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Assessment of Shrimp (*Pandalus borealis*) in Division 3M (Flemish Cap) - 1996

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 (unofficial) of approximately 28,000 tons in 1993, 24,000 tons in 1994 and 33,000 tons in 1995. Preliminary data from the fishery in 1996 indicate that removals for the first 7 months of the year have already reached 33,000 tons and Canadian surveillance estimates suggest that over 45,000 tons have been taken. Vessels from as many as 14 nations have participated in this fishery since 1993.

STACFIS conducted assessments of the resource at the Annual September Meetings in 1993, 1994 and 1995 but data were considered insufficient to provide a basis for the calculation of a TAC. The effects of intensive fishing were apparent 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). However, although the Fisheries Commission did make several decisions on conservation and enforcement measures for the shrimp fishery in Div. 3M in 1995 (NAFO, 1994), no regulations to effectively reduce the exploitation were introduced. Minimum mesh size was set at 40 mm; maximum bar spacings of sorting devices was 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.

Data from the 1995 fishery indicated that the exploitation pattern was imprudent and, in order to improve the situation, it was recommended that fishing mortality on male shrimp be minimized. Scientific Council recognized that, in practice, this would mean closure of the fishery in 1996 (NAFO, 1996 a). This recommendation was not followed and, instead, effort control was implemented. The details of the effort limitations, which effectively allowed for more effort (and catch) in 1996 than in any previous year, are given in NAFO/FC Doc. 95/21. Other management measures were carried over from the previous year (see above). Observer coverage was increased through a decision by Fisheries Commission to implement a Pilot Observer Project for 100% observer coverage of all vessels fishing in the Regulatory Area (NAFO, 1996 b).

The following provides a "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 identity and associations with shrimp in other areas.

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. 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 late March, decreasing thereafter. From early 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. As in the previous year, numbers subsequently declined to 6 during the last week of December. From 8 to 12 vessels fished for shrimp in Div. 3M from early January to mid February, 1996. This was followed by a sharp increase over the next 20 weeks to 91 vessels during the first week of July. Numbers remained high, thereafter, but declined to about 70 vessels by mid August.

A summary of the number of vessels by country and year is given below. The numbers represent best estimates of fleet size but might not be accurate for all entries.

Country/Year	1993	1994	1995	1996
CAN	13	8	7	6
E/DNK	2	2	1	-
EST	10	7	9	6
FRO	9	11	10	10
GRL	12	8	6	4
ISL	5	9	26	43
LVA	17	6	4	3
LTV	6	4	5	6
NOR	21	20	27	16
POR	-	-	1	-
RUS	2	3	31	26
E/ESP	2	-	1	1
St. Vin	1	1	-	-
N. Zea	-	-	1	-
TOTAL	107	81	133	123

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 in tons was taken by Faroe Islands and Norway. Canada and Greenland each caught approximately 3700 tons, Iceland about 2200 and Honduras 1265. Lesser amounts were reported for Denmark, Russia and Spain. These catch estimates have been updated from last year's document (Parsons, 1995) by including the NAFO provisional nominal catches for 1993 as reported in NAFO SCS Doc. 94/24 when they were greater than the values used in 1995.

1993

Nation	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Tot.
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			3788
HND										1265
ISL			691	376	424	364	80	180	128	2243
NOR		235	1753	1729	1270	893	789	362	152	7183
RUS										300
E/ESP										240
Total										28,088

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 2500 tons. Canadian vessels departed the area by the end of June, having taken only 1041 tons, substantially less than their 1993 catch. Greenlantic, Icelandic 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	Tot.
CAN			74	97	575	281						14	1041
E/DNK													400
EST		17	55	109	148	179	89	128	136	86	102	32	1081
FRO													6567
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	1555	1031	533	256		50	8460
RUS													300
E/ESP													300
St.Vln													75
Total													24,325

Catch data for 1995 show major changes in the distribution of the catches by nation. Most noteworthy are the decreases in the Faroese and Norwegian fisheries and the substantial increase in catches by Iceland and Russia. Catches by both Canada and Greenland were about the same as in 1994. 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	Tot.
CAN			100	267	268	330	5						970
E/DNK													200
EST	194	136	193	207	260	253	331	42		201	162	113	2092
FRO													5987
GRL					335	900	1086	82					2403
ISL		26	248	315	791	975	1734	1621	734	649	290	241	7623
LVA													350
LTV													675
NOR	28	112	139	396	1504	2621	2548	1319	548	277	32	10	9534
POR													150
RUS				148	497	758	664	376	172	88	85	50	2838
E/ESP													158
Total													32,980

The preliminary 1996 catch data show that as much shrimp was taken in the first 7 - 8 months of the year as in any other previous complete year. Icelandic catches increased from about 7600 tons in 1995 to more than 16,000 tons up to August, 1996. Norway, on the other hand, caught only 1300 tons during the first half of 1996 compared to 4800 tons for the same period in 1995.

In 1994, Canada, Greenland, Iceland and Norway produced similar catch rates, ranging from about 220 to 260 kg/hr. CPUE's for Estonia and Latvia were considerably lower at 132 and 147 kg/hr, respectively. Patterns in monthly CPUE's 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 CPUE's 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.

1994

Nation	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Tot.
CAN			174	212	280	305						132	263
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	293	255	240	188	171	146	-	247	228
RUS													
E/ESP													
St.Vln													

The Canadian catch rate for 1995 was slightly higher than the 1994 value but lower than the 1993. Monthly CPUE's 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 CPUE's 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.

1995

Nation	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Tot.
CAN			156	228	404	315	267					181	272
E/DNK													
EST	152	160	169	133	167	142	140	130		113	98	89	134
FRO													
GRL					269	285	301	263					289
ISL		278	247	146	258	244	246	175	131	162	143	176	203
LVA													
LTV													
NOR	189	247	288	253	301	297	262	211	165	188	110	125	253
RUS				124	179	201	135	92	119	194	210	193	149
E/ESP													

In 1996, monthly catch rates were generally lower than in the previous years for all fleets. Canadian, Estonian, Icelandic and Russian rates increased from January to the March-April period.

1996

Nation	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Tot.
CAN		178	196	231	236								229
EST	106	160	152	165	154	137							149
FRO													
GRL					173	222	175						194
ISL	203	244	256	206	186	199	184	154					192
LVA													
LTV													
NOR				202	228	234							225
RUS	82	101	135	124	128	169							139
E/ESP													

Catch (tons) per vessel per week were provided for the Faroe Islands fleet for 1993 to 1996. 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, to the 20 - 40 ton range. In 1996, rates generally declined over the March - August period. It was noted that, although the Faroese vessels have increased the use of double trawls since 1993, the effort data were not adjusted for CPUE calculations.

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 CL (ages 2, 3 and 4) and one of females at 26 -27 mm (ages 5+). Females 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 (ages 2 and 3). Females, while low in numbers, comprised three size groups at, roughly, 22, 25 and 27 mm (ages 4, 5 and 6). Data from all fleets for which sampling was conducted in 1996 showed that a single component of males at roughly 20 mm (the 1993 year class) dominated the catches throughout the area and season. While the proportions of females in the catches were variable by area, month and fleet, indications of smaller males (i.e. the 1994 year class) were consistently weak.

Nicolajsen (1995) produced biomass estimates of 24,000 tons in 1993 and 14,600 tons in 1994 based on 4754 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. No estimates of biomass and/or density were calculated for 1995.

2.6 Shrimp Discards

Data obtained by observers onboard the vessels of several nations indicate only low levels of shrimp discarding in this fishery since its inception.

2.7 Bycatches

Redfish (spp.) bycatch, a serious problem in 1993 and 1994, decreased to low levels in 1995 and 1996 and can be expected to remain low until the next strong year class is produced. Currently, there are no indications of strong redfish recruitment on Flemish Cap.

3. ENVIRONMENTAL DATA

Oceanographic data were obtained from the Flemish Cap during a Canadian survey conducted in July 1996 and compared to long-term (1961 - 1990) average conditions and those of 1993 and 1995 (Colbourne, 1996). The colder than normal temperatures experienced over the continental shelf and on the Flemish Cap since the late 1980's continued in 1996 with some improvement over 1993 and 1995, especially in depths greater than 50 m. Chlorophyll measurements indicated a delayed and/or extended plankton bloom compared to shelf waters. The water column was well-oxygenated, as seen in both 1993 and 1995, and current measurements continue to show the presence of the anticyclonic gyre around the Cap. It was noted that information on the circulation might be useful, in future, to evaluate whether or not recruitment of shrimp results from local retention or is produced elsewhere.

4. RESEARCH SURVEY DATA

EEC/EU groundfish surveys were conducted on Flemish Cap from 1988 to 1996 (del Rio, 1996). 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 88-90 and 94-96 periods. The 1994 estimate is likely biased downward due to a larger meshed liner in the codend of the trawl. The recent biomass level (94-96) is 2 to 3 times higher than the level observed during the 1988 - 1990 period.

Year	Biomass (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
1996	6502	4.62	+/- 0.34

The surveys also showed that biomass in most years was highest in the western, northern and northeastern parts of the Cap and in depths ranging from about 250 to 550 m. In 1994 and 1995, proportionately more biomass was found in western and southwestern areas while catch per tow in some eastern strata declined substantially, consistent with the westward shift in fishing effort. Fishing by some fleets in 1996 returned to the eastern slopes where the survey showed an improvement of shrimp catches over the previous two years.

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, although catches were dominated by the 1992 and 1993 year classes, the latter was not well represented in the survey. The 1993 year class was dominant in both the research survey and commercial fishery catches in 1996. Size distributions from the survey showed that the 1993 year class was dominant throughout the survey area.

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. Catches have been maintained at a high level (at least 33,000 tons to the end of August, 1996) due to increasing effort and an expansion of the fishing grounds to target smaller shrimp in shallower water. Catch rates from countries that fished each year were noticeably lower in 1994 than in 1993. The 1995 rates stabilized or improved slightly in some cases but remained below 1993 levels. The 1996 values were the lowest reported for all fleets and are expected to be even lower for the full year as rates decline in the second half of the year. The aggregated CPUE data are difficult to interpret as an index of abundance due to the major changes in fishing pattern between years.

The composition of the shrimp catches has also changed over time. Males were more prevalent in 1994 than in 1993 and more prevalent in 1995 than in 1994. In 1996, the fishery was largely dependent on the full recruitment of the 1993 year class which was also heavily fished in 1995. The large females in 1994 were the remains of the 1988 year class which did not contribute significantly to the fishery in subsequent years. The sharp decline in catch rates of large female shrimp from 1993 to 1996 is considered to be a reasonable reflection of the trend in the spawning biomass. Further, there has been a change in the age of sex reversal, as evidenced in the replacement of a component of large male shrimp by one of small females.

The 1993 year class, produced by a healthy spawning biomass which included part of the strong 1988 year class, was abundant but has already been subjected to two years of intensive fishing. If the 1994 year class is weak, as indicated in the 1996 fishery and survey data, then the fishery in 1997 will largely depend on what remains of the 1993 year class.

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 overexploited. This was particularly evident in 1996 as the fishery depended mainly one year class of male shrimp. Although it is not possible, at present, to quantify and compare the effects of fishing with natural events or establish the stock/recruitment relationship, it is clear that the continuation of an intensive fishery directed towards young, male shrimp is imprudent. The strong 1993 year class was produced by a healthy spawning biomass before the fishery started. 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.

6. ACKNOWLEDGEMENT

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