Stock Annex: Tusk (*Brosme brosme*) in subareas 4 and 7–9, and in divisions 3.a, 5.b, 6.a, and 12.b (Northeast Atlantic)

Stock specific documentation of standard assessment procedures used by ICES.

Stock:	Tusk
Working Group:	Working Group on Biology and Assessment of Deep-sea Fisheries Resources (WGDEEP)
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A. General

Overview of the fishery areas is in Figure 1.

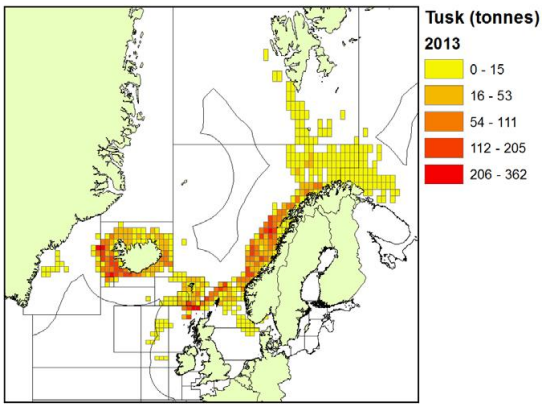

Figure 1. Reported landings of tusk in ICES areas by statistical rectangle in 2013. Data from Norway, Faroes, Iceland, France, UK (England and Wales) and Spain. Landings account for 99% of all reported landings in all ICES areas

A.1. Stock definition

In 2007, WGDEEP examined the available evidence of stock discrimination for tusk. Based on a genetic investigation, the Group suggested that Tusk in other areas (3.a, 4.a, 5.b, 6.a, 7, 8, 9 and other Areas of 12) should be treated as one unit.

A.2. Fishery

Tusk are bycatch in the trawl, gillnet and longline fisheries in a unified unit. Norway has traditionally landed the major proportion of total landings. Around 90% of Norwegian and Faroese landings are taken by longliners.

When landings from Areas 3–4 and 6.a–12 are pooled over the period 1988–2018, 35% of the landings have been in Area 4, 47% in Area 5.b, and 17% in Area 6.a (ICES, 2019a).

A.3. Ecosystem aspects

Tusk prefers hard, or sandy seabeds with large rocks. It inhabits depths that range from 50 to 1000 m, but is mainly found between 200 and 500 m (Pethon, 2005). It is believed that tusk occur alone or in small schools (Gordon *et al*., 1995). The maximum weight and length of tusk is about 15 kg and 1.1 m, respectively. Tusk matures between six and eight years and may live for 40 years. The main spawning areas are between Scotland and Iceland, but tusk also spawns along the Norwegian coast and in the fjords from April to August at depths between 200 and 400 m. (Pethon, 2005). Eggs and larvae are pelagic and hatch after about 9 days. Tusk feed mainly on shrimps, crabs. and small fish (Magnusson *et al*., 1997, Pethon, 2005).

B. Data

B.1. Commercial catch

Full landings data are available from 1988 to present but it is thought that fisheries in some of these areas pre-date the time series. Incomplete landings data are available from Norwegian longline fisheries from 1889 onwards. Nominal landings in Faroese waters are available from 1906. Additional landings data from other areas may be available from 1950 onwards.

The Norwegian and Faroese fleet are not allowed to discard tusk, and incentives for illegal discarding are believed to be low. Since around 2013, discard data are available from UK (Scotland) and France. The discard is less than 5% of the total landings.

B.2. Biological

Length data for the Norwegian reference fleet in other areas have been routinely collected since 2002.

Data for estimating length distributions for tusk in area 5.b were available from the commercial landings since 1994. Gutted weights from the period 1996-1999 and then since 2004 to the present are also avaiable for 1996-1999 and there are a few samples from the landings since 2015. There are a few measurements for fish lengths and round weights of tusk sampled during several surveys conducted inside the Faroese EEZ. Since 2014, there are also some gutted weights, gender, maturiy and otoliths measurements,.

There is substantial general information on the life history characteristics of this species.

The existing growth parameters for length and weight for blue ling are summarized in Tables 1 and 2 and maturity parameters in Table 3.

Table 1. Growth parameters of tusk.

Area	Sex	L_∞ (cm)	K (year^{-1})	t_0	Number of fish	Age range	Maximum observed size	Reference
5.b	Female	84.4	0.109	-1.434	667	2 - 17		WD 2017
5.b	Male	76.2	0.144	-0.675	618	3 - 18		WD 2017

Table 2. Maturity parameters, A_{50}: age at 50% maturity; L_{50} length at 50% maturity; N number of fish.

Area	Sex	A_{50}	N	L_{50} (cm)	N	Reference
5.b	Combined	6.75	1267	50.5	1292	WD 2017
5.b	Female	6.01	653	48.4	665	WD 2017
5.b	Male	7.77	614	53.3	627	WD 2017

Table 3. Coefficients, a and b, for weight–length relationship: $W=a(cm)^b$ for tusk.

Area	Sex	a	b	Number of fish	size range (cm)	Weight	Reference
5b	Combined	0.0098	3.023	15160		Round	WD 2017
5b	Females	0.0150	2.919			Round	WD 2017
5b	Males	0.0085	3.058			Round	WD 2017
5b	Combined	0.0126	2.952	6657		Gutted	WD 2017

B.3. Surveys

Survey indices for tusk in Faroese area (5.b) are available from an annual spring (since 1994) and summer (since 1996) groundfish survey. The survey covers the Faroe Plateau (depths less than 500 m) and the spring survey in February/March covers 100 stations while the summer survey in August has 200 stations. Density (mean kg/h for the whole survey period) and spatial distribution from the same survey can also be done. There are lengths (cm) and round weights of tusk from these two groundfish surveys and a recruitment index was calculated as the stratified number and biomass of tusk less than 40 cm. The abundance indices from the groundfish surveys are standardized according to number of stations in each stratum and weighted with strata area for all the different strata. Although that tusk is not a target species by these surveys, the index can be a useful indicator of trends in relative abundance. It has to be noted that these surveys have very few stations (< 5) deeper than 500 m and therefore mainly covers the shallower part of the distribution area.

In 2014, a deep-water trawl survey was introduced and repeated yearly. The deep-water survey covers the slope and banks around the Faroes. This deep-water survey together with the groundfish survey cover the main fishing areas of tusk in Faroese EEZ.

B.4. Commercial CPUE

Catch and effort data (cpue series) based on Norwegian longliners data in areaS 4, 5.b and 6.a and Faroese longliners fishing in 5.b are available.

A cpue series for Danish trawlers fishing in 4.a was available for the period 1992–2010.

Norway started in 2003 to collect and enter data from official logbooks into an electronic database and data are now available for the period 2000–2009. Vessels were selected that had a total landed catch of ling, tusk and blue ling exceeding 8 t in a given year. The logbooks contain records of the daily catch, date, position, and number of hooks used per day. The estimated cpue for each year and Subarea was the weighted catch in kg per hook for the entire fleet.

comparison, an unweighted cpue series was also constructed (i.e. the average cpue per boat).

In area 5.b, a standardized cpue series based on commercial longliner data targeting tusk in Faroese EEZ was available. Data used to estimate cpue for tusk in Faroese EEZ are obtained from

logbooks of the Faroese longliners. The effort obtained from the logbooks is estimated as 1000 hooks and the catch as kg stated in the logbooks. The targeted series for tusk from the Faroese longliners is limited to sets where the catch of tusk is more than 30% of the total catch in the set and the effort is larger than 1000 hooks.

A general linear model (GLM) was used to standardize all the cpue series (kg/1000 hooks) for the commercial fleet where the independent variables were the following: vessel, month (January–April, May–August, September–December) and years. The dependent variable was the log-transformed kg/1000 hooks measure for setting, which was back-transformed prior to use. The reason for this selection of settings was to try to get a series that represents changes in stock abundance.

B.5. Other relevant data

None

C. Assessment: data and method

Tusk in subareas 4 and 7–9, and in divisions 3.a, 5.b, 6.a, and 12.b (Northeast Atlantic) is a category 3 stock according to the ICES DLS approach proposed by the ADG in 2012.

No assessment model is used in the advice for tusk.

Two cpue series based on data from the Norwegian reference fleet for tusk, one using all data available and the other using only data when tusk 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 tusk 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)

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

Other data limited models have been explored and this study is still in progress.

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

No reference points are defined for this stock in terms of absolute values. The SPiCT-estimated values of the ratios F/F_{MSY} and B/B_{MSY} are used to estimate stock status relative to the proxy MSY reference points

Framework	Reference point	Value	Technical basis	Source
MSY approach*	MSY $B_{trigger_{proxy}}$	$\frac{B}{B_{MSY}} = 0.5$	Relative value from the SPiCT model. B_{MSY} is estimated directly from the SPiCT assessment model and changes when the assessment is updated.	ICES (2019)
	$F_{MSY_{proxy}}$	$\frac{F}{F_{MSY}} = 1$	Relative value from the SPiCT model. F_{MSY} is estimated directly from the SPiCT assessment model and changes when the assessment is updated.	ICES (2019)
Precautionary approach	B_{lim}			
	B_{pa}			
	F_{lim}			
	F_{pa}			
Management plan	SSB_{mgt}			
	F_{mgt}			

C.

H. Other Issues

H.1. Historical management

From 2003 to 2006, the annual advice was to reduce the effort for tusk by 30% for 2007 through 2013; the advice is based on the average catch for the three years before 2003.

From 2014, tusk has been managed by ICES stock data category 3.3.2, cpue trend-based assessment.

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