Northwest Atlantic Fisheries Organization

Serial No. N4350 **NAFO SCR Doc. 00/88**

SCIENTIFIC COUNCIL MEETING – NOVEMBER 2000

The Assessment of the International Fishery for Shrimp (*Pandalus borealis*) in Division 3M (Flemish Cap), 1993-2000

by

U. Skuladottir[1] and D. Orr[2]

[1] Marine Research Institute, Skulagata 4, P.O. Box 1390, 121 Reykjavik, Iceland
[2] Science Branch, Department of Fisheries and Oceans, P.O. Box 5667,
St. John's, Newfoundland, Canada, A1C 5X1

Abstract

The development of the international shrimp (*Pandalus borealis*) fishery in NAFO Division 3M is described. A standard four nation data set is used to create a series of standardized catch per unit effort (CPUE) indices with the purpose of tracking the status of the Div. 3M shrimp stock. Also an international database of observer samples is used (up to three countries contributing) of which ageing was carried out. The indices of recruitment and female stock are calculated from this using the Icelandic CPUE series (single and double trawl). Moreover there are female indices from the EU survey and the Faroese survey as well as the recruitment indices from the Faroese survey both from the main trawl and the juvenile bag. In this paper all these indices are gathered for use in the present evaluation the of the shrimp stock at Flemish Cap.

1. INTRODUCTION

The fishery for northern shrimp on the Flemish Cap began during the spring of 1993 and has since continued with estimated annual catches (unofficial) of approximately 28,000, 24,000, 33,000, 49,000, 25,000, 30,000 and 36,000 tons from 1993 to 1999, respectively. The catch of 1999 was the second highest in the series. Removals to October 2000 of approximately 40,000 tons are higher than those reported for the same period in 1999. Projections to the end of year 2000 are expected to reach 50,000 tons. Vessels from as many as 17 nations have participated in this fishery since its beginning.

The following is an overview of the international fishery for shrimp on Flemish Cap. Trends in catch and effort from data provided by the fleets of several nations are described. Standardized catch per unit effort (CPUE) series, addressing differences in catch rate due fishing power of individual vessels, and gear type are used as possible indicators of change in the stock over time.

Background on the assessment and management of this resource since 1993 can be found in Parsons (1998), Skuladottir *et al* (1999) and NAFO Scientific Council Reports (1999).

2. COMMERCIAL FISHERY

2.1. History of the Fishery

The shrimp fishery in Div. 3M began in late April 1993. Fishing activity (monitored by Canada) increased to include approximately 50 vessels from several nations in early July but subsequently declined over the remainder of the year.

The pattern of increasing activity to about mid-year followed by a decrease to the end of the year continued in subsequent years.

A summary of the number of vessels by country and year is given in Table 1. The numbers represent the best estimates of fleet size but might not be accurate for all nations.

2.2. **Trends in Catch**

2.2.1. **Catch by nation and year**

Preliminary estimates of catch (tons) by nation and year are shown in Table 2. In 1993, Faroe Islands and Norway took 56% of the estimated total catch in tons. Canada and Greenland each caught approximately 3,700 tons, Iceland about 2,200 and Honduras 1,265. Lesser amounts were reported for other nations.

Faroese and Norwegian vessels accounted for over 60% of the estimated catch in 1994. Estonia, Latvia and Lithuania joined the fishery that year and, in combination, caught approximately 2,600 tons. Canadian vessels caught 1,041 tons, substantially less than in 1993. Greenlandic and Danish catches were also less than those of the previous year whereas Icelandic catches remained roughly the same.

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 although catches by Faroe Islands and Norway were still very high.

The 1996 data showed substantial increases in catch for several nations. Icelandic catches increased from about 7,600 tons in 1995 to 20,700 tons in 1996. Catches by Faroe Islands increased from 6,000 tons to 8,700 tons and Russian catches from 2,800 to 4,400 tons. Latvia and Lithuania also increased their catches from 1995 to 1996 while catches by Canada, Greenland and Norway decreased.

Catches in 1997 of about 25,000 tons were much lower than in 1996. The reduction was, in part, due to the Icelandic quota of 6,800 tons (in effect, decreasing the catch by 14,000 tons), low CPUE and possibly a depressed market for northern shrimp, which affected all nations.

Catches in 1998 of about 30,000 tons were higher than in 1997. Most noteworthy was the increase in the catch by Estonia from 3,200 tons in 1997 to about 5,700 tons in 1998. Faroe Islands caught most both in 1997 and 1998.

Total catches increased in 1999 by 30% over 1998. The Estonian catch almost doubled to 10,800 tons. Iceland increased its quota and caught 9,200 tons. Catches to October 2000 were approximately 40,000 tons. Most noTable was the large increase of catch by Russia from 650 tons in 1999 to 5,600 tons in 2000. Preliminary results indicate that Estonia had the highest catch (>11,500 tons).

2.2.2. **By Month and Year**

Following a recommendation of an *ad hoc* working group on shrimp in Div. 3M (Parsons, 1996), a standard catch and effort data set was constructed. The current version includes data 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.

Monthly catches show an increasing trend from January to June or July, followed by a decrease to the end of the year (Table 3). The May-September accounted for most of the logged catch each year.

2.2.5. **By Area and Year**

The standard four country data set included a reference to area fished for each nation except Norway. The Cap was separated into four areas - northeast (No. 1), southeast (No. 2), southwest (No. 3) and northwest (No. 4) - at 47°10' N and 45°W. Logbook data showed that most of the recorded 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). All areas produced significant catches in 1996, including the southeast quadrant (area 2). The northwestern sector remained the preferred area through to 2000 although records indicate that substantial catches were taken in the northeast (area 1; Table 4).

2.3. Trends in Effort

The standard four country data set has been used to describe trends in fishing effort, assuming the data are representative of total fleet activities. When looking at the proportions of catch obtained by either double trawl or single trawl through the years it becomes evident that there is a strong trend to increase the efficiency of the fleet by increasing the useage of double trawls as compared to single trawls. Thus the usage of double trawls increased over time from 6% of total catch in 1993 and 1994 to 60% in 1997, about 70% in 1998 and 1999 and to 98 % in year 2000. It is therefore not appropriate to analyse data without making account for changes in technology (Tables 5-8).

2.4.1. CPUE

The main purpose for constructing the four country catch and effort data set was for the calculation of catch per unit of effort (CPUE). The following calculations are based on single and double trawl data from the nominal catch records of Canada, Greenland, Iceland and Norway. For each model, the CPUE was determined for ln(catch/effort) data using a SAS multiple regression procedure (GLM). The models presented below made use of data from Canada, Greenland, Iceland and Norway for the years 1993-1999 but only Canada, Greenland and Iceland for the year 2000.

Model 1

The single trawl model presented in the previous assessment (Skuladottir *et al*., 1999) was applied using updated information from 1999 and preliminary data for 2000 (to September).

The updated model, with 3 outlying observations deleted in the final run (IF -1.5<RESID.<1.5), used records for which CATCH > 0 kg and EFFORT > 10 hours. Also, the number of tows associated with each catch-effort record was used as a weighting factor. The model explained approximately 71% of the variation and both class variables were significant at $P < 0.05$ using type III sum of squares (Table 9). Results indicated that the estimate for 1993 was significantly higher ($P < 0.05$) than the 2000 standard. A plot of residuals is given in Fig. 1. Figure 2 is a plot of the standardized and unstandardized single trawl CPUE index.

Model 2

The double trawl accounted for approximately 63% of the variance in the data. Once again, both class variables had significant effects ($P<0.05$) upon the outcome of the model using type III sum of squares. In this case, however, the estimates for 1993, 1995, 1996 and 1997 were significantly different from the 2000 estimate (Table 10). The 1993 estimate was significantly higher than the 2000 estimate, while the 1995-1997 estimates were lower. Figure 3 presents residuals from the double trawl model. Figure 4 presents the standardized and unstandardized double trawl CPUE index.

Models 1 and 2 gave similar results. In both cases, the estimates for 1993 catch rates were significantly higher than the 2000 estimates, CPUE decreased during 1994 after which there was stability. However, the standard errors for annual estimates in model 2 (<0.07; 582 observations), were lower than in model 1 (>0.1; 1034 observations).

Model 3

The single + double trawl standard CPUE model accounted for approximately 74% of the variance in the data. This was the final model and it was agreed that outlying observations would not be removed from the model. Year, vessel and gear type had significant ($P<0.05$) interaction effects upon the model results. The 1993, 1994, 1995, 1996 and 1997 standardized CPUE estimates were significantly different than the 2000 estimate. The 1993 estimate was significantly above while the 1994-1997 estimates were significantly below the 2000 value (Table 11). The residuals around this model are presented in Fig. 5. Figure 6 presents the standardized and unstandardized single + double trawl CPUE index for the years 1993-2000. The unstandardized CPUE plot within Fig. 6 clearly shows the need for modelling to account for changes in technology. The unstandardized CPUE gives the false impression that the CPUE has been steadily increasing since 1994.

The single trawl is 0.7408 less efficient than the double trawl; conversely it may be said that the double trawl is 1.35 times as efficient as the single trawl. This is much lower than 1.9 as calculated from the Icelandic data in the years 1994-1999 (Skuladottir, 1999).

The CPUE index was ultimately developed to track the status of the shrimp stock.

3. RECRUITMENT

There are various indices for recruitment both from the Faroese survey and from the international sample data base after these have been age assessed, see below. The Faroese stratified random surveys have used a juvenile bag for three years and the results are shown in Fig. 7 and the Table below (Nicholajsen and Brynjolfsson, 2000). Moreover the abundance of two year olds obtained in the main trawl in the Faroese survey was observed for 4 years and is also shown in Fig. 7 and the Table below (Nicolajsen, 2000).

The recruitment index (number of 2 year olds) is calculated from the international sample data base by using the CPUE of Icelandic logbooks, first standardizing kg/hr to a 3,000 mesh trawl, where the effort of the double trawl is multiplied by 1.9 to match the catch per hour of a single trawl (Skuladottir, 1999). This index was compared with the recruitment indices provided by the Faroese survey and the juvenile shrimp bag that has been attached to the Faroese survey trawl since 1998. The raw data are provided in the Table below.

Survey/Year	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**
Faroese survey main trawl					901	226	214	108
Faroese survey juvenile bag						2725	5680	458
Icelandic CPUE	4987	6324	26156	2248	21887	3591	1896	666

Raw data used to derive the indices compared in Fig. 7.

Figure 7 illustrates these series, each of which had been standardized to the mean of that series. In all three cases, the comparison illustrates that the abundance of 2 year olds was the lowest during 2000. In 1999 two out of three show little recruitment whereas the juvenile bag in the Faroese series shows increase in recruitment. This should be reflected in a substantial increase of three year olds in the fishery in year 2000 as compared to three year olds of the year 1999, but that does not seem so apparent (Table 13).

4. FEMALE BIOMASS

Similarly, a spawning stock index was calculated as kg/hr. of primiparous plus multiparous females from the Icelandic CPUE series. This was compared with the EU survey (Bruno, 2000) and Faroese survey biomass indices (Nicolajsen, 2000). The raw data are provided in the Table below. Once again, each index was standardized to the mean of the series and shown in Fig. 8.

Survey/Year	**1988**	**1989**	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**
EU survey biomass	1874	1340	1132	5362	11509	6839	2823	4286	4149	3807	8091	9051	6553*
Faroese survey biomass										6766	12685	8616	9541
Icelandic CPUE						105	101	129	97	89	129	159	93

* Vazquez (2000) personal communication.

The spawning stock (female biomass) as determined from the survey biomass indices were slightly above average during 2000. However, the CPUE index indicated that the SSB was slightly below average during 2000.

Although the indices do not always agree, the time series is too short to draw conclusions about the quality of the CPUE index.

5. AGE ASESSMENTS

Age analysis was performed on biological samples obtained from Canadian, Greenlandic and Icelandic vessels. Shrimp were separated into males, primiparous females and multiparous females according to the sternal spine criterion provided in McCrary (1971). Oblique carapace lengths were measured and grouped into 0.5 mm length classes. These data form the International shrimp ageing database as recommended in Aappendix II of the 1999 NAFO Scientific Council Meeting on Shrimp (NAFO, 1999). Modal analysis (MacDonald and Pitcher, 1979) was conducted on a month basis using the monthly catch of each country for weighting. This analysis provided the mean lengths and proportions at age and sex. The mean lengths were converted to mean weights via length weight relationships (Skuladottir, 1997).

Since the Canadian data (Parsons and Veitch, 1996) were only available as yearly results for the years 1993-1995 the following two length/weight relationships were used for these:

For males and primiparous females for April and all year around :	ln y = 3.037*ln x - 7.549
For multiparous females in April-June:	ln y = 2.778*ln x - 6.689

Other equations used for multiparous females in later years were also the following:

For multiparous females July:	ln y = 2.921*ln x - 7.144
For multiparous females August:	ln y = 3.111*ln x - 7.689
For multiparous females Sept-March:	ln y = 2.929*ln x - 7.085

Tables 12-15 indicate the results of the above analysis. Table 12 shows proportion, mean weight at age and sex group

Table 13 provides the maturity ogive, while Tables 14 and 15 respectively provide the CPUE data in terms of standardized number and weight caught per hour by age. In general, strong and weak cohorts may be followed from the top through to the bottom. A peak seen among age 4 shrimp during 1998 as age 4 shrimp may be found in 1999 as 5 year old shrimp and finally in 2000 as 6 year old shrimp. Similarly a two year trough present during 1994 and 1995 as four year old shrimp may be followed during 1996 and 1997 as five year old shrimp and again in 1997 and 1998 as six year old shrimp.

6. SUMMARY

Catches of shrimp on Flemish Cap have been maintained at a high level (averaging more than 30,000 tons annually since the fishery began) due to: increasing effort up to 1996; an expansion of the fishing grounds to target smaller shrimp in shallower water (NAFO, 1997); and, more recently, a possible increase in biomass (NAFO, 1998). Both the unstandardized and standardized catch rates for 1994 were lower than the 1993 estimate. CPUE varied with no clear trend between 1994 and 1997; increased during 1998 and remained stable thereafter.

Over the years, the standardization has evolved and as noted above, there is evidence that the CPUE models follow trends in the data. Although the standardization of CPUE has been improved by including adjusted double trawl effort, results are still difficult to interpret as an index of stock size due to some changes in fishing pattern between years (i.e. areas/depths fished reflect targeting of the recruiting age class).

7. ACKNOWLEDGEMENT

Appreciation is expressed to all those who provided data for inclusion in this paper in advance of the 2000 November Meeting.

8. REFERENCES

NAFO. 1997. Scientific Council Reports, 1997, p. 182-183 and 207.

NAFO. 1998. Scientific Council Reports, 1998, p. 162-163 and 189.

NAFO. 1999. Scientific Council Reports, 1999, p. 265-269 and 284.

Bruno, I, 2000. Northern shrimp (*Pandalus borealis*) on Flemish Cap in July 2000). NAFO SCR Doc. 00/71, Serial No. N4328: 16p.

Nicolajsen, A, 2000. Biomass estimate, growth, length and age distribution of the northern shrimp (*Pandalus borealis*) stock on Flemish Cap (NAFO Division 3M), in June. NAFO SCR Doc. 00/83, Serial No. N4340: 17 p.

Nicolajsen, A, and S. Brynjolfsson, 2000. Young northern shrimp (*Pandalus borealis*) index for Flemish Cap (Division 3M), 1998-2000. NAFO SCR Doc. 00/82, Serial No. N4339: 7 p.

McCrary, J.A. 1971. Sternal spines as a characteristic for differentiating between females of some Pandalidae. J.Fish. Res. Board Can., 28: 98-100.

MacDonald P. D. M.. and T. J. Pitcher 1979. Age groups frojm size-frequency data: A versatile and efficient method of analysing distribution mixtures. . J. Fish. Res. Board Can., 36: 987-1011.

Parsons, D.G., 1996. Report of the *Ad Hoc* working group on shrimp (*Pandalus borealis*) Division 3M. NAFO SCS Doc. 96/19, Serial No. N2817; 7 p.

Parsons, D.G. and P.J. Veitch, 1996. The Canadian fishery for northern shrimp (*Pandalus borealis*) on Flemish Cap (NAFO Division 3M), 1993 to 1996. NAFO SCR Doc. 96/93, Serial No. N2776: 12 p.

Parsons, D.G., 1998. The International Fishery for Shrimp (*Pandalus borealis*) in Division 3M (Flemish Cap), 1993 - 1998. NAFO SCR Doc. 98/92, Serial No. N3093: 12 p.

Skuladottir, U., 1998. The Icelandic shrimp fishery (*Pandalus borealis* Kr.) at Flemish Cap in 1993-1998. NAFO SCR Doc. 98/89, Serial No. N3090: 27 p.

Skuladottir, U., 1999. The Icelandic shrimp fishery (*Pandalus borealis* Kr.) at Flemish Cap in 1993-1999. NAFO SCR Doc. 99/116, Serial No. N4197: 27 p.

Skuladottir, U., D.G. Parsons and D. Orr, 1999. The International Fishery for Shrimp (*Pandalus borealis*) in Division 3M (Flemish Cap), 1993 - 1999. NAFO SCR Doc. 99/112, Serial No. N4192: 21 p.

Table 1. Number of vessels by year and country fishing shrimp on the Flemish Cap.

Country/ year	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**
CAN	13	7	7	6	4	4	3	3
Cuba	-	-	-	-	-	-	1	1
EU/DNK	2	2	1	-	-	1	2	1
EST	-	4	6	5	5	7	10	9
EU	-	2	2	1	1	6	4	7
FRA	-	-	-	-	1	-	-	-
FRO	11	10	9	11	8	7	5	5
GRL	12	8	5	4	2	2	1	3
ISL	5	9	21	40	14	11	13	9
LVA	-	2	3	4	2	2	4	3
LTU	-	2	4	6	5	6	5	4
NOR	21	19	26	15	2	2	2	2
POL	-	-	-	-	1	-	1	1
POR	-	-	1	-	-	-	-	-
RUS	2	4	15	17	3	-	4	8
St. Vin.	-	1	-	-	-	-	-	-
N. Zea.	-	-	-	1	-	-	-	-
TOTAL	66	70	100	110	48	48	55	56

Table 2. Catch (tons) by nation.

Nation	1993	1994	1995	1996	1997	1998	1999	2000*
Canada	3724	1041	970	906	807	484	490	618
Cuba							119	
EU/Denmark	800	400	200			437	235	
Estonia		1081	2092	1900	3240	5694	10835	11542
Faroe Island	7333	6791	5993	8688	7410	9368	9199	6266
Greenland	3788	2275	2400	1107	105	853	576	1636
Honduras	1265							
Iceland	2243	2300	7623	20681	6381	6572	9217	6548
Latvia		300	350	1940	997	1191	3080	2181
Lithuania		1225	675	2900	1785	3106	2487	3049
Norway	7183	8461	9533	5683	1831	1339	2975	1451
Poland					288	148	894	
Portugal	300		150		170	203	227	163
Russia		300	2838	4444	1090		652	5585
EU/Spain	240	300	158	50	421	913	1019	913
St. Vincent's		75			150			
Total	**26876**	**24549**	**32982**	**48299**	**24675**	**30308**	**42005**	**39952**

* Provisional to October

Table 3. The standard four country (Canada, Greenland, Iceland and Norway) catch per unit effort data set broken down by month and year.

Month/Year	1993	1994	1995	1996	1997	1998	1999	2000*
JAN		485	28	363	73			277
FEB		975	130	355	133	65	134	619
MAR		679	387	1220	190	203	536	1285
APR		501	814	3007	960	371	997	1684
MAY	837	1740	2611	3647	1049	985	2600	1761
JUN	6129	3593	4754	4730	1235	1758	2726	2111
JUL	4098	2645	5439	3761	1396	2026	1894	1420
AUG	1928	1356	2265	2422	1031	1109	1301	579
SEP	1404	593	940	1566	872	1163	702	560
OCT	876	317	624	973	692	794	874	
NOV	542	21	187	397	286	382	755	
DEC	281	64	162	136	146	150	684	
TOTAL	**16095**	**12969**	**18341**	**22577**	**8063**	**9006**	**13203**	**10296**

* Provisional

Table 4. Canadian, Greenlandic and Icelandic shrimp catches (tons) by area in NAFO Div. 3M.

Area/ Year	1993	1994	1995	1996	1997	1998	1999	2000
1	2870	294	1365	3079	1492	2304	2405	1481
2	190	1	61	1221	182	88	1265	734
3	1605	1997	3488	4601	1501	853	1870	951
4	4246	2216	3896	7992	3057	4447	4804	3479
TOTAL	8911	4508	8809	16893	6232	7692	10344	6644

Table 5. Single trawl catches (kg) as provided by the four country standard CPUE data set for the Div. 3M shrimp fishery. These data were used in calculation of the standardized CPUE index (Norwegian data were not available for the 2000 estimates).

Month/Year	1993	1994	1995	1996	1997	1998	1999	2000
JAN		455913	28179	263393	69607			
FEB		785593	129287	150222	133281		46037	
MAR		521747	386187	557897	111038		282006	
APR		501220	712088	2074167	251103		469240	12510
MAY	827158	1735166	2313574	2321039	295939	155927	761749	81134
JUN	5943418	3474265	3698908	3109654	461895	440117	942320	32707
JUL	3894351	2434046	3752692	2692133	593528	609886	604997	
AUG	1730012	1159783	1789079	1822450	510222	320748	19706	
SEP	1170064	592275	763149	1167759	299770	272398	2838	
TOTAL	**13565003**	**11660008**	**13573143**	**14158714**	**2726383**	**1799076**	**3128893**	**126351**

Table 6. Double trawl catches (kg) as provided by the four country standard CPUE data set for the Div. 3M shrimp fishery. These data were used in calculation of the standardized CPUE index (Norwegian data were not available for the 2000 estimates).

Month/Year	1993	1994	1995	1996	1997	1998	1999	2000
JAN		28470		97205				273106
FEB		180940		202734		62691	83872	466270
MAR		156868		659682	79030	202737	488394	801627
APR			97700	910507	707058	369713	840383	1181313
MAY			285988	1311467	751805	817800	1526197	1192924
JUN	172327	110587	1047775	1608335	767329	1308134	1923768	1460125
JUL	195108	200651	1668551	1044940	795986	1413280	1434884	1002395
AUG	197274	194156	466857	597888	516033	782505	903661	120993
SEP	228773		174693	395295	565720	886384	640866	
TOTAL	**793482**	**871672**	**3741564**	**6828053**	**4182961**	**5843244**	**7842025**	**6498753**

Table 7. Single trawl effort (hrs.) as provided by the four country standard CPUE data set for the Div. 3M shrimp fishery. These data were used in calculation of the standardized CPUE index (Norwegian data were not available for the 2000 estimates).

Month/Year	1993	1994	1995	1996	1997	1998	1999	2000
JAN		1817	149	1208	399			
FEB		2798	515	620	626		88	
MAR		2920	1655	2367	326		991	
APR		2433	3131	9760	924		1690	85
MAY	1367	5922	7738	11012	1597	637	2838	351
JUN	14154	13393	12791	14038	2291	1456	2759	130
JUL	12270	10217	14533	13330	2329	2029	1821	
AUG	6341	6265	8749	9293	2115	1098	65	
SEP	4532	3574	4596	6718	1154	1181	12	
TOTAL	**38664**	**49339**	**53857**	**68346**	**11761**	**6401**	**10264**	**566**

Table 8. Double trawl effort (hrs.) as provided by the four country standard CPUE data set for the Div. 3M shrimp fishery. These data were used in calculation of the standardized CPUE index (Norwegian data were not available for the 2000 estimates).

Month/Year	1993	1994	1995	1996	1997	1998	1999	2000
JAN		64		283				542
FEB		251		427		149	150	887
MAR		280		1212	248	533	889	1418
APR			399	2287	1804	947	1928	2346
MAY			600	3723	2713	1715	3474	2919
JUN	229	178	2061	4364	2483	2229	3419	2362
JUL	320	430	3276	3445	2253	2787	2791	2029
AUG	329	545	1359	2026	1616	1907	1893	284
SEP	329		861	1377	1781	2692	1377	
TOTAL	**1207**	**1748**	**8556**	**19144**	**12898**	**12959**	**15921**	**12787**

Table 9. Multiplicative, year/vessel model (1) using single trawl logbook CPUE data for the period 1993-2000.

The GLM Procedure
Class Level Information

Class	Levels	Values
YEAR	8	93 94 95 96 97 98 99 2000
VESSEL	78	1128 12 1352 1383 1407 1462 1484 1506 1514 1576 1609 1628 1634 1742 1752 1753 1757 1768 1807 1809 1903 1905 1942 2013 2061 21 2155 2190 2197 2204 2206 2211 2212 2216 2218 2220 2237 2242 2244 2249 2258 2259 2262 2266 227 2286 2288 2332 29 40 41 43 44 47 5 58 66 67 68 69 70 OUKV OUOQ OWGG OWQU OWTI OWVM OYBZ OYCK OYHO OYKK OYRG OYRT OYXT OYZL OZDH OZKQ OZMA

Number of observations 1034

Dependent Variable: LNCPUE
Weight: WFACTOR

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	84	2578.025859	30.690784	27.06	<.0001
Error	949	1076.527814	1.134381		
Corrected Total	1033	3654.553673			

R-Square	Coeff Var	Root MSE	LNCPUE Mean
0.705428	19.35352	1.065073	5.503254

Source	DF	Type I SS	Mean Square	F Value	Pr > F
YEAR	7	1354.192183	193.456026	170.54	<.0001
VESSEL	77	1223.833676	15.893944	14.01	<.0001

Source	DF	Type III SS	Mean Square	F Value	Pr > F
YEAR	7	514.145229	73.449318	64.75	<.0001
VESSEL	77	1223.833676	15.893944	14.01	<.0001

Parameter		Estimate		Standard Error	t Value	Pr > |t|
Intercept		5.628644710	B	0.32490085	17.32	<.0001
YEAR	93	0.409119103	B	0.13213183	3.10	0.0020
YEAR	94	-0.174835937	B	0.13362592	-1.31	0.1911
YEAR	95	0.019514684	B	0.13490120	0.14	0.8850
YEAR	96	-0.152014688	B	0.13412537	-1.13	0.2573
YEAR	97	-0.120113887	B	0.13618284	-0.88	0.3780
YEAR	98	0.004398267	B	0.13935821	0.03	0.9748
YEAR	99	0.066318651	B	0.13655792	0.49	0.6273
YEAR	2000	0.000000000	B	.	.	.

Table 10. Multiplicative, year/vessel model (2) using double trawl logbook CPUE data for the period 1993-2000.

The GLM Procedure
Class Level Information

Class	Levels	Values
YEAR	8	93 94 95 96 97 98 99 2000
VESSEL	30	1352 1383 1609 2013 2061 2197 2211 2212 2216 2218 2220 2237 2242 2249 2262 2288 29 5 71 N8 OWGG OYBZ OYCZ OYHO OYPK OYRG OYXT OZDH OZKQ OZMA

Number of observations 582

Dependent Variable: LNCPUE
Weight: WFACTOR

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	36	1012.721387	28.131150	26.07	<.0001
Error	545	588.115255	1.079111		
Corrected Total	581	1600.836642			

R-Square	Coeff Var	Root MSE	LNCPUE Mean
0.632620	17.22457	1.038802	6.030933

Source	DF	Type I SS	Mean Square	F Value	Pr > F
YEAR	7	475.1994540	67.8856363	62.91	<.0001
VESSEL	29	537.5219334	18.5352391	17.18	<.0001

Source	DF	Type III SS	Mean Square	F Value	Pr > F
YEAR	7	101.5033285	14.5004755	13.44	<.0001
VESSEL	29	537.5219334	18.5352391	17.18	<.0001

Parameter		Estimate		Standard Error	t Value	Pr > |t|
Intercept		6.329627225	B	0.05010403	126.33	<.0001
YEAR	93	0.250846528	B	0.06841206	3.67	0.0003
YEAR	94	-0.069931905	B	0.06439400	-1.09	0.2780
YEAR	95	-0.108777752	B	0.04984139	-2.18	0.0295
YEAR	96	-0.230237507	B	0.04253499	-5.41	<.0001
YEAR	97	-0.206534127	B	0.04255390	-4.85	<.0001
YEAR	98	-0.053744726	B	0.03903142	-1.38	0.1691
YEAR	99	0.018105054	B	0.03749582	0.48	0.6294
YEAR	2000	0.000000000	B	.	.	.

Table 11. Multiplicative, year/vessel/gear model (3) using single + double trawl logbook CPUE data for the period 1993-2000.

The GLM Procedure
Class Level Information

Class	Levels	Values
YEAR	8	93 94 95 96 97 98 99 2000
VESSEL	122	1128 12 1352 1383 1407 1462 1484 1506 1514 1576 1609 1628 1634 1742 1752 1753 1757 1768 1807 1809 1903 1905 1942 2013 2061 21 2155 2190 2197 2204 2206 2211 2212 2216 2218 2220 2237 2242 2244 2249 2258 2259 2262 2266 2279 2286 2288 2332 29 40 41 43 44 47 5 58 66 68 69 70 71 N1 N11 N12 N13 N14 N15 N16 N17 N18 N19 N2 N20 N21 N22 N23 N24 N25 N26 N27 N28 N29 N3 N30 N31 N32 N33 N34 N35 N36 N37 N39 N4 N40 N41 N42 N44 N5 N6 N7 N8 N9 OUKV OUOQ OWGG OWQU OWTI OWVM OYBZ OYCK OYCZ OYHO OYKK OYPK OYRG OYRT OYXT OYZL OZDH OZKQ OZMA ZZZZ
GEAR	2	1 2

Number of observations 1852

Dependent Variable: LNCPUE
Weight: WFACTOR

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	129	7799.00258	60.45738	37.13	<.0001
Error	1722	2803.83618	1.62824		
Corrected Total	1851	10602.83877			

R-Square	Coeff Var	Root MSE	LNCPUE Mean
0.735558	22.65330	1.276027	5.632852

Source	DF	Type I SS	Mean Square	F Value	Pr > F
YEAR	7	3126.077063	446.582438	274.27	<.0001
VESSEL	121	4443.701804	36.724808	22.55	<.0001
GEAR	1	229.223713	229.223713	140.78	<.0001

Source	DF	Type III SS	Mean Square	F Value	Pr > F
YEAR	7	732.035151	104.576450	64.23	<.0001
VESSEL	121	2697.478923	22.293214	13.69	<.0001
GEAR	1	229.223713	229.223713	140.78	<.0001

Parameter		Estimate		Standard Error	t Value	Pr > |t|
Intercept		6.309722749	B	0.06366775	99.10	<.0001
YEAR	93	0.137110233	B	0.04156218	3.30	0.0010
YEAR	94	-0.222077600	B	0.04081105	-5.44	<.0001
YEAR	95	-0.090920776	B	0.04034808	-2.25	0.0244
YEAR	96	-0.245619403	B	0.03885004	-6.32	<.0001
YEAR	97	-0.240716191	B	0.04151489	-5.80	<.0001
YEAR	98	-0.060727082	B	0.04087204	-1.49	0.1375
YEAR	99	0.019920920	B	0.03877384	0.51	0.6075
YEAR	2000	0.000000000	B	.	.	.
GEAR	1	-0.299947790	B	0.02527992	-11.87	<.0001
GEAR	2	0.000000000	B	.	.	.

Table 12. Proportion of nominal catch by sex and age over the period 1993-2000. Also provided in this table are mean weights per age for the whole year CPUEs of the Icelandic fleet (whole year standardized to 3000 meshes) in terms of weight and number per trawling hour and finally total number caught by year.

				1993				
Sex	Age	Prop. by no.	Mean weight g	Prop. by weight	Nominal catch 26876	kg/hr 363	No./hour	Number (´000)
Males	1	0.0041	0.646	0.00265	9	0.1	178	13186
Males	2	0.1148	2.772	0.31823	1036	13.8	4987	369209
Males	3	0.2146	5.225	1.12128	3650	48.7	9322	690175
Males	4	0.1156	8.188	0.94653	3081	41.1	5021	371781
Primip.	5	0.2619	10.441	2.73450	8902	118.8	11376	842297
Multip.	6+	0.2890	11.189	3.23362	10526	140.5	12553	929453
Total		1.0000		8.3568	27203.80795	363.0004	43438	3216101
				1994				
Sex	Age	Prop. by no.	Mean weight g	Prop. by weight	Nominal catch 24549	kg/hr 240	No./hour	Number (´000)
Males	1							
Males	2	0.1817	2.576	0.46806	1666	16.3	6324	646823
Males	3	0.3629	4.998	1.81377	6457	63.1	12630	1291865
Males	4	0.0854	7.101	0.60642	2159	21.1	2972	304010
Primip.	5	0.1944	10.080	1.95955	6976	68.2	6766	692033
Multip.	6+	0.1756	11.664	2.04820	7291	71.3	6111	625108
Total		1.0000		6.8960	24549	240.0	34803	3559839
				1995				
Sex	Age	Prop. by no.	Mean weight g	Prop. by weight	Nominal catch 32982 tons	kg/hr 283	No./hour	Number (´000)
Males	1							
Males	2	0.4516	1.965	0.88739	5990	51.4	26156	3048376
Males	3	0.2714	4.924	1.33637	9020	77.4	15719	1831996
Primip.	4	0.0507	6.462	0.32762	2211	19.0	2936	342234
Primip.	5	0.0962	9.611	0.92458	6241	53.5	5572	649366
Multip.	6+	0.1301	10.84	1.41028	9519	81.7	7535	878197
Total		1.0000		4.88625	32982.0216	283.0	57918	6750169
				1996				
Sex	Age	Prop. by no.	Mean weight g	Prop. by weight	Nominal catch 48299 tons	kg/hr 217	No./hour	Number (´000)
Males	1	0.0001	0.78	7.9E-05	6.0E-01	2.7E-03	3	775
Males	2	0.0656	2.160	0.14177	1081	4.9	2248	500354
Males	3	0.5816	4.76	2.76845	21107	94.8	19922	4433677
Primip.	3	0.0416	5.982	0.24897	1898	8.5	1426	317269
Primip.	4	0.1591	9.223	1.46756	11189	50.3	5450	1212990
Multip.	3	0.0038	6.706	0.02541	194	0.9	130	28881
Multip.	4	0.0537	9.267	0.49720	3791	17.0	1838	409004
Multip.	5	0.0649	11.559	0.75008	5719	25.7	2223	494678
Multip.	6	0.0293	14.701	0.43075	3284	14.8	1004	223362
Multip.	7	0.0003	17.129	0.00482	37	0.2	10	2146
Total		1.0000		6.3351	48298.95536	217.0	34254	7623136

Table 12 (Continued)

				1997				
Sex	Age	Prop. by no.	Mean weight g	Prop. by weight	Nominal catch 24675	kg/hr 192	No./hour	Number (´000)
Males	1	0.0003	0.910	0.0002	1	0.0	8	1029
Males	2	0.0711	3.201	0.2275	891	6.9	2167	281106
Males	3	0.4034	4.117	1.6607	6507	50.6	12299	1595718
Males	4	0.1961	6.633	1.3006	5096	39.7	5979	775681
Primip.	3	0.0033	5.237	0.0174	68	0.5	101	13141
Primip.	4	0.1564	8.390	1.3120	5141	40.0	4768	618625
Multip.	3	0.0018	5.018	0.0091	36	0.3	55	7177
Multip.	4	0.0707	9.570	0.6768	2652	20.6	2156	279769
Multip.	5	0.0806	10.631	0.8567	3357	26.1	2457	318792
Multip.	6	0.0151	14.350	0.2168	849	6.6	461	59754
Multip.	7	0.0013	15.070	0.0192	75	0.6	39	5053
Total		1.0000		6.2972	24675	192.0	30490	3955845
				1998				
Sex	Age	Prop. by no.	Mean weight g	Prop. by weight	Nominal catch 30308 tons	kg/hr 294	No./hour	Number (´000)
Males	1	0.0002	1.270	0.0003	1	0.0	10	991
Males	2	0.0740	2.066	0.1530	759	7.4	3561	370219
Males	3	0.3259	3.938	1.2833	6364	61.7	15676	1629610
Males	4	0.2420	5.705	1.3806	6847	66.4	11641	1210146
Males	5	0.0011	8.4	0.0096	48	0.5	55	5707
Primip.	4	0.1218	7.394	0.9009	4468	43.3	5862	609323
Primip.	5	0.0184	10.325	0.1901	943	9.1	886	92050
Multip.	3	0.0024	4.293	0.0103	51	0.5	115	11991
Multip.	4	0.0916	8.642	0.7919	3927	38.1	4408	458224
Multip.	5	0.1159	11.187	1.2964	6429	62.4	5575	579518
Multip.	6	0.0066	14.453	0.0953	472	4.6	317	32960
Total		1.0000		6.1115	30308	294.0	48106	5000739
				1999				
Sex	Age	Prop. by no.	Mean weight g	Prop. by weight	Nominal catch 42033 tons	kg/hr 252	No./hour	Number (´000)
Males	1	0.0000	0.120	0.00001	0	0.0	2	331
Males	2	0.0476	2.024	0.09627	640	3.8	1895	315960
Males	3	0.2826	3.377	0.95437	6343	38.0	11260	1877240
Males	4	0.2137	5.581	1.19239	7924	47.5	8513	1419191
Males	5	0.0002	6.560	0.00114	8	0.0	7	1155
Primip.	4	0.0126	6.385	0.08019	533	3.2	500	83426
Primip.	5	0.2404	8.165	1.96294	13045	78.2	9579	1596922
Multip.	3	0.0003	3.988	0.00116	8	0.0	12	1924
Multip.	4	0.0023	6.200	0.01435	95	0.6	92	15371
Multip.	5	0.0898	8.690	0.78023	5185	31.1	3577	596401
Multip.	6	0.1015	11.073	1.12412	7471	44.8	4045	674342
Multip.	7	0.0088	12.838	0.11311	752	4.5	351	58525
Multip.	8	0.0003	17.480	0.00456	30	0.2	10	1733
Total		1.0000		6.3248	42033	252.0	39843	6642521
				2000				
Sex	Age	Prop. by no.	Mean weight g	Prop. by weight	Nominal catch 40000	kg/hr 245	No./hour	Number (´000)
Males	1							
Males	2	0.0163	1.429	0.0232	156	1.0	667	108749
Males	3	0.2506	3.040	0.7618	5100	31.2	10276	1675689
Males	4	0.2594	4.602	1.1938	7993	49.0	10638	1734701
Males	5	0.0075	5.551	0.0418	280	1.7	309	50321
Primip.	4	0.0110	6.249	0.0685	459	2.8	450	73354
Primip.	5	0.2148	7.435	1.5969	10691	65.5	8808	1436268
Multip.	4	0.0072	7.117	0.0513	344	2.1	296	48230
Multip.	5	0.0000	4.990	0.0001	1	0.0	1	179
Multip.	6	0.1896	9.113	1.7282	11571	70.9	7777	1268175
Multip.	7	0.0436	11.671	0.5088	3406	20.9	1788	291518
Total		1.0000		5.9745	40000	245.0	41008	6687184

Table 13. Shrimp. Maturity of females (primiparous + multiparous) at age at spawning in June-August.

Age gr.	1993	1994	1995	1996	1997	1998	1999	2000	Mean
2	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
3	0.000	0.000	0.000	0.056	0.005	0.005	0.000	0.000	0.008
4	0.000	0.000	1.000	1.000	0.508	0.482	0.007	0.134	0.391
5	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
6	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000

Table 14. Number per hour at age (based on data in Table 12).

Age gr.	1993	1994	1995	Age gr.	1996	1997	1998	1999	2000
1	178			1				2	
2	4987	6324	26156	2	2248	2167	3561	1895	667
3	9322	12630	15719	3	21478	12456	15792	11272	10276
4	5021	2972	2936	4	7288	12903	21911	9105	11383
5	11376	6766	5572	5	2223	2457	6515	13163	9117
6+	12553	6111	7535	6	1004	461	317	4045	7777
				7	10	39		351	1788
				8				10	
Total	43437	34803	57918	Total	34251	30483	48096	39843	41008

Table 15. Standardized kg per hour at age (based on data in Table 12).

Age gr.	1993	1994	1995	Age gr.	1996	1997	1998	1999	2000
1	0.1			1					
2	13.8	16.3	51.4	2	4.9	6.9	7.4	3.8	1.0
3	48.7	63.1	77.4	3	104.2	51.4	62.2	38.1	31.2
4	41.1	21.1	19.0	4	67.3	100.3	147.8	51.3	53.9
5	118.8	68.2	53.5	5	25.7	26.1	72.0	109.3	67.2
6+	140.5	71.3	81.7	6	14.8	6.6	4.6	44.8	70.9
				7	0.2	0.6		4.5	20.9
				8				0.2	
Total	363.0	240.0	283.0	Total	217.1	191.9	294.0	252.0	245.1

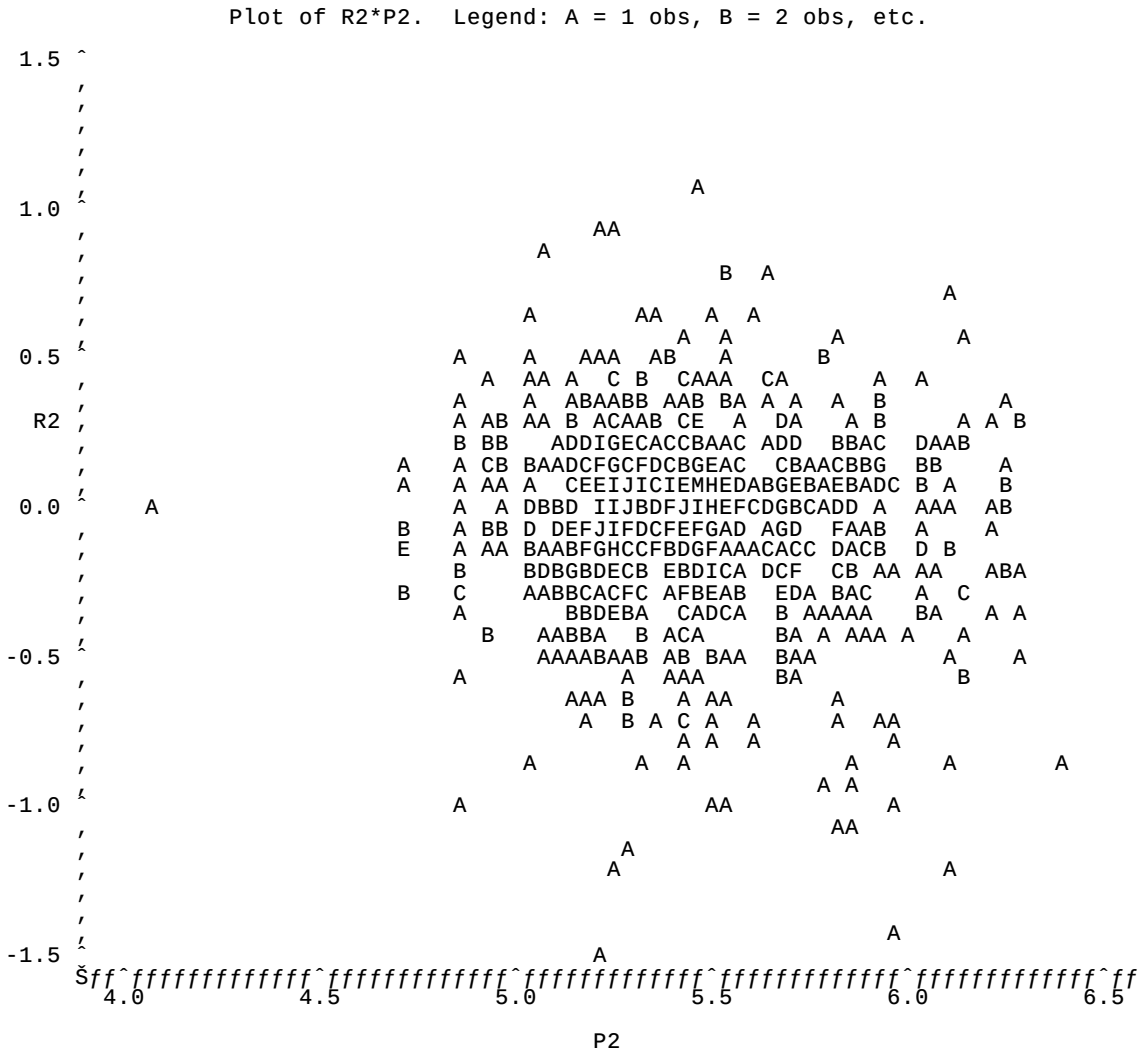

Figure 1. Residuals for the Year/ vessel model (1) for single trawl CPUE logbook data for the period 1993-2000.

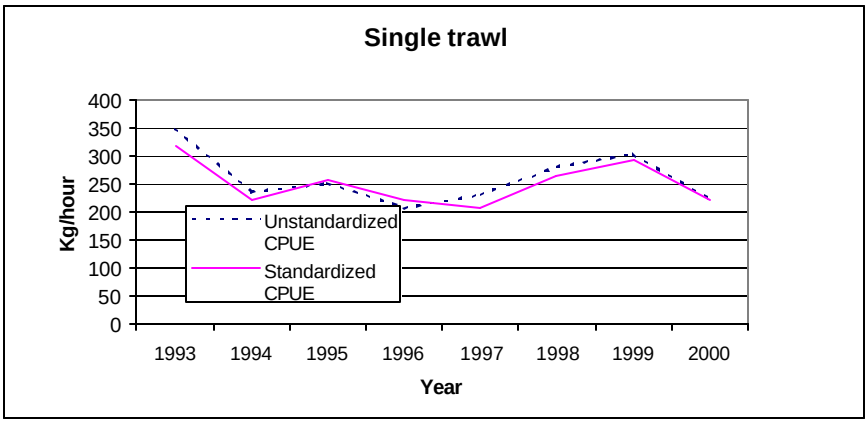

Figure 2. The standardized and unstandardized single trawl CPUE for the shrimp fishery in Div. 3M for the years 1993-2000.

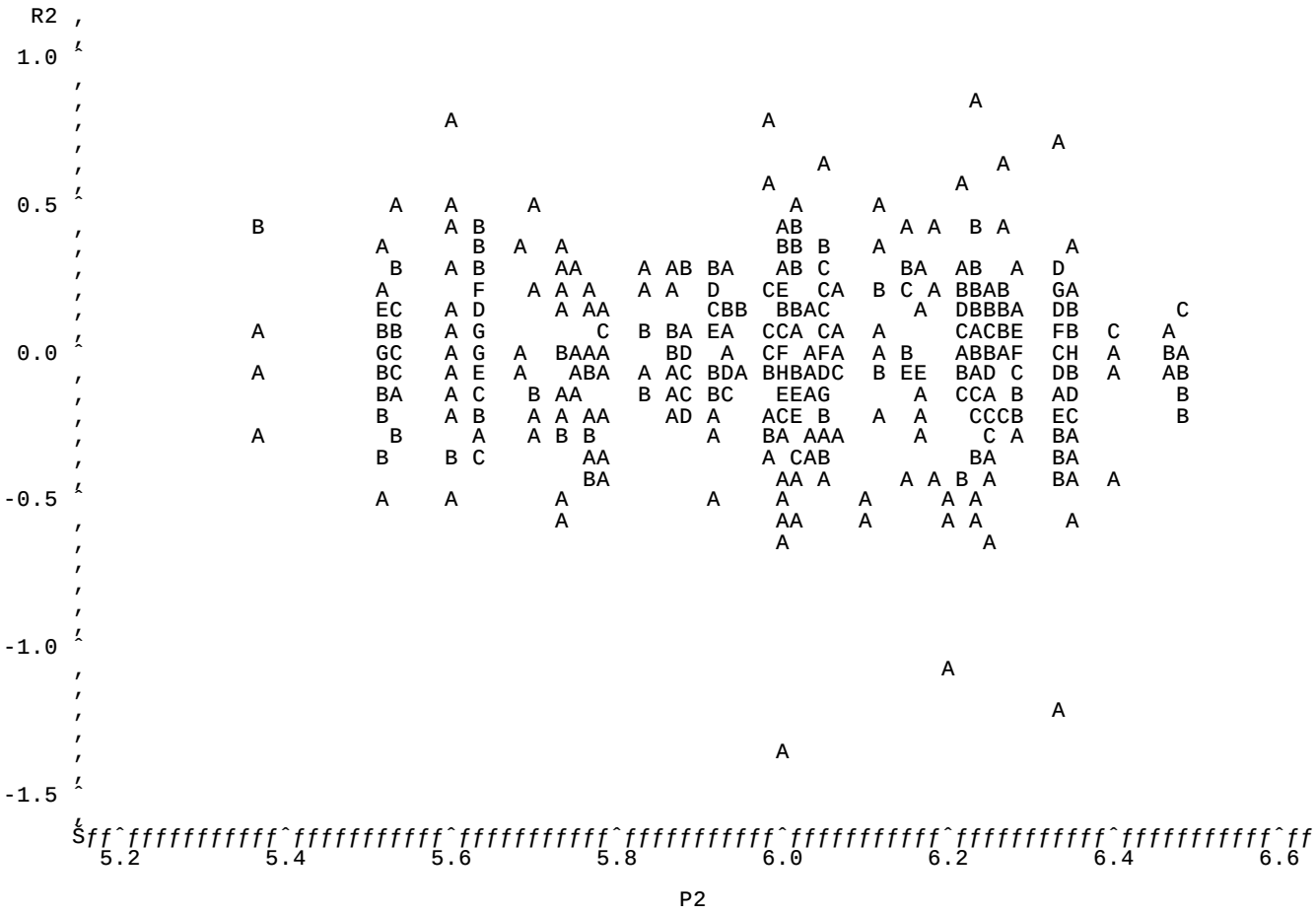

Figure 3. Residuals for the Year/ vessel model (2) for double trawl CPUE logbook data for the period 1993-2000.

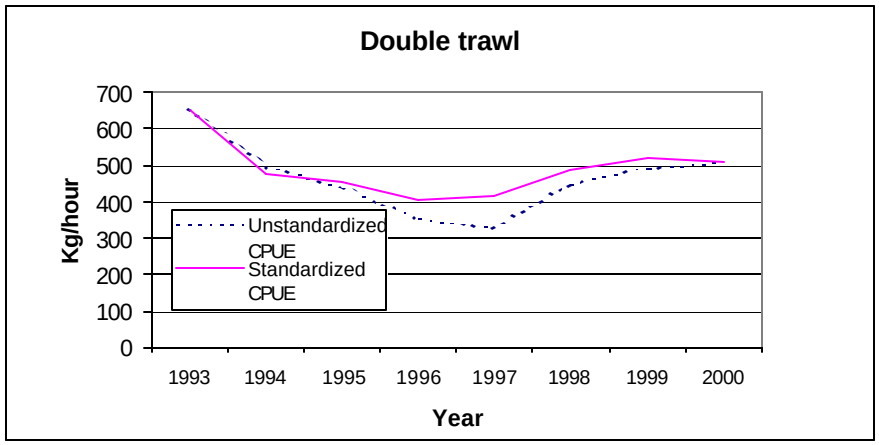

Figure 4. Standardized and unstandardized double trawl CPUE index for the shrimp fishery in Div. 3M between 1993 and 2000.

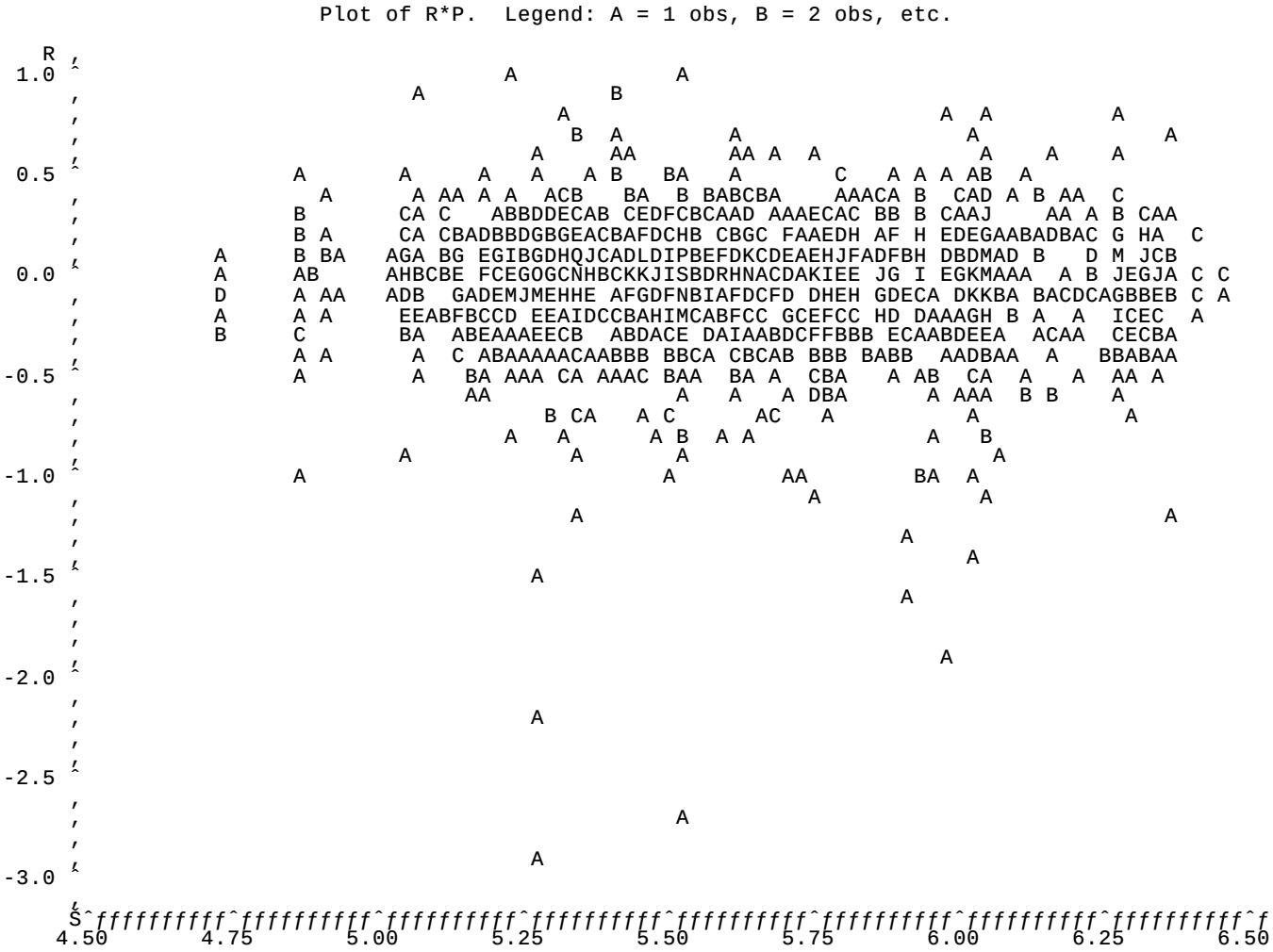

Figure 5. Residuals for the year/vessel/gear model (3) for single + double trawl CPUE logbook data for the period 1993-2000.

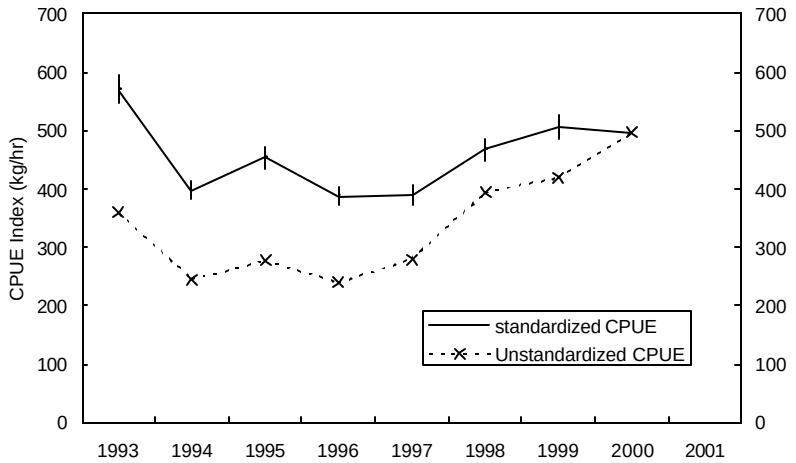

Figure 6. The standardized and unstandardized single + double trawl CPUE index for the shrimp fishery in Div. 3M during 1993-2000.

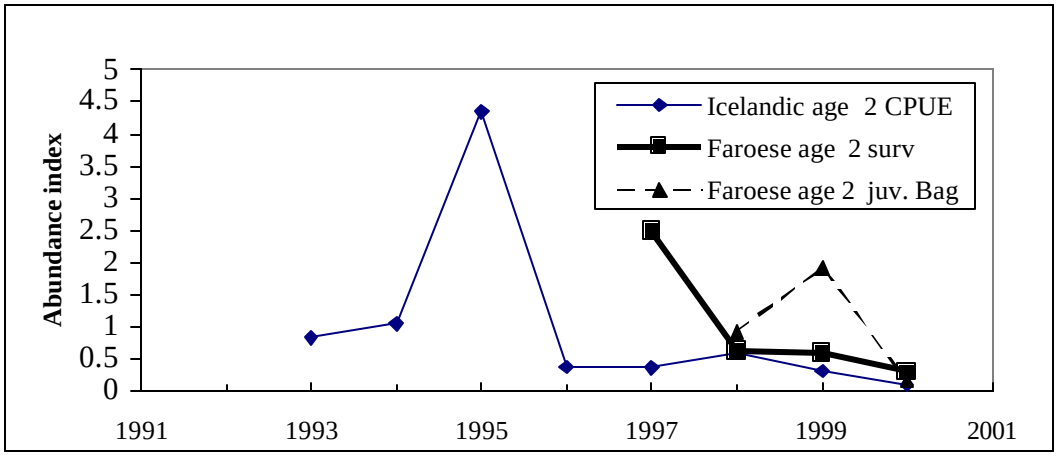

Figure 7. The Icelandic age 2 CPUE index, and Faroese survey age 2 index both from the main trawl and the juvenile bag. Each data series was standardized to the mean of the series.

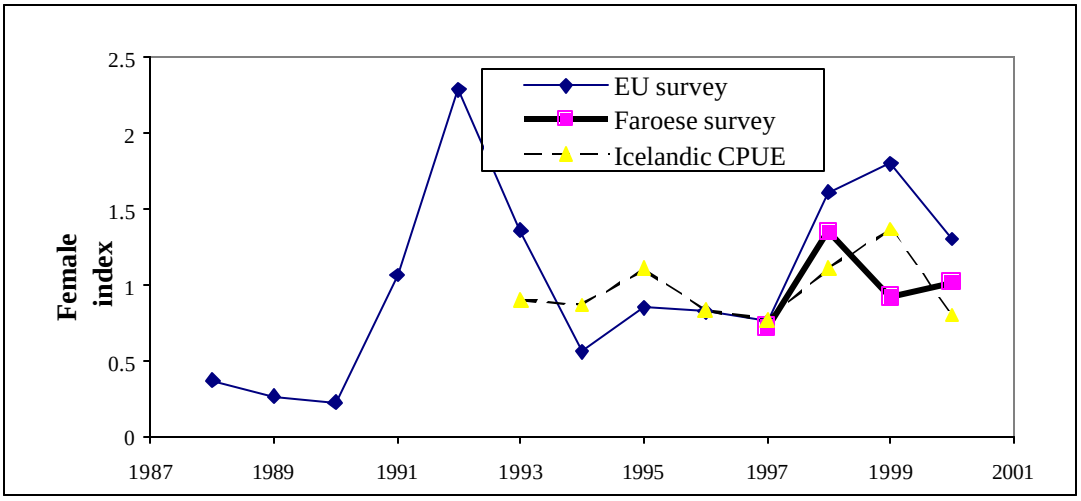

Figure 8. Female biomass index from EU trawl surveys, Faroese surveys and Icelandic female CPUE. Each data series was standardized to the mean of the series.