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The Canadian Fishery for Northern Shrimp (*Pandalus borealis*) in NAFO Division 0A and Subarea 1, 1979-1995

by

D. G. Parsons and P. J. Veitch

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

INTRODUCTION

Weekly quota reports, to October 31, 1995, show that only 1998 t of shrimp have been taken by Canadian vessels in Div. 0A from an allocation of 8500 t. The total shrimp catch for 1994 was estimated at 4766 t, about 56% of the quota. Eleven vessels have participated in the fishery to date in 1995, compared to 12 in 1994. The number of northern shrimp licences has remained at 17 since 1991.

Log book records and daily vessel hails provided preliminary information on fleet activity and performance in 1995. Data from previous years have been updated as much as possible in the present analysis. Catch, effort, catch per unit effort (CPUE) and size composition of shrimp from the commercial catches are compared over time 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 1994 and from available logs and daily hails up to October 22, 1995. The data were summarized by year, month and vessel (n = 584). Since 1981, fishing effort has been confined to NAFO Div. 0A in an area extending from about 67° to 68° 45' N and 58° to 59° 30' W (Fig. 1a). For the 1981 - 1995 period, catch and effort were totalled and the CPUE calculated within each cell (year/month/vessel) for standardization.

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

1. The catch reported in vessel logs/hails from 1979 to 1995 was divided by the corresponding effort, providing a series of unstandardized, weighted, annual catch rates.

2. Data from 1981 to 1995 were analyzed for year, month and vessel effects using SAS multiple regression procedures, producing a predicted, annual catch rate series. The catch and effort data set was selected for catch > 0 and month > 5 and the CPUE variable (catch/effort) was log (base e) transformed for standardization. Four observations were deleted after examination of residuals from an initial run of the regression analysis revealed them as outliers (i.e. data were retained in the final run if -0.75 < residual < 0.75). The annual log CPUE values, estimated from the analysis (n = 562), were retransformed to their original units of kg/hr.

Both unstandardized and standardized catch rates were indexed to 1981.

Available size compositions from the 1995 catches sampled by observers were summarized by month and length frequency distributions of total numbers caught in each year from 1981 to 1995 were constructed. Catch at length was estimated 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 1995 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

Over the past 15 years, the Canadian fishery has been restricted to Div. 0A, between the international boundary to the east and the 500 m depth contour to the west. Fishing positions, as recorded in vessel logs, showed changes in the distribution of effort over time (Fig. 1b). From 1981 to 1987, most activity occurred from about 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. High densities of shrimp (as represented by catch rates > 500 kg/hr) generally occurred throughout the area fished each year.

By 1989, virtually all the available grounds were fished and extensive coverage of the area also was achieved in 1990 and 1991. However, beginning in 1992, effort was displaced to the western and southern regions where catch rates were highest. The 1993 data are noteworthy in that activity to the west was restricted to area near the 500 m contour and that shrimp densities appeared to be lower outside this limited range. Although the 1995 data are incomplete, they show the same tendencies as the previous three years.

Catch, effort and CPUE

Catch, effort and CPUE for shrimp by month and year as derived from the available vessel logs (and hails in 1995) are given in Tables 1, 2 and 3, respectively. The fishery usually begins in late June - early July and continues into late November. However, most of the catch is taken and most of the effort expended in the August to October period. Catches fluctuated during the late 70's and early 80's, increased from about 2100 tons in 1984 to 7500 tons in 1992 and declined thereafter (Fig. 2). Unstandardized effort (Fig. 3a) showed approximately the same trend, over time, as catch. It is anticipated that the final catch and effort estimates for 1995 will be lower than those of 1994.

The seasonality of the fishery is also 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. In 1995, however, there was a substantial increase in September catch rates, followed by a decrease again in October. 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 and 1993 but catch rates in 1994 and 1995 returned to the level observed in the early 1980's.

The results of the multiple regression analysis to standardize the catch rates (Table 4a) showed that the model explained 68% of the total variation and that all three class variables (year, month and vessel) were highly significant. T-values indicated that catch rates for most years were significantly higher than the 1995 estimate and the 1994 rate significantly lower ($P < 0.05$).

Standardized effort (Fig. 3b) showed approximately the same trends as the unstandardized series except the increase from 1984 was more pronounced and continued to 1992. The log CPUE values were retransformed (Table 4b) to provide 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 standardized series indicated relative stability (Fig. 4b) up to 1993. However, the values predicted for 1994 and 1995 were the lowest in the fifteen year period and, from 1987 onward, a decreasing trend can be inferred. A complete summary of TAC, catch, effort and CPUE for the Canadian fishery is given in Table 5.

Length distributions

Length frequencies from catches sampled in 1995 (Fig. 5) showed some similarities in the size composition of shrimp taken in June, July and August. Two prominent size groups occurred in each month at modal lengths of 20 (males) and 25 mm CL (females). Evidence of separate size groups within the male component was more apparent in June and the proportion of female shrimp in the catches increased in July and August. Although the data for 1995 are incomplete, we assume that they are representative of the actual size composition of the catches taken during the June - August period.

Shrimp caught in 1995, on average, were smaller than those taken in the previous year (Fig. 6) due to the higher proportion of males around 20 mm. Males of all sizes in 1995 comprised 62% of the catch in numbers. The time series 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 distributions in 1990 and 1991 showed the relative importance of the 1985 year class (at 20 and 22 mm, respectively) as it recruited to the fishery. It contributed significantly to the 1992 catches as both males and females, sex inversion having been incomplete for this year class between 1991 and 1992 (NAFO, 1994). Catches in 1993 were dominated by two well-separated size groups, one male and one female. The separation between dominant size groups decreased in 1994 with the increase in length of the male component. The size composition in 1995 was similar in structure to those observed in 1990 and 1993.

Age composition

Ageing of commercial length distributions (Fig. 6) followed the procedures of Parsons and Veitch (1991). Since 1993, the analyses have included constraining the proportion of females (ages 7+) to that determined from the observer sampling data. Estimated mean lengths at age (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 1995 (Table 7) showed that the relative contribution of ages 7+ (females) to the catches declined from over 80% in 1981 to 47% in 1984, increased to 65% in 1985 and, from 1986 to 1993, varied between 43 and 58%. Less than 40% was estimated in this plus group both in 1994 and 1995. Three-year-old male shrimp did not contribute substantially to the catch up to 1987 but formed an identifiable mode at 14.6 mm in the 1988 length distribution (the 1985 year class). Modes in the 13 - 15 mm range also were evident in 1993, 1994 and 1995.

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, 10 and Fig. 7). Female ages are combined as 7+ in this analysis.

Age 3 males occurred only in low numbers in the years indicated above and no interpretation of the catch rates was made. Catch rates for males at age 4 showed substantial variation within an overall increasing trend. CPUE's for males aged 5 and 6 also increased over time with indications (peaks) that relatively strong year classes were produced in 1981, 1985, 1990 and possibly 1988. Ages 7+, representing the female component of the stock, are targeted by the fishery and the numbers caught per hour for these animals showed a decreasing trend since 1987, similar to 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 1.4% in 1995, the lowest level achieved over the 1981 - 1995 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 decreases in 1994 and 1995 might reflect the recent favourable markets for industrial grade shrimp.

By-catches

Observer data from the 1995 fishery (Table 12) show that by-catch accounted for 16% of the total catch weight of all species and that redfish was again the most prevalent fish species in the catches, representing 11% of the total observed catch weight. Greenland halibut (turbot) comprised 2% of the catch, lower than in the previous four years and similar to the proportions observed in the late 1980's. Typically, the incidence of Greenland sharks increases in November and, therefore, is not adequately represented in the 1995 data.

CPUE's (kg/hr - unstandardized) for redfish and Greenland halibut from 1981 to 1995 were:

Species/Year	'81	'82	'83	'84	'85	'86	'87	'88	'89	'90	'91	'92	'93	'94	'95
Redfish	32	20	9	15	20	85	119	78	72	59	86	73	68	66	52
Gr. halibut	3	4	5	6	4	8	13	15	12	12	19	17	15	14	9

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 300 tons of primarily small redfish were taken as by-catch and discarded in the Div. 0A fishery to date in 1995. 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. The estimated removal of Greenland halibut (mostly small) so far in 1995 was roughly 50 t.

DISCUSSION

We consulted with fishing captains and others within the industry to determine why the catch and effort in Div. 0A was so low in 1995. Although there were concerns and comments about low catch rates, small sizes, soft shell and poor quality, it appears that there were other, overriding factors which dictated the 1995 fishery. Ice was reported to be a limiting factor early in the year (July) but, more importantly, increased and unforeseen fishing opportunities in Div. 0B for both *Pandalus borealis* and *P. montagui* during August to October resulted in a displacement of activity from the more traditional grounds in Div. 0A to highly productive areas farther south.

The Canadian fishery for northern shrimp in Davis Strait has existed since the late 1970's and, from 1981 to present, has taken place in a limited area in Div. 0A. Although the area is small relative to the distribution of the stock and the fishery in recent years has accounted for only about 10% of the total offshore catch, trends and events have emerged from the data base which need to be documented and discussed in context with the broader view of stock status.

- Catch rate indices (unstandardized and standardized) have declined since 1987.

- Further analyses show that the decline was due to a gradual reduction in the catch rates of female shrimp which was not offset by increasing catch rates for males.

- Relatively strong year classes appear to be produced about every five years. Although recruitment of a few such year classes raised CPUE's in the early and late 1980's over the "base level" observed from 1983 to 1986, the strong 1985 year class only maintained catch rates in the early 1990's near a similar "base level".

- Recruitment of one or more successful year classes will be necessary in the short term to return CPUE's to the "base level", given that the 1994 and 1995 catch rates were below that level.

- The 1995 fishery data suggest that the 1990 year class is strong but, if the fishing pattern has changed in recent years to target smaller animals in order to maximize catch rates, as indicated in the data, then direct comparisons of the strengths of recent year classes with those of earlier years are not valid.

- Although the stock/recruitment relationship and recruitment mechanisms are unknown for shrimp in SA 0+1, the declining trends in the proportions and catch rates of female shrimp raise concerns for the reproductive potential of the stock.

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Table 1. Catch(t) by month/year from vessel logbooks - NAFO Division 0A, 1979-1995

Year	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	Sum
Month																		
4	.	.	.	.	.	0	.	.	.	.	.	.	.	.	.	.		0
6	.	.	347	.	17	.	290	309	144	42	509		.	.	.	.	31	1689
7	.	54	756	373	752	379	924	603	505	763	2105	890	1003	963	286	385	312	11053
8	.	.	665	650	1241	354	604	363	1157	1284	1280	1200	1591	1776	1377	1388	637	15567
9	42	.	585	458	798	398	414	241	1183	989	662	852	792	2956	1602	960	503	13435
10	71	.	833	335	992	324	582	242	2252	1294	1264	1214	1233	1214	1255	1248	83	14436
11	248	.	743	249	257	40	255	604	2	531	607	1157	676	524	816	661		7370
12	16	62	72	.	.	.	.	.	.	7	.	.	.	0	42	.		199
Sum	376	116	4001	2064	4057	1495	3069	2362	5244	4910	6427	5314	5295	7432	5377	4642	1566	63747
%Total	21.7	4.3	75.7	100	74.9	69.8	100	78.9	86	83.5	88.8	86	78	99.2	97.7	97.4	78.4	

Table 2. Effort (hrs) by month/year from vessel logbooks - NAFO Division 0A, 1979-1995

Year	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	Sum
Month																		
4	.	.	.	.	.	4	.	.	.	.	.	.	.	.	.	.	.	4
6	.	.	746	.	33	.	597	471	166	59	937	.	.	.	.	.	64	3073
7	.	121	1804	617	1928	845	2502	1340	519	1188	5391	2079	1906	1847	505	779	950	24321
8	.	.	2170	1836	4100	1360	2412	995	2341	3237	3738	3745	5482	4460	3770	4647	2076	46369
9	81	.	1968	1504	3151	1641	1784	731	2714	2595	1734	1826	3028	5773	4150	3430	1159	37269
10	325	.	3229	1248	3995	1370	1804	577	4944	2197	3210	3089	3233	3582	2769	4072	279	39923
11	1072	.	2980	953	1074	129	827	1191	3	1167	1423	2370	2377	1806	2056	2958	.	22386
12	114	203	483	.	.	.	.	.	.	50	.	.	.	4	56	.	.	910
Sum	1592	324	13380	6158	14281	5349	9926	5305	10687	10493	16433	13109	16026	17472	13306	15886	4528	174255

Table 3. CPUE by month/year from vessel logbooks - NAFO Division 0A, 1979-1995

Year	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95
Month																	
4	.	.	.	.	.	122	.	.	.	.	.	.	.	.	.	.	.
6	.	.	466	.	508	.	486	656	868	720	543	.	.	.	.	.	488
7	.	445	419	604	390	448	369	450	973	642	391	428	526	521	565	494	329
8	.	.	306	354	303	260	250	365	494	397	342	321	290	398	365	299	307
9	513	.	297	304	253	243	232	330	436	381	382	466	261	512	386	280	434
10	218	.	258	268	248	236	323	419	456	589	394	393	381	339	453	306	298
11	231	.	249	261	239	311	308	507	522	455	426	488	285	290	397	223	.
12	140	306	149	.	.	.	.	.	.	130	.	.	.	93	742	.	.

TABLE 4A. STANDARDIZATION OF CPUE - MULTIPLICATIVE, YEAR-MONTH-VESSEL REGRESSION MODEL, 1981 - 1995.

GENERAL LINEAR MODELS PROCEDURE

DEPENDENT VARIABLE: LNCPUE

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE	PR > F	R-SQUARE	C.V.
MODEL	67	60.46941105	0.90252852	15.45	0.0	0.676996	4.1417
ERROR	494	28.85083564	0.05840250		ROOT MSE		LNCPUE MEAN
CORRECTED TOTAL	561	89.32024669			0.24166609		5.83498740

SOURCE	DF	TYPE I SS	F VALUE	PR > F	DF	TYPE III SS	F VALUE	PR > F
YEAR	14	21.07334637	25.77	0.0	14	8.84393537	10.82	0.0001
MONTH	6	12.09708606	34.52	0.0001	6	7.45765985	21.28	0.0001
VESSEL	47	27.29897861	9.95	0.0	47	27.29897861	9.95	0.0

PARAMETER		ESTIMATE	T FOR H0: PARAMETER=0	PR > |T|	STD ERROR OF ESTIMATE
INTERCEPT		5.35305354 B	69.33	0.0	0.07721364
YEAR	81	0.34254450 B	3.82	0.0002	0.08971888
	82	0.49783760 B	4.87	0.0001	0.10226520
	83	0.22212958 B	2.68	0.0076	0.08283349
	84	0.18106769 B	1.69	0.0918	0.10718893
	85	0.05745082 B	0.53	0.5968	0.10853292
	86	0.17873907 B	1.94	0.0526	0.09199442
	87	0.49189077 B	6.61	0.0001	0.07440787
	88	0.38607964 B	5.41	0.0001	0.07135914
	89	0.15119807 B	2.28	0.0228	0.06620280
	90	0.21192832 B	3.18	0.0015	0.06657837
	91	0.10613462 B	1.59	0.1119	0.06664440
	92	0.17050596 B	2.70	0.0072	0.06313032
	93	0.16678077 B	2.59	0.0099	0.06438182
	94	-0.14593326 B	-2.36	0.0185	0.06176871
	95	0.00000000 B	.	.	.

TABLE 4B. RETRANSFORMED ANNUAL CATCH RATES FROM MULTIPLE REGRESSION.

	LN TRANSFORM			RETRANSFORMED		
SUMMARY	YHAT	YHATVAR	STDERR	MEAN	VARIANCE	STDERR
INTERCEP	5.3531	.0059619	.0772136	216.8762	280.1520	16.7377
YY81	5.6956	.0050326	.0709407	305.6183	469.8222	21.6754
YY82	5.8509	.0072072	0.084895	356.5736	914.8997	30.2473
YY83	5.5752	.0040788	.0638657	271.0762	299.7151	17.3123
YY84	5.5341	.0081162	.0900899	259.6450	546.0420	23.3675
YY85	5.4105	.0087703	.0936499	229.3779	460.3509	21.4558
YY86	5.5318	.0071847	.0847626	259.1620	481.8008	21.9500
YY87	5.8449	.0041092	.0641027	355.0100	517.8667	22.7567
YY88	5.7391	.0039553	.0628914	319.3897	403.4989	20.0873
YY89	5.5043	0.003912	.0625458	252.5355	249.4988	15.7955
YY90	5.5650	.0038933	.0623961	268.3499	280.3812	16.7446
YY91	5.4592	0.00402	.0634038	241.3950	234.2558	15.3054
YY92	5.5236	0.00434	.0658784	257.4037	287.5081	16.9561
YY93	5.5198	.0046324	.0680619	256.4090	304.4707	17.4491
YY94	5.2071	.0042167	.0649358	187.5917	148.3736	12.1809
YY95	5.3531	.0059619	.0772136	216.8762	280.1520	16.7377

Table 5. Data from the Canadian fishery for shrimp in NAFO SA 0+1, 1979 - 1995.

			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	306	1.00	17268
1982	5000	2064	335	1.12	6161	357	1.17	5782
1983	5000	5413	284	0.95	19060	271	0.89	19974
1984	5000	2142	280	0.94	7650	260	0.85	8238
1985	6120	3069	309	1.03	9932	229	0.75	13402
1986	6120	2995	445	1.49	6730	259	0.85	11564
1987	6120	6095	491	1.64	12413	355	1.16	17169
1988	6120	5881	468	1.57	12566	319	1.04	18436
1989	7520	7235	391	1.31	18504	253	0.83	28597
1990	7520	6177	405	1.35	15252	268	0.88	23049
1991	8500	6788	330	1.10	20570	241	0.79	28166
1992	8500	7493	425	1.42	17631	257	0.84	29156
1993	8500	5491	404	1.35	13592	256	0.84	21449
1994	8500	4766	292	0.98	16322	188	0.61	25351
1995	8500	1998	346	1.16	5775	217	0.71	9207

* Catches (tons) from 1979 - 1989 as reported in MacDonald and Collins (1990).
Catches from 1990 to 1994, inclusive, are not official statistics and 1995 incomplete (to Oct. 31).
Division 0A only from 1981 onward.

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

Table 6. Mean carapace length (mm) at age for shrimp in NAFO Division 0A, 1981 - 1995.

YEAR	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95
AGE															
3	-	-	-	-	-	-	-	14.62	-	-	-	-	14.51	13.75	13.26
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	17.61	16.86
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	19.7	19.75
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	22.04	21.66
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	24.88	24.93
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	26.04	26.59

Table 7. Proportion of shrimp caught at age as determined from commercial length frequency distributions - NAFO Division 0A, 1981 - 1995.

YEAR	_81	_82	_83	_84	_85	_86	_87	_88	_89	_90	_91	_92	_93	_94	_95
AGE															
3	0	0	0	0	0	0	0	0.02	0	0	0	0	0.026	0.015	0.024
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	0.107	0.053
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	0.164	0.345
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	0.321	0.197
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	0.179	0.341
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	0.214	0.039
TOTAL	1	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 - 1995.

Year/Age	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95
3	0	0	0	0	0	0	0	14842	0	0	0	0	19832	9968	7212
4	10185	5727	5227	29642	7042	12095	29070	68271	54333	37565	27551	29309	79328	71107	15927
5	25193	31393	65626	67170	47888	87594	107865	117991	153631	280921	83542	177805	205186	108986	103675
6	67540	31605	137640	48678	67607	87227	219554	164742	187355	149443	366162	296017	130434	213321	59200
7+	433111	143390	372267	126453	229581	179586	408509	376235	541457	348701	411488	473822	327993	261169	114493
TOTAL	536029	212115	580760	271943	352118	366502	764998	742081	936776	816630	888743	976953	762774	664551	300506

Table 9. Number of shrimp caught per hour (unstandardized) at age in Div. 0A, 1981 - 1995.

Year/Age	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95
3	0	0	0	0	0	0	0	1181	0	0	0	0	1459	611	1249
4	576	930	274	3875	709	1797	2342	5433	2936	2463	1339	1662	5836	4357	2758
5	1426	5095	3443	8780	4822	13015	8690	9390	8303	18419	4061	10085	15096	6677	17952
6	3822	5130	7221	6363	6807	12961	17687	13110	10125	9798	17801	16790	9596	13070	10251
7+	24508	23274	19531	16530	23115	26684	32910	29941	29262	22863	20004	26874	24131	16001	19826
TOTAL	30332	34429	30470	35548	35453	54458	61629	59055	50626	53542	43206	55411	56119	40715	52036
Effort (hrs)	17672	6161	19060	7650	9932	6730	12413	12566	18504	15252	20570	17631	13592	16322	5775

Table 10. Number of shrimp caught per hour (standardized) at age in Div. 0A, 1981 - 1995.

Year/Age	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95
3	0	0	0	0	0	0	0	805	0	0	0	0	925	393	783
4	590	990	262	3598	525	1046	1693	3703	1900	1630	978	1005	3698	2805	1730
5	1459	5429	3286	8154	3573	7575	6283	6400	5372	12188	2966	6098	9566	4299	11260
6	3911	5466	6891	5909	5045	7543	12788	8936	6552	6484	13000	10153	6081	8415	6430
7+	25082	24799	18638	15350	17130	15530	23793	20408	18934	15129	14609	16251	15292	10302	12435
TOTAL	31042	36685	29076	33011	26274	31693	44557	40252	32758	35430	31554	33508	35562	26214	32639
Effort (hrs)	17268	5782	19974	8238	13402	11564	17169	18436	28597	23049	28166	29156	21449	25351	9207

Table 11. Shrimp discards (% of total shrimp catch) in Div. 0A, 1981-95, estimated by observers.

Year	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995
Month															
May								0.7							
Jun	2.9		0.5		4.2	2.4	1.9	1.3	2.3						1.6
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	2.2	1.3
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	1.7	1.2
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	1.6	
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	1.5	
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	1.5	
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	1.63	1.35

Table 12. Observed catch composition (tons and %) by species in Div. 0A shrimp fishery, 1981-95.

YEAR	1981		1982		1983		1984		1985		1986		1987		1988		1989		1990		1991		1992		1993		1994		1995	
SPECIES	WT.	%	WT.	%	WT.	%	WT.	%	WT.	%	WT.	%	WT.	%	WT.	%	WT.	%	WT.	%	WT.	%	WT	%	WT.	%	WT.	%	WT.	%
SHRIMP	3897	84.49	2088	91.91	1847	93.55	1326	86.15	2174	85.95	2004	75.68	3406	83.03	2877	83.33	5173	78.93	2479	82.74	2521	71.81	3864	74.76	4195	78.59	2569	74.13	207.81	83.95
REDS	387	8.39	110.7	4.87	48.3	2.45	63.63	4.13	124.6	4.93	432.4	16.33	566.1	13.8	394	11.41	759.8	11.59	271	9.04	569.1	16.21	911.8	17.64	585.2	10.96	508.6	14.67	27.98	11.3
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	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	50.26	1.45	1.14	0.46
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	131.1	2	49.85	1.66	122.5	3.49	123.8	2.4	126.3	2.37	106.9	3.08	4.84	1.96
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	35.65	1.03	3.13	1.26
SHARK	247.4	5.36	37.14	1.63	6.9	0.35	71.65	4.66	143.6	5.68	110.1	4.16	32.01	0.78	57.75	1.67	273.2	4.17	68.7	2.29	119.8	3.41	40.73	0.79	87.06	1.63	6.46	1.35	0	0
OTHER	18.79	0.4	9.39	0.41	35.53	1.81	39.35	2.56	31.29	1.24	38.14	1.44	23.97	0.58	29.19	0.85	153.2	2.34	74.45	2.49	115.2	3.29	131.2	2.54	163.1	3.15	148.2	4.27	2.66	1.07
TOTAL	4612		2272		1974		1539		2529		2648		4102		3453		6555		2996		3510		5169		5338		982.3		247.6	

Fig. 1a. Northern shrimp fishing locations and density indices in Div. 0A 1981-1995.

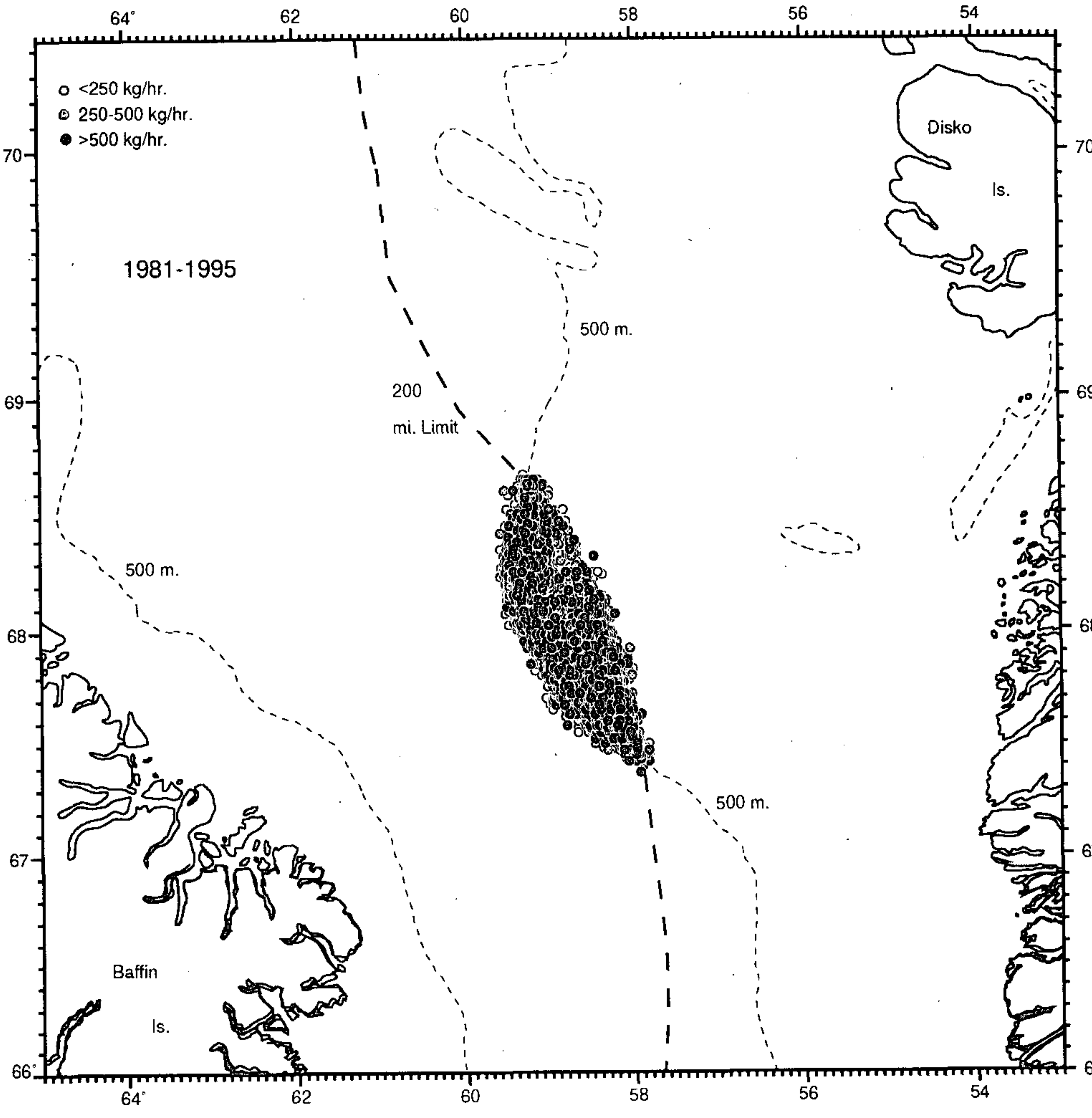


Fig. 1b. Northern shrimp fishing locations and density indices in Div. 0A by year, 1981-1995.

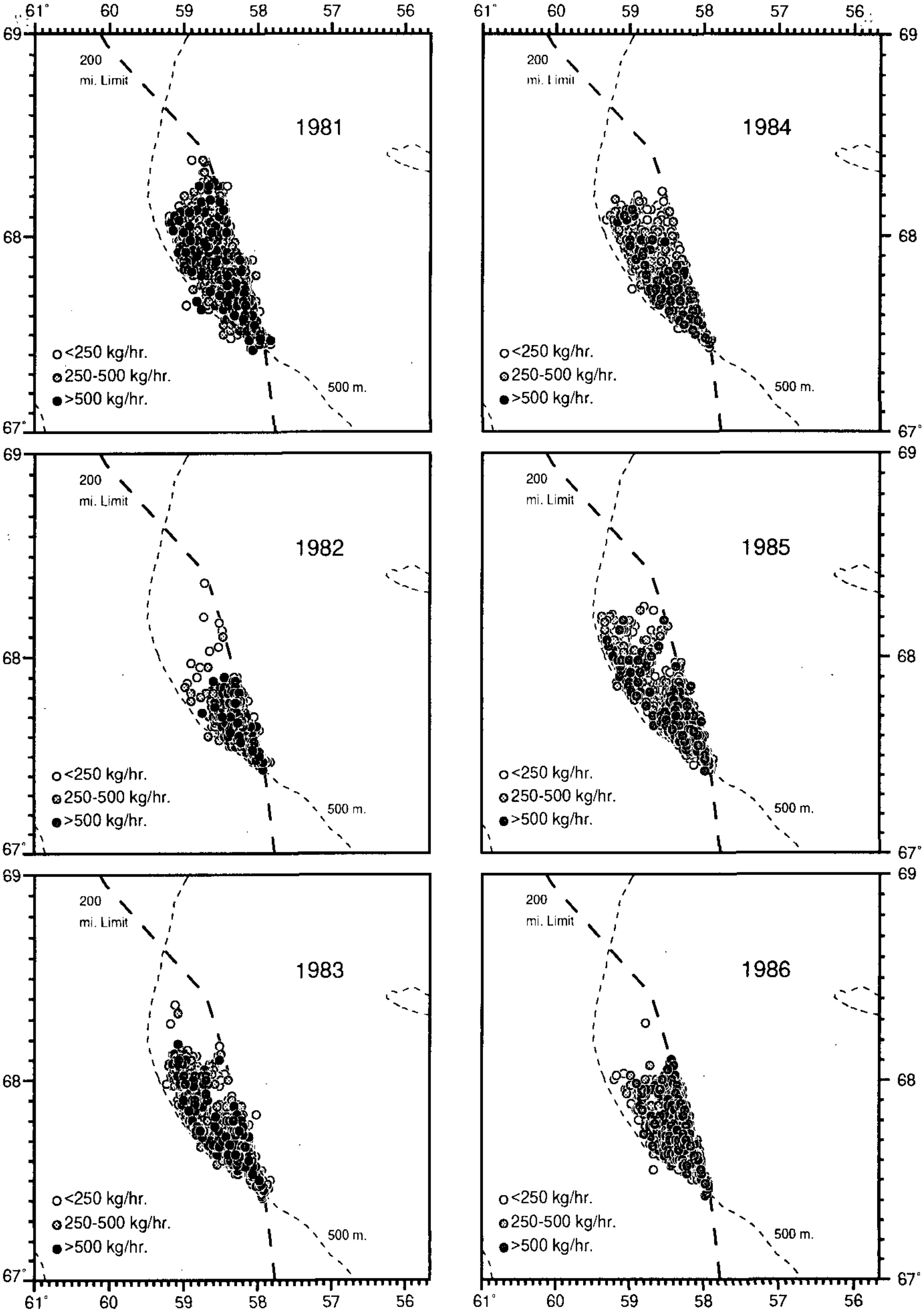


Fig. 1b. Continued.

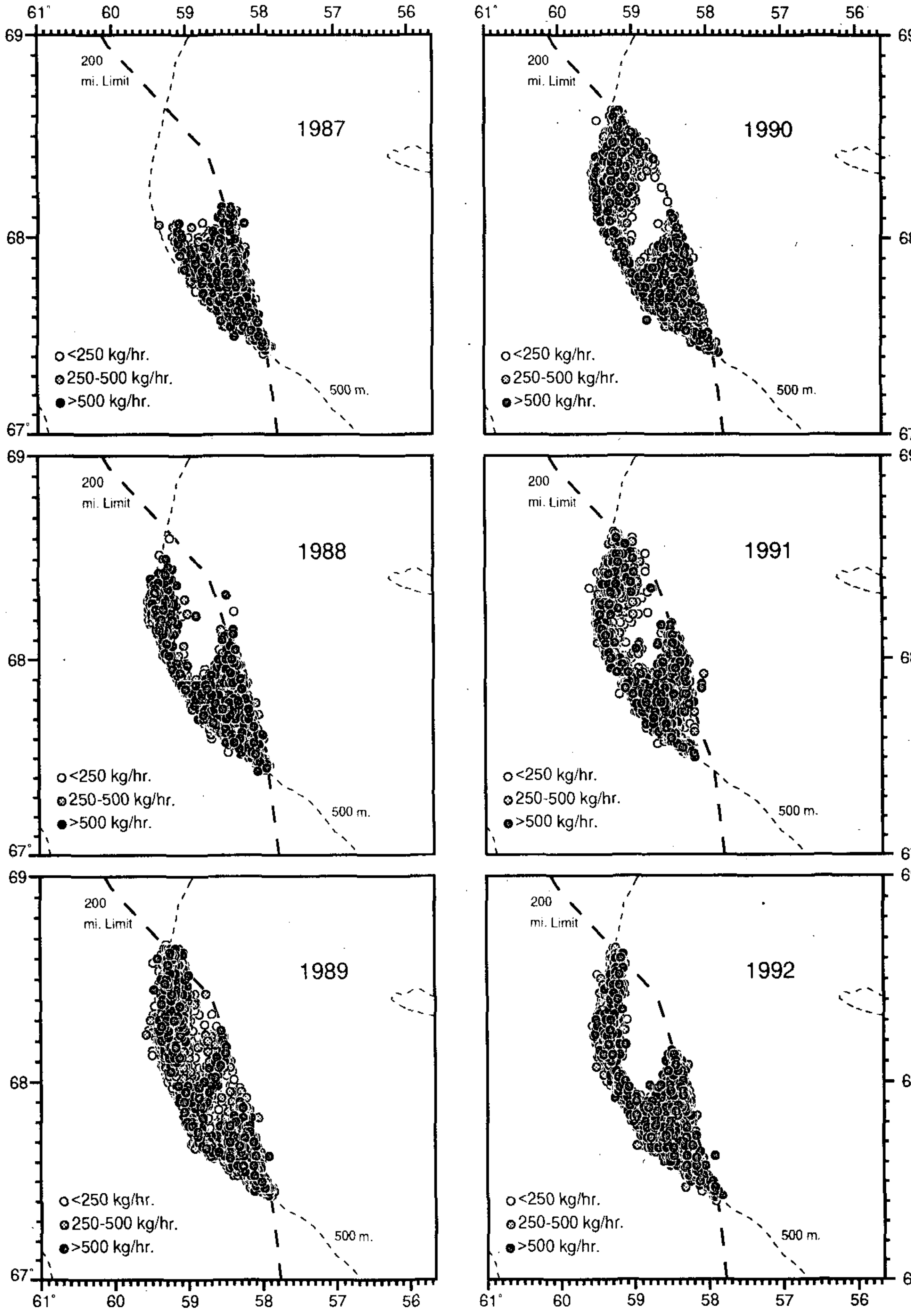
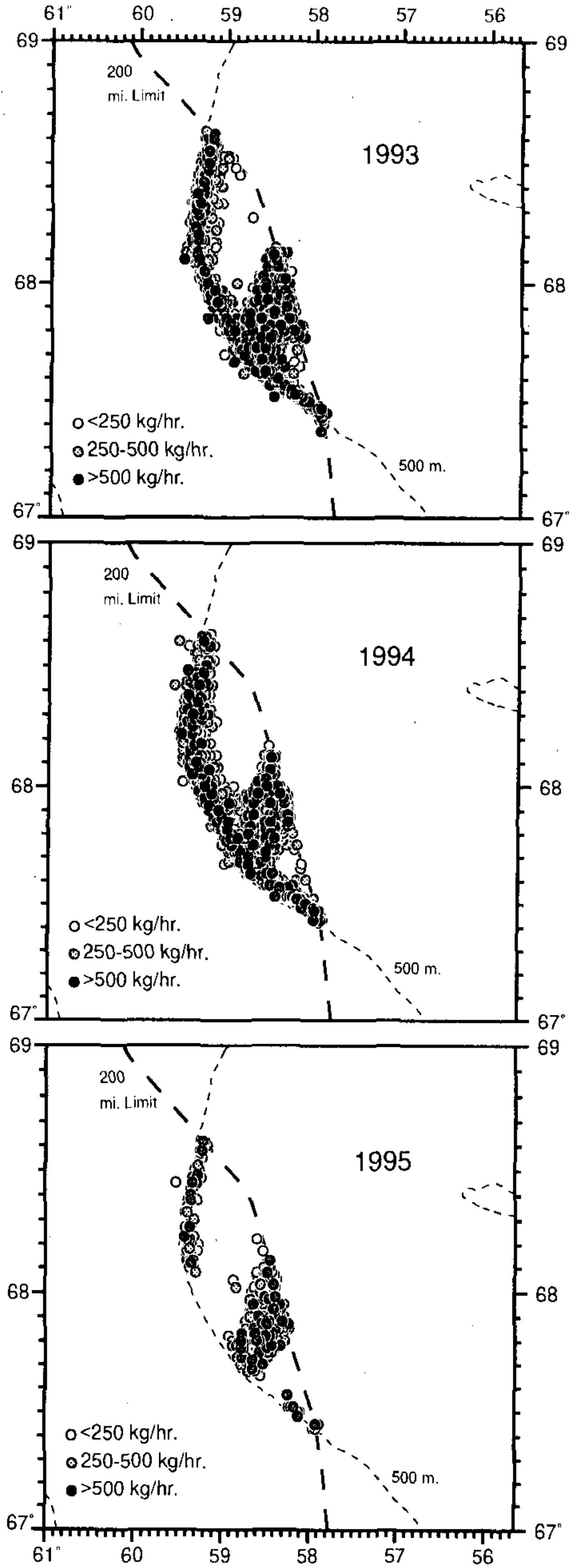


Fig. 1b. Continued.



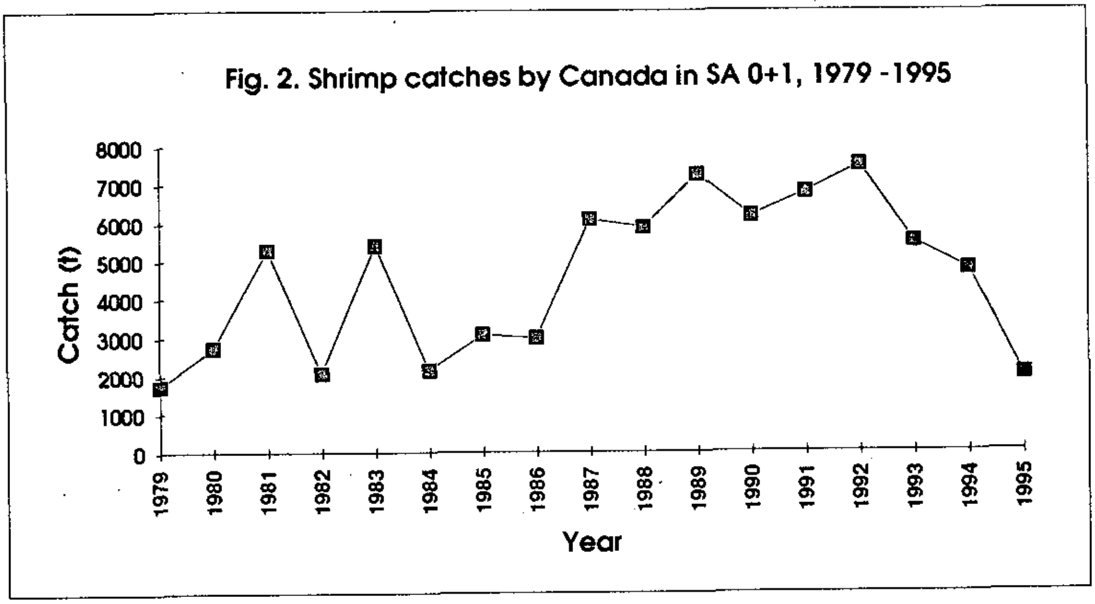


Fig. 2. Shrimp catches by Canada in SA 0+1, 1979 -1995
Catch (t)
0
1000
2000
3000
4000
5000
6000
7000
8000
1979
1980
1981
1982
1983
1984
1985
1986
1987
1988
1989
1990
1991
1992
1993
1994
1995
Year

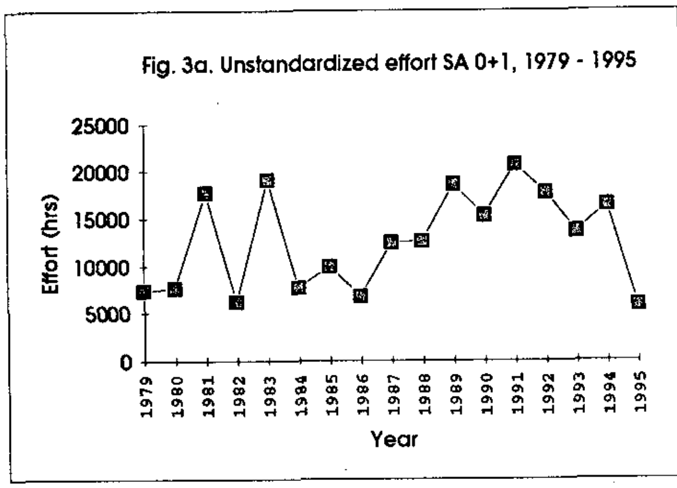


Fig. 3a. Unstandardized effort SA 0+1, 1979 - 1995
Effort (hrs)
0
5000
10000
15000
20000
25000
Year

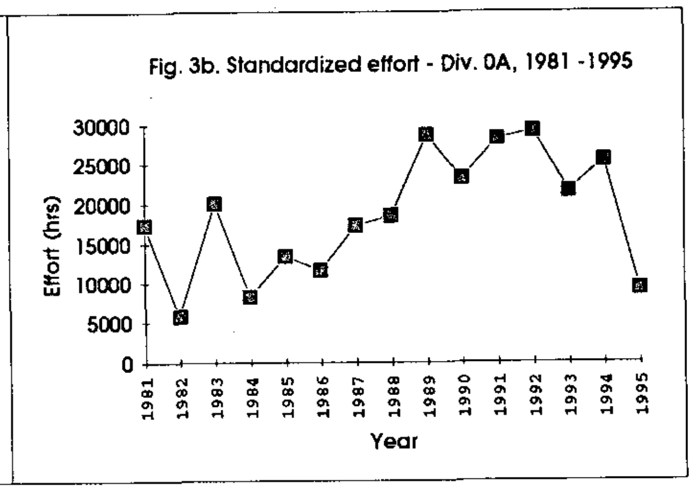


Fig. 3b. Standardized effort - Div. 0A, 1981 -1995
Effort (hrs)
0
5000
10000
15000
20000
25000
30000
Year

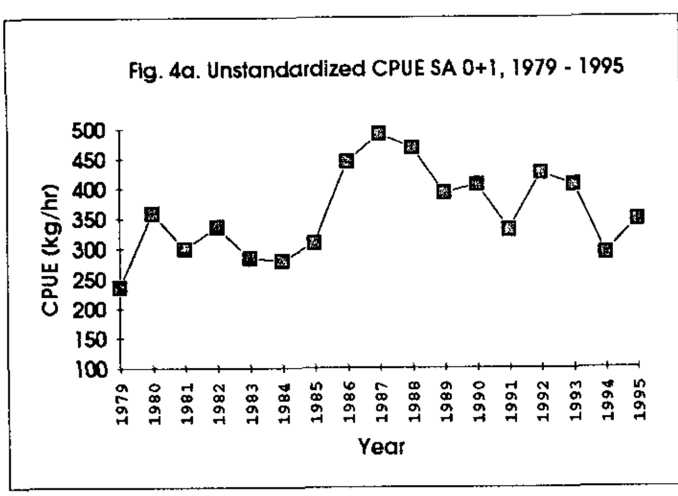


Fig. 4a. Unstandardized CPUE SA 0+1, 1979 - 1995
CPUE (kg/hr)
100
150
200
250
300
350
400
450
500
Year

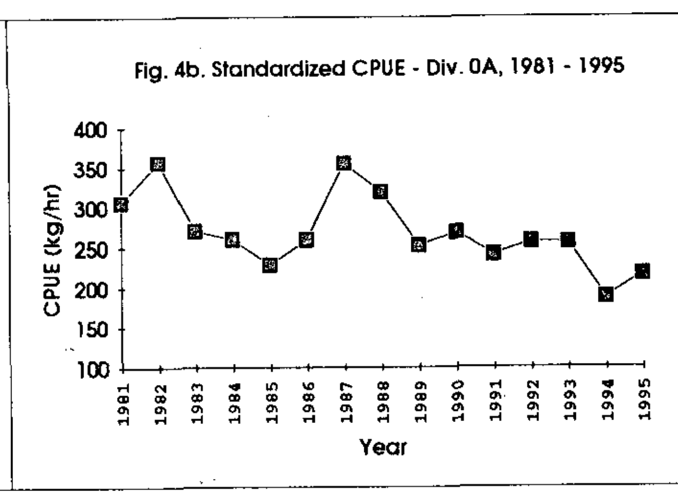


Fig. 4b. Standardized CPUE - Div. 0A, 1981 - 1995
CPUE (kg/hr)
100
150
200
250
300
350
400
Year

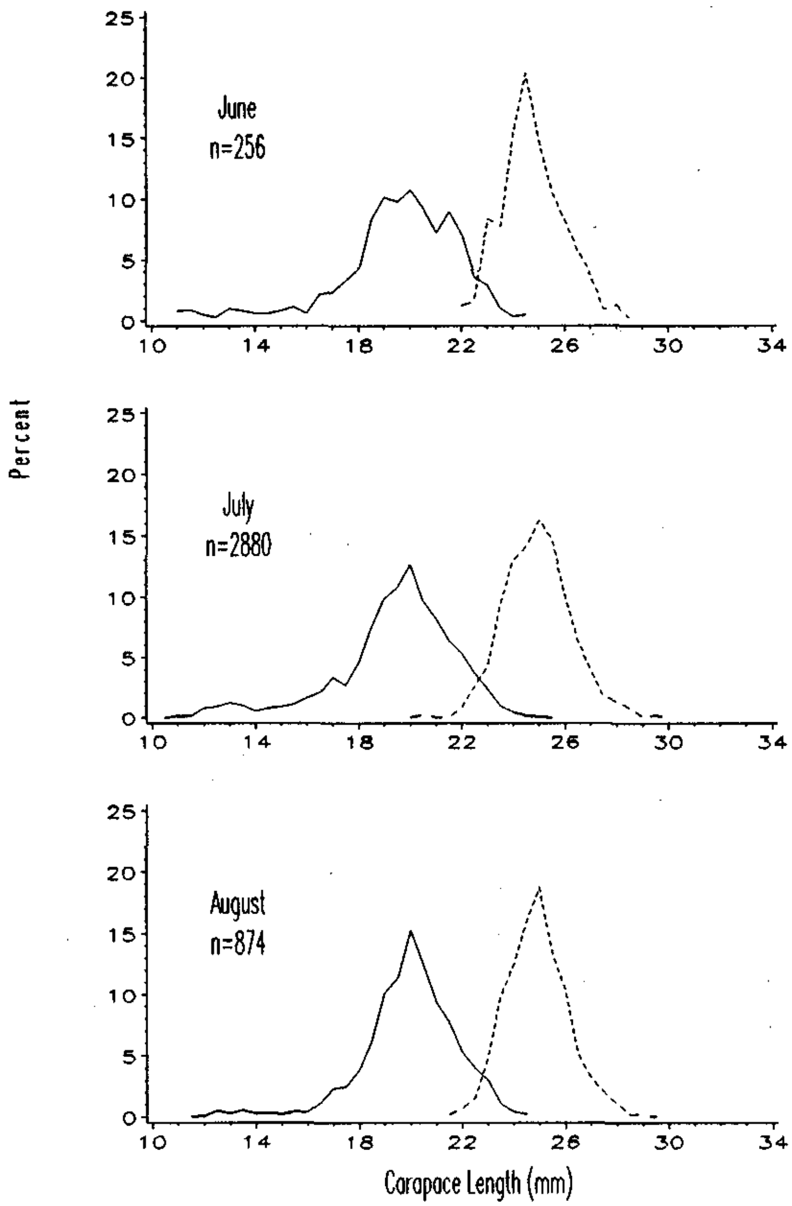


Fig. 5. Commercial length frequencies by month, 1995.(n=number measured, ---- female)

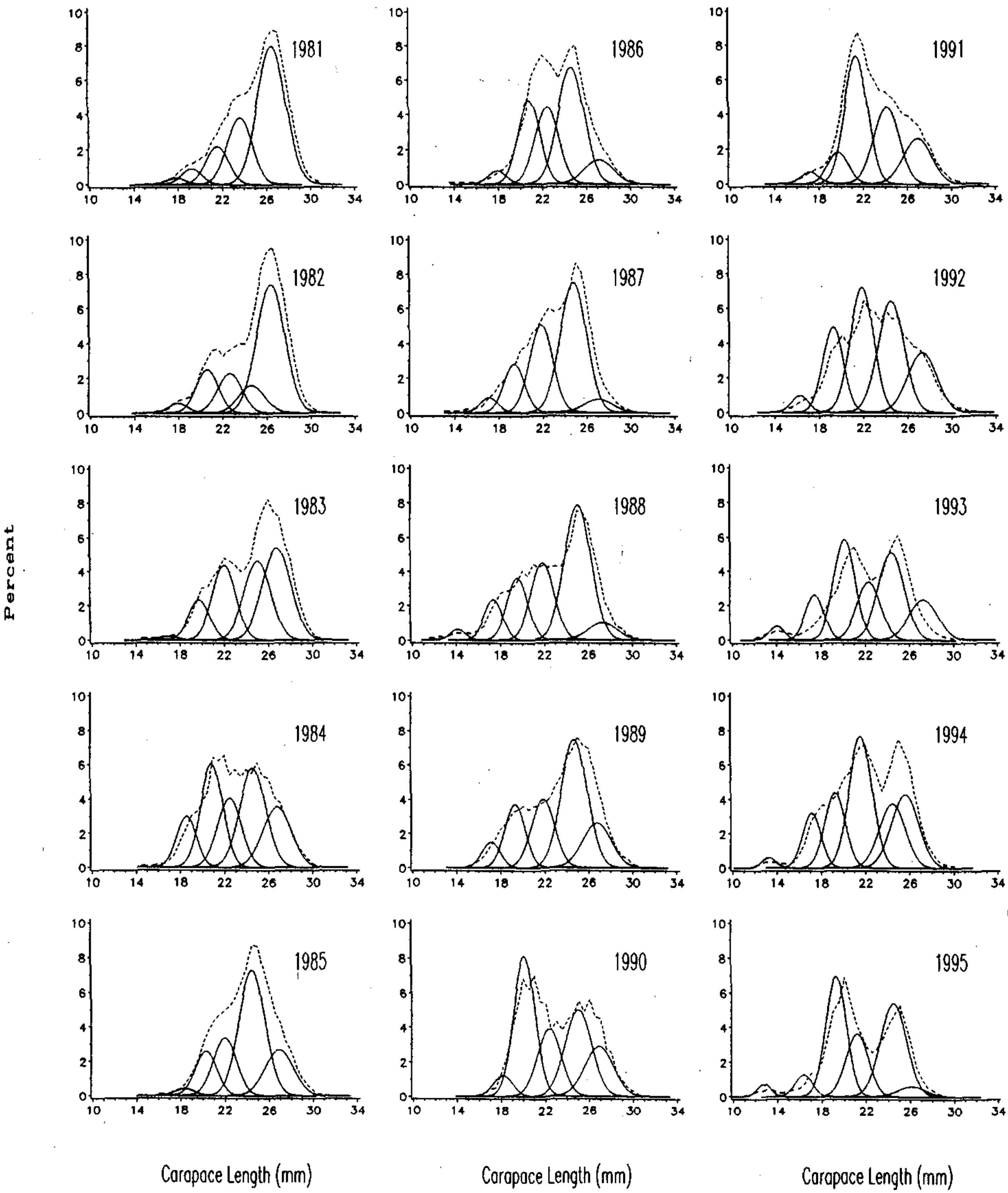


Fig. 6. Separation of ages from commercial length frequency data (broken line = commercial frequency), NAFO Div. 0A, 1981-1995.

Figure 7a. Number caught per hour (unstandardized) at age
Div. 0A, 1981 - 1995

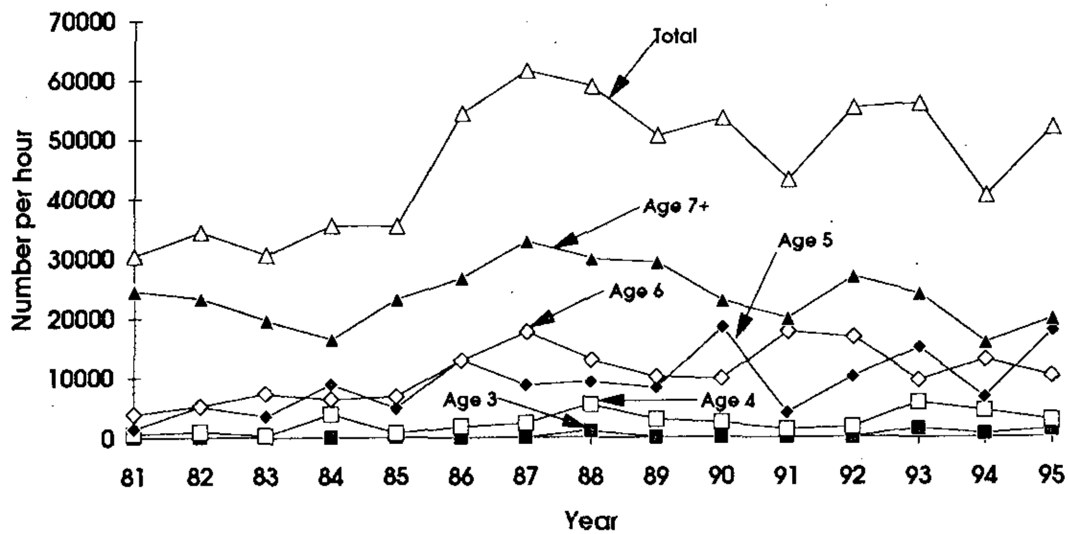


Figure 7b. Number caught per hour (standardized) at age
Div. 0A, 1981 - 1995