Table 13.5. VIRTUAL POPULATION ANALYSIS

NORTH SEA WHITING (FISHING AREA IV)

FISHING MORTALITY COEFFICIENT UNIT: Year-1 NATURAL MORTALITY COEFFICIENT = .20

	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1979-84
0	.110	.164	.288	.271	.238	.377	.470	.106	.314	.097	.267
1	.400	.334	.732	.295	.417	.205	.317	.317	.318	.233	.301
2	.918	1.180	.662	.572	.623	.573	.420	.345	.511	.437	.485
3	1.170	1.323	1.048	.664	.895	.943	.883	.582	.738	.729	.792
4	1.124	1.180	1.082	.909	.671	1.101	1.038	.764	.807	.850	.872
5	1.119	.955	1.078	.859	1.072	1.494	1.059	.912	.963	1.057	1.093
6	2.252	1.361	1.131	1.186	1.133	1.309	1.354	1.134	1.024	1.190	1.191
7	1.161	1.269	.763	1.489	.951	.934	1.347	.881	1.205	1.114	1.072
8	1.119	.708	2.775	1.779	.874	1.901	.960	1.241	1.253	1.000	1.201
9	1.392	.744	.262	1.525	.471	.493	.519	.650	1.129	1.000	.710
10	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
11+	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
(2- 6)U	1.317	1.200	1.000	.838	.879	1.084	.947	.747	.809	.853	

Table_13_6. VIRTUAL POPULATION ANALYSIS

NORTH SEA WHITING (FISHING AREA IV)

STOCK SIZE IN NUMBERS UNIT: thousands

BIOMASS TOTALS UNIT: tonnes

ALL VALUES ARE GIVEN FOR 1 JANUARY

	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1975-81
0	2522668	3081993	2931293	3183449	2475082	1160320	1509531	1101153	2724338	1870935	0	2409191
1	3174098	1850032	2140705	1799971	1988357	1597785	651755	772651	810489	1629698	1590187	1886100
2	725956	1741251	1034562	842606	1097168	1072634	1065839	388830	460651	482667	1056958	1090000
3	470349	237360	437953	458210	389253	481725	495051	573134	225528	226246	255272	424271
4	88391	119472	51779	125782	193163	130265	153676	171014	262164	88287	89356	123219
5	14757	23522	30046	14574	41497	60862	35460	44549	65210	95731	30895	34360
6	9518	3947	7413	8371	4984	11628	14862	10071	14655	20380	27236	8675
7	164	820	329	1959	2094	1314	2573	3141	2052	4310	5076	1396
8	2229	47	189	316	362	662	423	548	1065	651	1158	604
9	202	596	19	10	44	124	81	133	130	254	196	154
10	3	41	232	12	2	22	62	39	57	34	77	53
11+	0	0	5	0	5	9	2	12	0	0	10	3
TOTAL NO	7008334	7059082	6685026	6435060	6192012	4537350	3929311	3065275	4566938	4419194		
SPS NO	1602647	2191260	1761739	1582230	1859518	1869191	1754453	1245357	1084412	1059214		
TOT.BIOM	722633	720070	726217	484543	580864	518623	439210	372516	389440	408616		
SPS BIOM	352030	458309	420422	321692	370681	380362	360971	292805	268631	237751		

Table 13.7. NORTH SEA WHITING.

INPUT DATA FOR PREDICTION
***** **** *** **********

Stock numbers are for year 1985
Fishing mortality and weight at age are averages for the reference period 1979 to 1984
Fishing mortality has been rescaled so that for the Human Consumption FISHERY (landings + discards) F(bar) for the reference period = F(bar) 1984 = .795

AGE	STOCK NUMBER	AV. WT. STOCK	AV. WT. HC. LAND	AV. WT. DISC.	AV. WT. INDUST.	FISHING MORTALITY TOTAL	HC. LAND	DISC.	INDUST.	PROPORTION MATURE	NATURAL MORTALITY
0	2672000.	.016	.130	.050	.014	.268	.000	.012	.256	.000	.200
1	1390137.	.085	.202	.108	.054	.305	.000	.166	.131	.110	.200
2	1056958.	.177	.236	.166	.150	.491	.122	.204	.165	.920	.200
3	255272.	.258	.281	.209	.263	.804	.445	.167	.172	1.000	.200
4	89356.	.323	.334	.233	.375	.887	.675	.122	.090	1.000	.200
5	30895.	.387	.397	.262	.450	1.113	.925	.119	.070	1.000	.200
6	27236.	.451	.455	.265	.486	1.214	1.117	.059	.038	1.000	.200
7	5076.	.505	.507	.276	.504	1.093	1.064	.017	.011	1.000	.200
8	1158.	.615	.617	.365	.482	1.225	1.212	.003	.011	1.000	.200
9	196.	.686	.686	.000	.000	.724	.724	.000	.000	1.000	.200
10	77.	.852	.852	.000	.000	1.020	1.020	.000	.000	1.000	.200
11	19.	.678	.678	.000	.000	.680	.680	.000	.000	1.000	.200

YEAR	RECRUITMENT
1985	2672000
1986	2672000
1987	2672000

Table 13.8. Management Options: North Sea WHITING

1985			
Stock biomass	Spawning stock biomass	$\bar{F}_{(2-6)}$ H.C.	Total landings
470	308	.795	117*

1986							
Management option for 1986	Stock biomass	Spawning stock biomass	$\bar{F}_{(2-6)}$ H.C.	Total landings	H.C. landings	Industr. landings	Discards
$F_{86} = 0$	520	339	0	59	0	59	0
$F_{86} = .2F_{85}$			.159	78	21	57	14
$F_{86} = .5F_{85}$			.397	103	49	54	33
$F_{86} = F_{85}$			.795	135	85	50	61
$F_{86} = 1.5F_{85}$			1.192	159	113	46	85
$F_{86} = 2.0F_{85}$			1.590	177	134	43	105

1987		
Management option for 1986	Stock biomass	Spawning stock biomass
$F_{86} = 0$	713	525
$F_{86} = .2F_{85}$	674	487
$F_{86} = .5F_{85}$	623	438
$F_{86} = F_{85}$	553	370
$F_{86} = 1.5F_{85}$	498	316
$F_{86} = 2.0F_{85}$	453	273

*Includes Industrial landings = 45

Weights in '000 tonnes
Recruitment R_0 = 2,672 million in 1985-86
Stock biomass = fish of age 0 and older
Spawning stock biomass using maturity ogive
Exploitation pattern 1985-86 based on 1979-84 average
F values relate to human consumption fishery (landings + discards) only

Table 14.1. Nominal catch (in tonnes) of WHITING in Division VIa, 1975-84 (Data for 1975-83 as officially reported to ICES)

Country	1975	1976	1977	1978	1979
Belgium	1	14	-	-	-
Denmark	-	-	-	119	92
Faroe Islands	30	2	-	-	770
France	2,763	3,655	3,395	3,610	2,779
German, Dem.Rep.	-	31	-	-	-
Germany, Fed.Rep.	62	1	1	2	4
Ireland	2,429	3,255	2,752	2,080	2,791
Netherlands	85	255	78	23	17
Norway	-	1	-	-	-
Spain	1,871	821	763[1]	-	-
U.K. (England & Wales)	132	244	520	669	320
U.K. (Scotland)	12,668	16,658	9,873	8,174	10,613
U.K. (N. Ireland)	-	-	-	-	-
Total Division VIa	20,041	24,937	17,382	14,677	17,386
W.G. Total	20,043	24,937	17,411	14,677	17,081

Country	1980	1981	1982	1983	1984*
Belgium	+	-	2	-	-
Denmark	32[1]	-	+	-	-
Faroe Islands	-	-	-	-	-
France	2,609	1,637	1,798	2,029	1,373
German Dem.Rep.	-	-	-	-	-
Germany, Fed.Rep.	1	49	53	43	5
Ireland	4,407	8,148	3,406	3,578	3,397
Netherlands	2	6	285	- *	
Norway	-	-	-	-	-
Spain	-	-	99	76	
U.K. (England & Wales)	227	145	166	157	125
U.K. (Scotland)	7,386	8,519	8.419	10,019	11,255
U.K. (N. Ireland)	-	-	7	52	36
Total Division VIa	14,664	18,504	14,235	15,954	16,191
W.G. Total	12,816	12,203	13,871	15,971	15,902

*Provisional
[1] Includes Division VIb

Table 14.2. VIRTUAL POPULATION ANALYSIS

WHITING IN FISHING AREA VIA (NW. COAST OF SCOTLAND, N. IRELAND)

CATCH IN NUMBERS UNIT: thousands

	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984
1	14917	8500	16120	17670	6334	11650	5593	2991	3418	6966
2	16779	46421	13576	18175	34221	11378	24395	5785	7094	12334
3	36318	15757	25144	6682	13262	14860	11297	29094	8040	7943
4	2819	17425	3127	9400	3407	4155	4611	6821	22758	4239
5	281	1508	4719	941	3488	1244	1518	2043	6870	14324
6	57	66	292	1433	276	1085	452	805	1459	1887
7	7	13	15	65	374	84	197	254	399	699
8+	258	44	11	4	10	106	5	95	141	131
TOTAL	71415	89732	62302	54366	61372	44562	48068	47864	49359	48523

Table 14.3. VIRTUAL POPULATION ANALYSIS

WHITING IN FISHING AREA VIA (NW. COAST OF SCOTLAND, N. IRELAND)

MEAN WEIGHT AT AGE OF THE STOCK UNIT: kilogram

	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984
1	.209	.201	.200	.199	.213	.172	.192	.184	.216	.216
2	.245	.242	.244	.235	.232	.242	.228	.220	.249	.259
3	.305	.309	.296	.286	.306	.330	.269	.276	.280	.313
4	.471	.361	.392	.389	.404	.420	.382	.352	.340	.371
5	.651	.497	.431	.516	.536	.492	.409	.505	.409	.412
6	.615	.687	.629	.549	.678	.595	.409	.513	.494	.458
7	.841	1.050	.846	.602	.694	.722	.542	.503	.526	.438
8+	.713	.000	1.160	.975	.644	.876	.751	.603	.441	.601

Table 14.4. VIRTUAL POPULATION ANALYSIS

WHITING IN FISHING AREA VIA (NW. COAST OF SCOTLAND, N. IRELAND)

FISHING MORTALITY COEFFICIENT UNIT: Year-1 NATURAL MORTALITY COEFFICIENT = .20

	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1979-84
1	.12	.20	.25	.19	.09	.07	.10	.09	.07	.10	.09
2	.49	.62	.57	.49	.68	.24	.19	.23	.30	.40	.34
3	.76	1.28	.83	.62	.83	.73	.41	.37	.59	.65	.60
4	.77	1.08	1.01	.90	.77	.69	.53	.46	.56	.72	.62
5	1.26	1.38	1.03	1.01	1.08	.75	.58	.47	.99	.85	.79
6	1.18	1.29	1.22	1.09	.99	1.34	.66	.72	.73	1.02	.91
7	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
8+	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
(2- 4)U	.67	.99	.80	.67	.76	.55	.38	.35	.48	.59	

Table 14.5. VIRTUAL POPULATION ANALYSIS

WHITING IN FISHING AREA VIA (NW. COAST OF SCOTLAND, N. IRELAND)

STOCK SIZE IN NUMBERS UNIT: thousands

BIOMASS TOTALS UNIT: tonnes

ALL VALUES ARE GIVEN FOR 1 JANUARY

	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1975-81
1	150514	50660	80178	111618	77700	199113	41235	39870	53850	77677	0	101574
2	47144	109782	53825	51142	75474	57903	152506	38520	29945	41005	57315	75397
3	74545	23565	48375	15723	25587	31226	37170	102897	19784	18141	22504	36599
4	5727	28631	5351	17202	6699	9113	12303	20296	58125	9005	7754	12175
5	424	2175	7976	1602	5717	2609	3750	5943	10502	27219	5589	3465
6	89	99	448	2338	476	1585	1020	1712	3035	3202	9525	866
7	12	22	22	106	642	144	338	436	685	1200	945	184
8+	409	76	19	7	17	182	9	163	242	225	429	103
TOTAL NO	278864	215009	176193	199741	192512	301876	248339	201838	176168	177675		
SPS NO	128350	164349	96016	88122	114812	102762	207104	161968	122318	99998		
TOT.BIOM	69074	55539	44466	47601	48909	64382	60274	53792	50652	49760		
SPS BIOM	37616	45356	28430	25389	31970	30635	52357	46456	39020	32981		

Table 14.6.

List of input variables for the ICES prediction program.

WHITING IN FISHING AREA VIA (NW. COAST OF SCOTLAND)
The reference F is the mean F for the age group range from 2 to 4

The number of recruits per year is as follows:

Year	Recruitment
1985	66000.0
1986	90000.0
1987	90000.0

Data are printed in the following units:

Number of fish:	thousands
Weight by age group in the catch:	kilogram
Weight by age group in the stock:	kilogram
Stock biomass:	tonnes
Catch weight:	tonnes

age	stock size	fishing pattern	natural mortality	maturity ogive	weight in the catch	weight in the stock
1	66000.0	.10	.20	.00	.200	.200
2	57315.0	.39	.20	1.00	.238	.238
3	22504.0	.68	.20	1.00	.299	.299
4	7754.0	.70	.20	1.00	.378	.378
5	3589.0	.90	.20	1.00	.461	.461
6	9525.0	1.03	.20	1.00	.525	.525
7	945.0	1.00	.20	1.00	.571	.571
8+	429.0	1.00	.20	1.00	.653	.653

Table 14.7.

Effects of different levels of fishing mortality on catch, stock biomass and spawning stock biomass.

WHITING IN FISHING AREA VIA (NW. COAST OF SCOTLAND)

Year 1985					Year 1986					Year 1987	
factor	ref. F	stock biomass	sp.stock biomass	catch	factor	ref. F	stock biomass	sp.stock biomass	catch	stock biomass	sp.stock biomass
1.0	.59	44	31	14	.0	.00	47	29	0	64	46
					.1	.06			2	63	45
					.2	.12			3	61	43
					.4	.24			6	58	40
					.6	.35			9	55	37
					.8	.47			11	52	34
					1.0	.59			13	50	32
					1.2	.71			15	48	30
					1.4	.83			17	46	28
					1.6	.94			18	45	27
					1.8	1.06			20	43	25
					2.0	1.18			21	42	24

The data unit of the biomass and the catch is 1000 tonnes.
The spawning stock biomass is given for 1 January.
The reference F is the mean F for the age group range from 2 to 4

Table 15.1. Nominal catch (in tonnes) of WHITING in Division VIb, 1975-84. (Data for 1975-83 as officially reported to ICES).

Country	1975	1976	1977	1978	1979
Denmark	-	-	-	-	-
France	-	-	-	-	-
Germany, Fed.Rep.	-	-	-	-	-
Ireland	-	-	-	1	-
Spain	-	-	...[1]	-	-
U.K. (England & Wales)	-	3	2	5	1
U.K.(Scotland)	12	15	5	24	2
Total Division VIb	12	18	7	30	3

Country	1980	1981	1982	1983	1984*
Denmark	...[1]	-	-	-	-
France	3	-	-	-	2
Germany, Fed.Rep.	-	-	-	-	-
Ireland	-	-	-	-	
Spain	-	196	112	88	
U.K. (England & Wales)	+	-	-	-	2
U.K. (Scotland)	59	+	-	5	25
Total Division VIb	62	196	112	93	29

*Provisional

[1] Included in Division VIa

Table 16.1 Nominal catch (in tonnes) of WHITING in Division VIId & VIIe in 1975-84. (Data for 1975-83 as officially reported to ICES)

Country	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984*
Belgium	70	103	36	85	92	85	102	101	94	83
Denmark	-	18	-	1	2,585	6	2	-	-*	-
France	10,060	8,390	8,886	8,010	5,352	7,690	8,842	8,051	5,708	6,346
Germany Fed.Rep.	1	-	-	-	-	-	-	-	-	-
Ireland	-	-	11	12	-	13	-	-	-	-
Netherlands	14	5	1	2	1	2	2	70	-*	
UK (England & Wales)	1,255	1,504	1,342	1,038	930	839	1,136	1,222	1,210	800
Total Divs.VIId,e	11,400	10,020	10,276	9,148	8,960	8,635	10,084	9,444	7,012	7,229

* Provisional

Table 16.2. VIRTUAL POPULATION ANALYSIS

WHITING IN THE ENGLISH CHANNEL (FISHING AREAS VIIE AND VIID)

CATCH IN NUMBERS UNIT: thousands

	1976	1977	1978	1979	1980	1981	1982	1983	1984
1	12727	13847	19949	7333	4375	2764	7789	4343	3225
2	7313	13004	9201	7982	11628	10670	12863	13324	13810
3	5074	2835	4649	4542	5103	10831	13487	6766	10118
4	1410	843	1556	2482	2037	8200	2639	2412	2125
5	521	253	433	639	523	3217	1103	620	1211
6	74	46	88	93	58	1044	387	152	340
7+	0	8	0	10	8	688	114	53	32
TOTAL	27119	30836	35876	23081	23732	37414	38382	27670	30861

Table 16.3. VIRTUAL POPULATION ANALYSIS

WHITING IN THE ENGLISH CHANNEL (FISHING AREAS VIIE AND VIID)

MEAN WEIGHT AT AGE OF THE STOCK UNIT: kilogram

	1976	1977	1978	1979	1980	1981	1982	1983	1984
1	.260	.258	.207	.299	.282	.157	.173	.190	.157
2	.374	.347	.260	.379	.336	.233	.209	.228	.205
3	.479	.496	.346	.435	.436	.259	.282	.292	.267
4	.594	.642	.412	.518	.461	.297	.348	.341	.355
5	.696	.749	.668	.594	.538	.370	.407	.364	.288
6	.742	.850	.711	1.052	.633	.455	.417	.546	.314
7+	.740	.955	.711	.479	.700	.382	.415	.499	.454

Table_16.4. VIRTUAL POPULATION ANALYSIS

WHITING IN THE ENGLISH CHANNEL (FISHING AREAS VIIE AND VIID)

FISHING MORTALITY COEFFICIENT UNIT: Year-1 NATURAL MORTALITY COEFFICIENT = .20

	1976	1977	1978	1979	1980	1981	1982	1983	1984	1979-84
1	.33	.38	.45	.18	.10	.08	.16	.10	.25	.15
2	.71	.66	.46	.33	.47	.38	.68	.45	.50	.47
3	1.28	.67	.52	.44	.36	1.13	1.25	.96	.73	.81
4	1.31	.76	1.00	.59	.36	1.76	.99	.79	.96	.91
5	1.91	.91	1.22	1.89	.23	1.66	1.55	.67	1.31	1.22
6	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
7+	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
(2- 4)U	1.10	.69	.66	.45	.40	1.09	.97	.73	.73	

Table_16.5. VIRTUAL POPULATION ANALYSIS

WHITING IN THE ENGLISH CHANNEL (FISHING AREAS VIIE AND VIID)

STOCK SIZE IN NUMBERS UNIT: thousands

BIOMASS TOTALS UNIT: tonnes

ALL VALUES ARE GIVEN FOR 1 JANUARY

	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1976-81
1	49982	48482	60283	49431	49658	37967	58156	51693	16019	0	49297
2	15743	29487	27263	31469	33866	36695	28591	40597	38406	10214	29087
3	7596	6360	12522	14073	18593	17305	20466	11917	21290	19072	12741
4	2085	1729	2674	6088	7449	10640	4562	4815	3740	8400	5111
5	654	460	563	800	2765	4269	1506	1390	1792	1173	1603
6	127	79	151	160	100	1793	665	261	584	396	402
7+	0	14	0	18	14	1181	196	91	95	192	204
TOTAL NO	76187	86610	103557	102045	112424	109850	114142	110764	81886		
SPS NO	26205	38128	43273	52014	62786	71384	55986	59071	65867		
TOT.BIOM	25309	27429	25552	36638	38477	24999	24367	24893	18125		
SPS BIOM	11314	14921	13073	21858	24480	19039	14306	15072	15610		

Table 16.6 Nominal catch (in tonnes) of WHITING in Divisions VIIb,c & VIIg-k in 1975-84 (Data for 1975-83 as officially reported to ICES)

Country	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984*
Belgium	83	97	60	37	26	31	61	28	47	71
France	3,637	4,731	3,962	3,868	4,127	5,603	5,922	4,767	5,218	3,890
Germany Fed.Rep.	2	-	1	45	-	+	-	-	-	-
Ireland	2,562	1,980	1,201	1,172	2,674	3,710	3,612	4,073	2,714	2,087
Netherlands	66	112	86	63	3	4	21	78	216*	
Spain	2,974	2,772	-	-	-	-	-	85	91	
UK (England & Wales)	61	21	26	38	23	60	257	153	68	19
UK (Scotland)	-	-	2	1	1	80	1	-	-	112
USSR	64	2	-	-	-	-	-	-	-	-
Total Divs.VIIb,c & g-k	9,449	9,715	5,338	5,224	6,854	9,488	9,874	9,184	8,354	6,179

* Provisional

Table 17. Availability of quarterly age-composition and weight-at-age data, 1975 - present.
NORTH SEA STOCKS

Country	COD	HADDOCK	WHITING
Belgium	1975-1984		
Denmark	1975-1984	1975-1984	1975-1984
France	(1978-1979) 1980-1984	(1978-1979) 1980-1984	(1978-1979) 1980-84
Germany, Fed.Rep.	(1980-1982) 1983-1984	1974-1984 Quantities landed only	1974-1984 Quantities landed only
Netherlands	1975-1984	1975-1984 H.C. landings only	1975-1984 H.C.landings only 1975-1984 Discards
Norway	1976-1984 Quantities landed only	1978-1984 H.C.landings Quantities only 1979-1984 Industrial by-catch	1978-1984 H.C.landings Quantities only 1979-1984 Industrial by-catch
U.K. (England & Wales)	1975-1984	1975-1984	1975-1984
U.K. (Scotland)	1975-1984	1975-1984	1975-1984

Figure 3.1. NORTH SEA COD.
Rho Plot. x denotes predicted value.

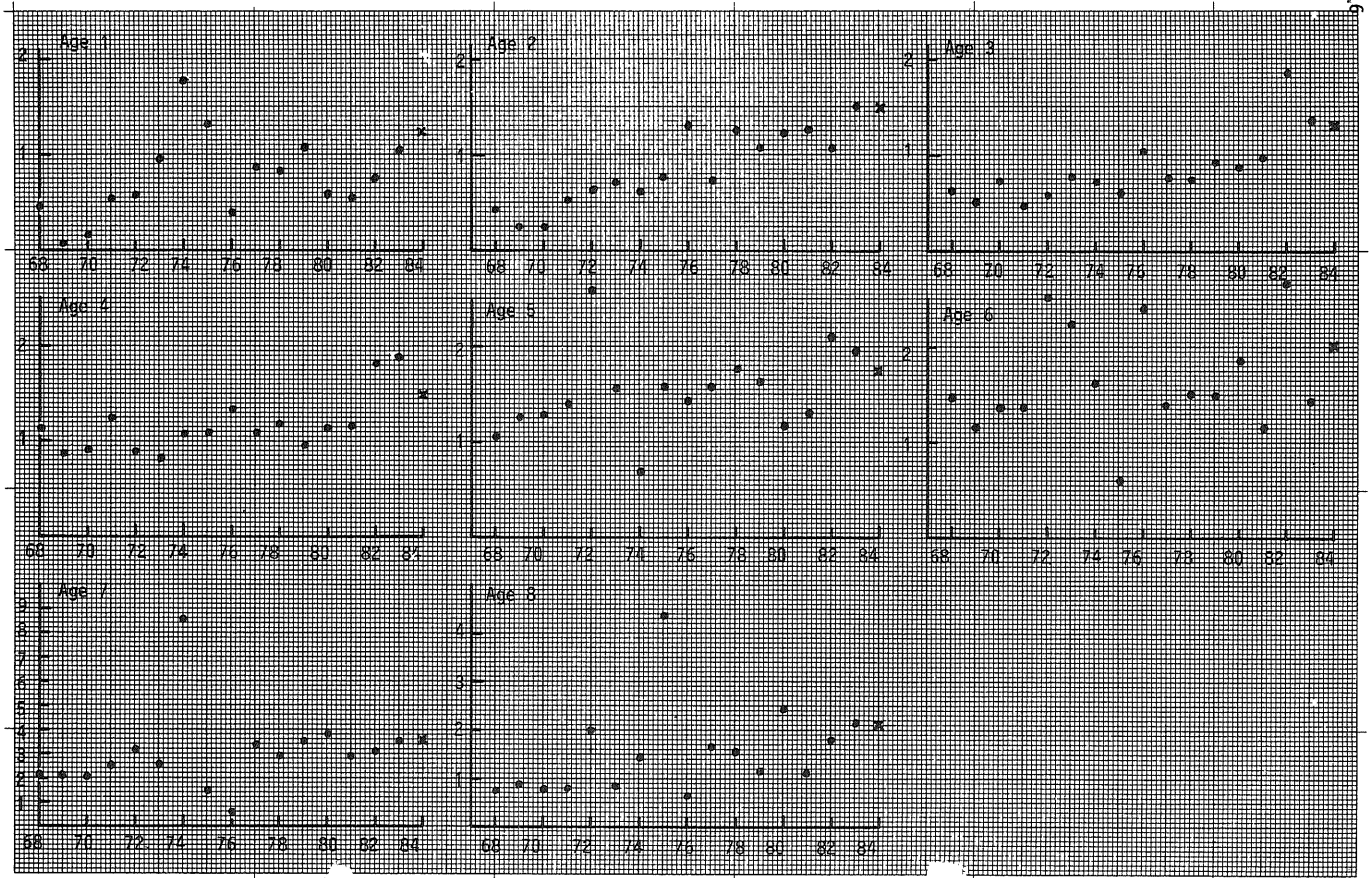


Figure 3.2. WEST OF SCOTLAND.
Rho Plot. x denotes predicted value.

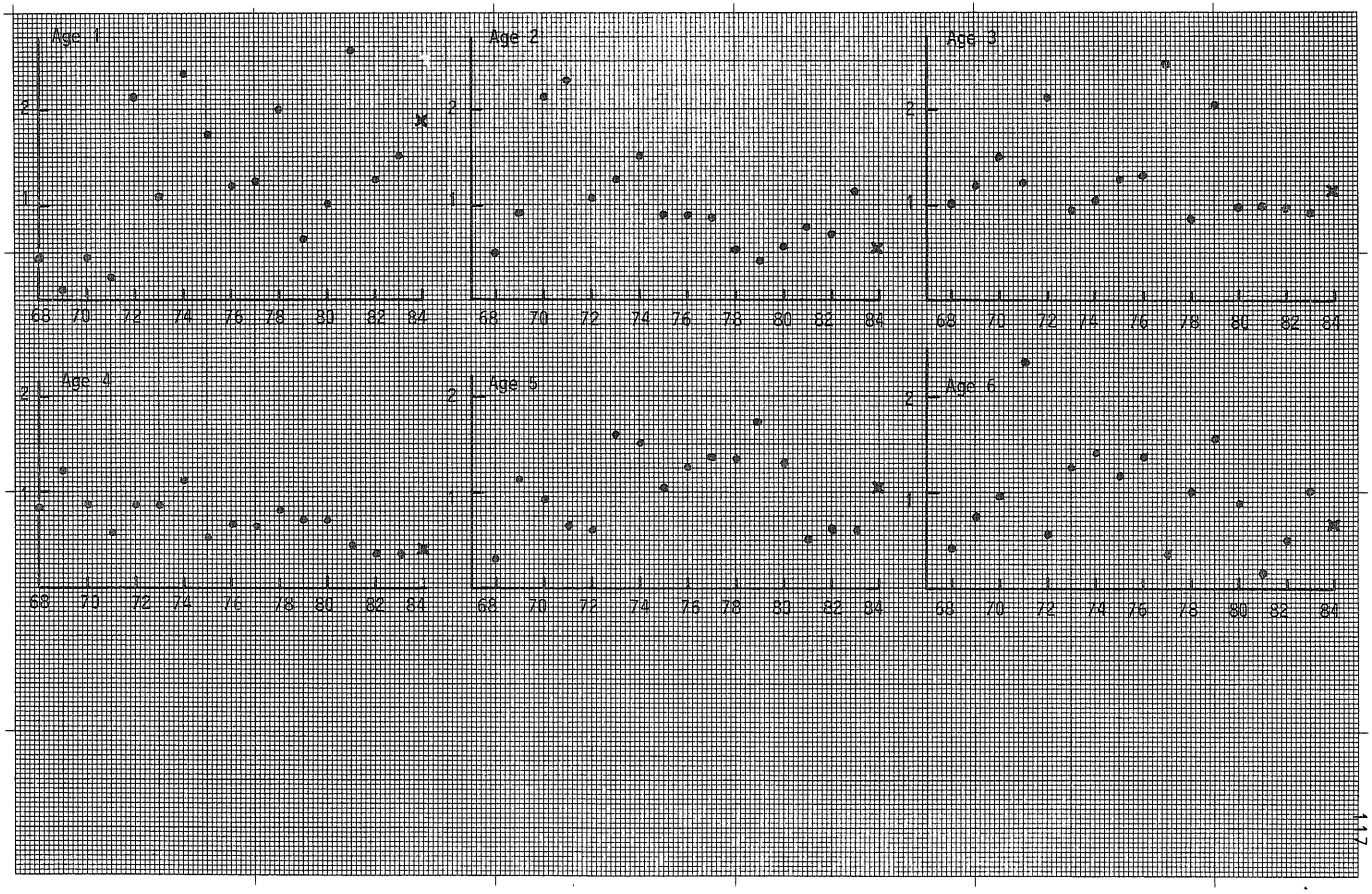


Figure 3.3. NORTH SEA HADDOCK.
Rho Plot. x denotes predicted value.

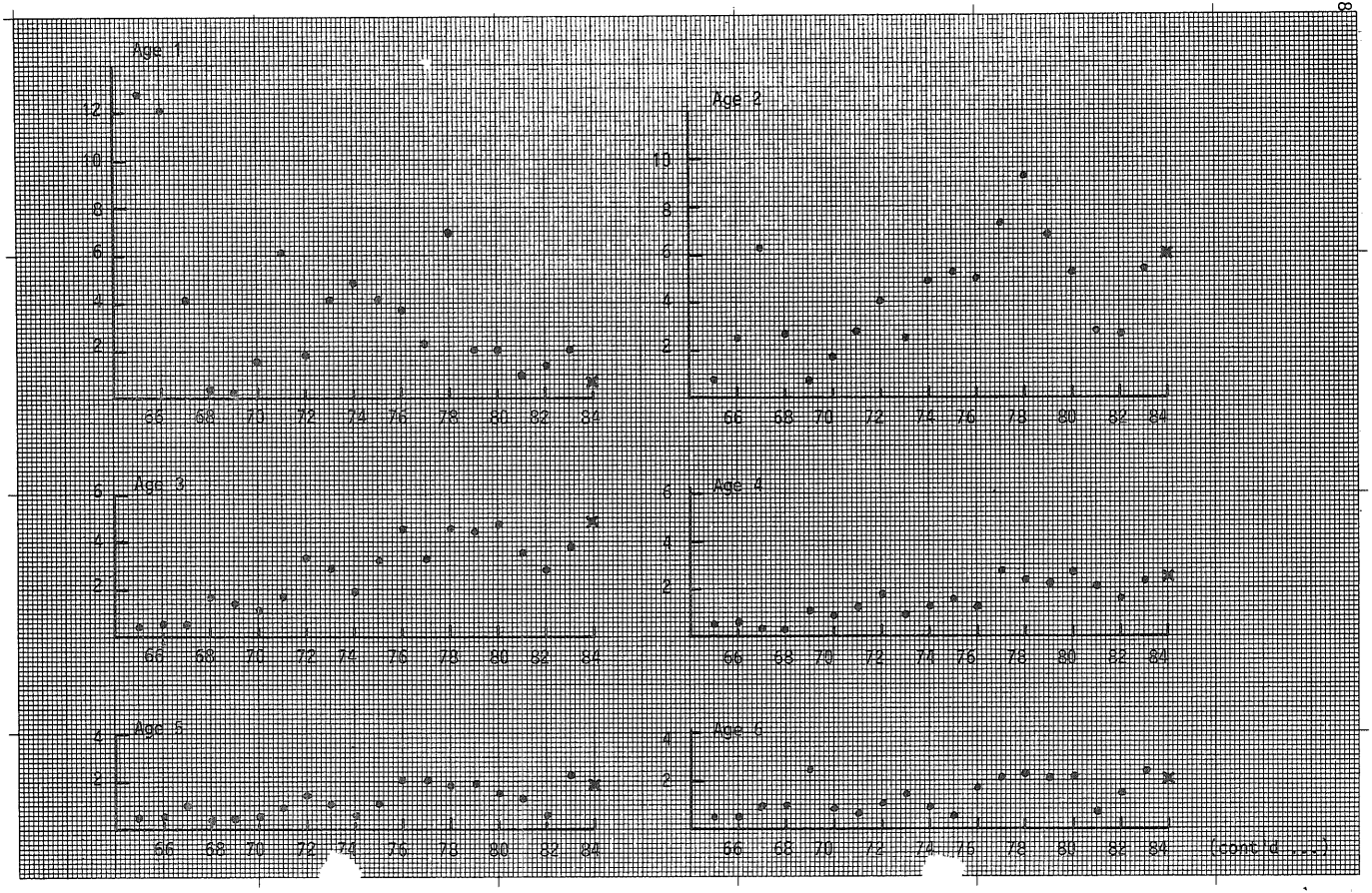


Figure 3.3. (cont'd)

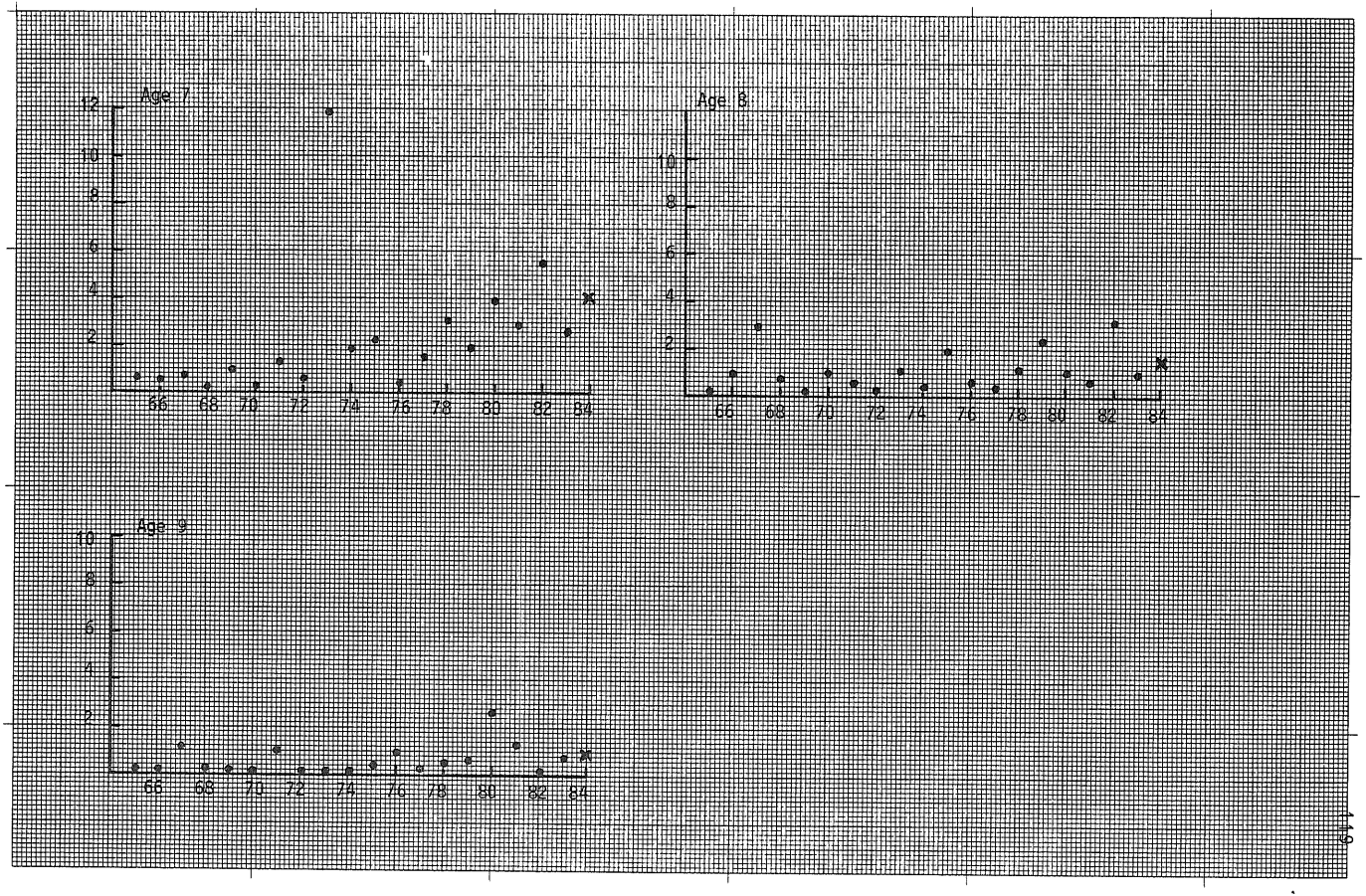


Figure 3.4. WEST OF SCOTLAND HADDOCK.
Rho Plot. x denotes predicted value.

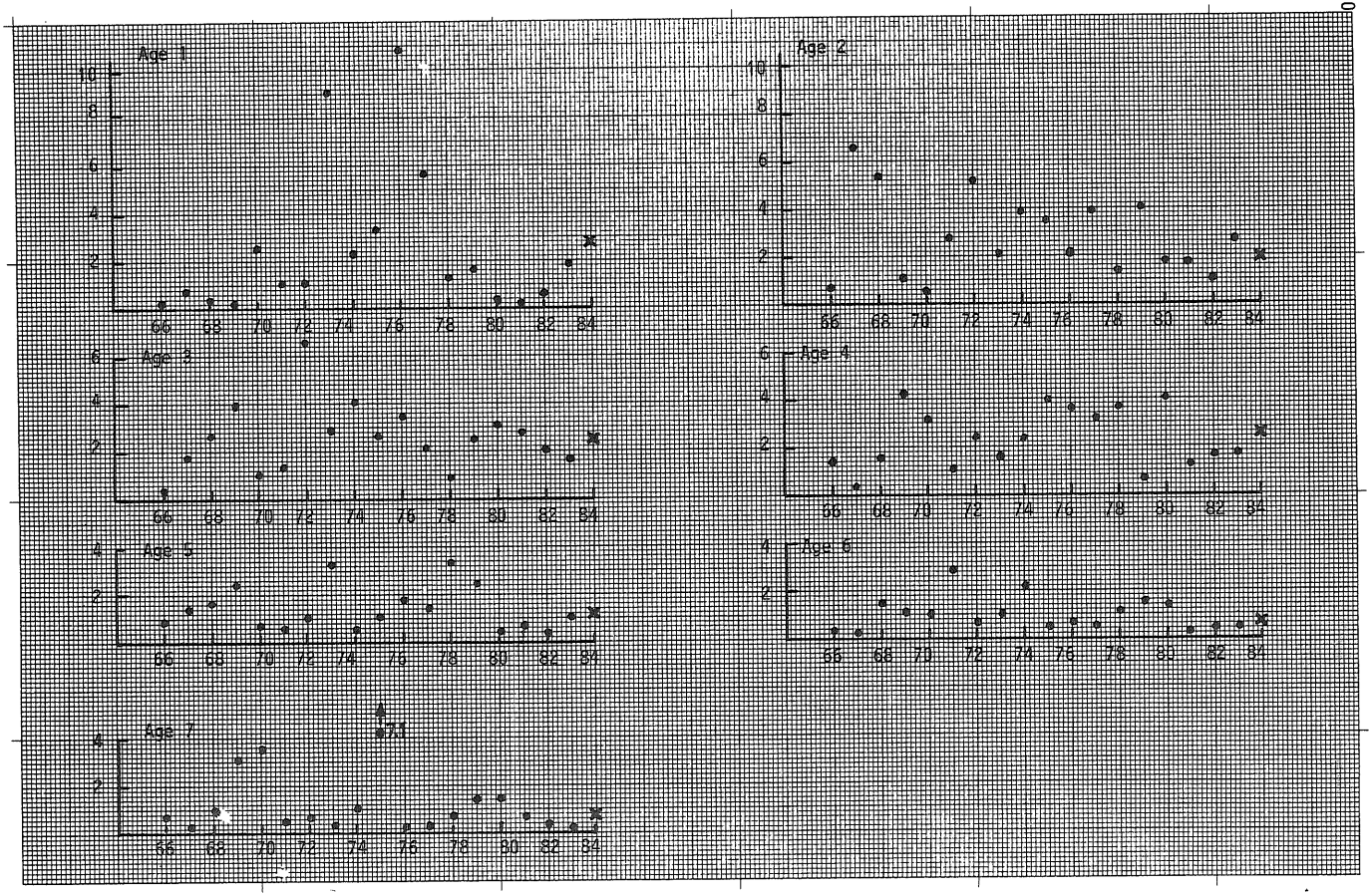


Figure 3.5. NORTH SEA WHITING.
Rho versus year (x denotes predicted values)

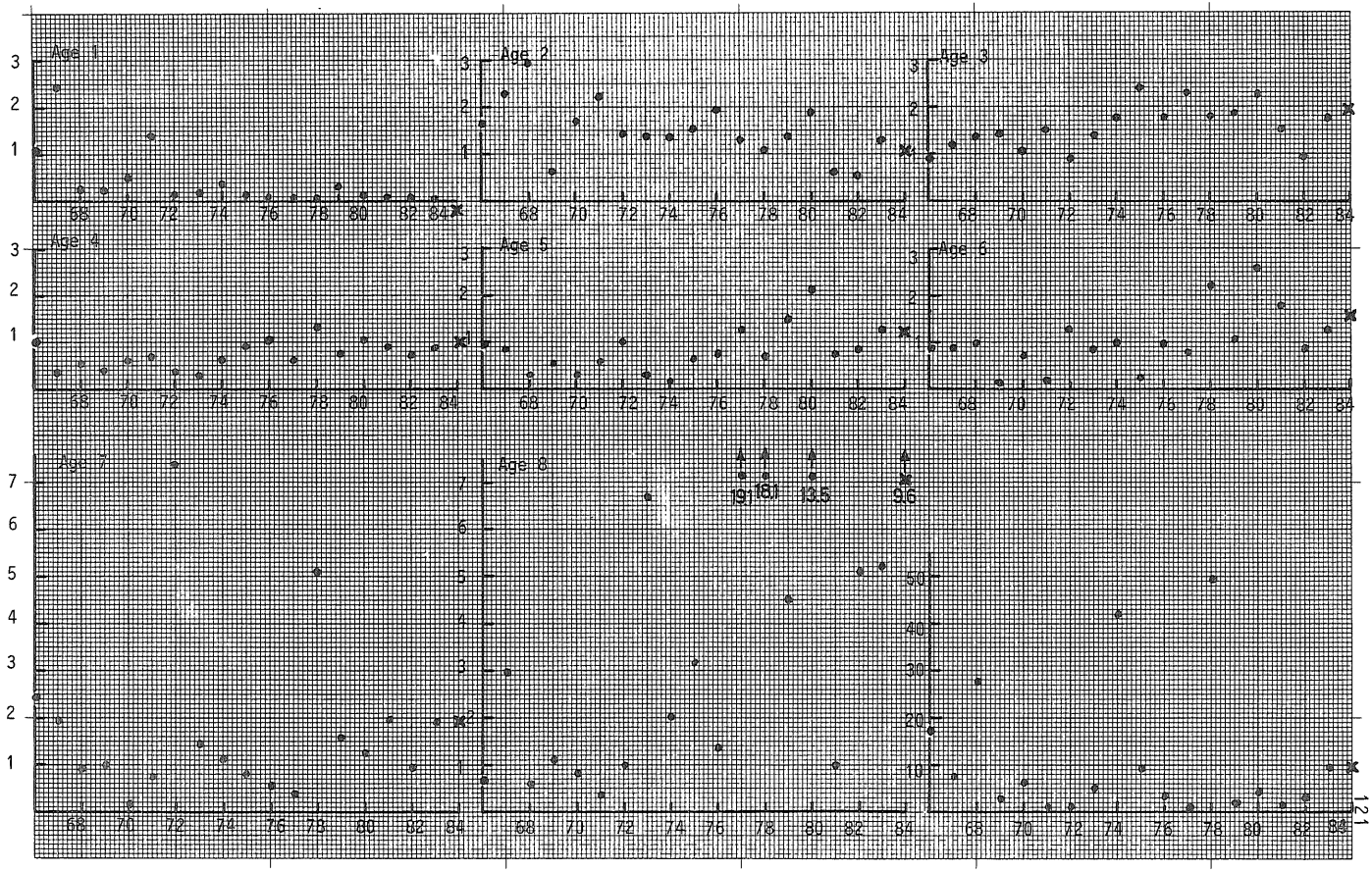


Figure 3.6. WHITING in Division VIa.
Rho versus year (x denotes predicted values)

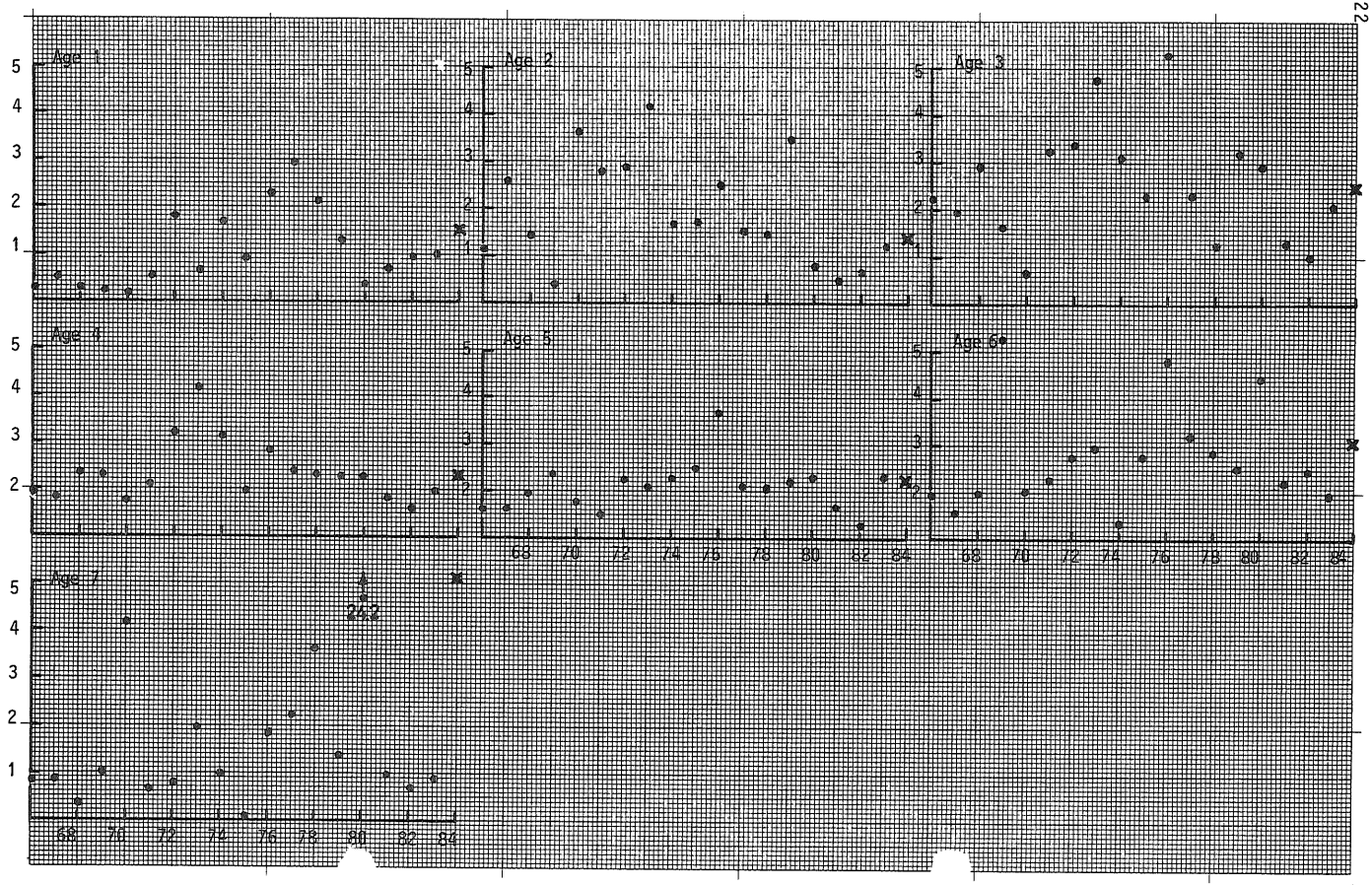
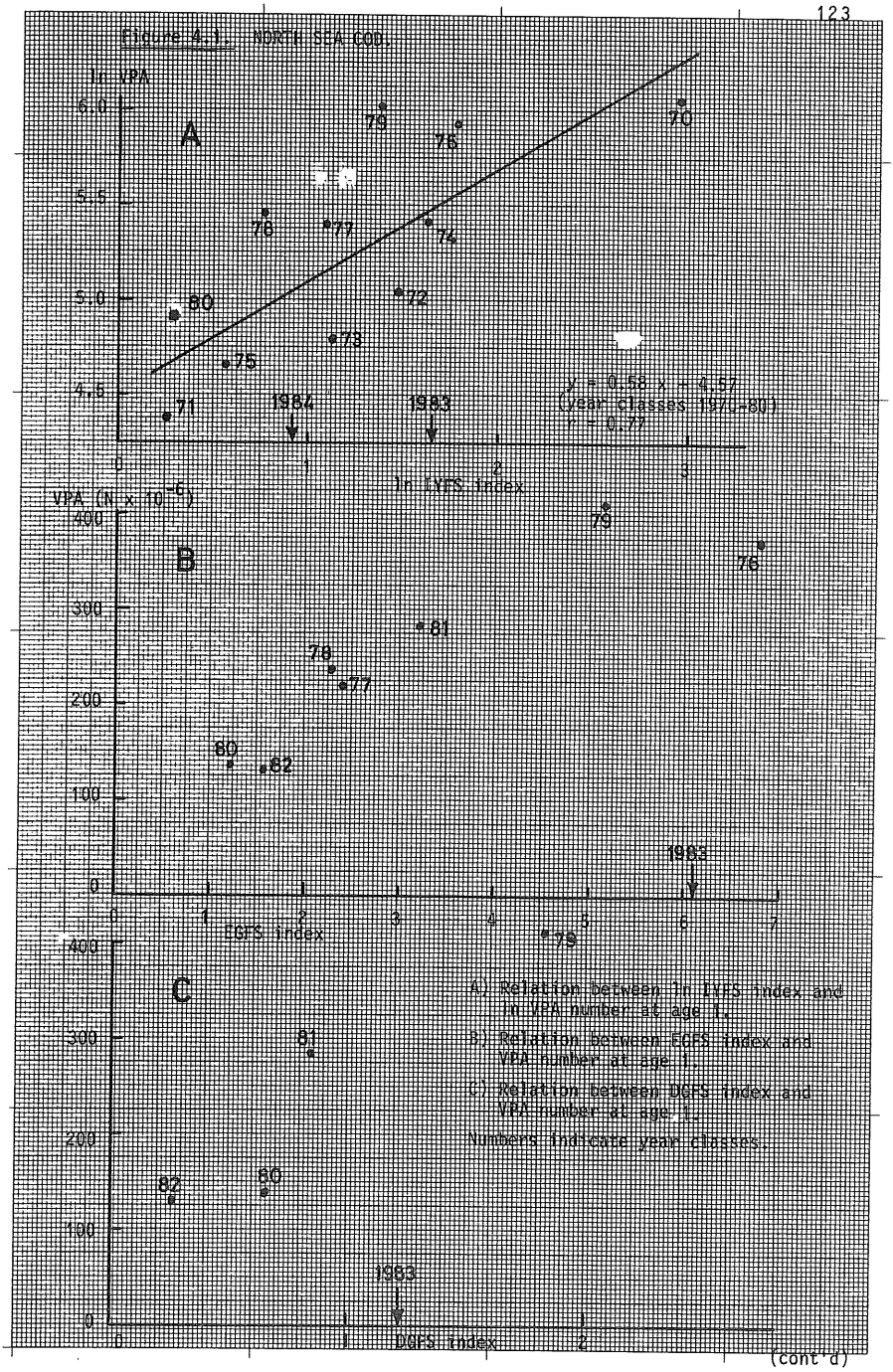
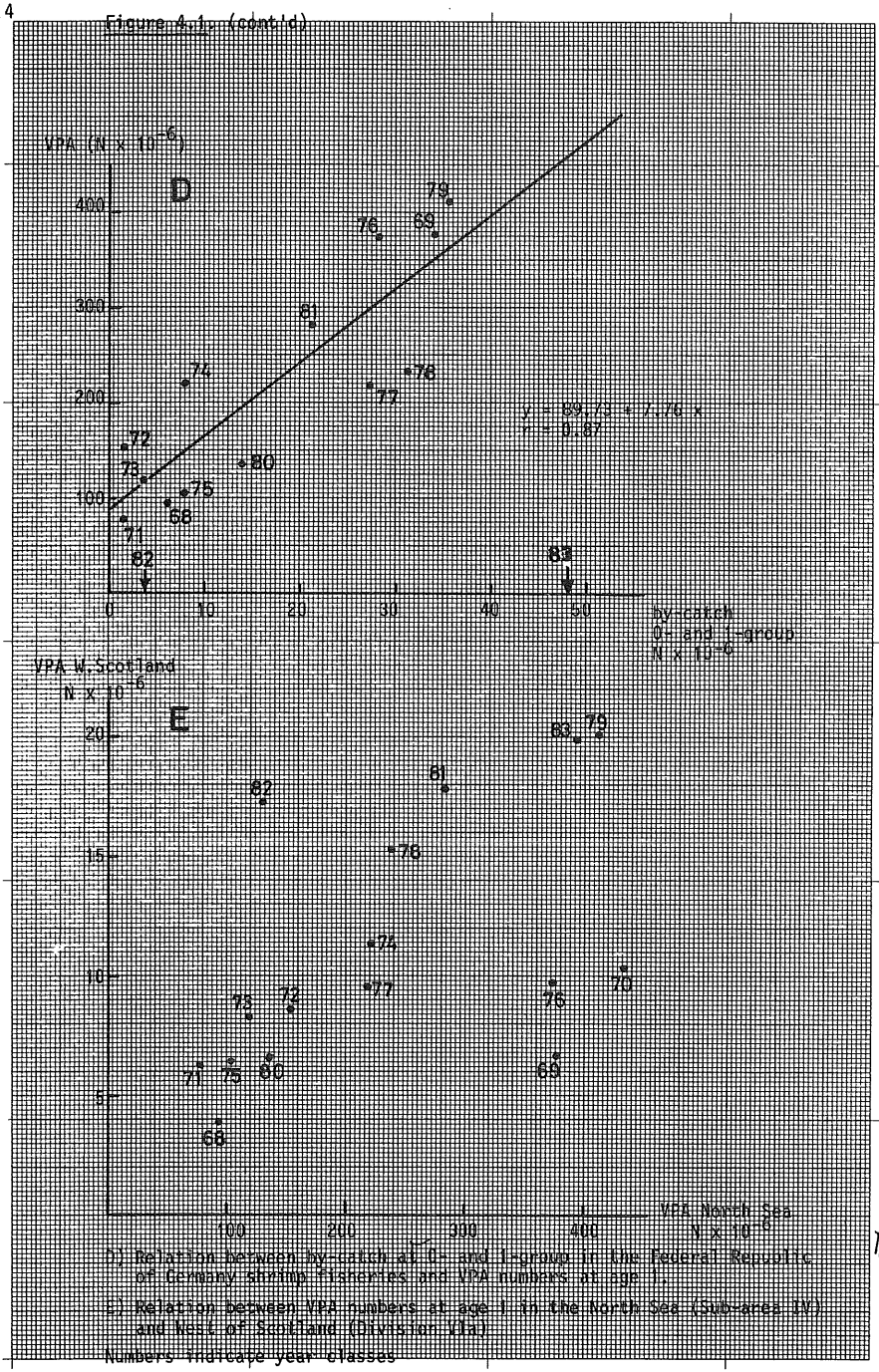


Figure 4.1. NORTH SEA COD.



(cont'd)

Figure 4.1b (contd)



b) Relation between by-catch at 0- and 1-group in the Federal Republic of Germany shrimp fisheries and VPA numbers at age 1.

c) Relation between VPA numbers at age 1 in the North Sea (Sub-area IV) and west of Scotland (Division VIa)

Numbers indicate year classes

Figure 4.2. NORTH SEA HADDOCK. Recruitment at age 1. Year classes indicated.

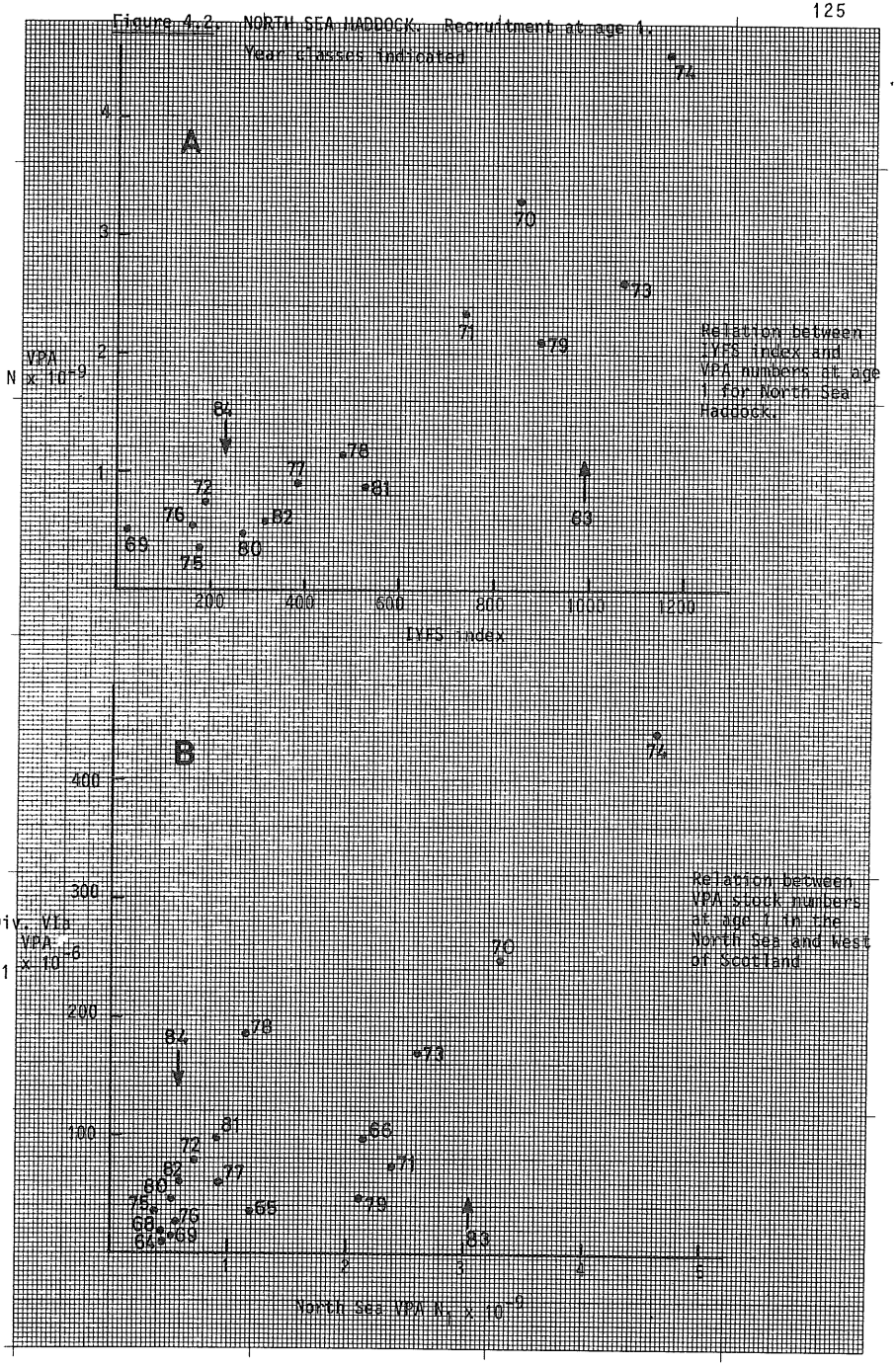


Figure 4.3. NORTH SEA WHITING.
Recruitment at age 1

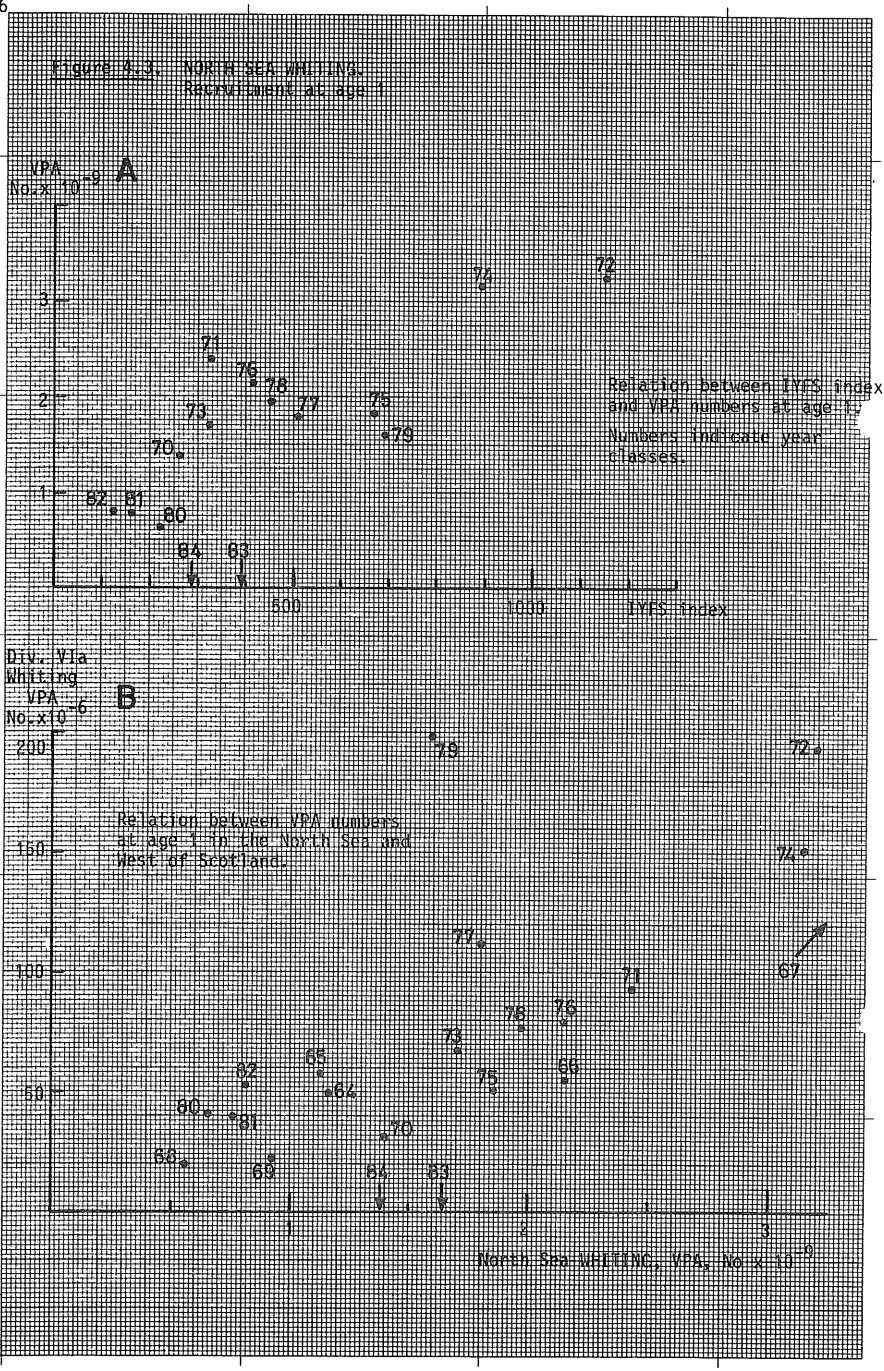
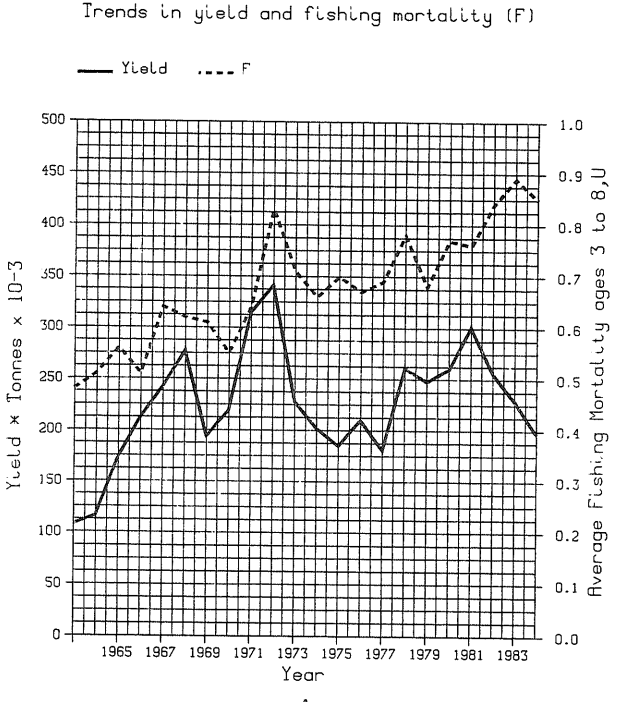


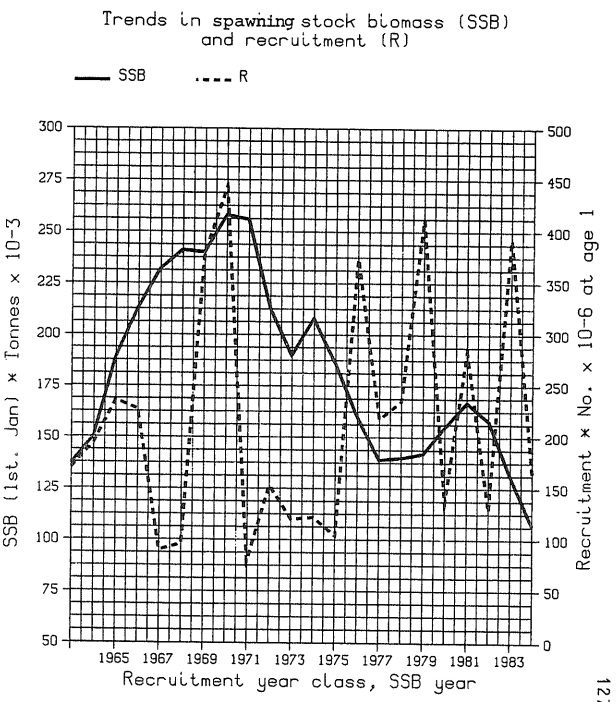
Figure 5.1.

FISH STOCK SUMMARY

STOCK: Cod - North Sea

20-3-1985





(cont'd)

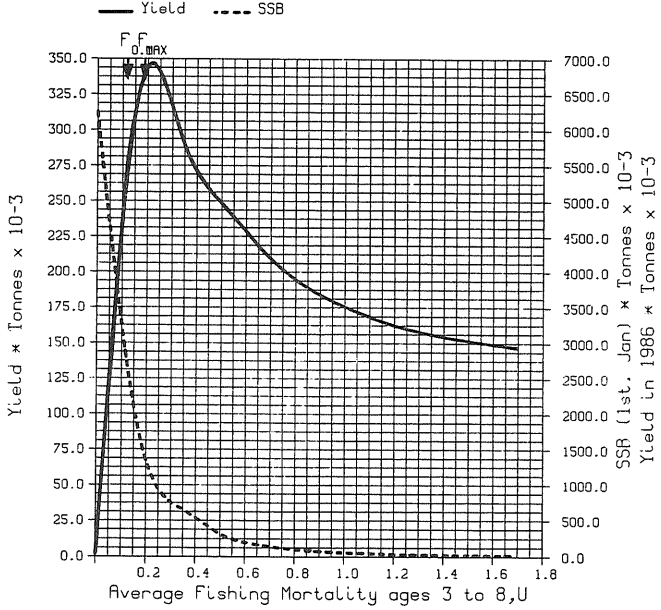
Figure 5.1 (cont'd)

FISH STOCK SUMMARY

STOCK: Cod - North Sea

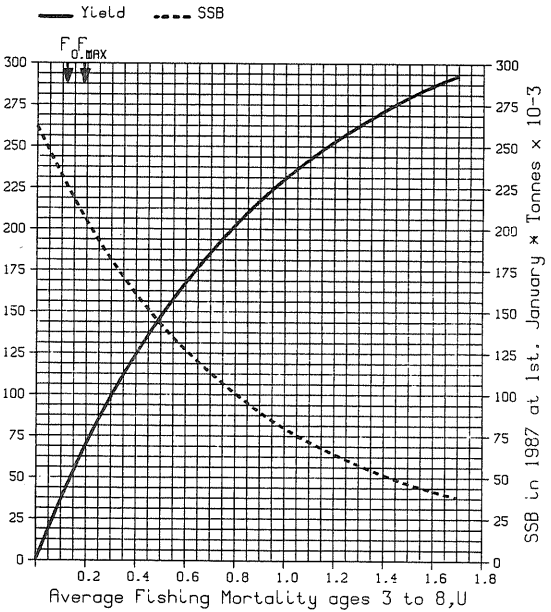
20-3-1985

Long term yield and spawning stock biomass (kg)



C

Short-term yield and spawning stock biomass



D

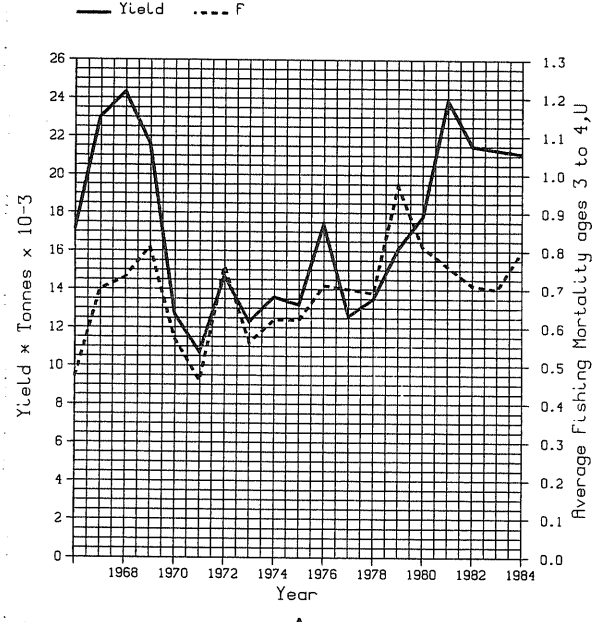
Figure 6.1.

FISH STOCK SUMMARY

STOCK: Cod - West of Scotland

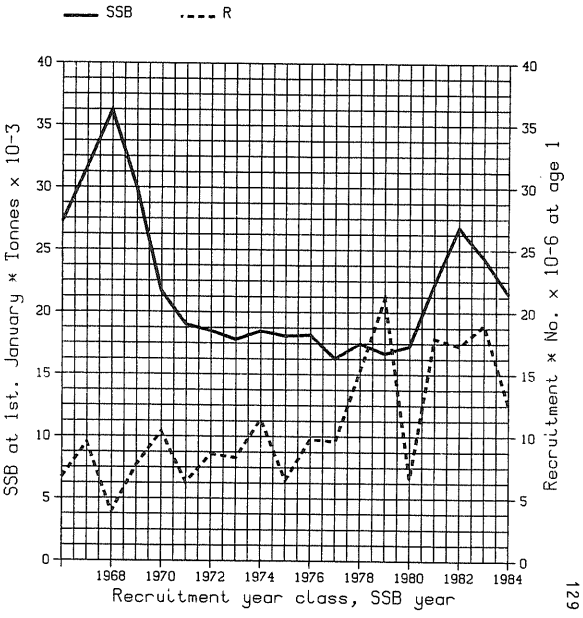
20-3-1985

Trends in yield and fishing mortality (F)



A

Trends in spawning stock biomass (SSB) and recruitment (R)



B

(cont'd)

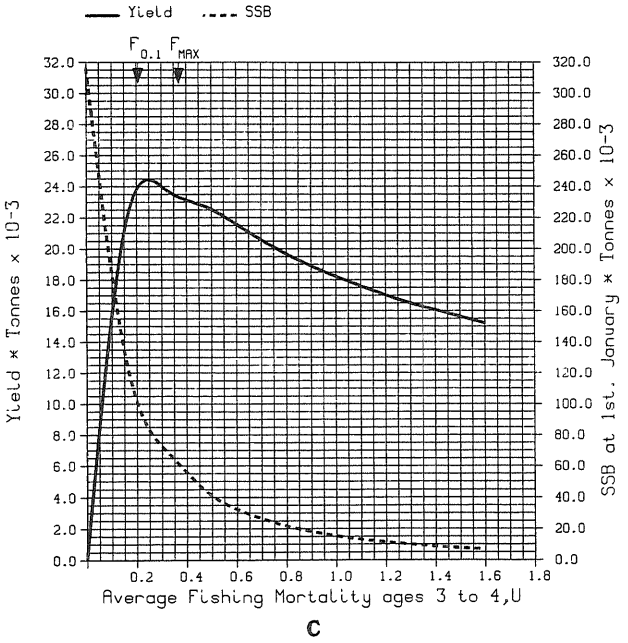
Figure 6.1 (cont'd)

FISH STOCK SUMMARY

STOCK: Cod - West of Scotland

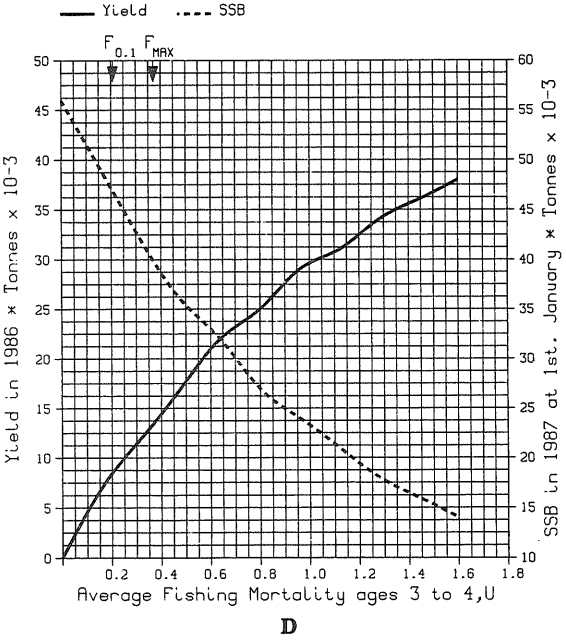
20-3-1985

Long term yield and spawning stock biomass (kg)



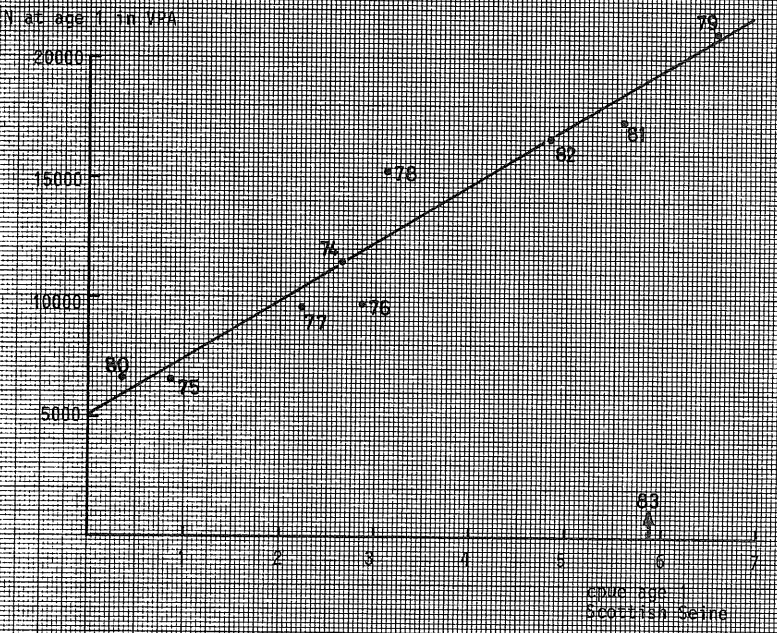
C

Short-term yield and spawning stock biomass



D

Figure 6.2. West of Scotland COD.
Relation between VPA numbers at age 1 and CPUE at age 1 for Scottish seiners.



$y = 2402x + 5010$

$r = .965 \quad n = 9$

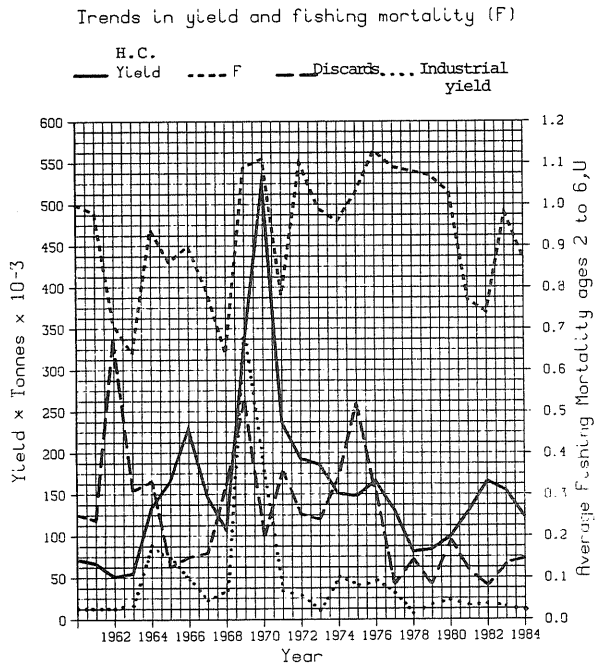
$\bar{x} = 5.886 \Rightarrow \bar{y} = 19\,148$

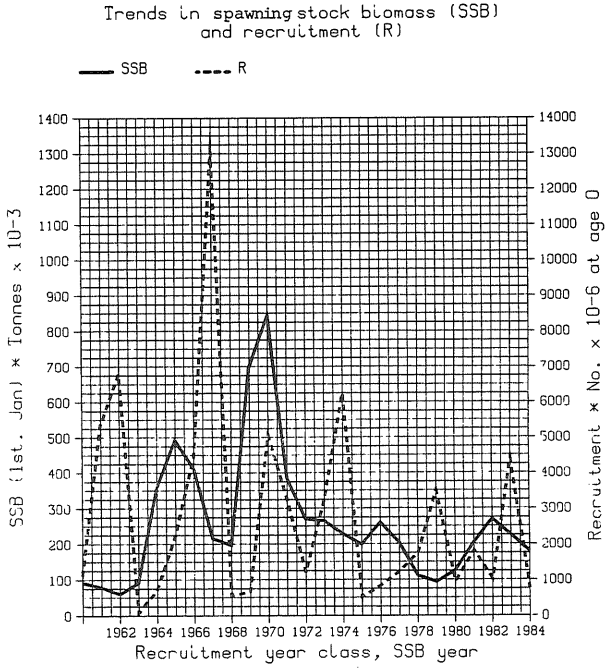
Figure 9.1.

FISH STOCK SUMMARY

STOCK: Haddock - North Sea

21-03-1985





(cont'd)

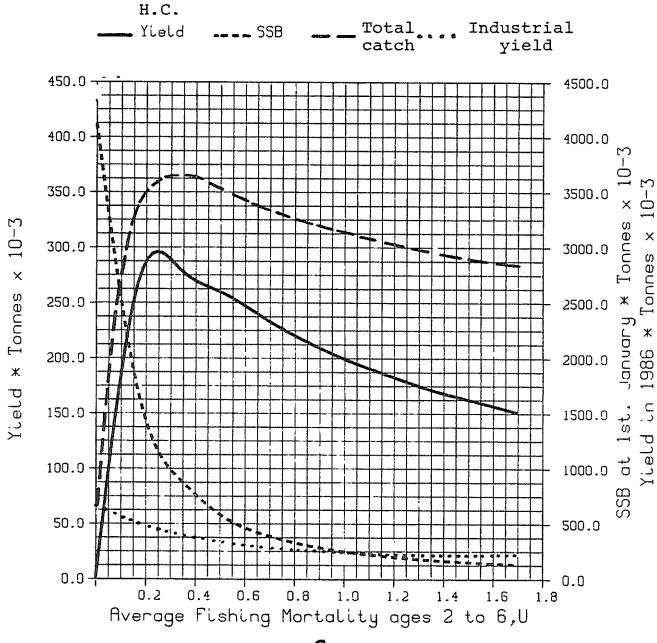
Figure 9.1 (cont'd)

FISH STOCK SUMMARY

STOCK: Haddock - North Sea

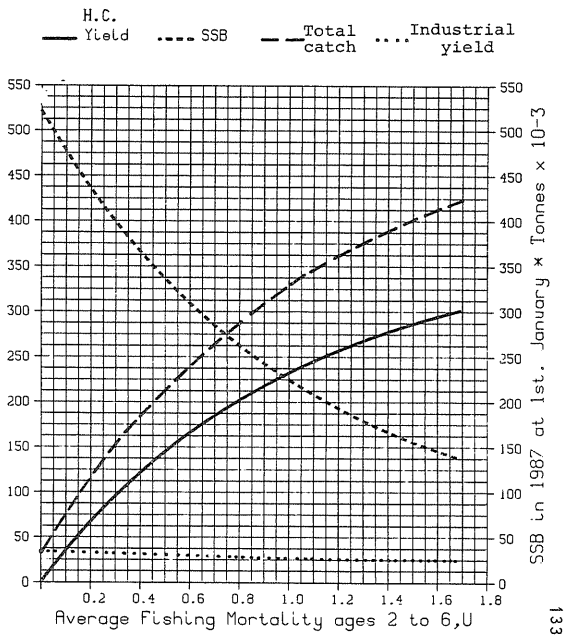
21-03-1985

Long term yield and spawning stock biomass (kg)



C

Short-term yield and spawning stock biomass



D

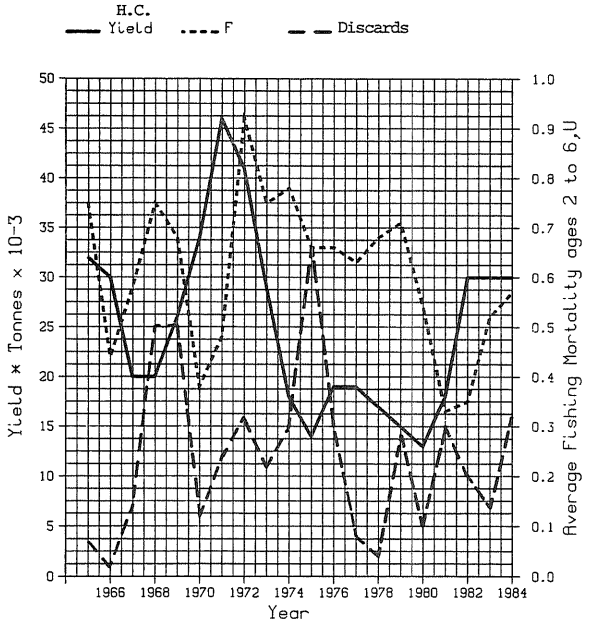
Figure 10.1.

FISH STOCK SUMMARY

STOCK: Haddock - West of Scotland

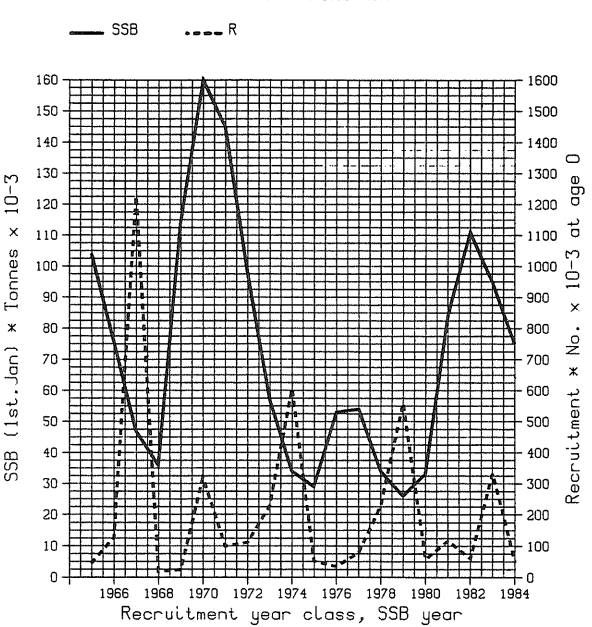
21-03-1985

Trends in yield and fishing mortality (F)



A

Trends in spawning stock biomass (SSB) and recruitment (R)



B

(cont'd)

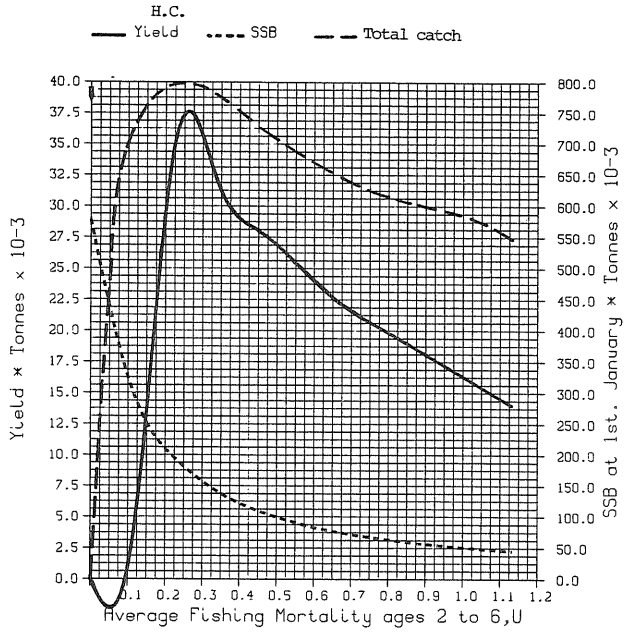
Figure 10.1 (cont'd)

FISH STOCK SUMMARY

STOCK: Haddock - West of Scotland

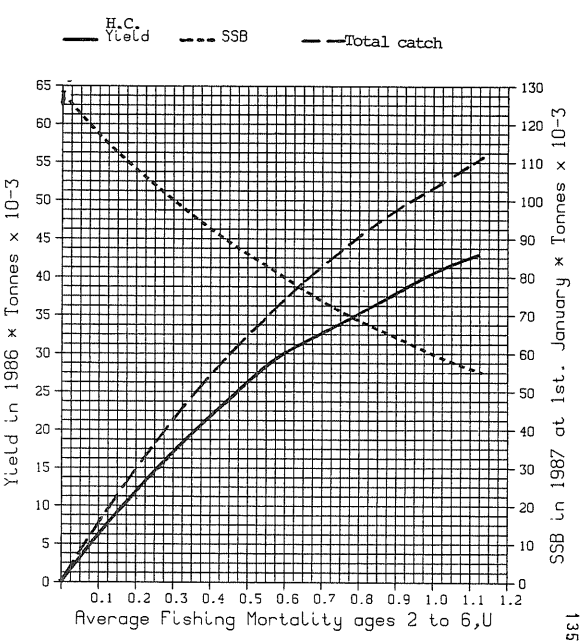
21-03-1985

Long term yield and spawning stock biomass (kg)



C

Short-term yield and spawning stock biomass



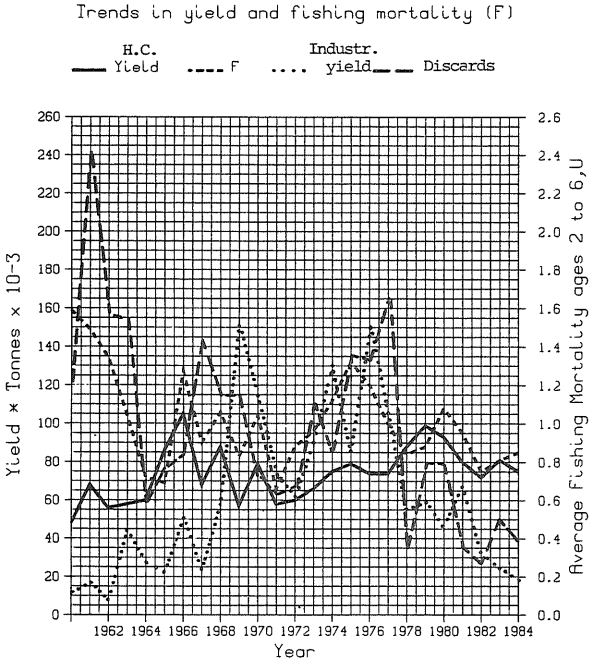
D

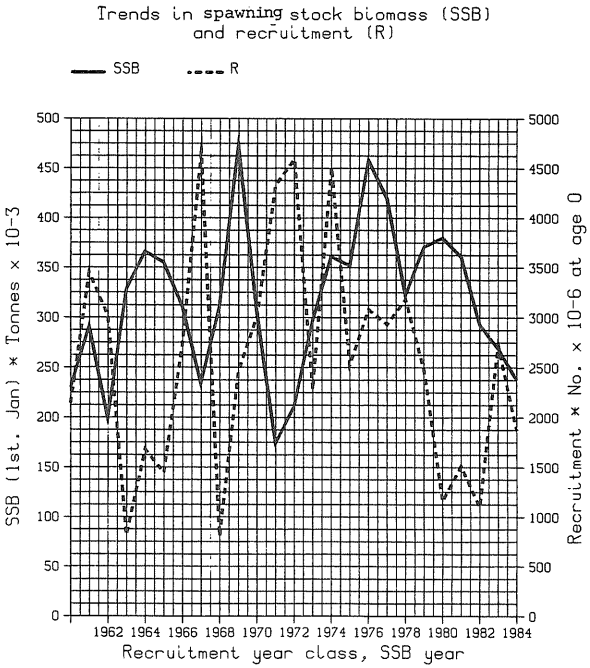
Figure 13.1.

FISH STOCK SUMMARY

STOCK: Whiting - North Sea

21-03-1985





(cont'd)

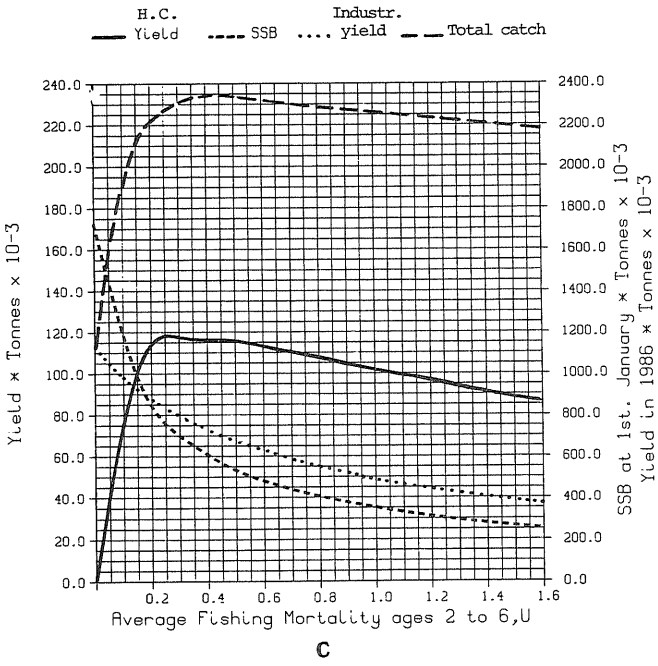
Figure 13.1 (cont'd)

FISH STOCK SUMMARY

STOCK: Whiting - North Sea

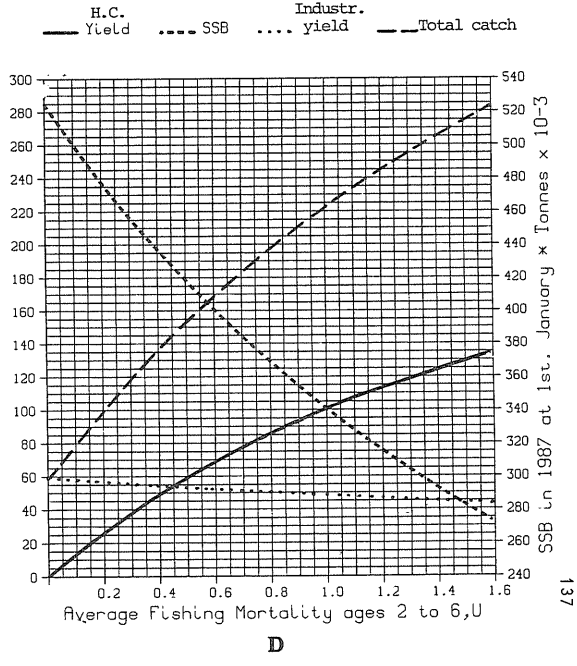
21-03-1985

Long term yield and spawning stock biomass (kg)



C

Short-term yield and spawning stock biomass



D

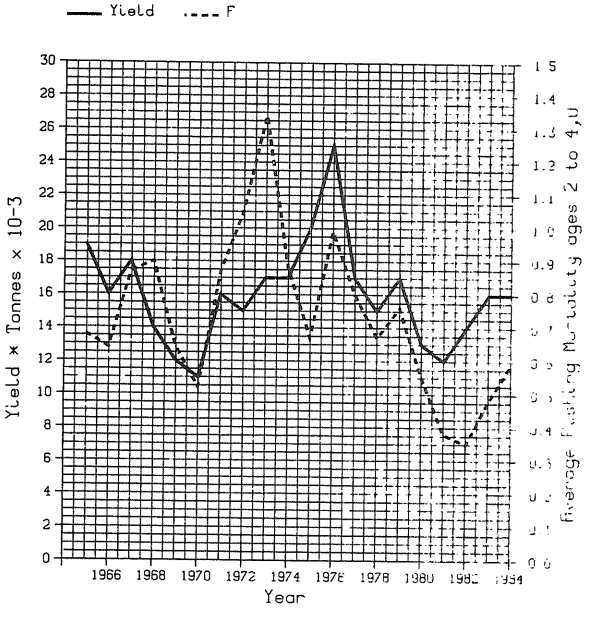
Figure 14.1.

FISH STOCK SUMMARY

STOCK: Whiting - West of Scotland

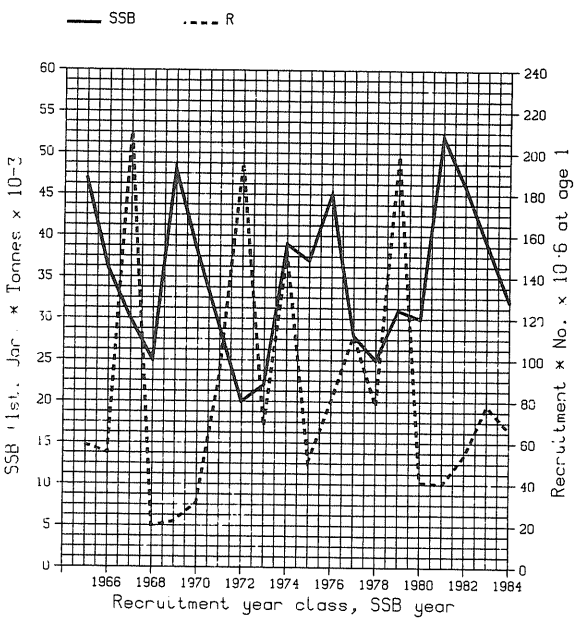
21-03-1985

Trends in yield and fishing mortality (F)



A

Trends in spawning stock biomass (SSB) and recruitment (R)



B

(cont'd)

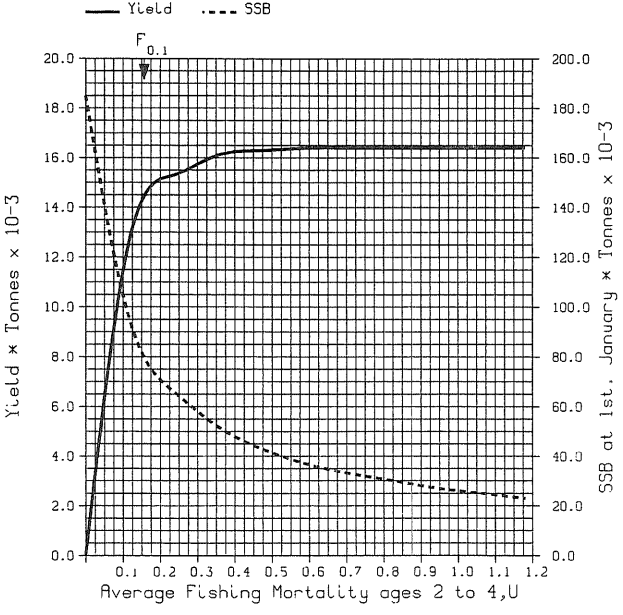
Figure 14.1 (cont'd)

FISH STOCK SUMMARY

STOCK: Whiting - West of Scotland

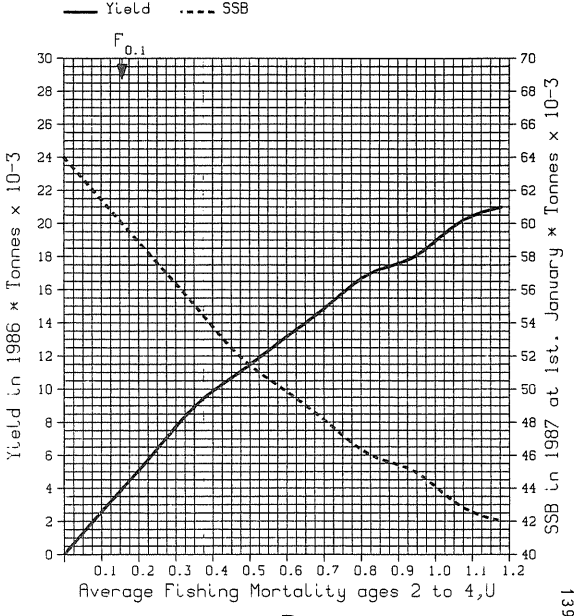
21-03-1985

Long term yield and spawning stock biomass (kg)



C

Short-term yield and spawning stock biomass



D

APPENDIX 1

A DESCRIPTION OF THE INTEGRATED STOCHASTIC VPA

by

P Lewy

Introduction

This model is a single species model, which goes along the lines introduced for instance by Fournier and Archibald (1982), Lassen (1983), Collie and Sissenwine (1982) and Pope and Shepherd (1984).

The scope of the model is: Assume that catch, effort and survey data are available. Assume further that catch at age data and survey data are subject to stochastic noise due to sampling error. Effort data are assumed to be known without sampling error. If the statistical distributions of catch and survey data are known, a usual statistical model can be formulated from which maximum likelihood estimates of stock abundance, fishing mortality and, in some cases, natural mortality can be derived. The standard deviations of those estimators can be calculated too.

The model includes situations where effort data are available for only some of the fleets exploiting the stock in question.

Notation

Indices
---

y	indicates	year
a	"	age
f	"	fleet
s	"	survey
fas	"	first age group included in the surveys
las	"	last " " " " " "

Parameters and observations

N(a,y) indicates population number

—

N(a,y)	"	mean population number
F(f,a,y)	"	fishing mortality created by fleet f
FR(a,y)	"	fishing mortality created by the fleet for which effort information exists
M(a)	"	natural mortality
q(f,y,a)	"	catchability coefficient
q(f,y)	"	technology factor
q(a)	"	behaviour factor
k(s)	"	survey parameter
c(f,a,y)	"	catch in number
cr(a,y)	"	catch in number for fleets for which no effort data exist

L(f)	"	landings of fleet f
LR	"	landings of fleets for which no effort data exist
e(f,y)	"	effort
i(s,a,y)	"	survey index measuring relative abundance
VC	"	variance of catch in number of each fleet
VR	"	variance of catch in number of CR
VS(s)	"	variance of survey index
s(f,a,y)	"	selectivity
sf	"	selection factor
fac	"	range factor
m(f,y)	"	mesh size
L	"	von Bertalanffy parameter
K	"	" "
t_0	"	" "

C(f,a,y), CR(a,y) and I(s,a,y) denote the stochastic variable corresponding to c, cr and i respectively

The following notation is used:

$$C \in LN(A,V)$$

means that the stochastic variable C follows a log normal distribution with exception

$$EC = A$$

and variance $V(C) = V$

Probability Distributions of Catch and Survey Indices

$$C(f,a,y) \in LN(\ln(F(f,a,y)\bar{N}(a,y))-VC/2,VC) \quad (1)$$

$$I(s,a,y) \in LN(\ln(k(s)N(a,y)-VS(s)/2,VS(s)) \quad (2)$$

(1) and (2) imply that

$$EC(f,a,y) = F(f,a,y)\,\bar{N}(a,y) \quad (3)$$

$$EI(s,a,y) = k(s)N(a,y) \quad (4)$$

(3) is the usual catch equation from the VPA and (4) indicates, that the survey indices are measu- ring the relative abundance.

(1) implies that the variance of ln catch in number is the same for all fleets. This is of course unrealistic, but may be considered as a first approximation which may be changed, when estimates of variance are available.

The Effort Model

The relation between fishing mortality and effort is

modelled as follows:

$$F(f,a,y) = q(f,a,y)e(f,y) \qquad (5)$$

The catchability coefficient q is

$$q(f,a,y) = q(f,y)s(f,a,y)q(a) \qquad (6)$$

In this model, (6), the catchability is assumed to be dependent of a) a technological factor, q(f,y), expressing the development of fishing power, b) the selectivity and c) the fish behaviour, q(a).

The selectivity is calculated from

$$s(a)=\frac{1}{2}(\tanh(\ con(a-a50)\ + 1) \qquad (7)$$

a50 and con are calculated by the aid of the von Bertalanffy curve as

$$a50 = t_0 - \ln\left(1 - \frac{m(f,y)\cdot sf}{L_\infty}\right)/k$$

$$a75 = t_0 - \ln\left(1 - \frac{m(f,y)\cdot sf}{L_\infty}\left(1 + \frac{1}{2fak}\right)\right)/k$$

$$con = \frac{\ln 3}{2(a75 - a50)}$$

The effective mesh size, m(f,y) is assumed to be known, but may possibly be estimated.

Model for fleets without effort data

In the model, the distribution of CR(a,y), the total catch in number for the fleets without effort data, is needed. Under reasonable conditions it can be shown, that

$$CR(a,y) \in LN(ER(a,y),VR) \tag{8}$$

where

$$ER(a,y) = \ln(FR(a,y)\,\bar{N}(a,y)) - VR/2 \tag{9}$$

$$\begin{aligned} VR &= \ln(1+v^2 \sum_{f \in G} p^2(f,a,y)) \\ v^2 &= \exp(V)-1 \\ p(f,a,y) &= F(f,a,y)/FR(a,y) \end{aligned} \tag{10}$$

G is the set of fleets, for which effort data are not available. In order to avoid inclusion of all the fishing mortalities F(f,a,y), $f \in G$, in the model, it is assumed that

$\sum_f p^2(f,a,y)$ is known for all "a" and "y".

Actually $\sum_f p^2(f,a,y)$ is estimated by

$$\sum_{f \in G} \left(\frac{L(f)}{LR}\right)^2 \simeq \sum_{f \in G} p^2(f,a,y) \tag{11}$$

e.g. assuming that the quantity, as a first estimate is constant for all ages and years. A better estimate is of course $\sum_{f\in G}\left(\frac{c(f,a,y)}{cr(a,y)}\right)^2$.

The Integrated Model

Under the assumptions that all the stochastic variables, the catch in numbers for all fleets and the survey indices, are stochastically independently distributed, the negative log likelihood can be written as-

$$l = -\ln P\{(\ln C(f,a,y)_{f,a,y\ f\notin G}),(\ln cr(a,y)_{a,y}),(\ln i(s,a,y)_{s,a,y})\} =$$

$$\sum_{f,a,y}\left(\ln\left\{\frac{c(f,a,y)}{F(f,a,y)\,\bar{N}(a,y)}\right\}+V/2\right)^2/V \quad +$$

$$\sum_{a,y}\left(\ln\left\{\frac{cr(a,y)}{FR(a,y)\,\bar{N}(a,y)}\right\}+VR/2\right)^2/VR \quad +$$

$$\sum_{s,a,y}\frac{\left(\ln\left\{\frac{i(s,a,y)}{k(s)\,N(a,y)}\right\}+VS(s)/2\right)^2}{VS(s)} \qquad (12)$$

The independency assumptions are unrealistic with respect to the catches, as presumably all sampling programmes imply that

$$COV(C(a), C(B)) \neq 0$$

for a given "f" and "y".

This may introduce serious troubles if the correlation coefficients are significantly different from zero. However, to avoid this assumption it it necessary to obtain estimates of the variances and co-variances for each of the national fleets. Until this is done, the model (11) is the only feasible solution to the problem.

The likelihood function, l, is a function (of) the parameters:

$$l = l\left\{ q(f,y)_{f,y},\ q(a)_a,\ N(\text{first age},y)_y,\ N(a,\text{first year})_{a\geq 2}\right.$$
$$\left. M(a)_a,\ k(s)_s,\ FR(a,y)_{a,y}\right\}$$

If there are 4 fleets with effort data, 8 age groups, 10 years, M(a) is constant and 2 surveys, then the number of parameters to estimate are 147.

In order to reduce the number of parameters the following is assumed:

FR(a,y) is separable for groups of 5 years, e.g., that fishing pattern is constant in 5 years.

Corresponding to this, the factor of technology, q(f,y), is assumed to be constant in 5 years for each fleet.

These two assumptions imply that the number of parameters are reduced to 60.

Input for the Model

The haddock results shown in Section 3. are based on the following input data: only the last ten years, 1975-84,were considered for the age groups 1-9. Three fleets supplying effort data were used: Scottish trawlers, Scottish seiners and Scottish light trawlers, and the mesh size for these fleets was set at 80, 95 and 80 mm, respectively, for all ten years.

The selection factors and ranges were the same as those used in the report of the North Sea Roundfish Working Group 1984 for all three species. The von Bertalanffy growth curves in this report were used too.

Indices for the 1- and 2-group were used for IYFS and EGFS for the years 1975-83 and 1977-84, respectively.

The constant defined in (11) was set at 0.2, corresponding to the 1983 figure. The natural mortality was set at 0.2 for all age groups.

To run the model, the following must be guessed:

a) the variance of the catches

b) the variance of survey indices.

The coefficient of variation of catch in number was in the first run set at 0.4, while the cofficient of variation of both IYFS and EGFS was set at 0.6.

In fact, the model was also run for three other alternative values for these coefficients of variation.

COMMENTS AND DISCUSSION

The model was implemented on the computer in Charlottenlund. The program was tested by aid of simulation: the catches and the survey indices are simulated from randomly selected parameters using the log normal distributions (1) and (2). Afterwards the parameters were estimated using the simulated observations in the model. Two tests were done: in case of no noise (the variance equal to zero) the randomly selected parameters were reproduced without error. In case of noisy data, the results seem very reasonable compared to "true" parameters.

The conclusion concerning the four alternative runs are that in the case where the coefficients of variation of the survey indices are higher than those of the catches then the estimates of fishing mortality and stock size are insensitive to changes in the variances.

Even very different input values of coefficient of variation only produced changes in fishing mortality and stock size of about 2 and 5%, respectively.

The validity of the sub-models compared to the reality needs thoroughly to be investigated.It is intended that the model could be a tool, which would make it possible to check some of the assumptions which most Working Groups make.

References

Collie, J S and M P Sissenwine. 1982. Estimating population size from relative abundance data measured with error. ICES, Doc. C.M.1982/G:34.

Fournier, D and C P Archibald. 1982. A general theory for analysing catch at age data. Can.J. Fish.Aquat.Sci., 39:1195-1207.

Lassen, H. 1983. Estimation of stock size and fishing mortality when data on catches and on stock abundance are available. are available. ICES, Doc. C.M.1983/D:5.

Pope, J G and J G Shepherd. 1984. On the integrated analysis of catch at age data and groundfish survey or cpue data. ICES, Doc. C.M.1984/G:16.