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Update on Cooperative Surveys of Yellowtail Flounder in NAFO Divisions 3LNO, 1996-2003

by

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Abstract

Results from cooperative grid surveys conducted in July showed that catch rates of yellowtail flounder were consistently high in July surveys (580-900 kg/hr) from 1996 through 2003. The 2003 CPUE for yellowtail flounder was the highest in the series. Catches of American plaice, cod and thorny skate also varied but were relatively stable at a lower level (less than 240 kg/hr) in those same surveys. The 2003 survey of the expanded grid area had lower catch rates of American plaice, cod and thorny skate than the 2002 expanded grid survey, with the yellowtail flounder CPUE increasing again in 2003.

Introduction

Cooperative trawl surveys directed for yellowtail flounder have been conducted in NAFO Divisions 3NO by the Canadian Department of Fisheries and Oceans (DFO) Newfoundland Region and a Newfoundland based fishing company, Fisheries Products International (FPI) Ltd. since July 1996. While the scientific and technical support for the surveys is the responsibility of DFO, FPI provides the vessel, crew, fishing gear, and related operating expenses for the surveys. These surveys are designed to provide data on the spatial distribution and abundance of yellowtail flounder in the survey area. The surveys also provide information on species such as American plaice, cod and thorny skate, which are taken as by-catches in the commercial fishery for yellowtail flounder. This paper summarizes the results from the surveys completed in 1996 to 2003.

Methods and Materials

Originally, the surveys were designed to cover an area of approximately 9 500 square nautical miles (bolded grid, Fig. 1), corresponding to the area where the yellowtail flounder stock is mainly distributed, and where the FPI fishery operated in most years prior to the 1994 NAFO-imposed moratorium on fishing. The original survey area grid is divided into l00 equal-sized blocks, and the same pre-selected position is fished, if possible, in each block in every survey. These positions were selected at the start of the first survey by FPI, based on their understanding of yellowtail flounder abundance and distribution, and their knowledge of the fishing grounds. Some of the areas in the grid represent well-known fishing grounds for yellowtail, while other areas were not traditionally fished. All aspects of the fishing operation, including vessel, skipper, trawl gear, and tow speed and duration were kept standard within and between surveys, and aspects such as tow direction and time of day have been kept constant for a given tow between surveys where possible. A July survey has been conducted each year since 1996, with seasonal surveys also carried out from 1997-1999.

In 2000, the grid area was expanded to cover an additional 100 blocks, an area equal in size and adjacent to the original grid (Fig. 1). Additional coverage was added in each of Div. 3L, 3N, and 3O. This expansion was necessary so that the survey would cover a larger portion of the yellowtail flounder stock, which has expanded its range since the start of the grid survey series in 1996. Blocks in the expanded grid area are identified by row and column, with

the exception of the labelled blocks. This expanded grid was surveyed immediately following the July survey of the original grid, using the same vessel and fishing protocols.

The vessel used in all surveys to date was the *Atlantic Lindsey*, a 44 m total length, 665 G.R.T., 1500 HP commercial stern trawler in FPI's Newfoundland fleet. The fishing gear used is an Engel (96) 145 Hi-Lift otter trawl, with rockhopper footgear, and is reflective of trawls historically used by FPI in the yellowtail flounder fishery (see Walsh and McCallum, 1999, for details). Brodie *et al.* (1997) give an in-depth comparison of this trawl used onboard the *Atlantic Lindsey* with the standard survey gears (Enge1 145 Hi-Lift otter trawl, and Campelen 1800 shrimp trawl) used by the DFO institute, Northwest Atlantic Fisheries Center (NAFC). There are major differences in the footgear, sweep/bridle lengths and mesh size. Unlike trawls used in research vessel (r.v.) surveys, no small mesh liner was used in the 156 mm codend of this commercial trawl. All trawl components were measured prior to use, to ensure consistency within and between trips. Trawl performance was monitored with SCANMAR during each fishing set, which is one-hour in duration at a speed of 3.0 knots (see Walsh and McCallum, 1999).

Catch numbers and weights of all yellowtail flounder in the catch of each set were recorded. Similar catch data on other species such as American plaice, cod and thorny skate were also collected, along with biological sampling (size and maturity) data for yellowtail flounder. Some temperature data have been collected using XBT's. Results from the original grid surveys are also compared with data from spring and fall stratified random surveys done by DFO (Walsh *et al*., 2000). Results from the expanded grid area are reported separately in this paper.

Results and Discussion

Sixteen surveys covering the original grid area were conducted, 1 in 1996, 4 each in 1997 and 1998, 3 in 1999 and 1 each in 2000 to 2003. In the last four years an expanded grid area was surveyed adjacent to the original grid, covering a further area equal in size to the original grid. Results are presented for both survey series.

Catch trends: Between 50 and 92 fishing sets were conducted during each survey (Tables 1a and 1b). For yellowtail flounder, plaice, cod and thorny skate, catch weights per tow in every March survey were lower than in other surveys of the original grid area (Table 1a, Fig. 2). Considering just the July surveys (Fig. 3) no obvious trend in catch rates is seen in the original grid area, although CPUE for yellowtail flounder and A. plaice follow the same pattern, with the exception of 1996-97. NAFO Div. 3N shows higher catches of yellowtail flounder and plaice than Div. 3O in the July surveys, but lower catch rates of cod (Fig. 4). Overall, yellowtail flounder and A. plaice mean CPUE were highest in July of 2003, and yellowtail flounder was lowest (excluding March data) in May-June of 1999 (Table 1a, Fig. 2).

Catch data from the expanded grid area, surveyed for the first time in August 2000, are included in Table 1b and Fig. 5. Average CPUE of yellowtail flounder in the expanded grid area has increased by about 5-10% each year since 2000. American plaice CPUE in the expanded grid area was stable from 2000-2002 at a much lower level than yellowtail flounder and decreased in 2003. Catches of the main species were lower in the expanded grid compared to the original grid, with the exception of cod in 2001. Mean catch weight of yellowtail was higher than that for cod and American plaice in both grid areas (Tables 1a and 1b).

Distributions of the catches of the 4 species considered from the 2002 and 2003 surveys are shown in Fig. 6-9. No major changes in distribution or CPUE of any of these species are apparent from 2002 to 2003.

American plaice by-catch: Overall, 10 common blocks were fished in the 16 trips following the original grid design. To investigate the by-catch of American plaice, the ratio of American plaice to yellowtail flounder was calculated in the common blocks fished in all sixteen surveys (Table 2a). Several sets produced by-catch ratios less than 5% (highlighted), but no block consistently produced by-catch ratio of less than 5%, the current by-catch limit in the Canadian fishery for yellowtail flounder. Furthermore, the overall mean by-catch for all blocks exceeded the 5% by-catch ratio. Excluding the ratios from the March 1999 survey, the majority of catches with a by-catch less than 5% occurred in the central portion of the grid (bounded by F4-H7). Largest by-catches of plaice are found in the southwest corner of the grid in Div 30. In the survey of the expanded grid area in 2003, the ratio of American plaice to yellowtail catch was less than 5% in only one block (Table 2b).

The July surveys (conducted from 1996 through 2003) have 36 common blocks. Tables 3 and 4 give catch rates for yellowtail flounder and American plaice in these common blocks. By-catch ratios of less than 5% are most frequently found in the central portion of the grid (Table 5), and four blocks have an average American plaice by-catch ratio equal to or lower than 5%. Another six blocks had plaice to yellowtail flounder ratios between 5 and 10% on average.

Figure 10 also gives an indication of the distribution of yellowtail flounder catches and American plaice by-catch. For each July survey, blocks fished are marked to indicate whether or not the catch criterion of >700 kg/hr was met (✓ or ×). A shaded block indicates that for that level of yellowtail flounder catch, the by-catch of American plaice was less than 5% (plots on the left) or 10% (plots on the right). Blank blocks were not fished. Figure 11 shows the same information for yellowtail flounder catches greater than 500 kg/hr. Many of the blocks surveyed met this yellowtail flounder catch criteria and the July survey in 2000 had the fewest blocks with American plaice by-catch below 5% while 1999 had fewest blocks with by-catch less than 10%. In July 2003, eight sets had yellowtail flounder catches above 700 kg and A. plaice by-catch below 5%, while 15 sets had yellowtail flounder catches above 700 kg and by-catch of A. plaice at 10% or less, a pattern similar to that seen in 2002, although there were fewer blocks with catch over 700kg/hr and by-catch under 10% (15 compared to 21). Figure 11 gives the same summary of by-catch information for yellowtail flounder catches greater than 500kg/hr.

Length Composition: In all surveys, less than 2% of fish captured were smaller than 26 cm in length and less than 11% of the catch was composed of individuals less than 30cm in length (Table 6). Typically, yellowtail flounder 26-46 cm in length make up the bulk of the length frequencies of the catches and furthermore, female frequencies tended toward larger sizes than male frequencies in all surveys. The percentage of yellowtail above 40 cm in length has been at the lowest levels in the most recent surveys. Length compositions of male and female yellowtail flounder caught during the 8 July (original grid) surveys and 4 expanded grid surveys are shown in Fig. 12. Otoliths were not collected during the grid surveys and therefore age compositions have not been calculated at this time.

The male portion of the catch is given on each of the length frequency plots and is summarized in Fig. 13. March surveys in the original grid area showed a higher percentage of males in the catch than surveys at other times, and a slight decline in male composition is apparent over the time series. Expanded grid surveys showed a higher male composition than the original grid area survey in the same year (2000-2003).

Comparison of results with research vessel data: The distribution of yellowtail from the 13 stratified random research vessel surveys conducted by DFO with the Campelen trawl in Div. 3LNO from 1995-2001 (7 fall surveys and 6 spring) was shown in Maddock *et al*. (2000, 2001, 2002). Results from the 2003 surveys are shown in Fig. 14 and compared with the mean numbers per tow from 2002. The grid, which is not part of the design of the DFO r.v. surveys, is superimposed on these plots, and in most surveys, the majority of the yellowtail flounder is caught within the boundaries of the grid. There was a decline in the percentage of yellowtail found in the original grid from 1996 to 2000 in the spring, and from 1995-2001 in the fall (Table 7, Fig 15). In the first four surveys (fall 95 to spring 97), between 80 and 90% of yellowtail flounder were located within the grid. Since then, less than 81% of yellowtail flounder in any survey was located in the grid area. The lowest values occurred in the fall surveys during 2000 and 2001, when only 40-47% of yellowtail flounder in the surveys were found within the original grid. Spring 2003 percentages were lower than those in 2001 and 2002, while fall 2003 percentages were slightly lower than 2002, but above the 2000-01 levels.

Data from the 2002-2003 spring and fall DFO surveys were also superimposed on the expanded grid, used for the first time in the grid surveys in 2000. For the spring surveys, about 80-90% of yellowtail flounder was contained within the expanded grid boundaries, with the 2002 and 2003 percentages being very similar, around 80% (Table 8, Fig 15). During the 2000 and 2001 fall surveys, only 56-67% of yellowtail flounder were found inside the expanded grid, although this increased to about 77-83% in 2002 and 2003. Most yellowtail flounder outside the expanded grid, both in spring and fall, were located just to the south of the grid boundary.

Overall, these observations are consistent with observed increases in the area of distribution of yellowtail flounder in recent years, as seen in both the survey and commercial fishery data. These increases in the range of distribution are also consistent with increases in stock size since the late-1990s, following reductions in stock size and distribution range in the early- to mid-1990s (Brodie *et al*., 1998).

Observations on sexual maturity of yellowtail: In all surveys thus far, with the exception of November 1998, observations on sexual maturity of yellowtail have been collected. These were generally obtained at sea by sampling 300-400 fish from each of 2 fishing sets per day, although the March 1998 data were collected from port samples immediately following the survey. Figure 16 indicates that on average, about 80% of the female yellowtail flounder caught were mature, and that there was a slight increasing seasonal trend in the 4 surveys in 1997 and the 3 in 1999. The July 1999 survey had the highest percentage of mature females in the July surveys, although the proportion mature showed an increasing trend from 2000 to 2003, with the 2003 value being similar to 1999 at about 90%. The August surveys (extended grid) had a slightly higher percentage of mature females in all 4 years (2000-03).

A closer look at the data from the 8 July surveys (Fig. 17) showed that most mature females had spawned prior to the surveys, particularly in 1997-2000. The July 1997 survey had the highest percentage of females judged to be maturing following a recent spawning (Sp. P Mat AN), and the lowest percentage of females with hydrated eggs (Mat B and Mat C stages). This suggests that spawning may have been earliest in 1997, although mean bottom temperature in depths <100 m on the Grand Bank during spring 1997 was the second lowest (next to 2003) in the years covered by the grid surveys (Colbourne and Bowering, 2001). The high percentage of spent females in 1999 corresponds with the highest mean temperature (<100 m bottom depth) in spring surveys of this area since 1983. In 1996, and 2001 to 2003, it appears that spawning had not been completed in the grid area by July, as evidenced by the higher number of females either with hydrated eggs or eggs in pre-spawning condition (Mat A stage). In these 4 years, similar numbers of mature females were judged to be in pre-spawning and spawning condition. The percentage of spent females in 2003 was similar to the values seen in 2001 and 2002, and combined with the high percentage of pre-spawning females (Mat A,B,C) in these three years, suggests that spawning may have been later in 2001-2003 than in 1997-2000. Mean temperatures at <100 m bottom depth in spring surveys of 2001-2003 were lower than in 1998-2000, with 2003 being the lowest value, similar to 1997. Overall, there was a positive correlation ($r = 0.52$) between the proportion of spent females in the summer grid surveys and spring bottom temperature, although 1997 is an outlier (Fig. 18).

Conclusions

Cooperative surveys between DFO and FPI in Div. 3LNO indicate that CPUE for yellowtail flounder in the July surveys of the original grid have been around 600-900 kg/hr, and have averaged about 800 kg/hr in the last 4 surveys (2000-03). American plaice CPUE ranged from 100 to 236 kg/hr in the July surveys, averaging about 220 kg/hr in the last 4 surveys. Overall catch rates in the expanded grid surveys are generally lower for all species considered when compared to the original grid. Mean catch rates of yellowtail flounder, American plaice and thorny skate in the original grid area were higher in 2003 than in 2002, while cod catch rates declined

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Table 1a. Catches (kg/hr) by species and trip from FPI/DFO cooperative grid surveys, original grid area.

Species	Trip	Trip #	N	Mean	StdDev	Max	Min
Yellowtail Flounder	Jul96	1	83	693.51	478.81	2503.57	34.00
	Mar97	2	68	123.99	605.47	4972.44	0.00
	May/Jun97	3	82	608.03	602.88	4607.00	24.50
	Jul97	4	85	666.41	478.62	3369.10	17.50
	Nov97	5	50	627.37	926.85	5931.00	3.50
	Mar98	6	84	74.99	91.65	427.74	0.00
	May/Jun98	7	73	653.62	504.02	2872.62	67.00
	Jul98	8	78	803.78	533.24	2678.27	0.00
	Nov98	9	63	553.61	776.78	5726.06	1.00
	Mar99	10	73	145.21	136.96	536.40	0.30
	May/Jun99	12	80	506.49	400.74	2289.83	57.60
	Jul99	13	64	583.61	341.74	1488.97	8.00
	Jul00	14	65	802.74	521.12	3319.19	62.00
	Jul01	16	72	752.24	416.05	1979.66	6.36
	Jul02	21	78	835.31	421.28	2065.76	20.00
	Jul03	23	63	898.27	472.07	2702.15	12.50
American Plaice	Jul96	1	83	106.73	125.89	942.94	3.00
	Mar97	2	68	20.44	44.23	234.50	0.00
	May/Jun97	3	82	168.57	133.70	759.80	3.50
	Jul97	4	85	180.92	265.55	1654.40	0.00
	Nov97	5	50	131.78	94.88	492.90	23.30
	Mar98	6	84	19.49	40.31	246.74	0.00
	May/Jun98	7	73	173.18	111.74	785.46	33.02
	Jul98	8	78	229.29	361.15	2197.82	12.72
	Nov98	9	63	136.74	106.51	471.60	13.78
	Mar99	10	73	17.53	47.55	330.00	0.00
	May/Jun99	12	80	176.22	158.31	890.08	21.20
	Jul99	13	64	151.72	175.80	975.20	8.48
	Jul00	14	65	219.43	203.19	1117.24	30.18
	Jul01	16	72	187.95	269.04	1534.35	22.79
	Jul02	21	78	224.90	388.24	3180.00	12.72
	Jul03	23	63	236.09	358.25	1895.81	22.26
Cod	Jul96	1	83	105.64	282.99	2509.09	0.00
	Mar97	2	68	0.76	1.95	10.00	0.00
	May/Jun97	3	82	43.82	65.66	308.00	0.00
	Jul97	4	85	71.38	110.58	644.00	0.00
	Nov97	5	50	72.08	103.38	411.50	0.00
	Mar98	6	84	3.09	10.46	55.00	0.00
	May/Jun98	7	73	55.47	95.07	400.00	0.00
	Jul98	8	78	106.47	248.92	1273.80	0.00
	Nov98	9	63	41.18	121.01	917.70	0.00
	Mar99	10	73	1.94	10.24	86.00	0.00
	May/Jun99	12	80	70.91	139.40	1005.87	0.00
	Jul99	13	64	192.85	773.21	6067.20	0.00
	Jul00	14	65	69.71	126.80	877.80	0.00
	Jul01	16	72	74.28	109.88	739.20	0.00
	Jul02	21	78	76.52	144.17	849.60	0.00
	Jul03	23	63	39.36	58.33	349.20	0.00
T. Skate	Jul96	1	83	62.48	74.05	435.50	0.00
	Mar97	2	68	28.00	50.74	281.00	0.00
	May/Jun97	3	82	33.61	36.77	135.00	0.00
	Jul97	4	85	96.99	174.70	922.50	0.00
	Nov97	5	50	166.27	239.29	1216.00	0.00
	Mar98	6	84	43.48	88.55	502.74	0.00
	May/Jun98	7	73	25.04	60.55	450.00	0.00
	Jul98	8	78	113.97	160.28	975.00	0.00
	Nov98	9	63	102.82	108.36	440.00	0.00
	Mar99	10	73	45.28	106.55	595.00	0.00
	May/Jun99	12	80	54.10	47.81	258.67	5.40
	Jul99	13	64	72.27	68.38	429.00	0.00
	Jul00	14	65	114.68	142.23	743.75	3.00
	Jul01	16	72	70.43	74.85	318.00	0.00
	Jul02	21	78	70.70	83.90	424.80	2.00
	Jul03	23	63	82.76	131.15	1011.50	2.00

Table 1b. Catches (kg/hr) by species and trip from FPI/DFO cooperative grid surveys, expanded grid area.

Species	Trip	Trip #	N	Mean	StdDev	Max	Min
Yellowtail Flounder	Aug00	15	83	419.32	346.50	1519.49	10.00
	Aug01	17	80	451.42	374.19	1704.48	14.50
	Aug02	22	89	506.04	417.49	2536.59	11.00
	Aug03	24	92	532.91	385.47	1898.40	17.00
American Plaice	Aug00	15	83	132.05	173.57	934.51	6.00
	Aug01	17	80	129.90	205.68	1159.46	5.30
	Aug02	22	89	125.68	160.01	1040.42	2.65
	Aug03	24	92	94.33	91.94	462.91	7.42
Cod	Aug00	15	83	51.96	58.05	340.80	0.00
	Aug01	17	80	88.30	199.69	1674.40	0.00
	Aug02	22	89	74.02	102.34	714.00	0.00
	Aug03	24	92	58.04	81.44	437.40	0.00
T. Skate	Aug00	15	83	12.47	30.64	227.50	0.00
	Aug01	17	80	14.51	37.39	224.00	0.00
	Aug02	22	89	17.27	26.26	146.00	0.00
	Aug03	24	92	8.92	18.11	96.00	0.00

Table 2a. Ratio of American plaice to yellowtail flounder catch, by block, from common blocks fished in sixteen surveys of the original grid area.

Block	Jul96	Mar97	May97	Jul97	Nov97	Mar98	May/ Jun98	Jul98	Nov98	Mar99	May/ Jun99	Jul99	Jul00	Jul01	Jul02	Jul03	Ratio Mean
G04	0.04	0.04	0.14	0.07	0.08	0.05	0.18	0.05	0.03	0.16	0.12	0.02	0.04	0.05	0.05	0.05	0.07
F05	0.01	0.34	0.05	0.02	0.02	0.26	0.03	0.01	0.06	0.07	0.12	0.15	0.08	0.06	0.01	0.03	0.08
G03	0.14	0.22	0.28	0.08	0.83	0.03	0.20	0.05	0.11	0.03	0.32	0.02	0.11	0.11	0.09	0.05	0.17
A01	0.18	0.50	0.44	0.11	0.09	0.02	0.36	0.10	0.25	0.02	0.06	0.14	0.17	0.20	0.28	0.13	0.19
A05	0.08	0.10	0.38	0.21	0.32	0.12	0.39	0.36	0.32	0.01	0.49	0.14	0.12	0.07	0.13	0.10	0.22
A03	0.08	0.33	0.91	0.06	0.65	0.33	0.45	0.26	0.38	0.00	0.38	0.11	0.05	0.19	0.24	0.21	0.29
G07	0.11	0.11	0.29	0.12	0.13	0.06	0.21	0.37	0.12	0.04	0.48	0.45	1.57	0.28	0.27	0.10	0.31
B02	0.14		0.39	0.33	1.15		0.51	0.20	1.28	0.24	0.43	0.45	0.32	0.19	0.14	0.26	0.44
C10	0.20	0.97	0.51	0.34	6.52	0.28	0.27	0.61	3.57	0.38	0.28	0.16	0.19	0.15	0.58	0.40	1.00
B09	1.65	1.25	3.66	0.56	19.57	4.18	0.36	7.70	28.15	11.17	1.47	2.73	0.34	0.49	1.28	0.47	5.64

Table 2b. Blocks from the expanded grid surveys, August 2000 to 2003, in which the ratio of plaice to yellowtail catch was under 5 percent.

Trip	Block	Yellowtail (kg/hr)	American Plaice (kg/hr)	Cod (kg/hr)	Thorny Skate (kg/hr)	Ratio (Plaice/Ytail)
Aug00	151	305.04	9.54	55.20	34.00	0.03
Aug00	505	688.37	28.62	16.80	0.00	0.04
Aug00	604	659.21	26.50	13.80	9.00	0.04
Aug01	162	196.98	5.30	410.40	224.00	0.03
Aug02	151	538.94	10.6	273.60	35.00	0.02
Aug02	601	64.00	2.65	52.80	0.00	0.04
Aug03	506	760.52	32.38	51.23	1.15	0.04

Table 3. Catches of yellowtail (kg/hr) in the common blocks fished in July surveys (original grid).

	Yellowtail								
Block	**96**	**97**	**98**	**99**	**00**	**01**	**02**	**03**	**Mean**
A01	1315.86	997.64	2236.80	1488.97	1132.44	1979.66	934.82	1237.90	1415.51
A03	1086.85	690.78	835.10	520.21	3319.19	797.39	711.33	606.18	1070.88
A05	1410.51	167.00	418.65	720.18	398.90	403.37	899.73	474.50	611.61
A07	576.73	845.50	572.27	516.58	438.24	779.90	907.66	1380.76	752.21
A08	325.95	637.30	270.55	554.12	301.90	651.60	681.18	636.91	507.44
B02	321.00	482.30	379.29	124.50	165.74	163.06	295.56	208.88	267.54
B04	492.90	90.00	219.58	178.76	384.38	304.06	630.75	496.80	349.65
B06	756.00	612.00	666.10	665.60	489.45	1074.30	1289.32	979.64	816.55
B08	642.20	857.00	506.90	649.10	340.29	563.70	740.67	736.29	629.52
B09	254.20	582.34	26.00	101.00	486.75	302.58	141.00	334.29	278.52
B10	146.50	17.50	0.00	8.00	62.00	34.45	63.00	239.90	71.42
C05	942.59	606.50	542.12	333.26	914.32	594.98	943.72	1913.04	848.82
C07	526.79	1240.50	2383.01	747.90	928.84	620.79	646.76	1264.76	1044.92
C08	115.38	720.50	333.14	1438.47	174.90	337.20	368.36	1247.40	591.92
C10	1430.89	1014.13	503.63	528.18	722.29	556.38	503.86	1062.78	790.27
D04	668.14	567.38	593.45	465.55	632.81	1328.60	923.26	812.36	748.94
D05	739.76	635.75	928.76	624.04	796.84	760.83	1094.13	705.60	785.71
D08	471.87	481.50	698.63	752.12	586.63	1083.22	888.16	1394.13	794.53
D09	684.76	513.20	903.64	682.98	965.14	1360.21	1136.24	1165.38	926.44
E01	713.85	3369.10	2678.27	710.46	851.43	751.58	666.08	1010.35	1343.89
E10	557.09	483.38	694.02	632.36	805.87	1096.10	1063.59	1308.05	830.06
F02	1037.00	653.25	858.87	671.33	607.61	1275.68	744.62	1475.20	915.45
F04	1032.34	704.00	1869.00	529.45	1471.18	1606.27	1875.01	1031.36	1264.83
F05	1818.10	1396.97	2284.75	170.50	959.57	959.32	1906.62	1938.94	1429.35
F06	955.94	728.30	1385.96	1087.21	1478.99	886.68	2065.76	2702.15	1411.37
F08	1755.34	639.19	1469.34	830.30	1401.36	1063.85	1689.75	1034.75	1235.49
F09	836.83	354.25	704.09	913.36	1095.84	675.05	910.60	1145.15	829.40
G01	664.77	538.50	301.76	296.04	453.21	373.86	433.74	558.36	452.53
G03	344.68	518.50	1039.25	667.28	642.23	742.41	462.76	573.10	623.78
G04	868.66	451.13	899.02	538.87	1096.56	837.70	1098.37	1106.36	862.08
G07	721.72	711.25	1042.11	589.41	246.13	655.72	887.16	882.10	716.95
H02	600.77	977.44	1198.47	853.26	1417.99	944.28	761.41	1052.88	975.81
H09	485.07	269.74	463.14	344.20	888.43	569.87	762.55	577.05	545.01
I01	278.50	483.15	824.50	807.22	488.63	391.93	515.95	485.74	534.45
I03	441.88	857.50	567.89	163.00	870.36	496.83	855.15	764.60	627.15
J08	507.58	439.67	477.88	196.20	296.26	484.86	442.50	588.04	429.12
Mean	736.92	703.73	882.67	586.11	786.46	764.12	859.48	975.88	

Table 4. Catches of plaice (kg/hr) in the common blocks fished in July surveys (original grid).

	American Plaice								
Block	**96**	**97**	**98**	**99**	**00**	**01**	**02**	**03**	**Mean**
A01	232.80	114.27	218.90	204.56	187.90	388.49	261.50	162.79	221.40
A03	84.50	40.95	213.38	56.53	176.89	149.46	168.54	126.08	127.04
A05	110.00	35.00	152.64	104.41	47.70	26.50	119.78	45.46	80.19
A07	29.50	220.50	76.32	27.32	63.60	29.68	68.90	50.04	70.73
A08	220.50	111.10	100.70	138.48	142.60	49.70	90.60	163.50	127.15
B02	45.00	158.70	77.23	56.00	53.00	30.74	42.40	55.12	64.77
B04	111.50	15.50	42.40	12.72	30.18	26.50	24.38	22.26	35.68
B06	34.00	37.03	56.71	68.04	72.08	97.52	93.50	59.80	64.84
B08	158.00	173.90	47.70	120.58	225.12	137.20	84.80	163.05	138.79
B09	420.23	326.93	200.10	276.16	166.10	149.10	180.00	155.82	234.31
B10	270.00	146.75	253.49	140.50	209.27	116.60	237.14	241.28	201.88
C05	47.00	88.64	120.84	50.46	110.72	73.14	110.40	901.26	187.81
C07	151.00	231.20	431.42	73.60	110.74	113.42	136.30	251.84	187.44
C08	53.08	88.05	179.62	714.75	403.78	148.86	142.06	258.45	248.58
C10	293.00	349.50	309.68	85.10	138.07	81.84	292.76	428.57	247.32
D04	41.00	66.50	49.82	21.52	48.58	71.55	34.80	71.60	50.67
D05	10.00	149.00	222.60	39.01	74.67	47.17	92.22	105.46	92.52
D08	124.00	96.00	389.90	385.90	496.72	218.56	169.60	159.00	254.96
D09	163.50	232.78	330.46	190.37	479.48	272.14	232.14	275.57	272.06
E01	80.00	130.40	120.66	15.90	208.14	87.98	58.30	39.57	92.62
E10	147.50	265.25	189.21	263.73	352.92	306.09	248.64	247.96	252.66
F02	47.50	35.63	34.98	47.40	75.79	118.19	45.58	60.12	58.15
F04	8.00	38.09	33.92	8.48	36.57	42.40	40.81	22.26	28.82
F05	20.00	22.25	15.90	26.00	74.61	54.06	12.72	64.66	36.28
F06	23.00	0.00	56.18	55.12	95.84	83.74	73.96	133.56	65.18
F08	91.00	73.92	326.75	171.92	424.94	146.28	149.34	87.26	183.93
F09	67.50	85.12	302.10	311.11	438.84	158.26	123.78	125.24	201.49
G01	42.00	49.90	72.08	31.80	81.62	28.62	34.98	54.59	49.45
G03	47.50	39.15	54.06	15.90	70.78	80.56	41.34	29.68	47.37
G04	39.00	30.57	44.52	8.48	41.87	42.40	51.94	58.30	39.64
G07	80.00	86.80	382.66	265.27	386.47	184.97	242.09	90.10	214.80
H02	67.00	92.81	80.56	122.96	367.56	237.44	258.38	139.80	170.81
H09	74.50	280.35	411.81	171.72	1117.24	631.58	624.43	1669.22	622.61
I01	86.50	214.60	114.48	57.71	121.90	142.04	168.54	129.79	129.45
I03	81.00	274.38	216.24	9.00	79.50	106.53	193.98	106.00	133.33
J08	387.00	1654.40	2197.82	975.20	403.86	1534.35	3180.00	1895.81	1528.56
Mean	110.77	168.22	225.77	147.88	211.55	172.60	225.85	240.30	

Table 5. Ratio of American plaice to yellowtail flounder catch from common blocks fished in July surveys (original grid).

	Ratio American plaice/yellowtail									
Block	**96**	**97**	**98**	**99**	**00**	**01**	**02**	**03**	**MEAN**	**Total Plaice/Total Ytail**
F04	0.01	0.05	0.02	0.02	0.02	0.03	0.02	0.02	0.02	0.02
F06	0.02	0.00	0.04	0.05	0.06	0.09	0.04	0.05	0.04	0.05
F05	0.01	0.02	0.01	0.15	0.08	0.06	0.01	0.03	0.05	0.03
G04	0.04	0.07	0.05	0.02	0.04	0.05	0.05	0.05	0.05	0.05
F02	0.05	0.05	0.04	0.07	0.12	0.09	0.06	0.04	0.07	0.06
D04	0.06	0.12	0.08	0.05	0.08	0.05	0.04	0.09	0.07	0.07
G03	0.14	0.08	0.05	0.02	0.11	0.11	0.09	0.05	0.08	0.08
B06	0.04	0.06	0.09	0.10	0.15	0.09	0.07	0.06	0.08	0.08
E01	0.11	0.04	0.05	0.02	0.24	0.12	0.09	0.04	0.09	0.07
A07	0.05	0.26	0.13	0.05	0.15	0.04	0.08	0.04	0.10	0.09
B04	0.23	0.17	0.19	0.07	0.08	0.09	0.04	0.04	0.11	0.10
G01	0.06	0.09	0.24	0.11	0.18	0.08	0.08	0.10	0.12	0.11
D05	0.01	0.23	0.24	0.06	0.09	0.06	0.08	0.15	0.12	0.12
A03	0.08	0.06	0.26	0.11	0.05	0.19	0.24	0.21	0.15	0.12
F08	0.05	0.12	0.22	0.21	0.30	0.14	0.09	0.08	0.15	0.15
A05	0.08	0.21	0.36	0.14	0.12	0.07	0.13	0.10	0.15	0.13
A01	0.18	0.11	0.10	0.14	0.17	0.20	0.28	0.13	0.16	0.16
H02	0.11	0.09	0.07	0.14	0.26	0.25	0.34	0.13	0.18	0.18
C05	0.05	0.15	0.22	0.15	0.12	0.12	0.12	0.47	0.18	0.22
C07	0.29	0.19	0.18	0.10	0.12	0.18	0.21	0.20	0.18	0.18
I03	0.18	0.32	0.38	0.06	0.09	0.21	0.23	0.14	0.20	0.21
B08	0.25	0.20	0.09	0.19	0.66	0.24	0.11	0.22	0.25	0.22
F09	0.08	0.24	0.43	0.34	0.40	0.23	0.14	0.11	0.25	0.24
B02	0.14	0.33	0.20	0.45	0.32	0.19	0.14	0.26	0.25	0.24
I01	0.31	0.44	0.14	0.07	0.25	0.36	0.33	0.27	0.27	0.24
A08	0.68	0.17	0.37	0.25	0.47	0.08	0.13	0.26	0.30	0.25
D09	0.24	0.45	0.37	0.28	0.50	0.20	0.20	0.24	0.31	0.29
E10	0.26	0.55	0.27	0.42	0.44	0.28	0.23	0.19	0.33	0.30
C10	0.20	0.34	0.61	0.16	0.19	0.15	0.58	0.40	0.33	0.31
D08	0.26	0.20	0.56	0.51	0.85	0.20	0.19	0.11	0.36	0.32
G07	0.11	0.12	0.37	0.45	1.57	0.28	0.27	0.10	0.41	0.30
C08	0.46	0.12	0.54	0.50	2.31	0.44	0.39	0.21	0.62	0.42
H09	0.15	1.04	0.89	0.50	1.26	1.11	0.82	2.89	1.08	1.14
B09	1.65	0.56	7.70	2.73	0.34	0.49	1.28	0.47	1.90	0.84
J08	0.76	3.76	4.60	4.97	1.36	3.16	7.19	3.22	3.63	3.56
B10	1.84	8.39		17.56	3.38	3.38	3.76	1.01	5.62	2.83

Table 6. Length compostion of Yellowtail flounder (sexes combined). Asterisk indicates expanded grid area.

		Percentage of Yellowtail		
Trip	Trip #	<26cm	<30cm	>=40cm
Jul96	1	1.90	6.31	26.41
Mar97	2	1.62	6.72	21.05
May/Jun97	3	1.11	5.80	26.88
Jul97	4	1.19	7.70	24.81
Nov97	5	0.16	2.73	31.49
Mar98	6	1.56	8.97	25.36
May/Jun98	7	0.88	6.05	24.81
Jul98	8	1.74	10.28	21.61
Nov98	9	0.79	5.81	24.56
Mar99	10	0.55	6.63	22.37
May/Jun99	12	0.62	5.99	24.90
Jul99	13	0.34	3.67	28.41
Jul00	14	0.64	4.45	21.88
Aug00 *	15	0.15	2.65	18.12
Jul01	16	0.63	4.84	20.05
Aug01 *	17	0.15	2.72	18.01
Jul02	21	0.80	5.76	16.64
Aug02*	22	0.18	2.96	17.92
Jul03	23	0.58	4.64	16.95
Aug03*	24	0.19	2.80	17.01

Table 7. Numbers and weights of yellowtail caught in the original grid area during DFO stratified random surveys in Div. 3LNO.

Yr/season	Ytail in original grid area		Yellowtail in survey		Pct of total catch in grid	
	Numbers	Weight (kg)	Numbers	Weight (kg)	% nos	%wt
95F	19842	4528	22276	4997	89.1%	90.6%
96S	14695	3878	16937	4619	86.8%	84.0%
96F	7038	1899	8640	2141	81.5%	88.7%
97S	12059	2807	15010	3882	80.3%	72.3%
97F	10640	2928	17349	5037	61.3%	58.1%
98S	14617	3950	20827	5734	70.2%	68.9%
98F	8987	2507	12512	3696	71.8%	67.8%
99S	21054	4976	34082	9600	61.8%	51.8%
99F	12778	2946	18570	4978	68.8%	59.2%
00S	14183	3924	23131	7263	61.3%	54.0%
00F	9091	2784	22438	6507	40.5%	42.8%
01S	26003	6900	32446	8939	80.1%	77.2%
01F	15396	4365	32783	9475	47.0%	46.1%
02S	12781	3523	16444	4734	77.7%	74.4%
02F	16487	4265	23282	6757	70.8%	63.1%
03S	23540	7106	34548	10511	68.1%	67.6%
03F	16019	4464	25191	7359	63.6%	60.7%

Table 8. Numbers and weights of yellowtail caught in expanded grid area during DFO stratified random surveys in Div. 3LNO.

Yr/Season	Ytail in exp. grid area		Yellowtail in survey		Pct in grid	
	Number	Wgt (kg)	Number	Wgt (kg)	% nos	% wgt
00S	20798	6453	23131	7263	89.9%	88.8%
00F	12574	3759	22438	6507	56.0%	57.8%
01S	29295	8000	32446	8939	90.3%	89.5%
01F	21456	6338	32783	9475	65.4%	66.9%
02S	13153	3613	16444	4734	80.0%	76.3%
02F	19208	5198	23282	6757	82.5%	76.9%
03S	27412	8473	34548	10511	79.3%	80.6%
03F	20457	5813	25191	7359	81.2%	79.0%

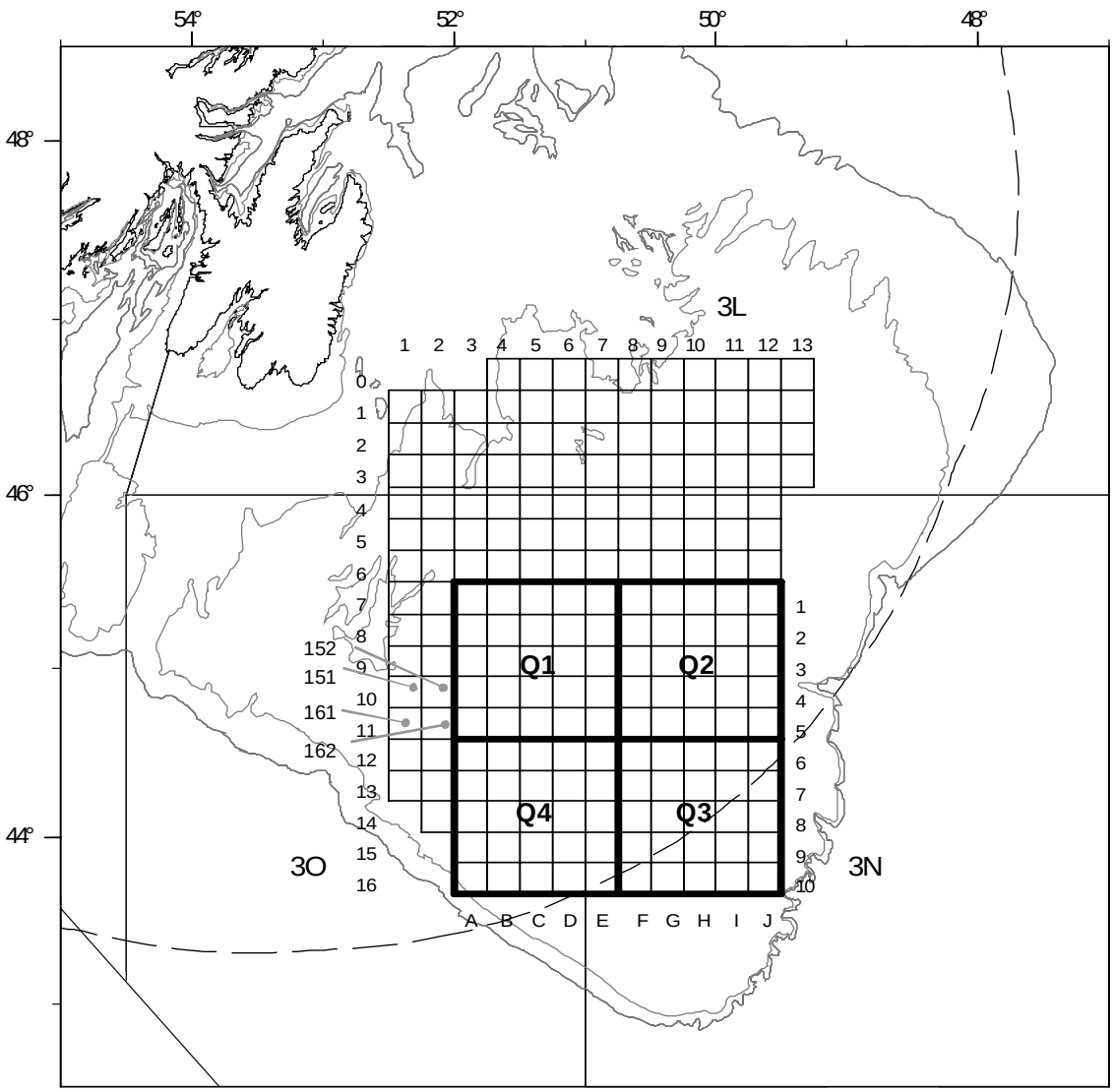

Figure 1. Location of grid used in cooperative surveys directed at yellowtail flounder. Original grid bolded with 5x5 blocks per quadrant. Expanded grid surveyed in 2000-2003.

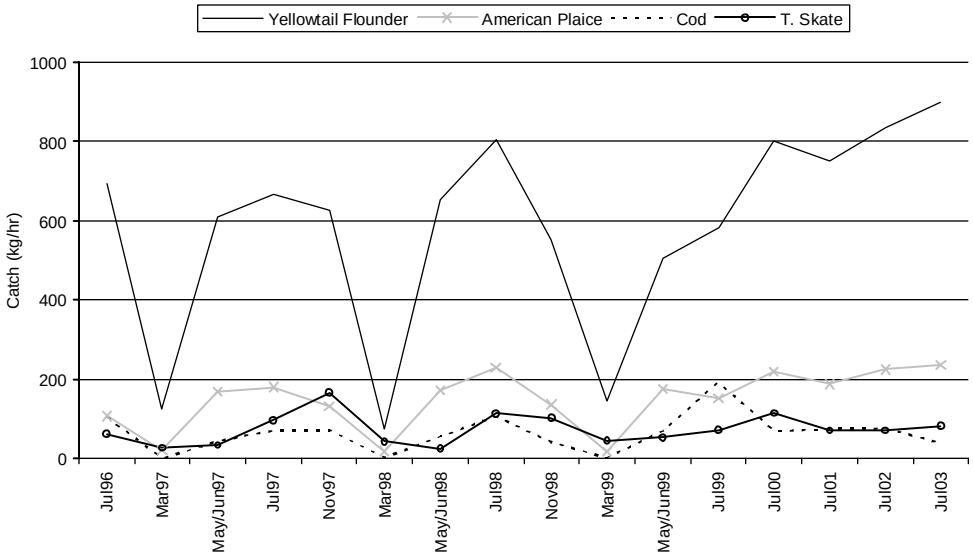

Figure 2. Mean catch (kg/hr) of yellowtail, American plaice, cod and thorny skate caught in original grid surveys from 1996-2003.

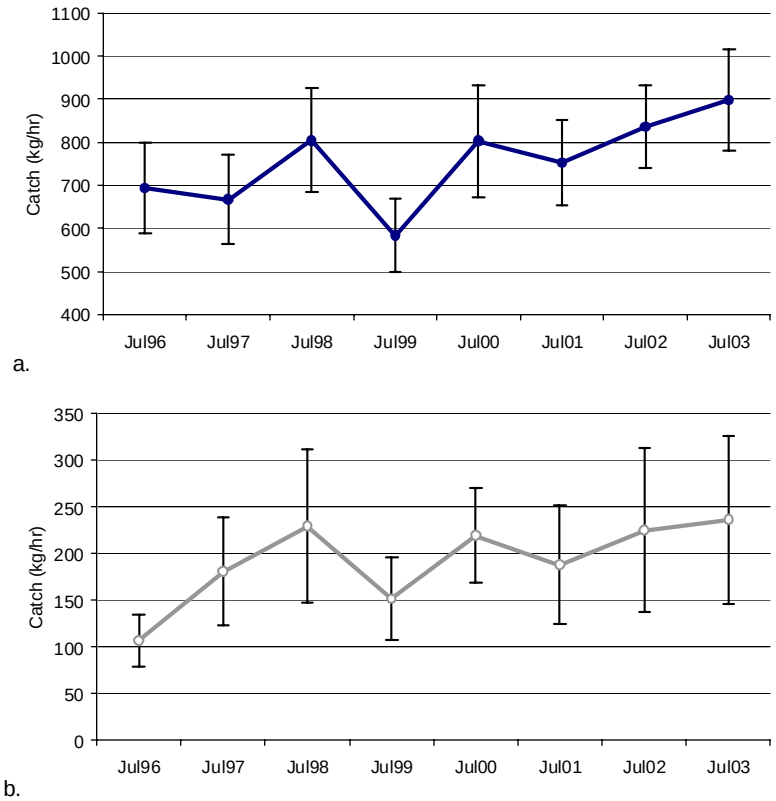

Figure 3. Average catches for yellowtail flounder (a) and American plaice (b) for July surveys. Data are mean ± 2 SE.

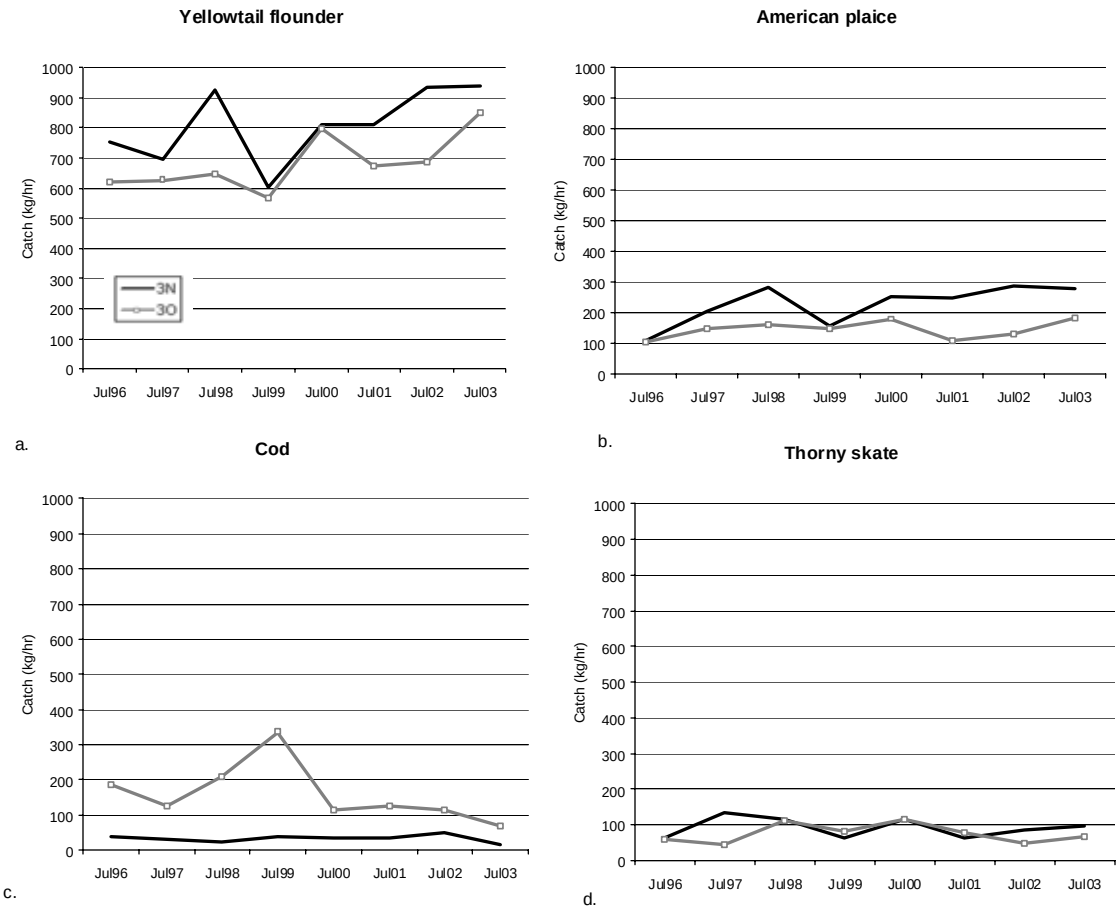

Figure 4. Catch (kg/hr) of yellowtail, American plaice and cod by NAFO Division, caught in cooperative surveys (original grid) from 1996-2003.

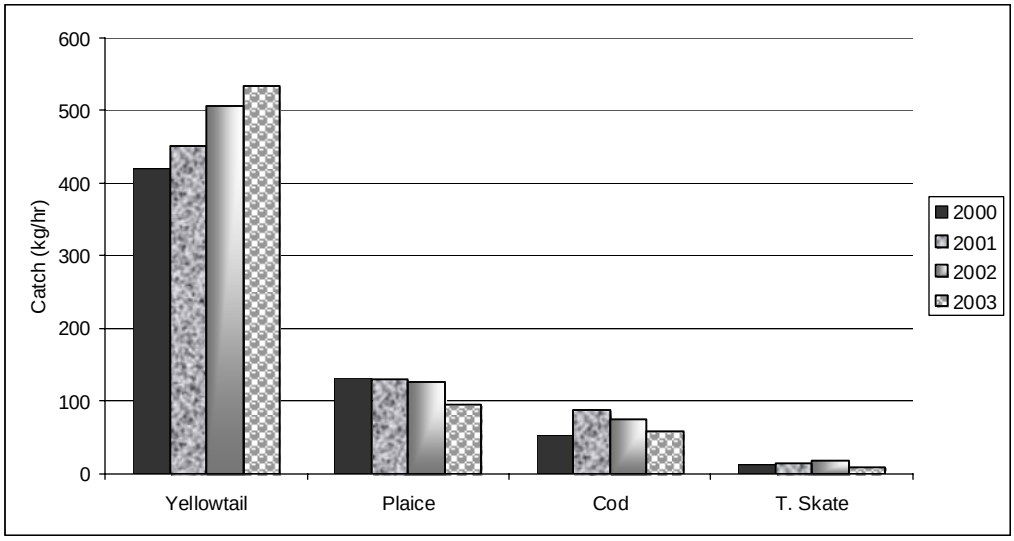

Figure 5. Catch (kg/hr) of yellowtail, American plaice, cod and thorny skate caught in surveys covering the expanded grid area.

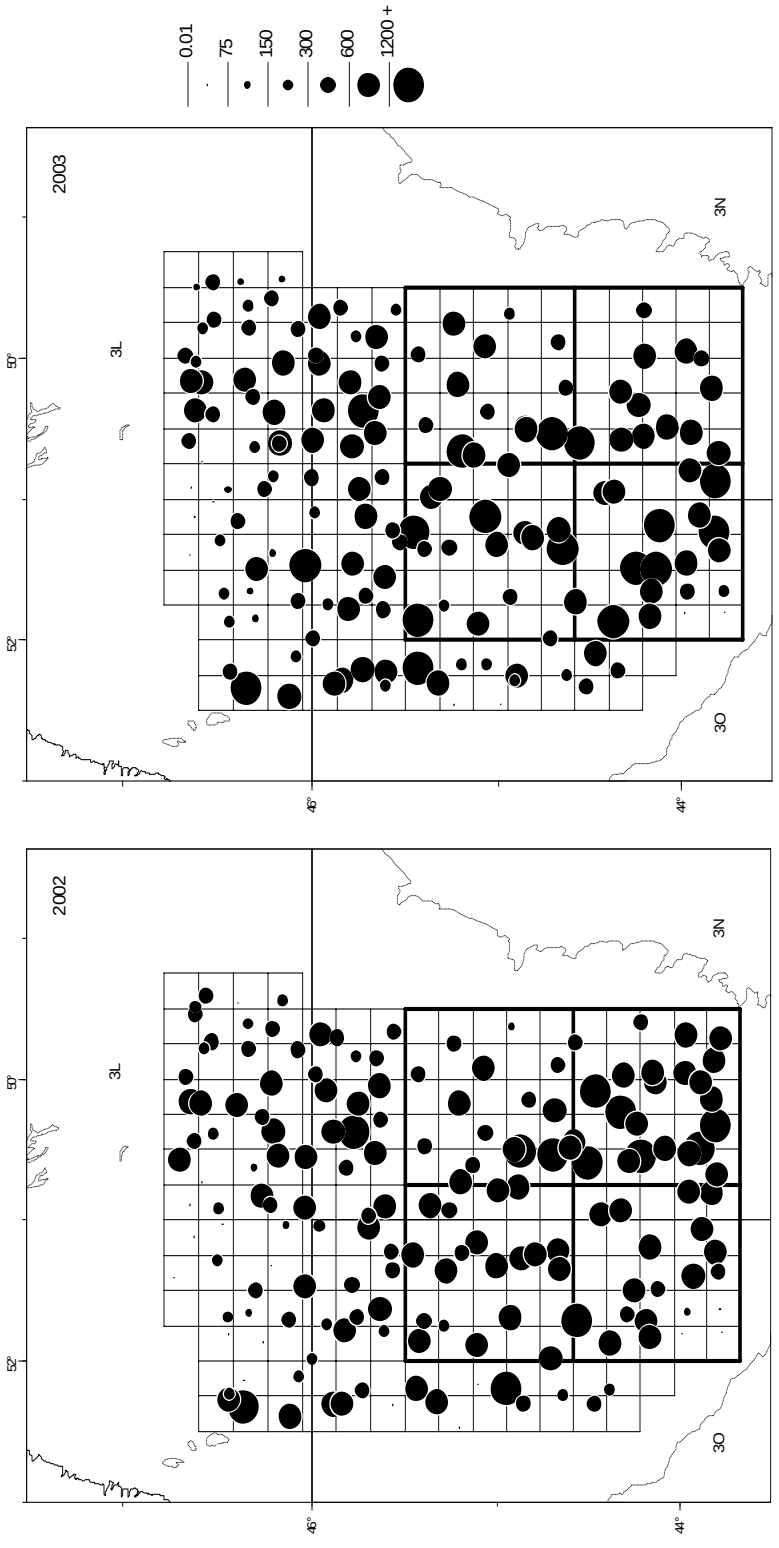

Figure 6. Distribution of yellowtail flounder catches (kg per standard 3Nm. tow) from industry grid surveys conducted in NAFO Div. 3LNO in 2002 and 2003.

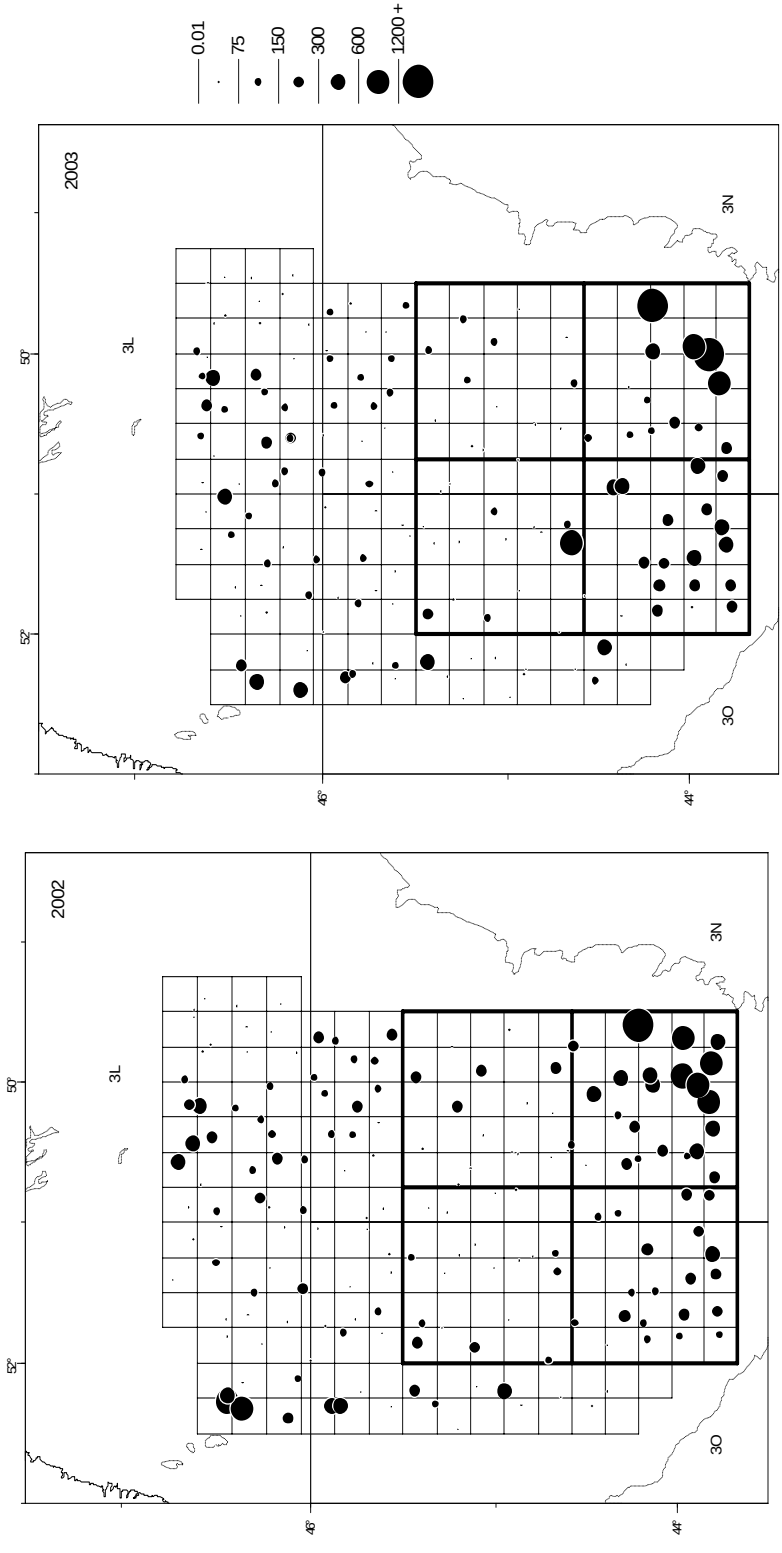

Figure 7. Distribution of American plaice catches (kg per standard 3Nm. tow) from industry grid surveys conducted in NAFO Div. 3LNO in 2002 and 2003.

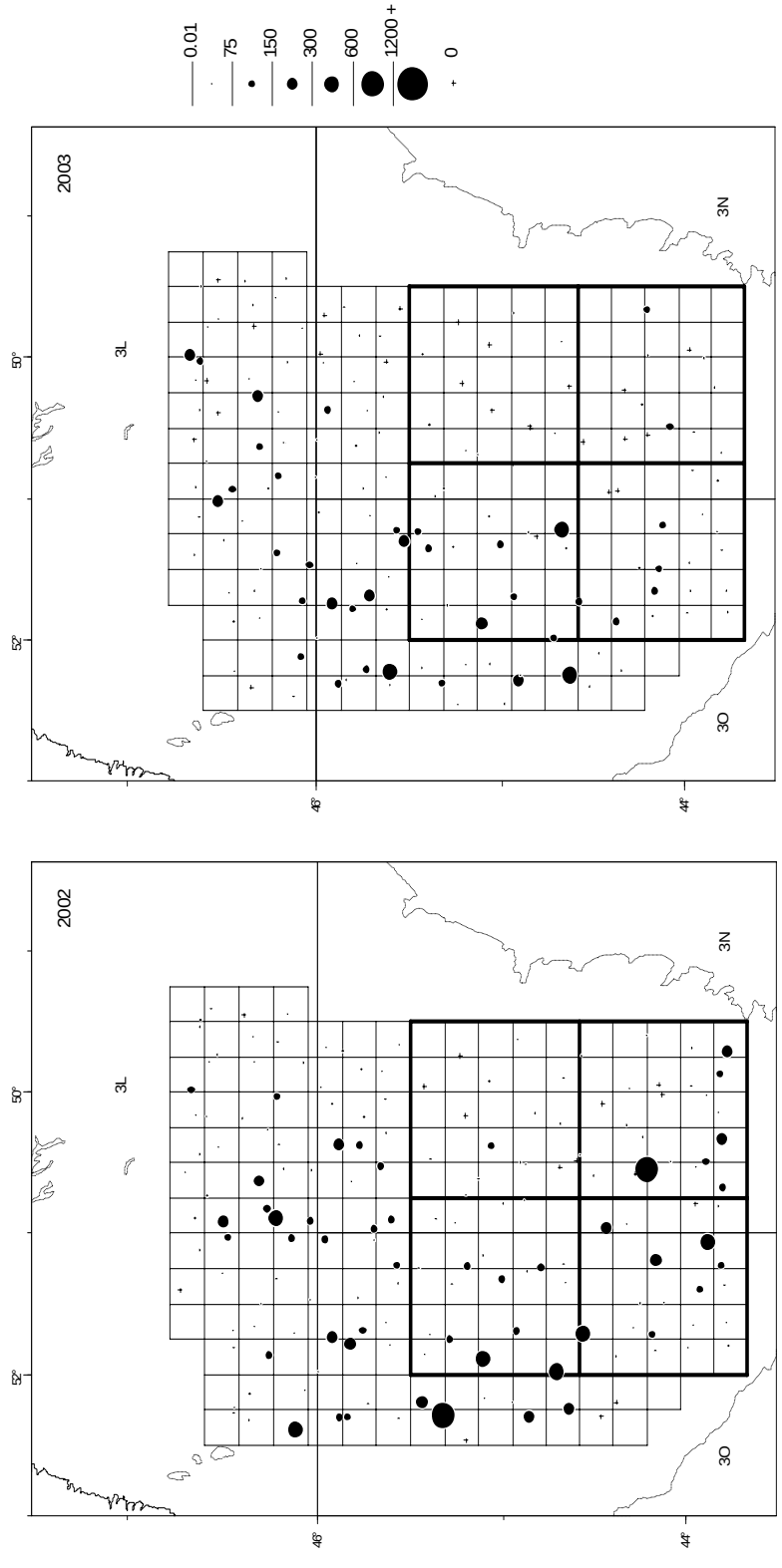

Figure 8. Distribution of atlantic cod catches (kg per standard 3Nm. tow) from industry grid surveys conducted in NAFO Div. 3LNO in 2002 and 2003.

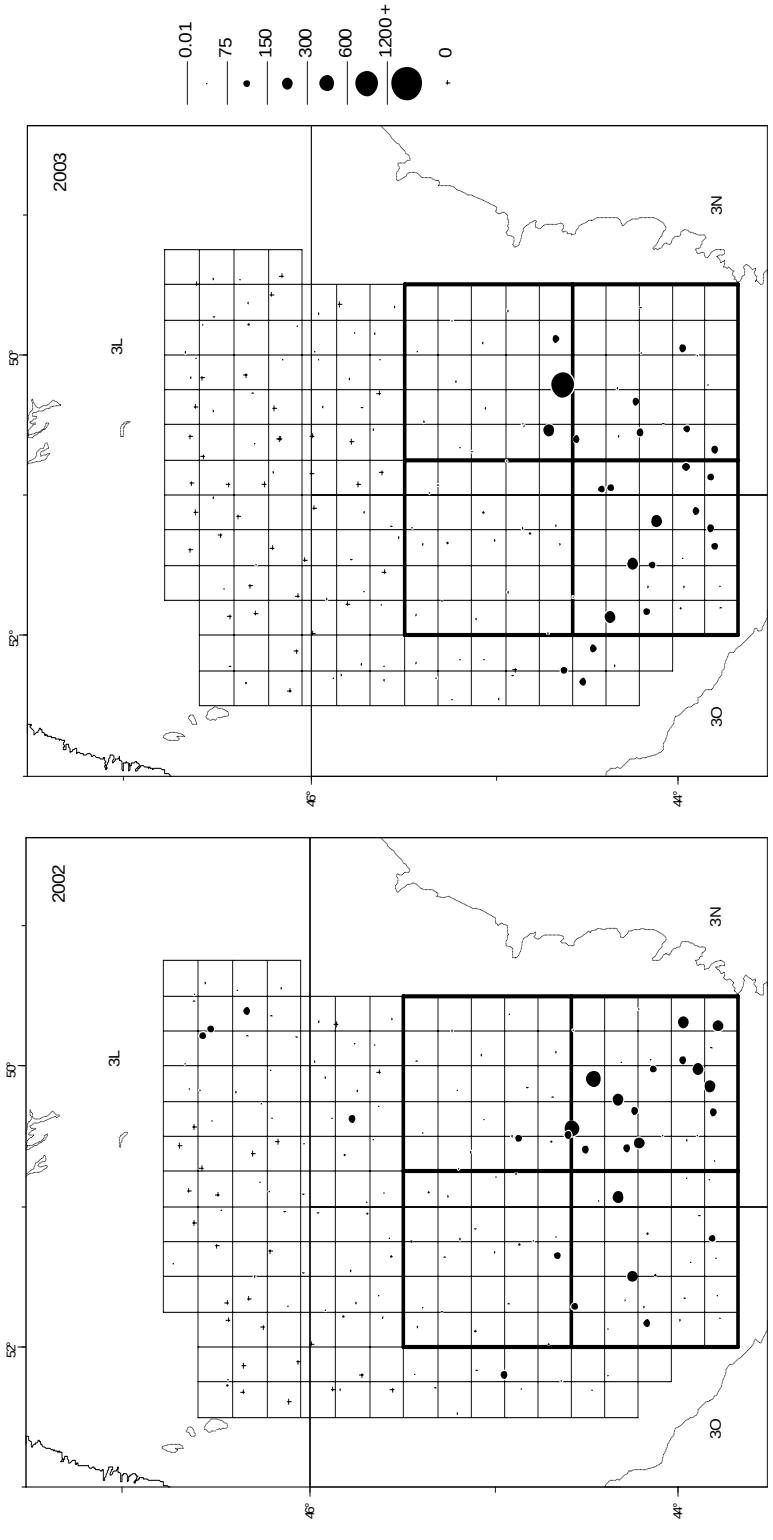

Figure 9. Distribution of thorny skate catches (kg per standard 3Nm. tow) from industry grid surveys conducted in NAFO Div. 3LNO in 2002 and 2003.

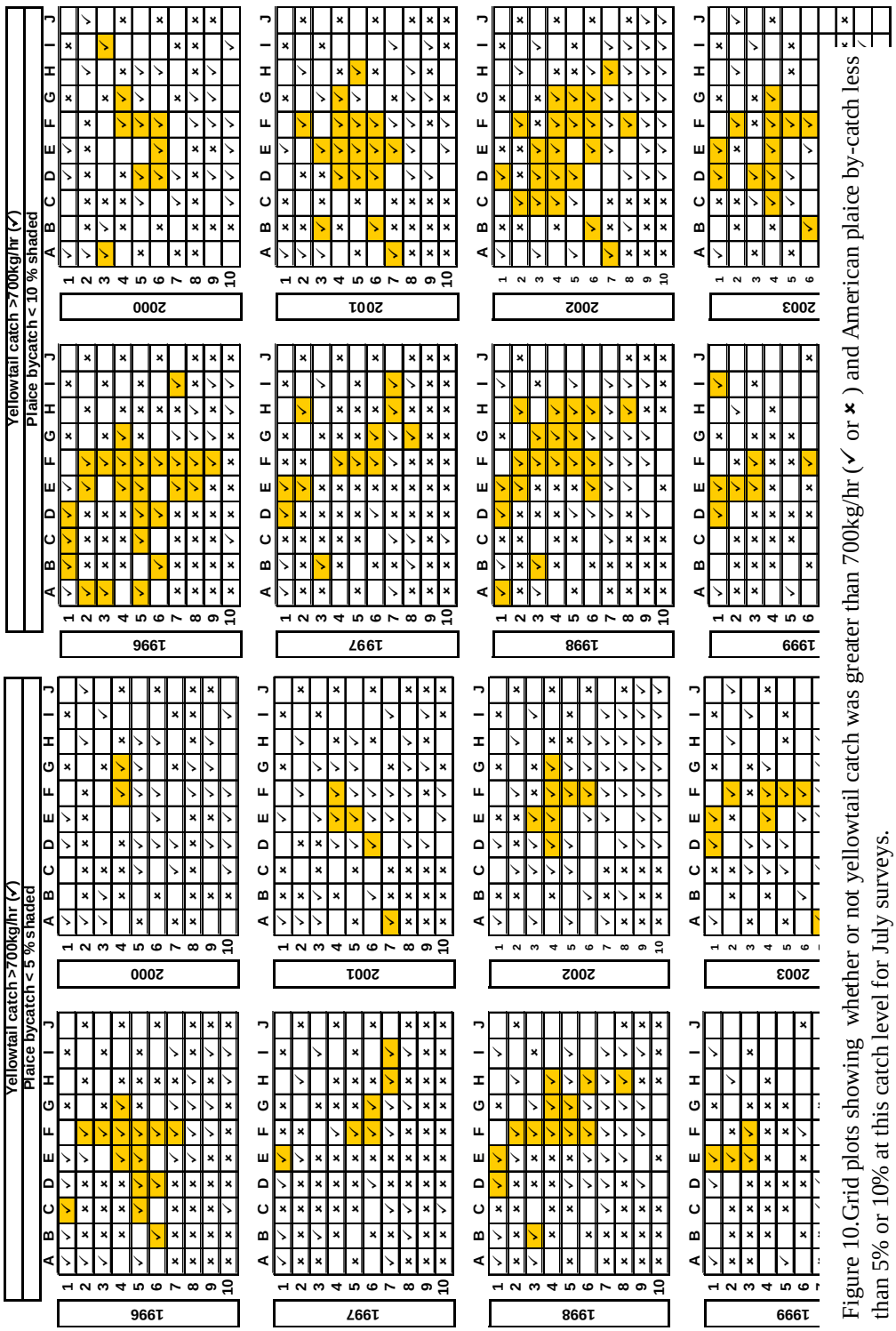

Figure 10.Grid plots showing whether or not yellowtail catch was greater than 700kg/hr (✓ or ✗) and American plaice by-catch less than 5% or 10% at this catch level for July surveys.

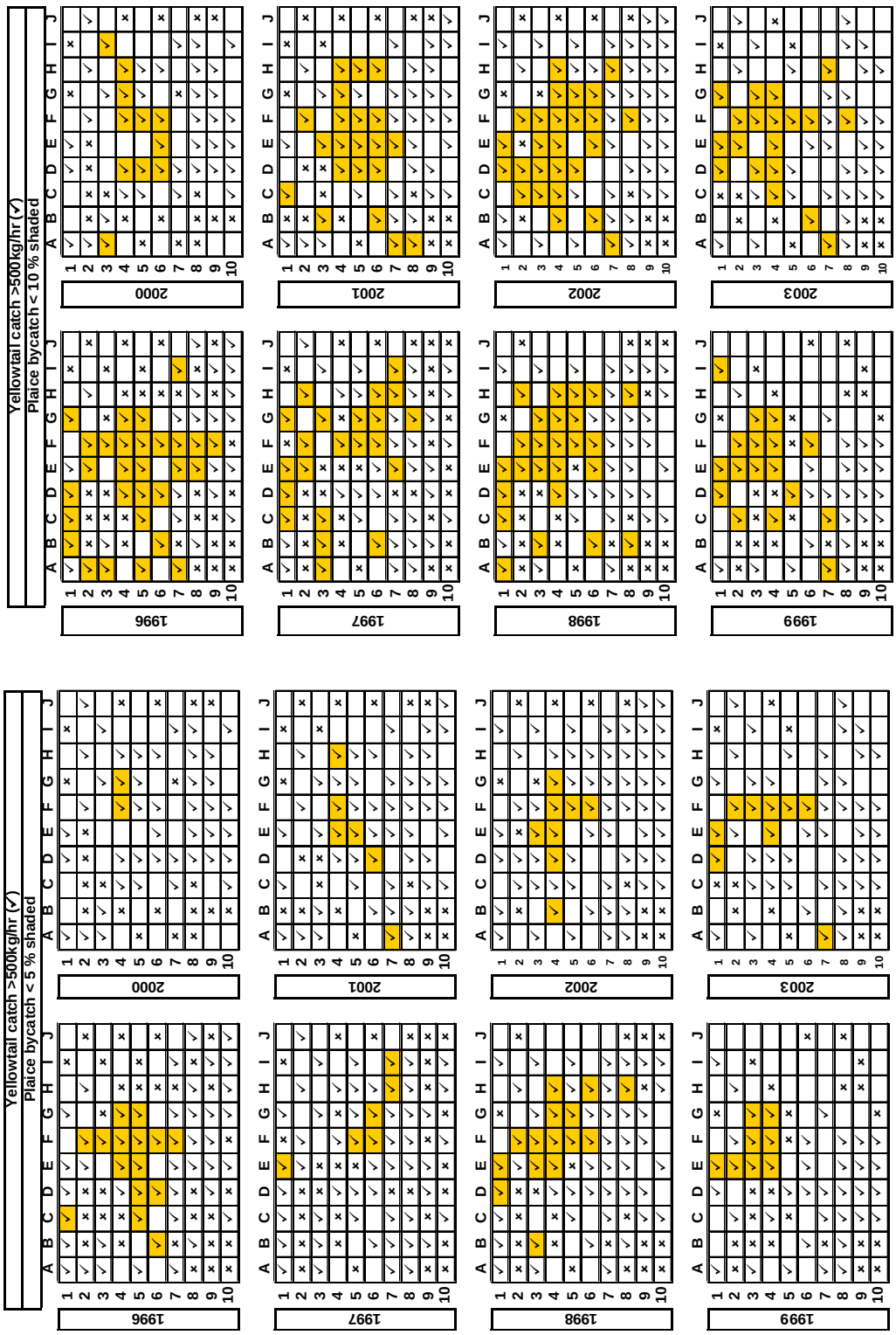

Figure 11.Grid plots showing whether or not yellowtail catch was greater than 500kg/hr (✓ or ✗) and American plaice by-catch less than 5% or 10% at this catch level for July surveys.

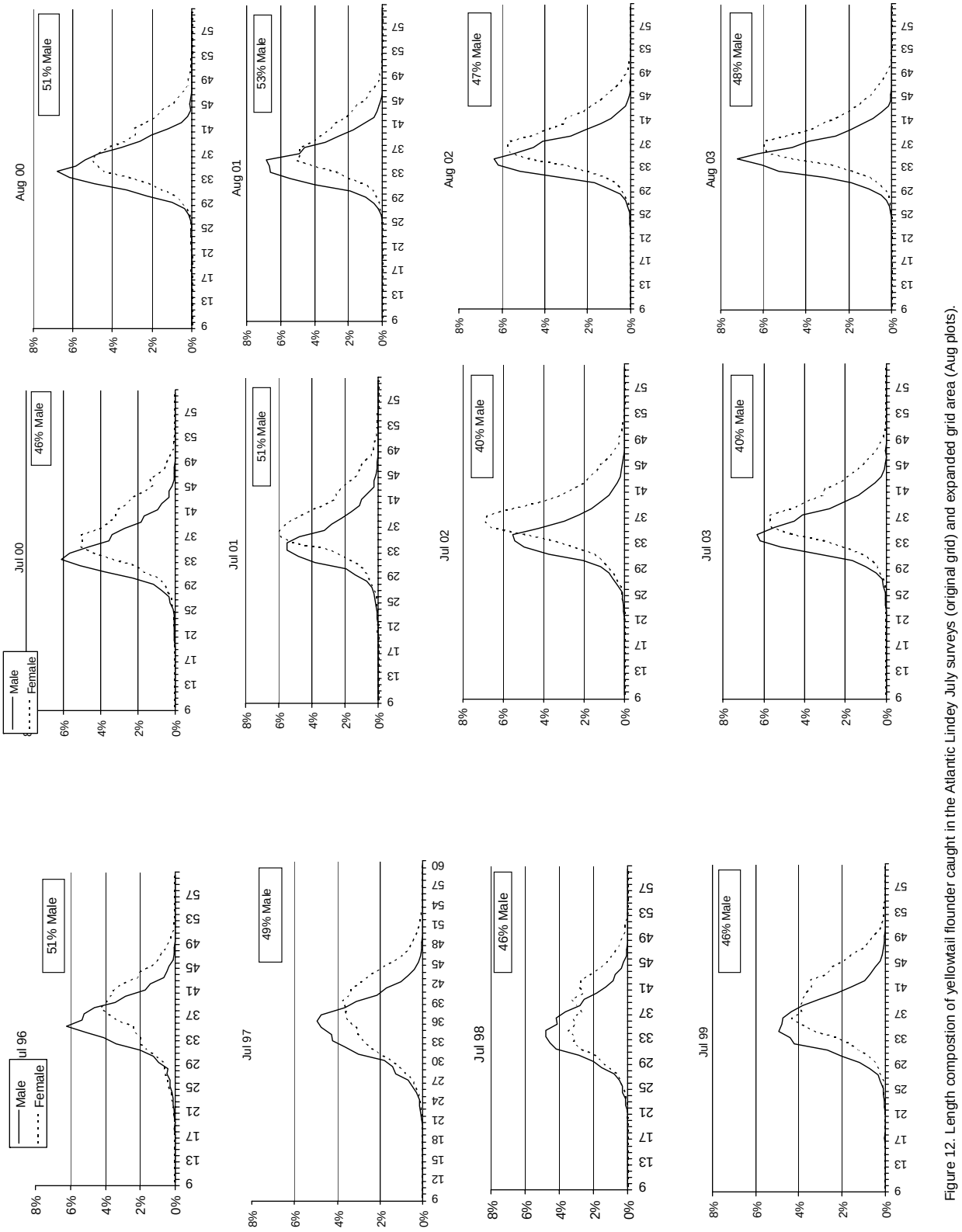

Figure 12. Length compostion of yellowtail flounder caught in the Atlantic Lindey July surveys (original grid) and expanded grid area (Aug plots).

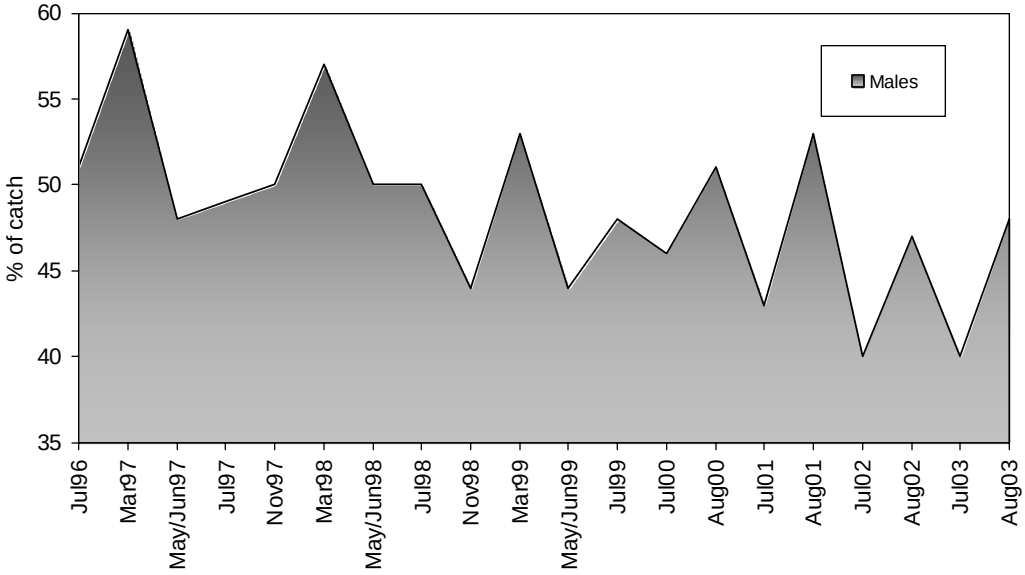

Figure 13. Sex ratio of yellowtail flounder catch for the Atlantic Lindsey surveys.

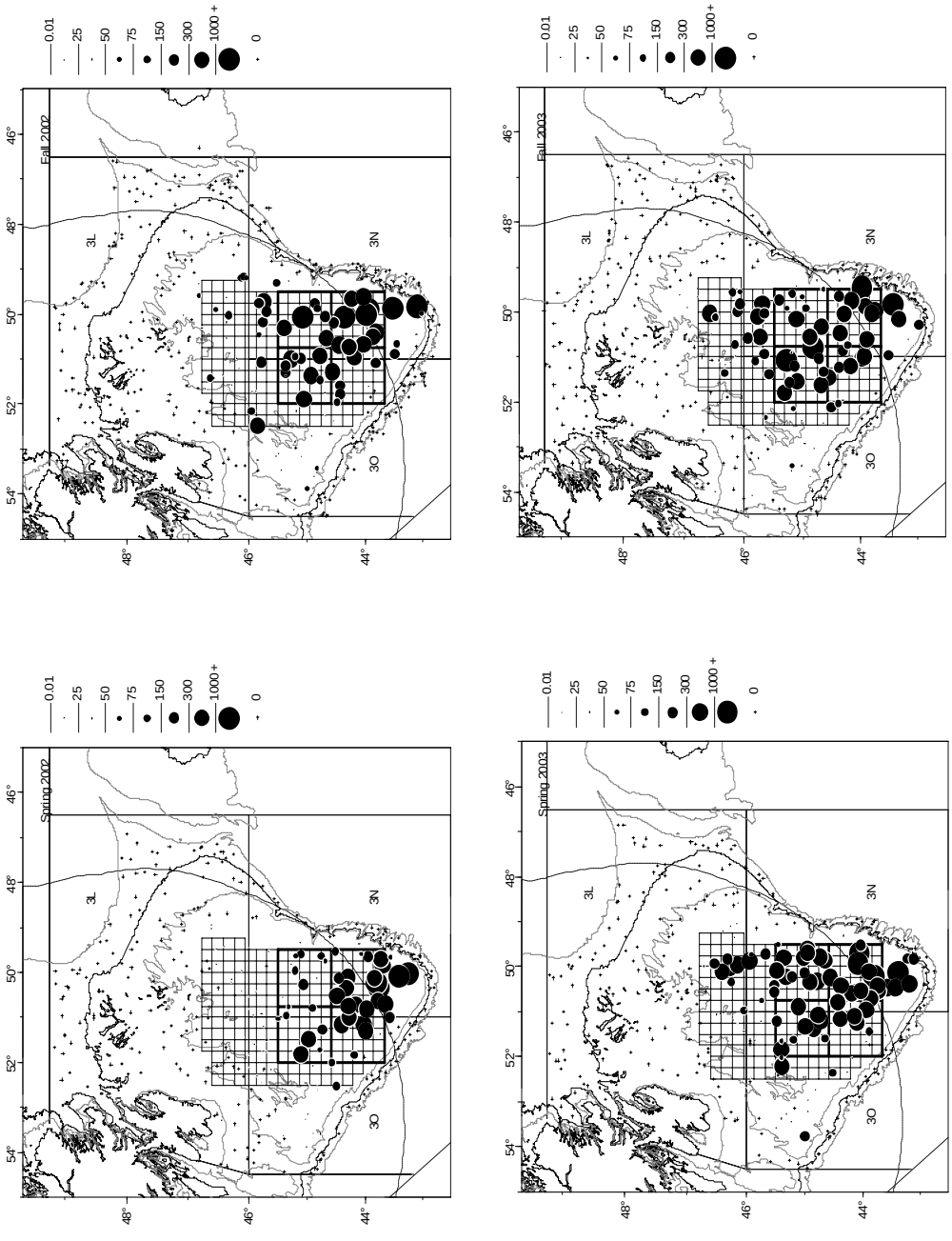

Figure 14. Distribution of yellowtail flounder catches (number/tow) from stratified random spring and fall surveys conducted in 2002 and 2003 with a Campelen 1800 trawl in Div. 3LNO. Grid used in DFO-FPI suveys is depicted for illustration.

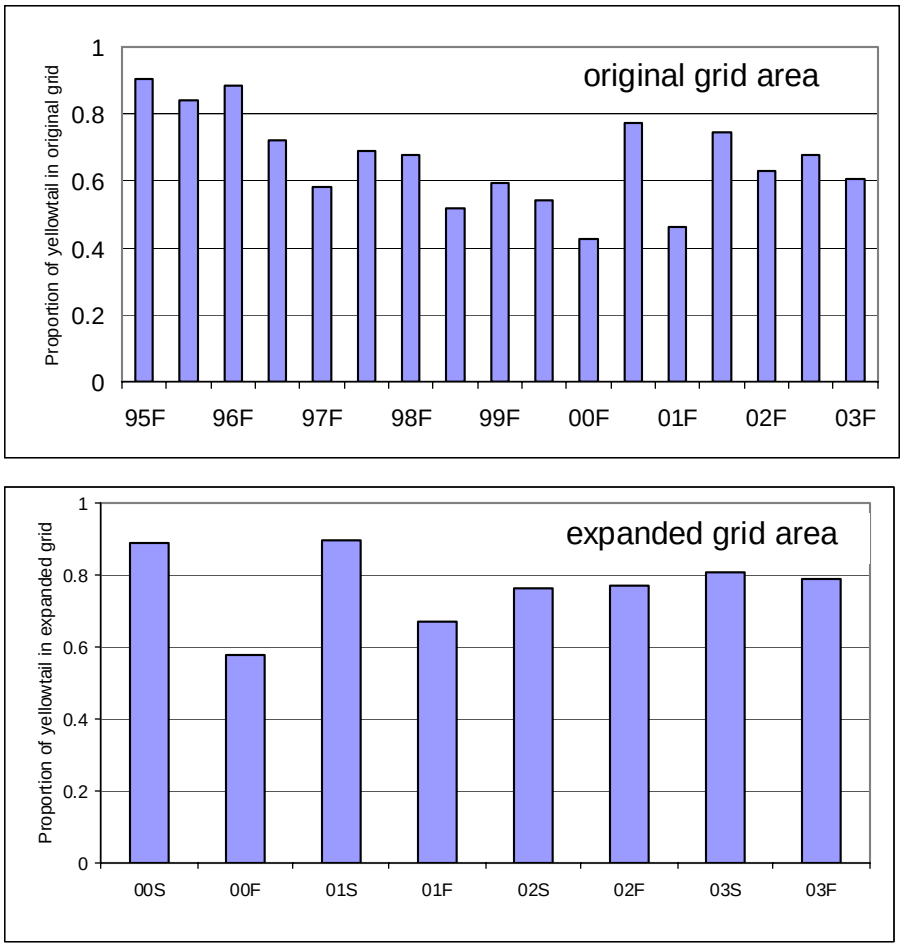

Fig. 15. DFO spring (S) and fall (F) surveys, 1995-2003 - proportion of total yellowtail flounder, by weight, caught within the original grid area (upper panel), and expanded grid (lower panel).

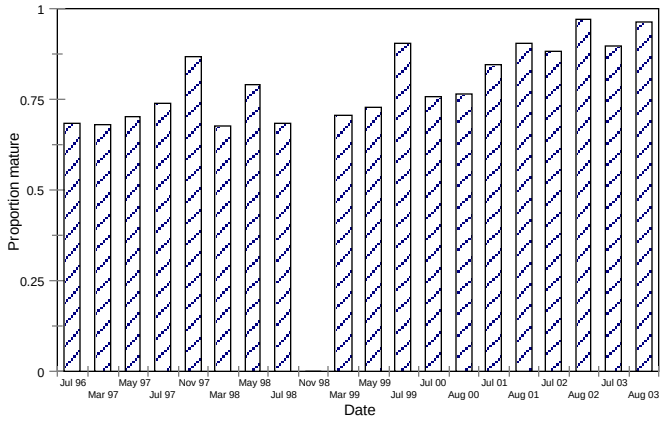

Fig. 16. Proportion of female yellowtail flounder considered to be sexually mature, from grid surveys in Div. 3NO

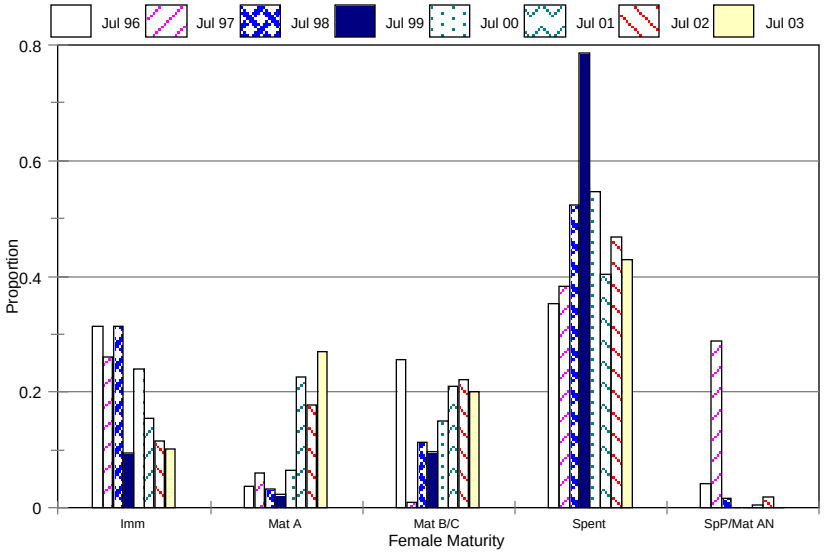

Fig. 17. Maturity stages of female yellowtail flounder, from grid surveys conducted in July in Div. 3NO.

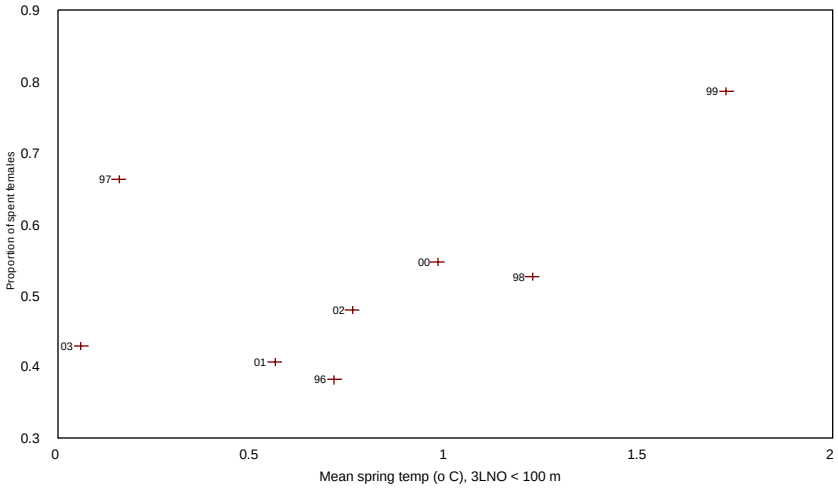

Fig. 18. Relationship between proportion of spent female yellowtail in the July grid surveys, and the mean spring bottom temperature, 3LNO < 100m.