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CAPELIN

Mallotus villosus

Assessment report

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General information

The capelin is a small pelagic schooling fish. It is a cold-water species that inhabits arctic and subarctic waters in the North Atlantic and North Pacific. Capelin in the Iceland-East Greenland-Jan Mayen area is considered to be a single stock.

Fisheries of capelin began in Iceland in the mid-1960s. Besides being commercially important capelin is a key species in the marine ecosystem off Iceland. It feeds on small zooplankton, especially copepods but also amphipods and krill, but is itself an important food for cod, seith, haddock, halibut and other commercial fish. It is also important prey for whales and birds. Thus, capelin is an important link in the transfer of energy and nutrients to the upper levels of the food web. Preferred temperature for capelin is usually 1-3°C during feeding migration and it is then often at the southern extent of cold Arctic water. When the adult capelin migrates from the feeding areas far north of Iceland, it is mainly considered to enter the continental shelf north of Iceland and then migrate clockwise around the island. Part of the main migration continues all the way towards the coast west of Iceland. Spawning takes place in shallow water in March-April in relatively warm seas south and southwest coast of the country. Spawning has also been observed in the north of the country but the extent of that spawning has been considered small compared to the number that spawns in the south. The capelin dies after spawning, usually at the age of 3 years. The spawning passage of the capelin contributes to a huge transfer of energy into the ecosystem of the Icelandic continental shelf. Larvae and juveniles drift clockwise along the continental shelf north and east of Iceland and in variable quantities towards Denmark Strait and to the shelf of East Greenland. Nursery grounds of capelin are in the waters north of Iceland and increasingly on the continental shelf of East Greenland (Bardarson et al, 2021).

Fisheries

No fisheries took place in the 2023/2024 fishing season. Total historical catch of the Icelandic capelin is shown in Figure 1 and distribution of the catches of the Icelandic fishing fleet can be seen on Figure 2.

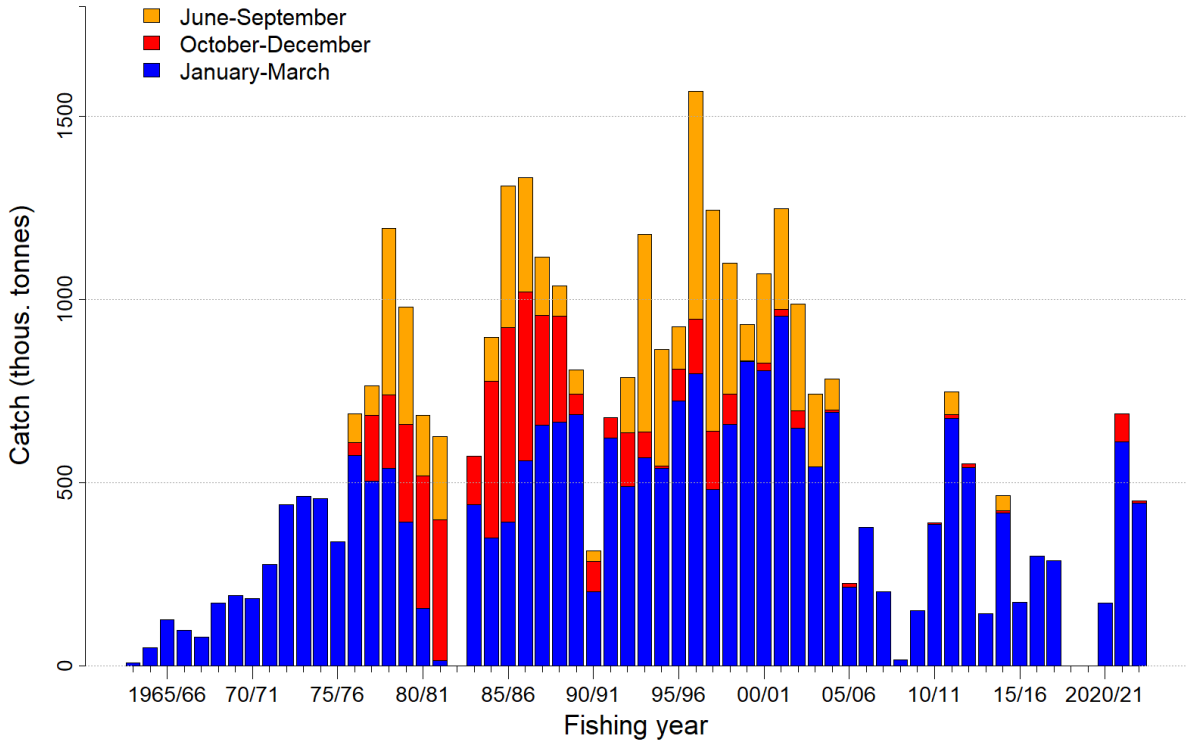

Figure 1: Capelin. The total catch (in thousand tonnes) of the Icelandic capelin since 1963/64 by season.

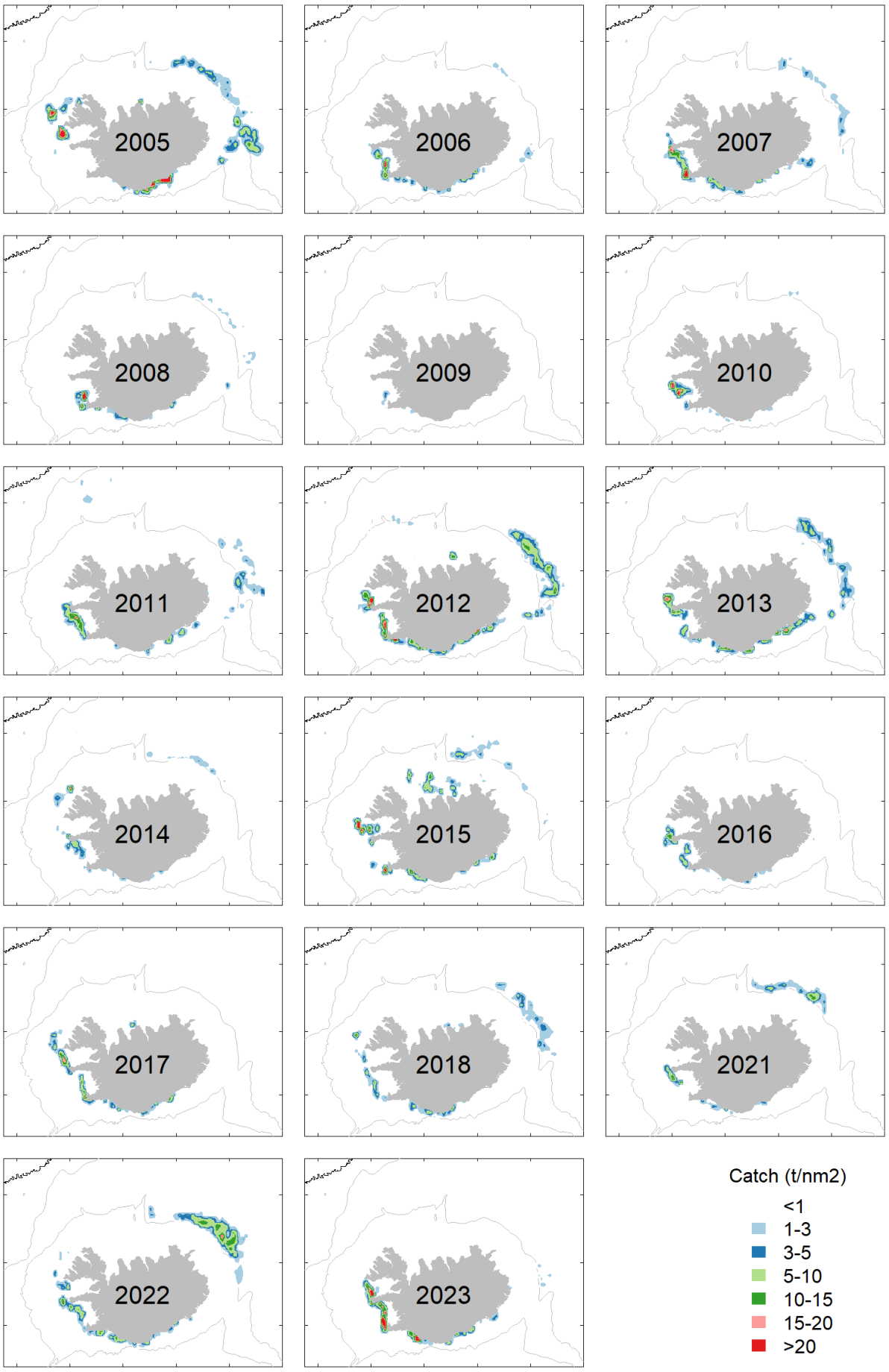
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017
2018
2021
2022
2023
Catch (t/nm2)
<1
1-3
3-5
5-10
10-15
15-20
>20

Figure 2: Capelin. Distribution of catches by the Icelandic fishing fleet based on logbooks.

Changes in fishing technology and fishing patterns

There were no catches in 2023/24, but historically a variable amount of the catches have been taken with pelagic trawl through the fishing seasons, related to the size of the TAC and when it is issued. Discards have been considered negligible.

Stock assessment

Fishery independent abundance surveys

The capelin stock in Iceland-East Greenland-Jan Mayen area has been assessed by acoustics annually since 1978. The surveys have been conducted in autumn (September–December) and in winter (January–February). An overview is given in the stock annex.

Autumn survey 2024

The survey was conducted with the aim of assessing both the immature and the maturing part of the stock (Bardarson et al, 2024). Since 2010, the autumn surveys have started in September, a month earlier than in previous years because of difficulties in covering the stock due to drift ice and weather during later months.

The survey was conducted on the behalf of MFRI by the r/v Arni Fridriksson until replacement by the f/v Polar Ammassak (due to engine failure of Arni) and r/v Tarajoq on behalf of GINR. The survey area was on and along the shelf edge off East Greenland from about 64°30´N towards about 72°15´ N, also covering the Denmark Strait and the slope off northwest Iceland. The Iceland Sea, Kolbeinsey ridge and Greenland basin were only briefly scouted due to time constraints and for same reason hydrographic measurements and zooplankton sampling were limited compared to previous years. There were also delays due to bad weather.

In general, drift ice did not limit the coverage of the survey vessels although icebergs and a lack of benthic mapping occasionally affected routes and limited extension of transects towards the Greenlandic coast.

Maturing capelin was mainly observed outside the Icelandic continental shelf off Vestfirdir and NW Iceland. In western Denmark Strait maturing capelin was mixed with immature capelin, but mainly maturing capelin was found further east. Similar as last year, distribution of mature capelin was only reaching shortly east of Denmark Strait and that is again a drastic change from observations preceding last autumn, when mature capelin was found on or along the East Greenland continental shelf south, east and north of Scoresby. Further, no capelin was found by West Jan Mayen ridge or Kolbeinsey ridge. In general, there were no signs of any important quantities of capelin east of Kolbeinsey ridge nor along Icelandic shelf edges. Juveniles (0-group) of various species, including capelin (although not quantified) were observed along the continental shelf north and northwest of Iceland and along the southwestern coverage of the Greenlandic shelf. Immature capelin was found along the Greenlandic shelf, dominating in southwestern part of the survey area and Denmark Strait. Overall, the distribution of maturing capelin was not reaching as far east in the autumn as in the years before 2023.

Figure 3 to Figure 5 show the cruise tracks, distribution, relative density and proportion mature of the capelin during the survey.

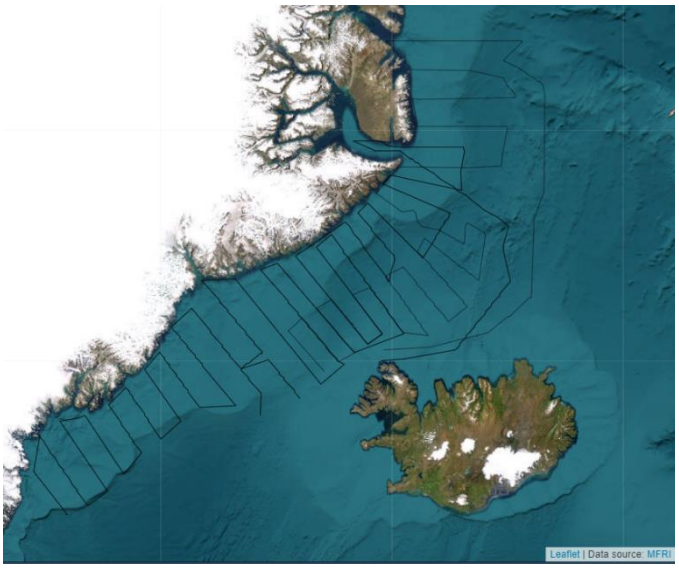

Figure 3: Capelin. Cruise tracks during an acoustic survey by r/v Arni Fridriksson, f/v Polar Ammassak and Tarajoq during 21 August – 1 October 2024.

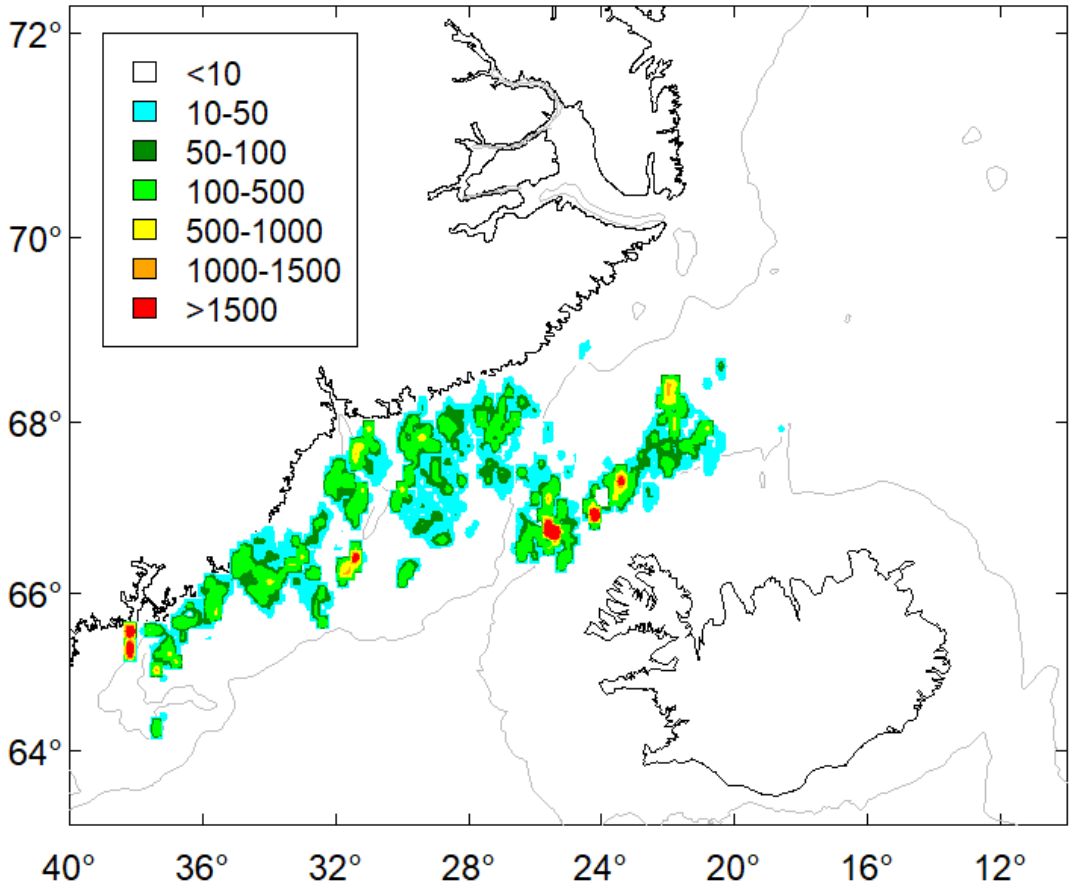

Figure 4: Capelin. Relative density and distribution of capelin shown as counterplot of capelin acoustic backscatter as NASC, during 21 August – 1 October 2024.

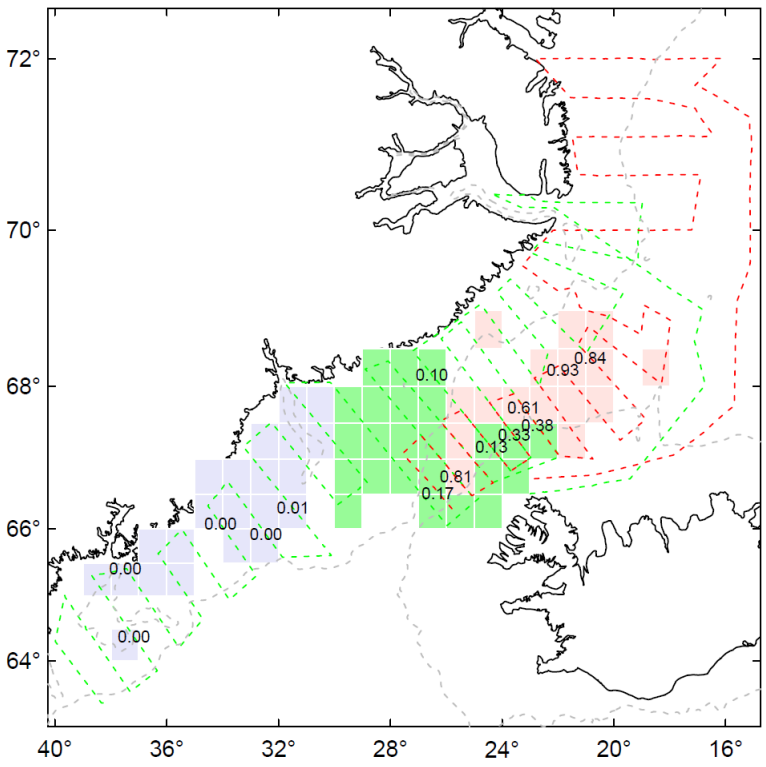

Figure 5: Capelin. Transects of the participating vessels and proportion mature within capelin samples and regional allocation in assessment during the autumn survey in 21 August – 1 October 2024.

The total number of capelin amounted to 74 billions where of the 1 year old was about 57.4 billions. The total estimate of 2 years old capelin was about 14.9 billions. The total biomass estimate was 610 000 tonnes of which about 320 000 tonnes were 2 years and older. About 1.2 % in numbers of the 1-group was estimated to be maturing to spawn, about 88.8 % of the 2 year old and 86.1 % of the 3 year old capelin appeared to be maturing. This gives about 307 000 tonnes of maturing 1 - 4 year old capelin.

Historical trend of mean weight of 1 and 2 year old capelin during autumn survey is shown in Figure 6.

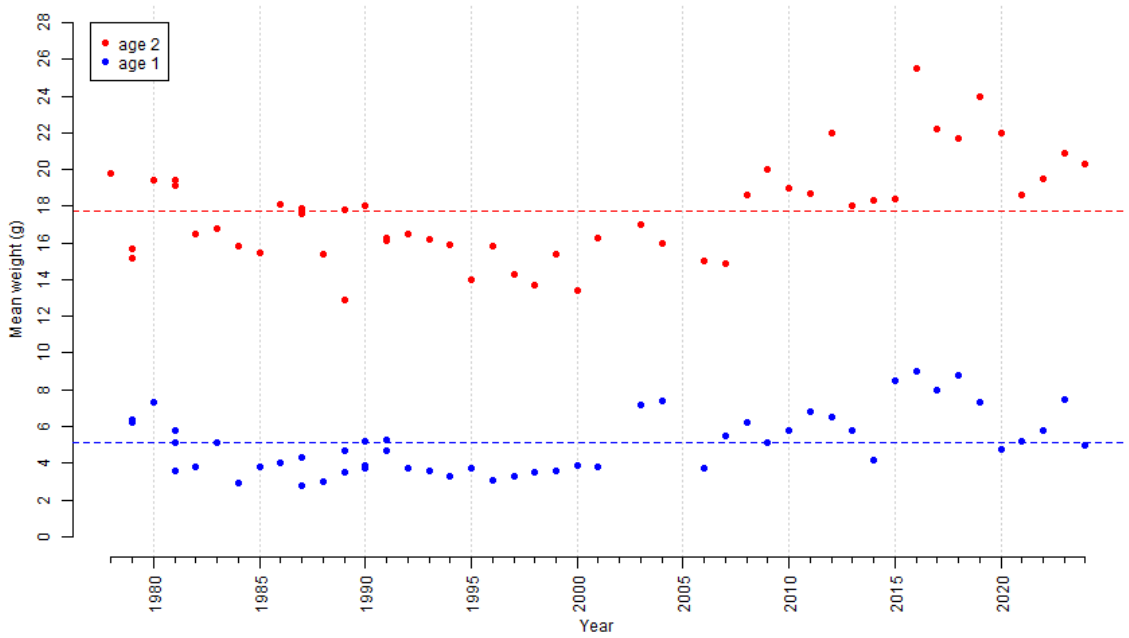

Figure 6: Capelin. Mean weight of 1 and 2 year old capelin in autumn surveys since 1978.

Predation model results and resulting advice

Following completion of surveys estimations of stock parameters and their uncertainty 100 thous. bootstrap replicates were used as starting values for predation model runs. The stock estimates from last two winter surveys were used along with the autumn survey estimate to predict the status and development of the capelin stock. Results from the predation model runs are given in Table 1 and shown in Figure 8 to Figure 9.

Table 1: Capelin. Quantiles and mean of SSB at time of spawning (15. March) and total predator consumption in thous. tonnes based on the predation model

Parameter	mean	5%	25%	50%	75%	95%
SSB	199.87	102.66	151.65	193.07	240.86	320.21
Predation	109.64	68.23	89.94	107.24	126.76	158.93

The model (ICES 2023a, ICES 2023b) is designed to cover predation on the main spawning migration of capelin. A schematic description of the model is in Figure 7.

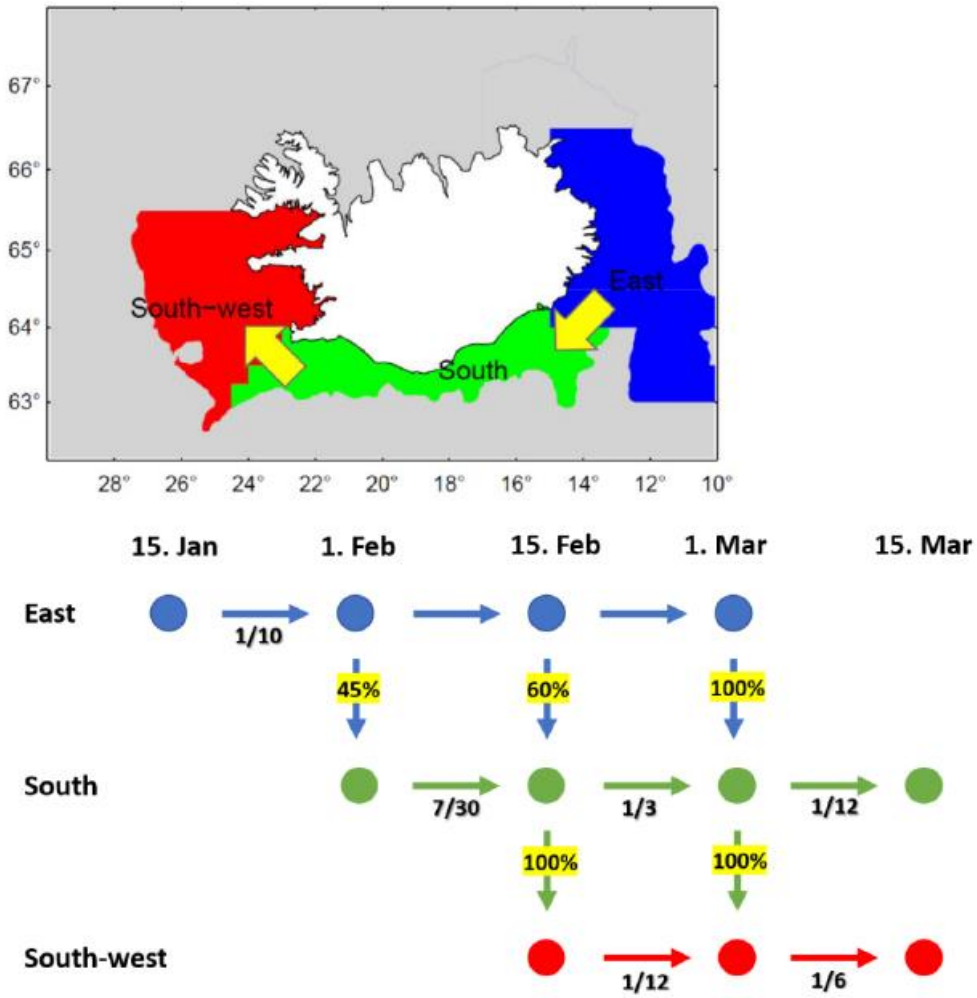

Figure 7

The predation model (ICES 2023a, ICES 2023b) applies to the stock component that migrates the clockwise route around Iceland. In most years, majority of the stock has migrated that route and nearly all the catches have been taken from that component. All the capelin stock is assumed to be in the east on 15th of January, and on 15th of March, it is assumed that all the capelin stock spawns in the south and southwest, a higher proportion in the southwest. The predators (cod, haddock and saithe) are assumed to be stationary during the period of capelin migration and their spatial distribution is obtained from the demersal survey in March from 1985 to previous year. The total abundance of each predator is predictions for the current year based on assessment in previous year.

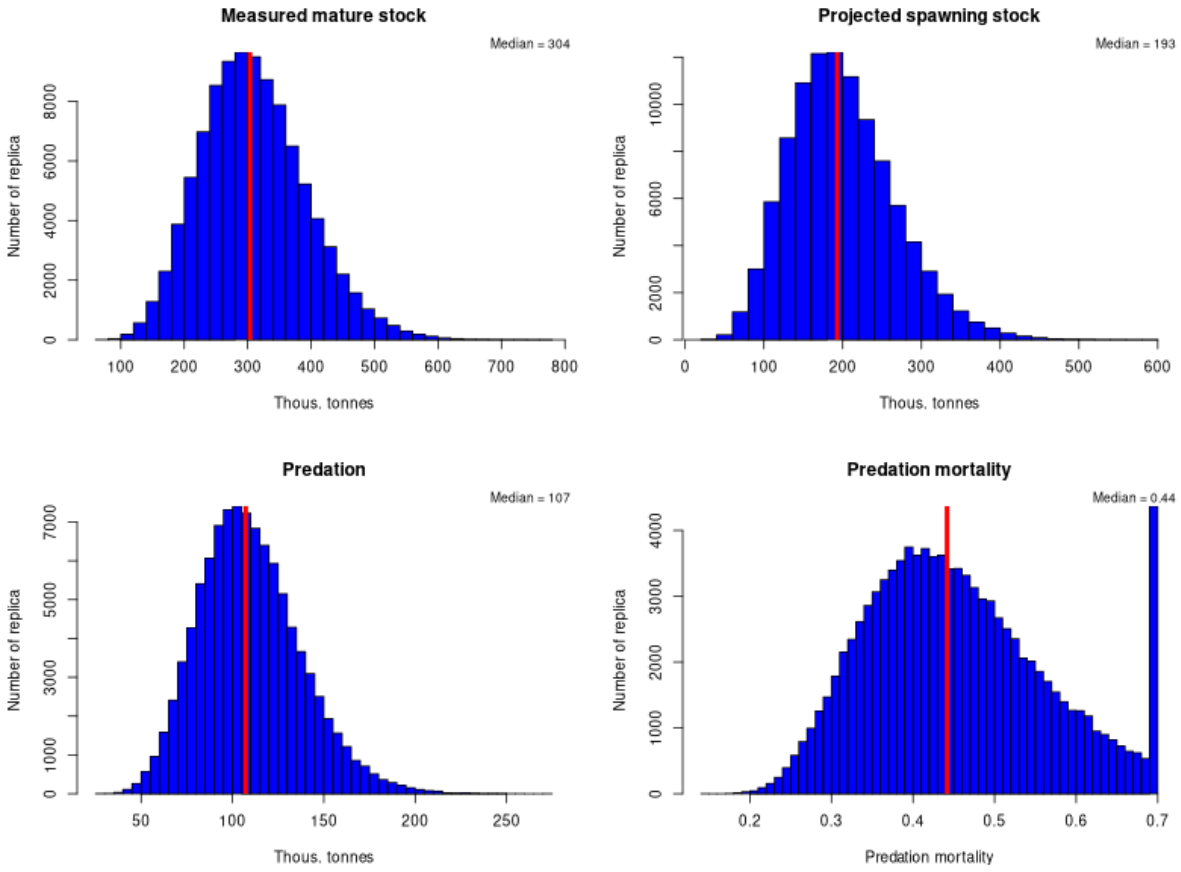

Figure 8: Capelin. Summary of results from the 2023 autumn acoustic survey and predation model Biomass survey estimates of mature capelin (top-left), the projected spawning stock biomass left for spawning based on the predation model (top-right), predicted predation 15 January – 15 March (bottom-left) and the applied predation mortality (bottom-right)

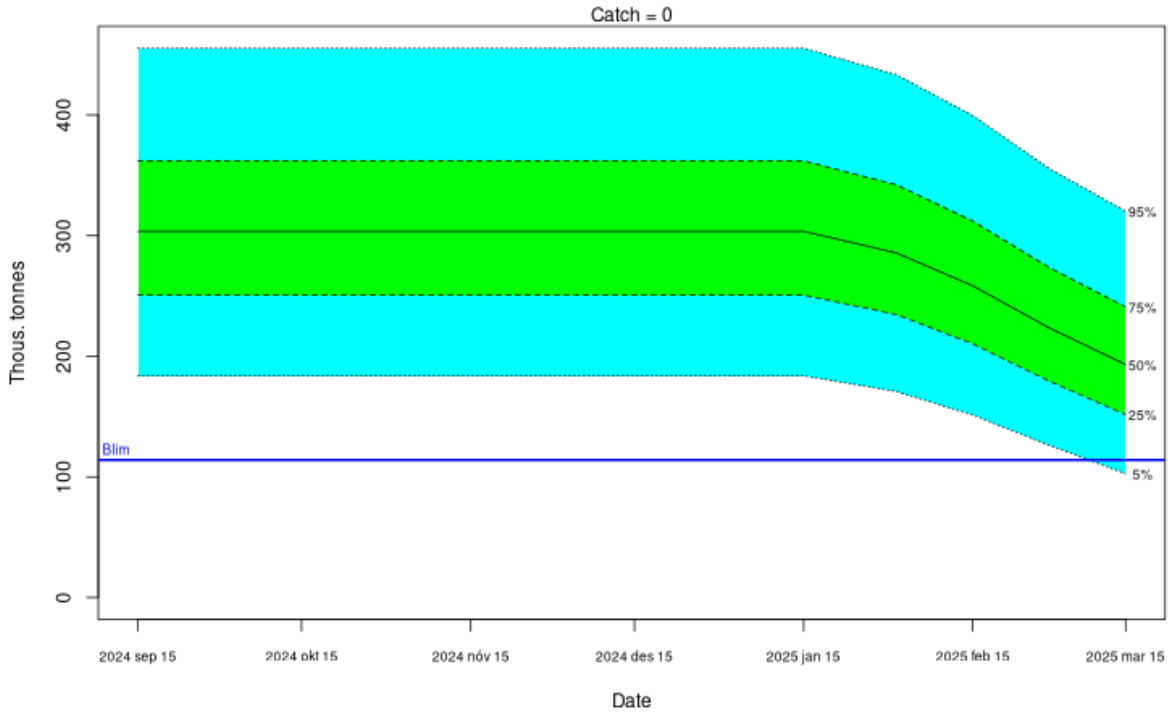

Figure 9: Predicted development of the SSB with no catch based on the predation model. Blue line indicates Blim = 114 000 tonnes (ICES 2023a, ICES 2023b).

Management plans and evaluations

Methods

The objective of the HCR for the stock is to leave at least 114 000 tonnes (= Blim) for spawning (escapement strategy). The initial (preliminary), intermediate and final TACs are based on acoustic surveys.

a) The initial TAC advice for the subsequent fishing season is issued by ICES in June. It is based on the autumn survey abundance estimate of immature capelin.

b) The intermediate TAC advice is issued by MFRI in autumn based on the biomass estimate of maturing capelin.

c) The final TAC advice is issued by MFRI in January/February based on the biomass estimate of maturing capelin.

The initial (preliminary) quota follows a simple forecast that is based on a linear relation between historic observations of the abundance of juveniles from the acoustic autumn surveys and the corresponding final TACs nearly 1½ year later. Based on this rule, advice on the initial quota for the fishing season 2024/25 is given. Figure 12.7.2 shows the relation and the associated precautionary initial quota.

The intermediate and final TACs are set so that there is at least 95% probability that there will be at least 114 000 tonnes (= Blim) of mature capelin left for spawning at the spawning time (15 March). This was done for the first time in 2015/2016 by the Icelandic Marine Research Institute and was not evaluated by ICES.

The estimated SSB at spawning time (March-April) has been recompiled for 1981-2023 (Figure Figure 10), using the model adopted in 2015 and 2023, i.e taking into account uncertainty in the acoustic measurements and using the predation model adopted in 2015. Uncertainty in acoustic measurements was recompiled for the years 2002-2006 and 2012-2014 by recalculating the acoustic indices and bootstrapping the results. Additionally, uncertainty was available for the years since 2015 when the advice has been given based on the new HCR. For earlier years the CV in the acoustic measurements was estimated by looking at survey reports as well as text from (Vilhjálmsson (1994)) The estimated CV was in the range of 0.15-0.25 and was included as a lognormal multiplier on available average values from the same sources.

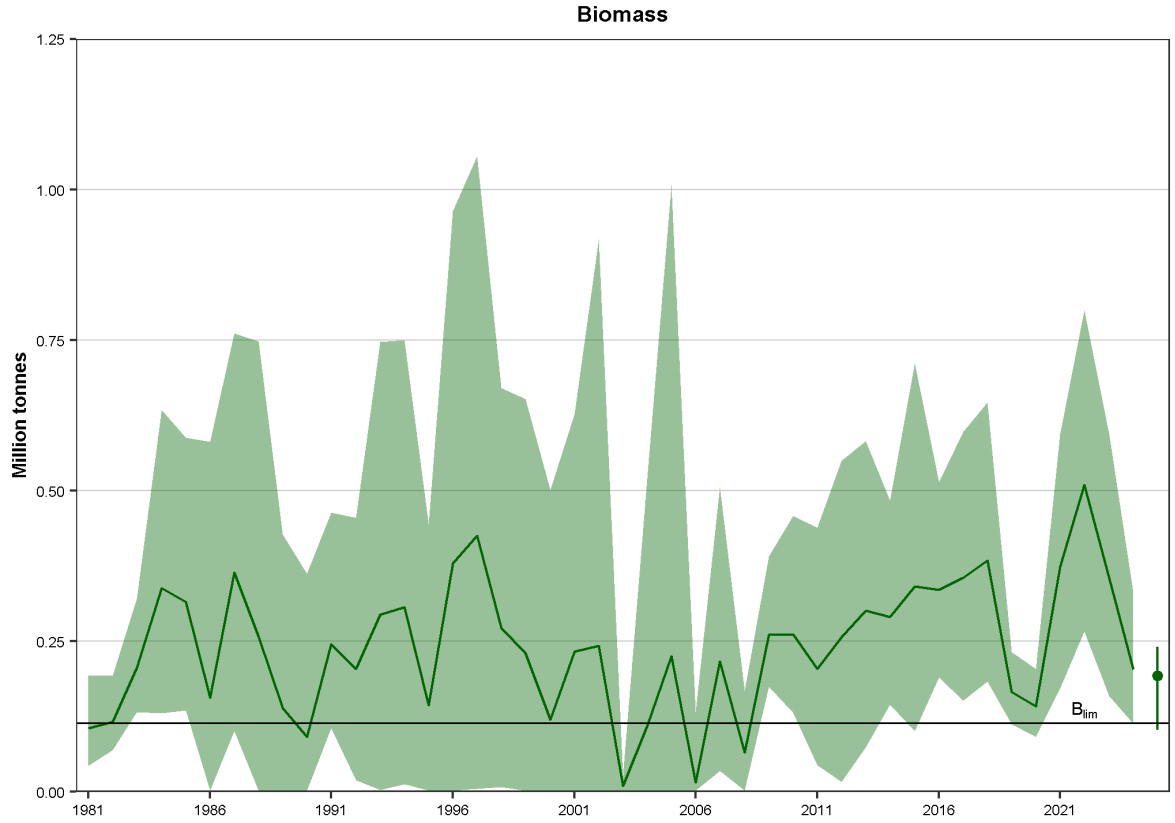

Figure 10: Capelin. 5th, 50th and 95th percentile of the spawning stock at spawning time (March-April) since 1981. Blim = 114 kt.

These methods were endorsed by the benchmark working group WKICE in 2015 and WKCAPELIN 2022 with minor adjustments. See WKICE (ICES, 2015), WKCAPELIN (ICES, 2023b) and the Stock Annex for the capelin in the Iceland-East Greenland-Jan Mayen area. Previously, (since early 1980s) the stock was managed according to an escapement strategy, leaving 400 000 tonnes for spawning (uncertainty of the estimates were not considered). To predict the TAC for the next fishing season a model was developed in the early 1990s (Gudmundsdottir and Vilhjalmsson, 2002). These models were not endorsed by the benchmark working group WKSHORT 2009.

Reference points

During WKICE, a Blim of 150 000 tonnes was defined (ICES, 2015) and following WKCAPELIN Blim was changed to 114 000 tonnes. No other reference points are defined for this stock.

State of the stock

The spawning stock biomass (SSB) was estimated to 307 000 tonnes in September 2024. The predation model (ICES, 2015), accounting for catches (in this case winter catch of 0 t) and predation between surveys and spawning by cod, saithe and haddock, estimated that 193 000 tonnes were left for spawning in spring 2025 (Table ??). Given the uncertainty estimates, there was less than 95% probability that at least 114 000 tonnes was left for spawning. This was below Blim within the sustainable HCR. The acoustic estimate of immature capelin from the autumn survey in September 2024 was 58.5 billion. The estimate close to longterm average (Figure ??) and the initial advice according to the HCR for the fishing season 2025/26 will be adviced by ICES in June 2025 .

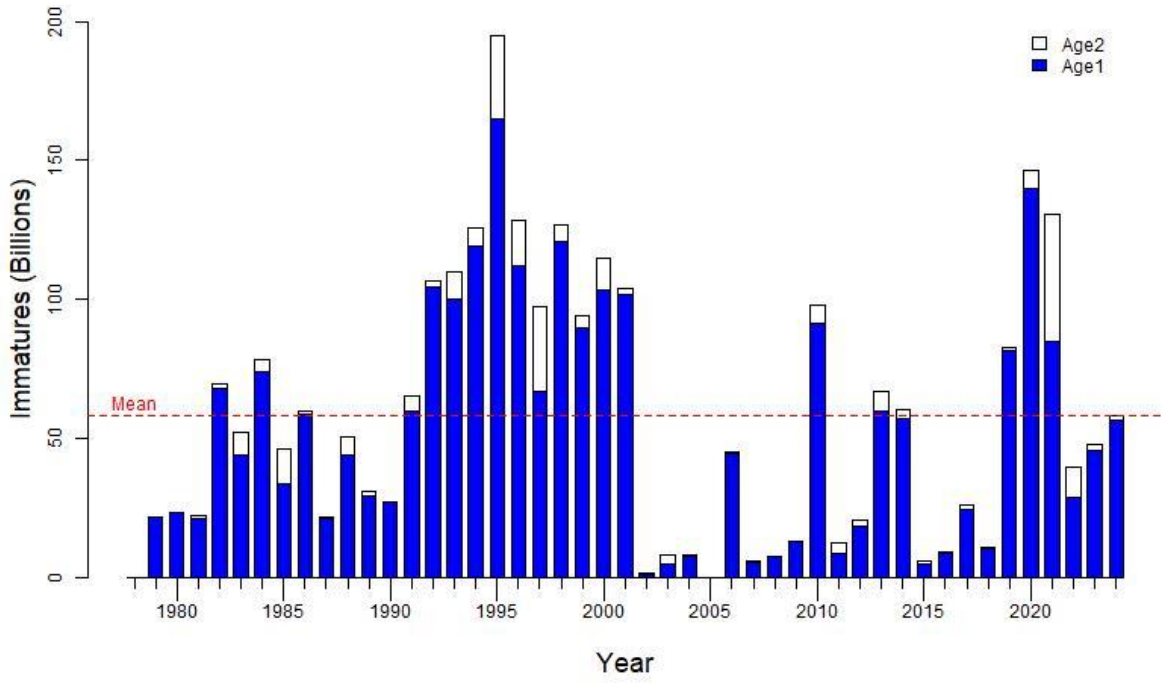

Figure 11: Capelin. Indices of immature 1 and immature 2 years old capelin from acoustic surveys in autumn since 1979.

Uncertainties in assessment and forecast

The uncertainty of the assessment and forecast depends largely on the quality of the acoustic surveys in terms of coverage, conditions for acoustic measurements and the aggregation (high patchiness leads to high variance) of the capelin.

The uncertainty is estimated by bootstrapping (see stock annex). The CV for the immature abundance was estimated to 0.15 in the 2024 autumn survey. The CV for the mature biomass was estimated to 0.25 in the 2024 autumn survey.

There was a good spatial coverage of the observed main distributions of the mature component of the stock in the autumn survey 2024. While the autumn survey was effected by time constrains the distribution of immature and mature components of the capelin stock seemed to have been covered.

Comparison with previous assessment and forecast.

For the fishing season 2024/2025 0 t initial quota was advised and intermediate TAC was also set to 0 tonnes.

Management considerations

The fishing season for capelin has since 1975 started in the period from late June to July/August when surveys on the juvenile part of the stock the year before have resulted in the setting of an initial (preliminary) catch quota. During summer, the availability of plankton is at its highest and the fishable stock of capelin is feeding very actively over large areas between Iceland, Greenland and Jan Mayen, increasing rapidly in length, weight and fat content. By late September/beginning of October this period of rapid growth is over. The growth is fastest the first two years, but the weight increase is highest in the year before spawning (Vilhjálmsson, 1994).

Given the large weight increase in the summer before spawning (Section 12.4) it is likely that there will be more biomass of maturing fish in autumn than in summer, even though the level of natural mortality is not well known during this time period. This should be considered for optimal timing of fishery in relation to yield and ecological impact. This is also supported by information for the Barents Sea capelin where it has been shown that fishing during autumn would maximize the yield, but from the ecosystem point of view a winter fishery were preferable (Gjøsæter *et.al.*, 2002). As the biology and role in the ecosystem of these two capelin stocks are similar, this is considered to be valid for the capelin in the Iceland-East Greenland-Jan Mayen area as well - until it is studied for this specific stock.

During the autumn surveys, juvenile and adult capelin is often found together. This should be considered during summer and autumn fishing because the survival rate of juvenile capelin that escapes through the trawl net is unknown.

Ecosystem considerations

Capelin is an important forage fish and its dynamics are expected to have implications on the productivity of their predators.

The importance of capelin in East Greenlandic waters is not well documented but effort has been increased considerably during autumn surveys towards evaluation of capelin role in the ecosystem e.g. by research on feeding of capelin, estimates of prey availability, predators' distributions and environmental monitoring.

In Icelandic waters, capelin is the main single item in the diet of Icelandic cod, a key prey to several species of marine mammals and seabirds and also important as food for several other commercial fish species (see e.g. Vilhjálmsson, 2002, Singh *et al.* 2023).

Regulations and their effects

Over the years, the fishery has been closed during April–late June and the season has started in July/August or later, depending on the state of the stock.

Areas with high abundances of juvenile age 1 and 2 capelin (on the shelf region off NW-, N- and NE-Iceland) have usually been closed to the summer and autumn fishery.

It is permissible to transfer catches from the purse seine of one vessel to another vessel, in order to avoid slippage. However, if the catches are beyond the carrying capacity of the vessel and no other vessel is nearby, slippage is allowed. In recent years, reporting of such slippage has not

been frequent. Industrial trawlers do not have the permission to slip capelin in order to harmonize catches to the processing.

In Icelandic waters, fishing with pelagic trawl is only allowed in limited area off the NE-coast (fishing in January) to protect juvenile capelin and to reduce the risk of affecting the spawning migration route (shuttering of migrating capelin schools by pelagic trawling has been hypothesized).

As a precautionary measure to protect juvenile capelin, the coastal states (Iceland, Greenland and Norway) have agreed that from 2021 fishing shall not start until 15. October.

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Tables

Table 2: Capelin. ICES advice and official landings. All weights are in tonnes.

Season	ICES advice	ICES initial TAC advice^	Intermediate TAC recommendation from MFRI – Iceland^^	Final TAC recommendation from MFRI - Iceland^^^	Agreed final TAC	ICES catch#
1986/1987	TAC	1 100 000	—	—	1 290 000	1 333 400
1987/1988	TAC	500 000	—	—	1 115 000	1 115 800
1988/1989	TAC	900 000	—	—	1 065 000	1 036 500
1989/1990	TAC	900 000	—	—	900 000	807 800
1990/1991	TAC	600 000	—	—	250 000	313 600
1991/1992	No fishery pending survey results	0	—	—	740 000	677 100
1992/1993	Precautionary TAC	500 000	—	—	900 000	787 700
1993/1994	TAC	900 000	—	—	1 250 000	1 178 700

Season	ICES advice	ICES initial TAC advice^	Intermediate TAC recommendation from MFRI – Iceland^^	Final TAC recommendation from MFRI - Iceland^^^	Agreed final TAC	ICES catch#
1994/1995	Apply the harvest control rule	950 000	—	—	850 000	863 900
1995/1996	Apply the harvest control rule	800 000	—	—	1 390 000	929 300
1996/1997	Apply the harvest control rule	1 100 000	—	—	1 600 000	1 570 900
1997/1998	Apply the harvest control rule	850 000	—	—	1 265 000	1 244 900
1998/1999	Apply the harvest control rule	950 000	—	—	1 200 000	1 099 400
1999/2000	Apply the harvest control rule	866 000	n/a	1 000 000	1 000 000	932 700
2000/2001	Apply the harvest control rule	650 000	n/a	1 110 000	1 090 000	1 071 300
2001/2002	Apply the harvest control rule	700 000	n/a	1 300 000	1 300 000	1 249 000
2002/2003	Apply the harvest control rule	690 000	—	1 000 000	1 000 000	987 700
2003/2004	Apply the harvest control rule	555 000	—	875 000	900 000	741 400
2004/2005	Apply the harvest control rule	335 000	n/a	985 000	985 000	784 000
2005/2006	Apply the harvest control rule	No fishery	0	238 000	235 000	247 000
2006/2007	Apply the harvest control rule	No fishery	n/a	385 000	385 000	376 800

Season	ICES advice	ICES initial TAC advice^	Intermediate TAC recommendation from MFRI – Iceland^^	Final TAC recommendation from MFRI - Iceland^^^	Agreed final TAC	ICES catch#
2007/2008	Apply the harvest control rule	207 000	—	207 000	207 000	203 400
2008/2009	Apply the harvest control rule	No fishery	0	0	0	15 100*
2009/2010	Apply the harvest control rule	No fishery	0	150 000	150 000	150 700
2010/2011	Apply the harvest control rule	No fishery	200 000	390 000	390 000	390 600
2011/2012	Set the TAC at 50% of the initial quota in the HCR	366 000	—	765 000	765 000	746 500
2012/2013	Precautionary approach	No fishery	300 000	570 000	570 000	551 000
2013/2014	Precautionary approach	No fishery	160 000	160 000***	160 000	141 700
2014/2015	Set the initial quota at 50% of the predicted quota in the harvest control rule	225 000	260 000	580 000	580 000	517 400
2015/2016	Precautionary approach**	53 600	44 000	173 000	173 000	173 600
2016/2017	Precautionary approach**	0	0	299 000	299 000	299 800
2017/2018	Harvest control rule agreed by Coastal States**	0	208 000	285 000	285 000	286 500
2018/2019	Harvest control rule agreed by Coastal States**	0	0	0	0	0
2019/2020	Harvest control rule agreed by Coastal States**	0	0	0	0	0

Season	ICES advice	ICES initial TAC advice^	Intermediate TAC recommendation from MFRI – Iceland^^	Final TAC recommendation from MFRI - Iceland^^^	Agreed final TAC	ICES catch#
2020/2021	Harvest control rule agreed by Coastal States**	169 520	0	127 300	127 300	130 225
2021/2022	Harvest control rule agreed by Coastal States**	400 000	904 200	869 600	869 600	688 780
2022/2023	Harvest control rule agreed by Coastal States**	400 000	218 400	459 800	459 800	449 552
2023/2024	Harvest control rule agreed by Coastal States**	0	0	0	0	0
2024/2025	Harvest control rule agreed by Coastal States**	0	0	—	—	—

^ Advised by ICES for the early part of the season based on the autumn survey conducted the year before the fishing season.
^^Intermediate TAC (missing for seasons prior to 1999/2000) recommended by Icelandic national scientists following the autumn survey conducted during the fishing season (July–March). From 2021 the fishing season starts 15 October.
^^^ Final TAC (missing for seasons prior to 1999/2000) recommended by Iceland national scientists following the winter survey conducted during the fishing season (July–March). From 2021, the fishing season starts 15 October.
# July–March of the following year. From 2021, the fishing season starts 15 October.
* Scientific fishing was allowed in the latter half of February 2009.
** Initial TAC advice, based on low probability of the advised catch being higher than the final TAC.
*** Intermediate TAC advice was used as final TAC advice due to unsuccessful winter surveys.
n/a = not available. In this case it represents incomplete surveys meaning intermediate TAC advice cannot be provided.