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# Comparison of Groundfish Catches from Research Vessel Surveys in the Area Around the 200-mile Limit on the Southern Grand Bank

by

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## Introduction

On January 1, 1977 Canada declared a 200 mile limit around its coastline in order to control the exploitation of resources on the continental shelf. Prior to 1977, catches of fish by non-Canadian vessels had been at very high levels off Canada's east coast, and the severe restrictions placed on entry into this zone brought on by the introduction of the 200 mile limit caused a significant decrease in these catch levels (Table 1). However, some fishing continued on the grounds outside the 200 mile limit in the areas of the Grand Bank known as the Nose and Tail (Fig. 1). Although the catches of some species, notably yellowtail flounder (Limanda ferruginea) and American plaice (Hippoglossoides platessoides), by foreign vessels not licensed to fish inside the 200 mile limit remained low from 1977 through the early 1980's, the catches increased dramatically from 1984 to 1985 i.e. from 2,500 t in 1984 to 13,500 t in 1985 for yellowtail and from 5,200 t in 1984 to 12,700 t in 1985 for American plaice (Brodie 1986a, b). Furthermore, in 1986 many Canadian trawler captains reported that the catch rates for many groundfish species were noticeably lower outside the 200 mile limit than inside.

The purpose of this paper is to determine whether or not significant differences existed in 1986 in the abundance of particular groundfish species in areas on the southern Grand Bank which are separated by the 200 mile limit. The paper will also relate the patterns of abundance and distribution observed in 1986 to those observed from 1971-86 and will attempt to determine if perceived differences can be related to the establishment of the 200 mile limit and the recent increase in fishing in the area outside the limit.

## Methods and Materials

All data analyzed in this paper were collected by Canadian research vessels over the periods 1971-82 and 1984-86. No information from commercial fisheries was considered because of the difficulty in obtaining sufficient data which could be broken down by position into a small enough scale to allow assignment into "outside" and "inside" 200 mile limit categories. Hence, the following sources of data were used:

A) Line transect survey, April 1986

To determine the distribution and abundance of groundfish species in the area surrounding the 200 mile limit in NAFO Div. 3N and 3O a survey was conducted by the research vessel WILFRED TEMPLEMAN from April 01 to April 10, 1986. This ship is a 50 metre stern trawler and was outfitted with an Engel 145' bottom trawl for this survey. Ten approximately perpendicular line transects across the 200 mile limit were chosen, spanning virtually the entire 200 mile limit in Div. 3NO (Fig. 2). From six to ten fishing stations (sets) were then chosen along each line, with the spacing of sets on each line being identical on both sides of the 200 mile limit. All sets on a line were approximately 6 nautical miles apart, with the exception of the end stations on lines D and I, which were approximately 15 nautical miles from the next sets. The direction of fishing was kept constant for all sets on a given line, and was generally parallel to the 200 mile limit. Fishing was carried out on a continuous (24 hr) basis where possible.

Only 3 tows were less than the prescribed 30 minute duration at a speed of 3.5 knots and the catches from these sets were subsequently adjusted upwards to correspond to the

norms, i.e. catches from a 20 minute tow were multiplied by 1.5 to correspond to a 30 minute tow. From each set, the following data were collected: mean fishing depth, numbers and weights of each species caught, and a temperature profile of the water column, including the bottom temperature. No information on the size and age compositions of species in the catches was collected.

B) Stratified random surveys, 1971-82, 1984-86

To compare the distribution of groundfish in the survey described above with the patterns of previous years, data from the series of stratified random surveys conducted in Div. 3N and 3O from 1971-86 were selected. These surveys were conducted annually in the April to June period by the research vessel A.T. CAMERON from 1971-82 and by the research vessels WILFRED TEMPLEMAN and ALFRED NEEDLER from 1984-86. There was no survey in 1983. The A.T. CAMERON was a 51 metre side trawler and used a Yankee #41-5 otter trawl, while the other two vessels are identical stern trawlers which used the Engel 145' trawl. To ensure that the locations surveyed in the random stratified sets corresponded roughly to the locations surveyed in the 1986 line transects, only sets from particular areas in certain strata were chosen from the historic database. As was the case for the line survey data, only valid sets were selected (trawl damage minimal or non-existant) and tows differing from 30 minutes duration or 3.5 knots towing speed were standardized to these values. The position of each of the sets was then compared against a series of positions along the 200 mile limit, and each set was designated as being inside or outside the 200 mile limit.

Because the survey coverage in recent years has been much more intense than in the earlier period, notably 1971-76, catch data were grouped by years, and analyses conducted, by year-group, on sets inside versus sets outside the 200 mile limit. These analyses were carried out on groups of 3 years, on the years grouped 1971-76 versus 1977-86, and on the years 1971-79 versus 1980-86. The years 1971-76 and 1977-86 were chosen because these are the time periods before and after establishment of the 200 mile limit, while 1971-79 and 1980-86 were chosen based on the assumption that differences in catches inside versus outside the 200 mile limit might take some years to show up after the 200 mile limit was declared.

To test the data from the line transect and stratified random survey for normality, the Shapiro-Wilk test was used for sample sizes of 50 or less, and the Kolmogorov test was used for sample sizes greater than 50 (Conover, 1980). To test for differences in catch levels inside versus outside the 200 mile limit, both overall and line by line, the Wilcoxon rank-sum test (normal approximation, with continuity correction of 0.5) was used. The Wilcoxon matched - pairs signed - rank test (Hollander and Wolfe 1973) was used to test for differences in paired observations on either side of the 200 mile limit. A pair of observations was taken as the results from the two sets on a given line which are equidistant from the 200 mile limit (Fig. 2). The statistical tests were then carried out by grouping the paired sets from all the transects. All tests were done using either SAS (SAS 1985) or SPSS (Nie et al. 1975) statistical computer packages.

## Results

A) Line transect survey, April 1986

A total of 81 tows was completed in the survey, 80 of which were relatively damage-free and therefore considered to be valid. The most frequently occurring groundfish species observed during the survey were American plaice, cod (Gadus morhua), yellowtail and thorny skate (Raja radiata). Because of the relative unimportance to the commercial fishery of the latter species, and the lack of significant numbers of catches of other species, only A. plaice, cod, and yellowtail were considered for analysis. For the catch numbers and weights of each species, all 12 of the 40-station datasets (sets inside and sets outside the 200 mile limit) were found to differ from a normal distribution, with $P < .01$. These results are quite usual for trawl survey data (Brodie and Wells 1985). Given the difficulties in dealing with zero catches when transforming this type of data logarithmically, as well as the current debate regarding statistically acceptable distribution of trawl survey data (Pennington 1983; Myers and Pepin 1987), non-parametric statistics were used to test hypotheses concerning differences in catch levels on either side of the 200 mile limit.

Figures 3 and 4 show the catches in numbers and weights per tow respectively, for the three main species. Overall, the average numbers and weights for each of these species were higher for the 40 sets inside the 200 mile limit than for the 40 sets outside the limit (Table 2). The Wilcoxon 2-sample tests (Table 3) showed 5 of these 6 cases with significant differences ($P < .01$ in all 5 cases) with the exception of American plaice numbers, which was barely non-significant at the 5% level ($P = .07$). For cod and yellowtail, the average catch weights for sets inside the 200 mile limit were 9.5 and 4.2 times higher respectively than the average catch weights outside the 200 mile limit. On

a transect by transect basis, most of the lines showed larger catches inside the 200 mile limit (Table 2) with many of the differences being statistically significant (Table 3).

American plaice were present in all but 4 of the 80 sets. Overall catches were small by commercial standards, with few exceeding 50 kg per 30 minutes (Fig. 4). The largest catches on average, were taken on line F, which had the greatest average depth of the transects (Table 2). On 4 of the transects, these being C, D, I, and J, the average numbers and weights were higher from the sets outside the 200 mile limit, however, only in the case of catch numbers on line C was this difference significant at the 5% level (Table 3). Lines A, B, E, F, and G all had higher average numbers and weights of A. plaice inside the 200 mile limit, with the catch differences, both in numbers and weights, being significant for lines A, F and G, and for weights only on line B. Although no size or age compositions of the catches are available, it is interesting to note that the average weight per fish of A. plaice caught was lower outside the 200 mile limit than inside on every one of the 10 line transects.

Cod were found in 50 of the 80 sets conducted (Fig. 3 and 4). Excluding line F, where all 10 sets contained no cod, 15 of the remaining 20 sets which had no cod were located outside the 200 mile limit. Catches were generally small, with only 5 sets (all inside the 200 mile limit) exceeding 100 kg per 30 minutes and only 3 sets containing more than 25 fish. However, a catch of 1014 kg at set 67, line I (Fig. 2) was more than twice as large as any other catch of a single species. For every line, the average catch numbers and weights of cod from sets inside the 200 mile limit were greater than (17 cases) or equal to (3 cases) the average numbers and weights from sets outside the 200 mile limit (Table 2). The differences in numbers were significant for lines D, I, and J, and the differences in weights were significant for lines C and I (Table 3). For 8 of the 9 transects on which cod were found, the average weight of cod from sets inside the 200 mile limit was greater than the average weight from sets outside. The only exception was line J, where only 1 cod was caught in the 3 sets outside the 200 mile limit. Cod from sets on both sides of the 200 mile limit were large, averaging 9.6 kg per fish inside and 4.9 kg outside the 200 mile limit.

Yellowtail flounder were caught on 8 of the 10 line transects, the exceptions being the lines with the greatest average depth, F and G, located on the southwestern part of the Grand Bank (Fig. 2). Excluding these lines, yellowtail were found in all but 9 sets, 8 of which were outside the 200 mile limit. A total of 11 sets yielded catches in excess of 50 kg per 30 minutes, 9 of which were inside the 200 mile limit, with 6 of the 9 catches being greater than 100 kg. With the exception of lines C and J, the catches of yellowtail from sets outside the 200 mile limit on each transect were lower than the catches inside the 200 mile limit (Table 2). These differences were significant, for both numbers and weights, for lines B, D, E, and I, and for weights only on line H (Table 3). As was the case for both cod and A. plaice, the average weight per fish of yellowtail was greater on virtually every line for catches inside versus catches outside the 200 mile limit, with the overall difference equalling 28 percent.

A further analysis of the line transect dataset was carried out, using the Wilcoxon matched-pairs signed-ranks test on 5 groups of paired observations (Table 4). Given the similarities in the previous analyses between numbers and weights, it was decided to use only catch weights in this instance.

In 14 of the 15 cases tested, the number of positive ranks greatly exceeded the number of negative ranks, with a positive rank denoting a larger catch weight inside versus outside the 200 mile limit, and a negative rank denoting the converse. For A. plaice, the Wilcoxon test showed the differences to be significant at the 5% level for the pairs of sets at the 15 and 21 mile intervals. For cod, the differences were significant for all groups except the one furthest from the 200 mile limit. In the case of yellowtail, only the sets at the 3 mile interval showed a significant difference, although the p value in all 5 tests was less than .10 (Table 4).

B) Stratified-random surveys, 1971-82, 1984-86

Table 5 shows the number of sets from the spring survey database selected for analysis. A total of 307 sets from 7 strata were chosen, based on their proximity to the sets in the 1986 line transect survey. As in the previous analyses, only the catches of A. plaice, cod, and yellowtail were selected from the sets. Sixty-five of the 307 sets were done prior to the establishment of the 200 mile limit in 1977, and 242 after (Fig. 5), and a total of 155 sets was inside the 200 mile limit, and 152 were outside (Table 6).

Virtually all datasets were significantly different from normal distributions, resulting in the use of the nonparametric Wilcoxon rank sum test to test for differences in catches inside and outside the 200 mile limit.

For A. plaice, the average number per tow was greater from sets outside the 200 mile limit in all 4 of the 3-year groupings from 1971-82, with the catch levels being significantly different in 1974-76 and 1977-79 (Tables 7 and 8). Only in 1984-86, was the average number per tow higher from the sets inside the 200 mile limit. The average weights per tow of A. plaice showed a different pattern, with the significant differences coming in 1977-79 (outside greater than inside) and 1984-86 (inside greater than outside). In all 5 time frames, the average weight of an individual A. plaice was higher from the sets inside the 200 mile limit. In the pre and post 200 mile limit comparisons, there were no significant differences in catch weights or numbers, although the average number per tow was greater in both periods for sets outside the 200 mile limit. The trends were the same in the second multi-year comparison, with the exception that 2 differences were statistically significant, these being outside numbers greater than inside numbers in the 1971-79 period, and inside weights greater than outside weights in the 1980-86 period (Table 8). Furthermore, the average number of fish per tow from the outside sets declined from 174 in 1971-79 to 79 in 1980-86 with a corresponding decline in the average catch weights from 56.0 to 31.4 kg. The average number per tow from inside sets was relatively constant in these 2 periods, while the average weight per tow increased from 34.9 kg in 1971-79 to 43.7 kg in 1980-86.

For cod, the comparisons revealed that the average number per tow from sets inside the 200 mile limit was always larger than the average number outside, in any given time frame (Table 7). The statistical tests used showed these differences to be significant in the 1980-82 and 1984-86 year groups, as well as the 1977-86 and 1980-86 time periods (Table 8). The average weights per tow showed the same patterns, with the exceptions that the weights per tow from the outside sets were higher, although not significantly, in 1971-73, and a statistically significant difference (inside greater than outside) existed for the weights in the 1977-79 year group, as well as in the 1971-79 period. The average weight of an individual cod was greater from the sets outside the 200 mile limit compared to the sets inside the limit in the 1971-73 and 1977-79 periods, as well as in the overall periods of 1971-76 and 1971-79. However, this situation was reversed in all time periods after 1979, with the average catch weight of cod from sets inside the 200 mile limit being much larger than those from sets outside (Table 7). It is also worth noting from Table 7 that the average weight per tow from sets inside the 200 mile limit increased from 11.7 kg in 1971-76 to 71.2 kg in 1977-86, while the corresponding values for sets outside the 200 mile limit were 10.9 and 8.3 kg respectively.

In the case of yellowtail flounder, the average number and weight per tow were greater from sets inside the 200 mile limit compared to sets outside in all time frames, with the exception of numbers in 1977-79 (Table 7). For the 3-year groupings, the differences in catch levels were statistically significant in 1971-73, 1977-79, and 1984-86. The differences were also statistically significant in all 4 periods of the multi-year comparisons (Table 8). The average weight of an individual fish was larger for the inside sets in all of the time frames, and there was virtually no difference between average weights in the periods before and after the declaration of the 200 mile limit. Unlike A. plaice and cod, there were no large changes in catch numbers and weights in the period prior to 1980 compared to the period after.

To further investigate changes in research vessel catches in the area around the 200 mile limit, data for A. plaice, cod, and yellowtail from the stratified-random surveys of 1982, 1984, 1985 and 1986 were examined (Table 9). The results for A. plaice clearly show a progressive change in the difference between catches inside the 200 mile limit and catches outside, both in absolute and relative terms. The largest decrease in the average weight per tow occurred from 1985 to 1986, dropping from 30.8 kg to 9.8 for the sets outside the 200 mile limit. The average number per tow from the outside sets declined from 94.1 fish in 1982 to 22.0 fish in 1986 and although the average number from inside sets also declined over this period, the decrease was not as severe. For cod, the average weight per tow from the inside sets increased steadily from 66.6 kg in 1982 to 143.5 kg in 1986, a value 35 times higher than the average catch from the sets outside the 200 mile limit in 1986. This increasing trend was not present in the average weights from the outside sets in the 1982-86 period. For yellowtail flounder, the ratio of catches from inside sets to catches from outside sets was between 0.6 and 1.9 in 1982 to 1985, but increased to 9.5 for catch numbers and 10.4 for catch weights in 1986. The average catch of 8.5 kg from the outside sets in 1986 represented a decrease of 46.9 kg per tow from the 1985 value.

## Discussion

It is apparent from the line transect survey conducted in 1986 that catches of American plaice, cod, and yellowtail were significantly larger from sets inside the 200 mile limit than from sets outside the limit. Not only was this true for the survey as a whole, but individual line transects often showed large differences in the catch levels on either side of the 200

mile limit (Table 2). Also, the differences in catch levels were obvious at all intervals along the line transects, as indicated in the paired-set comparisons (Table 4). Overall, the differences were greater for cod and yellowtail, which had ratios of 9.5 and 4.2 respectively for catch weights inside the limit to catch weights outside the limit.

There were no observed physical factors which could have affected the catch levels on either side of the 200 mile limit to any degree in the 1986 line transect survey. Factors relating to the operation of the fishing gear were kept constant where possible on both sides of the limit. Diel variation in catches was not analyzed, and while this may have influenced catches, particularly yellowtail (Walsh 1986), on certain lines, the overall effect should be minimal, given the 24-hour operation design of the survey. The line transects were designed so that the average fishing depths on both sides of the 200 mile limit on each line would be approximately equal, and this objective was met, with the overall averages being identical at 65.4 metres on both sides of the limit. Bottom temperatures at the fishing stations did show some variation on certain lines, for example, line G, but overall the average temperatures on both sides of the 200 mile limit were very similar.

There are of course many biological influences which could affect catches of groundfish species in the Tail of the Bank area. For example, it is well known that the spatial distribution of cod is greatly affected by spawning and feeding migrations (Templeman 1974). On the other hand, the two flatfish species in this analysis are somewhat sedentary (Pitt 1969), and it is generally accepted that neither form major spawning concentrations on the Grand Bank (Pitt 1966). In any case, it is virtually impossible to determine the effects of such biological factors within or between surveys, given that these surveys are generally conducted in a particular area only once in a year. Therefore, in an analysis such as the one presented here, the possible effects of such factors on fish distribution cannot be accounted for.

The results from the line transect survey of April 01-10, 1986 are generally in agreemen with those obtained in the 1986 stratified random survey in the same area, conducted by the same vessel from April 17 to May 04, 1986. In fact, the later survey showed larger differences in the ratios of inside to outside catches for all three species compared. As well, these ratios were substantially higher in 1986 than 1985, for example, the figures for yellowtail catch weights in these years were 10.36 and 0.86 respectively (Table 9).

The distributions observed in the two surveys of 1986 clearly differ from the patterns o previous periods. For A. plaice, Table 7 shows that the average number per tow was greater for sets outside the 200 mile limit in all but one (1984-86) of the multi-year periods examined. This was obviously not so in the 1986 surveys, and in fact Table 9 clearly indicates that there was a gradual progression from 1982 to 1986 in the difference between catches inside and outside the 200 mile limit, corresponding to an increase in fishing effort outside the limit over the same time. For cod, there was little difference in the average survey catches on either side of the limit in 1971-76, but the catches inside the limit were much larger in the 1977-86 period. Although the cod catches from sets outside the 200 mile limit in 1982-86 were relatively stable, with the exception of 1984, the average weight per tow from sets inside the limit increased steadily over the same period (Table 9). Yellowtail flounder, in virtually all periods, showed higher average catches inside the 200 mile limit than outside. However, an important point to note is that the averages for some of the 3 yea periods are not significantly different inside and outside the limit. Unlike A. plaice and cod, there does not seem to be a trend in the 1982-86 data, rather there is a dramatic change from 1985 to 1986. In fact, the 1985 survey shows higher catches outside the 200 mile limit, situation obviously not true in 1986. A probable explanation of this lies in the commercial fishery catches. In 1985, about 13,500 t of yellowtail was taken by vessels fishing on the Tail of the Bank, outside the 200 mile limit, compared to about 2,500 t in 1984. The Canadia catch, which is taken almost exclusively inside the 200 mile limit, increased only about 1,000 t to 13,400 t in the same period. The survey in the spring of 1985, which clearly indicated that yellowtail were abundant outside the 200 mile limit, was conducted before most of the 13,500 t was caught outside the limit. Both sets of survey results in 1986 reflect th relative abundance of yellowtail on either side of the 200 mile limit, after the increased catch outside the limit in 1985. Not surprisingly, preliminary indications for 1986 reveal that catches of yellowtail by many countries fishing outside the limit have decreased, primarily because of greatly reduced catch rates in the area (L. Strowbridge, Department of Fisheries and Oceans, pers. comm.).

There is little inference which can be drawn from examination of the average weight of fish on either side of the 200 mile limit over time, with the possible exception of the cod data. For the 2 flatfish species, the individual average weights were higher from sets insid the limit, both in the 1986 line transect survey and the 1971-86 stratified random surveys. For cod, the average weight of an individual fish was greater for sets outside the limit in most periods from 1971-79, with the opposite being true from 1979-86 (Table 7). However, without a detailed analysis of growth rates over the period covered by the surveys, particularly the most recent years, it is not possible to determine the effect of potentially different exploitation rates on either side of the 200 mile limit on the size composition of catches in these areas.

In summary, it is obvious from the 1986 survey results that A. plaice, cod, and yellowtail were much more abundant inside the 200 mile limit than outside. This was not true historically for all species, and the large differences in the survey catch rates on either side of the limit which occurred from 1985 to 1986 coincide with very large increases in catches of these species in the area outside the 200 mile limit. Given the natural differences in the biology, habitat, and distribution of the species in question, it is virtually impossible for physical or environmental factors to act in a manner that would greatly influence the survey catches of all 3 species over such a relatively small distance, i.e. a few miles on either side of the 200 mile limit. Therefore, it is concluded that increased commercial catches, particularly of the magnitude observed from 1985 to 1986, produced the changes in groundfish abundance, as measured by the surveys.

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Table 1. Average catches (t) of A. plaice and yellowtail in NAFO Divisions 3LNO, and cod in NAFO Divisions 3NO for the periods 1966-76, 1977-81, and 1982-85. Data taken from Brodie 1986 a and b, and Bishop and Baird 1986.

| Species | Time period | Countries | |
|---|---|---|---|
| | | Canada | Others |
| A. plaice | 1966-76 | 47,304 | 16,343 |
| | 1977-81 | 46,963 | 1,401 |
| | 1982-85 | 39,811 | 5,667 |
| Cod | 1966-76 | 2,924 | 104,569 |
| | 1977-81 | 5,979 | 14,814 |
| | 1982-85 | 13,143 | 19,064 |
| Yellowtail | 1966-76 | 15,168 | 6,291 |
| | 1977-81 | 14,127 | 375 |
| | 1982-85 | 11,589 | 4,857 |

Table 2. Average numbers and weights (kg) per tow for American plaice, cod, and yellowtail, and the average depth and bottom temperature of sets from the line transect survey conducted by the WILFRED TEMPLEMAN in April, 1986.

| Line | Position of sets relative to 200 mile limit | Number of sets | Species: A. plaice Average number per tow | A. plaice Average weight per tow | Cod Average number per tow | Cod Average weight per tow | Yellowtail Average number per tow | Yellowtail Average weight per tow | Av. depth (m) | Av. temp. (°C) |
|---|---|---|---|---|---|---|---|---|---|---|
| A | inside | 3 | 14.33 | 13.33 | 1.00 | 13.00 | 1.33 | 0.70 | 56.7 | 0.13 |
| | outside | 3 | 0.67 | 0.50 | 0.00 | 0.00 | 0.00 | 0.00 | 56.3 | 0.37 |
| | all | 6 | 7.50 | 6.92 | 0.50 | 6.50 | 0.67 | 0.35 | 56.5 | 0.25 |
| B | inside | 4 | 50.50 | 65.38 | 7.25 | 28.75 | 185.75 | 111.88 | 50.0 | 0.43 |
| | outside | 4 | 10.75 | 9.85 | 1.00 | 3.43 | 22.50 | 11.00 | 44.5 | 0.50 |
| | all | 8 | 30.63 | 37.62 | 4.13 | 8.38 | 104.13 | 61.44 | 47.3 | 0.46 |
| C | inside | 4 | 1.25 | 1.60 | 5.25 | 66.37 | 40.75 | 24.89 | 50.8 | 0.93 |
| | outside | 4 | 14.50 | 14.33 | 3.50 | 8.13 | 127.00 | 52.75 | 51.5 | 0.45 |
| | all | 8 | 7.88 | 7.97 | 4.38 | 37.25 | 83.88 | 38.82 | 51.1 | 0.69 |
| D | inside | 5 | 11.40 | 9.40 | 19.40 | 131.96 | 171.80 | 85.36 | 65.6 | 1.14 |
| | outside | 5 | 44.60 | 11.88 | 2.80 | 14.76 | 8.40 | 3.34 | 60.6 | 1.78 |
| | all | 10 | 28.00 | 10.64 | 6.98 | 73.36 | 90.10 | 44.35 | 63.1 | 1.46 |
| E | inside | 4 | 45.50 | 32.50 | 4.75 | 30.03 | 184.25 | 95.38 | 73.0 | 0.70 |
| | outside | 4 | 23.00 | 8.60 | 2.75 | 14.93 | 1.00 | 0.44 | 74.3 | 1.08 |
| | all | 8 | 34.25 | 20.55 | 3.75 | 22.48 | 92.63 | 47.91 | 73.6 | 0.89 |
| F | inside | 5 | 81.20 | 36.20 | 0.00 | 0.00 | 0.00 | 0.00 | 93.6 | -0.32 |
| | outside | 5 | 14.80 | 3.14 | 0.00 | 0.00 | 0.00 | 0.00 | 102.4 | -0.44 |
| | all | 10 | 48.00 | 19.67 | 0.00 | 0.00 | 0.00 | 0.00 | 98.0 | -0.38 |
| G | inside | 3 | 45.67 | 19.83 | 0.33 | 4.50 | 0.00 | 0.00 | 79.0 | 0.73 |
| | outside | 3 | 22.00 | 6.40 | 0.33 | 0.02 | 0.00 | 0.00 | 87.3 | -0.77 |
| | all | 6 | 33.84 | 13.12 | 0.33 | 2.26 | 0.00 | 0.00 | 83.2 | -0.02 |
| H | inside | 4 | 30.00 | 19.25 | 14.75 | 136.13 | 146.50 | 69.75 | 66.5 | 1.18 |
| | outside | 4 | 36.75 | 11.30 | 2.25 | 6.25 | 18.75 | 9.38 | 68.8 | 1.90 |
| | all | 8 | 33.38 | 15.28 | 8.50 | 71.19 | 82.63 | 39.57 | 67.6 | 1.54 |
| I | inside | 5 | 16.60 | 18.90 | 17.80 | 266.26 | 77.60 | 35.90 | 60.0 | 1.12 |
| | outside | 5 | 46.60 | 21.32 | 3.00 | 20.49 | 34.40 | 9.60 | 58.0 | 0.86 |
| | all | 10 | 31.60 | 20.11 | 10.40 | 143.38 | 56.00 | 22.75 | 59.0 | 0.99 |
| J | inside | 3 | 3.00 | 5.68 | 6.67 | 47.82 | 21.67 | 14.94 | 47.3 | 0.50 |
| | outside | 3 | 22.00 | 20.40 | 0.33 | 10.50 | 65.00 | 25.17 | 44.3 | 0.33 |
| | all | 6 | 12.50 | 13.04 | 3.50 | 29.16 | 43.34 | 20.06 | 45.8 | 0.42 |
| All lines | inside | 40 | 31.10 | 22.85 | 8.45 | 80.80 | 88.63 | 45.39 | 65.4 | 0.72 |
| | outside | 40 | 25.10 | 11.00 | 1.73 | 8.47 | 27.15 | 10.86 | 65.4 | 0.61 |
| | all | 80 | 28.10 | 16.93 | 5.09 | 44.64 | 57.89 | 28.13 | 65.4 | 0.67 |

Table 3. Results of the Wilcoxon 2-sample test for numbers and weights of A. plaice, cod and yellowtail from the 1986 line transect survey. The p-values listed are for one-taile hypothesis tests.

| Line | Position of sets relative to 200 mile limit | A. plaice | | Cod | | Yellowtail | |
|---|---|---|---|---|---|---|---|
| | | Rank sum, number per tow | Rank sum, weight per tow | Rank sum, number per tow | Rank sum, weight per tow | Rank sum, number per tow | Rank sum, weight per tow |
| A | inside | 15.0 | 15.0 | 13.5 | 13.5 | 13.5 | 13.5 |
| | outside | 6.0 | 6.0 | 7.5 | 7.5 | 7.5 | 7.5 |
| | p value | .04* | .04* | .10 | .10 | .10 | .10 |
| B | inside | 24.0 | 25.0 | 22.5 | 22.0 | 25.0 | 26.0 |
| | outside | 12.0 | 11.0 | 13.5 | 14.0 | 11.0 | 10.0 |
| | p value | .06 | .03* | .12 | .15 | .03* | .01* |
| C | inside | 11.0 | 12.0 | 22.0 | 25.0 | 12.0 | 13.0 |
| | outside | 25.0 | 24.0 | 14.0 | 11.0 | 24.0 | 23.0 |
| | p value | .97 | .94 | .15 | .048* | .94 | .90 |
| D | inside | 27.5 | 33.5 | 37.0 | 35.0 | 39.0 | 39.0 |
| | outside | 27.5 | 21.5 | 18.0 | 20.0 | 16.0 | 16.0 |
| | p value | .46 | .12 | .03* | .07 | .01* | .01* |
| E | inside | 24.0 | 24.0 | 20.0 | 22.0 | 26.0 | 26.0 |
| | outside | 12.0 | 12.0 | 16.0 | 14.0 | 10.0 | 10.0 |
| | p value | .06 | .06 | .33 | .16 | .01* | .01* |
| F | inside | 40.0 | 40.0 | - | - | - | - |
| | outside | 15.0 | 15.0 | - | - | - | - |
| | p value | .01* | .01* | - | - | - | - |
| G | inside | 15.0 | 15.0 | 10.5 | 11.0 | - | - |
| | outside | 6.0 | 6.0 | 10.5 | 10.0 | - | - |
| | p value | .04* | .04* | .40 | .50 | - | - |
| H | inside | 16.0 | 23.0 | 22.0 | 22.0 | 24.0 | 24.5 |
| | outside | 20.0 | 13.0 | 14.0 | 14.0 | 12.0 | 11.5 |
| | p value | .67 | .10 | .15 | .16 | .06 | .04* |
| I | inside | 25.0 | 30.0 | 37.0 | 40.0 | 38.0 | 40.0 |
| | outside | 30.0 | 25.0 | 18.0 | 15.0 | 17.0 | 15.0 |
| | p value | .66 | .34 | .03* | .01* | .02* | .01* |
| J | inside | 7.5 | 8.0 | 15.0 | 14.0 | 7.0 | 7.5 |
| | outside | 13.5 | 13.0 | 6.0 | 7.0 | 14.0 | 13.5 |
| | p value | .87 | .81 | .04* | .09 | .90 | .87 |
| All lines | inside | 1777.5 | 1956.0 | 1951.5 | 2018.5 | 1901.5 | 1945.0 |
| | outside | 1462.5 | 1284.0 | 1288.5 | 1221.5 | 1338.5 | 1295.0 |
| | p value | .070 | .006* | .005* | <.001* | .003* | .008* |

*Significant at the .05 level.

Table 4. Results of the Wilcoxon matched-pairs signed-ranks test for catch weights of A. plaice, cod, and yellowtail from the 1986 line transect survey. The 3 values in each of the columns headed "Ranks" are the number of negative ranks (catch weight from set inside the 200 mile limit is less than the corresponding catch weight outside the limit), the number of positive ranks, and the number of ties respectively.

| Distance of each set from 200 mile limit (n. miles) | Number of pairs of sets | A. plaice | | Cod | | Yellowtail | |
|---|---|---|---|---|---|---|---|
| | | Ranks | p-value | Ranks | p-value | Ranks | p-value |
| 3 | 10 | 3, 7, 0 | .12 | 1, 6, 3 | .046* | 1, 7, 2 | .01* |
| 9 | 10 | 2, 8, 0 | .06 | 0, 8, 2 | .01* | 2, 5, 3 | .06 |
| 15 | 10 | 2, 8, 0 | .02* | 1, 7, 2 | .01* | 2, 6, 2 | .06 |
| 21 | 7 | 1, 6, 0 | .046* | 1, 5, 1 | .02* | 1, 5, 1 | .06 |
| 27, 36 | 1, 2 | 2, 1, 0 | .30 | 0, 2, 1 | .09 | 0, 2, 1 | .09 |

*Significant at the .05 level.

Table 5. Number of sets selected from database of stratified-random surveys in NAFO Division 3N and 30, 1971-86.

| Stratum | Criteria for inclusion in or exclusion from historic database | Time period 1971-76 Outside 200 mile limit | 1971-76 Inside 200 mile limit | 1977-86 Outside 200 mile limit | 1977-86 Inside 200 mile limit | Percentage of stratum area inside 200 mile limit |
|---|---|---|---|---|---|---|
| 353 | omit sets west of 51°29'W | 2 | 3 | 10 | 11 | 79 |
| 354 | include all sets | 3 | 3 | 11 | 10 | 48 |
| 360 | omit sets south of 43°15'N | 8 | 4 | 49 | 12 | 7 |
| 361 | omit sets north of 44°30.7'N | 0 | 12 | 0 | 32 | >99 |
| 374 | omit sets north of 44°44.3'N and south of 44°24.5'N | 3 | 9 | 7 | 26 | 77 |
| 375 | omit sets north of 44°30'N and west of 49°56'W | 2 | 6 | 10 | .21 | 83 |
| 376 | include all sets | 8 | 2 | 39 | 4 | 11 |
| Total | | 26 | 39 | 126 | 116 | |

Table 6. Number of sets selected from stratified-random surveys in NAFO Divisions 3N and 3Ø from 1971-86, and their position relative to the 200 mile limit.

| Year | Position relative to 200 mile limit | Number of sets |
|---|---|---|
| 1971 | inside | 2 |
| | outside | 1 |
| 1972 | inside | 5 |
| | outside | 6 |
| 1973 | inside | 9 |
| | outside | 6 |
| 1974 | inside | 6 |
| | outside | 1 |
| 1975 | inside | 8 |
| | outside | 6 |
| 1976 | inside | 9 |
| | outside | 6 |
| 1977 | inside | 9 |
| | outside | 8 |
| 1978 | inside | 9 |
| | outside | 9 |
| 1979 | inside | 19 |
| | outside | 11 |
| 1980 | inside | 15 |
| | outside | 11 |
| 1981 | inside | 6 |
| | outside | 10 |
| 1982 | inside | 11 |
| | outside | 17 |
| 1983 | inside | 0 |
| | outside | 0 |
| 1984 | inside | 10 |
| | outside | 13 |
| 1985 | inside | 16 |
| | outside | 24 |
| 1986 | inside | 21 |
| | outside | 23 |
| Total | inside | 155 |
| | outside | 152 |

Table 7. Average numbers and weights (kg) per tow of American plaice, cod, and yellowtail from sets conducted during stratfied random research vessel surveys in the Tail of the Grand Bank area from 1971 to 1986.

| Time period | Position of sets relative to 200 mile limit | Number of sets | Species: A. plaice Average number per tow | A. plaice Average weight per tow | Cod Average number per tow | Cod Average weight per tow | Yellowtail Average number per tow | Yellowtail Average weight per tow |
|---|---|---|---|---|---|---|---|---|
| 1971-73 | inside | 16 | 50.1 | 45.6 | 9.4 | 9.8 | 181.5 | 89.8 |
| | outside | 13 | 60.6 | 31.1 | 6.9 | 18.6 | 47.5 | 21.4 |
| 1974-76 | inside | 23 | 71.8 | 33.3 | 13.6 | 13.1 | 189.7 | 84.8 |
| | outside | 13 | 106.7 | 32.1 | 9.5 | 3.3 | 167.0 | 63.2 |
| 1977-79 | inside | 37 | 68.3 | 31.2 | 20.2 | 21.9 | 142.5 | 69.8 |
| | outside | 28 | 257.9 | 78.5 | 9.2 | 13.7 | 80.9 | 34.5 |
| 1980-82 | inside | 32 | 74.1 | 41.5 | 26.5 | 63.0 | 172.7 | 76.0 |
| | outside | 38 | 125.8 | 43.5 | 9.1 | 6.9 | 179.7 | 69.4 |
| 1984-86 | inside | 47 | 52.0 | 45.3 | 18.8 | 115.5 | 145.5 | 75.0 |
| | outside | 60 | 49.6 | 23.7 | 9.0 | 6.7 | 99.6 | 44.0 |
| 1971-76 | inside | 39 | 62.9 | 38.3 | 11.9 | 11.7 | 186.3 | 86.9 |
| | outside | 26 | 83.7 | 31.6 | 8.2 | 10.9 | 107.2 | 42.3 |
| 1977-86 | inside | 116 | 63.3 | 39.7 | 21.4 | 71.2 | 152.0 | 73.6 |
| | outside | 126 | 118.9 | 41.8 | 9.1 | 8.3 | 119.6 | 49.6 |
| 1971-79 | inside | 76 | 65.5 | 34.9 | 15.9 | 16.7 | 165.0 | 78.5 |
| | outside | 54 | 174.0 | 56.0 | 8.7 | 12.4 | 93.6 | 38.3 |
| 1980-86 | inside | 79 | 61.0 | 43.7 | 21.9 | 94.3 | 156.5 | 75.4 |
| | outside | 98 | 79.2 | 31.4 | 9.0 | 6.8 | 130.6 | 53.9 |

Table 8. Results of the Wilcoxon 2-sample test for numbers and weights of A. plaice, cod, and yellowtail from sets conducted during stratified random surveys in the period 1971-86. Mean ranks, rather than rank sums are shown because of the uneven sample sizes The p-values listed are for two-tailed hypothesis tests.

| Time period | Position of sets relative to 200 mile limit | Species | | | | | |
|---|---|---|---|---|---|---|---|
| | | A. plaice | | Cod | | Yellowtail | |
| | | Mean rank, number per tow | Mean rank, weight per tow | Mean rank, number per tow | Mean rank, weight per tow | Mean rank, number per tow | Mean rank weight per tow |
| 1971-73 | inside | 16.6 | 17.1 | 14.5 | 14.4 | 18.5 | 18.8 |
| | outside | 13.0 | 12.4 | 15.6 | 15.8 | 10.7 | 10.4 |
| | p value | .27 | .15 | .74 | .68 | .01* | <.01* |
| 1974-76 | inside | 15.9 | 17.9 | 18.8 | 20.3 | 20.2 | 20.0 |
| | outside | 23.2 | 19.5 | 18.0 | 15.4 | 15.4 | 15.8 |
| | p value | .048* | .68 | .83 | .19 | .19 | .26 |
| 1977-79 | inside | 26.7 | 27.6 | 36.8 | 37.3 | 37.5 | 37.9 |
| | outside | 41.3 | 40.2 | 28.0 | 27.4 | 27.1 | 26.6 |
| | p value | <.01* | <.01* | .06 | .04* | .03* | .02* |
| 1980-82 | inside | 31.3 | 34.7 | 44.2 | 45.2 | 35.8 | 38.1 |
| | outside | 39.1 | 36.2 | 28.1 | 27.3 | 35.3 | 33.3 |
| | p value | .11 | .75 | <.01* | <.01* | .92 | .33 |
| 1984-86 | inside | 56.5 | 67.3 | 70.4 | 75.5 | 62.4 | 63.5 |
| | outside | 52.1 | 43.6 | 41.2 | 37.2 | 47.5 | 46.5 |
| | p value | .47 | <.01* | <.01* | <.01* | .01* | <.01* |
| 1971-76 | inside | 35.6 | 35.2 | 33.3 | 34.4 | 38.5 | 38.5 |
| | outside | 31.3 | 29.8 | 32.5 | 30.9 | 24.7 | 24.7 |
| | p value | .37 | .26 | .87 | .46 | <.01* | <.01* |
| 1977-86 | inside | 113.6 | 127.2 | 149.3 | 156.2 | 134.7 | 137.9 |
| | outside | 128.8 | 116.2 | 95.9 | 89.6 | 109.4 | 106.4 |
| | p value | .09 | .22 | <.01* | <.01* | <.01* | <.01* |
| 1971-79 | inside | 57.2 | 61.6 | 69.5 | 71.0 | 75.7 | 75.9 |
| | outside | 77.2 | 71.0 | 59.8 | 57.8 | 51.2 | 50.9 |
| | p value | <.01* | .16 | .15 | .048* | <.01* | <.01* |
| 1980-86 | inside | 87.1 | 100.9 | 114.0 | 120.4 | 97.5 | 100.4 |
| | outside | 90.5 | 79.4 | 68.8 | 63.7 | 82.1 | 79.8 |
| | p value | .66 | <.01 * | <.01* | <.01* | .046* | .01* |

*Significant at the 5% level.

Table 9. Comparisons of average numbers and weights (kg) per tow of American plaice, cod, and yellowtail from sets conducted during stratified random research vessel surveys in the Tail of the Grand Bank area from 1982 to 1986. Numbers in parentheses represent the number of sets used for all three species.

| | | Average numbers | | | | Average weights | | | |
|---|---|---|---|---|---|---|---|---|---|
| Species | Year | From sets inside 200 mile limit | From sets outside 200 mile limit | Inside minus outside | Inside ÷ outside | From sets inside 200 mile limit | From sets outside 200 mile limit | Inside minus outside | Inside ÷ outside |
| A. plaice | 1982 | 50.6(11) | 94.1(17) | -43.5 | 0.54 | 31.0 | 30.2 | 0.8 | 1.03 |
| | 1984 | 46.4(10) | 65.5(13) | -19.1 | 0.71 | 58.5 | 35.3 | 23.2 | 1.66 |
| | 1985 | 74.6(16) | 67.5(24) | +7.1 | 1.11 | 53.3 | 30.8 | 22.5 | 1.73 |
| | 1986 | 37.5(21) | 22.0(23) | +15.5 | 1.70 | 32.8 | 9.8 | 23.0 | 3.35 |
| Cod | 1982 | 33.5 | 3.0 | +30.5 | 11.17 | 66.6 | 2.8 | 63.8 | 23.79 |
| | 1984 | 30.3 | 30.2 | +0.1 | 1.00 | 83.1 | 15.3 | 67.8 | 5.43 |
| | 1985 | 22.8 | 4.5 | +18.3 | 5.07 | 99.1 | 4.4 | 94.7 | 22.52 |
| | 1986 | 10.3 | 1.7 | + 8.6 | 6.06 | 143.5 | 4.1 | 139.4 | 35.00 |
| Y. tail | 1982 | 222.4 | 144.6 | +77.8 | 1.54 | 84.9 | 45.2 | +39.7 | 1.88 |
| | 1984 | 215.6 | 198.4 | +21.2 | 1.11 | 91.7 | 85.9 | +5.8 | 1.07 |
| | 1985 | 85.9 | 125.6 | -39.7 | 0.68 | 47.4 | 55.4 | -8.0 | 0.86 |
| | 1986 | 157.5 | 16.6 | +140.9 | 9.49 | 88.1 | 8.5 | +79.6 | 10.36 |

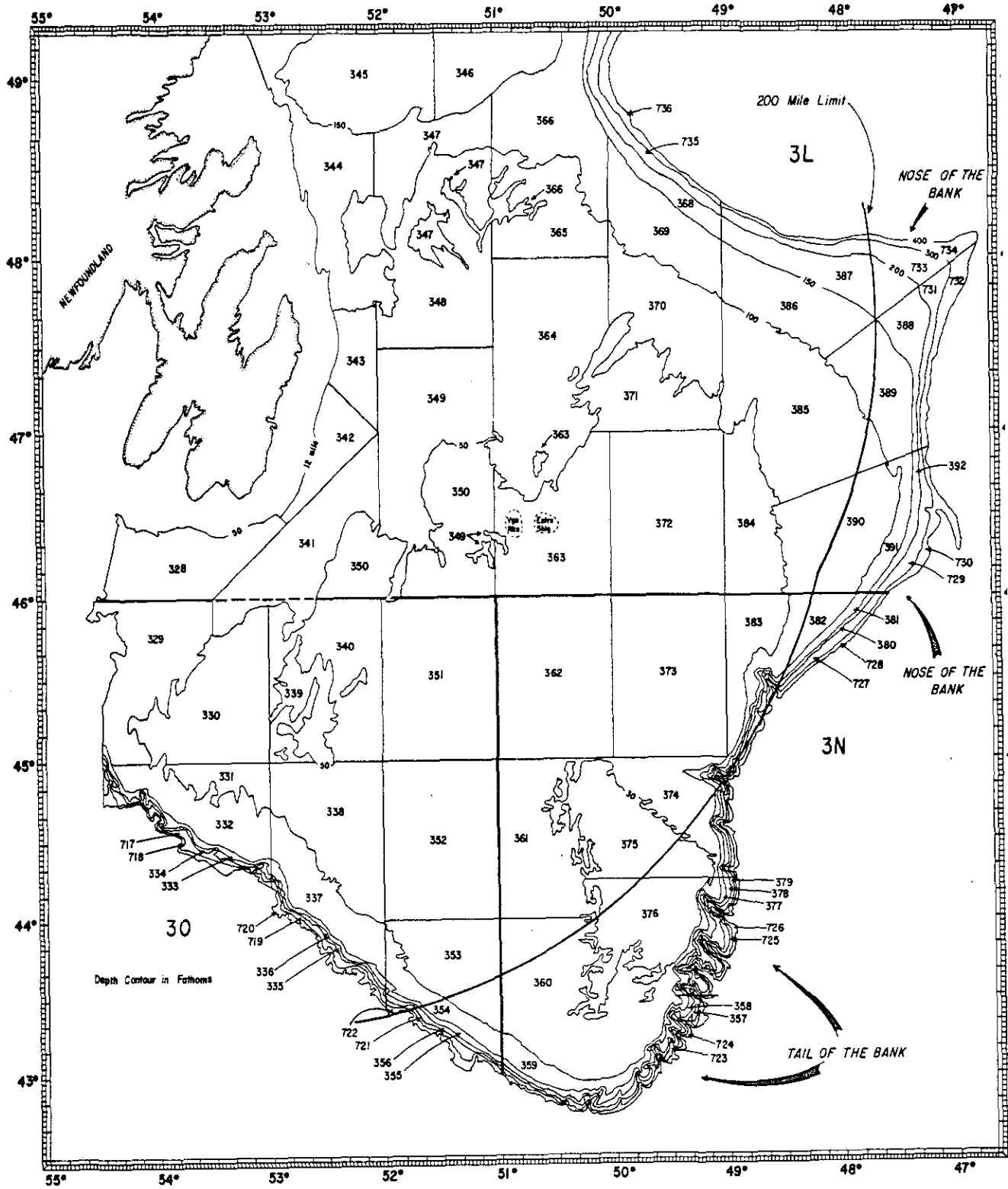


Fig. 1. Grand Banks, NAFO Div. 3LNO, showing the Canadian 200 mile limit in relation to the Nose and Tail of the Bank as well as the stratification scheme used in Canadian groundfish surveys.

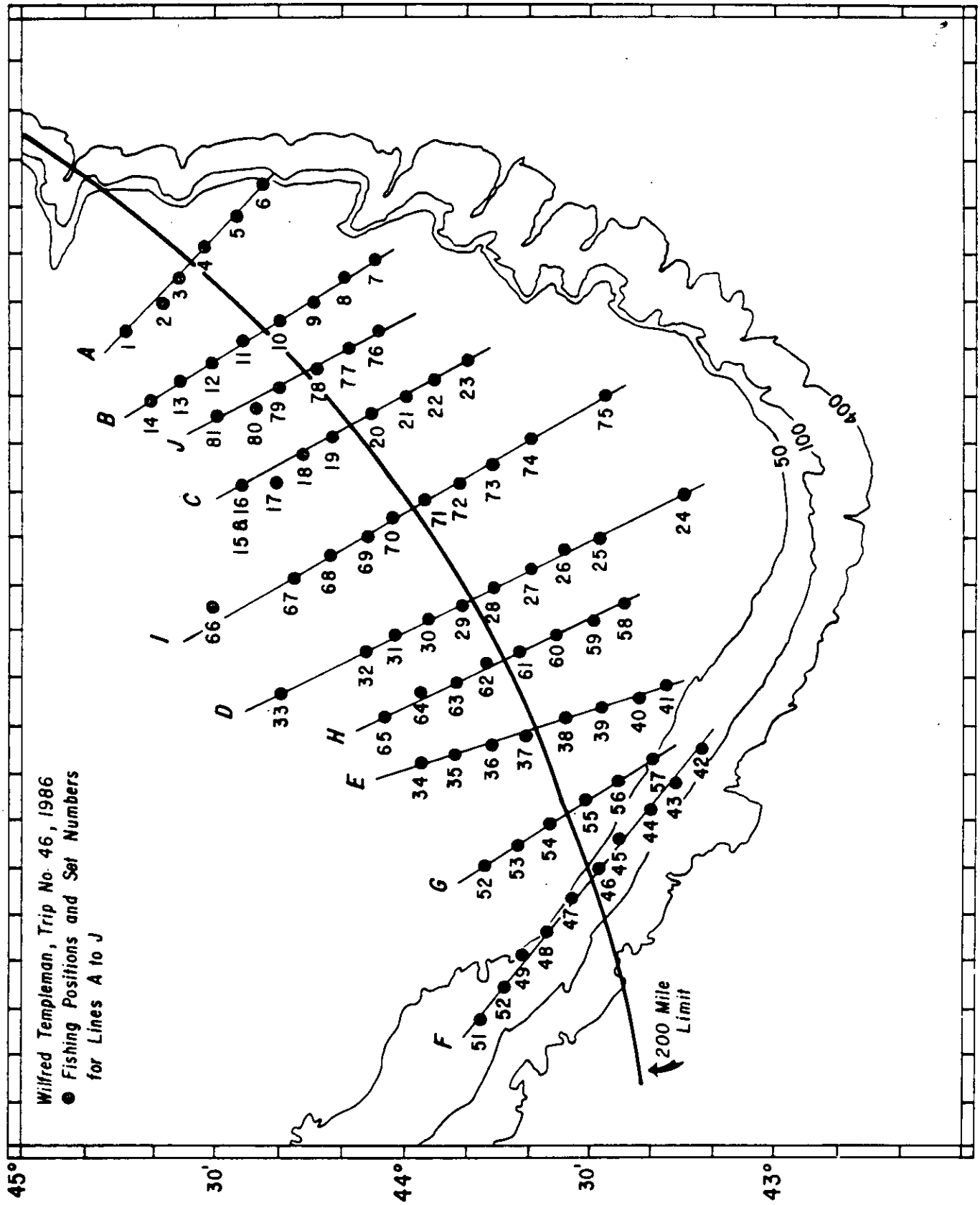


Fig. 2. Location of stations fished during the line transect survey conducted by the R. V. Wilfred Templeman from April 1-10, 1986 on the Tail of the bank.

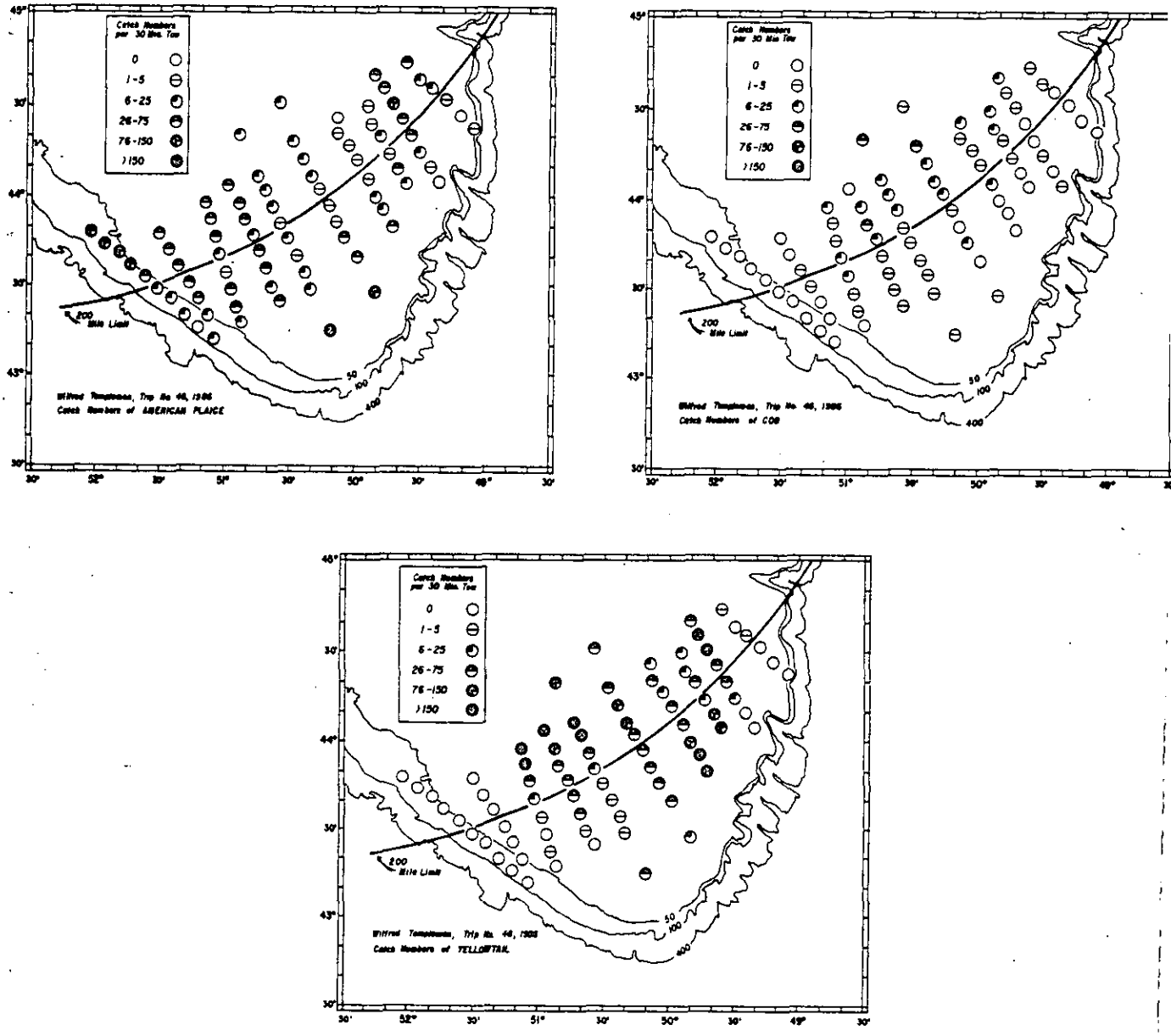


Fig. 3. Catch numbers of A. plaice, cod and yellowtail from the sets conducted during the line transect survey of April 1986 on the Tail of the Bank.

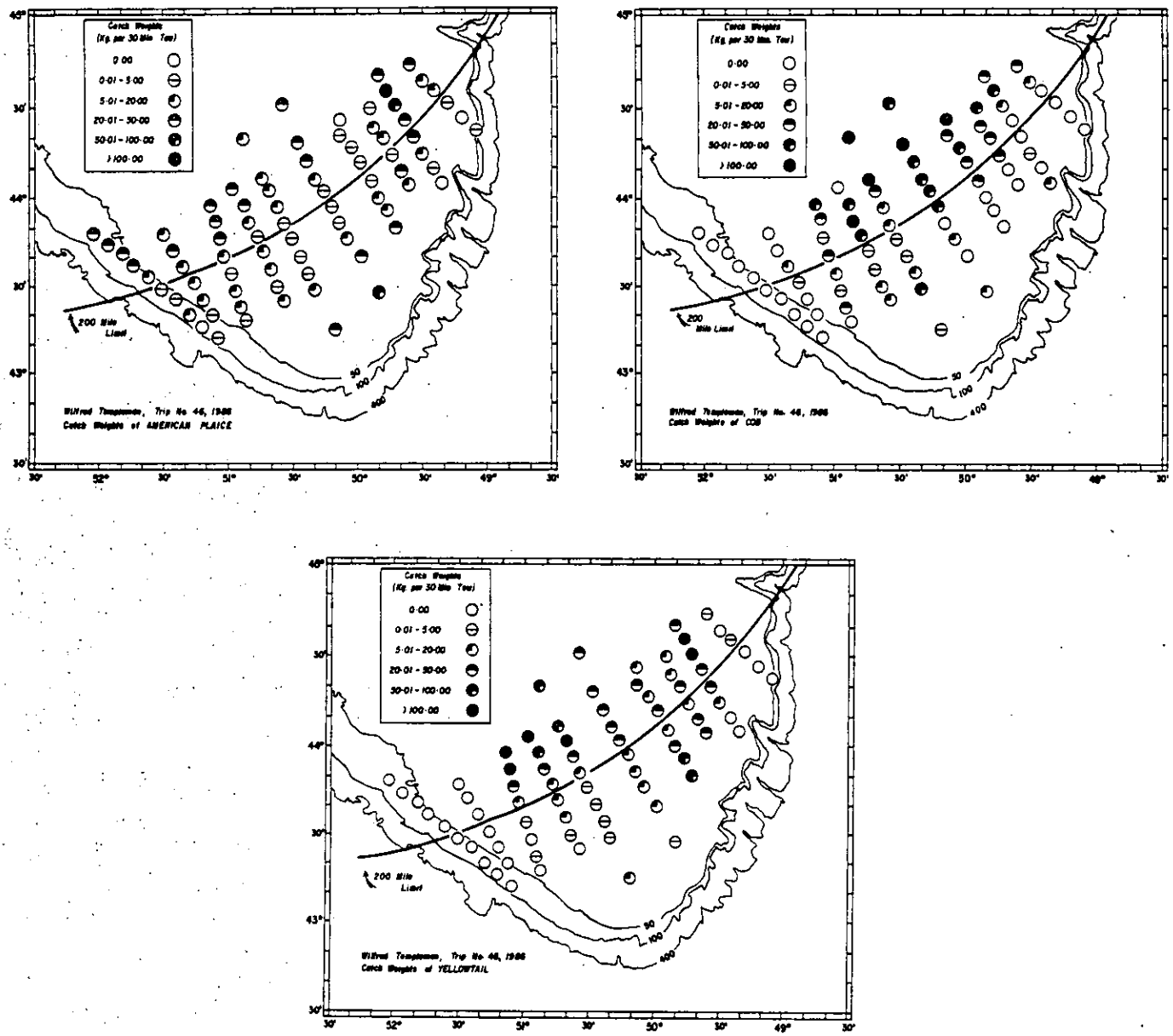


Fig. 4. Catch weights (kg) of A. plaice, cod and yellowtail from the sets conducted during the line transect survey of April 1986 on the Tail of the Bank.

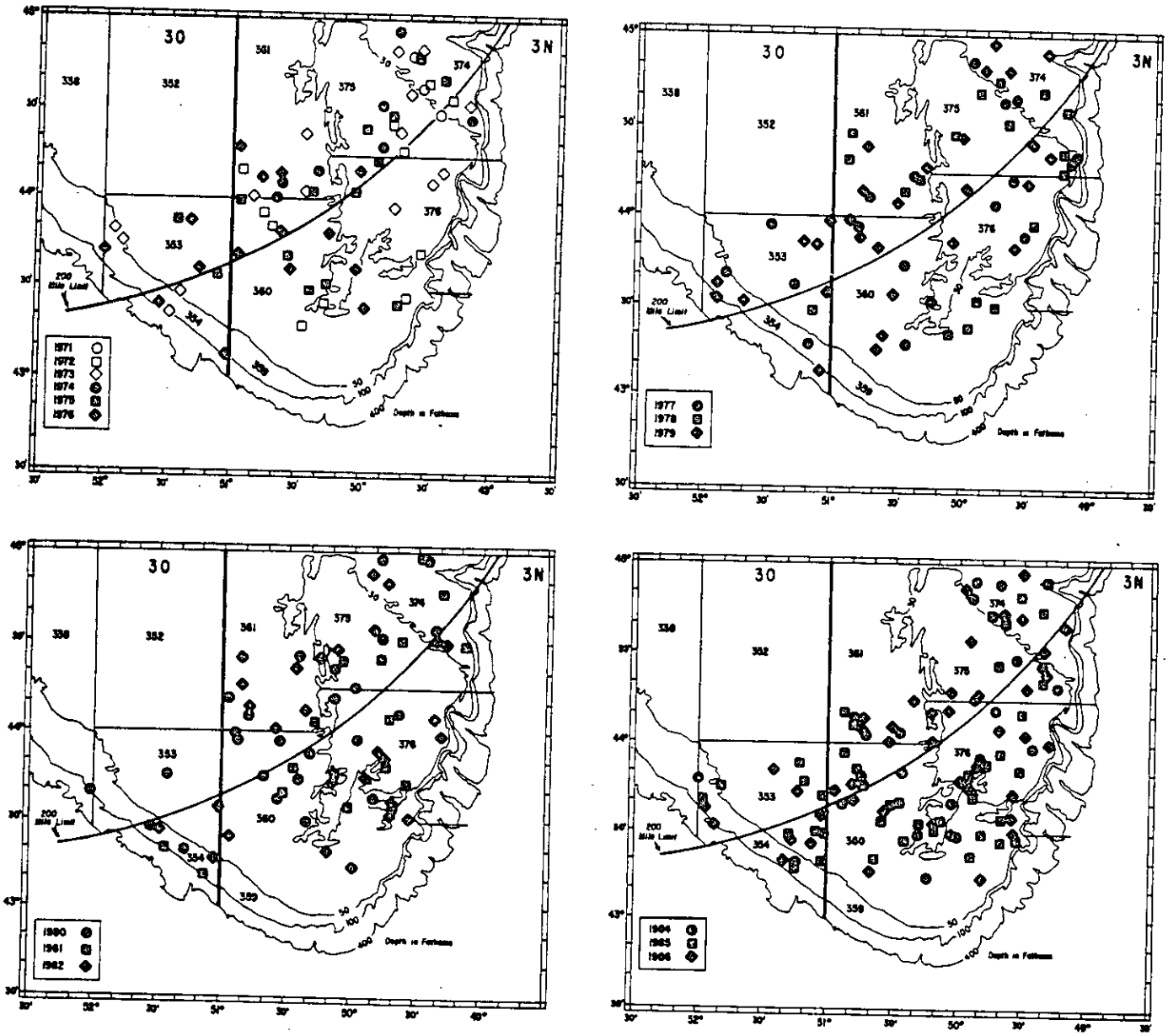


Fig. 5. Location of selected sets from stratified random surveys in the Tail of the Bank area from 1971-86.