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Stock Assessment of Short-finned Squid, *Illex illecebrosus*, in the Northwest Atlantic during 1992

by

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ABSTRACT

The status of the short-finned squid (*Illex illecebrosus*) stock is assessed for 1982-1992 based on indices of stock size and recruitment computed from research vessel survey data. Total landings from U.S. and Canadian waters have been dominated by the domestic fishery since 1983 and have been increasing, along with effort, since 1988. Concurrently, standardized domestic landings per unit of effort have generally been decreasing. Autumn survey indices of relative abundance during 1991 and 1992 suggest that *Illex* abundance on the continental shelf was intermediate to periods of high abundance during 1975-1981 and 1987-1990 and to periods of low abundance during 1967-1974 and 1982-1986. Based on the current overfishing definition, the stock was not overfished during 1992 and will not be overfished in 1993 or 1994. The stock is at a medium biomass level, and based on the current maximum sustainable yield (MSY) of 30,000, is under-exploited.

However, *Illex illecebrosus* has recently been documented to be an annual species, and therefore a new overfishing definition should be developed which recognizes that only a single cohort supports both the fishery and the spawning stock. Likewise, MSY should be re-evaluated based on this new life history information, since the potential for recruitment overfishing may be substantial. Furthermore, recruitment may vary significantly depending upon environmental favorability and predator-prey relationships. The implementation of a real-time assessment/management system would allow full exploitation of the stock while ensuring that adequate levels of spawning stock escapement are maintained.

INTRODUCTION

The short-finned squid (*Illex illecebrosus*) stock in the northwest Atlantic was last assessed during July of 1992 (NEFC 1992). This report represents an update of the July 1992 assessment for the period 1982-1992 and incorporates commercial fishery data, research survey data and new information about the life history of this species. The assessment relies on stock size and recruitment relative abundance indices, computed from the Northeast Fisheries Science Center (NEFSC) bottom trawl survey data, as well as standardized effort and LPUE. Pre-recruit fall survey indices were utilized to assess the status of the stock with respect to its overfishing definition.

Previous stock assessments assumed a two-year life cycle for this species based upon analyses of length frequency data (Lange and Sissenwine 1980). However, the differential growth and survival rates of squid microcohorts may bias the results of modal analyses of length frequency data if not accompanied by supplemental age data (Caddy 1991). Statolith aging methods, which involve counting daily growth increments on statoliths, have been validated for several squid species (Jereb *et al.* 1991; Rosenberg et al. 1981; Rodhouse and Hatfield 1990), including *Illex illecebrosus* (Dawe *et al.* 1985; Hurley *et al.* 1985). Recent research involving the back-calculation of hatching dates, based on statolith growth increment analysis, suggests a lifespan of less than one year for this species (Dawe and Beck 1992). In late autumn, *Illex* undergo long-distance migrations (Dawe *et al.* 1981) to major spawning grounds south of Cape Hatteras, then perish following spawning (Rowell and Trites 1985). Spawning may also occur in the southern New England and Georges Bank areas during some years (Lange and Sissenwine 1981). The following stock assessment has been updated assuming a one-year life cycle for this species.

The short-finned squid (*Illex illecebrosus*) population is assumed to constitute a unit stock throughout its range of commercial exploitation, from Newfoundland to Cape Hatteras, North Carolina. A foreign fishery occurs in Canadian waters, during the summer and fall, and is managed by the Northwest Atlantic Fisheries Organization (NAFO). Since 1980, the Total Allowable Catch (TAC) from these waters (NAFO Subareas 2, 3 and 4) has been 150,000 mt, despite catches of less than 11,000 mt since 1983. The *Illex* fishery in the U.S. EEZ, in NAFO Subareas 5 and 6, is managed by the Mid-Atlantic Fishery Management Council (MAFMC) under provisions of the Atlantic Mackerel, Squid, and Butterfish Fishery Management Plan (SMB FMP). This fishery has been managed by the Council since June of 1979. An overfishing definition for the stock was established in December of 1990. In 1992, the maximum optimum yield, the allowable biological catch, and the domestic allowable harvest were set at 30,000 mt (MAFMC 1991). Similar harvest levels will be in effect during 1993 and 1994 (MAFMC 1992).

THE FISHERY

Landings

Landings data from the U.S. EEZ were obtained from the Report of the Spring 1990 NEFC Stock

Assessment Workshop (Tenth SAW) (NEFC 1990), for 1963-1988, and the NEFSC commercial fisheries weighout database for 1989-1992. Effort data used in the analysis of the domestic fishery, from 1982-1992, were also obtained from the NEFSC weighout database. The sources of landings data from NAFO Subareas 2, 3, and 4 were the Report of the Fourteenth Northeast Regional Stock Assessment Workshop (NEFSC 1992) and E. Dawe of the Department of Fisheries and Oceans, Newfoundland, Canada (pers. comm. 1992) for 1973-1990 and 1991, respectively.

A commercial fishery for *Illex illecebrosus* occurs in the waters off Newfoundland, Canada and south to Cape Hatteras, North Carolina. In the U.S., a domestic bait fishery for *Illex* began as early as the 1800's. During 1928-1967, annual squid (*Illex illecebrosus* and *Loligo pealei* combined) landings from the waters off Maine to North Carolina averaged 1,000-2,000 mt (Lange 1980). Since 1963, annual landings of *Illex* from waters off the coasts of Canada and the U.S. have varied considerably (Table 1). Total landings within U.S. waters from Cape Hatteras to the Gulf of Maine were dominated by foreign fishing fleets during 1973-1982, averaging 19,400 mt, and by the domestic fleet during 1983-1989 (Figure 1). However, the average annual landings of the domestic fleet during the latter time period dropped by more than 50% to 7,500 mt. There has been no directed foreign fishing in the U.S. EEZ since 1987. During these same time periods, *Illex* landings from NAFO Subareas 2, 3, and 4 (waters off the coast of Canada) also dropped drastically, from an average of 51,500 mt to 1,600 mt, respectively. Domestic landings from the U.S. EEZ have been steadily increasing since 1988, averaging 13,700 mt during 1990-1992, but the directed fishery in NAFO Subareas 3 and 4 has not returned since its 1983 collapse. Total landings from Canadian and U.S. waters have been dominated by the domestic fishery since 1983.

In 1992, *Illex* landings in the U.S. EEZ reached a record high of 17,827 mt with an ex-vessel value of 9.7 million dollars and an average price of $0.54 per kg ($0.25 per lb). Landings and value in 1992 increased over 1991 by 50% and 40%, respectively, while the average price decreased by 7%. Preliminary landings reports for the squid, mackerel, and butterfish fisheries are incomplete, but indicate that at least 14,630 mt of *Illex* squid were landed during 1993.

In 1992, 99.9% of *Illex* squid landings from the U.S. EEZ were made with bottom otter trawl gear on a total of 356 trips made by 39 vessels. Other fishing gears (shrimp bottom otter trawls, paired bottom otter trawls and sea scallop dredges) accounted for less than 0.1% of the landings and 60 trips.

During 1992, the spatial pattern of *Illex* landings by statistical area (Figure 2) and month (Table 2) was similar to that of 1991. Landings in statistical area 622 accounted for 63% of the landings and 94% of the landings occurred during June-October. Based on a proration of the 1992 landings of *Loligo pealei* and *Illex illecebrosus*, by month and 2-digit statistical area, an additional 5 mt of unclassified squid were likely to have been *Illex*.

STOCK ABUNDANCE AND BIOMASS

Commercial Catch Rates

One fishery-dependent index of *Illex* relative abundance in the U.S. EEZ from Cape Hatteras to the Gulf of Maine is standardized landings per unit of effort (LPUE). A multiplicative model (Gavaris 1980) was applied to standardize both fishing effort and LPUE for the domestic *Illex* fishery during 1982-1992. Fishing trips that did not use bottom otter trawl gear were excluded from the general linear model (GLM) analysis. Trips were categorized by tonnage class (TC) based on the gross registered tonnage (GRT) of the fishing vessel. The classes were: TC 2, consisting of vessels between 5 and 50 GRT; TC 3, consisting of vessels between 51 and 150 GRT; and TC 4, consisting of vessels between 151 and 500 GRT. Vessels less than 5 GRT were excluded from the GLM because disaggregated effort data were not available for these vessels. Vessels greater than 500 GRT were excluded from the GLM because their participation in the fishery was limited to 1985; representing less than 2% of the total. The GLM used to standardize *Illex* fishing effort had the same form as in the last *Illex* assessment (NEFSC 1992), consisting of a main effects model with the factors year, tonnage class, and statistical area ($R^2 = 0.75$). The model results are presented in Table 3.

As indicated in Table 4 and Figure 3, domestic fishing effort in 1992 was the highest since 1982 and represented an increase of 93% over the 1991 effort level. In contrast, LPUE in 1992 was moderate and dropped by 22% from the 1991 level. Overall, fishing effort for *Illex* exhibited a decreasing trend during 1983-1988, but has been increasing since this time. In contrast, LPUE was relatively high during 1987-1989, but has been moderate since this time.

Catch in Numbers

Although *Illex* is an annual species, each cohort is composed of microcohorts spawned during a protracted spawning season, from December through June (Dawe and Beck 1992; Lange and Sissenwine 1983), and extending into summer in some areas (Lange and Sissenwine 1981). The protracted spawning period and rapid growth of *Illex* may lead to monthly fluctuations in the mean size of animals in the catch. To account for this potential heterogeneity, monthly mean weights were estimated from commercial length-frequency data obtained from the NEFSC weighout database. Mean weights of *Illex* squid by year, month and statistical area, during 1982-1992, are presented in Appendix 1. Monthly mean weights were computed by pooling length-frequency samples for each month then applying a length-weight equation derived from NEFSC survey data from combined areas, seasons and years (ln(weight) = -3.03444+2.71990 ln(length), weight in g and dorsal mantle length in cm) (Lange and Johnson 1981). Since no length samples were collected during February and March, the mean weight for January during 1982-1992 was substituted for these monthly mean weights. During each year, if no samples were collected during a specific month, the monthly mean weight was imputed as the average of the mean weights for that particular month during 1982-1992. Estimates of annual mean weight (W_a), stratified by month, were computed as a weighted average of the monthly mean weights (W_{am}),

where the weighting coefficient was the fraction of annual landings that occurred during each month (f_{am}). That is:

$$W_a = \sum_{m=1}^{12} W_{am} f_{am}$$

Annual mean weights were then divided into annual yields to compute annual numbers of *Illex* landed from U.S. EEZ waters between Cape Hatteras and the Gulf of Maine during 1982-1992 (Table 5).

Research Vessel Survey Indices

Fishery-independent indices of *Illex* relative abundance and biomass, in the U.S. EEZ from Cape Hatteras to Georges Bank, were computed from data obtained during NEFSC research bottom trawl surveys conducted during the spring (1968-1993), and fall (1967-1992). Provisional indices were also computed from the fall 1993 survey. Squid were not identified to the species level prior to the 1967 survey. Annual relative abundance indices (stratified mean number per tow) and biomass indices (stratified mean weight per tow, in kg) were computed from standard tows conducted in offshore strata 1-23, 25 and 61-76 (Figure 4). Survey procedures and details of the stratified random sampling design are provided in Grosslein (1969) and Azarovitz (1981).

Relative abundance and biomass indices for *Illex* pre-recruits (≤10 cm) and recruits (≥11 cm), during the fall and spring surveys are presented in Tables 6 and 7, respectively. During 1992, the fall numbers index was 11% below its long-term average, while the fall weight index was 61% below its long-term average. The fall abundance indices suggest that the *Illex* stock alternates between high and low abundance for periods of several consecutive years. In particular, the fall indices were well above average during 1975-1981 and 1987-1990 and were well below average during 1967-1974 and 1982-1986. Although fall abundance indices were below average in 1991 and 1992, provisional indices for the fall of 1993 are above average. In 1993, the spring numbers index was below its long-term average and the spring weight index was at its long-term average. This lack of concordance between the fall and spring survey indices is likely due to the low availability of the stock to the survey gear during the spring, when *Illex* is distributed further offshore or south of Cape Hatteras (Rowell and Trites 1985). As expected, greater sampling variability exists for the spring indices, since fewer individuals are captured during this survey. Overall, the *Illex* stock appears to be at a medium biomass level based on relative abundance indices.

Minimum Biomass and Population Size Estimates

Area-swept estimates of minimum biomass and minimum population size, for *Illex* captured on the continental shelf between Cape Hatteras and the Gulf of Maine, were computed from NEFSC fall bottom trawl surveys, assuming 100% catchability (Table 8). For 1967-1992, all offshore strata from Cape Hatteras to the Gulf of Maine (strata 1-30, 33-40 and 61-76) were used in this computation. For 1982-1992, inshore survey strata 1-55 were included in this computation to

maximize the areal coverage, but comparable inshore data for 1967-1981 were not available. Regardless, *Illex* were rarely captured within inshore strata during 1982-1992. The inclusion of inshore strata did not appreciably affect area-swept estimates, since inshore strata contributed no more than 0.2% to the estimated population size over all years. The area-swept estimates have limited utility because they provide the same information as the fall relative abundance indices. Nonetheless, they suggest that *Illex* abundance on the continental shelf was relatively high during 1975-1981 and 1987-1990, but was relatively low during 1968-1974 and 1982-1986. It should be noted, however, that the area-swept estimates grossly underestimate total stock size and biomass for this species because the 100% catchability assumption is unlikely to hold and because the NEFSC surveys only cover a portion of the stock's range. For example, during 1967-1974 and 1982-1986, when fall survey abundance indices were low, minimum biomass estimates were generally less than the landings; suggesting that further work is needed to evaluate the catchability and availability of *Illex* to the survey gear. Furthermore, standing stock estimates should be adjusted to acount for the rapid body weight growth of this species.

EVALUATION OF OVERFISHING DEFINITION

As defined in Amendment 3 of the Atlantic Mackerel, Squid and Butterfish FMP (MAFMC 1990), *Illex* is overfished when the three-year moving average of pre-recruits from the NEFSC fall bottom trawl survey falls within the lowest quartile of the time series from 1968 to the present. To apply this definition for 1992, 1993, and 1994, the lowest quartile of this series consists of the seven lowest pre-recruit indices (Table 6). For overfishing to occur, the three-year moving average of the pre-recruit time series must be less than the largest index in this lowest quartile. During 1992, the largest pre-recruit index was 0.3 and the three-year moving average was 1.6 (Table 9), so the stock was not overfished in 1992. During 1993, the largest possible index would be 0.3 and the smallest possible three-year moving average would be 1.2 (assuming a pre-recruit index of zero in 1993), so the stock will not be overfished in 1993. During 1994, the largest possible index would be 0.2 and the smallest possible three-year moving average would be 1.1 (assuming pre-recruit indices of zero in 1993 and 1994) so, based on the current overfishing definition, the stock will not be overfished in 1994. Based on the provisional pre-recruit index of 0.3 in 1993, it is possible that the stock may be overfished in 1995 if pre-recruit indices during 1994 and 1995 are zero. However, the current overfishing definition and MSY should both be re-evaluated to account for the one year life cycle of this species. A minimum biomass threshold or a minimum proportional escapement level should be considered.

CONCLUSIONS

Autumn research survey indices suggested that, in 1991 and 1992, the relative abundance of *Illex* on the continental shelf was intermediate to a period of high abundance during 1987-1990 and a period of low abundance during 1982-1986. Based on provisional survey indices for 1993, the stock appears to have remained at an intermediate biomass level. The relatively low abundance of *Illex* during 1982-1986 may have been the result of intensive fishing pressure during 1977-

1980, when more than 480,000 mt of *Illex* were landed in U.S. and Canadian waters. Regardless of this possibility, *Illex* recruitment to fishery areas within the U.S. EEZ has alternated irregularly between high (1975-1981 and 1987-1990) and low states (1967-1974 and 1982-1986). This irregular pattern of recruitment may reflect the influence of environmental factors, and in particular, may be related to variation in the success of juvenile dispersal via the Gulf Stream. On the other hand, the high rates of cannibalism in this species (Maurer and Bowman 1985) could lead to an overcompensatory stock-recruitment relationship, where *Illex* recruitment decreases with large spawning stock sizes. If this is the case, then multiple equilibria may be an inherent characteristic of the dynamics of the *Illex* population (May 1974). Alternatively, the irregular pattern of *Illex* recruitment to the U.S. EEZ fishery may reflect the opportunistic response of *Illex* to ecosystem-level reductions in the relative abundances of competitors and predators during the mid-1970's and late-1980's. Overall, further research will be needed to determine the relative importance of these factors on *Illex* recruitment.

Total landings of *Illex illecebrosus* from U.S. and Canadian waters have been dominated by the domestic fishery since 1983. The 1992 U.S. EEZ landings of *Illex* squid (17,800 mt) were the highest since 1982, but were still below the average level of landings (19,200 mt) obtained by the foreign fleet during 1973-1982. The domestic fishery has been expanding since the 1987 prohibition of directed foreign fishing for *Illex* in the U.S. EEZ. Domestic landings and fishing effort have been increasing since 1988 while LPUE has generally been decreasing. Given the short life span of this species and highly variable recruitment to fishery areas, future landings are difficult to project.

NEFSC autumn pre-recruit survey indices suggest that the stock was not overfished in 1992 and will not be overfished in 1993 or 1994, based on the current overfishing definition, and that the stock is under-exploited, based on the current MSY of 30,000 mt, and at a medium level of biomass. However, the overfishing definition and MSY should be re-evaluated to account for the one year life cycle of this species. Additionally, the implementation of a real-time management plan would allow full exploitation of the stock and ensure adequate spawning stock escapement.

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Table 1. Short-finned squid (*Illex illecebrosus*) landings (mt) from Cape Hatteras to the Gulf of Maine during 1963-1993[3] and from NAFO Subareas 2, 3 and 4, during 1973-1991.[1,2]

	Cape Hatteras to the Gulf of Maine NAFO Subareas 5 and 6			NAFO Subareas 2, 3 and 4	All Areas
Year	Domestic	Foreign	Subtotal	Subtotal	Total
1963	810	0	810	- [1]	810
1964	358	2	360	- [1]	360
1965	444	78	522	- [1]	522
1966	452	118	570	- [1]	570
1967	707	285	992	- [1]	992
1968	678	2,593	3,271	- [1]	3,271
1969	562	975	1,537	- [1]	1,537
1970	408	2,418	2,826	- [1]	2,826
1971	455	159	614	- [1]	614
1972	472	17,169	17,641	- [1]	17,641
1973	530	18,625	19,155	641	19,796
1974	148	20,480	20,628	283	20,911
1975	107	17,819	17,926	17,696	35,622
1976	229	24,707	24,936	41,767	66,703
1977	1,024	23,771	24,795	83,480	108,275
1978	385	17,310	17,695	94,064	111,759
1979	1,780	15,742	17,522	162,092	179,614
1980	349	17,529	17,878	69,606	87,484
1981	631	14,723	15,354	32,862	48,216
1982	5,902	12,350	18,252	12,908	31,160
1983	9,944	1,776	11,720	421	12,141
1984	9,547	676	10,223	715	10,938
1985	4,997	1,053	6,050	673	6,723
1986	5,176	250	5,426	111	5,537
1987	10,260	0	10,260	1,694	11,954
1988	1,966	1	1,967	846	2,813
1989	6,801	0	6,801	6,537	13,338
1990	11,316	0	11,316	10,867	22,183
1991	11,908	0	11,908	3,838	15,746
1992	17,827	0	17,827	- [2]	17,827 [2]
1993	14,630 [3]	0	14,630 [3]	- [2]	- [2]
AVERAGES					
1963-1992	3,540	7,020	10,560	- [1]	28,597 [1,2]
1973-1982	1,109 [1]	8,306	19,414	51,540	70,954
1983-1989	6,956	537	7,492	1,571	9,063
1990-1992	13,691	0	13,691	7,353	18,592 [2]

[1] Squid landings were not reported by species before 1973.

[2] *Illex* landings from NAFO Subareas 2, 3 and 4 in 1992 and 1993 are not available.

[3] Landings for 1993 are preliminary.

Table 2. Landings (mt) of *Illex* squid (*Illex illecebrosus*), by U.S. statistical area and month, during 1992.

AREA	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOTAL	%	AVG % 1982-92
513	0.3	-	-	-	-	-	0.1	-	-	0.1	0.1	-	0.6	<1	<1
514	-	-	-	-	-	-	-	-	-	-	0.8	-	0.8	<1	<1
522	-	-	-	-	-	-	-	0.2	-	-	-	-	0.2	<1	<1
526	-	0.2	4.8	23.7	-	-	-	-	-	-	-	-	28.7	<1	4
537	-	-	-	16.3	10.6	49.9	-	3.2	11.4	0.7	0.3	3.7	96.1	1	<1
612	-	-	-	-	-	1.5	-	-	-	-	-	-	1.5	<1	<1
613	0.9	-	-	-	-	-	-	-	-	0.6	-	-	1.6	<1	<1
614	-	-	-	-	-	-	-	0.1	-	-	-	-	0.1	<1	4
615	1.2	0.7	-	-	-	-	-	-	-	-	-	2.1	3.9	<1	<1
616	0.1	12.1	10.9	0.6	-	447.3	-	-	-	-	132.0	27.0	630.0	4	4
621	0.1	-	-	-	-	-	-	0.1	-	-	-	-	0.2	<1	<1
622	2.1	-	13.0	45.5	696.8	3,433.4	2,560.6	2,025.0	1,365.1	1,047.7	6.9	11.0	11,207.0	63	74
623	-	-	0.9	-	-	-	-	-	-	-	-	-	0.9	<1	1
626	-	0.8	0.1	0.3	-	-	1,409.0	2,382.9	227.8	69.3	-	-	4,090.1	23	9
632	-	-	-	-	-	-	-	-	812.1	907.1	46.1	-	1,765.3	10	4
TOTAL	4.8	13.7	29.7	86.3	707.3	3,932.1	3,969.7	4,411.6	2,416.4	2,025.4	186.2	43.8	17,827.0		
%	<1	<1	<1	<1	4	22	22	25	14	11	1	<1			
AVG % 1988-1992	<1	<1	<1	<1	1	11	25	31	24	7	1	<1			
AVG % 1982-1992	<1	<1	<1	<1	4	16	27	26	22	5	<1	<1			

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Table 3. General linear model analysis of landings per unit of effort (LPUE) in the domestic *Illex illecebrosus* fishery, between Cape Hatteras and the Gulf of Maine, during 1982-1992.

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	17	20946.899071	1232.170534	492.86	0.0001
Effort	2767	6917.605370	2.500038		
Corrected Total	2784	27864.504441			

R-Square	C.V.	Root MSE	LNCPUEDF Mean
0.751741	250.0968	1.5811509	0.6322154

Source	DF	Type I SS	Mean Square	F Value	Pr > F
YEAR	10	4007.4079459	400.7407946	160.29	0.0001
TONCLASS	2	9833.3698538	4916.6849269	1966.64	0.0001
AREA	5	7106.1212716	1421.2242543	568.48	0.0001

Source	DF	Type III SS	Mean Square	F Value	Pr > F
YEAR	10	259.6651938	25.9665194	10.39	0.0001
TONCLASS	2	40.9176373	20.4588186	8.18	0.0003
AREA	5	7106.1212716	1421.2242543	568.48	0.0001

Estimated fishing power coefficients (back-transformed, bias-corrected)

		Coefficient
YEAR	1982	1.000
	1983	0.431
	1984	0.739
	1985	0.391
	1986	0.461
	1987	0.626
	1988	0.706
	1989	0.669
	1990	0.763
	1991	0.827
	1992	0.451
TONCLASS	2	0.714
	3	1.076
	4	1.000
AREA	51	0.003
	52	0.011
	53	0.035
	61	0.071
	62	1.000
	63	0.608

Table 4. Standardized fishing effort and LPUE for *Illex* squid (*Illex illecebrosus*) landed by the domestic fishery in the U.S. EEZ, between Cape Hatteras and the Gulf of Maine, during 1982-1992.

Year	Standardized Effort[1] (days fished)	Domestic LPUE[2] (mt/df)	Standardized Abundance Index[3]
1982	258	22.9	1.00
1983	485	20.5	0.90
1984	210	45.5	1.99
1985	250	20.0	0.87
1986	140	37.0	1.62
1987	189	54.3	2.37
1988	37	52.9	2.31
1989	113	60.4	2.64
1990	385	29.4	1.28
1991	272	43.7	1.91
1992	526	33.9	1.48
AVERAGE 1982-1992	260	38.2	

[1] Effort for 1982-1987 has been prorated to account for Joint Venture landings.
[2] Ratio of total landings (mt) to standardized effort for *Illex* trips used in the GLM.
[3] Ratio of LPUE in year *t* to LPUE in 1982.

Table 5. Total numbers (millions) of *Illex illecebrosus* landed by the domestic fishery in the U.S. EEZ, between Cape Hatteras and the Gulf of Maine, during 1982-1992.

Year	Mean Weight (g)	Total Landings (mt)	Number of Squid Landed ($x10^6$)
1982	154	18,252	118.6
1983	130	11,720	90.2
1984	128	10,223	79.8
1985	130	6,050	46.4
1986	110	5,422	49.4
1987	132	10,260	77.4
1988	139	1,967	14.1
1989	126	6,802	54.0
1990	126	11,316	89.7
1991	140	11,929	85.2
1992	128	17,827	139.7
AVERAGE 1982-1992	131	10,161	77.4

Table 6. All sizes, pre-recruit (≤ 10 cm), and recruit (≥ 11 cm) stratified mean number per tow and mean weight per tow (kg) of *Illex illecebrosus* from the NEFSC fall bottom trawl surveys (offshore strata 1-23, 25 and 61-76, Cape Hatteras to Georges Bank), 1967-1993.

Year	All sizes (CV[1])	Pre-recruit (Number/tow)	Recruit (Number/tow)	Kg/tow
1967	2.1 (21%)	0.1	2.0	0.3
1968	2.3 (24%)	0.2	2.1	0.4
1969	0.8 (28%)	0.1	0.7	0.1
1970	3.4 (29%)	1.5	1.9	0.3
1971	1.9 (10%)	0.3	1.6	0.4
1972	3.5 (29%)	1.1	2.4	0.4
1973	1.3 (19%)	0.1	1.2	0.2
1974	3.0 (55%)	1.8	1.2	0.2
1975	12.4 (53%)	6.2	6.2	1.1
1976	30.9 (27%)	0.6	30.3	10.0
1977	15.8 (21%)	1.1	14.7	4.7
1978	29.4 (22%)	5.1	24.3	6.3
1979	32.8 (16%)	2.6	30.2	9.0
1980	17.1 (19%)	0.7	16.5	3.6
1981	61.9 (41%)	0.4	61.5	20.0
1982	4.6 (15%)	1.1	3.5	0.6
1983	2.8 (15%)	0.2	2.6	0.3
1984	6.4 (18%)	0.4	5.9	0.7
1985	2.0 (13%)	0.3	1.6	0.2
1986	3.2 (18%)	0.5	2.7	0.3
1987	30.0 (42%)	1.3	28.7	2.7
1988	24.0 (17%)	0.7	23.3	2.9
1989	22.2 (27%)	1.9	20.3	2.3
1990	24.5 (10%)	1.2	23.3	2.9
1991	8.6 (15%)	0.4	8.2	1.0
1992	12.3 (15%)	3.3	9.0	1.1
1993	17.2[2]	0.3[2]	16.9[2]	2.4[2]
AVERAGE 1967-1992	13.8 (24%)	1.3	12.5	2.7

[1] Coefficient of variation for the all sizes index.
[2] Provisional.

Table 7. All sizes, pre-recruit (≤ 10 cm), and recruit (≥ 11 cm) stratified mean number per tow and mean weight per tow (kg) of *Illex illecebrosus* from the NEFSC spring bottom trawl surveys (offshore strata 1-23, 25 and 61-76, Cape Hatteras to Georges Bank), 1968-1993.

Year	All sizes (CV[1])	Pre-recruit (Number/tow)	Recruit (Number/tow)	Kg/tow
1968	0.21 (49%)	0	0.21	0.02
1969	2.60 (50%)	2.30	0.30	0.04
1970	0.88 (42%)	0.24	0.64	0.04
1971	0.10 (37%)	0.01	0.09	0.01
1972	0.03 (39%)	0.01	0.03	<0.01
1973	0.05 (52%)	0	0.05	0.01
1974	1.16 (38%)	0.10	1.05	0.07
1975	0.27 (33%)	0.13	0.14	0.02
1976	0.35 (24%)	0.01	0.34	0.03
1977	0.32 (18%)	0.20	0.12	0.02
1978	1.35 (47%)	0.02	1.32	0.07
1979	0.93 (25%)	0.16	0.78	0.08
1980	0.63 (22%)	0.22	0.42	0.04
1981	1.74 (31%)	0.09	1.65	0.10
1982	1.22 (24%)	0.02	1.20	0.08
1983	0.11 (28%)	0.02	0.09	0.01
1984	0.40 (70%)	0.35	0.05	0.01
1985	1.47 (77%)	1.25	0.22	0.04
1986	0.35 (68%)	0.29	0.06	0.01
1987	0.50 (41%)	0.28	0.22	0.02
1988	0.20 (43%)	0.10	0.11	0.01
1989	0.47 (31%)	0.01	0.47	0.05
1990	0.64 (36%)	0.04	0.60	0.03
1991	1.92 (41%)	0.43	1.49	0.08
1992	0.88 (31%)	0.17	0.71	0.03
1993	0.60 (22%)	0.02	0.58	0.04
AVERAGE 1968-1993	0.75 (39%)	0.25	0.50	0.04

[1] Coefficient of variation for the all sizes index.

Table 8. Area-swept estimates of *Illex illecebrosus* minimum biomass(mt) and minimum population size (millions) computed from NEFSC fall bottom trawl survey data (Cape Hatteras to the Gulf of Maine), 1967-1992.

YEAR	MINIMUM BIOMASS (mt)	(S.D.)	MINIMUM POPULATION SIZE (millions)	(S.D.)
1967	1,542	(270)	10.3	(2.0)
1968	2,141	(357)	11.0	(2.4)
1969	493	(129)	4.0	(1.0)
1970	1,798	(271)	16.4	(4.2)
1971	2,343	(362)	11.4	(1.3)
1972	2,106	(334)	17.1	(4.4)
1973	2,328	(600)	9.6	(2.3)
1974	2,917	(1,179)	20.4	(8.3)
1975	9,686	(1,569)	67.8	(28.7)
1976	48,453	(10,751)	151.3	(34.2)
1977	24,110	(5,029)	81.3	(15.9)
1978	29,496	(7,385)	134.4	(26.5)
1979	48,112	(6,393)	165.3	(23.0)
1980	21,703	(4,100)	90.8	(14.9)
1981	74,503	(29,610)	236.6	(81.6)
1982	3,780	(430)	24.2	(3.1)
1983	1,525	(188)	11.2	(1.7)
1984	3,483	(640)	30.4	(5.1)
1985	2,107	(377)	14.2	(1.9)
1986	1,799	(284)	15.3	(2.3)
1987	11,729	(4,371)	127.1	(50.9)
1988	23,153	(8,444)	195.0	(80.6)
1989	12,450	(2,936)	109.6	(25.8)
1990	17,936	(1,543)	131.9	(12.0)
1991	5,400	(682)	43.6	(5.8)
1992	5,259	(599)	53.5	(7.3)
AVERAGE	13,860	(3,417)	68.6	(17.2)

Table 9. Three-year moving average of the *Illex illecebrosus* pre-recruit (stratified mean number per tow) index from the NEFSC fall bottom trawl surveys during 1969-1992.

Year	Average[1] Pre-recruit Number per Tow
1969	0.1
1970	0.6
1971	0.6
1972	0.9
1973	0.5
1974	1.0
1975	2.7
1976	2.9
1977	2.7
1978	2.3
1979	2.9
1980	2.8
1981	1.2
1982	0.7
1983	0.6
1984	0.6
1985	0.3
1986	0.4
1987	0.7
1988	0.8
1989	1.3
1990	1.3
1991	1.2
1992	1.6
1993[2]	1.3

[1] Average of pre-recruit indices in years *t*, *t*-1 and *t*-2.
[2] Provisional.

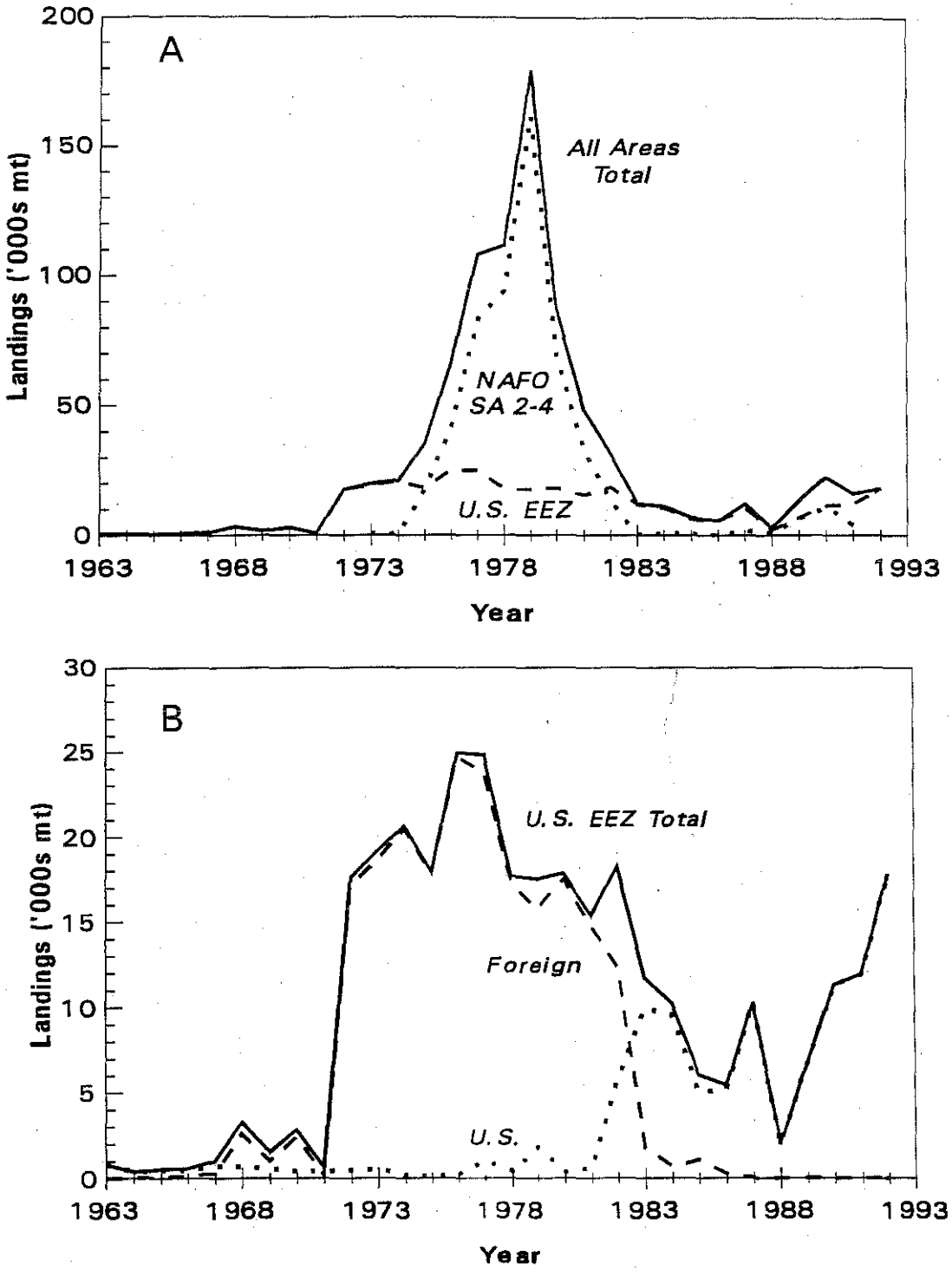

Figure 1. Trends in *Illex illecebrosus* landings from (A) NAFO Subareas 2-4 (1973-1991), U.S. EEZ, and all areas combined and B) U.S., foreign and total U.S. EEZ landings during 1963-1992.

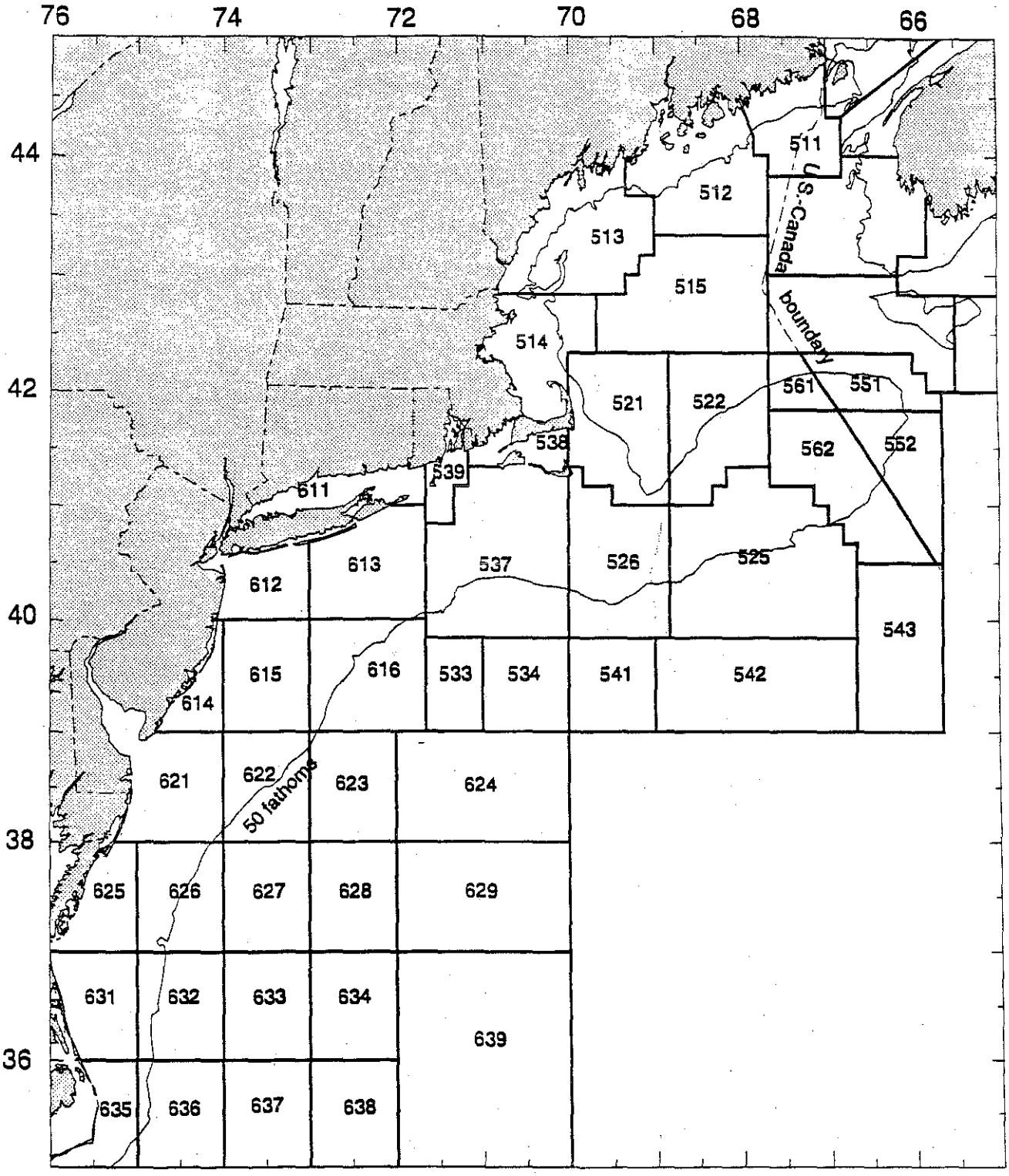

Figure 2. U.S. commercial statistical areas used to report landings in the northwest Atlantic.

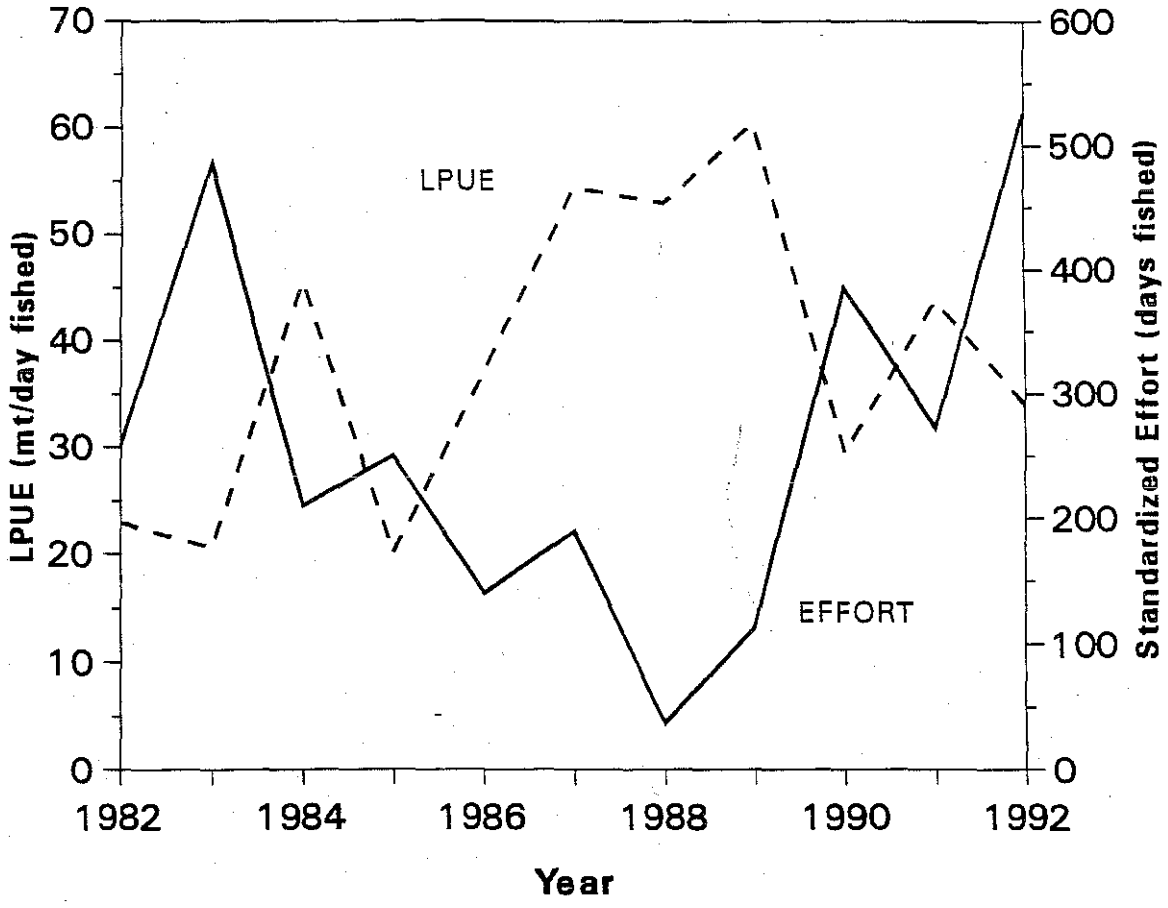

Figure 3. Standardized fishing effort and LPUE for Illex illecebrosus landed by the domestic fishery (Cape Hatteras to the Gulf of Maine) during 1982-1992.

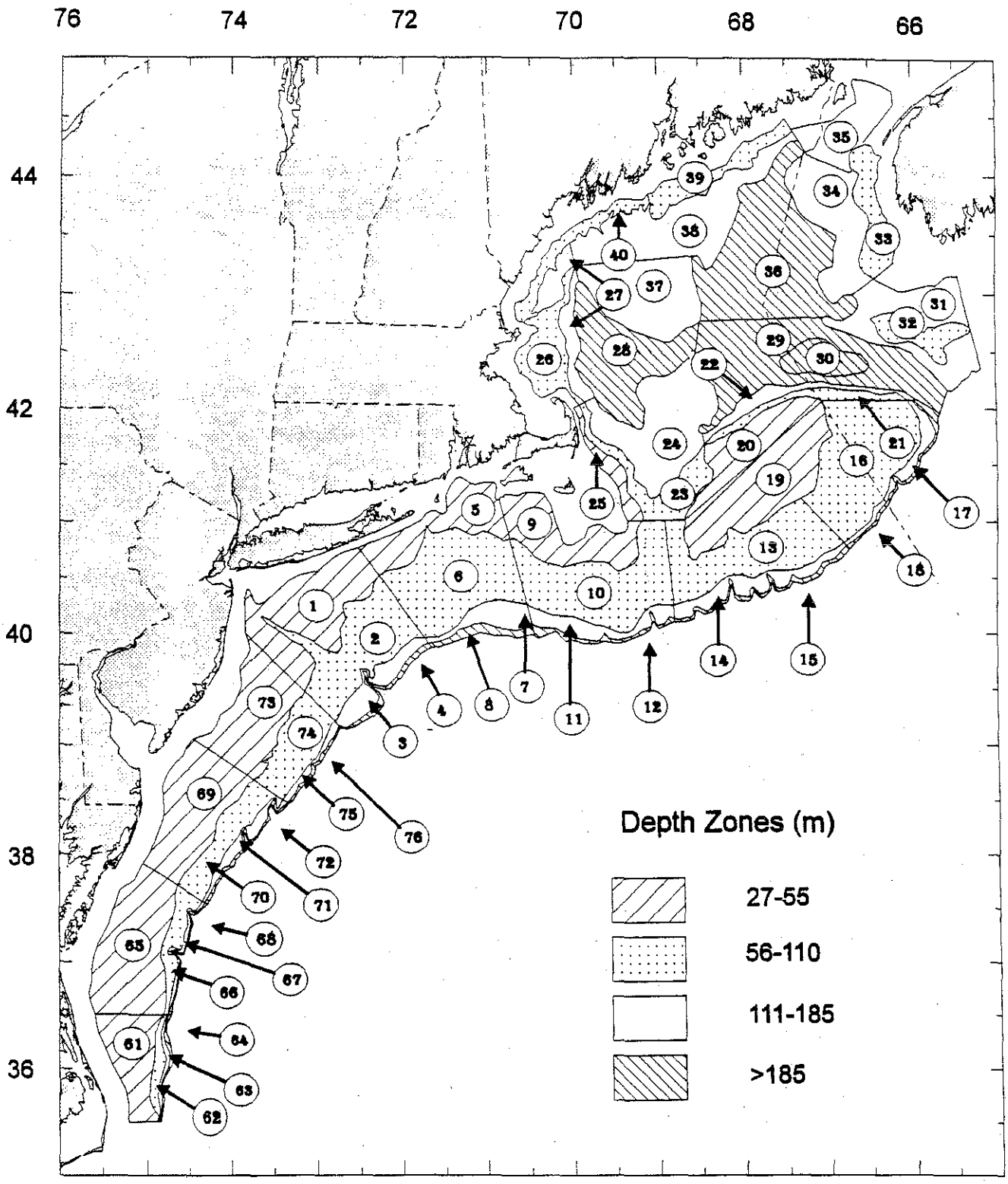

Figure 4. Area of the Northwest Atlantic showing offshore strata sampled during NEFSC bottom trawl surveys.

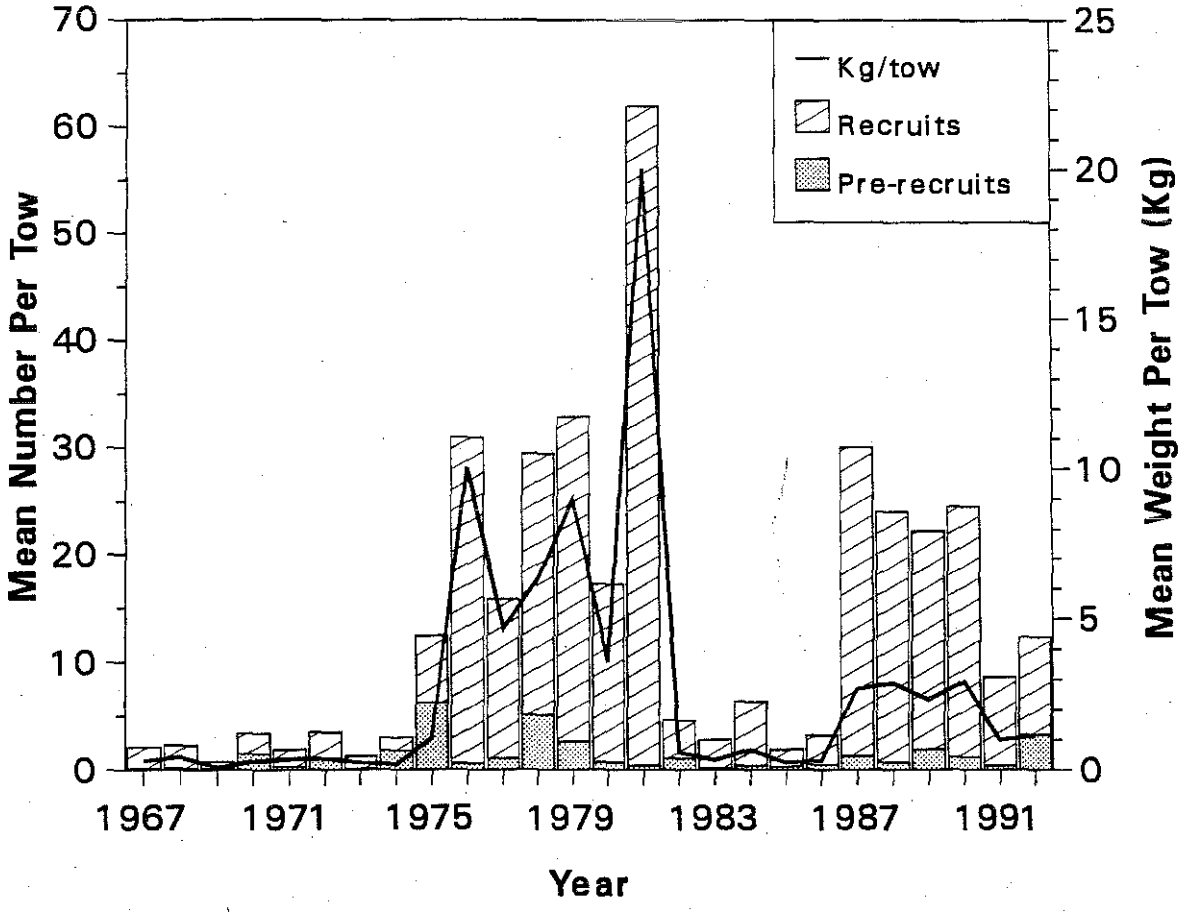

Figure 5. Stratified mean number per tow and mean weight per tow (Kg) of ***Illex illecebrosus*** in the NEFSC fall bottom trawl surveys, 1967-1992.

Appendix 1. Summary of U.S. EEZ *Illex* squid commercial length-frequency sampling and mean weights, by month and statistical area, during 1982-1992.

YEAR	MONTH	AREA	MEAN WEIGHT (grams)	SQUID SAMPLED	ANNUAL SAMPLE TOTAL	LENGTH-FREQUENCY SAMPLES
1982	6	622	179	2,020	2,961	59
	7	514	107	54		
	7	521	115	172		
	7	622	185	257		
	8	515	120	53		
	8	521	137	58		
	8	522	134	56		
	8	622	222	241		
	10	626	185	50		
1983	6	513	164	149	920	18
	6	636	89	52		
	7	622	88	67		
	7	626	98	54		
	7	632	113	55		
	7	636	104	53		
	8	626	157	51		
	8	632	125	53		
	8	636	151	52		
	9	622	143	168		
	9	626	159	105		
	11	513	216	61		
1984	4	626	71	45	1,690	33
	5	622	85	163		
	6	513	47	51		
	6	622	120	605		
	6	632	126	57		
	7	622	164	361		
	8	622	174	56		
	8	626	120	17		
	8	632	144	116		
	9	632	155	114		
	11	513	140	53		
	12	622	139	52		
1985	4	622	84	54	411	8
	4	626	43	7		
	5	622	79	50		
	6	626	124	53		
	8	626	128	30		
	9	626	139	57		
	9	632	143	112		
	12	513	212	48		

YEAR	MONTH	AREA	MEAN WEIGHT (grams)	SQUID SAMPLED	ANNUAL SAMPLE TOTAL	LENGTH-FREQUENCY SAMPLES
1986	5	622	56	137	866	17
	5	632	52	52		
	6	513	87	48		
	7	622	90	307		
	7	626	104	54		
	8	622	104	107		
	9	622	133	56		
	9	632	125	52		
	12	616	79	53		
1987	5	622	64	65	600	12
	6	622	113	435		
	6	632	152	53		
	7	622	140	47		
1988	1	622	91	58	759	15
	5	626	76	53		
	6	622	86	62		
	7	622	137	57		
	7	632	120	54		
	8	632	132	264		
	9	632	145	211		
1989	6	622	74	51	159	3
	8	626	121	108		
1990	6	626	107	56	324	6
	7	626	114	160		
	8	632	125	52		
	9	626	116	56		
1991	6	616	104	100	751	15
	6	632	96	50		
	7	622	149	100		
	7	626	148	150		
	8	616	158	101		
	8	622	150	200		
	8	626	139	50		
1992	6	622	90	50	800	16
	7	622	113	550		
	7	626	105	50		
	9	626	164	50		
	9	622	183	50		
	10	622	171	50		