Seasonal and Long-Term Changes in the Distribution and Abundance of Demersal Fishery Resources in Continental Shelf Waters off Ghana, West Africa

By

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Abstract

Between 1963 and 1990, the abundance of demersal fishery resources in Ghana's shelf waters underwent significant changes whereby the relative importance of major species changed in every trawl survey conducted in the area. Triggerfish (*Balistes capriscus*) dominated this ecosystem for nearly twenty years (from early 1970s to late 1980s) displacing bigeye grunt (*Brachydeuterus auritus*) as the most abundant species. The density of all demersal species (excluding triggerfish) assessed in bottom trawl surveys decreased from 50 kg ha^{-1} in 1963-64 to 32.4 kg ha^{-1} in 1990. The lowest density of 22.5 kg ha^{-1} occurred between 1973 and 1977. Density of triggerfish was high between 1973 and 1982, reaching a value of 28 kg ha^{-1} between depths of 30 and 50 m. Its density subsequently declined and by 1990, the species had virtually disappeared from the study area. In the period of decline of triggerfish, the density of rays, soles and cuttlefish increased. The observed changes in relative importance and density of species is attributed in part to the proliferation of the triggerfish in this ecosystem and also to changes in the marine climate over the period in question.

Keywords: Demersal species, Density, Triggerfish, Shelf ecosystem

Running title: Changes in the demersal fishery resources of Ghana

1. Introduction

Demersal fish species in continental shelf waters off Ghana include those of the families Haemulidae (grunts), Lutjanidae (snappers), Mullidae (goatfishes), Serranidae (groupers), Sparidae (seabreams) and Sciaenidae (croakers) (Table I). Fishing for these species is undertaken by small-scale (or artisanal), semi-industrial (or inshore), and industrial vessels. The artisanal fleet employs various gears including gill nets, and hook-and-line to catch demersal fish species and contributes to between 65 and 80 % of the total catch of marine fish in Ghana. The inshore fleet consists of mostly locally-built, wooden-hulled trawler/purse seiners, and the industrial fleet of large, steel-hulled, foreign-built trawlers and shrimpers use bottom trawl gear to catch demersal fish in Ghanaian waters. All vessels operate in about the same area, targeting similar species.

Between 1956 and 1990, a number of surveys of the demersal fishery resources were conducted on the continental shelf and upper slope off Ghana. Koranteng (1998) gives an elaborate description (treatise) of all trawling surveys conducted in Ghanaian waters between 1963 and 1990 involving the use of five research vessels. The different vessels and trawl gears used are also described.

The first comprehensive and most extensive survey in Ghanaian waters, and indeed, in the waters of West Africa, the Guinean Trawling Survey (GTS) was conducted in 1963-64 under the auspices of the Scientific Committee of the Organization of African Unity (Williams 1968). Following the establishment of the Fishery Research Unit (now the Marine Fisheries Research Division, MFRD) in Ghana in 1962, a number of bottom trawl surveys were also carried out in Ghana’s shelf waters using Ghanaian research vessels. The most recent international survey (Guinea 90) was conducted by the Spanish Institute of Oceanography in the waters between Sierra Leone and Ghana in April 1990 (Ramos *et al.* 1990).

The objectives of the surveys included the following:

i. exploration of the continental shelf for potential development of a trawl fishery (Salzen 1957),

ii. estimation of total biomass and catch rates (Rijavec 1980; Koranteng 1981, 1984),

iii. monitoring the biomass of fish stocks (Koranteng 1981, 1984),

Over the 28 year period under investigation, the marine environment in the Gulf of Guinea went through three climatic periods of distinct change as determined from time series analysis of some environmental parameters (Koranteng 1998). In the first climatic period covering 1963-1972, sea surface temperature (SST), both coastal and offshore, and bottom temperature (SBT) declined and coastal salinity was low. The second climatic period (1972-1982) was a cold one with less than average SST and SBT. During this period, the mixed layer was narrow with the thermocline remaining shallower than its long-term average position. Coastal and bottom salinity (measured at 100 m deep) were relatively high but the seasonal variation was minimal. In the final climatic period (1982-1990), temperatures were high, and salinity was low and erratic.

In this paper, changes in the abundance, density, potential yield and distribution of demersal species in Ghana's continental shelf waters assessed through the bottom trawl surveys are described. Variation in species composition over time is also described.

2. Materials And Methods

In the GTS survey, a systematic sampling scheme was adopted and depths of between 15 and 600 m were surveyed in the waters between Guinea Bissau and the Congo (Williams 1968). The MFRD surveys of 1969 - 1980 also followed systematic sampling methods (Rijavec 1980, Koranteng 1981). Stratified random designs were used in the 1981-82 and 1989 MFRD surveys (Koranteng 1984, 1998).

The sampling procedures were almost identical for all surveys. The depth of the station sampled was taken to be the average of the depth at start and end of the haul. The duration of tow was one hour in the surveys prior to 1980 and thirty minutes in subsequent surveys. In the MFRD surveys, cruises were conducted in both the upwelling and thermocline periods. At the end of each haul, the catch was sorted according to species or, in some instances, species groups (or genus). Fishes were identified according to Blache *et al.* (1970), Fischer *et al.* (1981) and Schneider (1990).

Data collected during the various surveys were compiled and re-analysed. Many of the names were cross-checked with entries in FISHBASE (FishBase 1996). For the MFRD surveys, only data for trips that covered the entire survey area were used. This was to avoid the problem of "over-weighting" as a result of some areas being worked more often than others in accordance with the sampling design (Koranteng 1984). The relevant data were total catch (in weight) and the number (MFRD surveys only) of each species in each haul. For hauls of 30 minutes duration (MFRD surveys), the catches were extrapolated to catch-per-hour of trawling. All data sets were inputted into the NAN-SIS computer program for survey data logging and analysis (Stromme 1992). The following families of (pelagic) fish were excluded from the analyses: Carangidae, Engraulidae, Clupeidae and Scombridae.

The stock biomass (B) was estimated by the 'swept area method' with catch per haul as the index of abundance. B is estimated by applying the equation:

$$B = \frac{A}{a} \cdot \frac{\overline{X}}{\boldsymbol{q}}$$

where A is the total area surveyed, a is the swept area of the net per haul, $\overline{X}$ is the average catch per haul (the index of abundance) and $\boldsymbol{q}$ is the catchability coefficient. A $\boldsymbol{q}$ value of 0.75 was used in this work (Koranteng 1998). The area swept by the net during one trawl haul is the product of the effective width ($\boldsymbol{b}$) of the net and the distance ($\boldsymbol{d}$) traversed by the gear during the haul. The effective width of each survey net was obtained from the survey reports, being 16.4 m in the GTS (Williams 1968) and MFRD surveys conducted between 1979 and 1990 (Koranteng 1984) and 15.3 m in the MFRD surveys conducted between 1969 and 1977 (Dinglassan 1973; Rijavec 1980). The following assumptions apply to the swept area method:

i. the speed of the vessel through the water is the same as that of the net on the seabed and that both vessel and net cover the same distance within the duration of the tow,

ii. the speed is constant for the duration of the tow,

iii. the vessel's movement through the water is not impeded by currents,

iv. the catch is proportional to area trawled.

Using the routines in NAN-SIS, the density of selected species and families and also the total stock (excluding triggerfish), were calculated for each survey. The families are grunts, seabreams, snappers (including *Lethrinus atlanticus*), groupers, croakers, rays (mainly Dasyatidae, Myliobatidae, Rhinobatidae, Torpedinidae), sharks (mainly Carcharhinidae, Squatinidae and Triakidae), cephalopods (mainly Sepiidae, Octopodidae and *Loligo* sp.) and soles (Soleidae, Citharidae and Bothidae). These families are extremely important in the demersal fishery either in total quantity landed or in value. The following species were also included in the analyses: Red mullet (*Pseudupeneus* *prayensis*), the bigeye grunt (also known as burrito, *Brachydeuterus auritus*), triggerfish (*Balistes capriscus*) and Atlantic bigeye (*Priacanthus arenatus*).

The data were grouped according to the four seasons of the year in Ghanaian waters; namely January - March (minor upwelling season), April - June (long warm or thermocline season), July - September (major upwelling season) and October - December (short warm season). For these analyses three depth ranges, namely 10-30 m, 31-50 m, and 51-100 m were used. These depth ranges are indicated in the tables as DR1, DR2 and DR3 respectively.

A subset of years with surveys in both thermocline (April - June) and major upwelling (July - September) seasons was selected and the densities obtained from these surveys were compared. For this comparison, the two GTS years were considered as one. To investigate seasonal and long-term changes in the density of demersal species and families, 'analysis of variance' (ANOVA) techniques were employed using a model of the form

$$d_{ijk} = \mu + b_i + s_j + y_k + \varepsilon_{ijk}$$

where μ is the overall mean density, b_i represents the effect of depth, s_j is season effect, y_k is the year effect on the density d_{ijk}, and ε_{ijk} are random variation. A model including first order interactions was fitted but the interactions were later omitted as none were found to be significant. The SPSS package was used for the ANOVA.

Results from the two international surveys (GTS and Guinea 90) were specifically compared, because the GTS was conducted at the beginning of the period and Guinea 90 survey at the end of the period under consideration. In addition, wider depth ranges were covered in these surveys than in the MFRD surveys.

3. Results

Table II shows how the relative importance of species (ranked on the basis of density) changed between 1963 and 1990. During the GTS (1963-64) and the MFRD1 (1969-70) surveys, the most abundant species was bigeye grunt. The species formed 14.2 % and 13.9 % respectively of the total assessed density of demersal species in the two surveys.

Table III gives the calculated density of selected species groups of commercial or scientific importance in the Ghanaian demersal fishery. The density of all species (excluding triggerfish) is higher in the upwelling season than in the thermocline season (Figure 1). A summary of average density values within depth ranges and seasons for the three climatic periods are given in Tables IV and V respectively. Probability values obtained from the analysis of variance to examine the significance of the fitted models are presented in Table VI. The results for both untransformed and transformed density values are shown; these are quite similar in most cases. A logarithmic transformation was applied to the density values.

Mean density calculated from the results of the GTS and Guinea 90 surveys are depicted in Figure 2 for selected species and families. Figure 3 indicates total demersal density per depth range obtained from the two surveys. Very clear differences in status of the selected fish species and families between the earlier and latter years are portrayed in Figure 2. The difference in pattern of change of density within the depth ranges is evident form Figure 3. Table VII shows the mean catch per hour’s trawling, the calculated total biomass of demersal species (excluding triggerfish) and density by depth range.

4. Discussion

Results of the investigations show clearly the changes in relative importance of the demersal species that occurred over the period. Table II shows how triggerfish emerged from virtually nowhere to take the ninth position in the species rankings in 1969/70 and then dominated the continental shelf ecosystem of Ghana for nearly twenty years. It is noteworthy that some species maintained their relative importance in the ecosystem whereas the relative importance of others increased or decreased.

Species like the bigeye grunt, red pandora (*Pagellus bellottii*), blue-spotted seabream (*Sparus caeruleostictus*) and red mullet (*Pseudupeneus prayensis*) maintained their relative importance throughout the period of investigation. With exception of the period 1973-1977 the bigeye grunt maintained its position at the top giving way only to triggerfish in the years that the latter species dominated this ecosystem. The small-mouth croaker (*Pseudotolithus brachygnathus*) and European squid (*Loligo* sp.) which were important during GTS became completely unimportant for the rest of the time. The other croakers in the GTS top twenty did not feature in the rankings after the GTS survey, except for the large-mouth croaker (*Pseudotolithus senegalensis*) which re-appeared once more (1979/80) but with a very low ranking (18th). The absence of these species could be an indication of over-exploitation.

The density of the demersal species (excluding triggerfish) underwent major change over the 28-year period of investigation; in 1963 density was estimated to be about 50 kg ha^{-1}, 22.5 kg ha^{-1} in 1975 and 32.4 kg ha^{-1} in 1990 (Table III). The average density over this period was 35.6 kg ha^{-1}. The difference in density between years is statistically significant (0.02). The difference in density between climatic periods (CPs) is not statistically significant ($p = 0.29$ for the untransformed density and for the transformed density p=0.93; Table VI) although the mean density declined from 39.2 kg ha^{-1} in 1963-1972 to 32.1 kg ha^{-1} in 1982-1990.

The total demersal biomass (excluding triggerfish) in waters of 100 m deep and less, declined from an average of 79,000 mt (evaluated during GTS) to less than half this quantity between 1973 and 1977 (average of 33,000 mt; Table VII). In the survey conducted in 1979-80, a higher average biomass of 75,000 mt was obtained. In successive surveys, the biomass increased further to a peak of about 83,000 mt in 1981-82 but declined thereafter.

The low estimates of biomass between 1969 and 1977 are rather notable. Several factors might have contributed to this situation, including (i) assessment and (ii) biological factors. All surveys during the period in question were conducted using the MFRD research vessel *R/V 1*. It is possible that the low catch rates were due to differences in rigging of the survey net, mode of shooting and hauling in the net and vessel noise. The effects of such factors on catch rates have been discussed by Somerton (1996). It is essential to note that as the vessels were of different designs, sizes and horsepower, they could be expected to have different fishing efficiencies. Similarly, as the trawl nets used in the surveys were of different types, designs and sizes, they would have different catching efficiency.

The difference in density of all demersal species estimated between the two international surveys (GTS and Guinea 90) is statistically significant ($p = 0.02$) with higher density recorded for the GTS than for the Guinea 90 survey. The reduction in density occurs for all depth ranges except at depths greater than 100 m (Figure 3) where the density estimated from the Guinea 90 survey is higher than that of the GTS. The higher density is due mainly to increased biomass of cuttlefish (*Sepia officinalis*) at these depths, especially on the eastern part of the shelf (Ramos *et al.* 1990).

On an individual species and family basis (Figure 2), there was a reduction in density of snappers, groupers, seabreams and even Atlantic bigeye which is not a high grade fish. The biggest change was with the grunts (mainly bigeye grunt). However, considering its semi-pelagic nature, and thus a possible higher influence of the environment on its abundance, it may be inadequate to measure change in bigeye grunt with information from just two surveys. The reduction in density of high value fishes like sparids, snappers and groupers was probably due to fishing. On the other hand, the density of sharks, rays, cephalopods and soles increased.

Tables V shows significant differences in density of all demersal species (excluding triggerfish) between the upwelling and thermocline seasons. In each climatic period, and over the entire period, the total demersal biomass was highest during the third quarter of the year, which is the major upwelling season in the study area (Koranteng 1998, Longhurst 1962). This difference is statistically significant ($p < 0.01$; see Table VI). Such a result is important for the timing of future surveys. The density of croakers, snappers and seabreams also exhibit a similar pattern of seasonal variation with higher catches (hence density) in the upwelling season; but the difference is not significant in any of these cases (Table VI).

Triggerfish was encountered in large quantities in the study area from about 1970 and its peak density occurred in 1977-80. The species occupied the biotopes of the sciaenid and lutjanid assemblages (i.e. 10-30 m and 30-50 m) expanding to the 50-100 m only from 1981 when its density in this ecosystem had started to decline. Gulland and Garcia (1984) hypothesised that the low temperature, high salinity environment that occurred in the Gulf of Guinea during the period of observation, was more conducive for the sparid assemblage to which triggerfish belongs. This may have contributed to the sudden increase in the abundance of this species. The abundance of other members of the assemblage (e.g. Sparidae and flying gurnard, *Cephalacanthus volitans*) also increased during the second climatic period (1972 - 1982).

Koranteng (1998) has shown that during the period when triggerfish dominated the study area, the total density of sciaenids declined. Also during the observational period (1964-1990), there were shifts in the distribution of lutjanids that normally inhabit the 30-50 m depth (Koranteng 1998). It appears that snappers were displaced by the colonizing triggerfish into either 10-30 m or 50-100 m. Seabreams were consistently present in all three depth ranges (especially the second and third) throughout the period of investigation. However, the density of sparids was low in the 10-30 m depth range, especially during 1972-1982. In 30-50 m depth range, there was a consistent reduction in the density of sparids between 1964 and 1990 whereas in the 50-100 m depth, where the density was generally highest, a decline was observed between 1977 and 1990.

5. Conclusion

The total density of demersal species (excluding triggerfish) in Ghana’s shelf waters decreased from 50 kg ha^{-1} in 1963-64 to 32.4 kg ha^{-1} in 1990. The lowest value of 22.5 kg ha^{-1} was obtained in the period between 1973 and 1977. There was also a significant difference between density of fish in the thermocline and upwelling seasons; density during upwelling being higher than that of the thermocline season.

The change in density of the demersal species was different for the three depth ranges, namely 10-30, 31-50 and 51-100 m, with the shallowest zone experiencing the largest drop in total density. On a species and genus basis, the density of triggerfish increased dramatically at the beginning of the 1970s reaching a high value of over 28 kg ha^{-1} in the 30-50 m depth zone at the peak of its abundance in 1979-80. Whereas some species (e.g. rays, cephalopods and soles) increased in abundance, especially in the 30-

50 m depth zone, apparently following the disappearance of triggerfish, others (e.g. sparids, lutjanids and sciaenids) declined consistently over the observational period.

Therefore, it appears that the proliferation of triggerfish in this ecosystem destabilized the assemblages of constituent demersal species. The sciaenid and lutjanid assemblages were most affected by the sudden change in the abundance of triggerfish.

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Table I: Some of the most important demersal species exploited in Ghana

Family	**Major species**
Sparidae	*Pagellus bellottii*
	Sparus caeruleostictus
	Dentex canariensis
Haemulidae	*Pomadasys incisus*
	Pomadasys jubelini
	Brachydeuterus auritus
Sciaenidae	*Pseudotolitus* spp.
	Umbrina spp.
Lutjanidae	*Lutjanus fulgens,*
	Lutjanus agennes
Mullidae	*Pseudupeneus prayensis*
Serranidae	*Epinephelus* spp.
Polynemidae	*Galeoides* spp.
Penaeidae	*Parapenaeopsis atlantica*
	Penaeus notialis
Sciaenidae	*Penteroscion mbizi*
Ariommatidae	*Ariomma bondi*
Geryonidae	*Geryon maritae*
Penaeidae	*Parapenaeus longirostris*
Sepiidae	*Sepia officinalis*
Soleidae	***

Table II: Top 20 species (or genus) (ratings are on the basis of density) in the Guinean Trawling Survey (1963/64; stations of depth <100 m only) and their ranks in subsequent surveys.

Species/Genus	GTS	MFRD						Guinea-90
	1963/ 64	1969/ 70	1973- 1977	1979/ 80	1981/ 82	1987/ 88	1989	1990
Brachydeuterus auritus	1	1	18	2	2	2	1	1
Pagellus bellottii	2	3	2	3	3	3	2	2
Dentex congoensis	3	23	3	11	11	14	11	-
Priacanthus arenatus	4	16	21	9	9	5	10	4
Sparus caeruleostictus	5	6	4	4	5	6	3	6
Epinephelus aeneus	6	10	11	7	7	11	4	11
Pseudupeneus prayensis	7	8	7	5	4	4	4	3
Dentex angolensis	8	-	19	10	19	18	27	-
Galeoides decadactylus	9	11	-	13	30	26	-	26
Pseudotolithus senegalensis	10	-	-	18	-	-	-	-
Loligo sp.	11	-	-	-	-	-	-	-
Paracubiceps ledanoisi	12	29	-	-	22	25	-	-
Dentex canariensis	13	4	6	6	6	7	6	8
Boops boops	14	13	23	22	14	31	19	20
Raja miraletus	15	-	-	-	29	21	24	17
Sphyraena sp.	16	12	-	21	28	32	22	-
Dactylopterus volitans	17	7	8	-	26	8	9	13
Drepane africana	18	-	-	-	-	-	-	33
Dentex gibbossus	19	26	15	16	13	23	-	33
Pseudotolithus brachygnathus	20	-	-	-	-	-	-	-
Balistes capriscus	-	9	1	1	1	1	17	-

Table III: Annual mean density (kg ha^{-1}) of selected species, families and all demersal species (excluding triggerfish) evaluated in the trawl surveys

Year	Demersal	Triggerfish	Croakers	Snappers	Seabreams	Grunts	Soles	Groupers	Rays	Cephalopods
1963	49.87		3.01	1.23	15.68	9.64	0.12	2.22	1.05	2.01
1964	43.65		0.93	1.20	12.41	9.78	0.06	1.61	0.79	0.23
1969	48.44	1.43	0.96	2.72	8.47	16.64	0.29	0.82	0.26	2.89
1970	30.78	1.02	0.67	1.34	8.64	2.54	0.15	1.37	0.12	2.22
1975	22.57	13.55	0.29	0.93	9.17	1.05	0.15	1.02	0.99	0.58
1977	33.90	24.32	0.18	2.16	21.11	0.23	0.06	1.23	0.38	0.70
1979	41.70	58.95	2.16	1.69	14.80	8.29	0.03	2.01	0.18	0.64
1980	30.11	14.57	0.58	1.40	11.27	4.99	0.06	2.80	0.20	0.55
1981	38.75	23.56	3.47	1.37	14.02	6.75	0.15	2.25	0.29	1.46
1982	55.13	40.79	0.18	0.79	14.80	19.18	0.12	2.07	0.29	1.90
1988	34.25	2.60	0.47	1.52	8.06	4.76	0.12	1.26	0.70	2.48
1989	29.64	0.50	0.29	1.90	8.09	5.58	0.15	1.14	0.53	1.52
1990	32.47	0.20	0.64	1.46	7.12	3.62	0.32	1.17	0.96	2.66

Table IV: Average density (per climatic period, CP and depth range DR) of indicated species and families (density in kg ha^{-1})

CP	DR	Demersal	Balistes	Croakers	Snappers	Seabreams
1	1	33.29	1.14	1.34	0.70	4.15
	2	32.82	1.40	0.82	2.01	10.48
	3	51.45	0.06	1.08	2.28	15.24
	All	39.19	0.88	1.08	1.66	9.96
2	1	20.59	30.40	0.53	1.08	6.07
	2	35.65	50.31	0.82	1.49	11.30
	3	54.37	3.59	2.74	1.43	22.89
	All	36.88	28.09	1.37	1.31	13.43
3	1	20.35	0.82	0.55	1.49	3.85
	2	30.08	1.64	0.23	1.64	6.77
	3	45.96	0.82	0.61	1.75	12.64
	All	32.12	1.11	0.47	1.64	7.77
All	1	23.56	12.56	0.73	1.14	4.82
	2	32.94	20.76	0.61	1.66	9.46
	3	50.60	1.72	1.55	1.75	17.32
	All	35.71	11.68	0.96	1.52	10.54

Table V: Average density (per climatic period, CP and season) of indicated species and families (density in kg ha^{-1})

CP	Season	Demersal	Balistes	Croakers	Snappers	Seabreams
1	1	33.26	0.64	1.20	1.20	9.05
	2	29.64	0.70	0.06	1.69	9.84
	3	47.04	0.50	1.20	2.25	11.01
	4	38.14	1.78	1.26	1.23	9.31
	All	39.19	0.88	1.08	1.66	9.96
2	1	25.61	21.35	0.18	1.31	10.89
	2	37.70	23.74	0.47	1.20	13.78
	3	52.47	3.53	4.29	1.96	17.20
	4	28.29	85.94	1.02	0.73	10.75
	All	36.88	28.09	1.37	1.31	13.43
3	1	33.84	2.66	0.20	1.46	8.96
	2	30.60	0.58	0.26	1.93	8.21
	3	36.18	0.93	1.05	1.49	7.56
	4	28.94	0.88	0.35	1.49	6.57
	All	32.12	1.11	0.47	1.64	7.77
All	1	30.13	10.07	0.47	1.31	9.81
	2	34.05	12.18	0.35	1.55	11.15
	3	45.23	1.66	2.16	1.90	11.91
	4	31.39	25.46	0.79	1.20	8.56
	All	35.71	11.68	0.96	1.52	10.54

Table VI: Probability values obtained from the analyses of variance

(‘All demersal’ does not include triggerfish)

	Probability			Probability	
	untransformed density	transformed density		untransformed density	transformed density
1. All demersal			**5. Croakers**		
DR	<0.01	<0.01	DR	0.82	0.72
Season	<0.01	<0.01	Season	0.79	0.64
Year	0.02	0.02	Year	0.11	0.28
CP	0.29	0.93	CP	0.29	0.36
2. Triggerfish			**6. Soles**		
DR	0.02	<0.01	DR	0.22	0.22
Season	0.01	0.01	Season	0.37	0.39
Year	<0.01	<0.01	Year	0.03	0.02
CP	<0.01	<0.01	CP	0.02	0.01
3. Snappers			**7. Cephalopods**		
DR	0.26	0.11	DR	<0.01	<0.01
Season	0.37	0.42	Season	0.76	0.75
Year	0.82	0.91	Year	0.03	<0.01
CP	0.64	0.69	CP	<0.01	<0.01
4. Seabreams			**8. Rays**		
DR	<0.01	<0.01	DR	0.94	0.99
Season	0.27	0.12	Season	0.08	0.04
Year	<0.01	<0.01	Year	0.11	0.02
CP	<0.01	<0.01	CP	0.04	0.01

Table VII. 95% confidence limits of catch rate and total biomass and calculated density in three depth ranges of demersal species (excluding triggerfish), from the indicated surveys.

Survey	Years	Mean catch rate (kg h-^{1})	Total biomass (mt)	Density in indicated depth range (m)		
				10-30	31-50	51-100
GTS	1963-64	242.8 - 332.6	67 200 – 92 100	46.1	33.9	38.6
	1969-70	94.3 - 132.0	35 400 – 49 600	10.3	23.3	32.3
	1973-77	67.6 - 114.1	25 400 – 42 800	9.8	17.9	22.3
	1979-80	189.6 - 290.1	61 000 – 93 300	36.2	41.9	31.9
MFRD	1981-82	214.2 - 307.7	68 900 – 98 900	37.9	42.9	39.6
	1987-88	179.5 - 232.8	57 700 – 74 900	20.1	32.7	48.2
	1989	132.7 - 168.8	42 700 – 54 300	19.8	21.2	31.6
	1990	151.4 - 199.6	48 700 – 64 200	20.7	28.0	34.3
GUINEA-90	1990	85.0 - 203.6	26 100 – 62 400	18.4	18.4	23.1

Legends for figures

Figure 1: Calculated mean density of all demersal species in survey years, 1963 - 1990.

Figures 2: Comparison of calculated density of selected demersal species – GTS II (March 1964) and Guinea 90 (April 1990) (back-transformed means).

Figure 3: Comparison of calculated mean density of total demersal species – GTS II (March 1964) and Guinea 90 (April 1990) (back-transformed means)