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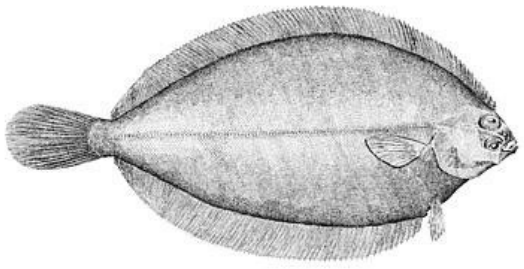
Canadian Science Advisory Secretariat
Gulf Region | Science Advisory Report 2022/028

STOCK ASSESSMENT OF WITCH FLOUNDER (*GLYPTOCEPHALUS CYNOGLOSSUS*) IN THE GULF OF ST. LAWRENCE (NAFO DIVISIONS 4RST) TO 2021



*Witch Flounder (*Glyptocephalus cynoglossus*)*
Source: Wikipedia

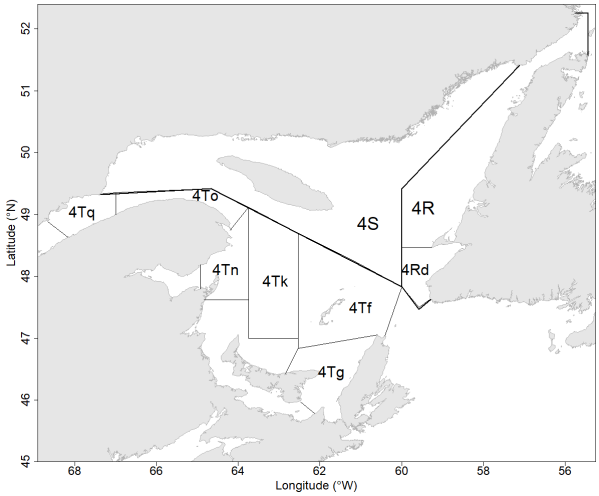


Figure 1. NAFO Divisions 4R, 4S and 4T (bordered by heavy solid line). The NAFO unit areas where most Witch Flounder are caught in commercial fisheries are labelled in lower case.

Context:

*The commercial fisheries for Witch Flounder (*Glyptocephalus cynoglossus*) in the northern Gulf of St. Lawrence (NAFO Divisions 4RS) came under quota management in 1977, with a quota of 3,500 t. In 1979, the Total Allowable Catch (TAC) in NAFO Divs. 4RS was increased to 5,000 t to remove an old and slow-growing component of the stock. This measure succeeded in reducing the age composition of the stock; however, landings declined and by 1982, the TAC was reduced to 3,500 t. During the 1980s, landings from NAFO Div. 4T increasingly dominated the Gulf of St. Lawrence Witch Flounder landings. The first detailed assessment of NAFO Divs. 4RS Witch Flounder was conducted in 1978 and continued yearly until 1981. When stock assessments resumed in 1991 and following the recommendation of the Fisheries Resource Conservation Council in 1994, the management unit was extended to NAFO Divs. 4RST in 1995. The last full assessments of this stock occurred in 2012 (DFO 2012; Swain et al. 2012) and in 2017 (DFO 2017c; Ricard and Swain 2018).*

This Science Advisory Report is from the March 1-2, 2022 science peer review meeting on the stock status and fishery advice for May 2022 to May 2027 for Witch Flounder from NAFO Divisions 4RST, Gulf of St. Lawrence. Participants at the meeting included DFO Science (Gulf, Maritimes, Newfoundland and Labrador, NCR, and Québec regions), DFO Fisheries Management (Gulf, Maritimes, Newfoundland and Labrador, NCR, and Quebec regions), NOAA-NMFS, DTU Aqua, and the fishing industry.

SUMMARY

- During the 2017-2018 to 2021-2022 fishing seasons the total allowable catch (TAC) of Witch Flounder in the Northwest Atlantic Fisheries Organization (NAFO) Divisions 4RST was set at 500 t. Landings for that period were between 349 t to 183 t. Preliminary landings for 2021-2022 were 212 t.
- The fishery for Witch Flounder is primarily a directed fishery, with most of the catch taken by Danish seines in southwest Newfoundland (NAFO Div. 4R) and northwestern Cape Breton Island (NAFO Div. 4T).
- There has been a contraction in the size composition of Witch Flounder in the landings. Fish 40 cm or longer made up 70% to 80% of the landings in the late 1970s but less than 20% of the landings in 2003 to 2012. The proportion of these large fish has increased in recent years, accounting for 20% to 30% since 2013.
- Based on research vessel surveys, the abundance of Witch Flounder measuring 30 cm and longer (the proxy for spawning stock biomass; SSB) has increased throughout the historical Gulf of St. Lawrence range since 2013, including the Estuary, western Newfoundland and around Anticosti Island.
- Reference points for the SSB of Witch Flounder were derived from a surplus production model. The Limit Reference Point (LRP), defined as 40% of the biomass for maximum sustainable yield (B_{msy}), is estimated at 10,700 t. The Upper Stock Reference (USR) of 80% B_{msy} is estimated at 21,400 t.
- The 2021 median spawning stock biomass estimate of Witch Flounder is 17,770 t, which is in the cautious zone of the DFO precautionary approach at 166% of the LRP and 83% of the USR. There is a 23% chance that the estimated SSB is at or below the LRP. The median estimate of the fishing removal rate in the last 5 years was between 0.011 to 0.023, which is below the maximum removal rate (F_{msy}) estimated at 0.071.
- Post-removal stock biomass projections for 2022 to 2026 indicate that the biomass is expected to increase up to a total annual catch of 1,000 t. The probability of the biomass being below the LRP in 2026 is 13% in a no catch scenario, 16% under a catch of 500 t and 22% under a catch of 1,000 t. The probability that the stock biomass will be in the healthy zone in 2026 is 60% under a no catch scenario, 52% under a catch of 500 t and 44% under a catch of 1,000 t.
- The stock is showing some positive signs of growth under current catch levels and is estimated to be in the Cautious zone. According to the Precautionary Approach, fisheries management actions for a stock in the Cautious zone should balance socioeconomic considerations while still promoting stock growth towards the Healthy zone.
- An interim year indicator update could be provided mid-way in the five-year assessment cycle to determine if the indicator signals that a re-assessment is warranted. This indicator is based on the combined research vessel surveys in NAFO Divisions 4RST.

INTRODUCTION

Witch Flounder (*Glyptocephalus cynoglossus* L.) is a righteye flounder species distributed over the northern Atlantic Ocean. In the western Atlantic Ocean, the species occurs from Cape Hatteras to the Labrador Sea. They most commonly occur in deep holes and channels and along the shelf slope on muddy bottom. The species is slow-growing and late-maturing, making it particularly vulnerable to over-exploitation.

The Fisheries

A fishery for Witch Flounder was developed in the Gulf of St. Lawrence (NAFO Divisions 4RST) in the 1950s. Annual landings averaged over 3,500 t in the 1960s and 1970s, declining to an average of 1,800 t in the 1980s. Landings declined further in the early 1990s to a low of 320 t in 1995. Landings then increased to an average of 850 t annually in 1998-2008 but declined again in 2009-2010. While the total allowable catch (TAC) remained at 1,000 t until 2011, landings in 2011 were 425 t. The TAC was reduced to 500 t in 2012, further reduced to 300 t in 2013 and then increased back to 500 t in 2017. Landings have closely matched the TAC for the period 2013-2016 and have been below the TAC since 2017 (Fig. 2). Primarily a directed fishery undertaken by Danish seine vessels, since 2013 the TAC has been allocated equally to the 4R (southwest Newfoundland) and the 4T (northwestern Cape Breton) fleets. Both fleets have since caught the near totality of the yearly TAC for the 2013 to 2018 period. In recent years (2018 to 2021), the 4T fleet only landed a portion of its quota while the 4R fleet has landed the near totality of its quota. Landings for the period 2017 to 2021 were between 349 t and 183 t. Preliminary landings for 2021 were 212 t.

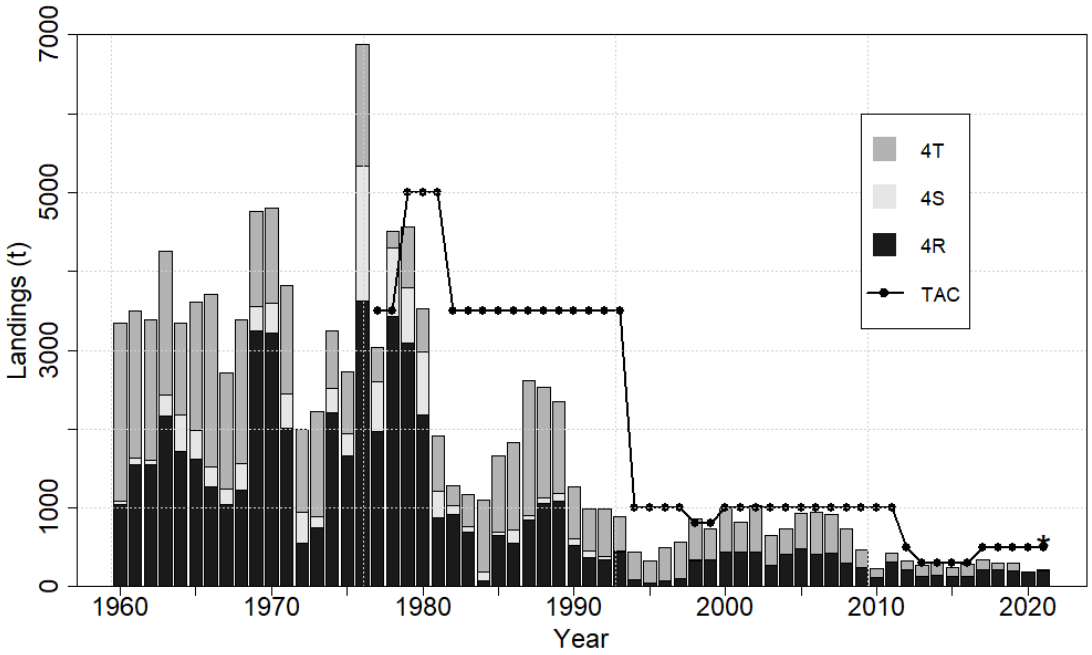


Figure 2. Landings and total allowable catch (TAC) of Witch Flounder in NAFO Divisions 4RST, 1960 to 2021. The asterisk indicates that landings for 2021 were obtained from Fisheries and Aquaculture Management quota monitoring systems and are preliminary.

The length composition of samples from the commercial fishery differed dramatically between samples collected in the 1970s and early 1980s and those collected in the 2000s (Fig. 3). The proportion of fish 40 cm and longer was around 80% for the period 1975-1978 and dropped to around 30% for the period 1986-2000. For the period 2007-2012, the proportion of fish 40 cm and longer was below 20% and has been increasing since in both NAFO Divisions 4R and 4T.

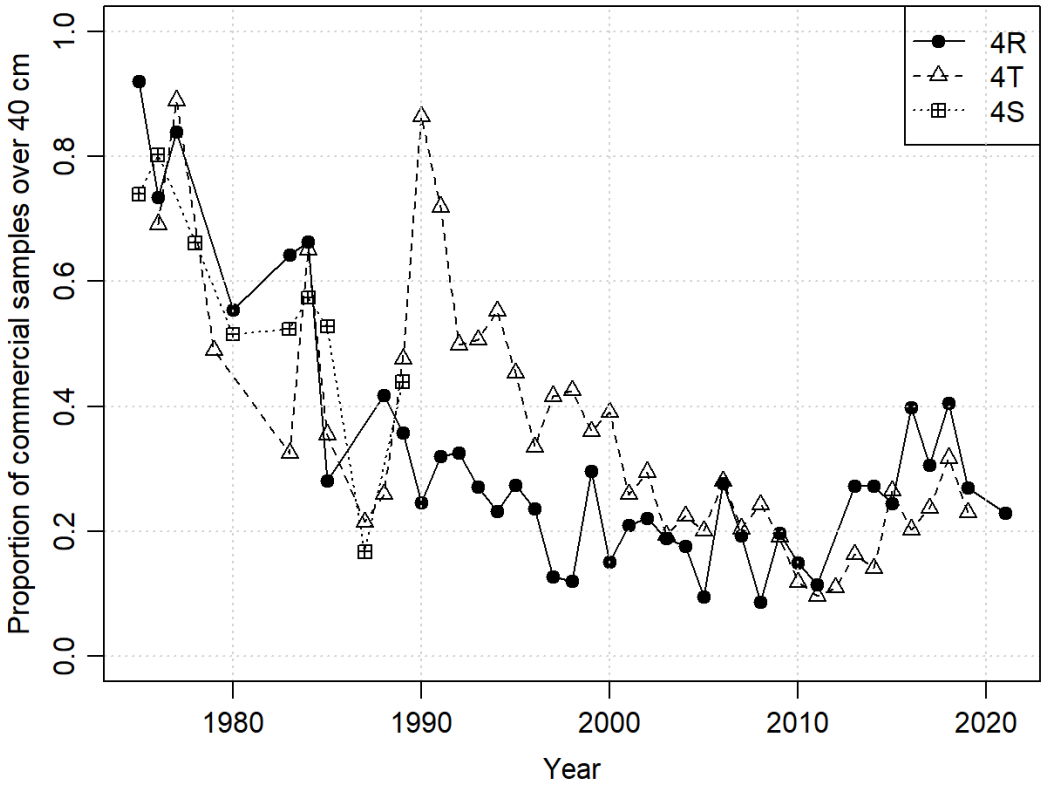


Figure 3. Proportion of fish from commercial samples that were over 40 cm. No commercial samples were available from NAFO Division 4R in 2012 and 2020, and from NAFO Division 4T in 2020 and 2021.

ASSESSMENT

Two stratified random bottom-trawl Research Vessel (RV) surveys were available to provide fisheries-independent information about Witch Flounder in the GSL. One survey has been conducted in the southern Gulf of St. Lawrence (NAFO Div. 4T) each September since 1971 and the second survey has been conducted in the Estuary and the northern Gulf of St. Lawrence (NAFO Div. 4RST) each August since 1984 (Fig. 4). Witch Flounder length frequency data (required for standardization between the two surveys) are only available since 1987 for the August survey. Survey indices were calculated using a set of strata sampled in most years (415-439 in the September survey and 401-414, 801-824, 827-832 in the August survey).

The RV surveys follow a stratified random sampling design. Based on analyses of the comparative fishing experiments, and additional analyses on diel variation in catchability of Witch Flounder, catches in the September and August surveys were standardized to a 1.75 nautical miles night tow by the *Lady Hammond* using the Western IIA trawl for most analyses.

A summer mobile-gear sentinel survey has been conducted annually in the northern Gulf of St. Lawrence since 1995. The survey is conducted using industry vessels with a trawl equipped with rockhopper gear and a restrictor cable to standardize the horizontal opening of the trawl. The surveys follow a stratified random design using the same strata as the August research vessel survey except that the sentinel surveys do not extend as far into the Estuary as does the RV survey. A similar sentinel survey, using the same gear and fishing procedures (except for the restrictor cable), has been conducted in August in the southern Gulf of St. Lawrence since 2003, but did not take place in 2020 and 2021. This survey uses the same strata as the September RV survey.

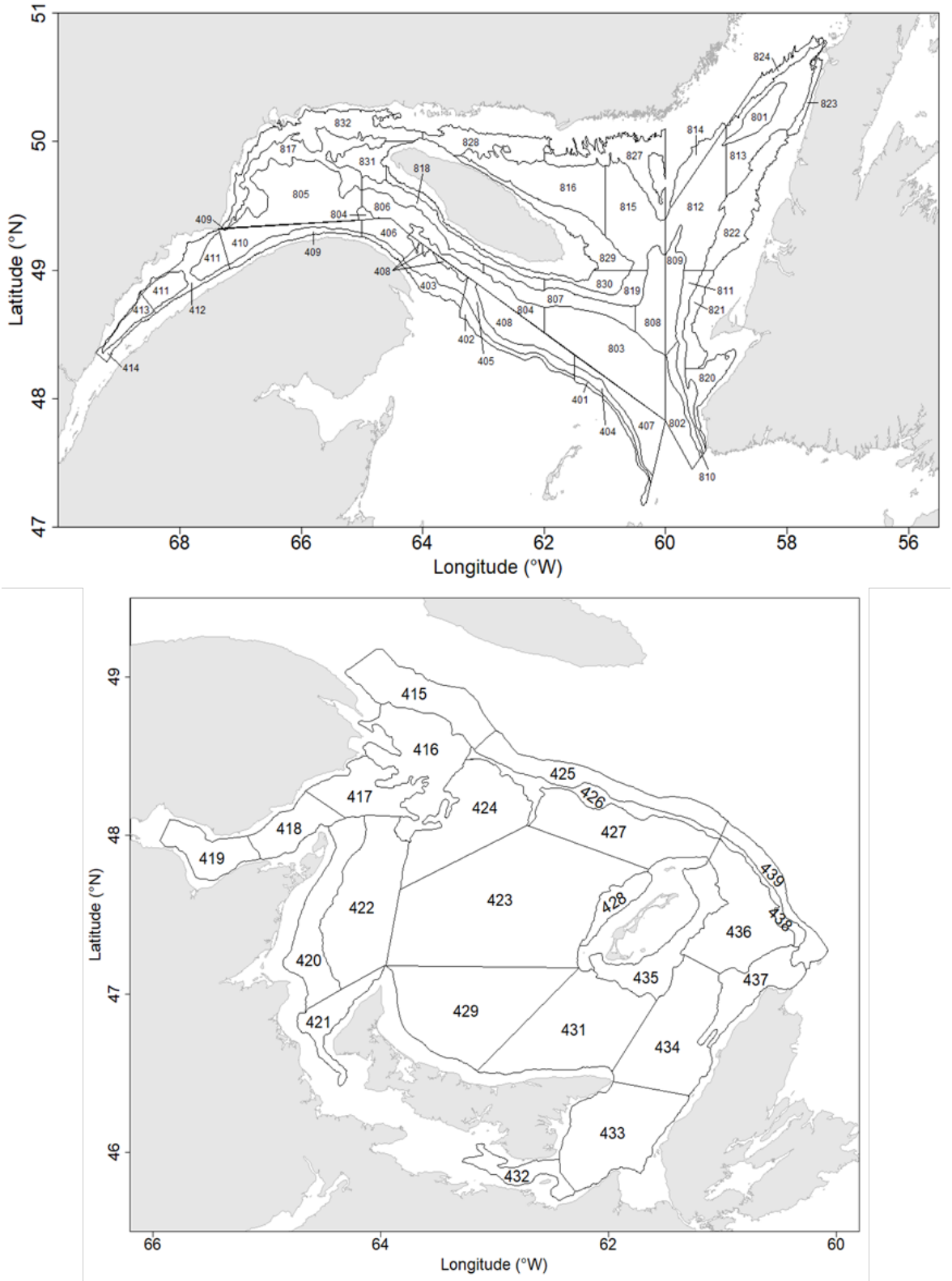


Figure 4. Strata boundaries for the September bottom trawl survey of the August bottom trawl survey of the northern Gulf of St. Lawrence (top panel) and for the southern Gulf of St. Lawrence (bottom panel). The strata appearing on the map are those used in the analyses.

Spatial distribution

In the 1987-1991 period, Larger commercial-sized Witch Flounder (30+ cm) showed concentrations in September occurring in the Cape Breton Trough west of Cape Breton Island, the Chaleur Trough and Shediac Valley east of the Gaspé Peninsula and the shelf off western Newfoundland, as well as in the Estuary (Fig. 5). After reduced occurrences in the period 1992 to 2011, concentrations of larger Witch Flounder have increased since 2012 in the Estuary, in western Newfoundland and around Anticosti Island.

Population Modelling

Witch Flounder in the Gulf of St. Lawrence (NAFO Divs. 4RST) was modelled as a single population. A similar population model to the two previous assessments was used; a state-space Schaefer production model adjusted using a Bayesian approach. Inputs were:

- The reported landings for the period 1960 to 2021 (Fig. 2).
- A trawlable biomass index of 30+ cm Witch Flounder (i.e., the proxy for spawning stock biomass) for the September RV survey from Div. 4T for 1971 to 1992. This index does not cover the entire stock area and was used only for this period because the proportion of the stock occurring in the September survey area changed as the stock declined in the early 1990s (Swain et al. 2012) (top panel of Fig. 6).
- A trawlable biomass index of 30+ cm Witch Flounder for the combined August and September RV surveys for NAFO Divs. 4RST for the period 1987 to 2021 (middle panel of Fig. 6).
- A trawlable biomass index of 30+ cm Witch Flounder for the combined July and August sentinel surveys in NAFO Divs. 4RST for the period 2003 to 2019 (bottom panel of Fig. 6).

Two model variants were explored. The first model had the intrinsic rate of population growth (r) fixed at a constant level over the whole time period. The second model had *r* varying by decade. The prior probability distributions used for the Schaefer model parameter *r* and for the catchability coefficients of the different surveys were the same as those used in the previous assessments (Swain et al. 2012; Ricard and Swain 2018).

Of the model variants examined, the model with a constant *r* over the time series was retained because there was weak evidence of a decadal change in productivity.

The retained model fit the abundance indices fairly well (Fig. 6). The model accounted for the long term trend but had difficulty fitting the higher frequency bumps and valleys in the indices (Fig. 6). The model outputs in this assessment are comparable to the values from the previous assessments. Model parameters estimates and associated metrics of interest to management (with 80% credible limits in parentheses) are presented in Table 1.

Reference Points for Witch Flounder from NAFO Divisions 4RST

Following DFO (2009), the Limit Reference Point (LRP) used was calculated as 40% of the estimated biomass producing the maximum sustainable yield (B_{msy}). For the NAFO Divs. 4RST stock of Witch Flounder, the B_{msy} was estimated at 26,750 t (Table 1). The LRP is calculated at 10,700 t and the Upper Stock Reference value corresponding to 80% of B_{msy} is 21,400 t. The maximum removal rate (E_{msy}), equivalent to F_{msy} is 0.071 (Table 1).

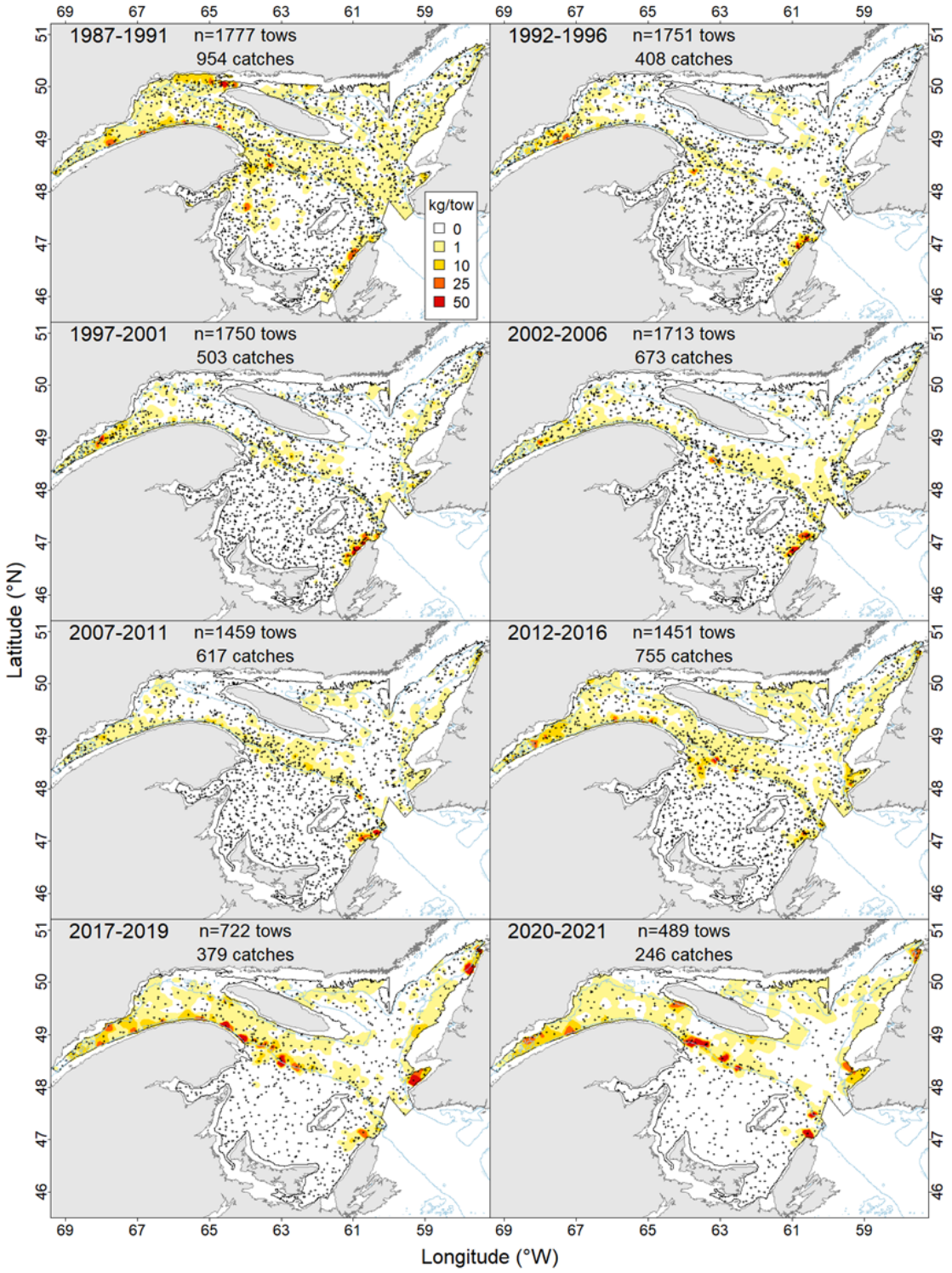


Figure 5. Distribution of biomass of Witch Flounder ≥ 30 cm in length in the August survey of the northern Gulf of St. Lawrence and the September survey of the southern Gulf of St. Lawrence, 1987 to 2021. All catch data are normalised to a 1.75 nautical miles night tow on the Lady Hammond using a Western IIA trawl. Catches are displayed using Inverse Distance Weighted interpolation (IDW) and all set locations are identified by a small black cross. The 200 m isobath is drawn in light blue.

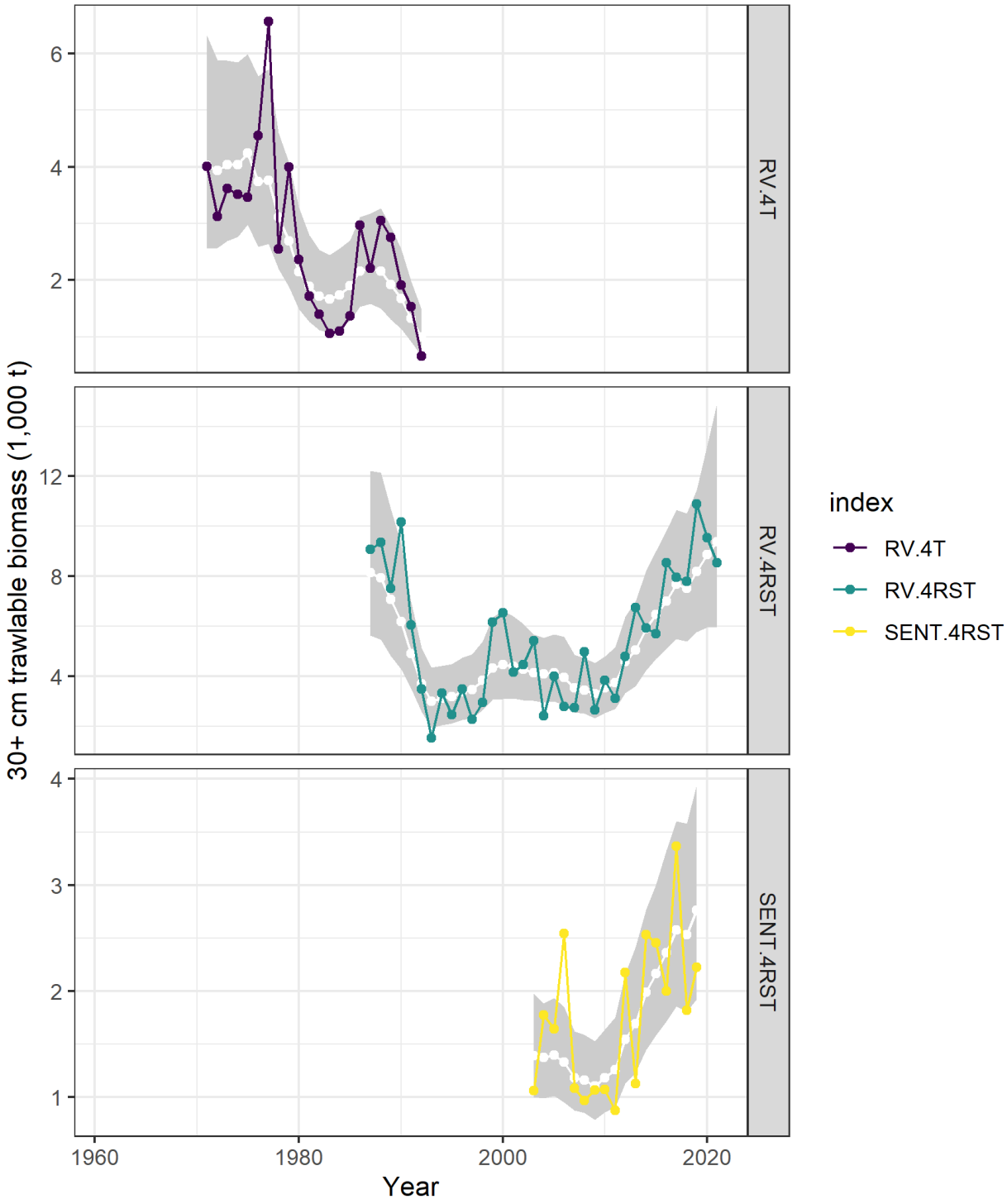


Figure 6. Fit of the single productivity surplus production model M1 of NAFO Div. 4RST Witch Flounder to the three population indices. The three indices are the NAFO 4T RV index (1971-1992, top panel), the NAFO 4RST RV index (1987-2021, middle panel) and the NAFO 4RST Sentinel index (2003-2019, bottom panel). The fit is shown by plotting each index using a solid coloured line and dots along with the model-derived median estimate of 30+ cm biomass as a solid white line with white dots and a grey polygon around the median denoting the 2.5th and 97.5th percentiles.

Table 1. Fitted parameter values and model-derived estimates of relative stock status using reference points for NAFO Divisions 4RST Witch Flounder. Median estimates are presented along with their associated 80% credibility intervals.

Parameter / quantity	Median estimate
r – Schaefer model productivity parameter	0.142 (0.097-0.193)
K – Schaefer model carrying capacity parameter (1,000 t)	53.498 (34.128-138.752)
B_{msy} – biomass at Maximum Sustainable Yield (1,000 t)	26.749 (17.064-69.376)
C_{msy} – catch at Maximum Sustainable Yield (1,000 t)	1.961 (1.242-4.151)
E_{msy} – removal rate at Maximum Sustainable Yield	0.071 (0.049-0.097)
LRP – Limit Reference Point (1,000 t)	10.7 (6.826-27.75)
USR – Upper Stock Reference (1,000 t)	21.399 (13.651-55.501)
B_{2021} – Biomass in 2021 (1,000 t)	17.768 (12.057-26.452)
B_{2021}/LRP – Ratio of the median biomass in 2021 and the median LRP	1.66
B_{2021}/USR – Ratio of the median biomass in 2021 and the median USR	0.83
$P(B_{2021} \geq LRP)$ – probability that the biomass in 2021 is above the LRP	0.77
$P(B_{2021} \geq USR)$ – probability that the biomass in 2021 is above the USR	0.33

Stock Status Relative to Reference Points

The median estimate of the spawning stock biomass (SSB; ≥ 30 cm) of Witch Flounder for the GSL has been consistently below the LRP since 1991 although there has been greater than 5% chance of SSB being below the LRP since 1979 (Fig. 7). The median of the SSB estimates rose above the LRP in 2014 and has remained there since. In 2021, the SSB was estimated at 17,700 t, 166% of the median LRP, with a 23% chance of being below the LRP (Table 1; Fig. 7).

Over most of the time series, the estimate exploitation rate has been above the maximum removal rate (E_{msy}; calculated as C_{msy}/B_{msy}) except for 1994 to 1996, and from 2010 to 2021 (Figs. 8 and 9).

Projections Relative to Different Catch Options

Five-year after fishery projections for 2022 to 2026 were made at four levels of annual catch; 0 t, 500 t, 1,000 t and 1,500 t. Median estimates of biomass of Witch Flounder (≥ 30 cm) increased over the five year period at catch options to 1,000 t (Fig. 10).

When a stock is in the cautious zone, removals should be at a level that allows rebuilding of the stock towards the healthy zone (DFO 2009). The percentages of the projected surplus production which is removed annually increases with increasing catch levels but decreases over time as the projected SSB increases (Table 2). For example, under a catch option of 500 t in 2022, the percentage of predicted surplus production extracted is 29% compared to 58.6% at a catch option of 1,000 t (Table 2).

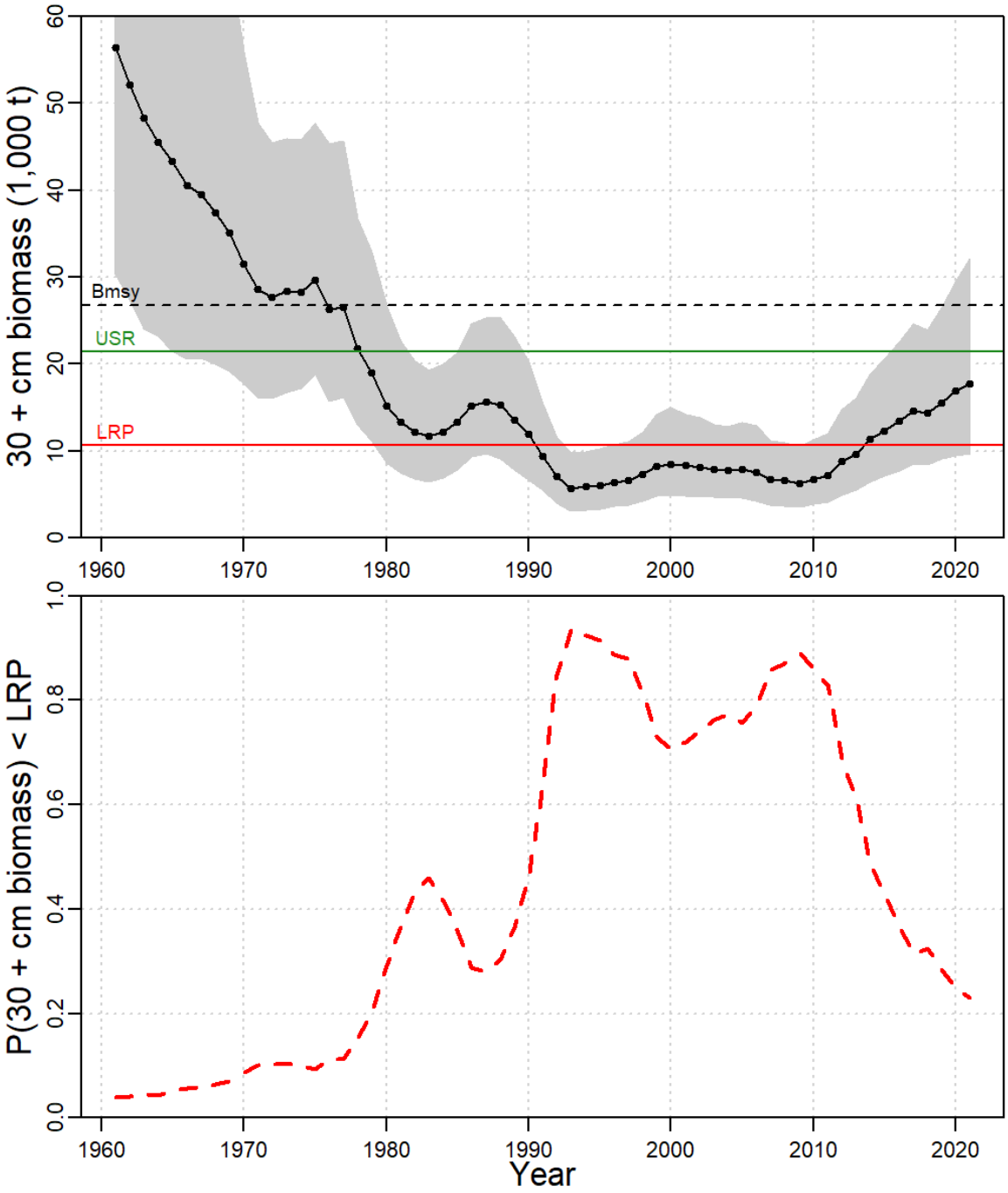


Figure 7. Estimated 30+ cm biomass from the single productivity surplus production model M1 of NAFO Div. 4RST Witch Flounder (top panel). The solid black line is the posterior median and the grey polygon spans the 2.5th and the 97.5th quantiles. The red horizontal line shows the limit reference point (LRP) which corresponds to 40% of B_{msy}, the green horizontal lines show the Upper Stock Reference (USR) which corresponds to 80% of B_{msy} and the black dashed horizontal line shows B_{msy}. The bottom panel shows the probability that the 30+ cm biomass is below the LRP.

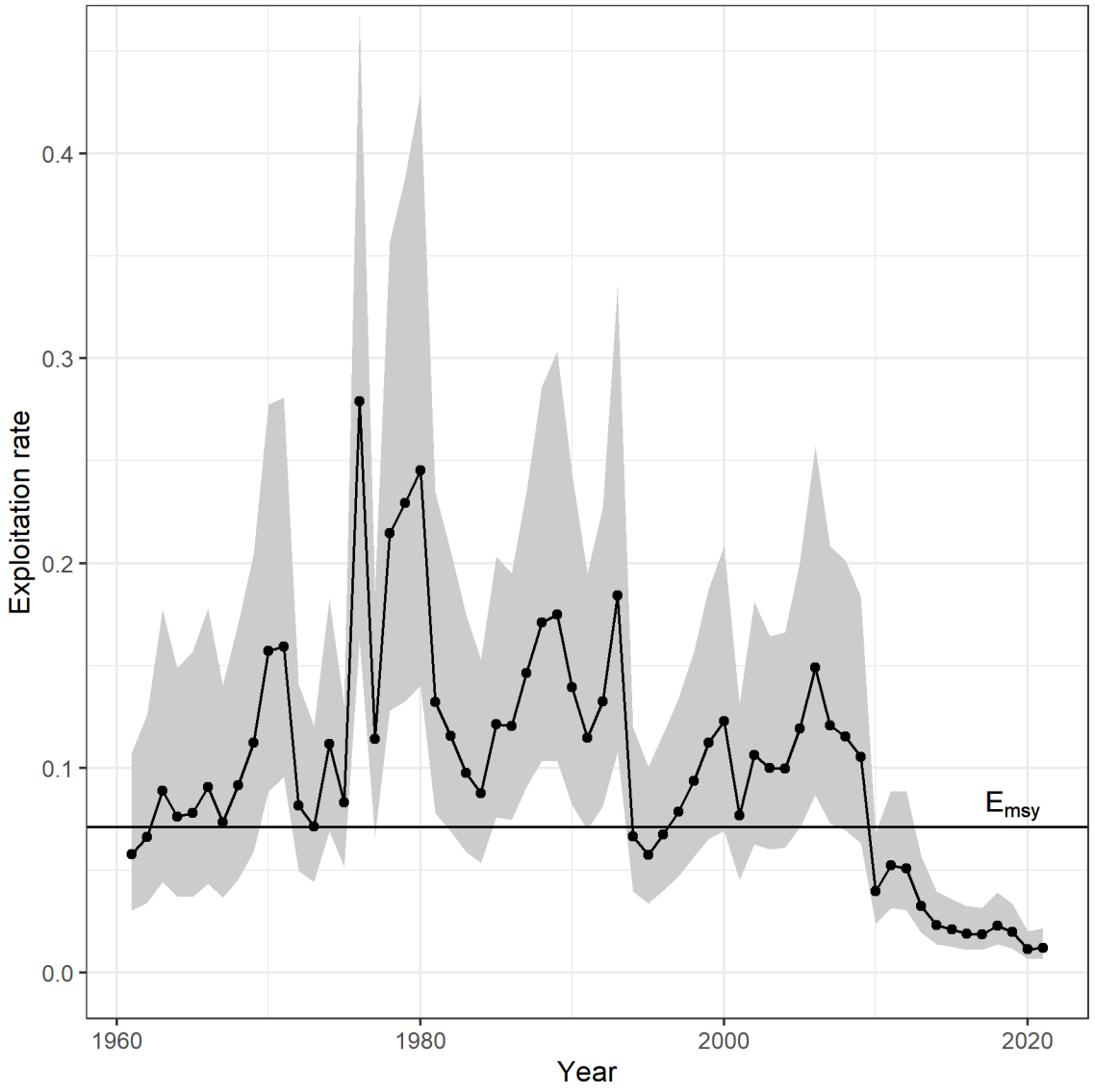


Figure 8. Model estimates of the exploitation rate on Witch Flounder from the Gulf of St. Lawrence, 1960 to 2021. The median of the maximum removal rate corresponding to E_{msy} (C_{msy}/B_{msy}) is also shown as the dotted horizontal line. The medians of the annual exploitation rates are the dark line with black circles and the 95% credibility intervals are defined by shading.

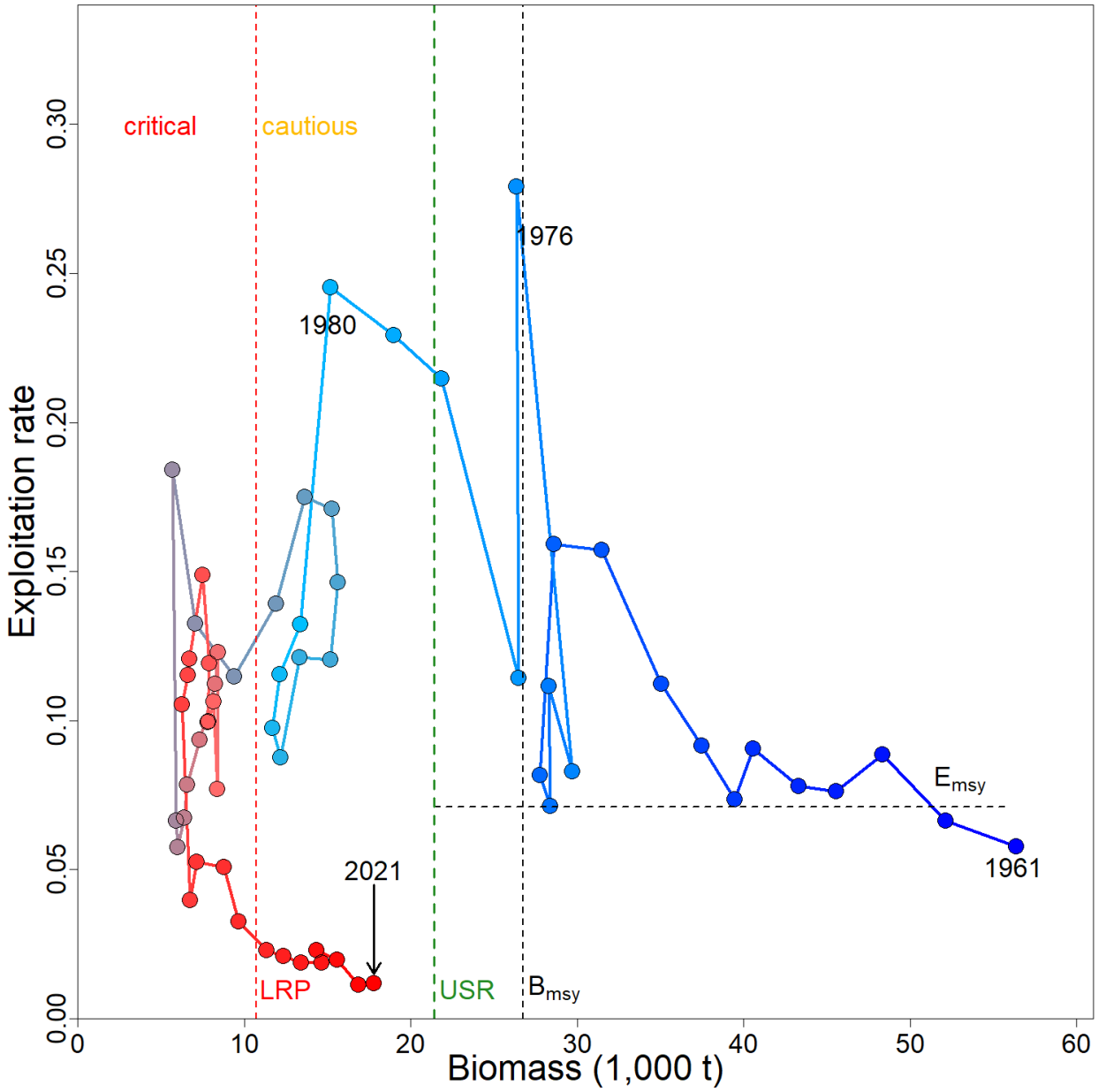


Figure 9. Trajectory of the spawning stock biomass (median of the estimate) relative to the exploitation rate (median of the estimate) for the Witch Flounder stock of the Gulf of St. Lawrence, 1961 to 2021. The symbols and lines are coloured from blue to red sequentially for the years 1961 to 2021. The dashed red vertical line corresponds to the Limit Reference Point, the dashed vertical green line corresponds to the Upper Stock Reference point, and the dashed horizontal line is the maximum removal rate. Also shown as a dashed black vertical line is the value corresponding to B_{msy}.

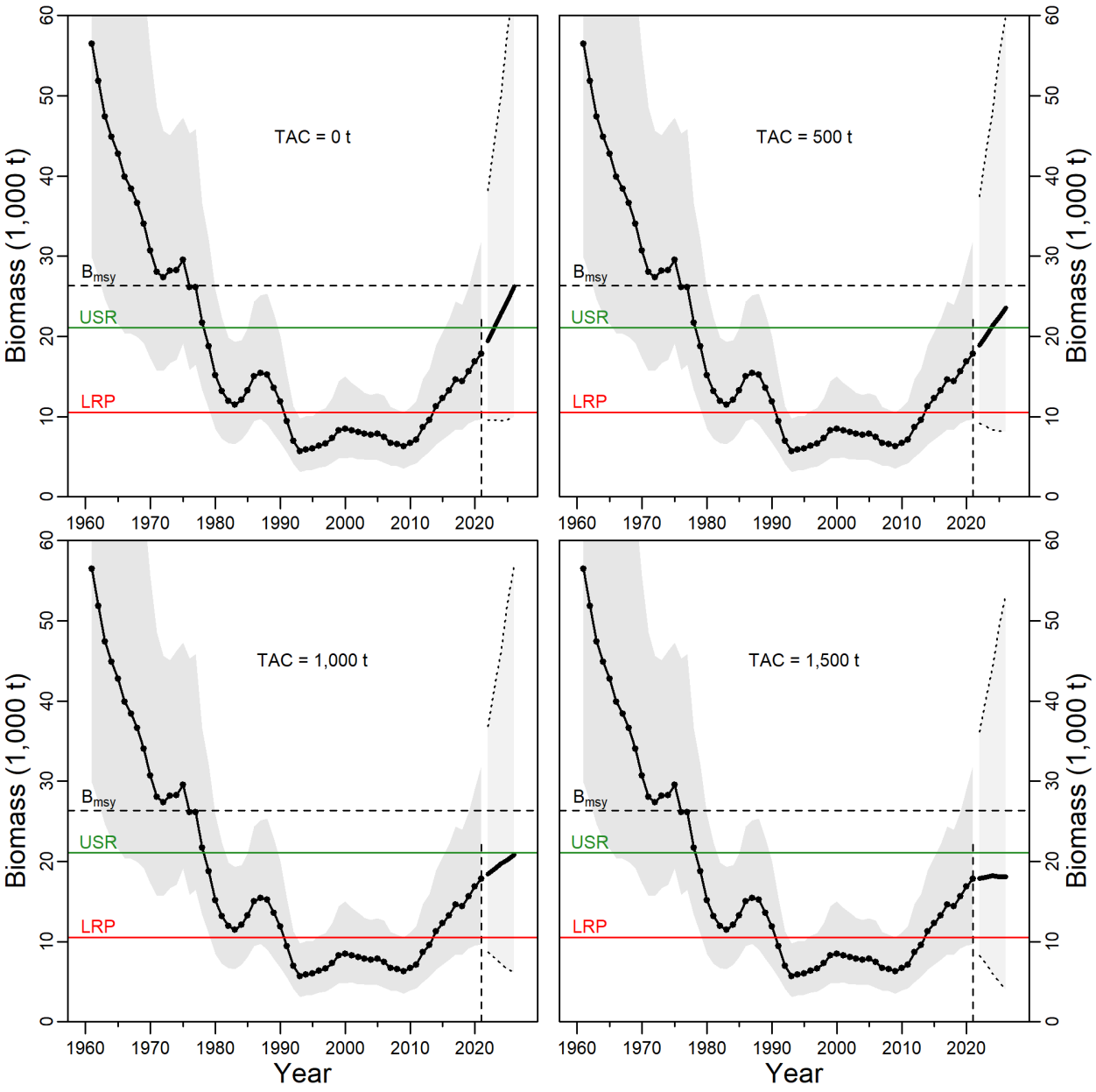


Figure 10. Projected 30+ cm biomass (1,000 t) of NAFO Div. 4RST Witch Flounder at various annual catch levels in 2022 to 2026 (0 t top-left panel, 500 t top-right panel, 1,000 t bottom-left panel and 1,500 t bottom-right panel) using the single productivity regime model M1. In all four panels, the solid black lines are the posteriors medians and the grey polygon spans the 2.5th and the 97.5th quantiles. Biomasses for years 2022 to 2026 are projected estimates. The red horizontal lines show the limit reference point (LRP) which corresponds to 40% of B_{msy}, the green horizontal lines show the Upper Stock Reference (USR) which corresponds to 80% of B_{msy}, and the horizontal dashed black lines show B_{msy}.

Table 2. Annual probabilities that the estimated biomass of NAFO Divisions 4RST Witch Flounder ≥ 30 cm after fishing will be less than or equal to the Limit Reference Point (LRP) and greater than or equal to the Upper Stock Reference Point (USR) for four levels of annual catch in 2022 to 2026. The four levels of catches considered are 0 t, 500 t, 1,000 t and 1,500 t. The projected surplus production (median; 80% credibility interval) and the percentages (median; 80% credibility interval) of the projected surplus production of biomass which would be extracted annually under each annual catch option are also presented.

		Catch option			
Measure	Year	0 t	500 t	1,000 t	1,500 t
Byear<LRP	2022	21%	22%	23%	24%
	2023	18%	20%	22%	25%
	2024	16%	19%	22%	27%
	2025	15%	18%	22%	28%
	2026	13%	16%	22%	29%
Byear≥USR	2022	40%	38%	36%	34%
	2023	46%	42%	38%	35%
	2024	51%	46%	41%	35%
	2025	56%	49%	43%	36%
	2026	60%	52%	44%	37%
Surplus production	2022	1,745.9 (826.3-3,180.9)	1,726.2 (832.2-3,111.3)	1,705.0 (836.6-3,040.6)	1,682.1 (839.5-2,968.0)
	2023	1,801.3 (796.2-3,407.4)	1,769.2 (816.6-3,269.5)	1,730.1 (831.2-3,124.5)	1,688.6 (838.9-2,988.0)
	2024	1,842.5 (747.6-3,633.9)	1,807.6 (790.8-3,437.4)	1,756.8 (822.2-3,221.3)	1,696.8 (837.8-3,013.9)
	2025	1,864.9 (690.8-3,824.7)	1,831.8 (764.2-3,566.3)	1,772.2 (815.1-3,281.5)	1,689.7 (838.7-2,991.6)
	2026	1,875.0 (609.2-4,035.3)	1,853.6 (725.1-3,715.8)	1,792.7 (802.6-3,368.4)	1,689.5 (838.8-2,991.1)
Percentage of surplus production removed	2022	0% (0-0)	29% (16.1-60.1)	58.6% (32.9-119.5)	89.2% (50.5-178.7)
	2023	0% (0-0)	28.3% (15.3-61.2)	57.8% (32-120.3)	88.8% (50.2-178.8)
	2024	0% (0-0)	27.7% (14.5-63.2)	56.9% (31-121.6)	88.4% (49.8-179)
	2025	0% (0-0)	27.3% (14-65.4)	56.4% (30.5-122.7)	88.8% (50.1-178.8)
	2026	0% (0-0)	27% (13.5-69)	55.8% (29.7-124.6)	88.8% (50.1-178.8)

Sources of Uncertainty

For the research vessels, fishing efficiency for Witch Flounder varies substantially between day and night. Efficiencies also vary among the vessels and gears used to conduct the summer and fall research surveys. Adjustments have been made for these changes in fishing efficiency using calibration factors estimated from comparative fishing experiments. However, there is uncertainty around these estimated factors.

The inclusion of the 4T index in the model assumes that there is no time trend in the proportion of the stock occurring in the 4T September survey area over the 1971 to 1992 period. Information on geographic distribution and changes in stock abundance in the 1970s and 1980s are consistent with this assumption, but its validity remains uncertain. Excluding this index results in a more severe decline in estimated biomass between 1961 and 2011.

There is no information on growth and age-at-maturation that is more recent than the early 1980s. Thus the extent to which the decline in size at maturation since the early 1980s reflects a response to high mortality versus an effect of slower growth is uncertain. Likewise, it is uncertain whether a decline in growth explains some of the observed loss of 40+ cm fish from the population.

The Schaefer production models do not provide support for changes in productivity regime for this stock. However, in these models, the intrinsic rate of population increase integrates recruitment, growth and natural mortality. Thus, it is possible that there have been counter-acting changes between the components of productivity. For example, a decline in growth rate or an increase in natural mortality rate could be obscured in the modeling by an increase in recruitment rate.

Stock structure is a source of uncertainty for this resource. It is possible that the dynamics of Witch Flounder in the Gulf, particularly those in eastern 4T, are linked to those of Witch Flounder in NAFO Div. 4VW.

CONCLUSIONS AND ADVICE

Witch Flounder is a species of low productivity and is vulnerable to overexploitation. Growth is slow and maturation is at a late age. In the 1974 to 1981 period, the mean length at 12 years was estimated to have been only 40 cm for males and 41 cm for females. For this same period, estimated ages at 50% maturity were 7.5 years for males and 10.4 years for females. An apparent shift towards earlier maturation in the 4RST stock between the 1970s and the 2000s suggests that this stock has experienced relatively high adult mortality.

The 2021 median estimate of the SSB is 17,770 t, above the LRP (10,700 t) with a 23% chance that the estimated biomass is at or below the LRP.

Projections of stock biomass after fishing for 2022 to 2026 indicate that the biomass is expected to increase for examined annual catch options to 1,000 t. The probability of the biomass after fishing being below the LRP in 2026 is 13% in the absence of fishing, 16% at an annual catch of 500 t and 22% at a catch option of 1,000 t. The probability that the stock biomass will be in the healthy zone, i.e., at or above USR, in 2026 after fishing is 60% with no catch, 52% at an annual catch of 500 t and 44% at an annual catch of 1,000 t. Caution is advised as the available evidence indicates that incoming recruitment of Witch Flounder < 30 cm is not as strong as the recruitment noted in 2009 and 2010.

Increased abundance of Witch Flounder in the Gulf is in contrast to the decreasing abundance trends of other large demersal fish species such as American Plaice (DFO 2016b), Yellowtail Flounder (DFO 2016c), Winter Flounder (DFO 2017b), Atlantic Cod (DFO 2019), White Hake (DFO 2016d) and skates (DFO 2017a) that are distributed in shallower waters of the southern Gulf of St. Lawrence. These other species show evidence of strong declines in productivity associated with increases in natural mortality. A model that considered changes in productivity for Witch Flounder over time was examined but there was no evidence of a change in productivity over the 1961 to 2021 period.

OTHER CONSIDERATIONS

Stock Status Indicator

The NAFO Divisions 4RST Witch Flounder stock is currently assessed and managed on a five-year cycle. Indicators are needed to characterize stock status in the intervening years between assessments (DFO 2016a). The chosen indicator is the combined biomass indices for Witch

Flounder ≥ 30 cm from the RV surveys conducted in the northern and southern Gulf of St. Lawrence. Since these indices can have large observation error and changes in stock status should not be inferred from annual variations in the index, a three-year moving average is used.

Since the Witch Flounder stock of NAFO Divs. 4RST is projected to increase in abundance and have a low probability (< 22%) of being below the LRP by 2026 at catch levels up to 1,000 t, a re-assessment would be recommended if the stock status indicator signaled a decline of the SSB to below the LRP. If the index indicates that the SSB is staying above the LRP, a re-assessment would not be recommended as the stock trajectory would be consistent with expectation from this assessment and the catch advice would still be relevant.

In order to implement this approach it is necessary to relate the LRP from its modelled population scale to the scale of the combined RV index in August and September. This is done by scaling the biomass over the whole stock area to the scale of the combined 4RST index using the catchability coefficient estimated from the model. The median value of the index catchability coefficient is 0.522. The LRP value of 10,700 t is equivalent to a re-scaled LRP of 5,590 t of trawlable biomass for the combined RV index (Fig. 11).

If requested, an interim year update can be provided mid-way in the five-year assessment cycle, i.e., in early December 2023, to allow sufficient time to complete a full assessment and plan the peer review if the indicator signals that a re-assessment is warranted in the winter of 2024.

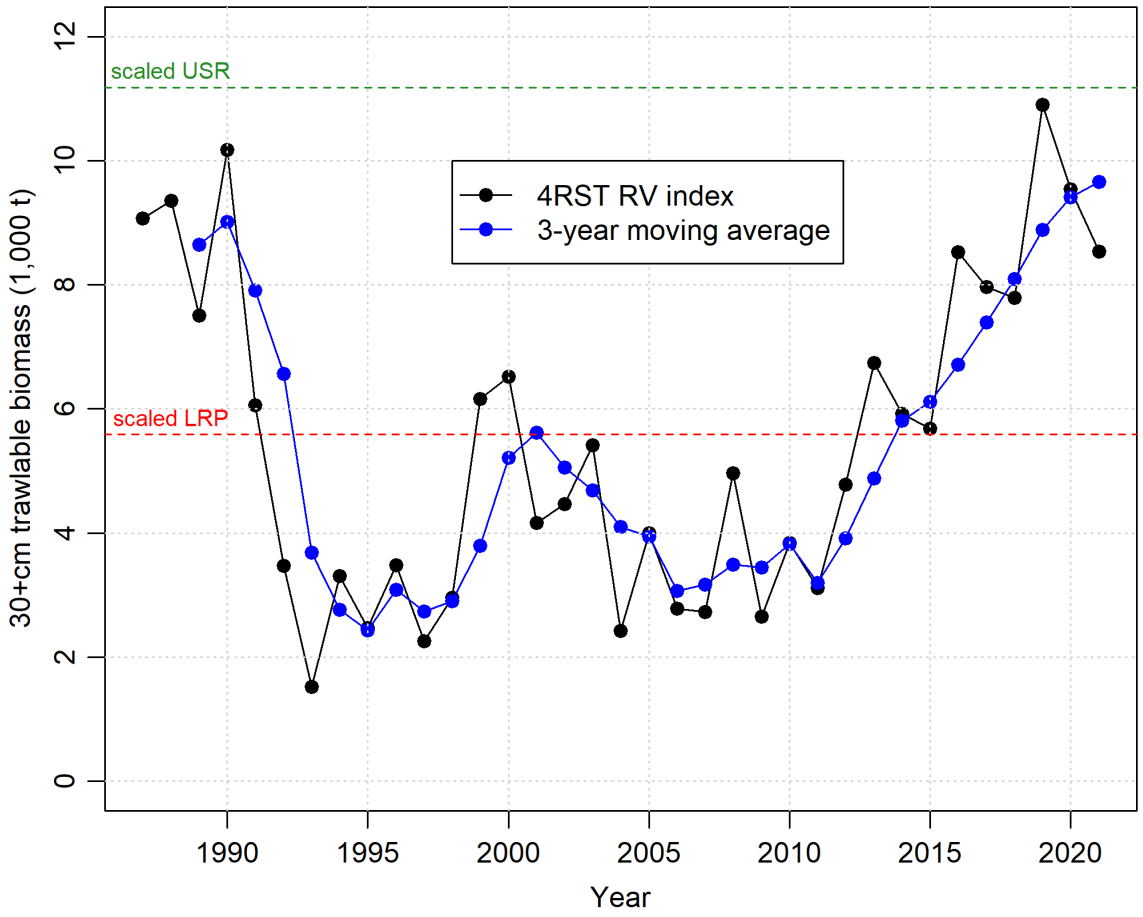


Figure 11. Stock status indicator for NAFO Div. 4RST Witch Flounder expressed in 30+ cm trawlable biomass. The solid black line and dots are the NAFO Divisions 4RST index and the solid blue line and dots are the 3-year moving average of the index shown in correspondence to the third year of the block of years. The scaled LRP and USR are identified by a red and a green horizontal line, respectively.

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SOURCES OF INFORMATION

This Science Advisory Report is from the Regional Advisory Meeting of March 1-2, 2022 on Stock status and fishery advice for May 2022 to May 2027 for Witch Flounder (*Glyptocephalus cynoglossus*) from NAFO Division 4RST, Gulf of St. Lawrence. Additional publications from this meeting will be posted on the Fisheries and Oceans Canada (DFO) Science Advisory Schedule as they become available.

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Ricard, D., and Swain, D.P. 2018. Assessment of Witch Flounder (*Glyptocephalus cynoglossus*) in the Gulf of St. Lawrence (NAFO Divisions 4RST), February 2017. DFO Can. Sci. Advis.Sec. Res. Doc. 2018/023. xi + 78 p.

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*MPO. 2022. Évaluation du stock de plie grise (*Glyptocephalus cynoglossus*) dans le golfe du Saint-Laurent (divisions 4RST de l'OPANO) jusqu'en 2021. Secr. can. des avis sci. du MPO. Avis sci. 2022/028.*