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An Assessment of the Long-finned Squid Resource Off the Northeastern United States Autumn 1984

by

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SUMMARY

Research survey biomass and abundance indices for the long-finned squid (Loligo pealei) off the northeastern USA are updated for 1983 and 1984. Commercial catch data are also updated for 1983 and January - October 1984. Distant-water-fleet (DWF) catches decreased in 1983 to the second lowest level since the directed DWF fishery began in the late 1960's, while domestic catches were nearly 3- times their previous high. Through November 1984, domestic catches (8,950 mt) were about 25% less than for the same period during 1983, but much greater than in any year prior to 1983, while DWF catches totaled about 9,500 mt.

Population abundance estimates for L. pealei based on the NEFC autumn 1983 bottom trawl survey were the second highest since 1968. Estimates based upon the 1984 autumn survey indicate a decrease in population size, both from the 1983 high and from the 1968-83 mean. Pre-recruit abundance is also well below (49%) the long-term mean.

Yield-per-recruit analyses, coupled with assumptions about the stock-recruitment relationship, suggest that yield in 1985 will be less than in recent years unless fishing mortality increases. At levels of F comparable to the average during 1978-81, yields of only 16,500 - 18,300 mt would be expected. However, if fishing mortality is increased to the level corresponding to the maximum equilibrium yield, the 1985 yield is projected to be 23,700 - 28,800 mt.

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INTRODUCTION

The long-finned squid (*Loligo pealei*) stock off the Northeastern United States is becoming increasingly important to the USA commercial fishery, with domestic catches approaching 16,000 mt in 1983. This document updates information regarding the status of the long-finned squid stock (Lange 1983) in the area from the Mid-Atlantic to the Gulf of Maine. Information presented includes a review of catch and length frequency data from the 1983 and 1984 USA and distant-water-fleet (DWF) fisheries, and minimum biomass, abundance, and pre-recruit indices and estimates for 1983 and 1984 (preliminary) from the NEFC autumn bottom trawl survey data.

BIOLOGY

Loligo pealei, the long-finned squid or common American squid, is generally distributed between the Gulf of Maine and Florida, with fishable concentrations between southern Georges Bank and Cape Hatteras. Long-finned squid undergo seasonal migrations to shallow inshore waters from southern Cape Cod to the Chesapeake Bay in spring and summer to spawn. Spawning occurs over about a 6-month period (May-October) with peaks in May and to a lesser extent in October resulting in two distinct cohorts in most years. In late autumn, they move offshore to overwinter along the edge of the continental shelf. The long-finned squid is a short-lived species which is assumed to die after spawning at about 18-36 months of age.

COMMERCIAL FISHERY

Description

The USA fishery for long-finned squid takes place primarily during the spring and summer while the stock has moved inshore toward spawning grounds. Most of the directed USA catch has traditionally occurred during the spring (May and June) in inshore waters of southern New England (Statistical Areas 537 and 538, Figure 1), while in recent years significant directed catches have also occurred in the Mid-Atlantic area (Statistical Areas 611-613, 622 and 632). Principal by-catch species in the inshore fishery include butterfish, summer flounder, scup, and winter flounder. The DWF fishery generally occurs offshore during the winter (December - March). Important bycatch species in that fishery include *Illex* squid, butterfish, and summer flounder.

Management

The long-finned squid stock in USA waters is currently managed on an April 1 - March 31 fishing year. Management is based on annual determinations of optimum yield (OY), domestic annual harvest (DAH), domestic annual processing (DAP), reserve, and total allowable level of foreign fishing (TALFF). These specifications are amounts that the Regional Director, Northeast Region of the National Marine Fisheries Service (NMFS), in consultation with the Mid-Atlantic and New England Fishery Management Councils, has determined to be appropriate for each sector of the fishery. Foreign fishing is restricted to 5 windows (Figure 2) in the offshore waters of the Mid-Atlantic and southern New England areas and is limited to specific seasons within each window. Domestic fishermen landing their catch on shore or transferring it to foreign processing vessels involved in joint ventures are not restricted to fishing within the windows.

Domestic and DWF allocations and catches of _L. pealei_ for the 1983-84 fishing year and preliminary values for the 1984-85 fishing year are presented in Table 1. Seventy-six percent of the allocated portion of the total allowable level of foreign fishing (TALFF) and 66% of the domestic annual harvest (DAH) were taken during the 1983-84 fishing year (Table 1). Final catches by the DWF amounted to 287% of their initial allocation.

DAH was established at 17,875 mt during the 1984-85 fishing year. Forty-four percent of the DAH was taken during April-November 1984. DWF allocations were reduced from 5,550 mt at the beginning of the 1983-84 fishing year to 3,250 mt at the start of the 1984-85 fishing year. Fifty-five percent of the 1984-85 TALFF was taken during April-November 1984. DWF allocations had totaled 20,350 mt during the 1982-83 fishing year.

Catch

The provisional international catch in 1983 was 27,660 metric tons (mt) (Table 1), a 30% increase from 1982 and 29% above the 1968-82 mean. The projected total for 1984 is about 20,000 mt.

The provisional 1983 USA catch, taken primarily between May and September, totaled 15,943 mt (Table 2), representing a 192% increase from 1982 and almost an eight-fold increase from the 1968-82 average. This amount included about 2,300 mt taken in joint ventures with foreign interests. The USA catch during January-November 1984 (8,950 mt) was about 25% less than during the same period in 1983 and includes only about 760 mt from joint ventures. The projected total USA catch for 1984 is about 10,000 mt.

Catches by Japan, Italy, and Spain (Table 2) totaled 11,720 mt in 1983, a 26% decrease from 1982 and a 40% decrease from the 1968-82 mean. DWF catches through November 1984 totaled 9,501 mt.

Catch per unit effort

Catch per unit effort (CPUE) data from the USA directed otter trawl fishery during 1976-84 are presented in Figure 3. Long-finned squid catches have been reported since the late

1800's but a significant directed USA fishery was not established until recently. Although catches are reported from the entire southern New England and Mid-Atlantic areas throughout the year and catches and effort have increased in the Mid-Atlantic in recent years, a directed fishery has occurred in Statistical Area 538 (Figure 1) during May since about 1976. This fishery has been prosecuted primarily by ton class 2 (5-50 gross registered ton, GRT) and 3 (51-150 GRT) vessels. Trip data from these vessels in this area and month were analysed to determine which trips were directed towards this species. The frequency distributions of numbers of trips by percent composition (in 5% intervals) of long-finned squid in the catch were examined to determine a percentage cut-off point for defining directed effort. A large number of trips during 1976-83 consisted of 24% or less squid and were assumed to be non-directed. The number of trips with 26-74% squid in the catch was low, while the number of trips reporting 75-100% squid was relatively high. Directed effort was, therefore, defined as that from trips in Statistical Area 538 during May in which 75% or more of the landings consisted of long-finned squid.

CPUE fluctuated widely during 1976-84, ranging from 2.55 mt per day in 1978 to 8.79 mt per day in 1983 for ton class 2 vessels and from 2.47 mt per day in 1978 to 12.02 mt per day in 1983 for ton class 3 vessels. However, similar patterns of fluctuation occurred for each vessel class indicating that these were related to abundance or availability rather than changes in the vessel fishing power. The 1983 values were the highest of the series for both vessel classes, with the ton class 3 value (12.02) 1.8 times the previous high (in 1976). The CPUE values in 1984 were below the 1983 levels by 18% and 6% for the ton class 2 and 3 vessels, respectively, but were still the third and second highest of the time series.

Composition of commercial catch

Length frequency samples obtained from the USA domestic and joint venture fisheries and the foreign directed fishery during 1984 were analysed to determine which cohorts and year classes contributed to each fishery. Domestic fishery samples were obtained by NEFC Fishery Statistics personnel from shoreside landings. USA joint venture and foreign directed fishery (DWF) length samples were obtained by NMFS Foreign Fishery Observer Program personnel aboard foreign processing or fishing vessels.

Catch from the foreign directed long-finned squid fishery in the fishing windows off the Mid-Atlantic area during January - March 1984 was comprised primarily of individuals from the spring 1983 cohort, with small proportions of the catch from the autumn 1982 and spring 1982 cohorts. These same cohorts, in similar proportions, also contributed to the USA domestic fishery during January - May (1984) in the Mid-Atlantic inshore waters. The DWF fishery was closed during April - June (1984) and fishing did not resume until September, while most of the USA catch, both domestic and joint venture, occurred during May - June. By June, 1984, the autumn 1983 cohort began to move inshore and contribute to the USA fisheries (domestic and joint venture) in both the southern New England and Mid-Atlantic areas. This cohort dominat d the USA catch during July - November 1984, and while the spring 1983 cohort continued to contribute to the USA catch, its importance declined as it began to spawn and die during late summer and autumn. When the DWF fishery resumed in September 1984 off the Mid-Atlantic area, it caught long-finned squid which had begun to move offshore for the winter. These catches were comprised primarily of the autumn 1983 cohort and a small percentage from the 1983 spring cohort.

BIOMASS AND ABUNDANCE

Minimum biomass and abundance estimates for L. pealei were derived by areal expansion of stratified mean weight and number per tow calculated from NEFC autumn bottom trawl survey data (Table 3). These estimates were made using the equation:

$$B = WA / a$$

where B = estimate of biomass or abundance, W = stratified mean weight or number per tow, A = strata area sampled (in square miles), and a = area swept by each tow (0.011 square miles). Three strata sets, southern New England - Mid-Atlantic (1-12, 61-76), Georges Bank (13-25) and Gulf of Maine (26-30, 36-40) were used to determine these estimates (Figure 4). Estimates were adjusted to account for day-night differences in abundance as this species is more available to the trawl during daylight than darkness. Catchability during daylight was assumed to be 100% for calculation of these estimates, while night-time catches were increased by factors of 2.7 for weight and 18.8 for numbers (Sissenwine and Bowman 1978). These are considered to be minimum estimates since, by assuming 100% catchability during day-time, they do not account for the portion of the stock which is above the net, and although long-finned squid are associated with the bottom during day-time, they probably spend much time a few meters off the bottom. These estimates for autumn include a high proportion of pre-recruits which will grow considerably by the time they enter the fishery in January-March.

The 1983 autumn survey estimates (62,363 mt and 4.5 billion individuals) were 135% and 94% above the 1982 estimates and 98% and 36% above the 1968-82 means (Table 3). The biomass estimate was the highest of the time series, while the abundance was the fourth highest, indicating that a lower proportion of small individuals was taken in the 1983 survey. In fact, the proportion of the abundance index (number per tow) comprised of pre-recruits ($\leq$ 8 cm) decreased from 0.83 in 1982 to 0.67 in 1983, compared to the mean during 1968-82 of 0.86 (Table 4). The 1983 pre-recruit index (251.1 individuals per tow) was still 8% above both the

1968-82 mean and median.

Preliminary estimates of minimum biomass and abundance from the 1984 autumn NEFC survey (36,927 mt and 2.5 billion individuals) were 41% and 43% below the 1983 levels but 16% above and 24% below the 1968-82 means. The 1984 pre-recruit abundance index was 43% below the 1968-83 mean and 46% below the 1983 level (Table 4). Pre-recruits represented about 76% of the total abundance index. Based on comparisons between length frequency distributions from daytime and nighttime tows, individuals of all sizes are near the bottom during daytime, but at night there is differential migration by size off bottom, with small individuals much less susceptible to the trawl than are large individuals. To estimate total recruitment from the 1984 year class, therefore, the overall ratio of pre-recruits to recruits was applied to a minimum biomass estimate based only on daylight tows. The resulting minimum estimate of 1.0 billion individuals was 68% below the 1983 value and 49% below the 1968-81 mean.

YIELD ANALYSIS

Yield analysis for L. pealei based on a simulation model described by Lange et al. (1984) provided estimates of yield per recruit at various levels of fishing mortality (F) and average abundance based on different assumptions of squid catchability in the survey trawl. In that analysis, yield per recruit was estimated for two types of fisheries with different exploitation patterns: a dominant offshore winter fishery coupled with a relatively small inshore summer fishery as has existed since the early 1970's (offshore/inshore), and a dominant inshore summer fishery similar to that traditionally conducted by USA fisherman with no offshore winter fishery (inshore fishery). The fishery probably operated somewhere between these two patterns during 1983 and 1984, as the relative importance of the USA fishery increased markedly. Yield per 1,000 recruits at the average level of fishing mortality estimated for 1978-81 (F = 0.41) and assuming 45% catchability (Lange et al. 1984) was 11.8 kg from an offshore/inshore fishery and 13.1 kg from an inshore fishery.

Overall, 1.0 billion pre-recruits were estimated from the 1984 autumn survey. During 1968-81, about 55% of the pre-recruits in the autumn survey were from the spring cohort. Assuming the same proportion in 1984 and assuming 45% catchability in the autumn survey trawl (Lange et al. 1984), 1.2 billion pre-recruits (1.0 X (.55/.45)) would be from the spring 1984 cohort and would enter the fishery during the late autumn or winter of 1984-85. Recruitment of the autumn cohort during the 1968-81 spring surveys was about 18% of that seen from the spring cohorts during the autumn surveys. Assuming the same proportion (0.18) in spring 1985, an additional 0.2 billion individuals should be recruited to the late winter or spring 1985 fishery. Total recruitment from the 1984 year class should, therefore, be about 1.4 billion individuals.

STOCK-RECRUITMENT RELATIONSHIP

Lange et al. (1984) examined the results of yield-per-recruit analysis for L. pealei in conjunction with a Beverton and Holt (1957) type stock-recruitment relationship to obtain estimates of equilibrium yield, as described by Shepherd (1982). Lange et al. (1984) found that, by assuming a moderate density-dependent relationship between spawning biomass and recruitment, maximum equilibrium yield for an offshore/inshore fishery would be 27,900 mt and would occur at F = 0.70 (Table 5). Beyond F = 0.93, yield would not be sustainable. For an inshore fishery, the maximum F at which equilibrium yield could occur would also be 0.93, and the maximum equilibrium yield of 33,200 mt would occur at F = 0.80. It must be noted that these represent long-term averages and do not take into account annual variations caused by environmental factors. Although these yield estimates represent long-term equilibrium and are not applicable to individual years, they are useful for comparison with current estimates based on yield-per-recruit analyses as an indication of the relative status of the stock.

The level of catch during 1983 (27,663 mt) was within 1% of the maximum estimated to be sustainable in the long term for a combined offshore/inshore fishery, while estimated recruitment in

1983 (4.6 billion) was 2.8 times the equilibrium recruitment associated with that level of yield. This indicates that greater yield could have been realized and that F during 1983 was probably substantially less than the 0.70 associated with the maximum equilibrium yield.

Simulations of yield for the 1984 year class for an offshore/inshore and an inshore fishery based on the model described by Lange et al. (1984) and on a recruitment of 1.4 billion individuals are presented in Table 6. For an offshore/inshore fishery, yield would be 23,600 mt at the F associated with the highest equilibrium yield for a moderate stock-recruitment relationship (F = 0.70) and 16,500 mt at the average F during 1978-81 (F = 0.41). The corresponding values of yield for an inshore fishery would be 28,800 mt at the F-level associated with maximum equilibrium yield for an inshore fishery (F = 0.80) and 18,340 at F = 0.41.

CONCLUSION

The _L. pealei_ fishery continues to move toward a primarily domestic fishery as the USA catch in 1983 exceeded that by the DWF for the first time since the directed foreign fishery began in 1967. Total catches in 1983 were the highest since management under the MFCMA led to reduced allocations to the DWF fishery.

Catch-per-effort in the USA fishery during 1983 and biomass estimates from the 1983 NEFC autumn survey were the highest on record, confirming high abundance in that year.

Abundance and biomass indices (preliminary) from the 1984 survey are lower than the long-term means. Recruitment from the 1984 year class is about one-half of the 1968-81 mean, and yield in 1985 will be less than in recent years unless fishing mortality increases. At levels of F comparable to the average observed during 1978-81, yields of only 16,500 - 18,300 mt would be expected. However, if fishing mortality is increased to the level corresponding to the maximum equilibrium yield, the 1985 yield is projected to be 23,700 - 28,800 mt.

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Table 1. Total domestic and distance-water-fleet (DWF) allocations and catches of long-finned squid during the 1983-84 and 1984-85 fishing years (in metric tons).

Item	1983-84	1984-85[1]
Optimum yield	44,000	44,000
Domestic annual harvest	22,000	17,875
Initial reserve	4,500	0
Initial TALFF[2]	4,500	3,250
Final TALFF	16,950	3,250
Domestic landings	14,583	7,855
shoreside	12,251	7,095
joint venture	2,332	760
DWF catch	12,916	1,790

1 Values as of 30 November 1984.

2 Total Allowable Level of Foreign Fishing

Table 2. Annual long-finned squid catches (in metric tons) from the Northwest Atlantic (Cape Hatteras to Gulf of Maine) by the USA and the distant-water-fleet (DWF), 1963-84.

Year	USA	DWF	Total
1963	1,294	0	1,294
1964	576	2	578
1965	709	99	808
1966	722	226	948
1967	547	1,130	1,677
1968	1,084	2,327	3,411
1969	899	8,643	9,542
1970	653	16,732	17,385
1971	727	17,442	18,169
1972	725	29,009	29,734
1973	1,105	36,508	37,613
1974	2,274	32,576	34,850
1975	1,621	32,180	33,801
1976	3,602	21,682	25,284
1977	1,088	15,586	16,674
1978	1,291	9,355	10,646
1979	4,252	13,068	17,320
1980	3,996	19,750	23,746
1981	2,316	20,212	22,528
1982	5,464	15,805	21,269
1983	15,943	11,720	27,663
1984 [1]	10,000	10,000	20,000

1 Projected.

Table 3. *Loligo pealei* minimum biomass (metric tons) and abundance (in millions) estimates[1] for the Mid-Atlantic to Gulf of Maine, 1968-84.

Year	Biomass	Abundance
1968	29,114	1,212
1969	48,055	2,393
1970	19,640	1,946
1971	14,050	1,106
1972	21,039	1,533
1973	44,252	3,092
1974	46,442	4,757
1975	48,636	7,789
1976	51,436	4,372
1977	27,421	3,157
1978	18,800	1,251
1979	19,333	2,114
1980	34,275	9,314
1981	24,345	3,411
1982	26,527	2,303
1983	62,363	4,460
1984[2]	36,927	2,546
1968-82 mean	31,558	3,317

1) From areal expansion of stratified mean weights (kg) and numbers per tow assuming 100% catchability during daytime. Nighttime catch data were expanded to account for diel differences in catch (Sissenwine and Bowman 1978).
2) Preliminary.

Table 4. Total and pre-recruit (≤8 cm) stratified mean numbers per tow of *Loligo pealei* from the NEFC autumn bottom trawl surveys (Mid-Atlantic to Georges Bank), 1967-84.[1]

Year	All sizes	Pre-recruits
1967	134.5	126.9
1968	176.5	159.9
1969	237.3	217.4
1970	85.6	79.3
1971	163.3	161.5
1972	271.4	258.5
1973	372.0	353.9
1974	251.7	233.3
1975	614.4	593.3
1976	410.9	302.5
1977	388.5	297.7
1978	144.2	93.4
1979	193.7	156.5
1980	364.1	279.8
1981	226.2	161.8
1982	310.4	256.6
1983	373.4	251.1
1984[2]	179.0	136.8
1968-82 mean	271.5	240.5

1 Stratified mean number per tow of all sizes and of individuals ≤ 8 cm mantle length.

2 Preliminary.

Table 5. Equilibrium recruitment in billions (R_E), equilibrium spawning biomass in thousands of tons (B_E), yield (kg) per 1,000 recruits and equilibrium yield in thousands of tons (Y_E), for two exploitation patterns (international and domestic) and assuming a moderate level of density dependence for the stock-recruitment relationship (A=0.8), and assuming a current recruitment level of 2.0 billion.[1]

F	R_E	B_E	YPR	Y_E
International Fishery				
0.27	2.09	75.7	8.5	17,800
0.41	1.97	62.1	11.8	23,200
0.55	1.83	49.7	14.6	26,700
0.70	1.65	38.4	16.9	27,900
0.80	1.51	31.6	18.3	27,600
0.93	1.30	23.7	19.8	25,700
1.20	Not sustainable			
Domestic Fishery				
0.27	2.12	64.6	9.3	20,000
0.41	2.01	52.6	13.1	26,300
0.55	1.87	42.1	16.3	30,500
0.70	1.73	30.0	19.0	32,900
0.80	1.61	24.00	20.6	33,200
0.93	1.42	16.5	22.9	32,500
1.20	Not sustainable			

1) From Lange et al. (1984).

Table 6. Estimated yield (in metric tons) of *Loligo* associated with various levels of fishing mortality and the 1984 recruitment level of 1.4 billion individuals.

F	Offshore/inshore	Inshore
0.27	11,900	13,020
0.41	16,520	18,340
0.55	20,440	22,820
0.70	23,660	26,600
0.80	25,620	28,840
0.93	27,020	32,060

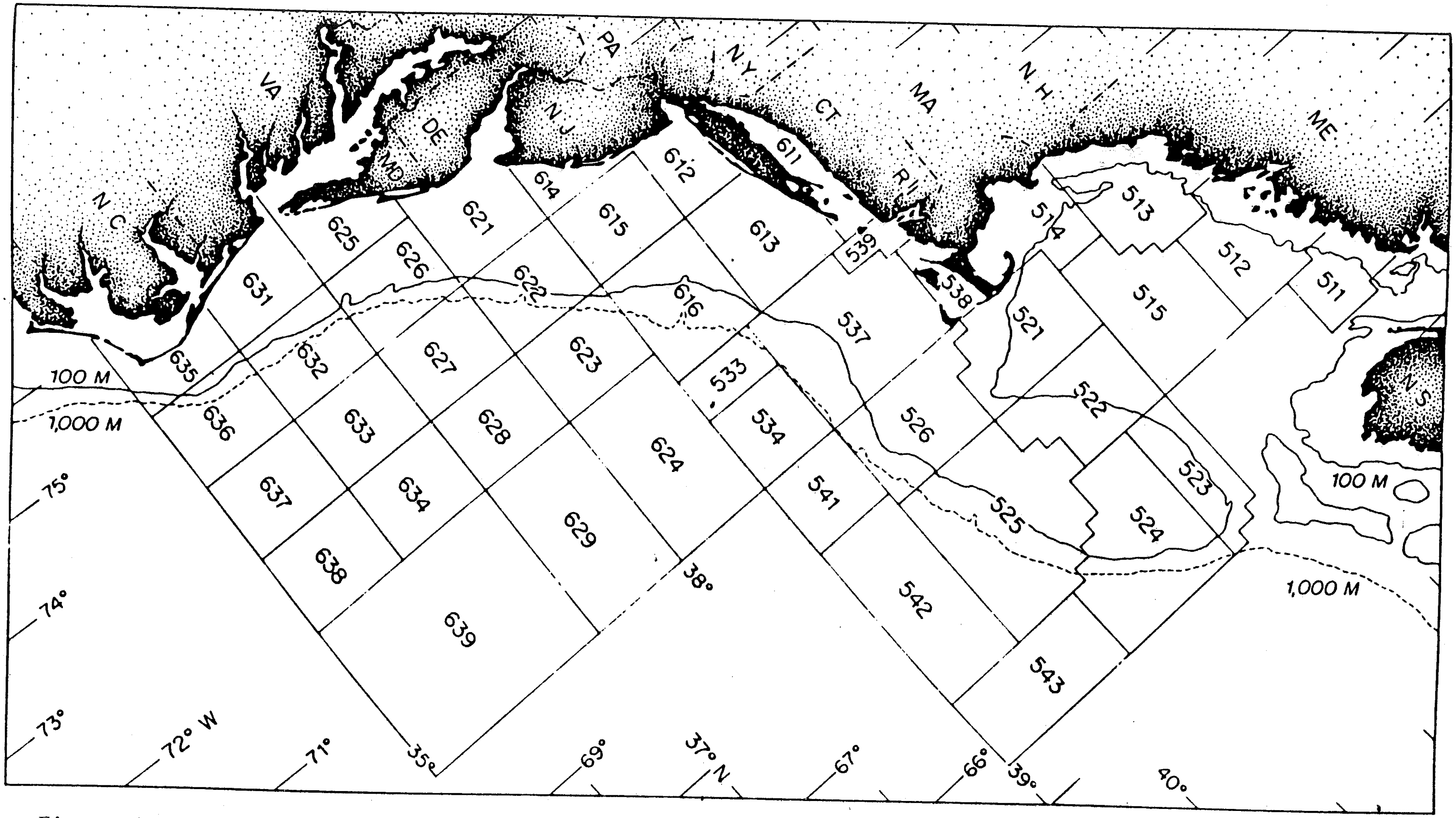

Figure 1. US Statistical Areas used in reporting location of catch and effort data.

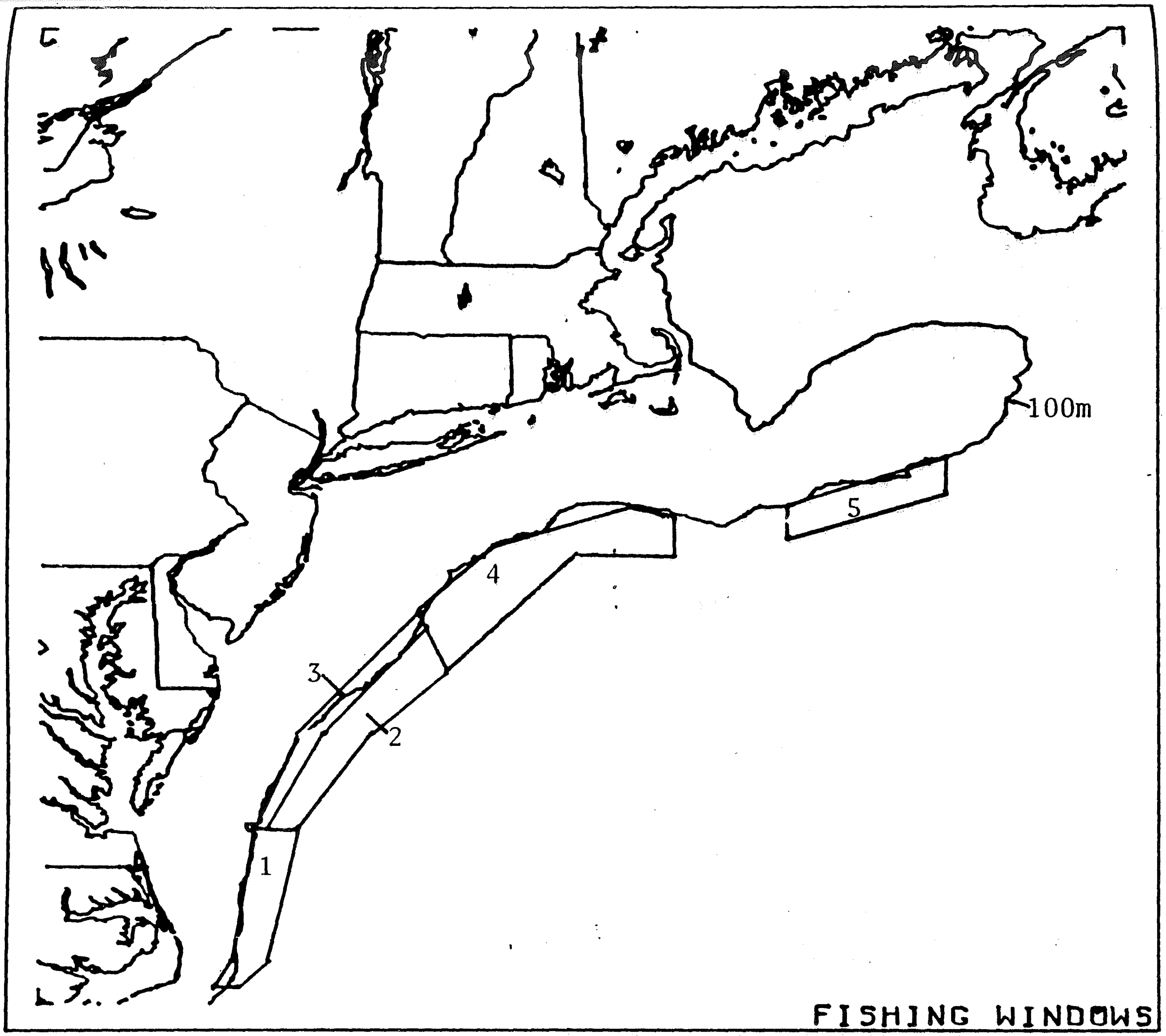

Figure 2. Areas of the Northwest Atlantic, off the USA, which are open to foreign fishing during authorized fishing seasons.

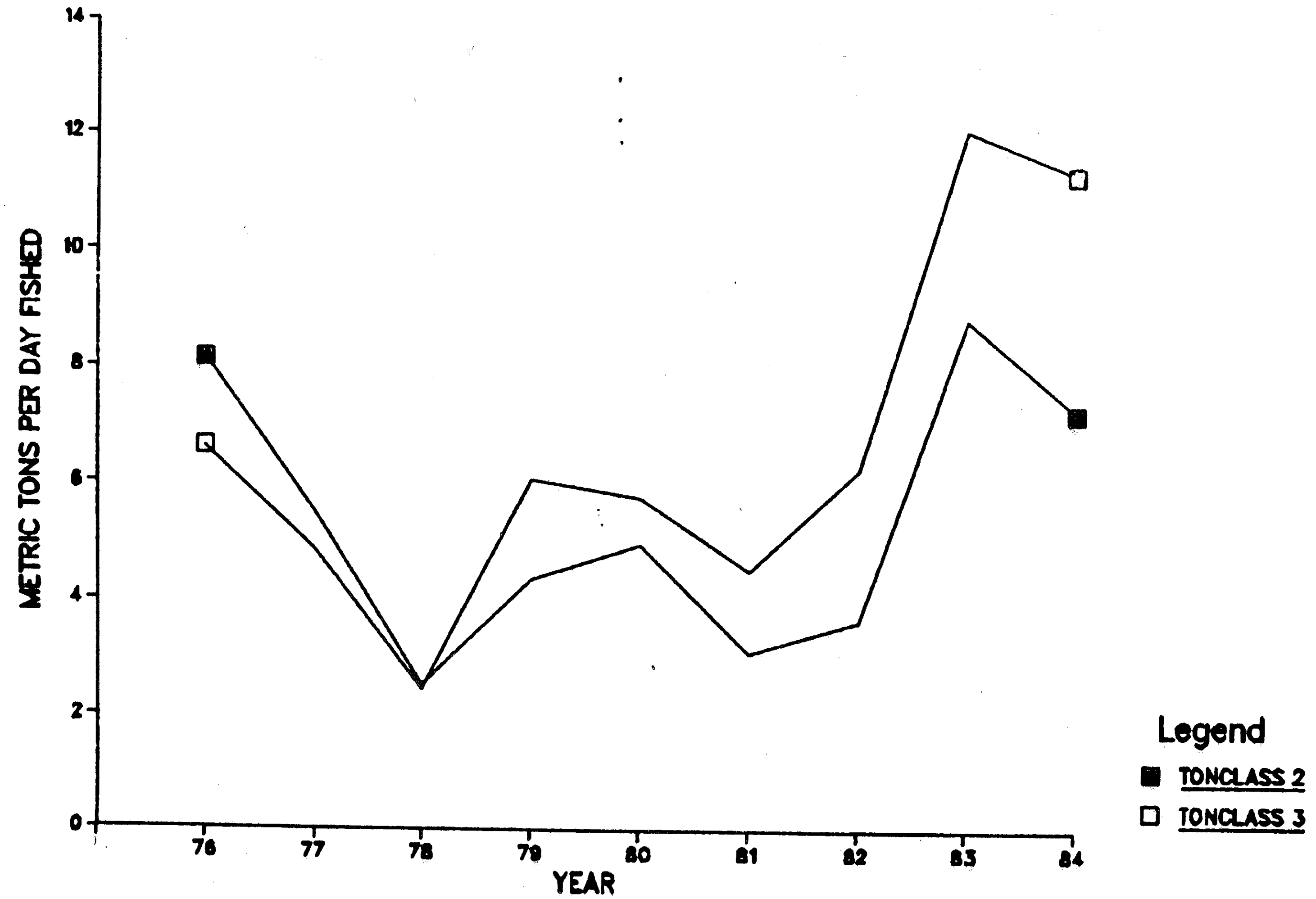

Figure 3. Catch-per-unit-effort in metric tons per day fished, of long-finned squid in the directed USA otter trawl fishery in Statistical area 538, during May, 1976-84.

A

B

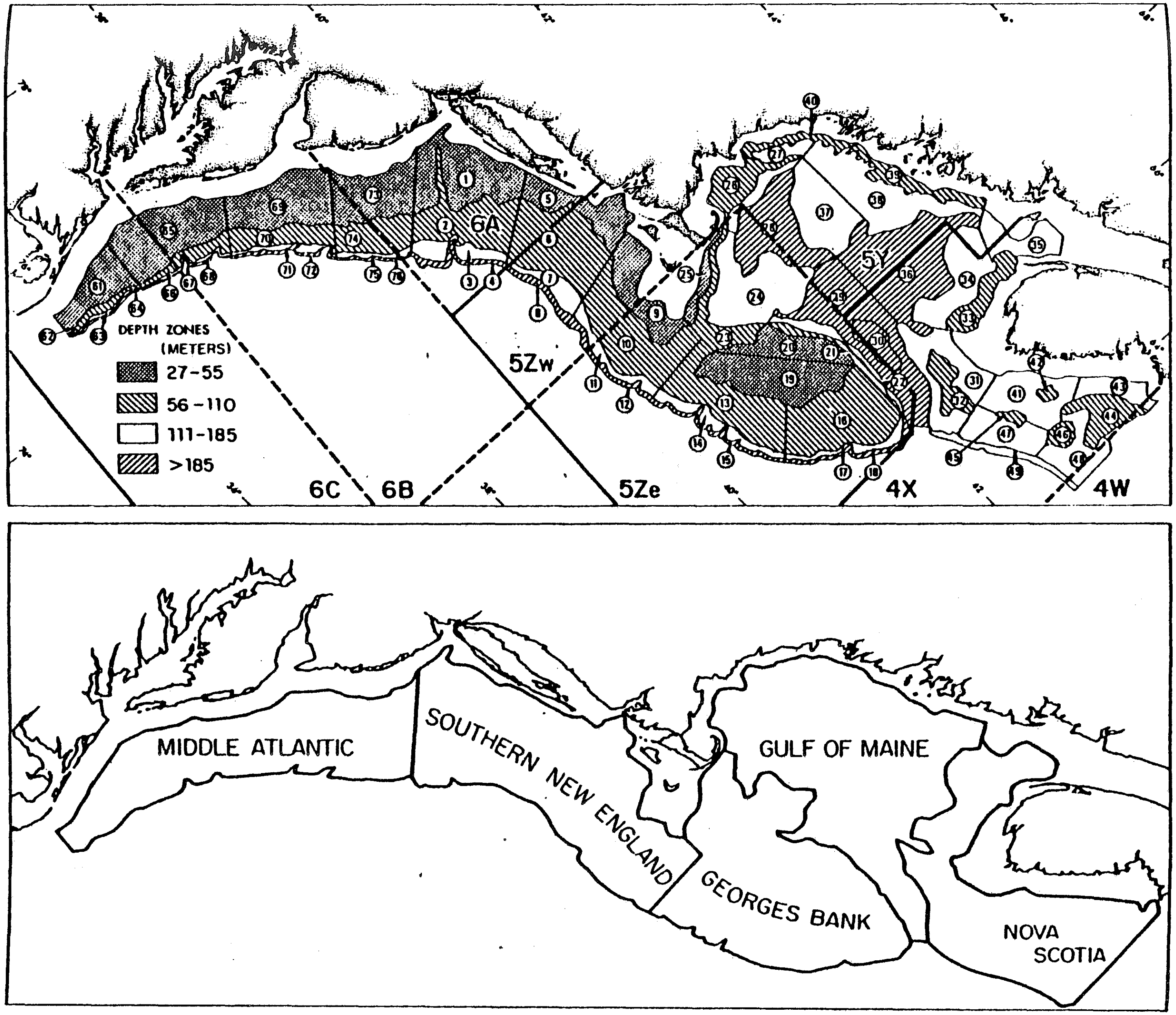

Figure 4. A. USA bottom trawl survey strata and NAFO Subareas 4-6.
B. Geographical areas off the Northeast coast of the United States.