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Redfish at West Greenland, Subarea 1

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ABSTRACT

In West Greenland waters both *Sebastes marinus* and *Sebastes mentella* occur. The commercial fishery exploits mainly the *S.marinus* stock. The spawning area for the West Greenland stock is found outside Subarea 1, probably in the Irminger Sea. Great many small redfish are discarded in the offshore shrimp fishery, the amount likely to be in the range of 8500 - 11500 tons for 1978. The catch of redfish per hour taken by the Danish research vessel ADOLF JENSEN on standard stations has decreased in the period 1968 to 1978. Using a general production model the level of the MSY is estimated to be about 25 000 tons.

1. INTRODUCTION

In connection with the decreasing stock of cod and the regulations of both the cod fishery and the offshore shrimp fishery in ICNAF Subarea 1, an increasing interest in the directed fishery for redfish has been noticed. The redfish fishery might well influence the cod stock and is influenced itself by the shrimp fishery, and it is, therefore, important to study the relationship between these fisheries, when discussing redfish fishery. Furthermore, the immigration and emigration of redfish in relation to Subarea 1 are important factors to consider.

2. MATERIAL

The material used for this paper derives from the ICNAF Stat.Bull., from tagging experiments on redfish carried out in the Godthåb Fiord (Div. 1D), and data on bycatches of small redfish in the offshore shrimp fishery, sampled by observers on the commercial Greenland trawler SISIMIUT or based on logbook information from the Greenland trawlers. Research data, which include catch-per-unit-effort figures from two standard stations in the period 1968-1978, are also used.

3. GENERAL BIOLOGICAL INFORMATION

3.1. The species complex

Both *Sebastes marinus* and *Sebastes mentella* occur in West Greenland waters, but the commercial fishery is based on *Sebastes marinus*. The two species occur in the same area at West Greenland, but they are separated more or less in relation to the depth. In the French Research Report for 1970 (Redbook 1971, Part II) there is some information about the vertical distribution of the two species in Subarea 1. In Div. 1D *Sebastes marinus* is spread uniformly from 150 m, while *S. mentella* is observed beyond 280 m. In Div. 1A-1C only *S. marinus* was caught in depth range 150-280 m, and the *S. mentella* was caught only in depths beyond 280 m. In East Greenland waters Icelandic investigations (J.Magnusson, 1978) show that *S. marinus* dominated the catches to depths of 300-350 m, whereas the proportion of *S. mentella* in the catches increase very rapidly beyond these depths.

Most of the offshore shrimp fishery takes place in depth range 150-250 m, especially in Div. 1B where most of the catches during the last 4-5 years have been taken. This means that *S. marinus* should be dominating species in the bycatches in the offshore shrimp fishery. The same appears in the cod fishery, because most of the cod caught at West Greenland are taken above 300 m depth.

3.2. Spawning areas and drift of larvae

Although redfish is one of the most common fish in the fishery at West Greenland the plankton surveys carried out along the coast show only very small catches of newly extruded redfish larvae (5-7 mm). These small larvae are caught only in the most southern part of the area at West Greenland, whereas bigger larvae are caught later in the year up to 65°N off the coast.

According to Tåning (1949), J.Magnusson (1968), and Cooper and Bainbridge (1971), the main spawning area of redfish in the North Atlantic is found in the Irminger Sea, the area south thereof and the area south of Greenland to approximately 50°N.

The drift of larvae takes place from the deep sea areas to the slope of the continental shelves. From the shelf at East Greenland the larvae drift southwards along the coast and to some extent around Kap Farvel to West Greenland. A great number of cod larvae drifts the same way along with the Irminger Current. At West Greenland redfish larvae possibly mix with some larvae of local origin and from the neighbouring areas (possibly from the area south of Greenland) and they drift together northwards along the West Greenland coast.

Few years later they occur in great quantities as small redfish in the fiords and on the banks approximately to 71°N off the coast.

3.3. Migration of adult redfish from West to East Greenland

In the period from 1956 to 1969 the Greenland Fisheries Investigations tagged 3825 redfish in the Godthåb Fiord (Div. 1D). The mean size of the tagged fish was 44.4 $\pm$3.3 cm.

From 1958 to 1978, 679 recaptures were reported, 645 from the fiord itself and 34 from the banks at West and East Greenland.

Table 1 shows the distribution of the offshore recaptures and the number of years spent between release and recapture. As the table shows, 24 of the offshore recaptures were reported from the West Greenland banks, 7 from the Irminger Sea and 3 from either off West or East Greenland.

The mean number of years spent in sea for the recaptures reported from West Greenland is 2.9 $\pm$2.1 years, and for the East Greenland recaptures 4.4 $\pm$1.4 years.

Of the known offshore recaptures 22.6% were caught off East Greenland. If that figure is taken for the yearly migration, corresponding to an instantaneous coefficient of migration of 0.26 for redfish from West to East Greenland, it seems to be bigger for redfish than for cod. The migration coefficient for cod for the whole ICNAF Subarea 1 used in cod assessment, Res.Doc. 76/VI/17 (Horsted, 1976) is o.o5 and for the two southern Divisions 1E and 1F 0.15.

4. THE FISHERIES

4.1. History of the fisheries

Landings of redfish taken in Subarea 1 have been recorded by the UK back to the mid-1930s, but the stock of redfish was not really exploited until 1953, when the landings raised from a few hundred tons in 1952 to 13 400 in 1953. It was Icelandic trawlers which started a directed fishery for redfish, and from 1955 trawlers from Fed.Rep. of Germany were also engaged in this fishery. The two nations have been dominating the fishery up till now; the Icelandic trawlers took part in the fishery from 1953 to 1967 and the FRG trawlers from 1955. Some other nations have also caught redfish during the period 1951 to 1977. In 1977 only Greenland, FRG, USSR, and Norway seem to have landed redfish from Subarea 1.

4.2. Trends in the catches

Table 2 shows the catches from 1951 to 1977. There was an increase from 1951 to the maximum catch in 1962: 60 352 tons; then from 1962 to 1970 the catches decreased to a level of 3000 tons. This low level was maintained through 1970-1975, but thereafter the catches increased to 31 000 tons in 1977, mainly due to an increase of the FRG fishery.

4.3. The nature of the fishery

In general *Sebastes marinus* occur in the same area as cod, but the proportion between redfish and cod changes with the depth. The proportion of the redfish increase with depth from virtually total absence in shallow water to nearly 100% in deeper water. Therefore, it is possible to some extent to direct the trawling so that one or the other species is the major part of the catch. In the 1960s, where the cod stock in Subarea 1 was rather big, the explanation of the decrease in the redfish fishery could be that trawlers, especially those from the FRG, prefered to catch cod

instead of redfish. On the other hand, the cpue figures from the directed redfish fishery have decreased from 1955 to 1974 (Fig. 1).

5. DISCARDING OF REDFISH

The discarding of redfish can be considered in three parts. The first part includes the amount of commercially sized redfish caught in the cod fishery (or other groundfish fisheries) which could be landed, but which vessels do not. The other part is the undersized redfish taken in the groundfish fishery, which are discarded unless used for reduction onboard. The third part is the small redfish taken as bycatch in the offshore shrimp fishery and generally discarded.

5.1. Discards in the cod fishery

Even though many trawlers prefered to catch cod instead of redfish in the period 1955-77, and therefore avoided areas with many redfish, they are nevertheless likely to have caught many redfish during that period, fish which were discarded.

From FRG trawlers' cod fishery with bycatches of redfish (Section 8.1) it may be possible to estimate the amount of redfish caught by other major nations in the trawl fishery for cod in Subarea 1. In order to achieve the most realistic figures several assumptions in relation to other nations' trawl fisheries have been made. Only those nations which caught many cod during the said period have been taken into account, these nations are: Denmark(F), France, Norway, Portugal, Spain, and United Kingdom. The Spanish pair trawlers are excluded (J.R.Fuertes, 1975).

Table 3 gives the assumptions used in relation to the various countries. Plus (+) means that the bycatch of redfish is estimated from the catch of cod assuming the same proportion of redfish as in the FRG directed cod fishery (for each division, year and quarter of the year). It was the intention to let calculation for the Faroese fleet follow those for Portugal, but the statistics in the past is insufficient, and the calculation for the Faroese fleet instead follows that for France.

Table 4 gives the estimate of the discarded amount of redfish in the cod fisheries of the above mentioned countries. The amount of discarded adult redfish in the cod fisheries varies between years from 1 to 44% of the annual total nominal catch of redfish.

The second category of discard is much more difficult to estimate. From Denmark observation on groundfish trawlers discard of undersized redfish varies between 5-10% by weight of the landed redfish, but discard varies from ground to ground and possibly from time to time. These figures are higher than the observations from FRG trawlers where the discard is in the order of 1-2% (FRG Res.Rep. to ICNAF).

5.2. Discard in the offshore shrimp fishery

Small redfish are the most common and the major part of the bycatches in the offshore shrimp fishery.

From logbooks it was possible to estimate the amount of small redfish caught in that fishery in 1978. The catches of shrimp covered by the available logbooks account for about half the total Greenland offshore shrimp catches, i.e. about 3200 tons of 6500 tons (provisional figures). The bycatches are calculated separately for each of the two tonnage classes, 50-150 and 500-1000 GRT.

From the estimated catch per unit effort for each of the two tonnage classes and in each of the three regulatory areas 1A, 1B+1C, and 1D, it was possible from the total catch of shrimp in each area to calculate the total amount of redfish taken and discarded.

Table 5 which gives both the catch of shrimp and redfish per hour trawled and the estimated catch of redfish, shows that redfish catch rate varies between areas and between tonnage classes.

For tonnage class 3 (50-150 GRT) the catch varies between 54-161 kg per hour trawled, for tonnage class 5 (500-1000 GRT) between 88-185 kg per hour. All these figures are below those found for Div. 1B in October 1976 and in June 1977, when observers were onboard a Greenland trawler (Tonnage class 5), and the catch of redfish per hour were found to be 303 and 299 kg for the two periods, respectively. Smaller figures but still higher than the 1978 figures have been observed in the Danish research vessel catches in Div. 1B in 1976 and 1977, i.e. 203 and 250 kg per hour. On the other hand Norwegian observers onboard the trawler PERO found a catch of small redfish per hour of only 60 kg, Div. 1D, August 1976 (Ulltang and Øynes, 1978).

Based on the catch per hour from each of the two tonnage classes 3 and 5 the two estimates of the total amount of redfish taken as bycatch are 11 900 tons and 8500 tons, respectively (Table 5).

From the observations in June 1977 the length distribution of redfish caught is given in Table 6. The corresponding average length and weight is is 13.8 $\pm$3.0 cm and 42 gram. Based on the average weight the number of redfish caught in 1978 were 283 x 10^6 and 202 x10^6 for each of the two estimated catches of redfish. The estimate for 1976 was between 8200 and 17 000 tons, but in that year the catch of shrimp was about 10 000 tons higher than in 1978.

6. RECRUITMENT OF REDFISH

Redfish are recruited to the commercial groundfish fishery (minimum cod-end mesh size of 130 mm) at a size of about 30 cm which corresponds to an age of 10 to 11 years.

As mentioned earlier the spawning area is generally outside the West Greenland waters, either in the area south of Greenland or in the Irminger Sea, probably mainly the latter.

6.1. 0-group survey in the Irminger Sea

Earlier surveys and present 0-group surveys of redfish carried out by Iceland in the Irminger Sea indicate a great variation in the number of

larvae found from year to year. None of the surveys have covered the total area of the distribution of larvae. It is not possible to separate the larvae into species (*S. marinus* and *S.mentella*) nor to allocate them to the part of redfish stock which is exploited. In order to indicate the year-to-year fluctuation in the abundance of young redfish, the results of the 0-group surveys are presented as index figure of individuals per nautical square mile. The results are given below

Year class	Number of 0-group redfish x 10^{-6} per n.sq.mile
1970	8.6
1971	12.6
1972	38.1
1973	74.0
1974	23.6
1975	12.6
1976	5.8
1977	13.0
1978	6.5

The year-class 1973 was a relatively good one for cod as well as for redfish. According to the reports of 0-group surveys a substantial part of the 0-group redfish drift over the East Greenland shelf and along the coast to West Greenland.

7. CATCH-PER-UNIT-EFFORT FIGURES FROM TWO RESEARCH STANDARD STATIONS,1968-78

Since 1968 the Danish R/V ADOLF JENSEN has fished two standard stations regularly by shrimp trawl with cod-end mesh size of 22 mm. These stations were not chosen in relation to redfish, but the cpue figures can be used as an index of abundance of redfish in that area. The stations are located in the Godthåb Dyb, Div. 1D (the deep between Fyllas Bank and Fiskenæs Bank) and in the Sukkertoppen Dyb, Div.1C(the deep between Fyllas and Tovqussaq Banks). The fishing depths are 300 and 510 m, respectively.

7.1. The catch of redfish per hour trawled

Table 7 gives the catch per hour by quarter of the years 1968-78 for redfish smaller and bigger than 30 cm, separately as well as total catch per hour. For both stations a decrease in the catch per hour has occurred during the period 1968-78 (Figs 2-3) for big as well as for small redfish.

Although the cpue figures are small there seems to be a decline in the abundance of redfish in that area. An explanation could be that at the end of the 1960s a local offshore shrimp fishery started. On the other hand it could also be a general decrease in the abundance of small redfish in the area north of Godthåb, because the size of the small redfish in the offshore shrimp fishery increase from north to south, which means that redfish could have started a southwards migration along the West Greenland coast early in their life, a migration which eventually ends in the spawning areas.

8. MAXIMUM SUSTAINABLE YIELD

8.1. Standardization of the effort

To get an idea about the level of the maximum sustainable yield from the present information it was necessary to estimate the cpue figures by using standard effort unit. The "days fished" by the Fed.Rep. of Germany trawlers of the 1000 and 2000 GRT class was chosen as a standard effort unit. The cpue figures derived were used against the total catches.

As the fishery for cod and redfish at West Greenland is more or less a mixed fishery, the FRG fishery of redfish is divided into three types of fishery, viz. i) cod fishery with bycatches of redfish, ii) fishery of redfish with bycatch of cod, and iii) a mixed fishery of cod and redfish. The criterion used for such a separation was: if more than 60% of the total catch of fin fish was either cod or redfish the fishery was classified as a directed cod or redfish fishery.

In each of the three categories of fishery for redfish there were three different effort units, one from each of the three size categories of vessels which the FRG had used during the period 1955-77.
The three categories are the ICNAF tonnage classes 5, 6, and 7, corresponding to the sizes of vessels on 500-1000, 1000-2000, and above 2000 GRT, respectively.

In order to estimate the conversion factors between the effort figures from each of the three vessel categories, the cod fishery with bycatches of redfish was chosen as the most applicable one. The cpue figures from that fishery were estimated from the total catches of cod and redfish by month and division for each of the three tonnage classes.

The conversion factors for effort 5 to effort 6 and for effort 7 to effort 6 were estimated as follows: catch per day from vessels of the tonnage classes 5 and 7 was divided with the corresponding figures from tonnage class 6, i.e. figures from the same months, same years, and same ICNAF division. To obtain the best conversion factors the following weighting factor for each set of data was estimated and used

$$\frac{(c/f_6)^4 \times f_6 \times f_{5 \text{ or } 7}}{(c/f_6)^2 \times f_6 + (c/f_{5 \text{ or } 7}) \times f_{5 \text{ or } 7}}$$

The estimated conversion factors were following

$$f_5 = 0.82 \times f_6$$

$$f_7 = 1.22 \times f_6$$

Table 8 gives the catch per unit effort for each of the three FRG types of fishery and the corresponding number of standard days fished estimated from total yearly catches of redfish. Figure 1 gives the total catch of redfish for each year and the corresponding effort and catch per unit effort estimated from the directed fishery for redfish.

8.2. Estimates of the catchability coefficient q

By using Leslie's method (Ricker, 1975) it was possible to determine the catchability coefficient q from the catch and cpue figures (from the directed fishery of redfish). The following equation was solved with respect to q

$$c_t/f_t = q\,N_o - q\,K_t$$

N_o = the biomass of the virgin population

K_t = cumulative catch to the start of internal t plus half taken during that interval.

The result was

$$c_t/f_t = 33.85063 - 0.000039\,K_t, \quad r = 0.82$$

The catchability coefficient q is 0.000039 and the standard deviation of the slope (q) is $\pm$0.000016, which is relatively high. An estimate of N_o gives a biomass of 868 000 tons

8.3. The general production model

It is supposed that the stock of redfish in Subarea 1 is in a non-equilibrium stage as nearly all exploited stocks of fish are.

Following abbreviations are used

Y	:	Yield
Y_E	:	Equilibrium yield
B	:	Stock biomass
B_E	:	Equilibrium stock biomass
B_∞	:	Maximum stock biomass
B_S	:	Stock biomass at maximum sustainable yield (MSY)
a	:	The parameter in the Schaefer model

$$\frac{1}{B}\frac{dB}{dt} = b - aB - q \times f$$

k	:	Maximum instantaneous growth rate of the stock
f	:	Effort, standard day fished
q	:	Catchability coefficient
i	:	i'th year

From each year's yield (Y), the effort (f) and the catchability coefficient (q) it is possible to estimate the stock biomass (B) from the equation (Table 9).

1. $B = Y/q \times f$

In order to get the equilibrium stock biomass (B_E) and the equilibrium yield (Y_E) expressed by the stock biomass (B) and the yield (Y) the following equations from G.G.Walter 1975 and 1976 were used

2. $$B_E = B_i + \frac{1}{a}\left(\frac{B_{i+1} - B_i}{B_{i+1}}\right)$$

3. $$Y_i = Y_E + q \times f \times \frac{B_\infty}{k} \times \ln\left(\frac{B_i}{B_{i+1}}\right)$$

The equation 2 was solved in respect to $X_B = \frac{B_{i+1} - B_i}{B_{i+1}}$ after the following rearranging

2a. $B_i = B_E - \frac{1}{a} (\frac{B_{i+1} - B_i}{B_{i+1}})$ with the result

$B_E = 517.740$, $\frac{1}{a} = -286.319$ and $r = 0.33$

It was then possible from equation 2. to estimate the equilibrium stock biomass B_E from the stock biomass (B). The figures for B_E are given in Table 9.

The equation 3. was solved with respect to $X_Y = q \times f \times \ln \frac{B_i}{B_{i+1}}$, which gave the solution

$Y_E = 20.3949$ $\frac{B_\infty}{k} = 543.607$ $r = 0.35$

After rearranging equation 3. the equilibrium yield (Y_E) was estimated (Table 9).

In order to get the maximum sustainable yield the equation

$Y_E/B_E = k - \frac{k}{B_\infty} (B_E)$ was solved with the result

4. $Y_E/B_E = 0.060931 - 0.000037\ B_E$ $r = 0.23$

Maximum instantaneous growth rate of the stock (k)	:	0.060931
Maximum stock biomass (B_∞)	:	1648×10^{-3} tons
Optimum stock biomass (B_S) at MSY	:	824×10^{-3} tons
Maximum sustainable yield (MSY)	:	25,102 tons
Fishing mortality at MSY	:	0.03
Standard days fished at MSY	:	781 standard days

The yield curve estimated from equation (4) is given in Figure 4.

Using the general production model modified by Gulland, where the fishing effort in year i and 5 or 7 years prior to year i were averaged and plotted against the catch per standard day fished in year i gave the results

(6 years average effort) $c/f = 15.7568 - 0.00191\ f$ $r = 0.27$

(8 years average effort) $c/f = 15.0488 - 0.00192\ f$ $r = 0.26$

and the corresponding MSY and effort at MSY

6 years MSY = 32.500 tons and f at MSY = 4125 standard days

8 years MSY = 29.500 tons and f at MSY = 3919 " "

Since the estimated effort at MSY from the modified Gulland model are very much greater than any observed effort, and the MSY and effort from the equilibrium model seems to fit better to the observed value of the effort (Fig. 4), the results from the latter model were chosen.

9. DISCUSSION

As mentioned earlier in this paper both *Sebastes marinus* and *Seabastes mentella* occur in West Greenland waters. The French Res.Rep. 1970 (Allain, 1971) stated that *S. mentella* was caught only beyond 280 m. However, the distribution of the two species both the horizontal and the vertical has to be investigated in more details. It is especially necessary to locate the feeding areas for the young redfish in relation to the inshore and offshore shrimp fishery.

The instantaneous emigration coefficient here estimated to be 0.26 has to be investigated carefully because the effect of an emigration of that size heavily influences the stock size estimates from a cohort analysis, both in the area from where they migrated and in the area to which they migrate, in this case the Irminger Sea.

In the present paper the catchability coefficient is used as a constant during the period 1955 to 1978, although it may well have changed during the period. The estimate of q using Leslie's method from an ordinary predictive regression line depends very much on the X-data, here the cumulative catches. When the estimates of the adults discarded redfish in the cod fishery for each year vary from 2 to 44% of the nominal catches, it might have some influence of the estimates of q and hence the estimates of the MSY. An estimate of q based on the nominal catches plus the estimated discard (Table 4) gave q-value of 0.000032, a corresponding MSY of 32 000 tons and an effort at MSY of 886 standard days. This is 7000 tons more than the estimated MSY based on the nominal catches.

The optimum stock biomass at MSY is estimated to 824 x 10^{-3} tons and the estimate of the present level of the stock biomass is about 650 x 10^{-3} tons, which corresponds to a yield of 20 000 tons.

Redfish are about 10 years old, when they enter the commercial fishery. In these 10 years before recruiting the small redfish are exposed to both offshore and inshore shrimp fisheries, and an annual catch of small redfish in the order of at least 200 mio might have some influence on the forthcoming recruitment.

When the slow growth of the redfish is taken into account together with the discard in the shrimp fishery and the decrease in the catch per unit effort observed by the research vessel, then the recovery of the stock to an optimum stock biomass will take several years, even if catches are several thousand tons beyond the 20 000 tons.

The stock biomass mentioned refers to the stock biomass at West Greenland, but the real stock biomass should be the combined biomass of the stock at the Irminger Sea and that in West Greenland waters. Therefore, assessment and management should include also the stock in the Irminger Sea.

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Table 1. Recaptures of redfish tagged in the Godthåb Fjord and recaptured in the offshore fishery at the banks off West and East Greenland. Number of years spent in sea between release and recapture is also given.

Subarea	Statistical area or locality	Number of recaptures	Number of years spent in sea between release and recapture									Mean number of years between tagging and recapture
			1	2	3	4	5	6	7	8	NK	
ICNAF 1	1D	9	3	4	1				1			2.3 ± 1.9
	1E	9	2	4	1			1		1		3.0 ± 2.4
	1F	3	1	1			1					2.7 ± 2.1
	NK	3				2		1				4.3 ± 0.6
	Total	24	6	9	2	2	1	2	1	1	-	2.9 ± 2.1
ICES XIV	Kap Walløe	3		1			1	1				4.3 ± 2.1
	Kap Tordenskjold	1					1					5.0
	Dohrn Bank	1					1					5.0
	NK	2			1		1					4.0 ± 1.4
	Total	7		1	1		4	1				4.4 ± 1.4
NK		3	1								2	1.0
GRAND TOTAL		34	7	10	3	2	5	3	1	1	2	3.2 ± 2.0

TABLE 2 NOMINAL CATCHES OF REDFISH SUBAREA 1, 1951-1978, METRIC TONS

	1951	52	53	54	55	56	57	58	59	60	61	62	63	64
DEN F											252	204	211	12
DEN G	12				52		55		144	301	346	134	168	222
FRA M														
FRG				174	14161	6639	14874	13180	18832	21709	45739	54972	42804	24346
ICE	27		12406	14689	17983	7349	13095	4055	11884	21094	7805	4495	2226	1956
GDR								322	16					
NOR			2	3			10	9	47	24	5			116
POL										1		164	60	3
PORT														
SPA														
USSR									1351	597			868	
UK	124	159	1057	654	53	20	103	379	266	403	271	383	320	521
ITALY										1				
NON M										94				2835
USA														
	163	159	13465	15520	32249	14008	28137	17945	32540	44224	54418	60352	46657	30011

	65	66	1967	68	69	70	71	72	73	74	75	76	77	78
DEN F	60	47				65	114	18	8					
DEN G	265	291	174	136	138	171	324	244	1112	2405	1406	2696	1077	
FRA M			2	3	6									
FRG	15821	14450	11288	8782	3962	3592	2023	2614	2078	568	3120	5074	29569	
ICE	1254	969	176											
GDR					573	1415	116	20	6	4				
NOR	56	25	10	35	103		56	47	56	81	45	38	44	
POL	3	46	6	68	5									
PORT											33	62		
SPA														
USSR	130		260	90	33	231	13	24	43	192	3982	5825	390	
UK	239	177	73	23		42	110	21	16	74	43	3		
ITALY														
NON M	1224	753	1221	469										
USA					5									
	19052	16758	13210	9606	4885	5516	2756	2988	3319	3324	8629	13698	31080	

Table 3. The assumptions made for estimating by-catches of redfish in the trawl fishery for cod.Plus (+) means the proportion between redfish and cod in the catches is equal to the proportion in FRG directed cod fishery.

Countries	Div. in ICNAF, subarea 1.					
	1A	1B	1C	1D	1E	1F
DEN - F				+	+	+
FRA - M				+	+	+
NOR	+	+	+	+	+	+
POR	OCT-MAY +	OCT-MAY +	OCT-MAY +	+	+	+
SPA				+	+	+
UK	+	+	+	+	+	+

Table 4. The estimated amount of discarded redfish in commersial size in the trawl fisheries for cod of the Fareose, France, Norway, Portugal, Spain and the U.K.

Year	Total Nominal catch	DEN-F,FRA,NOR,PORT,SPA and UK				Total non. catch plus estimated discard
		Nominal catch	Estimated catch	Discarded		
	tons	tons	tons	tons	%	tons
1955	32249	53	6341	6288	19	38537
56	14008	20	6127	6107	43	20115
57	28137	113	6911	6798	24	34935
58	17945	388	6426	6038	33	23983
59	32540	313	3824	3511	11	36057
60	44222	427	3477	3050	7	47274
61	54418	558	6075	5517	10	59935
62	60352	587	12125	11538	19	71890
63	46657	531	10419	9888	21	56545
64	30011	649	9568	8919	29	38930
65	19052	355	6385	6030	31	25082
66	16758	249	7758	7509	44	24267
67	13210	83	3800	3717	28	16927
68	9606	38	2060	2002	21	11608
69	4885	103	1663	1560	32	6445
70	5516	42	2947	2927	53	8443
71	2756	226	361	135	5	2891
72	2988	41	624	583	20	3571
73	3319	22	281	259	8	3578
74	3324	78	159	81	2	3405
75	8629	43	220	177	2	8806
76	13698	3	4	1	+	13699
77	31080					31080

Table 5. The estimated total catches of redfish in the offshore shrimp fishery by management area and tonnage classes together with the catch per hour for each of the two tonnage classes.

Div.	Shrimp+ total catch tons	TONNAGE CLASS 3 TONS shrimp pr.hour	redfish pr.hour	catch of redfish	TONNAGE CLASS 5 TONS shrimp pr.hour	redfish pr.hour	catch of redfish
1A	635	.357	.161	286	.468	.088	119
1B+1C	23955	.223	.105	11279	.462	.151	7830
1D	1665	.234	.054	384	.545	.185	565
	26255	.225	.102	11949	.463	.150	8514

+ premilinary

Table 6 The lenght distribution of redfish caught in June 1976 by the Greenlandic trawler Sisimiut.

cm	no	o/oo
5	6	2.3
6	89	34.1
7	66	25.3
8	25	9.6
9	34	13.0
10	82	31.5
11	209	80.2
12	248	95.1
13	281	107.8
14	361	138.4
15	382	146.5
16	416	159.6
17	245	94.0
18	110	42.2
19	34	13.0
20	11	4.2
21	3	1.1
22		
23	1	0.4
24		
25		
26	1	0.4
27		
28		
29	1	0.4
30		
31	1	0.4
32		
33		
34		
35		
36		
37	1	0.4
38		
39		
	2607	999.9

$\bar{w}$ 0.042 kg

$\bar{l}$ 13.8 $\pm$ 3.0 cm

Table 7 catch per hour of redfish taken by the Danish research vessel ADOLF JENSEN on two standard stations in the periode 1968-78. The catch per hour is given for the total catch of redfish, for redfish ≥30 cm and for redfish <30 cm, and for the three first qauters of the year.

St.	Year	1. qauter				2. qauter				3. qauter			
		No. of hauls	catch per hour,kg total	≥30 cm	<30 cm	No. of hauls	catch per hour,kg total	≥30 cm	<30 cm	No of hauls	catch per hour,kg total	≥30 cm	<30 cm
	1968					4	30	6	24				
	69	5	163	132	31	2	48	10	38	2	120	87	33
	70					3	22	6	16	1	28	14	14
	71	3	164	114	50	3	27	7	20	2	37	31	6
Godthåb	72					3	20	3	17	3	30	2	28
Deep	73	3	85	12	73	5	8	1	7				
	74	3	23	6	17	3	13	3	10	3	18	3	15
	75	3	58	23	35	6	15	2	13	3	24	19	5
	76	3	20	4	16	5	4	1	3	1	40	12	28
	77	3	59	0	59								
	78	3	3	2	1	2	2	0	2	3	3	1	2
	1968												
	69	3	200	73	127	2	59	24	35				
	70									3	50	13	37
	71					2	23	12	11	3	20	10	10
	72					3	20	11	9				
Sukker-	73	4	13	5	8	1	5	0	5				
toppen	74	2	15	5	10	2	27	13	14	1	19	18	1
Deep	75					3	10	3	7	1	7	5	2
	76	2	19	2	17	5	18	5	13				
	77	2	40	8	32	3	64	4	60				
	78	2	3	1	2					3	9	1	8

Table 8. The catch of redfish per standard day fished in each of the three type of fisheries mentioned in the text page 8 during the period 1955 to 1978. The effort figures are the total number of standard days, if the total catch of redfish were taken in each of the three fisheries.

Year	Catches		Cod fishery		Redfish fishery		Mixed fishery	
	Total	PRG	Effort	c/f	Effort	c/f	Effort	c/f
1955	32249	14161	4238	7.61	866	37.24		
1956	14008	6639	1841	7.61	471	29.76	1060	13.21
1957	28137	14874	112548	0.25	829	33.95	1501	8.75
1958	17945	13180	11216	1.60	600	29.93	1494	12.01
1959	32540	18832	32218	1.01	1171	27.79	2083	15.62
1960	44224	21709	36549	1.21	1707	25.91	3529	12.53
1961	54418	45739	10905	4.99	2771	19.64	3727	14.60
1962	60352	54972	11742	5.14	2654	22.74	4927	12.25
1963	46657	42804	12713	3.67	2366	19.72	3895	11.98
1964	30011	24346	9905[x]	3.03[x]	2186[x]	13.73[x]	2995[x]	10.02[x]
1965	19052	15821	9821[x]	1.94[x]	1124[x]	16.95[x]	1881[x]	10.13[x]
1966	16758	14450	6445[x]	2.60[x]	717[x]	23,38	2031[x]	8.25[x]
1967	13210	11288	8866	1.49	781	16.91	2020	6.54
1968	9606	8782	8501	1.13	587	16.36	1108	8.69
1969	4885	3962	5680	0.86	270	18.12	550	8.88
1970	5516	3592	3363	1.64	334	16.52	707	7.80
1971	2756	2023	5104	0.54	184	14.98	269	10.24
1972	2988	2614	2449	1.22	248	12.03	554	5.39
1973	3319	2078	3286	1.01	294	11.30	796	4.17
1974	3324	568	2292	1.45	347	9.57	475	7.00
1975	8629	3120	4988	1.73	572	15.09	1103	7.82
1976	13698	5074	4254	3.22	626	21.89	1285	10.66
1977	31080	29569	-	-	1225	25.38	-	-

x the standard days and cpue estimated from the actuel number of days fished.

Table 9. The estimated size of stock biomass (B), equilibrium stock biomass (B_E) and the equilibrium yield (Y_E) from the directed fishery of redfish, the catchability coefficient is estimated to q=0.000039

Year	Nominal catch tons	Effort standard day	CPUE tons	(qxf) F	B tonsx10^{-3}	B_E tonsx10^{-3}	Y_E tonsx10^{-3}	Y_{E/B_E} tonsx10^{-3}
1955	32249	866	37.2	0.034	947.1	1009.5	28.6	0.0283
56	14008	471	29.8	0.018	777.8	745.2	15.2	0.0204
57	28137	829	34.0	0.032	878.1	910.7	26.0	0.0285
58	17945	600	29.9	0.023	778.3	821.5	16.7	0.0203
59	32540	1171	27.8	0.046	706.5	726.8	30.8	0.0424
60	44224	1707	25.9	0.067	659.7	748.0	34.4	0.0460
61	54418	2771	19.6	0.108	503,7	465.6	62.8	0.1349
62	60352	2654	22.7	0.104	580.8	622.0	52.7	0.0847
63	46657	2366	19.7	0.092	507,6	633.0	28.5	0.0450
64	30011	2186	13.7	0.085	352.9	299.4	39.6	0.1323
65	19052	1124	17.0	0.044	434.1	354.8	26.8	0.0755
66	16758	717	23.4	0.028	600.0	704.2	12.0	0.0170
67	13210	781	16.9	0.030	440.0	455.5	12.3	0.0270
68	9606	587	16.4	0.023	417.4	399.4	10.4	0.0260
69	4885	270	18.1	0.011	445.4	460.6	4.6	0.0100
70	5516	334	16.5	0.013	423.1	439.7	5.1	0.0116
71	2756	184	15.0	0.007	400.0	495.3	1.7	0.0034
72	2988	248	12.0	0.010	300.0	300.0	3.0	0.0100
73	3319	294	11.3	0.011	300.0	378.2	1.9	0.0050
74	3324	347	9.6	0.014	235.7	122.0	7.2	0.0059
75	8629	572	15.1	0.022	390.9	300.7	13.1	0.0436
76	13698	626	21.9	0.024	570.8	537.0	15.3	0.0285
77	31080	1225	25.4	0.048	647.5			

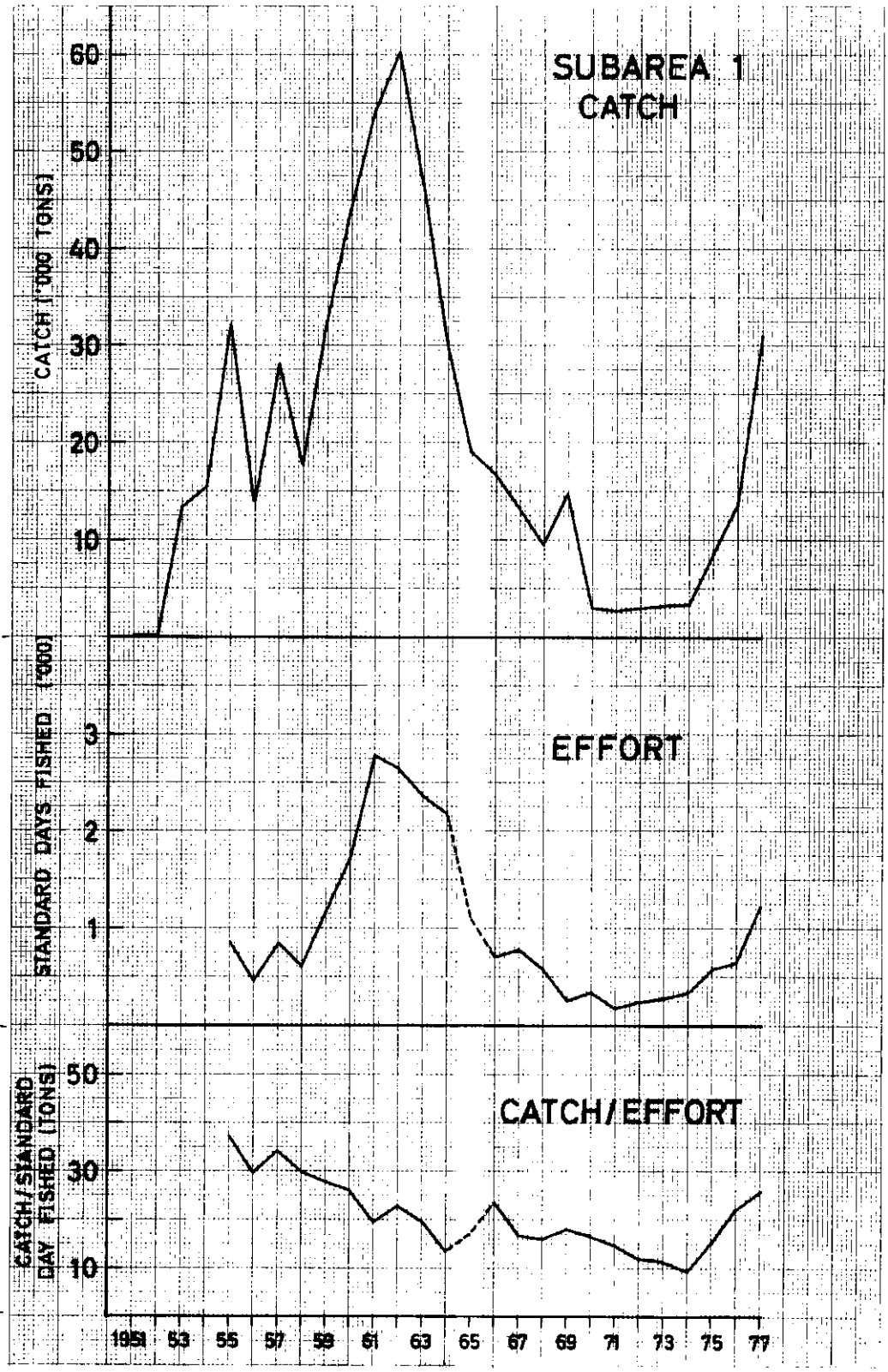


Fig. 1. Trends in catch, effort and catch per standard day fished in the directed fishery of redfish in Subarea 1.

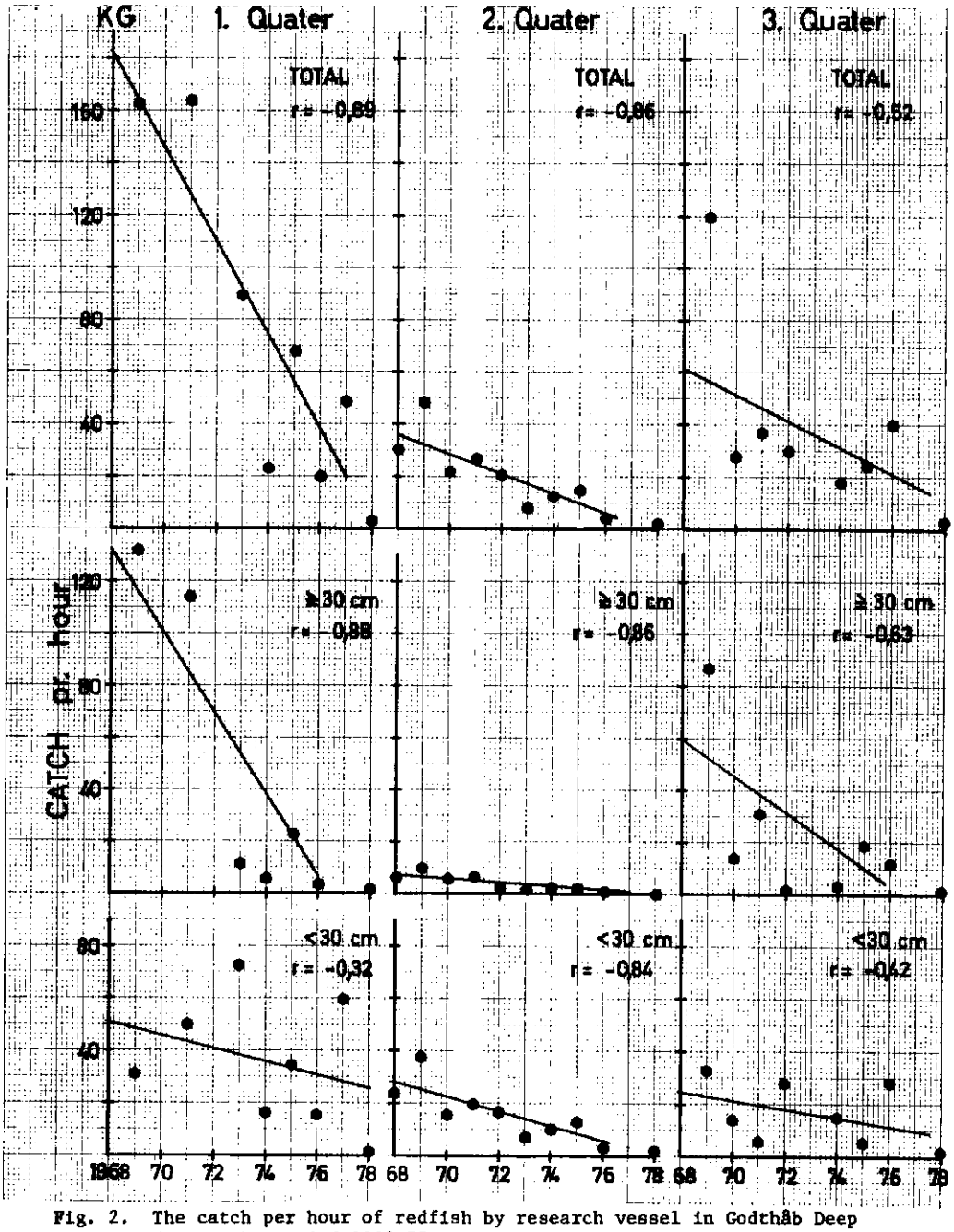
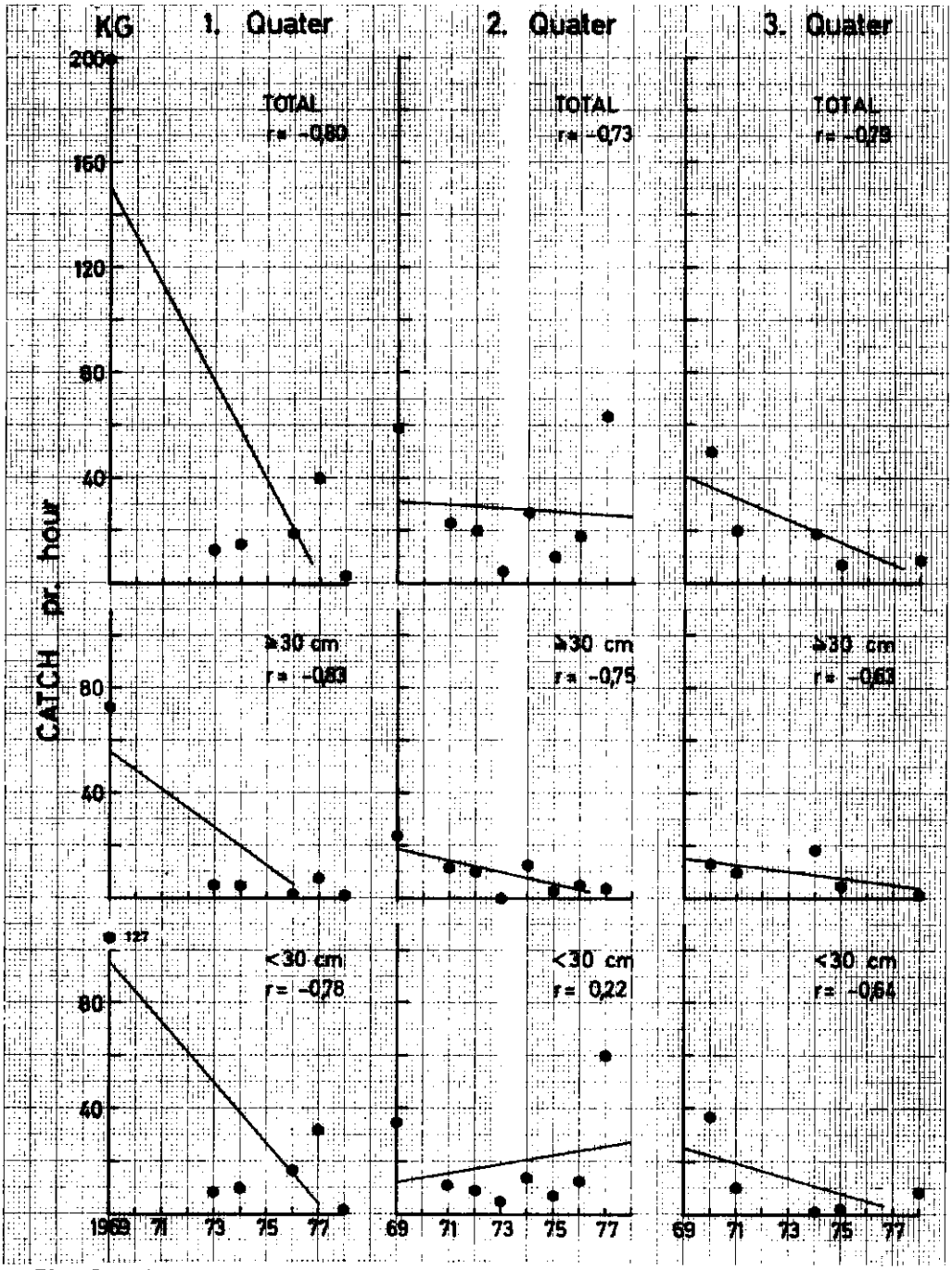


Fig. 2. The catch per hour of redfish by research vessel in Godthåb Deep during the period 1968-78. The catch per hour is given for the total catch as well as for the catch of redfish smaller and bigger than 30 cm, total length.



Nr. 2

Fig. 3. The catch per hour of redfish by research vessel in Sukkertoppen Deep during the period 1969-78. The catch per hour is given for the total catch as well as for the catch of redfish smaller and bigger than 30 cm, total length.

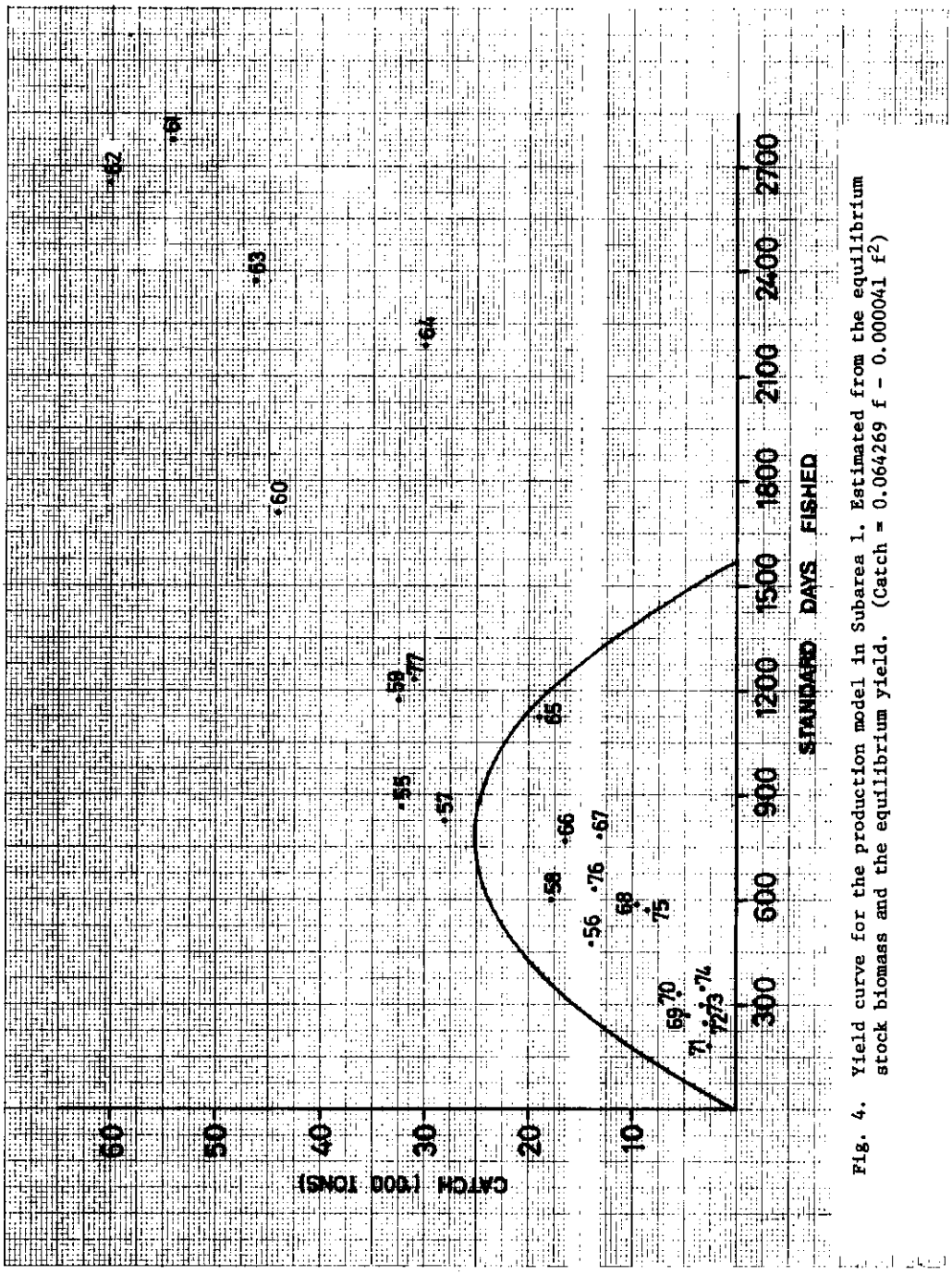


Fig. 4. Yield curve for the production model in Subarea 1. Estimated from the equilibrium stock biomass and the equilibrium yield. (Catch = 0.064269 f - 0.000041 f^2)