Serial No. N7322 NAFO SCS Doc. 22/18

Northwest Atlantic Fisheries Organization

Report of the Scientific Council Meeting

03 -16 June 2022
Halifax, Nova Scotia

NAFO
Halifax, Nova Scotia, Canada
2022

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Recommended Citation:
NAFO. 2022. Report of the Scientific Council, 03 -16 June 2022, Halifax, Canada. NAFO SCS Doc. 22/18.

Scientific Council June Meeting Participants
03 – 16 June 2022

From left to right:
Front row: Karen Dwyer, Chair of Scientific Council; Diana González-Troncoso, Vice-Chair of Scientific Council and Chair of STACREC; Rick Rideout, Chair of STACPUB; Miguel Caetano, Chair of STACFEN; and Mark Simpson, Chair of STACFIS.
Second row: Katherine Sosebee, Mariano Koen-Alonso, Fernando González-Costas, Andrew Kenny.
Third row: Laura Wheeland, Kevin Hedges, Margaret Treble.
Fourth row: Dawn Maddock-Parsons, Andrea Perrault, Kenji Taki.
Fifth row: Brian Healey, Martha Krohn.
Sixth row: Luis Ridao Cruz, Ricardo Alpoim
Back row: Tom Blasdale, Adolfo Merino Buisac, Paul Regular, Mar Sacau Cuadrado, Irene Garrido Fernandez.
Missing from Photo: David Bélanger, Frederic Cyr, Ellen Kenchington, Rajeev Kumar, Emilie Novaczek, Frank Oliva, Divya Varkey, Igor Yashayaev, Adriana Nogueira, Rasmus Nygaard, Pablo Durán Muñoz, Liivika Näks, Doug Butterworth, Carsten Hvingel, Fabian Zimmerman, Konstantin Fomin, Sergey Melnikov, Olga Zyatneva, Lisa Readdy, Paula Frantantoni, Lisa Hendrickson, Steve Cadrin, Jason Link, Anthony Thompson, Brynn Devine, Susanna Fuller, Rasmus Hedeholm, Emma Rayner, Katie Schleit.

REPORT OF SCIENTIFIC COUNCIL MEETING
03 -16 June 2022

Chair: Karen Dwyer Rapporteur: Tom Blasdale

I. PLENARY SESSIONS

The Scientific Council met at the Atrium building, Saint Mary's University, Halifax, NS, Canada, during 03 – 16 June 2022, to consider the various matters in its Agenda. Representatives attended from Canada, Denmark (in respect of Faroe Islands and Greenland), the European Union, Japan, the Russian Federation, the United Kingdom, and the United States of America. Observers from the Food and Agriculture Organization (FAO), Oceans North, and Sustainable Fisheries Greenland were also present. The Executive Secretary, Scientific Council Coordinator, and other members of the Secretariat were in attendance.

The Executive Committee met prior to the opening session of the Council to discuss the provisional agenda and plan of work.

The Council was called to order at 10:00 on 03 June 2022. The provisional agenda was **adopted**. The Scientific Council Coordinator was appointed the rapporteur.

The opening session was adjourned at 12:00 on 03 June 2022. Several sessions were held throughout the course of the meeting to deal with specific items on the agenda. The Council considered and **adopted** the STACFEN report on 10 June 2022, the STACPUB report on 14 June and the STACFIS and STACREC reports on 16 June 2022.

The concluding session was called to order at 09:00 on 16 June 2022.

The Council considered and **adopted** the report the Scientific Council Report of this meeting of 03 -16 June 2022. The Chair received approval to leave the report in draft form for about two weeks to allow for minor editing and proof-reading on the usual strict understanding there would be no substantive changes.

The meeting was adjourned at 12:30 on 16 June 2022.

The Reports of the Standing Committees as adopted by the Council are appended as follows: Appendix I - Report of the Standing Committee on Fisheries Environment (STACFEN), Appendix II - Report of Standing Committee on Publications (STACPUB), Appendix III - Report of Standing Committee on Research Coordination (STACREC), and Appendix IV - Report of Standing Committee on Fisheries Science (STACFIS).

The Agenda, List of Research (SCR) and Summary (SCS) Documents, and List of Representatives, Advisers and Experts, are given in Appendix V-VII.

The Council's considerations on the Standing Committee Reports, and other matters addressed by the Council follow in Sections II-XV.

II. REVIEW OF SCIENTIFIC COUNCIL RECOMMENDATIONS IN 2021

Recommendations from 2021 are considered in the relevant section of this report.

III. FISHERIES ENVIRONMENT

The Council **adopted** the Report of the Standing Committee on Fisheries Environment (STACFEN), as presented by Chair, Miguel Caetano. The full report of STACFEN is in Appendix I.

The recommendation made by STACFEN for the work of the Scientific Council as **endorsed** by the Council, are as follows:

- STACFEN **recommends** *considering Secretariat support for an invited speaker to address emerging issues and concerns for the NAFO Convention Area during the 2023 STACFEN meeting. Contributions from invited speakers may generate new insights and discussions within the committee regarding integrating environmental information into the stock assessment process.*
- STACFEN **recommends** the *elaboration of a work linking the widespread oceanographic-climate changes over the Convention Area.*
- STACFEN **recommends** that *further discussions occur between STACFEN and STACFIS members on environmental data integration into the various stock assessments.*

IV. PUBLICATIONS

The Council **adopted** the Report of the Standing Committee on Publication (STACPUB) as presented by the Chair, Rick Rideout. The full report of STACPUB is in Appendix II.

The recommendations made by STACPUB for the work of the Scientific Council as **endorsed** by the Council, are as follows:

- STACPUB **recommends** that *the Secretariat explore ways to make SC working papers permanently available to SC via a password-protected site.*

V. RESEARCH COORDINATION

The Council **adopted** the Report of the Standing Committee on Research Coordination (STACREC) as presented by the Chair, Diana Gonzalez-Troncoso. The full report of STACREC is in Appendix III.

The recommendations made by STACREC for the work of the Scientific Council as **endorsed** by the Council, are as follows:

- Spatio-temporal models used during the Joint ICES/NAFO shrimp benchmark in January 2022 to handle gaps in the surveys were presented by an ICES expert (F. Zimmerman, ICES 2022). More details about the presentation are in Section 7.d. These model-based survey indices are currently used for the Skagerrak-Norwegian Deep shrimp stock assessment substituting for the previous design-based indices. This type of models can handle survey gaps in one year and even missing years. From them, a biomass index, as well as gaps in the length/age distribution, can be derived. STACREC **recommends** this *type of model to be explored in the future in the NAFO Regulatory Area.*
- STACREC **recommends** *a comprehensive study to investigate redfish stock structure in NAFO Divisions 2 and 3, with consideration of species splitting and recent approaches to studying redfish stock structure in other RFMOs.*

VI. FISHERIES SCIENCE

The Council **adopted** the Report of the Standing Committee on Fisheries Science (STACFIS) as presented by the Chair Mark Simpson. The full report of STACFIS is in Appendix IV.

There were no general recommendations arising from STACFIS. The Council endorsed recommendations specific to each stock and they are highlighted under the relevant stock considerations in the STACFIS report (Appendix IV).

VII. MANAGEMENT ADVICE AND RESPONSES TO SPECIAL REQUESTS

1. The NAFO Commission

The Commission requests are given in Annex 1 of Appendix V.

The Scientific Council noted the Commission requests for advice on Northern shrimp (Northern shrimp in Div. 3M and Divs. 3LNO (Item 1)) will be undertaken during the Scientific Council meeting on 12 to 17 September 2022.

a) Request for Advice on TACs and Other Management Measures

The Fisheries Commission at its meeting of September 2010 reviewed the assessment schedule of the Scientific Council and with the concurrence of the Coastal State agreed to request advice for certain stocks on either a two-year or three-year rotational basis. In recent years, thorough assessments of certain stocks have been undertaken outside of the assessment cycle either at the request of the Commission or by the Scientific Council given recent stock developments.

Cod in Division 3M

Advice June 2022 for 2023

Recommendation for 2023

Yield corresponding to F less than or equal to 3/4 F_{lim} in 2023 results in a very low probability (≤10%) of SSB being below B_{lim} in 2024 and a very low probability (≤10%) of exceeding F_{lim}.

However, given the present level of the SSB and projected decline of total biomass under any fishing scenario, in order to promote growth in SSB with more than 60% probability, SC advises scenarios with F no more than Fsq.

Management objectives

No explicit management plan or management objectives have been defined by the Commission. Convention General Principles are applied (NAFO GC Doc. 07-04).

Convention objectives	*Status*	*Comment/consideration*
Restore to or maintain at B_{MSY}	🟡	Stock above B_{lim} in 2022. B_{MSY} is unknown
Eliminate overfishing	🟢	F< F_{lim} in 2021
Apply Precautionary Approach	🟢	F_{lim} and B_{lim} defined
Minimise harmful impacts on living marine resources and ecosystems	🟡	VME closures in effect, no specific measures
Preserve marine biodiversity	⚪	Cannot be evaluated

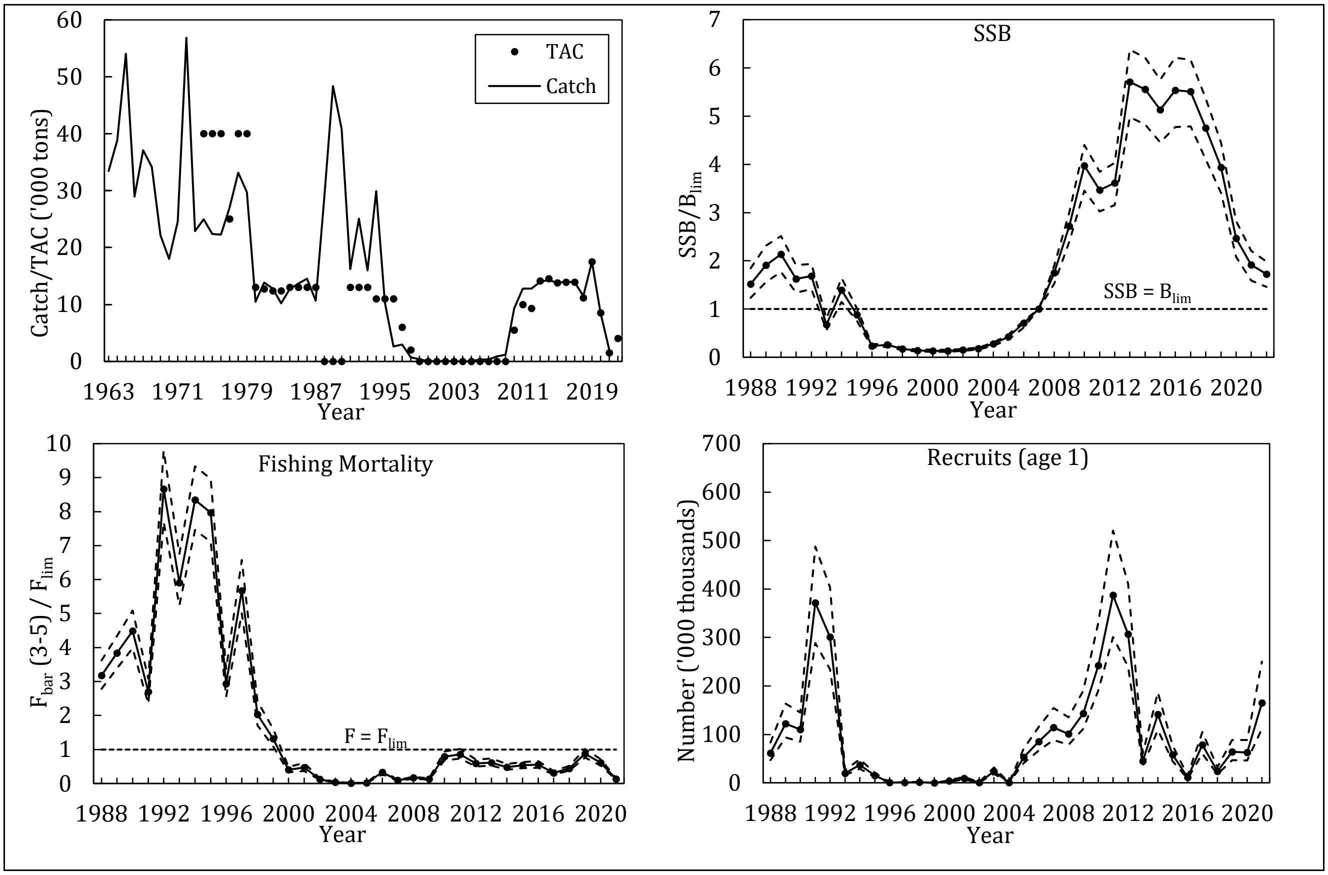
🟢	OK
🟡	Intermediate
🔴	Not accomplished
⚪	Unknown

Management unit

The cod stock in Flemish Cap (NAFO Div. 3M) is considered to be a separate population.

Stock status

SSB has been declining rapidly since 2017 but is still estimated to be above B_{lim} (median 15 037 t). The 2021 estimated recruitment showed a positive signal after a period of lower recruitment. Fishing mortality has remained below F_{lim} (median 0.166) since the fishery reopened in 2010.



Reference points

$B_{lim} = SSB_{2007}$: Median = 15 037 tonnes of spawning biomass (Scientific Council, 2022).

$F_{lim} = F_{30\%SPR}$: Median = 0.166 (Scientific Council, 2022).

Projections

Although advice is given only for 2023, projection results are shown to 2025 to illustrate the medium-term implications. F_{bar} is the mean of the F at ages 3-5 and used as the indicator of overall fishing mortality; F_{sq} is the status quo F, calculated as the mean of the last three years F_{bar} (2019-2021).

Table 1.

	B		SSB		Yield
	Median and 80% CI				
$F_{bar}=F_{sq}$ (median = 0.089)					
2022	50511	(45475 - 56297)	25994	(23085 - 28992)	4000
2023	48942	(43410 - 55808)	22651	(19983 - 25601)	5791
2024	47441	(41115 - 55572)	23797	(20536 - 27170)	6987
2025	43101	(35439 - 52003)	27046	(22345 - 32507)	
$F_{bar}=0$					
2022	50511	(45475 - 56297)	25994	(23085 - 28992)	4000
2023	48942	(43410 - 55808)	22651	(19983 - 25601)	0
2024	53489	(47131 - 61613)	29062	(25841 - 32474)	0
2025	55443	(47659 - 64531)	37876	(33038 - 43336)	
$F_{bar}=F_{2021}$ (median = 0.022)					
2022	50511	(45475 - 56297)	25994	(23085 - 28992)	4000
2023	48942	(43410 - 55808)	22651	(19983 - 25601)	3425
2024	49900	(43564 - 58037)	25929	(22708 - 29370)	4429
2025	47858	(40184 - 56840)	31201	(26375 - 36582)	
$F_{bar}=1/2F_{lim}$ (median = 0.083)					
2022	50511	(45475 - 56297)	25994	(23085 - 28992)	4000
2023	48942	(43410 - 55808)	22651	(19983 - 25601)	5446
2024	47801	(41467 - 55931)	24123	(20900 - 27453)	6610
2025	43807	(36133 - 52710)	27667	(22940 - 33046)	
$F_{bar}=2/3F_{lim}$ (median = 0.111)					
2022	50511	(45475 - 56297)	25994	(23085 - 28992)	4000
2023	48942	(43410 - 55808)	22651	(19983 - 25601)	7032
2024	46140	(39833 - 54302)	22661	(19467 - 26010)	8128
2025	40803	(33146 - 49719)	25127	(20387 - 30497)	
$F_{bar}=3/4F_{lim}$ (median = 0.125)					
2022	50511	(45475 - 56297)	25994	(23085 - 28992)	4000
2023	48942	(43410 - 55808)	22651	(19983 - 25601)	7787
2024	45350	(39053 - 53527)	21986	(18790 - 25344)	8790
2025	39437	(31811 - 48396)	23977	(19350 - 29304)	
$F_{bar}=F_{lim}$ (median = 0.166)					
2022	50511	(45475 - 56297)	25994	(23085 - 28992)	4000
2023	48942	(43410 - 55808)	22651	(19983 - 25601)	9915
2024	43154	(36866 - 51292)	20065	(16900 - 23469)	10431
2025	35770	(28221 - 44759)	20928	(16358 - 26280)	
Catch = 4000 tons					
2022	50511	(45475 - 56297)	25994	(23085 - 28992)	4000
2023	48942	(43410 - 55808)	22651	(19983 - 25601)	4000
2024	49306	(42971 - 57441)	25399	(22161 - 28803)	4000
2025	47760	(40074 - 56713)	31052	(26294 - 36499)	
Catch = 5000 tons					
2022	50511	(45475 - 56297)	25994	(23085 - 28992)	4000
2023	48942	(43410 - 55808)	22651	(19983 - 25601)	5000
2024	48274	(41931 - 56397)	24492	(21285 - 27869)	5000
2025	45838	(38143 - 54765)	29349	(24623 - 34867)	

Table 2.

	Yield			P(SSB < B_{lim})				P(F_{bar} > F_{lim})			
	2022	2023	2024	2022	2023	2024	2025	2022	2023	2024	P(SSB_{25} >SSB_{22})
F_{sq} = 0.089	4000	5791	6987	<1%	<1%	<1%	<1%	<1%	<1%	<1%	60%
F=0	4000	0	0	<1%	<1%	<1%	<1%	<1%	<1%	<1%	100%
F_{2021} = 0.022	4000	3425	4429	<1%	<1%	<1%	<1%	<1%	<1%	<1%	95%
1/2F_{lim} = 0.083	4000	5446	6610	<1%	<1%	<1%	<1%	<1%	<1%	<1%	67%
2/3F_{lim} = 0.111	4000	7032	8128	<1%	<1%	1%	1%	<1%	<1%	<1%	39%
3/4F_{lim} = 0.125	4000	7787	8790	<1%	<1%	1%	1%	<1%	<1%	3%	27%
F_{lim} = 0.166	4000	9915	10431	<1%	<1%	3%	6%	<1%	50%	50%	9%
C = 4000t	4000	4000	4000	<1%	<1%	<1%	<1%	<1%	<1%	<1%	94%
C = 5000t	4000	5000	5000	<1%	<1%	<1%	<1%	<1%	<1%	<1%	86%

The results indicate that under all scenarios with F_{bar}>0, total biomass during the projected years will decrease, whereas the SSB is projected to increase slightly in 2025 except in all scenarios with F≥2/3 F_{lim} (Table 1). The probability of SSB being below B_{lim} in 2024 is low (≤3%) in all the scenarios (Table 2). The probability of SSB in 2025 being above that in 2022 ranges between 9% and 100%, depending on the scenario.

Under all scenarios, the probability of F_{bar} exceeding F_{lim} is less than or equal to 3% in 2023 and 2024 except for F_{lim} as expected.

SC notes that projected values of risk, in particular more than one year ahead (Table 2), will be inherently more uncertain than the projected median stock sizes (Table 1). The risks are typically derived from the tails of a probability distribution which are less precisely estimated compared to the median (centre) of the same distribution.

Assessment

A Bayesian SCAA model, introduced at the 2018 benchmark, was used as the basis for the assessment of this stock with data from 1988 to 2021.

The next full assessment for this stock will be in 2023.

Human impact

Mainly fishery related mortality. Other sources (e.g., pollution, shipping, oil-industry) are undocumented.

Biological and environmental interactions

Redfish, shrimp and smaller cod are important prey items for cod. Recent studies indicate strong trophic interactions between these species in the Flemish Cap.

A 2018 summary of the state of the fish community in the Flemish Cap (3M) EPU indicated that this ecosystem has not experienced sustained reductions in overall productivity observed in other EPUs. With the exception of a short-lived increase in 2005-2009, total biomass has remained fairly stable over time despite the changes in individual stocks.

Fishery

Cod is caught in directed trawl and longline fisheries and as bycatch in the directed redfish fishery by trawlers. The fishery is regulated by quota. New technical regulations were introduced in 2021, in particular a closure of the directed fishery in the first quarter as well as sorting grids to protect juveniles.

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

	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
TAC	9.3	14.1	14.5	13.8	13.9	13.9	11.1	17.5	8.5	1.5	4.0
STATLANT 21	9.1	13.5	14.4	12.8	13.8	13.9	10.5	13.0	8.5	2.6	
STACFIS	12.8	14.0	14.3	13.8	14.0	13.9	11.5	17.5	8.5	2.1	

Effects of the fishery on the ecosystem

The impact of bottom fishing activities on major VMEs in the NRA was last assessed in 2021. The risk of Significant Adverse Impacts (SAIs) on sponge and large gorgonian VMEs was assessed to be low, while this risk for sea pen VMEs has been assessed as intermediate. The risks of SAIs on small gorgonian, black coral, bryozoan and sea squirt VMEs were assessed as high. A number of areas in the Flemish Cap (3M) EPU have been closed to fishing to protect VMEs.

Special comment

Despite the expected increases in SSB under most fishing scenarios, the total biomass will continue to decrease over the projected period under all fishing scenarios (F>0).

Sources of information

SCS Doc. 22/06, 22/07, 22/08, 22/13 and SCR Doc. 22/04, 22/12 and 22/25.

Scientific Council responded:

Available data indicate that biomass is at or below the long-term mean. The stock appears to be above the interim limit reference point (B_{lim}). In the absence of Canadian spring surveys in 2020 and 2021 proxy fishing mortality cannot be determined for those years. However, it is unlikely that levels of fishing mortality have changed substantially. Recruitment has been below the long-term average since the mid-2010s.

Scientific Council advises that catches should not exceed their current level of 11 500 t (the mean of the last 5 years).

Convention General Principles	***Status***	***Comment/consideration***
Restore or maintain at B_{MSY}	⚪	Status relative to B_{MSY} is unknown.
Eliminate overfishing	⚪	Estimates of proxy F are not available in recent years.
Apply Precautionary Approach	🟢	B_{lim} defined
Minimize harmful impacts on living marine resources and ecosystems	🟡	VME closures in effect, no specific measures
Preserve marine biodiversity	⚪	Cannot be evaluated

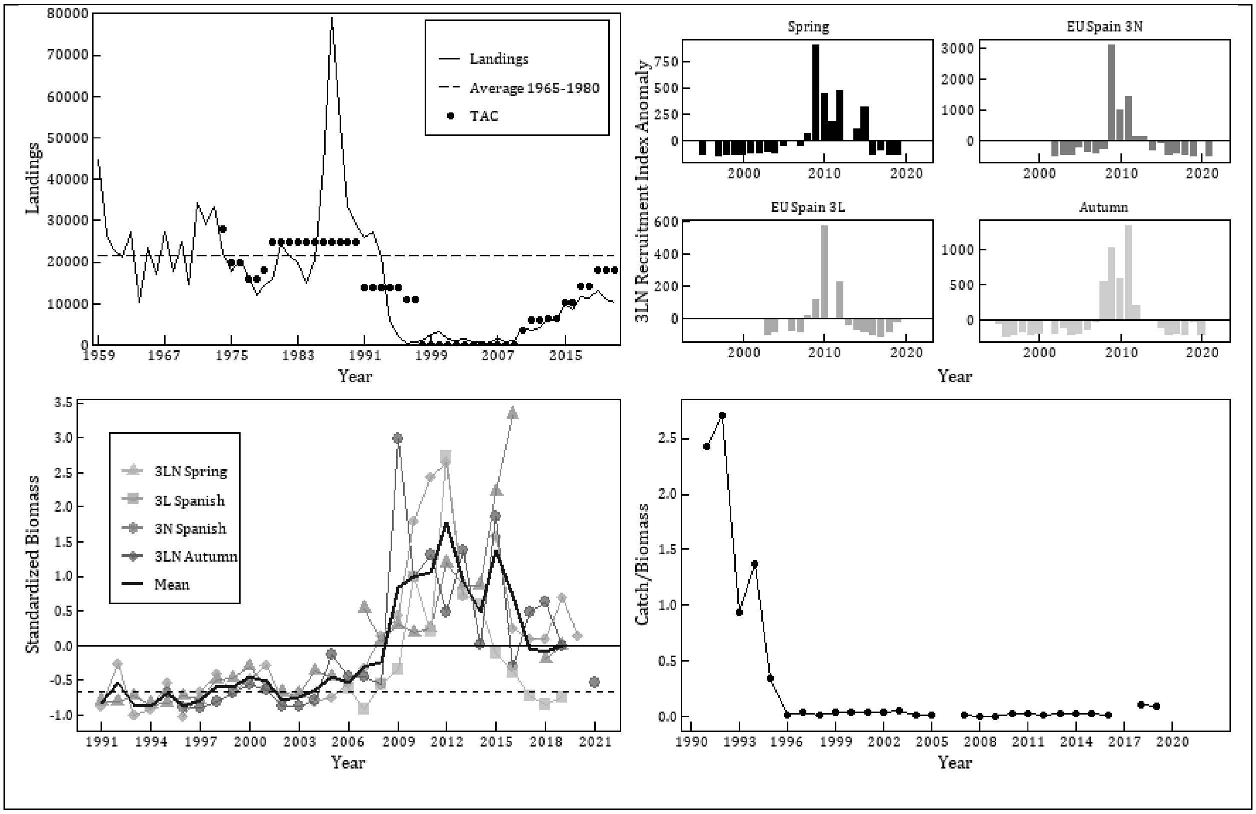
🟢	OK
🟡	Intermediate
🔴	Not accomplished
⚪	Unknown

Management unit

The management unit is defined as NAFO Divs. 3LN.

Stock status

Lack of survey indices in recent years limits our understanding of stock status since 2019, but available data indicate that biomass is at or below the long-term mean. The stock appears to be above the interim limit reference point (B_{lim}). Recruitment of redfish between 15 and 20 cm has been below the long-term average since the mid-2010s across Canadian 3LN spring and autumn as well as EU-Spain 3L and 3N survey series.



Reference points

An interim limit reference point was adopted for use while the MSE process is ongoing, based on the average of the mean standardized biomass of the Canadian spring and autumn 3LN and EU-Spain 3N surveys ($B_{lim} = B_{rec}$) from the period 1991-2005.

Assessment

The previous assessment model (ASPIC) was rejected at the 2022 assessment. Continued mismatch between recent observed survey indices and the ASPIC model biomass estimates resulted in a lack of confidence in the model. This assessment is based on an examination of an aggregate survey series including EU-Spain 3L and 3N surveys and Canadian 3LN spring and autumn surveys, as well as landings. The next assessment is scheduled for 2024.

The ASPIC model has continued to show patterning in residuals of input series and the use of a fixed MSY approach has resulted in an value of r that is considered too high for this species (>0.2).

Work is ongoing to develop an MSE for this stock.

Human impact

Mainly fishery related mortality has been documented. Mortality from other human sources (e.g. pollution, shipping, oil-industry) are undocumented.

Biology and Environmental interactions

There are two species of the genus *Sebastes* with distribution overlapping in several areas of Northwest Atlantic, namely on the Gulf of St. Lawrence, Laurentian Channel, off Newfoundland and south of Labrador Sea: the deep sea redfish (*Sebastes mentella*), with a maximum abundance at depths greater than 350m, and Acadian redfish (*Sebastes fasciatus*), preferring shallower waters of less than 300m.

Redfish diet varies across life history stages as juvenile redfish primarily eat crustaceans such as shrimp and adult redfish consume more fish.

The Grand Bank (3LNO) EPU continues to experience low overall productivity conditions, and total biomass remains well below pre-collapse levels. However, recent warming, earlier phytoplankton spring bloom, and an increase in the proportion of energy-rich copepod species may have positive effects on total ecosystem production in the coming years.

Fishery

Landings of this stock are primarily from directed fisheries. Following evaluation in the MSE, a stepwise harvest control rule (HCR) was adopted for this stock in 2014. Since then the TAC has increased in a steps from 6500 tonnes to 18100 tonnes, the maximum level evaluated for the HCR at the MSE. However, the HCR lacks feedback between the stock biomass levels and the TAC recommendation. Given recent missing surveys and recent downward trends in available survey indices, it is unclear if the TAC of 18100 is sustainable for the stock. Landings have also generally been increasing as per Scientific Council advice on TAC, but since 2016 landings have remained below the established TAC.

Recent catch estimates and TACs ('000 tonnes) are:

	2012	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**
TAC	6.0	6.5	6.5	10.4	10.4	14.2	14.2	18.1	18.1	18.1	18.1
STACFIS catch	4.3	6.2	5.7	9.9	8.5	11.8	11.3	13.1	11.1	10.2	
STATLANT	4.3	6.2	5.7	10.2	8.5	11.8	11.3	13.1	11.7	11.8	

Effects of fishery on the ecosystem

No specific information is available. General impacts of fishing gears on the ecosystem should be considered.

The impact of bottom fishing activities on major VMEs in the NRA was last assessed in 2021. The risk of Significant Adverse Impacts (SAIs) on sponge and large gorgonian VMEs was assessed to be low, while this risk for sea pen VMEs has been assessed as intermediate. The risks of SAIs on small gorgonian, black coral, bryozoan and sea squirt VMEs were assessed as high. This assessment of impacts of bottom fishing activities on VMEs does not include waters within coastal states jurisdictions. Within the Grand Bank (3LNO) EPU areas in Div. 3O and 3L have been closed to fishing to protect corals.

Special comments

Redfish are known to have variable and episodic recruitment, with potentially large periods of time between recruitment pulses and no strong relationships between stock size and recruitment. Impacts of delineations of stock boundaries and synchronicity between adjacent stocks are unknown. Work is ongoing to develop an MSE for this stock.

Sources of information

SCR Docs. 22/013; 22/007; 22/005; 20/014; SCS Docs. 22/06; 22/07; 22/09; 22/13

Witch flounder in Divisions 3NO

Advice June 2022 for 2023-2024

Recommendation for 2023 and 2024

In the projection period there is less than a 10% probability of being below B_{lim}, however the probability of exceeding F_{lim} is estimated to be above 30% in 2024 for F greater than $2/3F_{MSY}$. Scientific Council therefore recommends that F should be no higher than $2/3\ F_{MSY}$.

Management objectives

The Commission adopted a total allowable catch (TAC) of 1 175 t for 2021 and 2022. Convention General Principles are applied (NAFO GC Doc. 07-04).

Convention General Principles	*Status*	*Comment/consideration*
Restore to or maintain at B_{MSY}	🔴	Probability of $B_{2022} < B_{MSY} = 94\%$
Eliminate overfishing	🟢	$F < F_{MSY}$
Apply Precautionary Approach	🟢	Reference points defined
Minimise harmful impacts on living marine resources and ecosystems	🟡	VME closures in effect, no specific measures.
Preserve marine biodiversity	⚪	Cannot be evaluated

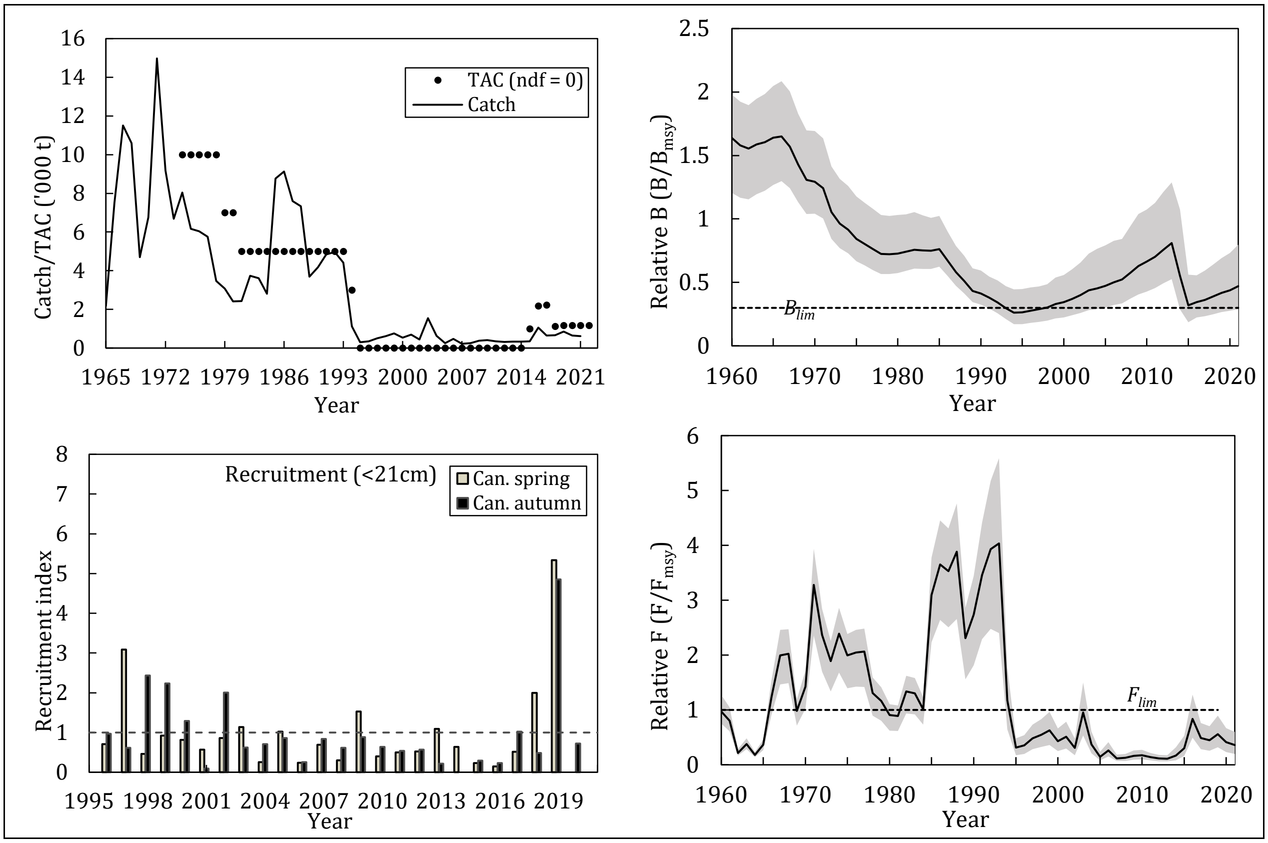
🟢	OK
🟡	Intermediate
🔴	Not accomplished
⚪	Unknown

Management unit

The management unit is NAFO Divisions 3NO. The stock mainly occurs 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, a higher percentage may be distributed in shallower water.

Stock status

The stock has increased slightly since 2015 and is estimated at 49% B_{MSY}. At the beginning of 2022, there is 9% risk of the stock being below B_{lim} and less than 1% risk of F being above F_{lim}. Recruitment is uncertain.



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.

Projections and risk analyses.

The probability of *F* exceeding F_{lim} in 2022 is 14% at a catch of 1 175 t (TAC 2022). The probability of *F* being above F_{lim} ranged from 1% to 50% for the catch scenarios tested. The population is projected to grow under all scenarios and the probability that the biomass in 2025 is greater than the biomass in 2022 is greater than 60% in all scenarios. The population is projected to remain below B_{MSY} through to the beginning of 2025 for all levels of *F* examined with a probability of 86% or greater. The probability of projected biomass being below B_{lim} by 2025 was 5% to 9% in all catch scenarios examined and was 4% by 2025 in the *F*=0 scenario.

Projected yield (t) and the risk of F> F_{lim}, B< B_{lim} and B< B_{MSY} and probability of stock growth (B_{2025}>B_{2022}) under projected F values of F=0, F_{2021}, 2/3 F_{MSY}, 85% F_{MSY}, and F_{MSY}, and catch=TAC (1 175 t) are presented in the following tables.

Projections with catch in 2022 = TAC (1 175 t)			
Year	Yield (t) median		Projected relative Biomass(B/B_{msy}) median (80% CL)
			F0
2023	0		0.53 (0.31, 0.94)
2024	0		0.58 (0.34, 1.03)
2025			0.62 (0.37, 1.12)
			F_{2021} = 0.022
2023	699		0.53 (0.31, 0.94)
2024	744		0.56 (0.33, 1.01)
2025			0.60 (0.35, 1.09)
			Catch 1 175t
2023	1175		0.53 (0.31, 0.94)
2024	1175		0.56 (0.32, 1.00)
2025			0.58 (0.33, 1.07)
			2/3 F_{msy} = 0.041
2023	1295		0.53 (0.31, 0.94)
2024	1367		0.55 (0.32, 1.00)
2025			0.58 (0.33, 1.06)
			85% F_{msy} =0.053
2023	1651		0.53 (0.31, 0.94)
2024	1724		0.55 (0.32, 1.00)
2025			0.56 (0.32, 1.05)
			F_{msy} =0.062
2023	1943		0.53 (0.31, 0.94)
2024	2010		0.54 (0.31, 0.99)
2025			0.55 (0.31, 1.04)

Catch 2022=1 175 t	**Yield (t)**			P($F>F_{lim}$)			P($B<B_{lim}$)				P($B<B_{msy}$)				
	2022	2023	2024	2022	2023	2024	2022	2023	2024	2025	2022	2023	2024	2025	**P(B_{2025}>B_{2022})**
F0	1175	0	0	14%	12%	<1%	9%	8%	6%	4%	94%	92%	89%	86%	0.73
F_{2021} = 0.022	1175	699	744	14%	12%	1%	9%	8%	7%	5%	94%	92%	89%	87%	0.68
Catch $_{2023}$ & $Catch_{2024}$= 1 175t	1175	1175	1175	14%	12%	11%	9%	8%	7%	6%	94%	92%	90%	87%	0.65
2/3 Fmsy = 0.041	1175	1295	1367	14%	12%	19%	9%	8%	8%	7%	94%	92%	90%	88%	0.64
85% Fmsy =0.053	1175	1651	1724	14%	12%	37%	9%	8%	8%	8%	94%	92%	90%	88%	0.62
Fmsy=0.062	1175	1943	2010	14%	12%	50%	9%	8%	9%	9%	94%	92%	90%	89%	0.60

Assessment

This stock is assessed utilizing a surplus production model in a Bayesian framework. Full assessments were conducted annually from 2017-2020 and in 2022.

The input data were catch from 1960-2021, Canadian spring survey series from 1984-1990, Canadian spring survey series from 1991-2019 (no 2006, 2020 or 2021 surveys) and the Canadian autumn survey series from 1990-2020 (no 2014 or 2021 surveys).

The next assessment is planned for 2024.

Human impact

Mainly fishery related mortality. Other potential sources (e.g. pollution, shipping, and oil-industry) are undocumented. The impact of bottom fishing activities on major VMEs in the NRA was last assessed in 2021. The risk of Significant Adverse Impacts (SAIs) on sponge and large gorgonian VMEs was assessed to be low, while this risk for sea pen VMEs has been assessed as intermediate. The risks of SAIs on small gorgonian, black coral, bryozoan and sea squirt VMEs were assessed as high. This assessment of impacts of bottom fishing activities on VMEs does not include waters within coastal states jurisdictions. Within the Grand Bank (3LNO) EPU areas in Div. 3O and 3L have been closed to fishing to protect corals.

Biological and environmental interactions

Witch flounder in NAFO Divs. 3NO are distributed mainly along the tail and southwestern slopes of the Grand Bank.

The Grand Bank (3LNO) EPU continues to experience low overall productivity conditions, and total biomass remains well below pre-collapse levels. However, recent warming, earlier phytoplankton spring bloom, and an increase in the proportion of energy-rich copepod species may have positive effects on total ecosystem production in the coming years.

Fishery

The fishery was reopened to directed fishing in 2015 and is exploited by otter trawl. Prior to the reopening, witch flounder were caught primarily as bycatch in bottom otter trawl fisheries for yellowtail flounder, redfish, skate and Greenland halibut.

Recent catch estimates and TACs ('000t) are:

	2013	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**
TAC	ndf	ndf	1.0	2.2	2.2	1.1	1.2	1.2	1.2	1.2
STATLANT 21	0.3	0.3	0.4	1.0	0.6	0.6	0.9	0.6	0.8	
STACFIS	0.3	0.3	0.4	1.1	0.7	0.7	0.9	0.7	0.6	

ndf = no directed fishery.

Effects of the fishery on the ecosystem

No specific information available. General impacts of bottom trawl gear on the ecosystem should be considered.

Special comments

It is unclear if the recruitment index (survey number of fish<21 cm) is representative. In the absence of Canadian surveys for 2021, current recruitment cannot be determined.

Sources of Information

SCR Docs. 22/005, 22/007, 22/014; SCS Docs. 22/06, 22/09, 22/10, 22/13

Redfish in Division 3O — Advice June 2022 for 2023-2025

Recommendation for 2023-25

The stock is below an interim survey-based proxy for B_{MSY} but above the limit reference point (B_{lim} =0.3$_{MSY}$-proxy) with a probability >99%. There is insufficient information on which to base predictions of annual yield potential. Catches have averaged about 9 000 t over the period used for the MSY proxy calculation (1991 -2021). Scientific Council is unable to advise on an appropriate TAC for 2023, 2024 and 2025.

Management objectives

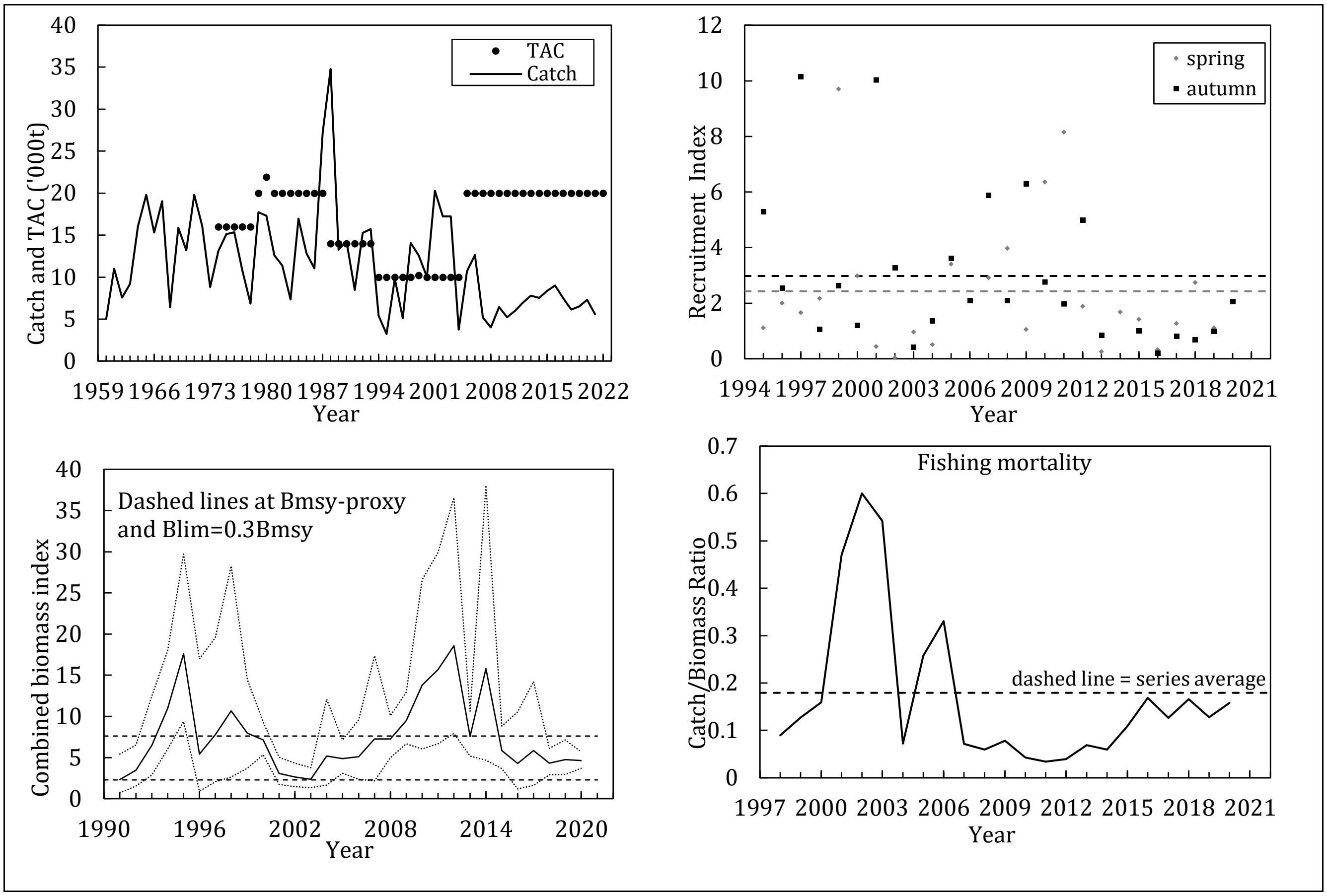
No explicit management plan or management objectives have been defined by the Commission. Convention General Principles are applied (NAFO GC Doc. 07-04).

.Convention General Principles	*Status*	*Comment/consideration*
Restore to or maintain at B_{MSY}	🔴	Stock is below an interim survey-based proxy for B_{MSY}.
Eliminate overfishing	🟢	Fishing mortality is near average
Apply Precautionary Approach	🟢	Interim B_{lim} defined at 0.3 B_{MSY} -proxy
Minimise harmful impacts on living marine resources and ecosystems	🟡	VME closures in effect, low bycatch reported
Preserve marine biodiversity	⚪	Cannot be evaluated

🟢	OK
🟡	Intermediate
🔴	Not accomplished
⚪	Unknown

Management unit

The management unit is confined to NAFO Div. 3O.



Stock status

Stock is below an interim survey-based proxy for B_{MSY}. Biomass in 2020 was above the limit reference point (B_{lim} =0.3 B_{MSY} proxy) with a high probability [P(B2020> B_{lim}) = >0.99]. Biomass relative to the reference point cannot be determined in 2021 as Canadian Spring and Autumn surveys did not occur in Div. 3O. However, given the slow growth of redfish and interpretation of year-over-year index fluctuations, stock status in 2021 is assumed to be similar to 2020.

Recruitment indices since 2012 have generally been at or below series averages.

Reference points

A survey-based proxy for B_{MSY} is defined as the time series average (since 1991) of a combined Biomass index from both CAN-Spring and CAN-Autumn surveys. An interim B_{lim} is defined at 0.3 B_{MSY} -proxy. As survey indices can show unrealistic fluctuations year over year, a single year above or below B_{lim} is insufficient to indicate a change in stock status.

Projections

Quantitative assessment of risk at various catch options is not available for this stock at this time.

Assessment

This assessment is based upon an evaluation of survey biomass , and recruitment indices and a fishing mortality proxy. Biomass indices show similar trends across the time series across Canadian Spring, Canadian Autumn, and EU-Spain surveys in Div. 3O. The assessment is considered data-limited and as such, associated with relatively high uncertainty. Input data are research survey indices and fishery data.

The next full assessment of this stock will be in 2025.

Human impact

Mainly fishery-related mortality has been documented. Other sources (e.g. pollution, shipping, oil-industry) are undocumented.

Biological and environmental interactions

Redfish are slow growing and bear live young. Genetic analyses linked strong year-classes of juvenile *S. fasciatus* sampled from the Gulf of St. Lawrence with adults collected in NAFO Divs. 3LNO and southern 3Ps. Local plus distant dispersal of young fish makes the influences of physical and environmental processes on stock dynamics difficult to interpret.

The Grand Bank (3LNO) EPU continues to experience low overall productivity conditions, and total biomass remains well below pre-collapse levels. However, recent warming, earlier phytoplankton spring bloom, and an increase in the proportion of energy-rich copepod species may have positive effects on total ecosystem production in the coming years.

Fishery

Redfish are caught primarily in bottom trawl fisheries, but in the past, some landings were reported from mid-water trawl fisheries. In directed redfish fisheries, Atlantic cod, American plaice, witch flounder and other species are landed as bycatch. In turn, redfish are also caught as bycatch in fisheries directing for other species. The fishery in NAFO division 3O is regulated by minimal mesh size and quota.

Recent catch estimates and TACs ('000 tonnes) are:

	2013	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**
TAC	20	20	20	20	20	20	20	20	20	20
STATLANT 21	7.8	7.5	7.9	8.6	7.3	4.3	6.5	7.3	5.4	
STACFIS	7.8	7.5	8.4	9.0	7.5	6.1	6.5	7.3	5.6	

Effects of the fishery on the ecosystem

The impact of bottom fishing activities on major VMEs in the NRA was last assessed in 2021. The risk of Significant Adverse Impacts (SAIs) on sponge and large gorgonian VMEs was assessed to be low, while this risk for sea pen VMEs has been assessed as intermediate. The risks of SAIs on small gorgonian, black coral, bryozoan and sea squirt VMEs were assessed as high. This assessment of impacts of bottom fishing activities on VMEs does not include waters within coastal states jurisdictions. Within the Grand Bank (3LNO) EPU areas in Div. 3O and 3L have been closed to fishing to protect corals.

Special comments

Reference points defined in the 2022 assessment are considered interim and will be reviewed at the 2028 assessment, or earlier if there are considerable advances in an analytical approach for this stock, or a significant change in available data or the understanding of stock dynamics.

Special comments

Redfish are known to have variable and episodic recruitment, with potentially large periods of time between recruitment pulses and no strong relationships between stock size and recruitment. Impacts of delineations of stock boundaries and synchronicity between adjacent stocks are unknown.

Sources of information

SCR Doc. 22/05, 07, 044; SCS Doc. 22/06, 07, 09, 13.

Thorny skate in Division 3LNO and subdiv. 3Ps

Advice June 2022 for 2023-2024

Recommendation for 2023-2024

The stock has been stable at recent catch levels in Div. 3LNO (approximately 3 710 t, 2017 - 2021) however, given the low resilience to fishing mortality and higher historic stock levels, Scientific Council advises no increase in catches.

Management objectives

No explicit management plan or management objectives have been defined by the Commission. Convention General Principles are applied (NAFO GC Doc. 07-04). Advice is based on survey indices and catch trends in relation to estimates of recruitment.

Convention General Principles	***Status***	***Comment/consideration***
Restore to or maintain at B_{MSY}	🟡	B_{MSY} unknown, stock at low level
Eliminate overfishing	🟡	F_{MSY} unknown, fishing mortality is low
Apply Precautionary Approach	🟢	B_{lim} defined from survey indices
Minimise harmful impacts on living marine resources and ecosystems	🟡	No specific measures, general VME closures in effect
Preserve marine biodiversity	⚪	Cannot be evaluated

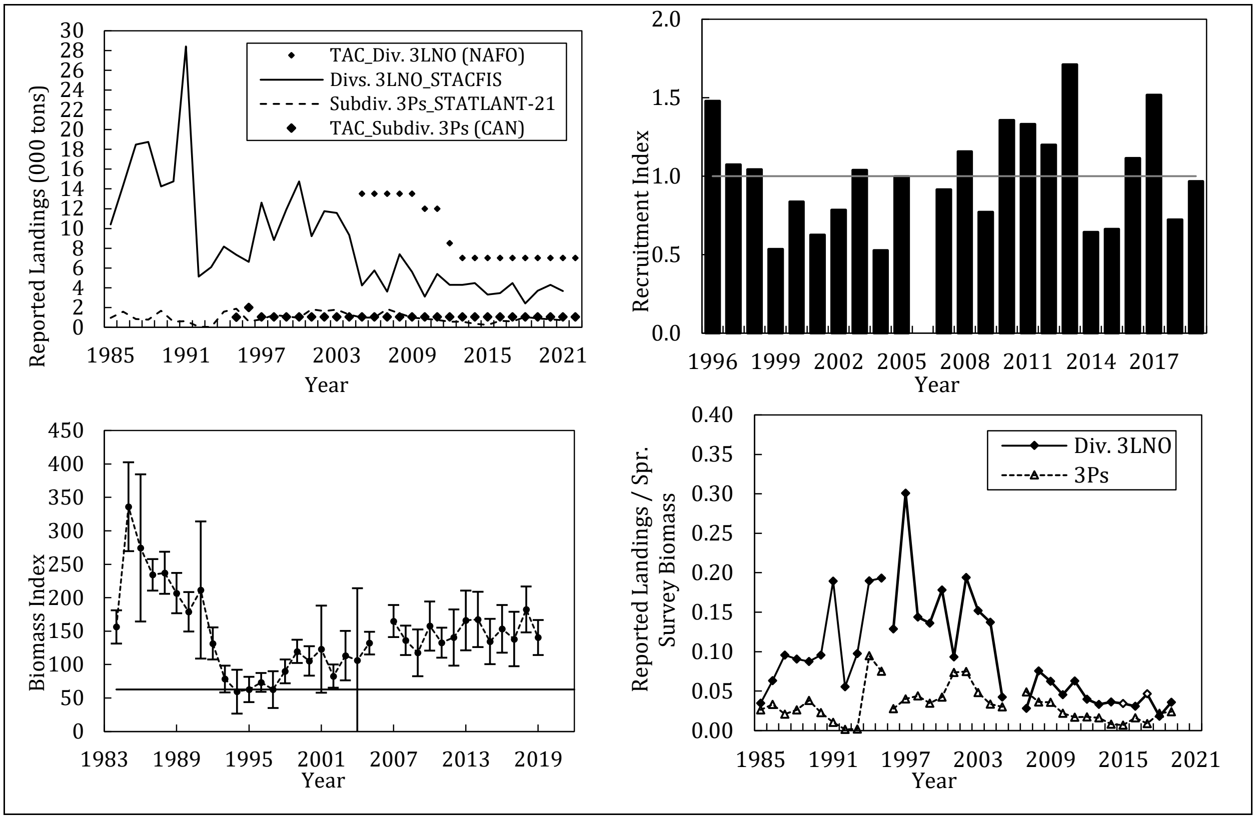
🟢	OK
🟡	Intermediate
🔴	Not accomplished
⚪	Unknown

Management unit

The management unit is confined to NAFO Div. 3LNO, which is a portion of the stock that is distributed in NAFO Div. 3LNO and Subdivision 3Ps.

Stock status

The stock was above B_{lim} in 2019. No new survey information is available to determine stock status. However, due to the longevity of the species and the stability of the catch in recent years, it is unlikely that there have been major changes to the state of the stock. Recruitment was average in 2019 and is currently unknown. Fishing mortality is currently unknown but thought to be low.



Reference points

B_{lim} defined from survey indices as B_{loss}; (SCS Doc 15/12)

Assessment

Based upon a qualitative evaluation of stock biomass trends and recruitment indices, the assessment is considered data limited and as such associated with a relatively high uncertainty. Input data are research survey indices and fishery data. The next full assessment of this stock will be in 2024.

Human impact

Mainly fishery related mortality has been documented. Mortality from other human sources (e.g. pollution, shipping, oil-industry) are undocumented

Biology and Environmental interactions

Thorny skate are found over a broad range of depths (down to 840 m) and bottom temperatures (-1.7 - 11.5ºC). Thorny skate feed on a wide variety of prey species, mostly on crustaceans and fish. Recent studies have found that polychaete worms and shrimp dominate the diet of thorny skates in Div. 3LNO, while hyperiids, snow crabs, sand lance, and euphausiids are also important prey items.

The Grand Bank (3LNO) EPU continues to experience low overall productivity conditions, and total biomass remains well below pre-collapse levels. However, recent warming, earlier phytoplankton spring bloom, and an increase in the proportion of energy-rich copepod species may have positive effects on total ecosystem production in the coming years.

Fishery

Thorny skate is caught in directed gillnet, trawl and long-line fisheries. In directed thorny skate fisheries, Atlantic cod, monkfish, American plaice and other species are landed as bycatch. In turn, thorny skate are also caught as bycatch in gillnet, trawl and long-line fisheries directing for other species. The fishery in NAFO division 3LNO is regulated by quota.

Recent catch estimates and TACs are:

	2013	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**
Div. 3LNO:										
TAC	7	7	7	7	7	7	7	7	7	7
STATLANT 21	4.4	4.5	3.3	3.5	4.2	1.5	3.7	4.0	4.0	
STACFIS	4.4	4.5	3.4	3.5	4.5	2.4	3.7	4.3	3.7	

Effects of the fishery on the ecosystem

The impact of bottom fishing activities on major VMEs in the NRA was last assessed in 2021. The risk of Significant Adverse Impacts (SAIs) on sponge and large gorgonian VMEs was assessed to be low, while this risk for sea pen VMEs has been assessed as intermediate. The risks of SAIs on small gorgonian, black coral, bryozoan and sea squirt VMEs were assessed as high. This assessment of impacts of bottom fishing activities on VMEs does not include waters within coastal states jurisdictions. Within the Grand Bank (3LNO) EPU areas in Div. 3O and 3L have been closed to fishing to protect corals.

Special comments

The life history characteristics of thorny skate result in low rates of population growth and are thought to lead to low resilience to fishing mortality.

Sources of Information

SCR Doc. 14/23.15/40,22/26,05,14,41; SCS Doc. 20/06,09,10,13

b) Monitoring of Stocks for which Multi-year Advice was Provided in 2020 or 2021

Interim monitoring updates of these stocks were conducted and Scientific Council reiterates its previous advice as follows:

Recommendation for Redfish (*Sebastes mentella* and *Sebastes fasciatus*) in Division 3M for 2022 – 2023: SC advises that catches do not exceed F0.1 level, given the life history of the stock. This corresponds to a TAC of 10 933 t in 2022 and 11 171 t in 2023.

Recommendation for American plaice in Division 3M for 2021 – 2023: The stock has recovered to the levels of the mid 1990s, when the fishery was closed. SC considers that there is not sufficient evidence that the stock would be able to sustain a fishery at this time and recommends that there be no directed fishing in 2021, 2022 and 2023. Bycatch should be kept at the lowest possible level.

Recommendation for Cod in Divisions 3NO for 2022 – 2024: No directed fishing in 2022 to 2024 to allow for stock rebuilding. Bycatch of cod in fisheries targeting other species should be kept at the lowest possible level. Projections of the stock were not performed but given the poor strength of all year-classes subsequent to 2006, the stock will not reach B_{lim} in the next three years.

Recommendation for American plaice in Div. 3LNO for 2022-2024: Scientific Council recommends that, in accordance with the rebuilding plan, there should be no directed fishing on American plaice in Div. 3LNO in 2022, 2023 and 2024. Bycatch of American plaice should be kept to the lowest possible level and restricted to unavoidable bycatch in fisheries directing for other species.

Recommendation for yellowtail flounder in Div. 3LNO for 2022 to 2024: Scientific Council advises that fishing mortality up to 85% F_{MSY}, corresponding to catches of 22 100 t, 20 800 t, and 19 900 t in 2022 to 2024 respectively, have risk of no more than 30% of exceeding F_{lim}, and are projected to maintain the stock above B_{MSY}.

Recommendation for Capelin in Divisions 3NO for 2022-2024: No directed fishery.

Recommendation for white hake in Divisions 3NO and Subdiv. 3Ps for 2022-2023: Given the absence of strong recruitment, catches of white hake in 3NO should not increase. Average annual total catches of the most recent five years were around 400 tonnes.

Recommendation for roughhead grenadier in Subareas 2 and 3: There will be no new assessment until monitoring shows that conditions have changed.

Recommendation for alfonsino in Division 6G for 2019 and beyond: The substantial decline in CPUE and catches on the Kükenthal Peak in the past year indicates that the stock may be depleted. SC advises to close the fishery until biomass increases to exploitable levels.

c) Special Requests for Management Advice

i) *Greenland halibut in SA2 + Divs. 3KLMNO: Greenland halibut in SA2 + Divs. 3KLMNO: monitor, compute the TAC using the agreed HCR and determine whether exceptional circumstances are occurring (request #2, Commission priority)*

The Commission requests the Scientific Council to monitor the status of Greenland halibut. Conditional on the absence of other reasons for Exceptional Circumstances arising (other than the missing Canadian spring 3LNO survey), to calculate in 2022 the HCR adjusting the TAC advised for 2022 using four survey indices (Canadian fall 2J3K, Canadian fall 3LNO, EU 3M 0-1400m, and EU-Spain 3NO surveys) to provide TAC advice for 2023. If other reasons for Exceptional Circumstances are occurring, the EC protocol will provide guidance on what steps should be taken.

Scientific Council responded:

With the exception of the three missing values from the Canadian spring 3LNO survey, SC advises that Exceptional Circumstances are not occurring. Therefore, the TAC for 2023 derived from the HCR is 15 156 t. This is 5% lower than the 2022 TAC (15 864 t).

An HCR for Greenland halibut in Subarea 2+Div. 3KLMNO was adopted by the Commission in 2017. The HCR has two components: target based and slope based. The full set of control parameters for the adopted HCR are shown in Table i.1 with a starting TAC of 16 500 t in 2018. All data inputs used to calculate the TAC for 2023 are shown in Table i.2. Inputs normally include five surveys; however, this year, there were insufficient observations from the Canadian spring 3LNO survey to utilize that series in the HCR. Sensitivity analyses indicated minimal impact on the HCR outputs (<5%). It was subsequently decided to exclude this survey from the HCR in 2022 to provide TAC advice for 2023. Equations below are modified accordingly.

	2017	2018	2019	2020	2021
Canada Fall 2J3K	✓	✓	✓	✓	✓
Canada Fall 3LNO	✓	✓	✓	✓	✗
EU 3M 0-1400m	✓	✓	✓	✓	✓
Canada Spring 3LNO	✗	✓	✓	✗	✗
EU-Spain 3NO	✓	✓	✓	✗	✓

Target based ***(t)***

The target harvest control rule (HCR) is:

$$\mathrm{TAC}_{y+1}^{target} = \mathrm{TAC}_y\left(1+\gamma\left(J_y-1\right)\right) \qquad (1)$$

where TAC_y is the TAC recommended for year y, γ is the "response strength" tuning parameter, J_y is a composite measure of the immediate past level in the mean weight per tow from surveys (I_y^i) that are available to use for calculations for year y; four survey series are used, with i = 1, 2, 3, and 4 corresponding respectively to Canada Fall 2J3K, EU 3M 0-1400m, EU-Spain 3NO and Canada Fall 3LNO:

$$J_y = \sum_{i=1}^{4}\frac{1}{{\sigma^i}^2}\frac{J_{current,y}^i}{J_{target}^i} \Big/ \sum_{i=1}^{4}\frac{1}{{\sigma^i}^2} \qquad (2)$$

with $(\sigma^i)^2$ being the estimated variance for index i (estimated in the SCAA model fitting procedure),

$$J^i_{current,y} = \frac{1}{q}\sum_{y'=y-q}^{y-1} I^i_{y'} \qquad (3)$$

$$J^i_{target} = \alpha\frac{1}{5}\sum_{y'=2011}^{2015} I^i_{y'} \quad \text{(where } \alpha \text{ is a control/tuning parameter for the MP)} \qquad (4)$$

and q indicating the period of years used to determine current status. Note the assumption that when a TAC is set in year y for year $y+1$, indices will not at that time yet be available for the current year y. Missing survey values are treated as missing in the calculation using the rule, as was done in the MSE. In such cases, q in equation (3) is reduced accordingly.

*Slope based (**s**)*

The slope harvest control rule (HCR) is:

$$\text{TAC}^{slope}_{y+1} = \text{TAC}_y\left[1 + \lambda_{up/down}\left(s_y - X\right)\right] \qquad (5)$$

where $\lambda_{up/down}$ and X are tuning parameters, s^i_y is a measure of the immediate past trend in the survey-based mean weight per tow indices, computed by linearly regressing lnI^i_y, vs year y' for $y' = y-5$ to $y' = y-1$, for each of the four surveys considered, with:

$$s_y = \sum_{i=1}^{4}\frac{1}{(\sigma^i)^2}s^i_y/\sum_{i=1}^{4}\frac{1}{(\sigma^i)^2} \qquad (6)$$

with the standard error of the residuals of the observed compared to model-predicted logarithm of survey index i (σ^i) as estimated in the SCAA base case operating model. Missing survey values are treated as missing in the calculation using the rule, as was done in the MSE. In such cases, the slope in equation (6) is calculated from the available values within the last five years.

*Combination Target and Slope based (**s+t**)*

For the target and slope based combination:

1. $\text{TAC}^{target}_{y+1}$ is computed from equation (1),
2. TAC^{slope}_{y+1} is computed from equation (5), and
3. $\text{TAC}_{y+1} = \left(\text{TAC}^{target}_{y+1} + \text{TAC}^{slope}_{y+1}\right)/2$

Finally, constraints on the maximum allowable annual change in TAC are applied, viz.:

$$\text{if} \quad \text{TAC}_{y+1} > \text{TAC}_y\left(1+\varDelta_{up}\right) \quad \text{then} \quad \text{TAC}_{y+1} = \text{TAC}_y\left(1+\varDelta_{up}\right) \qquad (7)$$

and

$$\text{if} \quad \text{TAC}_{y+1} < \text{TAC}_y\left(1-\varDelta_{\text{down}}\right) \quad \text{then} \quad \text{TAC}_{y+1} = \text{TAC}_y\left(1-\varDelta_{\text{down}}\right) \qquad (8)$$

During the MSE process, this inter-annual constraint was set at 10%, for both TAC increases and decreases, and these constraints were adopted as part of the adopted HCR.

Following the HCR using the agreed survey data, the recommended TAC for 2023 is 15 156 t (Table i.2). While the number of missing survey points are sufficient to declare Exceptional Circumstances, a series of sensitivity tests indicate that applying the HCR informed by four survey indices only (Canadian Fall 2J3K, Canadian Fall 3LNO, EU 3M 0-1400m, and EU-Spain 3NO surveys) serves as a reasonable option for providing TAC advice for 2023 with minimal deviation from the agreed Management Procedure (HCR output from a series of sensitivity tests did not deviate by more than 5%; SCR Doc. 22/015).

Table i.1. Control parameter values for the adopted HCR. The parameters α and X were adjusted to achieve a median biomass equal to B_{msy} for the exploitable component of the resource biomass in 2037 for the Base Case SCAA Operating Model.

TAC_{2018}	16 500 t
γ	0.15
q	3
α	0.972
λ_{up}	1
λ_{down}	2
X	-0.0056
δ_{up}	0.1
δ_{down}	0.1

Table i.2. Data used in the calculation of the TAC for 2023. The weights given to each survey in obtaining composite indices of abundance (target rule) and composite trends (slope rule) are proportional to the inverses of the squared values of the survey error standard deviations σ^i listed below.

	Canada Fall 2J3K	Canada Fall 3LNO	EU-Spain 3NO	EU 3M 0-1400m
2011	26.736	2.206	7.093	26.152
2012	23.504	1.712	7.373	19.198
2013	29.645	2.589	5.463	19.110
2014	33.336		6.239	23.921
2015	22.290	0.869	9.486	47.517
2016	18.541	1.314	8.796	28.298
2017	15.104	1.246	16.627	42.665
2018	17.054	1.887	7.875	29.803
2019	16.285	1.872	8.824	16.887
2020	15.840	2.714		13.230
2021	21.153		8.090	16.310
s^i_{2022}	0.0600	0.2329	-0.1393	-0.2735
$J^i_{current,2022}$	17.759	2.293	8.457	15.476
J^i_{target}	26.343	1.792	6.931	26.418
σ^i	0.220	0.260	0.380	0.210
$1/(\sigma^i)^2$	20.661	14.793	6.925	22.676

TAC_{2022}	15 864 t	TAC^{target}_{2023}	15 481 t
s_{2022}	-0.038	TAC^{slope}_{2023}	14 831 t
J_{2022}	0.839	TAC_{2023}	15 156 t

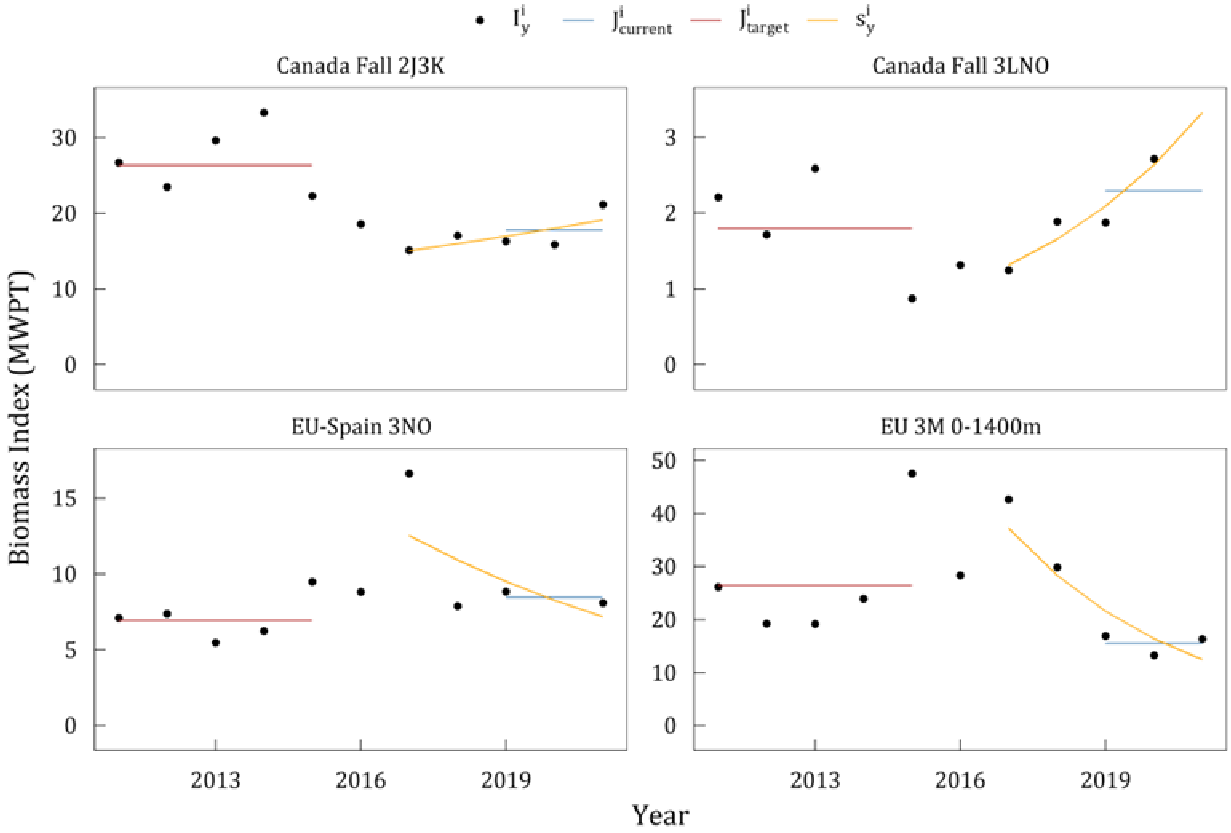


Figure. i.1. Input for the Greenland Halibut in Subarea 2 + Divisions 3KLMNO Harvest Control Rule along with visual representation of the target and slope based components of the rule. The red line represents the target (2011-2015 average; J_{target}^i), the blue line the current levels (2018 - 2021 average; $J_{current}^i$), and the orange line depicts recent log-linear trends (2016 - 2021 slope; s_y^i). Survey data come from Canadian fall surveys in Divs. 2J3K, Canadian fall surveys in Divs. 3LNO, EU Flemish Cap surveys (to 1400m depth) in Div. 3M and EU-Spain surveys in 3NO. Missing values within the last five years are not used in the calculation of the TAC using the HCR.

Exceptional Circumstances

In 2022, the SC evaluated each of the criteria indicated in the Exceptional Circumstances Protocol, as described below.

The following criteria constitute Exceptional Circumstances:

1. Missing survey data:

More than one value missing, in a five-year period, from a survey with relatively high weighting in the HCR (Canadian Fall 2J3K, Canadian Fall 3LNO, and EU 3M surveys);

More than two values missing, in a five-year period, from a survey with relatively low weighting in the HCR (Canadian Spring 3LNO and EU-Spain 3NO surveys);

Exceptional Circumstances are not occurring, other than the three missing values from the Canadian spring 3LNO survey series.

2. The composite survey index used in the HCR, in a given year, is above or below the 90 percent probability envelopes projected by the base case operating models from SSM and SCAA under the MS;

The composite survey index has remained within the 90% probability envelopes from the base case SCAA operating model (**Figure i.2**). Composite indices exceeded the 90% probability envelopes from the base case SSM between 2018 to 2020, which is not a conservation concern, and values since 2021 remain within the 90% probability envelopes (**Figure i.3**). Given the composite index remains within the 90% probability envelope from the SCAA and has been above or within the 90% probability envelope from the SSM projections, SC concludes that this does not constitute Exceptional Circumstances.

3. TACs established that are not generated from the MP.

The TAC established for 2022 was generated from the MP. This does not constitute Exceptional Circumstances.

The following elements will require application of expert judgment to determine whether Exceptional Circumstances are occurring:

1. the five survey indices relative to the 80, 90, and 95 percent probability envelopes projected by the base case operating models (SSM and SCAA) for each survey;

Survey indices from the past four years are primarily within the 80% probability envelopes from the base case SCAA operating model (16 out of 20 observations; **Figure i.2**). Likewise, survey indices were primarily within the 80% probability envelopes from the SSM projections (12 out of 20 observations; **Figure i.3**). SC does not consider this Exceptional Circumstances as most indices are within or above the probability envelopes from both models.

2. survey data at age four (age before recruitment to the fishery) compared to its series mean to monitor the status of recruitment;

This Exceptional Circumstance is not occurring as recent recruitment is near average (**Figure i.4**).

3. discrepancies between catches and the TAC calculated using the MP

The TAC for 2021 was 16 498 t. The catch in 2021 was 15 039 t (<10% difference). SC concludes that this does not constitute Exceptional Circumstances as catches are closely tracking the Management Procedure predictions.

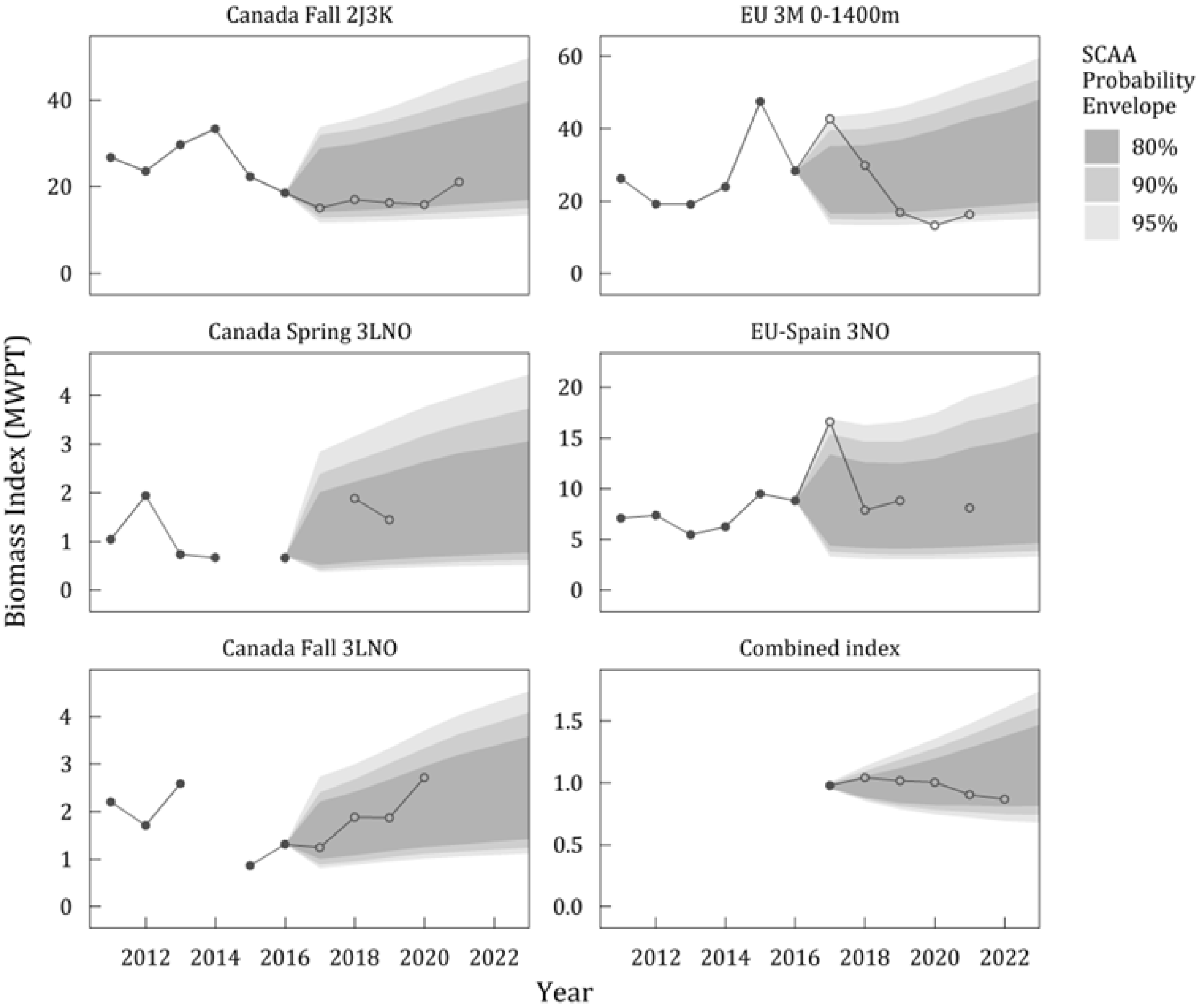


Figure. i.2. Greenland Halibut in Subarea 2 + Divisions 3KLMNO. Mean weight per tow from Canadian fall surveys in Divs. 2J3K, Canadian spring surveys in Divs. 3LNO, Canadian fall surveys in Divs. 3LNO, EU Flemish Cap surveys (to 1400m depth) in Div 3M and EU-Spain surveys in 3NO. The figure also shows the combined index used in the target based component of the HCR. For the survey and combined indices, 80%, 90% and 95% probability envelopes from the SCAA base case simulation are shown. Index values observed from 2017 onward are shown using open circles.

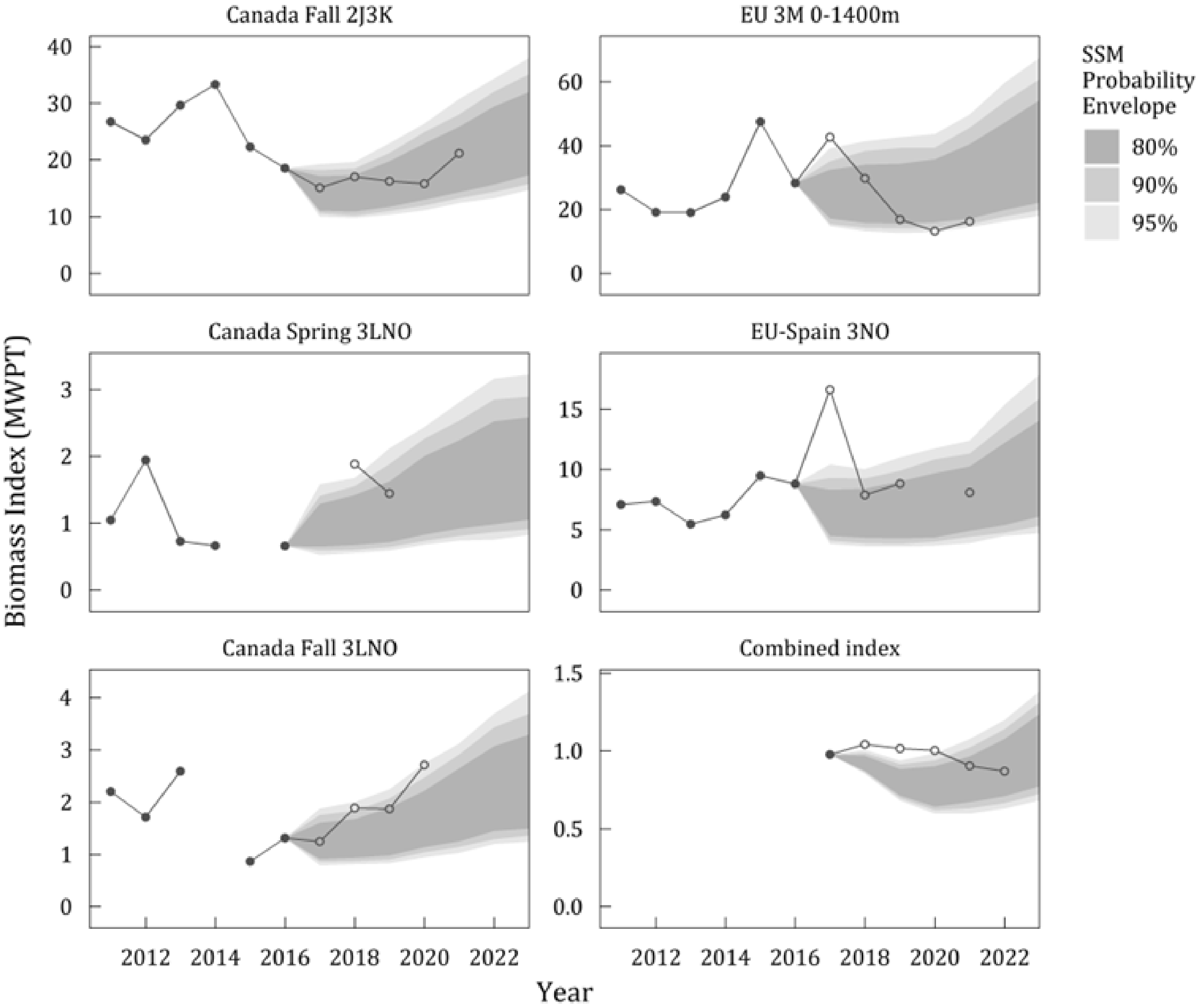


Figure. i.3. Greenland Halibut in Subarea 2 + Divisions 3KLMNO. Mean weight per tow from Canadian fall surveys in Divs. 2J3K, Canadian spring surveys in Divs. 3LNO, Canadian fall surveys in Divs. 3LNO, EU Flemish Cap surveys (to 1400m depth) in Div 3M and EU-Spain surveys in 3NO. The figure also shows the combined index used in the target based component of the HCR. For the survey and combined indices, 80%, 90% and 95% probability envelopes from the SSM base case simulation are shown. Index values observed from 2017 onward are shown using open circles.

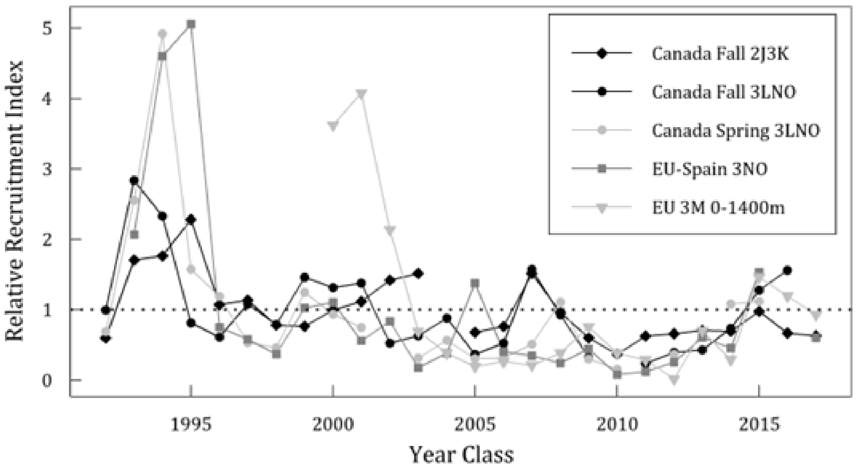


Figure. i.4. Greenland Halibut in Subarea 2 + Divisions 3KLMNO. Relative recruitment (age 4) indices from Canadian autumn surveys in Div. 2J3K, Canadian spring surveys in Div. 3LNO, Canadian fall surveys in Div. 3LNO, EU-Spain survey in 3NO and EU survey of Flemish Cap. Each series is scaled to its average, which then corresponds to the horizontal dotted line at 1.

ii) Continue the evaluation of trawl surveys on VMEs (request #3)

Commission Request 3.- The Commission requests that Scientific Council continue its evaluation of the impact of scientific trawl surveys on VME in closed areas and the effect of excluding surveys from these areas on stock assessments.

Scientific Council responded:

Recent studies on the exclusion of surveys from closed areas indicate that survey indices for a number of species show measurable changes in estimates when sets from closed areas are omitted.

These studies also indicated that recurrence times in scientific surveys in the NRA may not result in significant adverse impacts in some cases. SC/WGESA will further review these studies at its 2022 November meeting before making a final recommendation.

The SC analyzed the impact of the trawl surveys carried out in the NRA on the VME Closed Areas (SCR Doc. 22/34) and the effect of excluding the EU surveys (Flemish Cap, 3NO and 3L) from these areas on stock assessments (SCR Doc. 22/32). Both analyses were carried out based on the framework developed by Canada to support decisions on authorizing scientific surveys with bottom-contacting gears in closed areas (DFO., 2018). Among the main conclusions of the analysis are the following:

- There are no existing frameworks in NAFO to assist in determining under what conditions trawl scientific surveys can be permitted in protected areas.
- While the goal of the VME closures is to protect VMEs, their boundaries are not drawn solely on VME areas and are impacted by other considerations.
- The revision of the closed areas that is carried out every 4 years makes it difficult to analyze the impact of the scientific surveys in the closed areas since these areas can change over time.
- Surveys contribute to the maintenance of a large diversity of scientific advice that supports, among other things, sustainable fisheries management, the assessment of stock status, the monitoring of the recovery of depleted species and species at risk, the identification of conservation areas and the development of ecosystem indicators for ecosystem-approaches to management.
- Recurrence time for the surveys carried out in the NRA show that the benthic impact of the surveys activity is likely to have time to recover to the levels that existed prior to the benthic impact of the

sampling activity at least for the closed areas delimited for sea pens (Closed areas 7, 8, 9, 10, 11, 12, and 14).

- For the closed areas based on large gorgonians and sponges (Closed Areas 1, 2, 3, 4, 5, 6 and 13) the conclusions are less clear due to the available information about the longevity of some of the coral and sponges species and the recurrence times of surveys.
- Reducing the trawling time in European surveys from 30 to 20 minutes in the sets made within the closed areas would considerably reduce the benthic impact extending the recurrence time to more than 1500 years.
- For most of the stocks indices, the estimation of biomass, abundance, age/length structure and bias over time is very similar with and without the data of the sets carried out in the closed areas.
- Only the EU survey indices for two stocks, Greenland halibut Subarea 2 and Division 3LMNO and roughhead grenadier Subarea 2 and 3, show a measurable change in estimates when information on sets made within closed areas is omitted. There are other species in which their total biomass indices do not change considerably, but bias occurs in the estimation of their biomass index and/or their age or length indices change appreciably when hauls from closed areas are removed from the calculations (e.g., redfish and witch flounder indices). The impact of these factors on the assessment would be case-dependent, and the assessment models would have to be run with and without the hauls in the closed areas to evaluate the differences in the results.

SC **recommends** that *the results of these studies and the conclusions be reviewed by ecosystem experts at the next WG-ESA before making a final decision on bottom-trawl surveys in the Closed Areas.*

References:

DFO., 2018. Framework to support decisions on authorizing scientific surveys with bottom contacting gears in protected areas with defined benthic conservation objectives. DFO Can. Sci. Advis. Sec. Sci. Advis. Rep. 2018/043

iii) Initiate the first steps in both the 2+3KLMNO Greenland halibut and 3LN redfish MSE processes (request #4, Commission priority)

Scientific Council initiate the first steps in both the 2+3KLMNO Greenland halibut and 3LN redfish MSE processes during 2021-2022, namely:

a. Compile catch and survey data and any additional sources of information used in the current models;

b. Review and finalize the data inputs for review at the June 2022 Scientific Council meeting when conducting both the 3LN redfish assessment and the assessment of Greenland Halibut Exceptional Circumstances/ Provision of TAC advice

c. Time permitting, further work on the respective MSE work plans by the SC-GHL and SC-Redfish subgroups for presentation to WG-RBMS or SC.

Scientific Council responded:

Available survey data were compiled and reviewed for 2+3KLMNO Greenland halibut and 3LN redfish. For Greenland halibut, it was noted that within-survey coverage has been an issue for many of the surveys, and conflicting patterns in disparate survey indices were highlighted. For 3LN redfish, catch data were reviewed in addition to the survey data. There was some evidence of differences in the length compositions in 3L versus 3N, both in the commercial and survey redfish catches.

For redfish, the ASPIC-based MSE adopted in 2014 was updated with most recent data and exploration of production model formulations continues. Work has been initiated on the development of length-based models that will include both survey and commercial length frequencies, and thereby provide a more comprehensive picture of the stock structure and facilitate projections.

It was considered premature to finalize data inputs for both processes before further investigations could be considered.

A tentative workplan is proposed for both stocks, however given the complexity of MSE processes, additional intersessional meetings are likely to be required leading up to the data, OM, and MP review meetings. The timeline needs to allow sufficient time not only to accomplish the technical work, but also to complete documentation and review; and to allow adequate consultation with managers. Timeliness may therefore require adjustments by WG-RBMS to ensure there is sufficient time and capacity to complete these tasks, and finalization of data inputs and OMs are tentatively scheduled for June 2023 for Greenland halibut, and June 2024 for redfish.

a) Compile catch and survey data and any additional sources of information used in the current models

The available catch data for 3LN redfish were detailed and reviewed. For redfish, raw commercial catch length frequencies were compiled from various sources. Approaches are in development for scaling up the catch at length for use in the MSE. No additional information on catch was considered for Greenland halibut as the standard method for producing catch at age is considered sufficient for use in the OM phase of the MSE process.

An exploration of survey data was also conducted for both redfish and Greenland halibut, first through an overview of the spatiotemporal coverage of all available research vessel surveys. For both stocks, it was noted that within-survey coverage has been an issue for many of the surveys, and further testing is required to assess the impact of inconsistent survey coverage. Approaches for combining survey indices also require further consideration as many of the surveys only cover part of the redfish and Greenland halibut stock areas. For redfish, the utility of some short survey time-series were questioned, as was the exclusion of survey data prior to 1995 from the previous MSE process for Greenland halibut.

Additionally, for redfish, the data exploration provided some evidence that the commercial and survey catches in 3L were catching redfish of a larger size than in 3N. Divergent trends in biomass indices and shifts in length and age compositions for Greenland halibut indicate spatial shifts in their distribution. These observations will inform OM development for the MSE for each stock.

b) Review and finalize the data inputs for review at the June 2022 Scientific Council meeting when conducting both the 3LN redfish assessment and the assessment of Greenland Halibut Exceptional Circumstances/ Provision of TAC advice

It was considered premature to finalize data inputs for the MSE before further investigations could be considered (see section a above). Additional data will be explored for redfish, including additional survey length frequencies that were missing from the data review, and available maturity data. As such, final data inputs will be presented at a proposed SC Intersessional (2022/early 2023).

c) Time permitting, further work on the respective MSE work plans by the SC-GHL and SC-Redfish subgroups for presentation to WG-RBMS or SC

The MSE review for Greenland halibut is not expected to introduce substantive changes to the existing Management Procedure, unlike the redfish MSE, which will require a more fulsome review as there are plans to expand the modelling frameworks applied. In addition to the surplus-production operating models used in the last MSE process for redfish, length-based age structured models are being considered. This requires careful review of data and models not previously used to assess and manage the 3LN redfish stock. Extensive discussions will also be required to develop operating models that account for redfish life history (e.g., episodic recruitment). The previous Greenland halibut MSE was conducted relatively recently and our state of knowledge of the stock has not changed much since then. The Greenland halibut MSE process may therefore advance at a faster rate than the redfish MSE process. However, both processes will be conducted in parallel where possible as there is opportunity for the redfish MSE to learn, modify and adopt some aspects of

Greenland halibut MSE during the proposed course of development of both (especially MPs and performance metrics).

A tentative workplan is proposed for both stocks (Table iii.1), however given the complexity of MSE processes, additional intersessional meetings are likely to be required leading up to the data, OM, and MP review meetings. The timeline needs to allow sufficient time not only to accomplish the technical work, but also to complete documentation and review; and to allow adequate consultation with managers. Timeliness may therefore require adjustments by WG-RBMS to ensure there is sufficient time and capacity to complete these tasks, and finalization of data inputs and OMs are tentatively scheduled for June 2023 for Greenland halibut, and June 2024 for redfish.

d) Sources of information

SCR Doc. 22/016, 22/027, 22/042

Table iii.1. Tentative 3LN redfish and 2+3KLMNO Greenland halibut MSE

Expected Delivery	MSE Workplan	GHL Date Completed	RED Date Completed
SC June	Scoping discussion to provide possible direction for WG-RBMS on a full evaluation of the existing MSE.	SC June 2021	SC June 2021
WG-RBMS Aug	Broad scope of schedule proposed to the Commission	WG-RBMS Aug 2021	WG-RBMS Aug 2021
SC June	Review of the data and update of existing MSE work	SC June 2022	SC June 2022
WG-RBMS	Schedule finalized and proposed to the Commission; initiate discussion on CMPs and performance metrics.		
Potential SC Intersessional	Finalize data series to be used for the MSE		
SC June	Proposal and review of OMs to be used		
WG-RBMS Aug	Development of performance statistics; development of Candidate Management Procedures (CMP)		
SC June	Finalize OMs, consensus required at this time on OMs; application of CMPs		
WG-RBMS Aug	Finalize CMPs; refinement of performance statistics including risk tolerances and constraints;		
SC June	Evaluate performance statistics and make a final decision on the Management Strategy to propose to the Commission		
COM Sep	The Commission considers adoption of proposed new Management Strategy		

iv) Continue work on the sustainability of catches aspect of the Ecosystem Roadmap (request #5)

The Commission requests that Scientific Council continue work on the sustainability of catches aspect of the Ecosystem Roadmap, including:

a. *In consultation with WG-EAFFM via co-Chairs, convene independent experts to do a scientific review of; a) the estimation of fisheries production potential and total catch indices, and b) the adequacy of this analysis for their proposed use within the NAFO roadmap (Tier 1), while considering how species interactions are expected to be addressed in the future (Tier 2) within the overall Roadmap structure. The outcomes of this review would need to be tabled in June at Scientific Council to be available in advance of the planned workshop in 2022.*

Scientific Council responded:

Scientific Council, in consultation with COM-SC WGEAFFM, convened a three person independent expert panel to address this request. Based on the results of the external review, and the follow-up discussions, **SC concludes** that the EPP/TCI work is scientifically sound, and more than adequate for supporting implementation of the Tier 1 of the Roadmap. Also in line with the review results, SC considers that while the recommendations on presentation of the material, and additional sensitivity analyses indicated by the reviewers should be carried out, completing these should not delay implementation of Tier 1.

Scientific Council, in consultation with COM-SC WGEAFFM, convened a three member independent expert panel to review a) the scientific validity of the Ecosystem Production Potential (EPP) modelling work and its use to estimate Fisheries Production Potential (FPP) and the derivation of Total Catch Indices (TCIs) from the FPP distributions, and b) the adequacy of TCIs as an indicator for the provision of advice in support of implementation of Tier 1 within the broader context of the NAFO Roadmap towards an Ecosystem Approach (e.g. integration with Tier 2). The review panel was composed by Dr Jason Link (NOAA), Dr Sarah Gaichas (NOAA), and Dr. Éva Plagányi-Lloyd (CSIRO).

To carry out this review, WGESA produced two SCR documents, one main document summarizing the work done to date on EPP/TCI (SCR 2022/02), and a companion document providing an annotated list of documents, that capture key steps in the history and evolution of this work within NAFO SC and WGESA (SCR Doc. 22-03).

The members of the expert panel reviewed the material independently and provided written comments and suggestions. After the initial reviews were received, a follow-up meeting between the reviewers, WGESA and SC chairs, and scientists involved in developing this work was held on 24 May 2022. During this meeting, the scientists involved in the development of the EPP/TCI work provided initial responses to the feedback received, and further clarified some of the issues identified in the written reviews. After the meeting, additional analyses were generated and submitted to the reviewers to further address the questions posed. Based on the material provided, and the follow-up discussions, the expert reviewers produced a consolidated summary review that was presented to SC by Dr. Jason Link. This consolidated summary review reads (sic):

"Three reviewers independently evaluated the EPP/TIC approach for implementation of Tier 1 within the NAFO EAFM Road Map. They then met with the proponents of the approach and various NAFO staff and committee members to discuss the work and the review thereof.

***Bottom Line Up Front**: All reviewers agreed that the science presented in support of the total catch indices was sound and reasonable. Advice using the TCI approach would be sensible, reasonable, and even advisable in the NAFO EAFM Tier 1 context.*

Certainly, there was the usual detailed commentary on the work that is common amongst scientists, and a productive back-and-forth with the principal proponent of the Tier 1 approach occurred in the review discussion meeting, whereby many of the concerns raised in written review were addressed. There may be additional tweaks to be made to the EPP/TCI approach, but they should not delay the use of this approach.

*The consensus recommendation is that the overall approach should be implemented. As noted by one reviewer and heartily agreed to by all, at levels of 2*TCI "things go wrong and it's because of fishing" was readily apparent and defensible. Thus, the work should proceed and the approach be adopted with suitable and minor validation points (noted below) to be executed.*

***Supplemental thoughts to consider*:**

- All reviewers endorse the approach, especially as a starting point, based on it being scientifically sound and adequately accounting for uncertainty
- It was noted that the communication around the approach, especially context-setting, needs to be crystal clear relative to NAFO Tiers, EAF objectives, and what the approach is aiming to do rather than getting bogged down in modeling details or endless uncertainty evaluations.
    - In terms of communication, focusing on the robustness of 2TCI should help.
- It was agreed that "fully functional ecosystem" should be clearly, early and repeatedly defined as to how it is to be applied in this context
- A few more sensitivity tests (e.g. 20% exploitation rate) and simulations would be useful to definitively demonstrate robustness of the approach.
- For one specific, additional analysis that all reviewers raised and agreed upon, it was recommended that the authors focus on whether the 2TCI reference point that indicates fishing negatively impacts the system is robust to changing the assumptions of the model:
    1. alter 20% exploitation rate (perhaps use only those systems similar to this one instead of worldwide)
    2. drop the "fully functional ecosystem adjustment"
    3. alter the "fully functional ecosystem adjustment" with quantitative and repeatable definitions of "stability"
    - From that, if the 2TCI is sensitive to any of these (meaning the quadrant where biomass declines is no longer just over that line) that is important information for implementation. One could change the line until the quadrant where biomass declines is over the line regardless of model setup and use that as a reference point. If there isn't sensitivity, all the better.
    - Qualitatively some of these were done or initiated, and the results were promising enough for the reviewers to reach the overall conclusions that they did.
    - Similarly, and not essential to start nor should it hold up implementation of the proposed approach, but MSE testing will be helpful in the future to fully explore the range of behaviors from the approach relative to a suite of proposed management actions.
- Verification of the approach relative to other indicators was provided in the meeting, and it was agreed that the analysis appears to be catching the major signals and avoiding ecosystem overfishing, but these other indicators should be presented routinely as a matter of regular diagnostic checking
- The question arose-- what would one lose or gain by using the TCI, and it appeared that one wouldn't actually lose much of anything, and in fact might reap additional benefits. Executing the afore-mentioned analysis would further confirm this observation."

After the summary was presented, SC discussed the review work with Dr. Link, further clarifying the main elements and key take home messages from the expert review panel. This discussion also included elements that could be considered for the potential implementation of the EPP/TCI work as part the Tier 1 assessments within the Roadmap, with Dr. Link indicating if implemented this would make NAFO *"one of the leading places in the world adopting the ecosystem approach to fisheries management*".

Given the relevance of this review for the upcoming COM-SC WGEAFFM workshop on ecosystem objectives and implementation of Tier 1, the reviewers have also been invited to participate in this workshop.

Based on the results of the external review, and the follow-up discussions, SC concludes that the EPP/TCI work is scientifically sound, and adequate for supporting implementation of the Tier 1 of the Roadmap. Also in line with the review results, SC considers that while the recommendations on presentation of the material, and additional sensitivity analyses indicated by the reviewers should be carried out, completing these should not delay implementation of Tier 1.

Next steps towards concluding this review process includes the publication of the full suite of reviews (i.e. initial independent written comments, and follow-up consolidated review) as a SCS document, and the production of a new SCR summarizing the EPP/TCI work and addressing the feedback and recommendations emerging from the independent expert review.

b. Work to support the WG-EAFFM workshop in 2022, which will explore ecosystem objectives and further develop how the Roadmap may apply to management decision making.

Scientific Council responded:

Building upon its advice in 2020 and the results from the independent scientific review of EPP-TCI, Scientific Council **recommends** that, *as an interim measure in the implementation of Tier 1 of the NAFO Roadmap, a TCI-based assessment of ecosystem overfishing be adopted by the Commission to inform their fishery management decisions.*

This recommended initial implementation of TCIs effectively constitutes a traffic light approach as follows:

Red light *(total catches >2TCI; High risk of impacts due to ecosystem overfishing): this is a catch scenario to be avoided and if reached, management measures should be taken to reduce total catches below 2TCI;*

Yellow light *(1TCI<total catches<2TCI; Intermediate risk of impacts due to ecosystem overfishing): management measures should explicitly account for preventing the zone of high risk of ecosystem overfishing to be reached;*

Green light *(total catches <1TCI; Low risk of impacts due to ecosystem overfishing): no additional management measures are required to reduce the risk of ecosystem overfishing.*

The Commission may also wish to consider a hard form of the TCI approach with operational decision rules.

There is a need to define appropriate ecosystem level objectives against which the different technical elements of the Roadmap can be applied.

Preparations for a WGEAFFM workshop have been on-going since it was announced at the 41st Annual Meeting (2019) that a workshop would be organised to progress the implementation of all aspects of the NAFO Roadmap (COM SC Doc. 19-10). Specifically, it was agreed the workshop would have the following objectives: i. to advance the drafting of ecosystem level objectives, ii. to identify elements for their application, iii. to explore existing practice, and iv. to identify information needs for future development. However, with the onset of the COVID-19 pandemic it has been necessary to push-back the timetable for this workshop.

SC input at the workshop will be primarily from the standpoint of the application of the technical aspects (or elements) which underpin the Roadmap, specifically in relation to Tiers 1 and 2 assessment levels in general, and the Total Catch Index (TCI) and multi-species modelling work in particular.

TCI operational implementation

Given the current state of development, taking account of the Total Catch Index (TCI) represents a strategic approach to ecosystem sustainability by providing a tool to prevent impacts from ecosystem overfishing. It does not constitute a hard tactical limit for any specific stock, but it does provide information to synoptically assess the sustainability of the overall level of fisheries extraction, allowing for strategic planning over a 3 to 5 year timeframe.

Tier 1 of the Roadmap outlines the need to consider sustainability at the ecosystem level by identifying an upper bound to aggregate fisheries catches, and the Total Catch Index provides an operational metric to evaluate the risk of negative outcomes due to ecosystem overfishing as a function of the primary production and productivity state of the ecosystems being fished.

Building upon its advice in 2020 (SCS Doc. 20/14) and the results from the independent scientific review of EPP-TCI, **SC recommends** that, *as an interim measure in the implementation of Tier 1 of the NAFO Roadmap, a TCI-based assessment of ecosystem overfishing be adopted by the Commission to inform their fishery management decisions.* This recommended initial implementation of TCIs effectively constitutes a traffic light approach as follows:

Red light *(total catches >2TCI; High risk of impacts due to ecosystem overfishing): this is a catch scenario to be avoided and if reached, management measures should be taken to reduce total catches below 2TCI;*

Yellow light *(1TCI<total catches<2TCI; Intermediate risk of impacts due to ecosystem overfishing): management measures should explicitly account for preventing the zone of high risk of ecosystem overfishing to be reached;*

Green light *(total catches <1TCI; Low risk of impacts due to ecosystem overfishing): no additional management measures are required to reduce the risk of ecosystem overfishing.*

The Commission may also wish to consider a hard form of the TCI approach with operational decision rules. An illustrative example of this approach is given below. The details of implementation need to be co-developed between managers and scientists during the workshop to ensure that relevant aspects can be properly taken into account. This does not constitute a preferred option nor recommendation from SC on the way forward at this stage.

When exceeding 2TCI during an assessment cycle;

Apply reductions in TACs based on negotiations among Contracting Parties (CPs) like,

i. calculate the magnitude of the reduction in TACs required (Reduction= ΣTACs- 2TCI) within the corresponding functional guild, whilst;
ii. utilize the regular multilateral and bilateral meetings between CPs to negotiate and achieve consensus on how best to implement the required reductions.

Defining ecosystem level objectives

There is a need to define appropriate ecosystem level objectives against which the different technical elements of the Roadmap can be applied. This is not a trivial task but could be facilitated by framing the discussion on objectives during the workshop around the general objectives of the NAFO Convention as captured in the Ecosystem Summary Sheets. This can provide a first step towards examining the practical aspects of defining and implementing ecosystem objectives.

c. Continue its work to develop models that support implementation of Tier 2 of the EAFM Roadmap.

Scientific Council responded:

In order to advance the development of models in support of Tier 2 assessments, SC made progress by a) defining the features required for Tier 2 models and identifying potential advice applications, b) making explicit the formal steps and operational requirements needed for Tier 2 model development, and c) examining ongoing modelling work that could support Tier 2 assessments.

Building upon this progress, the next steps towards a strategy for a broader implementation of Tier 2 would include a) developing a triage procedure for identifying priorities for model development, and b) developing mechanisms to promote the engagement of the broader research community in Tier 2 model development.

In terms of specific applications, the exploration of the existing multispecies Flemish Cap model for the implementation of Tier 2 for the Flemish Cap is an obvious operational next step.

Finally, it is critical to highlight that any progress on Tier 2 development and implementation is conditional on the support provided by CPs. Current capacity does not exist within WG-ESA and SC to engage fully on Tier 2 development.

The Roadmap lays out the elements and structure required for the implementation of an Ecosystem Approach in NAFO. In terms of fisheries exploitation, the Roadmap looks at sustainability through a series of nested assessments focused on ecosystem (Tier 1), multispecies (Tier 2) and stock (Tier 3) levels. The goal is that by considering these assessments together, the tactical management measures ultimately put in place at the stock level will effectively be informed by and integrate the requirements for sustainability from all levels of ecological organization.

Within this context, Tier 2 assessments represent a bridge between the large-scale strategic ecosystem advice and the tactical advice at the stock level. The focus of the models used in Tier 2 assessments is to capture the key interactions affecting managed stocks, so that those interactions can be factored into the advice on sustainable exploitation rates. While many of these key interactions are expected to be trophic-related (e.g. predation, competition, food availability/limitations), these may also involve the effect of environmental drivers on the managed stocks (e.g. temperature and/or broader ocean climate effects, and climate change impacts).

In order to advance the development of models in support of Tier 2 assessments, SC made progress by a) defining the features required for Tier 2 models and identifying potential advice applications, b) making explicit the formal steps and operational requirements needed for Tier 2 model development, and c) examining ongoing modelling work that could support Tier 2 assessments.

This scoping and framing work was conducted through a dedicated discussion session within the 2021 WGESA meeting to which government scientists and academics not regularly involved in NAFO but involved in regionally relevant modelling and research were also invited. The results from this session informed the SC discussion on these matters.

Tier 2 models: features and applications

Given the type of focal interactions in Tier 2 models, and the potential need for using Tier 2 models to inform tactical advice in some cases (e.g. strong interactions among commercial stocks), these models need minimally to possess some basic features. These basic characteristics of Tier 2 models (without being overly prescriptive) are:

1) being time-dynamic, and including fishing as a driver;
2) incorporating only key interactions and drivers (e.g. Minimum-Realistic Models –MRM, Models of Intermediate Complexity for Ecosystem assessments –MICE); and
3) Being amenable to statistical model fitting evaluation, and/or robust simulation testing (depending on the purpose of application).

Other features, like spatially explicit dynamics, and/or age/size structure, may be needed for some applications, but not all Tier 2 models will necessarily have to consider these levels of complexity.

Since the tiered assessment structure within the Roadmap is aimed at defining sustainable catch levels, the most evident applications of Tier 2 models are those related to fisheries advice, such as the evaluation of trade-offs between fisheries, informing stock-assessment models (e.g. trends in natural mortality, consumption models for the estimation of predation mortality), and construction of ecosystem-informed Harvest Control Rules (HCRs). However, Tier 2 models can be equally relevant to address biodiversity advice, such as the evaluation of impacts on threatened species (e.g. through by-catch, but also through species interactions), and considering the role of Vulnerable Marine Ecosystems (VMEs) on stock/assemblage dynamics. Overall, Tier 2 models provide the platform for testing targeted hypotheses about ecosystem/multispecies functioning and dynamics.

Tier 2 models: developmental steps and operational requirements

The implementation of Tier 2 requires formalizing the way in which Tier 2 models are going to be developed. These models need to be examined within a formal process that can ensure that they are adequately aligned with the 3-tiered structure of assessments within the Roadmap, and that the models are fit for purpose within that structure.

In practice, the development of Tier 2 models has two distinct dimensions: one involves a science process that provides a scientifically defensible step-wise structure for model development, and the other identifying the logistical requirements for model construction and utilization.

The science process involves the development of the rationale (ecological case) to justify the need for the model, an iterative process to arrive at a suitable model structure for a specified use, and finally the generation of model outputs with a clearly defined role within the advice.

The logistical requirements distinguish between the needs of the initial model development, and the needs associated with the regular update and maintenance of the model. Both components require dedicated resources and capacity, but while initial model construction can be driven by a targeted project, the maintenance and update of the model requires sustained support over time that should be explicitly considered within the initial planning and developmental stage.

Another important element to consider is the requirement of a benchmark process to review and examine major model upgrades.

In terms of implementation, and considering limited SC capacity for model development, a process for triaging Tier 2 modelling needs is also required. A triage process would help to identify the cases where the need for Tier 2 modelling is more pressing.

Tier 2 models: Ongoing work and next steps

While the examination of ongoing work was not exhaustive, the results showed that there is a diversity of research initiatives that could support Tier 2 assessments. These projects are at different stages of development and cover a broad spectrum of cases. The methodologies being explored are similarly diverse. What is lacking at the moment is an organizational framework to foster a long-term engagement of interested experts from outside NAFO towards developing models that are aligned to and can support Tier 2 assessments.

Among the examples identified, the one that stands out for its level of development and potential for application in a Tier 2 context is the multispecies model for the Flemish Cap system. This model not only fulfills the requirements for a Tier 2 model, but its results have informed the 3M Cod benchmark process, and have also been explored in a Management Strategy Evaluation (MSE) context.

While the work by WGESA and SC has consolidated the concept of the Tier 2 assessment and what is required for Tier 2 model development, some important elements remain to be fully discussed and fleshed out. Among these, the triage procedure for identifying priorities for model development, and how to promote the engagement of the broader research community in Tier 2 model development, are reasonable next steps towards developing a strategy for a sustained implementation of Tier 2.

In terms of specific applications, the exploration of the existing Flemish Cap model for the implementation of Tier 2 for the Flemish Cap is also an obvious operational next step.

Finally, it is critical to highlight that any progress on Tier 2 development and implementation is conditional on the support provided by CPs. Current capacity within WGESA and SC is very limited, and has been dwindling in recent years. At present, there are no people available in the SC to fully engage on Tier 2 development, especially given the number of COM requests over the last few years.

v) Re-assess previously recommended VME closures 7a, 11a, 14a and 14b and Review NCEM, Chapter 2 (request #6)

The Commission requests that Scientific Council, in relation to VME analyses:

a. Conduct a re-assessment of its previously recommended closures of 7a, 11a, 14a and 14b, incorporating catch and effort data for fisheries of shrimp from 2020 and 2021 into the fishing impact assessments. This work is to be completed by the 2023 Scientific Council meeting.

b. Review the effectiveness of NAFO CEM, Chapter 2 from a scientific and technical perspective and report back to the WG-EAFFM. WG-EAFFM would subsequently in 2022 consider whether any modifications to this Chapter should be recommended.

Reassessment of closures 7a, 11a, 14a and 14b

Scientific Council responded:

The work to address this request is ongoing. Data preparations are underway, and analyses will be undertaken by SC in 2022 and 2023. Results are anticipated in 2023.

Given the ongoing and expected future demand of analyses like the one involved in this request, and to ensure SC can maintain effective quality control, transparency, ease of access and reproducibility of ecosystem-related assessment data sets and data products, **SC recommends:**

1. *Creating standardized data layers and products with supporting documentation (including metadata) for periodic reassessment purposes required to support the implementation of the NAFO Roadmap towards an Ecosystem Approach and to respond to requests from the Commission; and*
2. *Requesting the NAFO Secretariat to explore the feasibility of using GIS to manage, visualize and share those core data layers and derived products. This web-based application is intended for internal SC use only to preserve confidentiality and respect data ownership regulations from different Contracting Parties.*

Capacity currently exists for initial development of these standardized data layers but ongoing maintenance and support will require additional resources and capacity within the Secretariat.

The Commission has requested advice about the effects that closures adopted by the Commission in 2021 would have on the shrimp fishery. SC will address this request through the analysis of two complimentary datasets:

1. Yearly / Average effort (km/km^2/year) for longlines, groundfish trawls and shrimp trawls from all VMS tracks for the period 2010-2021 (split based on vessel information and reported catch)
2. Distribution of catch (unit to be determined) by fish species (including shrimp) from logbook-VMS combination derived trawl tracks starting from 2019 onwards, which have been linked to haul-by-haul catches in the logbook data.

Preparation of these data layers is underway. Their analysis will be undertaken by WGESA during its meeting in November 2022 and results presented to SC in June 2023 for consideration, and to produce the advice required for the reassessment of closures by the Commission at the 2023 Annual Meeting.

Over the years, WGESA has produced numerous summarised data products and GIS layers, both as results of specific analysis (e.g. VME polygons, VME biomass, VMS fishing effort, etc.) to address recurring requests for scientific advice. Many of these data sets and layers are used by SC in regular assessments and need to be updated or reproduced for new analyses as required.

The current practice for producing these layers and data products has proved inefficient. It depends on the regular attendance of specific individuals to the WGESA meetings where these analyses are conducted, and the recreation of data layers and products by different individuals has generated discrepancies in different versions of these products due to technical choices during their development. While these discrepancies have never impacted the outcomes of the analyses, nor affected the advice provided, they are detectable and highlight a weakness in the current practices that needs correcting.

Given the ongoing and expected future demand of analyses like the one involved in this request, and to ensure SC can maintain effective quality control, transparency, ease of access and reproducibility of ecosystem-related assessment data sets and data products, SC is moving towards adopting data standards for ecosystems analyses by:

1. Creating standardized data layers and products with supporting documentation (including metadata) for periodic reassessment purposes required to support the implementation of the NAFO Roadmap towards an Ecosystem Approach and to respond to requests from the Commission; and

2. Request the NAFO Secretariat to explore the feasibility of using GIS to manage, visualize and share those core data layers and derived products. This web-based application is intended for internal SC use only to preserve confidentiality and respect data ownership regulations from different Contracting Parties.

Capacity currently exists for initial development of these standardized data layers but ongoing maintenance and support will require additional resources and capacity within the Secretariat.

Review of NAFO CEM Chapter 2

Scientific Council responded:

Scientific Council discussed the effectiveness of NAFO CEM, Chapter 2 from a scientific and technical perspective

The primary issue related to the content of Articles 21 and 22 concerning potential effect any change in the fishing footprint would have on the provisions in case of VME encounters, specifically a need to re-evaluate the encounter thresholds. Furthermore, under Article 23 (re-assessment of bottom fishing activities) the text does not fully reflect the current process to assess the risk of SAI.

SC discussed the effectiveness of NAFO CEM, Chapter 2 based on the results of the review from WG-ESA.

After reviewing Chapter II, SC considered that Article 15 (definitions), Article 16 (map of the footprint), Article 17 (area restrictions), Article 18 (exploratory bottom fishing activities) may benefit from additional clarity to reflect the current practices related to the assessment of bottom fishing activities with respect to the risks of SAIs on VMEs.

SC had more substantive discussions in relation to the content of Article 21 (evaluation of exploratory bottom fishing activities), Article 22 (provisions in case of encounters) and Article 23 (re-assessment of bottom fishing activities) . The primary issue discussed was the potential effect any change in the fishing footprint would have on the provisions in case of VME encounters, specifically a need to re-evaluate the encounter thresholds. Furthermore, under Article 23 (re-assessment of bottom fishing activities) the text does not fully reflect the current process to assess the risk of SAI.

vi) Continue progression on the review of the NAFO Precautionary Approach (request #7, Commission priority)

The Commission requests Scientific Council to continue progression on the review of the NAFO PA Framework in accordance to the PAF review work plan approved in 2020 (NAFO COM-SC Doc. 20-04).

Scientific Council responded:

SC continued its work towards updating the NAFO Precautionary Approach (PA) framework. Progress was made by identifying the general conditions for when/if reference points should be re-evaluated, as well as on the structural aspects of the PA framework and the quantification of uncertainty and risk. SC **recommended** the *PA to have three zones (e.g. collapsed, cautious, and healthy zones) with associated reference points;* B_{lim} *based on unacceptable or irreversible outcomes, and* B_{target} *based on optimal yield objectives. Each zone would have associated management actions based on F reference points.* Additionally, SC **recommended** the *selection of an adaptable* F_{target} *based on approaches similar to* F_{eco} *(e.g. adjusting target F based on ecosystem conditions), as well as a "soft limit" for* B_{lim} *which would help to account for both, ecosystem considerations and a more stable estimation of uncertainties. Additionally, a soft limit for* B_{lim} *may serve as a point where a recovery plan should be implemented by managers to prevent reaching* B_{lim} *proper.*

The risk tolerances specified in the current NAFO PA framework and applied in the MSEs of NAFO stocks are generally consistent with the PA frameworks of other jurisdictions. However, unlike the NAFO PA, these tolerance levels are typically specified (i.e. they are not illustrative) to enable the proper provision of science advice. SC **recommends** the *updated PA framework to have clearly identified default probability levels to be used for advice unless otherwise specified.* Further on risk tolerances, **SC noted** that extreme probabilities (eg

5%, 95%) are difficult to estimate reliably, and RBMS should advise on whether more moderate probabilities (eg. 10%, 90%) should be considered in a revised framework.

Data-limited stock assessments may not support the information needed for precautionary status determination or catch advice, but data-limited management procedures can be evaluated to quantify risk for meeting management objectives using MSE or other suitable simulation approaches.

The PA framework provides the general tools and boundaries to determine stock status and guide the provision of catch advice. Those stocks managed with MSE may not require the estimation of all reference points, but performance metrics and objectives used in MSE development need to be consistent with the PA. Equally important, the procedures used for data limited stocks would also need to be consistent with the PA.

SC also discussed and **agreed** on the upcoming Scientists and Managers Precautionary Approach Workshop 15-16 August 2022 tentative agenda.

ToRs 1a and 1c related to mapping objectives have been completed by PA-WG and presented to SC and RBMS in 2021 (SCS Doc. 22/02). WG-RBMS shares the interpretation that the SC/PA-WG has made of how to implement the General Objectives of the NAFO Convention (NAFO GC Doc. 07-04) within the PAF and its preliminary conclusions and recommends the work to continue according to the schedule approved last year.

This year, a progress report was presented (NAFO SCS Doc. 22/15) with the progress made in the revision of the NAFO PA framework related to ToRs related with the conditions for when/if reference points should change and/or be re-evaluated (1g) and with the structural aspects and quantification of uncertainty and risk (1b, 1d, 1e and 1f).

In relation with the conditions for when/if reference points should change and/or be re-evaluated (1g) the SC/PA-WG recommended last September that there are three general conditions for re-evaluating reference points:

1. The decision to estimate either MSY reference points or proxies should be reconsidered when the content and quality of information substantially changes.
2. Reference points should be re-evaluated when there is strong evidence of a shift in productivity regime, the mechanism of the shift is understood, the current productivity has persisted, the current productivity is expected to continue, the stock would be viable if managed with the revised reference points, and there is sufficient information to estimate revised reference points. Evidence that current reference points are unsustainable is sufficient to revise reference points. Operational stock assessments should routinely test for a shift back to greater productivity.
3. Reference points can be revised when new information indicates that management procedures based on current reference points do not perform well for meeting the objectives and principles of the NAFO convention, or alternative management procedures based on new reference points are expected to perform better for meeting the objectives.

In relation to the structural aspects and quantification of uncertainty and risk (1b, 1d, 1e and 1f) the PA-WG presented to the SC its main conclusions and recommendations, which are contained in SCS 22/15. Different PA frameworks from different organizations and jurisdictions (USA, Canada, ICES, New Zealand, Australia and Tuna RFMOs) have been analyzed to address these terms of reference.

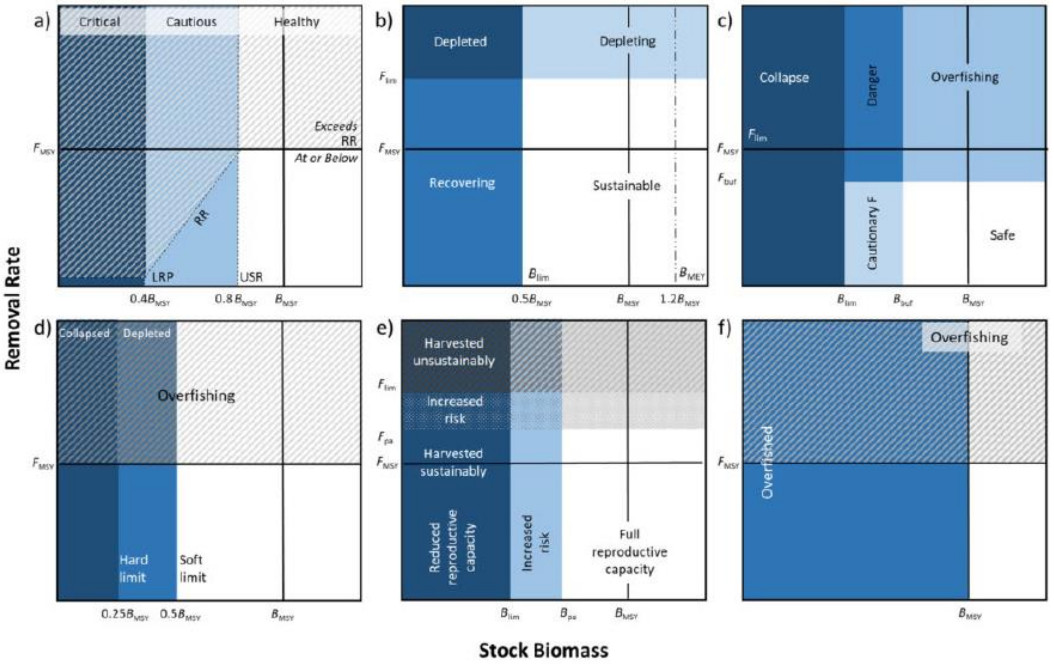


Figure vi.1. Stock status categories used in precautionary or risk-based fisheries management frameworks for a) Canada, b) Australia, c) NAFO, d) New Zealand, e) ICES, and f) a generalized Kobe plot used in many international contexts. Placement of each jurisdiction's reference points and labels relative to either F_{MSY} or B_{MSY} (including provisional or default values, where given) are specified. Provisional default values for Canadian reference points (LRP as 0.4 B_{MSY}, USR as 0.8 B_{MSY}, and three-part RR declining linearly from F_{MSY}) are presented in panel a) Other jurisdictions also specify default values of reference points (e.g., a B_{lim} of 0.5 B_{MSY} (or 0.2 B_0); Australia, New Zealand and B_{MSY} of the generalized Kobe plot). From Marentette et al 2021.

The PA-WG recommendations related to structural aspects from other PA systems were the following (SCS Doc. 22/15):

Reference points and definition of biomass zones are similar among PA frameworks:

- Collapsed zone:

  $B <= B_{lim}$ based on unacceptable or irreversible outcomes

  F_{MSY} triggers management for reduction in F to rebuild stock

- Cautious zone:

  $B_{lim} < B < B_{target}$

  Management based on low risk of $B <= B_{lim}$ or $F > F_{lim}$ for rebuilding toward B_{target}

- Healthy zone:

  $B \sim B_{target}$ based on optimal yield objectives

  Management based on low risk of overfishing ($F_{target} < F_{lim}$) or maintaining biomass above a precautionary threshold

SC discussed the possibility of including F_{eco} as a candidate for F_{target}. Based on the uncertainty of F_{MSY} and/or depending on the situation of the general ecosystem, higher when ecosystem is more productive, lower when it is not.

The possibility of establishing a biomass reference point (soft limits) greater than B_{lim} could be justified with ecological reasons and could help to implement recovery plans.

The PA-WG recommendations related to quantification of uncertainty and risk were the following:

The NAFO precautionary framework should be implemented using information from stock assessments (e.g., estimation error and stochastic projection), and MSE could be developed for a subset of NAFO managed stocks to test performance of a more general precautionary framework. Development of MSE for this purpose is beyond the scope and schedule of the current PA-WG terms of reference.

The risk tolerances specified in the current NAFO precautionary approach framework (20% probability of $F> F_{lim}$, 5-10% probability of $B< B_{lim}$) and applied in MSE of NAFO stocks (e.g., 30% probability of $F> F_{MSY}$ in the MSE for 3M cod) are generally consistent with other precautionary approach systems in which risk tolerance varies in association to the reference point it is associated with (e.g., lower risk of irreversible harm than suboptimal outcomes). However, extreme probabilities (e.g., 5%, 95%) are relatively difficult to estimate, and more moderate probabilities (e.g., 10%, 90%) are commonly applied in stock assessment. The Joint Commission-Scientific Council Working Group on Risk-Based Management Strategies would be the appropriate group to confirm or revise these risk tolerances.

Data-limited stock assessments may not support the information needed for precautionary status determination or catch advice, but data-limited management procedures can be evaluated to quantify risk for meeting management objectives using MSE.

SC discussed and approved the Scientists and Managers Precautionary Approach Workshop 15-16 August 2022 tentative agenda:

Agenda

Day 1 – Morning (9:00-12:00)

1. Opening, introductions, and approval of the agenda
2. Summary of recommendations
3. Key decisions and alternative PA structures to make to update the NAFO PA

Day 1 – afternoon (13:00-17:00)

4. Discussion Session on PA structure and key decision
5. Time to Delegations to study the proposals

Day 2 – morning (9:00-12:00)

1. Revision of decisions and consensus PA structure

Day 2 -afternoon (13:00-17:00)

2. Drafting of summary PA framework conclusions
3. Next steps
4. Other matters
5. Drafting Workshop conclusions and Closing of the workshop

vii) Continue to develop a 3-5 year work plan (request #8)

The Commission requests Scientific Council to continue to develop a 3-5 year work plan, which reflects requests arising from the 2021 Annual Meeting, other multi-year stock assessments and other scientific inquiries already planned for the near future. The work plan should identify what resources *are necessary to successfully address these issues, gaps in current resources to meet those needs and proposed prioritization by the Scientific Council of upcoming work based on those gaps.*

Scientific Council responded:

SC updated the 2022-2023 annual plan and identified resource gaps and priorities.

The plan includes annual requests from the Commission, including stock assessments and other scientific inquiries (e.g. from specific contracting parties for straddling stocks). The plan also includes work to address SC advice of its own accord.

SC noted that because there is no dedicated NAFO funding source for scientific research, the activities are subject to Contracting Party allocations that may not be stable/guaranteed. SC work falls to a small number of scientists who are over-burdened with requests, and the situation is unsustainable.

For example, there is a particularly important deficit in expertise to support Roadmap work, and therefore SC has created two additional ecosystem level designated expert positions. The positions remain vacant and SC requests help in filling these positions specifically and augmenting ecosystem expertise more generally.

SC emphasized the importance of stability in the work plan, i.e. that new requests should be clearly justified as they will have impact on delivering existing work plan items.

SC aims to update and review the plan each June and September to include all requests with prioritization and rationale where appropriate as well as the resources required to respond to the requests.

While this plan will be reviewed and updated twice a year, SC emphasized the importance of stability in the work plan, i.e. that new requests should be clearly justified as they will have impact on delivering existing work plan items.

The work plan was requested by the Commission in response to Scientific Council concerns over increased workload in recent years. SC identified an increase in requests as well as an increased number of SC and WG meetings in recent years. These increased demands combined with a decrease in numbers of scientists participating has made it difficult to fully address all requests over the year. It was also noted that the requests in recent years are not only more numerous but more complex and with increased scope.

It was also noted that a work plan would facilitate a more concrete discussion of trade-offs between effort dedicated to scientific activities, including addressing new versus the current/strategic requests. This rarely happens because the work falls to a small number of scientists who are over-burdened with recurring requests, often pressured to deliver, and therefore are incapable of delivering on new, strategic requests. This is in addition to other daily work they do unconnected to NAFO.

The 3-5 year workplan is not detailed - detailed plans are developed in working group specific work plans. The current approach will be to have a 5-year plan that allows for a high-level view of activities planned for the next 5 years, with annual plans in which resource gaps and priorities will be addressed.

The plan includes requests from the Commission from the annual meeting, including stock assessments and other scientific inquiries (e.g. requests from coastal states). The plan also includes requests SC has made of its own accord.

SC noted that where there is no dedicated NAFO funding source for scientific research, the activities are subject to Contracting Party allocations that may not be stable/guaranteed.

For example, there is a particularly important gap in expertise to support Roadmap work and therefore in an attempt to address this gap, SC has created two additional ecosystem level designated expert positions as a first step towards addressing this gap. The positions remain vacant and SC requests help in filling these positions specifically and augmenting ecosystem expertise more generally.

viii) Full assessment for Div. 3LN redfish (request #9)

> *The Commission requests that Scientific Council do a full assessment for Div. 3LN redfish and provide advice based on the projection for various harvest levels for two-years (2023 and 2024) to evaluate the impacts according to the performance statistics from NAFO CEM Annex I.H.*

The full assessment is included in section 1a above.

ix) Presentation of the stock assessment and the scientific advice of Cod 2J3KL (Canada), Witch 2J3KL (Canada) and Pelagic Sebastes mentella (ICES Divisions V, XII and XIV; NAFO 1) (request #10)

> *The Commission requests that any new results from stock assessments and the scientific advice of Cod 2J3KL (Canada), Witch 2J3KL (Canada) and Pelagic Sebastes mentella (ICES Divisions V, XII and XIV; NAFO 1) to be presented to the Scientific Council and request the Scientific Council to prepare a summary of these assessments to be included in its annual report.*

Update on Cod in Divs. 2J3KL (Canada)

The results of the most recent stock assessments and scientific advice of Atlantic cod (Gadus morhua) ("Northern cod," NAFO Divs. 2J3KL) was presented to Scientific Council (SC). The summary is as follows:

The Atlantic cod stock on the Newfoundland and Labrador continental shelf in NAFO Divs. 2J3KL is typically assessed annually by Fisheries and Oceans Canada using an age-structured state-space model (Northern Cod Assessment Model, NCAM; Cadigan, 2015, 2016). A conservation limit reference point (LRP) was established for Northern cod in 2010 (DFO, 2010), re-evaluated in 2019 (DFO, 2019), and is defined as the average spawning stock biomass (SSB) during the 1980s. This reference point is the stock level below which serious harm is occurring and the ability to produce good recruitment is impaired. This reference point also defines the boundary between the critical and cautious zones within Fishery and Oceans Canada's (DFO) Precautionary Approach (PA) framework (DFO, 2009).

Mechanical issues with research vessels and, to a lesser extent, weather conditions, impacted completion of the 2021 fall science surveys in NAFO Divisions 2J3KL. The reduced surveys have resulted in data gaps for 2021 and as a result, the 2J3KL Northern cod stock assessment, scheduled for March 2022, was cancelled.

It was decided to use the information and one year projection from the 2021 assessment, which determined that the stock remains in the critical zone with the SSB estimated at 411,000t (approximately 52 per cent of the LRP, 95% CI = 307-549 Kt). SSB has remained relatively stable since 2017 and projections from the Northern Cod Assessment Model (NCAM) suggest a 52 to 59 per cent chance of growth from 2021 to 2022 across a range of catch scenarios (0t to 15,360t). Under the status quo catch (catch of 11,816t) scenario, the stock is projected to be at 53 per cent of the LRP in 2022 (Figure ix. 1).

Annual average removals from the commercial (stewardship) fishery were approximately 11,000 t over 2016-2019 and removals from recreational catches were about 2000 t (estimated from tagging data) over the same time period. The fishing mortality rate associated with recent levels of catch is low at 0.018 with an average of 0.02 over the last 10 years (Figure ix. 2). Estimates of natural mortality are higher with recent estimates at a rate of 0.51, with an average rate of 0.39 over the last 10 years. These results indicate that natural mortality is the key factor limiting growth in recent years. Moreover, estimates from NCAM suggest that natural mortality contributed to the collapse of the stock (Figure ix. 2).

The collapse of the stock in the 1990s was not an isolated event; it was part of an ecosystem regime shift which included the collapse of the broader groundfish community and a key forage fish like capelin. Even with the increases in shellfish that also occurred during this period, total ecosystem biomass never rebuilt to pre-collapse levels. Consistent signals of rebuilding of the groundfish community appeared in the mid-late 2000s, including Northern cod, and this coincided with modest improvements in capelin, and the beginning of the shellfish decline. The conditions that led to the build-up of the groundfish community in the mid-late 2000s appear to have eroded, and this could be linked to simultaneous reductions in capelin and shrimp availability. Current ecosystem conditions remain indicative of an overall lower productivity state, with reduced total ecosystem biomass and low capelin levels.

Within this ecosystem context, studies focused on the dynamics of Northern cod have indicated that fishing and capelin availability are significant drivers of the stock, while predation by harp seals is not (Buren et al., 2014).

Furthermore, the significance of these drivers is not exclusive to Northern cod; differences in fishing pressure and prey availability underpin the drastically different stock trajectories of Northern cod and Barents Sea cod (Koen-Alonso et al., 2021). Starvation mortality emerges as an important component of Northern cod natural mortality as the values estimated by NCAM is associated with changes in cod body condition and capelin availability (Regular et al., 2022). These findings support the idea that prey availability was a contributing factor to the collapse of the stock in the early 1990s and, subsequently, has limited its recovery. Given the forecasted levels of capelin for the next two years (DFO, 2022), the prospects for cod stock growth appear limited.

Consistency with the Fisheries and Oceans Canada decision-making framework incorporating the precautionary approach requires that removals from all sources must be kept at the lowest possible level until the stock clears the critical zone.

SC comments: SC once again expressed concern about high levels of natural mortality which was discussed in plenary and asked that future scientific work in this area be included in any updates. Additionally, high levels of catch continue to be of concern to SC in light of the advice for catches at the lowest possible levels.

SC endorsed the conclusions of both the assessment results and advice.

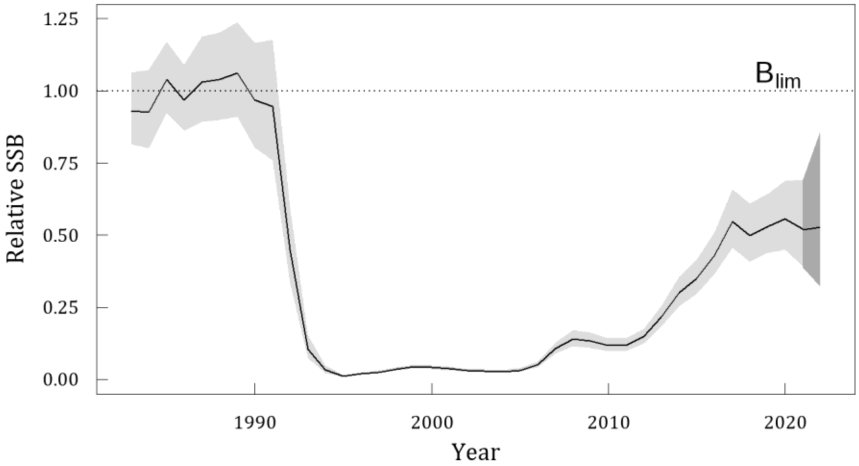


Figure ix.1. Trend in relative SSB (SSB/ B_{lim}) with one year projection (to 2022) of Northern cod SSB under status quo NCAM-predicted catch levels (11 816 t). The horizontal dashed line represents B_{lim}, which is defined as the average SSB during the 1980s. Model estimates are shown using the solid line and the grey envelopes show the 95% confidence intervals. The dark grey envelope are 95% confidence intervals for the projection period.

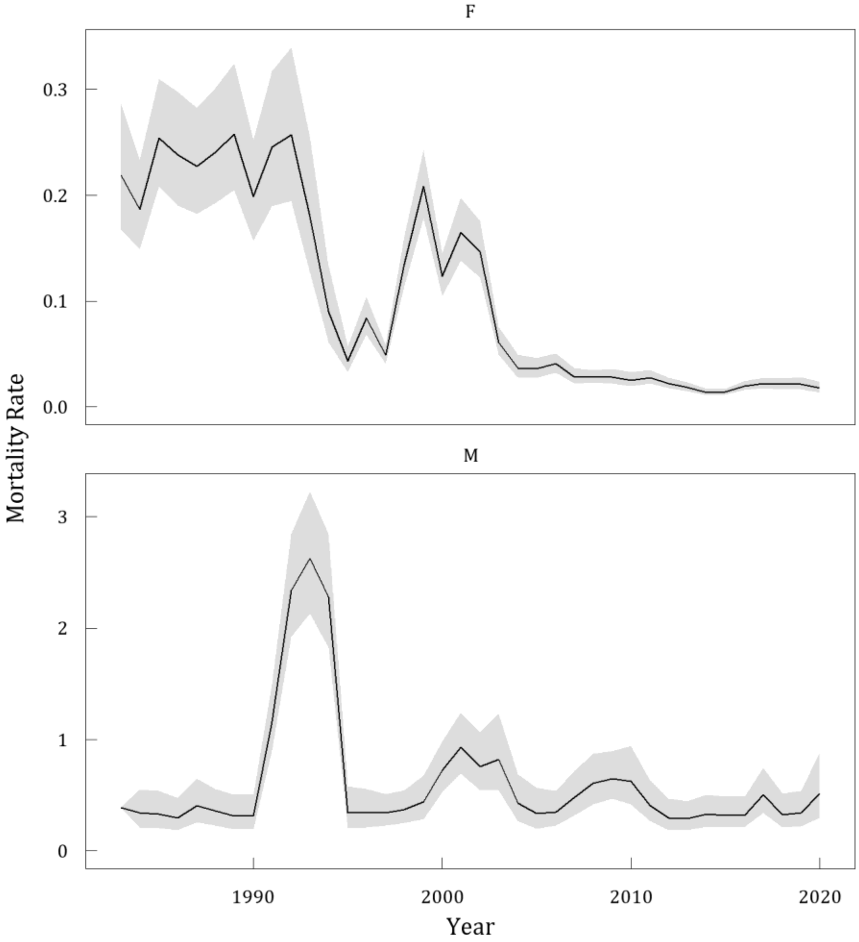


Figure ix.2. Rates of fishing (F) and natural (M) mortality estimated by NCAM from 1983 to 2020. Notice different scales of the y-axes in each plot.

References

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10. The COM request that the results of the stock assessment and the scientific advice of Cod 2J3KL (Canada), Witch 2J3KL (Canada) and Pelagic Sebastes mentella (ICES Divisions V, XII and XIV; NAFO 1) to be presented to the Scientific Council (SC), and request the SC to prepare a summary of these assessments to be included in its annual report.

Update on Witch Founder in NAFO Divs. 2J3KL(Canada)

The results of the most recent stock assessment and advice of Witch Flounder (*Glyptocephalus cynoglossus*) in Div. 2J3KL was presented to SC. The summary is as follows:

The last assessment of Witch Flounder in NAFO Divs. 2J3KL was completed by Fisheries and Oceans Canada (DFO) in May, 2022. The assessment of this stock is based on indices from Canadian-autumn RV surveys of NAFO Div. 2J3KL, and commercial catch (by-catch) data. The survey in 2021 was incomplete, therefore stock status in that year cannot be determined.

A moratorium on directed fishing has been in place in Canadian waters since 1995, and in the NAFO regulatory area since 1998. Bycatch of Witch Flounder averaged 134 t annually from 2017-21 (Figure ix.3), and is primarily taken in the Canadian Greenland Halibut fishery. A survey-based proxy indicates fishing mortality has remained low since the mid-2000s (Figure ix.4).

The stock continues to show signs of rebuilding, with indices of biomass, abundance, and spatial distribution increasing since the early 2000s, and the four highest values in the pre-recruit index series (1995 to 2020) occurring since 2013 (Figure ix.5).

A biomass Limit Reference Point (LRP) within the Canadian PA framework is set at B_{lim} = 0.4 B_{MSY} -proxy, where the B_{MSY} -proxy is the average survey biomass of years 1983-1984 (DFO 2019). B_{2020} was below the LRP with an 89% probability (Figure ix.6), and the stock is in the Critical Zone of the Canadian Precautionary Approach framework. Stock status in 2021 cannot be determined as the survey in that year was incomplete. Consistency with the DFO decision-making framework incorporating the precautionary approach requires that removals from all sources must be kept at the lowest possible level until the stock clears the critical zone.

SC comments

SC endorsed *the conclusions of both the assessment results and advice.* ***SC noted*** that a Limit Reference Point is also defined under the NAFO PA framework with B_{lim} = 0.3 B_{MSY} -proxy at the average survey biomass of years 1983-1984 (SCS Docs. 18/19, 19/22, SCR Doc. 18/50). **SC noted** that under the NAFO PA framework, this stock has a risk >10% of being below B_{lim}.

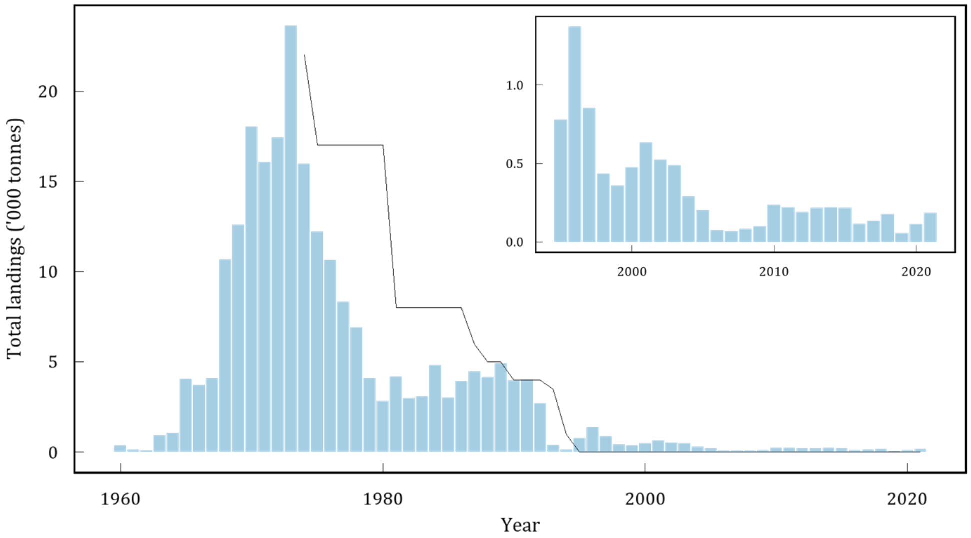

Figure ix.3. Landings (1963-2019, line) and TAC (points) for Witch Flounder in Div. 2J3KL. The inset shows the period since 1995.

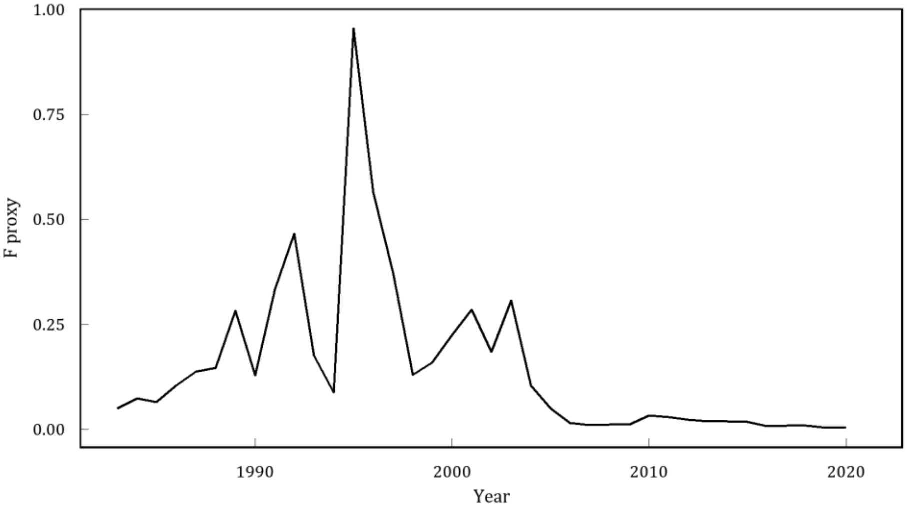

Figure ix.4. Proxy for fishing mortality (F proxy) calculated based on the ratio of catch to an index of exploitable (30cm+) survey biomass.

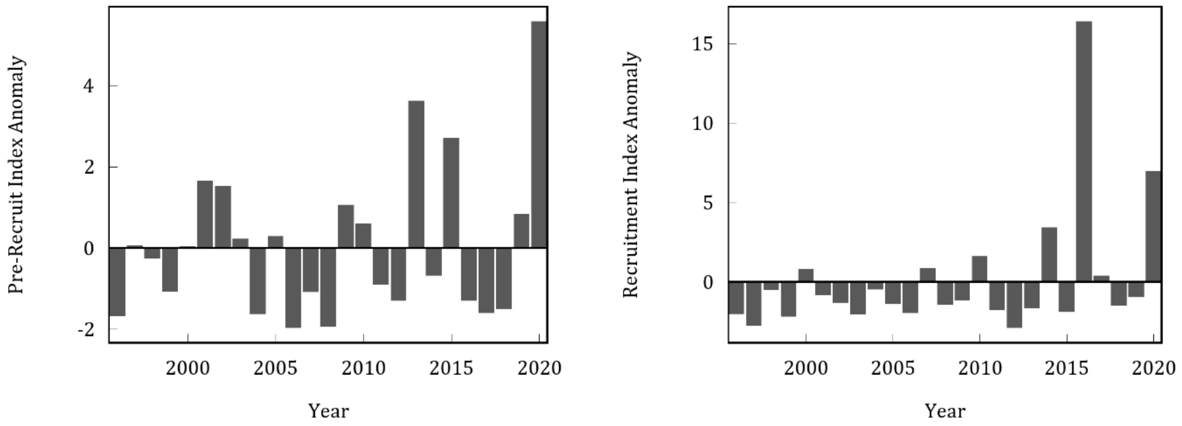

Figure ix.5. Pre-recruit (9-17cm] and recruitment (17-26cm] index anomalies for Witch Flounder in NAFO Div. 2J3KL (1995 to 2020).

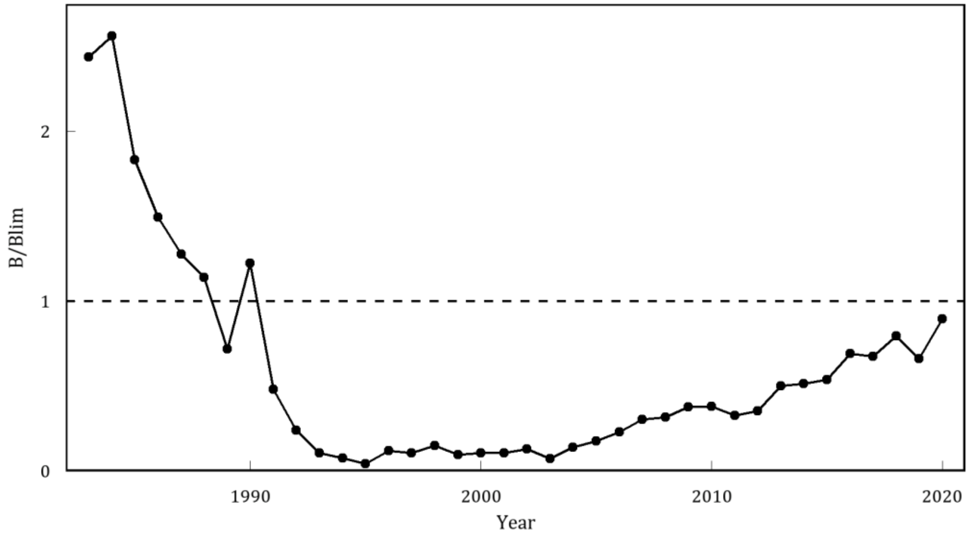

Figure ix.6. Relative survey biomass (B/ B_{lim}) for Witch Flounder in Div. 2J3KL (1983-2020). Horizontal line indicates B= B_{lim} (40% B_{MSY} proxy) under the Canadian PA framework.

Update on Pelagic *Sebastes mentella* in ICES Divisions V, XII and XIV and NAFO Subareas 1-2

The results of the most recent stock assessments and scientific advice of pelagic redfish (*Sebastes mentella*) in ICES Divisions V, XII and XIV and NAFO Subarea 1 were presented to Scientific Council. The summary is as follows:

ICES considers that there are two pelagic stocks of the species in the Irminger Sea and adjacent waters:

- a Shallow Pelagic stock (NAFO 1-2, ICES 5, 12, 14, <500 m)
- a Deep Pelagic stock (NAFO 1-2, ICES 5, 12, 14, >500 m)

The decision to classify pelagic redfish as two stocks was not unanimous in ICES. Russia's position regarding the structure of the redfish stock in the Irminger Sea and adjacent waters is that there is a single stock of pelagic *Sebastes mentella* in that area.

The last ICES assessment of the two stocks ("Shallow Pelagic" and "Deep Pelagic" stocks) was in 2021. The stock relevant to NAFO is the shallower stock since is the one that extents more to the NAFO areas, catches of the Deep Pelagic stock are scarce or null in NAFO areas (Figure ix.7)

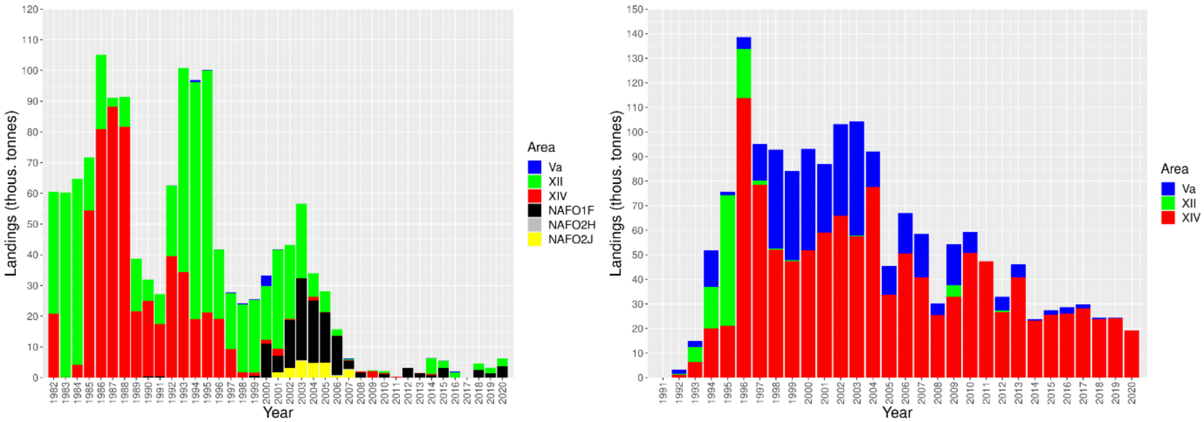

Figure ix.7. Catches of shallow pelagic stock (left panel) and deep pelagic stock (right panel) by area.

Acoustic surveys are conducted on pelagic redfish in the Irminger Sea and adjacent waters. An international trawl-acoustic survey (conducted by Iceland, Germany and Russia with Norway participating also in 2001) was carried out biennially 1999 – 2015 but since then triennially. The next survey is planned for 2024. The international trawl-acoustic redfish survey for the deep pelagic beaked redfish in the Irminger Sea and adjacent waters has been conducted since 1999.

"Shallow pelagic" Stock Assessment

No analytical assessment is carried out due to data uncertainties and the lack of reliable age data. The assessment is based on survey indices, catches, CPUE and biological data.

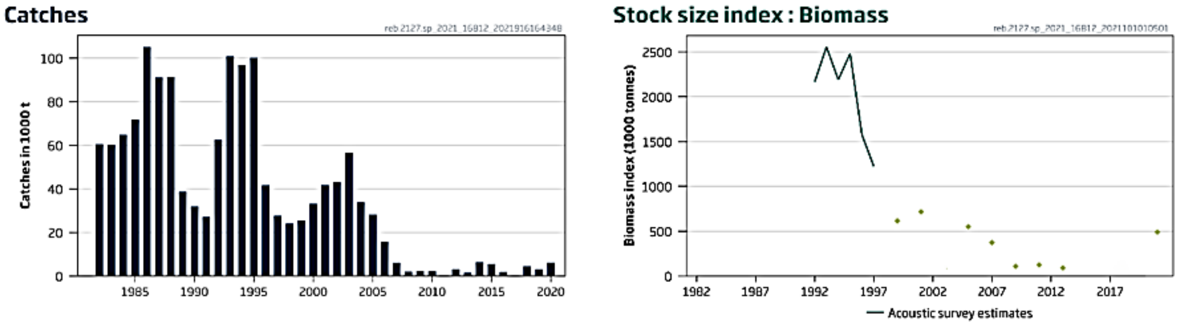

Figure ix.8. Beaked redfish in ICES Subareas 5, 12, and 14 and in NAFO Subareas 1 and 2 (shallow pelagic stock < 500 m). Left: Catch over time in thousand tonnes. Right: Stock size index (biomass) from the acoustic survey (in tonnes) in the Irminger Sea and adjacent waters. The line represents yearly values from 1991 to 1997 and points represent the international trawl-acoustic survey since 1999 (insufficient survey coverage between 2013 and 2021).

ICES cannot assess the stock and exploitation status relative to MSY and PA. The reference points are undefined; however, the stock is considered to be below any potential reference point.

ICES has advised that when the precautionary approach is applied, there should be zero catch in each of the years 2022, 2023, and 2024.

"Deep pelagic" Stock Assessment

The ICES assessment uses a length-structured model (Gadget).

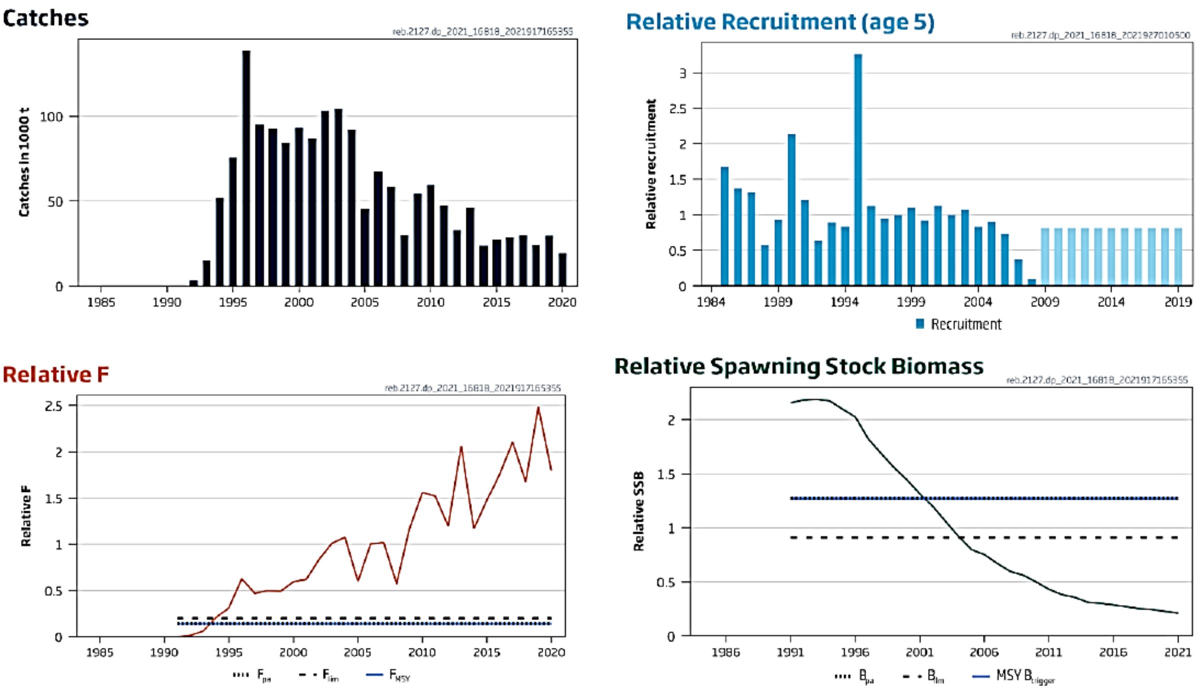

Figure ix.9. Beaked redfish in ICES subareas 5, 12, and 14 and in NAFO Subareas 1 and 2 (deep pelagic stock > 500 m). Top left: Catches (thousand tonnes). Top right: Relative recruitment (R) at age 5. Relative recruitment since 2009 is assumed to be at the geometric mean of 1985–2008 and is shown in pale blue. Bottom left: Relative fishing mortality (F). Bottom right: Relative spawning-stock biomass (SSB). R, F, and SSB are expressed relative to the average of the time-series (1985–2019 for R, 1991–2020 for F, and 1991–2021 for SSB).

Fishing pressure on the stock is above F_{MSY}, F_{pa}, and F_{lim}; spawning-stock size is below MSY $B_{trigger}$, B_{pa}, and B_{lim}.

ICES has advised that when the MSY approach is applied, there should be zero catch in each of the years 2022, 2023, and 2024.

ICES comments relating to both "shallow" and "deep" pelagic stocks

The total catches by all countries fishing for pelagic redfish have considerably exceeded the sum of ICES advised catch for both shallow pelagic and deep pelagic redfish stocks. This is particularly true since 2017, when the advice was for zero catch for both stocks.

In recent years ICES has not obtained catch estimates disaggregated by depth from all countries. ICES recommends that all countries should report depth information on a haul basis, in accordance with the NEAFC logbook format. Action is needed through NEAFC and NAFO to provide ICES with timely and complete information that may lead to more reliable catch statistics.

SC Comments

Scientific Council **endorsed** the conclusions of both the ICES assessment results and its advice.

SC is concerned with the level of catches of both stocks when the ICES advice has been 0 catches since 2017.

SC encourages a genetic analysis over the north Atlantic to study the relationship between all redfish stocks/management units (particularly NAFO and NEAFC stocks/management units).

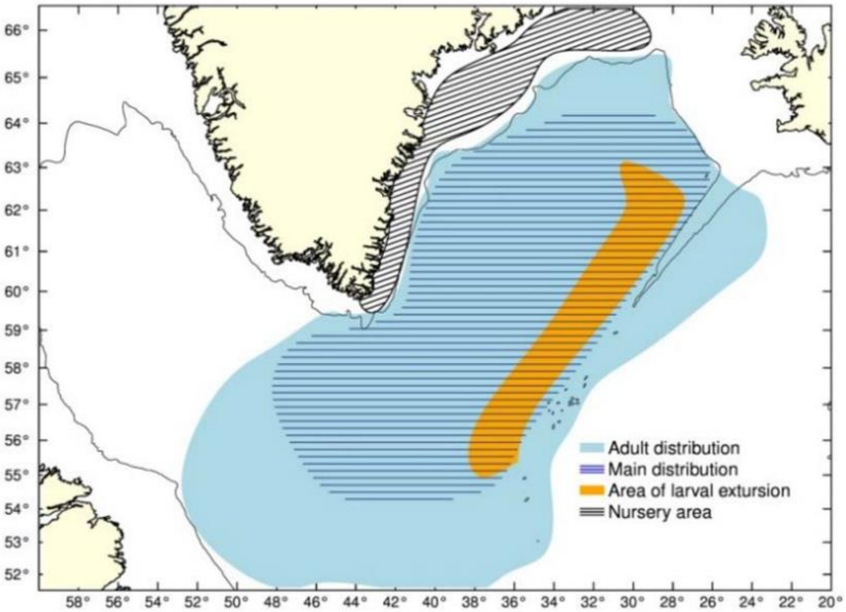

Figure ix.10. Distribution of both pelagic redfish stocks (shallow and deep) in the Irminger Sea and adjacent waters at different stages of the life cycle.

NAFO SC and Secretariat discussed the comment about catch information made by ICES in relation to NAFO. Both clarified that NAFO Secretariat only received catch information through the submission of the STATLANT 21 by Contracting Parties and SC **recommends** that *information about catches and any biological sampling, in NAFO areas, should be uploaded by CPs to the ICES databases in time for use in the assessments. ICES databases should be prepared to allow data from these areas to be uploaded.*

SC was informed that the next acoustic survey is scheduled for 2024. ICES advice was given for 2022-2024. Most likely, the next ICES full assessment of these stocks will be at the end of 2024. Therefore, it is not expected that SC will receive updated information until June 2025.

References and source of information

DFO. 2019. Stock Assessment of Witch Flounder (*Glyptocephalus cynoglossus*) in NAFO Divisions 2J3KL. DFO Can. Sci. Advis. Sec. Sci. Advis. Rep. 2018/053

ICES. 2021. Northwestern Working Group (NWWG). ICES Scientific Reports, 3:52. 556 pp. https://doi.org/10.17895/ices.pub.8186.

ICES. 2021. Beaked redfish (Sebastes mentella) in ICES subareas 5, 12, and 14 (Iceland and Faroes grounds, north of Azores, east of Greenland) and in NAFO subareas 1 and 2 (shallow pelagic stock < 500 m). In Report of the ICES Advisory Committee, 2021. ICES Advice 2021, reb.2127.sp. https://doi.org/10.17895/ices.advice.7839.

ICES. 2021. Beaked redfish (Sebastes mentella) in ICES subareas 5, 12, and 14 (Iceland and Faroes grounds, north of Azores, east of Greenland) and in NAFO subareas 1 and 2 (deep pelagic stock > 500 m). In Report of the ICES Advisory Committee, 2021. ICES Advice 2021, reb.2127.dp. https://doi.org/10.17895/ices.advice.7838.

Stock Annexes:

https://www.ices.dk/sites/pub/Publication%20Reports/Stock%20Annexes/2015/smn-sp_SA.pdf

https://www.ices.dk/sites/pub/Publication%20Reports/Stock%20Annexes/2015/smn-dp_SA.pdf

x) Ongoing analysis of the Flemish Cap cod fishery (request #11)

The Commission requests Scientific Council, jointly with the Secretariat, to conduct ongoing analysis of the Flemish Cap cod fishery data by 2022 in order to:

a. monitor the consequences of the management decisions (including the analysis of the redistribution of the fishing effort along the year and its potential effects on ecosystems, the variation of the cod catch composition in lengths/ages, and the bycatch levels of other fish species, benthos in general, and VME taxa in particular), and
b. carry out any additional monitoring that would be required, including Div. 3M cod caught as bycatch in other fisheries during the closed period.

Scientific Council responded:

The SC postpones the analysis of the Flemish Cap cod fishery data until two years of logbook data are available following the implementation of the management measures, and proposes monitoring the consequences of management decisions every two years afterward, if required.

The logbook data is the only haul by haul data available at this time to carry out the requested analysis. Problems were detected in the logbook data that have made it impossible to perform an analysis of the impact of the management measures adopted by the Commission in 2020. Additionally, the management measures have only been in force since the beginning of 2021, which means that only one year of data is available to analyze the effects of these measures. Furthermore, data from that year correspond to a very small TAC, making the analysis uninformative at this stage.

Therefore, the SC has decided to postpone the analysis until two years of data are available to allow a better analysis of the impact of the implementation of the management measures. In the meantime, the intention is to address the problems with the logbook data.

The SC has discussed the analyses needed to monitor the consequences of the management decisions, and proposes to monitor these measures every 2 years if required.

The SC notes the difficulty of monitoring the bycatch levels of benthos in general, and VME taxa in particular, with logbook data due to the lack of bycatch data of these species.

xi) With other international organizations, such as the FAO and ICES, inform the Scientific Council's work related to the potential impact of activities other than fishing in the Convention Area (request #12)

The Commission requests Secretariat and the Scientific Council with other international organizations, such as the FAO and ICES to inform the Scientific Council's work related to the potential impact of activities other than fishing in the Convention Area. This would be conditional on CPs providing appropriate additional expertise to Scientific Council.

Scientific Council responded:

SC reiterates its prior advice that there are a number of activities occurring in the NRA (especially oil and gas) which appear to have significant spatial overlap with NAFO bottom fisheries, NAFO closures and VMEs, and have the potential to impact fisheries resources and the ecosystem. These activities have increased in recent years.

Information on "activities other than fishing" (e.g. trends, spatial location, overlapping with fisheries, VMEs and closed areas, and potential impacts) will continue to be included in the Ecosystem Summary Sheets.

Geographical location of oil and gas activities in the NRA is publicly available from several sources. Conversely, information on the assessment of potential impacts of such activities, as well as mitigation measures, is scarce or difficult to obtain.

SC also notes that current expertise, within SC WG-ESA in particular, and SC in general, is insufficient to allow SC to fully assess the long-term impacts of these activities on fisheries resources, VMEs and the wider marine ecosystem.

SC requests access to the data and analysis from monitoring programs of oil and gas activities from Contracting Parties.

SC also reiterates that CPs provide expertise in evaluation of marine environmental impacts of activities other than fishing (eg. oil and gas).

The information presented to the SC was obtained through a literature review (SCR Doc. 21/051)[1] of publicly available data sources[2], including a report (Equinor, 2020)[3] on a development project located in the Flemish pass ("Bay du Nord Development Project").

An updated map of the geographical location of oil and gas activities in NAFO Divs. 3LNM (Figure xi.1) was presented to the SC, showing the location of the proposed production installation (yellow star) within the "Bay du Nord Development Project" in the Flemish Pass (outlined in blue). Some of the exploration and proposed production activities related with this project, appear to have significant spatial overlap with NAFO bottom fisheries, NAFO closures and VMEs in Division 3L, and particularly in Division 3M.

Figure xi.1 shows the overlap between oil and gas activities and NAFO fisheries which indicates potential conflict (e.g. reduction of fishing opportunities), as well as between oil and gas activities and a large number of VME areas closed by NAFO (particularly 2 and 10 which already have wells drilled).

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[1] Durán Muñoz and M. Sacau (2021). Information on activities other tan fishing (offshore oil and gas) in the NAFO Convention Area: Implications for the development of the Ecosystem Summary Sheets (Divisions 3LNO and 3M). NAFOSCRDoc.21/051SerialNo.N195

[2] Available data was collected mainly from the Canada-Newfoundland and Labrador Offshore Petroleum Board (C-NLOPB) [https://home-cnlopb.hub.arcgis.com/] and the Impact Assessment Agency of Canada (IAAC).

[3] Equinor Canada Ltd. (2020). Bay du Nord Development Project – Environmental Impact Statement. Prepared by Wood Environment & Infrastructure Solutions and Stantec Consulting. St. John's, NL Canada. July 2020.

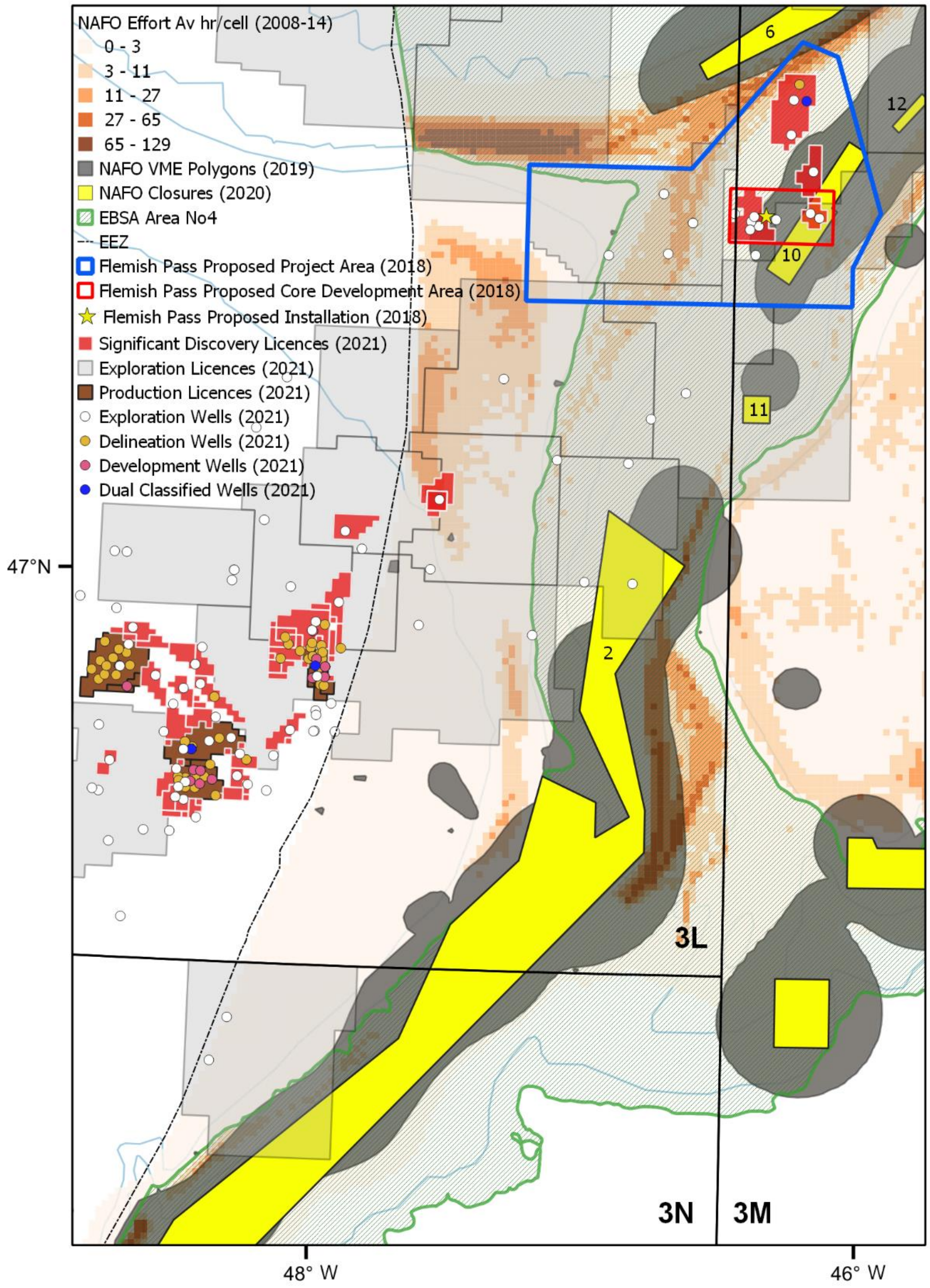

Figure xi.1. Updated map showing the geographical location of oil and gas activities in NAFO Divs. 3LNM. Available spatial information on oil and gas activities – at the reporting date, November 2021 – is noted in brackets (2021). Sources: NAFO, C-NLOPB and CBD.

In comparison with the information previously reported by WG-ESA (NAFO SCS Doc. 19/25), there are two new "exploration wells" in Division 3L, one of them located inside NAFO fishing grounds. The information assessed since 2018 indicates that offshore oil and gas activities in NAFO Divs. 3LM increased in recent years.

In general, data on geographical location of oil and gas activities is available in websites and project reports (including location and technical details of a development project in the Flemish Pass). In contrast, information on the adverse impacts of such activities (e.g. routine operations, accidental events, unauthorized discharges, exploratory drilling on VME closed areas, etc.), as well as details on mitigation measures, is scarce, less visible or difficult to obtain from such sources.

In 2019, information on oil and gas activities was included for the first time in the ecosystem summary sheet for Divs. 3LNO (NAFO SCS Doc. 19/25[4]). In 2021, the WGESA agreed that a similar exercise was needed for Division 3M, considering that, at present, most of the offshore oil and gas activities in NAFO Regulatory Area are located in Division 3M (see Figure xi.1). Some of these activities – particularly wells and licences – overlap fishing grounds, VME polygons (e.g. sponges, sea pens and black corals) and VME closures (e.g. Areas 6, 9, 10, 11 and 12).

SC noted that VMEs inside NAFO VME area closures or outside the NAFO footprint are currently protected against SAI from bottom fishing, but they are unprotected regarding potential threats from activities other than fishing (e.g. drilling activities inside VME closures in Divisions 3L and 3M). In recent years, oil and gas activities in VME closures have increased, which is of great concern. Moreover, there are other issues related with the use of the marine space e.g. potential conflicts between NAFO bottom fisheries and offshore oil and gas activities.

xii) Proceed with developing the ecosystem summary sheets for 3M and 3LNO and move toward undertaking a joint Workshop with ICES (request #13)

The Commission requests that Scientific Council proceed with developing the ecosystem summary sheets for 3M and 3LNO move toward undertaking a joint Workshop with ICES (International Council for the Exploration of the Sea) as part of a peer review of North Atlantic ecosystems.

Scientific Council responded:

SC noted that the request is a carryover from 2020.

SC has developed an action plan to move this work forward, but progress is effectively conditional on CPs providing the necessary support. This working plan includes:

Grand Bank (3LNO) EPU. The existing Ecosystem Summary Sheet (ESS) will be updated to the extent possible during the 2022 WGESA meeting, with a final review and formal approval by SC in June 2023.

Flemish Cap (3M) EPU. A draft ESS will be produced during the 2022 WGESA meeting, with an initial review and evaluation of progress by SC in June 2023. The extent of this progress will determine if a final ESS could be produced or if additional work is required.

Additional Data by CPs. ESSs may contain grey out items due to lack of data. In those cases where data may exist within CPs, **SC requests the Secretariat** to work with WG-ESA co-chairs to formalize the request of information to fill these gaps to extent possible.

Joint NAFO-ICES Workshop on Ecosystem Summaries. WGESA Co-chairs will re-establish contact with ICES about the possibility and potential scope for this workshop. Given current workload and capacity within SC, this workshop is not expected to take place until 2023 at the earliest. The renewed contact with ICES would be intended to keep the dialogue open on this matter, but without making concrete commitments.

SC considered that consolidating the creation and updating of ESSs would benefit from the creation of the Ecosystem-level Designated Expert (EDE) role, and created EDE positions for the Grand Bank (3LNO) and Flemish Cap (3M) EPUs. However, no experts were designated in these positions, which remain vacant as all members of SC stated they could not take on further workload. Experts to serve in these positions would need to be identified/nominated by SC and/or Contracting Parties (CPs), and formally designated by SC. CP support in the form of new positions and/or additional capacity would be required for making the new EDE roles operational.

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[4] Report of the 13th Meeting of the NAFO Scientific Council Working Group on Ecosystem Science and Assessment (WG-ESA). Northwest Atlantic Fisheries Organization. 17-26 November 2020, By WebEx. NAFO SCS Document 19/25.

This request is a carryover from 2020 (COM Request #18). SC had noted at that time that a near final version of the 3LNO Ecosystem Summary Sheet (ESS) was available in the June 2020 SC Report (SCS Doc. 20/14 Rev.), but it had not yet been formally approved as final by SC. Follow-ups on the status of this ESS were disrupted by the COVID-19 pandemic, and by the reduction in capacity and expertise within WGESA, which directly impacted the ESS work.

Initial conversations with ICES towards organizing a workshop to explore opportunities for collaboration on ecosystem summary sheets (NAFO) and ecosystem overviews (ICES) had been initiated in 2019, and the path tentatively identified for those collaborations was a joint in person meeting. The advent of the COVID-19 pandemic, the increasing workload within WGESA in 2020 related to the reassessment of Significant Adverse Impacts (SAIs) on Vulnerable Marine Ecosystems (VMEs), and the departure from NAFO of the scientist involved in planning this workshop resulted in this activity being put on hold. There is no question of the benefits of having this workshop, but given current workload and reduced capacity within WG-ESA and SC, there are real concerns of the ability of SC to carry out this work as initially intended.

Taking into account existing capacity limitations and currently expected workload within WGESA and SC, an action plan to address this request has been developed. Successfully completing this action plan remains conditional to CPs providing the support required to carry out the work, and assumes that no substantive additions to SC workload will occur. This action plan is as follows:

1. ***3LNO ESS***. Update as much as possible the existing 3LNO ESS, including at the very minimum the most updated survey information. This updated ESS will be compiled at the 2022 WG-ESA meeting and tabled at the 2023 SC June meeting for discussion and approval as a final version. This ESS may still contain some greyed-out elements depending on the data effectively compiled by the time the 2022 WGESA meeting takes place.
2. ***3M ESS***. Compile the necessary information to populate a 3M ESS and develop an initial 3M ESS draft. This draft will be produced at the 2022 WGESA meeting, and tabled for discussion at the 2023 SC June meeting. Depending on the amount of data successfully compiled, this initial draft could be sufficiently complete to be approved as final by SC, but this decision will be made at the 2023 SC June meeting.
3. ***Additional data from CPs***. The NAFO Secretariat will coordinate with the WGESA Co-chairs and relevant WGESA experts to formalize requests to CPs for any additional information required to complete the ESSs.
4. ***Joint NAFO-ICES Workshop on Ecosystem Summaries***. The WG-ESA Co-chairs will re-establish contact with ICES about the possibility and potential scope for this workshop. Given current workload and capacity within SC, this workshop is not expected to take place until 2023 at the earliest. At present, this renewed contact with ICES would be intended to keep the dialogue open, but any concrete commitment about the workshop would be conditional to the support provided by CPs for this activity.

Updating ESSs going forward will require compilation and consolidation of multiple data streams, as well as integration and interpretation of the emerging ecosystem signals and trends. While the general conclusions and main points would result from the discussion among the experts in WGESA and SC, carrying out the work still requires an expert to take the lead in coordinating the work, preparing material, analyses, and generating preliminary results and conclusions for the collective peer-review and discussion.

Given the workload, medium term time-commitment, and responsibility associated with this preparatory work, SC discussed the creation of an Ecosystem-level Designated Expert (EDE) role. These EDEs would lead/coordinate the compilation of information available from relevant specialists. This role would be analogous to those of existing stock-level DEs, and would be expected to received similar support and recognition by CPs to carry out their work. Experts to serve as EDEs would need to be designated for each Ecosystem Production Unit (EPU) within the NAFO Convention Area, with priority for those EPUs for which an ESS is currently being produced.

SC considered that the idea had merit and supported the development of an EDE structure within SC, where these EDEs would sit within WGESA to facilitate the development of ESSs and advance the work on the Roadmap towards an Ecosystem Approach to Fisheries Management within NAFO. Further, SC formally created the EDE positions for the Grand Bank (3LNO) and Flemish Cap (3M) EPUs, but no experts were designated in these positions, which remain vacant as all members of SC stated they could not take on further workload. Experts to serve in these positions would need to be identified/nominated by SC and/or Contracting

Parties, and formally designated by SC. CP support in the form of new positions and/or additional capacity would be required for making the new EDE roles operational.

2. Coastal States

a) Request by Denmark (on behalf of Greenland) for advice on management in 2023 of certain stocks in Subareas 0 and 1 (Annex 2)

Requests for management advice from Denmark (on behalf of Greenland) are presented in Annex 2 of Appendix V. Advice on stocks for which interim monitoring was requested is given in section 3c. below. Advice on *Pandalus borealis* is deferred to the September Scientific Council/NIPAG meeting.

The Scientific Council responded:

Greenland halibut in Division 1A inshore – Disko Bay Advice June 2022 for 2023-2024

Recommendation for 2023 – 2024
Scientific Council advises that the TAC in 2023 and 2024 should not exceed 5 215 tons.

Management objectives

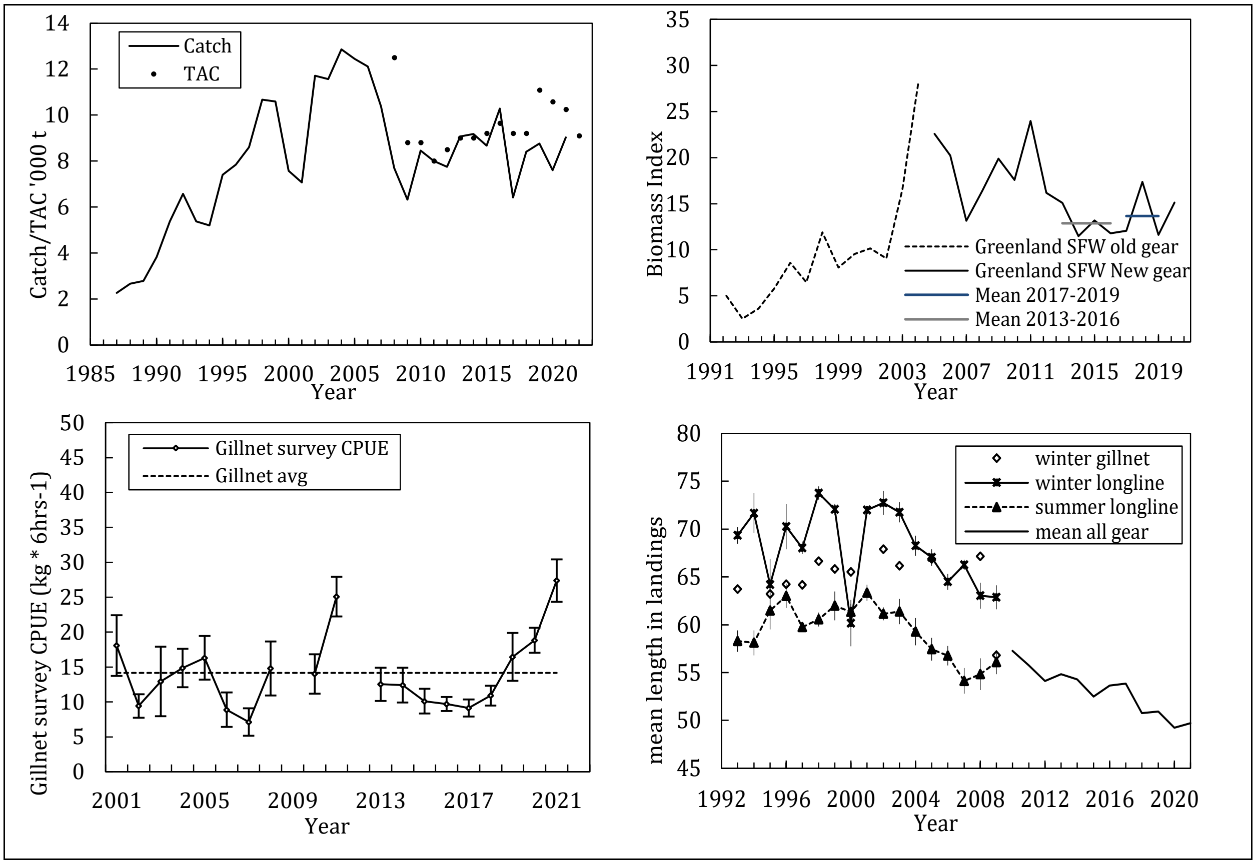
No explicit management plan or management objectives has been defined by the Government of Greenland but a management plan is currently under development.

Management unit

Three inshore stocks in Subarea 1A (Disko Bay, Uummannaq, and Upernavik) are believed to recruit from the SA 0+ 1 offshore spawning stock (in the Davis Strait), and there is little migration between the separated areas and the stock in SA 0 + 1 offshore. Separate advice is given for each area, within the specific management unit, in Subarea 1A inshore.

Stock status

Survey biomass index has been stable since 2013 but the recent increase in the gillnet survey indicates potential for growth of the stock based on an observed increase in small fish.



Reference points

Could not be established.

Assessment

No analytical assessment. A surplus production model in a Bayesian Framework was presented and while it was not accepted this year, work will continue.

The next assessment is planned for 2024.

Human impact

Mainly fishery related mortality. Removal of lost fishing gear (lost gillnets, longlines and more) by the GINR research vessel RV Sanna has been conducted in 2020 and 2021. Other mortality sources (e.g. pollution, shipping, oil-industry) are undocumented.

Biology and environmental interactions

No studies were reviewed in this assessment.

Fishery

Catches increased in the 1980s, peaked from 2004 to 2006 at more than 12 000 t, but then decreased substantially to just above 6000 t in 2009. From this level, catches gradually increased reaching 10 760 t in 2016. In 2017, catch rates were unusually low and only 6 409 t were caught in Disko Bay. Since then catches have increased to 9 028t in 2021.

Recent catch estimates ('000 tons) are as follows:

	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
1A Disko Bay – TAC	9.0	9.0	9.2	9.6	9.2	9.2	11.1	10.6	10.2	9.1
1A Disko Bay – STACFIS	9.0	9.2	8.7	10. 8	6.4	8.4	8.8	7.6	9.0	

Effects of the fishery on the ecosystem

Greenland halibut in the area is targeted with longlines and gillnets. Both gears select adult fish with large body size and do not retain recruits or small sized fish. Impacts on VMEs have not been addressed.

Basis for advice

The application of the ICES guidance on data limited stocks (DLS) method 3.2 (ICES 2012a and 2012b, ICES 2014) using the Greenland Shrimp and Fish survey (Div. 1A-F) was accepted by SC in 2016, as the basis for giving TAC advice on Greenland Halibut, in the Disko Bay. This method was applied again to provide the following advice for the next two years. This rule was developed and tested as an empirical approach that uses the trend in the stock response to fishing pressure (ICES 2012a, Jardim et al. 2015). The empirical basis was given a generic expression

$C_{y+1}=advice_{recent}*r$

where r=index mean for 2018-2020/index mean for 2014-2017 = 1.2 (no trawl survey in 2021)

Should changes in excess of +- 20% be generated using this rule, a 20% cap is applied. In 2016 or 2018, no precautionary buffer was applied. Since both the mean length in the fish landings and the commercial CPUE's have decreased in both 2018 and 2019 and stock status relative to reference points is unknown, a PA buffer was applied in 2020.

This results in the following advised catch:

2023 and 2024 $Catch_{advised}$ = 5215 t (catch advised for 2021 and 2022=4346*1.2)
This rule should be reviewed in the next assessment.

Multi-year advice is recommended when applying this index-ratio based rule. Also, Greenland has requested advice for as many years as is considered appropriate. A two-year advice cycle is suggested at this time.

Special comments

Although the index provided by the Greenland shrimp and fish trawl survey experienced vessel changes in 2018 -2020, the results are considered to be comparable with those from earlier years.

Recruits are mainly received from the offshore stock in SA 0 + 1 offshore.

Sources of Information

SCR Doc. 22/008, 028, 036; SCS Doc. 22/011.

Greenland halibut in Division 1A inshore - Uummannaq Advice June 2022 for 2023-2024

Recommendation for 2023 - 2024

Scientific Council recommends that TAC in 2023 and 2024 should not exceed 5153 t.

Management objectives

No explicit management plan or management objectives has been defined by the Government of Greenland. A management plan is currently under development.

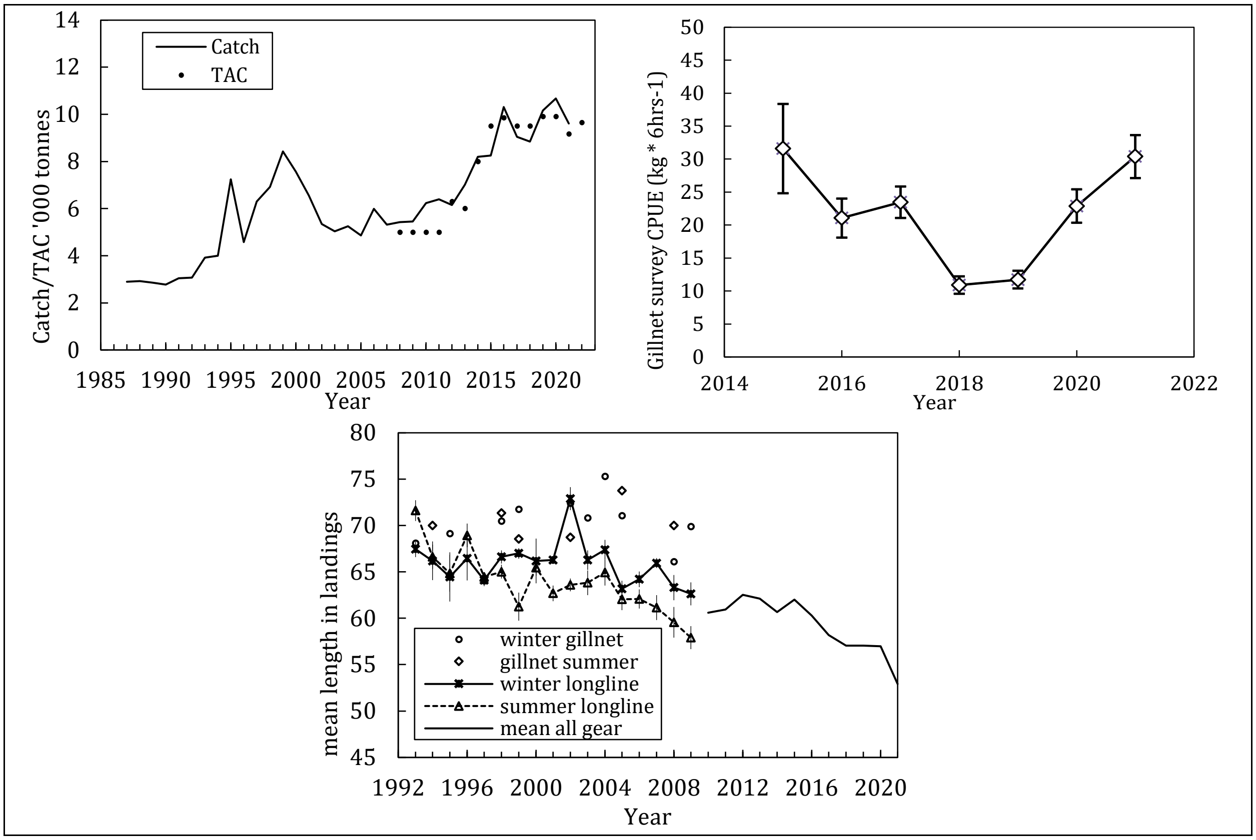
Management unit

Three inshore stocks in Subarea 1A (Disko Bay, Uummannaq, and Upernavik) are believed to recruit from the SA 0+ 1 offshore spawning stock (in the Davis Strait), and there is little migration between the separated areas and the stock in SA 0 + 1 offshore. Separate advice is given for each area, within the specific management unit, in Subarea 1A inshore.

Stock status

Although the size of the landed fish decreased substantially from 2020 to 2021, the gillnet index, which was lower in 2018 and 2019, has returned to its former level.

The length distribution in the gillnet survey further indicates the presence of large fish in the interval between 50 and 60 cm, and also a higher number of smaller recruits than previously observed.



Reference points

Could not be established.

Assessment

No analytical assessment was performed. Survey indices, and mean length in the landings were considered the best information to monitor the stock.

Human impact

Mainly fishery-related mortality. Other mortality sources (e.g. pollution, shipping, oil-industry) are undocumented.

Biological and Environmental interactions

Unknown

Fishery

Catches in the Uummannaq fjord gradually increased from the 1980s reaching 8 425 t in 1999, but then decreased to ~ 5 000 in 2002. Since 2004, catches gradually increased before stabilizing around 10 000 t/year.

Recent catch estimates ('000 ton) are as follows:

	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
1A Uummannaq - TAC	7.5	8.4	9.5	9.8	9.5	9.5	9.9	9.5	9.6	9.6
1A Uummannaq - catch	7.0	8.2	8.2	10.3	9.0	8.8	10.2	10.7	9.6	
STACFIS Total	7.0	8.2	8.2	10.3	9.0	8.8	10.2	10.7	9.6	

Basis for advice

The ICES Harvest Control Rule 3.2 for data limited stocks was used as a basis for giving TAC advice (mean survey index y2019-2021/mean y2015-2018=0.996). Multi-year advice is recommended when applying this index-ratio based rule. Also, Greenland has requested advice for as many years as is considered appropriate. A two-year advice cycle is suggested at this time.

This results in the following advised catch:

2023 and 2024 $\text{Catch}_{\text{advised}}$ = 5 153t (catch advised for 2021 and 2022=5153*0.996)

This rule should be reviewed in the next assessment.

Effects of the fishery on the ecosystem

Greenland halibut in the area is targeted with longlines and gillnets. Both gears select adult fish with large body size and do not retain recruits or small-sized fish. Ghost fishing by lost gillnets has been observed, but its effects in the Uummannaq fjord is unknown.

Special comments

Recruits are mainly received from the offshore stock in SA 0 + 1 offshore.

Sources of Information

SCR Doc. 22/010, 029, 037; SCS Doc. 22/011.

Greenland halibut in Division 1A inshore - Upernavik

Advice June 2022 for 2023-2024

Recommendation for 2023 - 2024

Scientific Council recommends that catch should not exceed 6 070 t.

Management objectives

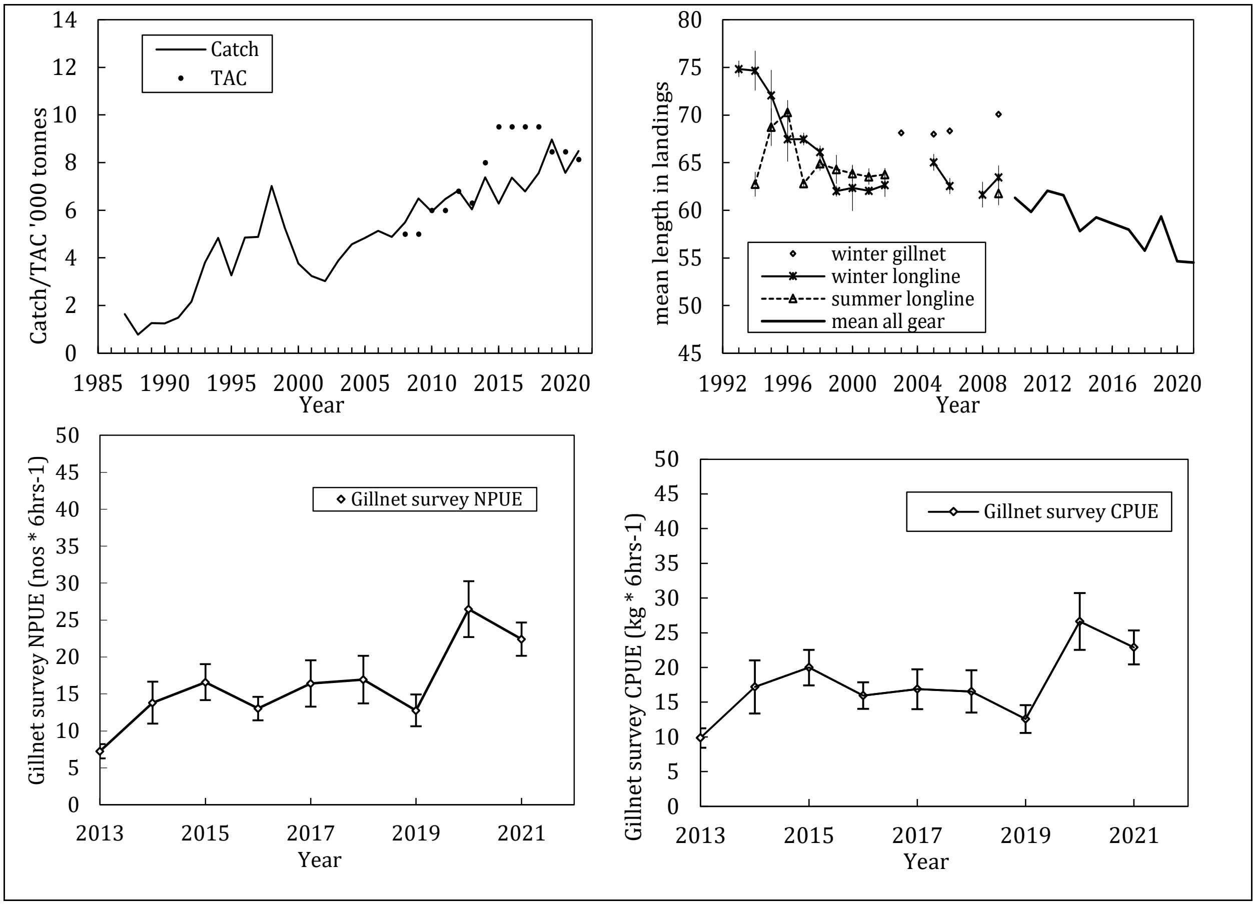
No explicit management plan or management objectives have been defined by the Government of Greenland. A management plan is currently under development.

Management unit

Three inshore stocks in Subarea 1A (Disko Bay, Uummannaq, and Upernavik) are believed to recruit from the SA 0+ 1 offshore spawning stock (in the Davis Strait), and there is little migration between the separated areas and the stock in SA 0 + 1 offshore. Separate advice is given for each area, within the specific management unit, in Subarea 1A inshore.

Stock status

The Upernavik scientific gillnet survey NPUE and CPUE increased relative to earlier levels in 2020 and 2021.



Reference points

Could not be established.

Assessment

No analytical assessment was performed. Survey indices, and mean length in the landings were considered the best information to monitor the stock.

Human impact

Mainly fishery-related mortality. Other mortality sources (e.g. pollution, shipping, oil-industry) are undocumented.

Biological and Environmental interactions

Unknown

Fishery

Catches increased from the mid-1980s and peaked in 1998 at a level of 7 000 t. Landings then decreased sharply, but during the past 15 years, catch has gradually increased to a level between 7 500 and 9 000 t.

Recent catch estimates ('000 ton) are as follows:

	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
TAC	8.0	9.5	9.5	9.5	9.5	9.5	8.5	8.5	10.0	9.3
Stacfis	6.0	7.4	6.3	7.4	6.8	7.6	9.0	7.6	8.5	

Basis for advice

The ICES Harvest Control Rule 3.2 for data limited stocks was used as a basis for giving TAC advice (mean survey index y2019-2021/mean y2015-2018=1.19). Multi-year advice is recommended when applying this index-ratio based rule. Also, Greenland has requested advice for as many years as is considered appropriate. A two-year advice cycle is suggested at this time.

This results in the following advised catch:

2023 and 2024 $\text{Catch}_{\text{advised}}$ = 6070 t (catch advised for 2021 and 2022=5058*1.2)

This rule should be reviewed in the next assessment.

Effects of the fishery on the ecosystem

Greenland halibut in the area is targeted with longlines and gillnets. Both gears select adult fish with large body size and do not retain recruits or small-sized fish. Ghost fishing by lost gillnets has been observed, but its effects are unknown.

Special comments

Recruits are mainly received from the offshore stock in SA 0 + 1 offshore.

Sources of Information

SCR Doc. 22/009, 033, 038; SCS Doc. 22/011.

b) Request by Canada and Denmark (Greenland) for Advice on Management in 2023 (Annex 2, Annex 3)

Requests for management advice from Canada and Denmark (on behalf of Greenland) are presented in Annex 2 and 3 of Appendix V. Advice on stocks for which interim monitoring was requested is given in section 3c. below. Advice on Pandalus borealis is deferred to the September Scientific Council/NIPAG meeting.

Scientific council responded:

Greenland halibut in Subarea 0+1 (offshore) Advice June 2022 for 2023-2024

Recommendation for 2023 and 2024

The main index for this stock has not been updated since 2017, consequently stock status is increasingly uncertain. However, SC notes that the stock varied without trend between 2013-2017 while the fishery was increasing. Average catches during this period were 29,640 t, therefore, SC recommends catches not to exceed this value in 2023 and 2024.

Management objectives

Canada and Greenland adopted a total allowable catch (TAC) of 36 370 t for 2019 to 2022. Canada requests that stock status be evaluated in the context of management requirements for long-term sustainability and the advice provided should be consistent with the precautionary approach.

Convention General Principles	***Status***	***Comment/consideration***
Restore to or maintain at B_{MSY}	⚪	B_{MSY} Unknown
Eliminate overfishing	⚪	F_{MSY} Unknown
Apply Precautionary Approach	🟡	B_{lim} *valid to 2017*
Minimise harmful impacts on living marine resources and ecosystems	🟡	Fishing closures are in effect in SA0 and Div. 1A. No specific measures.
Preserve marine biodiversity	⚪	Cannot be evaluated

🟢	OK
🟡	Intermediate
🔴	Not accomplished
⚪	Unknown

Management unit

The Greenland halibut stock in Subarea 0 + 1 (offshore) is part of a larger population complex distributed throughout the Northwest Atlantic. From 2020, separate assessments are made on the inshore management units in 1A-F and 0B.

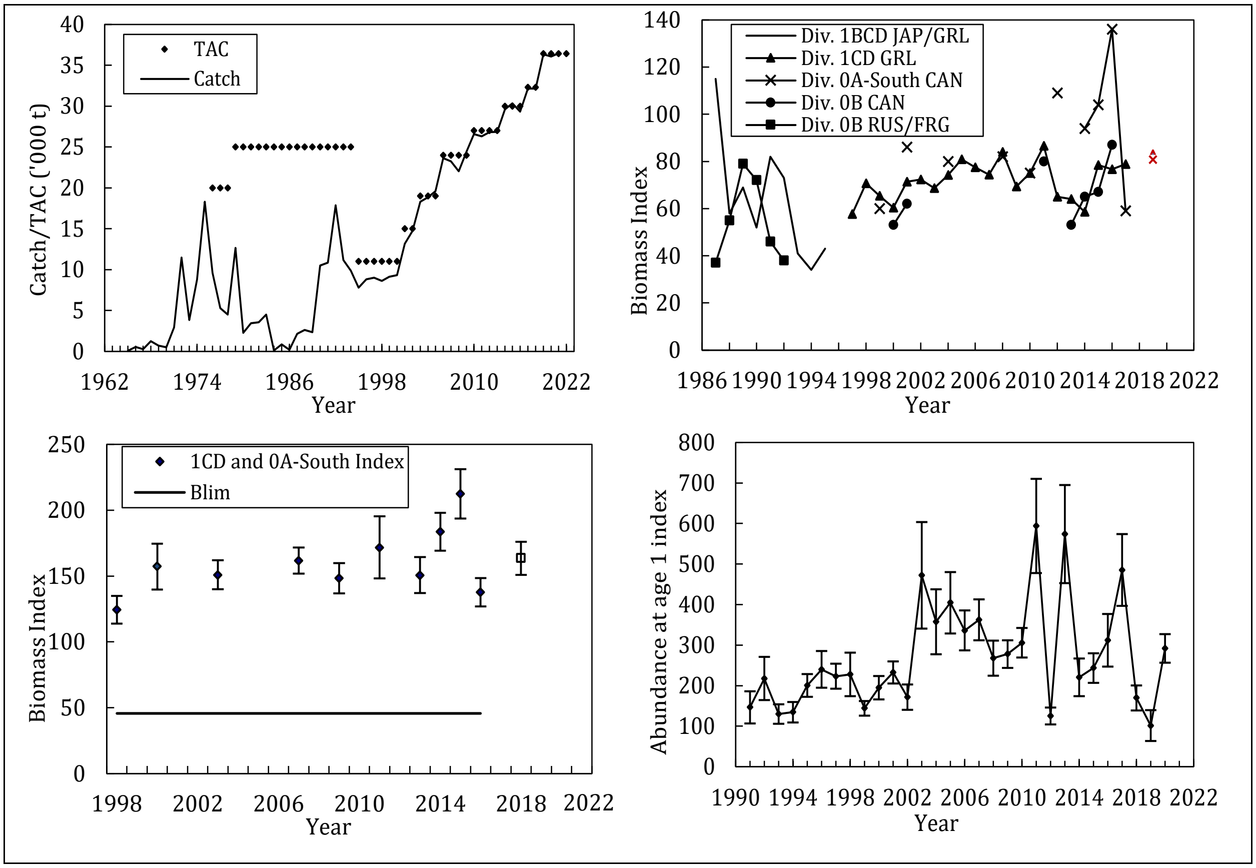
Stock status

The 0A-South and 1CD biomass index was above B_{lim} throughout the time series, 1999 to 2017. The 2019 value is similar in magnitude to previous surveys, however, it is not considered directly comparable. Despite a lack of index survey data in recent years the stock status is not expected to have changed drastically during 2018 to present.

Special Comment

The main index for this stock has not been updated since 2017, consequently stock status is increasingly uncertain: this increases the risks associated with management decisions. It is essential that surveys resume as soon as possible to update indices.

In assessing stock status SC considered the observed stability in length frequencies from surveys and the fishery, the age-1 index, that TACs have been consistently achieved, longevity of the species, and that status in 2017 was well above B_{lim}.



Reference points

B_{MSY} is not known for this stock. In 2015 a proxy for B_{lim} was developed based on 30% of a period of stability in the 0A-South and 1CD index (1999-2012). However, no surveys were conducted in 2018, 2020 or 2021 and the 2019 survey was not considered comparable to previous surveys. The previous B_{lim} was valid to 2017, but needs to be re-evaluated once a new time series is established.

Assessment

The assessment is qualitative with input from research surveys (total biomass and abundance indices to 2017, an index of age 1 fish to 2020, and length frequency distributions to 2017) and fishery length frequencies to 2021.

The next assessment is expected to be in 2024.

Human impact

Mainly fishery related mortality has been documented. Other sources (e.g. pollution, shipping, oil-industry) are undocumented.

Biology and Environmental interactions

No specific studies were reviewed during this assessment

Fishery

Catches were first reported in 1964. Catches increased from 1989 to 1992 due to a new trawl fishery in Div. 0B with participation by Canada, Norway, Russia and Faeroe Islands and an expansion of the Div. 1CD fishery with participation by Japan, Norway and Faeroe Islands. Catch declined from 1992 to 1995 primarily due to a reduction of effort by non-Canadian fleets in Div. 0B. Since 1995 catches have been near the TAC and increasing in step with increases in the TAC, with catches reaching a high of 36 436 t in 2021.

Recent catch and TACs ('000 t)

	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
TAC	27	30	30	30	32.3	32.3	36.4	36.4	36.4	36.4
STACFIS SA 0	13.4	14.9	15.4	14.1	15.9	16.0	18.3	17.9	19.1[2]	
STACFIS SA 1	13.5	14.7	14.9	15.2	16.2	16.2	18.0	18.1	17.3	
Total STACFIS[1]	26.9	29.6	30.3	29.3	32.1	32.2	36.3	36.0	36.4	

[1] Based on STATLANT, with information from Canada and Greenland authorities to exclude inshore catches.

[2] STACFIS estimate using 1.5 conversion factor for J-cut, tailed product; 1 129 t increase over reported catch.

Effects of the fishery on the ecosystem

The impact of bottom fishing activities on VMEs in SA 0 was assessed in 2016. Three areas have been designated as marine refuges, that exclude bottom contact fisheries: Disko Fan, Davis Strait and Hatton Basin. Areas in SA 1 have also been closed to fishing to protect benthic habitats.

Greenland Shark is a bycatch species of concern in the SA 0+1 (offshore) fishery given its low reproductive rate, slow growth rate and limited ecological information. SC has examined Greenland Shark bycatch records and survey encounters in the NAFO Convention Area to determine the amount of, and spatial and temporal patterns in Greenland Shark bycatch.

Basis for Advice

A quantitative assessment of risk at various catch options is not possible for this stock, therefore, it is not possible to quantitatively evaluate the sustainability of the TAC. There was no biomass index available for 2018, 2020 or 2021, and there is uncertainty in the comparability of the 2019 estimate. TAC advice in 2022 is based on a qualitative review of available data.

Sources of information

SCR 22/022, 023, 21/014; SCS Doc. 22/009, 012, 017

c) Monitoring of Stocks for which Multi-year Advice was provided in 2020 or 2021

Interim monitoring updates of these stocks were conducted and Scientific Council reiterates its previous advice as follows:

Recommendation for 2021 – 2023 for demersal redfish in Subarea 1:

Deep-sea redfish and Golden redfish: The Scientific Council advises that there should be no directed fishery.

There will be no new assessment until monitoring shows that conditions have changed; until then, the advice given above will remain.

Recommendation for 2021 - 2023 for Atlantic wolffish in Subarea 1:

Atlantic wolffish: The Scientific Council advises that there should be no directed fishery.

Spotted wolffish: The Scientific Council advises that the TAC should not exceed 1158 tonnes.

VIII. REVIEW OF FUTURE MEETINGS ARRANGEMENTS

1. Scientific Council, (in conjunction with NIPAG),12 – 17 September 2022

The Scientific Council shrimp advice meeting will be held in Copenhagen, Denmark, 12-17 September 2022.

2. Scientific Council, 19 to 23 September 2022

The Scientific Council September 2022 meeting will be held in Porto, Portugal, 19-23 September 2022.

3. WG-ESA, 15- 24 November 2022

The Working Group on Ecosystem Science and Assessment will meet at the NAFO Secretariat, Halifax, Nova Scotia, Canada, 15- 24 November 2022.

4. Scientific Council, June 2023

The Scientific Council June 2022 meeting will be held at Saint Mary's University, Halifax, 2 -15 June 2023.

5. Scientific Council (in conjunction with NIPAG), 2023

Dates and location to be determined.

6. Scientific Council, September 2023

Scientific Council noted that the Annual meeting will be held in September in Halifax, Nova Scotia, unless an invitation to host the meeting is extended by a Contracting Party.

7. NAFO/ICES Joint Groups

a) NIPAG, 12 – 17 September 2022

The joint NAFO/ICES Shrimp Assessment Group (NIPAG) 2022 meeting will be held in Copenhagen, Denmark, 12-17 September 2022.

b) NIPAG, 2023

Dates and location to be determined.

c) ICES – NAFO Working Group on Deep-water Ecosystem

Dates and location to be determined.

d) WG-HARP, 2022

Dates and location to be determined.

8. Commission- Scientific Council Joint Working Groups

a) WG-EAFFM

The joint SC-Commission Working Group on the Ecosystem approach to Fisheries Management (WG-EAFFM) will be held at the NAFO Secretariat, Halifax, Nova Scotia, Canada, 11-12 August 2022

b) WG-RBMS

The joint SC-Commission Working Group on Risk Based Management Systems (WG-RBMS) will be held at the NAFO Secretariat, Halifax, Nova Scotia, Canada 17-18 August 2022.

c) CESAG

The next meeting of the Catch Estimation Strategy Advisory Group (CESAG) will be in 2023.

IX. ARRANGEMENTS FOR SPECIAL SESSIONS

1. Topics of Future Special Sessions

No topics for future special sessions of SC were discussed.

X. MEETING REPORTS

1. Working Group on Ecosystem Science and Assessment (WG-ESA), November 2021 - SCS Doc. 21/21

The report of the meeting of the Working Group on Ecosystem Science and Assessment (WG-ESA) held by Webex, 16-25 November 2021 was presented by its Chair Andrew Kenny (UK) (Insert ref). Scientific Council welcomed Mar Sacau (EU-Spain) as new co-chair of this working group.

2. Meetings attended by the Secretariat

To be presented in September.

XI. REVIEW OF SCIENTIFIC COUNCIL WORKING PROCEDURES/PROTOCOL

1. General Plan of Work for September 2022 Annual Meeting

No new issues were raised that will affect the regular work plan for the September meeting.

XII. OTHER MATTERS

1. Presentation of NAFO Scientific Council Merit Award to Margaret Treble

NAFO SC was pleased to present a Scientific Merit Award to Margaret Treble (Canada) for her many science contributions to SC over the years as designated expert for the Greenland Halibut Subarea 0 and 1 stock since 2018, but also for her tenacity and relentless drive in supporting, promoting and improving the many publications that SC produces, as well as the Journal of Northwest Atlantic Fishery Science. Margaret was the STACPUB Chair for 12 consecutive years (2010-2021), and during this period she led the modernization of NAFO SC publications, keeping them relevant in a fast changing world. Additionally, Margaret has been imperative in pushing forward research on age and growth of Greenland Halibut and has been involved in international fish aging efforts, which she brought to NAFO.

Margaret has been a steadfast chair for STACPUB, and her reasoned interventions and friendship at Scientific Council have made SC a better place.

2. Designated Experts

The list of Designated Experts can be found below:

From the Science Branch, Northwest Atlantic Fisheries Centre, Department of Fisheries and Oceans, St. John's, Newfoundland & Labrador, Canada

Cod in Div. 3NO	Rick Rideout	rick.rideout@dfo-mpo.gc.ca
Redfish Div. 3O	Laura Wheeland	laura.wheeland@dfo-mpo.gc.ca
Redfish Div. 3LN	Bob Rogers	bob.rogers@dfo-mpo.gc.ca
American Plaice in Div. 3LNO	Laura Wheeland	laura.wheeland@dfo-mpo.gc.ca
Witch flounder in Div. 3NO	Dawn Maddock Parsons	dawn.parsons@dfo-mpo.gc.ca
Yellowtail flounder in Div. 3LNO	Dawn Maddock Parsons	dawn.parsons@dfo-mpo.gc.ca
Greenland halibut in SA 2+3KLMNO	Paul Regular	paul.regular@dfo-mpo.gc.ca
Northern shrimp in Div. 3LNO	Katherine Skanes	katherine.skanes@dfo-mpo.gc.ca

From the Department of Fisheries and Oceans, Winnipeg, Manitoba, Canada

Greenland halibut in SA 0+1	Margaret Treble	margaret.treble@dfo-mpo.gc.ca

From the Instituto Español de Oceanografia, Vigo (Pontevedra), Spain

Roughhead grenadier in SA 2+3	Fernando Gonzalez-Costas	fernando.gonzalez@ieo.csic.es
Splendid alfonsino in Subarea 6	Fernando Gonzalez-Costas	fernando.gonzalez@ieo.csic.es
Cod in Div. 3M	Diana Gonzalez-Troncoso	diana.gonzalez@ieo.csic.es
Northern Shrimp in Div. 3M	Jose Miguel Casas Sanchez	mikel.casas@ieo.csic.es

From the Instituto Nacional de Recursos Biológicos (INRB/IPMA), Lisbon, Portugal

American plaice in Div. 3M	Ricardo Alpoim	ralpoim@ipma.pt
Golden redfish in Div. 3M	Ricardo Alpoim	ralpoim@ipma.pt
Redfish in Div. 3M	Ricardo Alpoim (provisional)	ralpoim@ipma.pt

From the Greenland Institute of Natural Resources, Nuuk, Greenland

Demersal Redfish in SA1	Rasmus Nygaard	rany@natur.gl
Wolfish in SA1	Rasmus Nygaard	rany@natur.gl
Greenland halibut in Div. 1 inshore	Rasmus Nygaard	rany@natur.gl
Northern shrimp in SA 0+1	AnnDorte Burmeister	anndorte@natur.gl
Northern shrimp in Denmark Strait	Tanja B. Buch	TaBb@natur.gl

From Knipovich Polar Research Institute of Marine Fisheries and Oceanography (PINRO), Russian Federation

Capelin in Div. 3NO	Konstantin Fomin	fomin@pinro.ru

From National Marine Fisheries Service, NEFSC, Woods Hole, Massachusetts, United States of America

Northern Shortfin Squid in SA 3 & 4	Lisa Hendrickson	lisa.hendrickson@noaa.gov
Thorny skate in Div. 3LNO	Katherine Sosebee	katherine.sosebee@noaa.gov
White hake in Div. 3NO	Katherine Sosebee	katherine.sosebee@noaa.gov

3. Election of Chairs

No new Chairs were elected in 2022.

4. Other business

No other business was discussed.

XIII. ADOPTION OF COMMITTEE REPORTS

The Council, during the course of this meeting, reviewed the Standing Committee recommendations. Having considered each recommendation and also the text of the reports, the Council **adopted** the reports of STACFEN, STACREC, STACPUB and STACFIS. It was noted that some text insertions and modifications as discussed at this Council plenary will be incorporated later by the Council Chair and the Secretariat.

XIV. SCIENTIFIC COUNCIL RECOMMENDATIONS TO THE COMMISSION

The Council Chair undertook to address the recommendations from this meeting and to submit relevant ones to the Commission.

XV. ADOPTION OF SCIENTIFIC COUNCIL REPORT

At its concluding session on 16 June 2022, the Council considered the draft report of this meeting, and adopted the report with the understanding that the Chair and the Secretariat will incorporate later the text insertions related to plenary sessions and other modifications as discussed at plenary.

XVI. ADJOURNMENT

The Chair thanked the participants for their hard work and cooperation, noting particularly the efforts of the Designated Experts and the Standing Committee Chairs. The Chair thanked the Secretariat for their valuable support and St Mary's University for the excellent facilities. There being no other business the meeting was adjourned at 12:30 on 16 June 2022.

APPENDIX I. REPORT OF THE STANDING COMMITTEE ON FISHERIES ENVIRONMENT (STACFEN)

Chair: Miguel Caetano Rapporteur: David Bélanger

The Committee met at the Atrium Building, Saint Mary's University, 903 Robie St., Halifax, NS, Canada and by videoconference on the 03 and 04 of June 2022 to consider environment-related topics and report on various matters referred to it by the Scientific Council. Representatives attended from Canada, Denmark (in respect of the Faroe Islands and Greenland), European Union (Portugal, Spain and Estonia), Japan, the Russian Federation, Norway, United Kingdom and the United States of America. The Executive Secretary, Scientific Council Coordinator and other members of the Secretariat were in attendance.

1. Opening

The Chair opened the meeting by welcoming participants to this June 2022 Meeting of STACFEN.

The Committee noted the following documents would be reviewed: SCR Doc. 22/006, 22/017, 22/018, 22/019, 22/020, 22/021.

2. Appointment of Rapporteur

David Bélanger (Canada) was appointed rapporteur.

3. Adoption of the Agenda

The provisional agenda was adopted with no further modifications.

4. Review of Recommendations in 2021

STACFEN **recommended** *consideration of Secretariat support for an invited speaker to address emerging issues and concerns for the NAFO Convention Area during the 2022 STACFEN Meeting. Contributions from invited speakers may generate new insights and discussions within the committee regarding the integration of environmental information into the stock assessment process.*

STATUS: STACFEN was unable to secure a guest speaker for the June 2022 meeting due to ongoing restrictions relating to the COVID-19 pandemic. This recommendation is **reiterated,** and STACFEN will endeavour to have an invited speaker next year.

NAFO usually convenes a symposium on environmental issues every ten years. The last one was held in 2011 as "ICES/NAFO Symposium on the Variability of the North Atlantic and its Marine Ecosystems during 2000-2009". STACFEN suggested that the forthcoming ICES Symposium (2021) could take the place of the next NAFO symposium. STACFEN, therefore, recommended that Scientific Council support participation and possible co-sponsorship.

STATUS: NAFO agreed to co-sponsored the symposium "4th Decadal Variability of the North Atlantic and its Marine Ecosystems: 2010-2019", advertised as an ICES-NAFO event. The symposium was postponed to June 2022 due to restrictions related to the COVID-19 pandemic. STACFEN **recommends** that *the Scientific Council support participation in the event.*

Further discussions are encouraged between STACFEN and STACFIS members on environmental data integration into the various stock assessments.

5. Inventory of environmental data in the NAFO convention area - Report 2021 SCR 22/017

The Marine Environmental Data Section (MEDS) of the Oceans Science Branch of Fisheries and Oceans Canada serves as the Regional Environmental Data Center for NAFO. As part of this role, MEDS provides an annual inventory of environmental data collected in the NAFO Convention Area to STACFEN, including inventories and maps of physical oceanographic observations such as ocean profiles, near-surface thermosalinographs, drifting buoys, currents, waves, tides and water level measurements for the previous calendar year (2021).

For MEDS to carry out its responsibility of reporting to the Scientific Council, the Designated National Representatives selected by STACFEN are requested to provide MEDS with all marine environmental data collected in the Northwest Atlantic for the preceding years. The data of highest priority are those from the standard sections and stations, as described in NAFO SCR DOC., No. 1, Serial N 1432, 9p.

Data formatted and archived at MEDS are available to all members on request and are available from DFO institutes. Requests can be made by completing an online order form on the MEDS website http://www.meds-sdmm.dfo-mpo.gc.ca/isdm-gdsi/request-commande/form-eng.asp or by writing to MEDS-SDMM.XNCR@dfo-mpo.gc.ca. The following table summarizes data received by MEDS for the NAFO Convention Area (NCA) in 2021.

Data observed in NAFO Convention Area in 2021

Data Type	**Platform Type**	**Counts/Duration**
Oceanographic profiles	Autonomous drifting (Argo)	6131* profiles from 189 platforms
	Moorings (Viking)	990* profiles from 6 platforms**
	Gliders	3191* profiles from 5 platforms
	Ship	1662 profiles (133 CTD; 1196 CTD RT*; and 248 XBT RT* profiles)
Surface/near-surface observations	Ship (thermosalinograph)	(none reported)
	Drifting buoys	969242* obs. from 374 buoys
	Moored buoys	342760* obs. from 16 buoys**
	Fixed platforms	87966* obs. from 4 platforms
	Water level gauges	35 sites, avg. ~1 year each

*Data formatted for real-time transmission
**All Canadian wave buoys described in this report measure waves, and the moorings measuring CTD oceanographic profiles in this table are also equipped with surface buoys measuring waves

Data observed before 2021 in NAFO Convention Area and acquired between January 2021 and May 2022

Data Type	**Platform Type**	**Counts/Duration**
Oceanographic profiles	Ship	2174 profiles (1390 CTD + 693 bottle + 91 XBT profiles) from 76 cruises

6. Highlights of Climate and Environmental Conditions by NAFO Subarea for 2021 (SCR Doc. 22/021)

The highlights for the climate and environmental conditions in the NAFO Subareas during 2021 can be summarized as follows:

- A large majority of ocean climate indicators were above normal in 2021.
- In 2021, composite climate indices in subareas 2, 3 and 4 were warmer at a time series record. The index for Divs. 3LNO (Grand Bank) was at its second warmest value since the record-high of 2011.
- Spring bloom initiation in 2021 for subareas 0-1 was the earliest record during a year marked by unusually low sea ice coverage in the North Atlantic.
- The abundance of copepod and non-copepod zooplankton was at a record high on the Grand Bank (3LNO) in 2021, continuing a trend of above-normal levels that started in 2016.

6.1. SUBAREA 0 AND 1, GREENLAND AND DAVIS STRAIT

6.1.1. Recent Highlights in Ocean Climate and Lower Trophic Levels for Subarea 0-1

- The ocean climate index in Subarea 0-1 was above normal in 2021.
- Mean initiation timing of the spring phytoplankton bloom in 2021 was the earliest of the time series.
- Spring bloom magnitude (total production) was slightly below normal in 2021

Hydrographic conditions in this region depend on a balance of ice melt, advection of polar and sub-polar waters and atmospheric forcing, including the major winter heat loss to the atmosphere in the central Labrador Sea. The cold and fresh polar waters carried south by the east Baffin Island Current are counter balanced by warmer waters carried northward by the offshore branch of the West Greenland Current (WGC). The water masses constituting the WGC originate from the western Irminger Basin, where the East Greenland Currents (EGC) meet the Irminger Current (IC). While the EGC transports ice and cold low-salinity Surface Polar Water to the south along the eastern coast of Greenland, the IC is a branch of the North Atlantic current and transports warm and salty Atlantic Waters northwards along the Reykjanes Ridge. After the currents converge, they turn around the southern tip of Greenland, forming a single jet (the WGC) that propagates northward along the western coast of Greenland. The WGC is important for Labrador Sea Water formation, which is an essential element of the Atlantic Meridional Overturning Circulation. After receiving freshwater input from Greenland and Davis Strait at the northern edge of the Labrador Sea, part of the WGC bifurcates southward along the Canadian shelf edge as the Labrador Current.

6.1.2. Ocean Climate and Ecosystem Indicators

The ocean climate index in Subarea 0-1 has been predominantly above or near normal since the early 2000s, except for 2015 and 2018, which were below normal (Fig. 1A). After being in 2019 at its highest value since the record high of 2010, the index was normal in 2020 and again above normal in 2021. Before the warm period of the last decade, cold conditions persisted in the early to mid-1990s.

Spring bloom initiation has been oscillating between early (negative anomalies) and late (positive anomalies) timing between 2003 and 2020. In 2021, the average timing of the spring bloom in Subareas 0B1EFT was the earliest of the time series and followed the two latest bloom onsets on record for the region (Figure 1B). Spring bloom magnitude (total production) remained mostly below or near-normal between 2003 and 2020, with the exception of a few highly productive blooms in 2006, 2015 and 2018 (Fig. 1C). In 2021, the mean bloom magnitude in the region was slightly higher than normal (Fig. 1C).

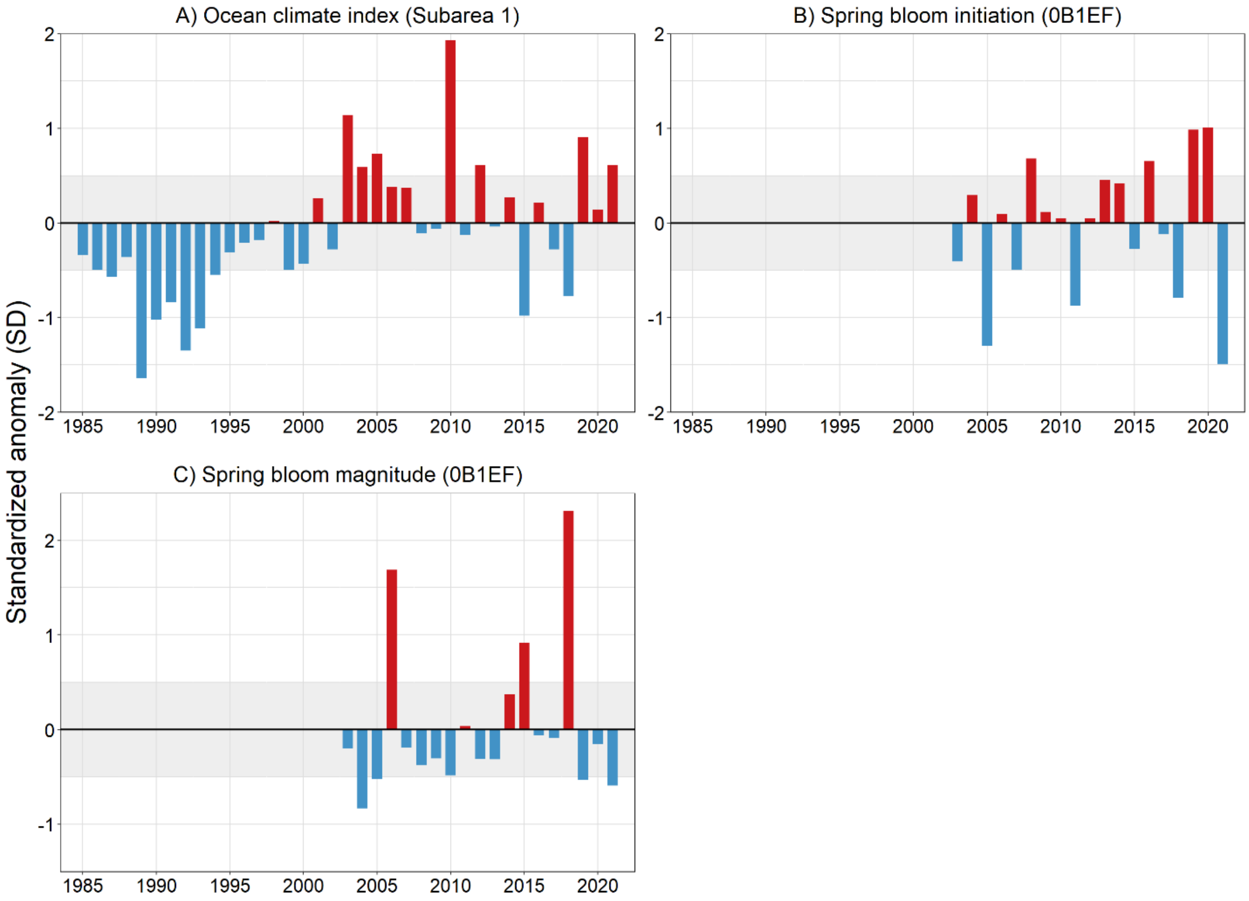


Figure 1. Annual anomalies of environmental indices for NAFO Subareas 0 and 1. The ocean climate index (A) for 1990-2020 is the average of 10 individual time series. These include standardized anomalies of 4 SSTs time series, 4 temperature time series at 3 hydrographic stations and 2 air temperatures time series (see text for details). Spring bloom anomalies (B, C) for the 2003-2021 period are derived from four satellite boxes (HS, NLAB, CLAB, GS). Positive (negative) anomalies indicate late (early) bloom timing or magnitude above (below) the mean for the reference period. Anomalies were calculated using the following reference periods: ocean climate index: 1981-2010, spring bloom indices: 2003-2020. Anomalies within ± 0.5 SD (shaded area) are considered near-normal conditions.

6.2. DIVISION 3M, FLEMISH CAP

6.2.1. Recent Highlights in Ocean Climate and Lower Trophic Levels for 3M

- After being mostly below normal (zero anomaly) between 2015 and 2019 (except for 2018), the ocean climate index in 3M, has been normal in 2020 and 2021.
- The initiation of the spring phytoplankton bloom was earlier than normal in 2021 after 2 consecutive years of near-normal timing.
- Spring bloom magnitude returned to near normal in 2021 after the low production spring of 2020.
- The abundance of copepods and non-copepods and total zooplankton biomass increased to above normal in 2021 after two consecutive years of near or below-normal levels.

The water masses characteristic of the Flemish Cap area is a mixture of Labrador Current Slope Water and North Atlantic Current water, generally warmer and saltier than the sub-polar Newfoundland Shelf waters with a temperature range of 3-4°C and salinities in the range of 34-34.75. The general circulation in the vicinity of the Flemish Cap consists of the offshore branch of the Labrador Current, which flows through the Flemish Pass on the Grand-Bank side and a jet that flows eastward north of the Cap and then southward east of the Cap. To the south, the Gulf Stream flows to the northeast to form the North Atlantic

Current and influences waters around the southern areas of the Cap. In the absence of strong wind forcing, a topographically induced anti-cyclonic (clockwise) gyre dominates the circulation over the central Flemish Cap. Variation in the abiotic environment influences the distribution and biological production of Newfoundland and Labrador Shelf and Slope waters, where arctic, boreal, and temperate species coexist. The elevated temperatures on the Flemish Cap result in relatively ice-free conditions that may allow longer phytoplankton growing seasons than in the Grand Banks, where cooler conditions prevail. The entrainment of nutrient-rich North Atlantic Current water around the Flemish Cap generally supports higher primary and secondary production compared with the adjacent shelf waters. The stability of this circulation pattern may also influence the retention of ichthyoplankton on the Grand Bank, which may influence the year-class strength of various fish and invertebrate species.

6.2.2. Ocean Climate and Ecosystem Indicators

The ocean climate index in Div. 3M (Fig. 2A) has remained mostly above normal between the late 1990s and 2013. After the record high of 2011, the index gradually decreased, reaching, in 2016, its lowest value since 1993. After being below normal between 2015-2019 (with the exception of 2018 which was normal), the index was normal in 2020 and 2021.

Mean spring bloom initiation timing has been oscillating between earlier or later than normal between 2003 and 2020 with no clear variation pattern except for three consecutive early blooms from 2004 to 2006 (Fig. 2B). Spring bloom magnitude (total production) has also been oscillating between above and below and above normal throughout the time series, with a change in the sign of the anomalies (positive to negative) every 2-3 years (Fig.2C). Bloom magnitude returned to near normal in 2021 after the below-normal levels of the previous year and the three consecutive years of above-normal production from 2017 to 2019 (Figure 2C). In general, early bloom onsets (i.e., negative initiation anomalies) are associated with higher primary production (i.e. positive magnitude anomalies) and vice versa, but there are exceptions (Fig. 2B-C). Total copepod abundance rapidly increased between 1999 and 2010 and varied more during the 2010s, although it mostly remained near or above normal except for the low abundances recorded in 2014 and 2019 (Figure 2D). The abundance of non-copepods showed a general increase from 1999 to 2018 but was followed by a decline in the late 2010s similar to that of copepods (Figure 2D, E). In 2021 the abundance of both copepods and non-copepods was back to above normal (Figure 2D, E). Total zooplankton biomass generally increased during the 2010s despite interannual variability and remained mostly near normal after the high value of 2016 (Figure 2F). In 2021, the mean zooplankton biomass in the region was slightly above normal (Figure 2F).

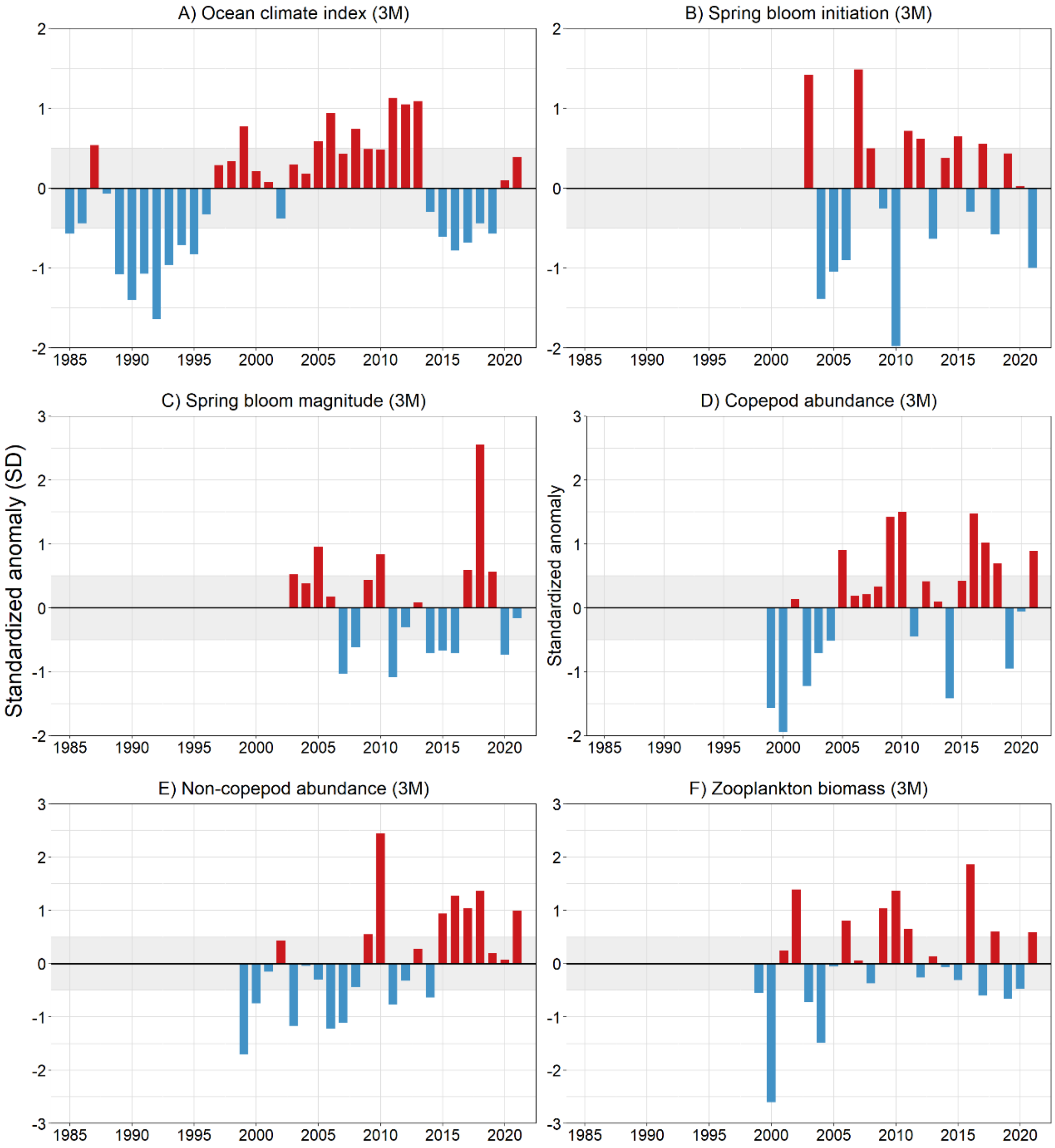


Figure 2. Annual anomalies of environmental indices for Flemish Cap (in NAFO Div. 3M). The ocean climate index (A) for 1990-2020 is the average of three time-series of standardized ocean temperature anomalies of sea surface temperatures (SSTs), hydrographic section observations, and summer mean bottom temperature over the cap. Spring bloom anomalies (B, C) for the 2003-2021 period were averaged over two satellite boxes. Zooplankton anomalies (D-F) for 1999-2021 were calculated using data from the portion of the FC section located within NAFO Div. 3M. Positive (negative) anomalies indicate late (early) bloom timing or conditions above (below) the mean for the reference period. Anomalies were calculated using the following reference periods: ocean climate index: 1981-2010, spring bloom indices: 2003-2020, Zooplankton indices: 1999-2020. Anomalies within ± 0.5 SD (shaded area) are considered near-normal conditions.

6.3. DIVISION 3 LNO, GRAND BANKS

6.3.1. Recent Conditions in Ocean Climate and Lower Trophic Levels

- In 2021, the ocean climate in NAFO Divs. 3LNO - Grand Bank was at its second warmest value of the entire time series, starting in 1975 (after the record high of 2011).
- Spring bloom initiation was near normal in 2021 for a 3rd consecutive year.
- Spring bloom magnitude decreased to below normal in 2021 and was among the lowest of the time series.
- The abundance of copepods and non-copepods remained above normal in 2021 for a 6th consecutive year with a time series record high for copepods.
- Zooplankton biomass was above normal in 2021 for the third time over the past five years.

The water mass characteristic of the Grand Bank is typical of sub-polar waters, with the presence of a winter-formed water mass is generally referred to as the Cold Intermediate Layer (CIL) and which last throughout the year until the late fall. The CIL (defined as water <0°C) extends to the ocean bottom in the northern areas of 3LNO, covering the bottom with sub-zero temperatures. The CIL is thus a reliable index of ocean climate conditions in this area. Bottom temperatures are higher in southern regions of 3NO, reaching 1 - 4°C, mainly due to atmospheric forcing, and along the slopes of the banks below 200 m depth due to the presence of Labrador Slope Water. On the southern slopes of the Grand Bank in Div. 3O, bottom temperatures may reach 4 - 8°C due to the influence of warm slope water from the Gulf Stream. The general circulation in this region consists of the relatively strong offshore Labrador Current at the shelf break and a considerably weaker branch near the coast in the Avalon Channel. Currents over the banks are very weak, and the variability often exceeds the mean flow.

6.3.2. Ocean Climate and Ecosystem Indicators

The ocean climate index in Divs. 3LNO (has remained mostly above normal between the late 1990s and 2013, reaching a peak in 2011. The index returned to normal conditions between 2014 and 2019 (except for 2015 and 2017 that was below normal). In 2020 and 2021, the ocean climate index was back to above normal value, reaching, in 2021, the second-highest value of the entire time series started in 1985 (only 2011 was the warmest).

Despite interannual variability, there was a general shift toward earlier spring bloom timing on the Grand Bank from 2003 to 2013 (Figure 3B). Spring bloom timing remained either near or later than normal afterwards, except for the early blooms of 2018. Spring bloom magnitude (total production) was quite variable in 3LNO throughout the time series with no clear temporal pattern (Figure 3C). Total spring production in 2021 was the third-lowest of the time series after three years of a steady decline that followed the 2018 record high (Figure 3C). Due to limited sampling the zooplankton abundance indices were restricted to one section in summer, and eight occupations of the high-frequency monitoring site (once monthly from April to December). The abundance of copepod and non-copepod zooplankton generally increased throughout the time series, with a clear transition from negative to positive anomalies around 2010 (Figure 3D, E). Abundance has remained above normal since 2016 for both groups, with a record high for copepods and one of the three highest values on record for non-copepods in 2021 (Figure 3D, E). Total zooplankton biomass generally declined from the early 2000s through 2014 but has increased to near or above normal afterwards (Figure 3F). In 2021, biomass was above normal for the third time over the past five years (Figure 3F).

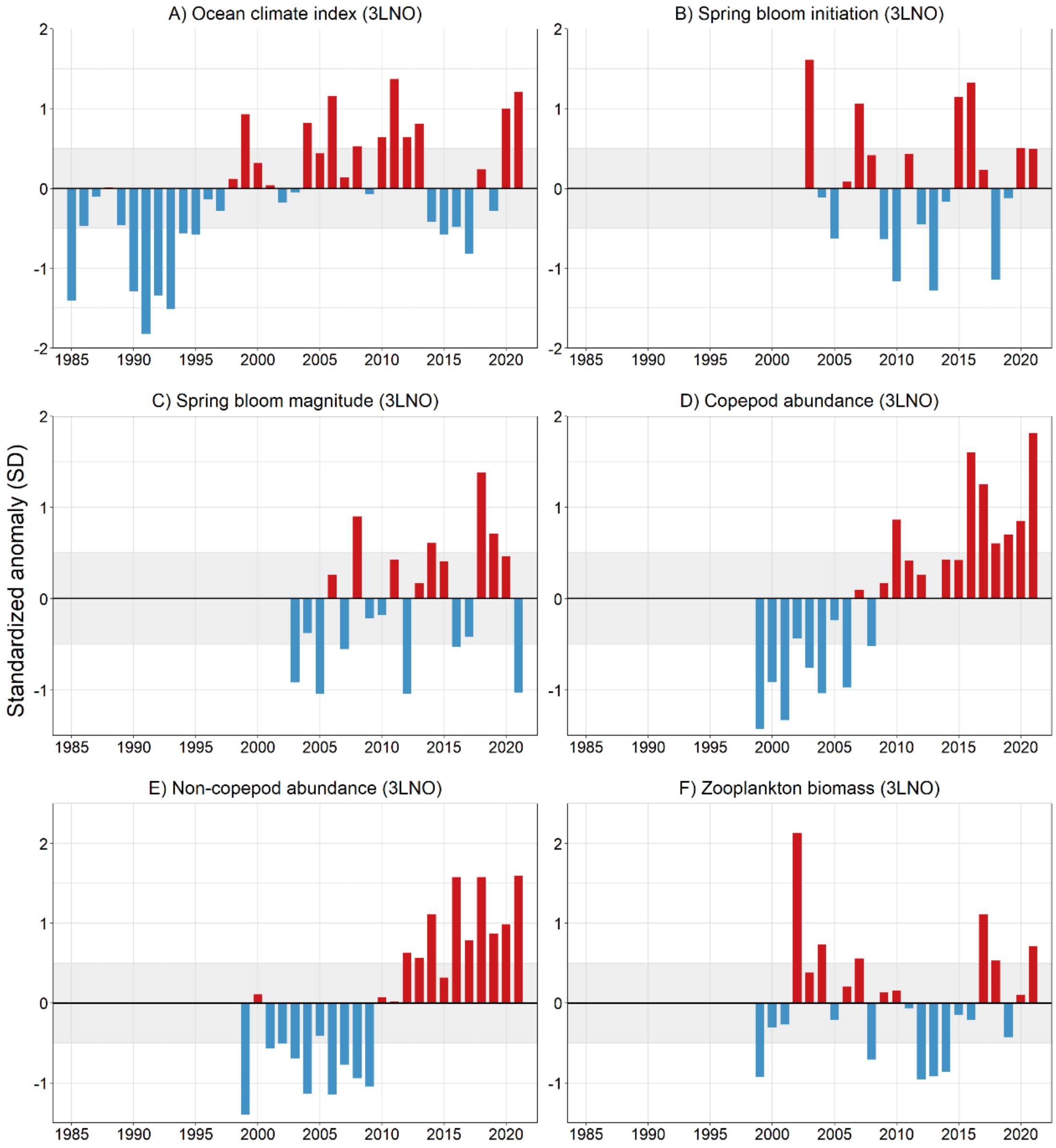


Figure 3. Annual anomalies of environmental indices for NAFO Divisions 3LNO. The ocean climate index (A) during 1985-2012 is the average of twelve individual time series of standardized ocean temperature anomalies: SSTs for Divs. 3L, 3N and 3O, vertically average ocean temperature (0-176 m) at Station 27, mean temperature and CIL volumes over standard hydrographic sections Seal Island, Bonavista and inshore Flemish Cap (FC-01 to FC-20), and mean bottom temperature in 3LNO for spring and fall (see text for details). Spring bloom anomalies (B, C) for the 2003-2020 period were averaged over two satellite boxes (NGB). Zooplankton anomalies (D-F) for the 1999-2021 period are derived from two oceanographic sections (3LN portion of FC, SEGB) and one coastal high-frequency sampling site (S27). Positive (negative) anomalies indicate late (early) bloom timing or conditions above (below) the mean for the reference period. Anomalies were calculated using the following reference periods: ocean climate index: 1981-2010, phytoplankton indices: 2003-2020, zooplankton indices: 1999-2020. Anomalies within ±0.5 SD (shaded area) are considered normal conditions.

6.4. SUBAREAS 2, 3 AND 4, NEWFOUNDLAND AND LABRADOR SHELF, SCOTIAN SHELF AND GULF OF MAINE

6.4.1. Recent Conditions in Ocean Climate and Lower Trophic Levels

- In 2021, ?? climatic index in subareas 2, 3 and 4 were all above normal, making the cumulative anomaly the warmest on record.
- Spring bloom initiation was, on average, earlier than normal in subareas 2, 3 and 4 in 2021, mostly because of the early bloom onsets observed on the Labrador Shelf (Subarea 2).
- Total spring production (bloom magnitude) was near normal in 2021 in subareas 2, 3 and 4.
- Mean copepod abundance was above normal for a second consecutive year in 2021 and particularly high in subarea 3.
- Mean abundance of non-copepod zooplankton was near-normal in 2021 after five consecutive years of above-normal observations. Abundances in subareas 3 and 4 were comparable to those observed in recent years but decreased in Subarea 2.
- Mean zooplankton biomass was near normal in 2021 but varied among regions with some of the highest values on record for subareas 2 and 3 and a time-series lowest for subarea 4..

The water mass characteristics of the Newfoundland and Labrador Shelf are typical of sub-polar waters with a sub-surface temperature range of -1-2°C and salinities of 32-33.5. Labrador Slope Water flows southward along the shelf edge and into the Flemish Pass region. This water mass is generally warmer and saltier than the sub-polar shelf waters, with a temperature range of 3-4°C and salinities from 34 to 34.75. On average bottom temperatures remain < 0°C over most of the northern Grand Banks but increase to 1-4°C in southern regions and along the slopes of the banks below 200 m. North of the Grand Bank, in Div. 3K, bottom temperatures are generally warmer (1-3°C) except for the shallow inshore regions where they are mainly <0°C. In the deeper waters of the Flemish Pass and across the Flemish Cap, bottom temperatures generally range from 3-4°C. Throughout most of the year, the cold, relatively fresh water overlying the shelf is separated from the warmer, higher-density water of the continental slope region by a strong temperature and density front. This winter-formed water mass is generally referred to as the Cold Intermediate Layer (CIL) and is considered a robust index of ocean climate conditions. In general, shelf water masses undergo seasonal modification in their properties due to the seasonal cycles of air-sea heat flux, wind-forced mixing and ice formation and melt, leading to intense vertical and horizontal gradients, particularly along the frontal boundaries separating the shelf and slope water masses.

Temperature and salinity conditions in the Scotian Shelf, Bay of Fundy and Gulf of Maine regions are determined by many processes: heat transfer between the ocean and atmosphere, inflow from the Gulf of St. Lawrence supplemented by flow from the Newfoundland Shelf, exchange with offshore slope waters, local mixing, freshwater runoff, direct precipitation and melting of sea-ice. The Nova Scotia Current is the dominant inflow, originating in the Gulf of St. Lawrence and entering the region through Cabot Strait. The Current, whose path is strongly affected by topography, has a general southwestward drift over the Scotian Shelf and continues into the Gulf of Maine, where it contributes to the counter-clockwise mean circulation. The properties of shelf waters are modified by mixing with offshore waters from the continental slope. These offshore waters are generally of two types, Warm Slope Water, with temperatures in the range of 8-13°C and salinities from 34.7-35.6, and Labrador Slope Water, with temperatures from 3.5°C to 8°C and salinities from 34.3 to 35. Shelf water properties have large seasonal cycles, east-west and inshore-offshore gradients, and vary with depth.

6.4.2. Ocean Climate and Ecosystem Indicators

A cumulative climate index for NAFO Subareas 2, 3 and 4 (from the Labrador Shelf to the Scotian Shelf) is presented in Fig. 4A. After a cold period from the late 1980s to the early 1990s, the index has remained relatively high since about the mid-2000s, with 2012 and 2006 being, respectively, the second and third warmest anomalies since 1985. After a recent return to near-normal values between 2014 and 2019 (mostly driven by cooler temperatures in Subarea 2 and 3), the index was back to a positive anomaly in 2020 and 2021, the latter year being the warmest on record for the region (since 1950, although only shown since 1985).

Mean timing of the spring phytoplankton bloom was variable across subareas 2-3-4 but remained mostly near normal from 2003 to 2020, with only two years of early (2006, 2010) and one year of late (2015) bloom onset (Fig 4B). In 2021, the mean timing of the bloom was earlier than normal, partly because of the low sea ice coverage in Subarea 2 that allowed for early bloom onsets on the Labrador Shelf (Figure 4B). Mean spring bloom production was also variable and mostly near normal throughout the time series including in 2021 (Figure 4C). Zooplankton indices in subarea 4 are normally derived from data collected along 3 oceanographic sections and one high-frequency monitoring sites. In addition to the sampling restrictions for subarea 3 highlighted in sections 6.2.2 and 6.3.2 above, technical issues related with zooplankton analysis for subarea 4 and data from the high-frequency monitoring site also limited the estimation of the indices. Mean copepod abundance generally increased from 1999 to 2005, then slightly decreased until the mid-2010s before increasing again to above-normal levels in recent years (Figure 4D). The abundance of non-copepods was near normal during most of the 2000s and increased in the early 2010s to reach above-normal levels from 2016 onwards, except for the near-normal value of 2021 (Figure 4E). The increase in copepod and non-copepod abundance over the past six years, including in 2021, was mainly driven by the conditions in Subarea 2and 3 (Figure 4D, E). Mean zooplankton biomass increased in the early 2000s to a maximum in 2002 and gradually decreased to a minimum in the mid-2010s (Figure 4F). Biomass has remained near normal since, with generally higher values in Subarea 2 and 3 compared to Subarea 4 (Figure 4F). Although mean biomass was near-normal in 2021, anomaly values for Subarea 2-4 and Subarea 4 were respectively higher and lower than those observed during the five previous years (Figure 4F).

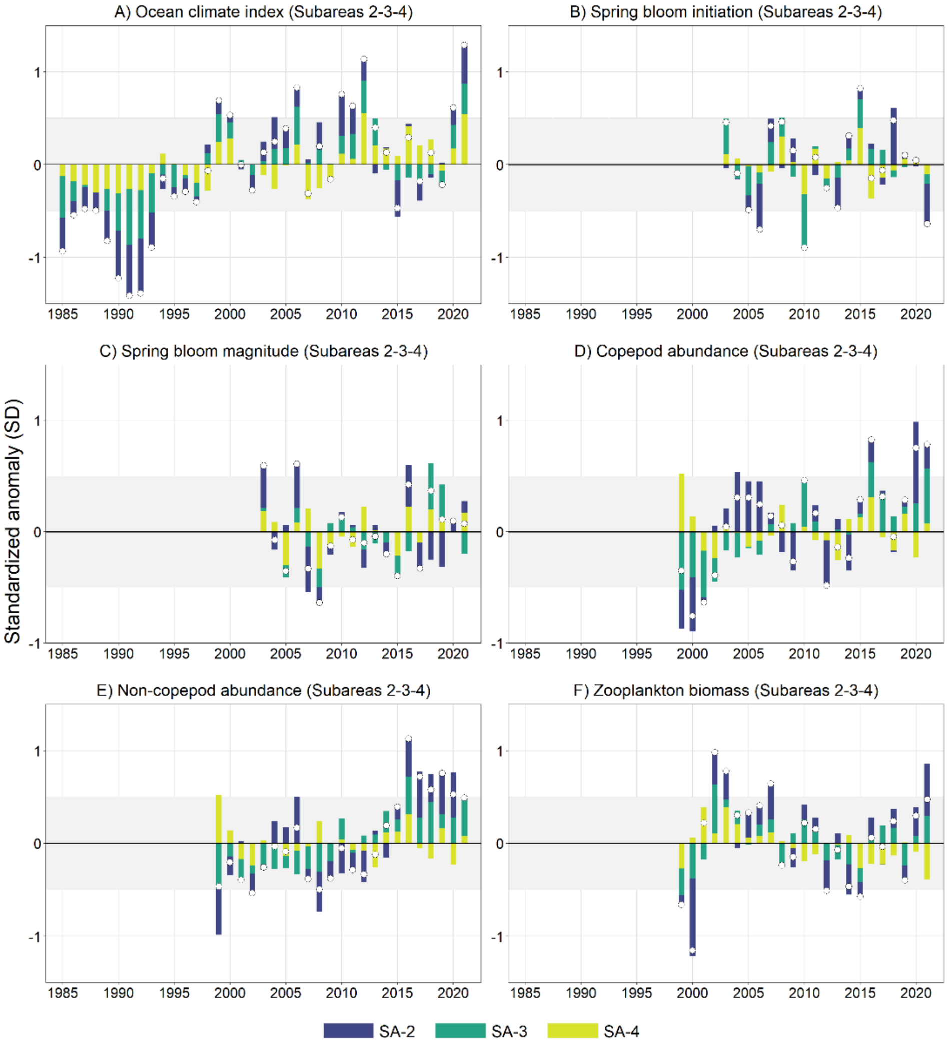


Figure 4. Annual anomalies of environmental indices for NAFO Subareas 2 to 4. The ocean climate index (A) during 1990-2020 is the average of 8, 16 and 12 individual time series, respectively, for Subarea 2, 3 and 4 (see text for details). Spring bloom anomalies (B, C) for the 2003-2020 period were averaged over two satellite boxes (NGB, SE). Zooplankton anomalies (D-F) for the 1999-2021 wee averaged over three (NLS, CLS, HB), seven (SAB, NENS, NGB, FP, FC, SES, SPB) and seven (NEGSL, NWGSL, MS, CS, ESS, CSS, WSS) ocean colour satellite boxes for Subarea 2, 3 and 4, respectively (see SCR Doc. 22/021 for more detail). Zooplankton anomalies were averaged over three sections (BI, MB, SI) for Subarea 2, three sections (BB, FC, SESG) and one high-frequency sampling site (S27) for Subarea 3, and 10 sections (TESL, TSI, TBB, TECN, TDC, TIDM, LL, HL, BBL) and four high-frequency sampling sites (R, S, P5, H2) for Subarea 4. Positive (negative) anomalies indicate late (early) bloom timing or conditions above (below) the mean for the reference period. The colour bar length indicates the relative contribution of each NAFO Subarea to the annual mean anomaly (open white circles). Anomalies were calculated using the following reference periods: ocean climate index: 1981-2010, phytoplankton indices: 2003-2020, zooplankton indices: 1999-2020. Anomalies within ±0.5 SD (shaded area) are considered normal conditions.

7. Review of the physical, biological and chemical environment in the NAFO Convention Area during 2021

a) NAFO Subarea 1. Report on hydrographic conditions off Southwest Greenland - May 2021 (SCR Doc. 22/006).

Hydrographic conditions were monitored at 4 of 10 hydrographic standard sections in May 2021 across the continental shelf off West Greenland. Three offshore stations have been chosen to document changes in hydrographic conditions off Southwest Greenland. The coastal water showed temperatures below the long-term mean south of the Sisimiut section. After some years with a relative saline Subpolar Mode Water mass, salinity dropped below its long-term mean.

b) Subareas 2, 3 and 4. Environmental and Physical Oceanographic Conditions on the Eastern Canadian shelves during 2021 (SCR Doc. 22/020).

Oceanographic and meteorological observations in NAFO Subareas 2, 3 and 4 during 2021 are presented and referenced to their long-term averages. The winter North Atlantic Oscillation (NAO) index, a key indicator of the direction and intensity of the winter wind field patterns over the Northwest Atlantic, was negative for the first time in 8 years. The majority of the environmental parameters presented in this report were above normal (defined as the average over the 1991-2020 climatological period). The air temperatures across the NW Atlantic were above normal in all regions. The sea-ice season volume and area across the Newfoundland and Labrador shelf was at its third-lowest level (after 2010 and 2011) since the beginning of the time series in 1969. Sea surface temperatures averaged over the ice-free months were normal to above normal across the different divisions and above-normal on average across the zone for the second consecutive year, at +0.9 SD. Observations from the summer AZMP oceanographic survey indicate that the cold intermediate layer area along Seal Island, Bonavista Bay and Flemish Cap section was the third-lowest since 1950. Spatially-averaged bottom temperatures in NAFO divisions 3Ps (spring) and 2J3K (fall) were at their second warmest since 1980, including a record in 3Ps. There were no spring or fall measurements in 3LNO due to limited ship availability. The transport on the Scotian Slope in 2021 remained below normal for eight consecutive years at -1.4 sd.

c) Subareas 2, 3 and 4. Biogeochemical oceanographic conditions in the Northwest Atlantic during 2021 (SCR Doc. 22/019).

This report reviews the spatial and inter-annual variation in biogeochemical indices derived from satellite observations (spring phytoplankton bloom initiation, duration and magnitude) and direct measurement of oceanographic variables (nitrate and chlorophyll-a concentration, zooplankton abundance and biomass) by the Atlantic Zone Monitoring Program (AZMP) across a network of cross-shelf sections and high-frequency monitoring sites spanning NAFO Subareas 2, 3 and 4. Spring bloom initiation, duration, and magnitude in 2021 were either near or below (i.e., earlier bloom initiation) long-term average in all subregions (EPUs or GSL) except for the late bloom timing on the Georges Bank, the longer bloom duration on the Newfoundland Shelf, and for the higher spring production on the Scotian Shelf. Mean integrated nitrate and chlorophyll inventories were also near normal in 2021. The missing data from the cancelled spring surveys certainly contributed to the negative anomalies observed on the Newfoundland Shelf and the Scotian Shelf. The abundance of copepods, more specifically that of the large, energy-rich *Calanus finmarchicus*, was generally higher in the NL Region than the Scotian Shelf and the Gulf of St. Lawrence, which was also reflected in the total zooplankton biomass index. The mean abundance of non-copepod zooplankton was above normal for a 7th consecutive year in 2021, with positive anomalies in all subregions except for the small negative anomaly on the Scotian Shelf.

d) Subareas 5 and 6. Hydrographic Conditions on the Northeast United States Continental Shelf in 2021 (SCR Doc. 22/018).

An overview is presented of the atmospheric and oceanographic conditions on the Northeast U.S. Continental Shelf during 2021. The analysis utilizes hydrographic observations collected by the operational oceanography programs of the Northeast Fisheries Science Center (NEFSC), which represents the most comprehensive, consistently sampled ongoing environmental record within the region. Overall, 2021 was characterized by warmer than average water temperatures observed across the entire Northeast U.S. Shelf. Extreme warm and salty anomalies observed in the northern Middle Atlantic Bight are linked to a shoreward displacement of the shelf-slope front. Deep (slope) waters entering the Gulf of Maine continue to be warmer and saltier than average, marking two full decades that southern source waters have dominated the slope water composition in the region. The Cold Intermediate Layer in the western Gulf of Maine was warmer than normal, while the underlying water mass was warmer and saltier than normal.

8. The Formulation of Recommendations Based on Environmental Conditions

STACFEN **recommends** *considering Secretariat support for an invited speaker to address emerging issues and concerns for the NAFO Convention Area during the 2023 STACFEN meeting.*

Contributions from invited speakers may generate new insights and discussions within the committee regarding integrating environmental information into the stock assessment process.

STACFEN **recommends** *the elaboration of a work linking the widespread oceanographic-climate changes over the Convention Area.*

STACFEN **recommends** that *further discussions occur between STACFEN and STACFIS members on environmental data integration into the various stock assessments.*

9. National Representatives

The National Representatives for hydrographic data submissions was updated by the Secretariat: E. Valdes (Cuba), Frank Oliva (Canada), **Vacant** (Denmark), **Vacant** (France), **Vacant** (Germany), **Vacant** (Japan), H. Sagen (Norway), **Vacant** (Portugal), E. Tel (Spain), L. J. Rickards (United Kingdom), and P, Fratantoni (USA), **Vacant** (Russian Federation).

10. Other Matters

No other subject was discussed.

11. Adjournment

The Chair thanked STACFEN members for their excellent contributions and the Secretariat for their support and contributions.

The meeting was adjourned at 18:30 on 10 June 2022.

APPENDIX II. REPORT OF THE STANDING COMMITTEE ON PUBLICATIONS (STACPUB)

Chair: Rick Rideout Contributor: Alexis Pacey

The Committee met at Saint Mary's University, 903 Robie St. Halifax, NS, on 6 June, 2022 at 2:45p.m., to consider publications and communications related topics and report on various matters referred to it by the Scientific Council. Representatives attended from Canada, Denmark (in respect of Faroe Islands and Greenland), European Union (Portugal, Spain, Estonia), Japan, Russian Federation, United Kingdom, and the United States of America. The Scientific Council Coordinator was in attendance as were other members of the Secretariat staff.

1. Opening

The Chair opened the meeting by welcoming the participants.

2. Appointment of Rapporteur

Alexis Pacey (NAFO Secretariat) was appointed rapporteur.

3. Adoption of Agenda

The agenda was presented at the beginning of the meeting.

4. Review of Publications

a) Journal of Northwest Atlantic Fishery Science (JNAFS)

Volume 52, Regular issue, was published online only December 2021, containing four articles. Currently, Volume 53 has one published article, three articles in review with associate editors and one in revision/re-submit stage with the authors. The decision to discontinue print volumes was made at the September 2021 SC Meeting.

b) NAFO Scientific Council Reports

The NAFO Scientific Council Reports 2021 (Redbook) volume (457 pages) was published May 2022 online. 10 Print copies were made. NAFO Scientific Council Reports 2020 (Redbook) had 10 copies printed.

c) NAFO Scientific Council Studies

There were no submissions for 2021.

d) NAFO Commission-Scientific Council Reports

These reports are found in the Meeting Proceedings of the Commission from September 2020-August 2021 (256 pages) and were posted online in December 2021. Five copies were made with a spiral binding. Fewer copies were printed due to meetings being held virtually.

e) ASFA

All SCR and SCS documents for 2021 have been submitted to ASFA as of May 31, 2022. JNAFS has also been added as of 31 May.

Many new technologies and inputting procedures took place over the last year, indexing datasets. FAO has a new online, open-access website that lists all records that were input using the new inputting software, OpenASFA, which was released in April 2021: https://www.fao.org/fishery/en/asfa. ProQuest, ASFA's publishing partner, are ingesting all indexed records from OpenASFA once per month. https://www.proquest.com/search (Login and password available through your library/institute) The old Xitami-ISIS system for inputting records is no longer being used. The Senior Pupblications/Web Manager continues to look for improvements to our ability to have easy access to reports and JNAFS articles. This has been completed and implemented. All PDFs are found in the initial article listing and below the abstract.

5. Recommendations

All recommendations were completed at the 43rd Annual Meeting, 20-24 September, 2021.

6. SCR Publication Guidelines & Monitoring

Discussions took place around the guidelines (https://www.nafo.int/Portals/0/PDFs/guidelines-SCR-docs.pdf) for the production of SCR documents, particularly the requirement for them to "be presented in person by the author or their designate, discussed at the appropriate meeting and changes requested by the Chair incorporated". It was noted that in the past few years, a small number of SCR documents that were not actually presented at a meeting had been uploaded to the NAFO public website after a meeting. This was a result of agenda items that were deferred. Since the SCR documents in question were all related to the work of Scientific Council, the publication of these documents does not necessarily constitute a major issue. However, STACPUB considered that it could result in oversight issues regarding the publication of SCR documents in the future.

STACPUB had preliminary discussions on how to ensure, in the future, that only SCR documents that are presented at Scientific Council or Scientific Council working group meetings are uploaded to the NAFO website. Various suggestions were discussed, including the possibility of having all SCRs submitted first as working papers and only converted to SCRs after they are presented. No decisions were made on this matter. It was decided that the STACPUB Chair and the Secretariat would continue discussions on the matter in the upcoming year.

7. Increased Transparency: Documentation and Working Papers

The 2018 NAFO Performance Review Panel recommended that NAFO makes all working documents publicly available, unless otherwise requested by a Contracting Party or subject to confidentiality rules. STACPUB discussed the relevance of this recommendation for SC working papers. Currently, SC working papers are treated as temporary documents intended only to be used and available for the meeting for which they are prepared. At the end of the meeting the working papers are not made accessible to the public and are also not available on a password-protected site for SC members. STACPUB concluded that the request to publish working papers was primarily an issue related to the Commission and that there was no merit or benefit to the publication of SC working papers.

STACPUB generalized SC working papers as fitting into two general categories. The first category are documents that will eventually be converted to SCR documents. Authors sometimes have not completed their SCR document(s) prior to presenting their work to SC and therefore submit their incomplete documentation as a working paper. These working papers later get converted to SCR documents when the work is completed (sometimes not until after the meeting is completed). Publishing these working papers would be a needless, and likely confusing, duplication of documentation. The second category of working papers are typically very short presentations of data (e.g. a table, figure, or short analysis) that were requested during the presentation of work to SC. Because they typically contain little or no supporting explanatory information (often no text at all), STACPUB concluded that there is a high likelihood that such working papers could be misinterpreted and should therefore not be made publicly available.

STACPUB **recommends** that *the Secretariat explore ways to make SC working papers permanently available to SC via a password-protected site.*

STACPUB also discussed the idea of a "sunset" provision, whereby only older working papers would be made public after many years. This idea was rejected for the same reasons as stated previously.

8. Figure Formats and using Rmarkdown

It was noted that some figures that are finalized and displayed in SC documents and reports could be improved to allow quicker and easier interpretation. Noted examples included bar plots that would be better represented by line plots, legends and axis labels that are too small, and lines and symbols that could be made more legible. In addition, colour could potentially be used more frequently and effectively. STACPUB will continue to discuss these things with SC and the Secretariat.

Many SC members use programs such as R to produce figures used in assessments and reports. The NAFO Secretariat, on the other hand, prefers to have figures in an editable format (e.g. Excel) to allow formatting modifications. STACPUB discussed the idea of having DEs/authors that want to use R plots work closely with the Secretariat to ensure that their R plots are created exactly to the Secretariat's specifications. This would eliminate duplication of effort for both authors and the Secretariat, particularly for those items that are created repeatedly (STACFIS reports, SC summary sheets), streamlining the whole process.

Furthermore, the benefits of using R/Rmarkdown to create and format not only the plots but to create and format the entire SCR/STACFIS/SC summary sheets would be more efficient. There would be an initial upfront cost and some training required for designated experts to utilize the program.

Paul Regular proceeded to demonstrate "NAFOdown" (SCR Doc. 21/16), an R package for creating fully formatted SCR documents, STACFIS reports (full assessment or interim monitoring report) and SC summary sheets. The program uses embedded sections of R code to render the figures, tables and text all together. It is able to render SCR documents directly into the correct, and formatted, SCR template. STACPUB discussed how the use of NAFOdown could streamline workflow, especially for documents created repeatedly by SC. It was noted that some SC members have already started using NAFOdown and have found it incredibly helpful.

Questions were raised about training, an instructional manual/video and storage of the data files. At this time, there is currently no training manual or videos, but it was noted that there is a help file. Adding references is done via BibTeX formatting, a file format that should be able to be exported from any reference database software.

9. Other Matters

a) Mailing delays and customs-duty fees

Various scientific and fishery coil-bound documents and reports that were mailed to the EU in the latter part of 2021, were delayed at customs, asking the receiver to pay duties on the package. A new requirement for receiving items of negligible value from a third party requires extra paperwork, such as a packing slip or statement indicating sender, receiver, contents, quantity and value of package. Although the NAFO documents have $0 commercial value, the packages were detained because there was insufficient paperwork to clear the package. This became a requirement on 1 July 2021, which was unknown to the NAFO Secretariat.

In future, packages will be sent either by FedEx, or if using Canada Post, a statement must be included along with the mailing slip, and a sticker containing a reference to:

Article 23 of Council Regulation (EC) No 1186/2009 (DRR). According to this provision and subject to the exceptions provided for in Article 24 of the same Regulation, any consignments made up of goods of negligible value dispatched direct from a third country to a consignee in the EU shall be admitted free of import duties. Paragraph 2 of Article 23 specifies that 'goods of negligible value' means goods the intrinsic value of which does not exceed a total of EUR 150 per consignment. https://eur-lex.europa.eu/legal-content/EN/ALL/?uri=celex%3A32009R1186

10. Adjournment

The Chair thanked the participants for their valuable contributions, the rapporteur for taking the minutes and the Secretariat for their support.

APPENDIX III. REPORT OF THE STANDING COMMITTEE ON RESEARCH COORDINATION (STACREC)

Chair: Diana González-Troncoso Rapporteur: Tom Blasdale

1. Opening

The Committee met at the Atrium Building, Saint Mary's University, on various occasions throughout the meeting to discuss matters pertaining to statistics and research referred to it by the Scientific Council. Representatives attended from Canada, Denmark (Faroes & Greenland), European Union (Estonia, Portugal and Spain), Japan, Norway, Russian Federation, United Kingdom and United States of America. The Scientific Council Coordinator and other members of the Secretariat were in attendance.

The June Scientific Council meeting was preceded by a virtual meeting on May 4, during which information on biological surveys carried out in 2021 in the NAFO Regulatory Area were presented. Future surveys for 2022 were also discussed.

2. Appointment of Rapporteur

The Scientific Council Coordinator, Tom Blasdale, was appointed as rapporteur for this meeting.

3. Review of previous recommendations from 2021 and new recommendations from 2022

i) Recommendations about surveys coverage

In 2015, STACREC **recommended** that *an analysis of sampling rates be conducted to evaluate the impact on the precision of survey estimates.* As a separate aspect, in September 2017 STACREC discussed possibilities for combining multiple surveys in different areas and at different times of the year to produce aggregate indices. In 2018, SC agreed at the September meeting that this constitutes a relevant topic for a special session, but in the future due to other commitments. In September 2019 it was agreed that a speaker on this general topic would be invited to the June 2020 SC meeting, and the STACREC chair will take the lead in arranging this invitation. However, due to the pandemic, it was not possible to have an invited speaker in June. Though, a Canadian scientist attended the ICES WKUSER (Workshop on Unavoidable Survey Effort Reduction) in January 2020 and presented information on survey coverage issues. Feedback from this meeting was presented to STACREC in May 2021.

Although having a Workshop could be useful, it would be very difficult due to the commitments that Scientific Council has for the next years. A follow-up WKUSER is planned to be held in September 2022, and a member of the Scientific Council is going to attend it. Feedback from that meeting is going to be presented to the Scientific Council in June 2023. The possibility of inviting an expert from that Workshop to the June 2023 Scientific Council meeting is going to be explored.

Linked with this, in June 2019 STACREC **recommends** the *following actions for future years whenever survey coverage issues arise*:

- *The STACREC report should contain, after the general survey presentation, a summary of the decisions and conclusions stock by stock regarding whether the survey can be used as a stock index for that year.*
- *The mean proportion (over time) of total survey biomass in the survey strata missed that year should be calculated.*
- *At this time, the following may be used as initial guidelines based on the value of the mean proportion of total survey biomass in the survey strata missed in that year:*
    - *If it is <10% : the survey index of that year is most likely acceptable.*
    - *If it is between 10% and 20% : the survey index of that year is questionable and needs to be examined carefully before deciding whether it is acceptable.*
    - *If it is >20% : the survey index of that year is most likely not acceptable. Any decision to accept it would require a clear and well justified rationale.*

In 2020, it was suggested that an added guideline might be: For age groups where there is a greater than 10% difference between total survey biomass in the survey strata missed that year in the index used (total or mean numbers), then it should be excluded from the model, if the model can handle missing values.

STACREC has discussed that point. An agreement about what the percentage for the differences in ages to be used was not agreed. A stock by stock approach, based in the result of the assessment in each case, would be preferable.

Spatio-temporal models used during the Joint ICES/NAFO shrimp benchmark in January 2022 to handle gaps in the surveys were presented by an ICES expert (F. Zimmerman, ICES 2022). More details about the presentation are in Section 7.d. These model-based survey indices are currently used for the Skagerrak-Norwegian Deep shrimp stock assessment substituting for the previous design-based indices. This type of models can handle survey gaps in one year and even missing years. From them, a biomass index, as well as gaps in the length/age distribution, can be derived. STACREC **recommends** *this type of models to be explored in the future in the NAFO Regulatory Area.*

Reference

ICES (2022) Benchmark workshop on Pandalus stocks (WKPRAWN). ICES Scientific Reports. 10.17895/ices.pub.19714204.v1.

ii) Recommendations about redfish

a) Most of the surveys conducted (except for the EU-3M survey in recent years) record redfish without separating by species and STACREC **recommended** in 2018 that *all surveys should aim to examine redfish composition at the species level, while recognizing that this may not always be achievable due to trade-offs between different activities and aims of surveys.*

This was again discussed at the 2019 meeting, where it was noted that no progress had occurred in species separation since the 2018 recommendation. There are difficulties to achieve this task that were noted in 2018 (such as the lack of an agreed methodology for species identification that all surveys would use in a consistent manner and lack of time and resources in some surveys to take on additional tasks). It was **agreed** that, as a first step, an attempt could be made at separating golden (*S. norvegicus*) from beaked (*S. mentella* and *S. fasciatus*) redfish for fish above a certain length, as this seems a relatively easy task.

During this meeting, Canada informed STACREC that a series of studies for separating redfish are made, and preliminary results are aimed to be presented during June 2023. There is not ongoing work in the rest of the surveys.

b) A preliminary compilation of information on the stock structure of redfish in Division 3O in relation to adjoining redfish stocks (Units 2, 3Ps and 3LN) was presented in the June 2019 SC meeting. It was concluded that the initial basis for delineating stock structure was weak. STACREC **recommends** *a comprehensive study to investigate redfish stock structure in NAFO Divisions 2 and 3, with consideration of species splitting and recent approaches to studying redfish stock structure in other RFMOs.*

Canada informed STACREC that some genetic studies across Divisions 2 and 3 are ongoing. In this stage, specimens of redfish are collected for genetic analysis. Preliminary results are aimed to be presented during June 2023 or 2024.

iii) Recommendations about reviewers

Reviewers attended NAFO June meetings in 2019 and 2020 to review some stocks assessed by NAFO. This year, reviewers of Tier 1 of the Ecosystem Roadmap have attended the meeting. For next year, some ideas were raised about the subjects to be reviewed, such as data poor stocks or for one of the MSEs, considering that GHL and redfish MSEs processes will be discussed next year by the SC. It is clear to STACREC that having a reviewer is a key point for improving our work.

Having a benchmark process for various stocks over time was raised, and it was recognized that it would be very useful, but it was agreed that currently, and in the near future, NAFO does not have the capacity to perform benchmarks in a regular way. One way to proceed could be having joint ICES/NAFO benchmarks incorporating NAFO stocks into the ICES benchmarks, as it is been currently performed with the Div. 3M shrimp. This is potentially a way to explore this.

It was decided to revisit this matter during the September meeting to decide which items would be interesting to be reviewed.

iv) Recommendations about future new surveys

STACREC notes that protocols from Article 4 in the Conservation and Enforcement Measures (NAFO COM Doc 21/01) do not require review of proposed survey research plans and confirmation of their scientific validity by SC. STACREC **recommended** that *the Commission amend this procedure to include a scientific review of proposed research surveys in the NRA to ensure scientific best practices are followed.*

This recommendation was covered by STACTIC (see section 7.f.).

4. Fishery Statistics

a) Progress report on Secretariat activities in 2020/2021

STATLANT 21A and 21B:

In accordance with Rule 4.4 of the Rules of Procedure of the Scientific Council, as amended by Scientific Council in June 2006, the deadline dates for this year's submission of STATLANT 21A data and 21B data for the preceding year are 1 May and 31 August, respectively. The Secretariat produced a compilation of the countries that have submitted to STATLANT and made this available to the meeting.

Some problems were raised with the submitting of the data for some countries which is being amended.

Table 1. Dates of receipt of STATLANT 21A reports for 2019-2021 and 21B reports for 2019-2021 received prior to 03 June 2022.

Country/component	STATLANT 21A (deadline, 1 May)			STATLANT 21B (deadline, 31 August)		
	2019	2020	2021	2018	2019	2020
CAN-CA	9 Jun 20					
CAN-SF	17 Apr 20	30 Apr 21	6 Jun 22	30 Aug 19	2 Jul 20	
CAN-G	14 May 20	5 May 21	27 May 22	23 Aug 19		
CAN-NL	30 Apr 20	30 Apr 21	26 May 22	4 Sep 19	31 Aug 20	31 Aug 21
CAN-Q						
CUB						
E/BUL						
E/EST	30 Apr 20	30 Apr 21	28 Apr 22	17 Dec 19	29 Jun 20	23 Aug 21
E/DNK	26 May 20	27 May 21	30 Mar 22	27 Aug 19	21 Aug 20	21 Jul 21
E/FRA						
E/DEU	18 May 20	30 Apr 21	7 Apr 22	19 Sep 19	29 Jun 20	30 Aug 21
E/LVA		26 Apr 21	21 Apr 22			
E/LTU			31 May 22	1 July 19		3 Jul 21
EU/POL						
E/PRT	29 May 20	26 Apr 21	19 Apr 22	19 Sep 19	31 Aug 20	28 Aug 21
E/ESP	14 May 20	31 May 21	14 Jun 22	12 Dec 19	24 Jun 20	7 Jun 21
GBR						
FRO	3 Jun 20	12 Jan 21	6 Apr 22	18 May 19	15 Dec 20	12 Jan 21
GRL	24 Apr 20	3 May 21	6 May 22	22 Aug 19	25 Aug 20	30 Aug 21
ISL						
JPN	8 May 20	28 Apr 21	27 Apr 22	30 Aug 19	28 Aug 20	24 Aug 21
KOR						
NOR	27 May 20	10 May 21	22 Apr 22	26 Aug 19	4 Sep 20	1 Sep 21
RUS	27 May 20	30 Apr 21	27 Apr 22			30 Aug 21
USA	4 Mar 22	4 Mar 22	25 May 22			
FRA-SP	8 May 20	21 Jun 21	26 Apr 22			
UKR						

5. Research Activities

a) Biological Sampling

i) Report on activities in 2021/2022

STACREC reviewed the list of Biological Sampling Data for 2021 prepared by the Secretariat and noted that any updates will be inserted during the summer. The SCS Document will be finalized for the September 2022 Meeting.

ii) Report by National Representatives on commercial sampling conducted

Canada-Newfoundland (SCS Doc. 22/10):

Information was obtained from the various fisheries taking place in all areas from Subareas 0, 2, 3 and portions of Subarea 4. Information was included on fisheries for the following stocks/species: Greenland halibut (SA 2 + Div. 3KLMNO), Atlantic salmon (SA 2+3+4), Arctic char (SA 2), Atlantic cod (Div. 2GH, Div. 2J+3KL, Div. 3NO, Subdiv. 3Ps), American plaice (SA 2 + Div. 3K, Div. 3LNO, Subdiv. 3Ps), witch flounder (Div. 2J3KL, 3NO, 3Ps), yellowtail flounder (Div. 3LNO), redfish (Subarea 2 + Div. 3K, 3LN, 3O, 3P4V), Northern shrimp (Subarea 2 + Div. 3KLMNO), Iceland scallop (Div. 2HJ, Div. 3LNO, Subdiv. 3Ps, Div. 4R), sea scallop (Div. 3L, Subdiv. 3Ps), snow crab (Div. 2J+3KLNO, Subdiv. 3Ps, Div. 4R), squid (SA 3), thorny skate (Div. 3LNOPs), white hake (Div. 3NOPs), lobster (SA 2+3+4), capelin (SA 2 + Div. 3KL), and marine mammals (SA 2,3, and 4). Additionally, a summary of recent stock assessments and research projects on several of marine species are included in this report.

Denmark/Faroe Islands (SCS 22/08):

A total of three Faroese commercial vessels conducted fishery operations in the NAFO Regulatory Area in 2021, mainly in subarea 3M. The fishery is conducted exclusively by longliners since 2017. Biological samples of cod are collected since 2014 (length and weight measurements). However no sampling occurred in 2021. In 2019 samples of Greenland halibut were provided to SC. The Faroese quota of cod in 3M is 22.35% of the total. Other commercial important fish species caught are Greenland halibut and Northern shrimp.

Denmark/Greenland (SCS 22/12):

Data on catch rates were obtained from trawl, gillnet and longline fisheries in NAFO Div 1A-F for American plaice, Arctic char, Atlantic halibut, Atlantic salmon, Atlantic cod, capelin, snow crab, Greenland cod, Greenland halibut, roundhead grenadier, roundnose grenadier, haddock, herring, lumpfish, polar cod, Arctic cod, deep-sea redfish, golden redfish, saithe, scallops, sea cucumber, Greenland shark, dogfish shark, Northern shrimp, skate, tusk, and wolffish. Length frequencies, from Greenland, were available for Greenland halibut trawl fishery in 1AB and 1CD, longline fishery in 1A and 1D inshore, and gillnet fishery in 1A inshore; for cod longline fishery in 1A, 1C , 1D and 1F inshore, from the gillnet fishery 1A inshore, with fishing rods in 1D, 1E and 1F inshore, and from pound nets in 1C to 1F inshore; for roundnose grenadier with a trawler in 1A and 1C offshore , for skates in a trawler in 1A offshore, and for shrimp in the trawler fishery from 1A to 1D offshore. A total of 318 length samples were taken, and 59 358 individuals, including Greenland halibut, cod, roundnose grenadier, skates and shrimp were measured, in NAFO Div. 1-F. A total of 966 otoliths in Div. 1A-F from cod, and Greenland halibut were collected. Also, 541 DNA samples in 1B to1F from cod were collected.

EU-Germany (NAFO SCS Doc. 22/17):

Data on catch rates were obtained from trawl catches for Greenland halibut in Div. 1C and 1D.

EU-Estonia (NAFO SCS Doc. 22/13):

Catch data were obtained from two fishing vessels in Subarea 3. Each vessel made two trips and spent a total of 280 fishing days in the area. The main target species were redfish, silver hake and Greenland halibut. To a lesser extent, cod, American plaice, yellowtail flounder and others, a total of 14 species were in the catches. NAFO observers sampled the length of most species and the number of samples of quota species remained comparable to the previous year.

EU-Portugal (NAFO SCS Doc. 22/13):

Data on catch rates were obtained from trawl catches for: redfish (Div. 3LMNO); Greenland halibut (Div. 3LMO) and cod (Div. 3M). Data on length composition of the catch were obtained for: cod (3LMNO); redfish (*S. mentella*) (3LMNO); Greenland halibut (3LMNO); American plaice (3LMNO); skates (thorny skate, skates spp. and smooth skate) (3LMNO); redfish (*S. norvegicus*) (3MNO); roughhead grenadier (3LMN); witch flounder (3LNO); pollock (3LNO); silver hake (3NO); yellowtail flounder (3N); white hake (3O); red hake (3M); and wolffish (*Anarhichas spp.* and *Anarhichas minor*) (3M).

EU-Spain (NAFO SCS Doc. 22/06):

A total of 9 Spanish trawlers operated in Div. 3LMNO NAFO Regulatory Area (NRA) during 2021, amounting to 1 170 days (18 296 hours) of fishing effort. Total catches based on preliminary logbook data for all species combined in Div. 3LMNO were 15 260 tons. In addition to NAFO observers (NAFO Observers Program), eight IEO scientific observer was onboard Spanish vessels during 2021, comprising a total of 350 observed fishing days, around 30% coverage of the total Spanish effort. Besides recording catches, discards and effort, these observers carried out biological sampling of the main species taken in the catch. For Greenland halibut, roughhead grenadier, American plaice and cod this includes recording weight at length, sex-ratio, maturity stages, performing stomach contents analyses and collecting material for reproductive studies. Otoliths of these four species were also taken for age determination. In 2021, 507 length samples were taken, with 66 880 individuals of different species examined to obtain the length distributions.

During 2021 there was no fishing activity of the Spanish fleet in NAFO Division 6G.

Japan (NAFO SCS Doc. 22/05):

Since 2016, one Japanese otter trawler operated in Div. 3L and 3M. The total catch including discards was 1 716 tons. Target species (main fishing Divisions) (catch) were Greenland halibut (1 253 tons) and redfish (366 tons) in 3LM. Number of size measurements in 2021 for Greenland halibut and redfish were 1 852, and 2 598 respectively. There were no catches of yellowtail flounder in 2021.

Russia (NAFO SCS Doc. 22/09):

Catch rates were available from Greenland halibut (Divs. 1ACD, 3LMN, with bycatch statistics), Atlantic cod (Div. 3LMNO), redfish (Divs. 3LN, 3M, 3O, with bycatch statistics), yellowtail flounder (Div. 3N), skates (Div. 3LMNO), American plaice (Div. 3LMNO), witch flounder (Div. 3NO), roughhead grenadier (Div. 3LM), roundnose grenadier (Div. 3LMN), white hake (Div. 3O), Atlantic halibut (3LMNO). Length frequencies were obtained from Greenland halibut (Divs. 1A, 1D, 3LMN), redfish (*Sebastes fasciatus* in Divs. 3LN), roughhead grenadier (Divs. 3LM), roundnose grenadier (Div. 3M), blue wolffish (Divs. 3LM), spotted wolffish (Div. 3N), blue antimora (*Antimora rostrata* in Divs. 3LM), black dogfish (*Centroscyllium fabricii* in Div. 3LM), threebeard rockling (*Gaidropsarus ensis* in Div. 3M), Greenland cod (Div. 3N), nezumia spp. (Divs. 3LM), Atlantic halibut (Div. 3N), American plaice (Div. 3N). Age-length distribution for Greenland halibut in Divs. 3LNO, as well as statistics on marine mammal occurrences and VME indicator species catches, are also available.

USA (SCS Doc. 22/14):

The report described catches and survey indices of 37 stocks of groundfish, invertebrates and elasmobranchs. Research on the environment, plankton, finfishes, marine mammals, and apex predators were described. Descriptions of cooperative research included a longline survey in the Gulf of Maine and Shark tagging. Other studies included age and growth, food habits, and tagging studies.

b) Biological Surveys

i) Review of survey activities in 2021 and early 2022 (by National Representatives and Designated Experts)

The May 4th 2022, meeting also reviewed the survey activities and data by contracting parties prior to the Scientific Council meeting in June and to evaluate whether the survey coverage was useful for stock assessments. The Canadian Spring and Fall surveys in Divs. 3LNO were not carried out in 2021, nor was the EU-Spain 3L survey.

Canada – Newfoundland and Labrador (SCR Doc. 22/07):

Research survey activities carried out by Canada (Newfoundland and Labrador Region) were summarized, and stock-specific details were provided. Canada-NL conducts two stratified random multispecies bottom trawl surveys per year, both using the Campelen 1800 survey trawl. In 2021, the spring multispecies survey (April 24 - May 17) covered only NAFO Subdivision 3Ps and had no coverage of Divs. 3LNO. It successfully completed 143 of the 478 planned tows (30%), covering 44 out of the 129 planned strata (34%). The spring survey fishes to a maximum depth of 732 m. The 2021 autumn RV survey (October 9 – December 15) covered portions of Divisions 2H, 2J and 3K but had no coverage of Divisions 3LNO. It successfully completed 204 out of 674 planned tows (30%), covering 85 out of 211 planned strata (43%). The autumn survey fishes to a maximum depth of 1500m in 2HJ3KL and 732m in 3NO.

The reduced coverage of the spring and autumn surveys add to a recent trend of survey coverage issues in the Canada-NL surveys, related to extensive mechanical delays, as well as COVID-19 related cancellations and complications. Coverage of deep strata in the autumn survey has typically been reduced or abandoned as one of the first responses to survey shortcomings, particularly in Div. 2H (all of the last 9 years) and Div. 3L (8 of the last 9 years), but also more recently in Divs. 2J3K (3 of the last 4 years). The complete lack of survey coverage of Divs. 3LNO in the 2020 and 2021 spring surveys and the 2021 autumn survey exacerbate recent coverage issues for this area (poor or incomplete coverage of Div. 3L in 3 of 5 years over 2015-2019). In addition to missed areas, overall survey allocations have been reduced in some or all of the survey area over the last 3 years, leading to increased uncertainty in the interpretation of survey indices. Deficiencies in these surveys impact the assessments of many groundfish and invertebrate stocks to varying degrees, uncertainties which are typically not factored into the assessment results nor management advice. Nevertheless, recent negative trends in survey indices for several Grand Bank stocks raise concern over the status of many of the fishery resources in this area and poor survey coverage results in a higher degree of uncertainty with respect to monitoring and understanding the ecosystem changes that appear to be occurring in this area. Insufficient Canadian survey coverage is impeding the ability to provide advice on the status of some stocks and EPUs.

The Canadian Coast Guard introduced two new research vessels (CCGS John Cabot, CCGS Captain Jacques Cartier) to replace the current vessels (CCGS Teleost, CCGS Alfred Needler). The new vessels arrived in 2020 but their transition into service was delayed by a series of mechanical, technical, and COVID-19 related issues. Attempts at comparative fishing began in 2021 but were generally not successful. Further attempts at comparative fishing are scheduled for 2022 and will be essential for ensuring that data collected by these new vessels can be used to extend existing data series.

STACREC noted continued concern over deficiencies in the spatial coverage of the Canadian surveys in recent years, and the potential impact on the ability to detect signal from noise in regard to evaluating trends in biomass, abundance, and biological characteristics of various species. The reduced survey coverage is generally considered to have led to increased, albeit unquantified, uncertainty with respect to the provision of scientific advice, and in some cases has prevented an evaluation of stock status. In addition to impacts on individual stock assessments, deficiencies in survey coverage also add uncertainty to the results of research on environmental (STACFEN) trends and ecosystem status, functioning and productivity (WG-ESA).

There were no Canadian surveys in Divisions 3LNO in 2021 so there are no spring or fall data points for stocks in that area. The 2021 Canadian autumn survey had partial coverage of Divs. 2J and 3K, but a number of deep-water (>750m) strata on the edge of the shelf were missed. The missed strata, typically accounted for most of the biomass index (>60%) for roughhead grenadier and therefore the 2021 autumn survey should not be used in future assessments of this stock. For Greenland halibut, the 2021 autumn survey point for Divs. 2J3K was considered acceptable since an average of <10% of the survey biomass was found in the missed strata in previous years.

Canada – Subarea 0 (SCR 22/030)

Summary of surveys in Northwest Atlantic Fisheries Organization Subarea 0, 1999-2019.

Research surveys have been conducted in NAFO Subarea 0 by Canada, using the R/V Paamiut (1999-2017) and a charter vessel C/V Helga Maria (2019). The surveys followed a depth stratified random sampling design and until 2003 sets were selected using a random number draw of grid cells within depth strata. In 2004, the independent and random placement of stations was replaced by a buffered random sampling to automatically avoid selecting stations in adjacent cells. Division 0A has been split in two at approximately 72ºN. Surveys covering depths 400-1500m using an Alfredo III bottom trawl were conducted in 0A-South (12 years), 0A-North (3 years), and 0B (7 years). During 2006-2009 a Cosmos trawl was also used to survey shallow strata (100-800 m). There were no surveys in 2002, 2003, 2005, 2018 2020 and 2021. In 2019, surveys were carried out with a chartered vessel, C/V Helga Maria fishing the Alfredo III trawl, but after examining gear performance the indices from the two vessels were not considered comparable to the remainder of the time series, particularly at depths deeper than 700 m. In 2022, surveys will be conducted with a new research vessel (R/V Tarajoq) and new trawl gear (Bacalao 476). These changes in vessel and gear provide an opportunity to expand the area and depths surveyed and improve biological sampling. It is also recommended to establish a protocol for addressing data gaps when strata are missed, and to assess the level of bias in the buffered random stratified set selection compared to other randomization methods.

Denmark/Greenland (SCR 22/06, 08, 09, 10, 11)

A hydrographic cruise was carried out across the continental shelf off West Greenland to sample 4 out of 10 standard sections onboard the Royal Danish Navy vessel Hdms Lauge Koch during the period May 19 to June 2, 2021 (NAFO 1B-F). Data from three offshore stations were taken to document changes in hydrographic conditions off Southwest Greenland (NAFO Div. 1D-F). Results were presented as Scientific Council Research Document.

The Greenland halibut gillnet surveys in 1A inshore were initiated in 2001, in the Disko Bay. The survey normally covers four transects and each gillnet set is compiled of five different nets with different mesh size (46, 55, 60, 70 and 90 mm half mesh). From 2013 to 2015, the surveys in Uummannaq and Upernavik gradually changed from longline surveys to gillnet surveys. Surveys are conducted with the R/V Sanna. In 2021, 44, 52 and 49 gillnet stations were set in Disko Bay, Uummannaq and Upernavik, respectively. Results are presented as three Scientific Research Document.

The Greenland halibut bottom trawl survey in 1D inshore (Nuuk, Ameralik and Qarajat fjords) was initiated in 2015. The survey has been conducted with the R/V Sanna equipped with a 1440 mesh bacalao trawl. The survey is bottom stratified with fixed stations (stations were selected where bottom conditions allow bottom trawling). A total of 20 valid stations were conducted in 2021. Survey results, including biomass and abundance indices for Greenland halibut, shrimp, deep-sea redfish and Golden redfish, were presented as Scientific Council Research Document.

No offshore surveys were carried out in 2021 because the new research vessel was unavailable.

EU-Spain and EU-Portugal (SCR 22/04 and 05):

Since 1995, Spain carries out annually a Spring-Summer survey in the NAFO Regulatory Area of Div. 3NO. In 2003, it was decided to extend the Spanish 3NO survey toward Div. 3L (Flemish Pass). In 2021, the 3L survey could not be carried out due to the exceptional pandemic situation caused by COVID-19.

The Spanish bottom trawl survey in NAFO Regulatory Area Div. 3NO was conducted from 29th of May to the 1st of July 2021 on board the R/V Vizconde de Eza. The gear was a Campelen otter trawl with 20 mm mesh size in the cod-end. Following the method used last year, a total of 113 valid hauls were taken within a depth range of 42-1394 m according to a stratified random design and 115 hydrographic profiles. Furthermore, a stratified sampling by length class and sex was used to sample otoliths of Atlantic cod, American plaice and Greenland halibut for growth studies. Also, gonads of Greenland halibut were sampled from histological maturity and fecundity studies. The results of this survey, including biomass indices with their errors and length distributions, as well as the calculated biomass based on conversion of length frequencies for Greenland halibut, American plaice, Atlantic cod, yellowtail flounder, redfish, witch flounder, roughhead grenadier, thorny skate and white hake are presented as Scientific Council Research Document. In addition, age distributions are presented for Greenland halibut and Atlantic cod.

The EU bottom trawl survey in Flemish Cap (Div. 3M) was carried out on board R/V Vizconde de Eza using the usual survey gear (Lofoten) from July 6th to August 15th 2021. The area surveyed was Flemish Cap Bank to depths up to 800 fathoms (1460 m) following the same procedure as in previous years. The number of hauls was 183 and three of them were null. Survey results including abundance indices of the main commercial species and age distributions for cod, redfish, American plaice, roughhead grenadier and Greenland halibut are presented as a Scientific Council Research document. Flemish Cap survey results for Northern shrimp (*Pandalus borealis*) were presented in SCR 21/047. Samples for histological assessment of sexual maturity of cod, redfish, Greenland halibut and roughhead grenadier were taken. Oceanography studies continued to take place.

VME data from the 2021 EU; EU-Spain and Portugal bottom trawl groundfish surveys in NAFO Regulatory Area (Div. 3MNO):

New data on deep-water corals and sponges were presented from the 2021 EU-Spain and Portugal bottom trawl groundfish survey. The data was made available to the NAFO WGESA to improve mapping of Vulnerable Marine Ecosystem (VME) species in the NAFO Regulatory Area (Divs. 3LMNO). Distribution maps of presence and catches above threshold for RV data of sponges (100 kg/tow), large gorgonians (0.6 kg/tow), small gorgonians (0.2 kg/tow), sea pens (1.3 kg/tow), Boltenia sea squirts (0.35 kg/tow), bryozoans (0.2 kg/tow) and black corals (0.4 kg/tow) were presented.

Sponges were recorded, with non-significant concentrations, in 85 of the 294 valid tows (28.9% of the valid tows analyzed), with depths ranging between 61 - 1345 m. Two Significant catches of sponges (≥ 100 kg/tow) were found.

Large gorgonians were recorded, with non-significant concentrations, in 8 of the 294 valid tows (2.7% of valid tows analyzed), with depths ranging between 352- 1161 m. One of the tows had significant catches of large gorgonians (≥ 0.6 kg/tow).

Small gorgonians were recorded, with non-significant concentrations, in 40 of the 294 valid tows (13.6% of valid tows analyzed), with depths ranging between 102- 1416 m. None of the valid tows had significant catches of small gorgonians (≥ 0.2 kg/tow).

Sea pens were recorded, with non-significant concentrations, in 92 tows (31.3% of valid tows analyzed), with depths ranging between 61 - 1416 m. One significant catch (> 1.3 kg/tow) was recorded.

Boltenia ovifera sea squirt was recorded, with non-significant concentrations, in 11 tows (3.7% of valid tows analyzed), with depths ranging between 50 – 315 m. Four significant catches (> 0.35 kg/tow) were recorded.

Black corals were recorded, with non-significant concentrations, in 9 tows (3% of valid tows analyzed), with depths ranging between 401 - 1221 m. No significant catches (> 0.4 kg/tow) were recorded.

All this information is summarized in an SCR Document (SCR Doc 21/050).

NEREIDA: IEO prepared a new NEREIDA Grant Proposal "Research in support of the reassessment of NAFO bottom fisheries in 2022 (NAFO)" that was send by NAFO to EU on December 1st 2021. This proposal is now under evaluation process. The proposed action has three specific activities: i) to analyze the methodology to study the bottom-fishing footprint in the NAFO Regulatory Area (NRA); ii) to monitor the spatial and temporal distribution of marine litter and iii) to update available information on spatial distribution of existing and planned activities other than fishing in NRA, particularly oil and gas.

New information on oil and gas activities: An updated map showing the geographical location of oil and gas activities in NAFO Divs. 3LMN was presented during the 2021 WGESA. This map shows the potential conflicts between oil and gas activities and NAFO fisheries, as well as between oil and gas activities and VME areas closed by NAFO (particularly, Areas 2 and 10). In comparison with the information assessed previously reported by the 2020 WGESA, there are two new "exploration wells" in Division 3L, one of them located inside NAFO fishing grounds. The lists of wells and licenses indicating their spatial location with respect to the NAFO VME closures and/or VME polygons were also presented, as well as a list of offshore oil spills and other relevant environmental incidents. All this information was obtained from publicly available data sources and summarized in a SCR Document (SCR 21/051).

USA (SCR Doc. 22/14):

The US conducted a spring survey in 2021 covering NAFO Subarea 5 and 6 aboard the FSV Henry B. Bigelow. There were 313 out of the normal 350-380 successfully completed with strata in the most southern area not covered. The fall survey successfully completed 358 stations in NAFO Subareas 5 and 6. Results are presented for a single survey for 37 stocks. The fall indices for both cod stocks are low and the stocks are exhibiting truncated age structure. Two of the three stocks of yellowtail flounder are near or at the lowest values observed.

ii) Summary of the decisions and conclusions stock by stock regarding whether the survey can be used as a stock index for 2022.

The Canadian spring and fall surveys in Divs. 3LNO were not carried out in 2021, nor was the EU-Spain 3L survey.

The 2021 Canadian autumn survey had partial coverage of Divs. 2J and 3K, but a number of deep-water (>750m) strata on the edge of the shelf were missed. The missed strata, typically accounted for most of the biomass index (>60%) for roughhead grenadier and therefore the 2021 autumn survey should not be used in future assessments of this stock. For Greenland halibut, the 2021 autumn survey point for Divs. 2J3K was considered acceptable since an average of <10% of the survey biomass was found in the missed strata in previous years.

No other problems regarding missing data with the rest of the stocks were encountered.

c) Tagging activities

A Canadian project was presented about some tagging activity. More information in section 7.c.

d) Other Research Activities

No items were reported for this section.

6. Review of SCR and SCS Documents

"A new longline based CPUE for Greenland halibut in NAFO division 1A inshore based on factory landing" (SCR 22/024)

Data quality improvements of the landing reports around 2012 has allowed for the calculation of a factory landings based CPUE from longline landings of Greenland halibut. A general linear model (GLM) with year, month, 4 vessel type (vessel, open boat, snowmobile and dogsledge) and catch area (the fieldcode) as factors was applied to the longline landings in the factory provided landing slips from 2013 to 2021. Besides providing a new independent index for stock assessment, the data reveals surprising insight in the nature of the people engaged in the fishery, climate conditions, and local differences within and between areas. Although the CPUE is based on a different source of data, the new factory landings CPUE reveals similar results as the formerly developed CPUE based on logbook reported events of longline fishery from vessels. This new CPUE is however based on a far greater number of observations and covers between 70 – 80 % of the total fishery in the areas and almost all of the longline fishery as individual fishing events. The remaining noncovered fishery is a gillnet fishery. These data and data for other species and areas, are however also available in the input data and similar analysis can be done for all fjord areas and species in Greenland.

7. Other Matters

a) Report on data availability for stock assessments (by Designated Experts).

During the 2019 STACREC meeting, it was suggested that there should be a better organized process for requesting and submitting data for stock assessment and other processes, such as National Research Reports. There was no time to discuss this again during the 2021 meeting. Some discussions were raised during this meeting. Several different issues about this were discussed. In all the cases, it was highlighted that special care has to be taken with regards to confidentiality and duplication of the data.

The second phase of the GEF-funded FAO ABNJ Deep-sea Fisheries Project was approved in April 2022 and it is aimed to start after July 2022. The project partners are the seven RFMOs (NAFO, NEAFC, GFCM, NPFC, SEAFO, SIOFA, SPRFMO), ICES, two industry groups (SIODFA, ICFA) and NOAA. The first two years will focus on: (1) data collection of "difficult-to-monitor" catch, including data-limited species, deepwater sharks, and VME indicators, (2) ecological modelling including catch and socio-economic considerations, and (3) cross-sectoral issues including OECMs. In the future, some ideas could be drawn from this project.

Types of available data and how to proceed with each:

1. Data that are in the SCR and SCS and are public.

   It was agreed that it is a good idea to make it public in the website. The way to do that is not currently clear. Protocols from ICES and USA are available and can be a good start point. This point will be investigated and reopened during the September meeting.

2. Data submitted to the Designated Experts by the National Representatives.

   These data are not public, so they cannot be shared in the NAFO website. They are submitted every year by the National Representatives to the Designated Experts. A better way to proceed could be to send these data to the NAFO Secretariat to be put in the Shared Point in some manner that every Designated Expert can access to the data that use, for example, via a tool like the STATLANT 21 database. This task can be easily implemented. The STACREC chair will prepare a protocol based on the different National Research Reports and will share it with the National Representatives to achieve a common protocol that can be used next June. This issue will be revisited in September to make a final decision about the protocol of submission.

3. Assessment data and code.

   It was agreed that having the data and the code of the different assessments run in NAFO would be very useful for reproductive purposes. Some if these data are already available in GitHub. The way to store the data, in the GitHub or in the NAFO Share Point, remains open for being discussed in future meetings.

4. Data that belongs to the Contracting Parties and are sent to NAFO.

   These data are not a NAFO matter. Each Contracting Party has its own protocols about the submission of the data. The only way to proceed is to have a link in the NAFO website to the data that are public and available for each Contracting Party.

b) Annual submissions of information to NAFO: National Research Reports, Inventories of biological surveys, List of biological sampling data, List of tag releases, RV surveys on a stock by stock basis.

Discussions on the above information has been ongoing for the past two years and further discussion continue during this meeting.

A first request was to convert *SC Request for Info* pdf (NAFO 22/121) into a fillable pdf. This will be done by the Secretariat to next year (April 2023).

<u>National Research Reports</u>: STACREC concluded that these reports are useful, and they should continue to be produced. Following the conclusion reached in section 7.a., once the format of the National Research Report is agreed, NAFOdown will be used to produce all the National Research Reports. Canada has already used NAFOdown to prepare the Canadian National Research Report, that are based on the Spanish and Portuguese Research Reports, so that code can be modify to the new data format.

<u>List of biological sampling data</u>: This information is annually collated into an SCS document in Excel format. It was concluded that there is utility in the information provided in the current tables and in having the information publicly available as is the case with the current SCS document. No changes were suggested at this stage.

<u>RV surveys on a stock by stock basis</u>: STACREC will continue to develop a format for these tables. It was agreed in 2019 that STACREC members preferred Excel spreadsheets rather than text files.

<u>Inventories of biological surveys</u>: This information is annually collated into an SCS document in Excel format. It was concluded that there is utility in the information provided in the current tables and in having the information publicly available as is the case with the current SCS document. No changes were suggested at this stage.

c) Tagging and telemetry of Greenland Halibut (NAFO DA 2+Div. 3KLMNO, SA0) and witch Flounder (NAFO Div. 2J3KL).

An overview of a new telemetry research project being undertaken by Fisheries and Oceans Canada was provided to STACREC. This program (2021-2025) is examining the movement ecology of Greenland halibut and witch flounder, and aim to quantify seasonal and inter-annual movements of these species in the context of habitat use, migration, and stock and survey boundaries. This work began in 2021 with the release of 133 witch flounder and 73 Greenland halibut with acoustic transmitters. Three deep water receivers were also deployed at the shelf edge of NAFO Divs. 2J and 3K, extending the existing receiver gates at these locations from 500m to 750m depth. To date in 2022, 51 additional transmitters and 40 pop-off archival satellite tags (PSATs) have been deployed in Greenland halibut captured near the shelf edge at the NAFO 3KL boundary.

Additional acoustic transmitter deployments (50 witch flounder in NAFO 2J3KL, 50 Greenland halibut across NAFO SA2+3K, and 50 Greenland Halibut in SA0), and further expansion of the acoustic array are planned for 2022-2023. PSATs will record information on depth and temperature use, and are expected to return data (including tag pop-off location) at timed intervals between July 2022 and March 2024.

This program also aims to advise on mitigation strategies to reduce Greenland shark bycatch in the Greenland halibut fishery based on spatial and temporal overlap in movement patterns. In 2022, one Greenland shark was tagged opportunistically with a pop-off archival tag.

Updates on project progress and analyses will be regularly shared with SC, with results anticipated at the 2024 or 2025 SC meeting.

d) Presentation of the methods used during the WKPRAWN 2022 ICES benchmark to avoid gaps in the surveys (presented by Fabian Zimmermann).

During the WKPRAWN 2022 ICES benchmark (ICES, 2022) of the two NIPAG stocks northern shrimp (*Pandalus borealis*) in divisions 3.a and 4.a East (Skagerrak and Kattegat and northern North Sea in the Norwegian Deep) and northern shrimp (*Pandalus borealis*) in subareas 1 and 2 (Northeast Arctic), the survey indices for both stocks were re-evaluated due to issues in the survey time series, notably in the survey coverage. The outcome of the benchmark process was presented, detailing the transition from design-based survey indices to model based approaches using generalized additive mixed effects models that include spatio-temporal correlation through Gaussian Markov random fields. Several different R packages were tested, resulting in a new biomass index for shrimp in subareas 1 and 2 implemented in sdmTMB and a biomass index as well as a length-based index implemented in sdmTMB (Anderson *et al.*, 2022) and a model framework optimized for handling length structure (Breivik *et al.*, 2021), respectively. The new indices in both stocks have been accepted and replace the previous design-based indices in the assessment. The results of the benchmark show that modelling approaches accounting for spatio-temporal correlation are suitable to deal with incomplete survey coverage in a statistically appropriate way that avoids ad-hoc solutions. Furthermore, the possibility to determine links with environmental covariates, random effects, conduct model selection, estimate uncertainty and handle data that does not follow random sampling were highlighted.

References

Anderson, S.C., Ward, E.J., English, P.A. & Barnett, L.A.K. (2022) sdmTMB: an R package for fast, flexible, and user-friendly generalized linear mixed effects models with spatial and spatiotemporal random fields. bioRxiv, 2022.2003.2024.485545. 10.1101/2022.03.24.485545.

Breivik, O.N., Aanes, F., Søvik, G., Aglen, A., Mehl, S. & Johnsen, E. (2021) Predicting abundance indices in areas without coverage with a latent spatio-temporal Gaussian model. ICES Journal of Marine Science, 78, 2031-2042. 10.1093/icesjms/fsab073.

ICES (2022) Benchmark workshop on Pandalus stocks (WKPRAWN). ICES Scientific Reports. 10.17895/ices.pub.19714204.v1.

e) Faroese survey in Division 3M targeting cod.

In June 2021 the Faroe Marine Research Institute conducted a scientific survey in NAFO Division 3M. This survey was presented by the Faeroe Islands as a complement to the EU Div. 3M bottom trawl research survey. In principle, a longline survey may provide additional information on the ecosystem in 3M. However, STACREC noted that the proposed survey design was insufficient (e.g. lack of proper consideration of number of hooks, stratification, catchability) to consider this as a valid scientific survey; an appropriate survey design, together with objectives and detailed survey protocols, is required to properly assess the potential scientific value of the data collected.

Moreover, in September 2021, STACREC was made aware that the catch from this survey totalled 630 t, accounting for removals equal to roughly 42% of the TAC of 1 500 t. For context, the EU bottom trawl survey of Div. 3M, which constitutes the most important fishery independent data for the assessment, caught about 7 t in total of cod in 2021. This indicates that the Faroe Islands longline survey is not optimized for the collection of information with minimum impact, as would be the case for a typical scientific survey.

With the information currently available, STACREC considered that this initiative does not fulfil the requirements of a valid scientific survey and more closely resembles a commercial fishery.

A statement was made during September 2021 by Denmark/Faroes Islands regarding this issue:

FAMRI (Faroese marine research institute) considers the survey carried out in NAFO 3M as a scientific survey. The aim and objective of the survey was to get an indication of the cod stock with an alternative gear and build a time series which can potentially be incorporated to the assessment. The survey followed a random-stratified design with 101 longline sets of 6 000 hooks each covering the shallow area (< 600 m) on Flemish Cap. The spatial location of the stations was as close as possible to those of the EU-survey. Thus, the survey coverage didn't not resemble the fishery distribution. In addition temperature recording devices were also employed in every set.

The protocol for sampling was the random selection of 30 cod individuals on every station for further biological measurements such as length, weight and age readings. In addition, samples of other fish species caught in the survey were also collected. A total of 1 009 length, 1 008 weight and 1 005 otoliths (age-readings) measurements were collected.

For 2022 another longline vessel will carry out the survey in NAFO 3M following the same protocol as that of 2021.

During this meeting, an SCS was submitted by Denmark/Faroe Islands with the results of the survey (SCS Doc. 22/08): A Faroese longline survey was carried out in NAFO 3M during the months of June and July in 2021. The aim and objective of the survey was to get an indication of the cod stock with an alternative gear and build a time series which can potentially be incorporated to the assessment. The survey followed a random-stratified design with 101 longline sets of 6 000 hooks each covering the shallow area (< 600 m) on Flemish Cap. The protocol for sampling was the random selection of 30 cod individuals on every station for further biological measurements such as length, weight and age readings. In addition, samples of other fish species caught in the survey were also collected. A total of 1 009 length, 1 008 weight and 1 005 otoliths (age-readings) measurements were collected.

In 2022 another longline vessel will carry out the survey in NAFO 3M following the same protocol as that of 2021, but in 2022 the catch of 3M cod taken during the survey will be removed off the Faroes quota for this species.

STACREC reiterates the concerns about this study being a survey and, again, **considered** that this initiative does not fulfil the requirements of a valid scientific survey and more closely resembles a commercial fishery.

f) Comment to the STACTIC request about revising Article 4 of the NAFO Conservation and Enforcement Measures (NAFO Com Doc. 22-01).

During the SC meeting, a request to the SC chair was raised by the STACTIC chair to provide comments on the following draft proposal for amending to the Article 4 of the NAFO Conservation and Enforcement Measures:

Proposal

To better regulate the use of commercial vessels for research activities and to ensure that these activities are compatible with other NAFO management measures, it is proposed to amend Article 4(3)(b), to insert a paragraph 4 in Article 4, to renumber the subsequent paragraphs of Article 4 accordingly, and to include the notifications under paragraphs 3-5 in the information to be posted by the NAFO Executive Secretary in the NAFO website:

Article 4 – Research Vessels

3. No less than seven days prior to the commencement of a fishery research period, the flag State Contracting Party shall:

> *(a) by electronic transmission in the format prescribed in Annex II.C, notify the Executive Secretary of all research vessels entitled to fly its flag it has authorized to conduct research activities in the Regulatory Area; and*
>
> *(b) provide to the Executive Secretary a Research Plan for all vessels entitled to fly its flag it has authorized to conduct research, including the purpose, location****, whether the catches obtained during the research activity will be prepared for market in any manner*** *and, for vessels temporarily engaged in research, the dates during which the vessel will be engaged as a research vessel.*

4. Unless otherwise approved by the NAFO Scientific Council, each Contracting Party shall ensure that its research vessels preparing for market the catches obtained during research activities in the Regulatory Area comply with all recording and reporting requirements in the CEM and that those catches are counted against the quota or fishing effort limitations set out in Annex I.

[…]

Duties of the Executive Secretary

8~~*7*~~*. Following notification****s*** *in accordance with paragraph****s*** *3****, 4 and 5***~~***(a)***~~*, the Executive Secretary without delay posts the names of all research vessels in the vessel registry to the NAFO website and includes in such posting any supporting documents* ***and the information*** *provided by the flag State Contracting Party, including the Research Plan.*

After some discussion, STACREC agreed the following response:

STACREC reviewed a letter sent to SC from STACTIC, which requested a review of proposed amendments to Chapter I, Article 4 of the NAFO CEM ("Research Vessels"). There was considerable discussion and agreement on the need to have clarity in distinguishing research and commercial activities. It was noted that there are some research programs which can be executed in partnership with commercial activities on fishing vessels (e.g. tagging of species for scientific studies during a commercial fishing trip). Instead of providing a detailed review and providing comments on the proposed NCEM amendments, SC decided a more pragmatic approach would be to highlight some considerations which may further the general applicability of Article 4 to both address current concerns and ensure future activities are consistent with typical scientific practice.

This could be accomplished by including the following considerations:

- For new proposals for survey/research activities in the NAFO Regulatory Area, the NCEM should treat such requests similar to Exploratory Bottom Fishing, including the requirement to submit advance notice of intent to conduct activities, similar to the protocols and requirements for Exploratory Bottom Fishing (NCEM Chapter II, Articles 18-21). A key element for new or proposed activities would be provision of a detailed protocol for the planned research, to be reviewed by SC during its next regularly scheduled meeting (i.e. June or September). STACREC would include an evaluation of the merits of the work in its report which would also be presented to the Commission.
- Retained catch from any research activity (new or existing) conducted by CPs must be included in STATLANT 21 data, and with appropriate accounting from relevant quota(s).

Further, SC noted that "Research Plans" as referenced in NCEM I.4 are presently undefined but some minimum requirements are given in Article 4, 3(b):

"provide to the Executive Secretary a Research Plan for all vessels entitled to fly its flag it has authorized to conduct research, including the purpose, location and, for vessels temporarily engaged in research, the dates during which the vessel will be engaged as a research vessel"

This could be revised to become a self-standing clause in Article 4:

"CPs must provide the Executive Secretary [at some advance timing interval to be decided by STACTIC] a Research Plan for vessels engaging in scientific research which must include:

Vessel Name, Purpose, Summary of Scientific Methods or Procedures, Location, Dates of Research Activity, and Principal Investigator. The Research Plan should also indicate the anticipated time frame for when research results would be presented to the Scientific Council.”.

Prior to, or in the absence of any amendments to the NCEM, SC welcomed CP proposals on proposed research which could be reviewed at future STACREC meetings.

8. Adjournment

The meeting was adjourned on June 16, 2022.

APPENDIX IV. REPORT OF THE STANDING COMMITTEE ON FISHERIES SCIENCE (STACFIS)

Chair: Mark Simpson Rapporteurs: Tom Blasdale

I. OPENING

The Committee met from 3 June to 16 June 2022 to consider and report on matters referred to it by the Scientific Council, particularly those pertaining to the provision of scientific advice on certain fish stocks. Representatives attended from Canada, Denmark (in respect of Faroe Islands and Greenland), the European Union, Japan, Norway, the Russian Federation, the United Kingdom, and the United States of America. Observers from Sustainable Fisheries Greenland, Oceans North and the Food and Agriculture Organization of the United Nations were also present. The Executive Secretary, Scientific Council Coordinator and other members of the Secretariat were in attendance. The Chair, Mark Simpson (Canada) opened the meeting by welcoming participants. The agenda was reviewed and a plan of work developed for the meeting in accordance with the Scientific Council plan of work. The provisional agenda was adopted with minor changes. Owing to the limited time available during the meeting, it was not possible to consider drafts of all report sections in plenary. As in previous years, designated reviewers were assigned for each stock for which an interim monitoring update was scheduled (see SC Report). Following presentation and discussion of Full assessments, Designated Experts produced drafts of their respective report sections which were reviewed in plenary.

II. GENERAL REVIEW

1. Review of Recommendations in 2020 and 2021.

STACFIS agreed that relevant stock-by-stock recommendations from previous years would be considered during the review of a stock assessment or noted within interim monitoring report as the case may be and the status presented in the relevant sections of the STACFIS report.

2. General Review of Catches and Fishing Activity

The NAFO Secretariat presented the catch estimates developed by CESAG in COM-SC CESAG-WP 22-01REV and made the supplementary data that went into the analyses available for SC to review. The Secretariat noted that the catches were estimated based on the strategy outlined in Annex 1 of COM-SC Doc. 17-08, amended following a recommendation from STACFIS in 2018, to include catch estimates of broken down by quarter and gear type. It was also noted that a number of contracting parties had not submitted catch submissions for 2021 at the time of the meeting, therefore many of the STATLANT 21A catches reported in the catch tables in this report should be considered provisional.

3. External Review.

Due to the difficulties caused by the COVID-19 pandemic, the SC executive decided not to have an external reviewer in 2022.

III. STOCKS ASSESSMENTS

A. STOCKS OFF GREENLAND AND IN DAVIS STRAIT: SUBAREA 0 AND SUBAREA 1

Recent Conditions in Ocean Climate and Lower Trophic Levels

- The ocean climate index in Subarea 0-1 above normal in 2021.
- Mean initiation timing of the spring phytoplankton bloom in 2021 was the earliest of the time series.
- Spring bloom magnitude (total production) was slightly below normal in 2021

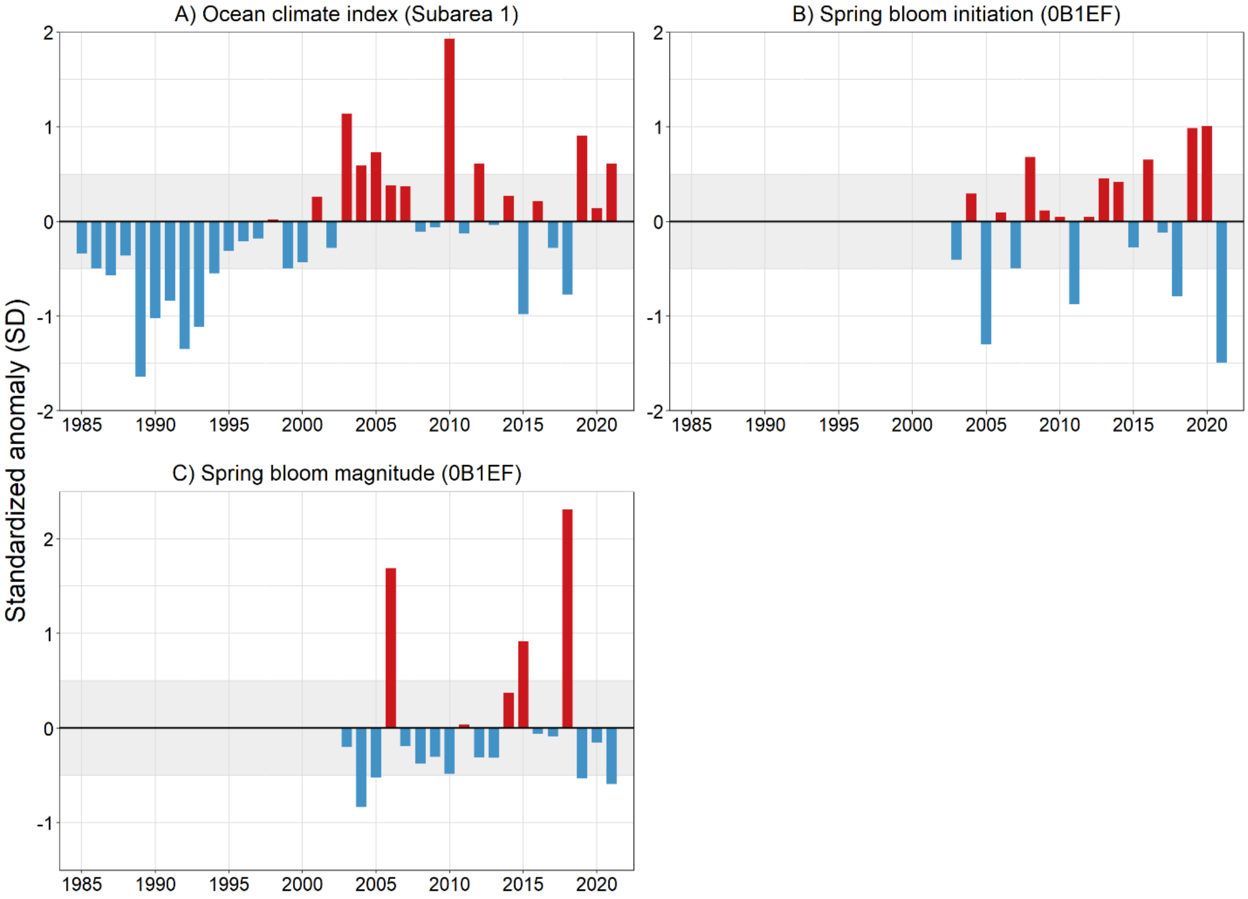


Figure A1. Annual anomalies of environmental indices for NAFO Subareas 0 and 1. The ocean climate index (A) for the period 1990-2020 is the average of 10 individual time series. These includes standardized anomalies of 4 SSTs time series, 4 temperature time series at 3 hydrographic stations and 2 air temperatures time series (see Cyr and Belanger 2022 for details). Spring bloom anomalies (B, C) for the 2003-2021 period are derived from four satellite boxes (HS, NLAB, CLAB, GS – see Cyr and Belanger 2022 for details). Positive (negative) anomalies indicate late (early) bloom timing or magnitude above (below) the mean for the reference period. Anomalies were calculated using the following reference periods: ocean climate index: 1981-2010, spring bloom indices: 2003-2020. Anomalies within ± 0.5 SD (shaded area) are considered near-normal conditions.

Environmental Overview

Hydrographic conditions in this region depend on a balance of ice melt, advection of polar and sub-polar waters and atmospheric forcing, including the major winter heat loss to the atmosphere that occurs in the central Labrador Sea. The cold and fresh polar waters carried south by the east Baffin Island Current are counter balanced by warmer waters are carried northward by the offshore branch of the West Greenland Current (WGC). The water masses constituting the WGC originate from the western Irminger Basin where the East Greenland Currents (EGC) meets the Irminger Current (IC). While the EGC transports ice and cold low-salinity Surface Polar Water to the south along the eastern coast of Greenland, the IC is a branch of the North Atlantic current and transports warm and salty Atlantic Waters northwards along the Reykjanes Ridge. After the currents converge, they turn around the southern tip of Greenland, forming a single jet (the WGC) that propagates northward along the western coast of Greenland. The WGC is important for Labrador Sea Water formation, which is an essential element of the Atlantic Meridional Overturning Circulation. At the northern edge of the Labrador Sea, after receiving freshwater input from Greenland and Davis Strait, part of the WGC bifurcates southward along the Canadian shelf edge as the Labrador Current.

Ocean Climate and Ecosystem Indicators

The ocean climate index in Subarea 0-1 has been predominantly above or near normal since the early 2000s, except for 2015 and 2018 that were below normal (1A). After being in 2019 at its highest value since the record high of 2010, the index was normal in 2020 and again above normal in 2021. Before the warm period of the last decade, cold conditions persisted in the early to mid-1990s.

Spring bloom initiation has been oscillating between early (negative anomalies) and late (positive anomalies) timing between 2003 and 2020. In 2021, the average timing of the spring bloom in Subarea 0B1EFT was the earliest of the time series and followed the two latest bloom onset on record for the region (Figure A1B). Spring bloom magnitude (total production) remained mostly below or near-normal between 2003 and 2020 with the exception of a few highly productive bloom in 2006, 2015 and 2018 (Figure A1C). In 2021, mean bloom magnitude in the region was slightly higher than normal (Figure A1C).

1. Greenland Halibut (*Reinhardtius hippoglossoides*) in Subarea 0 and 1 (Offshore)

(SCR Doc. 22/022, 22/023, 21/014; SCS Doc. 22/009, 22/012)

a) Introduction

The Greenland halibut stock in Subarea 0 and 1 (offshore) is part of a larger population complex distributed throughout the Northwest Atlantic (Roy et al. 2014). The fishery distribution includes Canadian (SA0) and Greenland (SA1) offshore waters. Canada and Greenland manage the fisheries independently and request advice from NAFO SC. The fishery came under quota regulation in 1976 when a TAC of 20,000 t was established. TAC was increased to 25,000 t in 1979. In 1994 analysis of tagging and other biological information resulted in the creation of separate management areas for inshore Div. 1A. The portion of the TAC allocated to Subarea 0+1A (offshore) and 1B-F was set at 11 000 t and the TAC remained at this level from 1995-2001, during which time the TAC was fished almost exclusively in Div. 0B and Div. 1CD. A series of surveys took place during 1999-2004 in areas of Div. 0A and 1AB that had not been surveyed before resulting in an expansion of the fishery into these northern divisions between 2001 and 2006. In 2020 studies of parasites, analysis of historic taggings and fishery data resulted in the creation of separate management areas for inshore Div. 1B-F (SCR Doc. 20/034).

The assessment is qualitative, and since 2014 has been based on an index of survey biomass that combines Divisions 0A-South and 1CD surveys (ICES 2013). The surveys are conducted by the same vessel and gear during the fall which allows for a combination of the survey results. An index based harvest control rule was accepted as the basis for TAC advice in 2016 and 2018.

The vessel that conducted surveys from 1997 to 2017 was retired in 2018 and a new research vessel built by the Greenland Institute of Natural Resources will begin a new survey time series in 2022. No survey was conducted in 2018, 2020 and 2021. A commercial vessel was used for the 2019 survey. This change in vessel had an effect on gear performance such that the 2019 index is not directly comparable to previous years. Also, earlier timing for the 0A-South survey in 2019 introduced additional uncertainty to the comparability of this index. Assessment and advice in 2020 and 2022 were based on a qualitative review of available survey and fisheries data. The absence of a continuous survey series limits the assessment and STACFIS may be unable to evaluate the impact of the advised TAC.

Fishery and Catch: Bottom otter trawl gear is used by most fleets in the Subarea 1 fishery. There have been longline vessels occasionally in the offshore, however gillnet gear is not allowed. The Subarea 0 fishery is a mix of trawl and gillnet (between 30-40% of the catch in recent years) with the occasional use of longline. The trawlers in both Subareas have been using both single and double trawl configurations since about 2000. The gillnet fishery in Subarea 0 began in 2005 and has been using baited gillnets since about 2015. Baiting gillnets has been shown to increase catch rates (Bayse and Grant 2020).

Catches were first reported in 1964 and rose to 20,027 t in 1975 before declining to 2,031 t in 1986. Catches increased from 1989 to 1992 (reaching a level of 17,888 t) due to a new trawl fishery in Div. 0B with participation by Canada, Norway, Russia and Faeroe Islands and an expansion of the 1CD fishery with participation by Japan, Norway and Faeroe Islands. Catch declined from 1992 to 1995 primarily due to a reduction of effort by non-Canadian fleets in Div. 0B. Since 1995 catches have been near the TAC, increasing in step with increases in the TAC. Since 2019 the TAC has been 36,400 t. In 2021 catches were 36,436 t (Figure 1.1).

Fisheries and Oceans Canada does not include the J-cut and tail off product in its product list for Greenland halibut, however, the majority of the catch in this fishery (~90%) is processed as this product. An interim conversion factor (CF) of 1.49 was therefore provided in at-sea observer manuals and used by vessel operators and observers since 2007. In 2021, the CF for J-cut, tail off product was lowered by Canadian authorities from 1.49 to 1.4. Based on a review of at-sea observer experiments conducted in Subarea 0 the appropriate value to estimate round weight from J-cut, tail off, dressed weight is 1.5, which is comparable with J-cut, tail off CF values used by other countries that fish in the SA0+1 stock area (SCR Doc. 22/023). The catch in SA 0 for 2021 was adjusted accordingly.

Recent catch and TACs ('000 t):

	2013	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**
TAC	27	30	30	30	32.3	32.3	36.4	36.4	36.4	36.4
STACFIS SA 0	13.4	14.9	15.4	14.1	15.9	16.0	18.3	17.9	19.1[2]	
STACFIS SA 1	13.5	14.7	14.9	15.2	16.2	16.2	18.0	18.1	17.3	
Total STACFIS[1]	26.9	29.6	30.3	29.3	32.1	32.2	36.3	36.0	36.4	

[1] Based on STATLANT, with information from Canada and Greenland authorities to exclude inshore catches.

[2] STACFIS estimate using 1.5 conversion factor for J-cut, tailed product; 1,129 t increase over reported catch.

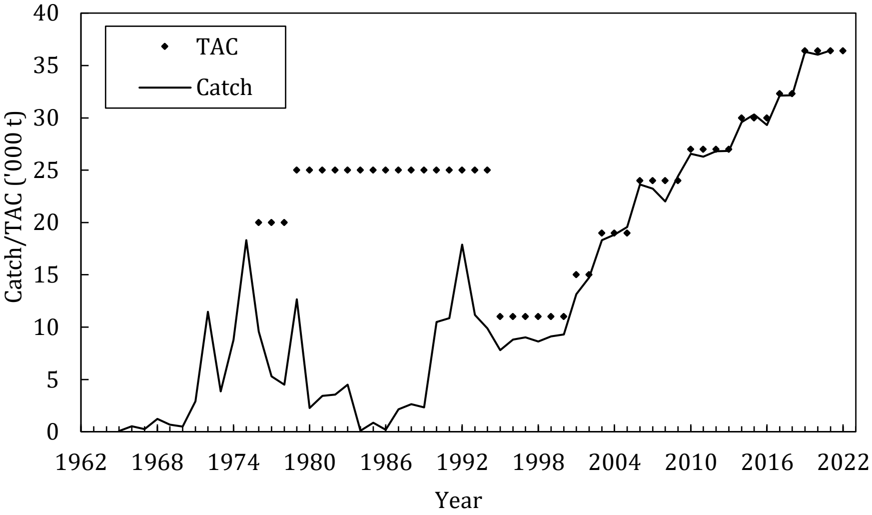


Figure 1.1. Greenland halibut in Subarea 0 and 1 (offshore): catches and TACs.

b) Data Overview

i) Commercial fishery

Length frequencies were available for 2021 from Greenland trawl fisheries in Div. 1AB, , Greenland, German, trawl fisheries in Div. 1CD, and from Canadian gillnet and trawl fisheries in Div. 0AB.

Length frequency data have been combined to produce an overview for the SA0+1 trawl fleets and the SA0 gillnet fleet. Modal length for the trawl fleets has varied from 49 to 51 cm and since 2014 the mode has remained above 50 cm. Modal length in the SA 0 gillnet fleet was approximately 61 cm prior to 2014 and since then has declined to about 56 cm observed in 2021.

ii) Research surveys

In the past, surveys were conducted by Russia and the Federal Republic of Germany in 0B (1987-1992) and by Greenland and Japan in 1BCD (1987-1995). Greenland and Canada began conducting surveys in 1997 and 1999, respectively (Figure 1.2).

Greenland Surveys (Div. 1CD)– Buffered stratified random bottom trawl surveys conducted during fall from 400 to 1500 m, from 1997-2017, and in 2019. Biomass in 1CD fluctuated with a slight positive trend through most of the time series (Figure 1.2). In 2017, biomass was similar to levels seen in 2015 and 2016. There were no surveys in years 2018, 2020 and 2021. The 2019 estimate is not comparable to previous values.

Canada Surveys (Div. 0A-South and occasionally in 0B and 0A-North**) –** Buffered stratified random bottom trawl surveys conducted during fall from 400 to 1500 m, in 1999, 2001, every second year between 2004 and 2014, annually to 2017 and in 2019. Biomass in Div. 0A-South varied with an increasing trend from 1999 to 2016 followed by a marked decline in 2017 (Figure 1.2). Biomass in Div. 0B in 2016 was similar to a previous high observed in 2011. There were no surveys in years 2018, 2020, and 2021. The 2019 0A-South estimate is not comparable to previous values.

Combined 0A-South and 1CD Surveys - In 2014 STACFIS adopted a recommendation from the ICES Greenland halibut benchmark meeting (ICES 2013) to create a combined survey index with which to monitor the overall Subarea 0+1 (offshore) stock. The surveys are conducted with the same vessel and gear during the fall which allowed for simple addition of the survey estimates to create the index. The biomass index had remained stable at a relatively high level during 1999-2012 and therefore, based on Precautionary Approach Framework guidance from NAFO SC for stocks assessed using an index (SCS Doc. 04/12), the average over this period was accepted as a proxy for $B_{MSY,}$ and B_{lim} was set as 30% of the proxy $B_{MSY.}$ The index increased between 2014 and 2016 and while it declined in 2017 it remained well above B_{lim} (Figure 1.3). Abundance followed a similar trend. The decline observed in 2017 was a result of a decline in 0A-South. The 2019 value is similar in magnitude to previous surveys, however, it is not considered directly comparable for use in provision of advice.

The length distribution for 0A-South and 1CD surveys combined ranged from about 5 cm to 100 cm. Modal lengths have shifted from 42-43 cm at the beginning of the time series to a high of 51 cm in 2015. Secondary modes were clearly present in 2008 and 2012-2017.

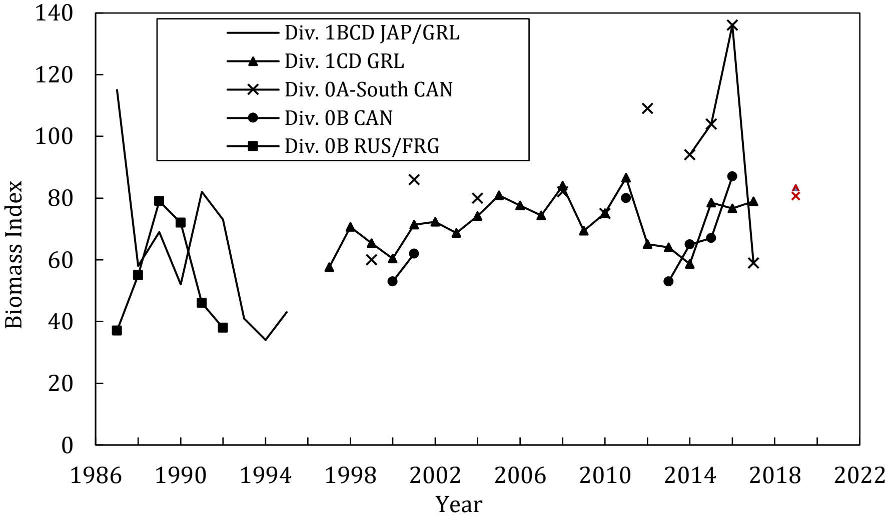


Figure 1.2 Greenland halibut in Subarea 0 and 1 (offshore): biomass indices from bottom trawl surveys. A survey in Div. 0A in 2006 is not included due to poor coverage.

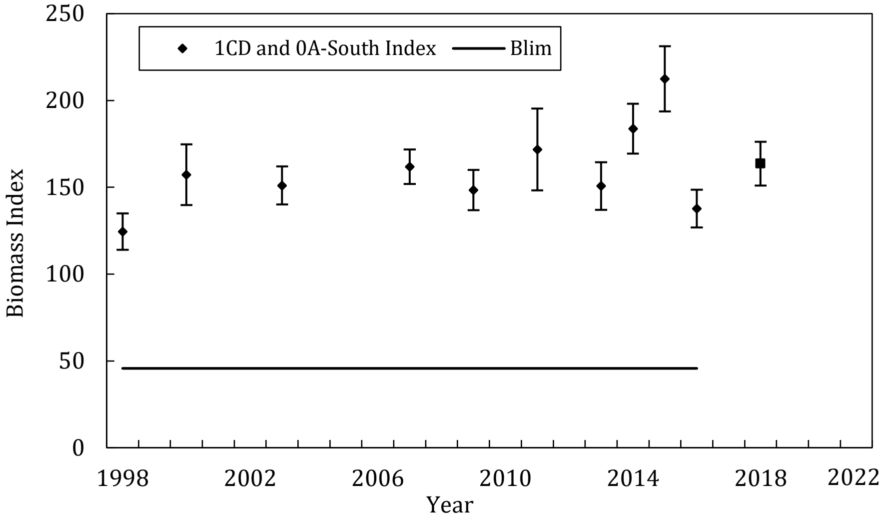


Figure 1.3 Greenland halibut in Subarea 0 and 1 (offshore): Biomass trends in Div. 0A-South + Div. 1CD survey and the proxy for B_{lim}.

Age-1 Abundance Index - The Petersen-method is used to assign Greenland halibut caught during the West Greenland shrimp survey to age 1, 2 and 3+ using length data. The survey takes place on the Greenland shelf in Div. 1A-F at depths 50 m to 600 m for fish sampling (SCR Doc. 21/014). The number of 1 year old fish in the survey area, including Disko Bay (also area within Division 0A when available), is used as an age-1 index. The index was generally increasing from 1988 to 2003, followed by a declining trend to 2010, and since then the index has been variable with series high values observed in 2011, 2013 and 2017 (Figure 1.4). Abundance in 2020 is near the series average. A change in survey vessel occurred in 2018, but gear performance analyses concluded the surveys were comparable (SCR 20/15).

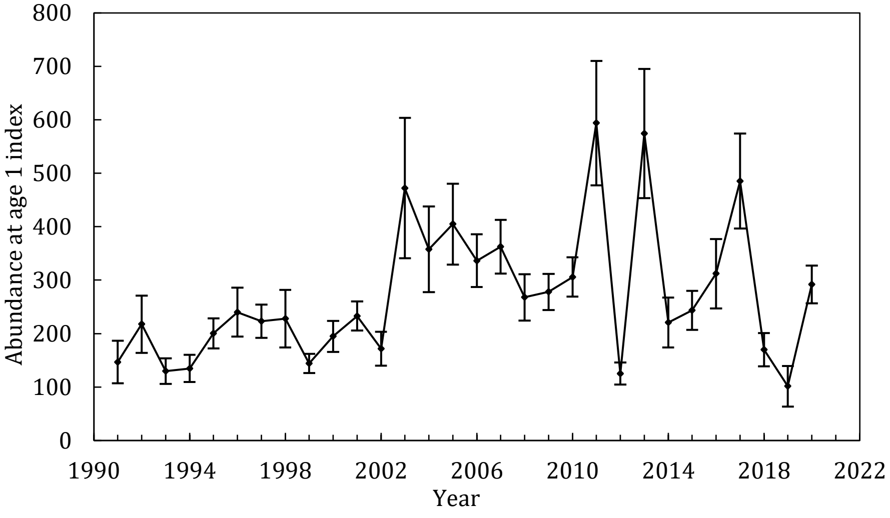


Figure 1.4 Greenland halibut in Subarea 0 and 1 (offshore): index at age 1 derived from the Greenland Shrimp and Fish Survey.

c) Assessment Results

There is no accepted analytical model. Several attempts to model the stock dynamics have been tried over the years using methods such as Yield per Recruit Analysis, XSA, ASPIC and Schaefer surplus production model.

i) Subarea 0 and 1 (offshore)

Biomass: The RV Pâmiut 0A-South+Div. 1CD combined survey biomass index, 1999 – 2017 had been relatively stable from 1999 to 2014 then more variable with a time series high in 2016 and a level near the series low in 2017, all values were above B_{lim}.

Recruitment: Recruitment is uncertain.

Fishing mortality: Fishing mortality is uncertain.

State of the Stock: The 0A-South and 1CD biomass index was above B_{lim} throughout the time series, 1999 to 2017. The 2019 value is similar in magnitude to previous surveys, however, it is not considered directly comparable. Despite a lack of index survey data in recent years the stock status is not expected to have changed drastically during 2018 to present.

d) Reference Points

B_{MSY} is not known for this stock. In 2015 a proxy for B_{lim} was developed based on 30% of a period of stability in the 0A-South and 1CD index (1999-2012). However, no surveys were conducted in 2018, 2020 or 2021 and the 2019 survey was not considered comparable to previous surveys. The previous B_{lim} was valid to 2017, but needs to be re-evaluated once a new time series is established.

The next full assessment of this stock is expected to be in 2024.

e) Recommendations:

In 2018 STACFIS **recommended** that *the CPUE data be explored and the General Linear Model examined to better understand the observed trends.*

In 2020 STACFIS **recommended** that *the overall 1A-F survey biomass be explored as an index of stock status instead of only the age 1 portion of this survey.*

STATUS: No progress has been made on these recommendations in 2022. However, effort is underway to explore spatial and length based models using all available survey indices as well as fishery catch and length frequencies, to identify the potential for their use in future assessments of this stock.

References

ICES 2013. Report of the benchmark on Greenland halibut stocks (WKBUT). ICES CM 2013/ACOM:44. 74pp.

Roy, D., D. C. Hardie, M. A. Treble, J. D. Reist and D. E. Ruzzante. 2014. Evidence of high gene flow in a locally adapted species: the paradox of Greenland Halibut (Reinhardtius hippoglossoides) panmixia in the Northwest Atlantic. Canadian Journal of Fisheries and Aquatic Science 71: 763-774.

2. Greenland Halibut (*Reinhardtius hippoglossoides*) in Subarea 1 inshore

(SCR Doc. 18/023, 22/008, 009, 010, 024, 029, 031, 035, 036, 037, 038; SCS Doc. 22/11) Full assessment.

a) Introduction

The fishery targeting Greenland halibut developed in the Disko Bay and south Greenland in the beginning of the twentieth century. The fishery is conducted with longlines or gillnets from small vessels, open boats and through holes in the sea ice during the winter months. The fishery gradually spread from the Disko Bay to Uummannaq and Upernavik, but the catches remained low until the 1980s.

Quota regulations were introduced in 2008 as a shared quota for all vessels . In 2012, the TAC was split in two components with ITQ's for vessels and shared quota for small open boats. In 2014, the Government of Greenland set "quota free" areas within each subarea, and in these areas, catches were not drawn from the total quota, although still included in landing statistics. In 2022 the quota free areas were abolished.

To protect juvenile fish in the area, sorting grids have been mandatory since 2002 in the offshore shrimp fishery at West Greenland and since 2011 in the inshore shrimp fishery in the Disko Bay. Trawl fishery is not allowed in the Uummannaq fjord and Upernavik area. In 2017, mesh size in gillnets were reduced from 110 mm to 95mm half mesh.

The stocks (Disko Bay, Uummannaq and Upernavik) are believed to depend on recruits from the offshore stock and adults are considered isolated from the stock in Davis Strait and Baffin Bay. Advice is given for each of the three areas on a two-year basis and a separate TAC is set for each of the inshore areas in Division 1A. Inshore stocks south of division 1A were separated from the offshore stock in 2020.

1. Disko Bay

Fishery and Catch: Catches increased in the 1980s, peaked from 2004 to 2006 at more than 12 000 t, but then decreased substantially to just above 6000 t in 2009. From this level, catches gradually increased reaching 10 760 t in 2016. In 2017, catch rates were unusually low and only 6 409 t were caught in Disko Bay. Since then Catches have increased to 9 028 t in 2021(Table 2.1 and figure 2.1).

Table 2.1.

	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
1A Disko Bay – TAC	9.00	9.00	9.20	9.65	9.20	9.20	11.08	10.58	10.25	9.10
1A Disko Bay - Catch	9.07	9.18	8.67	10. 76	6.41	8.40	8.76	7.60	9.03	
STACFIS Total	9.07	9.18	8.67	10. 76	6.41	8.40	8.76	7.60	9.03	

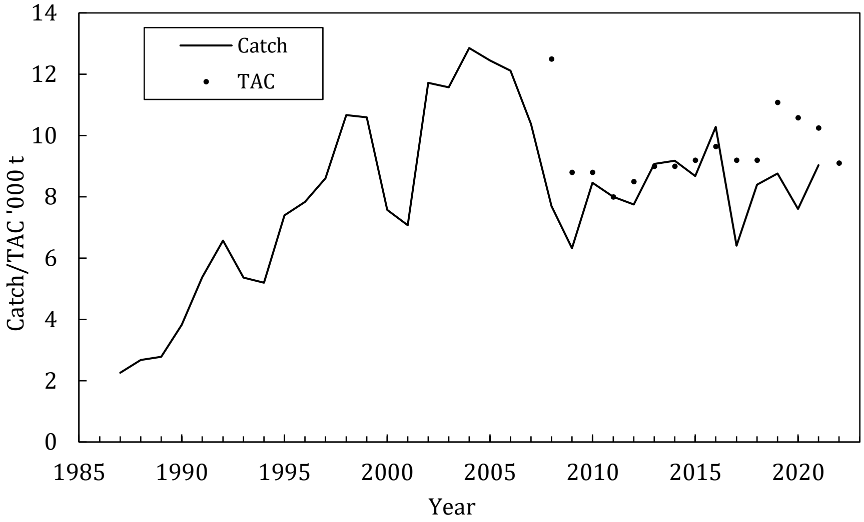


Figure 2.1. Greenland halibut in Division 1A inshore: Greenland halibut catches and TAC in t in Disko Bay.

a) Data overview

i) Commercial fishery data

Mean length in the landings gradually decreased for more than a decade in both the winter and summer longline fishery and in the overall mean length weighted by gear and fishing ground (figure 2.2).

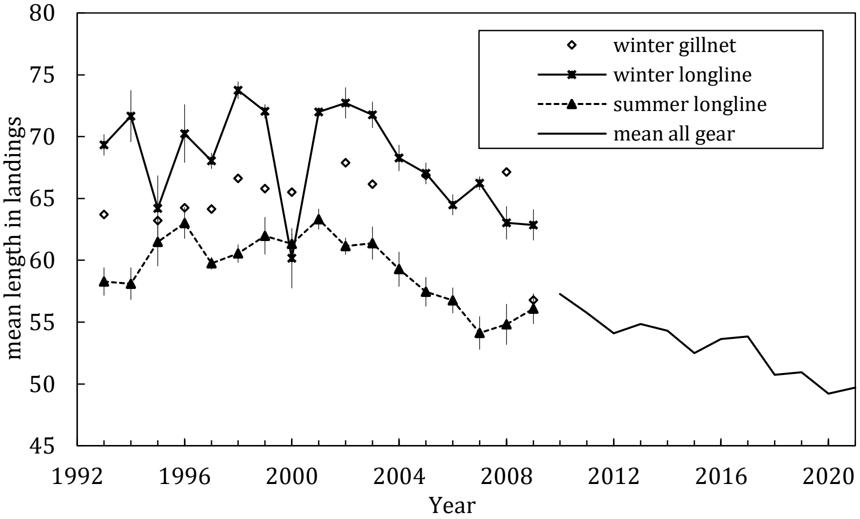


Figure 2.2. Greenland halibut in Division 1A inshore: Mean length in landings from longline fishery by season (summer and winter) and overall mean taking account of fishing ground, season and gear.

b) CPUE indices from the commercial catch

Two commercial CPUE indices are presented for the stock, one based on longline logbooks and one based on factory landings data (based on longline fishery).

The CPUE based on factory landings shows an initial decrease to 2017, but has been stable size 2018 (Figure 2.3)

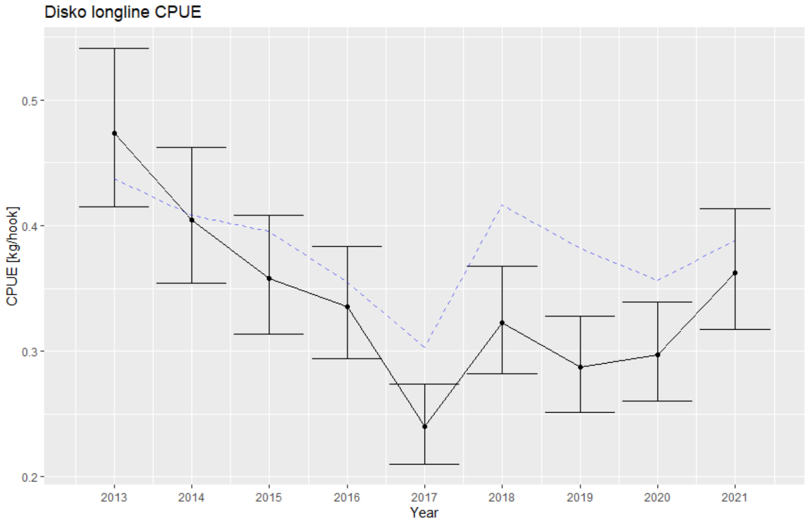


Figure 2.3. Greenland halibut in Division 1A inshore: Commercial CPUE (Kg/hook) based on factory landing reports standardized mean and 95% CI in Disko Bay.

The standardized CPUE based on longline logbooks show a decreasing trend from 2007 to 2017 and since 2018 has been stable (figure 2.4). Although the CPUE is based on only the larger vessels and a different source of statistics, the CPUE shows an almost identical trend as the Factory landings longline CPUE.

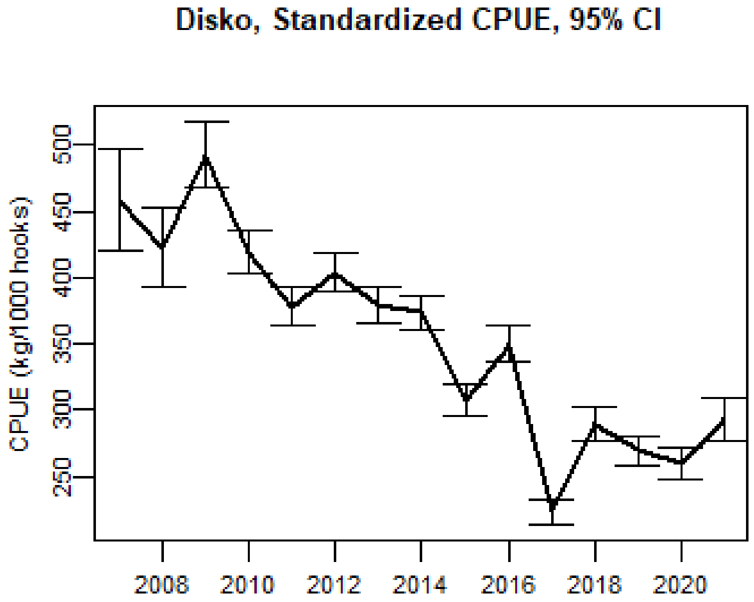


Figure 2.4. Greenland halibut in Division 1A inshore: Commercial CPUE (kg/1000 hooks) based on logbooks standardized mean and 95% CI in Disko Bay.

ii) Research survey data

The offshore Greenland shrimp and fish survey covers the inshore Disko Bay. Separate abundance and biomass indices are available for the Disko Bay until 2020 (figure 2.5).

The **1A Disko Bay** part of Greenland Shrimp and Fish Survey indicated an increasing biomass and abundance trends during the 1990s. After the gear change in 2005, the biomass and abundance indices gradually decreased and then stabilized after 2014.

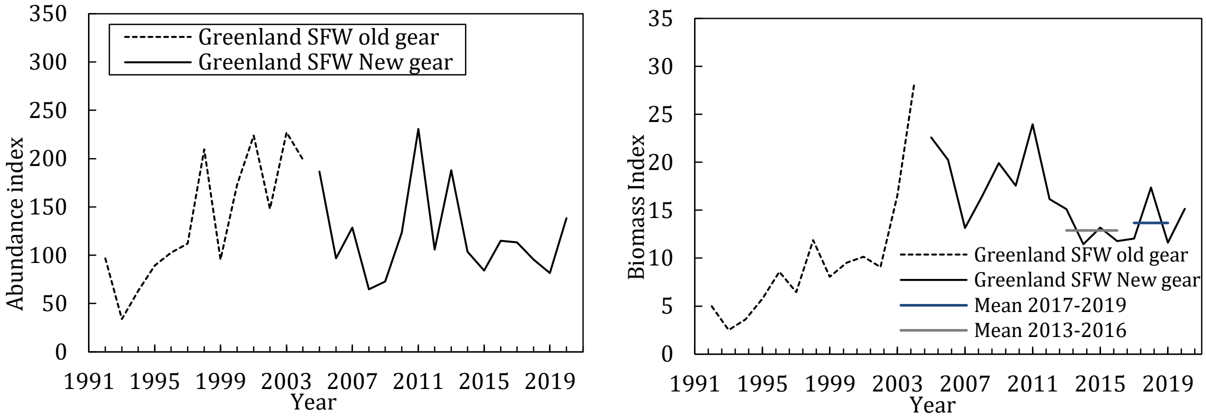


Figure 2.5. Greenland halibut in Division 1A inshore: Abundance and biomass indices in the Disko bay from the Greenland Shrimp Fish trawl survey.

The Disko Bay scientific gillnet survey, catch in Numbers-Per-Unit-Effort (NPUE) can be taken as an Index of abundance and the gillnet Catch-Per-Unit-Effort can be taken as an index of Biomass. From 2017 the NPUE and CPUE gradually and steadily increased to the highest levels observed in the timeseries (figure 2.6).

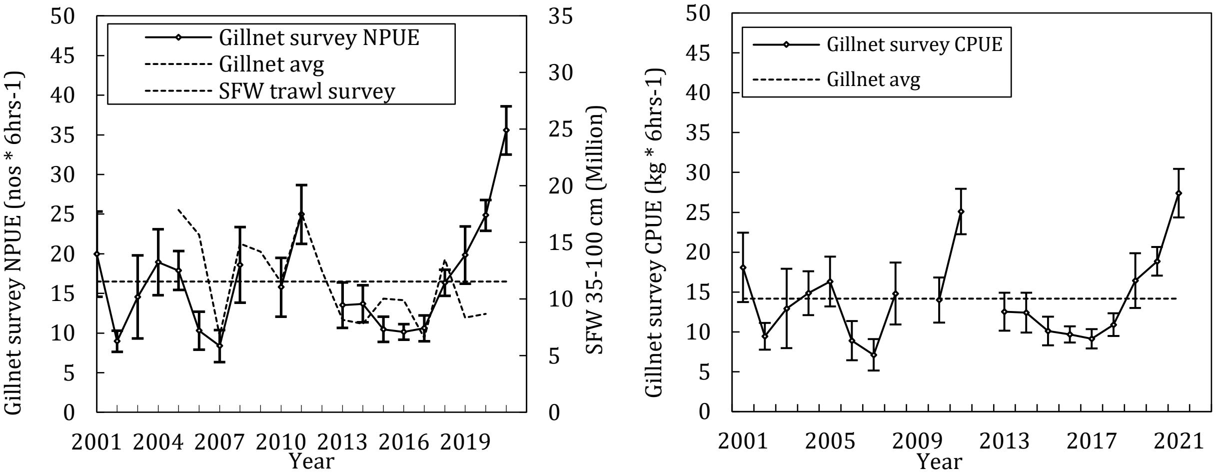


Figure 2.6. Greenland halibut in Division 1A inshore: Gillnet survey NPUE and CPUE +/-SE.

c) Assessment results:

Assessment:

No analytical assessment. A surplus production model in a Bayesian Framework was presented and while it was not accepted this year, work will continue.

Fishing mortality: Unknown

Biomass: Unknown

Recruitment:

The survey indices show signs of good recruitment, since 2015 and potentially also 2016 and 2017, indicating good recovery potential in the stock. The Gillnet survey targeted at pre fishery recruits >30cm has increased more than 3 fold in NPUE and CPUE over in the most recent 5 years.

State of the stock:

Survey biomass index has been stable since 2013 but the recent increase in the gillnet survey indicates potential for growth of the stock based on an observed increase in small fish.

d) Research recommendation

STACFIS **recommended** that *work continue on the surplus production model in a Bayesian framework.*

2. Uummannaq

Fishery and Catch: Catches in the Uummannaq fjord gradually increased from the 1980's reaching 8 425 t in 1999, but then decreased to ~ 5 000 in 2002. Since 2004, catches gradually increased before stabilizing around 10 000 t/year (Table 2.2 and figure 2.7).

Table 2.2

	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
1A Uummannaq - TAC	7.45	8.38	9.50	9.85	9.50	9.50	9.90	9.50	9.64	9.65
1A Uummannaq - catch	7.01	8.20	8.24	10.30	9.05	8.84	10.16	10.67	9.61	
STACFIS Total	7.01	8.20	8.24	10.30	9.05	8.84	10.16	10.67	9.61	

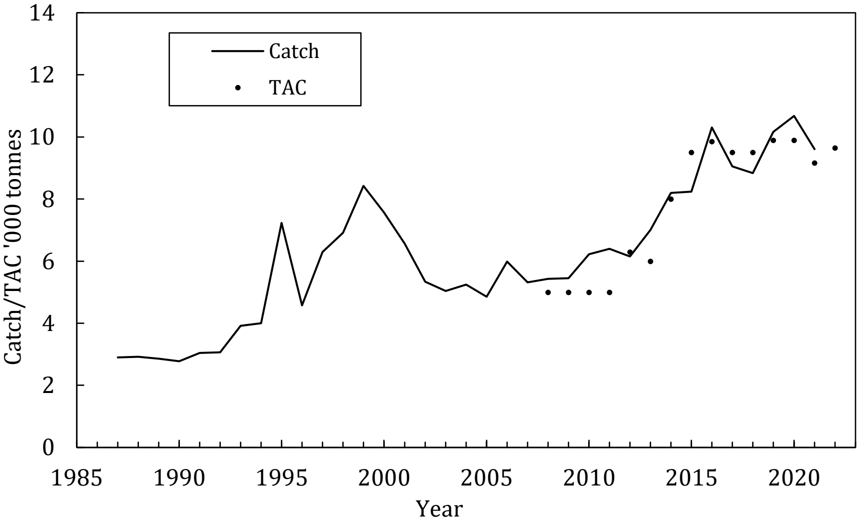


Figure 2.7. Greenland halibut in Division 1A inshore: Catches and TAC in t in Uummannaq.

a) Data overview

i) Commercial fishery data

In **1A Uummannaq,** the length distributions in the commercial landings have gradually decreased since 1993 (figure 2.2.2). In 2021 the Mean length in the landings decrease by 4 cm in just one year, from 57 cm in 2020 to 53 cm in 2021. Grader data provide from Uummannaq estimates 55.1 cm as a mean size in the landings.

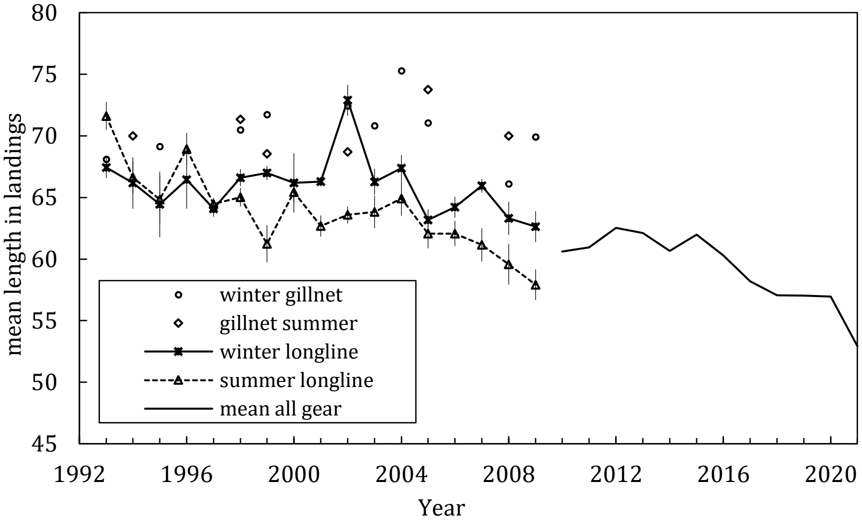


Figure 2.8. Greenland halibut in Division 1A inshore: Mean length in landings from longline and gillnet fishery by season and overall mean weighted by gear.

b) CPUE indices from the commercial catch

The CPUE based on factory landings, shows a substantial decrease from 2013 to 2017 and stabilized thereafter (figure 2.9).

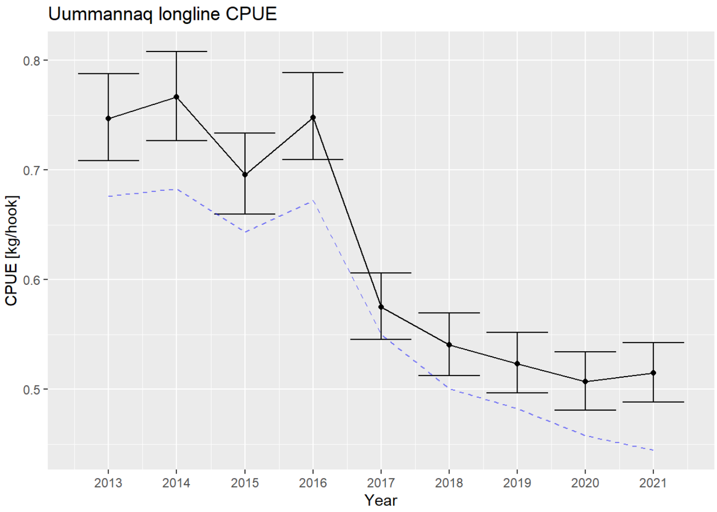


Figure 2.9 Greenland halibut in Division 1A inshore: Commercial CPUE (Kg/hook) based on factory landing reports from all factories in Uummannaq.

The standardised CPUE based on longline logbooks, initially declined from 2014 to 2017, and has been stable thereafter (figure 2.10).

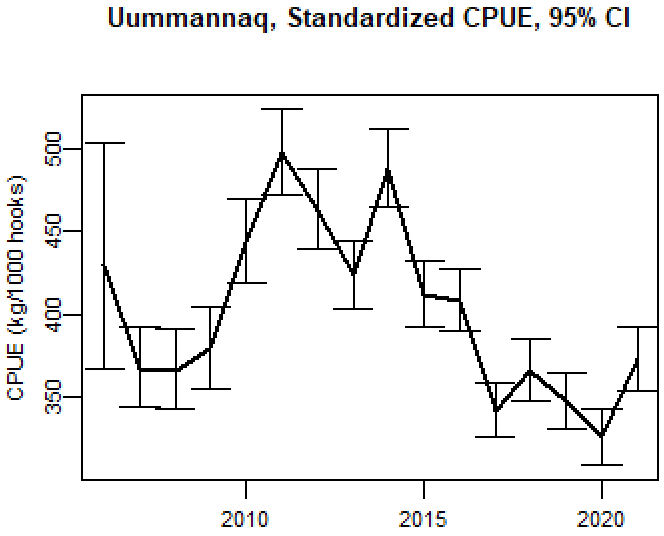


Figure 2.10 Greenland halibut in Division 1A inshore: Longline logbooks - Standardized mean and 95% CI CPUE based on logbooks from vessels larger than 30ft in Uummannaq.

ii) Research survey data

The Uummannaq scientific gillnet survey indices declined from 2015-2018 and have since increased. (figure 2.11). The high NPUE observed in 2020 was mainly caused by unusually high numbers of small Greenland halibut around 40 cm in the survey.

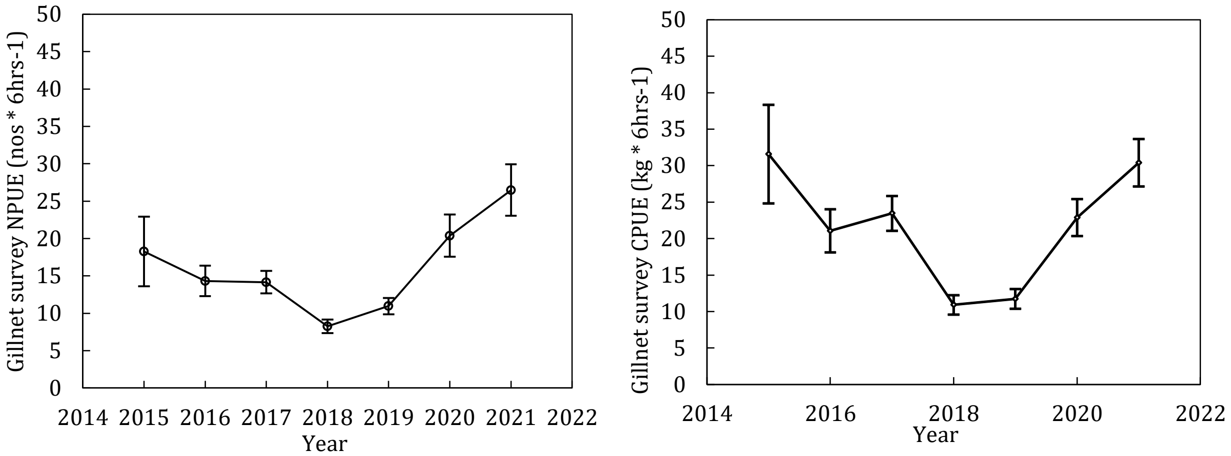


Figure 2.11 Greenland halibut in Division 1A inshore: Gillnet survey NPUE and CPUE +/-SE.

c) Assessment results:

Assessment: No analytical assessment was performed for the stock.

Biomass: Unknown.

Fishing mortality: Unknown.

Recruitment: The Gillnet survey selecting >30cm Greenland halibut has revealed an almost 3-fold increase in NPUE since the low values in 2018. The length distribution in the gillnet survey further supports the observation of a higher number of pre fishery recruits in the area than previously observed. Age composition in the surveys and in the commercial catch from 2021 further support the observation of unusual high number of recruits close to the commercial size range (2015 YC and younger)

State of the stock:

Although the size of the landed fish decreased substantially from 2020 to 2021, the gillnet index, which was lower in 2018 and 2019, has returned to its former level.

The length distribution in the gillnet survey further indicates the presence of large fish in the interval between 50 and 60 cm, and also a higher number of smaller recruits than previously observed.

3. Upernavik

Fishery and Catch: Catches increased from the mid 1980s and peaked in 1998 at a level of 7 000 t. Landings then decreased sharply, but during the past 15 years, catch has gradually increased to a level between 7 500 and 9 000 t. (Table 2.3 and fig 2.12).

Table 2.3 Recent catches and advice ('000 t) are as follows:

	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
1A Upernavik - TAC	7.95	9.50	9.50	9.50	9.50	9.50	8.46	8.46	9.91	9.30
1A Upernavik - Catch	6.04	7.38	6.27	7.36	6.78	7.55	8.97	7.57	8.48	
STACFIS Total	6.04	7.38	6.27	7.36	6.78	7.55	8.97	7.57	8.48	

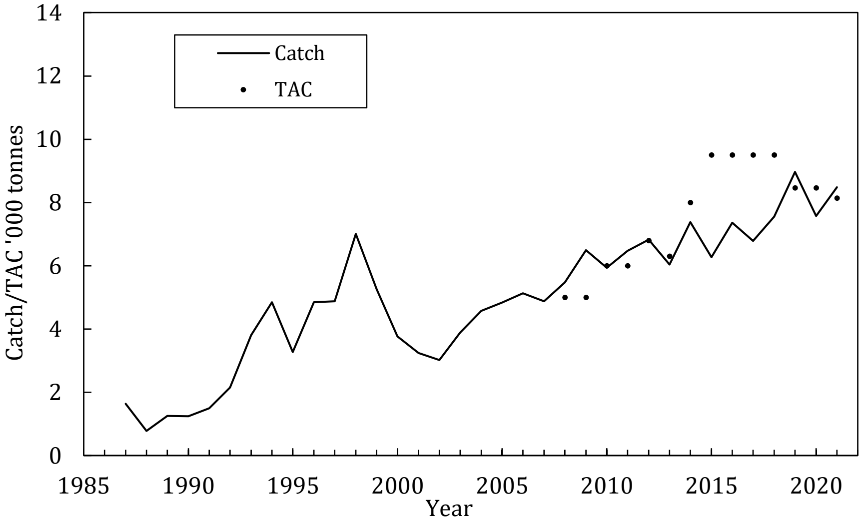


Figure 2.12. Greenland halibut in Division 1A inshore: Catches and TAC in t in Upernavik.

a) Data overview

i) Commercial fishery data

In **Upernavik,** the mean length in the commercial landings decreased from 1993 to 1998. From 1999 to 2009, the mean length in the longline fishery remained constant, but has since then decreased further.

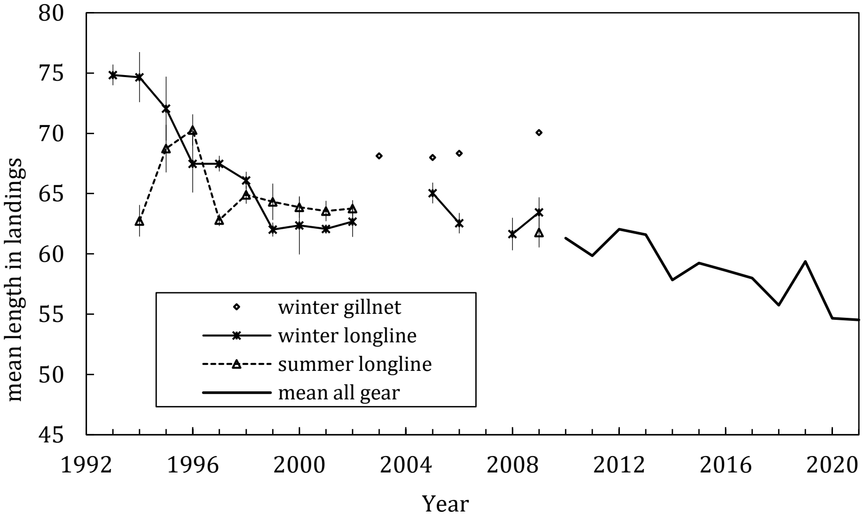


Figure 2.13. Greenland halibut in Division 1A inshore: mean length in landings from longline fishery by season (summer and winter) and after 2010 overall mean taking account of fishing ground, season and gear.

b) CPUE indices from the commercial catch

The CPUE based on factory landings, shows a gradual decrease from 2013 to 2020, except for 2018. In 2021, the CPUE increased to the level observed in 2017(figure 2.14).

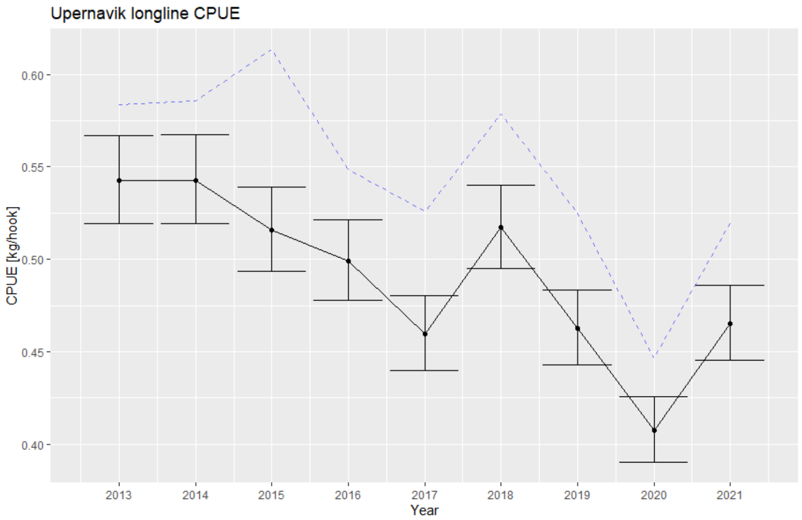


Figure 2.14. Greenland halibut in Division 1A inshore: Commercial CPUE (Kg/hook) based on factory landing reports from all factories in Upernavik.

The standardised CPUE based on longline logbooks, disregarding the outlier year 2020, has been stable since 2015(figure 2.15).

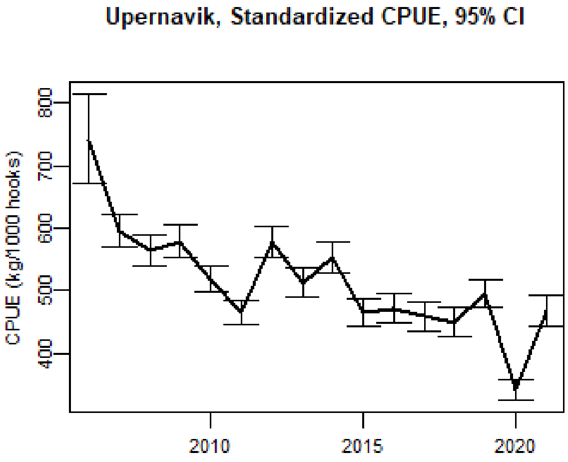


Figure 2.15. Greenland halibut in Division 1A inshore: Longline logbooks - Standardized mean and 95% CI CPUE based on logbooks from vessels larger than 30ft since 2006.

i) Research survey data

The Upernavik scientific gillnet survey NPUE and CPUE increased relative to previous levels in 2020 and 2021.

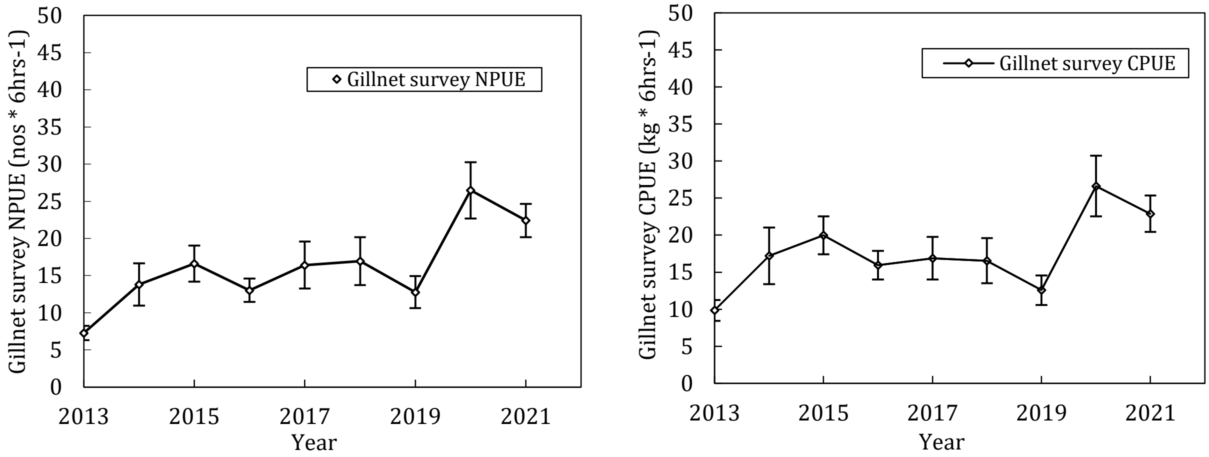


Figure 2.16. Greenland halibut in Division 1A inshore: gillnet survey NPUE (left) and CPUE (right) +/-SE.

c) Assessment results:

Assessment: No analytical assessment was performed for the stock.

1A Upernavik:

Biomass: Unknown.

Fishing mortality: Unknown.

Recruitment: unknown

State of the stock:

The Upernavik scientific gillnet survey NPUE and CPUE increased relative to earlier levels in 2020 and 2021.

These stocks will next be assessed in 2024.

3. Demersal Redfish (*Sebastes* spp.) in Subarea 1

(SCR Doc. 88/12, 96/36, 07/88, 20/012, 21/003, 011, 013, 014, 22/011; SCS Doc. 22/11)**.** Interim Monitoring Report

a) Introduction

There are two demersal redfish species of commercial importance in NAFO Subarea 1, golden redfish (*Sebastes norvegicus*) and demersal deep-sea redfish (*Sebastes mentella*). Connectivity to other redfish stocks off East Greenland, the Irminger Sea, the Newfoundland and Labrador Shelf, and Iceland is unclear.

Fisheries and Catches: Both redfish species (*S. norvegicus, S. mentella*) are included in the catch statistics. Greenland operates the quota uptake by categorising the catches in three types of redfish. Redfish caught by bottom trawl and longlines on the bottom are considered *Sebastes norvegicus* (REG) and redfish caught pelagic are considered *Sebastes mentella* (REB), however species identification does not occur in these fisheries in West Greenland*.* Catch of redfish in East Greenland are separated by sampling of the commercial catch. Redfish caught as by-catch in the shrimp fishery are considered *Sebastes sp.* (RED).

The fishery targeting demersal redfish in SA1 increased during the 1950s and peaked in 1962 at more than 60,000 t. Catches then decreased and have remained below 1,000 tons per year after 1986 with few exceptions. However, official catches are uncertain with evidence of overreported catches from 1974-1977 (cod and other species reported as redfish) and underreporting of redfish taken as bycatch in the shrimp fishery. Studies of bycatch in the shrimp fishery estimated catch of redfish to be more than 14,000 t in 1988 and 4,000 t in 1994. To reduce the bycatch of fish in the shrimp fishery, 22mm sorting grids have been mandatory since 2002.

Sorting grids and poor recruitment have since then limited the bycatch of redfish in the shrimp fishery to very low levels. Since 2019, the reported bycatches of redfish from shrimp trawlers has gradually increased from 1t in 2019 to 130 t in 2021; based on size (typically <20 cm) these redfish are primarily recruits. A further 7 t were reported from trawlers targeting Greenland halibut. Total reported by-catch in offshore fisheries targeting shrimp and Greenland halibut was 137 t. Besides these, 119 t of commercially sized redfish were landed to factories caught in fjords in west Greenland (figure 3.1).

Recent catches ('000 tons) are as follows:

	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
TAC	1	1	1	1	1	1	0	0	0	0
STATLANT 21	0.16	0.25	0.19	0.16	0.23	0.19	0.10	0.21	0.36	
STACFIS	0.17	0.17	0.26	0.17	0.24	0.19	0.14	0.20	0.26	

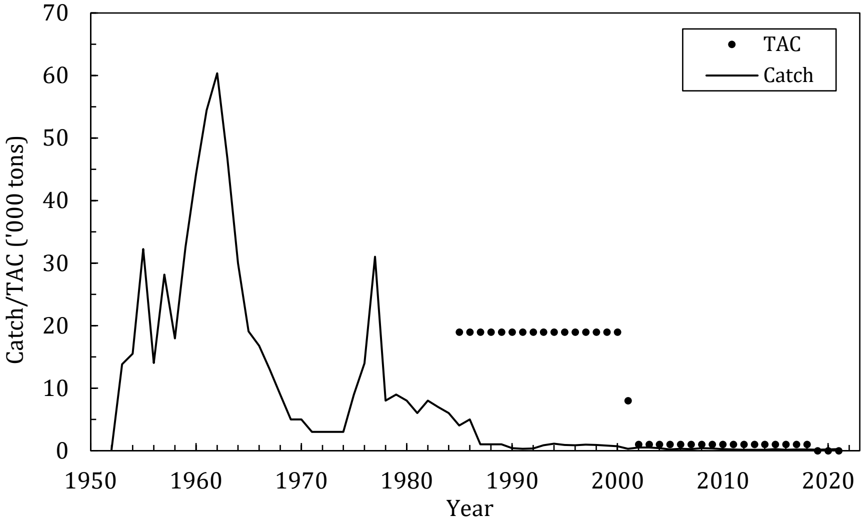


Figure. 3.1. Demersal redfish in Subarea 1: catches and TAC.

b) Data overview

i) Research survey data

Indices for the demersal redfish stocks in Subarea 1 are estimated from 5 offshore surveys and 2 inshore surveys. None of the offshore surveys occurred in 2021. The EU-Germany survey (RV Walther Herwig III) covers the shelf from 0-400 m in East Greenland south of 66N and in West Greenland divisions 1C to 1F, from 1982.

The Greenland deep-sea survey covers the shelf from 400-1500 m in divisions 1C and 1D. This survey was carried out from 1997 to 2017 with the R/V Pâmiut. The survey was cancelled in 2018 and 2020, but updated in 2019 with a chartered vessel.

The Greenland shrimp and fish survey (R/V Pâmiut until 2017 and chartered vessels from 2018 to 2020) covers the shelf in East Greenland south of 67N (since 2008) and South of 72N in West Greenland (1A-1F, 1992-2020) from 0-600 m. The Greenland shrimp and fish survey has a more appropriate depth and geographical coverage with regards to redfish distribution and covers the important nursery areas in division 1B. However, no separation of redfish species was made prior to 2006. The effect of the vessel change was examined in both offshore Greenland surveys and it was found that the changes had a minimal effect at depth< 700 m, where the redfish occurs. The inshore Gillnet survey in the Disko bay (1A) provides information on species composition. The inshore trawl survey in the Godthåb and Ameralik fjord (1D) has been conducted from 2015 with the R/V Sanna. Besides the recent surveys, another index is available from a joint Greenland-Japan offshore survey (RV Shinkai Maru) occurred from 1987 to 1995 in divisions 1B to 1D from 400 -1500 m.

Golden redfish (*Sebastes norvegicus*)

The EU-Germany survey biomass index decreased in the 1980s and was at a very low level in the 1990s (figure 3.2). Increasing biomass indices of golden redfish were observed from 2005 to 2015 and values decreased thereafter.

The Greenland shrimp and fish survey biomass index increased gradually from 2006 to 2016 and decreased thereafter. High indices in 2016 and 2019 were due to single hauls of large adults that provided the majority of the total biomass estimate in those years. The EU-Germany survey and the Greenland shrimp and fish survey show similar overall trends with decreasing indices in the most recent 6 to 7 years. The Greenland deep-sea survey and the historic Greenland-Japan survey is less informative due to shallower distribution of Golden redfish, and inshore surveys have low indices for Golden redfish.

Demersal deep-sea redfish (*Sebastes mentella*)

The EU-Germany survey biomass index has fluctuated at a low level throughout the time series (figure 3.3). The fluctuating trend is likely caused by poor overlap with the depth distribution of adult deep-sea redfish. The Greenland-Japan survey biomass index gradually decreased from 1987 to 1995 and low indices continued in the Greenland deep-sea survey from 1997 to 2006 (figure 3.3). From 2006, the Greenland deep-sea survey and the Greenland shrimp and fish survey biomass indices show similar trends. Biomass indices were low in both surveys in 2006 and gradually increased from 2007 to 2013 (figure 3.3). Both surveys had decreasing biomass indices since 2013 (excluding outlier years in 2016). The high 2016 biomass index in the Greenland shrimp and fish survey was caused by a single haul in division 1D of large redfish between 25 and 40 cm and is not considered reflective of population trends. About 80-95% of the redfish biomass in the trawl survey in Division 1D inshore since 2015 has been deep-sea redfish.

Juvenile redfish (<20cm both species combined)

The EU-Germany survey regularly found juvenile redfish from 1984 to 2000. After 2000, the abundance of juvenile redfish in the survey gradually decreased to a low level (figure 3.4). The Greenland shrimp and fish survey abundance of redfish decreased substantially from 1992 to 2004. In the Greenland shrimp and fish survey, the abundance of both species combined can be regarded as a recruitment index, since the survey initially had high numbers of small redfish in the fine meshed shrimp trawl used for the survey. From 1992 to 1999, high numbers of redfish recruits were observed annually, but the index gradually decreased and remained low until 2004. The decrease continued after the gear change in 2005 (figure 3.4). The increase in abundance in 2016 was primarily due to large redfish from a single large haul, and not recruits. Length distributions of redfish in the surveys showed a complete lack of new year classes from 2008 to 2019, but in 2020 a new year-class(YC) of redfish is observed. This YC is reflected in the increase in abundance in the Greenland SFW juvenile index (Figure 3.4). The inshore Shrimp and fish survey in 1D confirmed the new year-classes of redfish in 2020 and 2021.

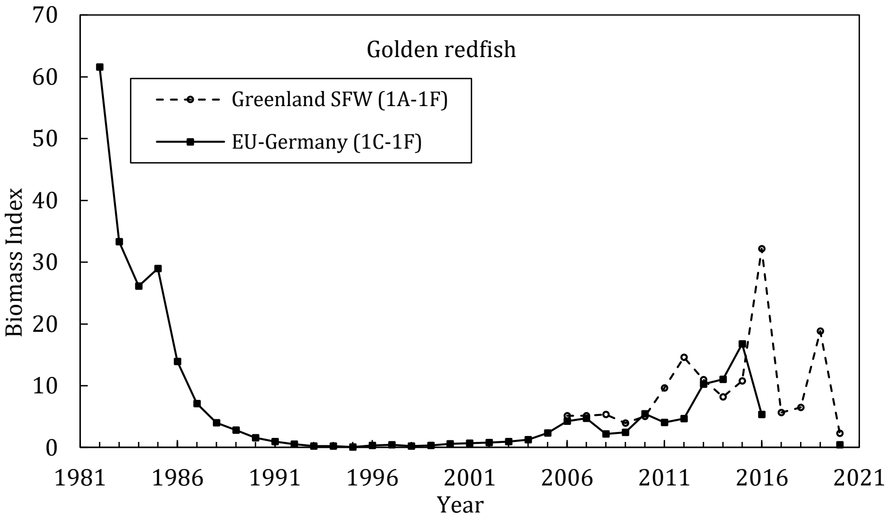


Figure. 3.2. Golden redfish biomass indices in the EU-Germany survey and the Greenland shrimp and fish survey. (no surveys in 2021)

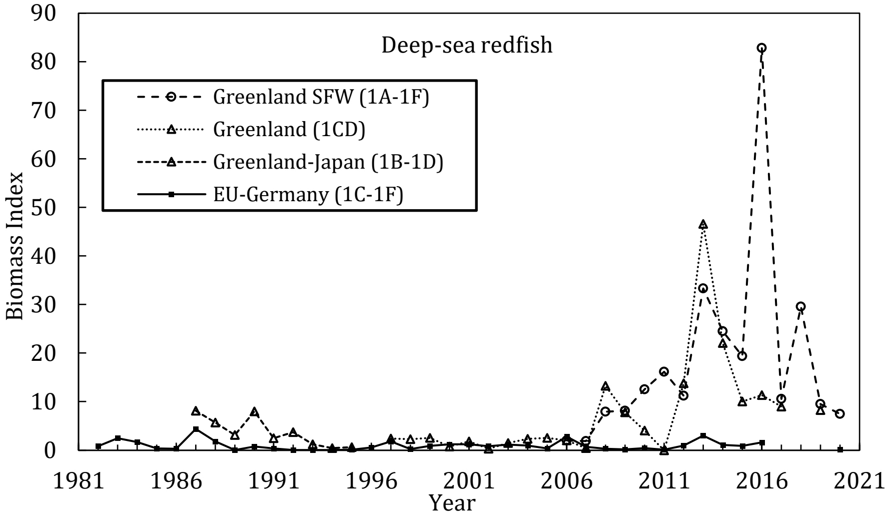


Figure. 3.3. Demersal deep-sea redfish survey biomass from the Greenland shrimp and fish survey , the Greenland deep-sea survey, the EU-Germany survey and the Greenland-Japan survey.

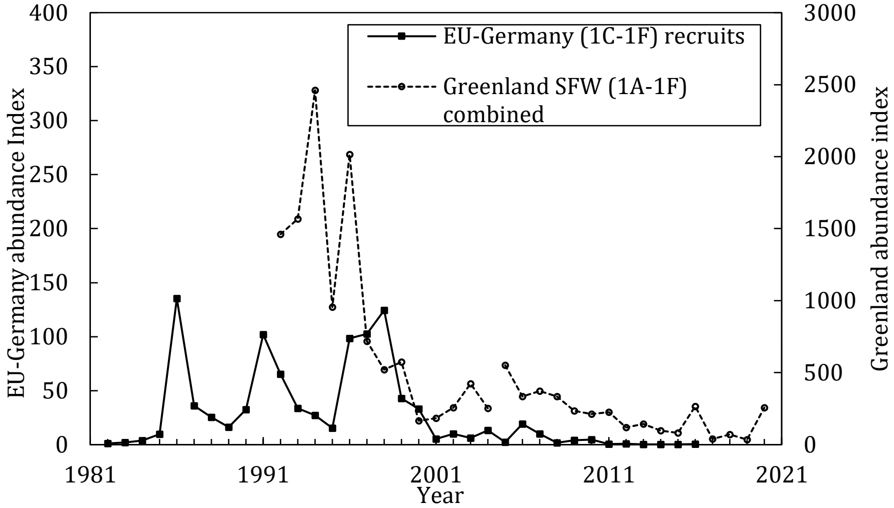


Figure. 3.4. Juvenile redfish abundance indices for the EU-Germany survey (*Sebastes sp.* <17cm), and the Greenland shrimp and fish survey (*Sebastes sp.* all sizes combined).

c) Conclusion

Golden redfish - *Sebastes norvegicus*

The stock was assessed in 2020 for the 2021-2023 period and current advice is "No directed fishery". With the updated indices there is no basis for a reassessment. Recruitment has been at a low level from 2008-2018 and the biomass indices in the surveys show decreasing trends.

Deep-sea redfish - *Sebastes mentella*

The stock was assessed in 2020 for the 2020-2023 period and current advice is "No directed fishery". With the updated indices there is no basis for a reassessment. Recruitment has been at a low level from 2008-2018 and the biomass indices in the surveys are in a decreasing trend.

This stock will next be assessed in 2023.

4. Wolffish in Subarea 1

(SCR Doc. 80/VI/72 77 96/036 07/88 20/040, 21/003 014 ; SCS Doc. 22/11). Interim Monitoring Report

a) Introduction

Three species of wolffish are common in Greenland. Only Atlantic wolffish (*Anarhichas lupus*) and spotted wolffish (*Anarhichas minor*) are of commercial interest. Northern wolffish (*Anarhichas denticulatus*) is an unwanted discarded bycatch. Atlantic wolffish has a more southern distribution and seems more connected to the offshore banks and the coastal areas. Spotted wolffish can be found further north in West Greenland than Atlantic wolffish both in the fjords and offshore. Atlantic wolfish has a shallower depth distribution (50-400m) than spotted wolffish (50-600m).

Fisheries and catches: Wolffish are primarily taken as a bycatch in other fisheries. A directed wolfish fishery typically occurs when quota ceilings has been reached for more economically important species. Although spotted wolffish and Atlantic wolffish are easily distinguishable from one another, the two species are rarely separated in catch statistics. The commercial fishery for wolffish in West Greenland increased during the 1950s and wolffish was initially targeted in the coastal areas. With the failing cod fishery off West Greenland, trawlers started targeting Atlantic wolffish on the banks off West Greenland and from 1974-1976 reported landings from trawlers were around 3,000 tons per year (Figure 4.1). After 1980, the cod fishery gradually stopped in West Greenland and catches of wolffish also decreased during this period. To minimize by-catch in the shrimp fishery, offshore trawlers targeting shrimp have been equipped with 22mm grid separators since 2002 and a inshore (Disko Bay) trawlers by 2011. Since 2015, reported catches have been at a lower level. The decrease is likely related to more profitable species being targeted. In 2021, 247 t of wolffish was landed to factories mostly taken as bycatch in inshore small boat fisheries and 4 t was reported from offshore vessels.

Recent nominal catches (000 tons) for Atlantic wolffish and Spotted wolffish.

	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
Atlantic wolffish TAC			1.00	1.00	1.00	1.000	0	0	0	0
Spotted wolffish TAC			1.03	1.03	1.02	0.975	0	0	0	0
Combined wolffish TAC	1	1	2.03	2.03	2.03	1.975	0	0	0	0
STATLANT 21	858	0.91	0.40	0.24	0.24	0.27	0.19	0.24	0.25	
STACFIS	858	0.91	0.40	0.20	0.24	0.26	0.19	0.25	0.25	

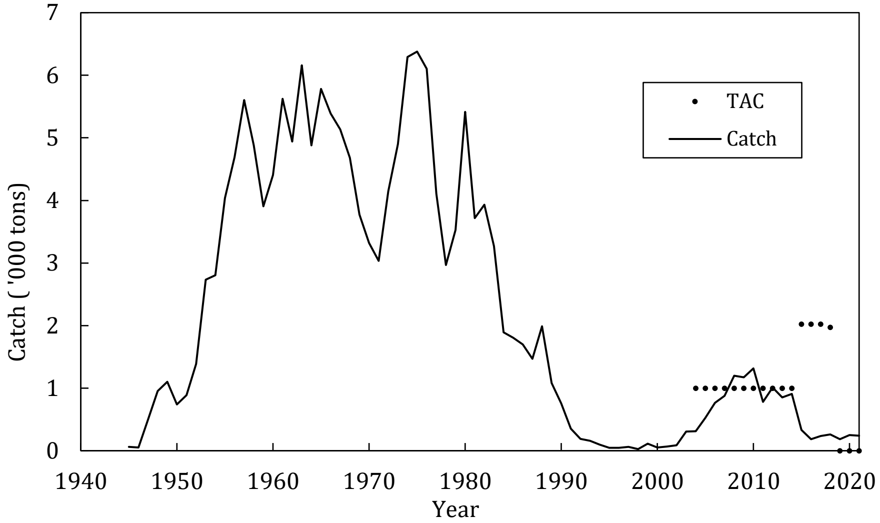


Figure 4.1. Wolffish in NAFO Subarea 1: Catches and TACs for Atlantic wolffish and spotted wolffish combined.

b) Data Overview

i) Research survey data

Indices for wolffish are derived from two different surveys, The EU-Germany survey and the Greenland shrimp and fish survey. None of these surveys were updated in 2021. Other surveys eg. Inshore trawl or gillnet surveys or offshore surveys in deeper water are not relevant in relation to wolffish. The EU-Germany survey covers the Greenland shelf from 67 N off West Greenland to 66N off East Greenland at depths from 0-400m (R/V Walther Herwig III). The survey started in 1982. In recent years not all strata have been covered particularly in divisions 1C and 1D. The Greenland shrimp and fish survey (Greenland-SFW) covers the Greenland shelf from 72N off West Greenland to 67N off East Greenland at depths from 50-600m. The survey started in 1991 with R/V Paamiut. The gear was changed in the Greenland-SFW survey in 2005, thus interrupting the survey index. R/V Pâmiut was decommissioned in 2017 and commercial vessels using Pâmiut gear has been used to update indices since 2018. Analysis of trawl performance between Paamiut and the chartered commercial vessels, have indicated that the indices are comparable. The Greenland-SFW survey has a more appropriate geographical coverage in relation to wolffish than the EU-Germany survey. Both surveys cover the main depth distribution of wolffish.

Atlantic wolffish:

The EU-Germany survey biomass index decreased significantly in the 1980s (Figure 4.2). From 2002 to 2005 biomass index increased to above average levels, but thereafter returned to the low levels observed during the 1990s. The index was not updated from 2016 to 2019, due to low coverage and survey cancellation. Abundance index in the EU-Germany survey decreased from the beginning of the time series, in 1982 to 1984, since then it remained stable with slightly increasing levels from 2002 until 2005. After 2005, the abundance index decreased to below average levels. This decrease may be related to a gradual reduction of the the surveyed area (figure 4.2).

The Greenland-SFW survey biomass index was at low levels during the 1990s, but increased slightly from 2002 and until the gear change in 2004. Since 2005 the biomass index has continued to increase (figure 4.2). The abundance index in the Greenland-SFW survey increased until the gear change in 2004 (Figure 4.2). From 2005 the increasing trend has continued. The increasing abundance and biomass in the Greenland SFW survey has partly been observed in divisions 1A-B, thus outside the EU-Germany survey area.

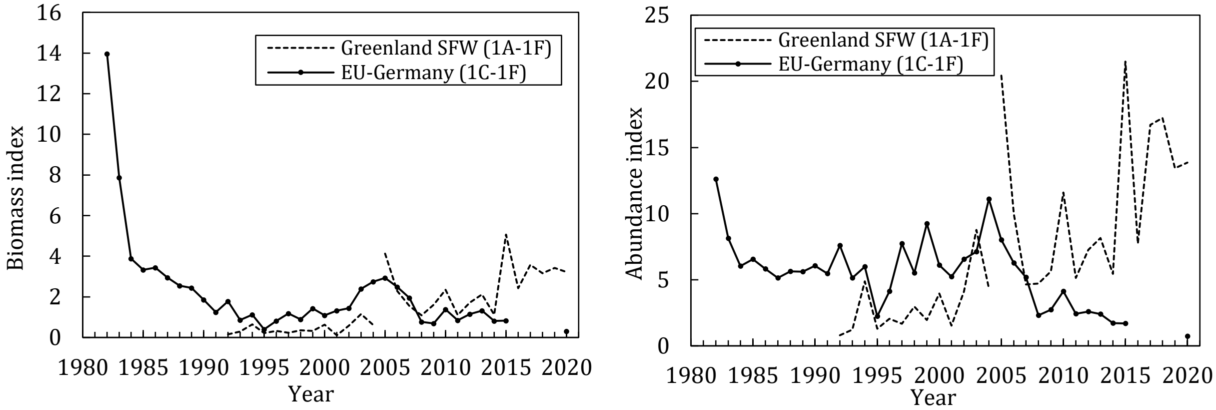


Figure. 4.2. Atlantic wolffish survey biomass index (left) and abundance index (right) from the surveys.

Spotted wolffish:

The EU-Germany survey biomass index decreased from 1982 to 1984 and remained at low levels during the 1990s (figure 4.3). From 2004, the survey biomass increased, and the recent indices were at the level observed at the beginning of the 1980s. Although highly variable, the abundance index has gradually increased since the mid 1990s (fig 4.3).

The Greenland SFW survey biomass index, was at low levels during the 1990s, but has gradually increased from 2002. After the gear change in 2005, survey biomass index has continued to increase (fig 4.3). The abundance index gradually increased both before and after the gear change (Fig 4.3).

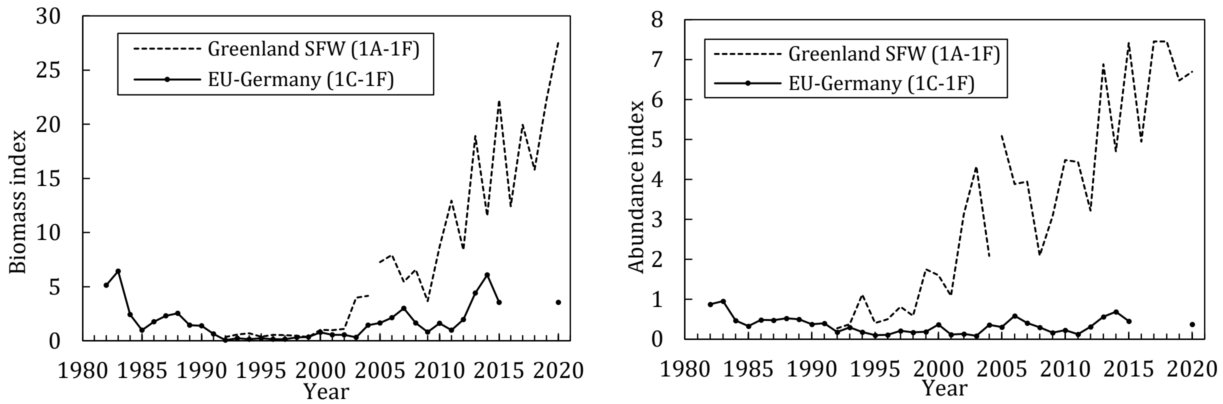


Figure 4.3. Spotted wolffish survey biomass index (left) and abundance index (right) from the Greenland SFW and the EU-Germany survey.

c) Conclusion

Atlantic wolffish

This stock underwent full assessment in 2020, with the advice that there should be no directed fishery targeting Atlantic wolffish in NAFO Subarea 1. With the updated indices there is no basis for a reassessment in 2021, since the biomass indices of the EU-Germany survey remain below the initial values.

Spotted wolffish

This stock underwent full assessment in 2020. The ICES Harvest Control Rule 3.2 for data limited stocks combined with the survey index from the Greenland-SFW survey has been used to formulate the advice since 2017. For 2021-2023 annual catch advice was increased and not to exceed 1158t. With the updated indices there is no basis for a reassessment in 2021. The survey indices have shown increasing trends.

These stocks will next be assessed in 2024.

B. STOCKS ON THE FLEMISH CAP (NAFO DIVISION 3M)

Recent Highlights in Ocean Climate and Lower Trophic Levels for 3M

- After being mostly below normal between 2015 and 2019 (except for 2018), the ocean climate index in 3M, has been normal in 2020 and 2021.
- The initiation of the spring phytoplankton bloom was earlier than normal in 2021 after 2 consecutive years of near-normal timing.
- Spring bloom magnitude returned to near normal in 2021 after the low production spring of 2020.
- The abundance of copepods and non-copepods as well as total zooplankton biomass increased to above normal in 2021 after two consecutive years of near or below-normal levels.

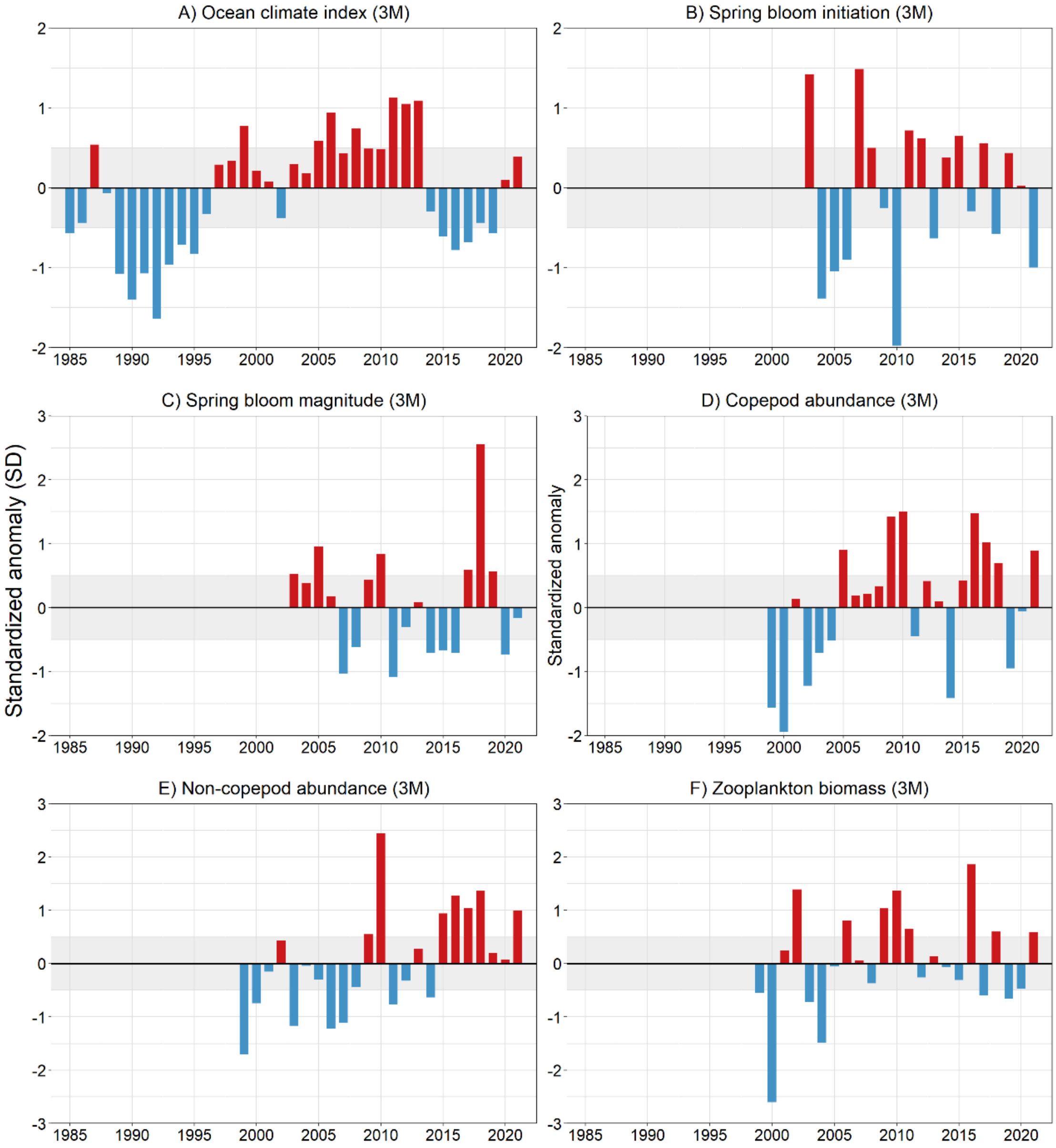


Figure B1. Annual anomalies of environmental indices for Flemish Cap (in NAFO Div. 3M). The ocean climate index (A) for the period 1990-2020 is the average of three time series of standardized ocean temperature anomalies of sea surface temperatures (SSTs), hydrographic section observations and summer mean bottom temperature over the cap (see Cyr and Belanger 2022 for details). Spring bloom anomalies (B, C) for the 2003-2021 period were averaged over two satellite boxes (FP, FC – see Figure. B1A for satellite boxes locations). Zooplankton anomalies (D-F) for the period 1999-2021 were calculated using data from the portion of the FC section located within NAFO Div. 3M (see Cyr and Belanger 2022 for details). Positive (negative) anomalies indicate late (early) bloom timing or conditions above (below) the mean for the reference period. Anomalies were calculated using the following reference periods: ocean climate index: 1981-2010, spring bloom indices: 2003-2020, Zooplankton indices: 1999-2020. Anomalies within ± 0.5 SD (shaded area) are considered near-normal conditions.

Environmental Overview

The water masses characteristic of the Flemish Cap area are a mixture of Labrador Current Slope Water and North Atlantic Current water, generally warmer and saltier than the sub-polar Newfoundland Shelf waters with a temperature range of 3-4°C and salinities in the range of 34-34.75. The general circulation in the vicinity of the Flemish Cap consists of the offshore branch of the Labrador Current which flows through the Flemish Pass on the Grand Bank side and a jet that flows eastward north of the Cap and then southward east of the Cap. To the south, the Gulf Stream flows to the northeast to form the North Atlantic Current and influences waters around the southern areas of the Cap. In the absence of strong wind forcing the circulation over the central Flemish Cap is dominated by a topographically induced anti-cyclonic (clockwise) gyre. Variation in the abiotic environment influences the distribution and biological production of Newfoundland and Labrador Shelf and Slope waters where arctic, boreal, and temperate species coexist. The elevated temperatures on the Flemish Cap result in relatively ice-free conditions that may allow longer phytoplankton growing seasons compared to the Grand Banks where cooler conditions prevail. The entrainment of nutrient-rich North Atlantic Current water around the Flemish Cap generally supports higher primary and secondary production compared with the adjacent shelf waters. The stability of this circulation pattern may also influence the retention of ichthyoplankton on the Grand Bank which may influence year-class strength of various fish and invertebrate species.

Ocean Climate and Ecosystem Indicators

The ocean climate index in Div. 3M (Figure. B1A) has remained mostly above normal between the late 1990s and 2013. After the record high of 2011, the index gradually decreased reaching in 2016 its lowest value since 1993. After being below normal between 2015-2019 (with the exception of 2018 that was normal), the index was normal in 2020 and 2021.

Mean spring bloom initiation timing has been oscillating between earlier and later than normal between 2003 and 2020 with no clear variation pattern except for three consecutive early blooms from 2004 to 2006 (Figure B1B). Spring bloom magnitude (total production) has also been oscillating between above and below and above normal throughout the time series with a change in the sign of the anomalies (positive to negative) every 2-3 years (Figure B1C). Bloom magnitude returned to near normal in 2021 after the below-normal levels of the previous year and the three consecutive years of above-normal production from 2017-2019 (Figure B1C). In general, early bloom onsets (i.e., negative initiation anomalies) are associated with higher primary production (i.e. positive magnitude anomalies) and vice versa, but there are exceptions (Figure. B1B-C). Total copepod abundance rapidly increased between 1999 and 2010 and varied more during the 2010s although it mostly remained near or above normal except for the low abundances recorded in 2014 and 2019 (Figure B1D). The abundance of non-copepods showed a general increase from 1999 to 2018 but followed by a decline in the late 2010s similar to that of copepod (Figure. B1D, E). In 2021 the abundance of both copepods and non-copepods was back to above normal (Figure. B1D, E). Total zooplankton biomass generally increased during the 2010s despite interannual variability, and remained mostly near normal afterwards besides the high value of 2016 (Figure. B1F). In 2021, mean zooplankton biomass in the region was slightly above normal (Figure. B1F).

5. Golden Redfish (*Sebastes norvegicus*) in Division 3M

(SCR Doc. 19/035, 22/004; SCS Doc. 22/05, 06, 07, 09, 13). Interim Monitoring Report

a) Introduction

There are three species of redfish that are commercially fished on Flemish Cap; deep-sea redfish (*Sebastes mentella*), golden redfish (*Sebastes norvegicus*) and Acadian redfish (*Sebastes fasciatus*). The term beaked redfish is used for *S. mentella* and *S. fasciatus* combined. Because of difficulties with identification and separation, all three species are reported together as 'redfish' in the commercial fishery. All stocks have both pelagic and demersal concentrations and long recruitment process to the bottom. Redfish species are long lived with slow growth.

The separation of the three species is made in the EU research survey. This requires extensive sampling effort by trained experts to examine internal features of individual redfish. The percentage per depth range of the three species in the EU Flemish Cap surveys, was used to separate the Div. 3M commercial catches into golden and beaked redfish. This method is also applied in assessments of beaked redfish.

Fishery and Catch: Catches of golden redfish in Division 3M increased from 1,158 tonnes in 2006 to a peak of 7662 tonnes in 2009. In 2010, catches decreased and remained relatively stable until 2014 between 2000 and 3000 tonnes. After 2014, catches decreased continuously, being from 2016 to 2019 at residual levels. In 2020 provisional catches of golden redfish are 78 tonnes. EU-Portugal, EU-Spain, the Russian Federation and EU-Estonia are responsible for the bulk of the redfish landings over the last two decades.

Recent catches and TACs ('000 t) are as follows:

	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
TAC[1]	6.5	6.5	6.7	7.0	7.0	10.5	10.5	8.6	8.4	10.9	11.2
STATLANT 21[1]	6.8	6.4	6.9	6.6	7.1	10.5	10.5	8.6	8.5		
STACFIS Total catch[1, 2]	7.8	7.4	6.9	6.6	7.1	10.5	10.5	8.8	8.3		
STACFIS Catch[3]	2.6	2.9	1.7	0.4	0.3	0.1	0.3	0.1	0.4		

[1] TAC, STATLANT 21 and STACFIS Total catch refer to all three redfish species combined.

[2] STACFIS total catch on 2011-2014 based on the average 2006-2010 bias.

[3] STACFIS golden redfish catch estimate, based on golden redfish proportions on observed catch.

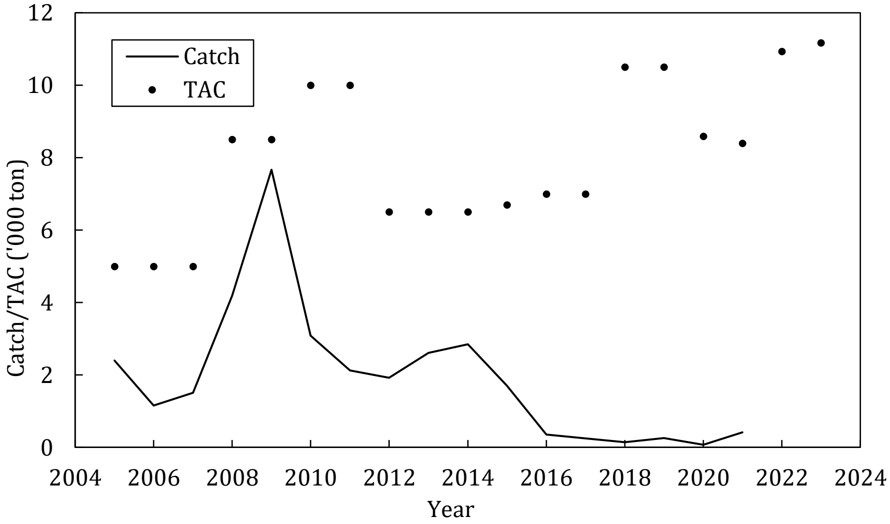


Figure 5.1. Golden redfish in Div. 3M: Golden redfish catches and TACs of all three redfish species combined.

b) Data Overview

i) Research surveys

The 1988-2021 EU survey biomass and abundance indices for golden redfish are presented in Figure 5.2. Besides some sporadic small peaks, the survey stock abundance and biomass oscillated since the beginning (1988) of the series till 2003 at low levels. From 2004 to 2008 both measured a huge increase that could not be explained only by recruitment. Since then, biomass and abundance declined and in 2021 are at low levels. Survey results are noisy, with the characteristic variance of redfish indices, but broad trends show through the noise.

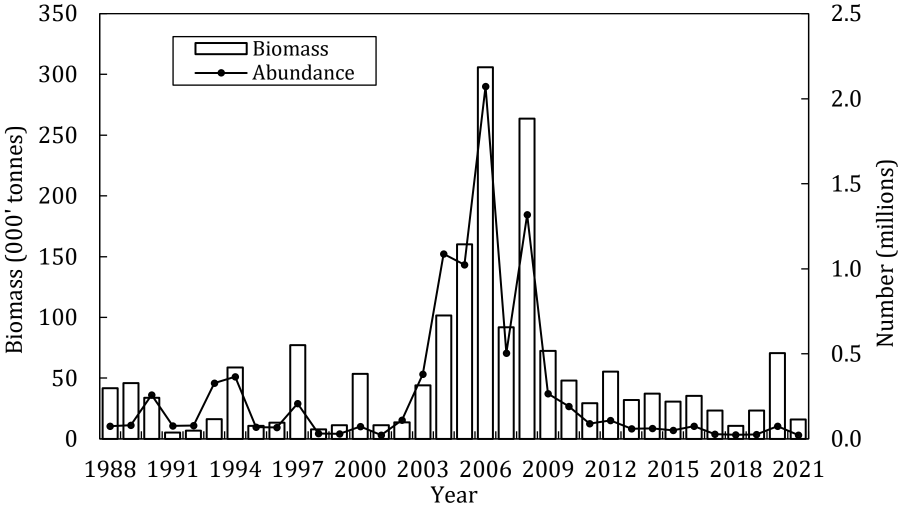


Figure 5.2. Golden redfish in Div. 3M: EU biomass and abundance indices, 1988-2021.

c) Conclusions

The perception of the stock status has not changed.

Given the current situation of the stock, it was not considered appropriate to apply any assessment model or to give advice for golden redfish separately. Nevertheless, as in previous years, advice for golden redfish is given indirectly based on the Div. 3M beaked redfish assessment (advice of 3M redfish applies the current percentage of golden redfish). SC will continue to monitor the golden redfish stock status and provide advice as part of the beaked redfish advice.

The next assessment of the stock is planned when the dynamic of the stock changes.

6. Cod 3M (*Gadus morhua*) in Division 3M

(SCS Doc. 22/06, 22/07, 22/08, 22/13 and SCR Doc. 22/04, 22/12 and 22/25)

a) Introduction

The cod fishery on Flemish Cap has traditionally been a directed fishery by Portuguese trawlers and gillnetters, Spanish pair-trawlers and Faroese longliners. Cod has also been taken as bycatch in the directed redfish fishery by Portuguese trawlers. Estimated bycatch in shrimp fisheries is low. Total annual catches from 1996 to 2010 were very small compared with previous years.

The mean reported catch was 32 000 t from 1963 to 1979 with high inter annual variability. Reported catches declined after 1980, when a TAC of 13 000 t was established, but Scientific Council regularly expressed its concern about the reliability of some catches reported in the period since 1963, particularly those since 1980. Alternative estimates of the annual total catch since 1988 were made available in 1995 (Figure 6.1), including non-reported catches and catches from non-Contracting Parties.

The fishery was under moratorium between 1999 and 2009. Annual bycatches between 2000 and 2005 were estimated to be below 60 t, increasing since then until the reopening of the fishery in 2010 with a TAC of 5 500 tons. Since 2013, catches have remained at the level of the TAC.

Recent catches ('000 tonnes) are as follow:

	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
TAC	9.3	14.1	14.5	13.8	13.9	13.9	11.1	17.5	8.5	1.5	4.0
STATLANT 21	9.1	13.5	14.4	12.8	13.8	13.9	10.5	13.0	8.5	2.6	
STACFIS	12.8	14.0	14.3	13.8	14.0	13.9	11.5	17.5	8.5	2.1	

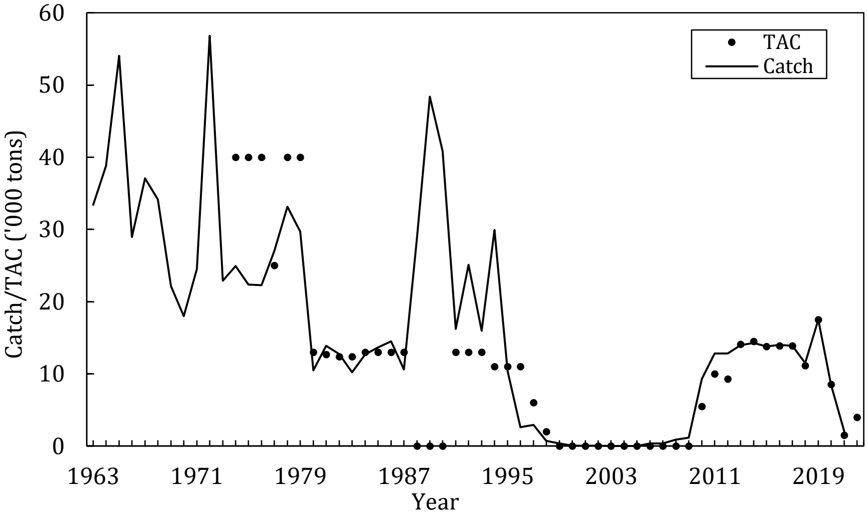


Figure 6.1. Cod in Division 3M: STACFIS catches and TAC.

b) Data Overview

i) Commercial Fisheries

In 2021 seven countries fished cod in Div. 3M, trawlers from EU-Estonia, EU-Portugal, EU-Spain, Japan and Russia and longliners from Faroe Islands and Norway.

Length and age compositions from the commercial catches are available from 1972 to 2021 with the exception of the 2002 to 2005 period. In 2021 there were commercial length distributions from EU-Estonia, EU-Portugal, EU-Spain and Norway. No samples were taken from the Faroes commercial vessels, so the Faroese survey length distribution was applied to the Faroese commercial catches (Figure 6.2). The mean lengths varied between 64 and 74 cm for the trawl fleets and between 69 and 75 for the longliner fleets. The mean length in the total commercial catch was 66 cm with a length range of 18-130 cm. Since 2013, the commercial catch at age data has been generated using Age Length Keys from the EU survey. Since 2015, ages 5 to 8+ have been the most abundant in the catch.

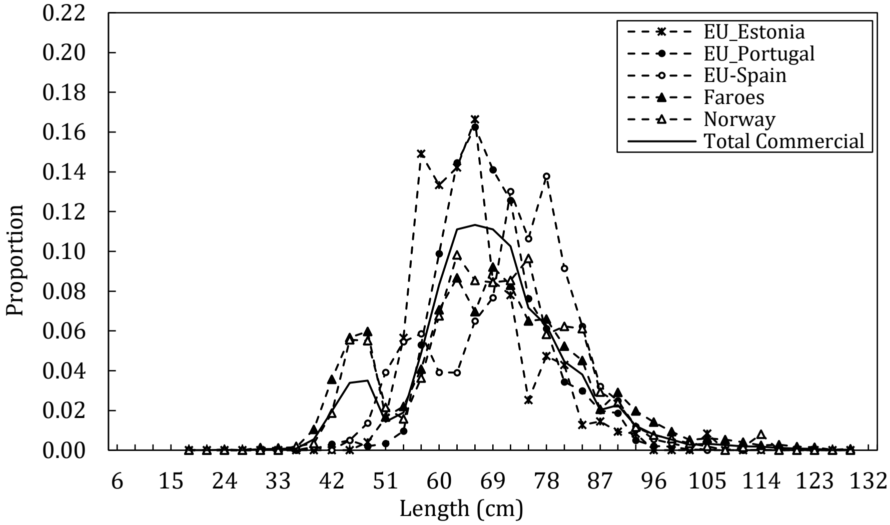


Figure 6.2. Cod in Division 3M: Length distribution of the commercial catches in 2021.

ii) Research surveys

Canadian survey. Canada conducted research surveys on Flemish Cap from 1978 to 1985 on board the R/V *Gadus Atlantica*, fishing with a lined Engels 145 otter trawl. The surveys were conducted annually in January-February covering depths between 130 and 728 m.

From a high value in 1978, a general decrease in biomass and abundance can be seen until 1985, reaching the lowest level in 1982 (Figure 6.3).

EU survey. The EU Flemish Cap survey has been conducted since 1988 in summer with a *Lofoten* gear type. The survey indices showed a general decline in biomass going from a peak value in 1989 to the lowest observed level in 2003. Biomass index increased from 2004 to 2014 and has decreased since. The growth of several strong year classes over 2005 to 2012 contributed to the increase in the biomass. Abundance rapidly increased between 2005 and 2011, declined from 2012 to 2016 and then stabilized . The difference in timing of the peaks in biomass and abundance over 2011-2018 is driven by the very large 2009 and 2010 year classes.

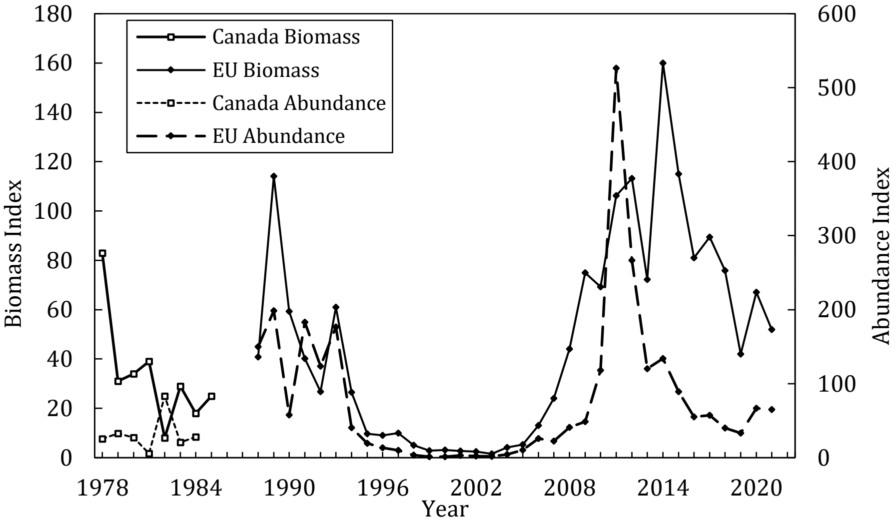


Figure 6.3. Cod in Division 3M: Survey abundance and biomass estimates from Canadian survey (1978-1985) and EU Flemish Cap survey (1988-2021).

iii) Recruitment

Three peaks in recruitment can be seen in 1982-1983, 1991-1992 and 2010-2021. Since 2018 recruitment seems to recover after a period of 5 years with poor recruitment (Figure 6.4).

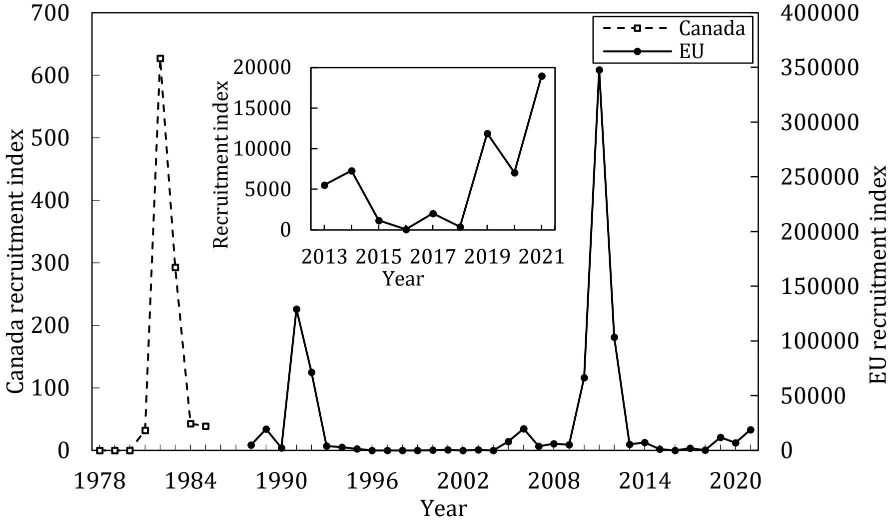


Figure 6.4. Cod in Division 3M: Number at age 1 in the Canadian survey (1978-1985) and EU survey (1988-2021). Inset plot , depicts recruitment since 2013.

iv) Biological parameters

The 2021 indices were derived from the 2021 EU survey ALK. Mean weight-at-age in the stock and in the catch had been decreasing continuously since the reopening of the fishery, reaching the minimum for ages 4 to 8 in 2015-2017. Since 2020 a high increase with respect to 2019 can be seen in the weight-at-age in stock in ages 5+, while decreasing for ages 2 and 3. Mean-weight in catch has a similar pattern, but less dramatic (Figures. 6.5 and 6.6).

Maturity ogives are available from the EU Flemish Cap survey for almost all years between 1988 and 2021. These were modelled using a Bayesian framework with missing values replaced with interpolations from adjacent years. There was a continuous decline of the A50 (age at which 50% of fish are mature), going from above 5 years old in the late 1980s to just below 3 years old in 2002 and 2003. Since 2005 there has been an increase in the A50, concurrently with the increase of the survey biomass, with the value in 2021 at the levels observed before 1990 (5.0 years old) (Figure 6.7).

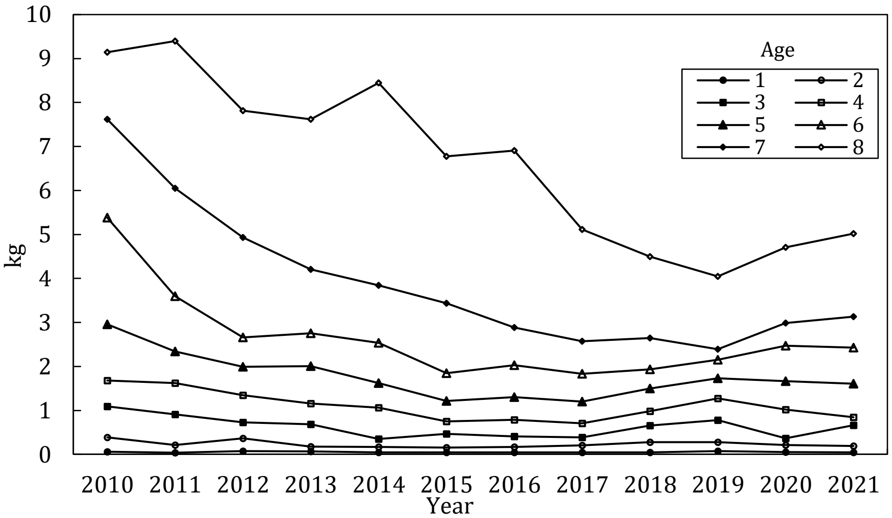


Figure 6.5. Cod in Division 3M: Mean weight-at-age in the stock for the 2010-2021 surveys.

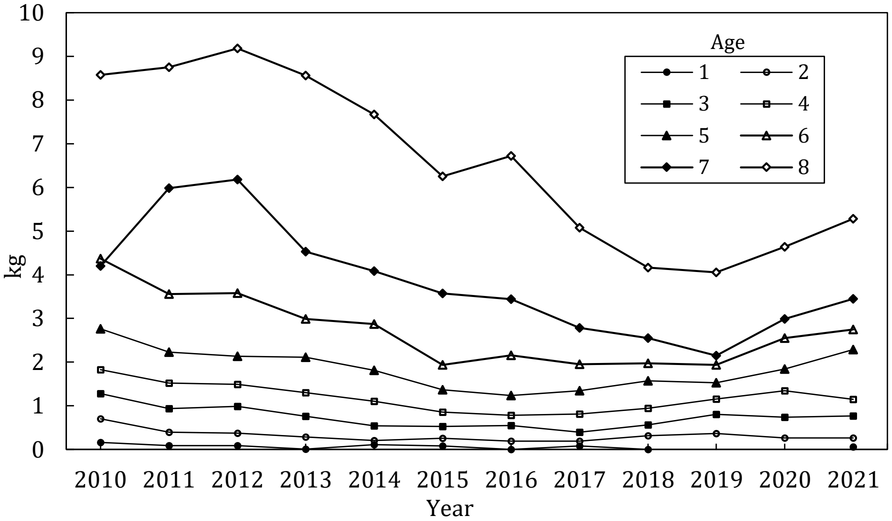


Figure 6.6. Cod in Division 3M: Mean weight-at-age in the catch for 2010-2021.

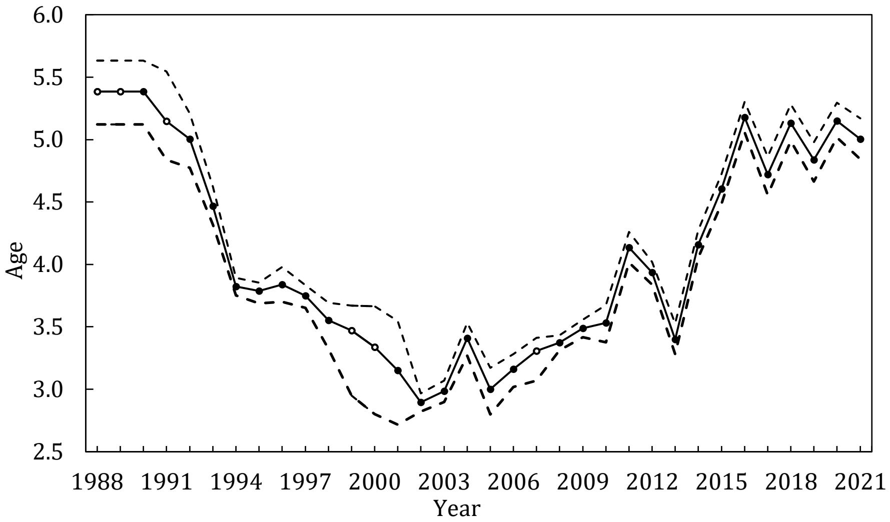


Figure 6.7. Cod in Division 3M: Age at 50% maturity (median and 90% confidence intervals) EU-Flemish Cap survey (1988-2021). Interpolated years are represented in white circles.

c) Estimation of Parameters

A Bayesian SCAA model, introduced at the 2018 benchmark, was used as the basis for the assessment of this stock with data from 1988 to 2021. Input data and settings are as follows:

Catch data: catch numbers and mean weight at age for 1988-2021, except for 2002-2005, for which only total catch is available. STACFIS estimates for total catch were used.

Tuning: numbers at age from EU Flemish Cap survey (1988-2021).

Ages: from 1 to 8+

Catchability analysis: dependent on stock size for age 1, estimated independently for ages 1 to 3 and for 4+ as a group.

Natural Mortality: M was set via a lognormal prior constant over years and variable through ages. Prior median is the same as last year assessment.

Additional priors: for recruitment in all the years, for the number-at-age for ages 2-8+ in the first year, for a year factor for F (f), for selectivity (rC), and for the natural mortality.

Likelihood components: for total catch, for catch numbers-at-age and numbers-at-age of the survey.

The model components are defined as follows:

Input data	Model component	Parameters
R 1988-2021	$LN\left(medrec, cvrec\right)$	*medrec*=45000, *cvrec*=10
N(1988,a), a=2-8+	Ages 2-7 $LN\left(median = medrec \times e^{-\sum_{age=1}^{a-1} M\left(age\right)+medFsurv\left(age\right)}, cv = cvsurv\right)$ Ages 8+ $LN\left(median = medrec \times \frac{e^{-\sum_{age=1}^{A-1}\left(M\left(age\right)+medFsurv\left(age\right)\right)}}{1-e^{-M\left(A+\right)+medFsurv\left(A+\right)}}, cv = cvsurv\right)$	*medFsurv*(1,…,7)={0.0001, 0.1, 0.5, 0.7, 0.7, 0.7, 0.7} *cvsurv*=10
f(y) y=1988-2021	Year 1988 $LN\left(median = medf\,,\ cv = cvf\,\right)$ Years 1989-2021 $LN\left(median = AR(1)\,over\ f\,,\ cv = cvf\,\right)$	*medf*=0.2, *cvf*=4
rC(y,a), a=2,8+ 1988-2021	Year 1988 $LN\left(median = medrC\left(a\right),\ cv = cvrC\left(a\right)\right)$ Years 1989-2021 $LN\left(median = last\ year\ rC,\ cv = cvrCcond\right)$	*medrC*(a)=c(0.01,0.3,0.6,0.9,1,1,1), *cvrC*(a)=c(4,4,4,4,4,4) *cvrCcond*=0.2
Total Catch 1988-2021	$LN\left(median = \sum_{age=1}^{A+} mu.C\left(y, age\right) wcatch\left(y, age\right),\ cv = cvcW\right)$ $mu.C\left(y,a\right) = N\left(y,a\right)\left(1-e^{-Z\left(y,a\right)}\right)\frac{F\left(y,a\right)}{Z\left(y,a\right)}$	*cvCW=0.077*
Catch Numbers at age, a=2,8+ 1988-2021	$LN\left(median = mu.C\left(y,a\right),\ cv = cv.C\right)$	*cv.C*=0.2
EU Survey Indices (I) 1988-2021	$I(y) \sim LN\left(median = \mu(y,a),\ cv = cvEU\right)$ $\mu(y,a) = q(a)\left(N(y,a)\frac{e^{-\alpha Z(y,a)} - e^{-\beta Z(y,a)}}{\left(\beta-\alpha\right)Z(y,a)}\right)^{\gamma(a)}$ $\gamma(a)\begin{cases}\sim N(\text{mean} = 1, \text{variance} = 0.25),\ if\ a = 1 \\ = 1,\ if\ a \geq 2\end{cases}$ $\log(q(a)) \sim N(\text{mean} = 0, \text{variance} = 5)$	I is the survey abundance index q is the survey catchability at age N is the stock abundance index *cvEU*=0.3 α = 0.5, β = 0.58 (survey made in July) Z is the total mortality
M	$M \sim LN(medM\,, cvM\,)$	*MedM*=c(1.26,0.65,0.44,0.35,0.30,0.27,0.24,0.24) *cvM*=0.15

d) Assessment Results

Total Biomass and Abundance: The median total abundance has declined between 2012 and 2020 by 78%. A steep increase in the abundance in 2021 reduces the decline to 56%. Median biomass has also declined by 64% since 2012 (Figure 6.8).

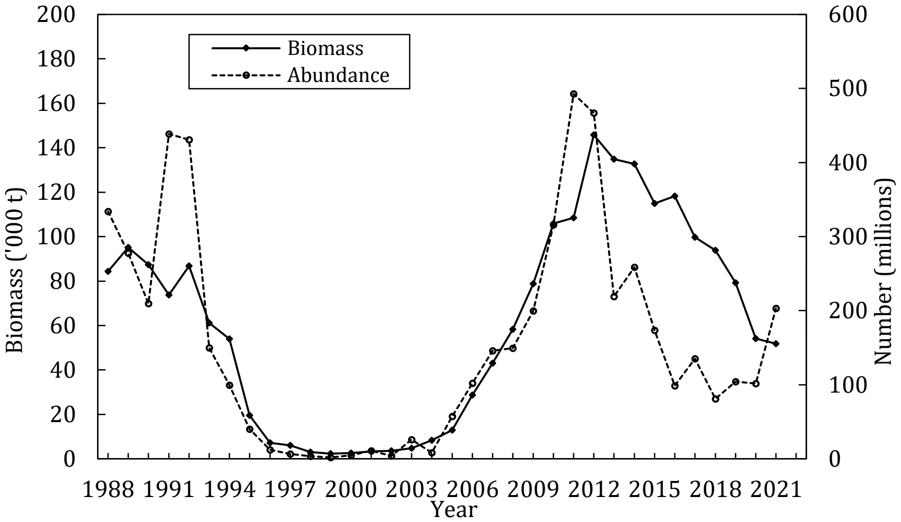


Figure 6.8. Cod in Div. 3M: Biomass and Abundance estimates.

Spawning stock biomass: Estimated median SSB over B_{lim} (Figure 6.9) increased since 2005 to the second highest value of the time series in 2017 (after 2014). This increase is due to several abundant year classes. The SSB has decreased since then. The probability of being below B_{lim} (median value of 15 037 t; see below, section g) in 2022 is very low (<1%). SSB in 2022 was calculated using the numbers estimated by the assessment at the beginning of 2022, applying the maturity ogive and mean weight at age in stock from 2021.

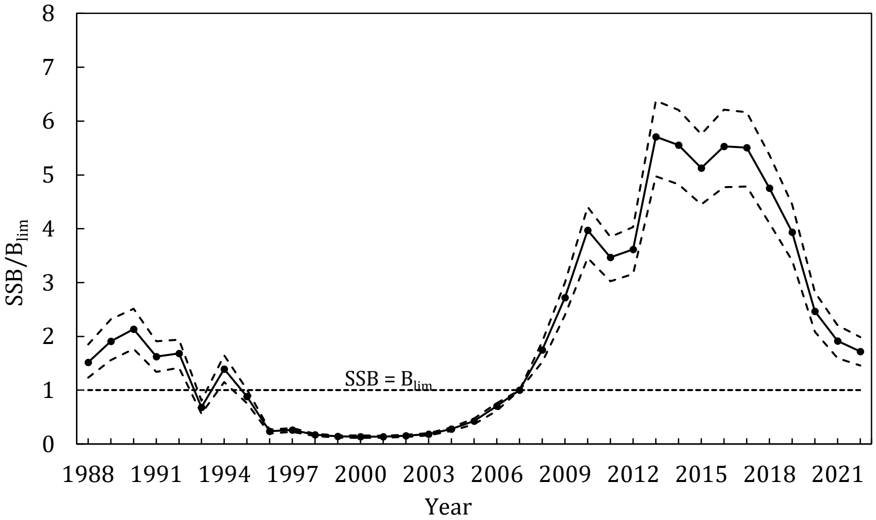


Figure 6.9. Cod in Div. 3M: Median and 80% probability intervals SSB/ B_{lim} estimates. The horizontal dashed line corresponds to SSB = B_{lim}.

Recruitment: Recruitment estimates (age 1) in 2021 was the highest since 2014 but remained well below the level observed in 2011 and 2012 (Figure 6.10).

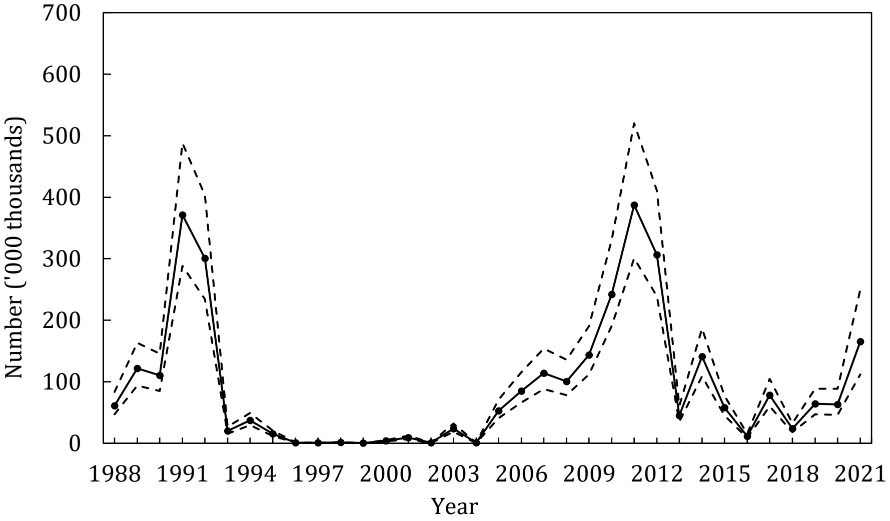


Figure 6.10. Cod in Div. 3M: Recruitment (age 1) estimates and 80% probability.

Fishing mortality: F increased in 2010 with the re-opening of the fishery although it has been below F_{lim} (0.166, see below, section g). (Figure 6.11).

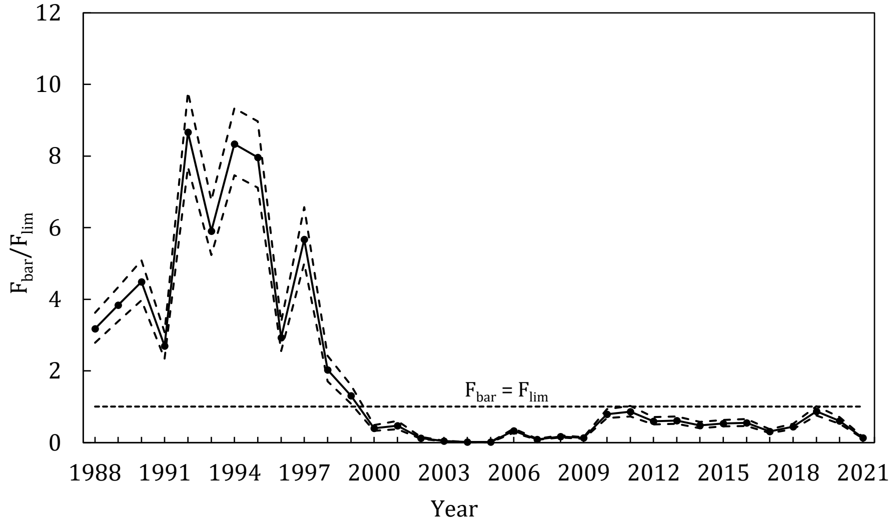


Figure 6.11. Cod in Div. 3M: F_{bar} (ages 3-5) estimates and 80% probability intervals. The horizontal dashed line corresponds to $F = F_{lim}$.

Natural mortality: The posterior median of M by age estimated by the model was:

Age	1	2	3	4	5	6	7	8
Posterior	1.35	0.60	0.34	0.24	0.26	0.37	0.33	0.41

e) Retrospective analysis

A five-years retrospective analysis with the Bayesian model was conducted by eliminating successive years of catch and survey data. Figures 6.12 to 6.14 present the retrospective estimates for age 1 recruitment, SSB and F_{bar} at ages 3-5.

Retrospective analysis shows revisions in the recruitment, mainly regarding the highest values of recruitment in the years 2009 to 2011, and in year 2019. This year the 2019 recruitment has been revised to a lower value. But no patterns are evident in recent years (Figure 6.12). These revisions lead to revisions in the SSB. There is very little evidence of a retrospective pattern in F, although the 2019 one was revised to a lower value (Figures 6.13 and 6.14).

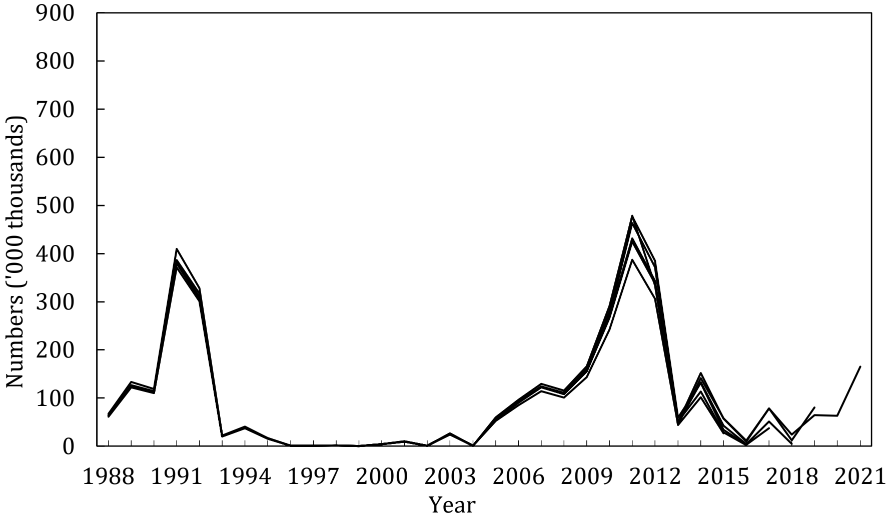


Figure 6.12. Cod in Div. 3M: Retrospective results for recruitment.

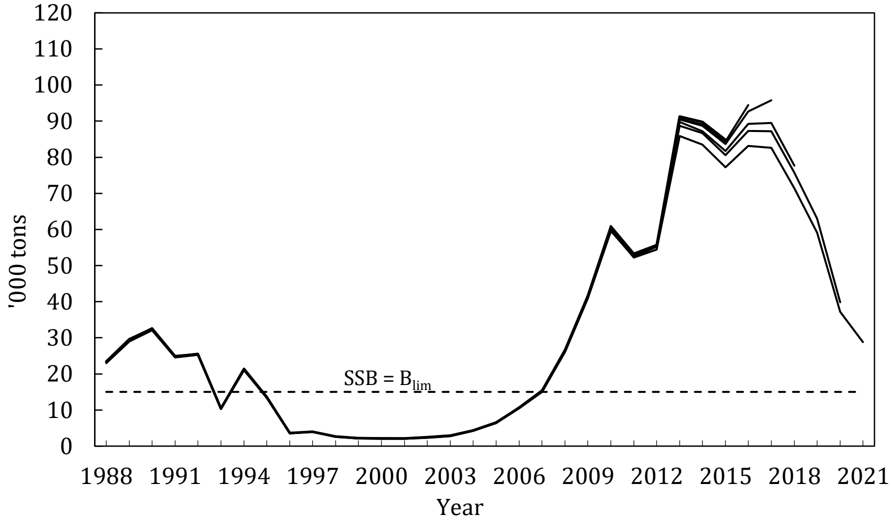


Figure 6.13. Cod in Div. 3M: Retrospective results for SSB.

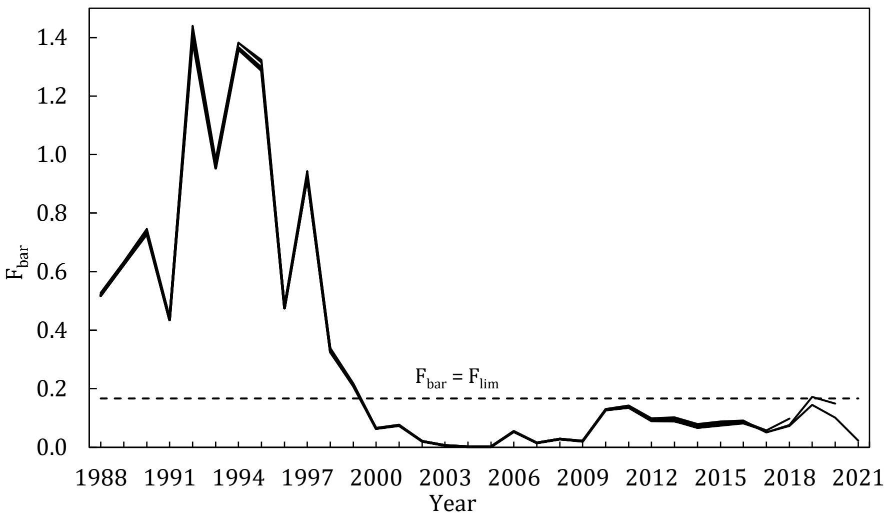


Figure 6.14. Cod in Div. 3M: Retrospective results for average fishing mortality.

f) State of the stock

SSB has been declining rapidly since 2017 but is still estimated to be above B_{lim} (median 15 037 t).

The 2021 estimated recruitment showed a positive signal after a period of lower recruitment

Fishing mortality has remained below F_{lim} (median 0.166) since the fishery reopened in 2010.

g) Reference Points

B_{lim} was estimated as the 2007 SSB, being its median value 15 037 tons (Figure 6.15). F_{lim} was estimated based on $F_{30\%SPR}$ calculated with the mean 2019-2021 input data as 0.166 (median value) (Figure 6.16).

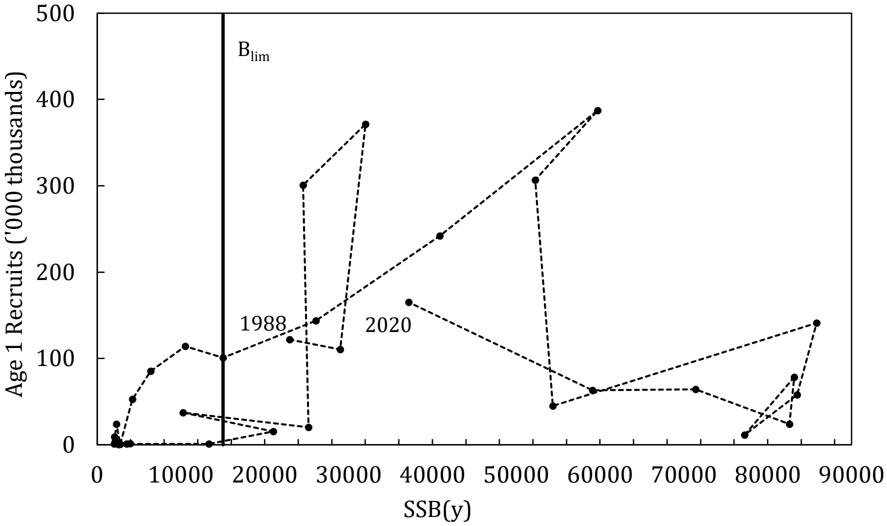


Figure 6.15. Cod in Div. 3M: Stock-Recruitment age 1 (posterior medians) plot. B_{lim} is plotted in the graph.

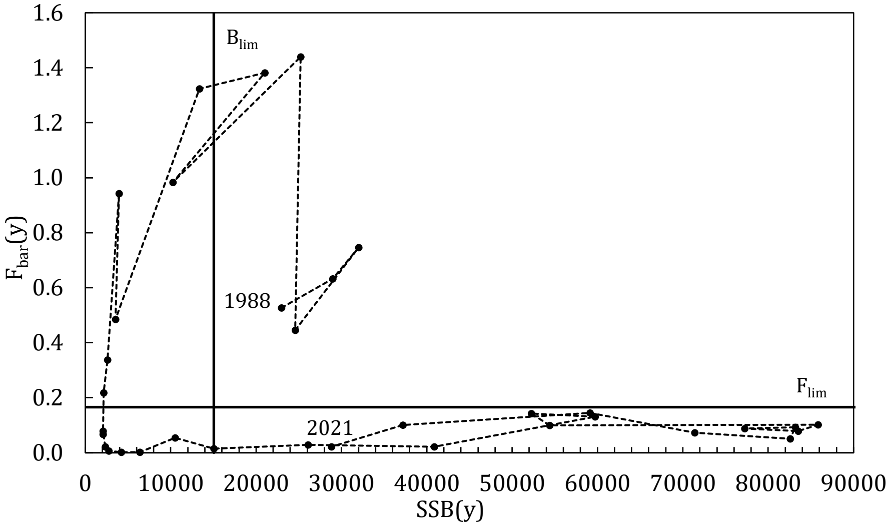


Figure 6.16. Cod in Div. 3M: Stock- F_{bar} (3-5) (posterior medians) plot. B_{lim} and F_{lim} are plotted in the graph.

h) Stock projections

The same method as last year was used to calculate the projections and the risk. Stochastic projections of the stock dynamics from 2022 to the start of 2025 were conducted. The variability in the input data is taken from the results of the Bayesian assessment. Input data for the projections are as follows:

Numbers aged 2 to 8+ in 2022: estimated from the assessment.

Recruitments for 2022-2025: Recruits per spawner were drawn randomly from 2018-2020.

Maturity ogive for 2022-2025: Mean of the last three years (2019-2021) maturity ogive.

Natural mortality for 2022-2025: 2021 natural mortality from the assessment results.

Weight-at-age in stock and weight-at-age in catch for 2022-2025: Mean of the last three years (2019-2021) weight-at-age.

PR at age for 2022-2025: Mean of the last three years (2019-2021) PRs.

F_{bar} *(ages 3-5)*: Nine scenarios were considered:

(Scenario 1) $F_{bar}=F_{sq}$ (median value = 0.089).

(Scenario 2) $F_{bar}=0$ (no catch).

(Scenario 3) $F_{bar}=F_{2021}$ (median value = 0.022).

(Scenario 4) $F_{bar}=1/2\ F_{lim}$ (median value = 0.083).

(Scenario 5) $F_{bar}=2/3\ F_{lim}$ (median value = 0.111).

(Scenario 6) $F_{bar}=3/4\ F_{lim}$ (median value = 0.125).

(Scenario 7) $F_{bar}= F_{lim}$ (median value = 0.166).

(*Scenario 8*) Catch in 2023-2024=4000 tons.

(*Scenario 9*) Catch in 2023-2024=5000 tons.

All scenarios assumed that the Yield for 2022 is the established TAC (4 000 t).

Although advice is given only for 2023, projection results are shown to 2025 to illustrate the medium-term implications. F_{bar} is the mean of the F at ages 3-5 and used as the indicator of overall fishing mortality; F_{sq} is the status quo F calculated as the mean of the last three years F_{bar} (2019-2021).

The results indicate that under all scenarios with $F_{bar}>0$, total biomass during the projected years will decrease, whereas the SSB is projected to increase slightly in 2025 except in all scenarios with $F \geq 2/3\ F_{lim}$ (Table 6.1). The probability of SSB being below B_{lim} in 2024 is low (≤3%) in all the scenarios (Table 6.2). The probability of SSB in 2025 being above that in 2022 ranges between 9% and 100%, depending on the scenario.

Under all scenarios, the probability of F_{bar} exceeding F_{lim} is less than or equal to 3% in 2023 and 2024 except for F_{lim} as expected.

SC notes that projections of risk, in particular more than one year ahead (Table 6.2), will inherently include more uncertainty than projected median stock sizes (Table 6.1). The risks are typically derived from the tails of a probability distribution which are less precisely estimated compared to the median (centre) of the same distribution.

Table 6.1. Medium-term projections

	B		SSB		Yield
	Median and 80% CI				
$F_{bar} = F_{sq}$ (median = 0.089)					
2022	50511	(45475 - 56297)	25994	(23085 - 28992)	4000
2023	48942	(43410 - 55808)	22651	(19983 - 25601)	5791
2024	47441	(41115 - 55572)	23797	(20536 - 27170)	6987
2025	43101	(35439 - 52003)	27046	(22345 - 32507)	
$F_{bar} = 0$					
2022	50511	(45475 - 56297)	25994	(23085 - 28992)	4000
2023	48942	(43410 - 55808)	22651	(19983 - 25601)	0
2024	53489	(47131 - 61613)	29062	(25841 - 32474)	0
2025	55443	(47659 - 64531)	37876	(33038 - 43336)	
$F_{bar} = F_{2021}$ (median = 0.022)					
2022	50511	(45475 - 56297)	25994	(23085 - 28992)	4000
2023	48942	(43410 - 55808)	22651	(19983 - 25601)	3425
2024	49900	(43564 - 58037)	25929	(22708 - 29370)	4429
2025	47858	(40184 - 56840)	31201	(26375 - 36582)	
$F_{bar} = 1/2F_{lim}$ (median = 0.083)					
2022	50511	(45475 - 56297)	25994	(23085 - 28992)	4000
2023	48942	(43410 - 55808)	22651	(19983 - 25601)	5446
2024	47801	(41467 - 55931)	24123	(20900 - 27453)	6610
2025	43807	(36133 - 52710)	27667	(22940 - 33046)	
$F_{bar} = 2/3F_{lim}$ (median = 0.111)					
2022	50511	(45475 - 56297)	25994	(23085 - 28992)	4000
2023	48942	(43410 - 55808)	22651	(19983 - 25601)	7032
2024	46140	(39833 - 54302)	22661	(19467 - 26010)	8128
2025	40803	(33146 - 49719)	25127	(20387 - 30497)	
$F_{bar} = 3/4F_{lim}$ (median = 0.125)					
2022	50511	(45475 - 56297)	25994	(23085 - 28992)	4000
2023	48942	(43410 - 55808)	22651	(19983 - 25601)	7787
2024	45350	(39053 - 53527)	21986	(18790 - 25344)	8790
2025	39437	(31811 - 48396)	23977	(19350 - 29304)	
$F_{bar} = F_{lim}$ (median = 0.166)					
2022	50511	(45475 - 56297)	25994	(23085 - 28992)	4000
2023	48942	(43410 - 55808)	22651	(19983 - 25601)	9915
2024	43154	(36866 - 51292)	20065	(16900 - 23469)	10431
2025	35770	(28221 - 44759)	20928	(16358 - 26280)	
Catch = 4000 tons					
2022	50511	(45475 - 56297)	25994	(23085 - 28992)	4000
2023	48942	(43410 - 55808)	22651	(19983 - 25601)	4000
2024	49306	(42971 - 57441)	25399	(22161 - 28803)	4000
2025	47760	(40074 - 56713)	31052	(26294 - 36499)	
Catch = 5000 tons					
2022	50511	(45475 - 56297)	25994	(23085 - 28992)	4000
2023	48942	(43410 - 55808)	22651	(19983 - 25601)	5000
2024	48274	(41931 - 56397)	24492	(21285 - 27869)	5000
2025	45838	(38143 - 54765)	29349	(24623 - 34867)	

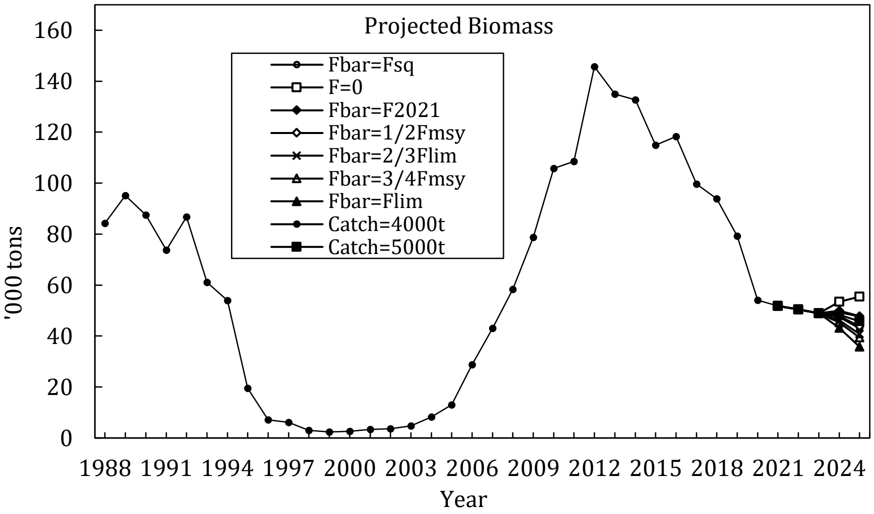


Figure 6.17. Cod in Div. 3M: Projected Total Biomass under all the Scenarios.

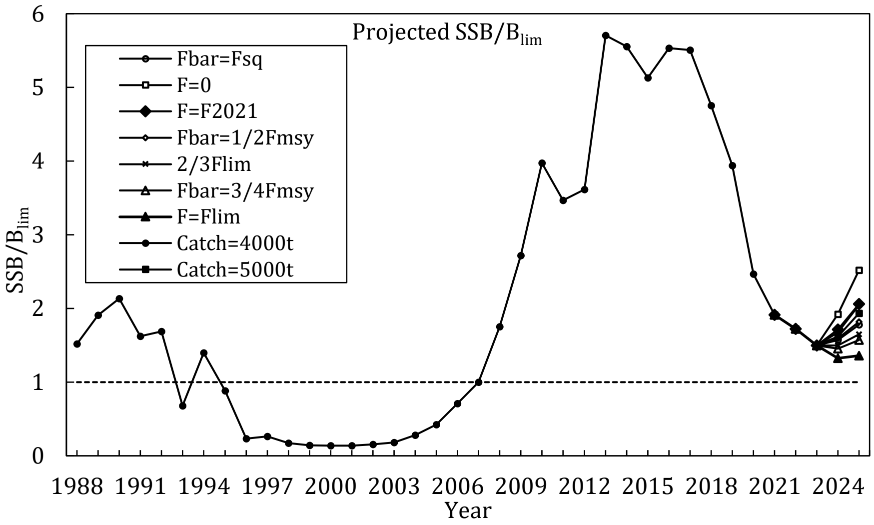


Figure 6.18. Cod in Div. 3M: Projected SSB under all the Scenarios

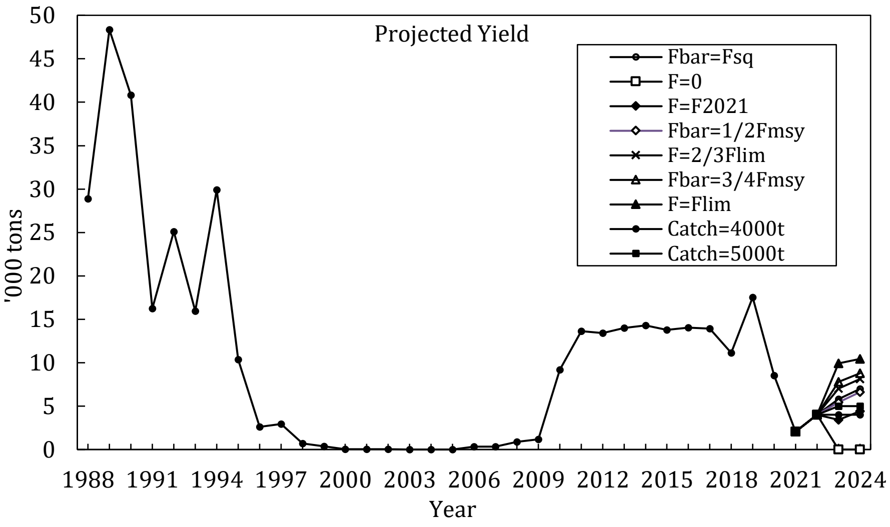


Figure 6.19. Cod in Div. 3M: Projected removals under all the Scenarios

Table 6.2 Projected yield (t) and the probability of SSB < B_{lim} and F_{bar}<F_{Lim} and probability of stock growth (B_{2025}>B_{2022}) under projected F values.

	Yield			P(SSB < B_{lim})				P(F_{bar} > F_{lim})			
	2022	2023	2024	2022	2023	2024	2025	2022	2023	2024	P(B_{25} > B_{22})
$F_{sq} = 0.089$	4000	5791	6987	0%	0%	0%	0%	0%	0%	0%	60%
F=0	4000	0	0	0%	0%	0%	0%	0%	0%	0%	100%
$F_{2021} = 0.022$	4000	3425	4429	0%	0%	0%	0%	0%	0%	0%	95%
$1/2F_{lim} = 0.083$	4000	5446	6610	0%	0%	0%	0%	0%	0%	0%	67%
$2/3F_{lim} = 0.111$	4000	7032	8128	0%	0%	1%	1%	0%	0%	0%	39%
$3/4F_{lim} = 0.125$	4000	7787	8790	0%	0%	1%	1%	0%	0%	3%	27%
$F_{lim} = 0.166$	4000	9915	10431	0%	0%	3%	6%	0%	50%	50%	9%
C = 4000t	4000	4000	4000	0%	0%	0%	0%	0%	0%	0%	94%
C = 5000t	4000	5000	5000	0%	0%	0%	0%	0%	0%	0%	86%

i) Research recommendations

STACFIS **recommended** that *an age reader comparison exercise be conducted.*

STATUS: An age-readers Workshop was held in November 2017 in order to reconcile the differences among age-readers of this stock. Much progress in understanding where the differences between the commercial and survey ALKs come from was made but still needs more research to completely know the problem. No progress since then was made. NAFO reiterates this recommendation.

STACFIS **encouraged** to *all Contracting Parties to provide length distribution samples from the commercial vessels fishing 3M cod*.

STATUS: NAFO reiterates this recommendation.

The next full assessment for this stock will be in 2023.

7. Beaked Redfish (*Sebastes mentella* and *Sebastes fasciatus*) in Division 3M

Interim Monitoring Report (SCR Doc. 21/34, 22/004; SCS Doc. 22/05, 06, 07, 09, 13)

a) Introduction

There are three species of redfish that are commercially fished on Flemish Cap; deep-sea redfish (*Sebastes mentella*), golden redfish (*Sebastes norvegicus*) and Acadian redfish (*Sebastes fasciatus*). The term beaked redfish is used for *S. mentella* and *S. fasciatus* combined. Because of difficulties with identification and separation, all three species are reported together as 'redfish' in the commercial fishery. All stocks have both pelagic and demersal concentrations and long recruitment process to the bottom. Redfish species are long lived with slow growth.

The separation of the three species is made in the EU research survey. This requires extensive sampling effort by trained experts to examine internal features of individual redfish. The percentage per depth range of the three species in the EU Flemish Cap surveys, was used to separate the Div. 3M commercial catches into golden and beaked redfish. This method is also applied in the assessment of golden redfish.

Fishery and Catch: The redfish fishery in Div. 3M increased from 20 000 tons in 1985 to 81 000 tons in 1990, and falling continuously since then until 1998-1999, when a minimum catch around 1100 tons was recorded mostly as by-catch of the Greenland halibut fishery. An increase of the fishing effort directed to Div. 3M redfish is observed from 2005 onwards pursued by the Portuguese bottom trawl and Russia bottom and pelagic trawl fleets. Part of this fishing effort has been deployed on shallower depths above 300m and is associated with the increase of cod catches and reopening of the Flemish Cap cod fishery in 2010.

STACFIS catch estimates were available till 2010. Over 2006-2010 an average annual bias of 15% plus was recorded between STACFIS catch estimate and STATLANT nominal catch. In order to mitigate the lack of independent catch data a 15% surplus has been added to the STATLANT catch of each fleet between 2011 and 2014. For 2015 the annual catch was given by the Daily Catch Reports (DCR's) by country provided by the NAFO Secretariat. For 2016 catch was calculated using the CDAG Estimation Strategy (NAFO Regulatory Area Only). The 2017 - 2021 catch estimates were obtained with the application of the CESAG method. The 1989-2021 catch estimates from those different sources are accepted as the 3M redfish landings.

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

	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
TAC[1]	6.5	6.5	6.7	7.0	7.0	10.5	10.5	8.6	8.4	10.9	11.2
STATLANT 21[1]	6.8	6.4	6.9	6.6	7.1	10.5	10.5	8.6	7.0		
STACFIS Total catch[1, 2]	7.8	7.4	6.9	6.6	7.1	10.5	10.5	8.8	8.3		
STACFIS Catch[3]	5.2	4.6	5.2	6.2	6.9	10.3	10.2	8.7	7.9		

[1] TAC, STATLANT 21 and STACFIS Total catch refer to all three redfish species combined.

[2] STACFIS total catch on 2011-2014 based on the average 2006-2010 bias.

[3] STACFIS beaked redfish catch estimate, based on beaked redfish proportions on observed catch.

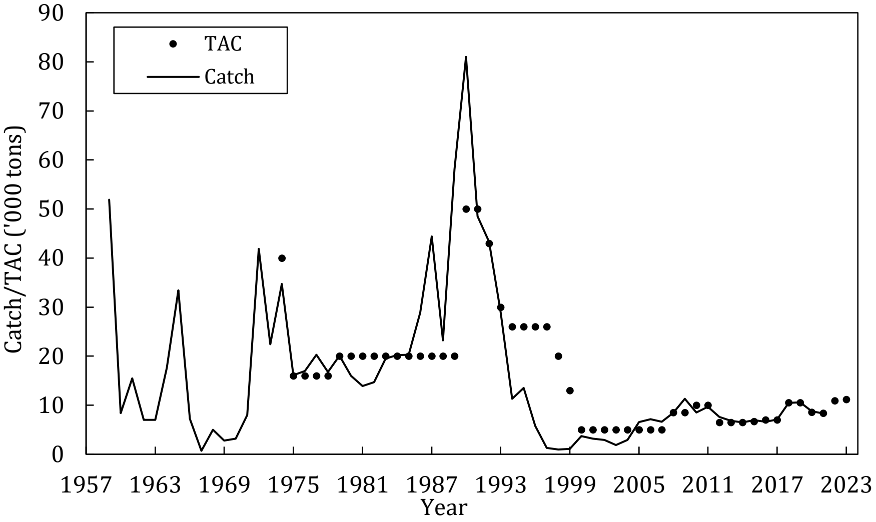


Figure 7.1. Redfish in Div. 3M: catches and TACs.

b) Data Overview

i) Research surveys

Flemish Cap Survey: Despite a sequence of abundant year classes and a low exploitation regime over almost twenty years, survey results suggest that the beaked redfish stock increased sharply from 2004 to 2006 and then declined rapidly over the second half of the 2000's. Such unexpected shift on the stock dynamics can only be attributed to mortality other than fishing mortality. Spawning stock biomass has remained high in recent years while exploitable biomass and abundance are declining since 2012, although some recover in recent years (Figure 6.2). There has been very low recruitment at age four in most recent years.

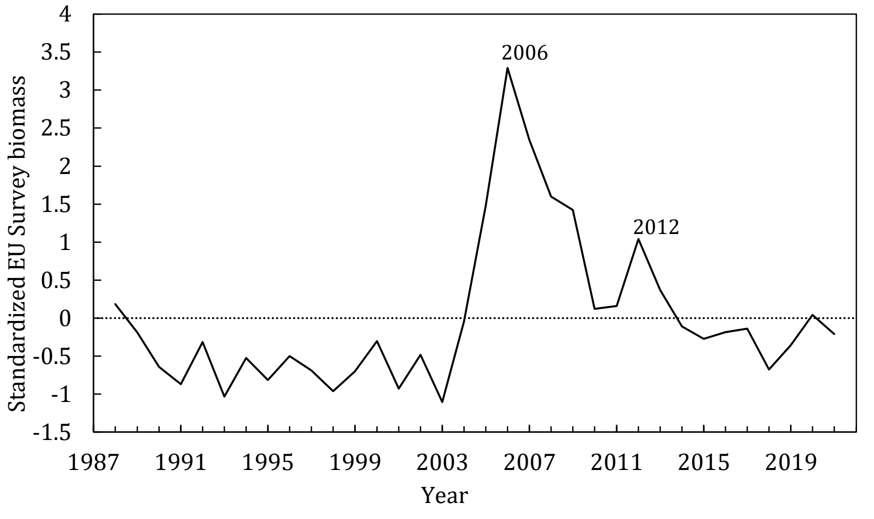


Figure 7.2. Beaked redfish in Div. 3M: survey standardized total biomass index (1988-2021).

c) Conclusions

The perception of the stock status has not changed.

d) Research recommendations

STACFIS **recommends** that *input data should be investigated in order to reduce the retrospective pattern of the XSA assessment, such as the ALKs used. Other assessment models, taking in account the ones used, on redfish stocks, with the same problem of more than one species, in the Golf St. Laurence and NAFO Div. 0, should be explored.*

The next full assessment of the stock is planned for 2023.

8. American Plaice (*Hippoglossoides platessoides*) in Div.3M

Interim Monitoring Report (SCR Doc. 22/004; SCS Doc 22/06, 07, 09, 13)

a) Introduction

Fishery and Catch: The stock declined during the late 1980s and since 1996 there has been no directed fishing. Total estimated STACFIS/CESAG bycatch in 2021 was 104 tons (Figure 8.1).

Recent catches and TACs ('000 t) are as follows:

	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
TAC	ndf	ndf	ndf	ndf	ndf	ndf	ndf	ndf	ndf	ndf
STATLANT 21	0.2	0.2	0.2	0.2	0.2	0.2	0.3	0.2	.05	
STACFIS	0.2	0.2	0.3	0.2	0.2	0.2	0.3	0.2	0.1	

ndf No directed fishing.

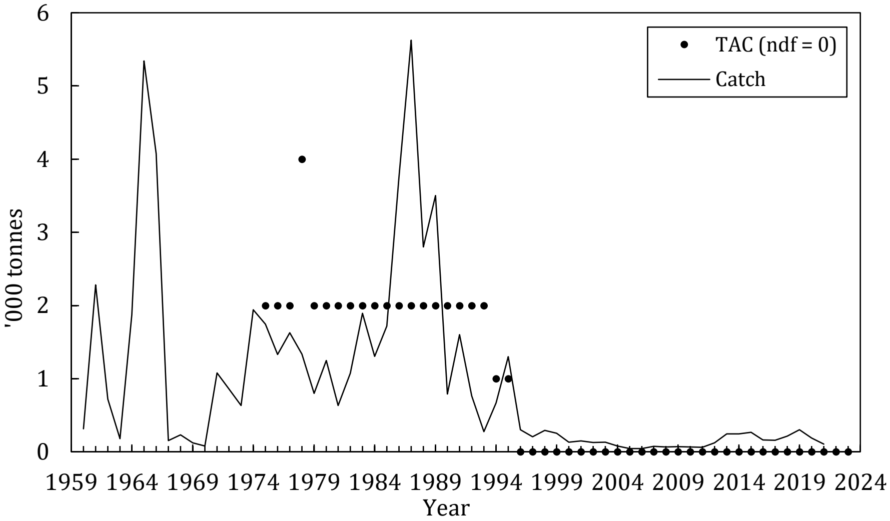


Figure 8.1. American plaice in Div. 3M: STACFIS catches and TACs. No directed fishing is plotted as 0 TAC.

b) Data Overview

i) Research surveys:

The EU bottom trawl survey on Flemish Cap was conducted during 2021. From 2017 to 2020 the biomass estimate has been relatively stable at levels observed in the mid 1990´s, prior to the fishery closure, the 2021 biomass estimate has increase slightly (Figure 8.2).

All of the 1991 to 2005 year-classes are estimated to be weak. Since 2006 recruitment improved, particularly the 2006, 2012, 2015 and 2018 year classes (Figure 8.3).

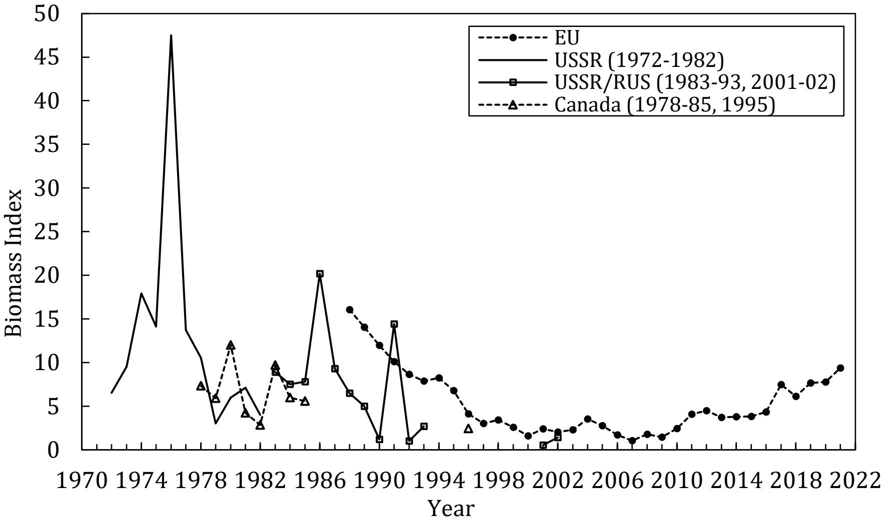


Figure 8.2. American plaice in Div. 3M: trends in survey biomass indices. EU survey data prior to 2003 have been converted to *RV Vizconde Eza* equivalents.

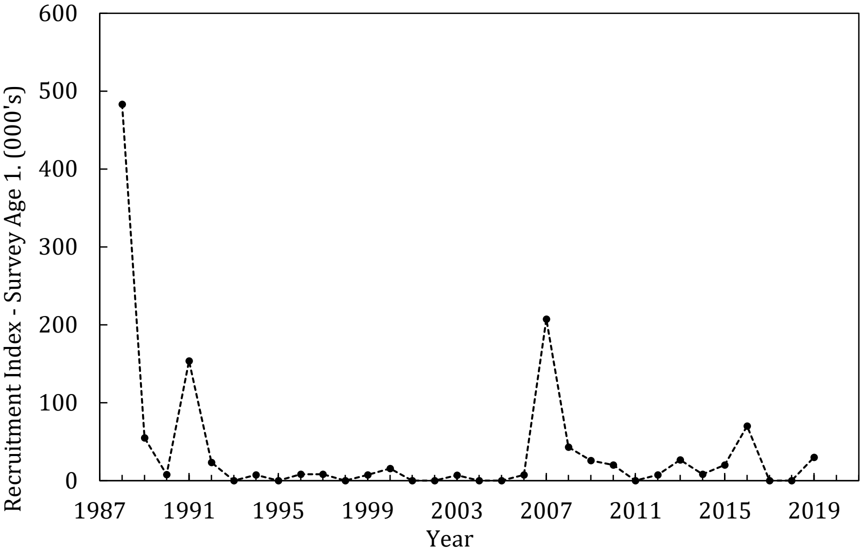


Figure 8.3. American plaice in Div. 3M: Recruitment index, trends in survey age 1 abundance.

c) Conclusion

Catches since 1996 have been low, below 300 t, and although survey biomass has been gradually increasing with signs of improvement in recruitment since 2007 (2006 year-class was particularly strong), the stock remains at a relatively low level. The recent increase is not enough to change the perception of the stock status and the previous advice of no directed fishing is still valid.

The next full assessment for this stock is planned for 2023.

C. STOCKS ON THE GRAND BANKS (NAFO DIVISIONS 3LNO)

Recent Highlights in Ocean Climate and Lower Trophic Levels for 3LNO

- In 2021, the ocean climate in NAFO Divs. 3LNO - Grand Bank, was at its second warmest value of the entire time series started in 1975 (after the record high of 2011).
- Spring bloom initiation was near normal in 2021 for a 3rd consecutive year.
- Spring bloom magnitude decreased to below normal in 2021 and was among the lowest of the time series.
- The abundance of copepods and non-copepods remained above normal in 2021 for a 6th consecutive year with a time series record high for copepods.
- Zooplankton biomass was above normal in 2021 for the third time over the past five years.

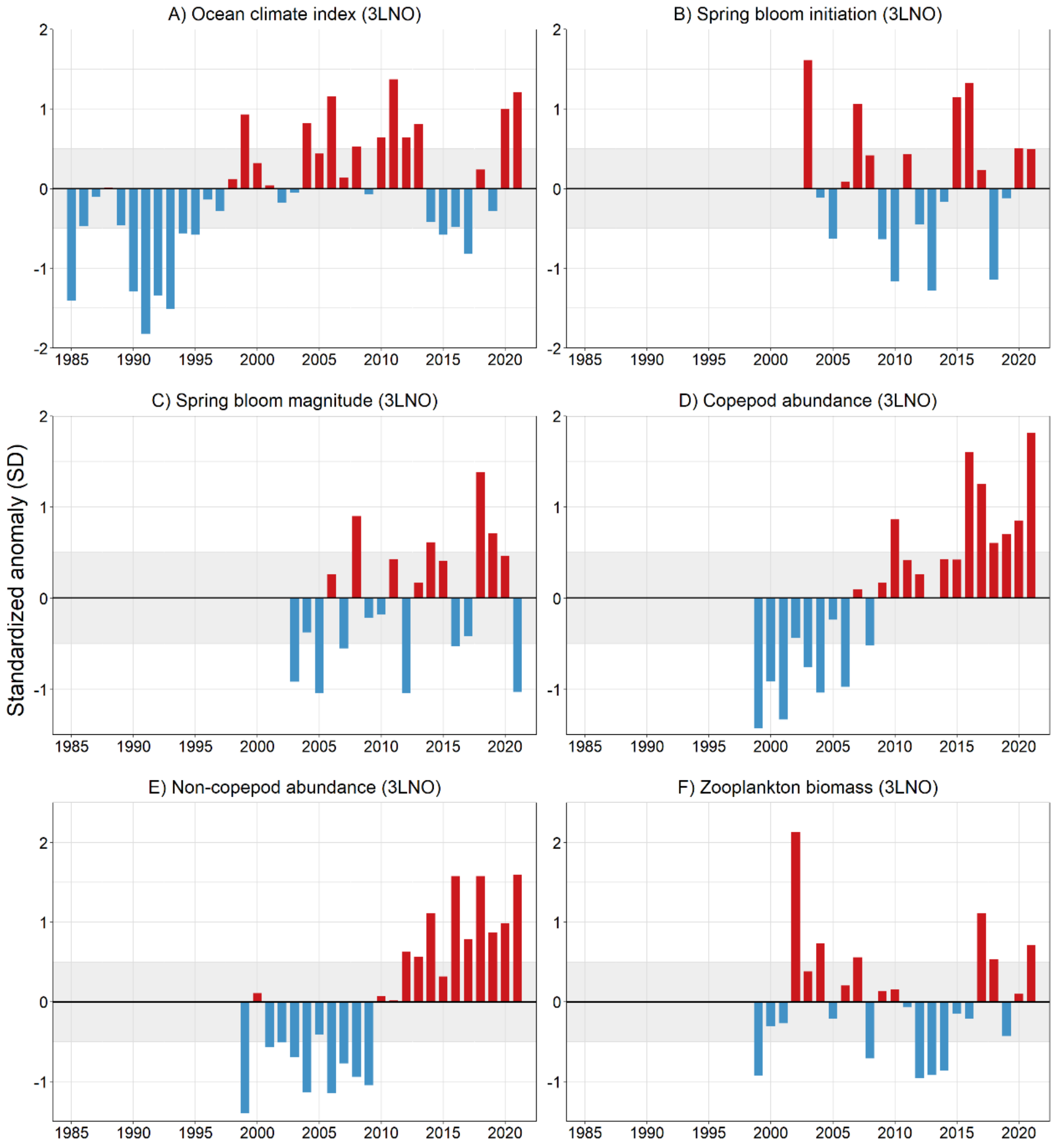


Figure C1. Annual anomalies of environmental indices for NAFO Divisions 3LNO. The ocean climate index (A) during 1985-2012 is the average of twelve individual time series of standardized ocean temperature anomalies: SSTs for Divs. 3L, 3N and 3O, vertically average ocean temperature (0-176 m) at Station 27, mean temperature and CIL volumes over standard hydrographic sections Seal Island, Bonavista and inshore Flemish Cap (FC-01 to FC-20), and mean bottom temperature in 3LNO for spring and fall (see Cyr and Belanger 2022 for details). Spring bloom anomalies (B, C) for the 2003-2020 period were averaged over two satellite boxes (NGB, SE – see Figure C1A for boxes location). Zooplankton anomalies (D-F) for the 1999-2021 period are derived from two oceanographic sections (3LN portion of FC, SEGB– see Cyr and Belanger 2022 for details) and one coastal high-frequency sampling site (S27). Positive (negative) anomalies indicate late (early) bloom timing or conditions above (below) the mean for the reference period. Anomalies were calculated using the following reference periods: ocean climate index: 1981-2010, phytoplankton indices: 2003-2020, zooplankton indices: 1999-2020. Anomalies within ±0.5 SD (shaded area) are considered normal conditions.

Environmental Overview

The water mass characteristic of the Grand Bank are typical of sub-polar waters, with the presence of a cold intermediate layer (CIL) formed during winter, and which last throughout the year until the late fall. The CIL (defined as water <0°C) extends to the ocean bottom in the northern areas of 3LNO, covering the bottom with sub-zero temperatures. The CIL is thus a reliable index of ocean climate conditions in this area. Bottom temperatures are higher in southern regions of 3NO reaching 1 - 4°C, mainly due to atmospheric forcing and along the slopes of the banks below 200 m depth due to the presence of Labrador Slope Water. On the southern slopes of the Grand Bank in Div. 3O bottom temperatures may reach 4 - 8°C due to the influence of warm slope water from the Gulf Stream. The general circulation in this region consists of the relatively strong offshore Labrador Current at the shelf break and a considerably weaker branch near the coast in the Avalon Channel. Currents over the banks are very weak and the variability often exceeds the mean flow.

Ocean Climate and Ecosystem Indicators

The ocean climate index in Divs. 3LNO (Figure C1A) has remained mostly above normal between the late 1990s and 2013, reaching a peak in 2011. The index has returned to normal conditions between 2014 and 2019 (except for 2015 and 2017 that was below normal). In 2020 and 2021, the ocean climate index was back to above normal value, reaching in 2021 the second highest value of the entire time series started in 1985 (only 2011 was warmest).

There was a general shift toward earlier spring bloom timing on the Grand Bank from 2003 to 2013 despite interannual variability (Figure C1B). Spring bloom timing remained either near or later than normal afterward except for the early blooms of 2018. Spring bloom magnitude (total production) was quite variable in 3LNO throughout the time series with no clear temporal pattern (Figure C1C). Total spring production in 2021 was third lowest of the time series after three years of a steady decline that followed the 2018 record high (Figure C1C). The abundance of copepods and non-copepods generally increased throughout the time series with a clear transition from negative to positive anomalies around 2010 (Figure C1D, E). Abundance has remained above normal since 2016 for both groups with a record high for copepods and one of the three highest values on record for non-copepods in 2021 (Figure C1D, E). Total zooplankton biomass generally declined from the early 2000s through 2014 but has increased to near or above normal afterward (Figure C1F). In 2021, biomass was above normal for the third time over the past five years (Figure C1F).

9. Cod (*Gadus morhua*) in NAFO Division 3NO

(SCR Doc. 22/05,07; SCS Doc. 22/06,07,08,09,010,013,014). Interim Monitoring Report

a) Introduction

This stock has been under moratorium to directed fishing since February 1994. Total bycatch during the moratorium increased from 170 t in 1995, peaked at about 4 800 t in 2003 and has been between 400 t and 1100 t since that time. The bycatch in 2021 was 493 t.

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

	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
TAC	ndf	ndf	ndf	ndf	ndf	ndf	ndf	ndf	ndf	ndf
STATLANT 21	1.1	0.7	0.5	0.6	0.6	0.3	0.5	0.3	2.0	
STACFIS	1.1	0.7	0.6	0.7	0.6	0.4	0.5	0.6	0.5	

ndf : No directed fishery

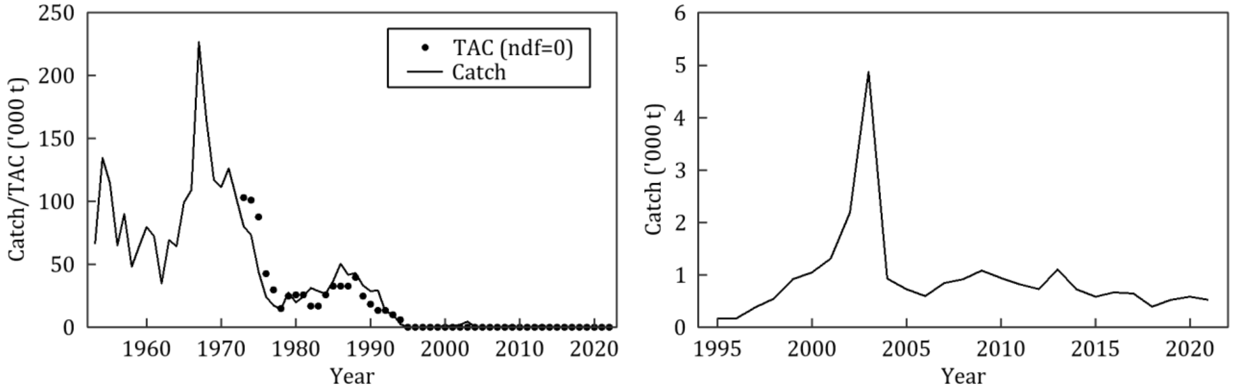


Figure 9.1. Cod in Div. 3NO: total catches and TACs. Panel at right highlights catches during the moratorium on directed fishing.

b) Data Overview

Canadian bottom trawl surveys. The spring survey biomass index declined from 1984 to 1995 and has generally remained low since that time (Figure 9.2). There was an increase in biomass during 2011-2014 but indices have subsequently declined again and the 2019 biomass indices were among the lowest in the time series. The trend in the autumn survey biomass index was similar to the spring series (Figure 9.2). Due to COVID-19 restrictions, the spring survey was not conducted in 2020, and due to operational difficulties, there was no 2021 survey (See appendix III, SCS Doc. 21-17).

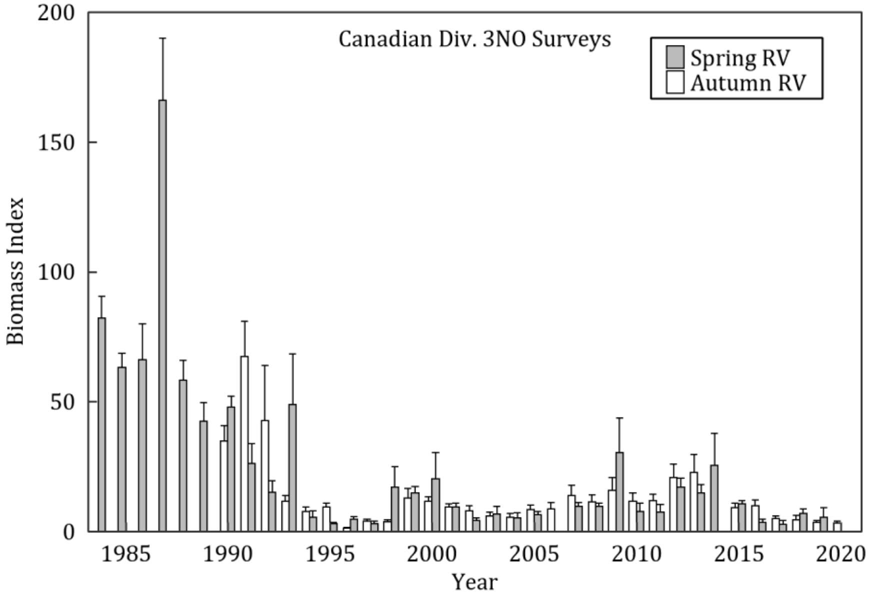


Figure 9.2. Cod in Div. 3NO: survey biomass index (+ 1 sd) from Canadian spring (grey) and autumn (white) research surveys.

EU-Spain Div. 3NO surveys. The biomass index was relatively low and stable from 1997-2008 with the exception of 1998 and 2001 (Figure 9.3). There was a considerable increase in the index from 2008-2011, followed by a decline to 2013. In 2014, the index increased to the highest value in the time series but has continually decreased in subsequent years. There was no EU-Spain survey in Divs. 3NO in 2020 but the index remained low in the 2021 survey.

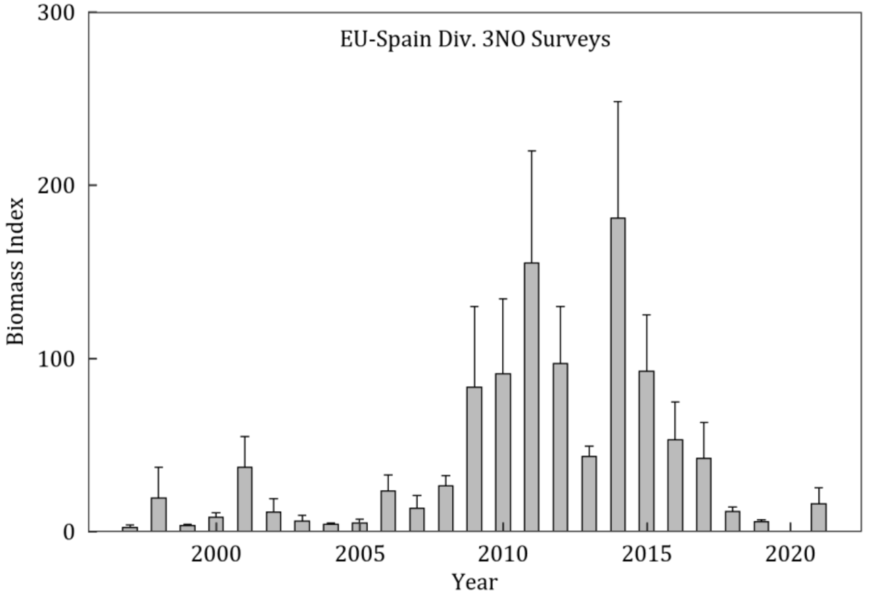


Figure 9.3. Cod in Div. 3NO: survey biomass index (+ 1 sd) from EU-Spain Div. 3NO surveys.

c) Conclusion

The most recent analytical assessment (2021) concluded that SSB was well below B_{lim} (60 000 t) in 2020. A lack of commercial sampling in 2020 prevented 2021 SSB from being estimated. Canadian RV surveys did not cover Divs. 3NO in 2021 but the EU-Spain survey index remained low. Overall, the 2021 index is not considered to indicate a significant change in the status of the stock.

The next full assessment of this stock will occur in 2024.

10. Redfish (*Sebastes mentella* and *S. fasciatus*) in Divisions 3LN

(SCR Doc. 20/014, 22/005, 007, 013; SCS Doc. 22/06, 07, 09, 13)

a) Introduction

There are two species of redfish in Divisions 3L and 3N, the deep-sea redfish (*Sebastes mentella*) and the Acadian redfish (*Sebastes fasciatus*) that have been commercially fished and reported collectively as redfish in fishery statistics. Both species, occurring in Div. 3LN are managed as a single stock and are thought to belong to a large Northwest Atlantic complex ranging from the Gulf of Maine to south of Baffin Island.

Between 1959 and 1960 reported catches dropped from 44 600 to 26 600 t, oscillating over the next 25 years (1960-1985) around an average level of 21 000 t. Catches increased to a 79 000 t high in 1987 and declined steadily to a 450 t minimum reached in 1996. The NAFO Commission implemented a moratorium on directed fishing for this stock in 1998. Catches remained at relatively low levels (450-3 000 t) until 2009. The Commission endorsed the Scientific Council recommendations from 2011 onwards and catches steadily increased to 13 050t in 2019, the highest level recorded since 1993.

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

	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
TAC	6.0	6.5	6.5	10.4	10.4	14.2	14.2	18.1	18.1	18.1	18.1
Total	4.3	6.2	5.7	9.9	8.5	11.8	11.3	13.1	11.1	10.2	
STATLANT	4.3	6.2	5.7	10.2	8.5	11.8	11.3	13.1	11.7	11.8	

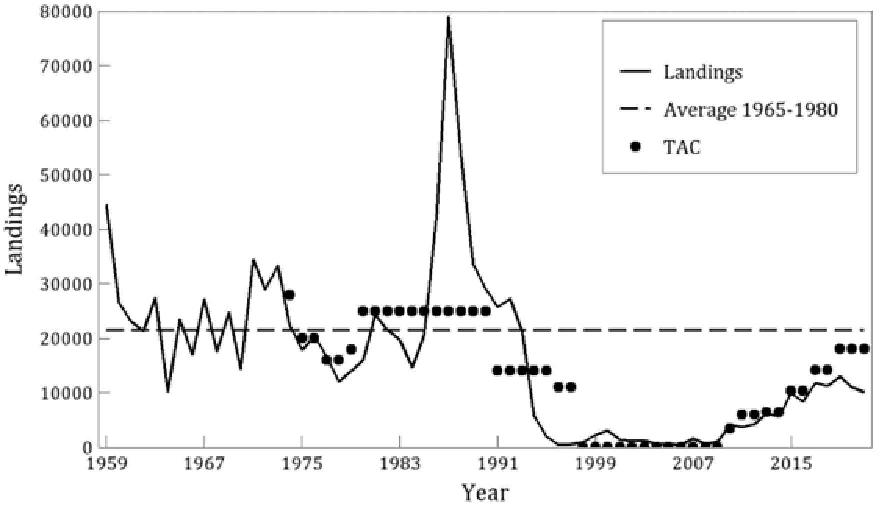


Figure 10.1. Redfish in Div. 3LN: catches and TACs (No directed fishing is plotted as zero TAC)

b) Data Overview

i) Commercial fishery data

Most of the commercial length sampling data available for the 3LN beaked redfish since 1990 comes from the Portuguese fisheries with data available from Spanish and Estonian fisheries since 2002 and 2008, respectively as well as more limited data available from other countries. Commercial length frequency data has largely been absent from the Canadian fishery since 1991, with only sporadic sampling of often small sized fish.

ii) Research survey data

From 1978 until 1990, several stratified-random bottom trawl surveys have been conducted by Canada in various years and seasons in Div. 3L. However, Canadian stratified-random surveys have covered the entire stock area only since 1991. No survey was carried out on Div. 3N in spring 2006 and autumn 2014 due to substantial operational issues. In the spring of 2017, there were problems with 3L survey coverage and none of the redfish 3L strata were sampled (Rideout and Ings, 2020; Rideout 2020). Due to COVID-19 restrictions, the spring survey was not conducted in 2020, and due to operational difficulties, there was no 2021 survey (see Appendix III, section 5.b). Lack of survey index values from 2020 and 2021 are hampering assessment of this stock. Canadian data collected using the Engel trawl (prior to 1996) has been converted to Campelen trawl equivalents.

Russian stratified-random bottom trawl surveys in NAFO Divs. 3LMNO occurred from 1983 to 1994.

In 1995 EU-Spain started a stratified-random bottom trawl spring (May-June) survey in the NAFO Regulatory Area of Divs. 3NO. All strata within the NRA were covered every year following the standard stratification. Early surveys were completed to a depth of 732m and were extended to 1464 m in 1998 (González et al, 2020). In 2003, this survey was extended northwards to include strata in Div. 3L, but it has only been since 2006 that an adequate coverage of 3L has been accomplished in this survey (Román et al, 2020). No EU-Spain survey was completed in 3N or 3L in 2020, nor in 3L in 2021 due to COVID-19 restrictions.

Preliminary analyses suggest changes in L50 and further investigation is recommended. SSB was therefore not examined in this assessment.

From the late 1970s to the beginning of the 1990s Canadian surveys in Div. 3L and Russian bottom trawl surveys in Div. 3LN suggest that stock size suffered a substantial reduction. Redfish bottom biomass from surveys in Div. 3LN remained well below average level over the 1990's and early 2000's. By the mid-2000s, most indices began to show increases with each index peaking in the mid-2010s. Since the mid-2010s, there have been some conflicting signals between survey indices.

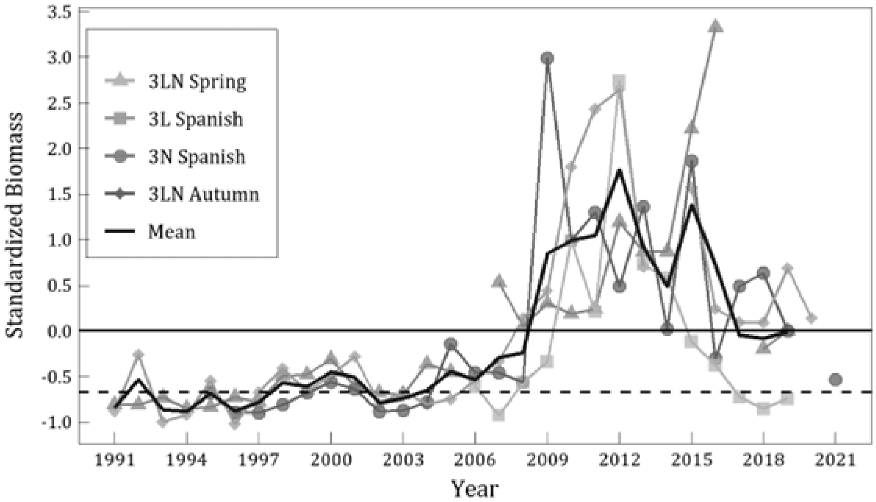


Figure 10.2. Redfish in Div. 3LN: standardized survey biomass. Each series standardized to zero mean and unit standard deviation. Dashed line represents the average of the mean standardized survey biomass index from 1991-2005 (B_{rec}).

During the first half of the 1990's, the stock was composed of primarily fish smaller than 25 cm, with very few larger fish present. Through the mid-2000s the movement of cohorts through the stock was apparent as modal lengths increased until 2008. In 2008, a pulse of <20cm redfish appeared in the autumn survey and could be tracked through the population via increases in modal size until 2017. Since 2017, few and small pulses of <15cm redfish have been observed. This stock is currently comprised primarily of larger, reproductive size fish with few recruits and pre-recruits being observed.

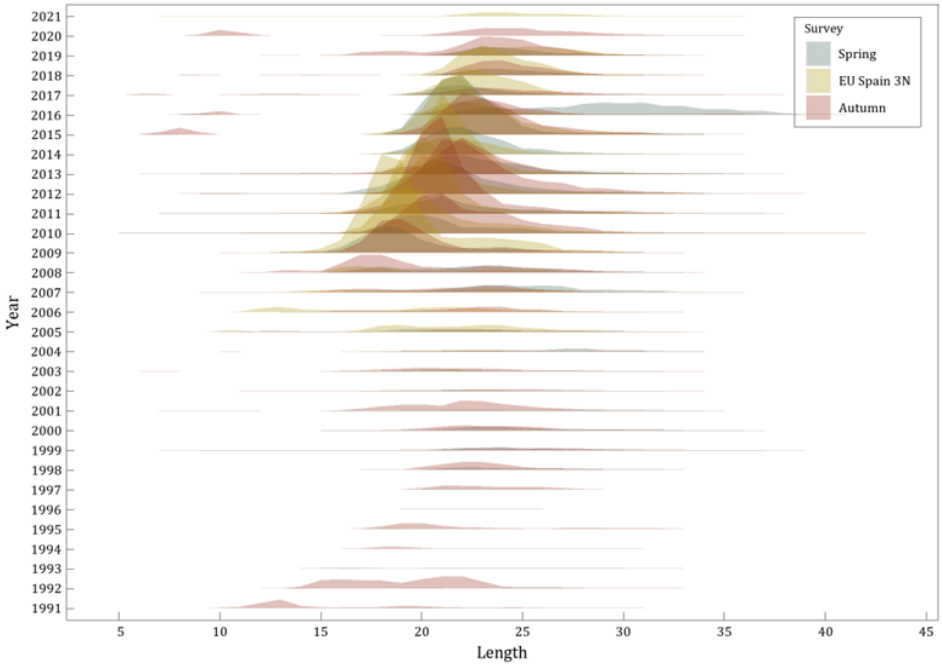


Figure 10.3. Survey length frequencies of 3LN redfish.

c) Recruitment

Recruitment in this stock, as with most redfish stocks, is sporadic. Previously, this assessment examined the abundance of redfish less than 20 cm as a recruitment index, whereas the current assessment will examine abundance of redfish between 15 and 20 cm as a recruitment index. Recruitment of redfish between 15 and 20 cm has been below the long-term average since the mid-2010s. The current recruitment index appears to show better consistency between available surveys than the previous index.

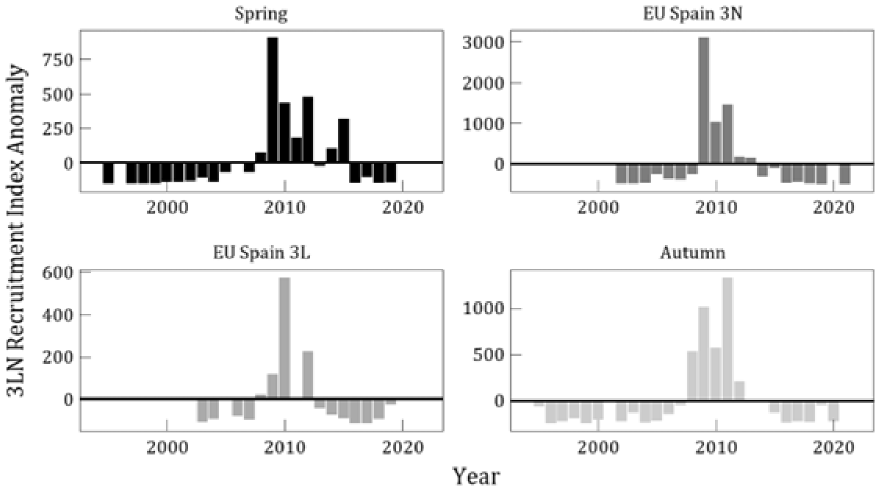


Figure 10.4. Recruitment index anomalies of 3LN redfish (15-20cm) from Canadian (DFO-NL) spring and autumn and EU-Spain 3L and 3N multispecies surveys.

d) Assessment Results

The previous assessment model (ASPIC) was rejected at the 2022 assessment. Continued mismatch between recent observed survey indices and the ASPIC model biomass estimates resulted in a lack of confidence in the model. The ASPIC model has continued to show patterning in residuals of input series and the use of a fixed MSY approach has resulted in an value of r that is considered too high for this species (>0.2). Simulations of a suite of MSY levels, including a freely estimated MSY, were undertaken but resulted in either a B_0 or an r value that was considered unrealistically high.

Mean of the standardized survey biomass indices indicates that biomass has declined from timeseries highs in the mid-2010s to the long-term mean. Estimates from 2020 and 2021 should be treated with caution as only one of a potential four survey was completed in each year.

Rejection of the assessment model and lack of the Canadian spring survey estimates in recent years precludes the calculation of the usual proxy fishing mortality index, but it is reasonable to expect that levels of fishing mortality have not changed substantially. From 2010 to 2016 this proxy of fishing mortality was at a level close to zero, then increased in 2018 and 2019. (no survey spring data available for 3L 2006 or 2017 and 3LN 2020-2021).

The input series of this assessment are:

- 3LN spring survey- Canadian spring survey biomass for Div. 3LN, 1991-2005, 2007-2016, 2018-2019;
- 3LN autumn survey- Canadian autumn survey biomass for Div. 3LN, 1991-2013, 2015-20;
- 3LN Power Russian survey- Russian spring survey biomass for Div. 3LN , 1984-1991;
- 3L winter survey- Canadian winter survey biomass for Div. 3L, 1985-1986 and 1990;
- 3L summer survey- Canadian summer survey biomass for Div. 3L, 1978-1979, 1981,1984-1985, 1990-1991 and 1993;
- 3L autumn survey- Canadian autumn survey biomass for Div. 3L, 1985-1986, 1990;
- 3N spring Spanish survey- Spanish survey biomass for Div. 3N, 1995-2019, 2021;
- 3L summer Spanish survey- Spanish survey biomass for Div. 3L, 2006-2019

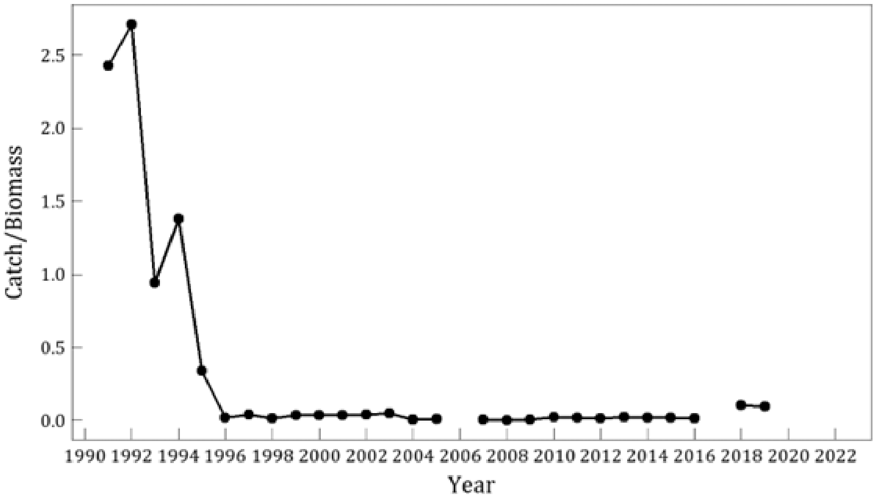


Figure 10.5. Redfish in Div. 3LN: C/B ratio using commercial catch and Canadian spring survey biomass (1991-2019). No Canadian spring survey data are available in 2020 or 2021.

Biomass: Biomass has declined from timeseries highs in the mid-2010s to the long-term mean.

Fishing mortality: In the absence of Canadian spring surveys in 2020 and 2021 proxy fishing mortality cannot be determined. However, it is unlikely that levels of fishing mortality have changed substantially.

Recruitment: Recruitment of redfish between 15 and 20 cm has been below the long-term average since the mid-2010s across Canadian 3LN spring and autumn as well as EU-Spain 3L and 3N survey series.

State of stock: Lack of survey indices in recent years limits our understanding of stock status since 2019, but available data indicate that biomass is at or below the long-term mean. The stock appears to be above the interim limit reference point (B_{lim}).

e) Short term projections

Projections could not be undertaken for this assessment due to rejection of the ASPIC assessment model.

f) Reference points

Prior reference points were dependent on the ASPIC model fit and outputs. Upon rejection of the assessment model and until the MSE process is completed, an interim limit reference point was adopted using the average of the mean standardized biomass of the Canadian spring and autumn 3LN and EU-Spain 3N surveys ($B_{lim} = B_{rec}$) from the period 1991-2005. This period was chosen as it represented a time when stock biomass recovered from a prolonged low level.

The next full assessment of this stock is scheduled for 2024.

g) Research recommendations

STACFIS **recommends** that *changes in maturity be explored for this stock*.

STACFIS **recommends** that *stock boundaries and definitions as well as synchronicity with adjacent stocks be explored for this stock*.

11. American plaice (*Hippoglossoides platessoides*) in NAFO Divisions 3LNO

(SCR Doc. 22/005, 007, 21/020, 025,032,035; SCS Doc. 22/006, 010, 013). Interim Monitoring Report

a) Introduction

Fisheries and Catch: American plaice supported large fisheries from the 1960s to the 1980s. However, due to the collapse of the stock in the early 1990s, there was no directed fishing in 1994 and a moratorium was put in place in 1995. Landings from by-catch increased until 2003, after which they began to decline. The majority of the catch has been taken by offshore otter trawlers. STACFIS agreed catches were 1 171t in 2020 and 1 556t in 2021 (Figure 11.1). American plaice are taken as by-catch mainly in the Canadian yellowtail flounder fishery, EU-Spain and EU-Portugal skate, redfish and Greenland halibut fisheries.

Recent nominal catches and TACs ('000 t) are as follows:

	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
TAC	ndf	ndf	ndf	ndf	ndf	ndf	ndf	ndf	ndf	ndf
STATLANT 21	2.2	1.4	1.1	1.0	1.1	0.8	1.2	1.1	1.3	
STACFIS	3.0[1]	2.3[1]	1.1[2]	1.7[2]	1.2	1.0	1.2	1.2	1.6	

ndf No directed fishing.

[1] Catch was estimated using fishing effort ratio applied to 2010 STACFIS catch.

[2] Catch was estimated using STATLANT 21 data for Canadian fisheries and Daily Catch Records for fisheries in the NRA.

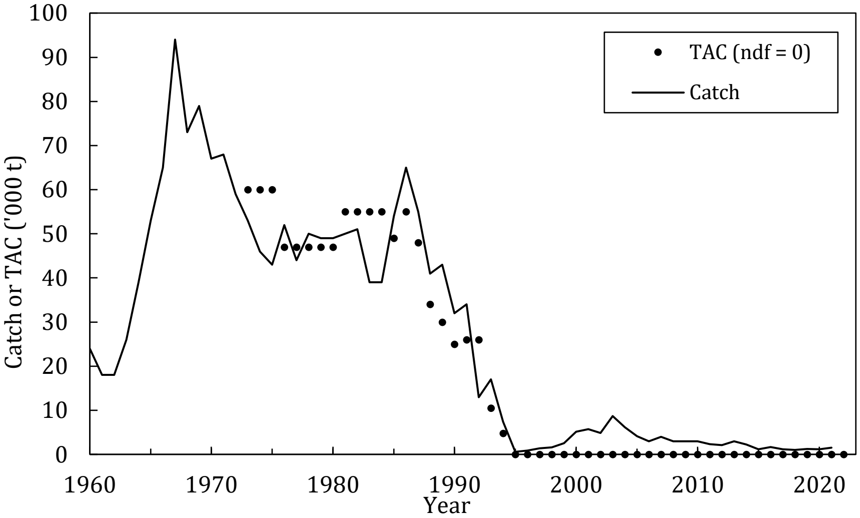


Figure 11.1. American Plaice in Div. 3LNO: estimated catches and TACs. No directed fishing is plotted as 0 TAC.

b) Data Overview

i) Research Survey Data

Canadian spring survey. Due to coverage issues in the Canadian spring survey, indices are not available from 2006, 2015, 2017. Due to COVID-19 restrictions there was no spring survey in 2020, and due to operational difficulties, the 2021 spring survey did not occur (see Appendix III, section 5.b).

Biomass and abundance estimates from spring surveys for Div. 3LNO declined during the late 1980s-early 1990s. Biomass indices generally increased from the mid-1990s to 2014 but declined sharply after that (Figure 11.2). The abundance index follows a similar trend. Spring estimates of biomass and abundance in 2019 are the lowest since 1995 and 1998, respectively.

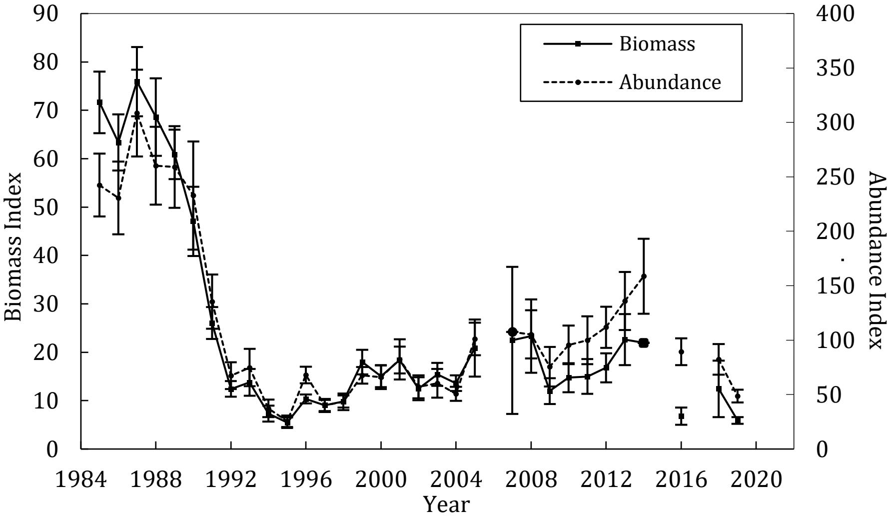


Figure 11.2. American Plaice in Div. 3LNO: biomass and abundance indices with approximate 95% confidence intervals from Canadian spring surveys. Data prior to 1996 are Campelen equivalents and since then are Campelen. Open symbols represent years where CIs extend to negative values.

Canadian autumn survey. Autumn survey points for 2004 and 2014 are excluded due to incomplete coverage of Div. 3L and 3NO, respectively. Due to operational difficulties, there was no autumn survey in

Div. 3LNO in 2021(see Appendix III, section 5.b). Biomass and abundance indices from the autumn survey declined rapidly from 1990 to the mid-1990s, and indices have generally been below average since. There was an increase in biomass to 2013 but this did not persist.

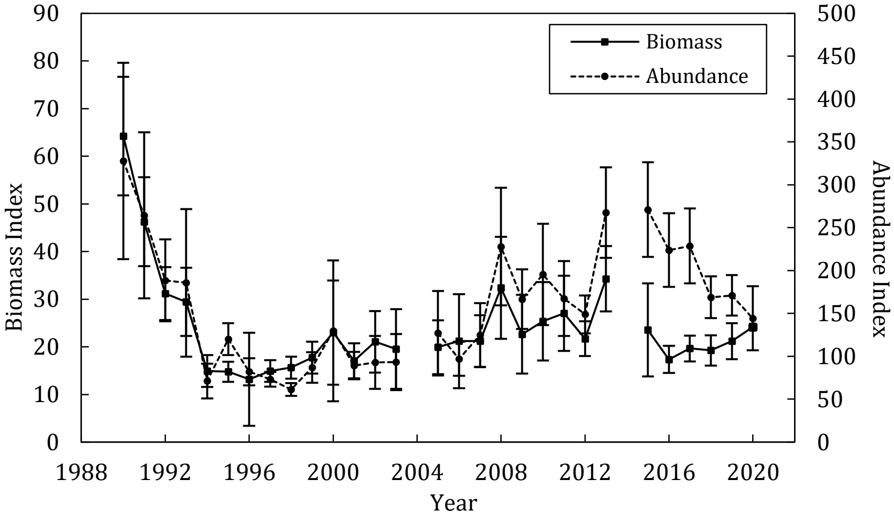


Figure 11.3. American Plaice in Div. 3LNO: biomass and abundance indices with approximate 95% confidence intervals from Canadian autumn surveys. Data prior to 1996 are Campelen equivalents and since then are Campelen.

EU-Spain Div. 3NO Survey. From 1998-2021, surveys have been conducted annually by EU-Spain in the Regulatory Area in Div. 3NO. There was no survey in 3NO in 2020. The biomass and abundance indices varied without trend for most of the time series but then subsequently declined to the lowest values in the time series.

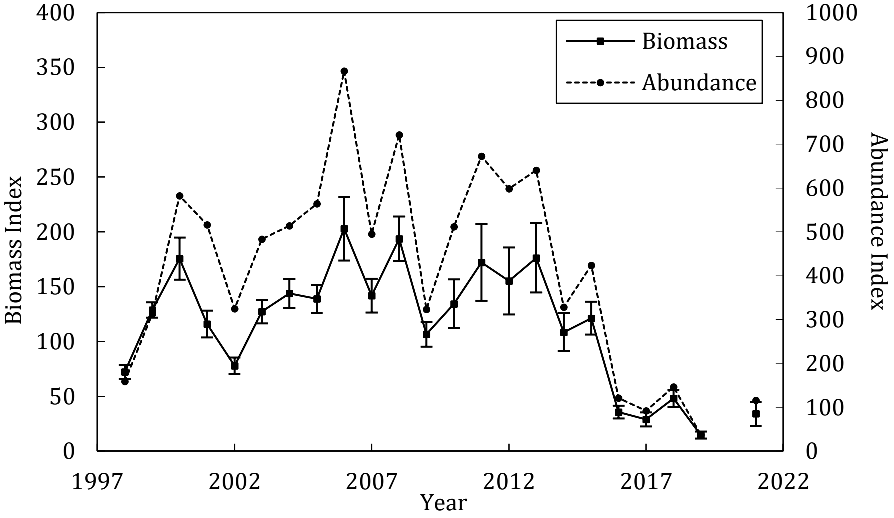


Figure 11.4. American Plaice in Div. 3LNO: biomass and abundance indices from the EU-Spain Div. 3NO survey (Data prior to 2001 are Campelen equivalents and since then are Campelen).

EU-Spain Div. 3L Survey. Since 2003 surveys have been conducted annually by EU-Spain in the Regulatory Area in Div. 3L. No EU-Spain survey was completed in 3N or 3L in 2020, nor in 3L in 2021 due to COVID-

19 restrictions. The biomass and abundance indices increased from 2010 to 2015, and subsequently declined to 2019.

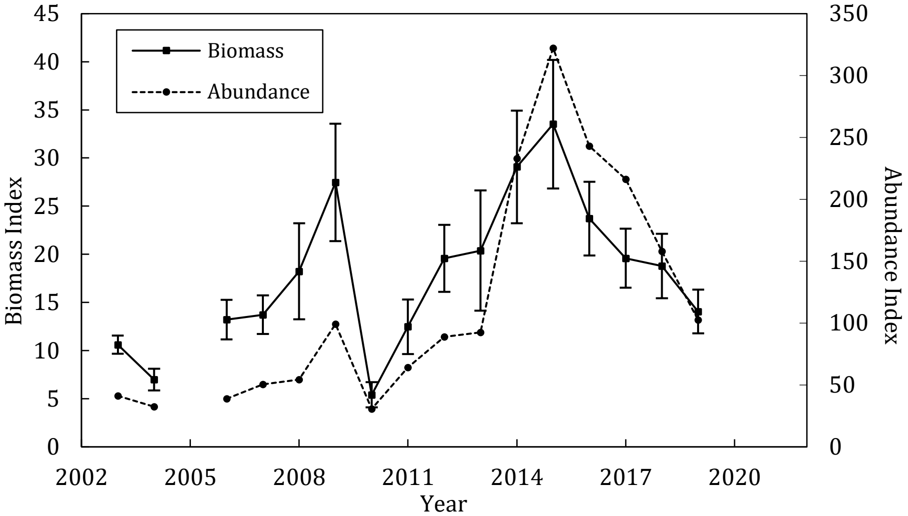


Figure 11.5. American Plaice in Div. 3LNO: biomass and abundance indices from the EU-Spain Div. 3L survey.

c) Conclusion

Based on available data, there is nothing to indicate a change in the status of the stock since the 2021 assessment.

The next full assessment of this stock is planned for 2024.

d) Research Recommendations

STACFIS **recommends** that *investigations be undertaken to compare ages obtained by current and former Canadian age readers.*

STATUS: Work is ongoing. This recommendation is reiterated.

STACFIS **recommends** that *investigations be undertaken to examine the retrospective pattern and take steps to improve the model.*

STATUS: Sensitivity analysis was completed during the 2021 assessment examining the impact of changing the model assumptions on M, and two alterative models in progress were examined. Work is ongoing. The recommendation is reiterated.

STACFIS **recommended** that *investigations be undertaken to reexamine which survey indices are included in the model.*

STATUS: Work is ongoing. This recommendation is reiterated.

12. Yellowtail Flounder (*Limanda ferruginea*) in Divisions 3L, 3N and 3O

(SCR Doc. 22/005, 22/007, 20/002, 20/009; SCS Doc. 22/06, 22/07, 22/09). Interim Monitoring Report

a) Introduction

Fisheries and Catch: There was a moratorium on directed fishing from 1994 to 1997, and small catches were taken as by-catch in other fisheries. The fishery was re-opened in 1998 and catches increased from 4 400 t to 14 100 t in 2001 (Fig 12.1). Catches from 2001 to 2005 ranged from 11 000 t to 14 000 t. The catch in 2006 was only 930 t, due to corporate restructuring and a labour dispute in the Canadian fishing industry. Since then, catches have continued to be influenced by industry related factors, remaining below the TAC and in some years, have been very low. In 2021, catches totalled 14 600 t.

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

	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
TAC	17	17	17	17	17	17	17	17	17	17
STATLANT 21	10.7	8.0	6.7	8.3	9.2	8.6	12.3	14.0	16.1	
STACFIS	10.7	8.0	6.9	9.3	9.2	8.7	12.8	14.8	14.6	

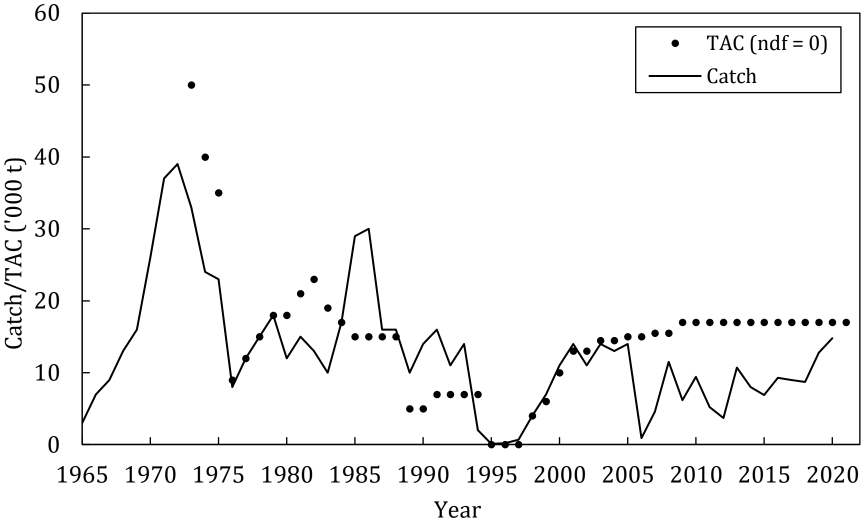


Figure 12.1. Yellowtail flounder in **Divs. 3LNO**: catches and TACs. No directed fishing is plotted as 0 TAC.

b) Data Overview

i) Research survey data

Canadian stratified-random spring surveys. . Although variable, the spring survey biomass index increased from 1995 to 1999 and since fluctuated at a high level to 2012. The spring biomass index then declined to 2016, but increased to 2018 before declining again in 2019. The 2006 and 2015 surveys did not cover the stock area and are not considered representative. Due to COVID-19 restrictions there was no spring survey in 2020, and due to operational difficulties, the 2021 spring survey did not occur. (see Appendix III, section 5.b)

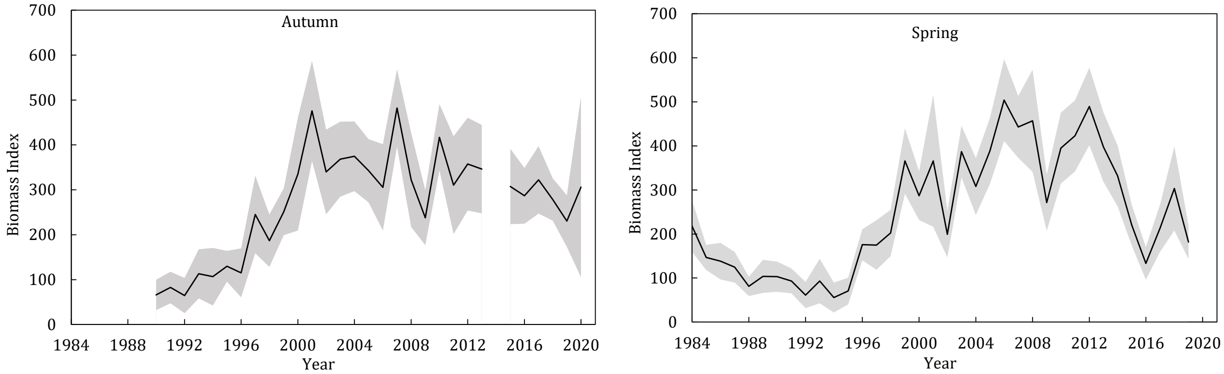


Figure12.2. Yellowtail flounder in Div. 3LNO: indices of biomass with approximately 95% confidence intervals, from Canadian spring and autumn surveys. Values are Campelen units or, prior to autumn 1995, Campelen equivalent units. There were no surveys in Canadian autumn of 2014 or 2021, 2015 and 2016 spring surveys were incomplete and there were no spring surveys conducted in 2020 or 2021.

Canadian stratified-random autumn surveys. The autumn survey biomass index for Div. 3LNO increased steadily from the early-1990s to 2001, and although variable, it remained relatively high since then (Figure 12.2). This survey did not show the sharp decline in biomass seen in the other surveys during the recent years, however a slight declining trend from 2001 to 2020 is evident. The 2014 survey was incomplete due to problems with the research vessel, and results are not considered representative. Due to operational difficulties there was no autumn survey in 2021. (STACREC reference?)

EU-Spain stratified-random spring surveys in the NAFO Regulatory Area of Div. 3NO. The biomass index of yellowtail flounder increased sharply up to 1999 and remained relatively stable until 2013. Since then, biomass estimates declined to a 20 year low in 2019 (Figure 12.3). Results are in general agreement with the Canadian series which covers the entire stock area.

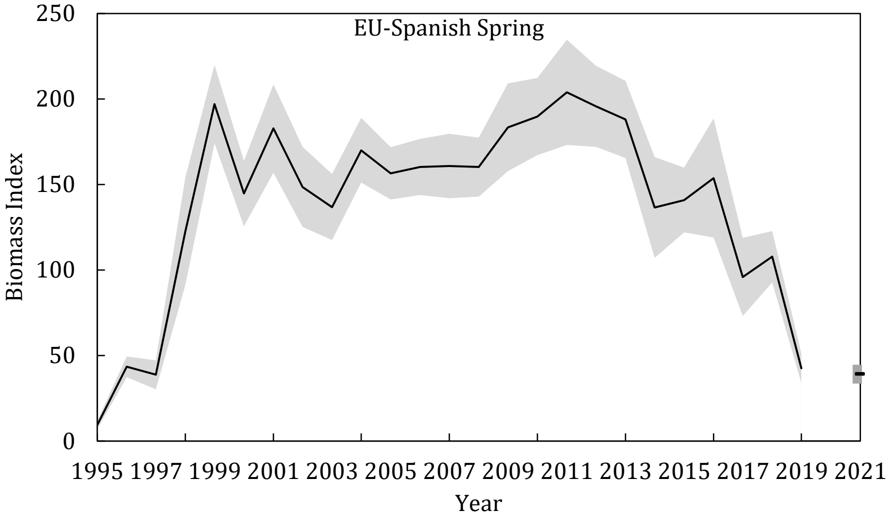


Figure12.3. Yellowtail flounder in Div. 3LNO: index of biomass from the EU-Spain spring surveys in the Regulatory Area of Div. 3NO ±1SD. Values are Campelen units or, prior to 2001, Campelen equivalent units. There was no survey conducted in 2020.

Stock distribution. In all surveys, yellowtail flounder were most abundant in Div. 3N, in strata on the Southeast Shoal and those immediately to the west (360, 361, 375 & 376), which straddle the Canadian 200 mile limit. Yellowtail flounder appeared to be more abundant in the Regulatory Area of Div. 3N in the 1999-2020 surveys than from 1984-1995, and the stock has continued to occupy the northern portion of its range in Div. 3L, similar 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, however in 2021, the number of small fish were at the mean.

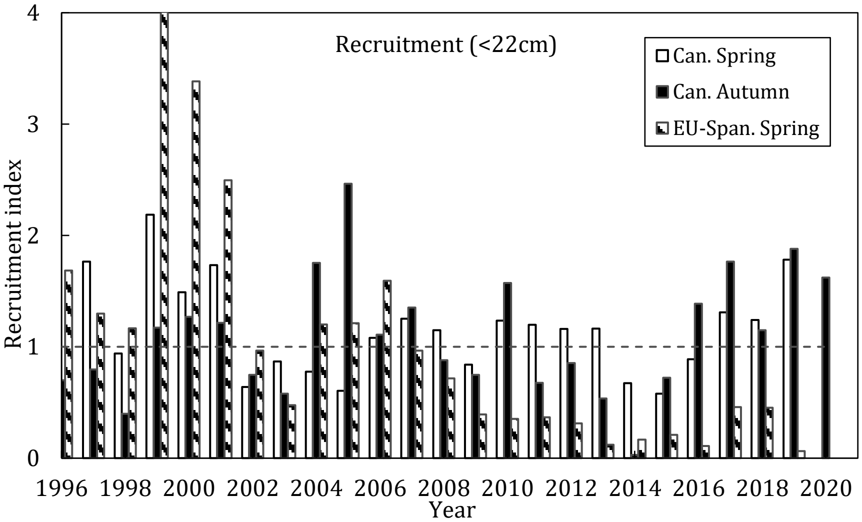


Figure12.4. Yellowtail flounder **in Divs. 3LNO**: Juvenile abundance indices from spring and autumn surveys by Canada (Can.) and spring surveys by EU-Spain. Each series is scaled to its mean (horizontal line).

c) Conclusion

The most recent (2021) analytical assessment using a Bayesian stock production model concluded that the stock size has steadily increased since 1994 and is presently 1.4 times B_{MSY} (B_{MSY} =89.79 t). There is very low risk (<1%) of the stock being below B_{MSY} or F being above F_{MSY}. Recent recruitment appears to be higher than average. There are no new survey points for 2021 that cover the entire stock area on which to base conclusions about changes in stock status. However, considering the medium term projections from the last assessment, and given that catch in 2021 was less than TAC, the stock is likely to have remained well above B_{MSY}.

The next full assessment of this stock is planned for 2023.

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

(SCR Docs. 22/005, 007, 0014; SCS Docs. 22/06, 09, 10, 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 2021, total catch was estimated to be 625 t.

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

	2013	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**
TAC	ndf	ndf	1.0	2.2	2.2	1.1	1.2	1.2	1.2	1.2
STATLANT 21	0.3	0.3	0.4	1.0	0.6	0.6	0.9	0.6	0.8	
STACFIS	0.3	0.3	0.4	1.1	0.7	0.7	0.9	0.7	0.6	

ndf = no directed fishery.

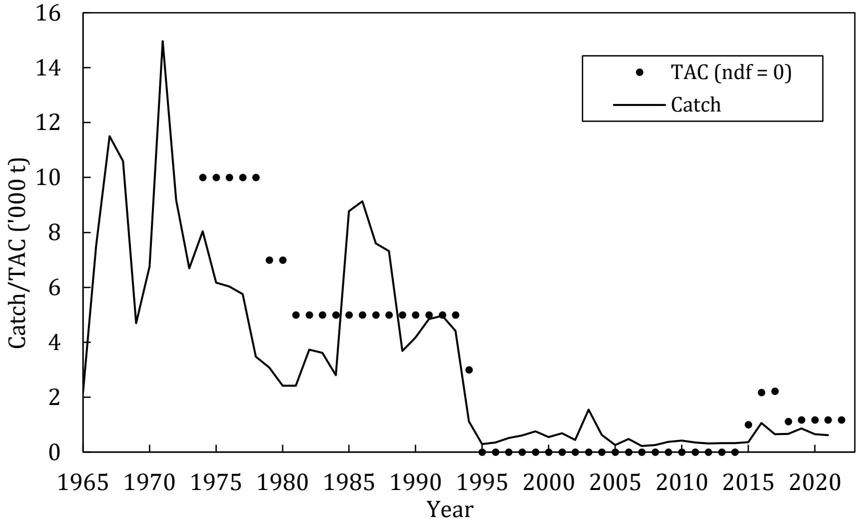


Figure 13.1. Witch flounder in Divs. 3NO (1960-2022): Catch and TAC ('000 tonnes).

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 2021. Canadian data indicated the catch and bycatch ranged between 24 and 55 cm with a mean length of ~40 cm (Figure 13.2). Length frequencies were available from bycatches in directed fisheries for yellowtail flounder, redfish, Greenland halibut, and skate by Spain, in 2021 (Figure 13.2). The Spanish data (SCS Doc. 22/06) from Divs. 3NO indicated most of the witch flounder catch and bycatch was between 27 and 49 cm in length (Figure 13.2). Limited sampling of commercial catch was available from Portugal, and showed fish mostly between 30 and 50 cm.

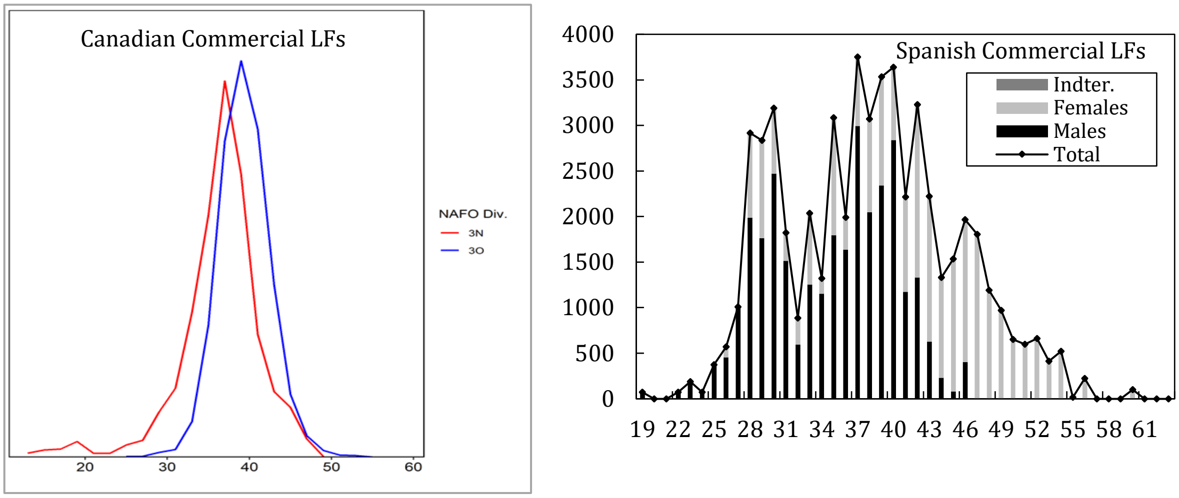


Figure 13.2. Witch flounder length frequency (cm) distributions for Canada and Spain (NAFO Divs. 3NO) commercial bycatch and directed fisheries in 2021.

ii) Research survey data

Canadian spring RV survey. Due to substantial coverage deficiencies, values from 2006 are not presented. Due to COVID-19 restrictions, the spring survey was not conducted in 2020, and due to operational difficulties, there was no 2021 survey (see Appendix III, section 5.b), 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).

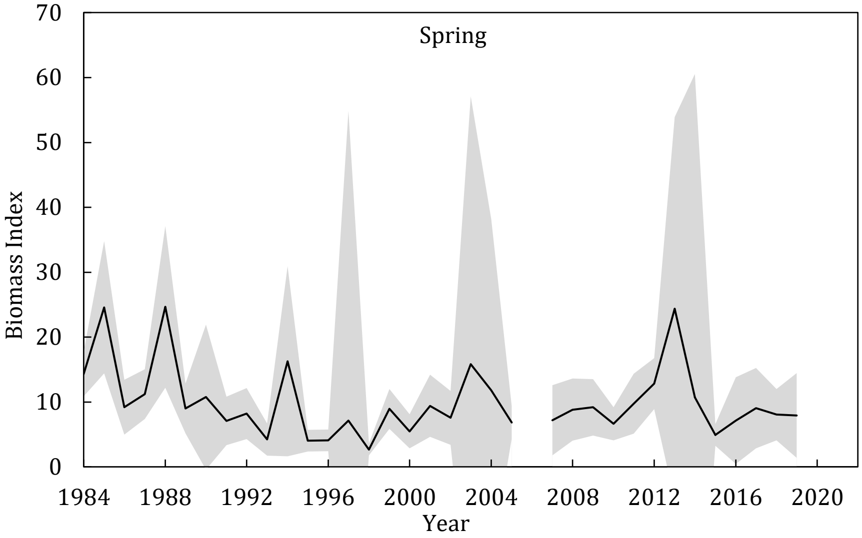


Figure 13.3. Witch flounder in NAFO Divs. 3NO: survey biomass indices from Canadian spring surveys 1984-2019 (95% confidence limits are given). Values are Campelen units or, prior to 1996, Campelen equivalent units.

Canadian autumn RV survey. Due to operational difficulties, there was no 2021 survey (see Appendix III, section 5.b)). 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.

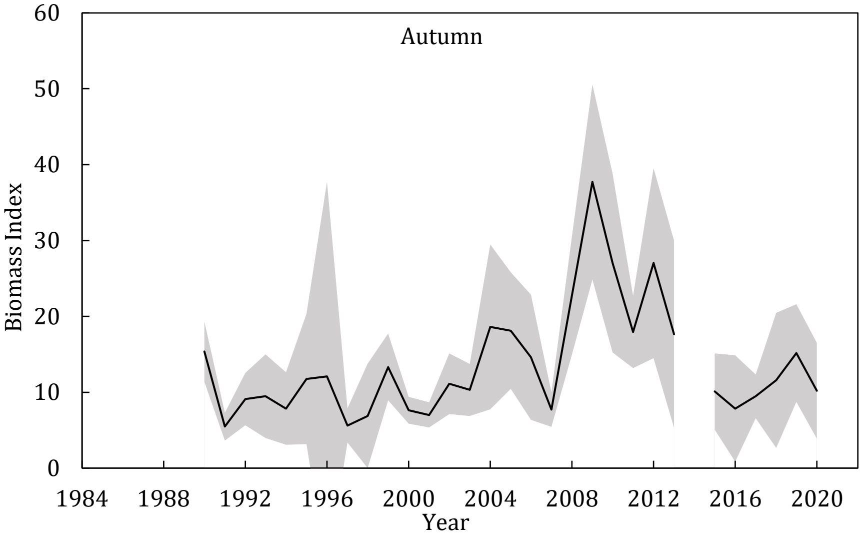
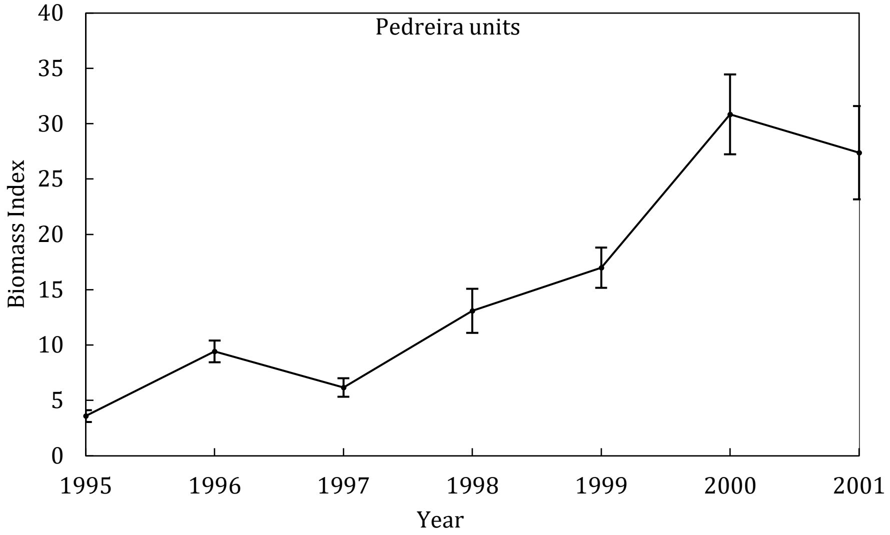


Figure 13.4. Witch flounder in Divs. 3NO: biomass indices from Canadian autumn surveys 1990-2019 (95% confidence limits are given). Values are Campelen units or, prior to 1996, Campelen equivalent units.

EU-Spain RV spring survey. Surveys have been conducted annually from 1995 to 2021 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 Doc. 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. No survey was conducted in 2020, and the 2021 survey biomass estimate increased to about the 2018 level. (Figure 13.5)



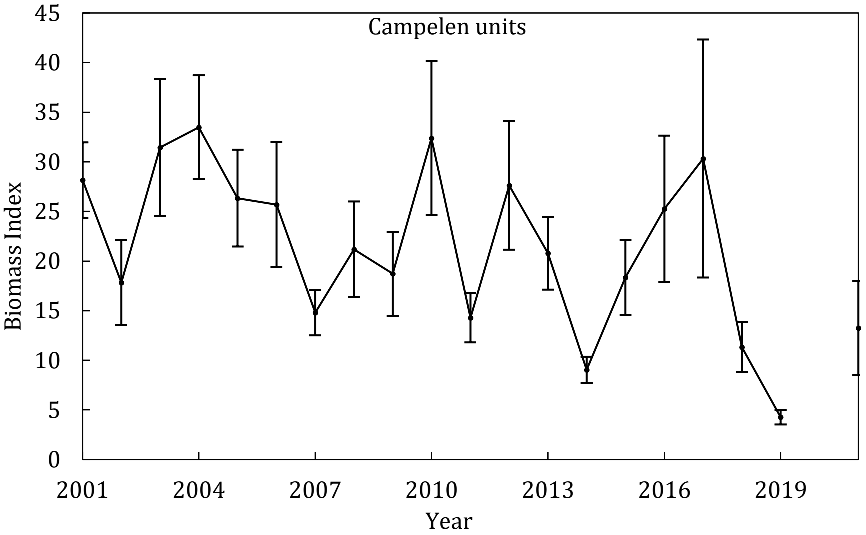


Figure 13.5. Witch flounder in Divs. 3NO: biomass indices from EU-Spanish Div. 3NO spring surveys (± 1 standard deviation). Data from 1995-2001 is in Pedreira units; data from 2001-2021 are Campelen units. Both values are presented for 2001.

Abundance at length. Length frequencies of 30-50 cm fish (generally, recruited sizes) 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 21-26cm 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. The 2020 fall autumn survey did not detect this recruitment peak, however, and there were no surveys that covered the stock area in 2021.

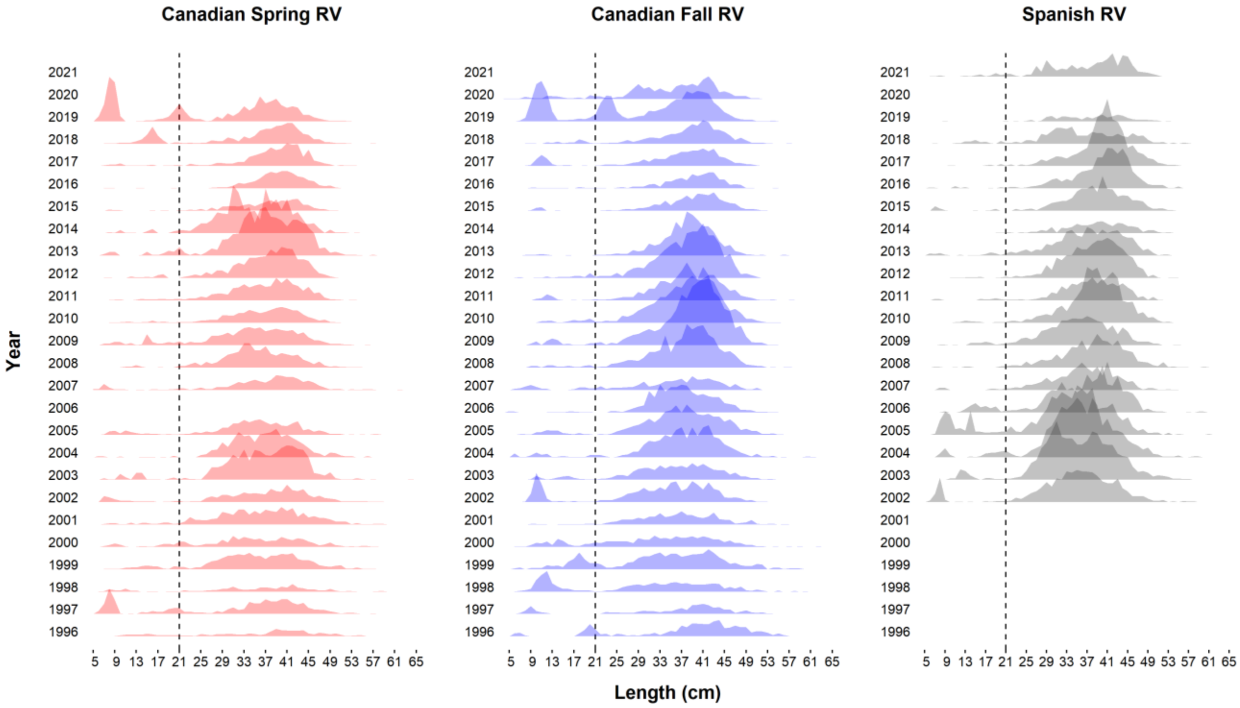


Figure 13.6. Length frequencies (abundance at length) of witch flounder from spring Canadian (1996-2019), autumn Canadian (1996 to 2020) and Spanish (2002-2021) RV surveys in NAFO Divs.3NO. No Canadian survey data was available in spring 2006, 2020, 2021 or autumn 2014 and 2021. Vertical line represents 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 1960-2021, Canadian spring survey series from 1984-1990, Canadian spring survey series from 1991-2019 (no 2006) and the Canadian autumn survey series from 1990-2020 (no 2014 or 2021). The model formulation was identical to the accepted formulation from the 2020 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 13.5) 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. Recruitment is uncertain, and in the absence of Canadian surveys for 2021, current recruitment cannot be determined.

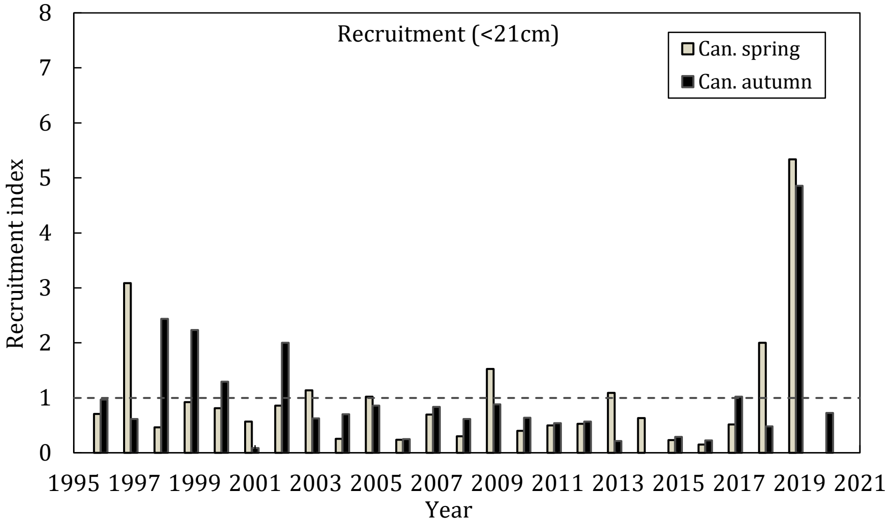


Figure 13.7. Recruitment index of witch flounder (<21cm) from spring and autumn Canadian RV surveys in NAFO Divs.3NO 1996-2020. No survey data available in autumn 2014, 2021 or spring 2006, 2020, 2021.

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. 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 3 824 (3 050 – 4 650) tonnes can be produced by total stock biomass of 60 510 (46 500 – 73 800) tonnes (B_{MSY}) at a fishing mortality rate (F_{MSY}) of 0.062 (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 at the beginning of 2022 is 49% of B_{MSY} with a probability of being below B_{lim} of 9%.

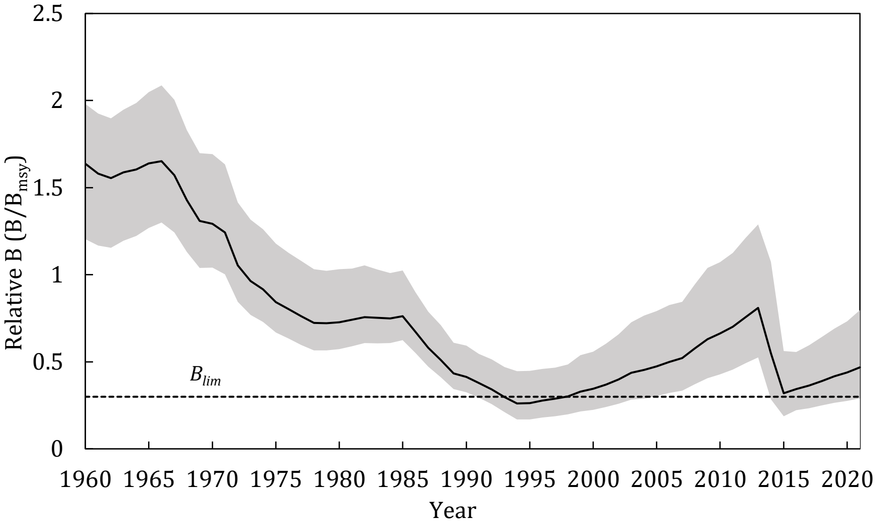


Figure 13.8. Witch flounder in Divs. 3NO. Median relative biomass (Biomass/ B_{MSY}) with 80% credible intervals from 1960-2021. The horizontal line is B_{lim} =30%B_{msy}.

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 36% of F_{MSY} with a low probability (<1%) of being above F_{MSY} in 2021.

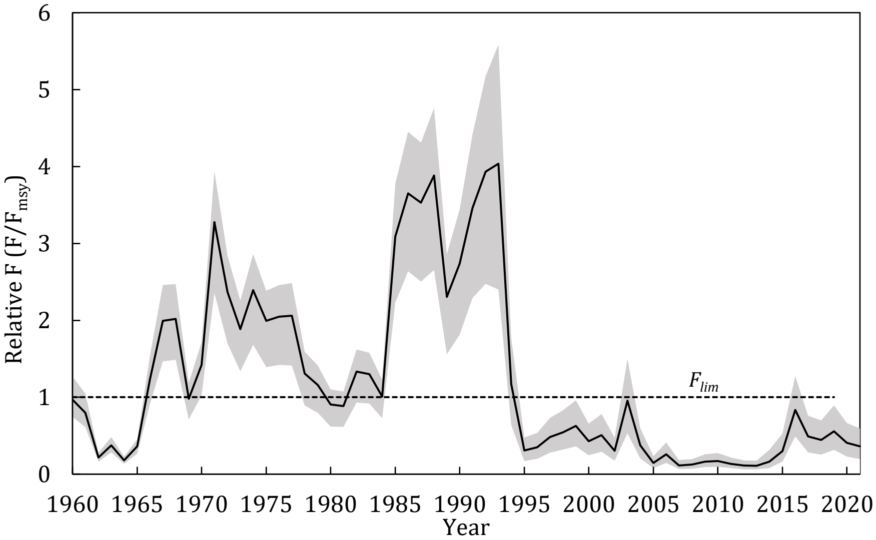


Figure 13.9. Witch flounder in Divs. 3NO. Median relative fishing mortality (F/ F_{MSY}) with 80% credible intervals from 1960-2021. The horizontal line is F_{lim} = F_{MSY}.

e) State of the Stock

The stock has increased slightly since 2015 and is estimated at 49% B_{MSY}. At the beginning of 2022, there is 9% risk of the stock being below B_{lim} and less than 1% risk of *F* being above F_{lim}. Recruitment is uncertain.

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 2025. Two scenarios were projected, one assumed that the catch in 2022 was equal to the TAC of 1 175 t, and the second assumed catch in 2022 was equal to the average catch in the last five years (700 t). These catch assumptions were then followed by constant fishing mortality for 2023 and 2024 at several levels of *F* ($F=0$, F_{2021}, 2/3 F_{MSY}, 85% F_{MSY}, and F_{MSY}) and also of catch equal to TAC_{2022}=1 175 t.

The probability that $F > F_{lim}$ in 2022 is 14% at a catch of 1 175 t (10.5% for $Catch_{2022}$=700 t). The probability of $F > F_{lim}$ in 2023 and 2024 ranged from 1 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 2025 is greater than the biomass in 2022 is 60% or greater in all scenarios. The population is projected to remain below B_{MSY} through to the beginning of 2025 for all levels of *F* examined with a probability of 85% or greater. The probability of projected biomass being below B_{lim} by 2025 was 5 to 9% in all catch scenarios examined and was 3 or 4% by 2025 in the *F*=0 scenarios, depending on the catch assumed in 2022.

Table 13.2. Medium-term projections for witch flounder under two scenarios: catch in 2022=TAC (1 175 t) and catch in 2022=average catch 2017-2021 (700 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_{2021}, 2/3 F_{MSY}, 85% F_{MSY}, F_{MSY}., and catch=TAC (1 175 t).

Projections with catch in 2022 = TAC (1 175 t)

Year	Yield (t) median	Projected relative Biomass(B/B_{msy}) median (80% CL)
F0		
2023	0	0.53 (0.31, 0.94)
2024	0	0.58 (0.34, 1.03)
2025		0.62 (0.37, 1.12)
F_{2021} = 0.022		
2023	699	0.53 (0.31, 0.94)
2024	744	0.56 (0.33, 1.01)
2025		0.60 (0.35, 1.09)
Catch 1 175t		
2023	1175	0.53 (0.31, 0.94)
2024	1175	0.56 (0.32, 1.00)
2025		0.58 (0.33, 1.07)
2/3 F_{msy} = 0.041		
2023	1295	0.53 (0.31, 0.94)
2024	1367	0.55 (0.32, 1.00)
2025		0.58 (0.33, 1.06)
85% F_{msy} =0.053		
2023	1651	0.53 (0.31, 0.94)
2024	1724	0.55 (0.32, 1.00)
2025		0.56 (0.32, 1.05)
F_{msy} =0.062		
2023	1943	0.53 (0.31, 0.94)
2024	2010	0.54 (0.31, 0.99)
2025		0.55 (0.31, 1.04)

Projections with catch in 2022=700 t

Year	Yield (t) median	Projected relative Biomass(B/B_{msy}) median (80% CL)
F0		
2023	0	0.54 (0.32, 0.95)
2024	0	0.58 (0.35, 1.04)
2025		0.63 (0.38, 1.13)
F_{2021} = 0.022		
2023	710	0.54 (0.32, 0.95)
2024	755	0.57 (0.34, 1.02)
2025		0.61 (0.36, 1.10)
Catch 1 175t		
2023	1175	0.49 (0.30, 0.90)
2024	1175	0.52 (0.31, 0.97)
2025		0.54 (0.31, 1.03)
2/3 F_{msy} = 0.041		
2023	1315	0.54 (0.32, 0.95)
2024	1387	0.56 (0.33, 1.01)
2025		0.58 (0.34, 1.07)
85% F_{msy} =0.053		
2023	1676	0.54 (0.32, 0.95)
2024	1749	0.56 (0.32, 1.01)
2025		0.57 (0.32, 1.06)
F_{msy} =0.062		
2023	1972	0.54 (0.32, 0.95)
2024	2039	0.55 (0.32, 1.00)
2025		0.56 (0.32, 1.05)

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_{2025}>B_{2022}) under projected F values of F=0, F_{2021}, 2/3 F_{MSY}, 85% F_{MSY}, F_{MSY}., and catch = TAC (1 175 t). Two scenarios are shown: catch in 2020=TAC (1 175t) and catch in 2022 = average catch 2017-2021 (700 t).

Catch 2022=1 175 t	Yield (t)			P(F>F $_{lim}$)			P(B<B $_{lim}$)				P(B<B $_{msy}$)				
	2022	2023	2024	2022	2023	2024	2022	2023	2024	2025	2022	2023	2024	2025	P(B_{2025}>B_{2022})
F0	1175	0	0	14%	12%	<1%	9%	8%	6%	4%	94%	92%	89%	86%	0.73
F_{2021} = 0.022	1175	699	744	14%	12%	1%	9%	8%	7%	5%	94%	92%	89%	87%	0.68
Catch $_{2023}$ & Catch$_{2024}$= 1 175t	1175	1175	1175	14%	12%	11%	9%	8%	7%	6%	94%	92%	90%	87%	0.65
2/3 Fmsy = 0.041	1175	1295	1367	14%	12%	19%	9%	8%	8%	7%	94%	92%	90%	88%	0.64
85% Fmsy =0.053	1175	1651	1724	14%	12%	37%	9%	8%	8%	8%	94%	92%	90%	88%	0.62
Fmsy=0.062	1175	1943	2010	14%	12%	50%	9%	8%	9%	9%	94%	92%	90%	89%	0.60

Catch2022= 700 t	Yield (t)			P(F>F $_{lim}$)			P(B<B $_{lim}$)				P(B<B $_{lim}$)				
	2022	2023	2024	2022	2023	2024	2022	2023	2024	2025	2022	2023	2024	2025	P(B_{2025}>B_{2022})
F0	700	0	0	1%	<1%	0%	9%	8%	5%	3%	94%	92%	89%	85%	74%
F_{2021} = 0.033	700	710	755	1%	<1%	1%	9%	8%	6%	5%	94%	92%	89%	86%	70%
Catch$_{2021}$ & Catch$_{2022}$= 1 175t	700	1175	1175	1%	<1%	10%	9%	8%	9%	8%	94%	93%	91%	89%	65%
2/3 F_{msy} = 0.042	700	1315	1387	1%	<1%	18%	9%	8%	7%	6%	94%	92%	90%	87%	66%
85% F_{msy} =0.054	700	1676	1749	1%	<1%	37%	9%	8%	7%	7%	94%	92%	90%	88%	63%
F_{msy}=0.063	700	1972	2039	1%	<1%	50%	9%	8%	8%	8%	94%	92%	90%	88%	62%

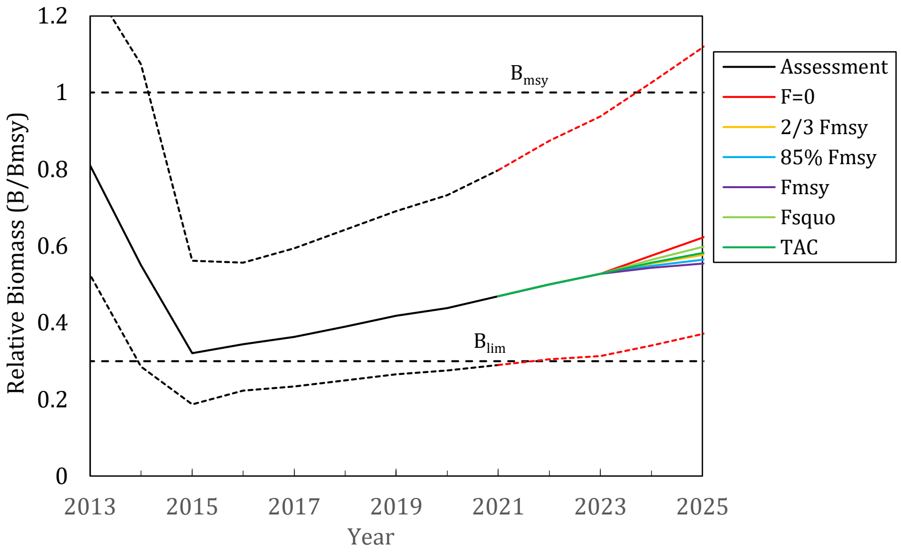


Figure 13.10. Witch flounder in Divs. 3NO: medium term projections of relative biomass (B/ B_{MSY}) at five levels of F (F=0, F_{2021}, 2/3 F_{MSY}, 85% F_{MSY} and F_{MSY}) and catch=TAC (1 175 t). A catch of 1 175 t is assumed in 2022. The 10th and 90th credible intervals are included for the model results up to 2021 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 9% and above F_{lim} is less than 1% (Figure 13.11).

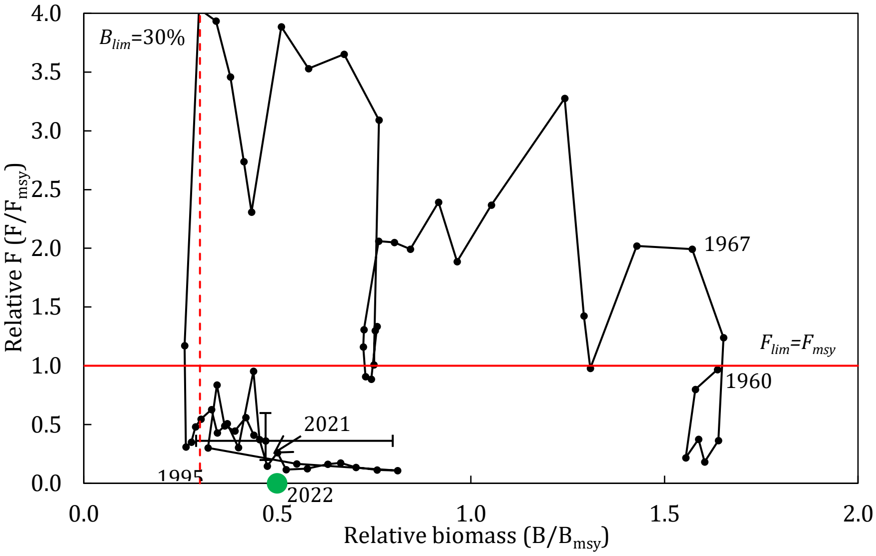


Figure 13.11. Witch flounder in Divs. 3NO: stock trajectory estimated in the surplus production analysis, under a precautionary approach framework.

The next assessment will be in 2024.

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

(SCR Doc. 22/005 and SCS Doc. 22/06, 22-10). Interim Monitoring Report

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:

	2013	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**
Recommended TAC	na	na	na	na	na	na	na	na	na	na
STACFIS	0	1	0	5	1	2	2	1	0	

na = no advice possible

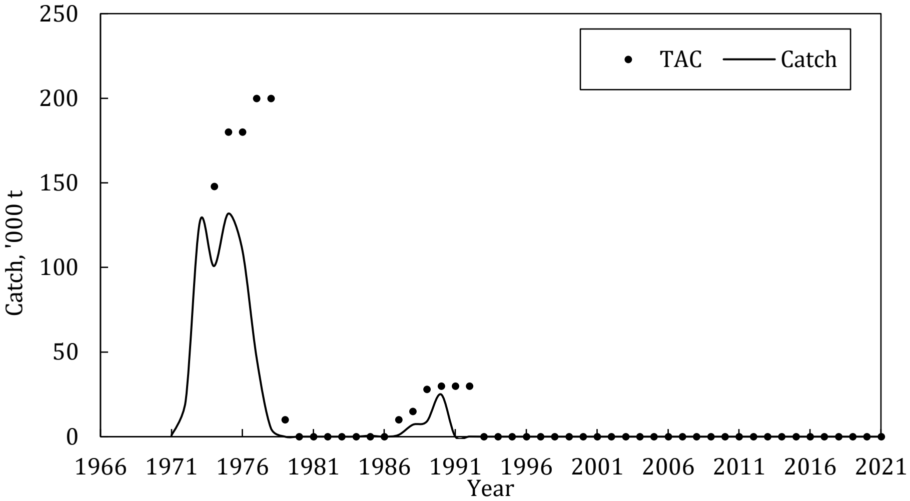


Figure 14.1. Capelin in Div. 3NO: catches and TACs.

b) Data Overview

i) Research survey data

Trawl acoustic surveys of capelin on the Grand Bank previously conducted by Russia and Canada on a regular basis have not been repeated since 1995. In recent years, STACFIS has repeatedly recommended the investigation of the capelin stock in Div. 3NO utilizing trawl-acoustic surveys to allow comparison with historical time series. However, this recommendation has not been acted upon. Available indicators of stock dynamics currently include the capelin biomass index from Canadian spring stratified-random bottom trawl surveys. This index varied greatly from 1995-2019 without any clear trend, however, three of the highest values have been observed in the most recent ten years of the time series (Figure 14.2). In 2016, the biomass indices declined to the historical minimum of 3.8 thousand tons. After increasing to 78.7 thousand tons in 2017, the index has decreased to 45.7 thousand tons in 2018. In 2019, further decrease was indicated, to 17.3 thousand tons. Due to COVID-19 restrictions, the spring survey was not conducted in 2020, and due to operational difficulties, there was no 2021 survey.

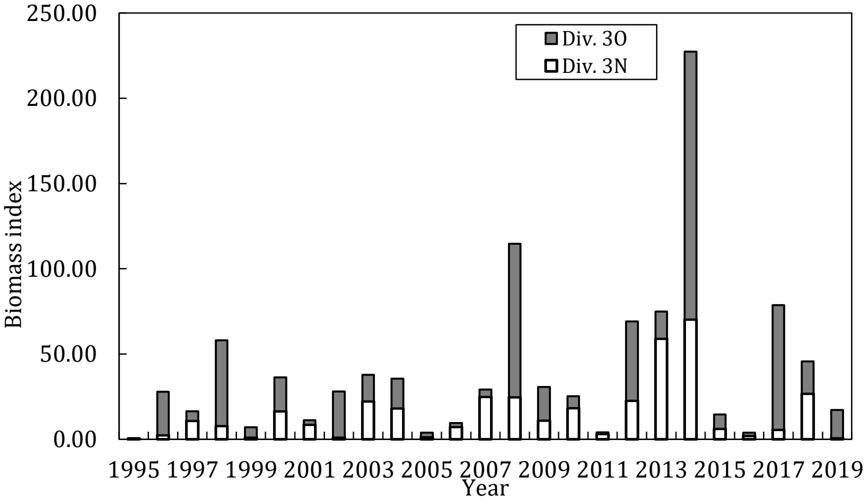


Figure 14.2. Capelin in Div. 3NO: survey biomass index (bottom trawl) from Canadian spring survey in 1995-2019.

Data from EU-Spain trawl surveys in Divs. 3NO for 1995-2021 are also available (Figure 14.3). Data from 1995-2000 are from the C/V "Playa de Menduíña", transformed to be comparable with the 2001-2021 R/V "Vizconde de Eza" data. It should be noted there is a gap in data for 2020, because of the pandemic.

Capelin biomass was at a maximum level in 2012 (151.4 thousand tons). During 2014-2017 biomass sharply declined from 85.5 thousand tons to 5.2 thousand tons. In 2018-2019, biomass rose to a level similar to that observed in the early 2000s (27.8-19.8 thousand tons). In 2021, capelin biomass declined to 9.0 thousand tons.

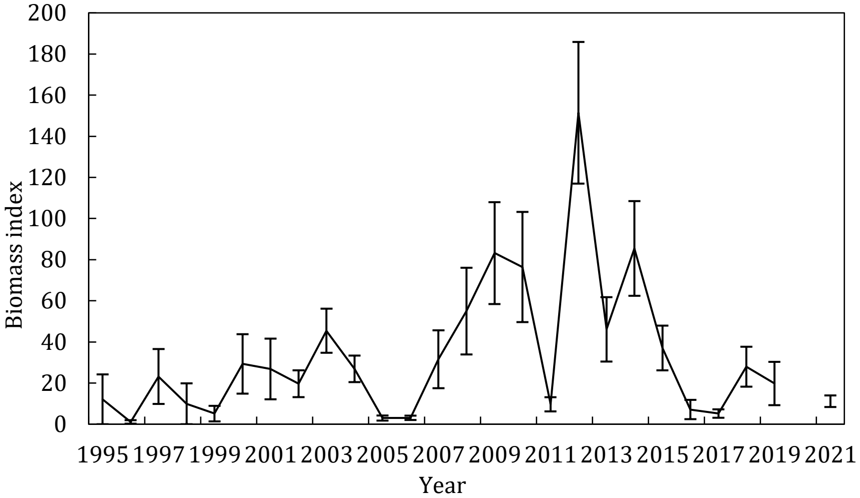


Figure 14.3. Biomass index and standard deviations of capelin (1995-2021) based on EU-Spain trawl 3NO surveys.

c) Conclusion

An acoustic survey series that terminated in 1994 indicated a stock at a low level. Biomass indices from bottom trawl surveys since that time have not indicated any change in stock status, although the validity of such surveys for monitoring the dynamics of pelagic species is questionable.

d) Research recommendations

STACFIS reiterates its **recommendation** that *initial investigations to evaluate the status of capelin in Div. 3NO should utilize trawl acoustic surveys to allow comparison with the historical time series.*

Commission has excluded the capelin from its triennial request for full assessment unless surveys indicate a significant change in the state of the stock.

15. Redfish *(Sebastes mentella* and *Sebastes fasciatus*) in Division 3O

(SCR Doc. 22/05, 07, 044 ; SCS Doc. 22/06, 07, 09, 13)

a) Introduction

There are two species of redfish that have been commercially fished in Div. 3O; the deep-sea redfish *(Sebastes mentella)* and the Acadian redfish *(Sebastes fasciatus*). The external characteristics are very similar, making them difficult to distinguish, and as a consequence they are reported collectively as "redfish" in the commercial fishery statistics. Most studies the Council has reviewed in the past have suggested a closer connection between Divs. 3LN and Div. 3O, for both species of redfish within this stock. A recent study (Valentin *et al.* 2015) showed that some juvenile *S. fasciatus* sampled in the Gulf of St. Lawrence had the genetic signature of adult redfish from Divs. 3LNO and southern 3Ps. These findings suggest that stock structure is not well understood for not only Div. 3O but also neighbouring redfish stocks. However, differences observed in population dynamics between Divs. 3LN and Div. 3O suggested that it would be prudent to keep Div. 3O as a separate management unit.

Fishery and catches: The redfish fishery within the Canadian portion of Div. 3O has been under TAC regulation since 1974 and a minimum size limit of 22 cm has been in place since 1995. Catch in the NRA portion of Div. 3O during that same time was regulated only by mesh size, and a TAC was adopted by NAFO in September 2004. The TAC has been 20 000 tons since 2005 and applies to the entire area of Div. 3O. Nominal catches have ranged between 3 000 tons and 35 000 tons since 1960, and have been in the range of 5500 to 9000 t since 2009 (Figure 15.1).

The redfish fishery in Div. 3O occurs primarily in the last three quarters of the year. Canadian, Portuguese, Russian and Spanish fleets, and since 2007 Estonia, have accounted for most of the catch. Bottom trawling accounts for greater than 90% of landings. Catch by midwater trawls is predominantly by Russia but there has been limited activity using this gear since 2004.

Nominal catches and TACs ('000 tons) for redfish in the recent period are as follows:

	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
TAC	20	20	20	20	20	20	20	20	20	20
STATLANT 21	7.8	7.5	7.9	8.6	7.3	4.3	6.5	7.3	5.4	
STACFIS	7.8	7.5	8.4	9.0	7.5	6.1	6.5	7.3	5.6	

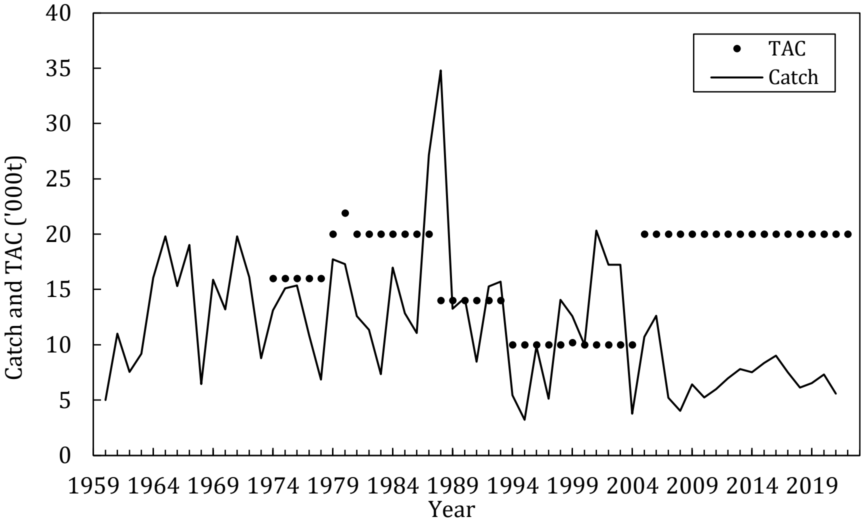


Figure 15.1. Redfish in Div. 3O: catches and TACs. TACs from 1974 to 2004 applied to Canadian fisheries jurisdiction, from 2005 for entire Div. 3O area.

b) Data Overview

i) Commercial fishery data

Since 2019, sampling of the redfish trawl fisheries was conducted by in all years by Spain and Portugal, by Estonia in 2019 and 2021, and by Russia in 2019 and 2020. There was no Canadian redfish catch sampled from 2019 to 2021. Size composition of the catch prior to 1998 consisted of a larger proportion of fish >25cm, but since has been relatively stable with the majority of the catch consisting of fish 15 to 30cm and few fish reported greater than 30cm.

ii) Research survey data

Abundance, biomass and size distribution data, as well as mean numbers and weights (kg) per tow, were available from Canadian spring surveys for 1991-2019 and autumn surveys for 1991-2020 and EU/Spain surveys in the NRA portion from 1997-2021. Due to COVID-19 restrictions, the spring survey was not conducted in 2020, and due to operational difficulties, there was no 2021 survey (See appendix III, SCS Doc. 21-17).

Abundance and biomass data were available from Canadian stratified-random surveys during 1991-2019 in spring and 1991-2020 in autumn. In 2006, only autumn indices were available due to inadequate survey coverage in the spring survey. There was no spring survey in 2006, 2020, or 2021, and no autumn surveys in 2014 or 2021. Surveys prior to 1991 did not cover the depth range of Redfish in Div. 3O. The surveys currently cover to depths of 732 m (400 fathoms). Until the autumn of 1995 these surveys were conducted with an Engels 145 high lift otter trawl. Thereafter a Campelen 1800 survey trawl was used. The Engel data were converted into Campelen equivalent units.

Data were available from EU-Spain spring surveys conducted in the NAFO Regulatory Area (NRA) of Div. 3O from 1995 to 2019 and in 2021. No EU-Spain survey was completed in 3N or 3L in 2020, nor in 3L in 2021 due to COVID-19 restrictions. These surveys use the same stratification scheme as the Canadian surveys. The area of redfish habitat in Div. 3O that is covered by the EU-Spain survey is estimated at less than 8% of that covered by Canadian surveys . During many years, less than 20% of the biomass in the Canadian surveys is observed in the NRA and therefore, the EU-Spain survey may not reflect stock trends. The EU-Spain surveys covered depths to 1500m (800 fathoms) with the exception of 1995-1996 when complete coverage was not achieved. Until 2001, these surveys were conducted using a Pedreira type bottom trawl and thereafter with a Campelen trawl similar to that used in Canadian surveys. The data prior to 2001 were converted into Campelen equivalent units.

Biomass indices

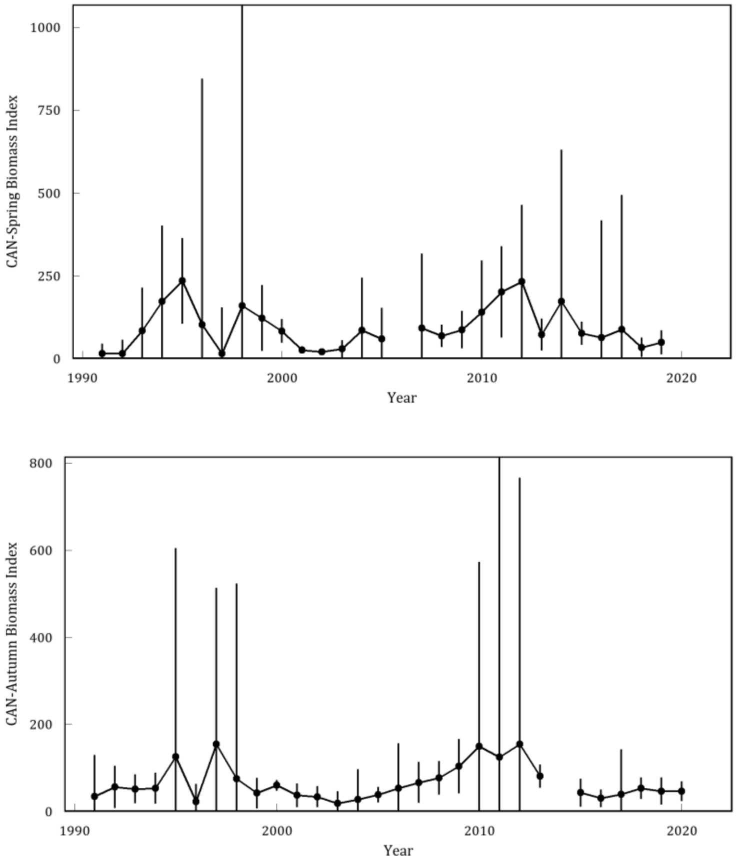


Figure 15.2. Redfish in Div. 3O: survey biomass indices from Canadian surveys (Campelen equivalent units for surveys prior to autumn 1995) with 95% confidence intervals.

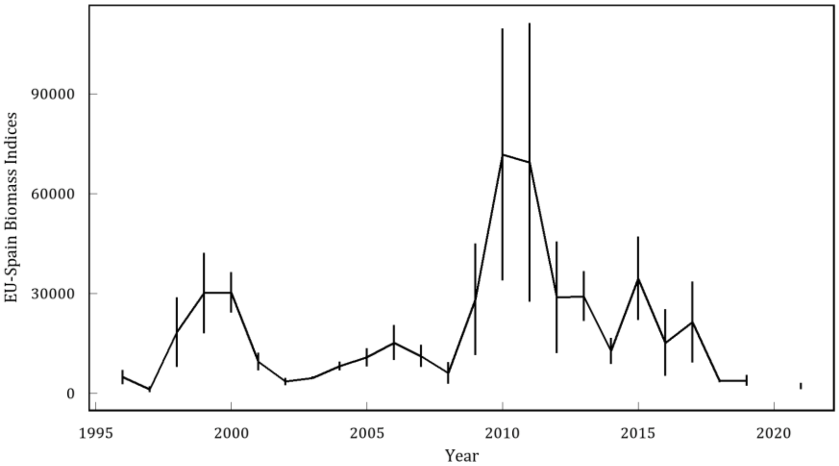


Figure 15.3. Redfish in Div. 3O: survey biomass indices (error bars are one standard deviation) from EU-Spain spring surveys in Campelen equivalent units for surveys prior to 2002.

Results of bottom trawl surveys for redfish in Div. 3O have shown a considerable amount of variability, making it difficult to interpret year to year changes. However, trends across the three survey series are consistent and show indices generally at or above the time-series mean during two periods: the mid to late 1990s, and during 2009 to 2015. All available surveys since 2018 have been below their long term mean.

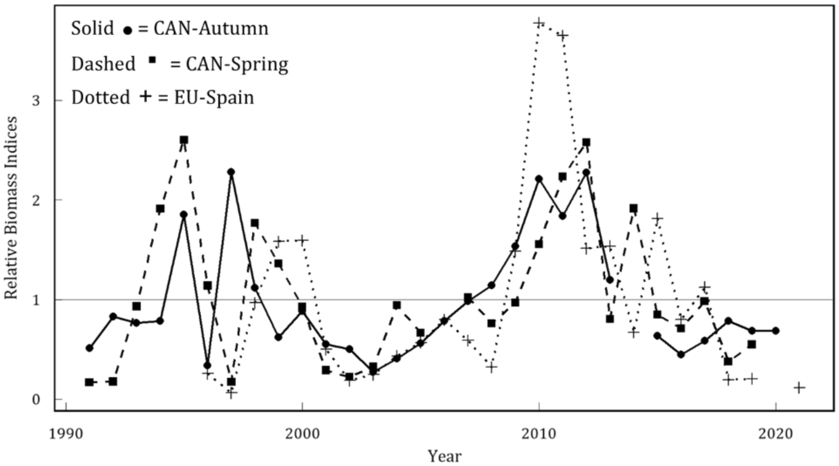


Figure 15.4. Redfish in Div. 3O: survey biomass indices from Canada (spring and autumn) and EU-Spain during 1991 to 20201. Indices were normalized by dividing each series by its mean from 1997-2021.

Localized biomass declines have been apparent recently within the NRA portion of the stock area, with EU-Spain indices near time series low over the last three years, and decreases evident in CAN-Autumn survey catches for strata areas within the NRA.

Recruitment

Recruitment indices were accepted for this stock as the abundance of fish 10-15cm in the CAN-Spring and CAN-Autumn surveys (Figure 15.5). Redfish <15cm are not consistently caught in the EU-Spain survey in Div. 3O, therefore this survey was not considered appropriate for quantifying recruitment. Fishery catch is typically between 15 and 30cm, therefore the recruitment index represents the abundance of fish in sizes close to those recruiting to the fishery. An early 2000's year class is the last indication of good recruitment apparent in both spring and fall indices. Recruitment indices since 2012 have generally been at or below the series averages. STACFIS noted that pulses of recruitment sometimes fail to track through to sizes caught in the fishery and uncertainty remains about potential contributions to recruitment from areas outside of Div. 3O.

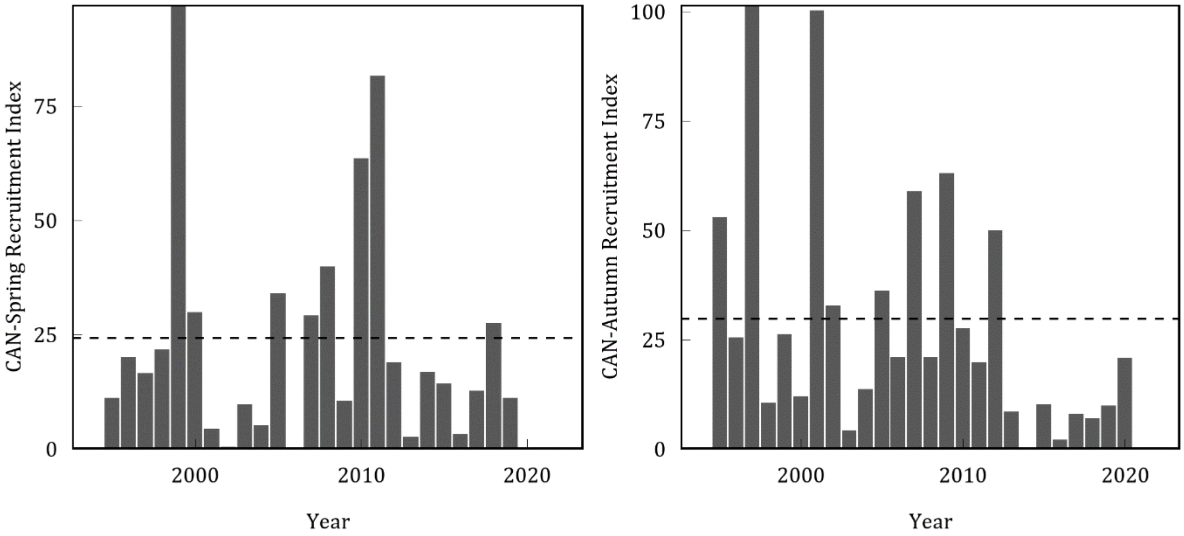


Figure 15.5. Recruitment indices defined as the abundance of redfish 10-15cm in the Canadian Spring (left) and Canadian Autumn (right) survey indices. Horizontal line indicates each time series average.

c) Estimation of Stock Parameters

i) Fishing mortality

A fishing mortality proxy was derived from catch to biomass ratios. As most of the catch is generally taken in the last three quarters of the year, the catch in year "*n*" was divided by the average of the Canadian Spring (year = *n*) and Autumn (year = *n*-1) survey biomass estimates to better represent the relative biomass at the time of the year before the catch was taken. In years when a survey index is missing, the available survey is used in place of the mean estimate. Prior to 1998, the catch was composed of fish greater than 25 cm which are not well represented in the survey catch. From 1998 to 2018, the fishery size composition more resembled the survey size composition. Accordingly, catch/biomass ratios were only calculated for the surveys from 1998-2020.

Relative fishing mortality was at or among the highest in the series from 2001 to 2006 (exception of 2004), before declining to 2007 (Figure 15.6).The values for 2007-2014 were among the lowest in the time series. Relative fishing mortality increased slightly from 2014 to 2016, and has remained at this level since.

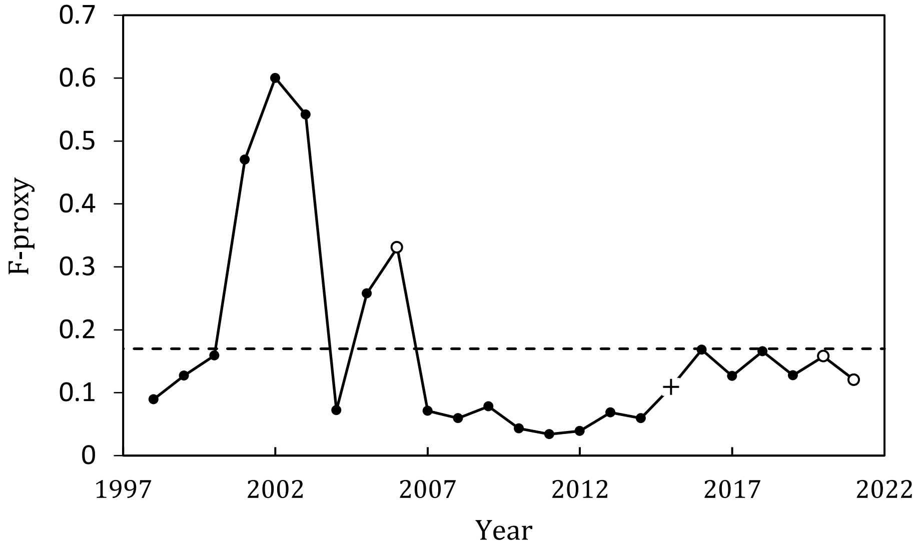


Figure 15.6. Redfish in Div. 3O: catch/survey biomass ratios. Open circles and + indicate years with no spring survey, or autumn survey included in the mean biomass, respectively. The dashed line indicates the time series mean.

d) Assessment Results

Biomass: All available survey index values since 2018 have been below average, well below the relatively high values observed in the early 2010s.

Fishing Mortality: Relative fishing mortality has been near the series average since 2015, remaining relatively low compared to the series high period of 2001-2006.

Recruitment: An early 2000's year class is the last indication of good recruitment apparent in both spring and fall indices. Recruitment indices since 2012 have generally been at or below series averages.

State of the Stock:

Stock is below an interim survey-based proxy for B_{MSY}. Biomass in 2020 was above the limit reference point (B_{lim} =0.3 B_{MSY} proxy) with a high probability [P(B2020> B_{lim})> 0.99]. Biomass relative to the reference point cannot be determined in 2021 as Canadian Spring and Autumn surveys did not occur in Div. 3O. However, given the slow growth of redfish and interpretation of year-over-year index fluctuations, stock status in 2021 is assumed to be similar to 2020.

Recruitment indices since 2012 have generally been at or below series averages.

e) Reference Points:

Candidate biomass reference points were examined, derived from CAN-Spring and CAN-Autumn surveys; these surveys cover the whole stock area. Given relative stability in catches through the history of the fishery, and trends in survey indices, the survey time series is considered to represent normal conditions for this stock (i.e. no apparent prolonged period of collapse). The average of the survey time series was therefore considered a reasonable proxy for B_{MSY}.

To combine CAN-Spring and CAN-Fall trawlable biomass indices, and account for uncertainty associated with estimates from both surveys, annual stratified means and variances from each survey were integrated using the properties of the variance and translated to shape and scale parameters for use in the gamma distribution. This approach accounts for sampling variance from both surveys while also accounting for the positive and skewed nature of these indices. In years when a survey index is missing, the available survey is used in place of the mean and variance estimate. This same approach was applied to account for the uncertainty in the B_{MSY}

proxy by applying the gamma distribution informed by averaged point estimates of mean and variance. The resultant distributions for the combined biomass index and B_{MSY} proxy can be used to assess stock status with probabilities (Figure 15.7).

Though the abovementioned approach accounts for sampling variance, it does not account for all sources of uncertainty. The available time series (1991-2021) is relatively short considering that redfish are slow growing and long-lived, and does not provide a full understanding of potential stock dynamics. The true value for MSY is likely to vary from this proxy. Uncertainty also exists in the degree of connectivity between Redfish in Div. 3O and adjacent stocks.

Notwithstanding uncertainty associated with time-series length and stock mixing, it was agreed that an interim limit reference point be established at a level corresponding to 30% of the proxy B_{MSY} level. This reference point is not considered perfectly known as uncertainty around this point is informed by variances from the survey indices. Determining status relative to the LRP considering uncertainty in both the proxy-B_{MSY} and the current Biomass level provides the most fulsome formulation of uncertainty in stock status and the most precautionary approach to advice.

As survey indices can show unrealistic fluctuations year over year, STACFIS noted that a single year is insufficient to indicate a change in stock status. Large inter-annual changes have been observed in the past (e.g. 1996, 2016), however such changes have not resulted in a >10% probability of this stock being below B_{lim}. Rather than constituting a conservation concern, extreme year over year changes are more likely associated with sampling noise.

The reference points described here are considered interim, and should be reviewed as additional information becomes available or as analytical methods advance for this stock.

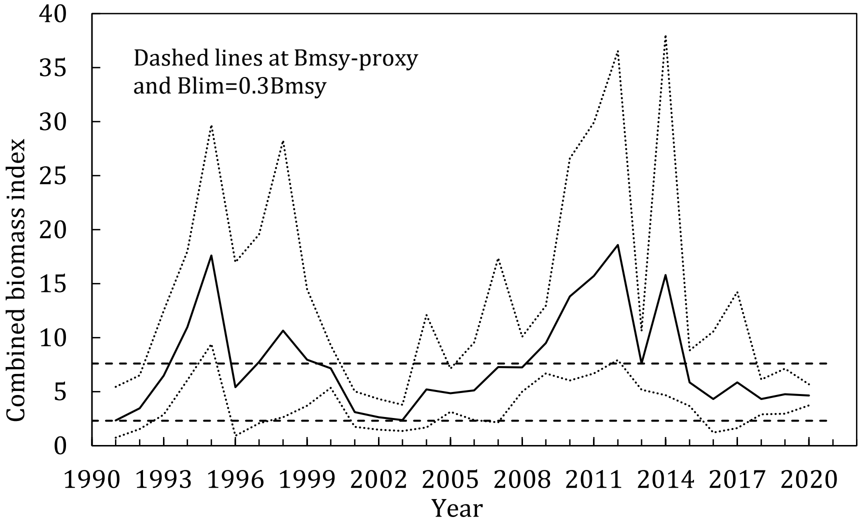


Figure 15.7. Combined CAN-Spring and CAN-Autumn biomass index (top) with 80% confidence intervals calculated using a gamma distribution. Horizontal dashed line indicates interim B_{lim} =0.3 B_{MSY} -proxy. Probability of By< B_{lim} is presented below, with the solid horizontal line at P(B< B_{lim} =0.1).

f) Recommendations

STACFIS **recommended** that *for Redfish in Div. 3O, work continue on developing a recruitment index with sizes close to those recruiting to the fishery*.

Recruitment indices were defined as the abundance of redfish 10-15cm in the CAN-Spring and CAN-Autumn surveys.

Status: complete.

STACFIS **recommended** that *for Redfish in Div. 3O, work continue on developing an assessment model for the stock. Aging should be conducted for redfish sampled during select years to support model development.*

Status: this recommendation is reiterated.

STACFIS **recommends** that *stock boundaries and definitions as well as synchronicity with adjacent stocks be explored.*

STACFIS **recommends** that *the reference point for this stock be reviewed at the 2028 assessment, or earlier if there are considerable advances in an analytical approach for this stock, or a significant change in available data or the understanding of stock dynamics.*

The next full assessment will be in 2025.

References:

Valentin, A. E., D. Power and J-M Sévigny. 2015. Understanding recruitment patterns of historically strong year classes in redfish (Sebastes spp.): the importance of species identity, population structure and juvenile migration. Can. J. Fish. Aquat. Sci. 72: 1-11.

16. Thorny Skate (*Amblyraja radiata*) in Divisions 3L, 3N, 3O and Subdivision 3Ps

(SCR Doc. 22/26, 22/005, 20/014; SCS Doc. 22/06, 09, 10, 13)

a) Introduction

Thorny Skate on the Grand Banks was first assessed by Canada in 1999 for the stock unit 3LNOPs. Subsequent Canadian assessments also provided advice for Divs. 3LNOPs. However, Subdivision 3Ps is presently managed as a separate unit by Canada and France in their respective EEZs, and Divs. 3LNO in the NAFO Regulatory Area (NRA) is managed by NAFO. Based on this species' continuous distribution and the lack of physical barriers between Divs. 3LNO and Subdiv. 3Ps, Thorny Skate in Divs. 3LNOPs is considered to constitute a single stock.

Fishery and Catch: Commercial catches of skates contain a mix of skate species. However, Thorny Skate dominates, comprising about 95% of skate species taken in Canadian and EU-Spain catches. Thus, the skate fishery on the Grand Banks can be considered a fishery for Thorny Skate. In 2005, NAFO Fisheries Commission established a Total Allowable Catch (TAC) of 13 500 t for Thorny Skate in the NRA of Divs. 3LNO (Figure 16.1). This TAC was lowered to 12 000 t for 2010-2011, and to 8 500 tons for 2012. The TAC was further reduced to 7 000 t for 2013-2022. In Subdiv. 3Ps, Canada established a TAC of 1 050 tons in 1997, which has not changed.

Catches from the NRA of Divs. 3LNO increased in the mid-1980s with the commencement of a directed fishery for Thorny Skate (Figure 16.1). The main participants in this new fishery were Spain, Portugal, USSR, and the Republic of Korea. Reported landings from all countries in Divs. 3LNOPs over 1985-1991 averaged 17 058 t; with a peak of 28 408 t in 1991 (STATLANT-21A). From 1992-1995, catches of Thorny Skate declined to an average of 7 554 t; however, there are substantial uncertainties concerning reported skate catches prior to 1996. Average STACFIS-agreed catch for Divs. 3LNO in 2014-2020 was 3 730 t, and 657 t for Subdiv. 3Ps. STACFIS catch in 2021 totaled 3 677 t for Divs. 3LNO, and 702 t for Subdiv. 3Ps.

Recent nominal catches and TACs (000 tons) in Divs. 3LNO and Subdiv. 3Ps are as follows:

	2013	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**
Divs. 3LNO:										
TAC	7	7	7	7	7	7	7	7	7	7
STATLANT-21A	4.3	4.5	3.3	3.5	4.2	1.5	3.7	4.0	4.0	
STACFIS	4.3	4.5	3.3	3.5	4.5	2.4	3.7	4.3	3.7	
Subdiv. 3Ps:										
TAC	1.05	1.05	1.05	1.05	1.05	1.05	1.05	1.05	1.05	1.05
STATLANT-21A	0.6	0.3	0.2	0.7	0.6	1.1	.9	0.8	0.7	
Divs. 3LNOPs:										
STATLANT-21A	4.9	4.8	3.6	4.1	4.8	2.3	4.6	4.8	4.7	
STACFIS	5.0	4.8	3.6	4.1	5.1	3.5	4.6	5.1	4.4	

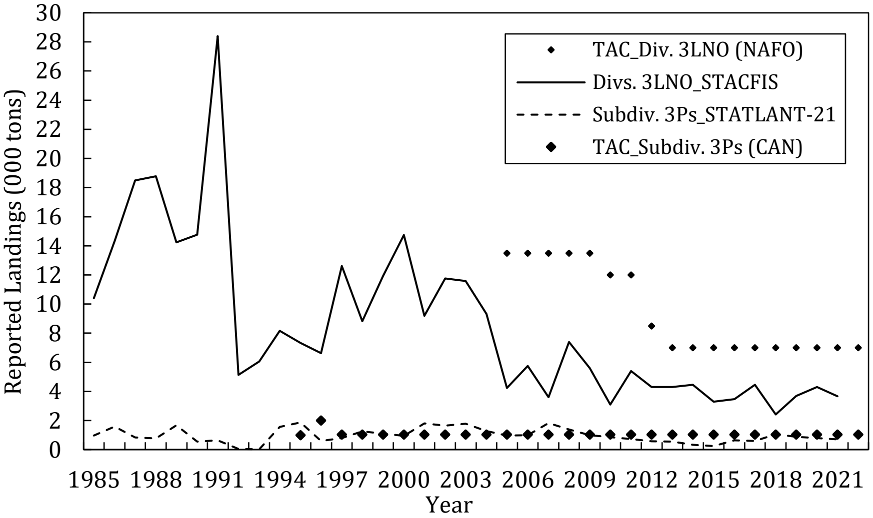


Figure 16.1. Thorny Skate in Divs. 3LNO and Subdiv. 3Ps, 1985-2021: total reported landings and TACs.

b) Data Overview

i) Commercial fisheries data

Thorny Skates from either commercial or research survey catches are currently not aged.

Commercial length frequencies of skates were available for EU-Spain (2021), EU-Portugal (2021), Russia (2020), and Canada (2020 and 2021).

In recent years, from skate-directed trawl fisheries (280 mm mesh) in the NRA of Divs. 3LNO over 2019-2021, EU-Spain reported 18-96 cm TL skates, with a small number of young-of-the-year (≤21 cm) caught in 2021. In trawl fisheries targeting other species (130-135 mm mesh) in Divs. 3LNO (NRA) in 2019 and 2021, EU-Portugal reported skate bycatch ranging from 14-100 cm TL. EU-Portugal did not sample Divs. 3LNO skate bycatch in 2020, while EU-Spain have not done so since 2009. Russian trawlers reported 15-95 cm skates in 2019-2020 Canadian trawlers in the Divs. 3LN redfish (*Sebastes* sp.) fishery in 2019 caught 42-88 cm Thorny Skates. In 2019-2021, skates caught by Canadian trawlers in the Divs. 3LNO Yellowtail Flounder (*Limanda ferruginea*) fishery ranged between 23-96 cm.

No standardized commercial catch per unit effort (CPUE) exists for Thorny Skate.

ii) Research survey data

Canadian spring surveys. Stratified-random research surveys have been conducted by Canada in Divs. 3LNO and Subdiv. 3Ps in spring; using a Yankee 41.5 otter trawl in 1972-1982, an Engel 145 otter trawl in 1983-1995, and a Campelen 1800 shrimp trawl in 1996-2021. Subdiv. 3Ps was not surveyed in 2006, nor was the deeper portion of Divs. 3NO, due to mechanical difficulties on Canadian research vessels. In 2015 and 2017, several strata were not sampled in Div. 3L, thus impacting biomass and abundance estimates of Thorny Skate. Due to COVID-19 restrictions there was no spring survey in 2020, and due to operational difficulties only Subdiv. 3Ps was sampled in spring 2021.

Indices for Divs. 3LNOPs in 1972-1982 (Yankee series) fluctuated without trend (Figure 16.2a).

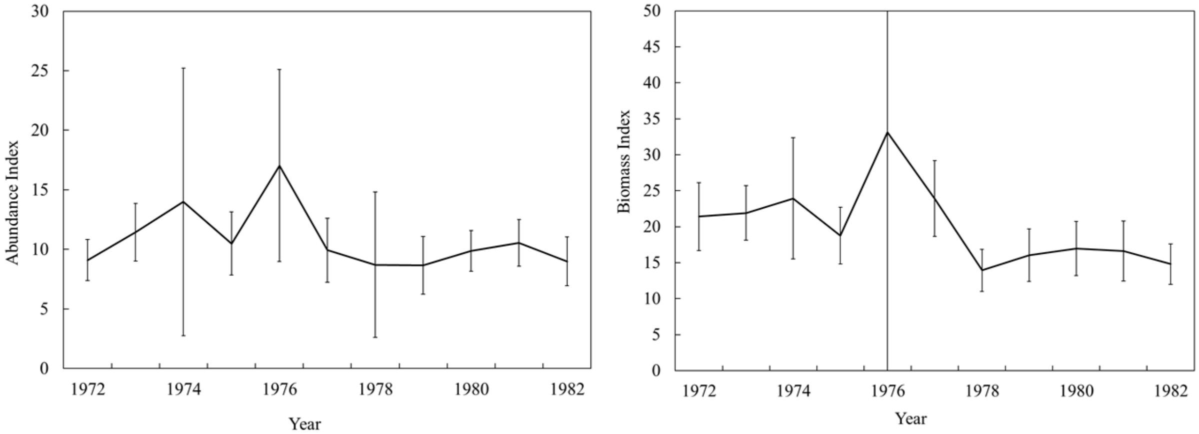


Figure 16.2a. Thorny Skate in Divs. 3LNOPs, 1972-1982: abundance (left panel) and biomass (right panel) indices from Canadian spring surveys.

Total survey biomass in Divs. 3LNOPs has fluctuated, but remained stable at low levels since 2007 (Figure 16.2b).

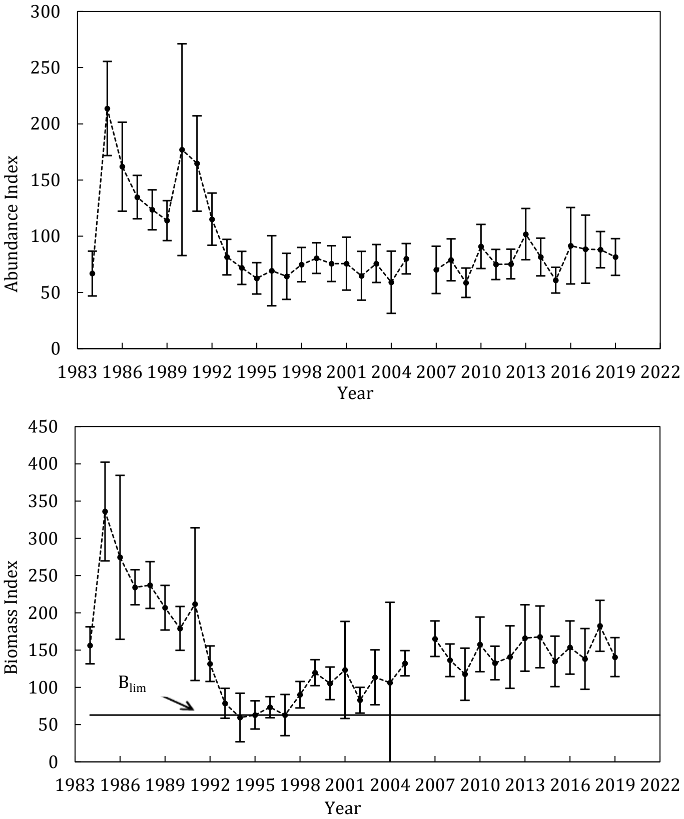


Figure 16.2b. Thorny Skate in Divs. 3LNOPs, 1984-2019: abundance (top panel) and biomass (bottom panel) indices from Canadian spring surveys. Horizontal line represents B_{lim}. Surveys in 2015 and 2017 (open circles) were incomplete. Due to COVID-19 restrictions there was no spring survey in 2020, and due to operational difficulties only Subdiv. 3Ps was sampled in spring 2021.

Canadian autumn surveys. Stratified-random research surveys have been conducted by Canada in Divs. 3LNO in the autumn, using an Engel 145 otter trawl in 1990-1994, and a Campelen 1800 shrimp trawl in 1995-2020.

Autumn survey indices, similar to spring estimates, declined during the early 1990s. Catch rates have been stable at very low levels since 1995 (Figure 16.3). Divs. 3NO were not surveyed in 2014, nor deep-water strata (>732 m) of Div. 3L in 2015, and 2017-2018; Due to operational difficulties, there was no 2021 survey (See appendix III, SCS Doc. 21/17). Autumn indices of abundance and biomass are, on average, higher than spring estimates. This is expected, because Thorny Skates are found deeper than the maximum depths surveyed in spring (~750 m), and are more deeply distributed during winter/spring.

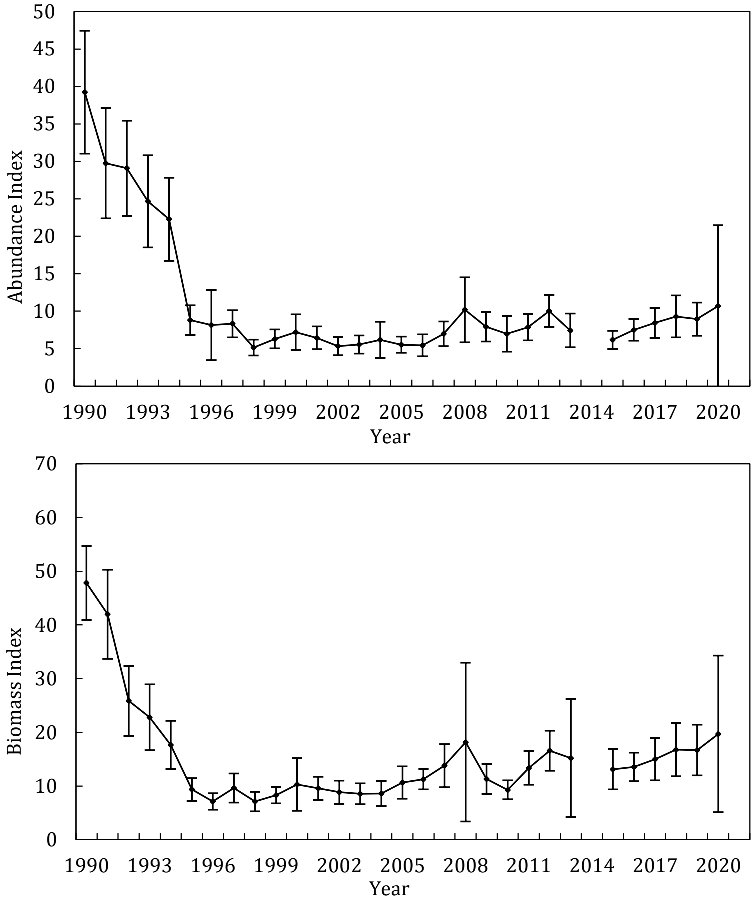


Figure 16.3. Thorny Skate in Divs. 3LNOPs, 1990-2020: abundance (top panel) and biomass (bottom panel) indices from Canadian autumn surveys. Divs. 3NO were not sampled in 2014, 2021 nor deep-water strata of Div. 3L in 2015, and 2017-2018.

EU-Spain Divs. 3NO Survey. EU-Spain survey indices (Campelen or equivalent) are available for 1997-2021, however the survey did not occur in 2020 due to COVID-19 restrictions. The survey only occurs in the NAFO Regulatory Area, thus not sampling the entire Divisions. The biomass trajectory from the EU-Spain surveys was similar to that of the Canadian spring surveys until 2006 (Figure 16.4). Since 2007, the two indices diverged: with an overall increase in the Canadian survey and a declining trend in the EU-Spain index to its lowest value in 2019.

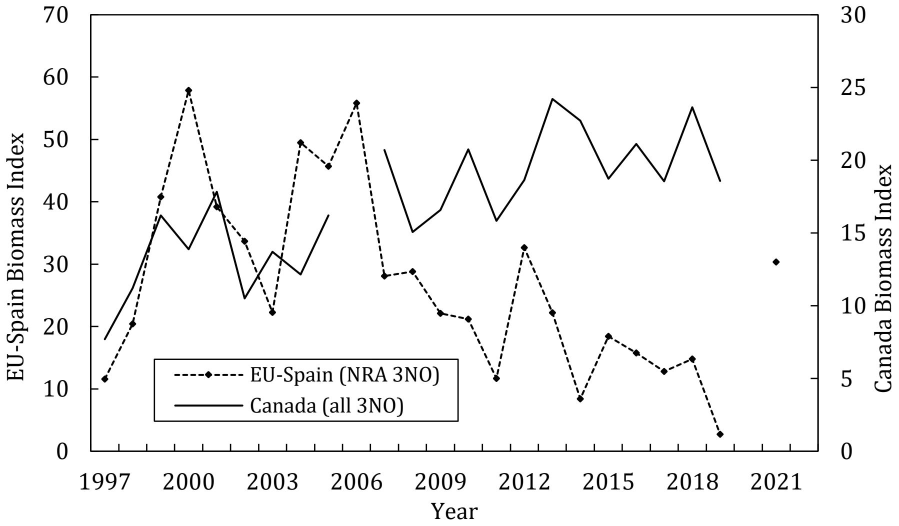


Figure 16.4. Thorny Skate in Divs. 3LNOPs, 1997-2021: biomass indices from the EU-Spain survey and the Canadian spring survey. Due to COVID-19 restrictions, the spring survey was not conducted in 2020, and due to operational difficulties, there was no 2021 survey (See appendix III, SCS Doc. 21/17).

EU-Spain Div. 3L survey. EU-Spain survey indices (Campelen trawl) are available for 2003-2019 (excluding 2005). No EU-Spain survey was completed in 3N or 3L in 2020, nor in 3L in 2021 due to COVID-19 restrictions. The survey only occurs in the NAFO Regulatory Area (Flemish Pass), thus not sampling the entire Division. Both the EU-Spain and Canadian autumn Div. 3L biomass indices generally declined from 2007-2011, while the Canadian spring index was more variable during this period (Figure 16.5). The Canadian autumn biomass index followed an increasing trend since 2011, while the Canadian spring index fluctuated at lower levels. The EU-Spain index has been following a declining trend since 2015.

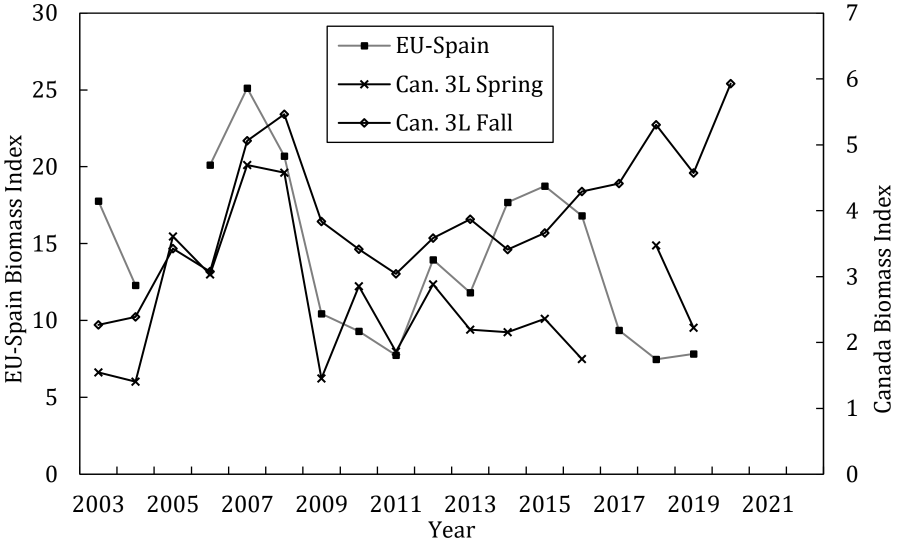


Figure 16.5. Thorny skate in Div. 3LNOPs, 2003-2019: Biomass indices from EU-Spain Div. 3L survey and the Canadian spring and autumn surveys of Div. 3L. No EU-Spain survey was completed in 3N or 3L in 2020, nor in 3L in 2021 due to COVID-19 restrictions.

iii) Biological studies

Recruitment index (skate ≤21 cm TL) was below average in 1999-2002 (Figure 16.6). The index was above average during 2010-2013. Recruitment declined to below average in 2014-2015, then increased to 1.3 in 2017.

This increase in 2017 was observed despite the missing Div. 3L survey strata which, in 2009-2016, contained on average 10% of the Thorny Skate recruits. This index was below average in 2018, and average in 2019. Life history traits of late maturity, low fecundity, and long reproductive cycles result in low intrinsic rates of increase, and impart low resilience to fishing mortality for this species.

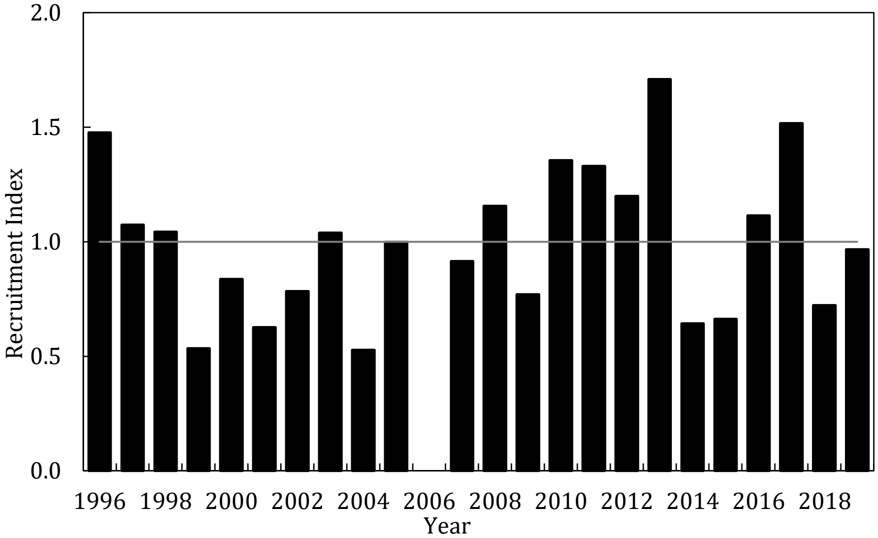


Figure 16.6. Thorny skate in Divs. 3LNOPs, 1996-2019: Standardized recruitment index for ≤21 cm TL males and females (combined) from Canadian Campelen spring surveys. Horizontal line depicts the standardized average recruitment for 1996-2019. The survey was incomplete in 2017. Due to COVID-19 restrictions, the spring survey was not conducted in 2020, and due to operational difficulties, there was no 2021 survey (see Appendix III, section 5.b)

c) Estimation of Parameters

Relative F (STACFIS-agreed commercial landings/Canadian spring survey biomass) in Divs. 3LNO declined over the late-1990s, and is currently low. Relative fishing mortality in Subdiv. 3Ps has also been low in recent years.

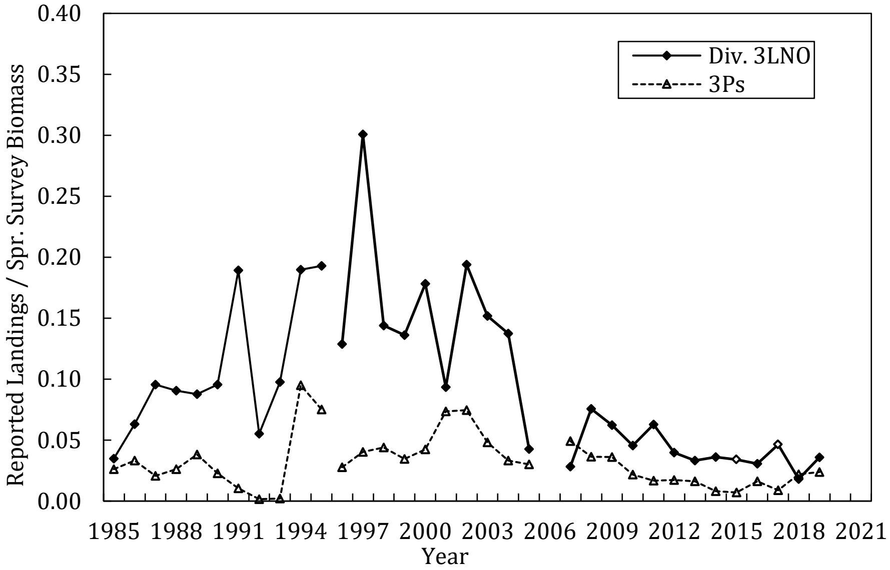


Figure 16.7. Thorny Skate in Divs. 3LNO and Subdiv. 3Ps, 1985-2019: estimates of Relative F from STACFIS-agreed commercial landings/Canadian spring survey biomass. was incomplete in 2015 and 2017 (open circles). Due to COVID-19 restrictions, the spring survey was not conducted in 2020, and due to operational difficulties, there was no 2021 survey (see Appendix III, section 5.b)

d) Assessment Results

Assessment Results: No analytical assessment was performed.

The Canadian spring survey is considered the primary indicator of the status of this stock, due to its spatial and temporal coverage. However, current state of the stock is unknown due to the lack of Canadian spring surveys in 2020 and 2021.

Biomass: Biomass of this stock has remained stable above B_{lim} since 2007.

Fishing Mortality: Relative F in Divs. 3LNOPs declined since the mid-1990s, and was low in 2019.
Recruitment: Recruitment was average in 2019.

State of the Stock: The stock was above B_{lim} in 2019. No new survey information is available to determine stock status. However, due to the longevity of the species and the stability of the catch in recent years, it is unlikely that there have been major changes to the state of the stock. Recruitment was average in 2019 and is currently unknown. Fishing mortality is currently unknown but thought to be low.

e) Reference Points

Limit reference points based on B_{loss}, which represents the lowest value for the Canadian spring survey conducted with Campelen survey gear, were accepted in 2015 as a proxy for B_{lim} (Figure 16.8).

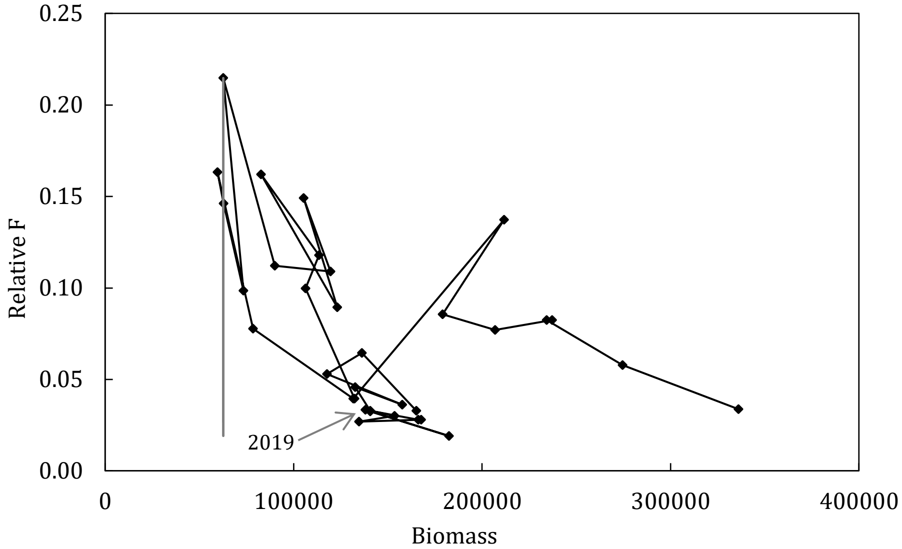


Figure 16.8. Thorny Skate in Divs. 3LNOPs, 1985-2019: stock trajectory under a precautionary approach framework. Red line is the limit reference point.

f) Research Recommendations

STACFIS **recommended** that *further work be conducted on development of a quantitative stock model.*

STATUS: Work ongoing. STACFIS reiterated this recommendation.

The next full assessment is planned for 2024.

17. White hake (*Urophycis tenuis*) in Divisions 3N, 3O, and Subdivision 3Ps

(SCR Doc. 22/005, 007; SCS Doc. 22/10). Interim Monitoring Report

a) Introduction

The advice requested by Fisheries Commission is for NAFO Div. 3NO. Previous studies indicated that white hake constitute a single unit in Div. 3NOPs, and that fish younger than 1 year, 2+ juveniles, and mature adults distribute at different locations within Div. 3NO and Subdiv. 3Ps. This movement of fish of different life stages between areas must be considered when assessing the status of white hake in Div. 3NO. Therefore, an assessment of Div. 3NO white hake is conducted with information on Subdiv. 3Ps included.

Fisheries and Catch: In 1988, Canada commenced a directed fishery for white hake in Div. 3NO and Subdiv. 3Ps. All Canadian landings prior to 1988 were as bycatch in various groundfish fisheries. EU-Spain and EU-Portugal commenced a directed fishery in 2002, and Russia in 2003, in the NAFO Regulatory Area (NRA) of Div. 3NO; resulting in the 2003-2004 peak in landings. In 2003-2004, 14% of the total landings of white hake in Div. 3NO and Subdiv. 3Ps were taken by Canada, but increased to 93% by 2006; primarily due to the absence of a directed fishery for this species by other countries.

A TAC for white hake was first implemented by Fisheries Commission in 2005 at 8 500 tons, and was then reduced to 6 000 t for 2010 and 2011. The 5 000 t TAC in Div. 3NO for 2012 was further reduced to 1 000 t for 2013-2022. Canada implemented a TAC of 500 t for Subdiv. 3Ps for 2018-2024.

From 1970-2009, white hake catches in Div. 3NO fluctuated, averaging approximately 2 000 t, exceeding 5 000 t in only three years during that period. Catches peaked in 1987 at 8 061 t (Figure 17.1). With the restriction of fishing by other countries to areas outside Canada's Exclusive Economic Zone in 1992, non-Canadian catches fell to zero. Average catch was low in 1995-2001 (422 t), then increased to 6 718 t in 2002 and 4 823 t in 2003; following recruitment of the large 1999 year-class. STACFIS-agreed catches in Divisions 3NO decreased to an average of 333 t over the period 2011-2020. STACFIS catch in 2021 was 509 t in Div. 3NO.

Commercial catches of white hake in Subdiv. 3Ps were less variable, averaging 1 114 t in 1985-93, then decreasing to an average of 619 t in 1994-2002 (Figure 17.1). Subsequently, catches increased to an average of 1 374 t in 2003-2007, then decreased to a 265 t average in 2011-2020. Catch in 2021 was reported as 115 t in Subdiv. 3Ps.

Recent reported landings and TACs (000 tons) in NAFO Div. 3NO and Subdiv. 3Ps are as follows:

	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
Div. 3NO:										
TAC	1[1]	1[1]	1[1]	1[1]	1[1]	1[1]	1[1]	1[1]	1[1]	1[1]
STATLANT 21	0.2	0.3	.4	.4	.5	.3	.3	.3	.2	
STACFIS	0.2	0.3	.5	.4	.5	.4	.3	.3	.5	
Subdiv. 3Ps:						.5	.5	.5	.5	.5
STATLANT 21	0.2	0.4	.3	.4	.3	.3	.2	.1	.1	

[1] May change in season. See NAFO FC Doc. 13/01 quota table.

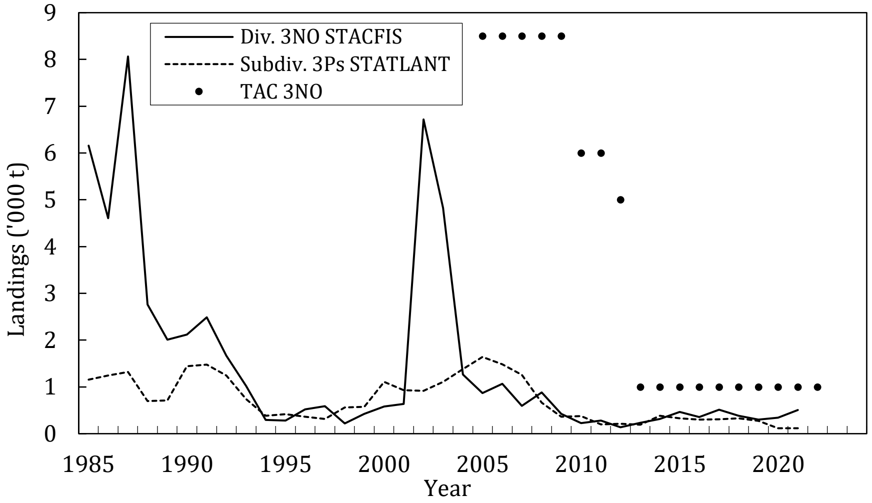


Figure 17.1. White hake in Division 3NO and Subdivision 3Ps: Total catch of white hake in NAFO Division 3NO (STACFIS) and Subdivision 3Ps (STATLANT-21A). The Total Allowable Catch (TAC) in the NRA of Divs. 3NO is also indicated on the graph.

b) Data Overview

i) Research survey data

Canadian stratified-random bottom trawl surveys. Data from spring research surveys in NAFO Div. 3N, 3O, and Subdiv. 3Ps were available from 1972 to 2021. In the 2006 Canadian spring survey, most of Subdiv. 3Ps was not surveyed, and only shallow strata in Div. 3NO (to a depth of 77 m in Div. 3N; to 103 m in Div. 3O) were surveyed; thus the survey estimate for 2006 was not included. Due to COVID-19 restrictions there was no spring survey in 2020, and due to operational difficulties, only Subdiv. 3Ps was sampled in spring 2021.. Data from autumn surveys in Div. 3NO were available from 1990 to 2020, due to mechanical difficulties the survey was not completed in 2014, or in the fall of 2021. Canadian spring surveys were conducted using a Yankee 41.5 bottom trawl prior to 1984, an Engel 145 bottom trawl from 1984 to 1995, and a Campelen 1800 trawl thereafter. Canadian autumn surveys in Div. 3NO were conducted with an Engel 145 trawl from 1990 to 1994, and a Campelen 1800 trawl from 1995-2019. There are no survey catch rate conversion factors between trawls for white hake; thus each gear type is presented as a separate time series.

Abundance and biomass indices of white hake from the Canadian spring research surveys in Div. 3NOPs are presented in Figure 17.2a. From 2007-2019, the population remained at a level similar to that previously observed in the Campelen time series for 1996-1998. The dominant feature of the white hake abundance time series was the very large peak observed over 2000-2001. In recent years, spring abundance of white hake increased in 2011, but declined to relatively stable levels over 2012-2018. In 2019, the abundance index of white hake has exhibited a strong increase comparable to that observed in 1999. Biomass of this stock increased in 2000, generated by the very large 1999 year-class. Subsequently, the biomass index decreased until 2009, and has since been relatively stable.

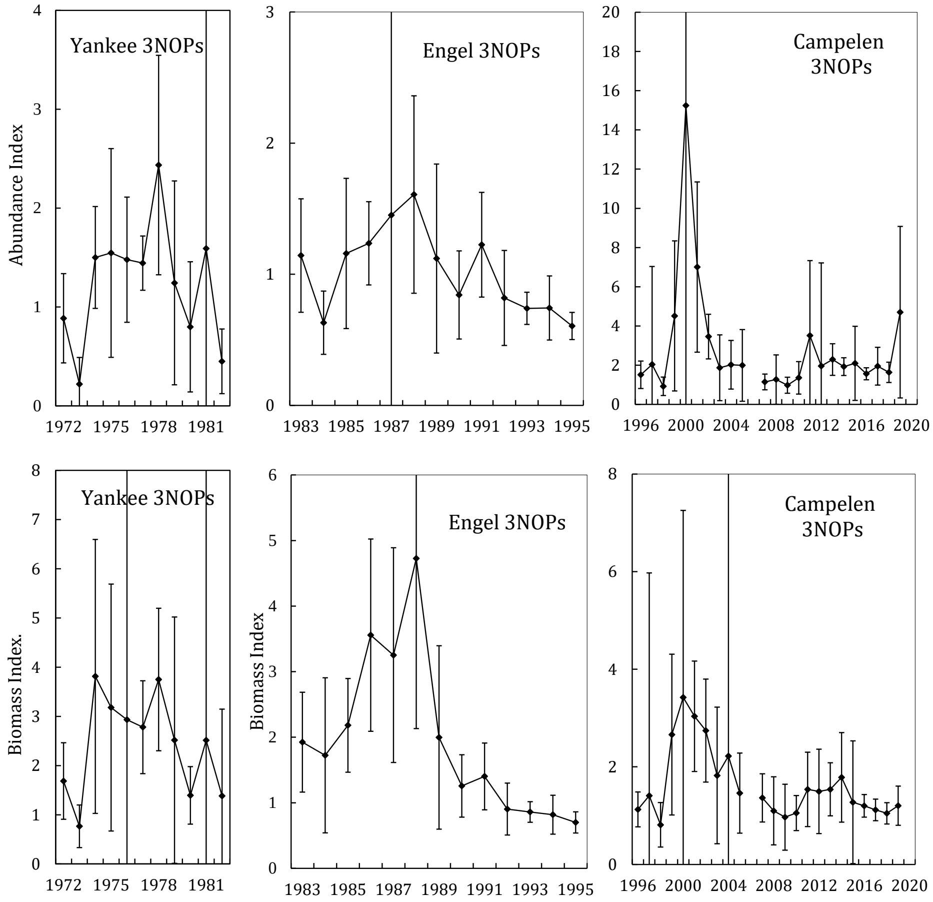


Figure 17.2a. White Hake in Div. 3NO and Subdiv. 3Ps: abundance (top panels) and biomass (bottom panels) indices from Canadian winter-spring research surveys, 1972-2019. Estimates from 2006 are not shown, since survey coverage in that year was incomplete. The survey was not conducted in 2020 nor in 2021. Yankee, Engel, and Campelen time series are not standardized, and are presented on separate panels. Error bars are 95% confidence limits. The bounds of the error bars in some panels extend above/below the graph limits.

Canadian autumn surveys of Div. 3NO have the peak in abundance represented by the very large 1999 year-class (Figure 17.2b). Autumn indices then declined to levels similar to those observed during 1996-1998. In recent years, both biomass and abundance appear to have been variable without trend. This survey was not completed in 2014 nor 2021.

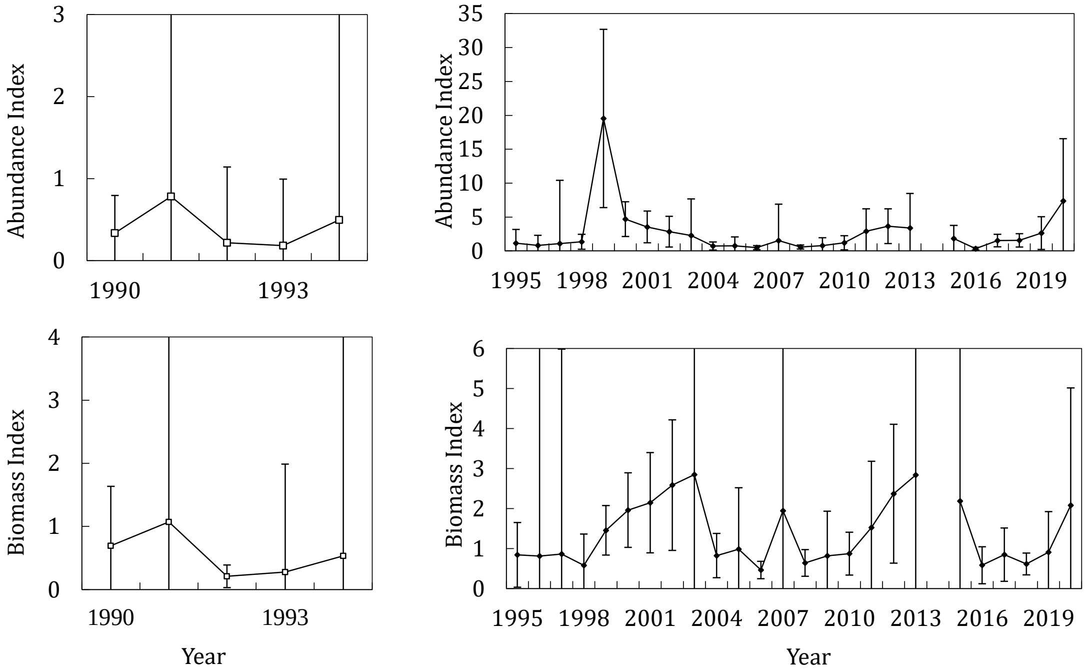


Figure 17.2b White hake in Div. 3NO: abundance (top panel) and biomass indices (bottom panel) from Canadian fall surveys, 1990-2020. There was no survey in 2021 Engel (☐, 1990-1994) and Campelen (♦, 1995-2013) time series are not standardized. Estimates from 2014 are not shown, since survey coverage in that year was incomplete. Error bars are 95% confidence limits. The bounds of the error bars in some panels extend above/below the graph limits.

EU-Spanish stratified-random bottom trawl surveys in the NRA. EU-Spain biomass indices in the NAFO Regulatory Area (NRA) of Div. 3NO were available for white hake from 2001 to 2021 (Figure 17.3). There was no survey in 2020 due to COVID-19 restrictions. EU-Spain surveys were conducted with Campelen gear (similar to that used in Canadian surveys) in the spring to a depth of 1 400 m. This survey covers only a small portion of the total stock area. The EU-Spain biomass index was highest in 2001, then declined to 2003, peaked slightly in 2005, and then declined to its lowest level in 2008. In 2009-2013, the EU-Spain index indicated a gradually increasing trend relative to 2008, which is similar to that of the Canadian spring survey index (figure. 17.3). However, the EU-Spain biomass index declined in 2014, followed by an increase over 2015-2016 to the highest level since 2005, while the Canadian index declined to its 2007 level. The EU-Spain index declined from 2016 to 2019 to a similar level as observed in 2008, while in 2019 the Canadian index increased. In 2021 the EU-Spain index increased to well above the 2017-2019 average.

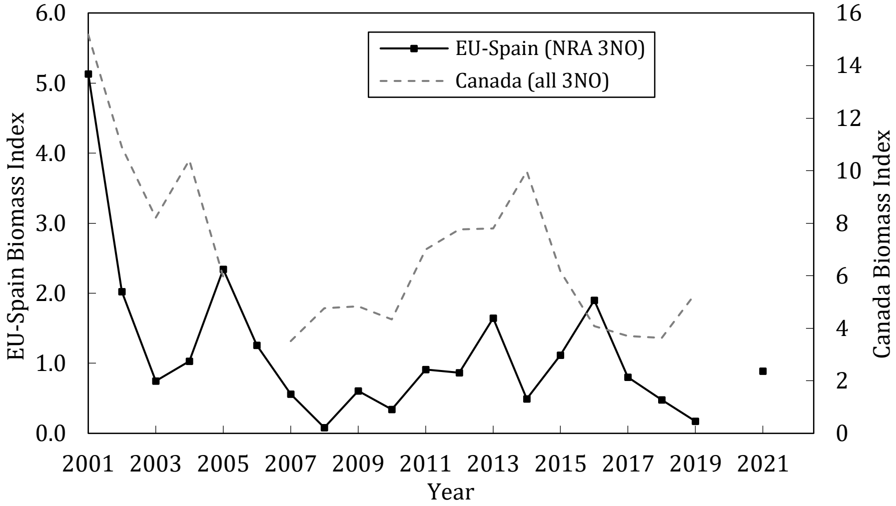


Figure 17.3. Biomass indices from EU-Spain spring 3NO surveys in 2001-2021 in the NRA compared to Canadian spring survey indices in all of Div. 3NO. Estimates from 2006 Canadian survey are not shown, since survey coverage in that year was incomplete. There was no EU-Spain in 2020, nor a Canadian survey in 2020 or 2021.

Recruitment. In Canadian spring research surveys, the number of white hake less than 27 cm in length is assumed to be an index of recruitment at Age 1. The recruitment index in 2000 was very large, but no large value has been observed during 2001-2019 (Figure 17.6). Recruitment was higher in 2011 and in 2019, but not comparable to the very high recruitment observed in 2000.

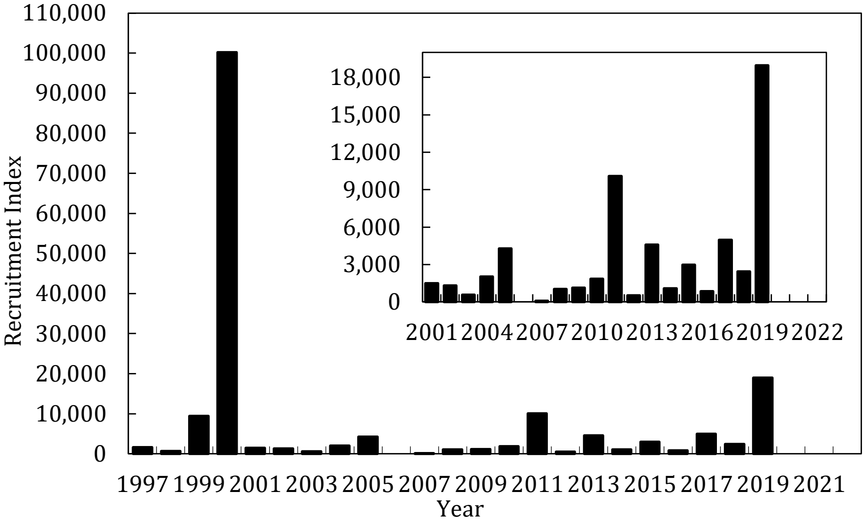


Figure 17.4. White hake in Div. 3NO and Subdiv. 3Ps: recruitment index for Age 1 males and females (combined) from Canadian Campelen spring surveys in Divs. 3NO and Subdiv. 3Ps in 1997-2019. Estimates from 2006 are not shown, since survey coverage in that year was incomplete. Inset plot depicts 2001-2019 on a smaller scale. Due to COVID-19 restrictions there was no spring survey in 2020, and due to operational difficulties only Subdiv. 3Ps was sampled in spring 2021.

c) Conclusion

Based on current information there is no significant change in the status of this stock. However, current state of the stock is unknown due to the lack of Canadian spring surveys in 2020 and 2021. Stock biomass remains at relatively low levels, and no large recruitments have been observed since 2000.

d) Research Recommendations

STACFIS **recommended** that *age determination should be conducted on otolith samples collected during annual Canadian surveys (1972-2016+); thereby allowing age-based analyses of this population.*

Otoliths are being collected, and aging has been initiated. STACFIS reiterates this recommendation.

STACFIS **recommended** that *survey conversion factors between the Engel and Campelen gear be investigated for this stock.*

No progress, STACFIS reiterates this recommendation.

STACFIS **recommended** that *work continue on the development of population models and reference point proxies.*

Various formulations of a surplus production model in a Bayesian framework were explored and work is continuing.

D. WIDELY DISTRIBUTED STOCKS: SUBAREA 2, SUBAREA 3 AND SUBAREA 4

Recent Highlights in Ocean Climate and Lower Trophic Levels

- In 2021, subareas 2, 3 and 4 were all above normal, making the cumulative anomaly the warmest on record.
- Spring bloom initiation was, on average, earlier than normal in subareas 2-3-4 in 2021, mostly because of the early bloom onsets observed on the Labrador Shelf (SA-2).
- Total spring production (bloom magnitude) was near normal in in 2021 in subareas 2, 3 and 4.
- Mean copepod abundance was above normal for a second consecutive year in 2021 and particularly high in subarea 3.
- Mean abundance of non-copepod zooplankton was near-normal in 2021 after five consecutive years of above-normal observations. Abundances in subareas 3 and 4 were comparable to those observed in recent years but decreased in Subarea 2.
- Mean zooplankton biomass was near normal in 2021 but varied among regions with some of the highest values on record for subareas 2 and 3, and a time-series lowest for subarea 4.

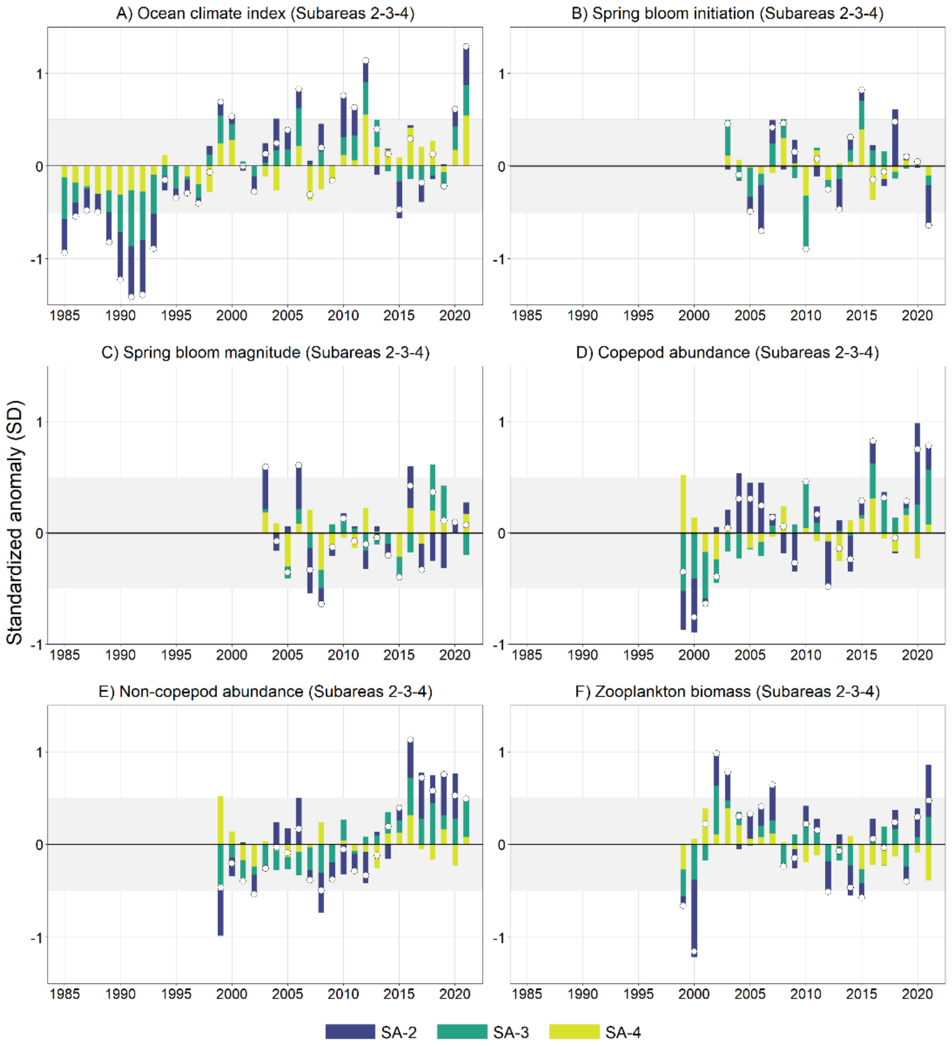


Figure D1. Annual anomalies of environmental indices for NAFO Subareas 2 to 4. The ocean climate index (A) during 1990-2020 is the average of 8, 16 and 12 individual time series respectively for SA 2, 3 and 4 (see Cyr and Belanger 2022 for details). Spring bloom anomalies (B, C) for the 2003-2020 period were averaged over two satellite boxes (NGB, SE – see Figure. D1A for boxes location). Zooplankton anomalies (D-F) for the 1999-2021 wee averaged over three (NLS, CLS, HB), seven (SAB, NENS, NGB, FP, FC, SES, SPB) and seven (NEGSL, NWGSL, MS, CS, ESS, CSS, WSS) ocean colour satellite boxes for Subarea 2, 3 and 4, respectively (see Cyr and Belanger 2022 for details). Zooplankton anomalies were averaged over three sections (BI, MB, SI) for SA-2, three sections (BB, FC, SESG) and one hight-frequency sampling site (S27) for SA-3, and 10 sections (TESL, TSI, TBB, TECN, TDC, TIDM, LL, HL, BBL) and four high-frequency sampling sites (R, S, P5, H2) for SA-4 (see SCR Doc. 21/023 for details). Positive (negative) anomalies indicate late (early) bloom timing or conditions above (below) the mean for the reference period. Coloured bars length indicate the relative contribution of each NAFO Subarea to the annual mean anomaly (open white circles). Anomalies were calculated using the following reference periods: ocean climate index: 1981-2010, phytoplankton indices: 2003-2020, zooplankton indices: 1999-2020. Anomalies within ±0.5 SD (shaded area) are considered normal conditions.

Environmental Overview

The water mass characteristics of Newfoundland and Labrador Shelf are typical of sub-polar waters with a sub-surface temperature range of -1-2°C and salinities of 32-33.5. Labrador Slope Water flows southward along the shelf edge and into the Flemish Pass region, this water mass is generally warmer and saltier than the sub-polar shelf waters with a temperature range of 3-4°C and salinities in the range of 34-34.75. On average bottom temperatures remain < 0°C over most of the northern Grand Banks but increase to 1-4°C in southern regions and along the slopes of the banks below 200 m. North of the Grand Bank, in Div. 3K, bottom temperatures are generally warmer (1-3°C) except for the shallow inshore regions where they are mainly <0°C. In the deeper waters of the Flemish Pass and across the Flemish Cap bottom temperatures generally range from 3-4°C. Throughout most of the year the cold, relatively fresh water overlying the shelf is separated from the warmer higher-density water of the continental slope region by a strong temperature and density front. This winter-formed water mass is generally referred to as the Cold Intermediate Layer (CIL) and is considered a robust index of ocean climate conditions. In general, shelf water masses undergo seasonal modification in their properties due to the seasonal cycles of air-sea heat flux, wind-forced mixing and ice formation and melt, leading to intense vertical and horizontal gradients particularly along the frontal boundaries separating the shelf and slope water masses.

Temperature and salinity conditions in the Scotian Shelf, Bay of Fundy and Gulf of Maine regions are determined by many processes: heat transfer between the ocean and atmosphere, inflow from the Gulf of St. Lawrence supplemented by flow from the Newfoundland Shelf, exchange with offshore slope waters, local mixing, freshwater runoff, direct precipitation and melting of sea-ice. The Nova Scotia Current is the dominant inflow, originating in the Gulf of St. Lawrence and entering the region through Cabot Strait. The Current, whose path is strongly affected by topography, has a general southwestward drift over the Scotian Shelf and continues into the Gulf of Maine where it contributes to the counter-clockwise mean circulation. The properties of shelf waters are modified by mixing with offshore waters from the continental slope. These offshore waters are generally of two types, Warm Slope Water, with temperatures in the range of 8-13°C and salinities from 34.7-35.6, and Labrador Slope Water, with temperatures from 3.5°C to 8°C and salinities from 34.3 to 35. Shelf water properties have large seasonal cycles, east-west and inshore-offshore gradients, and vary with depth.

Ocean Climate and Ecosystem Indicators

A cumulative climate index for NAFO Subareas 2, 3 and 4 (from the Labrador Shelf to the Scotian Shelf) is presented in Figure D1A. After a somewhat cold period from the late 1980s to the early 1990s, the index has remained relatively high since about the mid-2000's, with 2012 and 2006 being respectively the second, third warmest anomalies since 1985. After a recent return to near-normal values between 2014 and 2019 (mostly driven by cooler temperatures in SA 2 and 3) the index was back to a positive anomaly in 2020 and 2021, the latter year being the warmest on record for the region (since 1950, although only shown since 1985).

Mean timing of the spring phytoplankton bloom was variable across subareas 2-3-4 but remained mostly near normal from 2003-2020 with only two years of early (2006, 2010) and one year of late (2015) bloom onset (Figure D1B). In 2021, Mean timing of the bloom was earlier than normal, partly because of the low sea ice coverage in SA2 that allowed for early bloom onsets on the Labrador Shelf (Figure. D1B). Mean spring bloom production was also variable and mostly near normal throughout the time series including in 2021 (Figure. D1C). Mean copepod abundance generally increased from 1999 to 2005, then slightly decreased until the mid-2010s before increasing again to above-normal levels in recent years (Figure D1D). The abundance of non-copepods was near normal during most of the 2000s and increased in the early 2010s to reach above-normal levels from 2016 onwards except for the near-normal value of 2021 (Figure D1E). The increase in both copepod and non-copepod abundance over the past six years, including in 2021, was mainly driven by the conditions in SA2-3 (Figure D1D, E). Mean zooplankton biomass increased in the early 2000s to a maximum in 2002, and then gradually decreased to a minimum in the mid-2010s (Figure D1F). Biomass has remained near normal since with generally higher values in SA2-3 compared to SA4 (Figure D1F). Although mean biomass was near-normal in 2021, anomaly values for SA2-4 and SA4 were respectively higher and lower than those observed during the five previous years (Figure D1F).

18. Roughhead Grenadier (*Macrourus berglax*) in Subareas 2 and 3

(SCS Doc. 22/0622/07, 22/09 and SCR Docs. 98/57, 22/04, 22/05, 22/07 and COM-SC CESAG-WP 22-01 (Revised)). Interim Monitoring Report

a) Introduction

The stock structure of this species in the North Atlantic remains unclear because there is little information on the number of different populations that may exist and the relationships between them. Roughhead grenadier is distributed throughout NAFO Subareas 0 to 3 in depths between 300 and 2 000 m. However, for assessment purposes, NAFO Scientific Council considers the population of Subareas 2 and 3 as a single stock.

Fishery and Catch: A substantial part of the grenadier catches in Subarea 3 previously reported as roundnose grenadier was actually roughhead grenadier. To correct the catch statistics STACFIS (NAFO SCR Doc. 98/57) revised and approved roughhead grenadier catch statistics since 1987. In the period 2007-2012, catches for Subarea 2+3 roughhead grenadier were stable at levels around one thousand tons. In the period 2013-2021 catches were quite stable at a lower level, around 400 ton (Fig. 18.1). Most of the catches were taken in Divs. 3LMN by Spain, Portugal, Japan, Estonia and Russia fleets. Since 2015 all catches are from Subarea 3. There is no TAC for this stock.

Recent catches ('000 tons) are as follow:

	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
STATLANT 21	1.3	0.4	0.6	0.2	0.1	0.1	0.1	0.2	0.2	0.4
STACFIS	1.3	0.4	0.6	0.2	0.3	0.4	0.5	0.4	0.4	0.4

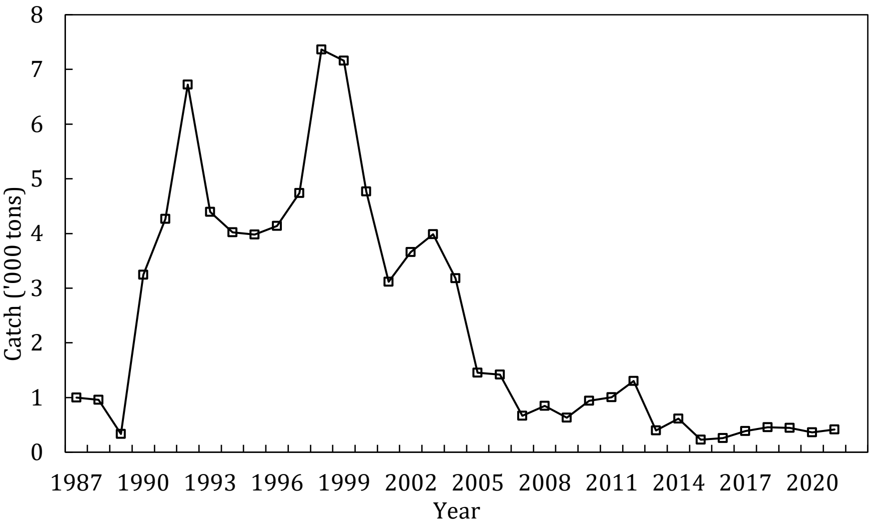


Figure 18.1. Roughhead grenadier in Subareas 2+3: STACFIS catches.

b) Data Overview

i) Research Surveys

There are no survey indices available covering the total distribution, in depth and area, of this stock. According to other information, this species is predominately at depths ranging from 800 to 1500 m, therefore the best survey indicators of stock biomass should be the series extending to 1500 meters depth as they cover the depth distribution of Roughhead grenadier fairly well. Figure 18.2 presents the biomass indices for the following series: Canadian fall 2J+3K Engel (1978-1994) and Canadian fall 2J+3K Campelen (1995-2020), EU 3NO (1997-2019), EU 3L (2006-2019) and EU Flemish Cap (to 1400 m; 2004-2021). Survey coverage deficiencies within Divs. 2J3K were such that the 2008, 2018, 2019 and 2021 index from Canadian fall Divs. 2J3K could not be considered comparable to that of the other years. In 2020 the EU 3NO and EU 3L and in 2021 the EU 3L surveys have not been carried out due to COVID-19 restrictions.. Survey biomass indices showed a general increasing trend in the period 1995-2004. Although the indices are variable across the past decade, there is a general decrease trend with the exception of the Canadian 2J3K survey, which has increased.

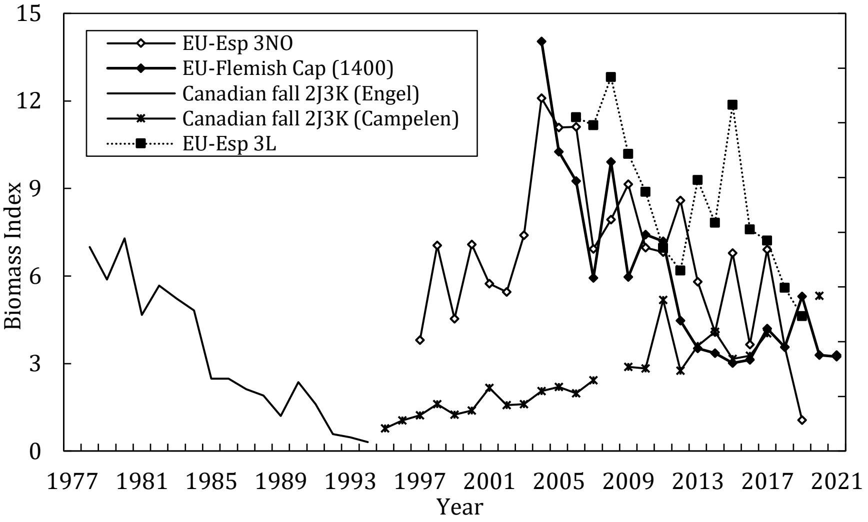


Figure 18.2. Roughhead grenadier in Subareas 2+3: Survey biomass indices.

The catch-biomass (C/B) ratios showed a clear declining trend from 1995-2005 and since then have been stable at low levels with the exception of the of the 3NO survey index in the year 2019 (Figure 18.3).The (C/B) ratio remained at levels, less than 0.1, since 2015 despite the decline of many of the survey biomass indices because catch levels since 2013 are very low.

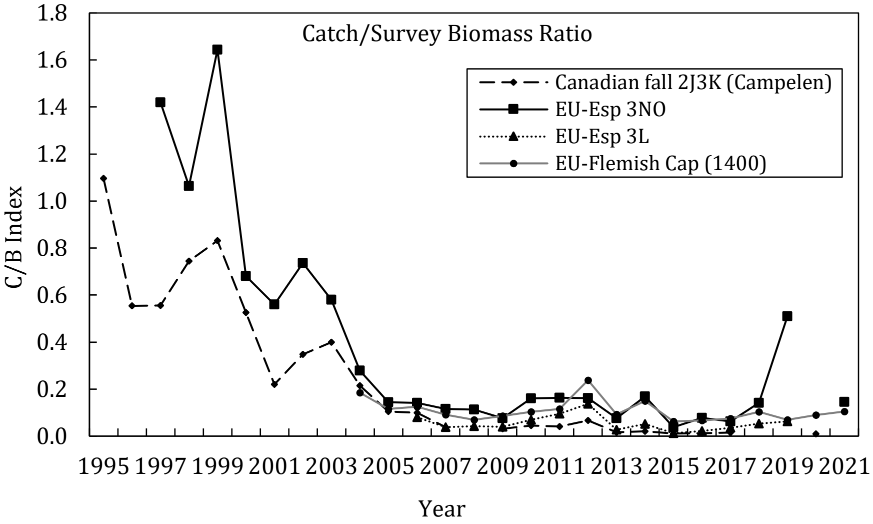


Figure 18.3. Roughhead grenadier in Subareas 2+3: catch/biomass indices based upon Canadian Autumn (Campelen series), EU-Spanish Div. 3NO, EU-Spanish 3L and EU-Flemish Cap (to1400 m depth) surveys.

c) Conclusion

Although the indices are variable across the whole time series, there is a general decrease over the past decade with the exception of the Canadian 2J3K survey, which has increased. Fishing mortality indices have remained at low levels since 2005 with the exception of the of the 3NO survey index in the year 2019. Based on overall indices for the current year, there is no change in the status of the stock.

This stock will be monitored in future by interim monitoring reports until such time conditions change to warrant a full assessment.

19. Greenland Halibut (*Reinhardtius hippoglossoides*) in Subarea 2 + Divisions 3KLMNO

Interim monitoring report (SCS 22/10, SCS 22/06, SCS 22/13, SCS 22/09; SCR Doc. 17/26, 19/31, 20/47, 22/04, 22/07; FC Doc. 03/13, 10/12, 13/23, 16/20; Com Doc 17/17)

a) Introduction

Fishery and Catches: TACs prior to 1995 were set autonomously by Canada; subsequent TACs have been established by NAFO Fisheries Commission (FC). Catches increased sharply in 1990 due to a developing fishery in the NAFO Regulatory Area in Divs. 3LMNO and continued at high levels during 1991-94. The catch was only 15 000 to 20 000 t per year in 1995 to 1998. The catch increased after 1998 and by 2001 was estimated to be 38 000 t, the highest since 1994. The estimated catch for 2002 was 34 000 t. The 2003 catch could not be precisely estimated, but was believed to be within the range of 32 000 t to 38 500 t. In 2003, a fifteen year rebuilding plan was implemented by Fisheries Commission for this stock (FC Doc. 03/13). Though much lower than values of the early 2000s, estimated catch over 2004-2010 exceeded the TAC by considerable margins. TAC over-runs have ranged from 22%-64%, despite considerable reductions in effort. The STACFIS estimate of catch for 2010 was 26 170 t (64% over-run). In 2010, Fisheries Commission implemented a survey-based Management Procedure, which incorporates a harvest control rule (HCR) (FC Doc. 10/12) to generate annual TACs over at least 2011-2014, through which period the catch exceeded the TAC in every year. In 2013

Fisheries Commission extended the 2010 management approach to set the TACs for 2015–2017 (FC Doc. 13/23), but did not apply the HCR in 2017, rather setting the TAC equal to the 2016 TAC (FC Doc. 16/20). TACs since 2018 have been based on the HCR adopted in 2017 (Com Doc 17/17). Catches have closely tracked TACs since 2015. The TAC in 2021 was 16 498 t and 15 039 t were caught. The TAC for 2022 is 15 864 t.

Recent catches and TACs ('000 t) are as follows:

	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
TAC	15.5	15.4	15.6	14.8	14.8	16.5	16.5	16.9	16.5	15.9
STATLANT 21	15.5	15.7	15.0	13.0	14.7	16.2	16.3	16.1	--	--
STACFIS	20.0	21.4	15.3	14.9	14.8	16.6	16.5	16.3	15.0	--

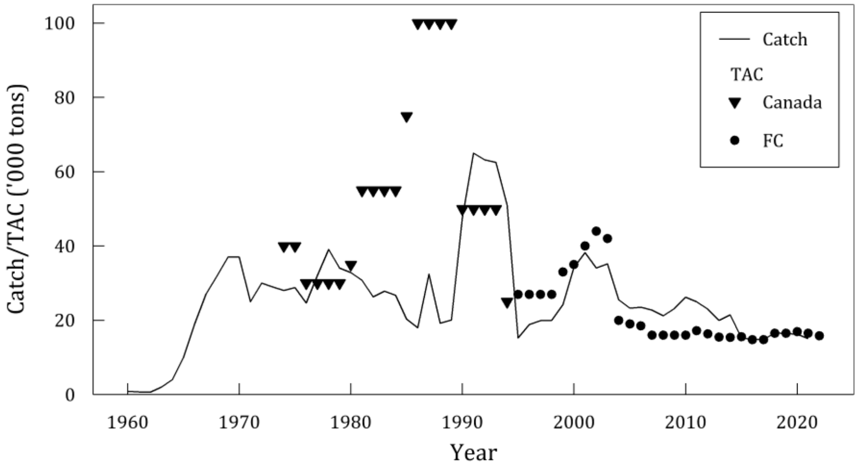


Figure 19.1. Greenland halibut in Subarea 2 + Divs. 3KLMNO: TACs and STACFIS catches.

b) Data Overview

Abundance and biomass indices were available from research vessel surveys by Canada in Divs. 2+3KLNO (1978-2021), EU in Div. 3M (1988-2021) and EU-Spain in Divs. 3NO (1995-2020). Different years are examined to represent population trends from the different surveys. For the Canadian autumn survey in Divs. 2J3K the years are 1978-2021 (excluding 2008); from the Canadian spring survey in Divs. 3LNO 1996-2020 (excluding 2006, 2015, and 2017 due to survey coverage issues; the survey was not conducted in 2020 due to the COVID-19 pandemic; the survey was not conducted in 2021 due to vessel issues); for the Canadian autumn survey in Divs. 3LNO to 730 m from 1996-2021 (excluding 2014 and 2021 when the survey was incomplete); for the survey in Div. 3M to 700 m 1988-2021, and to 1400 m 2004-2021; and for the survey by EU-Spain in Divs. 3NO 1997-2020 (this survey was not conducted in 2020 due to the COVID-19 pandemic).

i) Research survey data

STACFIS reiterated that most research vessel survey series providing information on the abundance of Greenland halibut are deficient in various ways and to varying degrees. Variation in divisional and depth coverage creates problems in comparing results from different years (SCR Doc. 19/31). A single survey series which covers the entire stock area is not available. A subset of standardized (depth and area) stratified random survey indices have been used to monitor trends in resource status, and are described below.

Canadian stratified-random autumn surveys in Divs. 2J and 3K: Abundance and biomass indices from the Canadian autumn survey of Divs. 2J3K have shown a series of increases and decreases since 1996 (Fig. 19.2). The abundance index decreased between 1996-2005, increased between 2005-2011 and, following a decrease in 2012, the index has remained relatively low and stable. The biomass index has fluctuated since 1996, with local maxima around 1999, 2007 and 2014, and local minima around 2002, 2010 and 2017; the index has been relatively low since 2017, with a potential increase in 2021.

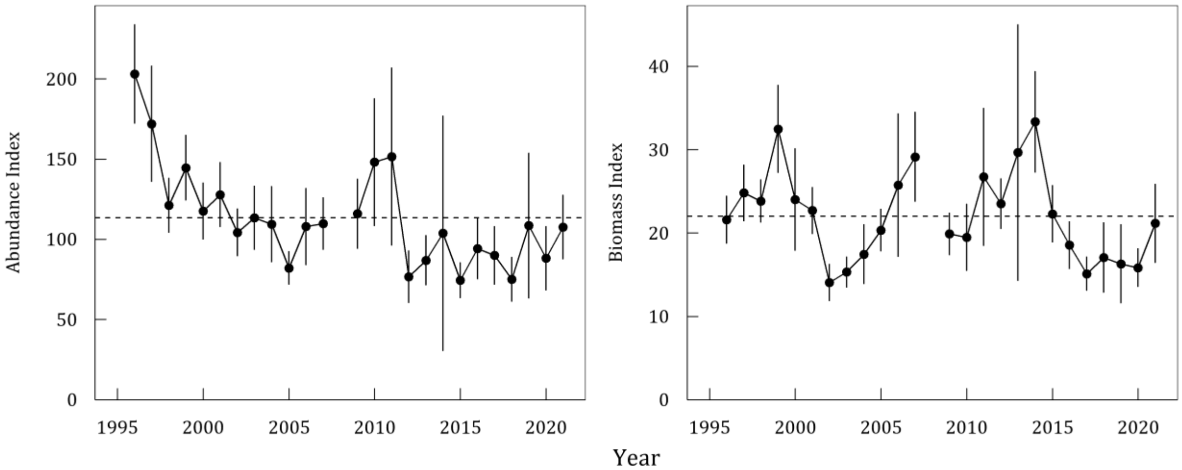


Figure 19.2. Greenland halibut in Subarea 2 + Divs. 3KLMNO: abundance (left) and biomass (right) indices (with 95% CI) from Canadian autumn surveys in Divs. 2J and 3K. The 2008 survey was not completed. The dotted line represents the time-series average.

Canadian stratified-random spring surveys in Divs. 3LNO: Abundance and biomass indices from the Canadian spring surveys in Divs. 3LNO (Fig. 19.3) declined from relatively high values in the late 1990s and has been relatively low in most years thereafter. The 2015 and 2017 surveys were incomplete and are not considered representative of the population. Abundance and biomass indices from 2018 and 2019 have increased from 2016 levels. This survey was not conducted in 2020, due to the COVID-19 pandemic, or 2021, due to vessel issues.

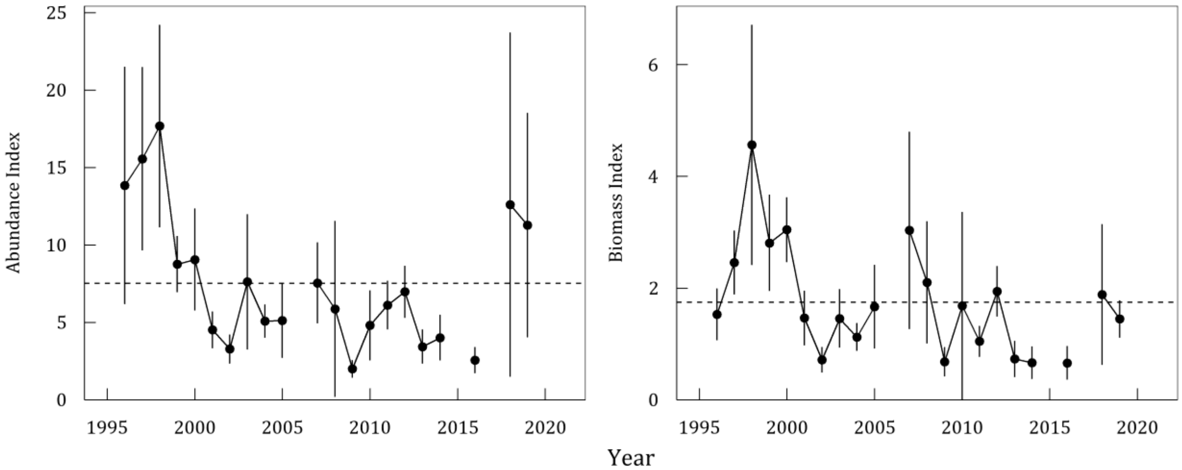


Figure 19.3. Greenland halibut in Subarea 2 + Divs. 3KLMNO: abundance (left) and biomass (right) indices (with 95% CI) from Canadian spring surveys in Divs. 3LNO. The dotted line represents the time-series average.

Canadian stratified-random autumn surveys in Divs. 3LNO: Time series of abundance and biomass were developed from the Canadian autumn surveys from 1996-2021 to a depth of 730 m. The abundance index from the Canadian autumn surveys in Divs. 3LNO (Fig. 19.4) declined from relatively high values in the late 1990s and has been relatively low in most years thereafter. The biomass index declined from 1998 to 2002 and then increased to 2005, to a level near that of the beginning of the time series. Abundance and biomass indices have been increasing since 2015; the abundance index has increased above levels observed between 1999-2010 and the biomass index has reached levels near those between 2005-2008. The 2014 and 2021 surveys were incomplete and are not considered compatible with the rest of the series.

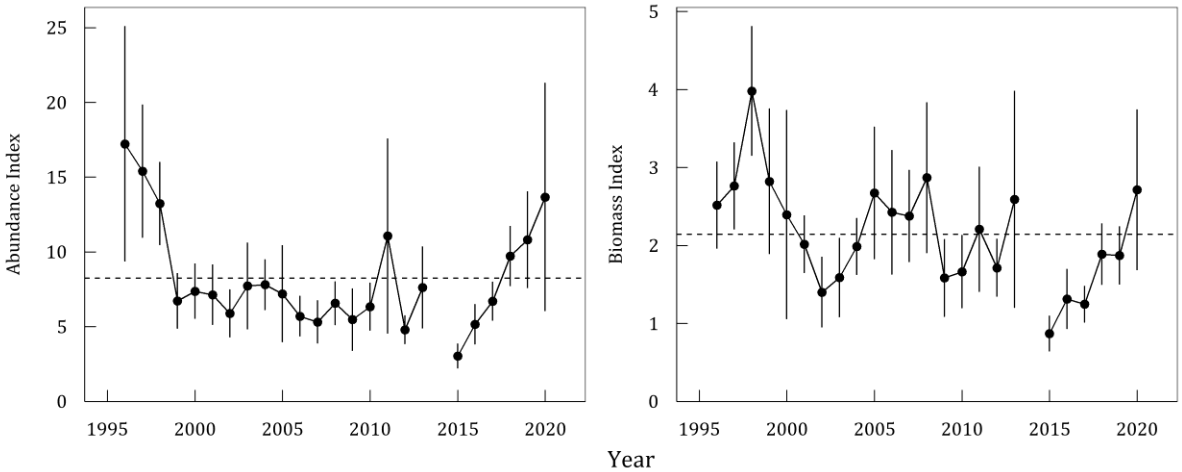


Figure 19.4. Greenland halibut in Subarea 2 + Divs. 3KLMNO: abundance (left) and biomass (right) indices (with 95% CI) from Canadian autumn surveys in Divs. 3LNO. The dotted line represents the time-series average.

EU stratified-random surveys in Divs. 3M (Flemish Cap): Surveys conducted by the EU in Div. 3M during summer indicate that the Greenland halibut biomass index in depths to 730 m increased to a maximum value in 1998 (Fig. 19.5). This biomass index declined continually over 1998-2002. The 2002-2008 results were relatively stable, with the exception of an anomalously low value in 2003. From 2009 to 2013 the index decreased to its lowest observed value. Since 2010, the index has remained below the series average. The Flemish Cap survey was extended to cover depths down to 1460 m beginning in 2004. Biomass estimates over the full depth range doubled over 2005-2008 but then declined to below the time series average in 2012 and 2013. From 2015-2017 the index has been variable but above the average of the time series, with 2015 and 2017 being the highest in the series. The index has since declined, falling below the time series average since 2019.

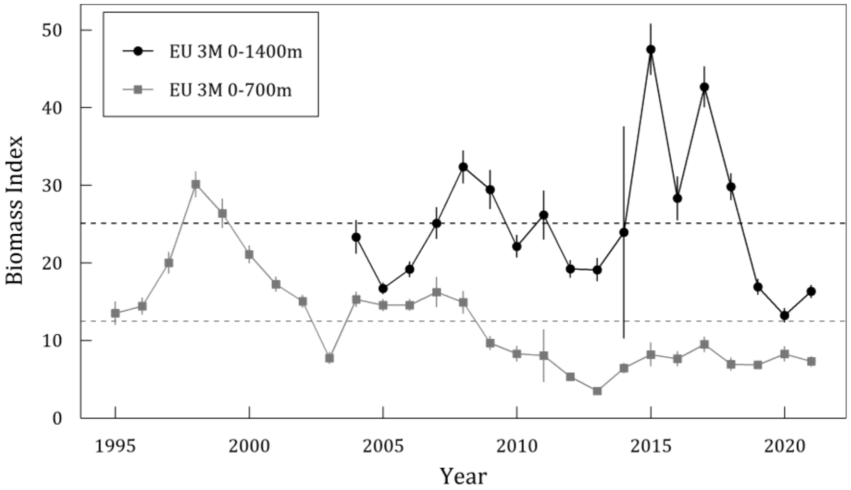


Figure 19.5. Greenland halibut in Subarea 2 + Divs. 3KLMNO: Biomass index (± 1 S.E.) from EU Flemish Cap surveys in Div. 3M. Grey squares: biomass index for depths <730 m. Black circles: biomass index for all depths <1460 m. Dotted lines represent time-series averages.

EU-Spain stratified-random surveys in NAFO Regulatory Area of Divs. 3LNO: The biomass index for the survey of the NRA in Divs. 3NO generally declined over 1999 to 2006 (Fig. 19.6) but increased four-fold over 2006-2009. The survey index increased from 2013 to 2017 but since declined to levels closer to the time series average. The biomass index for the survey of the NRA in Div. 3L increased from 2006 to 2008. After declining to lower levels in 2011 and 2012 it increased to a time series high in 2017, declining substantially in 2018 and increased again in 2019. This survey was not conducted in 2020 due to the COVID-19 pandemic.

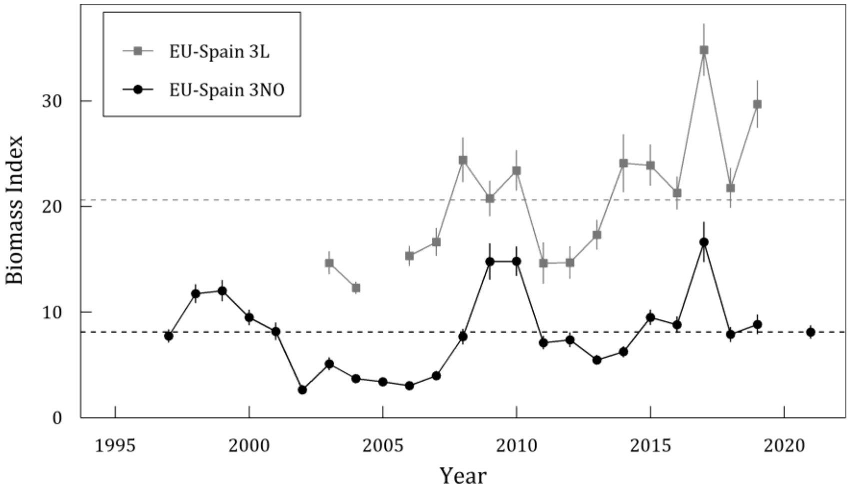


Figure 19.6. Greenland halibut in Subarea 2 + Divs. 3KLMNO: biomass index (±1 SE) from EU-Spain spring surveys in the NRA of Divs. 3NO and Div. 3L. Dotted lines represent time-series averages.

Summary of research survey data trends.

These surveys provide coverage of the majority of the spatial distribution of the stock and the area from which the majority of catches are taken. Over 1995-2007, indices from the majority of the surveys generally provided a consistent signal in stock biomass (Fig. 19.7). Results since 2007 show greater divergence which complicates interpretation of overall status; the overall trend since 2007 is unclear.

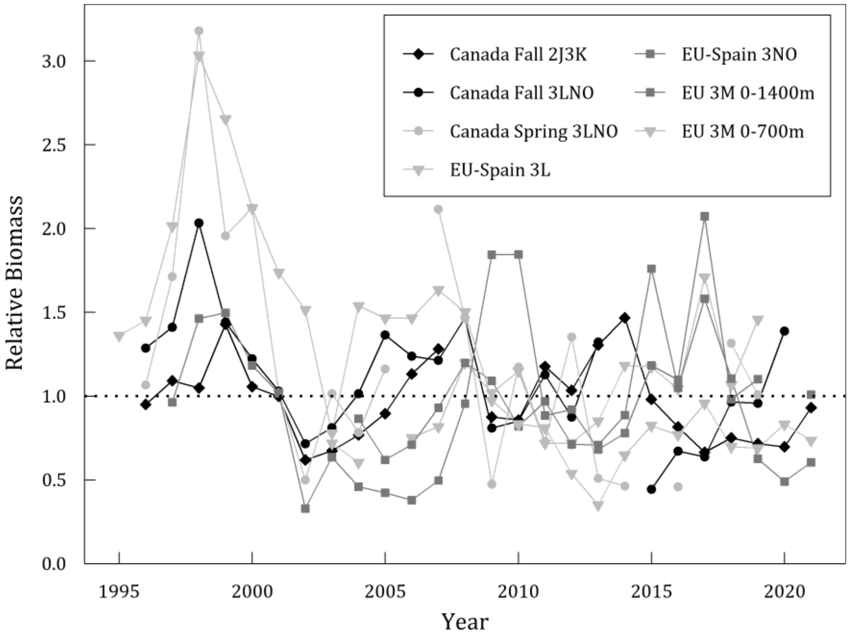


Figure 19.7. Greenland halibut in Subarea 2 + Divs. 3KLMNO: Relative biomass indices from Canadian autumn surveys in Divs. 2J3K, Canadian spring surveys in Divs. 3LNO, Canadian autumn surveys in Divs. 3LNO, EU survey of Div. 3M, and EU-Spain surveys of the NRA of Divs. 3NO. Each series is scaled to its average and the average line is shown as thin dotted line.

Recruitment from surveys.

Abundance indices at age 4 from surveys were examined as a measure of recruitment. Year classes from all surveys were above average between 1993-1994 and below average between 2009-2013. After three very large year classes of 2000-2002 in the EU survey of Div. 3M, abundance at age 4 fell below average for 12 years. There are some positive signals in recent years as estimates of the most recent year class (2015 to 2017) are near the time series average.

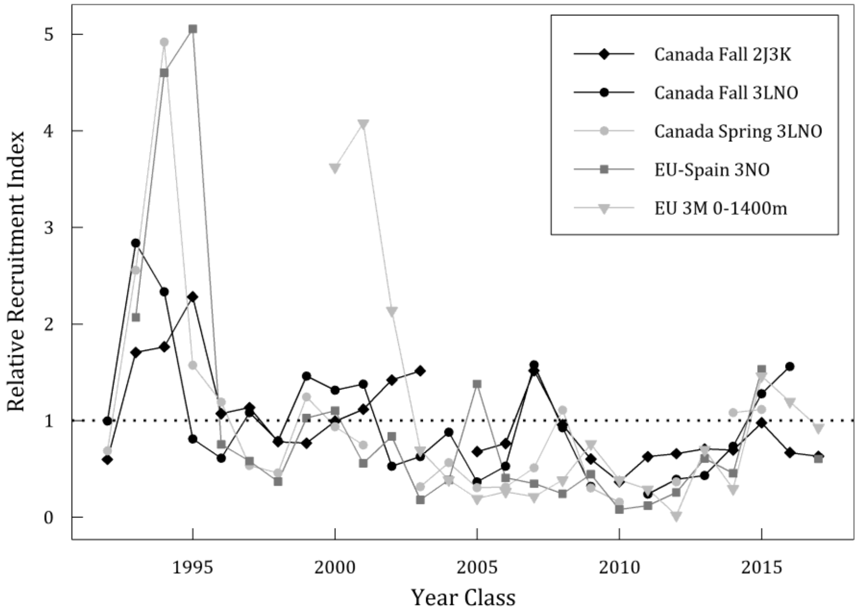


Figure 19.8. Greenland halibut in Subarea 2 + Divs. 3KLMNO: Relative recruitment indices from Canadian autumn surveys in Divs. 2J3K, Canadian spring surveys in Divs. 3LNO, and EU survey of Div. 3M. Each series is scaled to its average, which is shown using a dotted line.

c) Conclusion

Biomass: Survey indices since 2007 are variable which complicates the interpretation of overall status. The five surveys that are used in the HCR show differing trends over this period. In both 2020 and 2021, only one out of four available survey indices was above its time series mean.

Recruitment: Results of all surveys indicate that recruitment (age 4) has recently returned to average levels following a series of below average years.

State of the stock: Though divergent trends in the survey indices complicate interpretations of the state of the stock, the survey indices are not deviating significantly from expectations under the accepted management procedure. Most survey indices are within the 95% probability envelopes from the base case SCAA (SCR Doc. 17/26; Figure 19.9) and revamped SSM simulations (SCR Doc. 20/47; Figure 19.10). The composite index suggests that the stock is stable and the most recent value is within the 80% probability envelope from both models.

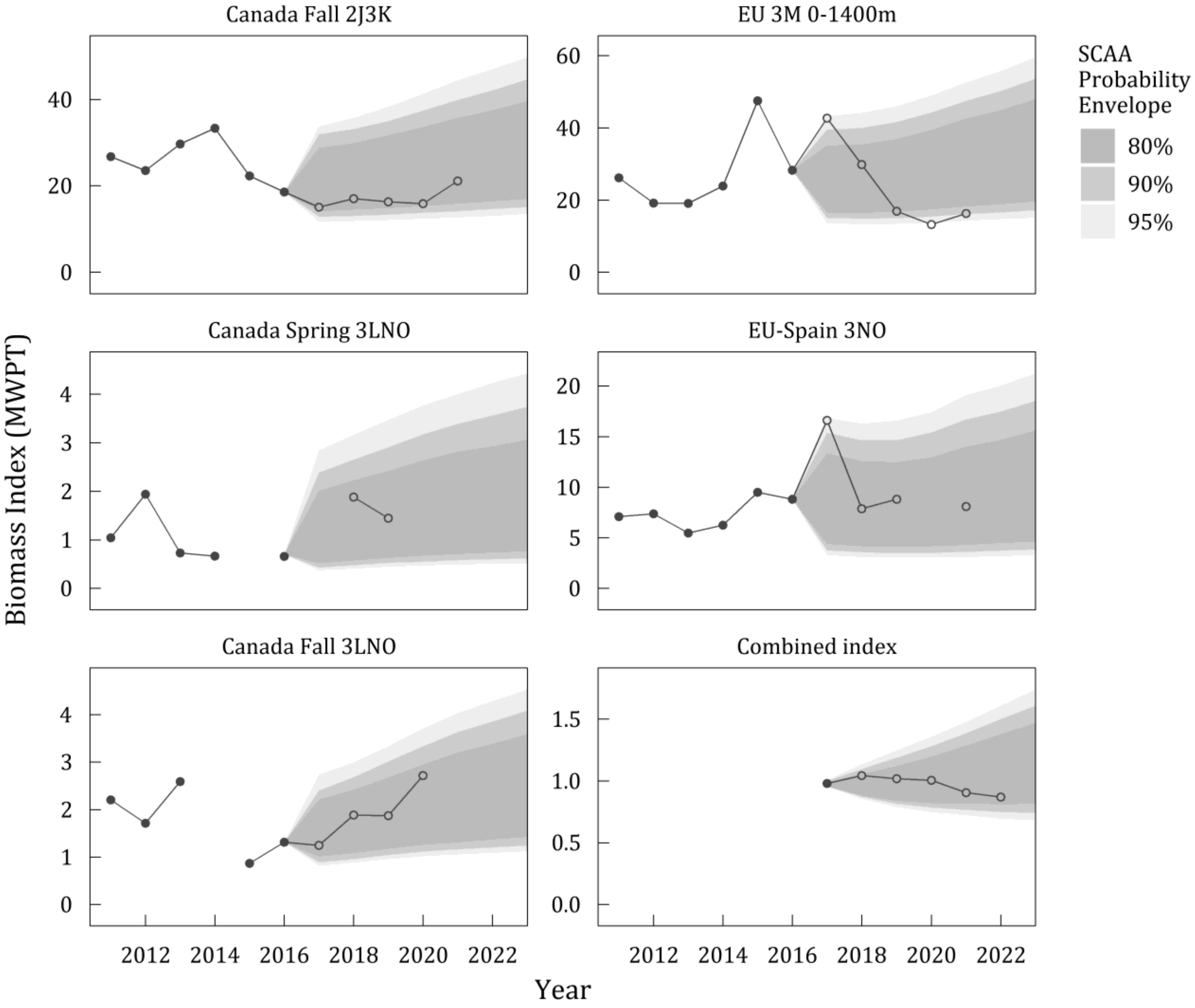


Figure 19.9. Greenland Halibut in Subarea 2 + Divs. 3KLMNO. Mean weight per tow from Canadian autumn surveys in Divs. 2J3K, Canadian spring surveys in Divs. 3LNO, Canadian autumn surveys in Divs. 3LNO, EU Flemish Cap surveys (to 1400m depth) in Div. 3M and EU-Spain surveys in 3NO. The figure also shows the combined index used in the target based component of the HCR. For the survey and combined indices, 80%, 90% and 95% probability envelopes from the SCAA base case simulation are shown. Index values observed from 2017 onward are shown using open circles.

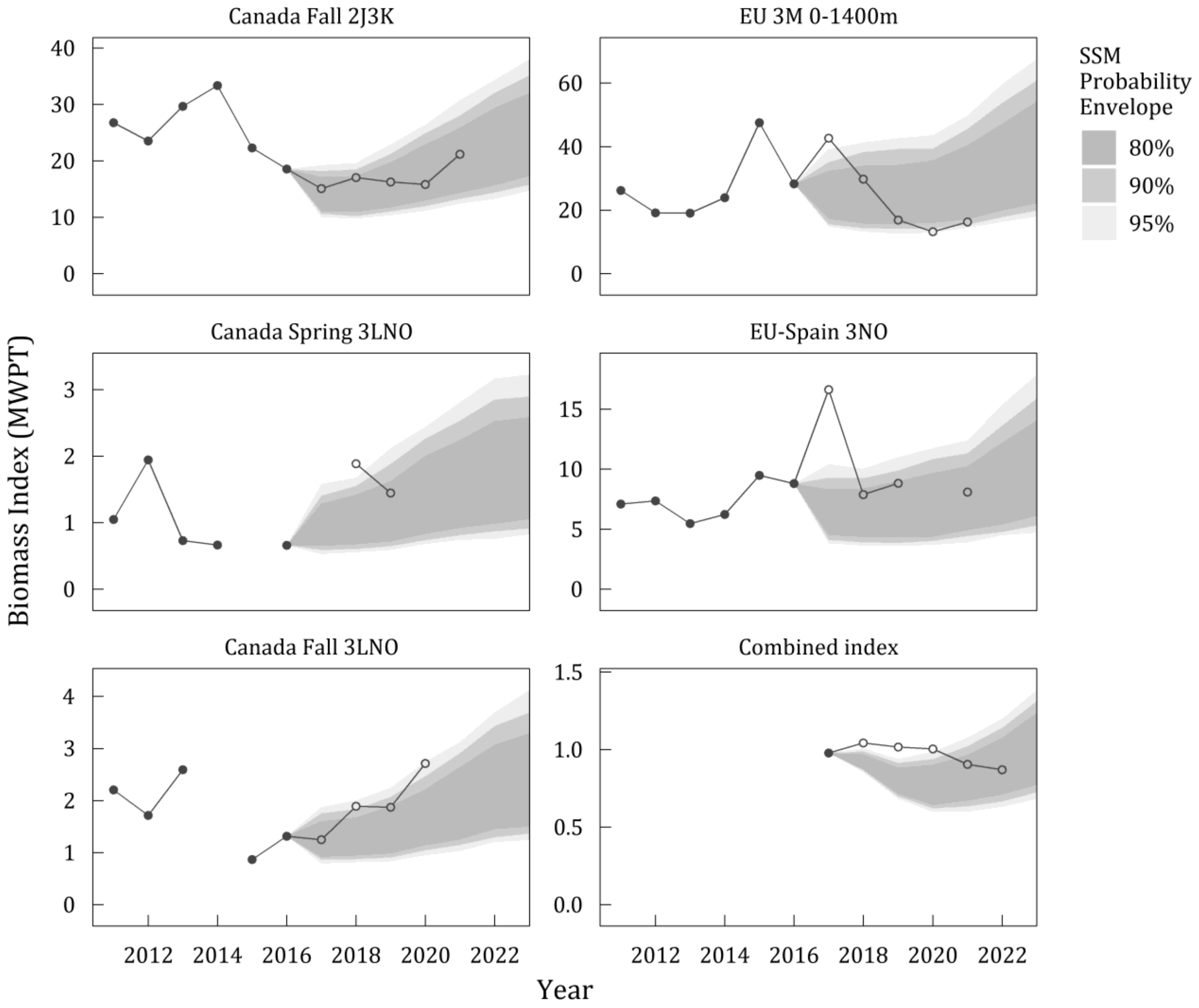


Figure 19.10. Greenland Halibut in Subarea 2 + Divs. 3KLMNO. Mean weight per tow from Canadian autumn surveys in Divs. 2J3K, Canadian spring surveys in Divs. 3LNO, Canadian autumn surveys in Divs. 3LNO, EU Flemish Cap surveys (to 1400m depth) in Div. 3M and EU-Spain surveys in 3NO. The figure also shows the combined index used in the target based component of the HCR. For the survey and combined indices, 80%, 90% and 95% probability envelopes from the SSM base case simulation are shown. Index values observed from 2017 onward are shown using open circles.

d) Research recommendation

The divergence in survey indices could be the result of movement of fish or because of transient age effects as a result of changing recruitment when different surveys cover differing age-ranges. STACFIS recommends that tagging and/or telemetry studies be undertaken to help elucidate movement of 2+3KLMNO Greenland halibut.

20. Northern shortfin squid (*Illex illecebrosus*) in Subareas 3+4

Deferred to the NAFO Annual Meeting in September 2022

21. Splendid alfonsino (*Beryx splendens*) in Subareas 6

(SCR Docs. 15/06, 20/36 and COM-SC CESAG-WP 22-01 (Revised)). Interim Monitoring Report

a) Introduction

Alfonsino is distributed over a wide area which may be composed of several populations. Alfonsino is an oceanic demersal species which forms distinct aggregations, at 300–950 m depth, on top of seamounts in the North Atlantic. Stock structure in NAFO Area is unknown. Until more complete data on stock structure is obtained it is considered that separate populations live on each seamount of Div 6G.

Most published growth studies suggest maximum life span between 10 and 20 years. The observed variability in the maximum age / length depends on the geographic region. Sexual maturation was found to begin at age 2 and at a mean length of 18 cm. By age 5–6 years, all individuals were mature at 25–30 cm fork length. On the Corner Rise Seamounts, alfonsino were observed to spawn from May-June to August-September.

As a consequence of the species' association with seamounts, their life-history, and their aggregation behaviour, this species is easily overexploited and can only sustain low rates of exploitation.

Fishery and Catch: Historically, catches of alfonsino in the NAFO Regulatory Area (NRA) have been reported from Div. 6E-H, although the bulk of those catches were made in the Corner Rise area Div. 6G. The development of the Corner Rise fishery was initiated in 1976. Commercial aggregations of alfonsino on the Corner Rise have been found on three seamounts. Two of them named "Kükenthal" (also known as "Perspektivnaya") and "C-3" ("Vybornaya") are located in NRA. One more bank named "Milne Edwards" ("Rezervnaya") is located in the Central Western Atlantic.

Russian vessels fished these areas during some periods between 1976 and 1999 using pelagic trawls. A directed commercial fishery had been conducted since 2005 by Spanish vessels. Since 2006 virtually all the effort has been made in the Kükenthal seamount with pelagic trawl gear.

Fishery was closed in 2020 based on scientific advice that the stock may be depleted.

The Russian fishery started in 1976 with a catch of 10 200 t (Figure 21.1). Thereafter the catches ranged between 10 and 3 500 t. There was no fishing effort from 1988-1993, 1998 and 2000 – 2003. From 2005 to 2019, an alfonsino directed fishery in Kükenthal seamount was conducted by Spanish vessels using a pelagic trawl gear, where catches have ranged between 1 and 1 187 t, with no fishery in 2008. In 2020 and 2021 the fishery was closed and alfonsino catches were zero.

Table 21.1. Recent catches (tons), effort and CPUE (Kg/hr fished) for the alfonsino fishery on Kukenthal Peak.

Year	2013	2014	2015	2016	2017	2018	2019	2020	2021
Catch (t)	114	118	122	127	51	2	1	0	0
Effort (days on ground)	17	15	13	16	12	8	8	0	0
Effort (hours fished)	87	117	92	116	68	33	33	0	0
CPUE (Kg/hour)	1310	1009	1326	1095	750	61	42		
Effort (vessels)	1	2	2	1	1	1	1	0	0

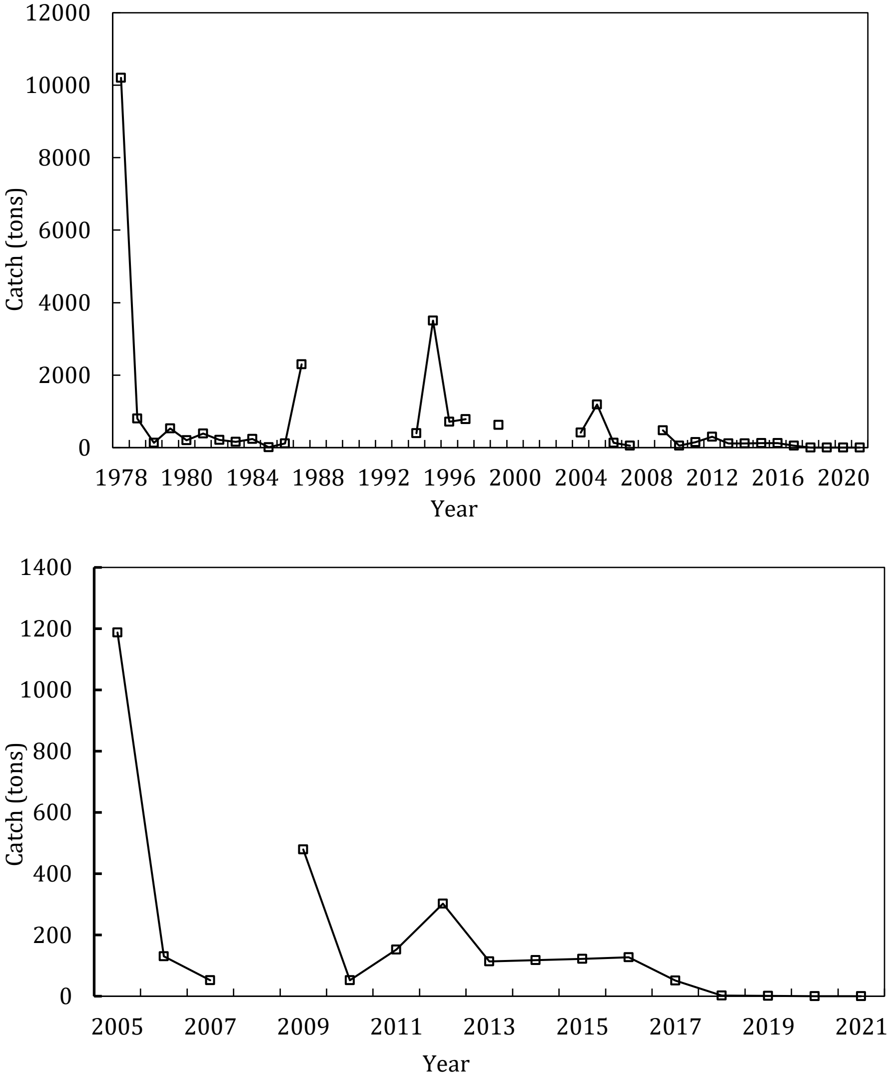


Figure 21.1. Alfonsino catches from Div. 6G. Top panel illustrates the whole catch series (1978-2021) and bottom panel illustrates the catch series since 2005.

b) Data Overview

ii) Research surveys

The only information available is the retrospective data from Russian research, exploratory and fishing cruises presented by Vinnichenko in 2015 (SCR Doc. 15/006). This data covers the period ending in 1995. The alfonsino biomass estimated on Corner Rise with this data was around 11,000-12,000 t. It should be taken into consideration that a time series 20-30 years was used for the calculations mentioned above. Based on this information; the greatest biomass of mature alfonsino (distribution depths of 400-950 m) was registered on the "Kükenthal" seamount. On the "C-3" and "Milne Edwards" seamounts, the biomass was much lower.

A acoustic survey plan to collect alfonsino data and estimate its biomass has been presented to the SC for discussion (SCR Doc. 20/36). The SC concluded that the acoustic survey plan would be appropriate to collect fishery independent information that can help the future evaluation of this stock.

c) Conclusion

No analytical or survey based assessment was possible. The most recent assessment, in 2019, concluded that the stock appears to be depleted. There is no new information available to update the 2019 assessment or the IMR of 2020. Fishery was closed in 2020 and 2021.

d) Special comments

Periods of decline in catches have been observed several times in the past after several years of fishing. In the past, catches have increased after a period of low/no removals however, it is unknown if this corresponded to stock recovery. In the absence of new data (eg. from an exploratory fishery or survey) there will be no basis to update the present assessment.

e) Research Recommendations

SC **recommended** in 2019 that *fishery independent information should be collected on this stock, and especially important given the fishery is closed and there will not be CPUE or any other fishery independent or dependent information to monitor whether there has been any recovery.* For this purpose, an acoustic survey plan was presented and discussed by the SC in 2021. The SC concluded that the presented acoustic survey plan would be appropriate to collect fishery independent information to inform future assessments of this stock

IV. OTHER MATTERS

1. FIRMS Classification for NAFO Stocks

Due to lack of time, STACFIS did not review the assessments of stocks managed by NAFO in June 2021. This task has been deferred to the September SC meeting.

2. Other Business

No additional items were discussed.

V. ADJOURNMENT

The meeting was adjourned on 15 June 2022.

APPENDIX V. AGENDA - SCIENTIFIC COUNCIL MEETING, 03 - 16 JUNE 2022

I. Opening (Scientific Council Chair: Karen Dwyer)
  1. Appointment of Rapporteur
  2 Presentation and Report of Proxy Votes
  3. Adoption of Agenda
  4. Attendance of Observers
  5. Appointment of Designated Experts
  6. Plan of Work
  7. Housekeeping issues

II. Review of Scientific Council Recommendations in 2021

III. Fisheries Environment (STACFEN Chair: Miguel Caetano)
  1. Opening
  2. Appointment of Rapporteur
  3. Adoption of Agenda
  4. Review of Recommendations in 2021
  5. Department of Fisheries and Oceans Canada, Oceans Science Branch, Marine Environmental Data Section (MEDS) Report for 2021
  6. Review of the physical, biological and chemical environment in the NAFO Convention Area during 2021
  8. Formulation of recommendations based on environmental conditions during 2021
  9. Other Matters
  10. Adjournment

IV. Publications (STACPUB Chair: Rick Rideout)
  1. Opening
  2. Appointment of Rapporteur
  3. Adoption of Agenda
  4. Review of Recommendations in 2021
  5. Review of Publications
    a) Annual Summary
      i) Journal of Northwest Atlantic Fishery Science (JNAFS)
      ii) Scientific Council Studies
      iii) Scientific Council Reports
  6. Other Matters
  7. Adjournment

V. Research Coordination (STACREC Chair: Diana González-Troncoso)
  1. Opening
  2. Appointment of Rapporteur
  3. Review of Recommendations in 2021
  4. Fishery Statistics
    a) Progress report on Secretariat activities in 2021/2022
      i) Presentation of catch estimates from the CESAG, daily catch reports and STATLANT 21A and 21B
  5. Research Activities
    a) Biological sampling

        - i) Report on activities in 2021/2022
        - ii) Report by National Representatives on commercial sampling conducted
        - iii) Report on data availability for stock assessments (by Designated Experts)
    - b) Biological surveys
        - i) Review of survey activities in 2021 and early 2022 (by National Representatives and Designated Experts)
        - ii) Surveys planned for 2022 and early 2023
    - c) Tagging activities
    - d) Other research activities
- 6. Review of SCR and SCS Documents
- 7. Other Matters
    - Data for assessments: protocol of submission
    - Data of the SCRs and SCSs: protocol of presentation
- 8. Adjournment

VI. Fisheries Science (STACFIS Chair: Mark Simpson)

- I. Opening
- II. General Review of Catches and Fishing Activity
- III. Stock Assessments
    1. Greenland halibut (*Reinhardtius hippoglossoides*) in SA 0+1 offshore (full assessment)
    2. Greenland halibut (*Reinhardtius hippoglossoides*) Div. 1A inshore Divs. 1BC inshore, Div. 1D inshore and Divs. 1EF inshore (full assessment)
    3. Demersal Redfish and deep-sea redfish (*Sebastes* spp.) in SA 1 (monitor)
    4. Wolffish in SA 1 (monitor)
    5. Golden redfish (*Sebastes norvegicus* aka *S. marinus*) in Div. 3M (monitor)
    6. Cod (*Gadus morhua*) in Div. 3M (full assessment)
    7. Redfish (*Sebastes mentella* and *Sebastes fasciatus*) in Div. 3M (monitor)
    8. American plaice (*Hippoglossoides platessoides*) in Div. 3M (monitor)
    9. Cod (*Gadus morhua*) in Divs. 3NO (monitor)
    10. Redfish (*Sebastes mentella* and *Sebastes fasciatus*) in Divs. 3L and 3N (full assessment)
    11. American plaice (*Hippoglossoides platessoides*) in Divs. 3LNO (monitor)
    12. Yellowtail flounder (*Limanda ferruginea*) in Divs. 3LNO (monitor)
    13. Witch flounder (*Glyptocephalus cynoglossus*) in Divs. 3NO (full assessment)
    14. Capelin (*Mallotus villosus*) in Divs. 3NO (monitor)
    15. Redfish (*Sebastes mentella* and *Sebastes fasciatus*) in Div. 3O (full assessment)
    16. Thorny skate (*Amblyraja radiata*) in Divs. 3LNO and Subdiv. 3PS (full assessment)
    17. White hake (*Urophycis tenuis*) in Divs. 3NO and Subdiv. 3PS (monitor)
    18. Roughhead grenadier (*Macrourus berglax*) in SA 2 and 3 (monitor)
    19. Greenland halibut (*Reinhardtius hippoglossoides*) in SA 2 + Divs. 3KLMNO (under management strategy: (monitor, COM request #2)
    20. Northern shortfin squid (*Illex illecebrosus*) in SA 3+4 (full assessment)
    21. Splendid alfonsino (*Beryx splendens*) in SA 6 (monitor)

- IV. Other Matters
    - a) FIRMS Classification for NAFO Stocks
    - b) Other Business
- V. Adjournment

VII. Management Advice and Responses to Special Requests (See Annex 1)

1. Fisheries Commission (Annex 1)

   a) Request for Advice on TACs and Other Management Measures (Item 1, Annex 1)

   For 2023
   - Cod in Div. 3M

   For 2023 and 2024
   - Redfish in Div. 3LN (see Comm. request 9)
   - Witch flounder in Div. 3NO
   - Thorny skate in Divs. 3LNO and Subdiv. 3PS

   For 2023, 2024 and 2025
   - Northern shortfin squid in Subareas 3+4
   - Redfish in Div. 3O

   b) Monitoring of Stocks for which Multi-year Advice was provided in 2017 or 2018 (Item 1)
   - Golden redfish in Div. 3M
   - Redfish (*Sebastes mentella* and *Sebastes fasciatus*) in Div. 3M
   - American plaice (*Hippoglossoides platessoides*) in Div. 3M
   - American plaice (*Hippoglossoides platessoides*) in Divs. 3LNO
   - Yellowtail flounder in Divs. 3LNO
   - Cod in Divs. 3NO
   -
   - Capelin in Divs. 3NO
   - Redfish (*Sebastes mentella* and *Sebastes fasciatus*) in Div. 3O
   - Alfonsino stocks in the NAFO Regulatory Area
   - Roughhead grenadier in Subareas 2 and 3
   - White hake in Div. 3NO
   - American Plaice in Divs. 3LNO

   c) Special Requests for Management Advice

      i) Greenland halibut in SA2 + Divs. 3KLMNO: Greenland halibut in SA2 + Divs. 3KLMNO: monitor, compute the TAC using the agreed HCR and determine whether exceptional circumstances are occurring (request #2, Commission priority)

      ii) continue the evaluation of trawl surveys on VMEs (request #3)

      iii) initiate the first steps in both the 2+3KLMNO Greenland halibut and 3LN redfish MSE processes (request #4, Commission priority)

      iv) continue work on the sustainability of catches aspect of the Ecosystem Roadmap (request #5)

      v) re-assess previously recommended VME closures 7a, 11a, 14a and 14b and Review NCEM, Chapter 2 (request #6)

      vi) continue progression on the review of the NAFO Precautionary Approach (request #7, Commission priority)

      vii) continue to develop a 3-5 year work plan (request #8)

      viii) full assessment for Div. 3LN redfish (request #9)

      ix) presentation of the stock assessment and the scientific advice of Cod 2J3KL (Canada), Witch 2J3KL (Canada) and Pelagic *Sebastes mentella* (ICES Divisions V, XII and XIV; NAFO 1) (request #10)

      x) ongoing analysis of the Flemish Cap cod fishery (request #11)

- xi) with other international organizations, such as the FAO and ICES, inform the Scientific Council's work related to the potential impact of activities other than fishing in the Convention Area (request #12)
- xii) proceed with developing the ecosystem summary sheets for 3M and 3LNO and move toward undertaking a joint Workshop with ICES (request #13)

2. Coastal States
   - a) Request by Denmark (Greenland) for Advice on Management in 2023 (Annex 2)
     - i) Monitoring of Stocks for which Multi-year Advice was provided in 2020 or 2021

   - b) Request by Canada and Greenland for Advice on Management in 2023 (Annex 2, Annex 3)
     - i) Monitoring of Stocks for which Multi-year Advice was provided in 2020 or 2021

VIII. Review of Future Meetings Arrangements
1. Scientific Council (in conjunction with NIPAG), 12 to 17 September 2022
2. Scientific Council, 19 to 23 September 2022
3. WG-ESA, 15 to 24 November 2022
4. Scientific Council, June 2023
5. Scientific Council (in conjunction with NIPAG), 2023
6. Scientific Council, Sep. 2023
7. WG-ESA, Nov. 2023
8. NAFO/ICES Joint Groups
   - a) NIPAG, 2022
   - b) NIPAG, 2023
   - c) WG-DEC
   - d) WG-HARP

IX. Arrangements for Special Sessions
1. Topics for future Special Sessions

X. Meeting Reports
1. Working Group on Ecosystem Science and Assessment (WG-ESA), Nov. 2021
2. Report from ICES-NAFO Working Group on Deepwater Ecosystems (WG-DEC), 2021
4. Meetings attended by the Secretariat

XI. Review of Scientific Council Working Procedures/Protocol
1. General Plan of Work for September 2022 Annual Meeting
2. Priority actions for Scientific Council from the Performance Review Panel WG (adopted by the NAFO Commission in September 2019):
   - peer review process for the science underlying the SC advice, applied consistently to all SC science used in advice [note: to be discussed by SC in June if time permits, otherwise in September]

XII. Other Matters
1. Designated Experts
2. Election of Chairs
3. Budget items

4. Other Business

XIII. Adoption of Committee Reports
1. STACFEN
2. STACREC
3. STACPUB
4. STACFIS

XIV. Scientific Council Recommendations to Commission

XV. Adoption of Scientific Council Report

XVI. Adjournment

ANNEX 1. COMMISSION'S REQUEST FOR SCIENTIFIC ADVICE ON MANAGEMENT IN 2023 AND BEYOND OF CERTAIN STOCKS IN SUBAREAS 2, 3 AND 4 AND OTHER MATTERS

(from SCS Doc. 22/01)

Following a request from the Scientific Council, the Commission agreed that items 1, 2, 4, 7, and 9 should be the priority for the June 2022 Scientific Council meeting subject to resources and COVID-related restrictions.

2. The Commission requests that the Scientific Council provide advice for the management of the fish stocks below according to the assessment frequency presented below. In keeping with the NAFO Precautionary Approach Framework (FC Doc. 04/18), the advice should be provided as a range of management options and a risk analysis for each option without a single TAC recommendation. The Commission will decide upon the acceptable risk level in the context of the entirety of the SC advice for each stock guided and as foreseen by the Precautionary Approach.

Yearly basis	Two-year basis	Three-year basis
Cod in Div. 3M Northern shrimp in Div. 3M	Redfish in Div. 3M Thorny skate in Div. 3LNO Witch flounder in Div. 3NO Redfish in Div. 3LN White hake in Div. 3NO Yellowtail flounder in Div. 3LNO Northern shrimp 3LNO	American Plaice in Div. 3LNO American Plaice in Div. 3M Northern shortfin squid in SA 3+4 Redfish in Div. 3O Cod in Div. 3NO

To implement this schedule of assessments, the Scientific Council is requested to conduct a full assessment of these stocks as follows:

- In 2022, advice should be provided for 2023 for Cod in Div. 3M and Northern shrimp in Div. 3M. With respect to Northern shrimp in Div. 3M, Scientific Council is requested to provide its advice to the Commission prior to the 2022 Annual Meeting based on the survey data up to and including 2022.

- In 2022, advice should be provided for 2023 and 2024 for: Thorny skate in Div. 3LNO, Redfish in Div. 3LN, Witch flounder in Div. 3NO.

- In 2022, advice should be provided for 2023, 2024 and 2025 for: SA 3+4 Northern shortfin squid, Redfish in Div. 3O.

Advice should be provided using the guidance provided in **Annexes A or B as appropriate**, or using the predetermined Harvest Control Rules in the cases where they exist (currently Greenland halibut 2+3KLMNO).

The Commission also requests the Scientific Council to continue to monitor the status of all other stocks annually and, should a significant change be observed in stock status (*e.g.*, from surveys) or in bycatch in other fisheries, provide updated advice as appropriate.

3. The Commission requests the Scientific Council to monitor the status of Greenland halibut. Conditional on the absence of other reasons for Exceptional Circumstances arising (other than the missing Canadian spring 3LNO survey), to calculate in 2022 the HCR adjusting the TAC advised for 2022 using four survey indices (Canadian fall 2J3K, Canadian fall 3LNO, EU 3M 0-1400m, and EU-Spain 3NO surveys) to provide TAC advice for 2023. If other reasons for exceptional circumstances are occurring, the EC protocol will provide guidance on what steps should be taken.

4. The Commission requests that Scientific Council continue its evaluation of the impact of scientific trawl surveys on VME in closed areas and the effect of excluding surveys from these areas on stock assessments.

5. Scientific Council initiate the first steps in both the 2+3KLMNO Greenland halibut and 3LN redfish MSE processes during 2021-2022, namely:

    a. Compile catch and survey data and any additional sources of information used in the current models;

    b. Review and finalize the data inputs for review at the June 2022 Scientific Council meeting when conducting both the 3LN redfish assessment and the assessment of Greenland Halibut Exceptional Circumstances/ Provision of TAC advice

    c. Time permitting, further work on the respective MSE work plans by the SC-GHL and SC-Redfish subgroups for presentation to WG-RBMS or SC.

6. The Commission requests that Scientific Council continue work on the sustainability of catches aspect of the Ecosystem Roadmap, including:

    a. In consultation with WG-EAFFM via co-Chairs, convene independent experts to do a scientific review of; a) the estimation of fisheries production potential and total catch indices, and b) the adequacy of this analysis for their proposed use within the NAFO roadmap (Tier 1), while considering how species interactions are expected to be addressed in the future (Tier 2) within the overall Roadmap structure. The outcomes of this review would need to be tabled in June at Scientific Council to be available in advance of the planned workshop in 2022.

    b. Work to support the WG-EAFFM workshop in 2022, which will explore ecosystem objectives and further develop how the Roadmap may apply to management decision making.

    c. Continue its work to develop models that support implementation of Tier 2 of the EAFM Roadmap.

7. The Commission requests that Scientific Council, in relation to VME analyses:

    a. Conduct a re-assessment of its previously recommended closures of 7a, 11a, 14a and 14b, incorporating catch and effort data for fisheries of shrimp from 2020 and 2021 into the fishing impact assessments. This work is to be completed by the 2023 Scientific Council meeting.

    b. Review the effectiveness of NAFO CEM, Chapter 2 from a scientific and technical perspective and report back to the WG-EAFFM. WG-EAFFM would subsequently in 2022 consider whether any modifications to this Chapter should be recommended.

8. The Commission requests Scientific Council to continue progression on the review of the NAFO PA Framework in accordance to the PAF review work plan approved in 2020 (NAFO COM-SC Doc. 20-04).

9. The Commission requests Scientific Council to continue to develop a 3-5 year work plan, which reflects requests arising from the 2021 Annual Meeting, other multi-year stock assessments and other scientific inquiries already planned for the near future. The work plan should identify what resources are necessary to successfully address these issues, gaps in current resources to meet those needs and proposed prioritization by the Scientific Council of upcoming work based on those gaps.

10. The Commission requests that Scientific Council do a full assessment for Div. 3LN redfish and provide advice based on the projection for various harvest levels for two-years (2023 and 2024) to evaluate the impacts according to the performance statistics from NAFO CEM Annex I.H.

11. The Commission requests that any new results from stock assessments and the scientific advice of Cod 2J3KL (Canada), Witch 2J3KL (Canada) and Pelagic *Sebastes mentella* (ICES Divisions V, XII and XIV; NAFO 1) to be presented to the Scientific Council and request the Scientific Council to prepare a summary of these assessments to be included in its annual report.

12. The Commission requests Scientific Council, jointly with the Secretariat, to conduct ongoing analysis of the Flemish Cap cod fishery data by 2022 in order to:

    a. monitor the consequences of the management decisions (including the analysis of the redistribution of the fishing effort along the year and its potential effects on ecosystems, the variation of the cod catch composition in lengths/ages, and the bycatch levels of other fish species, benthos in general, and VME taxa in particular), and

    b. carry out any additional monitoring that would be required, including Div. 3M cod caught as bycatch in other fisheries during the closed period.

13. The Commission requests Secretariat and the Scientific Council with other international organizations, such as the FAO and ICES to inform the Scientific Council's work related to the potential impact of activities other than fishing in the Convention Area. This would be conditional on CPs providing appropriate additional expertise to Scientific Council.

14. The Commission request that Scientific Council proceed with developing the ecosystem summary sheets for 3M and 3LNO move toward undertaking a joint Workshop with ICES (International Council for the Exploration of the Sea) as part of a peer review of North Atlantic ecosystems.

ANNEX A: Guidance for providing advice on Stocks Assessed with an Analytical Model

The Commission request the Scientific Council to consider the following in assessing and projecting future stock levels for those stocks listed above. These evaluations should provide the information necessary for the Fisheries Commission to consider the balance between risks and yield levels, in determining its management of these stocks:

1. For stocks assessed with a production model, the advice should include updated time series of:

- Catch and TAC of recent years
- Catch to relative biomass
- Relative Biomass
- Relative Fishing mortality
- Stock trajectory against reference points
- And any information the Scientific Council deems appropriate.

Stochastic short-term projections (3 years) should be performed with the following constant fishing mortality levels as appropriate:

- For stocks opened to direct fishing: 2/3 F_{msy}, 3/4 F_{msy}, 85% F_{msy}, 90% F_{msy},95% F_{msy}, F_{msy} 0.75 X $F_{status\ quo}$, $F_{status\ qu}$,1.25 X Status quo, F=0; TAC Status quo, 85% TAC Status quo, 90% TAC Status quo, 95% TAC Status quo
- For stocks under a moratorium to direct fishing: $F_{status\ quo}$, F = 0.

The first year of the projection should assume a catch equal to the agreed TAC for that year.

Results from stochastic short-term projection should include:

- The 10%, 50% and 90% percentiles of the yield, total biomass, spawning stock biomass and exploitable biomass for each year of the projections
- The risks of stock population parameters increasing above or falling below available biomass and fishing mortality reference points. The table indicated below should guide the Scientific Council in presenting the short-term projections.

				Limit reference points														
				P(F>F_{lim})			P(B<B_{lim})				P(F>F_{msy})			P(B<B_{msy})				P(B2024 > B2021)
F in 2022 and following years*	Yield 2022 (50%)	Yield 2023 (50%)	Yield 2024 (50%)	2022	2023	2024	2022	2023	2024		2022	2023	2024	2022	2023	2024		
2/3 Fmsy	t	t	t	%	%	%	%	%	%		%	%	%	%	%	%		%
3/4 Fmsy	t	t	t	%	%	%	%	%	%		%	%	%	%	%	%		%
85% Fmsy	t	t	t	%	%	%	%	%	%		%	%	%	%	%	%		%
90% Fmsy																		
95% Fmsy																		
Fmsy	t	t	t	%	%	%	%	%	%		%	%	%	%	%	%		%
0.75 X Fstatus quo	t	t	t	%	%	%	%	%	%		%	%	%	%	%	%		%
Fstatus quo	t	t	t	%	%	%	%	%	%		%	%	%	%	%	%		%
1.25 X Status quo	t	t	t	%	%	%	%	%	%		%	%	%	%	%	%		%
F=0	t	t	t	%	%	%	%	%	%		%	%	%	%	%	%		%
TAC Status quo																		
85% TAC Status quo																		
90% TAC Status quo																		
95% TAC Status quo																		

2. For stock assessed with an age-structured model, information should be provided on stock size, spawning stock sizes, recruitment prospects, historical fishing mortality. Graphs and/or tables should be provided for all of the following for the longest time-period possible:
    - historical yield and fishing mortality;
    - spawning stock biomass and recruitment levels;
    - Stock trajectory against reference points
    - And any information the Scientific Council deems appropriate

Stochastic short-term projections (3 years) should be performed with the following constant fishing mortality levels as appropriate:

- For stocks opened to direct fishing: $F_{0.1}$, F_{max}, 2/3 F_{max}, 3/4 F_{max}, 85% F_{max}, 75% $F_{status\ quo}$, $F_{status\ quo}$, 125% $F_{status\ quo}$,
- For stocks under a moratorium to direct fishing: $F_{status\ quo}$, F = 0.

The first year of the projection should assume a catch equal to the agreed TAC for that year.

Results from stochastic short-term projection should include:

- The 10%, 50% and 90% percentiles of the yield, total biomass, spawning stock biomass and exploitable biomass for each year of the projections
- The risks of stock population parameters increasing above or falling below available biomass and fishing mortality reference points. The table indicated below should guide the Scientific Council in presenting the short-term projections.

				Limit reference points														
				P(F.>F_{lim})			P(B<B_{lim})				P(F>F0.1)			P(F>F_{max})				P(B2024 > B2021)
F in 2022 and following years*	Yield 2022	Yield 2023	Yield 2024	2022	2023	2024	2022	2023	2024		2022	2023	2024	2022	2023	2024		
F0.1	t	t	t	%	%	%	%	%	%		%	%	%	%	%	%		%
F_{max}	t	t	t	%	%	%	%	%	%		%	%	%	%	%	%		%
66% F_{max}	t	t	t	%	%	%	%	%	%		%	%	%	%	%	%		%
75% F_{max}	t	t	t	%	%	%	%	%	%		%	%	%	%	%	%		%
85% F_{max}	t	t	t	%	%	%	%	%	%		%	%	%	%	%	%		%
0.75 X F_{2018}	t	t	t	%	%	%	%	%	%		%	%	%	%	%	%		%
F_{2018}	t	t	t	%	%	%	%	%	%		%	%	%	%	%	%		%
1.25 X F_{2018}	t	t	t	%	%	%	%	%	%		%	%	%	%	%	%		%

ANNEX B. Guidance for providing advice on Stocks Assessed without a Population Model

For those resources for which only general biological and/or catch data are available, few standard criteria exist on which to base advice. The stock status should be evaluated in the context of management requirements for long-term sustainability and the advice provided should be consistent with the precautionary approach.

The following graphs should be presented, for one or several surveys, for the longest time-period possible:

a. time trends of survey abundance estimates

b. an age or size range chosen to represent the spawning population

c. an age or size-range chosen to represent the exploited population

d. recruitment proxy or index for an age or size-range chosen to represent the recruiting population.

e. fishing mortality proxy, such as the ratio of reported commercial catches to a measure of the exploited population.

f. Stock trajectory against reference points

And any information the Scientific Council deems appropriate.

ANNEX 2. DENMARK (ON BEHALF OF GREENLAND) REQUESTS FOR SCIENTIFIC ADVICE ON MANAGEMENT IN 2023 AND BEYOND OF CERTAIN STOCKS IN SUBAREA 0 AND 1

(from SCS Doc. 22/03)

Denmark (on behalf of Greenland) hereby requests for scientific advice on management in 2023 of certain stocks in NAFO Subareas 0 and 1. Denmark (on behalf of Greenland) requests the Scientific Council for advice on the following species:

1. **Golden Redfish and Demersal Deep-Sea Redfish**
   Advice on Golden redfish (*Sebastes marinus*) and demersal deep-sea redfish (*Sebastes mentella*) in Subarea 1 was in June 2020 given for 2021-2023. The Scientific Council is requested to continue its monitoring of the stocks and provide updated advice as appropriate in the event of significant changes in stock levels.

2. **Atlantic Wolffish and Spotted Wolffish**
   Advice on Atlantic Wolffish (*Anarhichas lupus*) and Spotted Wolffish (*Anarhichas minor*) in Subarea 1 was in June 2020 given for 2021-2023. The Scientific Council is requested to continue its monitoring of the above stocks and provide updated advice as appropriate in the event of significant changes in stock levels.

3. **Greenland Halibut, Offshore**
   Advice on Greenland Halibut, Offshore in Subareas 0 and 1 was in 2020 given for 2021 and 2022. Denmark (on behalf of Greenland) requests the Scientific Council to provide advice on appropriate TAC levels for 2023 to 2024.

4. **Greenland Halibut, Inshore, West Greenland**
   Advice on the inshore stocks of Greenland Halibut in Subarea 1 was in 2020 given for 2021-2022. Denmark (on behalf of Greenland) requests the Scientific Council to provide advice on appropriate TAC levels for 2023 to 2024 for Division 1A inshore for the inshore regions Disko Bay, Uummannaq and Upernavik.

5. **Northern Shrimp, West Greenland**
   Subject to the concurrence of Canada as regards to Subareas 0 and 1, Denmark (on behalf of Greenland) requests the Scientific Council before December 2022 to provide advice on the scientific basis for management of Northern Shrimp (*Pandalus borealis*) in Subareas 0 and 1 in 2023 in line with Greenland's stated management objective of maintaining a mortality risk of no more than 35% in the first year prediction and to provide a catch option table ranging with 5,000 t increments. Future catch options should be provided for as many years as data allows for.

6. **Northern Shrimp, East Greenland**
   Furthermore, the Scientific Council is in cooperation with ICES requested to provide advice on the scientific basis for management of Northern Shrimp (*Pandalus borealis*) in Denmark Strait and adjacent waters east of southern Greenland in 2023 and for as many years ahead as data allows for.

ANNEX 3. REQUESTS FROM CANADA FOR ADVICE ON MANAGEMENT IN 2023 AND BEYOND

(from SCS Doc. 22/04)

1. Greenland halibut (Subarea 0 + 1 (offshore)[5]

The Scientific Council is requested to provide an overall assessment of status and trends in the total stock area throughout its range and to specifically advise on TAC levels for 2023 and 2024. The stock status should be evaluated in the context of management requirements for long-term sustainability and the advice provided should be consistent with NAFO's Precautionary Approach Framework.

It is noted that at this time only general biological advice and/or catch data are available, few standard criteria exist on which to base advice. Canada encourages the Scientific Council to continue to explore opportunities to develop risk-based advice in the future, noting that data conditions do not allow for such advice at this time.

2. Shrimp (Subarea 1 and Division 0A)

Canada requests the Scientific Council to consider the following options in assessing and projecting future stock levels for Shrimp in Subarea 1 and Division 0A:

The status of the stock should be determined and risk-based advice provided for catch options corresponding to Z_{msy}, in 5,000-10,000t increments (subject to the discretion of Scientific Council), with forecasts for 2023 to 2025. These options should be evaluated in relation to Canada's Harvest Strategy (attached) and NAFO's Precautionary Approach Framework, and presented in the form of risk analyses related to B_{msy}, 80% B_{msy}, B_{lim} (30% B_{msy}) and Z_{msy}.

Presentation of the results should include graphs and/or tables related to the following:

- Historical and current yield, biomass relative to B_{msy}, total mortality relative to Z_{msy}, and recruitment (or proxy) levels for the longest time period possible;
- Total mortality (Z) and fishable biomass for a range of projected catch options (as noted above) for the years 2023 to 2025. Projections should include both catch options and a range of effective cod predation biomass levels considered appropriate by the Scientific Council. Results should include risk analyses of falling below: B_{MSY}, 80% B_{msy} and B_{lim} (30% B_{msy}), and of being above Z_{msy} based on the 3-year projections, consistent with the Harvest Decision Rules in Canada's Harvest Strategy; and
- Total area fished for the longest time period possible.

Please provide the advice relative to Canada's Harvest Strategy as part of the formal advice (i.e., grey box in the advice summary sheet).

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[5] The Scientific Council has noted previously that there is no biological basis for conducting separate assessments for Greenland halibut throughout Subareas 0-3, but has advised that separate TACs be maintained for different areas of the distribution of Greenland halibut.

APPENDIX III: PROVISIONAL TIMETABLE

Scientific Council Meeting, 3-16 June 2022

Date	Time	Schedule
3 June (Friday)	0900	Registration, network connection
	0900-0930	SC Executive
	1000-1030	SC Opening
	1100-1200	STACFIS (Catch WG report, status of documentation, interim monitoring reports)
	1200-1300	Break
	1300-1800	STACFIS/STACFEN
04 June (Saturday)	0900-1200	STACFEN
	1300-1800	Scientific Council/STACFIS
	1830-2030	Scientific Council Reception/event
05 June (Sunday)	No meetings	
06 June (Monday)	0900-1200	STACPUB
	1300-1800	Scientific Council/STACFIS
07 June (Tuesday)	0900-1800	STACFIS/SC
08 June (Wednesday)	0900-1200	STACFIS/SC
	1300-1800	STACFIS/SC
09 June (Thursday)	0900-1800	STACFIS/SC
10 June (Friday)	0900-1800	STACFIS/SC
11 June (Saturday)	0900-1800	STACFIS Reports
12 June (Sunday)	No meetings	
13 June (Monday)	0830	Scientific Council Executive
	0900-1800	Scientific Council (Standing Committee Reports)
14 June (Tuesday)	0900-1800	Scientific Council
15 June (Wednesday)	0900-1800	Scientific Council
16 June (Thursday)	0900-1800	Scientific Council (advice and adoption of reports)

First week: plan to do STACFEN, 3LN Redfish, and WG-ESA parts of report.

Monday June 13 PAWG update

APPENDIX IV: EXPERTS FOR PRELIMINARY ASSESSMENT OF CERTAIN STOCKS

Designated Experts for 2022:

From the Science Branch, Northwest Atlantic Fisheries Centre, Department of Fisheries and Oceans, St. John's, Newfoundland & Labrador, Canada

Cod in Div. 3NO	Rick Rideout	rick.rideout@dfo-mpo.gc.ca
Redfish Div. 3O	Laura Wheeland	laura.wheeland@dfo-mpo.gc.ca
Redfish Div. 3LN	Bob Rogers	bob.rogers@dfo-mpo.gc.ca
American Plaice in Div. 3LNO	Laura Wheeland	laura.wheeland@dfo-mpo.gc.ca
Witch flounder in Div. 3NO	Dawn Maddock Parsons	dawn.parsons@dfo-mpo.gc.ca
Yellowtail flounder in Div. 3LNO	Dawn Maddock Parsons	dawn.parsons@dfo-mpo.gc.ca
Greenland halibut in SA 2+3KLMNO	Paul Regular	paul.regular@dfo-mpo.gc.ca
Northern shrimp in Div. 3LNO	Katherine Skanes	katherine.skanes@dfo-mpo.gc.ca

From the Department of Fisheries and Oceans, Winnipeg, Manitoba, Canada

Greenland halibut in SA 0+1	Margaret Treble	margaret.treble@dfo-mpo.gc.ca

From the Instituto Español de Oceanografia, Vigo (Pontevedra), Spain

Roughhead grenadier in SA 2+3	Fernando Gonzalez-Costas	fernando.gonzalez@ieo.csic.es
Splendid alfonsino in Subarea 6	Fernando Gonzalez-Costas	fernando.gonzalez@ieo.csic.es
Cod in Div. 3M	Diana Gonzalez-Troncoso	diana.gonzalez@ieo.csic.es
Northern Shrimp in Div. 3M	Jose Miguel Casas Sanchez	mikel.casas@ieo.csic.es

From the Instituto Nacional de Recursos Biológicos (INRB/IPMA), Lisbon, Portugal

American plaice in Div. 3M	Ricardo Alpoim	ralpoim@ipma.pt
Golden redfish in Div. 3M	Ricardo Alpoim	ralpoim@ipma.pt
Redfish in Div. 3M	Ricardo Alpoim (provisional)	ralpoim@ipma.pt

From the Greenland Institute of Natural Resources, Nuuk, Greenland

Demersal Redfish in SA1	Rasmus Nygaard	rany@natur.gl
Wolfish in SA1	Rasmus Nygaard	rany@natur.gl
Greenland halibut in Div. 1 inshore	Rasmus Nygaard	rany@natur.gl
Northern shrimp in SA 0+1	AnnDorte Burmeister	anndorte@natur.gl
Northern shrimp in Denmark Strait	Tanja B. Buch	TaBb@natur.gl

From Knipovich Polar Research Institute of Marine Fisheries and Oceanography (PINRO), Russian Federation

Capelin in Div. 3NO	Konstantin Fomin	fomin@pinro.ru

From National Marine Fisheries Service, NEFSC, Woods Hole, Massachusetts, United States of America

Northern Shortfin Squid in SA 3 & 4	Lisa Hendrickson	lisa.hendrickson@noaa.gov
Thorny skate in Div. 3LNO	Katherine Sosebee	katherine.sosebee@noaa.gov
White hake in Div. 3NO	Katherine Sosebee	katherine.sosebee@noaa.gov

APPENDIX VI. LIST OF SCR AND SCS DOCUMENTS

SCR Documents

Serial No.	Doc. No.	Author(s)	Title
N7263	SCR Doc. 22-001	G. Søvik, F. Zimmermann and T. H. Thangstad	Results of the Norwegian Bottom Trawl Survey for Northern Shrimp (Pandalus borealis) in Skagerrak and the Norwegian Deep (ICES Divisions 3.a and 4.a East) in 2022
N7266	SCR Doc. 22-002	Mariano Koen-Alonso, Pierre Pepin, Mike Fogarty, and Robert Gamble	Review and Assessment of the Ecosystem Production Potential (EPP) model structure, sensitivity, and its use for fisheries advice in NAFO
N7267	SCR Doc. 22-003	Mariano Koen-Alonso	Supporting material for the independent scientific review of the estimation of fisheries production potential and total catch indices, and their adequacy for their proposed used within the NAFO Roadmap
N7268	SCR Doc. 22-004	Diana González-Troncoso, Irene Garrido, Sonia Rábade, Mariña Fabeiro, Esther Román, César Tarrío, Jose Miguel Casas Sánchez and Ricardo Alpoim	Results from Bottom Trawl Survey on Flemish Cap of June-July 2021
N7269	SCR Doc. 22-005	Irene Garrido, Diana González-Troncoso, Fernando González-Costas, Esther Román and Lupe Ramilo	Results of the Spanish survey in NAFO Division 3NO
N7270	SCR Doc. 22-006	John Mortensen	Report on hydrographic conditions off Southwest Greenland May 2021
N7271	SCR Doc. 22-007	R.M. Rideout, B. Rogers, L. Wheeland, M. Koen-Alonso	Temporal And Spatial Coverage of Canadian (Newfoundland And Labrador Region) Spring And Autumn Multi-Species RV Bottom Trawl Surveys, With An Emphasis On Surveys Conducted In 2021
N7272	SCR Doc. 22-008	Rasmus Nygaard	Trawl and gillnet survey results from the Disko Bay, NAFO Division 1A Inshore
N7273	SCR Doc. 22-009	Rasmus Nygaard	Survey results from the Upernavik Gillnet survey, NAFO Division 1Ainshore
N7274	SCR Doc. 22-010	Rasmus Nygaard	Survey results from the Uummannaq gillnet survey in NAFO Division 1A inshore.
N7275	SCR Doc. 22-011	Rasmus Nygaard, Søren L. Post, Anja Retzel, Karl Zinglersen, Lars Heilmann, Sofie R. Jeremiassen, Signe Jeremiassen, Louise Mølgaard and Jørgen Sethsen	Biomass and Abundance of Demersal Fish Stocks in the Nuuk fjord
N7279	SCR Doc. 22-012	Steingrund and Ridao Cruz	Survey results of the longline survey on NAFO Division 3M
N7284	SCR Doc. 22-013	Bob Rogers, Andrea Perreault, Mark Simpson, Divya Varkey	Assessment of 3LN redfish using the ASPIC model in 2022 (*Sebastes mentella* and *S. fasciatus*)

N7286	SCR Doc. 22-014	D. Maddock Parsons, R. Rideout and B. Rogers	An assessment of the Witch flounder resource in NAFO Divisions 3NO
N7287	SCR Doc. 22-015	P.M. Regular, D. Butterworth, R. Rademeyer	Effect of missing values from the Canadian spring and fall surveys of NAFO Divisions 3LNO on the calculation of the TAC using the Greenland halibut HCR
N7288	SCR Doc. 22-016	Perreault A., Rogers B., González Troncoso D., Rideout R., Simpson M., Dwyer K., Varkey D.	Data review for 3LN redfish in preparation for an updated management strategy evaluation
N7289	SCR Doc. 22-017	Frank Oliva, Trajce Alcinov	Inventory of environmental data in the NAFO convention area - Report 2021
N7291	SCR Doc. 22-018	Paula Fratantoni	Hydrographic Conditions on the Northeast United States Continental Shelf in 2021 – NAFO Subareas 5 and 6
N7292	SCR Doc. 22-019	D. Bélanger, P. Pepin, G. Maillet	Biogeochemical oceanographic conditions in the Northwest Atlantic (NAFO subareas 2-3-4) during 2020
N7293	SCR Doc. 22-020	F. Cyr, P. S. Galbraith, C. Layton D. Hebert, N. Chen, G. Han	Environmental and Physical Oceanographic Conditions on the Eastern Canadian shelves (NAFO Sub-areas 2, 3 and 4) during 2021.
N7294	SCR Doc. 22-021	Bélanger and Cyr	Environmental indices for NAFO subareas 0 to 4 in support of the Standing Committee on Fisheries Science (STACFIS).
N7295	SCR Doc. 22-022	M. A. Treble and A. Nogueira	Assessment of the Greenland Halibut Stock Component in NAFO Subarea 0 + 1 (Offshore)
N7296	SCR Doc. 22-023	M. A. Treble and K. Hedges	Product to round weight conversion factors for the Subarea 0 Greenland halibut fishery
N7297	SCR Doc. 22-024	Frederik Bjare & Rasmus Nygaard	A new longline based CPUE for Greenland halibut in NAFO division 1A inshore based on factory landing reports
N7298	SCR Doc. 22-025	Diana González-Troncoso, Fernando González-Costas and Irene Garrido	Assessment of the Cod Stock in NAFO Division 3M
N7299	SCR Doc. 22-026	K.A. Sosebee, M.R. Simpson, and C.M. Miri	Assessment of Thorny Skate (*Amblyraja radiata* Donovan, 1808) in NAFO Divisions 3LNO and Subdivision 3Ps
N7301	SCR Doc. 22-027	Divya Varkey, Jiaxin Luo, Mark Simpson, Danny Ings, Bob Rogers	Update of the Management Strategy Evaluation for Redfish stock in NAFO Divisions 3LN
N7303	SCR Doc. 22-028		*Retracted
N7304	SCR Doc. 22-029	Rasmus Nygaard	Commercial data for the Greenland halibut fishery in Uummannaq
N7305	SCR Doc. 22-030	M.A.Treble	Summary of surveys in Northwest Atlantic Fisheries Organization Subarea 0, 1999-2019

N7306	SCR Doc. 22-031	Rasmus Nygaard	Commercial data for the Greenland halibut fishery in the Disko Bay
N7307	SCR Doc. 22-032	Diana González Troncoso, Irene Garrido and Fernando González-Costas	Effect in survey indices of removing stations in the NAFO closed Areas in the design of the EU surveys including the 2021 closed areas
N7308	SCR Doc. 22-033		*Retracted
N7309	SCR Doc. 22-034	Fernando González-Costas, Diana González-Troncoso, Irene Garrido	Information to support decisions on authorizing scientific surveys with bottom-contacting gears in NAFO closed areas
N7310	SCR Doc. 22-035	Rasmus Nygaard	Commercial data for the Greenland halibut fishery in Upernavik.
N7311	SCR Doc. 22-036	Rasmus Nygaard	An assessment of the Greenland halibut stock in the Disko Bay.
N7313	SCR Doc. 22-037	Rasmus Nygaard	An assessment of the Greenland halibut stock in the Uummannaq fjord.
N7314	SCR Doc. 22-038	Rasmus Nygaard	An assessment of the Greenland halibut stock in the Upernavik area.
N7315	SCR Doc. 22-039	N. Cadigan, R.M. Rideout, and P.M. Regular	A State-Space Assessment Model for 3NO Cod
N7316	SCR Doc. 22-040	N.G. Cadigan and R.M. Rideout	A Mixed-Effects Model to Smooth and Interpolate Survey Weights-at-Age for 3NO Cod
N7317	SCR Doc. 22-041	D. Maddock Parsons, Paul Regular and Rasmus Nygaard	Exploration of a surplus production model in a Bayesian framework for Greenland Halibut in Disko Bay NAFO Division 1A Inshore
N7319	SCR Doc. 22-042	Paul M. Regular, Andrea M.J. Perreault, Rick M. Rideout, Bob Rogers, Laura J. Wheeland	Exploratory analysis of disparate survey indices of Greenland halibut (*Reinhardtius hippoglossoides*) in NAFO divisions 2+3KLMNO
N7320	SCR Doc. 22-043	Paul M. Regular, Mariano Koen-Alonso, Semra Yalcin, Andrea M.J. Perreault, Laura J. Wheeland	Approximating uncertainty around indices from stratified-random trawl surveys using the Gamma distribution
N7321	SCR Doc. 22-044	Laura Wheeland, Emilie Novaczek, Paul Regular, Rick Rideout, and Bob Rogers	An Assessment of the Status of Redfish in NAFO Division 3O

SCS Documents

Serial No.	Doc. No.	Author	Title
N7258	SCS Doc. 22-01	NAFO	The Commission's Request for Scientific Advice on Management in 2023 and Beyond of Certain Stocks in Subareas 2, 3 and 4 and Other Matters
N7259	SCS Doc. 22-02	NAFO	Achieving NAFO Convention Objectives with a Precautionary Approach Framework Precautionary Approach Working Group (PA-WG) October 2021
N7260	SCS Doc. 22/03	Denmark (in respect of Faroe Islands and Greenland)	Denmark (on behalf of Greenland) Coastal State Request for Scientific Advice - 2023
N7261	SCS Doc. 22/04	Canada	Canada's Coastal State Request for Scientific Advice - 2023
N7264	SCS Doc. 22/05	Japan Fisheries Research and Education Agency	National Research Report of Japan (2022)
N7265	SCS Doc. 22/06	F. González-Costas, G. Ramilo, E. Román, J. Lorenzo, D. González-Troncoso, M. Sacau, P. Duran and J. L. del Rio	Spanish Research Report for 2021
N7276	SCS Doc. 22/07	L. Näks	Estonian Research Report
N7280	SCS Doc. 22/08	Luis Ridao Cruz	Faroese Research Report 2021
N7281	SCS Doc. 22/09	K. Fomin and M. Pochtar	Russian Research Report for 2021
N7282	SCS Doc. 22/10	Bob Rogers and Mark Simpson	Canadian Research Report for 2021
N7283	SCS Doc. 22/11	NAFO	Biological Sampling Data for 2021
N7285	SCS Doc. 22/12 REV. 2	Ramus Nygaard , Adriana Nogueira and AnnDorte Burmeister	Denmark/Greenland Research Report for 2021
N7290	SCS Doc. 22/13	J. Vargas and R. Alpoim	Portuguese Research Report 2021
N7300	SCS Doc. 22/14	K.A. Sosebee	United States Research Report for 2021
N7302	SCS Doc. 22/15	NAFO	Report of the Precautionary Approach Working Group (PA-WG), May 2022
N7312	SCS Doc. 22/16		*Retracted
N7318	SCS Doc. 22/17	H. O. Fock and C. Stransky	German Research Report for 2022

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