Stock Annex: Ling (*Molva molva*) in subareas 1 and 2 (Northeast Arctic)

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)
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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. Ling is one of the species included in a recently initiated Norwegian population structure study using molecular genetics, and new data may thus be expected in the future*'

A.2. Fishery

Ling has been fished in Subareas 1 and 2 for centuries, and the historical development is described in Bergstad and Hareide (1996). In particular, the post-World War II increase in catch caused by a series of technical advances, are well documented. Currently the major fisheries in Subareas 1 and 2 are the Norwegian longline and gillnet fisheries, and bycatches of ling are taken by other gears, such as trawls and handlines. Around 50% of the Norwegian landings are taken by longlines and 45% by gillnets, partly in directed ling fisheries and as bycatch in other fisheries. Other nations catch ling as bycatch in their trawl fisheries. Figure 1 shows the spatial distributions of the total catches for the Norwegian longline fishery in 2019. There was no fishery in the NEAFC regulatory area in 2019.

The Norwegian longline fleet (vessels larger than 21 m) increased from 36 in 1977 to a peak of 72 in 2000, and afterwards the number stabilized at 27. The number of vessels declined mainly because of changes in the law concerning the quotas for cod. The average number of days that the longliners operated in ICES Subareas 1 and 2 has declined since its peak in 2011 but with an increase in 2019. During the period 2000 to 2014 the main technological change in Subareas 1 and 2 was that the average number of hooks per day increased from 31 000 hooks to 35 000 hooks. During the period 1974 to 2014 the total number of hooks per year has varied considerably, but with a downward trend since 2002. However, with the increase in fishing days in 2019 the total number of hooks and total effort has increased (for more information see Helle and Pennington, WD 2019).

The cod stock in the Barents Sea has been very abundant for years, but now there is a downward trend in the cod stock which has resulted in lower quotas. Most likely the of lower quotas for cod has resulted in the observed increase in fishing pressure on ling.

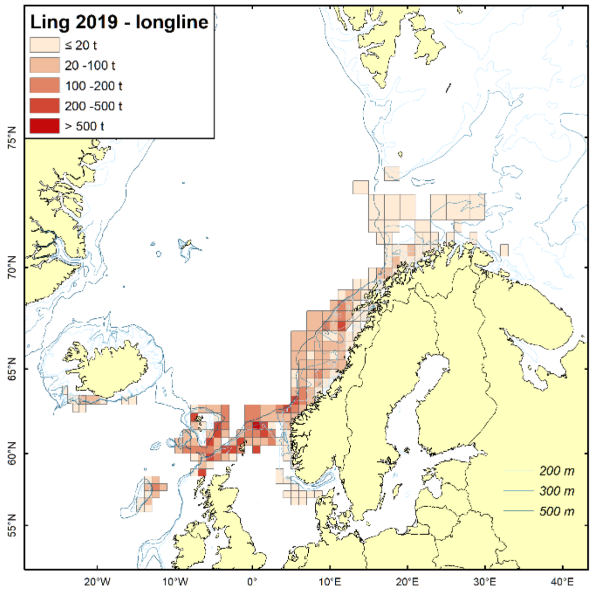

Figure 1. Distribution of the total catch of ling in Subareas 1 and 2 taken by the Norwegian longline fishery in 2019.

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 landing 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.

B.2. Fishery independent data

Fisheries independent scientific surveys do not sufficiently cover the deep-water habitats occupied by ling, and the amount of ling caught in the surveys are insufficient for use in traditional assessments (Helle and Pennington, 2004).

B.2. Biological

Length, weight and age data for the Norwegian reference fleet in Subareas 1 and 2 have been routinely collected since 2002.

Considerable general information is available on the life history characteristics of this species.

B.5. Other relevant data

C. Assessment: data and method

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

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

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:

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

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)

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

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).

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 other than $F_{MSY\ proxy}$ are defined for this stock.

Ling in subareas 1 and 2. Reference points, values, and their technical basis.

Framework	Reference point	Value	Technical basis	Source
MSY approach	MSY $B_{trigger\ proxy}$	Not defined		
	$F_{MSY\ proxy}$	87.75 cm (2018)	Expected mean length of catch above L_{mean} when F = M.	(ICES, 2019b)
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 based on the average catch for the three years before 2003. From 2014, has been managed as an ICES stock data category 3.3.2 and advice based on cpue trends

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