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Assessment of Subarea 3+4 Northern Shortfin Squid (*Illex illecebrosus*) for 2000

by

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Abstract

Two general levels of productivity, since 1970, were previously identified for the Subareas 3+4 component of the northern shortfin squid (*Illex illecebrosus*) population based on trends in survey relative biomass indices and squid mean weight, as well as nominal catches (Rivard *et al*. 1998, Hendrickson 1999). A period of high productivity (1976-1981) occurred between two low productivity periods (1970-1975 and 1982-1999). During 2000, pre-fishery, July survey abundance and biomass indices for Subarea 4 were at the lowest level since 1970. Total catches in Subareas 3+4 remained low during 2000 (340 t) and were similar to those from 1999 (305 t). The mean weights of squid caught in the Division 4VWX July survey and the Subareas 5+6 autumn survey were the lowest in each time series. Based on these trends, the Subareas 3+4 stock component remained in a state of low productivity during 2000.

1.0 Introduction

Northern shortfin squid (*Illex illecebrosus*), a species with a lifespan about one year (Dawe and Beck 1997), is considered to constitute a unit stock throughout its distributional range in the Northwest Atlantic Ocean; from Newfoundland to Cape Hatteras, North Carolina (Dawe and Hendrickson 1998). The onset and duration of the fisheries in each Subarea generally reflect the timing of squid migrations through each area. Management of the stock component in Subarea 3 (Newfoundland) and Subarea 4 (Scotian Shelf and Gulf of St. Lawrence) is based on a Total Allowable Catch (TAC) established annually by the Northwest Atlantic Fisheries Organization (NAFO) and was set at 34,000 t in 2000. Since 1977, the United States has managed the *Illex illecebrosus* in its Exclusive Economic Zone (EEZ) (Subareas 5+6). The TAC for the Subareas 5+6 stock component was 24,000 t in 2000. This paper provides an evaluation of the status of the Subareas 3+4 component in 2000, based on trends in commercial fishery data, survey relative abundance and biomass indices, and fishing mortality indices, with an emphasis on the present low productivity period (1982-2000).

2.0 Materials and Methods

2.1 Commercial Fishery Data

Fishery data evaluated herein include nominal catches from Subarea 3 and Subarea 4, during 1953-2000, and from Subareas 5+6 during 1963-2000. The catch series for all Subareas was extended to 2000 and was updated for Subarea 4 (Dawe *et al*. 2000). Subarea 4 catches (Dawe *et al*. 2000) were compared to two other catch series for the period 1987-1999. One of the comparative catch series consisted of NAFO STATLANT 21B catches and the other series consisted of the sum of catches (kept fraction only) of northern shortfin squid in the Scotian Shelf silver hake fishery plus catches from the Canadian Zonal Interchange Format (ZIF) Database. The ZIF database contains catches by Canadian vessels and international vessels with Canadian allocations. Squid catches in the silver hake fishery were obtained from the Maritimes Observer Program Database. During 1987-1999, observer coverage in the Scotian Shelf silver hake fishery was 100 percent (Showell and Fanning 1999).

Length and sexual maturity data for squid sampled from the Subarea 3 jig fishery in 2000 are presented in Dawe *et al*. (2001). No biological samples of northern shortfin squid were collected from the Subarea 4 catches in 2000 (NAFO 2001).

2.2 Research Survey Data

Fishery-independent indices of relative abundance (stratified mean number per tow) and biomass (stratified mean kg per tow) were available from stratified, random, multispecies bottom trawl surveys conducted by Canada in Division 4T (southern Gulf of St. Lawrence) since September of 1971, Division 4VWX (Scotian Shelf) since July of 1970, and by the United States of America in Subareas 5+6 during September-October since 1967. All strata were included in computations of the 4T survey indices (Koeller 1980) and the 4VWX survey indices (Fanning 1985). There were no gear or vessel conversion coefficients applied to indices from either of these two time series. All offshore strata, between depths of 27-366 m (Grosslein 1969), were included in the computations of survey indices for Subareas 5+6 and gear and vessel standardization coefficients were applied to these indices (NEFSC 1999).

2.3 Fishing Mortality

Annual fishing mortality indices for Subareas 3+4, during 1970-2000, were computed by dividing annual catches in Subareas 3+4 by the annual biomass indices from the July Division 4VWX surveys.

3.0 Results

3.1 Update of Subarea 4 catches during 1987-1999

Subarea 4 catches provided in Dawe *et al*. (2000), for 1987-1999, differ slightly from catches in the STATLANT 21B and the ZIF/Observer Database time series (Table 1). However, in some years, notably 1989, 1991 and 1992, the catches tabulated in Dawe *et al*. (2000) are 25-50% higher than those in the ZIF/Observer Database. Since observer coverage in the SA 4 silver hake fishery has been 100% since 1987, and data are collected on a tow-by-tow basis, catches from this source are considered the most accurate. Therefore, the SA 4 catches during 1987-1999 have been updated with these values (Table 2).

3.2 Subarea 3+4 Fisheries

Catches from the Subarea 3A fishery for *Illex illecebrosus* have been recorded since 1911 (Dawe 1981) and for the Subarea 4 fishery since 1920 (ICNAF 1973). Catches from Subarea 3 are primarily from a small-boat jig fishery that occurs in shallow, nearshore waters of Newfoundland. Subarea 4 catches are primarily from an international bottom trawl fishery for silver hake, squid and argentine that occurs on the Scotian Shelf. Since 1987, a peak in catches has occurred during September, in Subarea 3, and during July in Subarea 4 (Figure 1). Since 1992, Subarea 4 catches have been predominantly from the Cuban fleet involved in the silver hake fishery. Effort (days fished) in the international

Scotian Shelf silver hake fishery has been declining since 1991 (Showell and Fanning 1999), and in 2000, consisted of one Russian vessel that fished during May-July (Rikhter and Sigaev 2001). The Cuban fleet did not fish in Subarea 4 during 2000 (Valdez and Ramos 2001).

Catches in Subareas 3+4 increased during the 1970s and reached a peak of 162,092 t in 1979 (Table 2, Figure 2). During 1976-1981, total catches (Subareas 3-6) were dominated by those from Subareas 3+4; averaging 80,645 t in Subareas 3+4 and 19,661 t in Subareas 5+6. Following a 1979 peak, Subarea 3+4 catches declined sharply, to less than 1,000 t during 1983-1988. During 1997, Subareas 3+4 catches (15,616 t) reached their highest level since 1981 and were primarily from the Subarea 3 jig fishery (12,750 t). Since 1997, catches have declined to less than 1,000 t. Catches in Subareas 3+4, during 1999 (305 t) and 2000 (340 t), were the lowest since 1986.

The mean dorsal mantle length (DML) of squid sampled from the Subarea 3 inshore jig fishery, in September of 2000, were among the smallest sampled in this fishery since 1975 (Dawe *et al*. 2001).

3.3 Subareas 5+6 Fishery

Catches from Subareas 5+6 have been recorded since 1963 (Lange and Sissenwine 1980). International fleets, composed of midwater and bottom trawlers, began fishing for northern shortfin squid in Subareas 5+6 in 1968 (Dawe and Hendrickson 1998). Catches in Subareas 5+6 reached a peak of 24,900 t in 1976 and have ranged between 2,000 t and 23,000 t since this time. Since 1987, the Subareas 5+6 fishery has consisted solely of domestic bottom trawlers and the in peak catches has occurred in July or August. During 1987-1997, catches have generally been in the range of 10,000-18,000 t. During 1998, catches reached their highest level since 1977 (23,597 t) and the fishery was closed in August because the TAC (19,000 t) was taken. Catches during 2000 were 9,008 t, 22% higher than in 1999 (7,388 t).

3.4 Catches from all Subareas

Combined catches from Subareas 3-6 decreased from about 25,500 t in 1998 to 7,700 t in 1999 and 9,300 t in 2000 (Table 2, Fig. 2). This decline was due to decreases in all fishery areas, but primarily from Subareas 5+6.

3.5 Relative Abundance and Biomass Indices

The Division 4VWX July survey generally occurs prior to the Subarea 3 fishery and during the early phase of the Subarea 4 fishery, so it can be considered a pre-fishery biomass index. The survey in Subareas 5+6 occurs during September-October and can be considered a post-fishery biomass index. The Division 4VWX survey indices are probably the most representative indicators of *Illex* squid abundance and biomass in Subarea 3+4 due to the fact that this survey encompasses the largest expanse of *Illex* habitat in the Subarea 3+4 region. The Division 4T survey appears to only capture *Illex* squid during periods of high abundance.

Indices of relative biomass from the Division 4VWX survey indicate a period of high productivity during 1976-1981, averaging 12.6 kg/tow, followed by a low productivity period during 1982-2000, averaging 2.6 kg/tow (Figure 3, Table 3). Similar trends are apparent in the biomass indices from Division 4T. Indices of relative abundance and biomass from the Division 4VWX survey were the lowest on record during 2000. Biomass indices from all surveys were low in 2000.

Mean weights of squid caught in the 4VWX survey indicate squid were larger during the high productivity period and smaller during the low productivity period (Figure 4). Mean weights of squid during 2000, in the Division 4VWX survey and the Subareas 5+6 survey, were the lowest in each time series.

3.6 Fishing Mortality Indices

Annual fishing mortality indices for Subareas 3+4 were high during 1977-1981, reaching a peak of 4.09 in 1978 (Table 4, Figure 5) and averaging 1.67 during the high productivity period (1976-1981). Since 1982, relative fishing mortality rates have been much lower and averaged 0.19 during 1982-2000.

4.0 Discussion

Relative abundance and biomass indices, as well as the mean weight of squid caught in the Division 4VWX July survey, were the lowest on record during 2000. These data suggest that the Subarea 3+4 stock component remained in a low productivity state during 2000.

Acknowledgements

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References

Dawe, E. G., P. C. Beck, and J. Drew. 2001. An update of the fishery for short-finned squid (*Illex illecebrosus*) in Newfoundland area during 2000 with descriptions of some biological characteristics. NAFO SCR Doc. 01/57, Ser. No. N4435, 8 p.

Dawe, E. G., L. C. Hendrickson, and M. A. Showell. 2000. An update to commercial catch and survey indices for short-finned squid (*Illex illecebrosus*) in the Northwest Atlantic for 1999. NAFO SCR Doc. 00/37, Ser. No. N4266, 7 p.

Dawe, E. G. and L. C. Hendrickson. 1998. A review of the biology, population dynamics, and exploitation of short-finned squid in the northwest Atlantic Ocean, in relation to assessment and management of the resource. NAFO SCR Doc. 98/59, Ser. No. N3051, 33 p.

Dawe, E. G. and P. C. Beck. 1997. Population structure, growth and sexual maturation of short-finned squid at Newfoundland, Canada, based on statolith analysis. Can. J. Fish. Aquat. Sci. 54: 137-146.

Dawe, E. G. 1981. Development of the Newfoundland squid (*Illex illecebrosus*) fishery and management of the resource. J. Shellfish Res. 1: 137-142.

Fanning, L. P. 1985. Intercalibration of research survey results obtained by different vessels. CAFSAC Res. Doc. 85-83. 43 p.

Grosslein, M.D. 1969. Groundfish survey program of BCF Woods Hole. Commer. Fish. Rev. 31(8-9): 22-35.

Hendrickson, L.C. 1999. Fishery effects on spawner escapement in the Northwest Atlantic *Illex illecebrosus* stock. NAFO SCR Doc. 99/66, Ser. No. N4125. 8 p.

ICNAF. 1973. Nominal catch of squid in Canadian Atlantic waters (Subareas 2-4), 1920-68. ICNAF Redbook 1973, Part III: 154-161.

Koeller, P. A. 1980. Distribution, biomass and length frequencies of squid (*Illex illecebrosus*) in Divisions 4TVWX from Canadian research vessel surveys: an update for 1979. NAFO SCR Doc. 80/II/17. Ser. No. N049.

Lange, A. M. T. and M. Sissenwine. 1980. Biological considerations relevant to the management of squid *Loligo pealeii* and *Illex illecebrosus* of the Northwest Atlantic. Mar. Fish. Rev. 42(7-8): 23-38.

Northwest Atlantic Fisheries Organization [NAFO]. 2001. List of biological sampling data for 2000. NAFO SCS Doc. 01/12. Ser. No. N4376. 15 p.

Northeast Fisheries Science Center [NEFSC]. 1999. Report of the 29th Northeast Regional Stock Assessment Workshop (29th SAW): Stock Assessment Review Committee SARC) Consensus Summary of Assessments. Northeast Fisheries Science Center Ref. Doc. 99-14 347 p.

Rikhter, V. A., and I. K. Sigaev. 2001. Russian Research Report for 2000. PART 1. Research carried out by AtlantNIRO in NAFO Subarea 4. NAFO SCS Doc. 01/11, Ser. No. N4372. 3 p.

Rivard, D., L. C. Hendrickson and F. M. Serchuk. 1998. Yield estimates for short-finned squid (*Illex illecebrosus*) in SA 3-4 from research vessel survey relative biomass indices. NAFO SCR Doc. 98/75, Ser. No. N3068. 4 p.

Showell, M. A. and L. P. Fanning. 1999. Assessment of the Scotian Shelf silver hake population in 1998. Canadian Stock Assessment Research Document 99/148. 41 p.

Valdez, E. and I Ramos. 2001. Cuban research report for 2000. NAFO SCS Doc. 01/17, Ser. No. N4400. 3 p.

Table 1. Nominal catches (t) of *Illex illecebrosus* in Subarea 4, during 1987-1999, from Dawe *et al.* (2000), STATLANT 21B, and the sum of catches from the Canadian Zonal Interchange Format (ZIF) Database plus catches from the Scotian Shelf silver hake fishery obtained from the Canadian Maritimes Observer Program.

Year	Dawe *et al.* Catches (t)	STATLANT 21B Catches (t)	ZIF plus Silver Hake Fishery Catches (t)	Percent Difference ZIF/Hake vs. Dawe *et al.*	Percent Difference 21B vs. Dawe *et al.*
1987	372	370	368	1	1
1988	528	575	539	-2	-9
1989	3,899	2,649	2,870	26	32
1990	6,560	6,169	6,535	0	6
1991	2,277	1,167	1,194	48	49
1992	1,076	739	654	39	31
1993	2,398	2,493	2,410	0	-4
1994	4,016	4,079	3,997	0	-2
1995	984	1,017	1,007	-2	-3
1996	445	512	457	-3	-15
1997	3,032	3,001	2,866	5	1
1998	1,119	1,118	1,087	3	0
1999	294	294	286	3	0

Table 2. Nominal catches (t) of *Illex illecebrosus* in NAFO Subareas 3 and 4, during 1953-2000, and Subareas 5+6 (U.S. EEZ), during 1963-2000, and TACs in Subareas 3+4 and Subareas 5+6.

			Total		Total		
	Subarea 3[2]	Subarea 4[3]	Subarea 3+4	Subareas 5+6[4,5]	Subareas (3-6)[6]	TAC (t)[1]	
Year	(t)	(t)	(t)	(t)	(t)	3+4	5+6
1953	4,460	51	4,511		4,511		
1954	6,700	115	6,815		6,815		
1955	7,019	269	7,288		7,288		
1956	7,779	450	8,229		8,229		
1957	2,634	335	2,969		2,969		
1958	718	84	802		802		
1959	2,853	258	3,111		3,111		
1960	5,067	24	5,091		5,091		
1961	8,971	50	9,021		9,021		
1962	482	587	1,069		1,069		
1963	2,119	103	2,222	810	3,032		
1964	10,408	369	10,777	360	11,137		
1965	7,831	433	8,264	522	8,786		
1966	5,017	201	5,218	570	5,788		
1967	6,907	126	7,033	995	8,028		
1968	9	47	56	3,271	3,327		
1969	21	65	86	1,537	1,623		
1970	111	1,274	1,385	2,826	4,211		
1971	1,607	7,299	8,906	6,614	15,520		
1972	26	1,842	1,868	17,641	19,509		
1973	622	9,255	9,877	19,155	29,032		
1974	48	389	437	20,628	21,065		71,000
1975	3,751	13,945	17,696	17,926	35,622	25,000	71,000
1976	11,257	30,510	41,767	24,936	66,703	25,000	30,000
1977	32,754	50,726	83,480	24,795	108,275	25,000	35,000
1978	41,376	52,688	94,064	17,592	111,656	100,000	30,000
1979	88,833	73,259	162,092	17,241	179,333	120,000	30,000
1980	34,780	34,826	69,606	17,828	87,434	150,000	30,000
1981	18,061	14,801	32,862	15,571	48,433	150,000	30,000
1982	11,164	1,744	12,908	18,633	31,541	150,000	30,000
1983	5	421	426	11,584	12,010	150,000	30,000
1984	397	318	715	9,919	10,634	150,000	30,000
1985	404	269	673	6,115	6,788	150,000	30,000
1986	1	110	111	7,470	7,581	150,000	30,000
1987	194	368	562	10,102	10,664	150,000	30,000
1988	272	539	811	1,958	2,769	150,000	30,000
1989	3,101	2,870	5,971	6,801	12,772	150,000	30,000
1990	4,440	6,535	10,975	11,670	22,645	150,000	30,000
1991	1,719	1,194	2,913	11,908	14,821	150,000	30,000
1992	924	654	1,578	17,827	19,405	150,000	30,000

Table 2. (continued)

1993	276	2,410	2,686	18,012	20,698	150,000	30,000
1994	1,954	3,997	5,951	18,350	24,301	150,000	30,000
1995	48	1,007	1,055	14,058	15,113	150,000	30,000
1996	8,285	457	8,742	16,969	25,711	150,000	21,000
1997	12,748	2,866	15,614	13,629	29,243	150,000	19,000
1998	815	1,087	1,902	23,597	25,499	150,000	19,000
1999	19	286	305	7,388	7,693	75,000	19,000
2000	310	30	340	9,008	9,348	34,000	24,000
AVERAGES							
1976-1981	37,844	42,802	80,645	19,661	100,306		
1982-1986	2,028	538	2,566	10,637	13,203		
1987-1991	1,945	2,301	4,246	8,488	12,734		
1992-1996	2,297	1,705	4,002	17,043	21,046		
1997-2000	3,473	1,067	4,540	13,406	17,946		

[1] TACs during 1974 and 1975 for Subareas 5+6 include *Loligo pealeii* and, during 1975-1977, countries without allocations were permitted to land 3,000 t in Subsareas 3+4

[2] SA 3 catches include a small amount from Subarea 2

[3] SA 4 catches during 1987-2000 were updated based on catches in the Canadian Observer and ZIF Databases

[4] Subareas 5+6 catches during 1963-1978 were not reported by species, but are proration-based estimates by Lange and Sissenwine (1980)

[5] Subareas 5+6 catches during 1994-2000 are provisional

[6] Catches during 2000 are provisional for all Subareas

Table 3. Indices of relative abundance (stratified mean number/tow) and biomass (stratified mean kg/tow) from bottom trawl surveys conducted in Subareas 5+6 (Sept/Oct, 1967-2000), Division 4VWX (July, 1970-2000), and Division 4T (Sept, 1971-2000).

	Subareas 5+6 Survey		Division 4VWX Survey		Division 4T Survey	
Year	(number/tow)	(kg/tow)	(number/tow)	(kg/tow)	(number/tow)	(kg/tow)
1967	1.6	0.2				
1968	1.6	0.3				
1969	0.6	0.1				
1970	2.3	0.3	5.6	0.4		
1971	1.7	0.3	28.5	2.8	0.72	0.16
1972	2.2	0.3	6.6	0.7	0.05	0.01
1973	1.5	0.4	10.9	1.5	0.08	0.02
1974	2.8	0.4	13.4	1.8	0.06	0.00
1975	8.7	1.4	44.8	5.0	2.47	0.51
1976	20.6	7.0	231.2	42.7	30.76	8.04
1977	12.6	3.7	50.9	9.5	25.73	7.61
1978	19.3	4.5	16.4	2.3	55.95	15.87
1979	19.4	6.1	91.4	14.2	28.47	8.14
1980	13.8	3.3	23.3	2.2	18.04	4.58
1981	27.1	9.3	35.5	4.9	5.76	1.67
1982	3.9	0.6	26.0	2.1	0.38	0.08
1983	1.7	0.2	76.9	2.1	0.09	0.00
1984	4.5	0.5	14.1	1.5	0.03	0.00
1985	2.4	0.4	80.2	2.7	0.48	0.11
1986	2.1	0.3	7.7	0.4	0.08	0.01
1987	15.8	1.5	4.9	0.4	0.16	0.02
1988	23.2	3.0	47.3	2.7	1.33	0.40
1989	22.4	3.3	26.3	2.7	0.30	0.04
1990	16.6	2.4	40.6	4.8	0.88	0.14
1991	5.2	0.7	27.1	1.8	0.12	0.03
1992	8.2	0.8	121.7	7.3	0.28	0.05
1993	10.4	1.6	79.0	5.4	0.58	0.10
1994	6.8	0.9	45.3	4.2	0.26	0.10
1995	8.0	0.7	33.9	2.4	0.16	0.02
1996	10.8	0.9	11.9	0.9	0.70	0.11
1997	5.8	0.5	52.0	4.8	0.96	0.17
1998	14.6	1.4	10.0	0.9	0.96	0.21
1999	1.4	0.2	16.7	2.0	0.23	0.05
2000	7.4	0.7	4.0	0.1	0.19	0.02

Table 4. Fishing mortality indices (SA 3+4 nominal catch/Div. 4VWX July survey biomass index) of northern shortfin squid (*Illex illecebrosus*) in Subareas 3+4 during 1970-2000. Fishing mortality indices were divided by 10,000 to scale the values.

Year	SA 3+4 Nominal Catch (t)	Divison 4VWX July Survey Biomass Index (kg/tow)	Fishing Mortality Indices	
1970	1,385	0.4	0.35	
1971	8,906	2.8	0.32	
1972	1,868	0.7	0.27	
1973	9,877	1.5	0.66	
1974	437	1.8	0.02	
1975	17,696	5.0	0.35	
1976	41,767	42.7	0.10	
1977	83,480	9.5	0.88	
1978	94,064	2.3	4.09	
1979	162,092	14.2	1.14	
1980	69,606	2.2	3.16	
1981	32,862	4.9	0.67	
1982	12,908	2.1	0.61	
1983	426	2.1	0.02	
1984	715	1.5	0.05	
1985	673	2.7	0.02	
1986	111	0.4	0.03	
1987	562	0.4	0.14	
1988	811	2.7	0.03	
1989	5,971	2.7	0.22	
1990	10,975	4.8	0.23	
1991	2,913	1.8	0.16	
1992	1,578	7.3	0.02	
1993	2,686	5.4	0.05	
1994	5,951	4.2	0.14	
1995	1,055	2.4	0.04	
1996	8,742	0.9	0.97	
1997	15,614	4.8	0.33	
1998	1,902	0.9	0.20	
1999	305	2.0	0.02	
2000	340	0.1	0.34	
Average				
1976-1981	80,645	12.6	1.67	
1982-2000	3,907	2.6	0.19	

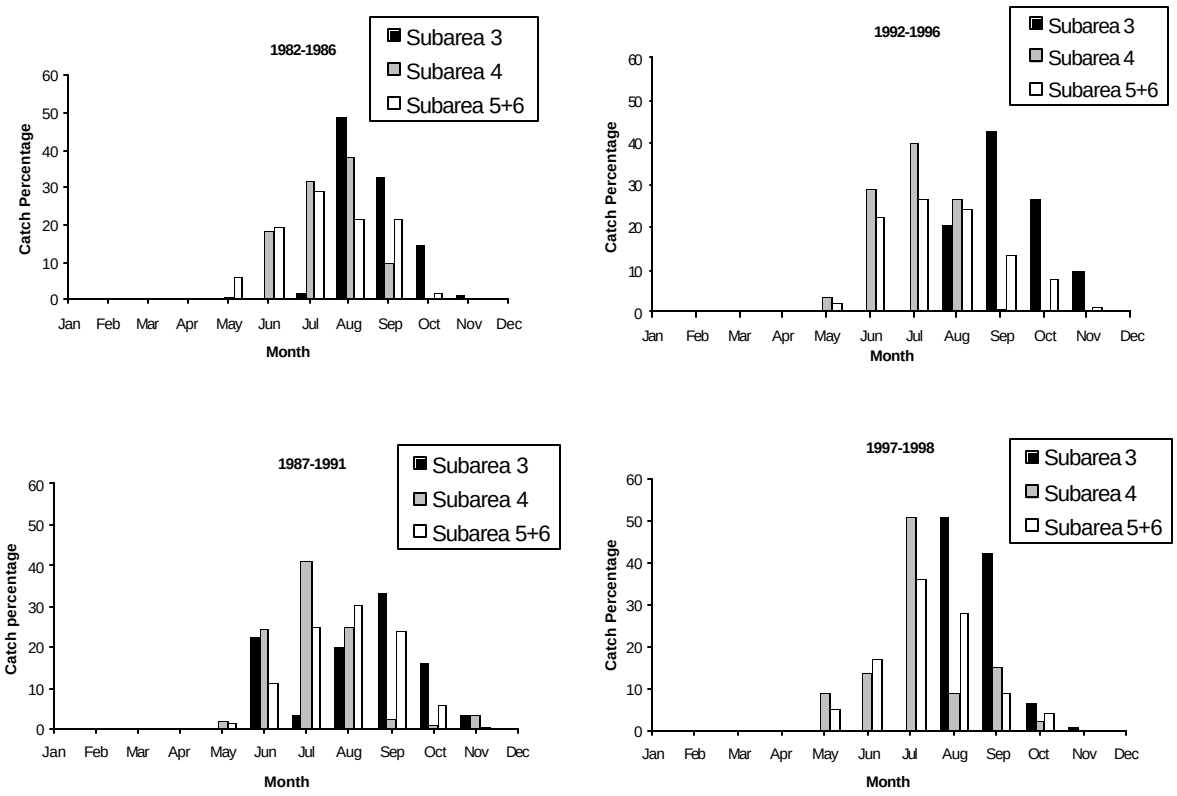

Figure 1. Average percentage of nominal catches of *Illex illecebrosus*, by month and Subarea, during 1982-1986, 1987-1991, 1992-1996 and 1997-1998

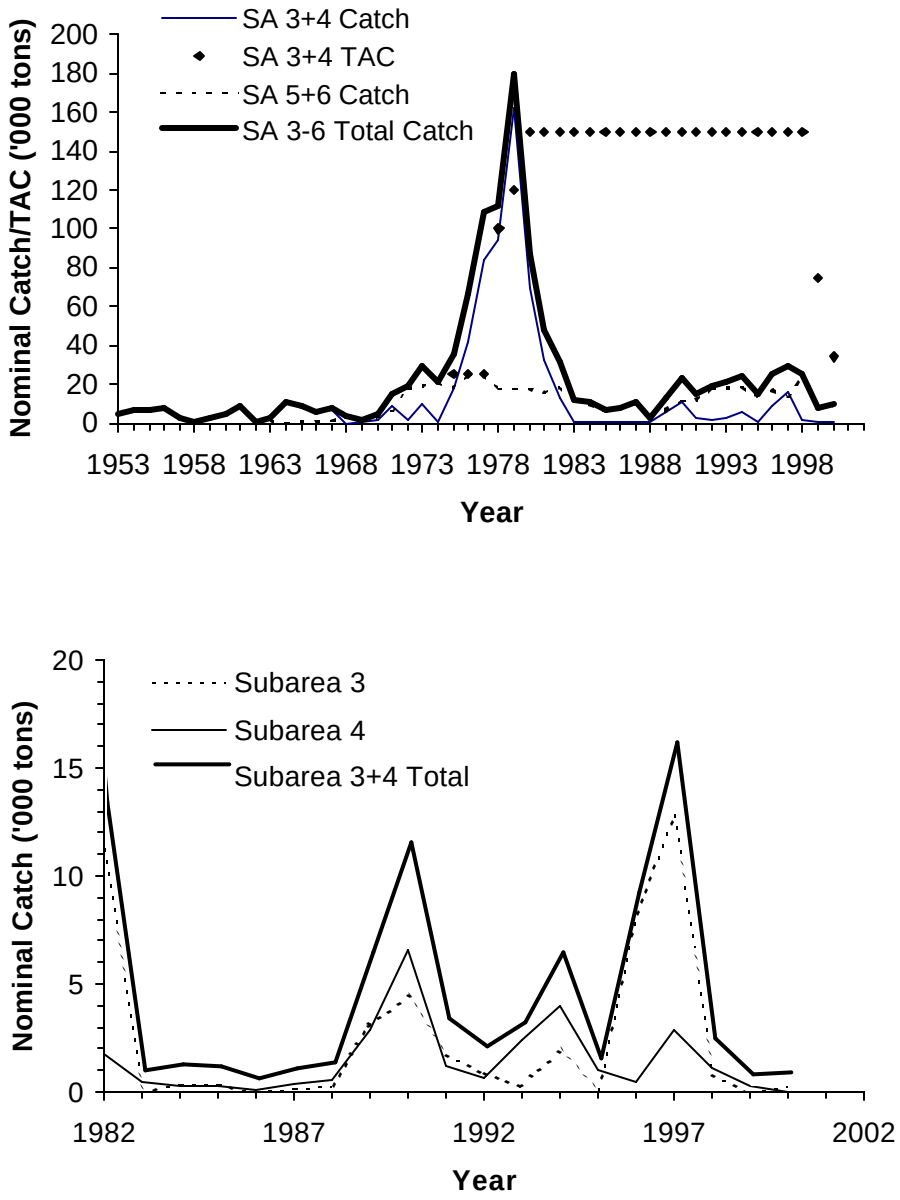

Figure 2. Nominal catches ('000 tons) of *Illex illecebrosus* and TACs in Subareas 3 and 4, during 1953-2000, and Subareas 5+6 during 1963-2000 (top) and nominal catches in Subarea 3 and Subarea 4 during 1982-2000 (bottom).

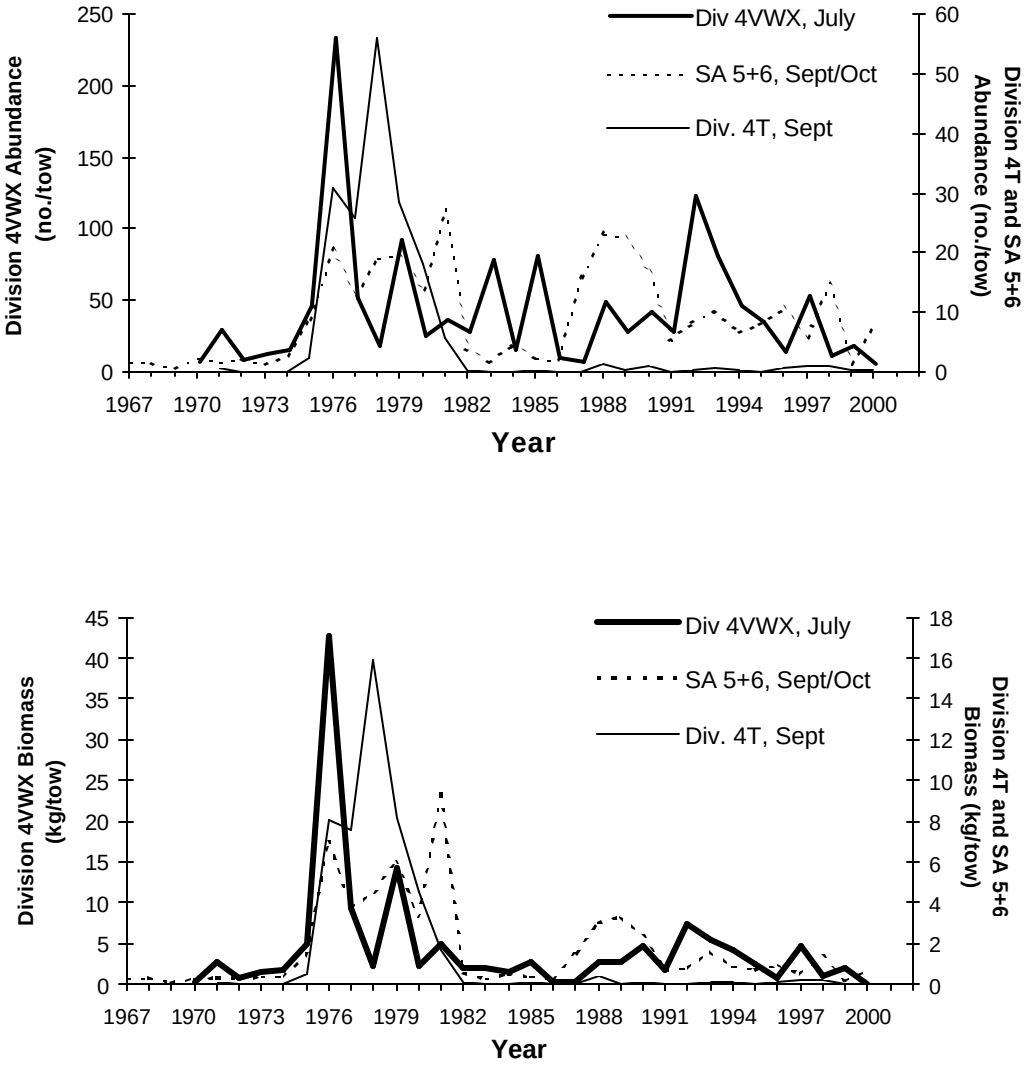

Figure 3. *Illex illecebrosus* relative abundance (stratified mean number/tow) (top) and biomass indices (stratified mean kg/tow) (bottom) from the Division 4VWX survey (July, 1970-2000), Division 4T survey (September, 1971-2000), and Subareas 5+6 survey (September/October, 1967-2000).

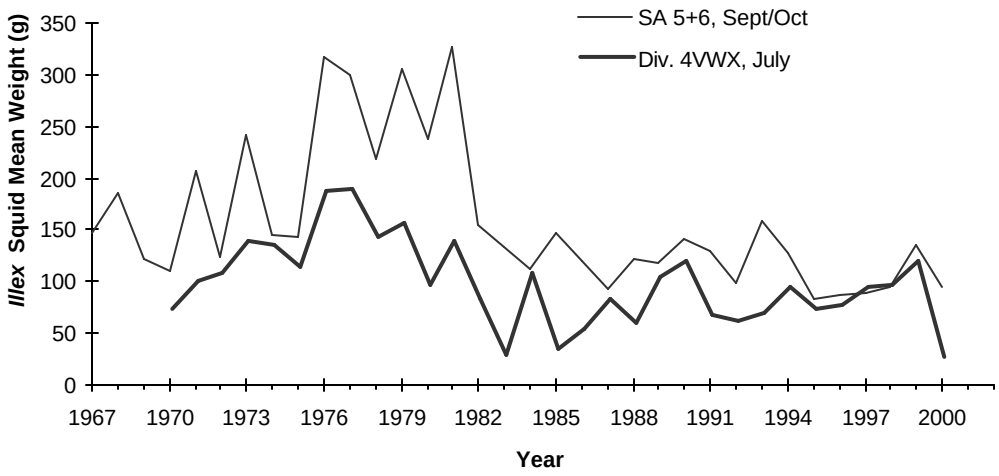

Figure 4. Mean weight (g) of *Illex illecebrosus* caught in the Subareas 5+6 bottom trawl survey, during September/October of 1967-2000, and in the Canadian Division 4VWX bottom trawl survey during July of 1970-2000.

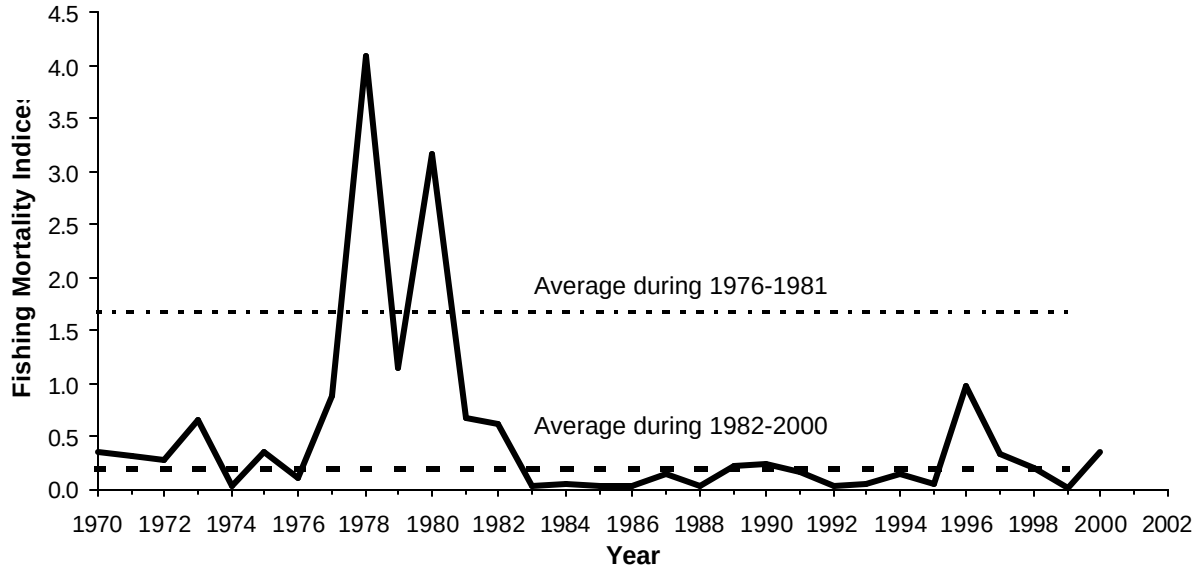

Figure 5. Fishing mortality indices (SA 3+4 nominal catch/Division 4VWX July survey biomass index) in Subareas 3+4, during 1970-2000, and averages during the high (1976-1981) and low (1982-2000) productivity periods. Fishing mortality indices were divided by 10,000 to scale the values.