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The Canadian Fishery for Yellowtail Flounder in NAFO Divisions 3LNO in 2004 and 2005

by

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Abstract

The catch of yellowtail flounder by Canadian vessels in NAFO Divisions 3LNO in 2005 was approximately 13 140 tons, the highest by this fleet since 1987 and similar to levels in 2003 and 2004. The catch increased from just under 10 000 tons in 2002, when effort was lower because of problems with by-catch of American plaice. Length compositions of yellowtail were similar in 2004 and 2005, with about 40% of the catch numbers coming from lengths in the range 36-39 cm. Much of the Canadian catch in 2004-2005 came from Div. 3N, mostly in areas just north and west of the Southeast Shoal. Otter trawl continues to be the dominant gear in this fishery. CPUE increased in 2004 and remained high in 2005, although it remains difficult to compare CPUE with periods prior to 1998, due to the changes in the fishery and in the fleet behaviour. Avoidance of by-catch of species under moratorium, such as American plaice and cod, continues to be a major influence on the Canadian fishery for yellowtail.

Introduction

Yellowtail flounder (*Limanda ferruginea*) is distributed off Newfoundland across much of the shallow portions of the Grand Banks within NAFO (Northwest Atlantic Fisheries Organization) Div. 3L, 3N, 3O and Subdiv. 3Ps (Fig. 1), as well as in many inshore areas around the coast. The largest concentrations in Canadian Atlantic waters are located on the south-central part of the Grand Bank in waters less than 100 m (Pitt, 1970; Walsh *et al.*, 2002). A mixed trawl fishery began in the early 1960s in Div. 3L, 3N and 3O, following drastic declines in the haddock stock. For much of the period up to 1994, yellowtail flounder was exploited primarily as a part of this mixed fishery with cod (*Gadus morhua*) and American plaice (*Hippoglossoides platessoides*). Following declines in stock abundance, the directed fishery for yellowtail flounder was closed by NAFO Fisheries Commission from 1 January 1994 until 1 August 1998. Since the reopening in 1998, the fishery has increased, following increases in stock abundance. Pitt (1970), Kulka (1999, 2002), and Brodie *et al*. (2004) provide further details on the historical fishery. Canada is allocated 97.5% of the 3LNO yellowtail quota by NAFO Fisheries Commission, and one company, Fishery Products International Limited, holds approximately 90% of the Canadian allocation.

This paper concentrates on information from the Canadian fishery for yellowtail flounder in 2004 and 2005. This fishery, since its reopening in 1998, has been much different than the fishery prior to 1994. The major difference is that the 2 other species which were often part of the mixed fishery, namely cod and American plaice, have remained closed to directed fishing. Thus a major factor in the prosecution of the yellowtail flounder fishery since 1998 has been the avoidance of by-catch of these species. This makes it difficult to compare the fishery from the pre and post-moratorium periods, given that the fleet was operating under very different rules in these periods.

The recent conservation measures for Canadian fleets fishing for 3LNO yellowtail flounder were summarized in Kulka (2002) as follows:

- Canadian vessels were restricted to fishing inside 200 miles in 3LNO.
- A minimum mesh size of 145 mm was to be used when directing for 3LNO yellowtail flounder.
- The by-catch protocols were applied pursuant to Part I, Section A.4(b) of the NAFO Conservation and Enforcement Measures, which states that "In cases where a ban on fishing is in force, incidental catches of the species concerned may not exceed 1 250 kg or 5%, whichever is the greater". The percentage is calculated as the percentage, by weight, for each species of the total catch retained on board.
- The small fish protocols were applied with a minimum fish size of 30 cm for yellowtail flounder in 3LNO. Areas will be closed for the specified fleet sector for a minimum of 10 days when the number of undersized yellowtail flounder reaches or exceeds 15% of the catch. The fishery can only re-open following a test fishery indicating that small fish is no longer a problem.
- Vessels directing for 3LNO yellowtail flounder were be subject to 100% observer coverage inside 200 miles in order to facilitate monitoring of conservation measures and collection of data. *
- A dockside-monitoring program is to be in place to monitor all landings.

* A change in these measures was introduced in 2004, permitting less than 100% observer coverage in both 2004 and 2005, as part of a pilot project.

In 2004 and 2005, voluntary measures were again taken by the fleet, including continued use of rigid sorting grates in the trawls to reduce by-catch (primarily cod), and closure of the fishery during the peak spawning time for yellowtail flounder, approximately 15 June to 31 July.

Methods

Fishery observers collected geo-referenced (latitude and longitude) information on the catch, effort, size of fish and other details of the capture of yellowtail flounder such as gear configuration and fishing strategies from the 1998-2005 large-vessel yellowtail flounder fishery. Each vessel greater than 100 feet in length, which comprises almost all the fishing effort, was required to carry an observer. During 2004, this regulation was replaced by a pilot project which allowed coverage in approximately 60% of the trips, and this was continued in 2005.

A multiplicative model was used to analyze the catch and effort data for this stock as in assessments prior to the moratorium (Brodie *et al*., 1994), and in recent years (Brodie *et al*., 2004). Because data from NAFO Statistical Bulletins exist only from 1974 onward in a format that identifies yellowtail as a main (directed fishery) species, it was decided to use Canada (Newfoundland) trawler data from 1965 to 1993, along with 1998-2005 data obtained from the Statistics Branch of the Department of Fisheries and Oceans in St. John's to derive a standardized catch rate series. It should be noted that for some years, particularly the late 1970s and since 1998, the Canadian fleet provided the only source of CPUE data for this stock. The historical data used in the model were the same data used to calculate the CPUE series in previous assessments (Brodie *et al*. 2004). Factors included in each model were a combination country-gear-tonnage-class category type (CGT), month, NAFO Division and year. Consistent with previous catch rate standardizations individual observations of catch less than 10 tons or effort less than 10 hours fished were eliminated prior to analysis. Subsequently, any remaining categories with less than five data points in total were also eliminated. Plots of residuals from a preliminary run indicated data with higher levels of catch and effort tended to be less variable, therefore a weighted regression was conducted.

Description of the Fishery

Catch trends

Figure 1 shows the catch and TAC history of the 3LNO yellowtail flounder stock. The Canadian catch peaked at just over 28 000 tons in 1973, but has not exceeded 18 500 tons since then. Following TAC increases, catches by the Canadian fleet increased steadily from 1998 to 2003 (Table 1), except for a decline in 2002 when by-catch of American plaice necessitated a reduction in effort. Catches in 2003 to 2005 were between 12 500 and 13 140 tons, with the latter value, from 2005, being the highest by Canada since 1987.

Canadian catches from 1973 onward are shown in Table 1, by year, Division and gear. With the exception of the 1991-1993 period when Canadian vessels pursued a mixed fishery for American plaice and yellowtail flounder in Div. 3O, the majority of catches has been taken in Div. 3N, by otter trawls. Canadian catches in Div. 3N were

relatively stable between 7 200 and 8 700 tons from 2000-2004, but increased to almost 10 600 tons in 2005, the highest value in 25 years. The Canadian catch of yellowtail flounder in Div. 3O in 2004 and 2005 was around 2 500 tons in each year. In Div. 3L, the 2004 catch of 2 760 tons was the highest since 1986, but the 2005 catch was only about one-tenth of that level, similar to 2001-2003.

The fishery in both 2004 and 2005 was almost all otter trawl, with small catches by gillnet in inshore 3L in both years (Table 2). Catches were taken in all months except July 2005, and temporal patterns were very similar in 2004 and 2005, with peak monthly catches occurring in April-May of both years. This contrasts with 2002-2003, when over 57% of the landed weight was taken in the last 4 months in both years. A significant part of the catch in 2004 and 2005 was taken by a larger vessel class (TC 6) new to the Canadian fishery in 2003, which froze yellowtail flounder at sea to be re-processed subsequently at shore-based plants.

The use of sorting grates, aimed at reducing cod by-catch, continued as a voluntary measure in 2004 and 2005. American plaice has been the main by-catch in the Canadian fishery for yellowtail flounder since 1998. During 2004 and 2005, it constituted about 9.6 and 9.2% of the total catch in the yellowtail flounder fishery, compared to 2.8 and 2.4% for cod. By-catches of both species were lower in the first quarter of both years, when cod and American plaice are probably distributed in deeper water. In both years, yellowtail flounder comprised 87-88% of the total landings in this fishery.

Length composition

At-sea observers measured in excess of 210 000 yellowtail flounder in each of 2002 to 2004 (215 000 in 2004). With the reduction in observer coverage introduced during 2004, and in effect for all of 2005, the number of measurements was reduced to 162 000. Observed codend mesh sizes ranged from 146 to 159 mm in 2004-05, with a predominance at 152-154 mm in 2004, and 151-152 mm in 2005. The length frequencies observed in 2004 and 2005 were very similar, with a mode at 36-37 cm (Fig. 2). About 40% of the catch in numbers in each year was between 36 and 39 cm in length. This is virtually identical to the results for 2000 to 2003 (Kulka, 2002; Brodie *et al.*, 2004). Annual mean lengths in the Canadian fishery from 2000 to 2003 ranged from 37.6 to 38.3 cm, but were slightly lower in 2004 and 2005, at 37.0 and 37.1 cm; this can be seen by comparing 2003 with 2004 and 2005 in Fig. 2. About 2 to 2.6% of the catch in numbers in 2004 and 2005 was less than 30 cm, similar to 2003, and well below the small fish protocol of 15%.

Otoliths were collected in both years, but ageing of samples has not been carried out in recent years, pending the outcome of detailed studies on ageing methodology (Dwyer *et al.*, 2003).

Spatial pattern

Since the fishery reopened in 1998, much of the distribution of effort by the Canadian fleet has been relatively localized (Kulka, 2002; Brodie *et al.*, 2004). In 2004-2005, much of the Canadian catch came from the area in central 3N, just to the north and west of the Southeast Shoal (Fig. 3). This figure shows a small geographical area, where 33% of the 2005 Canadian catch occurred. Since 2000, at least 22% of the catch, and as high as 40%, has come from this area. The size of this rectangular area is approximately 420 square nautical miles, or about 1.2% of the area on the Grand Bank less than 50 fm (91 m) in depth. Other important locations for the fishery include an area on the 3L/3N border, and an area in Div. 3O just east of 52 degrees longitude (Fig. 4).

CPUE

Tables 3A and 3B show the results of the CPUE analysis and Fig. 5 shows the standardized series from 1965 to 2005. In the top panel of Fig. 5, the catch per unit of effort declined steadily from 1965 to 1976, then increased marginally to a relatively stable level from 1980-85. The index again declined sharply in 1986 and remained at this relatively low level through to 1990. In 1991 the CPUE declined by almost half to the lowest level observed. The catch rate in 1998, after more than four and a half years of moratorium, increased sharply to a level comparable to the late 1960s. Catch rates increased by more than 25% between 1998 and 2004 and in 2004-2005 were comparable to the highest on record, i.e. at the start of the directed fishery in 1965. Monthly coefficients (Table 3A) indicated that CPUE was highest during the fall period (September-October). Data from the Canadian fleet indicate that by-

catch of American plaice has been problematic in this fishery, around 10%, since 2001, but no attempt has been made to account for this factor in the CPUE analyses.

Standardizations of the data separately by Division (Fig. 5, lower panel) showed that, overall, the historical trends were the same, although the catch rate is generally lower in Div. 3O than in Div. 3N, and that large fluctuations tend to occur more frequently in Div. 3O, primarily before 1985. In the period since the resumption of the directed fishery, from 1998-2005, catch rates showed opposite trends within each division between 1998 to 2001. CPUE increased sharply in Div. 3N from 2002 to 2004-2005, and has been relatively stable in Div. 3O since 2000.

As noted previously, e.g. Brodie *et al*. (2004), the fluctuations in the combined index from 1990 to 1993 was due primarily to the switch in effort of the fleet to Div. 3O. A substantial part of the effort labelled 'directed' for one species or the other in this Division was actually effort directed at a mixed fishery for American plaice and yellowtail flounder during 1991-1993. Given this major shift in the fishery from the 1965-90 to 1991-93, some caution must be used in comparison of catch rates between these periods. Nonetheless, it is reasonable to interpret the 1991-1993 values for CPUE as another indication that the stock was low at that time. Since the resumption of the fishery in 1998, there has been a by-catch restriction of 5% for both American plaice and cod which directly affected the fishing pattern of the Canadian fleet. The vessels spent additional time searching for good catches of yellowtail with low by-catches of both restricted species, which they found mainly in the central and northern areas of Div. 3N. Avoidance of yellowtail flounder too small for filleting machines (less than about 35 cm) has also been a factor in the fishery in recent years. Once again, caution should be used in comparing post-moratorium catch rates with other fishery periods. However, the overall CPUE since 1998, under the constraint of 5% by-catch limitations, suggests that the stock size has increased to a relatively high level, in agreement with survey indices (Walsh *et al.*, 2006; Gonzalez-Troncoso *et al.*, 2006; Maddock-Parsons and Brodie, 2005).

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Table 1. Canadian catches of yellowtail flounder by division, from 1973 to 2005. Data from 2003-05 are from preliminary Canadian ZIF statistics and maybe slightly different from STATLANT data.

	OTTER TRAWL				
YEAR	3L	3N	3O	3LNO	OTHER GEARS
1973	4,188	21,470	2,827	28,475	17
1974	1,107	14,757	1,119	16,983	70
1975	2,315	13,289	2,852	18,456	2
1976	448	4,978	2,478	7,904	6
1977	2,546	7,166	1,583	11,295	0
1978	2,537	10,705	1,793	15,035	56
1979	2,575	14,359	1,100	18,034	82
1980	1,892	9,501	578	11,971	40
1981	2,345	11,245	515	14,105	17
1982	2,305	7,554	1,607	11,466	13
1983	2,552	5,737	770	9,059	26
1984	5,264	6,847	318	12,429	8
1985	3,404	9,098	829	13,331	9
1986	2,933	10,196	1,004	14,133	35
1987	1,584	10,248	1,529	13,361	59
1988	1,813	7,146	1,475	10,434	173
1989	844	2,407	1,506	4,757	252
1990	1,263	2,725	668	4,656	310
1991	798	2,943	2,284	6,025	564
1992	95	1,266	4,633	5,994	820
1993	-	2,062	3,903	5,965	782
1994	-	-	-	-	0
1995	-	-	-	-	2
1996	-	-	-	-	0
1997	-	1	-	1	0
1998	-	2,968	742	3,710	29
1999	-	5,636	107	5,743	3
2000	1,409	7,733	278	9,420	43
2001	183	8,709	3,216	12,108	130
2002	22	7,707	2,035	9,764	195
2003	28	8,186	4,482	12,696	1
2004	2,760	7,205	2,609	12,574	3
2005	284	10,572	2,283	13,139	1

Table 2a. Canadian catches (ZIF data) of yellowtail flounder by Division, month, and gear, 2004.

	3L		3N	3O	3LNO
	OT	Gillnet	OT	OT	Total
Jan			530	7	537
Feb			447		447
Mar			1227		1227
Apr			2271	36	2307
May			888	1481	2369
Jun	274		1096	100	1470
Jul	15	2	44	31	92
Aug		1		81	82
Sep	427		9	546	982
Oct	125		121	307	553
Nov	955		321	20	1296
Dec	964		251		1215
Total	2760	3	7205	2609	12577

Table 2b. Canadian catches (ZIF data) of yellowtail flounder by Division, month, and gear, 2005.

	3L		3N	3O	3LNO
	OT	Gillnet	OT	OT	Total
Jan			956		956
Feb			765		765
Mar			565	4	569
Apr			1726	408	2134
May	228		1025	932	2185
Jun	56		758	138	952
Jul					
Aug		1		123	124
Sep			110	472	582
Oct			1067	73	1140
Nov			1491	133	1624
Dec			2109		2109
Total	284	1	10572	2283	13140

Table 3A. ANOVA results and regression coefficients from a multiplicative model utilized to derive a standardized catch rate series for Yellowtail flounder in NAFO Div. 3LNO (2005 based on preliminary data).

REGRESSION OF MULTIPLICATIVE MODEL

MULTIPLE R..... 0.762
MULTIPLE R SQUARED..... 0.581

ANALYSIS OF VARIANCE

SOURCE OF VARIATION	DF	SUMS OF SQUARES	MEAN SQUARE	F-VALUE
INTERCEPT	1	4.29E1	4.29E1	
REGRESSION	52	9.57E0	1.84E-1	25.666
Cntry|Gear|TC	3	7.90E-1	2.63E-1	36.740
Division	2	9.08E-1	4.54E-1	63.343
Month	11	4.56E-1	4.14E-2	5.780
Year	36	6.33E0	1.76E-1	24.540
RESIDUALS	962	6.90E0	7.17E-3	
TOTAL	1015	5.93E1		

REGRESSION COEFFICIENTS

CATEGORY	CODE	VAR #	REG. COEF	STD. ERR	NO. OBS
Cntry|Gear|TC(1)	3125	INT	0.085	0.115	1015
Division(2)	34				
Month(3)	10				
Year(4)	65				
(1)	3114	1	-0.296	0.033	162
	3124	2	-0.230	0.034	153
	3126	3	-0.075	0.054	50
(2)	32	4	-0.220	0.028	211
	35	5	-0.257	0.027	240
(3)	1	6	-0.106	0.076	24
	2	7	-0.200	0.071	28
	3	8	-0.136	0.060	41
	4	9	-0.164	0.049	70
	5	10	-0.126	0.042	134
	6	11	-0.204	0.042	133
	7	12	-0.223	0.043	128
	8	13	-0.122	0.044	123
	9	14	0.013	0.044	109
	11	15	-0.096	0.047	73
	12	16	-0.010	0.054	55
(4)	66	17	-0.044	0.145	11
	67	18	-0.095	0.154	12
	68	19	-0.236	0.143	14
	69	20	-0.400	0.134	20
	70	21	-0.397	0.121	42
	71	22	-0.429	0.119	41
	72	23	-0.534	0.119	45
	73	24	-0.404	0.118	50
	74	25	-0.819	0.122	37
	75	26	-0.833	0.121	38
	76	27	-0.899	0.130	26
	77	28	-0.750	0.123	38
	78	29	-0.710	0.119	51
	79	30	-0.694	0.119	47
(4)	80	31	-0.577	0.125	30
	81	32	-0.585	0.126	30
	82	33	-0.679	0.129	24
	83	34	-0.535	0.128	24
	84	35	-0.570	0.128	28
	85	36	-0.520	0.125	30
	86	37	-0.861	0.126	30
	87	38	-0.799	0.126	30
	88	39	-0.877	0.129	26
	89	40	-0.899	0.138	17
	90	41	-0.740	0.139	16
	91	42	-1.356	0.131	24
	92	43	-1.184	0.135	21
	93	44	-0.871	0.132	23
	98	45	-0.242	0.145	11
	99	46	-0.185	0.142	12
	100	47	-0.084	0.129	24
	101	48	-0.291	0.128	20
	102	49	-0.370	0.130	19
	103	50	-0.160	0.124	34
	104	51	0.016	0.125	30
	105	52	0.016	0.126	32

LEGEND FOR AVOVA RESULTS:

CGT CODES: 3114 = Can(NFLD) TC 4 Side Trawler
3124 = " TC 4 Stern Trawler
3125 = " TC 5 "
3126 = " TC 6 "

DIVISION CODES: 32 = 3L, 34 = 3N, 35 = 3O

Table 3B. Standardized catch rate index for Yellowtail flounder in NAFO Div. 3LNO from a multiplicative model utilizing HOURS FISHED as a measure of effort. (2005 based on preliminary data).

PREDICTED CATCH RATE

	LN TRANSFORM		RETRANSFORMED				% OF CATCH IN
YEAR	MEAN	S.E.	MEAN	S.E.	CATCH	EFFORT	THIS ANALYSIS
1965	0.0848	0.0133	1.085	0.125	3075	2834	39.5
1966	0.0411	0.0111	1.040	0.109	4185	4024	32.7
1967	-0.0105	0.0142	0.986	0.117	2122	2152	44.0
1968	-0.1515	0.0095	0.858	0.083	4180	4869	52.6
1969	-0.3157	0.0071	0.729	0.061	10494	14389	30.8
1970	-0.3119	0.0036	0.733	0.044	22814	31108	54.4
1971	-0.3442	0.0032	0.710	0.040	24206	34083	58.4
1972	-0.4488	0.0032	0.640	0.036	26939	42114	53.9
1973	-0.3197	0.0029	0.728	0.039	28492	39140	74.4
1974	-0.7340	0.0036	0.481	0.029	17053	35466	82.0
1975	-0.7484	0.0033	0.474	0.027	18458	38936	72.1
1976	-0.8142	0.0056	0.443	0.033	7910	17842	60.5
1977	-0.6654	0.0041	0.515	0.033	11295	21938	44.4
1978	-0.6257	0.0032	0.536	0.030	15091	28158	61.5
1979	-0.6091	0.0032	0.545	0.031	18116	33247	73.0
1980	-0.4922	0.0048	0.612	0.043	12011	19627	65.1
1981	-0.5004	0.0046	0.607	0.041	14122	23262	73.6
1982	-0.5943	0.0052	0.552	0.040	11479	20777	48.2
1983	-0.4498	0.0047	0.639	0.044	9085	14227	50.3
1984	-0.4848	0.0050	0.617	0.043	12437	20173	54.7
1985	-0.4351	0.0043	0.648	0.043	13440	20736	50.6
1986	-0.7767	0.0042	0.461	0.030	14168	30760	62.5
1987	-0.7146	0.0043	0.490	0.032	13420	27382	66.4
1988	-0.7921	0.0050	0.453	0.032	10607	23394	57.1
1989	-0.8143	0.0073	0.443	0.038	5009	11309	40.0
1990	-0.6555	0.0076	0.519	0.045	4969	9573	45.8
1991	-1.2709	0.0055	0.281	0.021	6589	23464	48.3
1992	-1.0990	0.0066	0.333	0.027	6814	20444	59.3
1993	-0.7862	0.0059	0.456	0.035	6747	14801	68.4
1998	-0.1568	0.0093	0.854	0.082	3736	4375	91.4
1999	-0.1004	0.0082	0.904	0.082	5746	6356	94.2
2000	0.0007	0.0052	1.002	0.072	9414	9398	99.2
2001	-0.2062	0.0048	0.815	0.056	12240	15025	96.5
2002	-0.2855	0.0053	0.752	0.055	9958	13236	98.0
2003	-0.0750	0.0037	0.929	0.057	12707	13673	99.4
2004	0.1011	0.0041	1.108	0.071	12576	11349	99.4
2005	0.1004	0.0044	1.107	0.073	13137	11866	66.1

AVERAGE C.V. FOR THE RETRANSFORMED MEAN: 0.074

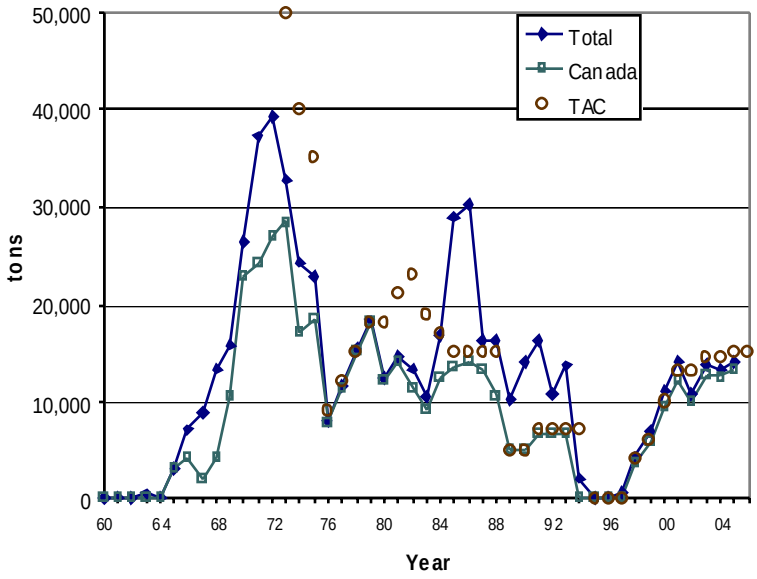

Fig. 1. Catches and TACs, yellowtail flounder in Div. 3LNO.

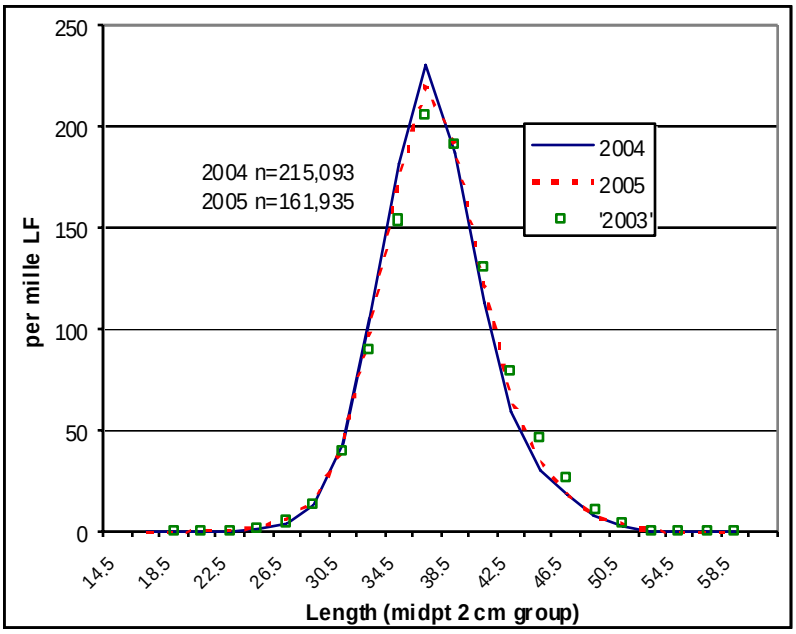

Fig. 2. Length compositions of yellowtail flounder caught in the Canadian fishery in Div. 3LNO in 2003 to 2005.

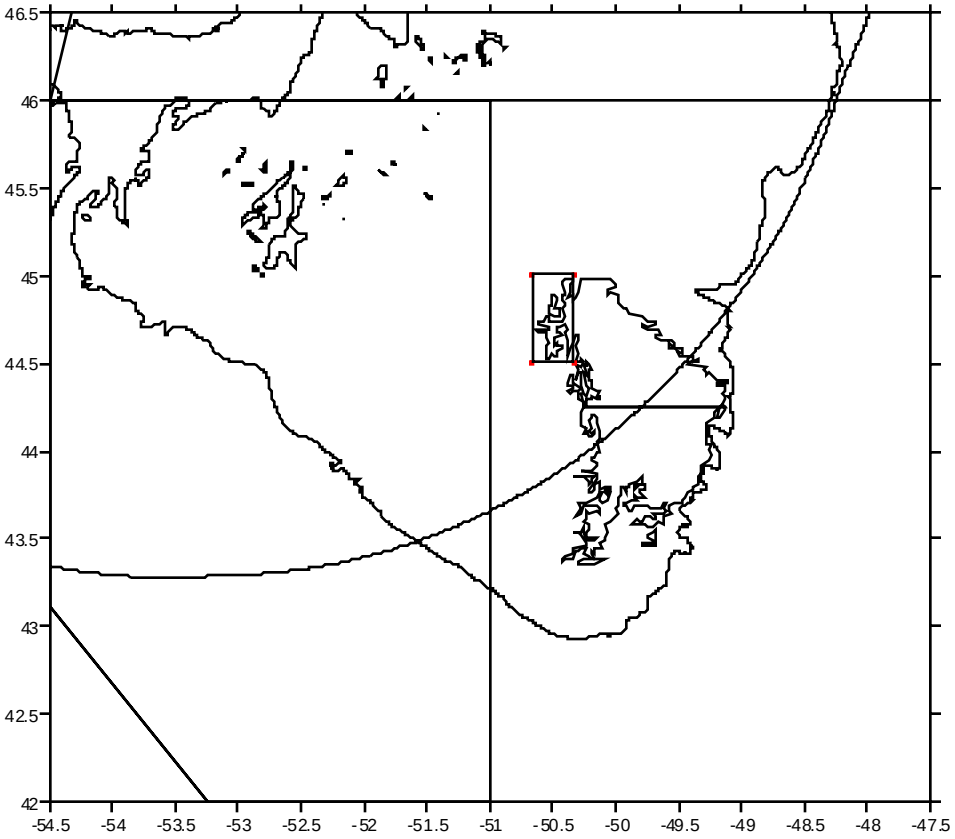

Fig. 3. Map showing small rectangular area near Southeast Shoal where Canadian fishery takes a high percentage of its yellowtail flounder catch.

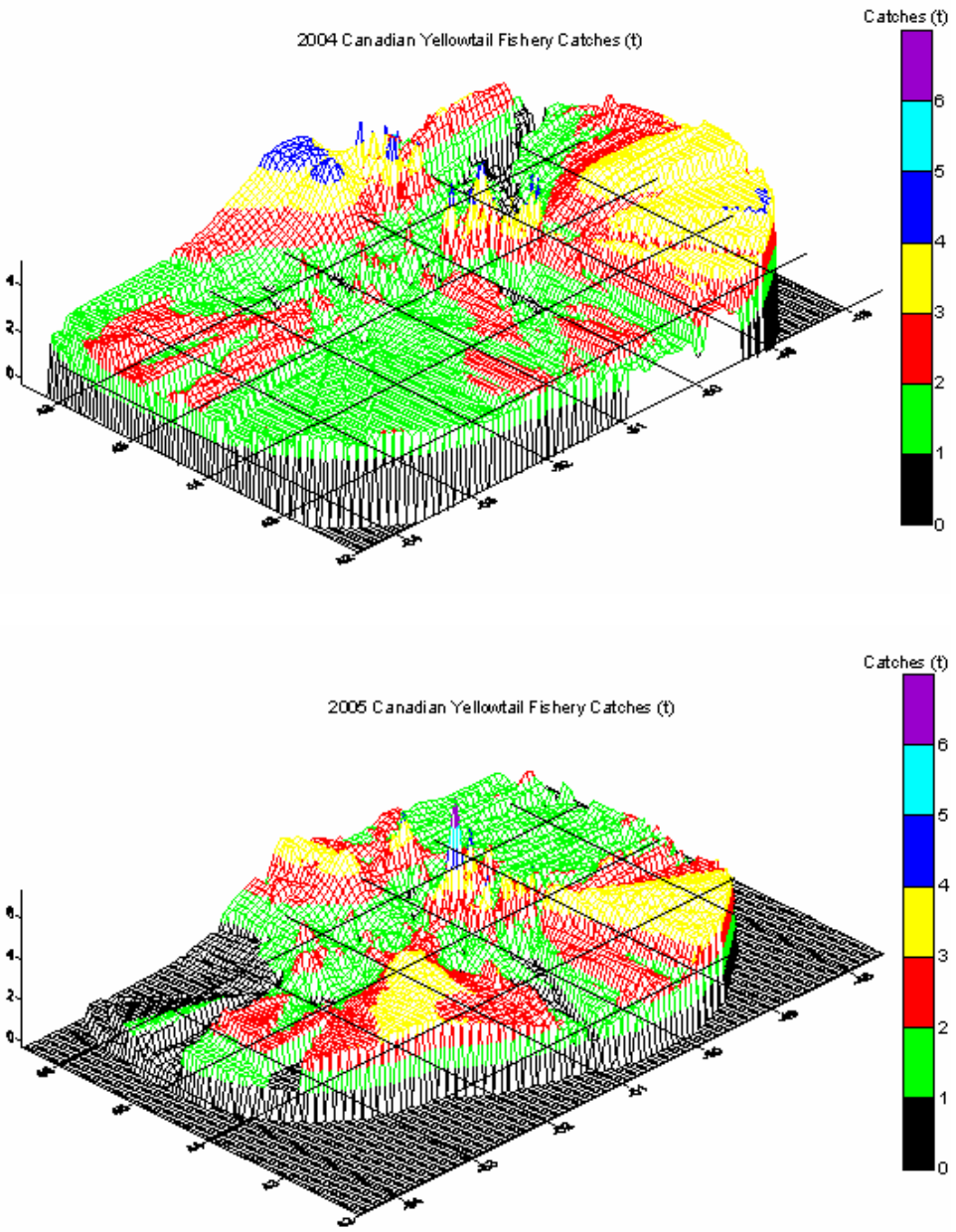

Fig. 4. Spatial distribution of Canadian catches of yellowtail flounder in Div. 3LNO in 2004 and 2005.

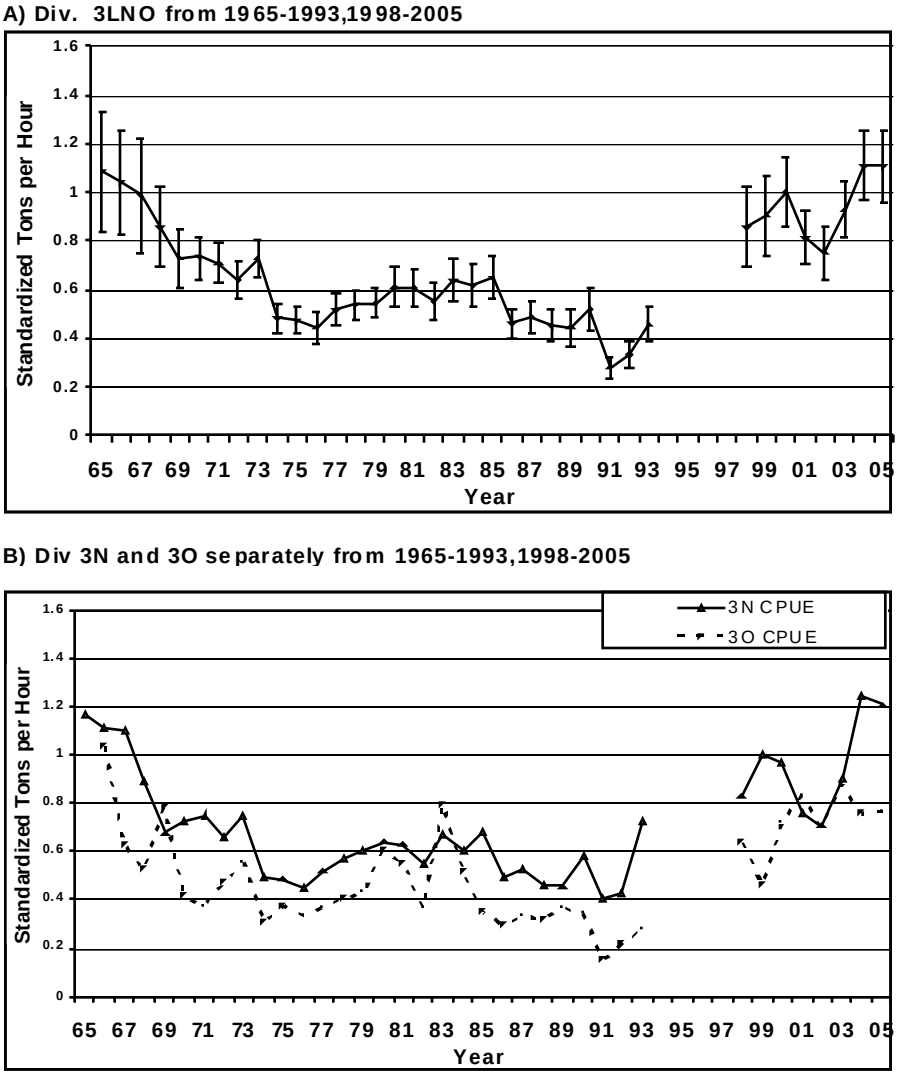

Fig. 5. Standardized CPUE (+/- 2 s.e.) of yellowtail flounder from the Canadian fishery in Div. 3LNO, 1965-2005.