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Redfish (Sebastes spp.) in Management Unit 4VWX: An Assessment of Present Stock Status

by

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Abstract

Landings of redfish from Divisions 4VWX in 1986 decreased 9% from 1985 to a provisional total of 12,718 t. This total represents 42% of the 1986 TAC. Redfish catch rate series for side and stern trawlers operating in Divisions 4VWX indicate contradictory trends since 1982. In 1986 both series show declines, although reasons for this are not clear at this time. Redfish biomass estimates from summer groundfish surveys show a variable but increasing trend since 1980. The variability in this series in recent years may be due, in part, to catches consisting of fish from two strong incoming year-classes which have a combined modal length of 20 cm in 1986. These two year-classes appear to be more numerous than any observed since the surveys were initiated in 1970. They were apparently recruited to the commercial fishery in small quantities in 1986. The continued increase in estimated biomass levels from summer groundfish surveys is corroborated by the results of redfish directed surveys conducted in 1985 and 1986 which show increases in estimated biomass levels in waters between 200 and 500 fms in all surveyed areas of the management unit.

Résumé

Les débarquements de sébaste des divisions 4VWX en 1986 ont diminué de 9 % par rapport à ce qu'ils étaient en 1985 et s'élèvent à un total provisoire de 12 718 t. Ce total représente 42 % du TPA pour 1986. Les séries de taux de capture de sébaste par les chalutiers à pêche latérale et à pêche arrière exploités dans les divisions 4VWX indiquent des tendances contradictoires depuis 1982. En 1986, les deux séries indiquent des diminutions quoique les raisons de ces diminutions ne sont pas encore évidentes. Les estimations de la biomasse de sébaste d'après les relevés de poisson de fond pendant l'été indiquent une tendance variable mais à la hausse de puis 1980. La variabilité de cette série au cours de dernières années peut être en partie attribuée à des captures provenant de deux fortes classes d'âge qui arrivent et dont la longueur modal combinée était de 20 cm en 1986. Ces deux classes d'âge semblent regrouper un plus grand nombre d'individus que toute autre observée depuis les débuts des relevés en 1970. Elles n'ont apparemment été recrutées qu'en petites quantités par la pêche commerciale en 1986. L'accroissement ininterrompu de la biomasse estimée indiqué par les relevés estivaux pour le poisson de fond est confirmé par les résultats des relevés portant sur le sébaste effectués en 1985 et 1986 qui indiquent des accroissements de la biomasse estimée dans les eaux comprises entre 200 et 500 brasses, et ce dans toutes les zones de l'unité de gestion qui ont fait l'objet de relevés.

History of the Fishery

The fishery for redfish in 4VWX was developed in the mid-1930s. Large catches were not reported until 1936 when the USA landed 7,195 t. The period of initial exploitation was completed in 1949 with a maximum catch of 77,142 t. Between 1952 and 1970, catches fluctuated between 10,000 and 40,000 t. Landings by Canadian fishermen were relatively insignificant until the beginning of the 1960s when their nominal catches averaged 2,658 t of an average total nominal catch of 33,473 t (1960-1964). Since 1967, Canadian fishermen have landed the largest proportion of the total catch. In 1961 the distant water fleet, composed mostly of vessels from the U.S.S.R., but later augmented by Polish, Japanese,and French vessels, began contributing significantly to total redfish catches from these divisions. The combined efforts of Canada, the USA, and the distant water fleet culminated in a nominal catch of 62,381 t in 1971 (Table 1). Since the establishment of Canada's 200 mile zone in 1977, the distant water fleet has not contributed significantly to 4VWX redfish catches. However, in 1985 and 1986 the Japanese fleet removed 923 and 1489 t, respectively.

From a maximum in 1971, catches declined rapidly, reaching 13,154 t in 1979. Landings increased between 1979 and 1982 but decreased to 10,244 t in 1984. For 1986 the provisional total of 12,718 t represents a 9% decrease over 1985 but accounts for only 42% of the TAC. A detailed history of TACs, quotas and landings by country since 1976 is given in Table 2.

The overall decrease in landings observed in 1986 was the result of decreases in 4Vn, 4Vs, and 4W — 2%, 68%, and 38% respectively. Landings in Division 4X increased by 22% due mainly to increased landings by TC5 stern trawlers and TC1-3 trawlers. Relative contributions (percent) by area are given below:

4Vn	28.1	4W	10.2
4Vs	13.1	4X	48.5

Tonnage class 4 (OTB1-TC4) side trawlers and tonnage class 5 (OTB2-TC5) stern trawlers accounted for 38% and 23% of the total Scotia-Fundy landings in 4VWX in 1986, (Table 3). Smaller trawlers (tonnage classes 1-3) contributed 32% of the total (Table 4) while the remaining 7% was landed by miscellaneous gears. Distribution of Scotia-Fundy redfish landings by gear type is shown on Figure 1.

The seasonal distribution of landings by the two major gear types (Tables 5 and 6) indicate that the bulk of the landings are made during the third quarter of the year.

Commercial Catch Rate Series

Previous calculations of commercial catch rate series used both catch and effort data for landings where the main species caught was redfish (i.e. where redfish comprised the largest single component of the catch). It was argued that this could have resulted in the calculation of non-representative catch rates by the inclusion of effort directed at species other than redfish during trips where redfish was the main species caught. For example, vessels may have fished for cod or other groundfish species at night when redfish catch rates for bottom fishing gear declined. To test this, catch and effort data were also selected for landings where redfish comprised 90% or more of the total landings for that trip. This effectively excludes most data where effort directed at other species may have been included in redfish directed effort. Results of these analyses show that although the magnitude of the catch rates calculated with strictly redfish directed effort is somewhat higher, overall trends shown by the two major gear types are not significantly altered (Figures 2 and 3).

Catch rates calculated from total annual effort and total annual catch for the two major gear types (Figure 2 and 3) show that side trawler catch rates increased rapidly between 1980 and 1985 and declined in 1986 (Figure 2A). The increasing catch rate is most evident in Division 4X (Figure 4). This is accompanied by increased catches by side trawlers over the same period (Table 3). The decline in 1985 is associated with a small decline in landings for 4X. Whether this down turn of catch rates represents an overall change in the catch rate series or is merely a reflection of interannual variability remains an open question. To minimize the potential effects of seasonal variations in catch rates, a second series using only third quarter values of catch and effort was calculated. The pattern shown is not substantially different from that obtained above (Figure 2B).

Stern trawler catch rates have been more variable. The full year series shows a relatively steady increase between 1976 and 1982 (Figure 3A). Between 1982 and 1986 the full-year stern trawler catch rates have declined. Third quarter catch rates calculated from strictly redfish directed effort show a slight increase between 1985 and 1986 (Figure 3B). Since this fishery is most active in Divisions 4Vn and 4Vs, the declines are most evident in these areas (Figure 4).

Since landings by smaller trawlers have increased steadily since 1978 (Table 4), we also examined a catch rate series for this fleet sector. Both catch rates and landings increased rapidly between 1978 and 1985 (Figure 5). In 1986, landings continued to increase while catch rates declined, showing a pattern similar to that observed for the larger side trawler catch rate series. Since this fleet sector concentrates its activities in Divisions 4W and 4X, separate catch rate series for each area were examined. That for 4W is more variable than the 4X series (Figure 6) — perhaps reflecting the lower catch levels.

Catches of redfish by stern trawlers (TC 5) have been highly variable over the history of the series while those of the side trawlers show greater consistency between years. This variability may indicate that these larger, more modern stern trawlers are usually deployed towards more lucrative fisheries with occasional diversions to Scotian Shelf redfish when market demands arise. In general terms, it appears that the increasing catch rates experienced by the more directed gear sectors from 1979-80 to 1985 represented an increase in the fishable biomass which may be due to the presence of the early 1970's year-classes. The decline in 1986 is presently unexplained.

Redfish Biomass Estimates

Two sources of data were used to estimate levels of trawlable biomass in 4VWX: July groundfish surveys which were initiated in 1970 and annually survey the 4VWX management unit between 15 and 200 fms for various commercial species; and trawl surveys, designed specifically to estimate redfish abundance levels between the 100 fathom contour and the lower limit of abundant distribution at approximately 500 fathoms, which have been conducted in the fall of 1982, 1983, 1985, and 1986.

Results of the July surveys are shown in Figure 7. The arithmetic mean estimates show levels of interannual variability which are inconsistent with known life history parameters. A three year median smooth of the arithmetic data (Figure 7) shows that the overall trend in these data is a decline through the 1970s and a consistent resurgence since 1980. The precipitous increase and decline between 1983 and 1985 in the unsmoothed arithmetic series were attributable to two extremely large catches of small fish belonging to two strong incoming year-classes. The 1986 estimate indicates that redfish biomass is continuing its slow increase started in 1980-1981.

Biomass estimates for individual areas (Figure 8) indicate that levels in 4Vn are relatively stable or increasing slightly, and that 4Vs shows an increasing trend since 1980. The dramatic changes in 4W and 4X between 1983 and 1985 are due mainly to extremely large catches in three strata in 1984. The estimated redfish biomass in Stratum 57 (4W) in 1984 was approximately six times the largest previous estimate. In Divisions 4X the increased biomass estimate in 1984 was due primarily to large catches in Strata 70 and 84. For Stratum 70 the 1984 estimate was the third highest ever, while for Stratum 84 it was the second highest. In Strata 57 and 70 the large catches observed in 1984 were composed largely of redfish 14-16 cm in length indicating that they belonged to the pair of large incoming year- classes which have been observed since 1982 (Zwanenburg et al. 1982, Zwanenburg 1983, Zwanenburg 1984, Zwanenburg 1985). Large catches of fish belonging to these two year-classes will likely continue to cause fluctuations in a generally increasing trend in estimated biomass as these fish increase in weight.

The July surveys probably underestimate total redfish biomass since they only extend to the 200 fm contour, while redfish are abundant at depths greater than 200 fathoms. Tables 7 and 8 summarize the estimates of redfish biomass derived from redfish specific surveys by depth and area. These results show that in areas of overlap between the two surveys, the redfish surveys generally estimate higher levels of biomass than the groundfish surveys. Given the contagious distibution of redfish, the generally higher sampling rate of the redfish surveys should result in more accurate estimates.

The results also indicate that significant amounts of redfish biomass occur at depths below those fished during the July groundfish surveys. It should be noted that in 1982 and 1983 the redfish surveys were restricted to the edge of the Scotian Shelf between the easternmost corner of Banquereau Bank and the western border of Division 4W, whereas in 1985 and 1986 the surveys extended from the Laurentian Channel to the Fundian Channel. Redfish biomass estimates derived from surveys show that the proportion of total estimated biomass which occurs between 200 and 500 fms represents on average 41% (Table 9) of that occurring over the entire area (total July survey and redfish surveys). Since the proportion of bottom areas at these depths varies by division and subdivision the total proportion of redfish biomass resident at these depths also varies. Estimates from the 1985-86 surveys indicate that in 4Vn and 4Vs 44-72% of the biomass resides below 200 fms while in 4W and 4X this ranges from 2-17%.

The increase in estimated redfish biomass levels indicated by the July surveys in 1986 are corroborated by the results of the redfish directed surveys which indicate an increase in biomass at depths greater than 100 fathoms in all surveyed portions of the management unit (Cabot Strait to the Fundian Channel). These surveys also indicate that redfish densities are greatest at depths greater than 200 fms in all divisions and subdivisions at this time of year. Between 1985 and 1986, the redfish directed surveys indicated an increase in redfish density in the 200-500 fms strata for all years.

Redfish Length-Frequency Estimates

Redfish length-frequency estimates for the entire management unit from 1970-1986 are shown on Figure 9. The feature of primary interest is the large group first observed in 1982 at a modal length of 8 cm. Closer examination of this peak revealed that it is actually composed of two groups; one first appearing in the fall of 1981 primarily in 4Vs and the other in the summer and fall of 1982, again primarily in 4Vs and to some extent in 4Vn (Zwanenburg 1985). These two groups are easily followed through the population in 1983 to a point where they appear to dominate the population in 1984 at a modal length of 15 cm, in 1985 at a length of 18 cm, and in 1986 at a modal length of 20 cm. Examination of redfish length-frequency estimates for 1986 by individual areas within the management unit (Figure 10) indicate that these year-classes are present in all areas but predominate in 4Vs and 4W.

Length-frequency data obtained during the 1982 and 1983 redfish directed surveys were restricted to Unit Area 4Vsc and Division 4W and depths greater than 100 fathoms. The results indicate the presence of a large group of fish with a modal length of 15 cm in the fall of 1982 and 18 cm in the fall of 1983 (Figure 11). It is of interest to note that the abundant 1980-81 year-classes observed since the 1982 July survey were not apparent in the 1982 redfish survey. There is some evidence that these abundant small fish began to show up in the redfish surveys in 1983. Analysis of length-frequency data from the 1985 and 1986 redfish surveys may help verify this observation.

Redfish Length-Frequency Distribution in Commercial Catches

Length-frequencies of commercially landed redfish were determined from samples collected by the Scotia-Fundy National Sampling Program. To estimate these size frequencies, samples collected within a year were weighted by catch, pooled, and applied to the total catch for that year. A constant length-weight relationship (determined from a large sample size (Clay 1980)) was assumed across years. Males and females were combined since their length/weight relationships are not significantly different.

The estimates of commercial length-frequencies are compared to population length-frequency estimates derived from July groundfish surveys, in Figure 12. Two salient points emerge. The first is that the commercial length-frequencies consistently include greater numbers of larger fish than are estimated to be present by the July survey. The second is that the abundant 1981-1982 year-classes, now at a modal length of 20 cm, are beginning to recruit to the fishable portion of the population.

The underestimation of the larger length classes by the July survey relative to the commercial fishery may be attributable to greater depths at which the commercial fishery occurs (mainly between 150-200 fathoms). A comparison of population length-frequency estimates derived from the 1982 and 1983 redfish surveys to those of the 1982-1983 July groundfish surveys shows that the redfish surveys give higher estimates of numbers of animals in the larger size classes (Figure 11). This stems from the fact that redfish are size stratified with depth, with larger animals inhabiting greater depths, and that the redfish surveys are conducted across the whole range of redfish depth distribution including these deeper strata. Since the commercial fishery is also most active at depths greater than those surveyed by the July surveys, the redfish surveys may be better indicators of the length-frequency distribution available to the commercial fishery.

Estimation of Fishable Biomass

Estimation of fishable biomass required an estimate of the selection or partial recruitment (PR) ogive of the fish to the fishery by length or age. Since no aged data are available, partial recruitment at length was calculated. Initially we attempted to estimate PR by normalizing:

$$\frac{C_{ij}}{S_{ij}}$$

where C_{ij} is the number of animals in the commercial catch at length i in year j and S_{ij} is the number of animals in the population at length i and year j estimated from July groundfish surveys. The results for 1980-1986 (Figure 13) indicates that this ratio does not reach an asymptote but continues to increase to a maximum with increasing length in most years. This may indicate that the survey is underestimating the availability of the larger fish to the fishery. Since the redfish surveys are conducted in the same depth ranges as the commercial fishery, we next attempted to estimate PR by normalizing C_{ij}/S_{ij} for the redfish surveys. In order to ensure comparability of the survey catch and commercial catch numbers at length we recalculated the commercial numbers at length for catches taken in the area of the survey (4VsW in 1982-1983). The resultant vectors of normalized C_{ij}/S_{ij} values for 1982 and 1983 are given on Figure 14 indicating full recruitment at 24 cm. Recruitment was assumed to be complete (1.0) at lengths beyond 24 cm. Given the similarity of the 1982 and 1983 partial recruitment curves, we calculated a mean value at each length (Figure 15).

Population biomass at length was calculated by converting numbers at length, estimated from July groundfish surveys, to biomass at length using Clay's (1980) combined male/female length weight relationship. Annual fishable biomass for the management unit between 1970 and 1986 was estimated by applying the mean PR vector estimated above to the annual estimates of biomass at length (Figure 16). A three year median smooth of these data indicate little or no trend in estimated fishable biomass since 1970.

The absolute values of the annual fishable biomass estimates are inconsistent with estimates of trawlable biomass in that the former exceed the latter. This is probably attributable to the use of a constant and perhaps poorly estimated length-weight relationship across all years. This, coupled with the calculation of selection ogives based on only an isolated portion of the fishery, make the present estimates of fishable biomass less than reliable. A more detailed and inclusive spatio-temporal analysis of both PR and population length- frequencies in conjunction with annual (or seasonal) estimates of the length weight relationships would improve the efficacy of these estimates.

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Table 1. Total redfish landings from 4VWX.

Year	4Vn	4Vs	4W	4X	Total
1968	7730	2222	1169	1982	13103
1969	6259	9347	3684	2763	22053
1970	4246	6694	16215	4424	31579
1971	6954	23698	19953	11776	62381
1972	4525	14580	22223	8972	50300
1973	7125	11213	14709	7126	40173
1974	6985	8112	11587	6153	32837
1975	7821	6772	9487	3903	27983
1976	5704	4718	3225	4812	18459
1977	5223	7123	2274	3225	17845
1978	3937	7856	1621	2680	16094
1979	4706	4979	1948	1521	13154
1980	3893	5431	2441	2351	14116
1981	6657	6789	3045	2453	18944
1982	6561	4585	598	4347	16091
1983	3706	3758	1491	3926	12881
1984	2209	2367	1708	4006	10290
1985	3205	4505	1843	4445	13998*
1986	3140	1461	1144	5415	12718**

* Provisional data.

** Provisional data (total includes landings for which area is not yet available).

Table 2. TAC's, quotas, allowances, and catches since 1974.

	1976	1977	1978	1979		1980		1981		1982	1983	1984	1985	1986
TAC	20000	20000	20000	20000	20000	30000	30000	30000	30000	30000	30000	30000	30000	30000
Landings	18459	17845	16094		13154		14116		18944	16092	12881	10290	13900	
Canada:														
Quota	12000	13000	17500	13000	18000	18500	29000	18500	29000	25000	27000	28000**	28000	26500
Landings	12625	14712	13576		12240		13108		17753	14366	11988	8053	12835	11160
France:														
Quota	250	250	250	500[a]	500[a]	500[a]	500[a]	500[a]	500[a]	500[a]	500[a,b]	500	500	500
Landings	279	63	121		20		21		3	2	4	2	5	
Japan												1500	1500	1500
												1330	923*	1489
Poland:														
Quota		Subsequent catches included with "Others".												
Landings														
USSR:														
Quota	1000	500												
Landings	1021	175	Subsequent catches included with "Others".											
USA:														
Quota	6000	6000	1500	See "Others"		10500	0	0	0	0	0	0	0	0
Landings	4446	2876	2147				885		762	1611	815	872	31	62
Others:														
Quota	750	250[b]	750[b]	6500	1500	500	500	11000	500	0	0	0	0	0
Landings	88	19	250		894		102		426	113	74	33	204	1500
Reserve										4500	2500	1000**		

[a] St. Pierre vessels only
[b] By-catch only
* Provisional Statistics
** Resource Short Plant Program

Landings to 1983 are from ICNAF and NAFO Statistical Bulletins.
In 1979, 1980 and 1981 quotas were amended during the year; initial and final ones are given.

Table 3. Total redfish landings by Scotia-Fundy OTB1-TC4 and OTB2-TC5 from 4VWX.

	4Vn		4Vs		4W		4X	
Year	OTB1	OTB2	OTB1	OTB2	OTB1	OTB2	OTB1	OTB2
1968	1892	70	985	217	198	103	1007	227
1969	2195	246	801	154	1537	177	1523	447
1970	1176	665	787	374	4087	1410	2222	752
1971	3189	511	4942	1441	4419	942	4515	1696
1972	1472	595	3077	968	5030	1482	1555	617
1973	1848	503	2246	298	3210	405	802	112
1974	2795	691	2924	423	1480	287	812	435
1975	1428	1492	1946	488	2174	487	475	378
1976	807	330	1717	171	1470	280	602	263
1977	1112	1115	2655	1099	635	654	479	307
1978	758	516	1795	2234	474	823	333	264
1979	1405	457	972	2185	546	1150	478	187
1980	1044	196	1286	2927	408	1672	516	586
1981	1795	1048	1640	3703	383	2044	1059	405
1982	743	1277	1756	1784	149	280	1035	1111
1983	1216	1319	1334	1514	308	723	1331	786
1984	319	582	562	1075	989	255	1328	171
1985	270	966	300	2506	978	195	2437	84
1986	369	575	162	671	681	62	2199	728

Table 4. Redfish landings by Scotia-Fundy trawlers (Tonnage Classes 1-3).

	Division			
Year	4Vn	4Vs	4W	4X
1968	82	58	2	39
69	166	12	6	113
1970	164	0	2	133
71	114	0	0	476
72	137	32	23	92
73	26	3	16	112
74	3	0	246	66
75	0	0	0	66
76	26	0	57	55
77	1	1	57	82
78	1	0	5	3
79	3	0	4	20
1980	6	8	5	202
81	139	4	116	136
82	36	63	3	422
83	0	2	32	693
84	4	2	298	1482
85	1	4	438	1825
86	59	32	344	2410

Table 5. Redfish landings by Scotia-Fundy OTB1-TC4 for 4VWX by Quarter.

	4Vn				4Vs				4W				4X			
Year	1st	2nd	3rd	4th	1st	2nd	3rd	4th	1st	2nd	3rd	4th	1st	2nd	3rd	4th
1968	67	971	380	474	199	315	83	388	51	75	51	21	45	200	646	116
1969	191	788	681	535	263	303	108	127	19	267	1199	52	113	456	660	294
1970	345	139	268	424	250	60	59	418	45	839	2819	384	57	156	1465	544
1971	116	1477	1105	491	740	2204	1270	728	708	1085	2466	160	41	1270	2407	797
1972	507	583	278	104	575	1500	788	214	308	1726	2367	629	48	676	724	107
1973	263	443	545	597	354	683	538	671	611	920	1043	636	40	459	203	100
1974	339	185	1422	849	607	809	803	705	202	435	617	226	311	138	256	107
1975	130	255	676	367	174	780	577	415	382	618	503	671	19	232	197	27
1976	168	94	457	88	165	616	915	21	39	614	794	23	42	132	389	39
1977	12	116	712	272	70	880	1301	404	23	153	355	104	9	93	334	43
1978	8	143	540	67	60	840	641	254	4	56	386	28	11	20	185	117
1979	13	115	1061	216	2	263	650	57	17	308	183	38	96	120	106	156
1980	10	243	789	2	23	329	708	226	19	168	203	18	7	62	381	66
1981	7	211	1050	527	32	590	507	511	13	108	42	220	36	1	637	385
1982	1	162	523	57	29	291	762	674	0	53	75	21	0	77	422	536
1983	10	589	611	6	24	47	524	739	0	5	23	280	2	124	735	470
1984	4	35	241	39	3	88	467	4	13	0	447	529	112	334	537	345
1985	10	16	235	9	0	49	251	0	0	521	456	0	379	670	863	525
1986	2	14	239	114	4	73	52	32	0	327	20	333	171	944	695	389

Table 6. Redfish landings by Scotia-Fundy OTB2-TC5 for 4VWX by Quarter.

	4Vn				4Vs				4W				4X			
Year	1st	2nd	3rd	4th	1st	2nd	3rd	4th	1st	2nd	3rd	4th	1st	2nd	3rd	4th
1968	0	70	0	0	60	52	0	105	19	18	0	66	51	6	53	117
1969	0	28	6	212	90	7	10	47	45	1	119	12	100	49	185	113
1970	176	11	327	151	217	14	5	138	56	13	332	1009	20	167	225	340
1971	117	42	309	43	633	528	79	201	108	347	241	246	40	523	801	332
1972	92	289	185	29	466	191	194	117	165	341	744	232	19	266	257	75
1973	420	31	23	29	89	152	34	23	249	97	27	32	50	2	13	47
1974	231	146	58	256	208	116	61	38	7	102	143	35	0	38	322	75
1975	356	85	780	271	110	94	230	54	29	193	12	253	7	94	157	120
1976	194	130	0	6	90	51	23	7	26	218	5	31	24	99	58	82
1977	108	261	718	28	55	111	497	436	37	59	493	65	33	125	52	97
1978	55	39	345	77	197	1089	610	338	32	343	345	103	21	168	64	11
1979	72	132	211	42	155	518	308	1204	2	684	402	62	19	4	1	163
1980	48	6	124	18	149	609	1630	539	32	785	648	207	36	222	80	248
1981	4	363	622	59	95	1809	1685	114	37	1282	594	131	12	252	46	95
1982	0	191	919	167	39	154	1355	236	10	96	97	77	67	106	495	443
1983	8	73	1092	146	146	389	869	110	36	279	210	198	172	158	284	172
1984	6	191	248	137	654	159	183	79	83	64	85	23	14	106	43	8
1985	3	221	453	289	836	359	802	509	9	2	153	32	19	19	1	45
1986	67	120	269	119	150	293	150	78	1	18	0	43	292	153	2	281

Table 7. Arithmetic mean biomass by depth estimated from redfish surveys. (Numbers in brackets are from the July groundfish surveys.)

Area	Depth (fm)	1982 (N005)	1983 (N020)	1985 (N053)	1986 (N069)
4Vn	100-200			13076 (5517)	38191 (13791)
	200-300			10968	16210
	300-400			-	-
	400-500			-	-
	∑			24044	54401
	200+ ∑			10968	16210
4Vs	100-200	3500 (1303)	4260 (1843)	17738 (9072)	41447 (18853)
	200-300	7068	2380	46986	113967
	300-400	2656	1085	2316	7050
	400-500	490	650	0	59
	∑	13714	8375	67040	162253
	200+ ∑	10214	4115	49302	121706
4W	100-200	1275 (156)	308 (1390)	6038 (158)	1171 (199)
	200-300	5259	3489	1631	3370
	300-400	11064	924	312	1514
	400-500	165	406	132	0
	∑	17760	5127	8113	6055
	200+ ∑	16488	4819	2075	4884
4X	100-200			490 (0)	1184 (260)
	200-300			572	1649
	300-400			23	26
	400-500			0	0
	∑			1085	2859
	200+ ∑			595	1705

Table 8. Geometric mean biomass by depth estimated from redfish surveys. (Numbers in brackets are from the July groundfish surveys.)

Area	Depth (fm)	1982 (N005)		1983 (N020)		1985 (N053)		1986 (N069)	
4Vn	100-200					11842	(5452)	23302	(8312)
	200-300					6799		11787	
	300-400					-		-	
	400-500					-		-	
	∑					18641		35090	
	200+ ∑					6798		11788	
4Vs	100-200	989	(438)	1182	(0)	3054	(1238)	4754	(2993)
	200-300	2082		779		21269		37034	
	300-400	608		70		75		441	
	400-500	27		78		0		35	
	∑	3707		2109		24398		42266	
	200+ ∑	2717		926		21344		37512	
4W	100-200	285	(203)	234	(381)	197	(33)	211	(99)
	200-300	650		1691		422		703	
	300-400	166		155		72		125	
	400-500	42		135		38		0	
	∑	1144		2215		730		1039	
	200+ ∑	859		1980		53		828	
4X	100-200					76	(0)	165	(121)
	200-300					158		554	
	300-400					17		26	
	400-500					0		0	
	∑					252		746	
	200+ ∑					176		580	

Table 9. Proportional distribution of redfish biomass by depth and NAFO area. (Details of calculations given in the text.)

Year	Area	Arithmetic Biomass > 200 fm (Total Biomass)	Proportion > 200 fm	Geometric Biomass > 200 fm (Total Biomass)	Proportion > 200 fm
1985	4Vn	10968 (18016)	.61	6798 (12882)	.47
	4Vs	49302 (112718)	.44	21344 (43829)	.49
	4W	2075 (11883)	.17	533 (5664)	.09
	4X	595 (13300)	.04	176 (7136)	.02
	∑	62940 (155914)	.40	28851 (69514)	.42
1986	4Vn	16210 (31180)	.52	11788 (20518)	.57
	4Vs	121706 (169512)	.72	37512 (57707)	.65
	4W	4884 (48824)	.10	828 (8931)	.09
	4X	1705 (78665)	.02	580 (33442)	.02
	∑	144505 (328181)	(.44)	50708 (120598)	(.42)

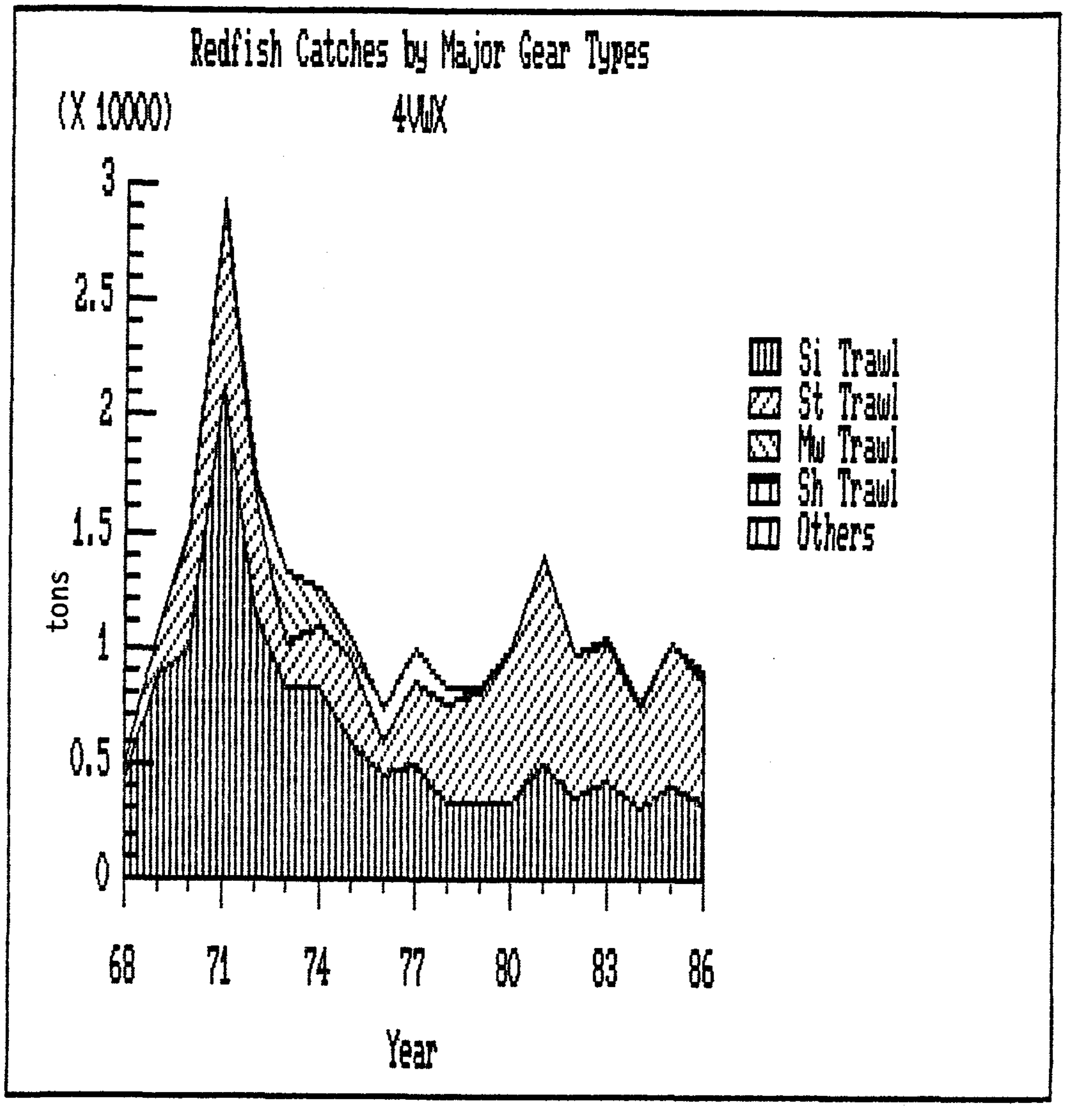
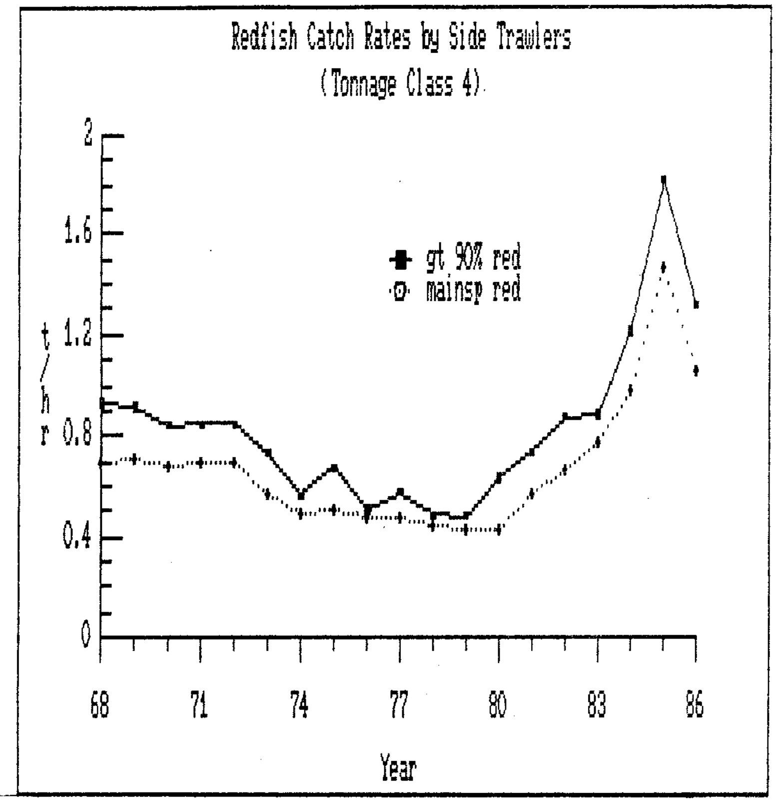


Figure 1. Redfish landings (Scotia-Fundy) from management unit 4VWX by major gear type (Si = side; st = stern; Mw = mid-water; Sh = shrimp.)

A



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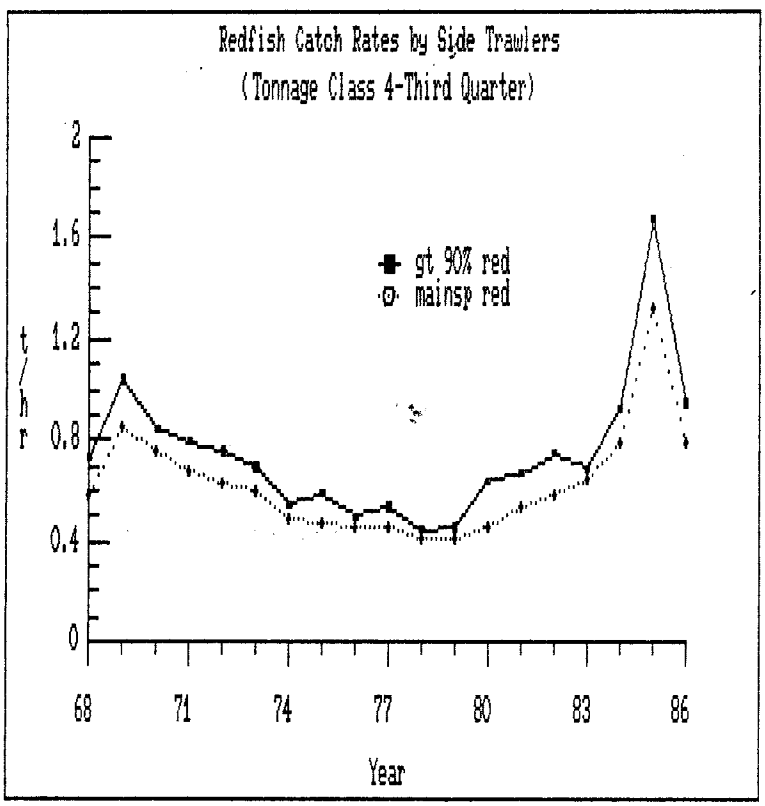
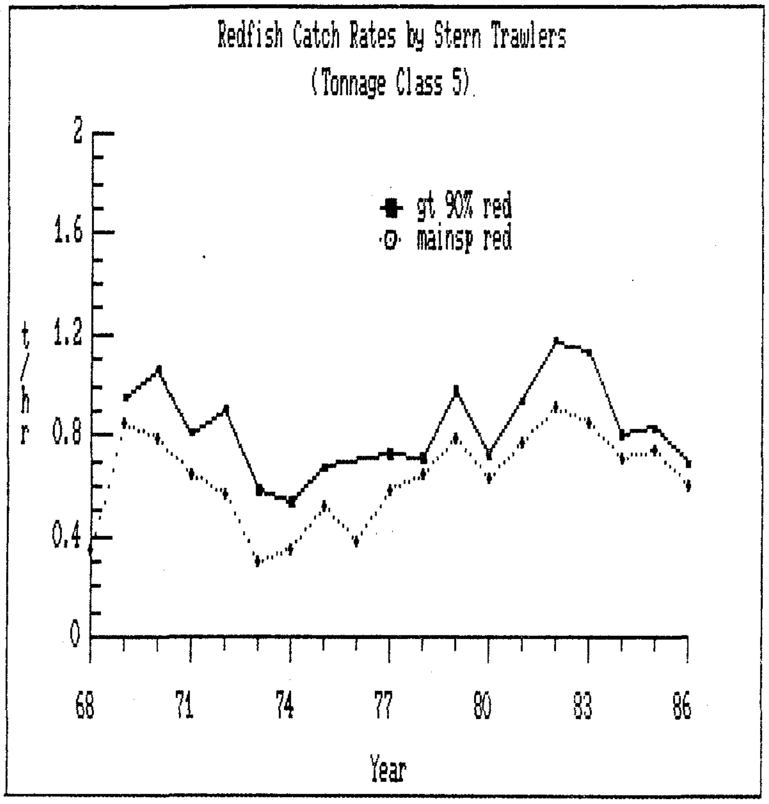


Figure 2. Redfish catch rate series (Scotia-Fundy vessels) for tonnage class 4 side trawlers (OTB1-TC4) calculated from (A) total annual catch and effort, and (B) 3rd Quarter catch and effort, where main species is redfish and where redfish comprise 90% or more of total catch reported for any trip.

A



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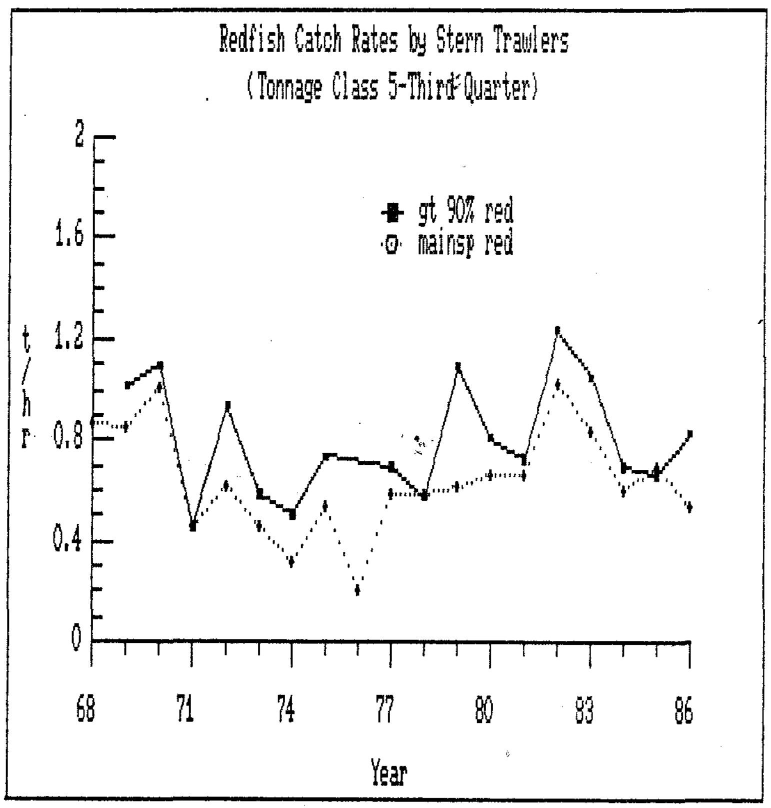
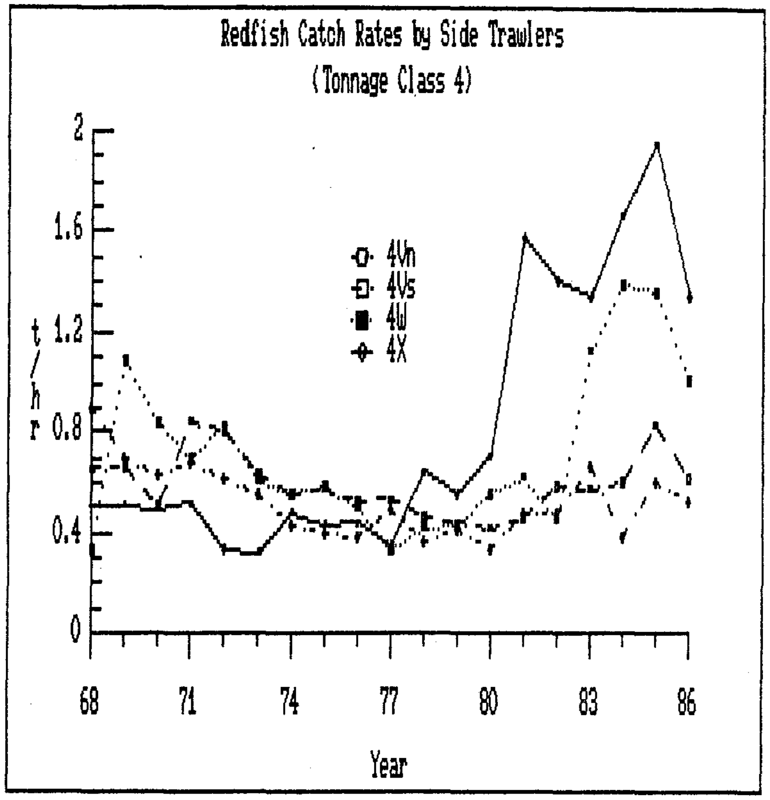


Figure 3. Redfish catch rate series (Scotia-Fundy vessels) for tonnage class 5 stern trawlers (OTB2-TC5) calculated from (A) total annual catch and effort, and (B) 3rd Quarter catch and effort, where main species is redfish and where redfish comprise 90 or more of total catch reported for any trip.

A



B

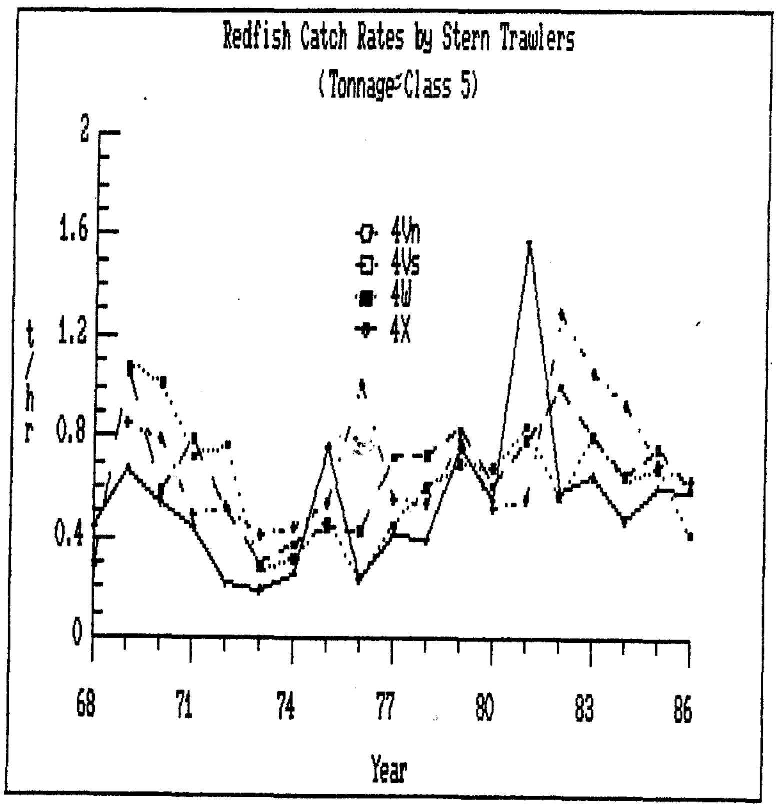


Figure 4 . Redfish catch rate series (Scotia-Fundy vessels) calculated from total annual catch and effort by division and subdivision for (A) tonnage class 4 side trawlers, and (B) tonnage class 5 stern trawlers.

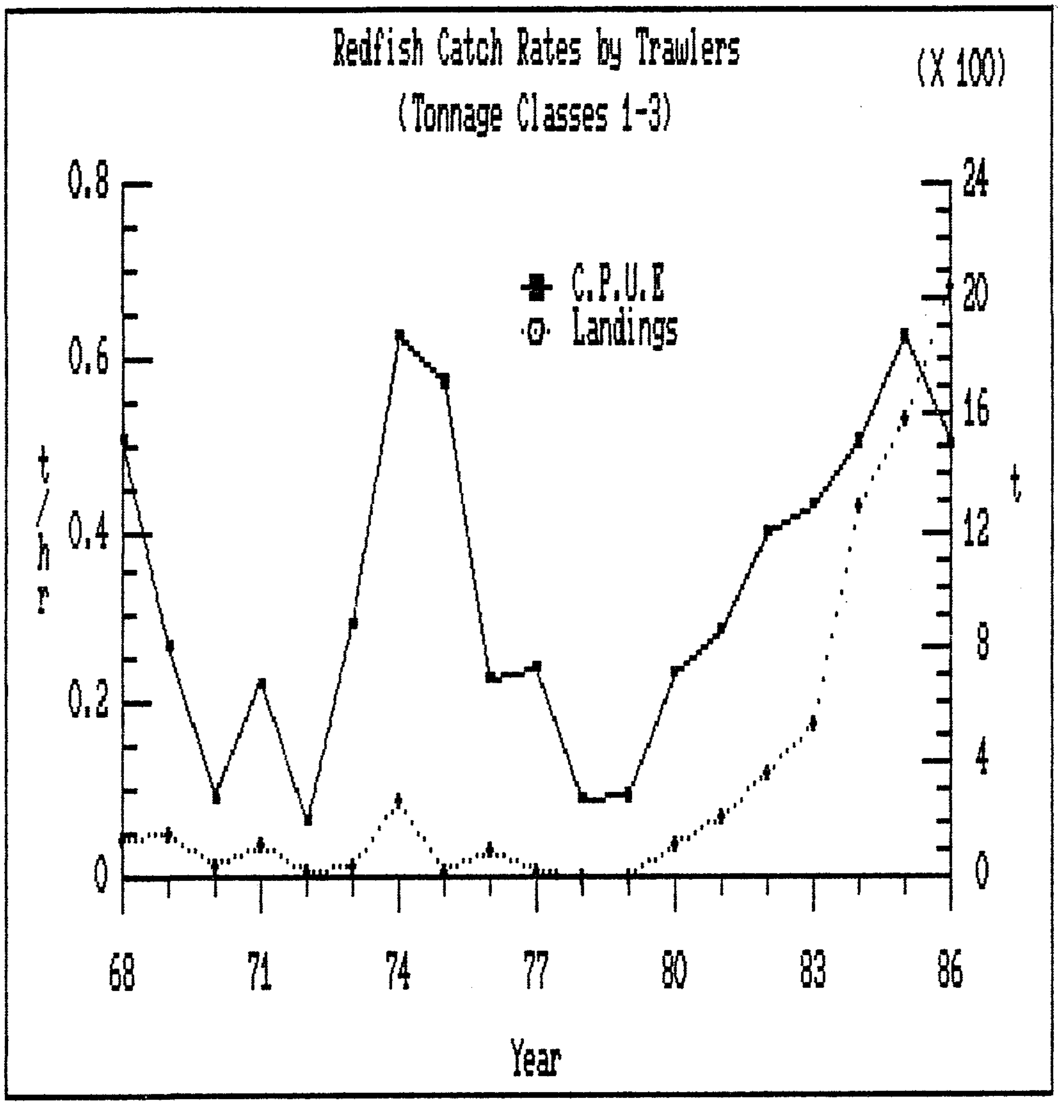


Figure 5. Redfish catch rate series and landings (Scotia-Fundy vessels) for tonnage class 1-3 side and stern trawlers. Catch rate calculated from total annual catch and effort.

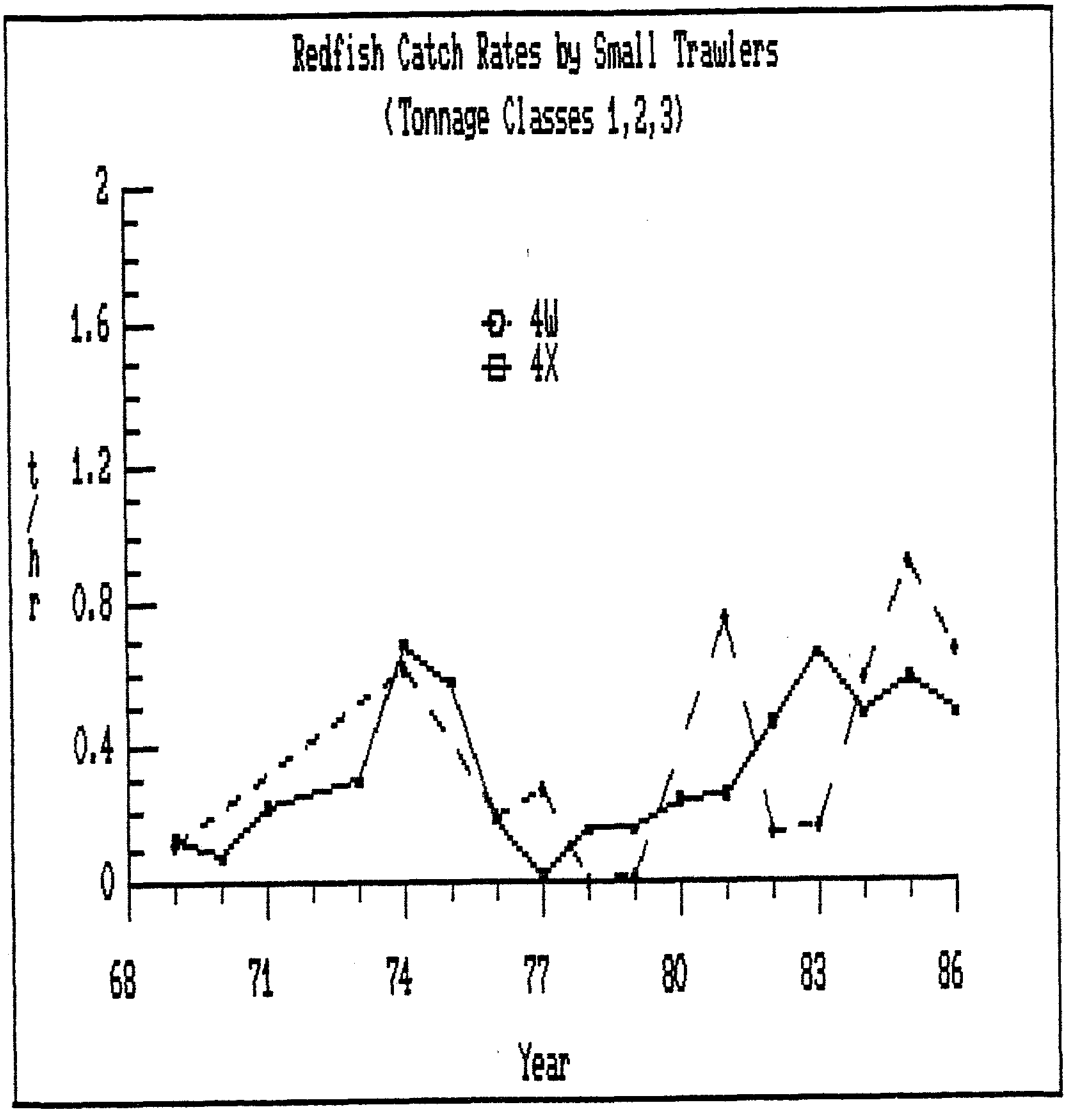


Figure 6. Redfish catch rate series (Scotia-Fundy vessels) for tonnage class 1-3 side and stern trawlers calculated from total annual catch and effort by division.

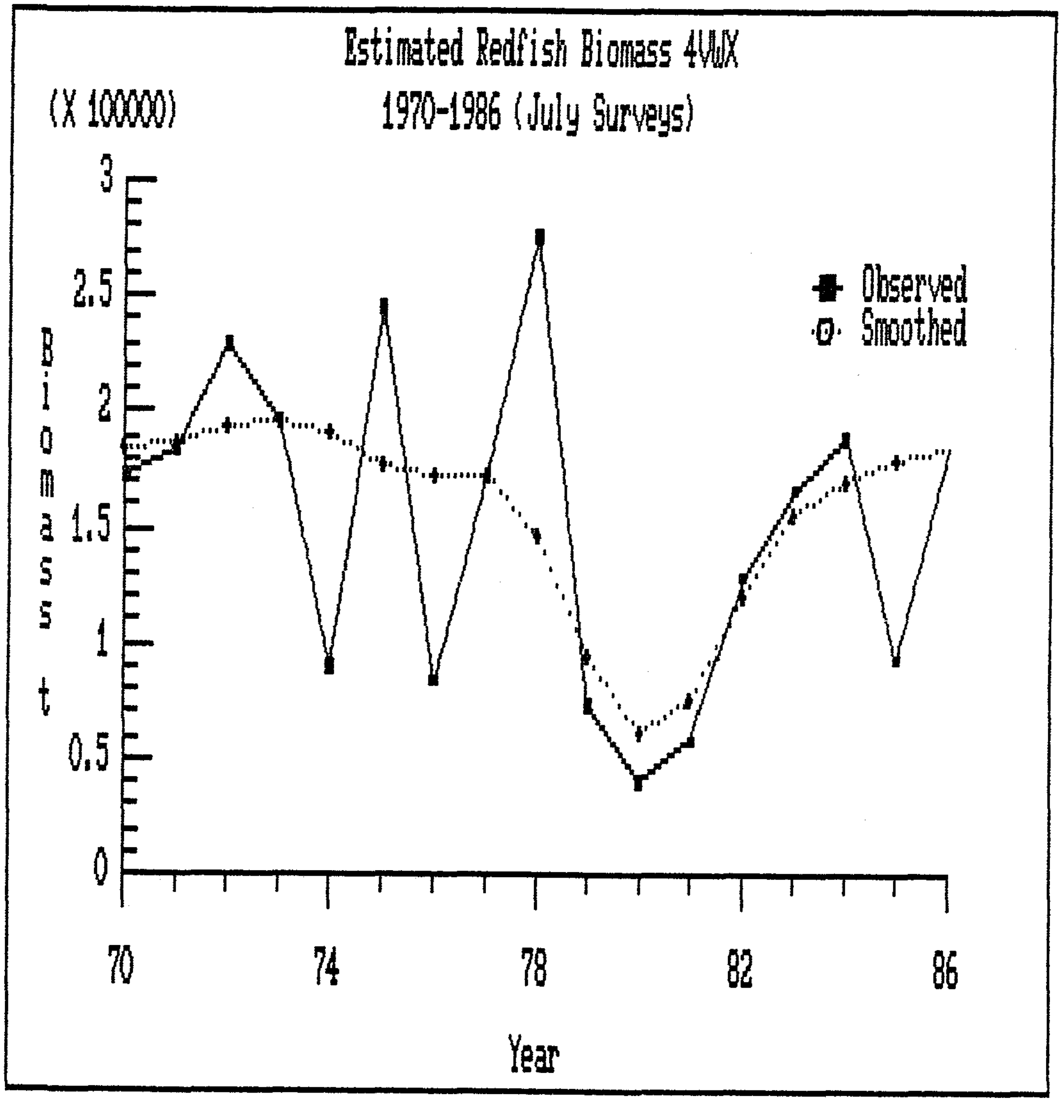


Figure 7. Annual estimates of redfish biomass in management unit 4VWX from July groundfish surveys, 1970-86.

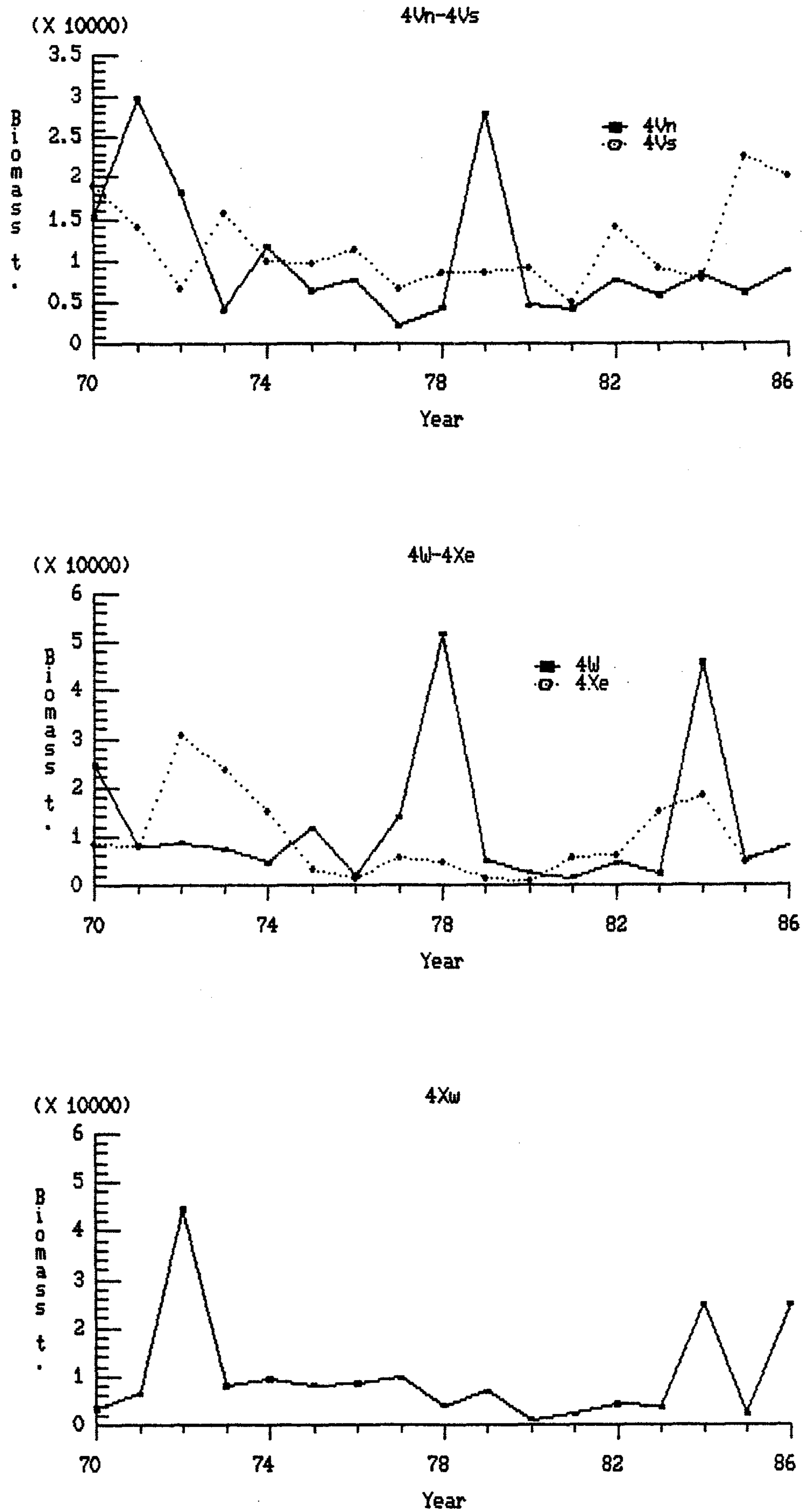


Figure 8. Annual estimates of redfish biomass by division and subdivision from July groundfish surveys, 1970-86.

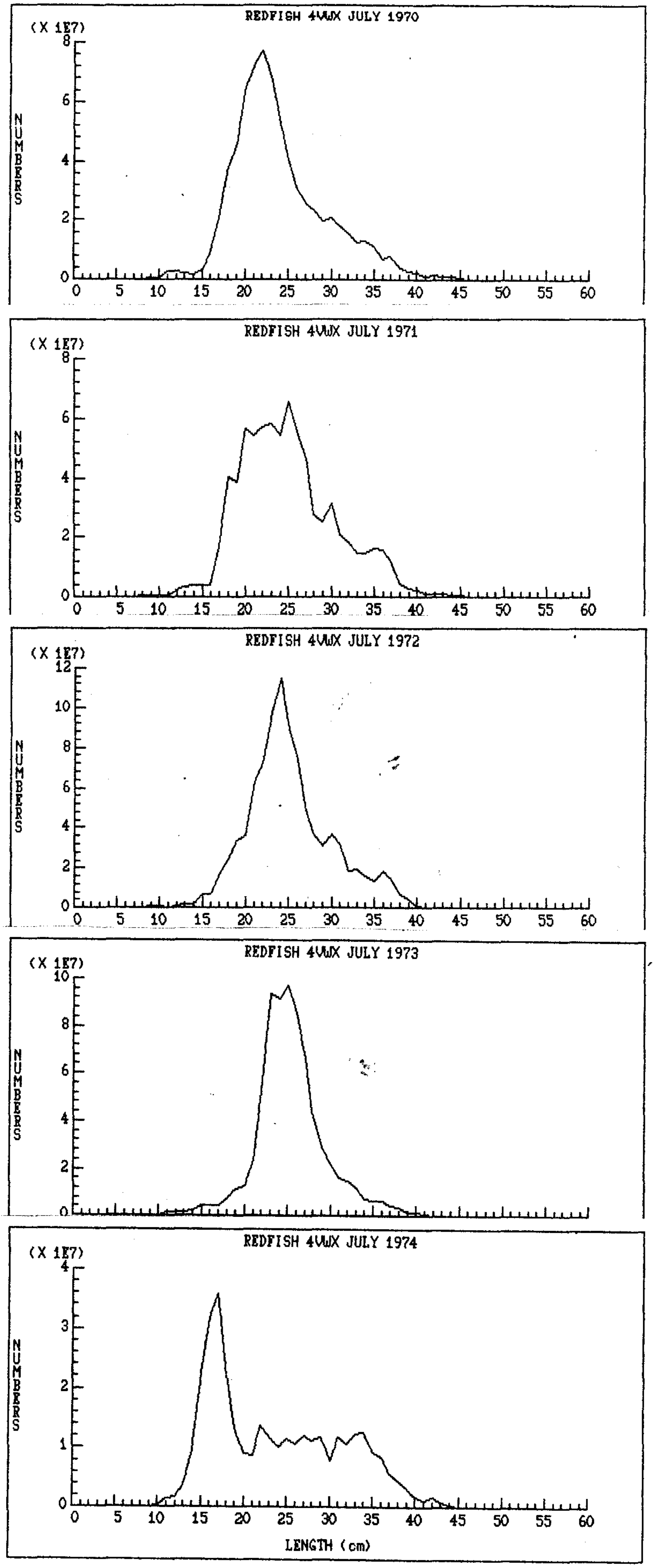
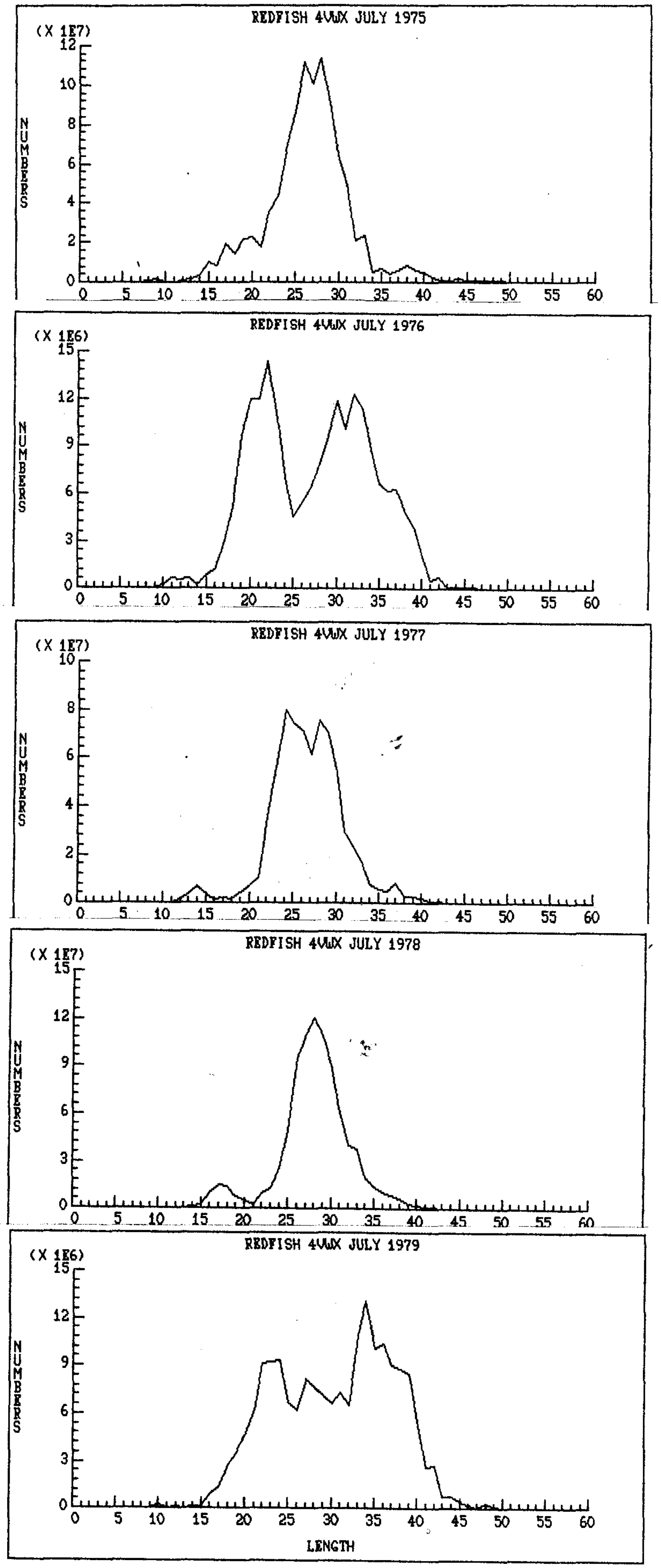


Figure 9. Estimated length-frequency distributions of redfish in management unit 4VWX from July groundfish surveys, 1970-86.



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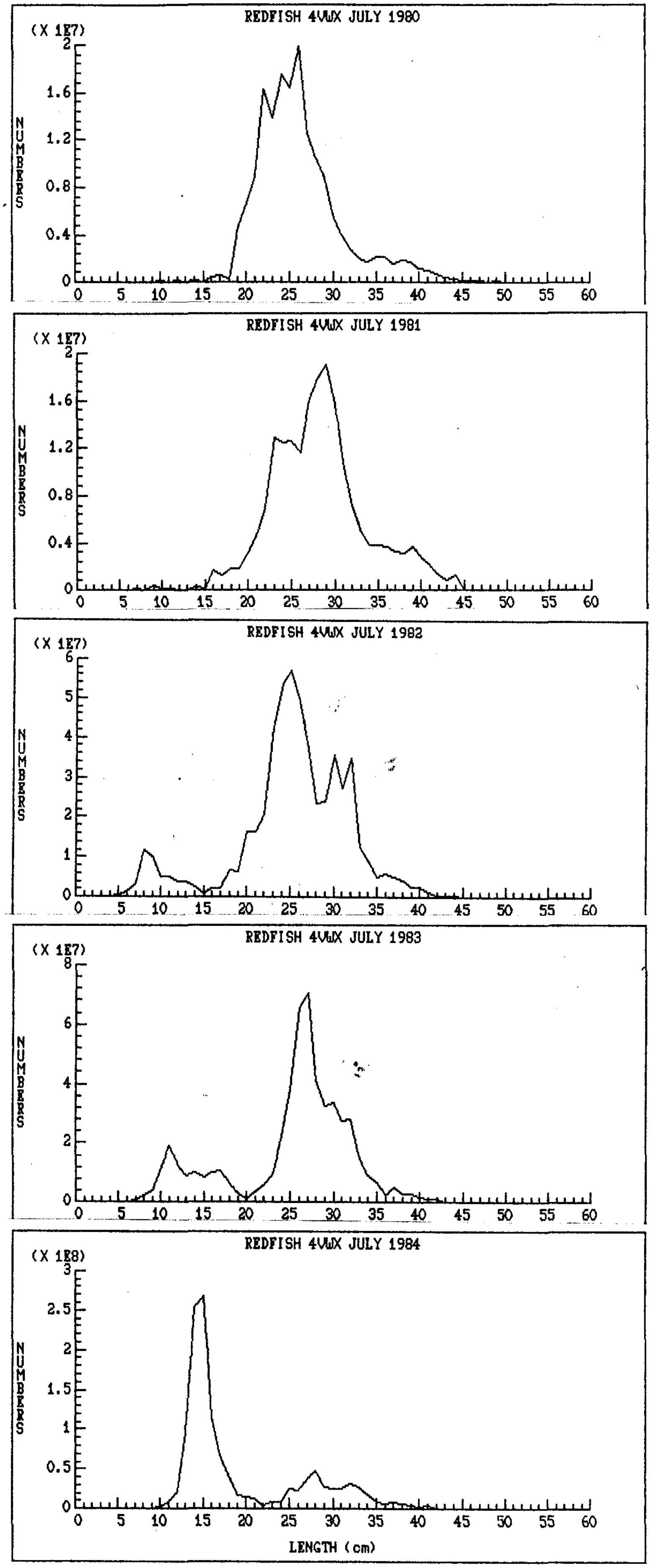

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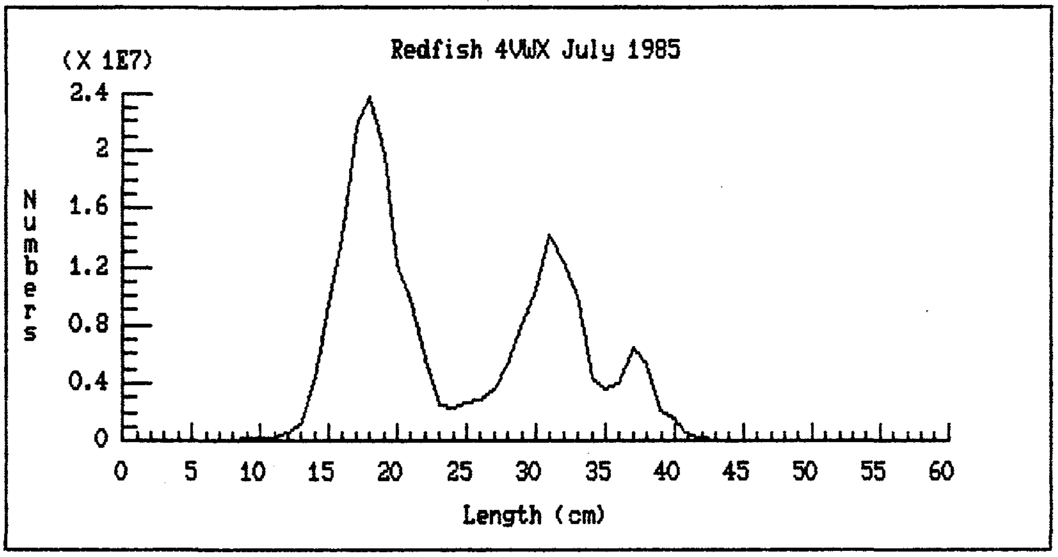


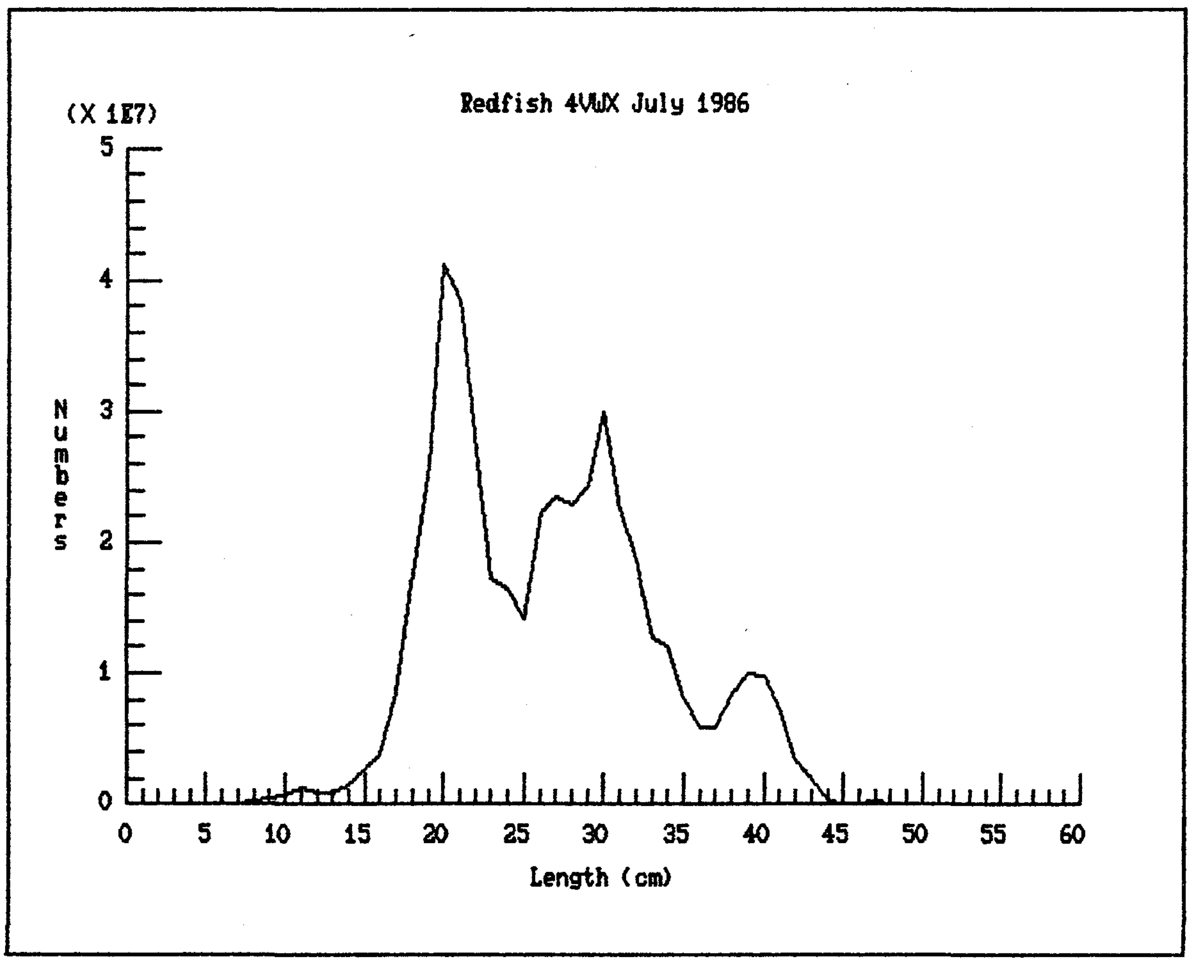


Figure 9. (Continued).

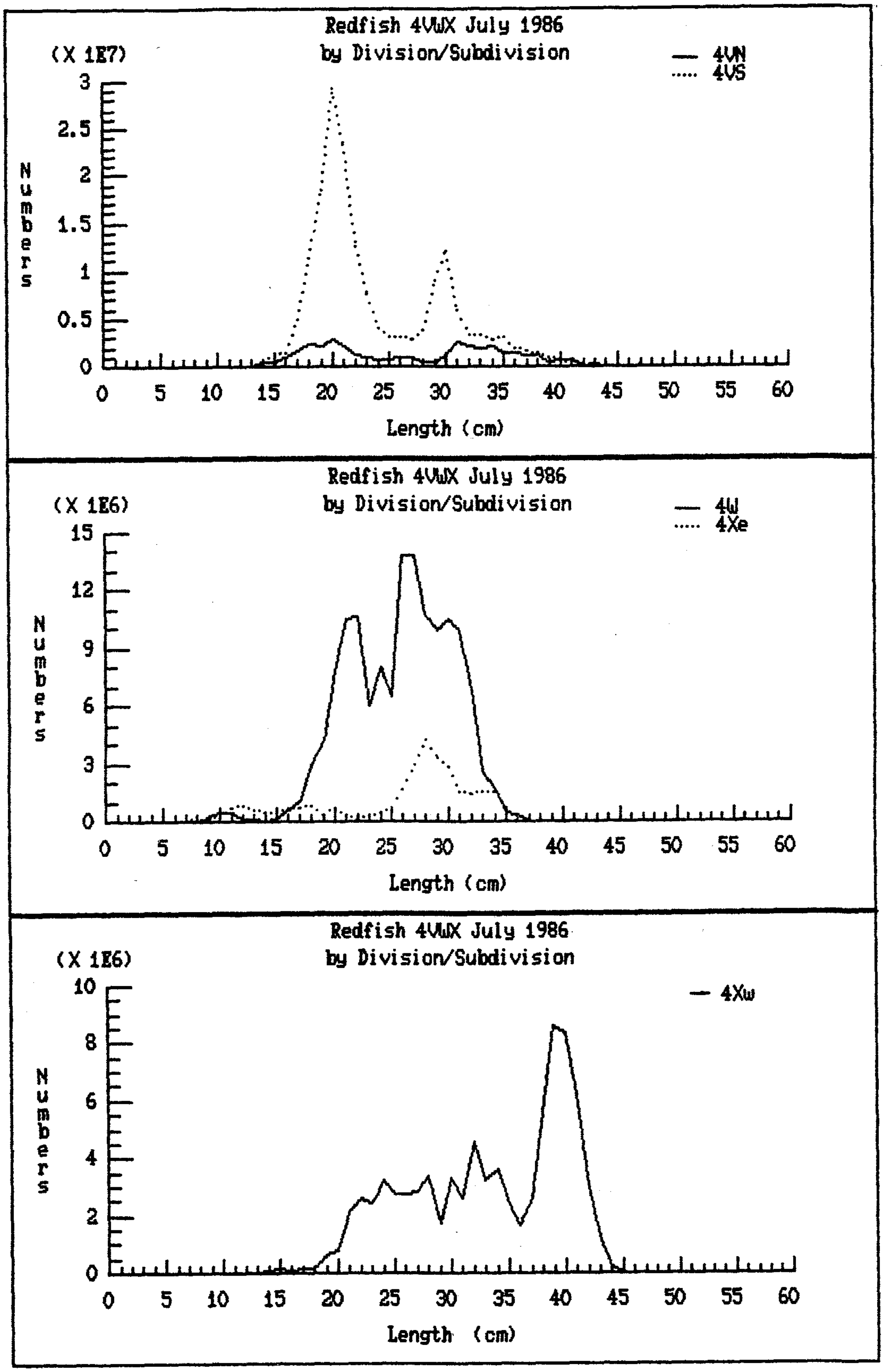
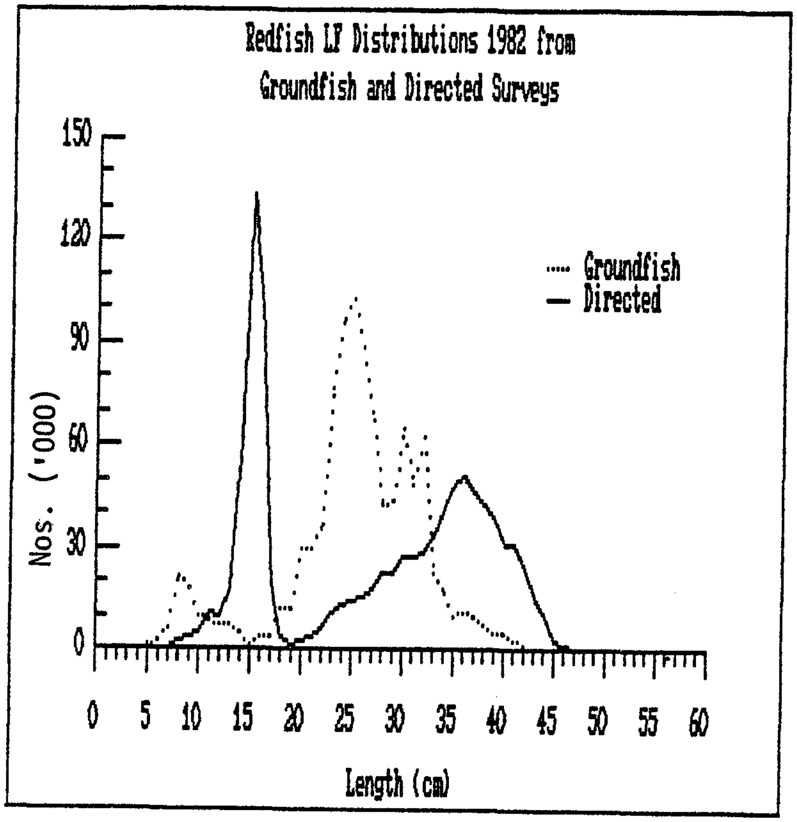


Figure 10. Estimated length-frequency distributions of redfish by division and subdivision from July 1986 groundfish survey.

A



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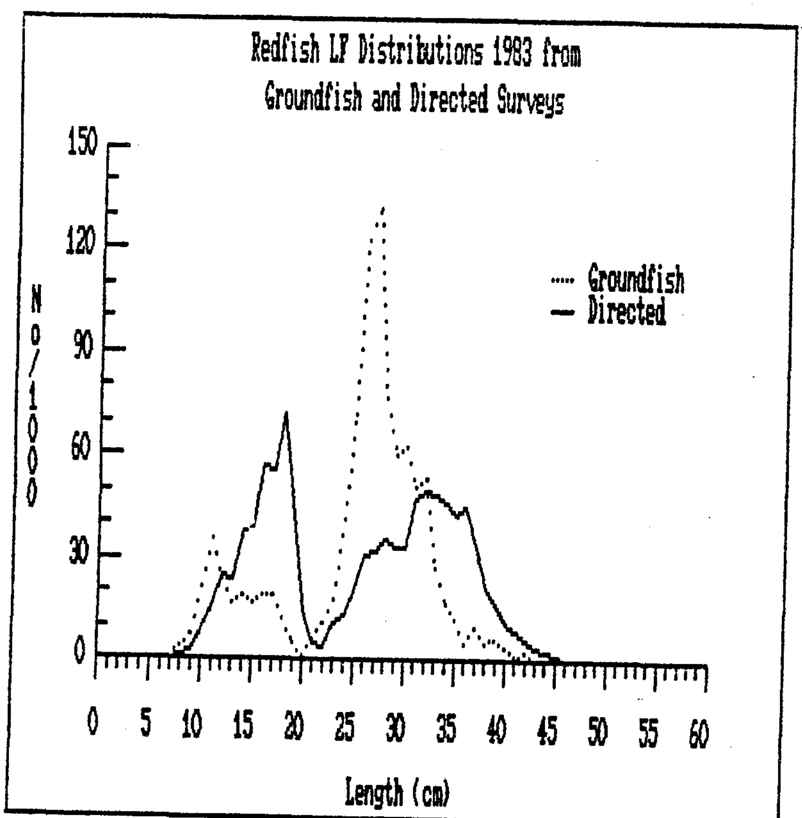
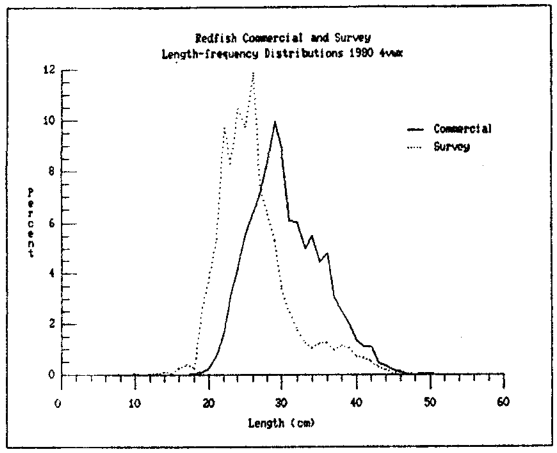
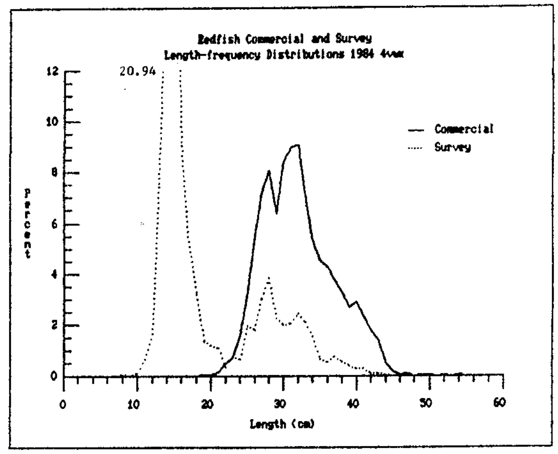
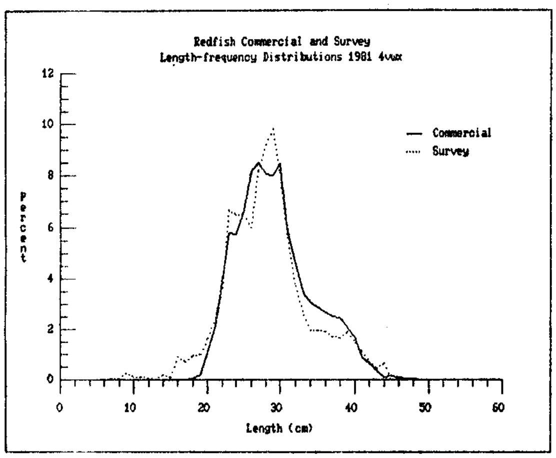
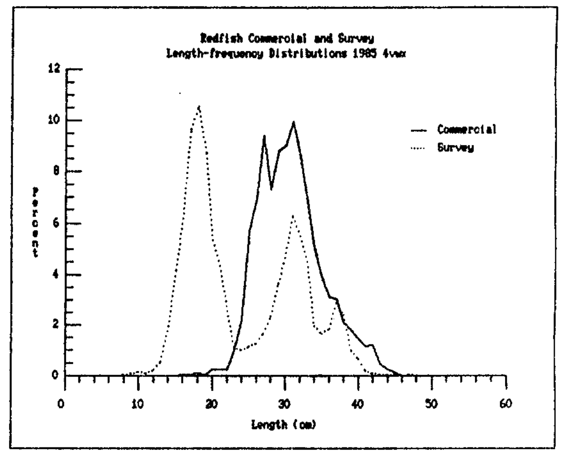


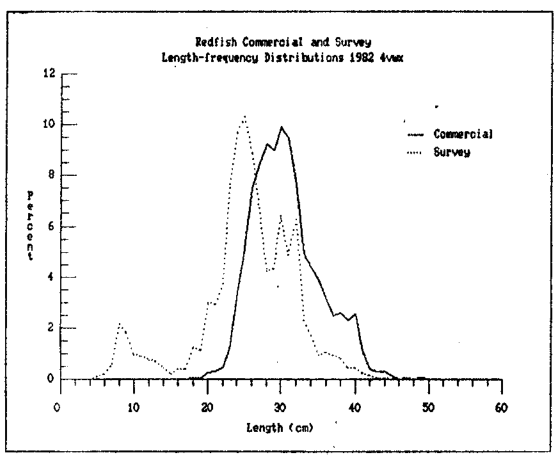
Figure 11. Redfish length-frequency distributions estimated from July groundfish surveys and directed redfish surveys, (A) 1982 and (B) 1983, in management unit 4VWX

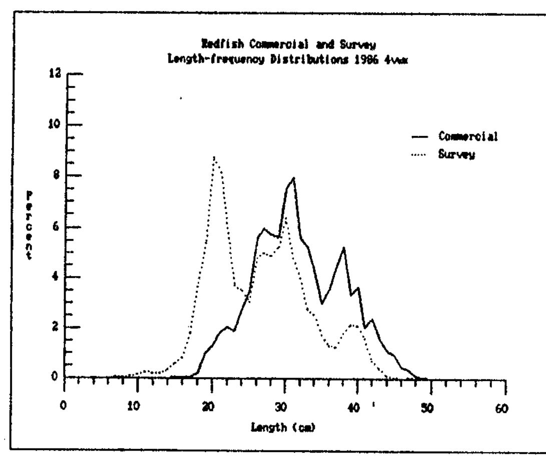












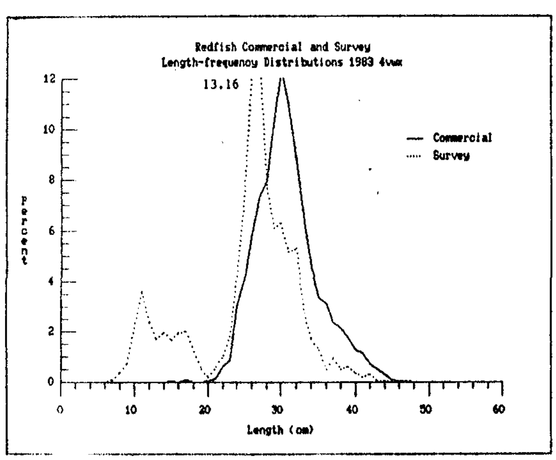
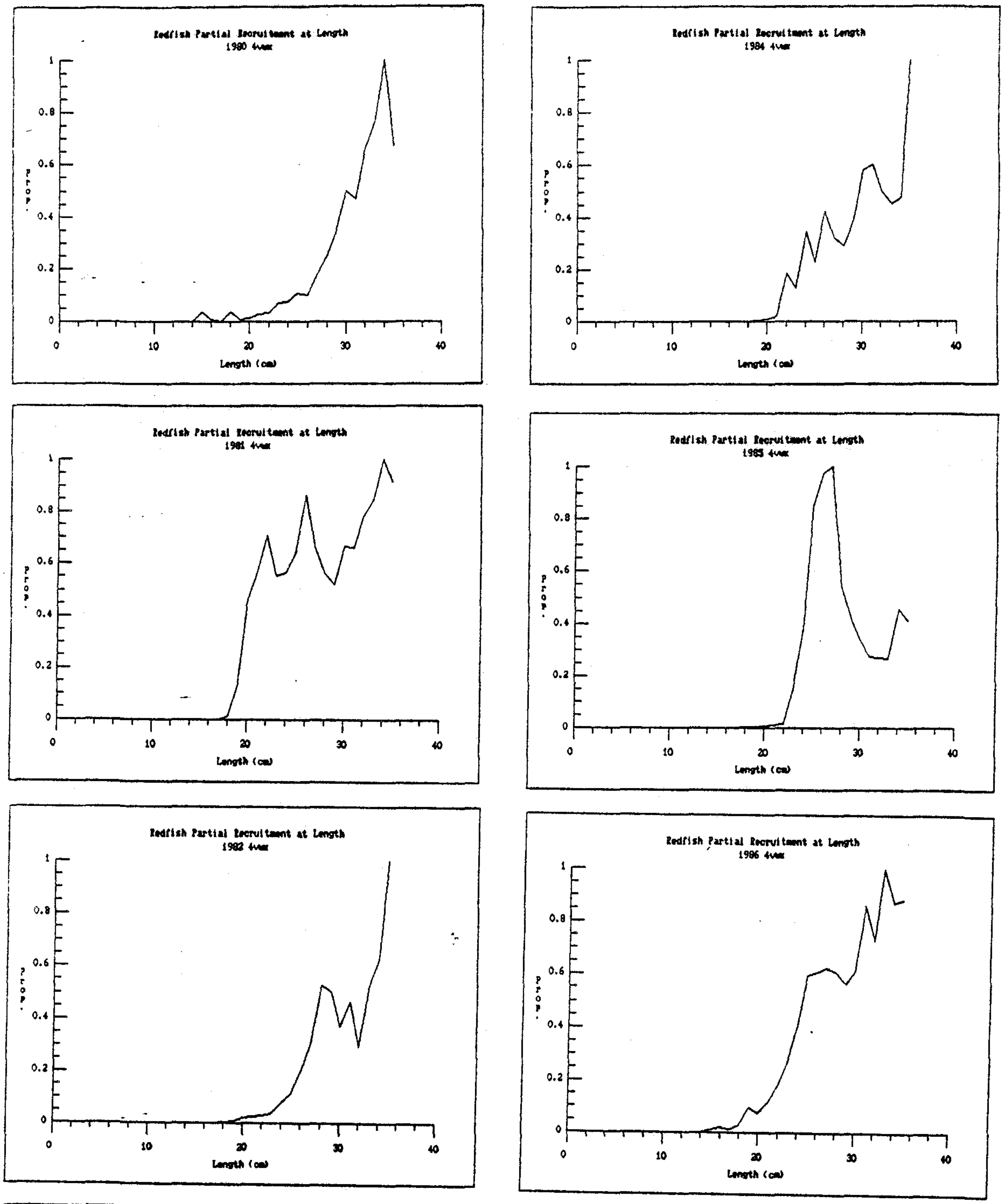


Figure 12. Estimated length-frequency distributions of redfish from commercial samples and from July groundfish surveys, 1980-86.



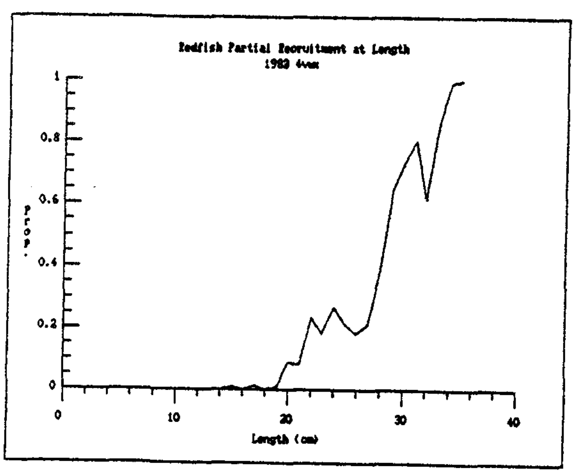


Figure 13. Redfish partial recruitment at length calculated from catch numbers over survey numbers, 1980-86.

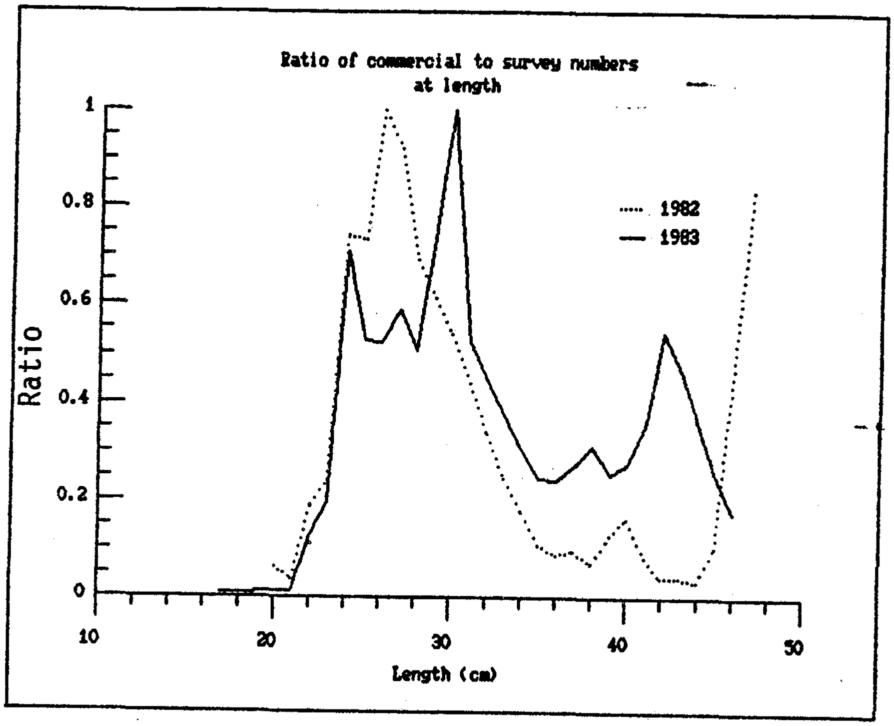


Figure 14. Normalized ratio of commercial and survey numbers at length, using redfish directed surveys from 1982 and 1983.

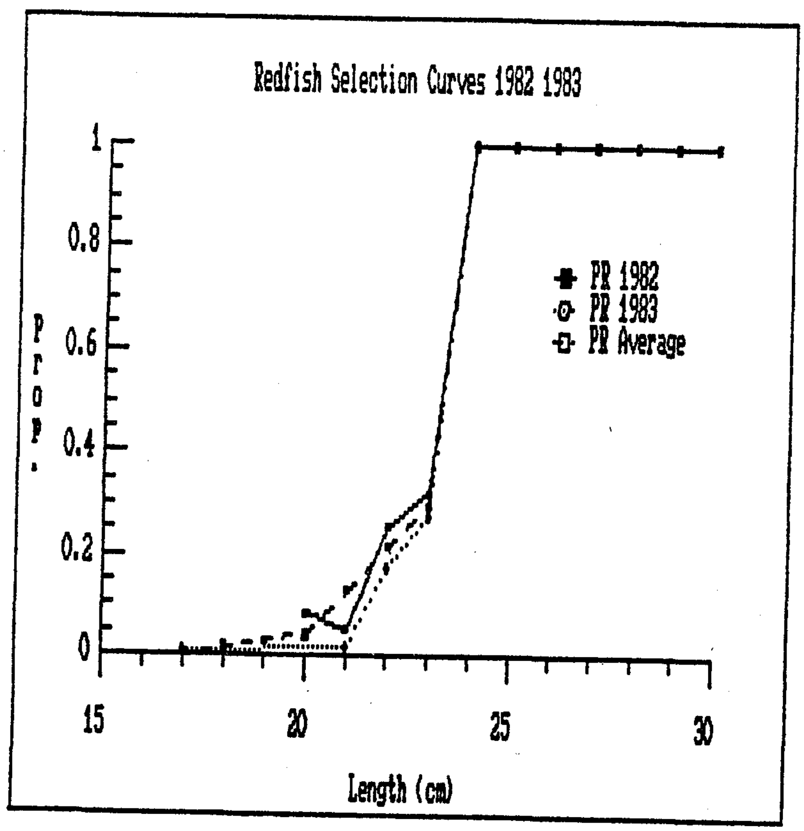


Figure 15. Redfish partial recruitment curves calculated from redfish directed surveys, 1982-83.

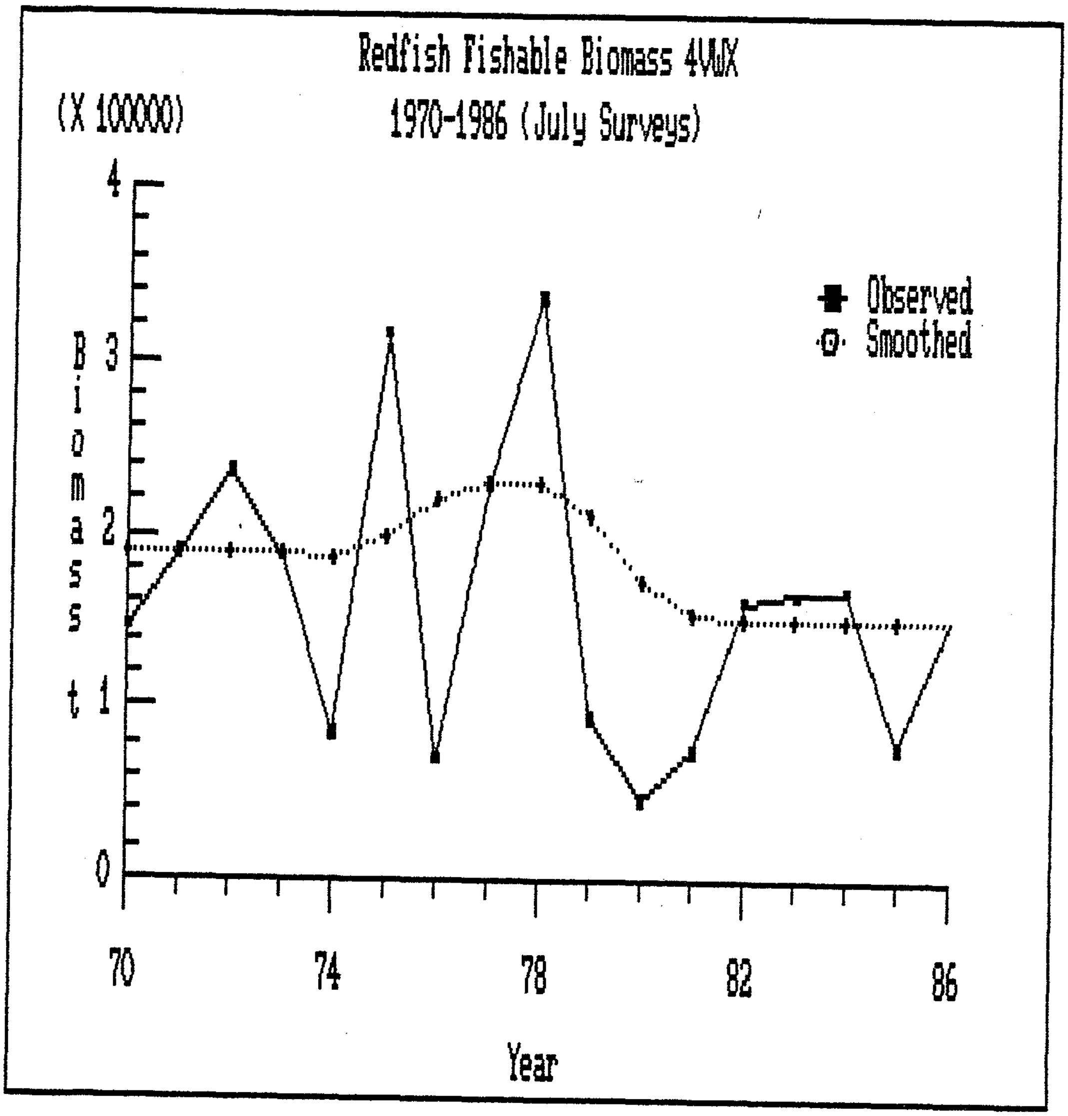


Figure 16. Estimated redfish fishable biomass in management unit 4VWX, 1970-86.