BLUE LING

Molva dypterygia

GENERAL INFORMATION

Blue ling is most common in south, west and northwest of Iceland along the Icelandic continental shelf, in deeper areas than most of the other gadoids. It is smaller than the common ling, reaching an average length of ~80 cm and a maximum of around 150 cm according to the Icelandic autumn groundfish survey. Sexual maturity is reached at 75-90 cm, males mature smaller/younger than females.

THE FISHERY

Geographical distribution of the Icelandic blue ling fisheries from 2003-2022 is shown in Figures 1-2.

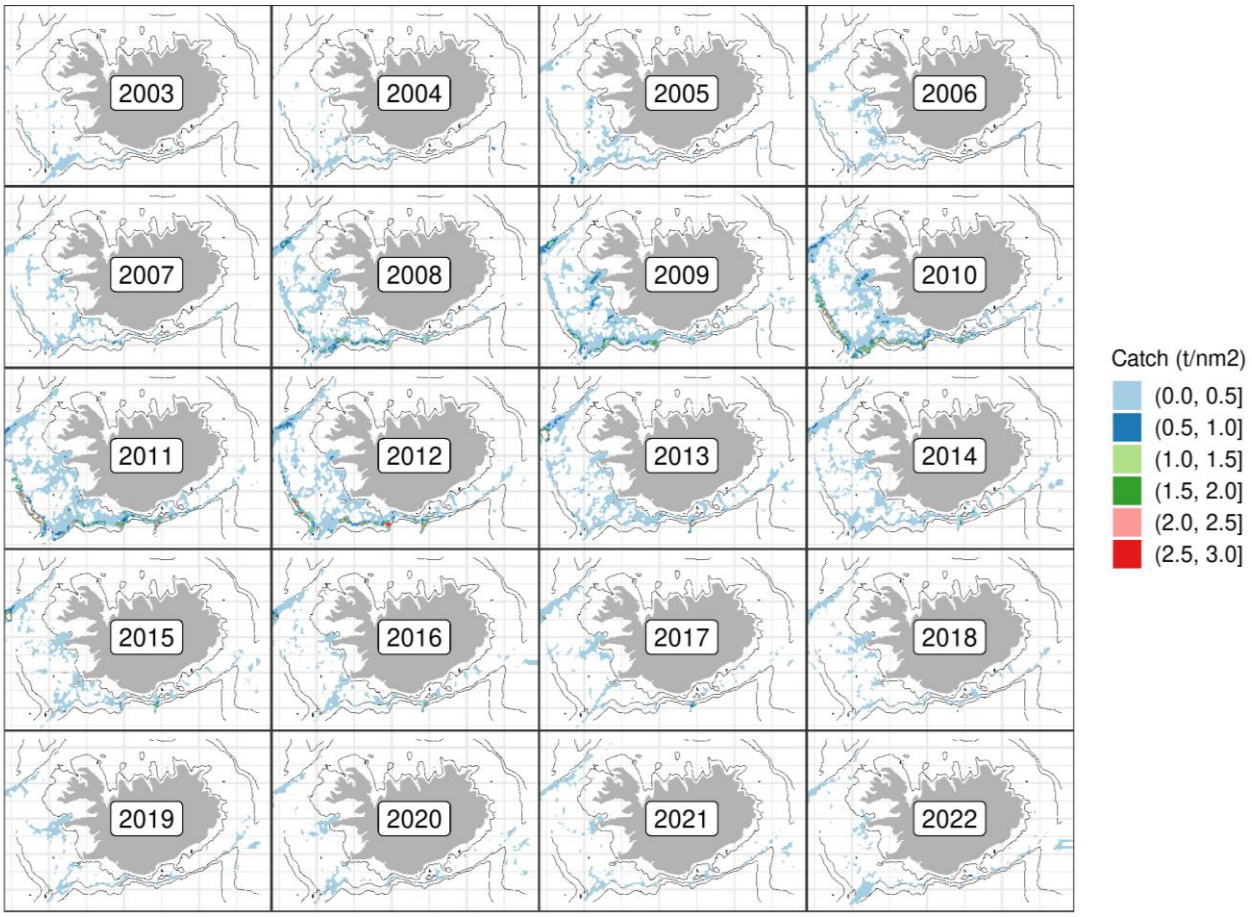

Figure 1. Blue ling. Geographic distribution of the Icelandic fishery since 2003 as reported in logbooks.

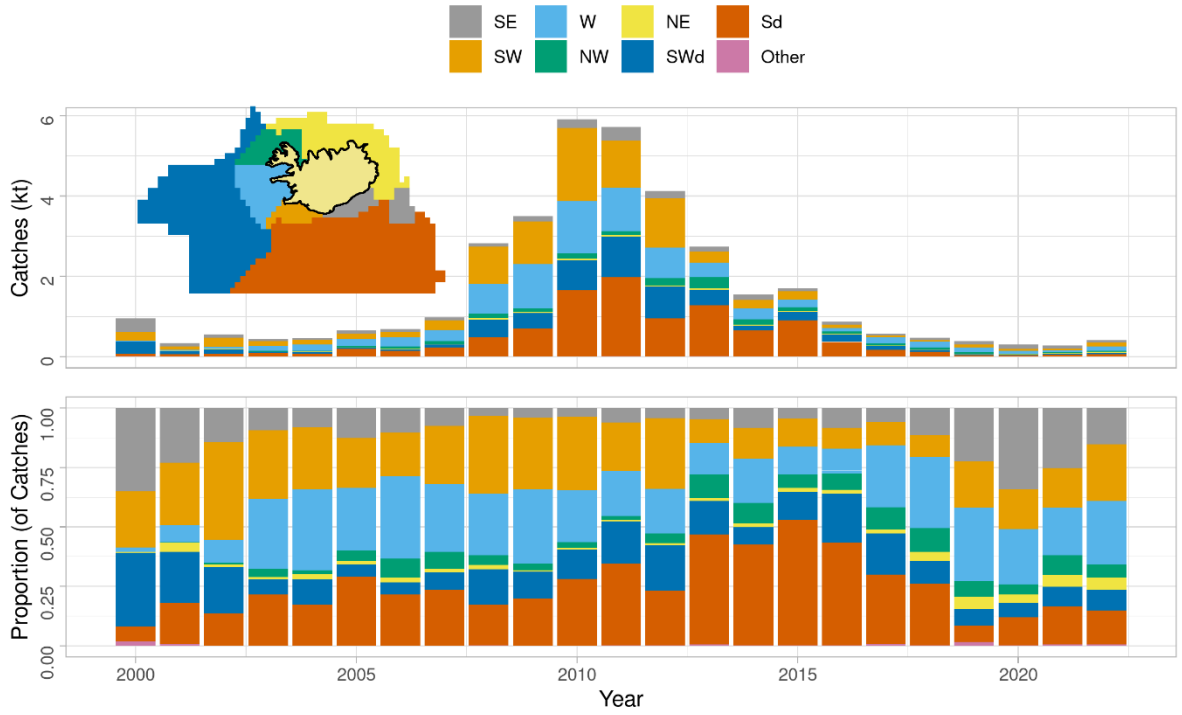

Figure 2. Blue ling. Spatial distribution of reported catches in tonnes (upper) and as annual proportions (lower). The inserted map shows the area division.

Before 2008, the majority of blue ling catches were by trawlers, as bycatch in fisheries targeting Greenland halibut, redfish, cod and other demersal species (Table 1). Most of the catches by trawlers are taken in waters shallower than 700 m and by longliners until 2008 mostly at depths shallower than 600 m (Figure 3).

After 2007 there was a substantial change in the fishery for blue ling (Table 1 and Figure 4). The proportion of catches taken by longliners increased from 7–20% in 2001–2007 to around 70% in 2011 as longliners started targeting blue ling. The trend has reversed and in 2015–2019 the proportion of longline catches decreased to 10–30%. At the same time longliners started fishing in deeper waters than before 2008 and until 2013 the bulk of the longline catches were taken at depths greater than 500 m. In recent years, the depth distribution resembles the distribution observed before 2008, or at depths less than 400 m (Figure 3).

Preliminary total landings in 2022 were 438 t of which the Icelandic fleet caught 427 t (Table 6). Catches of blue ling increased by more than 370% between 2006 and 2010, the main part of this increases can be attributed to increased targeting of blue ling by the longline fleet. Since then, catches decreased compared to 2010 or by around 6000 tonnes (Table 1).

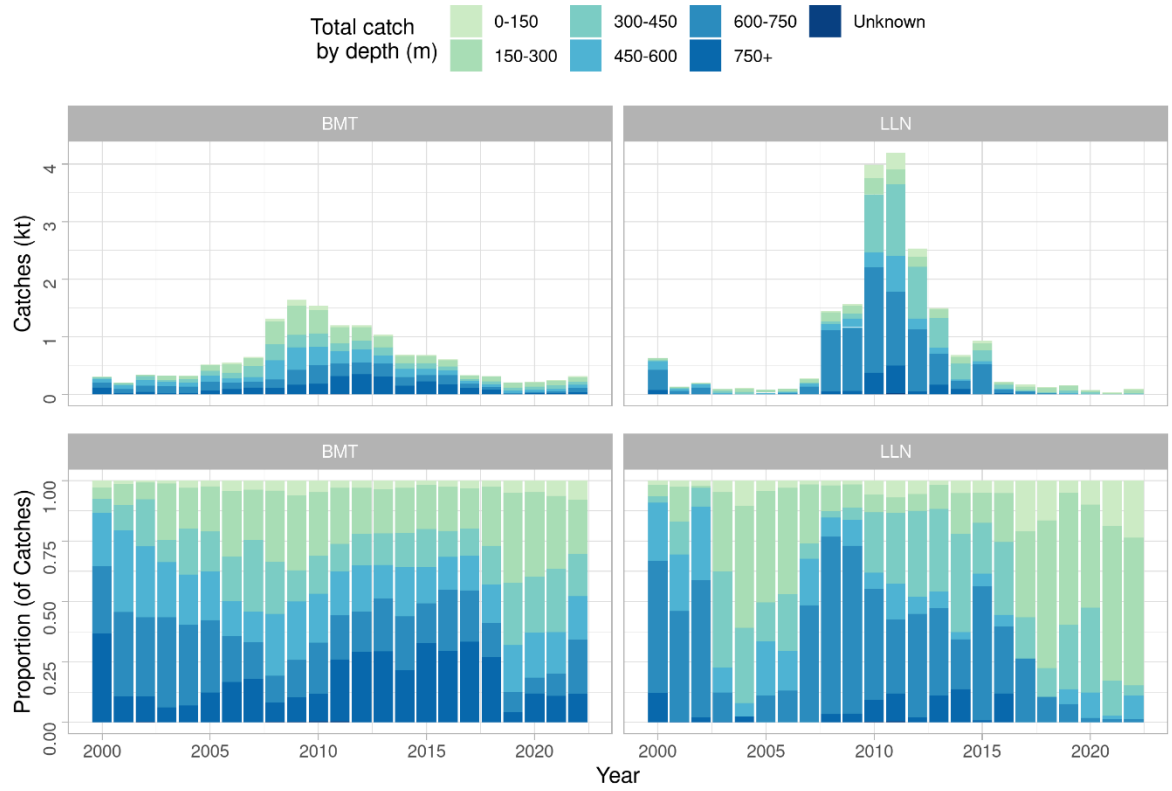

Figure 3. Blue ling. Depth distribution and proportion of longlines (LLN) and trawls (BMT) catches according to logbook entries.

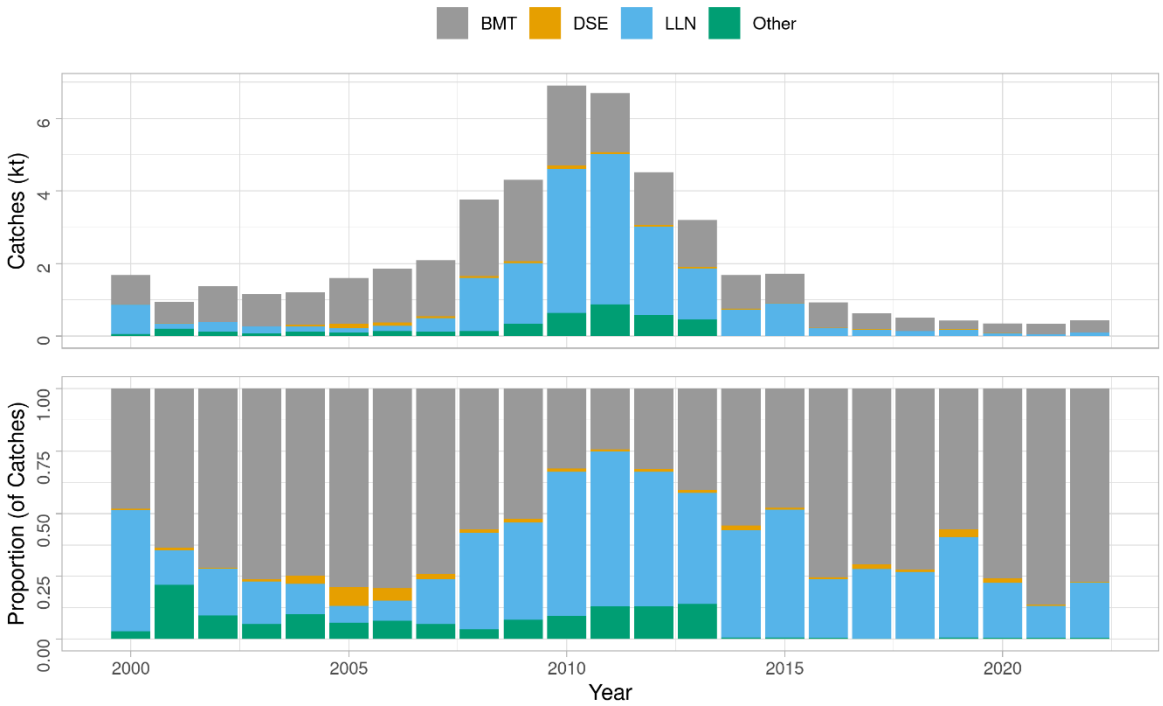

Figure 4. Blue ling. Total catch (landings) and proportion by fishing gear since 2000, according to statistics from the Directorate of Fisheries.

Table 1. Blue ling. Number of Icelandic boats with blue ling landings and their total landings

YEAR	LONGLINE	TRAWL	OTHER GEAR	TOTAL LANDINGS	LONGLINERS	TRAWLERS
	(tonnes)	(tonnes)	(tonnes)	(tonnes)	No. vessels	No. vessels
2000	808	801	26	1634	44	108
2001	131	597	34	762	39	110
2002	255	986	23	1264	41	105
2003	197	883	17	1098	47	105
2004	145	894	44	1083	53	112
2005	108	1261	127	1496	60	106
2006	151	1477	107	1734	69	105
2007	374	1544	76	1995	90	97
2008	1454	2111	88	3653	92	95
2009	1677	2242	211	4129	87	89
2010	3978	2201	198	6378	96	85
2011	4140	1630	135	5904	97	81
2012	2425	1449	332	4207	78	79
2013	1420	1300	48	2769	71	75
2014	622	923	43	1588	73	72
2015	868	821	22	1712	77	67
2016	213	701	10	925	53	66
2017	169	436	13	619	52	57
2018	132	363	7	502	59	65
2019	161	238	16	415	53	58
2020	70	264	8	343	46	58
2021	33	286	4	323	40	59
2022	86	338	2	427	37	55

CPUE AND EFFORT

Effort and nominal CPUE data from the Icelandic trawl and longline fleet are given in Figure 5. Due to changes in the fishery (expansion into new areas, fleet behaviour, etc.) and technical innovations CPUE is not considered a reliable index of biomass abundance of blue ling and therefore no attempt has been made to standardize the series. However, looking at fluctuations in CPUE and effort may be informative regarding the development of the fishery. CPUE from longlines was high from 2008-2013 but has decreased markedly since. CPUE from trawls has been gradually decreasing in the period. Effort from bottom trawls peaked in 2009 but has since then decreased sharply. Effort from longlines peaked in 2011 but has remained relatively stable since.

Figure 5. Blue ling. Estimates of CPUE (left) and fishing effort (right) from longlines and trawls based on logbook data where blue ling was recorded in catches. Note that in 2022, tow hours from bottom trawls were not available.

LANDINGS AND DISCARDS

Landing data from Icelandic fishing grounds are given in Tables 1 and 6. Discarding is banned in the Icelandic fishery. There is no available information on discarding of blue ling. Being a relatively valuable species with no minimum landing size there should be little incentive to discard blue ling. Furthermore, blue ling was not subjected to TAC constraints before the 2013/2014 fishing year.

SAMPLING FROM COMMERCIAL CATCHES

In general sampling is considered adequate from commercial catches from the main gears (longlines and trawls). The sampling does seem to cover the spatial distribution of catches for trawls. Similarly, sampling does seem to follow the temporal distribution of catches (ICES 2012). Fishing areas and sampling from bottom trawl in 2022 is shown in Figure 6.

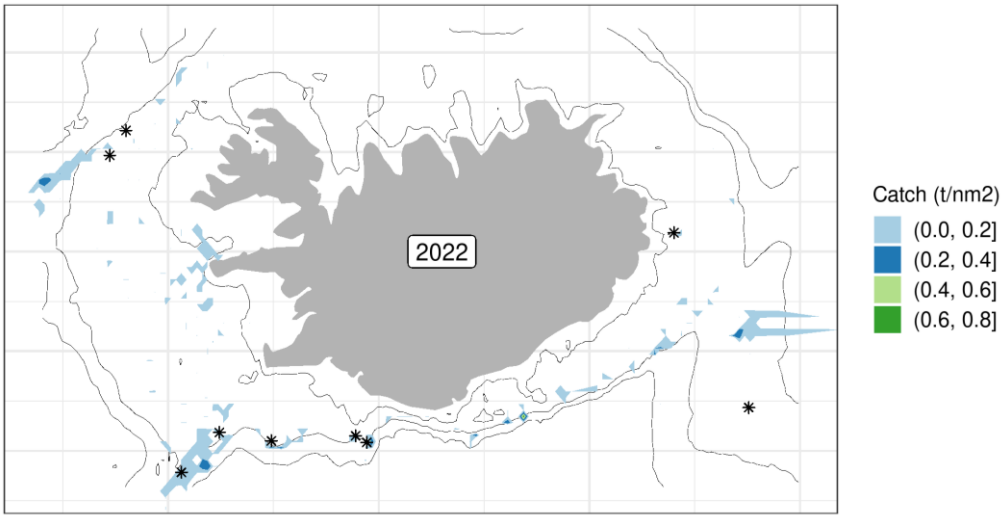

Figure 6. Blue ling. Spatial distribution of length samples (black dots) from commercial catches in Icelandic waters in 2022.

Table 2. Blue ling. Number of available length measurements from Icelandic commercial catches.

YEAR	LONGLINE		TRAWLS	
	Samples	Measured	Samples	Measured
2005	1	94	12	1164
2006	0	0	9	824
2007	2	238	12	1461
2008	14	1960	13	1685
2009	15	1940	23	2894
2010	38	5191	29	3161
2011	44	6513	12	1364
2012	27	3829	11	1135
2013	15	1564	6	757
2014	11	1222	5	411
2015	0	0	4	394
2016	0	0	3	309
2017	0	0	0	0
2018	1	120	2	240
2019	1	120	1	114
2020	1	120	2	126
2021	0	0	7	353
2022	3	253	6	282

LENGTH DISTRIBUTION OF THE CATCH

Nine samples were collected in 2022, six from bottom trawls and three from longlines (Table 2, Figure 6). Length distributions from the Icelandic trawl and longline catches for the period 2002–2022 are shown in Figure 7. Due to a mistake, no length measures were called for from commercial catches in 2017. Mean length from trawls increased from 79 cm in 2002 to 103 cm in 2018, but mean length was 86 cm in 2022. On average mean length from longlines is higher than from trawls.

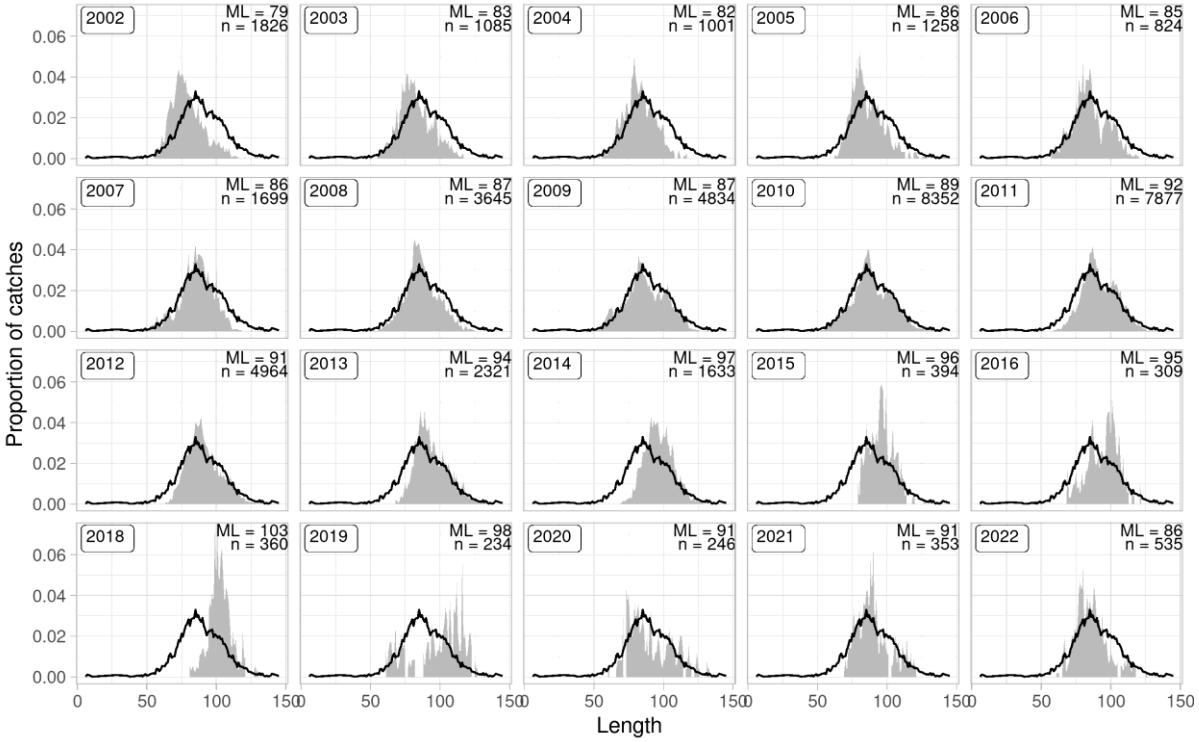

Figure 7. Blue ling. Length distribution of blue ling from trawls and longlines (grey area) of the Icelandic fleet since 2002. Black line is the mean length distribution of the period. No data available in 2017. ML is mean length, and n is the number of length measurements.

ICELANDIC SURVEY DATA

Time-series stratified abundance and biomass indices from the spring and autumn groundfish surveys are shown in Figure 8 and length distributions from the autumn survey and its spatial distribution in Figures 9 and 10. No estimates are available from the autumn survey for 2011.

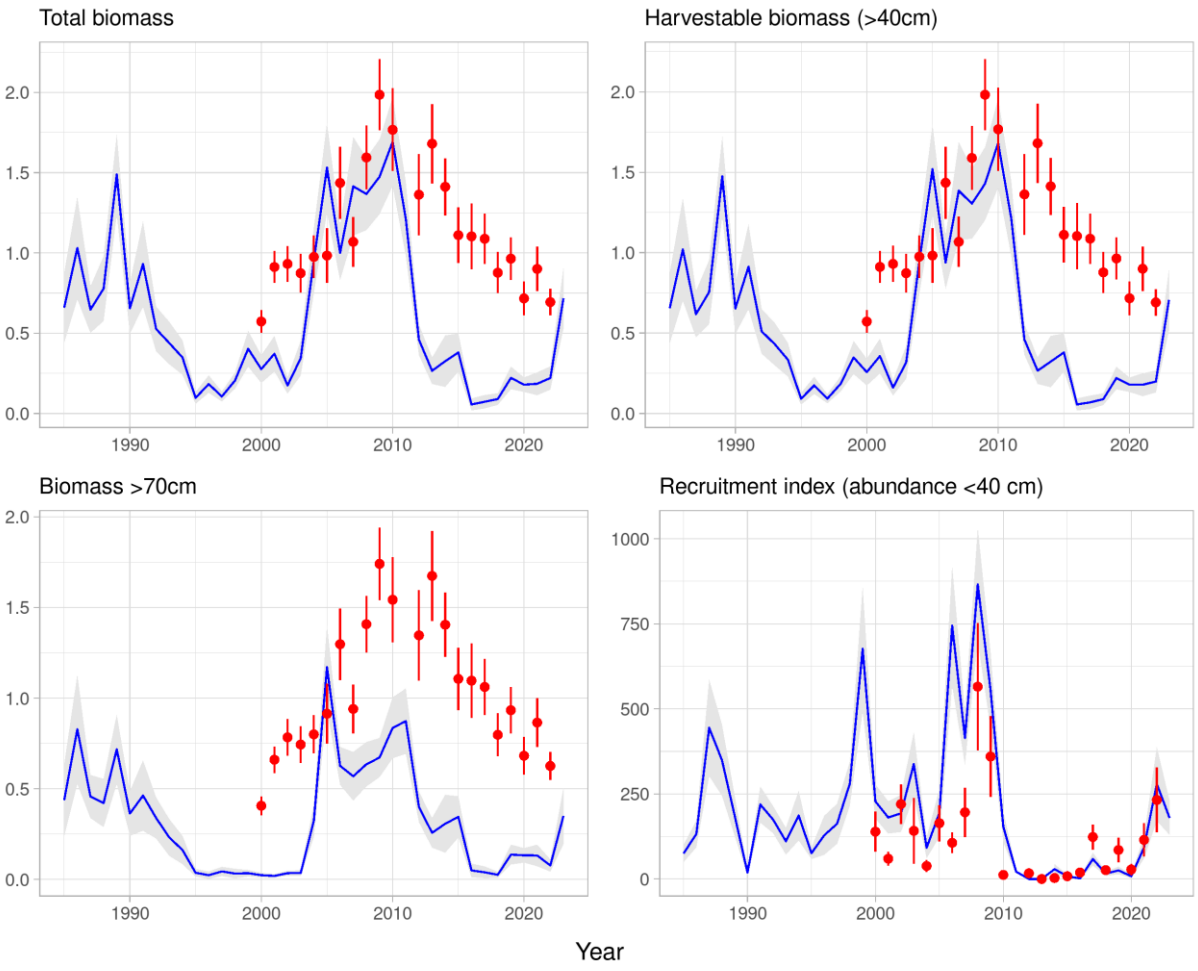

Figure 8. Blue ling. Abundance indices for blue ling in the Icelandic autumn survey since 2000 (red points and vertical lines) and the spring survey since 1985 (faded line and shaded area). Total biomass index (top-left), biomass of 40 cm and larger (top-right), biomass of 70 cm and larger (bottom-left) and abundance index of <40 cm (bottom-right). The shaded area and the vertical bar show +/- standard error of the estimate.

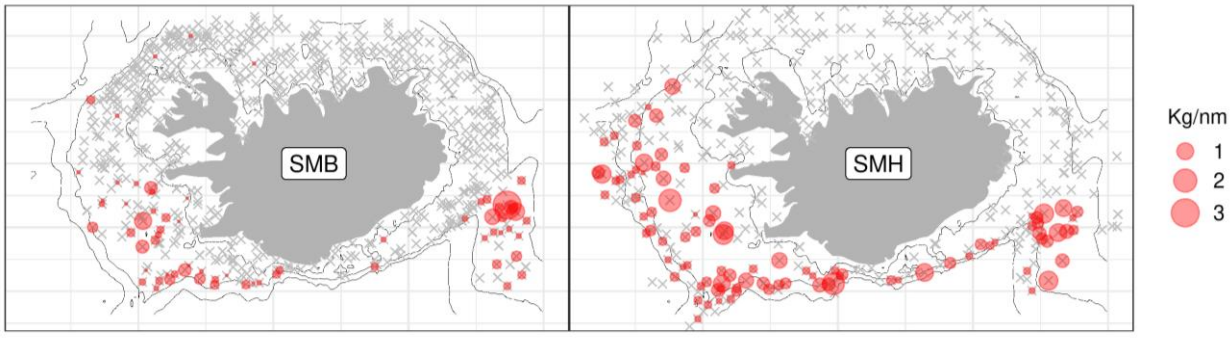

Figure 9. Blue ling. Abundance and location of blue ling in spring survey (SMB) in 2023 and autumn survey (SMH) in 2022.

Figure 10. Blue ling. Spatial distribution of biomass index from the Icelandic autumn survey since 2000.

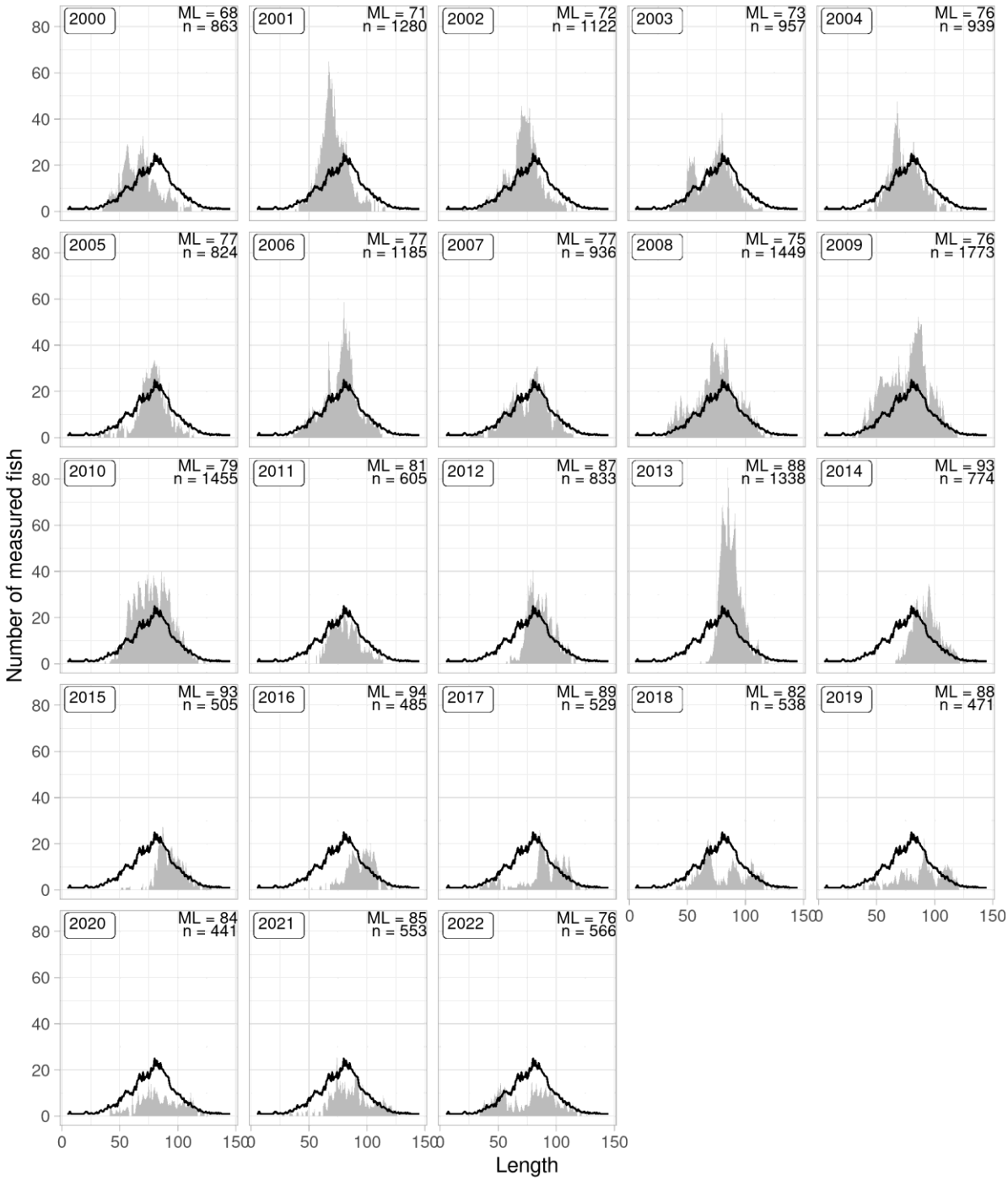

Figure 11. Blue ling. Length distributions from the Icelandic autumn survey since 2000. Black line is the average by length over the displayed period. ML is the mean length and n is the number of measurements.

DATA ANALYSES

AGE COMPOSITIONS

No new data were available. Existing data are not presented due to the difficulties in the ageing of this species.

WEIGHT-AT-AGE

No new data were available. Existing data are not presented because of difficulty in ageing.

MATURITY AND NATURAL MORTALITY

Length at 50% maturity is estimated at roughly 77 cm and the range for 10–90% maturity is 65–90 cm.

No information is available on natural mortality (M).

LANDINGS AND SAMPLING

Catches from the Icelandic longline fleet increased rapidly from 2007–2010 resulting in a rapid expansion of the fishing area and change in the selectivity of the fishery although there are now strong indications since 2012 that this may have reversed (Table 1).

In 2005 longliners caught 108 tonnes of blue ling when trawlers caught 1261 tonnes or 84% of the total catches (1496 tonnes). In 2011 trawlers caught 1630 tonnes, out of 5904 tonnes or 28%, but longliners 4140 tonnes or 70%. Since then, the proportion taken by longliners has decreased and in 2022 longliners caught 20% of the catches and trawls 80%. (Table 1, Figure 4).

As longliners take on average larger blue ling this will have resulted in an overall change in the selection pattern in 2006–2015. Total catches by the Icelandic fleet decreased between 2010 and 2013 and this decrease is mainly the result of decrease in trawls in 2011 but in longlines in 2012 and 2013. The expansion of the longline fleet to deeper waters (Figure 3) may be the result of decreased catch rates in shallower areas.

CPUE AND EFFORT

As stated above, CPUE indices from commercial catches are not considered a reliable index of stock abundance. Therefore, the rapid increase in CPUE from longlines should not be viewed only as an increase in stock biomass but might also be the result of increased interest by the longline fleet and its expansion into deeper waters (Figure 7). In 2011-2012 there was a slight decrease in CPUE from longline, but the CPUE increased again in 2013 to its highest value in the time-series. CPUE from trawling has remained at low levels while effort increased until about 2009 after which it has decreased (Figure 5).

SURVEYS

The spring survey covers only the shallower part of the depth distributional range of blue ling and shows high interannual variance (Figure 9). It is thus unknown to what extent the spring indices reflect actual changes in total blue ling biomass, given that it does not cover the depths where largest abundance of blue ling occurs. It is however not driven by isolated large catches at a few survey stations.

The shorter autumn survey, which goes to greater depths and is therefore more likely to reflect the true biomass dynamics, does indicate that there was an increase in blue ling biomass 2007-2009 (Figure 8). Since 2010 the biomass index has decreased to similar levels as observed in 2002–2005. A large increase of more than 200% in the recruitment index was observed in 2008 but in the 2010 it had decreased again to its lowest observed value and has not increased again for nine years, with the exception of 2017, when

an increase was observed (Figures 9 and 10). As a result, mean length measured in the autumn survey has been higher after 2009 than it was before. Due to industrial action, only part of the autumn survey was conducted in 2011.

STOCK ASSESSMENT

EXPLORATORY STOCK ASSESSMENT ON BLUE LING USING GADGET

An exploratory stock assessment of blue ling using the Gadget model was presented at ICES 2012. Updated results of the model were presented at ICES 2021.

COMMENTS ON THE ASSESSMENT AND ADVICE

The assessment is based on ICES rfb-rule for data limited stocks for the first time in 2021, where life history traits, exploitation characteristics and other relevant parameters for data-limited stocks are considered (ICES 2021). The rfb-rule has the following form:

$$A_{y+1} = A_{y-1}\, r\, f\, b\, m$$

where A_{y+1} is the advised catch, A_{y-1} is last years advice, r corresponds to the trend in biomass index (as in the current ICES "2 over 3" rule), f is a proxy for the exploitation (mean catch length divided by an MSY reference length) and b a biomass safeguard (reducing the catch when biomass index drops below a trigger value).

r is the ratio of the mean of the last two survey indices and the mean of the three preceding values or:

$$r = \frac{\sum_{i=y-2}^{y-1} I_1\,/2}{\sum_{i=y-3}^{y-5} I_1\,/3}$$

f is the length-ratio component where:

$$f = \frac{\overline{L}_{y-1}}{L_{F=M}}$$

where $\overline{L}$ is is the mean catch length above L_c. $L_{F=M}$ is calculated as:

$$L_{F=M} = 0.75L_c + 0.25L_\infty$$

where L_c is the length where frequency is half that of the modal value, and $L\infty$ is von Bertalanffy $L\infty$.

b is the biomass safeguard and is used to reduce catch advice when index falls below trigger,

$$b = min\left(1, I_y - 1/I_{trigger}\right)$$

where $I_{trigger} = i_{loss\omega}$

m is a multiplier based on stock growth. K for blue ling is < 0.2 and therefore m is 0.95.

ANALYSIS ON THE ASSESSMENT AND ADVICE

The assessment is based on the rfb-rule for ICES category 3 data-limited stocks and is applied for blue ling for the first time in 2022/23 and is a biennial advice and thus, applied for the next two fishing years (2022/23 and 2023/2024). The Icelandic autumn trawl survey (IS-SMH) was used as the index for the stock development. The advice is in accordance to $A_{y+1} = A_{y-1}\, r\, f\, b\, m$ or 334 t * 0.833 * 0.977 * 1 * 0.95 which result is advice for 2022/2023 and for 2023/2024 set at 259 t (23% reduction from last year's advice). From 2019-2021, the advice was based on the ICES framework for data limited stocks (Category 3.2) where the ratio of the mean of the last two survey indices (Index A) to the mean of the three

preceding values (Index B) is multiplied by the last years advice. In 2019, the precautionary buffer was applied and thus, it would have been applied this year, resulting in advice for 223 tonnes (33% reduction) (Table 3).

Table 3. Blue ling. Comparison between the *rfb*-rule and the "2 over 3" rule.

	rfb-rule	Old 2 over 3 rule
Previous advice	334	334
Index A	817	817
Index B	980	980
Ratio (A/B)	0.833	0.833
Length ratio	0.977	-
Biomass safeguard	1	-
Multiplier	0.95	-
Initial advice	258	-
Stability clause applied	-	-
Precautionary buffer*	-	0.8
Final advice	259	223
Advice change	-23	-33

***Last applied in 2019.**

APPLICATION OF RFB-RULE

- r is calculated as the average of last two years values, divided by average of three preceding years values which results in r=0.833 (Figure 12, Table 4)

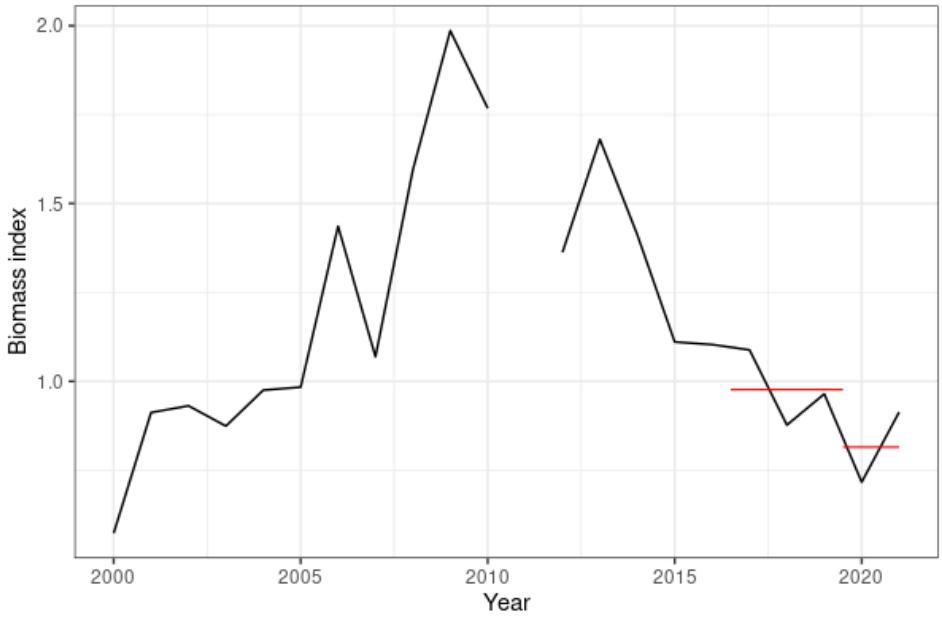

Figure 12. Blue ling in 5a and 14. Biomass index since 2000. No index is in the year 2011 (No survey). The red lines show the average of last two years values and the three preceding years.

- f is the length-ratio component. The mean length of last years´ catch was 93 cm and the target reference length (Lc, the length where frequency is half that of the modal value * 0.75 + L_∞ * 0.25) is **95.25** (Figure 13).

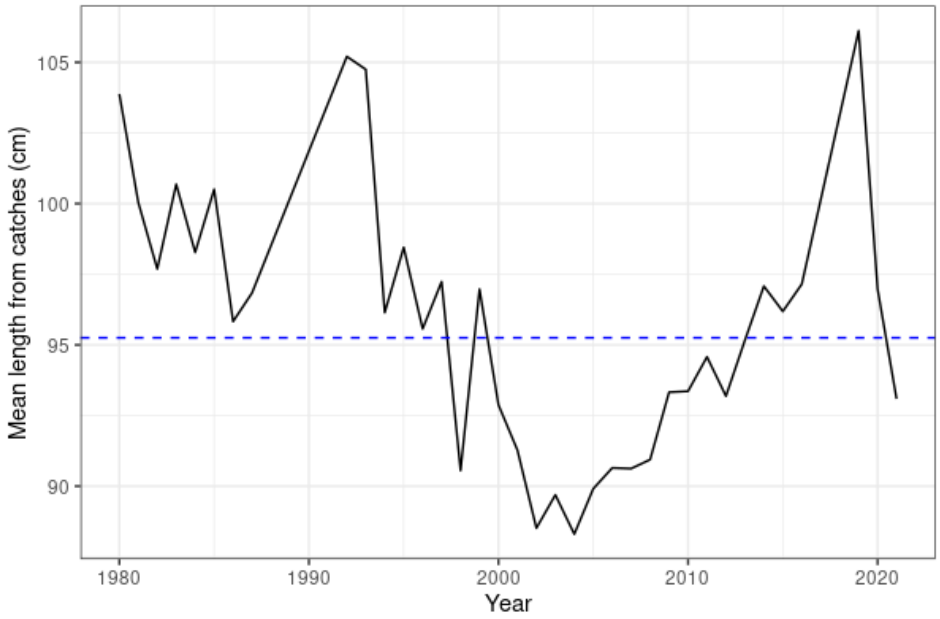

Figure 13. Blue ling in 5a and 14. Mean length from catches since 1980. The blue dashed line shows the target reference length.

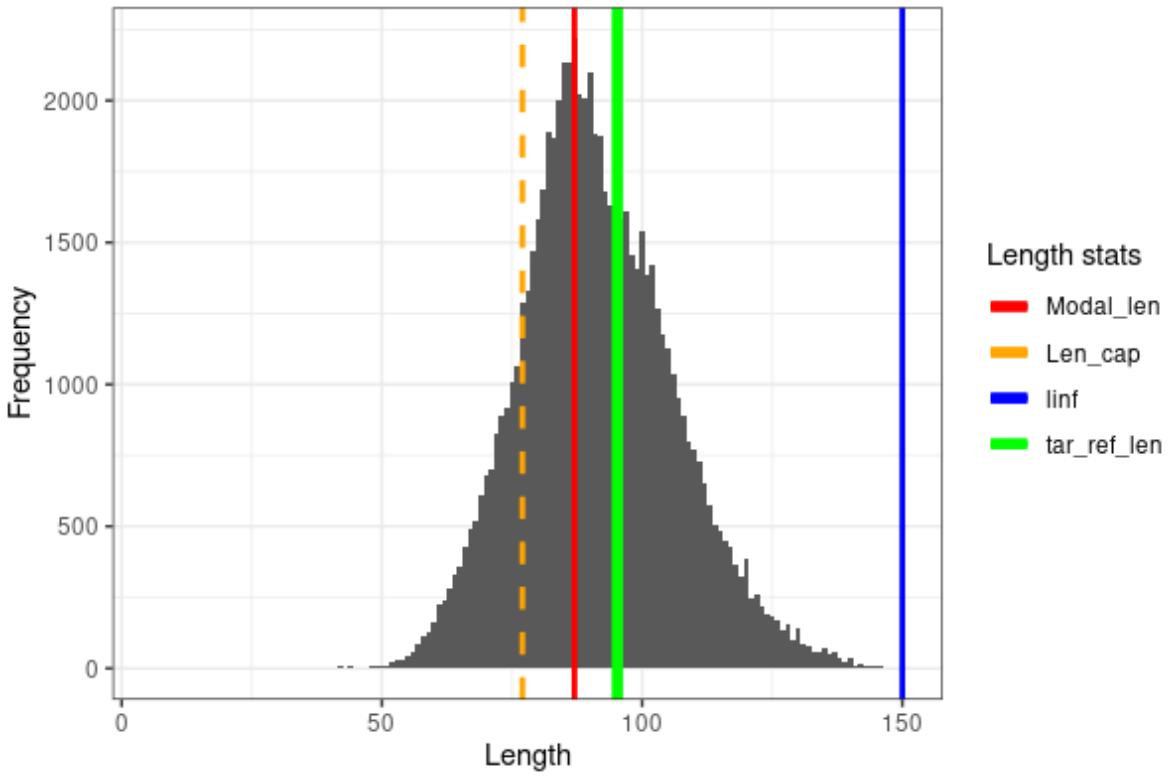

Figure 14. Blue ling in 5a and 14. Length frequency distribution from catches. Red line is the length of modal abundance, orange is the length where frequency is half that of the modal value, orange line is the length at first capture, green line is the target reference length, and the blue line is the L_{∞}.

- *b* is the biomass safeguard and is used to reduce catch advice when index falls below trigger. The lowest index or the I_{loss} for blue ling is 574 and was recorded in the year 2000. $I_{trigger}$ is I_{loss} *1.4 or 803.75 (Figure 14). Biomass index this year is 915 and above $I_{trigger}$ and *b* is therefore 1.

Figure 15. Blue ling in 5a and 14. Biomass index values since 2000. The red line is the $I_{trigger}$ and the red dot is the lowest observed value (I_{loss}).

- *m* is the tuning parameter and for slow growing species (with von Bertanlaffy K<0.2), *m* equals to 0.95.

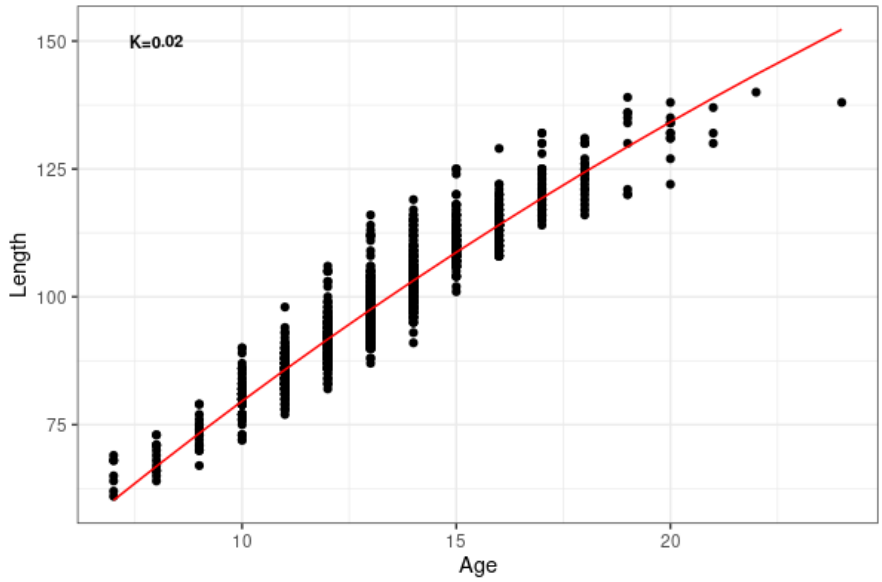

Figure 16. Blue ling in 5a and 14. The von Bertalanffy growth curve (red line) fitted to age and length data for blue ling.

EXPLORING SENSITIVITY OF *F* WITH OTHER L_∞ VALUES.

The *f* and TAC are sensitive to different L_∞ values (Figure 17, Table 4). The L_∞ used in the assessment is the maximum length from Icelandic catches. The 99th and 95th percentiles were tested for sensitivity, as well as the L_∞ from fishbase.org. Table 4 shows how higher L_∞ values decrease *f* by increasing the target reference length. Increased L_∞ values result in lower TAC as it decreases *f*.

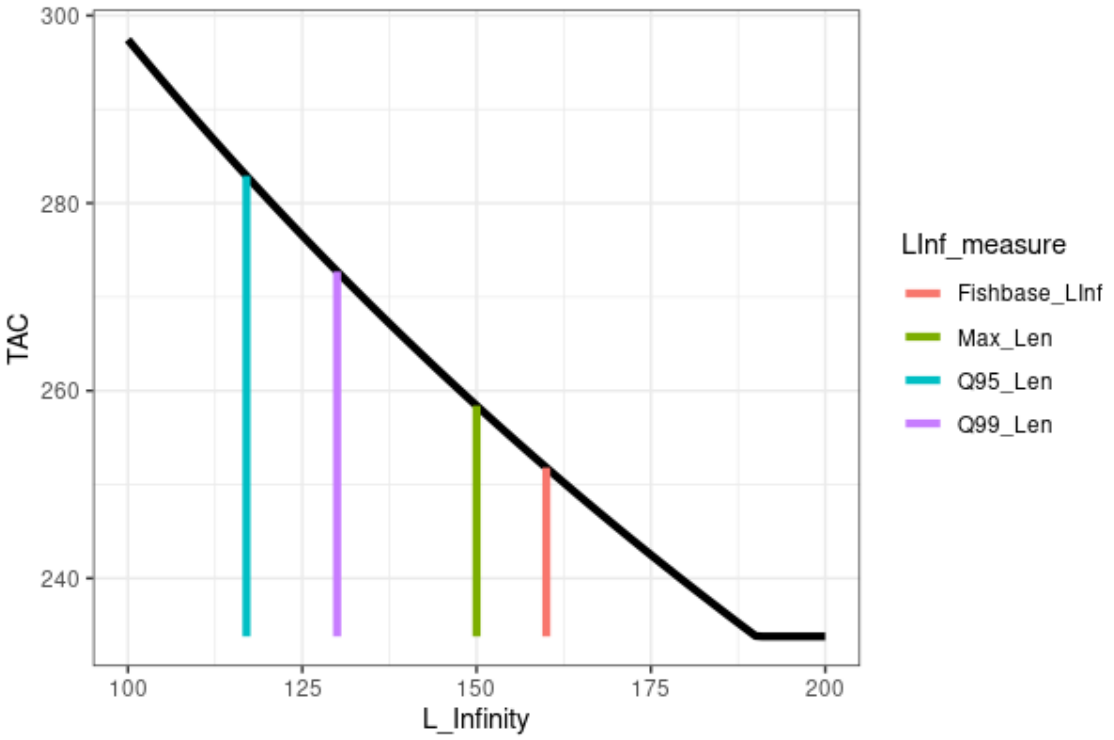

Figure 17: Blue ling. TAC sensitivity to different L_∞ values. Blue line shows the 95th percentile to the maximum length value (117 cm), purple line is the 99th percentile to the maximum value (130 cm), green line is the maximum length value (150 cm) and the red line shows the fishbase.org value (160 cm).

Table 4. Blue ling. Parameter sensitivity to different L_∞ values. The max length value is 150 cm, the 99th percentile of maximum length value is 130 cm, the 95th percentile is 117 cm and the fishbase.org value is 160 cm.

	L_∞ (max length)	L_∞ (99th percentile)	L_∞ (95th percentile)	L_∞ (fishbase.org)
Previous advice	334	334	334	334
Index A	817	817	817	817
Index B	980	980	980	980
Ratio (A/B)	0.833	0.833	0.833	0.833
$L_{F=M}$ (target reference	95.25	90.25	87	97.75
***f* (length ratio)**	0.977	1.03	1.07	0.952
Biomass safeguard	0.910	0.91	0.91	0.91
Multiplier	0.95	0.95	0.95	0.95
I_{loss}	574	574	574	574
$I_{trigger}$	804	804	804	804
Initial advice	259	273	283	252
Stability clause applied	0	0	0	0
Final advice	259	273	283	252
Advice change	-23	-18	-15	-25

MANAGEMENT

Before the 2013/2014 fishing year the Icelandic fishery was not regulated by a national TAC or ITQs. The only restrictions on the Icelandic fleet regarding the blue ling fishery were the introduction of closed areas in 2003 to protect known spawning locations of blue ling, which are in effect. As of the 2013/2014 fishing year, blue ling is regulated by the ITQ system (regulation 662/2013) used for many other Icelandic stocks such as cod, haddock, tusk, and ling. The TAC for the 2018/2019 fishing year was set at 1520 based on the recommendations of MFRI using the same advisory procedure as for ICES category 3 stocks. The difference between national TAC and landed catch in Icelandic waters can be attributed to species transformation. Net transfers for blue ling are from blue ling to other species and not *vice versa* as for most other species in the ITQ system (Figure 13).

Table 5. Blue ling. Recommended TAC, national TAC, and catches from Icelandic fishing grounds (tonnes).

FISHING YEAR	RECOMMENDED TAC	NATIONAL TAC	CATCHES ICELAND	CATCHES OTHER	TOTAL CATCH
2010/2011	-		6467	386	6853
2011/2012	4000	-	4242	319	4561
2012/2013	3100	-	2999	145	3144
2013/2014	2400	2400	1655	6	1661
2014/2015	3100	3100	1900	105	2005
2015/2016	2550	2550	1097	10	1107
2016/2017	2032	2032	636	3	639
2017/2018	1956	1956	549	4	553
2018/2019	1520	1520	464	7	471
2019/2020	483	483	371	5	376
2020/2021	406	406	365	12	377
2021/2022	334	334	369	3	372
2022/2023	259	259			

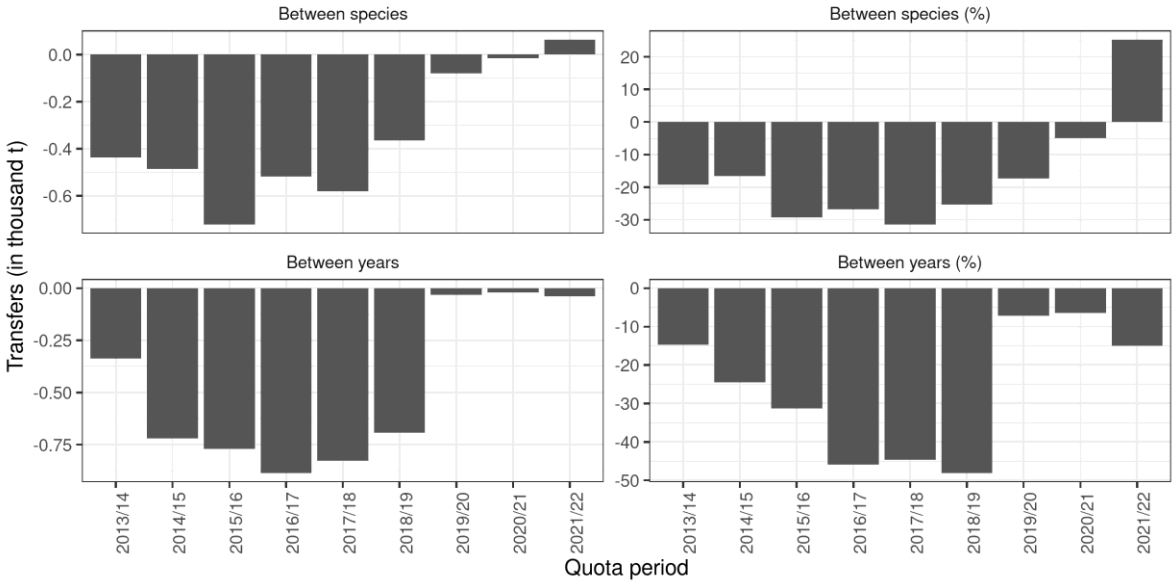

Figure 18. Blue ling in 5a and 14. Net transfer of quota, from blue ling to other species, in the Icelandic ITQ system by fishing year.

MANAGEMENT CONSIDERATIONS

Landings have decreased considerably in the last year and as blue ling is now part of the ITQ system such a rapid increase in landings as observed between 2006 and 2011 is unlikely. Blue ling is caught in mixed fisheries by the trawler fleet, mainly targeting redfish and Greenland halibut. After the inclusion of blue ling in the ITQ system the longliners have shifted from a directed fishery to a more mixed fishery for the species. Because of the restrictions of the TAC the implications of low blue ling TAC for the trawlers can be considerable, although the species is a low percentage in their catches.

Recruitment index from the autumn survey indicates very little recruitment to the stock since 2010, resulting in a truncated length distribution from both the survey and commercial catches.

Closure of known spawning areas should be maintained and expanded where appropriate.

CONCLUSIONS

The biomass index is approaching its lowest values, and only large blue ling are being caught, which is most likely because there has been no recruitment coming into the stock for nearly a decade.

The findings presented here support the general view of WGDEEP that advice should be more precautionary as long as there is no recruitment.

Table 6. Blue ling: Landings from Icelandic fishing grounds (5a).

YEAR	FAROE	GERMANY	ICELAND	NORWAY	UK	TOTAL
1975	69	1418	434	366	89	**2376**
1976	29	1222	624	135	28	**2038**
1977	39	1253	700	317	0	**2309**
1978	38	0	1237	156	0	**1431**
1979	85	0	2019	98	0	**2202**
1980	183	0	8133	83	0	**8399**
1981	220	0	7952	229	0	**8401**
1982	224	0	5945	64	0	**6233**
1983	1195	0	5117	402	0	**6714**
1984	353	0	3122	31	0	**3506**
1985	59	0	1407	7	0	**1473**
1986	69	0	1774	8	0	**1851**
1987	75	0	1693	8	0	**1776**
1988	271	0	1093	7	0	**1371**
1989	403	0	2124	5	0	**2532**
1990	1029	0	1992	0	0	**3021**
1991	241	0	1582	0	0	**1823**
1992	321	0	2584	0	0	**2905**
1993	40	0	2193	0	0	**2233**
1994	89	1	1542	0	0	**1632**
1995	113	3	1519	0	0	**1635**
1996	36	3	1284	0	0	**1323**
1997	25	0	1319	0	0	**1344**
1998	59	9	1086	0	0	**1154**
1999	31	8	1525	8	11	**1583**
2000	0	7	1605	25	8	**1645**
2001	95	12	752	49	23	**931**
2002	28	4	1256	74	10	**1372**
2003	16	16	1098	6	24	**1160**
2004	38	9	1083	49	20	**1199**
2005	24	25	1497	20	26	**1592**
2006	63	22	1734	27	9	**1855**
2007	78	0	1999	4	10	**2091**
2008	88	0	3653	21	0	**3763**
2009	178	0	4132	5	0	**4315**
2010	515	0	6377	13	0	**6905**
2011	797	0	5903	2	0	**6702**
2012	312	0	4207	2	0	**4521**
2013	435	0	2769	2	0	**3204**
2014	71	0	1588	30	0	**1689**
2015	10	0	1734	4	0	**1748**
2016	6	0	925	0	0	**931**
2017	4	0	619	0	0	**623**
2018	28	0	513	0	0	**541**
2019	5	0	415	4	0	**424**
2020	6	0	343	0.1	0	**349**
2021	1.3	0	323	7.5	0	**332**
2022	**1**	**0**	**427**	**10**	**0**	**438**

Table 7. Blue ling. Landing in Greenlandic fishing grounds. Source: STATLANT database.

YEAR	FAROE	GERMANY	GREENLAND	ICELAND	NORWAY	RUSSIA	SPAIN	UK	DENMARK	TOTAL
1983	0	621	0	0	0	0	0	0	0	**621**
1984	0	537	0	0	0	0	0	0	0	**537**
1985	0	315	0	0	0	0	0	0	0	**315**
1986	214	149	0	0	0	0	0	0	0	**363**
1987	0	199	0	0	0	0	0	0	0	**199**
1988	21	218	3	0	0	0	0	0	0	**242**
1989	13	58	0	0	0	0	0	0	0	**71**
1990	0	64	5	0	0	0	0	10	0	**79**
1991	0	105	5	0	0	0	0	45	0	**155**
1992	0	27	2	0	50	0	0	32	0	**111**
1993	0	16	0	3124	103	0	0	22	0	**3265**
1994	1	15	0	300	11	0	0	57	0	**384**
1995	0	5	0	117	0	0	0	19	0	**141**
1996	0	12	0	0	0	0	0	2	0	**14**
1997	1	1	0	0	0	0	0	2	0	**4**
1998	48	1	0	0	1	0	0	6	0	**56**
1999	0	0	0	0	1	0	66	7	0	**74**
2000	0	1	2	4	0	0	889	2	0	**898**
2001	1	0	1	11	61	0	1631	6	0	**1711**
2002	0	0	0	11	1	0	0	0	0	**12**
2003	0	0	3	0	36	0	670	5	0	**714**
2004	0	0	7	0	1	0	0	7	0	**15**
2005	2	0	6	0	1	0	176	8	0	**193**
2006	0	0	6	0	3	1	0	0	0	**10**
2007	19	0	1	0	1	0	0	0	0	**21**
2008	1	0	5	0	2	0	381	0	1	**390**
2009	1	0	5	0	3	0	111	4	0	**124**
2010	1	0	8	0	9	0	34	0	3	**55**
2011	0	0	8	0	2	0	0	1	6	**17**
2012	0	0	13	367	9	0	0	0	3	**392**
2013	0	0	16	0	0	0	0	3	9	**28**
2014	0	0	14	0	3	0	0	0	0	**17**
2015	0	0	66	0	1	0	0	0	5	**72**
2016	0	0	9	0	0	0	0	0	7	**16**
2017	0	0	3,7	0	4	0	0	0	3	**19**
2018	0	0	34	0	12	0	0	0	5	**51**
2019	0	7	20	0	36	0	0	0	0	**62**
2020	0	7	18	0	2	0	0	0	0	**27**
2021	0	6	1	0	9	0	0	0	0	**16**
2022	**0**	**0**	**22**	**0**	**7**	**0**	**0**	**0**	**5**	**34**

Table 8. Blue ling. Catches along with survey biomass index from the Icelandic Autumn survey and the calculated F_{proxy} ((Catches in Iceland and Greenland)/Index).

YEAR	ICELAND	GREENLAND	INDEX	FPROXY
2000	1635.876	896	574.1	4.41
2001	761.809	1710	914.3	2.70
2002	1264.674	12	933.2	1.37
2003	1098.029	711	884.4	2.04
2004	1089.908	8	985.4	1.11
2005	1502.326	187	985.7	1.71
2006	1736.037	4	1439.2	1.20
2007	1998.092	20	1075.5	1.87
2008	3653.183	385	1586.6	2.54
2009	4129.245	119	1967.2	2.16
2010	6377.866	47	1763.5	3.64
2012	4206.665	379	1363.3	3.36
2013	2769.869	28	1683.9	1.66
2014	1687.642	17	1415.2	1.20
2015	1727.363	72	1113.2	1.62
2016	930.790	16	1105.7	0.89
2017	622.257	19	1090.7	0.59
2018	502.955	17	883.0	0.59
2019	423.983	62	966.7	0.50
2020	349.307	27	718.1	0.52
2021	331.856	16	902.7	0.38
2022	437.831	34	695.0	0.68

EXPLORATORY ASSESSMENT MODEL USING GADGET

An exploratory Gadget model (**G**lobally applicable **A**rea **D**isaggregated **G**eneral **E**cosystem **T**oolbox, see www.hafro.is/gadget) was developed for blue ling in Icelandic waters.

DATA USED AND MODEL SETTINGS

The size-structured model contains two stock components: a mature and an immature stock. On an annual basis, recruits enter the immature component, and a fraction of the immature component moves to the mature component. Growth is modelled using a von Bertalanffy function. Fishing mortality results from multiple fleets, each of which has a unique selection pattern. As there is no information regarding natural mortality, values of 0.15 are applied to both components across length intervals.

The following data is used in the model:

- Length distributions from the autumn survey (2000 onwards) and commercial catches.
- Length-disaggregated abundance indices from the autumn survey. The following length groups were defined: 20-52 cm, 52-60 cm, 60-72 cm, 72-80 cm, 80-92 cm, 92-100 cm, 100-140 cm.
- Maturation data (ratio of mature to immature per length interval) from the autumn survey.

Existing age data was not included in the model due to the difficulties in the ageing of this species.

The parameters estimated in the model include:

- Initial numbers at age.
- Recruitment at age 3 each year.
- Size of recruits.
- Selection pattern of the commercial fleet and survey.
- Growth parameters.

MODEL DIAGNOSTICS

Overall fit to the predicted proportional length distributions is close to the observed distributions (Figures 19-21). The model captures the age truncation seen in the observed survey data with the median length increasing from 2010 to 2016 due to poor recruitment. A recruitment spike in 2017 led to a bimodal length distribution from 2017 to 2022. The bimodal distribution is visible in the observed survey data, though not as clearly defined as in the model.

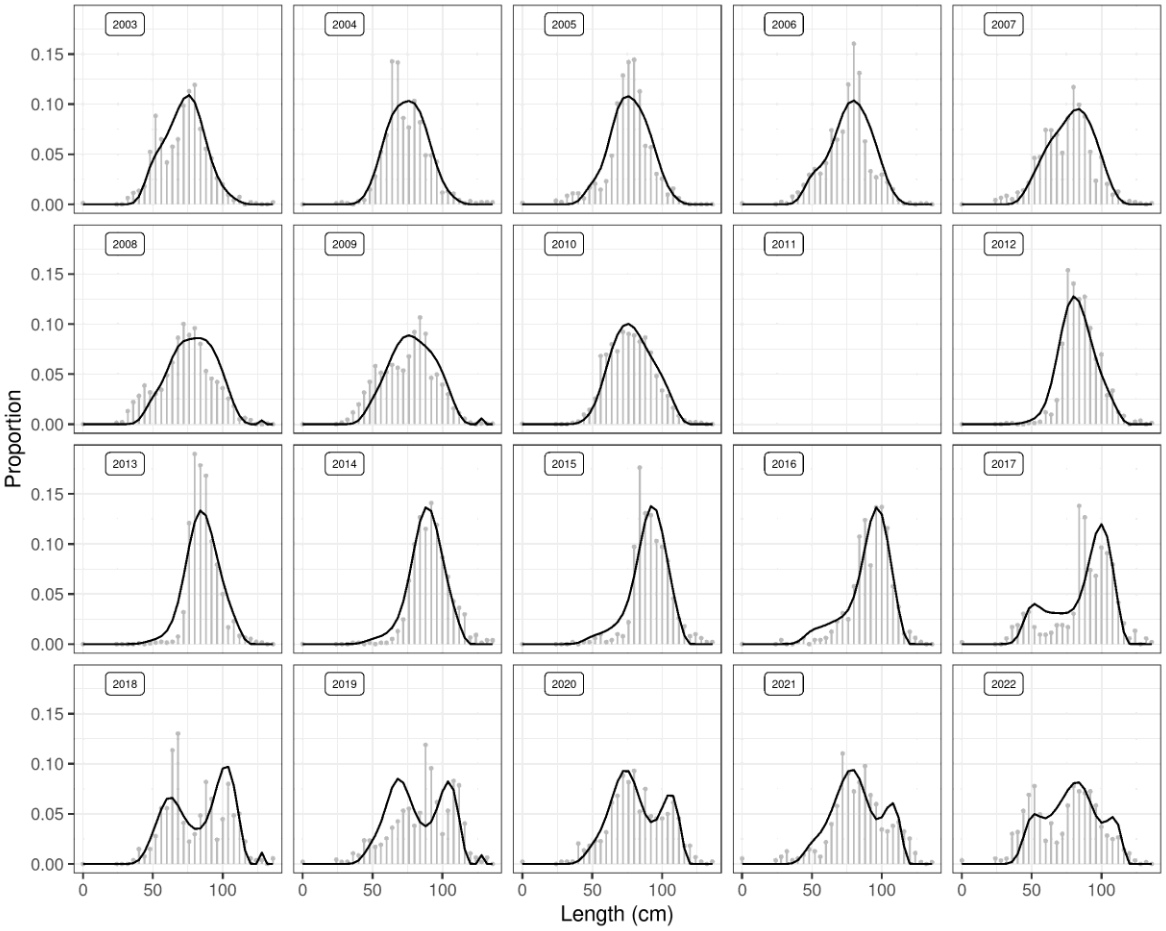

Figure 19. Blue ling. Fitted proportions-at-length from the Gadget model (black lines) compared to observed proportions in the autumn survey (vertical lines and points).

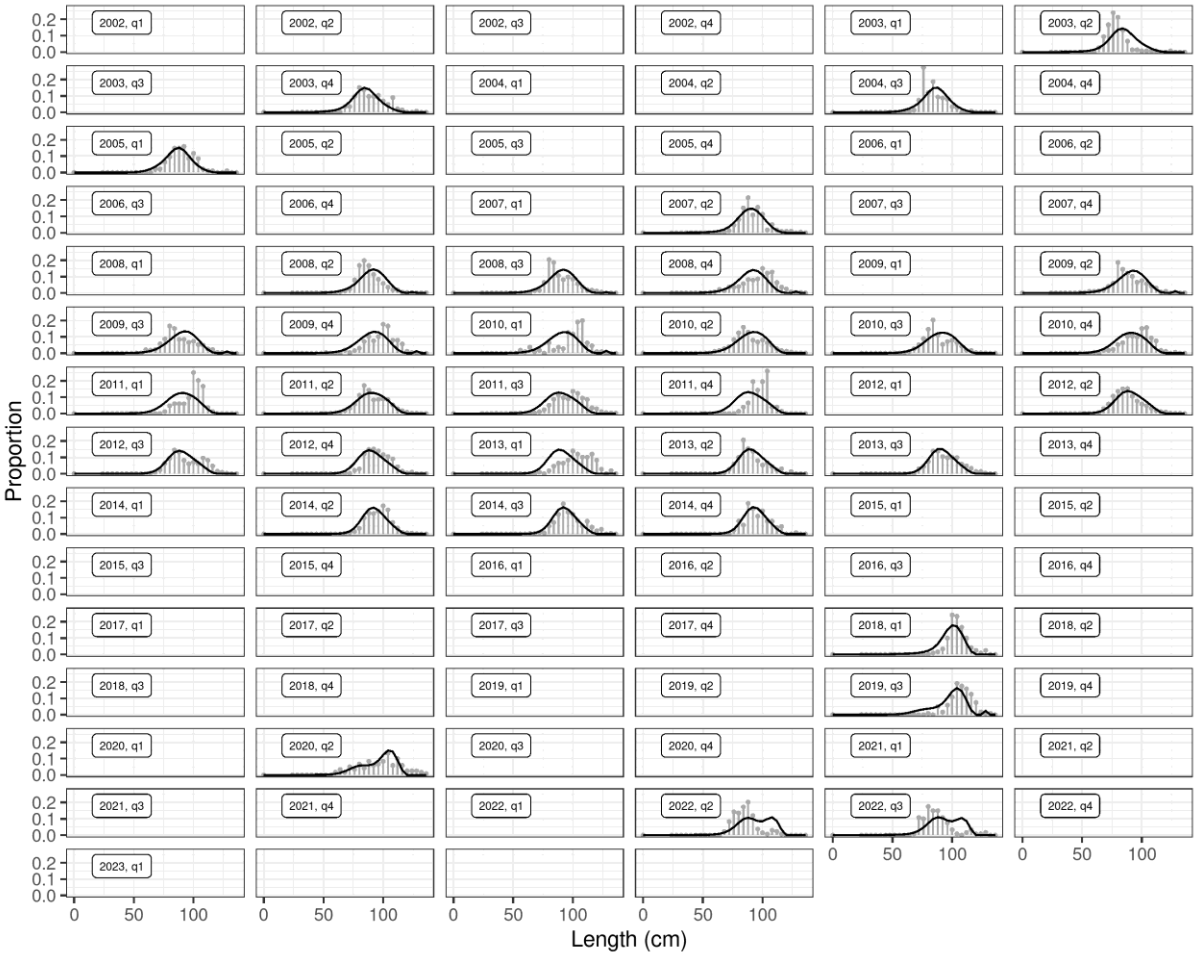

Figure 20. Blue ling. Fitted proportions-at-length from the Gadget model (black lines) compared to observed proportions from commercial catches (longline fleet).

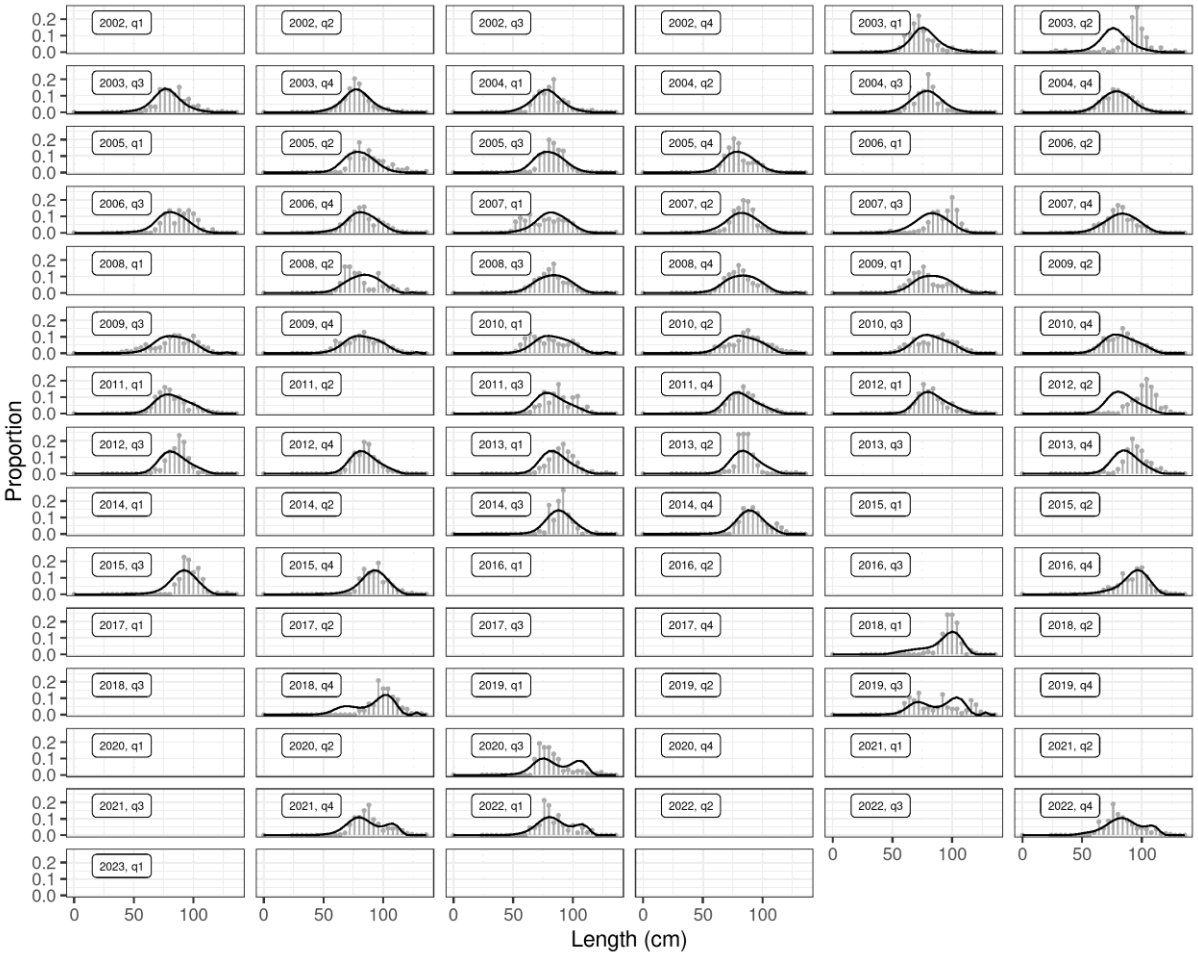

Figure 21. Blue ling. Fitted proportions-at-length from the Gadget model (black lines) compared to observed proportions from commercial catches (trawl fleet).

MODEL FIT

Figure 22 shows the overall fit to the length-disaggregated autumn survey indices. In general, the model captures the observed trends over time for each length interval. The deviation between the terminal estimates and the observed values are small for all length groups; however, these deviations are positive in 6/7 of the index groups, resulting in an overestimation of abundance in 2022.

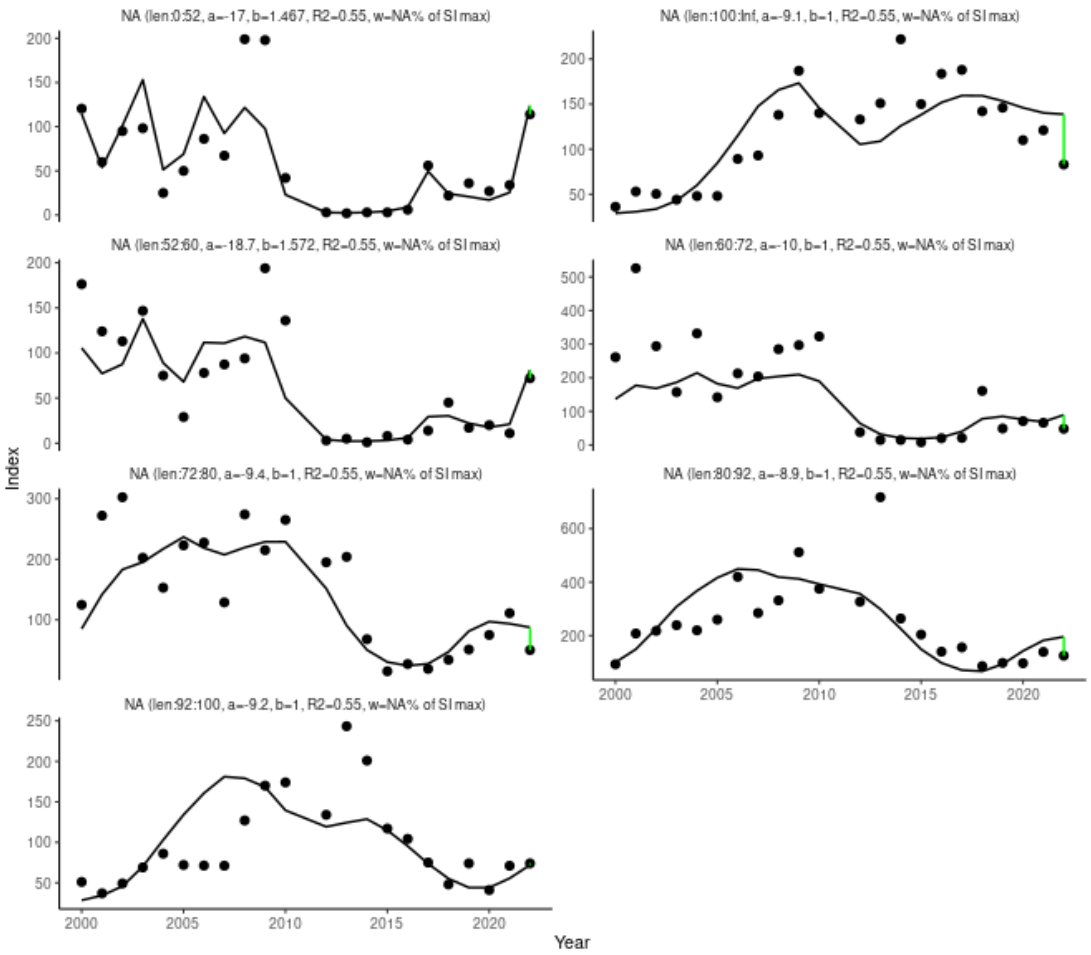

Figure 22. Blue ling. Fitted autumn survey index by length group from the Gadget model (black line) and the observed number of blue ling caught in the survey (points). The green line indicates the difference between the terminal fit and the observations.

RESULTS

The model results are presented in Figure 23. Total biomass and spawning stock biomass both peaked in 2009 and subsequently declined until 2017 and 2019 respectively. The total biomass and spawning stock biomass have gradually increased in the following years owing primarily to a large recruitment spike in 2017. Whilst this gradual increase is not seen in the biomass indices, the indices do suggest that from 2017 onwards the biomass levels are stabilising as opposed to continuing the downward trajectory from 2010. From 2000 to 2010, recruitment varies substantially between years. From 2010 to 2017, recruitment is minimal which is also seen in the recruitment index (Figure 8). Recruitment has since increased; whilst the values from 2019 to 2021 remain low and below the long-term average, the value for 2022 increased to pre-2010 levels (also seen in the index). Fishing mortality peaked in 2011 at approximately 0.5 and has decreased to around 0.05 in 2022.

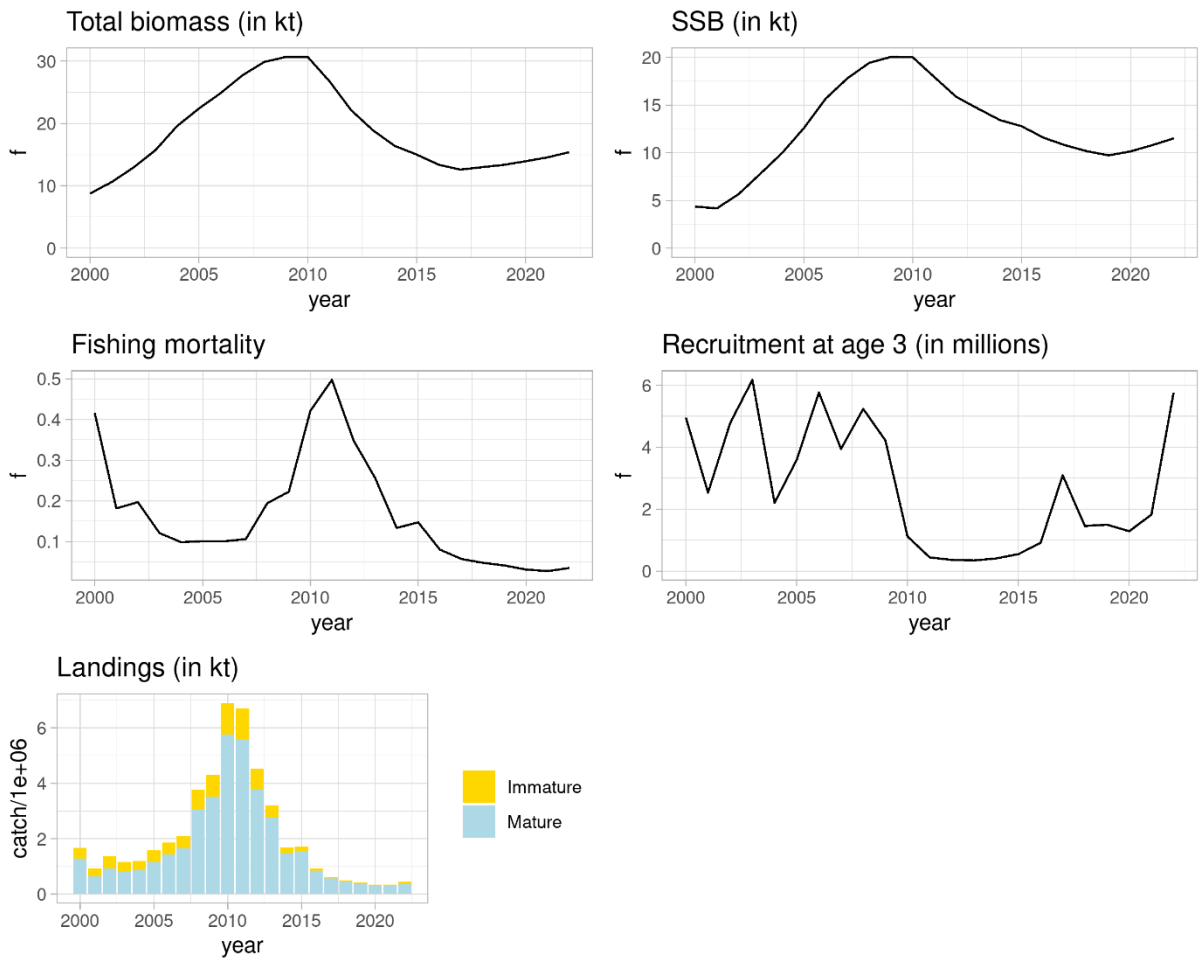

Figure 23. Blue ling. Estimated biomass, spawning stock biomass (SSB), fishing mortality, recruitment, and total catches.

Results of the retrospective analysis are seen in Figure 24. There was a downward revision of SSB with each successive peel from the 5-year peel. The revisions in SSB are accompanied by successive upward revisions in mortality from the 5-year peel. The retrospective patterns in recruitment are stable, although the 5- and 4-year peels produces larger estimates in 2006 and 2008 when the model is more closely followed the 20-50 cm survey index peaks. Further work is required to achieve greater stability in the retrospective analysis.

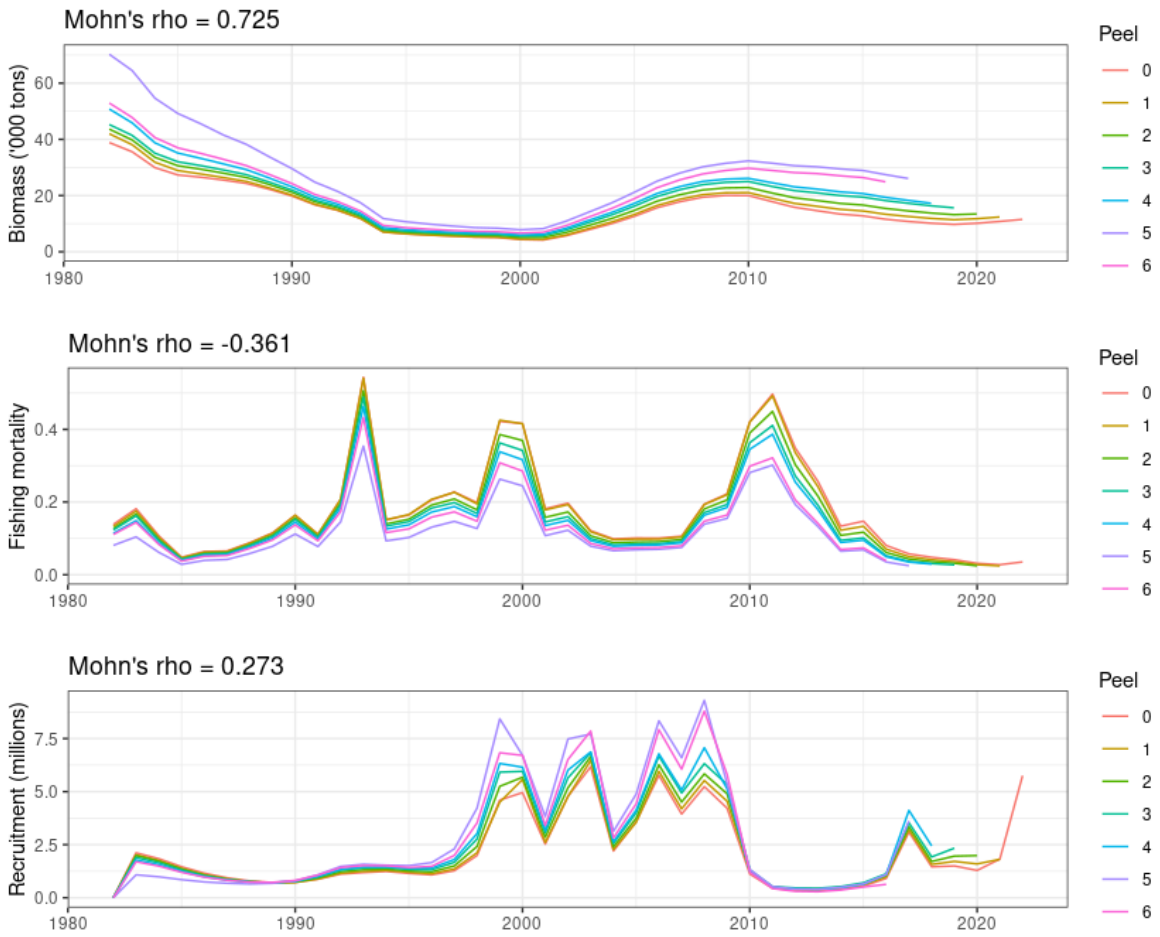

Figure 24. Blue ling. Retrospective plots illustrating stability in model estimates over a 5-year 'peel' in data. Results of spawning stock biomass, fishing mortality F, and recruitment (age 3) are shown.

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