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THE INTERNATIONAL FISHERY FOR SHRIMP (Pandalus borealis) IN DIVISION 3M (FLEMISH CAP), 1993 - 1997

by

D.G. Parsons

Science Branch, Department of Fisheries and Oceans
P.O. Box 5667, St. John's, Newfoundland, Canada, A1C 5X1

1. INTRODUCTION

The fishery for northern shrimp at Flemish Cap began in the spring of 1993 and has since continued with estimated annual catches (unofficial) of approximately 28,000, 24,000, 33,000 and 51,000 tons from 1993 to 1996, respectively. Preliminary data from the fishery in 1997 indicate that removals for the first 7 months of the year were about 17,000 tons. Values for 1996 and 1997 rely to some extent on Canadian surveillance data which are used in a catch model that includes an estimate of overpack (e.g. squeezing 5.75 kg of shrimp into a container with a nominal weight of 5.0 kg). Vessels from as many as 14 nations have participated in this fishery since its beginning.

The following provides an overview of the fishery for shrimp on Flemish Cap by describing and interpreting trends in catch and effort based on data provided by the fleets of several nations. A standardized catch per unit effort (CPUE) series also is constructed which addresses differences in catch rate due to fishing power of vessels, seasonality of the fishery and area fished.

2. BACKGROUND

STACFIS conducted annual assessments of the resource at the September Meetings from 1993 to 1996 but lacked a basis for the calculation of a TAC. In 1994, Scientific Council agreed that a reduction in effort would be required to protect younger animals at lower stock size (NAFO, 1995). Although the Fisheries Commission did make several decisions on conservation and enforcement measures for the shrimp fishery in Div. 3M in 1995 (NAFO/FC Doc. 94/8), 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, 1996a). 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, 1996b).

In 1996, Scientific Council reiterated the need for a significant reduction in fishing intensity to conserve both the male (recruitment) and female (spawning biomass) components of the stock (NAFO, 1997). The response of the Fisheries Commission was to "tighten" the effort regulations stipulated the previous year by limiting the number of fishing days for each Contracting Party in 1997 to 90% of the maximum number of fishing days observed in one year from 1993 to 1995

(NAFO/FC Doc. 96/5). Although effort to date in 1997 has been much reduced compared to 1996, the reduction is not a direct result of NAFO's effort control system.

3. COMMERCIAL FISHERY

3.1 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.

This pattern of increasing activity to June-July followed by a decrease to the end of the year continued in subsequent years. Maximum vessels observed were 71 in July 1995, 91 in July 1996 and 35 in June 1997. Also in 1997, the number of vessels was relatively stable from 30 to 35 vessels for the May-July period.

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 nations.

Country/Year	1993	1994	1995	1996	1997
CAN	13	7	7	6	3
E/DNK	2	2	1	-	-
EST	-	4	6	5	6
EU	-	2	2	1	1
FRO	11	10	9	11	6
GRL	12	8	5	4	1
ISL	5	9	21	40	12
LVA	-	2	3	4	2
LTV	-	2	4	6	4
NOR	21	19	26	15	2
RUS	2	4	15	17	3
St. Vin	-	1	-	-	-
N. Zea	-	-	-	1	-
TOTAL	**66**	**70**	**99**	**110**	**40**

3.2 Trends in Catch

3.2.1 By Nation and Year

A summary of catch (tons) by nation and year is provided in the following table. Values for 1996 and 1997 are preliminary and, as mentioned above, partly rely on Canadian surveillance data which are used in a catch model that includes an estimate of the overpack.

Nation	1993	1994	1995	1996	1997*
Canada	3724	1041	970	906	793
EU/Denmark	800	400	200	-	-
Estonia	-	1081	2092	1900	1500
Faroe Is.	8545	6567	5987	8677	5409
Greenland	3788	2275	2400	1107	100
Honduras	1265	-	-	-	-
Iceland	2243	2300	7623	21077	4285
Latvia	-	300	350	1940	1000
Lithuania	-	1225	675	2900	1600
Norway	7183	8460	9534	8150	1000
Portugal	-	-	150	-	164
Russia	300	300	2838	4446	675
EU/Spain	240	300	158	50	38
St. Vincent's	-	75	-	-	-
Total	**28 088**	**24 324**	**32 977**	**51 163**	**16 564**

* Provisional to July 31

In 1993, 56% 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.

Faroese and Norwegian vessels accounted for over 60% of the estimated catch in 1994. Estonia, Latvia and Lithuania joined the fishery that year and, combined, caught about 2600 tons. Canadian vessels caught 1041 tons, substantially less than in 1993. Greenlandic and Danish catches were also less than those of the previous year whereas Icelandic catches remained about the same.

Catch data for 1995 showed some changes in the distribution of the catches by nation. Most noteworthy are the substantial increases in catches by Iceland and Russia. Catches by Canada, Faroe Islands 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.

The 1996 data show substantial increases in catch for several nations. Icelandic catches increased from about 7600 tons in 1995 to over 21,000 tons in 1996. Catches by Faroe Islands increased from 6000 tons to 8700 tons and Russian catches from 2800 to 4400 tons. Latvia and Lithuania also increased their catches from 1995 to 1996 while catches by Canada, Greenland and Norway decreased.

Although the 1997 data are incomplete, it is likely that catches by year's end will be in the 25,000 ton range, much lower than in 1996. The reduction can be explained, in part, by the Icelandic quota of 6800 tons (in effect, about 14,000 tons less catch than in 1996) and possibly by a generally depressed market for northern shrimp which affects all nations.

3.2.2 By Month and Year

Following a recommendation of an *ad hoc* working group on shrimp in Div. 3M (NAFO SCS Doc. 96/19), a standardized data set was constructed which included catch and effort from Canada, Greenland, Iceland and Norway. Although these data represent only part of the total catch and effort, they are assumed to reflect temporal and spatial trends in the fishery.

CATCH (TONS)

Month/Year	1993	1994	1995	1996	1997
JAN	-	485	28	363	-
FEB	-	976	129	355	-
MAR	-	655	387	1220	189
APR	0	500	814	3004	774
MAY	838	1740	2610	3646	755
JUN	6129	3575	4753	4702	417
JUL	4098	2670	5439	3759	145
AUG	1927	1486	2229	2527	
SEP	1404	702	941	1576	
OCT	875	323	623	973	
NOV	541	21	187	397	
DEC	280	63	162	136	
TOTAL	**16092**	**13196**	**18304**	**22656**	**2280**

Monthly catches show an increasing trend from January to June or July, followed by a decrease to the end of the year. The May to August period has accounted for more than 65% of the logged catch each year from 1994 to 1996.

3.2.3 By Area and Year

The standardized data set included a reference to area fished for each nation except Norway. The Cap was separated into four areas - northeast, southeast, southwest and northwest - at 47° 10' N and 45° W. The logbook data showed that most of the catch was taken in the northwest quadrant (area 4) each year. However, changes are evident between years. Most of the catch was taken in the north (areas 1 and 4) in 1993 compared to the west (areas 3 and 4) in 1994. In 1995, the west was again the most productive area but a substantial catch was also taken in the northeast (area 1). The southeast quadrant (area 2) produced a high level of catch only in 1996 when the largest annual catch was reported in Div. 3M.

CATCH (TONS)

Area/Year	1993	1994	1995	1996	1997
1	2870	294	1365	3079	142
2	190	1	61	1221	5
3	1605	1997	3488	4601	289
4	4246	2216	3896	7992	626
TOTAL	**8911**	**4508**	**8809**	**16893**	**1062**

3.3 Trends in Effort

The standardized data set also was used to describe temporal and spatial trends in fishing effort, assuming the data are representative of total fleet activities despite being incomplete. The observations are hours fished for both single and double trawls.

3.3.1 By Month and Year

The temporal trend in effort is similar to that for catch. Activity generally increased from January

to June-July and then decreased to December. The May to August period accounted for more than 60% of the logged effort each year from 1994 to 1996 and the June - July period, more than 35%. Activities of the individual fleets are reported separately in research documents.

EFFORT (HRS)

Month/Year	1993	1994	1995	1996	1997
JAN	-	1887	149	1504	-
FEB	-	3067	508	1061	-
MAR	-	3209	1661	3590	574
APR	4	2433	3553	12116	2289
MAY	1381	5939	8366	14817	3060
JUN	14419	13622	14878	18427	1472
JUL	12634	10759	17864	16852	325
AUG	6674	7393	10156	11573	-
SEP	4875	4107	5469	8184	-
OCT	3640	2285	2808	5901	-
NOV	2242	181	1094	2042	-
DEC	865	309	942	651	-
TOTAL	**46734**	**55191**	**67448**	**96718**	**7720**

3.3.2 By Area and Year

The effort data were further examined based on the spatial designation described above. In 1993, fishing activity was concentrated in the north (areas 1 and 4), particularly in the northwest (area 4). More effort was deployed in the southwest (area 3) in 1994 while there was a large reduction in activity in the northeast (area 1). Effort increased in all areas in 1995 with renewed interest in the northeast. The 1996 fishing effort was extensive over the entire Cap, including the southeast sector (area 2). Most (46%) of the effort was estimated in the northwest, followed by the southwest (30%), the northeast (17%) and the southeast (7%). The records available for 1997 indicate about 60% of the effort to date has been deployed in the northwest.

EFFORT (HRS)

Area/Year	1993	1994	1995	1996	1997
1	7541	1533	5210	11701	547
2	521	4	215	4583	20
3	3543	7411	11772	21019	1069
4	10473	7931	12618	32084	2317
TOTAL	**22078**	**16879**	**29815**	**69387**	**3953**

Information from several fleets have shown that the depth distribution of effort also differed between years (Parsons, 1996). Fishing occurred in much shallower water in both 1995 and 1996 compared to previous years.

3.4 Trends in Catch Rates

The main purpose for constructing the standardized catch and effort data set was for the calculation of catch per unit of effort (CPUE). The following analyses are based on single trawl data from the logbook records of Canada, Greenland, Iceland and Norway.

3.4.1 By Month and Year

Seasonality in catch rates is evident in the data. The fishery began in spring 1993 and catch rates in May were high at more than 600 kg per hour. CPUE declined steadily to November and recovered slightly during the December - February period. During the remainder of 1994, CPUE increased from a low of 170 kg per hour in March to about 290 in May, declining thereafter to November. In 1995, catch rates again were highest in May, declining over the remainder of the year. The pattern in 1996 is different in that catch rates were more stable over the year. CPUE's from September to November were lower than other months when values ranged between 202 and 240 kg per hour. March, April and July rates in 1997 are high compared to those of the same months in previous years.

CATCH PER HOUR (KG)

Month/Year	1993	1994	1995	1996	1997
JAN	-	251	188	217	-
FEB	-	281	254	240	-
MAR	-	170	233	236	329
APR	63	206	227	213	345
MAY	607	293	299	210	237
JUN	420	258	289	220	290
JUL	317	239	258	202	446
AUG	273	189	200	202	-
SEP	258	171	166	174	-
OCT	230	141	198	155	-
NOV	187	116	154	180	-
DEC	261	205	172	209	-

The general pattern in the first three years was an increase in CPUE to May followed by a decline to November and some recovery during winter. This convention breaks down in 1996 and the pattern for 1997, with partial data, is not yet clear.

3.4.2 By Area and Year

CPUE can also be described spatially, based on the four general areas described previously. The northwest sector (area 4) is the preferred fishing area and has produced catch rates which compare favourably to other areas where effort is usually lower. In fact, except for 1994, catch rates were similar each year over all areas. The interpretation of annual trends, therefore, is a decrease from 1993 to 1994, some recovery or stability between 1994 and 1995, another decrease in 1996 and an increase in 1997.

CATCH PER HOUR (KG)

Area/Year	1993	1994	1995	1996	1997
1	371	167	233	207	289
2	358	-	243	210	237
3	386	256	237	189	273
4	396	238	238	204	265

3.4.3 By Nation and Year

Annual catch rates from single trawl effort show variation among nations. Canadian and Greenlandic CPUE's were usually higher than those of Iceland and Norway. CPUE's from all nations declined from 1993 to 1994 and, except for Canada, increased in 1995. Declines were seen for all nations between 1995 and 1996 and, in 1997, Canadian and Norwegian rates increased while the Icelandic CPUE continued to decline.

CATCH PER HOUR (KG)

Nation/Year	1993	1994	1995	1996	1997
CAN	403	263	235	229	320
GRL	379	267	294	258	-
ICE	359	181	232	197	161
NOR	291	227	252	211	323

In 1993, Canadian surveillance reports indicated that Russian rates were very low, by comparison, to all other fleets. In 1994, CPUE's for Estonia and Latvia were considerably lower than those given in the table above at 132 and 147 kg/hr, respectively (Parsons, 1996).

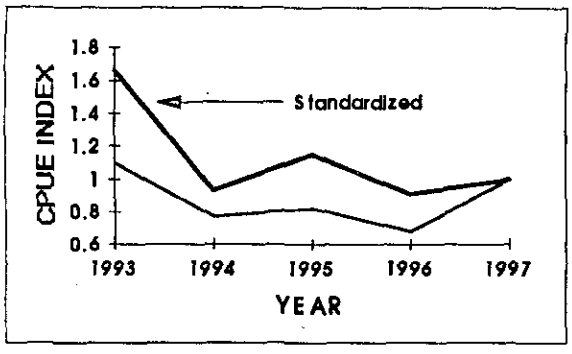
3.4.4. Standardized CPUE

The annual CPUE's ($\bar{y}$catch ÷ $\bar{y}$effort) from the integrated data set (single trawls only) are 333, 231, 247, 204 and 301 kg per hour for 1993 to 1997, respectively, supporting the interpretation of a decrease between 1993 and 1994, some recovery in 1995, a further decrease in 1996 and a second recovery in 1997.

Given the differences described above for the raw data, a standardized catch rate series was developed to account for effects such as seasonality, fishing power of vessels and area fished. The log (ln(catch/effort)) data (Norway omitted) were analyzed for year, month, area and vessel effects using a SAS multiple regression procedure (GLM). An investigative model revealed that NATION was not a significant class variable but VESSEL was highly significant. No investigation of interaction terms was attempted in this preliminary analysis but significant interaction of main effects is common in such data sets.

The final model, with outliers removed based on the penultimate run (IF -0.75<RESID.<0.75), used records where CATCH > 0 and EFFORT > 10. Also, the number of tows associated with each catch/effort record was used as a weighting factor. Over 80% of the variation was explained by the model and all class variables were highly significant using type III sum of squares (Table 1). Results showed that positive coefficients for 1993 and 1995 were significantly different ($P < 0.05$) from zero, the 1997 standard, whereas the negative coefficients for 1994 and 1996 were not ($P > 0.10$). A plot of residuals is given in Figure 1.

The standardized series produced a trend not unlike the unstandardized - a decline between 1993 and 1994, an increase in 1995, a decrease in 1996 and an increase in 1997. Standardization suggests that the initial decline was more pronounced than evident in the raw data and that the increase between 1996 and 1997 cannot be viewed as a significant recovery.



4. SUMMARY

Catches of shrimp on Flemish Cap have been maintained at a high level (more than 50,000 tons in 1996) due to increasing effort and an expansion of the fishing grounds to target smaller shrimp in shallower water (NAFO, 1997). The standardized catch rate for 1994 was much lower than the 1993 estimate. The 1995 rate improved slightly but remained well below 1993. The 1996 value was the lowest observed and the increase in 1997 (preliminary) was not significant.

Despite standardization, the CPUE data are still difficult to interpret as an index of stock size due to the major changes in fishing pattern between years (i.e. areas/depths fished reflect targeting of the recruiting age class).

5. ACKNOWLEDGEMENT

Appreciation is expressed to all those who provided data for inclusion in this paper in advance of the 1997 Annual Meeting.

6. REFERENCES

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NAFO. 1996a. Scientific Council Reports, 1995, p. 146.

NAFO. 1996b. Meeting Proceedings of the General Council and Fisheries Commission for 1995, p. 152.

NAFO. 1997. Scientific Council Reports, 1996, p. 166.

PARSONS, D.G. 1996. Assessment of shrimp (*Pandalus borealis*) in Division 3M (Flemish Cap) - 1996. *NAFO SCR Doc.*, No. 96/102, Serial No. N2785, 9 p.

TABLE 1. MULTIPLICATIVE, YEAR-MONTH-AREA-VESSEL MODEL, 1993 - 1997 14:59 Monday, August 25, 1997

General Linear Models Procedure
Class Level Information

Class	Levels	Values
YEAR	5	93 94 95 96 97
MONTH	12	1 2 3 4 5 7 8 9 10 11 12 99
AREA	4	1 2 3 4
VESSEL	66	1128 12 1383 1407 1462 1484 1506 1514 1576 1634 1742 1752 1753 1757 1768 1807 1809 1903 1905 1942 2013 2061 21 2155 2197 2204 2206 2211 2212 2216 2218 2220 2237 2244 2258 2259 2262 2266 29 40 41 43 44 47 5 58 66 68 69 70 OUKV OUOQ OWGG OWQU OWTI OWVM OYBZ OYCK OYHO OYKK OYRT OYXT OYZL OZDH OZKQ ZZZZ

Number of observations in data set = 806

Dependent Variable: LNCPUE
Weight: WFACTOR

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	83	2651.04350835	31.94028323	36.08	0.0001
Error	722	639.20227964	0.88532172		
Corrected Total	805	3290.24578799			

R-Square	C.V.	Root MSE	LNCPUE Mean
0.805728	17.09363	0.94091536	5.50447974

Source	DF	Type I SS	Mean Square	F Value	Pr > F
YEAR	4	1319.60320251	329.90080063	372.63	0.0001
VESSEL	65	1167.97405810	17.96883166	20.30	0.0001
MONTH	11	153.06771627	13.91524693	15.72	0.0001
AREA	3	10.39853148	3.46617716	3.92	0.0086

Source	DF	Type III SS	Mean Square	F Value	Pr > F
YEAR	4	416.20717562	104.05179390	117.53	0.0001
VESSEL	65	956.05944684	14.70860687	16.61	0.0001
MONTH	11	157.87470514	14.35224592	16.21	0.0001
AREA	3	10.39853148	3.46617716	3.92	0.0086

Parameter		Estimate	T for H0: Parameter=0	Pr > |T|	Std Error of Estimate
INTERCEPT		5.776251392 B	89.88	0.0001	0.06426614
YEAR	93	0.505641516 B	8.46	0.0001	0.05978931
	94	-0.070663305 B	-1.25	0.2135	0.05674971
	95	0.136741626 B	2.33	0.0201	0.05871958
	96	-0.089443471 B	-1.63	0.1045	0.05502788
	97	0.000000000 B	.	.	.

TABLE 2 (CONT'D.) Univariate Procedure

Variable=R

Moments

N	806	Sum Wgts	806
Mean	-0.02531	Sum	-20.3967
Std Dev	0.229158	Variance	0.052513
Skewness	-0.1543	Kurtosis	0.359699
USS	42.78938	CSS	42.27322
CV	-905.546	Std Mean	0.008072
T:Mean=0	-3.13514	Pr>|T|	0.0018
Num ^= 0	806	Num > 0	377
M(Sign)	-26	Pr>=|M|	0.0724
Sgn Rank	-16891.5	Pr>=|S|	0.0105
W:Normal	0.980032	Pr<W	0.0077

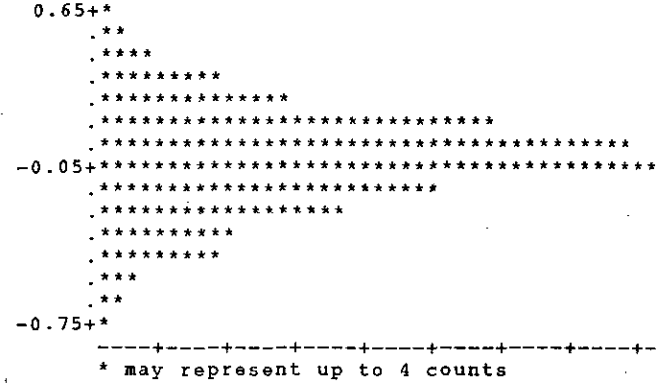
Quantiles(Def=5)

100% Max	0.667926	99%	0.537193
75% Q3	0.11529	95%	0.353729
50% Med	-0.01293	90%	0.240933
25% Q1	-0.1573	10%	-0.34752
0% Min	-0.73004	5%	-0.43065
		1%	-0.58329
Range	1.397962		
Q3-Q1	0.272588		
Mode	-0.73004		

Extremes

Lowest	Obs	Highest	Obs
-0.73004(	435)	0.585408(	634)
-0.70972(	26)	0.61189(	183)
-0.68987(	230)	0.63518(	7)
-0.67126(	633)	0.665895(	320)
-0.65633(	112)	0.667926(	438)

Histogram



#	Boxplot
4	0
7	0
13	
33	
53	
113	+------+
154	| |
164	*--+--*
100	+------+
71	
40	
34	
12	0
6	0
2	0

Normal Probability Plot

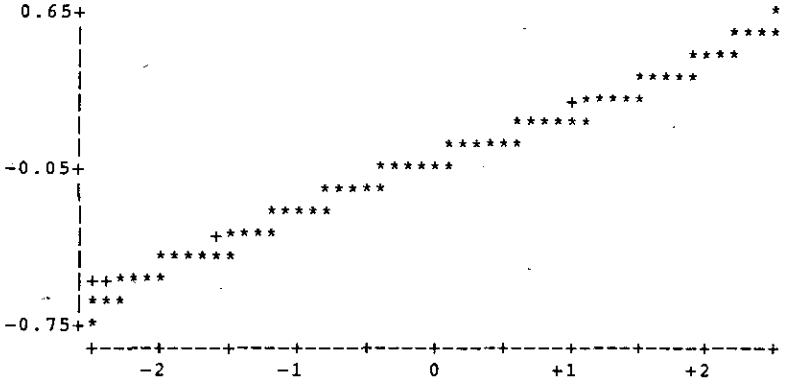


FIGURE 1. Plot of Residuals (R2*P2). Legend: A = 1 obs, B = 2 obs, etc.