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The effect of introduction of a regulated mesh size of 130 mm for Otter Trawlers in the Division 4X haddock fishery

by

R. O'Boyle, G. White, and J. McMillan
Marine Fish Division
Bedford Institute of Oceanography
Dartmouth, Nova Scotia
B2Y 4A2

ABSTRACT

It is proposed to enforce, on 1 January 1982, a regulation introduced on July 1, 1981, which states that no codend mesh size used in otter trawls should be smaller than 130 mm irrespective of material. In the fishery on 4X haddock, inshore otter trawlers (those of Tonnage class 1, 2, and 3) are likely the only group whose catch rates will be affected immediately by this change. The rest of the otter trawler fleet is believed to use 130 mm mesh.

In 1980, the total nominal catch of haddock from Division 4X was 29,006 t, 13,018 t (45%) of which was reported by inshore otter trawlers. Of the latter, 3,349 t (26% of inshore, 12% of total) was caught in 4Xr. The age composition of landings by the 4Xr component has, in many years, been dominated by 2 and 3 year old fish. This has not occurred in comparable vessels operating elsewhere in 4X.

While there is some evidence for a small resident haddock population in the Bay of Fundy, there is sufficient mixing that it is appropriate to treat the 4X stock as a single unit for yield calculations. Because the total catches affected by the changed mesh size are small, the yield increases for the 4X stock as a whole will be slight. If the overall fishing mortality rate is at the appropriate $F_{0.1}$ level, each 100 t caught at age 2 using 120 mm mesh gear would, if fished with 130 mm mesh gear, have generated an additional catch of 48 t over the next 11 years. Similarly, for three year old fish, projections showed a calculated gain of 22 t per 100 t taken at age 3. The majority of this increase occurs at ages 5 and 6.

These yield gains would, to some degree, be available to the fishery in 4Xr although they would be shared throughout the fishery.

A change from the use of 120 mm to 130 mm mesh will reduce catch rates of otter trawlers both in the short-term and in the long-term, primarily be reducing the catches of 2 and 3 year old fish. Catch rates have been and will remain highly variable. When the fishery concentrates on 2 and 3 year olds the reduction in catch rates may range as high as 50%, but would be much smaller when the fishery concentrates on older fish. Since there are currently several relatively strong year-classes in the fishery, these losses represent a missed opportunity to catch these younger age groups in future and not a direct reduction of 1982 rates relative to 1981. Prediction of 1982 losses is not feasible due to the absence of reliable abundance indices for pre-recruit haddock.

Discarding is known to have occurred during the 1970's. Discards of small fish will be reduced in future if the 130 mm mesh size is enforced. If this regulation is not implemented those boats presently using 130 mm mesh codends may revert to the use of the smaller mesh. This would cause substantial losses in yield.

RESUME

On se propose de mettre en vigueur le 1er jauvier 1982 un règlement introduit le 1er juillet 1981 à l'effet qu'aucune maille de cul-de-chalut ne doit être inférieure à 130 mm, quel que soit le matériel. Dans la pêche à l'églefin de la division 4X, les chalutiers côtiers (classes de tonnage 1, 2, et 3) seront probablement les seuls dont les taux de capture seront affectés par ce changement. On croit que le reste de la flottille de chalutiers utilise la maille de 130 mm.

En 1980, les prises nominales totales d'églefin de la division 4X étaient de 29 006 t dont 13 018 t (45%) avaient été rapportées par les chalutiers côtiers. De cette dernière quantité, 3 349 t (26% des côtiers, 12% du total) avaient été capturées dans 4Xr. Depuis plusieurs années, la composition des débarquements par âge en provenance de 4Xr est dominée par des poissons âgés de 2 et 3 ans. Ceci ne s'est pas produit avec des bateaux de taille comparable pêchant ailleurs dans 4X.

On a certaines indications qu'il existe dans la baie de Fundy une petite population résident d'églefins. Il y a cependant suffisamment de mélange pour justifier, dans les calculs de rendements, le traitement du stock de 4X comme une unité. Comme les prises totales touchées par le changement de grandeur de maille sont faibles, les augmentations de rendement du stock de 4X seront généralement peu importantes. Si le taux de mortalité par pêche est dans l'ensemble maintenu au niveau de $F_{0.1}$ approprié, chaque tonne capturée à l'âge 2 avec maille de 120 mm engendrerait, avec maille de 130 mm, des prises supplémentaires de 48 t dans les 11 prochaines années. De même, dans le cas des poissons de 3 ans, les projections donnent un gain de 22 t par 100 t capturées. Cette augmentation se produirait en grande partie aux âges 5 et 6.

Les bateaux pêchant dans 4Xr pourraient, jusqu'à un certain point, profiter de ces rendements améliorés, bien que ces derniers seraient répartis dans toute la division.

Le remplacement de la maille de 120 mm par une de 130 mm réduira les taux de capture, tant à court qu'à long terme, surtout par une réduction des prises de poissons de 2 et 3 ans. Comme par le passé, les taux de capture demeureront hautement variables. Quand la pêche se concentre sur les poissons de 2 et 3 ans, la diminution des taux de capture peut atteindre 50%. Elle serait toutefois beaucoup plus faible si la pêche se concentrait sur des poissons plus âgés. Comme il y a présentement dans cette pêche plusieurs classes d'âge relativement abondantes, ces pertes représentent une occasion manquée de capturer ces jeunes groupes d'âge plus tard et non une réduction directe des taux de 1982 comparativement à ceux de 1981. En l'absence d'indices d'abondance faibles des prérecrues, on ne peut prédire les pertes en 1982.

On sait qu'il y eut, dans les années 1970, rejet de jeunes poissons à la mer. L'adoption d'une maille de 130 mm réduira ce rejet. Par ailleurs, si le règlement n'est pas appliqué, il est possible que les bateaux utilisant présentement des culs-de-chalut de maille de 130 mm reviennent à la maille plus petite. Il y aurait alors substantielles pertes de rendement.

INTRODUCTION

The mesh regulation for otter trawlers operating in NAFO subareas 4 and 5 presently states that the codend mesh size (inside dimensions wet) should be no smaller than 120 mm for polyamide and polyester material and no smaller than 130 mm for polyethylene, polypropylene and manila fibres. It is proposed to change this regulation on 1 January 1982 to state that no codend mesh size should be smaller than 130 mm irrespective of material. Thus the specification for the differing materials is being dropped.

An ICNAF working group on mesh regulations (Beverton and Hodder, 1962) concluded that there would be a small decrease in the long-term yield of the 4X haddock stock when moving from 114 mm to 130 mm (manila) codend mesh. It is therefore advisable to reevaluate the 4X haddock situation in light of the new regulations.

The purpose of this document, then, is to present an analysis of (A) the short and long-term changes in the sustainable yield of the 4X haddock stock and (B) the short and long-term changes in the catch rates of the various fleet components.

STRUCTURE OF THE FISHERY

A. Catch Trends by Fleet Sector

Although there is a substantial longliner fleet sector, the change in mesh regulation does not involve them. Thus discussion here will be restricted to aspects of the otter trawler fleet.

The otter trawler fleet can be roughly divided into two components - those greater than 90 ft in overall length (referred to as offshore vessels) and those under 90 ft (referred to as inshore vessels). The former group is composed of tonnage classes 4 and 5 and due to size these vessels can operate all year round. Presently, however, their activity in 4X is restricted by fleet allocations to the early spring and late fall (O'Boyle, 1981). The inshore fleet is composed of tonnage class 1, 2, and 3 vessels which can only operate during the more clement weather of the late spring to late autumn (Figure 1).

Total reported nominal catches for all vessels fishing haddock in NAFO Division 4X are presented in Table 1 for the 1970 - 80 period. The landings for the inshore and offshore otter trawl fleets split by year and unit area, are presented in Tables 2 and 3.

In 1980, the total nominal catch of 4X haddock was 29,006 t, 13,018 (45%) of which was reported by inshore otter trawlers. Of the latter, 3,349 t (26% of inshore, 12% of total) was caught in unit areas 4Xr and 4Xs, Fig. 7. Summed over the 1970 - 80 period, nominal catches of haddock reported by otter trawlers fishing in 4Xr-s made up just under 12% of the total landings. Virtually all of this was by inshore vessels, particularly of tonnage classes 2 and 3. Almost half of the stock's yield during this period went to the offshore otter trawler fleet operating in 4Xm-q.

B. The Composition of the Fleet

Since 1967, an average of 134 vessels of tonnage class 2 and above have reported to operate fishing haddock in 4X each year (Table 4). Of these, about 62 (46%) have reported as fishing in 4Xr. However, the proportion of the fleet that fishes solely in the Bay of Fundy is quite small. This indicates that the various fleet components are quite mobile and fish wherever they can. This point has to be taken into consideration if one contemplates enforcement of the mesh regulation on a unit area basis.

C. The Codend Mesh Sizes in Use During the 1957 - 80 Period

Prior to 1957, most otter trawlers on the Scotian Shelf were using nets with codend mesh sizes lower than 76 mm inside dimension. This resulted in much potential yield being lost from the fishery. As a first step to the long-term management of the region's fish stocks, an overall increase in codend mesh size to 114 mm (4½") for all otter trawlers fishing in Subarea 4 came into effect in 1957. At this time most nets were made of manila twine. However, increasing numbers of nets made of synthetics such as polyamide, polypropylene and polyethylene had already begun to appear. Consequently, the advice was stated in terms of manila twine, with selectivity equivalents for synthetic nets being available from the commission. These are presented in ICNAF Special Publication No. 5 in which are summarized reports discussed at the 1957 joint ICNAF/ ICES/FAO Scientific meeting.

During 1959 - 61, an ICNAF working group carried out an evaluation of the mesh regulations in the Convention Area. These studies indicated that an overall increase in mesh size form 114 mm to 130 mm (manila) was desirable (Beverton and Hodder, 1962). After much discussion, a new set of regulations was enacted in 1973. These stated that the codend mesh for trawl nets used in subareas 4 and 5 should be no smaller than 120 mm for polyamide and polyester fibres and no smaller than 130 mm for polyethylene, polypropylene and manila fibres.

During the 1960's mesh measurement of the trawl codends were made by Fishery Officers at the posts of landings. The first sea boardings of domestic vessels did not occur until approximately 1975 (C. Jones, C. & P., Halifax, pers. comm.). Available mesh measurement reports for 1973 - 1974 indicate a variety of mesh sizes were in use, with an average size of 117 mm.

The practice of collecting these mesh measurement records subsequently fell into disuse. According to recent conversations with Yarmouth fisheries personnel, this occurred around 1976 due to the lack of convictions for violations by the courts. The records were not considered sufficient evidence for a prosecution. Therefore, little data are available for mesh sizes in use subsequent to 1976. A wide variety of materials was also in use. McCracken (1977) feels that the most common material in 1974 and 1976 was polypropylene of mesh sizes in excess of 130 mm.

However, the use of various synthetic fibres complicated enforcement in that it is virtually impossible to distinguish between the materials and thus effectively employ the equivalency regulation. McCracken (1977) reexamined the basis for the use of material equivalents and concluded that their use was illusionary on account of variability in experimental results, use of the nets, and measurements of the codend meshes. Certainly the dropping of the selectivity equivalents would make the enforcement of the regulation much more practical.

According to C. Jones (pers. comm.), around 1978 - 79, the offshore fleet (T.C. 4 & 5) began to go over to 130 mm mesh en masse. By this time, polyamide had virtually disappeared from use. No explanation for this disappearance of polyamide was available.

No such trend was reported to have occurred in the inshore fleet (T.C. 1 - 3). From discussion held with Yarmouth-Digby fisheries personnel, it appears that the two classes of inshore vessels presently operating in that area (30 - 45 ft and 60 - 65 ft) are using about 120 mm mesh mostly of polyproplyene and polyethylene material.

D. Age Composition of the Catch by Fleet Component

Sampling of the tonnage class 1, 2, and 3 vessels in 4X was low compared to the offshore vessels, during the 1970 - 80 period (Table 5). Averaged over the entire period, about one sample was taken for every 1218 t haddock landed by T.C. 1, 2, and 3 vessels operating in unit areas 4XM-Q. This compares to 256 t for the T.C. 4 & 5 vessels operating in the same area and 804 t for T.C. 1-3 vessels operating in the Bay of Fundy. However, sampling was non-existent for these vessels during 1977-79.

The percentage age composition of these samples is illustrated by year and unit area in Figure 2. All tonnage classes are considered together.

During the 1970 - 76 period, the peak age for Bay of Fundy catch was 2 - 3 compared to greater than age 3 for the 4XM-P samples. It is interesting to note that distribution of the 4Xq samples was often somewhere between those of 4Xm-p and 4Xr. This is understandable considering that vessels from many parts of 4X fish in this area. As well, components of both the Bay of Fundy and offshore haddock populations are probably resident in this area.

The composition of the two 1980 samples from the Bay of Fundy more closely resembles the composition observed in the offshore component of 4X.

These results were compared to the age composition of haddock observed in strata 90 - 95 of the July groundfish surveys (Table 7). During

1970 - 72, the research age composition more closely resembled that for the landings from 4Xm-p than from 4Xr-s. For 1973 - 76, the research vessel age composition follows the pattern observed in the 4Xr-s commercial fishery.

IMPACT OF MESH REGULATION ON YIELD

The analysis of the impact of a change in the mesh regulations is relatively straight-forward if one assumes homogeneity of the population within the management unit. There is however, some evidence to suggest that all haddock in 4X are not members of the same stock (Halliday and McCracken, 1970). In particular, the haddock observed in the Bay of Fundy have been suspected to be an inshore stock discreet from the population which spawns on Brown's Bank in late winter-early spring. Furthermore, the size and age composition of this Bay of Fundy population may be different from that observed for the Brown's Bank population.

Hennemuth et al., (1964) present a description of the 4X haddock population during 1956 - 61. In it, they consider the Bay of Fundy area (unit areas 4Xr-s) separate from the rest of 4X (unit areas 4Xm-q). Based on an analysis of the commercial sampling data, they found that haddock in the Bay of Fundy exhibited faster growth and a younger age composition than those found in the rest of 4X.

It is certainly evident from the commercial sample data presented above that the fishery operating in 4Xr-s is landing significantly smaller fish than is being landed from other areas in 4X.

Nevertheless, observations based on the commercial sampling data are too compounded by problems such as gear use, area of fishing, and mesh size to make definitive statements on possible stock structures.

Available groundfish research survey data for both the Scotian Shelf (Table 6) and Bay of Fundy (Table 7) areas do not indicate the same over-all dominance of younger ages groups in the Bay of Fundy population that was suggested by Hennemuth et al., (1964). However, they do indicate that, both in the mid-late 1960's and also recently, there has been a relative abundance of individuals younger than four years of age (Figure 3) in the Bay of Fundy.

Hennemuth et al. (1964) also observed that the Bay of Fundy haddock were considerably larger at age than their brothers on Brown's Bank. Although the same trend was observed in the research survey data set (Figure 4), the magnitude of the difference is quite small. Indeed, the age-size relationships found there are comparable with those that Hennemuth et al. (1964) found appropriate for the 5Y haddock populations. The earlier study may have suffered more problems due to gear selectivity than the authors thought.

Thus although there appear to be differences between haddock populations found on Brown's Bank and in the Bay of Fundy, these differences cannot be said to be consistent and significant. The analysis presented below assumes that there is sufficient mixing to allow treatment of the populations in 4X as a single stock for yield calculation purposes.

A. Choice of Selectivity Ogives

There has been an enormous number of studies on the selectivity characteristics of trawl gear for haddock. Holden (1971) presents the most comprehensive review for all studies prior to 1971. In the early studies, there was much emphasis on selectivity changes due to fibre type (Brandt, 1963; Clark, 1963; Clark et al., 1958; McCracken, 1963; Templeman, 1963). However, as McCracken (1977) points out, if one steps back and overviews the entire situation, it becomes clear that there are no definitive, quantifiable, trends in the selection factor by codend fibre type.

Clay (1979) provides a relationship between the 50% retention length (mm) and the codend mesh size (mm) which essentially ignores systematic affects due to codend mesh material. This formula generates 50% retention lengths of 40.7 and 44.034 cm for 120 and 130 mm mesh codends respectively. Selection at length (ℓ) for these two mesh sizes was obtained by first describing an appropriate pattern of selection change over length and then moving this ogive so that the 50% retention lengths agreed with those provided by the Clay (1979) equation.

The shape of the selection ogive was obtained by fitting a logistic curve to the data on selection at length for haddock caught in a 5" codend mesh net provided by Clark et al., (1958). The resulting formula was:

$$S(\ell) = \frac{1}{1+e^{a+\beta(\ell/L50)}} \qquad (1)$$

where $S(\ell)$ = Fraction selected at length
a = 12.194
β = -12.0777
ℓ = length
L50 = 50% retention length (in the units of ℓ)

The 50% retention lengths were then determined by the equation of Clay (1979):

$$L_{50} = 3.63M - 28.49 \qquad (2)$$

where L_{50} = 50% retention length in mm
M = codend mesh size in mm

The resulting selection ogives at length are provided in Table 8 and plotted on Figure 5.

These ogives were converted to selection at age by applying them to an age-length key available from the commercial sample data. The age-length key chosen was one consisting of all samples for T.C. 1, 2, and 3 vessels operating in 4Xm-s (i.e. all of 4X) during 1980. This key was chosen over others as it was felt that this component of the fleet will be the one most likely to be influenced by the change in regulation.

B. Calculation of Partial Recruitment Pattern by Fleet Component

The catch from a fishery during any given year can be expressed as:

$$\frac{dc}{dt} = FN \tag{3}$$

In the present situation, two fleet components are being considered - those vessels using 120 mm mesh gear (i.e. a subset of otter trawlers of T.C. 1, 2, and 3) and those using 130 mm codend mesh gear or equivalent (i.e. all other vessels operating in the fishery). Note that no difference in population age structure by area is being assumed. Therefore equation (3) becomes:

$$\frac{d(C_1,+C_2)}{dt} = (F_1+F_2)N_{TOT} \tag{4}$$

For each component,

$$C_1(t) = \int_t^{t+1} F_1\, N_{TOT} \tag{5}$$

$$= F_1 \int N_{TOT} \tag{6}$$

which assumes that the level of exploitation is constant over the year.

$$\text{But} \quad C_{TOT} = F_{TOT} \int N_{TOT} \quad \text{and} \quad \frac{C_{TOT}}{F_{TOT}} = \int N_{TOT} \tag{7}$$

Thus,

$$C_1 = F_1 \times \frac{C_{TOT}}{F_{TOT}} \tag{8}$$

or

$$\frac{C_1}{F_1} = \frac{C_{TOT}}{F_{TOT}} \tag{9}$$

Equation (9) assumes that same population structure is being exploited by all components of the fishery.

The fishing mortalities at age for 1980 were obtained from O'Boyle (1981). The contribution to it by the two fleet components was calculated by application of equation (9). The input parameters were:

C_{TOT} = total catch at age for 1980
F_{TOT} = total F at age for 1980
C_1 = catch at age for otter trawlers, of T.C. 1, 2, and 3 fishing in 4X

F_1 was thus calculated and represented the fishing mortality at age for inshore otter trawlers fishing in 4X.

F_2, the fishing mortality due to the second component of the fishery was calculated as:

$$F_2 = F_{TOT} \times \frac{(C_{TOT} - C_1)}{C_{TOT}} \tag{10}$$

Table 9 contains a summary of all the relevant data.

The next step is to make changes to F_1 and F_2 that would reflect changes due to the mesh regulation. As it is assumed that the offshore fleet is presently using 130 mm, no change in F_2 was expected. Therefore, only a change in F_1 is considered.

Ideally one would estimate the effect of changing only that portion of F_1 which currently fishes 120 mesh gear to 130 mesh. Since the available data do not permit a finer resolution, it was decided to overestimate the change by applying the selection ratio to the entire F_1 component. The resulting yield changes will consequently be exaggerated by an unknown amount.

The change was effected by use of the following relationship on an age by age basis.

$$\frac{S_{130}}{S_{120}} \times F_1 = F_{1,130} \qquad (11)$$

and,

$$F_{1,130} + F_2 = F_{TOT,130} \qquad (12)$$

Table 10 presents the results.

$F_{TOT,130}$ was then converted to a partial recruitment vector by dividing each element by the age 12 value.

C. Impact of New Regulation on Yield

1) Long-term effects on yield

The long-term impact of the mesh regulation change was evaluated through use of the Thompson and Bell yield per recruit model. Two predictions were made, one using the partial recruitment before the change, and the other using the derived partial recruitment after the change. In both cases, the mean weight at age (kg) for the 1962 - 80 period was employed. The results are presented in Table 11.

The change to the regulation causes a slight increase in the $F_{0.1}$ (0.302 vs 0.310) possible. There is a corresponding increase in the yield at $F_{0.1}$. Despite the exaggerated change in F_1, these changes are so slight that they must be considered insignificant. Certainly, they are well within the error bounds of the models and data employed.

Beverton and Hodder (1962) report a long-term decrease in yield of 3% and 10% for a change in mesh size from 4½ in. (114 mm) to 5 in. (127 mm) and 5½ in. (140 mm), respectively, for the entire fleet. This calculation assumed knife-edge recruitment, which may have shifted the location of optimum yield slightly (Gulland, 1963). Growth parameters in 1962 would be expected to be different, but as they are not reported by Beverton and Hodder (1962) it is not possible to determine the effect of changes in growth between 1962 and the 1970's.

Another way to look at the long-term yield effects is to consider how much more yield can be gained from 100 t of age 2 and 3 fish in moving from 120 to 130 mm codend mesh. These age groups were chosen as they are the two to be most affected by the regulation. The details of the calculations are given in Table 12. Basically, population sizes at ages 2 and 3, $N(a_o)$, were calculated which generated a catch of 100 t using the 120 mm mesh size. These populations were then fished at the new 130 mm mesh size to discern the increase in yield. If the overall fishing mortality is at the appropriate $F_{0.1}$ level, each 100 t caught at age 2 using 120 mm gear would, if fished with 130 mm mesh gear, generate an additional catch of 48 t over the next 11 years. Similarly, for 3 year old fish, projections showed a calculated gain of 22 t per 100 t taken at age 3. The majority of this increase occurs at ages 5 and 6.

2) Short-term effects on yield

Short-term effects were evaluated through use of catch projections using the 1982 population structure as defined during the 1981 assessment (O'Boyle, 1981) and mean weights at age for the 1962 - 80 period. This population structure was "fished" at $F_{0.1}$ assuming (i) no change in partial recruitment and (ii) a change to 130 mm mesh nets for the inshore fleet. The input data are given in Table 11 and the results presented in Table 13.

For the fishery as a whole, there would be a loss of 764 t in yield, or about 3% of the possible catch, during the first year. The loss would diminish to less than 1% during the second and subsequent years. By 1986, yield would have recovered to the level expected before any change in the regulation occurred.

Thus, as with the yield per recruit calculations, very little change is expected to occur in yield, on a total 4X areal basis. Again, it should be emphasized that these calculations exaggerate the magnitude of the expected changes.

D. Impact of New Regulation on Catch Rates

If it is assumed that the offshore vessels (tonnage class 4 and 5) presently use 130 mm codend mesh, then the effect on this segment of the fishery will be negligible or non-existent, both in the short and long-term.

The component of the fishery to be most seriously affected are the T.C. 1, 2, and 3 vessels, particularily those operating in the Bay of Fundy as this fleet concentrates on age 2 and 3 fish. In the long-term, the catch rates would not be expected to change significantly from their present levels. This is apparent from the short and long-term yield projections. Most of the effect on these vessels will be immediate - within the next two years. The extent of this effect depends to a large extent on the population age structure over this period. Needless to say, the change would be dramatic if a large sector of the population suddenly became unavailable to the gear.

These immediate effects were examined by perturbing the length-frequency distributions of individual historical commercial samples.

This perturbation was done on length-frequencies of commercial samples (representing individual trips) by multiplying each element of the distribution by the ratio of the selectivities at length (i.e. selectivity at length for (130mm) ÷ (selectivity at length for 120 mm), converting the lengths to weights and summing over all weights. In this manner, a before and after catch weight for the vessel and trip in question could be obtained. The ratio of the two catch weights is an indication of the change in catch rates (calculated as catch per trip) and thus reflects the impact on the catch rate.

This exercise was carried out on all samples taken for 4Xr landings during 1948 - 80 as well as for all T.C. 1, 2, and 3 vessel landings during 1980. The results are summarized in Tables 14 and 15 and illustrated in Figure 6.

In 4Xr, catch rate ratios ranged from 0.50 to 0.98 for the 1948 - 80 period. The range for all vessels operating in 4X during 1980 was only 0.8 to 0.99. The lower ratios observed in the 4XR samples is due to the fact that, as was discussed earlier, vessels operating there concentrate on age 2 and 3 fish. From the selectivity results (Table 10) it is evident that mortality of these 2 age groups will be the most dramatic to change in the fishery.

Thus, whereas vessels operating in other areas of 4X would be expected to be effected only slightly by the regulation, those operating in 4Xr may experience immediate declines in the catch rates in the order of 2 to 52%. The exact figure depends on a combination of the mesh size in use and the population size composition at the time of imposition of the regulation. In this analysis, it was assumed that all the fishing vessels are presently using 120 mm mesh. Obviously the effect on catch rates will be more dramatic if smaller mesh sizes are actually in use. Regarding the 1982 age composition, there is some indication (O'Boyle, 1981) that the size of the 1979 year class could be substantial, perhaps equaling the size of the 1962 year class, the second largest to occur in the fishery since 1981. If this is confirmed, then vessels restricted to fishing in 4Xr could experience declines in catch rates similar to those calculated for the mid 1960's in Table 14 (20 - 50%).

A key consideration here is that only those vessels restricted to 4Xr will be the most seriously affected. If vessels fishing there now can move out further onto the shelf, this will have a moderating effect on the catch rate declines. The vessels which must fish in 4Xr would have to gear up to increase their mobility if they wish to maintain present catch ratios. The precise number of vessels in this situation is presently unknown.

Whatever the case, yield gains resulting from the regulation would, to some degree, be available to the fishery in 4Xr although they would be shared throughout 4X.

One aspect of the regulation that sould not be overlooked is that future discards will be reduced at 130 mm mesh. Substantial discarding is known to have occurred in the past. If the regulation is not implemented, those boats presently using 130 mm mesh codends may revert to the use of smaller mesh and cause substantial losses in yield.

SUMMARY

Long-term and short-term yield and catch rate trends were examined in relation to application of a new mesh size regulation as of 1 January 1982. The regulation will stipulate that no codend mesh size should be less than 130 mm irrespective of the material used.

Of the two components exploiting the fishery, the T.C. 1, 2, and 3 otter trawlers, particularly those operating in 4Xr, are the most likely to be affected.

It was determined that very little change in yield will occur in both the long and short-term. Any differences observed in this study are well within the bounds of error present in the data and the models employed.

The findings imply little long-term change in catch rates. The same is not true for the short-term. The latter could decrease anywhere from 10 to 50% as a result of the mesh regulation. Timing of the regulation could have a major effect, as the largest decrease in catch rates would occur when the population is dominated by fish of ages 2 and 3. This, compounded with the other problems in the economy, makes a decision on a change in the mesh regulation a very hard one indeed.

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Table 1. Reported nominal catch (t) of haddock by year and country for all vessels operating in NAFO Division 4X.

Year	Canada	USA	Other	Total
1970	16012	1743	384	18139
1971	16404	751	445	17600
1972	12570	448	481	13499
1973	12680	269	154	13103
1974	12434	668	132	13234
1975	16059	2143	48	18250
1976	16338	986	100	17424
1977	19605	1662	2	21269
1978	25509	1134	29	26672
1979	24848	69	18	24935
1980*	28675	256	75	29006
Total	201134	10129	1868	213131

* Provisional NAFO SCS Doc. 81/VI/15
6 July 1981

Table 2. Reported nominal catch (t) of haddock by year and tonnage class for side and stern otter trawlers operating in unit areas 4Xm-q.

Year	1	2	3	4	5	Total Inshore	Total Offshore	Total
1970	90	576	2132	3664	2834	2798	6498	9296
1971	73	530	1808	4731	2960	2411	7691	10102
1972	63	201	874	2797	1929	1138	4726	5864
1973	47	226	346	2565	1663	619	4228	4847
1974	109	333	378	1069	554	820	1623	2443
1975	316	1289	2163	2414	1995	3768	4409	8177
1976	180	774	1290	3044	3096	2244	6140	8384
1977	456	1582	2725	3689	4656	4763	8345	13108
1978	713	2595	3625	3720	3836	6933	7556	14489
1979	747	2956	4216	4315	4319	7919	8634	16553
1980	1496	3542	4631	3660	3780	9669	7440	17109
TOTAL	4290	14604	24188	35668	31622	43082	67290	110372

Table 3. Reported nominal catch (t) of haddock by year and tonnage class for side and stern otter trawlers in unit areas 4Xr-s.

Year	1	2	3	4	5	Total Inshore	Total Offshore	Total
1970	116	1279	1040	2	0	2435	2	2437
1971	102	1079	913	21	0	2094	21	2115
1972	83	824	800	10	14	1707	24	1731
1973	59	590	621	0	0	1270	0	1270
1974	99	1626	1521	0	0	3246	0	3246
1975	0	1140	1252	0	0	2392	0	2392
1976	130	693	1309	0	3	2132	3	2135
1977	0	635	818	0	0	1453	0	1453
1978	217	742	1102	0	0	2061	0	2061
1979	137	844	1244	6	0	2225	6	2231
1980	642	974	1733	0	0	3349	0	3349
TOTAL	1585	10426	12353	39	17	24364	56	24420

Table 4. Number of otter trawlers fishing for haddock in NAFO Div. 4X by year, unit area and tonnage class.

YEAR	UNIT AREA	TONNAGE CLASS 2	3	4	5	TOTAL
1967	4XMNOP	9	11	15	9	44
	Q	6	7	4	3	20
	R	24	13	1	3	41
	S	8	8	2	1	19
	4XM-S	26	15	16	9	66
1968	4XMNOP	11	35	51	18	115
	Q	10	26	14	3	53
	R	35	42	9	3	89
	S	14	26	3	-	43
	4XM-S	43	53	52	19	167
1969	4XMNOP	13	29	47	19	108
	Q	8	16	17	7	48
	R	33	34	-	2	69
	S	11	24	-	-	35
	4XM-S	37	51	48	19	155
1970	4XMNOP	14	38	32	17	101
	Q	17	24	11	8	60
	R	29	32	2	-	63
	S	8	16	-	-	24
	4XM-S	38	53	32	17	140
1971	4XMNOP	13	35	38	19	105
	Q	18	28	10	5	61
	R	30	32	4	-	66
	S	11	12	-	-	23
	4XM-S	41	48	39	19	147
1972	4XMNOP	9	28	27	17	81
	Q	13	25	19	12	69
	R	23	30	1	1	55
	S	9	7	-	-	16
	4XM-S	32	44	27	17	120
1973	4XMNOP	6	10	26	14	56
	Q	16	26	16	7	65
	R	32	28	-	-	60
	S	7	9	-	-	16
	4XM-S	41	37	26	14	118
1974	4XMNOP	5	5	21	17	48
	Q	14	18	15	15	62
	R	38	30	-	-	68
	S	7	10	-	-	17
	4XM-S	45	36	22	18	121

Cont'd

Table 4 (Cont'd). Number of otter trawlers fishing for haddock in NAFO Div. 4X by year, unit area and tonnage class.

YEAR	UNIT AREA	TONNAGE CLASS 2	3	4	5	TOTAL
1975	4XMNOP	12	33	33	21	99
	Q	16	25	3	7	51
	R	30	30	-	1	61
	S	9	7	-	-	16
	4XM-S	44	40	33	21	138
1976	4XMNOP	16	21	28	27	92
	Q	21	21	4	10	56
	R	26	31	-	1	58
	S	7	6	-	-	13
	4XM-S	42	40	28	27	137
1977	4XMNOP	20	32	26	30	108
	Q	19	17	3	3	42
	R	24	26	-	-	50
	S	5	3	-	-	8
	4XM-S	38	39	26	30	133
1978	4XMNOP	29	34	28	35	126
	Q	21	19	5	3	48
	R	19	25	-	-	44
	S	5	5	-	-	10
	4XM-S	40	36	29	35	140
1979	4XMNOP	41	43	32	29	145
	Q	28	33	5	4	70
	R	20	34	-	-	54
	S	7	18	2	-	27
	4XM-S	51	48	32	29	160
1980	4XMNOP	43	49	26	33	151
	Q	39	30	6	2	77
	R	26	40	-	-	66
	S	10	17	-	-	27
	4XM-S	68	56	26	36	186

Table 5. Amount of tonnage per sample of haddock caught by otter trawlers in 4X during 1970-80. The number of samples is indicated in parenthesis.

Year	4XM-Q T.C. 1,2,3	4XM-Q T.C. 4,5	4XR-S T.C. 1,2,3	4XR-S T.C. 4,5
1970	2798 (1)	295 (22)	406 (6)	-
1971	1206 (2)	452 (17)	698 (3)	11 (2)
1972	569 (2)	236 (20)	854 (2)	-
1973	310 (2)	302 (14)	318 (4)	-
1974	205 (4)	325 (5)	812 (4)	-
1975	251 (15)	157 (28)	598 (4)	-
1976	1122 (2)	186 (33)	1066 (2)	-
1977	794 (6)	130 (64)	-	-
1978	-	157 (48)	-	-
1979	3960 (2)	262 (33)	-	-
1980	967 (10)	310 (24)	1675 (2)	-
$\bar{x}$	1218	256	804	11

Table 6. Numbers (000'0) of haddock in strata 70-85 (Scotian Shelf) as determined by July groundfish survey.

	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980
0	0	68	0	0	0	0	0	11	0	578	40
1	7871	161	7183	8195	13351	9135	6469	8071	8804	2293	29360
2	5967	14800	319	27832	29098	4076	6241	40824	6708	10183	4964
3	1936	4943	4299	960	32895	6426	4749	50550	12624	4754	13684
4	3426	2452	1777	3673	1238	9665	5024	14241	3413	9607	9796
5	1454	3757	1204	1737	5790	539	9501	14158	1959	6039	16182
6	3168	1742	1233	713	1174	2371	747	8270	4073	2315	5489
7	6640	2719	839	882	655	669	898	957	1474	3998	2129
8	1234	6417	1185	634	813	514	140	1310	0	1454	1687
9	412	999	1411	392	488	212	0	144	0	339	765
10	303	102	38	557	323	143	55	69	0	0	330
11	49	62	9	33	261	329	0	0	57	0	51
12+	45	84	7	0	0	275	425	315	115	164	0
NK	0	0	108	0	0	0	123	0	144	199	68

Table 7. Numbers (000'0) of haddock in strata 90-95 (Bay of Fundy) as determined by July groundfish survey.

	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980
0	0	0	0	0	0	0	0	0	0	21	0
1	123	0	65	35	2430	267	1129	622	37	478	1015
2	184	376	0	3297	3397	978	3093	5112	961	8892	4921
3	123	1503	249	52	13706	797	1197	2505	3526	6661	7991
4	350	478	283	428	209	1390	749	1299	1619	4570	1584
5	55	408	65	235	249	40	1067	1884	436	1090	1268
6	183	267	154	22	184	136	26	943	330	484	379
7	1576	351	67	154	90	0	51	173	227	576	0
8	120	1822	245	156	54	0	19	149	111	455	48
9	31	175	808	161	26	0	62	96	0	0	87
10	0	26	42	257	52	0	0	114	0	152	0
11	33	0	0	0	226	152	13	24	0	0	0
12+	0	52	19	20	0	65	90	294	206	29	21
NK	0	0	0	0	0	0	0	11	0	0	0

Table 8. Selection at length (mm) for haddock caught by 120 and 130 mm codend mesh trawl nets.

Length (mm)	Selection for 120 mm mesh net	Selection for 130 mm mesh net
16.50	0.00	0.00
18.50	0.00	0.00
20.50	0.00	0.00
22.50	0.00	0.00
24.50	0.01	0.00
26.50	0.01	0.01
28.50	0.02	0.01
30.50	0.04	0.02
32.50	0.07	0.03
34.50	0.12	0.06
36.50	0.20	0.10
38.50	0.32	0.15
40.50	0.46	0.24
42.50	0.60	0.35
44.50	0.73	0.48
46.50	0.83	0.62
48.50	0.90	0.74
50.50	0.94	0.83
52.50	0.97	0.89
54.50	0.98	0.93
56.50	0.99	0.96
58.50	0.99	0.98
60.50	1.00	0.99
62.50	1.00	0.99
64.50	1.00	1.00
66.50	1.00	1.00
68.50	1.00	1.00
70.50	1.00	1.00
72.50	1.00	1.00
74.50	1.00	1.00
76.50	1.00	1.00
78.50	1.00	1.00
80.50	1.00	1.00
82.50	1.00	1.00
84.50	1.00	1.00

Table 9. Summary of data used and generated in breakdown of 1980 fishing mortalities at age into F's at age by fleet component.

Age	F_{TOT}	C_{TOT}	C_1	C_2	F_1	F_2
1	0.000	12	55	-43	0.000	0.000
2	0.005	168	233	-65	0.007	-0.002
3	0.060	2692	1966	726	0.044	0.016
4	0.180	3283	2329	954	0.128	0.052
5	0.240	5321	1783	3538	0.080	0.160
6	0.720	3457	1251	2206	0.261	0.459
7	0.300	578	199	379	0.103	0.197
8	0.300	526	181	345	0.103	0.197
9	0.300	173	76	97	0.132	0.168
10	0.300	36	12	24	0.100	0.200
11	0.300	24	7	14	0.087	0.212
12	0.300	9	0	9	0.000	0.300

Table 10. Fishing mortalities at age by fleet component both before and after a change in selectivity.

Age	S_{130}	S_{120}	F_1	F_2	$F_{1,130}$	$F_{TOT,130}$
1	0.01	0.03	0.000	0.000	0.000	0.000
2	0.12	0.24	0.007	-0.002	0.003	0.001
3	0.47	0.68	0.044	0.016	0.030	0.047
4	0.76	0.90	0.128	0.052	0.108	0.161
5	0.91	0.97	0.080	0.160	0.075	0.235
6	0.97	0.99	0.261	0.459	0.256	0.715
7	0.99	1.00	0.103	0.197	0.102	0.299
8	0.96	0.98	0.103	0.197	0.100	0.297
9	1.00	1.00	0.132	0.168	0.132	0.300
10	1.00	1.00	0.100	0.200	0.100	0.300
11	1.00	1.00	0.087	0.212	0.087	0.299
12	1.00	1.00	0.000	0.300	0.000	0.300
L_{50} (cm)	40.7	44.34				

Table 11. Yield per recruitment calculations and 1982 population parameters used in the catch projection.

Age	Mean (1962-80) weight at age kg	1982 Catch at age number x 10^{-3}	1982 Population at age number x 10^{-3}	Old partial Recruitment	New partial Recruitment
1	0.287	10	40000	0.0003	0
2	0.472	140	32740	0.0167	0.005
3	0.784	3341	66706	0.2	0.155
4	1.119	3328	23369	0.6	0.536
5	1.466	5015	27120	0.8	0.782
6	1.828	2201	9778	1	1
7	2.209	2448	10874	1	1
8	2.510	406	1803	1	1
9	2.769	206	915	1	1
10	3.013	182	833	1	1
11	3.244	62	274	1	1
12	3.478	13	57	1	1
$F_{0.1}$				0.302	0.310
F_{max}				0.733	0.793
Yield at $F_{0.1}$, kg.				0.513	0.517
M				0.2	0.2

Table 12. Yield to the fishery from 100 t not captured at ages 2 or 3.

	Age at which fish are not captured a_o	
	2	3
mean wt. (kg)	0.472	0.784
$F_{0.1}$ (1980 PR)	0.302	0.302
PR (a_o)	0.0167	0.2
$N(a_o) \times 10^{-6}$	46882	2686
YPR (kg)	0.631	0.772
YIELD (t) at $F_{0.1}$ (130 mm PR)	147.5	121.5

Method of calculation:

$$YIELD = (1 - e^{M})\ N(a_o) \times YPR\ (a_o)$$

where $N(a_o)$ is the population size required to produce a catch of 100 t between ages a_o and $a_o + 1$ under the current partial recruitment and YPR is the yield-per-recruit at $F_{0.1}$ using the partial recruitment appropriate when all trawlers use 130 mm mesh.

Table 13. Catch projections at $F_{0.1}$ to 1986 under the 1982 conditions as outlined in Table 14. A value of 40 x 10^6 was taken for age one recruitment for 1983-86.

(A) No change in partial recruitment

Year	1+ population number $x10^{-3}$	Mean 1+ population biomass T	1+ catch biomass T
1982	214469	166377	25580
1983	199935	164483	31190
1984	185232	156299	30841
1985	174560	146705	29449
1986	167376	138628	26994

(B) Change to 130 mm mesh

Year	1+ population number $x10^{-3}$	Mean 1+ population biomass T	1+ catch biomass T	Δ catch biomass T
1982	214469	166377	25580	0
1983	199935	164862	30426	-764
1984	186080	157283	30635	-206
1985	175656	147951	29442	-7
1986	168571	140049	26992	-2

Table 14. Perturbation results of commercial samples taken for 4XR landings (OT1, 2 and 3) during 1948-60 period.

DATE	RECORD NO.	CATCH WEIGHT (KG) FOR TRIP		RATIO PERTURBED ÷ ACTUAL
		ACTUAL	PERTURBED	
7/48	1109	5851	5211	.89
12/49	1381	24366	20844	.86
6/55	1983	2994	1973	.66
7/58	2347	2948	2264	.77
7/58	2348	2177	2003	.92
7/58	2349	3402	2097	.62
7/58	2350	970	731	.75
7/58	2351	2953	1915	.65
9/58	2371	3039	2074	.68
9/58	2372	3765	3229	.86
9/58	2374	3266	2615	.80
6/59	2444	23067	16942	.73
6/59	2445	2041	1459	.71
9/59	2487	907	654	.72
9/59	2488	1134	836	.74
10/59	2504	816	720	.88
10/59	2504	1361	1023	.75
10/59	2506	1179	838	.71
6/60	2555	465	362	.78
6/60	2556	275	237	.86
6/60	2557	1742	1530	.88
6/60	2558	9797	9209	.94
6/60	2559	363	304	.84
12/60	2596	363	259	.71
12/60	2597	1009	648	.64
12/60	2598	1191	829	.70
12/60	2599	4309	3241	.75
12/60	2605	794	722	.91

Table 14. (Cont'd)

DATE	RECORD NO.	CATCH WEIGHT (KG) FOR TRIP ACTUAL	PERTURBED	RATIO PERTURBED ÷ ACTUAL
7/61	2654	635	440	.69
7/61	2655	2041	1401	.69
7/61	2656	3266	2433	.75
7/61	2657	1377	913	.66
7/61	2658	907	707	.78
8/61	2668	937	599	.69
6/62	2751	1157	960	.83
6/62	2752	1873	978	.53
6/62	2753	2420	1325	.55
6/62	2754	2722	2055	.76
6/62	2755	1866	1344	.72
10/62	2830	284	197	.70
10/62	2831	1388	948	.68
10/62	2832	3533	2688	.76
10/62	2833	2150	1397	.65
10/62	2834	1653	1103	.67
7/63	2929	408	254	.62
7/63	2930	363	247	.68
7/63	2931	408	247	.61
7/63	2932	363	241	.67
7/63	2934	408	251	.62
8/63	2950	11782	9691	.82
11/63	2996	1885	1679	.89
11/63	2997	5398	4147	.77
11/63	2998	3166	2733	.86
5/64	3063	3660	3261	.89
6/65	3212	4581	2948	.64
6/65	3214	2690	1795	.67
6/65	3222	4867	3461	.71
7/65	3235	1362	1266	.93
7/65	3236	1905	1493	.78
7/65	3237	762	570	.75
4/66	3340	6069	3149	.52
5/66	3349	447	272	.61
5/66	3350	2722	1359	.50
6/66	3363	1601	1103	.69
6/66	3366	10795	6845	.63
7/66	3384	14923	10675	.72
8/66	3397	21602	11825	.55
9/66	3411	18597	13446	.72
9/66	3412	27927	17232	.62
10/66	3431	4309	2801	.65
12/66	3456	11560	8098	.70

Table 14. (Continued)

DATE	RECORD NO.	CATCH WEIGHT (KG) FOR TRIP		RATIO PERTURBED ÷ ACTUAL
		ACTUAL	PERTURBED	
5/67	3518	453	280	.62
6/67	3523	10802	6499	.60
6/67	3524	7682	4801	.62
6/67	3527	4082	2903	.71
7/67	3534	10886	7330	.67
5/68	3694	3497	2509	.72
6/68	3714	5443	4143	.76
8/68	3745	680	516	.76
8/68	3746	27215	20058	.74
10/68	3775	1815	1247	.69
11/68	3792	4536	3603	.79
9/69	3919	2722	2223	.82
9/69	3920	9072	7461	.82
9/69	3921	6350	4874	.77
7/70	4048	408	250	.61
7/70	4049	2120	2073	.98
9/70	4070	3375	2293	.68

Table 14. (continued)

Date	Record No.	Catch weight (kg) for trip		Ratio
		Actual	Perturbed	Perturbed/Actual
8/71	4222	163	147	0.90
8/71	4223	185	179	0.97
9/71	4238	7257	4060	0.56
12/71	4267	11738	11383	0.97
12/71	4268	10402	10183	0.98
7/72	4355	2549	1752	0.69
10/72	4425	4572	4190	0.92
8/73	4563	150	84	0.56
9/73	4573	1089	520	0.48
10/73	4592	1388	664	0.48
11/73	4621	2041	1186	0.58
5/74	4728	2495	2304	0.92
5/74	4729	1633	1040	0.64
8/74	4769	1113	705	0.63
10/74	4825	1814	1463	0.81
6/75	4994	2086	1510	0.72
6/75	4997	1542	876	0.57
7/75	5026	4536	2865	0.63
8/75	5058	2177	1243	0.57
8/76	858	460	354	0.77
8/76	859	2293	1933	0.84
4/80	6487	8165	7418	0.91

Table 15. Perturbation results of commercial samples taken for OT 1, 2, and 3 vessels fishing in 4X M-S during 1980.

Area	Record No.	Catch weight (kg) for trip Actual	Perturbed	Ratio Perturbed/Actual
M-Q	6354	2969	2829	0.95
R	6487	8165	7418	0.91
S	6534	1742	1719	0.99
M-Q	6555	20693	19369	0.94
M-Q	6594	15333	14262	0.93
M-Q	6658	572	476	0.83
M-Q	6660	7397	6709	0.91
M-Q	6689	725	656	0.91
M-Q	6818	2631	2377	0.90
M-Q	6819	4728	4019	0.85
M-Q	6820	18973	15268	0.80
M-Q	6830	1625	1506	0.93

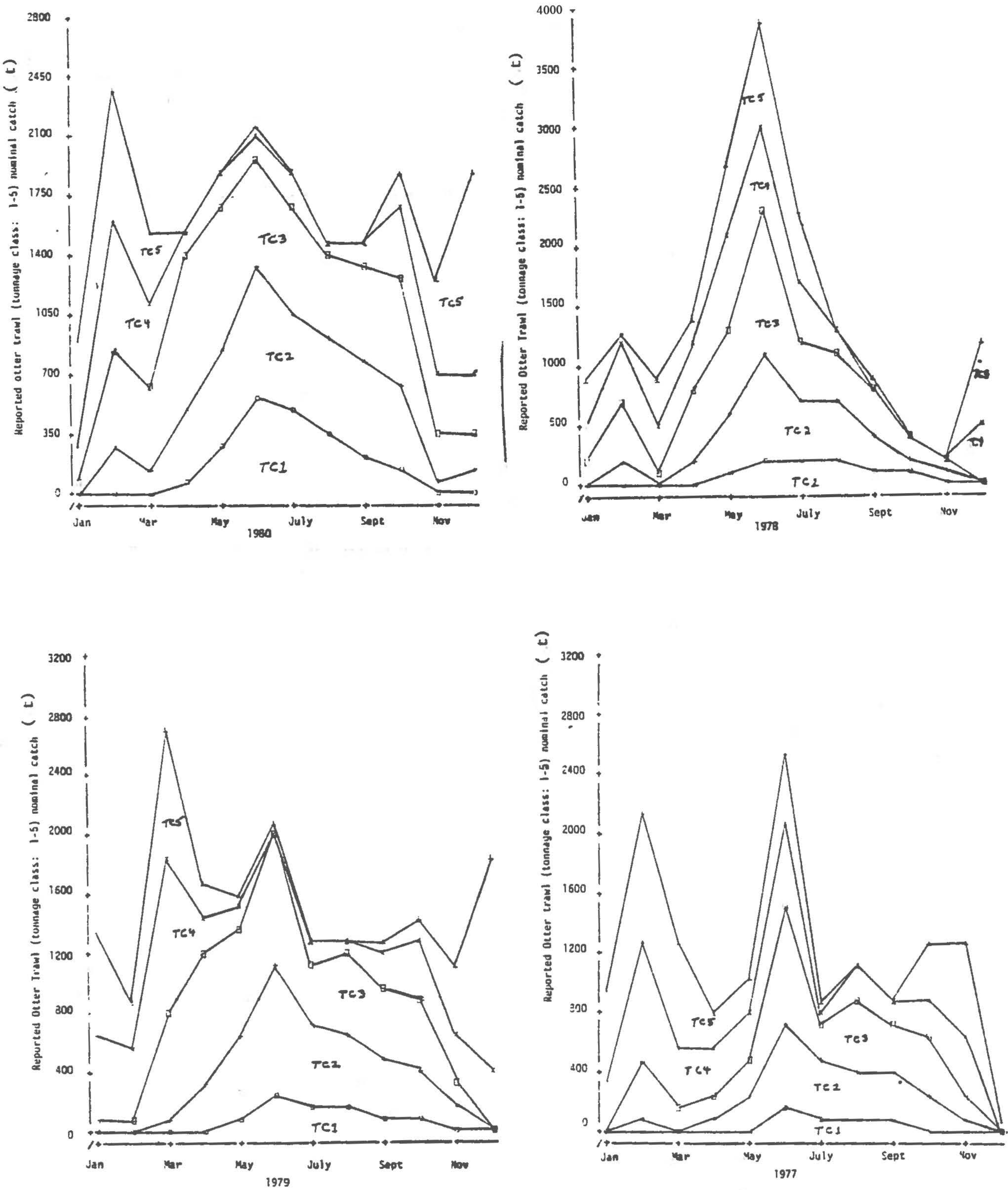


Figure 1. Distribution of landings by Canadian otter trawlers by month for the years 1977-1980

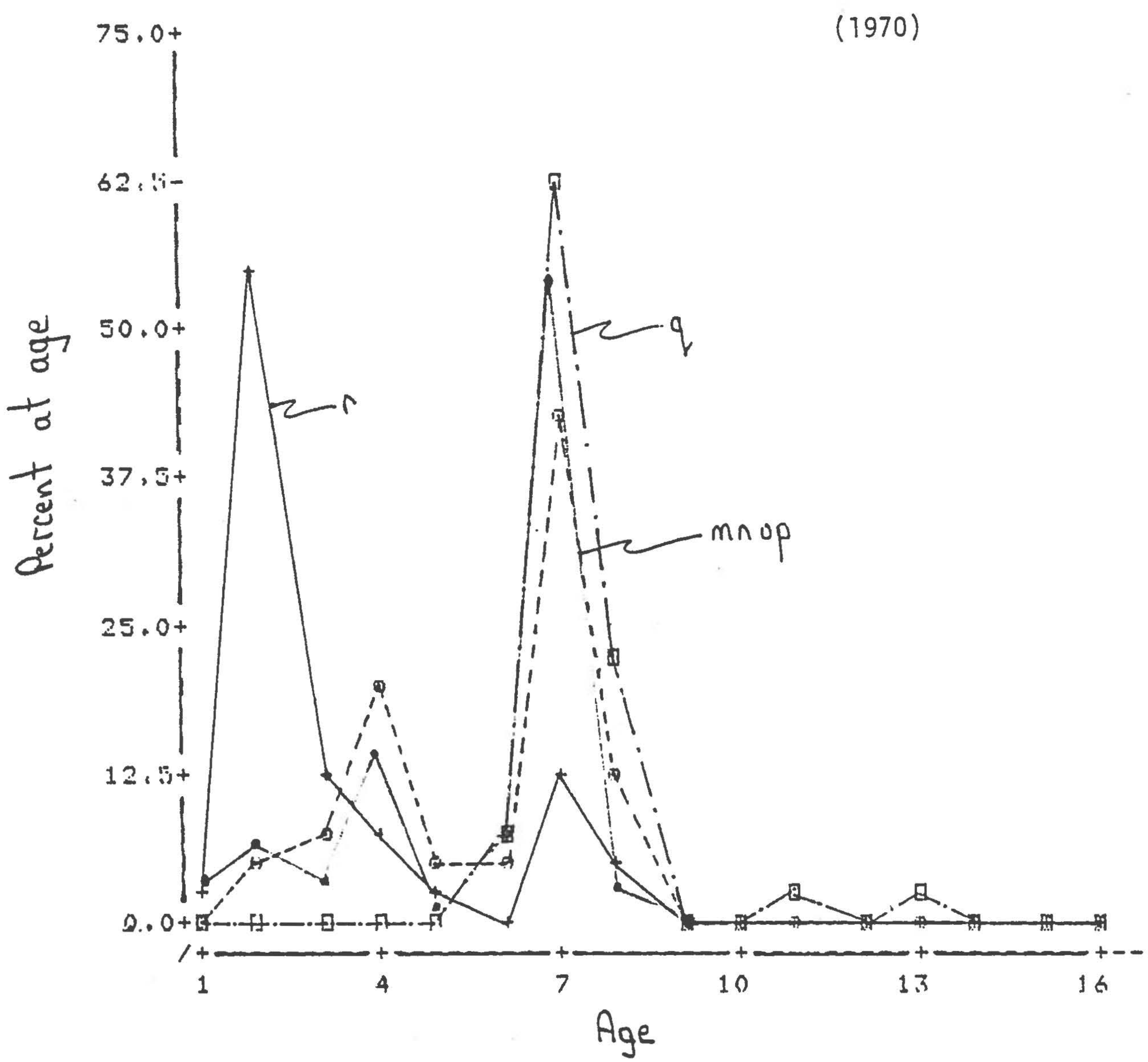


Fig. 2. Percentage age composition for 4X haddock fishery (all tonnage classes combined) during 1970-1980; by year and unit area. Age composition of July groundfish survey catch for strata 90-95 indicated by bold line.

(1971)

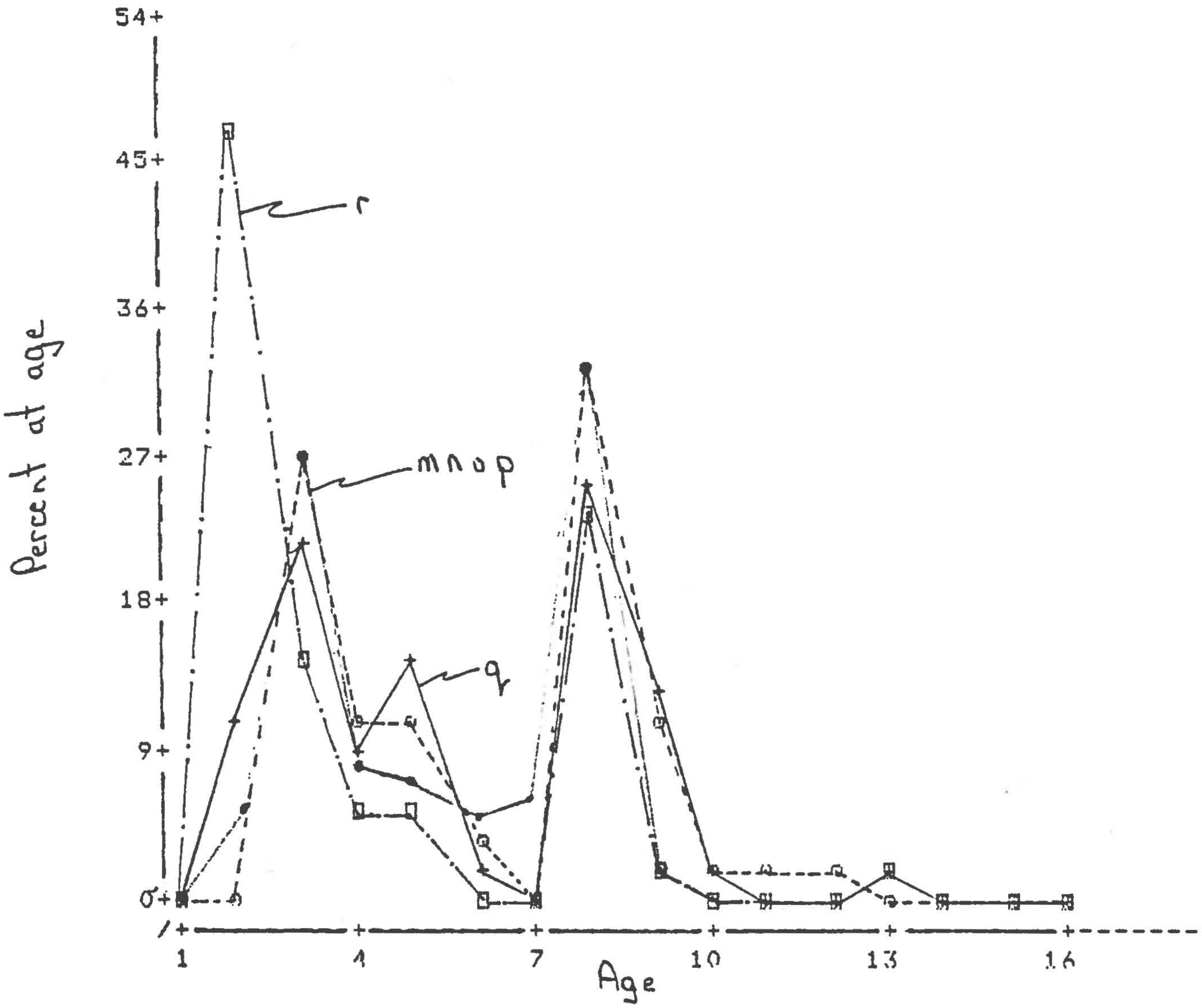


Fig. 2 (Cont'd). Percentage age composition for 4X haddock fishery (all tonnage classes combined) during 1970-1980; by year and unit area. Age composition of July groundfish survey catch for strata 90-95 indicated by bold line.

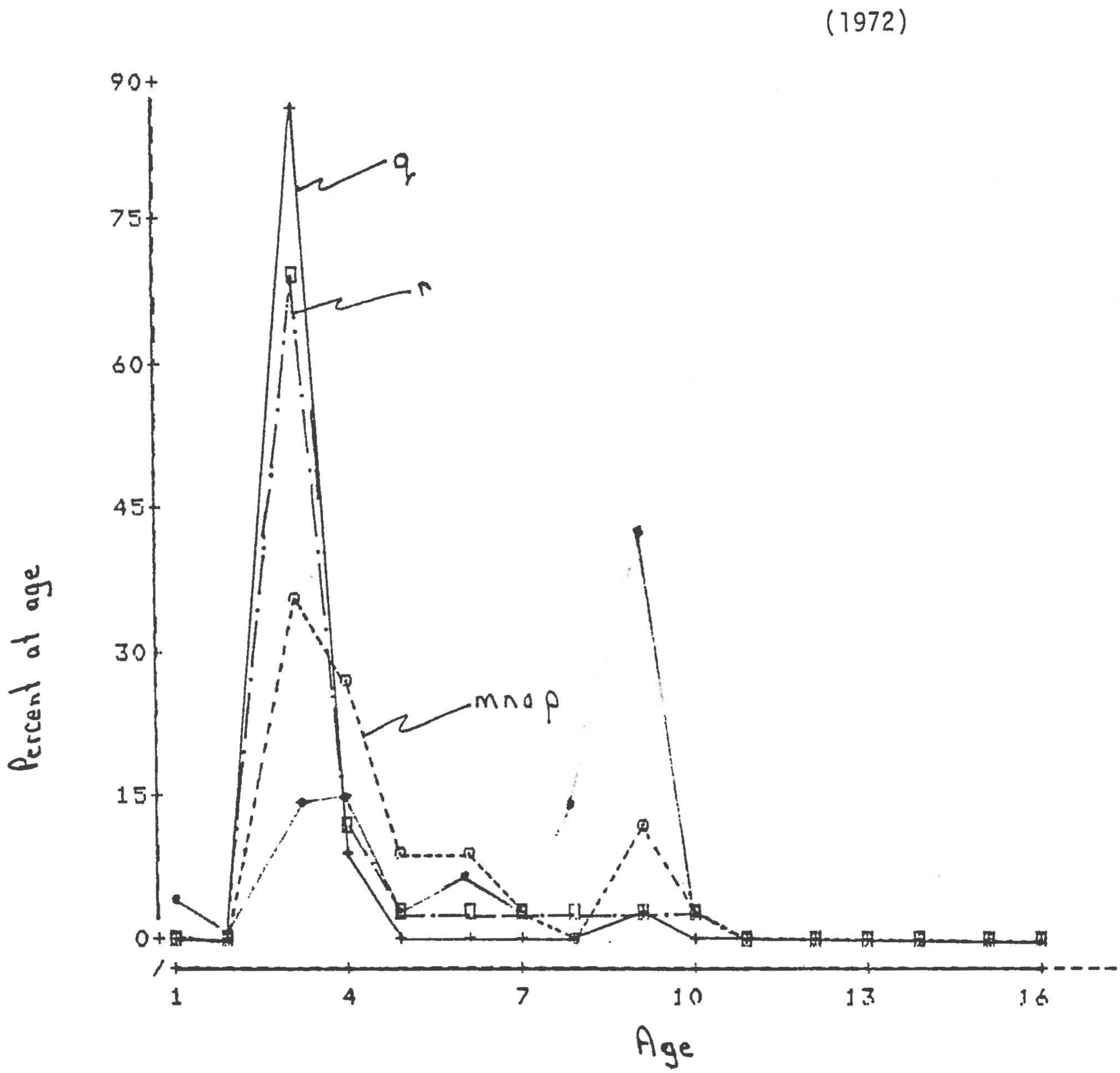


Fig. 2 (Cont'd). Percentage age composition for 4X haddock fishery (all tonnage classes combined) during 1970-1980, by year and unit area. Age composition of July groundfish survey catch for strata 90-95 indicated by bold line.

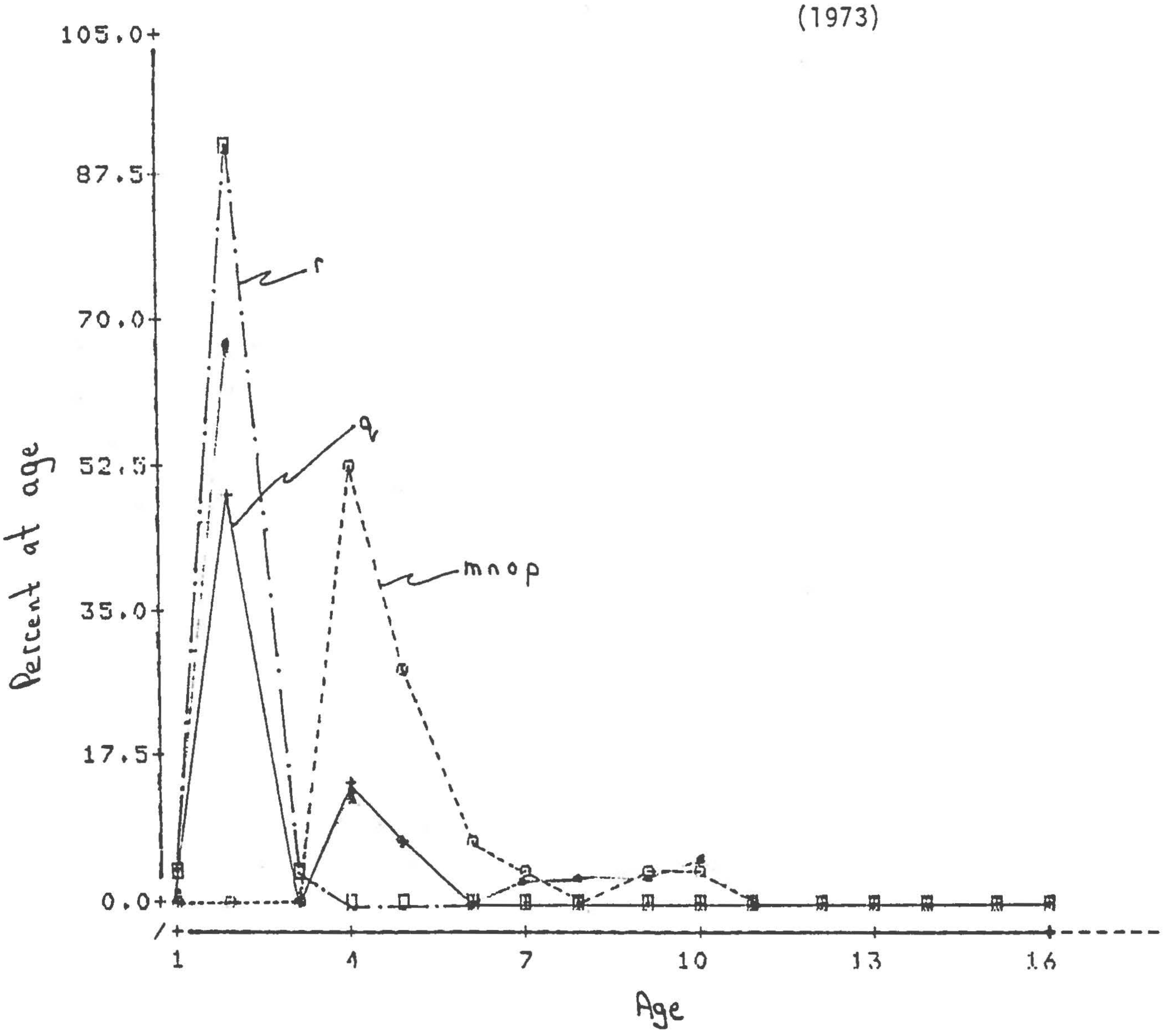


Fig. 2 (Cont'd). Percentage age composition for 4X haddock fishery (all tonnage classes combined) during 1970-1980, by year and unit area. Age composition of July groundfish survey catch for strata 90-95 indicated by bold line.

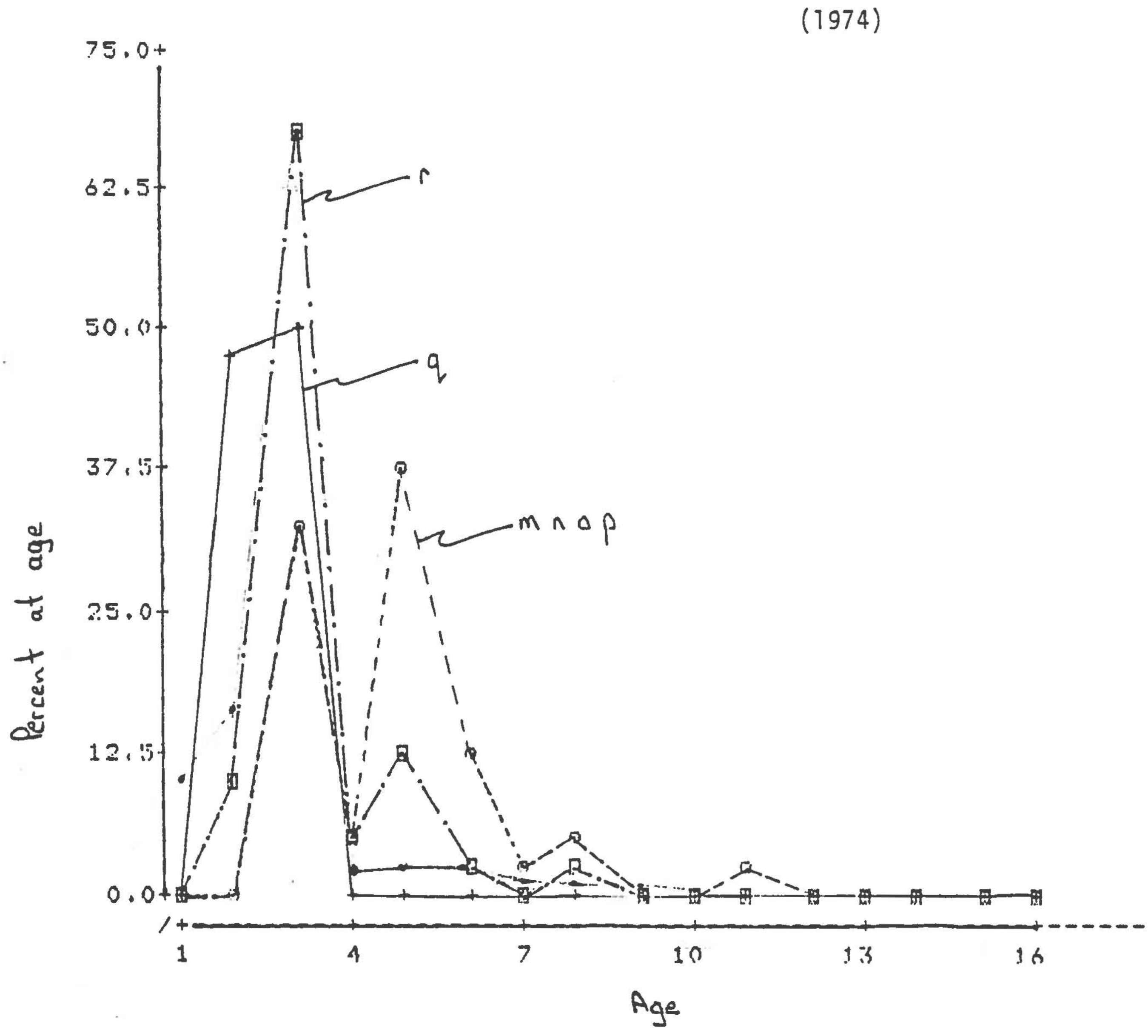


Fig. 2 (Cont'd). Percentage age composition for 4X haddock fishery (all tonnage classes combined) during 1970-1980, by year and unit area. Age composition of July groundfish survey catch for strata 90-95 indicated by bold line.

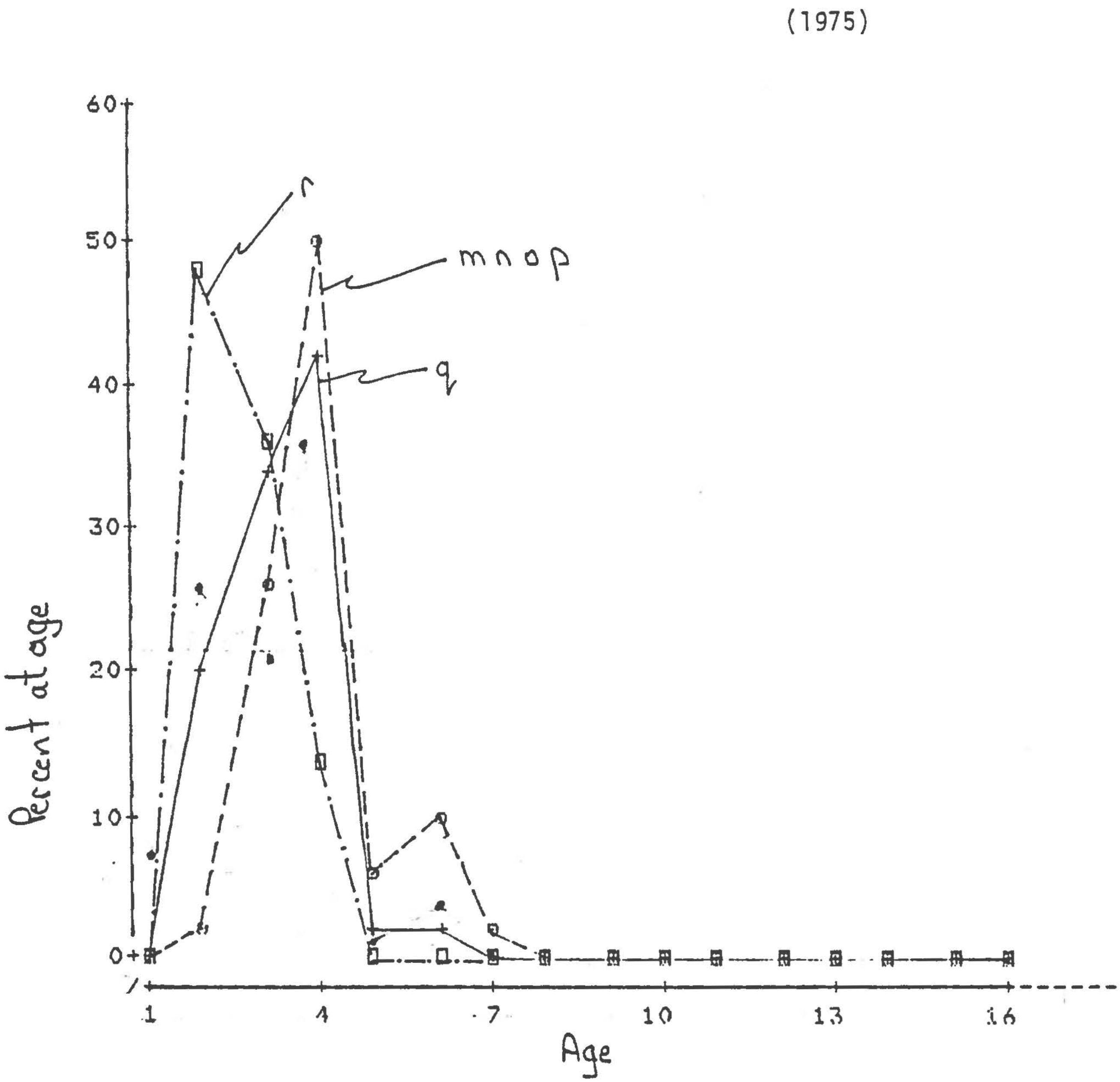


Fig. 2 (Cont'd). Percentage age composition for 4X haddock fishery (all tonnage classes combined) during 1970-1980, by year and unit area. Age composition of July groundfish survey catch for strata 90-95 indicated by bold line.

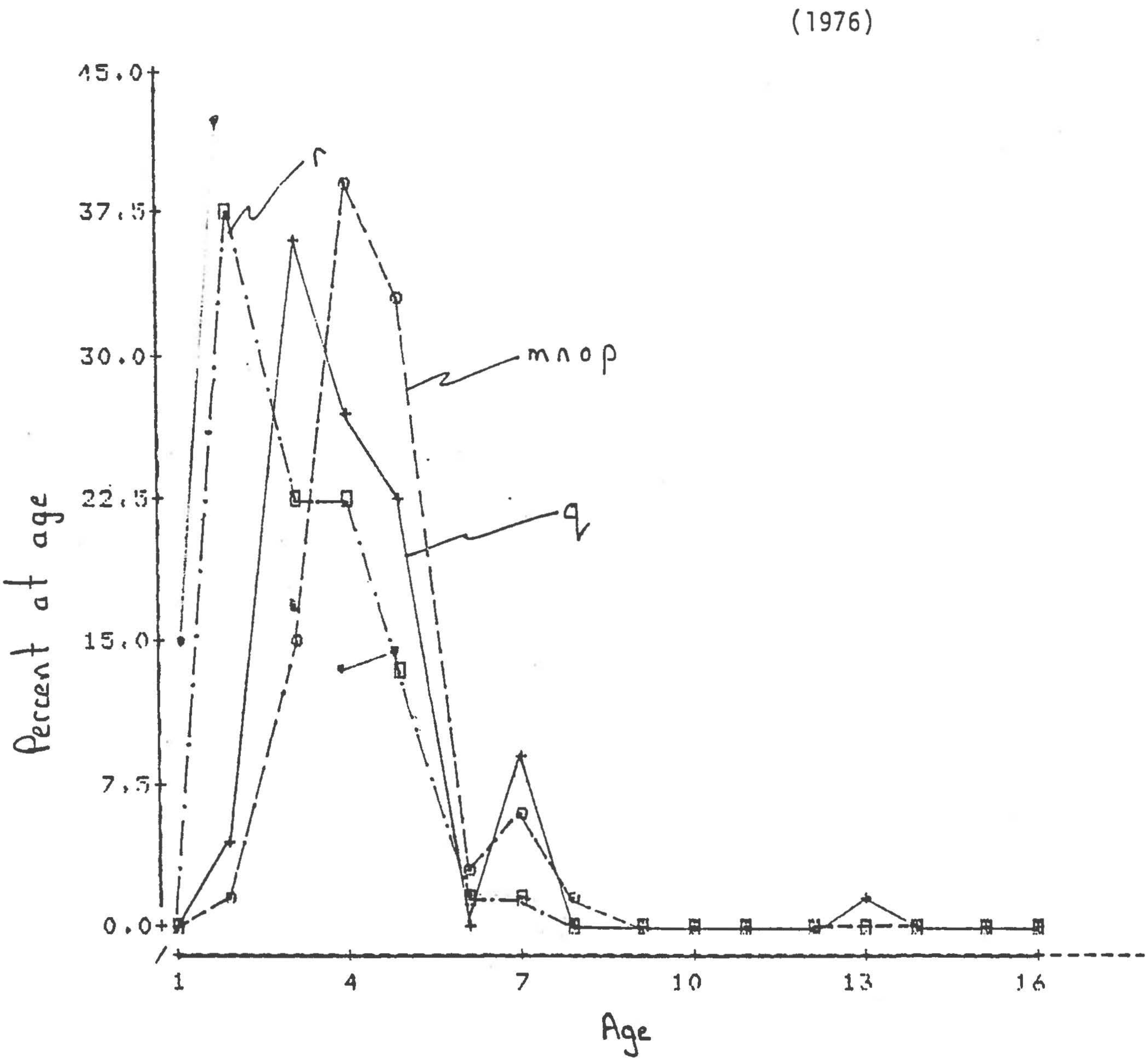


Fig. 2 (Cont'd). Percentage age composition for 4X haddock fishery (all tonnage classes combined) during 1970-1980, by year and unit area. Age composition of July groundfish survey catch for strata 90-95 indicated by bold line.

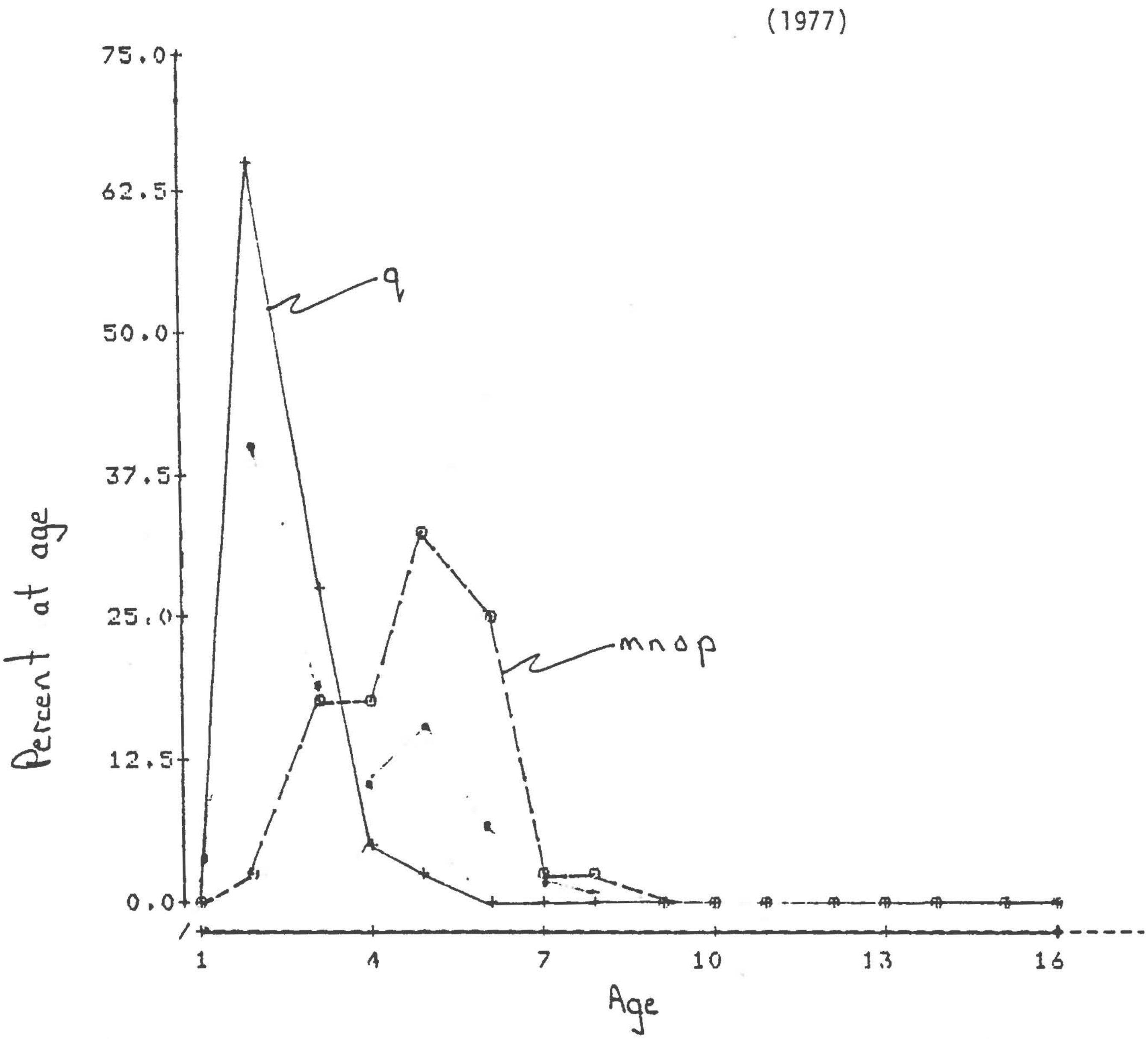


Fig. 2 (Cont'd). Percentage age composition for 4X haddock fishery (all tonnage classes combined) during 1970-1980, by year and unit area. Age composition of July groundfish survey catch for strata 90-95 indicated by bold line.

(1978)

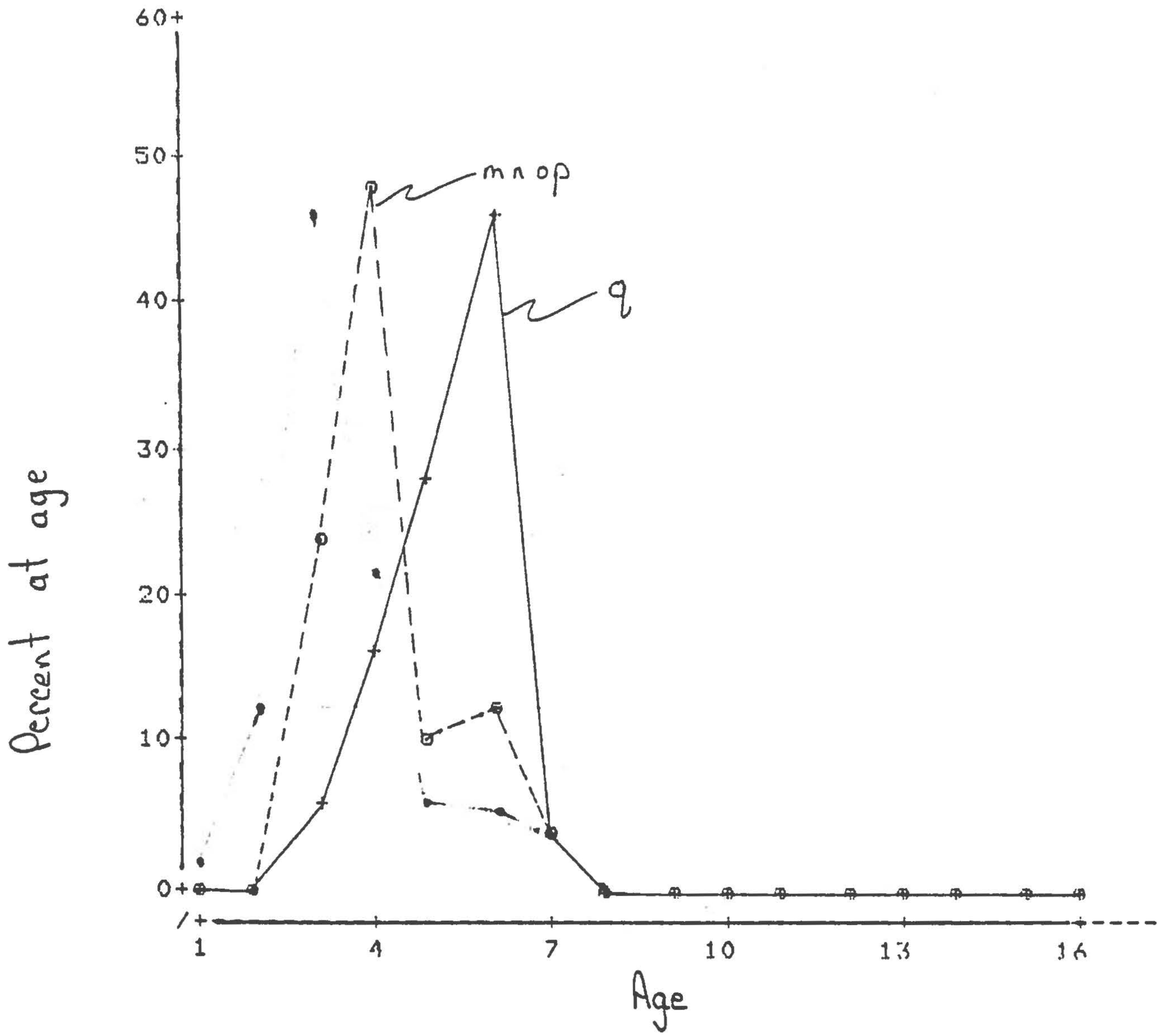


Fig. 2 (Cont'd). Percentage age composition for 4X haddock fishery (all tonnage classes combined) during 1970-1980, by year and unit area. Age composition of July groundfish survey catch for strata 90-95 indicated by bold line.

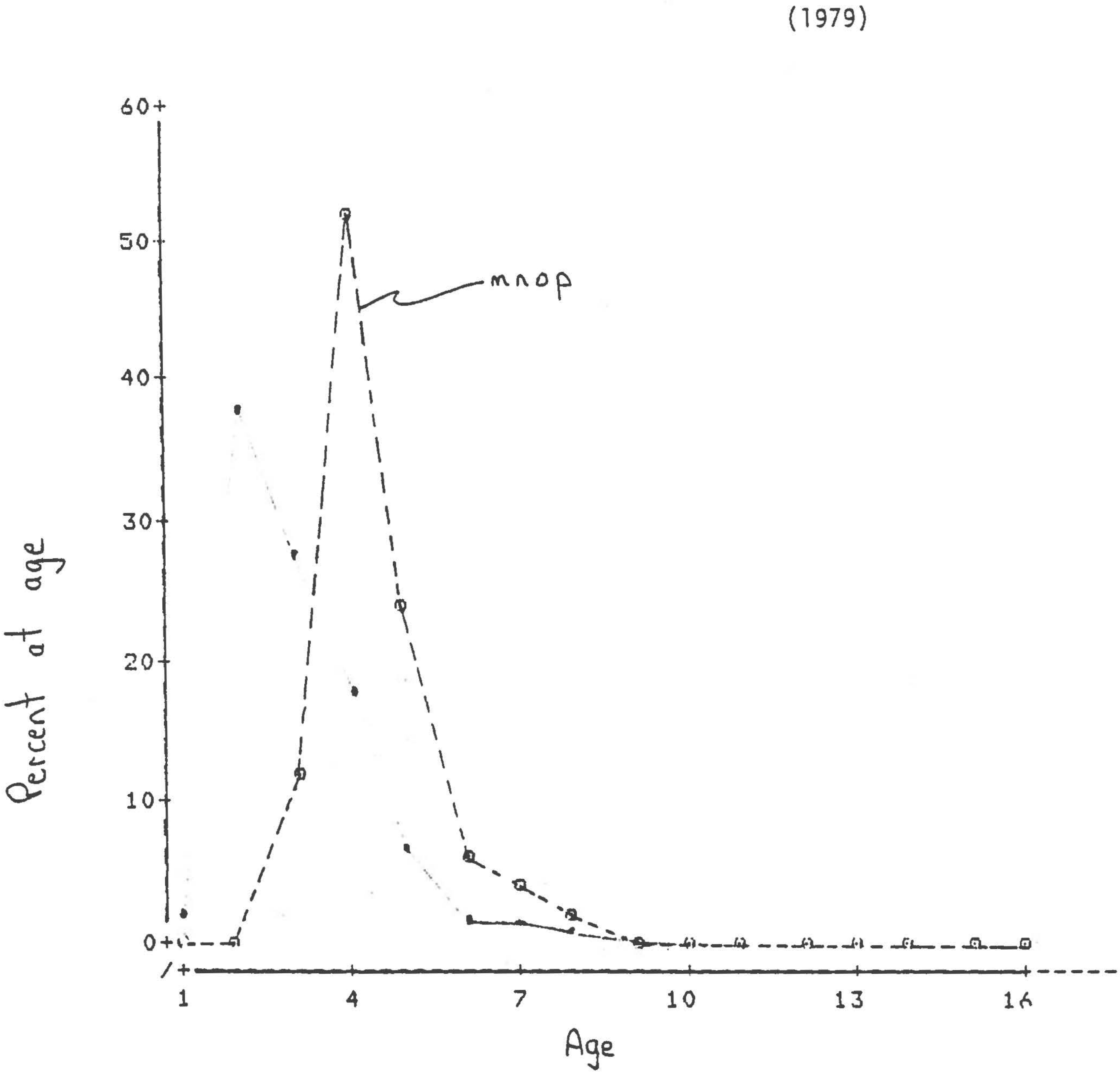


Fig.2 (Cont'd). Percentage age composition for 4X haddock fishery (all tonnage classes combined) during 1970-1980, by year and unit area. Age composition of July groundfish survey catch for strata 90-95 indicated by bold line.

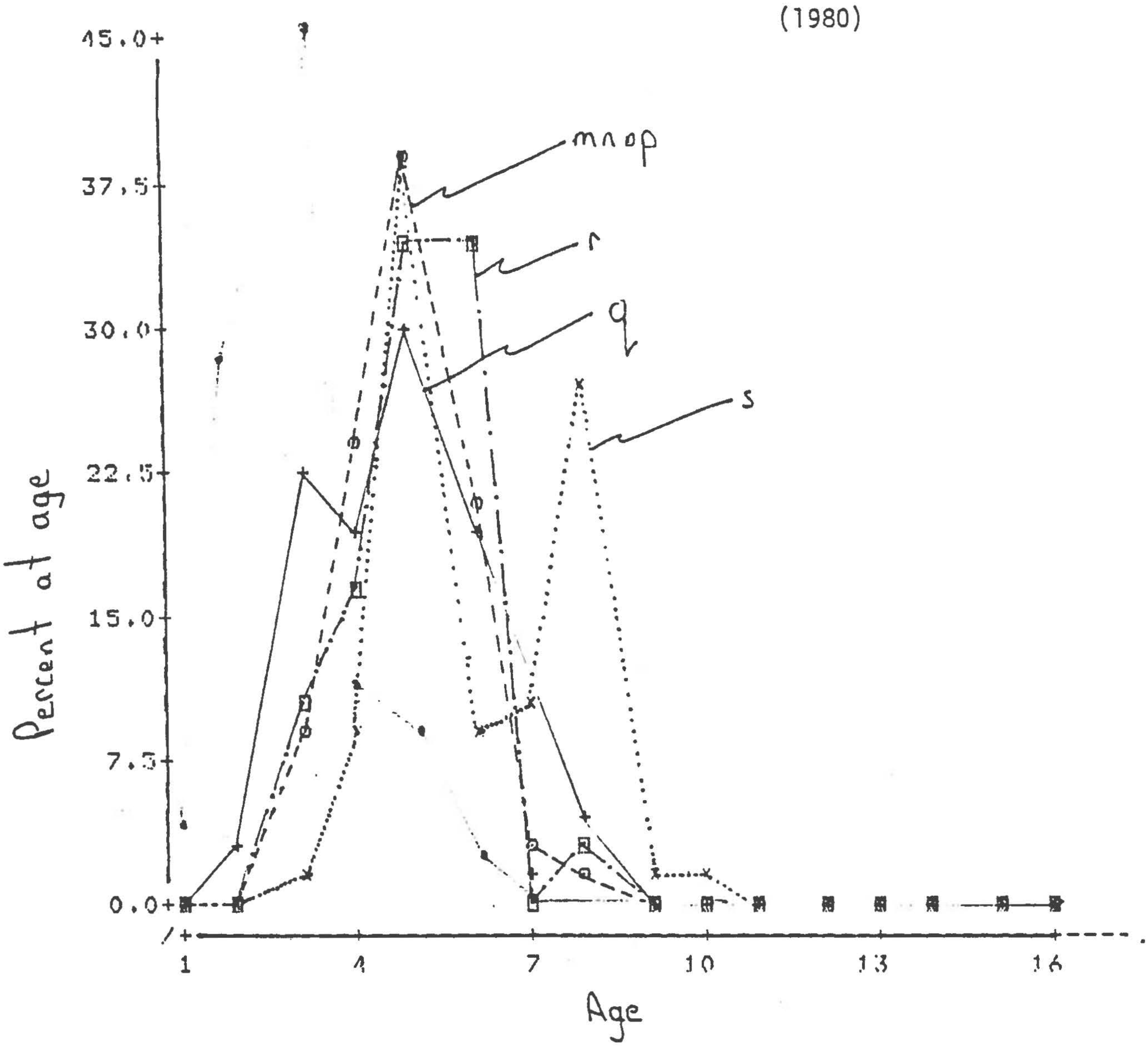


Fig.2 (Cont'd). Percentage age composition for 4X haddock fishery (all tonnage classes combined) during 1970-1980, by year and unit area. Age composition of July groundfish survey catch for strata 90-95 indicated by bold line.

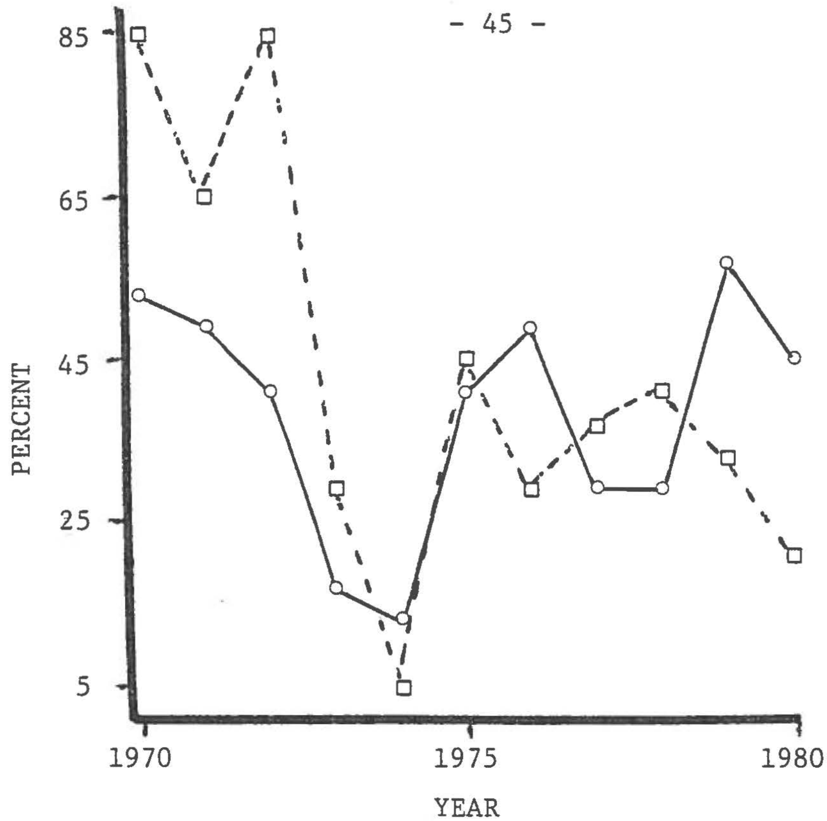


Fig. 3. Percent of haddock age four and older in strata 70-85 (-) and 90-95 (---), as determined by July groundfish survey.

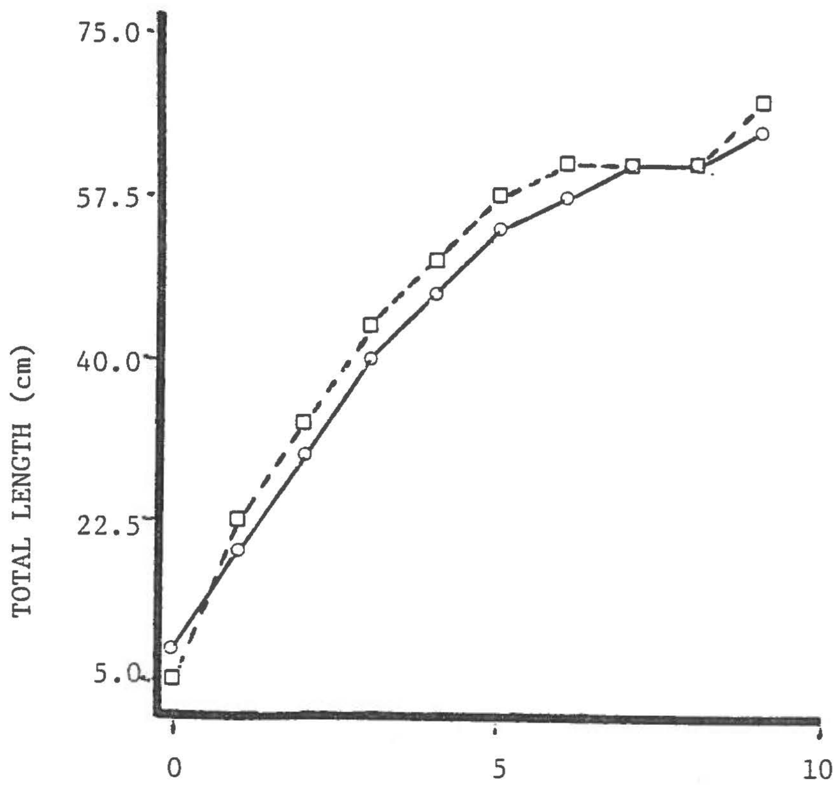


Fig. 4. Average (for 1970-80) total length at age (cm) for haddock in strata 70-85 (-) and 90-95 (---) as determined by July groundfish survey.

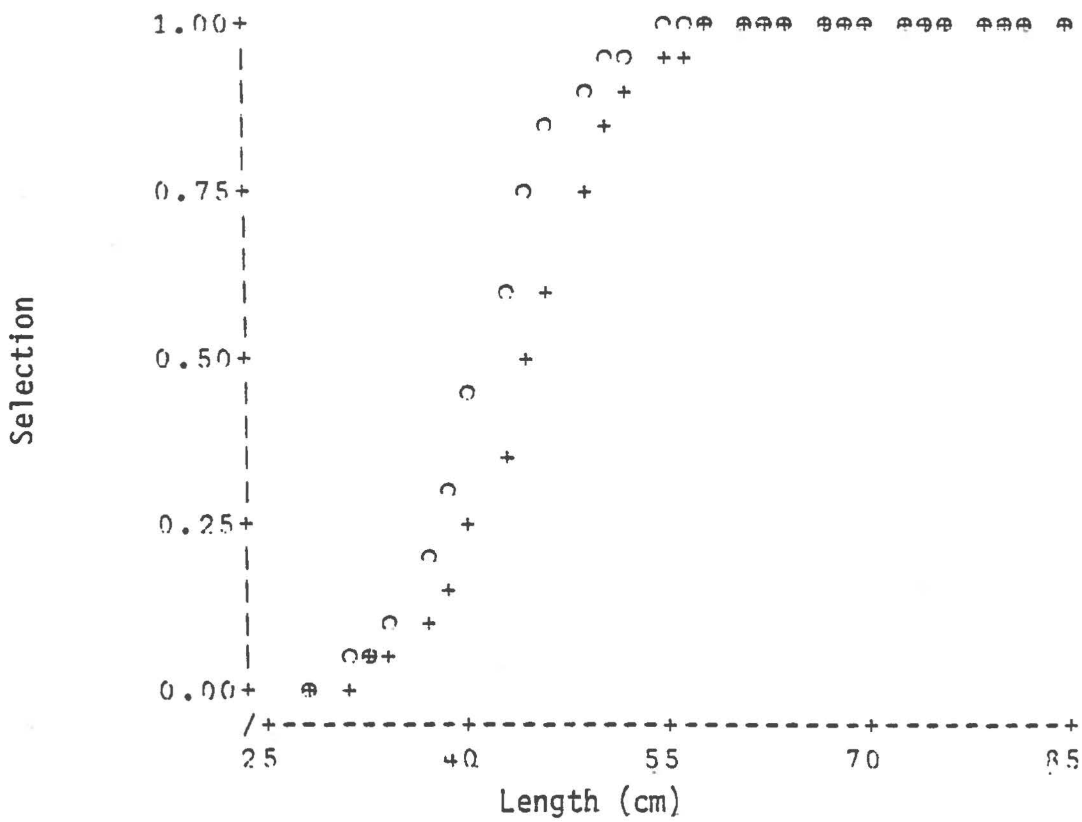
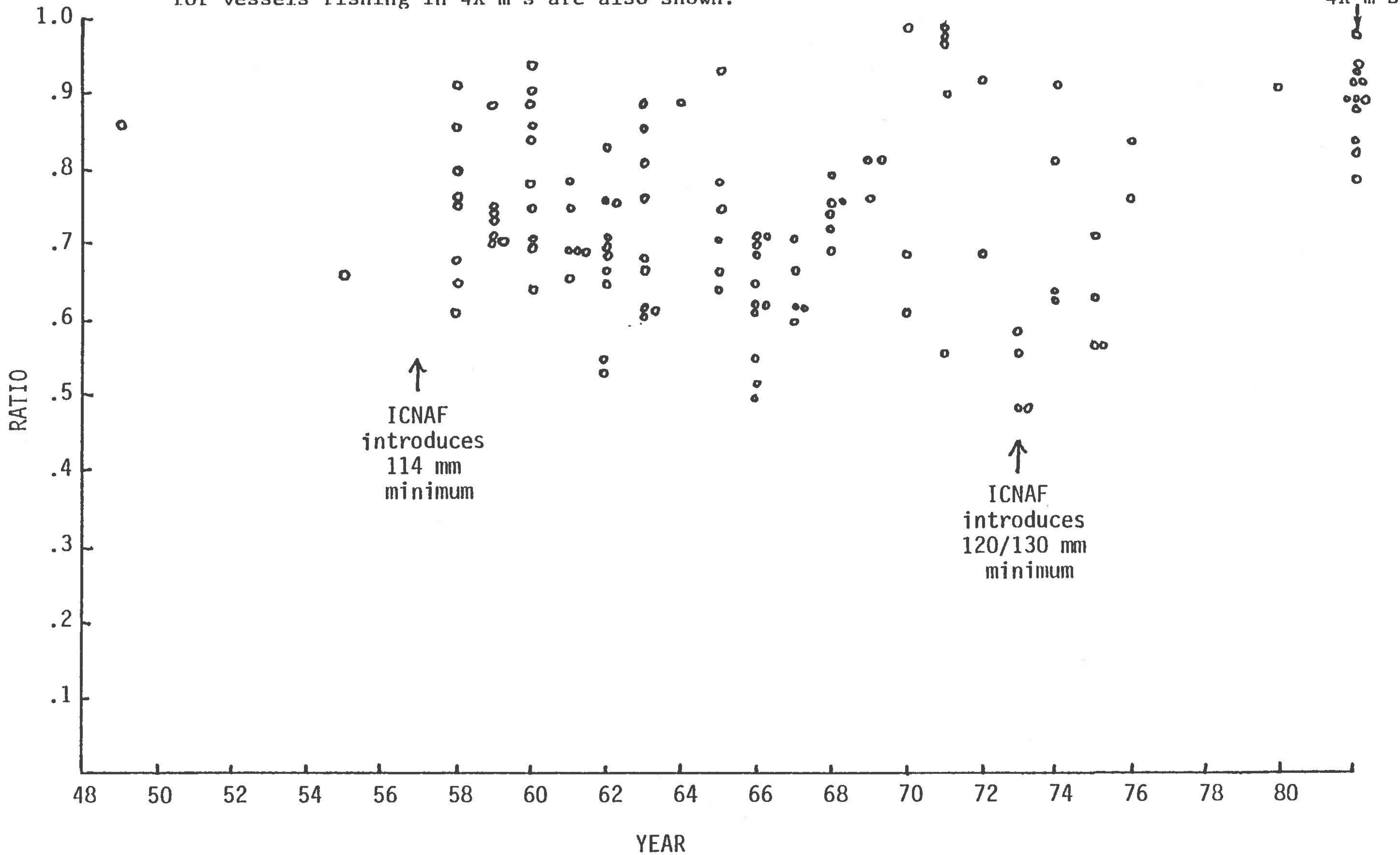


Fig. 5. Selection at length ogives for haddock caught in 120 (circles) and 130 mm (plus signs) codend mesh trawl nets.

Figure 6. Ratio of perturbed to unperturbed catches for otter trawlers (TC 1, 2 and 3) fishing in 4XR. Effect of changing from an assumed mesh size of 120 mm to 130 mm on catch rates (kg/trip) for otter trawlers in tonnage classes 1,2, and 3 fishing in 4XR during 1970-1980. Ratio plotted is changed to original catch rate (last column of Table 14). For comparison, 1980 ratios for vessels fishing in 4X m-s are also shown.



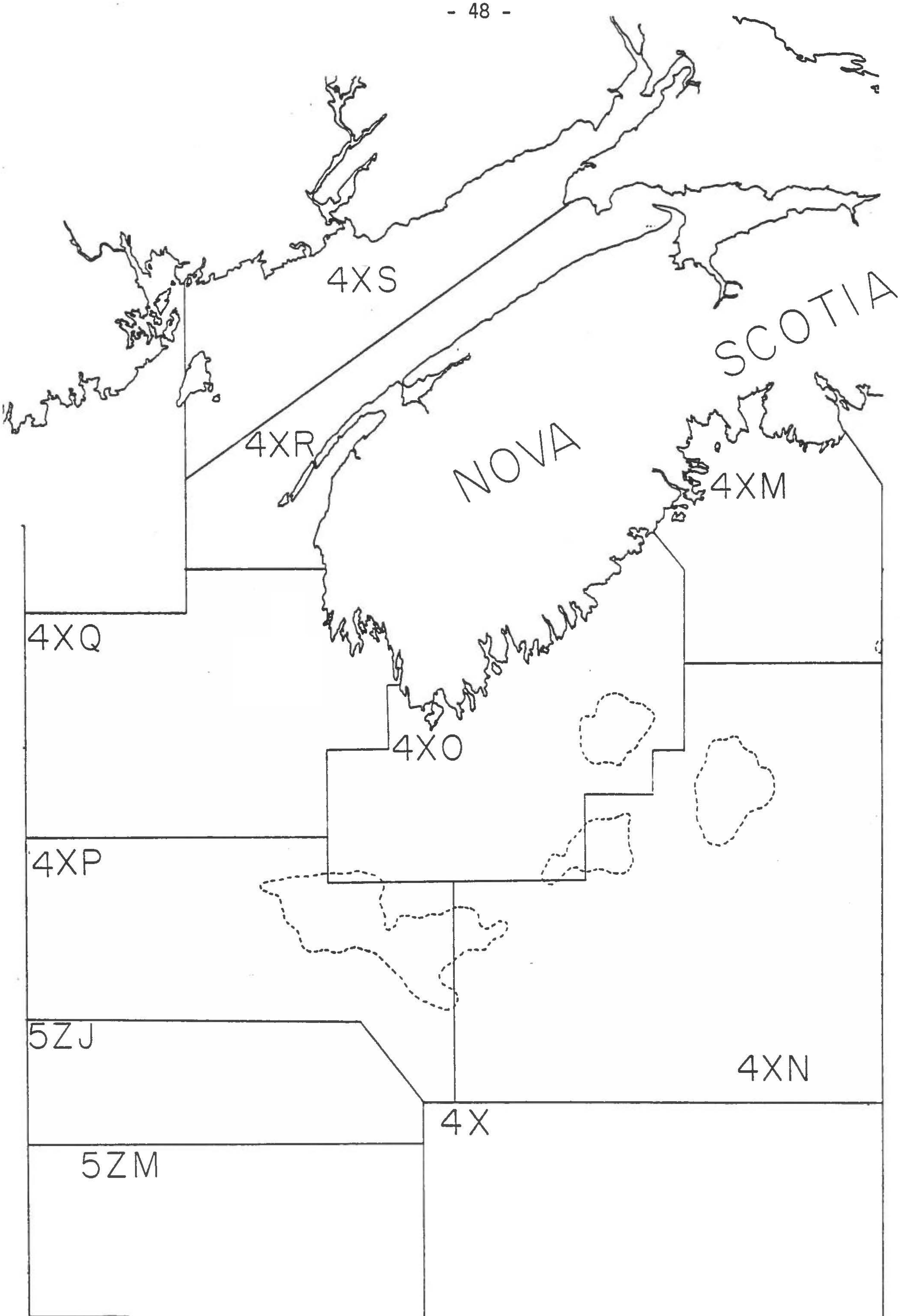


Figure 7. NAFO Division 4X unit areas.