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SEX RATIO AT SIZE OF THE SWORFISH (*XIPHIAS GLADIUS* L.) IN THE ATLANTIC AND MEDITERRANEAN SEA: SIMILARITY BETWEEN DIFFERENT SPATIAL-TEMPORAL STRATA

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SUMMARY

This paper analyzes the degree of similarity that exists int he sex-ratio at size of swordfish caught in different spatial-temporal strata of the Atlantic Ocean and Mediterranean Sea.

A total of 65,346 fish were samples during the 1986-1993 period, using landings at the fist markets and observers on board.

Four different agglomerative hierarchical methods were tested among the different spatial-temporal strata defined.

The results point to a considerable variability in this biological parameter, suggesting that at least three blocks of general groupings between strata are possible.

Certain well-defined areas in tropical zones of the west Atlantic show a very particular sex-ratio patters, unlike the pattern found in the other areas analyzed.

RESUME

Ce document analyse le degré de similitude existant dans le sex-ratio par taille de l'espadon capturé dans différents strates spatio-temporelles de l'océan Atlantique et en Méditerranée.

En tout, 65.346 poissons ont été échantillonnés durant la période 1986-93 sur les débarquements dans les marchés de poisson et l'embarquement d'observateurs à bord.

Quatre différentes méthodes aglomératives hiérarchiques ont été testées entre les différents strates spatio-temporelles définies.

Les résultats indiquent une variabilité considérable dans ce paramètre biologique, suggérant du moins 3 blocks ou agroupements généraux entre strates.

Des zones déterminées définies dans les zones tropicales de l'Atlantique ouest présentent un schéma de sex-ratio très particulier et différent du schéma trouvé dans les autres zones analysées.

RESUMEN

En el presente documento se analiza el grado de similaridad existente en el sex-ratio "at size" del pez espada capturado en diferentes estratos espacio-temporales del Océano Atlántico y Mar Mediterráneo.

Un total de 65346 peces han sido muestreados durante el período 1986-1993 aprovechando desembarcos en lonjas y embarques de observadores.

Cuatro diferentes métodos aglomerativo-jerárquicos de "cluster" fueron ensayados entre los diferentes estratos espacio-temporales definidos.

Los resultados ponen de manifiesto una variabilidad considerable en este parámetro biológico, sugiriéndose al menos 3 bloques o agrupamientos generales entre estratos.

Determinadas áreas definidas en zonas tropicales del Atlántico oeste presentan un patrón de sex-ratio muy particular y distante del patrón encontrado en las otras áreas analizadas.

INTRODUCTION

Based on observations made from the outset of the Atlantic swordfish fishery, several authors have pointed out the considerable difference that appears in the sex-ratio of the different size classes. (BECKET (1974), HOEY (1986), (1991), GARCIA & MEJUTO (1988), LEE (1992).

These differences in sex-ratio between different size classes have been explained, as most likely being due to a possible natural differential growth and/or mortality between sexes, among other possible hypotheses.

However, in spite of this pattern which has been repeatedly described, later research carried out by several authors on the sex-ratio at size of the swordfish demonstrated the high spatial-temporal variability of this biological parameter (HOEY (1991), DE LA SERNA et al. (1992), MEJUTO et al. (1991)).

This variability (probably multifactorial) has been explained as perhaps being caused by differential migratory behaviour by sex, in regard to physiological and oceanographic requirements, different stratification in depth, etc.

Most of the data available to date pertain to catches obtained using only one gear (surface longline), which could have a decisive effect on the results and their interpretation. Therefore, the comparison of data between several gears under one spatial-temporal heading could be of great interest.

All the information compiled from the Spanish fleet comes from the activity of commercial fleets using surface longline (generally used in the Atlantic and Mediterranean) and driftnet (whose has been used in restricted and specific areas and times). This limits to a large extent the representativity of the samples, since the behaviour pattern of the fleet has not changed substantially in recent years. There could be areas/seasons not correctly represented in the samplings, which would create additional difficulties in terms of confronting and interpreting the analyses.

This paper attempts to present an overall view of this parameter, aside from more detailed descriptions of specific areas than might be of future interest.

MATERIAL AND METHODS

The mid-1980's marked the beginning of the collection of biological data to assess the sex-ratio (SR) at size. Preliminary results from the Spanish fleet (temperate areas) have been reported in GARCIA & MEJUTO (1988).

Between 1986 and 1993 an intensive sampling campaign was started to sex swordfish in different Spanish ports and on board longline vessels that dressed the fish on board.

These data were classified considering the following variables : Date of capture, Port, Vessel, Gear, Position, Sex and Size (LJFL).

Sex identification during the landings was carried out "in situ" by two teams of observers. Team (1) covered the traditional landing ports in the North of Spain, while team (2) covered ports in Southern Spain (The Atlantic) and Mediterranean.

In order to make sure that the observation criteria used by both teams was identical, especially when small fishes were examined, both teams worked together for several days checking that there were no discrepancies in the observations (0.00%) for any given size analyzed.

This would allow us to rule out the possibility that the differences found between areas/seasons were actually due to different observation criteria.

In view of the fact that the sampling volume carried out in a specific year did not adequately cover the areas-seasons defined to be able to make our comparisons between years, the Year variable was not considered in this first approach. We assumed the non-existence of annual variability for one spatial-month stratum.

After several tentative analyses and data calculations, we decided to classify the data into 14 areas (Figure 1). Although the use of wider areas would invariably increase the number of observations available for each area, we nonetheless chose to maintain this tentative classification.

However, due to the low coverage in some months/areas, data were classified in six month periods (1= January-June), 2= July-December). Other temporal classifications, which perhaps would be more appropriate from a biological and oceanographic point of view, were unable to be tested due to a shortage of time. Further analyses will be developed taking into acount several time criteria.

The samplings carried out in the different ports, taking advantage of the landings of the traditional fleet, were not done on a random basis. We only had access to fishes that were dressed for commercial purposes which means that the sampling might be biased towards the sizes that are most frequently dressed.

On the other hand, the samplings carried out on board freezer fishing vessels (from observers) are highly representative, as 100% of the specimens caught in the trip were sexed.

Data were arranged according to the variables area/time/sex/size/ and sex-ratio values were calculated:

$$(\text{females} / (\text{females+males})) * 100$$

Some of the resulting area-time strata were discarded for future analyses due to the small number of observations.

For further analyses, only fishes in the 115<= LJFL <=200 size range were included. Sizes outside this range were excluded. They showed a very low number of observations, causing erratic variations in sex-ratio at size that could create a distorted view when calculating "distance" levels and making numerical comparisons.

In addition, the variability of sex-ratio at size usually appears within the size range chosen. Individuals measuring less than 115 cm usually have sex-ratios of around 50%, whereas individuals over 200 cm have values of around 90-100%. Although this is the general pattern that was expected, different specific situations might still appear.

The data matrix of area/time/size/sex-ratio was analyzed and classified into clusters or groups suggested by the data, not previously defined. Four different agglomerative hierarchical methods were used (DIGBY & KEMPTUN, (1991), PIELOU (1984), JONGMAN (1987)).

(1) Single linkage cluster analysis.
(2) Average linkage cluster analysis.
(3) Centroid hierarchical cluster analysis.
(4) Ward's minimum variance cluster analysis.

The difference between the cluster methods applied is determined by how the distances between clusters are calculated. The calculation of the distances as well as the cluster process were done using SAS software. The methodological details and the calculation of the distances are also indicated in SAS (1988).

RESULTS

During the 1986-1993 period, based on 3502 observations carried out in different landing ports and observer trips, 65346 individuals were sexed.

Table 1 presents a summary of information on the number of fishes sampled by area and sex for the 14 areas defined. Area 11 did not have any observations; therefore it is not included in the findings.

Due to the small number of observations obtained, the following strata were eliminated from the analyses:
Area= 3 Time= 1, Area= 20 Time= 1, Area= 21 Time 1.

As a result, 20 spatial-temporal strata were included and analyzed. The sex-ratios (SR) at size were calculated (Table 2).

Although the overall sex-ratio value (SR) may be of interest as a general indicator, it should, however, be interpreted with reservation. This value is highly conditioned by the sampling effort carried out on the different sizes. Nonetheless, despite these limitations, this variable has striking results, especially those pertaining to areas 7 and 8 (for any of the temporal strata).

A glance at the SR values at size for areas 7, 8 and 12 tells us that the values obtained are very different from what was expected.

The results of the cluster processes for the four methods applied (figures 2a, 2b, 2c, 2d) show relatively consistent groups.

Areas 4, 5, 6, 10, 20 and 21 appear to form a group that is relatively distant from the other strata under consideration. The results obtained from Ward's Minimum Variance Method are especially interesting. Areas 5, 20 and 21 (The Atlantic and Mediterranean Strait of Gibraltar) show a great similarity.

Areas 1, 2, 3 and 9 may be considered as a second group which is moderately homogeneous.

The group obtained for areas 7 and 8 was found to be especially worthy of attention in any one of the four methods used. These areas have a SR pattern that is totally different from that of the other areas analyzed (Table 2). The percentage of females for certain sizes is extremely low, producing a "black hole" of females in both areas, especially in area 7.

Once this base information was checked, it was confirmed that females caught in these zones are very scarce, frequently having high gonadal indices (ready to spawn or spawning).

There are several hypotheses that could explain this phenomenon, among others: (1) the absence of females in the fishing areas, (2) low catchability of females.

The reproductive processes of females could cause changes in their behaviour that would affect the surface longline catchability in these zones or the reduction of their nutritional requirements. The stratification of females in deeper areas might also explain the decrease in the catchability of females. Similar fenomena have been described for some spawning area-time of the Mediterranean Sea (SCRS 92/86).

However, if this were true, the same effect would be expected in other areas where females in advanced stages of maturity are found.

The possible concentration of females in more coastal zones, which are inaccessible to the fleets under study, should not be ruled out.

Thus, comparisons using data from traditional fleets/gears from coastal countries and the comparison with data from other fleets that fish with longlines in deeper waters could contribute highly interesting information.

The oceanographic conditions of the areas labelled as 7 (this area especially) and 8 are relatively far from the areas located more to the East at the same latitude.

Even though the superficial isotherms are quite similar in the entire equatorial-tropical strip, the thermocline of areas 7 and 8 is, however, found at a greater depth than in area situated more to the East, as can be seen in the XBT data from an observation cruise (QUINTANS, pers. comm.). An exampled is provides in Figure 3.

This could affect the bathymetric distribution of mature females and, consequently, the catchability of the traditional surface longline fleet.

Area 12 does not display a clearly defined relationship or grouping with the other areas. In general, the relationship might be very distant and, on occasion, the results suggest that it should even be considered as a separate group.

This area has a high number of large sized males, which is a rare aspect in other areas analyzed. This is, without a doubt, what shapes its particular characteristics.

An additional analysis was carried out to compare the SR of the catches obtained in a specific area (Area 5) using surface longline (LL) and gill driftnet (GN) gears. The results point to considerable differences in the SR obtained from both gears (Figure 4a , 4b). The percentage of females is lower in the case of the GN for size ranges 100-145. From this size on, the SR of both gears appears to converge. This differences will be further investigated.

ACKNOLEDGMENTS.

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AREA	TRIM	SEXO	[illegible] SUM
01	1	F	84.00
		M	26.00
	2	F	785.00
		M	901.00
	3	F	306.00
		M	395.00
	4	F	79.00
		M	66.00
02	1	F	166.00
		M	140.00
	2	F	28.00
		M	50.00
	3	F	254.00
		M	242.00
	4	F	242.00
		M	177.00
03	1	F	24.00
		M	61.00
	2	F	29.00
		M	49.00
	3	F	66.00
		M	26.00
	4	F	67.00
		M	61.00
04	1	F	1634.00
		M	1207.00
	2	F	309.00
		M	373.00
	3	F	950.00
		M	464.00
	4	F	1370.00
		M	936.00
05	1	F	700.00
		M	524.00
	2	F	3012.00
		M	3427.00
	3	F	2019.00
		M	1290.00
	4	F	1035.00
		M	1131.00
06	1	F	2647.00
		M	1760.00
	2	F	1953.00
		M	1351.00
	3	F	1933.00
		M	871.00
	4	F	2363.00
		M	1315.00
07	1	F	48.00
		M	295.00
	2	F	648.00
		M	3366.00
	3	F	112.00
		M	655.00
08	1	F	91.00
		M	318.00
	2	F	246.00
		M	390.00
	3	F	388.00
		M	701.00
	4	F	110.00
		M	105.00
09	3	F	1188.00
		M	744.00
	4	F	451.00
		M	485.00
10	3	F	22.00
		M	24.00
	4	F	893.00
		M	405.00
12	2	F	575.00
		M	536.00
20	1	F	143.00
		M	178.00
	2	F	314.00
		M	334.00
	3	F	772.00
		M	789.00
	4	F	579.00
		M	487.00
21	1	F	558.00
		M	631.00
	2	F	628.00
		M	695.00
	3	F	1280.00
		M	1418.00
	4	F	1417.00
		M	1398.00

Table 1. Number of fishes sampled by AREA, QUARTER and SEX.

STRAT	overal sex-ratio	T115	T120	T125	T130	T135	T140	T145	T150	T155	T160	T165	T170	T175	T180	T185	T190	T195	T200
011	0.484	37.805	38.889	38.333	36.283	28.736	45.528	37.956	38.060	38.298	46.939	51.923	49.412	62.500	68.000	86.275	86.364	100.00	100.00
012	0.502	39.535	56.757	49.057	43.860	41.270	42.683	32.877	44.118	49.254	45.098	47.059	47.500	53.571	71.429	64.706	77.273	92.857	100.00
021	0.505	30.435	41.667	35.714	30.435	61.905	47.619	43.478	33.333	43.333	48.000	53.846	58.333	66.667	60.000	100.00	75.000	100.00	100.00
022	0.542	53.125	54.054	50.000	58.182	51.786	53.191	52.830	50.000	49.206	47.692	46.667	51.064	48.387	56.250	77.778	60.000	90.476	91.667
032	0.565	42.857	66.667	70.000	37.500	50.000	53.333	60.000	50.000	55.000	20.000	50.000	33.333	33.333	80.000	66.667	66.667	75.000	75.000
041	0.561	44.660	42.437	46.693	47.791	47.451	50.455	56.459	54.357	63.212	62.562	61.979	70.000	69.421	76.596	78.462	82.090	82.609	86.842
042	0.625	36.441	44.578	51.351	45.205	55.022	51.695	62.992	62.185	66.204	70.089	67.241	71.667	72.067	76.159	80.142	78.571	81.944	91.398
051	0.490	23.962	28.849	30.503	34.653	44.800	52.101	50.681	63.496	72.660	74.232	76.658	79.118	84.416	86.512	84.314	87.121	91.781	92.241
052	0.615	42.258	40.203	38.860	46.537	49.280	54.167	65.157	68.056	72.404	75.982	81.905	82.659	82.772	84.188	85.057	87.218	93.043	97.902
061	0.598	43.089	52.055	48.682	55.474	60.624	58.882	66.419	62.554	64.108	67.916	67.225	75.427	76.446	74.479	82.424	88.785	90.000	95.146
062	0.663	52.560	47.799	57.382	62.044	57.045	64.964	68.085	69.118	70.103	76.201	77.839	84.932	80.827	82.063	85.535	88.489	88.421	96.296
071	0.164	25.373	9.333	7.273	10.738	6.341	5.747	4.367	2.087	3.610	6.695	15.902	22.275	38.028	56.364	78.667	88.095	90.323	100.00
072	0.146	33.333	23.810	5.556	7,692	0.000	1.471	2.632	4.902	4.082	3.297	16.364	22.222	64.000	81.250	88.889	87.500	100.00	100.00
081	0.322	33.333	28.125	25.714	15.217	17.308	11.268	8.475	15.238	15.385	18.391	28.571	38.095	61.224	76.667	83.333	85.000	100.00	95.455
082	0.382	41.176	28.571	19.643	10.638	12.903	6.849	7.921	12.097	15.686	16.667	26.250	47.826	59.091	76.471	89.189	93.750	90.323	100.00
092	0.571	53.191	50.602	34.722	26.087	36.283	39.735	37.324	36.471	36.810	38.983	51.176	58.373	64.972	78.235	90.833	90.698	97.196	97.872
102	0.681	58.333	67.089	75.439	54.762	76.316	60.784	65.000	67.857	62.500	60.000	73.913	71.605	78.878	91.837	85.714	84.375	93.333	94.737
121	0.518	100.00	30.000	53.333	42.105	43.750	27.586	34.091	34.884	32.857	32.727	31.579	31.169	52.941	58.704	47.436	63.636	68.333	65.517
202	0.514	47.619	44.068	51.111	51.807	66.000	50.000	47.059	78.378	67.857	100.00	81.250	81.250	86.667	100.00	100.00	100.00	100.00	100.00
212	0.490	41.121	43.155	49.580	44.000	52.212	55.779	57.955	71.000	63.918	77.778	78.261	85.366	78.571	87.500	95.238	100.00	100.00	100.00

Table 2. Overall sex-ratio and sex-ratio at size for each spatial-temporal stratum analyzed.

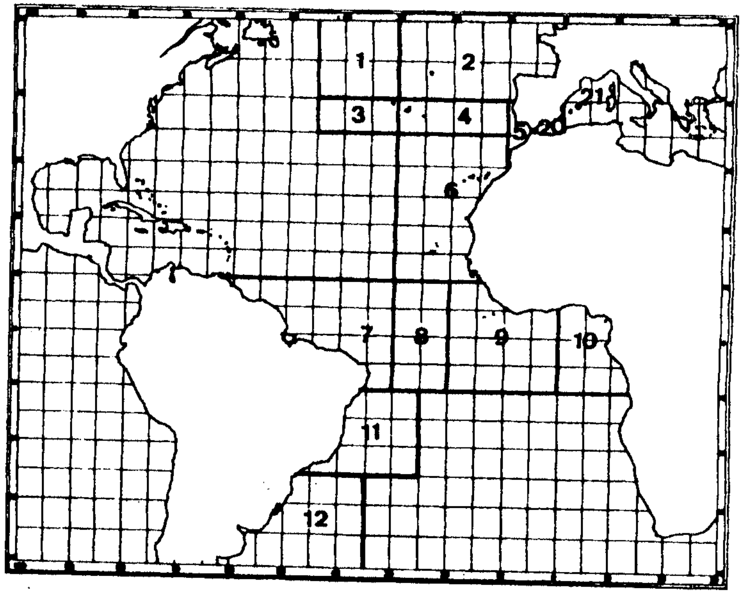

Figure 1. Definition of the geographical areas used in the analyses.

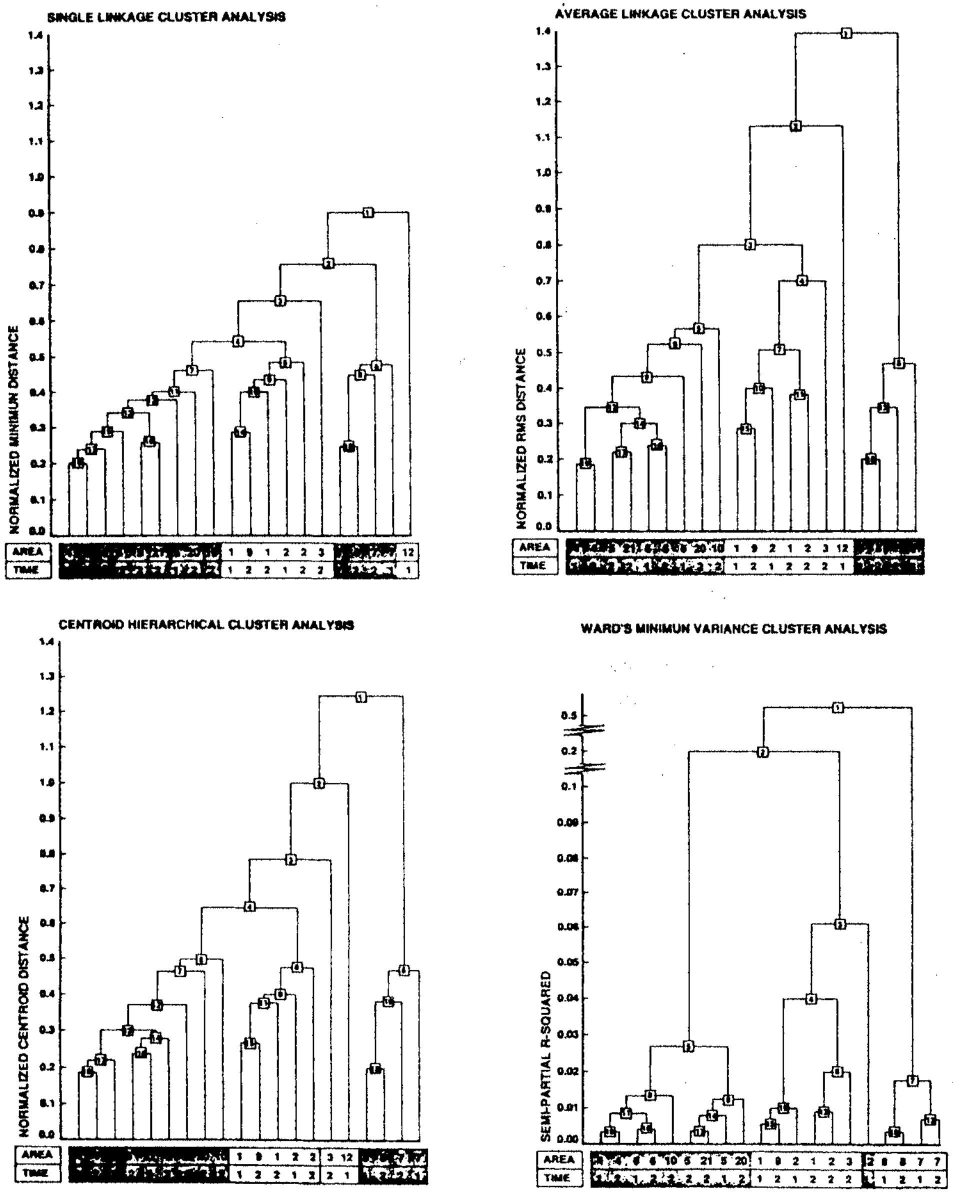

Figure 2. Distances between the different spatial-temporal strata defined for the 4 different agglomerative hierarchical cluster analyses tested.

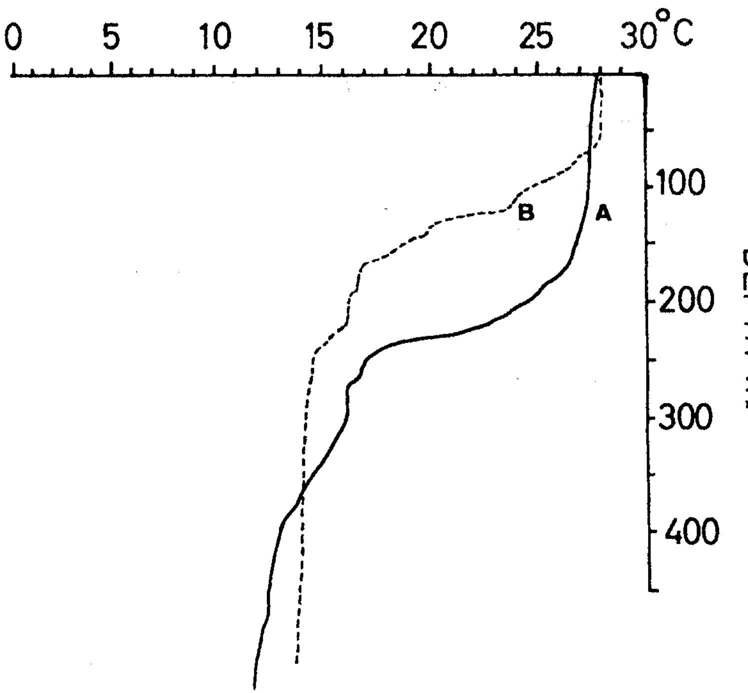

Figure 3. Variation of the temperature with depth (XBT data) in tropical Atlantic zones.

(A) POSITION : 00º 07'N - 32º 11'W , DATE : 25.3.90
(B) POSITION : 01º 17'N - 20º 23'W , DATE : 14.5.90

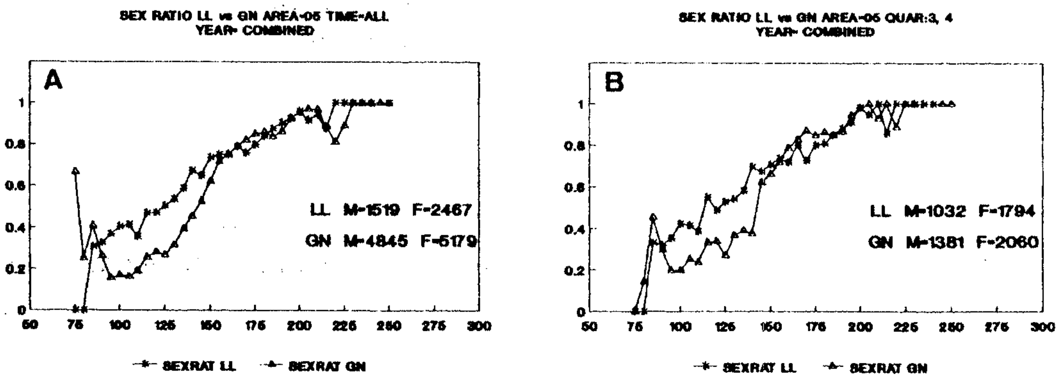

Figure 4. Sex-ratio at size obtained in AREA= 5, from catches made with both fishing gears, longline and driftnet. (A) : All the months combined. (B) Quarters 3 and 4.