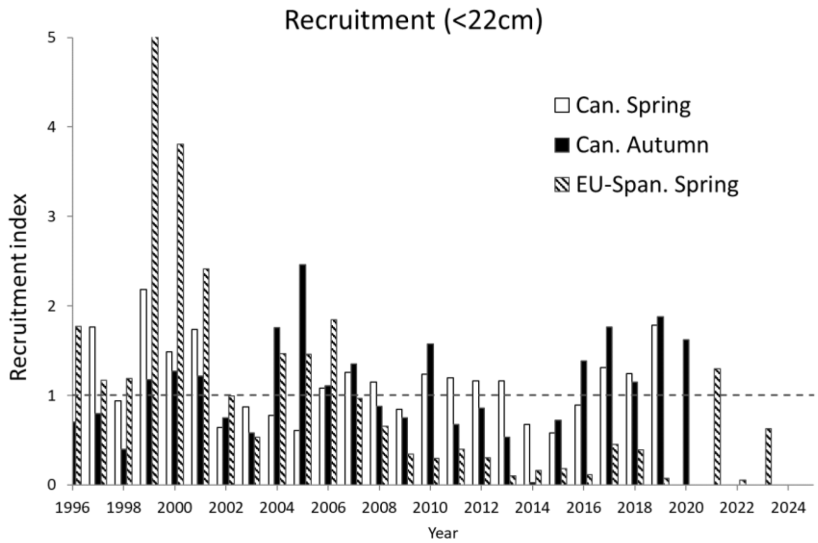

Figure 12.4. Yellowtail flounder in Divisions 3LNO: Juvenile abundance indices from spring and autumn surveys by Canada (Can.) and spring surveys by EU-Spain. Each series is scaled to its mean (horizontal line).

c) Conclusion

The most recent (2023) analytical assessment using a Bayesian stock production model concluded that the stock size steadily increased since 1994 and was 1.1 times B_{msy} (B_{msy}=91.1 t). There was very low risk (<1%) of the stock being below B_{msy} or F being above F_{msy}. Overall, the 2023 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 2025.

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

Full Assessment (SCR Doc. 24/007, 018, 036, 037; SCS Doc. 24/06, 08, 09, 11)

a) Introduction

From 1972 to 1984, reported catch of witch flounder in NAFO Divisions 3NO ranged from a high of about 9 200 tonnes (t) in 1972 to a low of about 2 400 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 TACs in 2015. 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 2023, total catch was estimated to be 268 t.

Table 13.1 Recent catches and TACs ('000 t) of witch flounder in NAFO Divisions 3NO

	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024
TAC	1.0	2.2	2.2	1.1	1.2	1.2	1.2	1.2	1.3	1.4
STATLANT 21	0.4	0.6	0.6	0.7	0.9	0.6	0.6	NA[1]	NA[1]	
STACFIS	0.4	1.1	0.7	0.7	0.9	0.7	0.6	0.6	0.3	

[1] NA - In 2022-2023, STATLANT 21 information is incomplete.

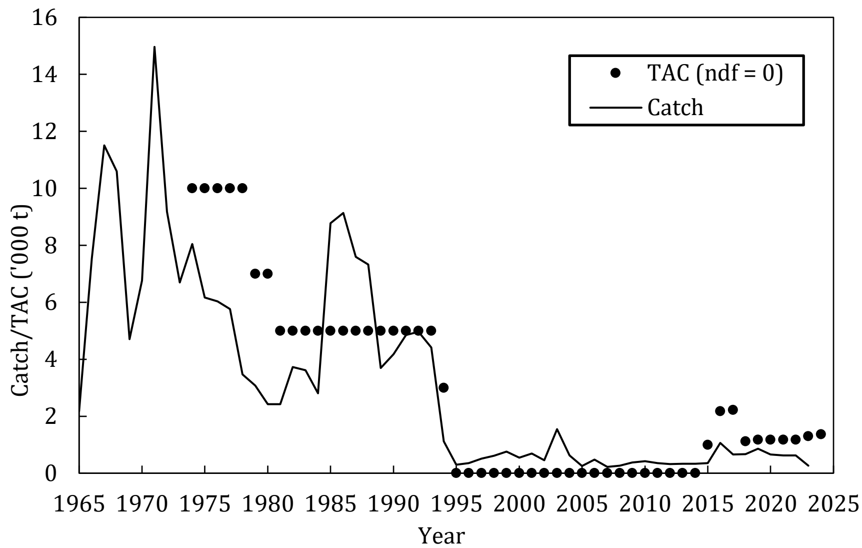

Figure 13.1. Witch flounder in Divisions 3NO (1960-2024): Catch and TAC ('000 tonnes).

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 Division 3O in 2022 and 2023**.** Canadian data indicated the catch and bycatch ranged between 30 and 55 cm with a mean length of ~40 cm (Figure 13.2). Length frequencies were available from bycatches in directed fisheries for redfish, Greenland halibut and skate by Spain, in 2023 (Figure 13.2). The Spanish data from Divisions 3NO indicated most of the witch flounder catch and bycatch was between 26 and 50 cm in length (Figure 13.2).

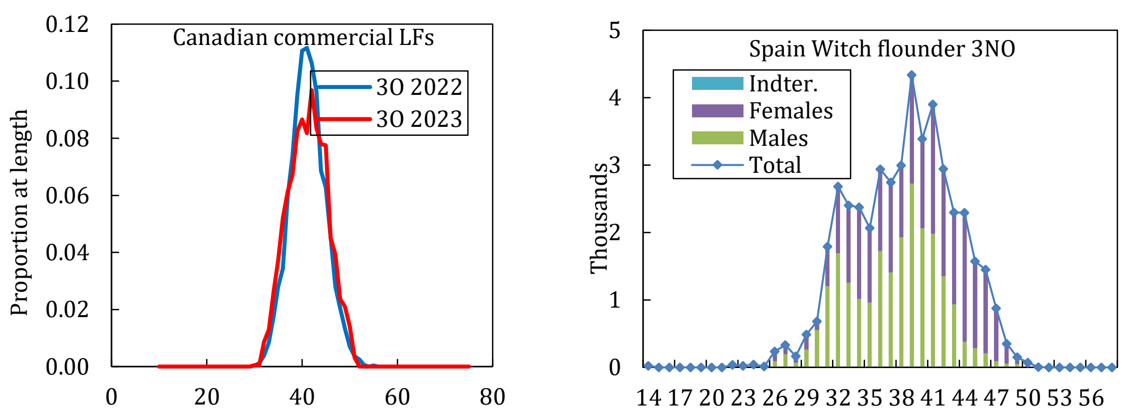

Figure 13.2. Witch flounder length frequency (cm) distributions for Canada (2022 and 2023) and Spain (2023) commercial bycatch and directed fisheries.

ii) Research survey data

New vessel time series – Modified Campelen series. Beginning in 2022, new survey vessels have been used to conduct the Canadian multi-species surveys. For witch flounder in NAFO Divisions 3NO, data from comparative fishing experiments were insufficient to provide conversion factors that would allow data from the new vessels to extend existing time series data from the former primary research vessels (CCGS Wilfred Templeman and CCGS Alfred Needler). As a result, the spring Canadian Campelen series (1984-2019) and the autumn Canadian Campelen series (1990-2020) have ended.

As well, occasionally throughout the survey time series the CCGS Teleost was used to compliment or replace the primary vessels, with the assumption that catches from the Teleost were directly comparable to those vessels. However, during the comparative fishing trials with the new vessels it was determined that the Teleost is comparable to the new vessels for witch flounder in Divisions 3NO, but not directly comparable to the Wilfred Templeman and Alfred Needler. For witch flounder in Divisions 3NO, use of the Teleost in the autumn surveys has little impact on this biomass index series as those survey sets were primarily in deep strata and very little of the total biomass was represented in those sets. For the spring series, since the Teleost sets are comparable to the new survey vessels, the years with complete/near-complete coverage with the Teleost (2014, 2016, 2018) have been removed from the 1984-2019 Campelen series, and included in a new spring time series which also includes the new survey series (modified Campelen).

Canadian spring RV surveys.

1984-2019 Campelen series. Due to substantial coverage deficiencies, values from 2006 are not presented. Due to COVID-19 restrictions and operational difficulties, respectively, the spring survey was not conducted in 2020 or 2021. The spring Campelen 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 remained relatively stable since 2015 (Figure 13.3).

2014-2023 Modified Campelen series. Biomass estimates from the modified Campelen series have been stable, but with wide error bars in some years (Figure 13.3).

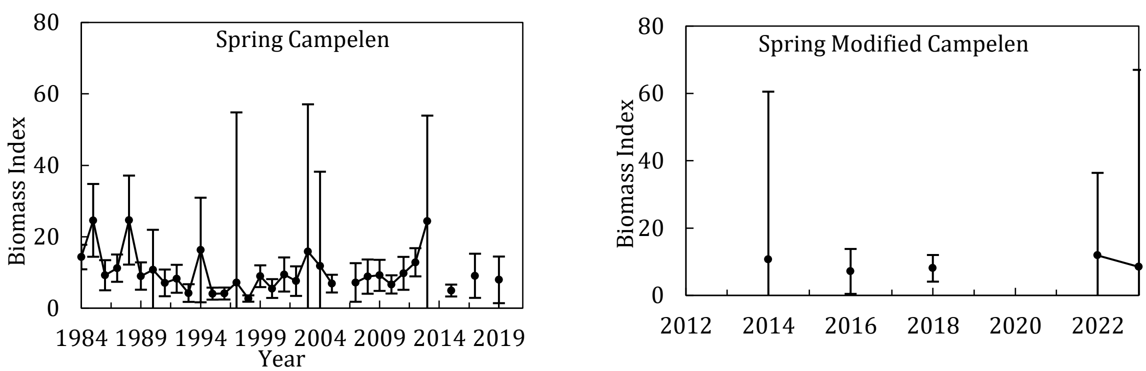

Figure 13.3. Witch flounder in NAFO Divisions 3NO: Left- survey biomass indices from Canadian Campelen spring surveys 1984-2019 (95% confidence limits are given) and right- the new survey index (2014-2023) with the Teleost and the Cabot (modified Campelen/equivalent units).

Canadian autumn RV surveys.

1990-2020 Campelen series. Due to operational difficulties, there were no 2014 or 2021 autumn surveys and, due to targeted comparative fishing exercises, there was no survey in autumn 2022. 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 increased slightly from 2016 to 2019, then decreased in 2020.

2023 Modified Campelen series. There was only one survey in autumn 2023 with the new vessel (no conversion factor available) (Figure 13.4).

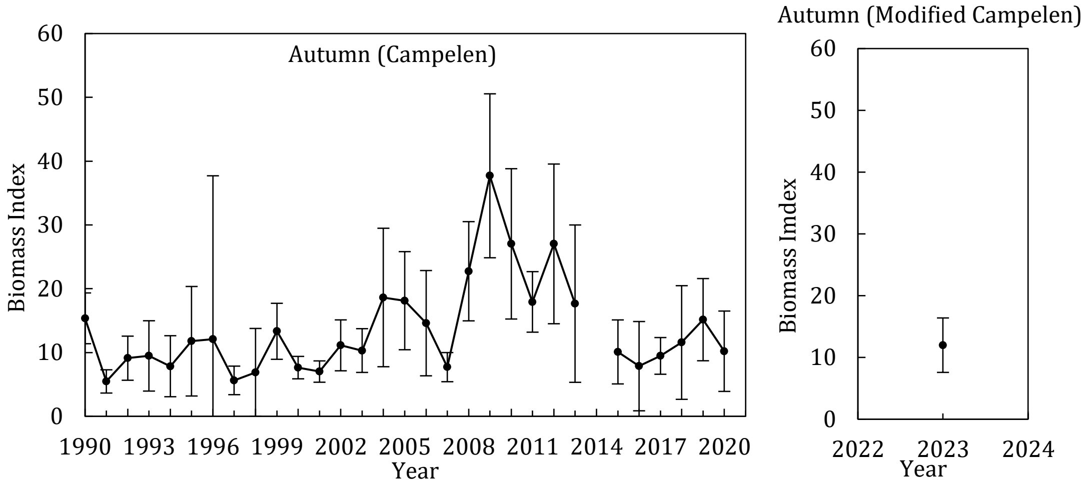

Figure 13.4. Witch flounder in Divisions 3NO: left plot is biomass indices from autumn Canadian surveys 1990-2019 (95% confidence limits are given; Campelen); right plot is biomass index from autumn Canadian survey (new vessel with modified Campelen; 2023 only).

EU-Spain RV spring survey. Surveys have been conducted annually from 1995 to 2023 by EU-Spain in the NAFO Regulatory Area in Divisions 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. 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 has shown a general decrease from 2004. No survey was conducted in 2020 (Figure 13.5).

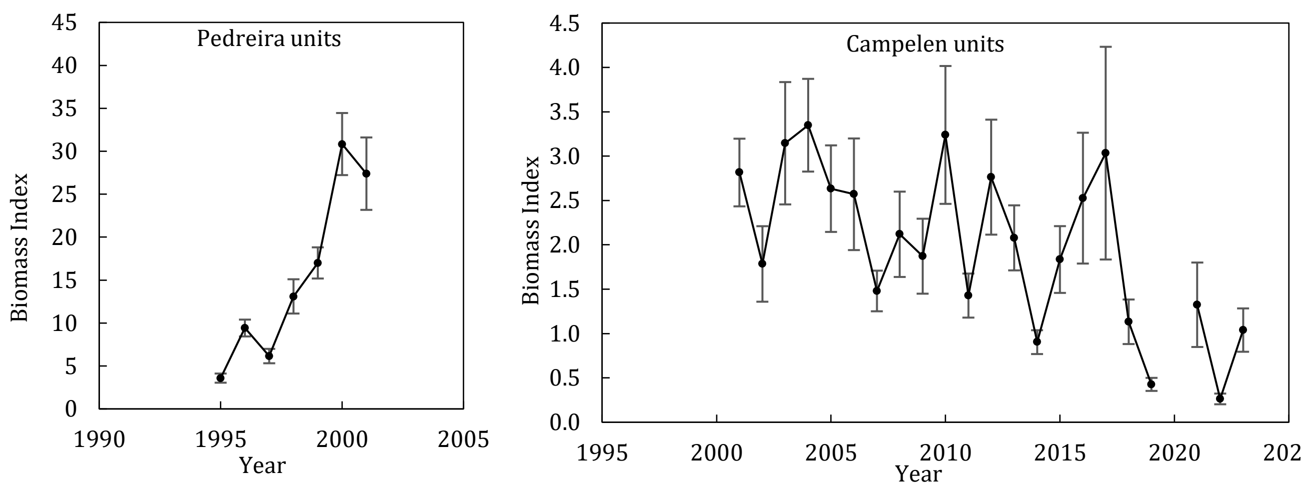

Figure 13.5. Witch flounder in Divisions 3NO: biomass indices from EU-Spanish Division 3NO spring surveys (± 1 standard deviation). Data from 1995-2001 are in Pedreira units; data from 2001-2023 are Campelen units. Both values are presented for 2001.

Abundance at length. Length frequencies of 30-50 cm fish increased from 2003 to 2005, decreased to pre-2002 levels from 2006 to 2007, and were then consistently higher from 2008 to 2014 (note there was no survey data collected in the fall of 2014, spring of 2020, or either season in 2021) with a mode generally within the mode of 40 cm (Figure 13.6). The increase in 30-50 cm fish is generally more pronounced in the fall survey data as opposed to the flatter distributions of the spring surveys. From 2015 to 2019, fish at this size mode were less prominent than seen in 2008 to 2014, although in fall 2020 this larger mode of fish increased.

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 2007-2009 and 2013-2014 in the Canadian spring series and from 2002-2004 and 2005-2006 in the Spanish spring series (Figure 13.6). In particular, 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 21-26 cm range. Another strong peak of fish at about 5 cm is observed in the 2019 spring Canadian survey which is evident at 7-10 cm in size in the Canadian autumn survey. The 2020 fall autumn survey did not detect this recruitment peak, however, and there were no surveys that covered the stock area in 2021 (Figure 13.6). The 2019 Spanish spring survey had low levels of witch flounder at all sizes. For surveys in the most recent years, there were few fish seen under 21 cm with the exception of the spring and autumn surveys in 2023. These modified Campelen surveys are not directly comparable with the previous Campelen series, but they do indicate that fish at this size range were present.

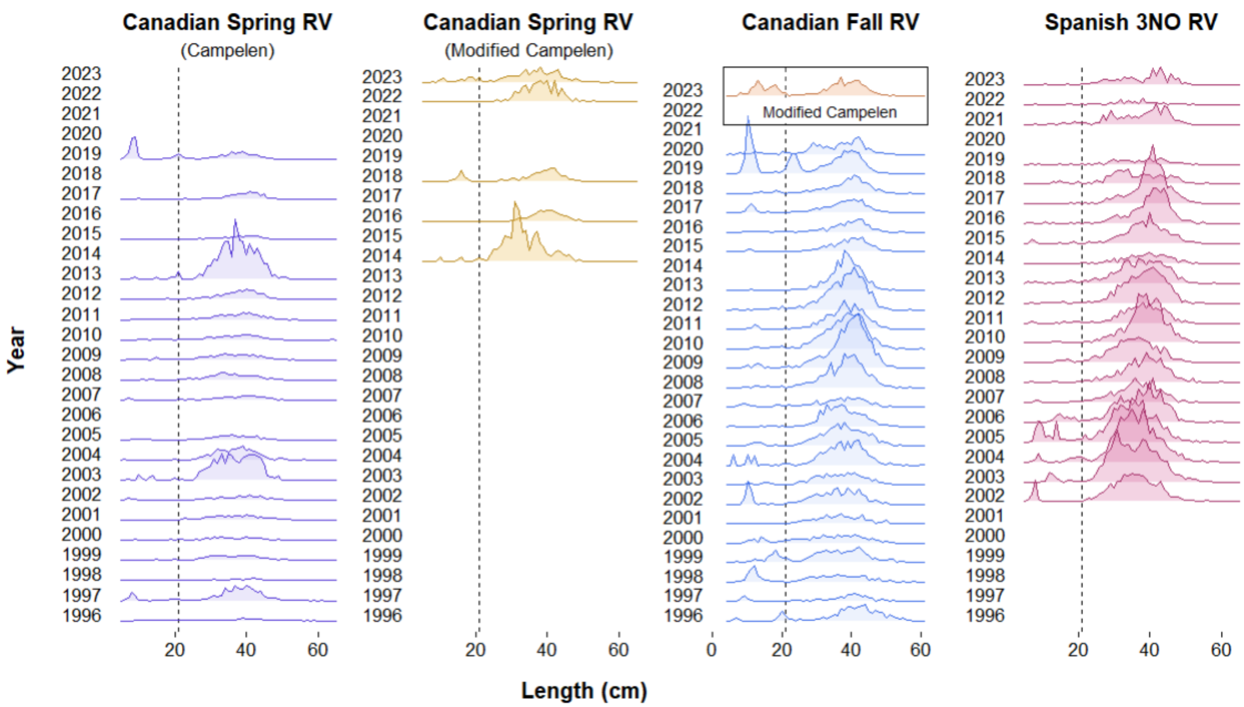

Figure 13.6. Length frequencies (abundance at length) of witch flounder from spring Canadian (1996-2019) Campelen and modified Campelen (2014, 2016, 2018, 2022-2023) series, autumn Canadian (1996 to 2020) Campelen and modified Campelen (2023) and Spanish (2002-2023) RV surveys in NAFO Divisions 3NO. No Canadian survey data was available in spring 2006, 2020, 2021 or autumn 2014, 2021, 2022. 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 Division 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 Division 3N both spring and autumn biomass proportions were fairly evenly distributed over a depth range of 57-914 m while those in Division 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 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 Divisions 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 1960-2023, Canadian spring Campelen survey series from 1984-1990, Canadian Campelen spring survey series from 1991-2019 (no 2006, 2014, 2016, or 2018), the Canadian autumn Campelen survey series from 1990-2020 (no 2014 or 2021), and the Canadian modified Campelen series 2014, 2016, 2018, 2022-2023. The model formulation was identical to the accepted formulation from the 2022 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 2017-2021 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) Assessment Results

Recruitment: With the exception of the growth of the stock following improved recruitment in the late 1990s, it is unclear if the recruitment index (survey number of fish <21 cm; Figure 13.7) is representative. Nevertheless, the recruitment index in 2019 was the highest in the time series. The small fish did not appear in the 2020 Canadian autumn survey, however, and the recruitment index was again below average. The number of small fish in the Canadian modified Campelen survey was about average in 2014, lower than average in 2022, and above average in 2018 and 2023. Recent recruitment appears to be average.

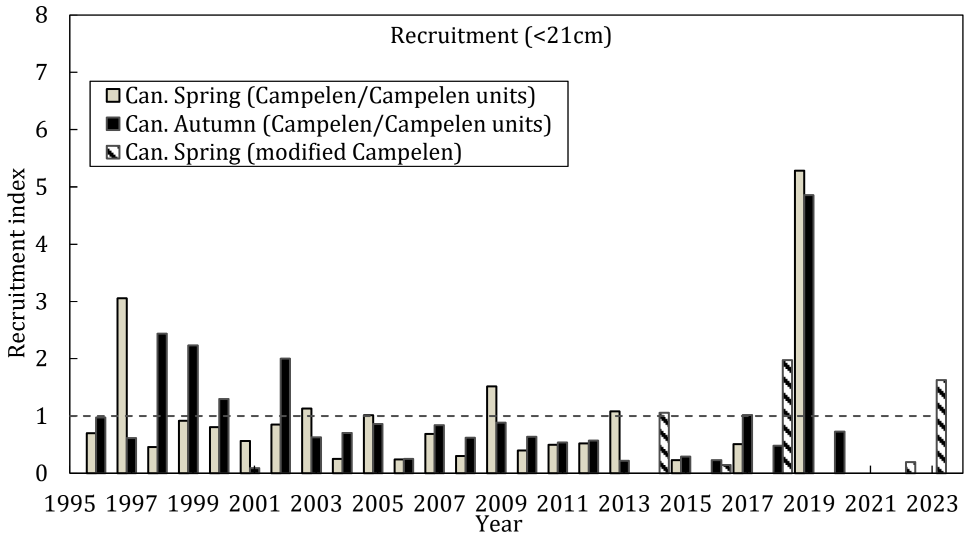

Figure 13.7. Recruitment index of witch flounder (<21cm) from spring and autumn Canadian RV surveys (Campelen) in NAFO Divisions 3NO 1996-2020 and spring Canadian modified Campelen (2014-2023). No survey data available in autumn 2014, 2021 or spring 2006, 2020, 2021.

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. The decline from 2013 to 2015 was followed by a general increase. The model suggests that a maximum sustainable yield (*MSY*) of 3 715 (3 052 – 4 652) tonnes can be produced by total stock biomass of 60 730 (46 529 – 73 780) tonnes (B_{msy}) at a fishing mortality rate (F_{msy}) of 0.061 (0.047-0.087) (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 at the beginning of 2024 is 48% of B_{msy} with a probability of being below B_{lim} of 11%.

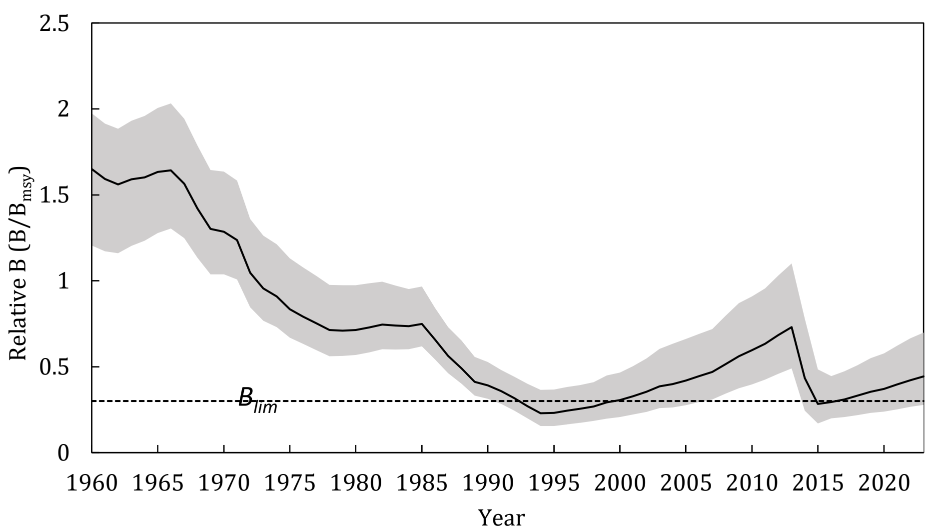

Figure 13.8. Witch flounder in Divisions 3NO. Median relative biomass (*Biomass/*B_{msy}) with 80% credible intervals from 1960-2023. The horizontal line is B_{lim}=30%B_{msy}.

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 16% of F_{msy} with a low probability (<1%) of being above F_{msy} in 2023.

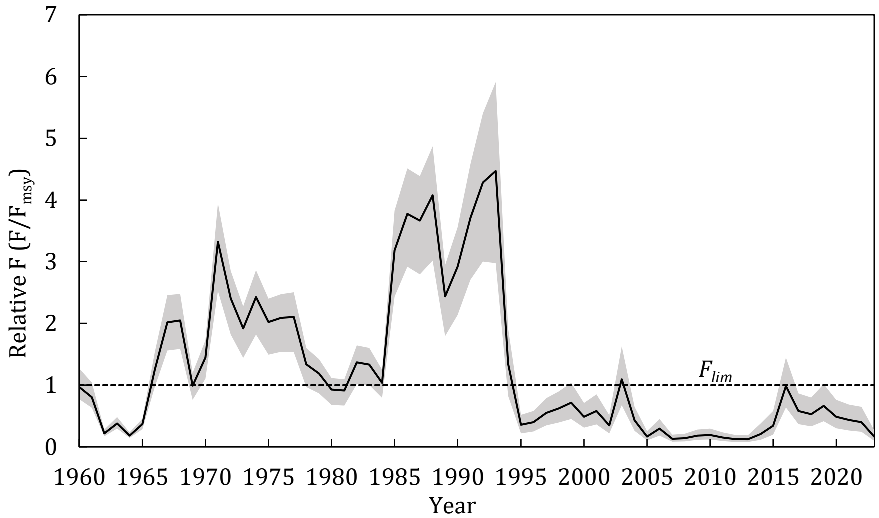

Figure 13.9. Witch flounder in Divisions 3NO. Median relative fishing mortality (F/F_{msy}) with 80% credible intervals from 1960-2023. The horizontal line is $F_{lim}=F_{msy}$.

e) State of the Stock

The stock has increased slightly since 2015 and is estimated at 48% B_{msy}. At the beginning of 2024, there is an 11% risk of the stock being below B_{lim} and less than 1% risk of F being above F_{lim}. Recent recruitment appears to be average.

f) 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 2027. Two scenarios were projected, one assumed that the catch in 2024 was equal to the TAC of 1 367 t, and the second assumed catch in 2024 was equal to the average catch in the last three years (505 t). These catch assumptions were then followed by constant fishing mortality for 2025 and 2026 at several levels of F ($F=0$, F_{2023}, 2/3 F_{msy}, 75% F_{msy}, 85% F_{msy} and F_{msy}).

The probability that $F > F_{lim}$ in 2024 is 14% at a catch of 1 367 t (10.5% for $Catch_{2024}$=505 t). The probability of $F>F_{lim}$ in 2025 and 2026 ranged from 1 to 51% for the catch scenarios tested (Tables 13.2 and 13.3). The population is projected to grow under all scenarios (Figure 13.10) and the probability that the biomass in 2027 is greater than the biomass in 2024 is 61% or greater in all scenarios. The population is projected to remain below B_{msy} through to the beginning of 2027 for all levels of F examined with a probability of 90% or greater. The probability of projected biomass being below B_{lim} by 2027 was 4 to 11% in all catch scenarios examined and was 4 or 5% by 2027 in the F=0 scenarios, depending on the catch assumed in 2024.

Table 13.2. Medium-term projections for witch flounder under two scenarios: catch in 2024= TAC (1 367 t) and catch in 2024=average catch 2021-2023 (505 t). Projected yield (t) and the 10th, 50th and 90th percentiles of relative biomass B/B_{msy} are shown, for projected F values of $F=0$, F_{2023}, 2/3 F_{msy}, 75% F_{msy}, 85% F_{msy} and F_{msy}.

Projections with Catch in 2024= 1367 t (TAC)		
Year	Yield (t) median	Projected relative B (B/Bmsy) median (80% CL)
F0		
2025	0	0.50 (0.30, 0.82)
2026	0	0.55 (0.33, 0.90)
2027		0.59 (0.36, 0.98)
F Status quo (0.010)		
2025	301	0.50 (0.30, 0.82)
2026	324	0.54 (0.32, 0.89)
2027		0.58 (0.35, 0.97)
2/3 Fmsy (0.0407)		
2025	1240	0.50 (0.30, 0.82)
2026	1305	0.53 (0.31, 0.87)
2027		0.55 (0.32, 0.93)
75% Fmsy (0.0458)		
2025	1395	0.50 (0.30, 0.82)
2026	1461	0.52 (0.31, 0.87)
2027		0.55 (0.31, 0.92)
85% Fmsy (0.0519)		
2025	1581	0.50 (0.30, 0.82)
2026	1646	0.52 (0.30, 0.87)
2027		0.54 (0.31, 0.91)
Fmsy (0.0611)		
2025	1860	0.50 (0.30, 0.82)
2026	1920	0.51 (0.30, 0.86)
2027		0.53 (0.30, 0.90)

Projections with Catch in 2024= 505 t (avg 2020-2023)		
Year	Yield (t) median	Projected relative B (B/Bmsy) median (80% CL)
F0		
2025	0	0.52 (0.32, 0.84)
2026	0	0.56 (0.34, 0.92)
2027		0.61 (0.37, 1.00)
F Status quo (0.010)		
2025	516	0.52 (0.32, 0.84)
2026	555	0.56 (0.34, 0.91)
2027		0.60 (0.36, 0.98)
2/3 Fmsy (0.0407)		
2025	1275	0.52 (0.32, 0.84)
2026	1341	0.54 (0.32, 0.89)
2027		0.57 (0.33, 0.95)
75% Fmsy (0.0458)		
2025	1435	0.52 (0.32, 0.84)
2026	1501	0.54 (0.32, 0.89)
2027		0.56 (0.33, 0.94)
85% Fmsy (0.0519)		
2025	1626	0.52 (0.32, 0.84)
2026	1691	0.53 (0.32, 0.88)
2027		0.55 (0.32, 0.93)
Fmsy (0.0611)		
2025	1913	0.52 (0.32, 0.84)
2026	1972	0.53 (0.31, 0.88)
2027		0.54 (0.31, 0.92)

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 (B_{2027}>B_{2024}) under projected *F* values of *F=0*, F_{2023}, 2/3 F_{msy}, 75% F_{msy}, 85% F_{msy} and F_{msy}. Two scenarios are shown: catch in 2024=TAC (1 367t) and catch in 2024=average catch 2020-2023 (505 t).

C2024=505 t (avg 2020-2023)	Yield			P(F>F_{lim})			P(B<B_{lim})				P(B<B_{msy})				
	2024	2025	2026	2024	2025	2026	2024	2025	2026	2027	2024	2025	2026	2027	P(B_{2027}>B_{2024})
F0	505	0	0	<1%	<1%	<1%	11%	8%	6%	4%	97%	95%	93%	90%	0.76
F2023=0.0100	505	310	334	<1%	<1%	<1%	11%	8%	6%	4%	97%	95%	93%	91%	0.74
2/3 Fmsy = 0.0407	505	1275	1341	<1%	17%	18%	11%	8%	7%	7%	97%	95%	94%	92%	0.68
75% Fmsy = 0.0458	505	1435	1501	<1%	24%	26%	11%	8%	8%	7%	97%	95%	94%	92%	0.67
85% Fmsy = 0.0519	505	1626	1691	<1%	35%	36%	11%	8%	8%	8%	97%	95%	94%	92%	0.66
Fmsy= 0.0611	505	1913	1972	<1%	51%	51%	11%	8%	8%	9%	97%	95%	94%	93%	0.64

C2024=TAC (1367 t)	Yield			P(F>F_{lim})			P(B<B_{lim})				P(B<B_{msy})				
	2024	2025	2026	2024	2025	2026	2024	2025	2026	2027	2024	2025	2026	2027	P(B_{2027}>B_{2024})
F0	1367	0	0	26%	<1%	<1%	11%	10%	7%	5%	97%	96%	93%	91%	0.73
F2023=0.0100	1367	301	324	26%	<1%	<1%	11%	10%	7%	5%	97%	96%	94%	91%	0.72
2/3 Fmsy = 0.0407	1367	1240	1305	26%	17%	18%	11%	10%	9%	8%	97%	96%	94%	92%	0.65
75% Fmsy = 0.0458	1367	1395	1461	26%	25%	26%	11%	10%	9%	9%	97%	96%	94%	93%	0.65
85% Fmsy = 0.0519	1367	1581	1646	26%	35%	36%	11%	10%	10%	9%	97%	96%	94%	93%	0.63
Fmsy= 0.0611	1367	1860	1920	26%	51%	51%	11%	10%	10%	10%	97%	96%	94%	93%	0.61

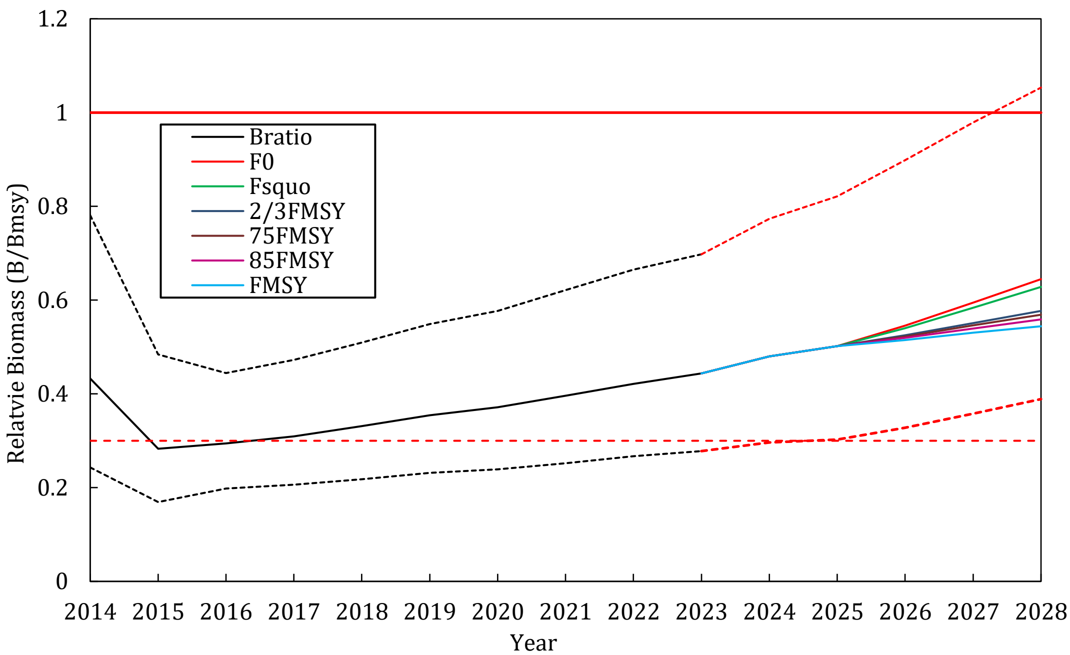

Figure 13.10. Witch flounder in Divisions 3NO: medium term projections of relative biomass (B/B_{msy}) at five levels of *F* (F=0, F_{2023}, 2/3 F_{msy}, 75% F_{msy} ,85% F_{msy} and F_{msy}). A catch of 1 367 t is assumed in 2024. The 10th and 90th credible intervals are included for the model results up to 2023 and for the projected period for the *F*=0 assumption.

g) 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 11% and above F_{lim} is less than 1% (Figure 13.11).

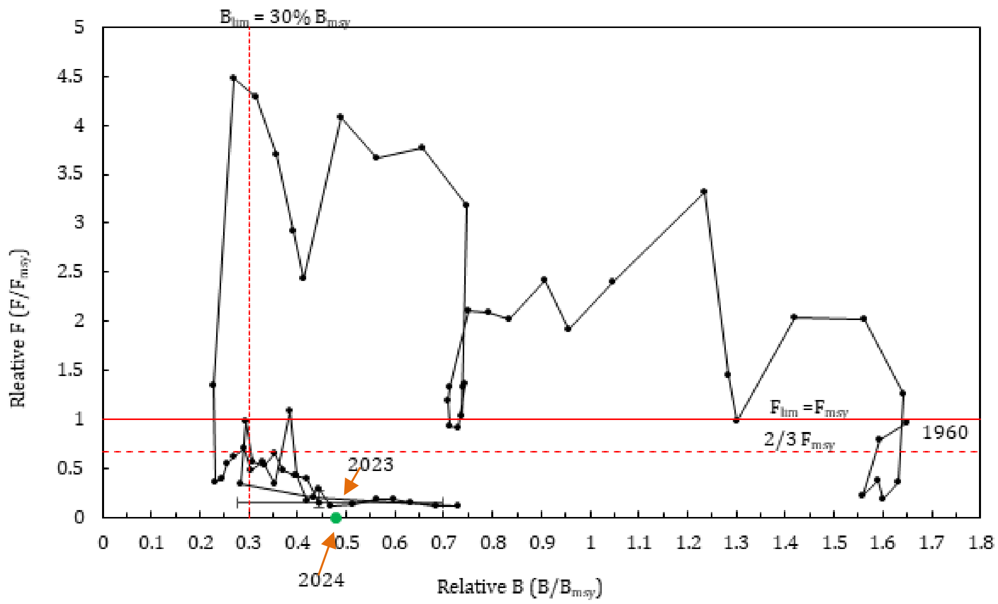

Figure 13.11. Witch flounder in Divisions 3NO: stock trajectory estimated in the surplus production analysis, under a precautionary approach framework.

The next assessment will be in 2026.

h) Research Recommendation

STACFIS **recommends** that *the Bayesian production model for this assessment be further explored in order to determine if adding the EU-Spain spring survey series (Pedreira and Campelen, either separately or if conversion is possible, a single time series) could be included as model inputs.*

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

Interim Monitoring Report (SCR 24/037 and SCS 24/08, 09)

a) Introduction

Fisheries and catches: 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) occurred from 2016 to 2020.

Recent catches and TACs (t) are as follows:

	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024
Recommended TAC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Catch, t (STACFIS)	0	5	1	2	2	1	0	0	0	

na = no advice possible