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Redfish Subarea 1 (0-400 m): Groundfish Survey Results, 1982-95 and Length Structure of German Catches, 1962-90

by

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Abstract

The 1994 survey results confirmed the severely depleted status of the redfish resource off West Greenland to almost non-existence of its exploitable component. Since 1982, golden redfish (≥17 cm) decreased by 99% in abundance and biomass. Estimates for beaked redfish (≥17 cm) vary without a clear trend but are determined to be extremely low since 1992. Length distributions indicate significant year effects for both stocks of golden and beaked redfish, which are dominated presently by small individuals (<30 cm). Considering the incomplete survey coverage (50%), the estimates for 1995 do not indicate significant canges from this assessment. Since 1986, juvenile redfish (<17 cm) are found to be very abundant but recruitment of the stocks failed recently. The increased effort of the shrimp fishery on traditional fishing grounds is suspected to select efficiently small sized fish and thus to have a negative effect on survival rates of recruits. However, species and stock identification of juvenile redfish is unclear, but reappearing peaks at 6, 10-12 and 15-16 cm might indicate annual growth increments and represent the age groups 0, 1 and 2 years.

The size structure of commercial catches of golden redfish taken off West Greenland and landed at Cuxhaven or Bremerhaven including measurments conducted directly on board of commercial or research vessels fishing on aggregations are presented for the period 1962-90. The calculated size reduction of commercial landings is found to be highly significant and amounts to 10 cm. Since 1986, the mean fish length remained under 36 cm.

Introduction

Since 1982, the demersal fish assemblage off West Greenland has been monitored annually by German groundfish surveys. The surveys were conducted during fall and represent the only source of information about the status of the groundfish stocks inhabiting the shelf and continental slope in Divisions 1B-1F outside the 3 mile zone down to 400m depth. This paper describes the most recent status and trends in stock abundance, biomass and length structure for juvenile, golden and beaked redfish as derived from survey catches. Furthermore, historical sampling effort and length structure of German redfish landings as collected by fish market sampling including measurements conducted on board of commercial or research vessels fishing on aggregations are given for the period 1962-90.

Materials and Methods

Abundance, biomass estimates and length structures have been derived using annual groundfish surveys covering shelf areas and the continental slope off West Greenland. Surveys commenced in 1982 and were primarily designed for the

assessment of cod. Because of favourable weather and ice conditions and to avoid spawning concentrations, autumn was chosen for the time of the surveys. These were carried out by the research vessel (R/V) WALTHER HERWIG (II) throughout most of the time period, except in 1984 and since 1994, when R/V ANTON DOHRN was used and she was replaced by the new R/V WALTHER HERWIG III, respectively. In 1995, the coverage of the survey area was incomplete for the first time due to technical problems. Only 50% of the strata were covered with hauls according to the strategy.

The fishing gear used was a standardized 140-feet bottom trawl, its net frame rigged with heavy ground gear because of the rough nature of the fishing grounds. A small mesh liner (10 mm) was used inside the cod end. The horizontal distance between wing-ends was 25 m at 300 m depth, the vertical net opening being 4m. In 1994, smaller Polyvalent doors (4.5 m^2, 1,500 kg) were used for the first time to reduce net damages due to overspread caused by bigger doors (6 m^2, 1,700 kg) which have been used previously. All calculations of abundance and biomass indices are based on the 'swept area' method using 22 m horizontal net opening as trawl parameter, i. e. the constructional width specified by the manufacturer. The towing time was normally 30 min. at a speed of 4.5 knots. Trawl parameters are listed in Table 1. Hauls which received net damage or became hangup after less than 15 minutes were rejected. Some hauls of the 1987 and 1988 surveys were also included although their towing time had been intentionally reduced to 10 minutes because of the expected large cod catches as observed from echo sounder traces.

Fish were identified to species or lowest taxonomic level and the catch in number and weight was recorded. Redfish (≥17 cm) were separated to golden (*Sebastes marinus* L.) or beaked redfish (*Sebastes mentella* Travin), whereas juvenile redfish (<17 cm) were classified as *Sebastes spp.* due to time-consuming and difficult species indentification.Total fish lengths were measured to cm below.

The surveys were primarily designed for the assessment of cod. In order to reduce the error of abundance estimates, the subdivision of shelf areas and the continental slope into different geographic and depth strata was required due to a pronounced heterogeneity of cod distribution. The survey area was thus split into four geographic strata. Each stratum was itself subdivided into two depth strata covering the 0-200m and 201-400m zones. Figure 1 and Table 2 indicate the names of the 8 strata, their geographic boundaries, depth ranges and areas in nautical square miles (nm^2). All strata were limited at the 3 mile offshore line.

The applied strategy was to distribute the sampling effort according both to the stratum areas and to cod abundance. Consequently, fifty percent of the hauls were allocated proportionally to strata by stratum area while the other fifty percent were apportioned on the basis of a review of the historical mean cod abundance/nm^2, all hauls being randomly distributed within trawlable areas of the various strata. Non-trawlable areas are mainly located inshore. During 1982-95, 1,303 successful sets were carried out, the numbers of valid sets by year and stratum being listed in Table 3.

Stratified abundance estimates were calculated from catch-per-tow data using the stratum areas as weighting factor (Cochran, 1953; Saville, 1977). Strata with less than five valid sets were rejected from the calculation. The coefficient of catchability was set arbitrarily at 1.0, implying that estimates are merely indices of abundance and biomass. Respective confidence intervals (CI) were set at the 95% level of significance of the stratified mean.

Total fish length (cm below) of German golden redfish landings at the fish markets in Bremerhaven and Cuxhaven or measured directly on board of commercial or research vessels fishing on aggregations was routinely recorded during 1962-90. Before their aggregation by quarter and year, numbers per length group were raised to the weight of an individual landing or total catch.

Correlation analysis and linear regressions were conducted using the program CSS-StatSoft, 1991.

Results

Tables 4 and 5 list abundance and biomass indices for golden redfish (≥17 cm) by stratum and total, 1982-95. Trends are illustrated in Figure 2. During 1982-94, both indices decreased by 99% from 130 million to 1 million individuals and from 56,000 tons to 500 tons, respectively. Golden redfish declined from all strata, lacking a clear spatial distribution pattern. The length structures in 1982-94 are listed in Table 6 and illustrated in Figures 3a and 3b. Until 1990, length distributions remained relatively unchanged and peaked each year around 30-33 cm. Thereafter, the fish size was significantly reduced and the length distributions became scattered due to extremely low catches. Considering the incomplete survey coverage (50%), the estimates for 1995 do not indicate significant canges from this assessment.

Trends in survey abundance and biomass indices for beaked redfish (≥17 cm) are shown in Figure 4 and listed in

Tables 7 and 8, respectively. Total estimates are accompanied with high confidence intervals exceeding 100% and vary among 160,000 and 15 million individuals and 30 and 4,300 tons without a clear trend. It should be noted, that estimates of the latest 3 years 1992-94 are very low. In contrast to golden redfish, beaked redfish show a pronounced spatial distribution pattern, i. e. to be most abundant in deep strata. Table 9 list the length distributions in 1982-95, which are illustrated in Figures 5a and 5b. Size structures show extreme changes between successive years but lack growth indications.

Survey abundance of unspecified and juvenile redfish (<17 cm) varied enormously (Fig. 6), while estimates of biomass are low due to low individual weight. Since 1985, this redfish category is found to be very abundant, although the indices are accompanied with high confidence intervals (Tab. 10 and 11). They were found to be mainly distributed in northern strata but tend to spread over the total survey area in most recent years. Length structures 1982-95 are listed in Table 12 and plotted in Figure 7a and 7b. Reappearing peaks at 6, 10-12 and 15-16 cm might indicate annual growth increments.

Table 13 describes the sampling effort and results derived from quaterly aggregated fish market samples or commercial and research vessels fishing on aggregations. Calculated mean lengths ± standard deviation are illustrated in Figure 8. A linear correlation and regression analysis was carried out with mean length as the dependent and time as the independent variable, resulting parameters being listed in Table 14. Compared with the fish size in the early 60-ies around 40-47 cm, the most recent observations revealed a highly significant and almost linear size reduction by 10 cm.

Discussion

The 1994 survey results confirmed the severely depleted status of the redfish resource off West Greenland and almost non-existence of the exploitable component whithin the area surveyed (Rätz, 1995). Since 1982, golden redfish (≥17 cm) decreased by 99% in abundance and biomass, while estimates for beaked redfish (≥17 cm) vary without a clear trend but were determined to be extremely low since 1992 (Fig. 2, 4; Tab. 4, 5, 7, 8). Uncertainties of this view araise mainly from the survey design which doesn't cover deeper areas of the stock distribution (Atkinson, 1987), inshore (fjord) and pelagic occurrence and areas north of 67° northern latitude, which is considered to be poor for commercial sized redfish (Pedersen and Nygård, 1992). The recent declines in abundance of golden and beaked redfish is also reflected by groundfish surveys for Greenland halibut (Ogawa et al., 1994; Yokawa et al., 1995) and by-catches during shrimp surveys (Bech, 1994). Considering the incomplete survey coverage (50%), the estimates for 1995 do not indicate significant canges from this assessment.

Due ot time-consuming and difficult species idenfication, juvenile redfish (<17 cm) were separately assessed. Since 1986, this component was found to be very abundant but varied without a distinct trend (Fig. 6; Tab. 10, 11). Their origin and migration routes are unclear. However, recruitment of the stocks failed recently. The increased effort of the shrimp fishery on traditional fishing grounds is suspected to select efficiently small sized fish and thus to have a negative effect on survival rates of recruits. In 1994, the redfish by-catch of a standard survey haul side by side with a shrimp trawler amounted to 852 specimens or 9% in weigth, although the different catch procedure of the shrimp fishery (different nets and lower towing speed) prevented direct estimation (Rätz 1995).

Length distributions indicate significant year effects for both stocks of golden and beaked redfish (≥17 cm), which are dominated presently by small individuals (<30 cm; Fig. 3a, 3b, 5a, 5b; Tab. 6, 9). Reappearing peaks at 6, 10-12 and 15-16 cm might indicate annual growth increments and represent the age groups 0, 1 and 2 years (Fig. 7a, 7b; Tab. 12), which is in good agreement with validated age determinations of Nedreaas (1990) for juvenile redfish. In September 1982-84 (1 months earlier than the normal survey time for Greenland), he found peaks at 4, 8-9 and 12 cm for the dominating 1982 year class of beaked redfish off Norway and related those to the age groups 0, 1 and 2.

The available sampling effort and size structure of commercial catches of golden redfish taken off West Greenland and landed at Cuxhaven or Bremerhaven including measurements conducted directly on board of commercial and research vessels fishing on aggregations were presented for the period 1962-90. The linear regression between mean length and time is found to describe the decreasing trend in fish size highly significant (Tab. 14). During 1962-90, the calculated size reductions amounted to 10 cm. Since 1986, the mean fish length remained under 36 cm (Fig. 8, Tab. 13).

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Table 1 Trawl parameters of the survey.

Gear	140-feet bottom trawl
Horizontal net opening	22 m
Standard trawling speed	4.5 kn
Towing time	30 minutes
Coefficient of catchability	1.0

Table 2 Specification of strata.

Stratum	geographic boundaries				depth	area
	south	north	east	west	(m)	(nm^2)
1.1	64°15'N	67°00'N	50°00'W	57°00'W	1-200	6805
1.2	64°15'N	67°00'N	50°00'W	57°00'W	201-400	1881
2.1	62°30'N	64°15'N	50°00'W	55°00'W	1-200	2350
2.2	62°30'N	64°15'N	50°00'W	55°00'W	201-400	1018
3.1	60°45'N	62°30'N	48°00'W	53°00'W	1-200	1938
3.2	60°45'N	62°30'N	48°00'W	53°00'W	201-400	742
4.1	59°00'N	60°45'N	44°00'W	50°00'W	1-200	2568
4.2	59°00'N	60°45'N	44°00'W	50°00'W	201-400	971
Sum						18273

Table 3 Numbers of valid hauls by stratum and total, 1982-95.

Year	1.1	1.2	2.1	2.2	3.1	3.2	4.1	4.2	Σ
1982	20	11	16	7	9	6	13	2	84
1983	26	11	25	11	17	5	18	4	117
1984	25	13	26	8	18	6	21	4	121
1985	10	8	26	10	17	5	21	4	101
1986	27	9	21	9	16	7	18	3	110
1987	25	11	21	4	18	3	21	3	106
1988	34	21	28	5	18	5	18	2	131
1989	26	14	30	9	8	3	25	3	118
1990	19	7	23	8	16	3	21	6	103
1991	19	11	23	7	12	6	14	5	97
1992	6	6	6	5	6	6	7	5	47
1993	9	6	9	6	10	8	7	0	55
1994	16	13	13	8	10	6	7	5	78
1995	0	0	3	0	10	7	10	5	35
Σ	262	141	270	97	185	76	221	51	1303

Table 4 Golden redfish (≥17 cm). Abundance indices (1,000) by stratum and total, 1982-95. Confidence intervals (CI) are given at the 95% level of significance in per cent of the stratified mean. *) incomplete coverage of the survey area (50%).

YEAR	1.1	1.2	2.1	2.2	3.1	3.2	4.1	4.2	TOTAL	CI
1982	7015	6340	88792	5512	5736	14876	4087		132357	111
1983	4025	3186	3355	6523	4043	5885	1697		28714	35
1984	1324	3438	460	1209	10671	2776	4214		24091	39
1985	4658	10451	6158	1569	3220	14441	4973		45471	45
1986	6327	4324	2077	3483	21503	2883	2717		43314	43
1987	906	653	1327		9612		659		13157	57
1988	831	2239	342	2255	5938	1954	731		14290	40
1989	421	422	776	690	6489		361		9160	62
1990	120	433	279	709	1038		146	2271	4996	34
1991	227	256	96	691	236	527	21	1671	3724	61
1992	126	106	73	190	193	477	192	835	2193	43
1993	169	481	59	267	80	132	0		1188	53
1994	111	325	156	167	65	46	151	247	1268	42
*) 1995					51	67	38	146	302	68

Table 5 Golden redfish (≥17 cm). Biomass indices (tons) by stratum and total, 1982-95. Confidence intervals (CI) are given at the 95% level of significance in per cent of the stratified mean. *) incomplete coverage of the survey area (50%).

YEAR	1.1	1.2	2.1	2.2	3.1	3.2	4.1	4.2	TOTAL	CI
1982	1798	1354	34440	2558	3206	9794	2532		55682	100
1983	846	945	1572	3042	1873	4815	1084		14178	37
1984	308	894	196	519	4935	2284	2089		11225	47
1985	1020	1819	2968	472	1427	9209	2718		19634	58
1986	1282	1215	752	1229	10122	1705	1762		18068	46
1987	255	247	660		4954		438		6553	63
1988	146	404	118	942	2570	1342	382		5902	41
1989	182	137	272	249	2619		209		3669	64
1990	39	149	75	275	479		79	1343	2438	46
1991	44	83	24	226	120	273	3	1007	1778	74
1992	18	35	20	61	53	241	70	447	947	49
1993	46	112	19	114	39	55	0		384	47
1994	34	146	48	64	26	35	40	80	473	43
*) 1995					19	19	20	43	101	59

Table 6 Golden redfish (≥17 cm). Length disaggregated abundance indices (n*1000), 1982-95. *) incomplete coverage of the survey area (50%).

Length (cm)	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	*)1995
0.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6.5	0	0	0	0	0	0	7	0	0	0	0	0	0	0
7.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0
9.5	0	0	0	0	0	0	22	0	0	0	0	0	0	0
10.5	0	0	0	0	0	0	15	0	0	0	0	0	0	0
11.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12.5	0	0	0	0	0	0	7	0	0	0	7	0	0	0
13.5	0	0	0	0	0	0	7	0	0	0	0	0	0	0
14.5	0	0	0	0	0	0	0	0	11	6	0	0	0	0
15.5	0	0	0	0	0	0	0	9	39	50	14	0	0	0
16.5	859	662	574	2381	1438	30	686	8	24	21	29	0	0	0
17.5	1003	629	572	1917	1347	64	321	46	131	86	15	0	0	0
18.5	955	510	442	1372	1733	51	131	37	58	94	51	35	90	0
19.5	1068	435	397	1258	1241	76	351	90	45	53	5	94	89	33
20.5	884	657	332	1434	1047	95	253	131	74	121	44	147	85	29
21.5	1170	614	378	1191	940	132	243	109	79	86	146	71	42	30
22.5	1334	770	418	1320	1156	187	303	140	139	134	80	22	48	15
23.5	1701	806	465	1284	1140	264	298	214	177	101	88	23	26	11
24.5	2031	808	532	1119	1787	449	464	320	189	131	146	44	70	11
25.5	3487	1231	690	1374	1611	381	640	343	249	160	106	109	68	4
26.5	4690	1408	833	1556	1717	631	765	561	215	184	139	40	91	7
27.5	6049	1509	994	2049	1879	647	798	678	251	171	95	86	71	29
28.5	9267	1690	1315	1781	2213	767	769	732	270	192	82	35	40	17
29.5	11170	1992	1490	2358	2549	936	913	871	224	273	140	16	65	14
30.5	10818	2524	2054	3193	3285	1023	1081	1070	410	141	144	74	44	14
31.5	14994	1941	1978	2321	3090	1155	947	709	329	192	107	41	45	7
32.5	11490	1797	1928	2872	3224	1028	826	715	266	192	132	49	49	25
33.5	10177	1422	1684	2080	2926	1234	720	625	205	236	150	35	19	0
34.5	8118	1188	1424	2144	2505	946	645	430	263	134	129	40	52	0
35.5	7888	1247	1250	1765	2198	901	721	397	259	184	105	27	54	11
36.5	6925	980	1052	1446	1321	650	562	328	215	133	62	44	49	30
37.5	5731	668	683	1211	945	485	467	219	169	156	57	43	0	0
38.5	3801	650	635	1288	631	251	364	115	130	81	21	20	37	0
39.5	2149	453	379	1091	413	251	252	120	82	114	9	36	40	0
40.5	1566	310	320	1107	415	201	234	51	128	102	62	4	5	0
41.5	995	259	236	537	222	128	127	27	118	25	5	4	11	0
42.5	472	231	179	572	84	56	64	11	82	65	17	23	29	15
43.5	598	222	197	430	94	39	65	22	54	28	14	0	16	0
44.5	234	101	110	243	40	42	53	15	0	27	0	10	23	0
45.5	152	106	120	221	22	22	45	0	42	19	0	12	14	0
46.5	133	119	92	185	25	13	53	0	24	5	0	0	5	0
47.5	23	48	65	94	17	5	16	0	18	14	0	0	0	0
48.5	42	85	64	94	0	0	4	0	12	6	0	0	0	0
49.5	41	23	37	68	0	0	6	4	0	0	0	0	0	0
50.5	37	73	48	22	9	0	0	4	12	0	0	0	0	0
51.5	46	20	9	6	0	4	0	4	0	0	0	0	0	0
52.5	41	71	14	11	0	0	0	3	0	0	0	0	0	0
53.5	20	89	9	6	4	0	8	4	0	0	0	0	0	0
54.5	9	50	10	22	8	4	6	0	0	0	0	0	0	0
55.5	23	39	5	17	12	0	0	0	0	0	0	0	0	0
56.5	9	47	5	4	0	0	6	0	0	0	0	0	5	0
57.5	18	16	14	5	0	0	0	0	0	0	0	0	0	0
58.5	11	38	0	6	0	0	0	0	0	0	0	0	0	0
59.5	32	28	5	6	5	0	6	0	0	0	0	0	0	0
60.5	18	50	23	0	9	0	0	0	0	0	0	0	0	0
61.5	5	6	5	3	4	0	3	0	0	0	0	0	0	0
62.5	9	33	9	6	0	0	0	0	0	0	0	6	0	0
63.5	9	11	0	0	0	0	0	0	0	0	0	0	0	0
64.5	32	17	0	0	4	0	0	0	0	0	0	0	0	0
65.5	11	11	5	0	0	0	0	0	0	0	0	0	0	0
66.5	5	11	0	0	0	0	0	0	0	0	0	0	0	0
67.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0
68.5	5	0	0	0	0	0	0	0	0	0	0	0	0	0
69.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0
70.5	5	11	0	0	0	0	6	0	0	0	0	0	0	0

Table 7 Beaked redfish (≥17 cm). Abundance indices (1,000) by stratum and total, 1982-95. Confidence intervals (CI) are given at the 95% level of significance in per cent of the stratified mean. *) incomplete coverage of the survey area (50%).

YEAR	1.1	1.2	2.1	2.2	3.1	3.2	4.1	4.2	TOTAL	CI
1982	0	390	17	348	0	2360	0		3116	105
1983	40	1011	70	2528	0	5236	0		8884	66
1984	41	2967	7	1276	0	1115	0		5405	82
1985	0	369	31	27	55	328	0		810	115
1986	2141	414	38	292	5	444	0		3333	76
1987	987	13679	42		56		0		14765	79
1988	150	3187	25	777	60	4619	0		8819	79
1989	0	186	9	102	0		8		303	59
1990	0	10	4	705	50		0	3881	4649	112
1991	0	0	0	0	0	652	0	1773	2425	106
1992	0	35	0	15	0	106	0	0	157	94
1993	0	24	0	159	7	0	0		190	160
1994	0	271	20	95	94	162	0	36	679	55
*) 1995					29	234	96	1468	1826	120

Table 8 Beaked redfish (≥17 cm). Biomass indices (tons) by stratum and total, 1982-95. Confidence intervals (CI) are given at the 95% level of significance in per cent of the stratified mean. *) incomplete coverage of the survey area (50%).

YEAR	1.1	1.2	2.1	2.2	3.1	3.2	4.1	4.2	TOTAL	CI
1982	0	96	6	114	0	893	0		1109	116
1983	16	213	26	1158	0	2857	0		4270	77
1984	6	798	4	490	0	472	0		1771	89
1985	0	96	15	11	27	110	0		260	108
1986	223	39	20	110	3	179	0		574	65
1987	84	1184	9		31		0		1307	62
1988	20	425	21	159	45	1878	0		2549	92
1989	0	23	7	15	0		1		46	50
1990	0	5	2	87	7		0	542	643	109
1991	0	0	0	0	0	153	0	445	598	104
1992	0	3	0	2	0	28	0	0	33	105
1993	0	5	0	23	2	0	0		29	130
1994	0	31	3	10	12	25	0	3	85	51
*) 1995					5	25	10	159	200	125

Table 9 Beaked redfish (≥17 cm). Length disaggregated abundance indices (n*1000), 1982-95. *) incomplete coverage of the survey area (50%).

Length (cm)	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	*) 1995
0.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0
9.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0
11.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12.5	0	0	0	0	0	0	0	0	5	0	0	0	0	0
13.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0
14.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0
15.5	0	0	0	0	0	6	0	5	5	5	0	0	0	0
16.5	0	23	95	29	657	5220	229	0	0	5	0	0	0	0
17.5	9	58	140	6	967	2177	217	14	72	0	0	0	0	0
18.5	29	51	102	9	304	2794	99	18	83	9	17	6	266	700
19.5	6	79	164	41	136	1721	965	64	240	31	25	6	163	365
20.5	28	89	149	26	98	1922	748	91	636	9	0	12	76	251
21.5	40	96	155	26	54	272	531	30	1078	71	20	6	30	349
22.5	18	143	130	13	88	131	722	25	1544	300	5	19	62	44
23.5	41	124	194	35	78	84	408	9	640	390	18	6	25	15
24.5	38	184	160	85	103	137	346	0	191	649	28	13	22	39
25.5	105	265	98	76	30	36	354	19	76	608	9	19	0	29
26.5	83	362	182	52	42	18	320	0	58	165	18	13	5	29
27.5	231	548	184	37	38	47	319	0	18	93	5	25	0	0
28.5	181	559	329	46	93	43	265	5	0	38	0	25	12	0
29.5	315	776	457	38	68	0	296	0	4	19	0	0	5	0
30.5	571	1452	742	55	76	52	454	0	0	29	0	12	0	7
31.5	391	1179	664	44	57	36	324	0	0	0	0	0	0	0
32.5	380	928	522	48	92	24	397	0	0	0	0	6	0	0
33.5	247	744	440	40	49	6	397	0	0	0	0	0	0	0
34.5	125	563	245	32	106	6	421	0	0	0	0	0	0	0
35.5	93	358	139	26	58	0	482	5	0	5	5	13	0	0
36.5	69	137	51	15	43	6	228	0	0	0	0	0	0	0
37.5	28	71	10	4	21	0	129	6	0	0	0	0	5	0
38.5	5	28	24	0	26	4	37	0	0	0	5	0	0	0
39.5	19	10	11	9	13	0	49	5	0	0	5	0	0	0
40.5	19	6	8	7	0	8	18	0	0	0	0	6	5	0
41.5	9	14	5	9	18	12	10	0	0	0	0	0	0	0
42.5	14	0	0	0	0	4	17	8	0	0	0	0	5	0
43.5	9	6	0	0	8	0	13	0	0	0	0	0	0	0
44.5	5	0	0	0	4	0	0	0	0	0	0	0	0	0
45.5	0	0	5	0	0	0	11	0	0	0	0	0	0	0
46.5	5	0	5	0	0	0	0	0	0	0	0	0	0	0
47.5	5	0	0	0	4	0	0	0	0	0	0	0	0	0
48.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0
49.5	0	0	0	0	0	0	10	0	0	0	0	0	0	0
50.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0
51.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0
52.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0
53.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0
54.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0
55.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0
56.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0
57.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0
58.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0
59.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0
60.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0
61.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0
62.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0
63.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0
64.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0
65.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0
66.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0
67.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0
68.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0
69.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0
70.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Table 10 Unspecified juvenile redfish (<17 cm). Abundance indices (1,000) by stratum and total, 1982-95. Confidence intervals (CI) are given at the 95% level of significance in per cent of the stratified mean. *) incomplete coverage of the survey area (50%).

YEAR	1.1	1.2	2.1	2.2	3.1	3.2	4.1	4.2	TOTAL	CI
1982	1057	358	121	27	8	42	22		1635	51
1983	3956	505	14	138	9	17	21		4660	74
1984	5021	3714	20	219	141	28	14		9155	74
1985	4889	9615	54	2712	47	67	55		17438	77
1986	10740	237636	113	1811	54	218	38		250611	182
1987	12455	113990	4		20		18		126488	120
1988	19679	42481	0	107	20	139	0		62424	50
1989	7717	13160	3071	5370	18		69		29407	45
1990	11256	35932	15417	1538	73		6199	848	71263	65
1991	51939	59845	34871	22668	13692	2508	892	1541	187954	35
1992	25715	19084	12691	17277	17463	13973	41	13718	119960	54
1993	5460	39035	664	11331	355	2773	14		59632	66
1994	3405	12002	9827	4013	1189	1731	10843	9867	52878	49
*) 1995					399	10236	855	34694	46184	113

Table 11 Unspecified juvenile redfish (<17 cm). Biomass indices (tons) by stratum and total, 1982-95. Confidence intervals (CI) are given at the 95% level of significance in per cent of the stratified mean. *) incomplete coverage of the survey area (50%).

YEAR	1.1	1.2	2.1	2.2	3.1	3.2	4.1	4.2	TOTAL	CI
1982	37	13	6	1	0	2	1		60	47
1983	103	21	1	6	0	1	1		133	67
1984	91	104	1	5	5	1	1		208	81
1985	82	367	2	58	2	3	1		515	103
1986	454	6645	3	77	2	6	1		7187	178
1987	265	5021	0		1		0		5286	129
1988	218	1491	0	4	1	5	0		1718	64
1989	111	270	22	49	0		1		453	40
1990	99	369	63	20	0		9	2	563	43
1991	198	797	73	242	29	24	2	15	1380	44
1992	152	385	49	111	74	220	1	65	1056	55
1993	72	512	17	265	6	77	1	0	950	75
1994	26	216	55	57	30	64	141	277	866	51
*) 1995					6	330	10	347	693	76

Table 12 Unspecified juvenile redfish (<17 cm). Length disaggregated abundance indices (n*1000), 1982-95. *) incomplete coverage of the survey area (50%).

Length (cm)	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	*) 1995
0.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4.5	0	0	0	0	5	0	7	0	14	59	0	0	0	0
5.5	0	6	255	25	36	121	97	40	3468	15519	2396	0	2393	26
6.5	6	78	584	111	97	850	486	1814	5708	59605	30723	117	9938	193
7.5	0	219	179	185	459	1394	1940	2111	2758	11108	27897	200	1054	142
8.5	70	518	425	326	1913	902	9815	2176	8484	15959	5799	1935	4092	540
9.5	56	580	835	2162	4221	658	7404	4284	11836	23916	11346	9481	9037	615
10.5	96	359	1432	4165	8596	941	3378	5703	6993	36922	8922	8917	5238	935
11.5	259	594	2150	1470	19713	2446	1453	4835	7050	16198	5788	5980	2910	5090
12.5	187	719	1284	508	106866	7018	1560	3156	7574	2388	7518	9526	6042	9656
13.5	114	511	680	1599	76492	8667	3243	2148	6284	1648	11462	5615	4357	4247
14.5	384	465	681	2715	14064	18412	8866	1020	4611	1196	6079	6020	2687	7343
15.5	461	609	651	4173	4188	47210	13644	709	3556	1549	1220	5822	2402	8718
16.5	0	0	0	0	5121	31716	4826	572	944	1005	391	3914	1329	5090
17.5	0	0	0	0	6513	6136	2998	505	654	591	379	2105	1241	3545
18.5	0	0	0	0	1400	0	2514	308	824	218	46	0	68	44
19.5	0	0	0	0	930	0	194	24	133	32	0	0	48	0
20.5	0	0	0	0	0	0	0	0	133	13	0	0	16	0
21.5	0	0	0	0	0	0	0	0	67	0	0	0	32	0
22.5	0	0	0	0	0	0	0	0	67	19	0	0	0	0
23.5	0	0	0	0	0	0	0	0	33	0	0	0	0	0
24.5	0	0	0	0	0	0	0	0	0	5	0	0	0	0
25.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Table 13 Golden redfish. Effort, mean fish length and standard deviation and no. of fish landed or caught as derived from German landings at fish markets in Bremerhaven or Cuxhaven, directly measured on board of commercial or research vessels fishing on aggregations, 1962-90.

Time	Samples	No. of Fish	Mean (cm)	Stand. Dev. (cm)	1969.13	2	124223	46.5	5.8
1962.13	5	450498	43.5	5.5	1969.88	2	230263	44.9	4.4
1962.38	6	608220	41.5	5.7	1971.13	1	95345	43.6	5.5
1962.63	7	577901	45.4	4.8	1971.88	1	100554	46.7	3.4
1962.88	5	280527	43.1	5.1	1972.63	1	95191	42.7	3.8
1963.13	4	258571	43.1	6.1	1975.88	2	272509	41	4
1963.38	4	279930	41.2	5.3	1976.88	5	623559	39.1	4.3
1963.63	6	331636	42.6	5.2	1977.13	3	355610	38.9	4.5
1963.88	7	357015	43.5	5.7	1978.13	1	16553	38.8	5.2
1964.13	6	311738	42.6	5.1	1983.38	1	86288	36.3	5.4
1964.38	5	293952	41.5	4.6	1983.63	1	5609	39.4	5.4
1964.63	2	116563	42.5	5.4	1984.63	2	71236	36.8	4.8
1964.88	1	21971	44.8	4.2	1984.88	1	6386	38.6	4.3
1965.13	1	138286	40.7	4	1985.13	1	145960	34.2	5.4
1965.63	1	74341	40.6	4.1	1985.38	1	19060	33	3.2
1966.13	2	30778	47.2	7	1985.88	1	151379	36.5	6.2
1966.38	2	51689	41.3	6.3	1986.13	1	124236	32.7	4.7
1966.63	1	19542	45.9	4.3	1986.88	1	162999	34.2	4
1966.88	1	28594	43.2	5.7	1987.88	1	70260	34.9	4.3
1967.13	2	156252	40.7	4.2	1988.13	2	123001	34.9	4
1967.63	1	13575	43.3	3.7	1989.13	2	58994	34.5	3.7
1967.88	3	65177	44.7	4.5	1989.88	1	7116	29.8	3.7
1968.13	2	111346	40.7	5.8	1990.13	1	2781	30.6	3.3
1968.63	1	88629	44.6	4.7	1990.88	1	16645	35.8	5.2

Table 14 Golden redfish. Function and parameters of linear correlation and regression analysis between mean fish length of commercial catches and time as listed in Tab. 13. Data are illustrated in Fig. 8.

dependent variable f(x) = mean fish length (cm)
independent variable x = time (years)

$f(x)= 796.914-0.383x$, $n=47$, $p<0.00$, $r^2=0.73$

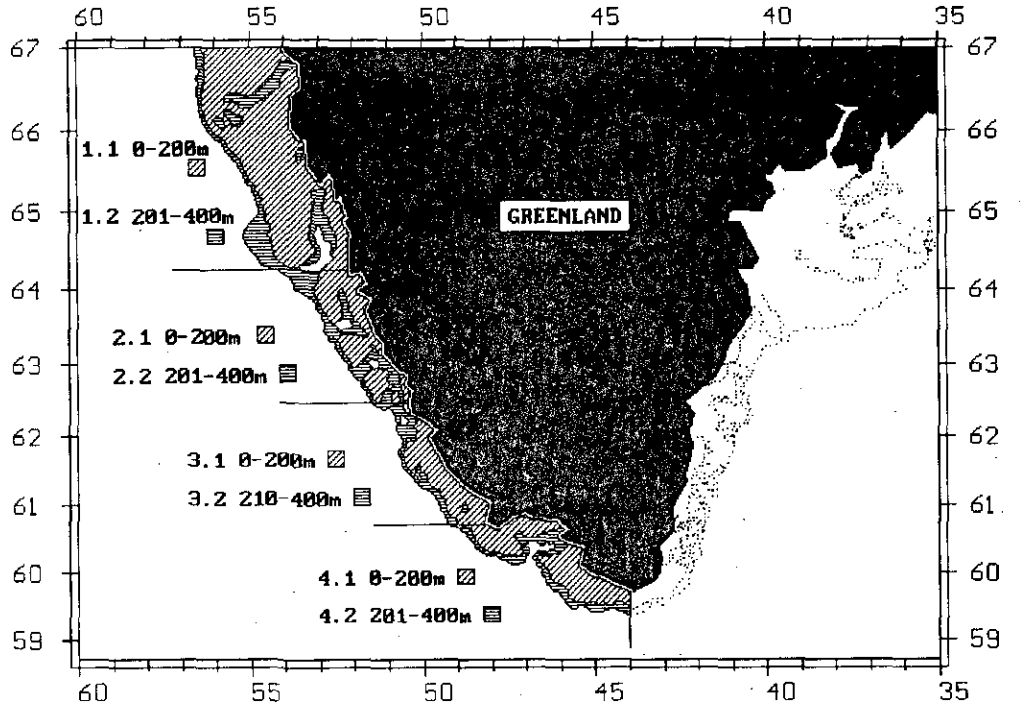

Fig. 1 Survey area and stratification scheme as specified in Table 2.

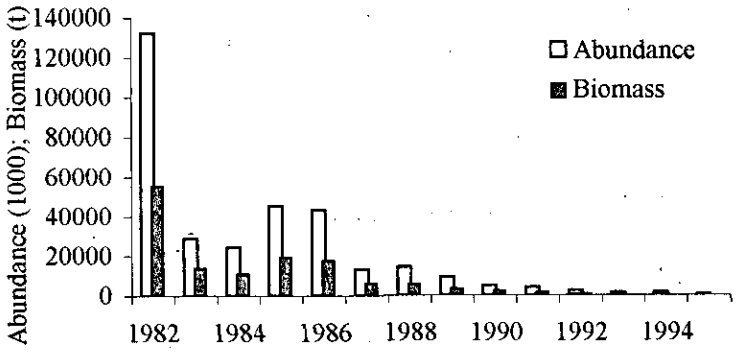

Fig. 2 Golden redfish (≥17 cm). Survey abundance and biomass indices as listed in Tab. 4 and 5, 1982-95. Incomplete coverage of the survey area (50%) in 1995.

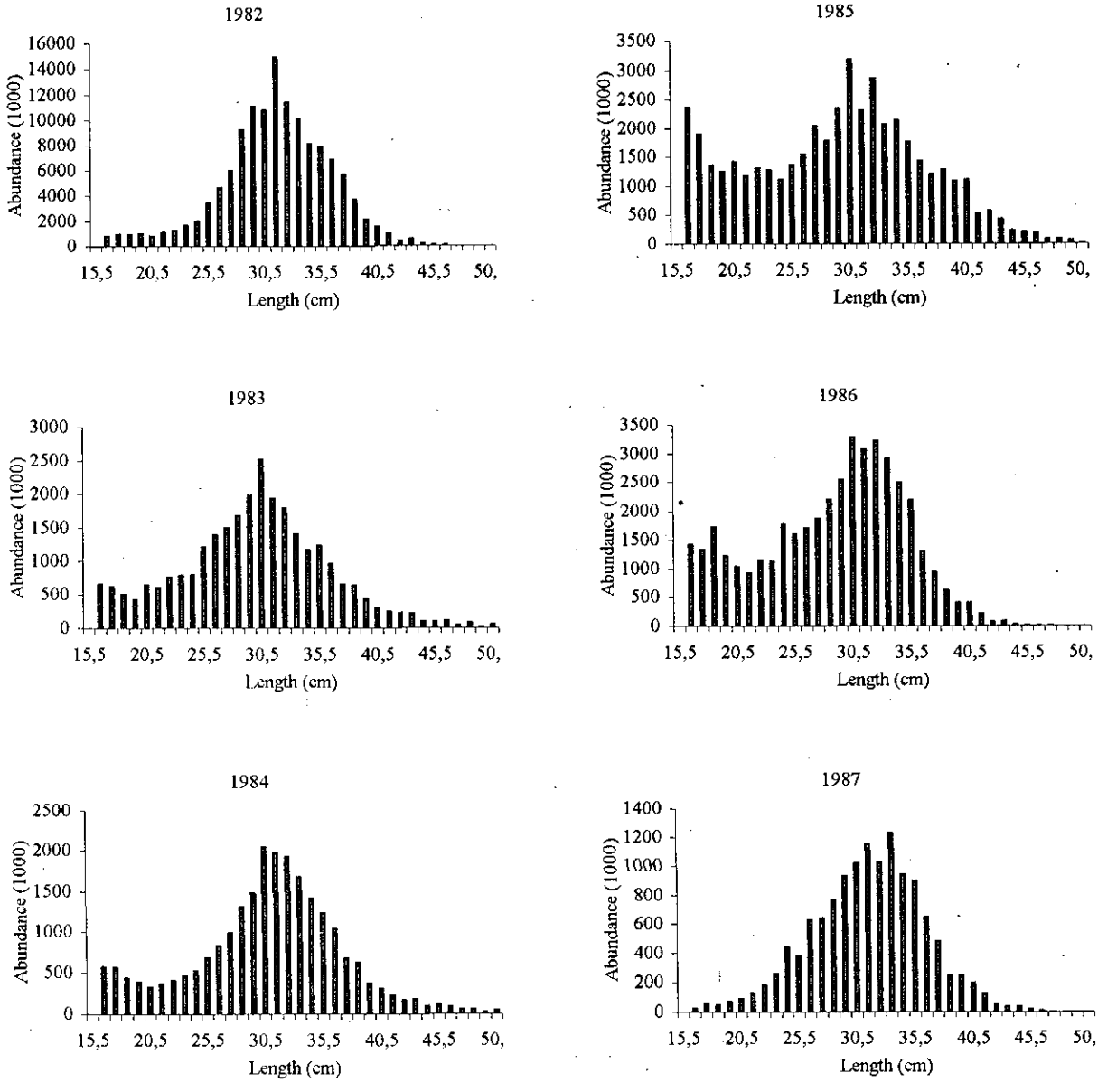

Fig. 3a Golden redfish (≥17 cm). Length frequencies, 1982-87.

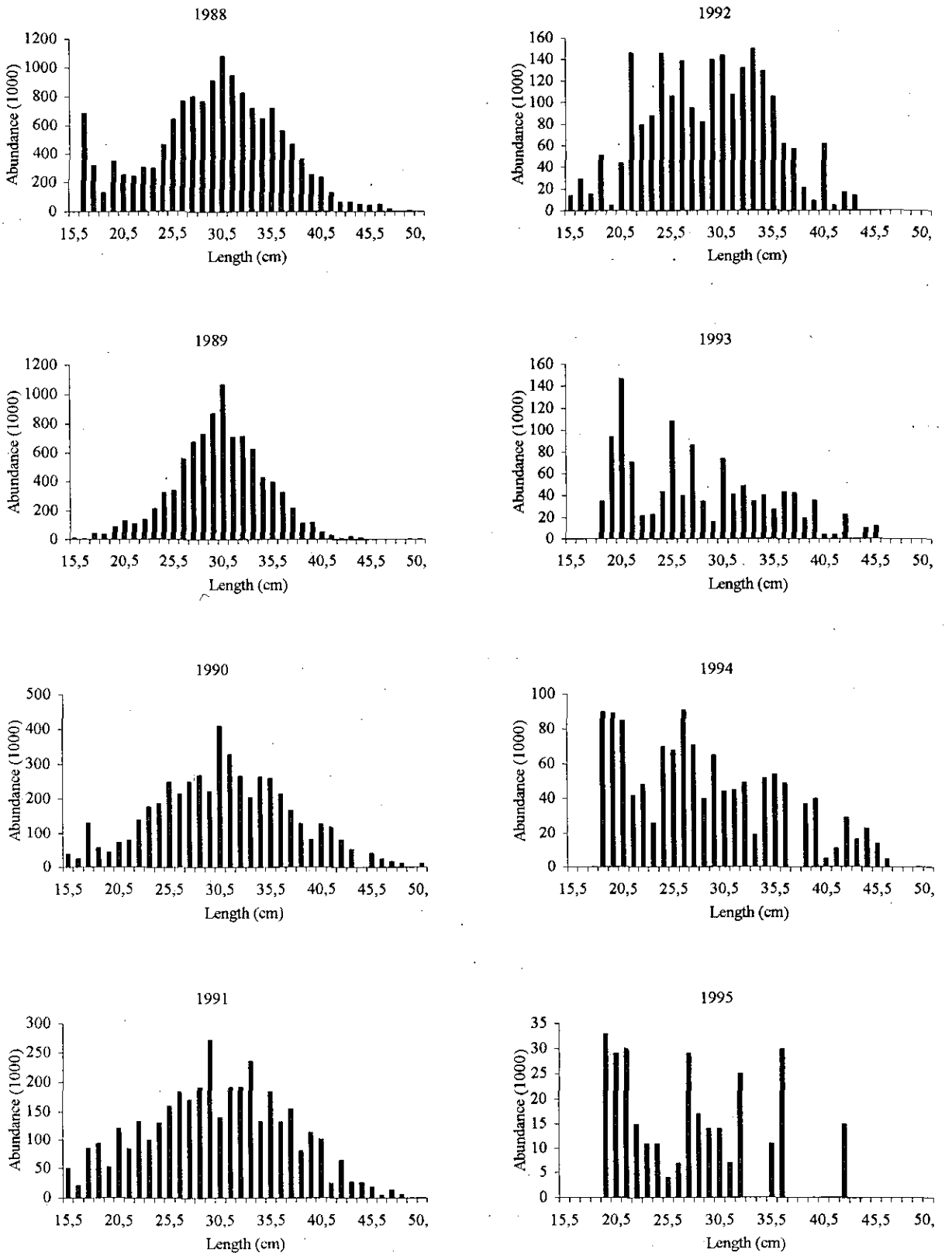

Fig. 3b Golden redfish (≥17 cm). Length frequencies, 1988-95. Incomplete coverage of the survey area (50%) in 1995.

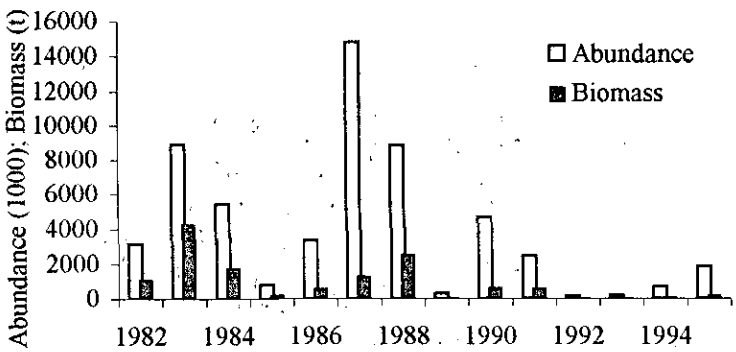

Fig. 4 Beaked redfish (≥17 cm). Survey abundance and biomass indices as listed in Tab. 7 and 8, 1982-95. Incomplete coverage of the survey area (50%) in 1995.

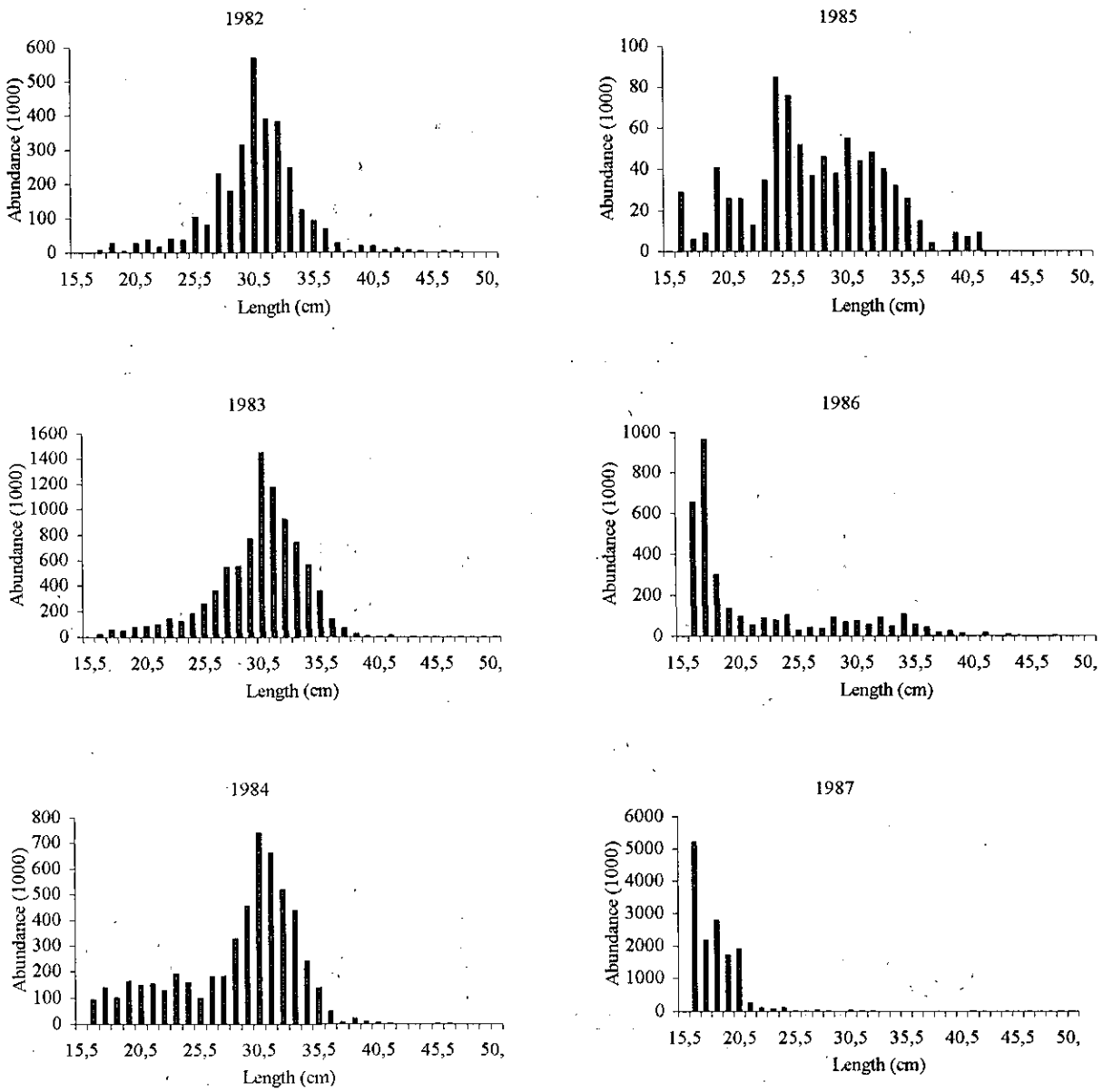

Fig. 5a Beaked redfish (≥17 cm). Length frequencies, 1982-87.

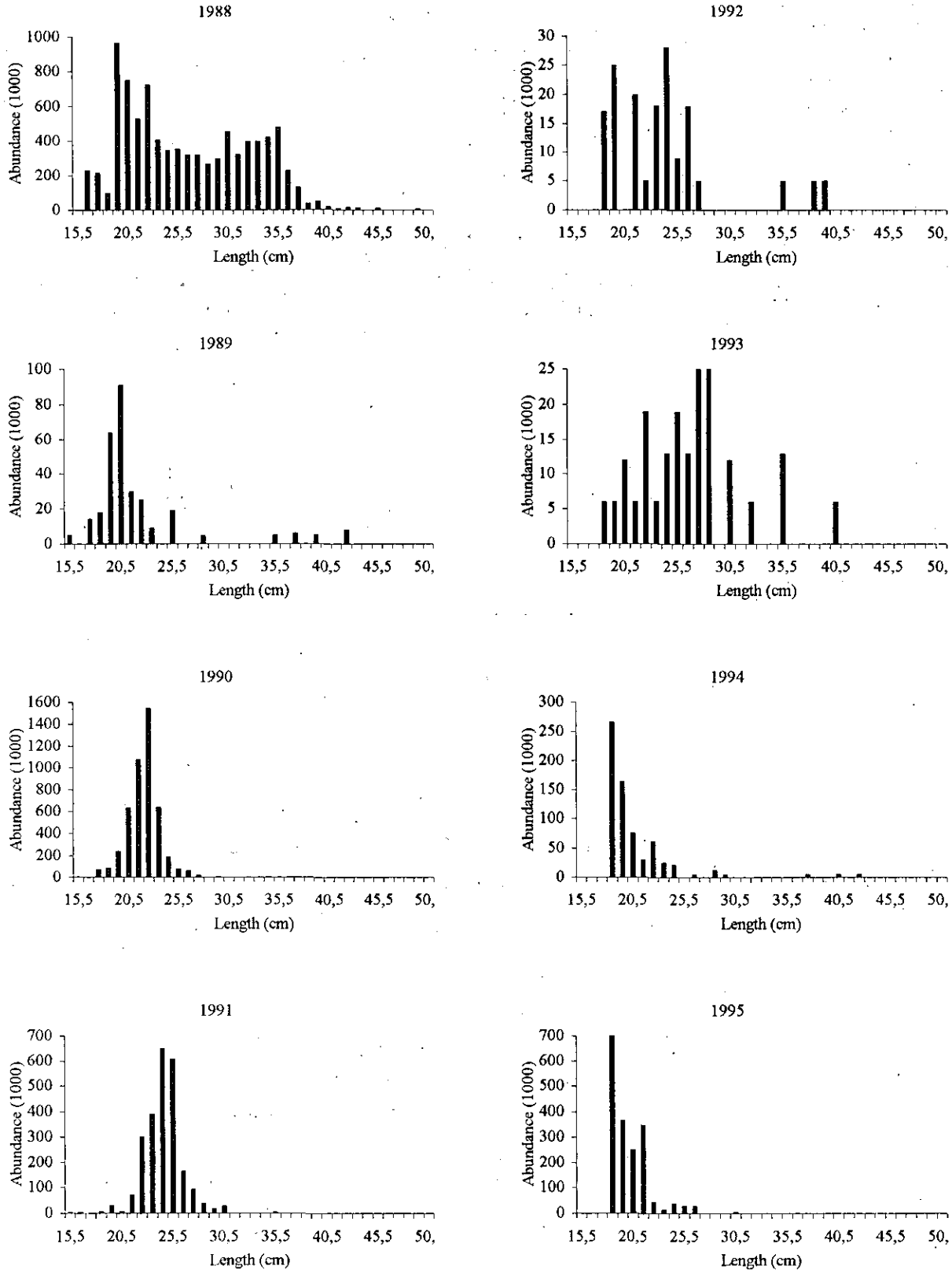

Fig. 5b Beaked redfish (≥17 cm). Length frequencies, 1988-95. Incomplete coverage of the survey area (50%) in 1995.

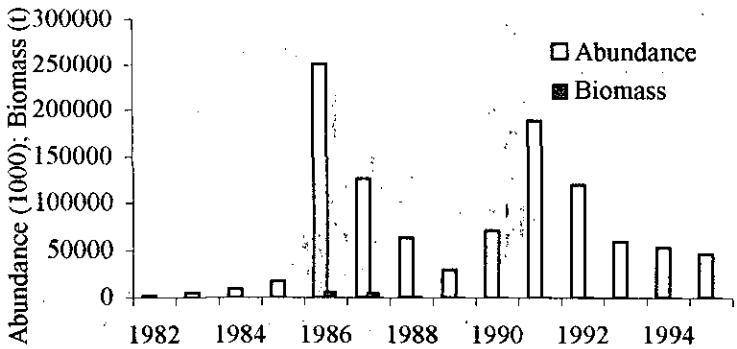

Fig. 6 Unspecified juvenile redfish (<17 cm). Survey abundance and biomass indices as listed in Tab. 10 and 11, 1982-95. Incomplete coverage of the survey area (50%) in 1995.

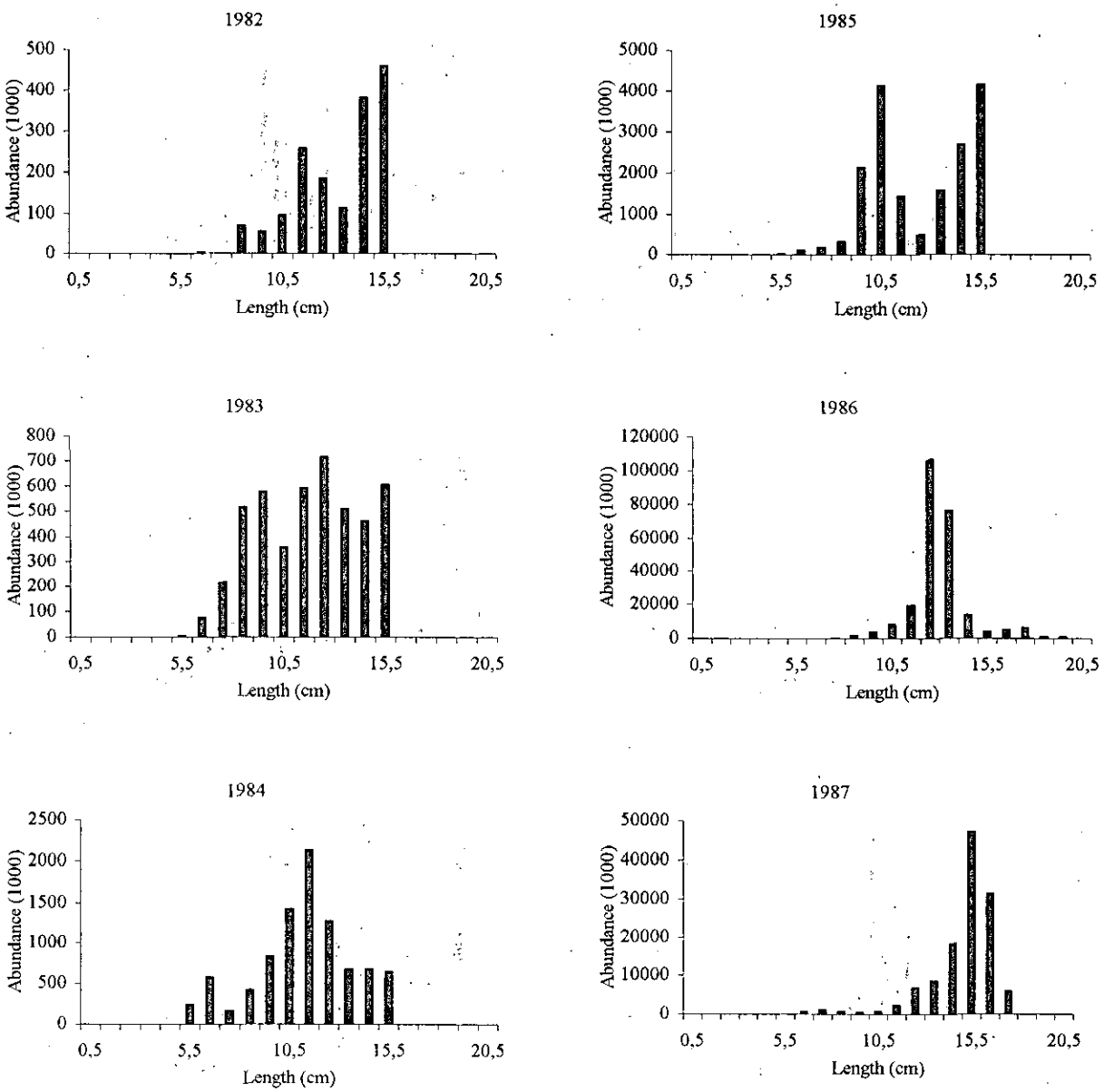

Fig. 7a Unspecified juvenile redfish (<17 cm). Length frequencies, 1982-87.

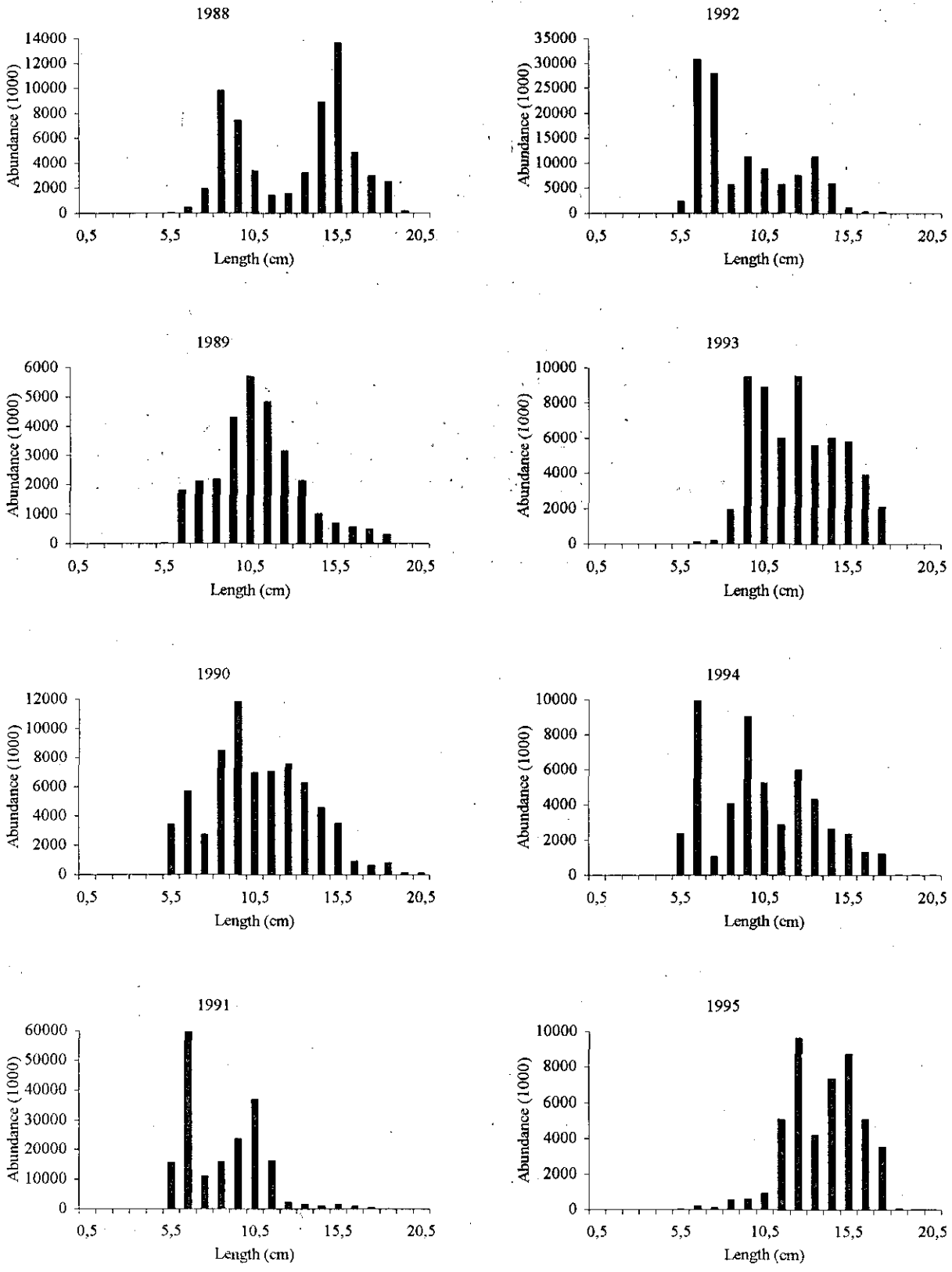

Fig. 7b Unspecified juvenile redfish (<17 cm). Length frequencies, 1988-95. Incomplete coverage of the survey area (50%) in 1995.

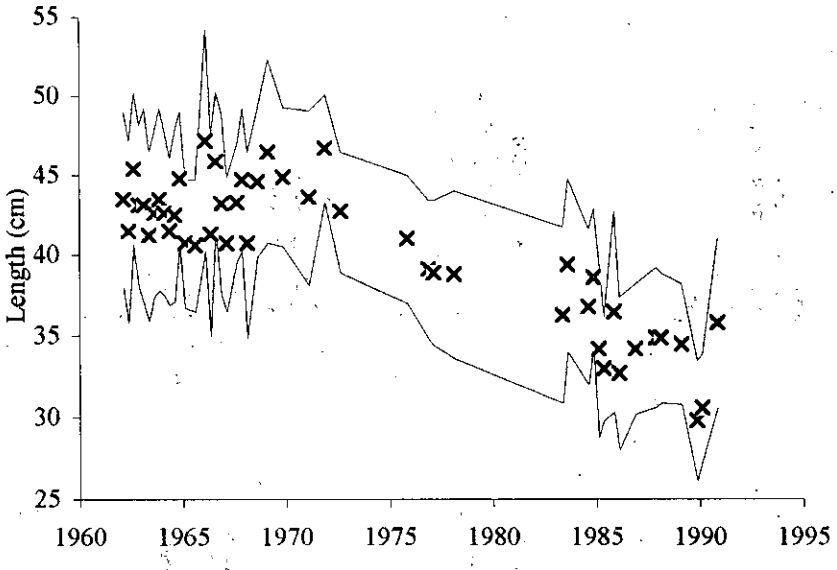

Fig. 8 Golden redfish, West Greenland. Mean fish length ± standard deviation of quaterly aggregated samples derived from German landings at fish markets in Bremerhaven or Cuxhaven, measurements on board of commercial or research vessels fishing on aggregations, 1962-90.