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STOCK STATUS AND ESTIMATES OF POTENTIAL YIELDS OF SQUID (*Loligo pealei* and *Illex illecebrosus*) POPULATIONS OFF THE NORTHEASTERN USA

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by

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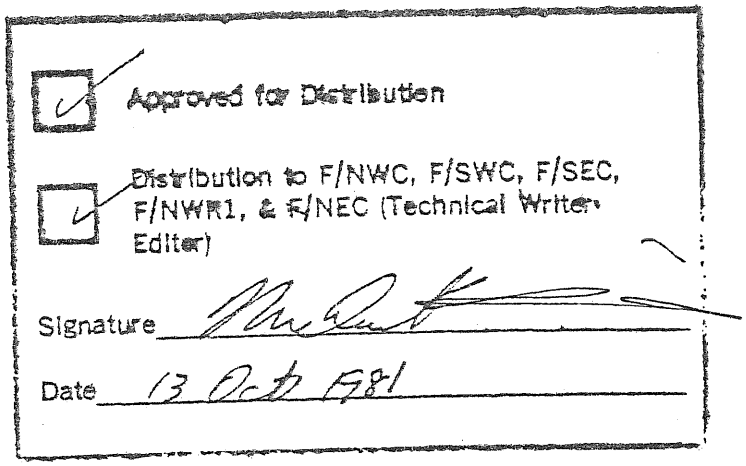

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INTRODUCTION

This document presents information regarding the current status of the Loligo pealei and Illex illecebrosus squid stocks from the Mid-Atlantic to the Gulf of Maine (Figure 1). USA and foreign commercial and USA research survey information presented include: catches and length frequencies from the 1980 USA and foreign fisheries and 1980 autumn abundance and pre-recruit indices. This is an update of the March 1980 stock status report (Lange 1980).

Estimates of potential yield and yield per recruit from the 1980 year classes for each species, based on 1980 autumn survey abundance estimates and size distributions of pre-recruits are also presented.

COMMERCIAL FISHERY

Provisional 1980 USA squid catches totaled 4,471 MT (Table 1), compared with 5,379 MT reported in 1979. This total was comprised of an estimated 4,128 MT of L. pealei and 343 MT of I. illecebrosus. The L. pealei catch decreased 3% from the 1979 catch but was still about three times the 1969-78 average, while I. illecebrosus catches were only 32% of the 1979 level, and 29% less than the 1969-78 average.

Catches of squid by the distant-water fleet totaled 30,736 MT (preliminary) in 1980, with 15,847 MT of L. pealei and 14,889 MT of I. illecebrosus. This represented a 21% increase in L. pealei and a 9% decline in I. illecebrosus catches, from 1979 levels. Compared with the 1969-79 average, L. pealei catches were down 25% while I. illecebrosus catches were up 2%. Countries participating in these fisheries were Italy, Japan, Spain, and Poland.

Management of these stocks since 1979 has been based on a fishing year of 1 April to 31 March. On this basis, 57% of the 35,075 MT L. pealei and 75% of the 25,000 MT I. illecebrosus total allowable levels of foregin fishing (TALFF's) for the 1980-81 fishing year were taken. However, allocation of the reserve amounts of the optimum yield (OY) of each species, late in the fishing year, are reflected in these TALFF levels. Catches by some countries would likely have been higher had the reserve amounts been allocated at the start of the fishing year. For example, catches of L. pealei by Spain and Italy were 80% and 47% greater than their initial allocations, and 14% of the final TALFF's were allocated to countries which did not participate in the L. pealei fishery. Also, for I. illecebrosus, Spain reported catches totaling 2.3 times its initial and 89.2% of its final allocation, while Italy reported taking 2.7 times and 88%, respectively, of these allocations.

Monthly length frequency distributions from the distant-water fleet squid fisheries (USA observer samples) are presented in Tables 2 and 3 for L. pealei and I. illecebrosus. Individual length samples were expanded to represent the total number of individuals at each length taken in the sampled tows. These weighted distributions were then summed for the entire fleet for each month to represent the overall monthly length composition of the catch.

Mean size of L. pealei in the distant-water fleet catch remained relatively constant, at about 11 cm, from January through March, as individuals from the 1979 year class continued to recruit to the fishery. During these months, 2-4% of the catch was over 20 cm in length and would probably

spawn in the spring. Mean lengths increased slightly from October through December, reflecting growth of spring-summer hatched individuals. Over 10% of the catch, in November and December, was over 20 cm in length and would probably have spawned in the spring of 1981. Illex illecebrosus length samples reveal the general increase in mean size of individuals of the 1979 year class through the year with indications of partial recruitment of the 1980 year class by November.

Mean length of L. pealei from the USA inshore fishery (Table 4) generally was greater than that observed in the foreign offshore fishery (Table 2) as the USA fishery typically is directed towards concentrations of spawning adults. Large, mature individuals were first observed in January in the Mid-Atlantic area, and by April and May in Southern New England. Mean sizes decreased in the Mid-Atlantic from January through March, but by April a late influx of larger individuals, and an absence of juveniles in the catches resulted in increases in average size from 11.4 to 19.6 cm. The large ($\geq$28 cm) individuals seen in the Southern New England area in April and May were not observed later in the year and had presumably spawned and died. Mean lengths decreased throughout the year with the arrival of smaller, yet mature, individuals (probably hatched late in 1979), and did not increase until October.

Length frequencies of I. illecebrosus from the 1980 USA commercial fishery were not available.

RESEARCH VESSEL SURVEYS

Minimum biomass and abundance estimates for L. pealei and I. illecebrosus, were calculated from areal expansion of stratified mean weight and numbers per tow from NMFS autumn bottom trawl surveys (Table 5). Loligo pealei estimates were adjusted to account for day-night differences, as noted by Sissenwine and Bowman (1978), as this species is more available to the trawl during daylight than darkness. The 1980 biomass estimate for L. pealei (50,523 MT) was 161% greater than in 1979 and 56% above the 1968-79 average. The minimum estimated total number of this species was up 341% (at 9.31 billion individuals) from the 1979 level and 222% above the 1968-79 average. The 1980 biomass estimate for I. illecebrosus (18,729 MT) was 55% below the 1979 level, while the estimated abundance for this species (80 million individuals) was 44% below the 1979 level. These estimates were 47% and 57% greater than the 1968-79 average in weight and numbers, respectively.

The lesser decrease in number, than in weight of I. illecebrosus, between 1979 and 1980, was due to a decrease in the average size of the individuals from 1979 to 1980. Also, the ratio of stratified mean number per tow of pre-recruit sized ($\leq$10 cm) individuals to all sizes (Table 6) decreased from 8% in 1979, to 4% in 1980. For L. pealei, the percentage of pre-recruits to the total abundance in 1980 remained at nearly the level observed in 1979 (77% vs 81%). Disproportionate increases in estimated biomass (weight) compared to abundance (number), (161% vs 341%) indicate an overall decline in average size of L. pealei and together with autumn

survey length frequencies, imply that peak spawning was delayed in 1980. This late spawning may result in increases in expected yield from this year class, over what would occur had spawning peaked in spring, since late spawned individuals will probably not enter the offshore fishery until the 1981-82 season.

ESTIMATES OF EXPECTED YIELD

The distribution of pre-recruit L. pealei (≤8 cm) in the 1980 USA autumn survey catches was significantly different than the average distribution observed during 1974-79. Loligo pealei spawn over an extended period, from spring to autumn, with two distinct cohorts (spring and late summer) observed in most years. The ratio of individuals found in the autumn survey assumed to be from the spring cohort (Lange 1980) versus the summer cohort (≥5 cm vs <5 cm) has been about 60:40 in most years. However, in 1980 this ratio was approximately 20:80, indicating that the greatest amount of spawning occurred later than usual and was attributed to the summer rather than the spring cohort. Also, the total abundance estimate in 1980 (9.3 billion individuals) was significantly greater than the average observed between 1968 and 1979 (2.1 billion), with an estimated 7.2 billion pre-recruits available at the time of the autumn survey. This implies a possible greater potential yield from this year class of L. pealei, relative to average year classes, with the summer cohort not becoming susceptible to the fishery until its second winter (Lange 1981), at a significantly larger size than the spring cohort.

Lange (1981) described a model to simulate yield per recruit and estimate total yield from the L. pealei fishery, based on estimates of

average annual recruitment, and assumptions of spawning patterns. This model was used to simulate yield per recruit and potential yield from the 1980 year class of L. pealei, assuming recruitment of 7.2 billion individuals and a 20:80 ratio of individuals in cohort I (spring) to cohort II (summer) as estimated from 1980 autumn survey data. Initial weights, growth, and relative fishing mortality for each cohort were as assumed by Lange (1981). Monthly natural mortality estimates (M = 0.03, 0.04, 0.08, and 0.15) were chosen to correspond to estimated lifespans of approximately 33, 25, 12.5, and 7 months, respectively, assuming $M \sim 1/\hat{T}$; where $\hat{T}$ = expected lifespan (Au 1976). The starting point for the simulation was November, assuming an initial population size equivalent to the number of pre-recruits estimated from the autumn survey.

Estimates of potential yield (Table 7, Figure 2) for natural mortality estimates of 0.03 and 0.04 were consistently greater than historical catches, ranging from 70,100 MT (F = 0.05) to 160,300 MT (F = 0.30) and from 61,500 MT (F = 0.03) to 141,800 MT (F = 0.30), respectively. For these levels of monthly M, maximum yield would be realized for F-multipliers of 0.30. Expected yields assuming monthly natural mortalities of 0.08 and 0.15 ranged from 31,300 MT to 90,000 MT and from 17,100 MT (F = 0.05) to 48,100 MT, respectively, with maximums occurring for F-multipliers of 0.35 and 0.50. Even at these high levels of natural mortality, expected yields were greater than realized in recent years for all but the lowest tested levels of fishing mortality. This is due not only to the above average levels of recruitment from the 1980 year class, but also to the abnormal distribution of spawning which produced this year class. If recruitment

is ignored and estimates of yield per recruit (Table 7, Figure 2) are compared with those presented by Lange (1980) for an average spring:summer cohort ratio of 60:40, the 1980 year class may be expected to produce between 3.1 and 4.7 times the yield of such an average year class.

It should be noted that this analysis is presented only as an indication of the relative strength of this year class and its potential yield, and that lacking appropriate spawner-recruitment relationships for this species, changes in allowable catch levels may not be warranted. However, comparison of those expected yields with the results of the 1981-82 fishery (relative to allowable catch and recent catch rates) may provide insight into the usefulness of similar analyses in predicting yield in the future.

Illex illecebrosus also spawn over an extended period, from winter through summer, with two cohorts evident for this species in most years. There is some indication that a greater portion than usual of the 1980 I. illecebrosus year class was attributed to the spring cohort. The overall proportion of pre-recruits ($\leq$10 cm) to recruits was less in 1980 than in 1979 (4% vs 8%), while the distribution within pre-recruits indicated a smaller portion than usual may be attributed to the winter versus the spring cohort (>7 cm vs $\leq$6 cm). This ratio was 67:33 in 1980 compared with an average of about 80:20 in other years (1973-79).

Although the NMFS autumn surveys may provide adequate estimates of relative abundance of I. illecebrosus, estimates of total abundance derived from areal expansion of survey catches probably do not reflect true abundance since this species is distributed over a much greater portion of the continental shelf, and into Canadian waters, than the surveys cover. Therefore,

yield (kg) per 1000 recruits were compared with those for similar levels of natural and fishing mortality estimated for the average distribution of spawning as presented in Lange (1981). This analysis is useful in predicting the effect of the time of spawning on potential yields of I. illecebrosus.

Unlike for L. pealei, this analysis indicates that delays in spawning of I. illecebrosus may result in significant decreases in yield per recruit, except at high levels of monthly natural mortality (0.10). Yield per recruit estimated for an average year class (winter:spring cohorts at 80:20) was between 1.1 and 1.5 times that estimated for the 1980 year class with an estimated winter:spring cohort ratio of 67:33 (Table 8, Figure 3). This predicted decline may be due to an increase in the effect of natural mortality with the delay in spawning and subsequent delay in entry to the fishery, and/or to the reduced mean size of the individuals taken throughout the course of the fishery.

CONCLUSIONS

The downward trend in L. pealei abundance after 1975 leveled off in 1979 and appears to have reversed in 1980, with abundance estimates the highest on record and biomass estimates comparable to the high levels observed in the mid-1970's. Although the commercial catch in 1980 was still well below the 1972-76 level (average of 32,300 MT) it was the highest since 1976. The bulk of the pre-recruits observed during the 1980 autumn survey will be contributing to both the US and the foreign fishery over the next year or so. Analyses indicate that, due primarily to the relative

delay in spawning resulting in the dominance of the late summer cohort over the spring cohort in 1980, the potential yield from this year class could be 3 to 4.5 times greater than that expected from the average year class, even if abundance was similar to other years.

The autumn 1980 I. illecebrosus abundance index remained well above historical levels, while the number of pre-recruits continued to decline from the 1978 level to below the 1967-79 average. Restrictions imposed by initial 1980 allocations from TALFF may have accounted, in part, for the low catches of I. illecebrosus by the distant-water fleet in 1980 (the lowest since 1972) since each of the countries in the directed squid fisheries (Japan, Italy, Spain, and Mexico) caught more than their initial allocations following allocation of the reserve portion of the OY late in the year.

The international catch of I. illecebrosus in Canadian waters declined 55% between 1979 and 1980, from 153,100 to 69,527 MT. This decrease was due primarily to declines in Canadian catches related, in part, to poor market conditions and consequent reductions in effort off Newfoundland and Nova Scotia.

Analyses indicate that the potential yield of I. illecebrosus from the 1980 year class may be less than from average year classes due to the relative increase in importance of the spring compared to the winter cohorts.

LITERATURE CITED

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Table 1. Annual squid (*L. pealei* and *I. illecebrosus*) catches (in Metric Tons) from the Northwest Atlantic (Cape Hatteras to Gulf of Maine), by the USA and the distant water fleet (DWF), 1963-1979.

	L. pealei			*I. illecebrosus*		
Year	USA	DWF	Total	USA	DWF	Total
1963	1294	0	1294	810	0	810
1964	576	2	578	358	2	360
1965	709	99	808	444	78	522
1966	722	226	948	452	118	570
1967	547	1130	1677	707	285	992
1968	1084	2327	3411	678	2593	3271
1969	899	8643	9642	562	975	1537
1970	653	16732	17385	408	2418	2826
1971	727	17442	18169	455	159	614
1972	725	29009	29734	472	17169	17641
1973	1105	36508	37613	530	18625	19155
1974	2274	32576	34850	148	20480	20628
1975	1621	32180	33801	107	17819	17926
1976	3602	21682	25284	229	24707	24936
1977	1088	15586	16674	1024	23771	24795
1978	1291	9355	10646	385	17310	17512
1979	4252	13138	17390	1086	16426	17512
1980[1]	4128	15847	19975	343	14889	15232

[1]Provisional.

Table 2. Loligo pealei length frequency distributions ([1](per mille), by month, from USA foreign fishery observer samples, 1980.

Length (cm)	Jan	Feb	Mar	Jul	Aug	Oct	Nov	Dec
1								
2								
3		*	1.3					
4	.4	2.0	5.4				1.3	4.4
5	2.8	15.3	22.9				12.7	21.2
6	25.7	47.1	76.9				56.7	62.5
7	66.3	76.0	125.2			64.4	85.7	94.7
8	116.4	126.9	126.3			138.0	143.4	95.5
9	142.0	145.6	102.5			97.2	133.4	106.8
10	126.3	142.3	81.2	45.1	115.3	31.1	136.7	95.4
11	121.9	102.7	87.3	422.1	242.5	82.2	92.9	76.9
12	94.1	88.7	82.0	397.5	375.2	169.1	54.5	62.6
13	81.3	67.4	75.4	82.0	117.8	213.8	40.9	47.9
14	78.9	55.8	60.3	36.9	82.6	120.4	36.4	45.4
15	42.9	31.8	40.5	16.4	48.9	54.3	27.7	38.5
16	23.1	22.7	25.5		17.2	13.5	22.2	44.8
17	18.3	15.0	19.2		.6	8.9	17.7	33.7
18	18.1	12.1	14.6			7.2	14.5	26.5
19	11.7	10.9	8.1				10.9	24.7
20	6.2	11.3	10.3				12.2	17.7
21	6.7	9.1	5.5				17.2	21.0
22	4.5	5.1	5.6				9.3	20.6
23	4.1	5.7	4.7				8.8	12.4
24	2.2	1.8	1.5				12.8	11.1
25	1.5	1.7	4.1				9.0	8.8
26	1.5	0.8	1.6				6.9	6.0
27	1.0	.8	1.8				9.9	6.7
28	.6	.6	1.3				5.3	6.6
29	.7	.2	2.3				15.6	2.2
30	.5		.3				1.6	2.7
31	.2	.1	1.1				.4	1.3
32	.2	.4	.3				.9	.8
33			1.2				.6	
34		*	1.8				.3	.1
35	.1	.2	.2				.4	.3
36			.8				.6	
37							.4	
38		*	.1				.2	
39			.8				.2	
40+			.1					
Total Number	1000	1000	1000	1000	1000	1000	1000	1000
Total Number in catch[2]	493.4	1195.5	666.9	.2	11.8	7.0	363.6	253.0
Total Weight in catch[3]	29.1	59.8	33.0	.01	.7	.5	25.2	17.7
Mean Length (cm)	11.3	10.9	10.9	11.7	12.0	11.4	11.7	12.3

[1]From samples taken by USA observers, expanded over the total sampled catch, and summed over all countries, vessels and areas.
[2]Estimated total number in sampled catch, in millions of squid.
[3]Total weight of squid in sampled catch, in metric tons.
[4]<0.05.

Table 3. *Illex illecebrosus* length-frequency distributions[1] (per mille), by month, from USA foreign fishery observer samples, 1980.

Length (cm)	Jan	Feb	Mar	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1										
2										
3										
4		*						*		
5							.5			
6		3.8	1.8				.2	*		
7	.7	7.2	3.7		*		.2	.1		2.4
8	.3	27.5	36.3		.5	.2	1.5	.6	.3	1.2
9	2.1	74.7	53.9		.6	.5	2.5	1.1	.3	4.9
10	8.7	94.4	63.1	.5	3.0	.7	5.7	4.0	.4	7.4
11	30.4	181.4	127.5	1.9	2.7	1.2	11.6	9.7	.6	11.1
12	30.4	201.0	138.3	4.2	1.7	3.7	15.5	17.9	.7	13.4
13	26.8	122.2	197.5	5.9	1.1	3.4	9.2	22.9	.8	14.7
14	22.2	82.6	220.2	5.9	2.4	3.5	8.6	65.0	1.0	13.0
15	20.4	87.6	103.0	13.1	2.3	4.4	15.1	11.1	1.2	11.5
16	16.9	41.0	30.2	24.0	5.3	7.4	12.1	10.6	1.5	17.6
17	12.5	24.6	11.2	57.7	15.2	14.8	16.7	10.3	3.6	21.1
18	30.8	26.2	10.8	132.3	59.8	26.1	26.2	9.5	10.1	27.2
19	18.7	8.1	.5	170.3	134.7	67.2	60.4	12.6	14.9	31.2
20	41.7	6.6	1.8	216.0	245.9	193.6	125.1	28.1	28.5	40.9
21	89.6	8.5		125.0	211.4	275.6	162.1	84.4	81.0	82.7
22	111.6	1.1		88.2	132.8	200.2	212.4	210.5	193.5	136.0
23	182.3	.5		57.9	71.9	101.9	147.1	222.5	223.6	200.1
24	95.2	.5		42.8	44.6	56.1	68.9	130.2	150.4	109.8
25	87.0			26.7	30.7	19.4	49.9	57.3	95.1	80.3
26	77.7			13.6	16.8	10.5	29.4	34.4	66.7	7.3
27	40.7			8.4	12.4	6.2	10.7	26.8	45.8	6.7
28	24.6			4.6	2.7	3.6	6.1	15.8	38.9	13.2
29	4.8			.9	.8	.4	1.6	7.9	23.8	27.5
30	23.9				.2		1.0	3.5	9.0	
31					.5			.8	6.0	
32								.2	2.1	
33								.2	.1	
34										
35										
36								.1	.1	
37								.1		
Total Number	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000
Total Number in Catch[2]	230024	59388	76210	580730	1468145	1922977	390400	2114288	825035	134049
Total Weight in Number[3]	50744	3652	2318	135608	323988	365860	83887	492537	230522	32540
Mean length (cm)	21.7	12.4	12.6	20.1	20.8	21.1	21.1	22.8	23.6	22.4

[1]From samples taken by USA observers, expanded over the total sampled catch, and summed over all countries, vessels and areas.
[2]Estimated total number in sampled catch, in thousands of squid.
[3]Total weight of squid in sampled catches, in metric tons.

Table 4. Length frequency distributions (per mille) of Loligo pealei, from the 1980 USA fishery, by area and month.

	GEORGES BANK	SOUTHERN NEW ENGLAND					MIDDLE ATLANTIC								
							6A		6B						
Length (cm)	Jan	Apr	May	Jun	Aug	Oct	Apr	May	Jan	Feb	Mar	Apr	Jun	Nov	Dec
1															
2															
3											17				
4											32				
5											30				
6											84				
7											118				
8					20						137				
9	20			40	30	27			10		105				
10	60		1	--	120	80			29		46				
11	20		1	20	80	53			19	15	34				3
12	20		2	40	70	73			10	10	36	9			16
13	80		7	40	80	60	22		48	55	42	9			13
14	80	20	15	60	150	120	38		58	85	34	37		66	35
15	120	40	40	140	130	80	65		96	65	34	65		145	38
16	120	40	96	80	100	147	103		144	126	38	65		127	47
17	120	140	145	40	60	67	147		87	146	46	139		235	66
18	100	120	155	80	40	80	136	12	106	111	38	74	4	205	72
19	100	120	131	80	30	40	168	25	67	85	21	139	--	133	72
20	60	120	91	100	30	40	120	49	29	95	15	111	42	90	63
21	60	100	55	40	--	60	82	68	10	65	29	120	61		116
22		40	56	60	20	40	60	117	48	45	23	56	106		60
23		60	42	40	10	7	22	173	48	55	17	37	205		75
24		60	23	40	20	13	11	154	10	25	8	46	183		31
25	20	20	30	40	--	--	11	167	29	10	10	28	148		28
26		40	19	40	--	--	16	99	19	--	2	--	118		72
27		20	22	20	10	7		74	29	5	4	19	65		44
28		--	23			7		49	29			19	49		47
29	20	20	14					12	10			--	15		22
30		20	7						10			19	--		19
31		--	6						10			--	4		22
32		20	8						--			9			13
33			4						29						6
34			1						--						--
35			--						10						16
36			3						--						3
37			1						10						
38			--												
39			--												
40			--												
41			1												
Total	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000
Number Measured	50	50	1082	50	100	150	184	162	104	199	525	108	263	166	318
Mean Length	16.4	20.4	20.0	18.1	14.4	15.6	18.6	23.8	19.0	17.8	11.4	19.6	24.1	17.1	21.8
Mean Weight (g)	104	168	159	132	77	109	132	227	154	122	59	154	231	127	213

Table 5. L. pealei and I. illecebrosus: Minimum biomass (Metric tons) and abundance (Numbers x 10^6) Estimates[1] for the Middle-Atlantic to Gulf of Maine, 1968-1980.

	L. pealei		I. illecebrosus	
Year	Biomass	Abundance	Biomass	Abundance
1968	29,114	1,212	1,845	10
1969	48,053	2,393	419	4
1970	19,640	1,946	1,524	15
1971	14,050	1,106	2,024	10
1972	21,039	1,533	1,716	15
1973	44,252	3,092	1,862	8
1974	46,442	4,757	2,500	18
1975	48,636	7,789	8,306	60
1976	51,436	4,372	42,929	134
1977	27,421	3,157	21,747	73
1978	18,800	1,251	26,435	121
1979	19,333	2,114	41,455	144
1980	50,523	9,314	18,729	80

[1]From areal expansion of stratified mean weights (kg) and numbers per tow, by strata set. For L. pealei night-time catch data was expanded to account for diel differences in catch (Sissenwine and Bowman 1979).

Table 6. Total abundance and pre-recruit indices of squid, 1967-80. (Stratified mean number per tow of Loligo and Illex of all sizes and of Loligo ≤8-cm and Illex ≤10-cm mantle length in autumn bottom trawl survey, Middle Atlantic to Georges Bank.)

Year	Loligo (#/tow)		Illex (#/tow)	
	All sizes	≤8 cm	All sizes	≤10 cm
1967	134.5	126.9	2.1	0.7
1968	176.5	159.9	2.3	0.6
1969	237.3	217.4	0.8	0.3
1970	85.6	79.3	3.4	0.2
1971	163.3	161.5	1.9	0.6
1972	271.4	258.5	3.5	1.8
1973	372.0	353.9	1.3	0.3
1974	251.7	233.3	3.0	2.1
1975	614.4	593.3	12.4	9.6
1976	410.9	302.5	28.7	0.6
1977	388.5	297.7	15.8	1.1
1978	144.2	93.4	28.4	5.1
1979	193.7	156.5	32.1	2.6
1980	364.1	279.8	17.0	0.7

Table 7. Estimated yields (MT) and yield (kg) per 1000 recruits of L. pealei for various assumptions of monthly natural mortality (M) and fishing mortality (F) rates, based on 1980 autumn survey abundance and cohort structure.[1]

	MONTHLY NATURAL MORTALITY							
	0.03		0.04		0.08		0.15	
F-Multiplier	Yield	YPR	Yield	YPR	Yield	YPR	Yield	YPR
0.05	70,110	9.8	61,514	8.6	31,305	4.4	17,067	2.4
0.10	98,431	13.8	98,939	13.8	58,812	8.2	26,812	3.7
0.15	139,158	19.5	121,709	17.0	73,450	10.3	34,449	4.8
0.20	153,003	21.4	134,306	18.8	82,283	11.5	39,677	5.5
0.25	159,148	22.2	140,209	19.6	87,190	12.2	43,191	6.0
0.30	160,347	22.4	141,773	19.7	89,465	12.5	45,485	6.4
0.35	158,447	22.2	140,587	19.7	89,995	12.6	46,910	6.6
0.40	154,681	21.6	137,718	19.3	89,391	12.5	47,716	6.7
0.45	149,865	21.0	133,876	18.7	88,071	12.3	48,086	6.7
0.50	144,533	20.2	129,531	18.2	86,317	12.1	48,146	6.7
0.55	139,029	19.4	124,985	17.5	84,322	11.8	47,992	6.7
0.60	133,568	18.8	120,434	16.8	82,213	11.5	47,140	6.6
0.65	128,280	17.9	115,996	16.2	80,076	11.2	47,283	6.6
0.70	123,240	17.2	111,742	15.6	77,963	10.9	46,814	6.5
0.75	118,484	16.6	107,706	15.1	75,911	10.6	46,303	6.5
0.80	114,026	15.9	103,910	14.5	73,939	10.3	45,770	6.4

[1]Assuming approximately 7.153 billion recruits, and that 80% of the 1980 year class was from the summer, rather than spring cohort.

Table 8. Estimated yield (kg) per 1000 recruits of I. illecebrosus for four assumptions of monthly natural mortality ($\bar{M}$) and a range of fishing mortality (F) multipliers, based on 1980 autumn survey size distributions.[1]

F-Multiplier	0.1	0.04	0.08	0.10
0.05	11.6	9.9	7.9	7.1
0.10	19.2	16.3	13.1	11.8
0.20	32.0	27.2	22.0	19.8
0.30	38.0	32.4	26.2	23.7
0.40	40.6	34.7	28.3	25.6
0.50	41.3	35.4	29.0	26.3
0.60	39.0	35.1	28.9	26.3
0.70	37.9	34.3	28.4	25.9
0.80	36.6	33.3	27.7	25.3
0.90	35.3	32.2	26.9	24.0
1.00	34.0	31.1	26.1	23.9
1.10	32.8	30.0	25.3	23.3
1.20	31.6	29.0	24.6	22.7
1.30	30.6	28.1	23.9	22.1
1.40	30.5	27.3	23.3	21.6
1.50	28.8	26.5	22.7	21.1

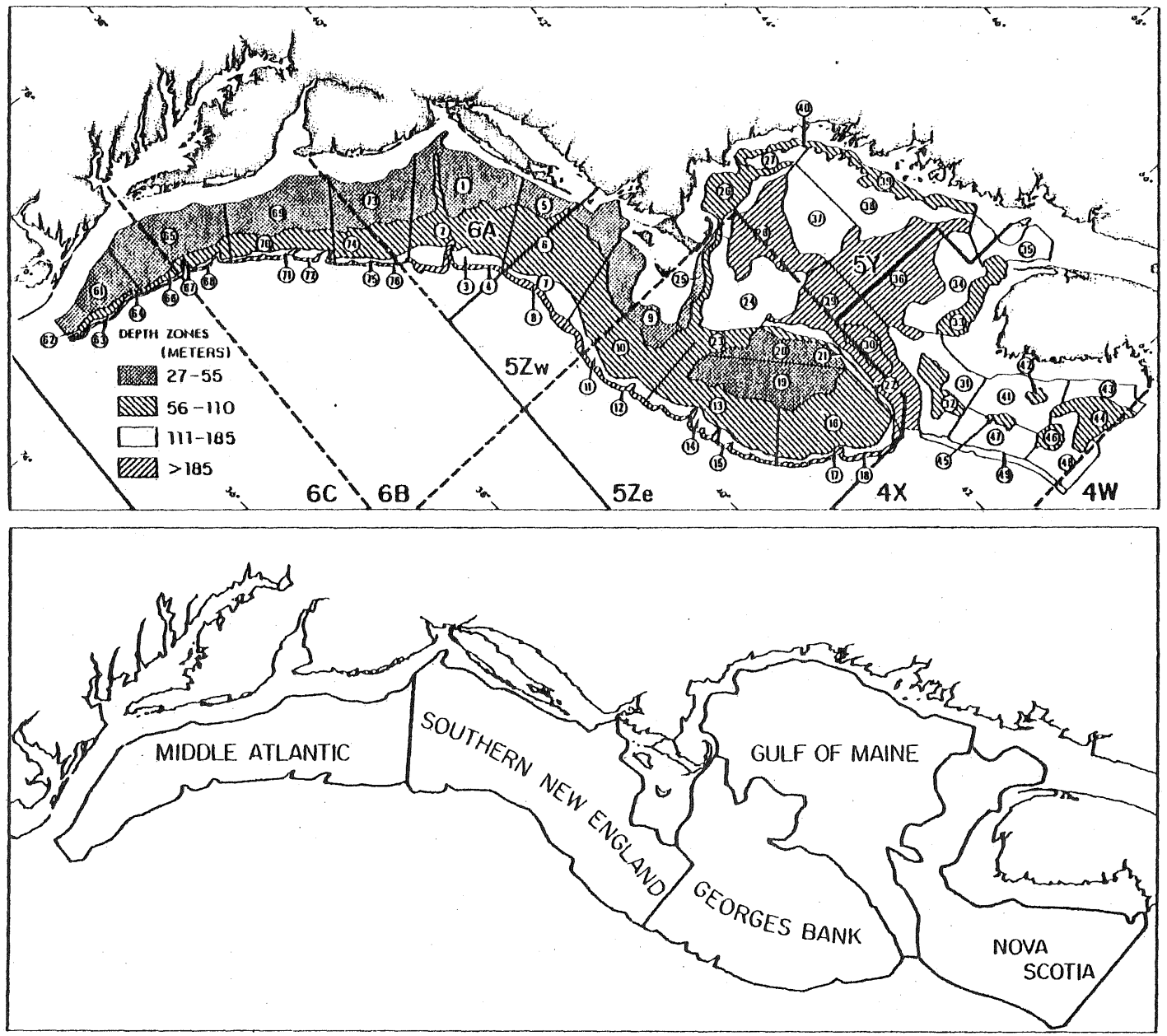

Figure 1. A. USA bottom trawl survey strata and ICNAF Subareas 4 and 5 and statistical area 6.
B. Geographical areas off the Northeast coast of the United States.

Figure 2. Estimated yield (MT) and yield (kg) per 1000 recruits, of L. pealei assuming the autumn 1980 distribution of pre-recruits for varying levels of monthly Natural (M) and Fishing (F) mortality.

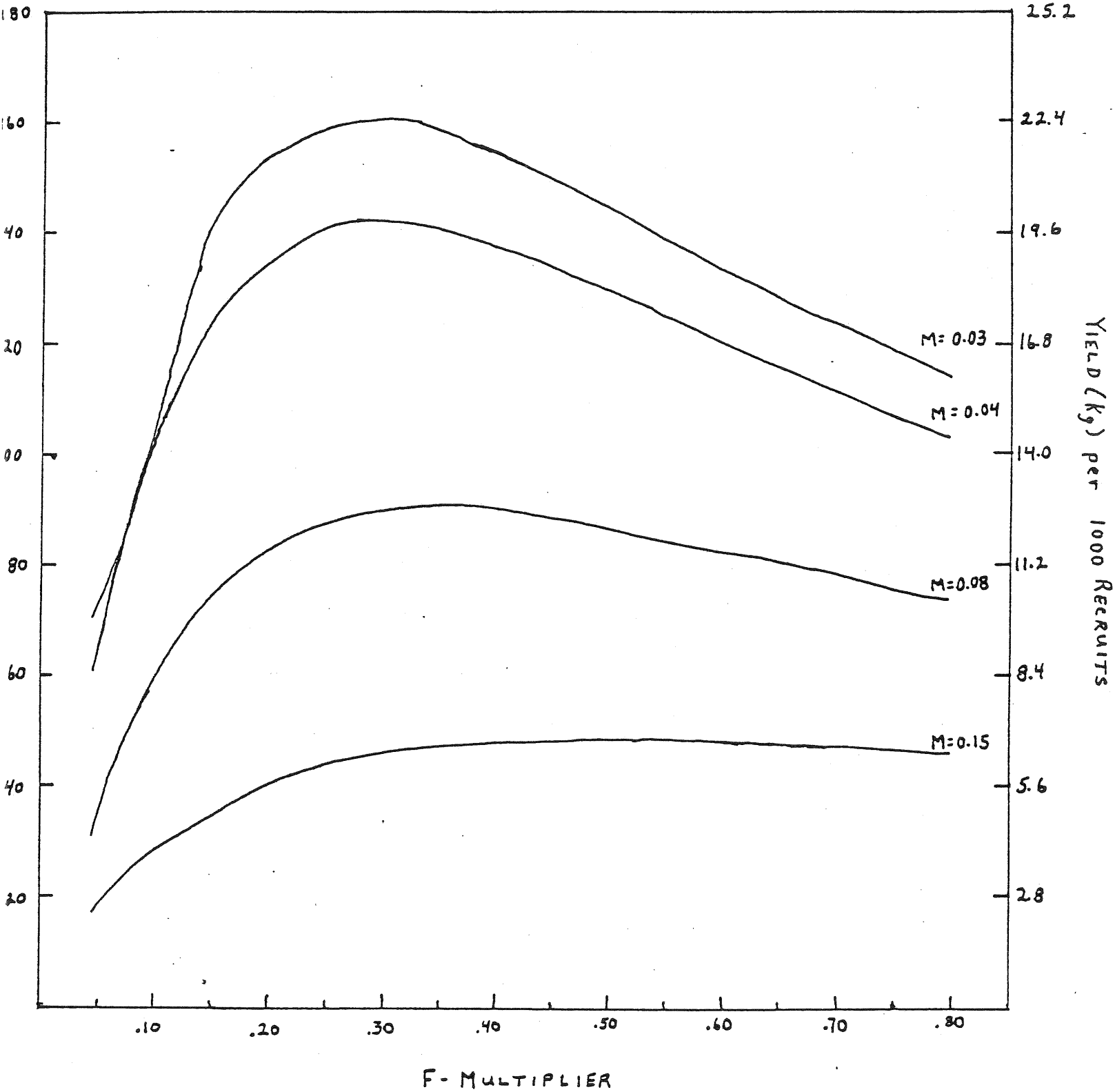

Figure 3. Estimated yield (kg) per 1000 I. illecebrosus recruits, assuming spawning distribution approximated from 1980 autumn survey, varying levels of monthly Natural (M) and Fishing (F) mortality.