(2) Cephalopods

The CPUA and estimated stock size for the three target cephalopods are presented below.

1) European squid *Loligo vulgaris*

The European squid is distributed along the East Atlantic coast from the North Sea to the Gulf of Guinea. It is a neritic and semipelagic species inhabiting at water depths between 20 and 250m (increased depths in the winter). This species undertakes horizontal and vertical migration depending on changes of its surrounding environment (Fischer *et al.*, 1987; Roper *et al.*, 1984).

a) Distribution of CPUA

Figure 3.20 shows the CPUA distribution of the European squid. This species was distributed the coastal zone at water depths of less than 200m, more the coast in the cold season and more offshore in the warm season. Throughout the survey, it tended to concentrate in the Northern coastal area south of Cape Blanc (up to 20° N) to the mouth of Lévrier Bay. Distribution of this species along the coast in the cold season (in April and May) and the concentration in the Northern coastal area in both seasons suggest a coastal migration for reproduction, as reported by Dia *et* Inejih (1991).

b) CPUA by stratum

Table 3.43 shows the CPUA for the European squid at each stratum in each area.

In the *Amrigue* survey area, the highest CPUA was 119, the mean CPUA by area being below 13.

In the *Al-Awam* survey area, the highest CPUA of this species was 1,244 (in the Phase 1 warm season, at the 20-30m stratum in the Northern area), the mean CPUA by stratum in each area was often higher in the warm season than in the cold season, whatever the stratum. The highest mean CPUA by stratum in each area occurred at the two strata of less than 30m in the cold season (except for the Northern area in Phase 2), while in the warm season, it occurred at each stratum between 30 and 200m in water depth. Besides some isolated cases, the mean CPUA by stratum in each season was higher in the Northern area, regardless of the stratum.

c) Stock size

Table 3.44 shows estimates of the stock size for the European squid.

In the *Amrigue* survey area, the total stock size of this species was between 20 and 78 tonnes (the European squid was not caught in the Banc d'Arguin, the stock refer therefore to the other area). The total stock size in the Phase 1 warm season was of less than 1 tonne, and was indicated by + in the Table. Considering the amplitude of a 95% confidence interval, this difference is not significant.

As for the total stock size of this species in the *Al-Awam* survey area, only Phase 2 results are shown below, during which period data on the 3-20m stratum were obtained throughout the survey area. The estimate of the total stock size in the cold and warm seasons was respectively 1,144 and 1,671 tonnes, with a 95% confidence interval of respectively ±399 and ±926 tonnes and a CV of 21% in both seasons. For the geographical distribution of the total stock size in both seasons, the stock size in the Northern area accounted for 69 and 73% of the total by season respectively. As for the vertical distribution, the 3-20m stratum occupied 63% of the total in the cold season, and the 30-80m stratum accounted for 86% of the total in the warm season.
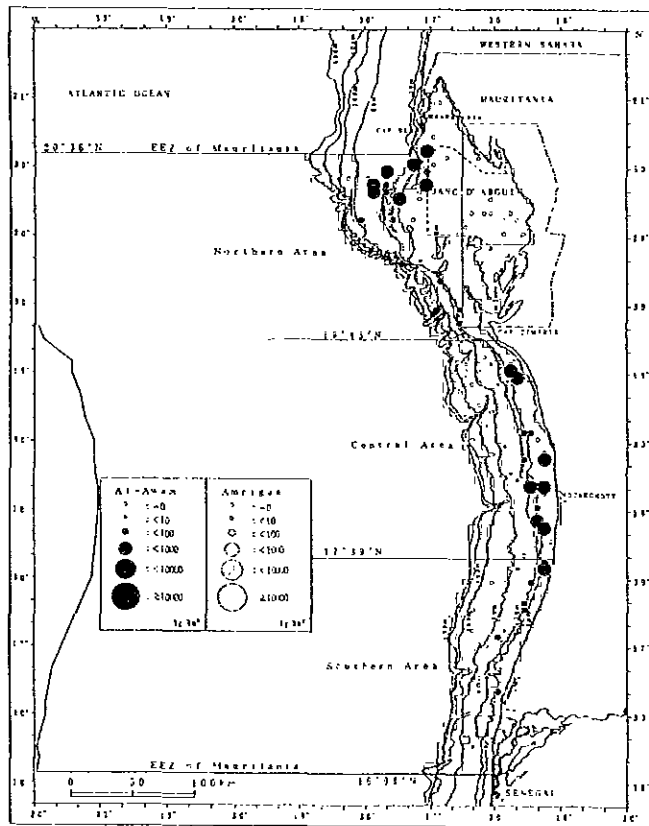
(A) Phase 1 cold season
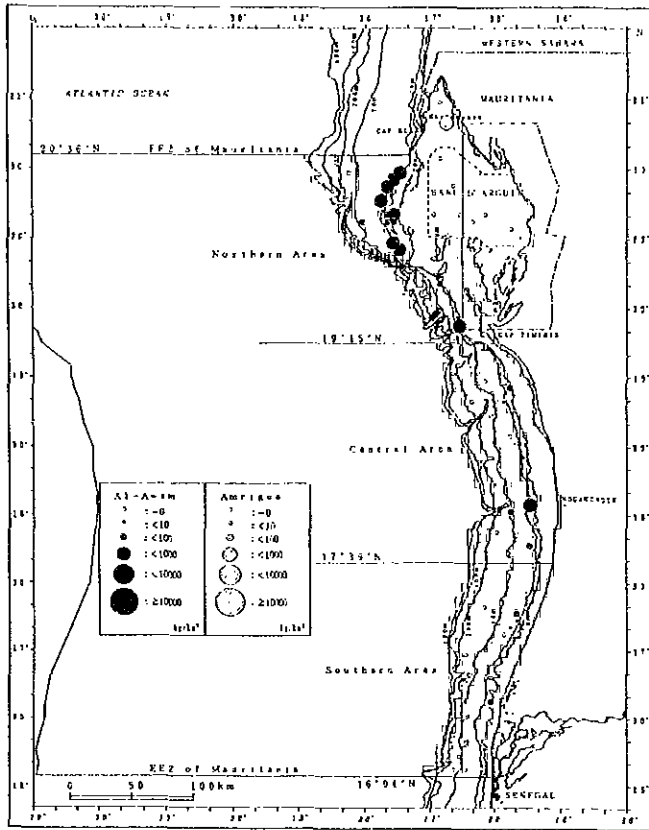
(B) Phase 1 warm season
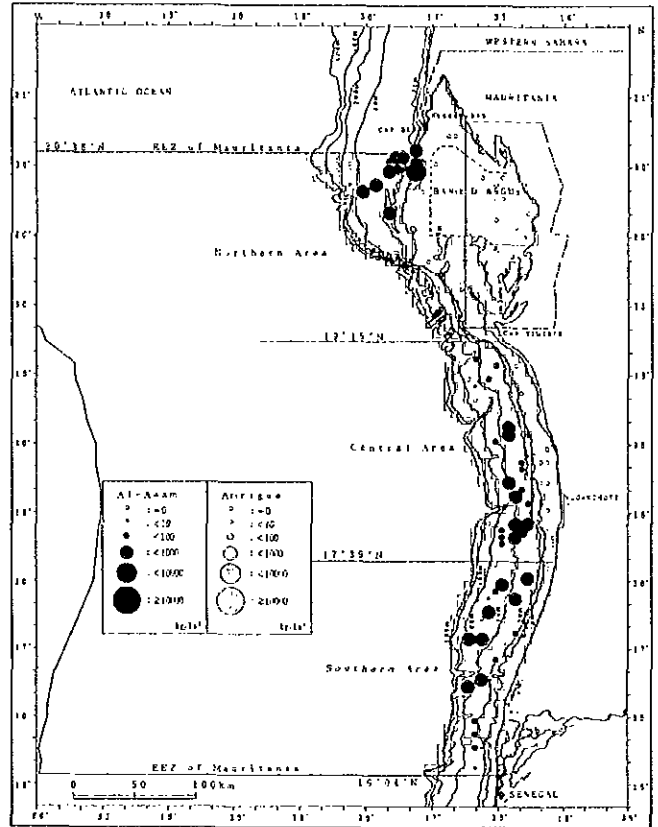
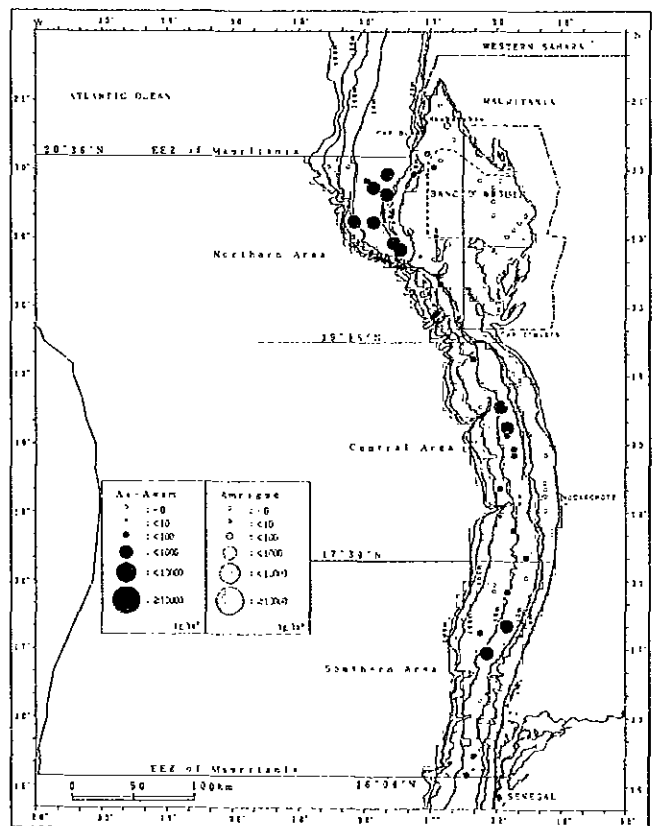**(C) Phase 2 cold season**

(D) Phase 2 warm season

Figure 3.20　Distribution of CPUA for European squid *Loligo vulgaris* .

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Table 3.43 CPUA of European squid *Loligo vulgaris* by stratum.

(A) *Amrigue* survey area

Northern coastal area (Stratum: 3-20m)	Phase 1						Phase 2					
	Cold season			Warm season			Cold season			Warm season		
	Mean	S. D.	Range	Mean	S. D.	Range	Mean	S. D.	Range	Mean	S. D.	Range
Banc d'Arguin	0.0	0.0	0.0 ~ 0.0	0.0	0.0	0.0 ~ 0.0	0.0	0.0	0.0 ~ 0.0	0.0	0.0	0.0 ~ 0.0
Other	13.2	39.7	0.0 ~ 119.0	+	0.1	0.0 ~ 0.4	0.0	0.0	0.0 ~ 0.0	3.4	8.2	0.0 ~ 21.9

(B) *Al-Awam* survey area

Subarea	Stratum	Phase 1						Phase 2					
		Cold season			Warm season			Cold season			Warm season		
		Mean	S. D.	Range	Mean	S. D.	Range	Mean	S. D.	Range	Mean	S. D.	Range
North	3-20m	-	-	-	-	-	-	76.8	95.9	0.0 ~ 240.3	15.0	13.7	0.6 ~ 27.7
	20-30m	100.3	32.9	53.7 ~ 139.0	542.0	480.6	179.9 ~ 1,243.7	111.3	84.6	28.8 ~ 195.4	24.0	41.1	0.0 ~ 71.5
	30-80m	176.2	154.2	34.0 ~ 519.4	612.1	277.8	193.6 ~ 1,013.7	64.0	57.1	0.0 ~ 148.2	363.0	279.1	28.1 ~ 706.7
	80-200m	0.0	0.0	0.0 ~ 0.0	0.6	1.0	0.0 ~ 1.8	0.0	0.0	0.0 ~ 0.0	39.7	68.3	0.0 ~ 118.6
	200-400m	0.0	0 0	0.0 ~ 0.0	0.0	0.0	0.0 ~ 0.0	-	-	-	0.0	0.0	0.0 ~ 0.0
	400-600m	-	-	-	-	-	-	-	-	-	-	-	-
Central	3-20m	-	-	-	0 0	0.0	0.0 ~ 0.0	83.0	112.4	0.0 ~ 343.5	0.0	0.0	0.0 ~ 0.0
	20-30m	72.8	91.0	0.0 ~ 192.7	2.0	4.1	0.0 ~ 8.2	49.9	42.9	0.0 ~ 104.6	0.0	0.0	0.0 ~ 0.0
	30-80m	1.2	3.6	0.0 ~ 12.5	151.9	189.7	2.5 ~ 591.4	2.7	4.1	0.0 ~ 9.7	63.1	107.0	0.0 ~ 352.5
	80-200m	2.7	8.5	0.0 ~ 26.9	71.7	74.9	0.0 ~ 210.0	0.6	2.0	0.0 ~ 6.4	18.5	25.3	0.0 ~ 67.9
	200-400m	0.0	0.0	0.0 ~ 0.0	0.0	0.0	0.0 ~ 0.0	0.0	0.0	0.0 ~ 0.0	0.0	0.0	0.0 ~ 0.0
	400-600m	-	-	-	0.0	0.0	0.0 ~ 0.0	-	-	-	-	-	-
South	3-20m	-	-	-	0.0	0.0	0.0 ~ 0.0	27.9	49.2	0.0 ~ 143.2	0.0	0.0	0.0 ~ 0.0
	20-30m	8.8	12.4	0.0 ~ 23.0	0.0	0.0	0.0 ~ 0.0	16.9	30.6	0.0 ~ 62.8	0.0	0.0	0.0 ~ 0.0
	30-80m	4.1	7.7	0.0 ~ 22.8	132.6	155.9	0.2 ~ 398.8	8.5	12.7	0.0 ~ 39.0	72.1	183.5	0.0 ~ 614.6
	80-200m	0.0	0.0	0.0 ~ 0.0	161.4	251.1	0.0 ~ 795.8	0.0	0.0	0.0 ~ 0.0	7.1	11.9	0.0 ~ 28.6
	200-400m	0.0	0.0	0.0 ~ 0.0	0.0	0.0	0.0 ~ 0.0	0.0	0.0	0.0 ~ 0.0	0.0	0.0	0.0 ~ 0.0
	400-600m	-	-	-	-	-	-	-	-	-	-	-	-

Remarks. S. D.: standard deviation, - : no trawl, +: less than 0.1.

Table 3.44 Stock size estimates of European squid *Loligo vulgaris.*

(A) *Amrigue* survey area

Subarea	Stratum	Area in km²	Stock size in tonnes			
			Phase 1		Phase 2	
			Cold season	Warm season	Cold season	Warm season
North	Banc d'Arguin	4,741	0	0	0	0
	3-20m	5,912	78	+	0	20
	Total	10,653	78	+	0	20
	95% confidence interval		±138	±0	±0	±21
	CV: coefficient of variation		100%	x	0%	91%

(B) *Al-Awam* survey area

Subarea	Stratum	Area in km²	Stock size in tonnes			
			Phase 1		Phase 2	
			Cold season	Warm season	Cold season	Warm season
North	3-20m	5,912	-	-	454	89
	20-30m	1,290	129	699	144	31
	30-80m	2,924	515	1,789	187	1,061
	80-200m	1,147	0	1	0	46
	200-400m	936	0	0	-	0
	Total	12,209	644	2,490	785	1,227
	95% confidence interval		±351	±1,226	±358	±1,250
	CV: coefficient of variation		25%	18%	29%	24%
Central	3-20m	2,783	-	0	231	0
	20-30m	835	61	2	42	0
	30-80m	2,870	4	436	8	181
	80-200m	2,767	7	198	2	51
	200-400m	1,453	0	0	0	0
	400-600m	848	-	0	-	-
	Total	8,773	72	636	282	232
	95% confidence interval		±109	±375	±241	±195
	CV: coefficient of variation		54%	27%	28%	43%
South	3-20m	1,485	-	0	41	0
	20-30m	805	7	0	14	0
	30-80m	2,640	11	350	22	190
	80-200m	3,025	0	488	0	22
	200-400m	994	0	0	0	0
	Total	8,949	18	838	77	212
	95% confidence interval		±22	±512	±83	±330
	CV: coefficient of variation		49%	34%	38%	69%
All	3-20m	10,180	-	0	726	89
	20-30m	2,930	197	701	199	31
	30-80m	8,434	529	2,575	217	1,433
	80-200m	6,939	7	687	2	118
	200-400m	3,383	0	0	0	0
	400-600m	848	-	0	-	-
	Total	22,534	734	3,964	1,144	1,671
	95% confidence interval		±406	±1,220	±399	±926
	CV: coefficient of variation		23%	14%	21%	21%

Remarks. - : no trawl, + : less than 1 tonne, x : could not be calculated.

2) Common cuttlefish *Sepia officinalis*

The common cuttlefish is distributed in the East Atlantic from the Baltic Sea and the North Sea down to South Africa, as well as in the Mediterranean. It occurs over sandy and muddy bottoms and in seaweed fields in a zone extending from the coast to a water depth of 200m. It is a demersal and littoral species particularly abundant down to a water depth of 100m, and undertakes a seasonal and vertical migration (Roper *et al.*, 1984; Fischer *et al.*, 1987).

a) Distribution of CPUA

Figure 3.21 shows the CPUA distribution of the common cuttlefish in each survey season.

This species was found mainly in the cold season at water depths of less than 30m, and in the warm season at water depths of less than 80m. In the Phase 1 cold season, it was not distributed in the Central area. But the distribution of this species in that season at the 3-20m stratum remains unknown as its survey did not take place. The CPUA distribution for this species is denser in the warm season than in the cold season, a phenomenon that is accentuated in the regions north and south of NKC. Dia *et* Inejih (1991) investigated the displacement of the species from inshore to offshore observe in both seasons, and Inejih (1990) recorded the concentration of common cuttlefish in the vicinities of NKC.

The globally higher density of CPUA for this species in the warm season suggests a cross section of north-south migration along the coast.

b) CPUA by stratum

Table 3.45 shows the CPUA for the common cuttlefish at each stratum in each area.

In the *Amrigue* survey area, the common cuttlefish was not caught in the Phase 1 warm season. The highest CPUA of this species in this area was 624 (in the other area in the Phase 1 cold season), and the mean CPUA by area was between 30 and 50 (except for 92).

In the *Al-Awam* survey area, the highest CPUA of this species was 1,023 at the 3-20m stratum in the Northern area in the Phase 2 cold season. The mean CPUA by stratum was 171 at most (at the above-mentioned stratum). Strata where the mean CPUA exceed 100 were very few, less than 50 for most of them. In all seasons, the mean CPUA by stratum was the highest at two strata shallower than 30m in each area.

c) Stock size

Table 3.46 shows estimates of the stock size for the common cuttlefish.

In the *Amrigue* survey area, the total stock size for this species tended to decrease in survey order, respectively with 722, 0, 470 and 384 tonnes. Except in the Phase 2 warm season, when the total stock was more or less equally distributed between the Banc d'Arguin and the other area, the latter comprised between 60 and 75% of the total.

As for the *Al-Awam* survey area, the results below refer only to those of Phase 2, when the data related to the 3-20m stratum were obtained for all area. The estimate of the total stock size in the cold and warm seasons was respectively 1,455 and 852 tonnes, with a 95% confidence interval of respectively ±716 and ±355 tonnes and a CV of 59 and 33%. The stock of this species concentrated in the north and declined towards the south. The stock was equally concentrated at the 3-20m stratum. This unbalanced geographical and vertical distribution is particularly acute in the cold season.

(A) Phase 1 cold season
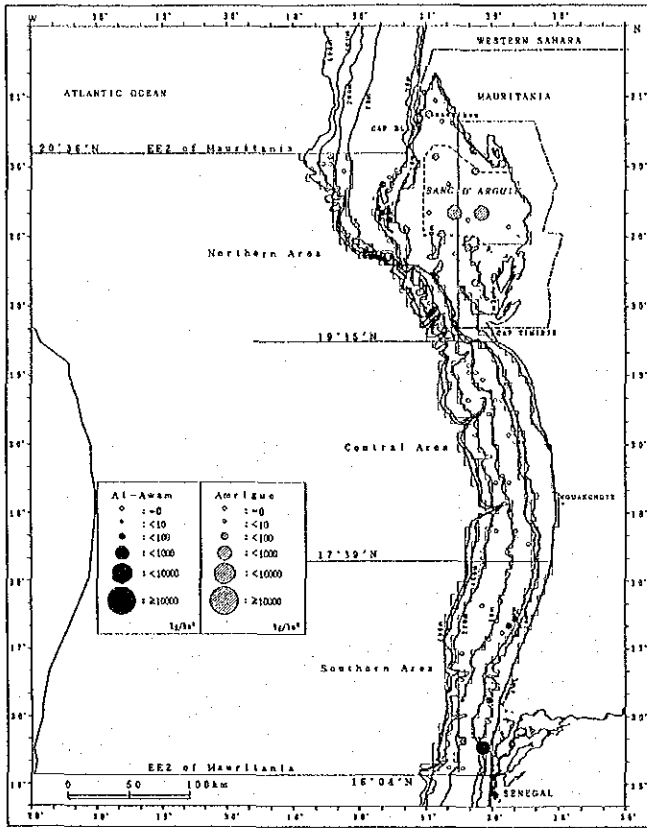
(B) Phase 1 warm season
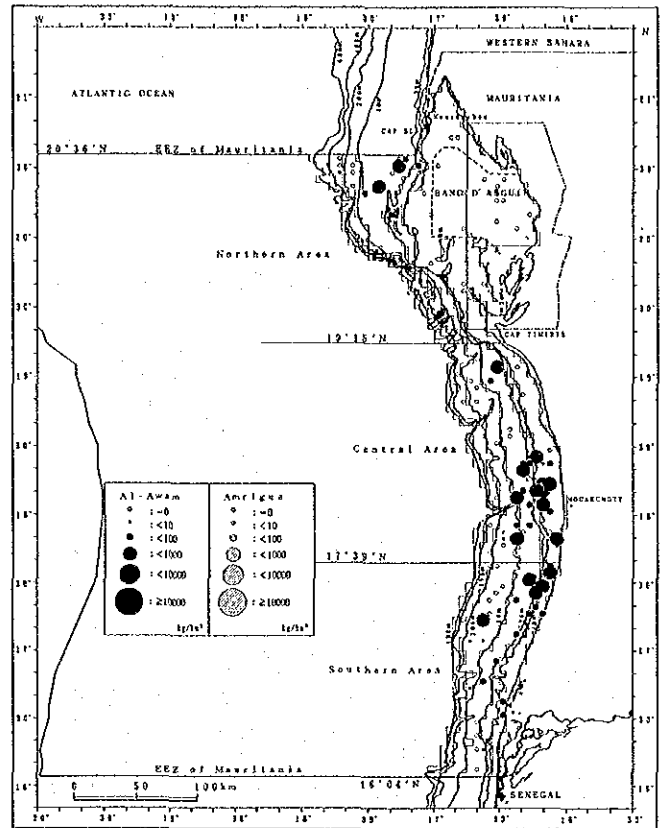
(C) Phase 2 cold season
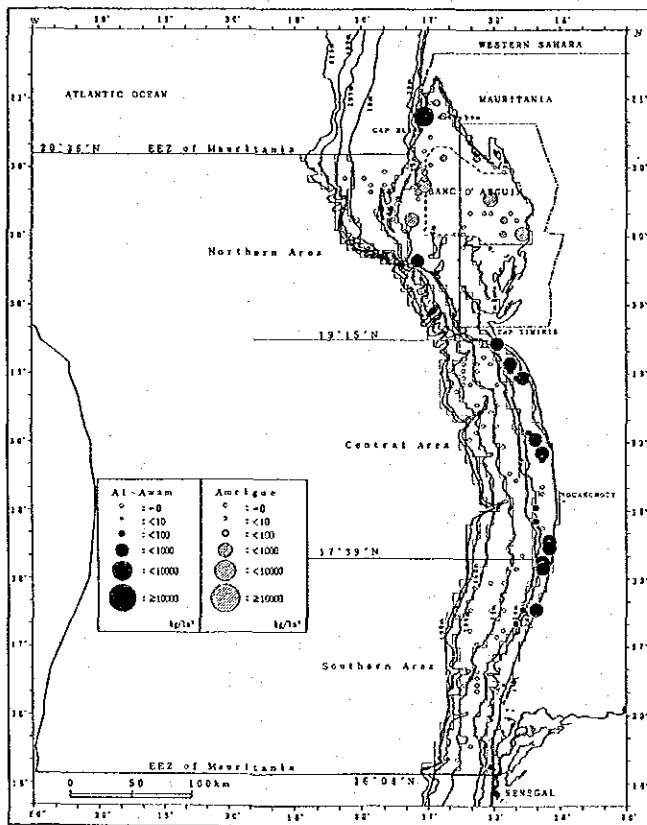
(D) Phase 2 warm season
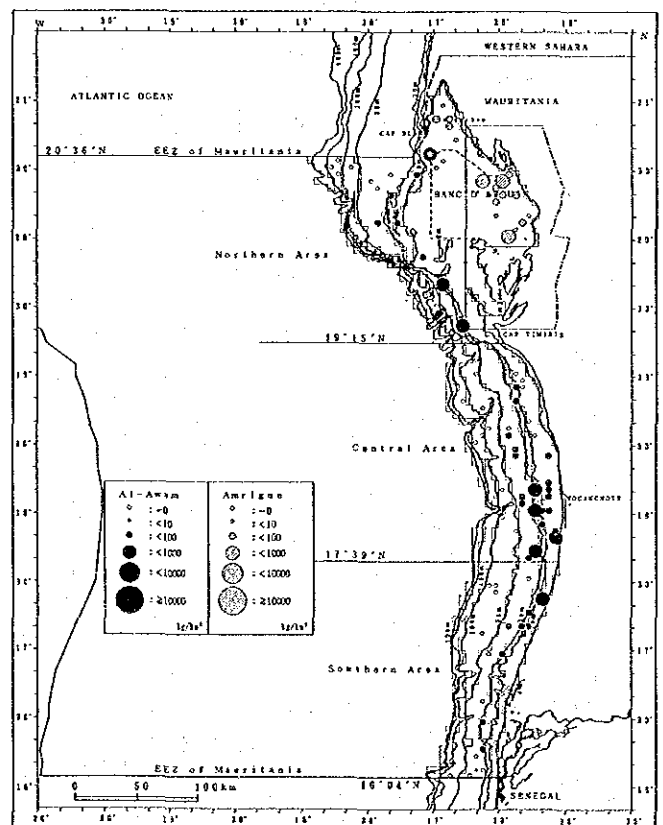
Figure 3.21 Distribution of CPUA for common cuttlefish *Sepia officinalis* .

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Table 3.45 CPUA of common cuttlefish *Sepia officinalis* by stratum.

(A) *Amrigue* survey area

Northern coastal area (Stratum: 3-20m)	Phase 1 Cold season Mean	S. D.	Range	Phase 1 Warm season Mean	S. D.	Range	Phase 2 Cold season Mean	S. D.	Range	Phase 2 Warm season Mean	S. D.	Range
Banc d'Arguin	37.8	50.2	0.0 ~ 144.3	0.0	0.0	0.0 ~ 0.0	39.9	76.2	0.0 ~ 225.0	43.6	65.0	0.0 ~ 204.6
Other	91.7	202.4	0.0 ~ 623.6	0.0	0.0	0.0 ~ 0.0	47.6	62.5	0.0 ~ 184.8	30.0	31.4	0.0 ~ 74.5

(B) *Al-Awam* survey area

| Subarea	Stratum	Phase 1 Cold season Mean	S. D.	Range	Phase 1 Warm season Mean	S. D.	Range	Phase 2 Cold season Mean	S. D.	Range	Phase 2 Warm season Mean	S. D.	Range
North	3-20m	-	-	-	-	-	-	171.1	378.7	0.0 ~ 1,023.4	46.4	82.7	0.0 ~ 169.9
North	20-30m	8.1	12.4	0.0 ~ 28.1	35.0	46.3	0.0 ~ 97.7	15.9	26.2	0.0 ~ 54.7	135.5	139.3	43.8 ~ 295.8
North	30-80m	3.7	9.7	0.0 ~ 27.6	47.1	53.5	0.0 ~ 114.6	0.0	0.0	0.0 ~ 0.0	18.8	38.1	0.0 ~ 111.6
North	80-200m	0.0	0.0	0.0 ~ 0.0	0.0	0.0	0.0 ~ 0.0	0.0	0.0	0.0 ~ 0.0	0.0	0.0	0.0 ~ 0.0
North	200-400m	0.0	0.0	0.0 ~ 0.0	0.7	1.3	0.0 ~ 2.2	-	-	-	0.0	0.0	0.0 ~ 0.0
North	400-600m	-	-	-	-	-	-	-	-	-	-	-	-
Central	3-20m	-	-	-	114.5	183.6	0.0 ~ 667.3	96.4	97.7	0.0 ~ 314.9	36.5	74.2	0.0 ~ 293.4
Central	20-30m	0.0	0.0	0.0 ~ 0.0	45.9	52.1	0.0 ~ 112.0	2.4	4.9	0.0 ~ 9.8	80.0	53.4	22.5 ~ 139.2
Central	30-80m	0.0	0.0	0.0 ~ 0.0	59.6	60.4	0.0 ~ 179.4	0.0	0.0	0.0 ~ 0.0	33.6	35.2	0.0 ~ 105.7
Central	80-200m	0.0	0.0	0.0 ~ 0.0	17.8	50.4	0.0 ~ 168.9	0.0	0.0	0.0 ~ 0.0	0.0	0.0	0.0 ~ 0.0
Central	200-400m	0.0	0.0	0.0 ~ 0.0	0.0	0.0	0.0 ~ 0.0	0.0	0.0	0.0 ~ 0.0	0.0	0.0	0.0 ~ 0.0
Central	400-600m	-	-	-	0.0	0.0	0.0 ~ 0.0	-	-	-	-	-	-
South	3-20m	-	-	-	47.6	51.7	0.0 ~ 154.9	89.0	141.4	0.0 ~ 391.1	31.6	74.6	0.0 ~ 223.1
South	20-30m	51.7	59.3	0.0 ~ 116.5	135.1	50.7	76.7 ~ 168.3	25.5	42.7	0.0 ~ 88.8	23.6	25.1	0.0 ~ 59.1
South	30-80m	4.0	8.2	0.0 ~ 22.0	40.2	59.6	0.0 ~ 190.0	0.0	0.0	0.0 ~ 0.0	6.4	11.0	0.0 ~ 33.0
South	80-200m	0.0	0.0	0.0 ~ 0.0	33.6	99.4	0.0 ~ 298.7	0.0	0.0	0.0 ~ 0.0	0.0	0.0	0.0 ~ 0.0
South	200-400m	0.0	0.0	0.0 ~ 0.0	0.0	0.0	0.0 ~ 0.0	0.0	0.0	0.0 ~ 0.0	0.0	0.0	0.0 ~ 0.0
South	400-600m	-	-	-	-	-	-	-	-	-	-	-	-

Remarks. S. D.: standard deviation, - : no trawl.

Table 3.46   Stock size estimates of common cuttlefish *Sepia officinalis*.

(A) *Amrigue* survey area

Subarea	Stratum	Area in km²	Stock size in tonnes			
			Phase 1		Phase 2	
			Cold season	Warm season	Cold season	Warm season
North	Banc d'Arguin	4,741	179	0	189	207
	3-20m	5,912	542	0	281	177
	Total	10,653	722	0	470	384
	95% confidence interval		±717	±0	±262	±250
	CV: coefficient of variation		56%	0%	28%	28%

(B) *Al-Awam* survey area

Subarea	Stratum	Area in km²	Stock size in tonnes			
			Phase 1		Phase 2	
			Cold season	Warm season	Cold season	Warm season
North	3-20m	5,912	-	-	1,011	274
	20-30m	1,290	10	45	21	175
	30-80m	2,924	11	138	0	55
	80-200m	1,147	0	0	0	0
	200-400m	936	0	1	-	0
	Total	12,209	21	184	1,032	504
	95% confidence interval		±25	±132	±1,026	±387
	CV: coefficient of variation		57%	38%	82%	53%
Central	3-20m	2,783	-	318	268	102
	20-30m	835	0	38	2	67
	30-80m	2,870	0	171	0	96
	80-200m	2,767	0	49	0	0
	200-400m	1,453	0	0	0	0
	400-600m	848	-	0	-	-
	Total	8,773	0	577	270	265
	95% confidence interval		±0	±372	±230	±182
	CV: coefficient of variation		0%	26%	25%	25%
South	3-20m	1,485	-	71	132	47
	20-30m	805	42	109	21	19
	30-80m	2,640	11	106	0	17
	80-200m	3,025	0	102	0	0
	200-400m	994	0	0	0	0
	Total	8,949	52	387	153	83
	95% confidence interval		±84	±220	±230	±125
	CV: coefficient of variation		54%	30%	47%	47%
All	3-20m	10,180	-	389	1,412	423
	20-30m	2,930	52	192	43	261
	30-80m	8,434	22	415	0	168
	80-200m	6,939	0	151	0	0
	200-400m	3,383	0	1	0	0
	400-600m	848	-	0	-	-
	Total	22,534	74	1,148	1,455	852
	95% confidence interval		±79	±494	±716	±358
	CV: coefficient of variation		42%	18%	59%	33%

Remark. - : no trawl.

3)   Common octopus *Octopus vulgaris*

The common octopus occurs in warm and tropical seas of all over the world. It is a demersal and littoral species found over various types of bottom in the coast off to the borders of the continental shelf. It normally hibernates in deep waters and migrates in the summer into shallow waters (Roper *et al.*, 1984; Fischer *et al.*, 1987).

a)   Distribution of CPUA

Figure 3.22 shows the CPUA distribution of the common octopus in each survey season. This species was found over a very wide area regardless of season. Zones of relatively high CPUA for this species were observed in each area, a particularly acute phenomenon in the Phase 1 warm season. Zones with a mass of high CPUA were off Cape Blanc in the Northern area, off south of Cape Timiris (southern portion) and off NKC in the Central area, and the region south of 17° 30' N in the Southern area (off the Senegalese border, at 17°N). According to Dia *et* Inejih (1991) and Hatanaka (1979), the stocks in the two zones in the Northern and Central areas should be subpopulations of the common octopus. But it remains to be studied whether the Southern area population is part of that in the Central area, or the stock is a new subpopulations.

b)   CPUA by stratum

Table 3.47 shows the CPUA for the common octopus at each stratum in each area.

In the *Amrigue* survey area, the common octopus was not captured in Phase 1. The highest CPUA of this species in Phase 2 was 160, the mean CPUA by area attaining at most 39.

In the *Al-Awam* survey area, the highest CPUA was 2,406 at the 30-80m stratum in the Southern area in the Phase 1 warm season. For all seasons, the highest mean CPUA by stratum was observed: for the Northern area, at the 80-200m stratum (approximately 100-600); for the Southern area, at the 30-80m stratum (approximately 200-500); and for the Central area, at the 20-30m stratum in the warm season (approximately 200-500) or at the 30-80m stratum in the cold season (approximately 300-600). Relatively high mean CPUA by stratum was also observed at strata next to those with the highest mean CPUA. At almost all strata, the mean CPUA by stratum was higher in Phase 1.

c)   Stock size

Table 3.48 show estimates of the stock size for the common octopus.

In the *Amrigue* survey area, the total stock size of this species in Phase 2 was 48 tonnes in the cold season and 244 tonnes in the warm season. Considering the amplitude of the 95% confidence interval, this difference was not considered significant.

In the *Al-Awam* survey area, the estimate of the total stock size of this species was, in survey order, 7,612 tonnes (95% confidence interval ±2,069 tonnes, CV 10%); 6,274 tonnes (95% confidence interval ±1,774 tonnes, CV 13%); 3,352 tonnes (95% confidence interval ±851 tonnes, CV 9%); and 3,521 tonnes (95% confidence interval ±1,486 tonnes, CV 20%). In the first two values above the stock size of the 3-20m stratum in the entire area and in the Northern area was not included, and the stock size of the 200-400m stratum in the Northern area was also excluded from the third value: therefore, those figures were underestimated. Considering, however, that the stock size level at the 3-20m stratum in the Phase 1

cold and warm seasons was in the same order as in the Phase 2 cold and warm seasons, the total stock size in Phase 1 would be of approximately 8,000 tonnes and 6,500 tonnes respectively. Also, if the common octopus presumably does not undertake great south-north migrations, then the total stock size would have declined about 3,000 tonnes between the Phase 1 warm season and the Phase 2 cold season. This decrease was evidenced by the successive fall of the stock size of each stratum at water depths over 20m, at which the survey was conducted in all seasons, particularly at the 30-80m and 80-200m strata.

As for the geographical and vertical distribution of the total stock size for the common octopus, only Phase 2 results are presented below. In the cold season, the Central and Southern areas accounted for 48% and 34% of the total stock size respectively; in the warm season, the Northern, Central and Southern areas made up 52%, 25% and 23% of the total respectively. The total stock size in Phase 2 was more or less stabilized around 3,000 tonnes. It is not presently known if those seasonal variations in geographical distribution are mainly due to the northward displacement of the stock in the Central and Southern areas observed from the cold season to the warm season, or, conversely, to the reverse displacement from the warm season to the cold season. In both seasons, the 30-80m and 80-200m strata accumulate near 90% of the total stock size.

The stock size of the common octopus was the largest among that of non-fish target species, accounting for 1 - 6% of the grand total. This ratio declined in survey order, 6%, 3%, 1% and 1% respectively (see Table 3.20, (B)).

(A) Phase 1 cold season
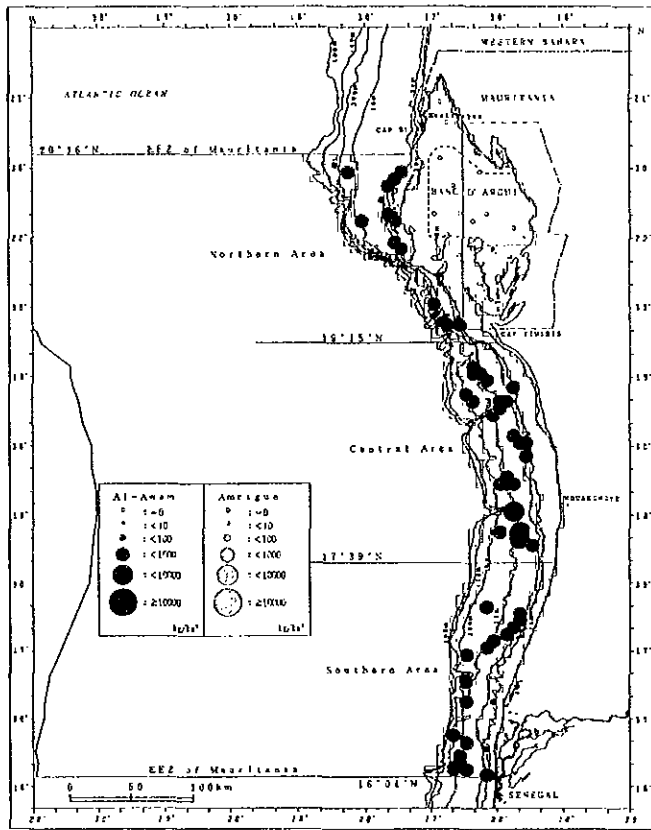
(B) Phase 1 warm season
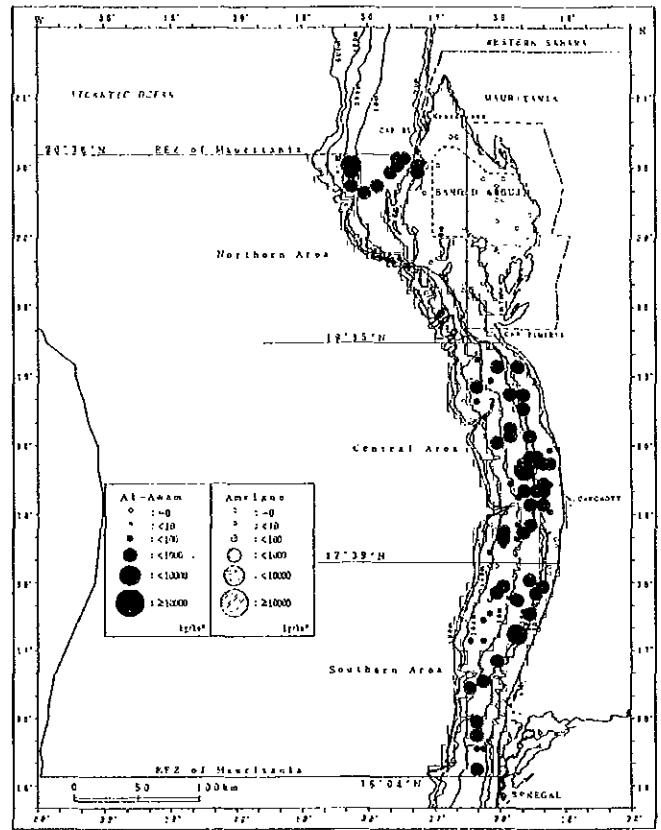
(C) Phase 2 cold season
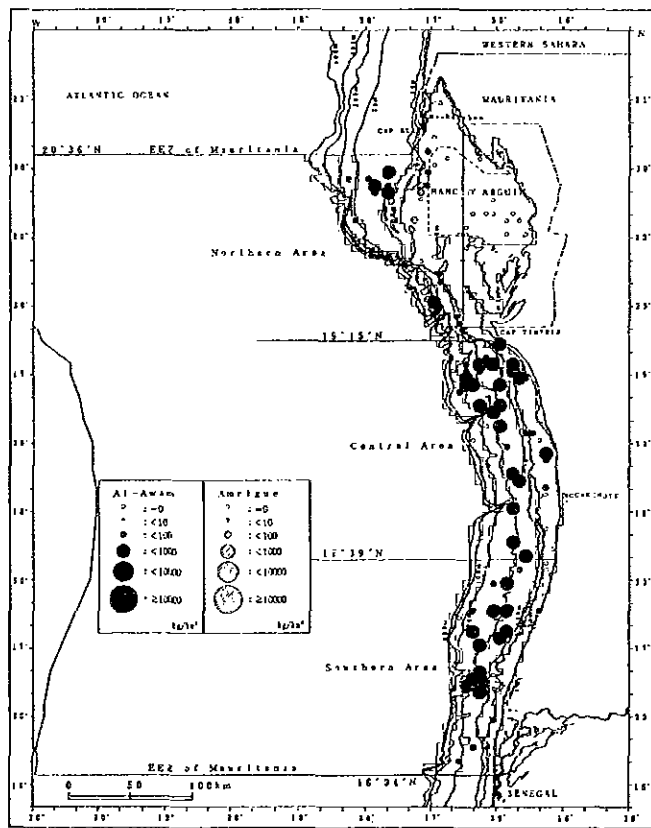
(D) Phase 2 warm season
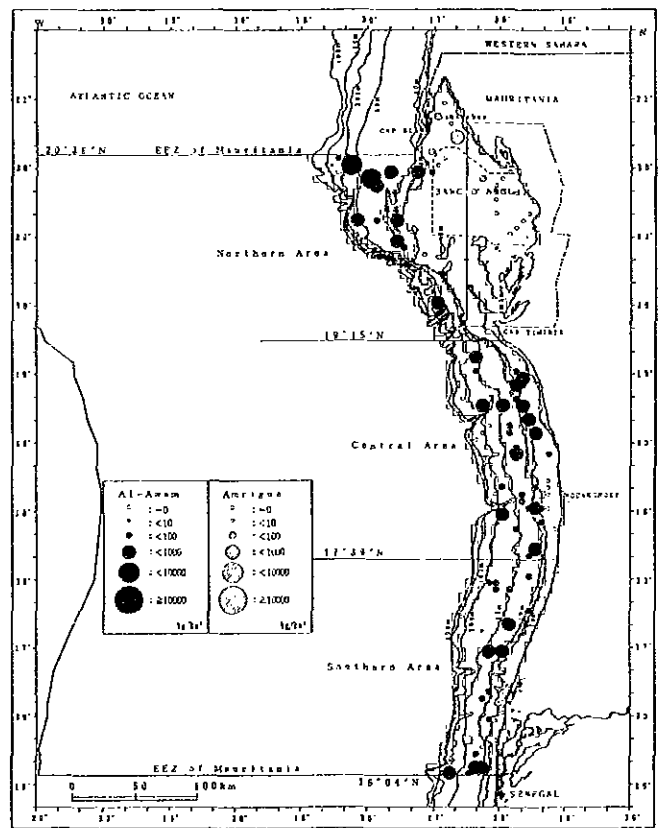
Figure 3.22 Distribution of CPUA for common octopus *Octopus vulgaris* .

Table 3.47 CPUA of common octopus *Octopus vulgaris* by stratum.

(A) *Amrigue* survey area

Northern coastal area (Stratum: 3-20m)	Phase 1								Phase 2							
	Cold season				Warm season				Cold season				Warm season			
	Mean	S. D.	Range		Mean	S. D.	Range		Mean	S. D.	Range		Mean	S. D.	Range	
Banc d'Arguin	0.0	0.0	0.0 ~	0.0	0.0	0.0	0.0 ~	0.0	0.0	0.0	0.0 ~	0.0	3.3	12.8	0.0 ~	49.4
Other	0.0	0.0	0.0 ~	0.0	0.0	0.0	0.0 ~	0.0	8.1	19.1	0.0 ~	54.6	38.6	59.5	0.0 ~	159.8

(B) *Al-Awam* survey area

Subarca	Stratum	Phase 1								Phase 2							
		Cold season				Warm season				Cold season				Warm season			
		Mean	S. D.	Range		Mean	S. D.	Range		Mean	S. D.	Range		Mean	S. D.	Range	
North	3-20m	-	-	-	-	-	-	-	-	25.2	36.7	0.0 ~	79.9	13.1	26.1	0.0 ~	52.3
	20-30m	186.0	168.7	39.8 ~	406.0	89.5	94.9	0.0 ~	193.0	21.1	33.4	0.0 ~	70.3	90.4	32.1	54.1 ~	115.3
	30-80m	204.8	119.9	32.1 ~	381.3	535.4	206.9	319.8 ~	930.7	103.4	107.7	3.1 ~	321.1	307.6	408.4	0.0 ~	1,201.3
	80-200m	487.1	34.8	457.2 ~	525.3	579.8	406.7	237.6 ~	1,029.4	111.9	66.8	66.5 ~	188.7	633.0	706.7	201.6 ~	1,448.5
	200-400m	18.3	31.7	0.0 ~	54.9	10.2	14.5	0.0 ~	26.8	-	-	-	-	17.0	23.3	0.0 ~	43.6
	400-600m	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Central	3-20m	-	-	-	-	134.7	127.9	0.0 ~	390.4	68.2	96.6	0.0 ~	352.5	52.5	49.9	0.0 ~	125.7
	20-30m	284.3	276.5	0.0 ~	656.5	467.8	190.8	252.9 ~	705.9	19.7	34.1	0.0 ~	70.6	205.4	176.6	59.4 ~	440.6
	30-80m	642.6	594.4	121.1 ~	2,108.3	393.4	325.6	60.0 ~	1,208.5	275.8	154.8	66.0 ~	563.1	105.5	80.7	18.0 ~	267.2
	80-200m	611.5	583.3	31.0 ~	2,116.3	89.2	58.0	0.0 ~	181.7	221.2	163.3	0.0 ~	512.6	94.3	79.0	0.0 ~	191.9
	200-400m	2.3	3.0	0.0 ~	6.4	11.1	27.3	0.0 ~	66.8	2.5	5.1	0.0 ~	10.2	0.0	0.0	0.0 ~	0.0
	400-600m	-	-	-	-	0.0	0.0	0.0 ~	0.0	-	-	-	-	-	-	-	-
South	3-20m	-	-	-	-	0.0	0.0	0.0 ~	0.0	11.0	21.9	0.0 ~	52.7	0.0	0.0	0.0 ~	0.0
	20-30m	68.3	32.2	36.0 ~	100.4	372.4	231.2	157.8 ~	617.2	0.0	0.0	0.0 ~	0.0	21.3	27.0	0.0 ~	56.1
	30-80m	456.1	225.9	188.8 ~	964.7	454.2	732.0	10.6 ~	2,405.5	202.4	181.5	0.0 ~	544.3	228.8	286.8	0.0 ~	940.8
	80-200m	383.5	171.9	160.3 ~	670.1	86.7	105.7	0.0 ~	305.9	192.1	96.9	47.3 ~	311.6	60.5	100.2	7.6 ~	263.7
	200-400m	0.6	0.8	0.0 ~	1.2	0.0	0.0	0.0 ~	0.0	0.0	0.0	0.0 ~	0.0	0.0	0.0	0.0 ~	0.0
	400-600m	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Remarks. S. D.: standard deviation. - : no trawl.

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Table 3.48 Stock size estimates of common octopus *Octopus vulgaris*.

(A) *Amrigue* survey area

Subarea	Stratum	Area in km²	Stock size in tonnes			
			Phase 1		Phase 2	
			Cold season	Warm season	Cold season	Warm season
North	Banc d'Arguin	4,741	0	0	0	16
	3-20m	5,912	0	0	48	228
	Total	10,653	0	0	48	244
	95% confidence interval		±0	±0	±53	±167
	CV: coefficient of variation		0%	0%	61%	55%

(B) *Al-Awam* survey area

Subarea	Stratum	Area in km²	Stock size in tonnes			
			Phase 1		Phase 2	
			Cold season	Warm season	Cold season	Warm season
North	3-20m	5,912	-	-	149	77
	20-30m	1,290	240	115	27	117
	30-80m	2,924	599	1,565	302	899
	80-200m	1,147	559	665	128	726
	200-400m	936	17	10	-	16
	Total	12,209	1,415	2,355	607	1,835
	95% confidence interval		±500	±992	±383	±2,052
	CV: coefficient of variation		11%	16%	24%	35%
Central	3-20m	2,783	-	375	190	146
	20-30m	835	237	390	16	171
	30-80m	2,870	1,844	1,129	792	303
	80-200m	2,767	1,692	247	612	261
	200-400m	1,453	3	16	4	0
	400-600m	848	-	0	-	-
	Total	8,773	3,777	2,157	1,614	881
	95% confidence interval		±1,555	±772	±496	±306
	CV: coefficient of variation		19%	14%	13%	16%
South	3-20m	1,485	-	0	16	0
	20-30m	805	55	300	0	17
	30-80m	2,640	1,204	1,199	534	604
	80-200m	3,025	1,160	262	581	183
	200-400m	994	1	0	0	0
	Total	8,949	2,420	1,761	1,132	804
	95% confidence interval		±773	±1,356	±424	±593
	CV: coefficient of variation		12%	36%	15%	32%
All	3-20m	10,180	-	375	355	224
	20-30m	2,930	532	806	44	305
	30-80m	8,434	3,647	3,894	1,628	1,806
	80-200m	6,939	3,411	1,174	1,322	1,170
	200-400m	3,383	21	26	4	16
	400-600m	848	-	0	-	-
	Total	22,534	7,612	6,274	3,352	3,521
	95% confidence interval		±2,069	±1,774	±851	±1,486
	CV: coefficient of variation		10%	13%	9%	20%

Remark. - : no trawl.

(3) Crustaceans

Among the five target crustaceans, the West African geryon *Chaceon* (*Geryon*) *maritae*, the pink spiny lobster *Palinurus mauritanicus* and the royal spiny lobster *Panulirus regius* are not presented here, as the first one was not caught throughout the survey and the CPUA in entire area of the last two species of lobster was less than 1 throughout the survey respectively. Presented below are the CPUA and estimated stock size values of the two target crustaceans.

1) Southern pink shrimp *Penaeus notialis*

The southern pink shrimp is found on the coasts of both sides of the Atlantic. On the American side, it occurs from the Yucatan Peninsula to Cabo Frio (Brazil), as well as in many Caribbean islands. It inhabits at water depths between 3 and 100m (generally at 3–50m), on sandy or muddy bottoms or on sandbanks surrounded by reefs (Carpenter *et al.*, 1993). On the western coast of Africa, it can be found from Cape Blanc to Angola as well as off São Tomé (Burukovsky, 1972).

a) Distribution of CPUA

Figure 3.23 shows the CPUA distribution of the southern pink shrimp in every survey season.

In the *Amrigue* survey area, this species was concentrated in the inner port of Lévrier Bay and/or along the east coast of Banc d'Arguin, a phenomenon that became acute in recent years. Overall, the CPUA there were higher than those in the *Al-Awam* survey area.

As for the latter, the southern pink shrimp was scattered along the coast at water depths of less than 80m. South of Cape Timiris, frequencies of occurrence were relatively high.

Lagardéra (1971) defined two zones of concentration for this species resource: 1) the southern region between NKC and Saint-Louis, and 2) the northern region between 18°50' and 20°00' N (zone including Lévrier Bay). Conversely, the three main resource zones observed in the present study, regardless of stock size, were the following: 1) Lévrier Bay, 2) the Banc d'Arguin, 3) south of Cape Timiris.

b) CPUA by stratum

Table 3.49 shows the CPUA for the southern pink shrimp at each stratum in each area.

In the *Amrigue* survey area, the highest CPUA was 439 in the Banc d'Arguin of the Phase 2 warm season, with the mean CPUA of 195 by area. The mean CPUA by area in the three seasons except the above season was between 2 and 71.

In the *Al-Awam* survey area, the highest CPUA was 281 at the 3-20m stratum in the Central area in the Phase 2 cold season. The mean CPUA by stratum ranged 0.1 - 21, but in most strata it was below 10. In all seasons except the Phase 1 cold season, the mean CPUA by stratum was higher at the 3-20m stratum in many case.

c) Stock size

Table 3.50 show estimates of the stock size for the southern pink shrimp.

In the *Amrigue* survey area, the estimate of the total stock size for this species was in serial order of survey, 72, 351, 121 and 1,342 tonnes (95% confidence interval and CV not mentioned). The total stock size

was greater in the warm season than in the cold season, and increased rapidly. In the Phase 1 cold season, the stock size in the other area accounted for 83% of the total stock size, but in all other seasons the Banc d'Arguin occupied 69 to 87% of the total.

In the *Al-Awam* survey area, the total stock size of this species is probably less than approximately 100 tonnes in each season. As for geographical and vertical distribution, the results presented here are limited to Phase 2. The stock size in the Central area made up 53% and 63% of the total stock size in the cold and warm seasons (respectively 106 and 25 tonnes). In the cold season, 94% of the total stock size was concentrated at the 3-20m stratum; in the warm season, 76% were found at the 30-80m stratum. These results, according to which the total stock size in the cold season is greater than that in the warm season, are opposed to those obtained by the *Amrigue*. However, considering the 95% confidence interval of the total stock size, the difference between the two seasons is not significant and no conclusions could be drawn. For the same reason, it cannot be said that the results obtained by analyzing the vertical distribution, namely a concentration of resources in the coastal area (3-20m stratum) in the cold season and in the offshore area (30-80m stratum) in the warm season, suggests a seasonal displacement of this species.

(A) Phase 1 cold season
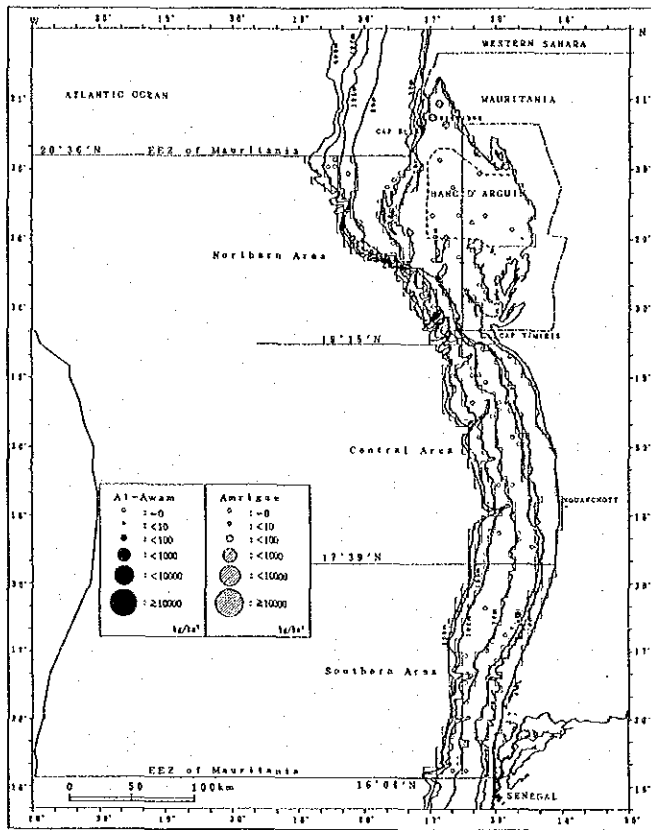
(B) Phase 1 warm season
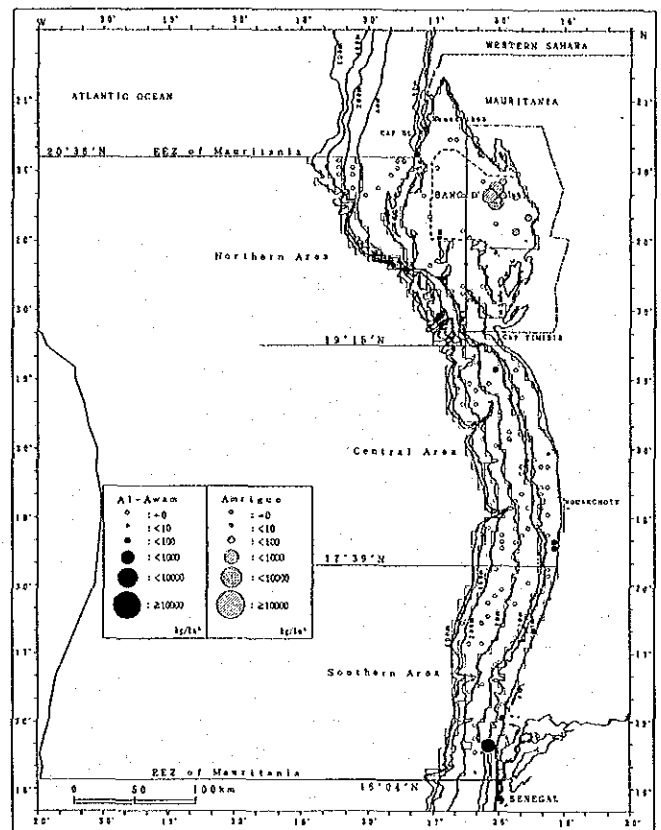
(C) Phase 2 cold season
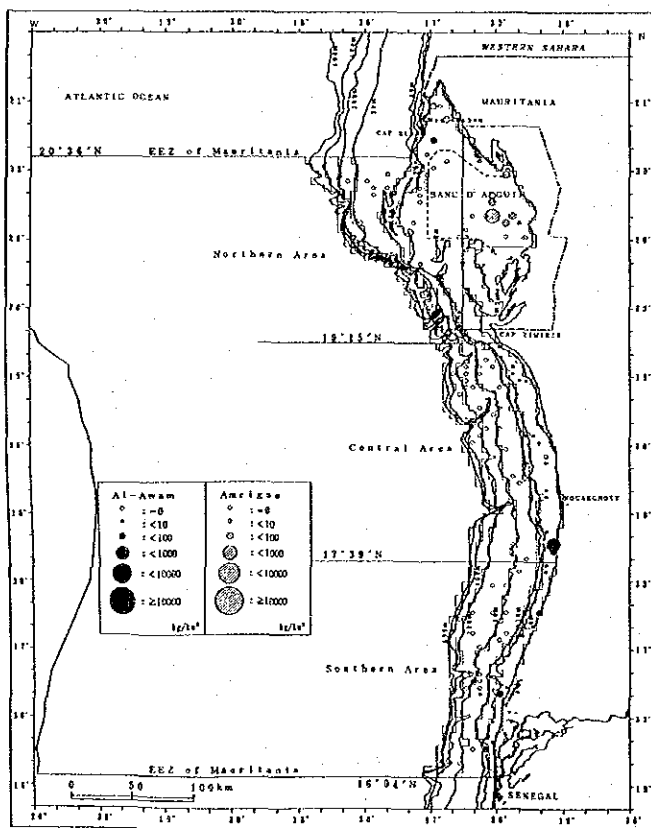
(D) Phase 2 warm season
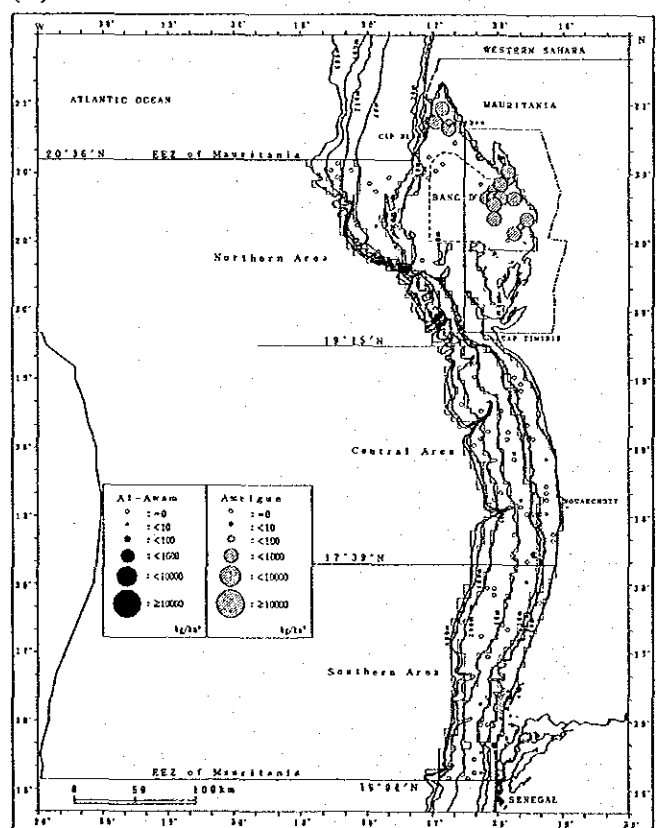
Figure 3.23 Distribution of CPUA for southern pink shrimp *Penaeus notialis* .

Table 3.49 CPUA of southern pink shrimp *Penaeus notialis* by stratum.

(A) *Amrigue* survey area

Northern coastal area (Stratum: 3-20m)	Phase 1						Phase 2					
	Cold season			Warm season			Cold season			Warm season		
	Mean	S. D.	Range	Mean	S. D.	Range	Mean	S. D.	Range	Mean	S. D.	Range
Banc d'Arguin	2.4	4.4	0.0 ~ 13.1	64.3	79.6	0.0 ~ 239.2	20.6	35.8	0.0 ~ 129.3	195.2	141.0	1.7 ~ 438.8
Other	10.2	16.5	0.0 ~ 44.9	7.8	24.5	0.0 ~ 85.2	3.9	11.8	0.0 ~ 44.6	70.5	90.2	0.0 ~ 229.2

(B) *Al-Awam* survey area

Subarea	Stratum	Phase 1						Phase 2					
		Cold season			Warm season			Cold season			Warm season		
		Mean	S. D.	Range	Mean	S. D.	Range	Mean	S. D.	Range	Mean	S. D.	Range
North	3-20m	-	-	-	-	-	-	5.2	13.3	0.0 ~ 35.3	0.0	0.0	0.0 ~ 0.0
	20-30m	0.0	0.0	0.0 ~ 0.0	4.5	6.1	0.0 ~ 12.9	0.3	0.5	0.0 ~ 1.0	0.1	0.1	0.0 ~ 0.3
	30-80m	0.5	1.4	0.0 ~ 3.9	0.0	0.0	0.0 ~ 0.0	0.0	0.0	0.0 ~ 0.0	1.2	3.2	0.0 ~ 9.1
	80-200m	0.0	0.0	0.0 ~ 0.0	0.0	0.0	0.0 ~ 0.0	0.0	0.0	0.0 ~ 0.0	0.0	0.0	0.0 ~ 0.0
	200-400m	0.0	0.0	0.0 ~ 0.0	0.0	0.0	0.0 ~ 0.0	-	-	-	-	0.0	0.0	0.0 ~ 0.0
	400-600m	-	-	-	-	-	-	-	-	-	-	-	-
Central	3-20m	-	-	-	2.5	6.0	0.0 ~ 20.4	20.2	69.5	0.0 ~ 280.5	0.2	0.4	0.0 ~ 1.4
	20-30m	0.3	0.5	0.0 ~ 1.0	0.1	0.1	0.0 ~ 0.3	0.3	0.5	0.0 ~ 1.0	0.7	1.5	0.0 ~ 3.0
	30-80m	0.1	0.5	0.0 ~ 1.8	1.0	3.5	0.0 ~ 12.2	0.0	0.0	0.0 ~ 0.0	4.9	14.0	0.0 ~ 44.7
	80-200m	0.0	0.0	0.0 ~ 0.0	0.0	0.0	0.0 ~ 0.0	0.0	0.0	0.0 ~ 0.0	0.0	0.0	0.0 ~ 0.0
	200-400m	0.0	0.0	0.0 ~ 0.0	0.0	0.0	0.0 ~ 0.0	0.0	0.0	0.0 ~ 0.0	0.0	0.0	0.0 ~ 0.0
	400-600m	-	-	-	0.0	0.0	0.0 ~ 0.0	-	-	-	-	-	-
South	3-20m	-	-	-	20.7	39.5	0.0 ~ 113.2	8.1	7.0	0.0 ~ 20.6	2.1	5.5	0.0 ~ 16.9
	20-30m	1.6	0.8	0.9 ~ 2.5	0.0	0.0	0.0 ~ 0.0	7.7	15.5	0.0 ~ 31.0	1.2	1.4	0.0 ~ 2.6
	30-80m	2.0	5.0	0.0 ~ 15.2	0.2	0.5	0.0 ~ 1.4	0.1	0.2	0.0 ~ 0.6	0.6	1.0	0.0 ~ 2.9
	80-200m	0.0	0.0	0.0 ~ 0.0	0.0	0.0	0.0 ~ 0.0	0.0	0.0	0.0 ~ 0.0	0.0	0.0	0.0 ~ 0.0
	200-400m	0.0	0.0	0.0 ~ 0.0	0.0	0.0	0.0 ~ 0.0	0.0	0.0	0.0 ~ 0.0	0.0	0.0	0.0 ~ 0.0
	400-600m	-	-	-	-	-	-	-	-	-	-	-	-

Remarks. S. D.: standard deviation, - : no trawl.

Table 3.50 Stock size estimates of southern pink shrimp *Penaeus notialis*.

(A) *Amrigue* survey area

Subarea	Stratum	Area in km²	Stock size in tonnes			
			Phase 1		Phase 2	
			Cold season	Warm season	Cold season	Warm season
North	Banc d'Arguin	4,741	12	305	98	925
	3-20m	5,912	60	46	23	417
	Total	10,653	72	351	121	1,342
	95% confidence interval		±61	±270	±105	±615
	CV: coefficient of variation		46%	30%	39%	20%

(B) *Al-Awam* survey area

Subarea	Stratum	Area in km²	Stock size in tonnes			
			Phase 1		Phase 2	
			Cold season	Warm season	Cold season	Warm season
North	3-20m	5,912	-	-	31	0
	20-30m	1,290	0	6	+	+
	30-80m	2,924	1	0	0	4
	80-200m	1,147	0	0	0	0
	200-400m	936	0	0	-	0
	Total	12,209	1	6	31	4
	95% confidence interval		±3	±10	±35	±10
	CV: coefficient of variation		100%	68%	96%	89%
Central	3-20m	2,783	-	7	56	1
	20-30m	835	+	+	+	1
	30-80m	2,870	+	3	0	14
	80-200m	2,767	0	0	0	0
	200-400m	1,453	0	0	0	0
	400-600m	848	-	0	-	-
	Total	8,773	1	10	56	15
	95% confidence interval		±1	±12	±131	±23
	CV: coefficient of variation		74%	52%	86%	84%
South	3-20m	1,485	-	31	12	3
	20-30m	805	1	0	6	1
	30-80m	2,640	5	1	+	2
	80-200m	3,025	0	0	0	0
	200-400m	994	0	0	0	0
	Total	8,949	6	31	18	6
	95% confidence interval		±11	±63	±20	±9
	CV: coefficient of variation		69%	66%	39%	51%
All	3-20m	10,180	-	38	99	4
	20-30m	2,930	1	6	7	2
	30-80m	8,434	7	3	+	19
	80-200m	6,939	0	0	0	0
	200-400m	3,383	0	0	0	0
	400-600m	848	-	0	-	-
	Total	22,534	9	47	106	25
	95% confidence interval		±10	±65	±167	±32
	CV: coefficient of variation		55%	46%	54%	55%

Remarks. - : no trawl, +: less than 1 tonne.

2) Deep-water pink shrimp *Parapenaeus longirostris*

The deep-water pink shrimp is found in the West Atlantic from off the state of Massachusetts (USA) through the Gulf of Mexico and the Caribbean down to off French Guiana. It also occurs in the Mediterranean and in the East Atlantic, from Portugal to Angola, at water depths between 20 and 700m (JAMARC, 1983). The deep-water pink shrimp lives over muddy and sandy/muddy bottom at water depths between 30 and 500m. It is rarely observed at water depths of less than 50m or at the 350 – 400m depth (Crosnier *et* Bondy, 1968).

a) Distribution of CPUA

Figure 3.24 shows the CPUA distribution of the deep-water pink shrimp in each survey season. This species is distributed mainly at water depths over 80m, and higher CPUA was concentrated at the 200-400m stratum. In the Southern area, the deep-water pink shrimp was also distributed at the 30-80m stratum.

In the *Amrigue* survey area, none of this species was caught throughout the survey.

b) CPUA by stratum

Table 3.51 shows the CPUA for the deep-water pink shrimp at each stratum in each area.

In the *Al-Awam* survey area, the highest CPUA was 202 at the 200-400m stratum in the Southern area in the Phase 2 cold season. Also, CPUA of 200 was found at the 200-400m stratum in the Central area in the Phase 1 cold season. The mean CPUA by stratum did not exceed 100 other than in two instances and was below 50 at many strata. Except in the Central area in the Phase 2 cold season, the mean CPUA by stratum had its highest value at the 200-400m stratum in all seasons and areas.

c) Stock size

Table 3.52 shows estimates of the stock size for the deep-water pink shrimp. The total stock size was, in survey order, 351, 232, 359 and 205 tonnes respectively. The total stock size increase slightly in the cold season, but in the past two years the total have stabilized between 200 and 350 tonnes. The 95% confidence interval and CV related to the total stock size was more or less stable, respectively within between ± 106 and ±206 tonnes and between 19 and 22%.

As for the geographical distribution, the Southern area had the highest ratio of the total stock size in all seasons, between 40 and 80%, followed by the Central area (18-41%) and by the Northern area (1-24%). Temporal changes in the stock size in the Northern and Southern areas were in opposition: in the Northern area, the stock size was low in the cold season and high in the warm season, while in the Southern area it was the other way round. In the Central area, the stock size declined over time, but recently it has begun to increase again, even in a quite limited way.

In terms of vertical distribution, the stock size at the 200-400m stratum accounted for 65 and 81% of the total stock size in all seasons except for the Phase 2 cold season. In the latter, the 80-200m stratum made up 51% of the total. In all seasons, the stock size by stratum decreased from deeper to shallower strata. The stock size at the 30-80m and 200-400m strata declined in serial order of survey.

(A) Phase 1 cold season

(B) Phase 1 warm season

(C) Phase 2 cold season

(D) Phase 2 warm season

Figure 3.24 Distribution of CPUA for deep-water pink shrimp *Parapenaeus longirostris* .

Table 3.51　CPUA of deep-water pink shrimp *Parapenaeus longirostris* by stratum.

(A) *Amrigue* survey area

Northern coastal area (Stratum: 3-20m)	Phase 1						Phase 2					
	Cold season			Warm season			Cold season			Warm season		
	Mean	S. D.	Range	Mean	S. D.	Range	Mean	S. D.	Range	Mean	S. D.	Range
Banc d'Arguin	0.0	0.0	0.0 ~ 0.0	0.0	0.0	0.0 ~ 0.0	0.0	0.0	0.0 ~ 0.0	0.0	0.0	0.0 ~ 0.0
Other	0.0	0.0	0.0 ~ 0.0	0.0	0.0	0.0 ~ 0.0	0.0	0.0	0.0 ~ 0.0	0.0	0.0	0.0 ~ 0.0

(B) *Al-Awam* survey area

Subarea	Stratum	Phase 1						Phase 2					
		Cold season			Warm season			Cold season			Warm season		
		Mean	S. D.	Range	Mean	S. D.	Range	Mean	S. D.	Range	Mean	S. D.	Range
North	3-20m	-	-	- ~ -	-	-	- ~ -	0.0	0.0	0.0 ~ 0.0	0.0	0.0	0.0 ~ 0.0
	20-30m	0.0	0.0	0.0 ~ 0.0	0.0	0.0	0.0 ~ 0.0	0.0	0.0	0.0 ~ 0.0	0.0	0.0	0.0 ~ 0.0
	30-80m	0.0	0.0	0.0 ~ 0.0	0.0	0.0	0.0 ~ 0.0	0.0	0.0	0.0 ~ 0.0	0.0	0.0	0.0 ~ 0.0
	80-200m	1.3	1.5	0.0 ~ 3.0	5.2	7.5	0.0 ~ 13.8	8.0	6.9	0.0 ~ 12.1	16.5	19.7	0.0 ~ 38.3
	200-400m	3.5	3.2	1.1 ~ 7.1	53.6	61.5	11.3 ~ 124.1	-	-	- ~ -	26.3	42.0	0.0 ~ 74.7
	400-600m	-	-	- ~ -	-	-	- ~ -	-	-	- ~ -	-	-	- ~ -
Central	3-20m	-	-	- ~ -	0.0	0.0	0.0 ~ 0.0	0.0	0.0	0.0 ~ 0.0	0.0	0.0	0.0 ~ 0.0
	20-30m	0.0	0.0	0.0 ~ 0.0	0.0	0.0	0.0 ~ 0.0	0.0	0.0	0.0 ~ 0.0	0.0	0.0	0.0 ~ 0.0
	30-80m	0.0	0.0	0.0 ~ 0.0	0.0	0.0	0.0 ~ 0.0	+	0.1	0.0 ~ 0.2	0.0	0.0	0.0 ~ 0.0
	80-200m	8.4	10.3	0.0 ~ 25.1	3.1	8.1	0.0 ~ 26.8	18.6	25.5	0.0 ~ 69.0	4.2	11.1	0.0 ~ 29.5
	200-400m	83.3	84.3	2.8 ~ 200.1	37.5	30.6	6.5 ~ 72.3	8.8	16.1	0.0 ~ 32.9	46.5	38.2	14.9 ~ 95.5
	400-600m	-	-	- ~ -	5.1	0.0	5.1 ~ 5.1	-	-	- ~ -	-	-	- ~ -
South	3-20m	-	-	- ~ -	0.0	0.0	0.0 ~ 0.0	0.0	0.0	0.0 ~ 0.0	0.0	0.0	0.0 ~ 0.0
	20-30m	0.0	0.0	0.0 ~ 0.0	0.0	0.0	0.0 ~ 0.0	0.0	0.0	0.0 ~ 0.0	0.0	0.0	0.0 ~ 0.0
	30-80m	8.3	14.3	0.0 ~ 41.8	3.8	6.5	0.0 ~ 17.4	3.8	8.4	0.0 ~ 22.2	2.2	5.4	0.0 ~ 17.2
	80-200m	15.6	27.5	0.0 ~ 76.4	4.5	7.2	0.0 ~ 22.3	40.4	54.7	0.0 ~ 169.1	12.0	13.8	0.6 ~ 38.2
	200-400m	133.5	16.8	121.7 ~ 145.4	85.3	32.6	47.6 ~ 105.3	155.0	75.2	68.3 ~ 202.4	40.6	15.4	23.5 ~ 53.4
	400-600m	-	-	- ~ -	-	-	- ~ -	-	-	- ~ -	-	-	- ~ -

Remarks. S. D.: standard deviation, - : no trawl, +: less than 0.1.

Table 3.52 Stock size estimates of deep-water pink shrimp *Parapenaeus longirostris*.

(A) *Amrigue* survey area

Subarea	Stratum	Area in km²	Stock size in tonnes			
			Phase 1		Phase 2	
			Cold season	Warm season	Cold season	Warm season
North	Banc d'Arguin	4,741	0	0	0	0
	3-20m	5,912	0	0	0	0
	Total	10,653	0	0	0	0
	95% confidence interval		±0	±0	±0	±0
	CV: coefficient of variation		0%	0%	0%	0%

(B) *Al-Awam* survey area

Subarea	Stratum	Area in km²	Stock size in tonnes			
			Phase 1		Phase 2	
			Cold season	Warm season	Cold season	Warm season
North	3-20m	5,912	-	-	0	0
	20-30m	1,290	0	0	0	0
	30-80m	2,924	0	0	0	0
	80-200m	1,147	1	6	9	19
	200-400m	936	3	50	-	25
	Total	12,209	5	56	9	43
	95% confidence interval		±5	±96	±17	±93
	CV: coefficient of variation		42%	60%	50%	60%
Central	3-20m	2,783	-	0	0	0
	20-30m	835	0	0	0	0
	30-80m	2,870	0	0	+	0
	80-200m	2,767	23	8	51	12
	200-400m	1,453	121	54	13	68
	400-600m	848	-	4	-	-
	Total	8,773	144	67	64	79
	95% confidence interval		±112	±52	±46	±60
	CV: coefficient of variation		43%	29%	39%	38%
South	3-20m	1,485	-	0	0	0
	20-30m	805	0	0	0	0
	30-80m	2,640	22	10	10	6
	80-200m	3,025	47	14	122	36
	200-400m	994	133	85	154	40
	Total	8,949	202	108	286	83
	95% confidence interval		±133	±80	±158	±42
	CV: coefficient of variation		18%	19%	25%	24%
All	3-20m	10,180	-	0	0	0
	20-30m	2,930	0	0	0	0
	30-80m	8,434	22	10	10	6
	80-200m	6,939	72	28	183	67
	200-400m	3,383	257	189	167	133
	400-600m	848	-	4	-	-
	Total	22,534	351	232	359	205
	95% confidence interval		±177	±120	±206	±106
	CV: coefficient of variation		20%	19%	21%	22%

Remarks. - : no trawl, +: less than 1 tonne.

3.4.6 Biological findings on target species

The biological data on the target species in this survey were obtained based only on the samples from which biological measurements were taken. Of the 23 target species, biological data on the golden grey mullet *Liza aurata* and the West African geryon *Chaceon (Geryon) maritae* are not presented, as they were not caught.

The data on the size composition of target species were corresponded to the stock size in numbers of those species (see 3.4.5) after standardization by unit area (km²), and extension to the area of each stratum. Those data were obtained mainly by the measuring-card punching method at the trawl stations where the number of individuals captured was sufficient (generally over 100 individuals). For the stations where the number of individuals captured was low, the data on the size composition were based on the body length measurement, one among the multi-item biological measurement. However, whenever the number of individuals captured by both the *Amrigue* and *Al-Awam* was actually insufficient, the multi-item biological measurement did not always occur.

Figures on the size composition of target species were prepared from the data obtained by the *Al-Awam*. For those data, captures achieved with the cod end (nominal mesh sizes: 45 mm, 70 mm and 100 mm) and the covernet (nominal mesh size: 20 mm) were uniformized, that is, the data utilized considered a cod end with a covernet of 20 mm mesh size. Species caught by the *Amrigue* were often (a) not abundant in number and (b) mainly comprising small individuals (juveniles). There was a strong probability of the obtained results not reflecting the actual size compositions of target species in nature, and thus the size composition of the species captured by that vessel was not illustrated. Exceptions was made, however, for the Senegalese sole *Solea senegalensis* and the southern pink shrimp *Penaeus notialis*, which were captured in greater by the *Amrigue* than by the *Al-Awam* and had more or less equivalent sizes between catches by both vessels.

(1) Fishes

Presented below are the biological findings obtained for the 14 target fishes in this survey.

1) Smooth-hound *Mustelus mustelus*

a) Body length range and mean body length

Table 3.53 (page 3-139) presents the minimum, maximum and mean total lengths obtained for the smooth-hound in each survey season and at each stratum in each area.

The total length in this species varied between 420 and 1,122 mm. The mean total length by area was between 620 and 650 mm in the cold season (area surveyed by the *Amrigue* in Phase 1 and the Northern area surveyed by the *Al-Awam* in Phase 2) and between 670 and 900 mm in the warm season (area surveyed by the *Al-Awam* in both Phases). The mean total length by area in the warm season was higher in the Southern area than in the Northern area. The mean total length by stratum obtained in the Northern area in the Phase 2 warm season was small (622 mm) in the shallower stratum (3-20 m) and increases with depth, attaining 880 mm in the 80-200 m stratum.

b) Size composition

Figure 3.25 (page 3-136, 3-140 to 3-142) presents the evaluation of the size composition for the smooth-hound stock. The total length class is indicated at intervals of 2 cm. To analyze the characteristic of

this composition, three groups were defined: (i) small-size (total length less than 60 cm), (ii) medium-size (length between 60 and 80 cm), (iii) large-size (length over 80 cm).

For all seasons, the majority of captured individuals were the medium-size. For the Phase 1 warm season, the dominant mode in the medium-size group was on the right half (70-80 cm) while in Phase 2, the dominant mode was on the left half (60-70 cm). Frequency of the large-size individuals was accentuated in the Phase 1 warm season, but low in the other seasons. As for the small-size individuals, some with a total length of less than 50 cm occurred in the warm season, particularly in Phase 2 (dominant mode at 42-44 cm class).

The smooth-hound is a viviparous species and the juveniles measure about 40 cm upon birth (Fish Base database: http://www.fishbase.org, hereinafter referred to as Fish Base). The small-size individuals observed in this warm season were thus very young larvae or juveniles.

Examining the size composition at each stratum in each area, one realizes the larvae and juveniles only appeared in the waters shallower than 20 m in the Northern area, which suggests the importance of that region as a nursery ground for this species. Also, if the large-size individuals appear simultaneously in the Northern and Southern areas, they predominate in the Southern area. The size composition at each stratum in the Northern area in the Phase 2 warm season shows the dominant mode displacing towards the right, or towards large-size, the deeper it becomes.
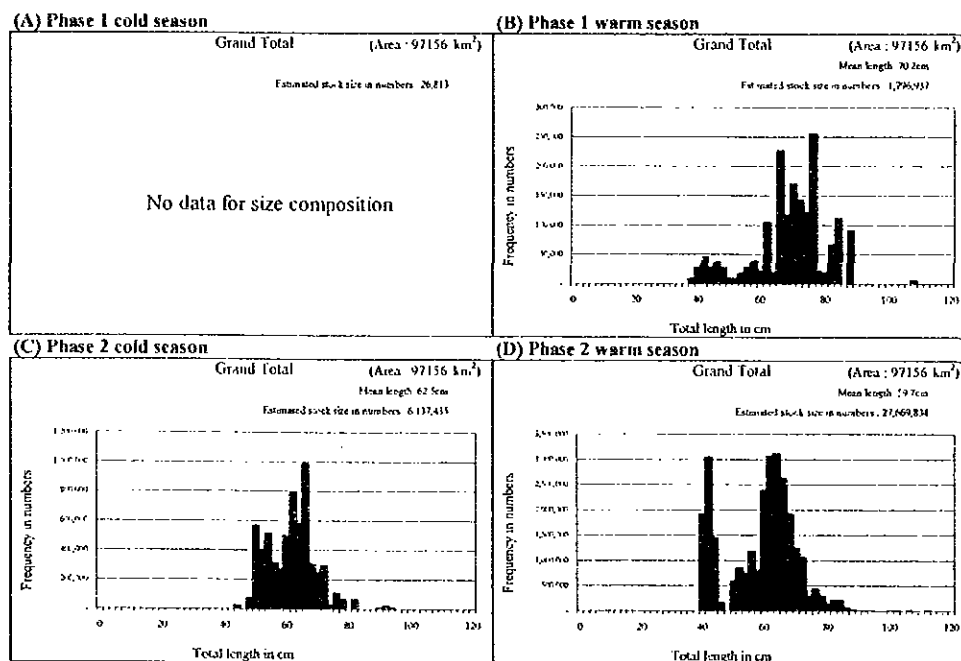
Figure 3.25   Size composition for smooth-hound *Mustelus mustelus*.

c) Length-weight relationship

Figure 3.26 presents the relationship between the total length and body weight for the smooth-hound. The length-weight equations obtained from all samples were the following:

Phase 1 cold season	: BW=	$1.150 \times 10^{-1} \times TL^{3.799}$	(r=0.9003)
Phase 1 warm season	: BW=	$2.695 \times 10^{-3} \times TL^{3.073}$	(r=0.9682)
Phase 2 cold season	: BW=	$1.585 \times 10^{-2} \times TL^{2.621}$	(r=0.9432)
Phase 2 warm season	: BW=	$1.558 \times 10^{-3} \times TL^{3.192}$	(r=0.9820)

where, BW : body weight (g), TL : total length (cm) and r : the coefficient of correlation.
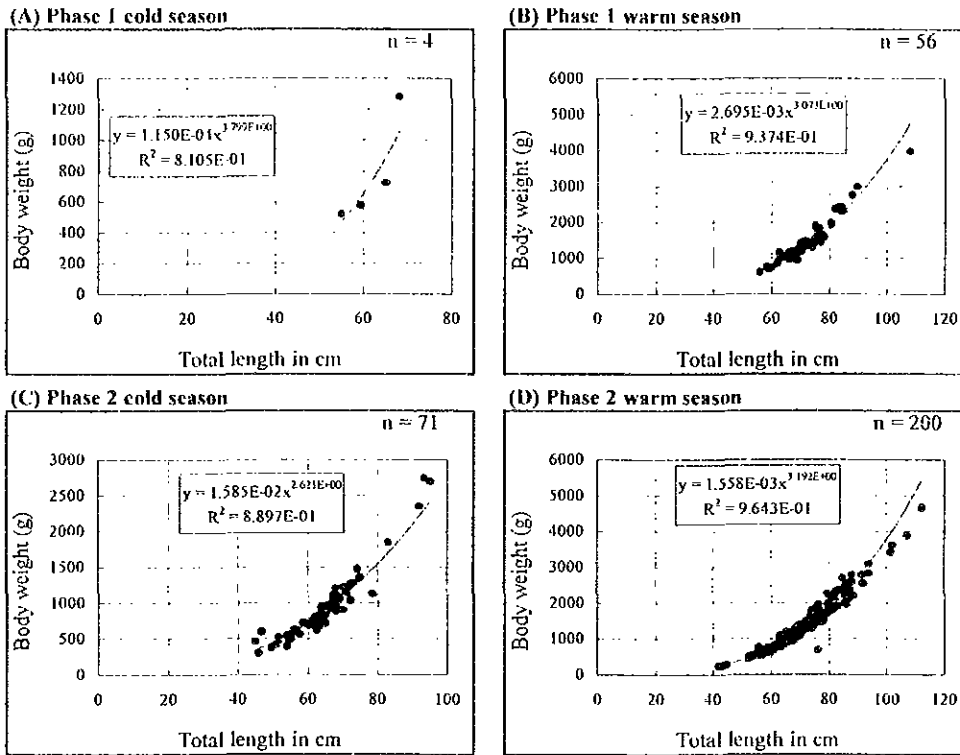
Figure 3.26   Length-weight relationship for smooth-hound *Mustelus mustelus*.

d) Length and weight by sex

Table 3.54 (page 3-143) summarizes the total length and body weight observed in each sex for the smooth-hound. In the cold season, except for the area surveyed by the *Amrigue*, females had a total length approximately 2 cm greater than that of males and a mean body weight approximately 160 g greater as well. Conversely, in the warm season, males were larger than females. In particular, in Phase 1, they are on the average approximately 3 cm and 80 g longer and heavier than females. In any case, the mean-size males and females are larger in the warm season than in the cold season.

e) Sex ratio and female maturity stage

Table 3.55 (3-144) summarizes the sex ratio and the female maturity stage in the smooth-hound.

Figure 3.27 (page 3-145) presents their distribution by length class.

For all seasons (except for the Phase 1 cold season, where data were too few), the overall sex ratio was respectively 0.33, 0.73 and 0.98 with the change of surveys. This proportion therefore shifts from a dominance of females to equilibrium between the two sexes. Geographical and vertical characteristics of the sex ratio were studied in the Phase 2 warm season, where data were relatively numerous. The sex ratio in this species was 0.80 in the Northern area and 19.00 in the Southern area. However, data are not very abundant in the Southern area, where males are mostly dominant, to allow for definitive conclusions. The sex ratio by stratum did not depend on depth and the each stratum does not seem to deviate much from the equilibrium (1.0).

A fully mature smooth-hound female should be at maturity stage III: in a viviparous species, stages I and II correspond to the maturity of eggs and stage III to the formation of a fetus. The ratio of mature females was 0% in the cold season (in the area surveyed by the *Amrigue* in Phase 1, a single female was observed and was not included in this analysis) and between 10 and 56% in the warm season (a higher ratio in Phase 2). The smooth-hound gives birth during warm season.

The sex ratio by length class and the female maturity stage were mainly studied in the Phase 2 warm season, where data were most numerous. The females were dominant in the 70-80 cm length class, but in other classes, the males were dominant, particularly for the total length longer than 90 cm, a class where no female was included. Conversely, in the Phase 2 cold season, all individuals with total length over 80 cm were females. In order to determine if the size-dependent change of the sex ratio is seasonal, more data will be needed. The total length at first maturity was approximately 60 cm, and the majority of females over 70 cm were mature.

f) Feeding habits

Table 3.56 (page 3-146) presents the stomach condition and the stomach content composition of the smooth-hound in each survey season. Figure 3.28 (page 3-147) presents the relationship between body length, stomach content somatic index (SSI*) and stomach content weight (SCW) from all data obtained in the course of the survey. The stomach content composition was analyzed by the occurrence method, extended for all target species.

The ratio of the empty stomachs was 19% in the Phase 2 cold season, and below 3% in all other seasons.

On the body length-SSI relationship, excepting SSI values above 30 observed for the total length over 80 cm, the maximum SSI values for each length class were distributed over a descending curve, meaning that SSI increased as total length decreased. Also, on the body length-SCW relationship, the highest SCW value for each length class were distributed over an ascending curve, therefore SCW increases with total length. This would mean that the large-size individuals do indeed eat much food, but also that the small-size individuals, with a high stomach content/total weight proportion, are voracious eaters for their size.

The smooth-hound was found to feed mainly crustaceans (many crabs and anomuras) but also fishes (in the warm season, engraulids, sardinellas, horse mackerels, Lusitanian sole, etc.). In the Phase 1 cold season, smooth-hound stomachs revealed great quantities of Sipunculoidea.

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*SSI= (SCW/SW) x 10^3; SW=BW-(SCW+GW+HW)
where SW=sarcous weight (g), BW=body weight (g), GW=gonad weight (g), and HW=hepatic weight (g).

Table 3.53 Body length range and mean body length for smooth-hound *Mustelus mustelus* : TL in mm.

(A) *Amrigue* survey area

Northern coastal area (Stratum: 3-20m)	Phase 1						Phase 2					
	Cold season			Warm season			Cold season			Warm season		
	Specimens	Range	Mean	Specimens	Range	Mean	Specimens	Range	Mean	Specimens	Range	Mean
Banc d'Arguin	3	593 ~ 682	641.3	0			0			0		
Other	1	550	550.0	0			0			0		
All area	4	550 ~ 682	618.5	0			0			0		

(B) *Al-Awam* survey area

Subarea	Stratum	Phase 1						Phase 2					
		Cold season			Warm season			Cold season			Warm season		
		Specimens	Range	Mean	Specimens	Range	Mean	Specimens	Range	Mean	Specimens	Range	Mean
North	3-20m	-	-	-	-	-	-	65	448 ~ 934	635.5	80	420 ~ 850	621.7
	20-30m	0			50	560 ~ 896	719.0	0			40	523 ~ 824	651.9
	30-80m	0			0			6	640 ~ 950	756.2	59	556 ~ 880	734.3
	80-200m	0			0			0			1	880	880.0
	200-400m	0			0			-	-	-	0		
	400-600m	-	-	-	-	-	-	-	-	-	-	-	-
	3-600m	0			50	560 ~ 896	719.0	71	448 ~ 950	645.7	180	420 ~ 880	666.8
Central	3-20m	-	-	-	0			0			0		
	20-30m	0			0			0			0		
	30-80m	0			0			0			0		
	80-200m	0			0			0			0		
	200-400m	0			0			0			0		
	400-600m	-	-	-	0			-	-	-	-	-	-
	3-600m	0			0			0			0		
South	3-20m	-	-	-	0			0			0		
	20-30m	0			0			0			0		
	30-80m	0			6	738 ~ 1,080	820.7	0			20	730 ~ 1,122	900.1
	80-200m	0			0			0			0		
	200-400m	0			0			0			0		
	400-600m	-	-	-	-	-	-	-	-	-	-	-	-
	3-600m	0			6	738 ~ 1,080	820.7	0			20	730 ~ 1,122	900 1

Remark. - : no trawl.

Figure3.25 (B) continued.
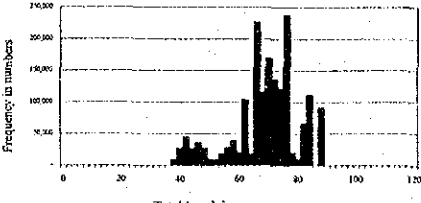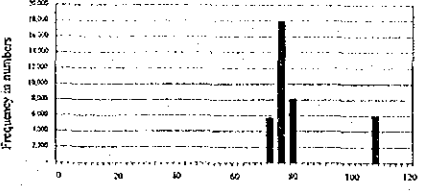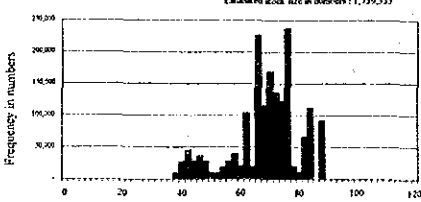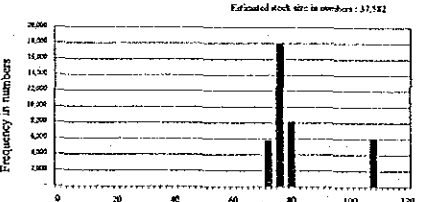
North 3-20m (Area : 5912 km²)	Central 3-20m (Area : 2783 km²)	South 3-20m (Area : 1485 km²)
No trawl	No catch	No catch

North 20-30m (Area : 1290 km²)
Mean length 69.9cm
Estimated stock size in numbers : 1,719,932

Central 20-30m (Area : 835 km²)

No catch

South 20-30m (Area : 805 km²)

No catch

North 30-80m (Area : 2924 km²)
Estimated stock size in numbers : 39,422

No data for size composition

Central 30-80m (Area : 2870 km²)

No catch

South 30-80m (Area : 2640 km²)
Mean length 82.3cm
Estimated stock size in numbers : 37,582

North 80-200m (Area : 1147 km²)	Central 80-200m (Area : 2767 km²)	South 80-200m (Area : 3025 km²)
No catch	No catch	No catch

North 200-400m (Area : 936 km²)	Central 200-400m (Area : 1453 km²)	South 200-400m (Area : 994 km²)
No catch	No catch	No catch

North 400-600m (Area : 738 km²)	Central 400-600m (Area : 848 km²)	South 400-600m (Area : 583 km²)
No trawl	No catch	No trawl

North Total (Area : 17688 km²)
Mean length 69.9cm
Estimated stock size in numbers : 1,759,355

Central Total (Area : 29244 km²)

No catch

South Total (Area : 21088 km²)
Mean length 82.3cm
Estimated stock size in numbers : 37,582

Mustelus mustelus / Al-Awam / 1 W

Figure3.25 (C) continued.

North 3-20m (Area : 5912 km²) Mean length: 62.4cm Estimated stock size in numbers : 6,012,398	Central 3-20m (Area : 2783 km²) Estimated stock size in numbers : 7,953	South 3-20m (Area : 1485 km²) Estimated stock size in numbers : 4,749
	No data for size composition	No data for size composition
North 20-30m (Area : 1290 km²)	Central 20-30m (Area : 835 km²)	South 20-30m (Area : 805 km²)
No catch	No catch	No catch
North 30-80m (Area : 2924 km²) Mean length: 76.0cm Estimated stock size in numbers : 52,336	Central 30-80m (Area : 2870 km²)	South 30-80m (Area : 2640 km²)
	No catch	No catch
North 80-200m (Area : 1147 km²)	Central 80-200m (Area : 2767 km²)	South 80-200m (Area : 3025 km²)
No catch	No catch	No catch
North 200-400m (Area : 936 km²)	Central 200-400m (Area : 1453 km²)	South 200-400m (Area : 994 km²)
No trawl	No catch	No catch
North 400-600m (Area : 738 km²)	Central 400-600m (Area : 848 km²)	South 400-600m (Area : 583 km²)
No trawl	No trawl	No trawl
North Total (Area : 17688 km²) Mean length: 62.5cm Estimated stock size in numbers : 6,328,733	Central Total (Area : 29244 km²) Estimated stock size in numbers : 7,953	South Total (Area : 21088 km²) Estimated stock size in numbers : 4,749
	No data for size composition	No data for size composition

Mustelus mustelus / Al-Awam / 2C

Figure3.25 (D) continued.

North 3-20m (Area : 5912 km²)
Mean length: 57.1cm
Estimated stock size in numbers : 20,810,247

Central 3-20m (Area : 2783 km²)

No catch

South 3-20m (Area : 1485 km²)

No catch

North 20-30m (Area : 1290 km²)
Mean length: 65.7cm
Estimated stock size in numbers : 5,607,823

Central 20-30m (Area : 835 km²)

No catch

South 20-30m (Area : 805 km²)

No catch

North 30-80m (Area : 2924 km²)
Mean length: 72.6cm
Estimated stock size in numbers : 1,739,740

Central 30-80m (Area : 2870 km²)

No catch

South 30-80m (Area : 2640 km²)
Mean length: 90.3cm
Estimated stock size in numbers : 105,141

North 80-200m (Area : 1147 km²)
Mean length: 89.6cm
Estimated stock size in numbers : 6,884

Central 80-200m (Area : 2767 km²)

No catch

South 80-200m (Area : 3025 km²)

No catch

North 200-400m (Area : 936 km²)

No catch

Central 200-400m (Area : 1453 km²)

No catch

South 200-400m (Area : 991 km²)

No catch

North 400-600m (Area : 738 km²)

No trawl

Central 400-600m (Area : 848 km²)

No trawl

South 400-600m (Area : 583 km²)

No trawl

North Total (Area : 17688 km²)
Mean length: 59.6cm
Estimated stock size in numbers : 27,564,693

Central Total (Area : 29214 km²)

No catch

South Total (Area : 21088 km²)
Mean length: 90.3cm
Estimated stock size in numbers : 105,141

Mustelus mustelus / Al-Awam / 2W

Table 3.54   Body length and weight by sex for smooth-hound *Mustelus mustelus*.

(A) *Amrigue* survey area

Phase	Season	Sex	Individuals of specimens	Total length in mm Range	Mean	Body weight in g Range	Mean
1	Cold	Male	3	550 ~ 649	597.3	520.0 ~ 720.0	605.0
		Female	1	682	682.0	1,280.0	1,280.0
		Indeterminate	0				
		Total	4	550 ~ 682	618.5	520.0 ~ 1,280.0	773.8
	Warm	Male	0				
		Female	0				
		Indeterminate	0				
		Total	0				
2	Cold	Male	0				
		Female	0				
		Indeterminate	0				
		Total	0				
	Warm	Male	0				
		Female	0				
		Indeterminate	0				
		Total	0				

(B) *Al-Awam* survey area

Phase	Season	Sex	Individuals of specimens	Total length in mm Range	Mean	Body weight in g Range	Mean
1	Cold	Male	0				
		Female	0				
		Indeterminate	0				
		Total	0				
	Warm	Male	14	630 ~ 1,080	754.2	980.0 ~ 3,965.0	1,568.6
		Female	42	560 ~ 896	721.8	620.0 ~ 2,990.0	1,484.6
		Indeterminate	0				
		Total	56	560 ~ 1,080	729.9	620.0 ~ 3,965.0	1,505.6
2	Cold	Male	30	496 ~ 750	635.8	380.0 ~ 1,480.0	838.3
		Female	41	448 ~ 950	653.0	300.0 ~ 2,740.0	1,000.5
		Indeterminate	0				
		Total	71	448 ~ 950	645.7	300.0 ~ 2,740.0	932.0
	Warm	Male	99	428 ~ 1,122	695.5	235.0 ~ 4,670.0	1,273.7
		Female	101	420 ~ 880	684.8	225.0 ~ 2,580.0	1,273.5
		Indeterminate	0				
		Total	200	420 ~ 1,122	690.1	225.0 ~ 4,670.0	1,273.6

Table 3.55   Sex ratio and female maturity stage for smooth-hound *Mustelus mustelus*.

(A)*Amrigue* survey area

Northern coastal area (Stratum: 3-20m)	Phase 1 cold season							Phase 1 warm season							Phase 2 cold season							Phase 2 warm season						
	Specimens		Sex ratio	♀ : maturity stage* (%)				Specimens		Sex ratio	♀ : maturity stage* (%)				Specimens		Sex ratio	♀ : maturity stage* (%)				Specimens		Sex ratio	♀ : maturity stage* (%)			
	♀	♂	(♂/♀)	I	II	III	IV	♀	♂	(♂/♀)	I	II	III	IV	♀	♂	(♂/♀)	I	II	III	IV	♀	♂	(♂/♀)	I	II	III	IV
Banc d'Arguin	1	2	2.00	0.0	0.0	100.0	0.0	0	0	E					0	0	E					0	0	E				
Other	0	1	E					0	0	E					0	0	E					0	0	E				
All area	1	3	3.00	0.0	0.0	100.0	0.0	0	0	E					0	0	E					0	0	E				

(B)*Al-Awam* survey area

Subarea	Stratum	Phase 1 cold season							Phase 1 warm season							Phase 2 cold season							Phase 2 warm season						
		Specimens		Sex ratio	♀ : maturity stage* (%)				Specimens		Sex ratio	♀ : maturity stage* (%)				Specimens		Sex ratio	♀ : maturity stage* (%)				Specimens		Sex ratio	♀ : maturity stage* (%)			
		♀	♂	(♂/♀)	I	II	III	IV	♀	♂	(♂/♀)	I	II	III	IV	♀	♂	(♂/♀)	I	II	III	IV	♀	♂	(♂/♀)	I	II	III	IV
North	3-20m	-	-	-	-	-	-	-	-	-	-	-	-	-	-	36	29	0.81	66.7	30.6	0.0	2.8	44	36	0.82	45.5	15.9	38.6	0.0
	20-30m	0	0	E					41	9	0.22	22.0	68.3	9.8	0.0	0	0	E					15	25	1.67	40.0	6.7	53.3	0.0
	30-80m	0	0	E					0	0	E					5	1	0.20	100.0	0.0	0.0	0.0	41	18	0.44	14.6	7.3	78.0	0.0
	80-200m	0	0	E					0	0	E					0	0	E					0	1	E				
	200-400m	0	0	E					0	0	E					-	-	-	-	-	-	-	0	0	E				
	400-600m	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	All stratum	0	0	E					41	9	0.22	22.0	68.3	9.8	0.0	41	30	0.73	70.7	26.8	0.0	2.4	100	80	0.80	32.0	11.0	57.0	0.0
Central	3-20m	-	-	-	-	-	-	-	0	0	E					0	0	E					0	0	E				
	20-30m	0	0	E					0	0	E					0	0	E					0	0	E				
	30-80m	0	0	E					0	0	E					0	0	E					0	0	E				
	80-200m	0	0	E					0	0	E					0	0	E					0	0	E				
	200-400m	0	0	E					0	0	E					0	0	E					0	0	E				
	400-600m	-	-	-	-	-	-	-	0	0	E					-	-	-	-	-	-	-	-	-	-	-	-	-	-
	All stratum	0	0	E					0	0	E					0	0	E					0	0	E				
South	3-20m	-	-	-	-	-	-	-	0	0	E					0	0	E					0	0	E				
	20-30m	0	0	E					0	0	E					0	0	E					0	0	E				
	30-80m	0	0	E					1	5	5.00	100.0	0.0	0.0	0.0	0	0	E					1	19	19.00	100.0	0.0	0.0	0.0
	80-200m	0	0	E					0	0	E					0	0	E					0	0	E				
	200-400m	0	0	E					0	0	E					0	0	E					0	0	E				
	400-600m	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	All stratum	0	0	E					1	5	5.00	100.0	0.0	0.0	0.0	0	0	E					1	19	19.00	100.0	0.0	0.0	0.0
All	3-20m	-	-	-	-	-	-	-	0	0	E					36	29	0.81	66.7	30.6	0.0	2.8	44	36	0.82	45.5	15.9	38.6	0.0
	20-30m	0	0	E					41	9	0.22	22.0	68.3	9.8	0.0	0	0	E					15	25	1.67	40.0	6.7	53.3	0.0
	30-80m	0	0	E					1	5	5.00	100.0	0.0	0.0	0.0	5	1	0.20	100.0	0.0	0.0	0.0	42	37	0.88	16.7	7.1	76.2	0.0
	80-200m	0	0	E					0	0	E					0	0	E					0	1	E				
	200-400m	0	0	E					0	0	E					0	0	E					0	0	E				
	400-600m	-	-	-	-	-	-	-	0	0	E					-	-	-	-	-	-	-	-	-	-	-	-	-	-
	All stratum	0	0	E					42	14	0.33	23.8	66.7	9.5	0.0	41	30	0.73	70.7	26.8	0.0	2.4	101	99	0.98	32.7	10.9	56.4	0.0

Remarks. * I: Immature, II: Semi-mature, III: Mature, IV: Spent. -: no trawl. E: Error. blank: no data.
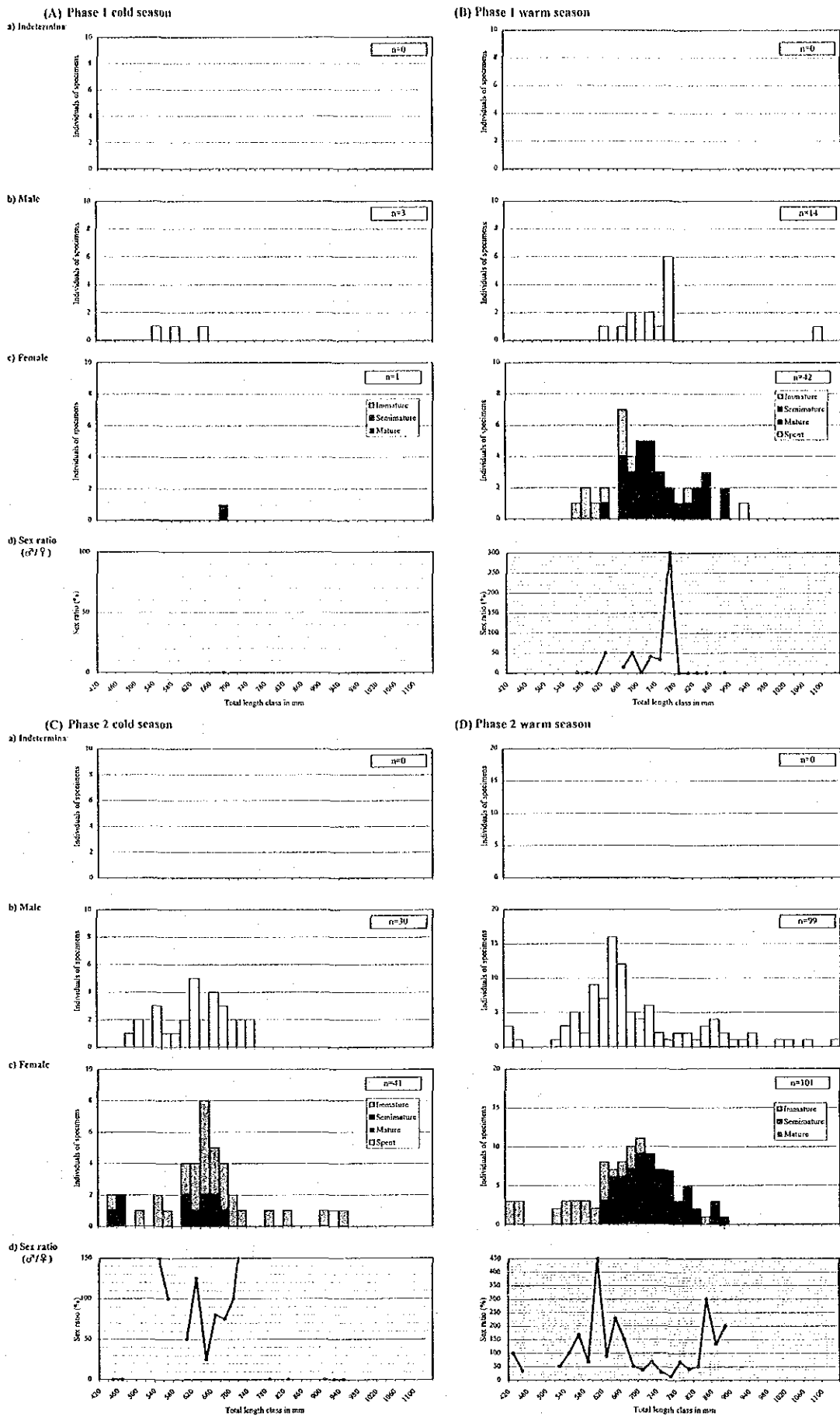
**Figure 3.27   Sex ratio and female maturity stage by length class
for smooth-hound *Mustelus mustelus*.**

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Table 3.56 Stomach content analysis of smooth-hound *Mustelus mustelus*.

(A) Stomach condition

Phase	Season	Stomach condition				Stomach content Somatic Index (SSI)			
		n*	Empty (%)	Evert (%)	Feeding (%)	n*	Min.	Max.	Mean
1	Cold	4	0.00	0.00	100.00	4	23.08	39.06	30.92
	Warm	56	1.79	0.00	98.21	56	0.00	51.28	21.27
2	Cold	70	18.57	0.00	81.43	70	0.00	59.57	14.25
	Warm	200	3.00	0.00	97.00	199	0.00	69.12	16.55

(B) Stomach content composition

Phase	Season	n*	Sipunculoidea	Mollusca					Polychaeta
				Gastropoda	Bivalvia	Decapoda	Octopoda	Other	
1	Cold	4	25.00						
	Warm	55						1.82	
2	Cold	57							
	Warm	185		1.08	1.08	1.08	1.08		3.24

(Continued)

Phase	Season	Echiuroidea	Crustacea					
			Stomatopoda	Crab	Galatheidae	Anomura	Shrimp	Other
1	Cold							25.00
	Warm		3.64	23.64			9.09	30.91
2	Cold		1.75	52.63		1.75	7.02	3.51
	Warm	0.54		42.70	0.54	38.38	14.05	9.19

(Continued)

Phase	Season	Fish					Unknown
		Engraulidae sp.	*Sardinella* sp.	*Trachurus* sp.	*Microchirus boscanion*	Other	
1	Cold						50.00
	Warm					18.18	29.09
2	Cold			1.75		14.04	28.07
	Warm	0.54	0.54		0.54	10.81	2.16

*: Individuals of specimens

(A) Relationship between total length and SSI
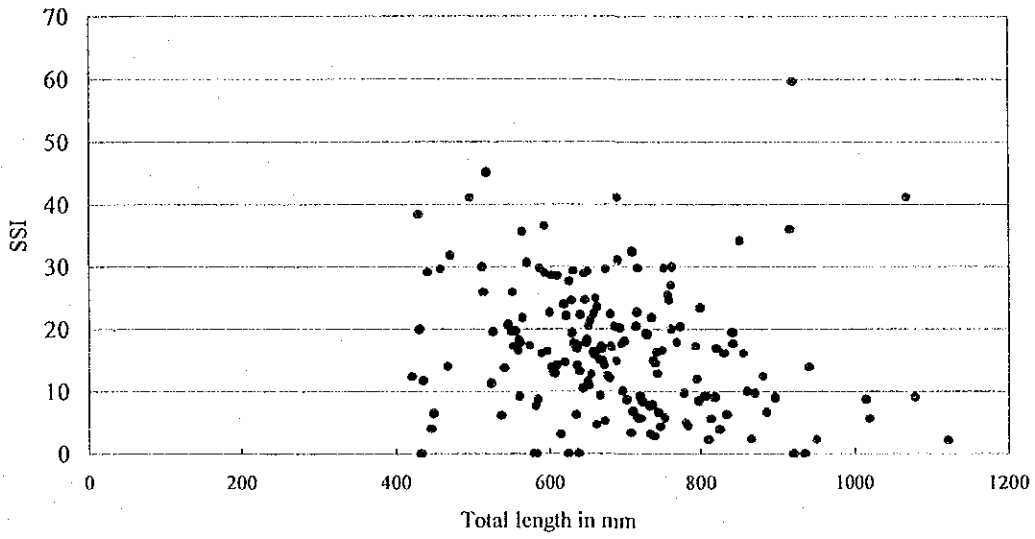
(B) Relationship between total length and SCW
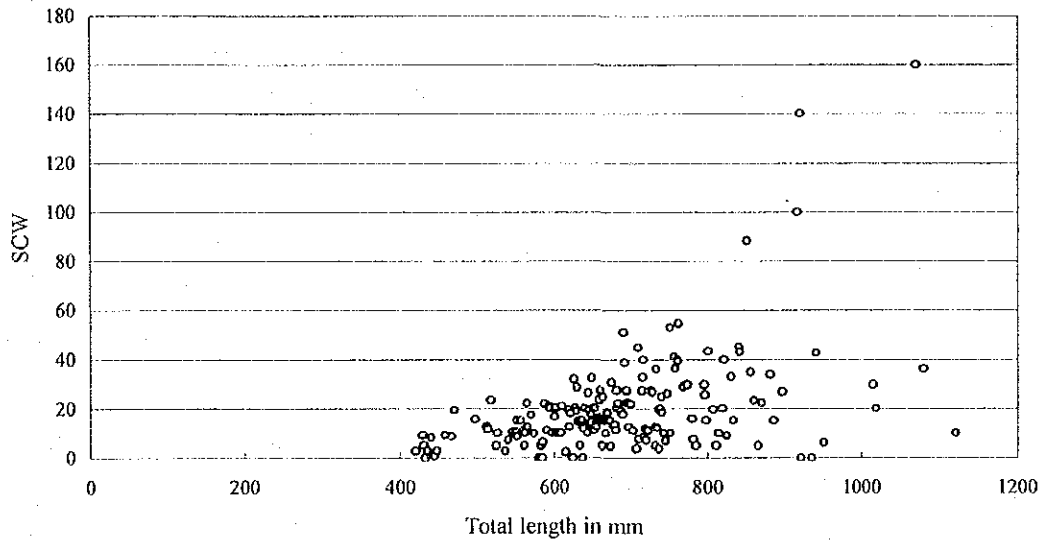
Figure 3.28 Relationship between body length and SSI (A) and SCW (B)
for smooth-hound *Mustelus mustelus*.

2) Senegalese hake *Merluccius senegalensis*

It has been explained in Section 3.4.5 items (1), 2) that the data for the Senegalese hake in all likelihood include also those for the Benguela hake *Merluccius polli* in Phase 1, but that, since each of the two species was carefully sorted in Phase 2, it was possible to obtain accurate information on each of them.

Therefore, the unreliable results of Phase 1 were discarded, and the biological findings for this species was based only on the results of Phase 2. For reference purposes, the biological findings for the Benguela hake are also shown. Also to be noted that, if the biological findings on the two species in Phase 1 are not described, results of their analysis are indicated in tables and figures.

a) Body length range and mean body length

Tables 3.57.1 (page 3-154) and 3.57.2 (page 3-155) show the minimum, maximum and mean total lengths obtained for the Senegalese hake and the Benguela hake in each survey season and at each stratum in each area.

The total length of the Senegalese hake varied between 100 and 700 mm. The geographic dependent change of the mean length by area was observed according to the season. In the cold season, the mean length increased from the Northern area to the Southern area (263→330→334 mm), while in the warm season it decreased from north to south (354→318→287 mm). Also, the mean length by stratum depended only on depth and not on the area or season. It was small in shallow strata and increased with depth: for instance, from the 30-80 m to the 200-400 m strata in the Central area in the cold season, it varied in the direction 154→276→453 mm.

The total length of the Benguela hake varied between 49 and 525 mm. The mean length by area and by stratum was both inferior to those of the Senegalese hake. As in the case of that species, the mean length by area and by stratum depended on geographical position and on depth respectively (the former only in the warm season).

b) Size composition

Figures 3.29.1 (page 3-149, 3-156 to 3-159) and 3.29.2 (page 3-150, 3-160 and 3-161) illustrate the evaluation of the size composition for both stocks of the Senegalese hake and the Benguela hake. The total length class is indicated at intervals of 2 cm. According to the Fish Base, the maximum total length for both species is approximately 80 cm. Since the size for both species were often of the same order, defining the following groups shows the size composition characteristics: (i) small-size (total length less than 20 cm), (ii) medium-size (length between 20 and 40 cm), (iii) large-size (length over 40 cm).

The medium-size group mostly form the overall stock in number of Senegalese hake. However, within their group, the dominant mode is located at the 26-28 cm class in the cold season, and at the 34-36 cm class in the warm season. In both seasons, the dominant mode in the medium-size group strongly reflects the dominant mode among the stock in the Northern area. Those two dominant modes suggest a growth of the medium-size group mainly composed of this species stock in number during the transitional period between seasons. The Small-size group was observed in the cold season at the 30-80 m stratum in the Central and Southern areas and, in the warm season, at the 80-200 m stratum in the Central area (with a few also at the same stratum in the Southern area). These results indicate the importance of those areas as nursing grounds

for the Senegalese hake. Regardless of season or area, the large-size group occurred mainly at the 200-400 m stratum, except in the Northern area in the cold season.

By area and by stratum, the dominant or main mode classes in the size composition were displaced to the right as depth increased (except in the Northern area). This phenomenon was more acute in the cold season.
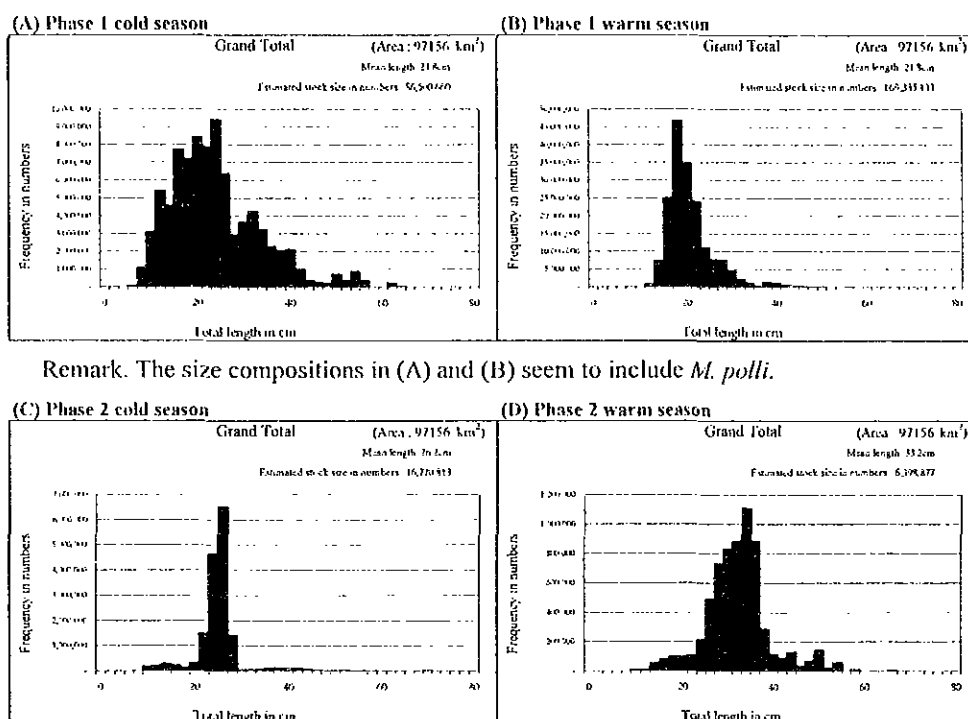
Remark. The size compositions in (A) and (B) seem to include *M. polli*.

Figure 3.29.1 Size composition for Senegalese hake *Merluccius senegalensis*.

The overall stock in number of Benguela hake was mainly composed of the small-size and medium-size groups. In the cold season, the small-size group with the dominant mode at the 4-6 cm class was mainly observed; but there were also some medium-size group with the dominant mode at 28-30 cm class and a few large-size group. The 4-6 cm class of the dominant mode for the small-size group corresponded to very small larvae (in a little while after hatching), so it is likely that its spawning period is in winter time (a month before April). In the warm season, the overall size composition exhibited a mono-modal distribution, with a mode at the 20-22 cm class. This mode suggested a growth of the small-size group in the cold season during the transitional period.

Analyzing the size composition at each stratum in each area, it can be seen that in the cold season, the small-size group strongly reflected the stock in number of the Southern area, particularly at the 30-80 m stratum. In the cold season, the small-size group was also distributed at the two strata between 30 and 200 m depth in the Northern and Central areas.

Distribution of the medium-size and the large-size groups was limited to the 80-200 m and 200-400 m strata in the Central area. In the warm season, the size compositions at each stratum in each area strongly suggested the growth of the small-size group in the cold season during the transitional period.
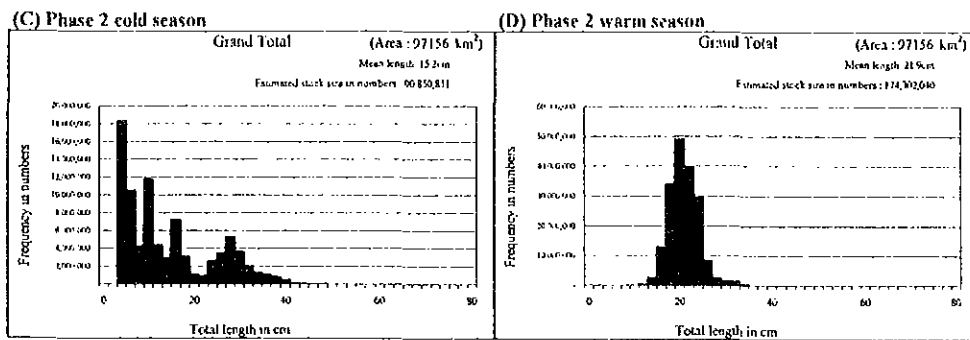
Figure 3.29.2 Size composition for Benguela hake *Merluccius polli.*

c) Length-weight relationship

Figure 3.30.1 presents the length-weight relationship in each survey season for the Senegalese hake. The length-weight equations obtained from all samples were the following:

Phase 2 cold season   : $BW = 9.294 \times 10^{-3} \times TL^{2.936}$ (r=0.9912)

Phase 2 warm season   : $BW = 9.666 \times 10^{-3} \times TL^{2.931}$ (r=0.9878)

where, BW : body weight (g), TL : total length (cm) and r : the coefficient of correlation.
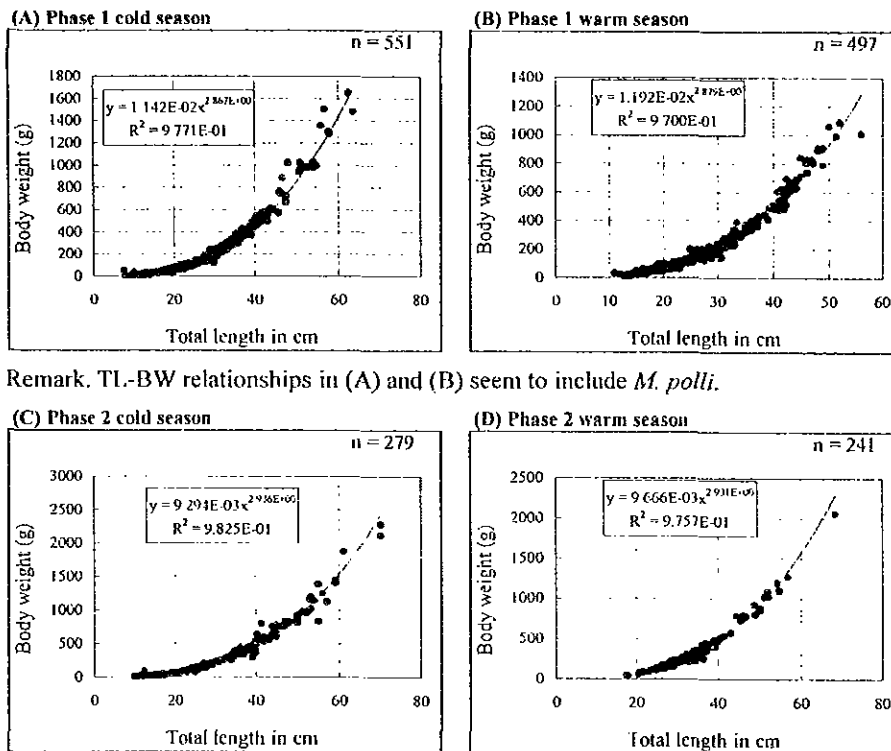
Remark. TL-BW relationships in (A) and (B) seem to include *M. polli.*

Figure 3.30.1 Length-weight relationship for Senegalese hake *Merluccius senegalensis.*

Figure 3.30.2 presents the length-weight relationship in each survey season for the Benguela hake. The

length-weight equations were:

Phase 2 cold season   : BW= 1.709×10^{-2}×TL$^{2.739}$ (r=0.9960)

Phase 2 warm season   : BW= 7.135×10^{-3}×TL$^{3.020}$ (r=0.9867)

where, BW : body weight (g), TL : total length (cm) and r : the coefficient of correlation.

(C) Phase 2 cold season   n = 263

(D) Phase 2 warm season   n = 300
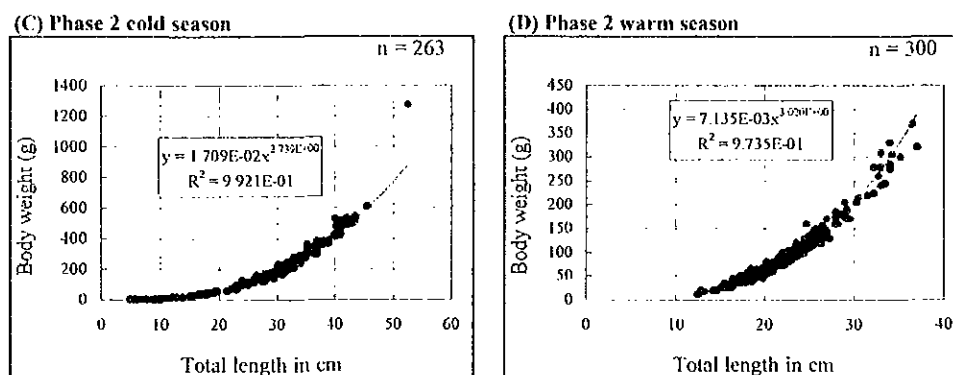
Figure 3.30.2 Length-weight relationship for Benguela hake *Merluccius polli*.

d) Length and weight by sex

Tables 3.58.1 and 3.58.2 (page 3-162 respectively) summarize the total length and body weight observed in each sex for the Senegalese hake and the Benguela hake.

In the cold season as in the warm season, females of the Senegalese hake were larger than males. The size difference between males and females was particularly strong in the cold season, the mean length and mean weight of females surpassing those of males in about 4 cm and 160 g respectively. Also, the mean-size males and females were larger in the cold season than in the warm season. The total length of individuals with sufficiently developed gonads to allow sex determination by visual inspection was 13–20 cm for females and 21–23 cm for males. Those differences between individuals in gonadal development can also be observed from the fact that the total length of individuals of indetermined sex reached 40 cm.

As for the mean-size males and females of the Benguela hake, the general trend was the same as with the Senegalese hake, but the difference between males and females was smaller. The total length from which gonads were discernible was 15-19 cm for males and females. Differences between individuals in gonadal development could also be realized by the fact that the total length of individuals of indetermined sex attained 36 cm.

e) Sex ratio and female maturity stage

Tables 3.59.1 (page 3-163) and 3.59.2 (page 3-164) illustrate the sex ratio and the female maturity stage for the Senegalese hake and the Benguela hake. Figures 3.31.1 (page 3-165) and 3.31.2 (page 3-166) show their distribution by length class.

e-1) Senegalese hake

The overall sex ratio was 0.82 in the cold season and 0.72 in the warm season, therefore a slight predominance of females. In the cold season, the sex ratio by stratum was more or less equal at all strata

shallower than 200 m depth, while at the 200-400 m stratum, females were overwhelmingly dominant. In the warm season, on the contrary, females were slightly dominant at the two strata between 80 and 400 m depth. By area, females were positively dominant in the Central area in the cold season as in the warm season, while in the two other areas, the sex ratio never deviated too much from equilibrium.

The female maturity ratio (at maturity stage III) in the overall area was 5% in the cold season and 9% in the warm season. Regardless of season, the ratio at each stratum increased with depth (in the cold season, figures included semi-mature females). The female maturity ratio in each area revealed a seasonal geographical-dependent: from the Northern area to the Southern area, it was 0, 5 and 21% in the cold season, 12, 7 and 9% in the warm season. The variation of the female maturity ratio with season, area and water depth suggests that spawning extends over a long period (although it is not known whether it is continuous or discontinuous), that it occurs earlier in deep strata and that it begins in the south in the cold season and in the north in the warm season. However, for definitive conclusions, one would need at least some monthly survey.

The size-dependent change of the sex ratio was expressed up to a certain length limit: 38 cm in the cold season and 28 cm in the warm season. Below those respective values, the sex ratio often deviates from equilibrium (100%), but above them, it is less than 100% and females are dominant. In particular, in the cold season as in the warm season, individuals over 58 cm were all female.

In addition, the total length at first maturity corresponded to the 38-40 cm class in the cold season and to the 28-30 cm class in the warm season.

e-2) Benguela hake

The overall sex ratio was 0.67 in the cold season and 0.96 in the warm season. In the latter, a state of male/female equilibrium in this species was observed in the sex ratio by stratum (in the 80-200 m and 200-400 m strata). In the warm season, males were slightly dominant in the Southern area while in the other two areas, females were slightly dominant.

The female maturity ratio in the entire area (data available only for the Central area in the cold season) was 3% in the cold season (62% if semi-mature females are included) and 1% in the warm season (9% including semi-mature females). In both the cold and warm seasons, mature individuals appeared only in the 200-400 m stratum (in the warm season, only in the Southern area). This result suggests that spawning extends over a long period centered on the cold season, and that it is limited to the deep strata and to the Central and Southern areas.

In the cold season, females are dominant in all length classes; while in the warm season, the state of male/female equilibrium was maintained in all length classes except for the total length over 34 cm, in which females were majority.

Finally, the total length at first maturity corresponded to the 42-44 cm class in the cold season and to the 22-24 cm class in the warm season.

f) Feeding habits

Tables 3.60.1 and 3.60.2 (page 3-167 respectively) show the stomach condition and the stomach content composition in each survey season for both hake species. Figures 3.32.1 (page 3-168) and 3.32.2

(page 3-169) show the relationship between body length and SSI and SCW for both species from all data gathered in the course of the survey (individuals with empty and feding together).

The ratio of the empty stomachs of the Senegalese hake was 68% in the cold season and 31% in the warm season. As both the Senegalese and the Benguela hakes inhabit deep waters, an evertion of the stomach due to a sudden change in water pressure at the time of capture was often observed. The ratio of the stomach eversion in the Senegalese hake was 6% in the cold season and 56% in the warm season. The relationship between body length and SSI and SCW showed that the largest individuals consume great quantities of food, while the small-size individuals are voracious eaters in relation to their body weight, a phenomenon even more accentuated in the cold season. The Senegalese hake feeds mainly on fish (shortnose greeneye *Chlorophthalmus agassizi*, scorpion fish *Scorpaena* sp., Cunene horse mackerel *Trachurus trecae*, carangids, etc.). It can also consume great quantities of crustaceans, especially shrimp.

The ratio of the empty stomachs of the Benguela hake was 79% in the cold season and 36% in the warm season. The ratio of the stomach eversion in the Benguela hake was 4% in the cold season and 42% in the warm season. The relationship between body length and SSI and SCW was identical to that presented above, but the mean SSI was higher than that of the Senegalese hake in the warm season. In the cold season, the Benguela hake feeds mainly on crustaceans, especially shrimp, but also on fish, while in the warm season, it basically feeds fish (shortnose greeneye, gobies, etc.), but also crustaceans (especially shrimp) and mollusks (mainly cuttlefish and squid).

Table 3.57.1 Body length range and mean body length for Senegalese hake *Merluccius senegalensis* : TL in mm.

(A) *Amrigue* survey area

| Northern coastal area (Stratum: 3-20m) | Phase 1 | | | | | | Phase 2 | | | | | |
| | Cold season | | | Warm season | | | Cold season | | | Warm season | | |
	Specimens	Range	Mean	Specimens	Range	Mean	Specimens	Range	Mean	Specimens	Range	Mean
Banc d'Arguin	0			0			0			0		
Other	0			0			0			0		
All area	0			0			0			0		

(B) *Al-Awam* survey area

| Saharan | Stratum | Phase 1 | | | | | | Phase 2 | | | | | |
| | | Cold season | | | Warm season | | | Cold season | | | Warm season | | |
		Specimens	Range	Mean	Specimens	Range	Mean	Specimens	Range	Mean	Specimens	Range	Mean
North	3-20m	-	-	-	-	-	-	0			0		
	20-30m	0			0			0			0		
	30-80m	94	77 ~ 255	186.9	0			71	125 ~ 310	257.5	0		
	80-200m	0			40	133 ~ 200	156.6	60	236 ~ 430	268.6	40	175 ~ 415	327.2
	200-400m	0			60	230 ~ 520	388.7	-	-	-	56	208 ~ 683	372.5
	400-600m	-	-	-	-	-	-	-	-	-	-	-	-
	3-600m	94	77 ~ 255	186.9	100	133 ~ 520	295.9	131	125 ~ 430	262.6	96	175 ~ 683	353.6
Central	3-20m	-	-	-	0			0			0		
	20-30m	0			0			0			0		
	30-80m	26	250 ~ 475	336.9	0			22	100 ~ 200	154.3	0		
	80-200m	128	100 ~ 512	284.5	96	110 ~ 425	215.6	27	230 ~ 533	276.0	70	232 ~ 569	297.5
	200-400m	80	188 ~ 580	312.3	119	155 ~ 560	254.3	43	340 ~ 610	453.3	18	271 ~ 548	397.9
	400-600m	-	-	-	20	188 ~ 514	315.6	-	-	-	-	-	-
	3-600m	234	100 ~ 580	299.8	235	110 ~ 560	243.7	92	100 ~ 610	329.8	88	232 ~ 569	318.1
South	3-20m	-	-	-	0			0			0		
	20-30m	0			0			0			0		
	30-80m	94	81 ~ 440	168.6	0			19	105 ~ 392	166.0	0		
	80-200m	89	98 ~ 635	279.0	102	130 ~ 372	207.4	27	312 ~ 570	384.0	55	178 ~ 340	285.1
	200-400m	40	200 ~ 540	291.8	60	121 ~ 340	209.0	10	390 ~ 700	517.0	2	340	340.0
	400-600m	-	-	-	-	-	-	-	-	-	-	-	-
	3-600m	223	81 ~ 635	234.7	162	121 ~ 372	208.0	56	105 ~ 700	333.8	57	178 ~ 340	287.1

Remarks. - : no trawl. The results obtained from *Al-Awam* survey area in Phase 1 seem to include *M.polli* .

(A) *Amrigue* survey area

Northern coastal area (Stratum: 3-20m)	Phase 1						Phase 2					
	Cold season			Warm season			Cold season			Warm season		
	Specimens	Range	Mean	Specimens	Range	Mean	Specimens	Range	Mean	Specimens	Range	Mean
Banc d'Arguin	0			0			0			0		
Other	0			0			0			0		
All area	0			0			0			0		

(B) *Al-Awam* survey area

Subarea	Stratum	Phase 1						Phase 2					
		Cold season			Warm season			Cold season			Warm season		
		Specimens	Range	Mean	Specimens	Range	Mean	Specimens	Range	Mean	Specimens	Range	Mean
North	3-20m	-	-	-	-	-	-	0			0		
	20-30m	0			0			0			0		
	30-80m	94	77~255	186.9	0			0			0		
	80-200m	0			40	133~200	156.6	0			0		
	200-400m	0			60	230~520	388.7	-	-	-	40	195~370	250.7
	400-600m	-	-	-	-	-	-	-	-	-	-	-	-
	3-600m	94	77~255	186.9	100	133~520	295.9	0			40	195~370	250.7
Central	3-20m	-	-	-	0			0			0		
	20-30m	0			0			0			0		
	30-80m	26	250~475	336.9	0			13	50~155	105.0	0		
	80-200m	128	100~512	284.5	96	110~425	215.6	140	152~350	243.7	40	128~352	216.5
	200-400m	80	188~580	312.3	119	155~560	254.3	80	260~525	351.1	80	146~340	241.8
	400-600m	-	-	-	20	188~514	315.6	-	-	-	-	-	-
	3-600m	234	100~580	299.8	235	110~560	243.7	233	50~525	272.9	120	128~352	233.3
South	3-20m	-	-	-	0			0			0		
	20-30m	0			0			0			0		
	30-80m	94	81~440	168.6	0			10	49~67	56.9	0		
	80-200m	89	98~635	279.0	102	130~372	207.4	20	60~213	113.5	80	124~282	186.1
	200-400m	40	200~540	291.8	60	121~340	209.0	0			60	171~328	221.8
	400-600m	-	-	-	-	-	-	-	-	-	-	-	-
	3-600m	223	81~635	234.7	162	121~372	208.0	30	49~213	94.6	140	124~328	201.4

Remarks. - : no trawl. The results obtained from *Al-Awam* survey area in Phase 1 seem to include *M.senegalensis*.

Figure3.29.1 (A) continued.

North 1-20m (Area 5912 km²)	Central 3-20m (Area 2783 km²)	South 3-20m (Area 1185 km²)
No trawl	No trawl	No trawl

North 20-30m (Area 1290 km²)	Central 20-30m (Area 835 km²)	South 20-30m (Area 805 km²)
No catch	No catch	No catch

North 30-80m (Area 2924 km²)
Mean length 17.6 cm
Estimated stock size in numbers 16,455,112

Central 30-80m (Area 2874 km²)
Mean length 13.5 cm
Estimated stock size in numbers 479,330

South 30-80m (Area 2640 km²)
Mean length 19.2 cm
Estimated stock size in numbers 4,766,961

North 80-200m (Area 1147 km²)
Mean length 28 cm
Estimated stock size in numbers 2,617,817

Central 80-200m (Area 2767 km²)
Mean length 27.6 cm
Estimated stock size in numbers 14,929,375

South 80-200m (Area 3025 km²)
Mean length 41.7 cm
Estimated stock size in numbers 5,197,269

North 200-400m (Area 936 km²)
Mean length 35.8 cm
Estimated stock size in numbers 2,159,153

Central 200-400m (Area 1453 km²)
Mean length 29.6 cm
Estimated stock size in numbers 26,305,347

South 200-400m (Area 994 km²)
Mean length 33.5 cm
Estimated stock size in numbers 5,261,597

North 400-600m (Area 738 km²)	Central 400-600m (Area 818 km²)	South 400-600m (Area 583 km²)
No trawl	No trawl	No trawl

North Total (Area 17688 km²)
Mean length 20.4 cm
Estimated stock size in numbers 21,412,494

Central Total (Area 29244 km²)
Mean length 27.8 cm
Estimated stock size in numbers 41,953,335

South Total (Area 21088 km²)
Mean length 23.5 cm
Estimated stock size in numbers 23,992,918

Merluccius senegalensis (M. polli) / Al-Awam / 1C

Figure3.29.1 (B) continued.

North 1-20m (Area 5912 km²)	Central 3-20m (Area 2783 km²)	South 3-20m (Area 1495 km²)
No trawl	No catch	No catch

North 20-30m (Area 1290 km²)	Central 20-30m (Area 835 km²)	South 20-30m (Area 805 km²)
No catch	No catch	No catch

North 30-80m (Area 2924 km²)	Central 30-80m (Area 2879 km²)	South 30-80m (Area 2640 km²)
Estimated stock size in numbers 92591		
No data for size composition	No catch	No catch

North 80-200m (Area 1147 km²)
Mean length 15.9cm
Estimated stock size in numbers 2,601,115

Central 80-200m (Area 2767 km²)
Mean length 21.6cm
Estimated stock size in numbers 12,591,246

South 80-200m (Area 3025 km²)
Mean length 19.3cm
Estimated stock size in numbers 14,627,717

North 200-400m (Area 936 km²)
Mean length 37.8cm
Estimated stock size in numbers 2,766,263

Central 200-400m (Area 1453 km²)
Mean length 21.7cm
Estimated stock size in numbers 58,395,232

South 200-400m (Area 994 km²)
Mean length 19.3cm
Estimated stock size in numbers 24,732,542

North 400-600m (Area 738 km²)
No trawl

Central 400-600m (Area 848 km²)
Mean length 33.6cm
Estimated stock size in numbers 4,145,412

South 400-600m (Area 583 km²)
No trawl

North Total (Area 17688 km²)
Mean length 23.9cm
Estimated stock size in numbers 5,649,949

Central Total (Area 29241 km²)
Mean length 21.1cm
Estimated stock size in numbers 74,345,395

South Total (Area 21088 km²)
Mean length 19.4cm
Estimated stock size in numbers 39,159,759

Merluccius senegalensis (M. polli) / Al-Awam / LW

Figure3.29.1 (C) continued.

North 3-20m (Area : 5912 km²)	Central 3-20m (Area : 2783 km²)	South 3-20m (Area : 1485 km²)
No catch	No catch	No catch

North 20-30m (Area : 1290 km²)	Central 20-30m (Area : 835 km²)	South 20-30m (Area : 805 km²)
Estimated stock size in numbers : 21453		
No data for size composition	No catch	No catch

North 30-80m (Area : 2924 km²)
Mean length 25.5cm
Estimated stock size in numbers : 6,153,161

Central 30-80m (Area : 2870 km²)
Mean length 19.7cm
Estimated stock size in numbers : 649,369

South 30-80m (Area : 2640 km²)
Mean length 17.0cm
Estimated stock size in numbers : 522,442

North 80-200m (Area : 1147 km²)
Mean length 26.4cm
Estimated stock size in numbers : 7,945,945

Central 80-200m (Area : 2767 km²)
Mean length 26.7cm
Estimated stock size in numbers : 476,747

South 80-200m (Area : 3025 km²)
Mean length 38.8cm
Estimated stock size in numbers : 199,377

North 200-400m (Area : 936 km²)	Central 200-400m (Area : 1453 km²)	South 200-400m (Area : 994 km²)
	Mean length 41.7cm	Mean length 52.4cm
	Estimated stock size in numbers : 657,667	Estimated stock size in numbers : 120,317
No trawl		

North 400-600m (Area : 738 km²)	Central 400-600m (Area : 848 km²)	South 400-600m (Area : 583 km²)
No trawl	No trawl	No trawl

North Total (Area : 17688 km²)
Mean length 26.3cm
Estimated stock size in numbers : 14,355,559

Central Total (Area : 29214 km²)
Mean length 27.7cm
Estimated stock size in numbers : 1,706,975

South Total (Area : 21088 km²)
Mean length 27.0cm
Estimated stock size in numbers : 843,338

Merluccius senegalensis / Al-Awam / 2C

Figure3.29.1 (D) continued.

North 3-20m (Area 5912 km²)	Central 3-20m (Area 2783 km²)	South 3-20m (Area 1485 km²)
No catch	No catch	No catch

North 20-30m (Area 1290 km²)	Central 20-30m (Area 835 km²)	South 20-30m (Area 805 km²)
No catch	No catch	No catch

North 30-80m (Area 2924 km²)	Central 30-80m (Area 2870 km²)	South 30-80m (Area 2640 km²)
No catch	No catch	No catch

North 80-200m (Area 1147 km²)
Mean length 31.6 cm
Estimated stock size in numbers 1 685 647

Central 80-200m (Area 2767 km²)
Mean length 25.6cm
Estimated stock size in numbers 972 194

South 80-200m (Area 3025 km²)
Mean length 27.9cm
Estimated stock size in numbers 762 446

North 200-400m (Area 936 km²)
Mean length 33 cm
Estimated stock size in numbers 2 714 089

Central 200-400m (Area 1453 km²)
Mean length 38.6cm
Estimated stock size in numbers 280 727

South 200-400m (Area 994 km²)
Mean length 53.4cm
Estimated stock size in numbers 27 425

North 400-600m (Area 738 km²)	Central 400-600m (Area 848 km²)	South 400-600m (Area 583 km²)
No trawl	No trawl	No trawl

North Total (Area 17688 km²)
Mean length 32.9cm
Estimated stock size in numbers 3 799,735

Central Total (Area 29244 km²)
Mean length 31.8cm
Estimated stock size in numbers 1,352,220

South Total (Area 21688 km²)
Mean length 28.8cm
Estimated stock size in numbers 859,723

Merluccius senegalensis / Al-Awam / 2W

Figure 3.29.2 (C) continued.

North 3-20m (Area : 5912 km²)	Central 3-20m (Area : 2783 km²)	South 3-20m (Area : 1185 km²)
No catch	No catch	No catch

North 20-30m (Area : 1290 km²)	Central 20-30m (Area : 835 km²)	South 20-30m (Area : 805 km²)
No catch	No catch	No catch

North 30-80m (Area : 2924 km²)	Central 30-80m (Area : 2876 km²)	South 30-80m (Area : 2640 km²)
No data for size composition		

North 80-200m (Area : 1147 km²)

Central 80-200m (Area : 2767 km²)

South 80-200m (Area : 3025 km²)

North 200-400m (Area : 936 km²)	Central 200-400m (Area : 1453 km²)	South 200-400m (Area : 991 km²)
No trawl		No data for size composition

North 400-600m (Area : 735 km²)	Central 400-600m (Area : 848 km²)	South 400-600m (Area : 583 km²)
No trawl	No trawl	No trawl

North Total (Area : 17688 km²)

Central Total (Area : 29244 km²)

South Total (Area : 21064 km²)

Frequency in numbers — Total length in cm

Merluccius polli / Al-Awam / 2C

Figure3.29.2 (D) continued.

North 3-20m (Area : 5912 km²)	Central 3-20m (Area : 2763 km²)	South 3-20m (Area : 1485 km²)
No catch	No catch	No catch

North 20-30m (Area : 1290 km²)	Central 20-30m (Area : 805 km²)	South 20-30m (Area : 805 km²)
No catch	No catch	No catch

North 30-80m (Area : 2924 km²)	Central 30-80m (Area : 2870 km²)	South 30-80m (Area : 2640 km²)
No catch	No catch	No catch

North 80-200m (Area : 1147 km²)	Central 80-200m (Area : 2767 km²)	South 80-200m (Area : 3025 km²)
Estimated stock size in numbers : 127621	Mean length 20.1cm / Estimated stock size in numbers : 14,069,665	Mean length 19.1cm / Estimated stock size in numbers : 9,093,477
No data for size composition		

North 200-400m (Area : 936 km²)	Central 200-400m (Area : 1453 km²)	South 200-400m (Area : 994 km²)
Estimated stock size in numbers : 4,213,726	Mean length 20cm / Estimated stock size in numbers : 72,323,960	Mean length 21cm / Estimated stock size in numbers : 77,365,732

North 400-600m (Area : 738 km²)	Central 400-600m (Area : 848 km²)	South 400-600m (Area : 583 km²)
No trawl	No trawl	No trawl

North Total (Area : 17688 km²)	Central Total (Area : 27244 km²)	South Total (Area : 21088 km²)
Mean length 23.1cm / Estimated stock size in numbers : 4,317,350	Mean length 21.1cm / Estimated stock size in numbers : 86,506,423	Mean length 21.1cm / Estimated stock size in numbers : 86,457,865

Merluccius polli / Al-Awam / 2W

Table 3.58.1 Body length and weight by sex for Senegalese hake *Merluccius senegalensis*.

(B) *Al-Awam* survey area

Phase	Season	Sex	Individuals of specimens	Total length in mm		Body weight in g	
				Range	Mean	Range	Mean
1	Cold	Male	208	110 ~ 540	269.8	10.0 ~ 980.0	182.7
		Female	234	77 ~ 635	290.5	10.0 ~ 1,655.0	255.8
		Indeterminate	109	81 ~ 360	146.6	5.0 ~ 345.0	31.6
		Total	551	77 ~ 635	254.2	5.0 ~ 1,655.0	183.9
	Warm	Male	107	140 ~ 560	286.9	20.0 ~ 1,010.0	234.3
		Female	154	121 ~ 520	284.2	25.0 ~ 1,090.0	246.1
		Indeterminate	236	110 ~ 330	195.3	10.0 ~ 295.0	67.3
		Total	497	110 ~ 560	242.6	10.0 ~ 1,090.0	158.6
2	Cold	Male	98	210 ~ 570	308.9	65.0 ~ 1,135.0	254.9
		Female	120	125 ~ 700	345.3	60.0 ~ 2,285.0	417.2
		Indeterminate	61	100 ~ 400	192.3	10.0 ~ 455.0	76.1
		Total	279	100 ~ 700	299.0	10.0 ~ 2,285.0	285.6
	Warm	Male	99	232 ~ 548	317.9	90.0 ~ 1,100.0	268.8
		Female	138	205 ~ 683	333.2	60.0 ~ 2,060.0	321.5
		Indeterminate	4	175 ~ 266	209.3	35.0 ~ 150.0	77.5
		Total	241	175 ~ 683	324.9	35.0 ~ 2,060.0	295.8

Remark. The results obtained from *Al-Awam* survey area in Phase 1 seem to include *M.polli*.

Table 3.58.2 Body length and weight by sex for Benguela hake *Merluccius polli*.

(B) *Al-Awam* survey area

Phase	Season	Sex	Individuals of specimens	Total length in mm		Body weight in g	
				Range	Mean	Range	Mean
2	Cold	Male	63	175 ~ 435	311.4	35.0 ~ 545.0	225.6
		Female	94	187 ~ 525	319.0	45.0 ~ 1,275.0	253.9
		Indeterminate	96	50 ~ 360	169.2	0.9 ~ 305.0	52.0
		Total	253	50 ~ 525	260.3	0.9 ~ 1,275.0	170.2
	Warm	Male	112	154 ~ 340	226.9	25.0 ~ 310.0	96.8
		Female	117	152 ~ 370	234.4	25.0 ~ 370.0	109.5
		Indeterminate	71	124 ~ 262	188.6	12.0 ~ 150.0	57.0
		Total	300	124 ~ 370	220.8	12.0 ~ 370.0	92.3

Table 3.59.1 Sex ratio and female maturity stage for Senegalese hake *Merluccius senegalensis*.

(A) *Amrigue* survey area

Northern coastal area (Stratum: 3-20m)	Phase 1 cold season							Phase 1 warm season							Phase 2 cold season							Phase 2 warm season						
	Specimens		Sex ratio	♀ : maturity stage* (%)				Specimens		Sex ratio	♀ : maturity stage* (%)				Specimens		Sex ratio	♀ : maturity stage* (%)				Specimens		Sex ratio	♀ : maturity stage* (%)			
	♀	♂	(♂/♀)	I	II	III	IV	♀	♂	(♂/♀)	I	II	III	IV	♀	♂	(♂/♀)	I	II	III	IV	♀	♂	(♂/♀)	I	II	III	IV
Banc d'Arguin	0	0	E					0	0	E					0	0	E					0	0	E				
Other	0	0	E					0	0	E					0	0	E					0	0	E				
All area	0	0	E					0	0	E					0	0	E					0	0	E				

(B) *Al-Awam* survey area

Subarea	Stratum	Phase 1 cold season							Phase 1 warm season							Phase 2 cold season							Phase 2 warm season						
		Specimens		Sex ratio	♀ : maturity stage* (%)				Specimens		Sex ratio	♀ : maturity stage* (%)				Specimens		Sex ratio	♀ : maturity stage* (%)				Specimens		Sex ratio	♀ : maturity stage* (%)			
		♀	♂	(♂/♀)	I	II	III	IV	♀	♂	(♂/♀)	I	II	III	IV	♀	♂	(♂/♀)	I	II	III	IV	♀	♂	(♂/♀)	I	II	III	IV
North	3-20m	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0	0	E					0	0	E				
	20-30m	0	0	E					0	0	E					0	0	E					0	0	E				
	30-80m	38	47	1.24	100.0	0.0	0.0	0.0	0	0	E					31	29	0.94	96.8	3.2	0.0	0.0	0	0	E				
	80-200m	0	0	E					13	3	0.23	76.9	23.1	0.0	0.0	29	31	1.07	96.6	3.4	0.0	0.0	22	15	0.68	90.9	9.1	0.0	0.0
	200-400m	0	0	E					40	18	0.45	40.0	22.5	37.5	0.0	-	-	-	-	-	-	-	28	28	1.00	46.4	32.1	21.4	0.0
	400-600m	-	-	-	-	-	-	-																					
	All stratum	38	47	1.24	100.0	0.0	0.0	0.0	53	21	0.40	49.1	22.6	28.3	0.0	60	60	1.00	96.7	3.3	0.0	0.0	50	43	0.86	66.0	22.0	12.0	0.0
Central	3-20m	-	-	-	-	-	-	-	0	0	E					0	0	E					0	0	E				
	20-30m	0	0	E					0	0	E					0	0	E					0	0	E				
	30-80m	17	9	0.53	88.2	11.8	0.0	0.0	0	0	E					1	0	0.00	100.0	0.0	0.0	0.0	0	0	E				
	80-200m	59	57	0.97	91.5	8.5	0.0	0.0	33	21	0.64	75.8	24.2	0.0	0.0	12	5	0.42	83.3	8.3	8.3	0.0	43	27	0.63	83.7	14.0	2.3	0.0
	200-400m	48	27	0.56	85.4	14.6	0.0	0.0	37	33	0.89	70.3	29.7	0.0	0.0	28	12	0.43	39.3	57.1	3.6	0.0	13	5	0.38	46.2	30.8	23.1	0.0
	400-600m	-	-	-	-	-	-	-	7	8	1.14	14.3	71.4	14.3	0.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	All stratum	124	93	0.75	88.7	11.3	0.0	0.0	77	62	0.81	67.5	31.2	1.3	0.0	41	17	0.41	53.7	41.5	4.9	0.0	56	32	0.57	75.0	17.9	7.1	0.0
South	3-20m	-	-	-	-	-	-	-	0	0	E					0	0	E					0	0	E				
	20-30m	0	0	E					0	0	E					0	0	E					0	0	E				
	30-80m	9	10	1.11	77.8	22.2	0.0	0.0	0	0	E					1	2	2.00	0.0	100.0	0.0	0.0	0	0	E				
	80-200m	48	36	0.75	91.7	8.3	0.0	0.0	15	21	1.40	40.0	60.0	0.0	0.0	10	17	1.70	20.0	40.0	40.0	0.0	30	24	0.80	36.7	53.3	10.0	0.0
	200-400m	15	22	1.47	100.0	0.0	0.0	0.0	9	3	0.33	88.9	11.1	0.0	0.0	8	2	0.25	0.0	100.0	0.0	0.0	2	0	0.00	100.0	0.0	0.0	0.0
	400-600m	-	-	-	-	-	-	-																					
	All stratum	72	68	0.94	91.7	8.3	0.0	0.0	24	24	1.00	58.3	41.7	0.0	0.0	19	21	1.11	10.5	68.4	21.1	0.0	32	24	0.75	40.6	50.0	9.4	0.0
All	3-20m	-	-	-	-	-	-	-	0	0	E					0	0	E					0	0	E				
	20-30m	0	0	E					0	0	E					0	0	E					0	0	E				
	30-80m	64	66	1.03	93.8	6.3	0.0	0.0	0	0	E					33	31	0.94	93.9	6.1	0.0	0.0	0	0	E				
	80-200m	107	93	0.87	91.6	8.4	0.0	0.0	61	45	0.74	67.2	32.8	0.0	0.0	51	53	1.04	78.4	11.8	9.8	0.0	95	66	0.69	70.5	25.3	4.2	0.0
	200-400m	63	49	0.78	88.9	11.1	0.0	0.0	86	54	0.63	58.1	24.4	17.4	0.0	36	14	0.39	30.6	66.7	2.8	0.0	43	33	0.77	48.3	30.2	20.9	0.0
	400-600m	-	-	-	-	-	-	-	7	8	1.14	14.3	71.4	14.3	0.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	All stratum	234	208	0.89	91.5	8.5	0.0	0.0	154	107	0.69	59.7	29.9	10.4	0.0	120	98	0.82	68.3	26.7	5.0	0.0	138	99	0.72	63.8	26.8	9.4	0.0

Remarks. * I: Immature, II: Semi-mature, III: Mature, IV: Spent. -: no trawl. E: Error. blank: no data. The results obtained from *Al-Awam* survey area in Phase 1 seem to include *M.polli*.

Table 3.59.2 Sex ratio and female maturity stage for Benguela hake *Merluccius polli.*

(A) *Amrigue* survey area

Northern coastal area (Stratum: 3-20m)	Phase 1 cold season							Phase 1 warm season							Phase 2 cold season							Phase 2 warm season						
	Specimens		Sex ratio	♀ : maturity stage* (%)				Specimens		Sex ratio	♀ : maturity stage* (%)				Specimens		Sex ratio	♀ : maturity stage* (%)				Specimens		Sex ratio	♀ : maturity stage* (%)			
	♀	♂	(♂/♀)	I	II	III	IV	♀	♂	(♂/♀)	I	II	III	IV	♀	♂	(♂/♀)	I	II	III	IV	♀	♂	(♂/♀)	I	II	III	IV
Banc d'Arguin	0	0	E					0	0	E					0	0	E					0	0	E				
Other	0	0	E					0	0	E					0	0	E					0	0	E				
All area	0	0	E					0	0	E					0	0	E					0	0	E				

(B) *Al-Awam* survey area

Subarea	Stratum	Phase 1 cold season							Phase 1 warm season							Phase 2 cold season							Phase 2 warm season						
		Specimens		Sex ratio	♀ : maturity stage* (%)				Specimens		Sex ratio	♀ : maturity stage* (%)				Specimens		Sex ratio	♀ : maturity stage* (%)				Specimens		Sex ratio	♀ : maturity stage* (%)			
		♀	♂	(♂/♀)	I	II	III	IV	♀	♂	(♂/♀)	I	II	III	IV	♀	♂	(♂/♀)	I	II	III	IV	♀	♂	(♂/♀)	I	II	III	IV
North	3-20m	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0	0	E					0	0	E				
	20-30m	0	0	E					0	0	E					0	0	E					0	0	E				
	30-80m	38	47	1.24	100.0	0.0	0.0	0.0	0	0	E					0	0	E					0	0	E				
	80-200m	0	0	E					13	3	0.23	76.9	23.1	0.0	0.0	0	0	E					0	0	E				
	200-400m	0	0	E					40	18	0.45	40.0	22.5	37.5	0.0	-	-	-	-	-	-	-	19	17	0.89	100.0	0.0	0.0	0.0
	400-600m	-	-	-																									
	All stratum	38	47	1.24	100.0	0.0	0.0	0.0	53	21	0.40	49.1	22.6	28.3	0.0	0	0	E					19	17	0.89	100.0	0.0	0.0	0.0
Central	3-20m	-	-	-	-	-	-	-	0	0	E					0	0	E					0	0	E				
	20-30m	0	0	E					0	0	E					0	0	E					0	0	E				
	30-80m	17	9	0.53	88.2	11.8	0.0	0.0	0	0	E					0	0	E					0	0	E				
	80-200m	59	57	0.97	91.5	8.5	0.0	0.0	33	21	0.64	75.8	24.2	0.0	0.0	46	34	0.74	93.5	6.5	0.0	0.0	25	8	0.32	96.0	4.0	0.0	0.0
	200-400m	48	27	0.56	85.4	14.6	0.0	0.0	37	33	0.89	70.3	29.7	0.0	0.0	48	29	0.60	37.5	56.3	6.3	0.0	35	39	1.11	88.6	11.4	0.0	0.0
	400-600m	-	-	-	-	-	-	-	7	8	1.14	14.3	71.4	14.3	0.0	-	-	-					-	-	-				
	All stratum	124	93	0.75	88.7	11.3	0.0	0.0	77	62	0.81	67.5	31.2	1.3	0.0	94	63	0.67	64.9	31.9	3.2	0.0	60	47	0.78	91.7	8.3	0.0	0.0
South	3-20m	-	-	-	-	-	-	-	0	0	E					0	0	E					0	0	E				
	20-30m	0	0	E					0	0	E					0	0	E					0	0	E				
	30-80m	9	10	1.11	77.8	22.2	0.0	0.0	0	0	E					0	0	E					0	0	E				
	80-200m	48	36	0.75	91.7	8.3	0.0	0.0	15	21	1.40	40.0	60.0	0.0	0.0	0	0	E					13	30	2.31	100.0	0.0	0.0	0.0
	200-400m	15	22	1.47	100.0	0.0	0.0	0.0	9	3	0.33	88.9	11.1	0.0	0.0	0	0	E					25	18	0.72	88.0	8.0	4.0	0.0
	400-600m	-	-	-												-	-	-	-	-	-	-							
	All stratum	72	68	0.94	91.7	8.3	0.0	0.0	24	24	1.00	58.3	41.7	0.0	0.0	0	0	E					38	48	1.26	92.1	5.3	2.6	0.0
All	3-20m	-	-	-	-	-	-	-	0	0	E					0	0	E					0	0	E				
	20-30m	0	0	E					0	0	E					0	0	E					0	0	E				
	30-80m	64	66	1.03	93.8	6.3	0.0	0.0	0	0	E					0	0	E					0	0	E				
	80-200m	107	93	0.87	91.6	8.4	0.0	0.0	61	45	0.74	67.2	32.8	0.0	0.0	46	34	0.74	93.5	6.5	0.0	0.0	38	38	1.00	97.4	2.6	0.0	0.0
	200-400m	63	49	0.78	88.9	11.1	0.0	0.0	86	54	0.63	58.1	24.4	17.4	0.0	48	29	0.60	37.5	56.3	6.3	0.0	79	74	0.94	91.1	7.6	1.3	0.0
	400-600m	-	-	-					7	8	1.14	14.3	71.4	14.3	0.0	-	-	-					-	-	-				
	All stratum	234	203	0.89	91.5	8.5	0.0	0.0	154	107	0.69	59.7	29.9	10.4	0.0	94	63	0.67	64.9	31.9	3.2	0.0	117	112	0.96	93.2	6.0	0.9	0.0

Remarks. * I: Immature, II: Semi-mature, III: Mature, IV: Spent. -: no trawl. E: Error. blank: no data. The results obtained from *Al-Awam* survey area in Phase 1 seem to include *M.senegalensis*.
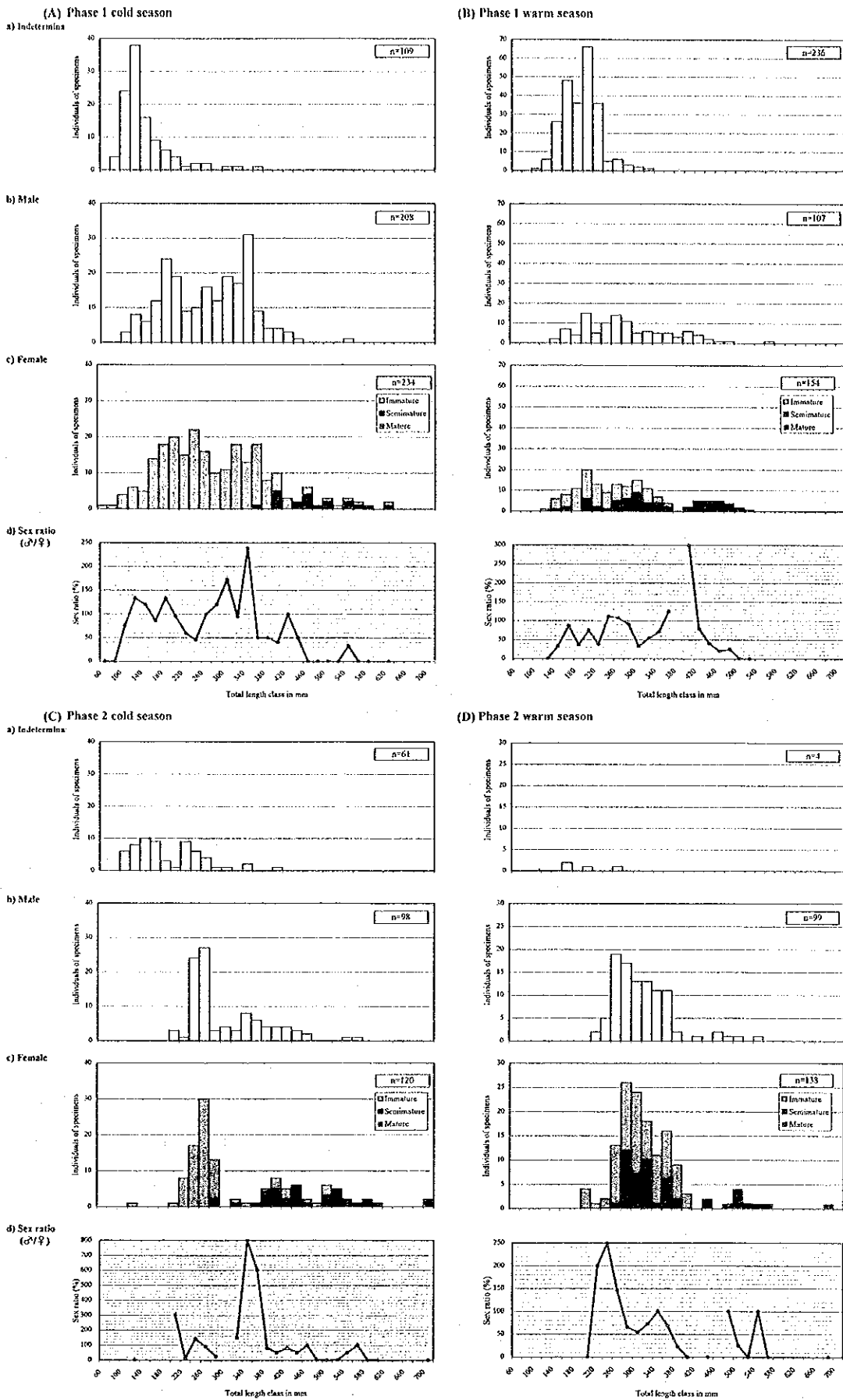
Figure 3.31.1   Sex ratio and female maturity stage by length class for Senegalese hake
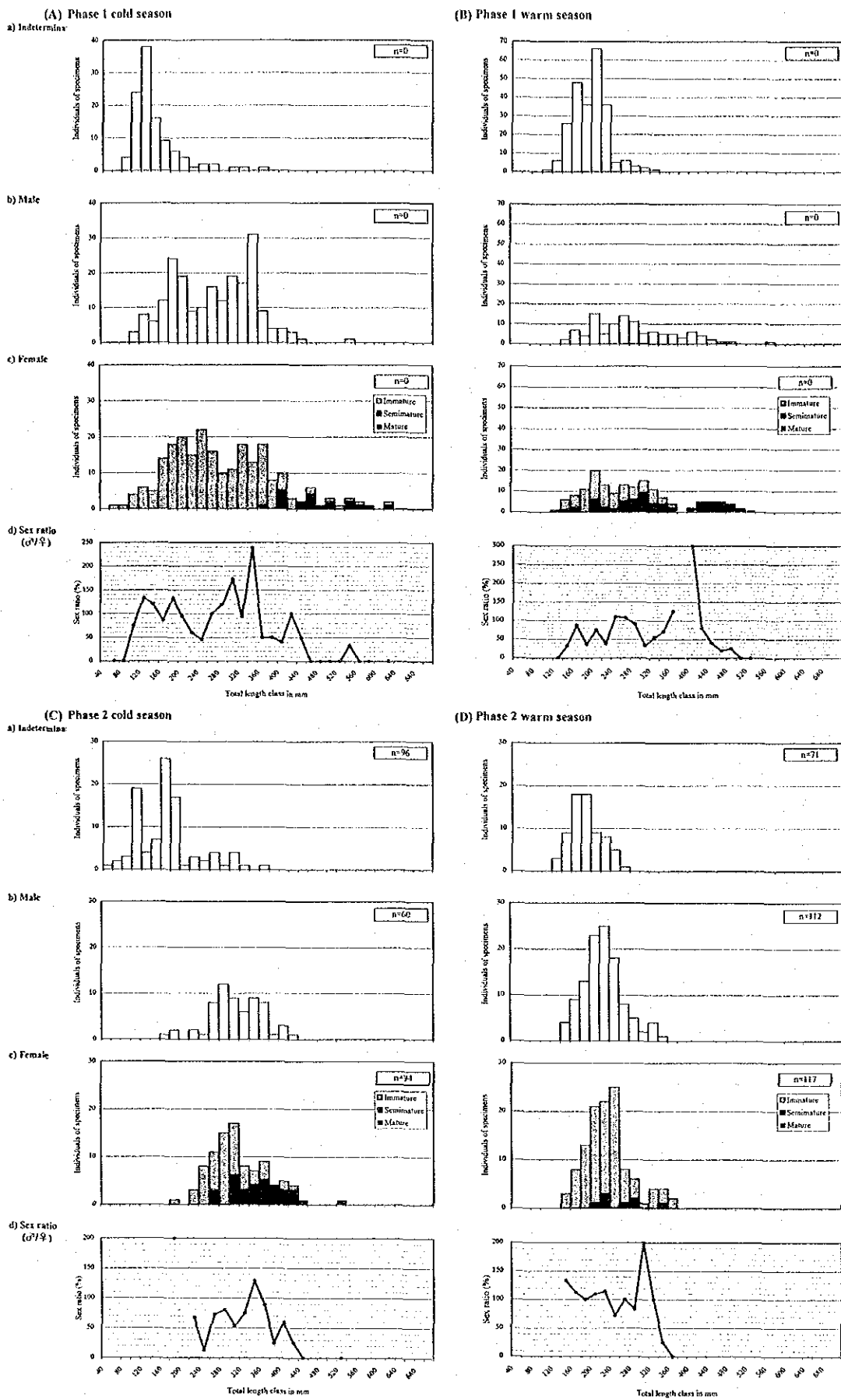*Merluccius senegalensis* . Remark. (A) and (B) seems to include *M. polli* .

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Figure 3.31.2 Sex ratio and female maturity stage by length class for Benguela hake *Merluccius polli*. Remark. (A) and (B) seems to include *M. senegalensis*.

Table 3.60.1 Stomach content analysis of Senegalese hake *Merluccius senegalensis*.

(A) Stomach condition

Phase	Season	Stomach condition				Stomach content Somatic Index (SSI)			
		n*	Empty (%)	Evert (%)	Feeding (%)	n*	Min.	Max.	Mean
1	Cold	529	44.99	24.57	30.43	395	0.00	230.00	18.03
	Warm	476	66.39	18.70	14.92	386	0.00	214.29	8.13
2	Cold	240	67.50	5.83	26.67	226	0.00	150.00	13.50
	Warm	236	30.93	55.51	13.56	104	0.00	82.05	7.38

(B) Stomach contents

Phase	Season	n*	Mollusca		Polychaeta	Crustacea		
			Abralia verauyi	Decapoda		Galatheidae	Shrimp	Other
1	Cold	161		2.48	1.24	0.62	2.48	22.98
	Warm	71		4.23			12.68	5.63
2	Cold	64					4.69	3.13
	Warm	32	3.13				25.00	

(Continued)

Phase	Season	Fish						Unknown
		Chlorophthalmus agassizi	*Scorpaena* sp.	*Trachurus trecae*	Carangidae sp.	Other		
1	Cold				1.24	52.17		18.01
	Warm					28.17		50.70
2	Cold	1.56	1.56			40.63		53.13
	Warm			3.13		50.00		21.88

Remarks. * : Individuals of specimens. The results obtained in Phase 1 seem to include *M. polli*.

Table 3.60.2 Stomach content analysis of Benguela hake *Merluccius polli*.

(A) Stomach condition

Phase	Season	Stomach condition				Stomach content Somatic Index (SSI)			
		n*	Empty (%)	Evert (%)	Feeding (%)	n*	Min.	Max.	Mean
2	Cold	189	78.84	3.70	17.46	179	0.00	287.50	9.49
	Warm	291	36.43	42.27	21.31	166	0.00	166.67	17.76

(B) Stomach contents

Phase	Season	n*	Mollusca		Crustacea		Fish			Unknown
			Sepia spp.	Decapoda	Shrimp	Other	*Chlorophthalmus agassizi*	Gobiidae	Other	
2	Cold	33			39.39	3.03			12.12	45.45
	Warm	62	3.23	3.23	6.45		1.61	1.61	50.00	37.10

Remark. * : Individuals of specimens.

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(A) Relationship between total length and SSI
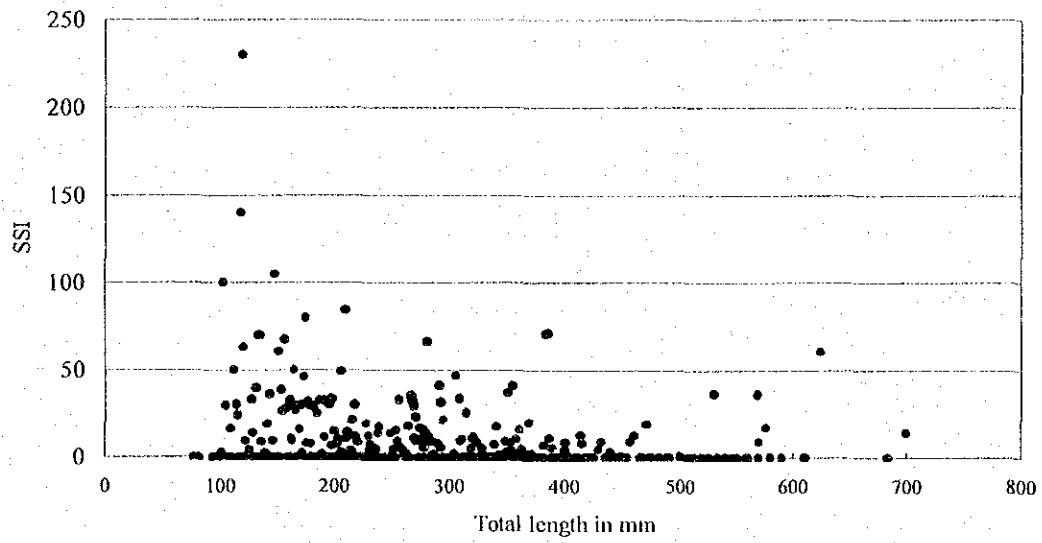
(B) Relationship between total length and SCW
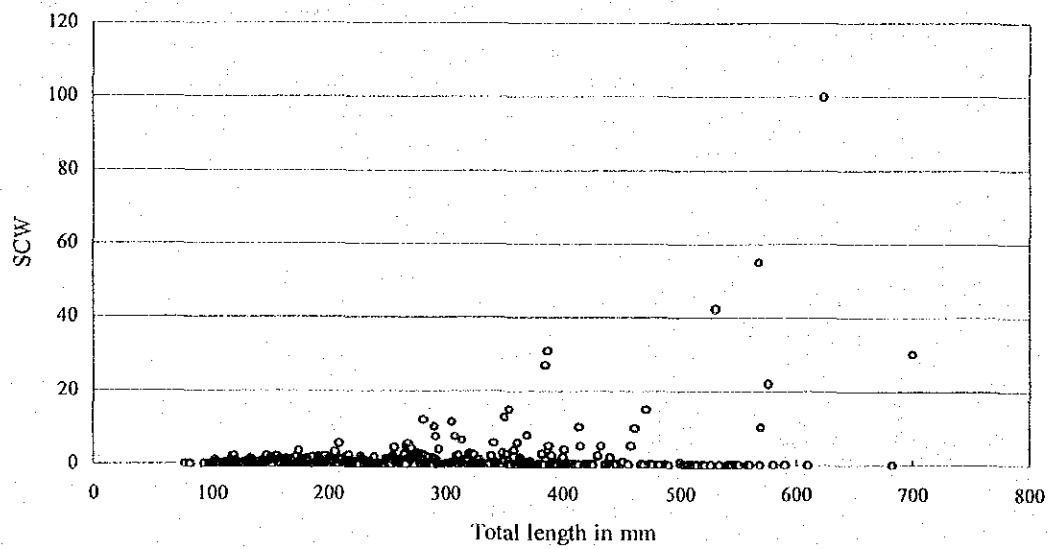
**Figure 3.32.1   Relationship between body length and SSI (A) and SCW (B)
for Senegalese hake *Merluccius senegalensis*.**

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(A) Relationship between total length and SSI
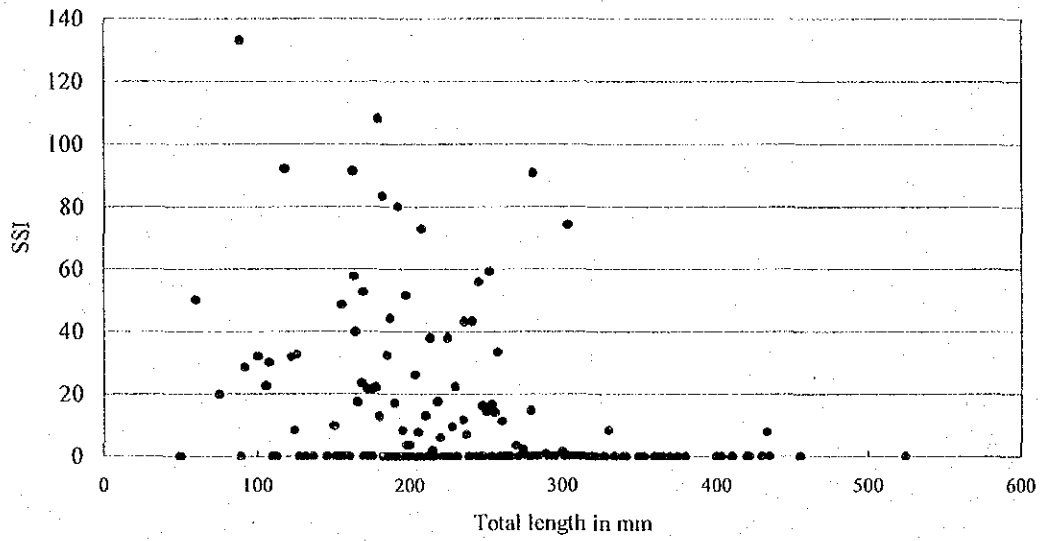
(B) Relationship between total length and SCW
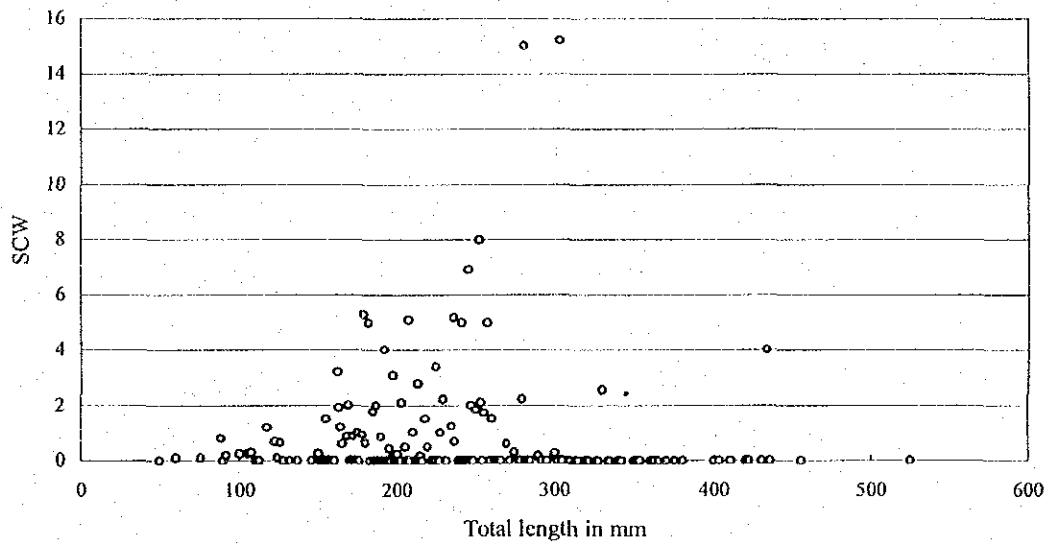
Figure 3.32.2 Relationship between body length and SSI (A) and SCW (B)
for Benguela hake *Merluccius polli.*

3) John dory *Zeus faber*

a) Body length range and mean body length

Table 3.61 (page 3-174) presents the minimum, maximum and mean total lengths obtained for the John dory in each survey season and at each stratum in each area.

The total length of this species varied between 55 and 550 mm. For all seasons, the mean total length by area was high in the cold season and low in the warm season. In the cold season, it was high in the Central area while in the warm season, it was high in the Northern area and decreased southwards. The mean total length by stratum was high in the 80-200 m stratum in all seasons except in the Phase 2 warm season.

b) Size composition

Figure 3.33 (page 3-171, 3-175 to 3-178) presents the evaluation of the size composition for the John dory stock. The total length class is indicated at intervals of 2 cm. For convenience, three groups were defined: (i) small-size (total length less than 20 cm), (ii) medium-size (length between 20 and 40 cm), (iii) large-size (length over 40 cm).

Setting aside weak modes (modes with low peaks), the size composition of the total stock size in number showed a bi-modal distribution in the cold season and a mono-modal distribution in the warm season. In the cold season, most of the total stock comprise the small- and medium-size groups. The medium-size group was a majority in Phase 1, while in Phase 2, the small- and medium-size groups were nearly in equilibrim. The dominant modes observed in the cold season among the small- and medium-size groups were present at the 8-10 cm and 28-30 cm classes in Phase 1, and at the 10-12 cm and 26-28 cm classes in Phase 2 respectively. Conversely, in the warm season, the total stock essentially comprised the small-size group, and the dominant mode was at the 16-18 cm class in Phase 1 and at the 14-16 cm class in Phase 2. The dominant mode class for the small-size group in the warm season suggests an growth of the small-size group in the cold season during the transitional period (in Phase 1, there was no compatibility in the number of individuals corresponding to those modes). Also, the dominant mode class for the medium-size group in the cold season did not appear in the warm season as a prominent mode. This result suggests that the medium-size group in the cold season died of the natural and fishing mortalities or that they were migrated toward the cold northern waters outside the survey area during the transitional period.

As for the size composition by stratum and by area, distribution of the three size groups-i, -ii and -iii mentioned above was clear. In the cold season, most of the individuals of group-i (small-size) with a dominant mode at the around 10 cm classes were distributed between the two strata in depths of less than 80 m in each area, particularly in the 30-80 m stratum. On the other hand, in the cold season, the individuals of group-ii (medium-size) with a dominant mode at classes between 26 and 30 cm, were mainly distributed at the 80-200 m stratum as well as at the strata above. In the warm season, group-i with a dominant mode at classes between 14 and 18 cm was widely distributed at the 30-80 m and 80-200 m strata in each area. In the cold season, group-iii (large-size) occurred at each stratum in each area, particularly at the 80-200 m stratum in the Central and Southern areas; in the warm season, however, it was concentrated at the 30-80 m and 80-200 m strata in the Northern area (in Phase 2, there were also some occurrences at the 80-20 m stratum in the Central area).
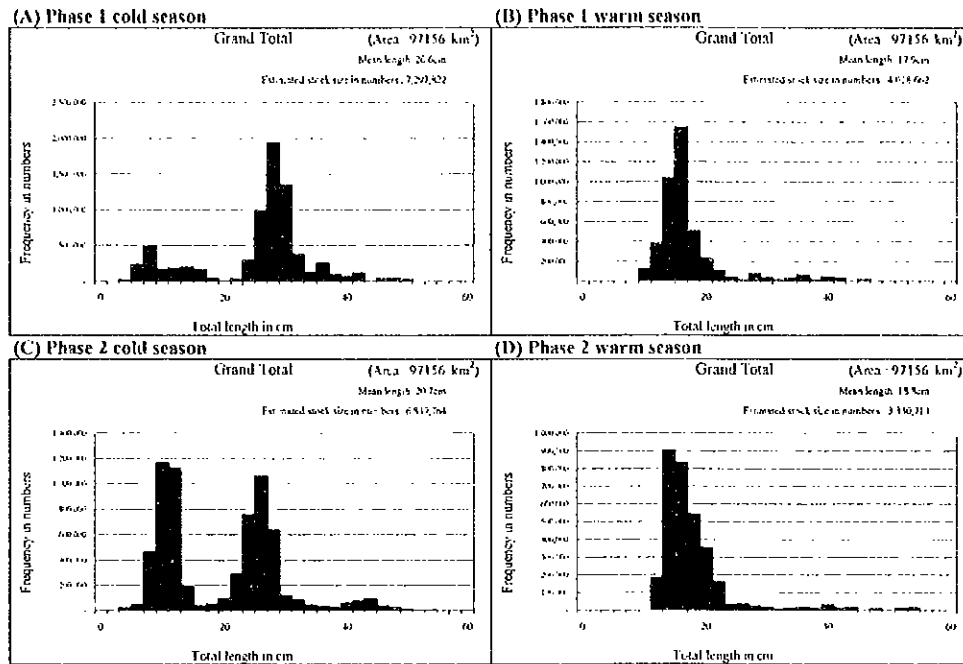
Figure 3.33   Size composition for John dory *Zeus faber.*

c) Length-weight relationship

Figure 3.34 presents the length-weight relationship observed in the John dory. The length-weight equations obtained from all samples were the following:

Phase 1 cold season　: BW=　$3.213 \times 10^{-2} \times TL^{2.786}$　　(r=0.9931)
Phase 1 warm season　: BW=　$2.043 \times 10^{-2} \times TL^{2.919}$　　(r=0.9837)
Phase 2 cold season　: BW=　$2.879 \times 10^{-2} \times TL^{2.809}$　　(r=0.9865)
Phase 2 warm season　: BW=　$2.486 \times 10^{-2} \times TL^{2.851}$　　(r=0.9850)

where, BW : body weight (g), TL : total length (cm) and r : the coefficient of correlation.
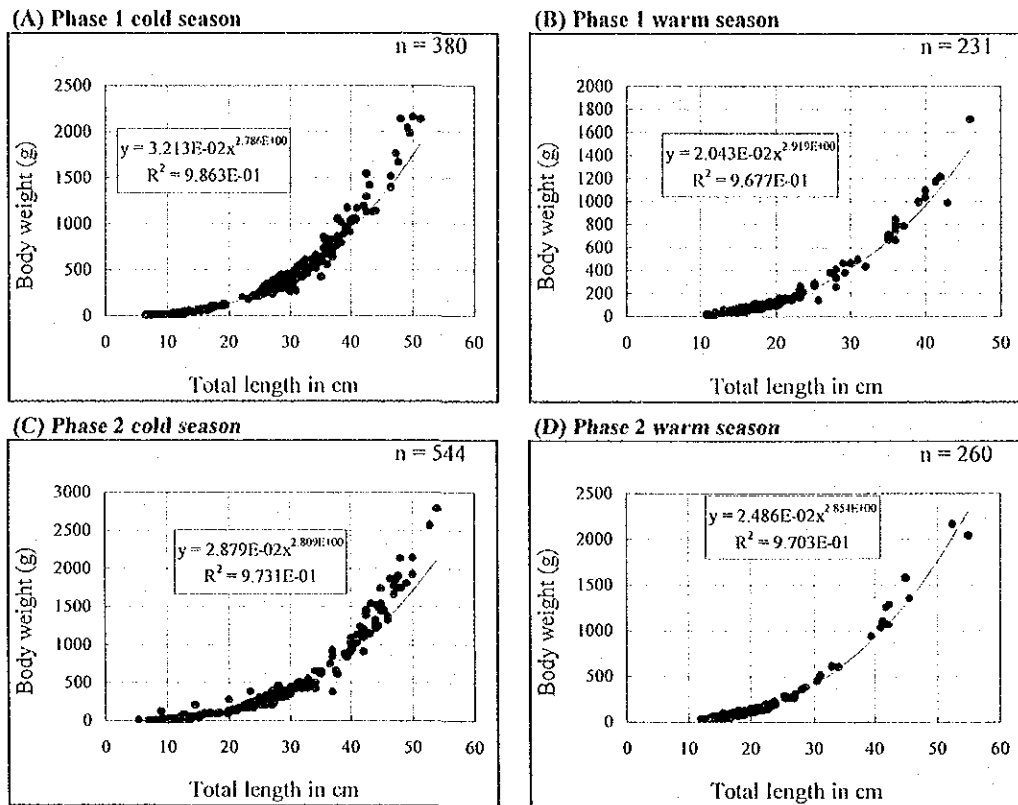
Figure 3.34 Length-weight relationship for John dory *Zeus faber.*

d) Length and weight by sex

Table 3.62 (page 3-179) summarizes the total length and body weight observed in each sex for the John dory.

The mean total length of males was greater than that of females in all seasons except in the Phase 2 warm season, but the difference was only of approximately 1 cm. The mean-size males and females were larger (in both total length and weight) in the cold season than in the warm season. But the mean weight of males was not always heavier than that of females even when their mean total length was greater. For all seasons, the maximum total length of females surpasses that of males.

The minimum total length for sex identification by visual inspection was often above 10 cm. It is conceivable that individual differences in gonadal development could be significant as the total length of individuals of indetermined sex varied from 20 to 40 cm.

e) Sex ratio and female maturity stage

Table 3.63 (page 3-180) summarizes the sex ratio and the female maturity stage for the John dory. Figure 3.35 (page 3-181) presents their distribution by length class.

The overall sex ratio varied between 0.72 and 1.37. Except in the Phase 1 cold season, females are

predominant in all seasons. Geographical variation of the sex ratio was found to depend on the season. In survey order, there was a predominance of males in all areas, then predominance of males in the Northern area and of females in the Central and Southern areas (especially in the latter), then a situation similar to that of the previous season, and finally a predominance of females in all areas. Vertical variation of the sex ratio was also found to be season-dependent.

The female maturity ratio in the entire area was higher in the cold season: in order, it was of 9, 7, 14 and 4%. Distribution of this ratio by stratum reveals a seasonal variation: in the cold season, it was higher in deep strata (15-21% at the 80-200 m stratum) while in the warm season, it was higher in shallow strata (19-21% in the 30-80 m stratum). Geographical variation of the female maturity ratio also depended on the season: while in the cold season, it increased southwards from the north, the reverse happened in the warm season. According to Josse *et* Garcia (1986), John dory found in the IRM spawns between April to June. According to Damain (1980), 55% of the John dory occurring in Senegal spawn between December and February and 30 to 55% do so May. The results of the present survey -- namely, that the ratio of mature females was higher (i) in the cold season than in the warm season, (ii) at deep strata in the cold season and at shallow strata in the warm season, and (iii) in the Southern area in the cold season and in the Northern area in the warm season – did not contradict the published data and included new information.

Distribution of the sex ratio by length class presents seasonal characteristics. Some fluctuations aside, the sex ratio in the 10 to 40 cm class during the cold season changed from an exclusively female population (sex ratio of 0%) to one with a predominance of females (< 100%), then to a male/female equilibrium situation (100%) and finally to a majority of males (> 100%). Above the 40 cm class, the proportion of males decreased abruptly and females became majority again. Beyond 48 cm class, all individuals were again females. In the cold season, the size-dependent change of the sex ratio was even more emphatic in the Phase 2. In the warm season, females were dominant for all length classes and above 44 cm there were no more males.

The total length class at first maturity was 22-24 cm. For all seasons, most females measuring over 40 cm were mature.

f) Feeding habits

Table 3.64 (page 3-182) presents the stomach condition and the stomach content composition of the John dory in each survey season. Figure 3.36 (page 3-183) shows the relationship between body length and SSI and SCW.

The ratio of the empty stomachs was between 50 and 60%. The relationship between body length and SSI and SCW showed that the largest individuals consume great quantities of food, while the small-size individuals are voracious eaters in relation to their body weight, a phenomenon even more accentuated in the cold season.

Regardless of season, the John dory mainly feeds on fish (greeneyes, carangids, etc.). It also consumes mollusks, polychaetes and crustaceans, even if their frequency of occurrence is low.

Table 3.61 Body length range and mean body length for John dory *Zeus faber* : TL in mm.

(A) *Amrigue* survey area

Northern coastal area (Stratum: 3-20m)	Phase 1 Cold season			Phase 1 Warm season			Phase 2 Cold season			Phase 2 Warm season		
	Specimens	Range	Mean	Specimens	Range	Mean	Specimens	Range	Mean	Specimens	Range	Mean
Banc d'Arguin	0			0			0			0		
Other	0			0			0			0		
All area	0			0			0			0		

(B) *Al-Awam* survey area

Subarea	Stratum	Phase 1 Cold season			Phase 1 Warm season			Phase 2 Cold season			Phase 2 Warm season		
		Specimens	Range	Mean	Specimens	Range	Mean	Specimens	Range	Mean	Specimens	Range	Mean
North	3-20m	-	-	-	-	-	-	0			0		
	20-30m	0			0			0			0		
	30-80m	20	92~375	204.8	13	150~430	266.6	20	90~330	124.2	8	180~550	391.3
	80-200m	21	245~425	303.6	22	160~460	315.6	40	141~420	286.4	60	120~448	195.8
	200-400m	0			0			-	-	-	0		
	400-600m	-	-	-	-	-	-	-	-	-	-	-	-
	3-600m	41	92~425	255.4	35	150~460	297.4	60	90~420	232.3	68	120~550	218.8
Central	3-20m	-	-	-	0			0			0		
	20-30m	0			0			0			0		
	30-80m	103	67~473	277.4	17	120~310	169.4	97	72~500	216.7	24	145~340	215.0
	80-200m	73	248~435	308.1	88	132~256	171.9	126	125~490	279.2	111	132~412	180.4
	200-400m	0			0			0			0		
	400-600m	-	-	-	0			-	-	-	-	-	-
	3-600m	176	67~473	290.1	105	120~310	171.5	223	72~500	252.0	135	132~412	186.6
South	3-20m	-	-	-	0			0			0		
	20-30m	12	75~350	244.9	0			0			0		
	30-80m	55	66~492	209.4	25	112~210	152.3	140	55~440	161.8	0		
	80-200m	96	232~513	317.0	66	108~205	158.2	121	118~540	298.5	57	125~225	168.1
	200-400m	0			0			0			0		
	400-600m	-	-	-	-	-	-	-	-	-	-	-	-
	3-600m	163	66~513	275.4	91	108~210	156.6	261	55~540	225.2	57	125~225	168.1

Remark. - ; no trawl.

Figure3.33 (A) continued.

North 3-20m (Area : 5912 km²)	Central 3-20m (Area : 2783 km²)	South 3-20m (Area : 1485 km²)
No trawl	No trawl	No trawl

North 20-30m (Area : 1290 km²)	Central 20-30m (Area : 835 km²)	South 20-30m (Area : 805 km²)
	Estimated stock size in numbers : 15,940	Mean length: 21.5cm Estimated stock size in numbers : 129,518
No catch	No data for size composition	

North 30-80m (Area : 2924 km²)	Central 30-80m (Area : 2870 km²)	South 30-80m (Area : 2640 km²)
Mean length: 18.4cm Estimated stock size in numbers : 200,369	Mean length: 29.3cm Estimated stock size in numbers : 1,424,371	Mean length: 14.1cm Estimated stock size in numbers : 1,195,438

North 80-200m (Area : 1147 km²)	Central 80-200m (Area : 2767 km²)	South 80-200m (Area : 3025 km²)
Mean length: 30.7cm Estimated stock size in numbers : 477,321	Mean length: 29.3cm Estimated stock size in numbers : 2,456,576	Mean length: 32.0cm Estimated stock size in numbers : 1,304,257

North 200-400m (Area : 936 km²)	Central 200-400m (Area : 1453 km²)	South 200-400m (Area : 994 km²)
No catch	No catch	No catch

North 400-600m (Area : 738 km²)	Central 400-600m (Area : 848 km²)	South 400-600m (Area : 583 km²)
No trawl	No trawl	No trawl

North Total (Area : 17688 km²)	Central Total (Area : 29244 km²)	South Total (Area : 21088 km²)
Mean length: 25.9cm Estimated stock size in numbers : 769,691	Mean length: 29.9cm Estimated stock size in numbers : 3,990,887	Mean length: 23.5cm Estimated stock size in numbers : 2,629,244

Zeus faber / Al-Awam / 1C

Figure 3.33 (B) continued.

North 3-20m (Area : 5912 km²)	Central 3-20m (Area : 2783 km²)	South 3-20m (Area : 1485 km²)
No trawl	No catch	No catch

North 20-30m (Area : 1290 km²)	Central 20-30m (Area : 835 km²)	South 20-30m (Area : 805 km²)
No catch	No catch	No catch

North 30-80m (Area : 2924 km²)
Mean length 27.0cm
Estimated stock size in numbers : 181,250

Central 30-80m (Area : 2870 km²)
Mean length 17.2cm
Estimated stock size in numbers : 399,274

South 30-80m (Area : 2640 km²)
Mean length 15.6cm
Estimated stock size in numbers : 370,833

North 80-200m (Area : 1147 km²)
Mean length 32.1cm
Estimated stock size in numbers : 241,846

Central 80-200m (Area : 2767 km²)
Mean length 17.4cm
Estimated stock size in numbers : 2,112,582

South 80-200m (Area : 3025 km²)
Mean length 16.1cm
Estimated stock size in numbers : 1,728,830

North 200-400m (Area : 936 km²)	Central 200-400m (Area : 1453 km²)	South 200-400m (Area : 994 km²)
No catch	No catch	No catch

North 400-600m (Area : 738 km²)	Central 400-600m (Area : 848 km²)	South 400-600m (Area : 583 km²)
No trawl	No catch	No trawl

North Total (Area : 17688 km²)
Mean length 29.0cm
Estimated stock size in numbers : 423,096

Central Total (Area : 29244 km²)
Mean length 17.3cm
Estimated stock size in numbers : 2,505,855

South Total (Area : 21088 km²)
Mean length 16.0cm
Estimated stock size in numbers : 2,099,712

Zeus faber / Al-Awam / 1W

Figure3.33 (C) continued.

North 3-20m (Area : 5912 km²)	Central 3-20m (Area : 2783 km²)	South 3-20m (Area : 1485 km²)
No catch	No catch	Estimated stock size in numbers : 17,700 No data for size composition

North 20-30m (Area : 1290 km²)	Central 20-30m (Area : 835 km²)	South 20-30m (Area : 805 km²)
No catch	No catch	Estimated stock size in numbers : 10,004 No data for size composition

North 30-80m (Area : 2924 km²) — Mean length: 12.7cm — Estimated stock size in numbers : 401,784

Central 30-80m (Area : 2870 km²) — Mean length: 20.0cm — Estimated stock size in numbers : 1,306,811

South 30-80m (Area : 2640 km²) — Mean length: 15.5cm — Estimated stock size in numbers : 2,603,204

North 80-200m (Area : 1147 km²) — Mean length: 28.0cm — Estimated stock size in numbers : 367,181

Central 80-200m (Area : 2767 km²) — Mean length: 27.4cm — Estimated stock size in numbers : 1,083,336

South 80-200m (Area : 3025 km²) — Mean length: 29.2cm — Estimated stock size in numbers : 959,714

North 200-400m (Area : 936 km²)	Central 200-400m (Area : 1453 km²)	South 200-400m (Area : 994 km²)
No trawl	No catch	No catch

North 400-600m (Area : 738 km²)	Central 400-600m (Area : 848 km²)	South 400-600m (Area : 583 km²)
No trawl	No trawl	No trawl

North Total (Area : 17688 km²) — Mean length: 19.3cm — Estimated stock size in numbers : 858,965

Central Total (Area : 29244 km²) — Mean length: 23.4cm — Estimated stock size in numbers : 2,390,147

South Total (Area : 21088 km²) — Mean length: 19.2cm — Estimated stock size in numbers : 3,590,652

Zeus faber / Al-Awam / 2C

Figure3.33 (D) continued.

North 3-20m (Area : 5912 km²)	Central 3-20m (Area : 2783 km²)	South 3-20m (Area : 1485 km²)
No catch	No catch	No catch
North 20-30m (Area : 1290 km²)	**Central 20-30m** (Area : 835 km²)	**South 20-30m** (Area : 805 km²)
No catch	No catch	No catch
North 30-80m (Area : 2924 km²) Mean length: 39.0cm Estimated stock size in numbers : 106,855	**Central 30-80m** (Area : 2870 km²) Mean length: 22.3cm Estimated stock size in numbers : 274,291	**South 30-80m** (Area : 2640 km²) Estimated stock size in numbers : 93,356
histogram: Frequency in numbers vs Total length in cm	*histogram: Frequency in numbers vs Total length in cm*	No data for size composition
North 80-200m (Area : 1147 km²) Mean length: 18.1cm Estimated stock size in numbers : 3,033,718	**Central 80-200m** (Area : 2767 km²) Mean length: 17.7cm Estimated stock size in numbers : 1,198,701	**South 80-200m** (Area : 3025 km²) Mean length: 16.9cm Estimated stock size in numbers : 601,289
histogram: Frequency in numbers vs Total length in cm	*histogram: Frequency in numbers vs Total length in cm*	*histogram: Frequency in numbers vs Total length in cm*
North 200-400m (Area : 936 km²)	**Central 200-400m** (Area : 1453 km²) Estimated stock size in numbers : 36,301	**South 200-400m** (Area : 994 km²)
No catch	No data for size composition	No catch
North 400-600m (Area : 738 km²)	**Central 400-600m** (Area : 848 km²)	**South 400-600m** (Area : 583 km²)
No trawl	No trawl	No trawl
North Total (Area : 17688 km²) Mean length: 20.8cm Estimated stock size in numbers : 3,140,368	**Central Total** (Area : 29244 km²) Mean length: 19.6cm Estimated stock size in numbers : 3,495,300	**South Total** (Area : 21088 km²) Mean length: 16.9cm Estimated stock size in numbers : 694,845
histogram: Frequency in numbers vs Total length in cm	*histogram: Frequency in numbers vs Total length in cm*	*histogram: Frequency in numbers vs Total length in cm*

Zeus faber / Al-Awam / 2W

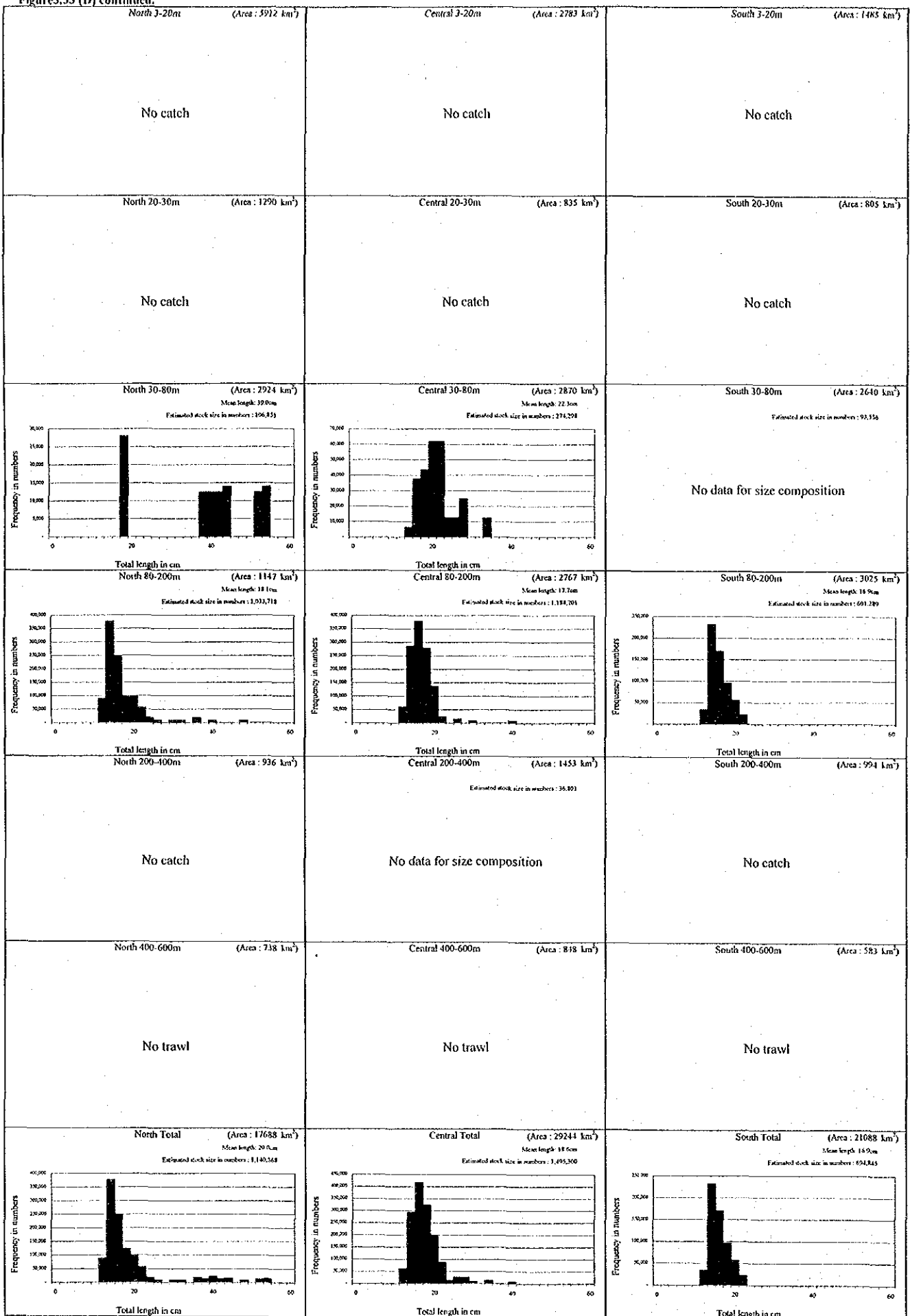**Table 3.62 Body length and weight by sex for John dory Zeus faber.**

(A) Amrigue survey area

Phase	Season	Sex	Individuals of specimens	Total length in mm		Body weight in g	
				Range	Mean	Range	Mean
1	Cold	Male	0				
		Female	0				
		Indeterminate	0				
		Total	0				
	Warm	Male	0				
		Female	0				
		Indeterminate	0				
		Total	0				
2	Cold	Male	0				
		Female	0				
		Indeterminate	0				
		Total	0				
	Warm	Male	0				
		Female	0				
		Indeterminate	0				
		Total	0				

(B) Al-Awam survey area

Phase	Season	Sex	Individuals of specimens	Total length in mm		Body weight in g	
				Range	Mean	Range	Mean
1	Cold	Male	214	93 ~ 465	290.2	10.0 ~ 1,520.0	437.2
		Female	156	66 ~ 513	277.4	5.0 ~ 2,160.0	445.4
		Indeterminate	10	73 ~ 257	105.5	5.0 ~ 246.0	39.6
		Total	380	66 ~ 513	280.1	5.0 ~ 2,160.0	430.1
	Warm	Male	78	117 ~ 420	192.6	26.0 ~ 1,215.0	159.6
		Female	108	112 ~ 460	184.6	22.0 ~ 1,715.0	144.5
		Indeterminate	45	108 ~ 400	171.1	25.0 ~ 1,035.0	131.0
		Total	231	108 ~ 460	184.7	22.0 ~ 1,715.0	147.0
2	Cold	Male	190	133 ~ 450	283.0	50.0 ~ 1,440.0	375.6
		Female	218	105 ~ 540	272.7	17.0 ~ 2,790.0	436.5
		Indeterminate	136	55 ~ 260	115.4	5.0 ~ 280.0	33.5
		Total	544	55 ~ 540	237.0	5.0 ~ 2,790.0	314.5
	Warm	Male	114	120 ~ 423	185.7	35.0 ~ 1,285.0	136.4
		Female	142	125 ~ 550	196.1	35.0 ~ 2,170.0	174.0
		Indeterminate	4	139 ~ 173	158.5	40.0 ~ 90.0	66.3
		Total	260	120 ~ 550	191.0	35.0 ~ 2,170.0	155.8

Table 3.63 Sex ratio and female maturity stage for John dory *Zeus faber*.

(A) *Amrigue* survey area

Northern coastal area (Stratum 3-20m)	Phase 1 cold season Specimens ♀	♂	Sex ratio (♂/♀)	♀: maturity stage (%) I	II	III	IV	Phase 1 warm season Specimens ♀	♂	Sex ratio (♂/♀)	♀: maturity stage (%) I	II	III	IV	Phase 2 cold season Specimens ♀	♂	Sex ratio (♂/♀)	♀: maturity stage (%) I	II	III	IV	Phase 2 warm season Specimens ♀	♂	Sex ratio (♂/♀)	♀: maturity stage (%) I	II	III	IV
Banc d'Arguin	0	0	E					0	0	E					0	0	E					0	0	E				
Other	0	0	E					0	0	E					0	0	E					0	0	E				
All area	0	0	E					0	0	E					0	0	E					0	0	E				

(B) *Al-Awam* survey area

Subarea	Stratum	Phase 1 cold season ♀	♂	♂/♀	I	II	III	IV	Phase 1 warm season ♀	♂	♂/♀	I	II	III	IV	Phase 2 cold season ♀	♂	♂/♀	I	II	III	IV	Phase 2 warm season ♀	♂	♂/♀	I	II	III	IV
North	3-20m	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0	0	E					0	0	E				
	20-30m	0	0	E					0	0	E					0	0	E					0	0	E				
	30-80m	7	12	1.71	85.7	14.3	0.0	0.0	6	6	1.00	66.7	0.0	33.3	0.0	1	1	1.00	0.0	100.0	0.0	0.0	5	3	0.60	20.0	20.0	60.0	0.0
	80-200m	11	10	0.91	72.7	18.2	9.1	0.0	6	10	1.67	0.0	50.0	50.0	0.0	16	23	1.44	18.8	75.0	6.3	0.0	35	25	0.71	88.6	8.6	2.9	0.0
	200-400m	0	0	E					0	0	E					-	-	-	-	-	-	-	0	0	E				
	400-600m	-	-	-	-	-	-	-																					
	All stratum	18	22	1.22	77.8	16.7	5.6	0.0	12	16	1.33	33.3	25.0	41.7	0.0	17	24	1.41	17.6	76.5	5.9	0.0	40	28	0.70	80.0	10.0	10.0	0.0
Central	3-20m	-	-	-	-	-	-	-	0	0	E					0	0	E					0	0	E				
	20-30m	0	0	E					0	0	E					0	0	E					0	0	E				
	30-80m	36	67	1.86	63.9	33.3	2.8	0.0	1	6	6.00	0.0	0.0	100.0	0.0	50	28	0.56	56.0	40.0	4.0	0.0	14	10	0.71	85.7	7.1	7.1	0.0
	80-200m	34	39	1.15	55.9	38.2	5.9	0.0	47	34	0.72	48.9	48.9	2.1	0.0	58	63	1.09	43.1	44.8	12.1	0.0	55	55	1.02	65.5	32.7	1.8	0.0
	200-400m	0	0	E					0	0	E					0	0	E					0	0	E				
	400-600m	-	-	-	-	-	-	-	0	0	E					-	-	-	-	-	-	-	-	-	-	-	-	-	-
	All stratum	70	106	1.51	60.0	35.7	4.3	0.0	48	40	0.83	47.9	47.9	4.2	0.0	108	91	0.84	49.1	42.6	8.3	0.0	69	66	0.96	69.6	27.5	2.9	0.0
South	3-20m	-	-	-	-	-	-	-	0	0	E					0	0	E					0	0	E				
	20-30m	5	4	0.80	0.0	100.0	0.0	0.0	0	0	E					0	0	E					0	0	E				
	30-80m	21	15	0.71	85.7	14.3	0.0	0.0	9	4	0.44	66.7	33.3	0.0	0.0	38	14	0.37	55.3	39.5	5.3	0.0	0	0	E				
	80-200m	42	67	1.60	51.2	24.4	24.4	0.0	39	18	0.46	61.5	38.5	0.0	0.0	55	61	1.11	36.4	29.1	34.5	0.0	33	20	0.61	54.5	45.5	0.0	0.0
	200-400m	0	0	E					0	0	E					0	0	E					0	0	E				
	400-600m	-	-	-	-	-	-	-																					
	All stratum	68	86	1.26	58.2	26.9	14.9	0.0	48	22	0.46	62.5	37.5	0.0	0.0	93	75	0.81	44.1	33.3	22.6	0.0	33	20	0.61	54.5	45.5	0.0	0.0
All	3-20m	-	-	-	-	-	-	-	0	0	E					0	0	E					0	0	E				
	20-30m	5	4	0.80	0.0	100.0	0.0	0.0	0	0	E					0	0	E					0	0	E				
	30-80m	64	94	1.47	73.4	25.0	1.6	0.0	16	16	1.00	62.5	18.8	18.8	0.0	89	43	0.48	55.1	40.4	4.5	0.0	19	13	0.68	68.4	10.5	21.1	0.0
	80-200m	87	116	1.33	55.8	29.1	15.1	0.0	92	62	0.67	51.1	44.6	4.3	0.0	129	147	1.14	37.2	41.9	20.9	0.0	123	101	0.82	69.1	29.3	1.6	0.0
	200-400m	0	0	E					0	0	E					0	0	E					0	0	E				
	400-600m	-	-	-	-	-	-	-	0	0	E					-	-	-	-	-	-	-	-	-	-	-	-	-	-
	All stratum	156	214	1.37	61.3	29.7	9.0	0.0	108	78	0.72	52.8	40.7	6.5	0.0	218	190	0.87	44.5	41.3	14.2	0.0	142	114	0.80	69.0	26.8	4.2	0.0

Remarks. * I: Immature, II: Semi-mature, III: Mature, IV: Spent. -: no trawl. E: Error. blank: no data.
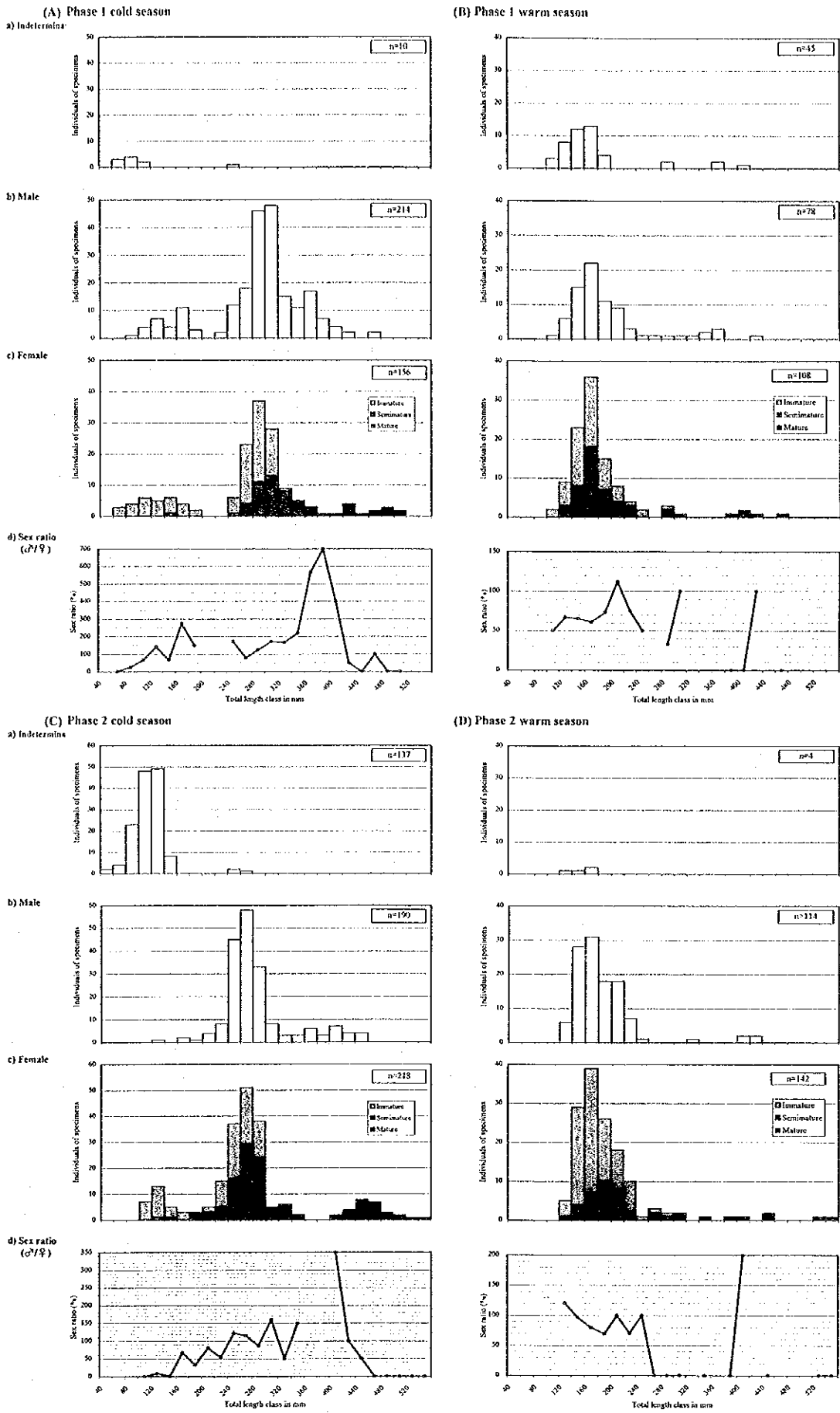
Figure 3.35 Sex ratio and female maturity stage by length class for John dory *Zeus faber*.

Table 3.64 Stomach content analysis of John dory *Zeus faber*.

(A) Stomach condition

Phase	Season	Stomach condition				Stomach content Somatic Index (SSI)			
		n*	Empty (%)	Evert (%)	Feeding (%)	n*	Min.	Max.	Mean
1	Cold	375	49.87	0.00	50.13	367	0.00	700.00	37.29
	Warm	229	60.26	0.00	39.74	219	0.00	170.73	19.34
2	Cold	437	59.95	0.00	40.05	435	0.00	1000.00	32.88
	Warm	246	55.28	0.00	44.72	244	0.00	240.00	30.59

(B) Stomach contents

Phase	Season	n*	Mollusca Decapoda	Polychaeta	Crustacea		Fish	
					Shrimp	Other	Engraulidae sp.	*Chlorophthalmus* sp.
1	Cold	188	1.06	0.53	0.53	0.53		
	Warm	91	1.10			1.10		
2	Cold	175					0.57	
	Warm	110					0.91	14.55

(Continued)

Phase	Season	Fish						
		Saurida brasiliensis	*Merluccius polli*	*Merluccius senegalensis*	*Merluccius* sp.	*Epigonus* sp.	*Trachurus trachurus*	*Trachurus trecae*
1	Cold							
	Warm							
2	Cold	0.57	0.57	0.57		2.86	2.29	2.29
	Warm				0.91			1.82

(Continued)

Phase	Season	Fish						Unknown
		Trachurus sp.	Carangidae sp.	*Diplodus bellottii*	Gobiidae	*Arnoglosus imperialis*	Other	
1	Cold	11.17					59.04	27.66
	Warm						60.44	37.36
2	Cold	4.57			1.14	0.57	60.44	37.36
	Warm			0.91	0.91		38.18	41.82

Remark. * : Individuals of specimens.

(A) Relationship between total length and SSI
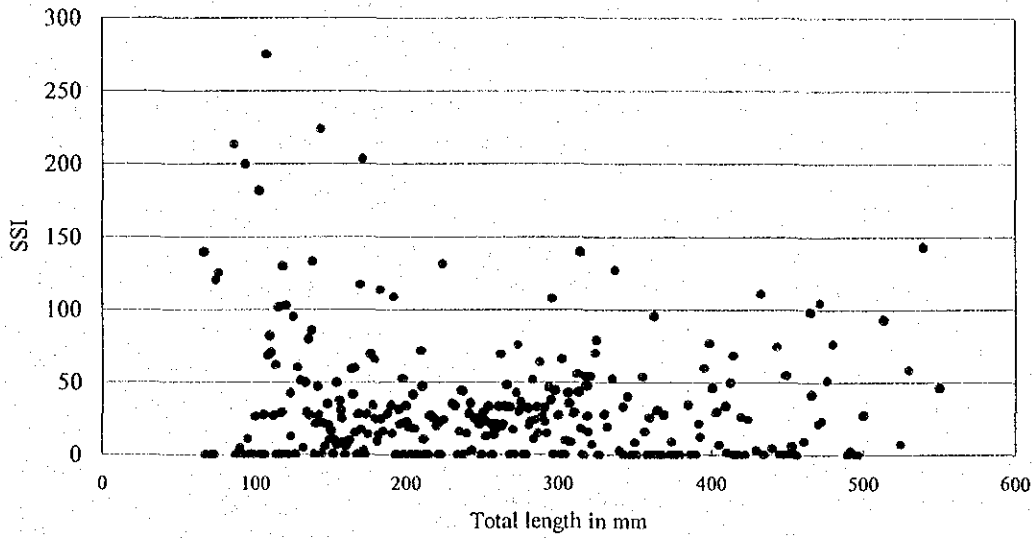
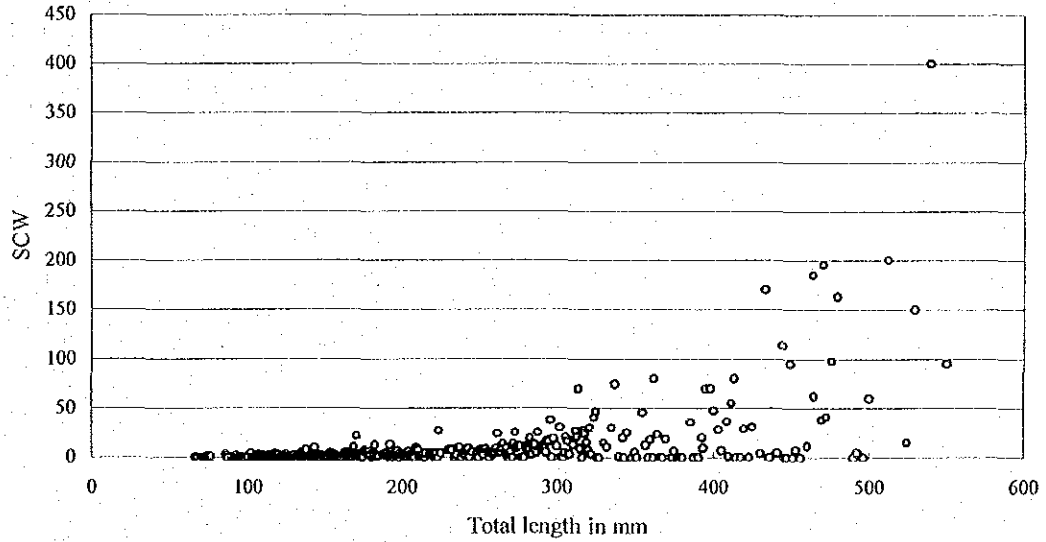(B) Relationship between total length and SCW

Figure 3.36 Relationship between body length and SSI (A) and SCW (B) for John dory *Zeus faber*.