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Effects of modifications to the Scotian Shelf Small Mesh Gear Line in 1994-96 on catch rates of silver hake.

by

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Abstract

Modifications to the Scotian Shelf Small Mesh Gear Line (SMGL) in 1994-96 are evaluated in terms of their effect on the conduct of the small mesh gear fishery and on the catch rates of silver hake in that fishery by comparing catch, effort, and catch rates for 1983-93 and 1994-96. Strict enforcement of a 190 m Small Mesh Gear Line and elimination of fishing east of 60°W would have reduced the available fishing grounds, but various exemptions were granted which resulted in the seasonal and spatial distribution of fishing being similar to what they were prior to 1994. Furthermore, commercial catch rates in the fishing area defined by the 1994 regulations were consistently as high or higher than in the broader fishing area encompassed by the preceding regulations. Thus, even if the 1994 fishing regulations were to be fully implemented, no effect on catch rates of silver hake is to be expected.

Introduction

The silver hake fishery on the Scotian Shelf (Div. 4VWX) was developed by the former Soviet Union in the early 1960's and was unrestricted in terms of area and season of fishing up until Canadian extension of jurisdiction to 200 miles in 1977. Bycatch reduction measures were introduced in 1977, when fishing with small mesh for silver hake, argentine and squid was restricted to deeper waters (>100-150 m) along the edge of the shelf (Fig. 1) from April 15 to November 15 (ICNAF, 1977; Waldron and Sinclair, 1985). This area, extending from 60 to 65°30'W, became known as the "Silver Hake Box" and its shoreward boundary as the "Small Mesh Gear Line" (SMGL). In 1980-83 some fishing was permitted as far east as 57°W and in 1984-93 as far east as 59°W. The area from 59 to 60°W became known as the "Extension" to the Silver Hake Box.

More restrictive bycatch reduction measures were introduced in 1994, when a new 190 m Small Mesh Gear Line was implemented, the 59-60°W Extension was eliminated, and use of a separator grate was made mandatory. The changes were based on scientific advice (Branton, MS 1994) that these changes would greatly reduce bycatches of cod, haddock and pollock while still allowing effective prosecution of the silver hake fishery. It was also recommended that the fishery be terminated at the end of June as bycatches rose thereafter. This last proposal was not adopted but steps were taken to encourage an earlier fishing season. However, in implementation of the new SMGL, the frequent granting of exemptions, which allowed fishing in the area between the new and old SMGLs, and in the Extension, weakened the regulation. In 1996, these exemptions also included moving parts of the boundary of the new SMGL northward to facilitate fishing in the vicinity of several canyons.

At the June 1996 meeting of the NAFO Scientific Council concern was expressed that these new SMGL regulations could have an effect on the catch rate of silver hake of sufficient importance that these effects should be taken into account in stock status calculations. The purpose of the present document

is to determine the effects of the changes to regulations since 1994 regarding fishing area on the catch rates of silver hake in the Scotian Shelf fishery.

Methods

Data used in this analysis are from the Canadian observer program in 1983-96 when the foreign small mesh gear fishery was directed almost entirely towards silver hake. Although there are observer data from 1977, there was a substantial squid fishery until 1982, so 1977-82 data were excluded from the analysis. Data selection, was on the basis of fishing sets by all vessels subject to the SMGL regulations where the main species sought was silver hake, resulting in data from over 115,000 fishing sets being retrieved for analysis. The recording of main species sought by observers makes these data particularly suitable for bycatch analysis, as sets which were unsuccessful in catching a predominance of the target species are included. Observer coverage was 100% in 1987-96 but catch and fishing effort observations for 1983-86 were multiplied by 2.5 to account for the 40% observer coverage in those years. The depth and location of each set was determined by averaging start and end depths and latitudes and longitudes.

The analysis that supported the imposition of the new SMGL regulations in 1994 was based on an examination of the spatial and temporal distributions of fishing in 1983-93 and calculations of the effects on directed and bycatch species catch rates and on the displacement of fishing effort, had different restrictions on fishing been imposed during that period.

The present analysis is based on a comparison of the observed distributions of fishing effort and catch rates of silver hake in 1994-96 with those in 1983-93 to determine what differences occurred in the spatial and temporal distributions between these periods, and to diagnose the causes for, or for lack of, change.

Results

The estimated silver hake catch (Fig. 2) derived from observer data is approximately equal to the nominal catch used for assessment purposes (Showell, MS 1996). The silver hake catch in 1983-93 ranged from 30,000 to 90,000 t and subsequently from 8,000 to 20,000 t.

Total groundfish bycatch in 1983-93 increased steadily and ranged between 6 and 19% of the silver hake caught (Table 1, Fig. 2). Total bycatch in 1994-96 was much lower than in 1983-93 and ranged between 3 and 7%. These bycatch changes between 1983-93 and 1994-96 are of course the result of separator grate introduction as well as to changes in SMGL regulations, and possibly also to changes in the relative abundance of species.

The start of the silver hake fishery (Fig. 3) ranged from as early as the beginning of March (week 9) to as late as the end of April (week 17) while the end ranged from as early as July (week 27) to as late as September (week 36). Within the period 1994-96, there was a tendency towards both an earlier start and later end, however both 1983-93 and 1994-96 had a similar range of start and end dates.

Total effort directed towards silver hake ranged between 20 and 40 thousand hours in 1983-93 and between 5 and 18 thousand hours in 1994-96 (Fig. 4). Effort was at its lowest for the entire period in 1994 but increased thereafter. The portion of effort in the Extension averaged 12% in 1983-93 and 3% in 1994-96. The portion of the effort in depths less than 190 m (% of total) was >40% until 1989, declined until 1992, and remained <40% until 1995 when it was again >40%. Although 1994 was lowest in the series (16%), the average for 1994-96 (35%) was higher than for 1990-93 (33%).

The silver hake catch rate was 2.6-3.8 t/hr in 1984-89, declined greatly in 1990 and was stable at 1.3 t/hr thereafter (Fig. 5). The annual average depth of fishing was about 275m in 1983-89 but deepened as catch rates declined to 360 m in 1992. Fishing became shallower again in 1993-96 when the average depth was about 325m. There was no great change in average depth fished between 1990-93, the period immediately prior to the regulatory change, and 1994-96, the period immediately after, thus there were no observable effects of the regulations on depth fished.

The silver hake fishery traditionally occurred (Fig. 6a) in a narrow band along the seaward edge of the SMGL, mostly in the canyons between 60 and 63°W, sometimes between 64 and 65°W and sometimes east of 60°W (Fig. 6a). Depth of fishing in the core area of the fishery (60-63°W) ranged mainly between 100 and 400 m, sometimes going as deep as 500 m (Fig. 6b). Depth of fishing in the area in the Silver Hake Box varies more and is deeper at the beginning of the season than at the end (Fig. 6c). The core of the fishery in this area occurs between 100-300 m during the April to July (week 14-28) period. Fishing in the Extension was mainly at 120-250 m during April to June (week 16-26) (Fig 6d). There was little activity in the Extension in 1994-96.

Fishing effort overall was most intense between 61 and 63°W at depths of 100 to 300 m (Fig. 7a,b). Effort in the Silver Hake Box in 1983-93 was most intense after the end of May (week 24) at depths of less than 160 m (Fig. 7c). Effort in the Silver Hake Box in 1994-96 occurred at about the same time and depth as in 1983-93 but intensified only briefly at several different times and depths as opposed to one single time span and depth range like 1983-93. Effort in the Extension in 1983-93 was most intense in mid April (week 15) at 120-220 m (Fig. 7d). There was little activity in the Extension in 1994-96.

Silver hake catch rates in 1983-93 ranged from 1-3 t/hr, and occasionally as high as 5 t/hr (Fig. 8a,b). Catch rates in 1994-96 rarely exceeded 2t/hr and were often less than 1 t/hr. Catch rates in the Silver Hake Box in 1983-93 were sometimes as high as 5t/hr in late March (week 12) at around 400 m and again in late April and May (week 15-19) at 100-300 m (Fig. 8c). Catch rates in June (week 22) in 1983-93 were 2-3 t/hr, declining steadily thereafter to less than 1 t/hr in late August (week 34). In 1994-

96, catch rates only sometimes exceeded 2t/hr, before the beginning of May (week 18) and very rarely after that. Catch rates in the *Extension in 1983-93 were 2-4 t/hr from mid* April to mid May (week 14-20) at 100-300 m and again in late July (week 30) at 100-200 m (Fig. 8d). Catch rates during 1994-96 in the Extension were 1-2 t/hr from the end of April to the beginning of June (week 17-22).

The fishery in 1994-96 was about 2 weeks later than in 1990-93 (Fig. 9). The average depth of fishing was slightly deeper in 1994-96 than in 1990-93 from late March to late May (week 14-21) and slightly shallower thereafter. The catch rates prior to June (week 26) were slightly higher in 1990-93 than in 1994-96 but after June were much higher in 1990-93 than in 1994-96 (Fig. 10), thus there was a tendency for the catch rate to drop off later in the season and this was more pronounced in 1994-96. Most fishing (10-90%) occurred at the same depths (120-300 m) during both periods and did not vary greatly with depth of fishing (Fig. 11).

Annual silver hake catch rates were as good as or better for fishing at depths >190 m than for the area overall in all but 3 years (1985, 1990, 1992), and only significantly worse in 1 year (-15% in 1985), in the period 1983-96 (Fig. 12). The years of best overall catch rate (1986-89) were also the years of best fishing at depths >190 m (up to +20%). Furthermore catch rates were almost identical (+/-5%) in all zones in 1990-96 and consistently better deeper (+2 to +5%) since 1993. Excluding or including the Extension in all years would have had little effect (+/-5%) on catch rates.

Discussion

Fishing area changes introduced at the beginning of 1994 had their greatest effect on the fishery in 1994 with only 16% of the fishing occurring at depths of less than 190 m and no fishing in the *Extension. Since then however,* more than 40% of the fishing has occurred at depths less than 190 m, which is much higher than the 33% average for the 4 years preceding the new regulations and not much different than the 48% average for 1983-93. Distribution of fishing effort in the Silver Hake Box where 80-100% of the fishing occurs was about the same in 1994-96 as in 1983-93 and essentially identical to the period 1990-93. Although less fishing has occurred in the Extension, over 6% of fishing in 1995 occurred there. Fishing continued to occur after June, in one case (1996) lasting until early August. Thus, the exemptions granted to the regulations in 1994-96 resulted in a spatial and temporal pattern of fishing very much the same as existed prior to their introduction.

Strict enforcement of a 190 m Small Mesh Gear Line and elimination of the Extension would reduce the available fishing grounds. However, catch rates in the fishing area defined by the 1994 regulations were consistently as high or higher than in the broader area encompassed by the preceding regulations. Thus, even if the 1994 regulations were to be fully implemented, no effect on catch rates of silver hake is to be expected.

Acknowledgments

We thank staff of the Canadian Observer Program, past and present, for the vast quantities of the data used in this analysis. We thank Shelley Bond and Cynthia Greencorn for the high quality of that data and we also thank Gerald A. Black for the ACON software used to prepare the spatial/temporal distribution maps.

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Table 1. Bycatch of other species (t) by year and species from foreign small mesh gear fleets directing for silver hake on the Scotian Shelf during the period 1983 to 1996, in order of descending total catch for entire period.

Species	83[1]	84[1]	85[1]	86[2]	87[1]	88[1]	89[2]	90[2]	91[2]	92[2]	93[2]	94[1]	95[1]	96[2]	Total
SPINY DOGFISH	1208	370	2168	1385	429	1409	2655	1760	1391	702	343	14	30	92	13957
POLLOCK	722	255	546	1219	622	1112	2099	1252	1599	2008	745	10	56	134	12378
SHORT-FIN SQUID	68	385	318	89	260	446	949	1134	805	499	1693	1290	715	442	9094
HAKE (NS)	773	495	664	834	780	732	702	497	736	475	234	59	150	397	7527
SKATES (NS)	224	214	207	168	441	545	659	1120	2152	562	781	18	123	197	7411
MACKEREL(ATLANTIC)	5	790	1065	709	48	697	403	923	204	629	631	39	58	82	6283
HERRING (ATLANTIC)	0	0	74	150	72	831	1368	1746	1161	265	43	0	6	181	5900
HADDOCK	658	983	569	558	339	461	668	384	346	155	142	8	32	47	5350
ANGLER	272	308	412	325	231	182	158	176	216	164	110	7	20	89	2670
ARGENTINE (ATLANTIC)	618	493	266	189	36	291	74	56	74	27	156	8	92	209	2589
REDFISH	66	44	350	130	66	83	279	316	418	286	139	19	41	54	2290
COD (ATLANTIC)	257	145	10	29	59	121	194	199	219	83	39	2	1	3	1361
CUSK	115	82	149	50	45	98	87	52	69	49	22	0	0	1	820
BASKING SHARK	69	27	49	13	23	72	55	78	141	140	77	9	20	9	782
AMERICAN PLAICE	47	84	77	55	53	81	37	74	75	55	68	13	18	23	761
HALIBUT (ATLANTIC)	67	16	50	28	48	39	45	58	78	51	38	1	3	5	526
WITCH FLOUNDER	18	30	28	19	23	37	22	35	52	34	49	2	19	25	393
AMERICAN LOBSTER	12	16	16	18	41	23	31	34	45	27	28	4	7	13	315
YELLOWTAIL FLOUNDER	5	70	8	24	7	43	9	20	29	15	42	0	9	4	285
ALEWIFE	1	0	2	15	0	1	0	0	37	58	32	0	0	14	161
~ 320 Other Species	53	74	66	95	87	67	68	112	146	143	92	13	65	79	1161
Total Cod+Haddock+Pollock	2123	1499	2747	1971	827	1991	3517	2343	1956	941	524	23	63	142	20668
Total Other Groundfish	3000	2908	3945	3928	2496	4844	5997	6404	7042	4816	3166	188	615	1424	50774
Total All Groundfish	5123	4407	6692	5899	3323	6835	9514	8746	8998	5757	3690	211	678	1567	71442
Total Other	133	475	400	202	389	536	1048	1280	997	669	1813	1307	787	534	10569
Grand Total	5257	4882	7092	6101	3712	7372	10562	10026	9996	6426	5502	1518	1465	2101	82011

[1] Estimated.

[2] Observed.

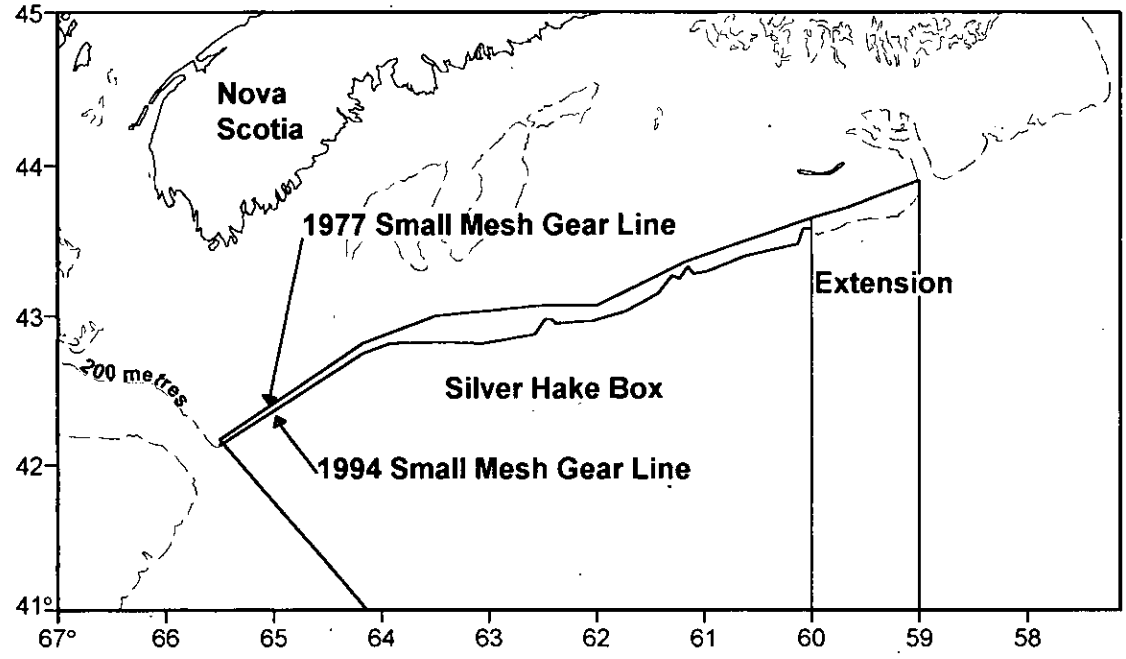


Figure 1. Location of Scotian Shelf Silver Hake Box and Extension and 1977 and 1994 Small Mesh Gear Lines (SMGL).

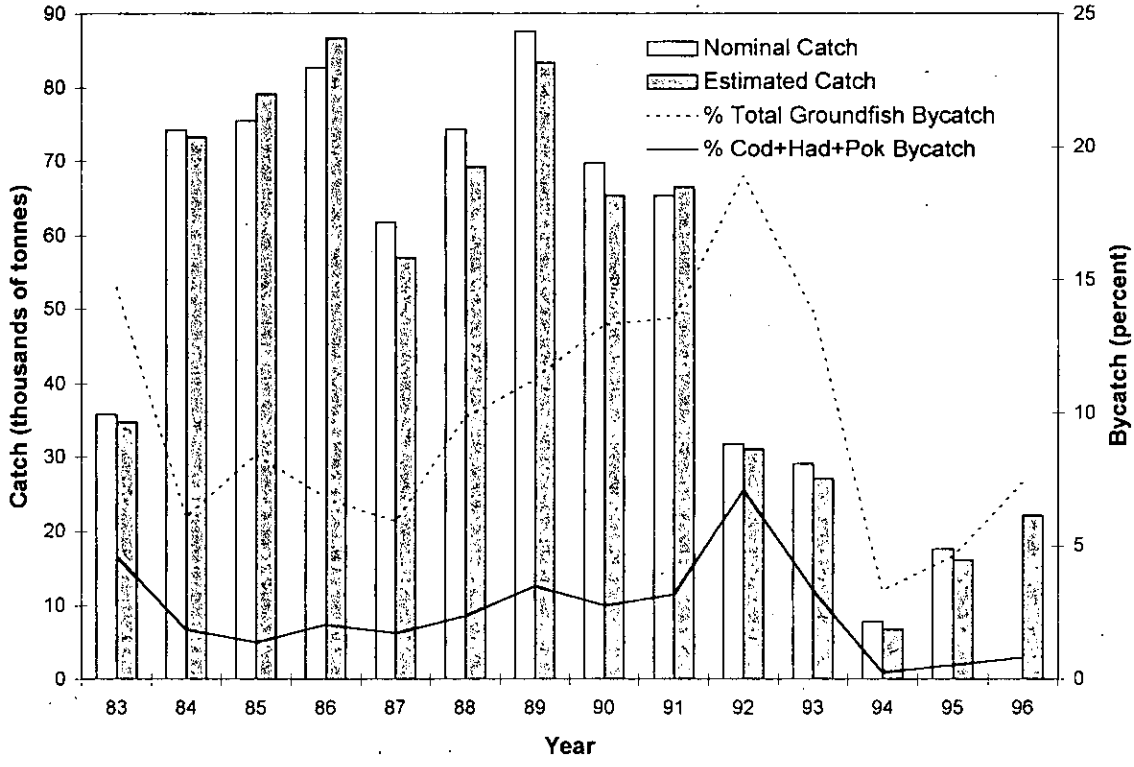


Figure 2. Nominal silver hake catch, estimated silver hake catch ('000 t), and total groundfish and cod+haddock+pollock bycatch as percentages of silver hake on Scotian Shelf, 1983-96.

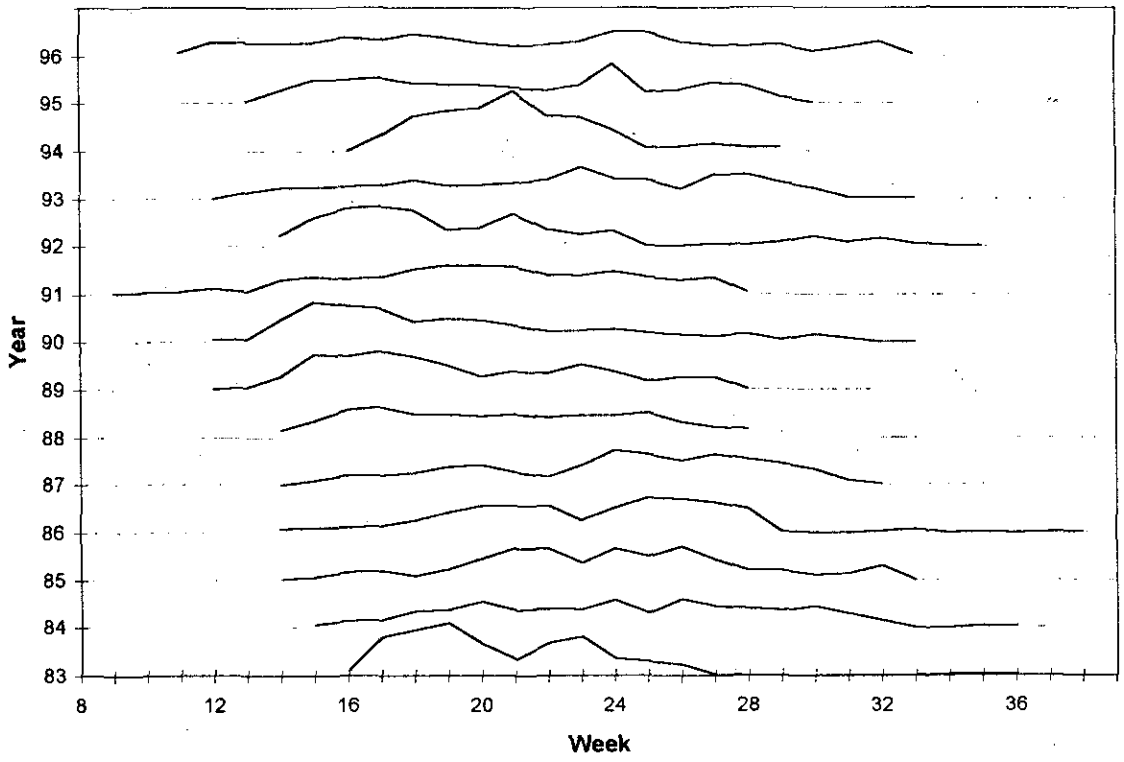


Figure 3. Percentage of annual silver hake catch by year and week for silver hake directed small mesh gear fleets on Scotian Shelf, 1983-96.

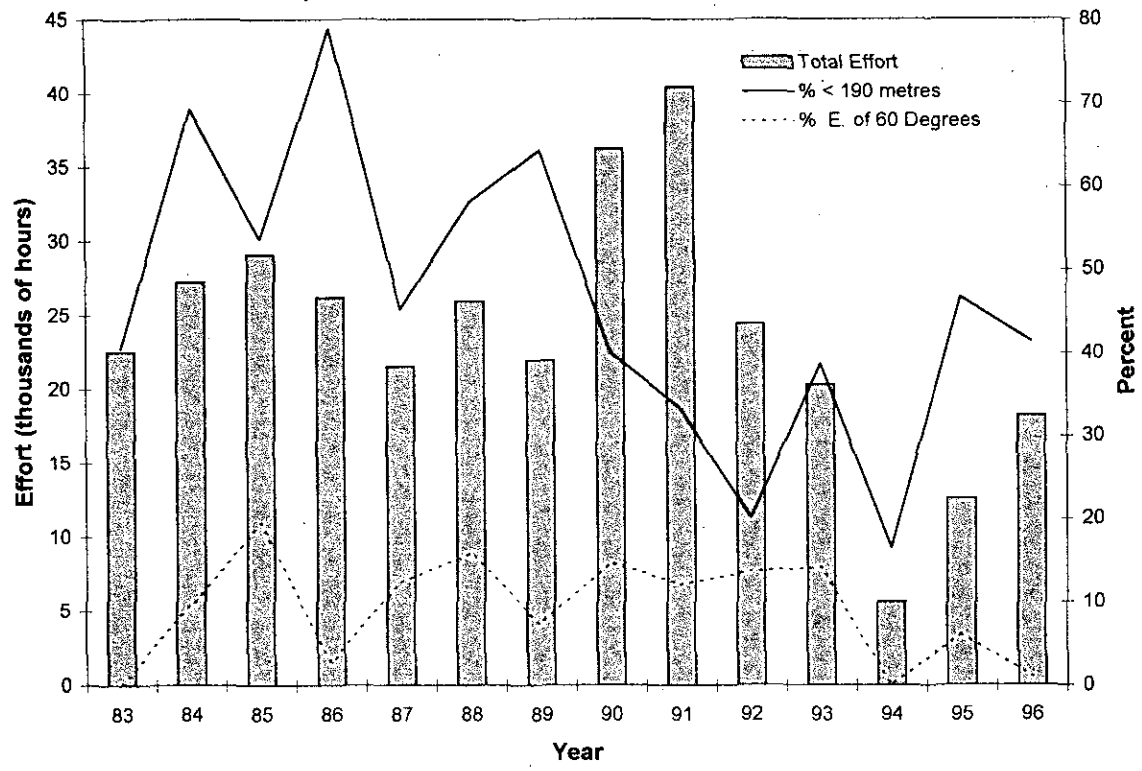


Figure 4. Total effort for all areas ('000 hr), and percentage of effort <190 m and in Extension directed towards silver hake on Scotian Shelf, 1983-96.

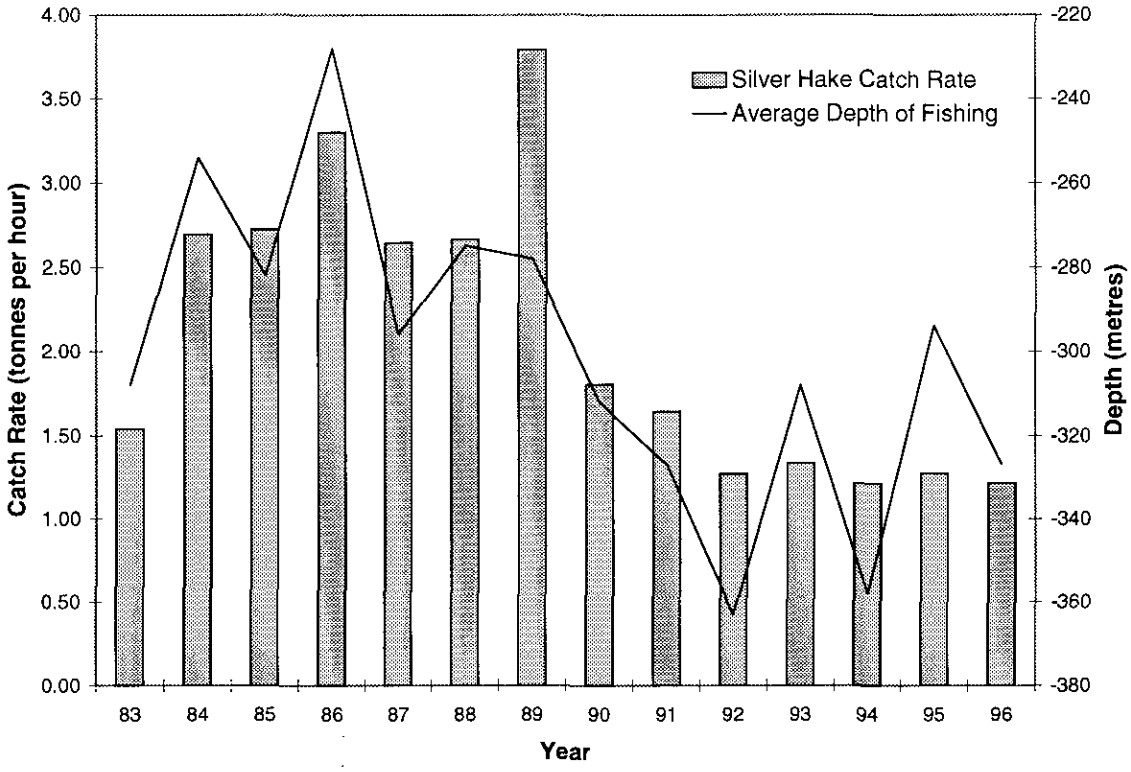


Figure 5. Silver hake catch rate (t/hr) and average depth of fishing (m) for silver hake directed small mesh gear fleets on Scotian Shelf, 1983-96.

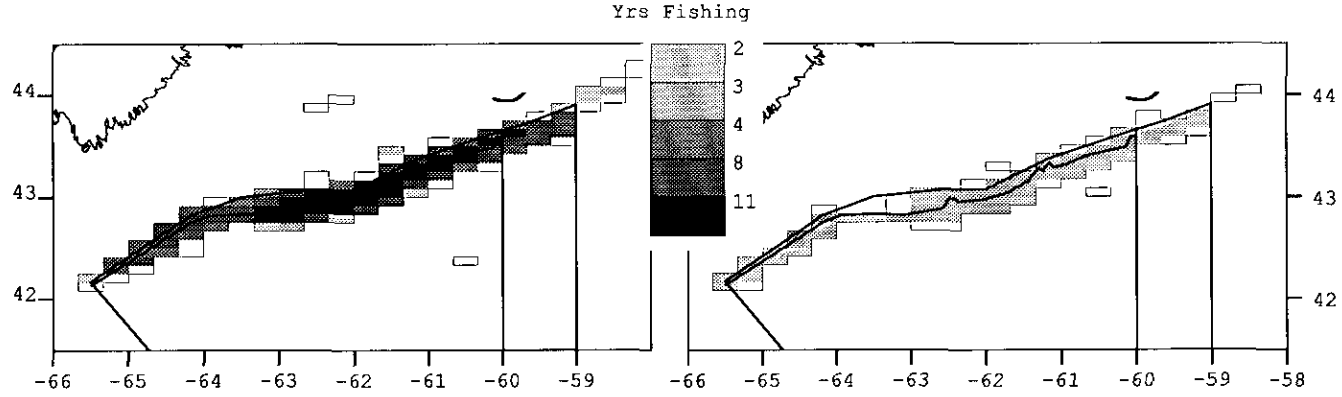


Figure 6.a. Number of years that fishing was directed towards silver hake on the Scotian Shelf by longitude (20' interval) and latitude (5' interval) during the periods 1983-93 (left panel) and 1994-96 (right panel).

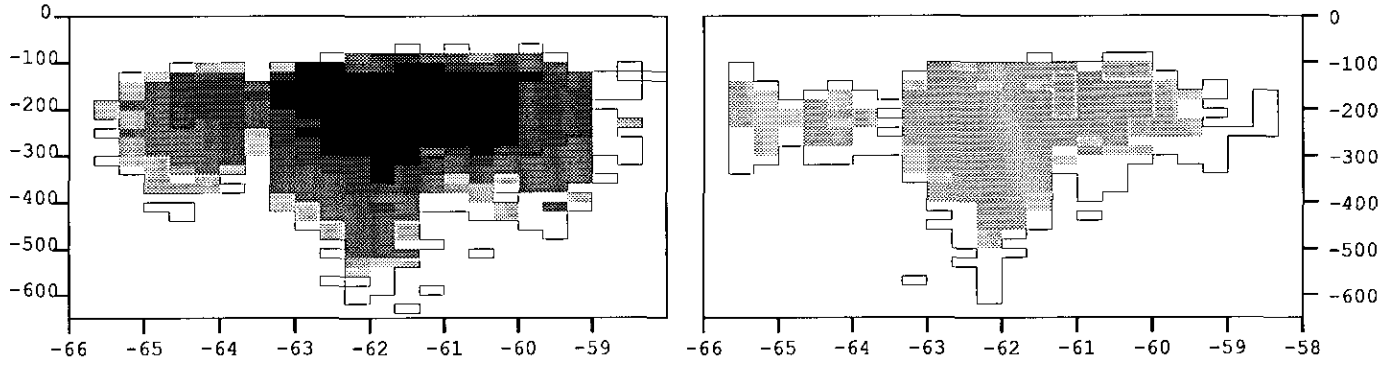


Figure 6.b. Number of years that fishing was directed towards silver hake on the Scotian Shelf by longitude (20' interval) and depth (20 m interval) during the periods 1983-93 (left panel) and 1994-96 (right panel).

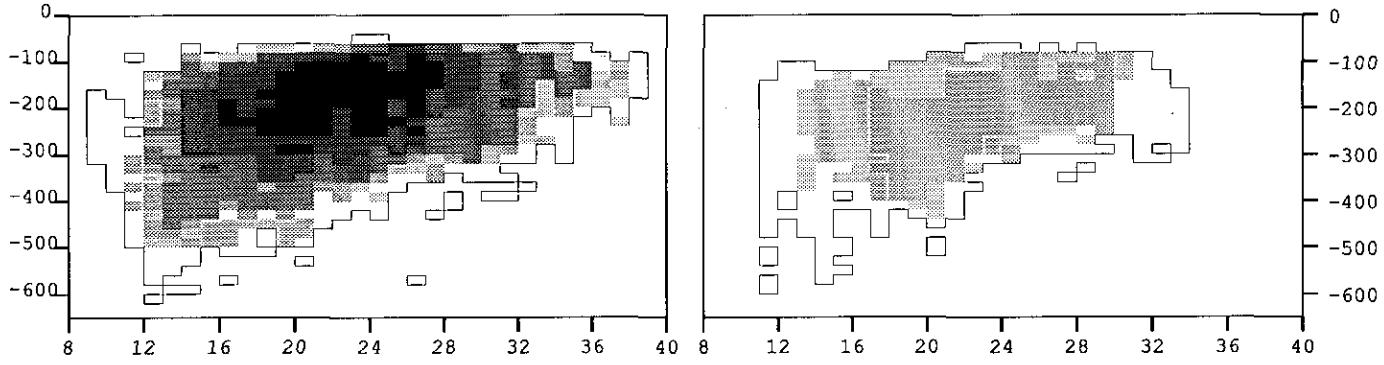


Figure 6.c. Number of years that fishing was directed towards silver hake in the Silver Hake Box by week and and depth (20 m interval) during the periods 1983-93 (left panel) and 1994-96 (right panel).

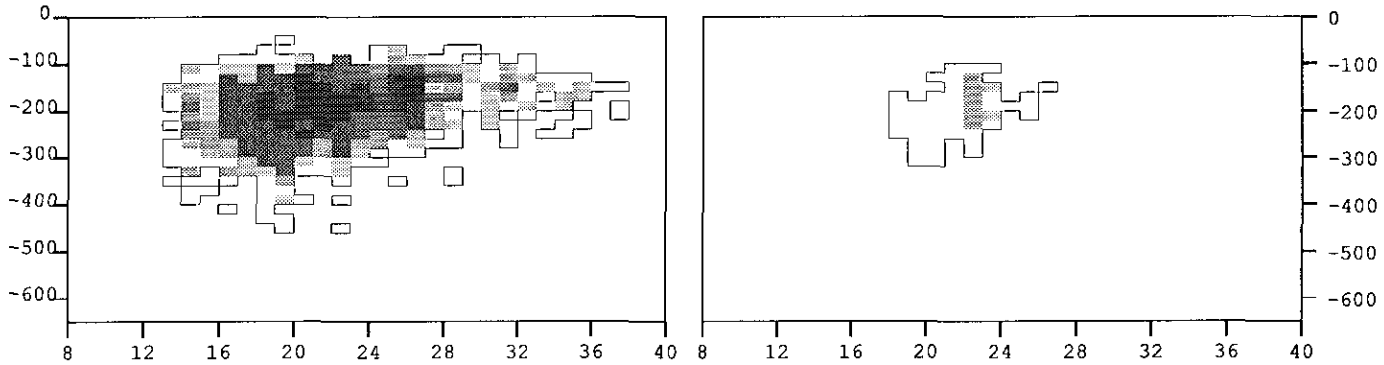


Figure 6.d. Number of years that fishing was directed towards silver hake in the Extension by week and depth (20 m interval) during the periods 1983-93 (left panel) and 1994-96 (right panel).

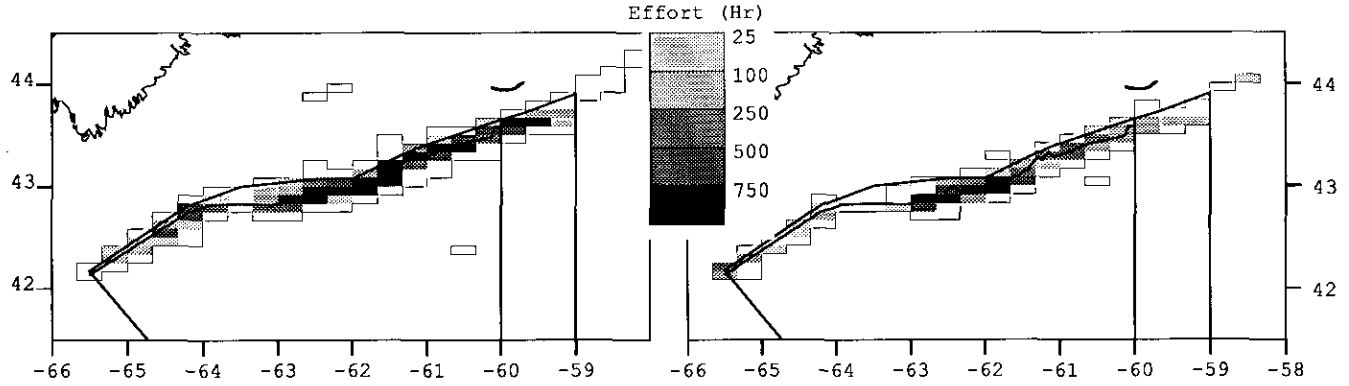


Figure 7.a. Fishing effort (hr/yr fished) directed towards silver hake on the Scotian Shelf by longitude (20' interval) and latitude (5' interval) during periods 1983-93 (left panel) and 1994-96 (right panel).

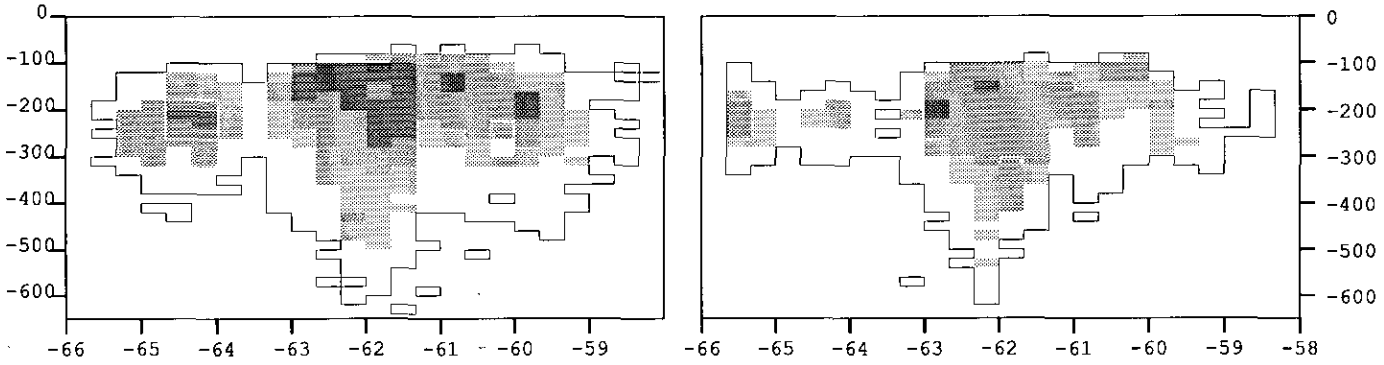
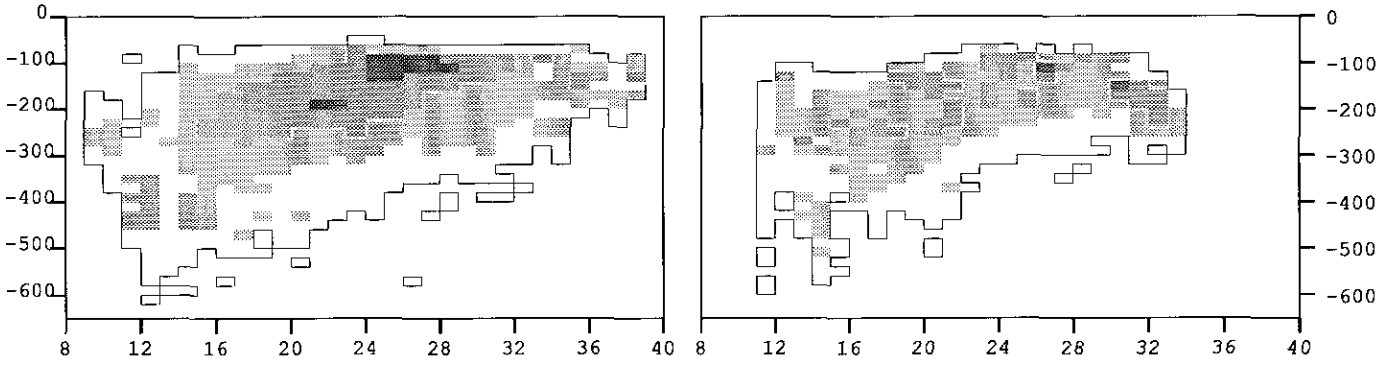


Figure 7.b. Fishing effort (hr/yr fished) directed towards silver hake on the the Scotian Shelf by longitude (20' interval) and depth (20 m interval) during the periods 1983-93 (left panel) and 1994-96 (right panel).



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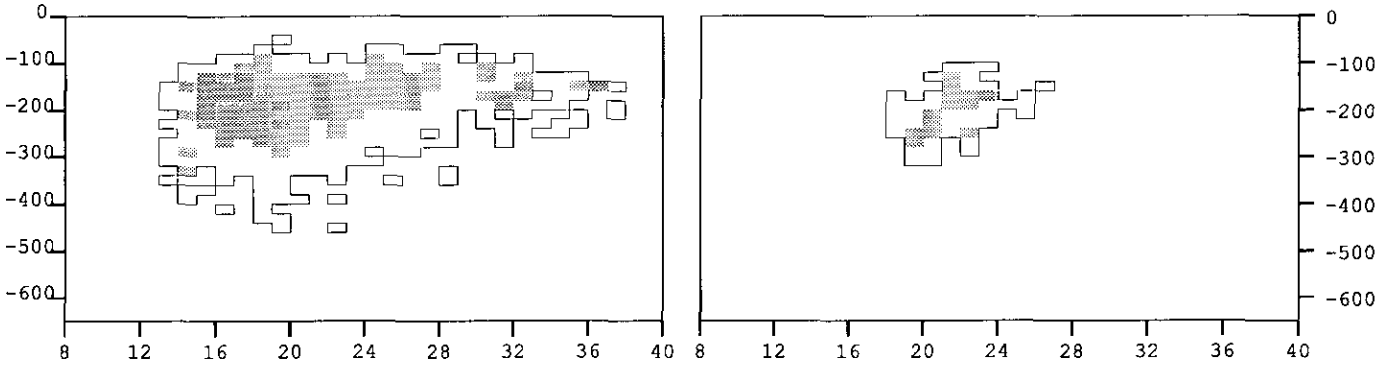

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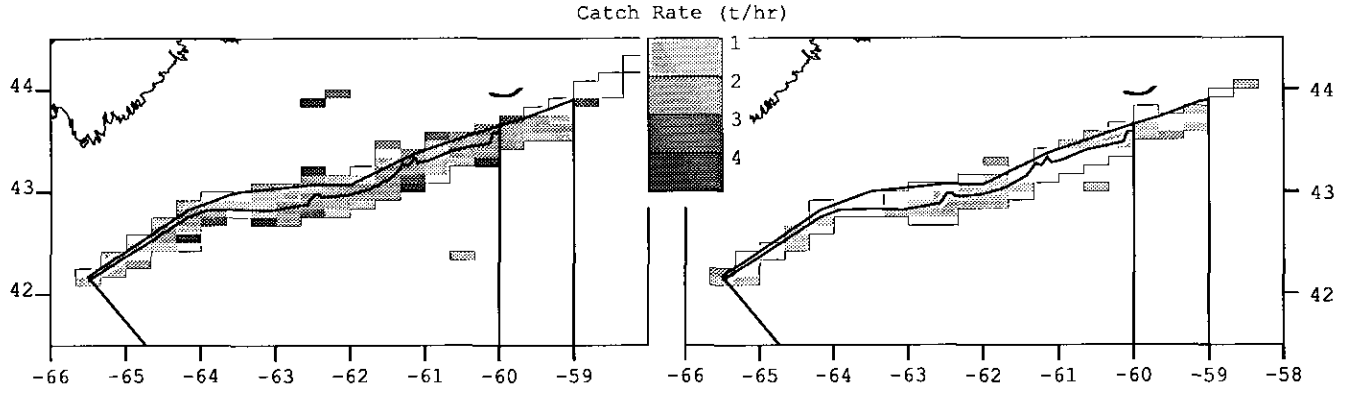
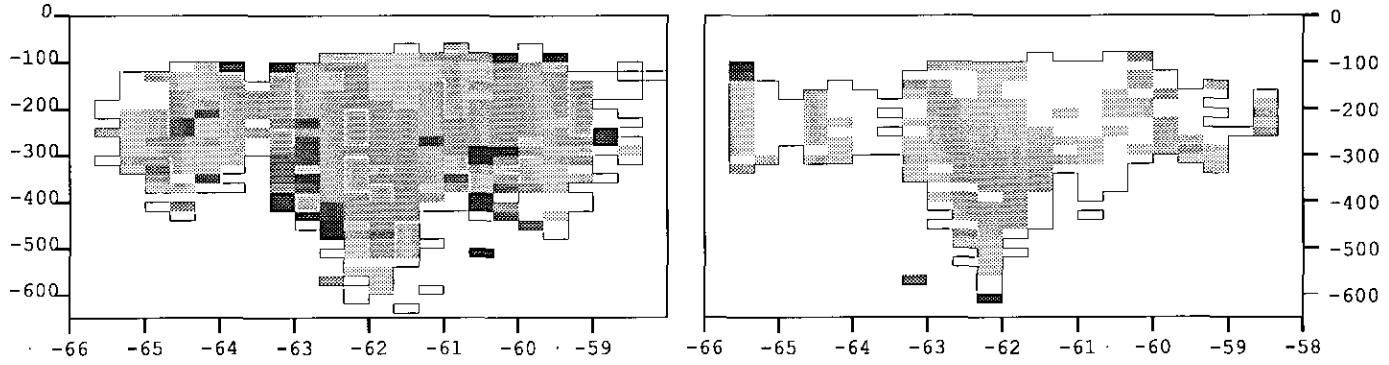


Figure 8.a. Silver hake catch rate (t/hr) on the Scotian Shelf by longitue (20' interval) and latitude (5' interval) during the periods 1983-93 (left panel) and 1994-96 (right panel).



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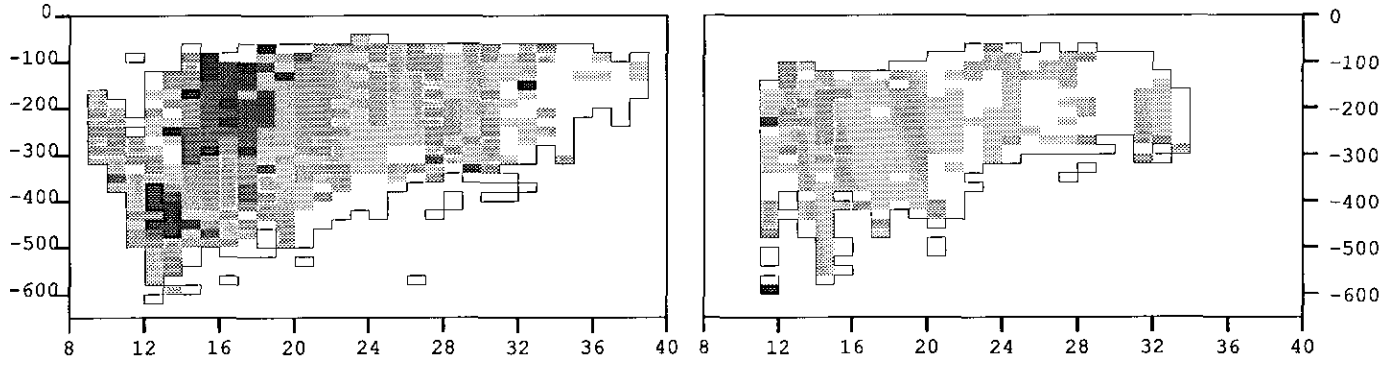

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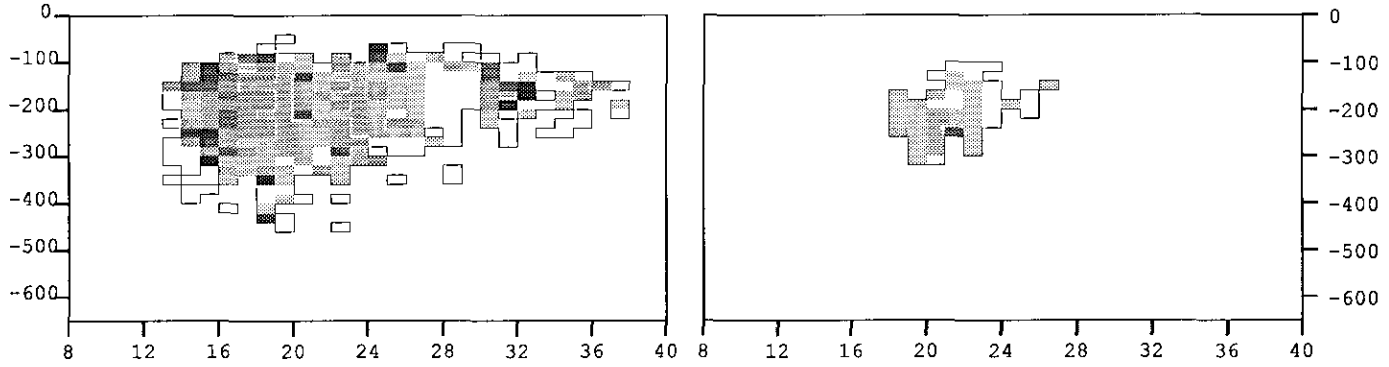

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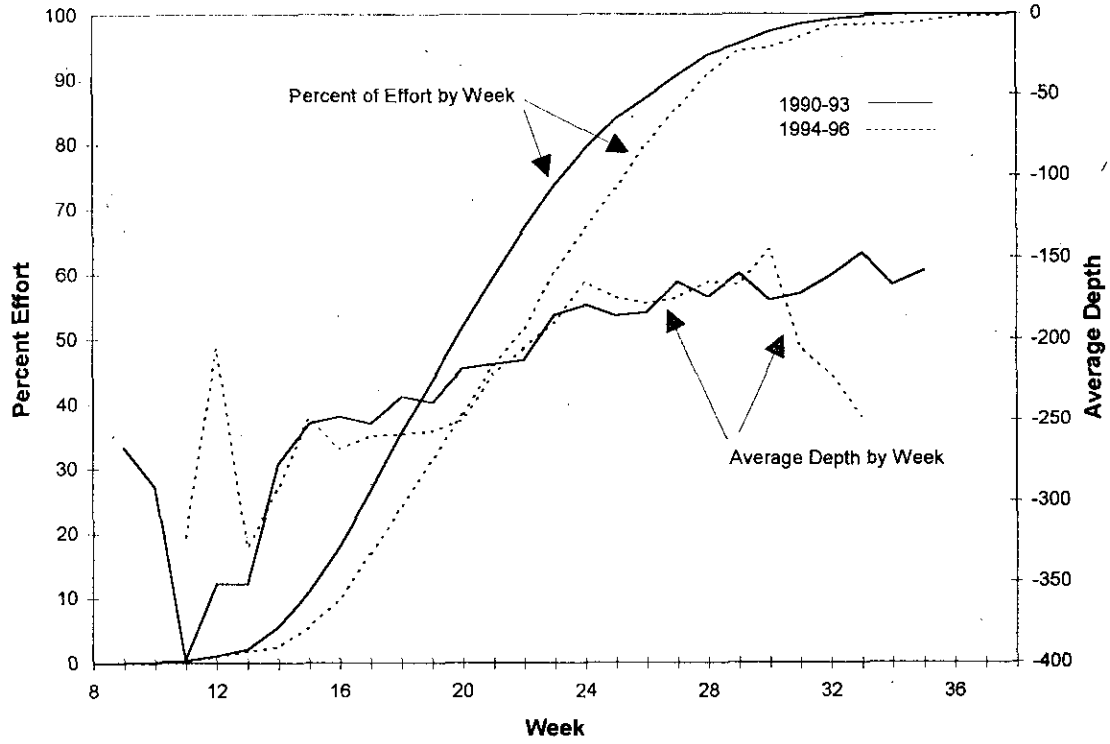

Figure 9. Cumulative percentage of fishing effort and average depth of fishing (m) by week for silver hake directed small mesh gear fleets on Scotian Shelf, 1990-93 and 1994-96.

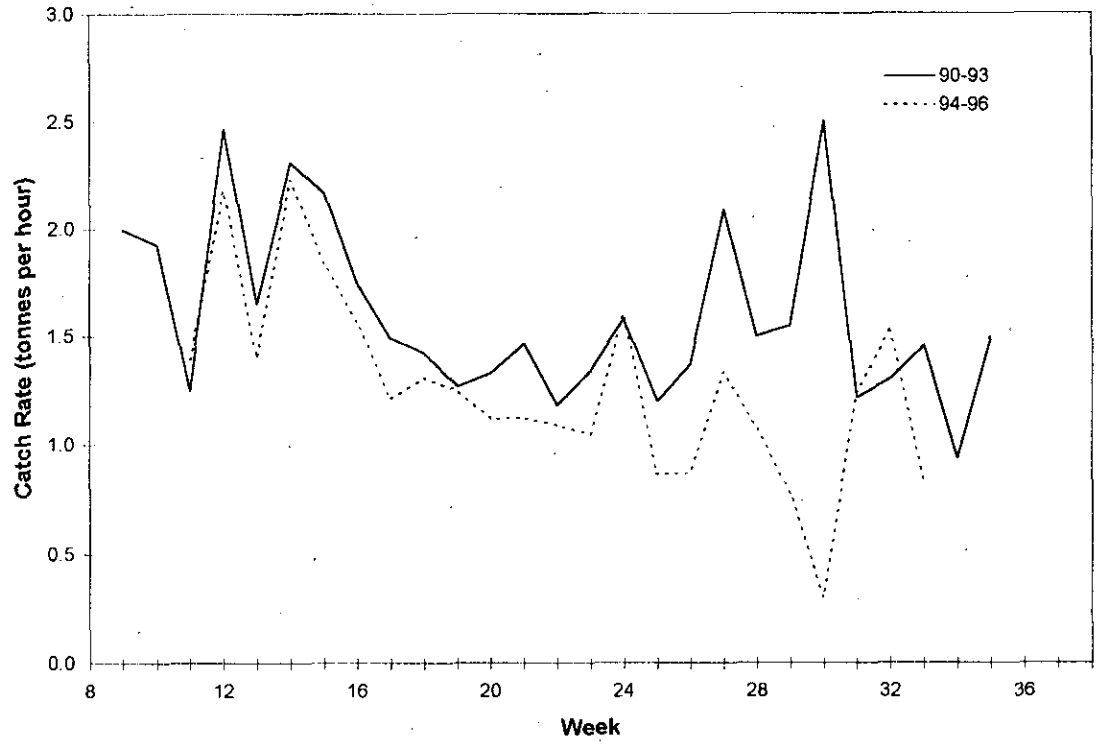

Figure 10. Average silver hake catch rate (t/hr) by week for silver hake directed small mesh gear fleets on Scotian Shelf, 1990-93 and 1994-96.

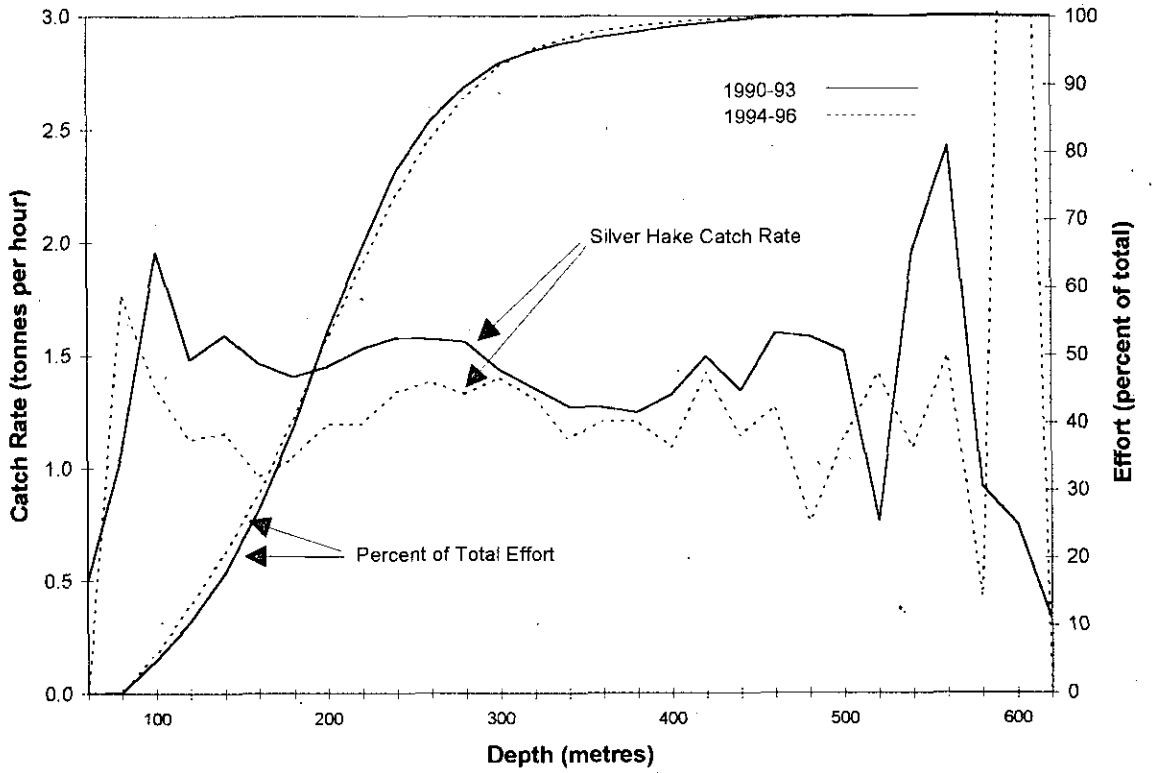

Figure 11. Cumulative percentage of fishing effort and silver hake catch rate (t/hr) by depth (20 m intervals) for small mesh gear fleets on Scotian Shelf, 1990-93 and 1994-96.

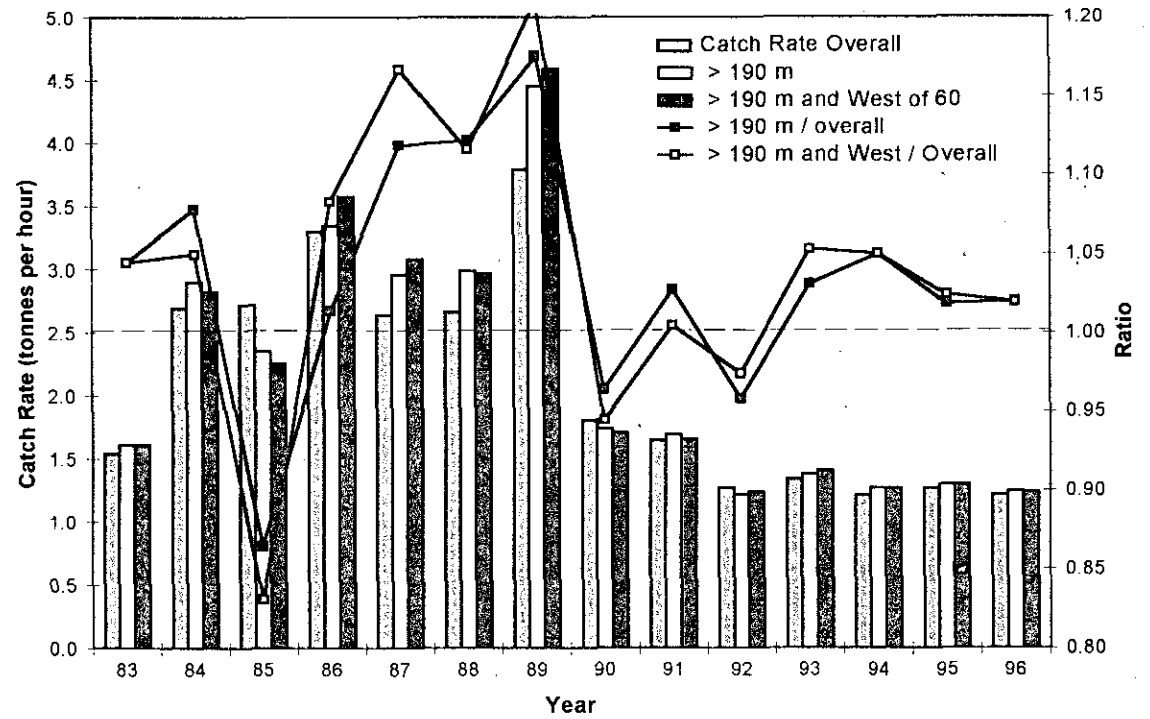

Figure 12. Silver hake catch rate (t/hr) by year and zone (overall, >190 metres, >190 and in Silver Hake Box) and ratios (>190 m/total , >190 m + Silver Hake Box/total) for small mesh gear fleets directing for silver hake on Scotian Shelf, 1983-96.