Northwest Atlantic Fisheries Organization

Serial No. N4299 **NAFO SCR Doc. 00/58**

SCIENTIFIC COUNCIL MEETING – SEPTEMBER 2000

Re-emergence of a Traditional Fishery in a Different Form - Description of the 1998 and 1999 Yellowtail Flounder Fishery on the Grand Banks with a Comparison to the Historic Mixed Fishery

by

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Abstract

The purpose of this paper is to provide a spatial/temporal description of the closely monitored and regulated, re-emerging yellowtail flounder fishery on the Grand Banks. This detailed description can assist managers and industry in planning and prosecuting the expanding fishery in a conservative and rational manner. Yellowtail was prosecuted in 1999 for the second year following a 3-year moratorium. Monitoring of the 1998 and 1999 fishery in the form of nearly full coverage by fishery observers facilitated a detailed examination of the catch, effort and biological parameters of the fishery. Comparing the 1998 and 1999 fisheries: duration – Aug. 1 to Nov. 15 in 1998, Apr. 23 to Nov. 12 in 1999; both were prosecuted on 4 distinct fishing grounds covering only 6.6% (1998) and 9.8% (1999) of the total area of the Grand Bank where bottom depth was less than 100 m. The 1999 fishery differed spatially from 1998 in that it extended further to the north. A new ground bordering on NAFO Div. 3L produced some of the highest catch rates ever observed for yellowtail (average 2.4 t per hour avg. in Apr.-May). Regulatory restrictions and location of dense concentrations resulted in yellowtail dominating the catches in all areas fished. This general pattern of directing for yellowtail where they were highly concentrated was very similar to 1998 but in contrast to the past practise of taking yellowtail in a mixed fishery over a very wide area (43% of the bank less than 100 m). Yellowtail flounder was successfully exploited as a single target species rather than part of a mixed fishery (per the historical fishery) by concentrating effort where it was most abundant and other restricted species, particularly American plaice and cod were minimal. By-catch levels within the regulated 5% limit for cod (1998 - 2.3%, 1999 – 1.3%) and plaice (1998 - 4.2%, 1999 – 4.3%) were achieved primarily by targeted spatial concentration of effort. The deployment of an excluder grate also contributed to the low by-catch levels of cod. Size of fish taken and particularly ratio of males to females in the catch was observed to differ among the 4 grounds fished. Proportion of males was much higher on the centrally located "bachelor" Ground 2 than other areas fished (99% and 86% males in 1998 and 1999 respectively). Other areas were closer to 50:50. Over all areas, average size and range of sizes of in the catch was very similar between years: mean size of males was 36.5 cm in 1998 vs. 35.9 cm in 1999 and females were 39.5 cm in 1998 vs. 38.7 cm in 1999. The size range and shape of frequencies was also consistent across grounds and years suggesting a similar age compositions over the entire grounds fished. Sizes were also consistent between years. Numbers of small fish (juveniles), those less than 26 cm constituted only 0.91% in 1998 and 0.43% in 1999 and those less than 30 cm (management cut-off) in the catches amounted to 5.31% in 1998 and 5.04% in 1999, a very small and consistent (between years) percentage of the catch The period of the fishery concentrated on a post-spawning fish in 1998 but targeted spawning concentrations in 1999 during the first three months of the fishery. A total of 12.9 million individuals were estimated to have been removed by the fishery in 1999 compared to 7.3 million in 1998, 1% of the population estimate in Div. 3NO.

Introduction

Yellowtail flounder (*Pleuronectes ferruginea*) is distributed off Newfoundland across much of the shallow portions of the Grand Banks within NAFO (Northwest Atlantic Fisheries Organization) Divisions 3L, 3N, 3O and Subdivision 3Ps (Fig.1). Early research survey work showed that the largest concentrations in Canadian Atlantic waters were located on the central part of the bank in less than 100 m (Walsh et al. 2000). A trawl fishery was initiated in Divisions 3L, 3N and 3O in 1960 during an expansion of fishing effort by Canada to the offshore and yellowtail flounder was found to be commercially viable. Since that time, until 1994, yellowtail had been exploited primarily as a part of a mixed fishery with cod (*Gadus morhua*) and American plaice (*Hippoglossoides platessoides*). Effort occurred mainly during the summer months over a large proportion of the Grand Bank. Over that period, total annual catches varied considerably ranging between 7 t in 1960 and 39,259 t in 1972 (Walsh et *al*. 1998). Except for the peak years of 1985 and 1986, catches between 1976-93 were in the range of 10,000 to 18,000 t. Walsh et *al*. (1999, 2000) provides further details of the historic fishery.

A productive mixed fishery for over 30 years, the NAFO Fisheries Commission closed the Grand Bank to directed fishing for yellowtail, plaice and cod in 1994. This action was taken even though a 7,000t TAC (Total Allowable Catch) for yellowtail had been recommended for that year. The fishery was closed because TAC's had been exceeded each year from 1985 to 1993, unreported catches outside 200 miles were a concern and overlapping cod and plaice stocks were in decline (NAFO Scientific Council). From 1995 until 1997, the only commercial catches of yellowtail on the Grand Banks occurred outside Canada's 200 mile limit, Reported as by-catch in other fisheries, 2,069 t was reported as taken primarily by Spain in 1994 subsequently falling to less than 300 t annually in 1995-97. Following 3 years of closure, the NAFO Scientific Council indicated that yellowtail in 3LNO was abundant enough to support a limited fishery in 1998 and an expanded fishery in 1999. The Council stipulated that the fishery be carefully monitored and sampled in both years including 100% coverage by Canadian fishery observers.

Stock assessments for yellowtail in 3LNO from 1994 to 1996 indicated low biomass and a moratorium on fishing for yellowtail (as well as plaice and cod) remained in affect in those years. In 1997, no analytical assessment of yellowtail was possible due mainly to uncertainties with catch and catch-at-age data (NAFO Scientific Council). However, given the reduced mortality due to the three year moratorium on fishing, many age classes were contributing significantly to the biomass and that the stock size had increased since 1994. Thus, the Council indicated that the stock should be able to sustain a limited fishery. A commercial fishery for yellowtail flounder was re-instituted in 1998. However, the stock biomass had not returned to historic levels and Scientific Council recommended that the TAC not exceed 4,000 t for 1998. Based on increased biomass of fully recruited fish, the quota was increased to 6,000 t for 1999. Of this, 5,850 t was allocated to Canada to be fished solely within the 200 mile limit. NAFO allocated 80 t to the European Union and the remainder to "other". The quota was allocated in this manner based on pre-moratorium allocations.

Historically, the Canadian fishery was prosecuted offshore by otter trawlers greater than 100 ft and it was this fleet sector that received most of the Canadian allocation from the re-opened fishery; 202 (1998) and 275 t (1999) for Nova Scotia based vessels, 3,581 (1998) and 5,439 t (1999) and for Newfoundland vessels for a total of 3,846 (1998) and 5,714 t (1999). The remaining 54 (1998) and 136 t (1999) was allocated to Canadian vessels 65-100 ft. For 1998, it was recommended that fishing should take place only after peak spawning was completed in June-July and the start date was set for Aug. 1. In 1999, fishing was permitted year round except from June 15-July 31, the peak period of spawning. Fishing on the northern part of the Grand Bank (NAFO Div. 3L) was prohibited given the continued low biomass index in this area (historically, 3L was not an area of dense concentration of yellowtail and thus not an important fishing ground for this species). In NAFO Divisions 3N and 3O, directed fishing was permitted only inside Canada's 200 mile limit.

Based in part on recommendations from NAFO, an Atlantic Canada Conservation Harvesting Plan (CHP) for vessels greater than 100 ft was used to define the parameters of the yellowtail fishery in 1998 and 1999. Restrictions were put in place to minimize by-catch of cod and American plaice still under moratorium: "Pursuant to NAFO Conservation and Enforcement Measures, "incidental catches of (each of plaice and cod) could not exceed 1,250 kg or 5% by weight of the total weight on board, whichever is greater". Exceeding this level would result in closure for 10 days and the invocation of a test fishery before reopening. Net material was restricted to diamond configuration and minimum mesh size permitted was 145 mm. Based on an earlier recommendation, the 1999 CHP specified use of a minimum 155 mm diamond mesh in the codend. However, mesh size as small as 145 mm were observed in

1999 as well as 1998. Although vessels were not required by regulation to deploy sorting grates for the purpose of reducing by-catch, all Newfoundland vessels used a rigid grate as a measure to maintain by-catch below the 5% threshold that would lead to closure of the fishery. An earlier joint study by Industry Development Division of Fisheries and Oceans and the fishing industry (Hickey et *al*. 1995) showed that by use of a rigid vertically oriented grate, cod by-catch could be reduced at locations where they mixed with flatfish species. A small fish protocol was employed to avoid excessive catch of small (not yet mature) fish. Under this directive, if the number of undersized fish exceeded 15% of the catch on any day, an area would be closed to yellowtail fishing for 10 days. For monitoring purposes, yellowtail flounder were considered undersized if less than 30 cm.

The 1998 season for yellowtail extended from Aug. 1-Nov. 15 and Apr. 23- Nov. 24 in 1999. In total, 9 vessels in 1998 and 15 in 1999 participated in the large vessel fishery (description of the 1998 fishery was presented by Kulka 1999). Fishery observers were required to monitor fishing activity in relation to regulations as well as guidelines laid out in the CHP. Complete coverage of the large vessel (greater than 100 ft) fleet by fishery observers was stipulated. Gear configuration, by-catch of restricted species and size of yellowtail (small fish protocol) were monitored. The limited Canadian 65-100 ft vessel effort was not observed (although landings were monitored dockside for all fleets). The information collected by fishery observers was also of use in assessing the impact of the fishery on the Grand Bank stocks and of benefit to industry is terms of strategic planning for upcoming fisheries. Set by set details of catch, by-catch, effort, fish size and details of gear configuration was acquired facilitating a detailed spatial/temporal examination of the 1998-99 Canadian fishery. The level of detail as recorded by observers is available from no other source.

The current paper focuses on spatial and temporal aspects of the 1999 and 1999 fisheries in comparison the pre-moratorium fishery. It examines spatial configuration of the fishing activity with respect to the distribution of yellowtail, plaice and cod derived from research surveys. It also describes spatial and temporal aspects of size, maturity and number of fish at length in the catches. The paper also looks at affect of gear modifications, in particular, the relationship of catch rate and fish size to various codend mesh sizes used and the effect of a sorting grate attachment on (by)catch rates and catch composition.

Methods

Fishery observers collected geo-referenced (latitude and longitude) information on the catch, effort and other details of the capture of yellowtail such as gear configuration and fishing strategies from the 1998 and 1999 large vessel yellowtail fishery in a manner specified in Kulka and Firth (1987). A comparison of total catch of yellowtail as recorded by the observers (3,555 t in 1998, 5,424 t in 1999) to landing statistics recorded by Fisheries & Oceans, Resource Allocation (3,795 t in 1998, 6,609 t in 1999) indicated that observed catch (sets where observers estimated catch by species) was 94% in 1998 and 82% in 1999 of the reported landings on NAFO Divisions 3N and 3O (observer data for Maritimes based vessels in 1999 were not available for this analysis and 65-100 ft vessels were not monitored in either year). It is estimated that a total of 1,777 and 3,259 fishing sets were prosecuted in the 1998 and 1999 yellowtail fishery respectively. A ratio of the landed to the observed catch of yellowtail was used to adjust observed by-catch weight to an estimate of total weight caught for each species taken in the fishery. Table 1a and c specifies, by month and fishing Ground, the number of sets from the observed fishery that were used for the spatial analysis and as well, it provides a summary of the associated catch, effort, by-catch, depth and gear parameters. Table 1b and d specifies the survey effort. The data were analysed by Ground rather than NAFO Division given that the grounds were not spatially distinct by division. The dividing line between Div. 3N and 3O was close to Ground 1 and overlapped Grounds 2-4.Ground 5 is solely contained in 3N but borders on 3L.

Potential mapping in SPANS (Anon 1997) was used to convert the commercial catch and effort and fall research trawl point data to surface maps describing the distribution of the fishery and the distribution of yellowtail in NAFO Divisions 3N and 3O. The potential mapping method transforms points (fishing sets consisting of catch (tonnes) per hour for the commercial fisheries data and standardised catch (kg) per tow for survey data) to a continuous surface spatially depicting differential densities of fish (catch rate subareas) or density of fishing effort (areas depicting differential in sets per km^2) by placing a circle around each point. The values of all points that fall within the circle (ie all points that are located within a specified distance of the circled point) is averaged and this value is assigned to the area encompassed by the circle. The procedure is repeated for each point creating overlapping circular areas equal to the total number of sets. A further averaging takes place where the circles overlap resulting in the creation of many more areas. The values from resulting areas are assigned to an underlying quadcell (a quadcell being a

variable sized raster dividing the study area into a fine grid). An integration of classified quadcells forms a surface depicting density of the fish. For this method, by choosing the appropriate circle size, the technique effectively smoothes the data at its maximum resolution, i.e. at the spatial distance of the fishing sets without extrapolating beyond the bounds of the data or interpolating within the matrix of points. Refer to Anon (1997) and Kulka (1998) for a more detailed technical description of the potential mapping method and quadcell structure within SPANS and its application to mapping and biomass analyses of marine species.

Different circle sizes were used for the commercial fisheries data and the research survey data because of very different average distances between sets (the commercial data points were much more closely situated than the survey points). In both cases, size of circle was increased until there were no gaps in the resulting surface thus defining optimal size. Further increasing circle size increasingly smoothes the data to a point where a single circle encompassing all points results in a single stratum with an average catch rate (density estimate) of all points. Thus, the smallest circle that can provide complete coverage of the survey area (no gaps between circles), the more detailed the definition of spatial variation of fish density (refer to Kulka 1998 for a detailed explanation of circle size selection). For the commercial fisheries data, a circle radius of 6 km was selected from a range of 1 to 8 km circles based on the criteria described above. Choosing this size had the added advantage that it corresponded the spatial scale of fishing effort. The length of a fishing set i.e. a typical set by a trawler fishing for yellowtail in 1998-99 extended over 14 km respectively. Thus, calculations of areas fished at the spatial resolution of fishing activity reflected the true extent of the fishing grounds. Spatial resolution fort the research survey data was much lower. The distance between sampling points was much greater, ranging from about 20 to 70 km. A series of circle sizes with 2 to 42 km. diameters by 2 km intervals were tested. A 38 km circle was chosen as the smallest that would create a surface with minimal gaps for the 1998 survey data in Divisions 3NO. The perimeter of the resulting density surface was constrained by the land/water boundary and the 1000 m depth contour.

The fishery took place at a number of distinct locations near the border of Divisions 3N and 3O. For the purpose of analyzing spatial patterns in catch rates, by-catch and size of fish in the catches, the area fished was delineated by 4 boxes encompassing 5 grounds (spatially distinct areas of fishing activity) observed to have been fished in 1999. Grounds 1 and 2 (Fig. 2), the major fishing areas were each assigned to a separate box for the purpose of spatial analysis. Ground 3 and 4, minor adjacent areas combined as 1 box, hereafter are referred to as Ground 3 are analysed as a unit. Ground 5, an extensive area bordering on NAFO Div. 3L was only fished in 1999. NAFO Divisions were not used in the analyses because their borders bore no relationship to distribution of the fish or the fishery.

Biological monitoring of the 1998 and 1999 yellowtail fishery comprised the collection of catch lengths and ageing materials (otoliths) by sex. However, difficulties in interpretation of the growth rings of the otoliths prevented ageing of the fish. This information was gathered using the protocols outlined in Kulka and Firth (1987). The length samples materials covered all time periods and areas fished allowing for a detailed spatio-temporal analysis of fish sizes in the catches. Data on maturity were also collected by port samplers. Table 2 specifies the catch (landings) and sample weight, number of fish measured and number of otoliths collected for the analysis of fish size and age in the commercial catches by fishing ground and month (refer to Fig. 2 for a delineation of fishing grounds). A total of 418 (1998) and 468 (1999) length samples were taken comprising 53,712 (1998) and 90,280 (1999) fish measured and sexed from the catches of the yellowtail fishery. Due to high the high level of coverage, the yellowtail catches were intensely sampled for length by sex. Proportion of total catch sampled was high, about 1.4% by weight and 1.0% by number. For all samples, weight was obtained by direct measurement. Sampling was spread proportionately across all fishing grounds and time periods and were spatially well distributed. A total of 1,534 fish from August in 1998 and 976 fish from May, June and August in 1999 were examined for stage of maturity. Each length frequency was adjusted to the catch weight for each set prior to estimation of numbers caught by sex for each length group by area (fishing ground) and by month. Numbers of fish at age were estimated by fishing ground by quarter of the year. Delineation of data by NAFO Division was not done since the areas fished were spatially unrelated to the line separating the two Divisions. All areas fished bordered on or overlapped Divisions 3N and 3O. Estimates were done by quarter in the same manner as was done for stock assessments. Other narrative information including industry opinions on the fishery, fishing strategies and the stock status recorded in observer trip reports are also discussed in the context of patterns observed in the data.

Results and Discussion

Spatial and temporal analysis

At depths less than 100 m, the Grand Bank is a large, relatively flat fishable area covering 141,000 km^2 (Fig. 1). Yellowtail flounder are distributed over most of this area in varying densities (refer to research survey results described below). The records collected by fishery observers show that the 1998 fishery for yellowtail extended over 8,986 km^2 or 6% of the Grand Bank at depths less than 100 m (Fig. 2). The 1999 area fished was 32% larger at 13,353 km^2 (10% of the available area) due to an expansion of effort to the north. However, this was still only a fraction of the 61,000 km^2 fished annually during the pre-moratorium mixed cod/plaice/yellowtail fishery (based on the 1991 to 1993 fisheries). The pre-moratorium fishery also covered a much wider range of depths as deep as 500 m (Fig. 2) whereas in 1998 and 1999, 95% of the fishing was restricted to 50 to 100 m.

The fishery took place at 5 distinct locations near the border of Divisions 3N and 3O (spatial statistics in Tables 1 and 2, catch statistics by month in Fig. 3 and maps of grounds in Fig. 4). In 1998, 4 areas were fished. Ground 1, the most densely fished and largest area extending over 4,010 km^2, contained 68% of the total effort and was centered at Lat. 44' 45^0, Lon. 50' 25^0. At 54 m average depth fished, this was the shallowest of the grounds. It is closest in proximity to the yellowtail nursery grounds located to the south on the Southeast Shoal (Walsh 1992). As well, it was the only area fished during all months (August-November) of the fishery. The other major area fished in 1998, Ground 2 at 2,630 km^2 was $2/3^{rds}$ the size of Ground 1 but contained only 29% of the total effort. It was centered northwest of Ground 1 at Lat. 45' 15^0, Lon. 51' 00^0. Fishing was deeper at this location (71 m) and took place from August to October. The other two minor Grounds 3&4 covered 1,780 km^2 but contained only 3.5% of the total effort. Similar to Ground 2, average depth fished was 72 m but effort took place only at the start of the fishery in August until mid September.

The 1999 fishery was also prosecuted at 4 discreet locations (Fig. 3) and similarly, 97.5% of the effort was concentrated at 2 locations. Ground 1, centred at Lat. 44' 45^0, Lon. 50' 25^0 is the most densely fished and largest area extending over 5,660 km^2. It contained 59% of the total effort and yielded 51% of the catch of yellowtail. This area was fished during all months but May and June (Table 1) but primarily during the latter months of the fishery. A new Ground (5) was fished for the first time in 1999. It extended over 4,271 km^2 and contained 39% of the total effort but yielded 48% of the catch because of higher catch rates in that area. It is centered north of Ground 1 at Lat. 45' 45^0, Lon. 50'00^0. Depth fished in this area averaged 73 m and was most heavily fished during the early part of the season. The other two minor Grounds 2 and 3 covered 3,420 km^2 but contained only 2.5% of the total effort and 1.7% of the catch. Average depth fished was 72 and 67 m for Ground 2 and 3 respectively. Effort although limited there took place during all months of the fishery except May.

In both 1998 and 1999, Effort fishing sets were spatially concentrated at any point in time. On average, an area of 3,500 km^2 was fished per month, only one quarter of the total extent of the grounds and about half of the total area fished contained 98% of the fishing sets illustrating that fishing effort for yellowtail was highly localized. This pattern resulted from a co-ordinated fleet effort to target dense concentrations of yellowtail and avoid areas where American plaice were concentrated as will be demonstrated below.

Catch rate (t per hour), reflecting local density of the fish varied over the area fished. In 1998, Fig. 5, middle panel and Table 1a show that the highest catch rates (average 0.91 t per hour) were achieved at Ground 4 although fishing effort there amounted to less than 4% of total sets prosecuted. Effort in this area was limited because of high by-catch. Plaice averaged about 8-9% of the total catch, exceeding the 5% regulatory limit. For the main areas fished in 1998, Grounds 1 and 2, catch rates were similar averaging 0.738 and 0.812 t per hour respectively over the entire period of the fishery. Thus, by concentrating effort where catch rate of yellowtail were moderately lower, the fleet was able to maintain by-catch levels within the specified guidelines. On Ground 1, catch rates were spatially fairly homogeneous although slightly higher at the centre of the ground and also to the south-east. Best catches on Ground 2 were taken on the north-east portion of the ground. In addition, there were a few large sets to the west. The pattern was somewhat different in 1999. Fig. 5, right panel and Table 1c show that the highest catch rates for either year (average 1.3 t per hour) were achieved at Ground 5 (an area not fished at all in 1998). Catch rates and corresponding effort within Ground 5 were highest to the west and during the earlier part of the fishing season, illustrated in the blow-up panel (lower right) of Fig. 5. On the south-west part of this ground, an small area encompassing 660 km^2 or 1.5% of the total ground yielded catch rates exceeding 2 t per hour. This was the most dense aggregation of

yellowtail encountered. The largest catch rate observed was 6.3 t per hour. This area was fished in April and May when the yellowtail were fully mature and highly aggregated and thus this may be a spawning area. In contrast, average catch rates on Grounds 1 and 2 were about half of what was observed for Ground 5, values similar to what was observed for those areas on 1998.

Figure 5, left panel (in comparison to the 1998 fishery, right panel) spatially illustrates catch rates of yellowtail achieved during the 1991-1993 period of mixed fishing on the Grand Banks, the last years prior to the closure of this (Canadian) fishery inside 200 miles (yellowtail was also fished outside 200 miles, primarily by Spain but no geo-referenced data were available to examine this component of the fishery). The 1991-93 fishing period is similar to the Canadian mixed fishery of the 1980's in that it covered a large area of the bank. The effort in those years, spread over 61,000 km^2 was about 5 times more extensive than in 1998-99. However, Kulka (1991) showed that the main yellowtail catches (as part of a mixed plaice/cod/yellowtail fishery) from 1980-1987 were centred slightly northeast of the 1991-1993 grounds. Similar vessels and gear, otter trawlers greater than 100 ft were used to fish both periods. Because the pre-moratorium fisheries were prosecuted in over a much wider area, catch rate of yellowtail (0.15 t per hour) was lower and the rate for plaice (0.21 t per hour) and cod (1.1 t per hour) was much higher. Although pre-moratorium effort was more extensive, areas of high catch rates of yellowtail were constrained to a small area that corresponded fairly well with high density areas observed in 1998 and 1999, particularly with respect to Ground 1. The average catch rate on Ground 1 during Aug.-Nov. in 1991-93 was 0.715 t per hour, almost identical to the 0.739 t per hour taken in 1998 and slightly higher than 0.640 in 1999 during the same time period. However, the catch rates for Grounds 2-4 and peripheral areas averaged only 0.30 t per hour in 1991-93, about $1/3^{rd}$ of the 1998 rates for the same area and time period. As well, the high concentration on Ground 5 fished in 1999 was not apparent in 1991-93. This suggests some consistency in the way that yellowtail was distributed between the two time periods although concentrations of yellowtail were more extensive in 1998 (Ground 2) and 1999 (Ground 5) than in 1991-93.

Figure 6 shows that the most densely fished areas were associated with higher catch rates of yellowtail in 1998 and more so in 1999. Over the periphery of the grounds where effort density was less than 0.025 sets per km^2, catch rates were lower averaging 0.5 and 0.4 t per hour in 1998 and 1999. Only 1% of the fishing effort occurred over these peripheral areas. Where density of sets exceeded 0.5 sets per km^2, (amounting to 12% of the total area of the grounds) 80% of sets occurred and catches averaged 0.8 and 0.9 t per hour in 1998 and 1999. This showed that the fleet was prosecuting the majority of the fishery where yellowtail was most dense (where catch rate was not only highest but most consistent). In contrast, plaice and cod by-catch rates were slightly to substantially lower at the more densely fished locations. Various fisheries observers noted that the primary fishing strategy employed by captains was to start fishing on known historical grounds then to adjust location to avoid by-catch, specifically cod and plaice. The spatial relationship observed between effort density and catch rates of yellowtail, plaice and cod confirms that this strategy was used. Thus, the fleet as a whole successfully avoided excessive by-catch over the period of the fishery while enhancing catch rate of the target species. In 1998 and 1999, although a total of 34 species or species groups were captured incidentally with yellowtail (Table 3), amounts were low. By-catch of all species taken with the yellowtail amounted to 449 t or 10.6% of the catch in 1998 and 599 t or 8.3% of the catch in 1999. The majority was American plaice (4.2% of the total catch in 1998 and 4.4% in 1999). Cod at 2.3% (1998) and 1.3% (1999) was the next most abundant by-catch. All of the plaice and cod were retained for landing. The only other significant by-catch was skate, primarily thorny (*Raja radiata*) where 84 and 87 tonnes (90%) were discarded in each of 1998 and 1999. Small amounts of such valuable species as witch, turbot, halibut and haddock were retained. This shows that in contrast to the past practise of taking yellowtail with lower catch rates in a mixed fishery, yellowtail can be successfully exploited as a single target species. It should be noted that in part, maintaining low by-catches was possible because of currently low biomass of cod and plaice and also because of the use of an excluder grate described below.

Density distribution of plaice and cod, the two dominant by-catch species in the yellowtail catches are illustrated in Fig. 7. Plaice, generally distributed at greater depths than yellowtail was more dense (catch rate was higher) around the periphery of Grounds 1, 2 and 3 and over much of Grounds 4 and 5 where depths fished were greater. This is probably the main reason for the lower level of fishing effort in these areas. Cod on the other hand tended to be taken in lower amounts and more variably across all grounds, lowest on Ground 2, highest on Ground 4 (the employment of a grate mitigated the catch of catch of cod over all areas). In general, catch rate of any species other than yellowtail was lowest on Ground 2 and this was one reason why Ground 2 was the most highly fished area.

Thus, based on spatial catch rate patterns of plaice observed in the 1998 and 1999 fisheries, best locations for minimizing by-catch was to fish the central portions of Ground 1 and 2.

Catch rates of yellowtail and by-catch were observed to vary temporally as well as spatially (Fig. 8). Comparing the two upper panels, the period Apr. 16 to Jun. 30 was fished only in 1999. During that time, catch rate of both yellowtail (avg. 1.8 t per hour) and plaice (0.1 t) was much higher than during the latter period. Most of that high yield effort occurred on the south-west corner of Ground 5 at a time when the yellowtail may have been aggregated to spawn as described above. Plaice by-catch, also at it highest during this period was the result of fishing the deeper Ground 5. However, for the matching (post-spawning) time period, Aug. 1 to Nov. 15, the patterns of catch rate of yellowtail, cod and plaice were similar between years. Yellowtail fluctuated around 0.8 t per hour in 1998 declining slightly over the first weeks of the fishery then rising at the end. In 1999, the rate was slightly lower at about 0.7 t but also declined then rose sharply at the end of the period. Plaice and cod catch per hour remained low throughout the entire period fished in both years (plaice – 0.04 and 0.03 t. cod – 0.02 and 0.01 t per hour in 1998 and 1999 respectively).

In 1998, effort dropped off rapidly during the last 6 weeks of the fishery as the quota was being reached (lower panel of Fig. 8). This suggests that concentrating effort later in the 1998 season (or a later start in the season) could have resulted in an even higher average catch rate of yellowtail. This panel also shows that average depth fished, codend mesh size and grate spacing (discussed in detail later) although variable did not change significantly over the life of the fishery (refer to Table 1a for a summary of the fishery and gear statistics by ground, by month). In 1999, although effort was low until Aug. (17% of total effort expended between Apr. 16 and Jun. 30) 25% of the total catch was taken. Depth fished decreased over time as effort shifted from the deeper Ground 5 to Ground 1to the south. Grate space and codend mesh size remained constant (except in late Apr. and late May when no grate was used).

Figure 9 compares distribution of yellowtail fishing effort to the distribution of yellowtail, plaice and cod (kg per tow) as derived from fall research survey data. It also overlays fishing locations with distribution of average yellowtail size (cm) based on a ratio of weight to numbers caught during the fall survey. The upper left panel in Fig. 9a (1998) and 9b (1999) shows that fishing effort (white dots) in both years corresponded with northerly areas of moderate to dense concentrations of yellowtail as determined for the fall survey period. Dense concentrations further south were probably not fished because of the higher concentrations of plaice in this areas as can be seen in the upper right panel of Fig. 9. Effort occurred only where plaice density was low with the exception of Ground 5 in 1999 where plaice were moderately dense. By-catch of plaice in the fishery was correspondingly highest for this area. Although fishing effort overlayed areas of moderate to high density areas of cod in both years, as noted above, the deployment of an excluder grate mitigated by-catch of cod.

The lower left panel of Fig. 9 shows that sets containing larger fish (pattern very similar between years), averaging greater than 0.4 kg tended to be located around the periphery of the distribution of dense concentrations of yellowtail and away from the commercial fishing grounds. Where yellowtail were larger in size, their density was lower and concentrations of American plaice was generally higher (upper right panel). Thus, fishing effort was not distributed to optimize size of fish taken. A small gain in average size of fish caught that would occur by fishing toward the periphery of the bank would have resulted in a lower catch rate of yellowtail and an increase in by-catch of plaice. That the fleet did not concentrate its effort in these areas is consistent with fishing strategies reported to the fishery observers by various vessel captains; to minimize by-catch of plaice while maintaining adequate catch rates of yellowtail.

Yellowtail is known to inhabit shallower (but overlapping) range of depths compared with cod and plaice. Thus, shifting location to avoid by-catch usually resulted in a reduction of depth fished. Figure 10, upper panel, an analysis of catch rate of yellowtail and by-catch levels in relation to depth fished shows that in 1998, yellowtail catch rates tended to increase with depth, particularly in 1999. Highest rates exceeding 1 t per hour were achieved in 71-90 m. By-catch of plaice was lowest in the shallowest areas, 41-60 m. and correspondingly where most sets were prosecuted (65% in 1998 and 52% in 1999). It was the expansion of effort to Ground 5 in 1999 that increased effort in the deeper waters. Cod by-catch was lowest in the shallower depths in 1998, the reverse in 1999, but very low in both years. These patterns in by-catch rate with respect to effort intensity by depth confirms that the captains strategy for minimizing by-catch by shifting from areas where cod and plaice were more abundant (generally from deeper to shallower locations) was successful.

Although the fishery was exploited solely by otter trawl, gear configurations namely mesh size and attachment of a sorting grate were not consistent among vessels or over time. Size of mesh in the codend varied throughout the 1998 fishery. The Conservation Harvesting Plan specified a minimum mesh size of 145 mm diamond in 1998 and 155 mm in 1999. However, size was found to between 145 and 155 mm in both years. Fig. 10, lower panel shows effect of mesh size on catch rate and by-catch was confounded by spatial differences in distribution (varying density) of the various species, even within Grounds. The different mesh sizes used appeared to have little effect on catch rate of yellowtail. Although catch rate for the 145-146 mm category was higher than for other sizes in 1999, this was because of an interaction with spatial variation in the distribution of yellowtail with respect to effort location. The vessels using the smaller mesh in 1998 fished the majority of their sets where yellowtail was more densely aggregated, on Ground 5 (catch rates in these area was high at these locations for all mesh sizes). Similarly, vessels using 151-52 mm mesh in 1998 fished the more dense locations of Ground 4. Other vessels using the other mesh sizes fished across all the grounds more evenly. By-catch of plaice and cod (1998) varied without trend with respect to mesh size used. Cod by-catch in 1999 was higher with larger mesh size used. However, the differences were small. It appears that size of mesh has little effect on amount of by-catch. Thus, within the 145-155 mm range used by the fleet in the yellowtail fishery, it appears that size of mesh used had little affect on the composition in the catches. Location fished was the apparently the most important factor influencing the catch rate of yellowtail or the by-catch levels of plaice or cod.

For the 1998 and 1999 yellowtail fishery, a 5% ceiling was imposed on the by-catch of cod and plaice. As a result, the vessels participating in the yellowtail fishery employed a gear attachment in the form of a rigid grate with vertically oriented bars as described by Hickey et *al*. (1995). That paper, a joint study by Industry Development Division of Fisheries and Oceans and the fishing industry indicated that by use of such a grate, cod by-catch could be reduced at locations where they mixed with flatfish species. Thus it was deployed for most of the sets of the 1998 (92%) and 1999 (95%) fisheries in an attempt to reduce by-catch. However, observations of the catches of yellowtail, plaice and cod for the 1998 and 1999 fisheries indicates that by-catch was only marginally more effectively exclude by the grate as shown in Fig. 11. However, the comparison of catch rates with no grate vs. grate should be viewed with caution since only a small number of sets were deployed without a grate. Comparing Ground by Ground and between years, catch rate of yellowtail was sometimes higher, sometimes lower with a grate (Fig. 11 a). Over all, catch rate of yellowtail without grate was 69% (1998) and 57% (1999) of the catch rate when a grate was deployed suggesting that the grate was excluding yellowtail (Fig. 11 b, upper panel). Although the by-catch of plaice and cod was low at all locations in both years regardless of whether a grate was deployed, at most locations in both years, plaice and cod by-catch was lower when the grate was deployed (Fig. 11 a). Over all, catch rate of plaice without grate was 36% (1998) and 47% (1999) of the catch rate when a grate was deployed suggesting that the grate was excluding a higher proportion of plaice than yellowtail. The same can be said for cod in 1998 (catch rate without grate was 30% of catch rate with grate) but not 1999 where catch rate of cod was slightly higher when a grate was deployed. On a finer spatial scale, an examination of catch rates of yellowtail, plaice and cod for sets immediately preceding and proceeding sets where no grate was used (spatially and temporally contiguous sets) showed that catch rate of all three species was generally higher in the majority of cases without the grate. This confirmed that the grate tended to reduce catch rate of not only cod and plaice but also yellowtail and was perhaps slightly more effective at excluding plaice. Thus, based on observations from the fishery, the grate while lowering overall catch rate is not highly effective in differentially reducing by-catch without affecting yellowtail catch rates. Spacing of the vertical bars in the excluder grate varied among vessels and also changed over time for some vessels. Fig. 11b, lower panel describes the effect of different bar spacings on catch rates of yellowtail, plaice and cod. The catch rates of all theree species fluctuated without trend with respect to grate spacing within the range of 76 to 151 mm. By-catch levels observed with respect to different bar spaces were likely confounded by differences in spatial distribution of the various species and spatial distribution of the fishing effort. Thus, the strategy employed by the fleet of selecting grounds where yellowtail was densely aggregated and avoiding locations where by-catch were abundant was much more effective than the use of the grate, regardless of grate size in minimizing by-catch.

Length Composition

Fisheries and Oceans, Resource Allocation landing records indicated that 3,795 t of yellowtail was taken in 1998 and 6,608 t in 1999 by Canada. It is this number that is used in the calculation of removals (numbers at length) in this section.

Length frequencies of commercial catches of yellowtail are illustrated in Figure 12, 1998 and 1999. The y axis shows estimated numbers of fish at length taken in the fishery. Across all grounds and time periods, the shape of the catch frequencies in both years are very similar and uni-modal with an overall (all areas, all months) average size of 38.3 cm and a range of 15 to 57 cm in 1998 and 37.8 cm and a range of 20 to 59 cm in 1999. Males averaged 36.5 cm in 1998 and 35.9 cm in 1999, females 39.5 cm in 1998 and 38.7 cm in 1999. Table 5, listing fish length statistics and numbers of fish caught by ground by month and as well, Fig. 13 illustrating trends in size statistics indicate that mean and mode of males and females was consistent over time for each ground within and between years. In 1998, the range of both males and females became increasingly restricted by about 10-12 cm between Aug. and Nov. particularly for Ground 2. There is no apparent change in gear configuration or fishing pattern over time that might have caused narrowing of the range of yellowtail taken. Thus, it appears likely that the range of lengths of fish available to the gear were becoming narrower over the period of the fishery. This pattern of increasing range was not apparent in 1999.

Fig. 14 illustrates spatial variation in size if yellowtail in the commercial catches and Fig. 15 summarizes average size captured by Ground by sex. The lower left panel of Fig. 14 shows that average length of fish caught was fairly homogeneous within Grounds in both years but differed somewhat among areas fished in 1998. The smallest fish averaging 36.8 cm were encountered on Ground 2 while the largest fish averaging 39.6 cm were taken on Ground 3&4 as a result of large females taken in this area (Fig. 15). Fish taken on Ground 2 were substantially smaller for two reasons. The average size of males and females were about 1 and 2 cm smaller respectively on Ground 2 compared to Ground 1 and 3&4. In 1999, the average size on Ground 5 was consistently lower than elsewhere. This is due to the smaller size if females in this area. Thus, by choosing to fish this area, the fleet traded off slightly smaller fish size to achieve a higher catch rate. More notably, is the difference in sex ratio among Grounds. There is a substantial difference in ratio of males to females taken on Ground 2 (0.99 in 1998, 0.86 in 1999) vs. Ground 1 (0.54 in 1998, 0.47 in 1999), 3&4 (0.581 in 1998) and 5 (0.62 in 1999). It appears that Ground 2 is a "bachelor" area, consistent between years whereas the other Grounds contain a more even mix. The biological reasons for this difference is not clear. Considering that average size of males was about 3 cm less than for females, the much higher proportion of males on Ground 2 was the main reason for smaller average size of the fish taken from this area. Sex ratio in the 1998-99 catches differs substantially from those observed for research surveys. A higher male to female ratio (above 1 and as high as 1.28 in 1995) has been observed for the survey catches since 1984 (Walsh et al. 1998). However, the surveys differ not only in the gear used (capturing a wider range of sizes) but they also cover a much broader area. The substantially lower ratio of males taken in commercial gear and substantial differences observed among commercial fishing grounds illustrates not only the differences in selectivity of sex between different gears but also the considerable spatial variation in the distribution of males and females.

Three size cut offs related to management and scientific issues are as follows: 26 cm - the length below which yellowtail are considered to be juveniles aged 1-4 (Brodie et al., 1998), 30 cm - for monitoring purposes, yellowtail were considered undersized if less than 30 cm according to the Conservation Harvesting Plan, and 40 cm – ages 1 to 7, the large majority of ages (excluding fish considered to be "large" from industry grid surveys (Walsh et al., 1999). Fig. 14 show that the spatial distribution of proportion of fish below the 3 cut-off lengths for Grounds 1, 2 and 5 and as well average length of yellowtail was somewhat complex. Sampling from Ground 3&4 in 1998 was limited to two samples only, not sufficient to examine spatial size related patterns. There was a good deal of spatial variability observed in both years but some patterns did emerge. In 1998, the area with the largest proportion of fish less than 26 cm (darker shades on the map) i.e. where juvenile fish comprised greater than about 1.5% of the catch occurred sporadically throughout much of Ground 1 but not on Ground 2. Further, the highest levels of juveniles in the catches were observed at the southern extent of Ground 1. This area borders on the northwest edge of the nursery ground as reported by Walsh (1992) where one would expect the greatest proportion of juveniles to occur. Similarly, the largest proportions of fish below 30 cm (comprising greater than 15% of the catch) were taken on the southern part of Ground 1. Moderate amounts (about 3-15% of the catch) were taken on the most of the rest of Ground 1 and the eastern part of Ground 2. There was a substantial difference in the proportion below 40 cm between Ground 1 and Ground 2 where much lower proportions were observed on Ground 1. This indicated that a greater proportion of older fish were removed from Ground 1 than from Ground 2. Thus the range of sizes caught (presumably because of a greater spread of sizes available to the gear) was greater on Ground 1. The pattern on Ground 1 in 1999 was not greatly different compared to 1998. Proportion below 26 cm and below 30cm was similar. The most significant difference between years was with respect to proportion below 40 cm that was considerably higher in 1999. Ground 5, fished only in 1999 was substantially different from Ground 1. Proportion below 26 cm was near zero (very few juveniles taken) on this Ground even though average size was smaller than on Ground 1 and proportion below 40 cm

was higher. This indicates that a narrower rang of fish was taken on Ground 5. Refer also to Fig 13, minimum and maximum size temporal trends. Thus, the spatial and temporal variation in size of fish and proportion by sex observed for the commercial catches suggests a complex and dynamic population structure within the confines of the commercial fishing grounds.

Fig. 16 showing the percent (upper panels) and numbers of fish (lower panels) taken in each of the cut off categories by ground illustrates the similarity size proportions among Grounds. In both years, the numbers of fish and range of percent of total numbers of fish in the catches below 26 cm was small (0.5 to 1.1% in 1998 and 0.3 to 0.9% in 1999) indicating that capture of juvenile yellowtail was trivial across all areas fished. For monitoring purposes, the numbers of fish and range of percent of total numbers of fish in the catches considered to be undersized (below 30 cm) averaged just over 5% (3.8 to 6.1% in 1998 and 4.6 to 5.5% in 1999) an acceptable level for management purposes. Proportion of "large" fish, these over 40 cm varied across Grounds but comprised 28% of the catch in 1998 and 24% in 1999. One might expect that size of mesh might affect size of fish taken. However within the range of meshes sizes used, 145-157 mm, Fig. 17 indicates that there was no relationship between the cut-off categories and average size of fish with respect to mesh size. Spatial and temporal variation in observed size composition was the result of differences in fish sizes within schools and among fishing grounds rather than the result of mesh size used.

One of the stated management objectives for the 1998 fishery was to fish the population after spawning was complete. Thus, an opening date of Aug. 1 was implemented. Yellowtail examined for maturity during the first two weeks of Aug. in both 1998 and 1999 confirmed that a large majority, 99% (1998) and 100% (1999) for males and 97.6% (1998) and 89.9% (1999) for females were either partly spent or spent (Fig. 18a). This indicated that by restricting fishing to Aug and later that the management objective of avoiding the exploitation of spawning fish had been achieved in 1998. In 1999, it was decided to allow fishing early in the year but prohibiting fishing during the period of peak spawning, June 15 to Jul. 30. Fishing did occur in April to June in that year and Fig. 18b shows that during these months, the fishery was capturing mature, spawning fish. In May, 99% of males and 84% of females in the catches were mature. In June, the proportions had declined to 95% mature males and 68% mature females. No maturity data are available for April. Thus, a fishery before July will likely capture a significant proportion of mature fish.

It is estimated that 7.3 million fish in 1998 and 12.9 million fish in 1999 were removed from the population, just 1% of the population numbers of fish estimated by Walsh et *al*. (2000) from spring survey data in Divisions 3N and 3O in 1998 and 1999. Of the estimated total fish caught, catches were split 70:30 between Ground 1 and 2 in 1998 and were split nearly 50:50 between Ground 1 and Ground 5 in 1999, the other areas being minor. Females were more abundant in the catches comprising about 65% of the total number of individuals caught in both years.

Conclusions

Intense monitoring of the re-emerging 1998 and 1999 yellowtail fishery in the form of nearly full coverage by fishery observers facilitated a detailed examination of the fishery. In terms of meeting both management and commercial objectives, analyses of the observer data indicate that the re-emerged fishery for yellowtail can be considered a success. Nearly all of the quota was taken, catch rates of yellowtail were higher than what was achieved just prior to closure of the fishery in 1991-93 (because of localized fishing on areas of high abundance), by-catch of plaice and cod was minimized (due to the localized fishing and employment of a sorting grate), small fish (less than 30 cm) constituted only a small proportion of the catch (using codend mesh ranging from 145 to 157 mm) and the period of the fishery concentrated on a post-spawning fish in 1998 but not in 1999. Unlike past years, the 1998-99 fishery directed for yellowtail by concentrating effort where yellowtail was abundant. This strategy assured the protection of the depressed cod and plaice stocks in Divisions 3N and 3O while generated higher average catch rates than in past years.

However, some industry participants in this fishery suggested following the 1998 season that by-catch restrictions set out in the management plans resulted in yellowtail being exploited over a very restricted area thus hampering the ability to fish for yellowtail over the entire extent of its distribution. For the 1998 fishery, the only location fished that yielded both high yellowtail catch rates and also a level of by-catch that led to an apparent restriction of effort was Ground 4, spatially speaking a minor ground. In 1999, the fleet located a "new' concentration to the north where catch rates were high and by-catch low. The existence of other (un-fished) yellowtail concentrations is likely,

but fishing activity limited to the 1998-99 grounds did not appear to negatively affect the ability of the fleet to take the quota in an efficient manner. Based on historic patterns, it seems likely that if the fishing effort is extended to areas other than those fished then catch rates of yellowtail in those non-fished areas would likely have been lower over most of those areas and depending on location, by-catch of cod and plaice would have been higher. Within the bounds of the 1998-99 grounds, catch rates of yellowtail were similar or higher compared to the 1991-93 rates at the same location. A concern is that yellowtail might be over-exploited within the localized areas fished. However, there was no evidence of cropping out on the grounds fished. Compared to 1998, catch rates were as good or better at the same locations in 1999.

References

Anon, 1997. SPANS. Vers. 7. Prospector Reference Manual. TYDAC Research Inc.

Brodie, W. B. , S. J. Walsh and D. Orr. 1997. Results of surveys directed at yellowtail flounder in NAFO Divisions 3NO, conducted on a Canadian commercial trawler. NAFO SCR Doc. 97/31 23 p.

Brodie, W. B., D. Maddock Parsons, D. Orr and S. J. Walsh. Results of surveys directed at yellowtail flounder in NAFO Divisions 3NO, conducted on a Canadian commercial trawler, 1996-98. NAFO SCR Doc. 98/73, 34 p.

Hickey, W. M., G. Brothers and D. L. Boulos 1995. A study of cod/flatfish separation in otter trawls with the use of rigid grates. Can. Tech. Rep. Fish. Aquat. Sci. No. 2027 35p.

Kulka, D. W. and J. R. Firth 1987. Observer Program Training Manual - Newfoundland Region. Can. Tech. Rpt. Fish. Aquat. Sci. No. 1355 (Revised). 197 p.

Kulka, D. W. 1991. A description of fisheries in the vicinity of significant oil discovery areas off Newfoundland. Can. Tech. Rep. Fish. Aquat. Sci. No. 1787 126 p.

Kulka D. W. 1998. SPANdex - SPANS geographic information system process manual for creation of biomass indices and distributions using potential mapping. DFO Atl. Fish. Res. Doc. 98/60 28p.

Kulka, D. W. 1999. A re-emerging fishery – Description of the 1998 yellowtail flounder fishery on the Grand Banks with a comparison to the historic effort. NAFO SCR Doc. 99/61 38 p

Walsh, S. J. 1992. Factors influencing distribution of juvenile yellowtail flounder (*Limnada ferruginea*) on the Grand Bank of Newfoundland. Neth. J. Sea Res. 29:193-203.

Walsh, S. J., W. B. Brodie, M. Veitch, D. Orr, C. McFadden and D. Maddock-Parsons 1998. An assessment of the Grand Bank Yellowtail flounder stock in NAFO Divisions 3LNO. NAFO SCR Doc. 98/72 78p.

Walsh, S. J., W. B. Brodie, M. J. Morgan, D. Power and M. Veitch 1999. The 1999 assessment of Grand Bank yellowtail flounder stock in NAFO Divisions 3LNO. NAFO SCR Doc. 99/68 x p.

Walsh, S. J., M. J Veitch, M. J. Morgan, W. R. Bowering and W. B. Brodie 2000. Distribution and abundance of yellowtail flounder (Limanda ferruginea) on the Grand Bank NAFO Divisions 3LNO as derived from annual Canadian bottom trawl surveys. NAFO SCR Doc. 00/35 54 p.

Table 1a. Catch and catch rates of yellowtail, by-catch rates, average depth and gear parameters by month and ground for the 1998 yellowtail fis hery.

		Month							
Ground		4	5	6	8	9	10	11	Total
1	# of sets				377	378	422	27	1,203
	Yellowtail catch (t)				703	692	1,071	105	2,571
	Avg chr yellow				0.672	0.591	0.882	1.487	0.738
	Avg chr plaice				0.038	0.029	0.020	0.102	0.030
	Avg chr cod				0.011	0.038	0.017	0.002	0.021
	Avg depth				55	54	54	53	54
	Avg codend (mm)				147	148	149	150	148
	Avg grate space (mm)				122	111	119	121	117
2	# of sets				213	292	5		511
	Yellowtail catch (t)				421	597	9		1,027
	Avg chr yellow				0.961	0.708	0.577		0.812
	Avg chr plaice				0.039	0.046	0.066		0.043
	Avg chr cod				0.014	0.010	0.003		0.012
	Avg depth				70	71	71		71
	Avg codend (mm)				147	148	149		148
	Avg grate space (mm)				109	111	125		110
3&4	# of sets				42	21			63
	Yellowtail catch (t)				181	16			197
	Avg chr yellow				1.219	0.313			0.912
	Avg chr plaice				0.099	0.101			0.100
	Avg chr cod				0.091	0.038			0.073
	Avg depth				72	69			71
	Avg codend (mm)				153	149			152
	Avg grate space (mm)				89	99			99
All	# of sets				632	692	427	27	1,777
Grounds	Yellowtail catch (t)				1,305	1,304	1,080	105	3,795
	Avg chr yellow				0.805	0.632	0.878	1.487	0.766
	Avg chr plaice				0.042	0.039	0.021	0.102	0.036
	Avg chr cod				0.017	0.026	0.017	0.001	0.020
	Avg depth				61	62	54	53	60
	Avg codend (mm)				148	148	149	150	148
	Avg grate space (mm)				117	110	119	121	115

Table 1b. Catch and catch rates of yellowtail, by-catch and average depth by month for the fall 1999 research survey.

	Month[1]			
	10	11	12	Total
# Sets	126	171	101	398
Avg wt of yellowtail	24.74	3.39	0.01	9.29
Avg number of yellowtail	88.3	8.1	0.0	31.4
Avg number of plaice	73.9	51.7	15.5	49.5
Avg number of cod	3.4	0.8	0.3	1.5
Avg depth	193.3	229.2	877.4	382.3

[1]November and December included sets in NAFO Div. 3L.

Table 1c. Catch and catch rates of yellowtail, by-catch rates, average depth and gear parameters by month and ground for the 1999 yellowtail fishery.

Ground		Month 4	5	6	8	9	10	11	Total
1	# of sets	34	0	0	123	450	725	574	1,906
	Yellowtail catch (t)	30.6			170.1	648.1	1,116.0	1,386.0	3,351
	Avg chr yellow	0.447			0.540	0.517	0.523	0.890	0.632
	Avg chr plaice	0.132			0.023	0.023	0.010	0.031	0.022
	Avg chr cod	0.010			0.032	0.018	0.010	0.004	0.011
	Avg depth	55			59	57	52	53	55
	Avg codend (mm)	148.0			151	150	150	149	150
	Avg grate space (mm)				122	120	117	114	119
2	# of sets	5	0	9	9	21	21	7	71
	Yellowtail catch (t)	15.6		12.2	7.4	27.0	19.1	11.0	92
	Avg chr yellow	1.493		0.708	0.593	0.495	0.304	0.402	0.536
	Avg chr plaice	0.208		0.052	0.121	0.080	0.058	0.092	0.085
	Avg chr cod	0.010		0.009	0.026	0.031	0.021	0.002	0.020
	Avg depth	72		71	71	70	72	75	72
	Avg codend (mm)	148.0		147	151	151	150	151	150
	Avg grate space (mm)			108	124	118	111	120	116
3	# of sets	1	0	0	1	1	5	1	10
	Yellowtail catch (t)	1.3			1.6	2.4	4.3	5.6	15
	Avg chr yellow	0.729			0.476	0.844	0.097	0.025	0.308
	Avg chr plaice	0.129			0.056	0.159	0.029	0.069	0.066
	Avg chr cod	0.009			0.522	0.026	1.040	0.000	0.200
	Avg depth	75			66	66	63	77	69
	Avg codend (mm)	148			152	154	152	149	151
	Avg grate space (mm)				122	122	115.75	102	
5	# of sets	17	256	225	425	263	85	0	1,272
	Yellowtail catch (t)	60.5	893.5	633.1	987.1	466.5	109.2		3,150
	Avg chr yellow	2.378	2.518	1.498	0.970	0.677	0.433		1.297
	Avg chr plaice	0.195	0.108	0.090	0.054	0.052	0.044		0.072
	Avg chr cod	0.013	0.012	0.014	0.007	0.009	0.011		0.010
	Avg depth	75	80	75	71	70	68		73
	Avg codend (mm)	148	148	149	151	149	151		150
	Avg grate space (mm)		123	121	128	121	121		123
All	# of sets	57	256	234	558	735	836	583	3,259
Grounds	Yellowtail catch (t)	108	893	645	1,166	1,144	1,249	1,403	6,608
	Avg chr yellow	1.117	2.518	1.469	0.869	0.574	0.506	0.882	0.889
	Avg chr plaice	0.157	0.108	0.088	0.048	0.035	0.015	0.031	0.043
	Avg chr cod	0.110	0.012	0.014	0.014	0.015	0.011	0.004	0.012
	Avg depth	63	80	74	68	62	55	53	62
	Avg codend (mm)	148.0	148	149	151	150	151	150	150
	Avg grate space (mm)		123	120	126	121	118	115	120

Table 1d. Catch and catch rates of yellowtail, by-catch and average depth by month for the fall 1999 research survey.

	Month[1]			
	10	11	12	Total
# Sets	126	171	101	398
Avg wt of yellowtail	24.74	3.39	0.01	9.29
Avg number of yellowtail	88.3	8.1	0.0	31.4
Avg number of plaice	73.9	51.7	15.5	49.5
Avg number of cod	3.4	0.8	0.3	1.5
Avg depth	193.3	229.2	877.4	382.3

Table 2a. Landings and biological sampling coverage of the Canadian fishery for yellowtail, by fishing ground, by month in 1998. Table includes samples collected by both fishery observers and port samplers.

Fishing Ground	Month	[1] Landings (t)	[2] Catch weight sampled (t)	Percent of catch sampled (by weight)	Number samples	Number measured	Number Otoliths
1	August	703	9.602	1.4%	72	8,856	831
	September	692	14.560	2.1%	102	13,081	208
	October	1,071	15.070	1.4%	108	14,035	493
	November	105	1.090	1.0%	8	1,048	37
2	August	421	5.332	1.3%	44	5,800	272
	September	597	10.080	1.7%	78	10,099	393
	October	9	0.252	0.3%	2	280	32
	November	0	0				
3&4	August	181	0	0%			
	September	16	0.497	3.1%	2	513	0
	October	0	0				
	November	0	0				
All	August	1,305	14.934	1.1%	116	14,656	1,103
Grounds	September	1,304	25.306	1.9%	184	23,693	601
	October	1,080	15.322	1.4%	110	14,315	525
	November	105	1.090	1.0%	8	1,048	37
	All Months	3,749	56.652	1.5%	418	53,712	2,266

[1] Observed catch weight adjusted to landings
[2] Total weight of fish samples

Table 2b Landings and biological sampling coverage of the Canadian fishery for yellowtail, by fishing ground, by month in 1999 Table includes samples collected by both fishery observers and port samplers.

Fishing Ground	Month	[1] Landings (t)	[2] Catch weight sampled (t)	Percent of catch sampled (by weight)	Number samples	Number measured	Number Otoliths
1	April	31	0.924	3.0	3	770	
	May	0					
	June	0					
	July						
	August	170	3.366	2.0	17	3,240	107
	September	648	11.956	1.9	61	11,657	226
	October	1,116	20.918	1.9	96	18,933	431
	November	1,386	14.485	1.1	67	13,249	46
2	April	16					
	May	0					
	June	12					
	July						
	August	7	0.045	0.6	1	102	
	September	27	0.045	0.2	1	115	
	October	19	0.118	0.6	1	221	61
	November	11					
3	April	1					
	May	0					
	June	0					
	July						
	August	2					
	September	2					
	October	4					
	November	6					
5	April	61	0.306	0.5	2	513	
	May	893	11.028	1.2	61	10,440	252
	June	633	6.236	1.0	21	6,137	178
	July						
	August	987	15.184	1.5	92	15,986	650
	September	467	6.904	1.5	30	6,249	94
	October	109	2.766	2.5	15	2,668	
	November	0					
All Grounds	April	108	1.230	1.1	5	1,283	
	May	893	11.028	1.2	61	10,440	252
	June	645	6.236	1.0	21	6,137	178
	July						
	August	1,166	18.595	1.6	110	19,328	757
	September	1,144	18.905	1.7	92	18,021	320
	October	1,249	23.802	1.9	112	21,822	431
	November	1,403	14.485	1.0	67	13,249	46
	All Months	6,608	94.281	1.4	468	90,280	1,984

[1] Observed catch weight adjusted to landings
[2] Total weight of fish samples

Table 3. Catch, by-catch and effort summary for yellowtail, plaice and cod for the 1998 and 1999 yellowtail fishery.

1998	Fishing Grounds	1	2	3	5	All	Catch/Effort
	% of Effort	67.7%	28.9%	3.5%			1,777 Total Sets
	Avg Depths fished (m)	54	71	72		61	
	Months Fished	8-11	8-10	8-9		8-11	Yellowtail
Yellowtail	Mean t per hour	0.739	0.8124	0.9404		0.7658	3,795 t Total Catch
	Min t per hour	0	0.0747	0.0729		0	
	Max t per hour	3.3612	2.1025	2.2376		3.3612	
	% of Catch	67.7%	27.1%	5.2%			
							Plaice
Plaice	Mean t per hour	0.030	0.043	0.038		0.037	176 t Total Catch
	Min t per hour	0.000	0.000	0.000		0.000	4.2 % of total catch
	Max t per hour	0.263	0.579	0.154		0.579	
							Cod
Cod	Mean t per hour	0.021	0.012	0.018		0.020	99 t Total Catch
	Min t per hour	0.000	0.000	0.000		0.000	2.3 % of total catch
	Max t per hour	0.500	0.391	0.154		0.574	

1999	Fishing Grounds	1	2	3	5	All	Catch/Effort
	% of Effort	58.5%	2.2%	0.3%	39.0%		3,259 Total Sets
	Avg Depths fished (m)	54	72	67	73	62	
	Months Fished	4, 8-11	4, 6-11	4, 8-11	4-10	4-11	Yellowtail
Yellowtail	Mean t per hour	0.632	0.536	0.308	1.297	0.889	6,608 t Total Catch
	Min t per hour	0.000	0.010	0.025	0.010	0.000	
	Max t per hour	2.752	2.679	0.844	6.269	6.269	
	% of Catch	50.7%	1.4%	0.2%	47.7%		
							Plaice
Plaice	Mean t per hour	0.022	0.085	0.066	0.072	0.043	3,14 t Total Catch
	Min t per hour	0.000	0.016	0.000	0.000	0.000	4.3 % of total catch
	Max t per hour	0.317	0.445	0.159	0.319	0.445	
							Cod
Cod	Mean t per hour	0.011	0.020	0.200	0.010	0.012	94 t Total Catch
	Min t per hour	0.000	0.000	0.000	0.000	0.000	1.3 % of total catch
	Max t per hour	0.380	0.265	0.522	0.220	0.522	

Table 4a. Breakdown of all species captured during the 1998 yellowtail fishery.

Species	# sets	Kept Wt (t)	Discard Wt (t)	Total Wt (t)	% Kept	% Discarded	% of Catch	t per hour
Atl herring	1	0.00	0.00	0.00	0.00%	0.00%	0.00%	0.000
Redfish	1	0.00	0.00	0.00	0.00%	0.00%	0.00%	0.000
Sea urchin	1	0.00	0.00	0.00	0.00%	0.00%	0.00%	0.000
Lanternfish	1	0.00	0.00	0.00	0.00%	0.00%	0.00%	0.000
Cusk	1	0.00	0.00	0.00	0.00%	0.00%	0.00%	0.001
Silver hake	1	0.00	0.00	0.00	0.00%	0.00%	0.00%	0.001
Sponges	1	0.00	0.00	0.00	0.00%	0.00%	0.00%	0.001
Sabinea sp	1	0.00	0.01	0.01	0.00%	100.00%	0.00%	0.002
Starfish	3	0.00	0.01	0.01	0.00%	100.00%	0.00%	0.001
Squid (Illex)	7	0.00	0.01	0.01	0.00%	100.00%	0.00%	0.000
Spiny dogfish	4	0.00	0.01	0.01	0.00%	100.00%	0.00%	0.001
Lumpfish	10	0.00	0.03	0.03	0.00%	100.00%	0.00%	0.001
Northern wolfish	7	0.02	0.03	0.05	40.00%	60.00%	0.00%	0.002
Spotted wolfish	1	0.05	0.00	0.05	100.00%	0.00%	0.00%	0.015
Monkfish	6	0.04	0.02	0.06	66.67%	33.33%	0.00%	0.003
Cnidaria	9	0.00	0.07	0.07	0.00%	100.00%	0.00%	0.002
Capelin	39	0.00	0.07	0.07	0.00%	100.00%	0.00%	0.001
White hake	18	0.09	0.00	0.09	100.00%	0.00%	0.00%	0.002
Sandlance	126	0.00	0.16	0.16	0.00%	100.00%	0.00%	0.000
Toad crab	180	0.00	0.93	0.93	0.00%	100.00%	0.02%	0.001
Haddock	63	0.39	0.01	0.40	97.50%	2.50%	0.01%	0.002
Eelpouts	139	0.16	0.29	0.45	35.56%	64.44%	0.01%	0.001
Snow crab	257	0.00	0.93	0.93	0.00%	100.00%	0.02%	0.001
Striped wolfish	133	1.46	0.00	1.46	100.00%	0.00%	0.03%	0.004
Halibut	79	1.69	0.02	1.71	98.83%	1.17%	0.04%	0.007
Turbot	3	1.92	0.00	1.92	100.00%	0.00%	0.05%	0.275
Sea raven	474	5.58	2.46	8.04	69.40%	30.60%	0.19%	0.006
Sea cucumber	366	0.00	10.16	10.16	0.00%	100.00%	0.24%	0.009
Witch	1,234	14.56	0.02	14.58	99.86%	0.14%	0.34%	0.004
Sculpins	900	32.76	6.00	38.76	84.52%	15.48%	0.91%	0.010
Skates	1,611	9.45	84.28	93.73	10.08%	89.92%	2.21%	0.019
Cod	1,298	98.93	0.00	98.93	100.00%	0.00%	2.33%	0.025
Plaice	1,704	175.92	0.00	175.92	100.00%	0.00%	4.15%	0.034
Yellowtail	1,707	3,794.00	1.13	3,795.13	99.97%	0.03%	89.43%	0.738
Total		**4,137.02**	**106.65**	**4,243.67**				

1. Weights recorded as 0 are values less than 10 kg.
2. Percent of catch recorded as 0 are less than 0.01%
3. T per hour are average catch rate for sets where that particular species was captured.

Table 4b. Breakdown of all species captured during the 1999 yellowtail fishery.

Species	# sets	Kept Wt (t)	Discard Wt (t)	Total Wt (t)	% Kept	% Discarded	% of Catch	t per hour
John Dory	1	0.00	0.00	0.00	100.00	0.00	0.00	0.0005
Squid Ns	1	0.00	0.00	0.00	0.00	100.00	0.00	0.0003
N Wolfish	1	0.00	0.00	0.00	100.00	0.00	0.00	0.0008
Atl Herring	2	0.00	0.00	0.00	100.00	0.00	0.00	0.0005
Mackerel	3	0.00	0.00	0.00	50.00	50.00	0.00	0.0004
At Hkear Sculpin	1	0.00	0.01	0.01	0.00	100.00	0.00	0.0033
Redfish	1	0.00	0.01	0.01	0.00	100.00	0.00	0.0033
Roughnose Gren	1	0.02	0.00	0.02	100.00	0.00	0.00	0.0044
Black Dogfish	5	0.00	0.02	0.02	0.00	100.00	0.00	0.0013
Blue Shark	1	0.00	0.02	0.02	0.00	100.00	0.00	0.0053
Sea Urchin	23	0.00	0.03	0.03	0.00	100.00	0.00	0.0007
Spiny Dogfish	13	0.00	0.03	0.03	0.00	100.00	0.00	0.0007
Common Lumpfish	13	0.00	0.04	0.04	0.00	100.00	0.00	0.0009
Illex	31	0.01	0.03	0.04	28.52	71.48	0.00	0.0004
Monkfish	6	0.04	0.00	0.04	100.00	0.00	0.00	0.0019
Turbot	1	0.06	0.00	0.06	100.00	0.00	0.00	0.0196
Capelin	27	0.00	0.07	0.07	0.00	100.00	0.00	0.0010
Sandlance	164	0.00	0.21	0.21	0.00	100.00	0.00	0.0004
Sp Wolfish	15	0.30	0.00	0.30	100.00	0.00	0.00	0.0052
Hyas corarctatus	87	0.00	0.31	0.31	0.00	100.00	0.00	0.0011
Toad Crab Ns	197	0.00	0.53	0.53	0.00	100.00	0.01	0.0009
White Hake	100	0.67	0.00	0.67	100.00	0.00	0.01	0.0018
Eelpout Ns	288	0.99	0.07	1.06	93.58	6.42	0.01	0.0013
S H Sculpin	89	0.50	1.34	1.84	27.04	72.96	0.03	0.0057
Snow Crab	330	0.00	2.15	2.15	0.00	100.00	0.03	0.0024
Halibut	78	2.30	0.01	2.31	99.53	0.47	0.03	0.0082
Haddock	276	3.05	0.00	3.05	99.96	0.04	0.04	0.0030
Hyas Araneas	532	0.00	3.26	3.26	0.00	100.00	0.05	0.0021
St Wolfish	262	5.73	0.01	5.74	99.89	0.11	0.08	0.0064
Sea Cucumber	484	0.00	8.63	8.63	0.00	100.00	0.12	0.0054
Witch	656	9.71	0.03	9.74	99.68	0.32	0.14	0.0045
Sea Raven	481	3.25	9.24	12.49	26.01	73.99	0.17	0.0076
Lh Sculpin	702	15.72	5.32	21.04	74.72	25.28	0.29	0.0089
Sculpin Ns	942	13.89	12.96	26.85	51.72	48.28	0.37	0.0083
Skates Ns	2273	2.68	87.54	90.21	2.97	97.03	1.25	0.0120
Cod	2047	93.60	0.00	93.60	100.00	0.00	1.30	0.0144
Plaice	2641	314.10	0.12	314.22	99.96	0.04	4.36	0.0374
Yellowtail	2673	6608.36	0.64	6609.00	99.99	0.01	91.69	0.7766
Total		**7,074.98**	**132.63**	**7,207.60**				

1. Weights recorded as 0 are values less than 10 kg.

2. Percent of catch recorded as 0 are less than 0.01%

3. T per hour are average catch rate for sets where that particular species was captured.

Table 5a. Summary statistics for length measurements of yellowtail sampled from the 1998 fishery.

			Length (cm)					Number of
Sex	**Month**	**Catch Wt.**	Mean	**Std Dev.**	**Min**	**Max**	**Mode**	**Fish**
Ground 1								
Male	Aug.		36.6	4.21	20	51	37	507,693
Female			39.1	5.44	17	56	40	774,655
Total		702,758	38.1	5.14	17	56	38	1,282,348
Male	Sept.		37.0	3.89	20	50	38	464,682
Female			39.6	4.74	20	56	41	800,348
Total		691,657	38.7	4.62	20	56	38	1,265,030
Male	Oct.		36.6	4.14	15	53	38	673,171
Female			39.5	4.58	20	57	41	1,354,166
Total		1,071,344	38.6	4.65	15	57	38	2,027,337
Male	Nov.		36.8	3.82	25	47	39	55,502
Female			39.4	4.30	25	53	38	152,669
Total		105,293	38.7	4.34	25	53	38	208,171
Male	All		36.7	4.08	15	53	38	1,701,048
Female			39.5	4.78	17	57	41	3,081,838
Total		**2,571,052**	38.5	**4.73**	**15**	**57**	**38**	**4,782,886**
Ground 2								
Male	Aug.		34.9	3.64	19	48	36	438,973
Female			36.9	4.36	21	54	37	494,149
Total		421,438	35.9	4.16	19	54	37	933,122
Male	Sept.		36.1	2.98	22	49	37	622,176
Female			38.6	3.76	22	52	39	594,474
Total		596,779	37.3	3.60	22	52	38	1,216,650
Male	Oct.		36.2	2.69	29	44	37	14,010
Female			37.8	3.50	29	45	40	7,593
Total		9,045	36.8	3.15	29	45	37	21,603
Male	All		35.7	3.29	19	49	37	1,075,159
Female			37.9	4.10	21	54	39	1,096,216
Total		**1,027,262**	36.8	**3.88**	**19**	**54**	**37**	**2,171,375**
Ground 3								
Male	Sept.		37.2	3.71	25	46	35	115,154
Female			41.1	4.76	26	52	41	197,914
Total		16,015	39.6	4.82	25	52	41	**313,068**
Male	All		37.2	3.87	25	46	35	115,154
Female			41.1	4.86	26	52	41	197,914
Total		**196,687**	39.6	**4.90**	**25**	**52**	**41**	**313,068**
All Grounds								
Male	All		36.5	3.75	15	53	37	2,891,361
Female	All		39.5	4.58	17	57	40	4,375,968
Total	**All**	**3,795,001**	38.3	**4.50**	**15**	**57**	**39**	**7,267,329**

Avg Wt 0.5222 kg

Table 5b - Summary statistics for length measurements of yellowtail sampled from the 1999 fishery.

			Length (cm)					Number of
Sex	**Month**	**Catch Wt.**	**Mean**	**Std Dev.**	**Min**	**Max**	**Mode**	**Fish**
Ground 1								
Male	Apr.		35.5	4.3	25	47	37	12,150.91
Female			39.2	4.9	26	53	41	37,461.30
Total		30,600	38.3	5.1	25	53	37	**49,612**
Male	Aug.		36.9	3.7	23	50	37	127,652
Female			40.4	4.6	23	54	40	198,992
Total		170,100	39.0	4.6	23	54	38	**326,644**
Male	Sept.		36.4	3.8	20	49	36	498,909
Female			39.3	4.5	21	55	39	801.459
Total		648,100	38.2	4.5	20	55	39	**1,300,368**
Male	Oct.		36.8	3.8	23	52	38	616,478
Female			39.7	4.4	20	59	38	1,447,116
Total		1,116,000	38.8	4.4	20	59	38	**2,063,594**
Male	Nov.		36.1	4.1	20	51	38	785,860
Female			39.3	4.3	21	58	38	1,833,787
Total		1,386,000	38.3	4.5	20	58	38	**2,619,648**
Male	All		36.3	3.9	20	52	37	2,041,051
Female			39.6	4.5	21	59	39	4,318,816
Total		**3,350,800**	38.5	4.5	20	59	38	**6,359,867**
Ground 2								
Male	Aug.		33.3	4.1	22	40	34	6,675
Female			38.0	4.9	27	49	36	12.778
Total		7,400	36.4	5.2	22	49	36	**19,453**
Male	Sept.		36.1	3.6	28	48	35	37,562
Female			37.1	4.0	26	48	37	32,109
Total		27.000	36.6	3.8	26	48	37	**69,671**
Male	Oct.		36.7	3.1	29	46	37	13,529
Female			40.4	3.6	28	51	42	22,494
Total		19,100	39.0	3.9	28	51	37	**36,024**
Male	All		35.4	3.6	22	48	35	57,766
Female			38.5	4.2	27	51	38	67,381
Total		**92,300**	38.0	4.6	22	51	36	**125,147**
Ground 3								
Male								6,258
Female								7,300
Total		**10,000**						**13,559**
Ground 5								
Male	Apr.		36.2	3.0	28	43	37	47,564
Female			38.6	3.5	28	48	39	54.331
Total		60,500	37.4	3.5	28	48	37	**101,895**
Male	May		35.7	3.2	25	47	37	813,428
Female			38.1	4.1	22	53	38	945,866
Total		893,500	37.0	3.9	22	53	37	**1,759,294**
Male	Jun.		35.9	3.4	22	47	37	527,911
Female			37.7	4.0	26	53	38	726,691
Total		633,100	36.9	4	22	53	37	**1,254,602**
Male	Aug.		35.6	3.6	20	48	37	633,955
Female			37.4	4.0	23	53	37	1,495,207
Total		987,100	36.9	4.0	20	53	37	**2,129,162**
Male	Sept.		36.1	3.1	24	51	36	359,565
Female			37.8	3.9	25	51	37	607,286
Total		466.500	37.2	3.7	24	51	37	**966,852**
Male	Oct.		36.9	3.3	24	48	38	67,520
Female			38.2	3.5	26	54	38	147,213
Total		109,200	37.8	3.5	24	54	38	**214,734**
Male	All		36.1	3.3	20	51	37	2,449,944
Female			38.0	3.8	22	54	38	3,976,595
Total		**3,149,900**	37.0	3.9	20	54	37	**6,426,539**
All Grounds								
Male	All		35.9	3.6	20	52	36.5	4,555,019
Female	All		38.7	4.2	21	59	38.5	8,370,092
Total	**All**	**6,593,000**	37.8	4.3	20	59	37.0	**12,925,111**
							Avg Wt	0.5100923

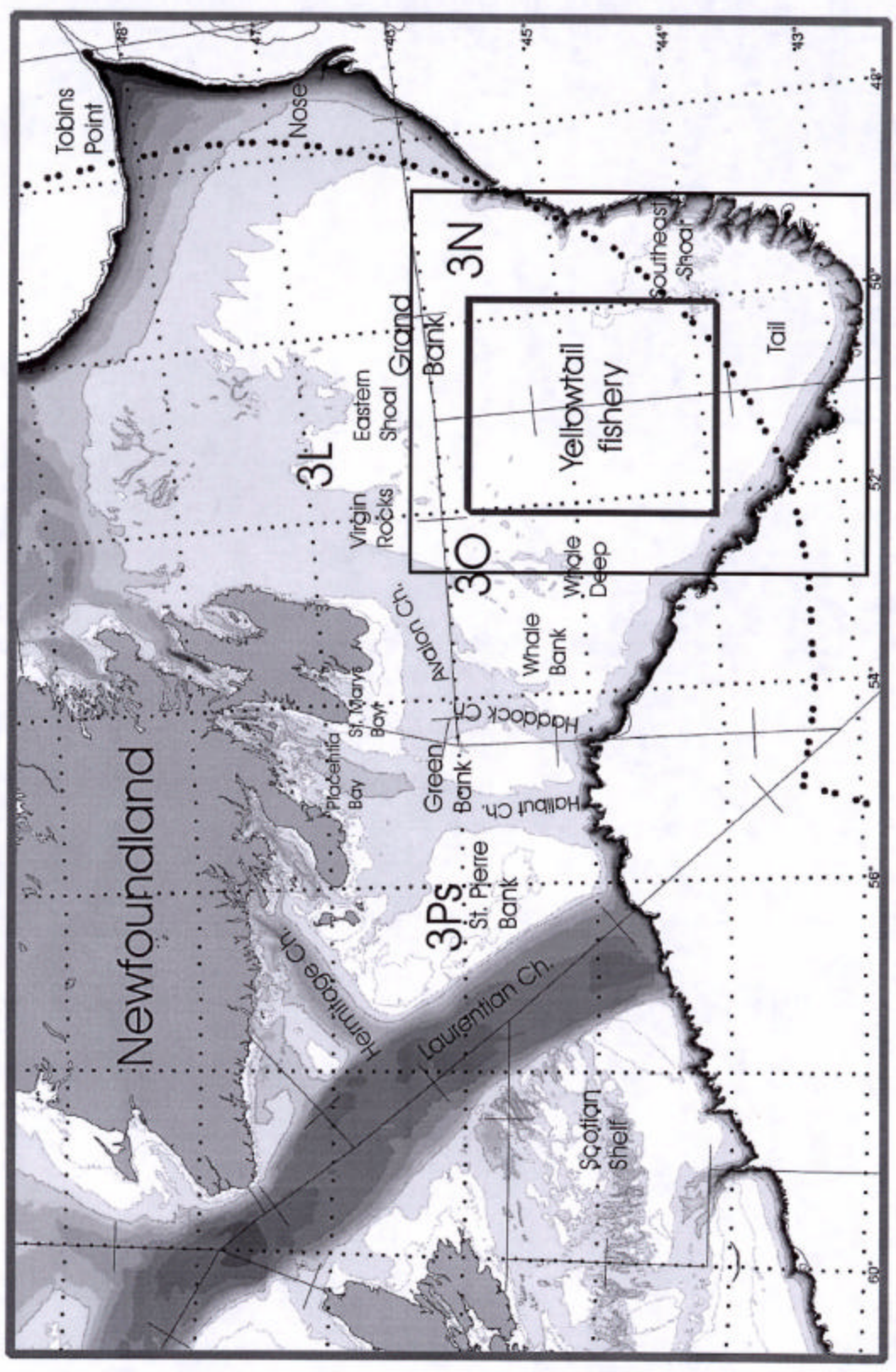


Fig. 1 Features of the Grand banks showing NAFO Divisions, the 200 mile limit, specific locations and bathymetry (0 to 450 m by 50 m then 500 to 1000 m by 100m). The inner box illustrates the extent of the 1998 yellowtail fishery. The outer box shows the area illustrated in subsequent map figures.

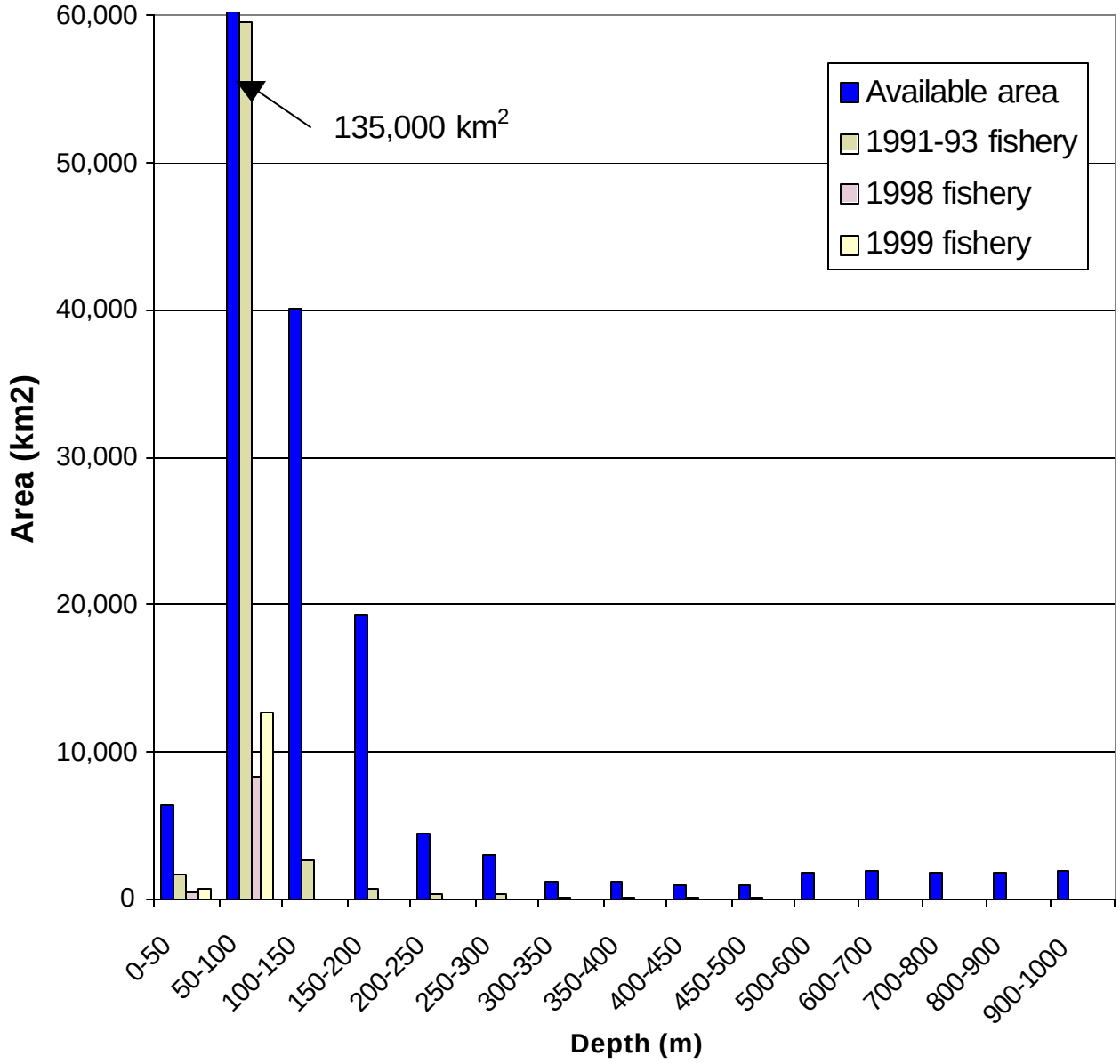
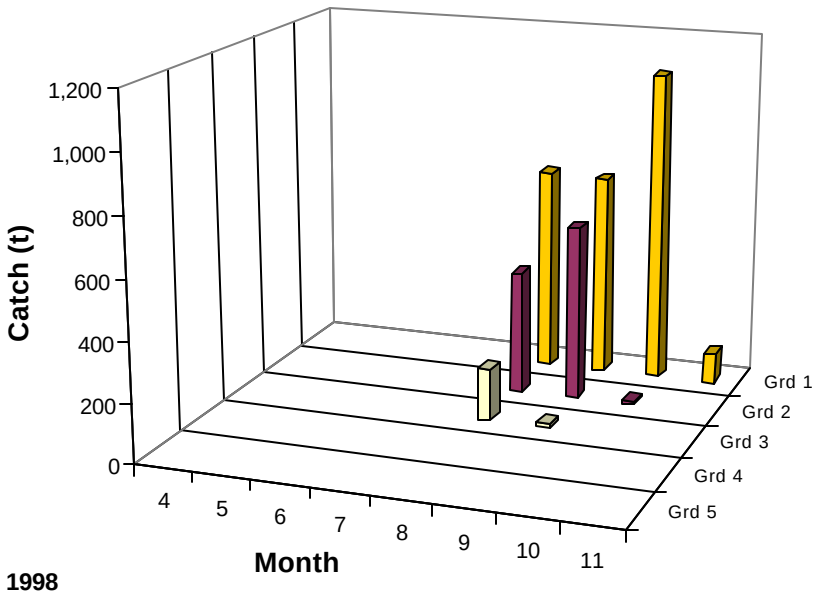
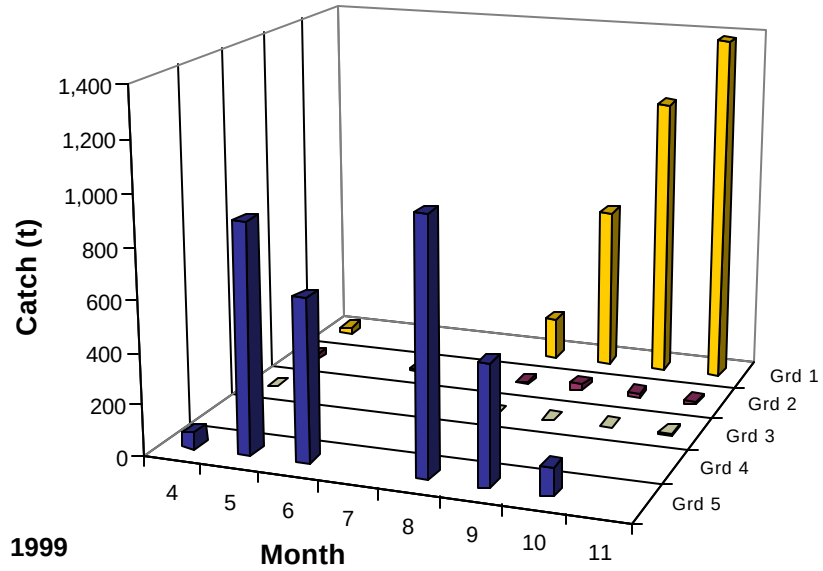


Fig. 2. Area (km²) of the Grand Banks in comparison the extent of area fished for yellowtail flounder in 1991-93 (mixed fishery for yellowtail, plaice and cod), 1998-1999. Available area at 50-100 m was 135,000 km².



1998

	4	5	6	7	8	9	10	11
Grd 5								
Grd 4								
Grd 3					181	16		
Grd 2					421	597	9	
Grd 1					703	693	1,071	105



1999

	4	5	6	7	8	9	10	11
Grd 5	61	893	633		987	467	109	
Grd 4								
Grd 3	1				2	2	4	6
Grd 2	16		12		7	27	19	11
Grd 1	31				170	648	1,116	1,386

Fig. 3. Catch of yellowtail by ground, by month in the 1998 and 1999 fisheries.

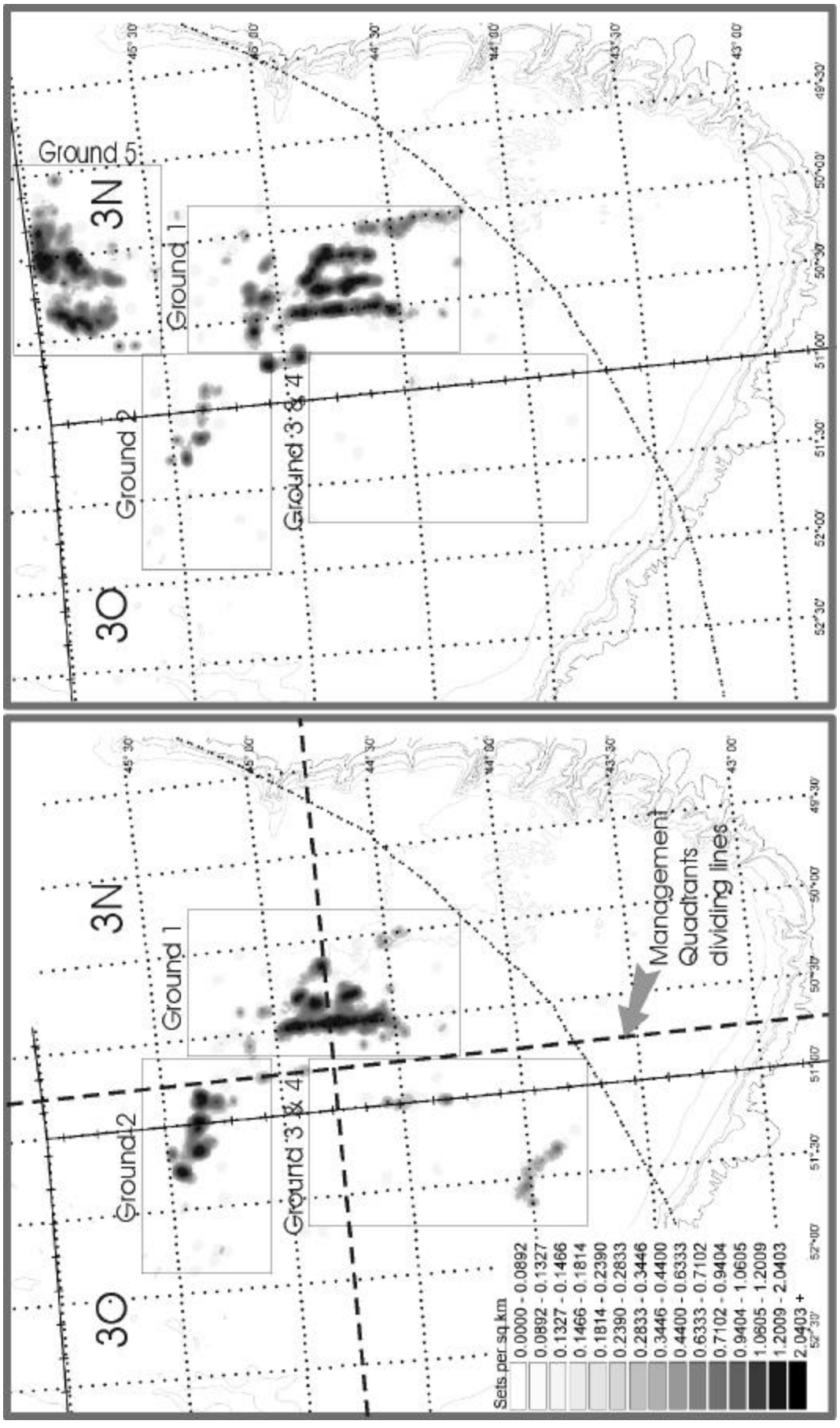


Fig. 4. Fishing grounds for yellowtail flounder in 1998. Darker grey shades denote more densely fished areas. Solid line boxes delineate fishing grounds. Dashed lines delineate managem,ent quadrants. Refer to Fig. X for a description of catch rates within fishing density classes.

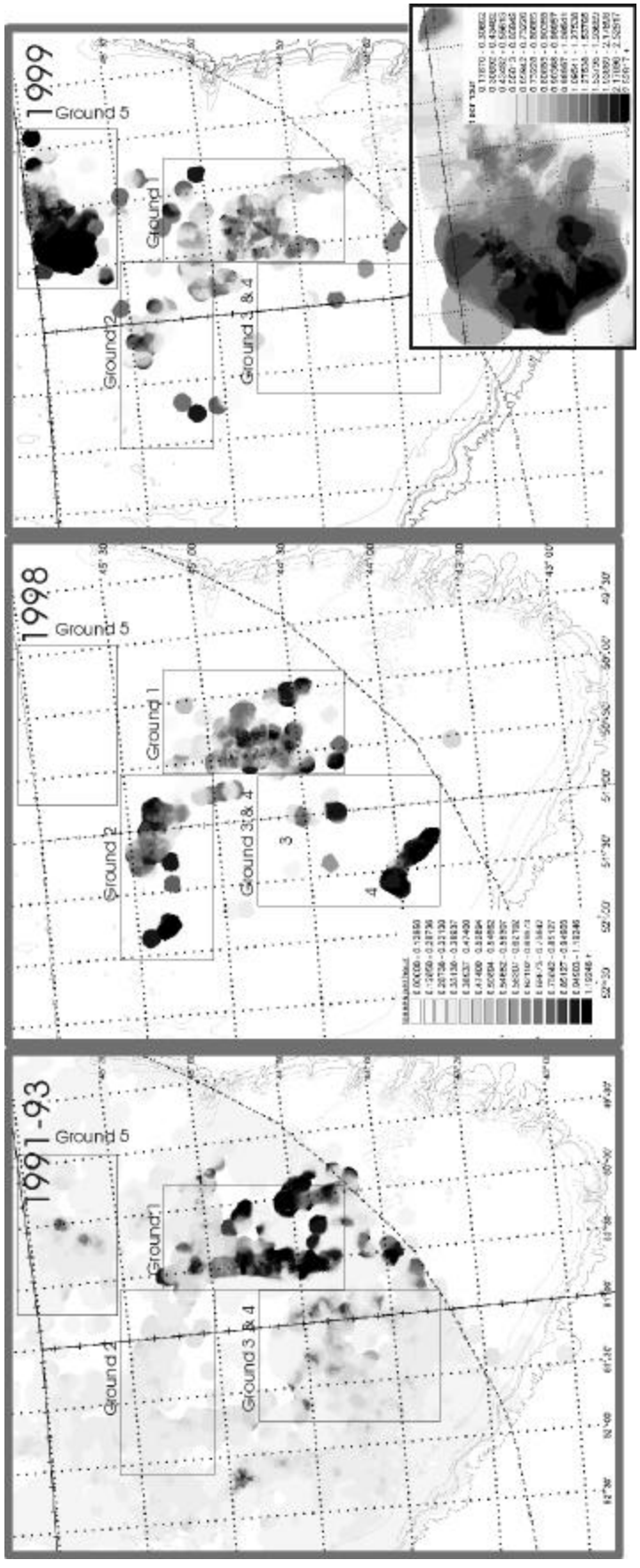


Fig. 5. Comparison of the density (catch per hour) from the fishery for yellowtail in 1998 and 1999 vs. 1991-1993 on the Grand Banks. The three main figures use the same scale of fish density shown in the 1998 panel. The insert panel (lower right) in the 1999 map shows Ground 5 at a higher scale for a more detailed depiction of the high density locations.

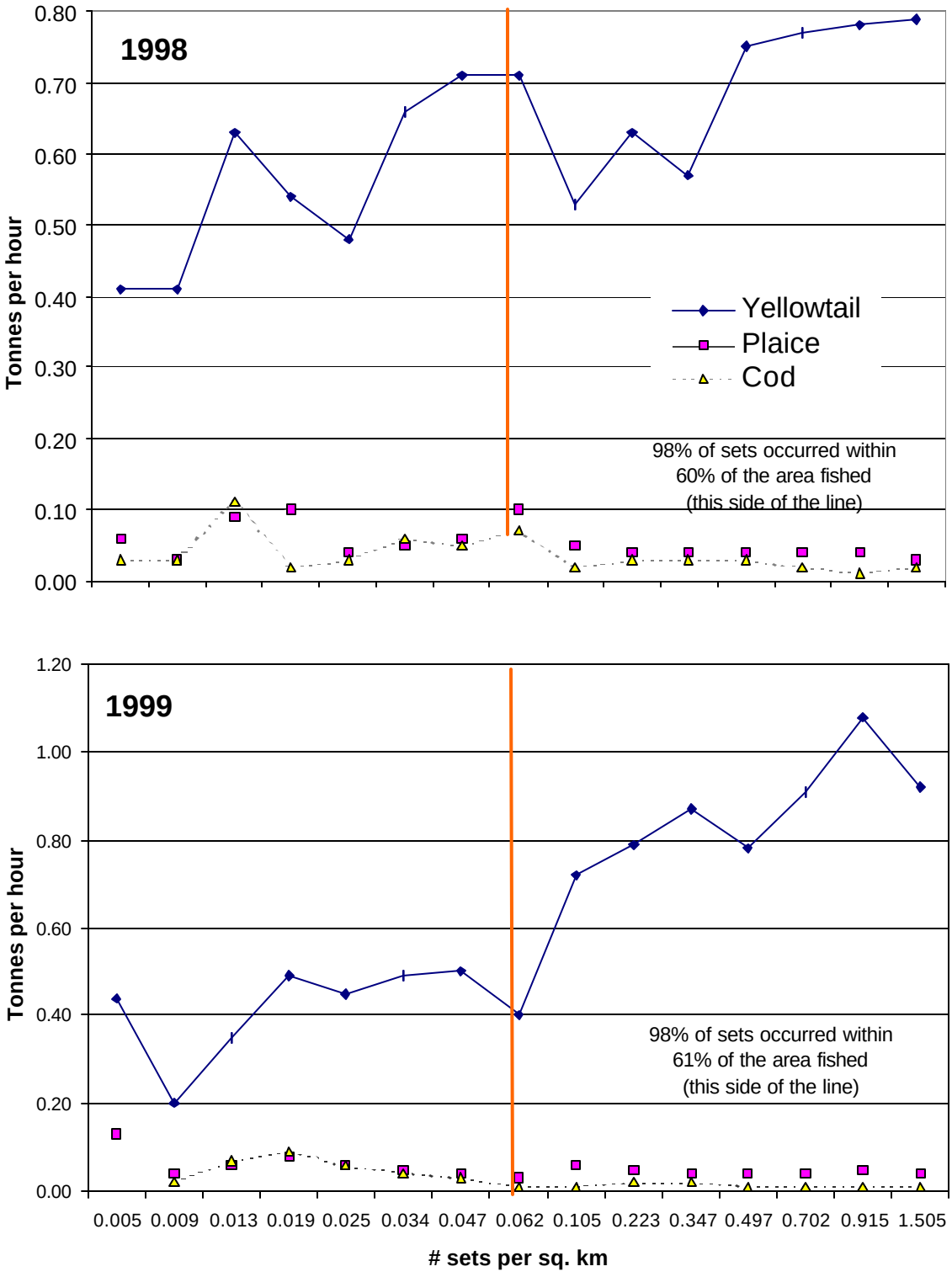


Fig. 6. Comparison of catch rate of yellowtail, plaice and cod by-catch with fishing density for the 1998 and 1999 yellowtail fishery.

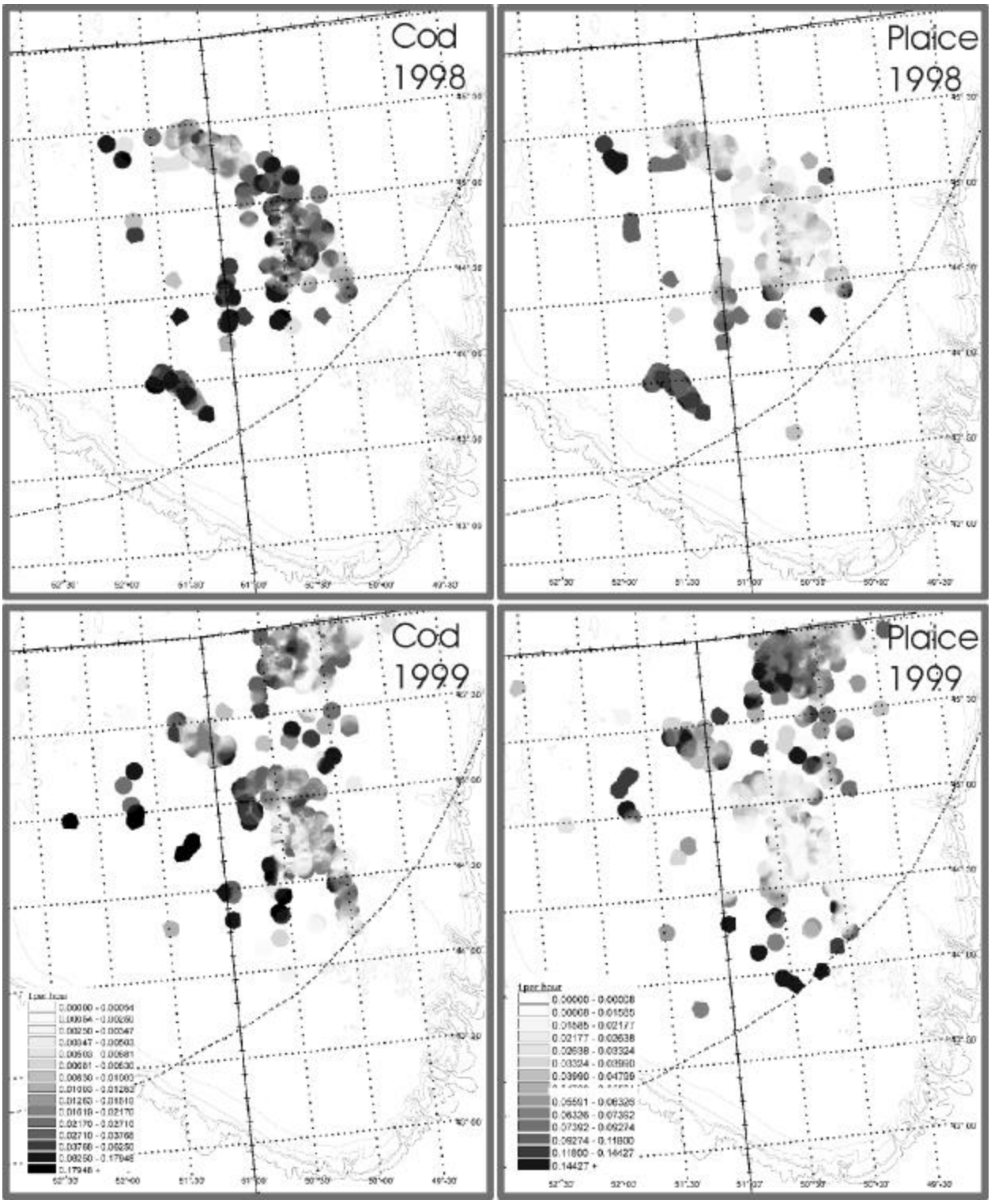


Fig. 7. Distribution of by-catch of cod and American plaice in the 1998 and 1999 yellowtail fishery. Different scales are used for the two different species due to different catch rates.

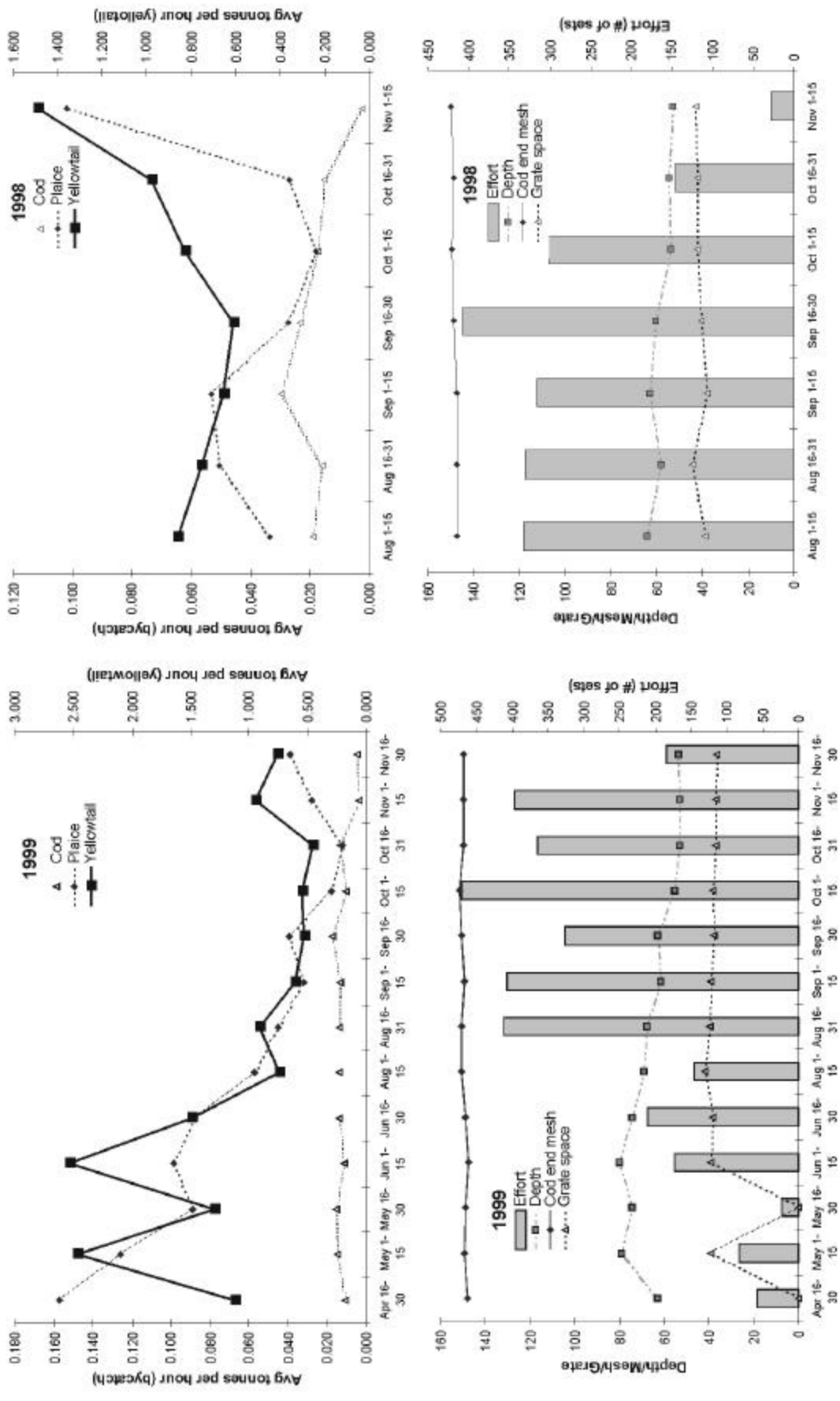


Fig. 8. Biweekly patterns in catch, effort and fishery parameters for yellowtail and by-catch of plaice and cod in the 1998 and 1999 fisheries

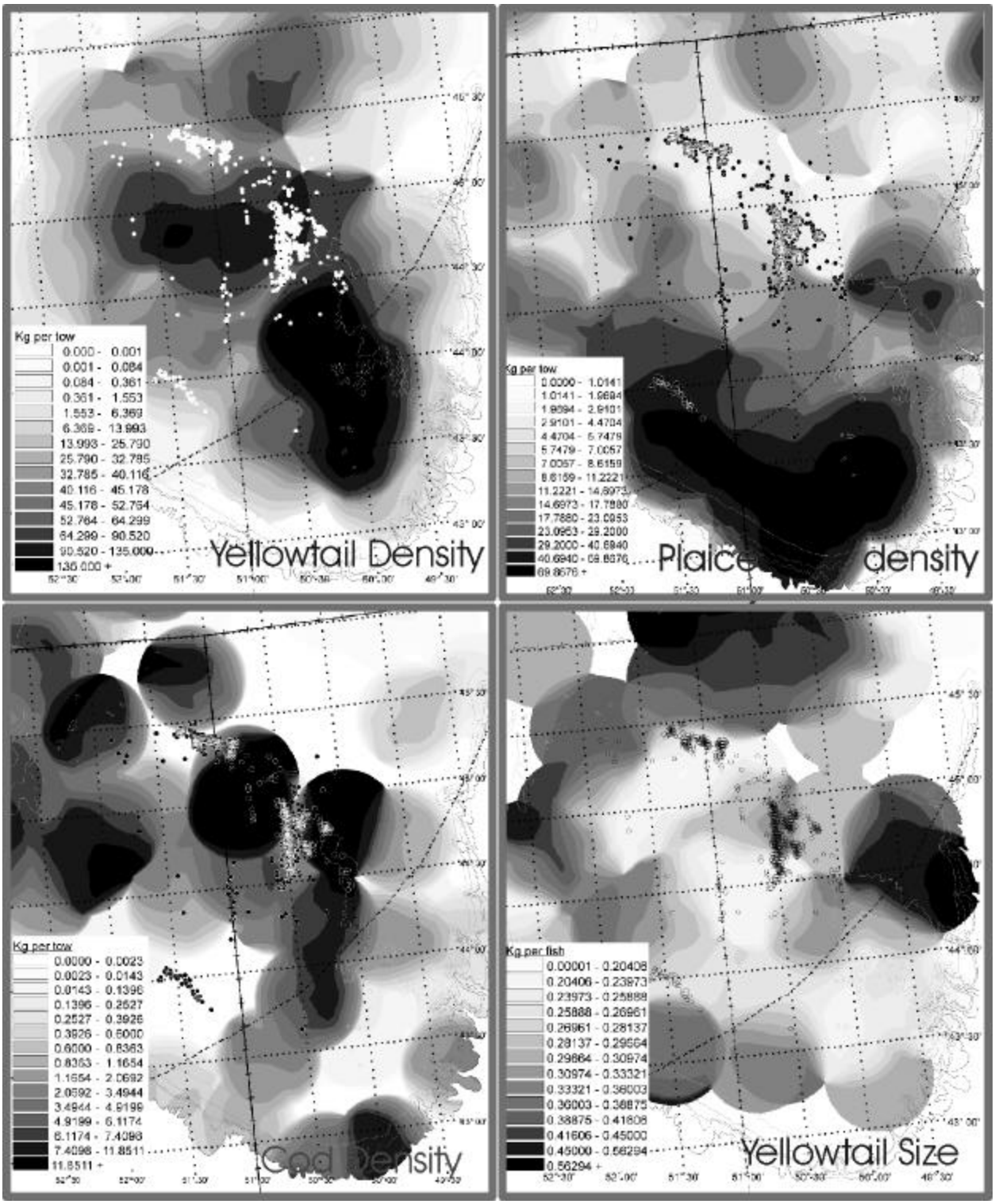


Fig. 9a. Distribution of sets from the 1998 yellowtail fishery (dots on each map) in comparison with density distribution (upper left) and size (lower right) of yellowtail and plaice and cod density distribution (upper right, lower left) from the 1998 fall research surveys.

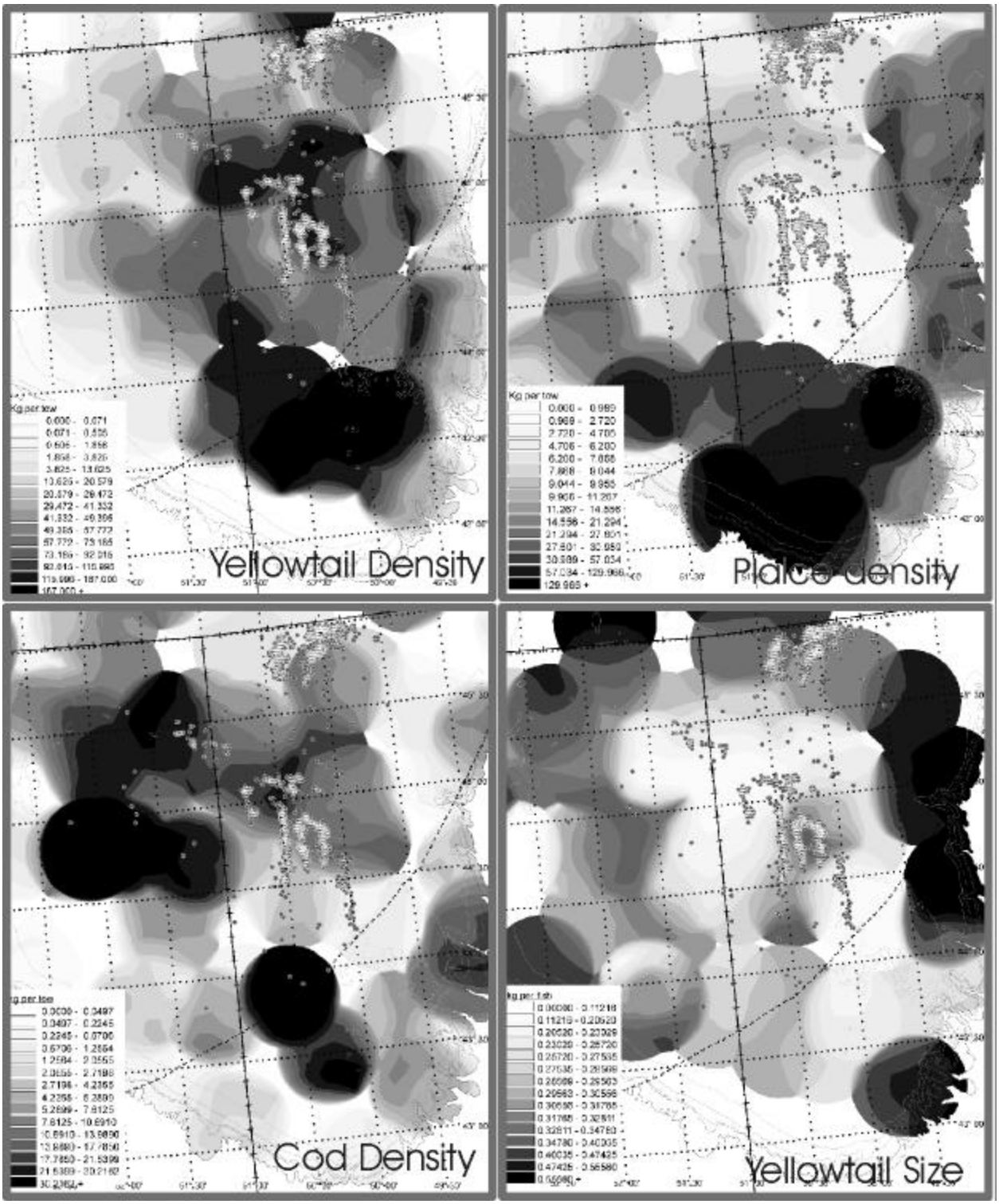


Fig. 9b. Distribution of sets from the 1999 yellowtail fishery (dots on each map) in comparison with density distribution (upper left) and size (lower right) of yellowtail and plaice and cod density distribution (upper right, lower left) from the 1998 fall research surveys.

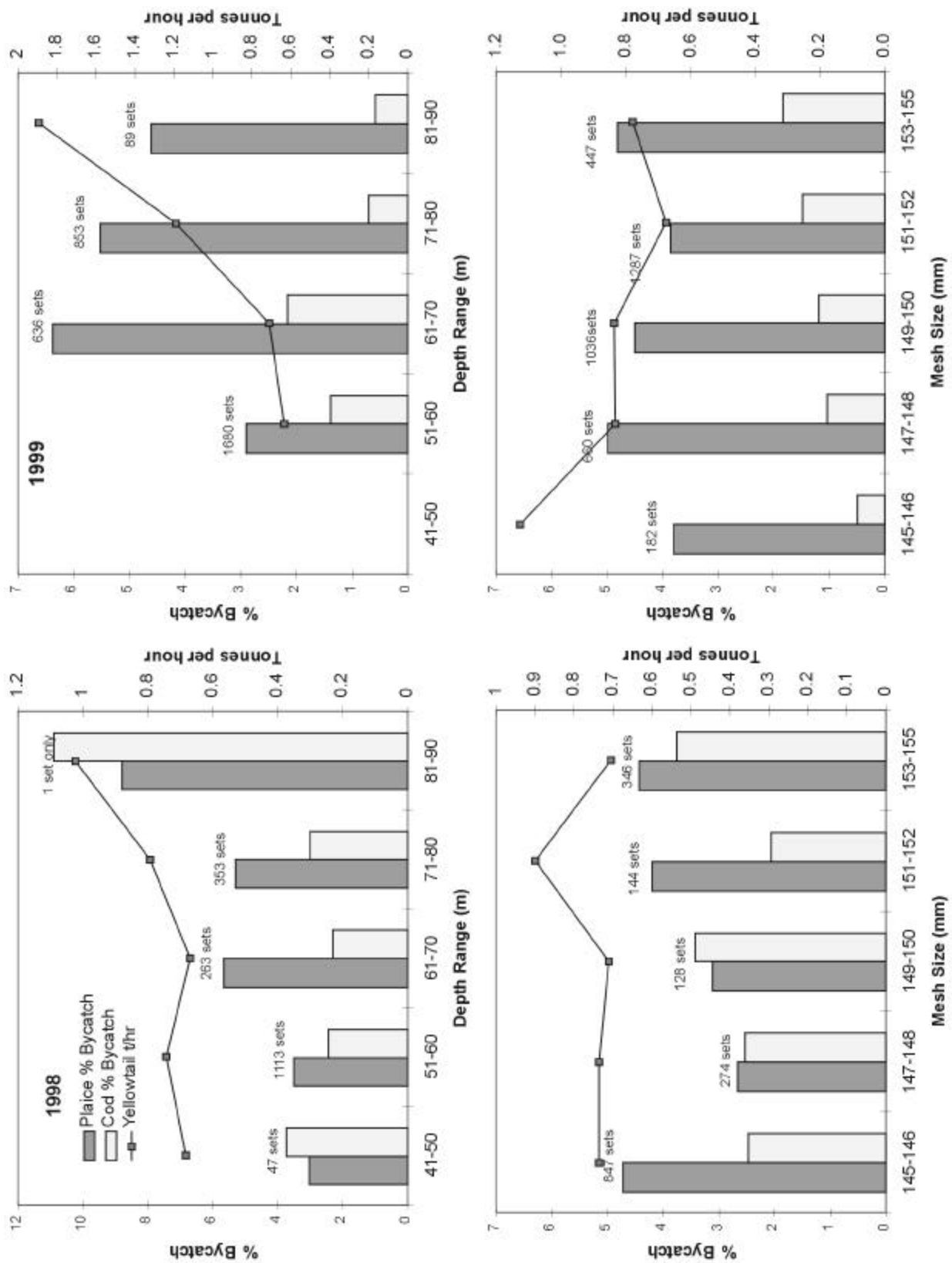


Fig. 10. Catch rate of yellowtail and percent by-catch of plaice and cod by depth ranges (upper panel and by mesh size (lower panel) in 1998 and 1999.

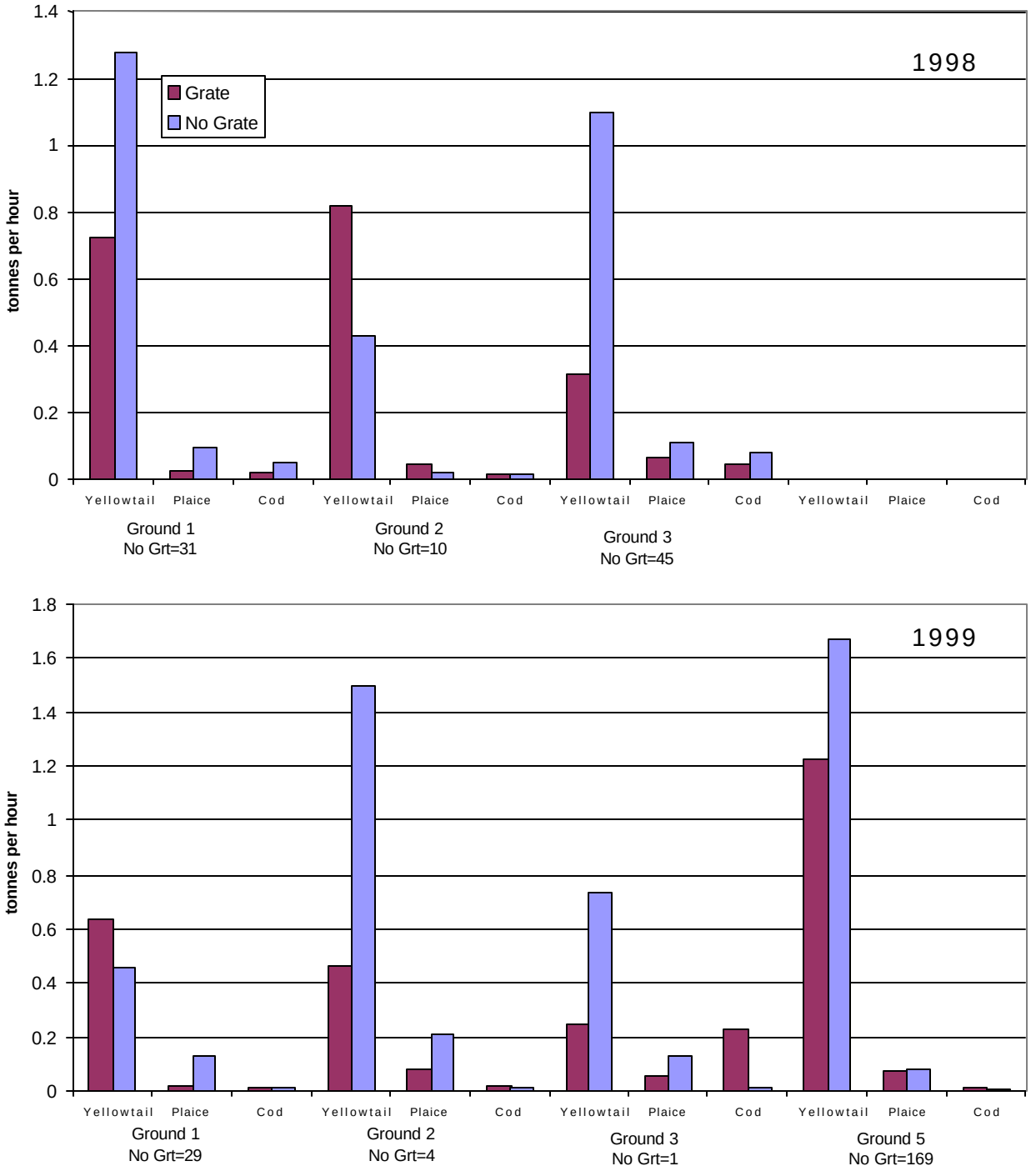


Fig. 11a. Effect of using a sorting grate on the catch rates of the directed species, yellowtail and by-catch of plaice and cod in 1998 (upper) and 1999 (lower) by fishing Ground.

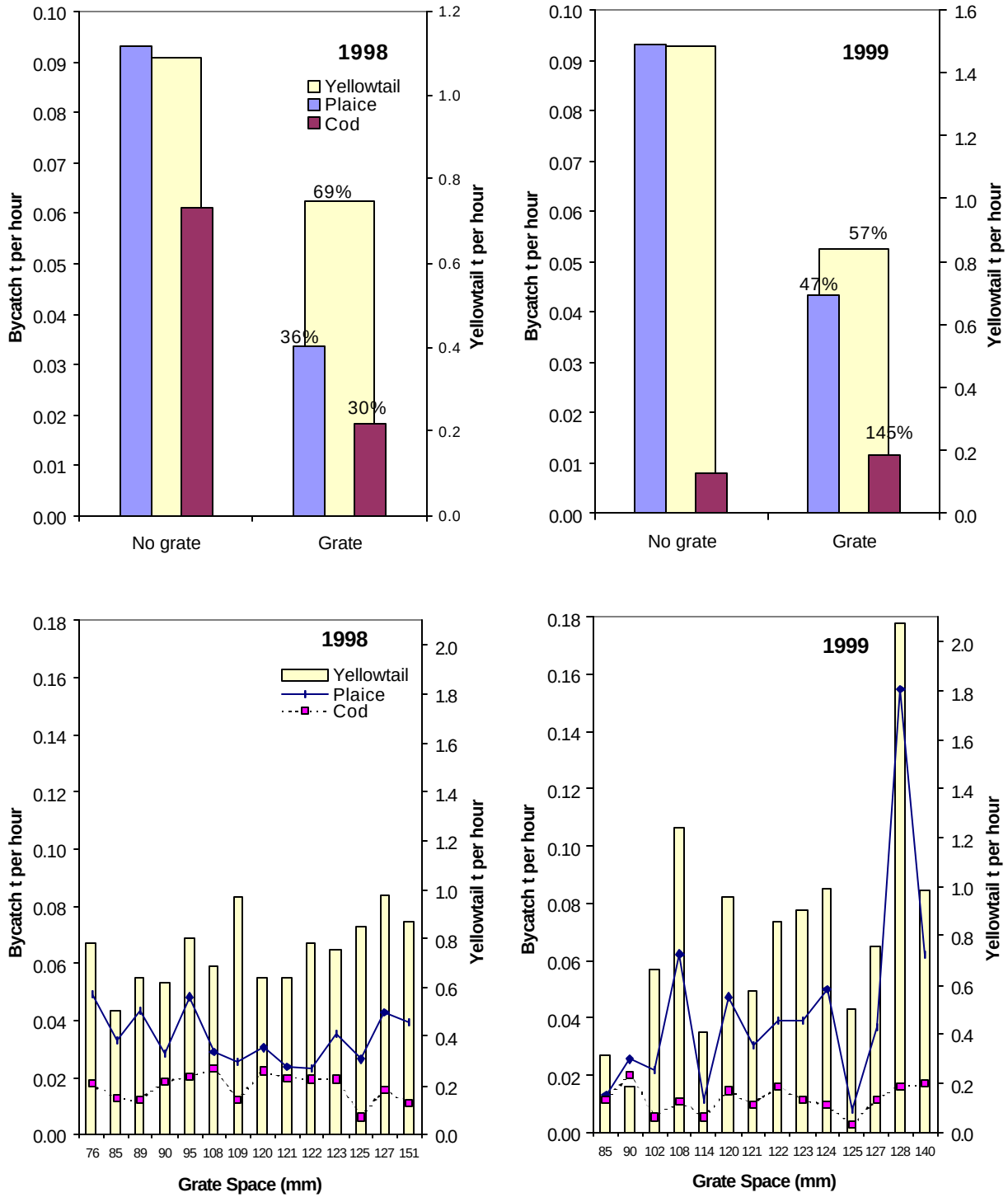


Fig. 11b. Effect of using a sorting grate on the catch rates of the directed species, yellowtail and by-catch of plaice and cod in 1998 and 1999 over all grounds (upper panels). Effect of spacing of the grate on the catch rates of the directed species, yellowtail and by-catch of plaice and cod in 1998 and 1999 (lower panels).

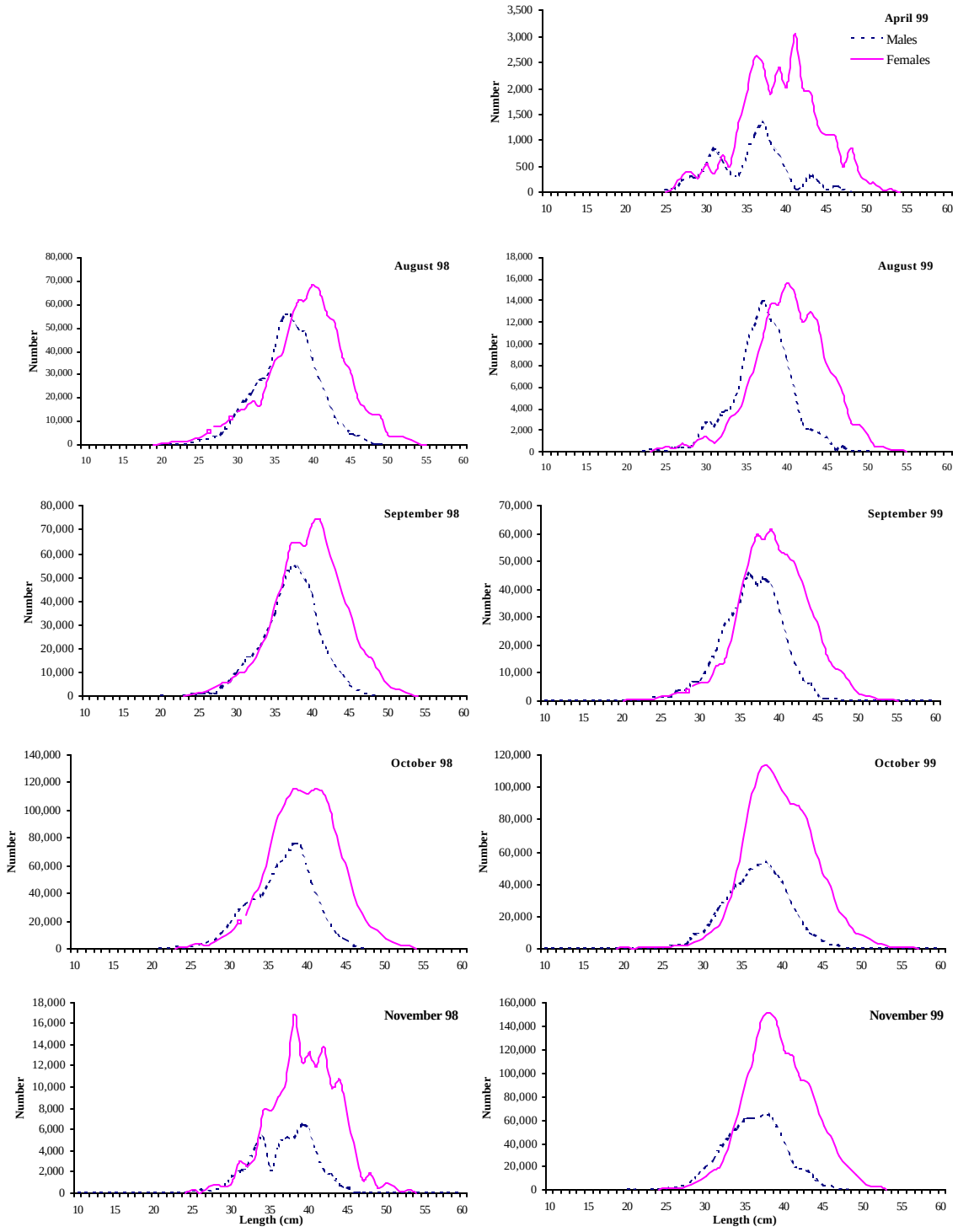


Fig. 12a. Sexed length frequency distributions by month for **Ground 1** yellowtail catches for 1998 and 1999. Refer to Fig. 2 for location of grounds.

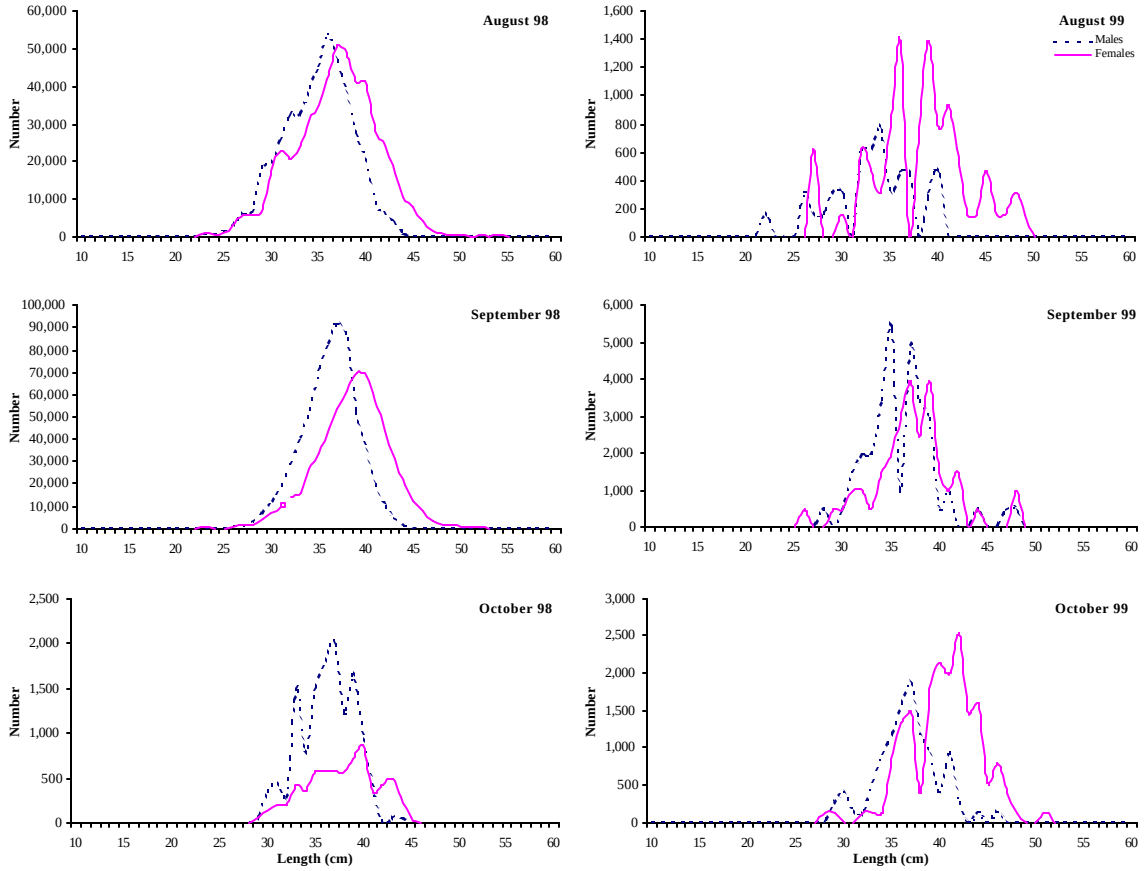


Fig. 12b. Sexed length frequency distributions by month for **Ground 2** yellowtail catches for 1998 and 1999. Refer to Fig. 2 for location of grounds.

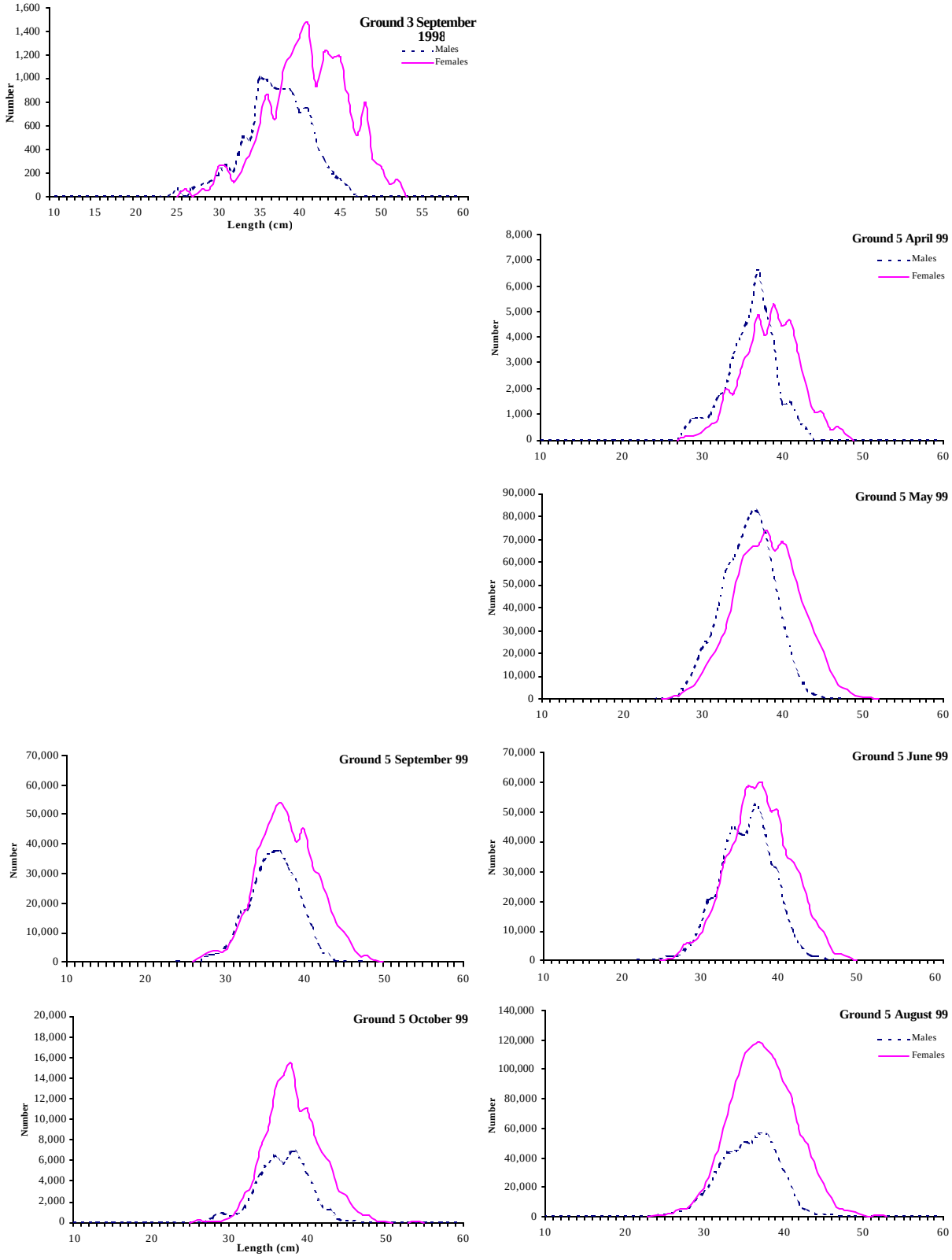


Fig. 12c. Sexed length frequency distributions by mo nth for **Ground 3&4** yellowtail catches for 1998 (upper figure) and **Ground 5** catches for 1999. Refer to Fig. 2 for location of grounds.

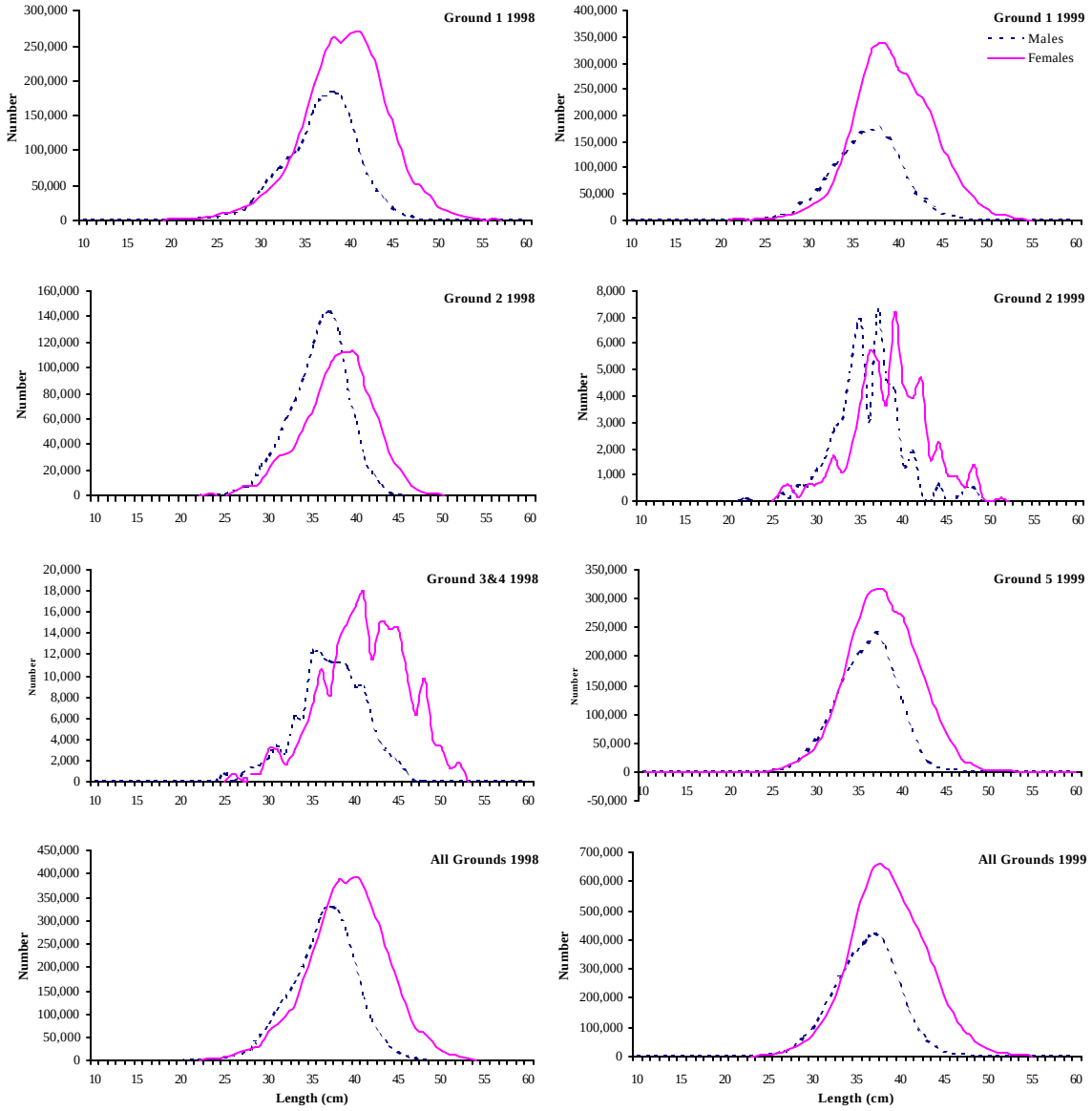


Fig.12d. Sexed length frequency distributions for yellowtail catches summarized by Ground. Lower figure shows overall frequency for all areas combined. See Fig. 2 for location of grounds.

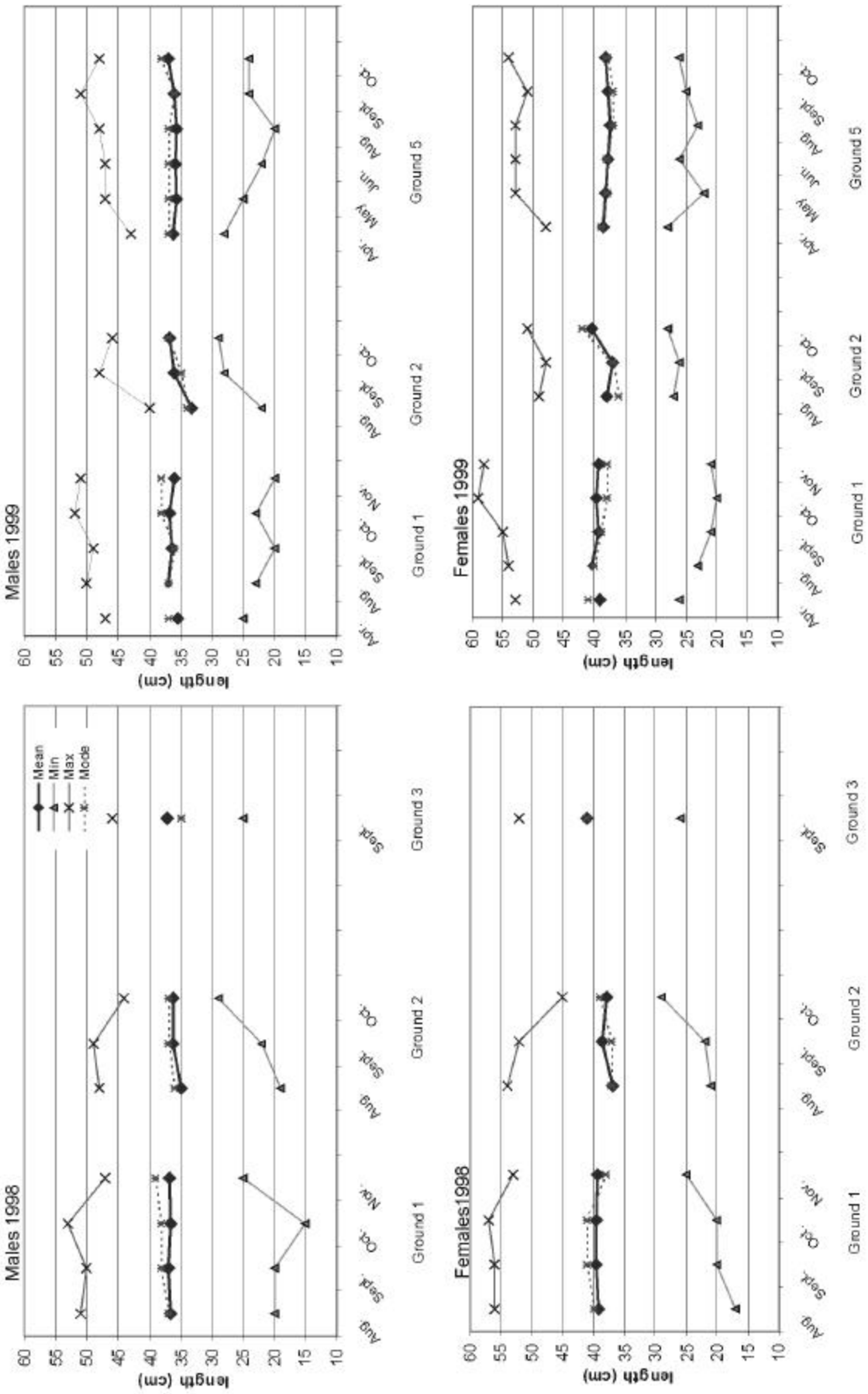


Fig. 13. Temporal trends in mean, minimum, maximum and mode lengths of yellowtail from the 1998 fishery by fishing ground.

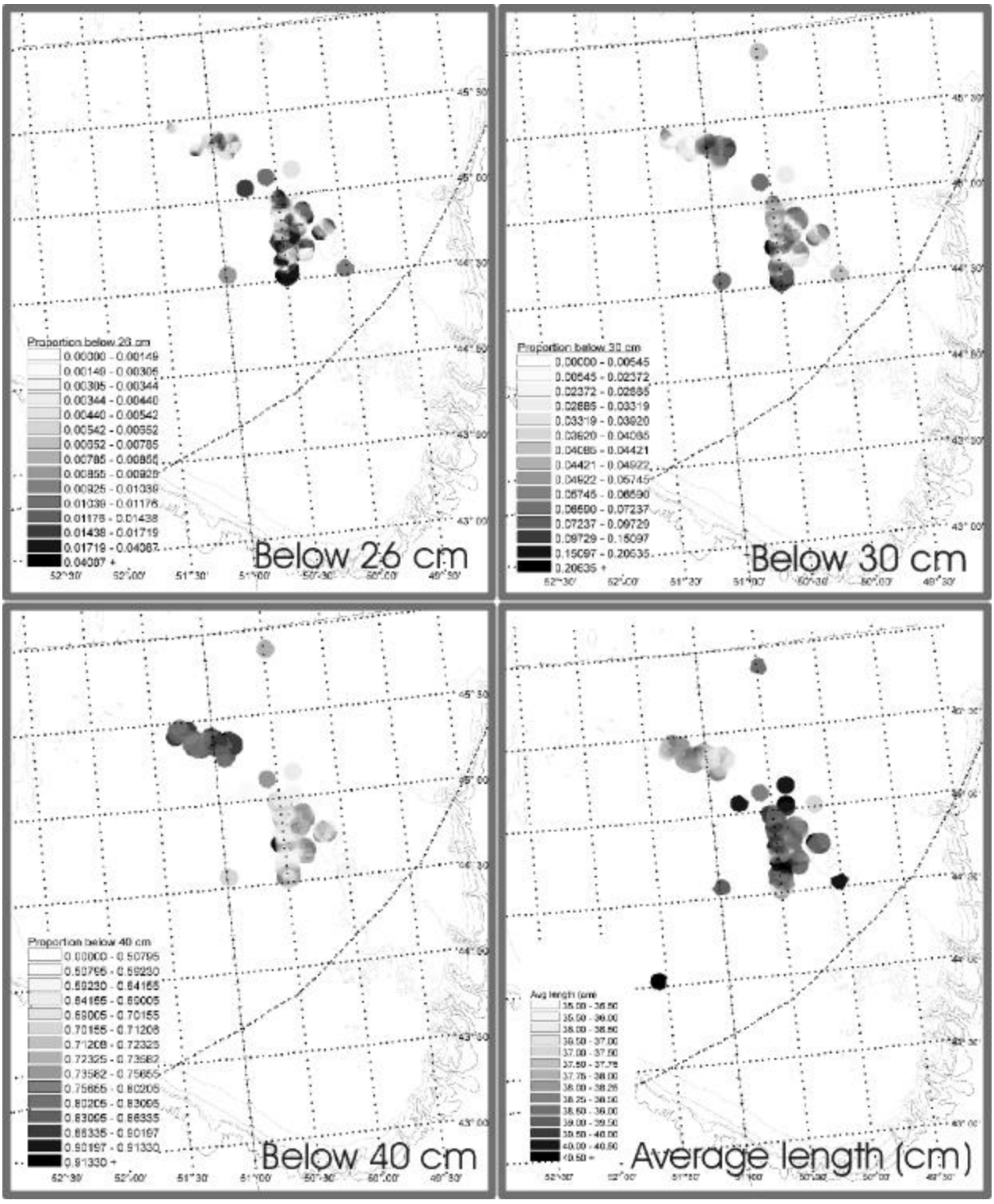


Fig. 14a. Proportion of fish below 26 cm, juveniles (upper left panel), below 30 cm, minimum acceptable landing size (upper right), below 40 cm, ages 1 to 7 (lower left) and average length (lower right) for 1998.

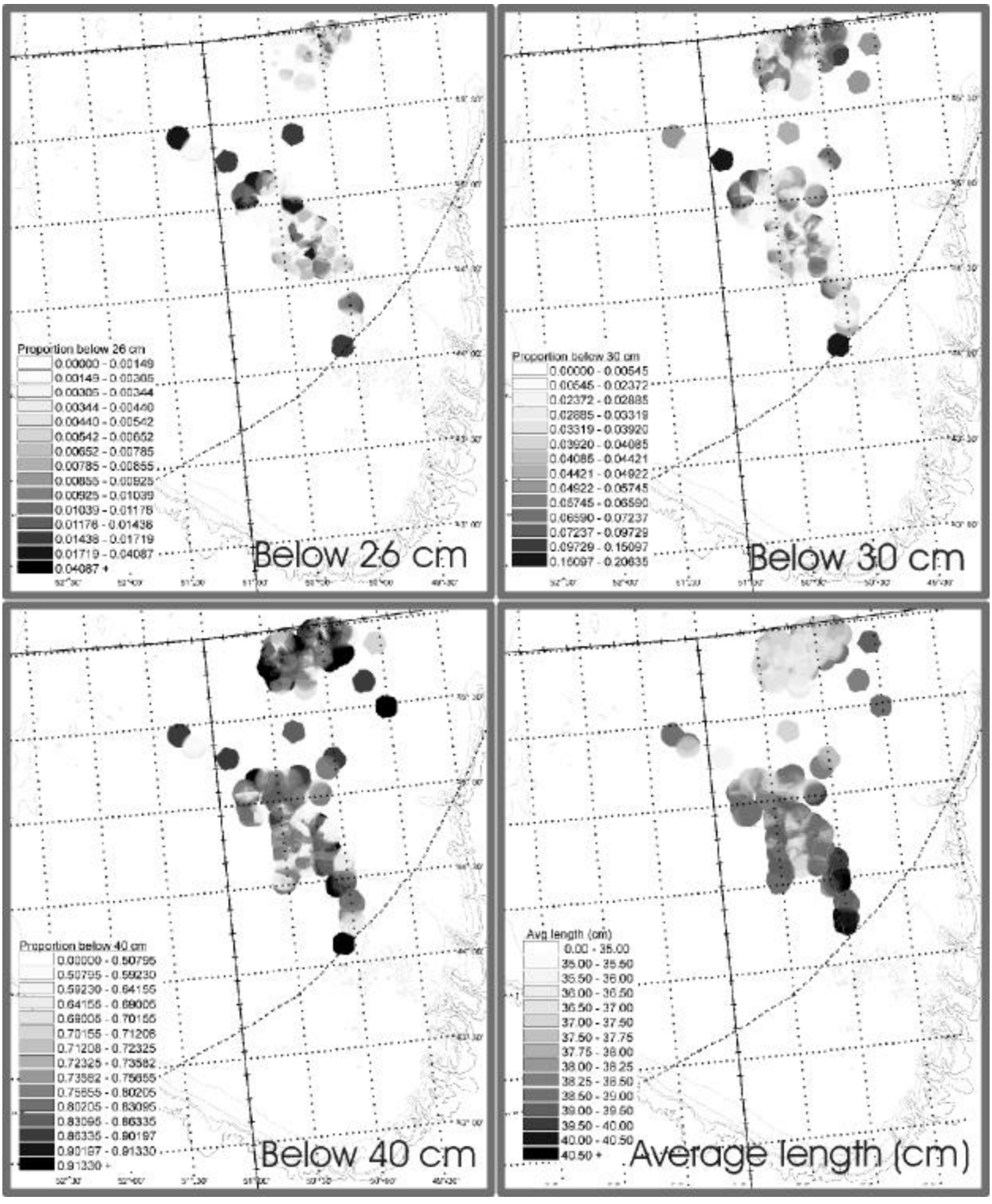


Fig. 14b. Proportion of fish below 26 cm, juveniles (upper left panel), below 30 cm, minimum acceptable landing size (upper right), below 40 cm, ages 1 to 7 (lower left) and average length (lower right) for 1999.

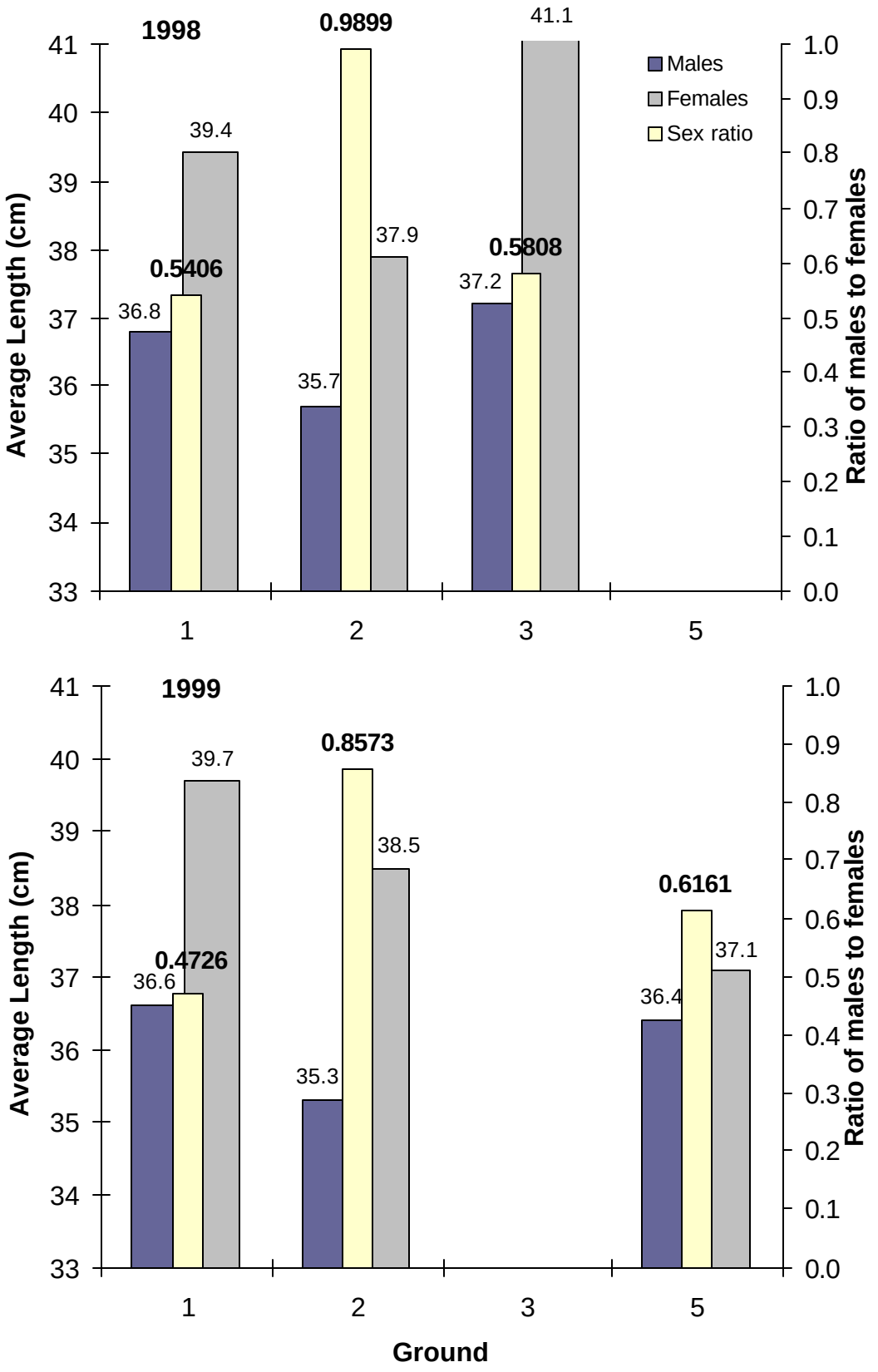


Fig. 15. Average length, numbers of fish caught and sex ratio by fishing ground for the 1998 yellowtail fishery.

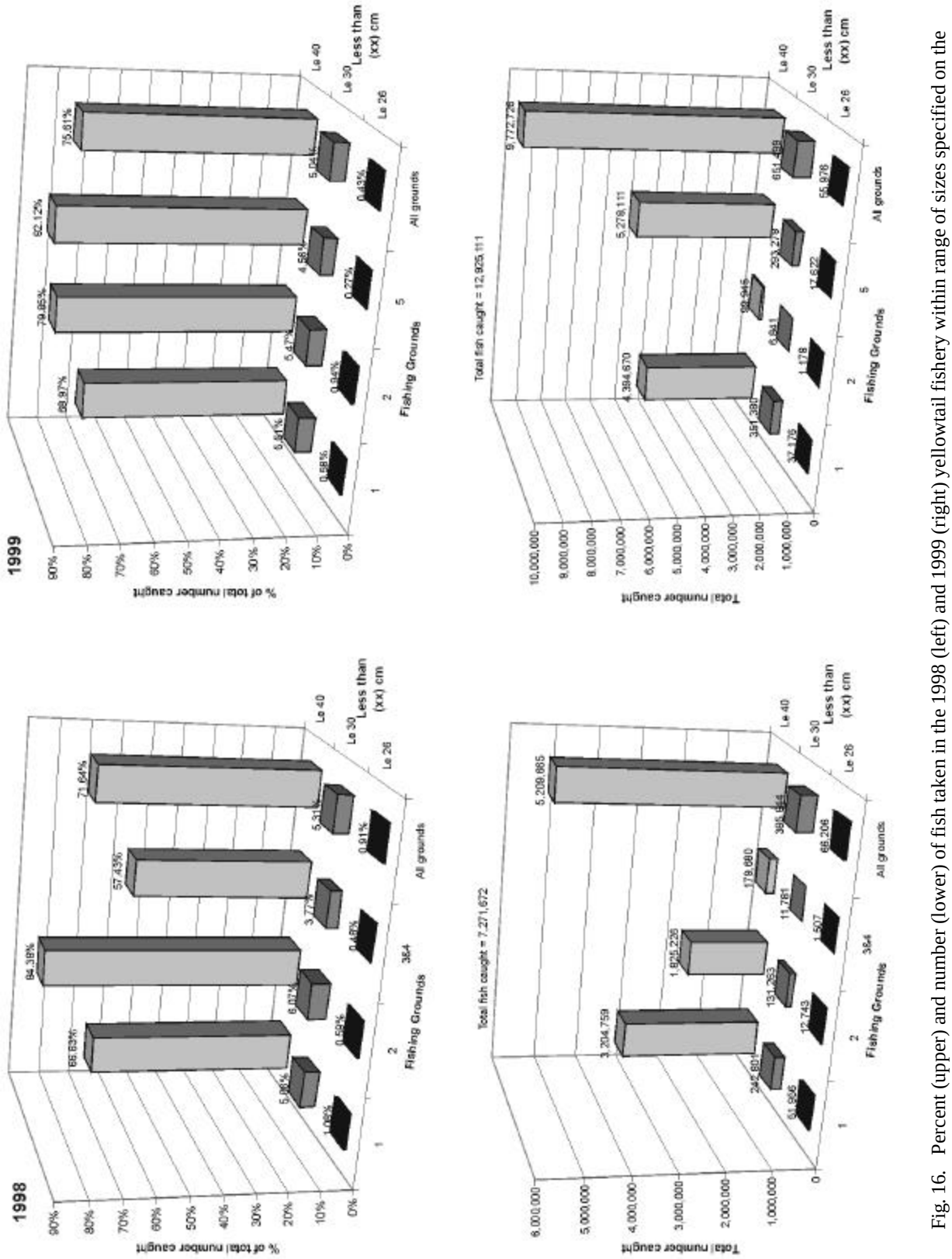


Fig. 16. Percent (upper) and number (lower) of fish taken in the 1998 (left) and 1999 (right) yellowtail fishery within range of sizes specified on the Z axis.

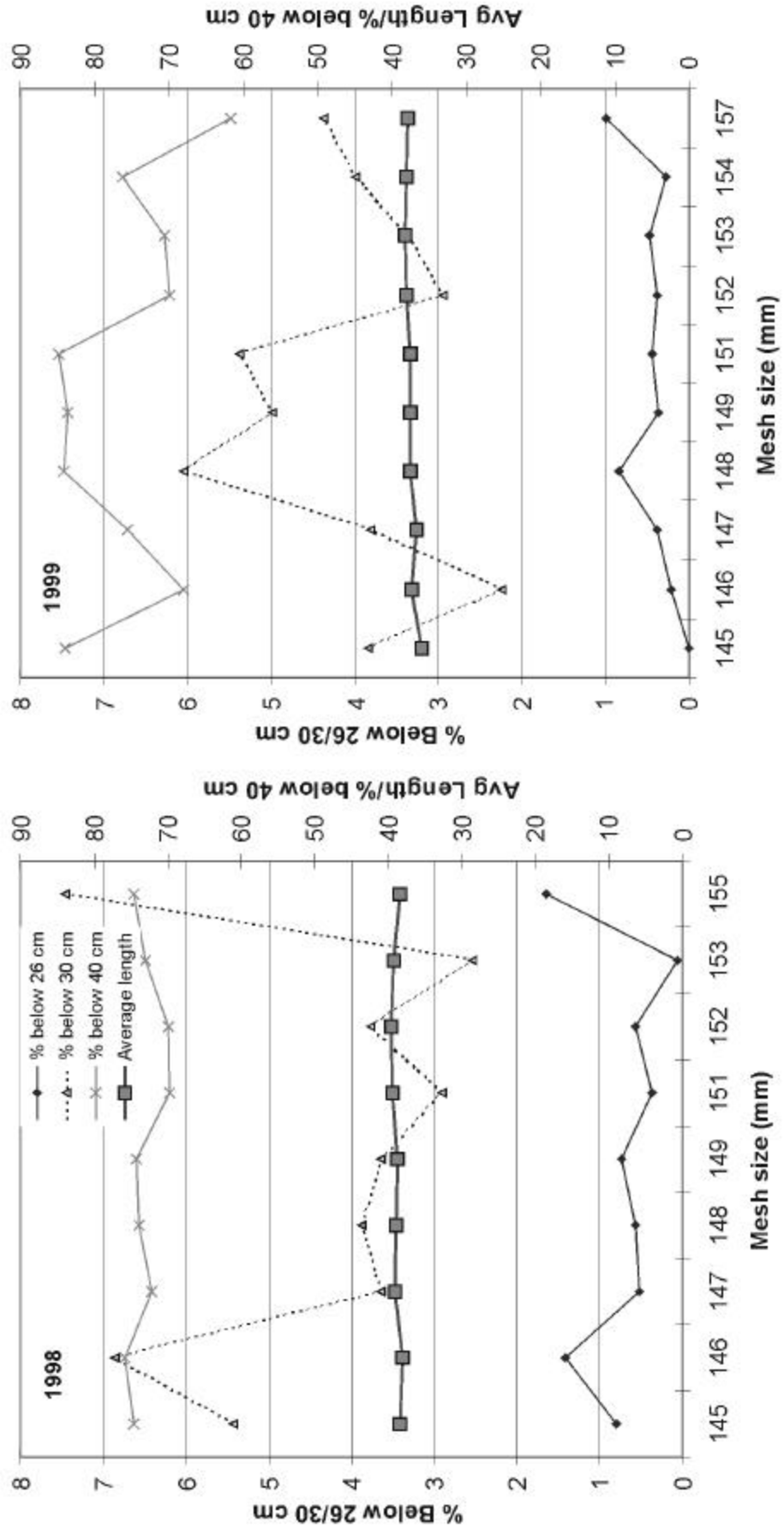


Fig. 17. Relationship between average length, % below of yellowtail 26 cm, % below 30 cm, % below 40 cm and mesh sizes used for catching yellowtail in the 1998 fishery.

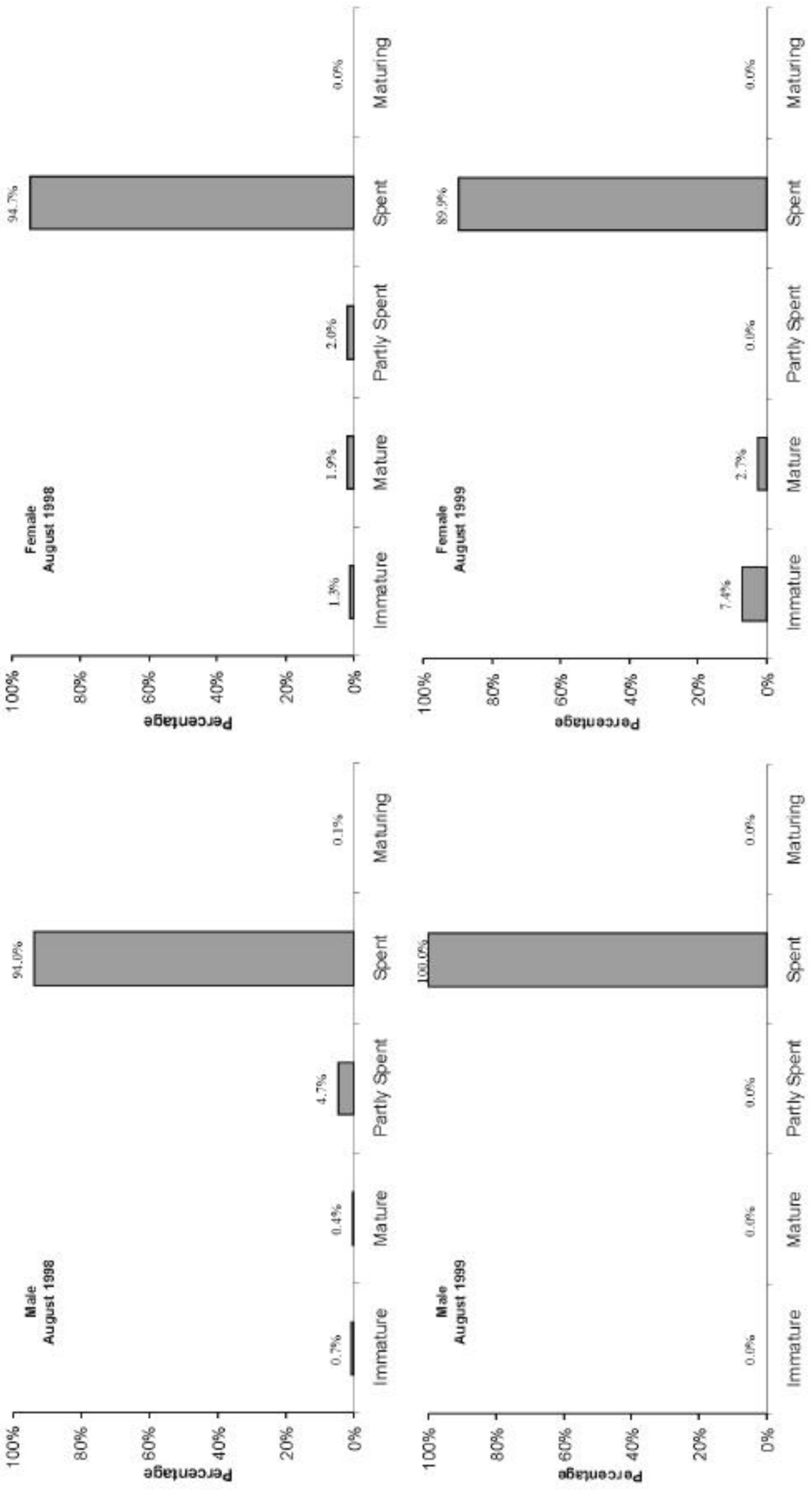


Fig. 18a. Maturity stages of yellowtail caught in the first two weeks of the 1998 directed fishery.

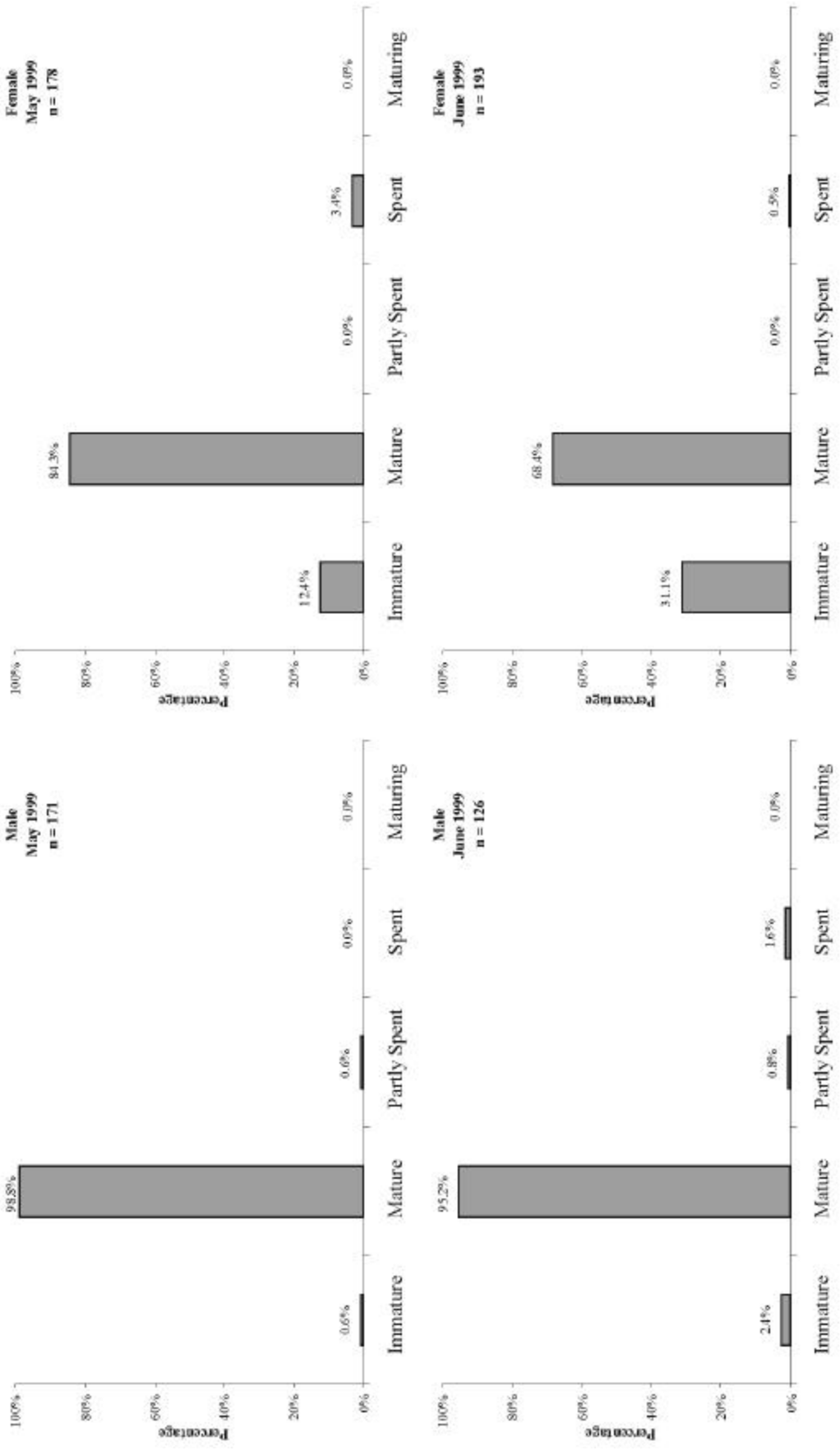


Fig. 18b. Maturity stages of yellowtail caught in the first two weeks of the 1999 directed fishery.