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The Catch Statistics of the Shrimp Fishery (*Pandalus borealis*) in the Denmark Strait in the Years 1980-1990

by

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Abstract

In this paper an effort has been made to gather and combine all information available on the effort and CPUE from the shrimp fishery of all countries in Denmark Strait. Total effort and mean CPUE of all countries combined has been calculated using the figures for nominal catch for every country. It is considered here that the shrimp stock is the same on both sides of the midline between Iceland and Greenland.

The downward trend in the catch rates is studied in various ways. Firstly by looking at the relationship between moving averages of catch of every three years against CPUE in the fourth year of the series. the relationship is linear and highly significant, namely the higher the catch the lower the CPUE. Secondly the relationship between the moving averages of effort, of two or three years against CPUE the second or third year respectively is studied using the generalproduction model or Fox's (1970) version of the Scaefer suplus yield model (1954) in calculation of sustainable yield. From this maximum sustainable yield (MSY) appears to ly between 10390 and 10830 tons. The yield (Y) at 2/3 of MSY effort (MSY f) lies between 9670 and 10080 tons. Both two years and the three years regressions of effort on CPUE have highly significant fits.

Introduction

The Denmark Strait area was first found in September 1976 but a fishery was first commenced in 1978 by Iceland. In the following year the Norwegians started to fish in the area. The fishery increased imensely in the year 1980 by the participation of Greenland, Denmark Faroe Islands and France. From then on the fishery was carried out by all these 6 countries.

In this paper all data available on the catch, effort and the CPUE, are gathered by months for all strata within the traditional area combined.

Material and Methods

For most of the countries there are data presented from logbóoks, namely catch and effort. The individual authors have also calculated the CPUE bydividing the catch per monyh (in kg) by the corresponding effort (in trawling hours). In order to assess the overall CPUE per every half year, all the effort in the period January to June was summed. Then only the catches that correspond to stated effort are summed by every half year. The subtotal sum of catch is divided by the subtotal sum of effort to get the CPUE per every half year. In order to assess the total effort exerted by each country in the area, the nominal catch per month is summed by every half year. The nominal catch is often higher than the catch reported in logbooks. Therefore the effort was corrected by every half year by dividing the nominal total catch by the CPUE of the same half year. It has been assumed here that the gear and the efficiency of all vessels of a country is more like that of the ones not reporting of the same country than that of other countries. Therefore the effort was first corrected by individual countries.

The use of the Fox model is carried out in the same manner as described in 1990 (Skúladóttir 1990 b).

Results and Discussion

The effort, catch and nominal catch as well as calculated CPUE are presented in tables 1 to 6 for the six countries. For the first years the CPUE and effort was taken from the NAFO Scientific Council Reports (1979, 1980 and 1983). Later the CPUE and effort data were obtained from the scientists of the respective countries. For Norway the data come from Smedstad and Torheim (1989,1990). For France the data come from Bertrand, Battaglia and Poulard (1988) The CPUE for the Faroe Islands in 1980 were obtained from Hoydal (1980). The catch data were obtained mostly from Carlsson (1981,1984,1985,1986,1987, 1988,1989,1990). When authors published later different figures for effort and CPUE where effort was higher than in the previous year these were preferred, taking into account that most of the NAFO meetings on the Denmark Strait shrimp took place in January which in some cases led to preliminary figures being given by respective countries. Sometimes there was discrepancy between the catch figures by month, by Carlson and the respective authors. In that case the higher figure was believed to be the nominal catch and the effort was corrected by dividing the nominal catch of every half year by the CPUE of the same half year by every country respectively. The data published in the review 1990 (Skúladóttir 1990) are here reprinted for all years uptill 1990 with small corrections for the years 1987-1989 in case of Greenland as well as data for the year 1990 (Carlsson and Kanneworff 1991). The data for 1990 are obtained from Smedstad and Torheim (1991), and Poulard (personal communication 1991).

From table 7 it is notable that there is considerable variation in the CPUE of the different countries. This could be due to different gear sizes and the difference in power of the respective vessels. For the Icelandic boats it is known that gear size peaked in 1987 and has been rather stable since then. There is also a fall in CPUE in the latter half of the year. However a second peak in catch rates can occur in september or december. The yearly catch rate is calculated in table 8. The yearly CPUE has been falling gradually since the year 1980and 1981 or from 245 kg per hour to 98 kg in1986 yilelding 11 thousand tons. In spite of doubling the effort there is little gain in additioon to the 11 thousand tons fished in 1986. The total catch is listed in Table 9 as well as adviced TAC by the Scientific Council of NAFO, by years. The effective TAC has usually been moderate and similar to the adviced TAC. The effective TAC of 14100 tons of Greenland authorities was fortunately not reached in 1990, perhabs because of failing catches at times throughout the year.

In order to see the impact the fishery is making in the shrimp stock, the moving averages of catch of every 3 years is put against the CPUE in the fourth year (table 10 and fig. 1). It turns out that the more shrimp is removed from the stock by fishing the less CPUE becomes. When fitted with a simple line the fit is significant at the $p = 0.001$ level. The forecast for CPUE of the year 1990 was 110kg per hr (Skúladóttir 1990 a) it turns out to be 111 kg. The forecast for 1991 is 119 kg per hr as the catch of the last three years, 1988-1990, is slightly less than that of 1987-1989.

The basic data for the Fox model are optained from table 8. In table 11 are shown the moving averages of effort of two or three years respectively. The regressions of effort on CPUE are shown in figs. 2 and 3. The resulting yield curves do not differ much from each other and less than they did a year prior using 10 sets instead of 11 here. The fit is also even more significant ($p = 0.001$) than that of last years. The yield curve is slightly lower in case of the 3 years average, giving rise to MSY about 10400 tons as compared to about 10800 tons in case of the 2 years average effort. The yield at 2/3 MSY f is about 9700 and 10100 respectively.

Conclusion

The fishery in the Denmark Strait appears to have reached the stage where stock level as judged by CPUE is below half of what it was in the early eighties.

The annual removals from the shrimp stock in the Denmark Strait seems to have reached the limit whereby further increase in effort does not seem to give any larger yield for the long run. The CPUE does not seem to be declining further. The catch should not be allowed to increase again much above the adviced 10 tousand tons.

References:

Bertrand, J., Battaglia A., Derible P. and Poulard J.C., 1988. Catch Effort and Biological Data of Shrimp (Pandalus borealis) in the French Fisheries off Greenland in 1986 and 1987. NAFO SCR Doc. No. 50, Ser. No. N1490. 17p.

Carlson, D.M. 1981. Data on the Shrimp Fishery at East Greenland in 1980 and 1981. NAFO SCR Doc. No.165, Ser. No. N473. 14p.

1984. Data on the Shrimp Fishery at East Greenland in 1983 compared to earlier years. NAFO SCR Doc. No. 5, Ser. No. N774.12p.

1985. Data on the Shrimp Fishery at East Greenland in 1984 compared to earlier years. NAFO SCR Doc. No. 12, Ser. No. N946.14p.

1986. Data on the Shrimp Fishery at East Greenland in 1985 compared to earlier years. NAFO SCR Doc. No. 5, Ser. No. N1103.14p.

1987. The Commercial Shrimp fishery in the Denmark Strait in 1986. NAFO SCR Doc. No. 9 Ser. No. N12.

1988. The Commercial Shrimp fishery in the Denmark Strait in 1987. NAFO SCR Doc. No. 57, Ser. No. N1497. 12p.

Carlsson, D. M., and P. Kanneworff. 1990. The commercial shrimp fishery in Denmark Strait in 1989 and early 1990. NAFO SCR Doc. No. 42, Ser. No. N1759. 22p.

1991. The commercial shrimp fishery in Denmark Strait in 1990 and early 1991. NAFO SCR Doc. No. , Ser. No. N . 31p.

Fox, W. W., Jr 1970. An exponential surplus-yield model for optimizing eploited fish populations. Trans. Am. Fish. Soc., 99: 80-8.

Gulland, J. A. 1961. Fishing and the stocks of fish at Iceland, 1961. Fishery invest. Lond. Ser. 2, 23(4): 52p.

Hoydal, K. 1980. Observations on the Faroese Prawn Fishery in East Greenland, March to June 1980. NAFO SCR Doc. 80/XI/172, Ser. No. N259. 9p.

Hallgrimsson, I. and Skúladóttir, U. 1985. The Icelandic shrimp (Pandalus borealis)fishery in the Denmark Strait in 1984. NAFO SCR Doc. 85/I/11, 5p.

1988. The Icelandic shrimp (Pandalus borealis) fishery in the Denmark Strait in 1987. NAFO SCR Doc. 88/64, 5p. Ser. No. N1506.10p.

NAFO Scientific Council Reports 1979-80

NAFO Scientific Council Reports 1983

NAFO Scientific Council Reports 1987

Schaefer, M. B. 1954. Some aspects of the dynamics of populations important to the management of the commerciel marine fisheries. Bull. Interam. Trop. Tuna comm., 1(2): 25-56.

Skúladóttir, U. 1985. The sustainable Yield of Pandalus boralis in the Denmark Strait Area. NAFO SCR Doc. 85/I/15. Ser. No. 15, Ser. No. N949 6p.

1990 a. A review of the Shrimpfishery (*Pandalus borealis*) in the Denmark Strait, in the years 1978-1989. NAFO SCR Doc. No 82. No N1804 14 p.

1990 b. The sustainable yield of *Pandalus borealis* in the Denmark Strait area, based on data for the years 1980-89. NAFO SCR Doc. No 91. No N1818 5p.

Skúladóttir, U. and Ingvar Hallgrimsson. 1987. The Icelandic shrimp (Pandalus borealis) fishery in the Denmark Strait in 1986. NAFO SCR Doc. No 4, 15p.

Smedstad, O. M. 1988. A preliminary Report of a cruise with M/T "Masi" to East Greenland waters in september 1987. NAFO SCR Doc. No 48, Ser. No. N1488. 10p.

1990. A preliminary Report of a cruise with M/T "Håkøy-II" to East Greenland waters in september 1989. NAFO SCR Doc. No 12, Serial No N1724, 13p.

Smedstad, O.M., and S. Torheim 1989. Norwegian investigations on shrimp (*Pandalus borealis*) in East Greenland waters in 1988. NAFO SCR Doc. No 18, Serial No N1594, 12p.

1990. Norwegian investigations on shrimp (*Pandalus borealis*) in East Greenland waters in 1989. NAFO SCR Doc. No 11, Serial No N1723, 13p.

1991. Norwegian investigations on shrimp (*Pandalus borealis*) in East Greenland waters in 1990.

Table 1. Catch rates (kg per hour trawling) and corresponding effort (hours trawling) and catch (tons) from the shrimp fishery in Denmark Strait by Greenland (and Denmark in the years1980-1982) in two periods of the year.

	January - June				July - December			
Year	Month	Cpue	Effort	Catch	Month	Cpue	Effort	Catch
1980	Apr	672	35	23.5	Jul	71	60	4.2
	May	392	1295	507.6	Aug	17	32	0.5
	Jun	139	315	43.8	Sep	181	482	87.2
					Oct	107	1165	124.7
					Nov	145	465	67.4
	Subtotal	350	1645	575.0	Subtotal	129	2204	284.0
	Total	350	1665	582.0	Total	129	2483	320.0
1981	Apr	486	1343	652.7				
	May	263	914	240.4				
	Jun	123	6	0.7				
	Subtotal	395	2263	893.8				
	Total	395	4013	1585.0				
1982	Mar	160	763	122.1				
	Apr	195	1570	306.2				
	May	280	1394	390.0				
	Subtotal	220	3727	818.3				
	Total	220	8432	1855.0				
1983	Mar	345	484	167.0				
	Apr	160	457	73.0				
	Subtotal	255	941	240.0				
	Total	255	5752	1467.0				
1984	Jan	600	105	63.0				
	Feb	356	312	111.0				
	Mar	224	281	63.0				
	Subtotal	340	698	237.0				
	Total	340	6627	2250.0				
1985	Jan	318	647	206.0	Oct	146	51	7.0
	Feb	309	610	188.0	Nov	230	360	83.0
	Mar	218	570	124.0	Dec	272	643	175.0
	Apr	228	625	143.0				
	Subtotal	270	2452	661.0	Subtotal	251	1054	265.0
	Total	270	6469	1744.0	Total	251	3389	852.0
1986	Jan	302	1565	473.0	Oct	50	77	4.0
	Feb	222	2593	576.0	Nov	326	686	223.0
	Mar	403	2413	972.0	Dec	529	1160	614.0
	Apr	252	1032	260.0				
	May	136	602	82.0				
	Subtotal	288	8205	2363.0	Subtotal	437	1923	841.0
	Total	288	14285	4114.0	Total	437	3812	1667.0
1987	Jan	348	3608	1257.3	Aug	113	81	9.2
	Feb	322	4471	1439.0	Sep	253	400	101.4
	Mar	296	2965	878.6	Oct	199	753	149.7
	Apr	208	951	197.6	Nov	162	1915	309.6
	May	300	403	121.0	Dec	115	4067	468.9
	Subtotal	314	12398	3893.5	Subtotal	144	7216	1038.8
	Total	314	17666	5547.0	Total	144	7502	1080.0
1988	Jan	301	6951	2089.8	Aug	117	1019	119.8
	Feb	226	7950	1793.2	Sep	121	1487	179.4
	Mar	152	6408	975.1	Oct	105	2586	270.5
	Apr	104	1121	116.0	Nov	157	3207	503.3
	May	114	550	62.9	Dec	203	4903	995.1
	Subtotal	219	22980	5037.0	Subtotal	157	13202	2067.9
	Total	219	24111	5285.0	Total	157	13622	2165.0
1989	Jan	249	6865	1707.5	Jul	27	15	0.4
	Feb	214	6361	1361.0	Aug	44	713	31.3
	Mar	131	3905	512.1	Sep	59	2290	135.1
	Apr	107	3565	380.6	Oct	98	2600	248.7
	May	88	2322	157.5	Nov	67	7031	474.1
	Jun	39	137	5.4	Dec	84	7107	598.9
	Subtotal	192	23095	4434.1	Subtotal	75	19756	1488.7
	Total	192	23287	4471.0	Total	75	20039	1510.0
1990	Jan	139	8602	1196.8	Jul	94	82	7.7
	Feb	185	8289	1533.1	Aug	59	351	20.6
	Mar	143	8299	1186.1	Sep	64	710	45.2
	Apr	473	1050	496.9	Oct	58	1734	101.4
	May	455	2133	971.5	Nov	65	2121	138.7
	Jun	45	116	5.2	Dec	79	5160	408.5
	Subtotal	189	28489	5389.8	Subtotal	71	10158	722.1
	Total	189	28956	5478.0	Total	71	10297	732.0

Table 2. Catch rates (kg per hour trawling) and corresponding effort (hours trawling) and catch (tons) from the shrimp fishery in Denmark Strait by France in two periods of the year.

	January - June				July - December			
Year	Month	CPUE	Effort	Catch	Month	CPUE	Effort	Catch
1981	Apr	424	160	67.8				
	May	241	557	134.3				
	Jun	145	257	37.4				
	Subtotal	246	974	239.5				
	Total	246	1436	353.0				
1982	Apr	206	345	71.1				
	May	258	577	148.9				
	Jun	179	247	44.1				
	Subtotal	226	1169	264.1				
	Total	226	1833	414.0				
1983	Apr	166	252	41.7				
	May	246	254	62.5				
	Jun	159	213	33.8				
	Subtotal	192	719	138.0				
	Total	192	1516	291.0				
1984	Mar	208	200	41.7				
	Apr	290	1044	303.3				
	May	205	517	106.2				
	Subtotal	256	1761	451.2				
	Total	256	1951	500.0				
1985	Apr	231	381	87.9	Oct	170	405	68.7
	May	199	605	120.4	Nov	170	55	9.3
	Jun	118	220	26.0				
	Subtotal	194	1206	234.3	Subtotal	170	460	78.0
	Total	194	2594	504.0	Total	170	814	138.0
1986	Mar	230	68	15.7	Sep	243	237	57.6
	Apr	175	1225	214.5	Oct	214	510	109.4
	May	184	1551	285.1	Nov	119	44	5.2
	Jun	124	355	43.9				
	Subtotal	175	3199	559.2	Subtotal	218	791	172.2
	Total	175	3415	597.0	Total	218	841	183.0
1987	Apr	227	400	90.9	Sep			94.0
	May	250	578	144.7	Oct			59.0
					Nov			170.0
	Subtotal	241	978	235.6	Subtotal			323.0
	Total	241	2599	626.0	Total			405.0
1988	Apr	147	462	68.1	Aug			2.0
	May	136	473	64.2	Sept			48.0
	Subtotal	141	935	132.3				
	Total	141	3138	444.0	Total			50.0
1989	Mar	203	247	50.2	Jul	58	116	6.7
	Apr	192	907	174.2	Aug	59	409	24.0
	May	23	23	0.5				
	Subtotal	191	1177	225	Subtotal	58	525	30.7
	Total	191	1525	291.3	Total	58	1536	89.8
1990	Mar	126	172	23.3				
	Subtotal	126	172	23.3				
	Total	126	286	36.0	Total			15.0

Table 3. Catch rate (kg per hour trawling) and cooresponding effort (hours tr and catch (tons) from the shrimp fishery in Denmark Strait by Norway.

	January - June				July - December			
Year	Month	CPUE	Effort	Catch	Month	CPUE	Effort	Catch
1980	Mar	904	398	360.0	Aug	95	874	83.0
	Apr	704	783	558.0	Sept	145	2883	418.0
	May	378	1071	405.0	Oct	99	3071	304.0
	Jun	98	714	70.0	Nov	160	1181	189.0
	Subtotal	468	2976	1393.0	Subtotal	124	8009	994.0
	Total	468	3108	1455.0	Total	124	8106	1006.0
1981	Mar	364	137	50.0	Aug	42	167	7.0
	Apr	296	3848	1139.0	Sep	46	65	3.0
	May	161	4057	653.0				
	Jun	119	1101	131.0				
	Subtotal	216	9143	1973.0	Subtotal	43	232	10.0
	Total	216	9296	2006.0	Total	43	232	10.0
1982	Mar	197	1548	305.0				
	Apr	171	4450	761.0				
	May	248	3339	828.0				
	Total	203	9337	1894.0				
1983	Apr	128	2734	350.0	Jul	133	45	6.0
	May	255	1439	367.0	Aug	98	622	61.0
	Jun	143	1797	257.0				
	SubTotal	163	5970	974.0	Subtotal	101	667	67.0
	Total	163	6830	1114.0	Total	101	6100	613.0
1984	Feb	232	341	79.0				
	Mar	224	2777	622.0				
	Apr	183	4000	732.0				
	May	167	2994	500.0				
	Subtotal	191	10112	1933.0				
	Total	191	11141	2128.0				
1985	Mar	184	4130	760.0				
	Apr	166	5994	995.0				
	May	137	1964	269.0				
	Subtotal	166	12088	2024.0				
	Total	166	12355	2051.0				
1986	Jan	112	277	31.0	Jul	71	28	2.0
	Feb	141	1475	208.0	Aug	131	885	116.0
	Mar	166	4400	737.0	Sep	110	427	47.0
	Apr	133	4120	548.0				
	May	131	2573	337.0				
	Total	145	12845	1861.0	Total	123	1340	165.0
1987	Feb	187	802	150.0	Aug	124	258	32.0
	Mar	140	4036	565.0	Sep	135	1659	224.0
	Apr	123	4886	601.0	Oct	91	2055	187.0
	May	133	1473	196.0	Nov	47	1213	57.0
	Subtotal	135	11197	1512.0	Subtotal	96	5185	500.0
	Total	135	11353	1533.0	Total	96	5261	507.0
1988	Jan	66	30	2	Jul	71	14	1
	Feb	112	2438	273	Aug	96	2271	218
	Mar	76	4013	305	Sep	86	3267	281
	Apr	74	4635	343	Oct	71	2479	176
	May	82	3939	323	Nov	61	295	18
	June	108	259	28				
	Subtotal	83	15314	1274	Subtotal	83	8312	693
	Total		15314	1274	Total		9332	778
1989	Jan	199	422	84				
	Feb	129	496	64	Aug	35	1600	56
	Mar	70	2300	161	Sep	37	6459	239
	Apr	88	4318	380	Oct	55	7309	402
	May	35	457	16	Nov	47	6106	287
	June	26	538	14	Dec	94	2883	271
	Subtotal	84	8532	719	Subtotal	52	24358	1255
	Total	84	8354	704	Total	52	27056	1394
1990	Jan	77	1584	122	July	38	368	14
	Feb	73	2425	177	Aug	37	2162	80
	Mar	70	3914	274	Sep	43	6465	278
	Apr	66	1848	122	Oct	52	6077	316
	May	237	1899	450	Nov	52	6981	363
	June				Dec	68	3500	238
	Subtotal	98	11671	1145	Subtotal	50	25553	1289
	Total	98	11982	1176	Total	50	26247	1324

Table 4. Catch rates (kg per hour trawling) and corresponding effort (hours trawling) and catch (tons) from the shrimp fishery in Denmark Strait by Iceland in two periods of the year.

	January - June				July - December			
Year	Month	CPUE	Effort	Catch	Month	CPUE	Effort	Catch
1980	Jun	125	1425	177.6	Jul	90	1478	133.6
					Aug	104	1176	121.8
					Sep	123	851	104.2
					Oct	96	802	77.2
					Subtotal	101	4307	436.8
	Total	125	1760	219.3	Total	101	5318	539.4
1981	Jun	99	688	68.0	Jul	79	603	47.3
					Aug	39	245	9.6
	Total	99	688	68.0	Total	67	848	56.9
1982	No fishery							
1983	Jun	99	52	5.1	Oct	172	80	13.8
					Nov	155	158	24.5
	Total	99	52	5.1	Total	161	238	38.3
1984	Jun	42	53	2.2	Jul	69	655	45.4
					Aug	69	116	8.0
					Sep	99	1546	152.7
					Oct	154	1887	291.0
					Nov	74	2391	175.7
					Dec	118	569	66.8
	Total	42	53	2.2	Total	103	7164	739.6
1985	Feb	105	60	6.3	Jul	100	3477	347.1
	Mar	13	8	0.1	Aug	82	3393	278.6
	Apr	22	22	0.5	Sep	90	4377	392.2
	May	70	2558	179.0	Oct	82	2022	166.2
	Jun	114	1837	210.1	Nov	83	1232	101.9
					Dec	253	443	112.0
	Total	88	4485	396.0	Total	94	14944	1398.0
1986	Apr	21	19	0.5	Jul	123	92	11.2
	May	74	2806	206.7	Aug	95	2163	204.8
	Jun	53	64	3.4	Sep	94	2689	251.6
					Oct	82	1892	155.7
					Nov	96	947	91.4
					Dec	494	228	112.8
	Subtotal	73	2889	210.6	Subtotal	103	8011	827.5
	Total	73	3205	234.0	Total	103	8893	916.0
1987					Jul	98	447	43.7
					Aug	83	3399	283.6
					Sep	92	3078	251.4
					Oct	61	2012	123.3
					Nov	75	1482	111.8
					Dec	106	259	27.3
					Subtotal	79	10677	841.1
					Total	79	16835	1330.0
1988	Jan	90	23	2.1	Jul	47	977	45.7
	Feb	42	21	0.8	Aug	52	4596	238.1
	Jun	108	1463	158.5	Sep	62	6257	386.1
					Oct	52	7166	372.3
					Nov	26	363	9.5
	Subtotal	107	1507	161.4	Subtotal	54	19359	1051.7
	Total		1769	189.5	Total		22735	1234.5
1989					Aug	51	3910	197.5
	May	154	2234	344.9	Sep	41	4558	186.4
	Jun	84	4188	349.6	Oct	27	321	8.5
	Subtotal	108	6422	694.5	Subtotal	45	8789	392.4
	Total		7835	847.3	Total		10722	478.7
1990	Jan	5	8	0.04	Jul	84	40	3.4
	Feb	44	11	0.5	Aug	69	168	11.7
	Apr	12	9	0.1	Sep	65	835	54.2
	Jun	81	2347	190.2	Oct	62	47	2.9
	Subtotal	80	2375	190.8	Subtotal	66	1090	72.2
	Total	80	2538	203.9	Total	66	1165	77.1

Table 5. Catch rates (kg per hour trawling) and corresponding effort (hours trawling) and catch (tons) from the shrimp fishery in the Denmark Strait by Faroe Islands.

	January - June				July-December	
Year	Month	CPUE	Effort	Catch	Month	Catch
1980	Mar	1015	40	40.5	Oct	128.0
	Apr	641	1159	743.1	Nov	213.0
	May	373	1011	377.1		
	June	210	1001	210.3		
	Subtotal	427	3212	1371.0	Subtotal	
	Total	427	9115	3892.0	Total	341.0
1981	Apr			41.0	Sep.	22.0
	May			430.0	Oct.	5.0
	June			215.0		
	Total			686.0	Total	27.0
1982	Feb			94.0		
	Mar			308.0		
	Apr			243.0		
	May			92.0		
	Total			737.0		
1983	Mar			185.0		
	Apr			122.0		
	May			63.0		
	June			73.0		
	Total			443.0		
1984	Mar			220.0	Nov	43.0
	Apr			193.0	Dec	49.0
	May			163.0		
	Total			576.0	Total	92.0
1985	Feb			46.0	Oct	78.0
	Mar			136.0	Nov	101.0
	Apr			209.0	Dec	91.0
	May			13.0		
	Total			404.0	Total	270.0
1986	Jan			185.0	Sept	2.0
	Feb			158.0	Oct	3.0
	Mar			87.0	Nov	94.0
	Apr			41.0	Dec	122.0
	May			35.0		
	Total			506.0	Total	221.0
1987	Jan			84.0	Oct	1.0
	Feb			184.0	Nov	80.0
	Mar			70.0	Dec	139.0
	May			37.0		
	Total			375.0	Total	220.0
1988	Jan			228.0	Aug	10
	Feb			301.0		
	Mar			69.0		
	Apr			36.0		
	May			35.0		
	Total			669		10
1989	Jan			150		
	Feb			86		
	Mar			99		
	Apr			103	May	44
	May			1	Dec	132
	Total			439	Total	156
1990	Jan			201		
	Feb			232		
	Mar			74		
	Apr			2	Nov	31
	May			176	Dec	127
	Total			685	Total	158

Table 6. Catch (tons) from the shrimp fishery in Denmark Strait by Denmark.

Year	January-June		July-December	
	Month	Catch	Month	Catch
1983	Mar	38.0		
	Apr	166.0		
	Total	204.0		
1984	Jan	284.0		
	Feb	102.0		
	Apr	57.0		
	Total	443.0		
1985	Mar	44.0		
	Apr	96.0		
	May	10.0		
	Total	353.0		
1986	Jan	260.0	Nov	27
	Feb	28.0	Dec	30
	Mar	54.0		
	Apr	51.0		
	May	50.0		
	Total	443.0	Total	57
1987	Feb	99.0	Sept	4
	Mar	173.0	Oct	26
	Apr	141.0	Nov	20
	May	18.0	Dec	74
	Total	431.0	Total	124
1988	Jan	156	Sept	23
	Feb	147	Oct	19
	Mar	23	Nov	36
	Apr	3	Dec	37
	Total	329	Total	115
1989	Jan	92	Aug	9
	Feb	153	Sept	20
	Mar	36	Oct	19
			Nov	17
	June	1	Dec	19
	Total	282	Total	84
1990	Jan	75	Jul	12
	Feb	23	Aug	19
	Mar	100	Sept	14
	Apr	6	Oct	24
	May	98	Nov	16
			Dec	3
	Total	302	Total	88

Table 7. Catch rates (kg per hour trawling) and corresponding effort (hours trawling) and catch (tons) from the shrimp fishery in Denmark Strait by all natons combined in two periods of the year.

		January-June			July - December		
Year	Country	CPUE	Effort	Catch	CPUE	Effort	Catch
1978	Iceland	215	298	64.2	314	952	299.2
1979	Iceland	186	166	30.9	229	1982	454.4
1980	Greenland, Denmark	350	1665	582.0	129	2483	320.0
	France			50.0			
	Norway	468	3108	1455.0	124	8106	1006.0
	Iceland	125	1760	219.3	101	5318	539.4
	Faroe Islands	427	9115	3892.0			341.0
	Subtotal	393	15648	6148.3	117	15907	1865.4
	Total	393	15775	6198.3	117	18815	2206.4
1981	Greenland, Denmark	395	4013	1585.0			
	France	246	1436	353.0			
	Norway	216	9296	2006.0	43	232	10.0
	Iceland	99	688	68.0	67	848	56.9
	Faroe Islands			686.0			27.0
	Subtotal	260	15433	4012.0	62	1080	66.9
	Total	260	18072	4698.0	62	1516	93.9
1982	Greenland, Denmark	220	8432	1855.0			
	France	226	1833	414.0			
	Norway	203	9337	1894.0			
	Faroe Islands			737.0			
	Subtotal	212	19602	4163.0			
	Total	212	23072	4900.0			
1983	Greenland	255	5752	1467.0			
	France	192	1516	291.0			
	Norway	163	6830	1114.0	101	6100	613.0
	Iceland	99	52	5.1	161	238	38.3
	Denmark			204.0			
	Faroe Islands			443.0			
	Subtotal	203	14150	2877.1	103	6338	651.3
	Total	203	17332	3524.1	103	6338	651.3
1984	Greenland	340	6627	2250.0			
	France	256	1951	500.0			
	Norway	191	11141	2128.0			
	Iceland	42	53	2.2	103	7164	739.6
	Denmark			443.0			
	Faroe Islands			576.0			92.0
	Subtotal	247	19772	4880.2	103	7164	739.6
	Total	247	23900	5899.2	103	8074	831.6

Table 7 continued

1985	Greenland	270	6469	1744.0	251	3389	852.0
	France	194	2594	504.0	170	814	138.0
	Norway	166	12355	2051.0			
	Iceland	88	4485	396.0	94	14944	1398.0
	Denmark			353.0			
	Faroe Islands			404.0			270.0
	Subtotal	181	25903	4695.0	125	19147	2388.0
	Total	181	30079	5452.0	125	21312	2658.0
1986	Greenland	288	14285	4114.0	437	3811	1667.0
	France	175	3415	597.0	218	841	183.0
	Norway	145	12845	1861.0	123	1340	165.0
	Iceland	73	3205	234.0	103	8893	916.0
	Denmark			443.0			57.0
	Faroe Islands			506.0			221.0
	Subtotal	202	33750	6806.0	197	14885	2931.0
	Total	202	38456	7755.0	197	16297	3209.0
1987	Greenland	314	17667	5547.0	144	7502	1080.0
	Norway	135	11353	1533.0	96	5261	507.0
	Iceland				79	16835	1330.0
	France	241	2599	626.0			405.0
	Denmark			431.0			124.0
	Faroe Islands			375.0			220.0
	Subtotal	244	31619	7706.0	99	29598	2917.0
	Total	244	34926	8512.0	99	37198	3666.0
1988	Greenland	219	24111	5285.0	157	13822	2165.0
	Norway	83	15314	1274.0	83	9332	778.0
	Iceland	107	1769	189.5	54	22735	1234.5
	France	141	3138	444.0			50.0
	Denmark			329.0			115.0
	Faroe Islands			669.0			10.0
	Subtotal	164	41194	6748.5	91	45889	4177.5
	Total	164	49996	8190.5	91	47811	4352.5
1989	Greenland	192	23287	4471.0	75	20039	1510.0
	Norway	84	8354	704.0	52	27056	1394.0
	Iceland	108	7835	847.3	45	10722	478.7
	France	191	1525	291.3	58	1536	89.8
	Denmark			282.0			84.0
	Faroe Islands			439.0			156.0
	Subtotal	154	41001	6313.6	59	59353	3472.5
	Total	154	45683	7034.6	59	63455	3712.5
1990	Greenland	189	28956	5478.0	71	10297	732.0
	Norway	98	11982	1176.0	50	26247	1324.0
	Iceland	80	2538	203.9	66	1165	77.1
	France	126	286	36.0			15.0
	Denmark			302.0			88.0
	Faroe Islands			685.0			158.0
	Subtotal	158	43762	6893.9	57	37709	2133.1
	Total	158	50027	7880.9	57	42323	2394.1

Table 8. Catch rates (kg per hour trawling) and corresponding effort (hours trawling) and catch (tons) from the shrimp fishery in Denmark Strait by years.

Year	Periods	CPUE	Effort	Catch
1980	Jan-Jun	393	15775	6198.3
	Jul-Dec	117	18858	2206.4
	Mean/Total	243	34633	8404.7
1981	Jan-Jun	260	18072	4698.0
	Jul-Dec	62	1516	93.9
	Mean/Total	245	19588	4791.9
1982	Jan-Jun	212	23072	4900.0
	Jul-Dec	-	-	-
	Mean/Total	212	23072	4900.0
1983	Jan-Jun	203	17332	3524.1
	Jul-Dec	103	6338	651.3
	Mean/Total	176	23670	4175.4
1984	Jan-Jun	247	23900	5899.2
	Jul-Dec	103	8074	831.6
	Mean/Total	211	31974	6730.8
1985	Jan-Jun	181	30079	5452.0
	Jul-Dec	108	21312	2658.0
	Mean/Total	158	51391	8110.0
1986	Jan-Jun	202	38456	7755.0
	Jul-Dec	197	16297	3209.0
	Mean/Total	200	54753	10964.0
1987	Jan-Jun	244	34926	8512.0
	Jul-Dec	99	37198	3666.0
	Mean/Total	169	72124	12178.0
1988	Jan-Jun	164	49996	8190.5
	Jul-Dec	93	47811	4352.5
	Mean/Total	128	97808	12543.0
1989	Jan-Jun	154	45683	7034.6
	Jul-Dec	59	63455	3712.5
	Mean/Total	98	109138	10747.1
1990	Jan-Jun	158	50027	7880.9
	Jul-Dec	57	42323	2394.1
	Mean/Total	111	92350	10275.0

Table 9. Nominal catch (tons) of shrimp in the Denmark Strait.

Country	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990 ***	1991
Denmark	-	-	702	581	740	204	443	353	500	555	444	366	390	
Faroe Islands	-	-	4233	713	737	443	668	674	727	595	679	595	843	
France	-	-	50	353	414	291	500	642	780	1030	494	381	51	
Greenland	-	-	200	1004	1115	1467	2250	2596	5781	6627	7456	5981	6210	
Iceland	363	485	759	125	0	43	742	1794	1150	1330	1424	1326	281	
Norway	-	800	2461	2016	1896	1727	2128	2051	2026	2041	2052	2098	2500	
Total catch	363	1285	8405	4792	4902	4175	6731	8110	10964	12178	12549	10747	10275	
Total catch eastern side	363	485	759	125	0	43	742	1794	1150	1330	1424	1326	281	
Total catch western side	0	800	7646	4667	4902	4132	5989	6316	9814	10848	11125	9421	9896	
Adviced TAC	-	-	-	-	4200	4200	4200	5000	-	-	-	10000*	10000*	10000*
Effective TAC western side	-	-	-	8000	4500	5725	5245	6090	7525**	7725**	8725**	9025**	14100	14500

*Adviced for a few years as a precautionary measure.

**Not including Greenland fishery north of 66° 30' N.

***Preliminary.

Table 10. The mean shrimpcatch of every 3 years against the CPUE in the 4th year. The linear regression between CPUE and mean catch, shown below is used to forecast the CPUE value for the year 1991.

Y = - 0.013 * X + 264.7 r = 0.9345

3 YEARS	MEAN CATCH Tons	4th YEAR	CPUE Kg
1977-79	549	1980	243
1978-80	3351	1981	245
1979-81	4827	1982	212
1980-82	6033	1983	176
1981-83	4623	1984	211
1982-84	5269	1985	158
1983-85	6339	1986	200
1984-86	8602	1987	169
1985-87	10417	1988	128
1986-88	11897	1989	98
1987-89	11822	1990	111
1988-90	11183	1991	?119

Table 11. The mean effort of several years against CPUE in the 2nd or 3rd year respectively.

2 Years	Mean effort tr hours	3 Years	Mean effort tr hours	2nd or 3rd year	CPUE kg/hr
1979-80	19964	1978-80	13800	1980	243
1978-81	27111	1979-81	19834	1981	245
1979-82	21330	1980-82	25764	1982	212
1980-83	23371	1981-83	22110	1983	176
1981-84	27822	1982-84	26239	1984	211
1982-85	41683	1983-85	35678	1985	158
1983-86	53110	1984-86	46064	1986	200
1984-87	63439	1985-87	59423	1987	169
1987-88	84966	1986-88	74895	1988	128
1988-89	103473	1987-89	93023	1989	98
1989-90	100750	1988-90	99769	1990	111

Table 12. The results of the Fox model for 2 years average effort, or 3 years against CPUE in the 2nd or 3rd year respectively.

	2 years	3 years
r	0.9167	0.9226
a	265.4	264.1
b	-0.000009014	-0.000009347
MSY f (tr hrs)	110939	106986
MSY CPUE (kg/hr)	97.6	97.2
MSY (tonnes)	**10832**	10394
2/3 f (tr hrs)	73959	71324
CPUE at 2/3 MSY f (kg/hr)	136.3	135.6
Y at 2/3 MSY f (tonnes)	10079	9671

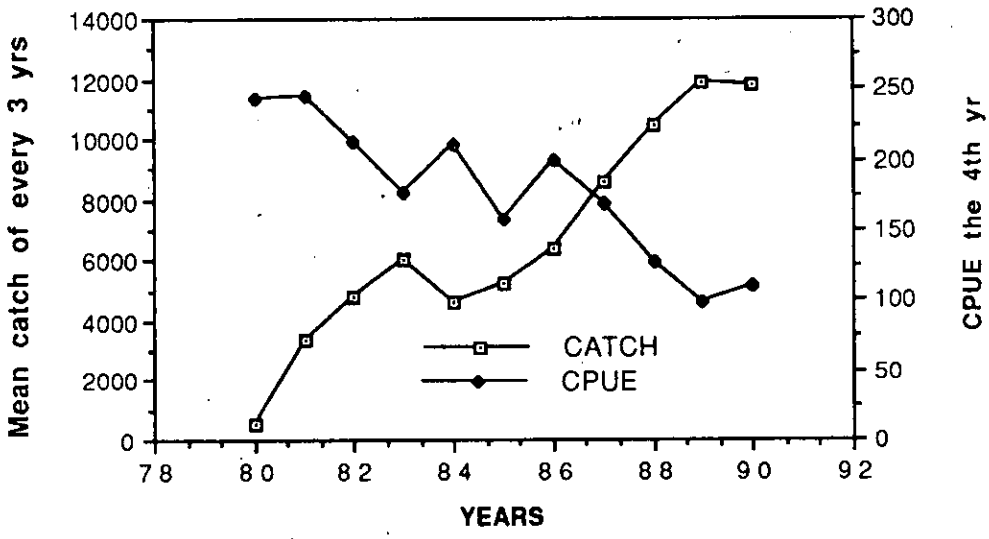

Fig. 1. The shrimp catch of every 3 years in Denmark Strait against the CPUE in the 4th year. As an example the catch of the years 1988-90 was 11183 tons against the mean CPUE 111kg for the whole year 1990 of all countries, see the 1990 values on the picture.

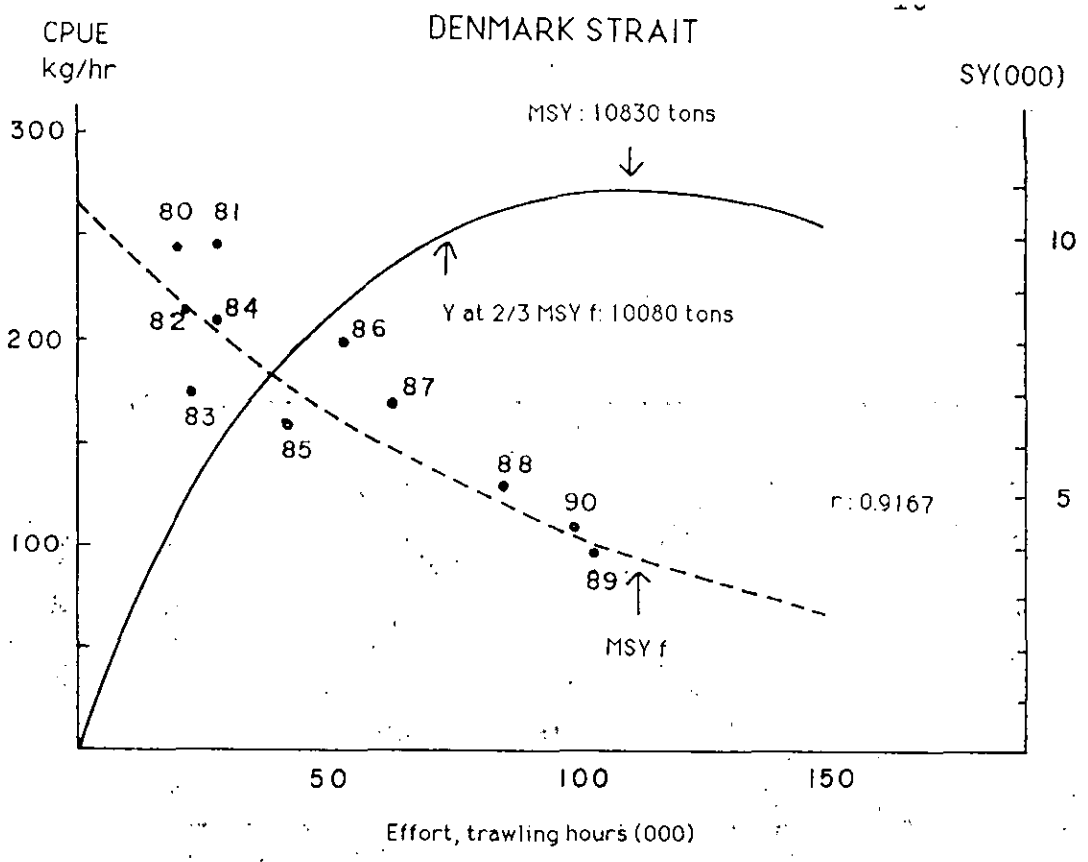

Fig. 2. The exponential regression of average effort every 2 years against the CPUE in the 2nd year (broken line), and the resulting sustainable yield (SY) curve (solid line).

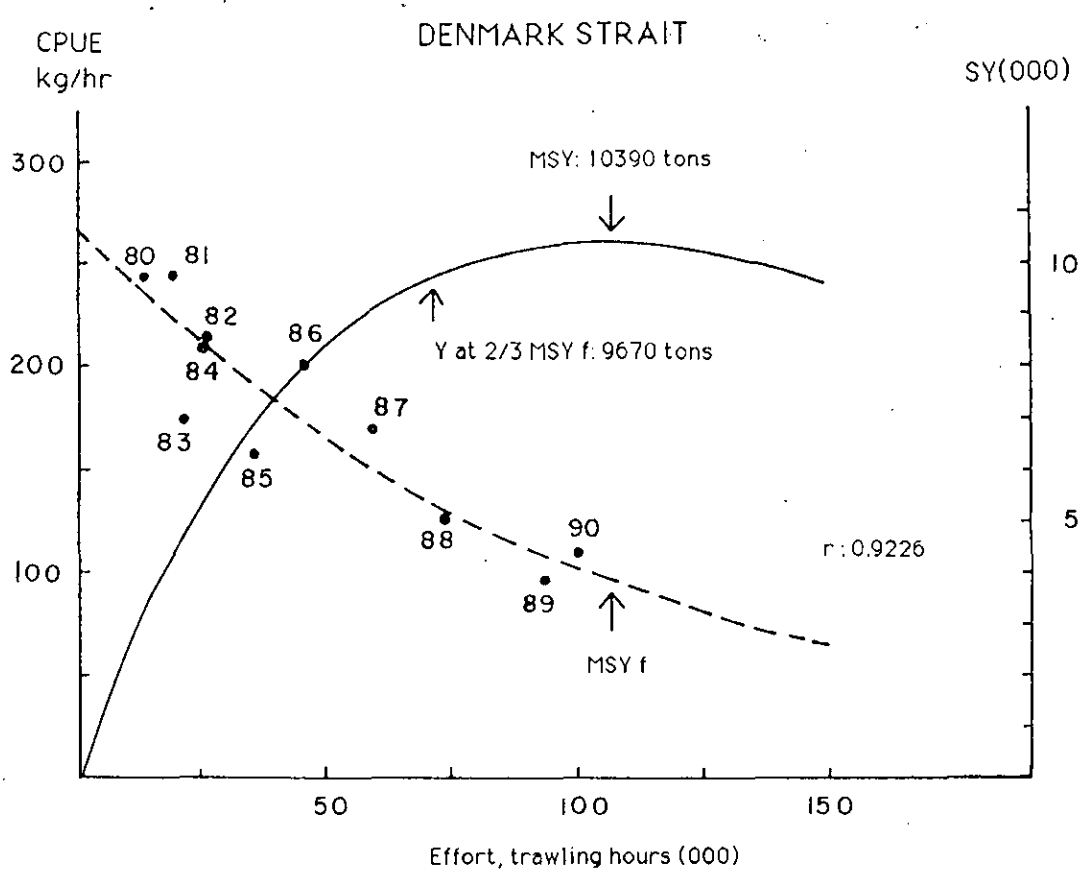

Fig. 3. The exponential regression of average effort every 3 years against the CPUE in the 3rd year (broken line), and the resulting sustainable yield (SY) curve (solid line).