Northwest Atlantic Fisheries Organization

Serial No. N2340 NAFO SCR Doc. 93/128

SCIENTIFIC COUNCIL MEETING - NOVEMBER 1993

The Canadian Fishery for Northern Shrimp (Pandalus borealis) in Davis Strait, 1979 - 1993

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

and

E. M. Seward

R.R. #1, Box 186, Portugal Cove, Newfoundland, A0A 3K0

INTRODUCTION

Quota reports (preliminary to November 3, 1993) show that 4882 t of shrimp have been taken in Division 0A so far in 1993. Eleven vessels participated, compared to 12 in 1992, and the number of licences remained at 17. The fleet was late starting due to their involvement in the new Flemish Cap (Div. 3M) shrimp fishery which began in the spring. The provisional quota of 6800 t in Div. 0A was adjusted upwards to 8500 t following the June Meeting when STACFIS advised that the TAC for Subarea 0+1 in both 1993 and 1994 be set at 50,000 t (NAFO, 1993).

Vessel log book records and daily vessel hails, covering as much of the fishing activity as possible, provided information on fleet performance in 1993. Catch, effort and size composition data for shrimp from the 1993 fishery are compared to previous years 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 and from available logs and hails up to October, 1993. Since 1981, fishing has been restricted to NAFO Div. 0A in an area extending from about 67^0 to 69^0 N and 58^0 to 60^0 W on the Canadian side of the Midline. 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 = 498). No vessel fished in every year.

Unstandardized and standardized CPUE's (kg/hr) were calculated for each year according to the methods used by Parsons and Veitch (1993). Size composition of the 1993 catches sampled by observers was summarized by month and a single length frequency distribution of total numbers caught to date in 1993 was constructed. The latter was converted to age composition by modal analysis using the methods and rationale described in Parsons and Veitch (1991).

Data on by-catches from 1981 to 1993 were compiled as percentages of the total observed catch and catch rates (kg/hr) for redfish and Greenland halibut were compared over the same period. Estimates of the proportions of discarded shrimp also were derived from the observer data.

RESULTS

Catch, effort and CPUE

Shrimp catch, effort and CPUE by month and year as derived from the data sources are given in Tables 1, 2 and 3, respectively. The fishery usually begins in June and continues 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. From 1984 to 1992, both catch and effort showed an increasing trend (Fig. 1 and 2a). The 1993 fishery has not yet finished but, given the pattern of fishing in past years, it is anticipated that both total catch and effort levels will be the lowest observed in the last five years. 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, declining during August - September and either stabilize or increase again in October and November. This general pattern was evident in 1993. In 1992, catch rates fluctuated over the year, similar to the events observed in 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 rates over the 1991 level was evident in both 1992 and 1993.

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 1993 estimate ($P < 0.05$), the other years not being significantly different from 1993 ($P > 0.05$).

The standardized effort (Fig. 2b) showed the same pattern as the unstandardized series except the increase from 1984 to 1992 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. Except for the high CPUE's in 1981-82 and 1987-88, the series indicates stability (Fig. 3b). Also, there is no indication of a substantial increase in CPUE between 1985 and 1986, as seen in the unstandardized data, rather the increase occurs between 1986 and 1987. 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 of fishing. 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 and 1988 values. If the 1981-82 and 1987-88 data points are omitted from the standardized series, stable catch rates are evident over a broad effort range.

Length and age distributions

Length frequencies for the monthly sampled catches in 1993 (Fig. 8) show the occurrence of two distinct size groups - one of males with a modal length of approximately 21 mm and another of females at 25 mm. The male component spans a broad size range from about 17 to 24 mm and includes, primarily, 5 and 6 year-old animals. Males at age 4 occur at the lower end of this size range but appear to be poorly represented. Age 3 males are also evident, forming a minor but distinct component between 12 and 16 mm CL. The female component (ages 7+) is dominant in July, declining in importance over the season. There are no separate size/age groups evident within the female component.

Catch-at-length in the Canadian zone in 1993 (Fig. 9) differed substantially from the previous six years but was similar to that observed in 1986 when two well-separated size groups, one of males and one of females, were dominant (Parsons and Veitch, 1993). The appearance of males in the sampling data at approximately 14 mm CL (age 3) is also noteworthy - the only other occurrence being in 1988 when the strong 1985 year class began to recruit to the fishery.

Ageing of the 1993 commercial length distribution by modal analysis produced expected counts that were similar ($P > 0.30$) to the observed (Fig. 9) and the estimated mean lengths (Table 6) agreed well with those produced from previous analyses (Parsons and Veitch, 1993). In order to define a component with mean length about 18 mm, it was necessary to constrain the second mean to be held fixed at a previously estimated value in the final run. About 48% of animals in the pooled and weighted samples were females of ages 7 and 8+ (primarily the 1985 and 1986 year classes), another 30% were 6 year-old males (1987 year class) and the remaining 22% comprised younger males of the 1988, 1989 and 1990 year classes. The available data on

size distribution in 1993 were not considered sufficient to provide a representative estimate of the catch-at-age for comparison with previous years. They represent less than 25% of the total data base up to October and the fishery in Div. 0A has not yet ended. They are presented here as preliminary to consider in relation to other data sources from both the fishery and research vessel surveys.

Shrimp discards

The percentages of shrimp discards estimated by observers (Table 7) declined in recent years from a high of 6.54% in 1991 to 1.90% in 1993, the lowest level achieved during the 1981 - 1993 period. 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 (and male?) shrimp in the 1992 catches. The further decrease in 1993 is consistent with the domination of the catches by the 1985 (female) and 1987 (male) year classes but might also reflect an effort by industry to reduce discards of the small, "industrial grade" shrimp.

By-catches

Catch composition data by species for the 1993 fishery (Table 8) show that by-catch accounted for approximately 21% of the total catch weight of all species and that redfish was again the most prevalent fish species in the catches, representing just over 10% of the total observed catch weight. Greenland halibut comprised less than 3% of the catch, similar to the proportion observed in 1992. Arctic cod (Boreogadus saida) occurred more frequently as by-catch in 1993 compared to previous years, accounting for almost 6% of the catch. No Amercian plaice have been observed since 1988 and the proportion of catch weight due to Greenland sharks has declined over the past five years.

Catch rates (kg/hr - unstandardized) for redfish and Greenland halibut (turbot) from 1981 to 1993 were:

Sp./Year	81	82	83	84	85	86	87	88	89	90	91	92	93
Redfish	32	20	9	15	20	85	119	78	72	59	86	73	45
Turbot	3	4	5	6	4	8	13	15	12	12	9	17	12

Redfish CPUE's increased substantially from 1983 to 1987, decreased to 1990, increased again in 1991 and declined further in 1992 and 1993. Based on the estimated unstandardized effort (Table 5), over 500 t of primarily small redfish have been taken as by-catch and discarded in the Div. 0A fishery so far in 1993. The highest removals were in 1987 when about 1500 t were caught. Catch rates for Greenland halibut showed a gradually increasing trend to 1987 and a period of higher but, more or less, stable CPUE's from 1987 to 1993. It is estimated that the removals of Greenland halibut (mostly small) to date in 1993 have been approximately 150 t.

DISCUSSION

The inclusion of a predicted annual CPUE for 1993 in the standardized catch rate series showed a continuation of the period of stability which began in 1989. This stabilization was largely due to the recruitment of the strong 1985 year class, appearing for the first time as females in 1992. At the 1993 June Meeting, STACFIS noted the possibility that part of the 1985 year class did not change sex between 1991 and 1992 (NAFO, 1993). Assuming the data from Div. 0A in 1993 are representative of the total stock area, it appears that sex inversion for this year class (and, presumably, most of the weak 1986 year class) is now complete. The 1987 year class contributed substantially to the catches in 1993 as age 6 males and should contribute further in 1994 as females.

The 1992 assessment concluded that the 1986, 1987 and 1984 year classes appeared to be much weaker than the 1985, thus raising concerns for recruitment and the status of the spawning biomass (NAFO, 1992). The conclusion was, for the most part, correct but the associated concerns were overly pessimistic. The 1984 year class is history and the status (past, present and future) of the 1986 year class will never be resolved due to the domination of the 1985 year class in recent years and the uncertainty associated with its sexual development. The 1987 year class, however, showed some potential based on its occurrence in the 1992 survey (NAFO, 1993) and did contribute in 1993, as stated above. It is likely, therefore, that the success of the 1994 fishery will depend on what remains of the 1985 year class and the actual strength of the 1987 year class as it becomes fully recruited as age 7 females (Parsons and Veitch, 1993).

STACFIS also noted the possibility of a strong 1989 year class, based on the results of the 1992 survey (NAFO, 1993). The 1993 fishery data in Div.0A do not support that observation but commercial fishery data are not particularly useful for evaluating year class strengths at the younger ages. The appearance of the 1990 year class in the same data, however, does deserve mention. The presence of an identifiable component of age 3 animals in the commercial catches in Div. 0A was observed only once, prior to 1993. That was in 1988 and represented the first indication of the strong 1985 year class. Should the 1990 year class prove to be strong, it might contribute substantially to the fishery as early as 1995.

REFERENCES

MacDonald, J.K. and J.F. Collins. 1990. Canada's Northern Shrimp Industry: An Economic Assessment of the Fishery. Economic and Commercial Analysis Report No. 79: 94p.

NAFO 1992. Scientific Council Reports. pp 132 - 136.

NAFO 1993. Scientific Council Meeting - June 1993. NAFO SCS Doc. 93/17, Ser. No. N2257. pp 106 - 111.

Parsons, D.G and P.J. Veitch. 1991. The Canadian fishery for northern shrimp (Pandalus borealis) in Division 0A, 1990. NAFO SCR Doc. 91/33, Ser. No. N1913: 27p.

Parsons, D.G and P.J. Veitch. 1993. The Canadian fishery for northern shrimp (Pandalus borealis) in Davis Strait, 1979 - 1992. NAFO SCR Doc. 93/78, Ser. No. N2263: 16p.

Table 1. Catch(t) by month/year - NAFO Division 0A, 1979-1993

Year	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	Total
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	258	10328
8	.	.	665	650	1241	354	604	363	1157	1284	1280	1200	1591	1776	1247	13411
9	42	.	585	458	798	398	414	241	1183	989	662	852	792	2956	1469	11838
10	71	.	833	335	992	324	582	242	2252	1294	1264	1214	1233	1214	775	12627
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	3749	55912

Table 2. Effort (Hrs) by month/year - Nafo Division 0A, 1979-1993

Year	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	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	464	22551
8	.	.	2170	1836	4100	1360	2412	995	2341	3237	3738	3745	5482	4460	3349	39225
9	81	.	1968	1504	3151	1641	1784	731	2714	2595	1734	1826	3028	5773	3802	32332
10	325	.	3229	1248	3995	1370	1804	577	4944	2197	3210	3089	3233	3582	1576	34379
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	9191	149726

Table 3. CPUE by month/year - NAFO Division 0A, 1979-1993

Year	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93
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	556
8	.	.	306	354	303	260	250	365	494	397	342	321	290	398	372
9	513	.	297	304	253	243	232	330	436	381	382	466	261	512	386
10	218	.	258	268	248	236	323	419	456	589	394	393	381	339	492
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 - 1993.

GENERAL LINEAR MODELS PROCEDURE

DEPENDENT VARIABLE: LNCPUE

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE	PR > F	R-SQUARE	C.V.
MODEL	64	51.63000256	0.80671879	14.64	0.0	0.695118	4.0043
ERROR	411	22.64513917	0.05509766		ROOT MSE		LNCPUE MEAN
CORRECTED TOTAL	475	74.27514173			0.23472891		5.86196443

SOURCE	DF	TYPE I SS	F VALUE	PR > F	DF	TYPE III SS	F VALUE	PR > F
YEAR	12	17.64280625	26.68	0.0	12	5.10667183	7.72	0.0001
MONTH	6	12.75497037	38.58	0.0001	6	7.41702731	22.44	0.0001
VESSEL	46	21.23222594	8.38	0.0001	46	21.23222594	8.38	0.0001

PARAMETER		ESTIMATE		T FOR H0: PARAMETER=0	PR > |T|	STD ERROR OF ESTIMATE
INTERCEPT		5.49214281	B	73.61	0.0	0.07461602
YEAR	81	0.18701125	B	2.17	0.0303	0.08602661
	82	0.35644296	B	3.63	0.0003	0.09822072
	83	0.07495007	B	0.95	0.3436	0.07903961
	84	0.03214384	B	0.31	0.7549	0.10291463
	85	-0.09665971	B	-0.93	0.3553	0.10446208
	86	0.01751594	B	0.20	0.8428	0.08828936
	87	0.33619402	B	4.88	0.0001	0.06892250
	88	0.23064143	B	3.49	0.0005	0.06607942
	89	-0.01922490	B	-0.32	0.7515	0.06066503
	90	0.03102347	B	0.51	0.6099	0.06076149
	91	-0.07606025	B	-1.25	0.2137	0.06107676
	92	-0.00980167	B	-0.17	0.8623	0.05646719
	93	0.00000000	B	.	.	.
MONTH	6	0.44599927	B	6.86	0.0001	0.06503194
	7	0.29553672	B	8.20	0.0001	0.03605646
	9	0.05692723	B	1.69	0.0914	0.03364528
	10	0.09531701	B	2.89	0.0040	0.03293633
	11	0.01819270	B	0.47	0.6366	0.03847869
	12	-0.55294593	B	-4.49	0.0001	0.12316401
	99	0.00000000	B	.	.	.
VESSEL	1	-0.49977183	B	-4.79	0.0001	0.10425786
	4	-0.20793100	B	-2.39	0.0171	0.08687298
	5	0.11114668	B	1.61	0.1084	0.06907430
	7	-0.08832620	B	-0.49	0.6229	0.17948532
	10	0.13516479	B	1.63	0.1045	0.08306931
	11	0.07175975	B	0.72	0.4690	0.09901453
	13	-0.06040216	B	-0.76	0.4484	0.07960819
	14	-0.11491695	B	-1.24	0.2154	0.09262546
	15	-0.35028474	B	-3.82	0.0002	0.09169588
	16	-0.01203275	B	-0.10	0.9187	0.11780601
	17	-0.63044546	B	-4.01	0.0001	0.15710549
	18	-0.47679275	B	-2.65	0.0083	0.17980674
	19	-0.73652833	B	-3.88	0.0001	0.18961124
	20	-0.67432813	B	-3.62	0.0003	0.18646418
	21	-0.01651993	B	-0.25	0.8062	0.06731059
	22	-0.22820196	B	-1.22	0.2248	0.18773299

TABLE 4A. (CONT'D.)

23	0.04744048 B	0.32	0.7459	0.14630546
24	0.17205309 B	1.24	0.2153	0.13865106
25	0.37750387 B	3.37	0.0008	0.11214609
26	-0.45746658 B	-2.80	0.0054	0.16361234
27	0.27572937 B	1.98	0.0480	0.13901912
28	0.18755605 B	1.35	0.1780	0.13901912
29	0.56972812 B	8.13	0.0001	0.07009348
30	0.37426416 B	4.18	0.0001	0.08959488
31	-0.76648147 B	-3.07	0.0023	0.24956949
32	0.53853058 B	6.98	0.0001	0.07716367
33	-0.08792053 B	-1.08	0.2796	0.08120607
34	0.41894449 B	4.27	0.0001	0.09814360
35	0.35059903 B	2.70	0.0072	0.12985312
36	0.47370082 B	5.53	0.0001	0.08559766
37	0.45889521 B	5.16	0.0001	0.08893596
38	0.38870304 B	4.08	0.0001	0.09525068
39	0.30170311 B	3.73	0.0002	0.08080604
40	0.55431082 B	7.68	0.0001	0.07217452
41	0.24347764 B	3.54	0.0004	0.06875754
42	0.52926150 B	6.24	0.0001	0.08477039
43	0.24508269 B	3.39	0.0008	0.07223186
44	0.43670751 B	5.18	0.0001	0.08430031
47	0.48625141 B	6.02	0.0001	0.08074960
48	0.30970378 B	1.75	0.0812	0.17718723
57	0.17108819 B	1.29	0.1983	0.13278393
58	0.49595100 B	4.91	0.0001	0.10091769
59	0.14011950 B	0.94	0.3487	0.14933680
66	0.50224572 B	2.04	0.0422	0.24644100
67	0.54436673 B	5.43	0.0001	0.10019696
68	0.41195164 B	3.80	0.0002	0.10847753
99	0.00000000 B	.	.	.

TABLE 4B. RETRANSFORMED ANNUAL CATCH RATES FROM STANDARDIZATION.

	LN TRANSFORM			RETRANSFORMED		
SUMMARY	YHAT	YHATVAR	STDERR	MEAN	VARIANCE	STDERR
INTERCEP	5.4921	.0055676	0.074616	248.8855	345.0966	18.5768
YY81	5.6792	.0048871	0.069908	300.1690	440.7682	20.9945
YY82	5.8486	.0069137	.0831484	355.2283	872.3822	29.5361
YY83	5.5671	.0039977	.0632271	268.4677	288.5428	16.9865
YY84	5.5243	.0077605	.0880937	256.7330	511.2730	22.6113
YY85	5.3955	.0084048	.0916775	225.6330	427.5535	20.6774
YY86	5.5097	0.007137	.0844806	253.0840	457.0659	21.3791
YY87	5.8283	.0041025	.0640511	348.5989	499.2310	22.3435
YY88	5.7228	.0039926	.0631871	313.6961	393.4550	19.8357
YY89	5.4729	.0040325	.0635016	244.3345	241.0742	15.5266
YY90	5.5232	.0040307	.0634874	256.9259	266.4421	16.3231
YY91	5.4161	.0041954	.0647717	230.8161	223.8099	14.9603
YY92	5.4823	.0046201	.0679712	246.5751	281.2104	16.7693
YY93	5.4921	.0055676	0.074616	248.8855	345.0966	18.5768

Table 5. Northern shrimp data from the Canadian fishery in NAFO Subareas 0 and 1, 1979 - 1993.

			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	300	1.00	17613
1982	5000	2064	335	1.12	6161	355	1.18	5814
1983	5000	5413	284	0.95	19060	268	0.89	20198
1984	5000	2142	280	0.94	7650	257	0.86	8335
1985	6120	3069	309	1.03	9932	226	0.75	13580
1986	6120	2995	445	1.49	6730	253	0.84	11838
1987	6120	6095	491	1.64	12413	349	1.16	17464
1988	6120	5881	468	1.57	12566	314	1.05	18729
1989	7520	7235	391	1.31	18504	244	0.81	29652
1990	7520	6177	405	1.35	15252	257	0.86	24035
1991	8500	6788	330	1.10	20570	231	0.77	29385
1992	8500	7493	425	1.42	17631	247	0.82	30336
1993	8500	4882	408	1.36	11966	249	0.83	19606

[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 1993, inclusive. The 1990, 91 and 92 data are provisional and the 1993 incomplete (up to November 3).

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

TABLE 6. MACDONALD & PITCHER MIXTURE ANALYSIS - 1993 AGE COMPOSITION.

INTERVAL	EXPECTED COUNT	OBSERVED COUNT	LEFT BOUNDARY
1	0.1184	2	12
2	0.8111	3	12.5
3	3.4916	5	13
4	8.7472	5	13.5
5	12.7702	9	14
6	10.88	8	14.5
7	5.4854	7	15
8	2.0592	6	15.5
9	2.1511	5	16
10	5.073	5	16.5
11	9.6797	9	17
12	13.8074	11	17.5
13	16.2524	15	18
14	19.2968	20	18.5
15	26.2917	30	19
16	37.3049	33	19.5
17	49.5385	50	20
18	60.2039	59	20.5
19	66.3217	72	21
20	64.3937	61	21.5
21	54.2996	54	22
22	42.3132	39	22.5
23	37.1607	44	23
24	42.9633	39	23.5
25	56.3032	57	24
26	68.9026	65	24.5
27	73.0392	76	25
28	66.1421	67	25.5
29	51.6138	54	26
30	35.5512	33	26.5
31	22.5132	22	27
32	13.7733	14	27.5
33	8.3922	8	28
34	5.0277	6	28.5
35	2.8397	3	29
36	1.4523	1	29.5
37	1.0349	1	

Proportions and their standard errors

0.04413	0.0532	0.12734	0.3	0.42643	0.04889
0.00657	0.01048	0.05798	0.05596	0.02854	0.02786

Means and their standard errors

14.3506	17.8997	20.037	21.6409	25.1485	27.3773
0.1085	FIXED	0.4326	0.2407	0.1388	0.5408

Sigmas (FIXED COEF. OF VAR. = 0.0480)

0.6648	0.8352	0.9378	1.0148	1.1831	1.2901

Degrees of freedom = 26 Chi-squared = 29.0064 (P = 0.3108)

Table 7. Shrimp discards (% of total shrimp catch) in Div. 0A, 1981 - 93, estimated by observers.													
Year	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993
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	1.5
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
Sep	5.8	3.6	3.6	6.1	3.2	2.2	1.6	2.5	6.2	5.2	8	4.8	1.8
Oct	5.8	3.7	5.2	3.3	4	2	2.1	3.3	3.5	2.4	5.6	3.5	2.1
Nov	3.6	3.3	5.8	6.7	2.4	2.3	2	4.2	3.6	2.2	3.8	4.7	
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	1.9

TABLE 8. OBSERVED CATCH (MT) AND % BY-CATCH IN DIV.0A SHRIMP FISHERY 1981-93																						
YEAR	1981		1982		1983		1984		1985		1986		1987		1988		1989		1990		1991		1992		1993	
SPECIES	WT.	%	WT.	%	WT.	%	WT.	%	WT.	%	WT.	%	WT.	%	WT.	%	WT.	%	WT.	%	WT.	%	WT	%	WT.	%
P. BOREALIS	3897.1	84.49	2088.48	91.91	1846.53	93.55	1325.77	86.15	2173.84	85.95	2003.58	75.68	3406.08	83.03	2877.32	83.33	5173.17	78.93	2479.16	82.74	2520.71	71.81	3863.89	74.76	1212.03	78.63
REDFISH (NS)	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	163.69	10.62
A. 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
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	87.41	5.67
G. HALIBUT	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	39.23	2.55
SKATE (NS)	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	11.38	0.74
SHARK (NS)	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	10	0.65
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	153.18	2.34	74.45	2.49	115.22	3.29	131.24	2.54	17.71	1.16
TOTAL	4612.3		2272.21		1973.92		1538.93		2529.24		2647.57		4102.13		3452.82		6554.5		2996.38		3510.4		5168.6		1541.45	

Fig.1. Shrimp catch SA 0 + 1 1979-1993

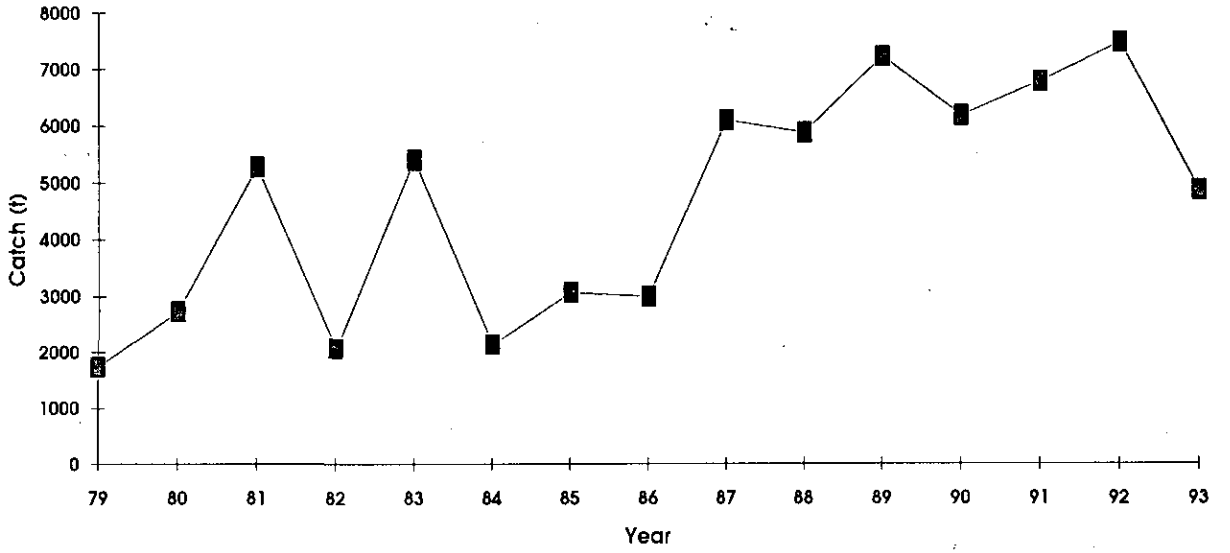


Fig.2a. Unstandardized effort
SA 0 + 1 1979-1993

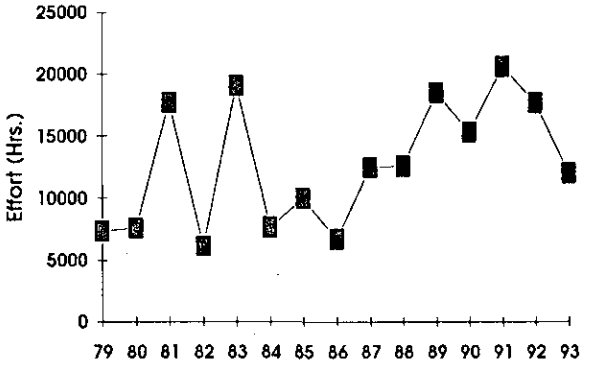


Fig.2b. Standardized effort
Div.0A 1981-1993

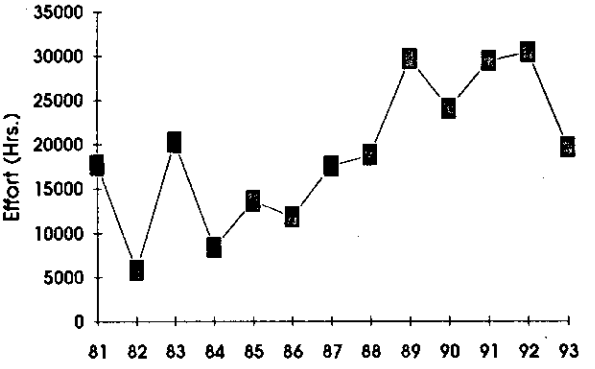


Fig.3a. Unstandardized CPUE
SA 0 + 1 1979-1993

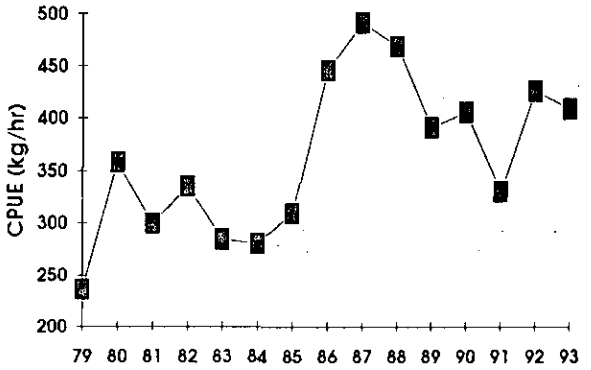


Fig.3b. Standardized CPUE
Div.0A 1981-1993

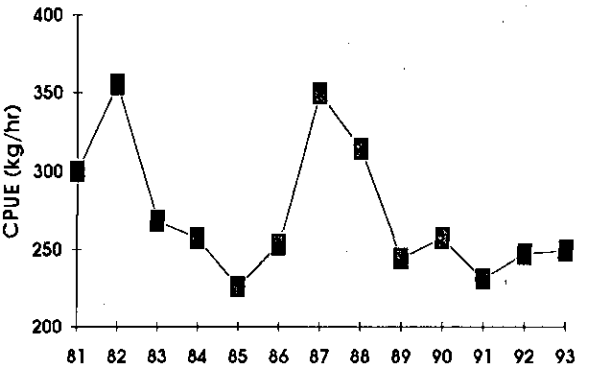


Fig.4a. Shrimp catch vs Unstandardized fishing effort

SA 0 + 1

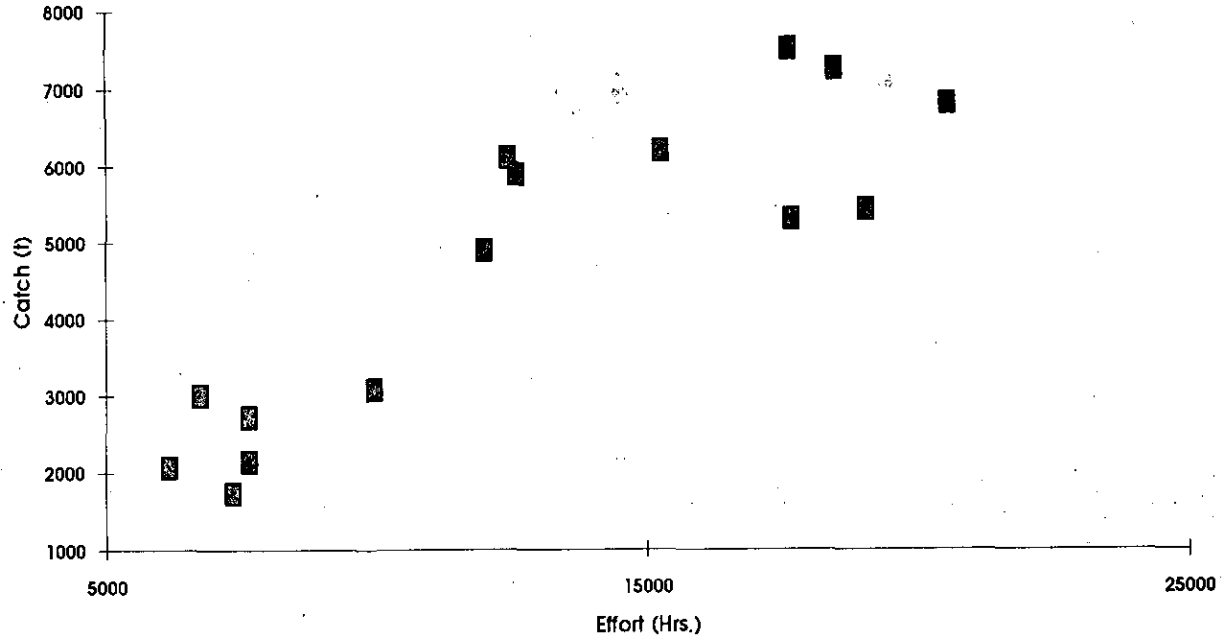
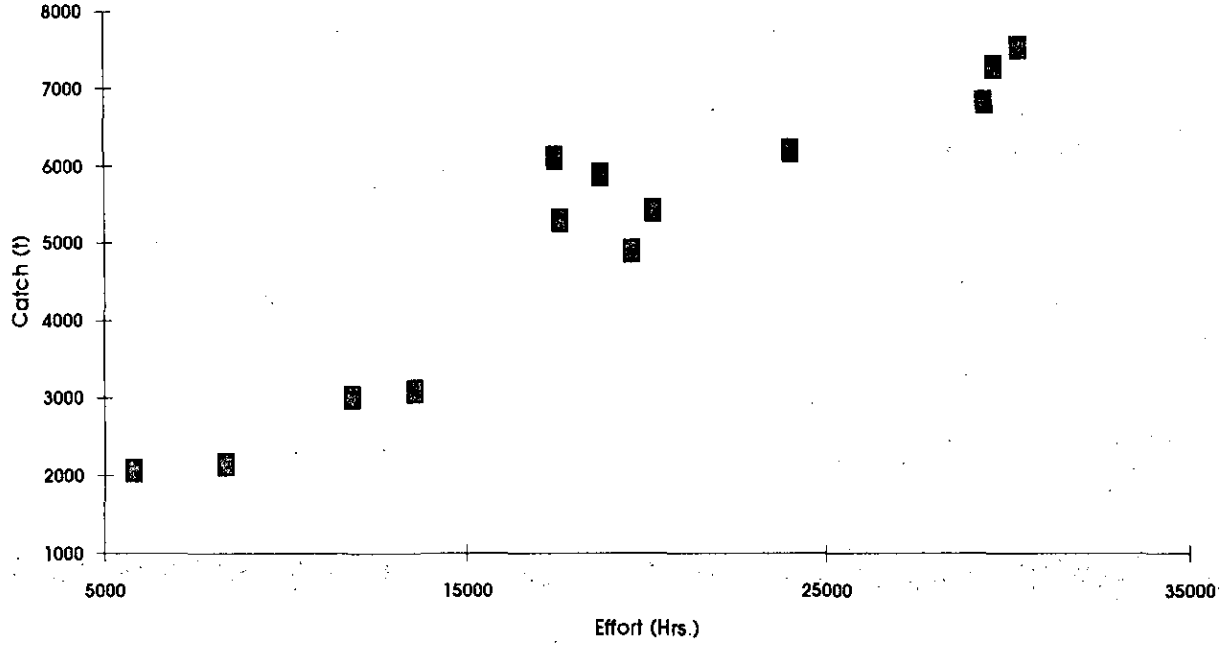


Fig.4b. Shrimp catch vs standardized fishing effort

Div.0A



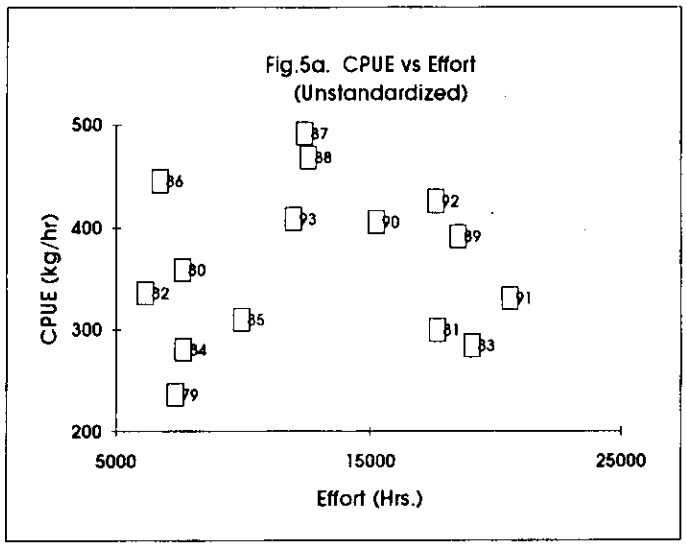


Fig.5a. CPUE vs Effort
(Unstandardized)
CPUE (kg/hr)
500
400
300
200
5000
15000
25000
Effort (Hrs.)

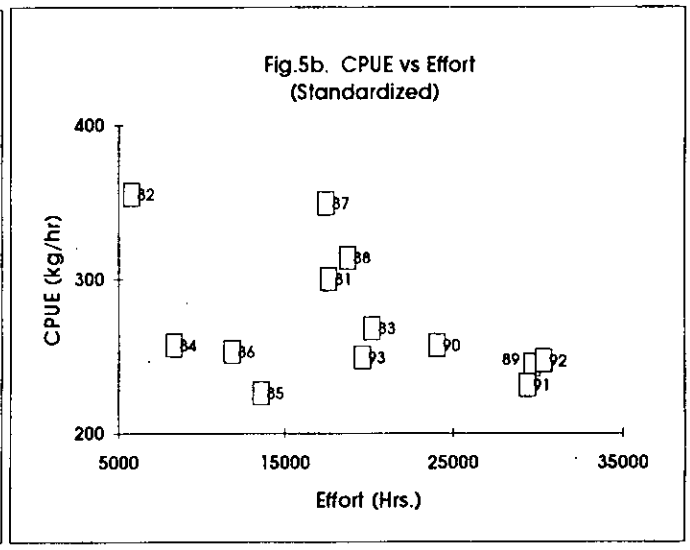


Fig.5b. CPUE vs Effort
(Standardized)
CPUE (kg/hr)
400
300
200
5000
15000
25000
35000
Effort (Hrs.)

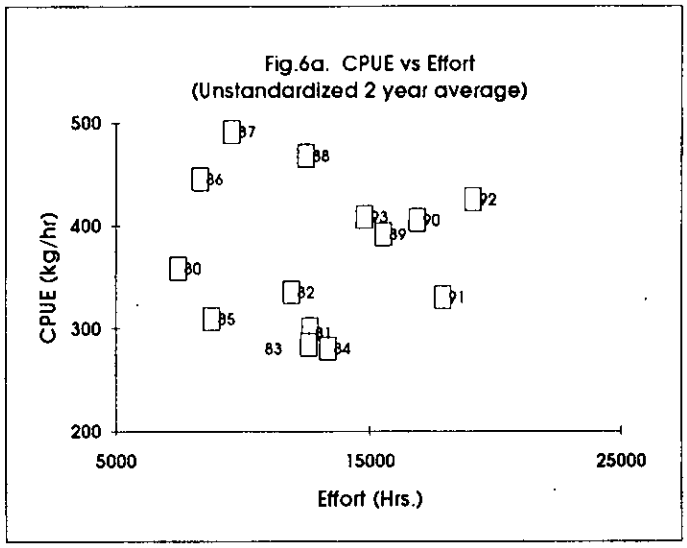


Fig.6a. CPUE vs Effort
(Unstandardized 2 year average)
CPUE (kg/hr)
500
400
300
200
5000
15000
25000
Effort (Hrs.)

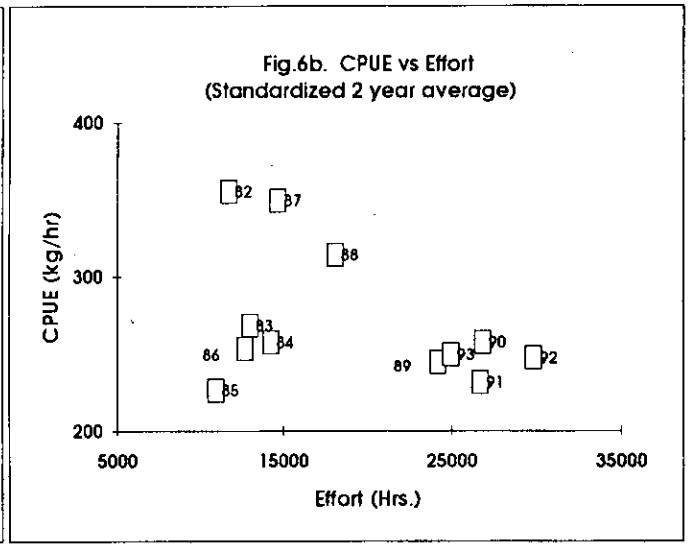


Fig.6b. CPUE vs Effort
(Standardized 2 year average)
CPUE (kg/hr)
400
300
200
5000
15000
25000
35000
Effort (Hrs.)

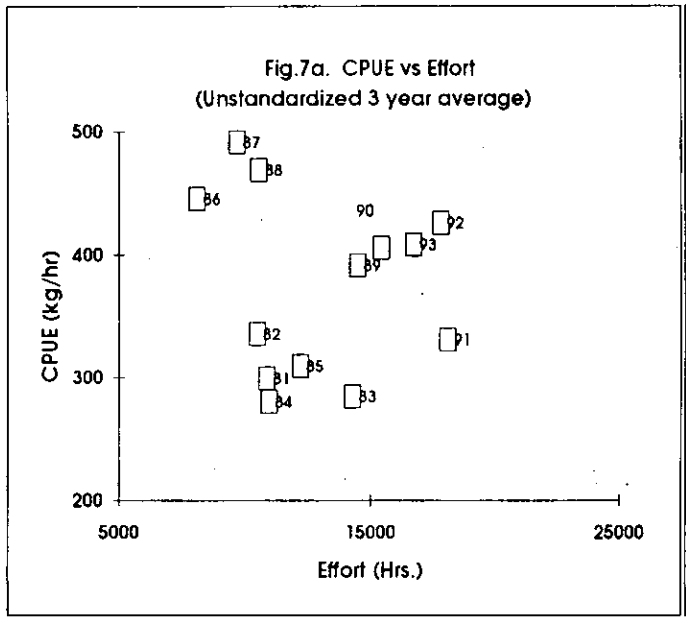


Fig.7a. CPUE vs Effort
(Unstandardized 3 year average)
CPUE (kg/hr)
500
400
300
200
5000
15000
25000
Effort (Hrs.)

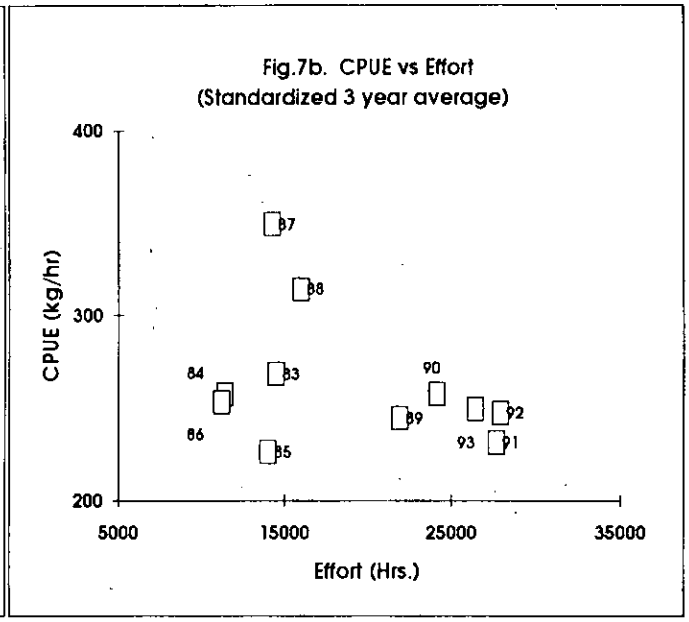


Fig.7b. CPUE vs Effort
(Standardized 3 year average)
CPUE (kg/hr)
400
300
200
5000
15000
25000
35000
Effort (Hrs.)

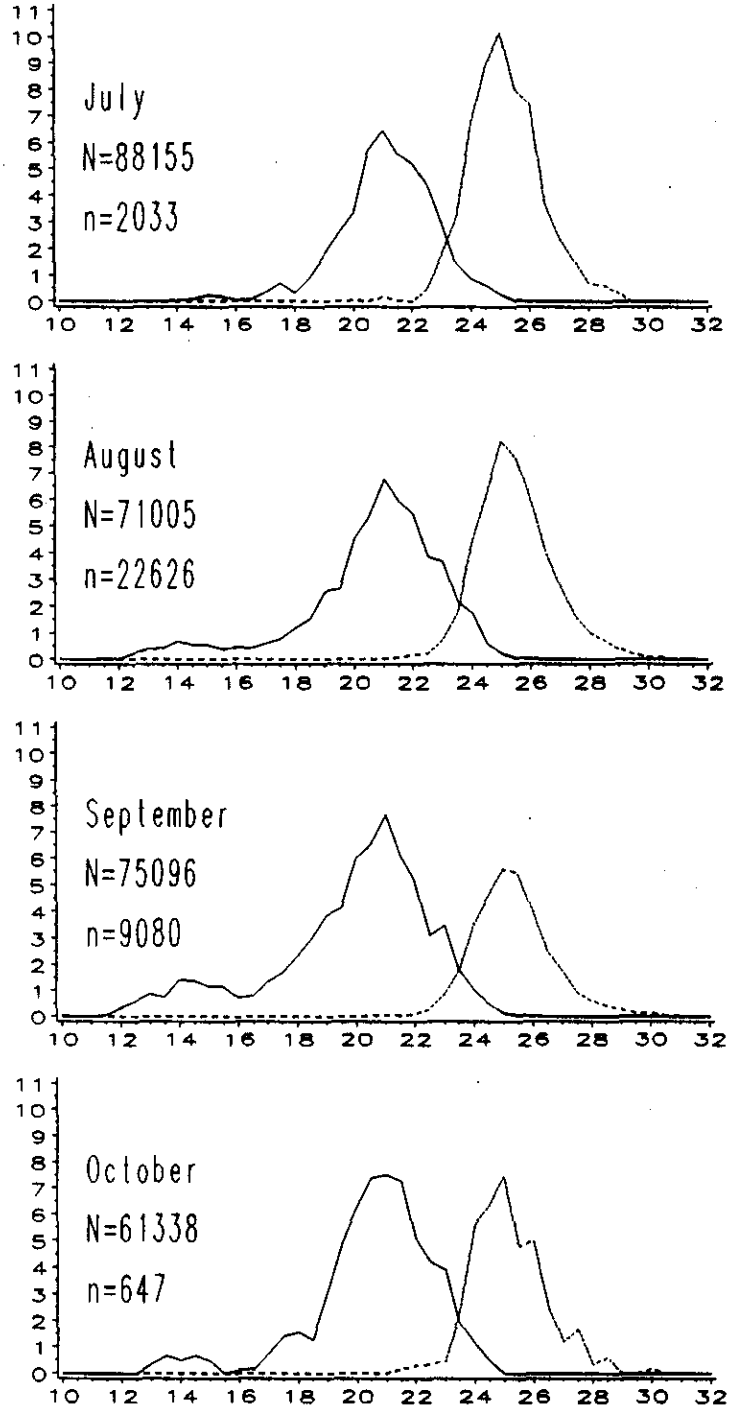


Fig. 8. Commercial length frequencies by month, 1993 (N=number per hour, n=number measured, ---- female).

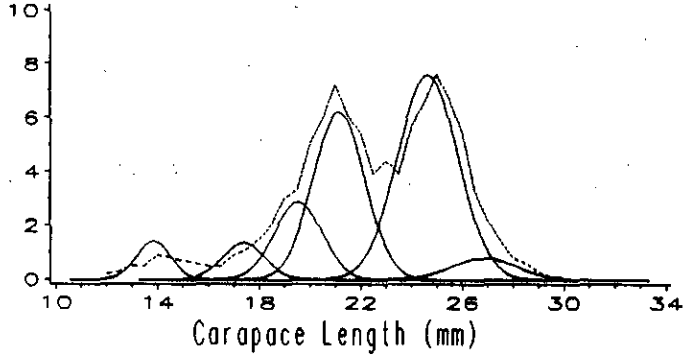


Fig. 9 Separation of ages from commercial length frequency data (broken line = commercial frequency), NAFO Div. 0A, 1993.