DFO Atlantic Fisheries
Research Document 96/104

MPO Pêches de l'Atlantique
Document de recherche 96/104

The Status of Monkfish in 4VWX5Zc

by

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ABSTRACT

Monkfish have traditionally been fished almost exclusively as a by-catch of scallop and groundfish ventures and have never been on quota management. Since 1990 the commercial importance of this species has grown dramatically due to new markets and high prices. Landings in 4X rose from 200t in 1989 to over 1,100t in 1994. The mobile gear fleet was subsequently restricted to a 20% by-catch until the results of a five-year joint science/industry study to assess the abundance of monkfish in 4X and its potential as a developing fishery could be evaluated. Summer RV results from both 4X and 4VW indicate declining abundance levels in the 1970s and 1980s, but an increasing trend in the 1990s with the best signs of recruitment in 4X. Survey length frequencies over the long term show a gradual decline in size range particularly in commercial size fish. There is insufficient information at this time to determine appropriate harvesting levels, but the impact of an essentially unregulated American monkfish fishery along with large monkfish bycatches from the scallop fishery and a possible resurgence of traditional groundfish stocks, indicate a need for a cautionary approach.

RÉSUMÉ

La baudroie est traditionnellement pêchée de façon presque exclusive comme prises accessoires des pêches du pétoncle et du poisson de fond, et n'a jamais fait l'objet d'une gestion par quota. Depuis 1990, l'importance commerciale de cette espèce a toutefois connu une expansion spectaculaire due à l'ouverture de nouveaux marchés et à des prix élevés. Dans 4X, les débarquements sont passés de 200 t en 1989 à plus de 1 100 t en 1994. On a alors imposé à la flottille aux engins mobiles une limite de prises accessoires de 20 %, jusqu'à l'analyse des résultats d'une étude conjointe science/industrie de 5 ans visant à évaluer l'abondance de la baudroie dans 4X et le potentiel de développement de la pêche de cette espèce. Les résultats des relevés scientifiques menés en été dans 4X et 4VW indiquent une baisse de l'abondance dans les années 70 et 80, mais une tendance à la hausse dans les années 90, les meilleurs signes de recrutement étant observés dans 4X. Dans les prises des relevés scientifiques, les fréquences de longueur à long terme montrent une baisse graduelle de la fourchette de taille, particulièrement chez les poissons de taille commerciale. On ne dispose pas à l'heure actuelle de suffisamment d'informations pour déterminer quels seraient les niveaux appropriés d'exploitation, mais, étant donné l'impact de la pêche américaine à la baudroie, qui pour l'essentiel n'est pas réglementée, ainsi que l'ampleur des prises accessoires de baudroie dans la pêche du pétoncle et la possibilité de rétablissement des stocks traditionnels de poisson de fond, il apparaît nécessaire d'adopter

Introduction

Monkfish (*Lophius americanus*) also known as goosefish and angler is a benthic fish occurring in the Northwest Atlantic from the northern Gulf of Saint Lawrence, southward to Cape Hatteras, North Carolina (Bigelow and Schroeder 1953, Scott and Scott 1988). It has a eurybathic depth distribution, having been collected from the tideline to over 800 meters (Markle and Musick 1974). It is the only lophiid to inhabit the northern waters of the north Atlantic, with the eastern waters of the Scotian Shelf and the Gulf of Saint Lawrence defining the limit of its northern distribution. Monkfish are tolerant of a large range of temperatures, but seem to be most abundant in temperatures between 3 and 11° C depending on the season and latitude.

The stock structure of monkfish is unknown, but USA survey distributions suggest northern and southern components with the shallow waters of central Georges as a boundary zone. Canadian survey distributions do not suggest a discontinuity between the 4X, 4W and 5Zc (NEFCS Report 1992) components of this stock. However, distribution patterns suggest a separate 4V component. The degree of mixing in both USA and Canadian waters is unknown and large scale migrations have not been reported in either literature or by industry observation. Spawning appears to take place in Canadian waters during the summer months, thus suggesting some degree of independence between the various components. As a matter of convenience, for this review, 4VWX5Zc will be recognized as the appropriate management unit but does not imply stock structure.

The importance of monkfish as a Canadian commercial species has increased dramatically since the early 1990s. Prior to this time, monkfish were fished almost exclusively as a by-catch of both scallop and groundfishing ventures and were not under quota management. Until recently, markets were not specific to monkfish and most of the catch was given as "crew share" and were sold only for the tails. However, a number of new market categories including whole fish and livers have emerged in recent years and trips targeting monkfish have now become common especially for the < 65' mobile gear fleet (ITQ). As a result, landings by this fleet increased from less than 100t in 1989 to well over 600t in 1994.

With the recent decline of many of the more traditional groundfish species, increased attention and fishing pressure has been focused on species such as monkfish, that were previously only lightly exploited. In USA waters, the nominal catch has risen steadily from around 2,600t in 1982 to 19,000t in 1993 (NEFCS Report 1992). Concerned about possible increased exploitation in Canadian waters, the 1995 license conditions for the <65' mobile gear fleet permitted only a limited by-catch fishery for monkfish, until such time as the feasibility of allowing various other management options could be assessed. It was emphasized that an understanding of monkfish population biology, including age, growth, maturity, timing of reproduction, distribution and mortality was a requirement for the establishment of a rational plan for the exploitation of monkfish on the Scotian Shelf and Georges Bank. The current scientific basis to develop such a management plan is incomplete and consists primarily of DFO groundfish Research Vessel Surveys.

To aid in assessing the viability of a commercial directed monkfish fishery and to collect the necessary biological information that would allow us to determine appropriate harvesting levels, a decision was made to allow the < 65' mobile gear fleet to submit conservation-based proposals for a cooperative science/industry study designed to assess the abundance of monkfish in the 4X area and its potential as a developing fishery. In September of 1995 a total of 200t of monkfish was allocated for this program. A joint DFO/industry selection committee reviewed all proposals and held interviews to determine the successful candidates. Five vessels were selected to participate in the study with each vessel being given an equal share of the available quota. These vessels utilized a larger mesh size (203 mm square) than the traditional groundfish fishery and required observer coverage on a minimum of 50% of their directed monkfish trips. As well, industry participants collected biological information including length frequencies and by-catch on all non-observed trips. The remainder of the fleet continued to be restricted to a by-catch fishery which would maintain the catch at no higher than the 1994 level.

The Fishery

Total landings of Scotian Shelf and northeastern Georges Bank monkfish increased from 96t in 1964 to a reported high of 18,000t in 1975 with the USSR the major exploiter of the resource (Table 1). However, USSR landings by species during that period are not considered to be reliable. Landings dropped to the 300t range in 1978 likely due to the extension of jurisdiction to the Canadian 200 mile limit. Between 1978 and 1985 the monkfish resource was not exploited in any significant way and in terms of reported landings, some uncertainty exists as to what may actually have been caught and discarded or used for meal. Since 1978, monkfish have been almost exclusively a by-catch fishery of groundfish and scalloping ventures with the highest landings being reported by the scallop fleet fishing in 4VW (Western Bank) during 1986 and 1987 and Georges Bank (5Zc) between 1989 and 1991 (Figure 1). Landings in both 4VW and 5Zc (Table 2, Figure 2) have declined since that time but have increased in 4X. As a by-catch in the groundfish fishery prior to 1990 monkfish were caught equally by fixed gear and mobile gear vessels < 65', while > 65' mobile gear vessels in 4VW made sporadic large catches (i.e. greater than 100 t).

Since 1993 the <65' mobile gear fleet have been directing for monkfish in 4X. As a result of this additional effort, 4X landings increased from just over 300t in 1991, to over 1100t in 1994. In order to control possible over-exploitation, the mobile gear fleet in 1995 was restricted to a 20% by-catch of monkfish during their regular groundfishing trips on 4X and 10% while fishing on Georges Bank. The five vessels permitted to direct for monkfish as part of the cooperative science/industry study were the only exception to this rule. Likely, as a result of these management measures, monkfish landings in 4X dropped to 930t in 1995. These restrictions however, have not been extended to the scallop fleet, which in some years reflected a high proportion of the total catch of monkfish. Landings by gear and area for 1990 to 1995 are presented in Table 3, Figure 3.

Market categories have expanded to utilize more of the fish and currently include round fish, tails, livers, cheeks and belly flaps. In general the <65' mobile gear fleet utilizes all of these market categories while the scallop fleet generally makes use of only the tail portion. In recent years the seasonality of monkfish landings appear to be very dependent on the market conditions. For the vessels directing for monkfish in 4X, landings indicate that fall markets are usually higher while for the fleet as a whole, monkfish landings are spread throughout the year with some concentration in the spring and fall months.

Resource Status

The Scotian Shelf summer RV survey (1970-1996) stratified mean numbers per tow in 4X (Table 4, Fig. 4), although variable from year to year, tend to indicate a period of relatively high abundance through the mid 1970s, lower abundance through the 1980s and an increasing trend from 1990 to a series high in 1995. The 1996 survey mean numbers have declined somewhat. Mean weight per tow exhibited a similar but less pronounced trend, but without a series high in 1995. This decrease in average size of monkfish may be an indication of improved recruitment (Figure 5).

The summer RV survey stratified mean numbers per tow in 4VW indicate a gradual decline to a series low in 1990, increasing to a high level in 1995, then declining to a more average level in 1996. Mean weight per tow indicates a steady decline to 1992 and a continuing low level to 1996.

A summer RV survey series is not available for Georges Bank (5Zc), however, February RV survey results from 1987 to 1996 for this area were examined. Stratified mean number per tow reached a series low in 1993, and has continued to increase since then. Mean weight per tow declined to a series low in 1993 and has been increasing slightly to 1996.

Summer RV Survey results over the last 26 years, show that catch rates of monkfish are not significantly correlated with depth or temperature (*Pers. Com.* K. Zwanenburg), and show no strong diel pattern. On the Scotian Shelf monkfish are usually caught at temperatures between 3 and 10 C. 1995 patterns are consistent with previous results, except for the increased numbers of small fish in the survey observed primarily in more inshore areas of the central shelf. (Figs. 6, 7).

Historically (1970-1992) the Summer RV survey results show that monkfish are more abundant on the central Scotian Shelf, than on either the western or eastern portions of the Shelf, although some monkfish are caught along the edge of the Laurentian Channel and in the Bay of Fundy and its approaches. In some years, large numbers were caught along the shelf edge in 4W (Simon *et al*, 1994). Recent years (1993-1996) show no significant changes in distribution (Figure 7). Currently, fewer monkfish appear to be present along the edge of the Laurentian Channel than from the period 1970 to 1990.

However, lack of understanding about the stock structure of monkfish raises several concerns. Although survey results show monkfish distribution across the shelf, the majority of commercial fishing for this species takes place in only a couple of "holes" and it would be very easy to over exploit this stock if indeed, it was concentrated in several small areas. As well, the possibility exists that the high exploitation of monkfish on the USA side of Georges Bank may impact the sustainability of the Canadian resource. The National Marine Fisheries Service (NMFS) autumn RV survey biomass indices indicate a significant decrease since the late 1970s. Spring indices show similar patterns. Results of both surveys indicate that monkfish are distributed north and south of Georges Bank (Figure 8)and although no seasonal patterns were noted in the northern range of their distribution, there appears to be movement between inshore and offshore shelf waters south and west of Nantucket shoals (NEFSC report, 1992).

Survey Length Frequencies

The long-term summer survey length frequency distribution of monkfish in both 4X and 4VW shows a wide range of sizes (7-120 cm) with relatively large numbers in the 40-90 cm size range. Over time (1970 to 1989), there has been a gradual decline in the size distribution in both areas and for the 1990 to 1995 period, fish larger than 60 cm are significantly less abundant especially in 4VW, than during the earlier time periods (Figs. 9, 10, 11). However, there has been a notable increase in the number of monkfish <40 cm during this same time period, possibly indicating improved recruitment. The declining trend in size range was not observed in the Georges Bank survey but there are too few monkfish to make any conclusions on recruitment trends.

Length frequencies from 1995 and 1996 were compared to the 1994 average (Figs. 12, 13). Large numbers of small monkfish are evident in both areas, but only the 1995 survey. These small monkfish were most prevalent in adjacent inshore stratum, specifically strata 460 in 4VW and strata 470 in 4X (Figure 14) where they were caught in more than one set. However, the 4VW peak in 1995 does not appear to be sustained in the 1996 survey while the continued appearance of the pulse of small fish in 4X in 1996 would support incoming recruitment.

Joint Industry/DFO Survey

An industry survey conducted in October as part of the five year joint study was also evaluated. The vessels involved used 130 mm square mesh to conduct the survey designed to cover all of 4X, including inshore areas that the Alfred Needler is unable to survey. Due to weather problems and gear bottom conflicts, only 141 sets of the proposed 189 were completed. The upper part of the Bay of Fundy was not included as none of the participants had a history of fishing in a strong tidal area. Sampling on the survey was conducted by observers with length frequencies and catch estimates taken for all species. Further details were summarized in O'Boyle *et al*: 1995. Winter flounder, haddock and cod were the most frequently caught species in the industry survey. Large

amounts of monkfish were caught only in NAFO unit area 4Xp and more specifically in Georges Basin.

Distribution patterns for the industry survey (Figure 15) are similar to the RV. Although catch rates appear higher in Georges Basin, this is likely the result of some commercial tows being executed during the survey since this is the area where most of the commercial fishery takes place. (Problems with the data prevented a separation of commercial and survey tows within a trip.) What is interesting to note, however, is that this survey picked up a number of small fish below 40 cm which are never seen in the commercial by-catch fishery utilizing the same mesh size (130 mm square). This will be further examined along with the commercial length frequencies.

Commercial Fishery

Catch Rates

A commercial catch per unit of effort (CPUE) series, based on mobile gear, tonnage class 1-3 monkfish catch, was estimated from zonal interchange format (ZIF) data for 1989-1995. This catch rate series includes all trips in 4X where monkfish was the main species and so results in a combination of both by-catch (using 130 mm square mesh) and directed (using 203 mm square mesh) fisheries. Catch rates have increased since 1989 primarily due to the fact that more fishing effort was directed toward monkfish by the <65' mobile gear fleet (Figure 16). As such, the catch rates cannot be used as an indicator of abundance but rather indicate the increased interest in the monkfish fishery by this fleet. However, this catch rate represents approximately 20 % of the catch only, while the majority of monkfish are caught as by-catch of vessels fishing other groundfish and scallops.

Commercial catch distributions for the ITQ fleet in both 1994 and 1995 indicate that monkfish were generally caught west of LaHave Bank to the mouth of the Bay of Fundy with high concentrations in Georges Basin in both years. Small amounts were also caught on Georges Bank in 1994 (Figure 17). With the introduction of management measures in 1995, a noticeable reduction in catch was observed in all areas. Catch distributions relating to the scallop fleet remained constant between 1994 and 1995, with Georges Bank the area of highest concentration (Figure 18).

By-catch

By-catch in the directed commercial fishery was examined and found to be generally well below 10%. Cod was the most abundant by-catch species in both the observed and unobserved trips (Table 5). This indicates that the 203 mm square mesh is successful in allowing a directed monkfish fishery with little concern about excessive by-catch in this area. Because the directed fleet fished almost entirely in the Georges Basin area (Figure 19), it is difficult to determine if the less than 10% by-catch levels would be sustained in other areas.

Commercial Length Frequencies

Requirements of the joint monkfish study were for full observer coverage on the survey and 50% coverage when directing for monkfish. This made it possible to compare size compositions from the industry survey and directed fisheries using the International Sampling Program (IOP) and the commercial by-catch fishery using the National Sampling Program (NSP).

Length frequencies from the commercial by-catch fishery and the directed monkfish fishery (Figure 20) were quite comparable despite the difference in mesh size (130 mm square Vs 203 mm square). The by-catch fishery length composition was variable with a peak at 50 cm, another at about 60 cm and a third at 70 cm, while the directed fishery samples tended to be more unimodal with most of the catch between 50 cm and 70 cm. The higher variability of the by-catch sample may be due to the vessels fishing in different unit areas (4Xq, 4Xo and 4Xp) while the directed fishery fished almost entirely within a small area in 4Xp. Also, the 1995 directed fishery samples (IOP) were all taken during the fall months, generally October to December while the by-catch samples (NSP) were distributed throughout the year.

Comparing the length frequency from the industry survey with the by-catch fishery (Figure 20), it appears the 130 mm square mesh gear tends to catch more small fish. It was apparent during the observed survey sets that this was indeed occurring. However, the commercial by-catch fishery using the same mesh size captured only a small percentage of monkfish less than 40 cm and appeared to have an unreasonably sharp selection curve. As these selection curves can be influenced by varying concentrations of fish on the fishing grounds, individual samples from each source were examined. Small monkfish were found in many of the survey sets with the highest numbers taken in 4Xp, the same area that to a large extent supports the commercial by-catch fishery. The absence of these small fish from the NSP suggests that either a certain amount of discarding is taking place or that small fish are often cut at sea for tails and thus not available to land based sampling. The discarding theory, however, is consistent with anecdotal information from industry that a small amount of discarding is occurring. This theory is further supported by the length composition observed for the directed fishery which also landed fish at a smaller size than the by-catch fishery even though a larger mesh was utilized.

Comparing the 1995 and 1996 commercial samples from the NSP indicate a similar size range, with fewer fish in the larger size range (Figure 21). However there were only three 1996 samples taken in the spring compared to eight 1995 samples taken throughout the year.

No length frequency information on monkfish was available from the scallop fleet.

Biological Studies

As part of the monkfish project, industry was required to hire a technician to conduct biological sampling on monkfish, with the goal to describe basic biological parameters i.e. age, growth and reproduction for this developing fishery on the Scotian Shelf.

To date, several hundred monkfish have been collected and sampled in detail for total length, total weight, and tail length and weight in order to determine size relationships of whole goosefish to the landed tail. To determine spawning seasonality and proportion mature at length, sex and maturity stages were determined by macroscopic examination of the gonads according to a criteria established by Armstrong (1987). As well, 46 gonads were prepared for histological examination.

Preliminary results indicate that monkfish spawn in the summer months and females appear to mature between 40 and 50 cm. The small sample size precluded the estimation of age or length at 50% maturity. Length frequencies by sex indicate that females grow larger than males.

Aging structures (vertebrae, otoliths) were collected. Vertebrae were chosen as the best method to age monkfish based on an exhaustive literature search and a preliminary examination revealing that each centrum contained concentric rings which appeared to be annuli. Vertebrae were cleaned of the excess soft tissue and baked in an oven to facilitate the interpretation of the growth zonation. To date, 149 vertebrae have been prepared and read, based on the methodology described by Armstrong *et al* (1992), and Hartley (1995). Preliminary results indicate that the ages in the fishery range between 1 and 10 for females and 1 and 8 for males, however this initial attempt at age interpretation for monkfish remains to be validated. A small number of otoliths were also prepared and examined, however annuli were difficult to discern and for the moment no further age interpretations have been attempted.

Summary

Little is known about the stock structure of the monkfish populations in the north Atlantic but the distribution of monkfish does appear to be continuous across the Scotian Shelf and Georges Bank. The American monkfish fishery and management scheme could, therefore, have a negative impact on the Canadian resource. Although landings have risen steadily as the demand increased and market prices improved, this fishery has remained largely unregulated. As a result, the monkfish populations in the USA are currently thought to be overexploited (NEFSC report, 1992). However, since there is no evidence of large scale migrations, and there appears to be discrete spawning in Canadian waters, the resource exploited by the Canadian fishery may be relatively independent.

The observed decline of commercial sized monkfish and the gradual decline in abundance through the 1970s and 1980s is a concern. Whether this is a natural fishery phenomena or incidental mortality related to unreported by-catch taken by the fleets directing for cod

haddock and pollock cannot be determined. The actual catch of monkfish was likely proportional to the cod, haddock and pollock caught. In the past few years with the decline in the traditional groundfish fishery, overall effort on the Scotian Shelf was reduced. But resurgence of the traditional gadoid fishery could result in an increased level of monkfish by-catch. This could translate into increased mortality and reduce the potential for a sustainable directed monkfish fishery.

As landings increased in 1993 and 1994 it was recognized that a monkfish fishery should not be developed further, until such time as a rational plan for the exploitation of this species on the Scotian Shelf could be developed. To achieve this goal a joint five year science/industry program, currently in its second year, was established to collect the necessary information. In the meantime, the 4X groundfish fleet has been restricted to fishing monkfish on a by-catch basis only.

While there is insufficient data to determine the abundance and exploitation of the Canadian resource at this time, there are clear signs of improved monkfish recruitment especially in 4X. Although the American experience with this resource has resulted in a precautionary approach to monkfish management in the Canadian zone, future management of this resource however, should also take into consideration the relatively large unregulated landings by the scallop fleet, particularly on Georges Bank. The continued commitment of both industry, science and management to provide better information on monkfish and to maintain catches at a low level should result in a reliable assessment of the resource status in the future and lay the basis for the rational development of this resource.

Acknowledgements

The authors would like to thank Bob Branton (MFD, BIO) for all his effort and patient explanations in helping to access the RV survey and Observer databases.

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Table 1. Total monkfish landings (t) by country for divisions 4VWX and 5Zc.

Year	Canada	Russia**	Other	Total
1964	96	-	-	96
1965	-	-	-	-
1966	56	640	-	696
1967	8	-	-	8
1968	8	2418	2	2428
1969	-	3295	-	3295
1970	1	2123	-	2124
1971	-	13506	-	13506
1972	7	2872	-	2879
1973	50	10241	-	10291
1974	14	11758	-	11772
1975	15	18250	-	18265
1976	29	3394	2	3425
1977	86	2840	2	2928
1978	141	186	3	330
1979	143	31	2	176
1980	120	202	3	325
1981	176	30	6	212
1982	182	10	16	208
1983	297	87	27	411
1984	480	39	32	551
1985	492	139	29	660
1986	2755	161	59	2975
1987	2597	336	41	2974
1988	1434	46	14	1494
1989	1740	46	9	1795
1990	2269	93	37	2399
1991	1634	139	45	1818
1992	1300	-	47	1347
1993*	1040			1040
1994*	1744			1744
1995*	1412			1412

* Foreign catch not available.

** Reported landings prior to 1978 cannot be verified so should not be used as any indication of exploitable biomass.

Table 2. Total monkfish landings (t) for divisions 4VWX and 5Zc.

Year	4VW	4X/5Y	5Zc[2]	Total
1964	-	96		96
1965	-	-		-
1966	641	55		696
1967	4	4		8
1968	2420	8		2428
1969	3291	4		3295
1970	2124	-		2124
1971	13372	134		13506
1972	2858	21		2879
1973	8991	1300		10291
1974	10422	1350		11772
1975	16161	2104		18265
1976	3408	17		3425
1977	2407	521		2928
1978	205	125		330
1979	98	78		176
1980	228	97		325
1981	77	135		212
1982	39	169		208
1983	123	288		411
1984	199	352		551
1985	291	369		660
1986	2096	540	339	2975
1987	1830	396	748	2974
1988	295	290	909	1494
1989	388	231	1176	1795
1990	438	407	1554	2399
1991	461	342	1015	1818
1992	415	463	469	1347
1993[1]	135	553	352	1040
1994[1]	44	1159	541	1744
1995[1]	63	930	419	1412

[1] Foreign catch not available.

[2] Catches prior to 1986 are for 5Ze so are not included here.

Table 3. Canadian monthly landings (t) by quarter of monkfish by gear and tonnage class 1990-1995.

OTB TC1-3															
	4VW					4X					5Zc				
	1st Quart.	2nd Quart.	3rd Quart.	4th Quart.	Total	1st Quart.	2nd Quart.	3rd Quart.	4th Quart.	Total	1st Quart.	2nd Quart.	3rd Quart.	4th Quart.	Total
1990	0	1	0	0	1	46	34	26	14	120	0	2	13	0	15
1991	0	0	3	0	3	24	19	27	20	90	0	1	4	0	5
1992	0	0	0	0	0	23	21	57	43	144	0	1	1	0	2
1993	0	2	4	1	7	61	48	98	94	301	0	3	9	16	28
1994	0	1	7	1	9	161	311	158	158	788	0	28	137	4	169
1995	0	0	10	0	10	138	99	149	161	547	0	1	21	2	24
OTB TC4+															
	4VW					4X/5Y					5Zc				
	1st Quart.	2nd Quart.	3rd Quart.	4th Quart.	Total	1st Quart.	2nd Quart.	3rd Quart.	4th Quart.	Total	1st Quart.	2nd Quart.	3rd Quart.	4th Quart.	Total
1990	3	10	6	3	22	1	3	1	0	5	0	0	0	0	0
1991	11	4	142	23	180	1	5	9	1	16	0	0	0	0	0
1992	5	98	9	7	119	0	17	0	0	17	0	1	0	0	1
1993	1	6	54	2	61	0	1	2	0	3	0	0	0	1	1
1994	1	4	2	1	8	0	17	0	2	19	0	0	1	0	1
1995	4	1	4	0	9	5	6	2	0	13	-	0	0	1	1

Table 3 (con't). Scallop Dredge - All Tonage Classes Combined.

4VW					
	1st Quart.	2nd Quart.	3rd Quart.	4th Quart.	Total
1990	0	97	143	-	240
1991	0	38	42	0	80
1992	0	40	148	9	197
1993	0	10	33	1	44
1994	0	13	8	1	22
1995	0	18	17	1	36
4X					
	1st Quart.	2nd Quart.	3rd Quart.	4th Quart.	Total
1990	1	3	111	22	137
1991	0	8	59	33	100
1992	3	40	72	27	142
1993	1	30	102	28	161
1994	1	46	169	48	264
1995	1	22	178	65	266
5Zc					
	1st Quart.	2nd Quart.	3rd Quart.	4th Quart.	Total
1990	177	340	577	430	1524
1991	118	321	432	128	999
1992	33	52	227	135	447
1993	8	56	127	115	306
1994	16	103	181	64	364
1995	9	82	179	117	387

Table 3 (con't). Fixed Gear - All Tonage Classes Combined.

4VW					
	1st Quart.	2nd Quart.	3rd Quart.	4th Quart.	Total
1990	2	5	42	10	59
1991	2	6	25	7	38
1992	0	6	28	11	45
1993	0	3	14	1	18
1994	1	0	3	0	4
1995	1	2	4	0	7
4X					
	1st Quart.	2nd Quart.	3rd Quart.	4th Quart.	Total
1990	12	12	62	19	105
1991	13	9	50	24	96
1992	17	13	66	50	146
1993	11	17	41	9	78
1994	2	12	43	17	74
1995	4	271	50	17	98
5Zc					
	1st Quart.	2nd Quart.	3rd Quart.	4th Quart.	Total
1990	0	1	12	1	14
1991	0	3	5	3	11
1992	0	3	11	5	19
1993	0	5	11	1	17
1994	0	1	6	0	7
1995	0	3	3	1	7

Table 3 (con't). Other Gear - All Tonage Classes Combined.

4VW					
	1st Quart.	2nd Quart.	3rd Quart.	4th Quart.	Total
1990	1	9	5	2	17
1991	0	3	0	1	4
1992	0	3	3	0	8
1993	0	5	3	0	5
1994	0	1	0	0	1
1995	0	0	1	0	1
4X/5Y					
	1st Quart.	2nd Quart.	3rd Quart.	4th Quart.	Total
1990	7	0	2	0	9
1991	9	0	1	2	12
1992	8	1	1	3	13
1993	9	1	0	0	10
1994	9	2	0	3	14
1995	5	0	0	1	6
5Zc					
	1st Quart.	2nd Quart.	3rd Quart.	4th Quart.	Total
1990	0	1	0	0	1
1991	0	0	0	0	0
1992	0	0	0	0	0
1993	0	0	0	0	0
1994	0	0	0	0	0
1995	0	0	-	-	-

Table 4. Mean Numbers/Tow (standard errors) and mean weights/tow (standard errors) for 4VW and 4X Monkfish for 1970-1995 (Summer Survey).

	4VW		4X		5Zc	
Year	Nos./Tow	Wts./Tow	Nos./Tow	Wts./Tow	Nos./Tow	Wts./Tow
1970	.43 (.17)	2.27 (.98)	.64 (.15)	5.07 (3.19)	-	-
1971	.27 (.09)	.95 (.33)	.28 (.10)	.93 (.48)	-	-
1972	.36 (.09)	1.31 (.32)	.57 (.15)	1.26 (.43)	-	-
1973	1.19 (52)	5.04 (1.65)	.61 (.13)	1.89 (.62)	-	-
1974	.81 (.21)	4.10 (1.21)	.41 (.10)	1.93 (.56)	-	-
1975	.54 (.12)	2.82 (1.33)	1.03 (.26)	5.49 (1.52)	-	-
1976	.55 (.23)	2.63 (1.09)	.64 (.24)	3.50 (.96)	-	-
1977	.83 (.16)	3.69 (.87)	1.08 (.33)	5.84 (2.37)	-	-
1978	.62 (.19)	2.64 (1.21)	.32 (.10)	1.61 (.55)	-	-
1979	.32 (.08)	.83 (.26)	.33 (.06)	2.26 (.57)	-	-
1980	.52 (.11)	1.47 (.33)	.28 (.11)	.94 (.39)	-	-
1981	.82 (.14)	1.72 (.36)	.32 (.10)	1.39 (.44)	-	-
1982	.55 (.15)	1.88 (.73)	.59 (.15)	1.64 (.54)	-	-
1983	.43 (.12)	.95 (.33)	.29 (.09)	1.49 (.58)	-	-
1984	.65 (.12)	1.47 (.31)	.62 (.13)	2.13 (.65)	-	-
1985	.45 (.10)	1.82 (.55)	.28 (.08)	.62 (.24)	-	-
1986	.60 (.12)	1.92 (.52)	.41 (.13)	1.71 (.63)	-	-
1987	.42 (.08)	.86 (.18)	.39 (.07)	1.71 (.41)	.30 (.11)	.92 (.34)
1988	.53 (.17)	1.53 (.42)	.36 (.13)	.96 (.43)	.35 (.08)	1.31 (.43)
1989	.31 (.12)	.58 (.20)	.15 (.06)	.50 (.25)	.17 (.05)	.69 (.27)
1990	.15 (.05)	.37 (.15)	.35 (.21)	.29 (.15)	.24 (.06)	.84 (.29)
1991	.34 (.09)	.64 (.16)	.46 (.13)	1.01 (.42)	45 (.17)	.25 (.11)
1992	.33 (.13)	.23 (.08)	.41 (.18)	.48 (.18)	.42 (.17)	.20 (.08)
1993	.32 (.08)	.42 (.08)	.71 (.20)	1.19 (.49)	.07 (.05)	.01 (.01)
1994	.52 (.11)	.36 (.12)	1.19 (.34)	.79 (.21)	.30 (.09)	.01 (.02)
1995	.98 (.33)	.96 (.26)	1.65 (.19)	1.87 (.58)	.36 (.14)	.47 (.26)
1996	.34 (.16)	.67 (.29)	1.01 (.07)	1.29 (.15)	.52 (.13)	.61 (.20)

Table 5. Species composition in bycatch from the 200 mt experimental directed fishery.

Species	% Bycatch in Directed Fishery
Cod	8.41
Haddock	2.70
Redfish	0.04
Yellowtail	0.48
Witch Flounder	0.48
Winter Flounder	0.89
Unspecified Flounder	0.35
Pollock	0.63
White Hake	1.64
Cusk	0.16
Catfish	0.00
Skate	0.60
Monkfish	83.62

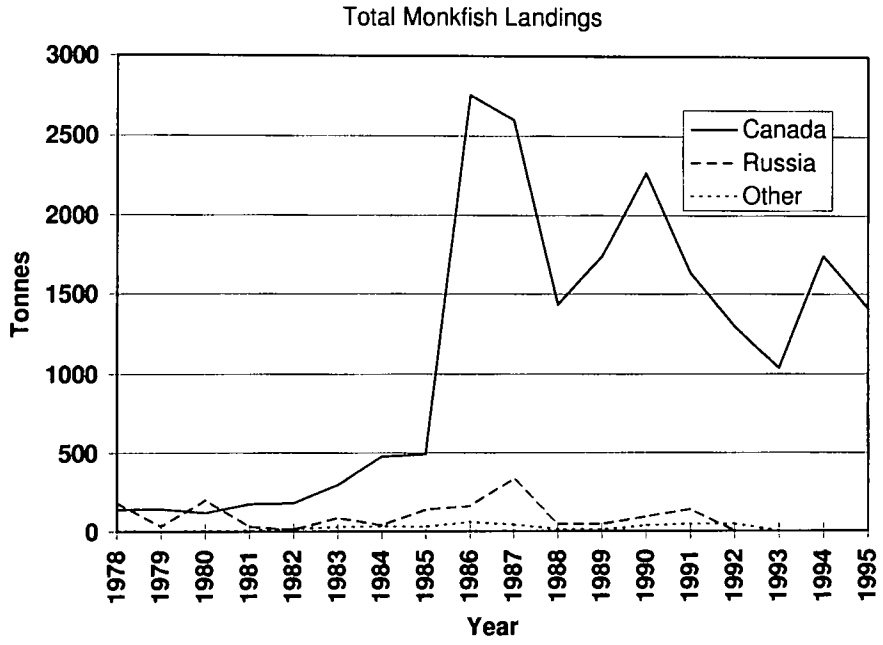


Fig. 1. Total monkfish landings by country.

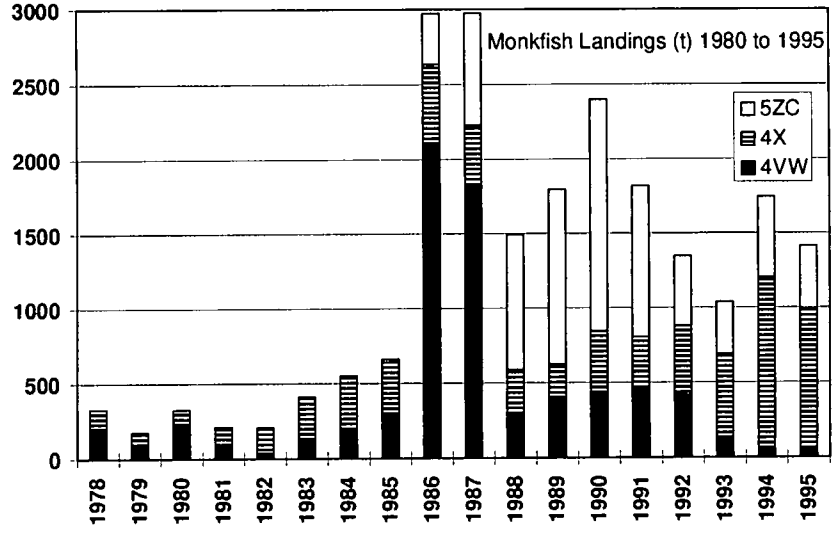
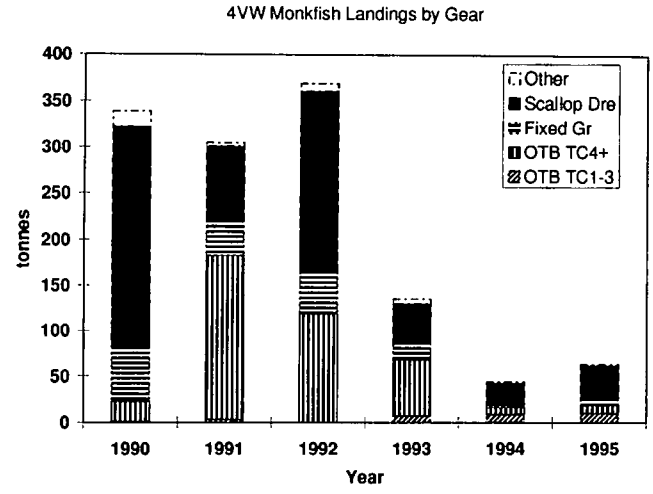
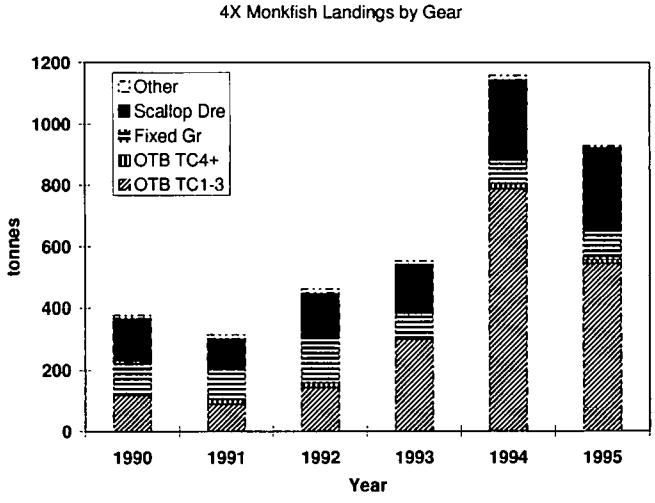


Fig. 2. Total monkfish landings by area.





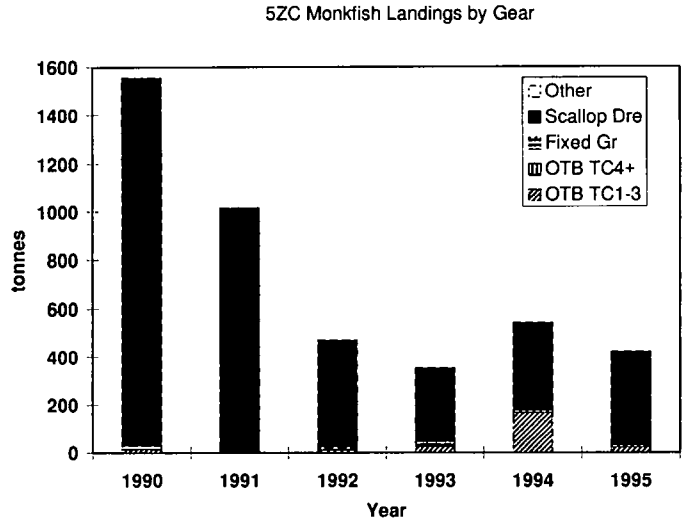


Fig. 3. Total monkfish landings by gear and area.

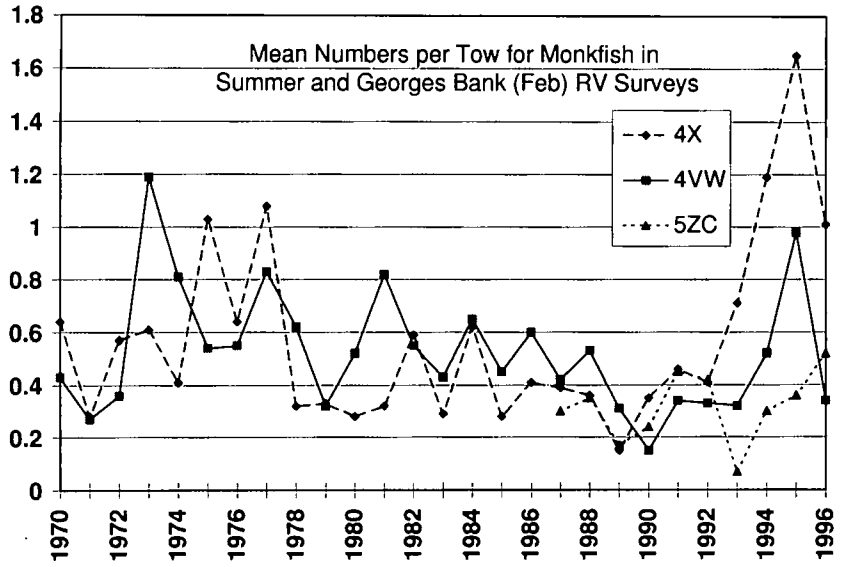


Fig. 4. Mean numbers per tow from research vessel surveys.

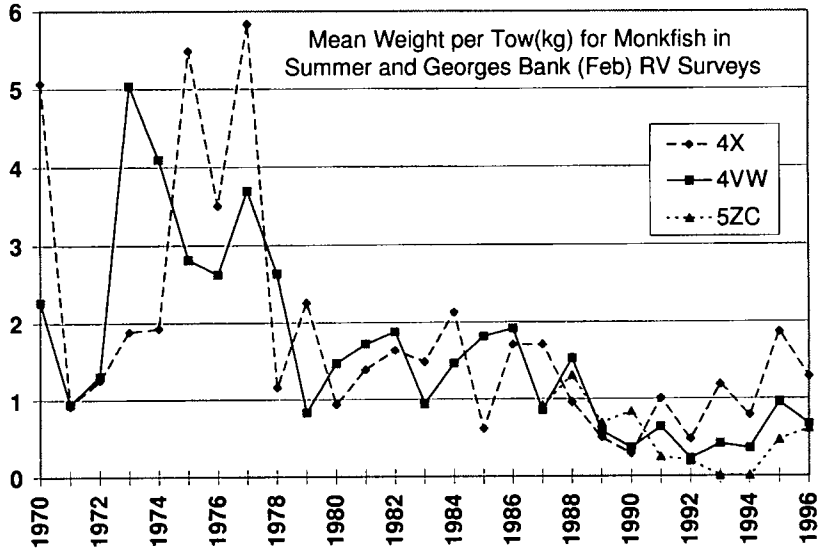
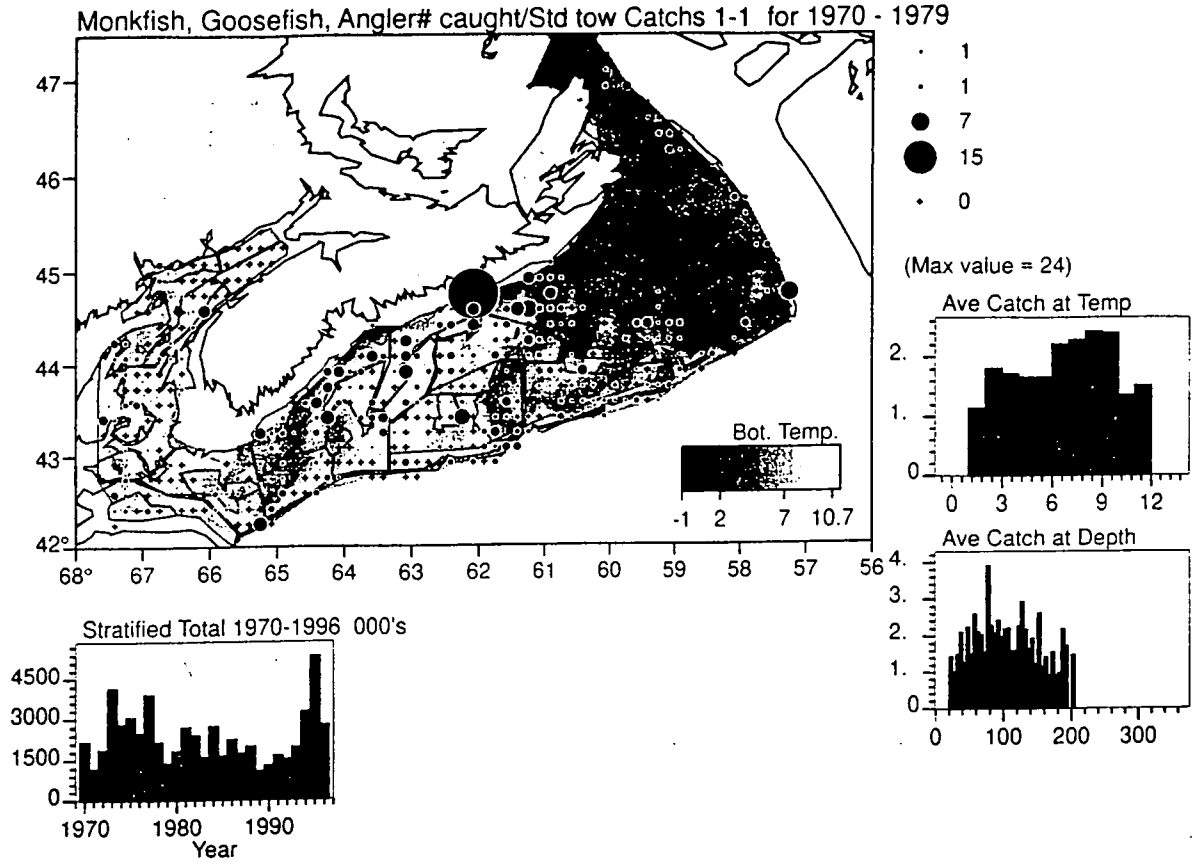


Fig. 5. Mean weight per tow from research vessel surveys.



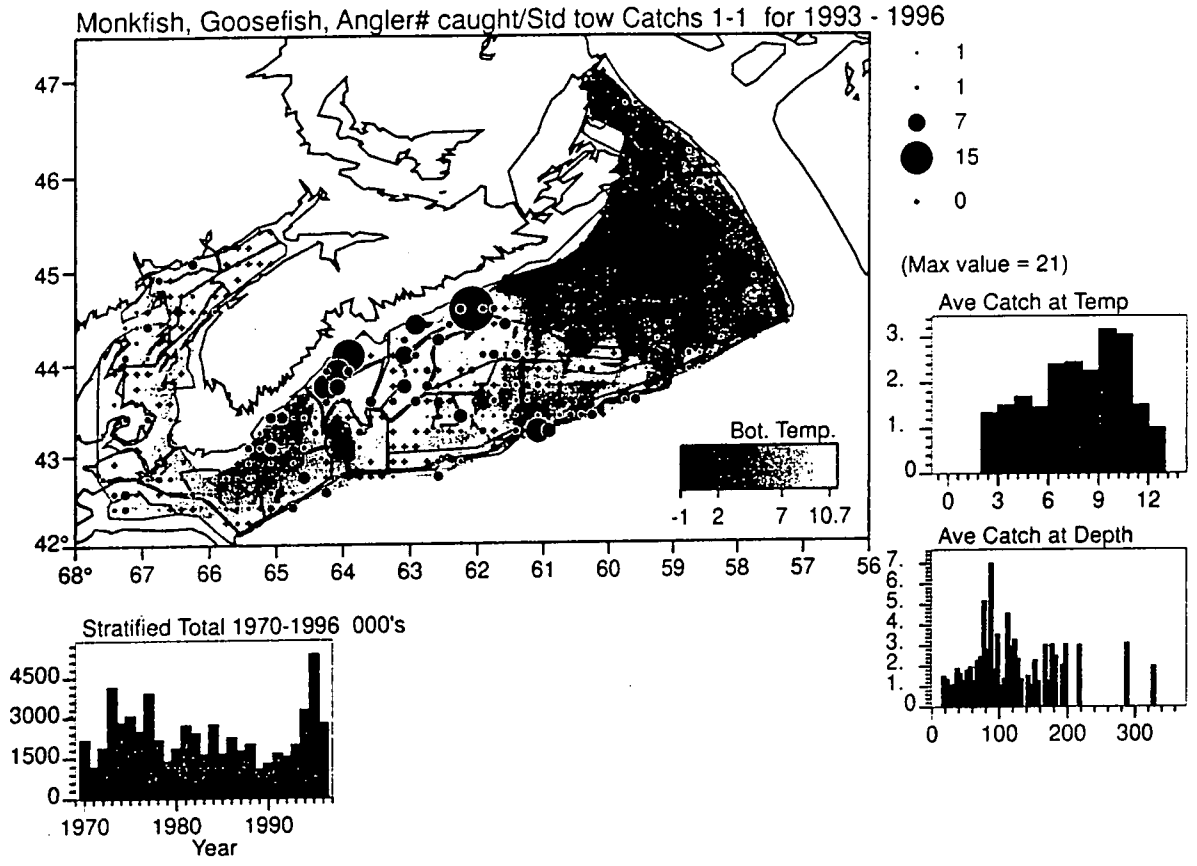
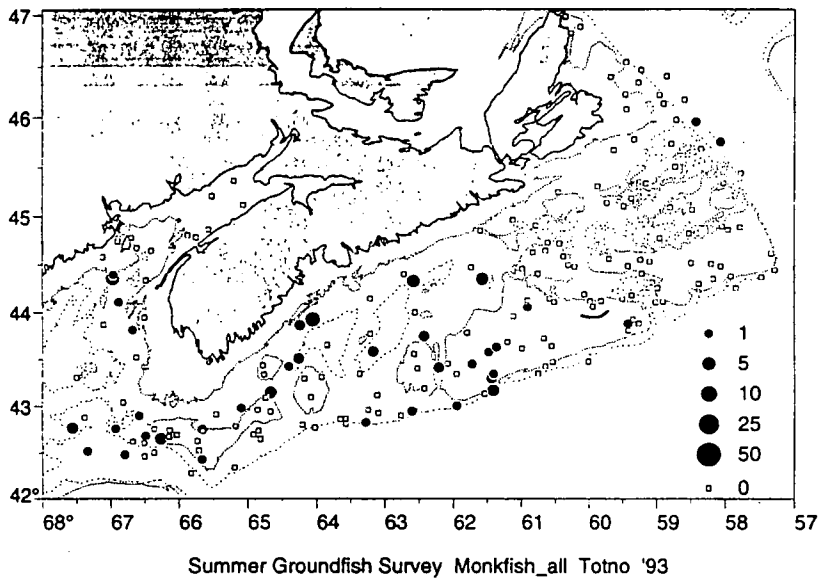
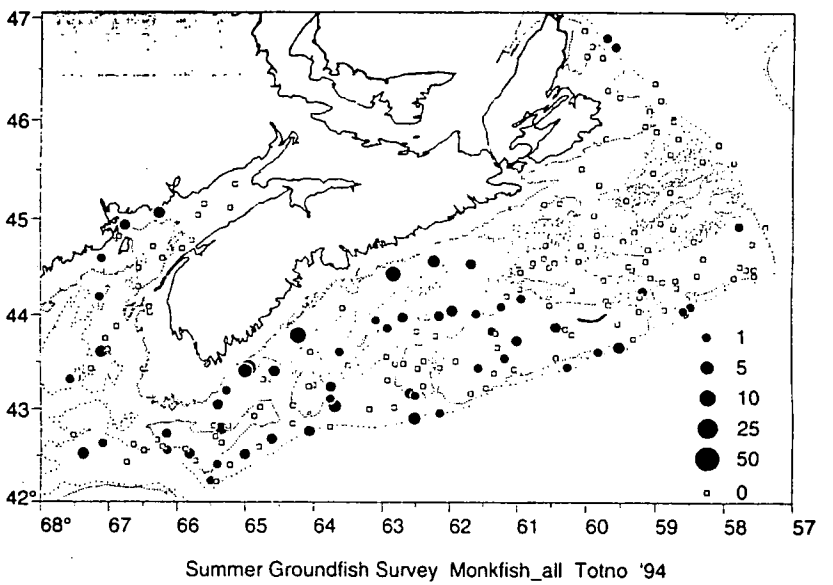
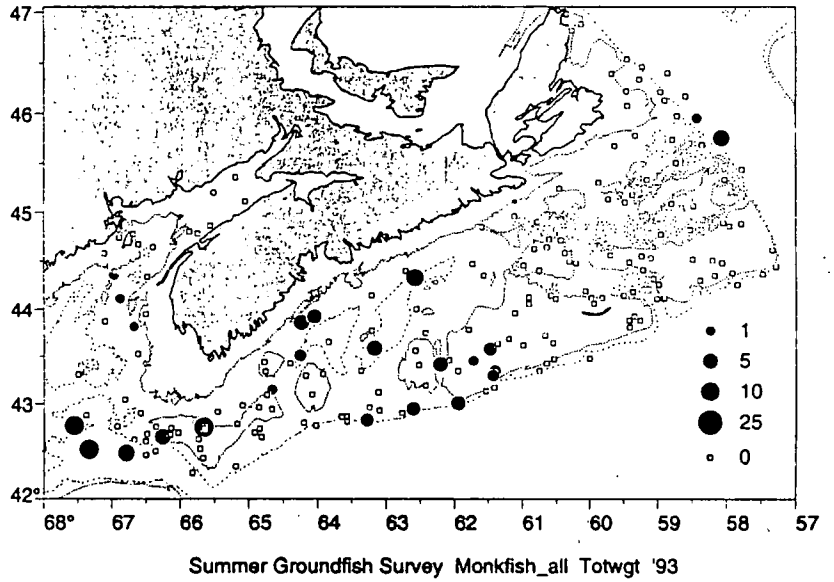


Fig. 6. Monkfish catch per tow from research vessel surveys.







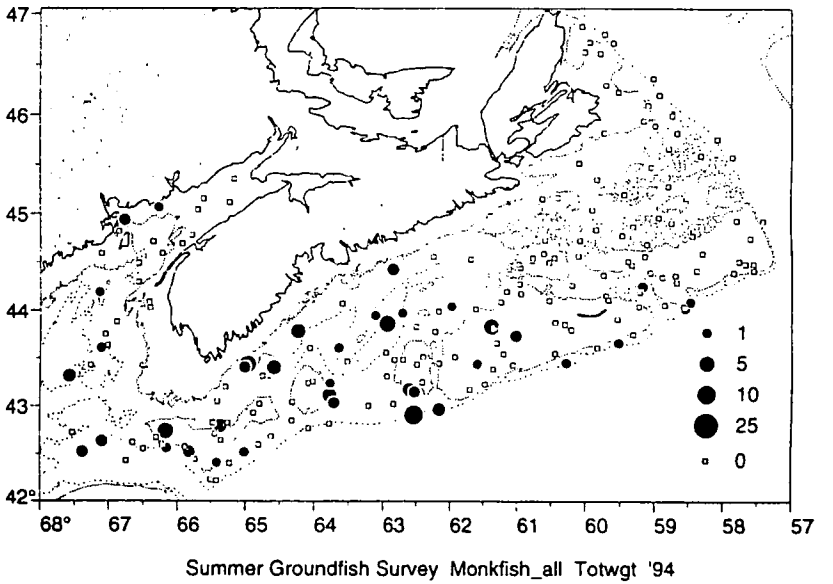
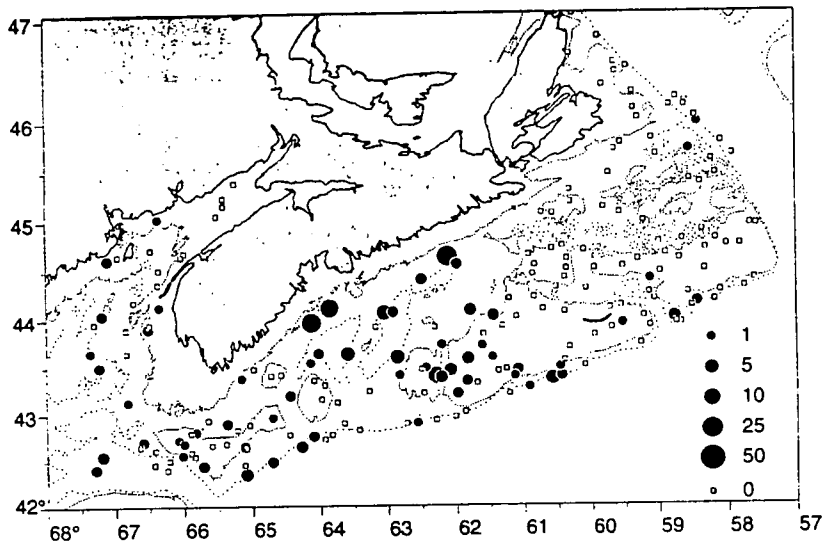
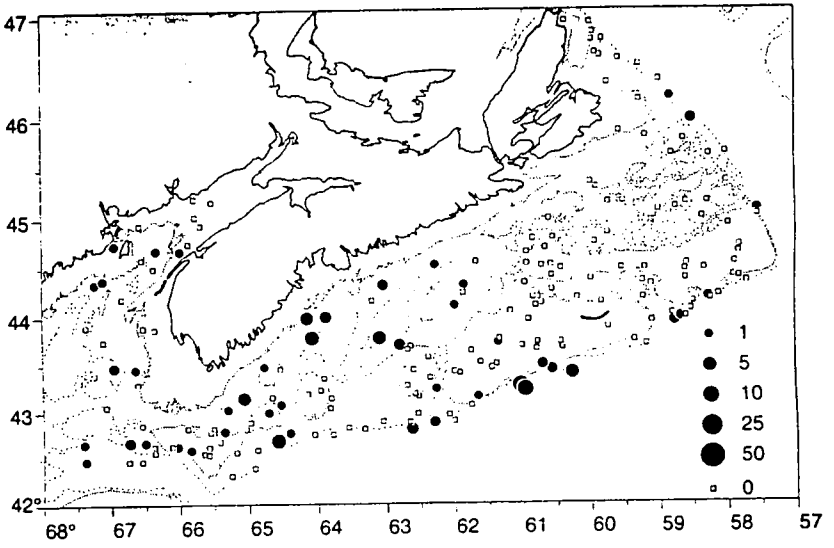


Fig. 7. Abundance (numbers) from summer research vessel surveys. (1993-1995)



Summer Groundfish Survey Monkfish_all Totno '95



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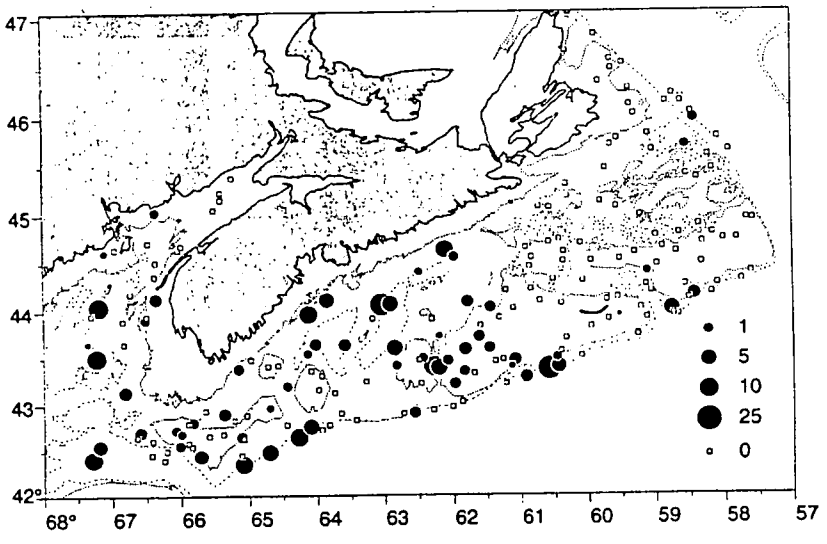
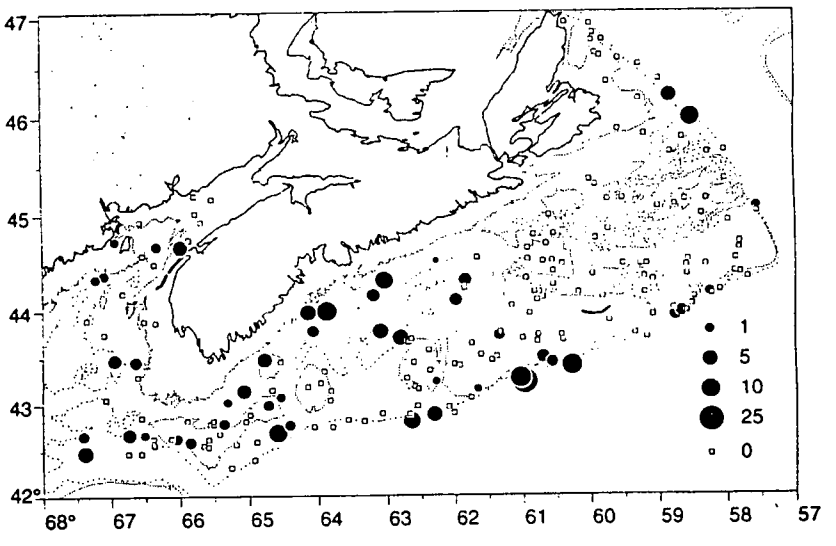
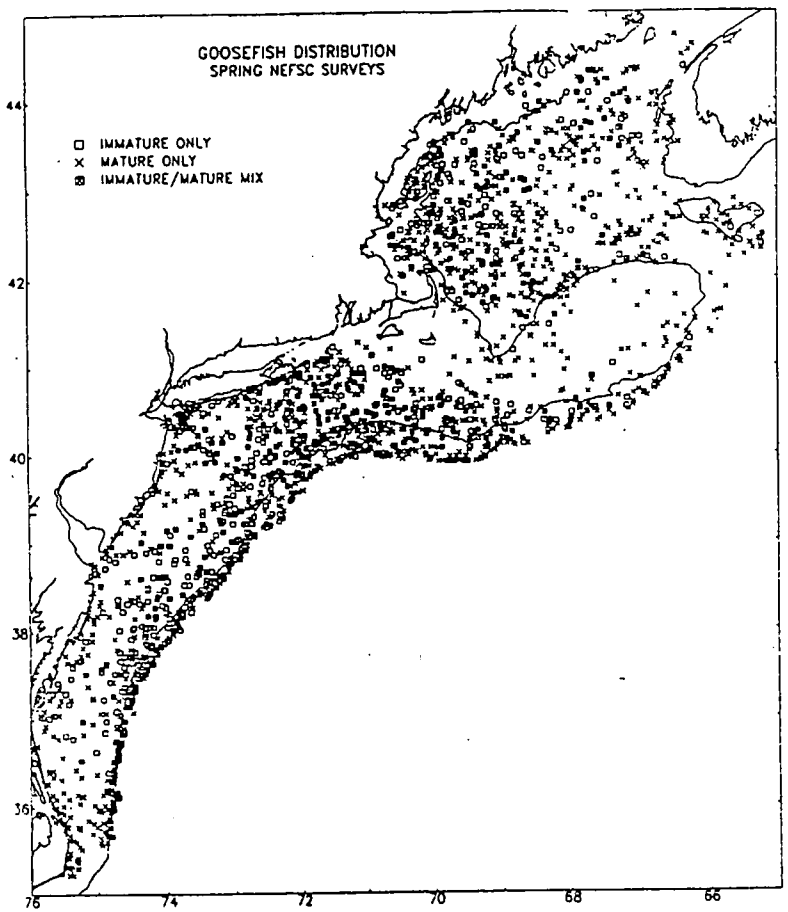


Summer Groundfish Survey Monkfish_all Totwgt '95



Summer Groundfish Survey Monkfish_all Totwgt '96

Fig. 7. (Continued)



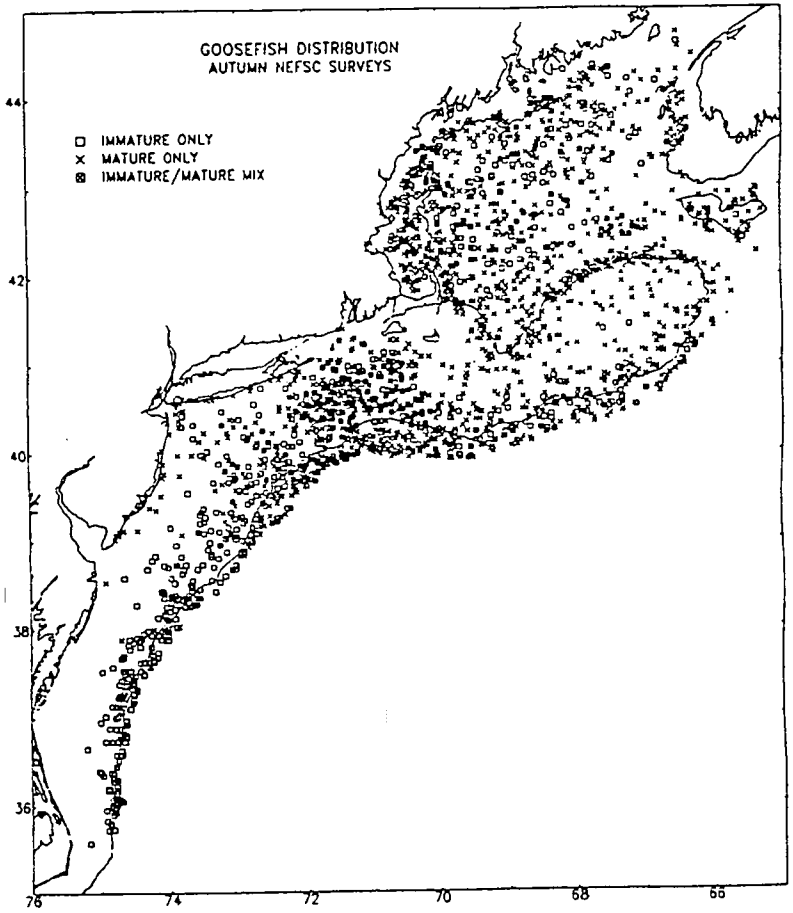


Fig. 8. Distribution of catches (presence/absence only) of immature and mature monkfish from NEFSC spring and autumn bottom trawl surveys. (1968-1991)

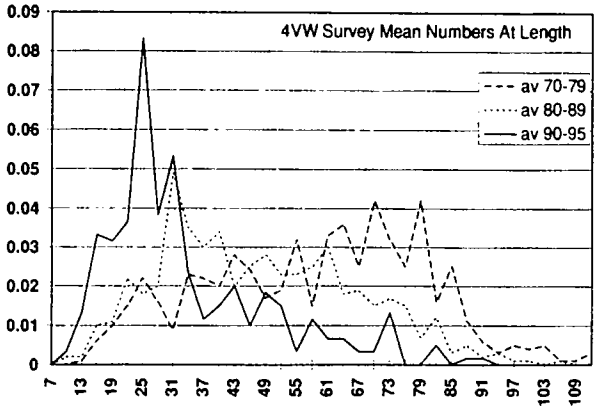


Fig. 9. Long term averages for 4VW mean numbers at length from Scotian Shelf summer research vessel surveys.

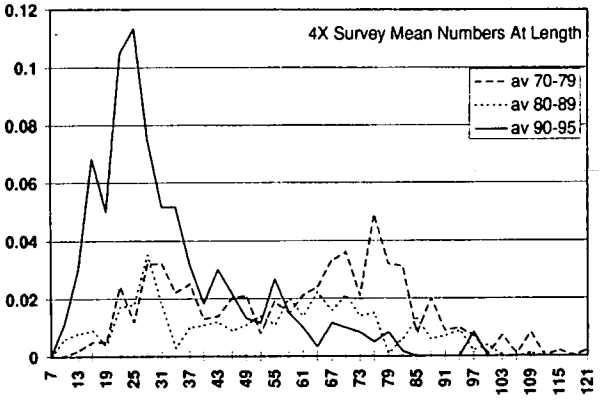


Fig. 10. Long term averages for 4X mean numbers at length from Scotian Shelf summer research vessel surveys.

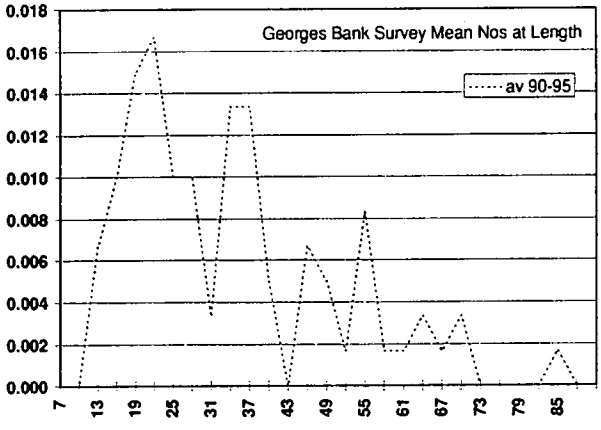


Fig. 11. Georges Bank average (1990-1995) mean numbers at length from Georges Bank February research vessel survey.

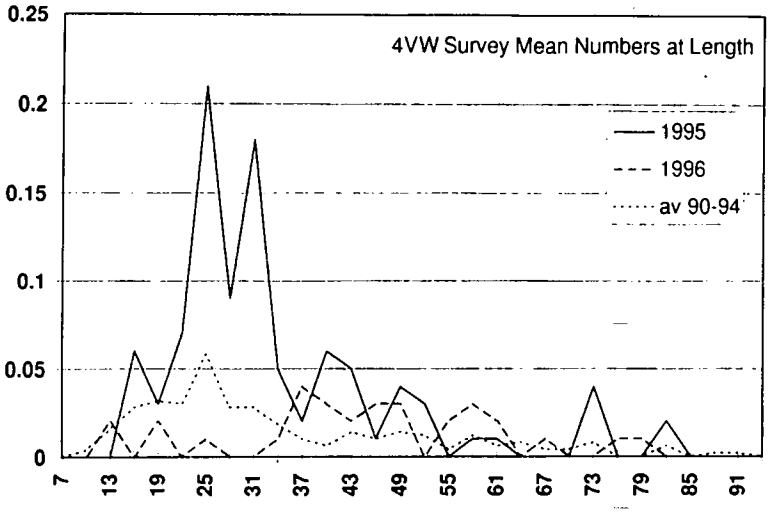


Fig. 12. 4VW survey numbers at length for 1995 and 1996 vs the average of 1990 to 1994.

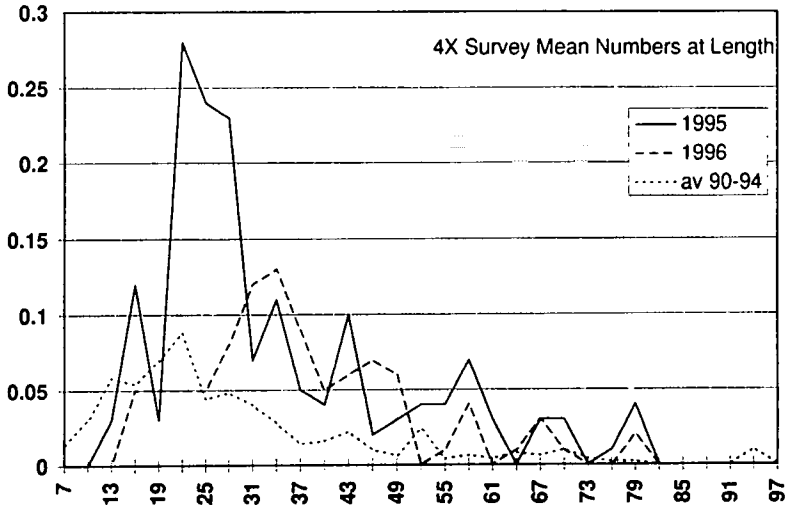


Fig. 13. 4X survey numbers at length for 1995 and 1996 vs the average of 1990 to 1994.

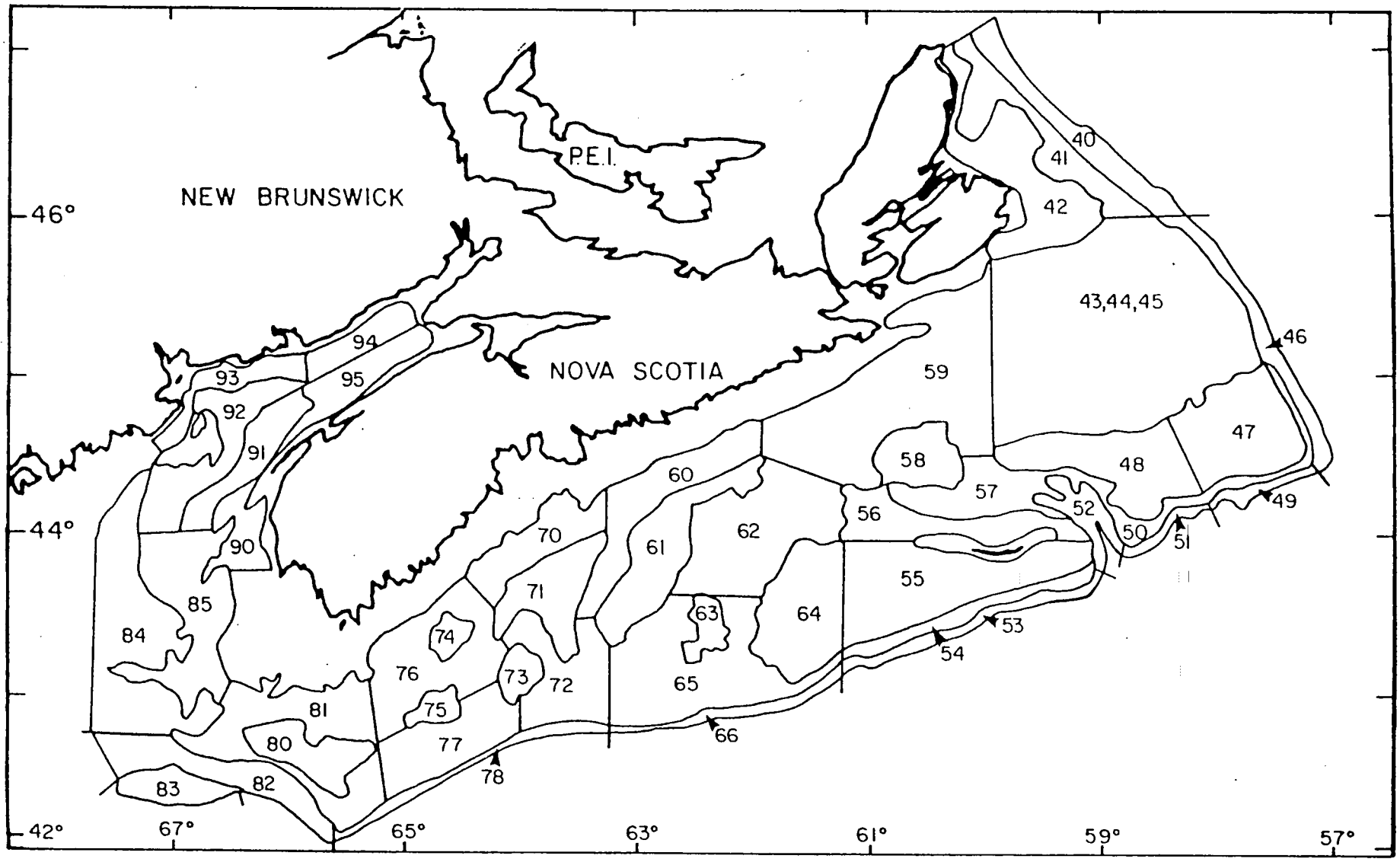


Fig. 14. Strata map for the Scotian Shelf summer research vessel survey.

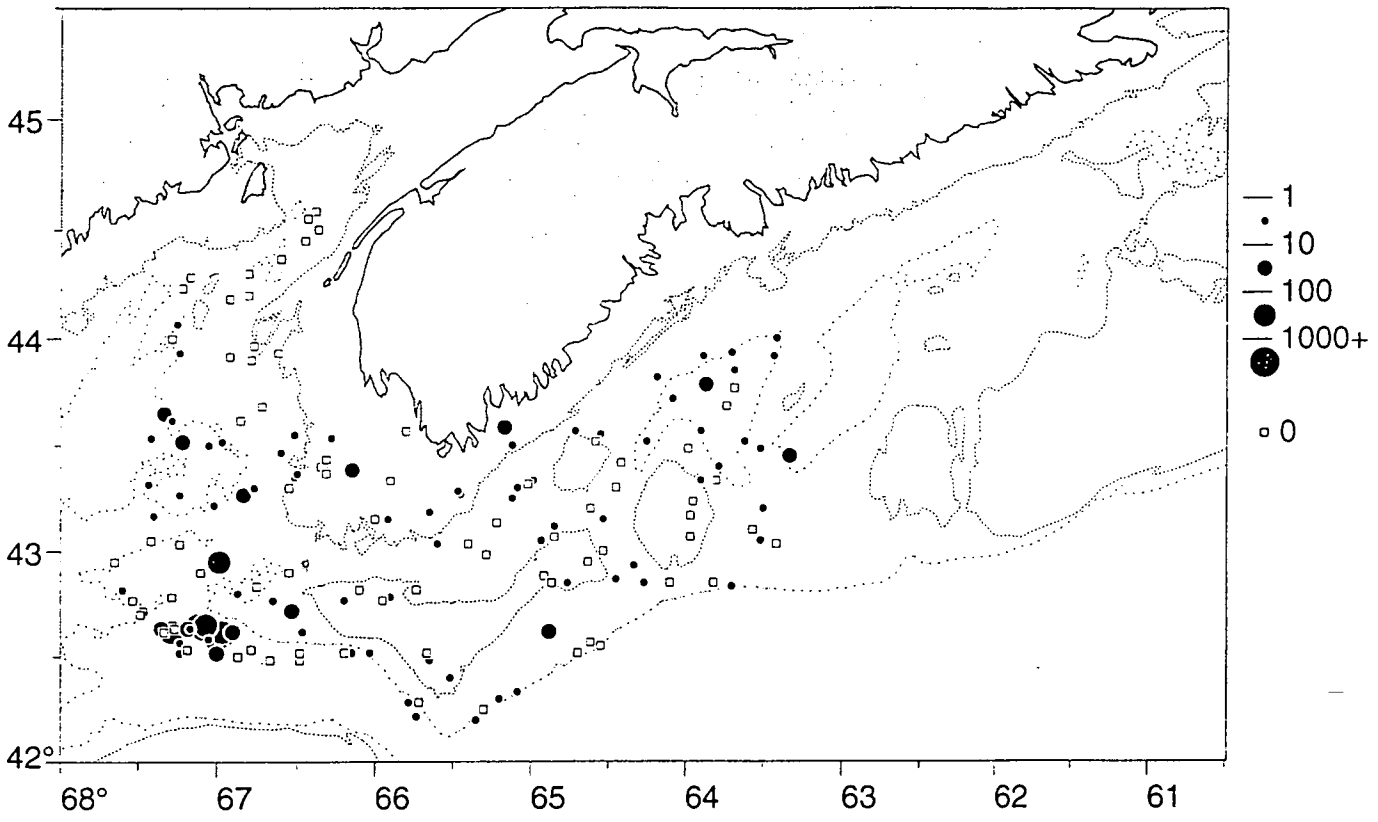


Fig. 15. Distribution of monkfish catches (kg) from the 4X monkfish industry survey in 1995.

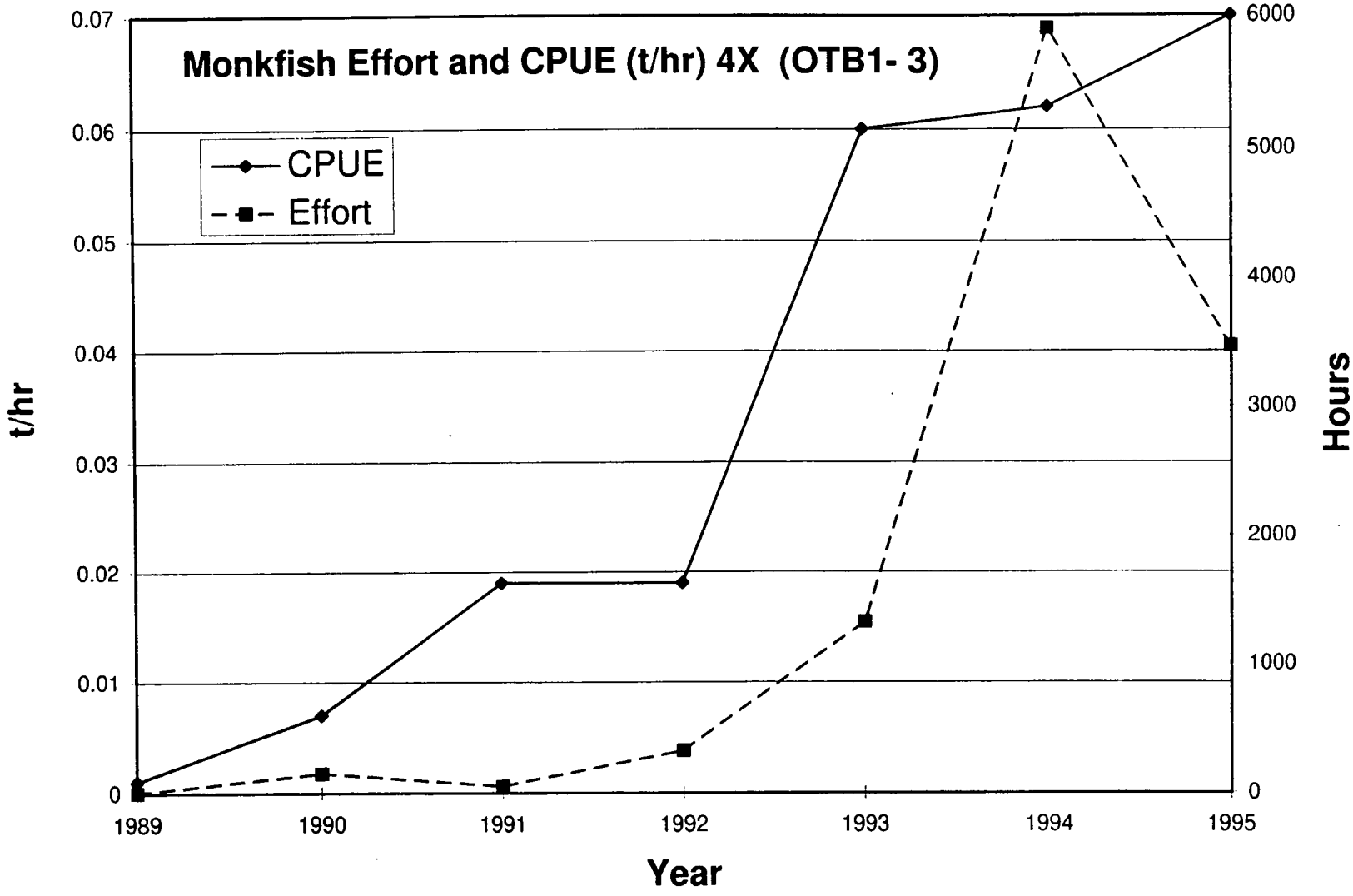


Fig. 16. Monkfish effort (hrs) vs CPUE (t/hr) in 1995.

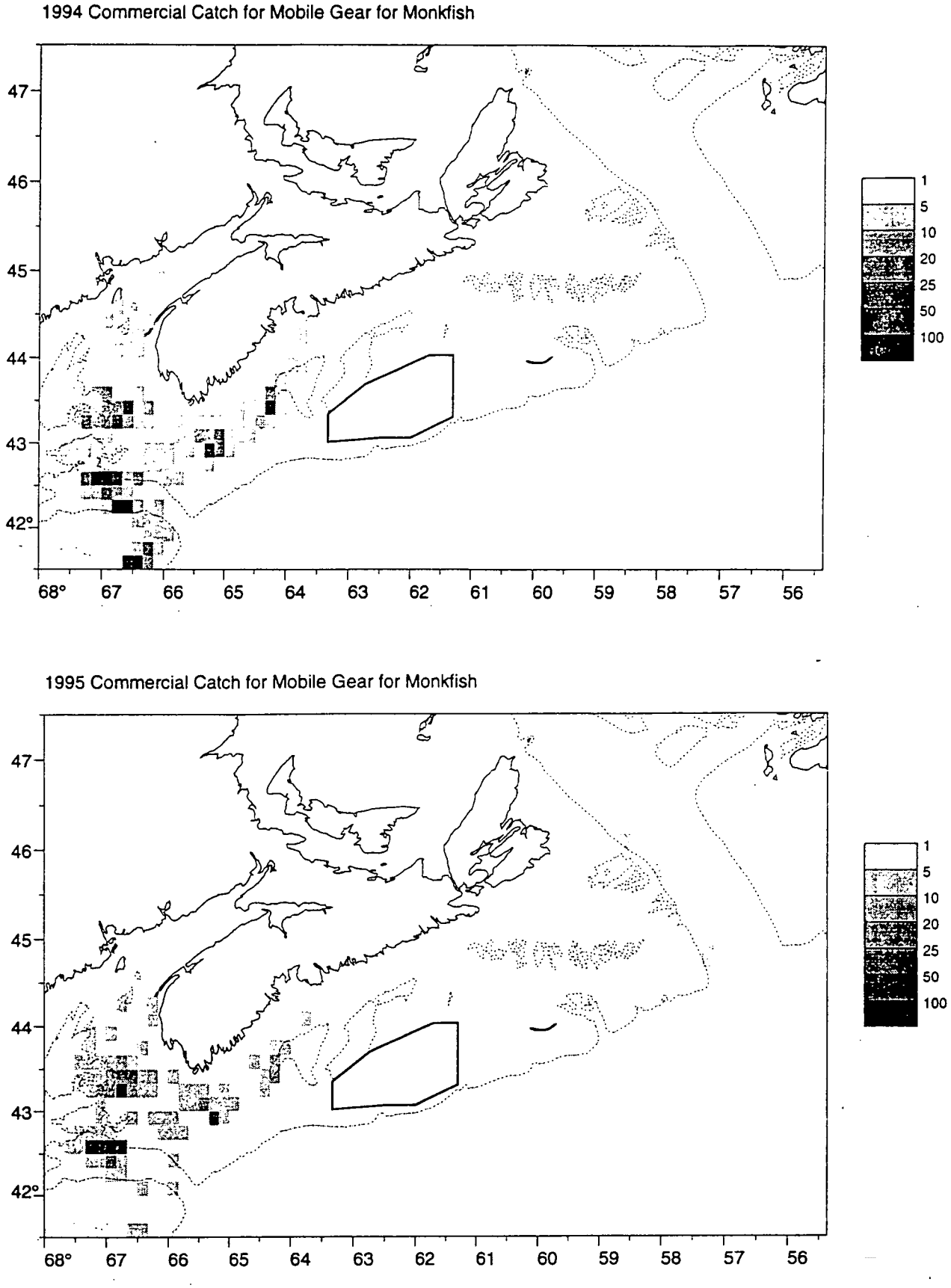


Fig. 17. Distribution of monkfish catches (kg) from mobile gear in 1994 and 1995.

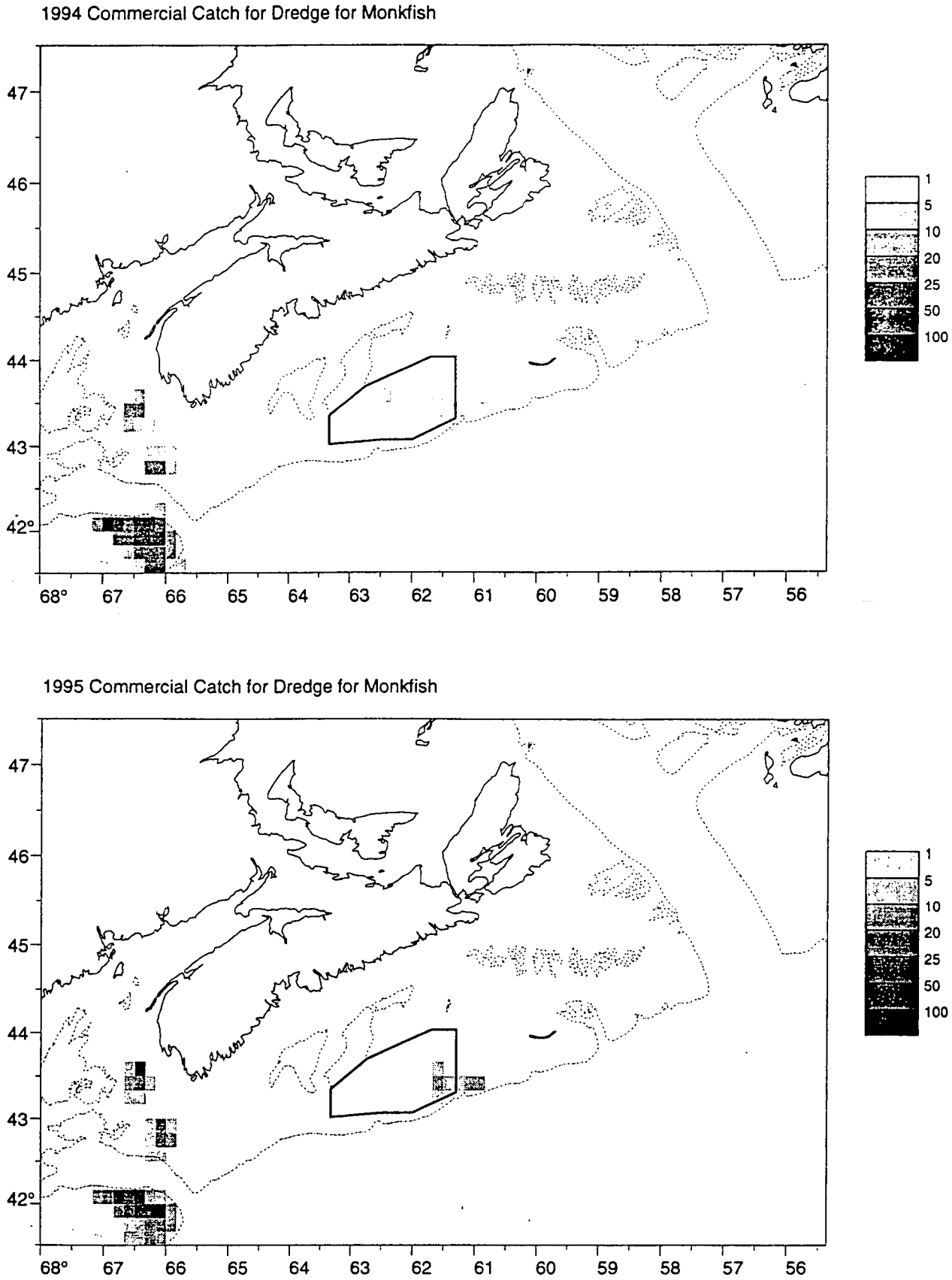


Fig. 18. Distribution of monkfish catches (kg) from scallop dredges in 1994 and 1995.

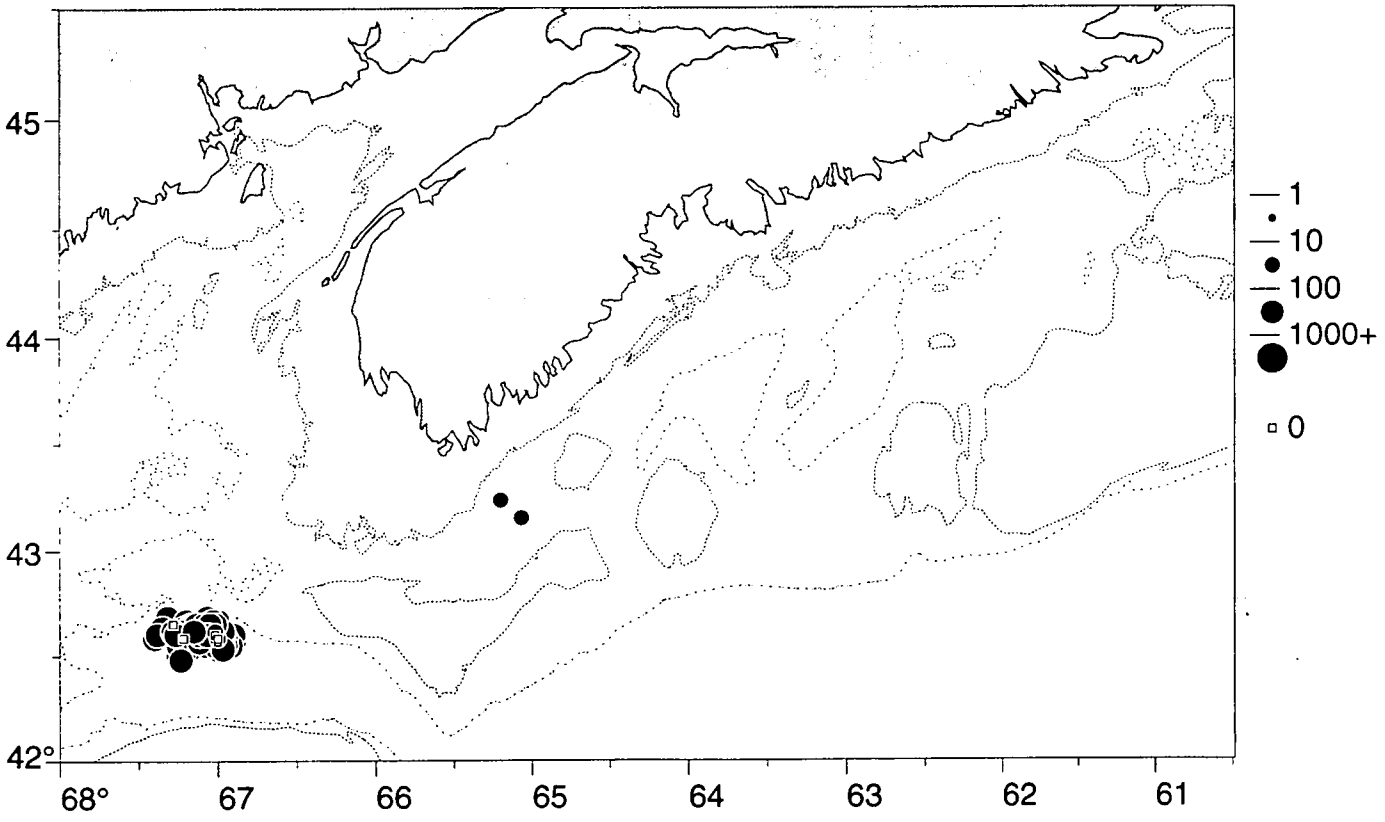


Fig. 19. Distribution of catches (kg) from the experimental monkfish fishery.

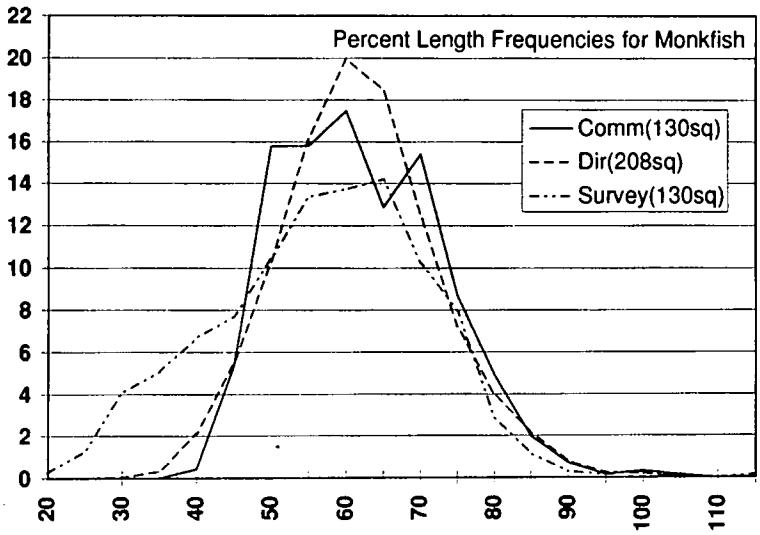


Fig. 20. Length frequencies (%) from the bycatch fishery (Comm), the experimental fishery (Dir) and the industry survey.

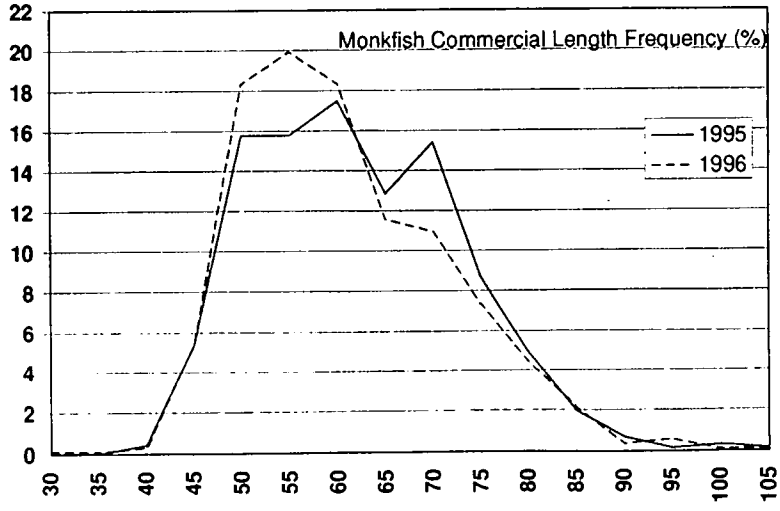


Fig. 21. Commercial length frequencies (%) for monkfish in 1995 and 1996.