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Assessment of Shrimp (*Pandalus borealis*) in Division 3M (Flemish Cap) - 1995

by

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1. Introduction

The fishery for northern shrimp in the Flemish Cap area began in the spring of 1993 and has since continued with estimated catches of approximately 27 000 tons in 1993 and 24 000 tons in 1994 (unofficial). Preliminary statistics (to August 31) indicate removals of about 23 000 tons so far in 1995. Vessels from as many as 13 nations have participated, on and off, since 1993.

STACFIS conducted assessments of the resource at the September Meetings in 1993 and 1994 but data were insufficient to provide a basis for the calculation of a TAC. Even though the effects of intensive fishing were evident in the 1994 data and Scientific Council agreed that a reduction in effort would be required to protect younger animals at lower stock size (NAFO, 1995), no regulations to effectively reduce the exploitation were introduced. Also, the by-catch of small redfish in this fishery has been a recurring problem, creating concern that redfish mortality in Div. 3M has been substantially increased. At the September 1993 Meeting, the mandatory and immediate use of sorting grates to minimize the by-catch problem was recommended (NAFO, 1994a). Grates with 28 mm bar spacings were used in 1994 but did not eliminate by-catch of redfish <21 cm (NAFO, 1995).

At the 1994 Annual Meeting, the Fisheries Commission made several decisions on conservation and enforcement measures for the shrimp fishery in Div. 3M in 1995 (NAFO, 1994b). Minimum mesh size was set at 40 mm; maximum bar spacings of sorting devices were set at 22 mm; vessels were required to immediately change fishing area (minimum of 5 n. mi.) if by-catches of all regulated groundfish species in any haul exceeded 5% by weight; and observer coverage was required for a minimum of 10% of a Contracting Party's total estimated fishing days for shrimp. Contracting Parties were further instructed to ensure that their vessels not conduct a directed fishery for shrimp in Div. 3LNO in 1995.

The following presents the preliminary assessment of the status of the shrimp resource on Flemish Cap by summarizing and interpreting data from the fishery, research vessel surveys and other studies on shrimp biology. The shrimp resource in Div. 3M is currently treated separately for assessment purposes in the absence of definitive information on stock structure.

2. Commercial Fishery

2.1 History of the Fishery

The shrimp fishery in Div. 3M began in late-April 1993, when two Canadian offshore vessels were granted exploratory permits to fish for *Pandalus borealis* in the area. Initial catch rates were favourable and, shortly thereafter, vessels from several Scandinavian countries joined in. Fishing activity (monitored by Canada) increased to include about 50 vessels in early-July but subsequently declined over the remainder of the year. Only 4 vessels were reported fishing shrimp at the end of December.

Fishing continued into 1994 at low intensity. Activity increased over winter to 17 vessels by late-February and remained near that level until early-April, decreasing thereafter. From mid-April to mid-June, the number of vessels increased from 7 to 47 and then decreased steadily to 3 at the end of the year.

In 1995, vessel activity was low throughout the January-March period but increased substantially from 7 vessels in early-April to 71 by late-July. Since then, about 60 vessels have continued to fish for shrimp up to the end of August.

2.2 Trends in Catch

A synopsis of catch (tons) by nation, month and year is provided in the following tables.

In 1993, over half of the estimated total catch tons was taken by Faroe Islands and Norway. Canada and Greenland each caught approximately 3 800 tons and Iceland about 2 200. Lesser amounts were reported for Denmark and Russia and, although vessels from Spain and St. Vincent apparently fished in 1993, no catch estimates are available.

	1993									
Nation	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
CAN	<1	696	2091	922	14					3724
E/DNK										800
FRO		1004	1747	1250	1565	1000	653	573	753	8545
GRL		53	2067	1279	223	155	9			3786
ISL			691	376	424	364	80	180	128	2243
NOR		235	1753	1729	1310	978	789	362	152	7308
RUS										300
E/ESP										?
St.Vin										?
Total										26706

Again, in 1994, the Faroes and Norway accounted for over half the estimated catch. Estonia, Latvia and Lithuania joined the fishery in 1994 and, combined, caught about 2 500 tons. Canadian vessels departed the area by the end of June, having taken only 1 041 tons, substantially less than their 1993 catch. Greenlandic and Danish catches were also less than those of the previous year.

	1994												
Nation	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
CAN			74	97	575	281						14	1041
E/DNK										400			
EST		17	55	109	148	179	89	128	136	86	102	32	1081
FRO	159	417	574	10	396	1630	1074	639	?	?	?	?	6556
GRL				70	471	850	637	178	70				2276
ISL	42	286	202			428	706	411	119	79	26	1	2300
LVA		12	15	26	70	69	69	?	?	?	?	?	300
LTV													1225
NOR	456	786	456	349	843	2145	1485	939	533	256		50	8299
RUS													300
E/ESP													300
St.Vin													75
Total													24153

Catch data for 1995 are preliminary to August but show major changes in the distribution of the catches by nation. Most noteworthy are the decreases in the Faroese and Norwegian fisheries, to date, and the substantial increase in catches by Iceland and Russia. Catches by both Canada and Greenland were about the same as in 1994. No catch was reported for Denmark or St. Vincent. One vessel from Portugal fished for shrimp in 1995 with an estimated catch of 150 tons.

	1995												
Nation	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
CAN			97	259	259	319	5						939
E/DNK													
EST	194	136	193	207	260	253	331	42					1616
FRO													3990
GRL					335	900	1086						2321
ISL		25	236	300	754	899	1616	439					4269
LVA													350
LTV													675
NOR													6100
POR													150
RUS													2500
E/ESP													158
St.Vin													
Total													23068

2.3 Trends in Effort

Available effort data (hours fished), based on vessel log records from some nations, are given below by year and month. Not all effort/catch is accounted for in these tables.

	1993									
Nation	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
CAN	5	1082	5494	4441	28					11050
E/DNK										
FRO										
GRL		113	4829	3675	724	622	33			9996
ISL			1849	1159	1361	1066	373	605	581	6994
NOR		428	4180	5652	4906	3544	3429	1931	582	24652
RUS										
E/ESP										
St.Vin										

	1994												
Nation	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
CAN			435	461	2088	937						114	4035
E/DNK													
EST		142	448	620	786	962	599	1276	1521	950	540	376	8220
FRO													
GRL				435	1225	3259	2351	725	455				8450
ISL	152	685	559			1320	2696	1576	586	492	182	8	8256
LVA		207	176	256	375	346	411						1771
LTV													
NOR	1816	2798	2547	1590	2883	8412	6177	4965	3108	1755		204	36255
RUS													
E/ESP													
St.Vin													

In 1995, some Greenlandic vessels reported towing two trawls, simultaneously and effort was presented in the documentation as hours fished for single and twin trawl vessels, separately (Siegstad and Hvingel, 1995). The data are adjusted below by doubling the effort for the latter and adding the value for the former.

Nation	1995 Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
CAN			631	1151	648	997	25						3452
E/DNK													
EST	1275	852	1141	1553	1561	1785	2367	322					10856
FRO													
GRL					865	2594	2673	308					6440
ISL		65	711	1120	2051	2784	4529	1842					13102
LVA													
LTV													
NOR													
RUS													
E/ESP													
St.Vin													

Information from three fleets showed that the spatial distribution of effort differed between years. Canadian vessels shifted effort to the west and southwest portions of the Cap in 1994 and 1995, compared to 1993. Further, fishing occurred in much shallower water in 1995 (Parsons and Veitch, 1995). Vessels from Greenland (Siegstad and Hvingel, 1995) and Faroe Islands (Nicolajsen, 1995) also reduced effort substantially in eastern areas compared to 1993.

2.4 Trends in Catch Rates

Catch rates in 1993 for Canada and Iceland were similar at roughly 330 kg/hr while Greenland's rate was higher at 380 kg/hr and Norway's lower at 296 kg/hr. Canadian surveillance reports indicated that Russian rates were very low, by comparison, to all other fleets.

CPUE declined over at least part of the season for several fleets. Canadian rates showed a large decline from May to July, Greenland from May to September, Iceland from June to October and Norway from May to November.

Nation	1993 Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
CAN	63	644	381	208	506					337
E/DNK										
FRO										
GRL		470	428	348	308	249	275			379
ISL			374	324	311	342	215	297	221	321
NOR		549	419	306	267	276	230	187	215	296
RUS										
E/ESP										
St.Vin										

In 1994, Canada, Greenland, Iceland and Norway produced similar catch rates, ranging from about 220 to 260 kg/hr. CPUEs for Estonia and Latvia were considerably lower at 132 and 147 kg/hr, respectively. Patterns in monthly CPUEs also occurred in 1994. Estonian and Norwegian vessels, which fished throughout the year, produced variable or increasing catch rates up to May, followed by an overall decrease to the end of the year. Canadian and Latvian CPUEs increased up to June while those for Greenland decreased from May to September. Icelandic rates were generally variable, without trend up to August but declined thereafter.

Nation	1994 Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
CAN			171	209	275	300						126	258
E/DNK													
EST		123	123	176	188	186	148	88	118	100	189	85	132
FRO													
GRL				152	313	267	271	222	190				260
ISL	216	325	281			252	204	203	159	125	113	75	218
LVA		58	85	102	187	199	168						147
LTV													
NOR	251	281	179	219	292	255	240	189	171	146	-	245	229
RUS													
E/ESP													
St.Vin													

The Canadian catch rate for 1995 was slightly higher than the 1994 value but lower than the 1993. Monthly CPUEs increased from March to May and then declined from May to July. Estonian catch rates in February and March, 1995 were higher than those for the same months in 1994 but, for the April-July period, the 1995 values were lower. A slight decrease occurred from May to August. The Greenlandic annual rate for 1995, when adjusted for double trawls, was higher than the 1994 value but lower than 1993. Monthly CPUEs increased during the May-July period. Icelandic rates were variable in 1995 and generally lower than those of the previous two years in months where comparisons were possible.

Nation	1995 Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
CAN			153	225	400	320	211						272
E/DNK													
EST	152	160	169	133	167	142	140	130					149
FRO													
GRL					269	285	301	263					289
ISL		278	246	199	272	239	264	177					241
LVA													
LTV													
NOR													
RUS													
E/ESP													
St.Vin													

Catch (tons) per vessel per week were provided for the Faroe Islands fleet for 1993 to 1995 (Nicolajsen, 1995). In 1993, there was a pronounced decrease during May and June, followed by a steady decrease to the end of the year. The 1994 data showed variation between 20 and 40 tons per vessel per week for most of the season. In 1995, rates increased from low levels in March to almost 60 tons/v/wk in May but declined, thereafter.

2.5 Biological Data

Size composition data from commercial sampling by Canada, Faroe Islands and Iceland in 1993 showed three size groups of males (about 16, 20 and 23 mm) and one of females (26-27 mm). Females (ages 5+) dominated the catches by number and weight. Samples from Canada, Faroe Islands and Iceland in 1994 showed a similar occurrence of modes in the length distributions but indicated that males were much more prevalent in the catches than in the previous year. The 1995 sampling data from Canada and Greenland showed a further increase in the importance of the male component. Only two size groups of males were evident at approximately 15 and 20 mm CL. Females, while low in numbers, comprised three size groups at, roughly, 22, 25 and 27 mm (Parsons and Veitch, 1995; Siegstad and Hvingel, 1995).

Nicolajsen (1995) produced biomass estimates of 24 000 tons in 1993 and 14 600 tons in 1994 based on 4 754 commercial trawl hauls of Faroese vessels made between May, 1993 and September, 1994. Average density declined from 2.03 g/sq. m. in 1993 to 1.24 in 1994.

2.6 Shrimp Discards

Data on shrimp discarding from the 1995 Canadian fishery (Parsons and Veitch, 1995) showed that, despite the decrease in mean size of shrimp due to the dominance of small males in the catches, discard levels remained low as in previous years. Greenlandic estimates of per cent discard in 1994 were low, ranging from 0 to 0.2% by month- 0.1% for the year (Siegstad and Hvingel, 1995). The smaller sizes encountered in 1995 were reflected in higher monthly values of between 0.1 and 0.7% - 0.4% for the year.

2.7 By-catch Data

By-catch in 1993 consisted primarily of small redfish (14 cm) and Canadian observer data indicated levels of 9 and 13% of the total catch weight in May and June, increasing to 44% in July. Redfish were still a problem in 1994 (up to 32% in April), despite the mandatory use of sorting grates, and occurred in large numbers at 17-18 cm. In 1995, redfish by-catch was much lower, increasing from <1% in March to 4.7% in June (Parsons and Veitch, 1995). If the Canadian data represent overall shrimp fishing conditions on the Cap; then it is highly likely that several thousand tons of small redfish have been taken as by-catch over the past three years. Although redfish by-catch was much lower in 1995, it is not clear whether or not this was entirely due to the reduction of maximum bar spacings from 28 mm in 1994 to 22 mm in 1995.

Redfish was the most dominant by-catch species taken by Greenland in both 1994 and 1995.

3. Environmental Data

Oceanographic data were obtained from the Flemish Cap during a Canadian survey conducted in July 1995 and compared to long-term (1961-1990) average conditions and those of 1993 (Colbourne, 1995). The 1995 temperature anomalies in depths greater than 300 m were about -0.3° while those in shallower water over the Cap ranged from -0.5 to -1.0°. These conditions, while remaining colder than normal, were an improvement over 1993 values, especially in the upper water layer (<50 m). Generally, the cold temperatures which occurred over the continental shelf and on the Flemish Cap since the late-1980s continued into 1995. Salinities in the Cap area in 1995 were saltier than normal in the upper layer and about normal over the rest of the water column.

The general circulation in the area is characterized by an anticyclonic gyre which could play an important role in the retention of shrimp larvae. This circulation, although present in 1995, was more pronounced in 1993. It is possible that changes in the intensity of the general circulation might affect the distribution of shrimp over the Cap.

4. Research Survey Data

EEC/EU groundfish surveys were conducted on Flemish Cap from 1988 to 1995 (Sainza, 1995). Shrimp biomass estimates were calculated from the catches obtained using a groundfish bottom trawl and therefore do not represent the absolute shrimp biomass. However, they show that relative shrimp biomass from 1991 to 1993 was substantially higher than during the 1988-90 period. Biomass apparently declined in 1994 but the estimate is likely biased downward due to a larger meshed liner in the codend of the trawl. Nonetheless, the declining trend continued in 1995 but the estimate was still higher than the level observed during the 1988-1990 period.

Year	Biomass Index (t)	Average catch per mile (kg)	Standard Error
1988	2164	1.54	+/- 0.28
1989	1923	1.37	+/- 0.24
1990	2139	1.53	+/- 0.21
1991	8211	5.83	+/- 0.71
1992	16531	11.75	+/- 1.86
1993	9256	6.57	+/- 1.04
1994	3337	2.37	+/- 0.35
1995	5413	3.85	+/- 0.44

The surveys also showed that abundance was highest in the western, northern and northeastern parts of the Cap and in depths ranging from about 300 to 500 m, the areas fished commercially since 1993. In 1994 and 1995, proportionately more biomass was found in western and southwestern areas while densities in some eastern strata declined substantially, consistent with the westward shift in fishing effort.

Age interpretation of the size distributions from the 1988 to 1994 surveys and the 1993 and 1994 commercial fishery samples identified the 1988 year-class as strong. This year-class contributed substantially to the fishery in the first two years but apparently declined in importance in 1994. The recruitment of the 1991 year-class helped maintain catch rates in the 1994 fishery. In 1995, the 1988 year-class was no longer important to the fishery and catches were dominated by the 1993 year-class.

4. Assessment Results

The research and commercial fishery data of recent years show that several changes have occurred on Flemish Cap related to the distribution, abundance and demographic structure of the shrimp resource. Although catches have been maintained at a high level (about 23 000 tons to the end of August, 1995), catch rates from countries that fished each year were noticeably lower in 1994 than in 1993. The 1995 rates improved slightly in some cases but remained below 1993 levels. Further, there is evidence to suggest that the area fished has changed. Data from some nations showed a clear shift to the west and southwest in 1994 and 1995 and the Canadian fishery extended into much shallower depths in 1995. Catch, effort and catch per unit effort all were much lower in eastern areas in 1994 and 1995 than in 1993. The 1994 and 1995 EEC/EU survey results are consistent with the commercial fishery data, in that respect.

The composition of the shrimp catches has also changed between years. Males were more prevalent in 1994 than in 1993 and more prevalent in 1995 than in 1994. The large females in 1994 were the remains of the 1988 year-class which did not contribute significantly to the 1995 fishery. The 1995 fishery, in fact, depended up the abundance of young male shrimp, notably the 1993 year-class (age 2) and, to a lesser degree, the 1992 year-class. Also, the 1991 year-class changed sex between 1994 and 1995, one year earlier than expected. The survey results are supportive of the sex change anomaly but do not show a dominance of the 1993 year-class. It is uncertain, however, how efficiently the lined research groundfish trawl retains these very small shrimp.

All data sources indicate that the spawning biomass (females) in 1995 was substantially lower than the level of the early-1990s. It is also clear that the 1988 year-class has passed through the population and that other, more recent, year-classes appear weaker. The 1993 year-class has already been subjected to intensive fishing in 1995. It is the younger male shrimp that will form the spawning biomass in two or three years time. The stock/recruitment relationship is unknown for shrimp on Flemish Cap.

5. Status of the Resource

The substantial changes observed both in the fishing pattern and catch composition since 1993 suggest that the shrimp resource on Flemish Cap is currently vulnerable to overexploitation. Although it is not possible, at present, to quantify and compare the effects of fishing with natural events, it is clear that the continuation of an intensive fishery directed towards animals as young as age 2 has implications for both growth and recruitment overfishing. The 1993 year-class was produced by a healthy spawning biomass, dominated by the strong 1988 year-class which, itself, was never fished prior to 1993. The current spawning biomass is

much weaker and may remain depressed if younger male ages continue to be heavily exploited before they have the opportunity to change sex and spawn at least once as females.

Redfish by-catch was much lower in 1995 than in the previous two years but it is uncertain whether or not this was a direct result of reducing the bar spacings in the sorting grates from 28 to 22 mm. If the by-catch levels of 1993 and 1994 were mainly due to the abundant 1989 year-class, these fish might have been big enough in 1995 to be excluded by grates with either spacing. More information on the size/age distribution of redfish in the Flemish Cap area is required to adequately address this question.

6. Acknowledgement

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7. References

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