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**Shifts in fishing effort, commercial landings and resource distribution for cod, haddock,
pollock and white hake in NAFO Division 4X**

by

D. Clark¹, J. Neilson¹, P. Hurley,²
P. Perley,¹ and M. Fowler²

Department of Fisheries and Oceans
Biological Station
St. Andrews, New Brunswick
E0G 2X0

Marine Fish Division
Bedford Institute of Oceanography
Dartmouth, Nova Scotia
B2Y 4A2

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¹ La présente série documente les bases scientifiques des évaluations des ressources halieutiques du Canada. Elle traite des problèmes courants selon les échéanciers dictés. Les documents qu'elle contient ne doivent pas être considérés comme des énoncés définitifs sur les sujets traités, mais plutôt comme des rapports d'étape sur les études en cours.

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Abstract

Effort directed at the major groundfish species has been concentrating in the Bay of Fundy. As a result, the proportions of 4X cod, haddock and pollock landed from the Bay of Fundy, as opposed to from the Scotian Shelf, have increased steadily over the last 10 years, more than tripling for pollock. Although there is little evidence from the summer surveys of a shift in resource distribution, fishermen report that this has occurred for cod and pollock. Factors such as a more balanced mix of groundfish species in the Bay of Fundy, and the impact of management measures may also contribute to the shift in distribution of effort.

At a fishing mortality approaching $F_{0.1}$, shifts in effort of the magnitudes seen here are unlikely to have serious implications for the entire Bay of Fundy; however, local concentrations of effort could deplete local spawning stocks. As a precautionary measure, when resource distribution or the fishery becomes concentrated, harvesting plans with lower exploitation levels than might otherwise be indicated should be considered, in the absence of any other management measures.

Résumé

Il y a eu concentration de l'effort de pêche dirigée sur les principales espèces de poisson de fond dans la baie de Fundy. Par conséquent, les proportions de morue, d'aiglefin et de goberge de 4X capturées dans la baie, contrairement au plateau néo-écossais, ont augmenté de façon constante au cours des dix dernières années, allant jusqu'au triple pour la goberge. Bien que les relevés d'été n'indiquent pas vraiment de modification de la répartition de la ressource, les pêcheurs ont signalé des déplacements pour la morue et la goberge. Certains facteurs, comme un mélange plus équilibré des espèces de poissons de fond dans la baie de Fundy et certaines mesures de gestion peuvent avoir influencé le déplacement de l'effort de pêche.

À une mortalité par pêche approchant la valeur du $F_{0.1}$, il est peu probable que des déplacements de l'effort de l'envergure de ceux signalés ici puissent avoir des incidences graves à la grandeur de la baie de Fundy, cependant, des concentrations de l'effort pourraient appauvrir des stocks de géniteurs locaux. Par mesure de précaution et en l'absence de toute autre mesure de gestion, il pourrait être envisagé d'imposer des plans de pêche à niveaux d'exploitation réduits lorsqu'il y a concentration de la ressource ou de l'effort de pêche.

Introduction

Concerns have been expressed by members of the fishing industry over a perceived increase in fishing effort in the Bay of Fundy and the impact this may be having on fish stocks. This pattern has been noted for the 4X cod fishery, where both landings and effort for some gear categories have shown a proportional shift into the Bay of Fundy (Clark, 1997). Some members of the otter trawl fleet have suggested that any concentration of their effort in the Bay of Fundy is due to the availability of a mix of species in this area which is proportional to their quota levels. This simplifies the task of ensuring that the quotas for all species are depleted concurrently. Others, however, have indicated that they have moved due to the scarcity of fish in some areas in the eastern half of Division 4X. Similarly, the shift in geographic distribution of gillnet landings has been linked to apparent declines in the abundance of fish in the eastern end of 4X, particularly in 4Xm. Gillnet landings from that unit area have declined more than 90% since the early 1980's.

If effort has increased in some areas, this could indicate an increase in fishing mortality within those areas. Since it appears that there is more than one spawning stock in 4X for at least some of the principle groundfish species (Clark, 1997; Neilson and Perley, 1996), and that there are differences in the geographic distributions of these stocks, a concentration of effort could have negative consequences for local stocks. Changes in the relative distribution of fishing effort or landings, on the other hand, could indicate a change in relative abundance of fish in different geographic areas, or a concentration of effort into areas which provide a species mix more consistent with the relative quotas in a mixed species fishery. This need not have negative implications for local stocks if the shift does not engender an increase in fishing mortality (which should be proportional to absolute effort).

We investigated trends in effort and landings to determine if there was any indication of fishery movement into the Bay of Fundy. Data from the summer groundfish surveys were also examined to determine if there was any indication of a shift in distribution of the primary gadid species. The potential impacts that any changes in the distribution of the fishery may be having on local stocks will be addressed in light of these analyses.

Methods

Geographic Boundaries

The Bay of Fundy component of 4X was defined as NAFO unit areas 4Xqrs and the Canadian portion of 5Y (Fig. 1) for commercial landings, and as DFO research vessel survey strata 484 to 495 (Fig. 2). The Scotian Shelf component of 4X was defined as NAFO unit areas 4Xlmnop and DFO research vessel survey strata 470 to 483. The strata and unit area boundaries are very similar, but do not precisely coincide. These boundaries have been identified as roughly separating the 4X area into regions of fast (Bay of Fundy) and slow (Scotian Shelf) growth for both cod and haddock (Clark, 1997, Hurley et al, 1997).

Landings

The distributions of landings for cod, haddock, pollock, and white hake were examined for the years 1984-1997. Landings for which no unit area was reported were divided between the Scotian Shelf and the Bay of Fundy, for each gear type, based on the proportional distribution of landings for which unit areas were known.

Fishing effort

Availability of effort data varies annually and with gear type and tonnage class (TC). Effort in hours is recorded for all otter trawl trips since 1991. However, for fixed gear the coverage is much lower until 1996. No effort information is available for vessels less than 35 ft. in the ZIFF database, since landings for these vessels are not associated with CFV prior to 1996. For larger fixed gear vessels, no effort (days at sea) is available for 1994, and the proportion of landings associated with effort is low and variable prior to that. The only measure which can be used reliably is number of trips (Gavaris, 1996).

Effort as hours fished for TC 1-3 otter trawlers, and trips for TC 2 and 3 gillnet and longline vessels, was associated with main species caught for that subtrip, and apportioned to unit areas within 4X for the years 1991 to 1997. These data were examined for temporal changes in distribution of effort among strata, and between the Bay of Fundy and the Scotian Shelf. Data are also displayed as the proportion of effort expended in each area by gear type to determine if the distribution of effort has changed independent of annual variation in total effort.

Groundfish Surveys

The distribution of cod, haddock, pollock, and white hake as seen in the annual summer groundfish surveys from 1970-1997 was investigated. These surveys exclude areas shallower than 50 fm along the southwest Nova Scotia coastline, and areas less than 20 fm in the Bay of Fundy (Fig. 2). Weight per tow for these four species has been determined by stratum, and adjusted by the number of trawlable units in each stratum to give an index of biomass. Inter-annual comparisons were made to determine if there was any indication of a shift in the relative contribution of Bay of Fundy strata (470-483) and Scotian Shelf strata (484-495) to the overall abundance of each species in 4X.

Results

Landings

Landings for the four species combined have shifted towards the Bay of Fundy over the past 8 years (Fig. 3). This shift is apparent for cod, haddock and pollock individually (Fig. 4), but not for white hake. The proportion of landings from the Bay of Fundy increased in the early 1980's as draggers became a larger component of the fleet in 4X, since their landings came primarily from the Bay of Fundy. In 1997 the proportions of cod and haddock landed from the Bay were only slightly higher than were seen in 1984 and 1985 and total landings remained below the highs seen in the early 1980's, and again in the early 1990's (Fig. 5). Much of the landings, however, came from further into the Bay than usual; above a line between Digby and Grand Mannan.

Landings for white hake have not followed the same trend as is seen for the other species (Fig 6). This fishery was prosecuted primarily in the Bay of Fundy in the past, with some processing plants on Digby Neck concentrating entirely on hake. As quotas for regulated species dropped in the early 1990's, some gillnet and longline vessels directed their effort towards hake. This fishery was prosecuted primarily in Unit Areas 4Xpq. The hook and line fishery in 4Xr, which accounted for up to 40% of white hake landings in 4X (over 1000t in 1989), has completely disappeared (4t in 1997). Hook and line landings now come primarily from 4Xp. Gillnet landings, which account for an increasing proportion of the total fishery, originated mainly from 4Xq.

Table 1. Percent of combined landings for cod, haddock, pollock, and white hake by NAFO Unit Area, excluding 4Xu

	85	86	87	88	89	90	91	92	93	94	95	96	97
4XM	15	17	18	19	15	13	10	7	6	7	3	4	3
4XN	11	12	21	13	18	12	13	16	16	8	13	13	10
4XO	28	32	27	27	26	32	28	35	27	32	15	18	13
4XP	6	5	10	15	18	12	13	8	13	12	26	20	18
4XQ	18	14	10	13	11	16	12	14	16	17	26	21	27
4XR	10	9	6	5	6	9	14	13	12	15	10	14	17
4XS	5	6	5	5	3	6	8	7	7	8	5	7	9
5Yc	6	4	4	3	3	2	1	2	2	2	2	2	2

There are also shifts among unit areas within the Scotian Shelf which are of note. Both the otter trawl and long line fisheries have greatly reduced the proportion of their landings of cod and haddock from 4Xo, and increased the proportion from 4Xn and p, as well as r and s. In most years over half of the hook and line landings of both cod and haddock were from 4Xo, however this is no longer the case. In 1997, 4Xn accounted for a higher proportion of haddock landings than did 4Xo. Landings of both pollock and white hake have declined in 4Xm and n and increased in 4Xp and q.

From 1985 to 1994, 4Xo contributed the bulk of the landings. In 1995 it fell to third in importance among unit areas and has since remained low. This decline in 4Xo is due to the reduction in cod and haddock landings in this area.

Effort

Effort has declined for all gear sectors in 4X since 1991. This is largely due to more restrictive quotas intended to reduce fishing mortality from the unsustainable levels reached in the early 1990's. Although total effort has declined, the reductions in effort have not been distributed throughout the management unit, and effort has even increased in some areas.

The number of trips made by TC2⁺ longline vessels in 1997 is the lowest observed this decade (Fig. 7). There does not appear to have been much change in the distribution of effort among unit areas; however, due to the high proportion of longline effort which is not attributed to a unit area, results from detailed analyses of these data would be suspect (Fig. 7). For this reason, the results which follow focus on gillnet and otter trawl effort.

Gillnet effort declined overall in 4X up to 1995. This decline has come entirely from the Scotian Shelf, primarily 4Xn (Fig. 8). Effort in the Bay of Fundy is currently at a level similar to 1991, with 4Xq comprising a higher proportion of the total than in past years. Most of the gillnet

effort in the early 1990's was associated with pollock (pollock was the main species caught; Fig. 9). Pollock associated effort has greatly decreased in 4Xmno and increased in 4Xpq. The proportion of gillnet trips in which white hake is the main species caught has increased, particularly in 4Xpq (Fig. 10). Gillnet effort associated with cod has also increased slightly, primarily in 4Xs (Fig. 11).

Otter trawl effort also declined in 4X up to 1995 (Fig 12). The decline has been primarily in Scotian Shelf unit areas, with effort in the Bay of Fundy in 1997 almost at the 1991 level. Effort associated with cod has declined, and is now located almost entirely in the Bay of Fundy (Fig. 13). Effort associated with haddock has increased, and the distribution of it has shifted into the Bay of Fundy (Fig. 14). Effort associated with pollock has declined, and is now distributed primarily in the Bay of Fundy, with 4Xq accounting for over half the total (Fig. 15).

Surveys

The summer survey is used as an index of abundance for cod and haddock, but not for white hake or pollock. It has been used for pollock at times, but is highly variable and it has been concluded that it is not sufficiently precise to provide a reliable index of abundance for this species (Neilson and Perley 1997). This is reflected in the distribution of biomass between the Bay of Fundy and the Scotian Shelf, which shows a great deal of inter-annual variability (Fig. 16). The proportion in the Bay of Fundy increased from 1990-96, decreasing again in 1997. No strong conclusion can be reached due to the variability in the data.

White hake appears to be consistently concentrated in the Bay of Fundy, with 70-80% of the biomass located there (Fig. 16). The survey data did not show any clear trend over the past decade.

The proportion of haddock biomass located in the Bay of Fundy has followed a generally increasing trend over the past 10 years, peaking in 1995 (Fig. 16). The proportion in the Bay of Fundy has fluctuated, peaking in the early 1980's.

The proportion of cod biomass located in the Bay of Fundy increased in the early 1970's and has generally remained above 50% of the total 4X biomass since then (Fig. 16).

Discussion

Landings of the major gadid species in NAFO Division 4X have been concentrating in the Bay of Fundy region (Fig. 3, 4). This trend is apparent for cod, haddock and pollock, starting in 1989 - 1990 (Fig. 4). Similarly, fishing effort in 4X by gillnet and otter trawl vessels appears to be concentrating in the Bay of Fundy (Figs. 8, 12 respectively). The proportional change reflects much reduced effort on the Scotian Shelf, as well as some increases in effort in the Bay of Fundy. The number of hours fished in the Bay by otter trawlers has increased since 1995, but remains lower than it was in 1991-93.

Among the factors that could potentially be responsible for this change, shifts in resource distribution are of obvious concern. The data from the summer surveys is equivocal regarding shifts in resource distributions over the past decade. The data from the summer surveys are highly

variable and give no clear indication of shifts in distribution for most species. These surveys, however, do not give insights into seasonal changes in fish distribution, nor do they cover inshore areas where significant fisheries occur. Fishermen have indicated that it has been difficult to catch both cod and pollock on traditional grounds on the Scotian Shelf and they have had to look further west into the Bay of Fundy (Clark, 1997; Neilson and Perley, 1997). This, despite the lack of clear trends from the surveys, suggests that there have been changes in resource distribution which may be contributing to the observed patterns in the fishery.

Fishery management actions may also have influenced the distribution of effort in 4X. The increase in duration of the Browns Bank closure in 1992 will have displaced some dragger effort, much of which will have been redirected to the Bay of Fundy where they fish at other times of the year. This would not account for the reduction in fishing in Western Hole in 4Xo. The "small fish" closures for the hook and line fishery on Roseway, Bacarro, and LaHave Banks in 1995 may also have contributed to the shift in effort in that year. The closures were not as extensive, however, in 1996 and 1997, and should not be responsible for the continued shift in longline landings. A further change in fishery management which may have influenced fishery distribution is the Temporary Vessel Replacement Program (TVRP), which allows larger offshore fleet components to transfer their quotas to smaller vessels. This has contributed to the increase in total effort by TC 1-3 otter trawlers, particularly in the last two years, but should have little influence on the proportional split between the Bay of Fundy and the Scotian Shelf. Factors suggested by industry, such as balancing quota needs, will also have contributed to the change.

It has been suggested that the development of the white hake fishery may be responsible for the pattern of apparent movement of the fishery to western 4X. Some of the sudden shift in the distribution of landings seen in 1995 is likely linked to the hake fishery. Longline and gillnet vessels targeted hake in 1995, when cod and pollock quotas declined by roughly 40%, to increase the amount of effort they could put into the fishery. White hake has declined in importance to the fishery again since then, and is not likely responsible for the continued shift. Furthermore, white hake is a very minor part of the otter trawl catch, and will not have influenced recent patterns in their fishery. On this basis, we considered it unlikely that the white hake fishery has contributing in a major way to the concentration of landings and effort in western 4X.

Changes in fishery/resource distribution are of particular concern if multiple spawning components exist within 4X. White hake within 4X is thought to consist of two stocks, one in the Gulf of Maine, and a second straddling the 4X/4W boundary (Fowler et al, 1996). For pollock, there is evidence for spawning at the mouth of the Bay of Fundy as well as in the vicinity of Roseway, LaHave and Browns Bank (Neilson and Perley 1996). McGlade (1983) examined meristic and morphometric data and concluded that differences exist between adult pollock found in the western Gulf of Maine and those which occurred on Browns and Roseway Banks. Haddock in coastal 4Xs have been considered part of the Gulf of Maine 5Y stock, however the bulk of landings in this unit area in recent years come from deep water near the boundary with 4Xr, and are considered to be part of the broader 4X stock. For cod, tagging studies, along with studies of vertebral numbers, parasite load and egg and larval distribution, suggest that a number of fairly discrete coastal stocks exist, along with at least one offshore spawning group (Templeman, 1962). Both spring and fall spawning components have also been identified in 4X. Some of these groups, such as the fall spawning cod off Halifax, are clearly in decline, as indicated by landings and

fishermen's reports, despite the overall increase in abundance of cod in 4X in the past 4 or 5 years (Clark, 1997).

For cod and haddock, growth rates are faster in the Bay of Fundy than on the Scotian Shelf. The fact that these differences in length at age are consistent, and seen for all ages, indicates that although there is mixing of fish from these areas, the mixing is limited enough that these distinctions are not lost. Thus, to varying extents, it is clear that evidence exists for spatial heterogeneity of stock components within 4X for the four species.

Given the observed changes in resource/fishery distribution and the indications of discrete components within 4X, what are the appropriate management actions to conserve the resource? There are fairly strong indications that stocks, or stock components, in eastern 4X are currently depleted. If there has been a shift in the distribution of biomass, a shift in the fishery would be a logical response that simply reflects the availability of fish. Measures intended to spread fishing effort throughout 4X may have deleterious effects if the effort is redirected to areas where stocks are depleted and less able to absorb additional exploitation. If fishing mortality is approaching $F_{0.1}$, shifts in effort of the magnitude seen here are unlikely to have serious implications for the entire Bay of Fundy; however, local concentration of effort could deplete local stocks.

Without precise knowledge of the seasonal migrations and mixing of the components of the 4X groundfish resources, it is not possible to determine the impacts of the observed changes in fishery distribution. A precautionary approach would be to accept that the changes in fishery and resource distribution are a clear danger signal, and to develop harvesting plans which include lower exploitation levels that might otherwise be indicated.

Acknowledgments

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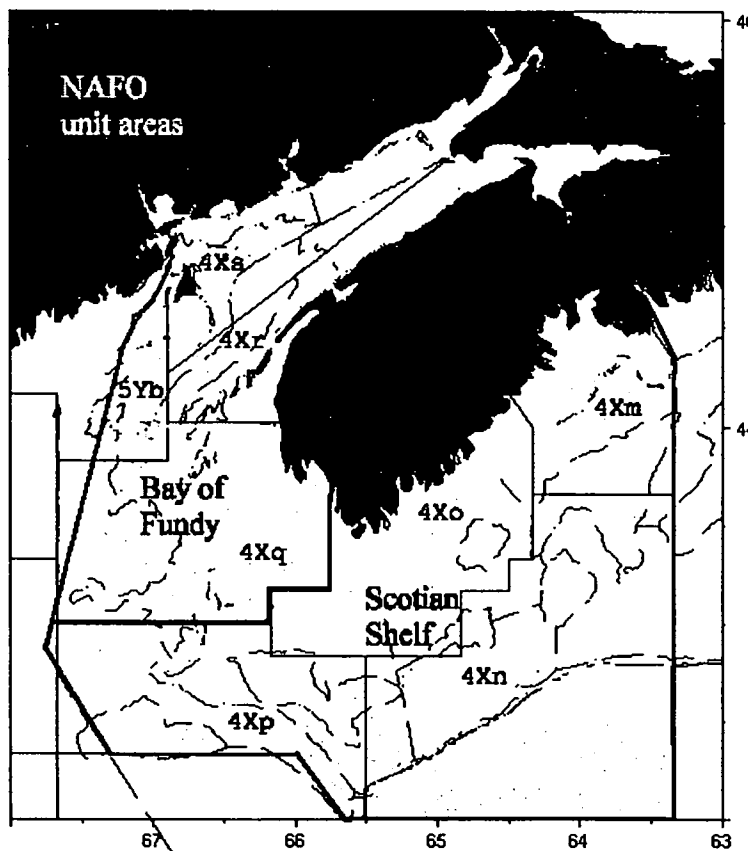


Fig. 1. Bay of Fundy and Scotian Shelf areas for commercial landings data.

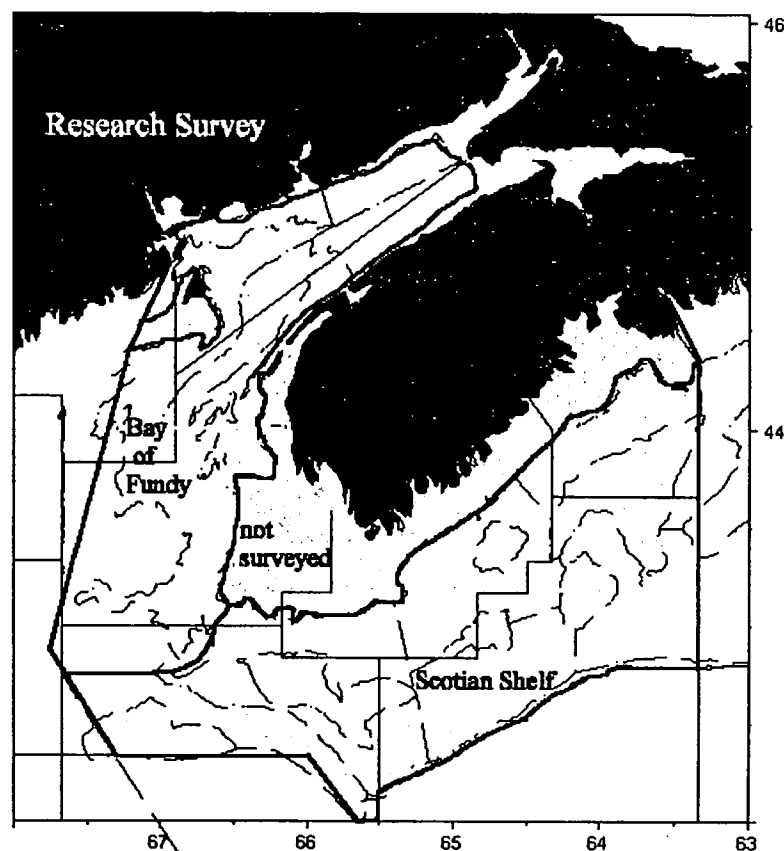


Fig. 2. Bay of Fundy and Scotian Shelf areas for research survey data.

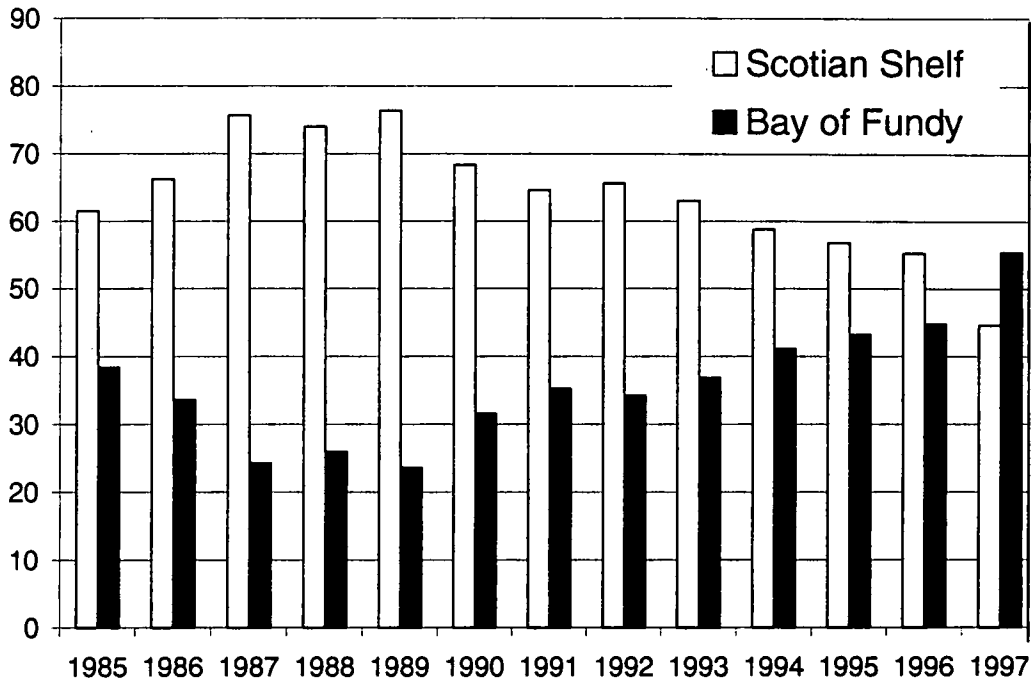


Fig. 3. Combined landings of cod, haddock, pollock and white hake by region within Division 4X.

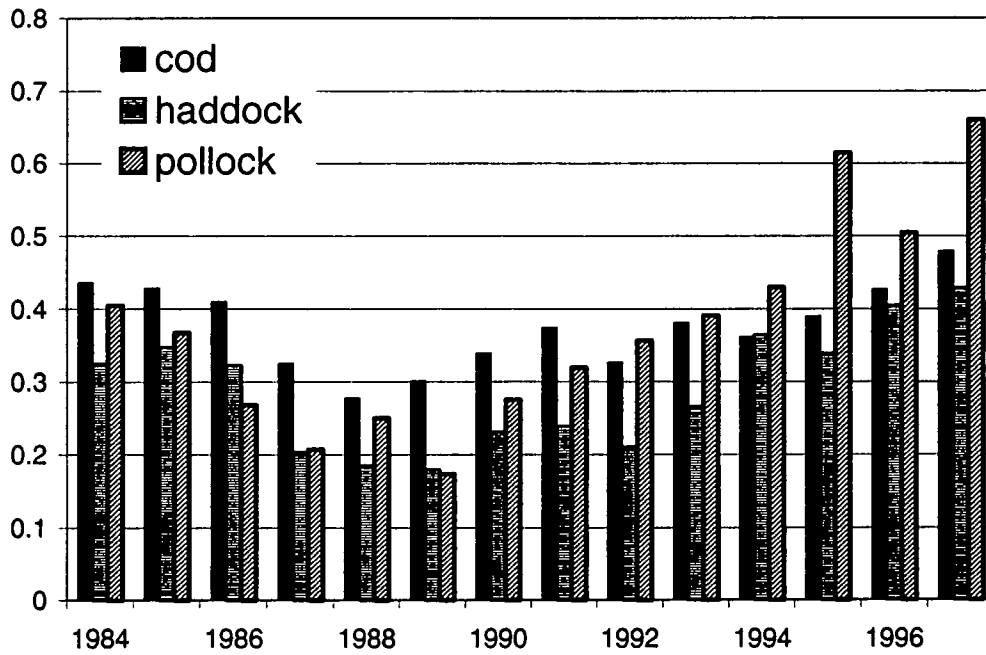


Fig. 4. Proportion of 4X cod, haddock and pollock landings taken from the Bay of Fundy.

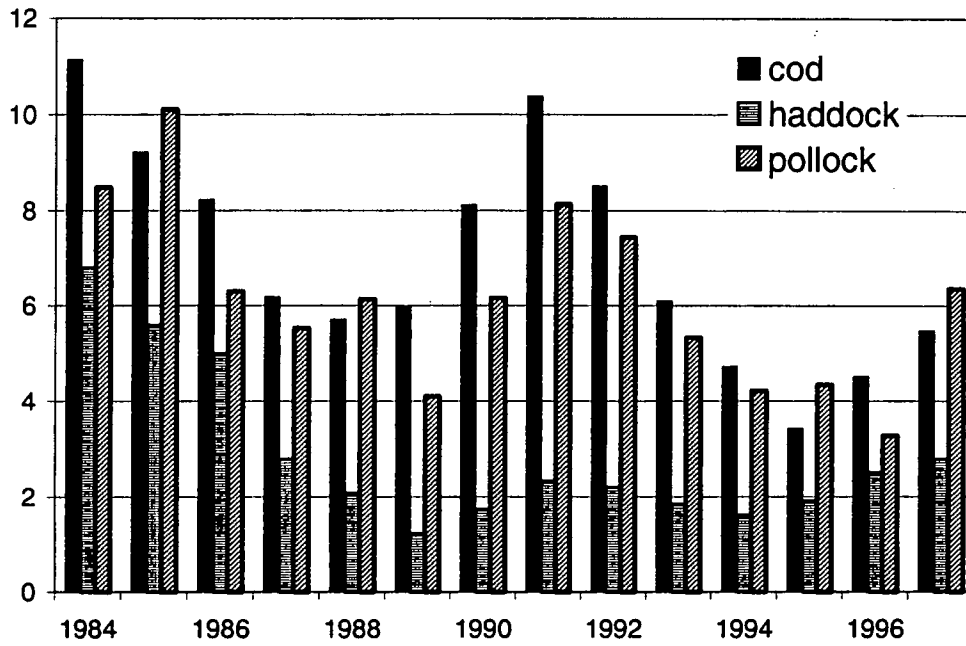


Fig. 5. Landings ('000t) of cod haddock and pollock from the Bay of Fundy.

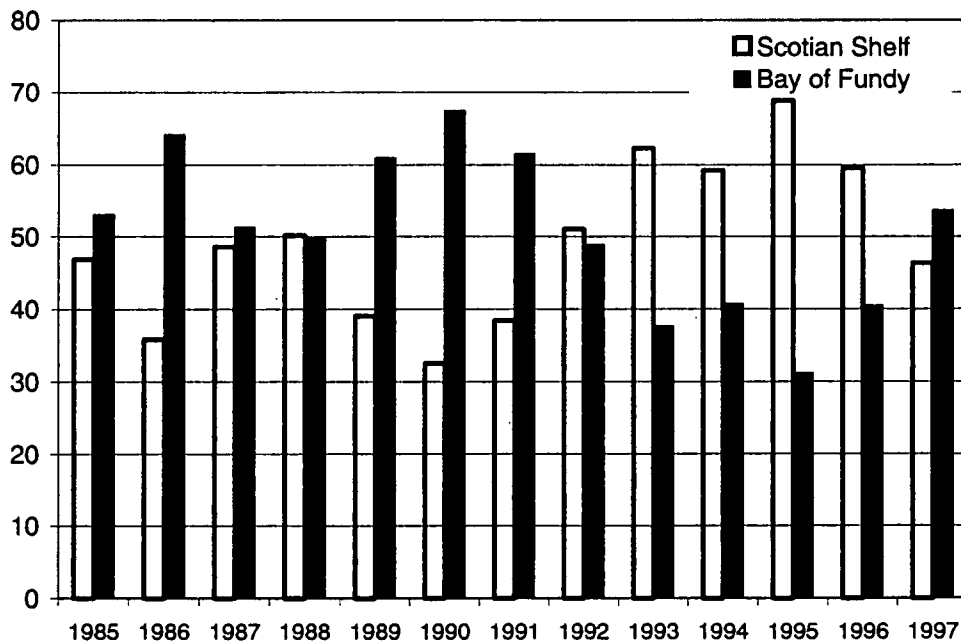


Fig. 6. Proportion of white Hake landings from the Scotian Shelf and Bay of Fundy regions in 4X.

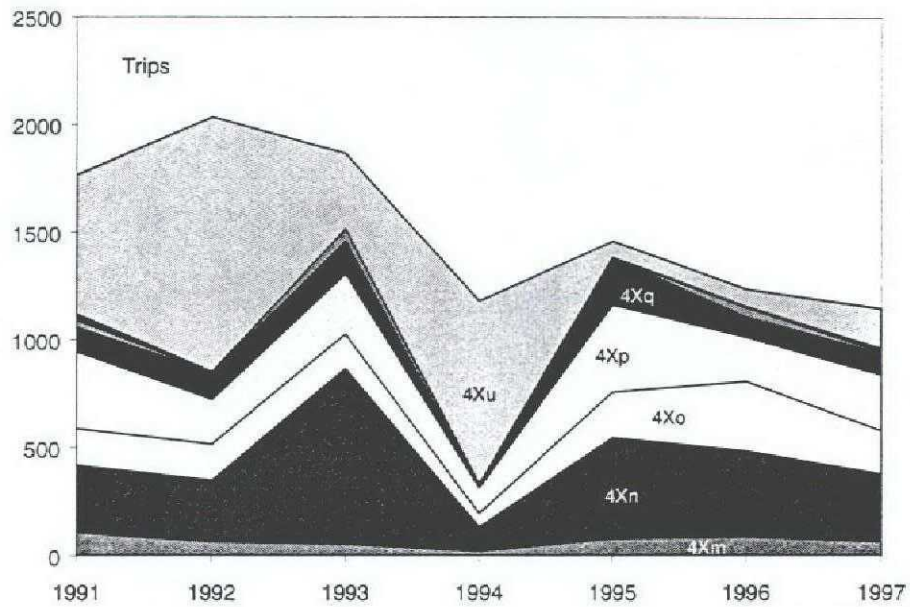


Fig. 7. Longline (TC2+) effort (trips) directed for cod, haddock, pollock, or white hake in 4X (4Xu = no unit area reported).

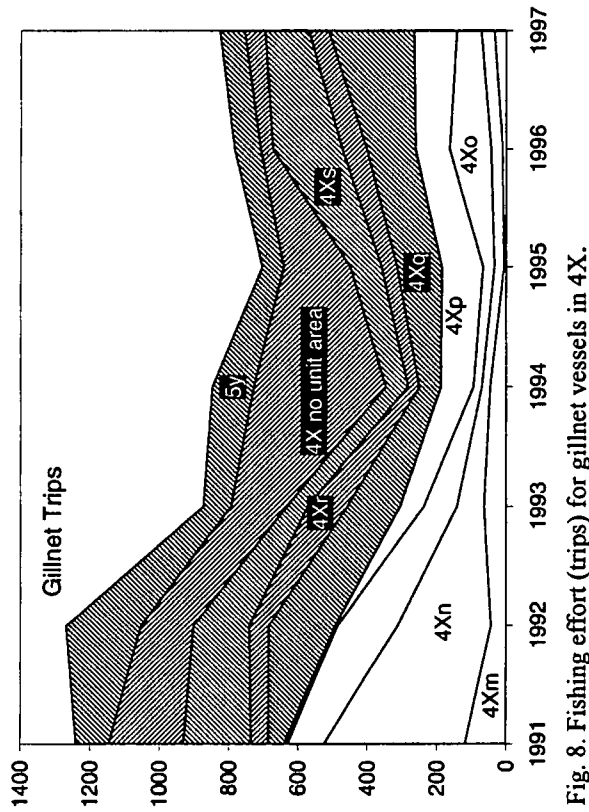


Fig. 8. Fishing effort (trips) for gillnet vessels in 4X.

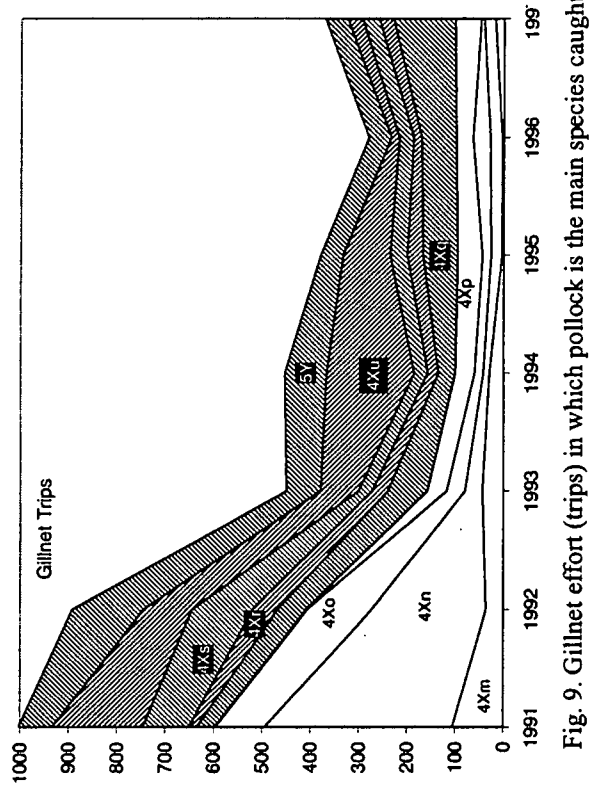


Fig. 9. Gillnet effort (trips) in which pollock is the main species caught.

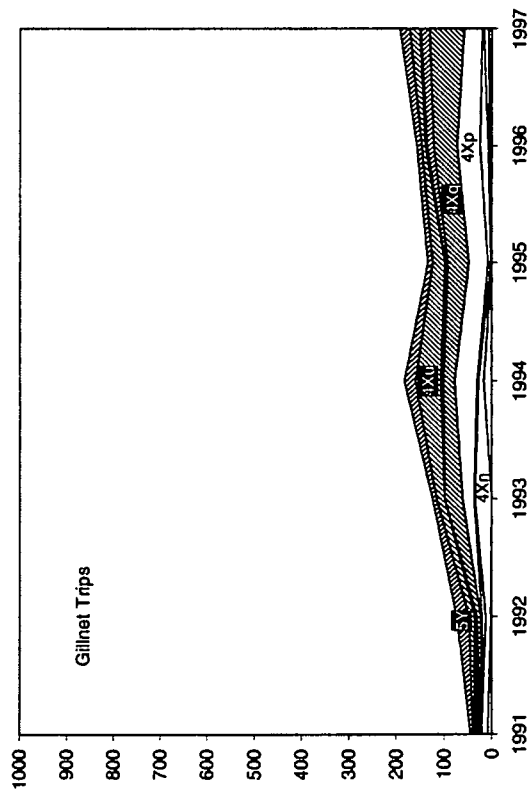


Fig. 10. Gillnet effort (trips) for which white hake is the main species caught.

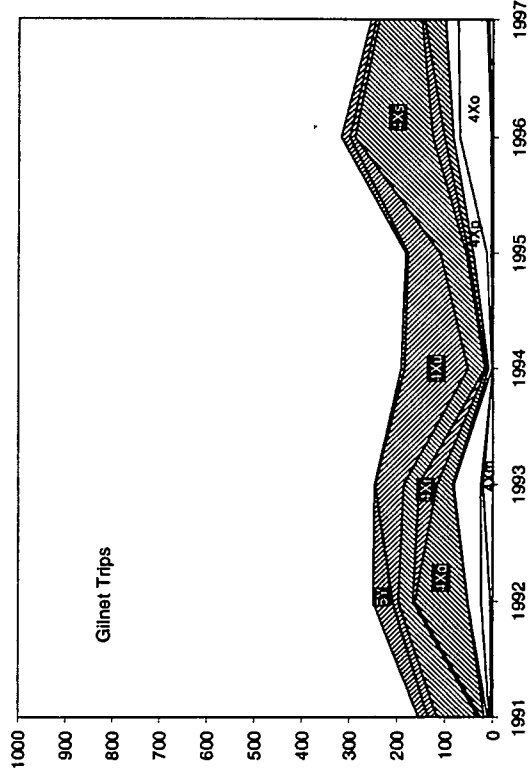


Fig. 11. Gillnet effort (trips) for which cod is the main species caught.

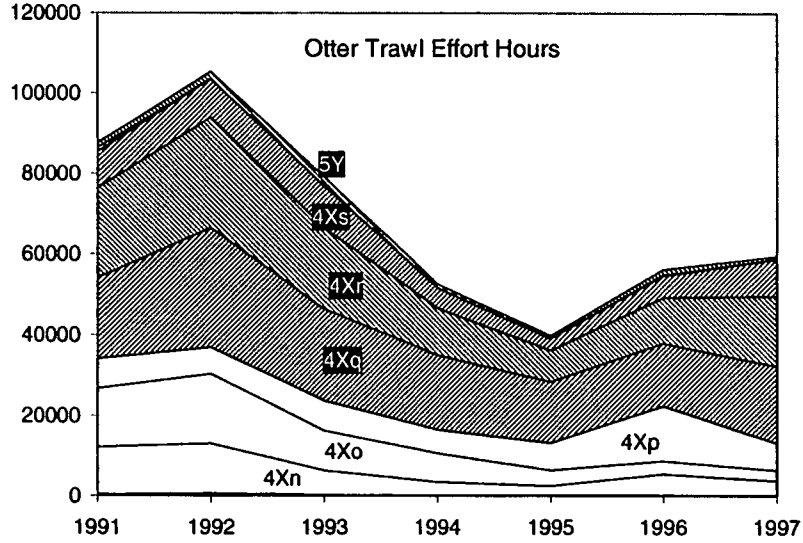


Fig. 12. Fishing effort (hrs.) for otter trawlers in 4X.

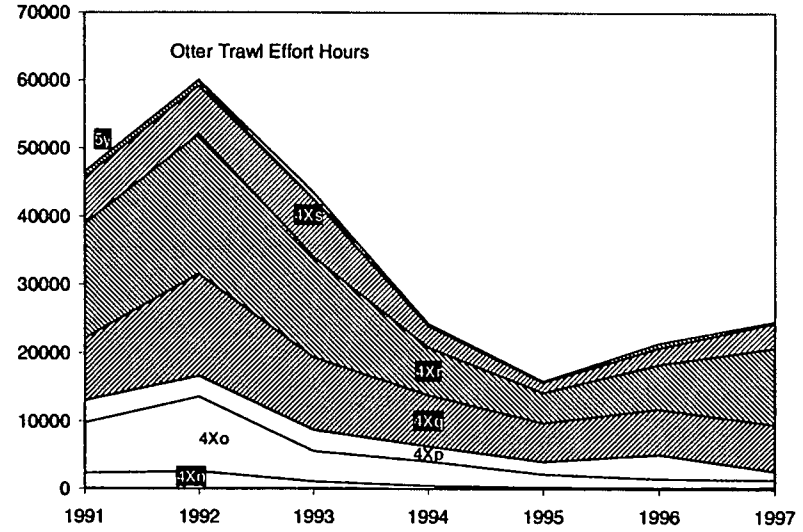


Fig. 13. Otter trawl effort (hrs.) for which cod is the main species caught.

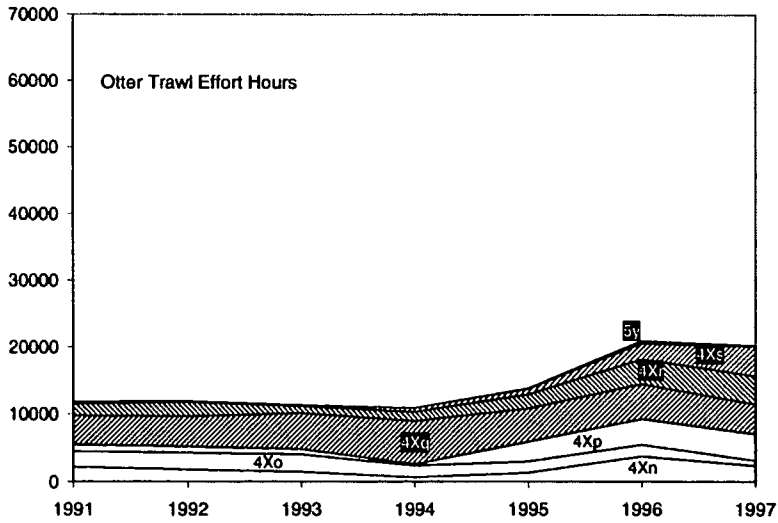


Fig. 14. Otter trawl effort (hrs.) for which haddock is the main species caught.

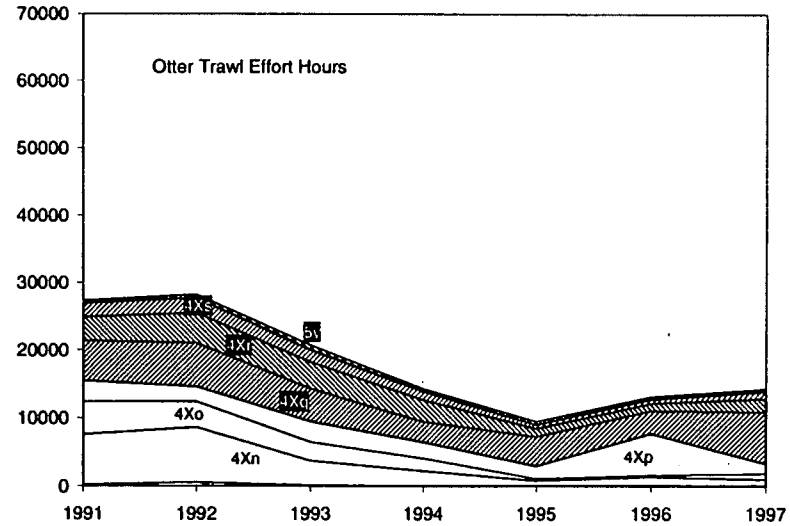


Fig. 15. Otter trawl effort (hrs.) for which pollock is the main species caught.

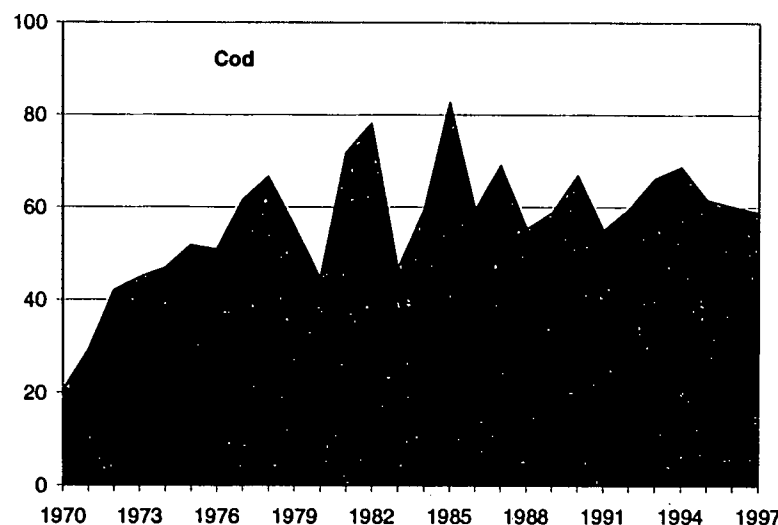
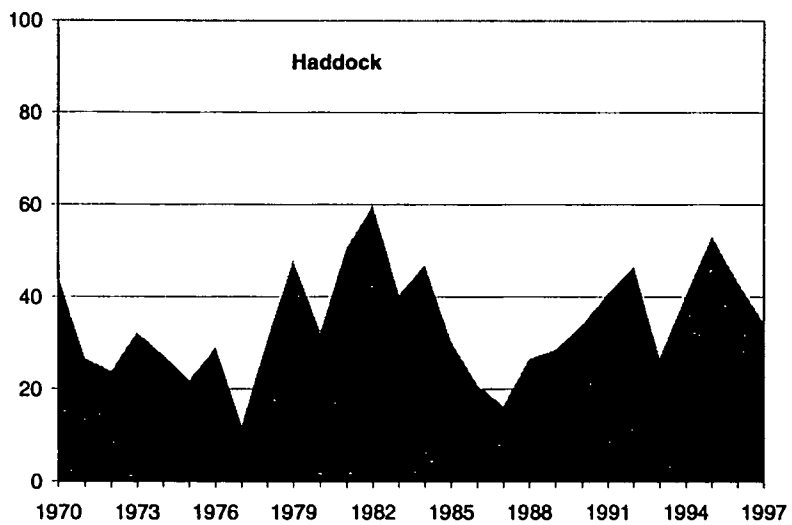
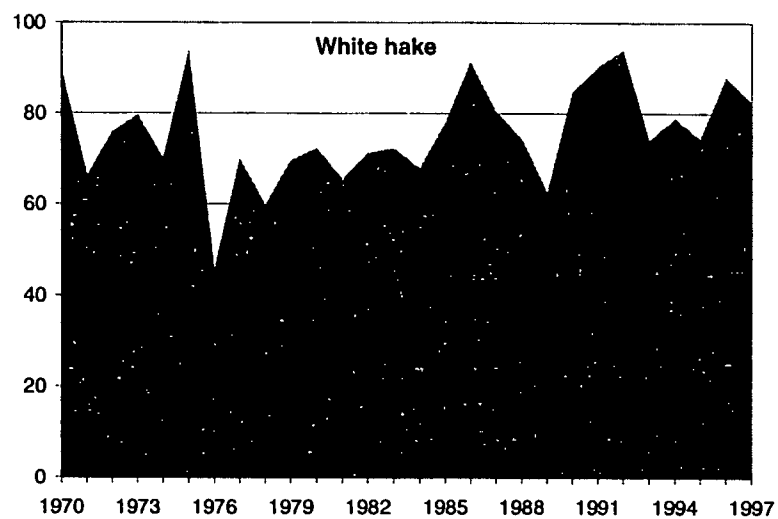
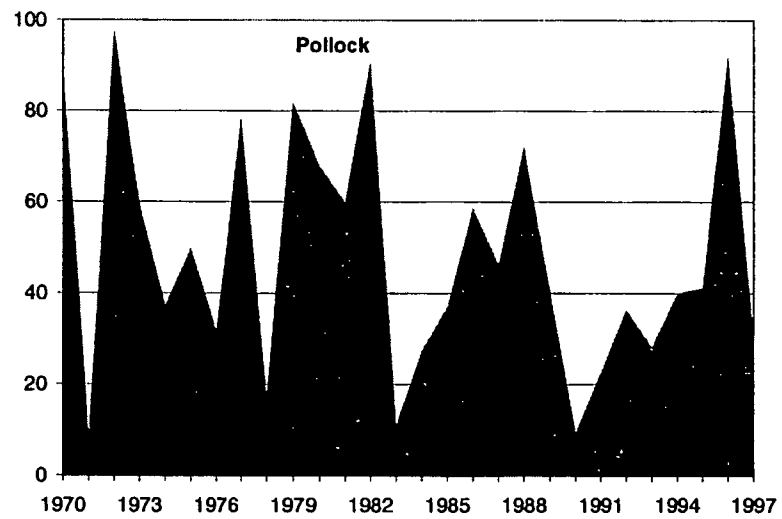


Fig. 16. Proportion of total summer research vessel survey biomass estimate attributed to Bay of Fundy strata by species for pollock, white hake, haddock, and cod.