A COMPARATIVE STUDY OF THE UNITED STATES AND SPANISH LONGLINE FLEETS TARGETTING SWORDFISH IN THE ATLANTIC OCEAN NORTH OF 40°N LATITUDE

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SUMMARY

Harvesting characteristics (size composition and catch rates) of the U.S. and Spanish fleets are examined in light of gear and operating (time-area) practices in the north Atlantic between 40° and 50° north latitude and between 20° and 50° west longitude. The two fleets have approached and overlapped operations in this area between 1983 and 1985. During 1986 the degree of overlap continued to increase.

RESUME

Les caractéristiques d'exploitation (composition de taille et taux de capture) des flottilles américaine et espagnole sont examinées à la lumière des engins et méthodes normalement employés dans l'Atlantique nord entre 40º et 50ºN de latitude, et 20º et 50ºW de longitude. La pêche de ces deux flottille s'est rapprochée, et même recoupée, dans ce secteur entre 1983 et 1985. En 1986, le degré de chevauchement a continué de s'accroître.

RESUMEN

Se examinan las características (composición por tallas y tasas de capturas) de la captura de las flotas española y estadounidense, a la luz de los artes empleados y del tipo de operación llevada a cabo (tiempo-zona) en el Atlántico Norte, entre 40 - 50º de latitud Norte y 20 - 50º grados de longitud Oeste. Las operaciones de ambas flotas han estado bastante cercanas y se han solapado en esta zona durante el periodo 1983-85. En 1986 continuó en aumento el grado de solapamiento.

INTRODUCTION

Current total Atlantic harvest levels (excluding the Mediterranean) are the highest on record (1950-1985, ICCAT) with 19 to 20 thousand metric tons reported for the past three years. Spain and the United States have accounted for 60, 51, and 50 percent, respectively, for the past three years. If the North Atlantic is considered separately from the South, Spain and the United States have accounted for three quarters of the total removals in recent years. Fleets from Spain and the United States have expanded operations beyond coastal areas which historically accounted for the majority of their landings. In the past three years, both fleets have operated north of the Azores and east of the Grand Banks.

The purpose of this project is to examine harvesting characteristics (size composition and catch rates) of the U.S. and Spanish fleets in light of gear and operating (time-area) practices in the North Atlantic between 40 and 50 degrees north latitude and between 20 and 50 degrees west longitude. The two fleets have approached each other between 1983 and 1984. In 1985 the fleets overlapped operations primarily along the 40 degree west longitude line in two five degree squares (4040 and 4540) east of the Flemish Cap. The amount of overlap has continued to increase during 1986. Landings from that area more than doubled for the U.S. and increased sevenfold for Spain, accounting for 27% of the total 1985 U.S. harvest and 52% of the total Spanish harvest from the Atlantic. In 1985, harvests from these three 10 degree squares, by Spain and the U.S. alone, accounted for 77% of the total North Atlantic harvest.

This cooperative research has been made possible by recent improvements in U.S. and Spanish data, and it offers a unique opportunity to improve our understanding of size specific distribution patterns in the North Atlantic. Questions of particular interest include size composition differences between fleets in adjacent areas or the same areas during the same month or season, changes in monthly size frequency, and changes over time. In light of the increased contribution of this region to the total North Atlantic harvest, the description of time-area effects on size composition may help direct harvesting strategies for specific age groups. This study and the improved North Atlantic swordfish data would not have been possible without the support and cooperation of commercial fishermen, processing industry representatives, and sampling agents of the U.S. and Spanish governments.

MATERIALS AND METHODS

Data collection

Despite differences in measurement units and data processing of catch, effort, and size composition, the U.S. and Spanish data are collected similarly. In both countries size composition data are collected as the fish are offloaded from a trip. In the U.S. the individual weights of the dressed carcasses (headed, gilled, gutted, and tailed) are recorded with vessel, gear, port, date, and fishing area information. In Spain, LJFL measurements are normally taken of each fish but sometimes round weights are measured and then converted to LJFL using the following equation:

WT(kg)=3.800x10-6*LJFL**3.242775

based on 2,306 measurements of LJFL and round weight over a length range of 74 to 279 cm and a weight range of 4 to 331 kg (Garces and Rey 1983). Numbers of fish are then compiled by 5cm intervals with the appropriate trip, month, and area data.

Data processing

So that comparisons can be made on the smallest time-area strata possible, three 10 squares (zones 1,2,3 - Figure 1) were defined in the area between 40 and 50 N and 20 and 50 W. Although the Spanish size frequency, catch, and effort data are recorded in month-5 degree square units, the U.S. data for the Grand Banks is assigned to the 10 degree square designated as zone 3. Based on the location specific data available at this time, this represents a reasonable designation for the bulk of the U.S. harvest.

Because the Spanish size frequency data are summarized by 5 cm intervals of LJFL, U.S. individual carcass weights were converted to LJFL using the following equation:

LJFL=44.2237*(Dwt)**.29257

where Dwt is the dressed carcass weight and the equation was based on 551 measurements of LJFL and Dwt over the independent variable range of 4 to 473 pounds (Turner 1986).

Fishing operations

Size frequency samples reflect specific gear and operating practices (time-area). In this area, both fleets utilize pelagic longline gear which is set at dusk and retrieved at dawn. The "haul-back" operation may take 8 to 12 hours depending on the catch and weather conditions. Although the materials and dimensions of the gear differ, the physical operation of setting and hauling the gear usually proceeds in a similar fashion with hooks spaced at relatively regular intervals along the mainline which is suspended from the surface by float lines. The lines can range in length from 8 to 60 KM and sections of the gear (usually a set number of floats) are marked by highflyers (radar reflectors or radio beacons).

The Spanish gear is very similar to the traditional longline gear used by the U.S. and Canadian fleets. These operations generally used shallower rigged gear with branch lines 10m or less and float lines 15m or less. As U.S. effort south of 35 N expanded in the mid to late 1970's, fishermen experimented with gear modifications adapting Cuban creole drift line techniques. The major changes included a switch from nylon multifilament mainlines and branch lines to monofilament construction of branch and float lines and later to complete monofilament mainlines, increased hook spacing, increased branch and float line lengths, and the use of chemical light sticks ("Cyalume" lights - trademark of American Cyanimid) in conjunction with each bait, and a switch from mackeral to squid bait.

Prior to 1982, the U.S. and Canada utilized traditional gear on the Grand Banks. In 1982 and 1983 the traditional gear dominated the U.S. size frequency sample while the 1984 sample reflects both gear types. In 1985 and 1986 size samples, the modified gear accounts for 80 to 90% of the trips sampled. This gear switch provides one indication of the wide acceptance of the modified gear throughout the U.S. fleet.

The modified ("Florida") gear was shown to be two to three times as effective as the traditional gear in the Straits of Florida (Berkeley, Irby, and Jolley 1981). At this time, no efficiency comparison has been made between the gear types operating north of 35 N. Although certain features of these modifications should comparably increase effectiveness (such as increased attractiveness of baits associated with lights and preference for squid baits over mackerel), other area specific adaptations, such as reduced avoidance of monofilament and deeper set depths, may not increase efficiency in this northern area where the mixed layer is shallower and the water is more opaque. Daily strategy decisions regarding the pattern of setting the gear, in terms of depth and surface temperature contours, affects the amount of gear set and the spacing within the gear. Gear characteristics such as construction material and specific dimensions are listed for Spanish, traditional U.S., and modified style longline gears (table 1a,b).

RESULTS

SIZE COMPOSITION

Annual size frequency samples from the Spanish and U.S. fleets operating between 40 and 50 N and 20 and 50 W are summarized in Table 2. Annual size frequency histograms and cumulative frequency plots for Spanish and U.S. data from 1983, 1984, and 1985 are presented (Figures 2a,2b,3a,3b). The annual size frequency histograms and frequency plots indicate that both the U.S. and Spanish fleets harvest fish of almost identical size in the study area despite gear and area-time differences. Annual cumulative size frequency plots for U.S. and Spanish size frequency samples are indistinguishable. Both data sets indicate a decline in the 50th percentile of LJFL of approximately 10 cm between 1983 and 1985.

Time and area differences in the Spanish and U.S. size frequency samples are summarized in Table 3 which lists the numbers of fish sampled by year, month, and zone. In order to examine size differences in light of the area-time sampling differences, several comparative plots of size frequency data were prepared. To examine seasonal differences Spanish data provided the necessary coverage to make appropriate comparisons. Size frequency histograms and cumulative frequency plots were prepared from the Spanish 1984 sample combining March, April, and May samples in one set of figures and August, September, and

October samples in another set (Fig. 4a,4b). Although this comparison matches a spring sample primarily from zone 1 with a fall sample from zones 1 and 2, it documents a decline in average size from spring months when the 50th percentile LJFL equals 175cm to the fall months when the 50th percentile LJFL equals 155cm. It is hypothesized that this seasonal decline in average size may be partially explained by increased availability of smaller fish in the fall months when mean sea surface temperatures are higher than the spring months. In order to examine fleet effects on seasonal shifts in size frequency a comparison of Spring (March-May) Spanish data for 1985 was made against fall (August-October) data from both the U.S. and Spanish fleets (fig 5a, 5b, 5c). This comparison documented a smaller reduction in average size from spring to fall months in the Spanish data (50 th percentile change from 165cm to 155 cm), and indicated that there were no differences between the U.S. and Spanish fall size frequencies. Again this last comparison is based on a zone 3 U.S. sample and a Spanish sample heavily weighted towards zone 1.

To examine west to east differences in size across the study area, September data from 1985 was plotted for both countries (Fig 6a, 6b). This comparison indicated that the U.S. September sample from zone 3 (westernmost area) is slightly larger (50th percentile @ 10cm larger) than the Spanish sample, which reflects fish from zone 1 and 2. A summary of area-time differences in mean LJFL (Table 4) reveals a complicated picture. Consistency in mean size across months and areas, with most mean LJFL values between 160 and 175 cm, would appear to be the dominant characteristic of this area. It is also apparent that months with mean LJFL values less than 160 cm appear more consistently in fall months (August - October) and in eastern zones.

CATCH RATES

A thorough evaluation of catch rates from Spanish and U.S. fleets operating north of 40 N, would have to address the gear differences previously described. This would require samples from both operations in the same year-month-zone strata. Although there is insufficient data to rigorously address these differences at this time, a presentation of mean CPUE values illustrates the affect gear differences can have on CPUE values calculated using different units of effort. CPUE's were calculated in terms of numbers of swordfish and weight (kg live weight) per 1,000 hooks and per set (Table 5). The Spanish longline gear has been relatively constant in terms of the construction material and component dimensions and rigging. Trends of increasing set size, in terms of hooks and miles of mainline, are attributed to operators setting additional sections of gear. Gear stability contributes to the low variability in Spanish CPUE's for both units of effort (hooks or sets). The Spanish data does however, show that higher catch rates have been realized as the fleet has moved to the west.

The U.S. data, in contrast, can be characterized by gear diversity and this is reflected in the variability of both hook and set based CPUE's. The hook based CPUE's are more variable than set based values, but the latter are still more variable than comparable Spanish data. In addition to the significant changes in gear construction adopted by the U.S. fleet, the major rigging change was increased hook spacing. The removal of ineffective hooks significantly increases hook based CPUE's and also increases set based CPUE's (Hamley and Skud 1978). Increased hook spacing, would however have a greater effect on hook based calculations. The 1983 U.S. catch rate values reflect smaller hook spacing with traditional gear, while the 1984 and 1985 data primarily reflect wider hook spacing in modified gear. This single gear modification undoubtedly contributes to the increasing CPUE's observed in the U.S. data between 1983 and 1985. Because of the significant differences in gear rigging, comparisons of set based CPUE's between U.S. and Spanish fleets in 1985 appear to be the most comparable. This comparison would be based on trips in the same or adjacent zones (2 and 3), and modified U.S. gear versus the stable Spanish gear configuration. U.S. catch rates in both numbers of swordfish and weight of swordfish are about 1.5 times greater than comparable Spanish catch rates. Because of the importance of harvests from this area and the apparently stable size structure, additional cooperative work on size specific catch rates and gear standardization procedures should represent a high priority research project for improving analytical assessments of Atlantic swordfish stocks. This cooperative approach should also be expanded to cover more extensive geographical areas and additional critical biological topics including sex and size specific distribution patterns, age and growth, and maturity studies.

DISCUSSION

Although the U.S. and Canada have exploited swordfish on the Tail of the Grand Banks with longline gear since the longline fishery was introduced in 1962 (previous harpoon harvests are documented), total North Atlantic harvests declined significantly between 1970 and 1978 as a result of U.S. Food and Drug administration regulations on acceptable mercury levels. Once the guidlines were increased to 1.0 ppm in 1978, the U.S. fishery expanded both to the south (increased proportion of U.S. landings south of 35 N) and to the northeast. The Spanish swordfish fishery also dramatically increased at the end of the 1970's and expanded operations from a coastal based fleet to more distant water operations. In the 1980's and especially in the last three years, this expansion has continued, reflecting a common exploitation pattern for oceanic pelagic resources. The North Atlantic fishery in particular can now be characterized as dominated by distant water fleets (primarily U.S. and Spain) which concentrate effort in area-time strata characterized by high abundance levels. In the North Atlantic, the importance of three ten degree squares (from the Grand Banks east to the

Azores) to the two largest harvesting nations provides an indication that most areas of high swordfish abundance in the North Atlantic are probably now being exploited. If this is the case then the recent expansion of the U.S. fleet into the Caribbean area (a documented spawning ground) and the fact that total Atlantic harvest (excluding the Mediterranean) is the highest on record collectively make it quite likely that the abundance levels of large fish have been impacted by commercial harvests, especially in some coastal areas, and will continue to remain below pre-longline levels of abundance. Recent analytical assessments of western North Atlantic swordfish data support this statement (Conser et al 1986, SEFC 1987). The rapid expansion of international distant water fleets along the northern and southern boundaries of the North Atlantic and possible further harvesting increases, represent the greatest potential threat to the resource.

Although significant differences in size composition were not apparent across the three ten degree squares studied, additional data from U.S. and Spanish fisheries harvesting areas south of 35 N, indicate that concentrations of small fish may be identified. Latitude is apparently of greater importance as a factor influencing size compostion than longitude, probably because it is a better indicator of sea surface temperature. The position of the Gulf Stream as it passes through the zones studied in this report undoubtedly influences the size compositon of harvested swordfish and may account for most of the variability in mean year-month-zone LJFL values. The consistency in size composition observed in this study area across years and months argues strongly for similar studies on a larger scale which may provide the basis for directing harvesting strategies on specific age groups so that long term maximum production can be attained.

Literature Cited

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TABLE 1. GEAR CHARACTERISTICS INCLUDING CONSTRUCTION MATERIAL AND COMPONENT DIMENSIONS FOR SPANISH, TRADITIONAL U.S., AND MODIFIED U.S. LONGLINE GEAR.

A)CONSTRUCTION MATERIAL

GEAR	SPANISH	U.S.+CAN TRADITIONAL	MODIFIED U.S.
HOOKS	3/0 SHARK	3/0 SHARK	9/0-10/0 BIG-GAME
MAINLINE	N MULTIFILAMENT 4mm	NYLON MULTIFILAMENT 4mm	MONOFILAMENT 600-700 lb-test
BRANCH LINES	<10m 2.7m nylon 5-7m steel	<10m 4-6m nylon .5m mono	10-40m 300-400 lb-test mono
FLOAT LINES	NYLON	NYLON	MONO

B)GEAR DIMENSIONS

GEAR	SPAIN	U.S.+CAN TRADITIONAL	U.S. MODIFIED
BRANCH LINES	8-10m	5-10m	10-40m
FLOAT LINES	5-20m	5-15m	15-30m
DISTANCE BETWEEN HOOKS	25-30m	15-30m	40-80m
NUMBER OF HOOKS/SET	1300-2000	900-2000	100-400
LENGTH OF MAINLINE	30-40 KM	20-60KM	8-30KM

TABLE 2. NORTH ATLANTIC SIZE FREQUENCY DATA FROM U.S. AND SPANISH LONGLINE FLEETS TARGETTING SWORDFISH NORTH OF 40 N

	UNITED STATES ZONE 3			SPAIN ZONE 1,2, AND 3		
YEAR	TRIPS SAMPLED	NUMBER SAMPLED	WEIGHT SAMPLED (MT LIVE)	TRIPS SAMPLED	NUMBER SAMPLED	WEIGHT SAMPLED T LIVE)
1983	34	6,371	420	23	4,019	283
1984	38	10,112	588	86	13,854	908
1985	40	13,366	763	87	14,603	914

TABLE 3. U.S. AND SPANISH SIZE FREQUENCY SAMPLES IN NUMBERS OF MEASURED FISH BY YEAR, MONTH, AND ZONE.

USA SIZE SAMPLE FOR GRAND BANKS AREA FOR 1983

ZONE	1	2	3	4	5	6	7	8	9	10	11	12	TOTAL
3	0	0	0	0	0	0	617	1931	1501	2184	138	0	6371

SPANISH SIZE SAMPLE FOR NORTH AZORES AREA FOR 1983

ZONE	1	2	3	4	5	6	7	8	9	10	11	12	TOTAL
1	0	393	233	0	0	0	40	0	0	468	2115	68	3317
2	0	161	0	199	342	0	0	0	0	0	0	0	702

USA SIZE SAMPLE FOR GRAND BANKS AREA FOR 1984

ZONE	1	2	3	4	5	6	7	8	9	10	11	12	TOTAL
3	0	0	0	0	0	180	1905	2553	3144	1394	936	0	10112

SPANISH SIZE SAMPLE FOR NORTH AZORES AREA FOR 1984

ZONE	1	2	3	4	5	6	7	8	9	10	11	12	TOTAL
1	139	1555	789	1405	865	848	101	286	116	1768	1741	311	9924
2	0	0	123	0	0	0	468	645	1557	687	0	450	3930

USA SIZE SAMPLE FOR GRAND BANKS AREA FOR 1985

ZONE	1	2	3	4	5	6	7	8	9	10	11	12	TOTAL
3	0	0	0	0	0	527	1615	4643	4496	2085	0	0	13366

SPANISH SIZE SAMPLE FOR NORTH AZORES AREA FOR 1985

ZONE	1	2	3	4	5	6	7	8	9	10	11	12	TOTAL
1	472	271	385	580	774	0	87	125	1090	2215	0	247	6246
2	0	345	1145	2447	1307	324	171	264	869	369	0	0	7241
3	0	0	0	0	0	452	0	0	436	228	0	0	1116

TABLE 4. MEAN LOWER JAW FORK LENGTHS FOR U.S. AND SPANISH SIZE FREQUENCY SAMPLES BY YEAR, MONTH AND ZONE.

USA MEAN LJFL FOR GRAND BANKS AREA FOR 1983

ZONE	1	2	3	4	5	6	7	8	9	10	11	12	TOTAL
3	0.	0.	0.	0.	0.	0.	179.	160.	172.	171.	165.	0.	6371

SPANISH MEAN LJFL FOR NORTH AZORES AREA FOR 1983

ZONE	1	2	3	4	5	6	7	8	9	10	11	12	TOTAL
1	0.	178.	170.	0.	0.	0.	170.	0.	0.	169.	167.	153.	3317
2	0.	172.	0.	176.	163.	0.	0.	0.	0.	0.	0.	0.	702

USA MEAN LJFL FOR GRAND BANKS AREA FOR 1984

ZONE	1	2	3	4	5	6	7	8	9	10	11	12	TOTAL
3	0.	0.	0.	0.	0.	163.	165.	163.	164.	168.	142.	0.	10112

SPANISH MEAN LJFL FOR NORTH AZORES AREA FOR 1984

ZONE	1	2	3	4	5	6	7	8	9	10	11	12	TOTAL
1	178.	170.	187.	180.	172.	162.	165.	141.	152.	162.	162.	173.	9924
2	0.	0.	171.	0.	0.	0.	159.	154.	155.	157.	0.	151.	3930

USA MEAN LJFL FOR GRAND BANKS AREA FOR 1985

ZONE	1	2	3	4	5	6	7	8	9	10	11	12	TOTAL
3	0.	0.	0.	0.	0.	158.	160.	160.	166.	162.	0.	0.	13366

SPANISH MEAN LJFL FOR NORTH AZORES AREA FOR 1985

ZONE	1	2	3	4	5	6	7	8	9	10	11	12	TOTAL
1	159.	168.	174.	167.	169.	0.	161.	156.	150.	160.	0.	160.	6246
2	0.	177.	173.	166.	164.	175.	167.	159.	153.	163.	0.	0.	7241
3	0.	0.	0.	0.	0.	164.	0.	0.	147.	166.	0.	0.	1116

TABLE 5. MEAN CPUE'S FROM SPANISH AND U.S. SWORDFISH FISHERIES NORTH OF 40 N IN NUMBERS AND WEIGHT PER 1000 HOOKS AND PER SET.

SPANISH DATA

YR	ZONE	TRIPS	CATCH PER 1000 HOOKS		CATCH PER SET	
			NUMBERS	KG LIVE	NUMBERS	KG LIVE
83	1	19	8.7	616	14	966
	2	4	6.3	409	11	698
84	1	79	5.7	380	10	676
	2	12	8.2	452	18	992
85	1	91	5.2	332	10	646
	2	41	9.9	588	20	1169
	3	6	12.5	766	23	1390

UNITED STATES

YR	ZONE	TRIPS	CATCH PER 1000 HOOKS		CATCH PER SET	
			NUMBERS	KG LIVE	NUMBERS	KG LIVE
83	3	15	25.8	1683	13	861
84	3	18	45.9	2691	31	1831 *
85	3	22	76.8	4042	35	1933 **

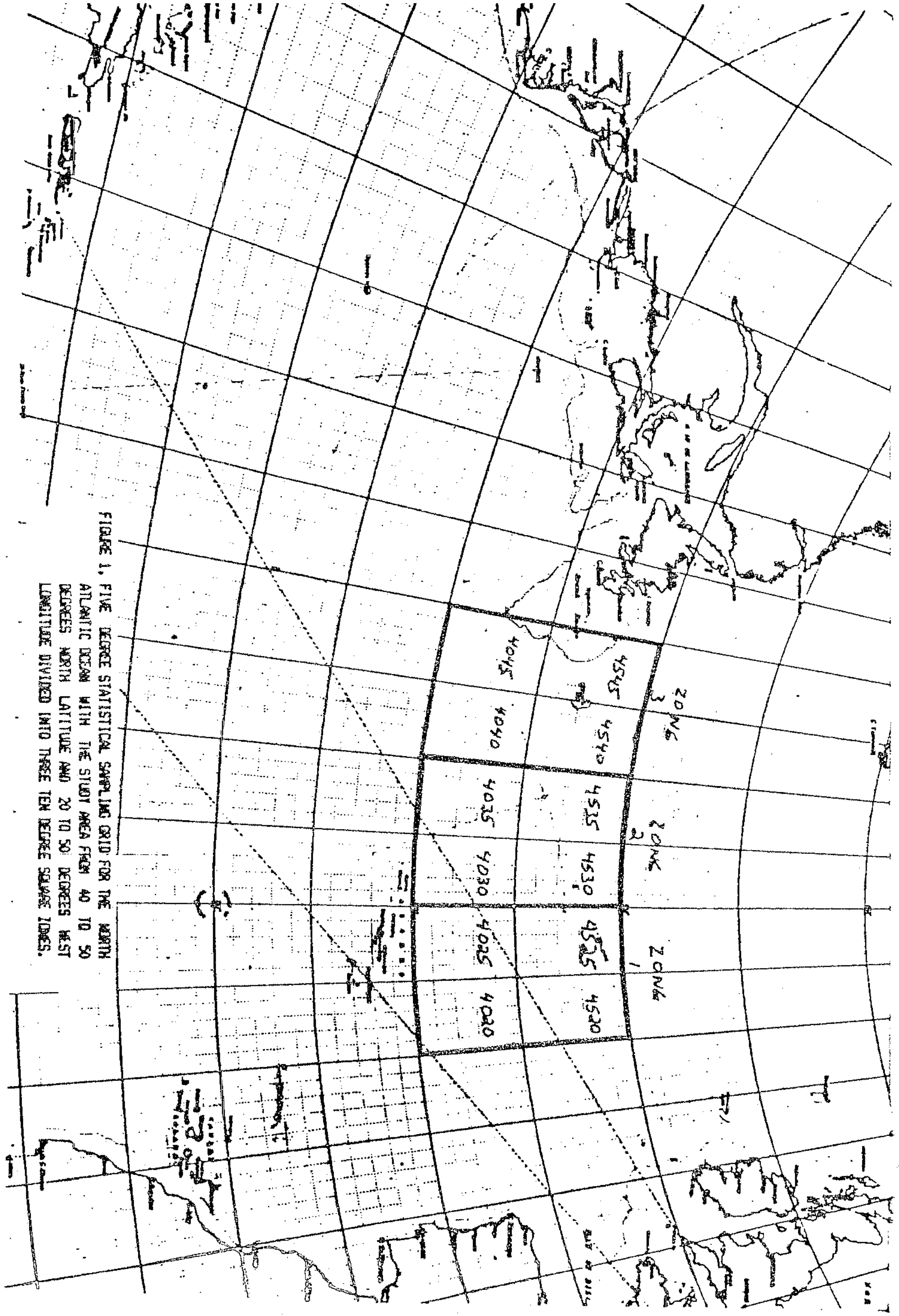


FIGURE 1. FIVE DEGREE STATISTICAL SAMPLING GRID FOR THE NORTH ATLANTIC OCEAN WITH THE STUDY AREA FROM 40 TO 50 DEGREES NORTH LATITUDE AND 20 TO 50 DEGREES WEST LONGITUDE DIVIDED INTO THREE TEN DEGREE SQUARE ZONES.

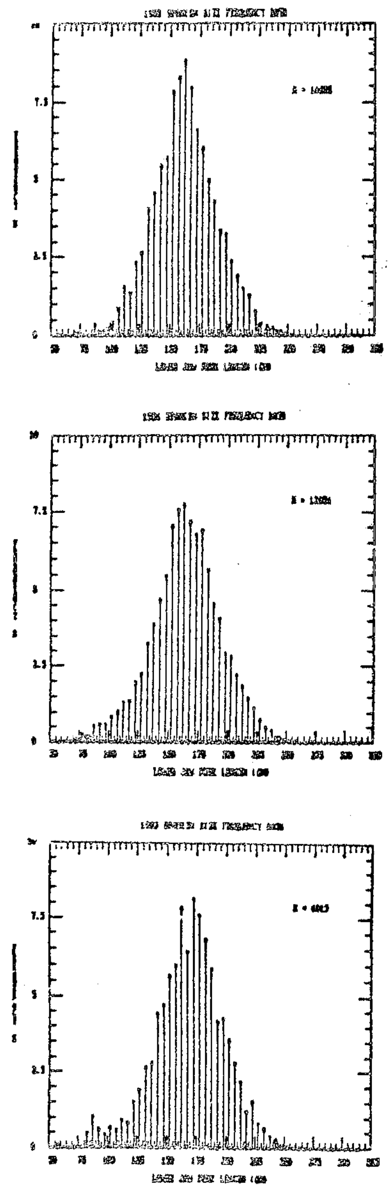


FIGURE 2a.

ANNUAL SPANISH SIZE FREQUENCY HISTOGRAMS FOR 1983 TO 1985.

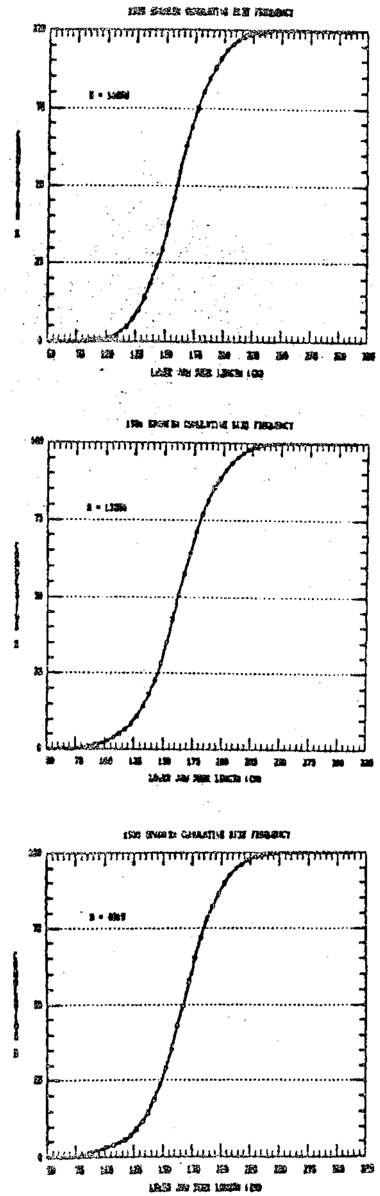


FIGURE 2b.

ANNUAL SPANISH CUMULATIVE FREQUENCY PLOTS FOR 1983 TO 1985.

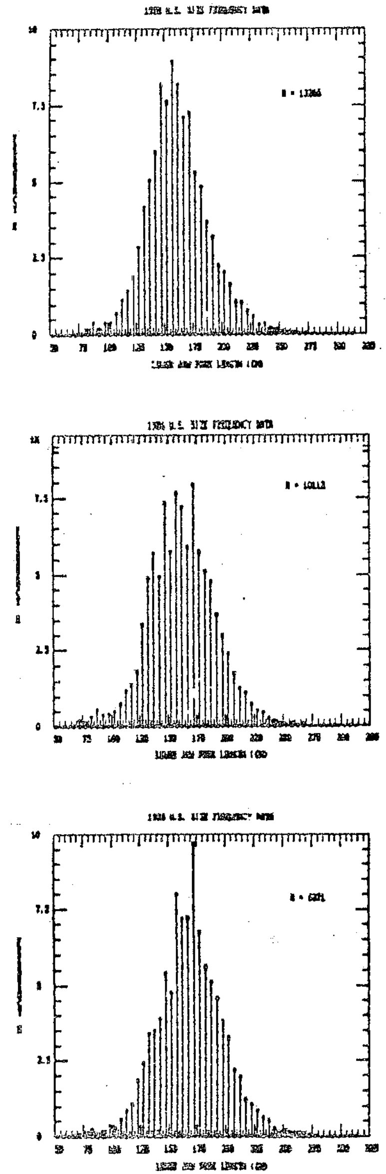


FIGURE 3a.

ANNUAL U.S. SIZE FREQUENCY HISTOGRAMS FOR 1983 TO 1985.

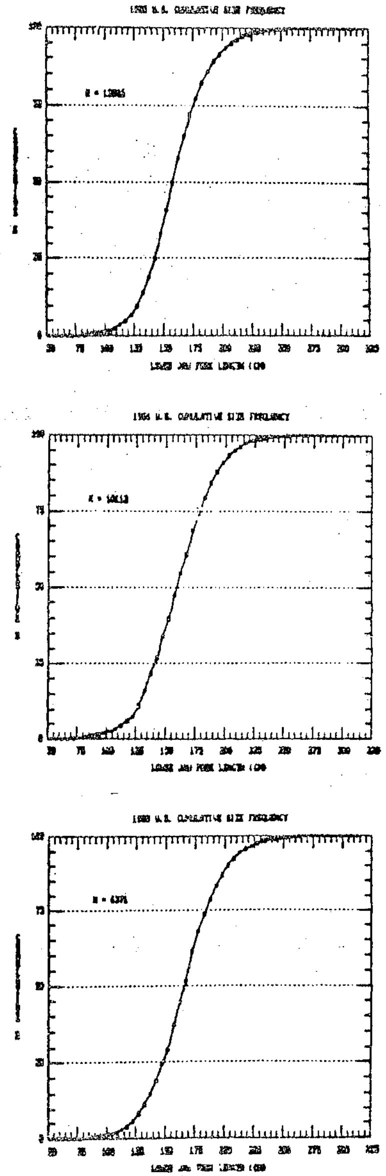


FIGURE 3b.

ANNUAL U.S. CUMULATIVE FREQUENCY PLOTS FOR 1983 TO 1985.

FIGURE 4a. SIZE FREQUENCY HISTOGRAM AND CUMULATIVE FREQUENCY PLOT FOR SPANISH DATA FROM MARCH, APRIL, AND MAY 1984.

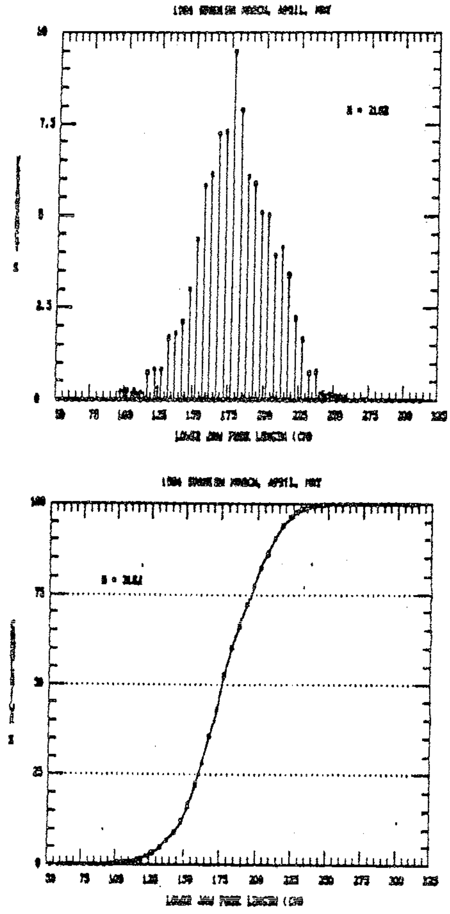
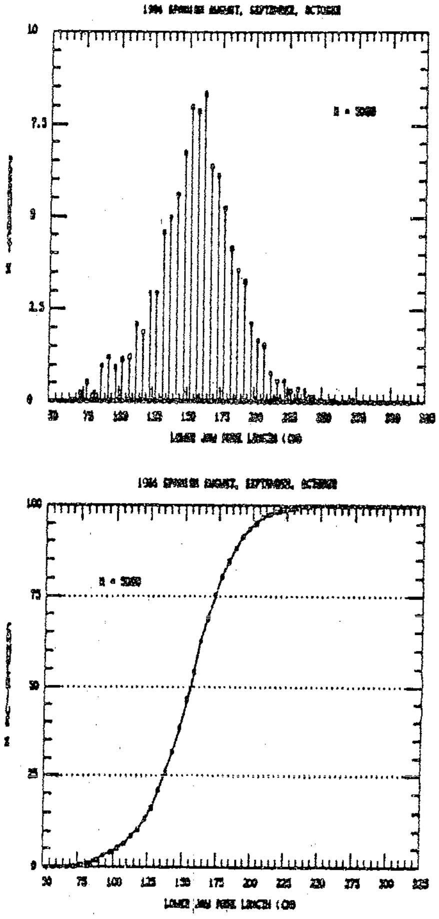


FIGURE 4b. SIZE FREQUENCY HISTOGRAM AND CUMULATIVE FREQUENCY PLOT FOR SPANISH DATA FROM AUGUST, SEPTEMBER, AND OCTOBER 1984.



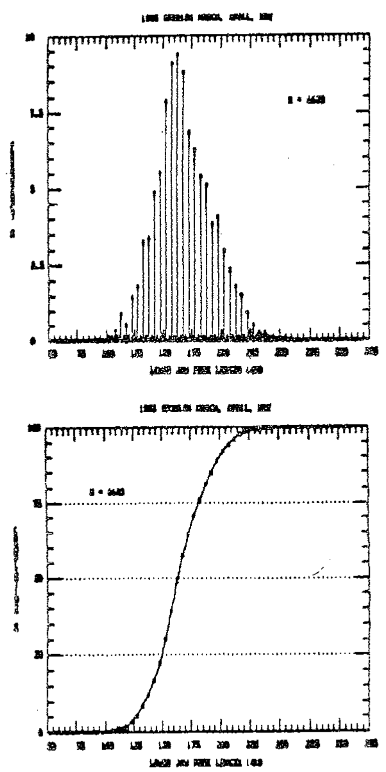


FIGURE 5a. SIZE FREQUENCY HISTOGRAM AND CUMULATIVE FREQUENCY PLOT FOR SPANISH DATA FROM MARCH, APRIL, AND MAY 1985.

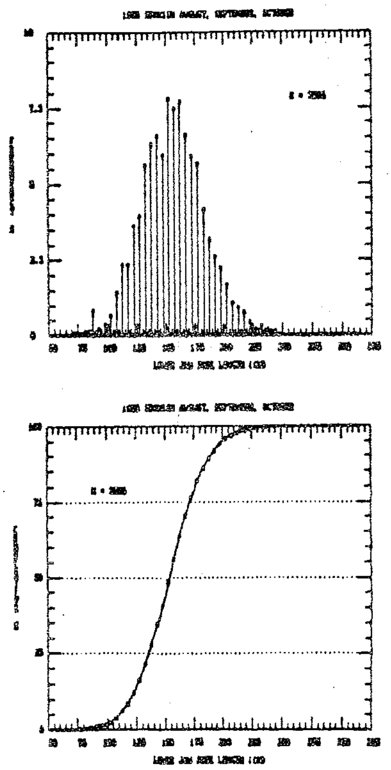


FIGURE 5b. SIZE FREQUENCY HISTOGRAM AND CUMULATIVE FREQUENCY PLOT FOR SPANISH DATA FROM AUGUST, SEPTEMBER, AND OCTOBER 1985.

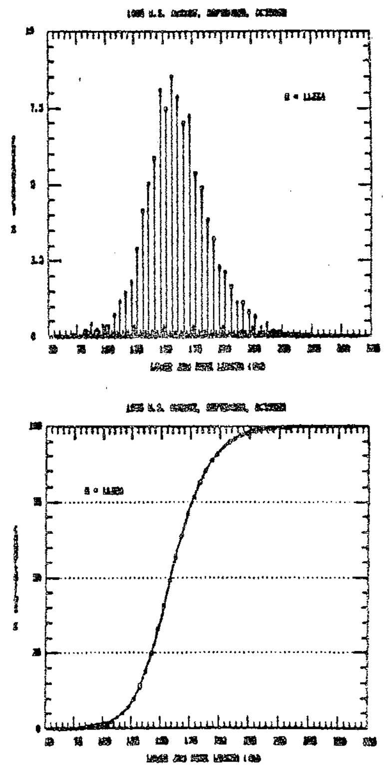


FIGURE 5C. SIZE FREQUENCY HISTOGRAM AND CUMULATIVE FREQUENCY PLOT FOR U.S. DATA FROM AUGUST, SEPTEMBER, AND OCTOBER 1985.

FIGURE 6a. SIZE FREQUENCY HISTOGRAM AND CUMULATIVE FREQUENCY PLOT FOR SPANISH DATA FROM SEPTEMBER 1985.

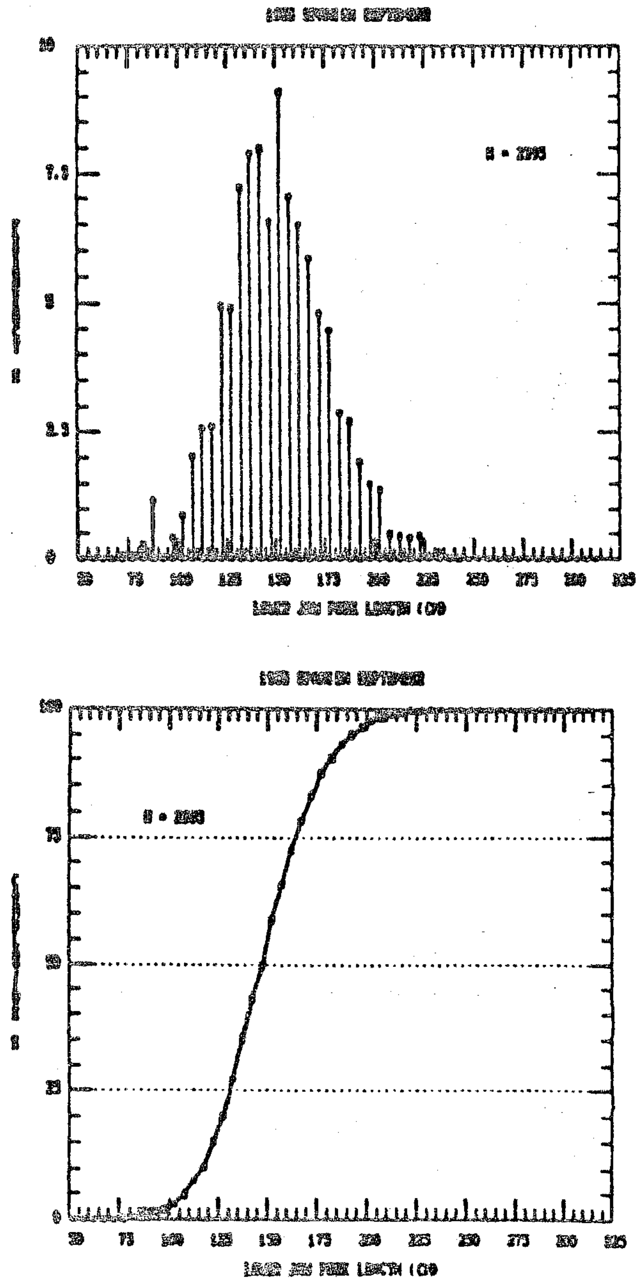


FIGURE 6b. SIZE FREQUENCY HISTOGRAM AND CUMULATIVE FREQUENCY PLOT FOR U.S. DATA FROM SEPTEMBER 1985.