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Assessment of Northern Shortfin Squid (*Illex illecebrosus*) in Subareas 3+4 for 2009

by

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Abstract

Two general levels of productivity have been identified for the Subareas 3+4 component of the Northern shortfin squid (*Illex illecebrosus*) stock based on trends in relative fishing mortality indices and relative biomass indices and squid mean body weights derived from the Canadian Division 4VWX July bottom trawl surveys (Rivard *et al*., 1998; Hendrickson, 1999). A period of high productivity (1976-1981) occurred between two low productivity periods (1970-1975 and 1982-2008). The relative biomass index from the Division 4VWX survey increased from a very low level in 2007 (1.5 kg per tow) to 6.0 kg per tow in 2009, which is close to the 1982-2008 average (3.0 kg per tow). The mean body weight of squid caught during the 2009 survey (86 g) was also near the 1982-2008 average (80 g). The 2009 relative fishing mortality index in Subareas 3+4 (0.01) reached the lowest level on record for the region. Based on these trends, the Subareas 3+4 stock component remained in a state of low productivity in 2009.

1.0 Introduction

Northern shortfin squid (*Illex illecebrosus*), a species with a lifespan of less than one year (Dawe and Beck, 1997; Hendrickson, 2004), is considered to constitute a unit stock throughout its range of exploitation 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 fishing area. Subarea 3 catches are primarily from a small-boat jig fishery that occurs in shallow, nearshore waters of Newfoundland. During 1987-2001, squid were harvested from Subarea 4 by an international bottom trawl fishery for silver hake (*Merluccius bilinearis*), *I. illecebrosus* and argentine (*Argentina* sp.) that occurred on the Scotian Shelf (Hendrickson *et al*., 2002). International fleets, comprising midwater and bottom trawlers, began fishing for Northern shortfin squid in Subareas 5+6 in 1968 (Dawe and Hendrickson, 1998). Since 1987, landings from Subareas 5+6 have been solely from a US bottom trawl fishery that occurs primarily in the Mid-Atlantic Bight (NEFSC, 1999).

Although the resource is continuously distributed between Cape Hatteras and inshore Newfoundland during summer through autumn, it is considered, for management purposes, to be composed of two components. Management of the northern component, in Subarea 3 (Newfoundland) and Subarea 4 (Scotian Shelf and Gulf of St. Lawrence), is based on an annual Total Allowable Catch (TAC) established by the Northwest Atlantic Fisheries Organization (NAFO). The TAC was 34,000 t during 2000-2009. The southern component (Subareas 5+6) is located within the

Exclusive Economic Zone (EEZ) of the United States and has been managed by the Mid-Atlantic Fishery Management Council since 1977. The annual TAC for the Subareas 5+6 stock component was 24,000 t during 2000-2009. The most recent assessment of the Subareas 3+4 stock component was conducted in 2006 (Hendrickson and Showell 2006). There was no Designated Expert available to conduct the Subareas 3+4 *Illex* assessments during 2007-2009. Therefore, the Scientific Council used trends in the annual catch data from Subareas 3+4 and relative biomass indices from the July Div. 4VWX surveys to assess stock status during 2006-2008. The subject assessment provides an evaluation of the status of the Subareas 3+4 stock component in 2009 based on trends in commercial fishery data, research survey biomass indices and squid mean body weights, and relative fishing mortality indices.

2.0 Materials and Methods

2.1 Commercial Fishery Data

Nominal catches have been recorded from the Subarea 3 fishery since 1911 (Dawe, 1981) and from the Subarea 4 fishery since 1920 (ICNAF, 1973). Landings from Subareas 5+6 have been recorded since 1963 (Lange and Sissenwine, 1980). Nominal catches from Subarea 3 and Subarea 4 are presented for 1953-2009 and for 1963-2009 for Subareas 5+6.

Subarea 4 catches after 1987 represent the sum of catches (kept fraction only) of Northern shortfin squid in the Scotian Shelf international fishery (for silver hake, *I. illecebrosus* and argentine) plus reported landings from the Canadian MARFIS Database, formerly known as the Zonal Interchange Format (ZIF) Database. The MARFIS database contains catches by Canadian vessels and international vessels with Canadian allocations. *Illex* catches in the international fishery were obtained from the Canada Divison of Fisheries and Oceans (DFO) Maritimes Observer Program Database. Catch data from the DFO Maritimes Observer Program Database are considered the most accurate because observer coverage of the Subarea 4 international fishery was 100% during 1987 to 1998 and the data were collected on a tow-by-tow basis (Showell and Fanning, 1999). Foreign flagged vessels were no longer licensed to fish on the Scotian Shelf from 1999 onwards. Catches from Subarea 3 were updated for 2003-2008 based on a combination of Canadian catches from the Fishery Statistics Division of the CA DFO Newfoundland Region (Earl Dawe, CA DFO, pers. comm.) and catches by international fleets that were reported to NAFO in the 21A database.

2.2 Research Survey Data

Fishery-independent indices of relative abundance (stratified mean number per tow) and biomass (stratified mean kg per tow) were derived for Subarea 4 and Subareas 5+6 from stratified random bottom trawl surveys conducted by the Canada DFO in Div. 4T (southern Gulf of St. Lawrence) during September (1971-2009), in Div. 4VWX (Scotian Shelf) during July (1970-2009), and by the Northeast Fisherie Science Center (NEFSC) of the U.S. National Marine Fisheries Service (NMFS) in Subareas 5+6 during September-October (1967-2009). Sampling in all surveys was conducted around the clock with the exception of 1971-1984, when the Div. 4T survey occurred during daylight only.

All survey strata were used to compute relative abundance and biomass indices for Div. 4T and Div. 4VWX. The sampling design and protocols used in these surveys are provided in Halliday and Koeller (1981) and Koeller (1980). Different vessels were used to conduct the Div. 4VWX surveys during 1970-1981 (RV A. T. Cameron), 1982 (RV Lady Hammond), 1983-2003 and in 2005 (CCGS Alfred Needler, Fanning 1985), and in 2004 as well as from 2006-2009 (CCGS Teleost). There are no gear or vessel conversion coefficients available with which to standardize the Div. 4VWX survey indices prior to 2004. However, a paired-tow vessel comparison study was conducted with the CCGS Alfred Needler and the CCGS Teleost during the summer of 2005 to determine vessel standardization coefficients. Previous assessments of the Subareas 3+4 *Illex* component contained 2004 indices which were adjusted to account for a significant vessel catchability effect based on preliminary results of the 2005 paired-tow study. However, the final study results (Fowler and Showell 2009) suggested that the catchabilities of the two vessels were not significantly different at an α level of 0.05 ($p = 0.095$), and therefore, the 2004 indices included herein have been revised accordingly. Vessel changes during the Div. 4T survey included use of the CCGS Wilfred Templeman during 2003 and the CCGS Needler and CCGS Teleost during 2004 and 2005 (Hugues Benoit, CA DFO, pers. comm.). The CCGS Teleost has been used in Div. 4T surveys since 2006. During 2003, there was

also a reduction in the number of strata sampled in Div. 4T. The Div. 4T survey indices have been adjusted for diel and vessel catchability differences during 1985-2002 (Benoit and Swain 2003) and during 2004-2005 (Benoit 2006). There are no data available to adjust the 2003 indices for vessel catchability differences and not enough data available to determine whether there is a significant diel effect between the CCGS Teleost and the CCGS Needler (Hugues Benoit, CA DFO, pers. comm.).

Survey indices computed for the Subareas 5+6 surveys include all offshore strata between depths of 27 and 366 m (Grosslein 1969) and were adjusted for gear and vessel catchability differences that occurred during 1967-2008 (NEFSC, 1999). The 2009 indices were adjusted for vessel catchability differences between the RV *Albatross IV* and the new survey vessel, the FSV *Henry B. Bigelow*. The applied vessel calibration factors are 1.38 and 1.41 for number per tow and weight per tow indices, respectively (Miller *et al*. 2010).

Research survey indices of abundance and biomass were only available for a small portion of *I. illecebrosus* habitat in Subarea 3; the July EU bottom trawl surveys of the Flemish Cap in Div. 3M (Saborido-Rey and Vazquez, 2001). Swept area estimates of minimum abundance and biomass were computed for 1988-2009 and were derived using all of the 3M survey strata. Due to a change in vessels, from the R/V Cornide de Saavedra to the R/V Vizconde de Eza, indices from 2003 onward were adjusted for differences in vessel catchability by dividing the R/V Cornide de Saavedra indices by 0.81 (the ratio of R/V Cornide de Saavedra catches to R/V Vizconde de Eza catches) (Antonio Vázquez, Instituto de Investigaciones Marinas, Spain, pers. comm.).

2.3 Fishing Mortality

Relative fishing mortality indices for Subareas 3+4, during 1970-2009, were computed by dividing the annual catches from Subareas 3+4 by the annual biomass indices from the July Div. 4VWX surveys.

3.0 Results and Discussion

3.1 Subareas 3+4 Fisheries

There has been no directed fishery for *Illex* in SA 4 since 1999 (NAFO 2003) and catches since then have been primarily from bycatch in Canadian bottom trawl fisheries and have totaled less than 50 t (Table 1). Since 2000, small amounts of bycatch by international vessels have also occurred; 12 t in 2000 and 4 t in 2003 by Russia (NAFO 2003) and 13 t in 2005 by Korea (T.-Y. Oh, National Fisheries Research and Development Institute, Korea, pers. comm.). The total catch in Subarea 4 during 2009 was 48 t.

It should be noted that there are several catch discrepancies between the data reported to NAFO by CA (Maritimes Region) and the official landings database for the CA DFO Maritimes Region (MARFIS). Large amounts of unspecified squid catches (NAFO species code 509) that were reported to NAFO in 4W and 4X during 2008 (2,154 t) and in 4W during 2009 (1,821 t) are not included in the subject assessment because the same catch data were not present in the MARFIS database (Mark Showell, CA DFO, pers. comm.) and the catches could not be confirmed by DFO staff that report the data to NAFO. In the future, removal of the "unspecified squid species" code (509) from the list of NAFO species codes should be considered in order to avoid similar reporting incidents that may result in the under-estimation of *I. illecebrosus* catches. A second potential source of underestimating *Illex illecebrosus* catches may be misreporting of squid species (i.e., *I. illecebrosus* catches reported as *Loligo pealeii*). Large amounts of *Loligo pealeii* catches in Div. 3N and Div. 4Vs (i.e., 2,373 t in 2004 and 2,311 t in 2005) were also reported to NAFO by CA (Maritimes Region). Large catches of *Loligo pealeii* are rare this far north (Dawe *et al*., 2007). However, the catches were not included in the subject assessment because, again, the catches could not be confirmed by DFO staff that report the data to NAFO.

During 1992-1999, annual catches in Subarea 3 from the Canadian inshore jig fishery were highly variable and ranged between 48 t in 1995 and 12,748 t in 1997 (Table 1). During 2000-2008, Subarea 3 catches were also predominantly from the Canadian jig fishery and ranged between 23 t in 2001 and 6,957 t in 2006. Small amounts of catch were also taken in Subarea 3 by international vessels during 2004 (16 t) and 2006-2008 (2-79 t). The total catch in Subarea 3 during 2009 was 642 t.

Catches in Subareas 3+4 increased during the 1970s and reached a peak of 162,092 t in 1979 (Table 1, Fig. 1). 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, Subareas 3+4 catches declined sharply, to less than 1,000 t during 1983-1988. During 1997, Subareas 3+4 catches (15,614 t) reached their highest level since 1981 and were primarily from the Subarea 3 inshore jig fishery (12,748 t). During 1999-2006, total catches from Subareas 3+4 have been highly variable, ranging between 57 t in 2001 and 6,981 t in 2006. Catches in Subareas 3+4 have been low since 2007 (246 t) and totaled 690 t in 2009; well below the 1982-2008 average of 3,208 t.

3.2 Subareas 5+6 Fishery

Catches from Subareas 5+6 reached a peak of 24,936 t in 1976 when an international fishery existed on the eastern USA shelf (Table 1, Fig. 1). Since 1987, the Subareas 5+6 fishery has consisted solely of domestic bottom trawlers. During 1987-1997, catches were generally in the range of 10,000-18,000 t. USA catches peaked in 1998 (23,597 t), but the fishery was closed beginning in August because the TAC (19,000 t) was exceeded. During 1999-2003, catches from Subareas 5+6 ranged between 2,750 t (in 2002) and 9,011 t (in 2000). The fishery was closed again in September of 2004, when the highest catch on record (26,097 t) was landed and the quota of 24,000 t was exceeded. Landings declined to 9,022 in 2007, but then increased to 18,418 t in 2009.

3.3 Catches from Subareas 3-6

The timing and duration of the Northern shortfin squid fisheries vary by Subarea. Since 1992, the Subarea 4 and 5+6 fisheries have occurred during June-October, with peak catches in July. The Subarea 3 fishery has occurred during July-November with peak catches in September (Hendrickson *et al*. 2002).

Total catches from Subareas 3-6 increased rapidly from 4,211 t in 1970 to a time series peak of 179,333 t in 1979, but then declined rapidly to 6,788 t in 1985 (Table 1, Fig. 1). Total catches declined further to 2,769 t in 1988, but then increased to 28,970 t in 1997. Thereafter, catches in Subareas 3-6 have been predominately from the Subareas 5+6 fishery. In 2004, catches for Subareas 3-6 reached 28,671 t, the second highest level since 1982. Total catches increased from 9,268 t in 2007 to 19,108 t in 2009.

3.4 Survey Abundance and Biomass Indices

Annual trends in relative abundance (stratified mean number per tow) and biomass (stratified mean kg per tow) are shown in Fig. 2 and presented in Table 2 for the three surveys with the longest time series. The Div. 4VWX survey generally occurs prior to the fishery in Subarea 3 and during the early phase of the former Subarea 4 fishery. Therefore, the Div. 4VWX survey is considered as a survey of pre-fishery biomass. Relative biomass indices from the Div. 4VWX survey indicate a period of high productivity during 1976-1981, averaging 12.6 kg/tow, followed by a low productivity period during 1982-2008, averaging 3.0 kg/tow (Fig. 2, Table 2). Large increases in the biomass index during 2004 (12.9 kg/tow) and 2006 (10.2 kg/tow) were followed by a very low indices in the subsequent years (i.e., 0.7 kg/tow in 2005 and 1.5 kg/tow in 2007). The biomass index increased gradually thereafter, and in 2009 reached 6.0 kg/tow, a level near the 1982-2008 average (3.0 kg/tow).

The Subarea 3 EU bottom trawl survey on the Flemish Cap (Div. 3M) is also conducted in July, but the biomass indices derived from the survey do not appear to track the same trends as those derived from the Div. 4VWX survey, probably because the Flemish Cap represents marginal *Illex* habitat during most years (Table 3, Fig. 3). During most years, indices from the Div. 3M survey have been very low. However, after 2005, biomass indices increased to much higher levels, reaching a peak of 4,161 t in 2008 but then declining to 1,363 t in 2009.

The autumn bottom trawl survey in Subareas 5+6 occurs late in the U.S. fishing season and reflects post-fishery biomass. The Canadian survey in Div. 4T also occurs during autumn, but the indices are of much lower magnitude than the Subareas 5+6 indices (Table 2). With the exception of the high productivity period (1976-1981), indices from the Div. 4T survey and the Subareas 5+6 survey do not exhibit similar trends (Fig. 2), suggesting that Div. 4T represents marginal *Illex* habitat during most years. Relative abundance indices from the Subareas 5+6 surveys were consistently high during 1976-1981, but have since been highly variable and generally of smaller magnitude than the Div. 4VWX indices (Fig. 2). The 2006 time series peak in relative abundance in Subareas 5+6 (29.5 squid per

tow), and the secondary peak in 2003 (28.5 squid per tow), were due to large catches at one or two stations and represent squid of a much smaller mean body size than during 1976-1981. In contrast, during 1981, when relative abundance (27.1 squid per tow) was similar to that of 2003 and 2006, catch rates were high at multiple stations. After 2006, relative abundance indices declined rapidly and reached 8.5 squid per tow in 2009.

3.5 Body Size

Mean body weights of squid were largest during the high productivity period (1976-1981) and lower during the low productivity periods in both the Div. 4VWX July survey and the Subareas 5+6 autumn survey (Fig. 4). Mean weights were much larger in the Subareas 5+6 surveys than in the Div. 4VWX surveys during the high productivity period. However, this size disparity subsequently decreased due to a gradual decline in the mean size of squid caught in the Subareas 5+6 surveys, such that squid from both surveys were of similar size (about 70-85g) during 2001-2003. During 2004-2008, the average body weight of squid caught in the Div. 4VWX survey was slightly greater than or equal to the mean weight of squid caught in the SA 5+6 surveys. During 2005, the mean weight of squid caught in the Subareas 5+6 survey reached the lowest level on record (67 g) for the region, but then increased to 104 g in 2009. During 2006-2009, the mean body weights of squid caught in the Div. 4VWX surveys declined, but remained greater than those in Subareas 5+6 until 2009, when the mean weight reached 86 g.

3.6 Relative Fishing Mortality Indices

Relative fishing mortality indices for Subareas 3+4 were highest during 1977-1981, reaching a peak of 4.09 in 1978 (Table 4, Fig. 5) and averaging 1.67. During 1982-2008, relative fishing mortality indices were much lower, averaging 0.15 with a peak of 0.97 in 1996. The relative fishing mortality index reached the lowest level on record in 2009 (0.01).

3.7 Limit Reference Points

For data-poor stocks, such as the Subareas 3+4 *Illex* stock component, the NAFO Study Group on Limit Reference Points recommended that 85% of the maximum observed biomass index be used as a proxy for B_{lim}, assuming that the highest index is equal to B_{MSY} (SCS Doc. 04/12). For all NAFO stocks, F_{lim} is considered as F_{MSY} or a proxy thereof. However, *Illex* is an annual, semelparous species. Recruitment is strongly influenced by environmental conditions (Dawe and Warren, 1993), and as a result, the Subareas 3+4 stock component has experienced low and high productivity states. During the low productivity state, since 1982, the response of the Div. 4VWX relative biomass indices to fishery removals has been inconsistent (a high annual biomass index has not consistently been associated with a high nominal catch during the same year). For example, the Div. 4VWX biomass indices were at a similar, medium level during 1993 and 1997 yet the Subareas 3+4 catches were more than five-fold greater in 1997 than in 1993 (Table 4). During 2004, the biomass index was the third highest on record, yet the catches were only 2,574 t and below the 1982-2003 average (3,441 t) and similar to the catch in 1993. Given this inconsistency and the lack of a stock-recruitment relationship, limit reference points or proxies thereof are not currently estimable for the Subareas 3+4 stock component.

4.0 Summary

In 2009, the relative biomass index from the Div. 4VWX July survey (6.0 kg/tow) was near the 1982-2008 average of 3.0 kg/tow for the low productivity period. The mean body weight of squid caught in the same survey during 2009 86 g) was also near than the 1982-2008 average of 80 g. The 2009 relative fishing mortality index was the lowest on record. Based on these trends, the Subareas 3+4 stock component remained in a state of low productivity during 2009.

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Table 1. Nominal catches (t) of *Illex illecebrosus* in NAFO Subareas 3 and 4 during 1953-2009 and Subareas 5+6 (U.S. EEZ) during 1963-2009, 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
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

Year	Subarea 3[2] (t)	Subarea 4[3] (t)	Total Subarea 3+4 (t)	Subareas 5+6[4,5] (t)	Total Subareas (3-6)[6] (t)	TAC (t)[1] 3+4	TAC (t)[1] 5+6
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	328	38	366	9,011	9,377	34,000	24,000
2001	23	34	57	4,009	4,066	34,000	24,000
2002	228	30	258	2,750	3,008	34,000	24,000
2003	1,087	45	1,132	6,391	7,523	34,000	24,000
2004	2,540	34	2,574	26,097	28,671	34,000	24,000
2005	548	30	578	12,013	12,591	34,000	24,000
2006	6,957	24	6,981	13,943	20,924	34,000	24,000
2007	230	16	246	9,022	9,268	34,000	24,000
2008	523	12	535	15,900	16,435	34,000	24,000
2009	642	48	690	18,418	19,108	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		
1997-2001	2,787	862	3,649	11,527	15,176		
2002-2008	1,730	27	1,758	12,302	14,060		
1982-2008	2,194	1,015	3,208	12,042	15,236		

[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 Subareas 3+4

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

[3] SA 4 catches from 1987 onward 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 and are proration-based estimates by Lange and Sissenwine (1980)

[5] Subareas 5+6 catches during 1994-2009 are provisional

[6] Catches from all Subareas during 2007-2009 are provisional

Table 2. Indices of relative abundance (stratified mean number/tow) and biomass (stratified mean kg/tow) from research vessel bottom trawl surveys conducted in Subareas 5+6 (Sept-Oct, 1967-2009), Div. 4VWX (July, 1970-2009), and Div. 4T (Sept, 1971-2009).

	Subareas 5+6		Div. 4VWX		Div. 4T	
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	0.20
1972	2.2	0.3	6.6	0.7	0.05	0.02
1973	1.5	0.4	10.9	1.5	0.08	0.03
1974	2.8	0.4	13.4	1.8	0.06	0.02
1975	8.7	1.4	44.8	5.0	2.47	0.54
1976	20.6	7.0	231.2	42.7	30.77	8.29
1977	12.6	3.7	50.9	9.5	25.74	7.62
1978	19.3	4.5	16.4	2.3	52.83	15.04
1979	19.4	6.1	91.4	14.2	28.47	8.19
1980	13.8	3.3	23.3	2.2	18.05	4.61
1981	27.1	9.3	35.5	4.9	5.76	1.70
1982	3.9	0.6	26.0	2.1	0.39	0.13
1983	1.7	0.2	76.9	2.1	0.09	0.02
1984	4.5	0.5	14.1	1.5	0.04	0.02
1985	2.4	0.4	80.2	2.7	0.32	0.12
1986	2.1	0.3	7.7	0.4	0.12	0.01
1987	15.8	1.5	4.9	0.4	0.22	0.05
1988	23.2	3.0	47.3	2.7	1.33	0.42
1989	22.4	3.3	26.3	2.7	0.97	0.24
1990	16.6	2.4	40.6	4.8	1.37	0.29
1991	5.2	0.7	27.1	1.8	0.17	0.03
1992	8.2	0.8	121.7	7.3	0.65	0.11
1993	10.4	1.6	79.0	5.4	0.83	0.13
1994	6.8	0.9	45.3	4.2	0.79	0.18
1995	8.0	0.7	33.9	2.4	0.32	0.03
1996	10.8	0.9	11.9	0.9	1.09	0.19
1997	5.8	0.5	52.0	4.8	0.89	0.14
1998	14.6	1.4	10.0	0.9	1.34	0.30
1999	1.4	0.2	16.7	2.0	0.47	0.11
2000	7.4	0.7	4.0	0.1	0.27	0.03
2001	4.5	0.3	3.3	0.2	0.08	0.01
2002	6.4	0.4	13.0	1.1	0.11	0.02
2003	28.5	1.9	12.1	0.9	0.22	0.05
2004	5.1	0.4	119.3	12.9	1.61	0.37
2005	11.0	0.7	9.6	0.7	0.46	0.10
2006	29.5	2.8	74.4	10.2	2.33	0.54
2007	15.7	1.3	15.5	1.5	7.27	1.43
2008	10.4	1.0	29.4	3.1	0.53	0.10
2009	8.5	0.9	69.9	6.0	0.88	0.18
Avg. 1982-2008	10.5	1.1	37.1	3.0	0.90	0.19

Table 3. Swept areas estimates of *Illex illecebrosus* biomass (tons) and abundance (000's of squid) derived from EU bottom trawl surveys conducted in Div. 3M during July, 1988-2009.

	Div. 3M	
Year	**Minimum Abundance (000's of squid)**	**Minimum Biomass (t)**
1988	46	5
1989	76	8
1990	18,589	1,647
1991	14,358	1,159
1992	879	66
1993	25	1
1994	2,978	211
1995	57	1
1996	1,288	87
1997	955	64
1998	1,179	71
1999	697	18
2000	173	3
2001	469	7
2002	429	7
2003	3,232	180
2004	3,637	381
2005	1,134	63
2006	21,897	2,869
2007	4,888	333
2008	39,496	4,161
2009	18,833	1,363
Average 1988-2008	5,547	540

Table 4. Relative 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 1970-2009. Indices were divided by 10,000 to scale the values.

Year	SA 3+4 Nominal Catch (t)	Div. 4VWX July Survey Biomass Index (kg/tow)	Relative 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	366	0.1	0.37
2001	57	0.3	0.02
2002	258	1.1	0.02
2003	1,132	0.9	0.13
2004	2,574	12.9	0.02
2005	578	0.7	0.09
2006	6,981	10.2	0.07
2007	246	1.5	0.02
2008	535	3.1	0.02
2009	690	6.0	0.01
Average			
1976-1981	80,645	12.6	1.67
1982-2008	3,208	3.0	0.15

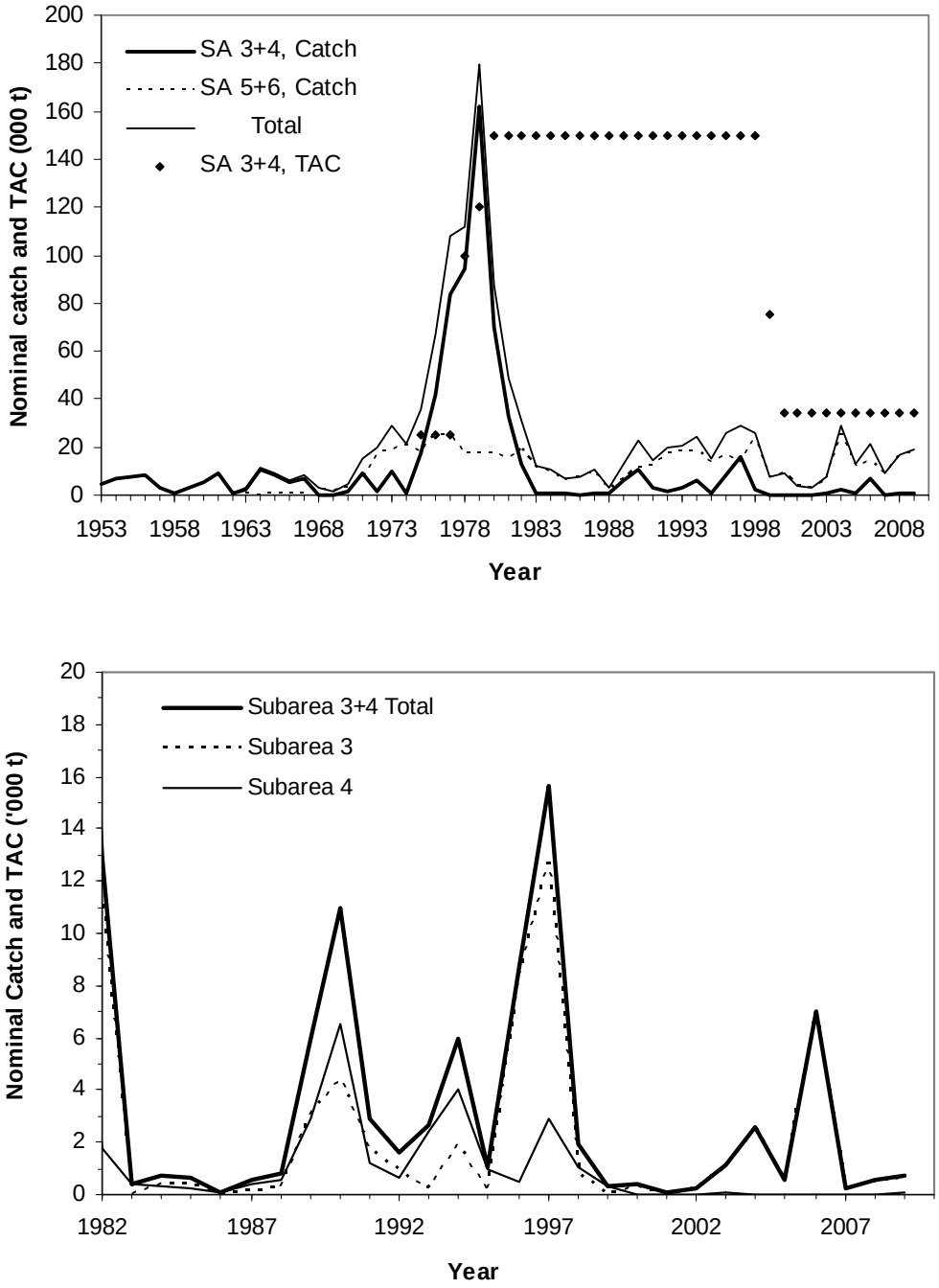

Fig. 1. Nominal catches (000's t) of *Illex illecebrosus* and TACs in Subareas 3 and 4 during 1953-2009, and Subareas 5+6 during 1963-2009 (top) and nominal catches in Subarea 3 and Subarea 4 during 1982-2009 (bottom).

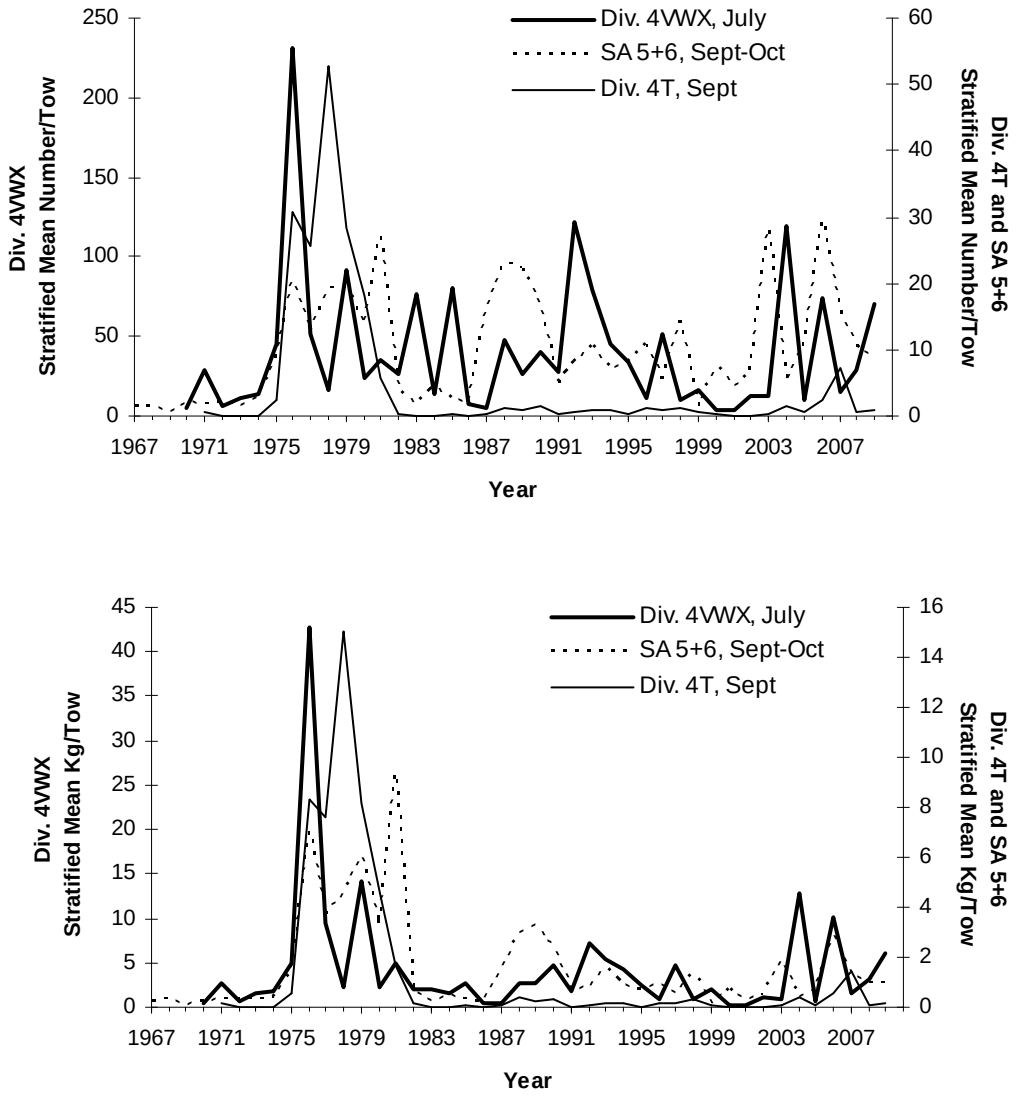

Fig. 2. *Illex illecebrosus* relative abundance (stratified mean number/tow) (top) and biomass indices (stratified mean kg/tow) (bottom) from the Canadian Div. 4VWX (July, 1970-2009) and Div. 4T surveys (September, 1971-2009), and the U.S. bottom trawl surveys in Subareas 5+6 (September-October, 1967-2009).

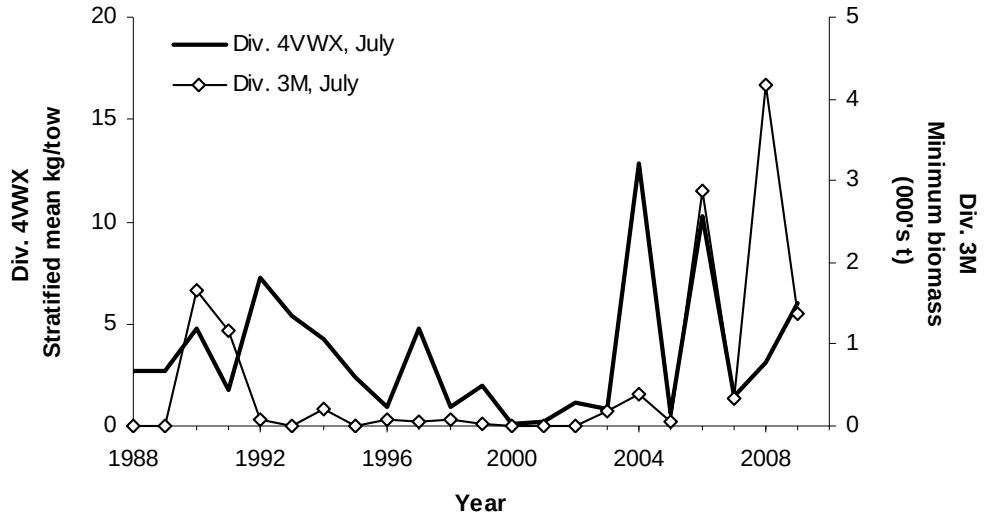

Fig. 3. Relative biomass indices (stratified mean number/tow) of *Illex illecebrosus*, during July of 1988-2009, derived from the Canadian bottom trawl surveys in Div. 4VWX and minimum biomass estimates (000's t) derived from the EU bottom trawl surveys in Div. 3M.

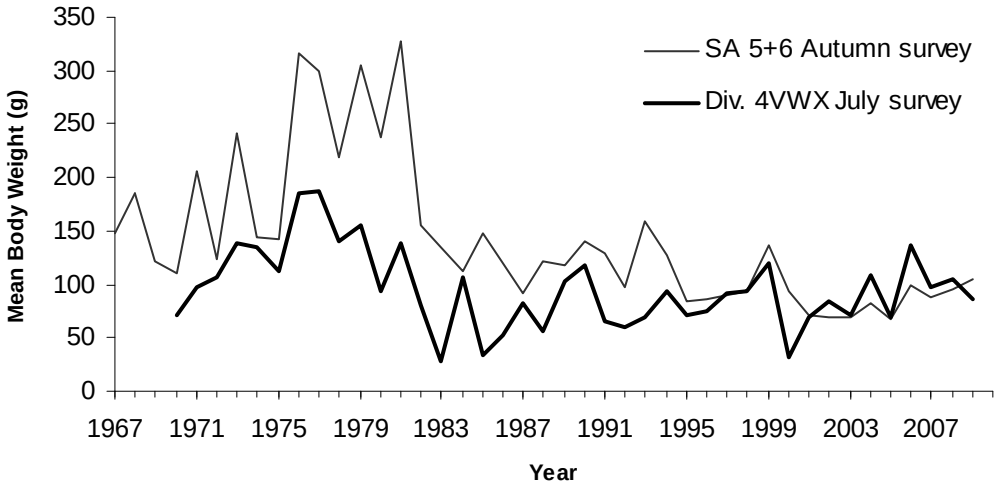

Fig. 4. Mean weight per individual (g) of *Illex illecebrosus* caught in the Subareas 5+6 autumn bottom trawl surveys (1967-2009) and Canadian Div. 4VWX July bottom trawl surveys (1970-2009).

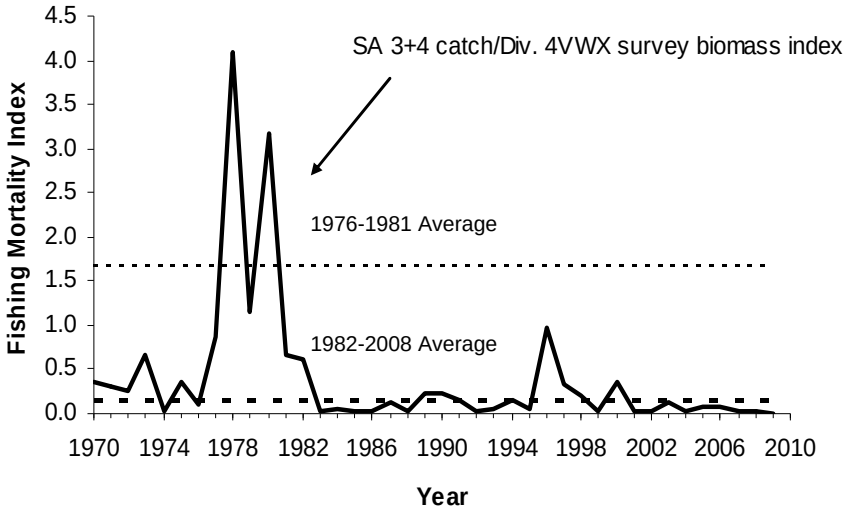

Fig. 5. Relative fishing mortality indices (SA 3+4 nominal catch/Div. 4VWX July survey biomass index) in Subareas 3+4 during 1970-2009, and averages during the high (1976-1981) and low (1970-1975 and 1982-2009) productivity periods. Indices were divided by 10,000 to scale the values.