to the mid-1980s when overall stock size was also relatively large. The vast majority of the stock is found in waters shallower than 93 m in both seasons.

Recruitment: Total numbers of juveniles (<22 cm) from spring and autumn surveys by Canada and spring surveys by EU-Spain are given in Figure 12.4 scaled to each series mean. High catches of juveniles seen in the autumn of 2004 and 2005 were not evident in either the Canadian or EU-Spain spring series. No clear trend in recruitment is evident, although since 2007, the number of small fish in several Canadian surveys has been above average. The spring survey by EU-Spain has shown lower than average numbers of small fish since 2007.

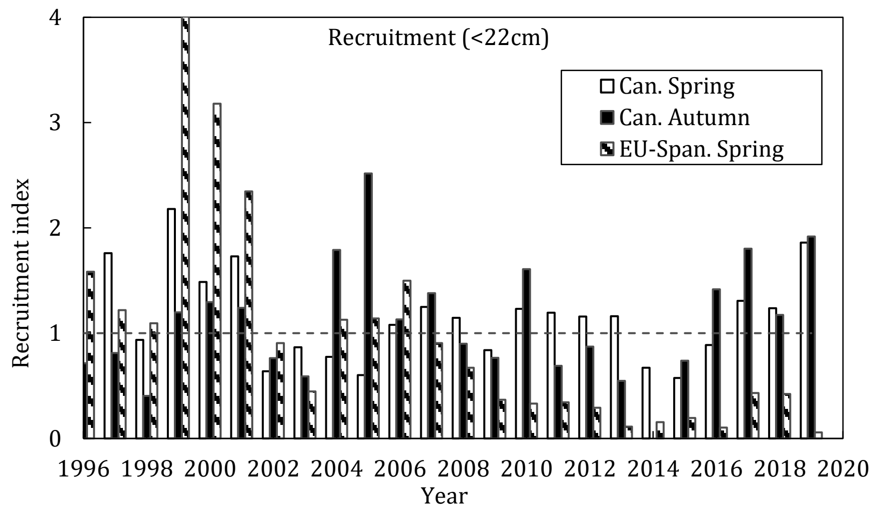

Figure 12.4. Yellowtail flounder **in Divs. 3LNO**: Juvenile abundance indices from spring and autumn surveys by Canada (Can.) and spring surveys by EU-Spain. Each series is scaled to its mean (horizontal line).

c) Conclusion

The most recent (2018) analytical assessment using a Bayesian stock production model concluded that the stock size has steadily increased since 1994 and is presently 1.5 times B_{msy} (B_{msy}=87 630 tonnes). There is very low risk (<1%) of the stock being below B_{msy} or F being above F_{msy}. Overall, the 2019 survey indices are not considered to indicate a significant change in the status of the stock.

The next full assessment of this stock is planned for 2021.

13. Witch Flounder (*Glyptocephalus cynoglossus*) in Divisions 3N and 3O

(SCR Docs, 20/002, 009, 046; SCS 20/06, 07, 09, 11, 13)

a) Introduction

From 1972 to 1984, reported catch of witch flounder in NAFO Divs. 3NO ranged from a high of about 9 200 t in 1972 to a low of about 2 400 tonnes (t) in 1980 and 1981 (Figure 13.1). Catches increased to around 9 000 t in the mid-1980s but then declined steadily to less than 1 200 t in 1995. A moratorium on directed fishing was imposed in 1995 and remained in effect until 2014. During the moratorium, bycatch averaged below 500 t. The NAFO Fisheries Commission reintroduced a 1 000 t TAC for 2015 and in 2015 set a TAC for 2016, 2017, and 2018 at 2 172 t, 2 225 t, and 1 116 t respectively. Not all Contracting Parties with quota resumed directed fishing for witch flounder until 2019, when participation in the fishery was more representative. Catch since 2015 has been below the TAC. In 2019, total catch was estimated to be 862 t.

In 2019 the assessment for this stock was evaluated and endorsed by an external reviewer.

Recent catches and TACs ('000 tones) are as follows:

	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
TAC	ndf	ndf	ndf	ndf	1.0	2.2	2.2	1.1	1.2	1.2
STATLANT 21	0.4	0.3	0.3	0.3	0.4	1.0	0.6	0.6	0.9	
STACFIS	0.4	0.3	0.3	0.3	0.4	1.1	0.7	0.7	0.9	

ndf = no directed fishery.

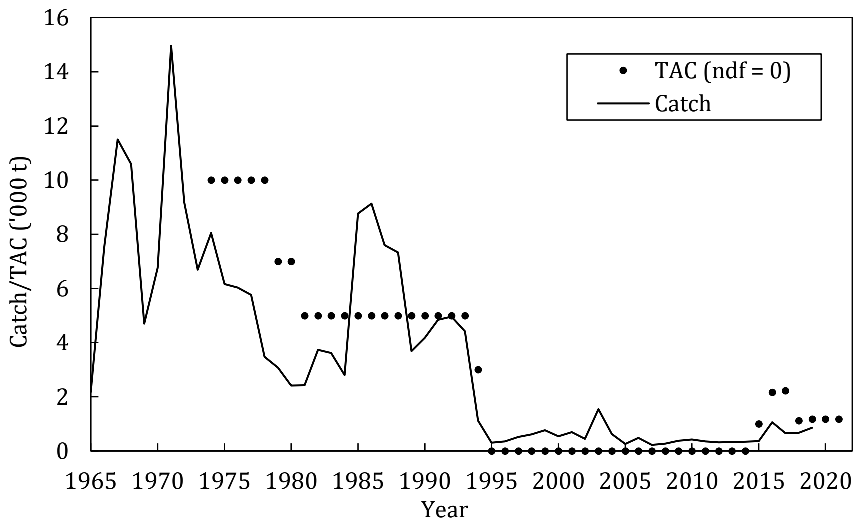

Figure 13.1. Witch flounder in Divs. 3NO (1960-2021): Catch and TAC (‘000 tonnes).

b) Data Overview

i) Commercial fishery data

Length frequencies. Length frequencies were available from observer data for Canadian witch flounder directed and bycatch fisheries in NAFO Divs. 3NO in 2019**.** Canadian data indicated the catch and bycatch ranged between 30 and 60 cm with a mean length of ~45 cm (Figure 13.2). Length frequencies were available from bycatches in directed fisheries for yellowtail flounder, redfish, Greenland halibut, and skate by Spain, in 2019 (Figure 13.2). The Spanish data (SCS 20/07) from Divs. 3NO indicated most of the witch flounder catch and bycatch was between 25 and 55 cm in length (Figure 13.2).

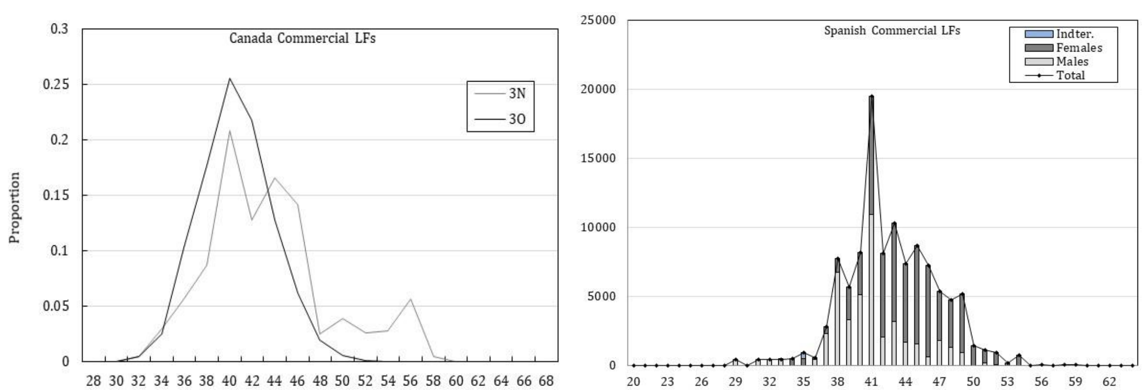

Figure 13.2. Witch flounder length frequency (cm) distributions for Canada and Spain (NAFO Divs. 3NO) commercial bycatch and directed fisheries in 2019.

ii) Research survey data

Canadian spring RV survey. Due to substantial coverage deficiencies, values from 2006 are not presented. The biomass index, although variable, had shown a general decreasing trend from 1985 to 1998, a general increasing trend from 1998 to 2003, and a general decreasing trend from 2003 to 2010. From 2010 to 2013 the index increased to values near the series high from 1987 (Figure 13.3). Biomass indices declined substantially from a high in 2013 to a value 51% of the time series average in 2015. Biomass indices have been relatively stable since 2015 (Figure 13.3).

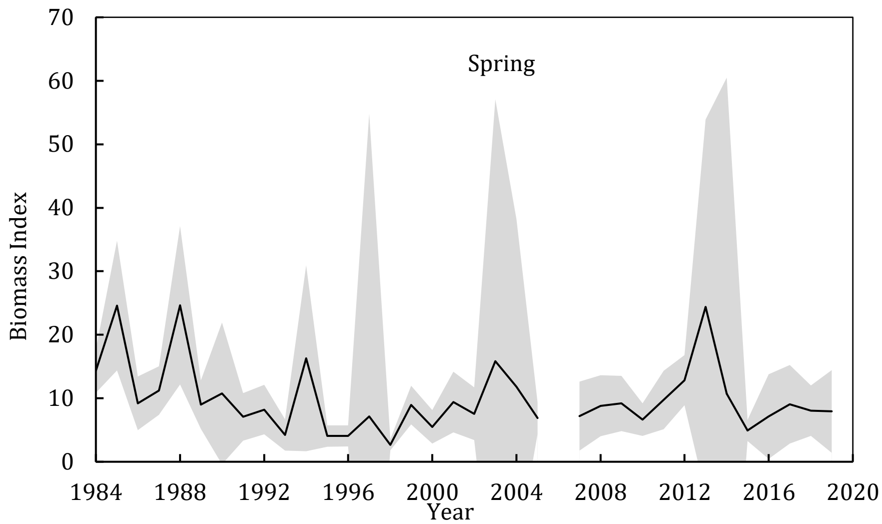

Figure 13.3. Witch flounder in NAFO Divs. 3NO: survey biomass indices from Canadian spring surveys 1984-2019 (95% confidence limits are given). Values are Campelen units or, prior to 1996, Campelen equivalent units.

Canadian autumn RV survey. Due to operational difficulties there was no 2014 autumn survey. The biomass indices showed a general increasing trend from 1996 to 2009 but declined to 54% of the time series average in 2016 (Figure 13.4). Biomass indices have increased slightly since 2016.

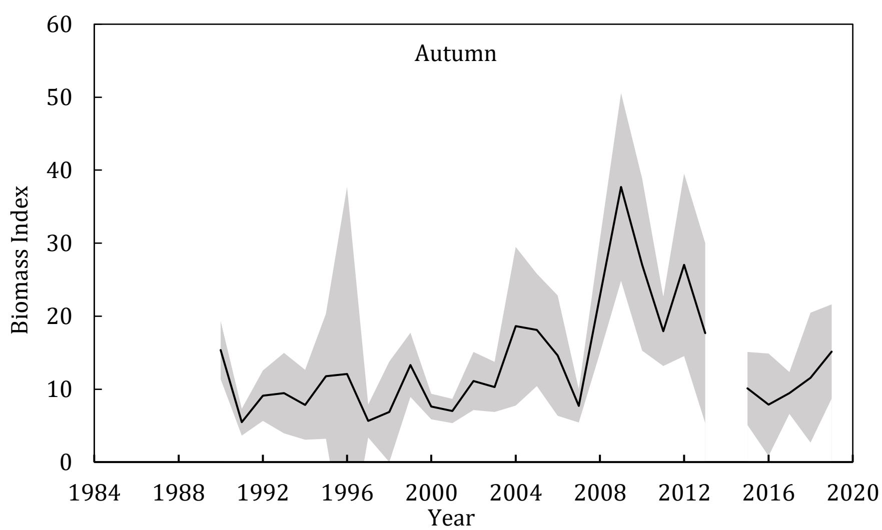

Figure 13.4. Witch flounder in Divs. 3NO: biomass indices from Canadian autumn surveys 1990-2019 (95% confidence limits are given). Values are Campelen units or, prior to 1996, Campelen equivalent units.

EU-Spain RV spring survey. Surveys have been conducted annually from 1995 to 2019 by EU-Spain in the NAFO Regulatory Area in Divs. 3NO to a maximum depth of 1,450 m (since 1998). In 2001, the vessel (*Playa de Menduiña*) and survey gear (Pedreira) were replaced by the R/V *Vizconde de Eza* using a Campelen trawl (NAFO SCR 05/25). Data for witch flounder prior to 2001 have not been converted and therefore data from the two time series cannot be compared. In the Pedreira series, the biomass increased from 1995-2000 but declined in 2001. In the Campelen series, the biomass has been variable, but relatively stable over the time series, however the 2019 estimate is the lowest in the series. (Figure 13.5).

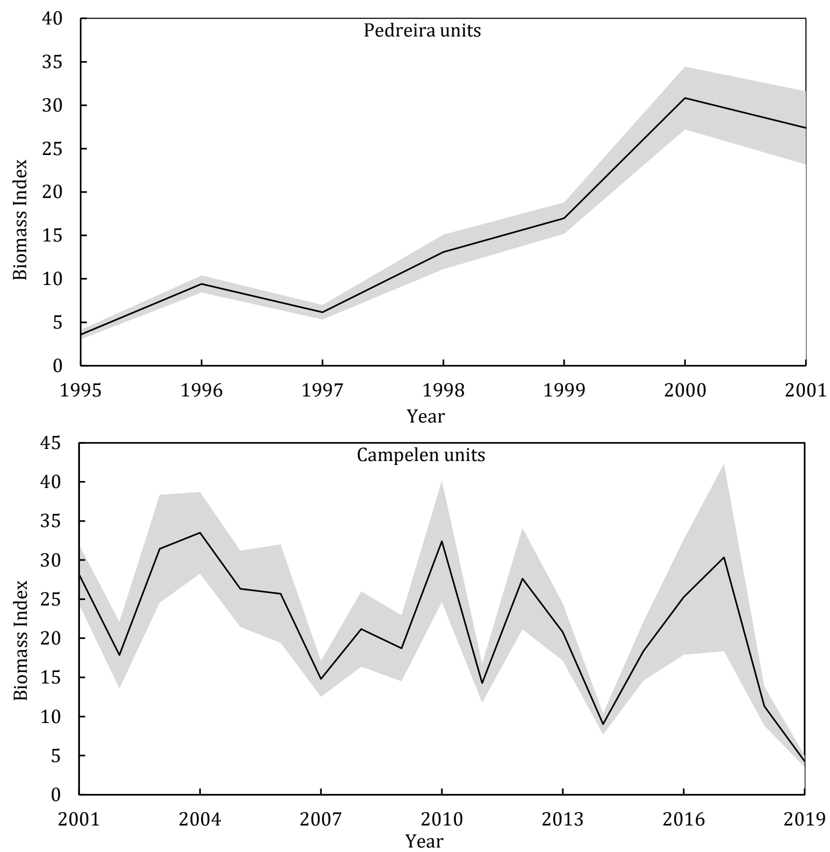

Figure 13.5. Witch flounder in Divs. 3NO: biomass indices from EU-Spanish Div. 3NO spring surveys (± 1 standard deviation). Data from 1995-2001 is in Pedreira units; data from 2001-2019 are Campelen units. Both values are presented for 2001.

Abundance at length. Abundance at length in the Canadian spring RV surveys appears to be fairly consistent since 2000 with few fish greater than 50 cm, and a mode generally around 38-40 cm (Figure 13.6). However, from 2007 to 2013 there was an increase in the number of larger fish in the 40-45 cm range except for an anomalous 30-35 cm range encountered in 2014 (Figure 13.6). Consistent with the decline in abundance observed in this survey, this size mode was smaller in amplitude from 2016 onward. Abundance at length in the Spanish spring RV surveys was fairly consistent at 33-35 cm from 2001 to 2007 (a smaller range than the Canadian surveys during the same time period). From 2008 to 2019 the size range has generally increased with more fish in the 38-43 cm range (Figure 13.6). In 2019 the mode was ~42 cm (Figure 13.6).

There were a number of distinctive peaks in the 5-15 cm range (recruitment year classes) in surveys that were evident and could be followed through successive years. This included the periods from 2007 to 2009 in the Canadian spring series and from 2005 -2006 in the Spanish spring series (Figure 13.6). A distinctive recruitment peak in the 10 cm range was evident in the 2017 Canadian autumn RV survey. Growth of this peak can be tracked through both Canadian spring and autumn surveys, and in 2019 these fish appear in a mode in the 21-26cm range. Another strong peak of fish at about 5cm is observed in the 2019 spring Canadian survey which is evident at 7-10 cm in size in the Canadian autumn survey. (Figure 13.6). The 2019 Spanish spring survey had low levels of witch flounder at all sizes.

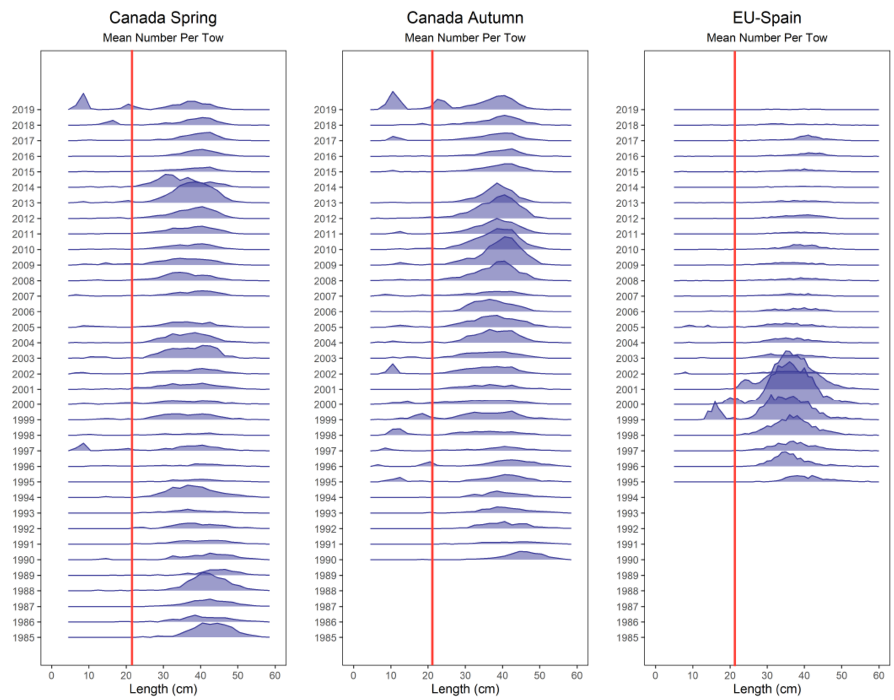

Figure 13.6. Length frequencies (abundance at length) of witch flounder from spring Canadian (1996-2019), autumn Canadian (1996 to 2019) and Spanish (2002-2019) RV surveys in NAFO Divs.3NO. No Canadian survey data was available in spring 2006 or autumn 2014. Vertical line represents the length at which fish are expected to be recruited to the population (21 cm).

Distribution. Analysis of distribution data from the surveys show that this stock is mainly distributed in Div. 3O along the southwestern slopes of the Grand Bank. In most years the distribution is concentrated toward the slopes but in certain years, an increased percentage may be distributed in shallower water. A 2014 analysis of Canadian biomass proportions by depth aggregated across survey years (spring 1984-2014 and autumn 1990-2014) indicated that in Div. 3N both spring and autumn biomass proportions were fairly evenly distributed over a depth range of 57-914 m while those in 3O were more restricted to a shallower depth range of 57-183m. Distributions of juvenile fish (less than 21 cm) were slightly more prevalent in shallower water during autumn surveys. It is possible however, that the juvenile distribution may be more related to the overall pattern of witch flounder being more widespread in shallower waters during the post-spawning autumn period, although other stocks show a pattern of juvenile fish occupying shallow and/or inshore areas. In years where all strata were surveyed to a depth of 1462 m in the autumn survey, generally less than 5% of the Divs. 3NO biomass was found in the deeper strata (731-1462 m).

c) Estimation of Parameters

A Schaefer surplus production model in a Bayesian framework was used for the assessment of this stock. The input data were catch from 1960-2019, Canadian spring survey series from 1984-1990, Canadian spring survey series from 1991-2019 (no 2006) and the Canadian autumn survey series from 1990-2019 (no 2014). The model formulation was identical to the accepted formulation from the 2019 assessment.

The priors used in the model were:

Median initial population size (relative to carrying capacity)	Pin~dunif(0.5, 1)	uniform(0.5 to 1)
Intrinsic rate of natural increase	r ~ dlnorm(-1.763,3.252)	lognormal (mean, precision)
Carrying capacity	K~dlnorm(4.562,11.6)	lognormal (mean, precision)
Survey catchability	q =1/pq pq ~dgamma(1,1)	gamma(shape, rate)
Process error (sigma=standard deviation of process error in log-scale)	For 1960-2013 and 2017-2019 sigma ~ dunif(0,10) precision:isigma2= $sigma^{-2}$ For 2014-2016 sigmadev <-sigma+1 precision: isigmadev2=$sigmadev^{-2}$	uniform(0 to 10)
Observation error (tau=variance of observation error in log-scale)	tau~dgamma(1,1) precision:itau2 = 1/tau	gamma(shape, rate)

d) State of the Stock

Recruitment: With the exception of the growth of the stock following improved recruitment in the late 1990s, it is unclear if this recruitment index is representative. Nevertheless, the recruitment index in 2019 is the highest in the time series.

Recruitment (defined as fish less than 21cm; Figure 13.7) in both the spring and autumn Canadian surveys, although somewhat variable, had generally been low since 2003. In 2016, recruitment approached the lowest of the time series. Recruitment in 2019 surveys, however, was the highest in the time series, at about six times the series' means.

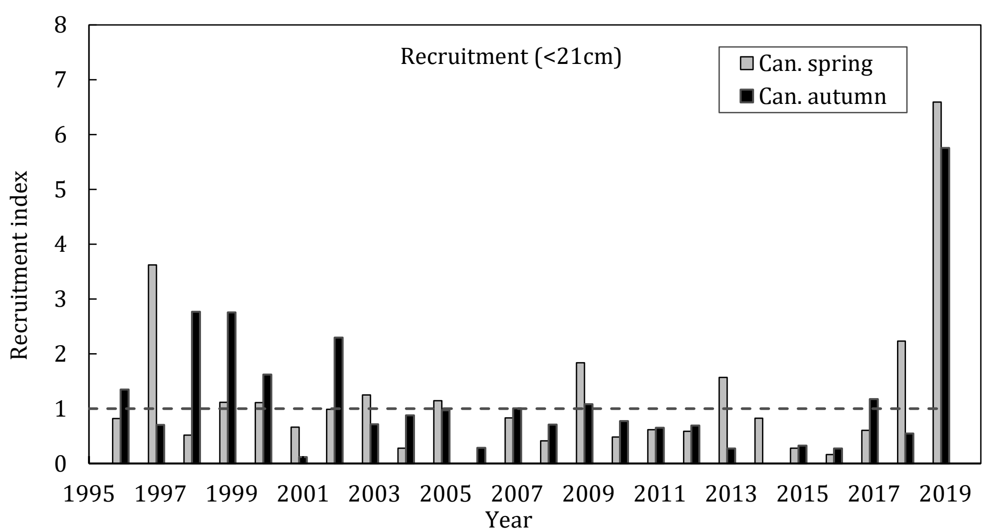

Figure 13.7. Recruitment index of witch flounder (<21cm) from spring and autumn Canadian RV surveys in NAFO Divs.3NO 1996-2019. No survey data available in autumn 2014 or spring 2006.

Stock Production Model: The surplus production model results indicate that stock size decreased from the late 1960s to the late 1990s and then increased from 1999 to 2013. There was a large decline from 2013 to 2015, with a subsequent small increase since. The model suggests that a maximum sustainable yield (*MSY*) of 3 789 (3 063 – 4 751) tonnes can be produced by total stock biomass of 59 880 (45 500 – 73 310) tonnes (B_{msy}) at a fishing mortality rate (F_{msy}) of 0.063 (0.05-0.09) (Figure 13.8).

Biomass: The analysis showed that relative population size (median B/B_{msy}) was below $B_{lim}=30\%B_{msy}$ from 1993-1997 (Figure 13.8). Biomass in 2019 is 44% of B_{msy} with a probability of being below B_{lim} of 14%.

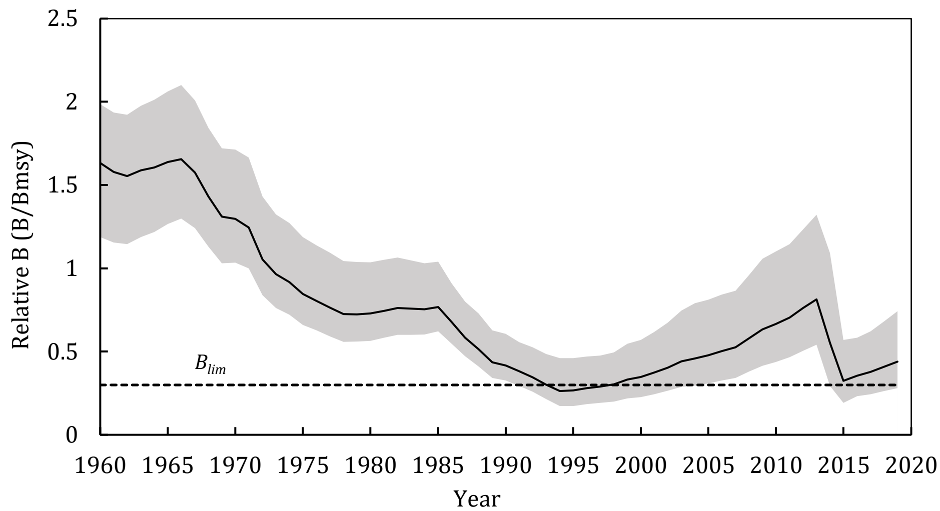

Figure 13.8. Witch flounder in Divs. 3NO. Median relative biomass (*Biomass*/B_{msy}) with 80% credible intervals from 1960-2019. The horizontal line is $B_{lim}=30\%B_{msy}$.

Fishing Mortality: Relative fishing mortality rate (median F/F_{msy}) was mostly above 1.0 from the late 1960s to the mid-1990s (Figure 13.9). *F* has been below F_{msy} since the moratorium implemented in 1995. Median *F* was estimated to be 53% of F_{msy} with a low probability (4%) of being above F_{msy} in 2019.

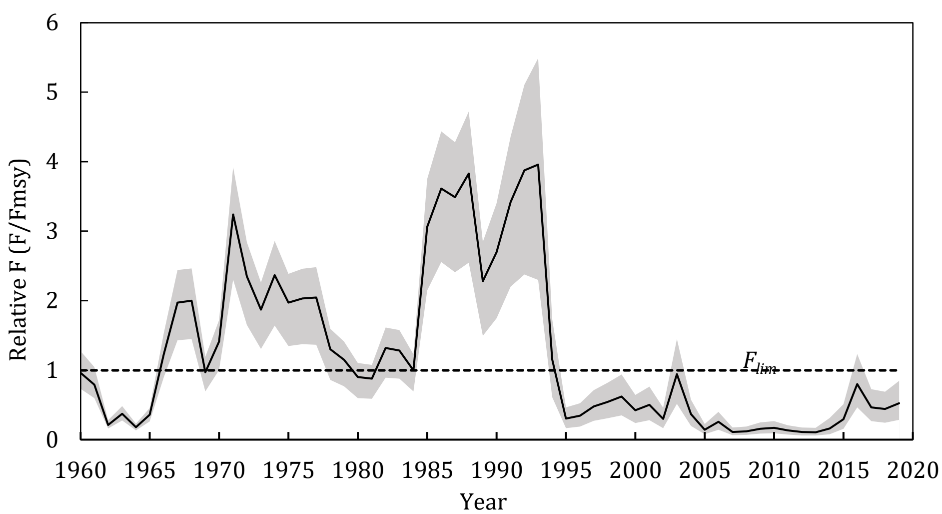

Figure 13.9. Witch flounder in Divs. 3NO. Median relative fishing mortality (F/F_{msy}) with 80% credible intervals from 1960-2019. The horizontal line is $F_{lim}=F_{msy}$.

State of the stock: The stock size increased from 1994 to 2013, then declined during 2013-2015 and has since increased slightly. In 2020 the stock is at 44% B_{msy} (59 880 tonnes). There is 14% risk of the stock being below B_{lim} and a 4% risk of *F* being above F_{lim} (F_{msy}=0.063). With the exception of the growth of the stock following improved recruitment in the late 1990s, it is unclear if the recruitment index is representative. Nevertheless, the recruitment index in 2019 is the highest in the time series.

e) Medium Term Considerations

The posterior distributions (13 500 samples) for r, K, sigma, and biomass and the production model equation were used to project the population to 2023. All projections assumed that the catch in 2020 was equal to the TAC of 1 175 t. This was followed by constant fishing mortality for 2020 and 2021 at several levels of F ($F=0$, F_{2019}, 2/3 F_{msy}, 85% F_{msy}, and F_{msy}) and two levels of catch (avg 2016-2019=800 t and $TAC_{2020\ and\ 2021}$=1 175 t).

The probability that $F > F_{lim}$ in 2020 is 16% at a catch of 1 175 t. The probability of $F>F_{lim}$ ranged from 2 to 50% for the catch scenarios tested (Table 13.2, 13.3). The population is projected to grow under all scenarios (Figure 13.10) and the probability that the biomass in 2023 is greater than the biomass in 2020 is greater than 60% in all scenarios. The population is projected to remain below B_{msy} through to the beginning of 2023 for all levels of F examined with a probability of greater than 88%. The probability of projected biomass being below B_{lim} by 2023 was 7 to 11% in all catch scenarios examined and was 4% by 2023 in the F=0 scenario.

A second set of projections was also conducted assuming that the catch in 2020 and 2021 was equal to the adopted TAC (1 175 t). The results were essentially the same as those assuming that the catch in 2020 equals the TAC. The probability of projected biomass being below B_{lim} by 2023 was 8 to 10% in all catch scenarios examined and was 7% by 2023 in the F=0 scenario.

Table 13.10. Medium-term projections for witch flounder under two scenarios: catch in 2020=TAC (1 175t) and catch in 2020 and 2021=TAC (1 175 t). The 10th, 50th and 90th percentiles of catch and relative biomass B/B_{msy}, are shown, for projected F values of $F=0$, F_{2019}, 2/3 F_{msy}, 85% F_{msy}, F_{msy}., and two levels of catch (Average 2016-2019=800 t and TAC= 1 175 t).

Projections with catch in 2020 = TAC (1 175 t)

Year	Yield (t) median	Projected relative Biomass(B/B_{msy}) median (80% CL)
F0		
2021	0	0.49 (0.30, 0.89)
2022	0	0.53 (0.32, 0.97)
2023		0.58 (0.35, 1.06)
Catch 800 t		
2021	800	0.49 (0.30, 0.90)
2022	800	0.52 (0.31, 0.97)
2023		0.54 (0.31, 1.03)
F_{2019} = 0.033		
2021	957	0.49 (0.30, 0.89)
2022	1011	0.52 (0.31, 0.96)
2023		0.55 (0.32, 1.03)
Catch 1 175t		
2021	1175	0.49 (0.30, 0.90)
2022	1175	0.52 (0.31, 0.97)
2023		0.54 (0.31, 1.03)
2/3 F_{msy} = 0.042		
2021	1212	0.49 (0.29, 0.89)
2022	1281	0.51 (0.30, 0.96)
2023		0.54 (0.31, 1.02)
85% F_{msy} =0.054		
2021	1554	0.49 (0.30, 0.89)
2022	1615	0.51 (0.30, 0.95)
2023		0.53 (0.30, 1.01)
F_{msy} =0.063		
2021	1823	0.49 (0.30, 0.88)
2022	1879	0.50 (0.29, 0.94)
2023		0.52 (0.29, 0.99)

Projections with catch in 2020 and 2021 = TAC (1 175t)

Year	Yield (t) median	Projected relative Biomass(B/B_{msy}) median (80% CL)
F0		
2021	1175	0.49 (0.30, 0.89)
2022	0	0.52 (0.31, 0.96)
2023		0.56 (0.33, 1.05)
Catch 800 t		
2021	1175	0.49 (0.30, 0.89)
2022	800	0.52 (0.31, 0.96)
2023		0.56 (0.33, 1.04)
F_{2019} = 0.033		
2021	1175	0.49 (0.30, 0.89)
2022	1006	0.52 (0.31, 0.96)
2023		0.55 (0.32, 1.03)
Catch 1 175t		
2021	1175	0.49 (0.30, 0.90)
2022	1175	0.52 (0.31, 0.97)
2023		0.54 (0.31, 1.03)
2/3 F_{msy} = 0.042		
2021	1175	0.49 (0.30, 0.89)
2022	1285	0.52 (0.31, 0.96)
2023		0.54 (0.31, 1.02)
85% F_{msy} =0.054		
2021	1175	0.49 (0.30, 0.89)
2022	1638	0.52 (0.31, 0.96)
2023		0.54 (0.31, 1.01)
F_{msy} =0.063		
2021	1175	0.49 (0.30, 0.89)
2022	1928	0.52 (0.31, 0.96)
2023		0.53 (0.30, 1.01)

Table 13.3. Projected yield (t) and the risk of *F*> F_{lim}, *B*<B_{lim} and *B*<B_{MSY} and probability of stock growth (B2023>B2020) under projected *F* values of *F=0*, F_{2019}, 2/3 F_{msy}, 85% F_{msy}, F_{msy}., and two levels of catch (Average 2016-2019=800 t and TAC= 1 175 t). Two scenarios are shown: catch in 2020=TAC (1 175t) and catch in 2020 and 2021=TAC (1 175 t).

Catch 2020=1 175 t	Yield (t)		P(F>F lim)		P(B<B lim)			P(B<B msy)			
	2021	2022	2021	2022	2021	2022	2023	2021	2022	2023	P(B 2023 >B 2020)
F0	0	0	0%	0%	11%	7%	4%	93%	91%	88%	74%
Catch 2021 & Catch 2022=800t	800	800	2%	2%	11%	9%	7%	93%	91%	89%	68%
F_{2019} = 0.033	957	1011	6%	7%	11%	9%	8%	93%	91%	89%	67%
Catch 2021 & Catch 2022= 1 175t	1175	1175	15%	13%	11%	9%	8%	93%	91%	89%	65%
2/3 F_{msy} = 0.042	1212	1281	17%	18%	11%	10%	9%	93%	91%	89%	66%
85% F_{msy} =0.054	1554	1615	35%	36%	11%	10%	10%	93%	91%	90%	63%
F_{msy}=0.063	1823	1879	50%	50%	11%	11%	11%	93%	92%	90%	61%

Catch2020 and 2021= 1 175 t	Yield (t)		P(F>F lim)		P(B<B lim)			P(B<B msy)			
	2021	2022	2021	2022	2021	2022	2023	2021	2022	2023	P(B 2023 >B 2020)
F0	1175	0	15%	0%	11%	9%	7%	93%	91%	88%	70%
Catch 2022=800t	1175	800	15%	2%	11%	9%	8%	93%	91%	89%	67%
F_{2019} = 0.033	1175	1006	15%	7%	11%	9%	8%	93%	91%	89%	66%
Catch 2021 & Catch 2022= 1 175t	1175	1175	15%	13%	11%	9%	8%	93%	91%	89%	65%
2/3 F_{msy} = 0.042	1175	1285	15%	18%	11%	9%	9%	93%	91%	89%	65%
85% F_{msy} =0.054	1175	1638	15%	36%	11%	9%	9%	93%	91%	89%	64%
F_{msy}=0.063	1175	1928	15%	50%	11%	9%	10%	93%	91%	90%	63%

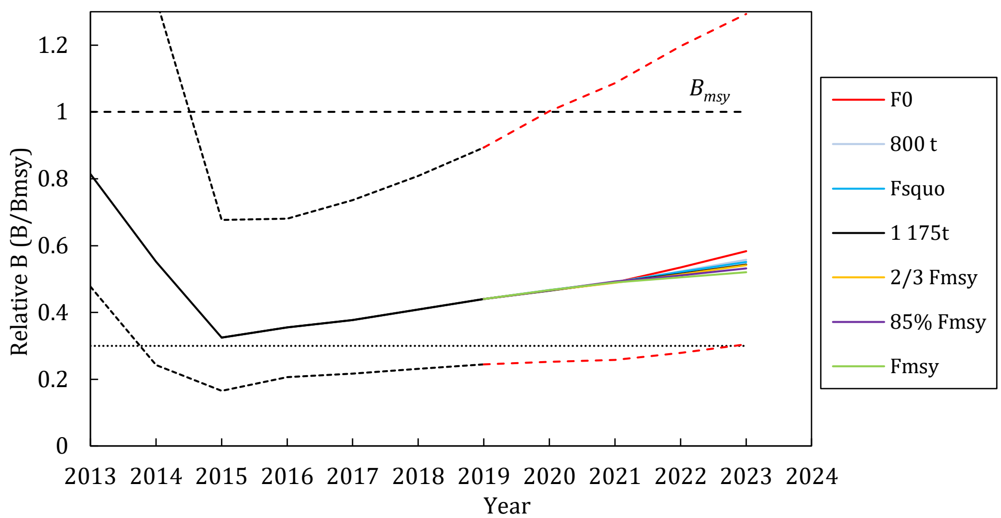

Figure 13.10. Witch flounder in Divs. 3NO: medium term projections of relative biomass (*B*/B_{msy}) at five levels of *F* (F=0, F_{2019}, 2/3 F_{msy}, 85% F_{msy} and F_{msy}) and two levels of catch (avg 2016-2019=800 t and TAC 1 175 t). A catch of 1 175 t is assumed in 2020. The 10th and 90th credible intervals are included for the model results up to 2019 and for the projected period for the *F*=0 assumption.

f) Reference Points

Reference points are estimated from the surplus production model. Scientific Council considers that 30% B_{msy} is a suitable biomass limit reference point (B_{lim}) and F_{msy} a suitable fishing mortality limit reference point for stocks where a production model is used.

At present, the risk of the stock being below B_{lim} is 14% and above F_{lim} is 4% (Figure 13.11).

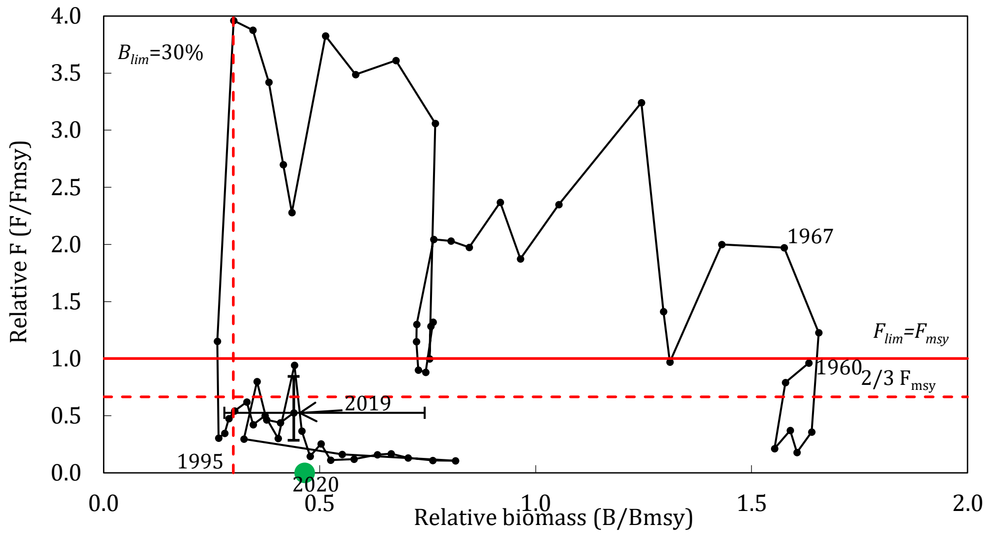

Figure 13.11. Witch flounder in Divs. 3NO: stock trajectory estimated in the surplus production analysis, under a precautionary approach framework.

g) Recommendations

The next assessment will be in 2022.

14. Capelin (*Mallotus villosus*) in Divisions 3NO

(SCR 20-10 and SCS 20-07, 20-11)

Interim Monitoring Report

a) Introduction

The fishery for capelin started in 1971 and catches were high in the mid-1970s with a maximum catch of 132 000 t in 1975 (Figure 14.1). The stock has been under a moratorium to directed fishing since 1992. No catches have been reported from 1993 to 2013. Small catches (mostly discards) started appearing from 2014 to 2019, with an exception of 2015.

Recent catches and TACs ('000 tonnes) are as follows:

	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Recommended TAC	na	na	na	na	na	na	na	na	na	na	na	na	na
Catch[1]	0	0	0	0	0	0	1	0	5	1	2	2	

[1]No catch reported for this stock
na = no advice possible