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The Canadian Fishery for Northern Shrimp (Pandalus borealis) in Davis Strait, 1979 - 1994

by

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INTRODUCTION

Weekly quota reports, to November 1, 1994, indicate that only 3920 t of shrimp have been taken in Division 0A from a total allocation of 8500 t. Twelve vessels have participated in the fishery, to date, the same number as in 1993. The number of licences has remained at 17 since 1991. The total shrimp catch for 1993 was estimated to be about 5500 t, 3000 t less than the TAC and 2000 t less than the 1992 catch.

Log book records and daily vessel hails provided preliminary information on fleet performance in 1994. Data from previous years have been updated from vessel logs in the present analysis. Catch, effort and size composition of shrimp from the 1981 - 1994 commercial catches are compared and information is provided on shrimp discards and by-catches. Details of catch composition were obtained at sea by fisheries observers assigned to each vessel in the fleet.

MATERIALS AND METHODS

Catch (kilograms) and effort (hours fished) were compiled from vessel logs for the period 1979 to 1993 and from available logs and daily hails up to October 31, 1994. The data were summarized by year, month and vessel (n = 539). 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. For the 1981 - 1994 period, catch and effort were totalled and the catch per unit effort (CPUE) calculated within each cell (year/month/vessel) for standardization. No vessel fished in every year.

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

1. The catch reported in vessel logs/hails from 1979 to 1994 was divided by the corresponding effort, providing a series of unstandardized, weighted, annual catch rates.

2. All data from 1981 to 1994 (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 a predicted, annual catch rate series.

The CPUE data (n = 520) were log (base e) transformed for standardization. Annual log CPUE estimates were retransformed and indexed to 1981.

Size composition of the 1994 catches sampled by observers were summarized by month and length frequency distributions of total numbers caught in each year from 1981 to 1994 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 0.5 mm carapace length (CL) intervals 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. (1994). 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). For each age, mean lengths, proportions, numbers and numbers caught per hour (unstandardized and standardized) were tabulated.

Data on by-catches from 1981 to 1994 were compiled as percentages of the total observed catch in each year and catch rates (kg/hr) for redfish and Greenland halibut were compared over the same period. Estimates of the proportions of discarded shrimp by month and year also were derived from the observer data.

RESULTS

Location of fishing

Fishing positions, as recorded in vessel logs, show changes in the distribution of effort over time (Fig. 1). From 1981 to 1987, most activity occurred from 67° 30' to 68° 10'N and 58° to 59° W but, beginning in 1988, substantially more effort was expended north of 68° N and west of 59° W. Over the past fourteen years, fishing has been confined to an area between 67° and 69° N and 58° and 60° W, west of the international boundary.

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 continues into late November or even early December. However, most of the catch is taken and most of the effort expended in the July to October period. From 1984 to 1992, catch showed an increasing trend (Fig. 2), declining thereafter. Effort showed approximately the same pattern (Fig. 3a) except that the recent decline began in 1992. Although the 1994 fishery is continuing, it is anticipated that the final catch and effort estimates will be lower than those of 1993.

The seasonality of the fishery is evident in the monthly CPUE data (Table 3). In most years, catch rates were relatively high during the June - July period, declined during August - September and either stabilized or increased in October and November. This general pattern was evident in both 1993 and 1994. Annual, unstandardized catch rates (Fig. 4a) were fairly stable up to 1985, increased to a substantially higher level from 1986 to 1988 and subsequently declined to 1991. Some improvement occurred in 1992 but catch rates declined again in 1993 and 1994.

The results of the multiple regression analysis to standardize the catch rates (Table 4a) show that the model explains 68% of the total variation and that all three class variables (year, month and vessel) were highly significant. T-values indicate that catch rates for most years were significantly higher ($P < 0.05$) than the 1994 estimate. Only the 1985 and 1991 estimates were not ($P > 0.05$).

Standardized effort (Fig. 3b) showed the same pattern as the unstandardized series except the increase from 1984 was more pronounced and continued to 1992. 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. Except for the high CPUE's in 1981/82 and 1987/88, the series indicates relative stability (Fig. 4b) up to 1993. However, the value predicted for 1994 is the lowest in the fourteen year period and, as stated above, significantly lower than eleven of the previous thirteen years. 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. 5a 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, have not shown any clear relationship with fishing effort (Parsons and Veitch, 1993).

Length distributions

Monthly length frequencies for the sampled catches in 1994 (Fig. 6) show a decrease in the proportion of female shrimp in the catches over the season, similar to that observed in 1993 (Parsons and Veitch, 1993). A broad size range, representing a number of year-classes, was also present. Compared to the previous year, the were proportionately more shrimp smaller than 19 mm CL in 1994. Three male components occurred in all months at modal lengths of approximately 18, 20 and 22 mm. Smaller/younger males are also present but weakly represented at sizes around 14 mm. There are no clear indications of separate size/age groups within the female component.

Shrimp caught in 1994 were, on average, larger than those caught in the previous year (Fig. 7) due to the higher proportion of females. Females about 25 mm (the 1987/86/85 year class) and males with modal length of 22 mm (the 1988 year class) comprised more than 75% of the catch in numbers. The remnants of the 1985 year class are obscured in the composite female group and it is uncertain what female year class(es) supported the fishery in 1994. The data showed a decrease in the mean length of the female mode (composed of at least two ages) between 1983 and 1985 and a period of similar size composition 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. This year class was expected to change sex between 1991 and 1992 and occur as age 7 females in the 1992 catches. It contributed significantly to the 1992 catches, as females, but was supported by a strong component of males at 22 mm. Catches in 1993 were dominated by two well-separated size groups, one male and one female, whereas sizes encountered in 1994 were similar to those of the 1987 - 1989 period.

Ageing of commercial length distributions followed the procedures of Parsons and Veitch (1991). Expected counts at length from the modal analyses of the 1981 - 1992 and 1994 data were virtually identical ($P > 0.98$) to the observed (Fig. 7). Analysis of the total length frequency was problematic for the 1993 data and reasonable results only could be obtained by analyzing males and females, separately.

Estimated mean lengths (Table 6) agreed well with those from the previous ageing study by Savard et al. (1994) and showed consistency from year to year. The estimated proportions at age of the numbers of shrimp caught from 1981 to 1994 (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. Since then, from 43% to 50% of the catch numbers have been female (except for 58% in 1989). 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). Modes at similar lengths also were evident in 1993 and 1994.

The proportions in Table 7 were applied to the total estimated catch numbers to derive a catch-at-age matrix (Table 8) which was 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.

Ages 3 and 4 males consistently occurred in very low numbers and do not show any trend over time (Fig. 8). Catch rates for ages 5 and 6 males show a slightly increasing trend with indications (peaks) that strong year classes were produced in 1981, 1985 and possibly 1988. 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.

Shrimp discards

The percentages of shrimp discards determined by observers (Table 11) declined in recent years from a high of 6.5% in 1991 to 1.3% in 1994, the lowest level achieved over the 1981 - 1994 period. The increasing trend from 1987 to 1991, followed by decreases in 1992 and 1993, is consistent with the recruitment of the strong 1985 year class through the late 1980's and its occurrence at large sizes in the 1992 and 1993 catches. The further decrease in 1994 is consistent with the domination of the catches by year classes produced before 1989 but also might reflect favourable markets for all sizes of shrimp in 1994.

By-catches

Observer data on catch composition for the 1994 fishery (Table 12) show that the by-catch accounted for 22% of the total catch weight of all species and that redfish was again the most prevalent fish species in the catches, representing almost 12% of the total observed catch weight. Greenland halibut comprised 3.3% of the catch, higher than in the previous two years and similar to the proportion observed in 1991. Arctic cod (Boreogadus saida) occurred more frequently as by-catch, accounting for just over 3% of the catch in 1994. Typically, the incidence of Greenland sharks increases in November and, therefore, is not adequately represented in the 1994 data.

Catch rates (kg/hr - unstandardized) for redfish and Greenland halibut from 1981 to 1994 were:

Species/Year	'81	'82	'83	'84	'85	'86	'87	'88	'89	'90	'91	'92	'93	'94
Redfish	32	20	9	15	20	85	119	78	72	59	86	73	68	57
Gr. halibut	3	4	5	6	4	8	13	15	12	12	19	17	15	18

Redfish CPUE's increased substantially from 1983 to 1987, decreased to 1990, increased again in 1991 and declined, thereafter. Based on the estimated, unstandardized effort (Table 5), about 650 t of primarily small redfish were taken as by-catch and discarded in the Div. 0A fishery to date in 1994. Catch rates for Greenland halibut show a gradual, increasing trend to 1987 and a period of higher and relatively stable CPUE's from 1987 to 1994. We estimated that the removal of Greenland halibut (mostly small) so far in 1994 was roughly 200 t.

DISCUSSION

Our previous interpretation of the standardized CPUE series for Div. 0A proposed two periods of stable catch rates at similar levels: 1983 to 1986 and 1989 to 1993. Further, there were two shorter periods of significantly higher CPUE's (1981-82 and 1987-88) which resulted in subsequent declines from 1982 to 1985 and 1987 to 1991. The relative stability attained from 1990 to 1993 was largely due to the recruitment of the strong 1985 year class, which appeared as females for the first time in 1992 but took two years to complete sex inversion (NAFO, 1993). The decline in CPUE (both unstandardized and standardized) in 1994 was likely a reflection of a further reduction of the 1985 year class through fishing and natural mortality and the comparatively lesser strengths of the 1986, 1987 and possibly 1988 years classes. At ten years old, the 1985 year class cannot be expected to contribute substantially to the 1995 fishery. The success (or failure) of that fishery will depend on the actual strengths of the 1987, 1988 (female) and 1989 (male) year classes.

There is no doubt that the 1985 year class was strong. It was first noticed at age 4 in the 1989 research survey and was easily tracked as males through both the research and commercial length frequency data of 1990 and 1991. Its fate from 1992 onward is complicated by sex change over two years and our inability to reliably separate female age classes. Despite its obvious strength, catch rates of the early 1990's only remained stable. It would appear, therefore, that recruitment of one or more strong year classes is required in the short term to maintain or improve catch rates. The November 1993 assessment

(NAFO, 1993) indicated that abundance of the 1988 and 1989 year classes was "relatively good", based on the 1993 survey. However, at age four in the 1992 and 1993 surveys, respectively, neither appears to be as strong as the 1985 year class (Andersen et al., 1993).

During the twelve years from 1981 to 1992, the presence of three-year-olds in the catch-at-age data from Div. 0A was only detected in 1988 (i.e. the 1985 year class). The occurrence of age three animals in both 1993 and 1994 might be an indication of strong 1990 and 1991 year classes but might also be a reflection of a need to target smaller shrimp to maintain catch rates at acceptable levels. Regarding the latter, it is noted that the value of small, "industrial" grade shrimp is reported to be high in 1994, making that product more desirable than in previous years.

Finally, conversations with fishermen have confirmed that the 1994 fishery in Div. 0A has been a disappointment and they have only continued to fish at such low CPUE's because of the currently favourable market prices. Some have suggested that the low catch rates reflect a shift in distribution between 1993 and 1994 rather than a decrease in abundance.

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Table 1. Catch(t) by month/year - NAFO Division 0A, 1979-1994

Year	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	Total
4	.	.	.	.	.	0	.	.	.	.	.	.	.	.	.	.	0
6	.	.	347	.	17	.	290	309	144	42	509	.	.	.	.	.	1658
7	.	54	756	373	752	379	924	603	505	763	2105	890	1003	963	286	387	10743
8	.	.	665	650	1241	354	604	363	1157	1284	1280	1200	1591	1776	1377	1147	14689
9	42	.	585	458	798	398	414	241	1183	989	662	852	792	2956	1602	631	12603
10	71	.	833	335	992	324	582	242	2252	1294	1264	1214	1233	1214	1255	789	13894
11	248	.	743	249	257	40	255	604	2	531	607	1157	676	524	816	.	6709
12	16	62	72	.	.	.	.	.	.	7	.	.	.	0	42	.	199
Total	376	116	4001	2064	4057	1495	3069	2362	5244	4910	6427	5314	5295	7432	5377	2954	60493

Table 2. Effort (Hrs) by month/year - NAFO Division 0A, 1979-1994

Year	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	Total
Month																	
4	.	.	.	.	.	4	.	.	.	.	.	.	.	.	.	.	4
6	.	.	746	.	33	.	597	471	166	59	937	.	.	.	.	.	3009
7	.	121	1804	617	1928	845	2502	1340	519	1188	6391	2079	1906	1847	505	744	23336
8	.	.	2170	1836	4100	1360	2412	995	2341	3237	3738	3745	5482	4460	3770	3690	43336
9	81	.	1968	1504	3151	1641	1784	731	2714	2595	1734	1826	3028	5773	4150	2006	34686
10	325	.	3229	1248	3995	1370	1804	577	4944	2197	3210	3089	3233	3582	2769	2236	37808
11	1072	.	2980	953	1074	129	827	1191	3	1167	1423	2370	2377	1806	2056	.	19428
12	114	203	483	.	.	.	.	.	.	50	.	.	.	4	56	.	910
Total	1592	324	13380	6158	14281	5349	9926	5305	10687	10493	16433	13109	16026	17472	13306	8676	162517

Table 3. CPUE by month/year - NAFO Division 0A, 1979-1994

Year	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94
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	565	520
8	.	.	306	354	303	260	250	365	494	397	342	321	290	398	365	311
9	513	.	297	304	253	243	232	330	436	381	382	466	261	512	386	315
10	218	.	258	268	248	236	323	419	456	589	394	393	381	339	453	353
11	231	.	249	261	239	311	308	507	522	455	426	488	285	290	397	.
12	140	306	149	.	.	.	.	.	.	130	.	.	.	93	742	.

TABLE 4A. STANDARDIZATION OF CPUE - MULTIPLICATIVE, YEAR-MONTH-VESSEL MODEL, 1981 -1994.

GENERAL LINEAR MODELS PROCEDURE

DEPENDENT VARIABLE: LNCPUE

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE	PR > F	R-SQUARE	C.V.
MODEL	66	53.39597780	0.80902997	14.35	0.0	0.676446	4.0543
ERROR	453	25.54006025	0.05637982		ROOT MSE		LNCPUE MEAN
CORRECTED TOTAL	519	78.93603806			0.23744436		5.85663428

SOURCE	DF	TYPE I SS	F VALUE	PR > F	DF	TYPE III SS	F VALUE	PR > F
YEAR	13	17.48426502	23.86	0.0	13	5.58642516	7.62	0.0001
MONTH	6	11.56697266	34.19	0.0001	6	7.26830253	21.49	0.0001
VESSEL	47	24.34474012	9.19	0.0	47	24.34474012	9.19	0.0

PARAMETER		ESTIMATE	T FOR H0: PARAMETER=0	PR > |T|	STD ERROR OF ESTIMATE
INTERCEPT		5.31097894 B	68.18	0.0	0.07789713
YEAR	81	0.37366728 B	4.20	0.0001	0.08896152
	82	0.54123105 B	5.35	0.0001	0.10117262
	83	0.25548390 B	3.12	0.0019	0.08196546
	84	0.22127475 B	2.09	0.0372	0.10586204
	85	0.08440729 B	0.79	0.4306	0.10699372
	86	0.20512083 B	2.27	0.0234	0.09016509
	87	0.52112525 B	7.18	0.0001	0.07259256
	88	0.38831522 B	5.63	0.0001	0.06900134
	89	0.16661742 B	2.59	0.0099	0.06435286
	90	0.22516331 B	3.49	0.0005	0.06448796
	91	0.12357146 B	1.92	0.0553	0.06431005
	92	0.19078896 B	3.19	0.0015	0.05975845
	93	0.17773954 B	2.90	0.0039	0.06121866
	94	0.00000000 B	.	.	.
MONTH	6	0.44255915 B	6.76	0.0001	0.06545330
	7	0.29939169 B	8.53	0.0001	0.03510989
	9	0.04463273 B	1.37	0.1721	0.03263596
	10	0.08955950 B	2.82	0.0050	0.03177164
	11	0.01270747 B	0.34	0.7309	0.03692611
	12	-0.29337987 B	-2.78	0.0057	0.10560246
	99	0.00000000 B	.	.	.
VESSEL	1	-0.49524397 B	-4.70	0.0001	0.10539575
	4	-0.20502165 B	-2.33	0.0200	0.08782272
	5	0.11364145 B	1.63	0.1044	0.06984220
	7	-0.08767112 B	-0.48	0.6293	0.18147543
	10	0.16344089 B	1.97	0.0494	0.08294727
	11	0.04020914 B	0.40	0.6869	0.09969176
	13	-0.06024777 B	-0.75	0.4545	0.08048531
	14	-0.11078399 B	-1.18	0.2372	0.09359298
	15	-0.34821283 B	-3.76	0.0002	0.09269429
	16	-0.05436661 B	-0.46	0.6462	0.11836782
	17	-0.71871207 B	-4.58	0.0001	0.15693151
	18	-0.47325890 B	-2.60	0.0095	0.18177096
	19	-0.86906091 B	-4.61	0.0001	0.18838487
	20	-0.67233099 B	-3.57	0.0004	0.18843557
	21	-0.01863574 B	-0.28	0.7806	0.06687976
	22	-0.22714299 B	-1.20	0.2321	0.18981795

TABLE 4A (CONT'D.)

23	0.04535775 B	0.31	0.7592	0.14789938
24	0.17567739 B	1.25	0.2108	0.14019591
25	0.37579479 B	3.32	0.0010	0.11325148
26	-0.45263737 B	-2.74	0.0065	0.16542261
27	0.27976270 B	1.99	0.0472	0.14055946
28	0.19158938 B	1.36	0.1735	0.14055946
29	0.55996979 B	8.28	0.0001	0.06765474
30	0.38066319 B	4.20	0.0001	0.09059673
31	-0.76716497 B	-3.04	0.0025	0.25213009
32	0.54172664 B	6.94	0.0001	0.07803155
33	-0.08966950 B	-1.09	0.2753	0.08209284
34	0.42539129 B	4.29	0.0001	0.09925669
35	0.37178776 B	2.83	0.0048	0.13125921
36	0.48041505 B	5.55	0.0001	0.08656000
37	0.45791630 B	5.10	0.0001	0.08986831
38	0.38293636 B	3.98	0.0001	0.09627959
39	0.30167705 B	3.70	0.0002	0.08156851
40	0.54945467 B	7.56	0.0001	0.07270154
41	0.24493002 B	3.61	0.0003	0.06779909
42	0.51609511 B	6.03	0.0001	0.08556522
43	0.23095080 B	3.28	0.0011	0.07031069
44	0.43507677 B	5.41	0.0001	0.08036596
47	0.41886478 B	5.53	0.0001	0.07575456
48	0.29480032 B	1.65	0.1005	0.17912641
57	0.15616960 B	1.16	0.2450	0.13415484
58	0.45007803 B	4.89	0.0001	0.09210701
59	0.12539923 B	0.83	0.4063	0.15087090
67	0.60277820 B	6.84	0.0001	0.08807062
68	0.30841181 B	3.27	0.0012	0.09440922
69	0.82550746 B	5.25	0.0001	0.15734545
70	-0.10199442 B	-0.65	0.5157	0.15678443
99	0.00000000 B	.	.	.

TABLE 4B. RETRANSFORMED ANNUAL CATCH RATES FROM STANDARDIZATION.

	LN TRANSFORM			RETRANSFORMED		
SUMMARY	YHAT	YHATVAR	STDERR	MEAN	VARIANCE	STDERR
INTERCEP	5.3110	0.006068	.0778971	207.7199	261.5994	16.1740
YY81	5.6846	0.004955	.0703919	301.9965	451.7822	21.2552
YY82	5.8522	.0070377	.0838911	356.7144	894.3356	29.9054
YY83	5.5665	0.004052	.0636553	268.4553	292.0720	17.0901
YY84	5.5323	.0079063	.0889175	258.9264	529.1337	23.0029
YY85	5.3954	.0085728	.0925892	225.7307	435.9084	20.8784
YY86	5.5161	.0071718	.0846867	254.8711	465.2315	21.5692
YY87	5.8321	0.004164	.0645289	350.1178	510.4921	22.5941
YY88	5.6993	.0040249	.0634424	306.5955	378.4194	19.4530
YY89	5.4776	.0040897	.0639504	245.6233	246.7711	15.7089
YY90	5.5361	.0040698	.0637951	260.4354	276.0877	16.6159
YY91	5.4346	.0042224	0.06498	235.2589	233.7169	15.2878
YY92	5.5018	.0046254	.0680104	251.5652	292.6870	17.1081
YY93	5.4887	.0049423	.0703016	248.2643	304.5383	17.4510
YY94	5.3110	0.006068	.0778971	207.7199	261.5994	16.1740

Table 5. Northern shrimp data from the Canadian fishery in NAFO SA 0+1, 1979 - 1994.

				UNSTANDARDIZED			*STANDARDIZED*	
YEAR	TAC (T)	CATCH * (T)	CPUE (KG/H)	INDEX	EFFORT ** (HR)	CPUE (KG/H)	INDEX	EFFORT ** (HR)
1979	2000	1732	236		7339			
1980	2500	2726	358		7615			
1981	5000	5284	299	1.00	17672	302	1.00	17497
1982	5000	2064	335	1.12	6161	357	1.18	5782
1983	5000	5413	284	0.95	19060	268	0.89	20198
1984	5000	2142	280	0.94	7650	259	0.86	8270
1985	6120	3069	309	1.03	9932	226	0.75	13580
1986	6120	2995	445	1.49	6730	255	0.84	11745
1987	6120	6095	491	1.64	12413	350	1.16	17414
1988	6120	5881	468	1.57	12566	307	1.02	19156
1989	7520	7235	391	1.31	18504	246	0.81	29411
1990	7520	6177	405	1.35	15252	260	0.86	23758
1991	8500	6788	330	1.10	20570	235	0.78	28885
1992	8500	7493	425	1.42	17631	252	0.83	29734
1993	8500	5491	404	1.35	13592	248	0.82	22141
1994	8500	3920	340	1.14	11529	208	0.69	18846

* 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 1994, inclusive. The 1991, 1992 and 1993 data are provisional and the 1994 incomplete (up to November 1)

** Effort calculated from catch/CPUE. CPUE calculated from vessel logs. Reference month for standardization is August.

Table 6. Mean carapace length (mm) at age for shrimp in NAFO Division 0A, 1981 - 1994.

YEAR	_81	_82	_83	_84	_85	_86	_87	_88	_89	_90	_91	_92	_93	_94
AGE														
3	-	-	-	-	-	-	-	14.62	-	-	-	-	14.51	13.81
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	17.94	17.63
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	20.63	19.69
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	22.83	21.98
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	24.86	25.45
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	27.77	28.09

Table 7. Proportion of shrimp caught at age as determined from commercial length frequency distributions - NAFO Division 0A, 1981 - 1994.

YEAR	_81	_82	_83	_84	_85	_86	_87	_88	_89	_90	_91	_92	_93	_94
AGE														
3	0	0	0	0	0	0	0	0.02	0	0	0	0	0.026	0.011
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	0.104	0.078
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	0.269	0.145
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	0.171	0.27
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	0.284	0.482
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	0.146	0.014
TOTAL	1	1	1	1	1	1	1	1	1	1	1	1	1	1

Table 8. Number (x10-3) of shrimp caught at age by year in Div. 0A, 1981 - 1994.

Year/Age	81	82	83	84	85	86	87	88	89	90	91	92	93	94
3	0	0	0	0	0	0	0	14842	0	0	0	0	19832	5785
4	10185	5727	5227	29642	7042	12095	29070	68271	54333	37565	27551	29309	79328	41018
5	25193	31393	65626	67170	47888	87594	107865	117991	153631	280921	83542	177805	205186	76251
6	67540	31605	137640	48678	67607	87227	219554	164742	187355	149443	366162	296017	130434	141984
7+	433111	143390	372267	126453	229581	179586	408509	376235	541457	348701	411488	473822	327993	260831
TOTAL	536029	212115	580760	271943	352118	366502	764998	742081	936776	816630	888743	976953	762774	525868

Table 9. Number of shrimp caught per hour (unstandardized) at age in Div. 0A, 1981 - 1994.

Year/Age	81	82	83	84	85	86	87	88	89	90	91	92	93	94
3	0	0	0	0	0	0	0	1181	0	0	0	0	1492	502
4	576	930	274	3875	709	1797	2342	5433	2936	2463	1339	1662	5968	3558
5	1426	5095	3443	8780	4822	13015	8690	9390	8303	18419	4061	10085	15437	6614
6	3822	5130	7221	6363	6807	12961	17687	13110	10125	9798	17801	16790	9813	12315
7+	24508	23274	19531	16530	23115	26684	32910	29941	29262	22863	20004	26874	24676	22624
TOTAL	30332	34429	30470	35548	35453	54458	61629	59055	50626	53542	43206	55411	57386	45613

Table 10. Number of shrimp caught per hour (standardized) at age in Div. 0A, 1981 - 1994.

Year/Age	81	82	83	84	85	86	87	88	89	90	91	92	93	94
3	0	0	0	0	0	0	0	775	0	0	0	0	896	307
4	582	990	259	3584	519	1030	1669	3564	1847	1581	954	986	3583	2176
5	1440	5429	3249	8122	3526	7458	6194	6159	5224	11824	2892	5980	9267	4046
6	3860	5466	6815	5886	4978	7427	12608	8600	6370	6290	12677	9956	5891	7534
7+	24753	24799	18431	15291	16906	15290	23459	19641	18410	14677	14246	15935	14814	13840
TOTAL	30635	36685	28753	32883	25929	31205	43930	38739	31851	34373	30768	32856	34451	27903

Table 11. Shrimp discards (% of total shrimp catch) in Div. 0A, 1981 - 94, estimated by observers.

Year	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994
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	3.7	2.6	1.4
Aug	4.6	3.5	3	5.4	3.6	2.6	3.5	1.6	3.1	4.8	7.8	3.5	2.3	1.3
Sep	5.8	3.6	3.6	6.1	3.2	2.2	1.6	2.5	6.2	5.2	8	4.8	2.8	1.1
Oct	5.8	3.7	5.2	3.3	4	2	2.1	3.3	3.5	2.4	5.6	3.5	2.5	
Nov	3.6	3.3	5.8	6.7	2.4	2.3	2	4.2	3.6	2.2	3.8	4.7	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**	**4.1**	**2.47**	**1.27**

Table 12. Observed catch composition (tons and %) by species in Div. 0A shrimp fishery, 1981-94.

YEAR	1981		1982		1983		1984		1985		1986		1987		1988		1989		1990		1991		1992		1993		1994	
SPECIES	WT.	%	WT.	%	WT.	%	WT.	%	WT.	%	WT.	%	WT.	%	WT.	%	WT.	%	WT.	%	WT.	%	WT	%	WT.	%	WT.	%
SHRIMP	3897.1	84.49	2088.48	91.91	1846.5	93.55	1325.8	86.15	2173.8	85.95	2003.6	75.68	3406.1	83.03	2877.3	83.33	5173.2	78.93	2479.2	82.74	2520.7	71.81	3863.9	74.76	4195	78.59	750.55	78
REDS	386.95	8.39	110.69	4.87	48.3	2.45	63.63	4.13	124.63	4.93	432.43	16.33	566.06	13.8	393.97	11.41	759.77	11.59	271	9.04	569.07	16.21	911.77	17.64	585.24	10.96	113.86	11.832
PLAICE	10.82	0.23	2.49	0.11	3.68	0.19	1.8	0.12	3.49	0.14	9.59	0.36	4.02	0.1	12.16	0.35	0	0	0	0	0	0	0	0	0	0	0	0
A. COD	2.83	0.06	0.29	0.01	0.32	0.02	2.71	0.18	10.57	0.42	8.03	0.3	2.1	0.05	0	0	26.45	0.4	33.14	1.11	25.78	0.73	59.5	1.15	131.6	2.47	29.21	3.04
TURBOT	40.04	0.87	19.98	0.88	26.72	1.35	25.49	1.66	24.65	0.97	36.42	1.38	60.01	1.46	69.98	2.03	131.07	2	49.85	1.66	122.49	3.49	123.8	2.4	126.34	2.37	31.6	3.28
SKATE	8.33	0.18	3.74	0.16	5.95	0.3	8.54	0.55	17.2	0.68	9.27	0.35	7.88	0.19	12.45	0.36	37.63	0.57	20.1	0.67	37.33	1.06	37.66	0.73	49.72	0.93	14.82	1.54
SHARK	247.4	5.36	37.14	1.63	6.9	0.35	71.65	4.66	143.58	5.68	110.09	4.16	32.01	0.78	57.75	1.67	273.23	4.17	68.7	2.29	119.82	3.41	40.73	0.79	87.06	1.63	0.63	0.07
OTHER	18.79	0.4	9.39	0.41	35.63	1.81	39.35	2.56	31.29	1.24	38.14	1.44	23.97	0.58	29.19	0.85	153.18	2.34	74.45	2.49	115.22	3.29	131.24	2.54	163.12	3.15	21.63	2.25
TOTAL	4612.3		2272.21		1973.9		1638.9		2529.2		2647.6		4102.1		3452.8		6554.5		2996.4		3510.4		5168.6		5337.9		962.3	

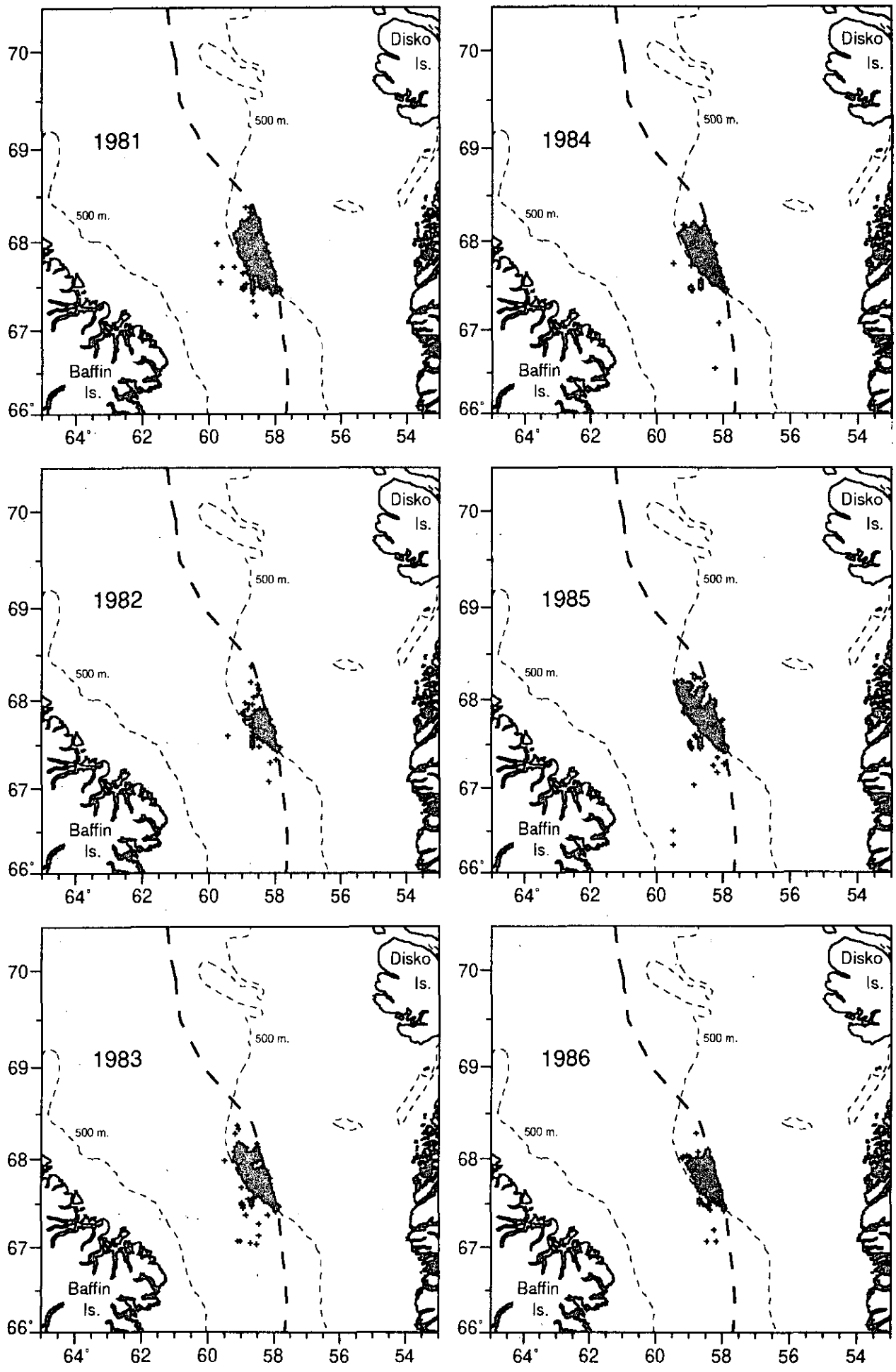


Fig. 1. Distribution of fishing effort by Canada in Div. 0A, 1981-1994, (— — 200 mi. Limit).

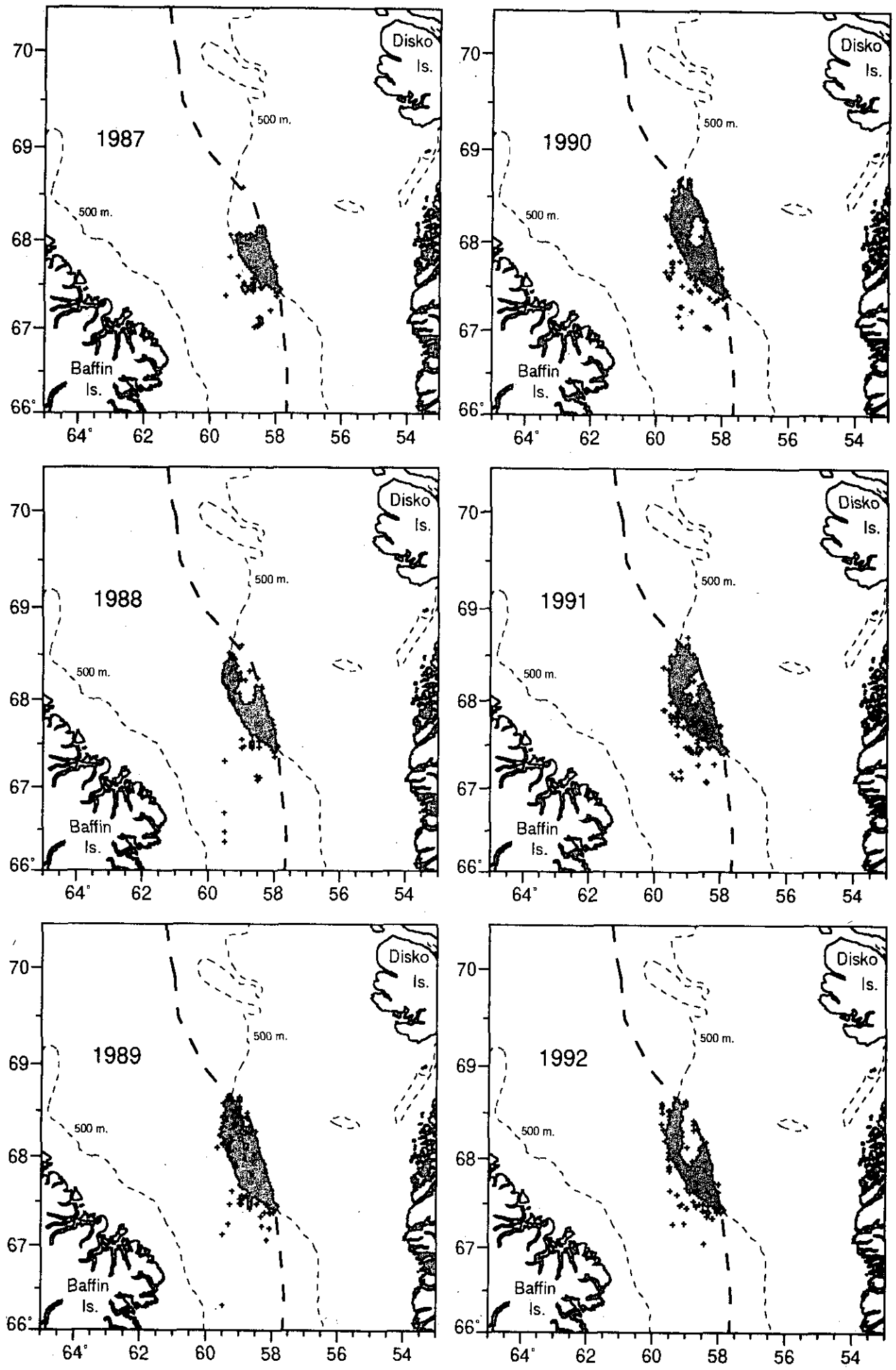


Fig. 1. Continued.

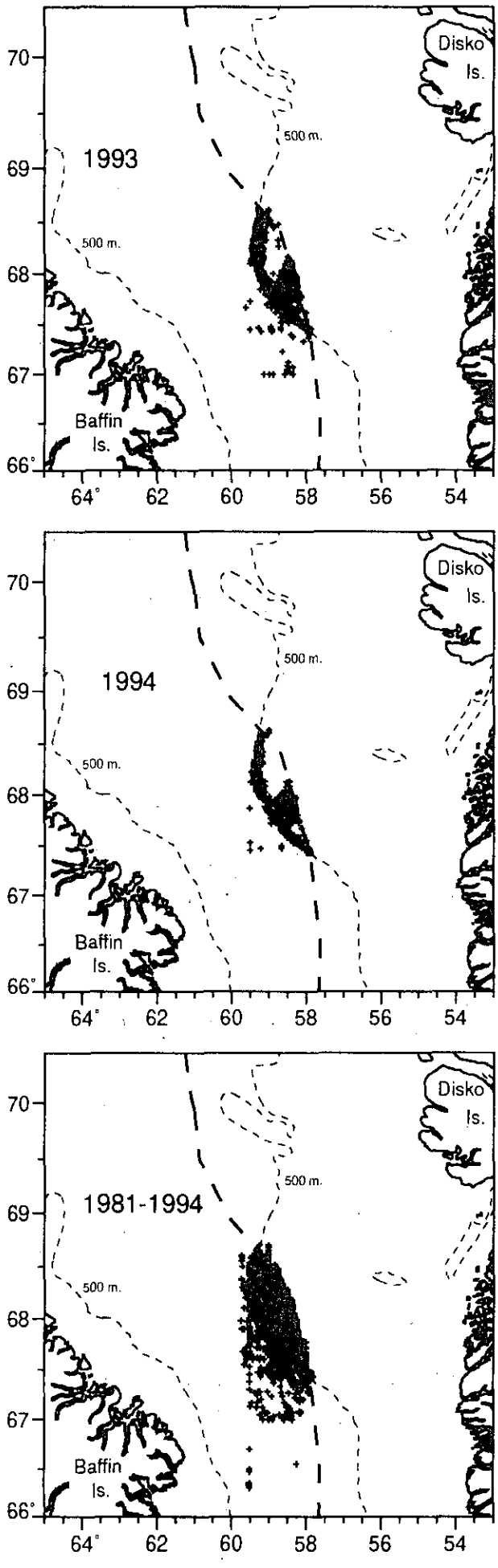


Fig. 1. Continued.

Fig. 2. Shrimp catch by Canada in SA 0+1, 1979 - 94

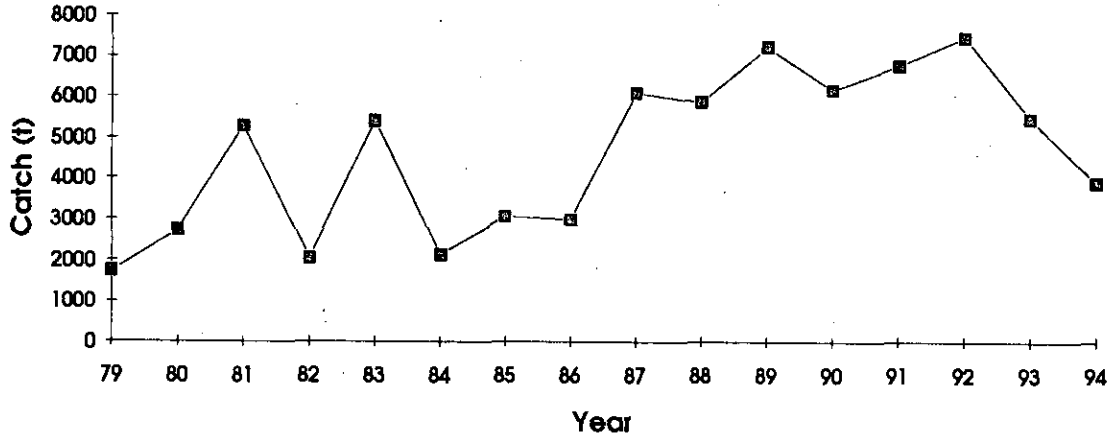


Fig. 3a. Unstandardized effort SA 0+1, 1979 - 94

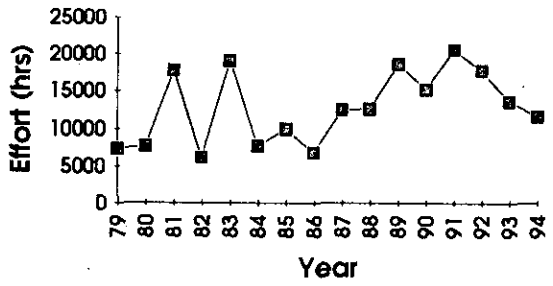


Fig. 3b. Standardized effort Div. 0A, 1981 - 94

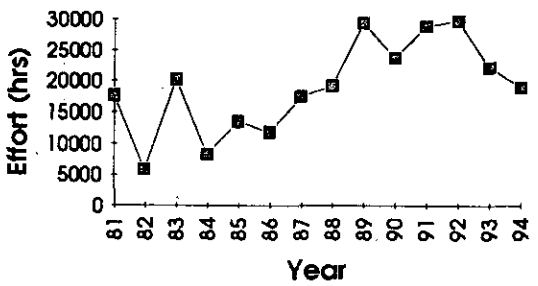


Fig. 4a. Unstandardized CPUE SA 0+1, 1979 - 94

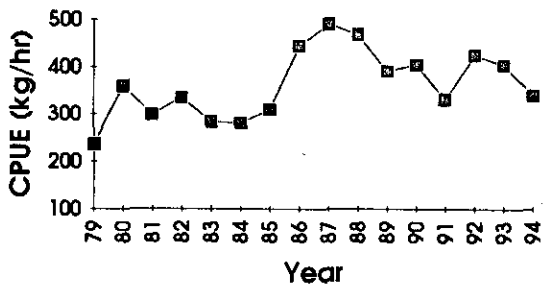


Fig. 4b. Standardized CPUE Div. 0A, 1981 - 94

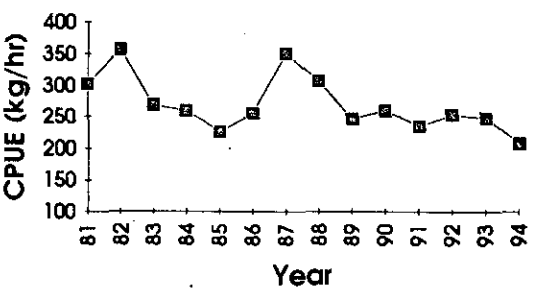


Fig. 5a. Shrimp catch vs unstandardized effort SA 0+1, 1979 - 94

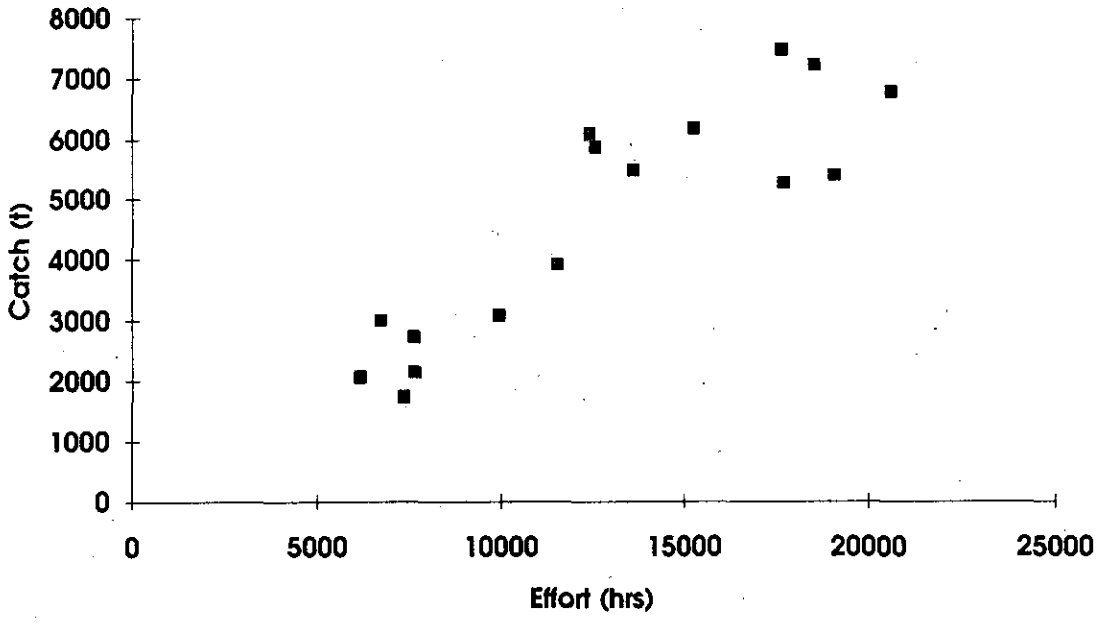
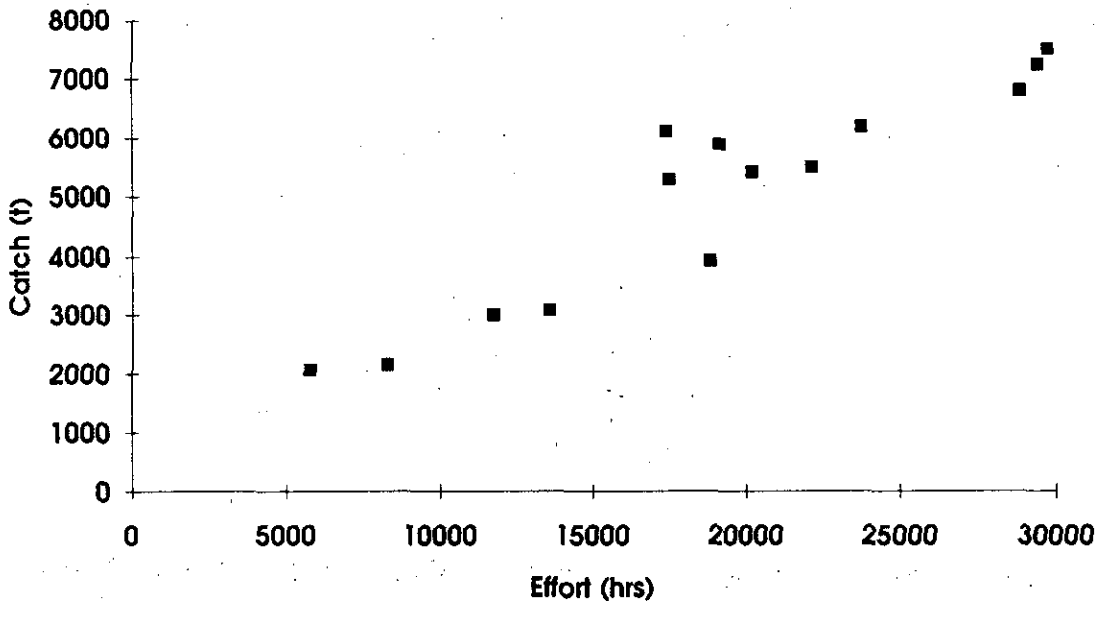


Fig. 5b. Shrimp catch vs standardized effort Div. 0A, 1981 - 94



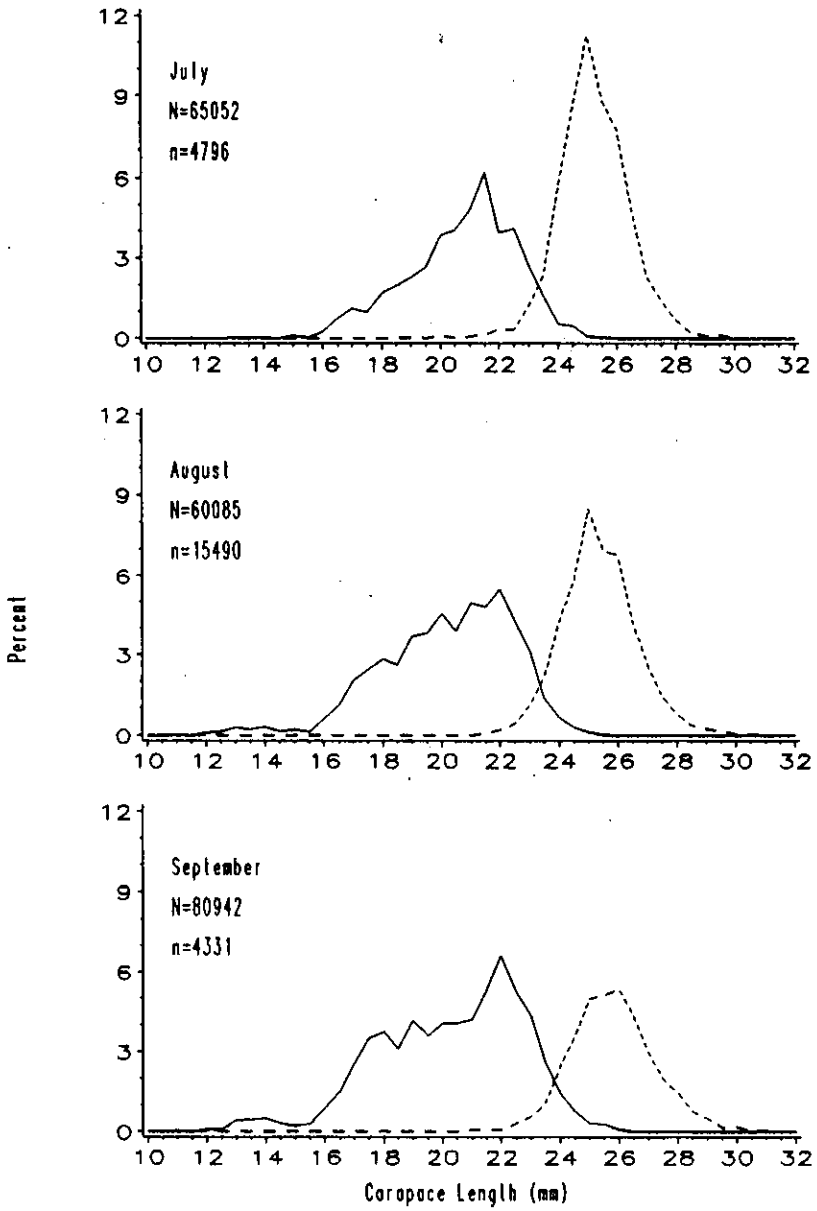


Fig. 6. Commercial length frequencies by month, 1994 (N=number per hour, n=number measured, ---- female).

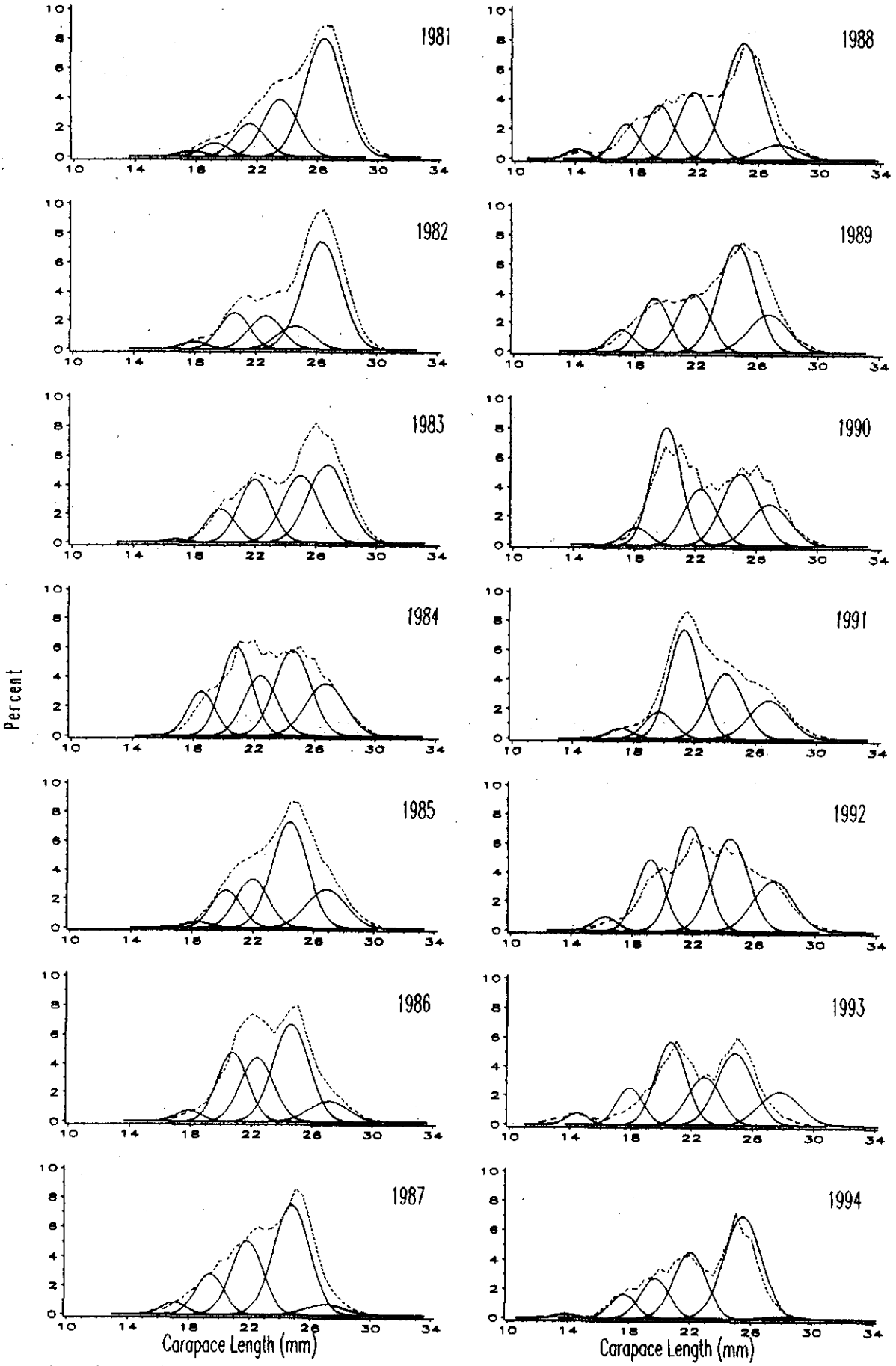


Fig. 7. Separation of ages from commercial length frequency data (broken line = commercial frequency), NAFO Div. 0A, 1981-1994.

Fig. 8a. Number caught per hour (unstandardized) at age
Div.0A, 1981 - 94

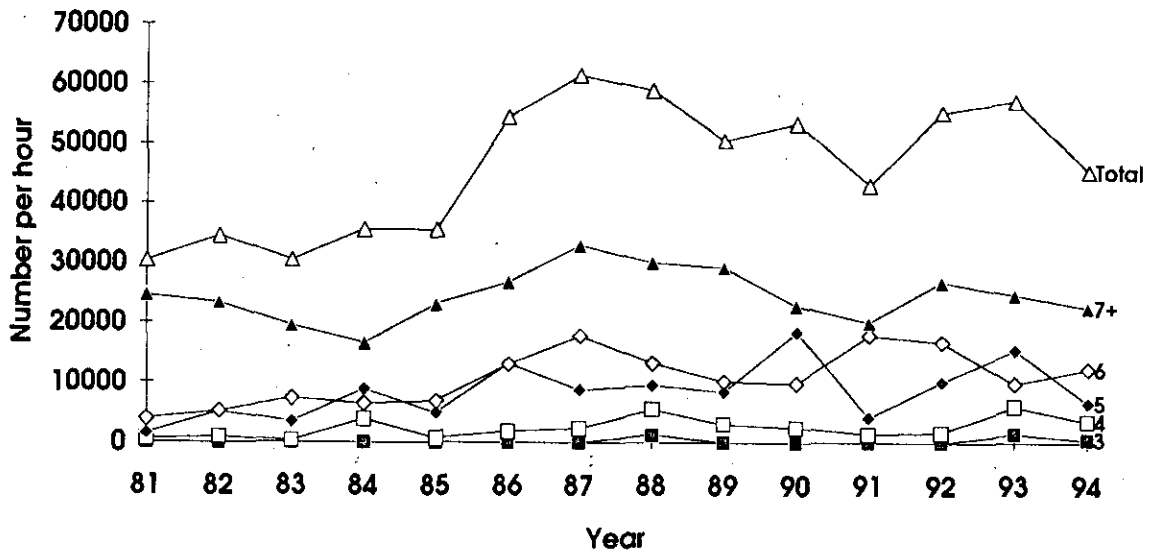


Fig. 8b. Number caught per hour (standardized) at age
Div. 0A, 1981 - 94