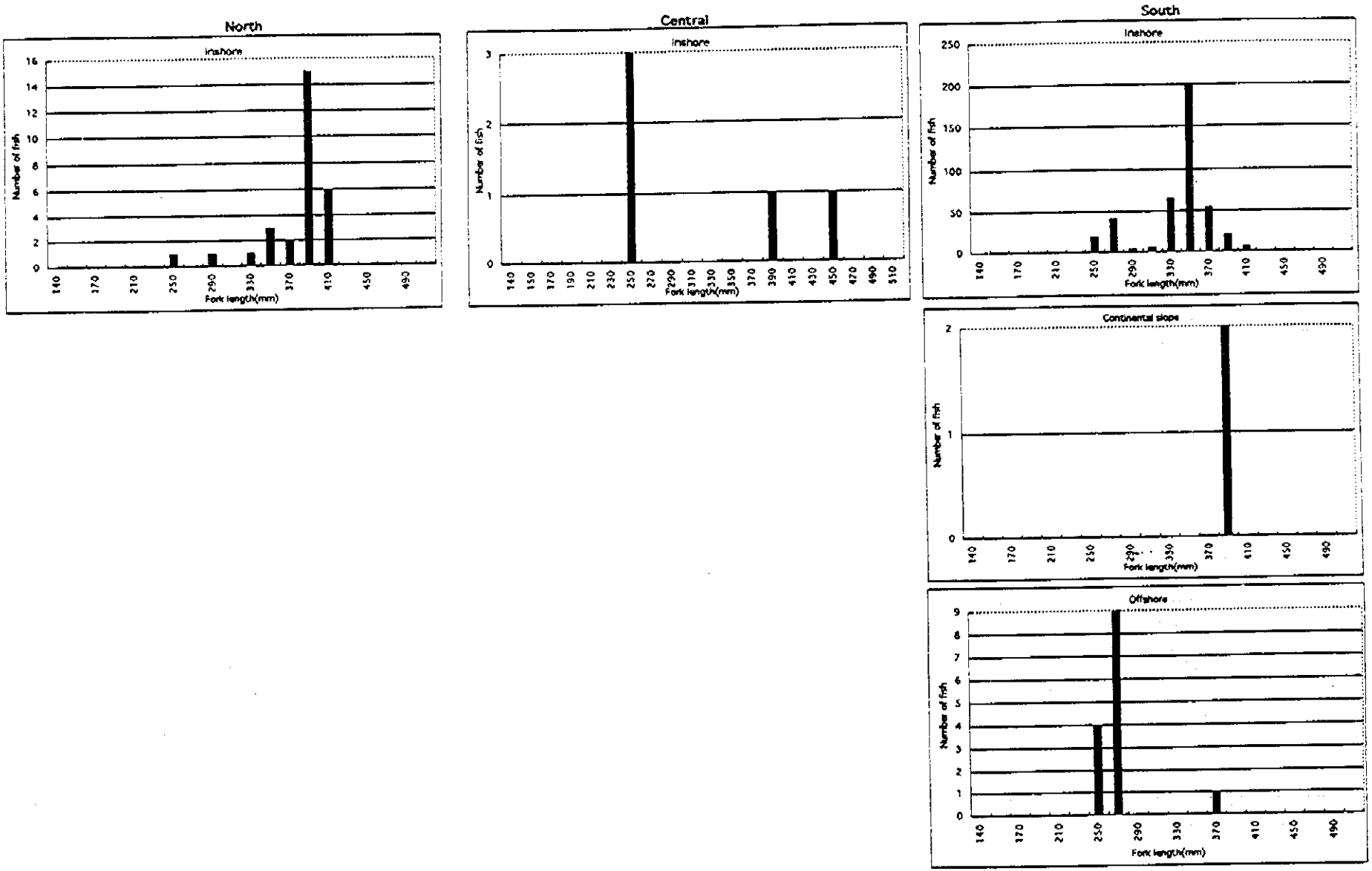


Figure 5-109. Fork length composition of *Auxis thazard* caught at each area in May - June, 1997.

advanced development, with GSI of 21.9 and ovary with small ova of 0.2 mm or less in diameter comprising 57 % and only 16 % having been 0.5 mm or above.

(7) Bullet mackerel (*Auxis rochei*)

The fish were observed in the whole survey area. The samples consisted of fish, 150 to 310 mm in length or 0.025 to 0.575 kg in weight, or 270 mm and 0.275 kg in modes and 260.7 mm and 0.28 kg in means.

In the southwest monsoon season of 1996, more fish were taken in the continental slope area of North Region and the offshore area of Central and South Regions. Their mode was either 270 mm or 0.325 kg. Modal length was 270 mm in the continental slope area of North Region and the offshore area in Central Region, but 250 mm in the South Region. Thus, there was a tendency that the fish from the North and Central Regions are larger than those from the South Region (Figures 5-110,113). They appeared frequently in the offshore area of Central Region and the South Region in the northeast monsoon season of 1996. The fish from the Central Region showed bimodes of 210 mm and 270 mm in length but a single mode of 0.175 kg in weight. Modes of fish from the offshore area of South Region were 270 mm and 0.275 kg (Figures 5-111,114). The fish appeared in almost the entire waters under survey in the southwest monsoon season of 1997, and their modes were 270 mm and 0.275 kg. These modal sizes applied to the fish from the North Region and the continental slope area of Central Region, but slightly smaller fish with main mode of 250 mm and submode of 230 mm were found in the continental slope area of the Central Region and the inshore area of the South Region (Figures 5-112,115). In the inshore area of the South Region, there was a trend of reducing size of fish as shown by a shift of modal length, 257 mm at Stations B-19 and B-22 on the boundary between the Central and South Regions, 253 to 258 mm at Stations B-26 and B-27, and 237 to 247 mm at the southernmost Stations B-32 and B-31. The mean length of fish from the continental slope area of North Region and the offshore area of Central Region was found ranging between 263 mm

and 269 mm. Samples from the inshore area of North Region was 266 mm, with frequent occurrence of large fish of 270 mm. Area of concentration of bullet mackerel changed drastically from season to season, and reduction of size of fish was found during the three seasons under discussion.

Stomachs collected during May and June 1997 were found to contain shrimps most frequently, followed by Euphausia and squids. Ochiai and Tanaka (1986) reported that closely spaced gill rakers suggested that bullet mackerel prefer shrimps and other crustacea to fishes and squids.

Gonads of eight fish were also taken during the fourth cruise. With regard to three of them, ova less than 0.2 mm comprised about 60 % and those of 0.2 to 0.5 mm comprised about 30 %. The remaining five fish had ovaries with ova of 0.2 mm or less in diameter comprising 70-79 %, and ova of 0.2 to 0.5 mm, 8 to 18 %. There was no remarkable variation of gonad weight and then GSI between individual fish. It is known that the fish in the waters other than the Vietnamese sea, mature when they reach 27 cm in fork length. Fish with GSI of around 16 start to spawn eggs of about 1 mm in diameter. The spawning season is known to vary depending on locality. Further research is required for spawning activities in the waters under discussion.

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

The test fishing revealed that the inshore area of South Region is major distribution zone for Little tuna, collecting fish of 150 to 160 mm in length with modes of 210 mm and 310 mm, averaging 359.8 mm, or of 0.2 to 4.3 kg in weight with mode of 0.3 kg and average of 1.03 kg.

The fish occurred only in the inshore areas of both North and South Regions in the southwest monsoon season of 1996. Fish taken in the North Region ranged between 590 mm and 610 mm in length and between 1.1 and 4.3 kg in weight, larger than those from the South Region where ranged between 410 mm and 470 mm, or 1.1 and 1.7 kg (Figure 5-116). In the northeastern monsoon season,

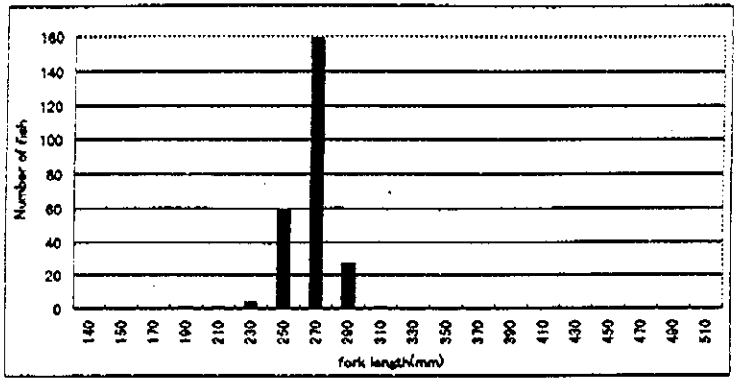
the fish were found only in the South Region, having been 310 mm and 0.5 kg in the offshore area, smaller than those from the inshore area, those 350 mm or larger (Figure 5-117). Most Little tuna with modes of 270 mm and 0.3 kg were collected in the inshore area of South Region during the southwest monsoon season of 1997 (Figure 5-118).

The Little tuna seemed to be distributed in the inshore area of South Region during the southwest monsoon season, but in the offshore area of the Region during the northeast monsoon season. The sample showed remarkable variation of size of fish, mostly large sized fish of 300 mm or above during the two cruises in 1996, but small sized fish of 150 to 230mm during the cruise in the southwest monsoon season of 1997.

(9) Skipjack tuna (*Katsuwonus pelamis*)

The fish occurred in almost the entire waters under discussion, more frequently length in the offshore areas of the Central and South Regions. Length and weight ranged from 230 to 710 mm and 0.50 to 8.25 kg, respectively, and three modes were found at 290 mm, 430 mm and 550 to 570 mm, or at 0.5 kg, 1.75 kg and 4.25 kg. The averages were 476.8 mm and 2.75 kg.

During the southwest monsoon season of 1996, skipjack tuna were found distributed in the offshore area of the Central and South Regions, and 430 to 450 mm in modal length but bi-modal at 1.75 kg and 4.25 kg in weight. There was slight local difference in size composition, bi-modes of 430 mm and 550 mm in the offshore area of South Region and 450 mm and 630 mm in the continental slope and offshore areas of South Region (Figures 5-119,122). The fish were frequently sampled in the offshore area of Central Region and the continental slope area of South Region during the northeastern monsoon season of 1996. There were three modes of 390 mm, 470 mm and 570 mm. Fish from the Central Region comprised



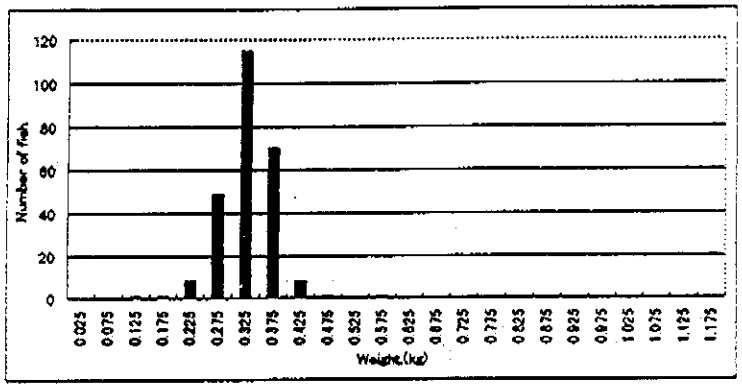
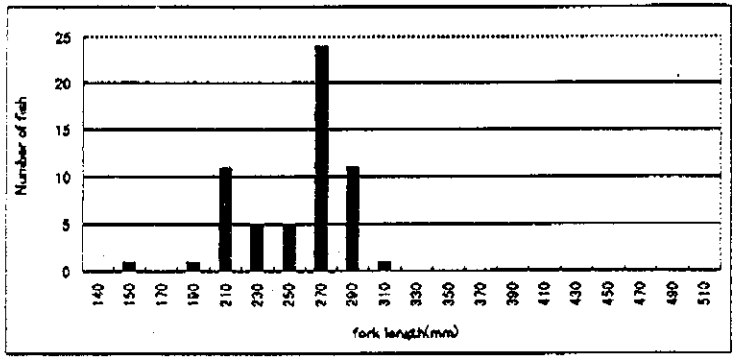


Figure 5-110. Body size composition of *Auxis rochei* caught in May - June, 1996.



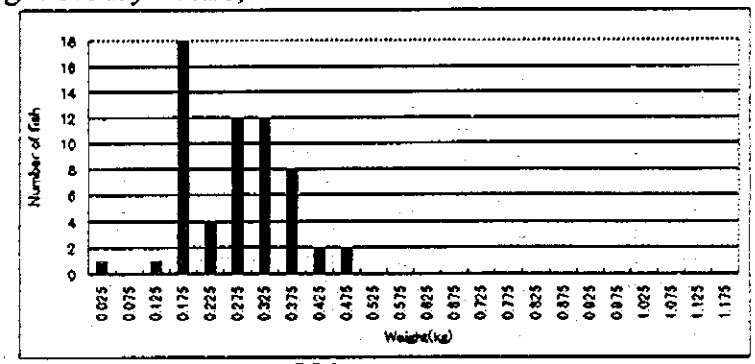
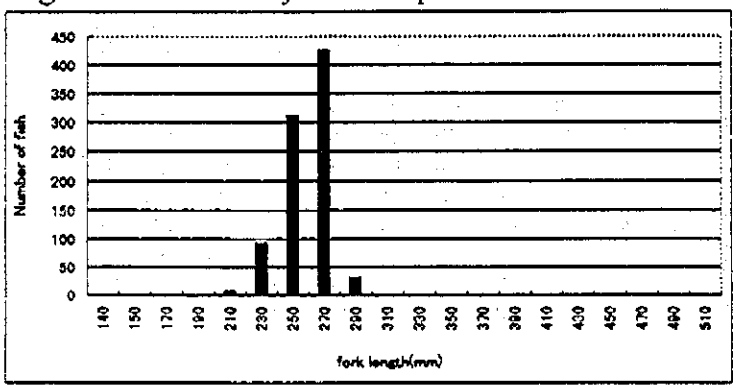


Figure 5-111. Body size composition of *Auxis rochei* caught in Sept. to Oct., 1996.



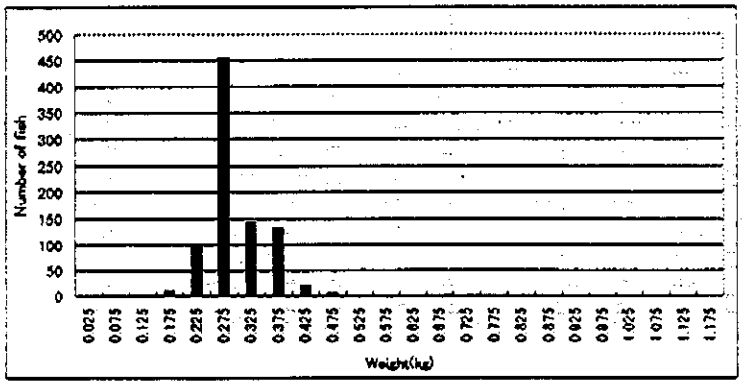


Figure 5-112. Body size composition of *Auxis rochei* caught in May - June, 1997.

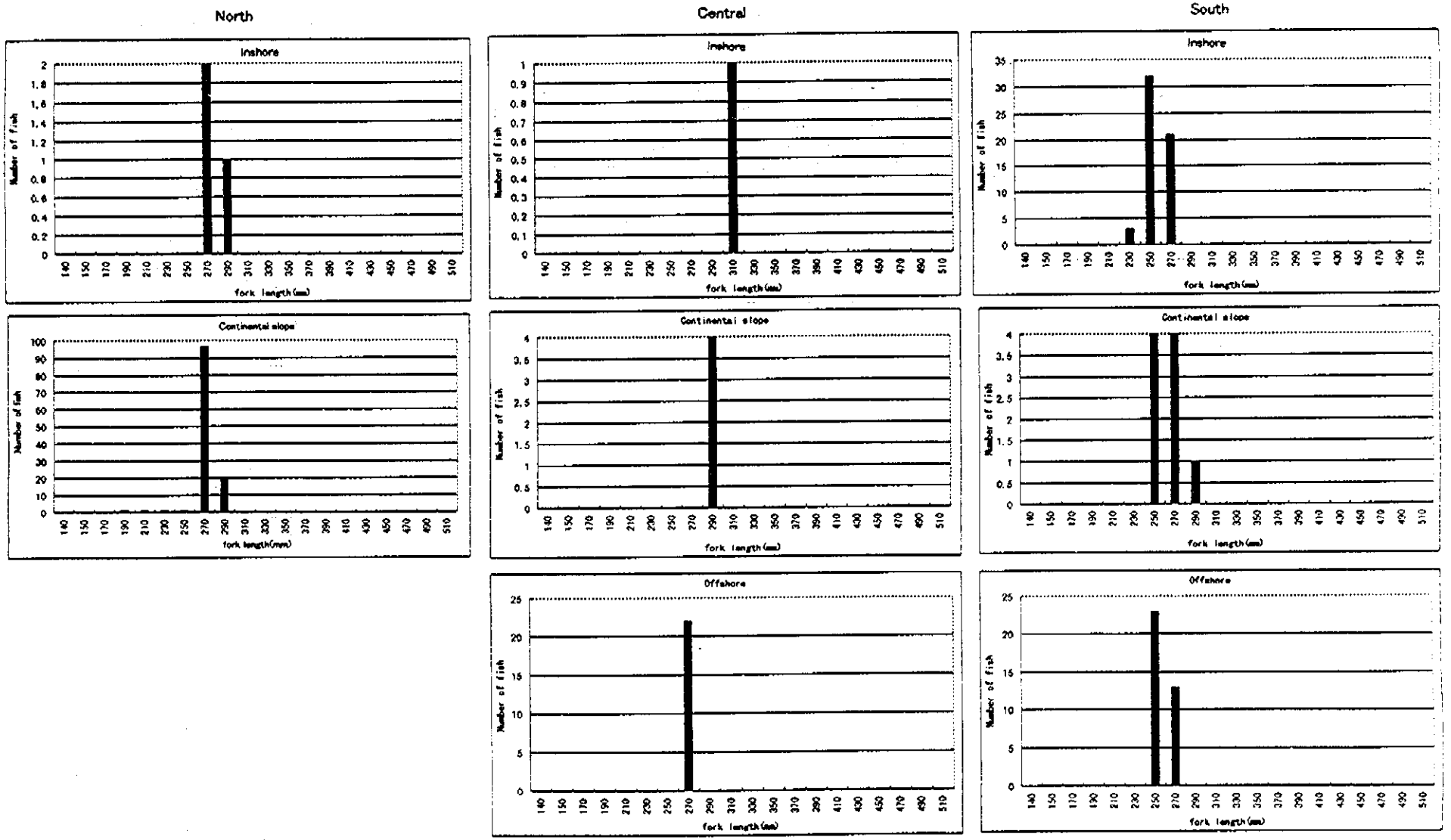


Figure 5-113. Fork length composition of *Auxis rochei* caught at each area in May - June, 1996.

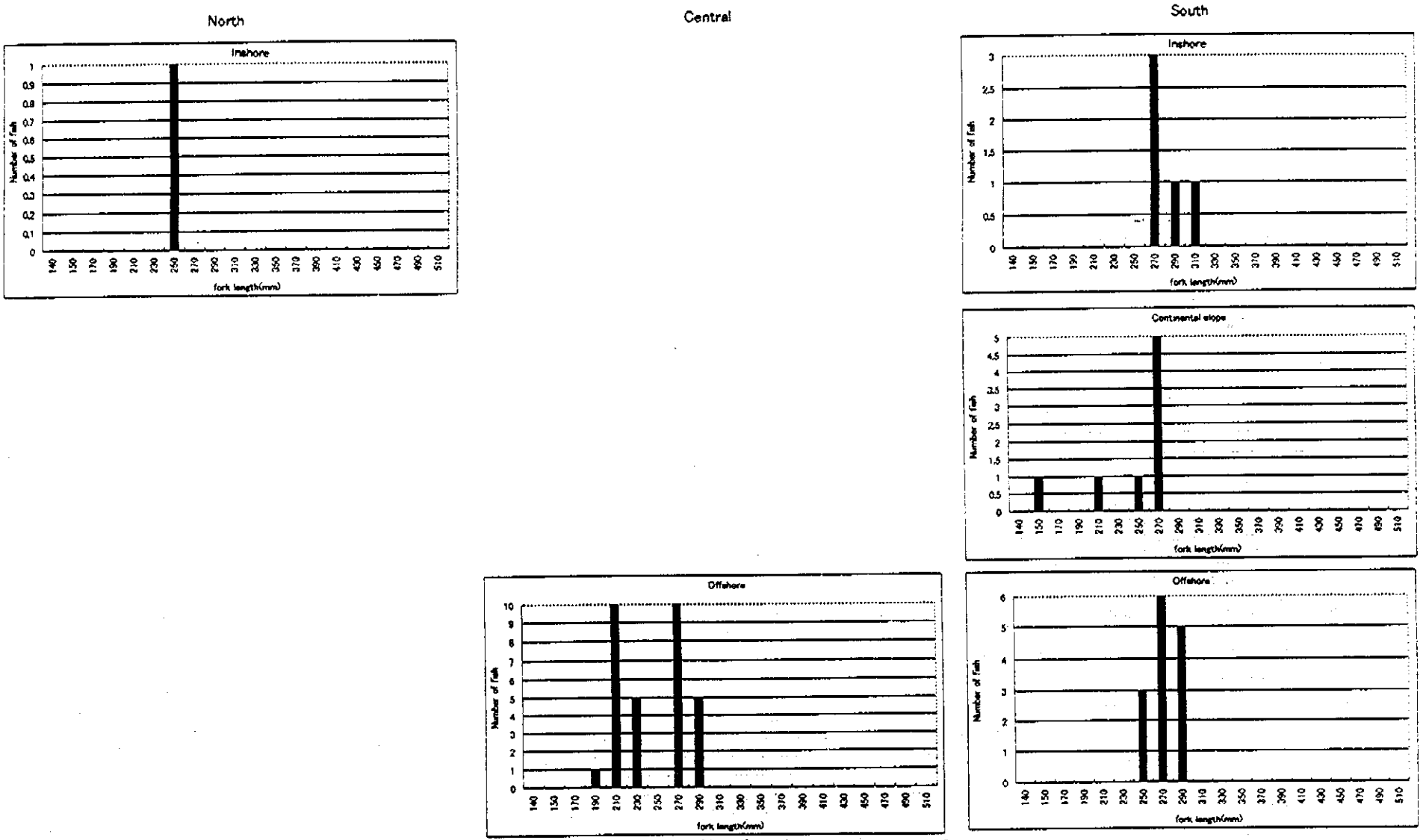


Figure 5-114. Fork length composition of *Auxis rochei* caught at each area in Sept. - Oct., 1996.

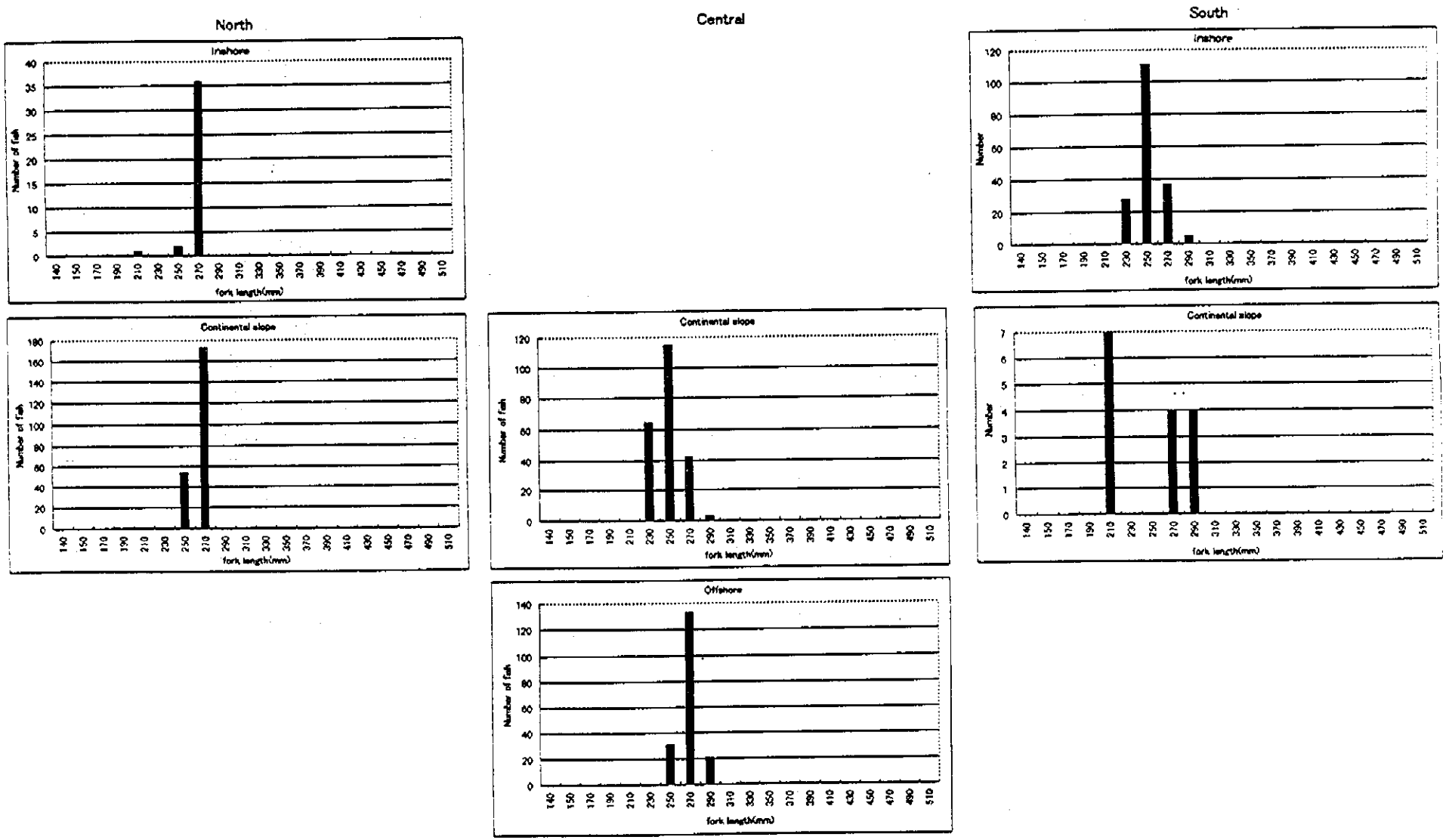
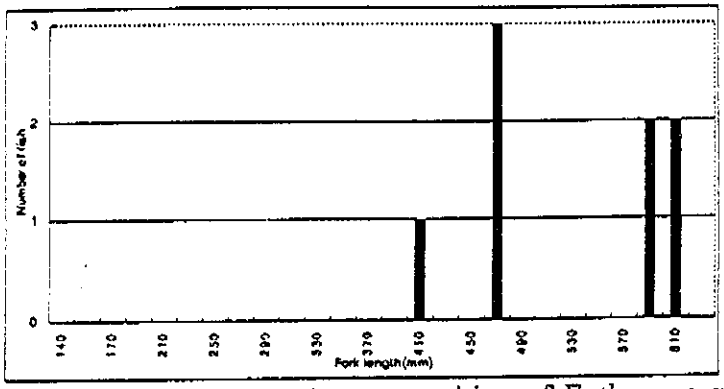


Figure 5-115. Fork length composition of *Auxis rochei* caught at each area in May - June, 1997.



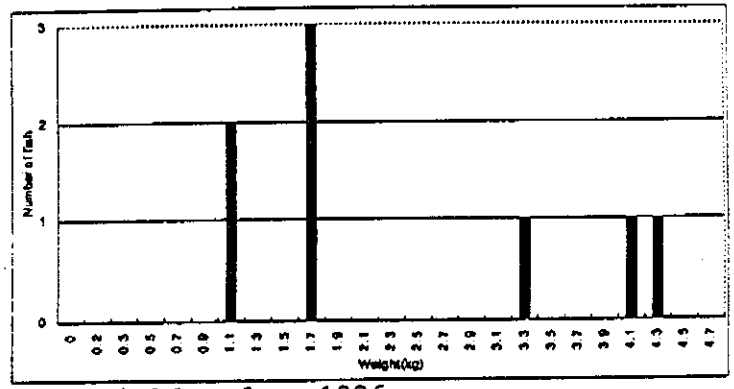
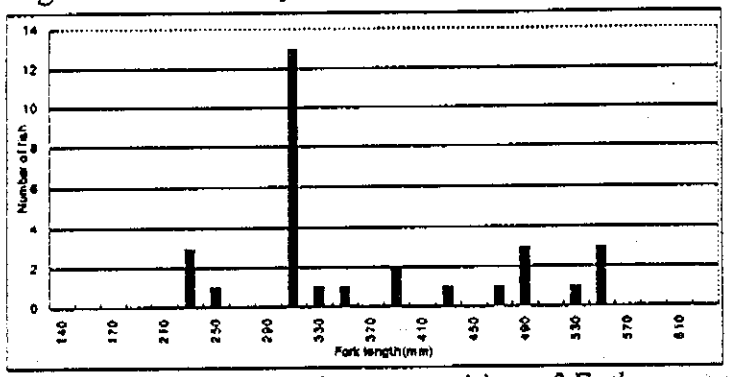


Figure 5-116. Body size composition of *Euthynnus affinis* caught in May - June, 1996.



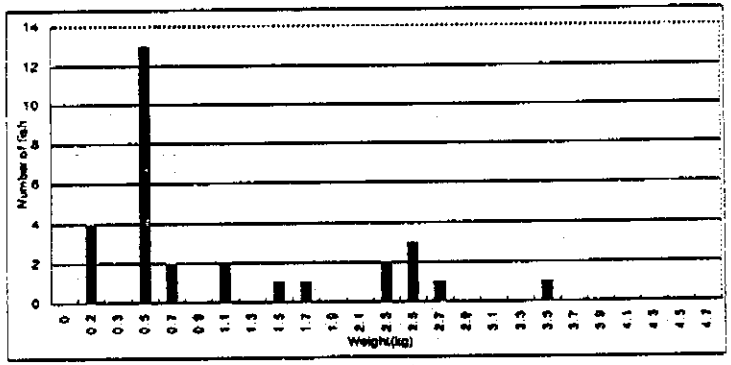
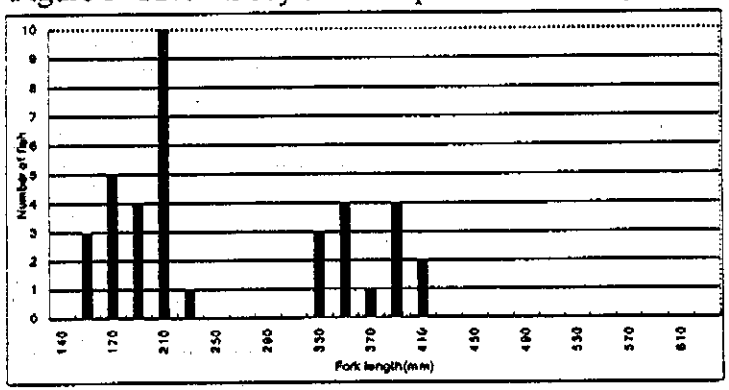


Figure 5-117. Body size composition of *Euthynnus affinis* caught in Sept. - Oct., 1996.



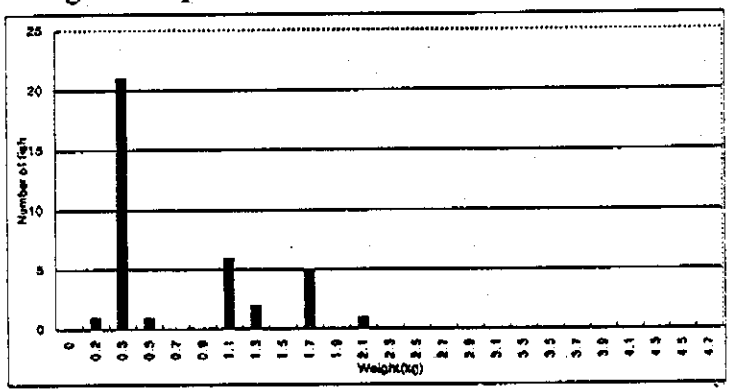
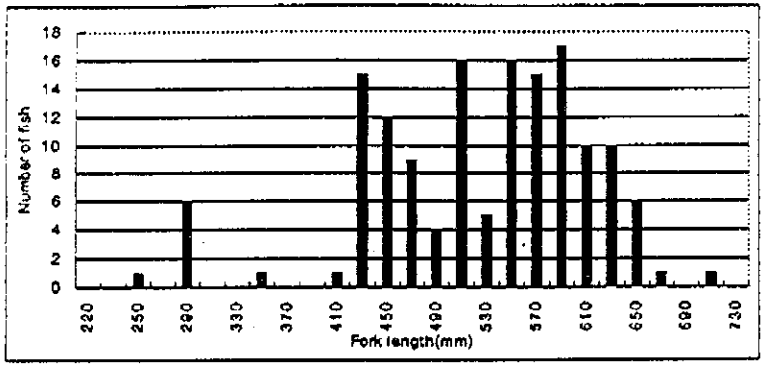


Figure 5-118. Body size composition of *Euthynnus affinis* caught in May to June, 1997.

three size groups with modal lengths of less than 400 mm, around 400 mm and around 500 mm, and those from the South Region consisted of two groups with modal lengths of around 400 mm and 500 mm. Small sized fish of 250 to 290 mm and less than 0.5 kg occurred only in the offshore area of the South Region (Figures 5-120,123). In the southwest monsoon season of 1997, most samples were collected in the offshore area of the Central and South Regions. The length frequency showed three modes of 270 to 290 mm, 430 mm and 550 mm. Large-sized fish of 400 to 500 mm comprised samples from the inshore area and small sized fish of 270 to 290 mm dominated in the offshore area (Figures 5-121,124). Thus, distribution and size composition of skipjack tuna varied remarkably between survey periods regardless of the season of the year.

There is substantial biological data on age and growth of skipjack tuna for its economic importance (Ochiai and Tanaka 1986). Reference to the previous reports indicates that two year of age fish might have dominated samples collected in the southwest monsoon season of 1996, that fish taken in the northeast monsoon season of 1996 might have consisted of one- and two-year olds, and that young fish of one year of age dominated those sampled in the southwest monsoon season of 1997. Bui Dinh Chung (1965) also stated that most fish of 45 to 60 cm taken in the Vietnamese waters are two-year olds. It is requested to elucidate these inferences through proceeding biological studies, in order to cope to possible variation of age and growth between year classes and stocks inhabiting different sea areas.

Stomach contents were taken in during the survey of September and October 1996 and then May and June 1997. Among 21 fish taken in the north-east monsoon season of 1996, 38 % were found with fishes and squids, 33 % with fishes only, 5 % with fishes, squids and shrimps and rest 10 % empty. Fishes and squids comprise 52 % and 35 % of forage organisms, respectively (Figure 5-125). Major fishes in stomachs were sardines, anchovies, carangids of Genus Caranx and Rastrelliger. Squids constituted 54 % of the prey found in stomachs collected in the



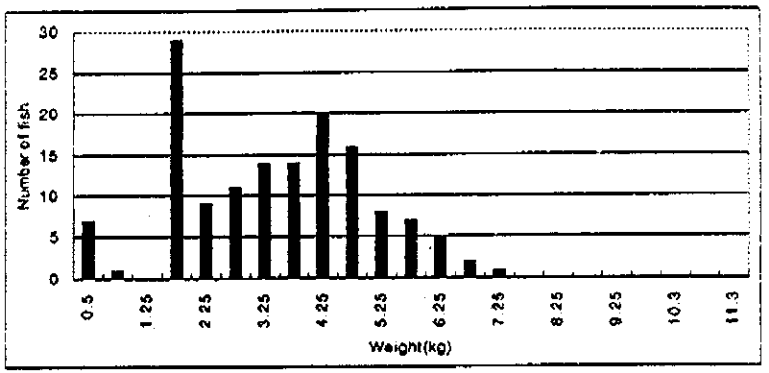
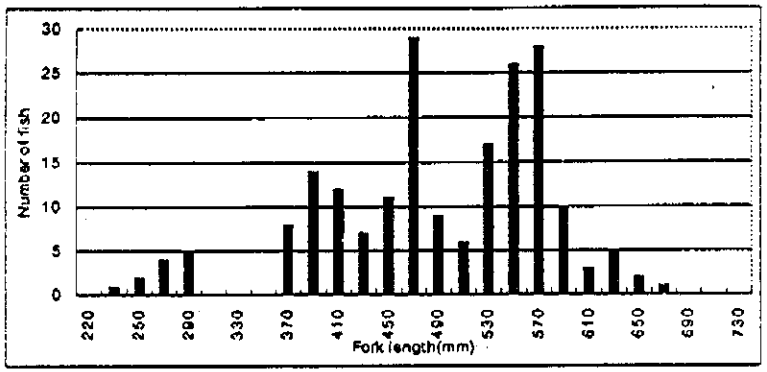


Figure 5-119. Body size composition of *Katsuwonus pelamis* caught in May - June, 1996.



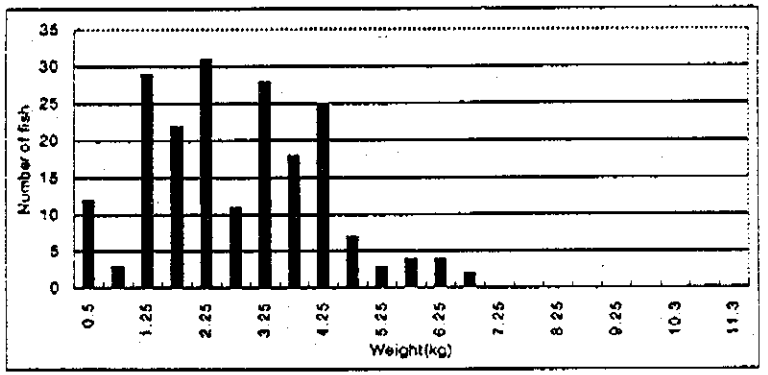
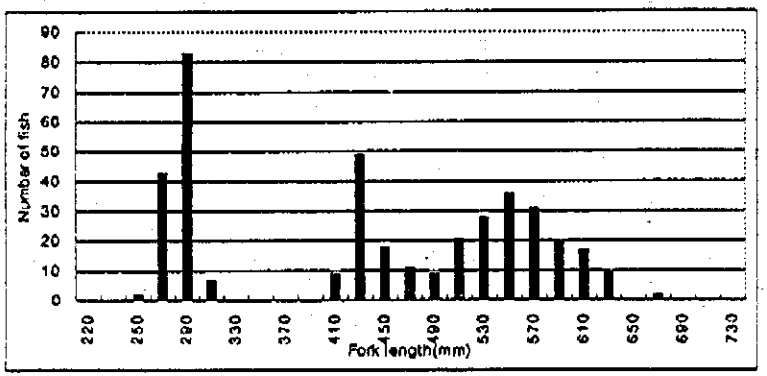


Figure 5-120 Body size composition of *Katsuwonus pelamis* caught in Sept. - Oct., 1996.



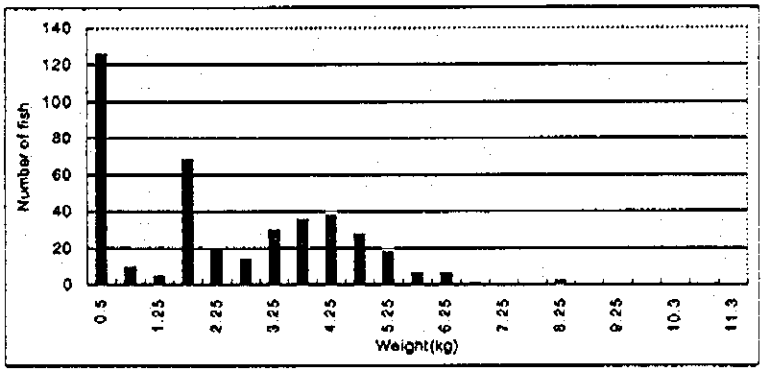


Figure 5-121 Body size composition of *Katsuwonus pelamis* caught in May - June, 1997.

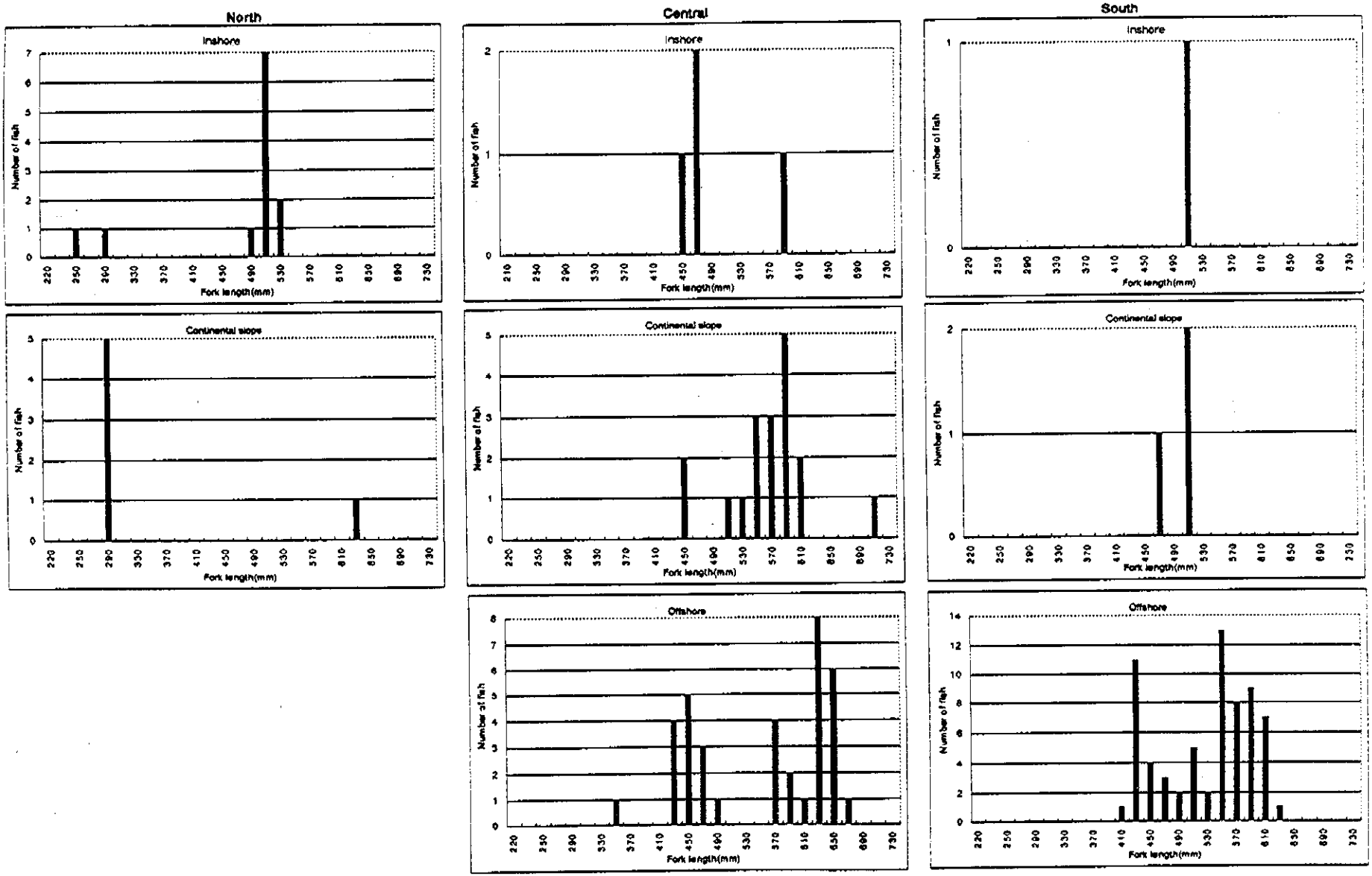


Figure 5-122. Fork length composition of *Katsuwonus pelamis* caught at each area in May - June,1996.

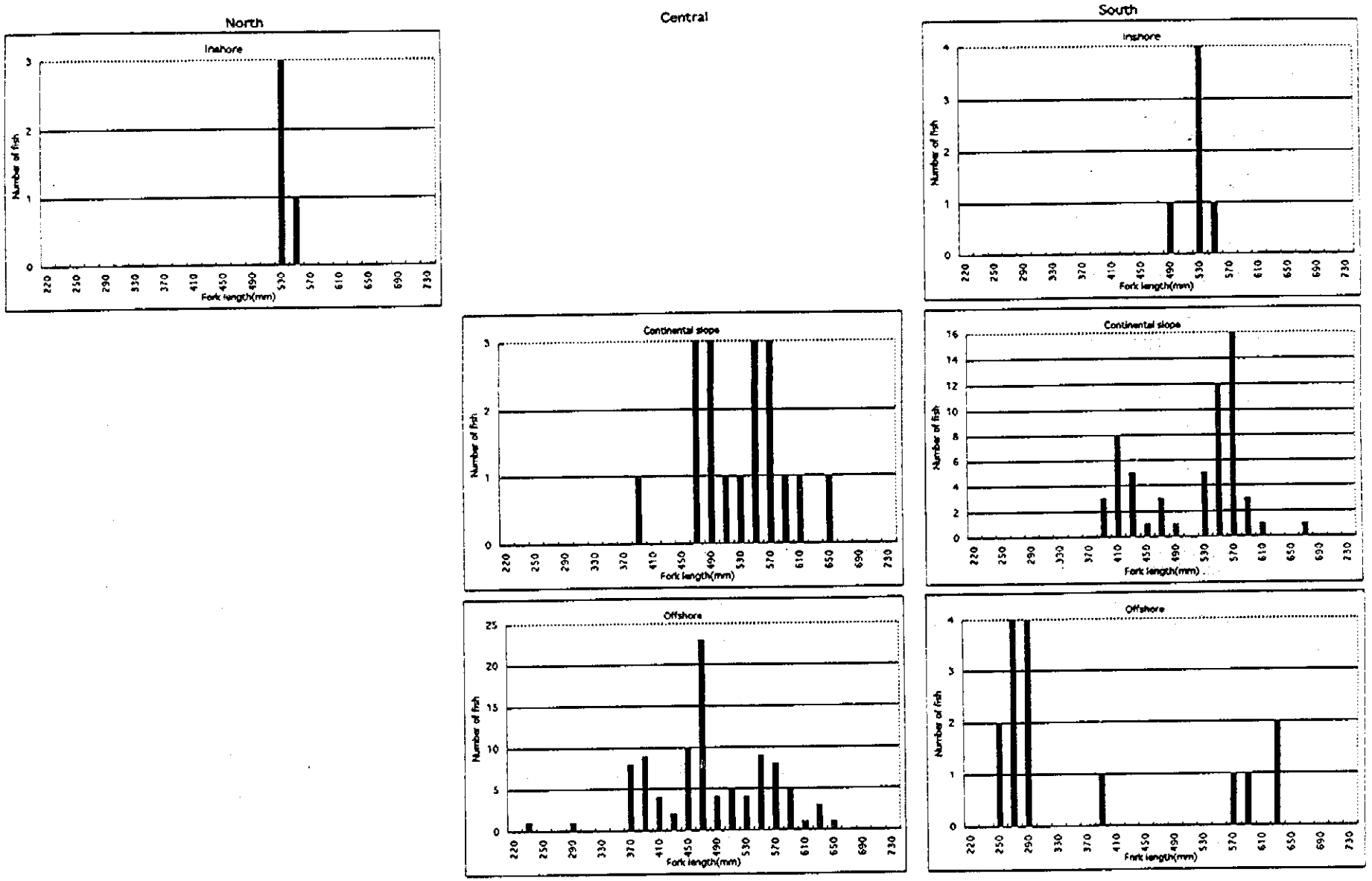


Figure 5-123. Fork length composition of *Katsuwonus pelamis* caught at each area in Sept. - Oct., 1996.

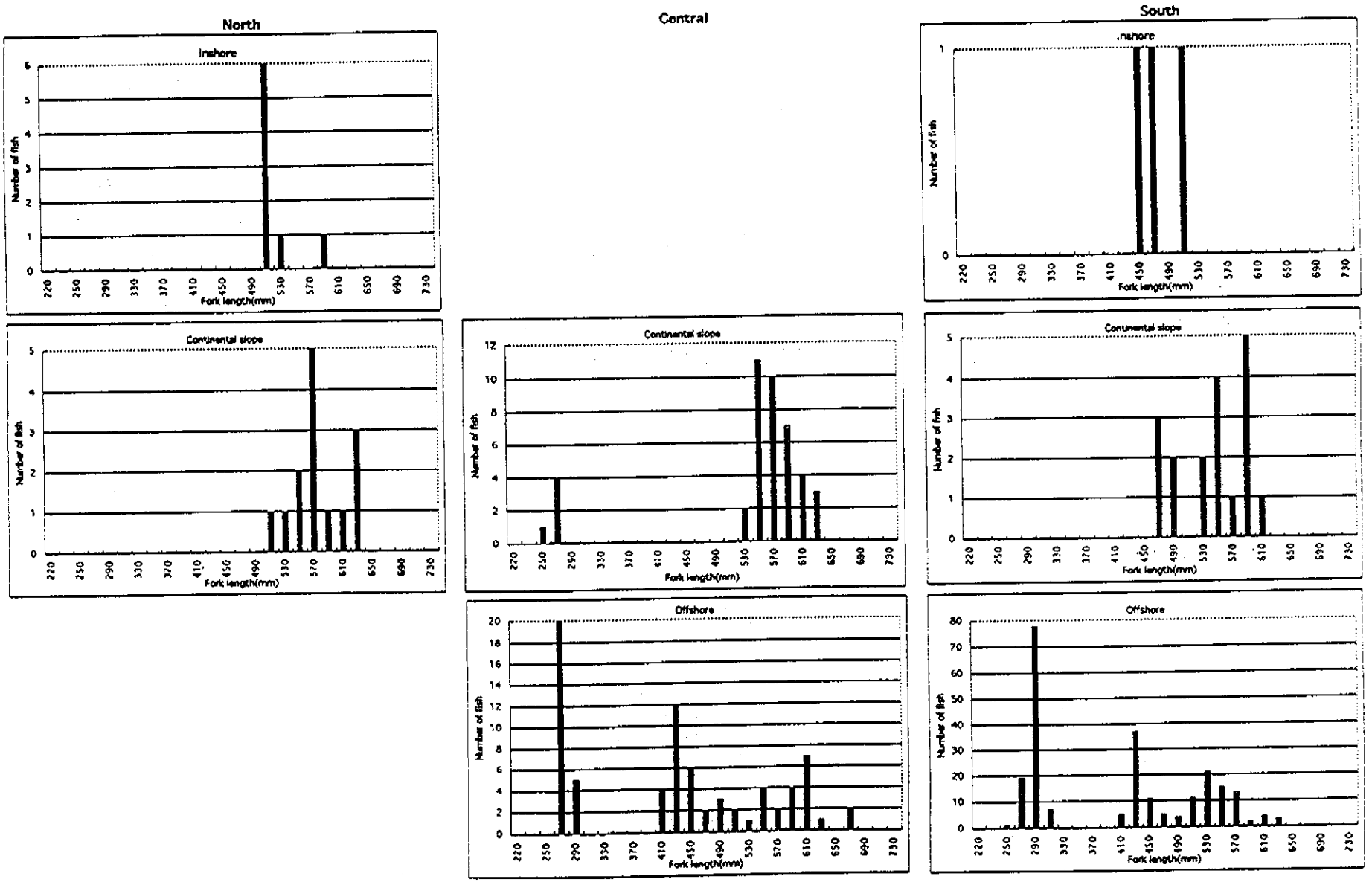


Figure 5-124. Fork length composition of *Katsuwonus pelamis* caught at each area in May - June, 1997.

southwest monsoon season of 1997. These results indicate that skipjack tuna depend upon mainly fishes and squids.

Ovaries were sampled in May and June 1996. A female of 515 mm had a gonad as heavy as 38.8 in GSI. Very small ova less than 0.1mm in diameter consisted of 51 % and the largest goup of ova of this fish, comprising 17.6 %, were still small at 0.4 to 0.5 mm in diameter. Skipjack tuna spawn in April through September in the northern subtropical waters, but the spawning season extends over the whole year in the equatorial waters (Ochiai and Tanaka 1986). It is desirable to clarify the spawning season in the waters for scrutinizing stock structure in the South China Sea.

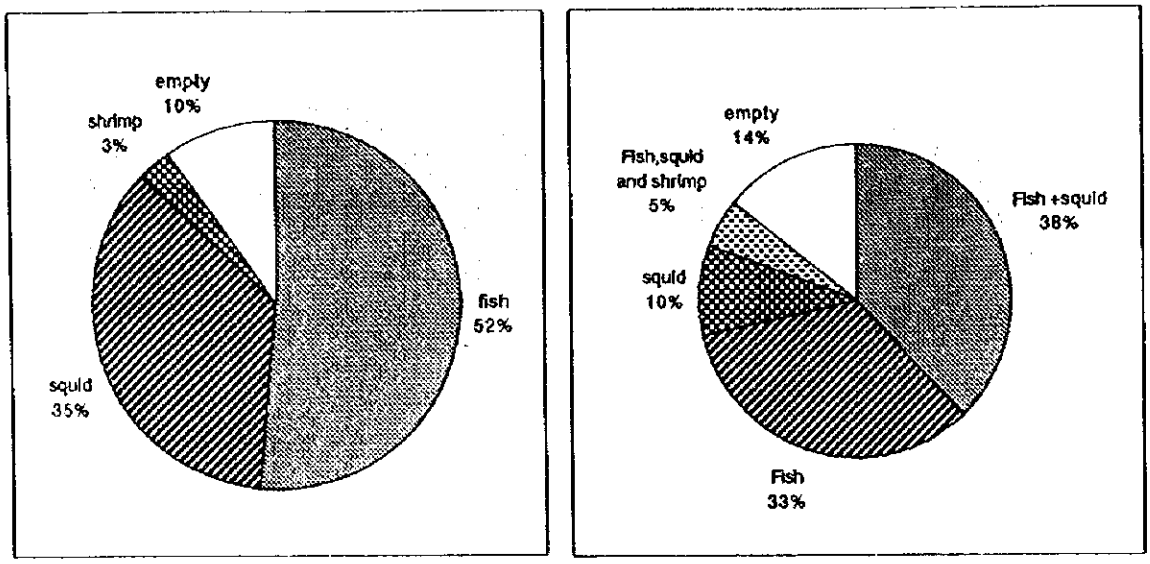


Figure 5-125. Composition of stomach contents of *Katsuwonus pelamis* caught in Sept. - Oct., 1996.

(10) Longtail tuna (*Thunnus tonggol*)

The fish appeared only in the inshore area of South Region. Samples taken by the present survey were 230 to 430 mm in length, with mode of 250 mm and mean of 300mm. These fish weighed 0.3～1.5 kg, and the mode was 0.3 kg. Fish taken in the northeast monsoon season of 1996 were 370 mm in modal

length and 0.9 kg in modal weight (Figure 5-126). Taken in the southwest monsoon season of 1997 were smaller fish with modes of 250 mm and 0.3 kg (Figure5-127). According to Mohsin (1996), there appear three age groups of longtail tuna, one year of age of 27 to 30 cm, two year of age of 35 cm and three year of age of 45 cm in the waters east of Malaysia and Gulf of Thailand. Applying this information, age of fish taken in the present survey is estimated as two years in the northeast monsoon season and one year in the southwest monsoon season.

(11) Yellowfin tuna (*Thunnus albacares*)

The fish occurred more frequently in the offshore area of the South Region than in the others. The whole sample consisted of fish ranging between 225 mm and 1,425 mm in length or 1 kg and 45 kg in weight, with modes of 275 mm and 1 kg and means of 461,2 mm and 4.5 kg. Dividing these materials into season of sampling, length frequencies showed two modes of 275 mm and 500 mm in the northeastern monsoon season of 1996, and only a single mode of 275 mm in the southwest monsoon season of 1997. A rearing experiment showed that the fish grow to 25 to 26 cm in six months after hatching and about 50 cm in one year. It is possible to consider that fish of the first year of life were taken in the survey area and one year old fish also appeared in the northeast monsoon season but only first year of life fish were taken in the southwest monsoon season. A fish of 1,425 mm taken in Sept. 1996 was found with eight leather jackets in the stomach. Content of another fish of 563 mm could not identified due to digestion. Stomachs of two other sample fish were empty.

(12) Bigeye tuna (*Thunnus obesus*)

Size frequency of the whole sample showed ranges and modes of 210 to 590 mm and 250 mm in length, and 0.1 to 0.4 kg and 0.3 kg in weight. The averages were 272.5 mm and 0.52 kg. The test fishing often caught bigeye tuna during the southwest monsoon season, but hardly in the northeast monsoon season.

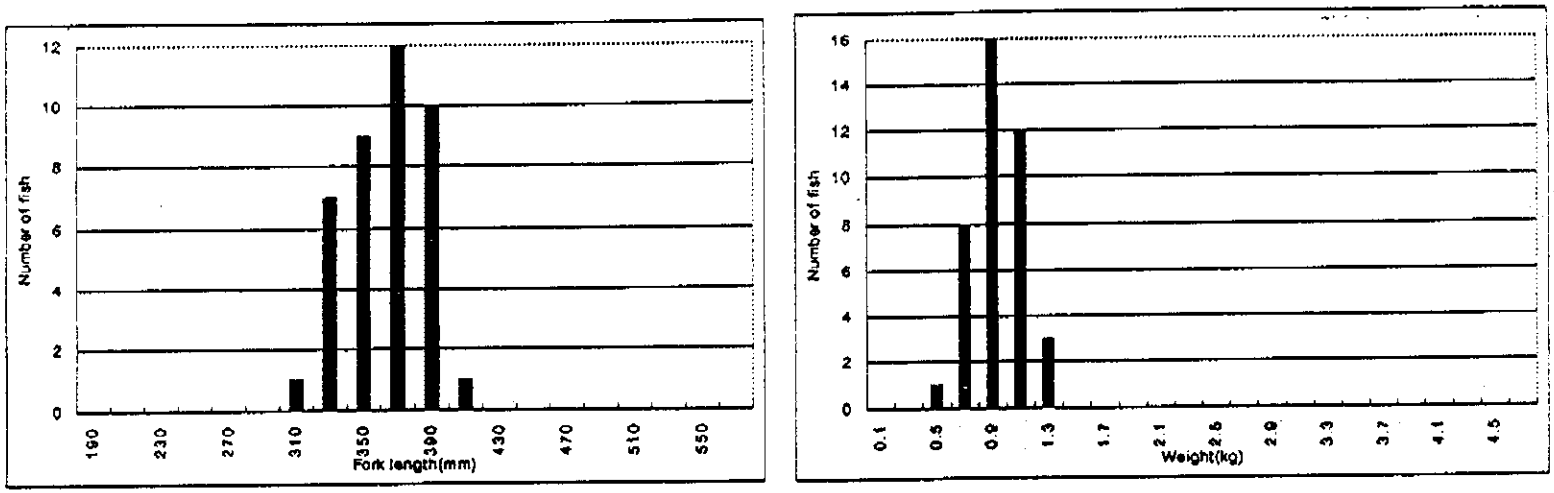


Figure 5-126. Body size composition of *Thunnus tonggol* caught in Sept. - Oct., 1996.

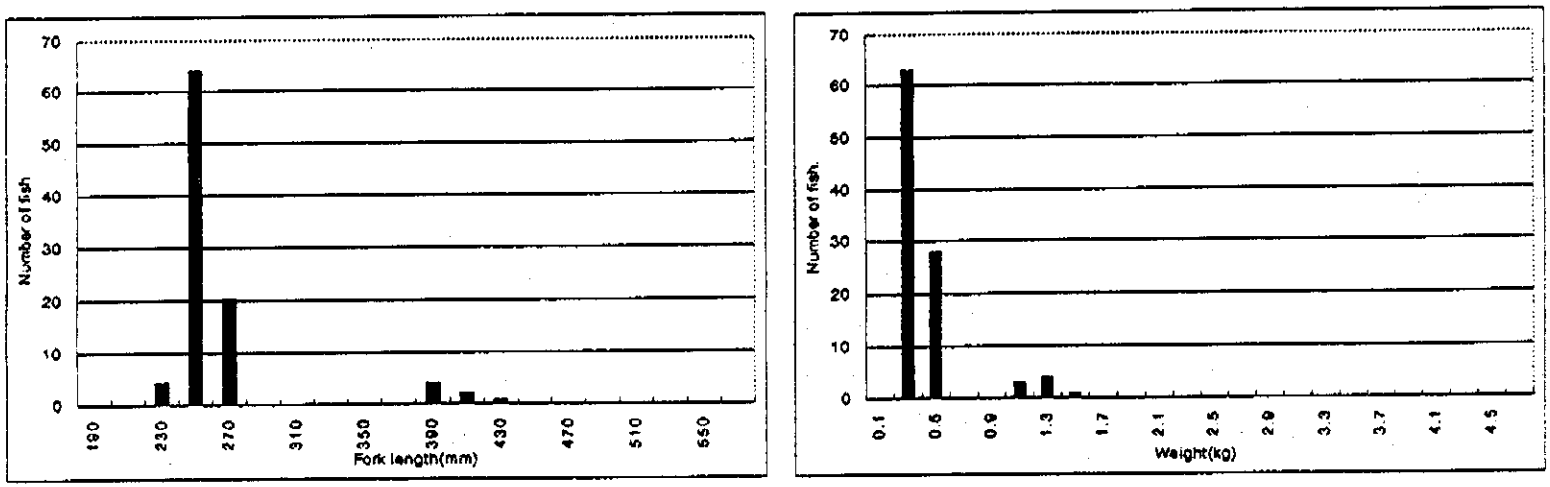


Figure 5-127. Body size composition of *Thunnus tonggol* caught in May - June, 1997.

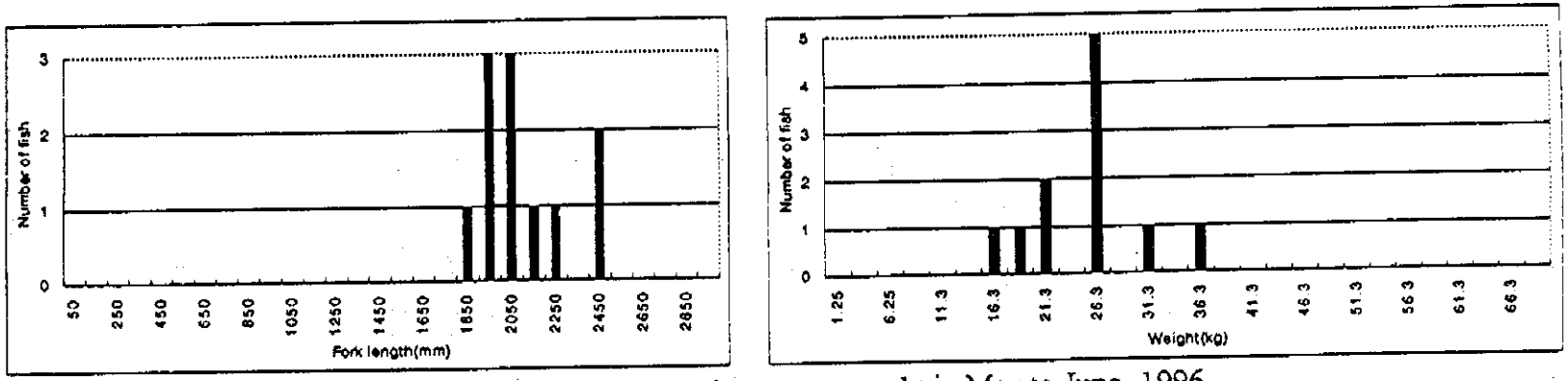


Figure 5-128. Body size composition of *Istiophorus platypterus* caught in May to June, 1996.

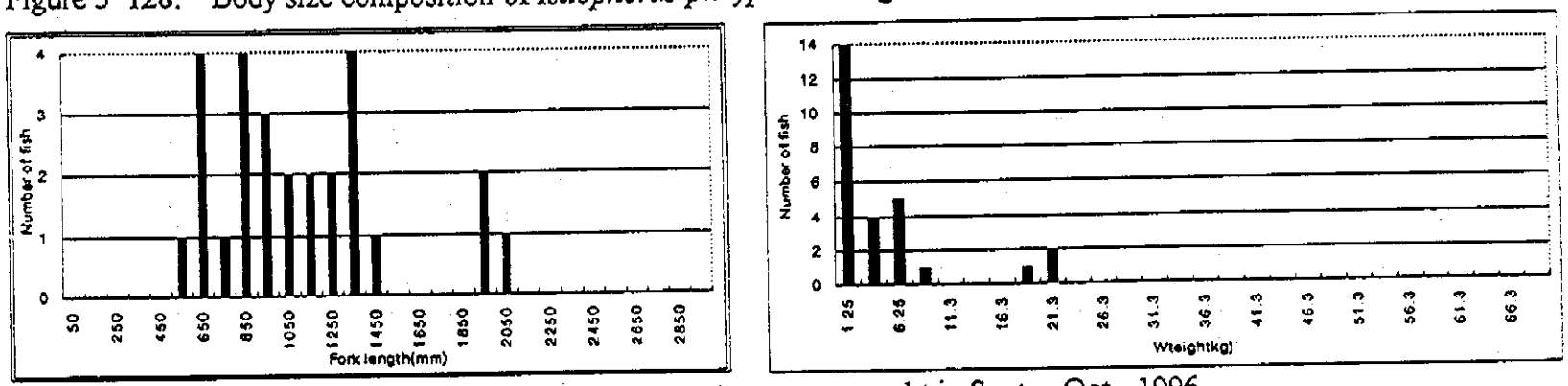


Figure 5-129. Body size composition of *Istiophorus platypterus* caught in Sept. - Oct., 1996.

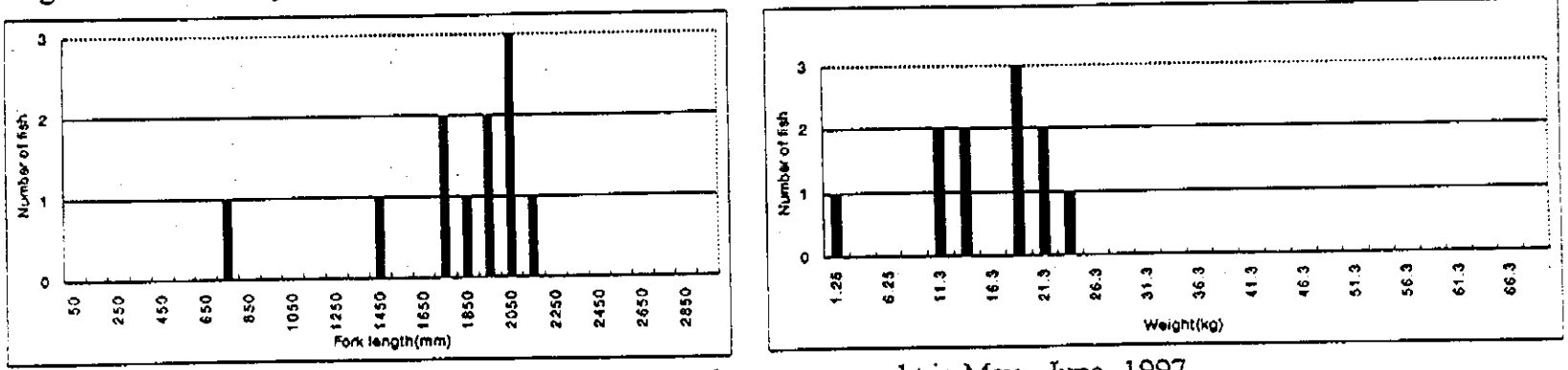


Figure 5-130. Body size composition of *Istiophorus platypterus* caught in May - June, 1997.

Samples were most frequently taken in the inshore to continental slope areas of North Region and the inshore area of South Region. Samples taken in these localities ranged between 210 mm and 250 mm and 0.1 kg and 0.5 kg. Since the species is known to reach 44 cm at the end of first year of life, most of samples taken in the present survey were considered to have been 0 of less than one year in age.

(13) Sailfish (*Istiophorus platypterus*)

Samples of this species were collected over the whole survey area. They ranged between 550 mm and 2,450 mm in length, and 1.25 kg and 36.25 kg in weight, with respective modes of 1,950 to 2,050 mm and 1.25 kg, and means of 1,458.3 mm and 11.51 kg. The fish taken in the southwest monsoon season were larger than those in the northeast monsoon season. Modes of the former were 1,950 to 2,050 mm and 18.75 to 26.25 kg (Figures 5-128,130). On the other hand, most fish sampled in the northeast monsoon season were less than 1,300 mm and 10 kg (Figure 5-129). It is known that the Atlantic species reach to 183 cm and 216 cm at the ends of first and second years of life representively (Ochiai and Tanaka 1986). Taking this information into account, the fish found in the northeast monsoon season were 0 year of age and those in the southwest monsoon season were one year of age or two year of age. Further studies are desirable on growth of the species that would be important to the local fisheries. Three specimens were obtained for examination of stomach contents in the northeast monsoon season of 1996. One of them had digested and unidentified fishes and two had empty stomachs.

(14) Other billfishes

There occurred billfishes of two families, in addition to sailfish, at some occasions.

① Black marlin, *Makaira indica*

The fish appeared more frequently in the inshore area of the South

Region than in the other areas. Samples ranged between 1,550 mm and 2,350 mm in length and between 17.5 kg and 72.5 kg in weight, with modes of 1,750 mm and 27.5 kg and means of 1,878mm and 33.3 kg. Fish taken in the southwest monsoon season had 1,650mm in modal length and 1,647 mm in mean length, 22.5 kg in modal weight and 21.3 kg in mean weight, were slightly smaller than those in the northeast monsoon season. Length had the figures of 1,750 mm, 1,878 mm, 27.5 kg and 33.25 kg respectively

② Blue marlin, *Makaira mazara*

During the surveys, blue marlin of the following measurements were taken; 1,025 to 2,450 mm in range of length, 1,717 mm in mean length, 22.5 kg to 108 kg in range of weight, and 33.9 kg in mean weight. Fish taken in the southwest monsoon season ranged between 1,650 mm to 2,450 mm or between 22.5kg and 108 kg, and were larger than those collected in the north- east monsoon season, ranging between 1,050 mm and 1,650 mm or 2.5 kg and 37.5 kg.

③ Striped marlin, *Tetrapterus audax*

Three specimens were taken at Station B-12, offshore area of the Central Region in the southwest monsoon season of 1997. They ranged between 2,320 mm and 2,494 mm in length and between 52 and 65 kg in weight.

④ Broadbill swordfish, *Xiphias gladius*

A specimen of the Xiphiid fish was obtained at Station B-21 in the offshore area of Central Region in the southwest monsoon season of 1997. The fish measured 1,900 mm in length and 24 kg in weight.

(15) Unicorn leatherjacket (*Aluterus monocerus*)

Almost all the samples of leather jacket were collected in the northeast monsoon season, not in the southwest monsoon season. The samples ranged between 130 mm and 350 mm in length, and 75 g and 725 g in weight, with modes of 190 to 210 mm and175 g, and means of 248.0 mm and 290 g. During the

northeast monsoon season of 1996, most samples came from the inshore area of North Region and the offshore area of South Region. Fish taken in the former area were 270 mm in modal length and 375 g in modal weight, larger than those, 210 mm and 225 g, in the latter area.

(16) Flying squid (*Sthenoteuthis oualaniensis*)

The only significant cephalopod appeared frequently in the continental slope and offshore areas, especially in the Central Region. Mantle length ranged between 120 mm and 330 mm with mode of 210 mm and mean of 206.3 mm. The comparable body weight figures were 125 g and 1,125 g, 475 g, and 440 g, respectively. Most specimens were taken in the offshore areas of both the Central and South Regions during the southwest monsoon season of 1996, and the modes were 230 mm 525 g. The modal length was small, 210 mm, only in the continental slope area of Central Region (Figures 5-131,134). During the northeast monsoon season of 1996, samples were more frequently collected in the offshore area of the Central Region than in the other areas. Modal length of 190 to 210 mm and modal weight of 425 g were found in all the areas (Figures 5-132,135). Test fishing took more samples in the offshore areas of Central and South Regions during the southwest monsoon season of 1997. These samples were found as large as 190 to 210 mm in modal length and 475 g in modal weight. Catches from the rest of the areas were similar in size, 210 mm in modal length (Figures 5-133,136). These findings suggest it probable to state that flying squid are more abundantly distributed in the offshore areas of Central and South Regions than in other areas, especially in these two areas during the southwest monsoon season and the more concentrated in the offshore area of the Central Region during the northeast monsoon season. Samples taken in the southwest monsoon season of 1996 were slightly smaller than those taken during the other survey periods.

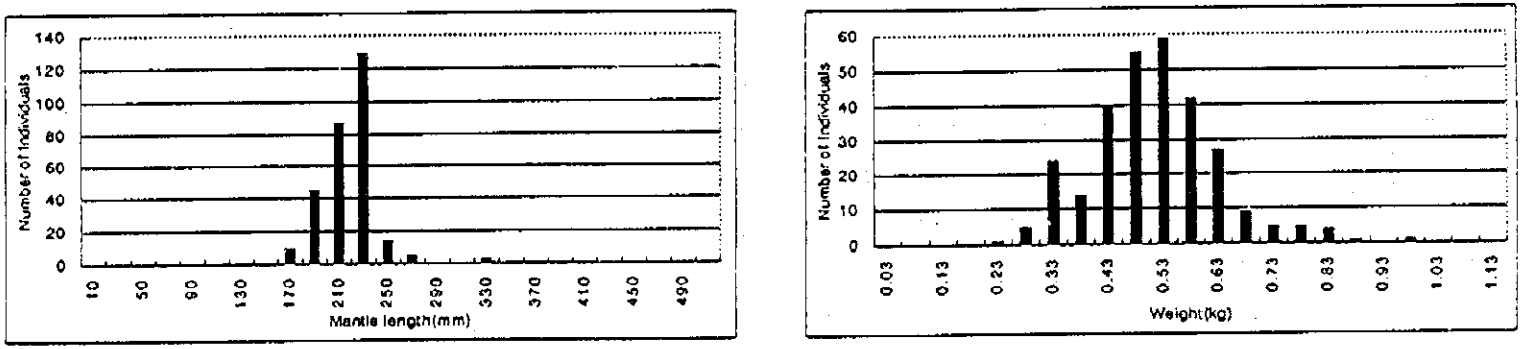


Figure 5-131. Body size composition of *Sthenoteuthis oualaniensis* caught in May - June, 1996.

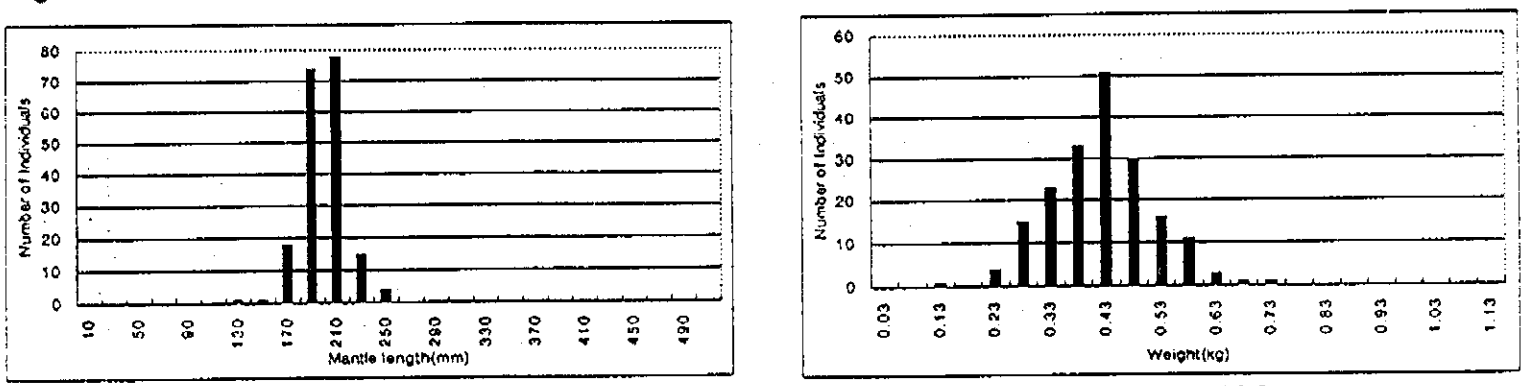


Figure 5-132. Body size composition of *Sthenoteuthis oualaniensis* caught in Sept. - Oct., 1996.

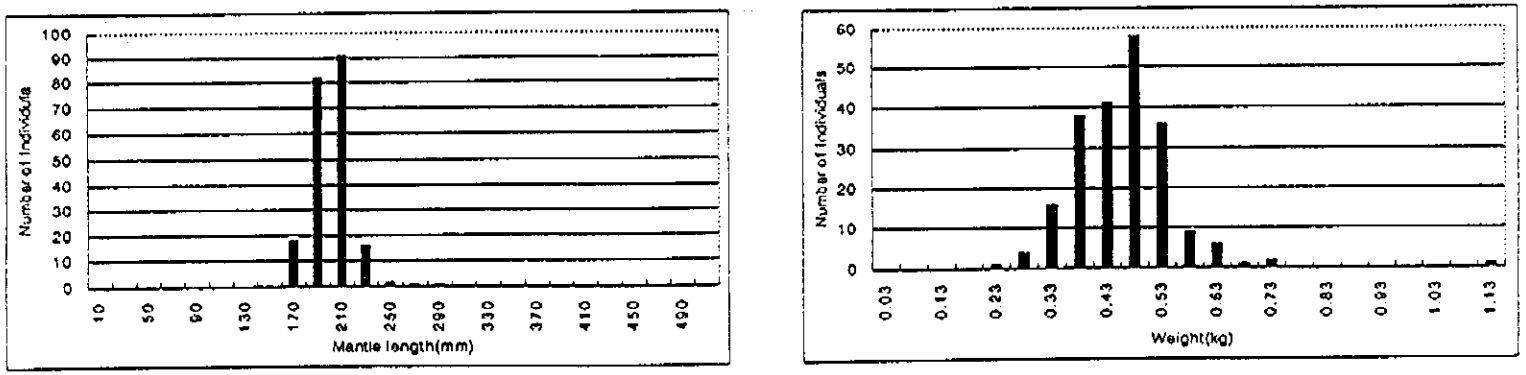


Figure 5-133. Body size composition of *Sthenoteuthis oualaniensis* caught in May - June 1997.

North

Central

South

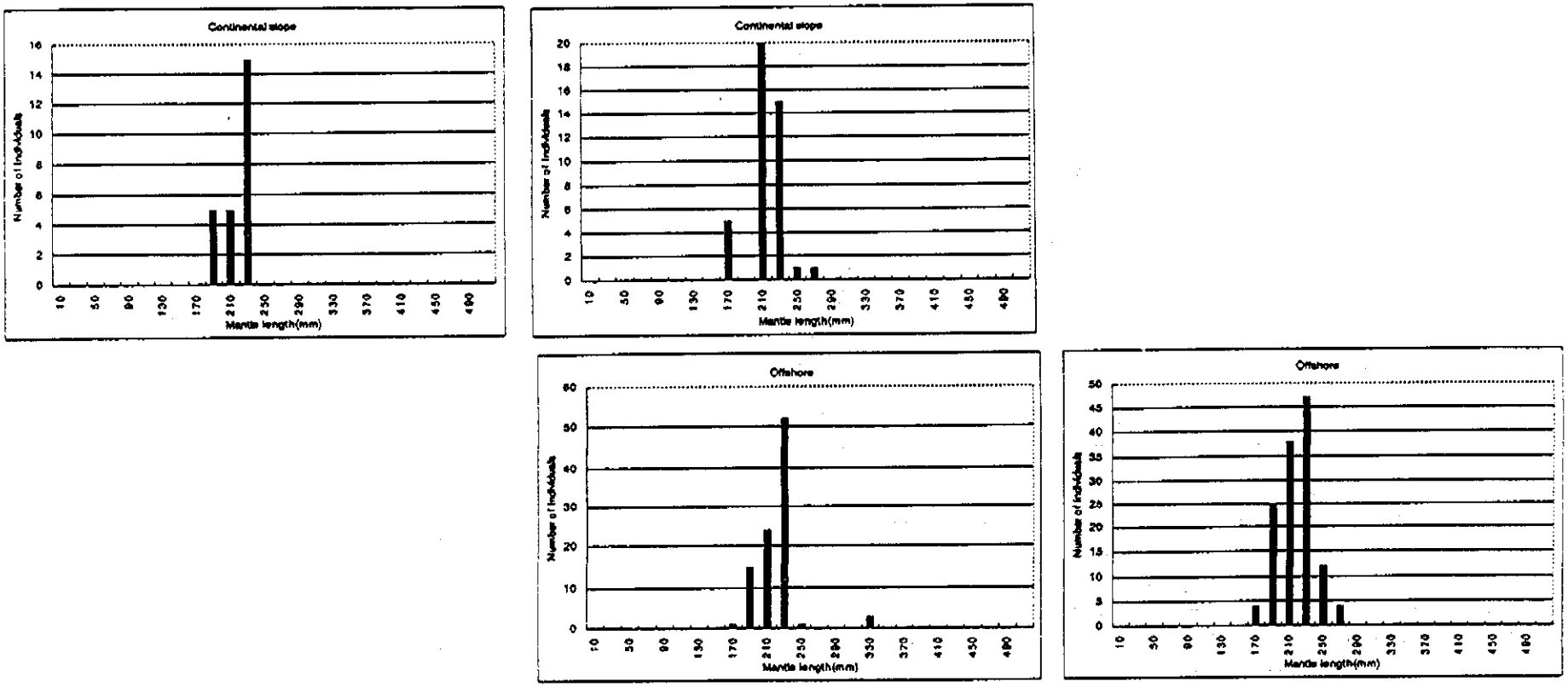


Figure 5-134. Mantle length composition of *Sthenoteuthis oualaniensis* caught at each area in May - June, 1996.

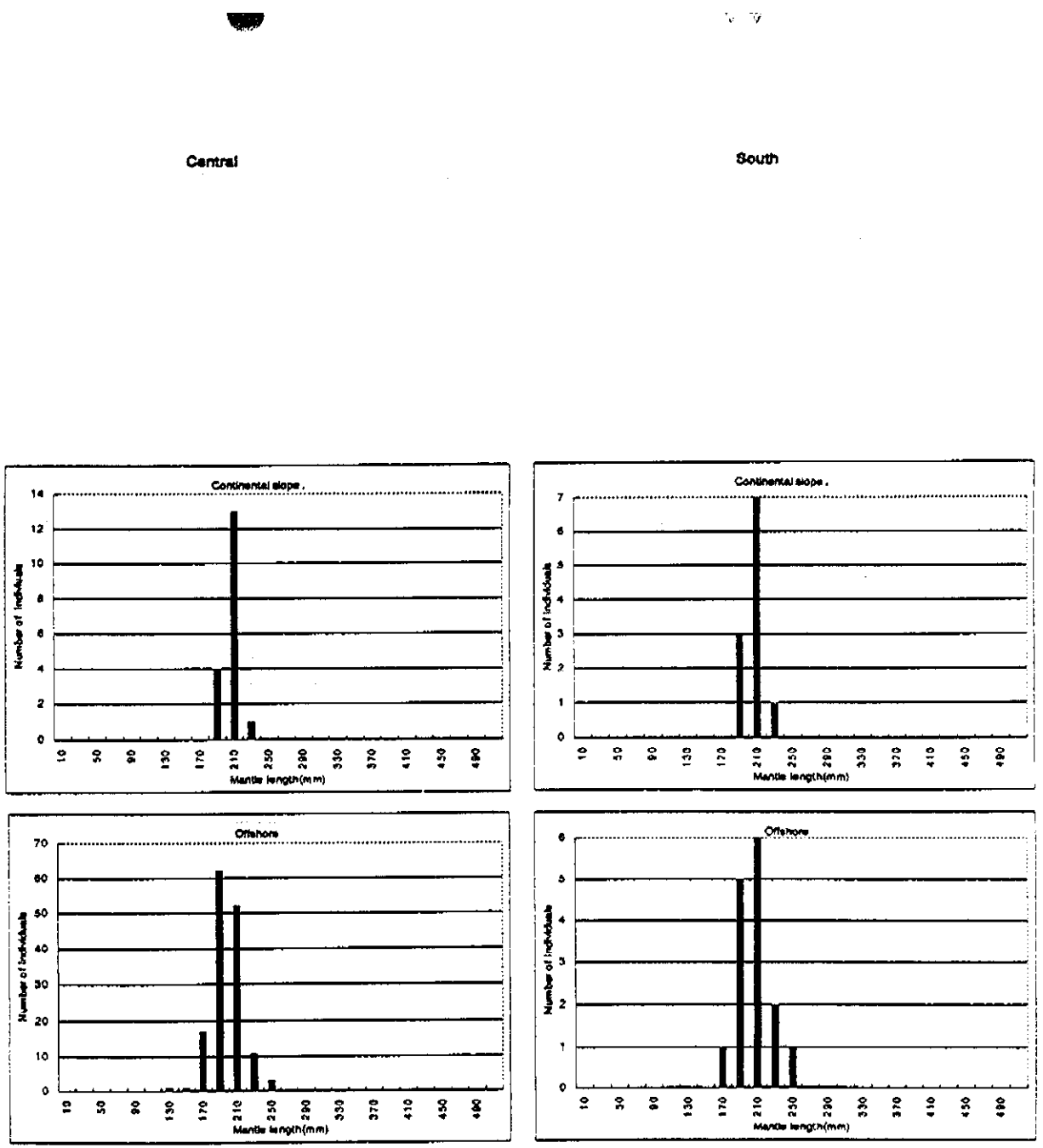


Figure 5-135. Mantle length composition of *Sthenoteuthis oualaniensis* caught at each area in Sept. - Oct., 1996.

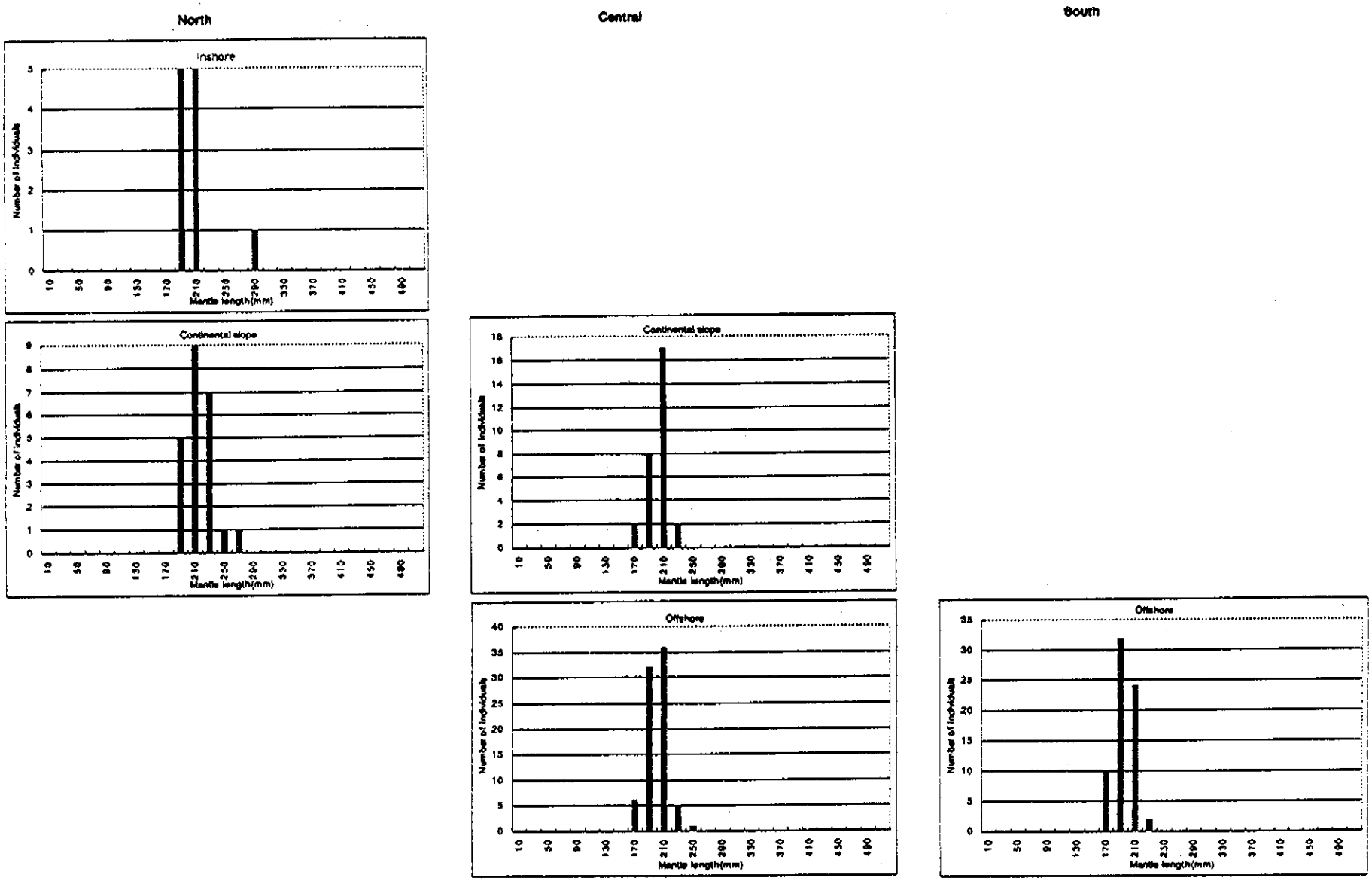


Figure 5-136. Mantle length composition of *Sthenoteuthis oualaniensis* caught at each area in May - June, 1997.

5-5. Mesh selectivity of drift gillnets

The drift gillnets adopted during the surveys consist of five different mesh sizes. Body length and body weight of fishes taken by the gear of five mesh sizes showed the difference in size composition due to the selectivity of nets.

Five species of fish and one of squid were chosen for identification of characteristics of mesh selectivity related to shape of the animals. Examination of data indicates that skipjack tuna represent typical mesh selectivity with difference of size of individual fish. The catch taken during the surveys extends across a wide range from 21 cm to 73cm in fork length (Table 5-12), which are divided into three size groups including small, less than 37 cm in fork length, medium, 37 to 49 cm, and large, exceeding 49 cm. The small sized fish were found mainly taken by the nets of 73-mm mesh, the medium sized fish by the nets of 93-mm and 123-mm mesh, and the large sized fish by the nets of 150-mm and 160-mm mesh (Figure 5-137). This phenomenon clearly indicates mesh size selectivity to the catch. Presence of exceptionally smaller or larger fish reflects existence of individuals in the population outside of selective range of each mesh size.

Gillnet selectivity curves for skipjack tuna were estimated by applying the maximum likelihood method of Millar & Holst (1997) to the data in Table 5-12-(5). Parameter estimated for four models in two cases are as follows:

	Equal fishing powers		Fishing powers α mesh-size	
Model	Parameters	Model Deviance	Parameters	Model Deviance
Normal:				
fixed spread	(k, σ) =(3.75, 0.68465)	169.67	(k, σ) =(4, 0.7071)	177.55
spred α m_j,	(k_1, k_2) =(3.8855, 0.3013)	212.19	(k_1, k_2) =(3.9650, 0.3038)	212.45
Gamma:				
spred α m_j,	(α, k) =(49.9161, 0.00782)	202.70	(α, k) =(50.9161, 0.00782)	202.70
Lognormal:				
spred α m_j,	(μ_1, σ) =(5.9076, 0.14237)	200.57	(μ_1, σ) =(5.9279, 0.14237)	200.57

Figure 5-138 shows gillnet selectivity curves for skipjack tua for three models, i.e. normal (fixed spread), normal (spread α m_j) and gamma (spread α m_j).

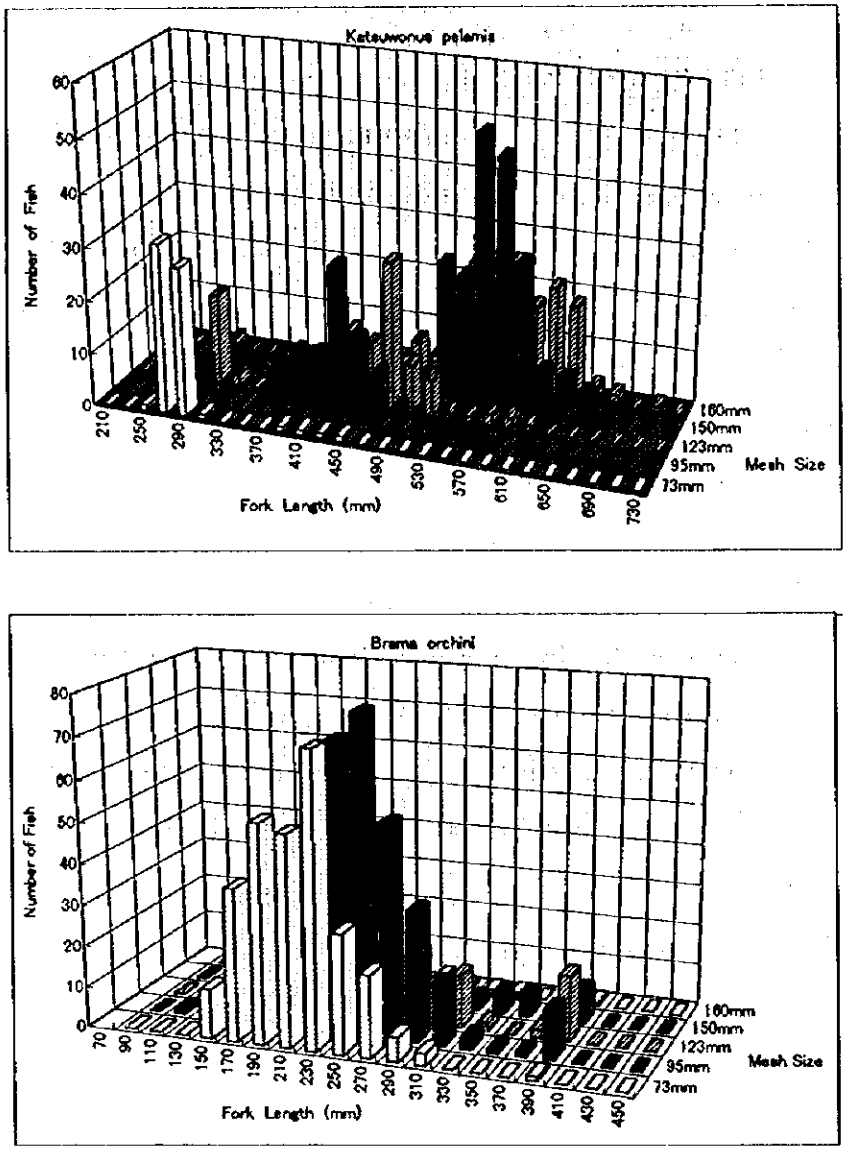


Figure 5-137. Frequency distribution of fork length of skipjack tuna and bigtooth pomfret caught by mesh size of gillnets.

Similar variation of size composition appeared for dolphinfish and pomfret (Figure 5-137 and Table 5-12). On the contrary, flying squid were taken solely by the nets of 73mm in mesh size, because the catch consisted of individuals of limited range, representing a monomodal frequency (Table 5-12). Exploited stocks of frigate and bullet mackerels might have a narrow range of body length, and then any significant mesh selectivity was not found (Table 5-12).

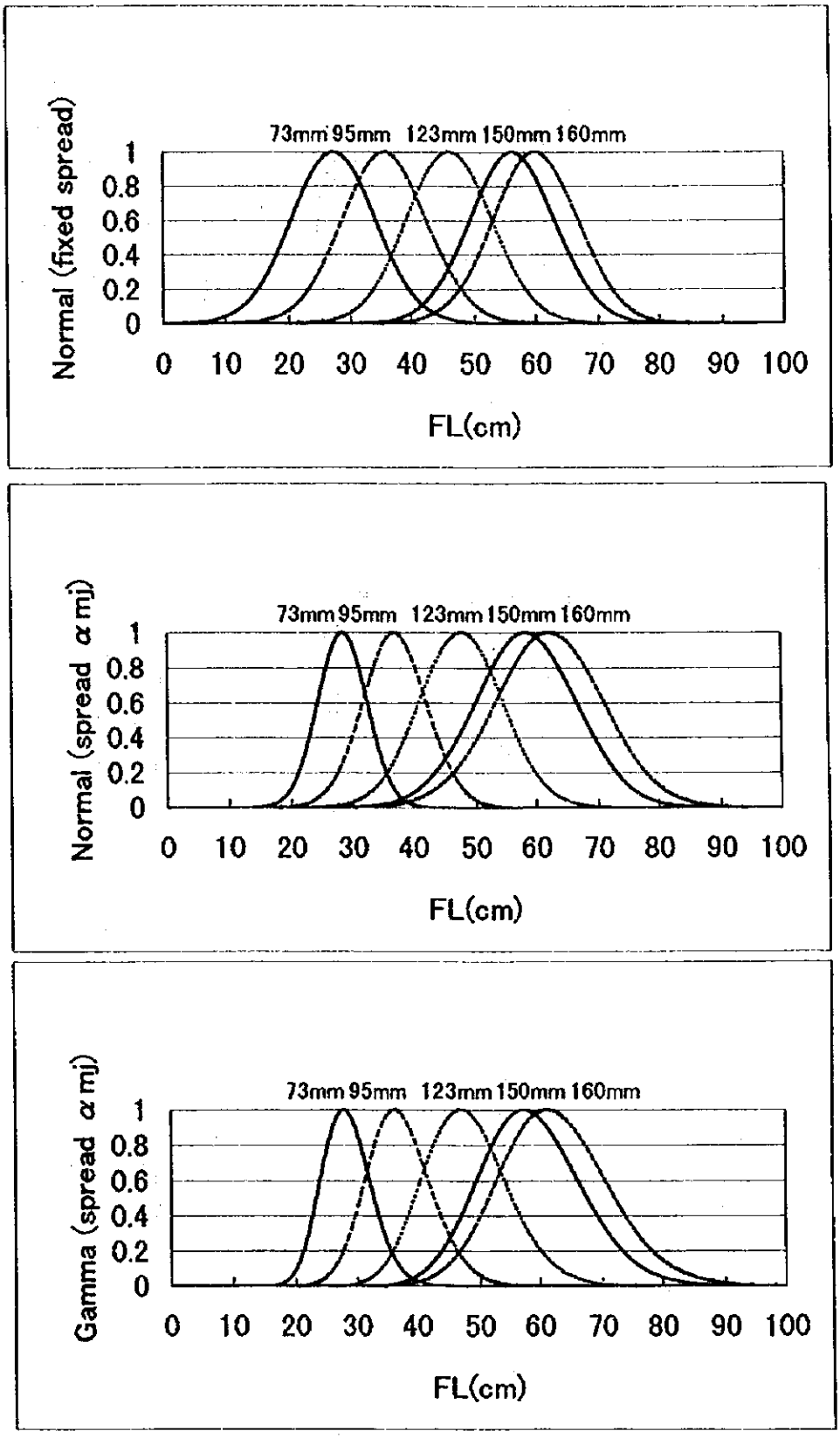


Figure 5-138. Gillnet selectivity curves for skipjack tuna in three models.

Table 5-12. Frequency distribution of body length six important species caught by mesh size of gillnets.

(1) Coryphaena hippurus

FL	73mm	95mm	123mm	150mm	160mm	Total
175	0	0	0	0	0	0
225	1	3	0	0	1	5
275	89	7	1	2	1	100
325	64	2	1	1	0	68
375	180	4	0	1	0	185
425	366	17	4	1	0	388
475	42	51	9	2	0	104
525	1	67	4	1	2	75
575	0	15	6	3	1	25
625	0	5	3	2	5	15
675	0	1	5	4	4	14
725	0	0	1	4	6	11
775	0	0	0	6	6	12
825	0	1	0	4	3	8
875	0	0	0	2	4	6
925	0	0	0	2	1	3
975	0	0	0	1	2	3
1025	0	0	0	0	0	0
1075	0	0	0	0	0	0
1125	0	0	0	1	0	1
1175	0	0	0	0	0	0
1225	0	0	0	0	0	0
Total	743	173	34	37	36	1023

(2) Brama orchini

BL	73mm	95mm	123mm	150mm	160mm	Total
70						
90	0	0	0	0	0	0
110	0	1	0	0	0	1
130	0	2	2	1	0	5
150	12	1	1	0	0	14
170	37	4	0	0	0	41
190	53	4	3	4	0	64
210	51	27	1	5	3	87
230	71	70	3	1	1	146
250	29	77	13	2	8	129
270	20	52	15	4	3	94
290	6	32	10	2	1	51
310	3	15	13	3	1	35
330	0	3	2	5	1	11
350	0	1	0	5	0	6
370	0	1	2	1	0	4
390	1	12	16	8	1	38
410	0	0	0	0	0	0
430	0	0	0	0	0	0
450	0	0	0	0	0	0
Total	283	302	81	41	19	726

(3) Auxis thazard

FL	73mm	95mm	123mm	150mm	160mm	Total
130	0	0	0	0	0	0
150	0	0	0	0	0	0
170	0	0	0	0	0	0
190	0	0	0	0	0	0
210	0	0	0	0	0	0
230	0	0	3	2	0	5
250	7	3	6	5	5	26
270	17	3	9	10	5	44
290	7	0	1	1	1	10
310	10	1	5	1	0	17
330	23	19	10	6	7	65
350	38	74	25	32	7	176
370	20	47	8	22	11	108
390	13	101	14	40	22	190
410	4	36	12	16	10	78
430	0	6	0	6	2	14
450	0	0	3	1	1	5
470	0	0	0	0	0	0
490	0	0	0	0	0	0
510	0	0	0	0	0	0
530	0	0	0	0	0	0
Total	139	290	96	142	71	738

(4) Auxis rochei

BL	73mm	95mm	123mm	150mm	160mm	Total
130	0	0	0	0	0	0
150	0	0	1	0	0	1
170	0	0	0	0	0	0
190	0	0	0	1	1	2
210	0	9	0	7	3	19
230	4	67	3	6	2	82
250	23	168	64	40	35	330
270	96	238	97	87	64	582
290	41	15	7	4	1	68
310	1	1	0	0	0	2
330	0	0	0	0	0	0
350	0	0	0	0	0	0
370	0	0	0	0	0	0
390	0	0	0	0	0	0
410	0	0	0	0	0	0
430	0	0	0	0	0	0
450	0	0	0	0	0	0
470	0	0	0	0	0	0
490	0	0	0	0	0	0
510	0	0	0	0	0	0
Total	165	498	172	145	106	1086

(5) Katsuwonus pelamis

FL	73mm	95mm	123mm	150mm	160mm	Total
210	0	0	0	0	0	0
230	0	0	0	1	0	1
250	1	0	2	0	1	4
270	32	3	2	0	2	39
290	28	7	17	0	0	52
310	1	0	2	0	0	3
330	0	0	0	0	0	0
350	0	1	0	0	0	1
370	0	8	0	0	0	8
390	1	12	0	0	1	14
410	1	12	2	2	0	17
430	1	29	14	1	2	47
450	1	16	12	7	3	39
470	0	10	28	4	7	49
490	0	4	9	2	5	20
510	0	1	7	26	9	43
530	0	1	1	24	24	50
550	0	1	1	51	25	78
570	0	0	2	47	25	74
590	0	0	2	28	17	47
610	0	0	1	8	21	30
630	0	0	0	7	18	25
650	0	0	0	5	3	8
670	0	0	0	2	2	4
690	0	0	0	0	0	0
710	0	0	0	0	1	1
730	0	0	0	0	0	0
Total	66	105	102	215	166	654

(6) Sthenoteuthis oualaniensis

ML	73mm	95mm	123mm	150mm	160mm	Total
50	0	0	0	0	0	0
70	0	0	0	0	0	0
90	0	0	0	0	0	0
110	0	0	0	0	0	0
130	1	0	0	0	0	1
150	1	0	0	0	0	1
170	46	0	0	0	0	46
190	201	0	0	0	0	201
210	253	3	0	0	0	256
230	158	1	0	1	0	160
250	17	3	0	0	0	20
270	0	5	0	0	0	5
290	1	0	0	0	0	1
310	0	0	0	0	0	0
330	3	0	0	0	0	3
350	0	0	0	0	0	0
370	0	0	0	0	0	0
390	0	0	0	0	0	0
410	0	0	0	0	0	0
430	0	0	0	0	0	0
Total	681	12	0	1	0	694

5-6. Comparison of catch made by mid-layer and surface drift gillnets.

A set of gillnets of 100-mm mesh size was placed at depth of about 10 m below the sea surface connected with surface nets of the same mesh size, to concurrently allow test fishing by surface nets of five different mesh sizes during the 4th cruise of the Second Phase.

5-6-1 Comparison of CPUE between surface and mid-layer gillnets

Table 5-13 shows number of species and catch per 20 tans of surface and mid-layer gillnets. The nets of two types produced CPUE both in terms of number and weight, converted to catch excluding manta and devil rays and incidentally taken animals, per net of 20 tans.

(1) Number of species and CPUE

Surface gillnets (hereinafter referred to as "surface nets") captured a total of 364 CPUE in number and 207 of that in weight of 34 species, against 243 in number and 93 in weight of 20 species taken by mid-layer gillnets (hereinafter referred to as "mid-layer nets").

Table 5-13 Number of species and catch per 2o tans of surface and mid-layer gillnets

St.	Gillnets on surface			Gillnets in mid-water		
	Catch			Catch		
	Species	CPUE in number	CPUE in weight	Species	CPUE in number	CPUE in weight
B-02	3	8	5.58	2	3	0.38
B-03	4	4	3.45	4	8	1.06
B-05	1	1	0.36	-	-	-
B-06	9	10	9.07	1	1	0.93
B-08	1	1	0.08	1	8	0.49
B-09	3	9	9.03	2	7	0.72
B-10	1	7	1.22	2	26	4.83
B-11	4	13	4.81	3	81	8.88
B-12	2	8	1.84	-	-	-
B-13	2	2	0.35	1	3	0.73
B-14	2	15	8.08	2	4	3.50
B-15	3	15	3.82	-	-	-
B-17	3	11	9.87	-	-	-
B-18	4	4	5.53	2	4	4.47
B-19	2	6	3.13	-	-	-
B-20	1	1	0.80	-	-	-
B-21	2	2	1.27	1	1	2.13
B-22	4	12	10.50	4	12	4.87
B-23	4	12	4.40	3	13	1.18
B-24	7	11	8.13	-	-	-
B-25	3	38	19.50	-	-	-
B-26	7	78	68.20	3	25	19.90
B-27	4	15	8.08	1	11	2.86
B-28	2	2	2.28	1	1	0.47
B-29	4	26	14.30	1	4	5.92
B-30	1	7	11.00	1	15	24.18
B-31	5	36	16.80	3	14	5.27
B-32	3	13	3.40	3	22	5.87
B-33	-	-	-	1	1	1
B-34	1	1	0.80	1	2	0.38
B-35	1	1	1.00	-	-	-
Total	34	364	207.22	20	243	93.10

The surface nets resulted in a better catch in terms of CPUE in number and weight, as well as number of species than the mid-layer nets. The major stocks in the waters under study comprise pelagic species living near the sea surface. CPUE of two types of nets suggested that the surface operation was more efficient than the deeper operation.

(2) Difference in species

Table 5-14 gives number and weight of fish of each species taken by two types of drift gill nets.

Table 5-14 CPUE of different species taken by surface and mid-layer gillnets in number and weight

Species		Gillnets on surface		Gillnets in mid-water	
		CPUE		CPUE	
Family name	Scientific name	Number	Weight	Number	Weight
Exocoetidae	*Cypselurus sp.*	2	0.33	–	–
Exocoetidae	*Cypselurus poecilopterus*	1	0.33	–	–
Exocoetidae	*Cypselurus cyanopterus*	1	0.33	–	–
Exocoetidae	*Cypselurus unicolor*	2	0.45	–	–
Exocoetidae	*Cypselurus nareali*	1	0.16	–	–
Exocoetidae	*Parexocoetus sp.*	1	0.08	–	–
Terapontidae	*Terapon jarbua*	–	–	1	0.63
Priacanthidae	*Priacanthus macracanthus*	7	0.87	–	–
Carangidae	*Parastromateus niger*	2	1.69	–	–
Carangidae	*Naucrates ductor*	4	0.93	–	–
Carangidae	*Seriolina nigrofasciata*	3	2.92	–	–
Carangidae	*Scomberoides commersonnianus*	2	0.60	1	0.25
Carangidae	*Trachinotus baillonii*	3	1.13	–	–
Carangidae	*Megalaspis cordyla*	1	0.60	–	–
Carangidae	*Decapterus russelli*	–	–	5	0.26
Carangidae	*Decapterus macrosoma*	–	–	5	0.41
Carangidae	*Decapterus maruadsi*	–	–	5	0.93
Carangidae	*Decapterus kheadsi*	3	0.47	4	0.43
Carangidae	*Selar crumenophthalmus*	4	0.93	1	0.20
Carangidae	*Carangoides orthogrammus*	1	0.16	–	–
Coryphaenidae	*Coryphaena hippurus*	21	21.89	1	1.47
Coryphaenidae	*Coryphaena equiselis*	4	1.84	–	–
Bramidae	*Brama orcini*	35	8.75	60	8.89
Lobotidae	*Lobotes surinamensis*	4	2.66	–	–
Scombridae	*Scomber australasicus*	7	1.22	24	4.13
Scombridae	*Auxis thazard*	90	72.45	28	20.71
Scombridae	*Auxis rochei*	56	15.23	44	10.61
Scombridae	*Euthynnus affinis*	15	10.51	3	0.93
Scombridae	*Katsuwonus pelamis*	66	33.09	26	36.67
Scombridae	*Thunnus tonggol*	11	3.93	7	2.47
Scombridae	*Thunnus obesus*	–	–	3	0.53
Nomeidae	*Psenes cyanophrys*	1	0.16	4	0.86
Nomeidae	*Cubiceps pauciradiatus*	1	0.08	19	1.18
Echeneididae	*Echeneis naucrates*	3	5.08	1	0.81
Balistidae	*Canthidermis maculata*	1	0.60	1	0.73
Monacanthidae	*Aluterus scriptus*	1	0.40	–	–
Diodontidae	*Diodon eydouxii*	5	3.87	–	–
Diodontidae	*Diodon hystrix*	1	1.00	–	–
Ommastrephidae	*Sthenoteuthis oualaniensis*	1	1.47	–	–
Total		364	207.22	243	93.1

In total 14 species of seven families were caught by both types of nets. They are two species of Carangidae, one species of Corphynidae, one species of Bramidae, six species of Scombridae, two species of Centrolophidae, one species of Echeneidae, and one species of Balistidae. Surface nets captured 19 species of 8 families which were not taken by mid-layer nets. They are six species of Exocoetidae, one species of Priacanthidae, 6 species of Carangidae, one species of Corphynidae, one species of Lobotidae, one species of Monacanth idae, one species of Diodontidae and one species of Ommastrephidae. Inversely, five species of three families were found caught by mid-layer nets, but not in that by surface nets. They are one species of Teraponidae, three species of Carangidae and one species of Scombridae. The species composition of the catch implies a vertical difference of ichthyofauna in the area under discussion. Namely, the surface operation captured the pelagic species more frequently, while sub-surface inhabitants less efficiently than the mid-layer operation.

(3) Catch of major species

Catch-per-unit effort of major species taken by surface and mid-layer drift nets are shown in Table 5-15.

Tale 5-15 CPUE of major species taken by surface and mid-layer gillnets.

Species		Gillnet on surface		Gillnet in mid-water	
		CPUE		CPUE	
Scientific name	English name	Number	Weight	Number	Weight
Coryphaena hippurus	Common dolphinfish	21	21.89	1	1.47
Coryphaena equiselis	Pomoano dolphinfish	4	1.84	–	–
Brama orcini	Bigtooth pomfret	35	8.75	60	8.89
Lobotes surinamensis	Triple tail	4	2.66	–	–
Auxis thazard	Frigate mackerel	90	72.45	28	20.71
Auxis rochei	Bullet mackerel	56	15.23	44	10.61
Euthynnus affinis	Eastern little tuna	15	10.51	3	0.93
Katsuwonus pelamis	Skipjack tuna	66	44.09	26	36.67
Thunnus tonggol	Longtail tuna	11	3.93	7	2.47
Thunnus obesus	Bigeye tuna	–	–	3	0.53
Sthenoteuthis oualaniensis	Flying squid	1	1.47	–	–
Total		303	182.82	172	82.28

Table 5-15 depicts CPUE of major species both in terms of number and of weight sorted out from Table 5-14. The values of major species are also shown in Figure

5-139. Surface nets resulted in sum of CPUE of 303 in number, 183 of in weight of 10 species, and mid-layer nets, 172 of that in number and 82 in weight of 8 species. Except for bigtooth pomfret and bigeye tuna, the surface operation resulted in greater harvest than the mid-layer operations. Even though catch of pompanos by mid-layer nets exceeded the catch by surface nets, the amount of yield by weight did not significantly differ.

It is also noted that 59 CPUE in number of the total 60 CPUE in number taken by mid-layer operations were caught by a single operation at B-11, but that catch made by surface operations came from 8 stations including 8 fish weighing 1.85 kg at B-11. It is possible to assume that the high concentration of bigtooth pomfret at the particular station B-11 might have been related to possible aggregation of the fish pursued by predatory animals, in addition to the possibility of size segregation.

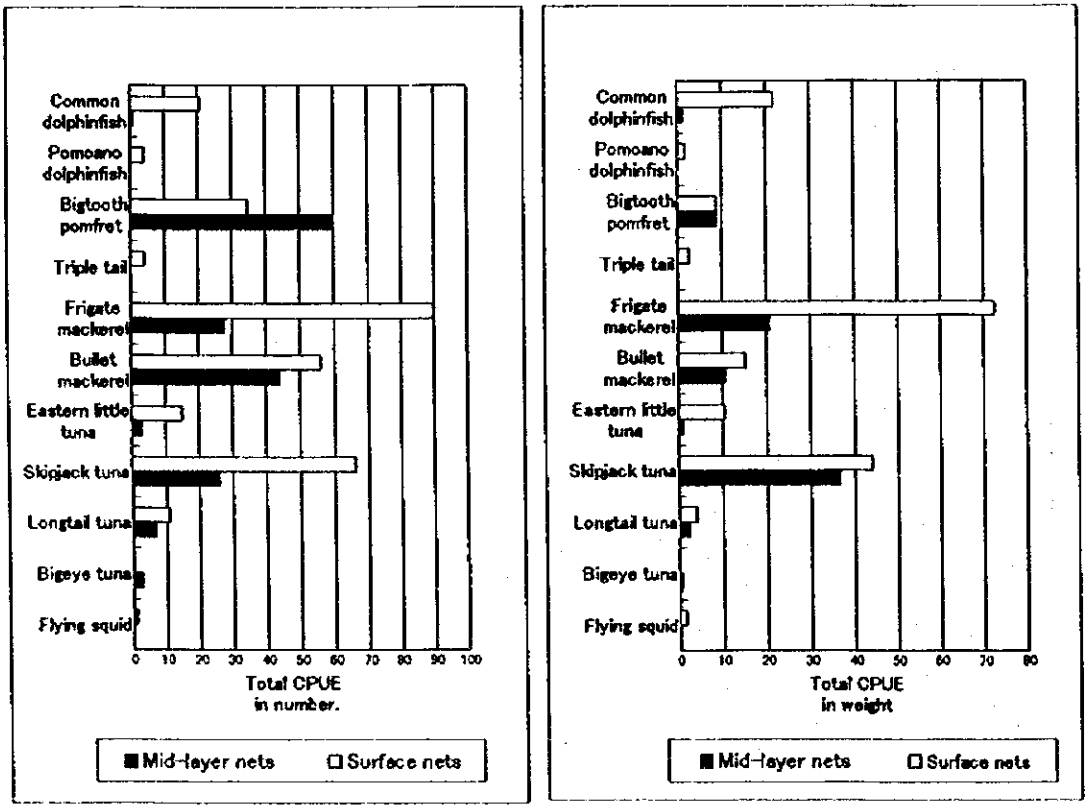


Figure 5-139 Catch-per-unit effort of major species taken by surface and mid-layer nets.

Fishes taken by surface operations but not by mid-layer operations are pompano dolphinfish, triple star and little tuna. In case of common dolphinfish, the surface operation took 21 fish against a single fish caught by the mid-layer operation.

Flying squid was not taken by the mid-layer operation. But the surface operation also took only a single specimen, and the mesh size was not appropriate to catch the slender animal. Frigate mackerel was taken more frequently by surface operations than by the other. The ratio between the surface catch and mid-layer catch was 3:1 in terms of both number and weight. The CPUE for skipjack tuna showed the same ratio of 3:1 in number, but was almost identical in terms of weight, due to difference of size of fish. The mid-layer operation caught large sized fish of 1-1.5 kg in body weight except for one of 400 g. The surface operations mostly caught small-sized fish of about 0.5 kg. Only 3 of 66 fish exceeded 1 kg in body weight.

5-7. Temperature and salinity related to CPUE in number of major species

CPUE in number of the most frequently occurring species were examined in relation to temperature and salinity at a sub-surface layer of 2 m below the sea surface as recorded by CTD(Appendix Table 61 ~62).

5-7-1 Review of temperature and salinity in the survey area

Table 5-16 shows the maxima, minima and mean temperatures as well as salinity found in each of the southwestern and northeastern monsoon seasons, together with places where respective maxima and minima were observed.

Table 5-16 Range and means of temperature and salinity in each of the two monsoon seasons, together with places where the maxima and minima were observed.

		SW monsoon	Observed stations	NE monsoon	Observed stations
Temperature	Min.	26.3°C	At B-22 in the coastal water off the Mekong Delta.	28.1°C	At B-11 in the Central Region.
	Max.	30.4 °C	At B-09 in the North Region and B-10 in the Central Region.	30.3 °C	At B-03 in the North Region.
	Mean	29.1°C		29.1°C	
Salinity	Min.	32.1	At B-26 in the coastal water off the Mekong Delta.	30.9	At B-26 in the coastal water off the Mekong Delta.
	Max.	34.0	At B-06 in the North Region and B-11 in the Central Region.	33.9	At B-14 and B18 in the Central Region.
	Mean	33.5		32.8	

During the southwestern monsoon season, both temperature and salinity lowered in the area facing the Gulf of Ton kin Bay of the North Region. The other combinations of maxima and minima do not occur consistently, but frequency of appearance was high in three areas: high temperature and low salinity in the coastal area near the Mekong Delta, high temperature and high salinity in the offshore areas of the North and Central Regions, and low temperature and high salinity in the coastal area of quadrangle B-16 of the Central Region. Average salinity was lower in the rainy northeastern monsoon season due to greater flow-in of river water rather than in the southwest monsoon season. In the rainy season, temperature and salinity were high in the coastal area along the Gulf of Ton kin Bay of the North Region, and low in the coastal area of the Mekong Delta off the Central Region, temperature was low and salinity was high.

5-7-2. Appearance of major species in relation to temperature and salinity

(1) Common dolphinfish (*Coryphaena hippurus*)

1) Southwestern monsoon season

Figures 5-140 and 141 show CPUE in number of common dolphinfish for sub-surface temperature and salinity in the southwestern monsoon season.

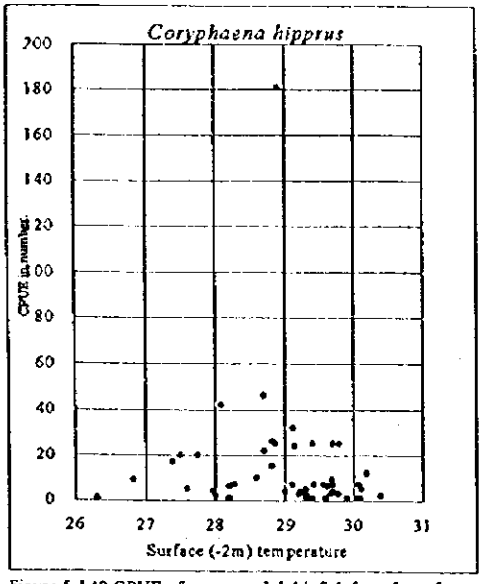


Figure 5-140 CPUE of common dolphinfish for sub-surface temperature during southwestern monsoon season.

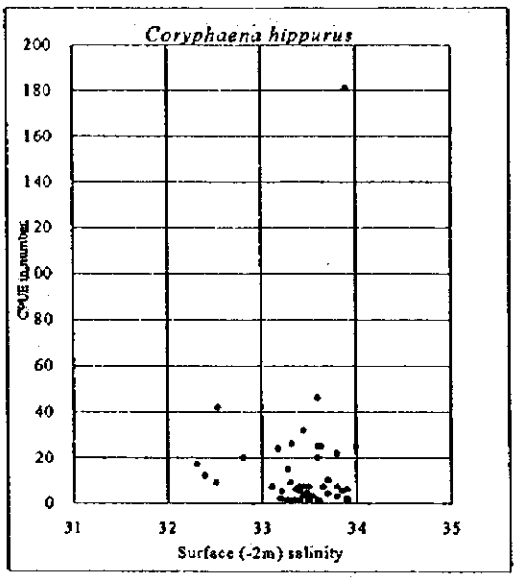


Figure 5-141 CPUE of common dolphinfish for sub-surface salinty during southwestern monsoon season.

During the southwestern monsoon season, common dolphinfish appeared in within waters of a wide range of temperatures extending between 26.3 and 30.4℃, but a narrow range of salinity of 32.3 to 34.0. One station, where 181 of CPUE in number were shown, was found to have high saline water at 33.9 with a temperature of 28.9℃.

2) Northeastern monsoon season

The fish were taken in the waters of 28.1 to 30.3℃ of temperature and of 30.9 to 33.9 salinity at the subsurface layer in the northeastern monsoon season. The range of temperature narrowed, and range of salinity widened from those in the southwestern monsoon season. The high value of CPUE in number, 30, was obtained in the warm and high saline waters (Figures 5-142 and 143).

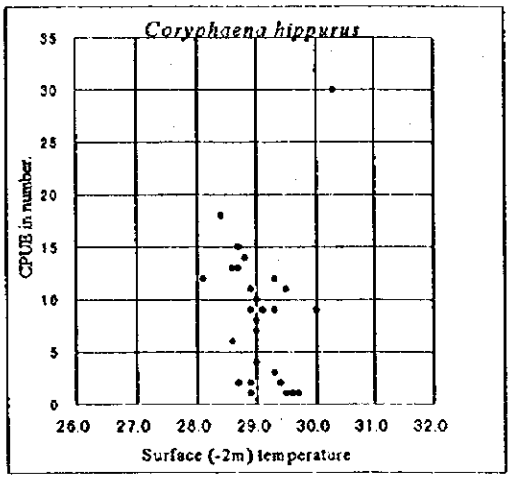


Figure 5-142 CPUE of common dolphinfish for sub-surface temperature during northeastern monsoon season.

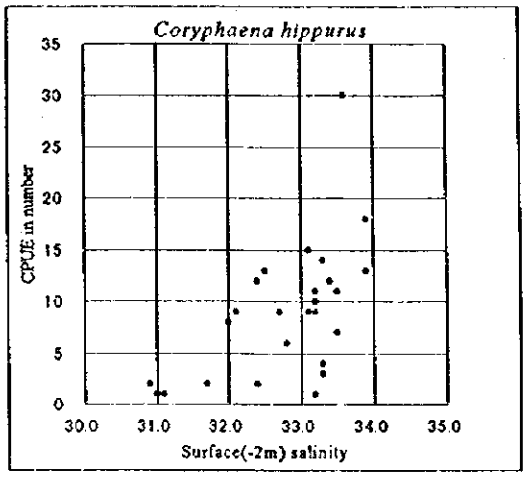


Figure 5-143 CPUE of common dolphinfish for sub-surface salinty during northeastern monsoon season.

(2) Pompano dolphinfish (*Coryphaena equiselis*)

1) Southwestern monsoon season

During the southwestern monsoon season, pompano dolphinfish appeared in waters with a wide range of temperature extending between 27.4 and 30.4℃, but a narrow range of salinity of 32.3 to 33.9. One station, where CPUE in number showed a value of 28, was noted with saline water of 33.3 and a temperature of 29.7℃ (Figure 5-144 and 145).

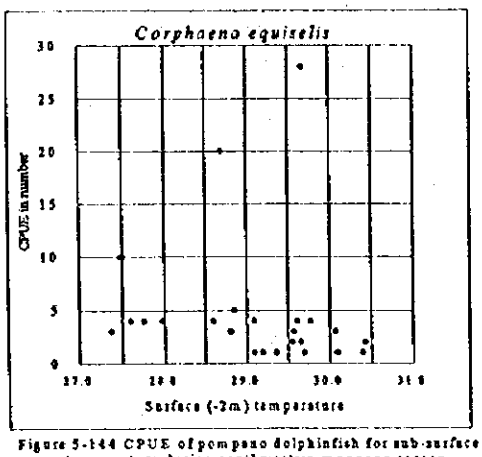


Figure 5-144 CPUE of pompano dolphinfish for sub-surface temperature during southwestern monsoon season.

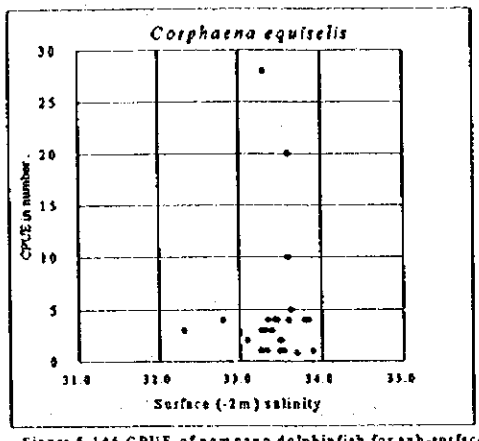


Figure 5-145 CPUE of pompano dolphinfish for sub-surface salinty during southwestrn monsoon season.

2) Northeastern monsoon season

The fish were taken in waters of temperature 28.6℃ to 30.3℃ and salinity of 32.0 to 33.9 at the subsurface layer in the northeastern monsoon season.. The range of temperature narrowed slightly from that in the southwestern monsoon season. One station, where 18 of CPUE in number were shown , was found to have high saline water of 33.6 and temperature of 30.3℃ (Figures 5-146 and 147).

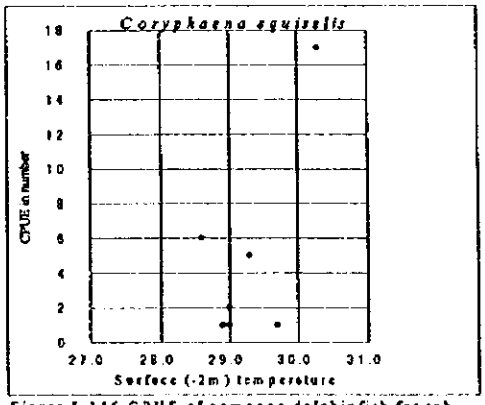


Figure 5-146 CPUE of pompano dolphinfish for sub-surface temperature during northeastern monsoon season.

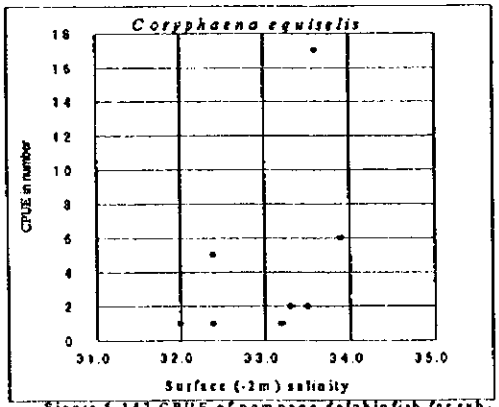


Figure 5-147 CPUE of pompano dolphinfish for sub-surface salinty during northeastern monsoon season.

(3) Bigtooth pomfret (*Bram orcini*)

1) Southwestern monsoon season

During the southwestern monsoon season, bigtooth pomfret appeared in waters with a wide range of temperature extending between 27.6 and 30.4℃, but a narrow range of salinity of 33.1 to 34.0. There was a tendency that the CPUE in number increased in cold and high salinity waters, and also that no fish could be caught in the

waters where salinity was less than 33.0. One station, where 45 of CPUE in number occurred, there was water with temperature of 28.8℃ and salinity of 33.3 (Figures 5-148 and 149).

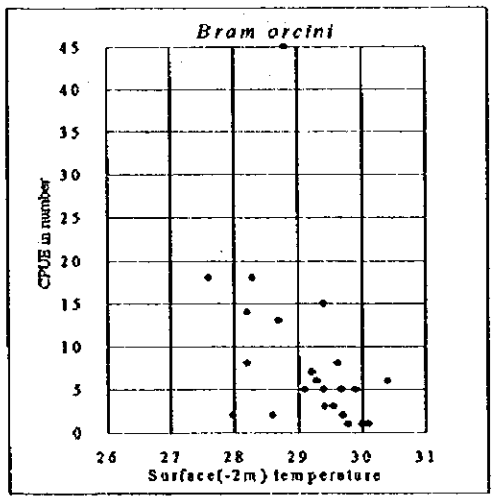


Figure 5-148 CPUE of bigtooth pomfret for sub-surface temperature during southwestrrn monsoon season.

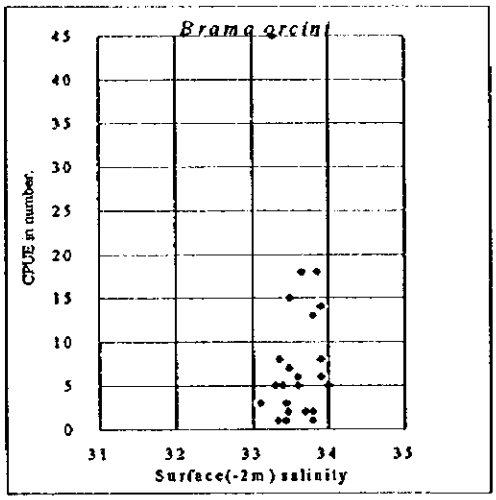


Figure 5-149 CPUE of bigtooth pomfret for sub-surface salinty during southwestrrn monsoon seaso

2) Northeastern monsoon season

The fish were taken in the waters with temperature of 28.1℃ to 29.7℃ and salinity of 31.0 to 33.9 at the subsurface layer in the northeastern monsoon season. One station, where 59 of CPUE in number were shown, was noted with high saline water at 33.2 and temperature of 29.5℃ (Figures 5-150 and 151).

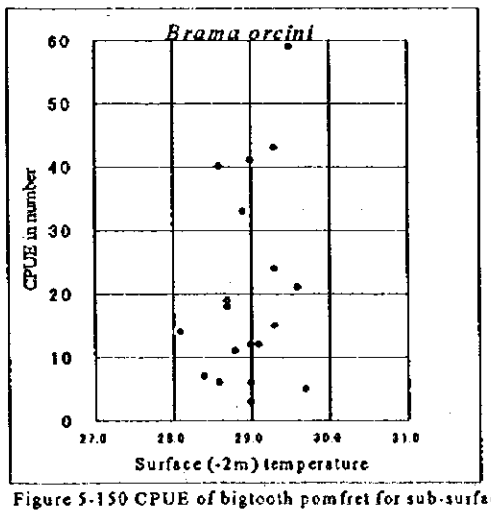


Figure 5-150 CPUE of bigtooth pomfret for sub-surface temperature during northeastern monsoon season.

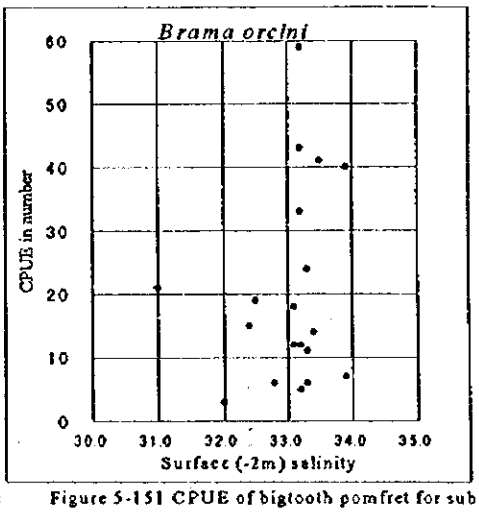


Figure 5-151 CPUE of bigtooth pomfret for sub-surface salinty during northeastern monsoon season

(4) Triple tail (*Lobotes surinamensis*)

1) Southwestern monsoon season

During the southwestern monsoon season, triple tail appeared in the waters of a wide range of temperatures extending between 27.5 and 30.4℃, but of a narrow range of salinity (33.2 to 34.0). High CPUE of 18 in number occurred at a station. This was covered by high saline water of 34.0 with high temperature of 29.8℃ (Figures 5-152 and 153).

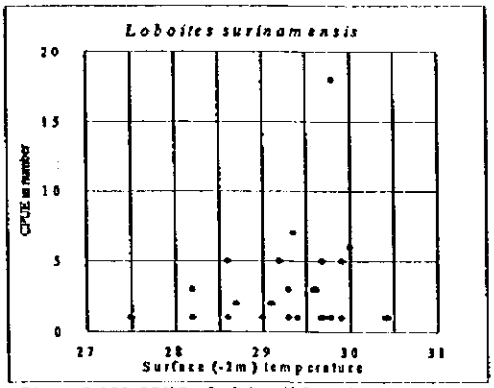


Figure 5-152 CPUE of triple tail for sub-surface temperature during southwestern monsoon season

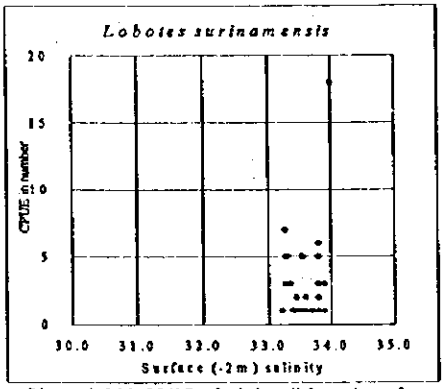


Figure 5-153 CPUE of triple tail for sub-surface salinity during southwestern monsoon season.

2) Northeastern monsoon season

The fish were taken in the waters of 28.1℃ to 29.7℃ of temperature and of 31.0 to 33.9 of salinity at the subsurface layer in the northeastern monsoon season. The range of salinity widened from those in the southwestern monsoon season, but there was found to be a tendency that the CPUE in number increased in high saline water to above 33.0. One station that showed 59 of CPUE in number, was noted with high saline water of 33.2 and temperature of 29.5℃ (Figures 5-154 and 155).

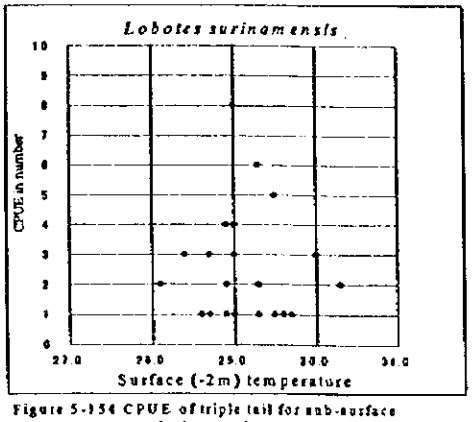


Figure 5-154 CPUE of triple tail for sub-surface temperature during northeastern monsoon season.

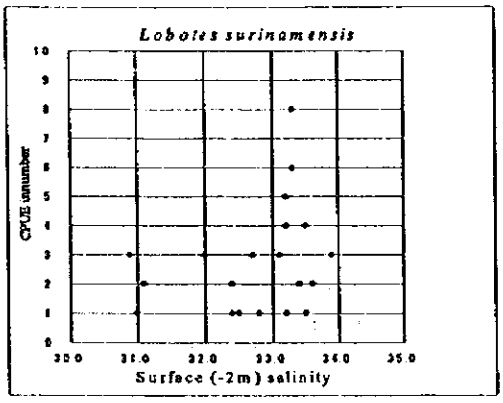


Figure 5-155 CPUE of triple tail for sub-surface salinity during northeastern monsoon season.

(5) Frigate mackerel (*Auxis thazard*)

1) Southwestern monsoon season

Temperature and salinity were found having ranged between 26.3℃ and 30.4℃, and 32.1 and 34.0, respectively, in the southwestern monsoon season. Thus, the range is wide for temperature, but narrow for salinity. At the station with the best catch, 222 of CPUE in number, temperature and salinity were 29.1 ℃ and 33.2. The value of CPUE appeared to have risen in temperature to between 29.0 and 30.0℃ (Figure 5-156 and 157).

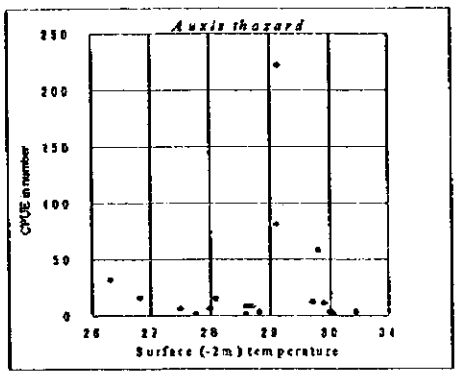


Figure 5-156 CPUE of frigate mackerel for sub-surface temperature during southwestrn monsoon season.

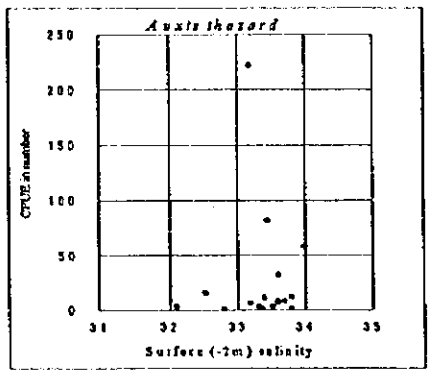


Figure 5-157 CPUE of frigate mackerel for sub-surface salinty during southwestrn monsoon season.

2) Northeastern monsoon season

During the northeastern monsoon season, frigate mackerel appeared in waters with a temperature of 28.6℃ to 30.3℃, and salinity of 30.9 to 33.9. In this season, temperature was limited to a narrow range, but salinity extended over a wide range. High CPUE occurred in cold and low saline waters (Figure 5-158 and 159).

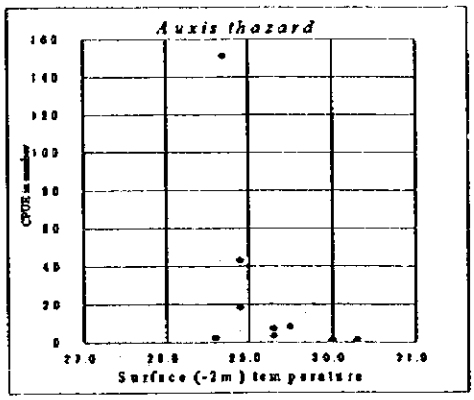


Figure 5-158 CPUE of frigate mackerel for sub-surface temperature during northeastern monsoon season.

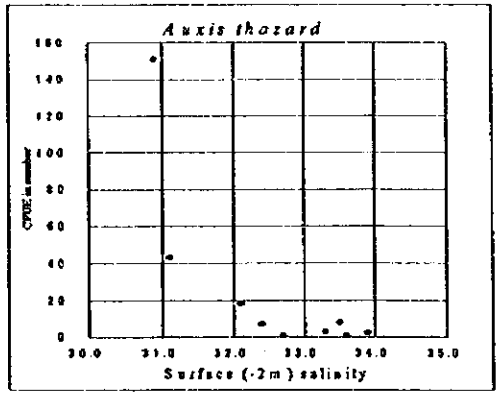


Figure 5-159 CPUE of frigate mackerel for sub-surface salinty during northeastern monsoon season.

(6) Bullet mackerel (*Auxis rochei*)

1) Southwestern monsoon season

During the southwestern monsoon season, bullet mackerel appeared in waters with a wide range of temperatures extending between 26.3℃ and 30.4℃, and a range of salinity of 30.8 to 34.0. A high CPUE of 231 in number, was noted in low saline water of 32.3 and low temperature of 27.4℃ (Figure5-160 and 161).

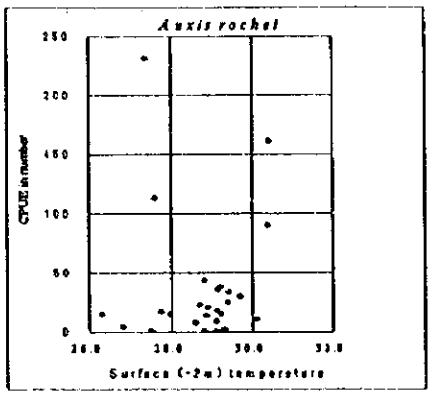


Figure 5-160 CPUE of bullet mackerel for sub-surface temperature during southwestern monsoon season.

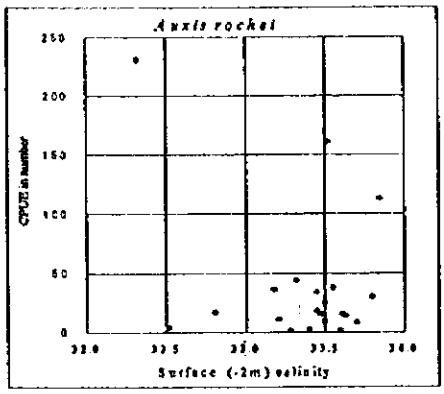


Figure 5-161 CPUE of bullet mackerel for sub-surface salinity during southwestern monsoon season.

2) Northeastern monsoon season

During the northeastern monsoon season, bullet mackerel appeared in waters with a temperature of 28.4℃ to 30.3℃ and salinity of 30.9 to 33.9. In this season, temperature was limited to a narrow range, but salinity extended over a wide range. At one station with 30 of CPUE in number, high saline water of 33.9 with temperature of 28.1℃ was observed. There was found to be a tendency that the CPUE in number increased in water with a high salinity of 33.0 to 34.0 (Figures 5-162 and 163).

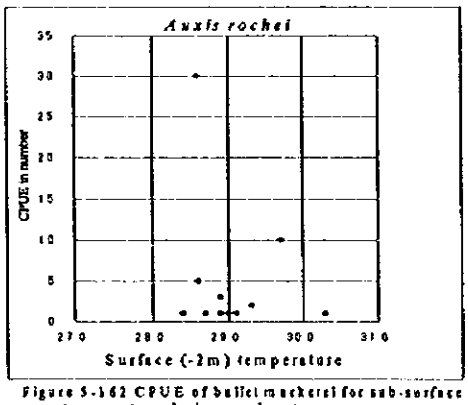


Figure 5-162 CPUE of bullet mackerel for sub-surface temperature during northeastern monsoon season.

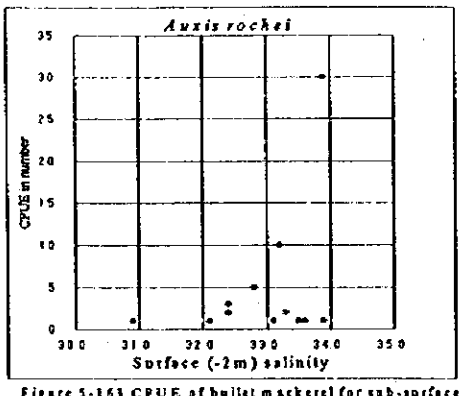


Figure 5-163 CPUE of bullet mackerel for sub-surface salinity during northeastern monsoon season.

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

1) Southwestern monsoon season

Temperature and salinity were found to range between 28.0℃ and 30.0℃, and 32.1 and 34.0, respectively, in the southwestern monsoon season. At the station with the best catch of CPUE 20 in number, temperature and salinity were 29.1℃ and 33.4 (Figure 5-164 and 165).

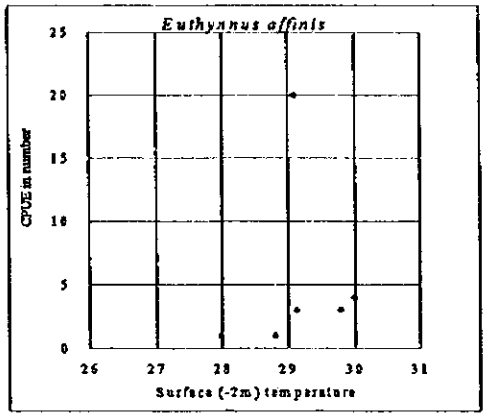


Figure 5-164 CPUE of eastern little tuna for sub-surface temperature during southwestern monsoon season.

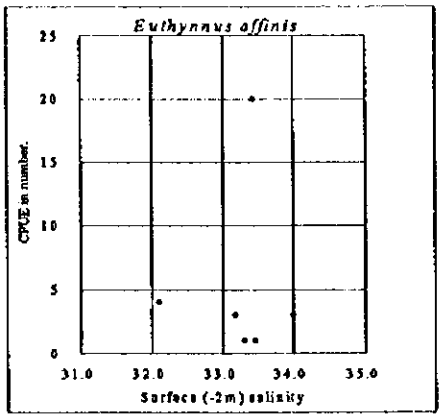


Figure 5-165 CPUE of eastern little tuna for sub-surface salinity during southwestern monsoon season.

2) Northeastern monsoon season

During the northeastern monsoon season, eastern little tuna appeared in the waters with 28.1℃ to 30.0℃ temperature, and 30.4 to 33.9 salinity. At the station with the best catch of CPUE 20 in number, temperature and salinity were 29.3 ℃ and 33.4. These values were near the average value of the survey areas (Figure 5-166 and 167).

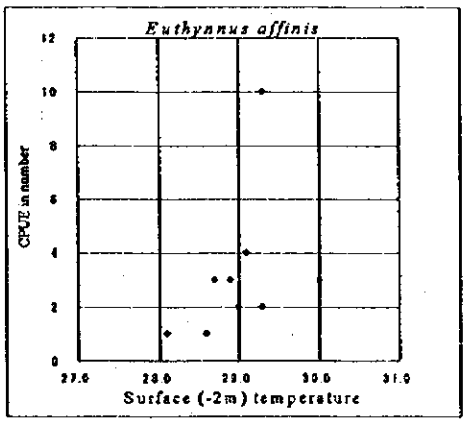


Figure 5-166 CPUE of eastern little tuna for sub-surface temperature during northeastern monsoon season.

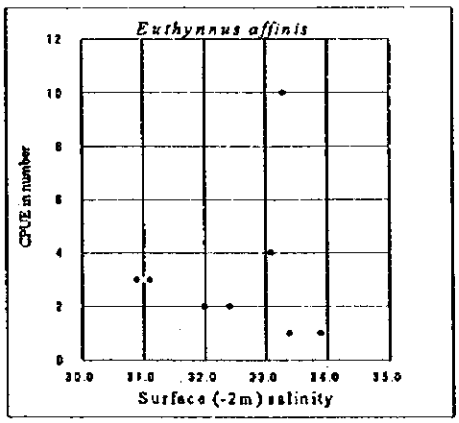


Figure 5-167 CPUE of eastern little tuna for sub-surface salinity during northeastern monsoon season.

(8) Skipjack tuna (*Katsuwonus pelamis*)

1) Southwestern monsoon season

During the southwestern monsoon season, skipjack tuna appeared in the waters of temperature 26.3 ℃ to 30.4 ℃ and salinity 33.1 to 34.0. The range was narrow for temperature but wide for salinity (Figures 5-168 and 169).

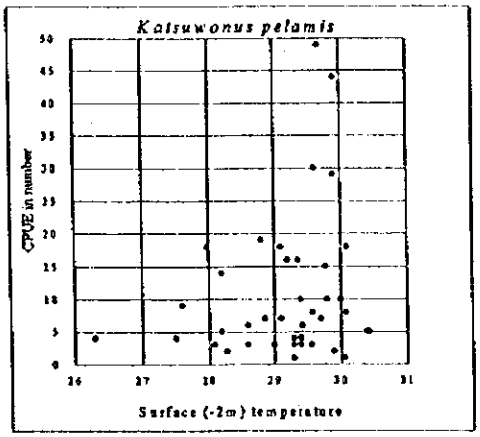


Figure 5-168 CPUE of skipjack tuna for sub-surface temperature during southwestern monsoon season.

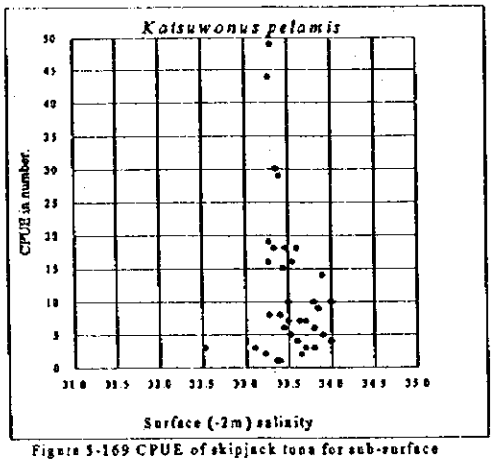


Figure 5-169 CPUE of skipjack tuna for sub-surface salinty during southwestern monsoon season.

2) Northeastern monsoon season

Temperature and salinity were found to be ranged between 28.1℃ and 30.3℃, and 30.9 and 33.9, respectively, in the northeast monsoon season. Thus, the range has slightly narrowed for temperature, but widened for salinity. The CPUE rose in cold and high saline waters (Figures 5-170 and 171).

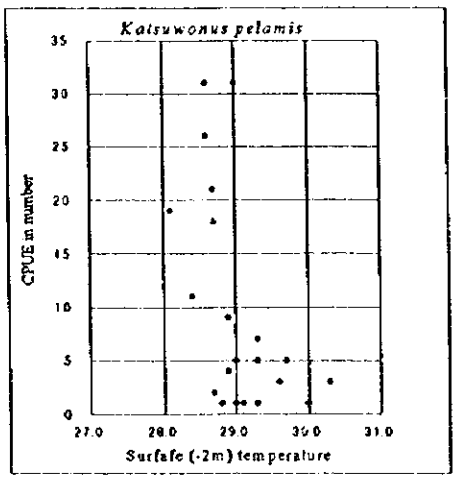


Figure 5-170 CPUE of skipjack tuna for sub-surface temperature during northeastern monsoon season.

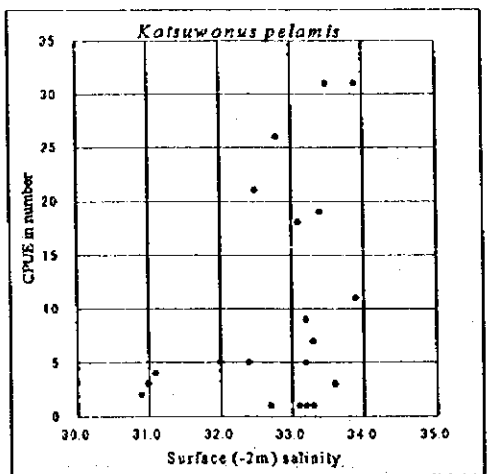


Figure 5-171 CPUE of skipjack tuna for sub-surface salinty during northeastern monsoon season.

(9) Long tail tuna (*Thunnus tonggol*)

1) Southwestern monsoon season

During the southwestern monsoon season, long tail tuna appeared at only 3 stations in waters of temperature 26.3℃ to 30.1℃ and salinity of 33.2 to 33.6. The range for temperature was wide. At the station with the best catch of CPUE 102 in number, temperature and salinity were 29.1℃ and 33.5 respectively.

2) Northeastern monsoon season

During the northeastern monsoon season, long tail tuna appeared at only 3 stations in waters with low temperature of 28.7℃ to 28.9℃ and low salinity of 30.9 to 32.1. The station with the highest CPUE of 22 in number was observed with low saline water of 30.9 with temperature of 28.7℃.

(10) Unicorn leatherjacket (*Aluterus monoceros*)

1) Southwestern monsoon season

During the southwestern monsoon season, unicorn leatherjacket appeared at only 4 stations in waters with high temperature of 29.0℃ to 30.0℃ and high salinity of 33.3 to 33.8.

2) Northeastern monsoon season

Temperature and salinity were found having ranged between 28.1℃ and 30.3℃, and 32.4 and 33.9, respectively, in the northeast monsoon season. There was found to be a tendency that the CPUE in number increased in waters of high temperature being over 29.0℃. The highest CPUE of 65 in number occurred at one station where it was observed to have saline water of 33.3 with a temperature of 29.3℃ (Figures 5-172 and 173).

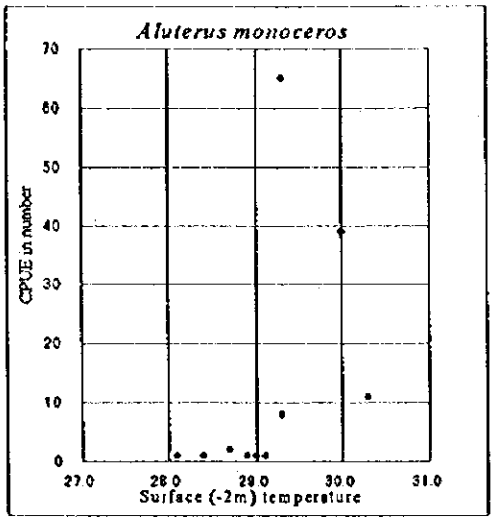


Figure 5-172 CPUE of unicon leatherjacket for sub-surface temperature during northeastern monsoon season.

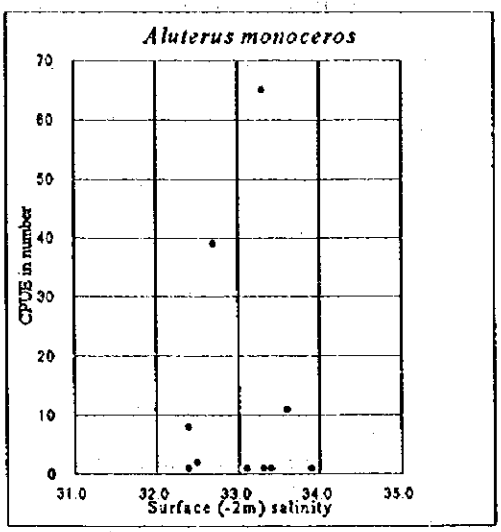


Figure 5-173 CPUE of unicon leatherjacket for sub-surface salinty during northeastern monsoon season.

(11) Flying squid (*Sthenoteuthis oualaniensis*)

1) Southwestern monsoon season

During the southwestern monsoon season, flying squid appeared in waters of temperature 27.4℃ to 30.4℃ and salinity 32.6 to 34.0. There was found to be a tendency that the CPUE in number increased in waters with high temperature and high salinity, this being over 33.0 (Figures 5-174 and 175).

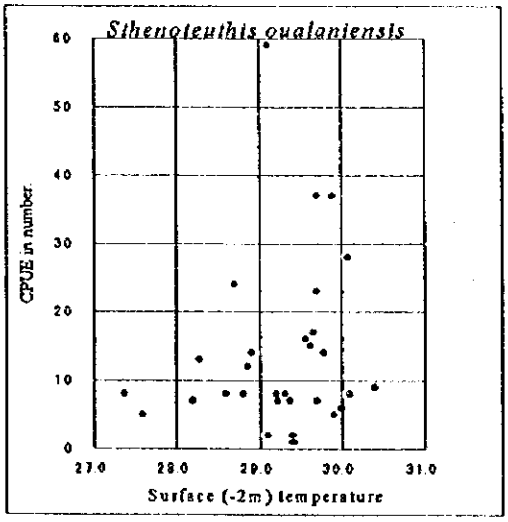


Figure 5-174 CPUE of flying squid for sub-surface temperature during southwestern monsoon season.

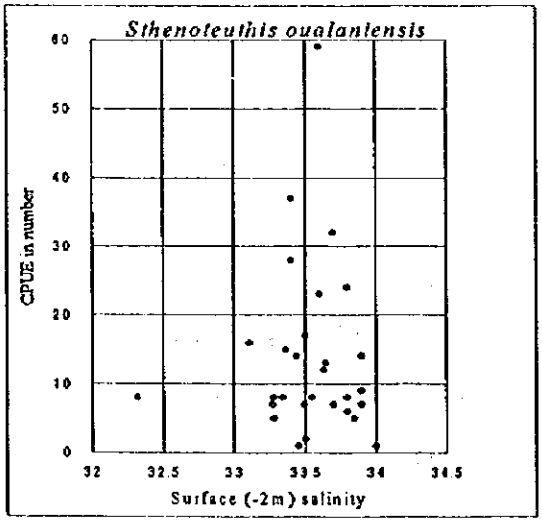


Figure 5-175 CPUE of flying squid for sub-surface salinty during southwestern monsoon season.

2) Northeastern monsoon season

Temperature and salinity were found to have ranged between 28.1℃ and 29.6℃, and 31.0 and 33.9, respectively, in the northeast monsoon season. The range has narrowed for temperature. Squid were taken at stations in waters of salinity lower than 33.0 (Figures 5-176 and 177).

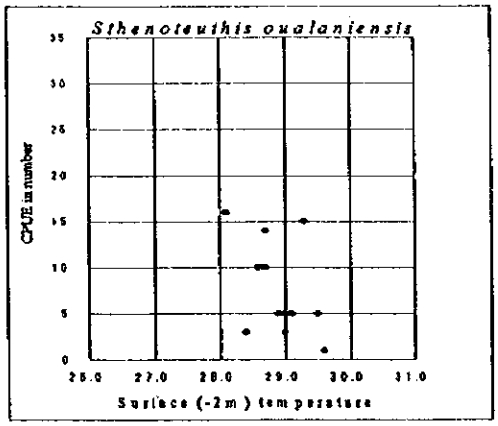


Figure 5-176 CPUE of flying squid for sub-surface temperature during northeastern monsoon season.

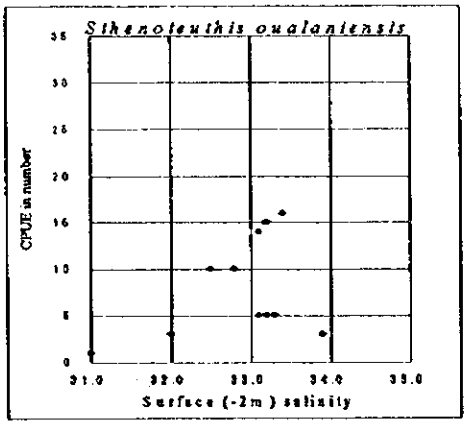


Figure 5-177 CPUE of flying squid for sub-surface salinity during northeastern monsoon season.

(12) Yellowfin tuna (*Thunnus albacares*)

1) Southwestern monsoon season

During the southwestern monsoon season, yellowfin tuna appeared at only 4 stations and was taken with CPUE 11 in number all together. The range of temperature was from 28.3℃ to 29.9℃, and salinity from 33.3 to 33.8. The fish did not appear in waters of low salinity, below 33.0.

2) Northeastern monsoon season

During the northeastern monsoon season, yellowfin tuna appeared at only 4 stations and was taken with CPUE 11 in number all together in the waters of 28.7℃ to 29.3℃ in temperature and 32.4 to 33.1 in salinity.

(13) Bigeye tuna (*Thunnus obesus*)

1) Southwestern monsoon season

During the southwestern monsoon season, bigeye tuna appeared in waters

of temperature 26.3℃ to 29.8℃ and salinity 33.3 to 33.8. There was found to be a tendency that the CPUE in number increases with higher temperature, 29.0℃ and high salinity, more than 33.2 (Figures 5-178 and 179).

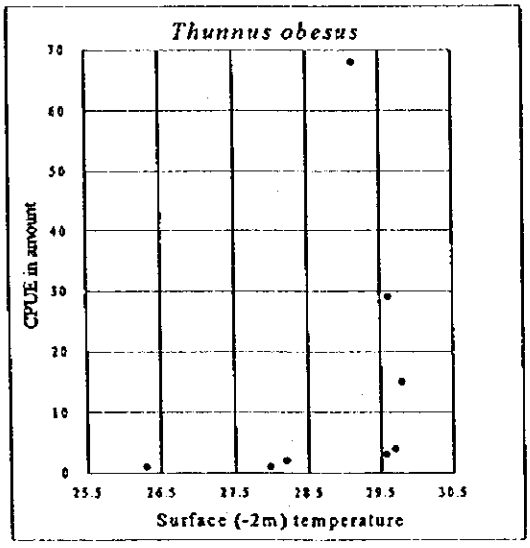


Figure 5-178 CPUE of bigeye tuna for sub-surface temperature during southwestrrn monsoon season.

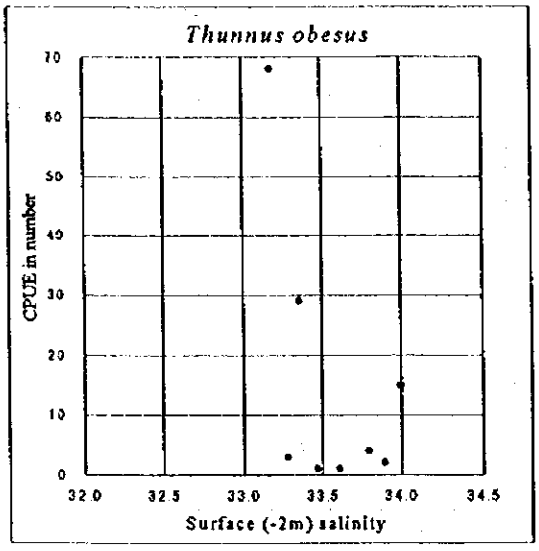


Figure 5-179 CPUE of bigeye tuna for sub-surface salinty during southwestrrn monsoon season.

2) Northeastern monsoon season

During the northeastern monsoon season, bigeye tuna appeared at only 4 stations and was taken with CPUE 4 in number all together in waters of temperature 28.1℃ to 29.3℃ and salinity 32.5 to 33.9. There was found to be a tendency that CPUE in number increases in waters with low temperature and high salinity, being more than 32.5.

(14) Sail fish (*Istiophorus platypterus*)

1) Southwestern monsoon season

During the southwestern monsoon season, sail fish appeared in waters of temperature 26.3℃ to 29.8℃ and salinity 33.2 to 34.0. There was found to be a tendency that CPUE in number increases in higher temperature, (29.0℃) and higher saline, (over 33.2). No fish appeared in the low saline waters of low salinity, below 33.0 (Figures 5-180 and 181).

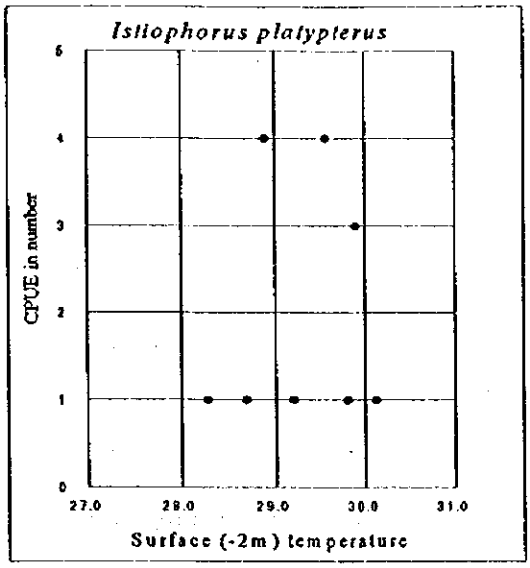


Figure 5-180 CPUE of sail fish for sub-surface temperature during southwestrrn monsoon season.

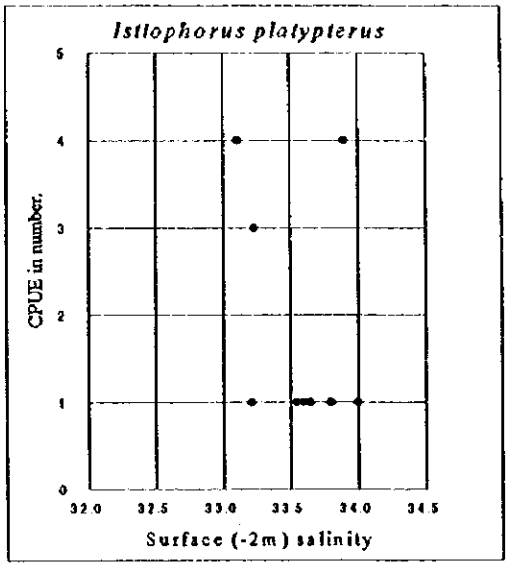


Figure 5-181 CPUE of sail fish for sub-surface salinty during southwestrrn monsoon season.

2) Northeastern monsoon season

Temperature and salinity were found having ranged between 28.7 and 29.7, and 31.1 and 33.2 respectively, in the northeast monsoon season. The range narrowed for temperature to within 1 degree; CPUE in number increased in the waters of low salinity when compared with those in the southwestern monsoon season (Figures 5-182 and 183).

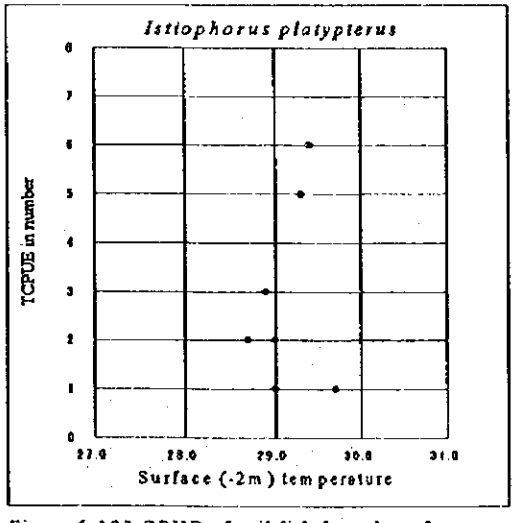


Figure 5-182 CPUE of sail fish for sub-surface temperature during northeastern monsoon season.

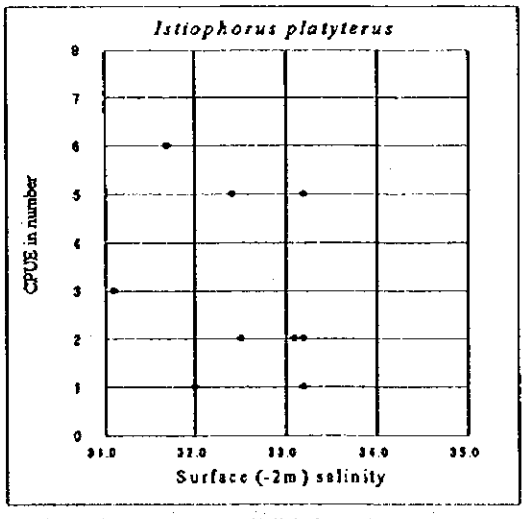


Figure 5-183 CPUE of sail fish for sub-surface salinty during northeastern monsoon season.

5-8 Abundance Index

5-8-1 Calculation of abundance index

As mentioned in chapter 3, Abundance Index was calculated by multiplying CPUE in a quadrangle by the relative area of a quadrangle.

Abundance index was calculated as a measure to be proportional to density of a fish stock in the area where a single test fishing was undertaken, i.e. the value was calculated by correcting catch-per- unit effort by number of nets of different mesh sizes and by duration from setting to hauling the nets. Assuming the abundance index represents the quadrangle of the test operation, the abundance index was calculated by multiplying extent of area of the quadrangle as a measure to be proportional to the stock size.

During the study, each operation represented one latitudinal degree times one longitudinal degree quadrangle. The area of each quadrangle varies depending on latitudinal degree and on to proportion of land. In this Report, relative area of a quadrangle was by expressed taking the area of a quadrangle including no land and located between Lat. 8 degree and 9 degree N as unity (Appendix Table 63).

Local features of abundance index are described by the North, Central and South Regions, two which, excluding the Central Region, were further divided into coastal and offshore areas. The boundary between coastal and offshore areas was defined as Long. 109 degree E line which runs close to 200-m or 100-fathom depth contour (Figure5-184).

The subdivision was not applied to the Central Region where the steep depth contour limits the coastal area that is shallower than 200-m being very narrow.

The numbers of quadrangles and total ratio of square measurement for the two areas of the North region are 3 and 2.39 in the coastal area, then 3 and 1.95 in the offshore area. Likewise, the Central region has 12 and 11.11, and the South region 5 and 4.96 in the coastal area, then with 9 and 8.98 in the offshore area respectively.

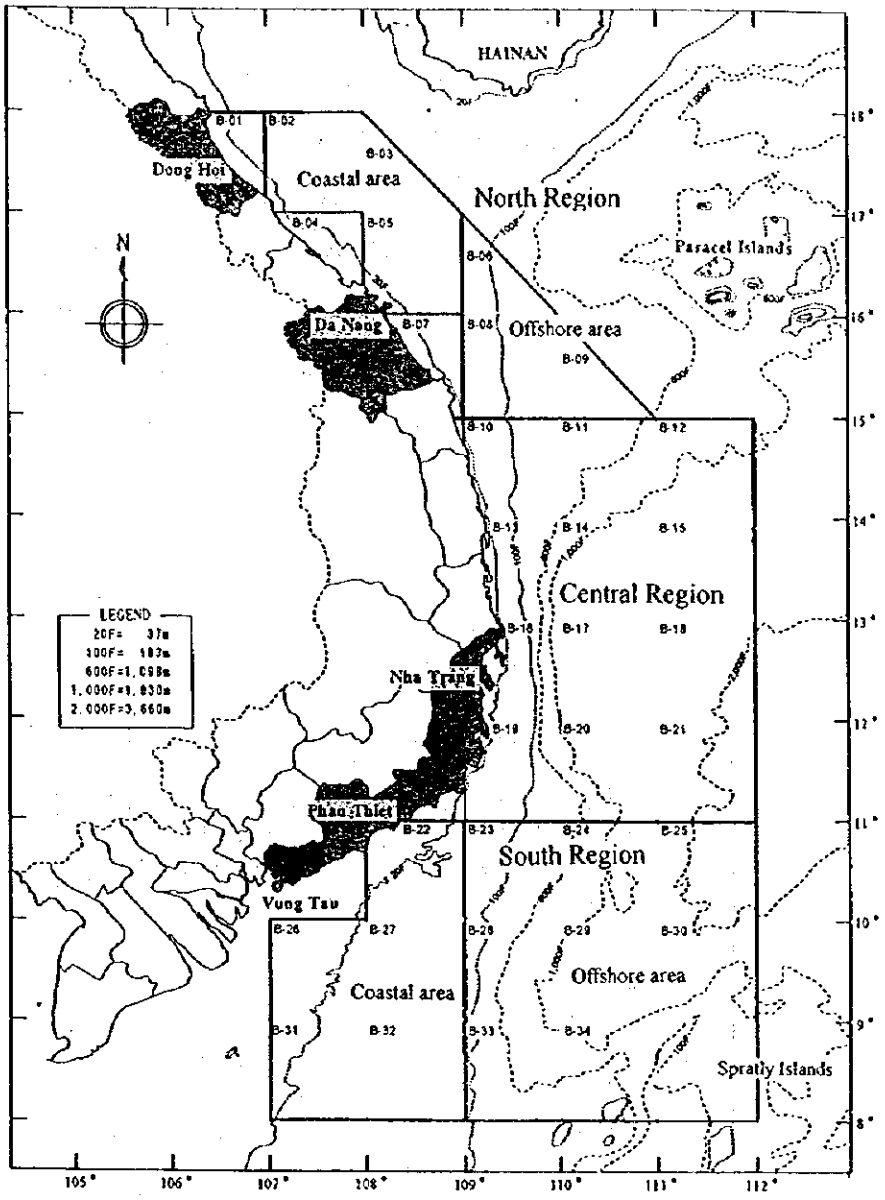


Figure 5-184 Division of sea area into the North, Central and South Regions, and coastal and offshore areas of the North and South Regions.

5-8-2 Abundance indexes of major species

Table 5-17 presents abundance indices of major species in terms of weight, for each survey period and for each region and area. The following description covers regional differences in the abundance indices of major species. Species* are represented in serial number given in Table 5-17 and reproduced as: 54 Coryphaena hippurus. The 2nd and 4th surveys covered the southwestern monsoon season, and the

3rd survey was conducted in the northeastern monsoon season.

Here it should be recalled that abundance indices were not obtained in the offshore area of the North Region during the 3rd cruise conducted in the northeastern monsoon season when the fishing operations were often forbidden by rough sea conditions inherent to the period of the year. Lack of data resulted in underestimation of abundance indices of all the species in the northeastern monsoon season represented by data taken during the 3rd cruise. Nevertheless, the indices of most species except bullet mackerel, sailfish and flying squid, taken by the 3rd survey were found higher than either one or both of the indices taken by the 2nd and 4th cruises as shown in the following descriptions.

Table 5-17 Abundance indices of major species* in terms of weight, for each survey and each region and area

Total	Survey No.	54	55	57	58	68	69	71	72	73	74	75	78	79	80	81	82	96	103
Coastal area of The North Region	2nd (SW)	38	5	0	0	12	0	0	0	0	4	0	13	0	19	0	0	0	0
	3rd (NE)	52	6	0	8	9	0	2	8	0	0	0	0	32	0	0	0	14	0
	4th (SW)	49	1	0	0	34	3	0	8	0	0	0	0	0	0	0	0	0	0
	Mean	46	4	0	3	18	1	1	5	0	1	0	4	11	6	0	0	5	0
Offshore area of The North Region	2nd (SW)	137	0	1	13	38	21	4	15	0	0	3	96	0	45	0	0	0	8
	3rd (NE)	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	4th (SW)	25	3	1	1	0	64	0	45	0	0	0	0	0	0	0	0	0	10
	Mean	81	1	1	7	19	42	2	30	0	0	1	48	0	23	0	0	0	9
All area of The Central Region	2nd (SW)	100	5	29	26	10	6	0	175	0	0	0	32	0	91	0	0	1	57
	3rd (NE)	131	2	80	21	0	7	1	303	0	47	8	30	0	33	0	0	2	49
	4th (SW)	69	8	23	17	3	103	0	316	0	2	11	45	0	0	232	33	0	45
	Mean	100	5	44	21	5	39	0	265	0	16	6	36	0	41	77	11	1	50
Coastal area of The South Region	2nd (SW)	63	0	0	2	21	14	6	3	0	0	1	60	67	14	0	0	0	0
	3rd (NE)	22	0	0	11	214	2	8	17	35	0	0	78	230	134	0	0	0	0
	4th (SW)	86	2	0	1	250	33	14	9	47	0	25	24	0	0	0	0	0	0
	Mean	57	1	0	5	162	16	9	10	27	0	9	54	99	49	0	0	0	0
Offshore area of The South Region	2nd (SW)	49	3	27	24	11	13	0	225	0	0	0	0	0	122	0	0	1	53
	3rd (NE)	75	5	49	27	4	5	20	203	0	22	0	12	0	0	0	0	11	9
	4th (SW)	15	13	3	33	5	4	3	427	0	5	7	94	0	0	0	0	0	27
	Mean	47	7	26	28	7	7	8	285	0	9	2	35	0	41	0	0	4	30
All survey area	2nd	388	13	56	66	92	54	10	418	0	4	4	202	67	292	0	0	2	119
	3rd	280	14	130	67	228	14	30	531	35	69	8	120	262	167	0	0	27	58
	4th	245	27	27	52	292	207	17	806	47	7	42	163	0	0	232	33	0	81
	Mean	304	18	71	62	204	92	19	585	27	27	18	162	110	153	77	11	10	86

* *54 Coryphaena hippurus*
55 Coryphaena equiselis
57 Brama orcini
58 Lobotes surinamensis
68 Auxis thazard
69 Auxis rochei
71 Euthynnus affinis
72 Katsuwonus pelamis
73 Thunnus tonggol
74 Thunnus albacares
75 Thunnus obesus
78 Istiophorus platypterus
79 Makaira indica
80 Makaira mazara
81 Tetrapterus audax
82 Xiphias gladius
96 Aluterus monoceros
103 Sthenoteuthis oualaniensis

(1) Common dolphinfish, (*Coryphaena hippurus*)

Figure 5-185 shows the abundance indices of common dolphinfish sorted by region and by survey period. The small area of the North Region resulted in low abundance in spite of high density indices. Total index for each period was the highest, 388 in the 2-nd survey, and the lowest, 245, in the 4th survey, both in the southwestern monsoon season. The average index was about 300.

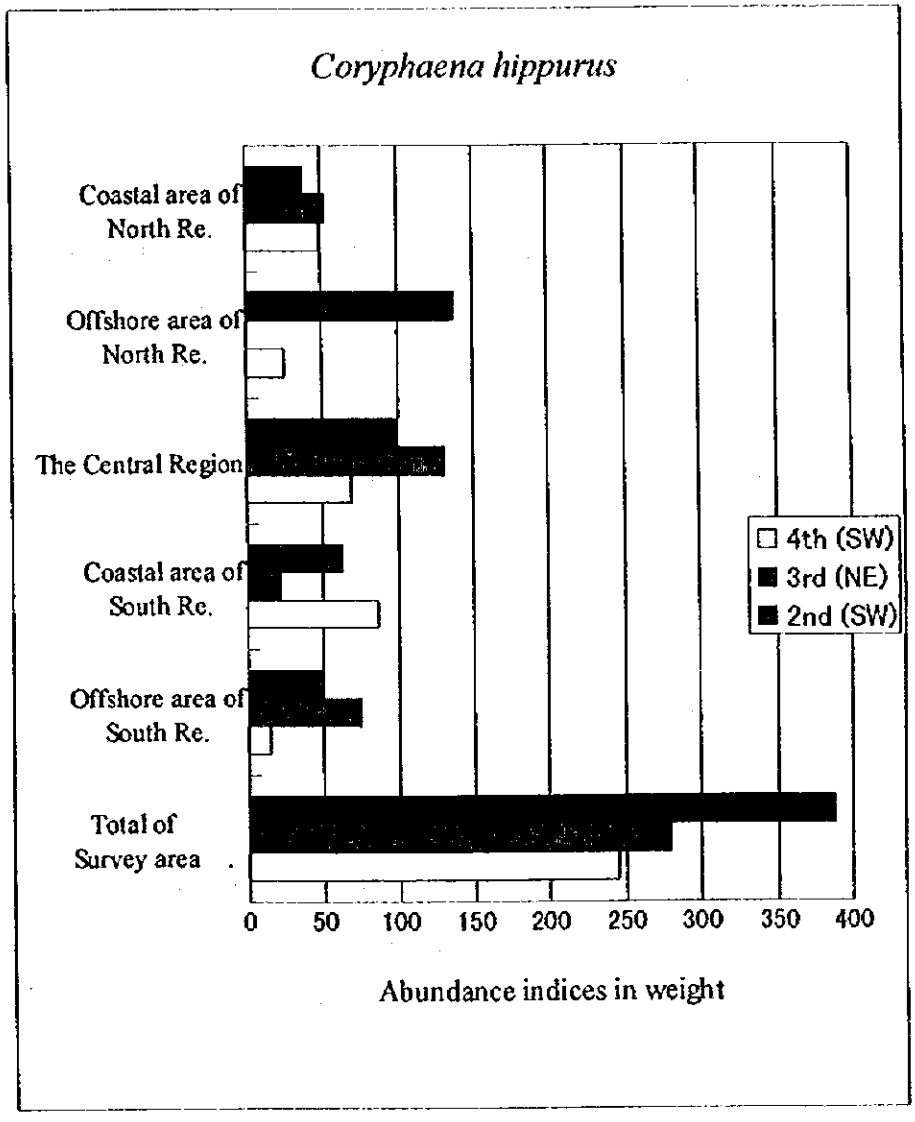


Figure 5-185 Abundance indices of common dolphinfish by region and area, and by cruise.

Lack of data in the offshore area of the North Region in the 3rd survey prevented comparison of the abundance indices with those in the other surveys. The value for the 3rd survey exceeded that for the 4th survey. The abundance of common dolphin fish does not seem to vary remarkably from season to season.

Indices by region, area and by survey varied between 15 and 137. Regional and area average for the three surveys is highest, 100, in the most extensive Central Region, followed by 81 in the offshore area of the North Region.

Mean abundance index of the fish in the coastal area of the North Region is 46 against the index of 57 in the coastal area of the South Region. The mean indices of the fish in the offshore areas are 81 in the North Region and 47 in the South Region. The total index from the North Region, 127, exceeds by about 20 % the figure, 104, from the South Region. The relative extents of the coastal and offshore areas are 2.34 and 1.95 in the North Region, and 4.96 and 8.98 in the South Region. In other words, the abundance indices are higher in the North Region that is narrower than the South Region. Therefore, CPUE in weight per unit area is higher in the North Region than in the South Region. Similarly, the density index given in CPUE is higher in the North Region than in the Central Region. It seems to be concluded that density index of dolphinfish is most high in the North Region.

(2) Pompano dolphinfish, (*Coryphaena equiselis*)

Figure 5-186 shows the abundance indices of pompano dolphinfish sorted by region and by survey period. Total abundance indices range from 13 to 27, and are averaged at 18, with only 1/15 of those being common dolphinfish (Table 5-17). The index in the 4th survey was twice as much of that in the 2nd phase, this being converse to the case of common dolphinfish. Area average ranged between 1 and 7, being the highest in the offshore area of the South Region, followed by the Central Region and coastal area of the North Region.

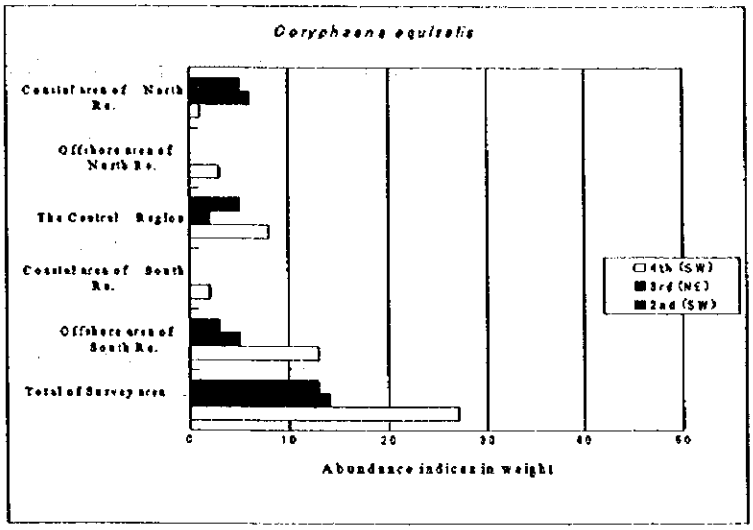


Figure 5-186 Abundance indices of pompano dolphinfish by region and area, and by cruise.

(3) Bigtooth pomfret, (*Brama orcini*)

Figure 5-187 shows the abundance indices of bigtooth pomfret sorted by region and by survey period. Regional indices ranged from 27 to 130. The values rose in the northeastern monsoon season, and declined to 1/3 to 1/2 in the south-western monsoon season. The abundance indices were very low, only 1 or less in the North Region and coastal area of the South Region (Table 5-17). High values above 50 occurred in the Central Region and offshore area of the South Region, where land water does not flow in. Abundance indices support the biological reasoning that bigtooth pomfret is an oceanic species.

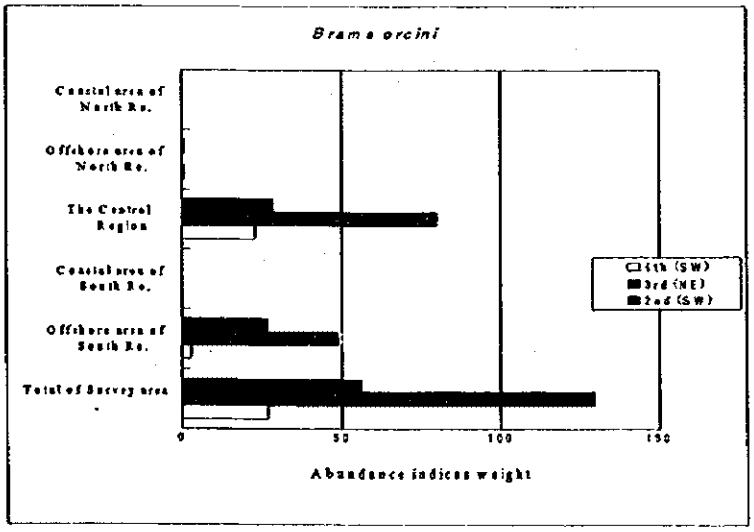


Figure 5-187 Abundance indices of bigtooth pomfret by region and area, and by cruise.

(4) Triple-tail, (*Lobotes surinamensis*)

Figure 5-188 shows the abundance indices of triple-tail sorted by region and by survey period. Total abundance indices are fairly stable during the three surveys, ranging between 52 and 67 around the mean of 62 (Table 6-17, Figure 5-188). Regional average showed the highest value of 28 in offshore area of the South Region, followed by 21 in the Central Region, and 7 in offshore area of the North Region. There was a tendency toward a rise in the indices from north to south (Figure 5-188).

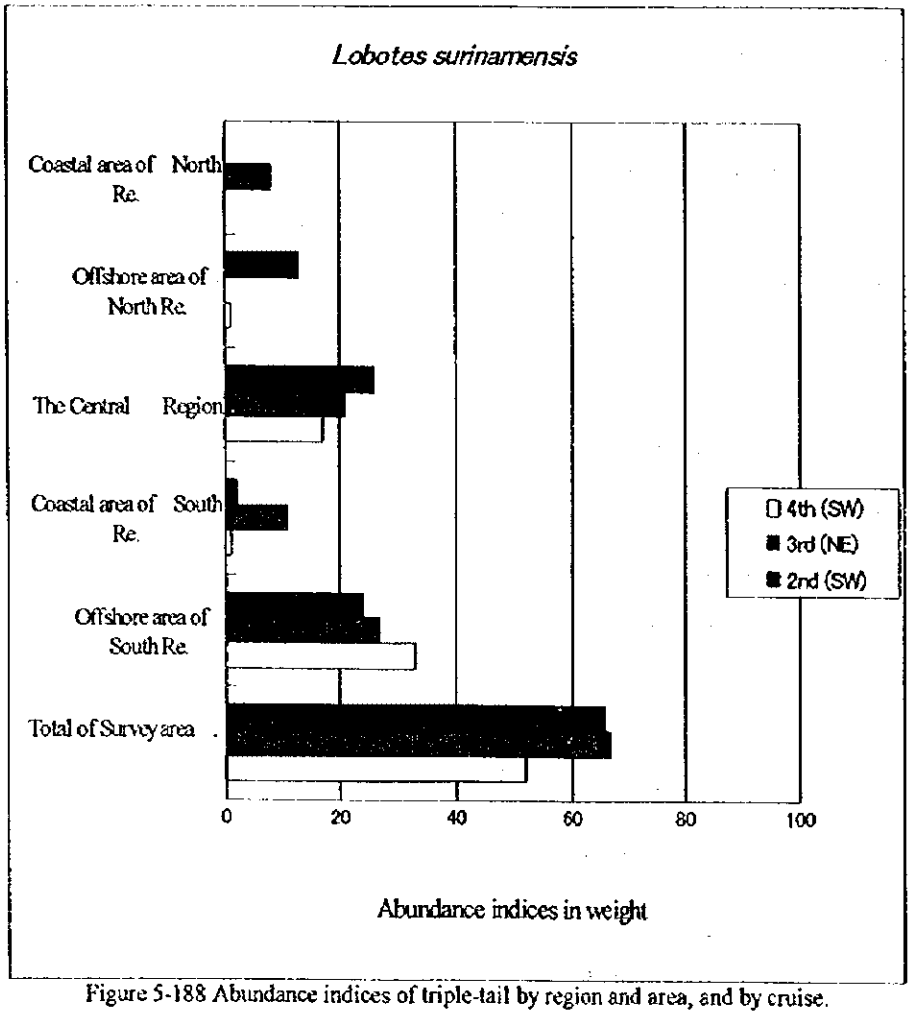


Figure 5-188 Abundance indices of triple-tail by region and area, and by cruise.

(5) Frigate mackerel, (*Auxis thazard*)

Figure 5-189 shows the abundance indices of frigate mackerel sorted by region and by survey period. Average of total abundance indices is the third highest after skipja- tuna and common dolphinfish. The range extends from 92 to 292. The variation between the two southwestern monsoon seasons exceeded 3 times, a much larger difference from values in the northeastern monsoon season. The coastal area of the South Region showed high values of 214 in the northeastern monsoon season and 250 in the southwestern monsoon of 1997, both comprised about 90 % of the seasonal total. The other high values of 34 or 38 occurred occasionally in the North Region. Abundance of this species has been continuously high in the coastal area of the South Region.

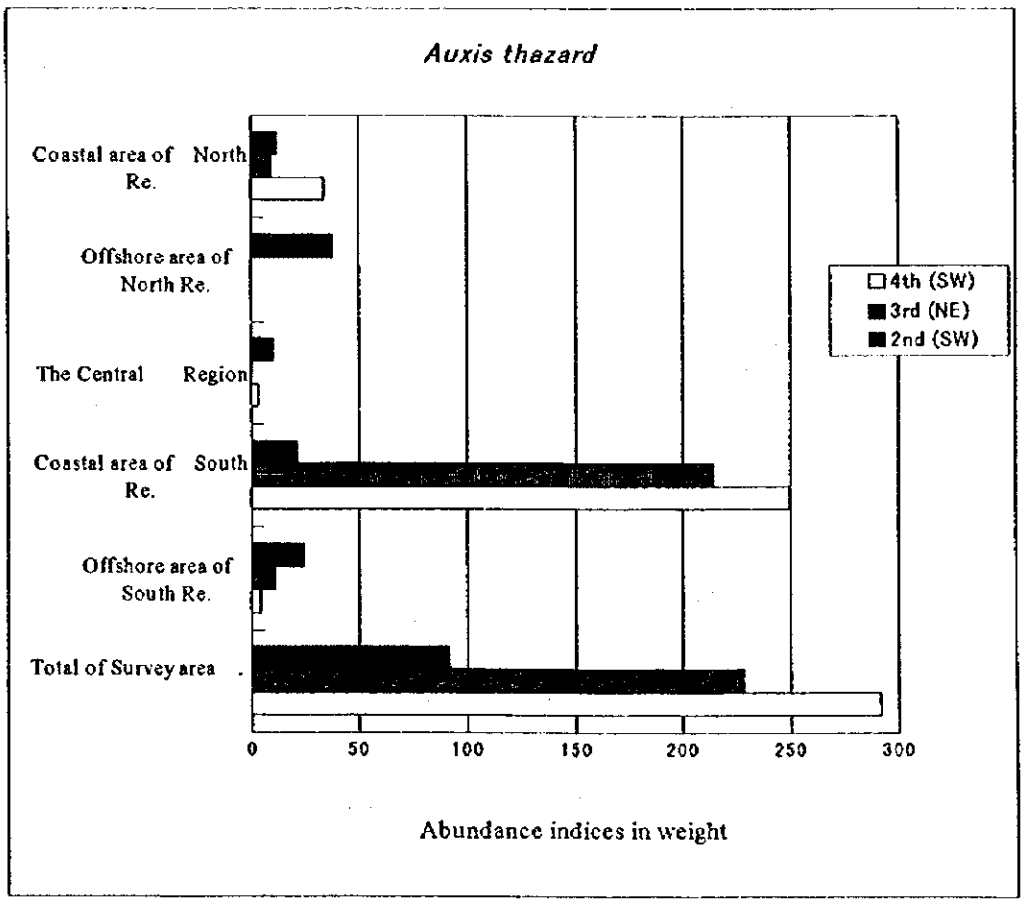


Figure 5-189 Abundance indices of frigate mackerel by region and area, and by cruise.

(6) Bullet mackerel, (*Auxis rochei*)

Figure 5-190 shows the abundance indices of bullet mackerel sorted by region and by survey period. Abundance indices varied quite extensively from 54 to 207, and are averaged at about 92. The regional averages were high, around 40 in the offshore area of the North Region and the Central Region, which covered about 80 % in the most prosperous season surveyed by the fourth cruise. Even though year-to-year variation is significant, the abundance indices tends to rise in the southwest monsoon season.

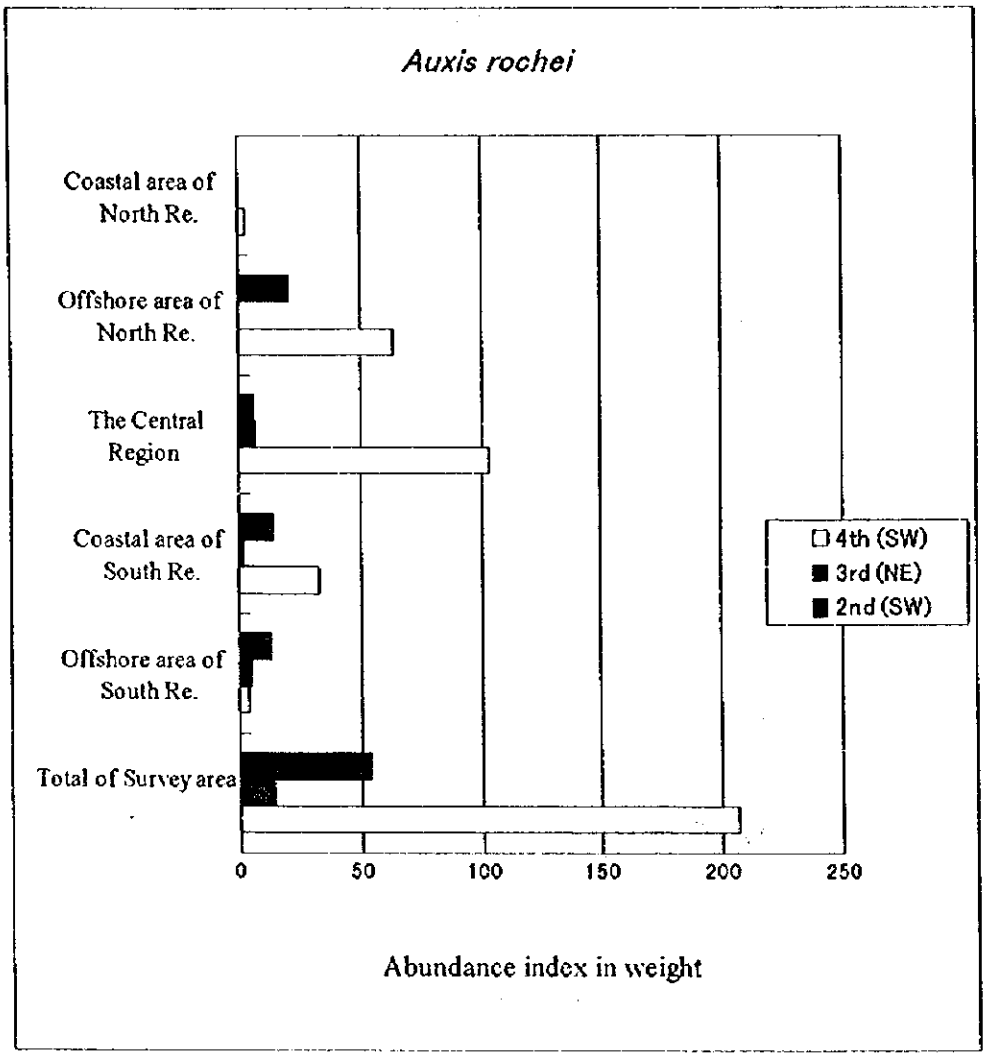


Figure 5-190 Abundance indices of bullet mackerel by region and area, and by cruise.

(7) Skipjack tuna, (*Katsuwonus pelami)*

Figure 5-191 shows the abundance indices of skipjack tuna sorted by region and by survey period. Average abundance index, 585, is the highest among 18 major species. The range extended from 418 to 806. The indices in the southwestern monsoon seasons showed wide year-to-year variation, 418 in 1996 and 806 in 1997. Skipjack tuna is mostly distributed in the Central Region and the offshore area of the South Region, with averages and ranges of 265 and 175-316 and 285 and 203-402, respectively. The offshore fish did not appear in coastal waters of the North and South Regions.

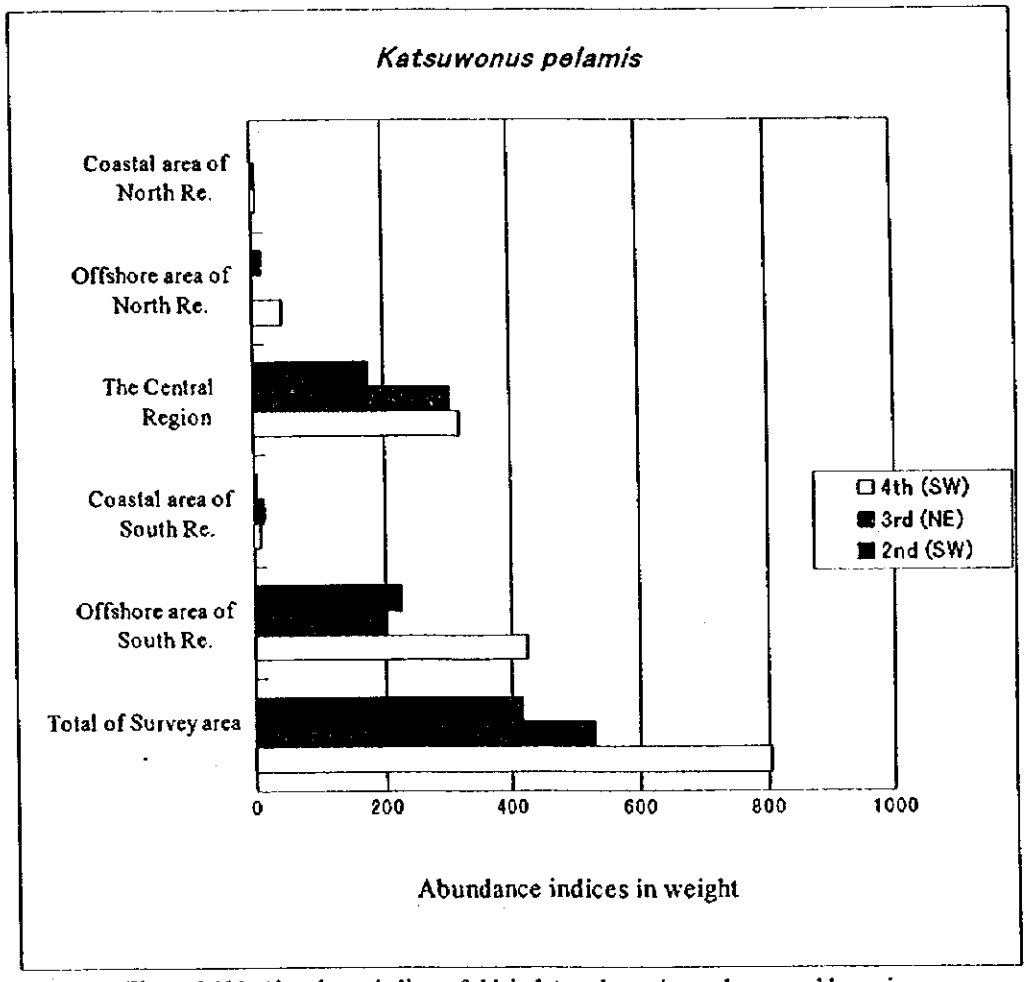


Figure 5-191. Abundance indices of skipjack tuna by region and area, and by cruise.

(8) Three species of Genus Thunnus, longtail tuna, (T. *tongogol*), bigeye tuna, (*T. obesus*), and yellowfin tuna, (*T. albacares*)

Figure 5-192 shows the abundance indices of three species of Thunnus sorted by region and by survey period. Relative abundance of three species combined changed drastically from 8 to 102, with an average of 24. There was no remarkable seasonal change, except significant year-to-year variation of the indices of longtail tuna and yellowfin tuna. Relatively high values were found in the coastal area of the South Region for longtail tuna and bigeye tuna. The values were low in the North Region (Table 5-17).

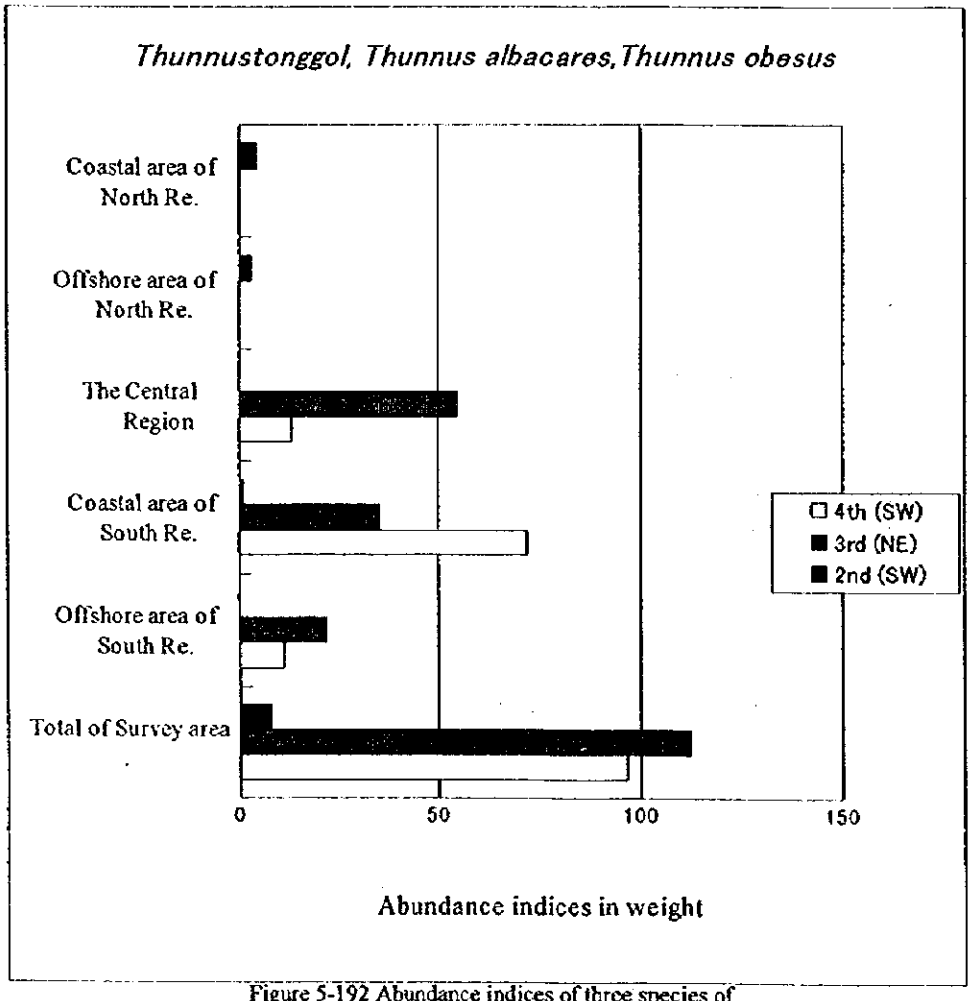


Figure 5-192 Abundance indices of three species of Genus Thunnus by region and area, and by cruise.

(9) Sailfish, (*Istiophorus platypterus*)

Figure 5-193 shows the abundance indices of sailfish sorted by region and by survey period. Total abundance indices varied between 120 and 202, with an average of 162. There was found to be no significant variation between monsoon seasons and between years. Usually the value was significant, 34 to 54, in most areas except the coastal area of the North Region, although there were some areas and seasons in which the fish did not appear at all.

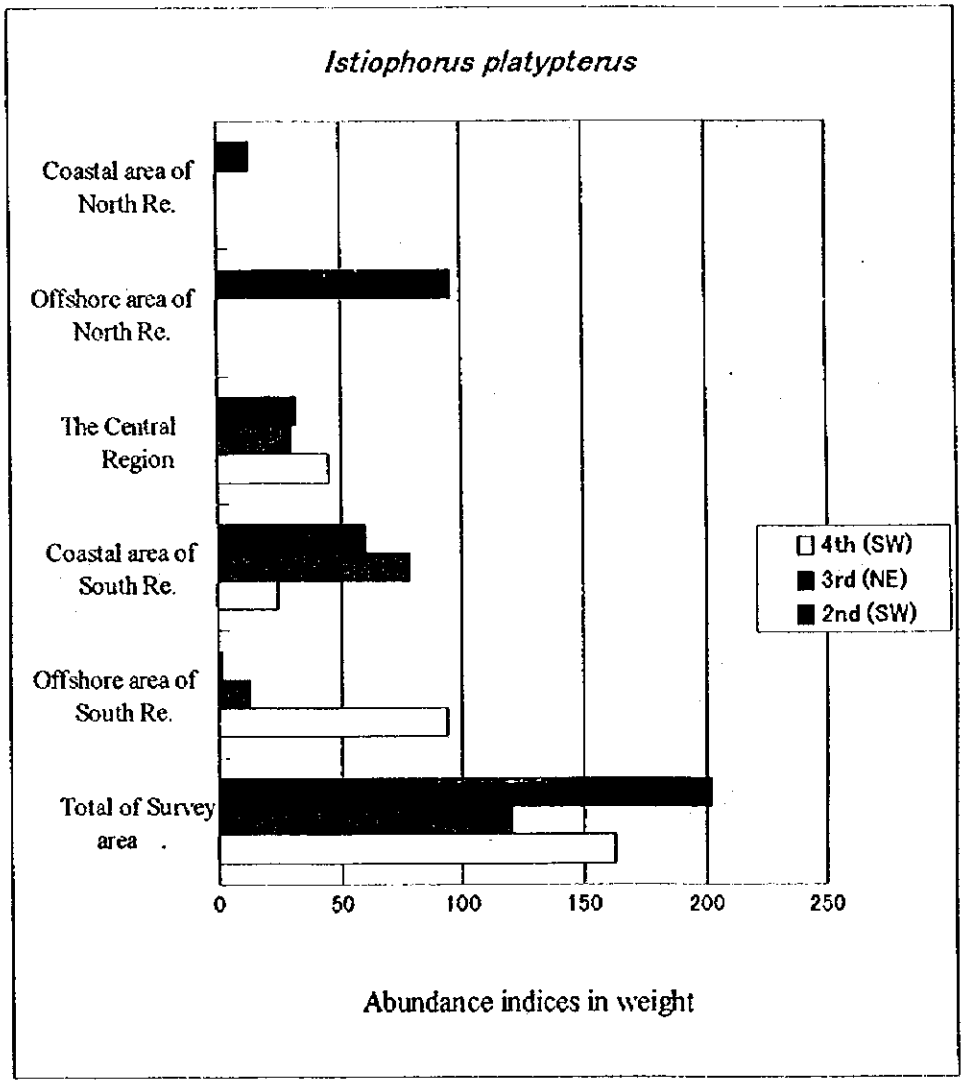


Figure 5-193 Abundance indices of sailfish by region and area, and by cruise.

(10) Unicorn leatherjacket, (*Aluterus monoceros*)

Figure 5-194 shows the abundance indices of unicorn leatherjacket sorted by region and by survey period. This is not an abundant species, with the average index of 10, ranging between 2 and 17. Relatively significant values exceeding the mean were sometimes found in the coastal area of the North and South Regions in the northeastern monsoon season.

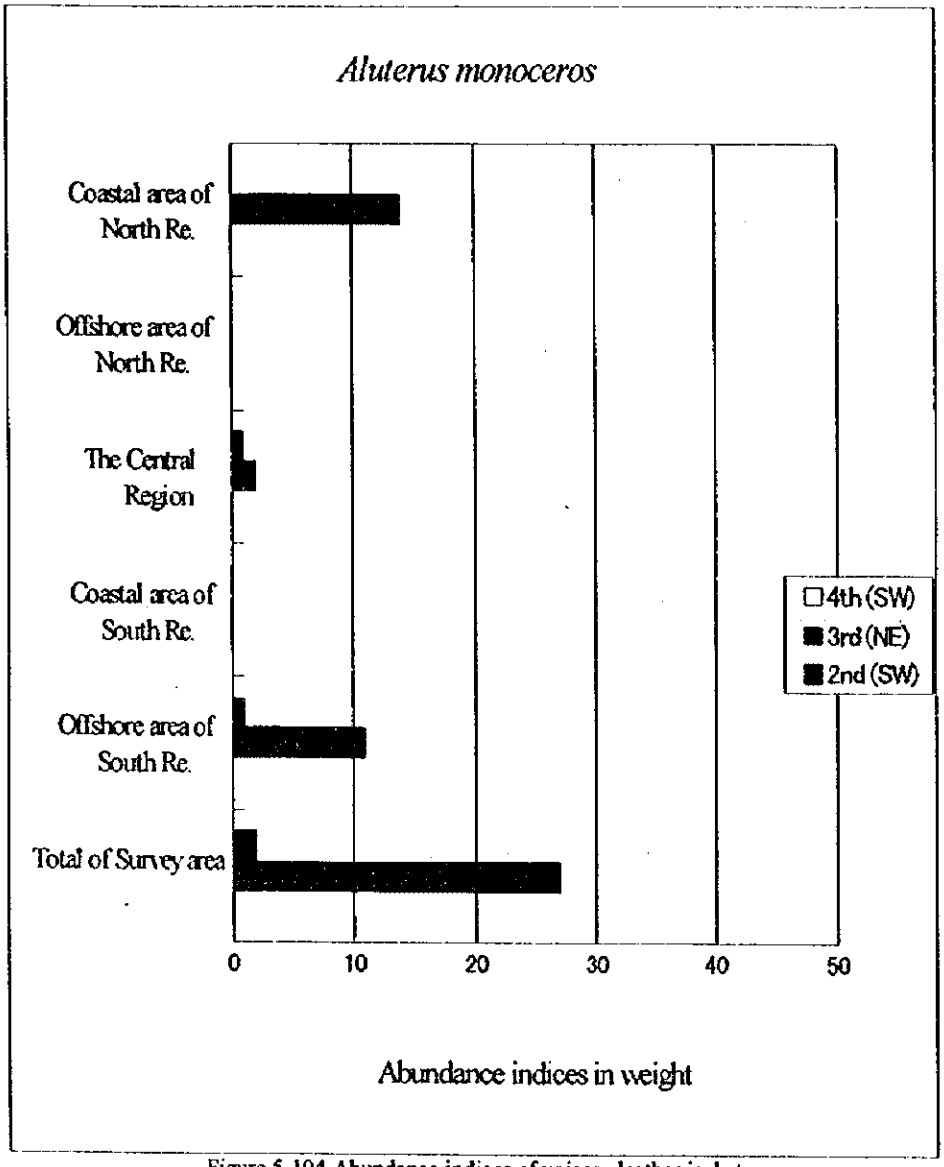


Figure 5-194 Abundance indices of unicorn leather jacket by region and area, and by cruise.

(11) Flying squid, (*Sthenoteuthis oualaniensis*)

Figure 5-195 shows the abundance indices of flying squid sorted by region and by survey period. Abundance indices varied quite extensively from 58 to 119, and the average was 86. In the most prosperous Central Region, the value stayed at fairly constant value around 50. The indices in the offshore area of the South Region were also high, but fluctuated from 9 to 53 between cruises. The squid did not appear in the coastal areas of the North and South Regions. In the offshore area of the North Region, the abundance indices stayed at low level of 8 to 10.

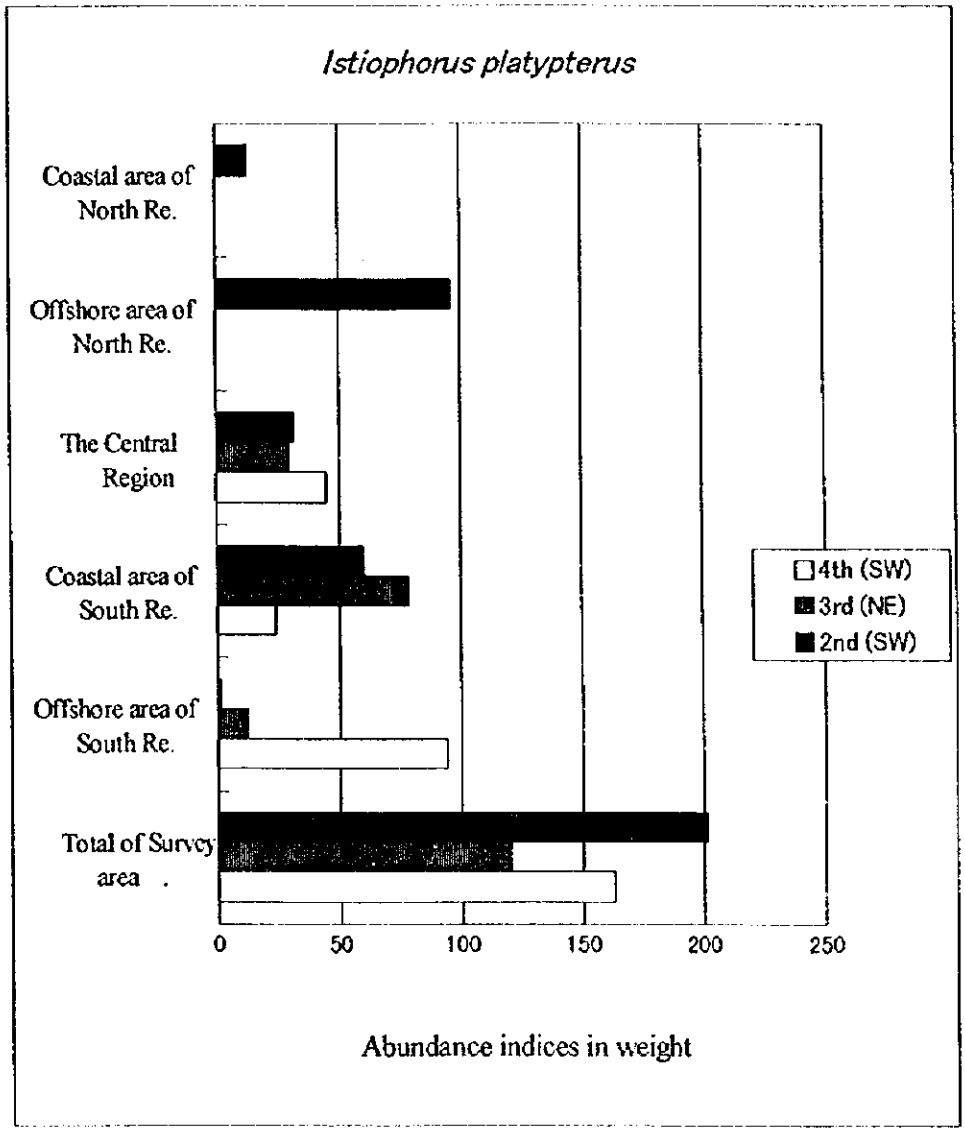


Figure 5-195 Abundance indices of flying squid by region and area, and by cruise

Chapter 6

Results of the Land Site Survey

Chapter 6. Results of the Land Site Survey

6-1. Fisheries Production Survey

(1) Fisheries Production

In Viet Nam prior to 1980, when fisheries were managed rigidly by the government, incentives for producers were weak and production efficiency generally low. In southern Viet Nam, fishery production during the period 1976-80 declined to a pre-1975 level. To overcome these problems and raise fishery production, in 1979 the Sixth Central Committee of the Communist Party introduced a new management system based on the financial autonomy of production units, either enterprises or households. The new management system, based on the independent accountability of individual production units, was first introduced in 1981 into SEAPRODEX, a state-run fisheries enterprise. In general this period was characterized by the abandonment of the principles of a centrally planned economy. Freedom of production and marketing was granted to state-run enterprises. Coupled with the removal of strict bureaucratic control, the new system was very successful, and has become known as the "SEAPRODEX model." Since 1985 the SEAPRODEX model has been applied to all enterprises in the fisheries sector (ADB/FAO, 1993) .

The growth in fishery production (the sum of capture fishery production and aquaculture production) in Viet Nam between 1981 and 1994 is shown in Table 6-1. From a total of 600,000 t of fishery production in 1981 has increased at an average annual rate of 6% to some 1,270,000 t in 1994. Since 1981 the ratio of capture fishery to aquaculture production has remained at 7:3. The main gear types employed in capture fisheries are the lift net, purse seine, trawl, gill net, hand line, and long line. They are used mostly in coastal fishing grounds, and 90% of fishers are small-scale operators. Fishery production was enhanced by the motorization of fishing boats and the introduction of synthetic fiber nets. However, since fishing boats in Viet Nam are generally too small to operate in offshore areas, effort is concentrated in narrow coastal water zones, thereby exacerbating the problem of overfishing in nearshore waters.

The bulk of aquaculture production in Viet Nam is derived from freshwaters. In contrast, brackishwater aquaculture is relatively underdeveloped. In 1991 freshwater aquaculture accounted for 82.5% of total production, whereas brackishwater production contributed only 17.5% (FAO, 1993). Although the percentage contribution of brackishwater aquaculture has increased from 7.3% (1984), this is still very low, compared with an average of 53.5% (1991) for the Asia-Pacific Region.

Table 6-1 Production of Fisheries in Viet Nam(1980~1994)

Unit : Ton

Year	Total Production	Capture Fisheries	Aquaculture
1981	596,356	416,356	180,000
1982	659,318	470,718	188,600
1983	724,399	519,869	204,530
1984	778,219	554,940	223,379
1985	857,998	626,848	231,150
1986	840,583	597,717	242,866
1987	890,509	640,569	249,940
1988	912,652	662,861	249,791
1989	913,495	661,365	252,130
1990	978,880	672,130	306,750
1991	1,062,163	714,253	347,910
1992	1,097,830	746,870	351,260
1993	1,172,529	798,057	374,472
1994	1,268,474	878,474	390,000

Source : MOF

Fishery production by the 28 coastal provinces in 1994 is shown in Table 6-2 With a total fishery production of 137,000 t, the Northern Region accounts for 10.8% of the national total. Of this 95,000 t is produced by capture fisheries and 42,000 t are derived from aquaculture. This constitutes 10.8% of national production in both sub-sectors. The Central Region produces 302,000 t, or 23.9% of the national total, of which 287,000 t (32.7%) is from capture fisheries. In this region aquaculture production is stagnant, at 16,000 t, or 4.0%

Table 6-2 Fisheries Production by Coastal Provinces in Viet Nam (Year 1994)

Region	Province	Capture Fisheries	Aquaculture	Total	Production Ranking
North	Quang ninh	11,665	2,095	13,760	21
North	Hai phong	12,500	6,500	19,000	17
North	Thai binh	6,000	3,800	9,800	26
North	Nam ha	7,976	7,500	15,746	20
North	Ninh binh	600	10,340	10,940	25
North	Thanh hoa	21,900	6,000	27,900	13
North	Nghe an	20,000	4,000	24,000	15
North	Ha tinh	14,300	2,000	16,300	19
Central	Quang binh	10,400	1,500	11,900	24
Central	Quan tri	6,844	800	7,644	27
Central	Thua Thien Hue	8,942	4,000	12,942	23
Central	QN Da nang	37,500	2,300	39,800	9
Central	Quang ngai	30,000	90	30,090	12
Central	Binh dinh	25,000	1,550	26,550	14
Central	Phuyen	15,525	1,500	17,025	18
Central	Khanh hoa	40,429	2,300	42,729	8
Central	Ninh thuan	18,500	540	19,040	16
Central	Binh thuan	94,000	1,000	95,000	3
South	BR Vung tau	83,340	2,000	85,340	5
South	Ho Chi Minh	14,500	17,000	31,500	10
South	Thien giang	27,000	22,000	49,000	7
South	Ben tre	38,000	13,000	51,000	6
South	Tra vinh	48,800	43,000	91,800	4
South	Vinh long	3,000	10,000	13,000	22
South	Can tho	913	5,960	6,873	28
South	Soc trang	15,500	15,000	30,500	11
South	Minh hai	96,590	55,000	151,590	2
South	Kien ginag	155,000	11,000	166,000	1
	Others	13,750	138,225	151,975	
	Total of 28 Provinces	878,474	390,000	1,268,474	

Source : MOF (Provinces Surveyed)

of the national total. Fishery production in the Southern Region amounts to 677,000 t, or 53.3% of the national total. Of this capture fisheries produce

483,000 t or 54.9% of the national total and aquaculture 194,000 t or 49.7%. Clearly the Southern Region is the center for both capture fisheries and aquaculture in Viet Nam. In contrast, the Northern Region makes only a small contribution to national fisheries production.

(2) Working Population and Labor Productivity

As shown in Table 6-3, the national fisheries working population increased 43% during the 7-year period 1985-92, from 740,000 persons in 1985 to 1,060,000 persons in 1992. When fisheries working population is classified by type of production unit, employment in the government enterprise sector has increased by 47,000 persons (from 38,000 to 85,000) and the private enterprise/cooperative sector by 255,000 persons (from 720,000 to 975,000). In 1992, of the 800,000 persons associated with marine capture fisheries, 289,000 are engaged directly in capture fisheries and another 511,000 also obtain a livelihood from fisheries-related business. Of the 260,000 persons engaged in aquaculture, 39,000 are full-time fish farmers and 211,000 are part-timers, many of whom concurrently work in agriculture.

Table 6-3 Fisheries Working Population in Viet Nam (1985~1992)

Year	Total	Government Sector	Private/Cooperative Sector
1985	740,240	38,050	720,190
1986	808,957	40,450	768,507
1987	772,589	41,337	731,172
1988	821,729	44,200	777,592
1989	934,433	45,200	894,233
1990	na	na	na
1991	na	na	na
1992	1,060,000	84,870	975,200

Source : MOF, 1993

Of the 383,000 adults (over 16 years-old) working in fisheries, 86% are men and 14% women. Of that total 78% work in the private sector, 19% in the

Table 6-4 Labor Productivity for Fisheries Sector

by Coastal Provinces in Central Region

Province	Fishing Production (ton)	Fisheries Working Population (man)	Per Capita Production
Quang binh	10,400	10,606	1.1
Quan tri	6,844	7,100	1.1
Thua Thien Hue	8,942	11,800	1.1
QN Da nang	37,500	26,285	1.5
Quang ngai	30,000	17,678	1.7
Binh dinh	25,000	20,100	1.3
Phuyen	15,525	13,807	1.2
Khanh hoa	40,429	18,599	2.3
Ninh thuan	18,500	6,500	2.9
Binh thuan	94,000	37,640	2.5

Source : MOF, 1993/1995 (Computed from the figure in 1994 for Fishing Production and in 1992 for Fisheries Working Population)

cooperative sector, and 3% in government enterprises. Their education level is generally low, with 68% not having completed primary school, 16% having only a primary education, 2% having a middle school education, and just 0.6% having graduated from either vocational school or university. The 14% women workers are mostly fish buyers, fish processors, or engaged in small-scale aquaculture and the production and repair of fishing gear. Further, if we take into account "informal labor" such as irregular and part-time work (shadow work) women are doing in fishing households, and so not included in official statistics, their contribution is far from insignificant.

Per capita productivity in the Southern Region is higher than in either the Northern or Central Regions. This gap differential results from (i) a regional difference in the means of production, i.e. fishing boats and gear, which are larger and better in the Southern Region, and (ii) a similar regional difference in the quality and size of fishing grounds, which are much richer and more productive in the Southern Region, with its large continental shelf. As demonstrated in Table 6-4, the 10 provinces that comprise the Central Region

Table 6-5 Total Motorized Fishing Boats and Engine Capacity in Viet Nam

Year	Total Moterized Fishing Boats (unit)	Total Engine Capacity (hp.)	Average Horsepower (hp. / boat)
1983	29,117	475,832	16.3
1984	29,549	484,114	16.4
1985	29,323	494,507	16.9
1986	31,906	515,629	16.2
1987	35,744	582,992	16.3
1988	43,922	603,078	13.7
1989	37,100	693,722	18.7
1990	41,266	727,585	17.6
1991	43,940	824,436	18.8
1992	54,612	986,420	18.1
1993	61,717	1,188,804	19.3
1994	65,124	1,416,080	21.7

Source : MOF, 1995

also share a similar trend in labor productivity. Per capita production is 1.1 t/year in the three provinces from Quang Binh to Thua Thien Hue, the northern area of the Central Region, 1.2 - 1.7 t/year in the four provinces of the middle area, from Quang Nam Da Nang to Phu Yen, and 2.3 - 2.9 t/year in the three provinces from Khanh Hoa to Binh Thuan, the southern part of the Central Region.

(3) Means of Production

3-1. Fishing Boats

In 1992, the fishing fleet of Viet Nam comprised 83,972 units, of which 54,612 were motorized. This number increased 65,124 in 1994. The average engine capacity is approximately 22 h.p., and 80% of the motorized boats have engines of less than 45 h.p.. All motorized boats are registered by the Fishing Boat Registration Department, the Ministry of Fisheries (MOF), and taxation in fisheries is based on this registration. According to RIMP, the horsepower and sizes of wooden fishing boats correlate as follows: 20 - 25 h.p. corresponds to a

Table 6-6 Number and Engine Capacity of Fishing Fleet by Province in 1994

Region	Province	Number of Fishing Boats	Engine Capacity (hp.)	Average Horsepower (hp./ boat)
North	Quang ninh	2,924	32,044	11.0
North	Hai phong	2,983	31,122	10.4
North	Thai binh	600	9,500	15.8
North	Nam ha	714	13,885	19.4
North	Ninh binh	14	920	65.7
North	Thanh hoa	1,974	30,000	15.2
North	Nghe an	3,425	49,074	14.3
North	Ha tinh	3,775	42,498	11.3
Central	Quang binh	2,807	39,125	13.9
Central	Quan tri	1,100	20,490	18.6
Central	Thua Thien Hue	2,517	32,800	13.0
Central	QN Da nang	3,758	66,430	17.7
Central	Quang ngai	3,527	74,137	21.0
Central	Binh dinh	3,824	82,940	21.7
Central	Phuyen	3,070	29,846	9.7
Central	Khanh hoa	4,300	70,000	16.3
Central	Ninh thuan	1,305	23,475	18.0
Central	Binh thuan	5,505	147,586	26.8
South	BR Vung tau	2,935	114,928	39.2
South	Ho Chi Minh	504	12,120	24.0
South	Thien giang	1,077	63,679	59.1
South	Ben tre	1,530	55,522	36.3
South	Tra vinh	637	18,772	29.5
South	Vinh long	600	17,548	29.2
South	Can tho	33	9,860	298.8
South	Soc trang	439	18,910	43.1
South	Minh hai	2,558	65,226	25.5
South	Kien ginag	6,689	243,643	36.4
	Total of 28 provinces	65,124	1,416,080	21.7

Source : MOF. 1996 (Provinces Surveyed)

14 m length and a 3.5 m beam, a 33 h.p. engine to a 15.3 m length and a 3.8 m beam; and a 60 h.p. engine to a 19.6 m length and a 4.8 m beam.

In recent years the number of motorized fishing boats has increased rapidly, (Table 6-5). Motorized boats increased 2.2 times from 29,117 in 1983 to 65,124 in 1994, an annual rate of 7.6 % during the 12-years period. However, average horsepower increased slightly during the same period, from 16.3 h.p. in 1983 to 21.7 h. p. in 1994. This important constraint has essentially confined fishing effort to coastal fishing grounds. The number and engine capacity of fishing boats in the 28 coastal provinces in 1994 is shown in Table 6-6.

The Northern Region has 16,409 boats, with an average engine capacity per boat of 12.7 h.p.; the Central Region has 31,713 boats, with an average engine capacity of 18.5 h.p., whereas the Southern Region has 17,002 boats, with an average engine capacity of 36.5 h.p.. These data illustrate the southward trend of increasing fishing boat size. Large boats are particularly evident in Ba Ria-Vung Tau, Thien Giang, Ben Tre, Soc Trang, Kieng Giang and Can Tho provinces in the Southern Region.

3-2. Fishing Gear and Methods

The principal fishing gear used in Viet Nam are the trawl, gill net, purse seine, lift net, set net, casting net, long-line and hand line. These are described briefly in this section.

3-2-1. Single Trawl

3-2-1-1. Southern Region

Although by the Vietnamese standards there are some very large trawlers operating in the Southern Region, with engine sizes of 180 - 599 h.p., and hull lengths of 18 - 30 m., such vessels are few, and of relatively minor significance. Most single trawl vessels in Ba Ria-Vung Tau Province have a hull length of 12 - 17 m, are powered by 33 - 150 h.p. engines and have a load capacity of 15 - 50 t. The only deck machinery of such boats is a hydraulic capstan for retrieving trawls. Some vessels lack drums for trawl rope and trawls are retrieved manually after otterboards have been stowed.

Such trawlers are located in Vung Tau and at many other fishing ports throughout the Southern Region. The seawards boundary of the fishing grounds worked by these trawlers is the 50m isobath (most operate within the 40 m isobath). Since fish holds are not adequately insulated, ice as well as fuel capacity limits fishing trips to about one week duration.

Target species are shrimp and various demersal fish species. Catch rates vary: during the Southwest Monsoon rates for a 100 h.p vessel are about 0.15 - 0.2 t/day, whereas during the Northeast Monsoon they are about half that figure (i.e., 0.075 - 0.1 t/day).

3-2-1-2. Central Region

Very few single trawl vessels with an engine capacity of 180 - 500 h.p. operate in this region, where their operations are effectively limited by a continental slope that is close inshore. No vessel in Viet Nam has the capacity to trawl beyond the 80 m isobath, since all lack large enough engines, large wire winches for net hauling, and sophisticated echo sounders.

In the Central Region, single-boat trawling is dominated by boats with an engine capacity of less than 75 h.p. These boats are 10 - 15 m in length and have no deck equipment. Trawls are small and simple, and are fitted with simple wooden otter boards with an iron frame.

In Binh Thuan Province, fishers use single-trawlers of the 8 - 10 t class. They have 5 - 6 crew members and make trips of 2 - 5 days duration. The length of the float line is 22 - 32 m and the depth of the cod end 6 - 6.5 m. A rectangular otter board of 120 - 130 cm wide, 50 - 60 cm long and 40 kg in weight is used. A nylon rope of 20 mm is used as the warp, and is adjusted to approximately five times the depth of the water.

Given trawling conditions in the Central Region, many boat owners prefer to send their vessels to operate in either the Northern or Southern Region for a large part of the fishing season. Target species are coastal shrimp in waters 5 - 20 m deep. Catch rates average 50 kg/trip, composed of 5 - 10 kg of shrimp,

5 - 10 kg of high value fish, with the balance being "by-catch". The latter is a mixed haul of small-size species like ponyfish as well as the small juveniles of high value species.

3-2-1-3. Northern Region

Single-boat trawlers in this Region are very small, with engine capacities in the 10 - 50 h.p. range, and operate within the 30m isobath. The boats lack any deck equipment, and otter board trawls are very small. Only overnight fishing trips are made on all nights when the weather permits, and average 20/month. The peak season is January-April, and crew sizes are 2 - 4 men.

The principal target species are shrimp (Yellow and Shiba prawn [*Metapeneus joyneri*]). Other shrimps are also caught as are ponyfish, rabbitfish. croakers, sea bream, lizardfish and small stingrays, among others species. Shrimp catches average 5 - 10 kg/ night and other species about 10 kg/night.

3-2-2. Pair Trawl

3-2-2-1. Southern Region

The pair-trawl fishery began in the early-1960s in Ba Ria-Vung Tau Province, imitating Chinese sailing trawlers. At present, most of pair-trawlers in the province are of the 40 t class, powered by 66 - 100 h.p. engines. One of a pair of boats is equipped with a fish hold(s) and the other carries the net. An average of five fishers make fishing trips of 20 - 25 days duration, during which fish are hold with ice. The length of sinker line of net is 36 - 40 m and the depth of the cod end 7 - 10 m. The rope extends 450 - 500 m in waters of 50 m deep. Many pair-trawlers are equipped with GPS and a radio, but often lack a fish-finder.

Vessels powered by 200 - 400 h.p. engines operate large bottom trawls. Deck and electronic equipment and target species are the same as for single-boat trawling. Catch rates are 0.7 - 2.0 t/day. Smaller vessels with engine capacities 20 - 100 h.p are much commoner. Trips are of 4 - 8 days duration, and the main

targets are cuttlefish, shrimp and high value demersal fish.

3-2-2-2. Central Region

A large number of pair-trawlers with engines of less than 100 h.p. operate in this region. Boats are 12 - 18m long and have a loading capacity of 8 - 30 t. Fishing is conducted at depths of 15 - 50 m. During the off fishing season, pair trawler owners normally send one vessel for routine maintenance and use the other for gill-netting. So trawling is done for 9 - 10 month per year and gill netting for 2 - 3 month per year. Fishing trips usually last 7 - 20 days and a pair of vessels will catch 10 - 25 t per trip. By-catches usually comprise 30% of the catch of each trip, or 2 - 5 t (averaging about 0.25 t/day), and is salted as caught for preservation. Target species are various high value demersal fish, especially snappers, groupers, pomfret and sea bream, as well as squid and cuttlefish.

Pair-trawlers in Quang Nam Da Nang Province are smaller than those in Ba Ria-Vung Tau Province. They are of the 5 - 10 t class, with four crew members, and make fishing trips of 7 - 10 days duration. Apparently pair-trawling was introduced to Quang Nam Da Nang Province from Ba Ria-Vung Tau Province.

3-2-2-3. Northern Region

There is only an insignificant amount of pair-trawling in the Northern Region, and no details are available.

3-2-3. Lift Net

Three methods are employed in lift netting to attract fish : (1) payao (2) light, (3) a combination of payao and light. The latter is said to increase productivity by about 20%. Many gear conflicts occur with trawlers which cross over payao at night. As a consequence, fewer payao are used these days. In Khanh Hoa Province, for example, the payao has not been used for 30 years,

owing to high maintenance costs, theft and frequent gear loss.

Single-lift netters operate overnight, using a bowl-shaped net with sinkers and floats attached. A fishing boat is positioned directly above a net sunk by sinkers. The net is raised by a rope and pulley attached to the top of the ship.

In the small-type single-lift net with payao and light, an operator arrives at his payao in the evening and switches-on the fluorescent lamp to attract fish. Several hours later, and after confirming that fish are aggregating around the boat, he slips into the sea a raft equipped with two electric bulbs and two fluorescent lamps. After turning off the fluorescent lamp on board, the boat is moved into position to cast the net. When completely cast the fishers close net end by hauling the rope with a winch. After that all crew members participate in net hauling.

3-2-3-1. Southern Region

In the Southern Region lift-netting operations have now been replaced by purse-seining.

3-2-3-2. Central Region

Lift-netting is conducted using a fixed gear serviced by one larger fishing boat powered by an engine of less 75 h.p, and equipped with a generator to provide light attraction. Up to 6 very small vessels, including circular woven boats, are used in the operation. Trips to service the net last 1 - 3 days, and fishing is conducted during the March - August period. For the remainder of the year the vessels are used for gill-netting. Depending on the size of the net, catching rates are 0.2 - 1.0 t per night. The target species in the Central Region is almost exclusively scad.

In Quang Binh Province, there are two kinds of lift net; one operated by four boats and known as "a four-ship lift net" and the other is worked by the only boat and called a "single lift net". The former was widely used. However, it

is inefficient because a large crew is required to operate it. A few years ago the single lift net was introduced. Now 40% of lift- netters use this gear.

This technology competes for the same target as purse-seining. It is likely that as the lift-net gear and other equipment wears out, operators will switch to purse-seining, as occurred in the Southern Region.

3-2-3-3. Northern Region

In this Region lift-netting uses smaller boats, powered by 15 - 40 h.p engines. Operations are conducted nightly, except at full moon, from April through September. During the rest of the year the vessels are used from either shrimp trawling or long-lining. Catch rates average 0.3 - 0.5 t per night, but the range can be very large. The target species is sardine, which comprises 95% of the catch by weight. The balance is made up of squid and various species of higher value fish.

3-2-4. Purse Seine

3-2-4-1. Southern Region

Off-shore, large-vessel purse-seining is conducted using boats 16 - 25 m in length and powered by 150 - 300 h.p. engines. Loading capacity is 30 - 100 t. Most vessels were built within the last 5 years. The deck equipment of these large purse-seniors comprises a block in a swinging mast to pass the seine ropes, and, if they use light attraction, a generator set powered by an old truck diesel engine. Some vessels have electronic equipment, mostly echosounders and satellite navigators, but most have only a radio-telephone for communicating between boats.

These larger off-shore boats operate at depths of 40 - 90 m, in waters off the Southeastern provinces in the period February - May and in the Gulf of Thailand during the rest of the year. Fishing trips last 7 - 15 days, and catch rates vary considerably, from 20 - 40 t/trip. Purse-seiners exploit mostly the smaller pelagics. Target species are scad (*Decapterus* sp.), trevally (*Selaroides*

sp.) and Indian mackerel (*Rastrelliger* sp.). Smaller species of tuna are also taken.

Nearshore purse-seining using smaller vessels powered by 60 - 150 h.p engines. Apart from a generator for light attraction, on which these smaller operations depend, there is no other deck equipment. Fishing is done in waters up to 50m deep and trips last 1 - 5 days. Target species are the same as for the larger operators, but with an emphasis on Scad.

3-2-4-2. Central Region

In the Central Region, two types of purse seine are used; a large type and a small one. The large type employs a net of 400 - 500 m long and 125 m high from a boat of 50 - 60 t. The small type uses a net 300 m long and 60 m high, from a 10 - 18 t boat. The type of purse-seine used in Nui Thanh District, Quang Nam Da Nang Province is operated from a 15 t net boat and a single 8 t transport and lighting. boat. The length of the net is 360 - 400 m and its height 110 - 120 m. They use net which is large relative to the size of the boats employed.

Although the purse-seine technology is gradually replacing lift-netting in the Central Region (as is has done entirely in the Southern Region), large vessels with large engines have not yet been introduced. In the Central Region, all purse-seining is conducted inshore using small boats powered by 20 - 60 h.p. engines. Apart from a generator to power attractors and winch, these vessels lack any deck equipment. The only electronic equipment is a radio-telephone.

Operations are conducted in waters up to 80m deep, and fishing trips are of 1 - 5 days duration. Depending on the type of seine net used, there are two main targets in the Central Region; scad, using a 20 - 30 mm mesh size, or bonito and mackerel, using a 60 - 85 mm mesh size. The larger mesh net is often used in conjunction with payao, a FAD of palm fronds attached to a small, anchored raft.