3.5.2 Cod in Sub-area IV (North Sea), Division VIId (Eastern Channel) and Division IIIa (Skagerrak)

State of stock/fishery: The stock is outside safe biological limits. The spawning stock is estimated to have been below $\mathbf{B_{pa}}$ since 1984, is presently below $\mathbf{B_{lim}}$, and is in a region where the risk of stock collapse is high. Fishing mortality has remained at about the historic high and above $\mathbf{F_{pa}}$ since the early 1980s, and F in 1999 is estimated to be above $\mathbf{F_{lim}}$. Except for the 1996 year class, recruitment has been below average since 1987. The 1997 year class was the poorest on record, and the 1998 and 1999 year classes are also estimated to be relatively poor. Preliminary indications suggest that the 2000 year class is not large.

Management objectives: In 1999 the EU and Norway have *"agreed to implement a long-term management plan for the cod stock, which is consistent with the precautionary approach and is intended to constrain harvesting within safe biological limits and designed to provide for sustainable fisheries and greater potential yield. The plan shall consist of the following elements:*

1. *Every effort shall be made to maintain a minimum level of SSB greater than 70 000 tonnes ($\boldsymbol{B_{lim}}$).*

2. *For 2000 and subsequent years the Parties agreed to restrict their fishing on the basis of a TAC consistent with a fishing mortality rate of 0.65 for appropriate age groups as defined by ICES.*

3. *Should the SSB fall below a reference point of 150 000 tonnes ($\boldsymbol{B_{pa}}$), the fishing mortality referred to under paragraph 2, shall be adapted in the light of scientific estimates of the conditions then prevailing. Such adaptation shall ensure a safe and rapid recovery of SSB to a level in excess of 150 000 tonnes.*

4. *In order to reduce discarding and to enhance the spawning biomass of cod, the Parties agreed that the exploitation pattern shall, while recalling that other demersal species are harvested in these fisheries, be improved in the light of new scientific advice from, inter alia, ICES.*

5. *The Parties shall, as appropriate, review and revise these management measures and strategies on the basis of any new advice provided by ICES."*

ICES considers that the agreed Precautionary Approach reference points in the management plan are consistent with the precautionary approach, provided they are used as upper bounds on F and lower bounds on SSB, and not as targets.

Advice on management: ICES recommends that fishing mortality on cod should be reduced to the lowest possible level in 2001. A rebuilding plan should be developed and implemented in order to rebuild SSB above $\mathbf{B_{pa}}$. The necessary reduction in fishing mortality on cod cannot be achieved by a reduction in TAC alone. The rebuilding plan should include provisions to deter directed fishing, reduce by-catches of cod in fisheries for other species to the lowest practical levels, and to deter discarding and mis-reporting of cod in all fisheries.

Relevant factors to be considered in management: The spawning stock in 2000 is in a situation where the probability of low recruitment is high and the potential for a recovery has been reduced. The relatively strong 1996 year class appears to have been heavily exploited and its potential to contribute further to significant recovery of the stock is low. Subsequent year classes are poor, and SSB is unlikely to recover in the near future.

Continued fishing at current rates is expected to lead to stock collapse, because the equilibrium biomass at present F is calculated to be zero (Figure 3.5.2.1). Fishing at $\mathbf{F_{pa}}$ the stock is expected to remain below $\mathbf{B_{pa}}$ after 2002 when the poorest year class observed so far will recruit into the spawning stock. Even if recruitment after 2001 improves to the recent (1987-1998) average recruitment, maintaining F at $\mathbf{F_{pa}}$ would produce only a 50% probability of bringing the SSB to $\mathbf{B_{pa}}$ over the next 5 years (Figure 3.5.2.2)

At recent exploitation rates, year-classes have suffered substantial fishing mortality before they mature and spawn. The SSB cannot be rebuilt unless fishing mortality on immature cod is reduced.

In recent years the growth rate of North Sea cod has declined. The reasons for this are not known, but if growth remains slow, the rate of recovery of SSB will be delayed and the age of maturity may also increase, making the stock more vulnerable to high exploitation. Lower growth may also expose juveniles to discarding for a longer time.

The TAC for the portion of the stock in Division VIId incorporates information from assessment of the stock in Division VIIe-k, and managers should take this advice into account when setting the quota for Division VII.

Catch forecast for 2001:

Basis: F(sq) = F(97–99 - scaled) = 0.90; Landings (2000) = 92.9, SSB(2001) = 59.

F(2001)	Basis	Landings in combined area (2001)	Lndgs in IIIa (2001) Skagerrak	Lndgs in IV (2001)	Lndgs in VIId (2001)	SSB (2002)	Medium-term effect (10 years) Probability (%) of SSB < $\mathbf{B}_{\mathbf{pa}}$
0	0*F99	0	0	0	0	135	<5%
0.18	0.2*F99	25.6	3.1	21.8	0.7	113	<5%
0.36	0.4*F99	47.5	5.8	40.4	1.3	94.9	<5%
0.45	0.5*F99	57.1	7.0	48.6	1.5	87.1	<5%
0.63	0.7*F99	74.4	9.1	63.3	2.0	73.6	<5%
0.65	$\mathbf{F}_{\mathbf{pa}}$	76.3	9.3	65	2.1	72	<5%
0.90	1.0F99	95.8	11.7	81.5	2.6	57.4	>>50%

Weights in '000 t.

Shaded scenario considered inconsistent with the precautionary approach.

Landings by Division or Sub-area are obtained by prorating to the combined area catch by 0.122 for IIIa, 0.851 for IV and 0.027 for VIId. These factors are the ratio of the mean catches by area to the combined area for the period 1992–1996.

Elaboration and special comment: Using information from the stock-recruit relationship it is possible to construct the expected equilibrium spawning stock biomass for a range of fishing mortality rates. This is shown in Figure 3.5.2.1 (heavy line). As F increases the expected equilibrium declines. Also shown on the graph are the observed values of SSB over time (thin line with years indicated). Where a particular year lies above the solid line, the stock would be expected to decline. Where a point lies below the line, the stock would be expected to increase. Consistent with the analysis, it can be seen that as fishing mortality has increased, the SSB has declined. The diagram shows that the expected equilibrium at the estimated 1999 F is effectively zero, i.e. that the stock will collapse.

The current assessment indicates that the fishing mortality is much higher, and SSB much lower than was perceived in last years assessment. ICES noted inconsistencies in the assessment last year and the tendency to revise the previous years values. Extensive investigation of the problem occurred during 2000 and a number of changes were made to the way data were handled in the assessment. In particular, it was apparent that commercial CPUE data used in calibrating the assessment had a strong tendency to give a much more optimistic estimate of the state of the stock than research vessel survey data. There are a number of reasons for believing that the commercial CPUE data may be biased. For example, there have been substantial changes in the distribution of the commercial fleet effort and the nature of vessels in the fleet, which may affect abundance indices derived from these sources. In addition, commercial fleets may target areas of high cod abundance leading to artificially higher abundance estimates. It should be noted that differing signals between commercial CPUE data and survey data affected assessments of some Canadian cod stocks, resulting in an over-optimistic decisions on the management of these stocks before they collapsed. In view of these problems, the assessment of North Sea cod this year did not use commercial CPUE data from Scottish fleets where this problem appeared to be most severe. An analysis investigating the performance of the revised assessment approach applied to previous years suggests that the problems identified in last year's assessment have been reduced. Furthermore, a number of additional analyses were performed using a variety of different assessment models. All these approaches gave very similar results. While no method is without uncertainty, the fact that a variety of methods give comparable results suggests the present perception of the state of the stock is more realistic than the previous assessment.

Assessments in 1997, 1998 and 1999 have overestimated SSB and underestimated F, because of inconsistencies in commercial effort data. The current assessment of the stock shows that SSB is at an historic low and F is at about the historic high.

The 1996 year class is the largest since 1985, but its influence has largely passed through the stock and fishery. In the catch forecast for *status quo* F the 1996 year class contributes about 30% of landings in 2000, but only 15% in 2001. This year class contributes about 50% of the SSB in 2000, and 20% in 2002.

Substantial under-reporting of cod landings occurred in 1998. There are no reasons to suspect substantial under-reporting in 1999 or 2000.

There is scope for investigating whether the geographical distribution for cod, haddock and whiting, based on surveys, may allow area specific measures to be devised.

Cod are taken by towed gears in mixed roundfish fisheries, which include haddock and whiting. They are also taken in directed fisheries using fixed gears. By-catches of cod occur in flatfish and shrimp fisheries, especially in the Southern North Sea and in *Nephrops* fisheries.

The assessment is based on analysis of catch at age data, calibrated with one commercial fleet and data from three surveys.

Reference points (1998)

ICES considers that:	ICES proposes that:
$\mathbf{B_{lim}}$ is 70,000 t, the lowest observed spawning stock biomass.	$\mathbf{B_{pa}}$ be set at 150,000 t. This is the previously agreed MBAL and affords a high probability of maintaining SSB above $\mathbf{B_{lim}}$, taking into account the uncertainty of assessments. Below this value the probability of below average recruitment increases.
$\mathbf{F_{lim}}$ is 0.86, the fishing mortality estimated to lead to potential stock collapse.	$\mathbf{F_{pa}}$ be set at 0.65. This F is considered to have a 95% probability of avoiding $\mathbf{F_{lim}}$, taking into account the uncertainty of assessments.

Technical basis:

$\mathbf{B_{lim}}$ = Rounded $\mathbf{B_{loss}}$ = 70,000 t.	$\mathbf{B_{pa}}$ = Previous MBAL and signs of impaired recruitment below: 150,000 t
$\mathbf{F_{lim}}$ = $\mathbf{F_{loss}}$ = 0.86	$\mathbf{F_{pa}}$ = Approx. 5th percentile of $\mathbf{F_{loss}}$,; implies an equilibrium biomass >$\mathbf{B_{pa}}$ and a less than 10% probability that (SSBMT<$\mathbf{B_{pa}}$)

Source of information: Report of the Working Group on the Assessment of Demersal Stocks in the North Sea and Skagerrak, October 2000 (ICES CM 2001/ACFM:07).

Landings for each of the three parts of this combined assessment area and for the combined area are given in Table 3.5.2.1 and Table 3.5.2.2.

North Sea (Sub-area IV)

Year	ICES Advice	Predicted catch corresp. to advice	Agreed TAC	Official landings	ACFM landings
1987	SSB recovery; TAC	100–125	175	167	182
1988	70% of F(86); TAC	148	160	142	157
1989	Halt SSB decline; protect juveniles; TAC	124	124	110	116
1990	80% of F (88); TAC	113	105	99	105
1991	70% of effort (89)		100	87	89
1992	70% of effort (89)		100	98	97
1993	70% of effort (89)		101	94	105
1994	Significant effort reduction		102	87	95
1995	Significant effort reduction		120	112	120
1996	80% of F(94) = 0.7	141	130	104	107
1997	80% of F(95) = 0.65	135	115	100	102
1998	F(98) should not exceed F(96)	153	140	114	122
1999	F = 0.60 to rebuild SSB	125	132.4	79.5	78.4
2000	F less than 0.55	<79	81		
2001	lowest possible catch	0			

Skagerrak (Division IIIa)

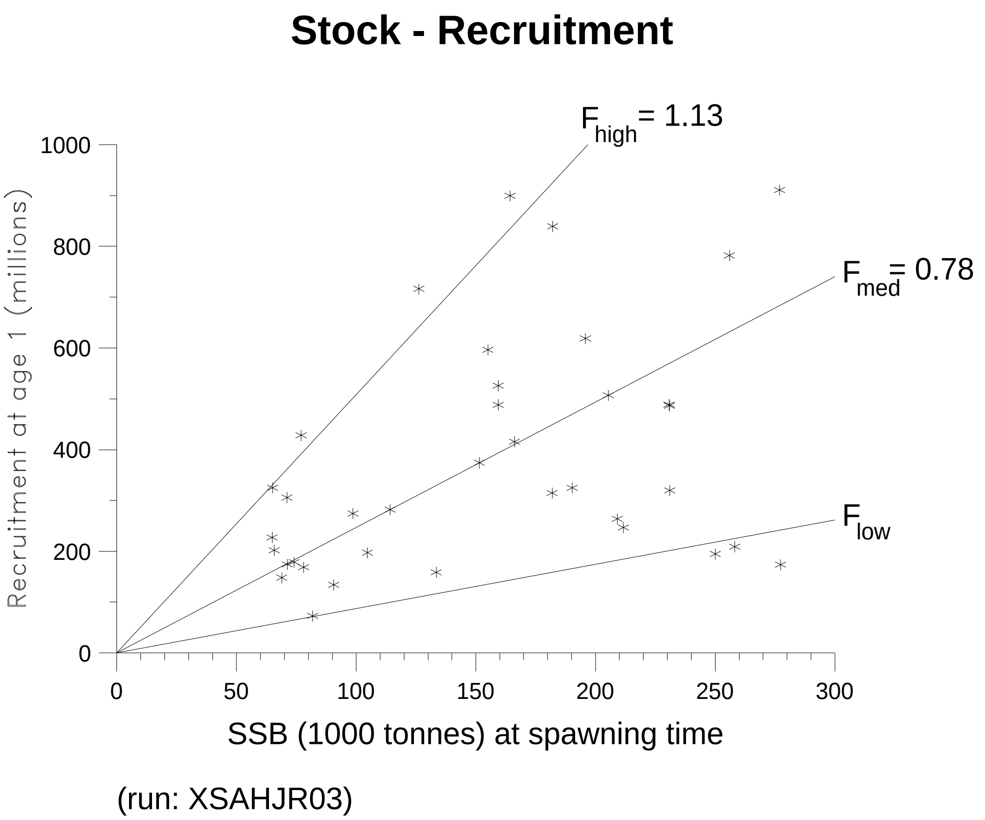
Year	ICES Advice	Predicted catch corresp. to advice	Agreed TAC[1]	ACFM Landings[1]
1987	F = $\mathbf{F_{max}}$	<21	22.5	20.9
1988	Reduce F		21.5	16.9
1989	F at $\mathbf{F_{med}}$	<23	20.5	19.6
1990	F at $\mathbf{F_{med}}$; TAC	21.0	21.0	18.6
1991	TAC	15.0	15.0	12.4
1992	70% of F(90)		15.0	14.8
1993	Precautionary TAC		15.0	15.3
1994	No long-term gain in increased F + precautionary TAC		15.5	13.9
1995	If required precautionary TAC; link to North Sea		20.0	12.1
1996	If required precautionary TAC; link to North Sea		23.0	16.4
1997	If required precautionary TAC; link to North Sea		16.1	14.9
1998	If required precautionary TAC; link to North Sea	21.9	20.0	15.3
1999	F = 0.60 to rebuild SSB	17.9	19.0	11.0
2000	F less than 0.55	<11.3	11.6	
2001	lowest possible catch	0		

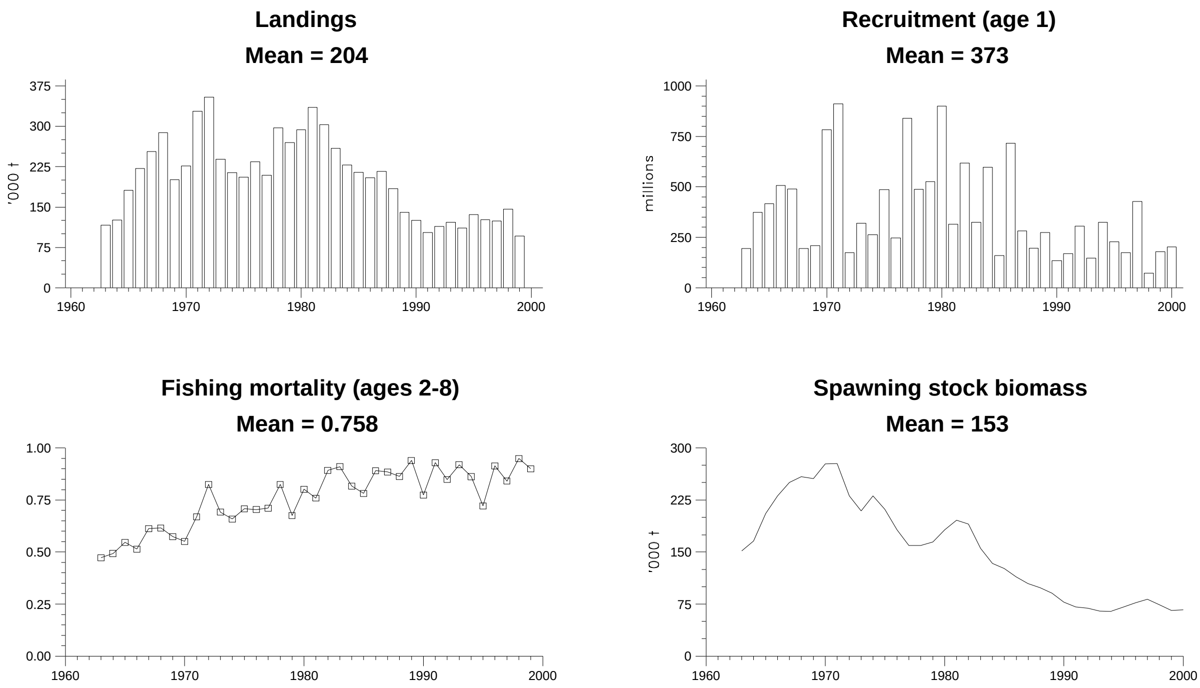
[1] Norwegian fjords not included. Weights in '000 t.

Eastern Channel (Division VIId)

Year	ICES Advice	Predicted catch corresp. to advice	Agreed TAC[1]	Official landings	ACFM landings
1987	Not assessed	-	-	9.4	14.2
1988	Precautionary TAC	-	-	10.1	10.7
1989	No increase in F; TAC	10.0[2]	-	n/a	5.5
1990	No increase in F; TAC	9.0[2]	-	n/a	2.8
1991	Precautionary TAC	3.0[2]	-	n/a	1.9
1992	If required, precautionary TAC	5.5[2]	-	2.7	2.7
1993	If TAC required, consider SSB decline	-	-	2.5	2.4
1994	Reduce F+ precautionary TAC		-	2.9	2.9
1995	Significant effort reduction; link to North Sea		-	4.0	4.0
1996	Reference made to North Sea advice		-	3.5	3.5
1997	No advice		-	7.2	7.0
1998	Link to North Sea	4.9	-	8.7	8.6
1999	F = 0.60 to rebuild SSB	4.0	-	0.6	6.9
2000	F less than 0.55	<2.5	-		
2001	lowest possible catch	0			

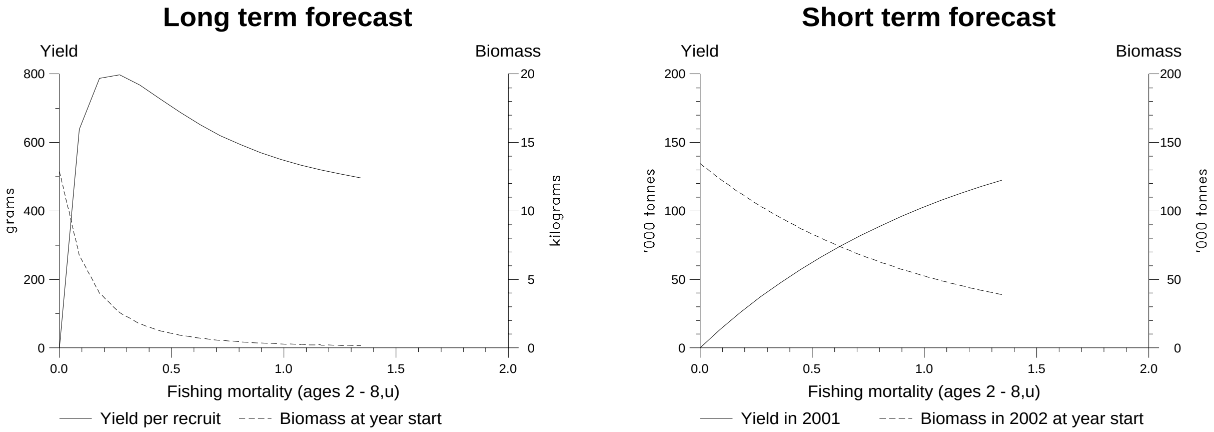
[1] Included in TAC for Sub-area VII (except Division VIIa). [2]Including VIIe. Weights in ‘000 t.





Cod in Sub-area IV (North Sea), Division VIId (Eastern Channel) and Division IIIa (Skagerrak)

Yield and Spawning Stock Biomass



Cod in Sub-area IV, Divisons VIId & IIIa

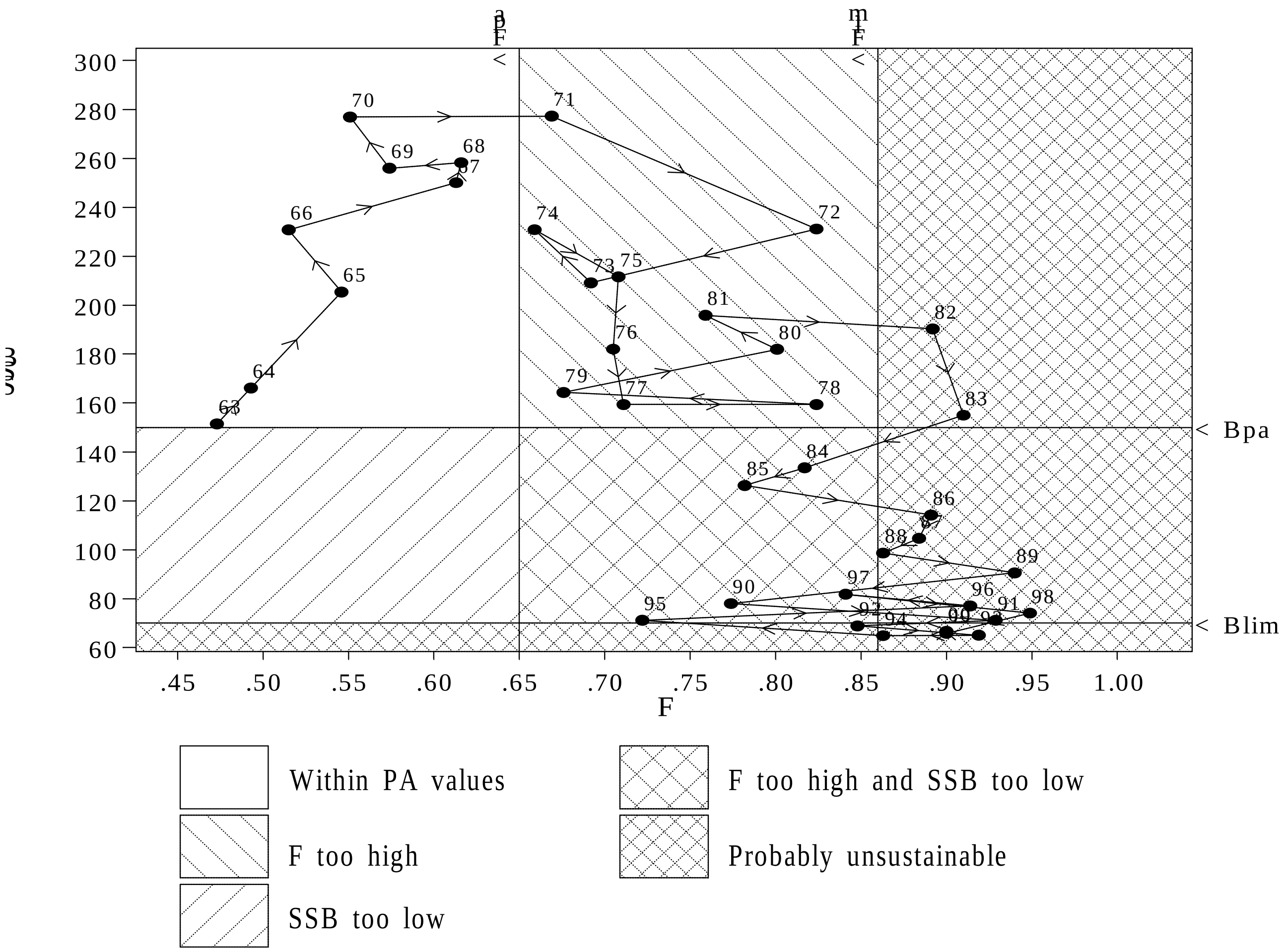


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Table 3.5.2.1 Nominal catch (in tonnes) of COD in IIIa (Skagerrak), IV and VIId, 1987–1999 as officially reported to ICES and as used by the Working Group.

Sub-area IV

Country	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Belgium	6,693	5,508	3,398	2,934	2,331	3,356	3,374	2,648	4,827	3,458	4,642	5,799	3,882
Denmark	36,948	34,905	25,782	21,601	18,998	18,479	19,547	19,234	24,067	23,573	21,870	23,002	19,697
Faroe Islands	57	46	35	96	23	109	46	80	219	44	40	102	-
France	8,199	8,323	2,578	1,641	975	2,146	1,868	1,868	3,040	1,920	3,779	2,934	1,750
Germany	8,230	7,707	11,430	11,725	7,278	8,446	6,800	5,974	9,457	8,344	5,179	8,045	3,386
Netherlands	21,347	16,968	12,028	8,445	6,831	11,133	10,220	6,512	11,199	9,271	11,807	14,676	9,068
Norway	5,000	3,585	4,813	5,168	6,022	10,476	8,742	7,707	7,358	5,884	5,829	5,749	7,770
Poland	13	19	24	53	15	-	-	-	-	18	31	25	19
Sweden	688	367	501	620	784	823	646	630	709	617	832	540	597
UK (E/W/NI)	29,960	23,496	18,375	15,622	14,249	14,462	14,940	13,941	14,991	15,930	13,413	17,745	10,344
UK (Scotland)	49,671	41,382	31,480	31,120	29,060	28,677	28,197	28,854	35,848	35,349	32,344	35,633	23,017
Total Nominal Catch	166,806	142,306	110,444	99,025	86,566	98,107	94,380	87,448	111,715	104,408	99,766	114,250	79,530
Unallocated landings	15,288	14,253	5,256	5,726	1,967	-758	10,200	7,075	8,308	2,160	2,403	7,853	-1,138
WG estimate of total landings	182,094	156,559	115,700	104,751	88,533	97,349	104,580	94,523	120,023	106,568	102,169	122,103	78,392
Agreed TAC	175,000	160,000	124,000	105,000	100,000	100,000	101,000	102,000	120,000	130,000	115,000	140,000	132,400

Division VIId

Country	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Belgium	815	486	173	237	182	187	157	228	377	321	310	239	172
Denmark	-	+	+	-	-	1	1	9	-	-	-	-	-
France	7,541	8,795	n/a	n/a	n/a	2,079	1,771	2,338	3,261	2,788	6,387	7,788	-
Netherlands	-	1	1	-	-	2	-	-	-	+	-	19	3
UK (E+W)	1,044	867	562	420	341	443	530	312	336	414	478	618	454
UK (Scotland)	-	-	-	7	2	22	2	+	+	4	3	1	-
Total Nominal Catch	9,400	10,149	n/a	n/a	n/a	2,734	2,461	2,887	3,974	3,527	7,178	8,665	629
Unallocated landings	4,819	580	-	-	-	-65	-29	-37	-10	-24	-135	-85	6,229
WG estimate of total landings	14,219	10,729	5,538	2,763	1,886	2,669	2,432	2,850	3,964	3,503	7,043	8,580	6,858

Division IIIa (Skagerrak)

Country	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Denmark	17,824	14,806	16,634	15,788	10,396	11,194	11,997	11,953	8,948	13,573	12,164	12,340	8,724
Sweden	1,924	1,648	1,902	1,694	1,579	2,436	2,574	1,821	2,658	2,208	2,303	1,608	1,909
Norway	152	392	256	143	72	270	75	60	169	265	348	303	345
Germany	-	-	12	110	12	-	-	301	200	203	81	16	54
Others	-	106	34	65	12	102	91	25	134	-	-	-	-
Norwegian coast *	838	769	888	846	854	923	909	760	846	748	911	976	788
Danish industrial by-catch *	491	1,103	428	687	953	1,360	511	666	749	676	205	97	62
Total Nominal Catch	19,900	16,952	18,838	17,800	12,071	14,002	14,737	14,160	12,109	16,249	14,896	14,267	11,042
Unallocated landings	0	0	-141	0	-12	0	0	-899	0	0	50	1,064	-68
WG estimate of total landings	9,900	16,952	18,697	17,800	12,059	14,002	14,737	13,261	12,109	16,249	14,946	15,331	10,974
Agreed TAC	22,500	21,500	20,500	21,000	15,000	15,000	15,000	15,500	20,000	23,000	16,100	20,000	19,000

Sub-area IV, Divisions VIId and IIIa (Skagerrak) combined

	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Total Nominal Catch	196,106	169,407	n/a	n/a	n/a	114,843	111,578	104,495	127,798	124,184	121,840	138,182	91,201
Unallocated landings	20,106	14,833	-	-	-	-823	10,171	6,139	8,298	2,136	2,318	8,832	5,024
WG estimate of total landings	216,212	184,240	139,936	125,314	102,478	114,020	121,749	110,634	136,096	126,320	124,158	146,014	96,225

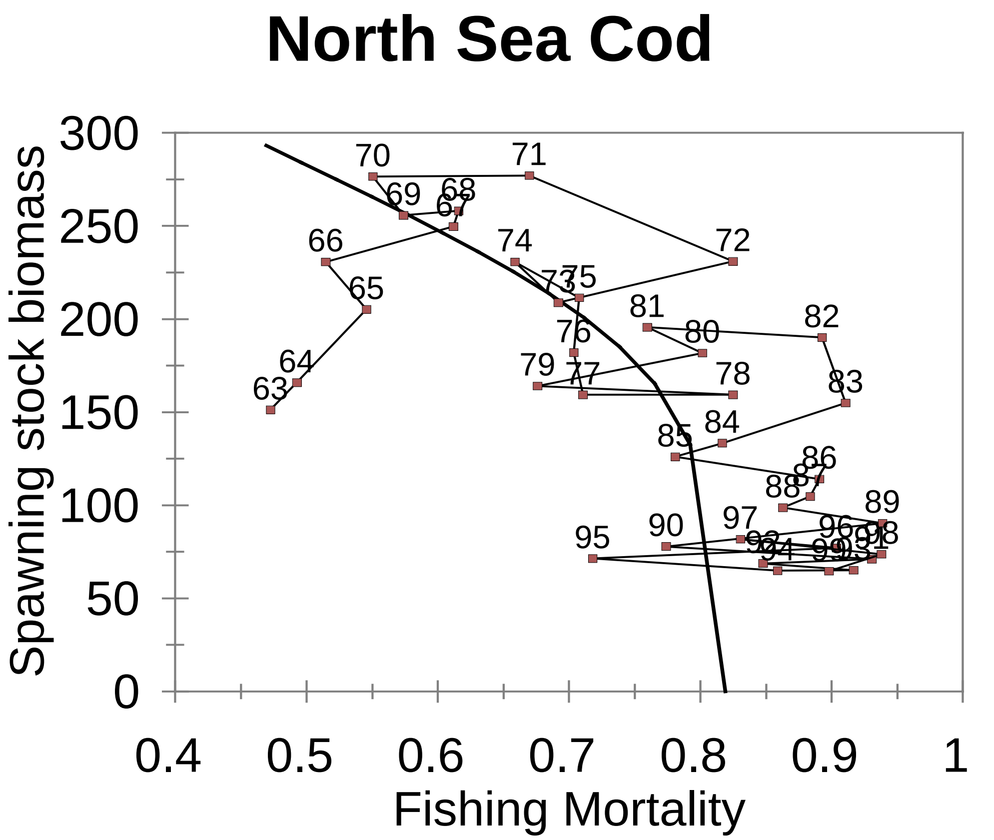
* The Danish industrial by-catch and the Norwegian coast catches are not included in the (WG estimate of) total landings of Division IIIa (Skagerrak)

Table 3.5.2.2 Cod in Sub-area IV, Division VIId & Division IIIa (Skagerrak)

Year	Recruitment Age 1	Spawning Stock Biomass	Landings	Fishing Mortality Age 2-8
1963	195.11	151.52	116.46	0.473
1964	374.09	166.13	126.04	0.493
1965	415.44	205.38	181.04	0.546
1966	506.86	230.74	221.34	0.515
1967	488.81	250.05	252.98	0.613
1968	194.60	258.25	288.37	0.616
1969	209.06	255.98	200.76	0.574
1970	781.99	276.92	226.12	0.551
1971	910.80	277.31	328.10	0.669
1972	173.51	231.10	353.98	0.824
1973	319.65	209.19	239.05	0.692
1974	263.66	230.87	214.28	0.659
1975	486.38	211.63	205.25	0.708
1976	246.43	182.07	234.17	0.705
1977	839.20	159.36	209.15	0.711
1978	488.16	159.39	297.02	0.824
1979	525.43	164.31	269.97	0.676
1980	899.52	181.92	293.64	0.801
1981	314.77	195.81	335.50	0.759
1982	618.49	190.28	303.25	0.892
1983	324.68	155.03	259.29	0.910
1984	596.31	133.46	228.29	0.817
1985	158.62	126.22	214.63	0.782
1986	716.24	114.19	204.05	0.891
1987	281.82	104.70	216.21	0.884
1988	197.05	98.63	184.24	0.863
1989	274.08	90.60	139.94	0.940
1990	133.96	78.04	125.31	0.774
1991	168.54	71.13	102.48	0.929
1992	305.42	68.90	114.02	0.848
1993	147.87	65.11	121.75	0.919
1994	325.00	64.84	110.63	0.863
1995	227.25	71.17	136.10	0.722
1996	174.29	77.03	126.32	0.914
1997	427.96	81.78	124.16	0.841
1998	72.57	74.07	146.01	0.949
1999	178.86	65.78	96.23	0.900
2000	202.00[1]	66.71[2]	.	.
Average	372.75	152.51	203.95	0.758
Unit	Millions	1000 tonnes	1000 tonnes	-

[1] Short-tem GM year classes 1988-1997.
[2] Based on $\mathbf{F_{sq}}$ and 1997-1999 arithmetic means of weight at age.

Figure 3.5.2.1. Long-term equilibrium SSB as a function of fishing mortality.



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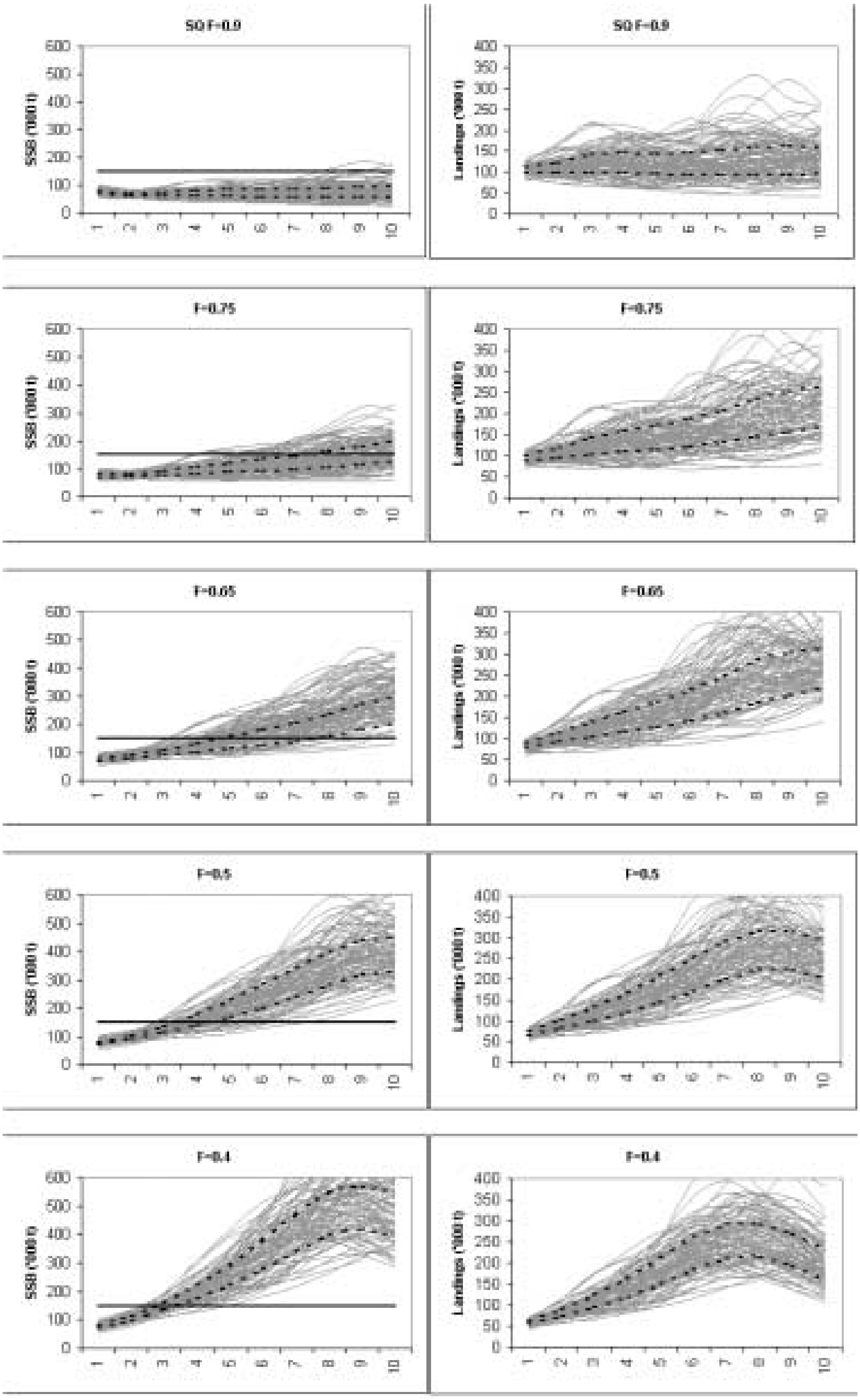

Figure 3.5.2.2. Cod in Sub-area IV and Divisions VIID and IIIA (Skagerrak). 10-year medium term projections of SSB ('000 t) left panel, and landings ('000 t) right panel. The horizontal solid lines in the SSB plots indicate $\mathbf{B_{pa}}$. The grey lines each represent one of 100 separate simulations. Heavy dashed lines indicate the 25 and 75 percentiles from 500 simulations.