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Changes in Distribution of Yellowtail Flounder on the Grand Bank During the Late-1980s and Early-1990s

by

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Introduction

Yellowtail flounder (*Pleuronectes ferruginea*) is a right-eyed, small-mouthed flounder that inhabits the continental shelf of the Northwestern Atlantic Ocean from Labrador to Chesapeake Bay at depths of 10-100 m, (Bigelow and Schroeder 1953). This species has reached its northern limit in commercial concentrations on the Grand Bank off the coast of Newfoundland. Juvenile yellowtail flounder are consistently found concentrated on the Southern Grand Bank, mainly in the NAFO Regulatory Area, and as they mature their distribution radiates in a west and northerly direction (Walsh, 1992). This movement may be a function of density and it is assumed that intraspecific competition for prey items may be the stimulus. However, historically the major portion of the biomass has always been located in the Southern Grand Bank area thus one can assume that this area, which also acts as a nursey area (Walsh, 1992), is the preferred habitat.

The stock on the Grand Bank declined in abundance during the mid to late 1980's and has remained at a low level since then (Brodie *et al.*, 1993). There have also been changes in distribution during this period, as evidenced by research vessel surveys from 1971-93. This paper will document these changes in distribution and examine them in relation to increased exploitation on the stock and changes in water temperatures on the Grand Bank.

Methods and Materials

Three series of Canadian research vessel surveys on the Grand Bank were examined: spring groundfish surveys from 1971 to 1994, seasonal (mostly fall) groundfish surveys from 1983 to 1993, and juvenile groundfish surveys (summer-fall) from 1986 to 1993. All surveys were conducted using a stratified-random design, based on the stratification scheme shown in Fig. 1. The groundfish surveys were done by the same vessel and gear after 1983, and the juvenile surveys were done on the same vessel but with a gear more suited for capture of small fish (for details on these survey series, see Brodie *et al.*, 1993).

Plots of distribution from the three survey series were done using ACON software (Black 1993). Estimates of abundance were calculated in the usual fashion for stratified-random surveys (Smith and Somerton 1981). Maximum northern occurrence was defined as the most northerly position at which at least 1 yellowtail was caught during a survey. Temperature data were collected during or immediately following each fishing set using either XBT or trawl-mounted CTD.

Results

Groundfish surveys: The abundance of yellowtail declined sharply in the mid to late 1980's (Fig.2) following a period of increased catches (Brodie *et al.*, 1993). Plots (Fig. 3) of spring survey data from 1978, 1985, 1990, and 1992 (from Brodie *et al.*, 1993) clearly show a contraction from a fairly wide distribution over the southern and central Grand Bank to one concentrated around the western side of the Southeast Shoal in Div. 3N. Of particular interest is the near disappearance of yellowtail from Div. 3L, where it was once relatively abundant (Fig. 4). Fall surveys of Div. 3LNO from 1990 to 1993 also show the concentration of the stock in and around the Southeast Shoal, and the relative scarcity of fish north of 45 degrees N. latitude in 1993 (Fig. 5).

Further analysis of the spring survey data showed a marked decline in the maximum northern latitude of occurrence of yellowtail in Div. 3L (Fig. 6). These data show that the maximum value for northern occurrence was in 1978, and that the minimums occurred in 1992 and 1993, with these values being about 50 nautical miles to the south of the 1971-91 mean value and almost 100 n. mi. south of the maximum in 1978. Fig. 6 also shows the trends in mean bottom temperature from the surveys at depth intervals 56-92 m (31-50 fm) and 93-183 m (51-100 fm). Of interest is the agreement in trends in the occurrence and temperature data, at least for many of the years, eg. peaks in 1971 and 1978, troughs in 1973-74 and 1992-93. However, the low temperatures in 1985-86 did not coincide with any decline in northerly distribution, and the temperatures in 1992-93 were similar to those in 1990-91 (93-183 m), 1985-86 and 1973-74, yet the maximum northern occurrence was much lower in the most recent period than during the earlier periods.

Comparison of the occurrence data with total estimated abundance of yellowtail in Div. 3LNO did not show good agreement in trends (Fig. 7). For example, the increase in northerly distribution in 1978-79 occurred at a time when the stock size was apparently stable, and the decline in stock size from 1984 to 1991 occurred when there was no noticeable decrease in the maximum northern latitude. The sharp declines in the occurrence index in 1992 and 1993 happened at stock sizes similar to those in the preceeding 4 years.

To show the relative decline in yellowtail abundance in the northern parts of Div. 3NO, biomass estimates in strata 351+362+373 (Fig. 1) were divided by the total biomass in Div. 3LNO from the spring surveys. Comparisons with mean bottom temperatures and total stock size are shown in Figs. 8 and 9 respectively. From 1978 to 1986, the proportion of stock biomass in these 3 strata was around 0.25 to 0.35 of the total, but from 1989 onward, the proportion has been 0.2 or less. This decline coincides with declining trends in both bottom temperature and stock size since the early 1980's.

Juvenile groundfish surveys: The annual late summer/fall juvenile fish surveys, 1986-1993, also showed a systematic change in distribution in Div. 3L (Figs. 10,11). In the 1993 survey the stock was almost exclusively found in Div. 3NO, concentrated on the Southeast Shoal and the adjacent area to the west, below 45^0 N. In the juvenile survey time series the 1985 year class was identified as the largest at most ages (Brodie et al., 1994). By plotting the location of this year class as the fish grows older, it was evident that there has been some dispersion into the northern Grand Bank, but that a major portion stayed in and around the nursery area (Fig. 12). Table 1 shows the distribution of the 1984-92 year-classes present in the 1993 survey of selected strata in Div. 3NO. The majority of the 1988 to 1992 year-classes at ages 1 to 5 were found in stratum 376 (the southern portion of the Southeast Shoal) and stratum 360, in Division 3N. The 1987 year-class at age 6 was dispersed evenly throughout most strata while the 1984-86 yearclass, at ages 7 to 9 were mainly found inside the 200 mile boundary, which is consistent with the distribution of yellowtail at these ages in earlier juvenile surveys (Brodie et al., 1993). These surveys also showed a decline in stock size in Div. 3L since 1986, during which time the total stock size remained relatively stable (Fig.13).

Discussion and Conclusions

The extensive sand sediments on the Southeast Shoal and the central part of the southern Grand Bank appears to be the preferred substrate for age 1-group, older juvenile and adult yellowtail flounder (Walsh, 1992). These areas are mainly composed of sand and to a lesser degree gravelly sand, i.e. 10-50% of the sand is gravel. This type of substrate is also found in certain areas of the northern section of the Bank in Div. 3L. Sediments also indirectly influence distribution by the composition of benthic food items preferred by yellowtail flounder which feed exclusively on surficial and interstitial macrofauna. Sandy substrate could also provide places for the newly settled to hide and avoid predators. On the southern Grand Bank there is a southeast to northwest change in bottom type with an accompanying change in concentrations of juveniles. Thus the observed changes in distribution may be influenced by depth or temperature but as Scott (1982) reported, sediment size may also be a contributing or determining factor. During the last 3 years, data on sediment type at most survey fishing stations have been collected but are not analyzed at present.

The analyses presented are purely exploratory and are inconclusive in determining the role of temperature or stock size on distribution and northern range of yellowtail on the Grand Bank. The decline in northern range in 1992 and 1993 occurred during a sustained cold period on the Grand Bank, but was also at a time when the stock had been at or near its lowest level for a number of years. Yellowtail flounder is a eurythermal species which remains on the offshore Grand Bank throughout the year with little change in depth distribution in response to wide changes in temperature (Walsh, 1992). Morozova (1993) also reported that yellowtail on the Grand Bank were less abundant in Div. 3L and that the northern limit of the species had declined since the 1970's, based on Russian surveys. She concluded that temperature was not a factor contributing to this change in distribution, but that stock abundance was believed to be an important factor. Similarily, Perry et al. (1988) showed that Scotian Shelf yellowtail did not change their distribution in response to wide fluctuations in temperature and salinity. Given the tendency of this species to remain in shallow depths on the Grand Bank, it is likely that distribution patterns define preferred substrates. Contraction of distribution may simply reflect movement of parts of the population from marginal habitats. Whether this is a response to environmental signals or is a function of stock density or some other factor is not presently known. Future work in this area could include examination of other factors such as salinity and bottom sediment type, defining less stringent criteria for maximum northern occurrence, and more detailed examination of abundance patterns throughout the stock area.

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Table 1. Percent abundance of the 1984 to 1992 year-classes in the various selected strata from the 1993 juvenile survey.

Year-class	Age	Mean len.(cm)	Abundance millions	Selected strata - Percentage 352	360[a]	361	375	376[b]
1992	1	6.2	3.9	0	64	5	0	28
1991	2	10.6	31.9	18	52	12	1	18
1990	3	16.1	39.6	16	53	16	0	16
1989	4	22.0	81.5	31	32	17	0	20
1988	5	27.1	105.6	16	39	22	2	20
1987	6	32.2	92.7	24	23	37	6	10
1986	7	37.2	88.6	32	13	40	11	3
1985	8	42.5	47.3	36	8	39	15	2
1984	9	47.5	10.1	30	10	43	15	2

[a]93% outside 200-mile limit.

[b]89% outside 200-mile limit.

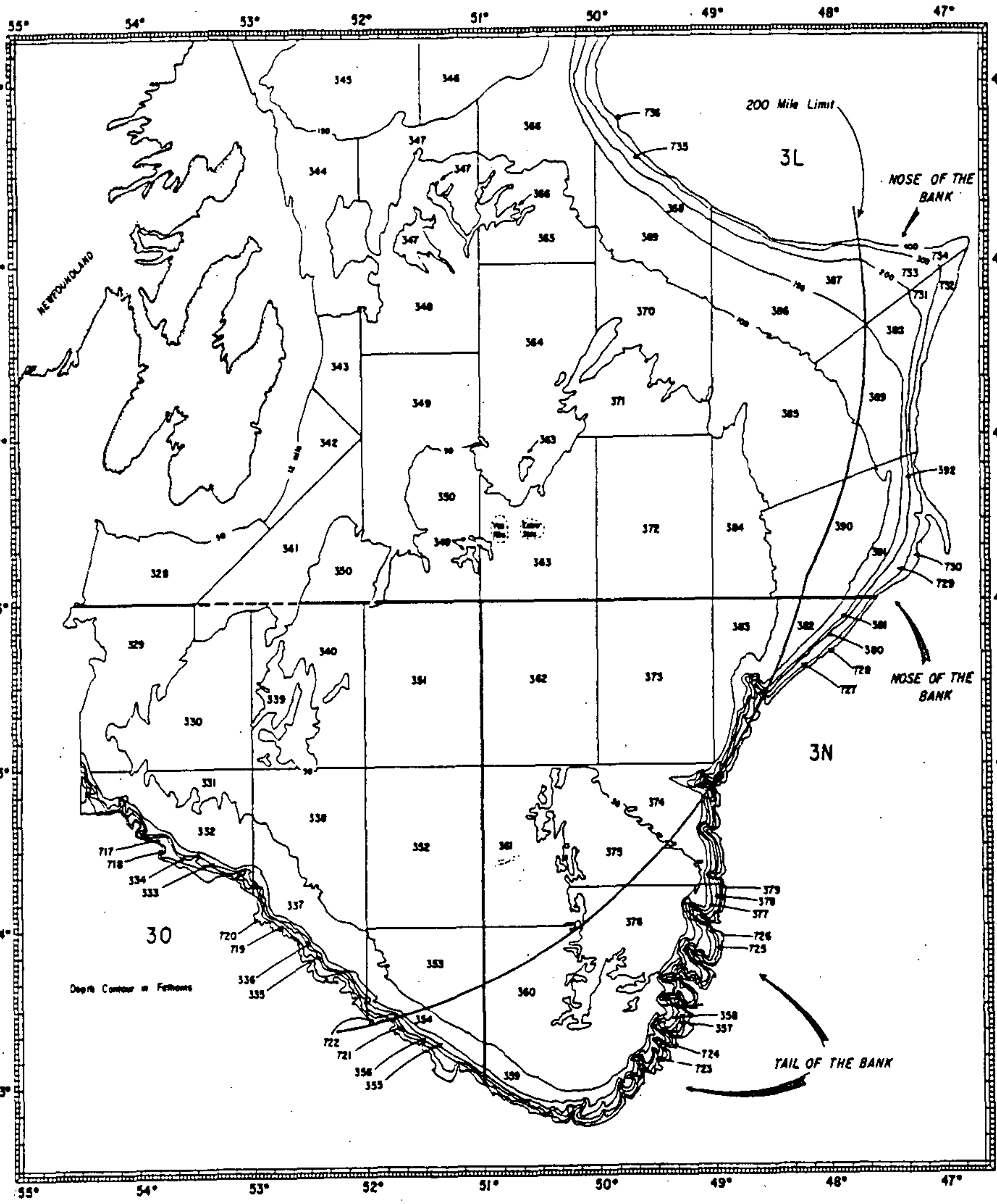

Fig. 1. Grand Banks, NAFO Div. 3LNO, showing the Canadian 200 mile limit in relation to the Nose and Tail of the Bank as well as the stratification scheme used in Canadian groundfish surveys.

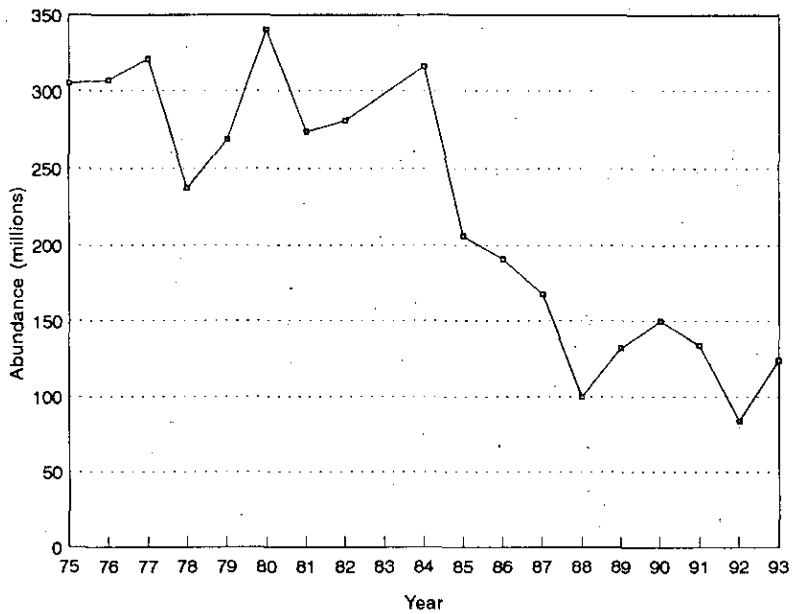

Fig. 2. Abundance of yellowtail in Div. 3LNO as measured by Canadian spring RV surveys.

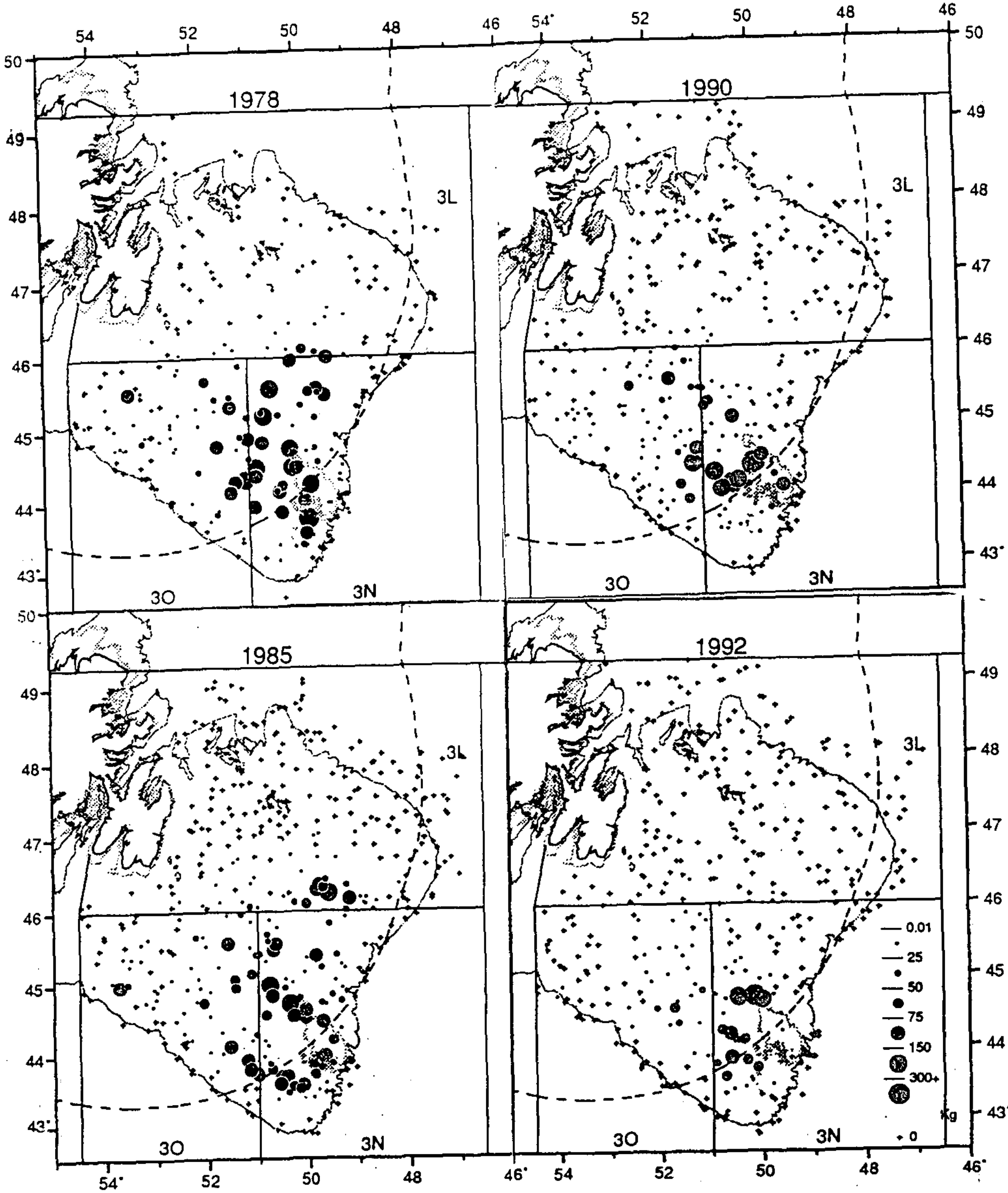

Fig. 3. Yellowtail distribution on the Grand Bank from spring groundfish surveys in 1978, 1985, 1990, and 1992.

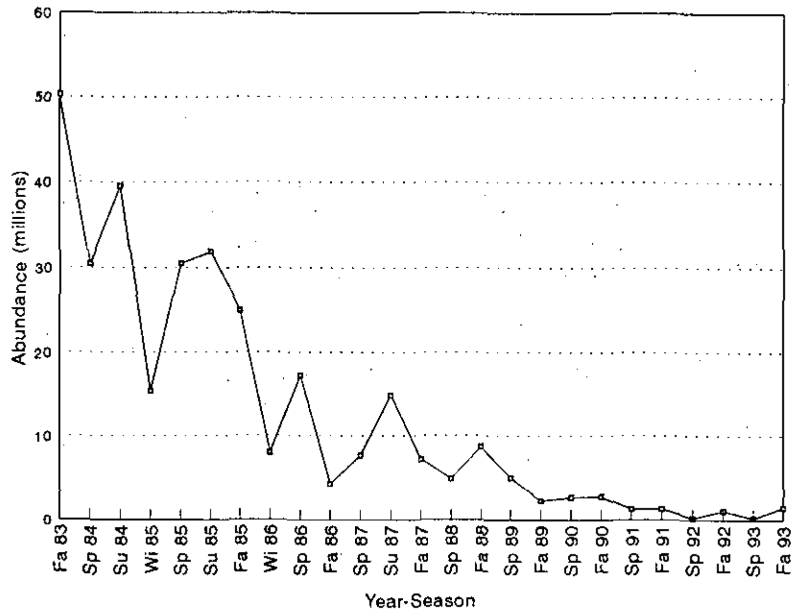

Fig. 4. Abundance of Yellowtail from surveys conducted at various times in Div. 3L.

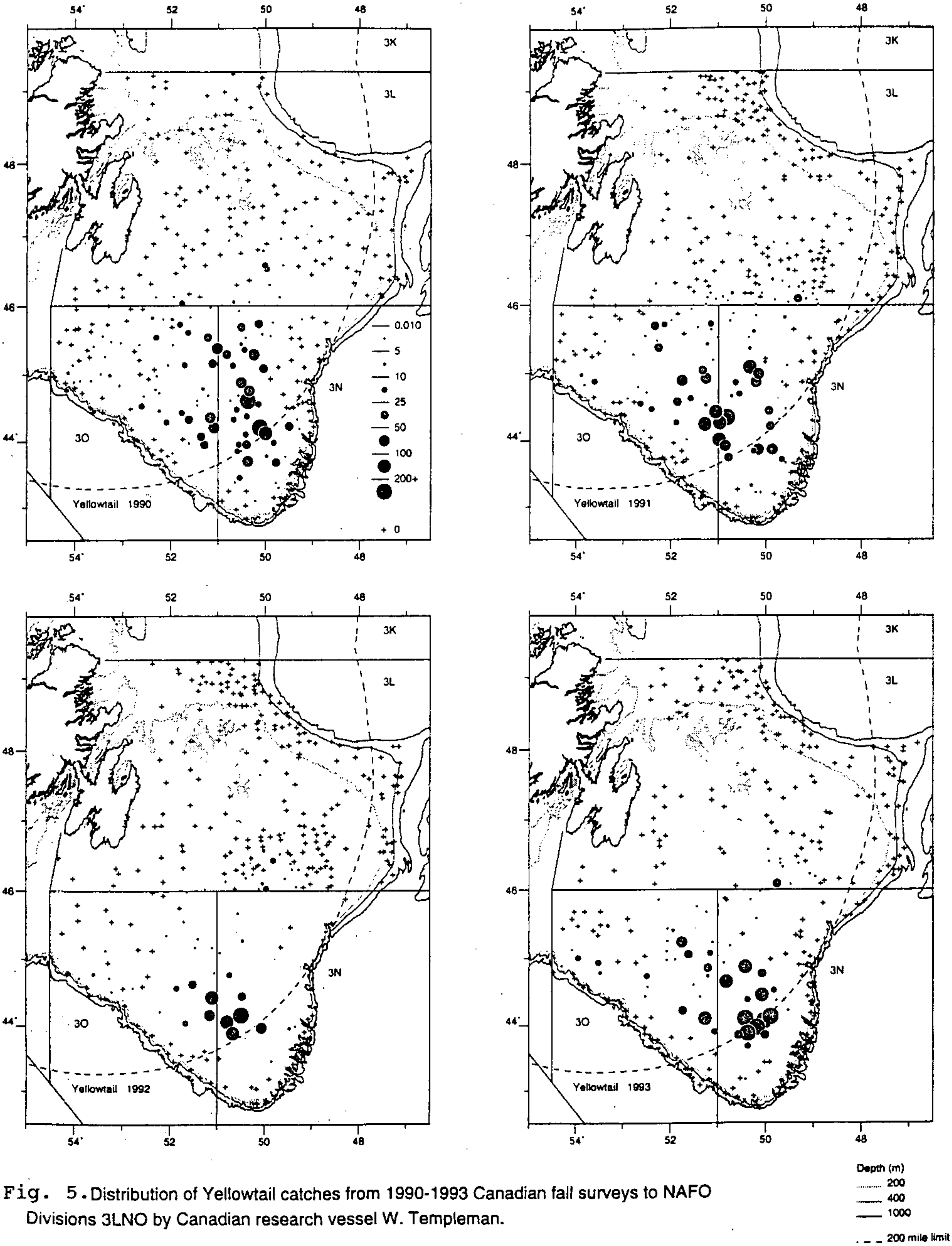

Fig. 5. Distribution of Yellowtail catches from 1990-1993 Canadian fall surveys to NAFO Divisions 3LNO by Canadian research vessel W. Templeman.

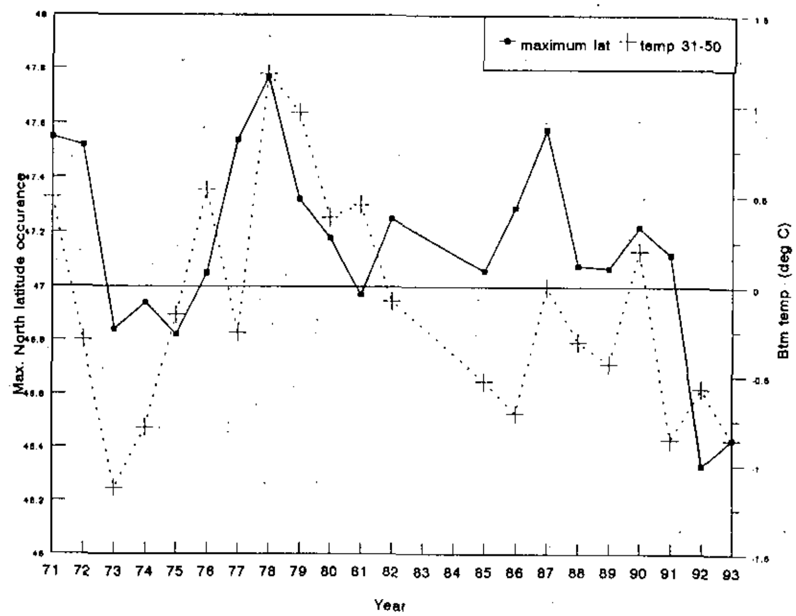

Fig. 6a. Comparison of maximum north latitude occurence of yellowtail and mean btm temp 31-50 fm, 3L spring surveys.

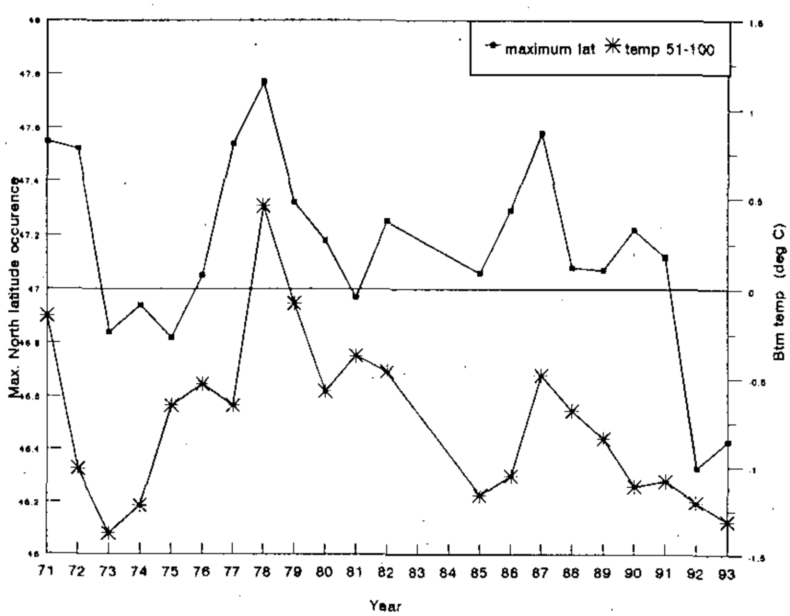

Fig. 6b. Comparison of maximum north latitude occurence of yellowtail and mean btm temp 51-100 fm, 3L spring surveys.

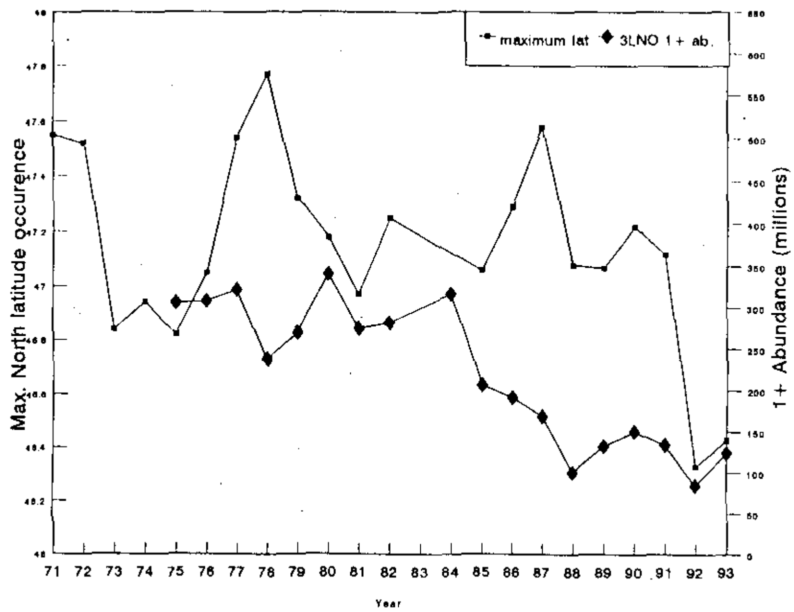

Fig. 7 Comparison of maximum north latitude occurence of yellowtail and 1+ abundance estimates, 3LNO spring surveys.

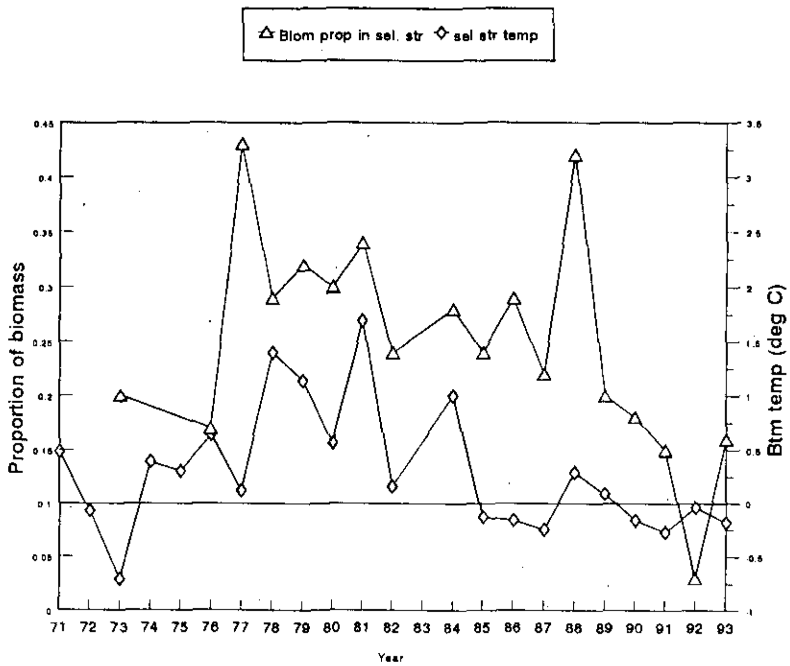

Fig. 8. Comparison of proportion of biomass in strata 351+362+373 and mean bottom temperature in these strata.

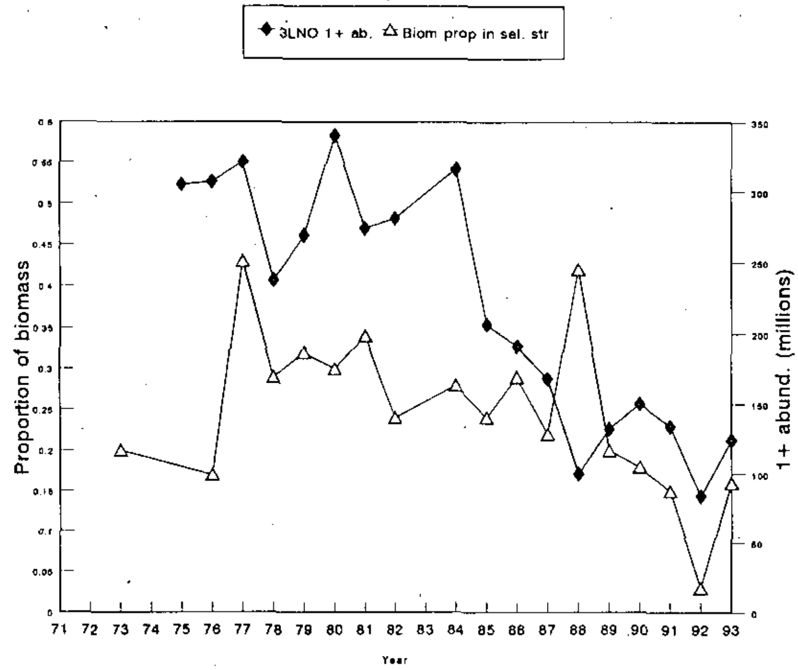

Fig. 9. Comparison of proportion of biomass in strata 351+362+373
and 3LNO 1+ abundance from spring surveys.

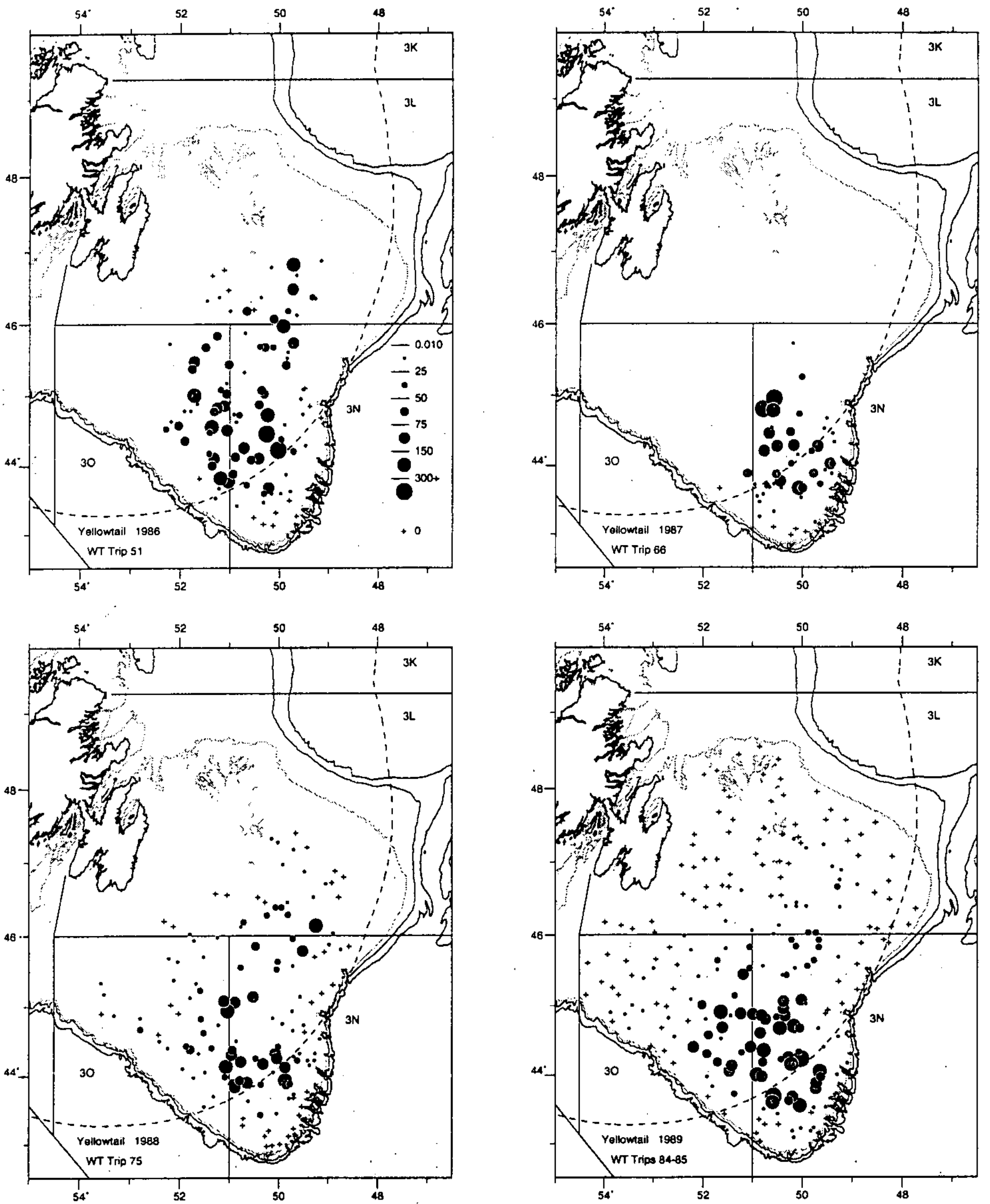

Fig. 10 Distribution of Yellowtail catches from 1986-1989 Canadian Juvenile Flatfish surveys to NAFO Divisions 3LNO by Canadian research vessel Wilfred Templeman.
Plots are of the catch per standard tow (kg). All survey tows standardized to 1.3 nautical miles.

Depth (m)
200
400
1000
200 mile limit

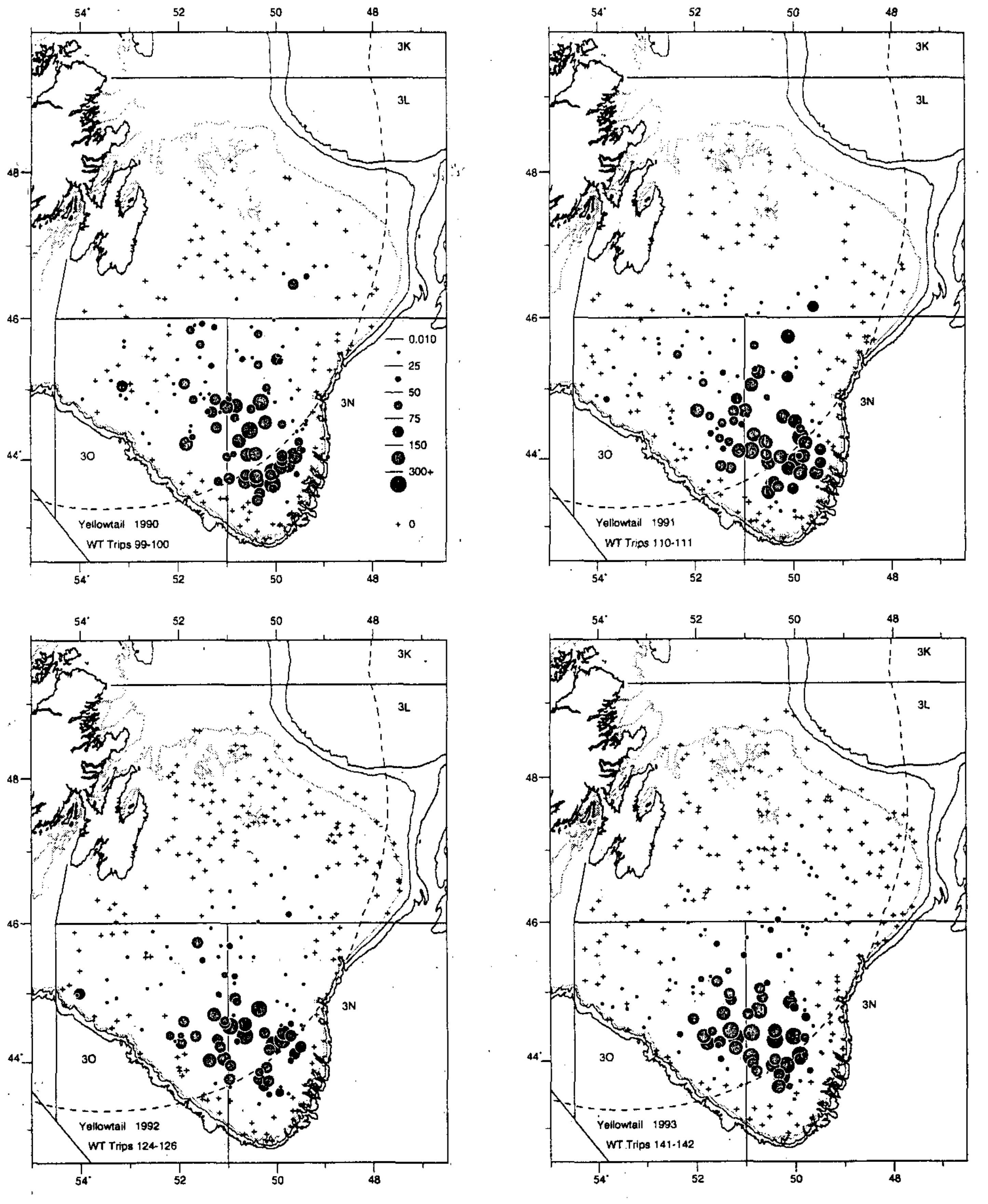

Fig. 11 Distribution of Yellowtail catches from 1990-1993 Canadian Juvenile Flatfish surveys to NAFO Divisions 3LNO by Canadian research vessel *Wilfred Templeman*.
Plots are of the catch per standard tow (kg). All survey tows standardized to 1.3 nautical miles.

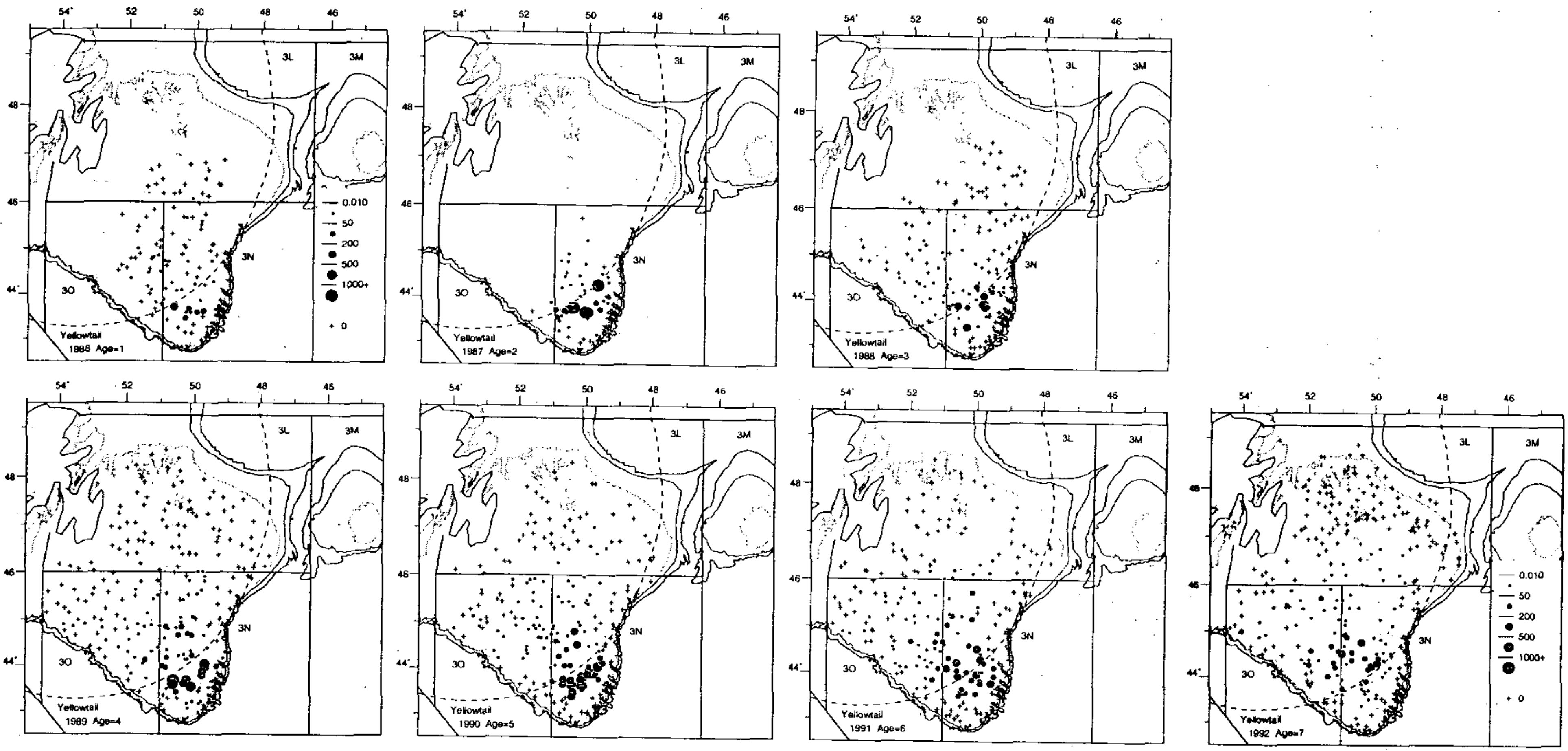

Fig. 12 Distribution of Yellowtail catches from 1986-1991 (1985 year class) Canadian Juvenile Flatfish surveys to NAFO Divisions 3LNO by the Canadian research vessel Wilfred Templeman. Plots are of the # of fish for year class 1985.
All survey tows standardized to 1.3 nautical miles.

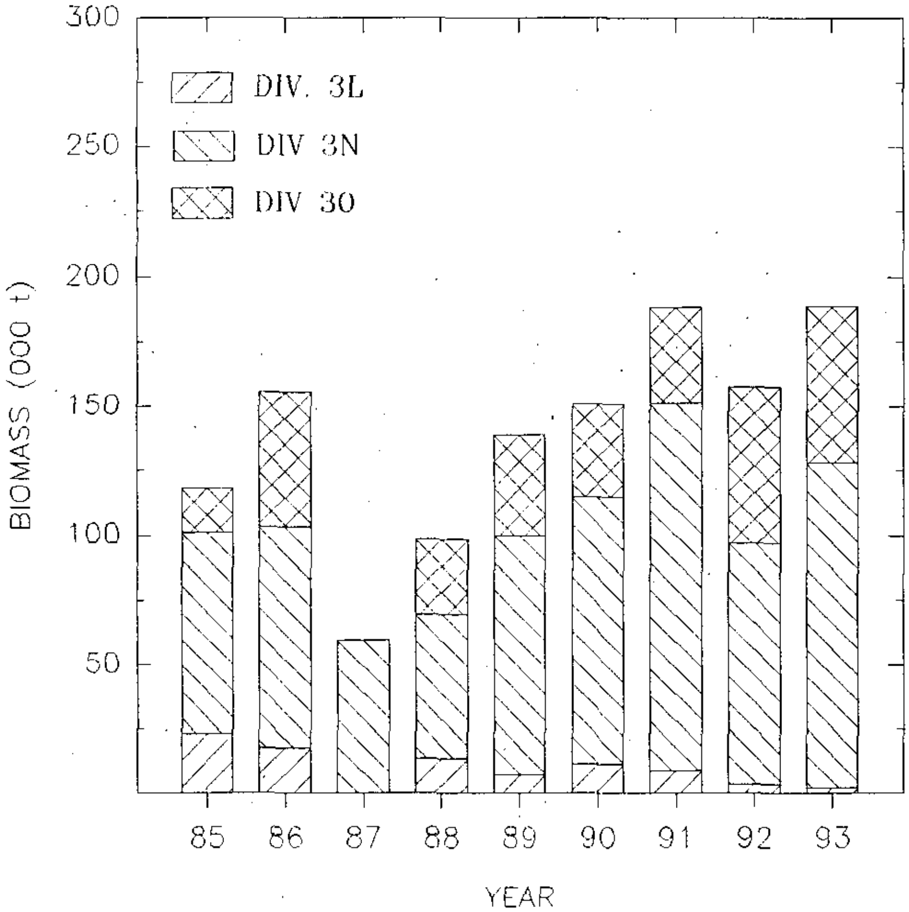

Fig 13 Trends in biomass of yellowtail from the Canadian juvenile surveys of the Grand Bank.