SAITHE - UFSI
Pollachius virens

GENERAL INFORMATION

Saithe (*Pollachius virens*) is a common fish species in Icelandic waters, with wide distribution and higher abundance on the southern and south-western part of the Icelandic shelf. Saithe is considered both demersal and pelagic with the optimum depth range between 150-300 m but can be found down to 450 m. Adult saithe prefers to dwell in the water column and also by various bottom structures, with no particular preference. Saithe forages by schooling behaviour in the water column and its diet indicates pelagic feeding. The most important prey species are capelin, krill, blue whiting, herring and sandeel. Changes in the distribution of pelagic stocks, can affect the propensity of saithe to migrate off shelf. The ideal sea temperature for saithe is around 4-12°C but it can also tolerate temperature down to 2°C.

Saithe spawns mainly in the warmer southern waters with the main spawning areas southwest of Iceland. It is believed that the spawning period for saithe on the main spawning grounds starts earlier (February-April), than for cod for example. Eggs are pelagic and west- and northward pelagic egg- and larval drift mainly occurs clockwise to the nursery grounds situated in the west and northern area. During mid-summer when saithe juveniles are around 3-5 cm in length, they can be found at very shallow depth in fjords, ports, and coves all around Iceland. At age 2-4 they move to deeper waters. Saithe becomes mature at age 4–7.

THE FISHERY

Spatial patterns of fishing activity and catch distribution shown in Figures 1 and 2 are produced from logbook data with 100% coverage of all the fleet since 2000.

In recent years, the distribution of saithe has, like for many other species, shifted to the north so large part of the fishing is conducted in the northwest (Figure 1 and 2). The saithe fishery on Icelandic grounds is almost entirely Icelandic, with small amounts reported by Faroese vessels. Cod is by far the most important demersal species in Iceland so much of demersal fisheries are aimed at cod, sometimes avoiding it, sometimes getting cod without too much bycatch and sometimes targeting certain mixture. In recent years approximately 90% of the saithe has been caught by bottom trawl (Figure 4) in mixed fisheries where the goal is often to get as much saithe as possible. The reason is that saithe is more difficult to catch than cod and the captains want to catch most of the cod late in a fishing trip and land it fresh. Trawlers that freeze the catch aboard catch relatively more saithe compared to cod than those that land the catch fresh. Gillnet used to be an important gear in the saithe fisheries but its share has decreased since 1995, mostly due to general reduction in gillnet fisheries (Figure 4, Table 1). At the same time, longline fisheries have increased but longliners do not catch much saithe.

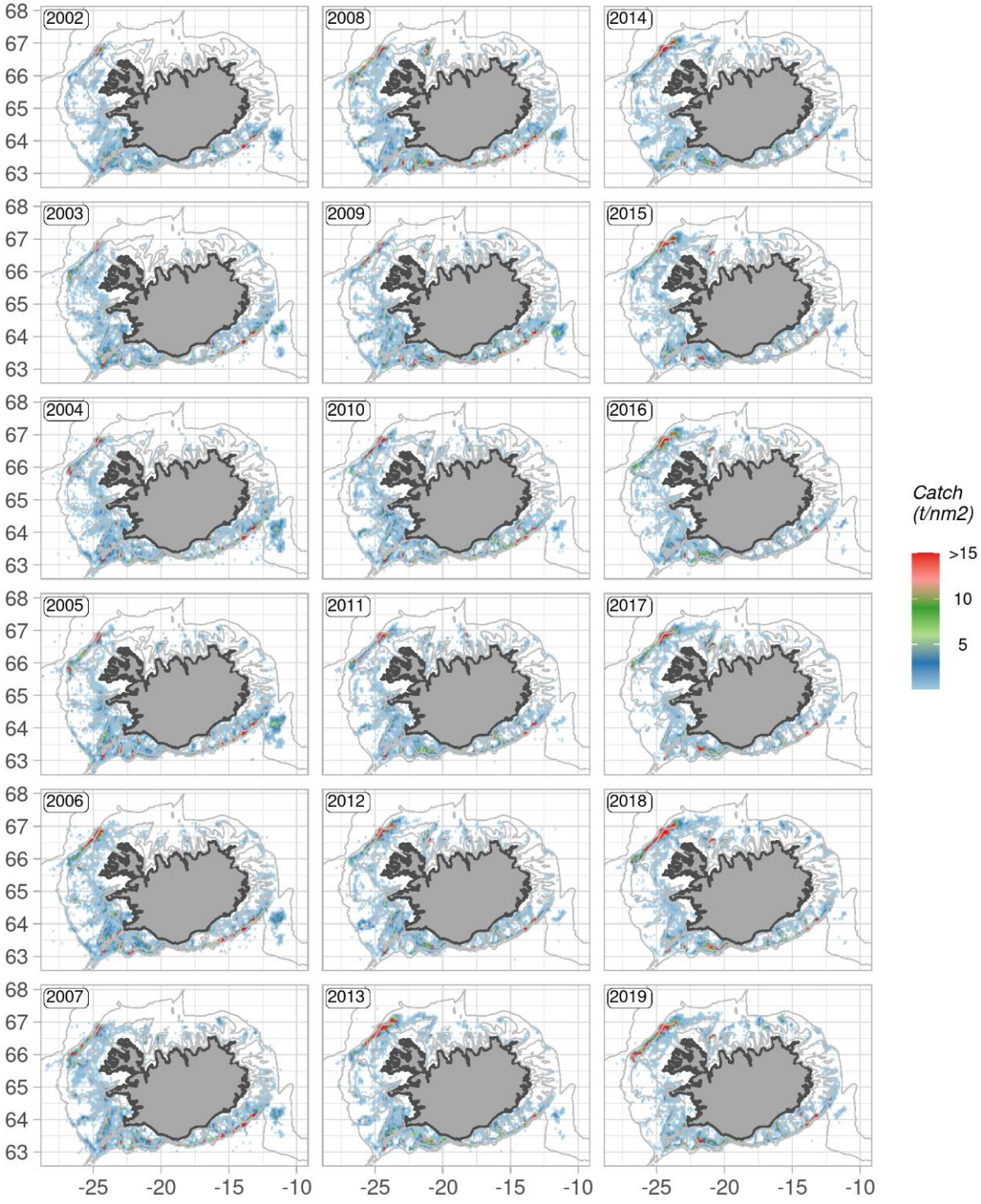

Figure 1. Saithe. Geographical distribution of the Icelandic fishery since 2002. Reported catch from logbooks. The 100, 200, and 500 m isobaths are shown.

Mynd 1. Ufsi. Útbreiðsla botnvörpuveiða á Íslandsmiðum frá 2002 samkvæmt afladagbókum. Sýndar eru 100, 200 og 500 m dýptarlínur.

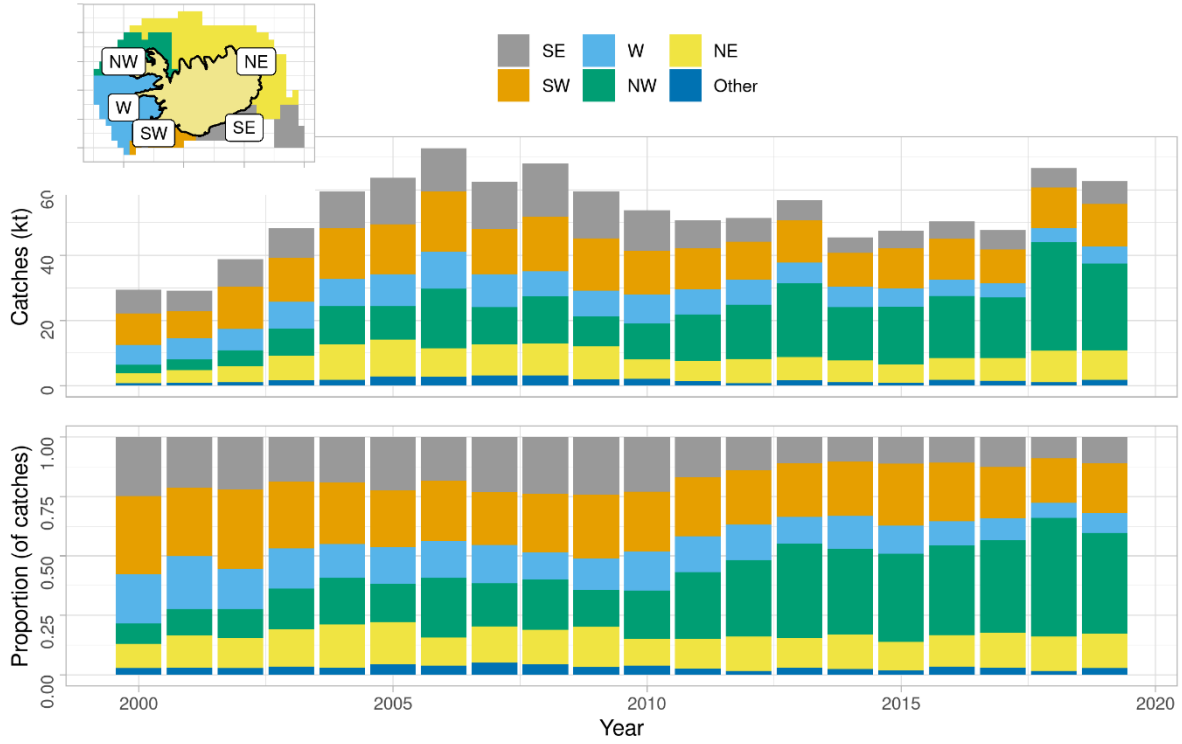

Figure 2. Saithe. Spatial distribution of the Icelandic fishery by fishing area since 2000 according to logbooks. All gears combined.

***Mynd 2. Ufsi.* Útbreiðsla veiða á íslensku veiðisvæði frá árinu 2000 samkvæmt aflaskýrslum. Öll veiðarfæri samanlagt.**

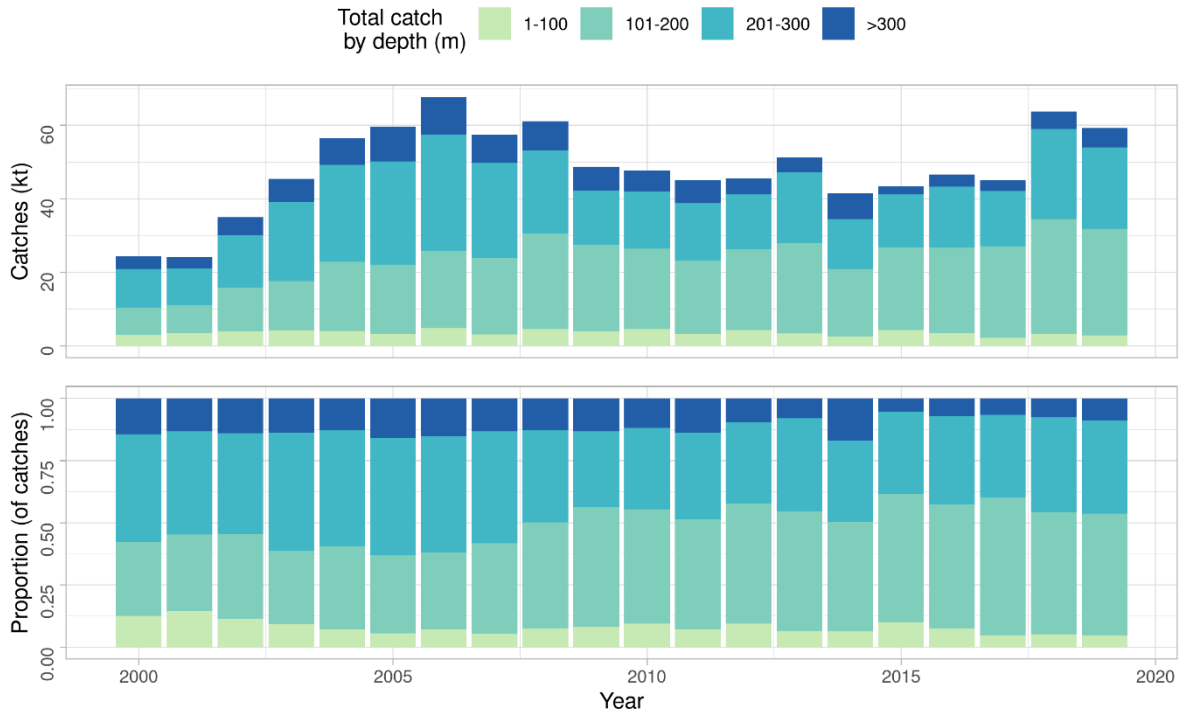

Figure 3. Saithe. Depth distribution of catches according to logbooks.

Mynd 3. Ufsi. Afli samkvæmt afladagbókum, skipt eftir dýpi.

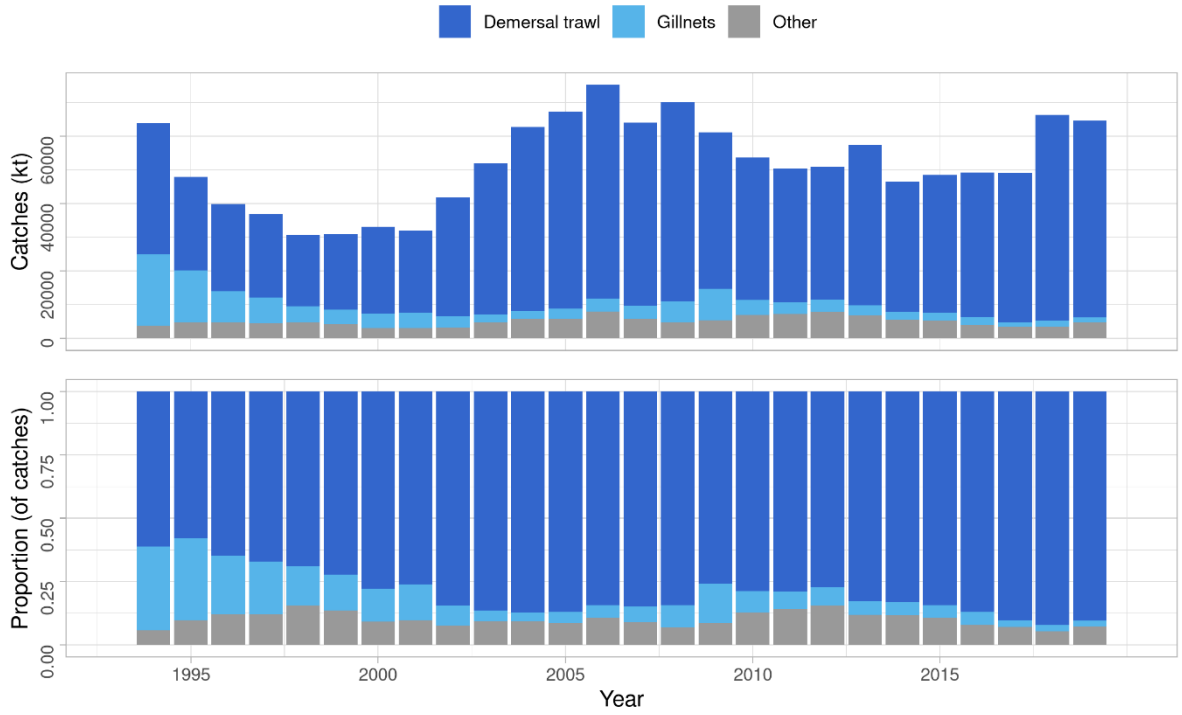

Figure 4. Saithe. Total catch (landings) by fishing gear since 1994, according to statistics from the Directorate of Fisheries.

Mynd 4. Ufsi. Landaður afli eftir veiðarfærum frá 1994, samkvæmt aflaskráningarkerfi Fiskistofu.

Since 1994, the number of vessels reporting catches over 10 tonnes of saithe in total annually, has decreased by more than a half and this decline is noticeable in both fleets (trawlers and gillnetters) (Table 1). Total catches on the other hand have increased steadily in the trawler fleet but declined in the gillnets to 1 thous. tonnes in 2019. Discards are illegal in Icelandic waters. Discarding of saithe estimated annually from 2001-2007 was hardly detectable ([1]). The tendency to discard saithe has been considered to be minimal as the saithe quota has often been difficult to catch. For the same reason incentive for misreporting is considered to be small. Saithe is occasionally found as bycatch in pelagic fisheries, mainly for blue whiting. In 2005-2008, 2010 and 2012 registered bycatch was 1000-2000 tonnes each year.

Table 1. Saithe. Number of Icelandic vessels landing catch of 10 tonnes or more of saithe, and all landed catch divided by gear type.

Tafla 1. Ufsi. Fjöldi íslenskra skipa sem landað hafa yfir 10 tonnum af ufsa og allur landaður afli eftir veiðarfærum.

	NUMBER OF VESSELS			CATCHES (THOUS. TONNES)			
YEAR	*Trawlers*	*Gill-netters*	*Other*	*Trawl*	*Gillnet*	*Other*	***Sum***
1994	115	130	63	39	21	4	**64**
1995	123	85	73	28	15	5	**48**
1996	107	85	67	26	9	5	**40**
1997	103	73	79	25	8	5	**37**
1998	109	68	92	21	5	5	**31**
1999	102	68	69	22	4	4	**31**
2000	102	62	48	26	4	3	**33**
2001	91	76	65	24	5	3	**32**
2002	85	59	65	36	3	3	**42**
2003	82	41	113	45	2	5	**52**
2004	90	44	129	55	2	6	**63**
2005	85	48	114	59	3	6	**67**
2006	81	48	166	63	4	8	**75**
2007	81	35	114	54	4	6	**64**
2008	72	31	125	59	6	5	**70**
2009	69	38	125	46	9	5	**61**
2010	67	30	151	42	5	7	**54**
2011	61	29	159	40	4	7	**50**
2012	65	31	140	39	4	8	**51**
2013	65	28	137	48	3	7	**58**
2014	59	22	102	39	2	6	**47**
2015	57	26	100	41	2	5	**49**
2016	58	25	78	43	3	4	**49**
2017	62	23	65	44	1	4	**49**
2018	62	17	66	61	2	6	**66**
2019	58	19	83	58	1	5	**65**

The number of vessels accounting for 95% of the annual catch of saithe in Icelandic waters reduced from almost 300 in 1998 to about 75 vessels in 2019 (Figure 5). The reduction in vessel numbers around year 2000 occurred in accordance with a decrease in annual catch, however in the last two decades the catch has been relatively stable between 50 and 70 thous. tonnes but the decrease was still noticeable (Figure 5).

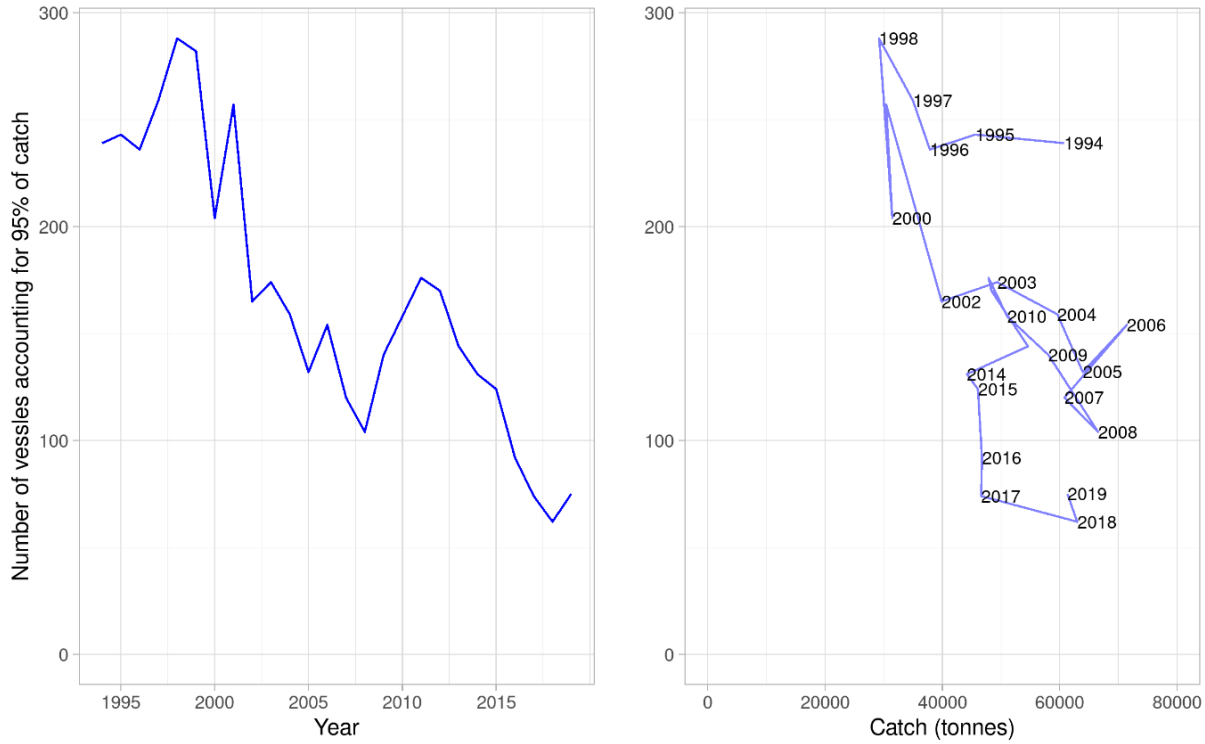

Figure 5. Saithe. Number of vessels (all gear types) accounting for 95% of the total catch annually since 1994. Left: Plotted against year. Right: Plotted against total catch. Data from the Directorate of Fisheries.

Mynd 5. Ufsi. Fjöldi skipa og báta (öll veiðarfæri) sem veiddu 95% heildaraflans hvert ár frá 1994. Vinstri: Sýnt eftir árum. Hægri: Sýnt í samanburði við heildarafla. Gögn frá aflaskráningarkerfi Fiskistofu.

CATCH PER UNIT EFFORT (CPUE) AND EFFORT.

CPUE estimates of saithe in Icelandic waters are not considered representative of stock abundance as changes in fleet composition and technical improvements among other things have not been accounted for when estimating CPUE.

Non-standardized estimates of CPUE of demersal trawl (kg/hour) in hauls where saithe is more than 10% of the catch, increased considerably since the lowest CPUE in 2000 with 400 kg/hour to the highest with approximately 1200 kg/hour in 2018 (Figure 6, left). In the last two years, the CPUE has declined slightly and was around 1050 kg/hour in 2019.

Total fishing effort (number of towing hours where saithe was more than 10% of the total catch) for saithe in demersal trawl increased between years 2001-2006 and around at highest 85 thous. tow-hours in 2006 (Figure 6). Since 2006 total fishing effort has declined and was around 50 thous. tow-hours in 2019.

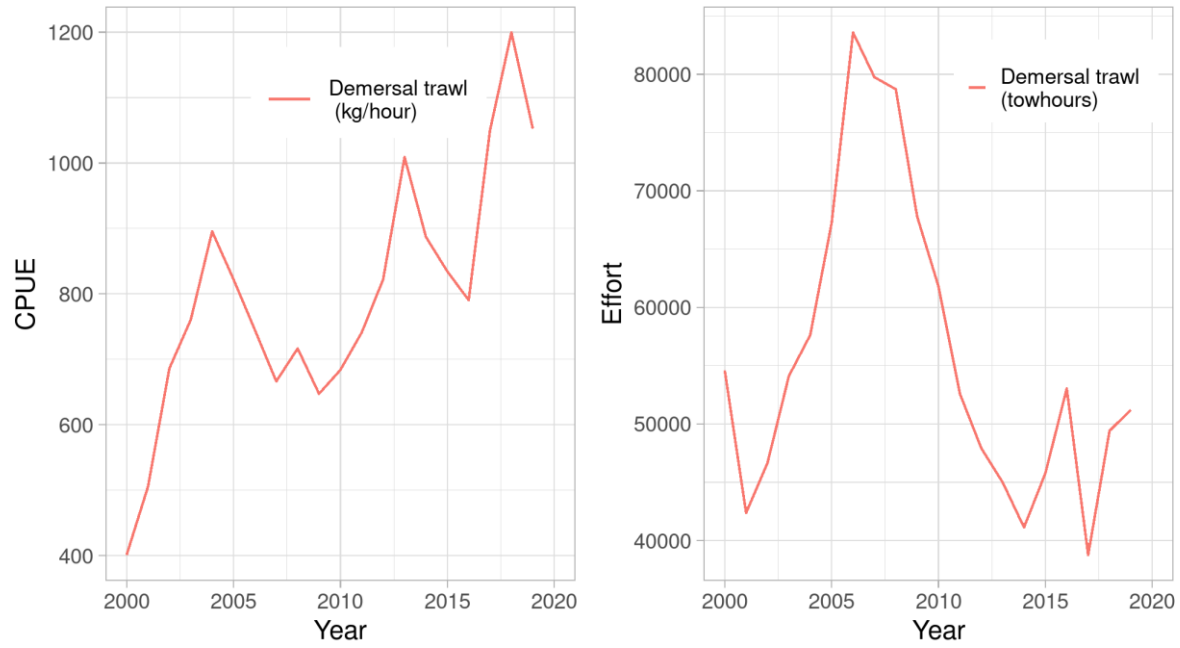

Figure 6. Saithe. Non-standardised estimates of CPUE (left) from demersal trawl (kg/h). Fishing effort (right) for demersal trawl (tow-hours).

Mynd 6. Ufsi. Afli á sóknareiningu (vinstri) í botnvörpu (kg/togtími). Sókn (hægri) með botnvörpu (togtímar).

AGE DISTRIBUTION OF LANDED SAITHE

Table 2 shows the number of otoliths samples and number of age reading in 2010-2019 divided by gear type and Figure 7 shows the location of otoliths sampling in 2019.

Table 2. Saithe. Number of samples and aged otoliths from landed catch.

Tafla 2. Ufsi. Fjöldi sýna og aldursgreindra fiska úr lönduðum afla.

	DEMERSAL TRAWL		GILLNET	
YEAR	*Samples*	*Otoliths*	*Samples*	*Otoliths*
2010	189	5128	11	550
2011	117	4706	6	299
2012	247	6294	9	402
2013	185	3993	9	449
2014	179	2513	9	250
2015	106	2426	15	375
2016	120	2565	12	300
2017	112	1541	6	82
2018	63	1659	3	75
2019	51	1270	0	0

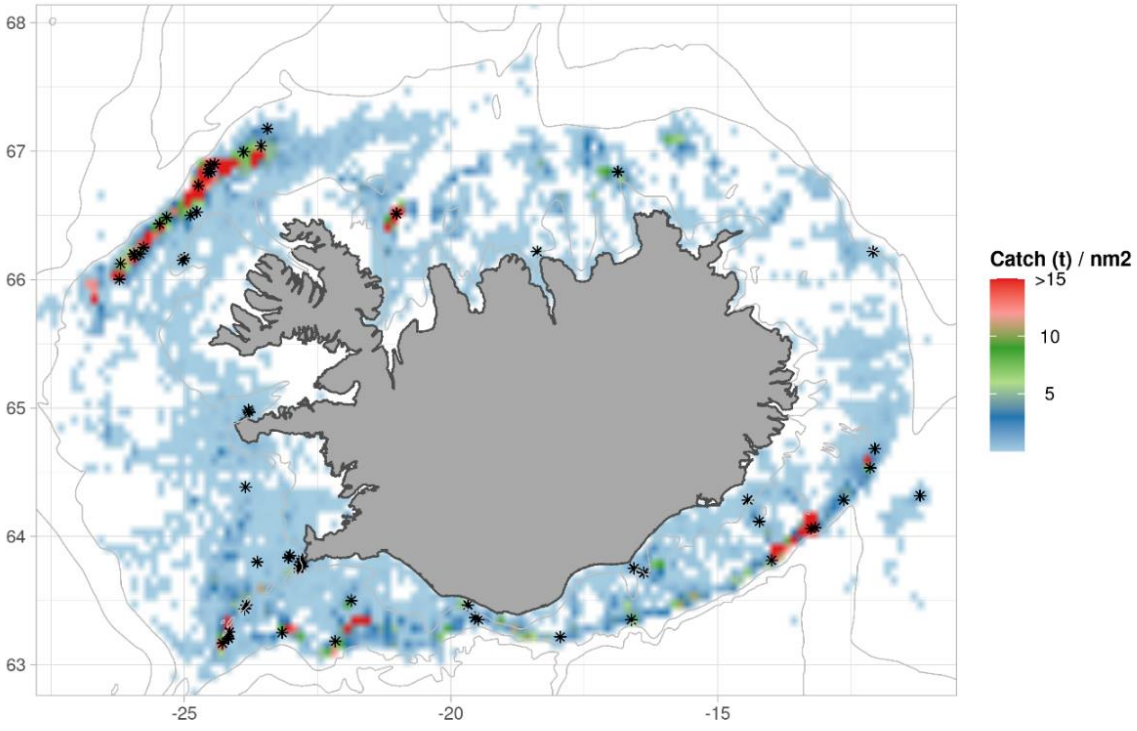

Figure 7. Saithe. Fishing grounds in 2019 as reported in logbooks and positions of samples taken from landings (asterisks).

Mynd 7. Ufsi. Veiðisvæði við Ísland árið 2019 samkvæmt afladagbókum og staðsetningar sýna úr lönduðum afla (stjörnur).

LENGTH COMPOSITIONS OF LANDED SAITHE

The length measurements of saithe from the main fleet segments are shown in Figure 8. The length distribution caught in the main gear, demersal trawl is rather stable between 50-90 cm and since 2010 more or less between 50-75 cm. Saithe caught in gillnets is generally larger, about 75-110 cm. The number of measurements available fluctuates in relation to changes in the fleet composition.

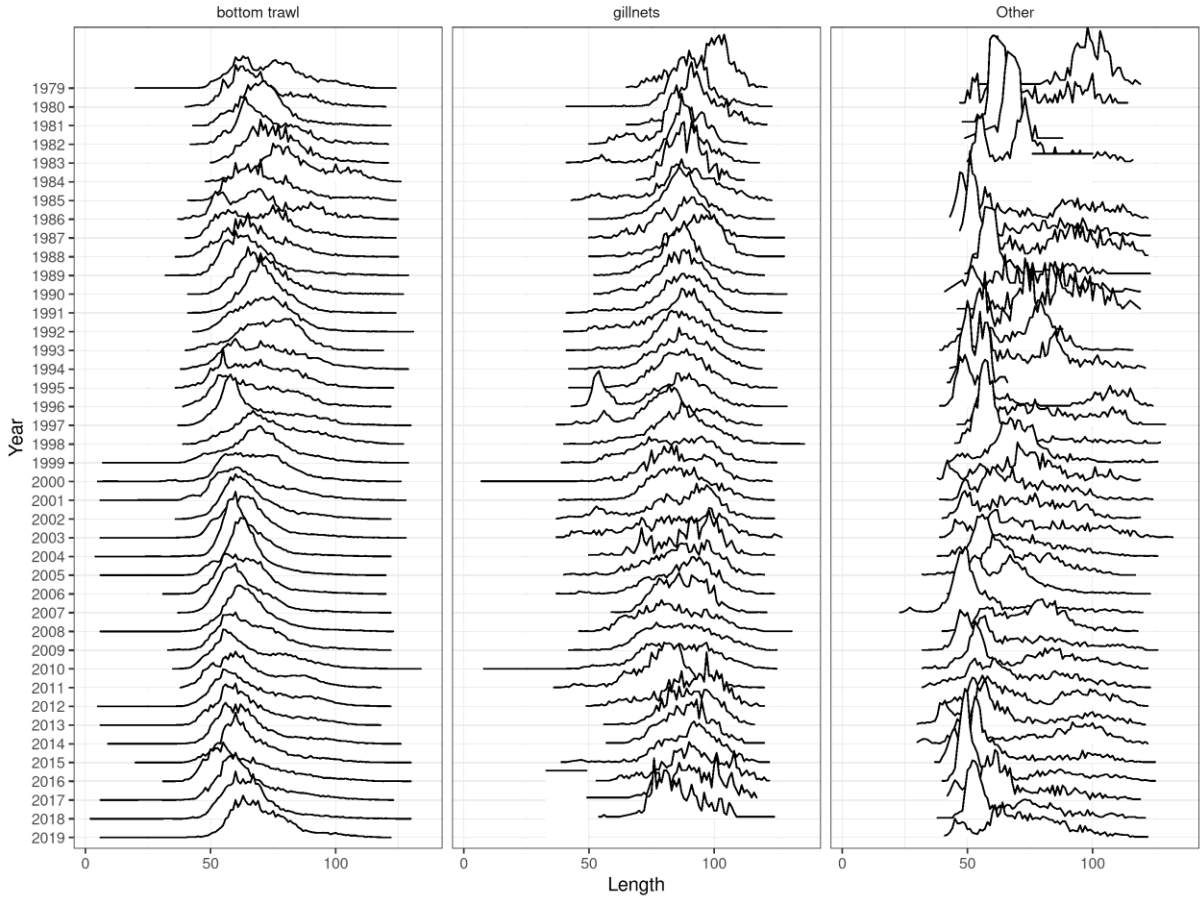

Figure 8. Saithe. Length distribution from landed catch divided by gear and year.

Mynd 8. Ufsi. Lengdardreifing úr afla skipt eftir helstum veiðarfærum og árum.

SURVEY DATA

The Icelandic spring groundfish survey (hereafter spring survey) has been conducted annually in March since 1985. In addition, the Icelandic autumn groundfish survey (hereafter autumn survey) was commenced in 1996. The spring survey focuses on depths shallower than 500 m and has a relatively dense station-net on the shelf (approximately 560 stations). The autumn survey has around 380 stations but also covers a much larger area including depths to below 1000 m and is also designed to cover Greenland halibut and S. *mentella*. As a result, the distance between the stations is considerably greater than in the March survey. Saithe is found in the autumn survey at stations deep south of Iceland added in 2000 so those stations have to be excluded if the survey since 1996 is used as a time series. Compared to the autumn survey, the spring survey has larger number of stations (lower CV) and a longer time series.

Figure 9 shows various biomass indices and a recruitment index based on abundance of saithe. Survey length-disaggregated abundance indices are shown in Figures 10-11, and spatial distribution in Figures 13-15.

Saithe is among the most difficult demersal fishes to get reliable information from demersal trawl surveys. In the spring survey, which has 500–600 stations, a large proportion of the saithe is caught in relatively few hauls and there seems to be considerable inter-annual variability in the number of these hauls (Figures 14). The biomass indices from the spring survey (Figure 14) fluctuated greatly in 1985–1995 but were consistently low from 1995–2001. Since 1995 the indices have been variable but compared to the period 1985–1995 the variability seems "real" rather than noise. This difference is also seen by the estimated confidence intervals of the indices that are smaller after 1995. In 2018, the indices were the highest in the series and had tripled since 2014. Most of the increase was caused by the 2012 year class that was strong in the surveys 2015–2018. The biomass index from the March survey shows lower index in 2020 than in recent years (Figure 8.12). Similar reduction in survey biomass has been seen before. The biomass indices from the autumn survey follow the trends of the spring survey with occasional outliers.

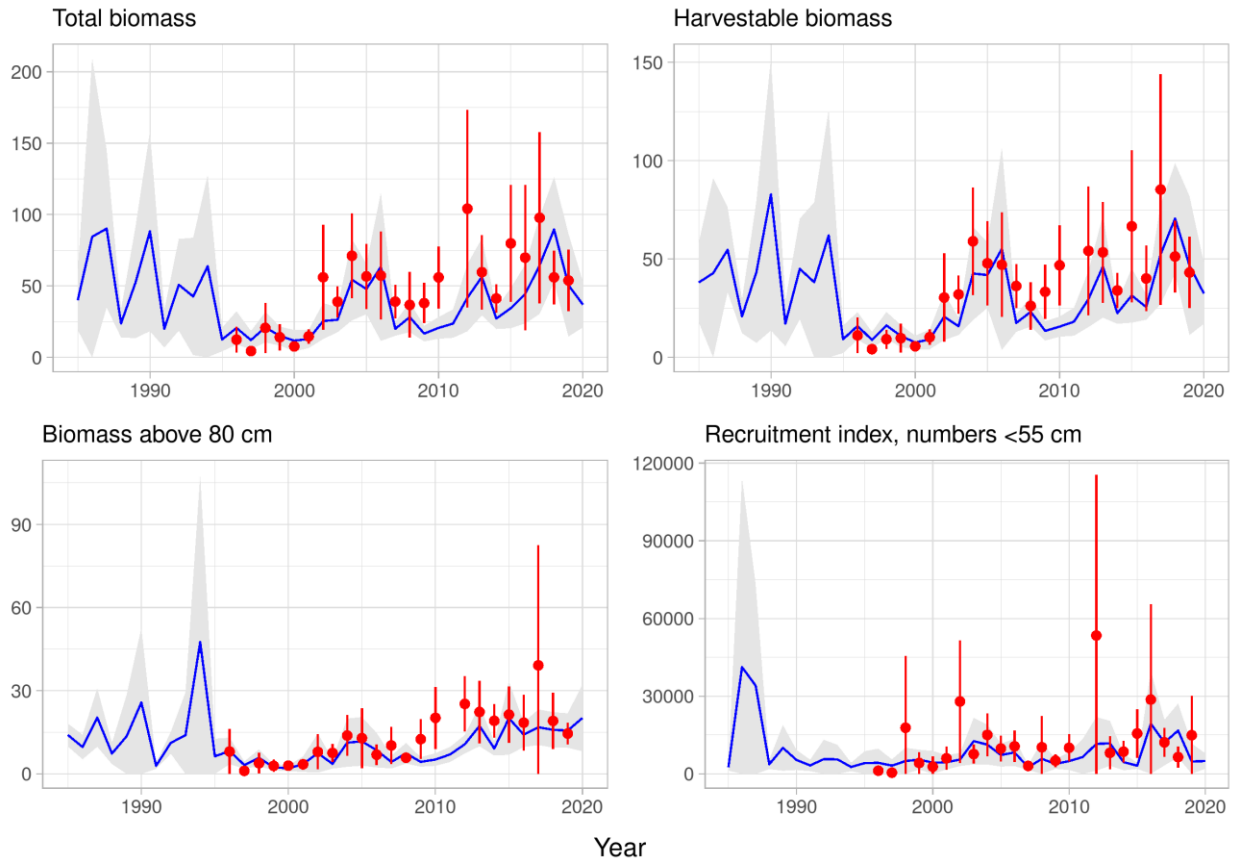

Figure 9. Saithe. Total biomass indices (upper left) and harvestable biomass indices (≥55 cm) (upper, right), biomass indices of larger ind. (≥80 cm) (lower left) and juvenile abundance indices (≤55 cm) (lower right) from the spring survey (blue) from 1985 and autumn survey (red) from 1996, with 95% CI.

Mynd 9. Ufsi. Stofnvísitala (efri til vinstri), vísitala veiðistofns (55 cm og stærri, efri til hægri) og vísitala stærri einstaklinga (80 cm og stærri, neðri til vinstri) og nýliðunarvísitala (≤55 cm, neðri til hægri), úr stofnmælingu botnfiska að vori (blátt) frá árinu 1985 og hausti (rautt) frá árinu 1996, ásamt 95 % öryggismörkum.

Length distribution of saithe in both surveys is not characterised by any particular pattern as the saithe catch is rather sporadic event. However, the distinction between the year-classes is noticeable.

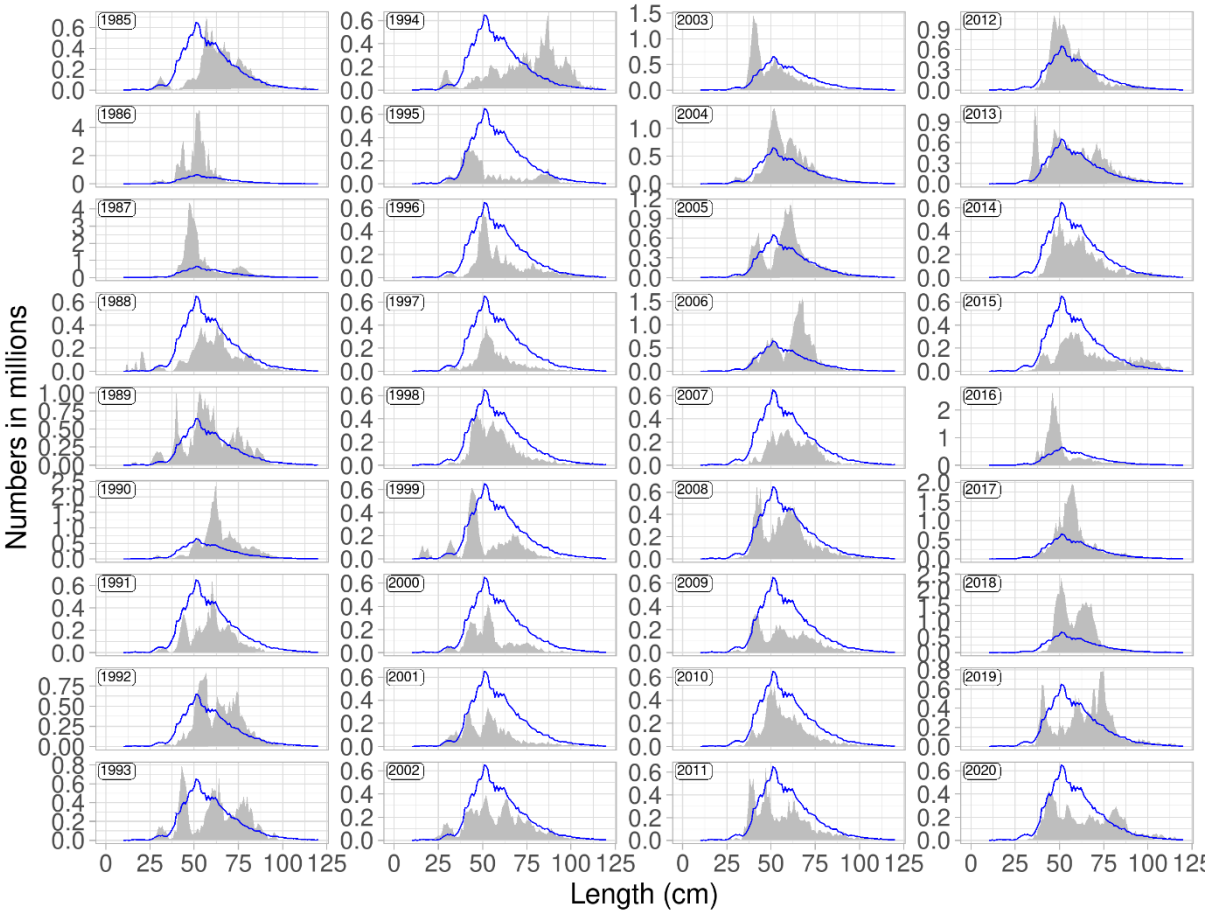

Figure 10. Saithe. Length-disaggregated abundance indices from the spring survey. The blue line shows the mean for all years. Note different scale on y-axes.

Mynd 10. Ufsi. Lengdarskiptar vísitölur úr stofnmælingu botnfiska að vori frá 1985 ásamt meðaltali allra ára (blá lína). Ath. mismunandi skali á y-ásum.

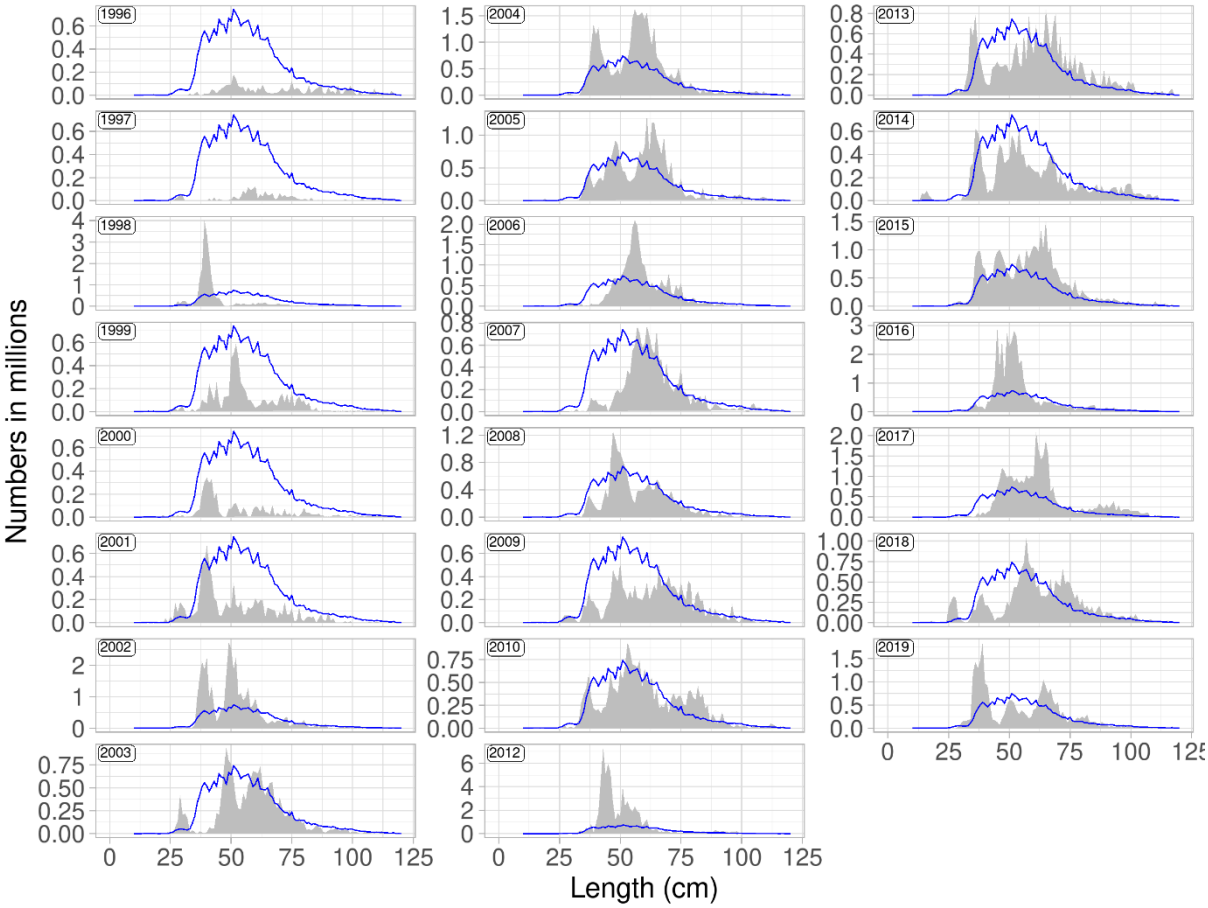

Figure 11. Saithe. Length-disaggregated abundance indices from the autumn survey. The blue line shows the mean for all years. Note different scale on y-axes.

Mynd 11. Ufsi. Lengdarskiptar vísitölur úr stofnmælingu botnfiska að hausti frá 1996 ásamt meðaltali allra ára (blá lína). Ath. mismunandi skali á y-ásum.

Saithe in the spring survey in 2020 was mostly caught at the continental slope in the NW and SE and at the spawning grounds to the south (Figure 12). Spatial distribution of the total biomass index of the catch in the spring survey, shows that the W and recently NW areas are dominating in almost all years (Figure 13). However, the spatial distribution of saithe in both surveys is to some degree unpredictable.

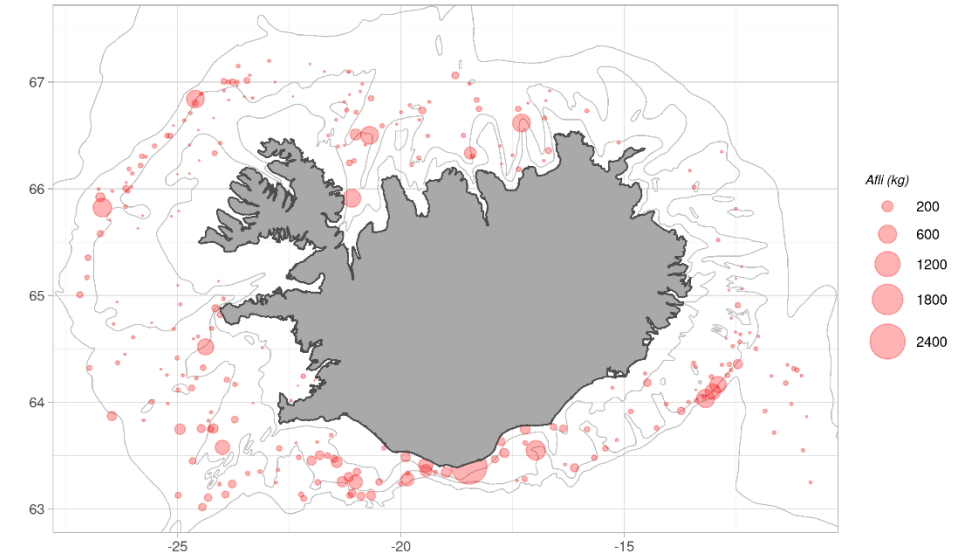

Figure 12. Saithe. Spatial distribution in the spring survey in 2020. The 100, 200 and 500 m isobaths are shown.

Mynd 12. Ufsi. Útbreiðsla í stofnmælingu botnfiska að vori 2020. Sýndar eru 100, 200 og 500 m dýptarlínur. sýndar.

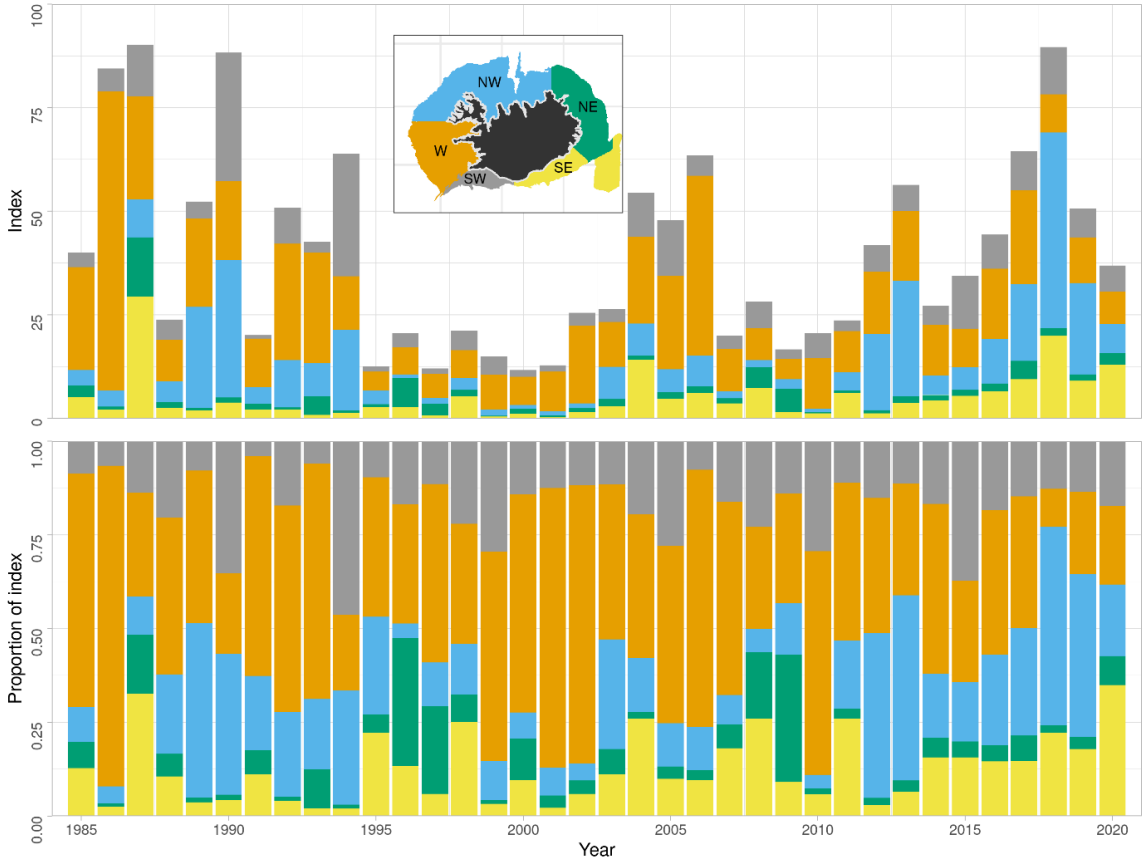

Figure 13. Saithe. Spatial distribution of biomass index from the spring survey.

Mynd 13. Ufsi. Dreifing lífmassavísitölu í stofnmælingu botnfiska að vori.

Spatial distribution of saithe in the autumn survey in 2019 was all around Icelandic shelf except of the NE area (Figure 14). The W and NW areas have dominated in catch distribution in most recent years (Figures 15).

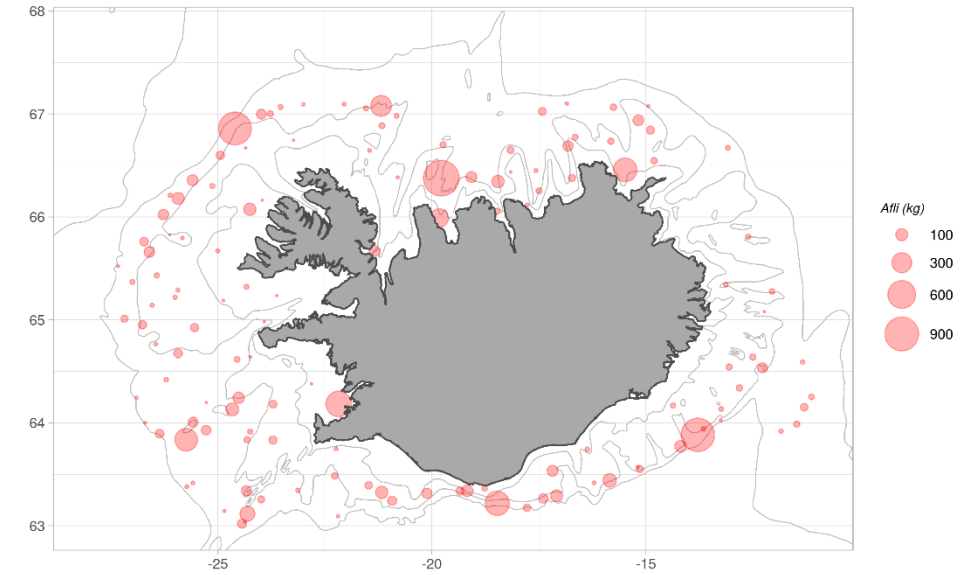

Figure 14. Saithe. Spatial distribution in the autumn survey in 2019. The 100, 200 and 500 m isobaths are shown.
Mynd 14. Ufsi. Útbreiðsla í stofnmælingu botnfiska að hausti árið 2019. Sýndar eru 100, 200 og 500 m dýptarlínur.

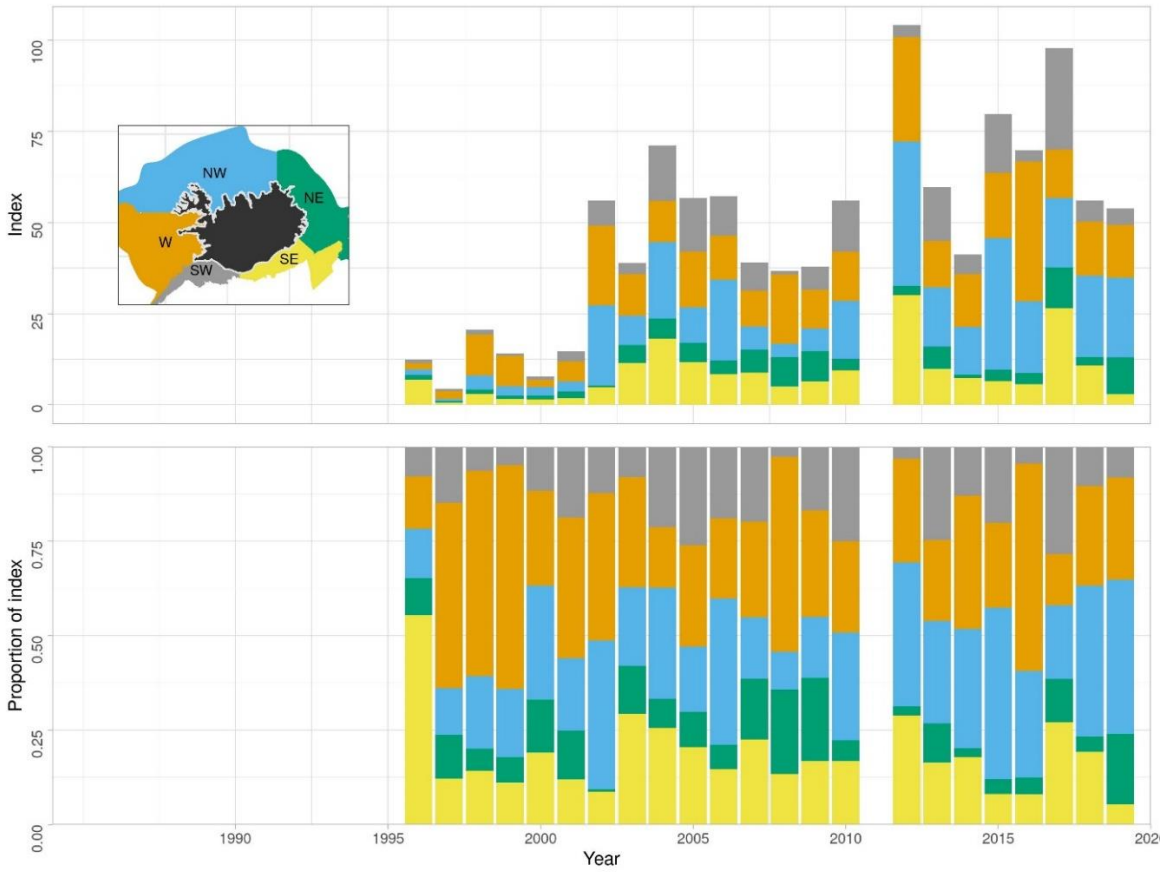

Figure 15. Saithe. Spatial distribution of biomass index from the autumn survey.

Mynd 15. Ufsi. Dreifing lífmassavísitölu í stofnmælingu botnfiska að hausti.

STOCK ASSESSMENT

Assessment of Icelandic saithe was benchmarked in 2010 and management plan for the stock was adopted in 2013 after being evaluated by ICES. Reference points were evaluated by the North Western Working group in 2016. Both the assessment and the management plan evaluation were in 2019 done using the same model (Muppet) which is in principle a separable stock assessment/prediction model. The goal was to review the assessment methodology and management plan and continue using them if they were still accepted by ICES.

The input data are catch at age 3-14 and spring survey age-disaggregated indices age 2-10. Selection pattern is estimated separately for predefined periods. For Icelandic saithe, the periods are 1980-1996, 1997-2003 and 2004 onwards. The first change in selection is in a period where gillnet fisheries that target the largest fish decreased while the second change in selection was when increased targeting of young fish was noticed. Allowing for change in selection is somewhat delayed process, change in selection requires few years of pattern in catch residuals. Residuals from the survey each year are modelled by an 1st order AR model with ρ estimated and what is minimized is

$$\frac{\log(I+\epsilon)}{\log(\widehat{I+\epsilon})}$$

where ϵ is a value of the index corresponding to 2-4 otoliths, used to reduce weight of low values.

Observed survey biomass shows more contrast than predicted survey biomass (Figure 16). Large discrepancy can be seen in 2018 where observed biomass is twice the predicted one, but similar or larger discrepancies can be seen historically. The figure shows better relationship after 1995 than before. Survey biomass is here a derived number as the tuning is done with log residuals by age.

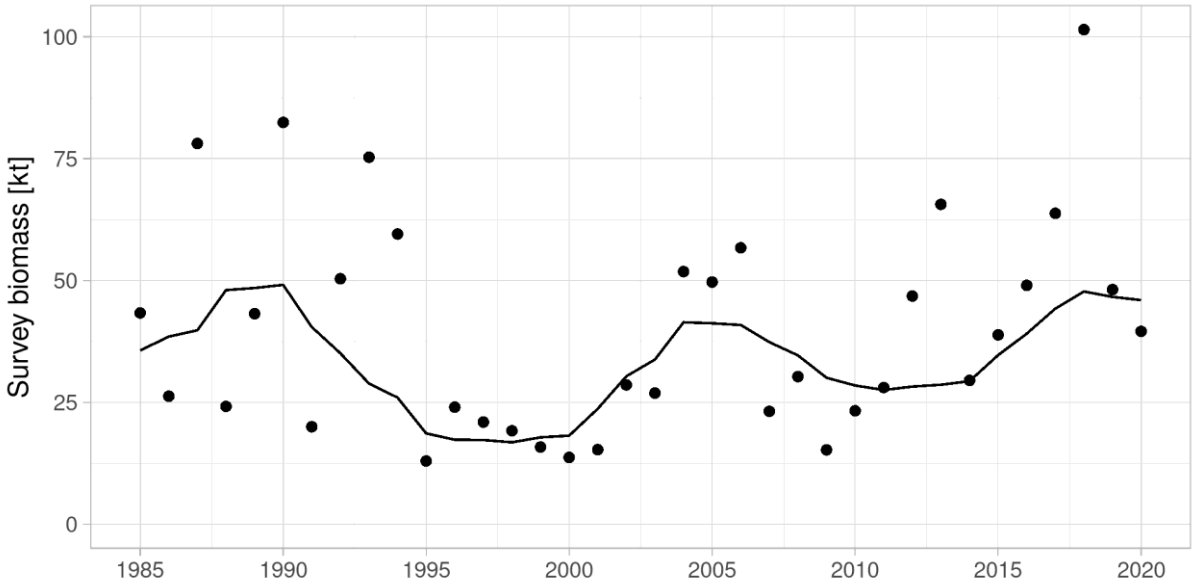

Figure 16. Saithe. Observed aggregated age-based survey indices (point) and modelled indices (lines) for the spring survey.

Survey residuals (Figure 17) clearly show the tendency for positive and negative blocks. The negative blocks occur in years where no large school of saithe is encountered in the survey. Correlation between age groups in the survey is modelled by 1st order AR model but the residuals shown are the input to the AR model. The estimated value of for the survey residuals is 0.56 in the 2019 assessment.

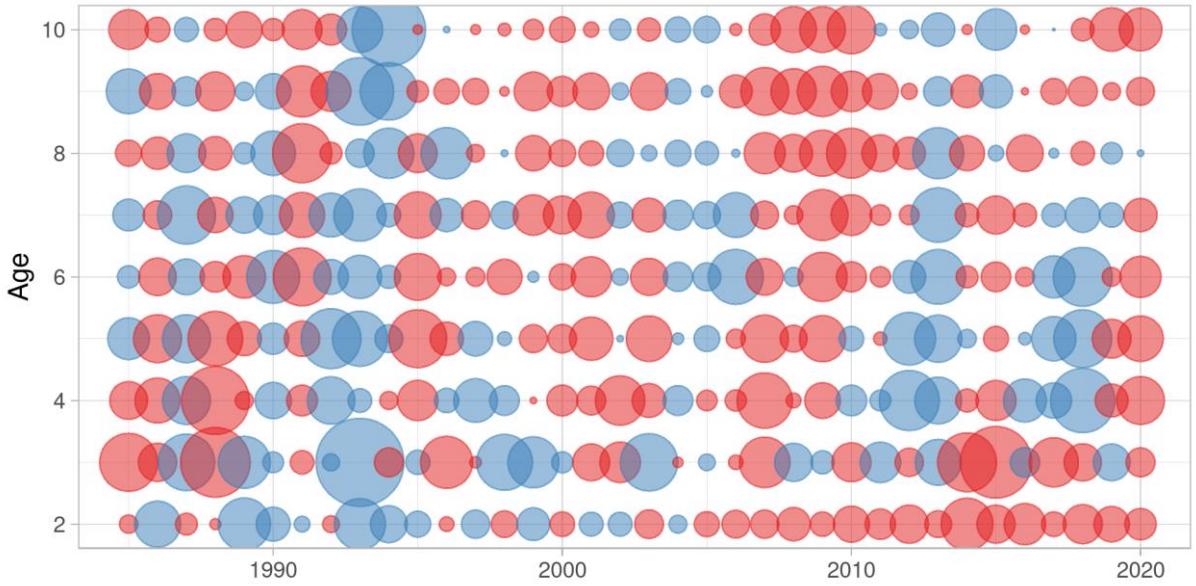

Figure 17. Saithe. Residual from the model fit to the abundance indices (SMB) by year and age (blue – measured values above the model fit, red – measured values below the model fit.

Selection by period demonstrates considerable difference between 2004-2019 and the other periods, that are similar (Figure 18). Catch residuals indicate that there might be some change in selection in recent decade with less fish caught of ages 3 and 4 (Figure 19).

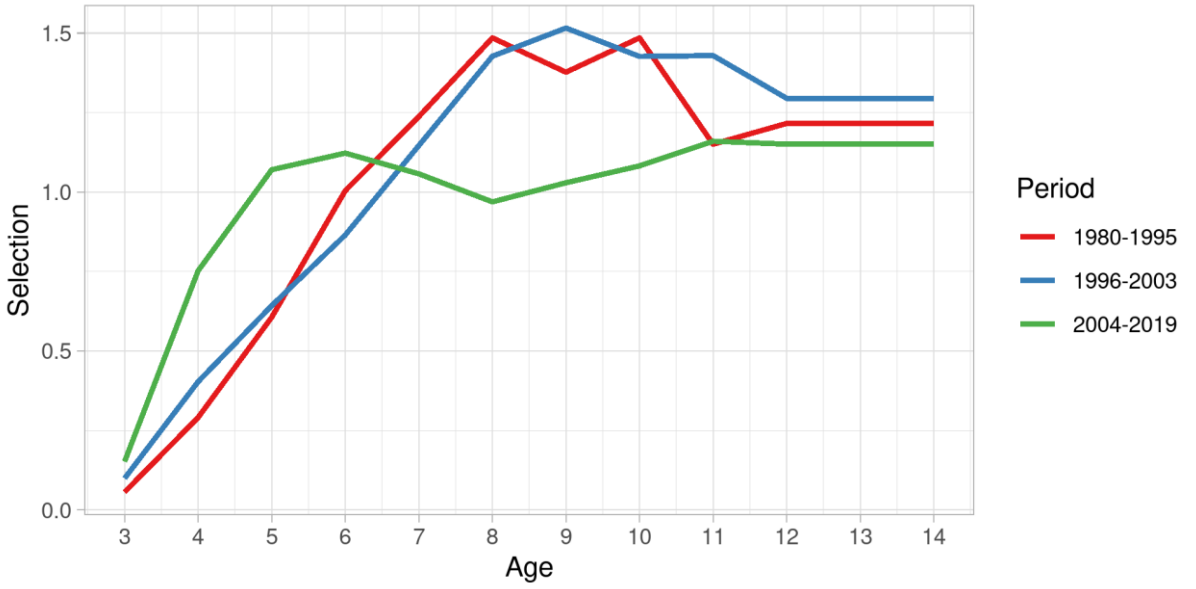

Figure 18. Saithe. Selection at age for the 3 periods 1980-1995, 1996-2003 and 2004 -2016.

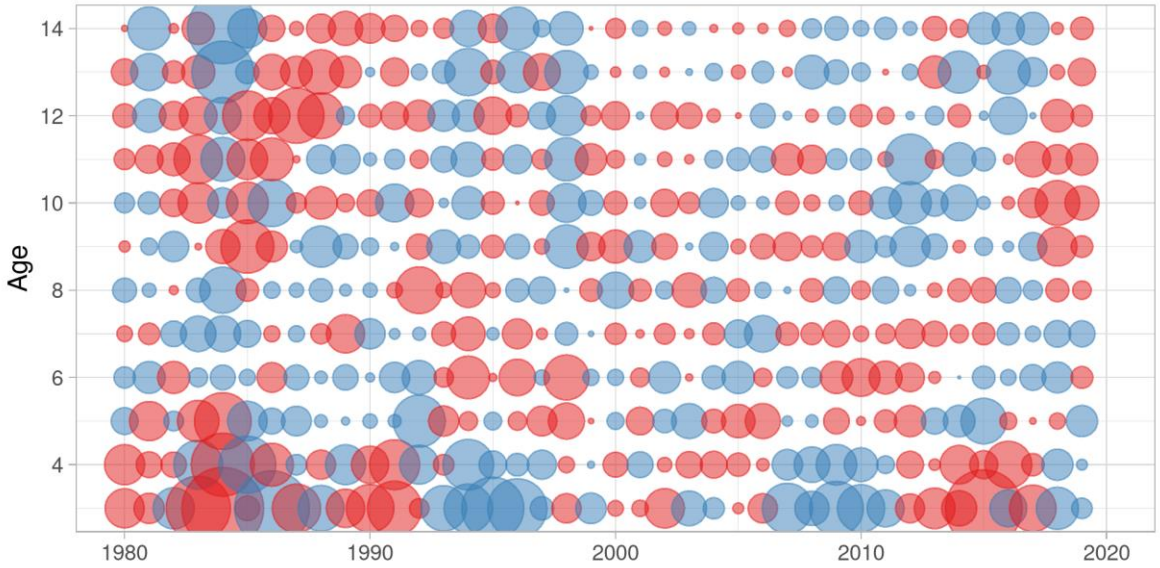

Figure 19. Saithe. Residual from the model of the catch at age (blue: measured values above the model fit, red: measured values below the model fit.

The spawning-stock biomass (SSB) is currently at the time-series maximum (Figure 20). The harvest rate has declined from 2009 and is presently estimated below HR_{MGT}. Recruitment in the last decade has been high. The reference biomass has increased since 2015 due to the large 2012 yearclass. Yearclasses 2013 and 2014 are estimated to be above average but yearclass 2015 small. The reference biomass in 2020 is estimated to be 382 268 tonnes.

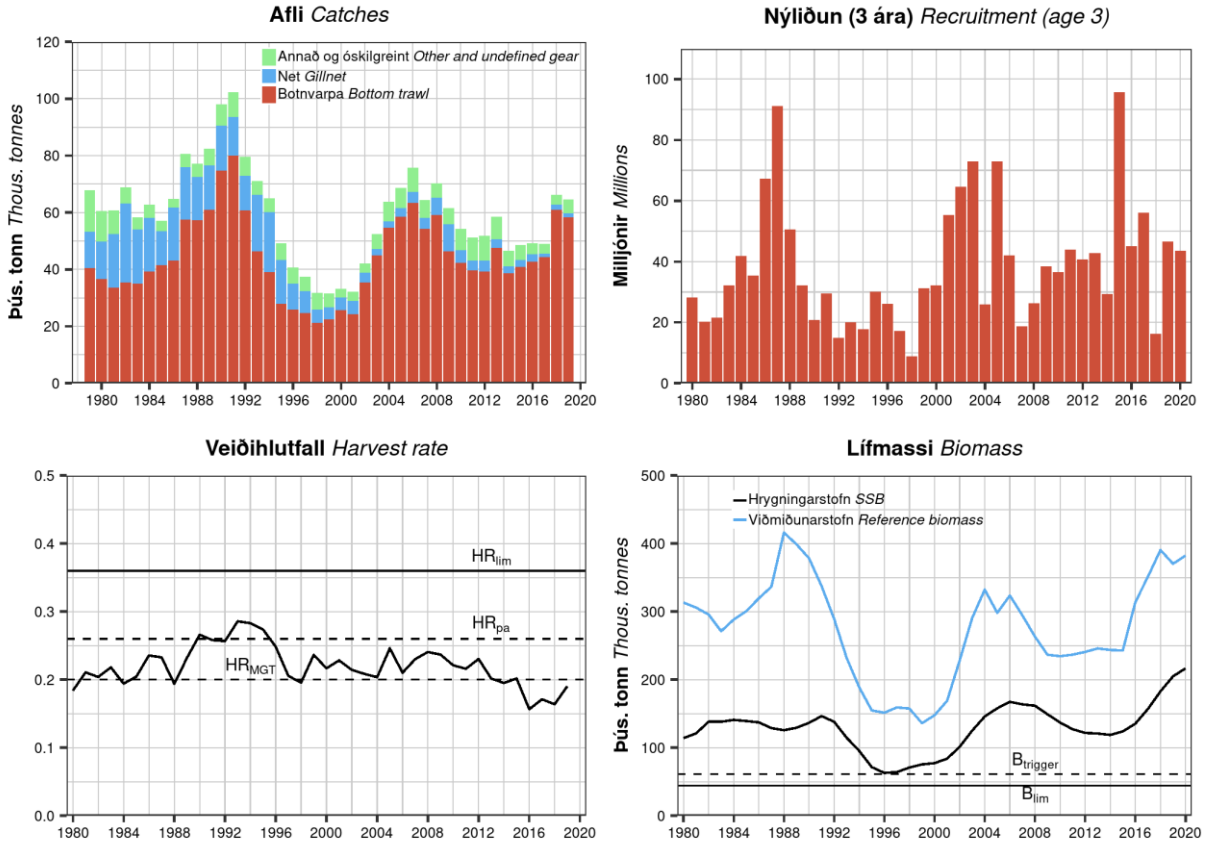

Figure 20. Saithe. Stock summary plot. Catch, recruitment, fishing mortality and harvest rate, reference stock biomass (B4+) and spawning stock biomass (SSB).

MANAGEMENT

The Ministry of Industries and Innovation is responsible for management of the Icelandic fisheries and implementation of legislation. Saithe was included in the ITQ system in 1991. A formal harvest rule was adopted in 2013 and the TAC being set according to that since the fishing year 2013/2014.

The current management plan is:

If $SSB_{y} \geq B_{trigger}$

$$Tac_{y/y+1} = \frac{Tac_{y-1/y} + 0.2 \times B_{4+,y}}{2} \quad (1)$$

If $SSB_{y} \leq B_{trigger}$

$$Tac_{y/y+1} = \alpha \times Tac_{y-1/y} + (1-\alpha) \times \frac{SSB_{y}}{B_{trigger}} \times 0.2 \times B_{4+,y} \quad (2)$$

$$\alpha = 0.5 \times \frac{SSB_{y}}{B_{trigger}} \quad (3)$$

Where $Tac_{y/y+1}$ is the TAC for the fishing year starting 1 September in year y ending 31 August in year $y+1$. $B_{4+,y}$ the biomass of age 4 and older in the beginning of the assessment year compiled from catch weights. The latter equation shows that the weight of the last years Tac does gradually reduce from 0.5 to 0.0 when estimated SSB changes from $B_{trigger}$ to 0.

This rule has been evaluated by ICES to be in conformity with the precautionary approach. A historical overview of the advice, the set TAC and the catches are provided in table 6. In recent years the fleet has not caught the TAC (Table 6).

Table 6. Saithe. Advice, recommended TAC, National TAC set by the Ministry, and landings (tonnes).

Tafla 6. Ufsi. Tillögur Hafrannsóknastofnunar um hámarksafla, ákvörðun stjórnvalda um aflamark og landaður afli (tonn).

FISHING YEAR	ICES ADVICE	REC. TAC	NATIONAL TAC	ICELANDIC CATCH
1991/92	TAC	75000	75000	86000
1992/93	No measurable gains from increase in F	80000	92000	76000
1993/94	No measurable gains from increase in F	75000	85000	67000
1994/95	No measurable gains from increase in F	70000	75000	50000
1995/96	No measurable gains from increase in F	65000	70000	40000
1996/97	No measurable gains from increase in F	50000	50000	37000
1997/98	F below F_{med} = 0.23	30000	30000	32000
1998/99	F below 60% of F(97)	30000	30000	31000
1999/00	F below 60% of F(98)	25000	30000	30000
2000/01	F = 70% of F(99)	25000	30000	32000
2001/02	No directed fishing	25000	37000	36000
2002/03	2/3 F_{pa} to rebuild stock	35000	45000	47000
2003/04	No advice	50000	50000	56000
2004/05	F_{pa}	70000	70000	70000
2005/06	F_{pa}	80000	80000	78000
2006/07	F_{pa}	80000	80000	66000
2007/08	No advice	60000	75000	68000
2008/09	Maintain SSB > B_{pa}	50000	65000	62000
2009/10	F reduced below 0.22	35000	50000	58000
2010/11	F_{MSY}	40000	50000	51600
2011/12	F_{MSY}	45000	52000	49700
2012/13	MSY framework [B-rule]	49000	50000	51300
2013/14	Management plan	20% HCR (57000)[1)]	57000	54300
2014/15	Management plan	20% HCR (58000)	58000	52100
2015/16	Management plan	20% HCR (55000)	55000	48900
2016/17	Management plan	20% HCR (55000)	55000	48800
2017/18	Management plan	20% HCR (60237)	60237	58748
2018/19	Management plan	20% HCR (79092)	79092	70150
2019/20	Management plan	20% HCR (80588)	80588	

1) Amended harvest control rule (HCR).

Figure 21 shows the net transfers of saithe quota in the Icelandic ITQ-system (Figure 16). Part of the unused TAC is transferred to other species, but part is unused (Figure 6). The reason for the unused quota is limitation in how much quota a company can transfer between species and that catching the saithe is not considered profitable. The price of saithe is low (approximately 1/3 of price of cod) so catch rates have to be reasonable to make the fisheries profitable. The constraint of wanting little bycatch of cod might also have an effect.

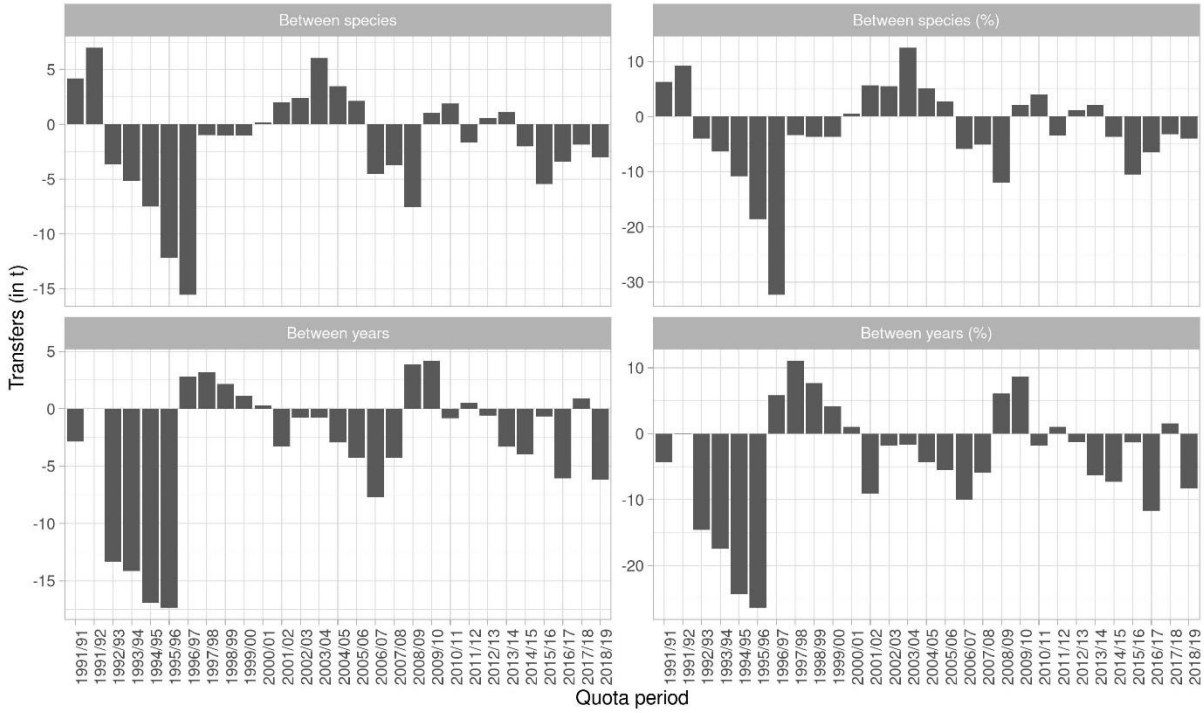

Figure 16. Saithe. Net transfers of quota to and from saithe in the Icelandic ITQ system by quota year. Between species (upper): Positive values indicate a transfer of other species to saithe, but negative values indicate a transfer of saithe quota to other species. Between years (lower): Net transfer of quota for a given quota year.

Mynd 16. Ufsi. Nettó tilfærsla á kvóta eftir fiskveiðiárum. Tilfærsla milli tegunda (efri myndir): Jákvæð gildi tákna tilfærslu á kvóta annarra tegunda yfir á ufsa en neikvæð gildi tilfærslu ufsakvóta á aðrar tegundir. Tilfærsla milli ára (neðri myndir): Nettó tilfærsla kvóta á viðkomandi fiskveiðiár.

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