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Update on the By-catch in the Shrimp Fisheries in Davis Strait to Flemish Cap

by

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NAFO Division 3M (Shrimp Area 7)

A fishery for shrimp, in existence since the late 1970s on the Labrador Shelf, and in the Hudson and Davis Straits expanded to the Flemish Cap (NAFO Division 3M) in 1993. As with the shelf fishery, the Div. 3M grounds overlap with the distributions of other species resulting in a by-catch consisting primarily of small fish and invertebrates. A portion of the Canadian and Norwegian fleets carried fishery observers and the data collected by these individuals were used to examine the characteristics of the catch. This paper updates the changes that took place between 1993 and 1998 based on the observed portion of the fishery. Because of the use of small mesh gear and a complex local community structure, the by-catch in this fishery comprised about 125 species. The level and composition of by-catch was found to diminish over time due in part to the introduction of an excluding attachment, the Nordmore grate in 1994 and a reduction in bar spacing in subsequent years interacting with a changing community structure. Total by-catch was reduced from 33.26% of the catch in 1993 when no grate was in use to 4.29%, 3.44% and 2.43% in 1996, 1997 and 1998 respectively when narrow (19 to 22 mm) bar spacings were employed (Table 1).

In 1993 with no grate, redfish was dominant (28.5% of the total catch or 138 million fish) in the by-catch and along with other commercially valuable species namely wolffishes, skates, and turbot, comprised the majority of the catch (Fig. 2 and 4). Other commercially valuable species taken in lesser amounts were capelin, witch, plaice, cod and roundnose grenadier. The by-catch mix changed significantly with introduction of the grate in 1994. Primarily small or thin fish about the width of a shrimp that could fit through the bars of the grate were the main by-catch. However, redfish continued to make up the main by-catch until 1998 but at progressively reduced levels, specifically 19.0%, 1.1%, 1.0% 0.6% and 0.6% of the catch by weight, equivalent to 89, 5, 18, 4 and 5 million fish in 1994, 1995, 1996, 1997 and 1998 respectively (1998 estimate of numbers based on 1997 size composition). Redfish comprised mainly 2 to 8-year olds but the mix of year classes was found to fluctuate from year to year (Fig. 5). The majority were 5 and 6 year olds in 1993, 6 and 7 in 1994 and the same in 1995. However, there was an 18 fold decrease in numbers of redfish between 1994 and 1995 concurrent with a reduction of grate spacing from 28 to 22 mm (Fig. 3). Although weight of redfish as a percent of total catch did not increase in 1996, numbers increased more than threefold. This was due to a large proportion of 2-year olds taken in 1996, not encountered in other years. Age 2 redfish being as small as the shrimp were not excluded by the grate. In 1997, redfish (mainly 3 to 6 year olds) was no longer the main by-catch. A mix of lanternfish (Myctophidae), small pelagic species about the size of shrimp constituted the largest by-catch component in that year. In 1998, redfish was again the most abundant by-catch although the small pelagic species continued to constitute a significant part of the by-catch. Lost yield of redfish is estimated for a series of natural mortality levels. Using Canadian weight-at-age and assuming a constant mortality of 0.1 with $F_{0.1}$ of 0.124, the estimated lost yield relating to by-catch mortality in the shrimp fishery for 1993 to 1997 was 40 000 tons. Lost yield has not been calculated for 1998.

Table 1 - List of species caught in the northern shrimp fishery in NAFO Division 3M, 1993 - 1998. Estimated amounts are based on the catch composition from Canadian (1993-1998) and Norwegian (1995-1998) vessels.

3M Species	1993		1994		1995		1996		1997		1998		1999	
	Catch	Percent	Catch	Percent	Catch	Percent	Catch	Percent	Catch	Percent	Catch	Percent	Catch	Percent
<i>Shrimp</i>	28,088.0	66.74	24,325.0	78.15	32,980.0	97.41	51,163.0	95.71	25,450.0	96.56	34,305.00	97.57		0.00
Redfish	11,970.0	28.44	5,902.7	18.96	374.2	1.11	549.5	1.03	157.4	0.60	216.44	0.62	55.00	0.16
Lanternfish	70.2	0.17	63.6	0.20	144.7	0.43	296.5	0.55	195.4	0.74	106.63	0.30		0.00
Eelpout	38.5	0.09	82.4	0.26	75.8	0.22	292.3	0.55	127.6	0.48	79.04	0.22		0.00
Turbot	309.2	0.73	96.7	0.31	32.2	0.10	78.6	0.15	41.6	0.16	57.12	0.16		0.00
Striped. Wolfish	176.8	0.42	69.0	0.22	56.4	0.17	153.2	0.29	64.6	0.24	17.68	0.05		0.00
¹ Skates	354.2	0.84	22.8	0.07	12.2	0.04	67.5	0.13	16.9	0.06	36.60	0.10		0.00
Spotted Wolfish	392.5	0.93	20.3	0.07	12.5	0.04	35.7	0.07	5.7	0.02	7.96	0.02		0.00
Common Grenadier	5.5	0.01	79.7	0.26	27.3	0.08	129.1	0.24	20.4	0.08	12.91	0.04		0.00
Roughhead Grenadier	15.8	0.04	75.9	0.24	7.8	0.02	60.0	0.11	1.1	0.00	41.56	0.12		0.00
Snipe Eel	10.4	0.02	15.9	0.05	2.1	0.01	45.9	0.09	27.2	0.10	88.42	0.25		0.00
Barracudina	4.0	0.01	15.9	0.05	7.3	0.02	60.1	0.11	44.2	0.17	38.20	0.11		0.00
Viperfish	10.1	0.02	19.6	0.06	5.7	0.02	60.2	0.11	14.2	0.05	24.93	0.07		0.00
Longfin Hake	14.1	0.03	24.6	0.08	5.8	0.02	46.7	0.09	14.2	0.05	15.03	0.04		0.00
Greenland Shark	46.6	0.11	50.1	0.16	0.0	0.00	7.6	0.01	0.0	0.00	0.00	0.00		0.00
Capelin	65.5	0.16	12.8	0.04	2.7	0.01	1.5	0.00	7.5	0.03	3.71	0.01		0.00
Northern Wolfish	69.7	0.17	0.2	0.00	0.0	0.00	0.4	0.00	1.9	0.01	16.98	0.05		0.00
Plaice	59.9	0.14	11.1	0.04	6.4	0.02	7.1	0.01	1.9	0.01	1.41	0.00		0.00
Lancefish	24.5	0.06	3.0	0.01	6.1	0.02	23.9	0.04	0.5	0.00	13.97	0.04		0.00
Witch	31.9	0.08	12.1	0.04	5.3	0.02	10.1	0.02	4.4	0.02	3.71	0.01		0.00
Roundnose Grenadier	10.4	0.02	10.3	0.03	0.1	0.00	5.4	0.01	21.2	0.08	0.00	0.00		0.00
Basking Shark	35.3	0.08	0.0	0.00	0.0	0.00	0.0	0.00	9.5	0.04	0.00	0.00		0.00
Cod	18.9	0.04	2.3	0.01	0.3	0.00	0.1	0.00	0.1	0.00	0.00	0.00		0.00
Silver Hake	0.1	0.00	17.4	0.06	0.0	0.00	0.0	0.00	0.0	0.00	0.00	0.00		0.00
Haiibut	8.0	0.02	0.0	0.00	0.0	0.00	0.0	0.00	2.0	0.01	1.77	0.01		0.00
² Other	255.6	0.61	192.4	0.62	92.1	0.27	361.0	0.68	125.9	0.48	68.59	0.20		0.00
Sum	42,085.9		31,125.8		33,856.8		53,455.3		26,355.4		35,157.7		55.0	

¹Consists of approximately 95% percent Thorny Skate

²Other - comprises 110 other species caught in varying amounts.

	1993	1994	1995	1996	1997	1998	1999	Sum	Avg
Redfish	11,970	5,903	374	550	155	216	55	19,167.5	3,194.6
Wolfishes	639	90	69	189	71	43		1,100.2	183.4
Lanternfishes	70	64	145	296	192	107		873.4	145.6
Eelpouts	38	82	76	292	125	79		693.9	115.5
Turbot	309	97	32	79	41	57		614.7	102.5
Skates	354	23	12	68	17	18		491.0	81.8
Shrimp	28,088	24,325	32,980	51,163	25,000	34,305		195,861.0	

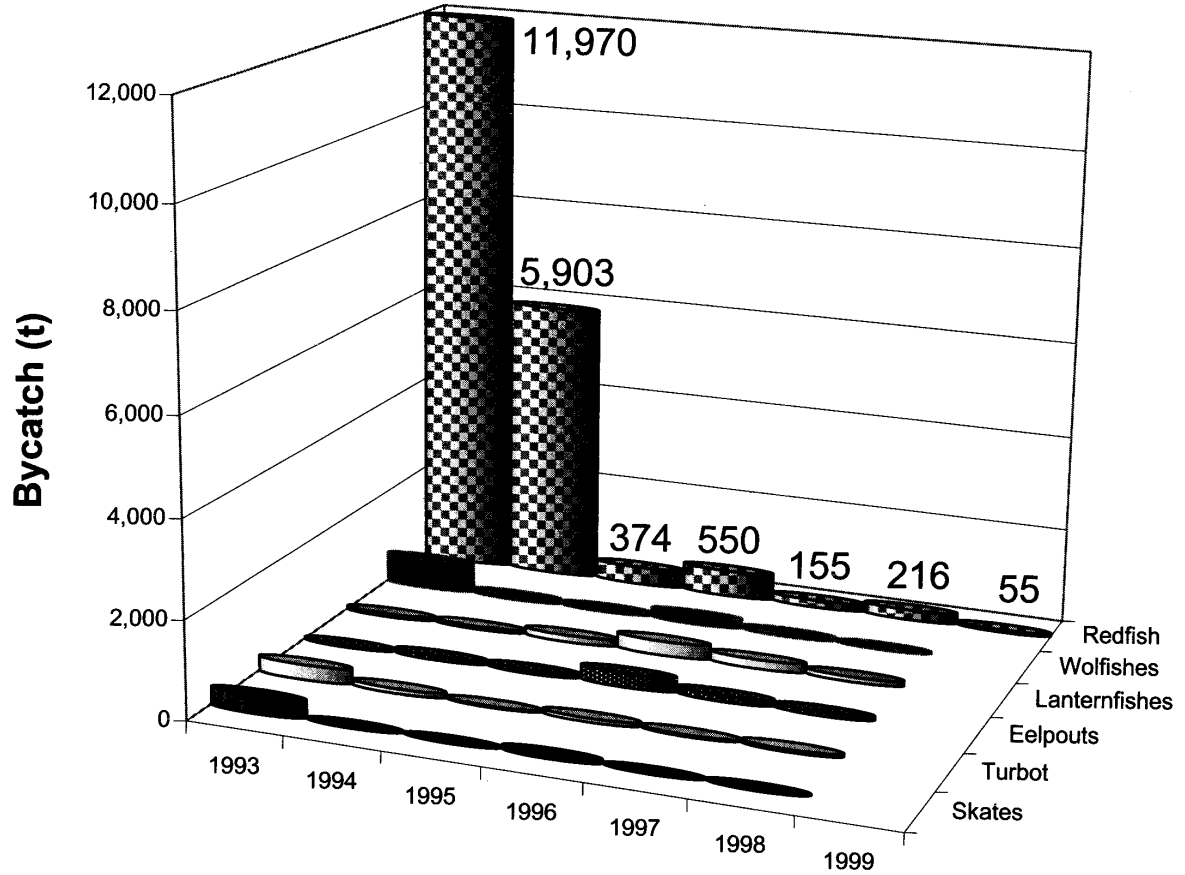


Figure 1. By-catch of groundfish in the NAFO Division 3M shrimp fishery, 1993-1998.

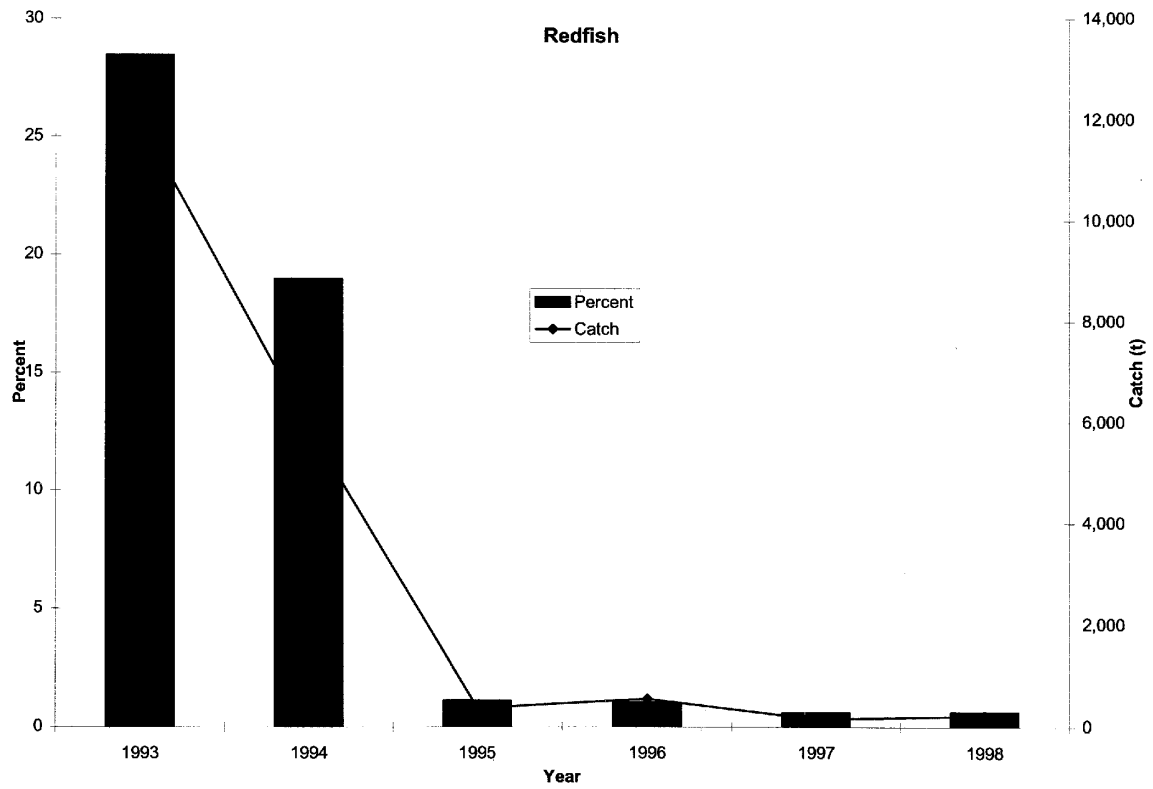


Figure 2. Redfish discards in the Div. 3M shrimp fishery, 1998.

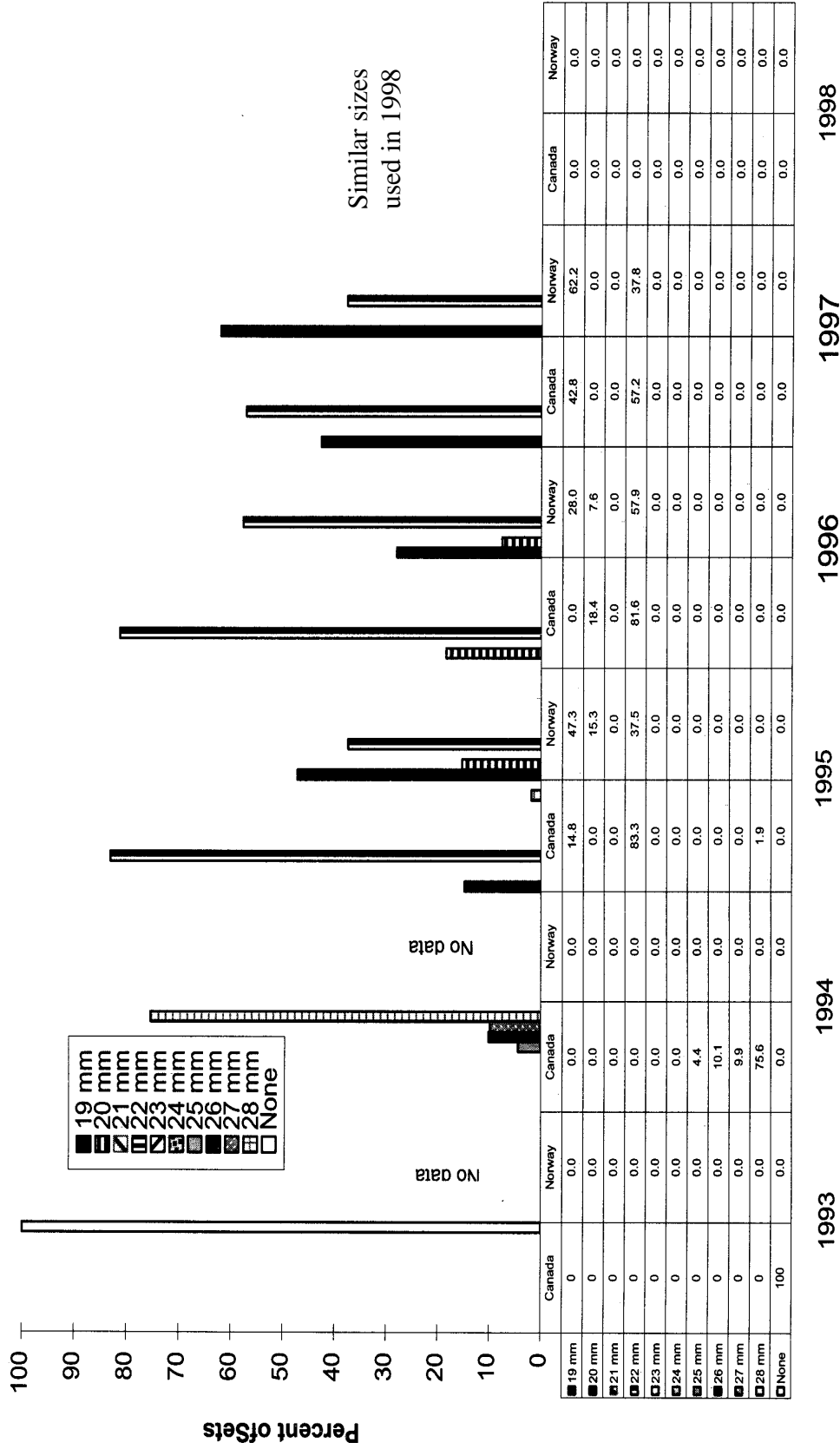


Figure 3. Observed Nordmore grate usage for observed Canadian and Norwegian shrimp fishery on the Flemish Cap, 1993-1998.

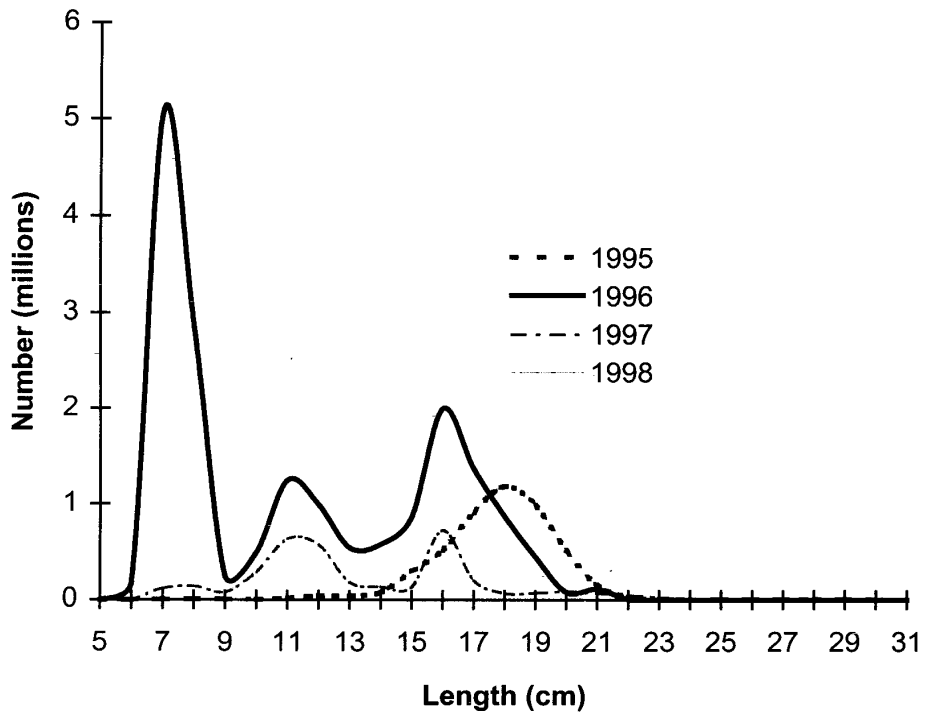
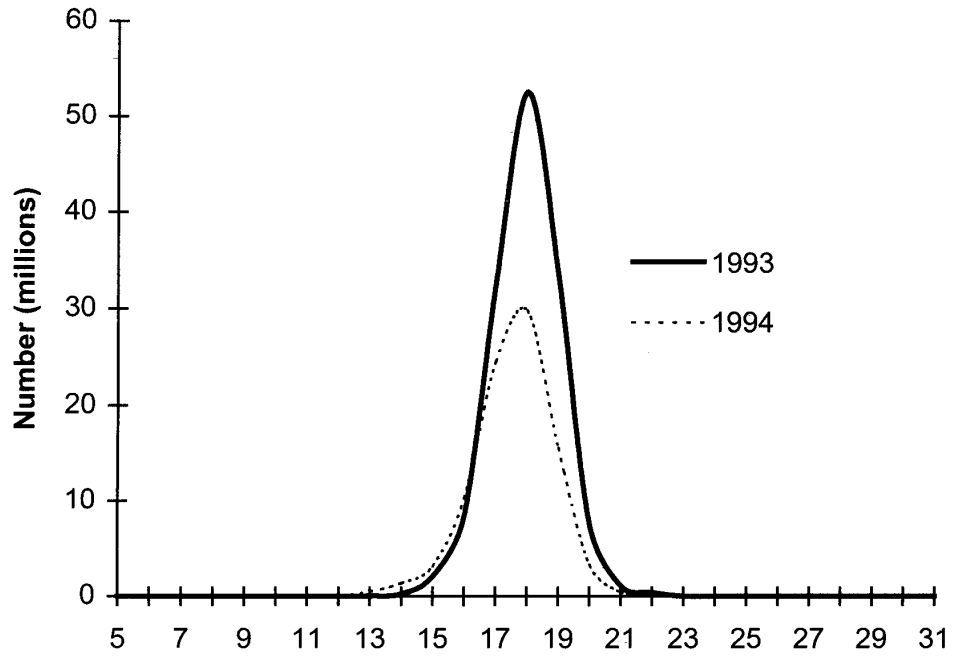


Figure 4. Numbers at length of redfish taken as by-catch in the Flemish Cap shrimp fishery. Upper panel shows years where no grate was used. Lower panel shows years where the grate was used.

#'s at Age	1	2	3	4	5	6	7	8	9	10	11	12	13	14+	Total
1993	0	0	195	98,004	1,688,139	39,594,369	66,647,415	25,703,839	3,755,980	537,733	17,963	0	0	0	138,043,637
1994	0	0	2,167	389,677	3,061,298	30,843,241	39,488,339	13,315,336	1,768,285	243,622	7,245	0	0	0	89,119,209
1995	366	14,675	16,765	62,837	225,815	1,410,515	1,956,160	901,837	174,575	33,309	6,688	5,245	4,401	13,182	4,826,373
1996	364,987	7,584,546	1,213,829	1,654,235	1,593,324	3,104,647	1,840,427	472,677	69,055	10,258	725	0	0	0	17,908,710
1997	7,858	267,253	517,133	839,620	553,680	783,151	374,392	155,066	55,383	16,896	6,138	1,495	438	188	3,578,893
1998	373,212	7,866,474	1,750,090	3,044,374	7,122,256	75,735,923	110,306,732	40,548,756	5,823,278	841,818	38,759	6,741	4,839	13,370	253,476,621

Percent	1	2	3	4	5	6	7	8	9	10	11	12	13	14+
1993	0.0%	0.0%	0.1%	1.2%	12.8%	28.7%	48.3%	18.6%	2.7%	0.4%	0.0%	0.0%	0.0%	0.0%
1994	0.0%	0.0%	0.0%	0.4%	3.4%	34.6%	44.3%	14.9%	2.0%	0.3%	0.0%	0.0%	0.0%	0.0%
1995	0.0%	0.3%	0.3%	1.3%	4.7%	29.2%	40.5%	18.7%	3.6%	0.7%	0.1%	0.1%	0.1%	0.3%
1996	2.0%	42.4%	6.8%	9.2%	8.9%	17.3%	10.3%	2.6%	0.4%	0.1%	0.0%	0.0%	0.0%	0.0%
1997	0.2%	7.5%	14.5%	23.5%	15.5%	21.9%	10.5%	4.3%	1.5%	0.5%	0.2%	0.0%	0.0%	0.0%
1998	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
All years	0.1%	3.1%	0.7%	1.2%	2.8%	29.9%	43.5%	16.0%	2.3%	0.3%	0.0%	0.0%	0.0%	0.0%

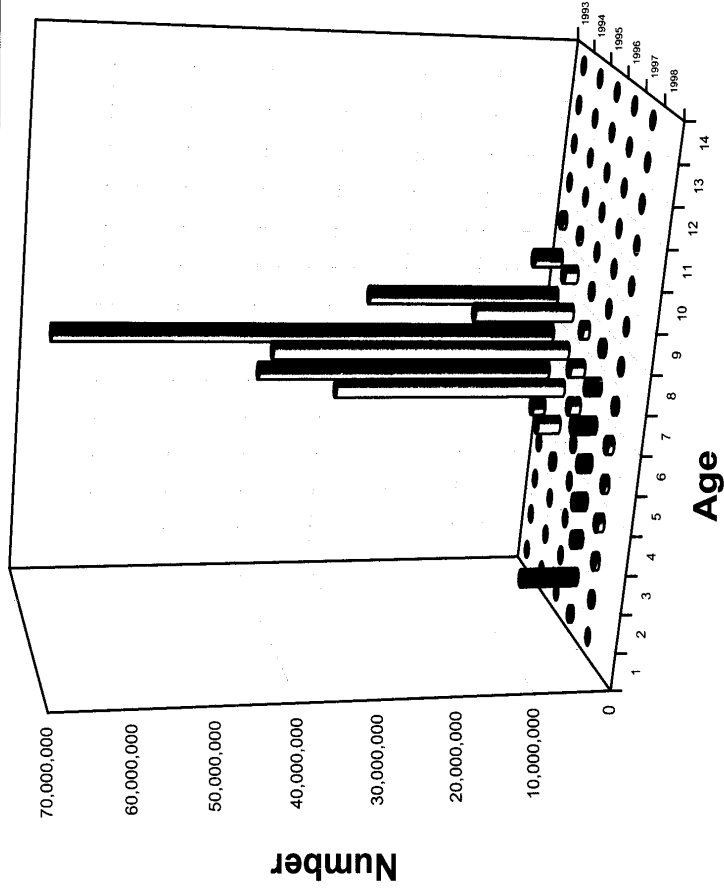


Figure 5. Estimated numbers of redfish at age taken as by-catch in the Flemish Cap shrimp fishery, 1993-1998.

Shrimp Area 1-4

A fishery for shrimp (*Pandalus borealis* and *P. montagui*) has existed since the late 1970s in Atlantic Canadian waters. As with most shrimp fisheries of the world, by-catch, primarily finfish is commonly taken by the small meshed otter trawl gear. This paper focuses on by-catch taken from 4 statistical areas in and adjacent to Davis Strait. This northern fishery comprises 6 distinct grounds overlapping extensively with the distributions of various other species. Based on the records of fishery observers, a mix of both shrimp species plus about 125 other fish and invertebrates were recorded in the catches with redfish and turbot comprising the majority. Because of the use of small mesh gear (30 mm), this by-catch was often comprised of pre-recruit fish in substantial numbers. Specifically, for Statistical Area 1 (Davis Strait North) total by-catch (fish and invertebrates) peaked at 30% of the total catch in 1992 but declined to 8% by 1997 and 12.5% in 1998. The predominant species, redfish, amounted to 1,951 tons (137 million fish, mainly 2-5 year olds) in 1992 but declined dramatically to 46 tons (2.2 million fish mainly 3-4 year olds) in 1997 and 89 tons (4.3?? million fish mainly 3-4 year olds) in 1998. The redfish tended to be distributed fairly evenly across the area where shrimp were fished. Similarly, turbot by-catches have dropped from 321 tons (2.1 million fish) in 1991 to 4 tons (12,823 fish) in 1997 and 11 tons (35,000 estimated) in 1998. The majority were taken on the eastern extent of the fishing ground.

For the SA 2(Davis Strait South) fishery, comprising 4 grounds, the main area fished adjacent to Statistical Area 3, total by-catch was considerably lower than to the north ranging from 23% of the catch in 1991 to 3.4% in 1997 and 1.7% in 1998 (average 5.5% in 1995-1997). The catches of redfish in this area peaked in 1992 at 258 tons (9.8 million fish). Amounts have remained at similar levels averaging 193 tons (3.2 million fish mainly 2-4 year olds) between 1995 and 1998. Turbot by-catches in this area have dropped from 96 tons (2 million fish) in 1998 to 4 tons in 1993, increasing to 38 tons (30,076 fish) in 1997 and 13.4 tons in 1998.

Reduction of the by-catch is due in part to the introduction of the Nordmore grate in 1993 and its mandatory use in 1997-98. In particular, a decrease in bar spacing from 28 to 22 mm appeared to have the greatest effect on reduction of the by-catch. At 28 mm, it appears that a substantial proportion of fish taken, particularly (smaller) redfish to the north can slip through the wider grate spacing. The decreased numbers observed in 1995-1998 may also relate to fewer fish available to the gear although all species except the very smallest individuals tended to decline somewhat proportionately illustrating the importance of the grate in by-catch reduction particularly with narrower bar spacing. Other common species taken in order of importance were sculpins, Arctic cod, skates, sea snails and jellyfish (Cnidaria).

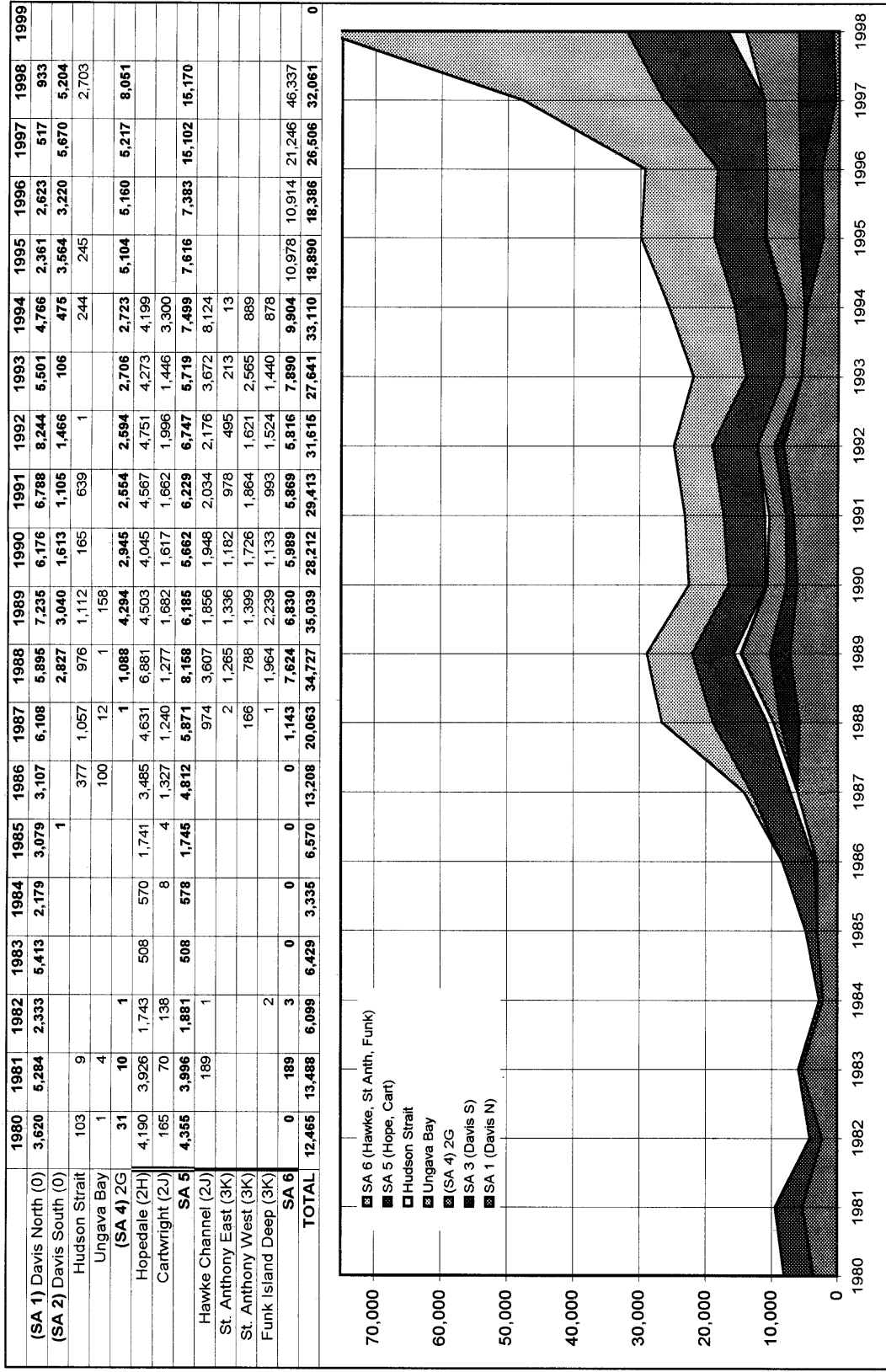


Figure 6. Landings of shrimp in Shrimp Areas 1-6, 1980-1998.

Table 2. Shrimp Area 1-4 – 1998-99 by-catch.

Stock	Landed Shrimp	Observed Kept Shrimp	Observed Redfish		Observed Turbot		Observed Plaice		Estimated Redfish		Estimated Turbot		Estimated Plaice		Landed Total Catch	% of Catch		
			Catch	Catch	Catch	Catch	Catch	Catch	Catch	Catch	Catch	Catch	Catch	Catch		Redfish	Turbot	
1998																		
Large Vessel, with Grate																		
0A	917.411	808.010	74.800	9.180	0.000	0.180	84.928	10.423	0.000	0.204	933	8.47%	1.12%					
0B	6,683.140	6,683.140	51.380	13.360	0.000	0.160	51.380	13.360	0.000	0.160	5,204	0.76%	0.20%					
2G	7,765.049	6,085.750	78.770	10.110	0.020	0.240	100.506	12.900	0.026	0.306	8,051	1.28%	0.17%					
Hud																		
Large Vessel, without Grate																		
0A	15.589	13.730	3.790	0.510	0.010	0.010	4.303	0.579	0.011	0.011	21.63%	3.58%						
0B	245.300	245.350	1.660	0.510	0.000	0.000	1.660	0.510	0.000	0.000	0.67%	0.21%						
2G	285.951	224.110	2.440	0.860	0.000	0.010	3.113	1.097	0.000	0.013	1.08%	0.38%						
Hud																		
1999																		
Large Vessel, with Grate																		
0A											933	0.95%	0.11%					
0B		833.180	4.710	0.910	0.000	0.010	51.380	13.360	0.000	0.160	5,204	0.56%	0.06%					
2G		381.400	3.660	0.240	0.000	0.020					8,051							
Hud																		
Large Vessel, without Grate																		
0A							1.660	0.510	0.000	0.000								
0B																		
2G																		
Hud																		

Redfish	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Davis North	557.6	525.4	123.5	142	109.7	178	628.9	1090.2	725.2	1085	801.3	1419.8	1950.9	779.4	907.3	356.41	202.86	0	4.303	
Davis North	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	76.07	121.99	46.09	84.928	
Davis North	557.6	525.4	123.5	142	109.7	178	628.9	1090.2	725.2	1085	801.3	1419.8	1950.9	779.4	907.3	432.48	324.85	46.09	89.231	
Davis South	0	0	0	0	0	0	0	0	74.8	197	181.6	168.6	258.3	19	41.9	185.99	111.21	0.35	1.66	
Davis South	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	59.5	99.81	122.19	51.38	
Davis South	0	0	0	0	0	0	0	0	74.8	197	181.6	168.6	258.3	19	41.9	245.49	211.02	122.54	53.04	
Ungava/Hudson	0	0.1	0	0	0	0	0.2	4.1	4.1	1.9	0.1	3	0.2	0	0.2					
NAFO Div. 2G	0	0.4	0	0	0	0	0	0.1	66.7	132.1	137.1	117.6	214.5	100	45.9					
Sum	557.6	525.9	123.5	142.0	109.7	178.0	629.1	1,094.4	872.8	1,416.0	1,120.1	1,709.0	2,423.9	898.4	995.3	678.0	535.9	168.6	245.9	0.0
Percent North	100%	100%	100%	100%	100%	100%	100%	100%	83%	77%	72%	83%	80%	87%	91%	64%	61%	27%	36%	

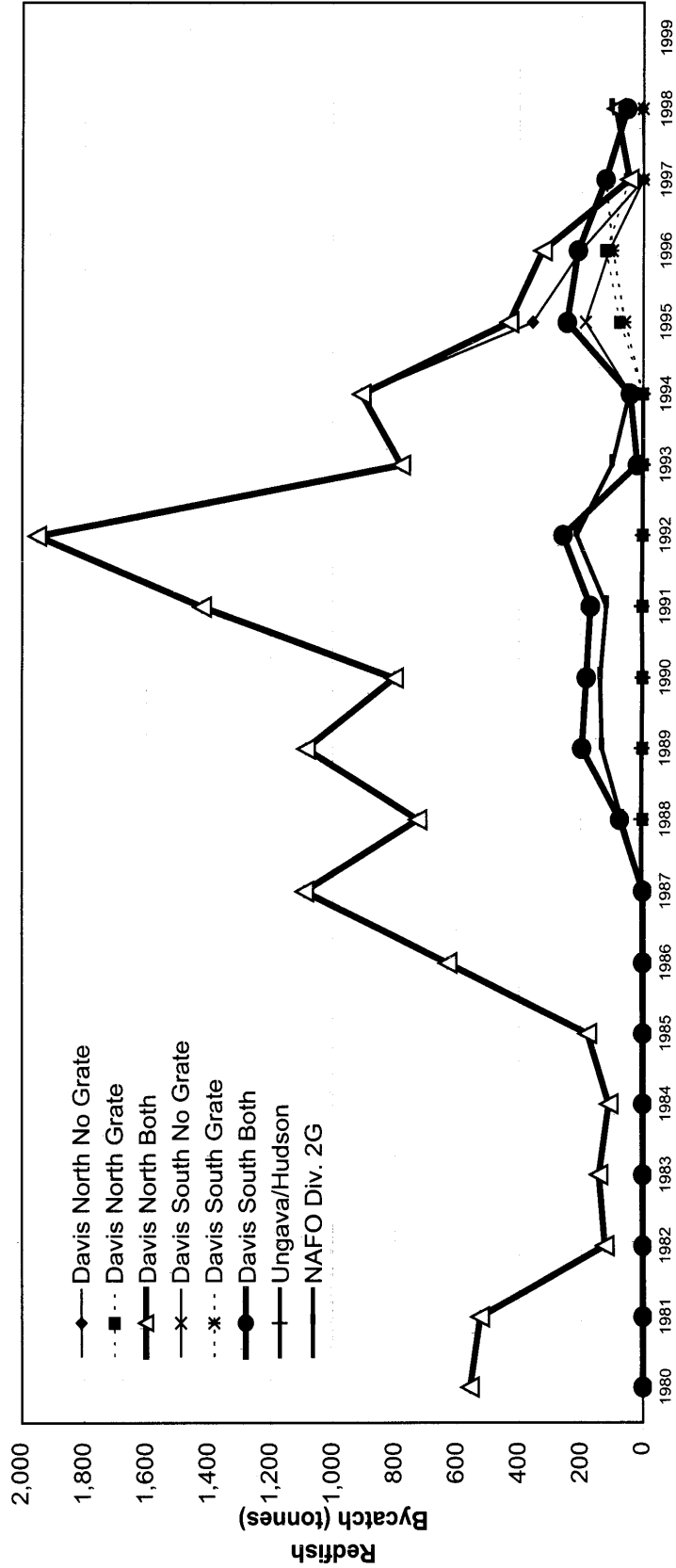


Figure 7. Shrimp Area 1-4 – Redfish by-catch 1980-1998.

Turbot	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Davis North	23.6	56.0	22.1	77.2	43.8	35.8	56.2	139.4	139.3	171.8	158.2	320.8	262.8	166.6	179.9	95.5	86.3	0.0	0.6	
Davis North																8.6	26.4	4.0	10.4	
Davis North	23.6	56.0	22.1	77.2	43.8	35.8	56.2	139.4	139.3	171.8	158.2	320.8	262.8	166.6	179.9	104.0	112.7	4.0	11.0	
Davis South	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Davis South																				
Davis South	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Ungava/Hudson	0.2	2.3	0.0	0.0	0.0	0.0	0.0	7.2	7.1	12.3	0.5	13.5	0.1	0.0	8.8					
NAFO Div. 2G	0.3	0.7	0.0	0.0	0.0	0.0	0.0	0.1	11.7	75.5	44.8	29.6	30.2	11.3	9.5					
Sum	24.1	59.0	22.1	77.2	43.8	35.8	56.9	146.7	224.8	355.5	231.1	405.9	333.1	181.6	207.4	173.6	168.8	42.0	38.9	0
Percent North	97.9%	94.9%	100.0%	100.0%	100.0%	100.0%	98.8%	95.0%	62.0%	48.3%	68.5%	79.0%	78.9%	91.7%	86.7%	59.9%	66.7%	9.6%	28.3%	#DIV/0!

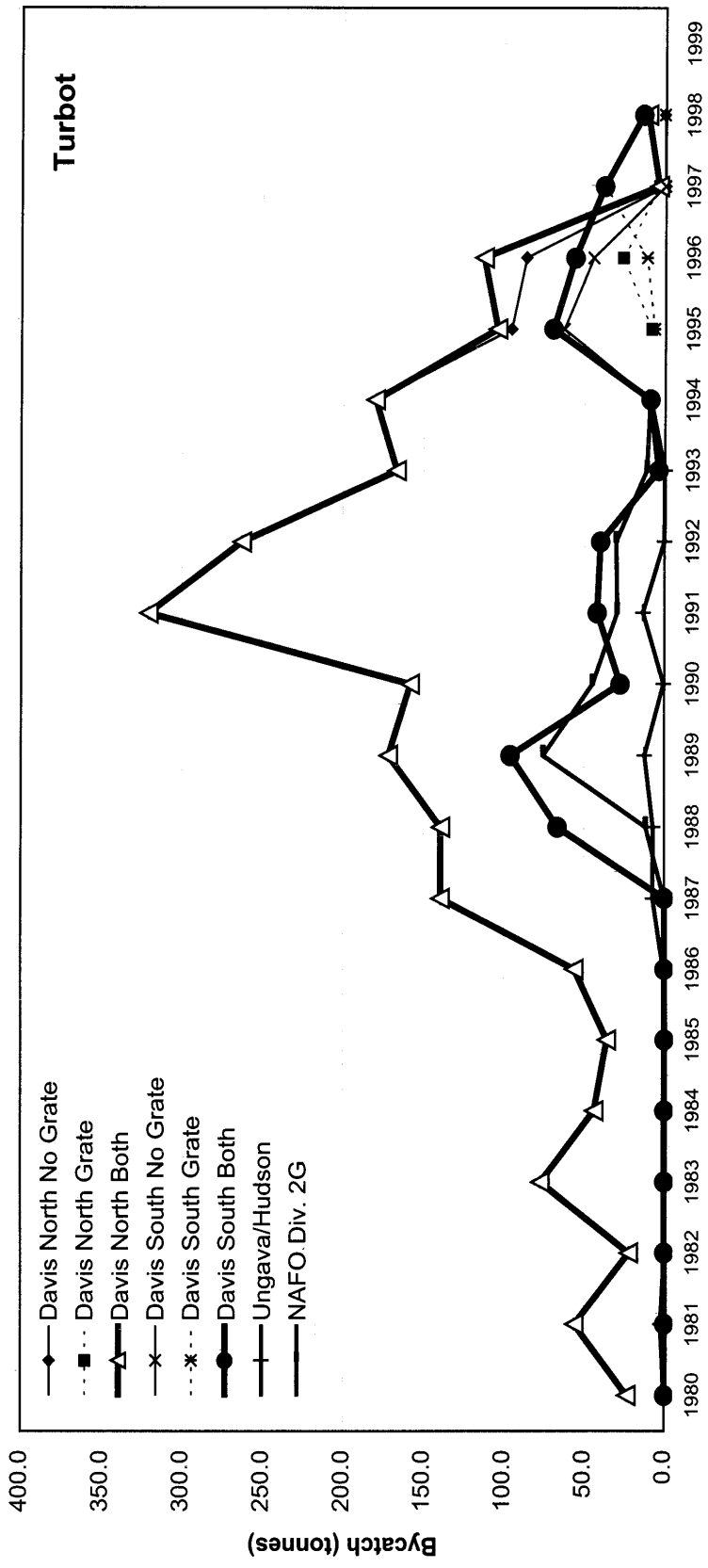


Figure 8. Shrimp Area 1-4 – Turbot by-catch 1980-1998.

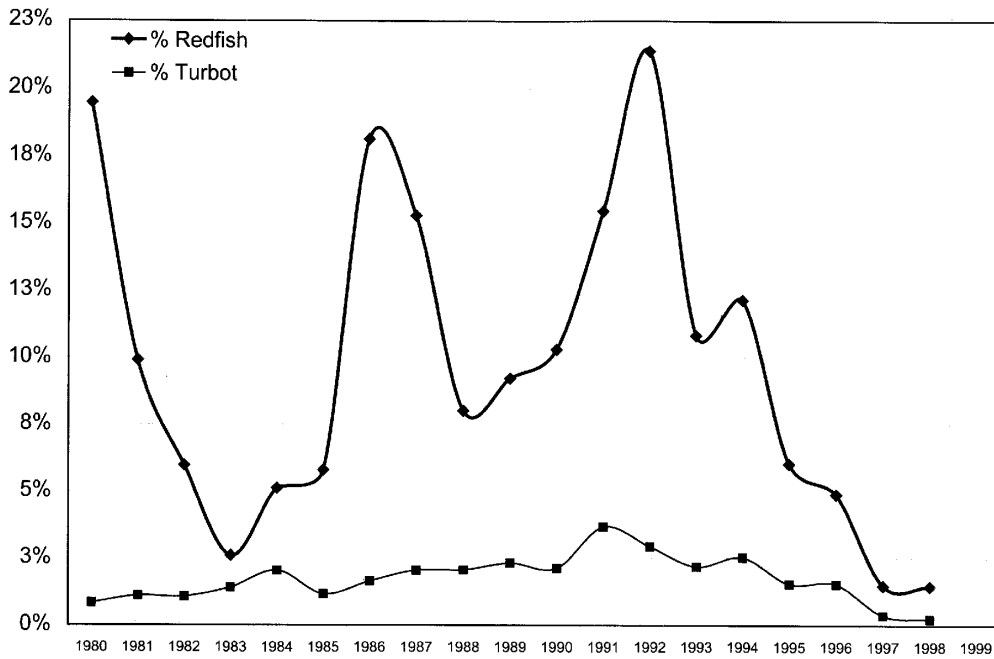


Figure 9. Statistical Area 1-4 – percent redfish and turbot by-catch 1980-1998.

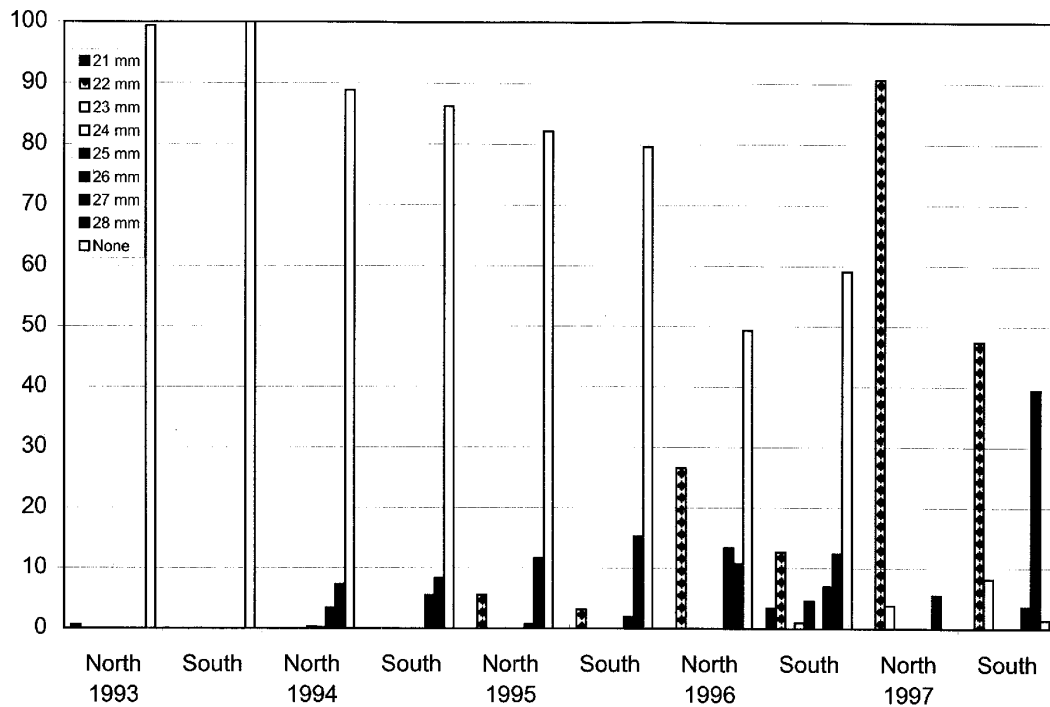


Figure 10. Percent of grate spacing used by the shrimp fleet, 1994-1997 by area.

Table 3 (continued). Estimated by-catch in Shrimp Areas 5 and 6 in 1998.

Stock	Area Landed	Observed	Estimated			% Obs	Ratio	Observed			Total							
			Redfish	Turbot	Cod			Plaice	Redfish	Turbot		Cod	Plaice	Redfish	Turbot	Cod	Plaice	Catch
<u>1998. Small Vessel. Grate</u>																		
SA5	Hope	58						0.20	0.36	0.00	0.05							
	Cart	56						0.04	0.05	0.02	0.00							
	SA5	371	0.8	1.3	0.1	0.0	30.49%	0.24	0.41	0.02	0.05	0.11%	0.18%	0.018%	0.00%			371
SA6	Hawke	642						0.87	0.89	0.00	0.04							
	St Anth E	189						0.18	0.10	0.00	0.00							
	Sr Anth W	28						0.01	0.38	0.00	0.01							
	Funk	223						0.36	1.05	0.01	0.08							
	SA6	30,073	39.5	67.3	0.3	0.0	3.60%	1.42	2.42	0.01	0.13	0.07%	0.11%	0.001%	0.00%			30,073
<u>1998. Large & Small Vessel. Grate & No. Grate</u>																		
SA5	Hope	1,970																
	Cart	8,628																
	SA5	15,198	23	101	1	9	69.73%					0.08%	0.33%	0.005%	0.06%			371
SA6	Hawke	970																
	St Anth E	189																
	Sr Anth W	30																
	Funk	2,223																
	SA6	46,337	52	143	1	66	7.36%					0.06%	0.15%	0.002%	0.14%			30,073
	SA 5&6	#####	14,009.7	75.0	244.1	1.8	75.1											
	% of Shrimp		0.12%	0.40%	0.00%	0.12%	0.64%											

Table 4. 1998 Shrimp Fishery – By-catch as a function of grate spacing for vessels licensed in the Newfoundland Region.

Vessels < 65 ft	22mm		23mm		25mm		26mm		27mm		28mm	
	Catch(t)	Percent of Total	Catch(t)	Percent of Total	Catch(t)	Percent of Total	Catch(t)	Percent of Total	Catch(t)	Percent of Total	Catch(t)	Percent of Total
Cod	0.02	0.00%										
Plaice	0.10	0.01%			0.01	0.01%					0.02	0.01%
Turbot	0.96	0.12%			0.3	0.24%	0.04	0.09%			1.22	0.52%
Redfish	1.27	0.16%			0.27	0.22%	0.06	0.13%			0.21	0.09%
Other fish	6.11	0.78%			0.84	0.68%	0.17	0.36%			1.26	0.54%
Total Bycatch	8.46	1.09%			1.42	1.15%	0.27	0.57%			2.71	1.15%
Shrimp	769.89				122.56		46.74				232.37	
Vessels > 100 ft												
Cod	0.45	0.00%							0.03	0.00%	0.67	0.00%
Plaice	6.03	0.04%			0.02	0.03%			0.26	0.01%	5.94	0.03%
Turbot	73.83	0.49%	0.26	0.03%	0.13	0.16%			10.76	0.57%	74.72	0.40%
Redfish	115.15	0.76%	5.92	0.66%	0.84	1.06%			5.44	0.29%	89.47	0.47%
Other fish	101.01	0.67%	18.03	2.00%	0.35	0.44%			13.29	0.71%	104.72	0.55%
Total Bycatch	296.47	1.95%	36.26	4.02%	1.34	1.70%			29.78	1.59%	275.52	1.46%
Shrimp	14,891.76		866.83		77.68		1,843.58				18,612.88	