

Stock Annex: Ling (*Molva molva*) in subareas 6–9, 12, and 14, and in divisions 3.a and 4.a (Northeast Atlantic and Arctic Ocean)

Stock specific documentation of standard assessment procedures used by ICES.

Stock:	Ling
Working Group:	Working Group on Biology and Assessment of Deep-sea Fisheries Resources (WGDEEP)
Created:	March 2011
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Last updated:	April 2021
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A. General

A.1. Stock definition

WGDEEP 2006 indicated: *'There is currently no evidence of genetically distinct populations within the ICES area. However, ling at widely separated fishing grounds may still be sufficiently isolated to be considered management units, i.e. stocks, between which exchange of individuals is limited and has little effect on the structure and dynamics of each unit. It was suggested that Iceland (5.a), the Norwegian Coast (2), and the Faroes and Faroe Bank (5.b) have separate stocks, but that the existence of distinguishable stocks along the continental shelf west and north of the British Isles and the northern North Sea (Subareas 4, 6, 7 and 8) is less probable.'*

A.2. Fishery

Significant fisheries for ling are conducted in Subareas 3 and 4 at least since the 1870s pioneered by Swedish longliners. Since the mid-1900s, the major ling targeted fishery in Area 4.a (Bergstad and Hareide, 1996). There Norwegian longliners conducted around Shetland and in the Norwegian Deep. There are little activity in Area 3.a. The Norwegian total landings in 2019 in Subareas 3 and 4 were: 83% taken by longlines, 9% by gillnets, and the remainder by trawls. The bulk of the landings from other countries were taken by trawls as bycatches, and the landings from the UK (Scotland) are the most substantial. The comparatively low landings from central and southern North Sea (4.b,c) are bycatches from various other fisheries.

The major directed ling fishery in Area 6 is the Norwegian longline fishery. Catches of ling by trawl fisheries from the UK (Scotland) and from France are primarily bycatches.

When Areas 3–4 and 6–14 are summed over 1988–2019, 42% of the total landings were in Area 4, 30% in Area 6, and 24% in Area 7.

In Subarea 7, Divisions b, c, and g–k provide most of the landings of ling. Norwegian landings, and some Irish and Spanish landings are from targeted longline fisheries, whereas other landings are primarily bycatches in trawl fisheries. Data split by gear type were not available for all countries, but the bulk of the total landings (at least 60–70%) were taken by trawls in these areas.

In Subareas 8 and 9, 12 and 14 all landings are bycatches from various fisheries.

A.3. Ecosystem aspects

Ling prefers hard seabed, or sandy seabed with large rocks. It inhabits depths that range from 60 to 1000 m, but is mainly found between 300 and 400 m (Pethon, 2005). It is believed that they occur alone or in small schools (Gordon *et al.*, 1995). The growth is slow ($k=0.1$) and they can live to 30 years. The maximum weight and length of a ling are about 40 kg and 2 m, respectively. Ling are mature at 6-8 years old, the males a little before the females. The main spawning areas are between Scotland and Iceland, but ling also spawns along the Norwegian coast south of Vesterålen (69°N) from April to June at depths between 100 and 300 m (Pethon, 2005). Natural mortality is usually set to 0.15. Ling feeds mainly on fish, but also on crustaceans, cephalopods, and echinoderms (Magnusson *et al.*, 1997, Pethon, 2005).

B. Data

B.1. Fishery dependent data

The Norwegian Directorate of Fisheries provided the logbook records for longliner vessels that were longer than 21 m and had a total landings of ling, tusk (*Brosme brosme*), and blue ling (*Molva dipterygia*) greater than 8 tons in a given year. These data included the total daily catch of all commercial species, where the vessel was fishing, and the number of hooks set each day.

The Norwegian Directorate of Fisheries also provide sale slips. The reference fleet provide data on length and weight, occasionally also sex and maturity. They also provide samples such as otoliths and tissue sampling for genetics and gonad samples.

Landings from all participating countries are provided to ICES. Landings during the 20th century, from 1988 to 2000 are detailed in this stock annex as data which are not susceptible to be revised.

Table 1. ICES estimates of landings from 1998 to 2000.

Ling 3

Year	Belgium	Denmark	Germany	Norway	Sweden	E & W	France	Total
1988	2	165	-	135	29	-		331
1989	1	246	-	140	35	-		422
1990	4	375	3	131	30	-		543
1991	1	278	-	161	44	-		484
1992	4	325	-	120	100	-		549
1993	3	343	-	150	131	15		642
1994	2	239	+	116	112	-		469
1995	4	212	-	113	83	-		412
1996		212	1	124	65	-		402
1997		159	+	105	47	-		311
1998		103	-	111	-	-		214
1999		101	-	115	-	-		216
2000		101	+	96	31			228

Division 4.a

Year	Belgium	Denmark	Faroës	France	Germany	Neth.	Norway	Sweden ¹⁾	E&W	N.I.	Scot.	Total
1988	3	408	13	1143	262	4	6473	5	55	1	2856	11 223
1989	1	578	3	751	217	16	7239	29	136	14	2693	11 677
1990	1	610	9	655	241	-	6290	13	213	-	1995	10 027
1991	4	609	6	847	223	-	5799	24	197	+	2260	9969
1992	9	623	2	414	200	-	5945	28	330	4	3208	10 763
1993	9	630	14	395	726	-	6522	13	363	-	4138	12 810
1994	20	530	25	n/a	770	-	5355	3	148	+	4645	11 496
1995	17	407	51	290	425	-	6148	5	181		5517	13 041
1996	8	514	25	241	448		6622	4	193		4650	12 705
1997	3	643	6	206	320		4715	5	242		5175	11 315
1998	8	558	19	175	176		7069	-	125		5501	13 631
1999	16	596	n.a.	293	141		5077		240		3447	9810
2000	20	538	2	147	103		4780	7	74		3576	9246

(1) Includes 4b from 1988 to 1993.

Division 4.bc.

Year	Belgium	Denmark	France	Sweden	Norway	E & W	Scotland	Germany	Netherlands	Total
1988					100	173	106	-		379
1989					43	236	108	-		387
1990					59	268	128	-		455
1991					51	274	165	-		490
1992		261			56	392	133	-		842
1993		263			26	412	96	-		797
1994		177			42	40	64	-		323
1995		161			39	301	135	23		659
1996		131			100	187	106	45		569
1997	33	166	1	9	57	215	170	48		699
1998	47	164	5		129	128	136	18		627
1999	35	138	-		51	106	106	10		446
2000	59	101	0	8	45	77	90	4		384

Division 6.a

Year	Belgium	Denmark	Faroes	France ⁽¹⁾	Germany	Ireland	Norway	Spain(2)	E&W	IOM	N.I.	Scot.	Total
1988	4	+	-	5381	6	196	3392	3575	1075	-	53	874	14 556
1989	6	1	6	3417	11	138	3858		307	+	6	881	8631
1990	-	+	8	2568	1	41	3263		111	-	2	736	6730
1991	3	+	3	1777	2	57	2029		260	-	10	654	4795
1992	-	1	-	1297	2	38	2305		259	+	6	680	4588
1993	+	+	-	1513	92	171	1937		442	-	13	1133	5301
1994	1	1		1713	134	133	2034	1027	551	-	10	1126	6730
1995	-	2	0	1970	130	108	3156	927	560	n/a		1994	8847
1996			0	1762	370	106	2809	1064	269			2197	8577
1997			0	1631	135	113	2229	37	151			2450	6746
1998				1531	9	72	2910	292	154			2394	7362
1999				941	4	73	2997	468	152			2264	6899

(1) Includes 6.b until 1996 (2) Includes minor landings from 6.b.

Division 6.b.

Year	Faroes	France ⁽¹⁾	Germany	Ireland	Norway	Spain ⁽²⁾	E & W	N.I.	Scotland	Russia	Total
1988	196		-	-	1253		93	-	223		1765
1989	17		-	-	3616		26	-	84		3743
1990	3		-	26	1315		10	+	151		1505
1991	-		-	31	2489		29	2	111		2662
1992	35		+	23	1713		28	2	90		1891
1993	4		+	60	1179		43	4	232		1522
1994	104		-	44	2116		52	4	220		2540
1995	66		+	57	1308		84		123		1638
1996	0		124	70	679		150		101		1124
1997	0		46	29	504		103		132		814
1998		1	10	44	944		71		324		1394
1999		26	25	41	498		86		499		1175
2000	+	18	31	19	1172		157		475	7	1879

(1) Included in 6.a until 1966 included in 6.a. (2) Included in 6.a.

Subarea 7. Landings not reported by Division. Landings reported by Division of subarea 7 are presented in the next tables.

Year	France	Total
1988	5057	5057
1989	5261	5261
1990	4575	4575
1991	3977	3977
1992	2552	2552
1993	2294	2294
1994	2185	2185

Division 7.a.

Year	Belgium	France	Ireland	E & W	IOM	N.I. ⁽¹⁾	Scotland	Total
1988	14		100	49	-	38	10	211
1989	10		138	112	1	43	7	311
1990	11		8	63	1	59	27	169
1991	4		10	31	2	60	18	125
1992	4		7	43	1	40	10	105
1993	10		51	81	2	60	15	219
1994	8		136	46	2	76	16	284
1995	12	9	143	106	1		34	305
1996	11	6	147	29	-		17	210
1997	8	6	179	59	2		10	264
1998	7	7	89	69	1		25	198
1999	7	3	32	29			13	84
2000	3	2	18	25			25	73

⁽¹⁾ Included in UK (EW) from 1995 to 1999.

Division 7.bc

Year	France	Germany	Ireland	Norway	E & W	N.I.(1)	Scotland	Total
1988		-	50	57	750	-	8	865
1989		+	43	368	161	-	5	577
1990		-	51	463	133	-	31	678
1991		-	62	326	294	8	59	749
1992		-	44	610	485	4	143	1286
1993		97	224	145	550	9	409	1434
1994		98	225	306	530	2	434	1595
1995	78	161	465	295	630	-2	315	1944
1996	57	234	283	168	1117	-2	342	2201
1997	65	252	184	418	635	-2	226	1780
1998	32	1	190	89	393		329	1034
1999	51	4	377	288	488		159	1366
2000	123	21	401	170	327		140	1182

(1) Included in UK (EW) from 1995 to 1999.

Division 7.de.

Year	Belgium	Denmark	France	Ireland	E & W	Scotland	Ch. Islands	Total
1988	36	+		-	743	-		779
1989	52	-		-	644	4		700
1990	31	-		22	743	3		799
1991	7	-		25	647	1		680
1992	10	+		16	493	+		519
1993	15	-		-	421	+		436
1994	14	+		-	437	0		451
1995	10	-	885	2	492	0		1389
1996	15		960		499	3		1477
1997	12		1049	1	372	1	37	1472
1998	10		953		510	1	26	1500
1999	7		545	-	507	1		1060
2000	5		454	1	372		14	846

Division 7.f.

Year	Belgium	France	Ireland	E & W	Scotland	Total
1988	77		-	367	-	444
1989	42		-	265	3	310
1990	23		3	207	-	233
1991	34		5	259	4	302
1992	9		1	127	-	137
1993	8		-	215	+	223
1994	21		-	379	-	400
1995	36	110	-	456	0	602
1996	40	121	-	238	0	399
1997	30	204	-	313		547
1998	29	204	-	328		561
1999	16	108	-	188		312
2000	15	91	1	111		218

Divisions 7.g–k.

Year	Belgium	Denmark	France	Germany	Ireland	Norway	Spain ⁽¹⁾	E&W	IOM	N.I.	Scot.	Total
1988	35	1		-	286	-	2652	1439	-	-	2	4415
1989	23	-		-	301	163		518	-	+	7	1012
1990	20	+		-	356	260		434	+	-	7	1077
1991	10	+		-	454	-		830	-	-	100	1394
1992	10	-		-	323	-		1130	-	+	130	1593
1993	9	+		35	374			1551	-	1	364	2334
1994	19	-		10	620		184	2143	-	1	277	3254
1995	33	-	1597	40	766	-	195	3046			454	6131
1996	45	-	1626	169	771		583	3209			447	6850
1997	37	-	1574	156	674		33	2112			459	5045
1998	18	-	1362	88	877		1669	3465			335	7814
1999	-	-	1220	49	554		455	1619			292	4189
2000	17		1062	12	624		639	921			303	3578

⁽¹⁾ Includes 7.b,c until 2011

Subarea 8.

Year	Belgium	France	Germany	Spain	E & W	Total
1988		1018			10	1028
1989		1214			7	1221
1990		1371			1	1372
1991		1127			12	1139
1992		801			1	802
1993		508			2	510
1994		n/a		77	8	85
1995		693		106	46	845
1996		825	23	170	23	1041
1997	1	705	+	290	38	1034
1998	5	1220	-	543	29	1797
1999	22	234	-	188	8	452
2000	1	227		106	5	339

Subarea 9.

Year	Spain	Total
1997	0	0
1998	2	2
1999	1	1
2000	1	1
2001	0	0
2002	0	0
2003	0	0
2004		
2005		
2006		
2007	1	1

Subarea 12

Year	Faroes	France	Norway	E & W	Scotland	Germany	Total
1988				-			0
1989				-			0
1990				3			3
1991				10			10
1992				-			0
1993				-			0
1994				5			5
1995	5			45			50
1996	-		2				2
1997	-		+	9			9
1998	-	1	-	1			2
1999	-	0	-	-	+	2	2
2000		1	-		6		7

Subarea14.

Year	Faroes	Germany	Iceland	Norway	E & W	Scotland	GREEN-LAND	Total
1988		3	-	-	-	-		3
1989		1	-	-	-	-		1
1990		1	-	2	6	-		9
1991		+	-	+	1	-		1
1992		9	-	7	1	-		17
1993		-	+	1	8	-		9
1994		+	-	4	1	1		6
1995	-	-		14	3	0		17
1996	-			0				0
1997	1			60				61
1998	-			6				6
1999	-			1			8	9
2000			26	-			0	26

B.2. Fishery independent data– Surveys

Ling are caught in small numbers (average of 14 individuals per year since 1997) in the French WIBTS-Q4 (EVHOE) survey covering ICES divisions 7.g,h,j,k and 8.a,b,d. populations indices are however presented, but are not considered representative of stock trends in the area.

The Spanish bottom trawl survey on the Porcupine Bank (ICES divisions 7.c and 7.k) has been carried out annually since 2001 to study the distribution, relative abundance and biological parameters of commercial fish. The survey provides estimates of biomass and abundance indices (ICES, 2019).

B.3. Biological data

Average fish length, weight–length relationships and the length distribution for the Norwegian longline and gillnet fishery from Areas 4a, 6a, 6b are available.

From the Spanish Porcupine Bank (NE Atlantic) surveys Estimated Length distributions are available for the years 2013-2019.

Age data are available from the Norwegian longline fleet and from the Spanish survey on porcupine bank.

Maturity

The maturity at length and age estimates from sampling of the catch of the Norwegian fleet are shown in figure 1. The maturity parameters are:

Stock	L ₅₀	N	A ₅₀	N	Source
lin.27.3.a4.a6-91214	63.6	1472	4.8	336	Norwegian long liners and survey data

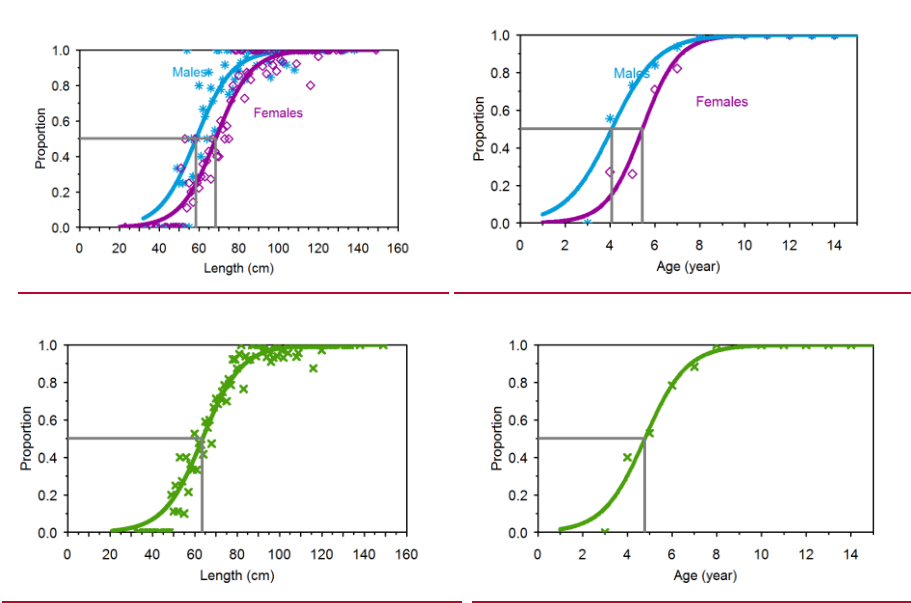


Figure 1. Ling (lin.27.3a4a6-91214), maturity ogives for age and length for males and females (top panel) and sexes combined (lower panel).

C. Assessment: data and method

Ling are assessed by the ICES Working Group on the Biology and Assessment of Deep-sea Fisheries Resources (WGDEEP). IMR is the stock coordinator and provides data as the basis for the advice.

C.1. Assessment model

Two cpue series based on data from the Norwegian reference fleet for ling, one using all data available and the other using only data when ling were targeted (>30% of the total catch). A generalized linear model was found appropriate

$$y_{i,j,k,l} = c + \mu_i + \alpha_j + \beta_k + e_{i,j,k,l} \quad (1)$$

where; $y_{i,j,k,l}$ is the catch (kg) per hook in year i , month j for set l by vessel k ; c is a constant; μ_i , $i = 2000-2015$, is the year effect; α_j is the month effect; β_k is the vessel effect, and $e_{i,j,k,l}$ is the error term model (for more details see Helle *et al.*, 2015).

Since the data often contains a large proportion of zeros, the GLM model (1) was combined using the delta method (Pennington, 1983; Stefánsson, 1996; Maunder and Punt, 2004). That is the estimator of the year effect, μ_i based on all the data is given by:

$$\hat{\mu}_i = \frac{m}{n} \hat{\mu}'_i, \quad (2)$$

where m is the number of catches of ling greater than zero, n is the total number of sets and $\hat{\mu}'_i$ is the year effect based on model (1). If the number of zeros is statistically independent of $\hat{\mu}'_i$ and the distribution of zeros is assumed to be binomial, then the variance estimator of $\hat{\mu}_i$ is given by (Pennington, 1983; 1996)

$$\text{var}(\hat{\mu}_i) = \frac{m(m-1)}{n(n-1)} \text{var}(\hat{\mu}'_i) + \frac{m(n-m)}{n^2(n-1)} (\hat{\mu}'_i)^2. \quad (3)$$

As always, it should be emphasized that commercial catch data are typically observational data when used to estimate trends in abundance; that is, there were no scientific controls on how or from where the data were collected from the actual fish population. Therefore, it is not known with certainty if a cpue series tracks the population and how accurate the measures of uncertainty associated with the series are (see, for example, Rosenbaum, 2002; Helle *et al.*, 2015).

D. Short-Term Projection

No short-term projections done.

E. Medium-Term Projections

No medium-term projections done.

F. Long-Term Projections

No long-term projections done.

G. Biological Reference Points

Evaluation of reference points

At the 2012 WGDEEP meeting several methods were trialled to estimate reference points for ling in all other areas. These methods included the Gislason method, the Extended Beverton–Holt yield simple model (BHAC) and FLAdvice as recommended in WKLIFE.

The input parameters were as follows:

For Gislason: L_{\max} of 180 cm

$$AFC = 5.$$

For BHAC: natural mortality $M = 0.15$

$$k \text{ VB growth } K = 0.09$$

$$\text{Length 1st maturity } L_{\text{mat}} < 70$$

$$L \text{ infinity } L_{\text{inf}} < 160$$

For FLAdvice: Age range is 1–16

$$L \text{ infinity } L_{\text{inf}} < 160$$

$$k \text{ VB growth } K = 0.09$$

$$\text{LW relationship } a = 0.0043$$

$$\text{LW relationship } b = -3.051$$

Several estimates from the different approaches were available. The table below summarizes the outputs of the different methods:

Method/Estimate	F _{MAX}	F _{0.1}	F _{30%SPR}	F _{40%SPR}	F _{msy}
Gislason spreadsheet (WKLIFE) with AFC=5	0.22	0.1	0.13	0.09	
BHAC (WKLIFE)	0.21	0.11			
FLAdvice (WKLIFE) based on Linf and K	0.16	0.08	0.10		
FLAdvice (WKLIFE) based on Linf, K and LW parameters	0.14	0.06	0.08		0.09

This analysis indicated that F_{\max} (around 0.22) for the Gislason spreadsheet and (0.21) for the BHAC methods were similar, in both methods the estimation of $F_{0.1}$ is similar at ca. 0.1. FLAdvice was tested with the input of LW parameters and without, The F_{\max} values were lower for FLAdvice based on Linf and K and lower still when LW parameters were included in the calculations.

There is no obvious basis for selecting an F_{MSY} proxy from the range of values described above however values between 0.1 and 0.2 would seem appropriate.

No biological reference points have been defined

Ling in subareas 6–9, 12, and 14, and in divisions 3.a and 4.a. Reference points, values, and their technical basis.

Framework	Reference point	Value	Technical basis	Source
MSY approach	MSY $B_{\text{trigger proxy}}$	Not defined	-	ICES (2019)
	$F_{\text{MSY proxy}}$	83 cm (2018)	Expected mean length of catch above L_{mean} when $F = M$.	
Precautionary approach	B_{lim}	Not defined		
	B_{pa}	Not defined		
	F_{lim}	Not defined		
	F_{pa}	Not defined		
Management plan	SSB_{mgt}	Not defined		
	F_{mgt}	Not defined		

H. Other Issues

H.1. Historical overview of previous assessment methods

From 2003 to 2006 the advice was to reduce the effort for ling by 30% for 2007 through 2013, which the advice is based on the average catch for the three years before 2003. From 2014, ling has been managed as an ICES stock data category 3.3.2 and advice based on cpue trends

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