International Council for
the Exploration of the Sea.

C.M.1980/G:49
Demersal Fish Committee.

AN ASSESSMENT OF THE COD STOCK AT EAST GREENLAND

by

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SUMMARY

An assessment of the cod stock at East Greenland on the basis of the Virtual Population Analysis technique is presented. Due to the known phenomenon of spawning migration of cod from Greenland to Iceland a coefficient of emigration has been included, ranging from 0.1 to 0.29, the latter figure being the one which the ICES North-Western Working Group estimated by 1970 for the East Greenland plus ICNAF Div. 1E - 1F stock complex as a whole. Irrespective of the value used for emigration in the range given there is a clear picture of a high stock biomass in the late 1960's declining to a minimum level in 1974-75. Some recovery occurred with the recruitment of the 1972 and 1973 year classes, but fishing mortality in the late 1970's (including estimates for unreported catches) seems to have been higher than in the 1960's, and the stock appears to have been fished down again.

Maximum yield per recruit for East Greenland cod can only be achieved by very high levels of fishing mortality, but this would reduce spawning stock biomass to a very low level. A full evaluation of the size of the spawning stock of East Greenland cod would require inclusion of data for the fishing at Iceland in the analysis, and a full assessment of the West Greenland - East Greenland - Iceland stock complex would require analyses by a more refined, dynamic model.

1. Introduction

The purpose of this paper is to make available recent data and to present an up-to-date assessment of the East Greenland (ICES Subarea XIV) cod fishery. It is well known, however, that there is some interchange of cod between East Greenland and West Greenland and also that there is some emigration of adult fish from East Greenland to Iceland. For West Greenland cod regular annual assessments have been made by ICNAF's Standing Committee on Research and Statistics, and by the Scientific Council of the Northwest Atlantic Fisheries Organisation (NAFO) (see, for example, NAFO 1980) but there has been no published assessment of the East Greenland cod since the 1976 meeting of the ICES North-Western Working Group (ICES, 1976).

The problem of migration from Greenland to Iceland has been described by Jones (1978) who used a Virtual Population Analysis (VPA) model which made allowances for migration from Greenland to Iceland.

2. Trends in the fishery

Landings of cod from Subarea XIV in the period 1965-72 averaged 21 000 tonnes (Table 1, Figure 1A). From a peak of 31 500 tonnes in 1971 there was a rapid decline in landings to 6 000 tonnes in 1975. Observations of year class strength at Greenland indicated that this decline was due mainly to the small size of recruiting year classes resulting in a very low abundance of both the fishable stock and the spawning stock. As a consequence the Council of the European Economic Communities (EEC) decided that from 1977 there should be no directed cod fishing at Greenland except for a small quantity to be taken by Greenland vessels.

The stock size began to improve with the recruitment of the somewhat more abundant year classes of 1972 and 1973. Catches officially reported from East Greenland have continued to be very low but there has been additional fishing since 1977 the catches of which have not been officially reported to ICES. Table 1 includes estimates by the authors of unreported landings for the years 1977-79 and shows that the estimated total catches increased to a peak value of 34 000 tonnes in 1979 sustained mainly by the 1972 and 1973 year classes.

A more effective control af fishing activity in 1980 seems to have led to decreased effort and a decrease in catches compared to those estimated for the years 1977-79. On the basis of catches in the first half of the year the authors estimate that the 1980 fishery will result in a catch of about 8 000 tonnes of cod from East Greenland.

3. Stock interrelationships

The dividing line between Convention Areas of the two North Atlantic Fisheries Commissions passes through Cape Farewell with East Greenland falling in the area of the Northeast Atlantic Fisheries Commission (NEAFC), and West Greenland in the area covered by the Northwest Atlantic Fisheries Organisation (NAFO). As a consequence of this the management of Greenland cod has in the past been divided between the two Commissions. All the Greenland fisheries are now managed by the European Communities, and annual assessments of the cod at West Greenland are provided by the Scientific Council of NAFO. By comparison cod at East Greenland have been less well studied, and very few assessments have been made.

The boundaries of the management areas, however, do not constitute stock boundaries, and there is an interchange of cod between East and West Greenland and also between Greenland and Iceland.

In the Cape Farewell region migration may fluctuate seasonally from west to east and *vice versa*, but the resultant net migration is considered to be of mature cod from West to East Greenland, while for some year classes there is evidence of flow of immature cod (often pre-recruits) from South East to South West Greenland. This seems, for instance, to have been the case for the 1973 year class.

In the assessment of West Greenland cod the ICNAF Assessment Committee until 1973 made assessments for cod in Div. 1A-1D and in Div. 1E-1F separately. The ICES/ICNAF Working Group on Cod Stocks in the North Atlantic (Anon., 1973) treated the ICNAF Div. 1E-1F and East Greenland cod as a unit stock for assessment purposes. The latter working group found that migration from Div. 1A-1D to East Greenland/Iceland was insignificant while the emigration from Div. 1E-1F and East Greenland could be equivalent to a migration coefficient of 0.15, although migration may fluctuate between years and year classes.

Since 1973 the age composition and distribution of the stock at West Greenland has led the ICNAF/NAFO committees to consider the West Greenland cod as a unit stock. In doing so the emigration from West to East Greenland has been taken into account by including in assessments an emigration coefficient of 0.05 on age groups 6 and older. The actual emigration rate varies between years and year classes, and the value of 0.05 may be much too low for the 1973 year class.

The assessment presented here has considered the East Greenland fishery as a single management unit. Ideally an assessment for East Greenland should be based on a dynamic model using data from East and West Greenland and from Iceland and making allowances for migrations between areas, but since not all

data necessary for such a model were available this has not been attempted in the present paper, and the assessment is based on East Greenland data only. Allowance has been made for emigration from East Greenland to Iceland. A calculation has been made of the likely net contribution to the East Greenland stock of mature cod from West Greenland in recent years using the data from Table 3 in Schumacher *et al.*, (1980). The results of this calculation are given in Table 2.

Comparing the figures in Table 2 to the estimates of present stock size at East Greenland as given in Tables 4-6 indicates that the annual inflow of West Greenland cod to the East Greenland stock in the years 1975-80 has accounted for less than 10% of the standing stock of fish six years old or older at East Greenland. However, as this standing stock already includes immigrants from West Greenland from previous years the relative importance for the East Greenland stock of the total contribution from West Greenland is underestimated. It may be even more underestimated if the emigration rate for West Greenland is higher than indicated by the coefficient of 0.05.

Furthermore, it should be noted that in the period for which this analysis was carried out the West Greenland cod stock has been in a very depressed state, specifically in so far as older age groups are concerned. The number of cod undertaking spawning migration to East Greenland has therefore been at a minimum.

4. Estimates of emigration from tagging experiments

Based upon tagging experiments at Greenland the ICES North-Western Working Group in 1970 (ICES, 1971) concluded that the actual overall proportion of mature fish at East Greenland and in the southern part of West Greenland (ICNAF Div. 1E-1F) emigrating to Iceland was about 25% per year to which would correspond an emigration coefficient of 0.29.

At its meeting in 1976 the Working Group had available the results of Danish tagging experiments carried out in the years 1966-72. However, this additional material was rather limited, and the Working Group did not find any basis for a revision of its former estimate of the emigration.

Tagging experiments since 1972 have been even more limited and mainly confined to small fish in the coastal region of ICNAF/NAFO Div. 1D. In most recent years some offshore tagging experiments on larger fish have been conducted, but results cannot be evaluated until more time for migration and recaptures has been allowed. However, some recaptures at Iceland do confirm the continued existence of some (spawning) migration from Greenland to Iceland, but the material is too limited to allow any new assessment of

the rate of emigration at present. Consequently, as their best initial estimate of emigration rate the authors used the values from the reports of the North-Western Working Group (ICES, 1971 and 1976).

5. Catch in numbers by age groups

Table 28 in the Report of the ICES North-Western Working Group, 1976 contains estimates of catch in numbers per age group for Subarea XIV cod for the years 1960-75. These figures were obtained by raising figures for the Fed.Rep. of Germany catches as estimated by A. Meyer to total Subarea XIV cod catches.

The authors of the present paper used the same figures for their analyses with the exception of those for 1975 for which there is an evident inconsistency between the age composition and the overall mean weight of fish. Considering the given relative age composition for that year to be correct a new overall mean weight was calculated by applying mean weight of age groups from recent West Greenland analyses (Horsted, 1980, Table 12), and numbers caught were revised accordingly.

For the years 1976-80 catch in numbers by age groups have been based on commercial samples from the Fed.Rep. of Germany trawlers and/or Greenland trawlers. When ever possible each fleet's catches were treated separately with its own samples and for the proper period of the year when the individual samples were taken. Mean weight of fish in the landings were used to raise numbers in samples to numbers in the catch.

As a check sums of products of catch numbers and mean weights (Table 8) were calculated, and these were compared with the landed weight. This resulted in a tolerable range of differences between +13 and -9%. The resultant age composition of the landings is listed in Table 3.

6. Virtual Population Analysis

Using the catch-at-age data given in Table 3 three VPA runs were made. A value for natural mortality of M = 0.2 was used in all cases. Allowance was made for emigration for age groups seven and older by including a coefficient of emigration E which was set to E = 0.1, 0.2 and 0.29 in the three VPA runs, the latter one being the one which was calculated by the ICES North-Western Working Group (ICES, 1971), see Section 4.

There was very little information to give guidance in the selection of F values for input to the VPA for the oldest age groups, and for the most recent year. Values for the oldest age groups were determined mainly from preliminary trial VPA runs (not presented in this paper) with an emigration coefficient

E = 0.0, while those for the last year were based on catch curves and what is known on the relative fishing for cod in the area. For the runs with E = 0.1 and 0.2 the F values were reduced somewhat from those used with E = 0.0 to allow for the reduction in estimates in F which result from making allowances for emigration. For the run for E = 0.29 the original higher F values determined for the run for E = 0.0 were used in order to obtain some indication of the influence the choice of input F values has on the calculated values of F and stock size.

Tables 4-6 give estimates of fishing mortality and stock numbers calculated by VPA for the three runs and a summary is given in Table 1.

As the emigration rate increases the estimates of year class strength increase and estimates of fishing mortality decrease. In the period from 1965 the year classes of 1961 and 1963 are seen to be very abundant. These are followed by a succession of year classes of poor or average (1964 and 1968 year classes) abundance until the abundant 1972 and 1973 year classes appear. None of the subsequent recruited year classes have shown up in any great abundance in either commercial catches or research surveys, and the indications at present are that they are all poor. The value of the coefficient of fishing mortality averaged for age groups 7 to 14+ was approximately 0.35 (depending on the value of E) in the period 1965-71 but in 1972 fishing mortality showed a sharp increase and has remained at a relatively high level up to 1979. Stock weights given in Table 7 were calculated using the weight-at-age data given in Table 8.

7. Management Considerations

As far as the cod fishery is concerned no single part of the West Greenland - East Greenland - Iceland complex is completely independent of the other parts. Consequently, if the overall area is broken down into separate management units, the fishery in any one management unit is going to be affected by the management policy in the other areas as well as by the management policy adopted for the area concerned. For example an increase in fishing at West Greenland will reduce the potential contribution of mature West Greenland cod to the fishery at East Greenland. Similarly the effect of a policy of maintaining fishing mortality at a low level at East Greenland to maintain a large spawning stock size could be reduced if intensive fishing was permitted on the Icelandic spawning stock to which the East Greenland emigrants contribute and from where part of the progeny would be expected to recruit to the East Greenland fisheries.

As far as the fishery at East Greenland is concerned the stock situation over the last fifteen years is summarized in Table 7 and Figure 1. The exploitable

stock biomass (age groups 4-14+) plotted in Figure 1B shows clearly how the stock size has fluctuated. Irrespective of the value used for the emigration coefficient there is a clear picture of a high stock biomass in the late 1960's declining to a minimum level in 1974-75. This was followed by a recovery with the recruitment of the 1972 and 1973 year classes but fishing mortality in the late 1970's was higher than in the 1960's, and the recovery in stock biomass was less than it might have been, and the stock appears to have been fished down again to the low level it reached in 1974-75. As is shown in Figure 1C the calculated estimates of fishing mortality (average for age groups 7-14+) are not greatly influenced by the value of the emigration coefficient used in the calculation.

Yield-per-recruit curves for the fishery at East Greenland (Table 8, Figure 2) shows that, even at low emigration rates, maximum yield-per-recruit could only be obtained at very high levels of fishing mortality. If the management policy was to maximize yield-per-recruit this would only be achieved at very high levels of fishing mortalities thereby reducing the spawning stock biomass to a very low level.

It is not possible to evaluate the size of the spawning stock of East Greenland cod because part of the stock spawns at Iceland and a quantitative estimate of this component would require inclusion of data for the fishery at Iceland in the analyses.

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Table 1. Nominal catch (in thousand tons) of Cod. ICES Sub-area XIV, 1965-79.
(Data for 1965-78 from Bulletin Statistique)

COD	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979 x)
Faroe Islands	-	-	-	-	-	-	-	0.9	0.2	0.7	0.6	0.4	1.4	-	-
German Dem.Rep.	-	-	-	-	-	-	-	-	+	+	0.3	-	-	-	-
Germany, Fed.Rep.	11.0	7.8	12.1	8.3	12.6	13.9	25.6	21.6	9.3	2.3	1.6	7.1	3.6	3.9	1.1
Greenland	0.9	0.9	0.7	0.6	0.6	0.5	0.5	0.3	0.2	+	0.2	0.4	1.8	1.3	3.0
Iceland	4.7	4.0	10.5	6.7	4.5	5.5	4.6	3.2	1.4	3.0	0.8	3.1	+	+	+
Norway	-	-	-	-	-	-	-	-	-	-	1.9	0.4	0.2	-	+
Poland	-	-	-	-	-	0.8	0.4	0.3	+	+	+	-	-	-	-
UK	0.9	0.2	1.4	+	-	0.1	+	0.2	0.7	0.5	0.6	1.5	1.4	-	-
USSR	-	-	+	-	+	+	0.3	0.1	-	-	-	0.1	-	-	-
Total	17.5	12.9	24.7	15.7	17.8	20.9	31.5	26.6	11.8	6.6	6.0	13.0	8.4	5.3	4.1
Total, incl. estimates of unreported catches													18.0	26.0	34.0

x) preliminary

Table 2. Number of cod (in thousands) migrating from West to East Greenland according to the June 1980 assessment by the NAFO Scientific Council when emigration coefficient is taken to be 0.05. For 1980 a value of F = 0.35 (corresponding to a catch of 55 000 tonnes) has been assumed.

	Year	1975	1976	1977	1978	1979	1980
Age Group	6	112	89	126	105	1158	330
	7	281	48	30	57	43	487
	8	73	81	19	11	24	18
	9	35	30	18	7	5	10
	10	18	12	16	7	3	2
	11	6	8	5	9	3	1
	12	5	2	2	2	5	1
	13+	3	3	1	1	1	6
Total	6+	533	273	217	199	1242	855

Table 3. Cod. East Greenland (ICES Sub-area XIV) 1960-75. Catch in numbers per age group (1000 fish).

Age group	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980 x)
3		28							4	4	57	257			5	
4	131	21	145	104	31	66	25	27	25	63	57	175	4635	427	145	52
5	35	470	302	630	252	76	171	85	197	22	339	162	1205	6808	1184	178
6	91	89	2346	502	849	500	159	254	126	488	86	590	513	1828	4700	56
7	879	137	564	2505	770	1539	1051	295	250	176	783	228	652	188	2755	927
8	661	1071	210	238	2103	1060	3785	1299	82	185	155	1546	208	205	797	785
9	1484	359	1292	62	170	1715	1580	3184	710	52	82	158	424	111	121	107
10	59	418	492	144	38	237	1326	818	959	329	21	116	164	278	51	23
11	27	23	371	69	82	32	171	470	222	259	66	53	77	130	18	2
12	139	3	37	27	68	63	19	136	72	65	52	13	29	93	11	10
13	29	27	17	5	24	48	4	26	19	11	16	30	9	56	1	7
14+	178	36	81	25	86	27	14	53	7	2	4	2	1	19	1	4
Total number	3713	2682	5857	4311	4473	5363	8305	6647	2673	1656	1718	3330	7917	10143	9789	2151
Weight landed (tons)	7500	12900	24700	15700	17800	20900	31500	26600	11800	6600	6000	13000	18000	26000	34000	8000

x) Estimate for the year.

Table 4. EAST GREENLAND COD. Estimates from VPA of fishing mortality and stock size. M = 0.2 E = 0.29.

	Age group	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980
	3		.000							.001	.001	.002	.008			.001	
	4	.003	.001	.003	.006	.006	.009	.004	.002	.010	.013	.009	.009	.186	.192	.062	.010
	5	.004	.012	.014	.015	.018	.018	.030	.016	.018	.011	.091	.032	.076	.455	.215	.100
FISHING	6	.032	.011	.079	.028	.026	.044	.047	.057	.029	.056	.054	.225	.135	.158	.662	.150
	7	.091	.071	.107	.130	.063	.070	.142	.133	.084	.059	.137	.228	.485	.077	.441	.300
MORTALITY	8	.168	.209	.202	.081	.211	.156	.338	.363	.067	.112	.091	.625	.474	.388	.771	.300
	9	.473	.177	.600	.114	.104	.372	.519	.781	.491	.075	.089	.172	.496	.738	.602	.300
	10	.052	.328	.556	.165	.129	.283	.820	.840	.868	.648	.052	.241	.379	1.111	1.580	.300
	11	.115	.034	.805	.189	.183	.210	.482	1.281	.874	.937	.360	.248	.349	.881	.252	.300
	12	.307	.022	.096	.163	.404	.288	.256	1.485	1.067	1.084	.720	.151	.290	1.543	.223	.300
	13	.271	.122	.234	.022	.295	.832	.036	.999	1.506	.659	1.491	2.648	.204	3.224	.071	.300
	14+	.500	.500	.500	.500	.500	.500	.500	.800	.800	.500	.400	.700	.800	.800	.800	.300
	3	37059	67739	23889	7124	9579	9031	18358	3356	6511	8496	27359	36935	3291	3269	7047	
	4	51546	30341	55434	19559	5832	7842	7394	15030	2748	5328	6952	22348	30008	2694	2676	5765
	5	11000	42084	24822	45255	15920	4747	6361	6031	12281	2227	4305	5641	18139	20395	1821	2060
NUMBER OF	6	3186	8974	34031	20050	36483	12806	3818	5053	4861	9877	1803	3219	4472	13764	10594	442
COD IN	7	12716	2526	7000	25769	16018	28834	10008	2972	3918	3884	7682	1403	2106	3207	9602	4470
STOCK	8	5370	7112	1442	3853	13856	9218	16475	5321	1593	2207	2243	4103	684	795	1820	3785
	9	4884	2781	3534	722	2177	6873	4831	7200	2268	913	1210	1255	1345	261	330	516
(thousands)	10	1482	1864	1428	1188	394	1202	2901	1761	2019	850	519	678	647	502	76	111
	11	312	863	822	502	617	212	555	783	466	519	272	302	326	271	101	10
	12	656	170	511	225	254	315	105	210	133	119	125	116	144	141	69	48
	13	153	296	102	284	117	104	145	50	29	28	25	37	61	66	18	34
	14+	352	71	160	50	170	53	28	85	11	4	9	3	2	31	2	11

Table 5. EAST GREENLAND COD. Estimates from VPA of fishing mortality and stock size. M = 0.2, E = 0.1.

	Age group	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980
	3		.001							.001	.001	.002	.008			.001	
	4	.004	.001	.004	.009	.012	.017	.007	.003	.014	.016	.011	.009	.182	.184	.062	.010
	5	.007	.019	.022	.024	.028	.037	.057	.029	.025	.015	.111	.040	.083	.441	1.124	.100
FISHING	6	.066	.023	.127	.047	.041	.070	.100	.113	.055	.081	.076	.286	.173	.174	.627	.130
	7	.156	.141	.204	.204	.100	.102	.217	.286	.164	.107	.190	.309	.622	.093	.453	.250
MORTALITY	8	.274	.323	.374	.138	.295	.216	.437	.513	.133	.195	.144	.795	.584	.458	.791	.250
	9	.668	.263	.946	.200	.154	.472	.653	.955	.678	.130	.138	.239	.601	.840	.618	.250
	10	.107	.452	.795	.276	.203	.373	.973	1.015	1.046	.925	.079	.332	.472	1.265	1.619	.250
	11	.197	.061	1.119	.265	.280	.294	.575	1.504	1.034	1.114	.538	.325	.433	1.015	.258	.250
	12	.440	.033	.147	.232	.514	.406	.321	1.682	1.297	1.247	.818	.212	.334	1.924	.229	.250
	13	.344	.158	.298	.029	.374	1.001	.044	1.153	1.739	.809	1.694	2.886	.249	3.475	.093	.250
	14+	.450	.450	.450	.450	.450	.450	.450	.700	.700	.450	.350	.620	.700	.700	.700	.250
	3	22489	43723	15406	3520	5140	4903	12953	2429	5392	6821	25224	37711	3409	3269	7047	
	4	33086	18413	35772	12613	2882	4208	4014	10605	1989	4411	5581	20600	30643	2791	2676	5765
	5	5427	26970	15056	29157	10233	2332	3386	3264	8658	1606	3555	4518	16708	20914	1900	2060
NUMBER OF	6	1570	4412	21657	12054	23303	8150	1840	2618	2595	6911	1295	2605	3553	12592	11018	506
COD IN	7	7026	1199	3527	15649	9378	18291	6204	1364	1909	2002	5221	986	1605	2452	8664	4821
STOCK	8	3172	4454	771	2131	9456	6289	12234	3700	759	1200	1332	3200	536	639	1656	4082
	9	3466	1787	2389	393	1376	5215	3755	5853	1641	492	731	855	1070	222	299	556
(thousands)	10	672	1316	1018	687	238	874	2410	1449	1668	617	320	472	498	435	71	120
	11	174	447	621	340	386	144	446	675	389	434	181	219	251	230	91	10
	12	447	106	312	150	193	216	80	186	111	102	106	78	117	121	62	52
	13	114	213	76	199	88	86	107	43	26	23	22	35	47	62	13	36
	14+	297	60	135	42	143	45	23	76	10	3	7	3	1	27	1	9

Table 6. EAST GREENLAND COD. Estimate from VPA of fishing mortality and stock size. M = 0.2 E = 0.2 (age group 7-14+)

	Age group	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980
	3	0	.001	0	0	0	0	0	0	.001	.001	.002	.007	0	0	.001	0
	4	.004	.001	.004	.007	.008	.013	.005	.002	.012	.014	.010	.008	.175	.184	.062	.010
	5	.005	.016	.017	.020	.022	.026	.042	.021	.021	.013	.098	.034	.073	.418	1.124	.100
	6	.046	.016	.100	.036	.033	.056	.069	.080	.039	.066	.063	.245	.142	.150	.573	.130
FISHING	7	.118	.100	.147	.162	.079	.084	.175	.194	.117	.077	.159	.262	.522	.078	.393	.230
	8	.212	.258	.272	.105	.249	.183	.384	.430	.094	.147	.111	.691	.517	.390	.698	.230
MORTALITY	9	.554	.213	.738	.149	.125	.413	.581	.863	.572	.097	.110	.196	.527	.766	.541	.230
	10	.066	.376	.651	.204	.158	.323	.889	.920	.951	.756	.064	.281	.404	1.099	1.476	.230
	11	.136	.040	.900	.216	.214	.242	.523	1.371	.944	1.017	.418	.282	.386	.867	.222	.230
	12	.332	.025	.104	.177	.435	.317	.278	1.555	1.129	1.146	.762	.167	.309	1.684	.196	.230
	13	.272	.122	.234	.022	.296	.835	.036	1.017	1.513	.662	1.512	2.683	.208	3.263	.077	.230
	14+	.370	.370	.370	.370	.370	.370	.370	.610	.610	.370	.300	.530	.610	.610	.610	.260
	3	29050	53814	18995	4956	7003	6792	15704	2899	6083	8120	28597	39099	3409	3269	7047	
	4	41288	23784	44034	15552	4057	5734	5561	12858	2373	4977	6645	23362	31780	2791	2676	5765
	5	7593	33685	19454	35921	12639	3294	4635	4530	10503	1920	4018	5389	18969	21844	1900	2060
	6	2232	6185	27155	15655	28841	10120	2628	3640	3632	8421	1552	2984	4266	14443	11777	506
NUMBER OF	7	9511	1748	4994	20179	12340	23091	7904	2012	2747	2878	6427	1191	1912	3033	10162	5432
COD IN	8	4161	5663	1061	2891	11500	7647	14230	4449	1110	1639	1786	3675	614	761	1881	4600
STOCK	9	4154	2255	2933	542	1745	6012	4269	6499	1940	678	949	1072	1234	246	345	627
	10	1119	1600	1222	940	313	1032	2654	1601	1839	734	412	570	591	488	77	135
(thousands)	11	256	702	736	427	514	179	501	732	427	476	231	259	288	264	109	12
	12	591	150	452	201	231	278	94	199	124	111	115	102	131	131	74	59
	13	147	284	98	273	113	100	136	48	28	27	24	36	58	65	16	41
	14+	370	75	169	52	179	56	29	88	12	4	9	4	2	31	2	10

Table 7. EAST GREENLAND COD. Summary of average fishing mortality and stock size 1965-1980 for different emigration rates.

E = emigration coefficient $\bar{F}$ = average fishing mortality

		Age group	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980
E=.29	$\bar{F}$	7-14+	.247	.183	.387	.171	.236	.339	.386	.835	.720	.509	.418	.627	.434	1.095	.592	.300
	Stock no.	4-14+	92	97	129	118	92	72	53	44	30	26	25	39	58	42	27	17
	($\times 10^{-6}$)	7-14+	26	16	15	33	34	47	35	18	10	9	12	8	5	5	12	9
	Stock weight	4-14+	226	237	293	310	295	268	212	152	100	82	78	91	115	108	85	53
	(1000 tons)	7-14+	132	90	82	140	156	214	180	108	59	44	56	43	30	26	50	41
E=0.1	$\bar{F}$	7-14+	.330	.235	.542	.224	.296	.414	.459	.976	.849	.622	.494	.715	.499	1.221	.595	.250
	Stock no.	4-14+	55	39	81	71	58	46	34	30	20	18	18	34	55	40	26	18
	($\times 10^{-6}$)	7-14+	15	10	9	18	21	31	25	13	7	5	8	6	4	4	11	10
	Stock weight	4-14+	136	145	184	192	188	177	149	108	66	54	54	73	104	101	82	56
	(1000 tons)	7-14+	80	56	51	84	100	145	132	81	39	27	36	32	23	21	45	44
E=0.2	$\bar{F}$	7-14+	.258	.188	.427	.176	.241	.346	.404	.870	.741	.534	.429	.636	.435	1.095	.527	.234
	Stock no.	4-14+	71	131	102	93	72	58	43	37	25	22	22	39	60	44	29	19
	($\times 10^{-6}$)	7-14+	20	12	12	26	27	38	30	16	8	7	10	7	5	5	13	11
	Stock weight	4-14+	177	187	233	245	235	218	178	128	82	67	66	85	116	112	91	62
	(1000 tons)	7-14+	105	73	66	110	126	177	155	93	48	35	46	38	27	25	52	49

Table 8. EAST GREENLAND COD. Parameters used for the calculation of yield per recruit curves.

Age	Relative F based on average 1973-76 E = 0.29	E = .1	E = .2	Average weight per age group kg
3	.004	.004	.004	.72
4	.017	.015	.014	1.23
5	.06	.06	.06	2.02
6	.116	.15	.14	2.71
7	.20	.24	.20	3.78
8	.30	.39	.34	4.90
9	.47	.54	.50	6.40
10	.74	.73	.67	7.80
11	1.0	1.0	1.0	9.00
12	1.0	1.0	1.0	9.70
13	1.0	1.0	1.0	10.20
14+	1.0	1.0	1.0	10.50

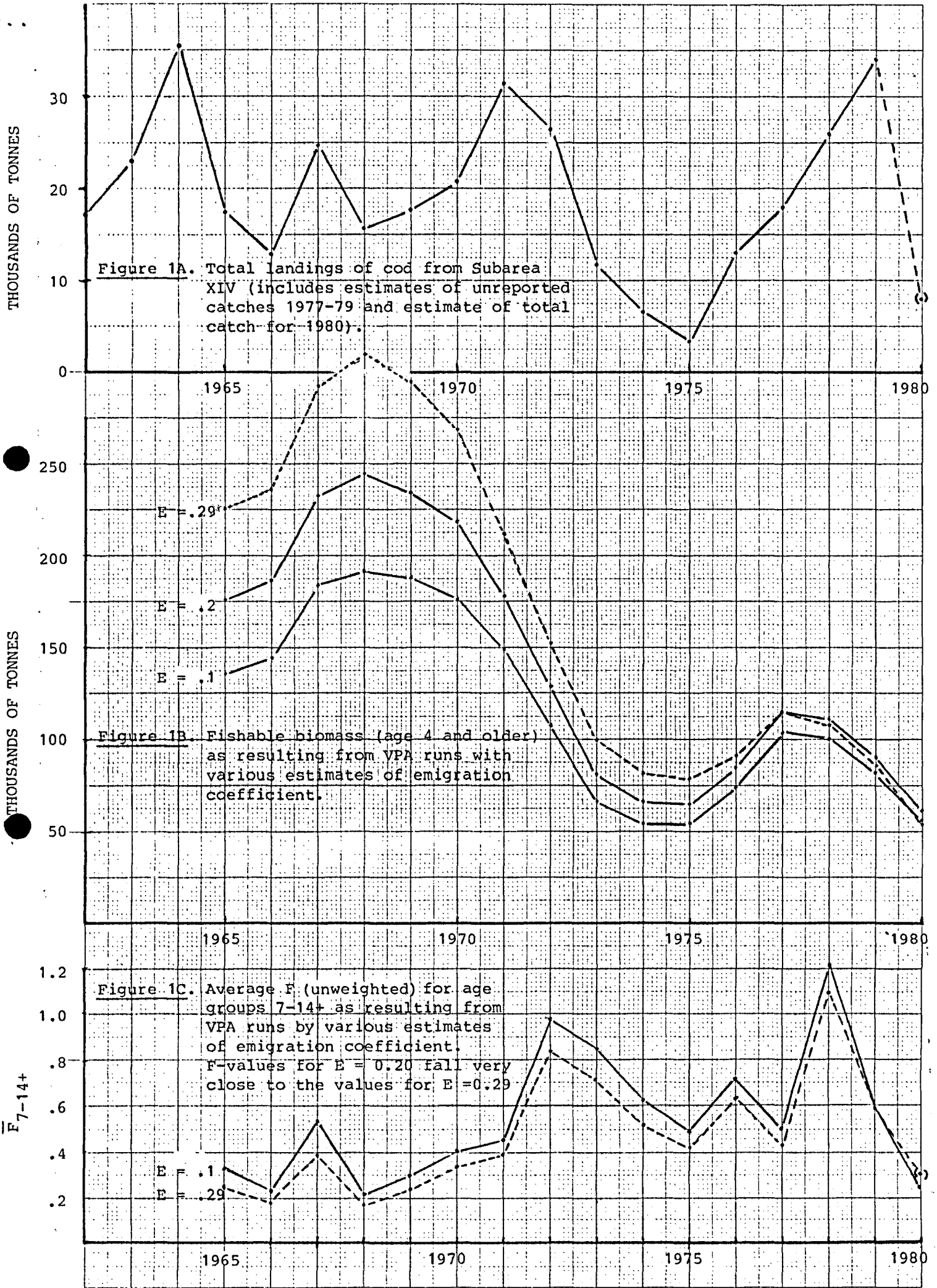

Figure 1A. Total landings of cod from Subarea XIV (includes estimates of unreported catches 1977-79 and estimate of total catch for 1980).

Figure 1B. Fishable biomass (age 4 and older) as resulting from VPA runs with various estimates of emigration coefficient.

Figure 1C. Average F (unweighted) for age groups 7-14+ as resulting from VPA runs by various estimates of emigration coefficient. F-values for E = 0.20 fall very close to the values for E =0.29

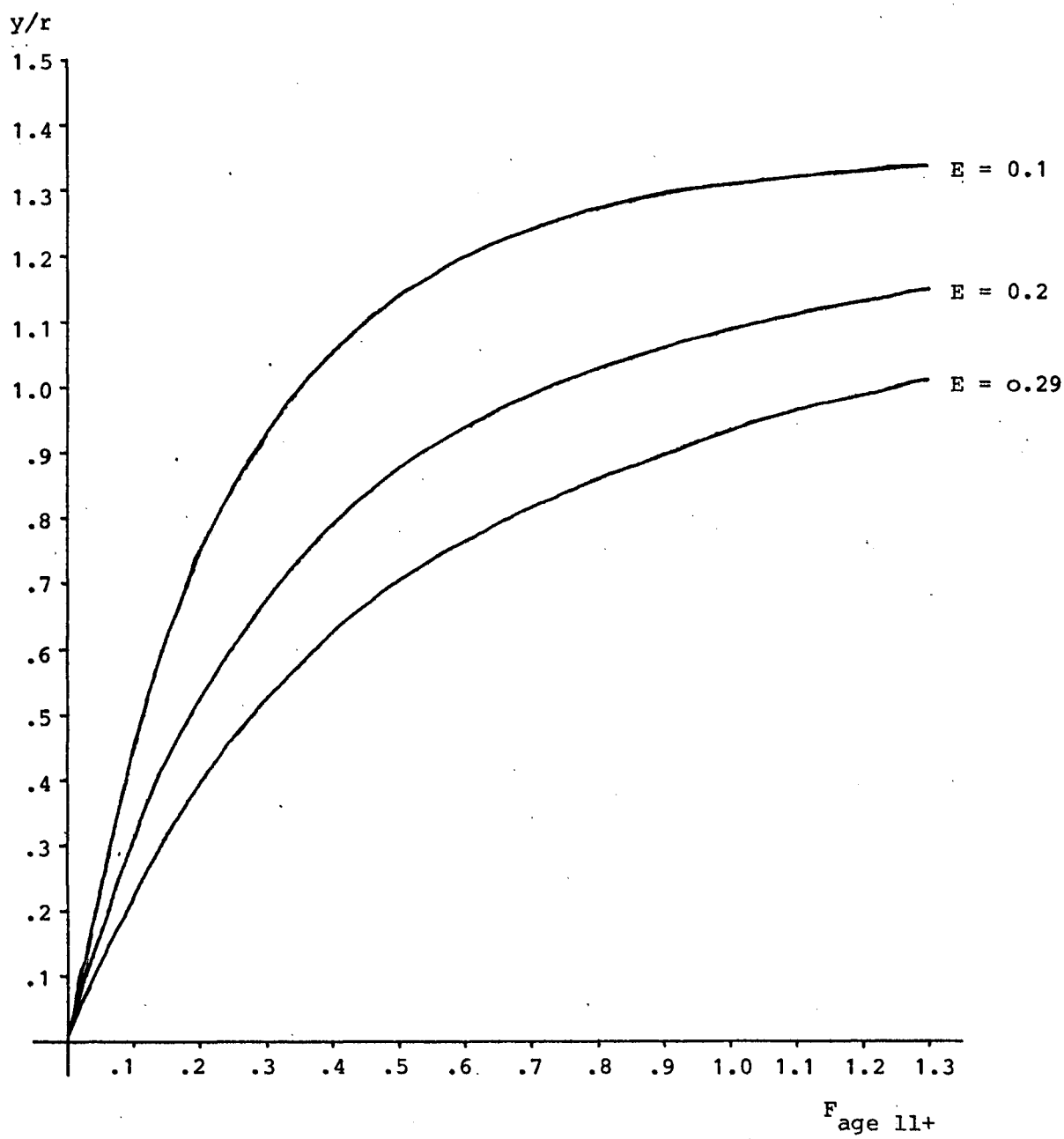

Figure 2. East Greenland Cod.
Yield per recruit for different rates of emigration (E).