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The Canadian Fishery for Northern Shrimp (*Pandalus borealis*) in Davis Strait, 1979 - 1992

by

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INTRODUCTION

Quota reports (preliminary to December 31, 1992) show that 7493 t of shrimp were taken in Division 0A in 1992, 1007 t less than the TAC of 8500 t but 705 t more than the 1991 catch. The fishery began in early July and continued into the first week of December. Twelve vessels participated, compared to 13 in 1991, and the number of licences remained at 17. The NAFO (1992) recommendation for a reduction in TAC in 1992 was not followed but a provisional TAC for 1993 has been set for Div. 0A at 6800 t, 1700 t less than the 1992 level.

Vessel log book records, supplemented by observer data covering most of the fishing activity, provided information on fleet performance in 1992. All data from previous years have been updated in the present analysis. Catch, effort and size composition data for shrimp from the 1981 - 1992 commercial catches are compared and information is provided on shrimp discards and by-catches.

MATERIALS AND METHODS

Catch (kilograms) and effort (hours fished) were compiled from vessel logs for the period 1979 to 1992. Since 1981, fishing has been restricted to NAFO Div. 0A in an area extending from about 67° to 69° N and 58° to 60° W. The data, from 1981 onward, were summarized by year, month and vessel for effort standardization. Catch and effort were totalled and catch per unit effort (CPUE) calculated within each cell (n = 467). No vessel fished in every year.

Annual CPUE's (kg/hr) were calculated two ways:

1. The catch reported in vessel logs from 1979 to 1992 was divided by the corresponding effort, providing unstandardized, weighted, annual catch rates.

2. All data from 1981 to 1992 (except for one observation in April, 1984 and another in December, 1992) were analyzed for year, month and vessel effects using SAS multiple regression procedures, producing predicted, annual catch rates.

The CPUE data were log (base e) transformed for standardization. Annual log CPUE estimates were retransformed and indexed to 1981. The method is the same as used by Parsons and Veitch (1992).

Size composition of the 1992 catches sampled by observers were summarized by month and length frequency distributions of total numbers caught in each year from 1981 to 1992 were constructed. The latter was done in three steps: 1. the number in the sample was adjusted (by ratio of weight) to the number caught in the set; 2. numbers from all sets for the month were totalled and adjusted (by weight) to the monthly catch reported in vessel logs; 3. the numbers from all months were totalled and adjusted (by weight) to the total catch for the year.

The numbers caught at length (0.5 mm CL) for each year were converted to catch at age by modal analysis (Macdonald and Pitcher, 1979) of the annual length frequency distributions. The number of age components in the catch and initial estimates of their mean lengths were based on the findings of Savard et al. (1989). Final runs were made with all coefficients of variation held fixed at an average value of 0.048. The rationale for this constraint is described in Parsons and Veitch (1991). Tables were constructed for mean length at age, proportions and numbers caught at age and numbers caught per hour (unstandardized and standardized) at age.

Data on by-catches were compiled as percentages of the total observed catch in each month. Catch rates for redfish and Greenland halibut were compared for the period 1981 to 1992. Estimates of the proportions of discarded shrimp also were derived from the observer data.

RESULTS

Catch, effort and CPUE

Catch, effort and CPUE for shrimp by month and year as derived from the available vessel logs are given in Tables 1, 2 and 3, respectively. The fishery usually begins in June and can continue into late November or early December. However, most of the catch is taken and most of the effort expended in the July to October period. Since 1984, both catch and effort have shown an increasing trend (Fig. 1 and 2a).

The seasonality of the fishery is evident in the monthly CPUE data (Table 3). In most years, catch rates are relatively high during the June - July period, decline during August - September and either stabilize or increase again in October and November. This pattern was not evident in 1992 as catch rates fluctuated over the year, similar to the events of the 1990 fishery. Annual, unstandardized catch rates (Fig. 3a) were fairly stable up to 1985, increased to a substantially higher level from 1986 to 1988 and subsequently declined to 1991. Some improvement in catch rate was evident in 1992.

The results of the multiple regression analysis to standardize the catch rates (Table 4a) show that the model explains about 70% of the total variation. All three class variables (year, month and vessel) were highly significant. T-values indicate that only the 1981, 82, 87 and 88 catch rates were higher than the 1992 estimate ($P < 0.05$), the other years not being significantly different from 1992 ($P > 0.05$).

The standardized effort (Fig. 2b) showed the same pattern as the unstandardized series except the increase since 1984 becomes more pronounced. Log CPUE values were retransformed (Table 4b) to provide the standardized estimates in the original units (kg/hr). The interpretation of these predicted, mean catch rates differs from the unstandardized values in that, except for the high CPUE's in 1981/82 and 1987/88, the series and supporting statistics indicate stability (Fig. 3b). Also, the increase in CPUE between 1985 and 1986 is not nearly as great after standardization. A complete summary of TAC, catch, effort and CPUE for the Canadian fishery is given in Table 5.

Catch increased with both unstandardized and standardized effort (Fig. 4a and b) but, for the former, no substantial increase in catch is seen beyond approximately 12,000 hours. The standardized effort, on the other hand, does suggest continued increases in catch beyond 17,000 hours. Catch rates, unstandardized and standardized, are not clearly related to fishing effort, even when two and three year averaging of effort are used (Fig. 5,6 and 7). A negative slope is evident for the 1987 - 1992 period but the relationship is dependent on the high 1987/88 CPUE's.

Length distributions

Monthly length frequencies for the sampled catches in 1992 (Fig. 8) show a broad size range representing a number of year-classes. Two male components are clearly evident in all months at modal carapace lengths of 20 and 22 mm. Smaller/younger males are also present but weakly represented at sizes around 14 and 17 mm. The first female mode, at roughly 25 mm, is prominent in July, October and November but is obscured by larger (presumably older) females with modal length of about 27 mm in August and September. The proportion of females in the catches declined from July to October.

Shrimp caught in 1992 were, on average, slightly larger than those caught in the previous year (Fig. 9). Males with modal length of 22 mm (the 1986 year class?) and females about 25 mm (the 1985 year class) comprised most of the catch. The 1985 year class did not appear to dominate the catches as it did in the previous two years. The data showed a decrease in the mean length of the female mode (composed of at least two ages) between 1983 and 1985, followed by a period of similar size composition, especially from 1987 to 1989. The length distribution in 1990 showed the relative importance of the 1985 year class (20 mm mode) as it recruited to the fishery. It clearly dominated as males at 22 mm in the 1991 fishery and was strong enough to maintain 1991 catch rates at levels similar to the previous two years but lower than in 1987 and 1988. This year class changed sex between 1991 and 1992, occurring as age 7 females in the 1992 catches. It again contributed significantly to the 1992 catches but was supported by the strong component of males at 22 mm.

Ageing of commercial length distributions followed the procedures of Parsons and Veitch (1991). Expected counts at length from the modal analysis of the 1981 - 1992 data were virtually identical ($P > 0.98$) to the observed (Fig. 9).

Estimated mean lengths (Table 6) agreed well with those from the previous ageing study by Savard et al. (1989) and showed consistency from year to year. The estimated proportions at age of the numbers of shrimp caught from 1981 to 1992 (Table 7) show that the relative contribution of females (ages 7 and 8+) to the catches declined from over 80% in 1981 to 47% in 1984, increasing again to 65% in 1985. From 1986 to 1988, females accounted for about half the catch, increasing to 58% in 1989. About 43% of the catch numbers in 1990 were females, increasing to 46% in 1991 and 49% in 1992. Three year old male shrimp did not contribute substantially to the catch in any year but formed an identifiable mode at 14 - 15 mm in the 1988 length distribution (the 1985 year class).

The proportions in Table 7 were applied to the total estimated catch numbers to derive a catch at age matrix (Table 8) and these data were subsequently divided by both the unstandardized and standardized fishing effort to produce age-specific indices of abundance (Tables 9 and 10). Female ages are combined as 7+ in this analysis.

Age 4 males consistently occurred in very low numbers and do not show any trend over time (Fig. 10a and b). Catch rates for ages 5 and 6 males show a generally increasing trend with indications (peaks) that strong year classes were produced in 1981 and 1985. Ages 7+, representing the female component of the stock, are targeted heavily by the fishery and the trend in the numbers caught per hour for these animals resemble the catch rate series from the vessel log data. Particularly evident in this group is the decline from 1987 to 1991 followed by some recovery in 1992.

Mean weight of shrimp caught (total catch weight/total numbers) declined from 9.9 g in 1981 to 7.9 g in 1984, increased to 8.7 g in 1985 and followed a steady decline to 7.6 in 1990 and 1991. There was a slight increase to 7.7 g in 1992.

Estimates of total mortality (Z) from the catch-at-age matrix were not possible because shrimp are not fully recruited till age 7 and there are no data currently available on which to base the separation of female ages 7 and 8+ over the time series. It is noted that, in most cases, numbers caught per hour (Tables 9 and 10) increase substantially from age 6 in one year to 7+ the next. The increases were lowest, however, between 1987/88 and 1991/92 when the strong 1981 and 1985 year classes recruited as females.

Shrimp discards

The percentages of shrimp discards determined by observers (Table 11) show that estimates ranged from a low of 2.24% in 1987 to 6.54% in 1991. The increasing trend from 1987 to 1991, followed by a decrease in 1992, is consistent with the recruitment of the 1985 year class through the late 1980's and its occurrence as large, female shrimp in the 1992 catches. It recently has been recognized that actual discard rates are higher than estimated by observers. Studies are currently being conducted in eastern Canada on ways and means to avoid the catching of the small, "industrial grade" shrimp.

By-catches

Observer data on catch composition for each month of the 1992 fishery (Table 12) show that the proportion of by-catch ranged from 21% of the total catch weight of all species in September to 30% in July. Redfish was again the most prevalent fish species in the catches, representing between 10 and 25% of the total observed catch weight. Greenland halibut comprised less than 3% of the catch in each month of the fishery. Typically, the incidence of Greenland sharks increased in November. The catch rates (kg/hr - unstandardized) for redfish and Greenland halibut from 1981 to 1992 are:

	Year											
	'81	'82	'83	'84	'85	'86	'87	'88	'89	'90	'91	'92
Redfish	32	20	9	15	20	85	119	78	72	59	86	147
Gr. halibut	3	4	5	6	4	8	13	15	12	12	19	18

Redfish CPUE's increased substantially from 1983 to 1987, then decreased to 1990 and increased again up to 1992 to the highest level observed. The trend in catch rates from the mid 1980's onward is similar to that observed in the shrimp CPUE series. Based on the estimated effort (Table 5), over 2500 t of primarily small redfish were taken as by-catch and discarded in the Div. 0A fishery in 1992. Catch rates for Greenland halibut show a gradual, increasing trend to 1987 and a period of higher CPUE's from 1987 to 1992. It is estimated that the removal of Greenland halibut (mostly small) in 1992 was approximately 300 t. An extensive review of the by-catch problem throughout the Canadian northern shrimp fishery is currently being conducted (Kulka and Parsons, unpublished).

DISCUSSION

The standardization of CPUE for Div. 0A shows two periods of stable catch rates at similar levels: 1983 to 1986 and 1989 to 1992. Two shorter periods of significantly higher CPUE's (1981-82 and 1987-88) also are evident resulting in declining trends from 1982 to 1985 and 1987 to 1991. The stabilization attained since 1990 was largely due to the recruitment of the strong 1985 year class, appearing for the first time as females in 1992. The improvement in CPUE in 1992 from the 1991 level is more obvious in the unstandardized series. It is noted that Canadian fishermen regard the 1992 fishery as being considerably better (for both catch rate and size of shrimp) than the previous two or three years. Our data support that observation.

A similar pattern is evident in the numbers of female shrimp (ages 7+) caught per hour. Animals at these ages/sizes are targeted by the fishery and are not likely subjected to significant discarding. This series can be considered comparable to the large shrimp index for Div. 1B (Carlsson and Kanneworff, 1992) which also showed a decrease from 1987 to 1989 and stabilization thereafter. Catch rates of male shrimp (ages 5 and 6), on the other hand, have shown an increasing trend since the early 1980's, which might reflect the need to target the younger ages (smaller sizes) in order to maintain catch rates at acceptable levels if female abundance has declined over the long term.

Catch-at-age data show that the 1985 year class contributed substantially to the catches in 1990 and 1991 as age 5 and 6 males, respectively. As age 7 females in 1992, it overlapped with older females in a plus group and is not distinguishable as a separate cohort. Nevertheless, given the apparent strength of this year class in both 1990 and 1991, it is surprising that the number of females caught per hour in 1992 did not increase substantially over the previous two years. The occurrence of variable recruitment patterns between years and cohorts might be a factor and it is noted that similar conditions arose in 1988 when the 1981 year class first contributed as females.

The 1992 assessment concluded that the 1986, 1987 and 1984 year classes appeared to be much weaker than the 1985, raising concerns for recruitment and the status of the spawning biomass (NAFO, 1992). The 1992 fishery data from Div. 0A do not support that conclusion. Both the 1986 and 1987 year classes were well-represented in the 1992 catches and large females, possibly representing the 1984 year class, were clearly evident in the catches in August and September. Four explanations are proposed to address the discrepancy: 1. modal analysis used for ageing shrimp can result in overestimation of strong year classes that tend to overlap adjacent cohorts in the length frequency distributions; 2. predicting recruitment, even in the short-term, has always proven difficult suggesting that availability of younger shrimp to both commercial and research gear is incomplete and variable between years; 3. it has been suggested (D.M. Carlsson, personal communication) that the 1986 year class was, in fact, weak and that the animals assumed to be age 6 males in 1992 are, in reality, part of the 1985 year class (age 7) which split into two groups, the faster-growing changing sex and the slower remaining as males; 4. some combination of all the above. Debate on any or all of these points would be extensive and, at this stage, is not warranted. For whatever reasons, the previous pessimistic view of recruitment and the level of the spawning biomass is not supported by the 1992 fishery data from Div. 0A. The catch rate and size composition of the catches in 1992 are similar to those observed in 1984 and observations subsequent to the latter, although not quantitative, do not suggest cause for concern.

CONCLUSION

In 1992 we stated: "Catch rates in Subareas 0+1 have fluctuated since the fishery began around 1970, probably in response to pulses of above-average recruitment. The problem is, we are not yet able to predict the recruitment in time to make effective management decisions. Advising a reduction in TAC for 1993 .... is short-sighted given our uncertainty about recruitment in 1993." Nevertheless, it was agreed that immediate reductions were necessary because of the existing data that suggested the stock was declining. In hind-sight, the uncertainty for recruitment applied equally to 1992, despite having most of the 1991 fishery and research vessel data available for the assessment.

If the 1992 research survey results and fishery data from SA 1 agree with the analysis from Div. 0A, the STACFIS recommendation that the TAC in 1993 not exceed 40,000 tons will require review before consideration of the catch level for 1994. It also is necessary to discuss and decide if, how and when shrimp assessments will be conducted by STACFIS in the future.

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Table 1. Catch (t) by month/year - NAFO Division 0A, 1979-1992

Year	79	80	81	82	83	84	85	86	87	88	89	90	91	92	Total
Month															
4	.	.	.	.	.	0	.	.	.	.	.	.	.	.	0
6	.	.	347	.	17	.	290	309	144	42	509	.	.	.	1659
7	.	54	756	373	752	379	924	603	505	763	2105	890	1003	963	10070
8	.	.	665	650	1241	354	604	363	1157	1284	1280	1200	1591	1776	12165
9	42	.	585	458	798	398	414	241	1183	989	662	852	792	2956	10369
10	71	.	833	335	992	324	582	242	2252	1294	1264	1214	1233	1214	11851
11	248	.	743	249	257	40	255	604	2	531	607	1157	676	524	5892
12	16	62	72	.	.	.	.	.	.	7	.	.	.	0	157
Total	376	116	4001	2064	4057	1495	3069	2362	5244	4910	6427	5314	5295	7432	52162

Table 2. Effort (hrs) by month/year - Nafo Division 0A, 1979-1992

Year	79	80	81	82	83	84	85	86	87	88	89	90	91	92	Total
Month															
4	.	.	.	.	.	4	.	.	.	.	.	.	.	.	4
6	.	.	746	.	33	.	597	471	166	59	937	.	.	.	3009
7	.	121	1804	617	1928	845	2502	1340	519	1188	5391	2079	1906	1847	22087
8	.	.	2170	1836	4100	1360	2412	995	2341	3237	3738	3745	5482	4460	35876
9	81	.	1968	1504	3151	1641	1784	731	2714	2595	1734	1826	3028	5773	28530
10	325	.	3229	1248	3995	1370	1804	577	4944	2197	3210	3089	3233	3582	32803
11	1072	.	2980	953	1074	129	827	1191	3	1167	1423	2370	2377	1806	17372
12	114	203	483	.	.	.	.	.	.	50	.	.	.	4	854
Total	1592	324	13380	6158	14281	5349	9926	5305	10687	10493	16433	13109	16026	17472	140535

Table 3. CPUE (kg/hr) by month/year - NAFO Division 0A, 1979-1992

Year	79	80	81	82	83	84	85	86	87	88	89	90	91	92
Month														
4	.	.	.	.	.	122	.	.	.	.	.	.	.	.
6	.	.	466	.	508	.	486	656	868	720	543	.	.	.
7	.	445	419	604	390	448	369	450	973	642	391	428	526	521
8	.	.	306	354	303	260	250	365	494	397	342	321	290	398
9	513	.	297	304	253	243	232	330	436	381	382	466	261	512
10	218	.	258	268	248	236	323	419	456	589	394	393	381	339
11	231	.	249	261	239	311	308	507	522	455	426	488	285	290
12	140	306	149	.	.	.	.	.	.	130	.	.	.	93

TABLE 4A. STANDARDIZATION OF CPUE - MULTIPLICATIVE, YEAR-MONTH-VESSEL MODEL, 1981 - 1992.

GENERAL LINEAR MODELS PROCEDURE

DEPENDENT VARIABLE: LNCPUE

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE	PR > F	R-SQUARE	C.V.
MODEL	62	49.17644991	0.79316855	14.08	0.0	0.694451	4.0960
ERROR	384	21.63700837	0.05634638		ROOT MSE		LNCPUE MEAN
CORRECTED TOTAL	446	70.81345828			0.23737392		5.85237664

SOURCE	DF	TYPE I SS	F VALUE	PR > F	DF	TYPE III SS	F VALUE	PR > F
YEAR	11	16.84260420	27.17	0.0	11	4.91295124	7.93	0.0001
MONTH	6	11.03992287	32.65	0.0001	6	6.44032380	19.05	0.0001
VESSEL	45	21.29392284	8.40	0.0001	45	21.29392284	8.40	0.0001

PARAMETER ESTIMATES

VARIABLE	DF	PARAMETER ESTIMATE	STANDARD ERROR	T FOR H0: PARAMETER=0	PROB > |T|
INTERCEP	B	5.49360543	0.06997059	78.513	0.0001
YY81	B	0.19545707	0.08115492	2.408	0.0165
YY82	B	0.35234057	0.09457087	3.726	0.0002
YY83	B	0.07161421	0.07327694	0.977	0.3290
YY84	B	0.037208	0.0996841	0.373	0.7092
YY85	B	-0.0891156	0.10121686	-0.880	0.3792
YY86	B	0.03325994	0.08567923	0.388	0.6981
YY87	B	0.33022991	0.06323183	5.223	0.0001
YY88	B	0.22738315	0.05931046	3.834	0.0001
YY89	B	-0.0217153	0.05263179	-0.413	0.6801
YY90	B	0.02903383	0.05348023	0.543	0.5875
YY91	B	-0.0765394	0.05411151	-1.414	0.1580
YY92	0	0	.	.	.
MON6	B	0.44520403	0.06609447	6.736	0.0001
MON7	B	0.28223694	0.03790625	7.446	0.0001
MON9	B	0.06313642	0.03572635	1.767	0.0780
MON10	B	0.0922211	0.03458658	2.666	0.0080
MON11	B	0.02048035	0.03938046	0.520	0.6033
MON12	B	-0.417537	0.11276690	-3.703	0.0002
MON99	0	0	.	.	.
V1	B	-0.50501	0.10546824	-4.788	0.0001
V4	B	-0.208056	0.08787871	-2.368	0.0184
V5	B	0.11280262	0.06986076	1.615	0.1072
V7	B	-0.101339	0.18150548	-0.558	0.5769
V10	B	0.16933419	0.08300878	2.040	0.0420
V11	B	0.05061708	0.09975885	0.507	0.6122
V13	B	-0.0629882	0.08051197	-0.782	0.4345
V14	B	-0.118424	0.09370145	-1.264	0.2071
V15	B	-0.348557	0.09274558	-3.758	0.0002
V16	B	-0.0410921	0.11864989	-0.346	0.7293
V17	B	-0.685221	0.15741515	-4.353	0.0001
V18	B	-0.488258	0.18185407	-2.685	0.0076
V19	B	-0.815285	0.18928714	-4.307	0.0001
V20	B	-0.671284	0.18861662	-3.559	0.0004
V21	B	-0.0223819	0.06808232	-0.329	0.7425
V22	B	-0.236285	0.18990244	-1.244	0.2142
V23	B	0.03956346	0.14796693	0.267	0.7893
V24	B	0.16524269	0.14027039	1.178	0.2395
V25	B	0.36651119	0.11361825	3.226	0.0014
V26	B	-0.463078	0.16553837	-2.797	0.0054
V27	B	0.26830240	0.14063486	1.908	0.0572
V28	B	0.18012908	0.14063486	1.281	0.2010
V29	B	0.54070301	0.07389202	7.317	0.0001
V30	B	0.37595275	0.09061625	4.149	0.0001
V31	B	-0.780592	0.25263213	-3.090	0.0021
V32	B	0.53854737	0.0780462	6.900	0.0001
V33	B	-0.0871914	0.08215922	-1.061	0.2892
V34	B	0.42206346	0.09926692	4.252	0.0001
V35	B	0.35229283	0.13134144	2.682	0.0076
V36	B	0.47771922	0.08657138	5.518	0.0001
V37	B	0.45726301	0.09004425	5.078	0.0001
V38	B	0.39297034	0.09635525	4.078	0.0001
V39	B	0.36633235	0.08548881	4.285	0.0001
V40	B	0.58178680	0.07531915	7.724	0.0001
V41	B	0.23653934	0.07162045	3.303	0.0010
V42	B	0.52831262	0.08588151	6.152	0.0001
V43	B	0.25903393	0.07603121	3.407	0.0007
V44	B	0.43525516	0.08534595	5.100	0.0001
V47	B	0.42700951	0.08660261	4.931	0.0001
V48	B	0.31688069	0.17925179	1.768	0.0779
V57	B	0.17265133	0.13443659	1.284	0.1998
V58	B	0.47431407	0.11354781	4.177	0.0001
V59	B	0.13940544	0.15117744	0.922	0.3570
V67	B	0.46439103	0.12546979	3.701	0.0002
V68	B	0.46334517	0.13620688	3.402	0.0007
V99	0	0	.	.	.

TABLE 4B. RETRANSFORMED MEAN ANNUAL CATCH RATES FROM STANDARDIZATION.

	LN TRANSFORM			RETRANSFORMED		
SUMMARY	YHAT	YHATVAR	STDERR	MEAN	VARIANCE	STDERR
INTERCEP	5.4936	.0048959	.0699706	249.4901	305.0430	17.4655
YY81	5.6891	.0050187	.0708426	303.3279	462.1794	21.4984
YY82	5.8459	.0071019	.0842728	354.4803	892.2826	29.8711
YY83	5.5652	.0041176	.0641682	268.1171	296.4024	17.2163
YY84	5.5308	.0079674	.0892604	258.5492	532.3030	23.0717
YY85	5.4045	.0086204	.0928463	227.7924	446.9106	21.1403
YY86	5.5269	.0074404	.0862579	257.5986	493.5768	22.2166
YY87	5.8238	.0042372	.0650935	347.2273	511.5290	22.6170
YY88	5.7210	.0041215	.0641989	313.3093	405.1290	20.1278
YY89	5.4719	.0041644	0.064532	244.2203	248.7121	15.7706
YY90	5.5226	.0041662	.0645459	256.9339	275.3990	16.5952
YY91	5.4171	.0043567	.0660051	231.1693	233.1072	15.2678
YY92	5.4936	.0048959	.0699706	249.4901	305.0430	17.4655

Table 5. Northern shrimp data from the Canadian fishery in NAFO Subareas 0 and 1, 1979 - 1992.

			UNSTANDARDIZED			STANDARDIZED		
YEAR	TAC (T)	CATCH[1] (T)	CPUE (KG/H)	INDEX	EFFORT[2] (HR)	CPUE (KG/H)	INDEX	EFFORT[2] (HR)
1979	2000	1732	236		7339			
1980	2500	2726	358		7615			
1981	5000	5284	299	1.00	17672	303	1.00	17439
1982	5000	2064	335	1.12	6161	354	1.17	5831
1983	5000	5413	284	0.95	19060	268	0.88	20198
1984	5000	2142	280	0.94	7650	259	0.85	8270
1985	6120	3069	309	1.03	9932	228	0.75	13461
1986	6120	2995	445	1.49	6730	258	0.85	11609
1987	6120	6095	491	1.64	12413	347	1.15	17565
1988	6120	5881	468	1.57	12566	313	1.03	18789
1989	7520	7235	391	1.31	18504	244	0.81	29652
1990	7520	6177	405	1.35	15252	257	0.85	24035
1991	8500	6788	331	1.11	20508	231	0.76	29385
1992	8500	7493	425	1.42	17631	249	0.82	30092

[1] Catch (tons) from statistics as reported in economic assessment of the northern shrimp fishery (MacDonald and Collins, 1990) or vessel logs, whichever is greater. Division 0A only from 1981 to 1992, inclusive. 1990, 1991 and 1992 data - provisional.

[2] Effort calculated from catch/CPUE. CPUE calculated from vessel log data. Reference month for standardization is August.

Table 6. Mean carapace length (mm) at age (yrs) for shrimp in NAFO Division 0A, 1981 - 1992.

Year	_81	_82	_83	_84	_85	_86	_87	_88	_89	_90	_91	_92
Age												
3	-	-	-	-	-	-	-	14.62	-	-	-	-
4	18.32	18.48	17.43	19.03	18.86	18.38	17.59	17.87	17.51	18.63	17.66	16.74
5	19.73	21.08	20.23	21.33	20.76	21.26	19.85	20.05	19.76	20.58	20.2	19.7
6	22.03	23.13	22.51	22.92	22.47	22.87	22.3	22.34	22.31	22.83	21.85	22.32
7	24.06	25.09	25.53	25.04	24.92	25.11	25.25	25.56	25.17	25.47	24.58	24.94
8	26.97	26.82	27.27	27.22	27.38	27.61	27.54	27.8	27.22	27.36	27.39	27.77

Table 7. Proportion of shrimp caught at age as determined from commercial length frquency distributions - NAFO Division 0A, 1981 - 1992.

Year	_81	_82	_83	_84	_85	_86	_87	_88	_89	_90	_91	_92
Age												
3	0	0	0	0	0	0	0	0.02	0	0	0	0
4	0.019	0.027	0.009	0.109	0.02	0.033	0.038	0.092	0.058	0.046	0.031	0.03
5	0.047	0.148	0.113	0.247	0.136	0.239	0.141	0.159	0.164	0.344	0.094	0.182
6	0.126	0.149	0.237	0.179	0.192	0.238	0.287	0.222	0.2	0.183	0.412	0.303
7	0.242	0.112	0.285	0.279	0.465	0.398	0.482	0.445	0.418	0.264	0.279	0.302
8	0.566	0.564	0.356	0.186	0.187	0.092	0.052	0.062	0.16	0.163	0.184	0.183
Total	1	1	1	1	1	1	1	1	1	1	1	1

Table 8. Number of shrimp caught at age by year, (x10-3), NAFO Div. 0A.

Year	81	82	83	84	85	86	87	88	89	90	91	92
Age (Years)												
3	0	0	0	0	0	0	0	14842	0	0	0	0
4	10185	5727	5227	29642	7042	12095	29070	68271	54333	37565	27551	29309
5	25193	31393	65626	67170	47888	87594	107865	117991	153631	280921	83542	177805
6	67540	31605	137640	48678	67607	87227	219554	164742	187355	149443	366162	296017
7	433111	143390	372267	126453	229581	179586	408509	376235	541457	348701	411488	473822
Total	536029	212115	580760	271943	352118	366502	764998	742081	936776	816630	888743	976953

Table 9. Number of shrimp caught per hour (Unstandardized) at age-NAFO Div.0A.

Year	81	82	83	84	85	86	87	88	89	90	91	92
Age (Years)												
3	0	0	0	0	0	0	0	1181	0	0	0	0
4	576	930	274	3875	709	1797	2342	5433	2936	2463	1343	1662
5	1426	5095	3443	8780	4822	13015	8690	9390	8303	18419	4074	10085
6	3822	5130	7221	6363	6807	12961	17687	13110	10125	9798	17855	16790
7	24508	23274	19531	16530	23115	26684	32910	29941	29262	22863	20065	26874
Total	30332	34429	30470	35548	35453	54458	61629	59055	50626	53542	43336	55411

Table 10. Number of shrimp caught per hour (Standardized) at age-NAFO Div.0A.

Year	81	82	83	84	85	86	87	88	89	90	91	92
Age(Years)												
3	0	0	0	0	0	0	0	790	0	0	0	0
4	584	982	259	3584	523	1042	1655	3634	1832	1563	938	974
5	1445	5384	3249	8122	3558	7545	6141	6280	5181	11688	2843	5909
6	3873	5420	6815	5886	5022	7514	12500	8768	6318	6218	12461	9837
7	24836	24591	18431	15291	17055	15470	23257	20024	18260	14508	14003	15746
Total	30737	36377	28753	32883	26158	31571	43552	39496	31592	33977	30245	32466

Table 11. Shrimp discards (% of total shrimp catch) in Div. *0A*, 1981 - 92, *estimated by observers.*

Year	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992
Month												
May								0.7				
Jun	2.9		0.5		4.2	2.4	1.9	1.3	2.3			
Jul	2.7	2.6	1.6	6.9	3.1	2.4	1.8	1.8	1.9	9.8	8.2	3.5
Aug	4.6	3.5	3	5.4	3.6	2.6	3.5	1.6	3.1	4.8	7.6	3.5
Sep	5.8	3.6	3.6	6.1	3.2	2.2	1.6	2.5	6.2	5.2	8	5
Oct	5.8	3.7	5.2	3.3	4	2	2.1	3.3	3.5	2.4	5.6	3.1
Nov	3.6	3.3	5.8	6.7	2.4	2.3	2	4.2	3.6	2.2	3.8	3.2
Dec	3.3							1.2				
Mean	4.31	3.3	3.41	5.54	3.48	2.31	2.24	2.57	3.26	4.36	6.54	4.01

Table 12. By-catch estimates from observer data - Div. 0A, 1992

Month	July		August		September		October		November	
	Weight (t)	%	Weight (t)	%	Weight (t)	%	Weight (t)	%	Weight (t)	%
SPECIES										
SHARK (NS)	9.08	0.93	14.39	0.92	4.98	0.26	2.11	0.34	10.17	11.17
SKATE (NS)	7.09	0.73	15.61	1	9.03	0.47	5	0.8	0.93	1.02
COD	0.36	0.04	0.92	0.06	1.46	0.08	0.46	0.07	0.01	0.01
ARCTIC COD	10.04	1.03	21.58	1.38	19.22	1	7.85	1.25	0.81	0.89
WOLLFISH (NS)	0.95	0.1	2.66	0.17	1.84	0.1	0.73	0.12	0.01	0.01
EELPOUTS (NS)	0.93	0.1	2.89	0.19	3.66	0.19	0.97	0.15	0.19	0.21
REDFISH (NS)	244.72	25.08	284.14	18.23	267.98	13.99	105.79	16.86	9.14	10.04
SCULPINS	0	0	1.35	0.09						
G. HALIBUT	12.34	1.26	37.5	2.41	54.71	2.86	17.58	2.8	1.67	1.84
SHRIMP (P.B)	682.11	69.89	1130.2	72.53	1513.24	78.98	472.55	75.32	65.79	72.31
OTHER	8.34	0.85	47.1	3.02	39.77	2.08	14.36	2.29	2.26	2.49
ALL	975.96	100	1558.36	100	1915.89	100	627.4	100	90.97	100

Fig.1 Shrimp catch SA 0 + 1 1979-1992

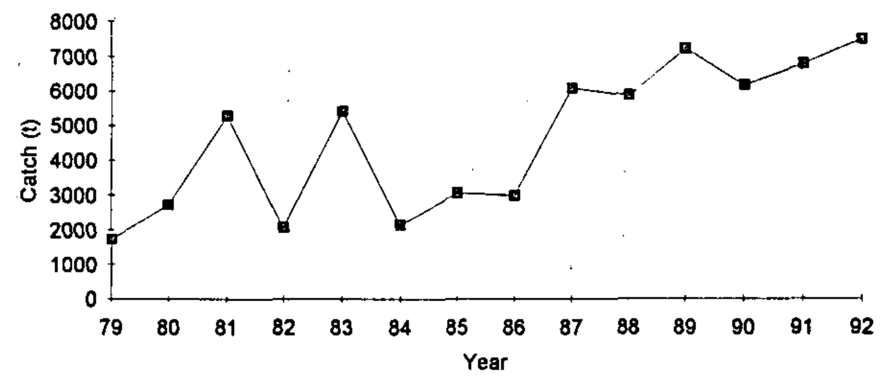


Fig.2a. Unstandardized effort SA 0 + 1 1979-1992

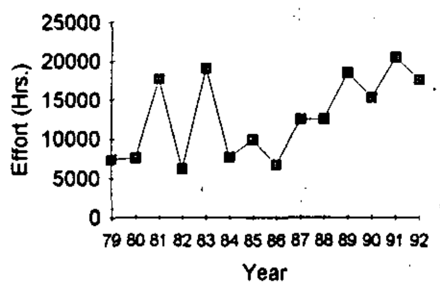


Fig.2b. Standardized effort Div. 0A 1981-1992

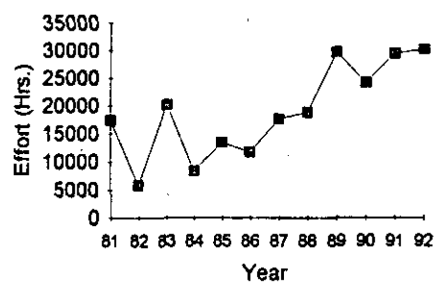


Fig.3a. Unstandardized CPUE SA 0 + 1 1979-1992

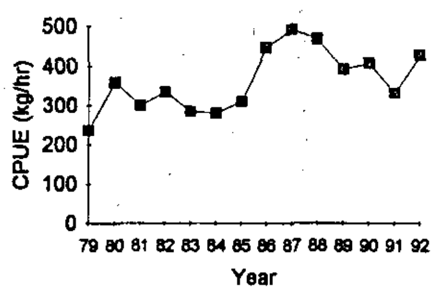


Fig.3b. Standardized CPUE Div.0A 1981-1992

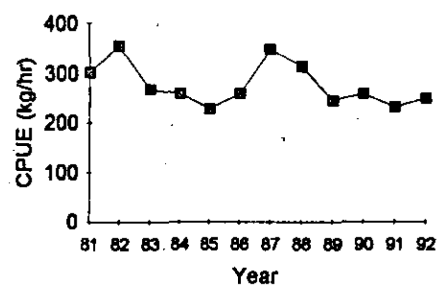


Fig. 4a. Shrimp catch vs unstandardized fishing effort
SA 0 + 1

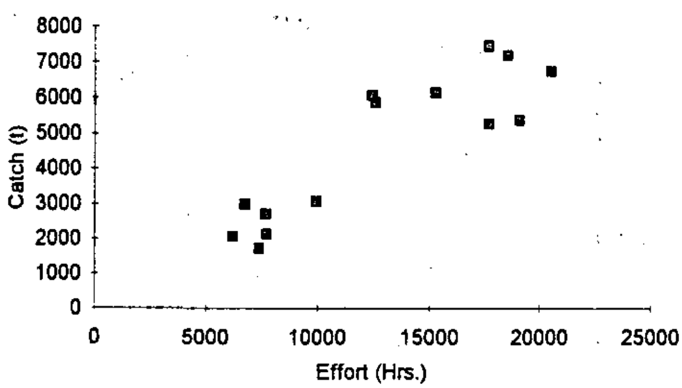


Fig. 4b. Shrimp catch vs standardized fishing effort
Div. 0A

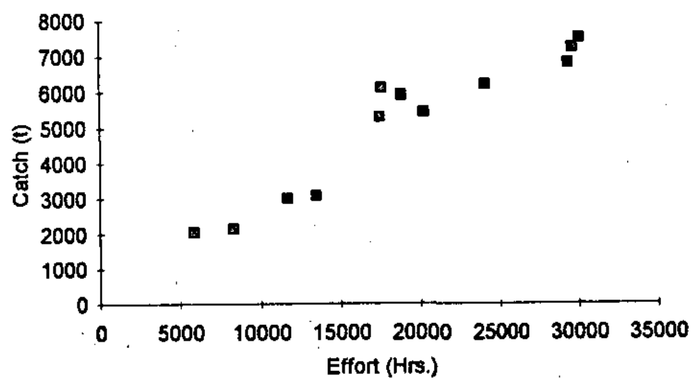


Fig.5a. CPUE vs. effort
(Unstandardized)

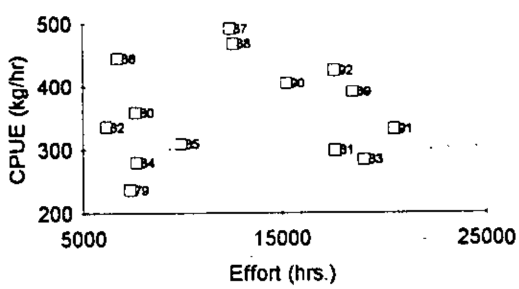


Fig.5b. CPUE vs. effort
(Standardized)

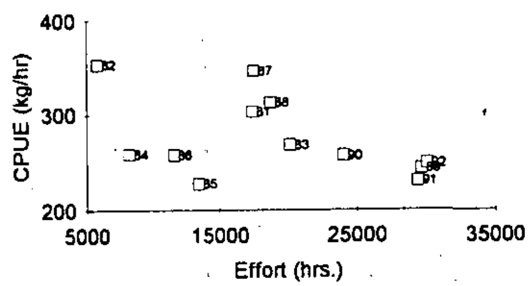


Fig.6a. CPUE vs. effort
(Unstandardized 2 year average)

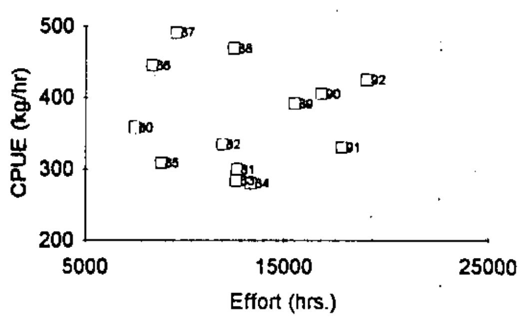
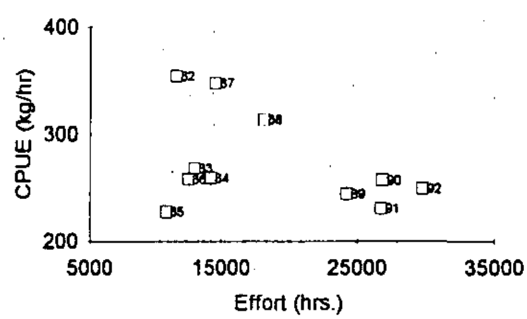


Fig.6b. CPUE vs. effort
(Standardized 2 year average)



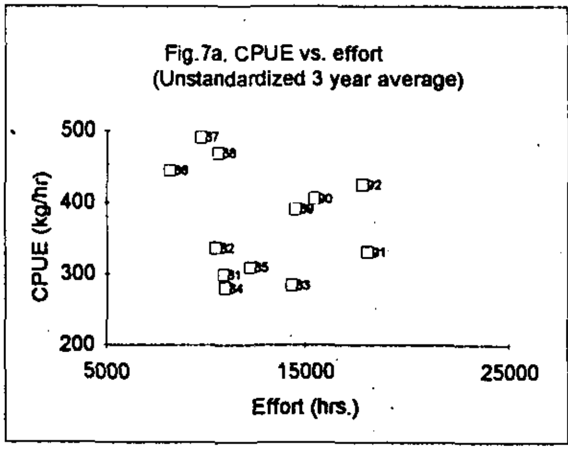


Fig.7a. CPUE vs. effort (Unstandardized 3 year average)

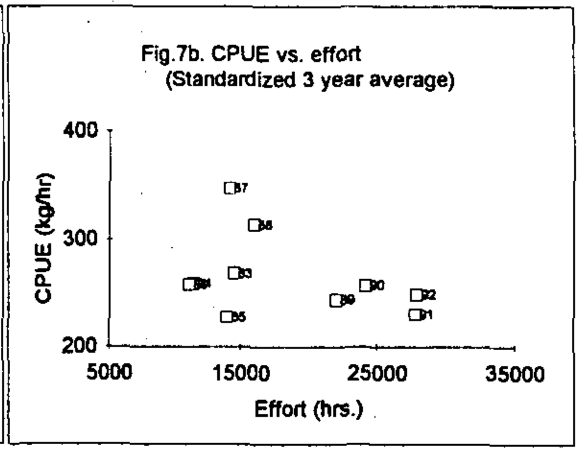


Fig.7b. CPUE vs. effort (Standardized 3 year average)

Fig. 8 Commercial length frequencies for shrimp by month, 1992 (N=number per hour, n=number measured, ----- female.)

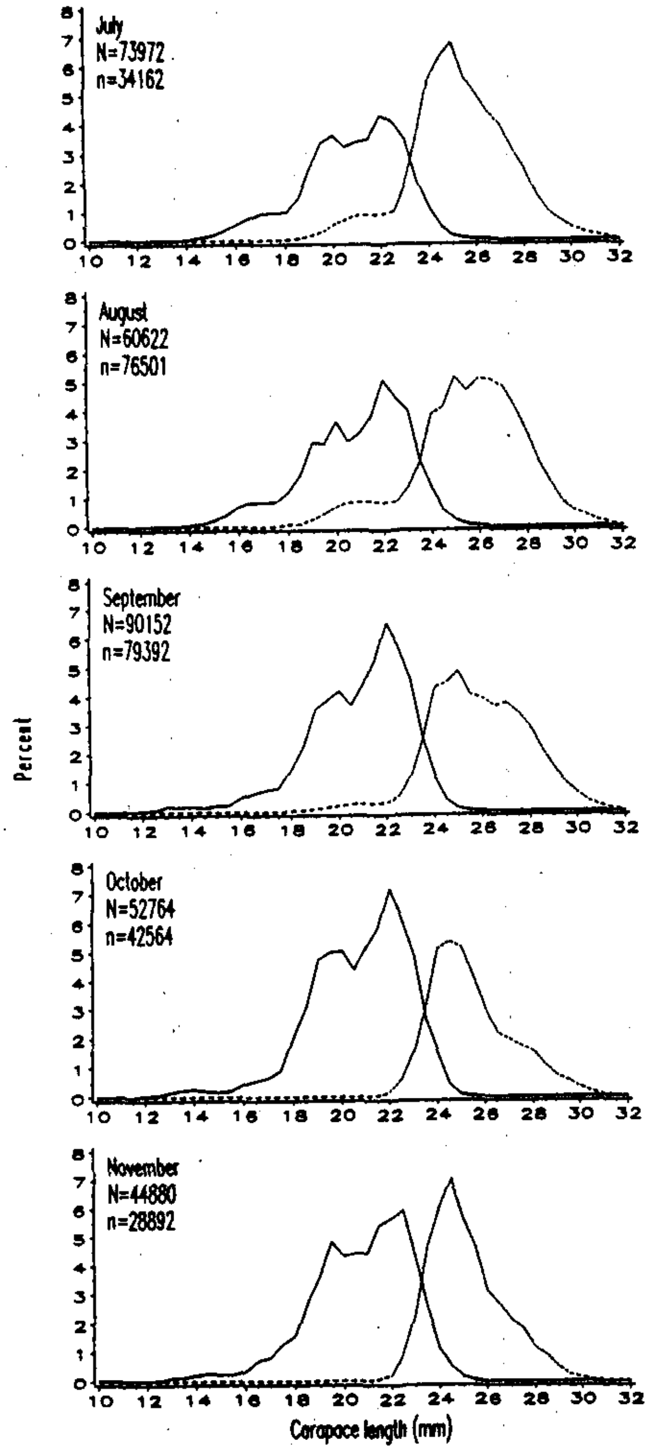
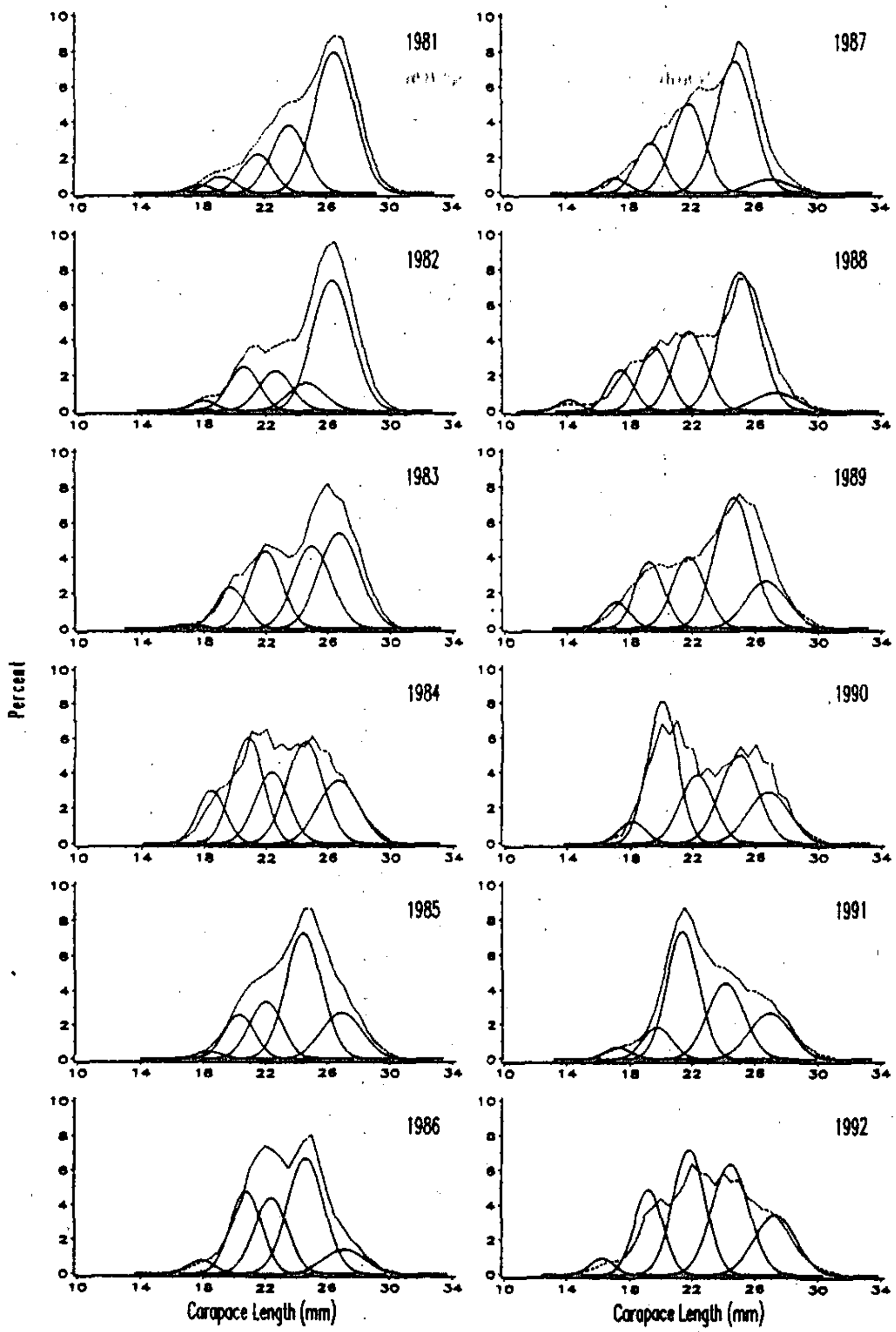


Fig. 9 Separation of ages from commercial length frequency data (broken line = commercial frequency). NAFO Div. 0A, 1981-1992



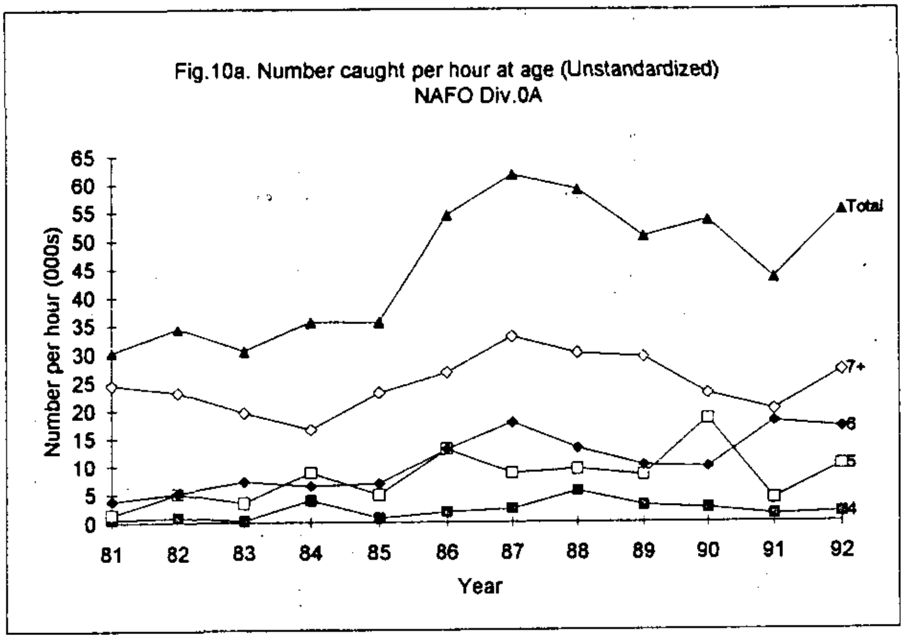


Fig.10a. Number caught per hour at age (Unstandardized)
NAFO Div.0A
Number per hour (000s)
65
60
55
50
45
40
35
30
25
20
15
10
5
0
Total
7+
6
5
4
81
82
83
84
85
86
87
88
89
90
91
92
Year

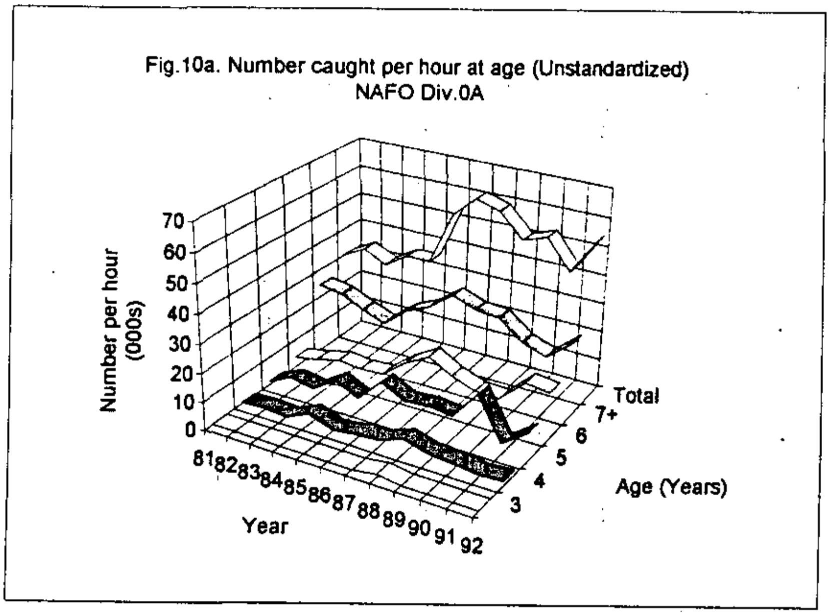


Fig.10a. Number caught per hour at age (Unstandardized)
NAFO Div.0A
Number per hour (000s)
70
60
50
40
30
20
10
0
81 82 83 84 85 86 87 88 89 90 91 92
Year
Total
7+
6
5
4
3
Age (Years)

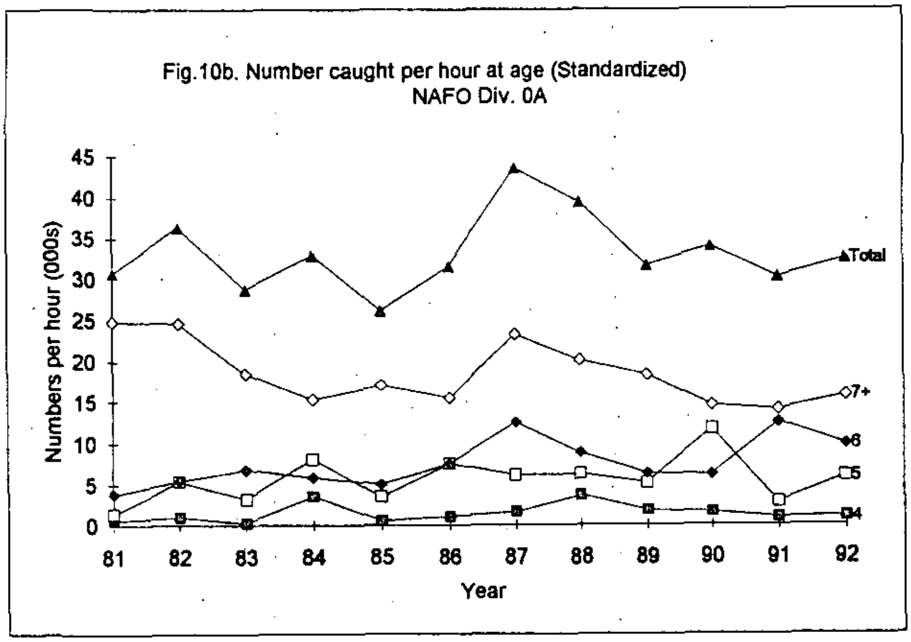


Fig.10b. Number caught per hour at age (Standardized)
NAFO Div. 0A
Numbers per hour (000s)
45
40
35
30
25
20
15
10
5
0
Total
7+
6
5
4
81
82
83
84
85
86
87
88
89
90
91
92
Year

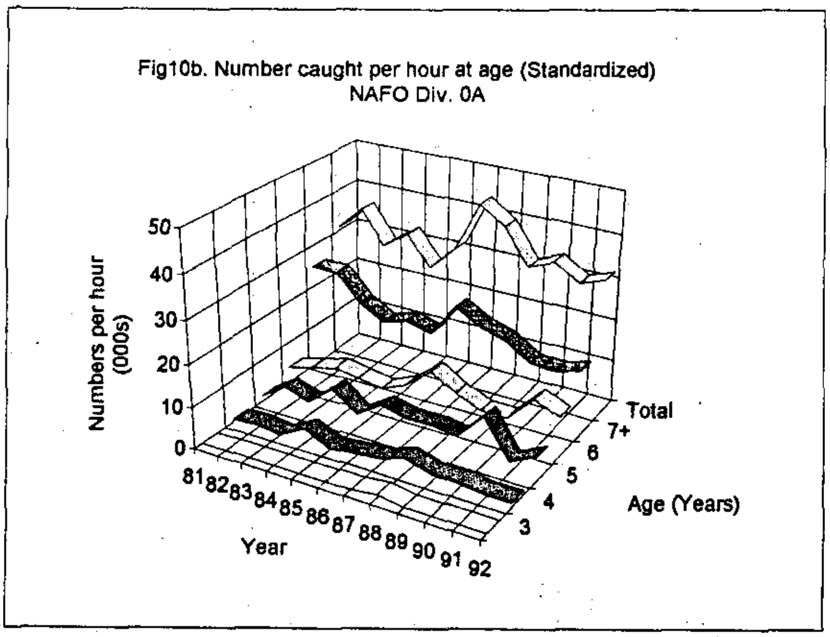


Fig10b. Number caught per hour at age (Standardized)
NAFO Div. 0A
Numbers per hour (000s)
50
40
30
20
10
0
81
82
83
84
85
86
87
88
89
90
91
92
Year
Total
7+
6
5
4
3
Age (Years)