Serial No. N6966 NAFO SCS Doc. 19/20

Northwest Atlantic Fisheries Organization

Report of the Scientific Council Meeting

31 May -13 June 2019
Halifax, Nova Scotia

NAFO
Dartmouth, Nova Scotia, Canada
2019

Report of the Scientific Council Meeting

31 May -13 June 2019
Halifax, Nova Scotia

Recommended Citation:

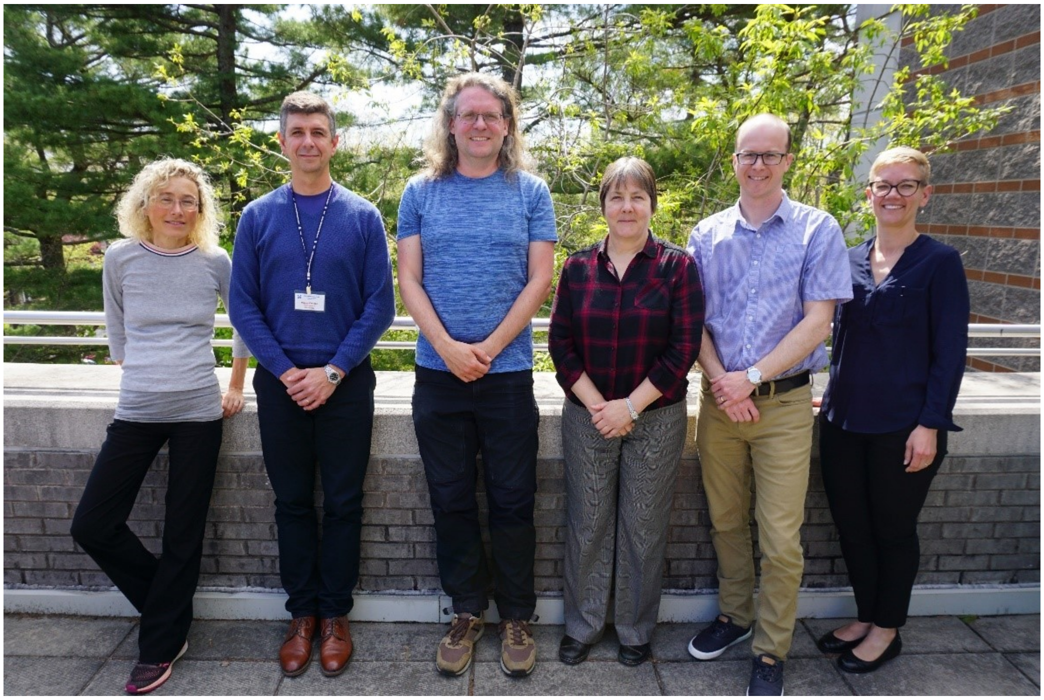
NAFO. 2019. Report of the Scientific Council, 31 May -13 June 2019, Halifax, Canada. NAFO SCS Doc. 19/20

Scientific Council June Meeting Participants

31 May – 13 June 2019

Scientific Council Participants 2019

Scientific Council Chairs and External Reviewer



From left to right: Carmen Fernandez (Vice-Chair of Scientific Council and Chair of STACREC), Miguel Caetano (Chair of STACFEN), Daniel Howell (External Reviewer), Margaret Treble (Chair of STACPUB), Brian Healey (Scientific Council Chair), and Karen Dwyer (Chair of STACFIS)

REPORT OF SCIENTIFIC COUNCIL MEETING
31 May -13 June 2019

Chair: Brian Healey Rapporteur: Tom Blasdale

I. PLENARY SESSIONS

The Scientific Council met at the Sobey Building, Saint Mary's University, Halifax, NS, Canada, during 31 May – 13 June 2019, to consider the various matters in its Agenda. Representatives attended from Canada, Denmark (in respect of Faroe Islands and Greenland), the European Union (Portugal, Spain, the United Kingdom), Japan, the Russian Federation and the United States of America. Observers from the Ecology Action Centre, Food and Agriculture Organization (FAO) and the North Pacific Fisheries Commission (NPFC) 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 10:45 on 31 May 2019. The provisional agenda was **adopted** with modification. The Scientific Council Coordinator was appointed the rapporteur. Of note, there was no Commission request for advice for Witch Flounder in Divs. 2J+3KL, so this stock was removed from the agenda and not considered at the current meeting.

The opening session was adjourned at 12:15 on 31 May 2019. Several sessions were held throughout the course of the meeting to deal with specific items on the agenda. The Council considered and **adopted** the reports of STACFEN and STACPUB on 12 June 2019 and the STACFIS and STACREC reports on 13 June 2018.

The concluding session was called to order at 09:00 on 13 June 2019.

The Council considered and **adopted** the report the Scientific Council Report of this meeting of 31 May -13 June 2019. 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 13:00 on 13 June 2019.

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-IX.

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 2018

Recommendations from 2018 are considered in the relevant sections of this report.

III. FISHERIES ENVIRONMENT

The Council **adopted** the Report of the Standing Committee on Fisheries Environment (STACFEN), as presented by the 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, is as follows:

- STACFEN **recommends** *consideration of Secretariat support for an invited speaker to address emerging issues and concerns for the NAFO Convention Area during the 2020 STACFEN Meeting.*

IV. PUBLICATIONS

The Council **adopted** the Report of the Standing Committee on Publications (STACPUB) as presented by the Chair, Margaret Treble. 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 and the Chair of STACPUB work intersessionally to develop a set of guidelines for the SCS documents, including consideration of the national research reports, and present these for review by STACPUB in June 2020.*
- STACPUB **recommends** that *the Secretariat continue to investigate solutions that would be compatible with reference management software.*
- STACPUB **recommends** that *the Secretariat ensure options for figure formats are clearly provided in the instructions for authors for JNAFS*.
- STACPUB **recommends** that *the Secretariat explore development of a "run-to-code" or other method that would simplify the process for figure preparation by Designated Experts and other authors so that they can more easily provide an editable figure that fits the SC standards*.

V. RESEARCH COORDINATION

The Council **adopted** the Report of the Standing Committee on Research Coordination (STACREC) as presented by the Chair, Carmen Fernandez. 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:

- STACREC **recommends** that, *for all surveys, aggregate annual total biomass indices should be presented in the future, in addition to the stock by stock indices currently presented, so as to provide a general perspective on overall trends.*
- In relation to Greenland halibut in SA2+3KLMNO, STACREC **recommends** that *the 2018 Canadian fall 2J3K and spring 3LNO indices be included in the calculation of the HCR but that the impact on age structure be examined before these indices are included in any age structured model.*
- Generally, for all surveys and stocks, STACREC **recommends** that *a consistent approach to determining if an incomplete survey can be considered as an index for a particular stock be developed and, as part of that, an analysis of past decisions to include or exclude incomplete surveys be conducted.*

Following from this recommendation, a review of past decisions in relation to Canadian surveys was presented during the meeting and STACREC made the following recommendation:

- 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 ("preliminary") 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.*

    These are preliminary guidelines and sampling biases may also be relevant in the considerations for each specific stock and survey. In particular, the finer structure of the indices needs to be considered if they are used disaggregated by age or length in stock assessments.
- 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 Karen Dwyer. The full report of STACFIS is in Appendix IV.

STACFIS made the following general recommendation which was **endorsed** by the Scientific Council:

- STACFIS **recommends** that *CESAG review the Catch Estimation Strategy to consider potential refinements, such as the inclusion of gear type, mesh size, and quarter into the strategy.*

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.

The Scientific Council noted that, owing to a data availability issue, the assessment of Northern shortfin squid (*Illex illecebrosus*) in Subareas 3+4 is deferred to the Scientific Council meeting, 23 – 27 Sep 2019, and advice for 2020, 2021 and 2022 will be provided to the Commission at that time.

Additionally this year, advice for 2020 will be drafted for Northern shrimp in Div. 3M and Northern Shrimp in Divs. 3LNO during a WebEx scheduled to occur prior to the Annual Meeting, 23 – 27 Sep 2019.

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.

The Scientific Council advice for stocks fully assessed during this meeting follows below.

Cod in Division 3M

Advice June 2019 for 2020

Recommendation for 2020

Scientific Council notes that the strong year classes of 2009 to 2011 are dominant in the current *SSB*. Subsequent recruitments are much lower, therefore substantial declines in stock size are occurring and expected to continue in the near future under any fishing scenario.

Yields during 2020 of either 8 531 tonnes (¾ F_{lim}) or 5 619 tonnes ($F_{2016\text{-}2018}$) result in a very low probability of *SSB* being below B_{lim} in 2021 and a low probability of *F* exceeding F_{lim}. However, under both of these scenarios, the probability $SSB < B_{lim}$ in 2022 is high (≥20%).

Management objectives

A management strategy evaluation process has been initiated for this stock by the Commission and Scientific Council but has not yet been finalized. At this moment Convention General Principles are applied.

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

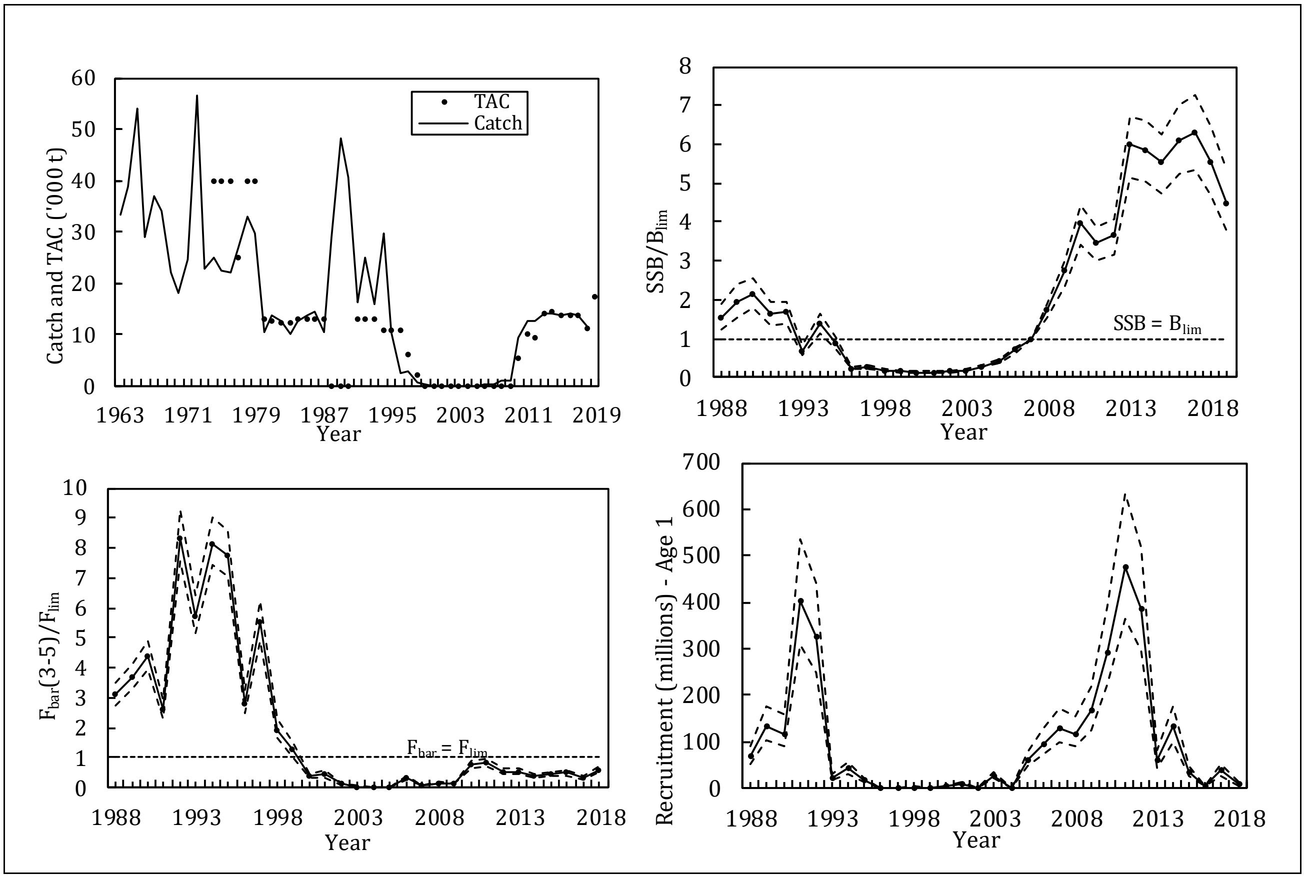
🟢 OK
🟡 Intermediate
🔴 Not accomplished
⚪ Unknown

Management unit

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

Stock status

Current *SSB* is estimated to be well above B_{lim} (15 177 t) although it is expected to decline rapidly in the near future due to poor recruitment since 2015. *F* increased in 2010 with the re-opening of the fishery but it has remained below F_{lim} (0.167).



Reference points

$B_{lim} = SSB_{2007}$: Median = 15 177 t of spawning biomass (Scientific Council, 2019).

$F_{lim} = F_{30\%SPR}$: Median = 0.167 (Scientific Council, 2019)

Projections

	B		SSB		Yield
	Median and 80% CI				
$F_{bar}=F_{lim}$ (median=0.167)					
2019	76891	(67817 - 86311)	69015	(60552 - 78262)	17500
2020	43969	(36989 - 51393)	38538	(32067 - 45573)	10876
2021	26256	(20590 - 32652)	22083	(17017 - 27722)	6275
2022	15086	(10689 - 20149)	12350	(8454 - 16718)	
$F_{bar}=3/4F_{lim}$ (median=0.125)					
2019	76891	(67817 - 86311)	69015	(60552 - 78262)	17500
2020	43969	(36989 - 51393)	38538	(32067 - 45573)	8531
2021	28637	(22958 - 34999)	24368	(19275 - 29993)	5405
2022	17653	(13236 - 22793)	14842	(10933 - 19242)	
$F_{bar}=F_{2016-2018}$ (median=0.079)					
2019	76891	(67817 - 86311)	69015	(60552 - 78262)	17500
2020	43969	(36989 - 51393)	38538	(32067 - 45573)	5619
2021	31634	(25964 - 37966)	27230	(22125 - 32840)	3953
2022	21241	(16828 - 26434)	18302	(14356 - 22736)	

	Yield			P(B < B_{lim})				P(F > F_{lim})			
	2019	2020	2021	2019	2020	2021	2022	2019	2020	2021	P(B_{22} > B_{19})
F_{lim} = 0.167	17500	10876	6275	<1%	<1%	5%	78%	20%	50%	50%	<1%
3/4F_{lim} = 0.125	17500	8531	5405	<1%	<1%	1%	55%	20%	3%	9%	<1%
F_{16-18} = 0.079	17500	5619	3953	<1%	<1%	<1%	20%	20%	<1%	<1%	<1%

Although advice is given only for 2020, projection results are shown to 2022 to illustrate the medium term implications.

The results indicate that under all scenarios, total biomass and *SSB* during the projected years will decrease sharply. The probability of *SSB* being below B_{lim} in 2021 is very low (≤5%) in all cases. In 2022, due to rapid stock declines, the risk of being below B_{lim} is quite high (20-78%). The probability of *SSB* in 2022 being above that in 2019 is <1%.

Under ¾ F_{lim} the probability of *F* exceeding F_{lim} is less than 10% in 2020 and 2021.

Assessment

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

Timing of the next full assessment of this stock will be subject to the timelines of the ongoing MSE process.

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.

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.

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

	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
TAC	5.5	10.0	9.3	14.1	14.5	13.8	13.9	13.9	11.1	17.5
STATLANT 21	5.2	10.0	9.1	13.5	14.4	12.8	13.8	13.9	10.5	
STACFIS	9.3	12.8	12.8	14.0	14.3	13.8	14.0	13.9	11.5	

Effects of the fishery on the ecosystem

General impacts of fishing gear on the ecosystem should be considered. A large area of Div. 3M has been closed to protect sponge, seapens and other coral.

Special comments

Given the rapid declines projected for this stock, an additional projection was conducted assuming no removals (F=0). The results show that even with no fishing, the total biomass and *SSB* during the projected years will decrease sharply. The probability of *SSB* in 2022 being above *SSB* in 2019 is <1%. Further, the probability that *SSB* in 2022 is below B_{lim} is <1%.

Sources of information

SCS Doc. 18/18, 19/06, 19/07, 19/09, 19/10, 19/11 and SCR Doc. 19/21, 19/26.

Redfish (*Sebastes mentella* and *Sebastes fasciatus*) in Division 3M

Advice June 2019 for 2020-2021

Recommendation for 2020 and 2021

SC advises that catches should not exceed the $F_{0.1}$ level given the recent very low productivity of the stock. This corresponds to a TAC of 4 319 tonnes in 2020 and 4 624 tonnes in 2021.

Management objectives

No explicit management plan or management objectives have been defined by the Commission. Convention General Principles are applied.

Convention General Principles	***Status***	***Comment/consideration***
Restore to or maintain at B_{msy}	⚪	B_{msy} unknown. Stock above historical average level
Eliminate overfishing	🔴	F_{msy} unknown. Catch at a low level over past 25 years
Apply Precautionary Approach	🔴	Candidate Yield per recruit reference points available and used, but need to be confirmed
Minimise harmful impacts on living marine resources and ecosystems	🟡	VME closures in effect, no specific measures, low bycatch reported
Preserve marine biodiversity	⚪	Cannot be evaluated

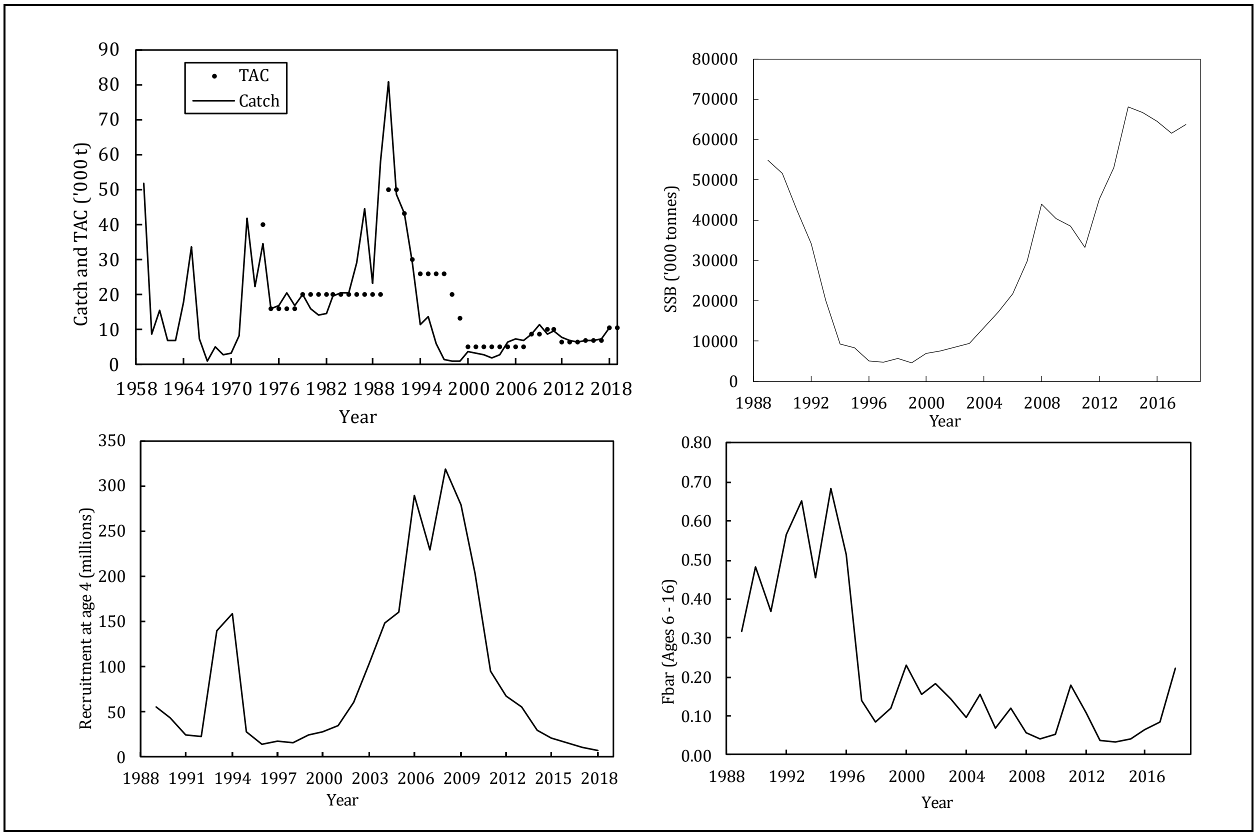
🟢	OK
🟡	Intermediate
🔴	Not accomplished
⚪	Unknown

Management unit

Catches of redfish in Div. 3M include three species of the genus *Sebastes*; *S. mentella, S. norvegicus* (=*S. marinus*) and *S. fasciatus*. For management purposes, they are considered as one stock. The assessment and advice are based on data for only two species (*S. mentella* & *S. fasciatus*), labeled as beaked redfish. The TAC advice is adjusted to reflect all three species on the Flemish Cap, based upon the relative species distribution in recent surveys.

Stock status

The stock is declining after a marked recovery that started in 2002-2003. High levels of biomass were maintained until 2014, supported by low fishing mortalities and individual growth of survivors, but could not be sustained. The decline in abundance is more pronounced, with no perspective to stop in the short term since year classes at recruitment continue to be extremely weak.



Reference points

No reference points have been adopted.

Assessment

Input data comes from the EU Flemish Cap bottom trawl survey and the fishery. A quantitative model (XSA) introduced in 2003 was used. Increased natural mortality was assumed from 2006 to 2010, but natural mortality was low (more typical of redfish) in other years. In order to include an independent approach to natural mortality in the 2017 sensitivity *M* framework, natural mortality was then estimated by a number of published models. There is no evidence that natural mortality has increased recently from the level of 0.1 adopted in the 2017 assessment, and therefore, the 2019 XSA assessment was run with average *M* in 2017 and 2018 kept at 0.10.

The next full assessment of this stock will be in 2021.

Projections

Short term (2020-2022) stochastic projections were carried out for female spawning stock biomass (*SSB*) and catch, under the most recent level of natural mortality and considering three options for fishing mortality ($F_{statusquo}$, $F_{0.1}$ and F_{max}). Projections were initialized at the beginning of 2020 assuming $F_{statusquo}$ during 2019. Assumed recruitment for 2019 to 2021 is the geometric mean of the most recent recruitments (age 4 XSA, 2015-2017).

Results for the three projection scenarios show biomass declines of 25% (for $F_{0.1}$), 34% (F_{max}) and 36% ($F_{statusquo}$) between 2019 and 2022. In all three scenarios, the biomass remains at a high level relative to historical values but has a low probability of being above 2019 levels.

$Fstatusquo_{2018}$=0.220

	SSB Median and 80% CI	Yield Median	TAC
$2019_{deterministi}$	67553	12536	
2020	55768 (50610 - 62034)	9682	9925
2021	49656 (44935 - 54955)	9262	9495
2022	43021 (39130 - 47816)		

Fmax=0.188

	SSB Median and 80% CI	Yield Median	TAC
$2019_{deterministi}$	67553	12536	
2020	55768 (50610 - 62034)	8379	8590
2021	50617 (45816 - 56012)	8241	8448
2022	44764 (40713 - 49757)		

F0.1=0.091

	SSB Median and 80% CI	Yield Median	TAC
$2019_{deterministi}$	67553	12536	
2020	55768 (50610 - 62034)	4213	4319
2021	53703 (48634 - 59372)	4510	4624
2022	50573 (46050 - 56165)		

average beaked redfish proportion in the 2017-2018 3M redfish catch 0.98

	Fstatus quo	F0.1	Fmax
$P(SSB_{2020}>SSB_{2019})$	<10%	<10%	<10%
$P(SSB_{2021}>SSB_{2019})$	<10%	<10%	<10%
$P(SSB_{2022}>SSB_{2019})$	<10%	<10%	<10%

Human impact

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

Biology and Environmental Interactions

Since 2004 a rapid increase was observed on survey biomass both of golden (*Sebastes norvegicus*) and Acadian (*Sebastes fasciatus*) redfish stocks. Due to their shallower depth distributions these two redfish species overlap with cod to an extent greater than deep sea redfish (*Sebastes mentella*). Since 2006, the cod stock started to recover, while those two redfish stocks declined sharply. Redfish is an important component in the diet of cod, especially in those years when successful recruitment events were observed in redfish stocks.

Fishery

Redfish is caught in directed bottom trawl fisheries at intermediate depths (300-700m), but also as bycatch in fisheries directed for cod and Greenland halibut. The fishery in NAFO Div. 3M is regulated by minimum mesh size and quota.

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

	2010	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**
TAC	10.0	10.0	6.5	6.5	6.5	6.7	7.0	7.0	10.5	10.5
STATLANT 21	8.2	9.7	5.4	6.8	6.4	6.9	6.6	7.1	10.5	
STACFIS Total catch [1, 2]	8.5	11.1	6.2	7.8	7.4	6.9	6.6	7.1	10.5	
STACFIS Catch [2, 3]	5.4	9.0	6.3	5.2	4.6	5.2	6.2	6.9	10.3	

[1] Estimated redfish catch of all three redfish species.

[2] On 2011-2014 STACFIS catch estimates based on the average 2006-2010 bias.

[3] STACFIS beaked redfish catch

Effects of the fishery on the ecosystem

General impacts of fishing gears on the ecosystem should be considered. A large area of Div. 3M has been closed to protect sponge, seapens and coral.

Sources of information: SCR Doc. 19/016; SCR Doc. 19/014REV, 017,021; SCS Doc. 19/06, 09, 10,11

Redfish in Division 3O — Advice June 2019 for 2020-2022

Recommendation for 2020-22

There is insufficient information on which to base predictions of annual yield potential for this resource. Stock dynamics and recruitment patterns are also poorly understood. Catches have averaged about 12 000 t since the 1960s and over the long term, catches at this level appear to have been sustainable. Scientific Council is unable to advise on an appropriate TAC for 2020, 2021 and 2022.

Management objectives

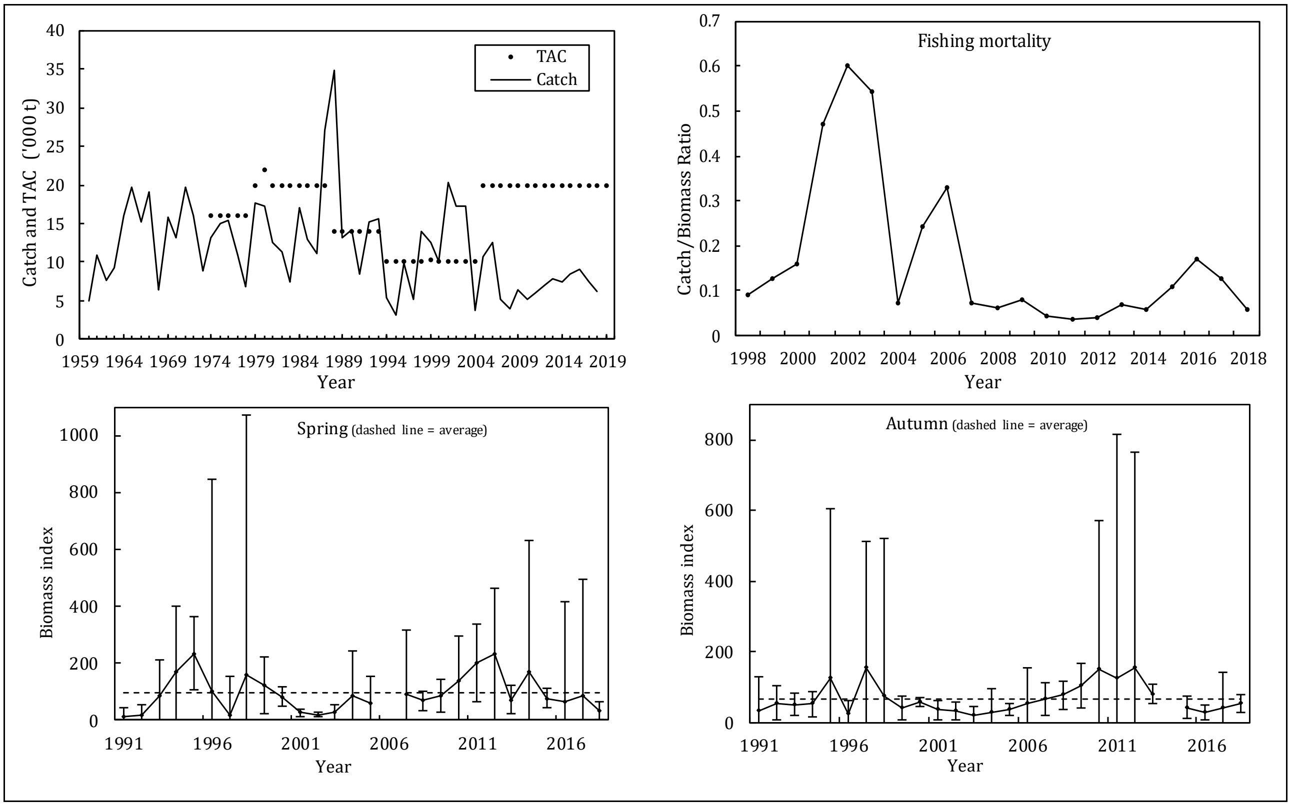
No explicit management plan or management objectives have been defined by the Commission. Convention General Principles are applied.

Convention General Principles	*Status*	*Comment/consideration*
Restore to or maintain at B_{msy}	○	B_{msy} unknown
Eliminate overfishing	🟢	Fishing mortality low
Apply Precautionary Approach	🔴	Reference points not defined
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

Survey index values for the past three years were generally at or below their time-series average compared to relatively high values observed in 2010 to 2012. Current fishing mortality is low, and recent recruitment is unknown.

Reference points

Not defined.

Projections

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

Assessment

This assessment is based upon a qualitative evaluation of trends in stock biomass and a fishing mortality proxy. 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 2022.

Human impact

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

Biological and environmental interactions

Redfish are slow growing and bear live young. Recently, 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 is currently experiencing low productivity conditions and biomass has declined across multiple trophic levels and stocks since 2014.

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:

	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
TAC	20	20	20	20	20	20	20	20	20	20
STATLANT 21	6.5	6.0	7.0	7.8	7.5	7.9	8.6	7.3	4.3	
STACFIS	5.2	6.0	7.0	7.8	7.5	8.4	9.0	7.5	6.1	

Effects of the fishery on the ecosystem

The impact of bottom fishing activities on major VMEs in the NRA has been assessed. The risk of Significant Adverse Impacts (SAIs) on coral and large gorgonian VMEs was estimated to be low, while this risk for seapen VMEs has been estimated as high. Impacts on other VMEs (erect bryozoans, large size sea squirts, crinoids, cerianthid anenomes, and small gorgonian corals) were not assessed. This assessment of bottom fishing impacts on VMEs does not include waters within coastal states jurisdictions.

A large area of Div. 3O has been closed to protect corals.

Special comments

Length data from commercial fisheries suggest that the Div. 3O redfish fishery takes predominantly immature fish.

Sources of information

SCR Doc. 19/15, 18, SCS Doc. 19/06, 09, 10, 11.

White Hake in Divisions 3NO and Subdiv. 3Ps Advice June 2019 for 2020-2021

Recommendation for 2020-2021

Given the absence of strong recruitment, SC recommends catches of white hake in Divs. 3NO should not increase. Average annual catches over 2014 to 2018 were 406 tonnes.

Management objectives

No explicit management plan or management objectives have been defined by Commission. Convention General Principles are applied. 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	🔴	Reference points not defined
Minimise harmful impacts on living marine resources and ecosystems	🟡	No specific measures, general VME closures in effect.
Preserve marine biodiversity	⚪	Cannot be evaluated

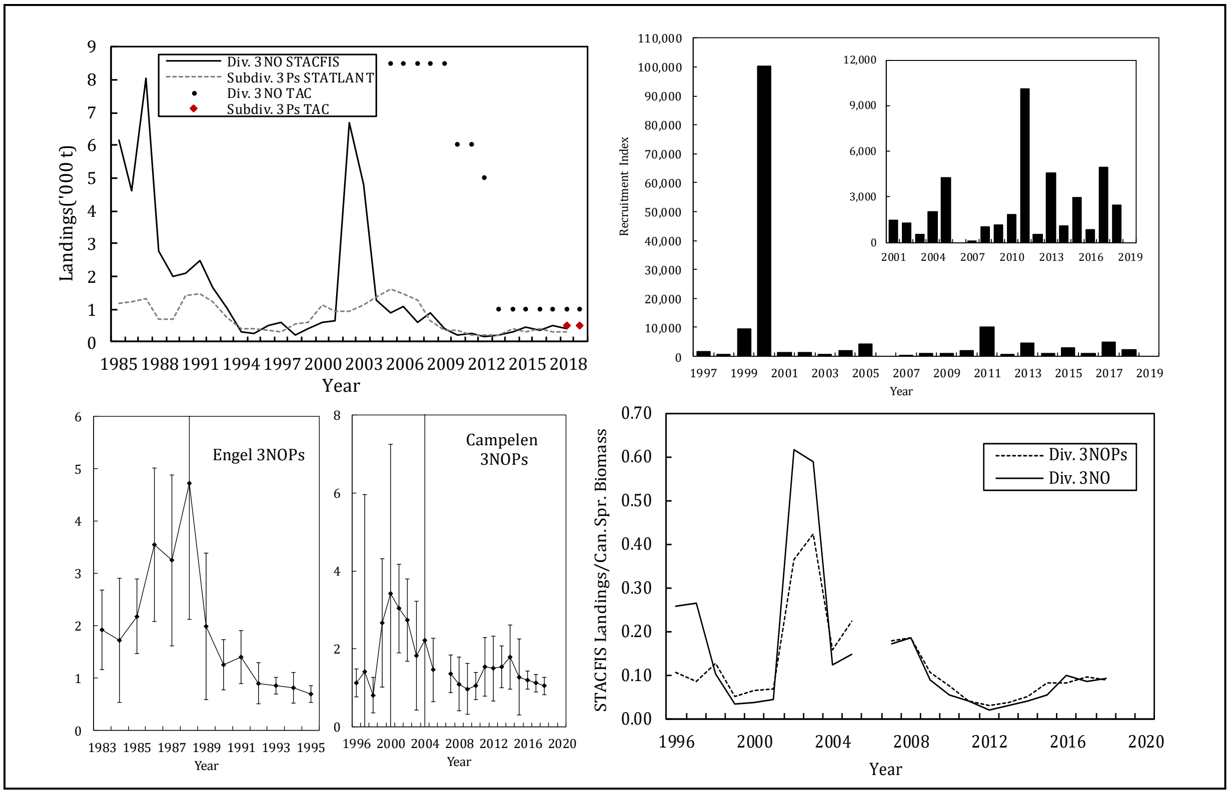
🟢	OK
🟡	Intermediate
🔴	Not accomplished
⚪	Unknown

Management unit

The management unit is confined to NAFO Div. 3NO, which is a portion of the stock that is distributed in NAFO Div. 3NO and Subdivision 3Ps.

Stock status

The assessment is considered data limited and is associated with a relatively high uncertainty. Biomass of this stock increased in 1999 and 2000, generated by the large recruitment observed in those years. Subsequently, the biomass index decreased and has since remained variable but lower. No large recruitments have been observed since 2000. Fishing mortality is low.



Reference points

Not defined.

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 2021.

Human impact

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

Biology and Environmental interactions

On the Grand Bank, white hake are near the northern limit of their range, concentrating along the southwest slope of the Grand Bank at temperatures above 5°C. The major spawning area is located on the shelf-edge on the Grand Bank. Weaker ocean currents on the continental slope during the spawning period is hypothesized to reduce potential losses of eggs and larvae due to entrainment in the Labrador Current and increase recruitment potential.

The Grand Bank (3LNO) EPU is currently experiencing low productivity conditions and biomass has declined across multiple trophic levels and stocks since 2014.

Fishery

White hake is caught in directed gillnet, trawl and long-line fisheries. In directed white hake fisheries, Atlantic cod, black dogfish, monkfish and other species are landed as bycatch. In turn, white hake are also caught as bycatch in gillnet, trawl and long-line fisheries directing for other species. The fishery in NAFO division 3NO is regulated by NAFO and in subdivision 3Ps, by Canada (quota initially established in 2018). The fishery is opportunistic when favorable ecosystem conditions allow good recruitment.

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

	2010	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**
Div. 3NO:										
TAC	6	6	5	1	1	1	1	1[1]	1[1]	1[1]
STATLANT 21	0.3	0.2	0.1	0.2	0.3	0.4	0.4	0.5	0.3	
STACFIS	0.2	0.2	0.1	0.2	0.3	0.5	0.4	0.5	0.4	
Subdiv. 3Ps:										
TAC									0.5	0.5
STATLANT 21	0.4	0.2	0.2	0.2	0.4	0.3	0.4	0.3	0.3	

[1] May change in-season. See NAFO Com. Doc. 19/01.

Effects of the fishery on the ecosystem

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

Sources of Information

SCR Doc. 19/15,20,22; SCS Doc. 19/09,10,11.

b) Monitoring of Stocks for which Multi-year Advice was Provided in 2017 or 2018

Interim monitoring of the of Splendid alfonsino in SA 6 showed a substantial decline in CPUE and catches on the Kükenthal peak in the past year. Consequently, Scientific Council decided to provide new advice for this stock in 2019 and beyond (Section VII.3.).

Interim monitoring updates of other stocks assessed in prior years were conducted and Scientific Council reiterates its previous advice as follows:

Recommendation for American plaice in Division 3M for 2018 – 2020: There should be no directed fishery on American plaice in Div. 3M in 2018, 2019 and 2020. Bycatch should be kept at the lowest possible level.

Recommendation for cod in Divisions 3NO for 2019 – 2021: No directed fishing in 2019 to 2021 to allow for stock rebuilding. By-catches 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 Divisions 3LNO for 2019-2021: *SSB* remains below B_{lim}, therefore Scientific Council recommends that, in accordance with the rebuilding plan, there should be no directed fishing on American plaice in Divisions 3LNO in 2019, 2020, and 2021. Bycatches of American plaice should be kept to the lowest possible level and restricted to unavoidable bycatch in fisheries directing for other species.

Recommendation for capelin in Divisions 3NO for 2019-2021: No directed fishery.

Recommendation for thorny skate in Divisions 3LNO and Subdiv. 3Ps for 2019-2020: The stock has been stable at recent catch levels (approximately 4 060 t, 2013 - 2017) however, given the low resilience to fishing mortality and higher historic stock levels, Scientific Council advises no increase in catches.

Recommendation for yellowtail flounder in Divisions 3LNO for 2019-2021: At a fishing mortality of 85% F_{msy}, catches of 24 900 t, 22 500 t, and 21 100 t in 2019 to 2021, respectively, have less than a 30% risk of exceeding F_{lim}. At these yields the stock is projected to have an 82% probability of remaining above B_{msy}.

c) Special Requests for Management Advice

i) Conduct a full assessment of Witch Flounder in Divs. 3NO. The advice should be provided for 2020 and 2021 (COM. Request 2)

Scientific Council responded:

Witch Flounder in Divs. 3NO Advice for 2020 and 2021

Recommendation for 2020 and 2021

All scenarios evaluated for 2020 and 2021 with fishing mortality greater than zero resulted in more than a 10% probability of the stock being below B_{lim} in 2020-2022. Advice is provided in the context of the NAFO Precautionary Approach framework which specifies that there should be a very low probability of being below B_{lim}.

SC recommends that there be no directed fishing in 2020 and 2021.

Management objectives

No explicit management plan or management objectives have been defined by the Commission. Convention General Principles are applied.

Convention General Principles	***Status***	***Comment/consideration***
Restore to or maintain at B_{msy}	🔴	Probability of $B_{2019} < B_{msy} = 97\%$
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

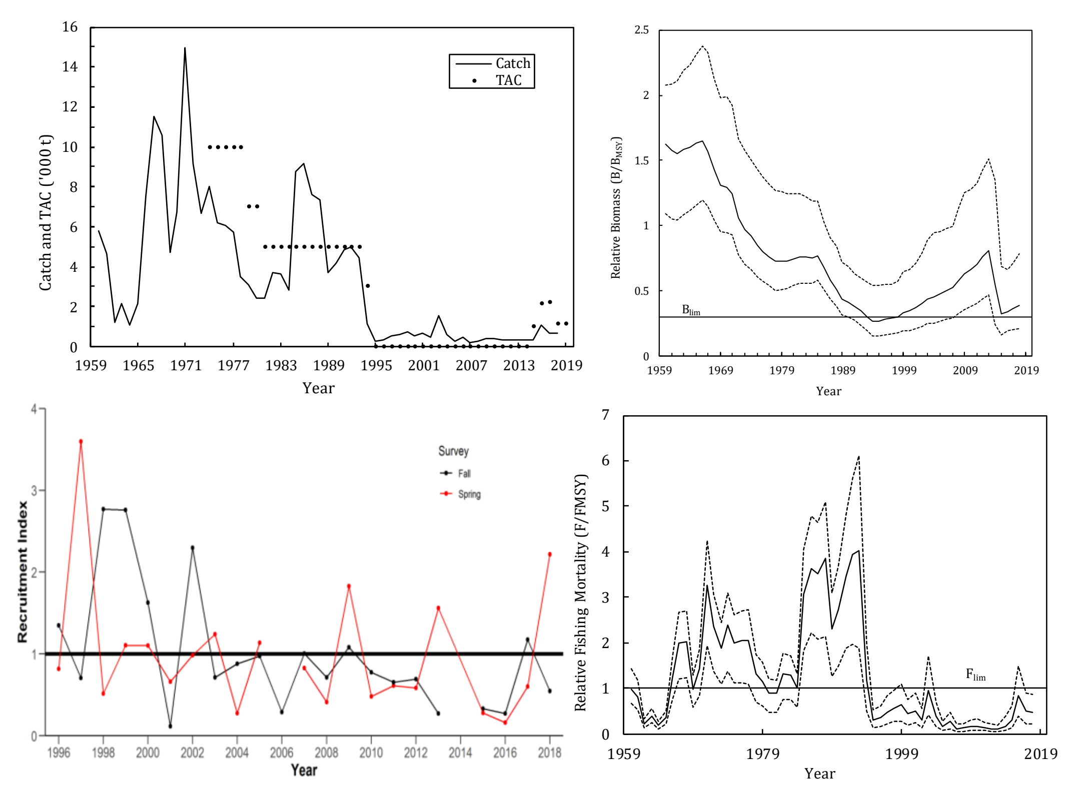
🟢	OK
🟡	Intermediate
🔴	Not accomplished
⚪	Unknown

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 size increased from 1994 to 2013 and then declined from 2013-2015 and has since increased slightly. In 2019 the stock is at 41% B_{msy} (60 000t). There is 20% risk of the stock being below B_{lim} and a 2% risk of F being above F_{lim} (0.063). With the exception of the growth of the stock following improved recruitment in the late 1990s, it is unclear if the recruitment index is representative.



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 2019 is 26% at a catch of 1 175 t (TAC 2019). The probability of F being above F_{lim} ranged from 4% to 50% for the catch scenarios tested. The population is projected to grow under all scenarios and the probability that the biomass in 2022 is above the biomass in 2019 is greater than 60% in all scenarios. The population is projected to remain below B_{msy} through to the beginning of 2022 for all levels of F examined with a probability of greater than 90%. The probability of projected biomass being below B_{lim} by 2022 was 13% to 17% in all catch scenarios examined and was 10% by 2022 in the F=0 scenario.

A second set of projections assuming that the catch in 2019 was equal to the average catch of 2017 and 2018 (662 t) was also conducted. The results were essentially the same as those assuming that the catch in 2019 equals the TAC. The probability of projected biomass being below B_{lim} by 2022 was 12% to 16% in all catch scenarios examined and was 8% by 2022 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 ($B_{2022} > B_{2019}$) under projected F values of F=0, F_{2018}, 2/3 F_{msy}, 85% F_{msy}, and F_{msy}, are presented in the following tables:

	Projections with catch in 2019 = 1 175 t	
	Projected Yield (t)	Projected Relative Biomass (B_y / B_{msy})
F=0	Median	Median (80% CI)
2020	0	0.44 (0.26, 0.79)
2021	0	0.48 (0.28, 0.88)
2022		0.52 (0.30, 0.97)
F_{2018}=0.029		
2020	745	0.44 (0.26, 0.79)
2021	792	0.47 (0.27, 0.86)
2022		0.50 (0.28, 0.94)
2/3 F_{msy}=0.042		
2020	1081	0.44 (0.26, 0.79)
2021	1144	0.46 (0.26, 0.86)
2022		0.48 (0.27, 0.92)
85% F_{msy}=0.054		
2020	1379	0.44 (0.26, 0.79)
2021	1443	0.46 (0.26, 0.85)
2022		0.47 (0.26, 0.91)
F_{msy}=0.063		
2020	1622	0.44 (0.26, 0.79)
2021	1681	0.45 (0.25, 0.85)
2022		0.46 (0.25, 0.90)

Projections with catch in 2019 = 1 175 t											
	Yield 2020	Yield 2021	P(F>F_{lim})		P(B<B_{lim})			P(B<B_{MSY})			P(B_{2022}>B_{2019})
			2020	2021	2020	2021	2022	2020	2021	2022	
F=0	0	0	0	0	18%	13%	10%	96%	94%	91%	73%
F_{2018}=0.029	745	792	4%	4%	18%	15%	13%	96%	94%	92%	67%
2/3 F_{msy}=0.042	1081	1144	18%	19%	18%	16%	14%	96%	94%	92%	65%
85%F_{msy}=0.054	1379	1443	36%	36%	18%	17%	16%	96%	94%	93%	63%
F_{msy}=0.063	1622	1681	50%	50%	18%	18%	17%	96%	95%	93%	61%

Assessment

This stock is assessed utilizing a surplus production model in a Bayesian framework. A full assessment was conducted in 2019.

The input data were catch from 1960-2018, Canadian spring survey series from 1984-1990, Canadian spring survey series from 1991-2018 (no 2006) and the Canadian autumn survey series from 1990-2018 (no 2014).

The next assessment is planned for 2021.

Human impact

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

Biological and environmental interactions

Witch flounder in NAFO Divs. 3NO are distributed mainly along the tail and southwestern slopes of the Grand Bank. The Southern Grand Bank (3NO) EPU is currently experiencing low productivity conditions and biomass has declined across multiple trophic levels and stocks since 2014.

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:

	2010	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**
TAC	ndf	ndf	ndf	ndf	ndf	1.0	2.2	2.2	1.1	1.2
STATLANT 21	0.4	0.4	0.3	0.3	0.3	0.4	1.0	0.6	0.6	
STACFIS	0.4	0.4	0.3	0.3	0.3	0.4	1.1	0.7	0.7	

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

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

Sources of Information

SCR Docs, 19/15, 19/18,19/29, 19/34; SCS 19/06, 19/08, 19/09, 19/10 19/11, 19/13

ii) Greenland halibut in SA2 + Divs. 3KLMNO: Monitor the status annually to determine whether exceptional circumstances are occurring (COM. Request 3)

The Commission requests the Scientific Council to monitor the status of Greenland halibut in Subarea 2+Div 3KLMNO annually to compute the TAC using the agreed HCR and determine whether exceptional circumstances are occurring. If exceptional circumstances are occurring, the exceptional circumstances protocol will provide guidance on what steps should be taken.

Scientific Council responded:

The TAC for 2020 derived from the HCR is 16 926 t.

SC notes that exceptional circumstances are not occurring.

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.

*Target based (**t**)*

The target harvest control rule (HCR) is:

$$TAC_{y+1} = TAC_y\left(1 + \gamma(J_y - 1)\right) \tag{1}$$

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*; five survey series are used, with *i* = 1, 2, 3, 4 and 5 corresponding respectively to Canada Fall 2J3K, EU 3M 0-1400m, Canada Spring 3LNO, EU 3NO and Canada Fall 3LNO:

$$J_y = \sum_{i=1}^{5} \frac{1}{(\sigma^i)^2} \frac{J^i_{current}}{J^i_{target}} \Big/ \sum_{i=1}^{5} \frac{1}{(\sigma^i)^2} \tag{2}$$

with $(\sigma^i)^2$ being the estimated variance for index *i* (estimated in the SCAA model fitting procedure, see **Table ii.1**)

$$J^i_{current} = \frac{1}{q}\sum_{y'=y-q}^{y-1} I^i_{y'} \tag{3}$$

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

with *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*.

*Slope based (**s**)*

The slope harvest control rule (HCR) is:

$$TAC_{y+1} = TAC_y\left[1 + \lambda_{up/down}(s_y - X)\right] \tag{5}$$

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

$$s_y = \sum_{i=1}^{5} \frac{1}{(\sigma^i)^2} s_y^i \Big/ \sum_{i=1}^{5} \frac{1}{(\sigma^i)^2} \tag{6}$$

with the standard error of the residuals of the observed compared to model-predicted logarithm of survey index *i* (σ^i) estimated in the SCAA base case operating model (Table ii.1).

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

For the target and slope based combination:

1) TAC_{y+1}^{target} is computed from equation (1),
2) TAC_{y+1}^{slope} is computed from equation (5), and

3) $TAC_{y+1} = \left(TAC_{y+1}^{target} + TAC_{y+1}^{slope}\right)/2$

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

$$\text{if } TAC_{y+1} > TAC_y\left(1+\Delta_{up}\right) \text{ then } TAC_{y+1} = TAC_y\left(1+\Delta_{up}\right) \quad (7)$$

and

$$\text{if } TAC_{y+1} < TAC_y(1-\Delta_{down}) \text{ then } TAC_{y+1} = TAC_y(1-\Delta_{down}) \quad (8)$$

During the MSE process, this inter-annual constraint was set at 10%, for both TAC increases and decreases.

The control parameters for the adopted HCR are shown in Table ii.2 with a starting TAC of 16 500 t in 2018. Missing survey values are treated as missing in the calculation of the rule, as was done in the MSE. In such cases, q in equation (3) is reduced accordingly.

Table ii.1. The weights given to each survey in obtaining composite indices of abundance (target rule) and composite trends (slope rule) are proportional to the inverse squared values of the survey error standard deviations σ^i listed below.

Survey	σ^i
Canada Fall 2J3K	0.22
EU 3M 0-1400m	0.21
Canada Spring 3LNO	0.49
EU 3NO	0.38
Canada Fall 3LNO	0.26

Table ii.2. 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.

TAC_{2018}	16 500 tonnes
γ	0.15
q	3
α	0.972
λ_{up}	1.00
λ_{down}	2.00
X	-0.0056
Δ_{up}	0.10
Δ_{down}	0.10

Table ii.3. Data used in the calculation of the TAC for 2020.

	Survey				
	Canada Fall 2J3K	EU 3M 0-1400m	Canada Fall 3LNO	EU 3NO	Canada Spring 3LNO
2014	33.34	23.92		6.24	0.66
2015	22.29	47.52	0.9	9.49	
2016	18.54	28.3	1.3	8.8	0.66
2017	15.1	42.67	1.3	16.63	
2018	17.1	29.8	1.89	7.88	1.9
J^i_{target}	25.12	25.20	1.71	6.61	1.02

The TAC for 2020 was calculated based on the HCR. The target based component was 16 690 t and the slope based component was 17 161 t resulting in a computed TAC of 16 926 t for 2020. This is not greater than a 10% increase (TAC 2019 = 16 521 t) and so the 10% constraint on TAC change is not applied.

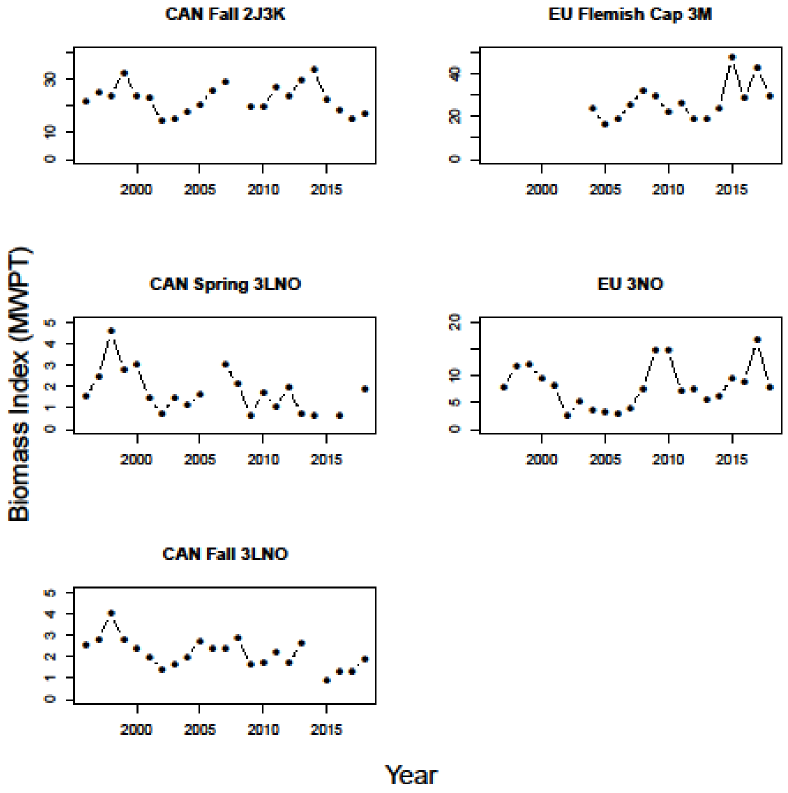


Figure ii.1. Input for Greenland Halibut in Subarea 2 + Divisions 3KLMNO Harvest Control Rule. Survey data come from Canadian fall surveys in Divs. 2J3K, Canadian spring surveys in Divs. 3LNO (2015 and 2017 surveys incomplete and not used in the calculation of the HCR), Canadian fall surveys in Divs. 3LNO (2014 survey incomplete and not used in the calculation of the HCR), EU Flemish Cap surveys (to 1400m depth) in Div. 3M and EU surveys in 3NO.

Exceptional Circumstances

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

The following criteria constitute Exceptional Circumstances:

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);*

> SC notes that both the Canadian fall 2J3K and spring 3LNO surveys were incomplete in 2018. Areas that were missed are inhabited by Greenland halibut. The unavailability of the strata missed in 2018 had minimal impact on the indices (see STACREC: Appendix III, section 7e). It was determined that the 2018 Canadian fall 2J3K and spring 3LNO indices would be included in the calculation of the HCR. Therefore, exceptional circumstances do not presently arise from missing survey data.

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;

> Confidence intervals for the projected indices in the SSM model are not available due to incomplete documentation of the MSE and SC is not currently able to compute them. SC will provide an update assessment and further investigate this issue in 2020. Consequently, probability envelopes are currently only included for the SCAA operating model. The composite survey index was above the 90 percent probability envelope in 2017 but within those bounds in 2018. SC does not consider that this constitutes exceptional circumstances for 2018.

TACs established that are not generated from the MP .

> The TAC established for 2019 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:

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;

> As noted previously, confidence intervals for the projected indices in the SSM model are not available due to incomplete documentation of the MSE.
>
> The survey indices are within the defined envelopes from SCAA operating models except for the EU 3M survey and the EU 3NO survey in 2017, both of which were above the 90% but within the 95% probability envelope. In 2018 all surveys are within the specified probability envelopes. This does not constitute exceptional circumstances for 2018.

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

> Recruitment at age 4 has been below average for the last 6 year classes. SC does not consider that this constitutes exceptional circumstances at this time; however, this remains a concern.

discrepancies between catches and the TAC calculated using the MP

> The TAC for 2018 was 16 500 t. The catch in 2018 was 16 630 t (<1% difference). SC does not consider that this constitutes exceptional circumstances.

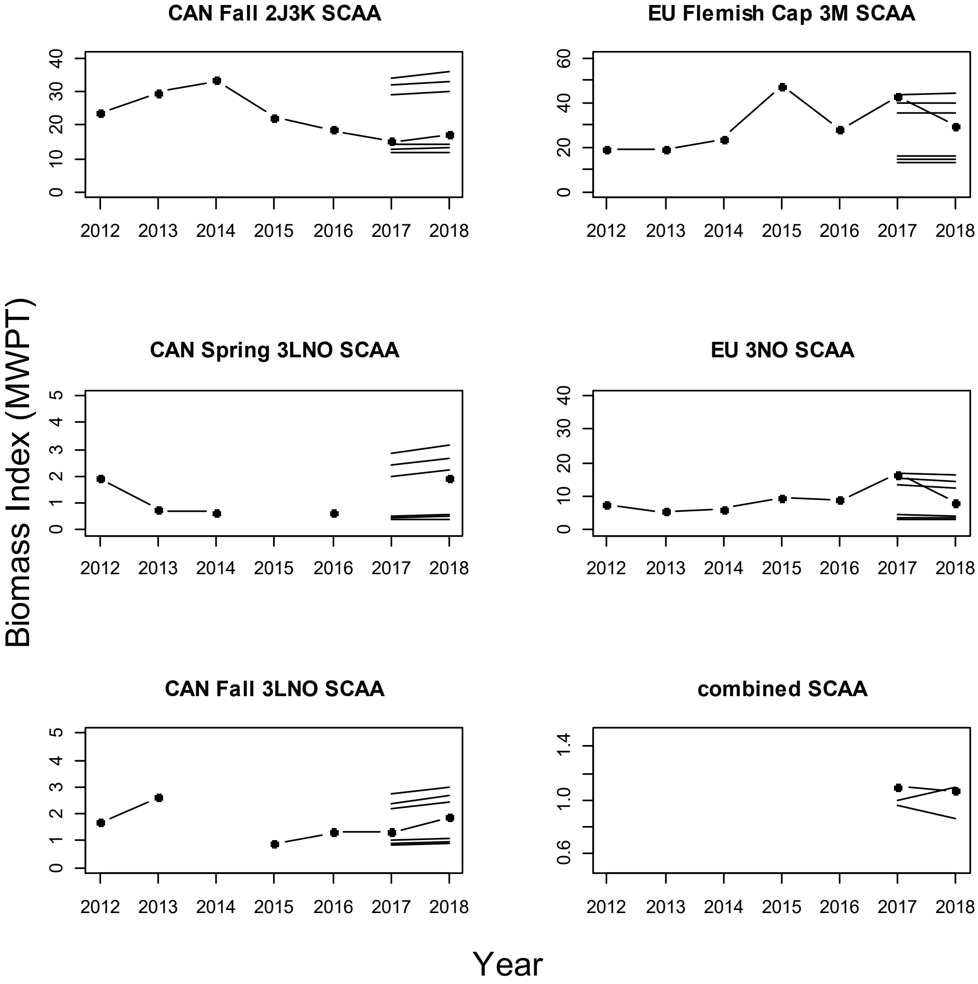


Figure ii.2. Greenland Halibut in Subarea 2 + Divisions 3KLMNO. Mean weight per tow from Canadian fall surveys in Divs. 2J3K, Canadian spring surveys in Divs. 3LNO (2015 and 2017 surveys incomplete and not used in the calculation of the HCR), Canadian fall surveys in Divs. 3LNO (2014 survey incomplete and not used in the calculation of the HCR), EU Flemish Cap surveys (to 1400m depth) in Div 3M and EU surveys in 3NO. The figure also shows the composite index used in the target based component of the HCR. For the survey indices the 80, 90 and 95 percent probability envelopes are shown (for 2017 and 2018). For the composite index the 90 percent probability envelope is shown (for 2017 and 2018). All probabilities are from the SCAA base case simulation.

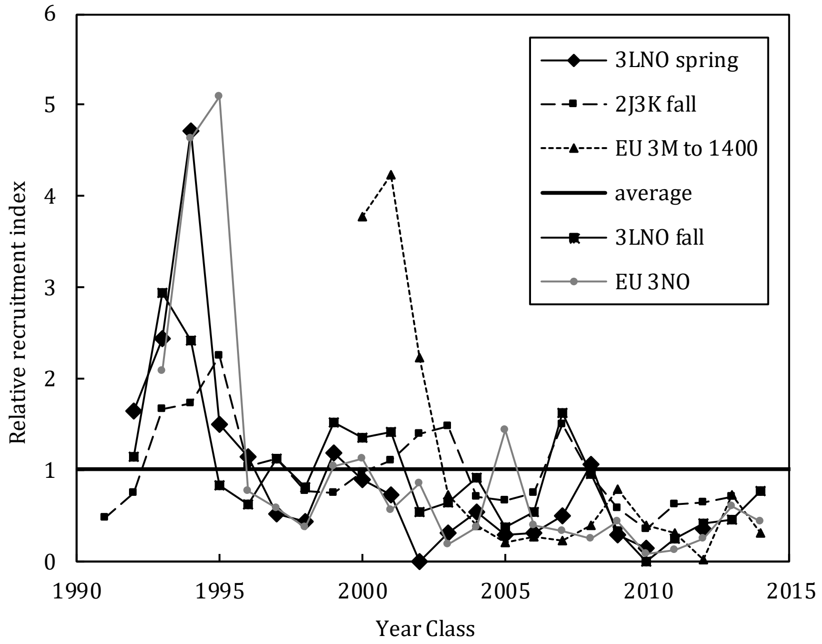


Figure ii.3. Greenland Halibut in Subarea 2 + Divisions 3KLMNO. Relative recruitment indices from Canadian autumn surveys in Div. 2J3K, Canadian spring surveys in Div. 3LNO, Canadian fall surveys in Div. 3LNO, EU survey in 3NO and EU survey of Flemish Cap. Each series is scaled to its average and the average line is shown. Note that the Canadian fall 2J3K and Canadian spring 3LNO survey for 2018 are not included.

iii) Implement agreed steps in the workplan for 3M cod MSE (COM. Request 4)

The Commission requests the Scientific Council to implement the steps as described in the revised calendar (COM/SC Doc. 18-02, Annex 4) relevant to the SC for progression of the 3M Cod Management Strategy Evaluation for 2019.

Scientific Council responded:

SC reviewed the progress of the 3M cod MSE work to date. SC encouraged continued progress on the technical aspects of this project and will review the full suite of OMs in future, as required. SC emphasized that future work should take the time required to develop the technical basis and to allow sufficient review.

SC reviewed the progress of the 3M cod MSE work to date. This review included the results of the meeting of SC in January 2019 as well as the April 2019 WG-RBMS meeting. Particular note was taken of the RBMS April 2019 decision to delay the 3M cod MSE timeline until September immediately prior to the NAFO Annual Meeting. At that time, a recommendation will be made to either continue with the MSE or to abandon the current project.

Low recruitment Operating Models (OMs) have been developed following the April WG-RBMS meeting. The SC recognized the substantial effort made by the technical team to conduct the tasks agreed for the MSE in a timely manner and thanked them for their extensive efforts.

Results from a selection of OMs with low recruitment regime were presented with $F = 0$, as well as with slope and target Harvest Control Rules (HCRs). The outcomes of these scenarios indicate that if the current low level of recruitment continues for 2 or 3 more years, the risk of the *SSB* falling below B_{lim} in the short to medium term is greater than 50%, even with no fishing. Another conclusion that can be drawn from all MSE results seen until now is that the HCRs currently being considered (and, particularly, the target HCR) need to be improved by further investigating the values of the different parameters that control the HCR (e.g. starting TAC, parameters controlling rate at which HCR responds to stock changes, etc.).

SC discussed potential ideas for improving the current set of OMs. Some of the aspects discussed include the uncertainty of the biological parameters, the recruitment in the projections and the specifications of the HCRs. SC noted the focused debate on these issues during the January intersessional SC meeting and that improvement in these aspects for this case is not an easy task and would require substantial time and effort.

SC encouraged continued progress on the technical aspects of this project and will review the full suite of OMs in future meetings, as required. SC emphasized that future work should take the time required to develop the technical basis and to allow sufficient review. The existing MSE schedule is not realistic to allow the technical work to complete and have sufficient time to consult with managers on results. Should WG-RBMS continue with the 3M cod MSE after September 2019, the current schedule (adopted in September 2018) should be modified ensuring sufficient time to conduct and review the technical work and to allow the requisite consultation and discussion with managers on the results.

iv) Continue evaluation of the impact of scientific trawl surveys on VME (COM. Request 5)

The Commission requests that Scientific Council continue its assessment of scientific trawl surveys on VME in closed areas, and the effect of excluding surveys from these areas on stock assessment metrics.

Scientific Council responded:

SC notes that work planned to complete this task did not occur as a result of other work commitments.

Based on previous analysis, SC reiterates its ongoing recommendation that until this issue is fully resolved scientific bottom trawl surveys in existing closed areas be avoided if possible and additional work be expedited to complete the evaluation of excluding RV surveys in closed areas on stock assessment metrics.

Additionally, as noted in 2018, SC is currently unaware of monitoring plans and sampling methods for VMEs (other than trawls), and therefore the Commission may wish to consider possible options for non-destructive regular monitoring within closed areas.

v) Implement the steps of the action plan for progression in the management and minimization of Bycatch and discards (COM. Request 6)

The Commission requests the Scientific Council to implement the steps of the Action plan relevant to the SC and in particular the tasks identified under section 2.2 of the Action Plan, for progression in the management and minimization of Bycatch and discards (COM Doc 17-26).

Scientific Council responded:

SC reiterates the advice given in 2018 that work on items will continue over the next two years.

The following action points in the action plan are addressed to Scientific Council:

Action point 2.2. Specific issues by time, area, depth, fleet and fishery

Identification of species under NAFO catch or effort limits with high survivability rates. AM 2020 SC

This would require at a minimum a literature search and potentially discard mortality experiments.

Action point 3.1. Moratoria species

Identify moratoria stocks where the level of bycatch/discards may be impeding recovery SC (with BDS) AM2021

For most stocks under moratorium, even if the levels of bycatch are low, these seem to be delaying recovery, combined with impacts of any environmental factors.

Action point 3.2. Areas where there is a risk of causing serious harm to by-catch species

Identify areas, times and fisheries where by-catch and discards, notably of moratoria species, that have a higher rate of occurrence. SC (with BDS) AM2021

This item should include the Secretariat and should examine several years of haul by haul logbook data as well as observer data. Some work has been done in the past examining landed bycatch in various fisheries and a preliminary look at the logbook data for 2016 was presented at BDS in 2017. SC plans to address this further in 2020 in preparation for 2021.

Action point 4.2. Fishery-specific solutions

For NAFO fisheries identified as priorities under Action group 3, assess the merits of specific solutions per fishery, including the development and assessment, with the Scientific Council, of selectivity tests. WG-BDS, STACTIC, SC AM 2021

Action point 4.3 Identification of best practices

Best practices / possible mitigation measures to avoid by-catch per time, area, depth, fleet and fishery. BDS SC AM 2020

As this action relies on action group 3 completion of which is not due until 2021, this work cannot be completed until after that time.

vi) Conduct a full assessment of 3M golden redfish (COM. Request 7)

The Commission requests Scientific Council to conduct a full assessment on 3M golden Redfish in 2019 and, acknowledging that there are three species of redfish that exist in 3M and are difficult to separate in the catch, provide advice on the implications for catch reporting and stock management.

Scientific Council responded:

SC conducted a full assessment of 3M golden redfish, no models were applied; the assessment was based on EU survey and catch data. The separation of the three species is difficult and therefore it is impossible to implement in catch reporting. This separation is made in the EU research survey.

Only two pulses of recruitment were observed (1990/1991 and 2004/2006), otherwise recruitment has been poor. A large increase in the stock biomass and abundance was observed during the mid to late 2000s but these have since declined and are now at very low levels. Catches have also been very low in recent years.

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.

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.

There are three species of redfish on the Flemish Cap (NAFO Division 3M): deep-sea redfish (*Sebastes mentella*) with a maximum abundance at depths greater than 300m; golden redfish (*Sebastes norvegicus,* formerly *S. marinus*) and Acadian redfish (*Sebastes fasciatus*) preferring shallower waters of less than 400m. Due to their external resemblance, *S. mentella* and *S. fasciatus* are commonly designated as beaked redfish.

The separation of the three species is very difficult and therefore it is impossible to implement separation at the level of catch reporting. This separation 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 applied in assessments of beaked redfish (Table vi.1 and Figure vi.1).

Table vi.1 Commercial catches (tonnes) by species groups and golden redfish percentage in the catches, 2005- 2018.

	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Beaked redfish	4148	5997	5149	4277	3656	5410	8994	6281	5168	4565	5243	6152	6914	10330
Golden redfish	**2402**	**1158**	**1513**	**4188**	**7662**	**3086**	**2127**	**1927**	**2609**	**2851**	**1701**	**358**	**251**	**148**
Total	6550	7156	6662	8465	11317	8496	11121	8208	7778	7416	6944	6510	7165	10478
% golden redfish	36.7	16.2	22.7	49.5	67.7	36.3	19.1	23.5	33.6	38.4	24.5	5.5	3.5	1.4

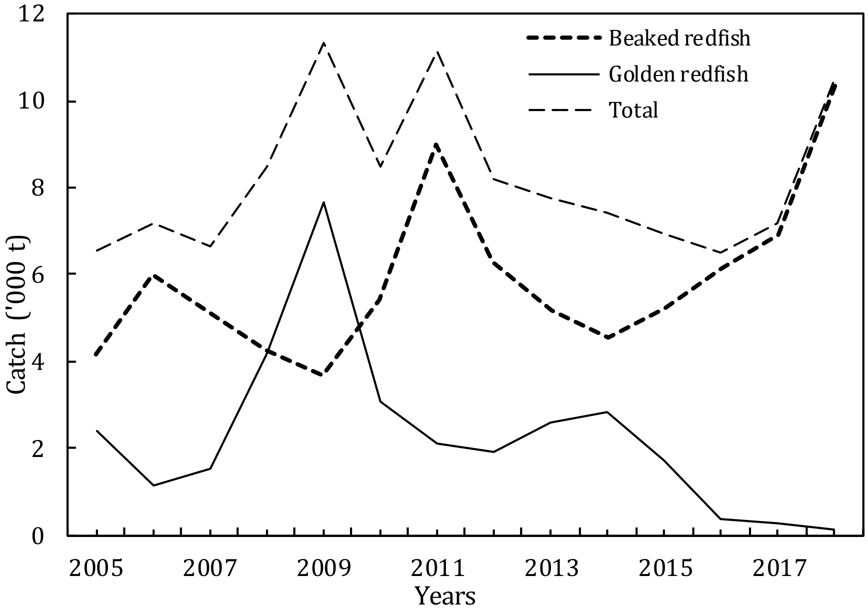


Figure vi.1. Commercial catches of Div. 3M Redfish by species groups, 2005-2018.

SC conducted a full assessment on 3M golden redfish, no models were applied; the assessment was based on EU survey and catch data (SCR Doc. 19/035).

The 1988-2018 EU survey biomass and abundance indices for golden redfish are presented in Figure vi.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 2018 are at very low levels. Survey results are noisy, with the characteristic variance of redfish indices, but broad trends show through the noise.

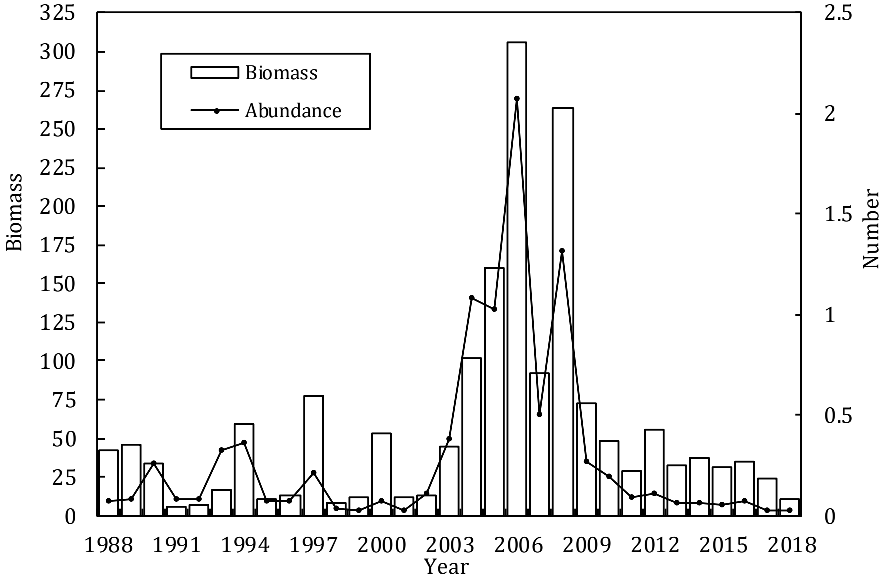


Figure vi.2. EU biomass and abundance indices, 1988-2018.

Only two pulses of recruitment were observed during the EU survey series, 1990/1991 and 2004/2006, since then only poor recruitments have been observed (Figure vi.3).

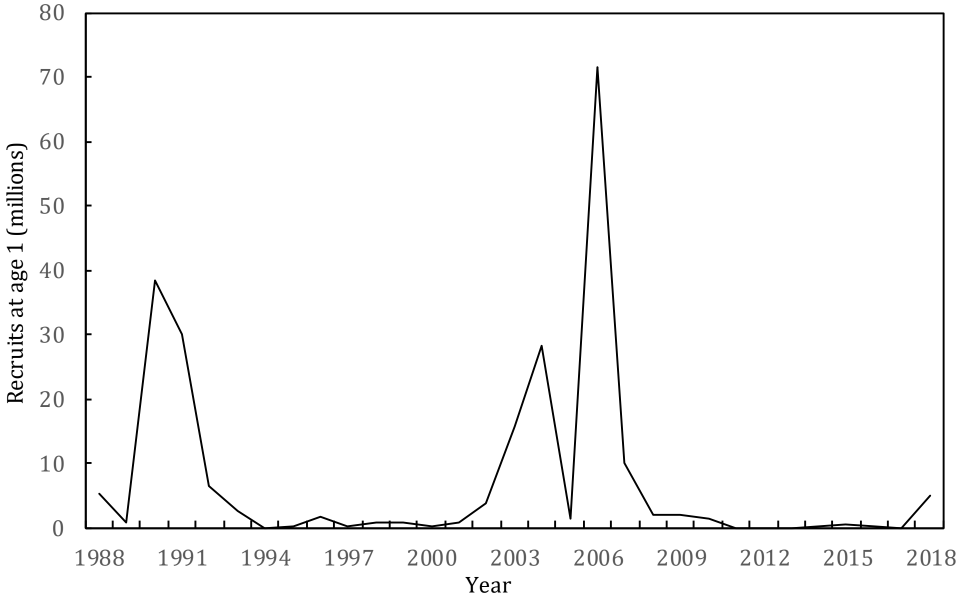


Figure vi.3. EU survey: abundance at age 1, 1988-2018.

No relationship was observed between spawning biomass and recruitment (Figure vi.4).

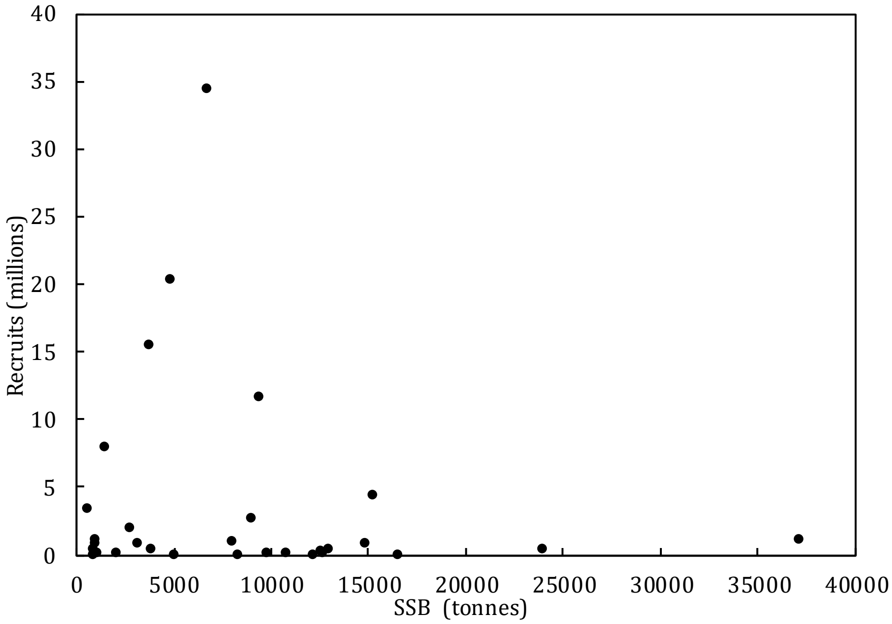


Figure vi. 4. Div. 3M golden redfish *survey SSB and Recruitment (Age 1)*.

An analysis of the yield, biomass and *SSB* per recruit curves gives F reference points values that are high for redfish, however it is premature to draw conclusions from these due to the uncertainties found in several of the input biological parameters.

In recent years the survey biomass index has dropped and the percentage of golden redfish in the commercial fishery is practically residual (Figure vi.1). 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.

This assessment was reviewed and approved by an external reviewer during the current meeting.

vii) Provide further guidance on the implementation of an ecosystem approach and application of the Ecosystem Road Map (COM. Request 8)

The Commission requests the Scientific Council continue to refine its work under the Ecosystem Approach Roadmap, including testing the reliability of the ecosystem production potential model and other related models, and to report on these results to both the WGEAFFM and WGRBMS to further develop how it may apply to management decisions.

Scientific Council responded:

As further guidance on the implementation of an ecosystem approach and application of the NAFO Roadmap, SC notes that Total Catch Indices (TCIs) aim to provide information for ecosystem-level strategic management advice that can complement stock-level tactical advice. In principle, once TCIs can be estimated with sufficient reliability and precision, these should provide an ecosystem context to evaluate the aggregate removals within an EPU, and could serve to address questions not considered as part of single species assessments (e.g., tradeoffs). Meaningful progress toward the implementation of ecosystem management measures based on SC Advice requires managers to provide specific ecosystem-level objectives.

A work plan has been developed to evaluate the reliability of the Ecosystem Production Potential (EPP) model and will be further reported on next year.

Accordingly, SC **recommends** the *Commission develop, through WG-EAFFM, options by which ecosystem considerations can be operationally integrated into fisheries management advice and management measures through consideration of the risk of damage or deterioration of the ecosystem based on the principles of Total Catch Indices.*

NAFO's amended convention, which came into force in 2017, commits the organization to apply an ecosystem approach to fisheries management. The Roadmap provides the guiding principles that NAFO is following to achieve this goal, and an operational perspective of how the implementation of the ecosystem approach is being conceived in a workflow process that suits NAFO structure and practices.

To date, NAFO has made significant progress in several areas of the Roadmap including the identification and delineation of VMEs and the establishment of fishing closures for their protection, and the initial assessment of significant adverse impacts on VMEs from fishing activities. SC has defined Ecosystem Production Units (EPUs) within NAFO Regulatory Area (NRA), and progress has been made on tiered modelling approaches to investigate ecosystem production potential and multispecies interaction. In terms of further implementation of the Roadmap, SC has been developing ecosystem-level summary sheets aimed at providing an analogous synthesis of information found in the stock summary sheets. In addition, the way of considering and using information contained within the ecosystem summary sheet when discussing and setting Total Allowable Catches (TACs) for individual stocks within an EPU is a step currently under discussion to further implementation of the Roadmap.

Ecosystem Summary Sheets

Analogous to current Stock Summary Sheets, Ecosystem Summary Sheets (ESS) are intended to provide a synoptic perspective on the state of NAFO ecosystems and their management regime and they are to be updated every 3-5 years. Sample ESS were developed by SC in June 2018 and formally presented to WG-EAFFM in August 2018.

As a way of example, SC developed and populated an initial ecosystem summary sheet for the Grand Bank (3LNO) EPU during the June 2018 meeting, one of the EPUs being used as pilot ecosystems for the implementation of the Roadmap for the period 2013-2017. The example was formally presented to WGEAFFM where managers raised a number of concerns about the structure, content, and terminology used in the ESS draft example (COM-SC WGEAFFM Report 2018).

Use of terminology that can be confused with existing concepts in a single-species context, especially those that have prescribed legal ramifications, was a concern. For example, the term "overfishing" can have a specific technical meaning in a single-species stock assessment context and this term can trigger prescribed legal and management procedures. Also, there is no formal and broadly adopted definition of ecosystem overfishing, nor is there a legal/management framework that can formally trigger actions. Consequently, SC will refer to cases in which catches are "exceeding" or "above" indicator values.

The potentially restrictive interpretation of the term "Total Catch Ceiling" in the context of implementing Tier 1 of the Roadmap was also a concern. The term "Total Catch Ceiling" was coined to refer to the estimated level of catches considered to be sustainable from an ecosystem productivity perspective. Estimates for these ecosystem-level catches have so far been derived from Ecosystem Production Potential models (EPPs), and are being provided as guidelines and not as hard limits. The concept formerly known as "Total Catch Ceilings" will be renamed "Total Catch Indices" (TCI) in the Ecosystem Summary Sheets and in reporting on ecosystem-level Fishery Production Potential (FPP).

A number of elements of the Ecosystem Summary Sheet example included in the June 2018 report were incomplete. Under "Ecological features", the sub-grouping "State of biological diversity" will have two components: 1) "Status of VMEs", and 2) "Status of non-target species and protected species (or in need of protection)". In addition, SC was asked to consider incorporation of topics under "Management Measures/Other Consideration". Originally this section under management measures only contained references to activities other than fisheries (e.g. oil and gas, pollution). This section has been expanded to include fisheries not managed by NAFO. Under this topic two line items have been included to allow a general reporting on these fisheries, and the protection provided to VMEs by other jurisdictions within the same ecosystem unit. The indicators should be developed in collaboration with these other organizations and/or coastal states. **The sections that have been altered appear in *italics* in the example summary sheet for the 3LNO EPU shown below**. WGESA will carry out a formal evaluation of the new indicators at the WG Meeting in November 2019.

3LNO EXAMPLE Ecosystem Status

Example recommendation: The Grand Bank (3LNO) EPU is currently experiencing low productivity conditions and biomass declines across multiple trophic levels and stocks. Although reduced productivity appears to be driven by bottom-up processes, current aggregate catches for piscivore species have been increasing and exceeding the guideline level for ecosystem sustainability. Reductions in piscivore catch levels are recommended.

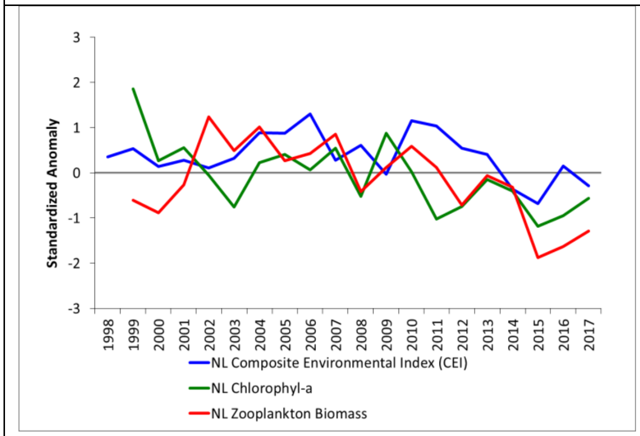
ECOLOGICAL FEATURES					
Convention Principle					**Comment**
a		**Ecosystem status and trends (long-term sustainability)**	**S**	**T**	**Summary of multiple trends/state**
	1	Physical Environment	🟨	🟨	No clear 5-yr trend but 10-yr declining trend
	2	Primary Productivity	🟥	🟨	Reduced nutrients, phytoplankton standing stocks and productivity.
	3	Secondary Productivity	🟥	🟥	Reduced total zooplankton biomass, with increased abundance of small-sized taxa.
	4	Fish productivity	🟥	🟥	Declines in total, finfish, and shellfish biomass since 2013-14. Overall biomass below pre-collapse levels.
	5	Community composition	🟨	🟨	Shellfish has declined in dominance, but piscivores have yet to regain their pre-collapse dominance.
b		**Ecosystem productivity level and functioning**			**Summary of multiple trends/state**
	1	Current Fisheries Production Potential	🟥	🟥	Total biomass further declined from 50% to ~30% of the estimated pre-collapse level.
	2	Status of key forage components	🟥	🟥	Reduced levels of capelin, sandlance, arctic cod, and shrimp.
	3	Signals of food web disruption	🟨	🟥	Diet variable, declining trend in stomach content weights.
e		**State of biological diversity**			**Summary of multiple indicators**
	1	*Status of VMEs*			*VME state and change of state in recent period will be initially monitored using 1) the area of the VME habitat (i.e. KDE polygon), 2) the level of biomass that indicates a high concentration of VME-defining taxa, and 3) the frequency and magnitude of observations of VME-defining taxa and benthic communities within the VME habitat outside defined VME protection zones.*
	2	*Status of non-target species and protected species (or in need of protection)*			*The status of non-target species will be monitored through 1) the proportion of taxa below some specified level, e.g. 20% of maximum historical biomass/abundance based on survey indices for fish species, 2) trends in key benthic species/communities for regular surveys, 3) trends in marine mammals, and 4) trends in seabirds.*

MANAGEMENT MEASURES					
Convention Principle					**Comment**
c/ d		**Apply Precautionary *Principle***	**S**	**T**	**Summary of metrics on level of management action**
	1	*Total Catch Indices (TCI) and catches*	🟥	🟥	*Piscivores catches have been exceeding their TCI; suspension feeding benthos exceeded their TCI in 2016.*
	2	Multispecies and/or environmental interactions	🟥	🟥	No explicitly consideration of species interactions and/or environmental drivers.
	3	Production potential of single species	🟨	🟨	Only 60% of stocks are in conditions of supporting fisheries; some stocks have declining trends.
d/ e		**Minimize harmful impacts of fishing on ecosystems**			**Summary of metrics on level of management action**
	1	Level of protection of VMEs	🟨	🟩	*Some VMEs without protection. Protection has improved. Fishing with bottom contacting gears does not intrude in closed areas. The level of risk to VMEs by fisheries outside closed areas needs to be assessed.* *Level of protection to VMEs will be monitored using 1) the fraction of VME biomass/area under protection, and 2) the level of fishing effort exerted within unprotected VME habitats.*
	2	Level of protection of exploited species	🟨	🟩	*Total Catch Index guidelines have been developed. 70% of managed stocks have LRPs or HCRs, but some stocks only have survey-based LRPs. No multispecies assessment in place.*
d/ f		**Assess significance of incidental mortality in fishing operations**			**Summary of metrics on level of management action**
	1	*Discard level across fisheries*	▨	▨	*Integrative indicators need to be compiled. These indicators include: 1) the tonnage of discards in each and across fisheries, 2) the fraction of discard by fishery and across fisheries, 3) the fraction of discard with respect to stock/community size and/or productivity, and 4) the amount/fraction of discard related to undersize fish.*
	2	*Incidental catch of depleted/protected/unregulated species*	▨	▨	*Integrative indicators need to be compiled. These indicators include: 1) records of frequency and amount of catches, and 2) the ratio between these catches and estimates of stock size when available. At minimum, a list of these species incidentally caught needs to be compiled.*
OTHER CONSIDERATIONS (outside mandate of NAFO Convention)					
Human Activities other than fisheries					**Comment**
	1	Oil and gas activities	▨	▨	There are four offshore production fields on the Grand Bank and intense exploration activities along the eastern shelf break and Flemish Pass.
	2	Pollution	▨	▨	…
Fisheries not managed by NAFO					***Comment***

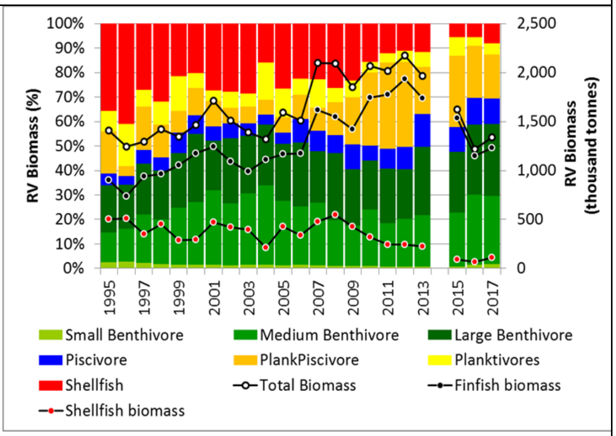
		Non-NAFO fisheries *(coastal states and other RFMOs)*			*To the extent possible compile the description, indicators and/or reporting level to be developed in collaboration with coastal states and/or other RFMOs*
		Level of protection of VMEs (coastal states and other RFMOs)			*To the extent possible compile the description, indicators and/or reporting level to be developed in collaboration with coastal states and/or other RFMOs*

Figure vii.1. Upper left-hand panel shows anomalies of the standardized composite environmental index (blue), composite index of chlorophyll *a* abundance (green) and the composite index of zooplankton biomass (red). Upper-right panel shows the relative composition of the fish and shellfish community functional feeding groups derived from research vessel trawl surveys (colour bars – referenced to the left axis with the legend at the bottom) and the total, finfish and shellfish biomass. Lower left-hand panel shows the nominal total catch of functional groups (estimated from STATLANT21A data) scaled relative to the Ecosystem Production Potential model-derived estimates of Total Catch Indices disaggregated for each functional group. The content of the lower-right panel has yet to be determined.

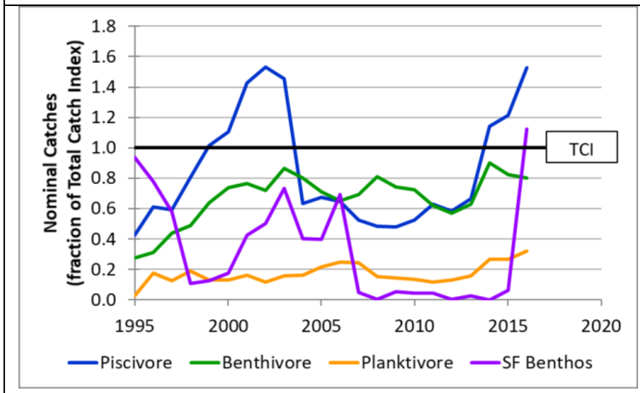
PHYSICAL ENVIRONMENT AND LOWER TROPHIC LEVELS



FISH COMMUNITY COMPOSITION AND BIOMASS



ECOSYSTEM AGGREGATE CATCHES



BY-CATCH IMPACTS

To be defined

3LNO EXAMPLE Ecosystem Status Narrative

ECOLOGICAL FEATURES

Ecosystem Status and Trends

The last 5 years have been characterized by reduced levels of nutrients, phytoplankton standing stock and primary production, and total zooplankton biomass. Reduction in zooplankton biomass has been accompanied with changes in the composition of the zooplankton community, where small-sized taxa have significantly increased in abundance while the larger, lipid-rich taxa have declined. Since 2013, total fish biomass has lost the gains built-up since the mid-1990s. Fishes have increased their dominance in the community at the expense of shellfish, but the piscivore functional group has not regained its pre-collapse dominance.

Ecosystem productivity level and functioning

The Grand Bank is experiencing low productivity conditions. After the regime shift in the late 1980 and early 1990, this ecosystem never regained its pre-collapse level. Improved conditions between the mid-2000s and early 2010s allowed built-up of total biomass up to ~50% the pre-collapse level. This productivity was associated with good environmental conditions for groundfish, and modest increases in forage species (capelin). Since 2013, forage species have declined, and a reduction in total biomass to ~30% of pre-collapse levels has occurred across all fish functional groups. Although variable, diet composition of cod suggests reduced contributions of forage species, and average stomach content weights of cod and Greenland halibut have shown declines, suggesting poor foraging conditions.

State of biological diversity

Biological diversity is a multi-faceted concept. Out of its many dimensions, assessment of its state is being limited to Vulnerable Marine Ecosystems (VMEs) and the number of fish species considered depleted. Although identification and delineation of VMEs is being done, it is difficult to assess their status given the absence of a defined baseline and the unquantified impacts from historical fishing activities. Work on metrics to assess VME state and the evaluation of depleted species is ongoing, but results are not yet available.

MANAGEMENT MEASURES

Precautionary Principles

The NAFO Roadmap addresses sustainability of fishing at three nested levels of ecosystem organization: ecosystem, multispecies and stock levels. Catches of piscivore species have been above their Total Catch Index (TCI) in the past, are currently increasing, and since 2014 are once again above their TCI. Catches for suspension feeding benthos were also above their TCI in 2016. Only 60% of the NAFO managed stocks in the Grand Bank are in conditions of supporting fishing, and some of these stocks are showing declining trends. Impacts of species interactions and/or environmental drivers are not currently being considered in advice or management.

Minimize harmful impacts of fishing on ecosystems

Minimization of harmful impacts of fishing on benthic communities has been focused on the protection of VMEs. Many coral and sponge VMEs in the Grand Bank are currently protected with dedicated closures, but the 3O coral closure does not provide protection for the identified VMEs in that area. Other non-coral/sponge VMEs have been identified on the tail of the Grand Bank but remain unprotected because of difficulties in delineation of areas of high concentration at appropriate spatial scales.

At the ecosystem level, Total Catch Indices for this ecosystem have been developed, while at the stock level 70% of managed stocks have LRPs or HCRs, although some LRPs are based on survey indices. At this time, there are no multispecies assessments to inform on trade-offs among fisheries, and no stock-assessment explicitly considers species interactions and/or environmental factors as drivers, but there is ongoing work on these issues.

Assess significance of incidental mortality in fishing operations

By-catch limits and move-on measures are in place for some fisheries, but there is no integrated assessment of by-catch in fisheries operations and their potential impact at the ecosystem scale. There are no dedicated measures to quantify and manage by-catch of listed species. Additional work on these topics is required.

OTHER CONSIDERATIONS

Human activities other than fishing

There are four offshore oil and gas fields currently in production in the southern Grand Bank, and exploration activities are ongoing along the eastern shelf break of the Grand Bank and the Flemish Pass. Exploration activities involve seismic surveys and exploratory drilling.

Update of Total Catch Indices (TCI) in NAFO Ecosystem Production Units (EPUs)

The NAFO Roadmap establishes a 3-tier hierarchical sequence to derive sustainable harvest levels. Tier 1 evaluates fisheries productivity at the ecosystem level, taking into account environmental conditions and ecosystem state. Towards implementing Tier 1 considerations, SC has been producing guidelines for Total Catch Indices (TCIs) for the three Ecosystem Production Units (EPUs) targeted for pilot Roadmap implementation. These EPUs are the Flemish Cap (3M), the Grand Bank (3LNO), and the Newfoundland Shelf (2J3K).

Derivation of TCIs (tonnages) is based on a minimum realistic ecosystem production potential (EPP) model which allows exploitation of suspension-feeding benthos, planktivores, benthivores and piscivores. This exploited production represents the Fishery Production Potential (FPP) for these aggregates, assuming that 100% of the piscivores and benthivores, 50% of the planktivores, and 10% of suspension-feeding benthos are associated with species and/or stages of potential commercial value and accessible to fisheries.

The maximum sustainable exploitation rate was defined as the median of the ratio of new primary production (primarily by larger phytoplankton species) to total primary production – 20% (Rosenberg et al. 2014). A range (probability distribution) of FPPs is estimated based on uncertainty in primary production, fractionation of small and large phytoplankton and transfer efficiencies among trophic levels. The 25th percentile of the distribution of FPP can be used to define a TCI to ensure a low probability of exceeding ecosystem sustainability, and the median (50th percentile) of the distribution is seen as providing an indication of situations where total catches are likely to have exceeded sustainability levels. A major assumption of the EPP model is that the ecosystem is fully functional but when the biomass of the exploitable community is reduced (e.g. relative to pre-collapse levels) a penalty factor has to be derived based on the current state of the ecosystem. The recommended TCIs reflect maximum sustainable exploitation rates which are deemed consistent (i.e. necessary but not sufficient) with maintaining ecosystem sustainability given the current productivity state of the ecosystem.

In principle, once these can be estimated with sufficient reliability and precision, TCIs should be seen as recommended guidelines for upper boundaries for sustainable total catches of aggregates of species. TCIs provide guidance for strategic management, and should complement stock-level tactical advice. TCIs are not a replacement for single species assessments but provide an avenue to start investigating how recommendations across stocks fare when considered together at the ecosystem level, and can serve to address questions not considered for single species (e.g., trade-offs).

WGEAFFM raised concerns about the underlying reliability of the EPP model and the rationale and robustness of the 25th percentile of the FPP distribution as the one to be used as a metric of TCI. Furthermore, consolidating previous analyses, and adding to them using more extensive reviews of the predictions from similar types of models should improve the foundation on which FPP estimates of TCIs can rest. It is also important to clearly outline underlying assumptions of the EPP model and their potential impact on predictions. Such analyses could affect the applicability of the advice in decision-making, and allow an assessment of how the estimated TCIs may be altered by changes in ecosystem state (e.g. annual primary production and nutrient inventories).

In response to these concerns, SC will undertake the following tasks:

1. Assess whether the 25th percentile of the FPP distribution is the correct precautionary metric to define TCI (i.e. fishery carrying capacity).
2. Explore development of a dynamic version of the EPP model to develop projections and further inform the assessment of ecosystem-level risks.
3. Assess whether the historical biomass and proportional distribution of functional feeding groups is an appropriate representation of a fully functional/high productivity ecosystem state.
4. Evaluate whether ecosystem productivity (i.e. from lower to upper trophic levels, as possible) has changed following the major changes in ecosystem status.
5. Undertake sensitivity assessment of the sources of uncertainty in EPP model projections.
6. Contrast sustainable exploitation rates from EPP and other approaches (e.g. maximum sustainable yield) and investigate alternative scenarios in the distribution of exploitation rates among functional groups.

These tasks are consistent with the overall findings and recommendations from the peer review of the US efforts around the use of FPP models in management procedures (https://www.nefsc.noaa.gov/program_review/).

Development of Draft Ecosystem-Level Objectives

If TCIs were to be operationalized, an important issue is the need to define criteria and timeframes for management action when aggregated catches exceed the TCIs, as well as the exceptional circumstances that may alter or preclude the need for action. Rules guiding this decision-making process should be linked with ecosystem state and to the risk of damage to or deterioration of the ecosystem associated with catches that exceed recommended levels for sustainability (TCIs). However, to move forward SC needs input from the Commission in setting/identifying candidate operational (ecosystem and multispecies) objectives and potential policy tools that would be deemed plausible/acceptable for implementation. This guidance from the Commission would help SC to focus its efforts towards further Roadmap implementation.

Accordingly, SC requested that the Commission consider developing options by which ecosystem considerations can be operationally integrated into fisheries management advice through consideration of the risk of damage or deterioration of the ecosystem, whilst recognizing the uncertainties associated with integrating ecosystem effects on stock status and trends. WGEAFFM was to undertake intersessional discussions to investigate further options for the implementation of the NAFO Roadmap.

During the meeting of WGESA, a small SC-COM group started a dialogue on the development of management actions appropriate to the practical implementation of ecosystem objectives consistent with the NAFO Roadmap. Several options were explored and set aside because the task was complex and the limited participation from members of WGEAFFM prevented further progress. However, meaningful progress toward the implementation of ecosystem management measures requires managers to provide specific ecosystem-level objectives. WGEAFFM must develop an action plan to establish fishery and ecosystem objectives and consider synthesis of management actions and consequences to stock status to evaluate the appropriateness and effectiveness of the objectives and management actions.

Reference

Rosenberg, A.A., Fogarty, M.J., Cooper, A.B., Dickey-Collas, M., Fulton, E.A., Gutiérrez, N.L., Hyde, K.J.W., Kleisner, K.M., Kristiansen, T., Longo, C., Minte-Vera, C., Minto, C., Mosqueira, I., Chato Osio, G., Ovando, D., Selig, E.R., Thorson, J.T. & Ye, Y. 2014. *Developing new approaches to global stock status assessment and fishery production potential of the seas*. FAO Fisheries and Aquaculture Circular No. 1086. Rome, FAO. 175 pp.

viii) Assessment of NAFO bottom fisheries (COM. Request 9)

In relation to the assessment of NAFO bottom fisheries, the Commission endorsed the next re-assessment in 2021 and that SC should:

a) Assess the overlap of NAFO fisheries with VME to evaluate fishery specific impacts in addition to the cumulative impacts;
b) Consider clearer objective ranking processes and options for objective weighting criteria for the overall assessment of significant adverse impacts and the risk of future adverse impacts;
c) Maintain efforts to assess all of the six FAO criteria (Article 18 of the FAO International Guidelines for the Management of Deep Sea Fisheries in the High Seas) including the three FAO functional SAI criteria which could not be evaluated in the current assessment (recovery potential, ecosystem function alteration).
d) Continue to work on non-sponge and coral VMEs (for example bryozoan and sea squirts) to prepare for the next assessment.

Scientific Council responded:

SC made further progress in assessing the overlap of NAFO fisheries with VME through an analysis of haul-by-haul log-book data in combination with VMS data for 2017. Such analysis significantly improves the spatial definition of specific fishing areas within the NAFO footprint. This approach will be used for re-assessment for years for which haul by haul logbook data are available, otherwise the previously adopted approach will be applied.

Furthermore, SC has made progress in developing models and methodological approaches which assess the functional significance of VMEs and the estimation of recovery rates of different VME indicator species. This provides valuable insight to assess the level of VME connectivity between different areas.

Updated analysis (including new data) has been performed on non-coral and non-sponge VME indicator species and further work is planned.

SC notes that changes in the availability of CP resources directed to support this work are likely to impact SC's capacity to fully address the planned activities in support of the reassessment of bottom fisheries by 2021.

Overlap of NAFO fisheries with VME

Haul-by-haul logbook data was merged with the vessel monitoring system (VMS) data to provide a more accurate measure of when vessels are trawling, for 2017 only. It also allowed each haul to be assigned to a fishery directed at a specific species. The haul-by-haul effort maps are considered to be an improvement over past effort maps derived from a 1 – 5 knot speed filter, as they remove spurious effort points (Figure 1). Overall, the areas represented by the logbook haul-time filter method and the simple speed filter method show fishing activities in the same general areas with similar patterns of intensity, but with the new method, there are fewer cells displaying fishing effort within the vulnerable marine ecosystem (VME) closures. Mapping of trawl tracks would potentially enable a more accurate estimate of seabed impacts and would facilitate more accurate swept area estimates to be performed. Improved information on gear dimensions (especially the parts of the gear that contact the seabed, e.g. ground rope and trawl doors) would also be beneficial for improving the accuracy of these calculations. To facilitate this, the WG-ESA co-chair will discuss with the Secretariat to confirm what information is currently available and recommend what else may be needed.

Both methods will be used for the reassessment in 2020 as logbooks are now available for recent years.

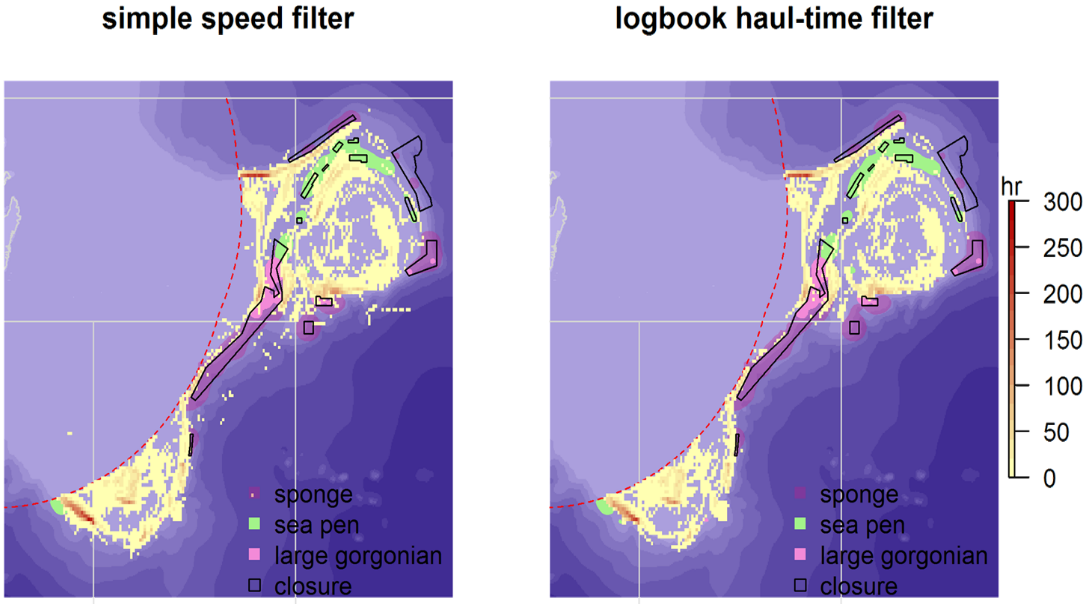


Figure viii. 1. Cumulative fishing effort maps (hours fished per cell) from 2017 VMS and logbook data produced by two different methods. Left: VMS data was filtered for speeds within 1-5 knots, right: VMS was filtered if it was within the reported fishing time interval in the logbook.

Consider clearer objective ranking processes and options for objective weighting criteria for the overall assessment of significant adverse impacts and the risk of future adverse impacts

Objective ranking processes and weighting criteria for the overall assessment of SAI can only be completed once work towards advancing the assessment of all six of the FAO criteria (as described in the following subsection) for the next reassessment is concluded. At that time, the objective ranking and weighting criteria will become a Term of Reference for WGESA.

Maintain effort to assess all six of the FAO criteria

SC continues to develop and refine methodological approaches that can provide an estimate of the rates of VME recovery and resilience, such estimates will address FAO criteria IV. The approaches being developed rely on: i. developing empirical models which utilize observed cumulative VME indicator biomass in response to observed levels of fishing effort, as reported by SC in 2017; and ii. developing a spatially explicit agent-based model to simulate the life history of corals and sponges.

SC noted that the sensitivity analysis performed on the empirically driven resilience model suggests that estimates of fishing trawl-track density and the amount of time taken to contact a given area are particularly important in determining the impact and subsequent estimates of recovery time for sea pen (VME). The observed pattern of fishing effort will be used in the estimates of sea pen resilience.

SC also noted that the initial results from the sea pen agent-based model reveal important connectivity pathways within the model domain. While self-recruitment within an area is an important source for local recovery, overall rebuilding also depends on connectivity between areas. Further work utilizing this approach is continuing.

SC notes that progress has been made in developing the biological traits analysis to help determine the functional significance of VMEs in the NAFO regulatory area and to help address FAO criteria V. A workplan has been defined (see below) that will help quantify how taxa interact with their environment through a number of important processes (e.g. filtration of sea water). VME biological traits and associated habitat functions, rather than the VME species themselves, will be used to define and quantify the significance of potential bottom fishing impacts in conjunction with the same analysis performed on specific VMEs.

VME Biological Traits Analysis workplan:

1. Creation of trawl sample traits matrix for trawl survey biomass data. This task is project-dependent; if project funds are not made available this task will not be undertaken.
2. Creation of specific trait-based VME maps (using multivariate analysis e.g. cluster analysis)
3. Reassessment of trait-based VMEs at risk of impact and/or impacted, by assessing the trait map data in relation to maps of fishing effort
4. Bi-variate trait response curves to fishing effort
5. Determine Trait Diversity Indices for each of the VME types
6. Determine the relationship between Species density and VME traits.
7. Determine the overlap of fish distributions with habitats and VMEs/Traits using SDMs

Develop risk assessment frameworks appropriate for assessing the specific VME types in the NRA.

Non-sponge and non-coral VMEs

SC notes that additional information on the distribution of bryozoans and sea squirts (*Boltenia ovifera*), fishing effort and other habitat data (e.g. surficial geology layers) should be examined prior to the reassessment of the VME fishery closures in 2020.

SC understands that work on a spatially continuous 75 m grid layer with a substrate prediction for each cell that includes the Tail of the Grand Bank, an area where significant concentrations of non-sponge and non-coral VME indicator species are found, is intended to be published in 2019. SC notes that if this substrate layer becomes available on time it should be included in the compilation of additional information to support the identification and delineation of the non-coral and non-sponge VME prior to the reassessment of the VME fishery closures in 2020.

ix) Review the proposed revisions to CEM Annex I.E, Part VI (COM. Request 10)

Review the proposed revisions to Annex I.E, Part VI as reflected in COM/SC WG –EAFFM WP 18-01, for consistency with the taxa list annexed to the VME guide and recommend updates as necessary.

Scientific Council responded:

SC noted the last VME indicator species list was compiled in 2011 and, in preparation for the review of closures in 2020, an update of the Annex 1.E list of VME indicator species is required, including the addition of the three letter FAO species codes where appropriate.

The nomenclature of some species has also been revised, and several large sponges have now been described at the species level. SC recommends that Annex 1.E, Part VI, list of VME indicator species be replaced with the list provided here (with the addition of FAO codes where they are currently lacking, provided by the secretariat) prior to the 2019 annual Meeting if possible (Table 1).

A review of the current list of Vulnerable Marine Ecosystem indicator species in Annex 1.E of the NAFO Conservation and Enforcement Measures (NCEM) is required in order to prepare for the next review of the VME fishery closures in 2020. The last assessment of VME species found in the NAFO Regulatory Area (NRA) occurred in 2011, where over 500 different taxa were reviewed and assessed against the FAO criteria.

Since then additional information has become available on the presence of 13 new species of large sponge, calling for a review of the list found in the NAFO CEM (NAFO, 2019). At the same time the nomenclature of a few species on the NCEM list has been revised according to the taxonomic database WORMS (World Register of Marine Species http://www.marinespecies.org/). The addition of the three letter FAO species codes is also required to facilitate observer recording where appropriate.

SC notes that the new species of sponge were assessed against the FAO criteria for VME species, based on their fragility, vulnerability and capacity to provide structure for other organisms when aggregating. All were considered to meet the FAO criteria for VME indicator species designation.

SC recommends that the VME indicator species in Table 1 below replace the existing list in the Annex 1.E, Part VI, of the NCEM:

Table ix.1. Updated List of VME Indicator Species for inclusion in Annex I.E of the NAFO CEM. Also included are the FAO ASFIS 3-alpha codes. Codes for the genus level are indicated in brackets. Blank entries indicate that no code exists for that taxon. Those taxa marked with an asterisk were documented exclusively from the NAFO seamount closures.

Common Name and FAO ASFIS CODE	Taxon	Family	FAO ASFIS CODE
Large-Sized Sponges (PFR - Porifera)	*Asconema foliatum*	Rossellidae	ZBA
	Aphrocallistes beatrix	Aphrocallistidae	
	Asbestopluma (Asbestopluma) ruetzleri	Cladorhizidae	ZAB (Asbestopluma)
	Axinella sp.	Axinellidae	
	Chondrocladia grandis	Cladorhizidae	ZHD (Chondrocladia)
	Cladorhiza abyssicola	Cladorhizidae	ZCH (Cladorhiza)
	Cladorhiza kenchingtonae	Cladorhizidae	ZCH (Cladorhiza)
	Craniella spp.	Tetillidae	ZCS (Craniella spp.)
	Dictyaulus romani	Euplectellidae	ZDY (Dictyaulus)
	Esperiopsis villosa	Esperiopsidae	ZEW
	Forcepia spp.	Coelosphaeridae	ZFR
	Geodia barretti	Geodiidae	
	Geodia macandrewii	Geodiidae	
	Geodia parva	Geodiidae	
	Geodia phlegraei	Geodiidae	
	Haliclona sp.	Chalinidae	ZHL
	Iophon piceum	Acarnidae	WJP
	Isodictya palmata	Isodictyidae	
	Lissodendoryx (Lissodendoryx) complicata	Coelosphaeridae	ZDD
	Mycale (Mycale) lingua	Mycalidae	
	Mycale (Mycale) loveni	Mycalidae	
	Phakellia sp.	Axinellidae	
	Polymastia spp.	Polymastiidae	ZPY
	Stelletta normani	Ancorinidae	WSX (Stelletta)
	Stelletta tuberosa	Ancorinidae	WSX (Stelletta)
	Stryphnus fortis	Ancorinidae	WPH
	Thenea muricata	Pachastrellidae	ZTH (Thenea)
	Thenea valdiviae	Pachastrellidae	ZTH (Thenea)

	Weberella bursa	Polymastiidae	
Stony Corals (CSS - Scleractinia)	*Enallopsammia rostrata**	Dendrophylliidae	FEY
	*Lophelia pertusa**	Caryophylliidae	LWS
	*Madrepora oculata**	Oculinidae	MVI
	*Solenosmilia variabilis**	Caryophylliidae	RZT
Small Gorgonians (GGW)	*Acanella arbuscula*	Isididae	KQL (Acanella)
	Anthothela grandiflora	Anthothelidae	WAG
	Chrysogorgia sp.	Chrysogorgiidae	FHX
	*Metallogorgia melanotrichos**	Chrysogorgiidae	
	Narella laxa	Primnoidae	
	Radicipes gracilis	Chrysogorgiidae	CZN
	Swiftia sp.	Plexauridae	
Large Gorgonians (GGW)	*Acanthogorgia armata*	Acanthogorgiidae	AZC
	Calyptrophora sp.*	Primnoidae	
	Corallium bathyrubrum	Coralliidae	COR (Corallium)
	Corallium bayeri	Coralliidae	COR (Corallium)
	Iridogorgia sp.*	Chrysogorgiidae	
	Keratoisis cf. *siemensii*	Isididae	
	Keratoisis grayi	Isididae	
	Lepidisis sp.*	Isididae	QFX (Lepidisis)
	Paragorgia arborea	Paragorgiidae	BFU
	Paragorgia johnsoni	Paragorgiidae	BFV
	Paramuricea grandis	Plexauridae	PZL (Paramuricea)
	Paramuricea placomus	Plexauridae	PZL (Paramuricea)
	Paramuricea spp.	Plexauridae	PZL (Paramuricea)
	Parastenella atlantica	Primnoidae	
	Placogorgia sp.	Plexauridae	
	Placogorgia terceira	Plexauridae	
	Primnoa resedaeformis	Primnoidae	QOE
	*Thouarella (Euthouarella) grasshoffi**	Primnoidae	
Sea Pens (NTW – Pennatulacea)	*Anthoptilum grandiflorum*	Anthoptilidae	AJG (Anthoptilum)
	Distichoptilum gracile	Protoptilidae	WDG
	Funiculina quadrangularis	Funiculinidae	FQJ
	Halipteris cf. *christii*	Halipteridae	ZHX (Halipteris)

	Halipteris finmarchica	Halipteridae	HFM
	Halipteris sp.	Halipteridae	ZHX (Halipteris)
	Kophobelemnon stelliferum	Kophobelemnidae	KVF
	Pennatula aculeata	Pennatulidae	QAC
	Pennatula grandis	Pennatulidae	
	Pennatula sp.	Pennatulidae	
	Protoptilum carpenteri	Protoptilidae	
	Umbellula lindahli	Umbellulidae	
	Virgularia mirabilis	Virgulariidae	
Tube-Dwelling Anemones	*Pachycerianthus borealis*	Cerianthidae	WQB
Erect Bryozoans (BZN – Bryozoa)	*Eucratea loricata*	Eucrateidae	WEL
Sea Lilies (CWD – Crinoidea)	*Conocrinus lofotensis*	Bourgueticrinidae	WCF
	Gephyrocrinus grimaldii	Hyocrinidae	
	Trichometra cubensis	Antedonidae	
Sea Squirts (SSX – Ascidiacea)	*Boltenia ovifera*	Pyuridae	WBO
	Halocynthia aurantium	Pyuridae	
Unlikely to be observed in trawls; *in situ* observations only:			
Large xenophyophores	*Syringammina* sp.	Syringamminidae	

x) Conduct a re-assessment of VME closures by 2020 (COM. Request 11)

The Commission requests Scientific Council to conduct a re-assessment of VME closures by 2020, including area #14.

Scientific Council responded:

SC has agreed to a workplan to review the VME fishery closures to be concluded by 2020. This review will provide the basis for the reassessment of bottom fishing activities with respect to impacts on VMEs currently scheduled for 2021.

SC notes that changes in the availability of CP resources directed to undertake this work are likely to impact SC's capacity to fully address the planned activities in support of the review of VME fishery closures.

SC has agreed to the following workplan for the reassessment of VME fishery closures:

1. An update of the Kernel Density Estimation (KDE) analysis conducted in 2014, including all additional VME indicator species data from trawl surveys, up-to and including the 2019 survey data. The updated survey data should be provided by 1st October 2019 in order to allow sufficient time to progress the analysis. Up-dated KDE analysis and maps will be produced for: i. sea pens (assemblage), ii. sponges (*Geodia*), iii. large gorgonians (assemblage), iv. small gorgonians (assemblage), v. bryozoans (assemblage), and vi. stalked tunicates (*Boltenia sp*). Data on glass sponges will also be compiled and provisionally analysed. In the event that the updated data is not available by the deadline above, it was agreed that the analyses would proceed with the data provided as of that date.

2. An update on Species Distribution Models (SDM) incorporating new data and species if possible. Otherwise previous SDMs will be used to underlie the KDE polygons and closed areas.
3. For the bryozoan turf (assemblage), and stalked tunicates (*Boltenia sp*) additional seabed physical data (where available) will be used to refine the KDE polygons for these two VME indicator species.
4. Consideration of the connectivity of VMEs through links between propagule/larval transportation and VME distribution/location should be included.
5. Consideration of the biodiversity of the closed areas as well as observed differences between VME species diversity and VME functions will be considered in the review.
6. It was noted that the Corner Rise and New England Seamounts were originally discussed together; however, only revisions to the New England Seamounts closures have been made since. To ensure consistency in approach, other seamount closures, in particular the Corner Rise seamount, should be revised and include any updates on known VME presences.

xi) Continue progress on the NAFO PA (COM. Request 12)

The Commission requests the Scientific Council to continue progression on the review of the NAFO PA Framework.

Scientific Council responded:

Progress was previously made in the context of Precautionary Approach elements of an ecosystem approach to management. As a result of heavy workloads, other priorities from the Commission in 2017 and 2018, and limited capacity, Scientific Council will be unable to complete this complex review in the short to medium term.

To complete this work, participation of the Commission will be required, for example, to specify risk tolerances, potential inclusion of buffers, etc.

xii) Provide the map and coordinates of the Kükenthal Peak (COM. Request 13)

According to the Scientific Advice for years 2019, 2020 and 2021, fishing should not be allowed to expand above current levels on Kükenthal Peak (Div. 6G, part of the Corner Rise seamount chain). To allow this recommendation to be enforceable the Commission requests the Scientific Council to provide the map and coordinates of the Kükenthal Peak.

Scientific Council responded:

Maps are provided of the location of Kükenthal Peak and a simple polygon encompassing the 1800m contour and recent fishing effort (VMS 2008 to 2018 and Spanish observer data from 2009, 2012 and 2016-2018). The coordinates of the polygon are presented in Table 1.

Note Scientific Council has provided updated advice for the Alfonsino fishery on Kükenthal Peak (see section VII.3).

Kükenthal peak in NAFO Div. 6G is the western summit of the Corner Rise seamount. SC plotted the location of the peak as defined by its 1800m contour according to bathymetric charts produced by GEBCO (www.gebco.net) and the Canadian hydrographic service. The correspondence between the two data sources was reasonably good (Figure xii.1), however it should be noted that confidence in available bathymetry mapping is uncertain. A simple polygon encompassing the 1800m contour in both data sets is also shown in Figure 1 and coordinates of this polygon are given in Table xii.1.

SC does not consider that bathymetry alone is sufficient to delineate the fishing area on Kükenthal peak as the gear used in the alfonsino fishery is pelagic trawl. Figure xii.2 shows VMS positions between 2008 and 2018 in the vicinity of the peak, filtered for speeds between 0.5 and 5 knots, which is commonly assumed to correspond to fishing speed for trawlers. 80% of the fishing positions in Division 6G derived using this speed filter fall within the polygon. Shoot and haul positions from Spanish scientific observers from 2009, 2012 and 2016-

2018 (the years for which observer data were available) are shown in Figure xii.3. 99% of these positions fall within the polygon.

The high degree of correspondence between the observer positions and a group of VMS positions towards the center of the polygon suggest that the 0.5 to 5 knot speed filter may not be appropriate for pelagic trawling. An alternative speed filter of 3 – 6 knots was applied (Figure xii.4). Using this speed filter, 83% of fishing positions fall within the polygon.

Table xii.1. Coordinates of the rectangle containing Kükenthal Peak in Division 6G.

Coordinate number	Latitude	Longitude
1	35°38'13"N	52°03'00"W
2	35°38'13"N	51°47'42"W
3	35°26'42"N	51°47'42"W
4	35°26'42"N	52°03'00"W

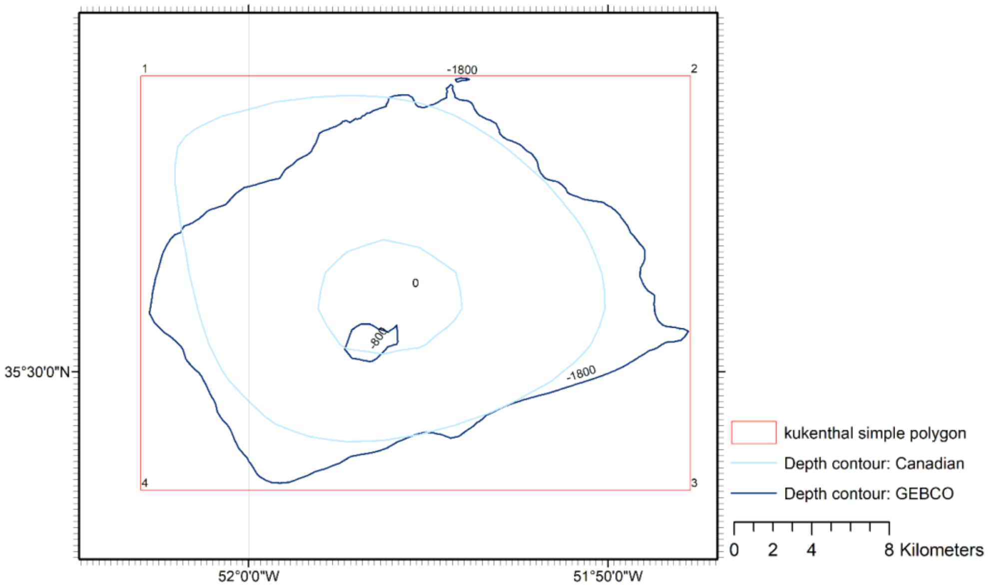


Figure xii.1. Location of Kükenthal Peak mapped according to the 800m and 1800 m depth contours from GEBCO and Canadian hydrographic service, with a polygon (red line) proposed to delineate the Kükenthal peak.

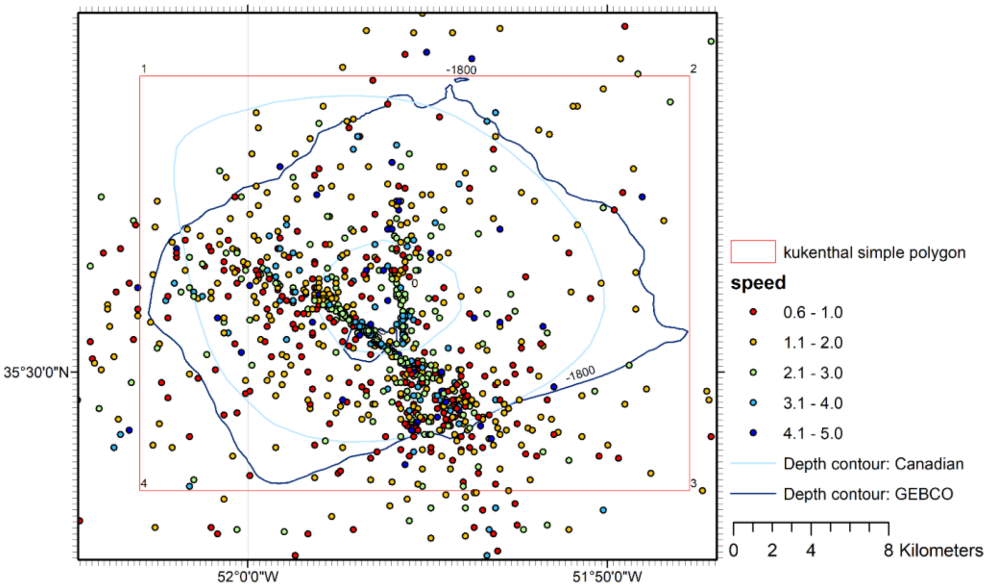


Figure xii.2. VMS positions in the vicinity of Kükenthal Peak filtered for speeds between 0.5 and 5 knots, with a polygon (red line) proposed to delineate the Kükenthal peak.

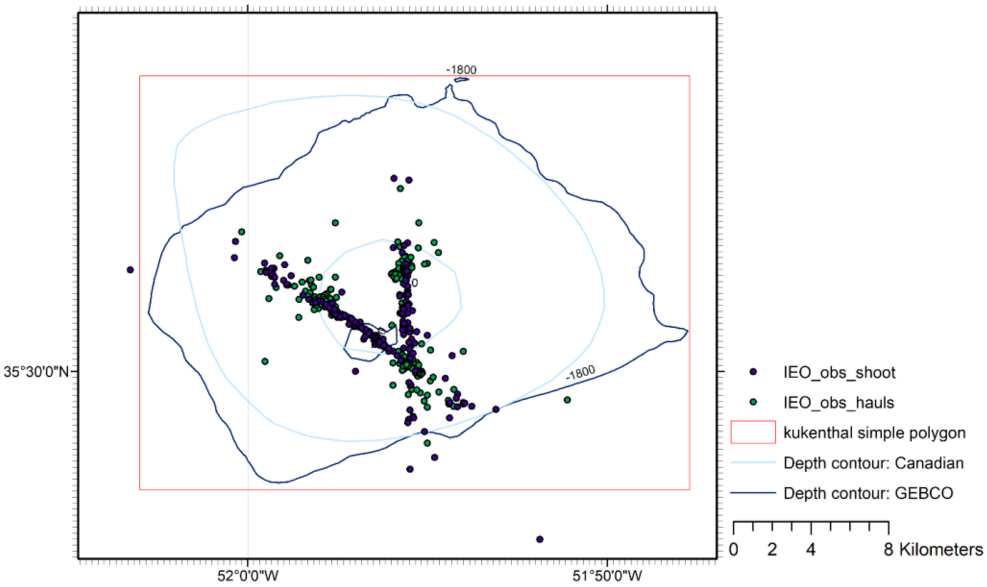


Figure xii.3. Start and end positions of fishing operations observed by Spanish scientific observers from 2009, 2012 and 2016-2018, with a polygon (red line) proposed to delineate the Kükenthal peak.

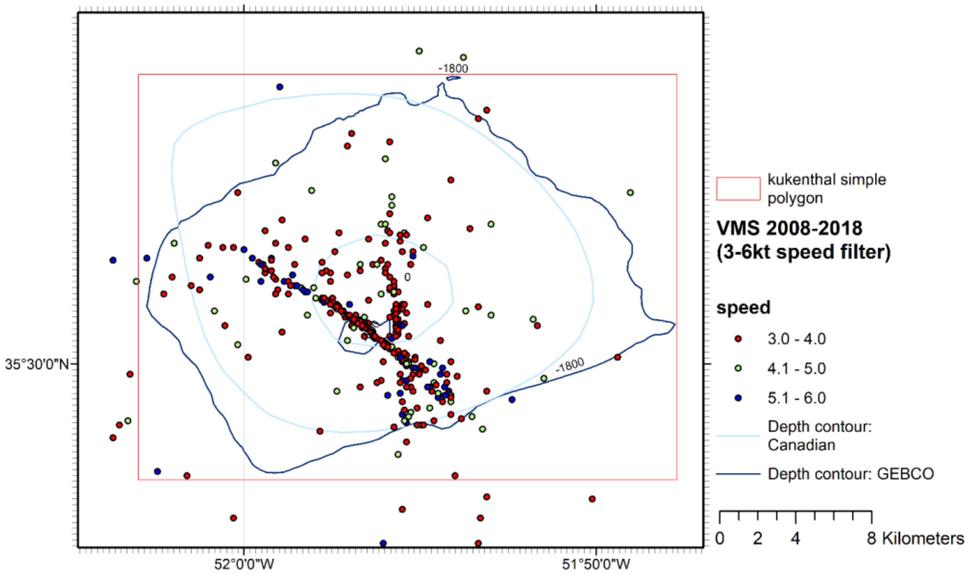


Figure xii.4. VMS positions in the vicinity of Kükenthal Peak filtered for speeds between 3 and 6 knots, with a polygon (red line) proposed to delineate the Kükenthal peak..

xiii) Work with WG- BDS to identify areas and times where bycatch and discards of Greenland sharks have a higher rate of occurrence. (COM. Request 14)

The Commission requests Scientific Council work with WG-BDS to identify areas and times where bycatch and discards of Greenland sharks have a higher rate of occurrence. This work will support WG-BDS in developing appropriate management recommendations, including safe handling practices for live release of Greenland sharks, for consideration by the Commission at its 2021 Annual Meeting.

Scientific Council responded:

SC identified data availability and uncertainty issues that could limit the ability to respond to this request. NAFO At-Sea Observer data from at least 2008 to 2018, and going forward, is needed in an electronic format by January 2020 (or sooner if possible) in order to proceed with analyses during the June 2020 Scientific Council meeting.

SC also identified a problem where Greenland shark discards have been recently reported as landings in the STATLANT database. The data on Greenland shark discards that is required by the CEM should be maintained separately and that these data, as well as data from coastal states, be made available to SC.

Sources of uncertainty in available bycatch and discard data of Greenland shark within the NAFO Convention Area were reviewed (SCR Doc. 19-030). Issues were identified with regards to reporting rates and inconsistencies in reporting requirements. Catch weights are highly uncertain given they are visually estimated, and catch numbers have typically not been reported. These factors will need to be considered during ongoing work aimed at identifying areas and times of high bycatch occurrence. SC noted that efforts are underway within NAFO and Flag States to improve reporting of Greenland shark bycatch (including information on catch numbers, length, sex, and condition) with the addition of these requirements to the NAFO CEM 2019 (NAFO COM 2019/01).

The NAFO At-Sea Observer program collects data that will be important for addressing this Commission request. Currently, electronic records from observers are only available from 2014-2017. Work is underway in the Secretariat to digitize remaining data from other years. A lack of a sufficient time series is a barrier to adequately assessing areas and times of high bycatch. The remaining data should be entered into the database and made available to SC. VMS data should also be considered to facilitate the spatial and temporal characterization of fishing effort as required to address this request.

SC noted a significant increase in STATLANT 21 reported "landings" for Greenland shark in 2017 and 2018. This increase is primarily from Greenland and coincides with increased reporting requirements for bycatch and discards within Greenland fisheries. STATLANT databases are designed for landings data, and discards of Greenland shark or other species should be excluded. SC suggests that clarification is needed on the implementation of the new CEM requirements for reporting Greenland shark data.

xiv) Provide regular updates on relevant research related to the potential impact of activities other than fishing in the Convention Area (COM. Request 15)

The Commission requests Scientific Council to monitor and provide regular updates on relevant research related to the potential impact of activities other than fishing in the Convention Area, such as oil exploration, shipping and recreational activities, and how they may impact the stocks and fisheries as well as biodiversity in the Regulatory Area.

Scientific Council responded:

SC reiterates its prior advice from 2015 and 2016 that there are a number of activities occurring in the NRA which have the potential to impact fisheries resources and the ecosystem, and that multi-sectoral governance issues are the main impediment for comprehensively addressing them.

SC notes that as an example, there is significant spatial overlap between oil and gas exploration and production activities, fisheries and VME in the Flemish Pass area.

SC notes that without a significant commitment from Contracting Parties (CPs) to: a) establish regular reporting of activities other than fishing with sufficient detail to allow for adequate analysis and assessment of impacts on fisheries resources and the ecosystems that support them, b) increase SC capacity to address these issues, and c) engage in comprehensive multi-sectoral cooperation, these types of requests can only be rudimentarily addressed at best.

The issue of impacts on stocks and ecosystems by activities other than fishing has been previously addressed by SC for COM requests in 2015 (NAFO SCS 15/12, Request xi) and 2016 (NAFO SCS 16-14, Request xi).

In these responses, SC a) outlined the anthropogenic activities other than fishing that were occurring or had the potential of occurring in the NAFO Convention Area and listed possible stressors and their possible impacts on fish stocks and the ecosystem, and b) highlighted that multi-sectoral governance issues are the main impediment for comprehensive protection of VMEs in the NRA.

SC reiterates its previous responses; both the activities (other than fishing) potentially impacting fisheries resources and ecosystems remain the same, and most of the multi-sectoral governance issues preventing comprehensive protection of VMEs in the NRA still exist.

SC notes that the preliminary results emerging from an EU-funded research project (ATLAS) include a Marine Spatial Planning (MSP) case study on the Flemish Cap. This work is on-going, but a provisional map showing the potential conflicts between different users of the Flemish Cap marine space (e.g. new oil & gas exploration/exploitation and traditional high seas fisheries), or between users and natural ecosystem components (e.g. oil & gas exploration/exploitation and VMEs) has been compiled (Figure 2).

SC notes that activities other than fishing occurring in the NRA are not formally, nor regularly reported to SC. Therefore, SC does not have the basic information which is required to monitor and provide regular updates on these activities.

SC also reiterates that these types of analyses require a multidisciplinary approach and that the full range of expertise required is not currently available in SC.

SC notes that without a significant commitment from Contracting Parties (CPs) to: a) establish regular reporting of activities other than fishing with sufficient detail to allow for adequate analysis and assessment of impacts on fisheries resources and the ecosystems that support them, b) increase SC capacity to address these issues, and c) engage in comprehensive multi-sectoral cooperation, these types of requests can only be rudimentarily addressed at best.

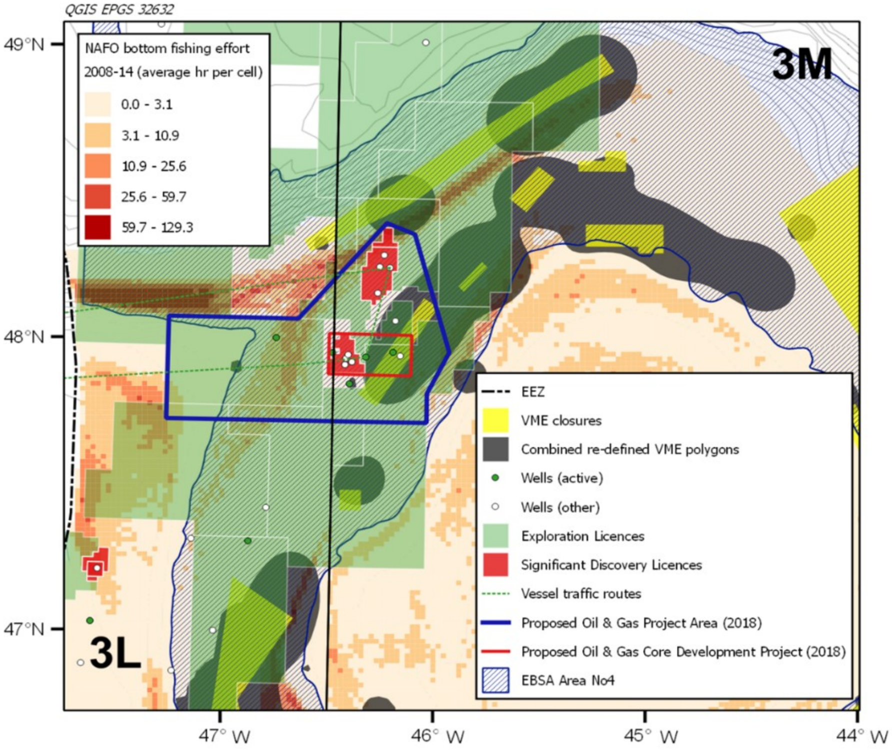


Figure xiv.1. Map of Flemish Cap showing the potential spatial conflict between VME, VME fishery closures, oil and gas activities, shipping and fisheries.

xv) Develop a 3-5 year work plan for the Scientific Council (COM. Request 16)

The Commission requests Scientific Council to take the first steps to develop a 3-5 year work plan, which reflects requests arising from the 2018 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 agreed with the need for identification of priorities and required resources and noted this should be an iterative discussion between the Commission and SC and should reflect the non-NAFO workload of SC members.

SC intends to develop a 5-year plan that allows for a high-level view of activities planned for the next 5 years, with more detailed annual plans for each year in which resource gaps and priorities will be addressed.

The plan would include requests from the Commission, including stock assessments and other scientific inquiries (e.g. from specific contracting parties for straddling stocks). The plan would also include work to address SC advice of its own accord. A record of work plan-related issues, ideas for addressing them, and additional activities that have been suggested will be included.

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.

Once an initial comprehensive workplan has been developed, SC will update and review the plan each September to include all requests with prioritization and rationale where appropriate as well as the resources required to respond to the requests. The plan would be reviewed each June at the annual SC meeting.

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 address all requests over the year and to have thorough and transparent documentation (e.g. Greenland Halibut MSE). The Council agreed with the need for identification of priorities and required resources. It was also noted that the requests 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. 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 highlighted that SC members are typically not dedicated to NAFO scientific activities exclusively and that the increased SC activities and travel have added significant demands and pressure to individuals.

SC discussed the structure, content, and process for a work plan and noted detailed plans were not needed, as they 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 would include requests from the Commission from the annual meeting, including stock assessments and other scientific inquiries (e.g. requests from coastal states). The plan would also include requests SC has made of its own accord. A record of work plan-related issues, ideas for addressing them, and additional activities that have been suggested will be included in an annex. The work plan will be linked to recommendations in the performance review and to the associated action plan.

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.

In terms of process, when an initial plan is drafted SC will update and review the plan each September for the next year to include all requests with prioritization and rationale where appropriate as well as the resources required to respond to the requests. The plan would be reviewed each June. As such, the plan will be a living document and September and June reviews will include prioritization of current versus strategic work/requests.

Table xv.1. Shows an example (for illustrative purposes only) of a five year work plan.

Activity	Designated expert	Resources required	Resource gaps	Priority
Full assessments: ***June meeting: May 31-June 13 2019*** 1. 3M Cod 2. 3M Redfish-ext. review 3. 3O Redfish 4. Grenadier 5. N. Shortfin squid 6. S. alphonsino 7. 3NO Witch-ext. review 8. 3M Golden redfish (including request #7 on implications of species splitting) 9. White hake ***NIPAG:*** 1) 3M shrimp	**Full assessments:** ***June meeting: May 31-June 13 2019*** 1. Diana Gonzalez Troncoso 2. Antonio Avila de Melo 3. Danny Ings 4. Fernando Gonzalez-Costas 5. Lisa Hendrickson 6. Fernando Gonzalez-Costas 7. Joanne Morgan 8. Ricardo Alpoim 9. Mark Simpson ***NIPAG:*** 1) J. Miquel Casas Sanchez	Both human and financial 2-5 additional members with analytical/quantitative expertise 2 full time agers for witch flounder, yellowtail, redfish, S. alfonsino Dedicated time to plan a survey or work with industy to design an experimental fishery. May not take place for a number of years, but planning before would be required.	For some assessments limited Science advice can be provided. Advice could be improved with the following: More quantitative NAFO SC members are to all the assessments at the identified assessment schedule More aging would support SC ability to give comprehensive Science advice (name stocks that are not aged) S. alfonsino has no survey. Some fisheries independent information or carefully monitored experimental fishery would be required to monitor the stock provide Science advice. To better understand redfish stock dynamics within and among areas, redfish should be speciated in the surveys. A paired trawl survey will be required for calibration between the charter and new vessel for the SA 0 and 1 survey (shrimp and Greenland Halibut)	medium-high medium high medium for now, high to re-open fishery medium high
3LN redfish HCR· - Calculation for 2020 -Consider timing for reviewing/evaluating HCR's (SC advice due for 2021 decision).				
Greenland Halibut (2+Div 3KLMNO) HCR's **-**Monitor stock status to compute TAC using HCR -Determine whether there are exceptional circumstances				
3M cod MSE: ***Meeting RBMS Sept 21*** *2019* -Implement agreed steps to have MSE ready for September 2019 for harvest decision for the 2020 season	**Technical team**: Diana Gonzalez Trancoso; Fernando Gonzalez, Agurtzane Urtizberea, Jose de Oliveira, Tomas Brunnel, Panayiota Apostakali, Ricardo Alpoim, Antonio Avila de Melo and Carmen Fernandez	**Technical developments and preparatory work**: 250.000€ (EU Financial support)	Inadequate financial resources beyond December 2019	Top priority
	SC meeting January 2019 RBMS meeting April 2019	-	-	

PA framework -Progress on the review of the NAFO PA Framework.	-	-	EU fund for 2020 available	Top priority
WG EAFFM meeting: *July 16-18 2019* -Evaluation of the impact of scientific trawl surveys on VME in closed areas -Evaluate the effect of excluding surveys from closed areas on stock assessments.				
In preparation of the next re-assessment of NAFO bottom fisheries in 2021: **-**Assess the overlap of NAFO fisheries with VME to evaluate fishery specific impacts in addition to the cumulative impacts; -Continue to work on non-sponge and coral VMEs (for example bryozoan and sea squirts) to prepare for the next assessment. -Maintain efforts to assess all of the six FAO criteria including the three FAO functional SAI criteria which could not be evaluated in the current assessment. -Consider clearer objective ranking processes and options for objective weighting criteria for the overall assessment of significant adverse impacts and the risk of future adverse impacts;				
Seamounts -Provide map and coordinates of Kükenthal Peak (related to *S. alphonsino*)				
Impact of oil and gas -Monitor and provide updates on research related to the potential impact of activities other than fishing in the Convention Area.				
Road map Tier 1 -Continue to refine work on the Ecosystem Road Map, including testing the reliability of the ecosystem production potential model and other related models -Report on these results to WG –EAFFM and WG-RBMS to further develop how it may apply to management decisions.				
Action Plan -Implement SC-related steps of the Action plan (in particular the tasks for progression in the				

management and minimization of Bycatch and discards)				
WG- Bycatch, Discards, and Selectivity -Work with WG- BDS to identify areas and times where bycatch and discards of Greenland sharks have a higher rate of occurrence in time for consideration by the Commission in 2021				
Survey planning, participation in surveys, data collection, dissemination, analysis, interpretation and report writing for SC. Each year for 7 + fisheries surveys as well as a number of oceanographic surveys, and dedicated benthic surveys.				

2. Coastal States

a) Request by Denmark (on behalf of Greenland) for advice on management in 2020 of certain stocks in Subareas 0 and 1 (Annex 2)

i) Monitoring of Stocks for which Multi-year Advice was provided in 2017 or 2018

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

Recommendation for 2018 - 2020 Deep-sea redfish and Golden redfish: The Scientific Council advises that there should be no directed fishery. The next full assessment of this stock will take place in 2020.

Recommendation for 2018 - 2020 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 975 t.

Recommendation for Greenland halibut, in Division 1A inshore - Disko Bay for 2019 – 2020: Scientific Council advises that the TAC should not exceed 5120 t.

Recommendation for Greenland halibut in Division 1A inshore—Upernavik for 2019 – 2020: All available indicators have declined under current levels of removals.

Scientific Council recommends that catch should not exceed 5330 t. This is a reduction over the previous advice accounting for the reduction in mean individual size in the recent catches.

Recommendation for Greenland halibut in Division 1A inshore – Uummannaq for 2019-2020: All available indicators have declined under current levels of removals.

Scientific Council recommends catch should not exceed 5800 t. This is a reduction over the previous advice accounting for the reduction in mean individual size in the recent catches.

b) Request by Canada and Denmark (Greenland) for Advice on Management in 2020

i) Monitoring of Stocks for which Multi-year Advice was provided in 2017 or 2018

Scientific Council responded:

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

Recommendation for Greenland halibut in SA 0 + Div. 1A Offshore and Div. 1B-1F for 2019 and 2020: Scientific Council advises that there is a low risk of Greenland halibut in Subarea 0 + 1A (offshore) and 1B-F being below B_{lim} if the TAC for 2019 and 2020 does not exceed 36370 t.

There is no scientific basis with which to provide separate advice for Div. 0A+1AB and Div. 0B+1C-F. Scientific Council advises that consideration be given to the distribution of effort in each area to avoid localized depletion.

3. Scientific Council Advice of its own Accord

Alfonsino in Division 6G **Advice June 2019 for 2019 and beyond**

Recommendation 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.

Management objectives

No explicit management plan or management objectives have been defined by the Commission. Convention General Principles are applied.

Convention General Principles	***Status***	***Comment/consideration***
Restore to or maintain at B_{msy}	🔴	B_{msy} unknown, stock appears depleted
Eliminate overfishing	🔴	Unknown F level; current catches appear unsustainable
Apply Precautionary Approach	🔴	Reference points not defined
Minimise harmful impacts on living marine resources and ecosystems	⚪	Pelagic fishery; unknown gear impact
Preserve marine biodiversity	⚪	Cannot be evaluated

🟢 OK

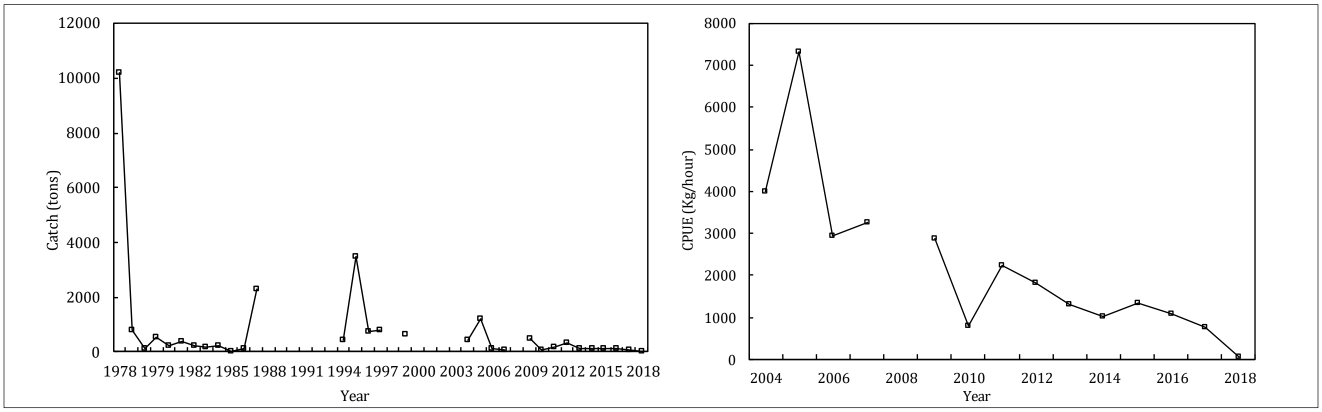
🟡 Intermediate

🔴 Not accomplished

⚪ Unknown

Management unit

Alfonsino is an oceanic demersal species which form distinct aggregations, at 300–950 m depth, on top of seamounts in the North Atlantic. Alfonsino is distributed over a wide area which may be composed of several populations. Stock structure is unknown. Until more complete data on stock structure is obtained it is considered that separate populations live on each seamount.



Stock status

Appears to be depleted.

Projections

No projections can be conducted.

Reference points

Not defined.

Assessment

No analytical or survey based assessment were possible. The only data available at present are the catch and effort time series.

Despite the difficulties of interpreting the CPUE as an indicator of stock status and knowing that this species is easily overexploited and can only sustain low rates of exploitation, the sharp decline in CPUE to the lowest observed (92% lower than in 2017) and catches in the last year indicate an apparent overfishing situation and that the stock may be depleted.

Human impact

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

Environmental impact

Limited information is available.

Fishery

Commercial aggregations of alfonsino on the Corner Rise have been found on three seamounts. Two of them named "Kükenthal" (known also as "Perspektivnaya") and "C-3" ("Vybornaya") are located in the NAFO Regulatory Area. One more bank named "Milne Edwards" ("Rezervnaya") is located in the Central Western Atlantic. Russian vessels fished in this area in different periods between 1976 and 1999 using pelagic trawls. There is no statistics on the Russian fishery on separate seamounts.

Based on the information collected in the 2004 Spanish experimental survey in Corner Rise, 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.

Recent catch estimates (tonnes) are as follows:

	2010	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**
STATLANT 21	53		298	112	118	77	129	51	
STACFIS	52	152	302	114	118	122	127	51	2

Effects of the fishery on the ecosystem

Midwater trawls (pelagic and semi-pelagic) can produce significant adverse impacts (SAI) on VME communities, as per information provided by the Scientific Council in 2010 and further addressed by the Scientific Council in 2015. Such impacts are typically associated with: 1.) habitat destruction or direct contact with VMEs by the gear when it is fished near the seafloor and 2.) lost gear that becomes entangled in VMEs. Given the slow growth/reproductive rates that characterize VME-forming species, these impacts to VMEs can cumulatively result in Significant Adverse Impact (SAIs).

Special comments

The next assessment of this stock was previously scheduled for 2021. The SC is providing new advice this year due to the abrupt drop of catches and CPUE in the past year. Subject to data availability, the next assessment will be conducted according to the Commission request or if SC considers it is warranted.

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.

Sources of Information SCR 15/06; SCS Doc. 19/10.

Roughhead grenadier in Subareas 2+3

Recommendation

There will be no new assessment until monitoring shows that conditions have changed.

Management objectives

No explicit management plan or management objectives defined by the Commission. Convention General Principles are applied.

Convention General Principles	***Status***	***Comment/consideration***
Restore to or maintain at B_{msy}	⚪	Cannot be evaluated
Eliminate overfishing	🟢	Low *F*
Apply Precautionary Approach	⚪	Reference points not defined
Minimise harmful impacts on living marine resources and ecosystems	🟢	VME closures in effect
Preserve marine biodiversity	⚪	Cannot be evaluated

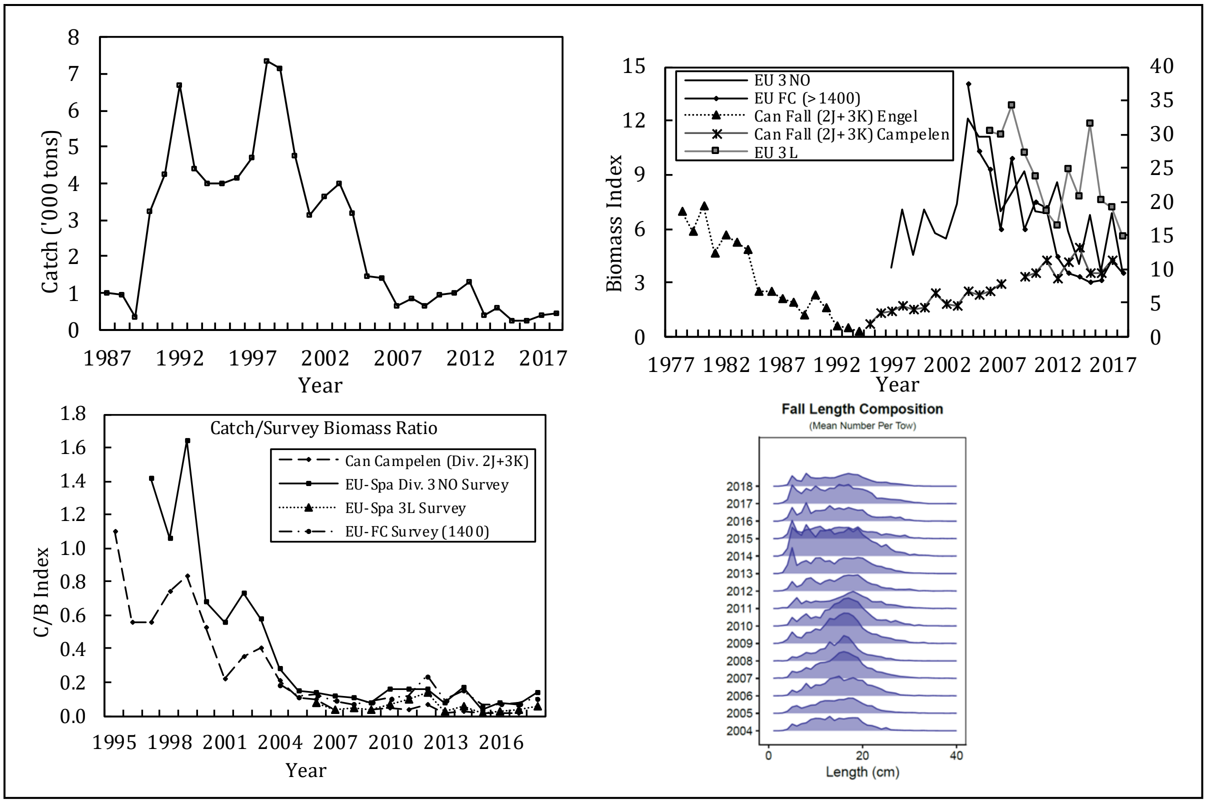
🟢	OK
🟠	Intermediate
🔴	Not accomplished
⚪	Unknown

Management unit

The stock structure of this species in the North Atlantic remains unclear. Roughhead grenadier is distributed throughout NAFO Subareas 0 to 3 in depths between 300 and 2000 m. However, for assessment purposes, NAFO Scientific Council considers the population of Subareas 2 and 3 as a single stock.

Stock status

There is a general decrease in biomass indices 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. An increase in the abundance of small sized fish (less than 10 cm) after 2010 until 2018 can be observed in the surveys.



Reference points

Not defined.

Assessment

Biomass indices from the surveys with depth coverage to 1400 meters are considered as the best survey information to monitor trends in resource status because they cover the depth distribution of roughhead grenadier fairly well.

Human impact

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

Biological and Environmental impact

Roughhead grenadier are a wide ranging species. The impacts of physical and biological interactions are poorly understood.

Fishery

Roughhead grenadier is taken as by catch in the Greenland halibut fishery, mainly in NRA Divisions 3LMN. Most roughhead grenadier catches are taken by trawl and the only management regulation applicable to roughhead grenadier in the NRA is a general groundfish regulation requiring the use of a minimum 130 mm mesh size.

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

	2010	2011	2012	2013	2014	2015	2016	2017	2018
STATLANT 21	0.8	1.0	1.3	0.4	0.6	0.2	0.1	0.1	0.1
STACFIS	0.9	1.0	1.3	0.4	0.6	0.2	0.3	0.4	0.5

Effects of the fishery on the ecosystem

SC completed the assessment of the risk of Significant Adverse Impacts (SAIs) from bottom fishing activities on VMEs in the NRA. The results indicated that both large gorgonians and sponges VME have a low overall risk of SAI, while sea pen VMEs were assessed as having a high overall risk of SAI.

Special comments

This stock will be monitored by interim monitoring report until such time as monitoring suggests a major change.

Sources of Information

SCR Doc. 19/13, 15, 20, 21 and 23; SCS Doc. 19/09, 10 and 11.

VIII. REVIEW OF FUTURE MEETINGS ARRANGEMENTS

1. Scientific Council (in conjunction with NIPAG) September 2019 (date to be determined)

Meeting by WebEx to update the assessment of 3M and 3LNO shrimp

2. Scientific Council, 23 – 27 Sep 2019

Scientific Council noted the Scientific Council meeting will be held in Bordeaux, France, 23-27 September 2019.

3. Scientific Council, (in conjunction with NIPAG), 08 – 13 Nov 2019

Scientific Council noted that the Scientific Council shrimp advice meeting will be held in Tromsø, Norway, 08 – 13 November, 2019, immediately following the ICES/PICES/NAFO shellfish symposium.

4. WG-ESA, 19- 28 Nov, 2019

The Working Group on Ecosystem Science and Assessment will meet at the NAFO Secretariat, Nova Scotia, Canada, 19-28 November, 2019.

5. Scientific Council, June 2020

Scientific Council agreed that its June meeting will be held on 29 May - 11 June 2020, at Saint Mary's University, Halifax.

6. Scientific Council (in conjunction with NIPAG), 2020

Dates and location to be determined.

7. Scientific Council, Sep 2020

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.

8. Scientific Council, June 2021

Scientific Council agreed that its June meeting will be held 28 May - 10 June 2021 (dates to be confirmed) at Saint Mary's University, Halifax.

9. NAFO/ICES Joint Groups

a) NIPAG, 08 – 13 Nov 2019

Scientific Council noted that the Scientific Council shrimp advice meeting will be held in Tromsø, Norway, 08 – 13 November, 2019.

b) NIPAG, 2020

Dates and location to be determined.

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

Dates and location to be determined.

d) WG-HARP, 2019

The report of the 2018 WGHARP meeting is not available and the date and location of the next meeting are unknown.

10. Commission- Scientific Council Joint Working Groups

a) WG-RBMS

The joint SC-Commission Working Group on Risk Based Management Systems (WG-RBMS) will be held in Bordeaux 21 Sept 2019.

b) WG-EAFFM

The joint SC-Commission Working Group on the Ecosystem approach to Fisheries Management (WG-EAFFM) will be held in Halifax, Nova Scotia, Canada, 16-18 July 2019.

c) CESAG

The next meeting of the Catch Estimation Strategy Advisory Group (CESAG) will be in July 2019.

IX. ARRANGEMENTS FOR SPECIAL SESSIONS

1. Topics of Future Special Sessions

In September 2019 and June 2020 SC will discuss the possibility of future special sessions including survey standardization as discussed in STACREC.

2. ICES/PICES/NAFO International Symposium on "Shellfish Resources and Invaders of the North"

The ICES/PICES/NAFO International Symposium on "Shellfish Resources and Invaders of the North" that will be held 5-7 November 2019 in Tromsø, Norway.

X. MEETING REPORTS

1. Working Group on Ecosystem Science and Assessment (WG-ESA) - SCS Doc. 18/23

The report of the meeting of the Working Group on Ecosystem Science and Assessment (WG-ESA) held 13-23 November 2018 in Dartmouth, Nova Scotia was presented by its co-Chairs Pierre Pepin (Canada) and Andrew Kenny (EU).

2. ICES-NAFO Working Group on Deep-water Ecology (WG-DEC)

The 2019 meeting of the ICES-NAFO Working Group on Deep-water Ecology (WG-DEC) took place in 3rd – 7th June 2019 in Esporles in Mallorca, Spain. The report of this meeting will be discussed by SC in September.

3. Report from ad hoc Joint Commission- Scientific Council Working Group on Catch Estimation Strategy Advisory Group (CESAG)

The report of the meetings of ad hoc Joint Commission- Scientific Council Working Group on Catch Estimation Strategy Advisory Group (CESAG) was presented by its co-Chair Katherine Sosebee (USA).

4. Meetings Attended by the Secretariat

23–25 Jan.	ABNJ Fourth Project Steering Committee Meeting
13–14 Mar.	Workshop and Fourth Joint Meeting of the Sargasso Sea Commission and Hamilton Declaration Signatories
25–26 Mar.	1st Preparatory Meeting of the Western Central Atlantic Fishery Commission (WECAFC) Reorientation
25 Mar. – 05 Apr.	Second session of the Biodiversity Beyond National Jurisdiction IGC
02–03 May	Fourteenth round of Informal Consultations on "Performance reviews of regional fisheries management organizations and arrangements",
6 May	Global Deep-Sea Symposium – ABNJ Deep Seas Project

XI. REVIEW OF SCIENTIFIC COUNCIL WORKING PROCEDURES/PROTOCOL

1. General Plan of Work for September 2019 Annual Meeting

The assessment of northern shortfin squid in subareas 3 + 4 will be undertaken during the Scientific Council meeting

XII. OTHER MATTERS

1. Archiving of Assessment Data

Secretariat will contact DEs after the meeting to ensure that all assessment data is in the SharePoint.

2. Scientific Merit Awards

NAFO Scientific Council (SC) was pleased to present a merit award to **Dr. M. Joanne Morgan (Canada)** to acknowledge and celebrate her extensive contributions to SC over her career as a Research Scientist.

Joanne has served the SC in numerous capacities, including as a Designated Expert (DE) for multiple stocks, primarily as the DE for American Plaice in NAFO Divs. 3LNO. Joanne provided exceptional leadership to SC during her tenure as chair of the SC subcommittees STACREC (2001-2003) and STACFIS (2009-2011). During 2003-2005, Joanne was the chair of the Scientific Council, the first woman to hold this position.

In addition to serving as a chairperson within SC, Joanne is an Associate Editor for the *Journal of Northwest Atlantic Fishery Science*. She was also instrumental in initiating and leading the work of the NAFO SC *Working Group on Reproductive Potential* over the course of its work from 1998-2013. Joanne's knowledge, experience and guidance have been essential to the work of SC. Members of SC congratulated Joanne on her contributions, thanked her for her wisdom and offered best wishes for the future.

3. Budget Items

SC discussed the proposed Scientific Council budget for 2020 (scwp-19-002). The Secretariat will prepare a revised WP incorporating SC's comments for the Annual meeting in September 2019.

4. Other business

a) FAO ABNJ Deep Seas Project

Tony Thompson, FAO, introduced the "Sustainable fisheries management and biodiversity conservation of deep-sea living resources and ecosystems in the ABNJ" (ABNJ Deep Seas Project) which started in 2014 and will end in 2019. This project had a diverse range of outcomes, many of which are available as reports[1] . It also acted as a forum for RFMOs to share experiences and participate in side-events at the UN BBNJ discussions.

A follow-on project, under the GEF-7[2] replenishment fund, is being developed to build upon successful outcomes from the first project and to open the scope to include new topics of importance in the management of ABNJ resources. It is envisaged that this project will have a similar operational structure, with a Common Oceans program that will include a deep seas project, possibly with closer links to the tuna project. Two meetings have been held at FAO in Rome to develop the Common Oceans programme framework, which includes immediate outcomes dealing with (1) legal instruments and fisheries management, (2) ecosystem approach to fisheries (EAF), (3) multi-sectoral coordination, and (4) knowledge sharing and transparency.

These outcomes were incorporated into an EAF framework covering the institutional, ecological and human elements, and workflows discussed that aligned with priorities and needs of NAFO SC. NAFO's work on the ecosystem approach framework fits well into the proposed structure. Any future ABNJ deep seas project could

---

[1] http://www.fao.org/in-action/commonoceans/en/

[2] https://www.thegef.org/topics/areas-beyond-national-jurisdiction

provide transformational change by improving the application of EAF and by supporting mechanisms to enhance two-way coordination and cooperation between management and science, single- and multi-sector, and promoting knowledge sharing and transparency.

Preparations for the next ABNJ project include the development of a PIFlite (Concept note) by end 2019 and a full project document by end 2020. If successful, the next project should start in 2021/22.

NAFO Scientific Council discussed the presented outcomes and super-imposed ecosystem approach framework and felt that this could support their current work plan and particularly cross-cutting issues related to the uptake of information within and across RFMOs and different sectors. SC requested that special consideration be given to the participatory nature of the work and the inclusion of industry representatives and other stakeholders. Several members of SC offered their assistance to FAO to develop certain aspects of the project.

b) Request on the use of bottom gear with 90mm mesh size

Russian Federation requests the Scientific Council to consider the possibilities of using bottom gear with 90 mm mesh size when fishing for redfish in Divs. 3LNO.

SC noted that this request did not conform to the usual process of submitting requests for SC advice. Not withstanding this, SC reiterates its previous concerns (SCS Doc. 07-19) that 90 mm mesh size should not be used in bottom trawl fisheries due to issues of bycatch of other species.

5. 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	Danny Ings	danny.ings@dfo-mpo.gc.ca
American Plaice in Div. 3LNO	Laura Wheeland	laura.wheeland@dfo-mpo.gc.ca
Witch flounder in Div. 3NO	Joanne Morgan	joanne.morgan@dfo-mpo.gc.ca
Witch flounder in Div. 2J+3KL	Laura Wheeland	laura.wheeland@dfo-mpo.gc.ca
Yellowtail flounder in Div. 3LNO	Dawn Maddock Parsons	dawn.parsons@dfo-mpo.gc.ca
Greenland halibut in SA 2+3KLMNO	Joanne Morgan	joanne.morgan@dfo-mpo.gc.ca
Northern shrimp in Div. 3LNO	Katherine Skanes	katherine.skanes@dfo-mpo.gc.ca
Thorny skate in Div. 3LNO	Mark Simpson	mark.r.simpson@dfo-mpo.gc.ca
White hake in Div. 3NO	Mark Simpson	mark.r.simpson@dfo-mpo.gc.ca

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

Greenland halibut in SA 0+1	Margaret Treble	margart.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.es
Roundnose grenadier in SA 2+3	Fernando Gonzalez-Costas	fernando.gonzalez@ieo.es
Cod in Div. 3M	Diana Gonzalez-Troncoso	diana.gonzalez@ieo.es
Shrimp in Div. 3M	Jose Miguel Casas Sanchez	mikel.casas@ieo.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	Antonio Avila de Melo	amelo@ipma.pt
Redfish in Div. 3LN	Antonio Avila de Melo	amelo@ipma.pt

From the Greenland Institute of Natural Resources, Nuuk, Greenland

Redfish in SA1	Rasmus Nygaard	rany@natur.gl
Other Finfish in SA1	Rasmus Nygaard	rany@natur.gl
Greenland halibut in Div. 1A	Rasmus Nygaard	rany@natur.gl
Northern shrimp in SA 0+1	AnnDorte Burmeister	anndorte@natur.gl
Northern shrimp in Denmark Strait	Frank Riget	frri@natur.gl

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

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 13 June 2019, 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 13:00 on 13 June 2019.

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

Chair: Miguel Caetano Rapporteur: David Bélanger

The Committee met at the Sobey School of Business (Unilever Lounge), Saint Mary's University, 903 Robie St., Halifax, NS, Canada, on May 31th, 2019, 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 Greenland), European Union (Portugal, Spain and UK), Russian Federation, and USA.

1. Opening

The Chair opened the meeting by welcoming participants to this June 2019 Meeting of STACFEN.

The Committee adopted the agenda and discussed the work plan and noted the following documents would be reviewed: SCR Doc. 19/07, 19/09, 19/10, 19/11, 19/27, 19/39, 19/40.

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 2018

STACFEN **recommends** *consideration of Secretariat support for an invited speaker to address emerging issues and concerns for the NAFO Convention Area during the 2019 STACFEN Meeting.*

STATUS: Considering the different subjects in discussion in the STACFEN meeting and the early stage of the newly installed Chairperson, no attempts were made to attract an invited speaker for this meeting. This recommendation is **reiterated** and STACFEN will endeavor to have an invited speaker next year.

5. Oceanography and Science Data (OSD) Report for 2018 SCR 19/27

The Marine Environmental Data Section (MEDS) of the Oceans Science branch of DFO acts as Regional Environmental Data Center for NAFO. Thus, NAFO member countries that perform research cruises within the convention area are requested to provide MEDS with all marine environmental data. In order to communicate the data collected during 2018 or during this year, a report was requested to MEDS by the Council for its meeting in June 2019 of a completed oceanographic inventory. The data collected in the NAFO Convention Area can be grouped by a number of ways (variable type, sampling type, platform type, real-time vs. delayed mode, source, etc.). The data reported within the convention area consisted of vertical profiles of temperature, salinity, dissolved oxygen, chlorophyll, nutrients and currents. This data was collected through ships operating expendable bathythermographs (XBT), CTD, rosette sampling, automated platforms, moorings with instruments at various depths and acoustic profilers. Surface or near-surface data was collected using moored buoys, drifting buoys, water level gauges, ship-borne thermosalinographs and wind/wave hindcast. Additional data derived from subsurface moorings through regional collaboration. Data that have been formatted and archived at MEDS are available to all members on request or are available from DFO institutes. Requests can be made by telephone (613) 990-6065, by e-mail to info@dfo-mpo.gc.ca, by completing an online order form on the MEDS web site at http://www.meds-sdmm.dfo-mpo.gc.ca/isdm-gdsi/request-commande/form-eng.asp. The following table summarizes counts for 2018 by data type.

Data observed in NAFO Convention Area in 2018

Data Type	Platform Type	Counts/Duration
Oceanographic profiles	autonomous drifting (Argo)	4876* profiles from 197 platforms
	Moorings (Viking)	2214* profiles from 7 platforms**
	Gliders	19132* profiles from 7 platforms
	Ship	5879 profiles (4547 CTD; 247 CTD*; 215 bottle, 346 XBT and 524 XBT* profiles) from at least 32 ships and one helicopter
Surface/near-surface observations	ship (thermosalinograph)	44923* obs. from 3 ships
	drifting buoys	359173* obs. from 155 buoys
	moored buoys	116885* obs. from 21 buoys**
	fixed platforms	84691* obs. from 3 platforms
	water level gauges	12 sites, avg. ~1 year each
Sub-surface observations	moored CTD, ADCP, O2	8 moorings

*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 prior to 2018 in NAFO Convention Area and acquired between January 2018 and May 2019

Data Type	Platform Type	Counts/Duration
Oceanographic profiles	Ship	1867 profiles (1430 CTD + 219 bottle + 217 XBT profiles) from 14 ships

6. Highlights of Climate and Environmental Conditions by NAFO Sub-Area for 2018

a) Meteorological and Ice Conditions (Sub-Areas 1-6)

Winter NAO was relatively high at 1.3 SD above normal, but unusual spatial patterns in the sea level pressure over the North Atlantic have led to strong seasonal variations in air temperature (warm March over the Arctic, cold spring in mid-latitude and warm summer).

Over sub-areas 2 and 3, the annual air temperatures were normal.

The annual air temperatures over West Greenland (Nuuk), Labrador (Cartwright) and Newfoundland (St. John's) were normal.

Surface air temperatures over most of the Labrador Sea were below normal in February, May, and June, but strongly above normal in March (e.g., 6°C above normal in Cartwright and Iqaluit).

Air temperature anomalies were positive at all 6 sites examined in sub-area 4, ranging from 0.2°C (0.2 SD) above normal at St. John to 0.8°C (1.3 SD) above normal at Boston.

Air temperatures were also warmer than average over the northeastern United States (NEUS) continental shelf, with enhanced positive anomalies in winter and late summer.

Sea ice extent on the Newfoundland shelf increased substantially during the winter of 2014, with the first positive (larger than normal extent) anomaly observed in 16 years, it was near normal in 2015 but returned to slightly below normal conditions between 2016 and 2018.

Due to the warm air temperature in March, the sea-ice seasonal cycle exhibited a large ice volume anomaly during mid-season but finished with normal conditions.

b) Ocean Climate Indices

Sub-Area 2 and 3 NL Shelf

On average, sea surface temperatures (SST) anomalies were below normal in sub-areas 2 and 3, except south of the Grand Bank.

At Station 27, vertically averaged temperature was above normal, and salinity anomaly was the lowest (freshest) since 1948.

Large positive anomalies in bottom temperature were observed in sub-area 2 along the Labrador shelf. Bottom temperatures were slightly warmer than normal in most sub-area 3, except for the center of the Grand Banks where bottom temperatures were slightly colder than normal.

The cold intermediate layer was slightly warmer than normal as were most subsurface portions of the Seal Island, Bonavista and Flemish Cap hydrographic sections.

Fresh anomalies were observed in the inshore areas of Seal Island, Bonavista and Flemish Cap hydrographic sections.

The Labrador Current transport, as measured by satellite altimetry, was higher than normal on the Labrador and northern Newfoundland slopes.

Division 3M, Flemish Cap

Data of the annual EU survey was not processed in time to be included in the report.

Annual SST around the Flemish Cap was colder than normal for a fifth consecutive year in 2018 with a standardized anomaly -0.7 SD.

The average temperature along the offshore portion of the Flemish Cap section (as measured during the Atlantic Zone Monitoring Program summer 2018 survey) was normal.

Sub-Area 4, Scotian Shelf

Overall in 2018, the air temperatures were warmer than normal in Sub-area 4.

SST anomalies were largely above normal on the Scotian Shelf and Gulf of Maine.

At the Halifax-2 and Prince-5 stations, vertically averaged temperature was above normal.

Large warm anomalies in bottom temperature were observed in sub-area 4.

The Labrador Current transport, as measured by satellite altimetry, was weaker than normal on the Scotian slope.

c) Biological and Chemical Indices

Reference periods for biological indices derived from Ocean Colour satellite data (spring bloom magnitude and initiation) and oceanographic surveys (nitrate, chl *a*, zooplankton abundance [copepod, non-copepod, *Calanus finmarchicus*, *Pseudocalanus* spp.] and zooplankton biomass) were 1998-2015 and 1999-2015, respectively.

Sub-Areas 0-1, Labrador Sea and Hudson Strait

Due to ongoing satellite data reprocessing, Ocean Colour data for the western Greenland Shelf was not available in 2018.

Spring bloom magnitude (total production) in 2018 was slightly below normal in the Labrador Sea (1F), and near normal in the Hudson Strait (0B). For the Labrador Sea, this represents a decrease in total primary production compared to 2017.

Spring bloom initiation in 2018 occurred later than normal in the Labrador Sea (1F), and near normal in the Hudson Strait (0B). Bloom timing in the Labrador Sea was similar to that observed in 2017.

Sub-Areas 2-3, NL Shelf

Nitrate inventories in the upper (0-50m) water column were below normal in 2018 on the southern Labrador Shelf (2J) and above normal on the Northeast Newfoundland Shelf (3K). This represents an increase compared to 2017 in NAFO Div. 3L where shallow nitrate inventories were near normal.

Deeper (50-150 m) nitrate inventories in 2018 were similar to those of the previous year with below normal concentrations on the southern Labrador Shelf (2J), and near normal concentrations on the Northeast Newfoundland Shelf (3K).

Chlorophyll *a* inventories (0-100 m) in 2018 were similar to those of the previous year with above-normal concentrations on the Southern Labrador Shelf (2J), and near normal concentrations on the Northeast Newfoundland Shelf (3K).

The magnitude (total production) of the phytoplankton spring bloom in 2018 was below normal on the Southern Labrador Shelf (2HJ) and above or near normal on the northeast Newfoundland Shelf (3K).

The initiation of the phytoplankton spring bloom in 2018 occurred later than normal (large positive anomalies) on the southern Labrador Shelf (2HJ), and near or later than normal on the northeast Newfoundland Shelf (3K).

The abundance of non-copepod zooplankton in 2018 was near normal on the Southern Labrador Shelf (2J) and above normal on the Northeast Newfoundland Shelf (3K). On the Southern Labrador Shelf, this represents a decrease compared to the positive anomaly observed in 2017.

The abundance of copepods in 2018 was slightly above normal on the NL Shelf (2J3K) in 2018. This represents a decrease compared to the larger positive anomalies observed in 2017.

The abundance of the large grazing copepod *Calanus finmarchicus* in 2018 was slightly above normal on the Labrador Shelf (2J) and slightly below normal on the Northeast Newfoundland Shelf (3K) in 2018. For the Southern Labrador Shelf (2J), this represents an increase compared to the negative anomaly observed in 2017.

The abundance of small grazing *Pseudocalanus* copepod species was slightly below normal on the NL Shelf (2J3K). This represents a decrease compared to the near-normal conditions observed in 2017.

Total zooplankton biomass in 2018 was above normal on the Southern Labrador Shelf (2J), and near normal on the Northeast Newfoundland Shelf (3K). This represents a significant increase across the NL Shelf compared the markedly large negative anomalies observed in 2017.

Sub-Area 3, Grand Bank and Flemish Cap

Nitrate inventories in the upper (0-50m) water column in 2018 were near or below normal in NAFO Div. 3LMNO. This represents a significant decrease in nitrate concentration across the Grand Bank region compared to the mainly positive anomalies observed in 2017.

Deeper (50-150 m) nitrate inventories were below normal across the Grand Bank area (3LMNO) in 2018. This represents a decrease in nitrate concentration across the region compared to the near-normal conditions observed in 2017.

Chlorophyll *a* inventories in the first 100 m of the water column were either near or above normal in 2018 on the Grand Bank (3LMNO). This represents an increase on the Central (3LN) and the Southeastern (3LNO) Grand Bank areas where respectively near and below normal chlorophyll concentrations were observed in 2017.

The magnitude (total production) of the phytoplankton spring bloom was mainly near normal on the Grand Bank (3LNOPs) and above normal in the Flemish Pass (3M) in 2018. Overall conditions were similar to those observed in 2017.

Timing of the initiation of the phytoplankton spring bloom was near normal on the Grand Bank in 2018. This represents a shift toward earlier blooms compared to 2017 when spring blooms occurred later than normal throughout most of the area.

The abundance of both non-copepod and copepod zooplankton was above normal on the Grand Bank region (3LMNO) in 2018. The abundance of non-copepod zooplankton increased compared to 2017 when abundance was already above normal, while the abundance of copepod remained at comparable levels.

The abundance *Calanus finmarchicus* and *Pseudocalanus* spp. copepods in 2018 were similar to that observed in 2017 with near normal abundance on the central Grand Banks (3LM) and above normal abundance on the Southeastern Grand Banks (3LNO).

Zooplankton biomass was below normal across the Grand Bank region (3LMNO) in 2018. However, despite the negative anomalies observed across the region, total zooplankton abundance increased by ~50% on the central Grand Banks (3LM) and decreased by ~50% on the south-eastern Grand Banks (3LNO) compared to 2017.

Sub-Area 4, Gulf of St. Lawrence (GSL)

Nitrate inventories in the upper (0-50m) water column in 2018 were largely below normal throughout the GSL (4RST). This represents a marked decrease compared to 2017 when shallow nitrate inventories were mainly near or above normal.

Deeper (50-150 m) nitrate inventories in 2018 were either near, or below normal in the GST (4RST). Overall, conditions were similar to those observed in 2017. with the exception of an appreciable decrease on the Grand Banks.

Chlorophyll *a* inventories in the first 100 m of the water column were near normal throughout most the GSL in 2018, with the exception of the large positive anomaly observed in the western GSL contrasting with the negative anomaly observed in 2017. Chl a concentration decreased in the southern GSL (4T) compared to the previous year.

The magnitude (total production) of the phytoplankton spring bloom in the GSL was mainly near normal in 2018 with the exception of the large positive anomaly observed in the Cabot Strait, contrasting with the negative anomaly of the previous year. A general decrease in total spring bloom production, compared to 2017, was observed throughout the GSL.

The initiation of the phytoplankton spring bloom occurred earlier than normal throughout most of the GSL in 2018,but slightly later than in 2017.

The abundance of non-copepod zooplankton was near normal across the GSL region (4RST) in 2018. Abundance anomalies shifted from slightly negative in 2017 to slightly positive in 2018 in the western GSL and at the Rimouski high-frequency sampling station.

There was no consistent spatial trend in copepod abundance in the GSL in 2018 with near-normal levels observed in the eastern (4RS), western (4ST) and southern (4T) GSL, above-normal levels at the Rimouski (4T) high frequency sampling station, and below-normal levels in the Cabot Strait (3Pn, 4Vn).

The abundance of both *Calanus finmarchicus* and *Pseudocalanus* copepod species were mostly near normal across the GSL region in 2018. The abundance of *C. finmarchicus* decreased in the eastern GSL (4RS) and in the Cabot Strait (3Pn, 4Vn), and increased in the western GSL (4ST) compared to 2017. The abundance of *Pseudocalanus spp*. showed a general increase compared to 2017 except in the eastern GSL and in the Cabot Strait.

Zooplankton biomass was below normal across the GSL region for a second consecutive year in 2018

Sub-Area 4, Scotian Shelf (SS)

Nitrate inventories in the upper (0-50m) water column in 2018 were near, or below normal on the Scotian Shelf (4VsWX). Inventories were similar to those observed during the previous year except for the large negative anomaly observed on the Eastern SS (4Vs), which contrasted with the 2017 positive anomaly.

Deeper (50-150 m) nitrate inventories in 2018 were below normal across the Scotian Shelf (4VsWX) in 2018, despite having increased on the Central and Western SS (4WX) compared to 2017.

Chlorophyll *a* inventories in the first 100 m of the water column were near normal on the Eastern (4Vs) and Central SS (4W), and below normal on the Western SS (4W) in 2018. This represents an increase in chl *a* inventories for the Western and central SS, and a decrease for the Eastern SS compared to 2017.

The magnitude (total production) of the spring bloom was above normal on the Eastern SS (4Vs), near normal on the Central SS (4W), and below normal on the Western SS (4X). Total phytoplankton spring bloom production markedly increased on the Eastern SS where the large positive anomaly observed in 2018 contrasted with the 2017 negative anomaly.

Spring bloom initiation timing was near normal across the SS (4VsWX) in 2018. This represents a shift toward later blooms compared to 2017.

The abundance of non-copepod zooplankton was near normal on most of the SS in 2018. A decrease in non-copepod zooplankton abundance was observed on the Western SS as well as in the Bay of Fundy (4X).

Copepod abundance was either near or below normal on the SS in 2018 with an overall decrease in abundance on the central and western SS compared to 2017.

The abundance of *Calanus finmarchicus* copepods was below normal across the SS (4VsWX) in 2018. This represents an overall decrease compared to 2017, when *C. finmarchicus* abundance was mostly near, or above normal.

The abundance of *Pseudocalanus spp*. copepods was near, or below normal on the SS (4VsWX) in 2018 with an exceptionally large negative anomaly observed in the Bay of Fundy. Abundance anomalies in 2018 were higher than in the previous year, with the exception of the Prince-5 high-frequency station (Bay of Fundy) where the abundance anomaly was more than three times lower than in 2017.

Zooplankton biomass was near, or below normal on the SS in 2018 with biomass levels comparable to those observed in 2017.

7. Review of the physical, biological and chemical environment in the NAFO Convention Area during 2018

The winter North Atlantic Oscillation (NAO) index is the difference in winter (December, January and February) sea level atmospheric pressures (SLP) between a high SLP region near the Azores and low SLP region near Iceland. It generally considered as a measure of the strength of the winter westerly and northwesterly winds over the Northwest Atlantic. A high (positive phase) NAO index occurs from an intensification of the Icelandic Low and Azores High. This favors strong northwest winds, cold air and sea temperatures and heavy ice conditions on the NL Shelf regions. Analysis has shown that variability in the NAO can account for a significant portion of the variability in key ocean climate indices, including Labrador Sea convection and the cold-intermediate-layer (CIL) water mass overlying much of the Newfoundland and Labrador continental Shelf. In 2018, the NAO index declined from the record high of 2015 but remained in a positive phase for the fifth consecutive year at 1.3 SD above the long term mean. The SLP pattern momentary reverse for the month of March 2018 (low SLP above Greenland), causing low NAO index (-0.93) and warm temperature anomalies during this month, especially in the northern portion of the NAFO convention area. The high NAO phase however resumed for the rest of the year, causing colder than normal air temperature above the region in the spring, especially in May (NAO index at +2.12) and June.

a) Sub-areas 0 and 1. Environmental Conditions in the Labrador Sea in 2017-2018 was presented in SCR Doc. 19/39, 19/40.

In the Labrador Sea, wintertime surface heat losses result in the formation of dense waters which plays an important role in ventilating the deep ocean and driving the global ocean overturning circulation. In the winter of 2016-17, as in the previous winter, the mid-high latitude North Atlantic experienced more moderate surface heat loss in the region than in the winter of 2014-15, characterized by the highest heat losses in more than two decades. In 2016-17, the winter North Atlantic Oscillation (NAO) index still exceeded its 1981-2010 mean, but its value (2.7 mb) was significantly lower than the 2014-15 value which was the largest in 122 years. However, the surface conditions showed positive air temperature anomaly ranging from 1°C to 4°C over the Labrador Sea, positive sea surface temperature anomalies about 1.5°C, and a slightly lower than normal Labrador Shelf ice extent in the winter. Despite a reduction in the cumulative heat losses from the sea surface after 2014-15, the depth of winter convection continued to increase resulting in the most significant formation, in terms of volume, density and depth, of Labrador Sea Water (LSW) since 1994, reaching below 2000 m. This is mainly due to the water column preconditioning caused by convective mixing in the previous years. Bedford Institute of Oceanography (BIO) North Atlantic model simulations suggest however that the strength of the Labrador Current (defined as the barotropic transport) had been declining since 1996. The average current was about 4 Sv and 2 Sv weaker in 2017 and 2016, respectively. Phytoplankton bloom onset occurred earlier than usual in the two shelf regions, but while the duration acted on the Greenland Shelf to bring the magnitude to relatively high levels, the situation was reversed on the Labrador Shelf with a relatively lower than average phytoplankton bloom. Extensive cloud cover from end of April to early June of 2017 reduced the percent coverage of the central region with ocean colour data to less than 20% in any of the seven days composite images. Missing an important portion of the bloom initiation phase made it impossible to estimate its magnitude. As a result of the cancellation of the spring research survey, we were unable to update the rate of decline in pH, previously reported as -0.002 y^{-1} over the 1994-2016 period, nor was it possible to assess the state of *Calanus finmarchicus*, the dominant mesozooplankton in the Labrador Sea, following the record lows reported in 2016.

In the winter of 2017-18, the mid-high latitudes of the North Atlantic experienced more moderate surface heat loss in the region than in the winter of 2014-15, characterized by the highest heat losses in more than two decades. The winter (Dec-Mar) NAO index in 2017-18 and winter heat fluxes in the central Labrador Sea were near-normal. However, a high atmospheric pressure anomaly extended throughout the Labrador Sea in winter, resulting in above-normal air and sea surface temperatures in the western Labrador Sea, and below-normal temperatures in the northeastern Labrador Sea. For SST, these conditions persisted into the spring but appeared to have propagated cyclonically. Sea ice concentration anomalies in February and March 2018 were generally negative in the western Labrador Sea, and positive in the northeastern Labrador Sea, consistent with atmospheric circulation and air temperatures. Ocean temperature in the central Labrador Sea was near normal, and continued a negative trend observed since 2010 for the 15-100 m layer, and since 2011 for the 200-2000 m layer caused by deepening of winter convection. Despite a reduction in the cumulative heat losses from the sea surface after 2014-15, the depth of winter convection continued to increase resulting in the most significant formation, in terms of volume, density and depth, of Labrador Sea Water (LSW) since 1994 reaching below 2000 m. This is mainly due to the water column preconditioning caused by convective mixing in the previous years. BIO North Atlantic model simulations suggests however that the transport of the Labrador Current decreased between 1995 and 2014, but has since increased slightly.

Both total carbon and SF6 averaged over the top 1000 m showed an increasing trend in the past decade, reflecting a continuation of uptake of the anthropogenic gases by the subpolar North Atlantic. This trend was accompanied by a reduction in pH level critical for marine ecosystems. However, the CFC-12 concentration is presently significantly lower than in the previous decade which is likely related to the reduction in the CFC emissions observed since the start of the century.

Extensive cloud covers form April to June of 2018 reduced the percent coverage of the Labrador Shelf/Slope and Central Basin regions ocean color data to less than 20% in any of the seven days' composite, and most of the good pixels were provided by the northeast corner of the box. Missing an important portion of the bloom initiation phase made it difficult to estimate its extent and magnitude. Although the general tendencies go toward lower abundances in general for copepods, the three largest *Calanus* species abundances are larger than average in the Labrador basin.

b) Sub-area 1. The report on hydrographic conditions off Southwest Greenland in 2018 was presented in SCR Doc. 19/07.

Hydrographic conditions were monitored at 7 hydrographic standard sections in June-July 2018 across the continental shelf off West Greenland. The three northern sections were not occupied due to technical problems. 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.

c) Sub-areas 2, 3 and 4. A description of the physical oceanographic environment on the Newfoundland and Labrador Shelf and Scotian Shelf was presented in SCR Doc. 19/11.

Oceanographic and meteorological observations in NAFO Sub-areas 2, 3 and 4 during 2018 are presented referenced to their long-term (1981-2010) means. 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 strongly positive during 2018. However, the spatial patterns of the associated atmospheric pressure fields resulted in a normal annual air temperature, characterized by a warm month of March, cold spring and warm summer. On the Scotian Shelf and Gulf of Maine, the annual air temperature was above normal in 2018. The sea ice volume across the Newfoundland and Labrador Shelf, although close to the long-term mean over 2018, exhibited a strong negative anomaly in March as a consequence of warm air temperature over the Arctic during this month. Annual sea-surface temperature (SST based on infrared satellite imagery) trends on the Newfoundland and Labrador Shelf, while showing an increase of about 1°C since the early 1980s, were mostly below normal during 2018 for NAFO Divisions 2 and 3 (e.g., up to -1.6 SD and -1.9 SD for Hamilton Bank and Hudson Strait, respectively) and above normal for NAFO Division 4 (e.g. +2.0 SD for the Bay of Fundy and the Western Scotia Shelf). In 2018, vertically averaged salinity at station 27 was at a record low (fresh) since the beginning of the time series in 1948. Observations from the summer AZMP oceanographic survey indicated that after a predominance of colder than average conditions since 2012, the volume of cold-intermediate-layer (CIL, <0°C), reduced in 2018, especially in the northern part of the region where it was -1.6 SD below normal at Seal Island section (second smallest volume since 1980). The spatially averaged bottom temperature during the spring in 3LNOPs remained slightly above normal at +1.0 SD in 2018. For the fall, the bottom temperature in 2J3KLNO was also above normal at +0.8 SD, a return to positive anomaly after the cold anomaly of 2017 (the first one on average since 1995). In Divisions 4X, bottom temperatures in 2018 were the 5th warmest year on record, 2.0 SD above average. Vertically averaged temperature and salinity anomalies at long-term Station Prince 5 were 2.0 SD and 0.8 SD above average, respectively. Labrador Current transport index along the Labrador and northern Newfoundland shelf slope in 2018 was at a record high since the beginning of the time series in 1993 (equal with 1994 at +1.7 SD) while it was lower than average on the Scotian slope.

d) Sub-areas 2, 3, 4 and 5. Overview of the biogeochemical conditions in the NW Atlantic during 2018. SCR Doc. 19/10.

Biological and chemical variables collected in 2018 from coastal high frequency monitoring stations and seasonal (spring, summer and fall) sampling of standard oceanographic sections covering the Newfoundland and Labrador Shelf (NAFO Subareas 2 and 3), the Grand Banks (Subareas 2 and 3), the Gulf of St. Lawrence (Subarea 4), the Scotian Shelf (Subarea 4) and the Gulf of Maine (Subarea 5) are presented and referenced to information from earlier periods when available. We review interannual variations in phytoplankton spring bloom indices (magnitude, initiation and duration) derived from satellite Ocean Colour imagery, as well as nitrate, chlorophyll *a*, and zooplankton abundance and biomass inventories collected as part of the 2018 Atlantic Zone Monitoring Program (AZMP). All time series are presented in standardized anomalies relative to a 1998-2015 (Ocean Colour data) or 1999-2015 (oceanographic survey data) climatology. In general, nitrate inventories in the upper (0-50 m) and lower (50-150 m) water column were near, or below normal throughout the NW Atlantic in 2018 and presented respectively the second lowest, and the lowest cumulated anomaly indices of the 20-y time series. The concentration of chl *a* in the first 100 m of the water column was near, or above normal across the study area with the exception of the Bay of Fundy where a significant negative anomaly was observed. Chl *a* inventories in 2018 were higher than expected considering the usual positive relationship between chl *a* and shallow nitrate, or 1-year lag deep nitrate concentrations. Spring bloom indices derived from Ocean Colour satellite data indicated that the magnitude (total production) was mainly near, or below normal in most sub-regions. Phytoplankton blooms were later and slightly shorter than normal in the Labrador Sea and on the Labrador Shelf, earlier and longer than normal in most of the Gulf of St. Lawrence, and of normal timing and duration almost everywhere else. Spatial patterns in the abundance of copepod and non-copepod zooplankton in 2018 were similar to those of the previous year with above-normal abundances on the Newfoundland Shelf and the Grand Bank, and mainly near-normal abundances in the Gulf of St. Lawrence and on the Scotian Shelf with the exception of few negative copepod anomalies on the central and eastern Scotian Shelf. Overall copepod abundance in the NW Atlantic decreased for a second consecutive year since the time-series record high observed in 2016, reaching its lowest level in five years. The abundance of *Calanus finmarchicus* copepods increased to near-normal levels in the Western Gulf of St. Lawrence, decreased to below-normal levels in the Cabot Strait and on the Eastern and Central Scotian Shelf, and showed little variation compared to 2017 on the Northeast Newfoundland Shelf, the Grand Bank, and the Western Scotian Shelf. The abundance of *Pseudocalanus* copepods decreased to below-normal levels on the NL Shelf, but increased almost everywhere else in the NW Atlantic, except in the Bay of Fundy where an unusually large negative anomaly was observed. Overall zooplankton biomass increased in 2018 after the three consecutive time series record low, of the previous years, but nonetheless remained below normal across the NW Atlantic, except on the Labrador Shelf.

e) Sub-areas 5 and 6. The hydrographic Conditions on the northeast United States Continental Shelf in 2018 – NAFO Subareas 5 and 6 was presented in SCR Doc. 19/09.

An overview is presented of the atmospheric and oceanographic conditions on the Northeast U.S. Continental Shelf during 2018. 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, 2018 was characterized by warmer than average water temperatures observed everywhere except in the southern Middle Atlantic Bight. Warming was enhanced toward the north, with the largest positive anomalies observed in the Gulf of Maine. Large fresh anomalies were observed throughout the Middle Atlantic Bight during fall, consistent with the record high precipitation rates observed over this region during 2018. Overall, deep (slope) waters entering the Gulf of Maine were predominantly warmer and saltier than average, and their temperature and salinity suggest a subtropical source. Extremely warm winter air temperatures, followed by late-onset storms and extreme cold during April, confined winter mixing to the western shelf and upper slope in the Gulf of Maine, leading to minimal intermediate water formation during 2018.

8. The Formulation of Recommendations Based on Environmental Conditions in 2018

Further discussions are encouraged between STACFEN and STACFIS members on environmental data integration into the various stock assessments. For example, the composite zooplankton indices were further broken down by specific areas relevant to stock assessments on the NL Shelf and Grand Bank. Further emphasis has been given to summarize data from the Flemish Cap area. Additional consideration of integrating environmental indices was suggested to assist the committee work.

9. National Representatives

The current list of National Representatives for hydrographic data submission showed several vacancies or individuals that have unknown status. The Secretariat will facilitate the updating of this list prior to the next STACFEN meeting.

10. Other Matters

It has been previously noted that the STACFEN Chair, or designate, be included in the presentation of scientific advice from the Scientific Council to the Commission at their annual September meeting every 5 years, and more frequently if significantly large changes in the environment are observed. On this basis, it was suggested that a bring up-to-date climate information and ecosystem health (provided by WG-ESA) in the main NAFO stock areas be included in the 2020 SC's presentation of advice to the Commission.

11. Adjournment

Upon completing the agenda, the Chair thanked STACFEN members for their excellent contributions, the Secretariat and the rapporteur for their support and contributions. The Chair expresses its gratitude to the former STACFEN chair, Eugene Colbourne, for the kind contribution just prior to his recent retirement.

The meeting was adjourned at 17:00 on 31 May 2019.

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

Chair: Margaret Treble Rapporteur: Alexis Pacey

The Committee met at the Sobey School of Business at Saint Mary's University, 903 Robie St. Halifax, NS, Canada, on the 31 May-13 June 2019, 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 Greenland), European Union (UK, Portugal, and Spain), Russian Federation, Japan 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 as given in the Provisional Agenda distributed prior to the meeting was adopted.

4. Review of Recommendations in 2018

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 remove the WG-ESA report from the SC Reports (Redbook) and instead include a hyperlink to the report. This will address SC transparency and communication objectives. The Joint NAFO Commission-Scientific Council documents can remain in the Meeting Proceedings of the Commission.*

  STATUS: Implemented

- STACPUB **recommends** that *the Secretariat provide a summary of the 2018 ASFA Board Meeting for the June 2019 STACPUB meeting and that the Secretariat continue to submit SC documents and publications to the ASFA database*.

  STATUS: This has been implemented. A Review of 2018 ASFA (Aquatic Sciences and Fisheries Abstracts) Board Meeting is found under Other Matters in this Report.

- STACPUB **recommends** that *the Secretariat explore ways to make SC meeting documents from previous meetings available on the SharePoint*.

  STATUS: Implemented.

- STACPUB **recommends** that *the Secretariat provide a group email on the Designated Experts webpage.*

  STATUS: Implemented. https://www.nafo.int/Science/Designated-Experts

- STACPUB **recommends** that *the Secretariat and the Chair of STACPUB work intersessionally to develop a set of guidelines for the SCS documents, including consideration of the national research reports, and present these for review by STACPUB in June 2019*.

  STATUS: In progress.

- STACPUB **recommends** that *the Secretariat research bibliographic-citation or reference software that can be used to facilitate the download of citations for all documents and publications within NAFO, not just the Journal.*

  STATUS: Initiated for JNAFS with all volumes up to 2008 completed. The Secretariat web developer/analyst created a simple solution.

5. Review of Publications

a) Journal of Northwest Atlantic Fishery Science (JNAFS)

Volume 50-Regular issue: This volume was not published in 2018 but four articles have been received for 2019; two are in review with associate editors, one was withdrawn, and one was rejected.

b) NAFO Scientific Council Reports

The NAFO Scientific Council Reports 2018 (Redbook) was published online in May 2019. Twenty spiral bound copies were also printed for distribution to those who request a paper copy.

c) NAFO Scientific Council Studies

There were no submissions for 2018.

d) NAFO Commission-Scientific Council Reports

These reports are found in the Meeting Proceedings of the Commission for September 2017-August 2018. This document was published in September 2018 with15 spiral bound copies printed and distributed.

e) ASFA

All science publications and documents have been submitted to ASFA as of May 31, 2019. This includes *The Journal of the Northwest Atlantic Fisheries*, SC Reports, and SC Research/Summary Documents for 2018.

6. Other Matters

a) ASFA 2018 Board Meeting and Survey Results

The Senior Publications/Web Manager attended the 46th Annual Meeting of the Aquatic Sciences and Fisheries Abstracts (ASFA) Advisory Board. It was hosted by the International Oceanographic Data and Information Exchange (IODE) and took place from 11 to 15 June 2018 at the UNESCO/IOC Project Office for IODE, in Oostende, Belgium.

This meeting focused on the strengths and challenges ASFA faces today. The Board should reflect on the increasingly competitive global environment and how ASFA can adapt. The meeting discussed the impact evaluation studies and future plans. Informal discussion groups took place around several topics, such as broader promotion of ASFA, selecting a new business model, and updating the ASFA software. A three-year plan-of-action was established. It was also recommended that a survey be created and circulated amongst the partners who would then distribute it further. The survey ran from 2nd November – 5th December, and the ASFA Secretariat was pleased to receive 568 responses from 49 countries. Internet searches were the most common way to source information, 89% of respondents said they used this method. Age was a factor, with those under 24 least likely to use a specialized database such as ASFA (62.5% of respondents).

The Aquatic Sciences and Fisheries Abstracts (ASFA) database is the premier reference in the field of fisheries, aquatic and marine sciences. Input to the ASFA database is provided by an international network of information centers monitoring over 3000 serial publications, in addition to books, reports, conference proceedings, translations and grey literature covering the science, technology and management of marine, brackish water, and freshwater environments. For more information about ASFA visit their webpage: www.fao.org/fishery/asfa/en

ASFA newsletter: http://www.fao.org/documents/card/en/c/CA2512EN

b) SCS Documents

STACPUB reiterates the recommendation from 2018 and **recommends** that *the Secretariat and Chair of STACPUB work to develop guidelines for SCS documents.*

c) Referencing JNAFS Articles

A citation link/button was created for each JNAFS online article and it appears just above the abstract. This provides a text version of the citation for each paper that can be copied and pasted to other applications. STACPUB discussed the benefits of this feature and determined that it was a good starting point, but that it would be time consuming to continue this for all SC documents. The Secretariat was encouraged to continue exploring options that would provide researchers with a citation that could be easily uploaded to reference management software, e.g. RIS, BibTex, Endnote, RefWorks etc. STACPUB would re-visit this decision in the future.

STACPUB **recommends** that *the Secretariat continue to investigate solutions that would be compatible with reference management software.*

d) HTML links in references

Increasingly, citations include HTML links and in some cases they can become inactive. STACPUB discussed the implications for and solutions to this problem. It was noted that NAFO Secretariat should not try to change the references, even though they may have broken links, this would be an enormous task. DOIs (digital object identifiers) provide stable links and the Secretariat confirmed that JNAFS and SC Studies use DOIs.

e) Figure formats

Discussion took place around figure formats for the Journal and Scientific Council reports and documents.

The Journal guidelines ask authors to submit figures in EPS format, however, newer software packages may not have this format option. Several STACPUB members noted that there are a variety of software packages to produce figures and wondered if there were formats other than EPS that could allow the Secretariat to standardize figures for publication. Offering flexibility in formats for figures in the Journal guidelines to authors would be helpful.

For SC meeting reports and SCR/SCS documents the Secretariat requires figures and data to be submitted in Excel file formats. However, as noted in the earlier discussion, STACPUB members use different software packages and then have to export their data to MS Excel prior to submitting to the Secretariat. They wondered if it would be possible to develop code or a more automated process to standardize figures for these NAFO publications.

STACPUB **recommends** that *the Secretariat ensure options for figure formats are clearly provided in the instructions for authors for JNAFS.*

STACPUB **recommends** that *the Secretariat explore development of a "run-to-code" or other method that would simplify the process for figure prepartition by Designated Experts and other authors so that they can more easily provide an editable figure that fits the SC standards.*

7. 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: Carmen Fernandez Rapporteur : Paul Regular

The Committee met at the Sobey School of Business, Saint Mary's University, Halifax, NS, Canada, 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 (UK, Portugal and Spain), Japan, Russian Federation and United States of America. The Scientific Council Coordinator and other members of the Secretariat were in attendance.

1. Opening

The Chair opened the meeting at 14:00 hours on 1 June 2019, welcomed all the participants and thanked the Secretariat for providing support for the meeting. Several sessions were held throughout the course of the meeting to deal with specific items on the agenda.

2. Appointment of Rapporteur

Paul Regular was appointed as rapporteur.

3. Review of previous recommendations and new recommendations in 2019

a) Communication of scientific studies to fishing fleets in the NAFO area (recommendation from 2015)

In 2015, STACREC **recommended** that *the NAFO Secretariat develop a framework for communicating tagging study information to vessels from Contracting Parties and Coastal States fishing in the Convention Area (e.g., via a link to this information on the NAFO website homepage)*.

The matter was discussed several times, including in the 2018 SC June and September meetings and again in the 2019 SC June meeting. Potential options considered for communicating information on relevant scientific studies (not necessarily only tagging studies) to fishing vessels in the NAFO area include advertising the information on the NAFO webpage and via the Android application for onboard observers that is currently being developed by the Secretariat. Another potential option would be to include the information in the package that fishing vessels operating in the NAFO NRA receive yearly from the NAFO Secretariat. STACREC should provide the available scientific information (brought to the SC) in the June meeting every year for its inclusion in this package. The SC chair has initiated discussions with the STACTIC chair, which will continue over the next few months. The intention is to find a pro-active way of sending notifications to the fishing fleets about any relevant scientific studies of which the SC is aware. *The matter will be reviewed again at the September SC meeting hoping closing the matter at that time.*

b) Survey-related recommendations (previous and new recommendations)

Recommendations from 2015 and 2017:

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*.

During 2018 and 2019 SC meetings, survey issues were discussed again. Participants considered that the two topics previously identified, *i.e. how to deal with reduced survey coverage / reduced sampling rates, and possibilities for combining multiple surveys to produce aggregate indices of stock abundance*, would together constitute the basis of a future practical ("hands-on") workshop, with participation of both external scientists and scientists regularly attending the SC meetings. Given the overall shortage of resources, the timing and organisation of such a workshop would depend on other commitments the SC may need to attend in the near future (such as e.g. the NAFO PA framework review and the upcoming VME fisheries work). A realistic work plan is necessary. *STACREC agreed to revisit the issue during the September SC meeting.*

It was agreed that a speaker on this general topic would be invited to the June 2020 SC meeting, and the current STACFIS chair will take the lead in arranging this invitation.

New recommendations in 2019:

STACREC **recommends** that*, for all surveys, aggregate annual total biomass indices should be presented in the future, in addition to the stock by stock indices currently presented, so as to provide a general perspective on overall trends.*

The following STACREC recommendations are developed in Section 7.e of this report, where more details can be found:

In relation to Greenland halibut in SA2+3KLMNO, STACREC **recommends** that *the 2018 Canadian fall 2J3K and spring 3LNO indices be included in the calculation of the HCR but that the impact on age structure be examined before these indices are included in any age structured model.*

Generally, for all surveys and stocks, STACREC **recommends** that *a consistent approach to determining if an incomplete survey can be considered as an index for a particular stock be developed and, as part of that, an analysis of past decisions to include or exclude incomplete surveys be conducted*.

Following from this recommendation, a review of previous decisions made by SC to include or exclude Canadian survey data points with reduced spatial coverage was prepared and presented during the meeting (details in Section 7.e). Following from that analysis, STACREC made the following recommendation:

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 ("preliminary") 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.

These are preliminary guidelines and sampling biases may also be relevant in the considerations for each specific stock and survey. In particular, the finer structure of the indices needs to be considered if they are used disaggregated by age or length in stock assessments.

c) Recommendations concerning redfish (previous and new recommendations)

Recommendation from 2018:

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 recognising 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.

New recommendation in 2019:

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.*

4. Fishery Statistics

a) Progress report on Secretariat activities in 2018/2019

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.

Table 1. Dates of receipt of STATLANT 21A and 21B reports for 2015-2018 up to 1 June 2019

Country/component	STATLANT 21A (deadline, 1 May)			STATLANT 21B (deadline, 31 August)		
	2016	2017	2018	2015	2016	2017
CAN-CA	30 May 17	31 May 18		4 May 16	30 May 17	31 May 18
CAN-SF	28 Apr 17	05 May 18	29 Apr 19	30 Aug 16	7 Sep 17	Sep 18
CAN-G	26 May 17	30 Apr 18		30 Aug 16	16 Aug 17	24 Aug 18
CAN-NL	26 Apr 17	17 May 18	17 May 19	29 Aug 16	29 Aug 17	
CAN-Q						
CUB						
E/BUL						
E/EST	22 May 17	04 May 18	30 Apr 19	23 Aug 16	30 Aug	13 Sep 18
E/DNK	23 May 17	23 Apr 18	1 May 19	15 Jun 16	31 Aug	03 Sep 18
E/FRA						
E/DEU	25 Apr 17	25 Apr 18	30 Apr 19	29 Aug 16	31 Aug	30 Aug 18
E/LVA	20 Apr 17		24 Apr 19			
E/LTU	9 May 17	24 Apr 18	24 Apr 19		31 May 17	24 Apr 18
EU/POL						
E/PRT	19 Apr 17	20 Apr 18	30 Apr 19	23 Aug 16	29 Aug 17	03 Sep 18
E/ESP	31 May 17	30 May 18		5 Aug 16	7 Aug 17	02 Aug 18
E/GBR	25 Apr 17	31 May 18				24 Jul 18
FRO	2 May 17	18 May 18	22 May 19	1 Jun 16	09 Jun	
GRL	1 May 17	30 Apr 18	29 Apr 19	30 Aug 16	22 Aug 17	
ISL						
JPN	19 Apr 17	01 May 18	23 Apr 19		30 Aug 17	31 Aug
KOR						
NOR	4 May 17	23 Apr 18	25 Apr 19	29 Aug 16	25 Aug 18	16 Aug 18
RUS	11 May 17	04 May 18	14 May 19	1 Sep 16	21 Jul 17	
USA		10 Jul 18				
FRA-SP	25 May 17	18 May 18	14 Mar 19	8 Jun 16		
UKR						

Development of Android application for NAFO onboard observers:

The NAFO Secretariat is developing an Android application for transferring the information collected by NAFO observers on fishing vessels to the NAFO Secretariat via the internet. A presentation was provided during the meeting, including developments since the previous presentation to STACREC in September 2018. It was noted that reward tags are now included in the application. Testing of the application by observers will start as soon as possible.

The following specific items arose in the discussion that followed the presentation: It was asked whether the observer could take photos and include them in the application; this is currently not possible but the capability could be developed if considered important. However, since photos are relatively large files, there could be technical limitations for their remote transferring. It was suggested to have the option to record discards in weight and/or in numbers, depending on what is most appropriate for the species. In response to a question, the application developer explained that other fish or non-fish (e.g. coral) species could potentially also be included in the application. It was also clarified that the application could include extra information on species identification. The application currently allows recalculation of live weight changing the conversion factor. Regarding backup options for data logged on the application, there is a microSD card for a backup and it can also be backed up on a laptop. A report to be presented following a trip can be generated by the application. The background database is SQL compliant. It was noted that practical use of this application may require training, not only in the user interface but also the underlying database.

STACREC considered this application very useful for facilitating data collection and encouraged its further development. It was noted that the application was very portable and that it could potentially be used by many different observers (not just NAFO onboard observers) in NAFO or in other regions of the world.

The possible use of this application to help communicate relevant scientific studies to fishing fleets was discussed by STACREC (see Section 3.a of this report).

5. Research Activities

a) Biological Sampling

i) Report on activities in 2018/2019

STACREC reviewed the list of Biological Sampling Data for 2018 prepared by the Secretariat and noted that any updates will be inserted during the summer. The SCS Document will be finalized for the September 2019 Meeting. Further discussion on this item can be found in Section 7.b of this STACREC report.

ii) Report by National Representatives on commercial sampling conducted

Canada-Newfoundland (SCS Doc. 19/13, plus information within various SC assessment documents):

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 19/07):

Data on catch rates were obtained from trawl and longline fisheries in NAFO Div 3M for Atlantic cod (*Gadus moruha*) from 2015 to 2018 (n=737, NAFO-observers). Length frequencies (NAFO-observers and crew members) were also available from 2014 to 2018 (number of samples, n=207). In addition weight measurements were taken by crew members from 2014 to 2018 (n=69). The fishery is conducted exclusively by longliners since 2017.

Denmark/Greenland (SCR 19/32, SCS 19/12):

Data on catch rates were obtained from trawl, gillnet and longline fisheries in NAFO Div 1A-F for Artic char, Atlantic halibut, Atlantic salmon, Atlantic cod, capelin, snow crab, Greenland halibut, roundhead grenadier, roundnose grenadier, lumpfish, polar cod, redfish, saithe, scallops , 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 inshore and 1D inshore, and gillnet fishery in 1A inshore; and for cod trawl fishery offshore in Div. 1C and 1E, from the longline fishery in 1A inshore and 1D inshore, longline in 1D, 1E and 1F, from the gillnet fishery 1A inshore and 1D inshore, with handlines in 1CD inshore, and pound nets inshore 1B-D. A total of 264 length samples were taken, and 62060 individuals including Greenland halibut and cod were measured in NAFO Div. 1-F. A total of 104 otolith in 1A and 4247 otoliths in 1C-F were collected from cod.

EU-Germany (NAFO SCS Doc 19/14):

Data on catch rates were obtained from trawl catches for: Greenland halibut (Div. 1C and 1D). Data on length composition of the catch were obtained for: Greenland halibut (Div. 1C).

EU-Portugal (NAFO SCS Doc. 19/09):

Data on catch rates were obtained from trawl catches for: redfish (Div. 3LMNO); Greenland halibut (Div. 3LMN) and cod (Div. 3M). Data on length composition of the catch were obtained for: redfish (*S. mentella*) (Div. 3LMNO); American plaice (Div. 3MNO); cod (Div. 3MN); Greenland halibut, redfish (*S. marinus*) and roughhead grenadier (Div. 3LM); thorny skate and witch flounder (Div. 3M).

EU-Spain (NAFO SCS Doc. 19/07):

A total of 10 Spanish trawlers operated in Div. 3LMNO NAFO Regulatory Area (NRA) during 2018, amounting to 1,074 days (16,608 hours) of fishing effort. Total catches for all species combined in Div. 3LMNO were 16,674 tons. In addition to NAFO observers (NAFO Observers Program), 8 IEO scientific observers were onboard Spanish vessels, comprising a total of 279 observed fishing days, around 26% 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 2018, 425 length samples were taken, with 44,499 individuals of different species examined to obtain the length distributions.

One Spanish trawler operated during 2018 in Div. 6G NAFO Regulatory Area using a midwater trawl gear. The fishing effort of this trawler was 8 days (33 hours). The most important species in catches was the *Beryx splendens*. In 2018, 11 length samples were taken, with 761 Alfonsino individuals examined to obtain the length distributions.

Japan (NAFO SCS Doc. 19/08REV):

In 2018, one Japanese otter trawler operated in Div. 3L, 3M, 3N and 3O. The total catch (10 species) including discards was 2,908 tons. Target species, (main fishing Divisions) (catch) were Greenland halibut (3L) (1,130 tons), redfish (3LM) (1,016 tons) and yellowtail flounder (3N) (634 tons). Number of size measurement for Greenland halibut, redfish and yellowtail flounder were 1,450, 3,400 and 1,150 respectively. For further details, refer to the National Report (SCS Doc. 19/08REV).

Russia (NAFO SCS Doc. 19/11):

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. 3LMNO), Roughhead grenadier (Div. 3LM), Roundnose grenadier (Div. 3LN), White hake (Div. 3NO), Atlantic halibut (3LMNO). Length frequencies were obtained from Greenland halibut (Divs. 1A, 1D, 3LMN), Redfish (*Sebastes fasciatus* in Divs. 3LN, *S. mentella* in Div. 3L), Roughhead grenadier (Divs. 3LM), Roundnose grenadier (Divs. 3LM), Witch flounder (Divs. 3L), Skates (*Amblyraja radiata* in Divs. 3LM), Blue wolffish (Divs. 3LM), Blue antimora (*Antimora rostrata* in Divs. 3LM), Black dogfish (*Centroscyllium fabricii* in Div. 3O), Threebeard rockling (*Gaidropsarus vulgaris* in Div. 3L), Red hake (*Urophycis chuss* in Div. 3L), Greater eelpout (*Lycodes esmarkii* in Div. 3L), Marlin-spike grenadier (*Nezumia bairdii* in Div. 3L). Age-length distribution for Greenland halibut in Divs. 3LMN, as well as statistics on marine mammal occurrences and VME indicator species catches, are also available.

USA (SCS Doc. 19/15):

The report described catches and survey indices of 37 stocks of groundfish, invertebrates and elasmobranchs. Of note, the indices for Gulf of Maine cod, Georges Bank cod, Georges Bank yellowtail flounder, Southern New England yellowtail flounder, and Georges Bank winter flounder and thorny skate were among the lowest values in the time series. No Atlantic halibut were caught in the strata set used for the stock. Gulf of Main and Georges Bank haddock decreased while still remaining above average. Barndoor skate increased to a time series high. Research on the environment, plankton, finfishes, marine mammals, and apex predators were described. Descriptions of cooperative research included work to estimate the efficiency of the survey net and a longline survey in the Gulf of Maine. Other studies included age and growth, food habits, tagging studies, and observer trips.

b) Biological Surveys

i) *Review of survey activities in 2018 and early 2019 (by National Representatives and Designated Experts)*

Canada – Newfoundland and Labrador (SCR Doc. 19/15):

Research survey activities carried out by Canada (Newfoundland Region) were summarized, and stock-specific details were provided. The major multispecies stratified-random surveys carried out by Canada in 2018 include a spring survey of Divs. 3LNOPs, and an autumn survey of Divs. 2HJ3KLNO. Both surveys were completed with the Campelen 1800 survey trawl.

The 2018 spring survey in Div. 3LNOPs continued a time series begun in 1971. It was conducted from late April to mid-June, and consisted of 439 successful tows (478 planned) covering 124 of 129 planned strata to a maximum depth of 732m by the research vessels CCGS Alfred Needler and CCGS Teleost. Although the 2018 spring survey coverage was much improved relative to other recent surveys, the inability to complete the survey of Div. 3L again in 2018 (although only 3 strata were missed) continues to be a concern for the assessment of fishery resources in this area. Coverage of Div. 3L has been incomplete in three of the last four years.

The 2018 autumn survey was conducted from mid-September to mid-December in Divs. 2HJ3KLNO, and consisted of 586 tows (674 planned) covering 183 of 208 planned strata to a maximum depth of 1500m in 2HJ3KL and 732m in 3NO. The reduction in sets was primarily due to mechanical issues that caused incomplete sampling in 2 deepwater strata in Div. 2J, 9 deepwater strata in Div. 3K, and 16 deepwater strata in Div. 3L. The 2018 survey marked the sixth time in seven years that the deepwater strata in Div. 3L have not be completed.

STACREC noted concern over deficiencies in the spatial coverage of the Canadian surveys in recent years, and the impact on the ability to detect signal from noise in regards to evaluating trends in biomass and abundance 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. 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).

Coverage issues in the 2018 Canadian Spring survey were not considered severe enough to warrant removing this data point from relevant assessments conducted in 2019. However, coverage issues in the 2018 Canadian autumn survey resulted in this survey not being used in the 2019 assessment of SA2+3 roughhead grenadier (see Section 7.e of this STACREC report). The Canadian spring and autumn survey indices also intervene in the HCR agreed for Greenland halibut in SA2+Divs. 3KLMNO and, therefore, the quality of the 2018 indices for this stock was also investigated concluding that both could be used (Section 7.e of this report). It is possible that further concerns regarding 2018 survey coverage issues may still arise when these data are evaluated in future full assessments and evaluation of management measures such as harvest control rules. An examination of past SC decisions regarding the use of survey indices in years with reduced coverage was undertaken during the meeting and the findings are summarized in Section 7.e. STACREC also developed initial ("preliminary") guidelines on the matter, which are presented in the same report section.

Denmark/Greenland (SCR 19/07, 08, 33):

A hydrographic cruise was carried out across the continental shelf off West Greenland to sample 7 standard sections Royal Danish Navy vessel HDMS EJNAR MIKKELSEN during the periods 9 June to 15 June and 1 July to 12 July 2018 (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 Shrimp and Fish trawl survey in West Greenland in NAFO Div. 1A-F (100- 600 m) was initiated in 1988. From 1988 to 1900, several vessels conducted the survey. From 1991 to 2017, the surveys have been conducted onboard RV Paamiut. In 2018, a charter vessel was used in the survey in 2018 which used all the standard gear from the research vessel Paamiut (cosmos trawl, doors, all equipment such as bridles etc., and Marport sensors on doors and headlines), in an effort to make the 2018 survey as identical as possible with the previous years' surveys. The survey was carried out between June 5 – July 13, onboard CV Sjudarberg using the Cosmos gear with a mesh size 20 mesh liner in the cod-end. The survey follows a buffered stratified random sampling. A total of 224 valid hauls were conducted. Survey results including biomass and abundance indices for Greenland halibut, cod, deep see redfish, golden redfish, American plaice, Atlantic wolfish, spotted wolfish, and thorny skate were presented as Scientific Council Research Documents.

The Greenland halibut gillnet surveys in 1A inshore was initiated in 2001 in the Disko Bay. The survey normally covers 4 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. In 2018, 185 gillnet stations were set. Results are presented as Scientific Research Document.

STACREC noted that a different vessel was used for the 2018 surveys and yet a different one will be used in 2019. STACREC was concerned about the lack of a calibration analysis with the pre-2018 vessel (Paamiut), but this seems to be no longer possible as the Paamiut vessel has stopped operating. The 2018 survey index for shrimp was accepted by NIPAG, but this does not necessarily imply that it can be accepted for other species.

In 2020, when new advice for Greenland halibut will need to be provided, it would be very helpful to see the details of the different vessels that have been used, to be able to compare them to the extent possible. In addition, an investigation of Greenland halibut survey indices with the different vessels would be required; for example, length frequencies of "bigger fish" (i.e. excluding the smaller fish where one would expect to see variability from year to year related to incoming recruitment) could be examined through time, investigating if unusual inconsistencies were observed in 2018 or 2019. In the meantime, it was requested that plots showing survey series avoid having a continuous line between the 2017 and 2018 survey values.

EU-Spain and EU-Portugal (SCR 19/08, 11, 12, 13, 18, 19):

The Spanish bottom trawl survey in NAFO Regulatory Area Div. 3NO was conducted from 25th of May to the 23rd of June 2018 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 114 valid hauls were taken within a depth range of 47-1410 m according to a stratified random design. A hydrographic profile was casted in each fishing station. Survey results, including abundance indices and length distributions of the main commercial species, are presented as Scientific Council Research documents. In addition, age distributions are presented for Greenland halibut and Atlantic cod.

In 2003 it was decided to extend the Spanish 3NO survey toward Div. 3L (Flemish Pass). In 2018, the bottom trawl survey in Flemish Pass (Div. 3L) was carried out on board R/V Vizconde de Eza using the usual survey gear (Campelen 1800) from July 30th to August 19th. The area surveyed was Flemish Pass to depths up 800 fathoms (1463 m) following the same procedure as in previous years. The number of hauls was 101 and one of them was nulls. Survey results, including abundance indices and length distributions of the main commercial species, are presented as Scientific Council Research documents. Samples for histological (cod) and aging (Greenland halibut, American plaice, roughhead grenadier and cod) studies were taken. One hundred hydrographic profile samplings were made in a depth range of 107-1456 m.

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 June 25th to July 25th 2018. 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 184 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. 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 2018 EU (Spain and Portugal) bottom trawl groundfish surveys in NAFO Regulatory Area (Divs. 3LMNO):

New data on deep-water corals and sponges were presented from the 2018 EU (Spain and Portugal) bottom trawl groundfish surveys. 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).

“Significant” catches (according to the NAFO definition from groundfish surveys) of deep-water corals and sponges were provided and mapped together with the closed areas. Distribution maps of presence and catches above threshold for RV data of sponges, large gorgonians, small gorgonians and sea pens following the thresholds were presented.

Sponges: For the EU 2018 Data sponges were recorded in 129 of the 397 valid tows (31.7% of the total tows analyzed), with depths ranging between 77 - 1442 m. Significant catches of sponge (≥ 75 kg/tow) were found in three tows. These catches were located in Flemish Pass area inside the KDE sponge polygon. Sponge catches for these tows ranged between 78.65 - 385.35 kg.

Large Gorgonians: For the EU 2018 Data, large gorgonians were recorded in 9 of the 397 valid tows (2.3% of total tows analyzed), with depths ranging between 110 - 1347 m. None of the tows have significant catches of large gorgonians (≥ 0.6 kg/tow).

Small Gorgonians: For the EU 2018 data, small gorgonians were recorded in 44 tows (10.5 % of total tows analyzed), with depths ranging between 331 - 1364 m. Significant catches (> 0.15 kg/tow) were recorded in two tows (0.5% of the total tows) located at the top of closed area 2 in the Flemish Pass and closed area 14 in the eastern part of Flemish Cap, outside of the actual closed areas with depths of 648 and 1152 m.

Sea Pens: For the EU 2018 data, sea pens were recorded in 137 tows (34% of total tows analyzed), with depths ranging between 136 - 1442 m. Significant catches (> 1.4 kg/tow) were recorded in two tows (1.5- 2.6 kg), one located at north of Flemish Cap (723 m - 1.5 kg) and the other located in the southwest part of Flemish Cap (1152 m - 2.6 kg), both of them inside the corresponding VME KDE polygon.

USA (SCS Doc. 19/15):

The US conducted a spring survey in 2018 covering NAFO Subareas 4, 5 and 6 aboard the FSV *Henry B. Bigelow*. All planned strata were covered, although the number of tows per stratum was slightly reduced. The survey was conducted in a normal time frame. The US conducted an autumn survey in 2018 covering NAFO Subareas 4, 5, and 6 aboard the FSV *Henry B. Bigelow*. All planned strata except 01300 were covered as were most for the Gulf of Maine. The timing for the areas covered was similar to that in the past. Biomass indices were presented for 32 stocks and abundance for the two squid stocks.

ii) Surveys planned for 2019 and early 2020

Information was presented and representatives were requested to review and update before finalization of an SCS document in September. Further discussion on this item can be found in Section 7.b of this STACREC report.

c) Tagging Activities in 2018 and early 2019

Information was presented and representatives were requested to review and update before finalization of an SCS document in September. Further discussion on this item can be found in Section 7.b of this STACREC report.

It was noted that an SCR document is anticipated for next year concerning progress on the Greenland halibut tagging programme in Canada.

d) Other Research Activities

No items were reported for this section.

6. Review of SCR and SCS Documents

"EU SC05 project: "Multispecies Fisheries Assessment for NAFO". Estimation of multispecies based HCRs and use of a multispecies MSE framework to assess the risk of collapse and the fishery-ecological trade-offs'' (SCR Doc. 19/017):

The document was presented via webex at the STACREC meeting. A summary of the presentation follows:

The multispecies tier is an essential part of the NAFO roadmap for an Ecosystem Approach to Fisheries management, connecting the "Ecosystem" tier with the "Single species" tier. The EU DG-MARE launched in 2017 the project SC05 "Multispecies Fisheries Assessment for NAFO" with the intention of identifying the potential alternatives to implement a multispecies approach in NAFO, with the Flemish Cap as a case study.

In this paper, an MSE framework is developed, with GadCap (cod, redfish and shrimp Gadget multispecies model in the Flemish Cap) as operating model. Reference points and Harvest Control Rules (HCR) are designed taking into account the multispecies interactions. Finally, traditional single species and new multispecies HCRs are assessed from the precautionary and MSY perspectives. The results suggest that HCRs designed under a single species approach are not precautionary for all the stocks and that it is not possible maintaining the 3 stocks above B_{lim} at the same time due to strong trophic interactions. Disregarding one stock may allow finding precautionary multispecies reference points for the other stocks. Precautionary HCRs for two stocks at once were only found when shrimp *SSB* in relation to B_{lim} was disregarded. The results showed that the two stage HCRs for cod reduces predation and increases probability of cod and redfish being above B_{lim}. This result supports that alternative two stage HCRs, or some other HCRs with other shapes, may increase the possible combinations of fishing pressure for these three stocks.

Finally, in this project SC05, an MSE framework has been developed, but it is important to note that an MSE has not been conducted. In the future, some of the elements of this framework should be improved, especially the observation and the implementation error models. Finally, when conducting the risk analysis to the selected management procedures, the influence in the uncertainty in some other processes of the ecological OM GadCap should be considered, as well as the mentioned observation and implementation errors.

Summary of comments by STACREC:

STACREC considered this work to be a big step forward and encouraged its continuation. STACREC noted that the continuation of this work will require that further funding be made available.

Some more specific comments from STACREC were as follows: As noted when earlier versions of this work were presented to the NAFO SC, an important modification should be the separation in the model of the redfish stock into golden redfish (*Sebastes norvegicus*) and beaked redfish (*S.mentella* and *S.fasciatus*). The inclusion of technical interactions (mixed fisheries) in the model also seems relevant. Another element to reexamine in future work are the values of the reference points used in the HCRs. It was noted that the B_{lim} value for cod is in the line with that used in the single species approach currently applied by the NAFO SC, but this may not be the case for other reference points. It was also noted that the current advice framework used by the NAFO SC takes risk (probability of falling below B_{lim}) into account in the annual calculation of advice and not just in long-term equilibrium. One of the key take-home messages from the work presented is that it may not be possible to maintain all species above a pre-determined B_{lim} value at the same time because of the trophic interactions between the species, which highlights the necessity to consider multispecies interactions and not just examine single species in isolation. Ignoring multispecies interactions could result in non-precautionary management. Given the technical complexity of this work, a workshop (e.g. a benchmark-type exercise) to thoroughly review the model and to adjust or modify certain aspects of it would likely be necessary before considering using the approach for practical advisory purposes in NAFO.

“Proposals for redfish fishery regulation with occasional recruitment in the Flemish Cap Bank area” (SCR 19/014REV):

The document (by V. Korzhev and M. Pochtar) was presented on behalf of the authors by a colleague present at the STACREC meeting. A summary of the presentation follows:

The object of the study is redfish species of the Flemish Cap Bank in NAFO Div. 3M, the Northwest Atlantic statistical area. The aim of the work is to develop proposals for a management strategy for the redfish fishery allowing for the precautionary approach, based on the population dynamics model, with a random choice of the stock recruitment size.

It is shown that the main cause of stock variations in Div. 3M (along with fishery) is change in the recruitment abundance (redfish abundance at the age of 4). The redfish fishery management strategy should be based on maintaining spawning stock at the level of 35-40 x 10^3t. It is recommended to set the exploitation rate (fishing mortality) in the range of biological reference points from F_{msy} to F_{max} (0.08-0.20) depending on the recruitment abundance variation. With such exploitation, the long-term average annual catch can be from 10 to 16 x 10^3t, and the stock of redfish species will be within biological safe limits. The analysis can be used to determine the strategy for the exploitation of the redfish stock on the Flemish Cap Bank in the long term, the grounds for an increase in the TAC (total allowable catch) for 2019-2020, 10.5 x 10^3 t and the possibility of further increasing the yield to 12-16 x 10^3t .

Summary of comments by STACREC:

As noted by STACREC last year, when related work by the same authors was presented, the NAFO SC separates beaked redfish (*S. mentella* and *S. fasciatus*) from golden redfish (*S. norvegicus*) in the provision of catch advice for redfish in Division 3M, because of the different biological features of these species. STACREC recommends that this type of modelling be developed for beaked and golden redfish separately, giving priority to the work on beaked redfish.

Assumptions about future recruitment should be further inspected. The analysis assumed that annual recruitment deviations (from a Beverton-Holt stock-recruitment curve) were independent from year to year, which does not seem realistic. For example, it is not uncommon for redfish to have pulses of recruitment separated by many consecutive years of much lower recruitment. Given the strong influence of recruitment assumptions in long-term simulation results, it is very important that the generated future recruitment patterns can be considered realistic in view of the knowledge about the species and past stock dynamics.

It was noted that in the NAFO Precautionary Approach framework, F_{msy} is considered a limit fishing mortality, to be exceeded only with low probability (such as e.g. no more than 30% probability). Some concern was raised that the combination of recruitment assumptions used in the analysis and the F_{msy} values proposed for management resulted in catch values that may not be sustainable for the stock, given what has been observed in the past, and that lower F values should be considered for management. Investigating management options based on $F_{0.1}$, while assuming a low recruitment level, could be relevant. It should be clarified how F_{msy} was calculated and projections should take into account the current depressed state of recruitment. It was also said that interaction of redfish with cod should be taken into account in the analysis, given the likely impact of cod predation on redfish recruitment.

STACREC encouraged the work to be developed further, taking the above comments into account. To help understand the work done and the results, STACREC recommended that more comprehensive explanations are provided in future SCR documents, including more explanation concerning the technical details of the model and simulation settings. The work could be presented at WG-RBMS once it is further refined.

“Data Collection and Processing Protocols for the United States NEFSC Surveys, 1963-2018” (SCR 19/024):

The document was presented at the STACREC meeting. A summary of the presentation follows:

Standardized groundfish surveys have been conducted at the Northeast Fisheries Science Center since 1963. The way in which data were collected has evolved over time from various forms of paper logs to automated computer data entry systems. The paper logs were used from 1963-2001 and changed as computer capabilities increased and sampling requirements changed. Initial paper logs collected information that could fit into an 80 character record, as that was the limit of cards in the 1960s and 1970s. In the 1980s, more information could be collected. In 1991, biological sampling changed from a certain number per watch to a certain number per tow and a new individual species log was created. In 2001, a new computerized data collection system (FSCS-Fisheries Scientific Computing System) was deployed on the spring survey. This system allowed for digital data collection and some real-time data validation. Biological sampling requirements were more automated and post-tow auditing was faster than from paper logs. In 2011, a completely revised system (FSCS 2.0) was implemented on the fall survey. This system was Oracle based and allows for more flexible sampling, more accurate weights with all containers barcoded and quicker post-tow auditing.

Summary of comments by STACREC:

STACREC found the material presented very relevant to get an understanding of survey protocols. Having this type of information also available from other surveys would be helpful, to be able to learn best practices from others. It was noted that similar information was already available for the EU survey in the Flemish Cap ("Protocols of the EU bottom trawl survey of Flemish Cap", SC Studies, number 46). It was acknowledged that the information may already exist for several surveys but that it is difficult to know where to find it. It was also noted that some years ago there was an intention to review the NAFO Groundfish surveys manual (SC Studies, number 2), but the initiative never managed to progress.

It was concluded that a compilation and review of the documentation already available in NAFO concerning survey protocols about the surveys currently used in the SC for stock assessment purposes should be undertaken by STACREC at the earliest opportunity.

"A Summary of the Calibration Studies Conducted by the Northeast Fisheries Science Center for the Spring and Fall Groundfish Bottom Trawl Surveys" (SCR 19/025):

The document was presented at the STACREC meeting. A summary of the presentation follows:

The Northeast Fisheries Science Center (NEFSC), bottom-trawl surveys have been conducted annually for over half a century. During this time there have been several gear and vessel changes and experiments have been conducted for most of these. In the 1970s, a set of 6 cruises was conducted to determine the difference in catchability of the two nets used for the spring survey. The net used during 1973-1981 was generally more efficient than the standard net. The door change in 1985 was tested during 8 cruises in the 1980s. In general, the new doors were more efficient for all species tested. The main vessel used between 1963 and 2008 was the FSV Albatross IV but it was sporadically replaced for various reasons by the FSV Delaware II. Five pairs of cruises were conducted between 1981 and 1991. The DE II was more efficient, likely due to the slower winches and the 11-foot trawl door backstrap which may have herded fish. The exceptions were horseshoe crab (N = 15) and Atlantic sea scallop (Cis included 1). In 1997, the DEII was completely refit so 5 additional cruises were conducted to determine if the differences between the two ships still remained. For many species, the difference with the new DE II was smaller or had changed direction. In 2009, the AL IV was changed to the FRV Henry B Bigelow. At this time, the survey net was also changed and the survey protocols were changed. In 2008, 636 paired tows conducted. The new configuration is generally 2-10 times more efficient than the old setup. Analyses have been conducted for various species at length using methods including length cut-points, double logistic, and an orthogonal polynomial smoother.

Summary of comments by STACREC:

STACREC acknowledged the significant amount of work that has been done here to develop calibrations of bottom trawl surveys. It was noted that one of the main leaders of this work has been in discussion with Canadian colleagues in relation to the conversion work to be undertaken in 2020 for Canadian surveys (when new survey vessels are expected to be in operation in the Atlantic area). In the STACREC discussion, it was also said that vessel noise could affect catchability, and that a camera in the net would be helpful in these types of studies because fish may swim in and out of the net.

7. Other Matters

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

Designated Experts were reminded to provide the stock assessment data and relevant stock assessment software (e.g. R scripts used in the stock assessment) to the Secretariat. It was agreed to store the files on the meeting SharePoint under a folder entitled "DATA".

During the STACREC meeting, it was suggested that there should be a better organised process for requesting and submitting data for stock assessment and other processes, such as National Research Reports. There was no time to discuss this during this meeting, but it is an item to be discussed in a future STACREC meeting.

Deadlines for data submission were discussed briefly. These deadlines are considered to be very useful by Designated Experts and should remain in place.

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

The above information is requested by NAFO on an annual basis and national scientists are normally the ones that prepare and submit this information. National Research Reports are submitted as SCS documents, whereas the other information is submitted to the Secretariat which compiles it into four SCS documents (one per topic). Given the amount of effort this implies for the scientists that prepare the submissions and the Secretariat, a discussion was held in STACREC concerning the value of producing this information in the requested format, particularly as it was unclear if anyone was using these SCS documents. It was noted that the process of collecting and collating the information in SCS documents as text files probably started a few decades ago and that these days there are more practical ways of finding and displaying this type of information.

It was noted that it should be taken into account that the usefulness of this type of compiled information is not just a matter of whether people are using it or not, but that there are also considerations related to transparency and accountability of the scientific advisory process.

National Research Reports:

STACREC concluded that these reports are useful and they should continue to be produced. However, their quality was perceived to be somewhat variable and it was felt that developing a standard format, or at least identifying minimum requirements, would be helpful. It was noted that the reports need to be very clear concerning the information displayed; for example, length-frequency distributions could mean different things depending on how they were compiled/produced, so reports need to be very clear about this type of detail to avoid misinterpretation of the information. The needed direction may be towards a National Sampling Report instead of a National Research Report. It was noted that a tool, e.g. Rmarkdown, could be useful for producing consistent reports.

As a step towards improving the reports, it was suggested to have informal exchanges between those SC members most heavily involved in producing or using the reports, in which the main uses and "deficiencies" of the different national reports could be identified. These exchanges could take place in the next June STACREC meeting and would require the National Research Reports to be available at the beginning of the June meeting. In advance of that, the Secretariat agreed to investigate for September 2019 if a format already exists in NAFO for these documents, to ensure that, if such a format exists, it is considered in future discussions about these reports.

List of biological sampling data: 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.

RV surveys on a stock by stock basis: This information is annually provided by the Designated Experts as tables by stock and tables are all included in an SCS document in text file format. Although there was a variety of views as to the usefulness of providing these tables, it was concluded that there is some utility in the information provided in the current tables and in them being publicly available, as is the case with the current SCS document. However, finding a more convenient way to provide and present this information would be helpful.

For example, rather than submitting plain text files with the information, it would be better to have this information in a relational spreadsheet or database (or similar idea). The Secretariat agreed to conduct an initial exploration of options in this regard and to inform STACREC in September 2019. STACREC members expressed a preference for using Excel rather than text files to submit the information in 2020. STACREC will aim to develop a format (e.g. fields needed, how best to structure the information, i.e. by stock or by survey, etc…) during the September 2019 meeting that could be tried for submissions in 2020.

<u>Inventories of biological surveys:</u> This information is annually collated into an SCS document as a text file. STACREC members did not think this document was useful. Therefore, STACREC recommended that this information no longer be collected in 2020 and that the SCS be discontinued after 2019, subject to confirmation in September 2019.

<u>List of tag releases:</u> This information is annually collated into an SCS document in Excel. STACREC members did not find this useful as they thought it unlikely that anyone would go to this document nowadays to check data holdings instead of, e.g., resorting to the internet. Therefore, STACREC recommended that this information no longer be collected in 2020 and that the SCS be discontinued after 2019, subject to confirmation in September 2019.

c) NAFO Catch Estimates Methodology Study

STACREC was informed that the final report of the catch data methodology study contracted by NAFO to MRAG Americas will be submitted in early July. CESAG will be having a webex meeting after the report is submitted. Further information will be provided in a future meeting.

d) Survey for STACTIC about onboard observers.

STACREC was presented with a (very short) survey that SC could send to STACTIC concerning the training, or lack thereof, of NAFO observers. The objective of doing this would be to increase understanding of the quality of the NAFO observer database for scientific advice at the NAFO SC. After discussion by STACREC it was concluded that this was a useful idea, but that the clarity of the survey questionnaire needed to be improved. This was done during the meeting and the survey will be forwarded to STACTIC.

e) Validity of Canadian survey indices in 2018 in relation to Greenland halibut and roughhead grenadier. Conclusions from STACREC and initial guidelines for dealing with years with incomplete survey coverage.

<u>Canadian surveys in 2018 in relation to Greenland halibut in SA2+3KLMNO:</u>

Both the Canadian fall 2J3K and spring 3LNO surveys were incomplete in 2018. Areas that were missed are inhabited by Greenland halibut. In the fall 2J3K survey the areas missed in 2018 contained on average 8% of the Greenland halibut biomass in the survey index and 6% in the area missed in the spring 3LNO survey. Both of these surveys are used in the calculation of the harvest control rule (HCR) for this stock as mean weight per tow. In order to determine if these indices from 2018 should be included in the calculation of the HCR an examination was conducted of the impact on the index of not surveying the areas missed in 2018. The survey indices were recalculated with sets removed from the strata that were missed in each survey in 2018. These recalculated indices were compared to indices including sets in these strata. The removal of sets from the strata missed in 2018 had minimal impact on the indices (see Figure 1).

STACREC therefore **recommended** that *the 2018 Canadian fall 2J3K and spring 3LNO indices be included in the calculation of the HCR but that the impact on age structure be examined before these indices are included in any age structured model.*

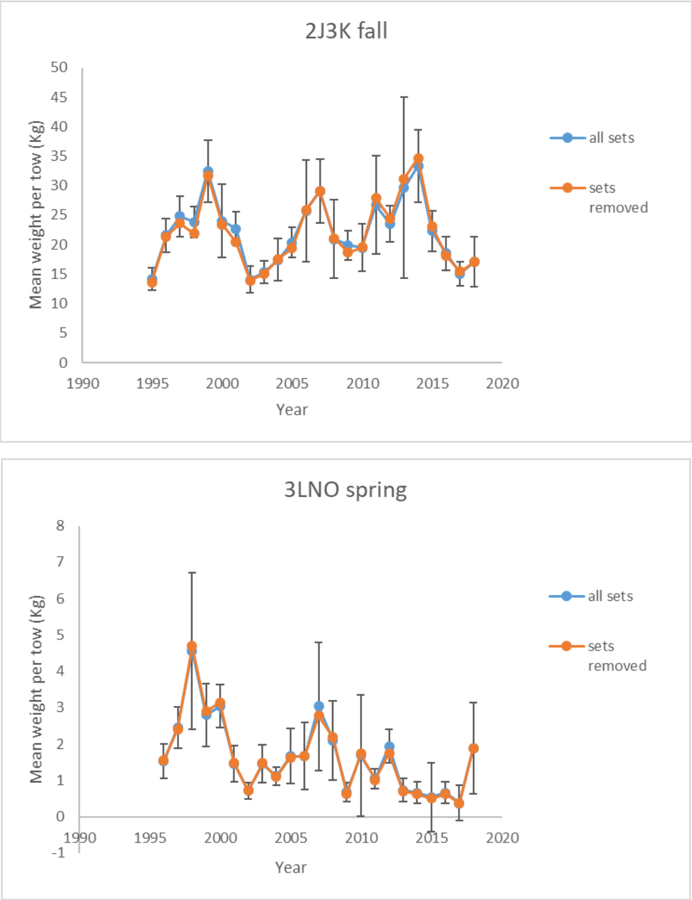


Figure 1. Survey indices (mean weight per tow (Kg)) for the Canadian fall 2J3K (top) and spring 3LNO surveys (bottom)) using all sets in the survey ("all sets") and with sets removed from the strata that were missed in the 2018 surveys ("sets removed"). The confidence intervals are those for the "all sets" series.

Canadian surveys in 2018 in relation to roughhead grenadier in Subareas 2 and 3:

An analysis similar to that undertaken for Greenland halibut was conducted for the 2018 Canadian fall survey index in relation to roughhead grenadier in Subareas 2 and 3. For this stock, the percentage of the index biomass in the strata missed in 2018 was quite high over time, mostly above 40% since the start of the survey series in 1995. The impact on the mean weight per tow index was seen to be strong and, therefore, it was agreed not to consider the 2018 survey index in the stock assessment of roughhead grenadier.

Conclusions from STACREC and initial guidelines for dealing with years with incomplete survey coverage:

STACREC **recommended** that *a consistent approach to determining if an incomplete survey can be considered as an index for a particular stock be developed and, as part of that, an analysis of past decisions to include or exclude incomplete surveys be conducted*.

The recommendation was already acted upon during the meeting and an SCR document (SCR Doc. 19/031) reviewing decisions made by SC to include or exclude Canadian survey data points with reduced spatial coverage was prepared and presented during the meeting. The work examined the Campelen time series (i.e. 1995 – present for the autumn survey, 1996 – present for the spring survey). For years that had (usually multiple) incomplete strata, the incomplete strata from that year were also removed from all other years and the stratified estimates of biomass were recalculated. The proportional differences between these stratified estimates and those calculated using all available strata were calculated. Detailed results by stock can be found in the SCR, and a summary across stocks (Figure 2 of this report) was presented in the same SCR.

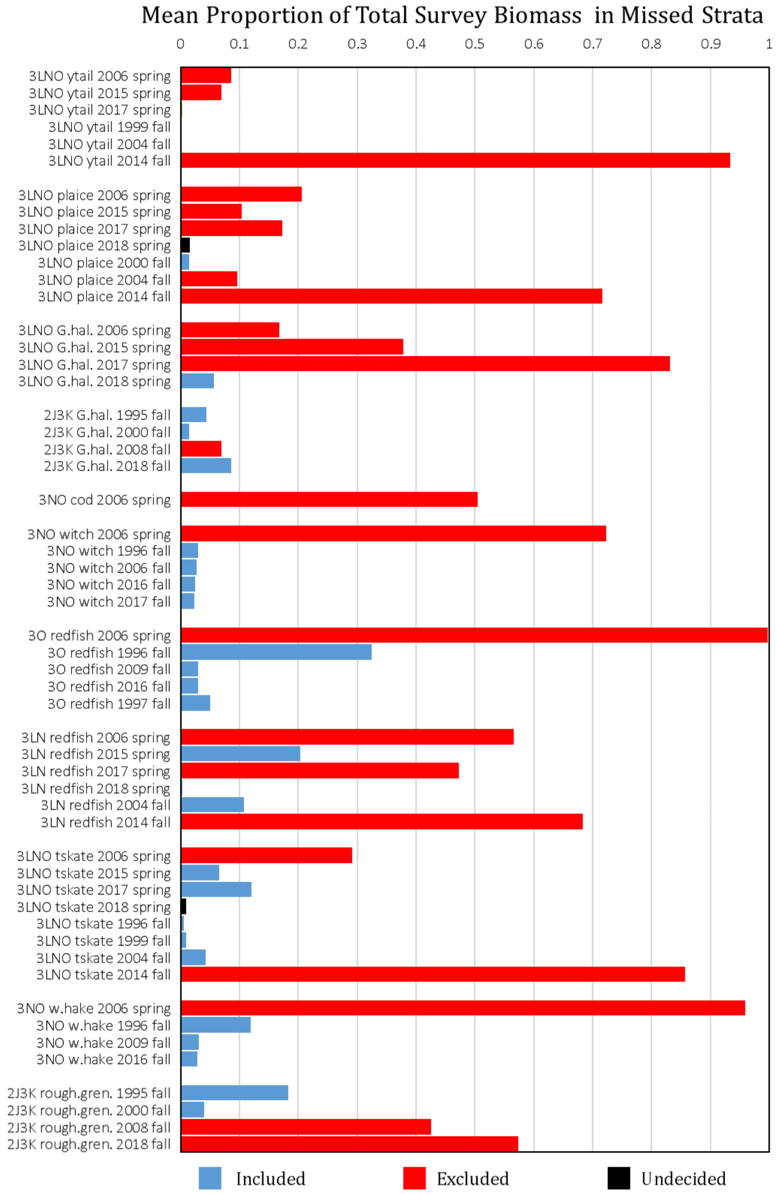


Figure 2. An examination of the SC consistency in handling survey data points with reduced spatial coverage across stocks and years. Colours indicate whether that survey point was included (blue) in the corresponding stock assessment, or excluded (red). Survey points that are "undecided" have occurred after the last full assessment of that stock.

STACREC found this analysis very useful and **recommended** 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 of total survey biomass in the survey strata missed that year (see Figure 2 of this report) should be calculated.
- At this time, the following may be used as initial ("preliminary") 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.

These are preliminary guidelines and sampling biases may also be relevant in the considerations for each specific stock and survey. In particular, the finer structure of the indices needs to be considered if they are used disaggregated by age or length in stock assessments.

STACREC considered it desirable that this work could be presented at the upcoming ICES WKUSER workshop (Workshop on Unavoidable Survey Effort Reduction). A Canadian scientist will likely be able to attend the workshop and, in that case, should be able to inform STACREC next year of any relevant feedback.

8. Adjournment

The Chair thanked the participants for their presentations to the Committee. Special thanks were extended to the rapporteur and the Scientific Council Coordinator and all other staff of the NAFO Secretariat for their invaluable assistance in preparation and distribution of documents. There being no other business the Chair adjourned the meeting at 11:00 hours on 13 June 2019.

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

Chair: Karen Dwyer Rapporteur: Tom Blasdale

I. OPENING

The Committee met at the Sobey School of Business, Saint Mary's University, Halifax, NS, Canada, from 31 May to 13 June 2019, 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 the Faroe Islands and Greenland), the European Union (Portugal, Spain and the United Kingdom), Japan , the Russian Federation, and the United States of America. Various members of the Committee, notably the designated stock experts, were significant in the preparation of the report considered by the Committee.

The Chair, Karen Dwyer (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, designated reviewers were assigned for each stock for which an interim monitoring update was scheduled (see SC Report). The provisional agenda was adopted with minor changes.

II.GENERAL REVIEW

1. Review of Recommendations in 2019

STACFIS agreed that relevant stock-by-stock recommendations from previous years would be reviewed during the presentation 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 19-03 (Rev. 2) 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. The strategy relies primarily on the port inspection data as well as the daily catch report data and is applied on a trip basis. For trips that overlapped calendar years (e.g. began in December 2017 and ended in January 2019), the catches have been estimated for the 2018 calendar year only.

The STACFIS Chair highlighted the recommendation from the Scientific Council from last June relating to the potential for additional information to be included in the analyses (gear type, mesh size and quarter). The Secretariat noted that these additions would require a change in the CESAG method (Annex 1 of COM-SC Doc. 17-08), and that CESAG would have to review these changes. SC members also asked if species that are not in Annex I.A of the NAFO CEM could be included in the CESAG method, and the Secretariat noted that roughhead grenadier and alfonsino have been included based on past requests and that others could be included as well.

STACFIS **recommends** that CESAG review the Catch Estimation Strategy to consider potential refinements, such as the inclusion of gear type, mesh size, and quarter into the strategy.

It was also noted that a number of contracting parties had not sent in catch submissions for 2018 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 and stresses the importance of timely submission of catches to the NAFO Secretariat.

3. Invited Speaker and External Review

The invited speaker of STACFIS for 2019 was Dr. Daniel Howell from the Institute of Marine Research (IMR) in Norway. The abstract of the Dr. Howell's presentation is provided below:

Ecosystem Assessments: what are they good for?

Daniel Howell, Institute of Marine Research, Norway

Integrated ecosystem assessments and ecosystem modelling are relatively new tools for improving our understanding of ecosystem functioning and how this is influenced by human actions. To date they have functioned more as tools for research and understanding rather than being fully integrated into our management systems. This presentation focused specifically on fisheries management and quota setting in particular. It looked at reasons why the take-up of ecosystem models and assessment has been slow, and highlighted routes by which such knowledge could successful enter current management schemes. Specifically, identifying key processes required for assessment forecast or simulation models, through using more realistic Operating Models in MSE simulations, and by influencing the choice of target F with the F_{msy} ranges which have already been identified as providing good yield with low risk. The last suggestion came from WKIRISH 2018 and will be further developed at the follow-up WKIRISH 2019. It was stressed that integration of ecosystem information into the advice process would only be possible where the work of the ecosystem research was coupled with that of the assessment groups, and that targeted and specific inputs into the management models were required.

Comments and discussion

The presentation was well received by SC participants, and a useful exchange of ideas ensued. Some discussion took place about how to incorporate ecosystem information into stock assessments and the presenter indicated that this was already happening both non-directly or out of necessity already (examples are time varying mortality, changing weights at age, cannibalism, adjusting process error to allow r and k to change etc.). There was also a lengthy discussion on the fact that ecosystem based assessments could not happen without management involvement. It was pointed out that partnerships with management and even co-operation between scientific working groups with Scientific Council should be encouraged to progress incorporation of ecosystem information into single species assessments.

It was determined that the chair of STACFIS would seek out an invited speaker on the topic of combining (partial) survey indices for wide ranging stocks for June 2020.

External Reviewer

Dr. Howell also served as an external reviewer for two stocks at the June 2019 Scientific Council meeting. Prior to June 2019 the Executive committee of SC decided, based on the Terms of Reference (See Terms of Reference for External Review of NAFO Scientific Council Stock Assessments, STACREC Report 2017, SCS Doc. 17-16 Appendix III) guide for choosing stocks for review, to examine Redfish Div. 3M and Witch Flounder Div. 3NO.

The reviews were conducted as part of a more widely focused meeting. Consequently, time was somewhat limited, and the reviews were more thorough and involved than the process for the non-reviewed stocks but not as thorough as might occur in something like an ICES benchmark. The reviews were of what was presented at the meeting, there was not any time spent on investigating if different formulations of the models might have produced a better assessment. The reviews specifically comment on if the model can be considered to provide a viable basis for the advice, if the modelling approaches are appropriate to the stock and data, and then go on to make specific recommendations for future work.

All assessments were endorsed by the external reviewer.

The reviews are as follows:

Golden redfish text

Note: The documents presented for review refer to *Sebastes marinus*. This species has been reassigned as *Sebastes norvegicus*. This review will refer to *S. norvegicus* throughout, and it is recommended that the stock assessment also use this name.

Summary

An exploratory analysis of the golden redfish (*Sebastes norvegicus*) was presented for area 3M. Such an analysis is valuable, both for potential management of the *S. norvegicus* and for understanding the behavior of the overall redfish stock complex in and around 3M.

The analysis presented is based on the EU survey in 3M and the catch data with a post hoc split into beaked/golden redfish. The split is based on the species split at depth found in the survey applied to catches based on depth of capture. It was not clear during the presentation how this was done for catches where such information was not available. The degree of precision of the species splitting process is questionable and should be further investigated. It is likely that this will be the weakest link in any assessment or analysis. However, the trends in catches are so strong that it is likely that the overall trends (if not necessarily year-to-year variations or absolute values) can be considered to be informative of actual catch trends. The survey suffers from year-to-year variation which cannot be explained by redfish stock dynamics, but again the overall signal is strong enough that it is unlikely to be completely eroded by the noise. It may be worth investigating putting a smoother through the survey data to attempt to highlight trends and smooth out the noise. Overall, although there are difficulties with the data, there is a strong and consistent signal from the catch and survey time series.

Comments and suggestions for further work

Given that age data is derived by applying an age-length key to raw length data, it is likely that length data is more reliable than age data. It is recommended that the precision of the age conversion be investigated, but also that more reliance is placed on direct length data than the converted age data. It would be worth plotting mean length in the survey on the same graph as survey abundance. This would identify if rises in abundance are due to in situ growth of small fish, or due to large fish entering the survey area.

It would be valuable for the estimates of *S. norvegicus* as a fraction of the overall stock be compared with the model of beaked redfish, especially to investigate if the changes in M and maturation found in the beaked redfish model can be explained by changing species composition rather than changes in the biology of the beaked redfish.

Redfish are only split by species in the 3M survey, surveys in the adjacent areas are simply reported as redfish. It is strongly recommended that all of the surveys split the redfish, at least into beaked vs. golden redfish at sizes where the identification can be readily conducted. This would give a better picture of the redfish dynamics across the wider area.

The work has been extended to YRP analysis to try and identify F0.1 and Fmax. This represents commendable ambition but seems rather premature for this stock. Without understanding better the recruitment event it is difficult to see how reference points could be identified for this stock. It was not clear if an analytical assessment model is desired for this stock. If so then given the available data I would not recommend anything more complex than a production model (at least in the first instance). There is an underlying unresolved question: should *S. norvegicus* in 3M be considered as a manageable stock or as a single poorly understood recruitment event?

3 M Redfish review text

Note: The documents presented for review refer to *Sebastes marinus*. This species has been reassigned as *Sebastes norvegicus*. This review will refer to *S. norvegicus* throughout, and it is **recommended** that the stock assessment also use this name.

Summary

The assessment is conducted with an XSA model with *Sebastes mentella* and *Sesbastes fasciatus* combined into a single stock of “beaked redfish”. The smaller catches of *S. norvegicu*s are handled as a correction factor to the projected catches. The plus group for the model (19+) is sufficiently high for this stock such that only a small fraction of the stock and catch are in the plus group. The model allows for varying natural mortality to handle variable cod predation, and accounts for varying maturation and weight-at-age. The model is tuned to catch-at-age and single survey (EU survey in 3M).

Based on the 3M EU survey, the population dynamics of the redfish in area 3M can be summarized as *S. mentella* having a very slightly increasing trend, while *S. norvegicus* and *S. fasciatus* had a major one-off influx around 2009 and subsequently a steadily decreasing biomass as these fish age and die. According to the survey, *S. fasciatus* is currently about half the biomass of the *S. mentella* in the area, and this proportion is continuing to decline. The combined recruitment of the redfish species has been extremely low in the last c. 5 years, and thus limited recruitment to the fishable and spawning stock in the coming years. The use of a combined two species model may be problematic for periods in the hindcast with large proportions of non-mentella redfish (especially in the years immediately after 2009) but is likely to be reasonable as a summary of the recent stock status. Although the model only includes S. mentella and S. fasciatus, the splitting between these beaked redfish and S. norvegicus may be inexact, especially in the commercial catches. In years with high abundance of S. norvegicus this may impact on the data quality for the model

There are concerns around the use of an XSA model which assumes exact catch at age, and further concerns around the method of converting the assessment to advice during a period of poor recruitment.

The selectivity of the fishery can to vary significantly between years. Boats fish in different depths in different years, and the timing of the fishery varies between years depending on when the quota is exhausted. Consequently, predicting the age composition of the catches in the short-term forecast may be difficult.

Although there are a number of concerns and specific recommendations, this review considers the assessment model to provide a viable basis for advice. The procedure for producing the advice is consistent with previous years, although in the absence of a defined B_{lim} a continued decline in stock size may give rise to future concerns over precautionarity.

Specific concerns and recommendations

It should be noted that the details of the assumptions behind the yield-per-recruit analysis (e.g. choice of forcing of the selection pattern) were not investigated in detail at this meeting, and this review will not comment further on these. There were concerns raised around the method for projecting F-at-age, specifically if there was a mis-match between the age range in the Fbar (age 6.16) and the relative F values (i.e. PR or selection pattern) at ages 4-18. This is being checked after this review was completed, but could potentially result in a very slight implementation error between the desired forecast F and the realized F in the simulations.

The different dynamics of the different redfish species within the area has a number of implications for the assessment. Firstly, the estimates of catches (and especially catch-at-age) of beaked redfish immediately after 2009 may be unreliable because the proportion of *S. norvegicus* in the total catches were higher and variable in those few years. Secondly, it is possible that the observed changes in mortality and maturation are due to the changing species composition rather than (or in addition to) density dependent effects. Thirdly, although the *S.fasciatus* and *S. norvegicus* are currently at a low level, any new incoming pulse of *S. fasciatus* and/or *S. norvegicus* may impact on the reliability of the assessment and would require careful evaluation of the model. Finally, one obtains a very different understanding of the dynamics depending on the species split. Combining the species indicates a stock which peaked in 2009 and has declined rapidly, which a split species analysis of the survey indicates that *S. mentella* has been at a relatively constant (and even slightly increasing) level over the time series (but with a great deal of year-to-year noise), while *S. fasciatus* and *S. norvegicus* had a single recruitment to the area which is in the process of disappearing. These two viewpoints for the same overall biomass give very different outlooks for the population.

The review therefore **recommends** that the viability of conducting a two-species assessment for beaked redfish be considered, even if the catches cannot be split. If this is not possible then the review **recommends** that the survey split into three species continue to be used in interpreting the results, and be used to guide forecast scenarios. The review **recommends** that the species split from the survey be investigated as a possible explanation for the variations in mortality and maturation identified in the assessment. In particular misidentification *of S. norvegicus* as beaked redfish may influence the estimates for mortality and maturation. This has the potential to simplify the procedure for setting these parameters within the combined species model. The review further **recommends** that the three species index continue to be compiled, and that all surveys covering redfish in the broader region (not just the one in 3M) should be split by species in order to examine the dynamics at a species level over the wider region.

The major concern with the assessment model itself centers on the catch-at-age data. There are several sources of error here beyond those typically associated with catch-at-age data. Firstly, the data is computed by applying an age-length key derived from a relatively small sample of only one of the beaked redfish species to the sampled length distributions for the whole catch, even though the proportions of the two species has changed over time. While this may be a reasonable approximation between the two beaked redfish species, it becomes more problematic in the face of potentially changing fractions of misidentified golden redfish in the overall catch. In addition, the method for estimating total catches has changed repeatedly through time, with changes of >10% arising from the changes in methodology. The difficulty is that the XSA model treats catch-at-age as being exact. This review therefore **recommends** that models which treat catch-at-age data as being error prone should be considered for the assessment in future. Models which can directly incorporate length data (such as Stock Synthesis) could also be worth investigating here in order to reduce the reliance on the accuracy of the length to age conversion.

The advice is based on 3-year forecasts using fishing reference points derived from the yield per recruit analysis. The review notes that YPR analysis is conducted every assessment. This is necessary because of ongoing weight-at-age changes, and the review supports this approach. However, there are two concerns. First, there is no clear B_{lim}, and thus no explicit biomass level which management should aim to avoid. The second concern is that the stock has gone through a prolonged period of near-zero recruitment, and little recruitment to the *SSB* can be expected in the medium term. Only looking forward 3 years at a time may thus drive the stock down to a level at which the fishery would face severe curtailment or even closure in order to protect the *SSB*. The review therefore **strongly recommends t**hat a Harvest Control Evaluation/Management Strategy Evaluation style analysis be conducted to examine the viability of catches under a period of prolonged poor recruitment, and that a B_{lim} proxy (even if only BLOSS) be derived as part of this work. In such a case fishing should be based on a maximum of F0.1 given the low productivity and long time lag inherent in redfish stocks, but there should be a possibility to reduce this if necessary in periods of poor recruitment. It should be noted, however, that the estimated *SSB* is currently at a reasonably high level, and although F is rising it is still relatively low. Catches around status quo are thus likely to be sustainable in the short term.

It should be noted that there is a significant amount of noise in this survey. The interannual variability is too large to plausibly represent biological changes in a long-lived redfish species, but must arise from varying coverage or catchability. As a result, while overall time-averaged trends may give good information about the stock trends, year-to-year variations should be treated with extreme caution. This does not invalidate the assessment model, which will have fit to the overall trend in the survey.

The method used to decide to keep the previous mortality value of M=0.1 unchanged for 2017 and 2018 is novel, but is probably adequate and has arrived at a reasonable conclusion. The method to decide on previous changes in the M was not reviewed at this meeting, what was presented was based on analyzing updates to the M series using the most recent years of data. The review **recommends** that the assessment do a revision of the entire M series with the full time series of data available**.** The review also **recommends** that a Mohn's rho be calculated for the retrospectives to provide a more objective method of comparing different M scenarios.

Maturation at length is allowed to vary over time within the model. It was not possible to extract the biomass at length data during the course of the meeting to identify the degree to which these changes impact on the estimate of *SSB*. It is therefore **recommended** that such an analysis be conducted to identify how sensitive the *SSB* estimate is to the change in maturation parameters.

For both maturation and natural mortality, the period in which estimated values change corresponds to the high biomass from *S. fasciatus* and *S. norvegicus*. The changes were presented as related to the change in the stock size, which is certainly possible, and the varying predation pressure from cod (which must have changed given the strong changes in cod biomass over this time). However, this period also represents a change in species composition, with both *S. fasciatus* and *S.norvegicus* representing a much higher fraction of the combined stock in these years compared to the rest of the time series, and as noted some of the *S. norvegicus* may be incorrectly assigned as beaked redfish. The changes in the aggregated modelled "stock" may thus be wholly or partially due to the change in species composition in the population. The possibility also exists that the changing species composition may interact poorly with an assumption of a single homogenous stock in the model, and cause the model to produce spurious results during times of rapid changes in species composition. The review reiterates that it is **recommended** to examine the possibility of a species-disaggregated model, but again notes that this is less of an issue at current low levels of stocks of *S. fasciatus* and *S.norvegicus*. Conducting a sperate assessment of the *S. norvegicus* stock and estimating levels of misidentification would be an alternate method of dealing with any future increase in *S. norvegicus* in the area.

The short-term projections cover a reasonable range of possible fishing levels (F=0, F0.1, Fmax and Fstatusquo), and are projected for an appropriate period of time. Female *SSB* is an appropriate quantity to track, although I did not notice any sexual dimorphism to specifically estimate "female" *SSB* within the model.

Although the simulations themselves cover a range of cases, given the absence of any B_{lim}, it is difficult to judge precautionarity or make choices between the options.

Review text, witch flounder

Summary

Although there is a reasonable amount of data for this stock, there are problems with both the fisheries and survey data. The stock is modelled using a Bayesian production model, which seems to be a reasonable choice given the limited data available and the high uncertainties for the stock. The choice of priors has been investigated, and there is clear evidence that the model does update the priors. There are clearly difficulties with the assessment, and this review notes some concerns around the tuning data, but the modelling approach does seem appropriate given the difficulties with the available data. Given the limitation in the data, there is limited scope for improving the assessment through further development of the modelling techniques.

A change in the model was made to increase the process variance around year 2014. This change was made prior to the current meeting and not presented in detail this year. This review will therefore make no comments on this change.

This review considers the current model provides an acceptable basis for advice this stock, and that it seems unlikely that the data would support a more sophisticated modelling approach. The procedure for producing the advice is consistent with the agreed precautionary basis of advice.

Specific concerns and recommendations

The change in survey coverage in 1991 has been dealt with appropriately by splitting the survey series into two periods. The length distributions of the surveys indicate both surveys have poor coverage of fish below around 30cm, but the coverage seems reasonable over the fishable size used in model tuning. The survey length range (around 30cm-50cm) is somewhat offset from that in the fishery (around 35cm-55cm). It seems likely that the difference in biomass levels is rather small, but the review **recommends** that if this has not already been investigated then it should be. The surveys show significant year effects that cannot be due to stock dynamics (years when all length ranges in the surveys go up or down together and then reverse this trend in a subsequent year). This could potentially represent a problem in model fitting. However, the survey fit residuals indicate that the model fitting has not followed the most unrealistic points. This review **recommends** that there should be an investigation of the impacts of identifying individual years where the majority of length classes have increased one year and then decreased the following (or vice versa) and then excluding these years from the model tuning as reflecting year effects rather than stock dynamics. In passing it can be noted that because of the extended partial moratorium, it may not be possible to run the production model without the survey.

On the catch side, a large part of the catch is taken as bycatch and therefore may well reflect changes in quotas for other species rather than the development of this stock. This may also result in changes in CPUE and potentially selectivity as the target fishery changes. The fishery splits into periods of heavy fishing, partial moratorium, and recent (largely bycatch) fishery. These factors do raise concerns for tuning a production model, although these are mitigated by the fact that there is no CPUE tuning series in the model (which would likely not be informative given the history of the fishery). They do mean that the biomass at the end of the partial moratorium may not be well estimated. The change in model structure in 2014 increases this uncertainty, as there are few years between the end of the moratorium and the change in model dynamics for the model to use for tuning.

The surveys are poor at picking up fish under around 30cm, and extremely poor between about 21cm-28cm. In some years small peaks are seen below 21cm. However, these peaks show almost no year to year consistency since c. 2008 and the survey does not seem to reliably find fish between 21cm and 28cm in any year. This does not pose difficulties in tuning a production model, where fishable biomass is the quantity being modelled. However, it does mean that the survey data is not reliable for estimating the abundance of young fish below around 30cm of size, and there is likely little to be gained from using this data to attempt to estimate or investigate recent recruitment. It is possible that the survey is capable of identifying periods with higher recruitment levels should these occur, and the review therefore **recommends** that the recruitment index continue to be collated, but that little reliability be attached to this unless year-to-year consistency can be seen in the length distributions, For the advice, the short term forecasts assume that the intermediate year catch with equal the TAC (following the official request), even though the TAC has not been taken in recent years. A sensitivity analysis was conducted to indicate that status quo catches (662 tonnes instead of 1175 tonnes). The change in the forecasts are rather small, the chance of falling below B_{lim} is lower with status quo fishing but is above the agreed acceptable limit of 10%. The advice of zero direct catch is consistent with the agreed precautionary management procedure.

III. STOCKS ASSESSMENTS

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

Recent Conditions in Ocean Climate and Lower Trophic Levels

- The ocean climate index, (a composite temperature index) in Subarea 0-1 has remained mostly above normal since the early 2000s. It reached a peak in 2010 but has been in decline since then, reaching normal conditions in 2015, 2017 and 2018.
- Total production of the spring bloom (magnitude) was normal in 2018 and similar to conditions observed in 2017.
- Spring bloom initiation was delayed in 2018 compared to 1998-2015 climatology.

Environmental Overview

Hydrographic conditions in this region depend on a balance of atmospheric forcing, advection and ice melt. Winter heat loss to the atmosphere in the central Labrador Sea is offset by warm water carried northward by the offshore branch of the West Greenland Current. The excess salt accompanying the warm inflows is balanced by exchanges with cold, fresh polar waters carried south by the east Baffin Island Current. The water mass circulation off Greenland comprises three main currents: Irminger Current (IC), West Greenland and East Greenland Currents (WGC and EGC). The EGC transports ice and cold low-salinity Surface Polar Water (SPW) to the south along the eastern coast of Greenland. The East Greenland Coastal Current (EGCC), predominantly a bifurcated branch of the EGC on the inner shelf, transports cold fresh Polar Water southwards near the shelf break. The IC is a branch of the North Atlantic current and transports warm and salty Atlantic Waters northwards along the Reykjanes Ridge. The current bifurcates south of the Denmark Strait and a small branch continues northward through the strait to form the Icelandic Irminger Current. The bulk of the IC recirculates to the south making a cyclonic loop in the Irminger Sea. The IC transports then southwards salty and warm Irminger Sea Water (ISW) along the eastern continental slope of Greenland, parallel to the EGC. The core properties of the water masses of the WGC are formed in the western Irminger Basin where the EGC meets the IC. After the currents converge, they turn around the southern tip of Greenland, forming a single jet (the WGC) and propagate northward along the western coast of Greenland. During this propagation considerable mixing takes place and ISW gradually deepens. The WGC consists thus of two components: a cold and fresh inshore component, which is a mixture of the SPW and melt water, and saltier and warmer ISW offshore component. The WGC transports water into the Labrador Sea and, hence, is important for Labrador Sea Water formation, which is an essential element of the Atlantic Meridional Overturning Circulation (AMOC).

Ocean Climate and Ecosystem Indicators

The ocean climate index in Subarea 0-1 has remained mostly above normal since 2001. The peak in the series occurred in 2010 but has declined in recent years to near normal levels (Figure 1A). Before the warm period of the last decade, cold conditions persisted in the early to mid-1990s.

Total production (magnitude) of the spring bloom has decreased to near normal levels in 2017 and 2018 after two consecutive years of high production in 2015-2016. Spring bloom production was near normal from 2012 to 2014. After largely negative anomalies from the mid-2000s. (Figure 1B). The initiation of the spring bloom occurred later than normal in 2018. (Figure 1C).

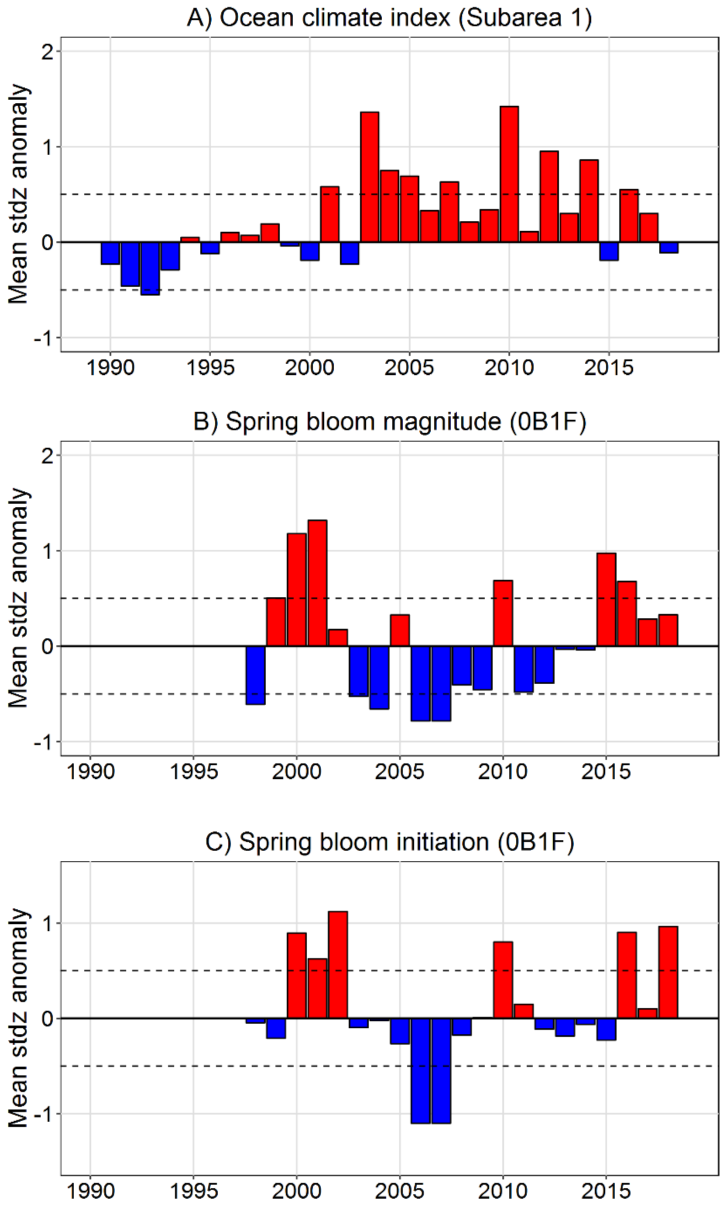


Figure A.1. Environmental indices for NAFO Subarea 0 and 1 during 1990-2017. The ocean climate index (A) for Subarea 1 (West Greenland) is the averaged of 5 individual time series of standardized ocean temperature anomalies: sea surface temperatures (SSTs) for Central Labrador Sea and West Greenland Shelf, vertically average ocean temperature at Fyllas Bank Station 4 (FB-4; 0-50 m) and Cape Desolation Station 3 (CD-3; 75-200 m), as well temperature at 2000 m at CD-3. SSTs time series are presented in Cyr et al. (2019) and FB-4 and CD-3 time series are obtained from the ICES report on ocean climate (IROC; https://ocean.ices.dk/iroc/). Phytoplankton spring bloom magnitude (B) and initiation (C) indices for the 1998-2018 period are derived from two satellite boxes located in NAFO Div. 0B (Hudson Strait) and 1F (Labrador Sea). Positive/negative anomalies indicate conditions above/below (or late/early timing), Anomalies were calculated using the following reference periods: ocean climate index: 1981-2010; Spring bloom indices (magnitude and peak timing): 1998-2015. Anomalies within ±0.5 SD (horizontal dashed lines) are considered normal conditions.

1. Greenland Halibut (*Reinhardtius hippoglossoides*) in Subareas 0+1A offshore and Divisions 1B-F

Interim Monitoring Report (SCR Docs 19/08; SCS Docs. 19/11, 19/12).

a) Introduction

A TAC for Greenland halibut in Subarea 0 + 1 (excluding Div. 1A inshore) was established in 1994, following the separation of the 1A inshore stock area from the offshore. Catches before 1994 varied with peaks in 1975 and 1992 of 20 000 t. Since 1994 catches have increased in response to increases in TAC from approximately 9 000 t to 34 000 t in 2018.

Table 1.1. Recent catches and TACs ('000 t):

	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
TAC	27	27	27	27	30	30	30	32	32	36
SA 0	13	13	13	13	15	14	14	16	16	
SA 1	13	14	14	15	16	17	17	18	18	
Total STACFIS[1,2]	26	27	27	28	31	31	31	34	34	

[1] Based on STATLANT, with information from Canada and Greenland authorities used to exclude 1A and 0B inshore catch.

[2] Includes inshore 1B-F catches that were <500t prior to 2013 and have varied between 1 000 t and 2 000 t since then.

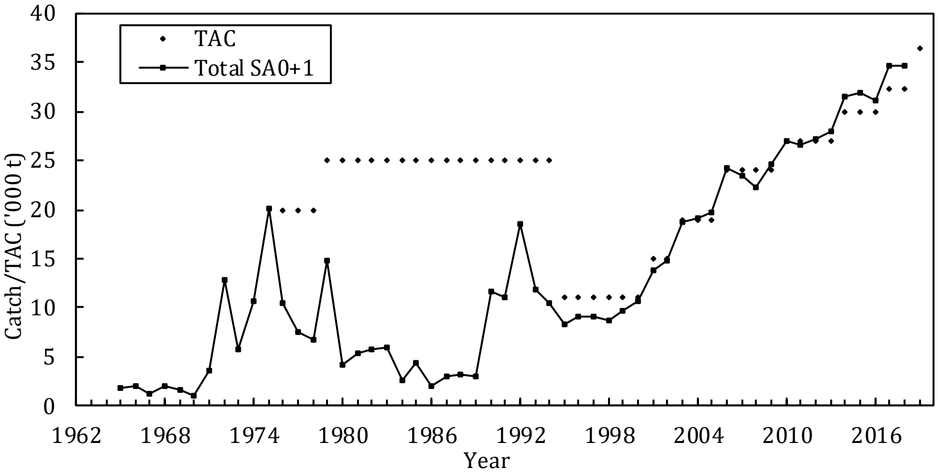


Figure 1.1. Greenland halibut in Subareas 0+1 (excluding Div. 1A inshore): catches and TAC.

b) Data Overview

Surveys for both Greenland and Canada have been completed with the RV Pâmiut from 1997 to 2017. This vessel was decommissioned following the 2017 surveys. No vessel was available for the Greenland 1CD bottom trawl survey or the Canadian SA0 bottom trawl survey in 2018.

A charter vessel, the C/V Sjudarberg, was used in 2018 for the West Greenland shrimp survey from which the recruitment index is derived. This vessel used all the standard gear from the RV Pâmiut (cosmos trawl, doors, bridles etc.) with trawl performance monitored with Marport sensors on doors and headlines in an effort to make the 2018 survey as similar as possible with the previous years' surveys. No comparative fishing was completed between these two vessels, and comparability of this survey point with the previous time series for Greenland halibut has yet to be determined. This will be examined during the next full assessment of this stock.

Greenland Surveys. Since 1997 Greenland has conducted stratified random bottom trawl surveys during September-October in NAFO Div. 1CD, from 400 to 1500 m; prior to this Greenland collaborated with Japan on a series of surveys from 1987-1995. The index of biomass in Div. 1CD in 2017 was similar to levels seen in 2015 and 2016. A vessel was not available to conduct the survey in 2018.

Canada Surveys. Surveys in 0A-South (to 72°N) have been completed in 1999, 2001, every second year between 2004 and 2014, and annually to 2017. The 2006 survey had poor coverage and was not considered valid. Biomass in Div. 0A-South varied with an increasing trend from 1999 to 2016 followed by a marked decline in 2017. Surveys in 0B have been less frequent with surveys in 2000, 2001, 2011 and 2013-2016. Biomass for Div. 0B in 2016 was similar to a previous high observed in 2011. A vessel was not available to conduct the survey in 2018.

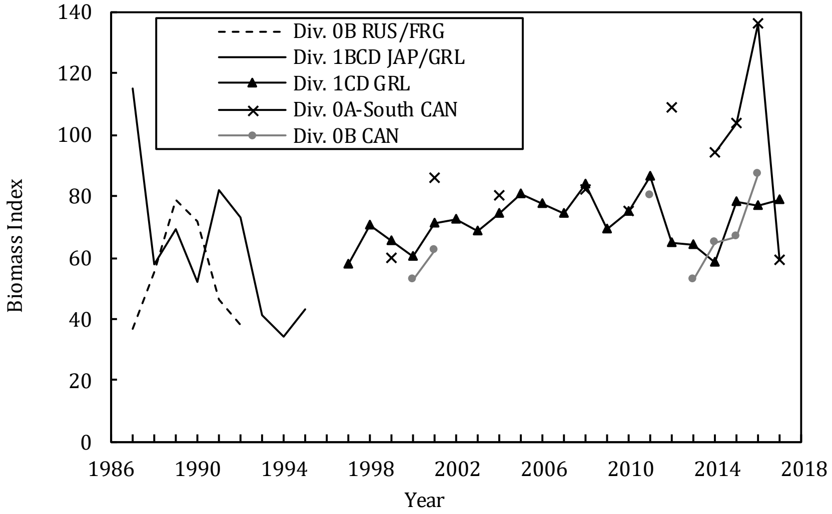


Figure 1.2. Greenland halibut in Subareas 0+1 (excluding Div. 1A inshore): biomass indices from bottom trawl surveys. The survey in Div. 0A in 2006 is not included due to poor coverage.

Combined 0A-South and 1CD Survey Index. 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 (excluding Div. 1A inshore) 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 index had remained stable at a relatively high level during 1999-2012. 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 remains above B_{lim}. The decline observed in 2017 is a result of a decline in the 0A-South survey biomass.

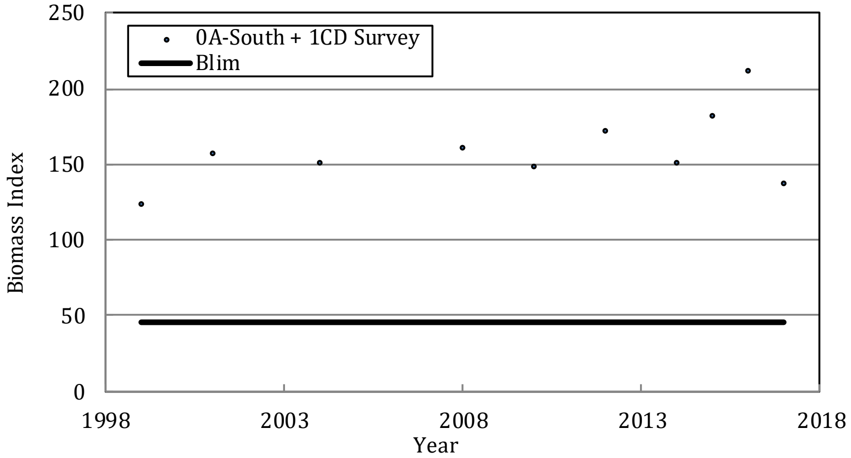


Figure 1.3 Greenland halibut in Subarea 0+1 (excluding Div. 1A inshore): 0A-South and 1CD combined biomass index (circles), and B_{lim} (line).

Recruitment. 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 number of age 1 fish in the survey area, including Disko Bay, is used as an index of recruitment. 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. A change in survey vessel occurred in 2018. Comparability of this vessel and the resulting recruitment index will be examined at the next full assessment.

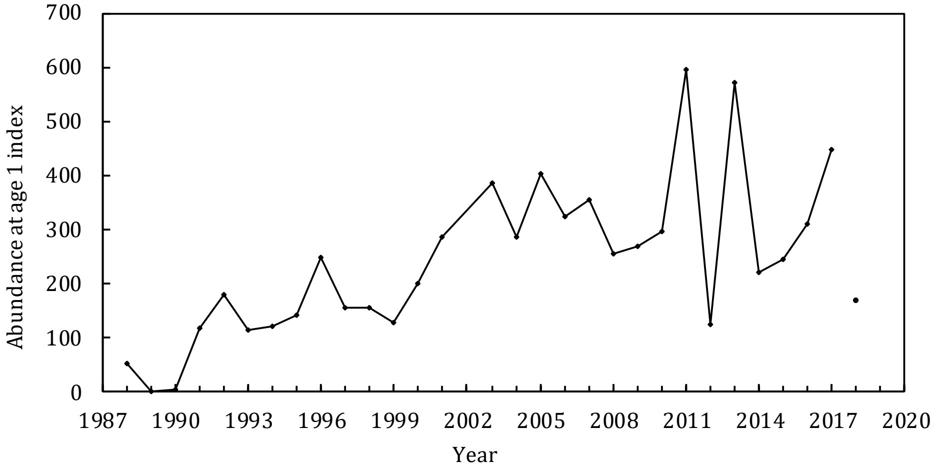


Figure 1.4. Greenland halibut in Subareas 0+1: recruitment index at age 1 in Subarea 1 derived from the Greenland shrimp surveys. The survey coverage was not complete in 1990 and 1991 therefore, the 1989 and 1990 year-classes are poorly estimated as age 1. The 2018 index is presented as a separate point due to the vessel change in 2018.

Catch-per-unit Effort. Catch-per-unit effort has been standardized for Division, fleet, vessel size and month, using a General Linear Model for SA0+1 trawl fleets and SA0 gillnet fleets. The trawl index has been fluctuating with a generally increasing trend since 1997 and the gillnet index since the beginning of the time series in 2003. However, it is not known how the technical development of fishing gear and changes in the vessels fishing in the fleets has influenced the estimation of catch rates. Therefore this index should be interpreted with caution.

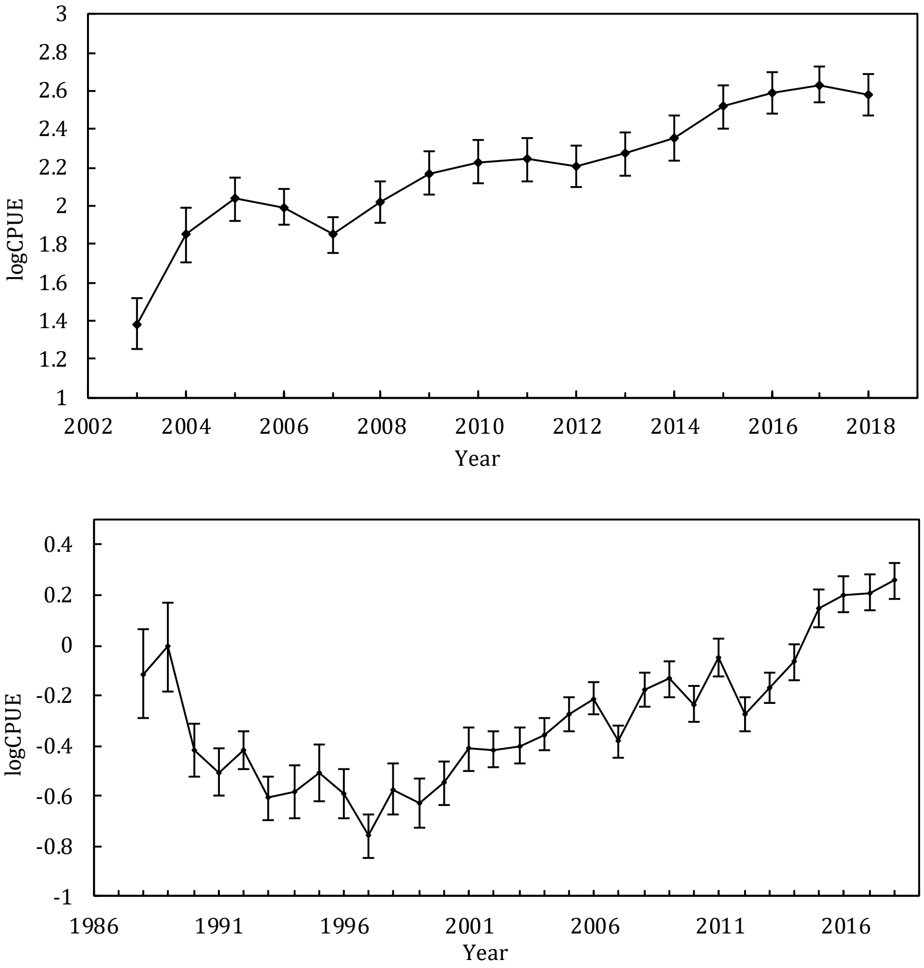


Figure 1.5. Greenland halibut in Subareas 0+1 (excluding Div. 1A inshore). Standardized CPUE ±S.E for SA0 gillnet fleets (top panel) and SA0+1 trawl fleets (bottom panel).

c) Conclusion

The RV Pâmiut was decommissioned following the 2017 surveys. No vessel was available for the Greenland Div. 1CD bottom trawl survey or the Canadian SA0 bottom trawl survey in 2018.

This stock underwent full assessment in 2018 based on survey indices. This assessment indicated that the stock is above B_{lim}. The combined biomass index was relatively stable until 2014 then increased to 2016. A decline observed in 2017 was a result of a decrease in the 0A-South survey biomass. Recruitment has been variable in recent years with series high values observed in 2011, 2013 and 2017.

In 2018 the ICES Harvest Control Rule 3.2 for data-limited stocks was used to formulate the advice. Based on this information, Scientific Council advised that there is a low risk of Greenland halibut in Subarea 0 + 1A (offshore) and 1B-F being below B_{lim} if the TAC for 2019 and 2020 does not exceed 36,370 t.

The advice from the 2018 assessment is still considered valid.

The next full assessment of this stock is planned for 2020.

2. Greenland halibut in Division 1A inshore.

Interim monitoring report (SCR Doc. 19/32, 19/33 SCS Doc. 19/12).

a) Introduction

The fishery in Division 1A inshore mainly takes place in the Disko Bay, the Uummannaq fjord and the Fjords surrounding Upernavik, besides a small developing fishery in the Qaanaaq fjord. The stocks are believed to depend on recruits from the offshore stocks and adults are considered isolated from the stocks in Davis Strait and Baffin Bay. Advice is given for each of the three main areas on a two-year basis and a separate TAC is set for each area. The assessment is qualitative in all three areas. In the Disko Bay area, an index based harvest control rule was accepted as the basis for TAC advice in 2016.

Catch history

The inshore fishery for Greenland halibut developed at the beginning of the twentieth century, with the introduction of the longline to Greenland in 1910. Catches remained at a lower level until the 1980s, but increased substantially thereafter. The fishery is conducted mainly with longlines and gillnets from small vessels, open boats and through holes in the sea ice during the winter months. Quota regulations were introduced as a shared quota for all vessels in 2008. In 2012, the TAC was split into 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. Sorting grids have been mandatory since 2002 in the offshore shrimp fishery in West Greenland and in the inshore areas from 2011. In 2017, mesh size in gillnets were reduced to 95mm half mesh. Besides the three main areas, a fishery is slowly developing in the Qaanaaq fjord (77 degrees North) since 2011. Recent catches and TACs are given in table 2.1 and Figure 2.1.

Disko Bay: Catches increased in the 1980s, peaked from 2004 to 2006 at more than 12 000 t, but then decreased substantially. From 2009, catches gradually increased and reached 10 760 t in 2016, before decreasing to 6 409 t in 2017. In 2018, catches were 8 399 t.

Uummannaq: Catches in the Uummannaq fjord gradually increased from the 1980s reaching 8 425 t in 1999, but then decreased and remained between 5 000 and 6 000 t from 2002 to 2009. After 2009 catches gradually increased reaching 10 305 t in 2016. In 2018, 8 839 t were caught in the area.

Upernavik: 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, they have gradually returned to the higher level. In 2018, a record high 7 549 t were caught in the area.

Table 2.1. Recent catches and advice ('000 t) are as follows:

		2010	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**
Disko Bay	TAC	8.8	8.0	8.0	9.0	9.0	9.2	9.6	9.2	9.2	8.2
	Catch	8.5	8.0	7.8	9.1	9.2	8.7	10.8	6.4	8.4	
Uummannaq	TAC	5.0	6.0	6.0	7.4	8.4	9.5	9.8	9.5	9.5	9.5
	Catch	6.2	6.4	6.1	7.0	8.2	8.2	10.3	9.0	8.8	
Upernavik	TAC	6.0	6.5	6.5	8.0	9.5	10.0	9.5	9.5	9.5	8.5
	Catch	5.9	6.5	6.8	6.0	7.4	6.3	7.4	6.8	7.6	
Qaanaaq	TAC		-	-	-	-	-	-	-	-	-
	Catch		<0.1	0.1	<0.1	0.1	0.1	0.1	0.2	0.2	
STACFIS Total		20.6	20.9	20.8	22.1	24.9	23.3	28.6	22.4	25.0	

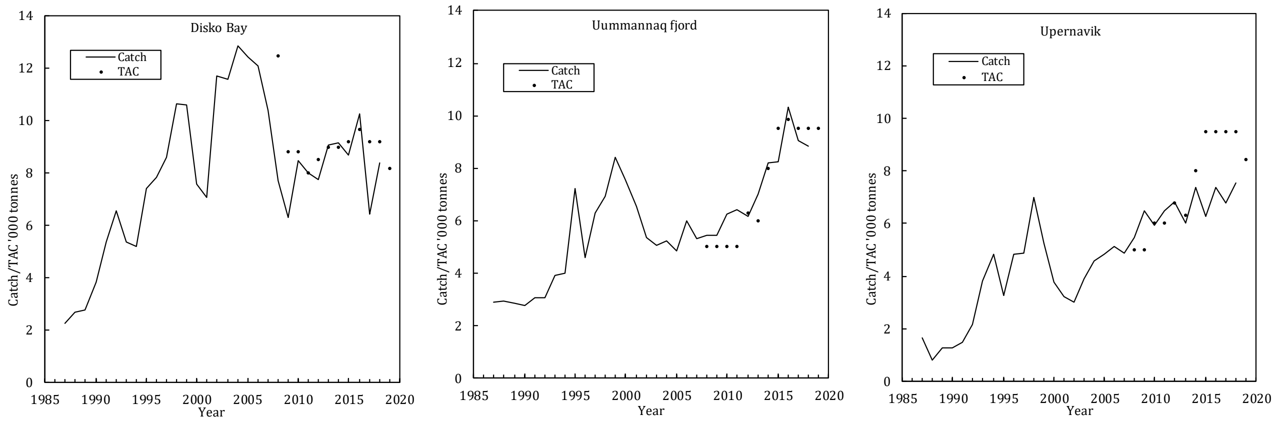


Figure 2.1. Greenland halibut in Division 1A inshore: Greenland halibut catches and TAC in t in Disko Bay, Uummannaq and Upernavik.

b) Data overview

i) Commercial fishery data

Length frequencies from factory landings are available since 1993. These data were used to calculate the mean length in the landings by season, gear and a year overall mean (from 2010) accounting for season, gear and area (Figure 2.2).

In the Disko Bay area**,** 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. Glacier ice limits the access to the deep areas of the Ilulissat Icefjord (Kangia) during the summer, causing the difference between the summer and winter fishery mean length. In most years total catch from Kangia is between 5-10% of the total catch.

In **Uummannaq,** the length distributions in the commercial landings have gradually decreased since 1993, but at a higher rate in recent years. Since there is little difference between summer and winter fishing grounds, only small differences in the summer and winter length distributions are observed.

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 relatively constant but has since then decreased further.

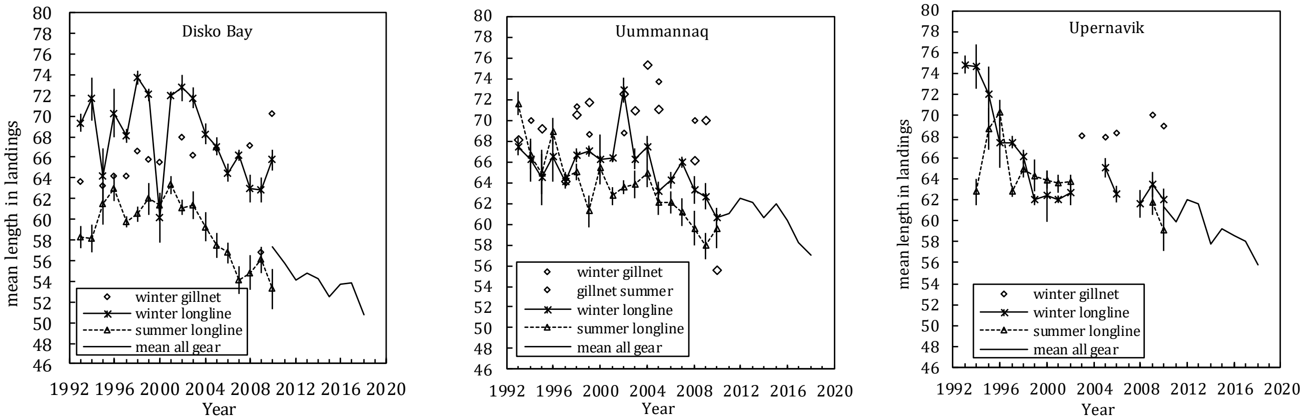


Figure 2.2. Greenland halibut in Division 1A inshore: mean length in landings from gillnet and longline fisheries by season (summer and winter) and overall mean taking account of fishing ground, season and gear.

The decreasing size distribution in the landings means that the recent catches in numbers are a record high. Although catch in tonnes decreased in the Disko Bay in 2016, the estimated catch in numbers is still at the level of the previous high catches (figure 2.3). In all areas catches in numbers are a record high in recent years.

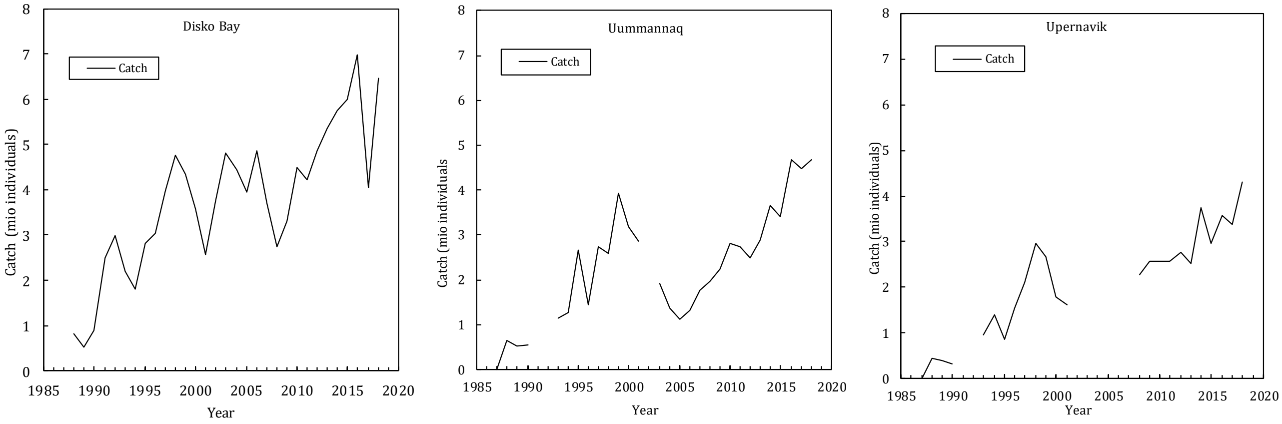


Figure 2.3. Greenland halibut in Division 1A inshore: Greenland halibut catch in million individuals.

CPUE index based on logbooks. Logbooks have been mandatory for vessels larger than 30 ft since 2008. A general linear model (GLM) with year, month and boat as factors was applied to fit the longline and gillnet logCPUE available. Use of illegal fine-meshed (80mm knot to knot) gillnets are well documented in the Disko Bay and mesh size was in the legislation reduced in 2017 (from 110 to 90mm). Gillnet CPUE is therefore not used in the analysis. CPUE observations were log-transformed prior to the GLM analysis. Least-mean square estimates were used as standardized CPUE series. (Figure 2.4).

In the **Disko Bay,** the standardized CPUE series show a decreasing trend since 2009.

In **Uummannaq**, the initial years (2008-2010) were based on fewer observations. Although the CPUE increased slightly in 2018, the CPUE index has been in a gradually decreasing trend since 2011.

In **Upernavik,** the CPUE has been in a gradually decreasing trend, with the most recent 4 years being among the lowest observed.

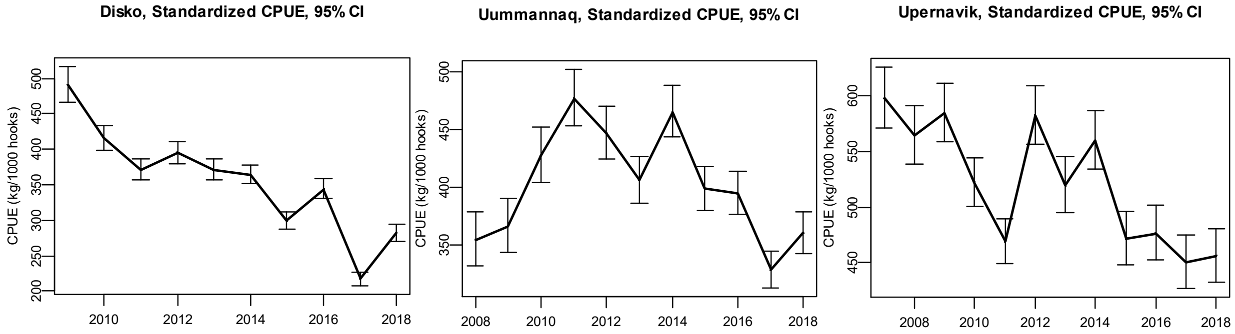


Figure 2.4 Standardized mean and 95% CI of longline CPUE in Disko bay (left), Uummannaq (center) and Upernavik (right).

Research survey data

The Greenland shrimp and fish survey (NAFO Div. 1A-F from 100 to 600 m) also covers the Disko Bay area. Separate abundance and biomass indices and length frequencies have been calculated for the Disko Bay part of the survey (Figure 2.5). RV Pâmiut was previously used for this survey but decommissioned in 2017 and a commercial vessel using a Cosmos trawl was used in 2018.

In this survey up to 90% of the Greenland halibut caught in the survey are juveniles at age 1 and 2, leading to a somewhat fluctuating abundance index. The Disko Bay part of Greenland Shrimp and Fish Survey indicated an increasing abundance trend during the 1990s and high abundances (mainly age 1) were found from 1998 to 2005. After 2006, the abundance indices returned to the lower levels except for the high abundances identified in 2011 and 2013. Although recruitment seems to vary from year to year, this does not seem to be the case at age two or three. There is a weak correlation between age one and older ages in subsequent years. The biomass indices in the trawl survey indicate a steady increase during the 1990s, with a substantial increase observed in 2003 and 2004. After the gear change in 2005, the biomass index has been in a decreasing trend. The 2018 survey had higher than usual numbers of Greenland halibut in the size interval of 30-40 cm (2015 YC).

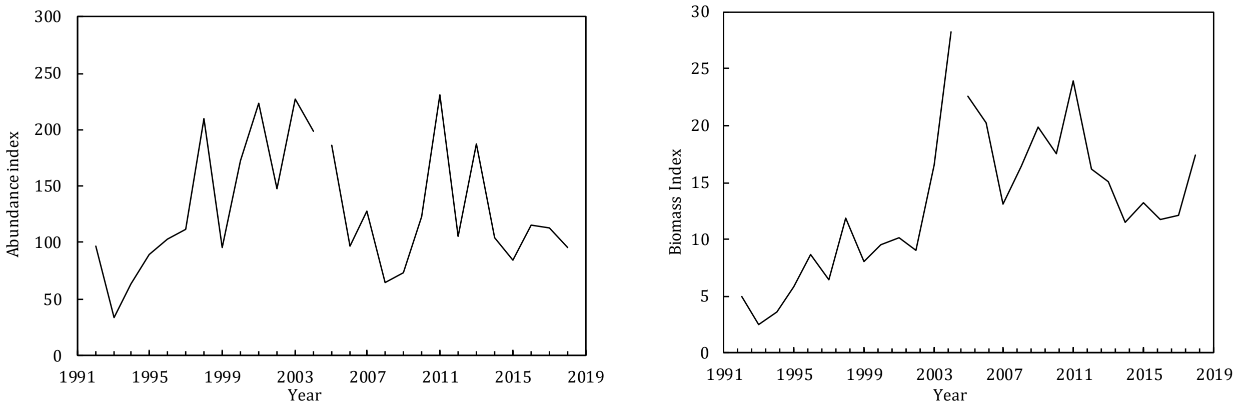


Figure 2.5. Greenland halibut in Division 1A inshore: Abundance and biomass indices in the Disko Bay from the Greenland Shrimp Fish trawl survey.

Gillnet surveys were originally designed to target pre fishery recruits at lengths from 35-55 cm. Since the survey uses gillnets with narrow selection curves and normally catches the same sized fish, but in varying numbers, there is little difference between the trends of the CPUE (kg/ 6 hr) and NPUE (number per 6 hr) indices.

The Disko Bay gillnet survey varied around average levels from 2001-2010 and was unusually high in 2011 (Figure 2.6). Since 2013, the Gillnet survey CPUE has gradually decreased and remained below average levels in the most recent 4 years. In 2018, the survey NPUE increased mainly caused by increasing numbers of Greenland halibut in the size interval from 30 to 40 cm. The apparent correlation between the gillnet survey NPUE and the number of Greenland halibut larger than 35 cm in the trawl survey implies a level of agreement between the surveys, although both surveys show large year to year variation. A larger mesh size added in 2016 did not impact the overall length distribution in Disko Bay, indicating few larger individuals in the surveyed area (55-70 cm).

The Uummannaq gillnet survey was performed using the same method and setup as in Disko Bay. It is not possible to draw any conclusions about the trends in the survey due to a low number of stations prior to 2015. The number of fish caught in the Uummannaq survey has in general been higher and the size distribution been larger than observed in the Disko Bay (Figure 2.7). In 2018 the Uummannaq survey indices decreased substantially.

The Upernavik gillnet survey was performed using the same method and setup as in the Disko Bay. The CPUE over the recent 3 years was almost twice as high as observed in the Disko Bay (Figure 2.8). The length distributions indicated the presence of pre-fishery recruits of 30-40 cm comparable to the levels observed in the Disko Bay. A larger mesh size added in 2016 caught some larger Greenland halibut in the size range 55-65 cm in Upernavik. The survey CPUE seems relatively stable in the most recent 4 years.

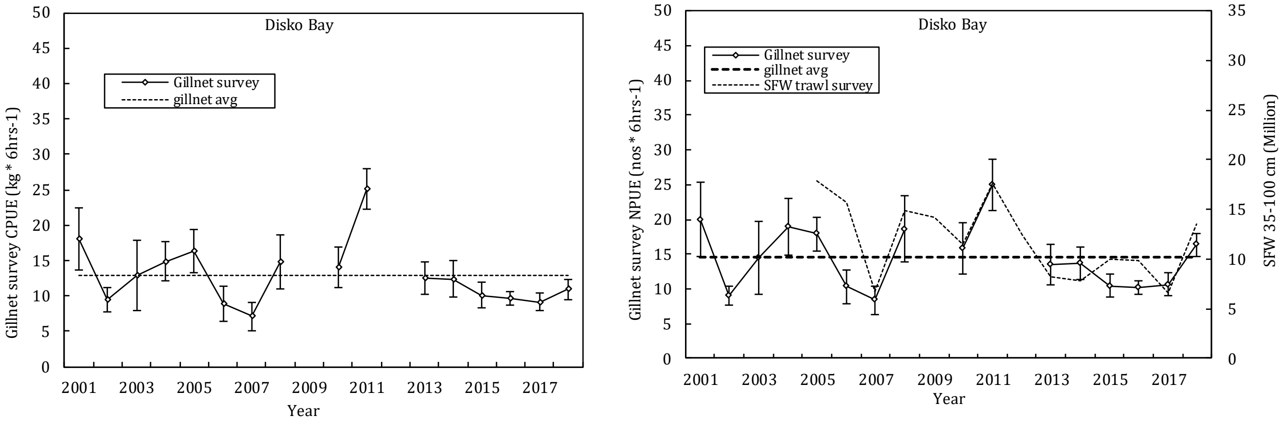


Figure 2.6. Greenland halibut in Division 1A inshore: Gillnet survey CPUE and NPUE +/-SE.

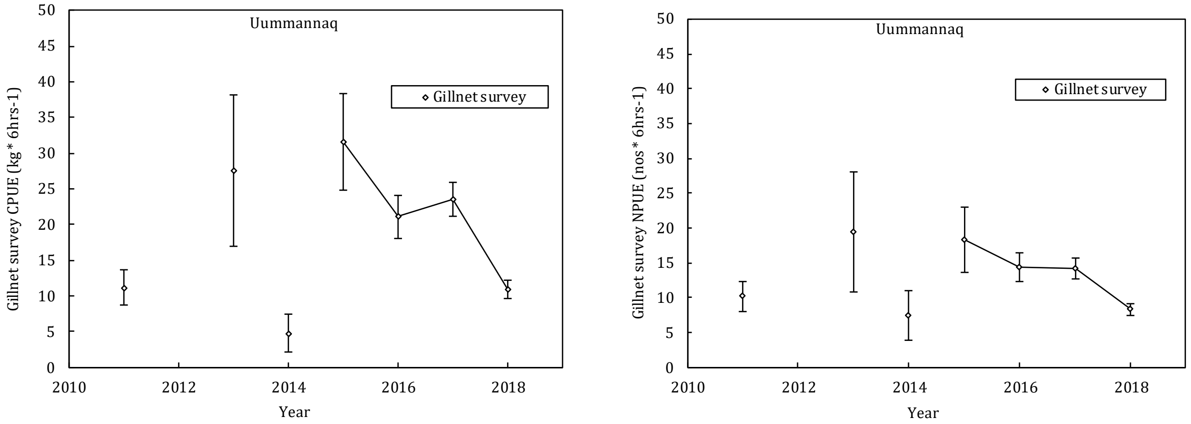


Figure 2.7. Greenland halibut in Division 1A inshore: Gillnet survey CPUE and NPUE +/-SE.

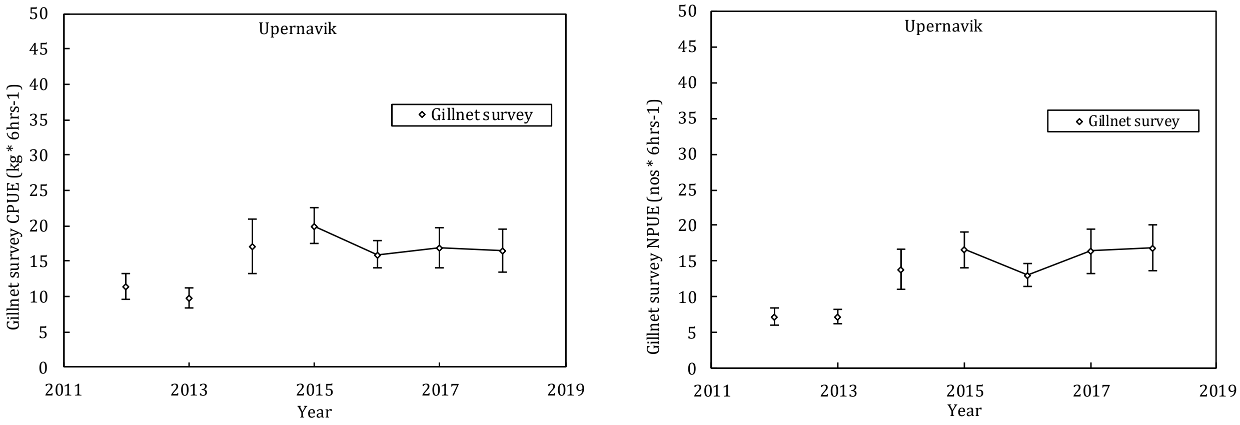


Figure 2.8. Greenland halibut in Division 1A inshore: Gillnet survey CPUE and NPUE +/-SE.

c) Conclusion:

Disko Bay

The ICES Harvest Control Rule 3.2 for data limited stocks combined with the survey index from the Greenland shrimp and fish survey has been used to formulate the advice since 2016. In 2018, catch advice was reduced to 5 120t. The increase in biomass in the 2018 survey is mainly caused by increasing numbers of small Greenland halibut (2015 YC) in the surveys. Although the CPUE based on longline logbooks increased slightly in 2018, the index remains within the overall decreasing trend seen since 2009. Furthermore, the mean individual length in landings continues to decrease. Based on the updated indices there is no basis to change the advice for Greenland halibut in the Disko Bay.

Uummannaq:

Due to decreasing mean individual length in the landings, the advice was reduced to 5 800 t in 2018. With updated data from 2018, the mean individual length in landings decreased further in 2018. The CPUE based on longline increased slightly in 2018, but is still within the decreasing trend observed since 2011. Based on the updated indices there is no basis to change the advice for Greenland halibut in the Uummannaq fjord.

Upernavik:

Due to decreasing mean individual size in the landings, the advice was reduced to 5 330 t in 2018. With updated data from 2018, the mean individual length in landings has continued to decrease. Although the CPUE based on longline logbooks increased slightly in 2018, the index remains within the decreasing trend seen 2007. Based on the updated indices there is no basis to change the advice for Greenland halibut in the Upernavik area.

These stocks will next be assessed in 2020.

3. Demersal Redfish (*Sebastes* spp.) in Subarea 1

Interim Monitoring Report (SCR Doc. 88/12, 96/36, 07/88, 17/039 19/008; SCS Doc. 19/12)

a) Introduction

There are two demersal redfish species of commercial importance in subarea 1, golden redfish (*Sebastes norvegicus = S. marinus*) and demersal deep-sea redfish (*Sebastes mentella*). Connectivity to other redfish stocks off East Greenland, Irminger Sea and Iceland is unclear. Survey data reveal an almost continuous distribution of both species from East Greenland to West Greenland. Historic catches however suggest decade-long concentrations of redfish in both areas.

i) Fisheries and Catches

Both redfish species are included in the catch statistics, since no species-specific data are available. Greenland operates the quota uptake by categorising the catches in three types of redfish: 1) fish caught by bottom trawl and longlines on the bottom are considered *Sebastes norvegicus*. 2), fish caught by pelagic gear are considered *Sebastes mentella* and 3) fish caught as by-catch in the shrimp fishery are named *Sebastes sp*. From offshore and inshore surveys in West Greenland, it is known that the demersal redfish on the shelf and in the fjords are a mixture of *S. norvegicus* and *S. mentella*.

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, catches are highly uncertain with evidence of cod being misreported as redfish and other species in the 1970s, and by-catches of redfish in the shrimp fishery not appearing in official statistics in some years. Bycatch of redfish was estimated to be more than 14 000 t in 1988 and 4 000 t in 1994. To reduce the amount of fish taken in the trawl fishery targeting shrimp, sorting grids have been used since 2002. In 2018, 43 t was reported as by-catch in offshore fisheries (1 tons from shrimp trawlers) and 150 t were taken inshore mainly as a bycatch in cod and Greenland halibut fisheries (Figure 4.1).

Recent catches (‘000 tons) are as follows:

	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
TAC	1	1	1	1	1	1	1	1	1	1	1
STATLANT 21	<0.1	0	0.2	0.12	0.2	0.2	0.2	0.2	0.2	0.2	
STACFIS	0.4	0.3	0.2	0.2	0.2	0.2	0.3	0.2	0.2	0.2	

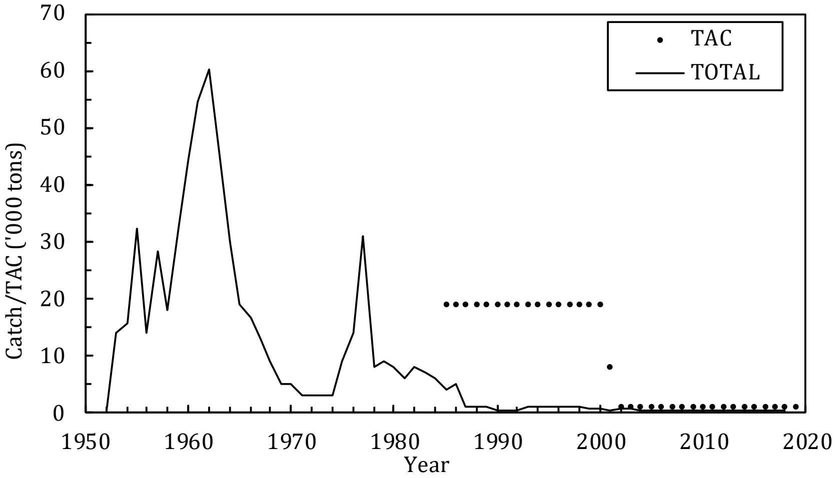


Figure. 3.1. Demersal redfish in Subarea 1: catches and TAC.

b) Data Overview

i) *Commercial fisheries*

Mean length of golden redfish catches from sampling of EU-Germany commercial catches during 1962-90 revealed significant mean size reductions from 45 to 35 cm across the time series. There are no data available to estimate the size composition of catches of deep-sea redfish. Since redfish are currently taken as bycatch and landed in small amounts, no data of recent size composition in the landings are available. Logbooks and factory landings data were available.

ii) *Research surveys*

There are three surveys covering the demersal redfish stocks in Subarea 1. The EU-Germany survey (Walther Herwig III, 0-400m, NAFO 1C-F, ICES XIV, since 1992), the Greenland deep-sea survey (Pâmiut, 400-1500m, NAFO 1CD over 1998-2017 and a charter vessel in 2018) and the Greenland shrimp and fish survey (Pâmiut until 2017 and a charter vessel in 2018, 0-600m, NAFO 1A-F, since 1992 (SFW), ICES XIV since 2007 (SFE)). The Greenland shrimp and fish survey has a more appropriate depth and geographical coverage in regards to redfish distribution, and covers the important nursery areas in 1B. However, no separation of redfish species was made prior to 2006 and the gear was changed in 2005 in the survey, thus breaking the index. In 2017, the EU-Germany survey had few stations in West Greenland and the index is not updated. Besides the recent surveys, a joint Greenland-Japan survey (Shinkai Maru, -1500m, NAFO 1B-D, 1987-1995) existed with somewhat overlapping the areas and depths as the present Greenland deep-sea survey. RV Pâmiut was decommissioned in 2017 and a commercial vessel using a Cosmos trawl was used in 2018.

Golden redfish (Sebastes norvegicus)

The EU-Germany survey biomass index (1C-F) decreased in the 1980s and was at a very low level in the 1990s (Figure 3.2). However, the survey has revealed increasing biomass indices of golden redfish (>17cm) since 2004 and the 2015 index reached the highest level observed since 1986. The survey had low coverage in both 2016 and 2017 and was updated in 2017. **The Greenland shrimp and fish survey** biomass index for golden redfish increased substantially since 2011 (Figure 3.2). The peaks observed in 2016 are caused by few single hauls accounting for most of the year's estimate; in 2016, more than 80% of the biomass derives from a single haul in division 1E consisting of large golden redfish at lengths between 45 and 70 cm. This was not the case in 2017 and 2018, and the index returned to lower levels.

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 when the survey ended

(Figure 3.3). **The Greenland deep-sea survey** (1CD) indices were at a low level from 1997 to 2007, but the biomass index remained at a higher level since 2008 (Figure 3.3). T**he Greenland shrimp and fish survey** biomass index for deep-sea redfish steadily increased after 2006 and the 2016 indices were among the highest observed (Figure 3.3). However, the high 2016 biomass index was caused by a single haul in division 1D of large redfish between 25 and 40 cm. In 2017, there were no such large hauls in the survey but the indices remain in an increasing trend.

Juvenile redfish (both species combined)

The EU-Germany survey regularly found juvenile redfish from 1984 to 2000. After 2000, the abundance of juvenile redfish have decreased to a low level and has remained low since then (Figure 3.4). **The Greenland shrimp and fish survey** initially had high levels of juvenile redfish in the survey and the total abundance of both species combined can be regarded as a recruitment index. From 1992 to 1999, high numbers of redfish recruits were observed annually, but the index gradually decreased and remained low until 2004. After the gear change in 2005, the abundance index gradually decreased (Figure 3.4). Length distributions reveal that the increase in survey biomass observed in 2016 is primarily large mature redfish and not recruits. Length distributions also reveal that since 2011, virtually no new incoming year classes have been observed in West Greenland. Data from the Greenland Shrimp and fish survey in East Greenland, which could potentially supply West Greenland with recruits (as known for other species such as Atlantic Cod and Haddock) reveal that new significant incoming year classes of redfish have not been observed since 2010.

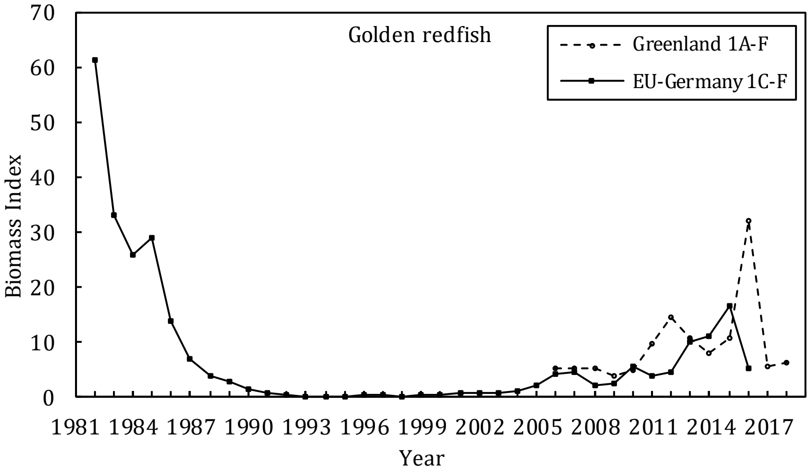


Figure. 3.2. Golden redfish biomass indices in the EU-Germany survey (1C-F) and the Greenland shrimp and fish survey (1A-F).

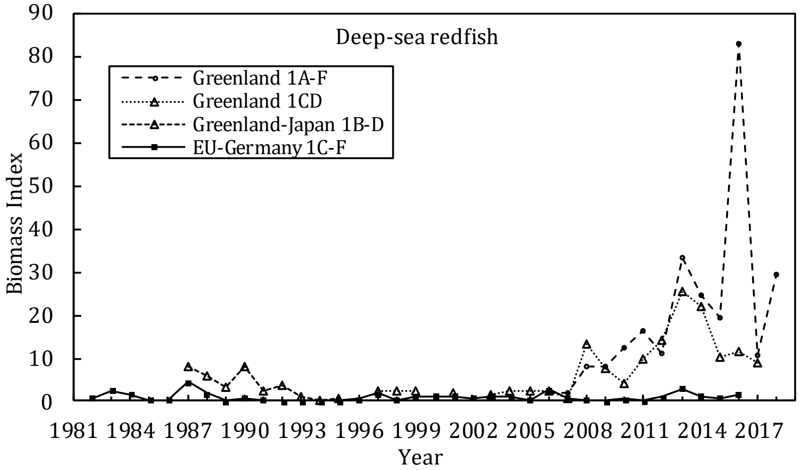


Figure. 3.3. Demersal deep-sea redfish survey biomass from the Greenland shrimp and fish survey (1A-F), the Greenland deep-sea survey (1CD), the EU-Germany survey (1C-F) and the Greenland-Japan survey (1B-D).

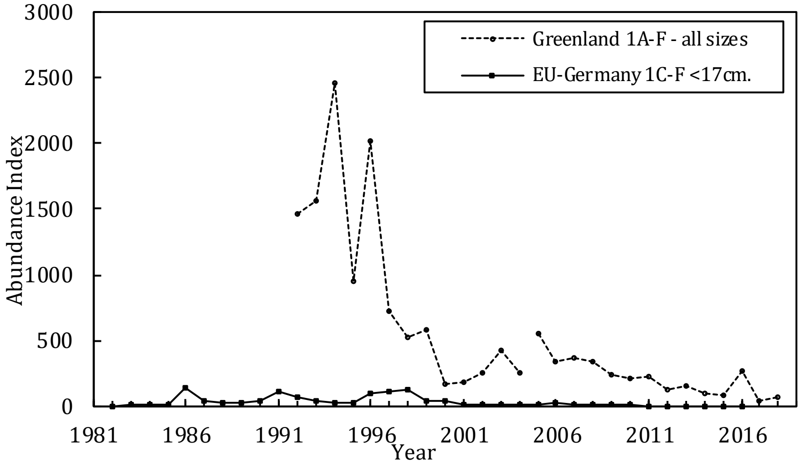


Figure. 3.4. Juvenile redfish abundance indices (deep-sea redfish and golden redfish) for the EU-Germany survey (1C-F), and the Greenland shrimp and fish survey (1A-F, all sizes).

c) Conclusion

Golden redfish - *Sebastes norvegicus*

The stock was assessed in 2017 for the 2018-2020 period and current advice is "No directed fishery". With the updated indices there is no basis to change the advice as the biomass remains far below historic levels and recruitment has been at a low level for years.

Deep-sea redfish - *Sebastes mentella*

The stock was assessed in 2017 for the 2018-2020 period and current advice is "No directed fishery". With the updated indices there is no basis to change the advice. Although the biomass in the surveys have been higher in recent years, recruitment remains at a very low level.

This stock will next be assessed in 2020.

4. Wolffish in Subarea 1

Interim monitoring report (SCR Doc. 80/VI/72 77 96/036 07/88 17/036 19/008; SCS Doc. 19/12)

a) Introduction

Three species of wolffish are common in Greenland. Only Atlantic wolffish (*Anarhichas lupus*) and spotted wolffish (*Anarhichas minor*) are of commercial interest, whereas 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 and both inshore and offshore but is the dominant species of wolffish in the coastal areas and inside the fjords. Atlantic wolfish has a shallower depth distribution (0-400m) than spotted wolffish (0-600m).

Fisheries and catches.

Wolffish are primarily taken as a bycatch in other fisheries. A directed wolfish fishery typically occurs when access to more economically important species are limited. 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 4a.1). After 1980, the cod fishery gradually decreased 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 grid separators since 2002 and inshore (Disko Bay) trawlers since 2011. After 2014, the reported catches have gradually decreased. In 2018, inshore landings of wolffish were 157 t and offshore reported catches were104 t, mainly reported as bycatch.

Recent nominal catches (000 tons) for Atlantic wolffish and Spotted wolffish.

	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Atlantic wolffish TAC						1.0	1.0	1.0	1.0	1.0
Spotted wolffish TAC						1.0	1.0	1.0	1.0	1.0
Combined wolffish TAC	1	1	1	1	1	2.0	2.0	2.0	2.0	2.0
STATLANT 21	<0. 1	0.8	1.0	0.9	0.9	0.4	0.2	0.2	0.3	
STACFIS	1.3	0.8	1.0	0.9	0.9	0.4	0.2	0.2	0.3	

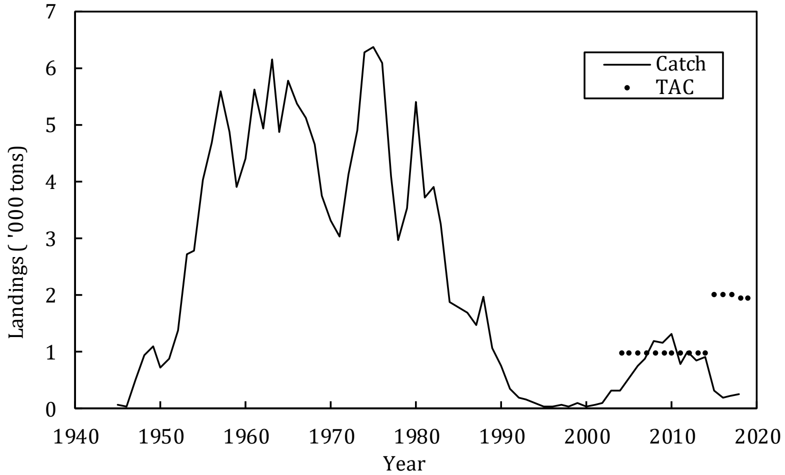


Figure 4.1. Wolffish in Subarea 1: Catches and TACs for Atlantic wolffish and spotted wolffish combined from 1945 to 2018.

b) Input data

i) Research survey data

The EU-Germany survey (RV Walther Herwig III, 0-400m, NAFO 1C-F, ICES XIV, since 1982) only covers the southern part of the West Greenland shelf. The survey had low coverage in West Greenland in 2017 and was cancelled for 2018.

The Greenland shrimp and fish survey (RV Pâmiut, 0-600m, NAFO 1A-F (South Greenland to 72N), 1992-2017, ICES XIV (South Greenland to 67N) 2007-2017) covers a larger geographical area and depth range. The gear was changed in the Greenland shrimp and fish survey in 2005, thus interrupting the survey index. RV Pâmiut was decommissioned in 2017 and a commercial vessel using a Cosmos trawl was used in 2018.

The Greenland shrimp and fish survey has a more appropriate geographical coverage in relation to wolffish, although none covers the main inshore fishing areas. Both surveys covers 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 indices increased to above average levels, but thereafter returned to the low levels observed during the 1990s. The index has not been updated since 2016, due to low coverage and survey cancellation.

Abundance indices in the EU-Germany survey decreased from the start of the time series in 1982, but were at a stable and perhaps slightly increasing level until 2005. After 2005, abundance indices in this survey decreased to below average levels. This decrease may be related to a gradual decrease in the surveyed area (Figure 4.2).

The Greenland shrimp and fish survey biomass indices were at low levels during the 1990s, but increased slightly from 2002 and until the gear change in 2004. After 2005, the biomass index has been variable, but generally increased from 2006 onwards (Figure 4.2). Abundance indices in the Greenland shrimp and fish survey increased until the gear change in 2004 (Figure 4.2). From 2005 the increasing trend has continued with a few outlier years in the index. The increase in abundance indices in the Greenland shrimp and fish survey has been observed in divisions 1A-B, north of the EU-Germany survey area.

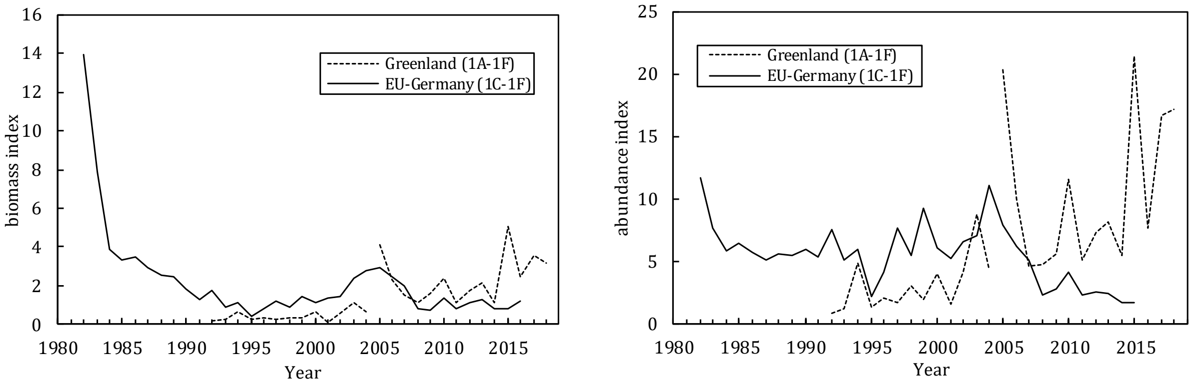


Figure. 4.2. Atlantic wolffish survey biomass index (left) and abundance index (right) from the surveys.

Spotted wolffish:

The EU-Germany survey biomass index decreased from 1982 and as at low levels during the 1990s (Figure 4.3). After 2002, the survey biomass increased and the recent indices are at the level observed in the beginning of the 1980's. Although highly variable, the abundance index has gradually increased since the mid-1990s (Figure 4.3).

The Greenland shrimp and fish survey biomass index, were at low levels during the 1990s, but increased from 2002. After the gear change in 2005, survey biomass has increased substantially (Figure 4.3). The abundance index gradually increased both before and after the gear change. (Figure 4.3).

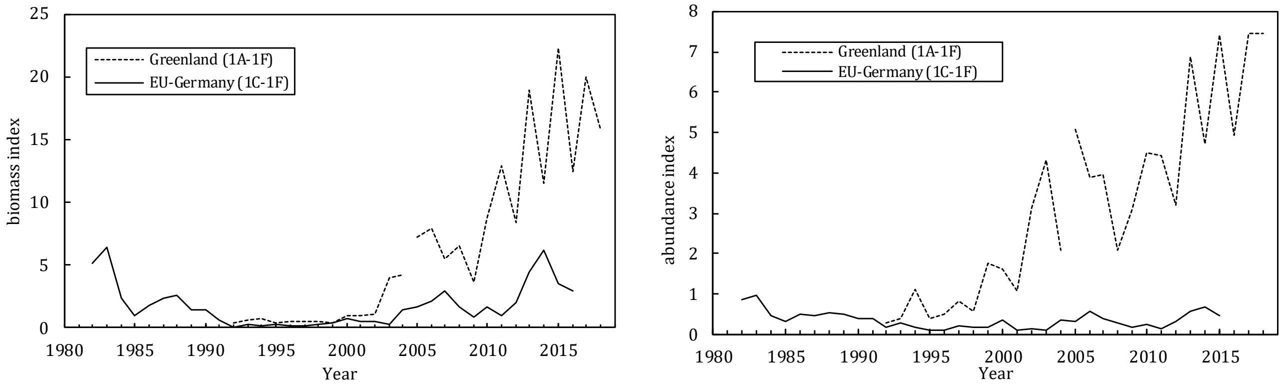


Figure. 4.3. Spotted wolffish survey biomass index (left) and abundance index (right) from the surveys.

c) Conclusion

Atlantic wolffish

This stock underwent full assessment in 2017, with the advice that there should be no directed fishery targeting Atlantic wolffish in Subarea 1, since the biomass indices of the EU-Germany survey are far below the initial values. Although the Greenland shrimp and fish survey index is increasing, there is no major change in the perception of the stock.

Spotted wolffish

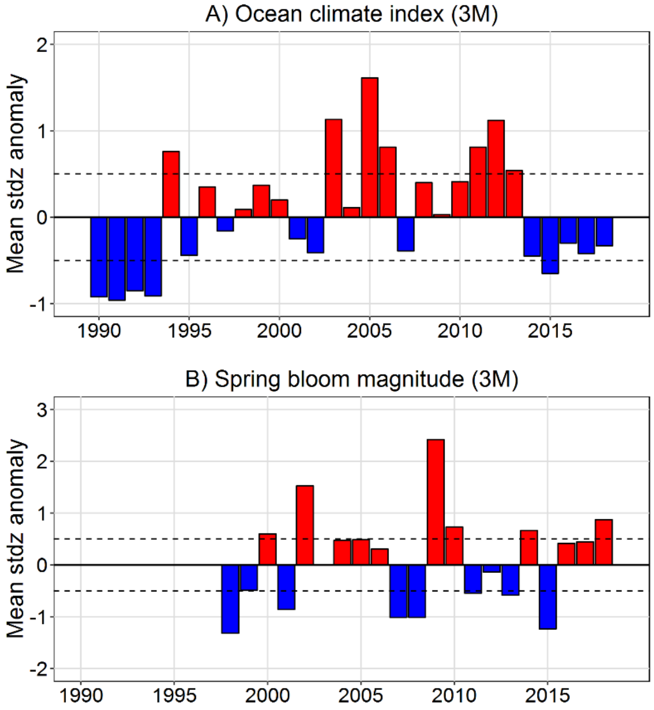
This stock underwent full assessment in 2017. The ICES Harvest Control Rule 3.2 for data limited stocks combined with the survey index from the Greenland shrimp and fish survey has been used to formulate the advice since 2017. Although the survey indices were increasing, the advice was reduced to 975 t, after applying a first year precautionary buffer. As both abundance and biomass indices remain high, there is no major change in the perception of the stock.

These stocks will next be assessed in 2020.

B. STOCKS ON THE FLEMISH CAP (NAFO DIVISION 3M)

Recent Conditions in Ocean Climate and Lower Trophic Levels

- The ocean climate index for 2018 in SA3 – Flemish Cap, after being predominantly above normal since 2003, was negative but within the range of normal conditions between 2014 and 2018 (except 2015 were it was below normal).
- Total production of the spring bloom (magnitude) on the Flemish Cap was above normal in 2018 after three years of below or near normal production. Spring bloom initiation remained near normal in 2018 for a second consecutive year.
- Zooplankton abundance has remained above normal since 2015 with three of the four highest anomalies for the time series observed during that period.
- Zooplankton biomass increased to near normal levels in 2018 after the time series record low observed in 2017.



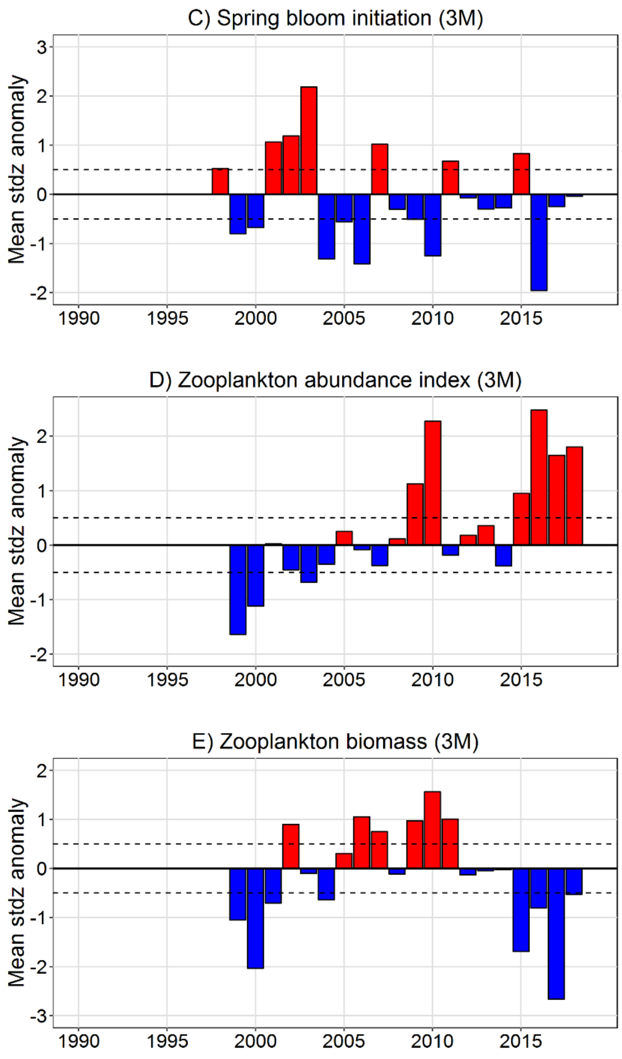


Figure B1. Environmental indices for Flemish Cap (in NAFO Div. 3M) during 1990-2018. The ocean climate index (A) for Flemish Cap is the average of 3 time series of standardized ocean temperature anomalies: sea surface temperatures (SSTs) for Flemish Cap, mean temperature over the offshore portion of Flemish Cap hydrographic section (stations FC-15 to FC-35) summer mean bottom temperature over the cap. SSTs time series and observations along Flemish Cap hydrographic section are presented in Cyr et al. (2019). Bottom temperatures are derived using the same procedure used in Cyr et al. (2019), but only for the top 1000m of the cap. Data used for this calculation is mostly from (although not limited to) the EU summer survey which did not occur in 2018. Phytoplankton spring bloom magnitude (B) and duration (C) indices for the 1998-2018 period are derived from one satellite Ocean Colour box (Flemish Pass) located in NAFO Div. 3M. the Flemish Pass. Zooplankton abundance (D) and biomass (E) indices for the 1999-2018 period are derived from a subset of eleven AZMP sampling stations covering the Flemish Pass, the Flemish Cap, and the outer shelf break. The Zooplankton abundance index includes total copepod and non-copepod abundances. Positive/negative anomalies indicate conditions above/below (or late/early timing) the long-term average for the reference period. All anomalies are mean standardized anomaly calculated using the following reference periods: ocean climate index, 1981-2010; phytoplankton indices (magnitude and peak timing): 1998-2015; zooplankton indices (abundance and biomass): 1999-2015. Anomalies within ±0.5 SD (horizontal dashed lines) are considered 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 3-4oC 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 is thought to influence the distribution and biological production of Newfoundland and Labrador Shelf and Slope waters, given the overlap between arctic, boreal, and temperate species. The elevated temperatures on the Cap as a result of relatively ice-free conditions, may allow longer growing seasons and permit higher rates of productivity of fish and invertebrates on a physiological basis compared to cooler conditions prevailing on the Grand Banks and along the western Slope waters. The entrainment of North Atlantic Current water around the Flemish Cap, rich in inorganic dissolved nutrients 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 bank which may influence year-class strength of various fish and invertebrate species.

Ocean Climate and Ecosystem Indicators

The ocean climate index in Subarea 3 (Div. 3M) was mostly, above normal from the mid-1990’s to 2013. The index has declined since 2013 reaching a 22-year record-low in 2015. The ocean climate index was however normal during the period 2016-2018 (Figure 2A).

Spring bloom total production (magnitude) was above normal in 2018 after three consecutive years of low or normal production. Production in 2018 was the highest observed since the 2008 time series record high (Figure 2B). The timing of the spring bloom initiation was normal in 2018 for a second consecutive year after the time series record low observed in 2016. Spring bloom initiation mainly occurred earlier than, or near the normal timing for the region since 2004 (Figure 2C).

Zooplankton abundance was above normal in 2018 for 4th consecutive year after having remained near normal during from 2011-2014 following the time series record high observed in 2010 (Figure 2D). Zooplankton biomass increased to near normal in 2018 after three consecutive years of below normal levels, including a time-series record low in 2017 (Figure 2E).

5. Golden redfish (*Sebastes norvegicus* aka *S. marinus*) in Division 3M

This stock was assessed by STACFIS in response to Commission Request 7. The assessment is presented in section VII. 1. c. vi of this report.

6. Cod (Gadus morhua) in Division 3M

(SCS Doc. 18/18, 19/06, 19/07, 19/09, 19/10 and SCR Doc. 19/21, 19/26)

a) Introduction

The cod fishery on the 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. Large numbers of small fish were caught by the trawl fishery in the past, particularly during 1992-1994. 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.

Catches exceeded the TAC from 1988 to 1994, but were below the TAC from 1995 to 1998. In 1999 the directed fishery was closed and catches were estimated in that year as 353 t, most of them taken by non-Contracting Parties according to Canadian Surveillance reports. Fleets of non-Contacting Parties did not participate in the fishery since 2000. Annual bycatches between 2000 and 2005 were estimated to be below 60 t, increasing to 339 and 345 t in 2006 and 2007, respectively. In 2008 and 2009 catches increased to 889 and 1 161 t, respectively. From the reopening of the fishery in 2010, catches increased until 2013 to the TAC value, and remained at this level since.

In 2018 a 3M cod benchmark meeting was held by the Scientific Council. The assessment framework was reviewed and endorsed by a panel of three external reviewers. A Bayesian SCAA model was approved during the benchmark (SCS doc 18/18).

Recent catches ('000 tons) are as follow:

	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
TAC	5.5	10.0	9.3	14.1	14.5	13.8	13.9	13.9	11.1	17.5
STATLANT 21	5.2	10.0	9.1	13.5	14.4	12.8	13.8	13.9	10.5	
STACFIS	9.3	12.8	12.8	14.0	14.3	13.8	14.0	13.9	11.5	

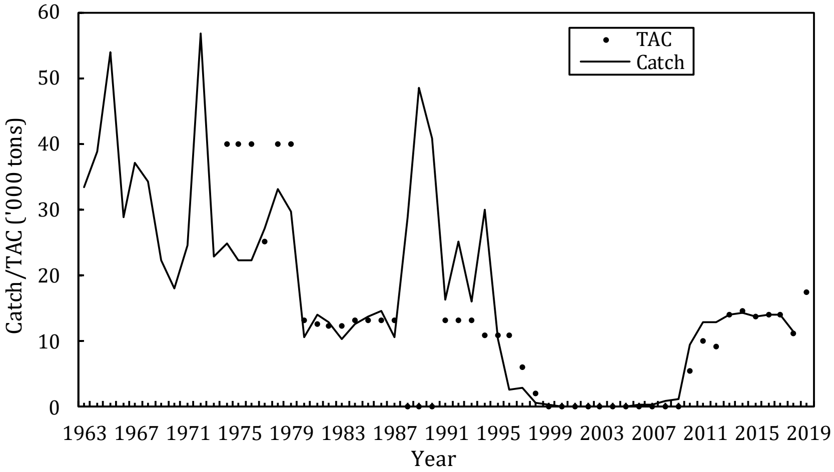


Figure 6.1. Cod in Division 3M: STACFIS catches and TAC.

b) Data Overview

i) Research survey data

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 was observed until 1985, reaching the lowest level in 1982 (Figure 6.2).

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, decreasing since 2012. 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.

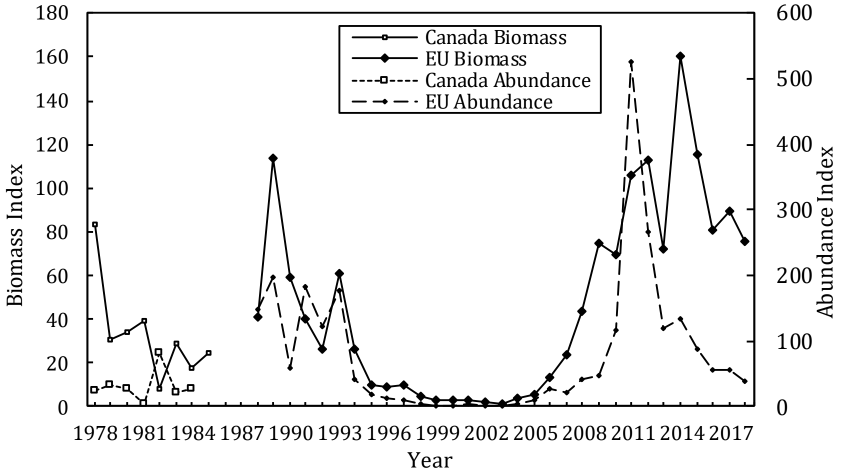


Figure 6.2. Cod in Division 3M: Survey abundance and biomass estimates from Canadian survey (1978-1985) and EU-Flemish Cap survey (1988-2018).

ii) Recruitment

The recruitment index (age 1) from the Canadian survey was estimated to be at low levels except for 1982 and 1983. After several series of above average recruitments during 1988-1992, the EU Flemish Cap survey has shown poor recruitments during 1996-2004, even obtaining an observed zero value in 2002. From 2005 to 2012 increased recruitments were observed. In particular, the age 1 index in 2011 is by far the largest in the EU series (Figure 6.3; note that the level of both surveys is different in the two y-axis). From 2013 the recruitment index dropped to a level similar to the beginning of the recovery of the stock, with 2015 to 2018 being among the lowest levels observed in the series.

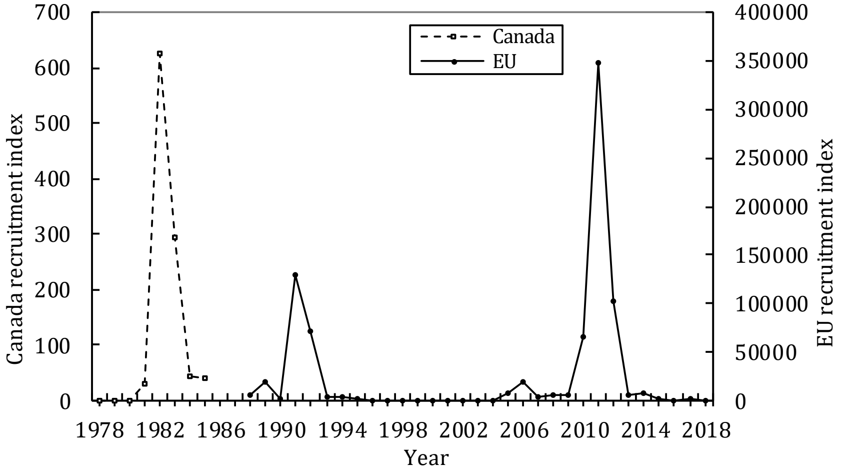


Figure 6.3. Cod in Division 3M: Number at age 1 in the Canadian survey (1978-1985) and EU survey (1988-2018).

iii) Fishery data

In 2018 eight countries fished cod in Div. 3M, trawlers from EU-Estonia, EU-Portugal, EU-Spain, Japan and Russia and longliners from Norway, Faroe Islands and USA.

Length and age compositions from the commercial catches are available from 1972 to 2018 with the exception of the 2002 to 2005 period. Since 2010, length information was available for the major participants in the fishery. In 2018 there were length distributions from EU-Estonia, EU-Portugal, EU-Spain, Faroe Islands and Norway (Figure 6.4). The mean in the length composition for EU-Estonia was 58 cm, being 62 cm for EU-Portugal, 69 cm for EU-Spain, 71 cm for the Faroese longliners and 74 cm for Norwegian longliners. The mean in the total commercial catch length distribution was 64 cm with a length range of 27-133 cm. Since 2013, the commercial catch at age data has been generated using ALKs from the EU survey. During last year assessment, the 2017 survey ALK was not available so the EU survey 2016 ALK was used. This year, 2017 and 2018 ALKs from the survey are available, so the 2017 indices were updated from last year and the 2018 were generated. In 2017, age 6 was the most abundant in the catch, being ages 7 and 8 in 2018.

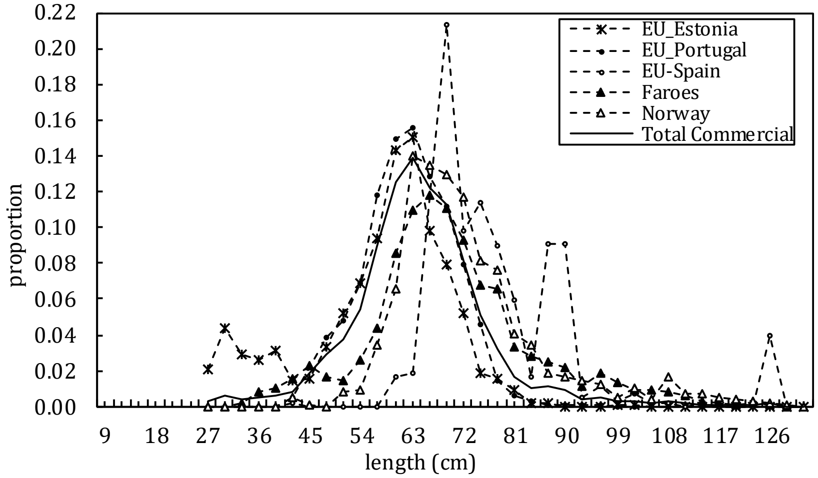


Figure 6.4. Cod in Division 3M: Length distribution of the commercial catches in 2018.

iv) Biological parameters

The 2017 mean weights-at age in the stock and the catch were updated from last year using the 2017 EU survey ALK. The 2018 indices were derived from the 2018 EU survey ALK. Mean weight-at-age in both have been decreasing continuously since the reopening of the fishery, reaching the minimum for ages 4 to 8 in 2015-2017. In 2018, all the ages increased their weight except ages 7 and 8 in the catch and age 8 in the stock (Figure 6.5 and 6.6).

Maturity ogives are available from the EU Flemish Cap survey for almost all years between 1988 and 2018. These were modelled using a Bayesian framework with missing values replaced with interpolations from adjacent years. Since the 2017 maturity ogive was not available, the 2016 one was used in the previous assessment. This year, the actual 2017 maturity ogive was available and it was used. 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 A_{50}, concurrently with the increase of the survey biomass, with the value in 2018 at the levels observed before 1990 (5.1 years old) (Figure 6.7).

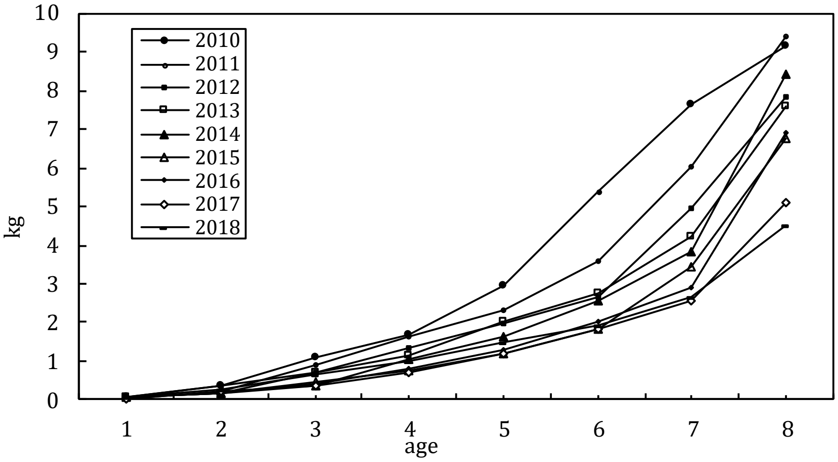


Figure 6.5. Cod in Division 3M: Mean weight-at-age in the stock for the 2010-2018 surveys.

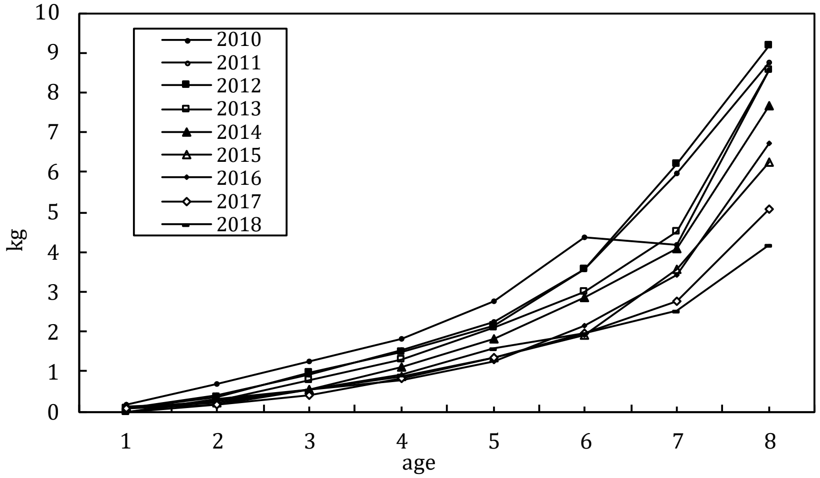


Figure 6.6. Cod in Division 3M: Mean weight-at-age in the catch for 2010-2018.

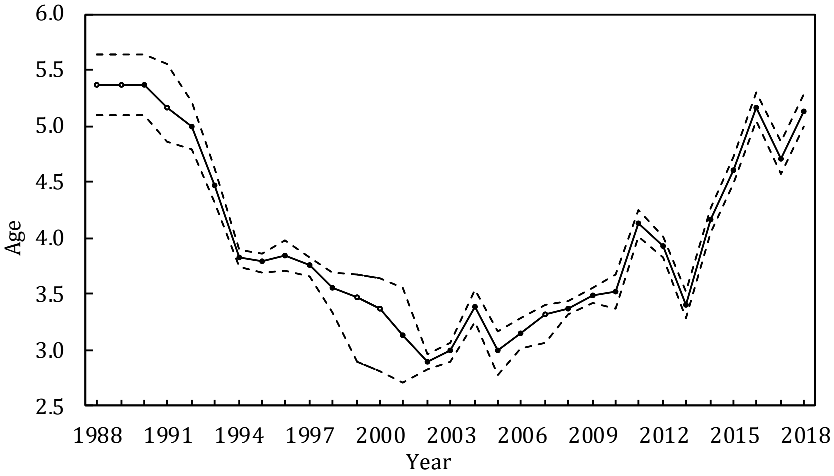


Figure 6.7. Cod in Division 3M: Age at 50% maturity (median and 90% confidence intervals) from Canadian survey (1978-1985) and EU-Flemish Cap survey (1988-2018). Interpolated years are represented in white circles.

c) Estimation of Parameters

A Bayesian SCAA model was used as the basis for the assessment of this stock. Input data and settings are as follows:

Catch data: catch numbers and mean weight at age for 1988-2018, 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 (1988-2018).

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 1988-2018	$LN\left(medrec, cvrec\right)$	*medrec*=45000, *cvrec*=10
N(1988,a), a=2-8+	Ages 2-7 $LN\left(median = medrec \times e^{-\sum_{age=1}^{a-1} M(age)+medFsurv(age)}, cv = cvsurv\right)$ Ages 8+ $LN\left(median = medrec \times \frac{e^{-\sum_{age=1}^{A-1}\left(M(age)+medFsurv(age)\right)}}{1-e^{-M(A+)+medFsurv(A+)}}, cv = cvsurv\right)$	*medFsurv*(1,...,7)={0.0001, 0.1, 0.5, 0.7, 0.7, 0.7, 0.7} *cvsurv*=10
f(y) y=1988-2018	Year 1988 $LN\left(median = medf,\ cv = cvf\right)$ Years 1989-2018 $LN\left(median = AR(1) over\ f,\ cv = cvf\right)$	*medf*=0.2, *cvf*=4
rC(y,a), a=2,8+ 1988-2018	Year 1988 $LN\left(median = medrC\left(a\right),\ cv = cvrC\left(a\right)\right)$ Years 1989-2018 $LN\left(median = last\ year\ rC,\ cv = cvrCcond\right)$	*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 1988-2018	$LN\left(median = \sum_{age=1}^{A+} mu.C\left(y,age\right) wcatch\left(y,age\right),\ cv = cvcW\right)$ $mu.C\left(y,a\right) = N\left(y,a\right)\left(1-e^{-Z(y,a)}\right)\frac{F\left(y,a\right)}{Z\left(y,a\right)}$	*cvCW=0.077*
Catch Numbers at age, a=2,8+ 1988-2108	$LN\left(median = mu.C\left(y,a\right),\ cv = cv.C\right)$	*cv.C*=0.2
EU Survey Indices (I) 1988-2018	$I(y) \sim LN\left(median = \mu(y,a),\ cv = cvEU\right)$ $\mu(y,a) = q(a)\left(N(y,a)\frac{e^{-\alpha Z(y,a)} - e^{-\beta Z(y,a)}}{\left(\beta-\alpha\right)Z(y,a)}\right)^{\gamma(a)}$ $\gamma(a)\begin{cases} \sim N(\text{mean}=1, \text{variance}=0.25),\ if\ a=1 \\ =1,\ if\ a \geq 2 \end{cases}$ $\log(q(a)) \sim N(\text{mean}=0, \text{variance}=5)$	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: As a consequence of lower recruitment since 2015, the median total aggregate abundance has declined in recent years (since 2012) by 39% to levels observed prior to the closure of the fishery. Median biomass has also declined, but to a lesser extent (by 60%) as the strong year classes of 2009 to 2011 have grown and dominate the biomass (Figure 6.8).

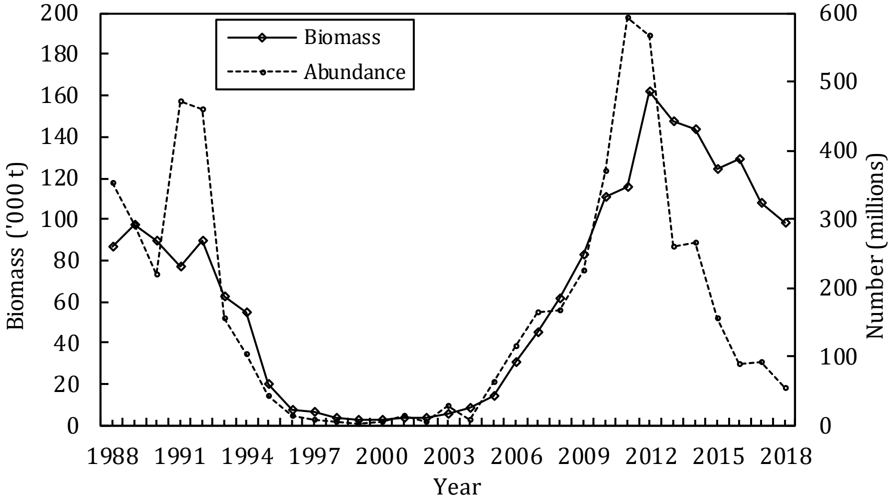


Figure 6.8. Cod in Div. 3M: Biomass and Abundance estimates.

Spawning stock biomass: Estimated median *SSB* over B_{lim} (Figure 6.9) increased since 2005 to the highest value of the time series in 2017. 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 15 157 t; see below, section g) in 2019 is very low (<1%). *SSB* in 2019 was calculated using the numbers estimated by the assessment at the beginning of 2019, applying the maturity ogive and mean weight at age in stock from 2018.

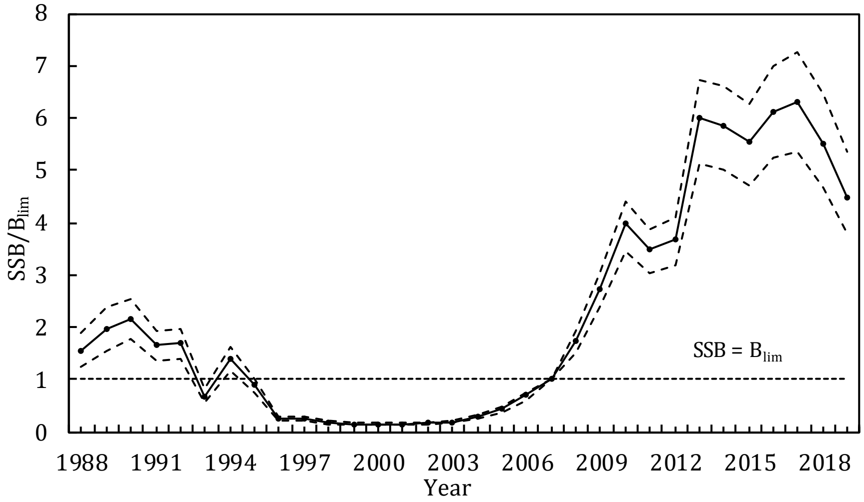


Figure 6.9. Cod in Div. 3M: Median and 80% probability intervals *SSB* /B_{lim} estimates. The horizontal dashed line corresponds to *SSB* = B_{lim}.

Recruitment: After a series of recruitment failures between 1996 and 2004, recruitment estimates (age 1) were higher in 2005-2012, especially in 2011 and 2012. Since 2015 recruitment has been very low (Figure 6.10).

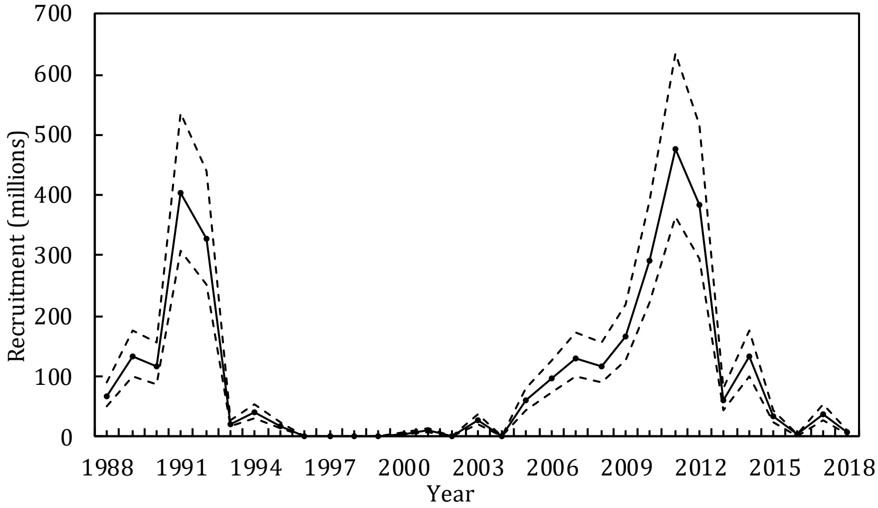


Figure 6.10. Cod in Div. 3M: Recruitment (age 1) estimates and 80% probability.

Fishing mortality: F increased in 2010 with the re-opening of the fishery although it has remained below F_{lim} (0.167) (see below, section g) (Figure 6.11).

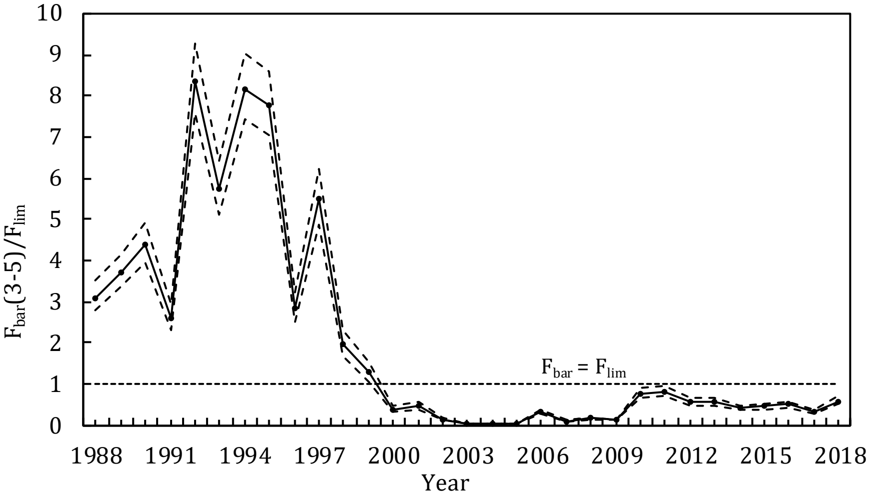


Figure 6.11. Cod in Div. 3M: F_{bar} (ages 3-5) estimates and 80% probability intervals. The horizontal dashed line corresponds to $F = F_{lim}$.

Natural mortality: The posterior median of M by age estimated by the model was:

Age	1	2	3	4	5	6	7	8
Posterior	1.41	0.62	0.37	0.27	0.27	0.36	0.32	0.38

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, but no patterns are evident in recent years (Figure 6.12). There is very little evidence of a retrospective pattern in *SSB* and F (Figures 6.13 and 6.14).

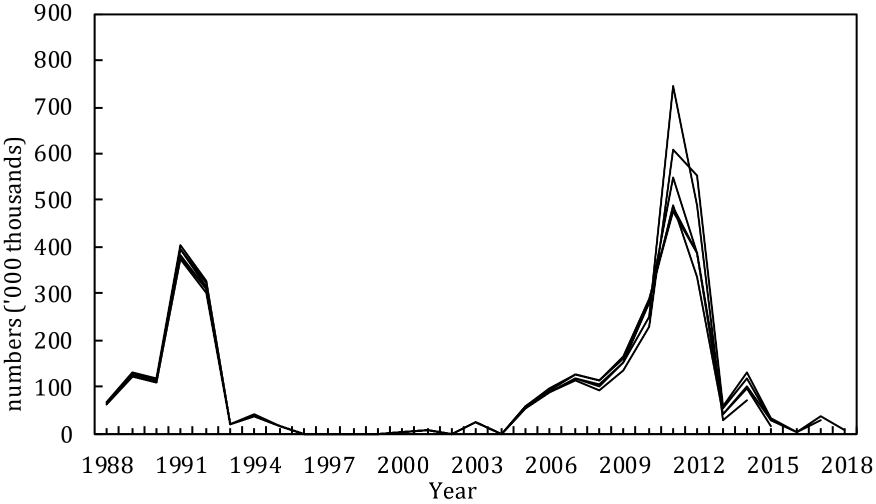


Figure 6.12. Cod in Div. 3M: Retrospective results for recruitment.

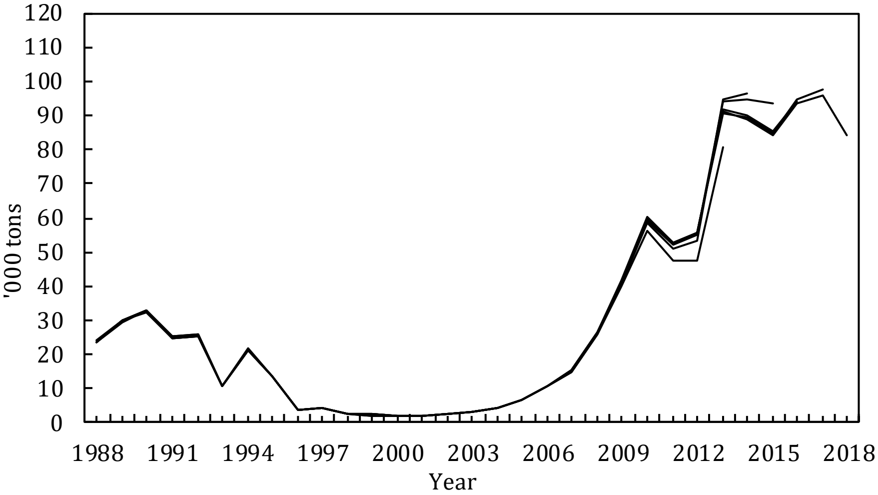


Figure 6.13. Cod in Div. 3M: Retrospective results for *SSB*.

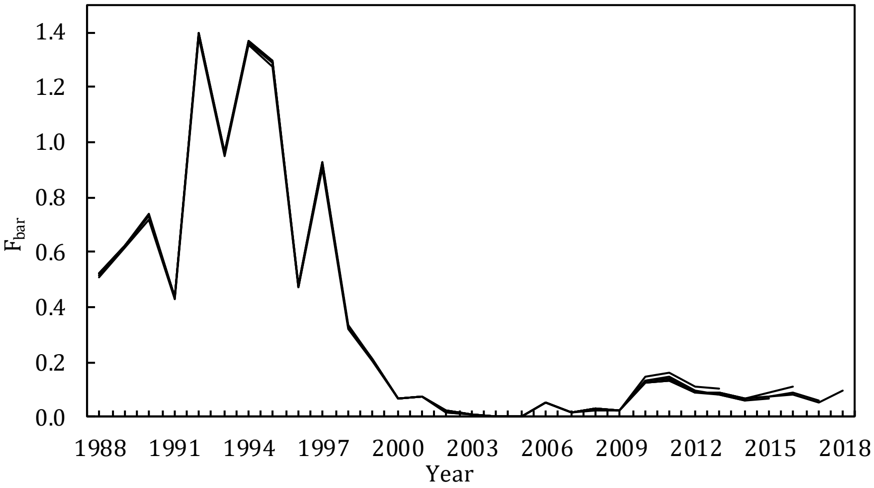


Figure 6.14. Cod in Div. 3M: Retrospective results for average fishing mortality.

f) State of the stock

Current *SSB* is estimated to be well above B_{lim} (median 15 177 t) although it is expected to decline rapidly in the near future due to the poor recruitment since 2015.

F increased in 2010 with the re-opening of the fishery although it has remained below F_{lim} (median 0.167).

g) Reference Points

Last year, the assessment results were used to estimate limit reference points. The stock recruit scatter was examined to find an *SSB* below which no good recruitments have been observed (Figure 6.15). A *SSB* of 20 000 t was set as B_{lim}. During the January 2019 Scientific Council meeting regarding the 3M cod MSE, it was agreed to use the 2007 *SSB* as B_{lim}, as this is the highest value of the three years (2005-2007) in which good recruitment leading to stock recovery was observed in the past. This results in B_{lim} = 15 177 t (median value).

F_{lim} was estimated based on $F_{30\%SPR}$ calculated with the mean 2016-2018 input data as 0.167 (median value) (Figure 6.16). This period was chosen due to the rapid change in biological parameters in the stock.

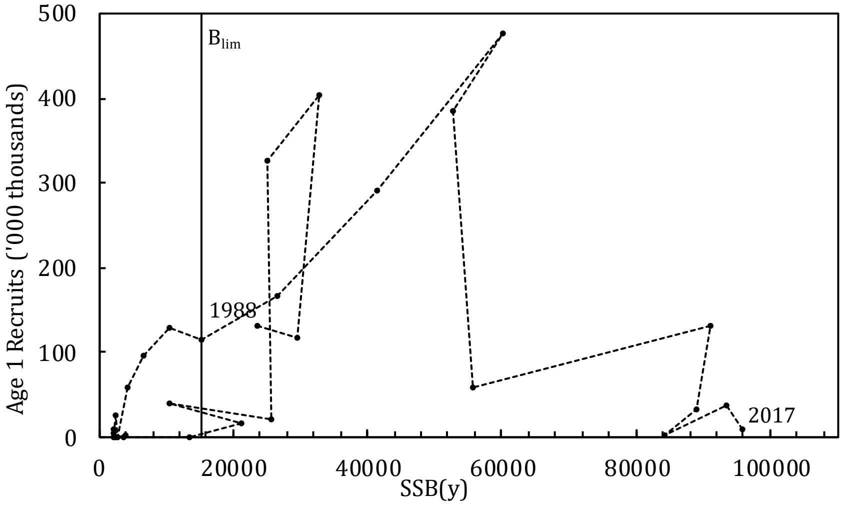


Figure 6.15. Cod in Div. 3M: Stock-Recruitment age 1 (posterior medians) plot. B_{lim} is plotted in the graph.

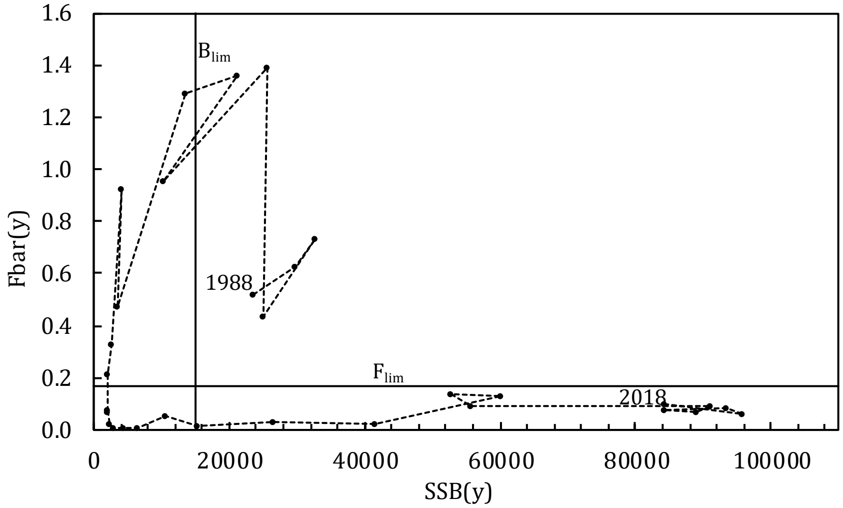


Figure 6.16. Cod in Div. 3M: Stock-F_{bar}(3-5) (posterior medians) plot. B_{lim} and F_{lim} are plotted in the graph.

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 2019 to the start of 2023 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 2019: estimated from the assessment.

Recruitments for 2019-2022: Recruits per spawner were drawn randomly from 2015-2017.

Maturity ogive for 2019-2023: 2018 maturity ogive.

Natural mortality for 2019-2022: 2018 natural mortality from the assessment results.

Weight-at-age in stock and weight-at-age in catch for 2019-2023: 2018 weight-at-age.

PR at age for 2019-2022: Mean of the last three years (2016-2018) PRs.

F_{bar}*(ages 3-5)*: Four scenarios were considered:

(*Scenario 1*) $F_{bar}=F_{lim}$ (median value = 0.167).

(*Scenario 2*) $F_{bar}=3/4F_{lim}$ (median value = 0.125).

(*Scenario 3*) $F_{bar}=F_{statusquo}$ (median value = 0.079).

(*Scenario 4*) $F_{bar}=0$ (no catch).

All scenarios assumed that the Yield for 2019 is the established TAC (17 500 t). $F_{statusquo}$ was established as the mean fishing mortality over 2016-2018.

The results indicate that under all scenarios, total biomass and *SSB* during the projected years will decrease sharply (Figures 6.17 and 6.18). The probability of *SSB* being below B_{lim} in 2021 is very low (≤5%) in all cases. In 2022 and 2023, due to rapid stock declines, the risk of being below B_{lim} is quite high in all cases with the exception of F=0. The probability of *SSB* in 2022 being above that in 2019 is <1%.

Under ¾ F_{lim} and $F_{2016-2018}$, the probability of *F* exceeding F_{lim} is less than 10% in 2020 and 2021.

Under all scenarios, the projected yield has a decreasing trend in the projected years (2020-2022).

Results of the projections are summarized in the following table:

	B		SSB		Yield
	Median and 80% CI				
F_{bar}=F_{lim} (median=0.167)					
2019	76891	(67817 - 86311)	69015	(60552 - 78262)	17500
2020	43969	(36989 - 51393)	38538	(32067 - 45573)	10876
2021	26256	(20590 - 32652)	22083	(17017 - 27722)	6275
2022	15086	(10689 - 20149)	12350	(8454 - 16718)	3545
2023	8803	(5242 - 13051)	6997	(4033 - 10442)	
F_{bar}=3/4F_{lim} (median=0.125)					
2019	76891	(67817 - 86311)	69015	(60552 - 78262)	17500
2020	43969	(36989 - 51393)	38538	(32067 - 45573)	8531
2021	28637	(22958 - 34999)	24368	(19275 - 29993)	5405
2022	17653	(13236 - 22793)	14842	(10933 - 19242)	3303
2023	10933	(7370 - 15204)	9009	(6028 - 12496)	
F_{bar}=$F_{2016-2018}$ (median=0.079)					
2019	76891	(67817 - 86311)	69015	(60552 - 78262)	17500
2020	43969	(36989 - 51393)	38538	(32067 - 45573)	5619
2021	31634	(25964 - 37966)	27230	(22125 - 32840)	3953
2022	21241	(16828 - 26434)	18302	(14356 - 22736)	2645
2023	14177	(10497 - 18490)	12106	(9069 - 15645)	
F_{bar}=0					
2019	76891	(67817 - 86311)	69015	(60552 - 78262)	17500
2020	43969	(36989 - 51393)	38538	(32067 - 45573)	0
2021	37465	(31837 - 43711)	32807	(27628 - 38492)	0
2022	29262	(24806 - 34479)	26096	(22110 - 30692)	0
2023	22406	(18583 - 26998)	20149	(16929 - 23775)	

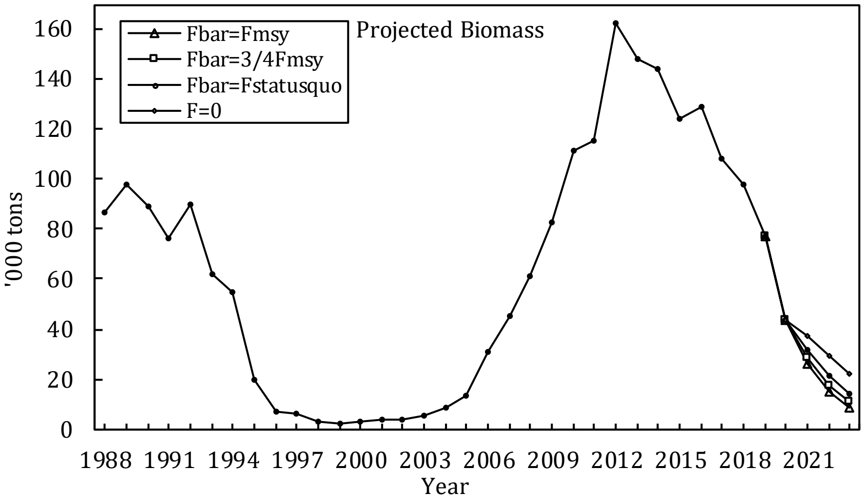


Figure 6.17. Cod in Div. 3M: Projected Total Biomass under all the Scenarios.

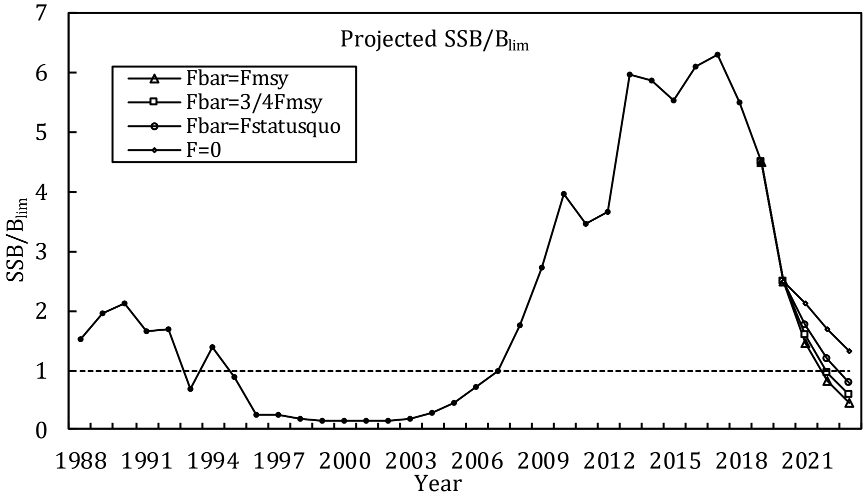


Figure 6.18. Cod in Div. 3M: Projected *SSB* under all the Scenarios

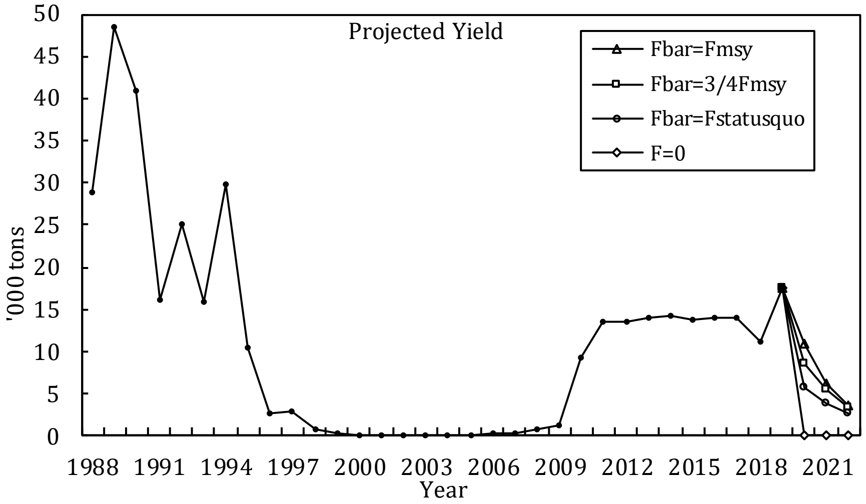


Figure 6.19. Cod in Div. 3M: Projected removals under all the Scenarios

The risk of each scenario is presented in the following table:

	Yield			P(B<B_{lim})				P(F>F_{lim})			
	2019	2020	2021	2019	2020	2021	2022	2019	2020	2021	p(B_{22}>B_{19})
F_{lim} = 0.167	17500	10876	6275	<1%	<1%	5%	78%	20%	50%	50%	<1%
3/4F_{lim} = 0.125	17500	8531	5405	<1%	<1%	1%	55%	20%	3%	9%	<1%
F_{16-18} = 0.079	17500	5619	3953	<1%	<1%	<1%	20%	20%	0%	0%	<1%
F = 0	17500	0	0	<1%	<1%	<1%	<1%	20%	0%	0%	<1%

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. Significant progress in understanding where the differences between the commercial and survey ALKs come from was made but more research is still needed to completely understand the problem. No progress has been made since then. This recommendation is reiterated.

STACFIS **encouraged** to *all Contracting Parties to provide length distribution samples from the commercial vessels fishing 3M cod*.

STATUS: NAFO reiterates this recommendation.

Timing of the next full assessment of this stock will be subject to the timelines of the ongoing MSE process.

7. Redfish (*Sebastes mentella* and *Sebastes fasciatus*) in Division 3M

(SCR Doc. 19/016; SCR Doc. 19/014REV, 017, 021; SCS Doc. 19/06, 09, 10, 11).

a) Introduction

There are three species of redfish that are commercially fished on Flemish Cap; deep-sea redfish (*Sebastes mentella*), golden redfish (*Sebastes marinus = S. 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 behaviour as well as a long recruitment process to the bottom, extending to lengths up to 30-32 cm. All redfish species are long lived with slow growth. Female sexual maturity is reached at a median length of 26.5 cm for Acadian redfish, 30.1 cm for deep-sea redfish and 33.8 cm for golden redfish.

In 2019 this assessment was evaluated and approved by an external reviewer.

i) Description of the fishery

The redfish fishery on Division 3M increased from 20 000 tons in 1985 to 81,000 tons in 1990, falling continuously since then till 1998-1999, when a minimum catch around 1 000 tons has been recorded as by-catch of the Greenland halibut fishery. This drop of the 3M redfish catches was related with the simultaneous decline of stock biomass and fishing effort deployed in this fishery during the first half of the 1990's. In the 2000s catches recorded a stepwise increase, from an average level of 3 000 tons (2000-2004) to 7 000 tons (2005-2017) and to 10 478 tons on 2018, sticking to the increased 2018-2019 TAC of 10 500 tons. EU-Portugal, EU-Spain, the Russian Federation and EU-Estonia states are responsible for the bulk of the redfish landings over the last two decades.

From July 2004 to July 2006 Flemish Cap EU survey showed a 3.5 fold increase in bottom biomass of both golden and Acadian redfish. Cod stock and cod by-catch also went up, and the Flemish Cap cod fishery reopened in 2010. Redfish catch responded positively to those events and since the mid 2000's is a blend of by-catch from cod fishery (depths above 300m, a mixture of golden and beaked redfish), catch from bottom trawl directed fishery (depths between 300-700m, primarily beaked redfish), and by-catch again from Greenland halibut fishery (bellow 700m, 100% deep sea redfish).

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 2011and 2014. For 2015 the annual catch was given by the Daily Catch Reports (DCRs) by country provided by the NAFO Secretariat. For 2016 catch was calculated using the CDAG Estimation Strategy (NAFO Regulatory Area Only). The 2017 and 2018 catch estimates were obtained with the application of the CESAG method. The 1989-2018 catch estimates from those different sources are accepted as the 3M redfish landings.

Recent TACs, catches are as follows -catch ('000 t) are as follows:

	2010	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**
TAC	10.0	10.0	6.5	6.5	6.5	6.7	7.0	7.0	10.5	10.5
STATLANT 21	8.2	9.7	5.4	6.8	6.4	6.9	6.6	7.1	10.5	
STACFIS Total catch [1, 2]	8.5	11.1	6.2	7.8	7.4	6.9	6.6	7.1	10.5	
STACFIS Catch [2, 3]	5.4	9.0	6.3	5.2	4.6	5.2	6.2	6.9	10.3	

[1] Estimated redfish catch of all three redfish species.

[2] On 2011-2014 STACFIS catch estimates based on the average 2006-2010 bias.

[3] STACFIS beaked redfish catch

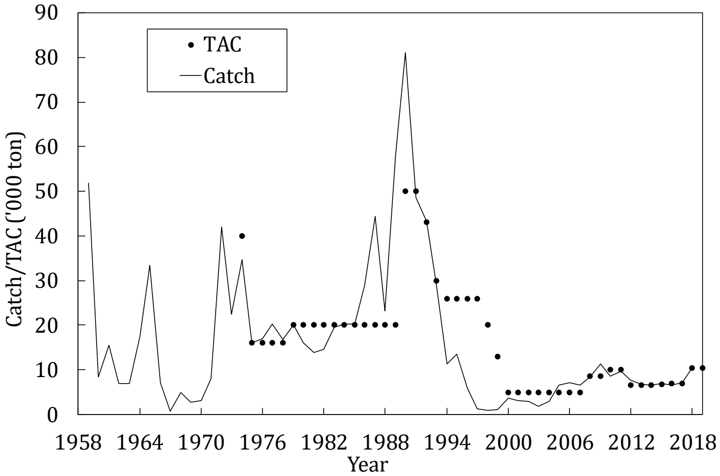


Figure 7.1. Redfish in Div. 3M: total catches and TACs.

b) Input Data

The 3M redfish assessment is focused on beaked redfish, regarded as a management unit composed of two populations from two very similar species: the Flemish Cap *S. mentella* and *S. fasciatus*. The reason for this approach is the historical dominance of this group in the 3M redfish commercial catch. During the entire series of EU Flemish Cap surveys beaked redfish also represents the majority of redfish survey biomass (78%).

i) Commercial fishery and by-catch data

Sampling data. Usually Portuguese beaked redfish length sampling was applied to the beaked redfish catch of other bottom trawl fleets with the exception of the Russian, Spanish and Japanese fleets for the years where respective length sampling data are available (Table 3a). However, in 2015 and 2016, most of the Portuguese sampling effort was made on beaked redfish catch from shallower depths than the ones traditionally associated with the redfish fishery, while Spanish sampling still came from 300-700m bottoms where most of the beaked redfish catch is expected to occur. So Spanish sampling substitute the Portuguese sampling as regards the length distributions for other countries estimated catches on those years. Depth distribution of Portuguese redfish catches went back to normal on 2017-2018 and so Portuguese length sampling return to be applied to other countries but Spain and Russia on 2017 and including Russia on 2018.

The available 1998-2018 3M beaked redfish commercial length weight relationships from the Portuguese commercial catch were used to compute the mean weights of all commercial catches and corresponding catch numbers at length.

Redfish by-catch in numbers at length for the Div. 3M shrimp fishery is available for 1993-2004, based on data collected on Canadian and Norwegian vessels. No bycatch information has been available from 2005-2010 when the fishery was very low and hence bycatch was assumed to be negligible, and there has been no shrimp fishery since 2010. The commercial and bycatch length frequencies were summed to establish the total removals at length. These were converted to removals at age using the *S. mentella* age-length keys with both sexes combined from the 1990-2016 EU surveys. Annual length weight relationships derived from Portuguese commercial catch were used for determination of mean weights-at-age.

The 1999-2002 and 2005 cohorts dominated the overall catch through most years of the 2001-2012 interval. The 2009-2011 cohorts are the most abundant in the catch between 2014 and 2016. Larger sizes corresponding to older ages, and 11 and 12 years old fish (from 2005-2006 cohorts) were the most abundant in the catch on 2017. However most abundant ages return to much younger redfish on 2018, with ages 6 and 7 (2012-2011 cohorts) being the most abundant in the catch.

ii) Research survey data

EU Flemish Cap bottom trawl survey

Survey biomass was calculated based on the abundance at length and annual length weight relationships from the EU bottom trawl survey for the period 1988-2018.

Age compositions for Div. 3M beaked redfish EU survey stock and mature female stock from 1989 to 2018 were obtained using the *S. mentella* age length keys. Mean weights-at-age were determined using the EU survey annual length weight relationships.

Gonads from Flemish Cap beaked redfish were collected since 1994 though not every year. Maturity at length ogives from 1994 were used in previous assessments. New maturity at length ogives were estimated based on microscopic inspection of histological sections of gonads collected throughout 14 years between 1994 and 2018. Maturity data were combined for both species within each year and fitted to a logistic function. For the years in between, where data was missing, curve parameters were estimated as the weighted average of the adjacent years where maturity ogives were available. The new maturity at length results were used in the present assessment.

Survey results. The survey stock abundance and biomass declined in the first years of the survey and remained low until 2003. A sequence of above average year classes (2001-2005), including the strongest of the survey series (2002), with high survival rates and coupled to a sudden but major increase of the size of the *S. fasciatus* component, lead the exploitable beaked redfish stock as a whole to a maximum in 2006. Both spawning stock and exploitable biomass were high from the mid 2000s to 2009. But year class strength declined afterwards, and the lasts cohorts entering the exploitable stock are among the lowest at age 4 (2010-2014). At the same time, S. *fasciatus* dropped as fast as it went up. Spawning stock biomass has remained high in recent years while exploitable biomass and abundance are declining since 2012 (Figure. 7.2). There has been very low recruitment at age four in most recent years.

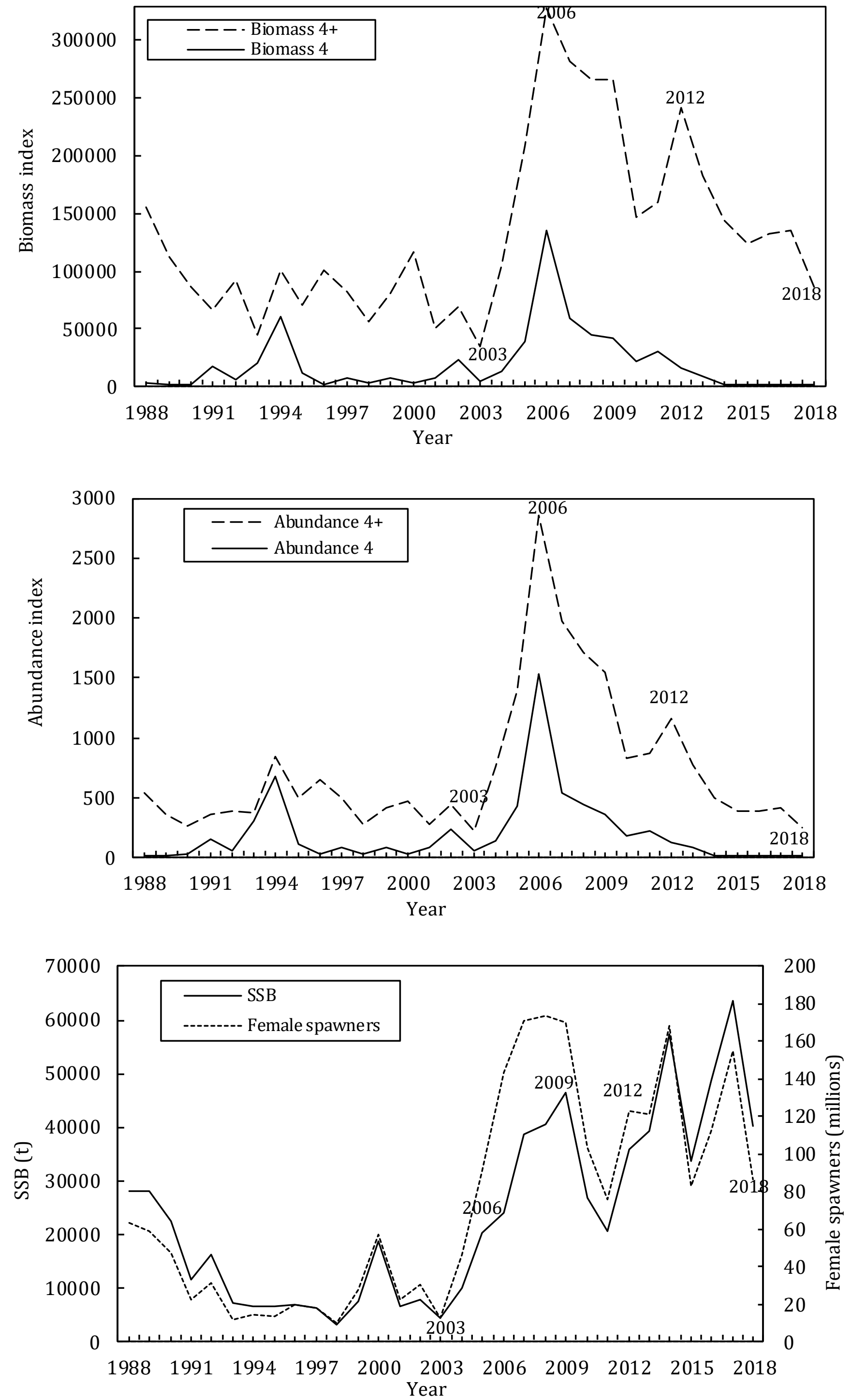


Figure 7.2. Beaked redfish in Div. 3M: exploitable biomass, female spawning biomass /abundance and recruitment at age 4 abundance from EU surveys (1988-2018).

iii) Natural mortality

In the mid 2000's, the Flemish Cap cod stock started recovering, not only in terms of abundance but also in terms of individual growth, leading to a continuous and steep increase of cod biomass between 2006 and 2012. There is a strong possibility that important increases in redfish consumption by cod are associated with this recovery leading to anomalously high levels (M> 0.1) of beaked redfish natural mortality, from 2006-2010.

Attempts to track changes on natural mortality have been made on previous assessments since 2011 for a range of M candidates between 0.1 - 0.4. Having 2006 as the starting year for the sensitivity analysis, time windows of variable width were considered where the best M option should minimize the $SS\ log\ q_{age}$ residuals and maximize correlation between exploitable survey abundance and XSA abundance. So far the approach to the actual magnitudes of M has been strictly dependent of beaked redfish survey indices, which in turn should capture the dynamics of the ensemble of the two redfish populations at times of very low recruitment, low exploitation and high predation.

In 2015, STACFIS recommended that, *in order to quantify the most likely redfish depletion by cod on Flemish Cap, and be able to have an assessment independent approach to the magnitude of such impact ...work continue to investigate recent changes in natural mortality*.

In order to include an independent approach to natural mortality in the 2017 sensitivity M framework, the beaked redfish natural mortality has been estimated by a number of different published models derived from cross-species comparative analyses, either by size/age-independent and size/age-dependent methods.

c) Estimation of Parameters

The Extended Survivors Analysis (XSA) (Shepherd, 1999)[3] was used to estimate stock size. The month of peak spawning (larval extrusion) for Div. 3M *S. mentella*, was taken to be February, and was used for the estimate of the proportion of fishing mortality and natural mortality before spawning. EU survey abundance at age was used for calibration. The XSA model specifications are the same as in the assessments in 2015 and 2017, and are given below:

Catch data from 1989 to 2018, ages 4 to 19+

Fleets	**First year**	**Last year**	**First age**	**Last age**
EU summer survey (Div. 3M)	1989	2018	4	18

Tapered time weighting not applied

Catchability independent of stock size for all ages

Catchability independent of age for all ages up to age 15

Terminal year survivor estimates not shrunk towards a mean F

Oldest age survivor estimates not shrunk towards the mean F of previous ages

Minimum standard error for population estimates from the last true age of each cohort age = 0.5

Before 2006, M remained at 0.1. The rationale to select the best options for natural mortality between 2006 and 2017 are thoroughly explained in the sensitivity analysis sections of previous assessments (NAFO SCS Doc. 17/16REV). A natural mortality of 0.4 was tuned to ages 4-6 between 2006 and 2010, and extended to all ages in 2009-2010 to reflect cod predation. Since then natural mortality was assumed to be again an age independent parameter, and on 2011-2012 declined to 0.125, a level much closer to what is considered the magnitude of natural mortality on redfish stocks (0.1). However, from 2013-2014 the best fit to survey data implied again a marginal increase of M to 0.14.

The best M option found for the 2017 XSA assessment was a natural mortality of 0.1 on 2015-2016 and previous natural mortality levels kept from the past 3M beaked redfish assessments.

---

[3] SHEPHERD, J. G. 1999. Extended survivors analysis: an improved method for the analysis of catch-at-age data and abundance indices. *ICES J. Mar. Sci.*, **56**(5): 584-591.

The sensitivity analysis preceding the 2019 XSA assessment considers the following set of 2017-2018 candidate *M*'s

$XSA2019_{\text{sensitivity analysis}}$ M candidates for 2017-2018	0.08	0.09	0.1	0.11	0.12	0.14	0.16	0.18	0.2

For all XSA 2019 preliminary runs	M = 0.40 on ages 4 - 6 on 2006 - 2008, and on all ages groups on 2009 - 2010;
M2015-2016 XSA 2017 runs	M = 0.125 on all age groups on 2011-2012.(XSA2013 & 2015 assessment framework)
	M = 0.14 on all age groups on 2013-2014.(XSA2015 assessment framework)
M2011-2016 XSA 2017 runs	M is kept constant on all age groups on 2011-2018

The objective is to check, using the survey based diagnostics combined with retrospective analysis, if average natural mortality on most recent years, 2017-2018, could have returned to a level higher than 0.1(the best "biological based" 2015-2016 *M* option found on last assessment) and, if so, what level would optimize the model fit.

The goodness of fit of the model runs to survey data is measured by the following diagnostics

1. Lower $SS\ log\ q_{age}$ residuals on 2017-2018 together with
2. Lower $SS\ log\ q_{age}$ residuals back to 2011 (*M* started to decline from the anomalous high 2006-2010 levels) and
3. Higher correlation between exploitable (4+) survey abundance and XSA abundance over recent years (2011-2018).

Diagnostics results for these two sets of runs are shown below.

$M_{2017\text{-}2018}$	**0.08**	**0.09**	**0.1**	**0.11**	**0.12**	**0.14**	**0.16**	**0.18**	**0.2**
SS log q $\text{residuals}_{2017\text{-}2018}$	7.04	7.10	7.12	7.18	7.24	7.36	7.53	7.666	7.86
SS log q $\text{residuals}_{2011\text{-}2018}$	23.02	23.19	23.30	23.46	23.57	23.90	24.25	24.59	25.00
XSA *versus* SURVEY $r^2{}_{2011\text{-}2018}$	0.8957	0.8953	0.8949	0.8944	0.8939	0.8928	0.891514	0.8901	0.8885

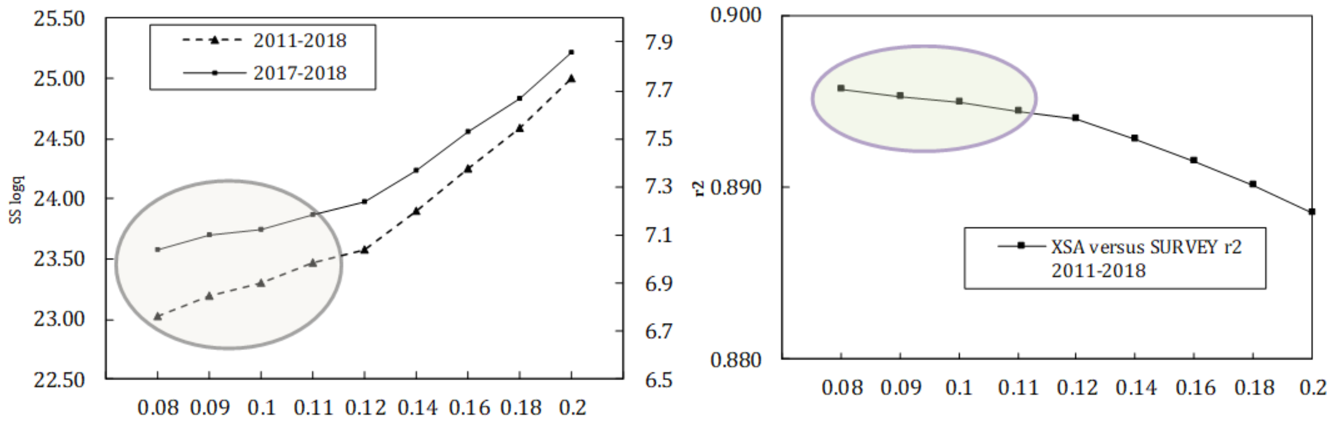


Figure 7.3. Beaked redfish in Div. 3M: goodness of fit diagnostics of XSA_{2019} for several 2017-2018 *M* options. Left panel is SS log q's 2017-2018 and 2011-2018, right panel is r^2 between XSA_{2019} and 4+ survey results.

A comparative one (2018-2017) and two years window (2018-2016) retrospective analysis for the range of the best 2017-2018 *M* candidates according with the above criteria was finally performed in order to confirm the goodness of the previous diagnostics results.

Both *SS* log q_{age} and (survey/XSA) correlation results showed that an average 2017-2018 natural mortality level within 0.08 and 0.11 deliver better diagnostics of the model fit than levels of *M* equal or greater to 0.12. And that the same judgement can be inferred from the comparative retrospective results, as regards either 4+ biomass, (female) *SSB* or average *F* (ages 6-16). Furthermore the best results are achieved with the lowest value of *M* in the ranking (0.08).

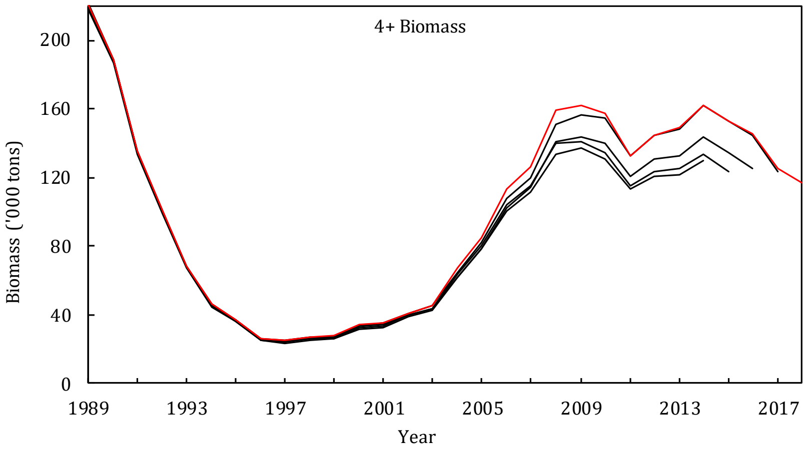
However the primary aim of this exercise was not to track a best value for the most recent *M* level, but to find out if there was evidence that natural mortality has increased from the former level of 0.1, adopted in 2017 assessment as the best option for average *M* in 2015-2016. From the results of the present sensitivity analysis that hypothesis has not been confirmed.

So, the 2019 XSA assessment run with average *M* in 2017 and 2018 kept at 0.10.

d) Assessment Results

The 2017 XSA diagnostics kept the main features from past assessments: high variability associated with mean catchabilities and survivors, namely at younger ages, together with a similar patchwork of *log q@age* residuals that remains with only small changes from its predecessors.

A retrospective $XSA_{2018\text{-}2014\ (\text{last year})}$ was carried out for checking patterns and magnitude of bias on the main results of recent assessments back in time (Figure 7.4). Retrospective patterns of relatively small magnitude are observed in exploitable, female spawning biomass and recruitment (underestimate) and average fishing mortality (overestimate) for most recent years. In the current assessment, the revised magnitude of the 2010-2012 year classes at age 4, corresponding to the 2014-2016 recruitments has increased compared to the previous assessment. The low abundance of these cohorts makes them difficult to quantify, namely on their first age and year within the assessment.



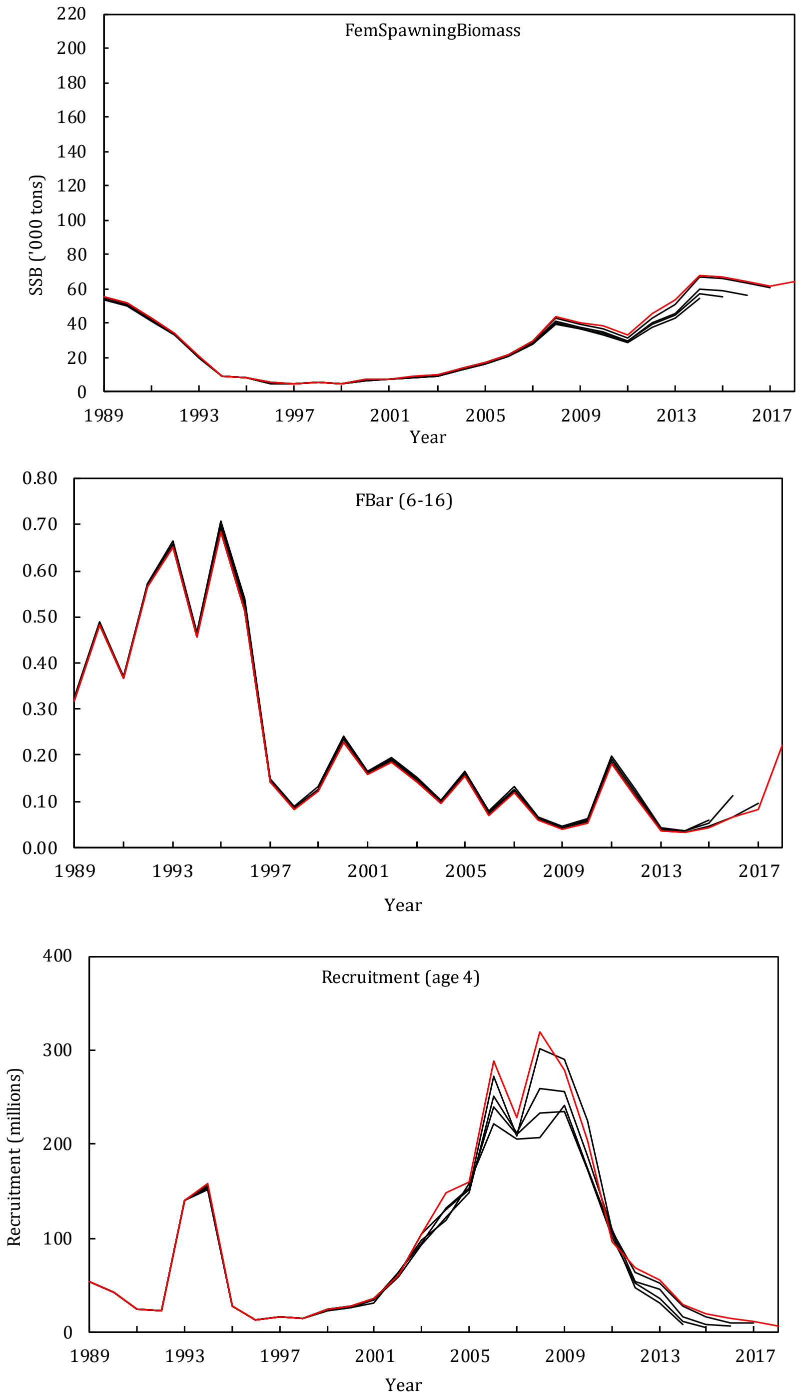


Figure 7.4. Beaked redfish in Div. 3M: XSA retrospective analysis, last year 2018-2014: exploitable 4+ biomass, female spawning stock biomass, average fishing mortality (ages 6-16) and recruitment (age 4).

Taking into account the consistency of present assessment with the previous ones, the 2019 XSA assessment was accepted with 2017-2018 natural mortality at 0.1.

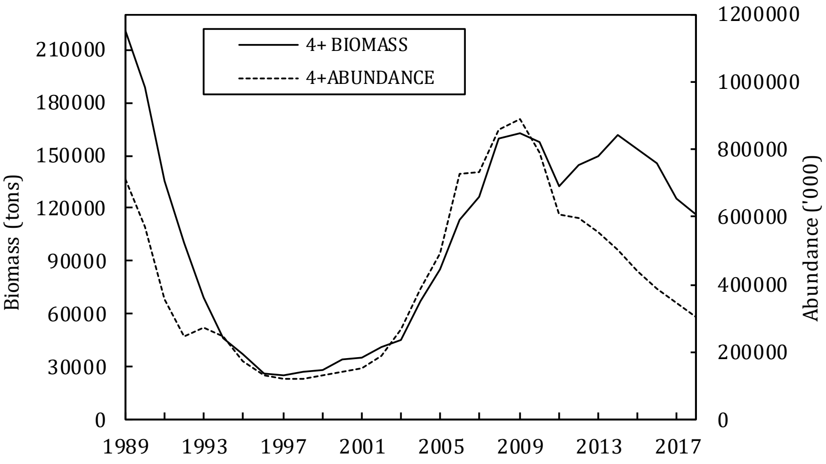


Figure 7.5. Beaked redfish in Div. 3M: age 4+ biomass and age 4+ abundance from XSA.

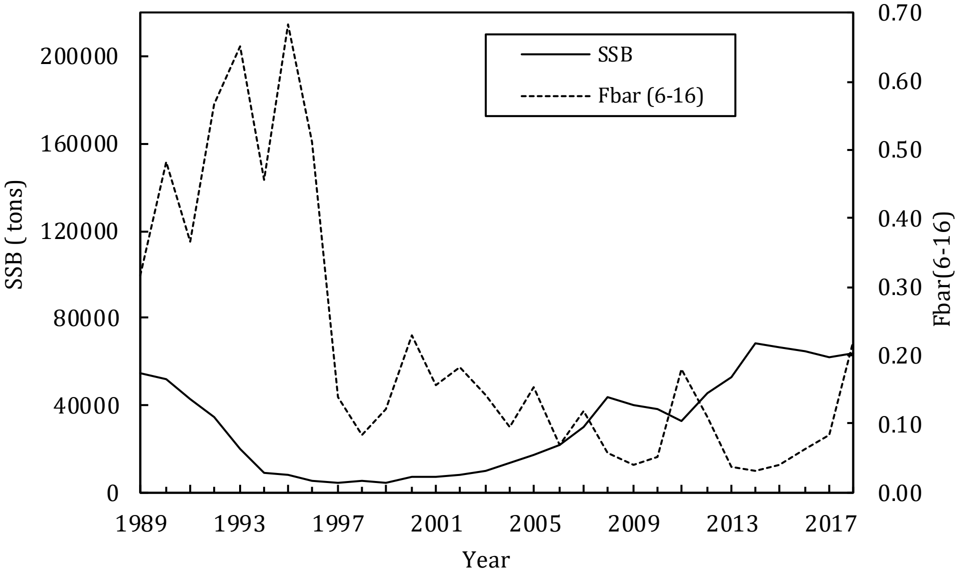


Figure 7.6. Beaked redfish in Div. 3M: female spawning biomass and fishing mortality trends from XSA.

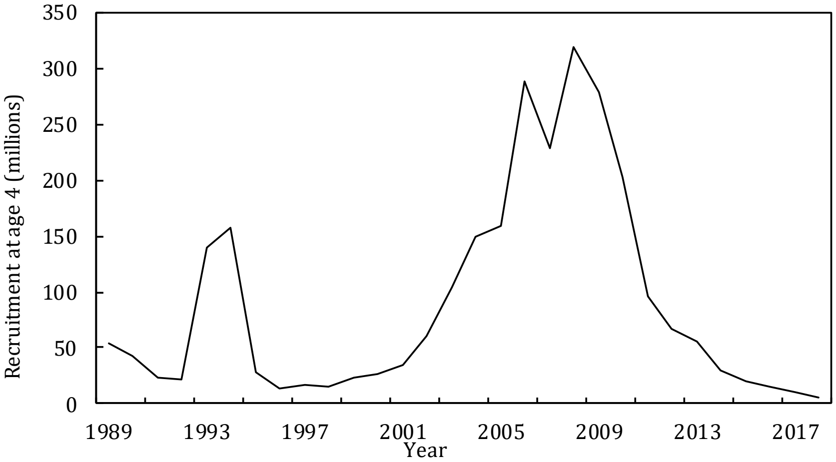


Figure 7.7. Beaked redfish in Div. 3M: recruitment at age 4.

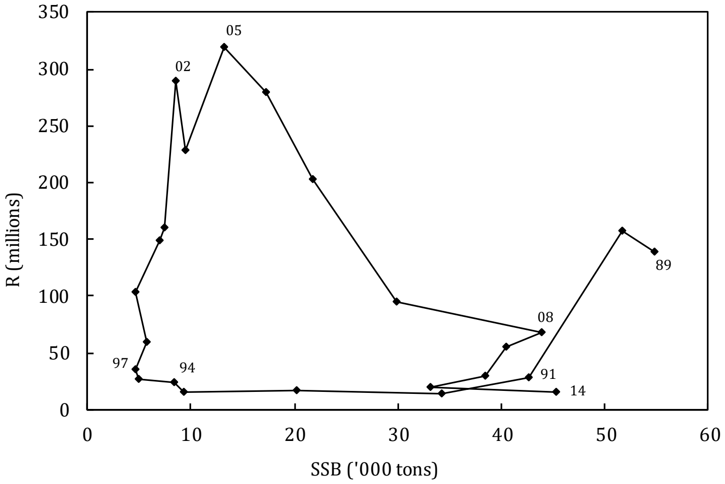


Figure 7.8. Beaked redfish in Div. 3M: Stock/Recruitment plot (labels indicate age class).

Biomass and abundance (Figure 7. 5): Experienced a steep decline from the 1989 until 1996. The exploitable stock was kept at a low level until the early 2000s, following years of low recruitment. Above average year classes coupled with high survival rates allowed a rapid growth of biomass and abundance since 2003 and sustained the biomass at high levels until 2014. Its decline starts afterwards and continues on 2018. From 2010 onwards abundance went down being still in 2018 at a level above the 1995-2001 low.

Spawning stock biomass (Figure 7.6): *SSB* showed an increasing trend since the late 1990s and is still maintained at maximum level on 2017-2018.

Fishing Mortality (Figure 7.6): Between 1989-1993 very high commercial catches led to high fishing mortalities through the first half of the 1990's. Fishing mortality fell until 1997 and fluctuated between low and average levels since then. However a substantial increase is recorded in 2018.

Recruitment (Figures 7.7 and 7.8): Recruitment at age 4 increased with a sequence of above average year classes from 1999 until 2007, some of them the highest observed in the series (2002-2006). However recruitment to exploitable stock is declining continuously since 2009 and was in 2017-2018 at an historic minimum level.

State of the stock: The stock is declining after a marked recovery that started in 2002-2003. High levels of biomass were maintained until 2014 supported by low fishing mortalities and individual growth of survivors, but could not be sustained. Decline inaAbundance is more pronounced, with no perspective to stop in the short term since year classes at recruitment continue to be extremely weak. Natural mortality has stayed in recent years (2015-2018) at 0.1, its 1980s-1990s-early 2000s assumed magnitude.

e) Yield per recruit analysis

In order to get proxies of $F_{0.1}$ and F_{max} in line with the most recent declines observed in all mean weights at age, and most recent partial recruitment (*PR*) results, a new yield per recruit analysis (*ypr*) was performed.

The *PR* vector is given by the 2016-2018 average of the relative *F* at ages 4-18. *M*'s were kept at 0.10 through ages and years but with an associated *CV* correspondent to an allowed variability of natural mortality between 0.08 and 0.12 (the *M* range associated with best sensitivity analysis diagnostics). All input weight at age and maturity at age vectors were averages from the most recent three years. In order to reduce the weight of the plus group on the final results, ages were virtually extended to age 29 with a plus group set at age 30. Mean weights and female maturity were kept constant and were the ones of the XSA 19 plus group.

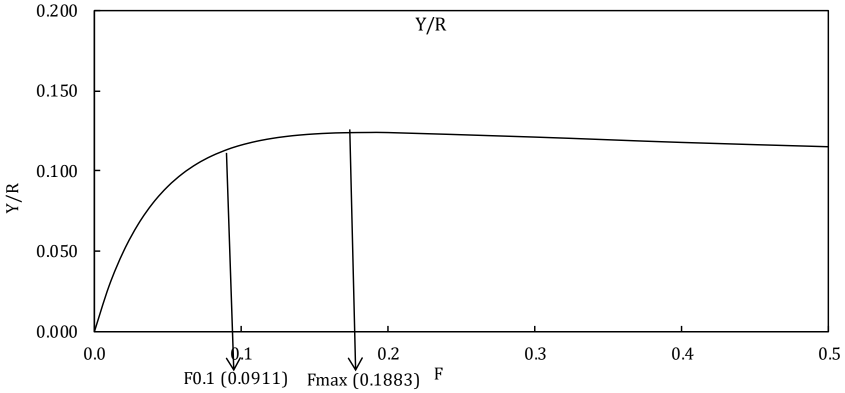


Figure 7.9. Beaked redfish in Div. 3M: yield per recruit analysis at M=0.10 (2016-2018 average inputs)

As regards $F_{0.1}$ the 2019 *ypr* results (Figure 7.9) were close to the ones of 2017, despite the former analysis different input framework, from a larger time interval back in time (2006-2016) and a flat top *PR* not assumed at present. $F_{0.1}$ is at 0.091 and F_{max} is at 0.188. These values have been used for short term projections. The results regarding $F_{0.1}$ and F_{max} are at the moment candidates to 3M beaked redfish fishing mortality reference points that still need to be confirmed in near future.

f) Short term projections

Short (2020-2022) term projections were carried out for female spawning stock biomass (*SSB*) and catch, under most recent level of natural mortality and considering four options for fishing mortality as follows:

1. No fishing, F_0
2. $F_{statusquo}$@age (last year $F_{bar6\text{-}16,2018}$ times average partial recruitment for the last three years)
3. $F_{0.1}$ and F_{max}

Projections were initialized at the beginning of 2020 assuming $F_{statusquo}$@age during 2019. Recruitment entering in 2019 and 2020 is assumed constant at the geometric mean of recent recruitments (age 4 XSA, 2015-2017).

Stochastic projections of yield and female spawning stock biomass (*SSB*) under the four *F* options were initialized with abundance for ages 5 and older at the beginning of 2020. The coefficients of variation for population@age at the beginning of 2020, was set as the internal standard errors from XSA diagnostics. For 2021 and 2022, recruitment was randomly resampled with residuals from the geometric mean of 2015-2017 recruitments (age 4 XSA, 2015-2017). All other inputs at age are the last three year averages with associated errors at age.

Short term projections for female *SSB* (at beginning 2022, 10th, 50th and 90th percentile) and average 2020-2021 yield (50th%ile) under the selected *F* options and *M* at 0.10 are summarized on the table below:

Table 7. Short term projections for female *SSB* (50%ile at the beginning of 2020 and 2021, 90%ile/50%ile/10%ile at the beginning of 2022) and yield predicted for 2020 and 2021 (50%ile) under several F options.

Fstatusquo$_{2018}$=0.220

	SSB Median and 80% CI	Yield Median	TAC
2019$_{\text{deterministi}}$	67553	12536	
2020	55768 (50610 - 62034)	9682	9925
2021	49656 (44935 - 54955)	9262	9495
2022	43021 (39130 - 47816)		

Fmax=0.188

	SSB Median and 80% CI	Yield Median	TAC
2019$_{\text{deterministi}}$	67553	12536	
2020	55768 (50610 - 62034)	8379	8590
2021	50617 (45816 - 56012)	8241	8448
2022	44764 (40713 - 49757)		

F0.1=0.091

	SSB Median and 80% CI	Yield Median	TAC
2019$_{\text{deterministi}}$	67553	12536	
2020	55768 (50610 - 62034)	4213	4319
2021	53703 (48634 - 59372)	4510	4624
2022	50573 (46050 - 56165)		

F0

	SSB Median and 80% CI	Yield Median
2019$_{\text{deterministi}}$	67553	12536
2020	55768 (50610 - 62034)	
2021	56783 (51409 - 62722)	
2022	56753 (51619 - 62981)	

average beaked redfish proportion in the 2017-2018 3M redfish catch 0.98

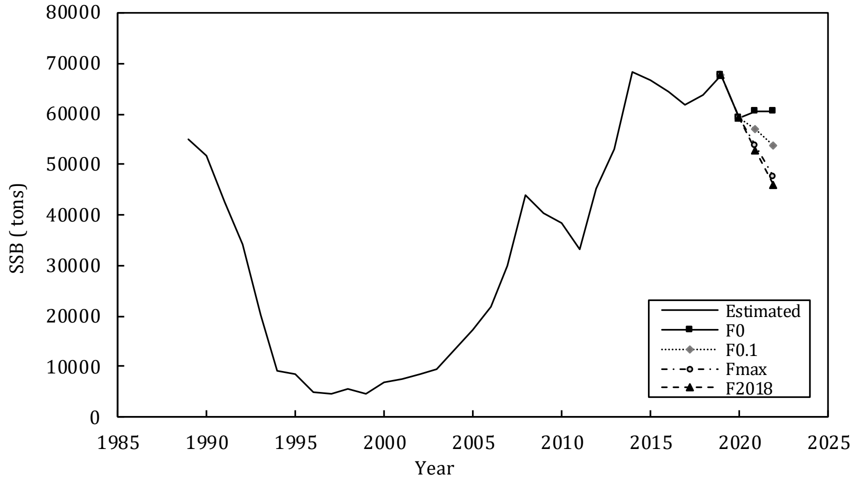


Figure 7.10. Beaked redfish in Div. 3M: *SSB* trajectory (1989-2019) and 2020-2022 projections (50%ile) under several F options

Projection results indicate a 12% decline from 2019 to 2020 (i.e., interim year under $F_{statusquo}$). Thereafter, the stock remains stable if there is no fishing (F=0). Results for the three projection scenarios show biomass declines of 25% (for $F_{0.1}$), 34% (F_{max}) and 36% ($F_{statusquo}$) between 2019 and 2022. In all three scenarios, the biomass remains at a high level relative to historical values but has a low probability of being above 2019 levels.

	Fstatus quo	F0.1	Fmax
P(SSB_{2022}>SSB_{2019})	<10%	<10%	<10%

g) Reference Points

There are no accepted limit reference points for this stock. Yield per recruit reference points are used in the projections and may be candidate reference points for this stock.

The next full assessment for this stock is planned to be in 2021.

8. American Plaice (*Hippoglossoides platessoides*) in Division 3M

Interim Monitoring Report (SCR Doc. 19/21; SCS Doc 19/09)

a) Introduction

A total catch of 215 tons was reported for 2018 (Figure 8.1).

Recent catches and TACs ('000 t) are as follows:

	2010	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**
TAC	ndf	ndf	ndf	ndf	ndf	ndf	ndf	ndf	ndf	ndf
STATLANT 21	0.1	0.1	0.2	0.2	0.2	0.2	0.2	0.2	0.2	
STACFIS	0.1	0.1	0.1	0.1	0.2	0.3	0.2	0.2	0.2	

ndf No directed fishing.

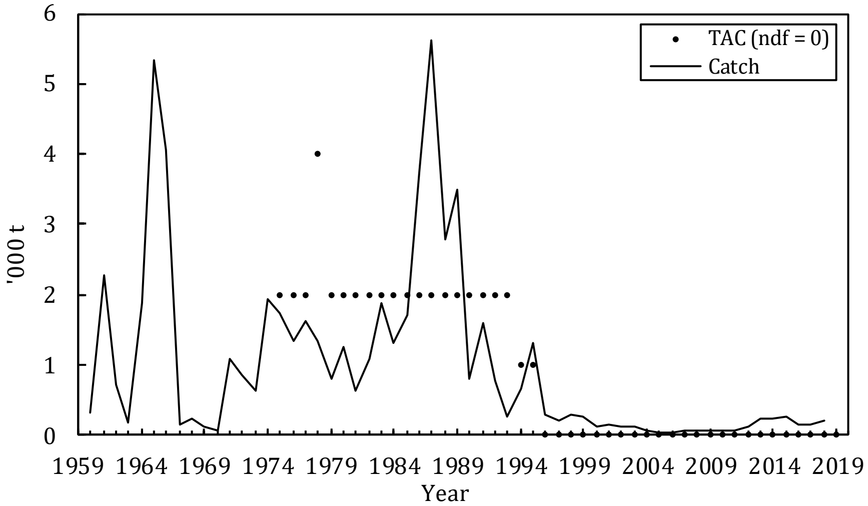


Figure 8.1. American plaice in Div. 3M: STACFIS catches and TACs. No directed fishing is plotted as 0 TAC.

b) Data Overview

The EU bottom trawl survey on Flemish Cap was conducted during 2018. The survey estimates improved in recent years, but remained at low levels (Figure 8.2).

All of the 1991 to 2005 year classes are estimated to be weak. Since 2006 the recruitment improved, particularly the 2006 year class.

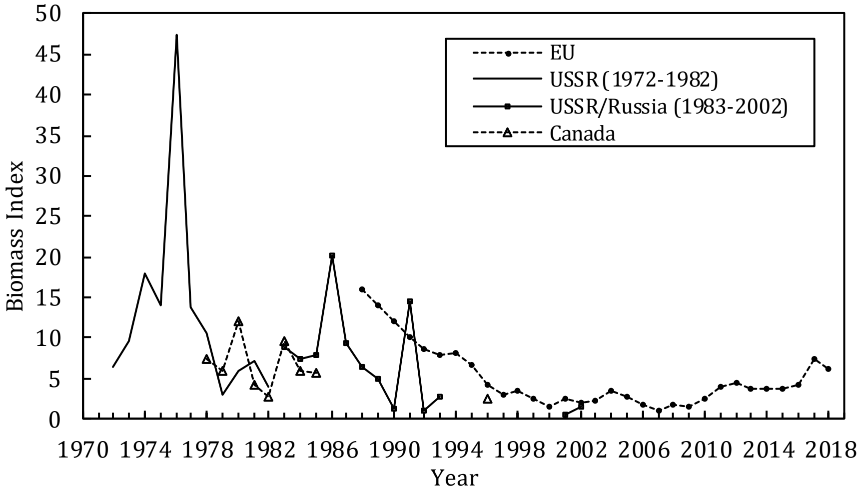


Figure 8.2. American plaice in Div. 3M: trends in survey biomass indices. EU survey data prior to 2003 have been converted to RV Vizconde Eza equivalents.

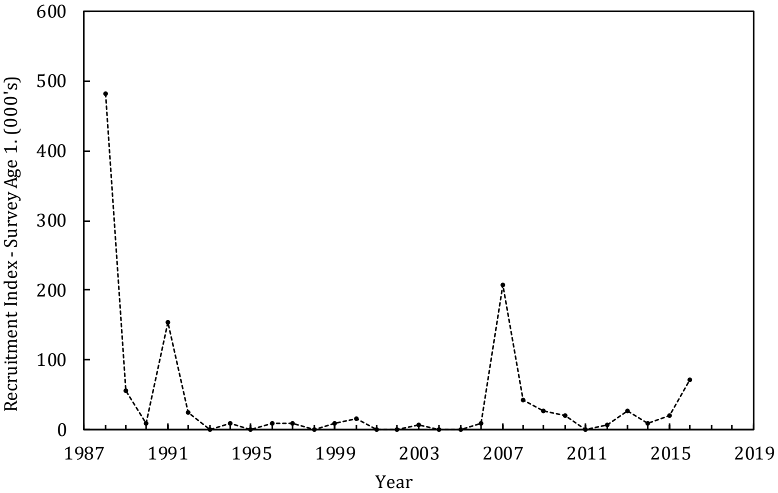


Figure 8.3. American plaice in Div. 3M: Recruitment index, trends in survey age 1 abundance.

c) Conclusion

Although the stock has increased slightly in recent years and recruitment has improved since 2007 (2006 year-class was particularly strong) it continues to be in a poor condition. Although the level of catches since 1996 is low, all the analysis indicates that this stock remains at a low level. There is no major change to the perception of the stock status.

d) Research recommendations

STACFIS **recommends** that *several input frameworks be explored in both models (such as: q's; M (e.g. in relation to* $F_{0.1}$*); ages dependent of the stock size; the proxies and its distribution in the VPA-type Bayesian model).*

No progress was made this year. STACFIS recommends that the work continue in order to explore the possibility of using the results to estimate stock size and to calculate reference points. Other types of models should also be explored.

Due to the recent recruitment improvement at low SSB, STACFIS **recommends** *exploring the Stock/Recruitment relationship and* B_{lim}*.*

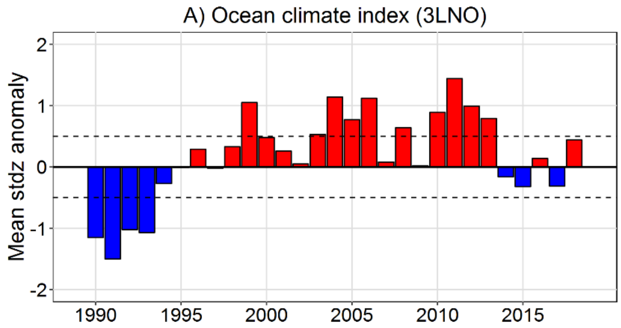
With the income of recent good year-classes at low SSB it is not possible at the moment to define a SSB/R relationship.

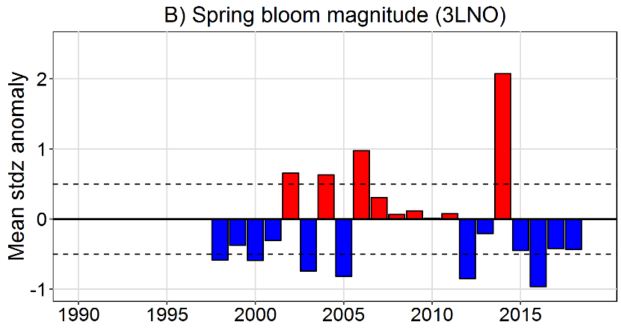
The next assessment is planned for 2020.

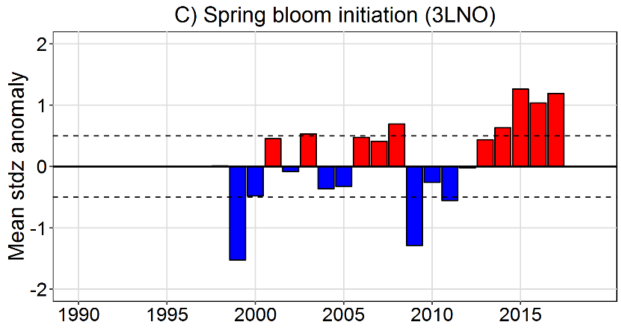
C. STOCKS ON THE GRAND BANK (NAFO DIVISIONS 3LNO)

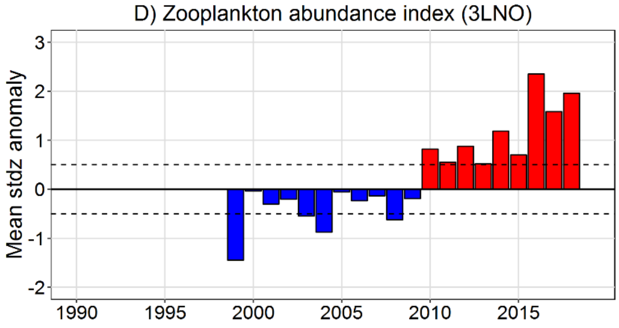
Recent Conditions in Ocean Climate and Lower Trophic Levels

- Following more than a decade of above average ocean climate conditions in NAFO Divs. 3LNO (Grand Bank), the ocean climate index since 2014 has been within its normal range, with 2018 being the warmest of this 5-year period.
- Spring bloom total production (magnitude) was near normal in 2018 for a 2nd consecutive year. Spring bloom initiation was later than normal in 2018 for fourth consecutive year.
- Zooplankton abundance reached its highest level of the time series in 2018 and has remained above normal over nine of the past ten years.
- Zooplankton biomass was below normal in 2018 for a 4th consecutive year.


A) Ocean climate index (3LNO)


B) Spring bloom magnitude (3LNO)


C) Spring bloom initiation (3LNO)



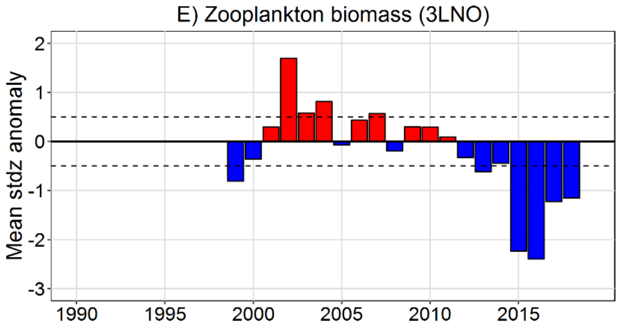


Figure C1. Environmental indices for NAFO Divisions 3LNO during 1990-2018. The ocean climate index (A) is the average of 12 individual time series of standardized ocean temperature anomalies: sea surface temperatures (SSTs) for Avalon Channel, Hibernia and Flemish Pass, vertically average ocean temperature (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. All these variables are presented in Cyr et al. (2019). Phytoplankton spring bloom magnitude (B) and duration (C) indices for the 1998-2018 period are derived from three satellite Ocean Colour boxes (Avalon Channel, Hibernia, and Southeast Shoal) distributed across NAFO Div. 3LNO. Zooplankton abundance (D) and biomass (E) indices for the 1999-2018 period are derived from two standard cross-shelf oceanographic sections (Flemish Cap and Southeastern Grand Banks) and one high-frequency coastal sampling station (Station 27) distributed across NAFO Div. 3LNO. The Zooplankton abundance index includes total copepod and non-copepod abundances. Positive/negative anomalies indicate conditions above/below (or late/early initiation) the long-term average for the reference period. All anomalies are mean standardized anomaly calculated using the following reference periods: ocean climate index, 1981-2010; phytoplankton indices (magnitude and peak timing): 1998-2015; zooplankton indices (abundance and biomass): 1999-2015. Anomalies within ±0.5 SD (horizontal dashed lines) are considered normal conditions.

Environmental Overview

The water mass characteristic of the Grand Bank are typical cold intermediate layer (CIL) sub-polar waters which extend to the bottom in northern areas with average bottom temperatures generally <0°C during winter and through to autumn. The winter-formed CIL water mass is 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 south. 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 has remained well above normal since the late 1990s, reaching a peak in 2011 (Figure 3A). The index have returned to normal conditions between 2014 and 2018, the latter being the warmest of this 5-year time series.

Spring bloom total production (magnitude) was near normal in 2018 for a 2nd consecutive year after the time series lowest production observed in 2016 (Figure 3B). Spring bloom total production has been below average since 2015. a notably high spring bloom production observed in 2014. Spring bloom initiation was later than normal in 2018 for a 4th consecutive year after having remained mostly near normal during the first 15 years of the time series, with the exceptions of the early blooms observed in 1998 and 2009 (Figure 3C).

Zooplankton abundance shows an overall increasing trend since the beginning of the time series in 1999. The zooplankton abundance index was at a time series record high in 2018 and has remained above normal over nine of the past ten years (Figure 3D). Zooplankton biomass was below normal in 2018 for a 4th consecutive year. (Figure 3E). Zooplankton biomass has been generally decreasing in NAFO divisions 3LNOsince the early 2000s.

9. Cod (*Gadus morhua*) in NAFO Divisions 3NO

Interim Monitoring Report (SCR 19/15,19; SCS 19/6,7,8,9,10,11)

a) Introduction

This stock has been under moratorium to directed fishing since February 1994. Since the moratorium, catch increased from 170 t in 1995 to a peak of about 4 800 t in 2003, and since then, catches have been between 400 t and 1 100 t. The catch in 2018 was 401 t.

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

	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
TAC	ndf	ndf	ndf	ndf	ndf	ndf	ndf	ndf	ndf	ndf
STATLANT 21	0.8	0.8	0.7	1.1	0.7	0.5	0.6	0.6	0.3	
STACFIS	0.9	0.8	0.7	1.1	0.7	0.6	0.7	0.6	0.4	

ndf : No directed fishery

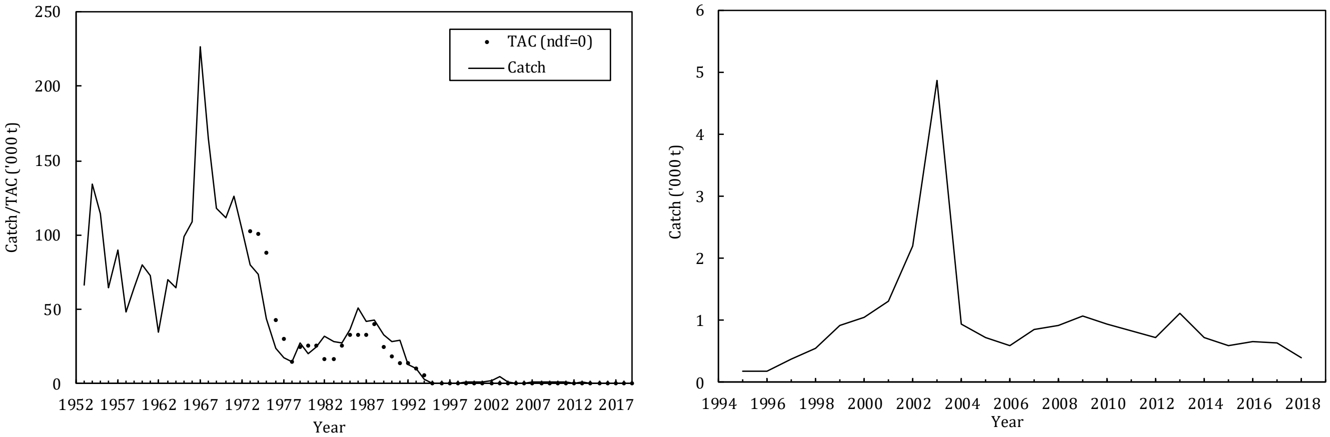


Figure 9.1. Cod in Div. 3NO: total catches and TACs. Panel at right highlights catches during the moratorium on directed fishing.

b) Data Overview

Canadian bottom trawl surveys. The spring survey biomass index declined between 1984 and 1995 and has generally remained low since 1995 (Figure 9.2). Biomass increased during 2011-2014 but indices have subsequently declined again and were among the lowest in the time series during 2017 and 2018. The trend in the autumn survey biomass index was similar to the spring indices (Figure 9.2).

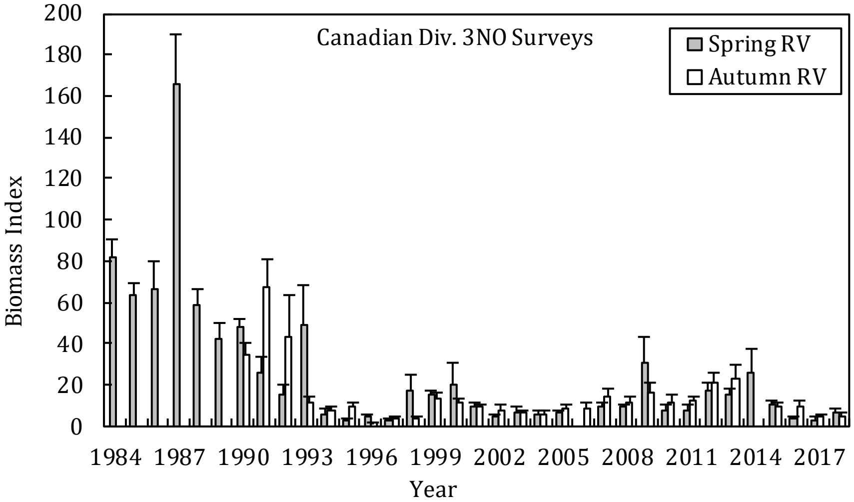


Figure 9.2. Cod in Div. 3NO: survey biomass index (+ 1 sd) from Canadian spring and autumn research surveys.

EU-Spain Div. 3NO surveys. The biomass index was lowest during 1997-2005 with the exception of 1998 and 2001 (Figure 9.3). There was a considerable increase in the index between 2007 and 2011, but this trend was followed by a decline to 2013. In 2014, the index increased to the highest value in the time series but then continually decreased through 2018 to a very low level.

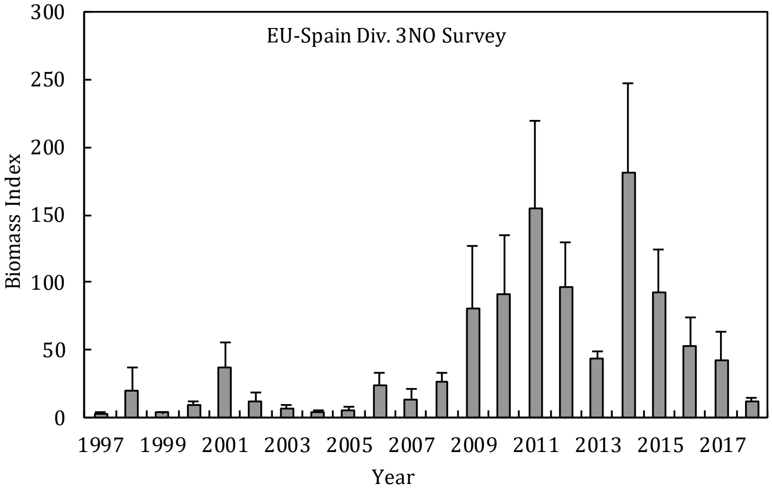


Figure 9.3. Cod in Div. 3NO: survey biomass index (+ 1 sd) from EU-Spain Div. 3NO surveys.

c) Conclusion

The most recent analytical assessment, in 2018, concluded that SSB was well below B_{lim} (60 000 t) in 2017. Canadian and EU-Spain survey indices for 2018 have remained similar and declined, respectively, relative to 2017. Overall, the 2018 indices are not considered to indicate a significant change in the status of the stock.

The next full assessment of this stock will occur in 2021.

d) Research recommendations

STACFIS **recommends** *exploration of sensitivity runs of input surveys on the ASPIC formulation for this stock.*

STACFIS **recommends** that *alternate models be explored for this stock.*

10. Redfish (*Sebastes mentella* and *Sebastes fasciatus*) in Divisions 3LN

Interim Monitoring Report (SCR Doc. 19/012, 013, 015, 018, SCS Doc. 19/06, 09, 10,11)

a) Introduction

There are two species of redfish that have been commercially fished in Div. 3LN, 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 and the surveys.

Catches declined to low levels in the early 1990s. From 1998-2009 a moratorium was in place. During that time catches were taken as by-catch primarily in Greenland halibut fisheries. With the reopening of the fishery in 2010 catches increased steadily, with removals of 11,800 t in 2017 and 11,300 t in 2018.

Recent nominal catches and TACs ('000 t) for redfish are as follows:

	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
TAC	3.5	6.0	6.0	6.5	6.5	10.4	10.4	14.2	14.2	18.1
STATLANT 21	3.1	5.4	4.5	6.3	5.7	9.9	8.7	11.9	11.2	
STACFIS	4.1	5.4	4.3							

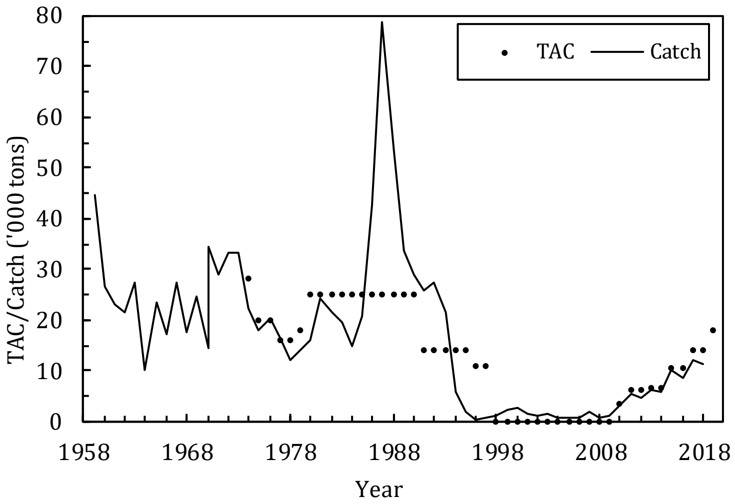


Figure 10.1. Redfish in Div. 3LN: catches and TACs.

b) Data Overview

i) Research surveys

All of the available surveys in Div. 3L and Div. 3N have been incorporated in the most recent assessment framework for this stock. These surveys are updated for 2018 and standardized in order to be presented in Figure 10.2.

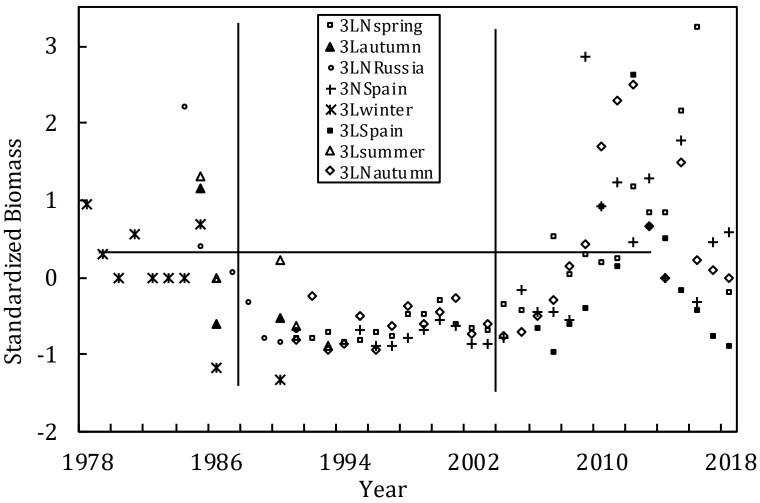


Figure 10.2. Redfish in Div. 3LN: standardized survey biomass (1978-2018). Each series is standardized to the mean and unit standard deviation. Surveys labeled as 3LNspring, 3Lautumn, 3Lwinter, 3Lsummer and 3LNautumn were conducted by Canada.

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 1990s and early 2000s. Clear increases of survey biomass are evident in 2007-2015, followed by declines in 2016-2018.

c) Estimation of Stock Parameters

i) Relative exploitation

Ratios of catch to the Canadian 3LN spring survey biomass were calculated and are considered a proxy of fishing mortality (Figure 10.3). The spring survey series was chosen since it is usually carried out on Div. 3L and Div. 3N from May to the beginning of June, and can give an index of the average biomass at the middle of each year.

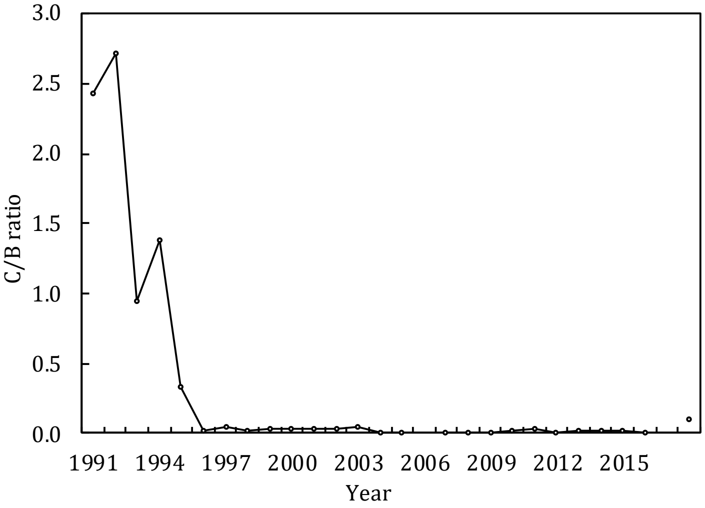


Figure. 10.3. Redfish in Div. 3LN: C/B ratio using commercial catch and Canadian spring survey biomass (1991-2018).

Catch/Biomass ratio declined from 1991 to 1996. From 1996 to 2016 this proxy of fishing mortality is at a level close to zero, with a marginal increase in 2018 (no 3L spring survey data available for 2006 or 2017).

d) Conclusions

There is nothing to indicate a substantial change in the status of the stock given by the most recent surveys and the 2018 assessment.

The next full assessment of this stock is planned for 2020.

11. American plaice (*Hippoglossoides platessoides*) in NAFO Divisions 3LNO

Interim Monitoring Report (SCR 19/12, 19/15, 19/19, SCS 19/09, 19/10, 19/13)

a) Introduction

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 172t in 2017 and 1 002t in 2018 (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:

	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
TAC	ndf	ndf	ndf	ndf	ndf	ndf	ndf	ndf	ndf	ndf
STATLANT 21	1.5	1.2	1.3	2.2	1.4	1.1	1.0	1.1	0.8	
STACFIS	2.9	2.4[1]	2.1[1]	3.0[1]	2.3[1]	1.1[2]	1.7[2]	1.2	1.0	

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.

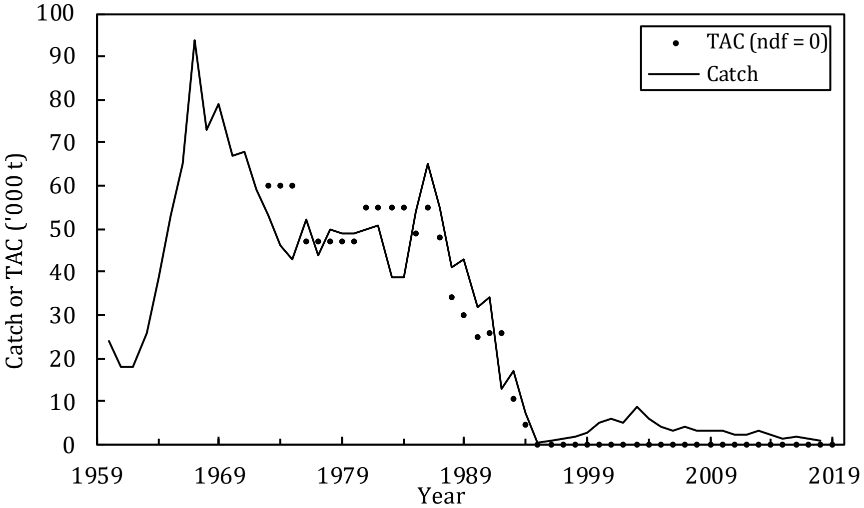


Figure 11.1. American Plaice in Div. 3LNO: estimated catches and TACs. No directed fishing is plotted as 0 TAC.

b) Research Survey Data

Canadian spring survey. Due to coverage issues in the Canadian spring survey, indices are not available from 2006, 2015, or 2017. The 2018 spring survey was incomplete (3 missed strata in Div. 3L), but coverage is considered to be sufficient to be indicative of trends. However, the impact of the missed area on age composition should be investigated prior to use in an age structured model.

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.

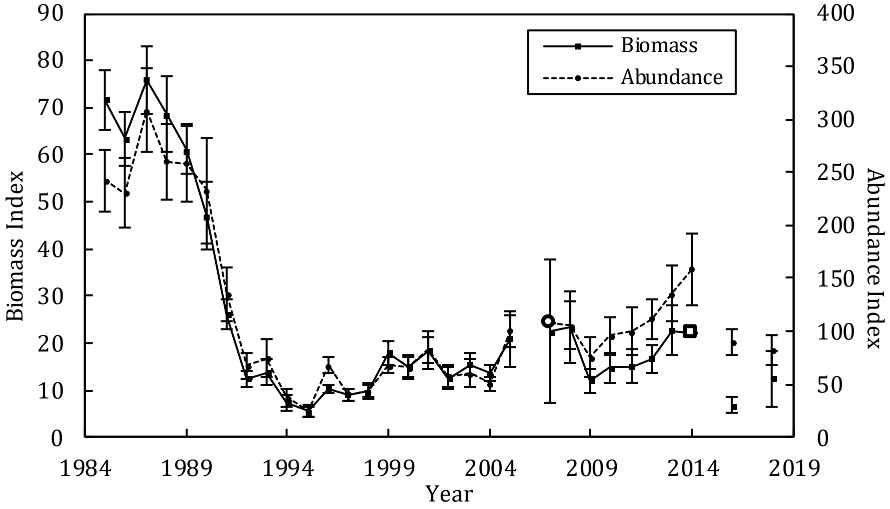


Figure 11.2. American Plaice in Div. 3LNO: biomass and abundance indices with approximate 95% confidence intervals from Canadian spring surveys. Data prior to 1996 are Campelen equivalents and since then are Campelen. Open symbols represent years where CIs extend to negative values.

Canadian autumn survey. Autumn survey points for 2004 and 2014 are excluded due to incomplete coverage of Div. 3L and 3NO, respectively. Biomass and abundance indices from the autumn survey declined rapidly from 1990 to the mid-1990s, followed by an increasing trend to 2013. Abundance indices subsequently declined from 2015 to 2018. Biomass indices also declined and have been below average in the past two surveys (Figure 11.3).

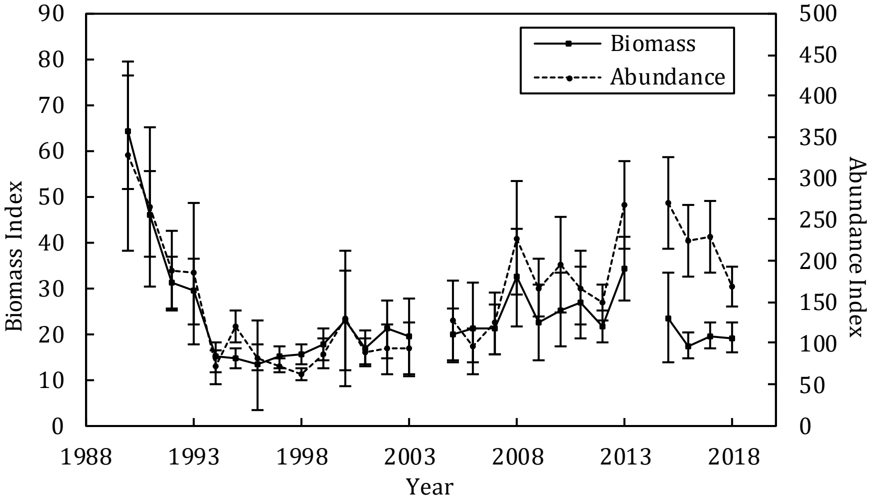


Figure 11.3. American Plaice in Div. 3LNO: biomass and abundance indices with approximate 95% confidence intervals from autumn surveys. Data prior to 1996 are Campelen equivalents and since then are Campelen.

EU-Spain Div. 3NO Survey. From 1998-2018, surveys have been conducted annually by EU-Spain in the Regulatory Area in Div. 3NO (Figure 11.4). The biomass and abundance indices varied without trend for most of the time series but then declined from 2013 to the lowest in the time series in 2016, remaining at this low level to 2018.

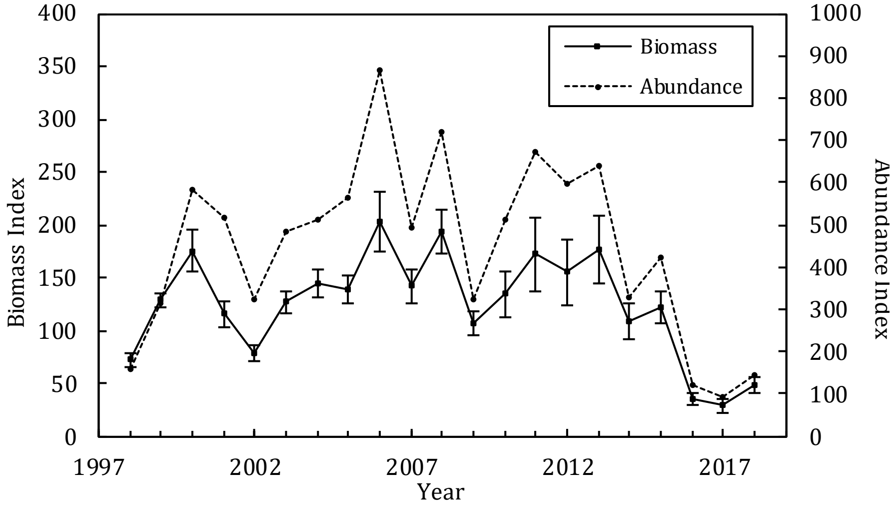


Figure 11.4. American Plaice in Div. 3LNO: biomass and abundance indices from the EU-Spain Div. 3NO survey (Data prior to 2001 are Campelen equivalents and since then are Campelen).

EU-Spain Div. 3L Survey. From 2003-2018, surveys have been conducted annually by EU-Spain in the Regulatory Area in Div. 3L, with the exception of 2005. The biomass and abundance indices increased from 2010 to 2015, and have subsequently declined to 2018 (Figure 11.5).

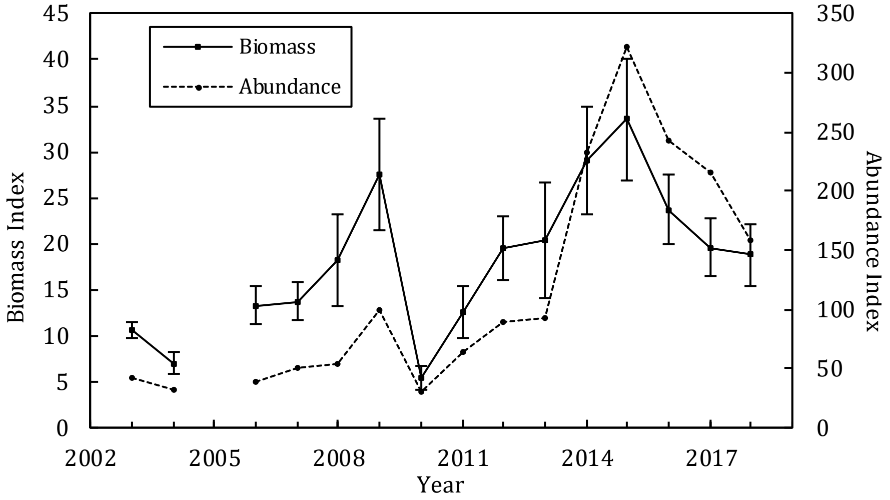


Figure 11.5. American Plaice in Div. 3LNO: biomass and abundance indices from the EU-Spain Div. 3L survey (Data prior to 2001 are Campelen equivalents and since then are Campelen).

c) Conclusion

Based on available data, there is nothing to indicate a change in the status of the stock since the 2018 assessment.

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

d) Research Recommendations

STACFIS **recommended** 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 2018 assessment examining the impact of changing the model assumptions about the F-ratio on the plus group, and will be explored further. 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 3LNO

Interim Monitoring Report (SCR 19/015 19/018; SCS 19/06, 19/08, 19/10, 19/11)

a) Introduction

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 (Figure 12.1). Catches from 2001 to 2005 ranged from 11 000 t to 14 000 t. Since then, catches have been below the TAC and in some years, have been very low. The low catch in 2006 was due to corporate restructuring and a labour dispute in the Canadian fishing industry. Industry related factors continued to affect catches which remained well below the TAC in since 2007. However, from 2013 to 2018, catches were higher, ranging from 6 900 t to 10 700 t.

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

	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
TAC[1]	17	17	17	17	17	17	17	17	17	17
STATLANT 21	9.1	5.2	3.1	10.7	8.0	6.7	8.3	9.0	8.7	
STACFIS	9.4	5.2	3.1	10.7	8.0	6.9	9.3	9.0	8.7	

[1] SC recommended any TAC up to 85% F_{msy} in 2009-2021.

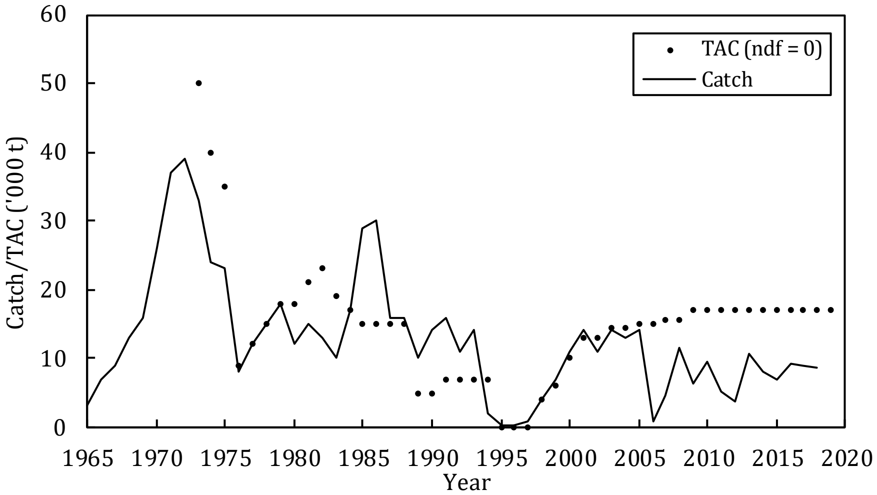


Figure 12.1. Yellowtail flounder in **Divs. 3LNO**: catches and TACs. No directed fishing is plotted as 0 TAC.

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 in 2017 and 2018. Spring surveys in several years have not completed full coverage, missing a number of strata in Divs. 3LNO. For yellowtail flounder, the 2006 and 2015 results are not considered representative, and surveys in other years are considered to have adequately covered the yellowtail flounder stock area.

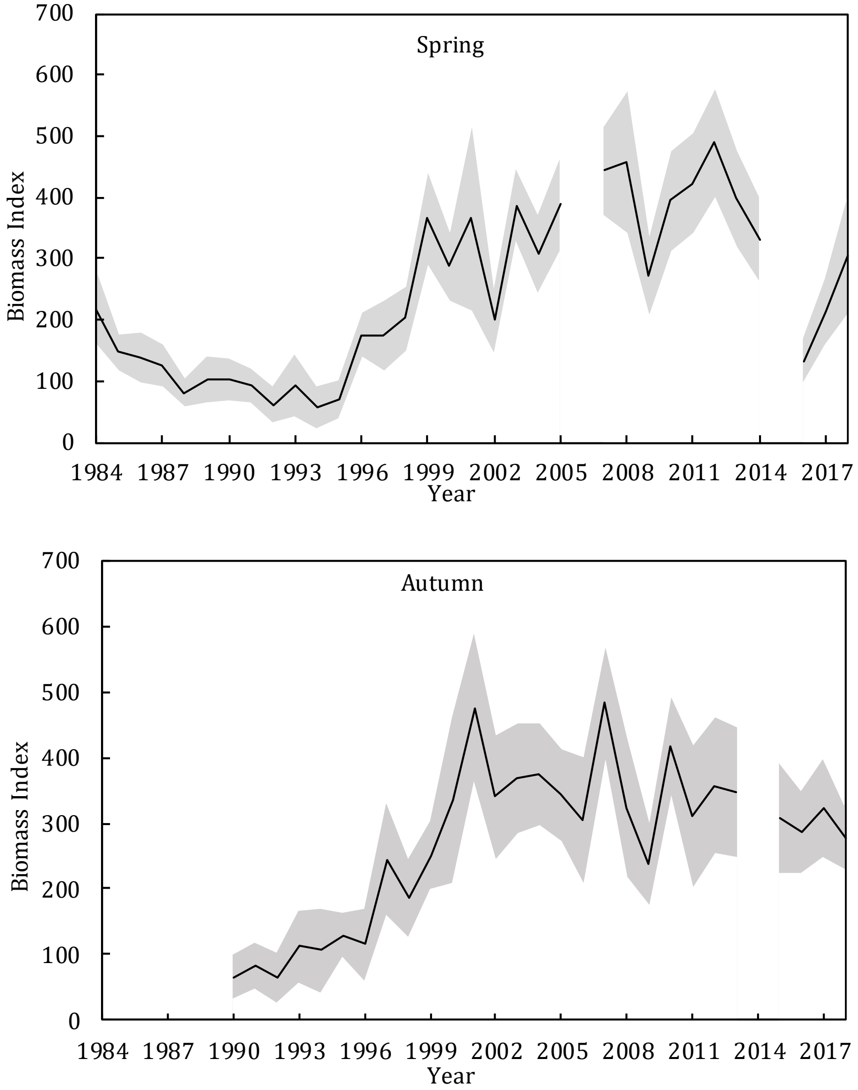


Figure 12.2. Yellowtail flounder in **Divs. 3LNO**: indices of biomass with approximate 95% confidence intervals, from Canadian spring and autumn surveys. Values are Campelen units or, prior to autumn 1995, Campelen equivalent units. The 2014 Canadian autumn and 2015 Canadian spring surveys were not considered representative.

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 decline in biomass seen in the other surveys during recent years. Fall surveys in several years have not completed full coverage, missing a number of strata in Divs. 3LNO. For yellowtail flounder, only the 2014 results are not considered representative, and surveys in other years are considered to have adequately covered the yellowtail flounder stock area.

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 2017, reaching the lowest level since 1999, and then increased slightly in 2018 (Figure 12.3). The index follows the same general trend as the Canadian series, which covers the entire stock area.

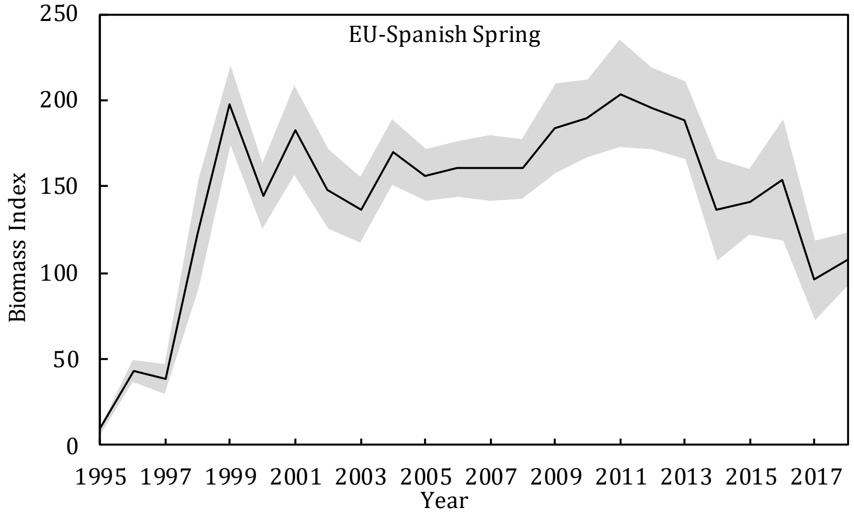


Figure 12.3. Yellowtail flounder in **Divs. 3LNO**: index of biomass from the EU-Spain spring surveys in the Regulatory Area of Divs. 3NO ±1SD. Values are Campelen units or, prior to 2001, Campelen equivalent units.

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 1999-2018 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 Div. 3NO has shown lower than average numbers of small fish in the last eleven surveys.

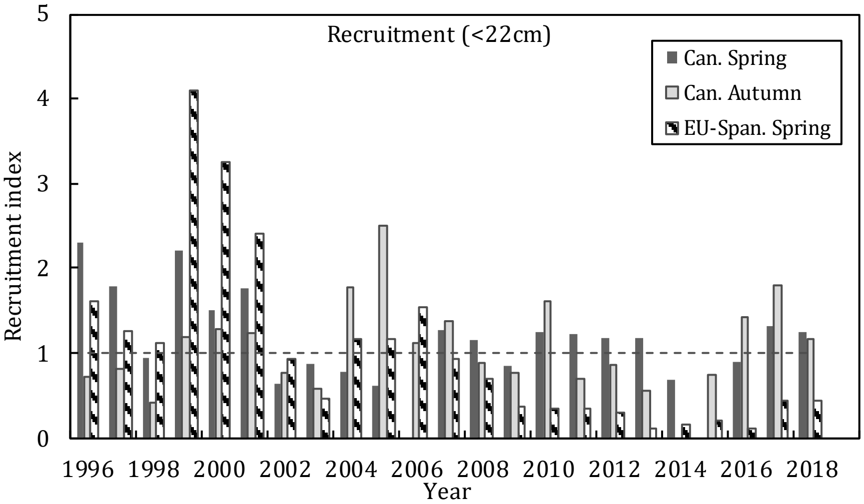


Figure 12.4. Yellowtail flounder **in Divs. 3LNO**: Juvenile abundance indices from spring and autumn surveys by Canada (Can.) and spring surveys by EU-Spain. Each series is scaled to its mean (horizontal line).

c) Conclusion

The most recent (2018) analytical assessment, using a Schaefer surplus production model in a Bayesian framework, concluded that the stock size has steadily increased since 1994 and is presently 1.5 times B_{msy} (B_{msy}=87.63). There is very low risk (<1%) of the stock being below B_{msy} or F being above F_{msy}. Overall, the 2018 survey indices are not considered to indicate a significant change in the status of the stock.

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

13. Witch Flounder (Glyptocephalus cynoglossus) in Divisions 3NO

(SCR Docs, 19/15, 18,29, 34; SCS 19/06, 08, 09, 10 1, 13)

a) Introduction

Witch flounder in Divs. 3NO was under moratorium to directed fishing from 1995 to 2014. Reported catches in the period 1972-84 ranged from a low of about 2,400 tonnes (t) in 1980 and 1981 to a high of about 9,200 t in 1972 (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 when a moratorium was imposed on the stock. 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. In 2018 total catch was estimated to be 669 t.

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

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

	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
TAC	ndf	ndf	ndf	ndf	ndf	1.0	2.2	2.2	1.1	1.2
STATLANT 21	0.4	0.4	0.3	0.3	0.3	0.4	1.0	0.6	0.6	
STACFIS	0.4	0.4	0.3	0.3	0.3	0.4	1.1	0.7	0.7	

ndf = no directed fishery.

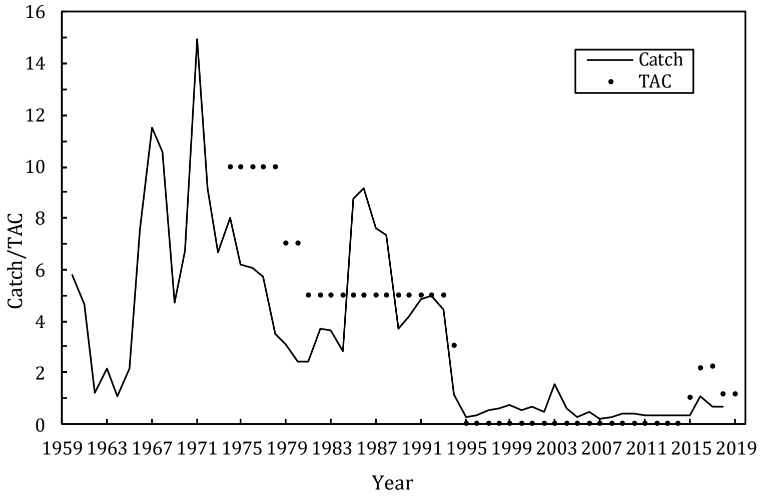


Figure 13.1. Witch flounder in Divs. 3NO (1960-2018): Catch and TAC ('000 tonnes).

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 2018**.** Canadian data indicated the catch and bycatch ranged between 30 and 55 cm with a mean length of ~45 cm (Figure 13.2). Length frequencies were available from bycatches in directed fisheries for yellowtail flounder, redfish, Greenland halibut, and skate by Spain, in 2018 (Figure 13.2). The Spanish data (SCS 19/10) from Divs. 3NO indicated most of the witch flounder catch and bycatch was between 25 and 55 cm in length (Figure 13.2). These length frequencies represent 80% of the catch.

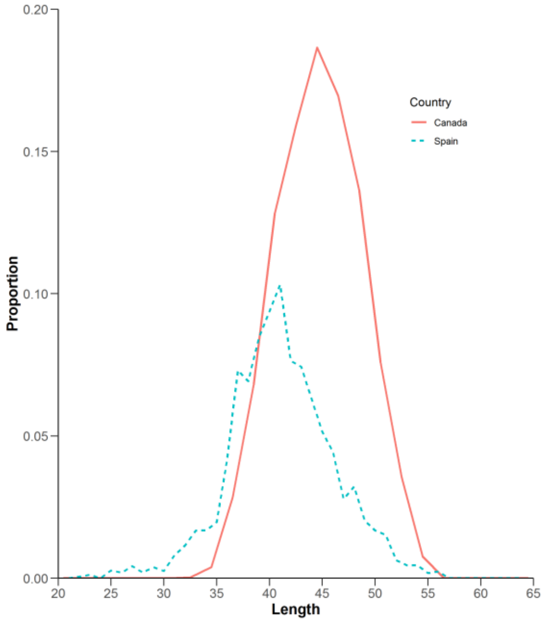


Figure 13.2. Witch flounder length frequency (cm) distributions for Canada (NAFO Div. 3O) and Spain (NAFO Divs. 3NO) commercial bycatch and directed fisheries in 2018.

ii) Research survey data

Canadian spring RV survey. Due to substantial coverage deficiencies, values from 2006 are not presented. The biomass index, although variable, had shown a general decreasing trend from 1985 to 1998, a general increasing trend from 1998 to 2003, and a general decreasing trend from 2003 to 2010. From 2010 to 2013 the index increased to values above the previous time series high of 1988 (Figure 13.3). Biomass indices declined substantially from a high in 2013 to a value 49% of the time series average in 2015. Biomass indices have been stable since 2015 (Figure 13.3).

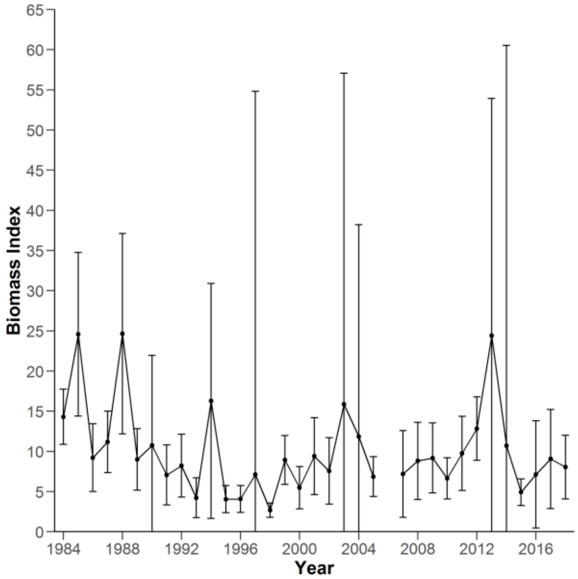


Figure 13.3. Witch flounder in NAFO Divs. 3NO: survey biomass indices from Canadian spring surveys 1984-2018 (95% confidence limits are given). Values are Campelen units or, prior to 1996, Campelen equivalent units.

Canadian autumn RV survey. Due to operational difficulties the 2014 autumn survey was not considered representative of stock size. The biomass indices showed a general increasing trend from 1996 to 2009 but declined to 57% of the time series average in 2016 (Figure 13.4). Biomass indices have been stable since 2015.

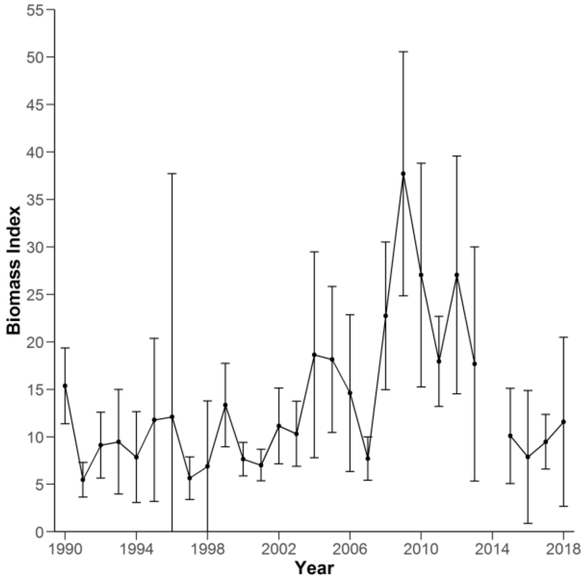


Figure 13.4. Witch flounder in Divs. 3NO: biomass indices from Canadian autumn surveys 1990-2018 (95% confidence limits are given). Values are Campelen units or, prior to 1996, Campelen equivalent units.

EU-Spain RV spring survey. Surveys have been conducted annually from 1995 to 2018 by EU-Spain in the NAFO Regulatory Area in Divs. 3NO to a maximum depth of 1,450 m (since 1998). In 2001, the vessel (*Playa de Menduiña*) and survey gear (Pedreira) were replaced by the R/V *Vizconde de Eza* using a Campelen trawl (NAFO SCR 05/25). Data for witch flounder prior to 2001 have not been converted and therefore data from the two time series cannot be compared. In the Pedreira series, the biomass increased from 1995-2000 but declined in 2001. In the Campelen series, the biomass has been relatively stable over the time series. (Figure 13.5).

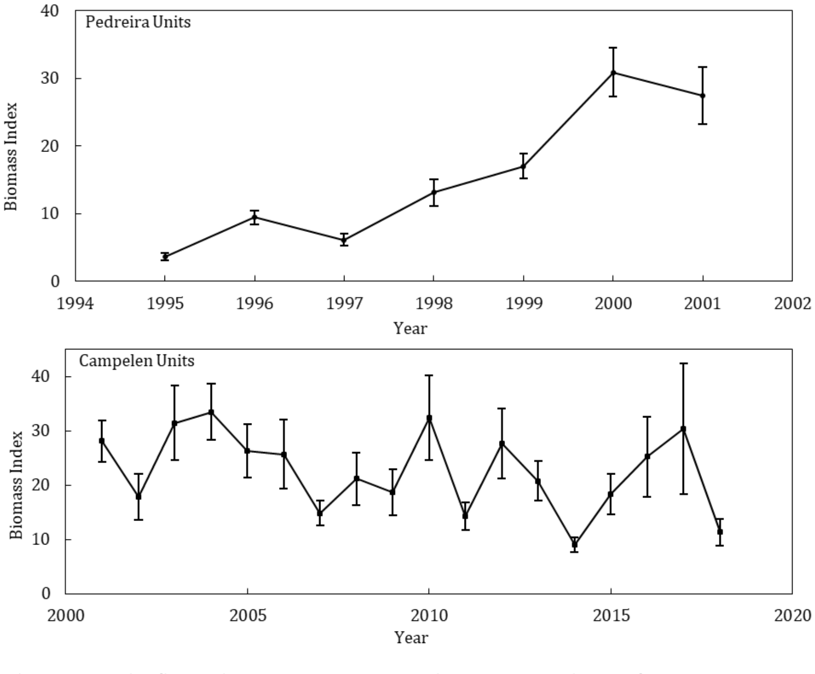


Figure 13.5. Witch flounder in Divs. 3NO: biomass indices from EU-Spanish Div. 3NO spring surveys (± 1 standard deviation). Data from 1995-2001 is in Pedreira units; data from 2001-2018 are Campelen units. Both values are presented for 2001.

Abundance at length. Abundance at length in the Canadian spring RV surveys appears to be fairly consistent since 2000 with few fish greater than 50 cm, and a mode generally around 38-40 cm (Figure 13.6). However, since 2007 there has been an increase in the number of larger fish in the 40-45 cm range except for an anomalous 30-35 cm range encountered in 2014 (Figure 13.6). Abundance at length in the Spanish spring RV surveys was fairly consistent at 33-35 cm from 2001 to 2007 (a smaller range than the Canadian surveys during the same time period). From 2008 to 2018 the size range has generally increased with more fish in the 38-43 cm range (Figure 13.6). In 2018 the mode was ~42 cm (Figure 13.6).

There were a small number of distinctive peaks in the 5-15 cm range (recruitment year classes) in both surveys that were evident and could be followed through successive years. This included the periods from 2007 to 2009 in the Canadian spring series and from 2005 -2006 in the Spanish spring series (Figure 13.6). A distinctive recruitment peak in the 10 cm range was also evident in the 2017 Canadian autumn RV and a peak in the 15cm range in the 2018 spring RV survey (Figure 13.6). However, length frequency distributions showed a consistent gap between about 20 cm and 30 cm.

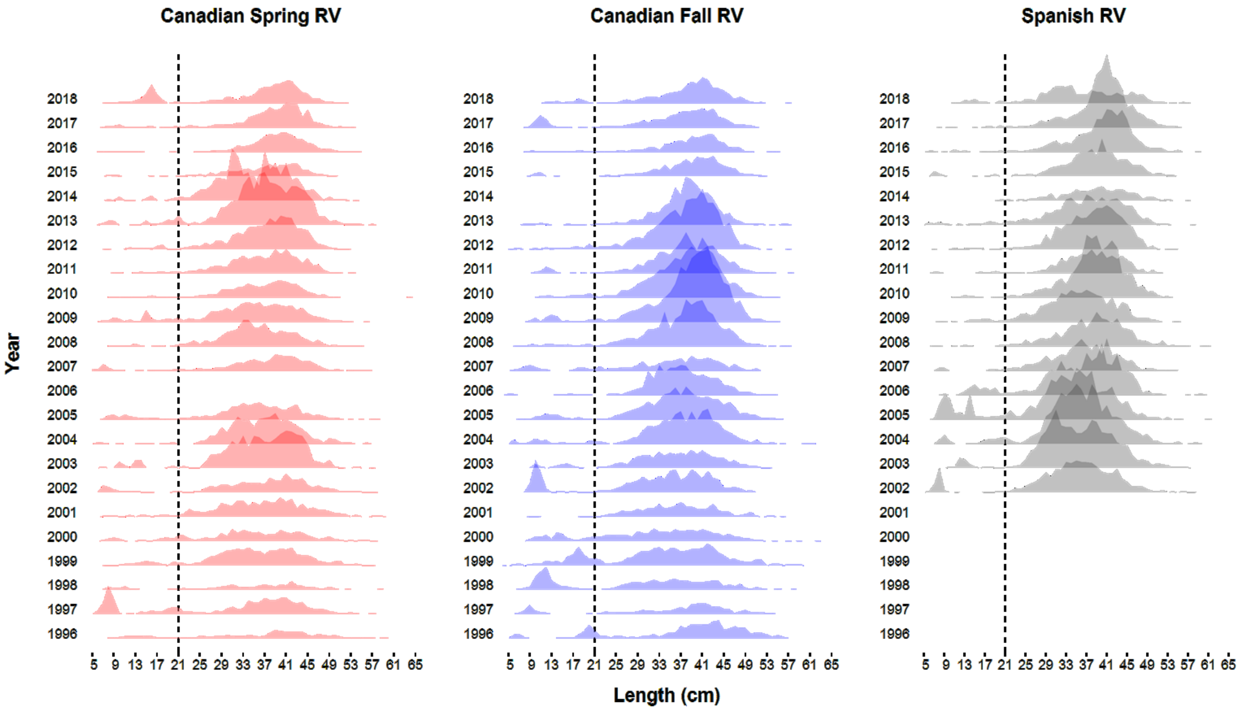


Figure 13.6. Length frequencies (abundance at length) of witch flounder from spring Canadian (1996-2018), fall Canadian (1996 to 2018) and Spanish (2002-2018) RV surveys in NAFO Divs.3NO. No Canadian survey data was available in spring 2006 or autumn 2014. Vertical dashed line represents the length at 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 fall 1990-2014) indicated that in Div. 3N both spring and fall 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 1960-2018, Canadian spring survey series from 1984-1990, Canadian spring survey series from 1991-2018 (no 2006) and the Canadian autumn survey series from 1990-2018 (no 2014).

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 2017-2018 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)

The formulation used in the 2017 assessment of this stock had very large process error and this process error had trend. In addition, the model predicted fall survey indices were above the observations in the last 3 years. The survey indices have been declining faster than can be explained by the process being modelled. To account for this a change was made to the process error, which was allowed to increase in 2014, 2015 and 2016 compared to the rest of the years (the sigma parameter was increased by 1 in those years).

This resulted in large process error in 2014 and 2015 but much smaller overall process error with no trend and a better fit to the fall survey index. This change to the formulation is a way to account for an apparent change in state of the population that is not captured in the process being modelled. There is increased structural uncertainty which is not reflected in the overall uncertainty used in the projections of stock status. The decline in biomass from 2014 to 2016 estimated using the present formulation is consistent with declines in other fish species on the Grand Bank and with changes in other components of the ecosystem.

In 2019, four formulations of the model were investigated using data up to 2017 (SCR 19/029). These were;

1: standard deviation on the prior of K =100

2: standard deviation on the prior of K=1000

3: standard deviation on the prior for r = 0.24

4: prior (uniform) on the initial population size as a proportion of K of 0.5 – 1.5.

The model estimates and the uncertainty intervals were robust to the changes in priors. STACFIS therefore concluded that the model formulation accepted in 2018 should form the basis of the assessment.

d) Assessment Results

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

Recruitment (defined as fish less than 21cm) in both the spring and fall Canadian surveys, although somewhat variable, has generally been low since 2003 (Figure 13.7). Recruitment in spring and fall surveys in 2016 approached the lowest of the time series (Figure 13.7). Recruitment in 2018 surveys decreased in the fall to about half of time series mean while those in the spring increased to a value well above the time series mean (Figure 13.7).

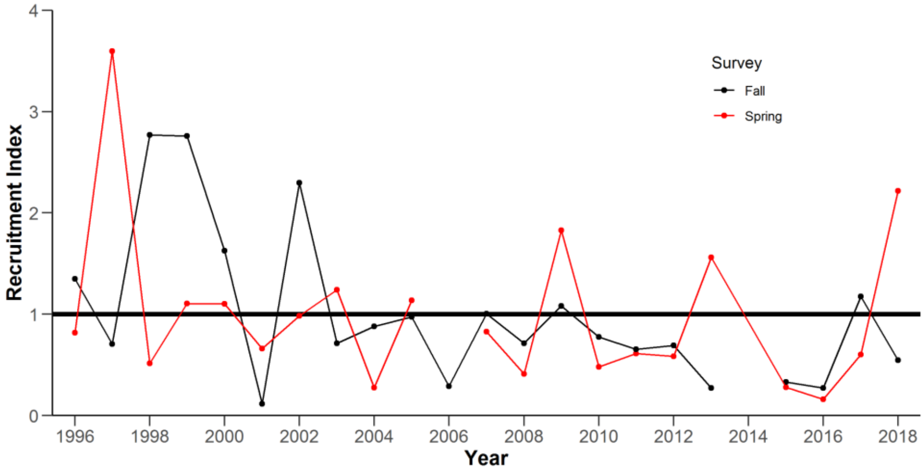


Figure 13.7. Recruitment index of witch flounder (<21cm) from spring and fall Canadian RV surveys in NAFO Divs.3NO 1996-2018. No survey data available in fall 2014 or spring 2006.

Stock Production Model: The surplus production model results indicate that stock size decreased from the late 1960s to the late 1990s and then increased from 1999 to 2013. There was a large decline from 2013 to 2015, with a subsequent small increase since. The model suggests that a maximum sustainable yield (*MSY*) of 3 781 (3 054 – 4 755) tonnes can be produced by total stock biomass of 60 020 (45 879 – 73 561) tonnes (B_{msy}) at a fishing mortality rate (F_{msy}) of 0.063 (0.05-0.09) (Figure 13.8).

Biomass: The analysis showed that relative population size (median B/B_{msy}) was below $B_{lim}=30\%\ B_{msy}$ from 1993-1997 (Figure 13.8). Biomass in 2019 is 0.41 of B_{msy} with a probability of being below B_{lim} of 0.20.

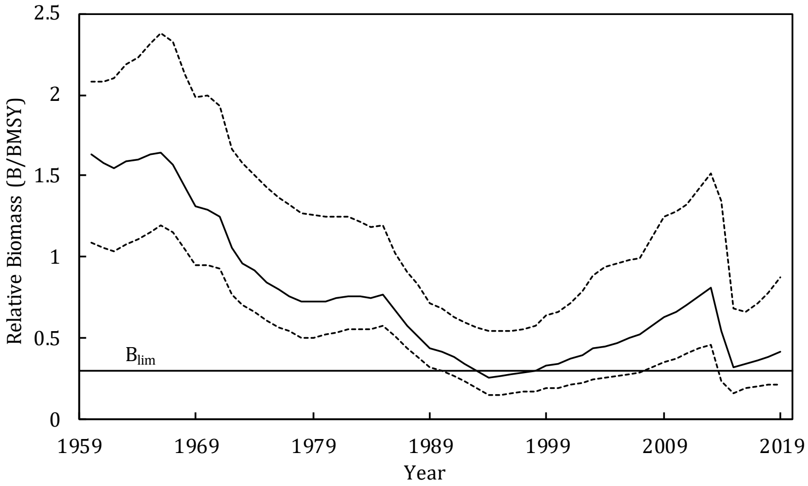


Figure 13.8. Witch flounder in Divs. 3NO. Median relative biomass ($Biomass/\ B_{msy}$) with 80% credible intervals from 1960-2019. The horizontal line is $B_{lim}=30\%\ B_{msy}$.

Fishing Mortality: Relative fishing mortality rate (median F/F_{msy}) was mostly above 1.0 from the late 1960s to the mid-1990s (Figure 13.9). F has been below F_{msy} since the moratorium implemented in 1995. Median F was estimated to be 46% of F_{msy} with a very low probability (0.02) of being above F_{msy} in 2018.

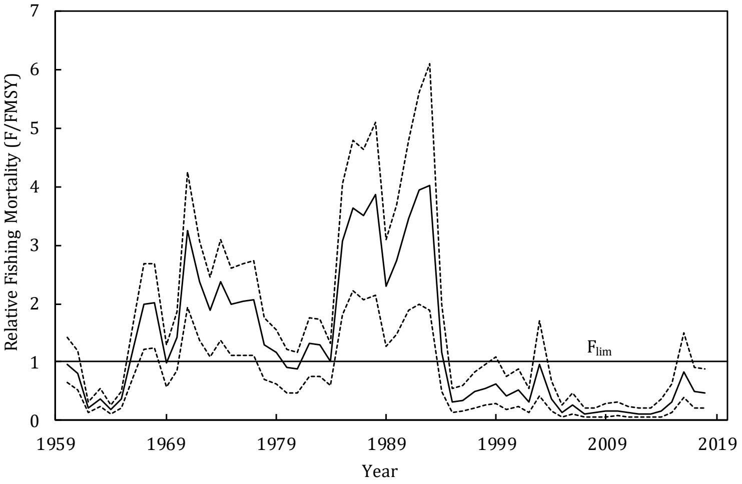


Figure 13.9. Witch flounder in Divs. 3NO. Median relative fishing mortality (F/ F_{msy}) with 80% credible intervals from 1960-2018. The horizontal line is $F_{lim}= F_{msy}$.

e) State of the Stock

The stock size increased since 1994 to 2013 and then declined from 2013-2015 and has since increased slightly. In 2019 the stock is at 41% B_{msy}.(60 000t) There is 0.20 risk of the stock being below B_{lim} and a 0.02 risk of F being above F_{lim} (0.063). With the exception of the growth of the stock following improved recruitment in the late 1990s, it is unclear if the recruitment index is representative.

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 2022. Two assumptions were made about the level of catch in 2019: first that catch was equal to the TAC of 1 175 t and second that catch in 2019 was equal to the average of 2017 and 2018 (662 t). This was followed by constant fishing mortality for 2020 and 2021 at several levels of F ($F=0$, F_{2018}, 2/3 F_{msy}, 85% F_{msy}, and F_{msy}).

The probability that F > F_{lim} in 2019 is 26% at a catch of 1 175 t. The probability of F>F_{lim} ranged from 4 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 2022 is greater than the biomass in 2019 is greater than 60% in all scenarios. The population is projected to remain below B_{msy} through to the beginning of 2022 for all levels of F examined with a probability of greater than 90%. The probability of projected biomass being below B_{lim} by 2022 was 13 to 17% in all catch scenarios examined and was 10% by 2022 in the F=0 scenario.

A second set of projections assuming that the catch in 2019 was equal to the average catch of 2017 and 2018 (662 t) was also conducted. The results were essentially the same as those assuming that the catch in 2019 equals the TAC. The probability of projected biomass being below B_{lim} by 2022 was 12 to 16% in all catch scenarios examined and was 8% by 2022 in the F=0 scenario.

Table 13.10. Medium-term projections for witch flounder. The 10th, 50th and 90th percentiles of catch and relative biomass B/B_{msy}, are shown, for projected F values of $F=0$, F_{2018}, 2/3 F_{msy}, 85% F_{msy} and F_{msy}.

	Projections with catch in 2019 = 1 175 t	
	Projected Yield (t)	Projected Relative Biomass (B_y/B_{msy})
F=0	Median	Median (80% CI)
2020	0	0.44 (0.26, 0.79)
2021	0	0.48 (0.28, 0.88)
2022		0.52 (0.30, 0.97)
F_{2018}=0.029		
2020	745	0.44 (0.26, 0.79)
2021	792	0.47 (0.27, 0.86)
2022		0.50 (0.28, 0.94)
2/3 F_{msy}=0.042		
2020	1081	0.44 (0.26, 0.79)
2021	1144	0.46 (0.26, 0.86)
2022		0.48 (0.27, 0.92)
85% F_{msy}=0.054		
2020	1379	0.44 (0.26, 0.79)
2021	1443	0.46 (0.26, 0.85)
2022		0.47 (0.26, 0.91)
F_{msy}=0.063		
2020	1622	0.44 (0.26, 0.79)
2021	1681	0.45 (0.25, 0.85)
2022		0.46 (0.25, 0.90)

	Projections with catch in 2019 = 662 t	
	Projected Yield (t)	Projected Relative Biomass (B_y /B_{msy})
F=0	Median	Median (80% CI)
2020	0	0.45 (0.26, 0.80)
2021	0	0.49 (0.29, 0.89)
2022		0.53 (0.31, 0.98)
F_{2018}=0.029		
2020	760	0.45 (0.26, 0.80)
2021	808	0.47 (0.28, 0.88)
2022		0.50 (0.29, 0.95)
2/3 F_{msy}=0.042		
2020	1102	0.45 (0.26, 0.80)
2021	1166	0.47 (0.27, 0.87)
2022		0.49 (0.28, 0.93)
85% F_{msy}=0.054		
2020	1495	0.45 (0.26, 0.80)
2021	1470	0.46 (0.27, 0.86)
2022		0.48 (0.27, 0.92)
F_{msy}=0.063		
2020	1653	0.45 (0.26, 0.80)
2021	1713	0.46 (0.26, 0.86)
2022		0.47 (0.26, 0.91)

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 (B2022>B2019) under projected F values of F=0, F2018, 2/3 F_{msy}, 85% F_{msy}, and F_{msy}

Projections with catch in 2019 = 1 175 t											
	Yield 2020	Yield 2021	P(F>F_{lim})		P(B< B_{lim})			P(B<B_{MSY})			P(B_{2022}>B_{2019})
			2020	2021	2020	2021	2022	2020	2021	2022	
F=0	0	0	0	0	18%	13%	10%	96%	94%	91%	73%
F2018=0.029	745	792	4%	4%	18%	15%	13%	96%	94%	92%	67%
2/3 F_{msy} =0.042	1081	1144	18%	19%	18%	16%	14%	96%	94%	92%	65%
85% F_{msy} =0.054	1379	1443	36%	36%	18%	17%	16%	96%	94%	93%	63%
F_{msy} =0.063	1622	1681	50%	50%	18%	18%	17%	96%	95%	93%	61%

Projections with catch in 2019 = 662 t											
	Yield 2020	Yield 2021	P(F>F_{lim})		P(B<B_{lim})			P(B< B_{msy})			P(B_{2022}>B_{2019})
			2020	2021	2020	2021	2022	2020	2021	2022	
F=0	0	0	0	0	16%	12%	8%	96%	93%	91%	75%
F2018=0.0229	760	808	4%	4%	16%	14%	12%	96%	94%	92%	69%
2/3 F_{msy} =0.042	1102	1166	17%	18%	15%	15%	13%	96%	94%	92%	67%
85% F_{msy} =0.054	1405	1470	35%	36%	16%	15%	15%	96%	94%	92%	65%
F_{msy} =0.063	1653	1713	50%	50%	16%	16%	16%	96%	94%	93%	63%

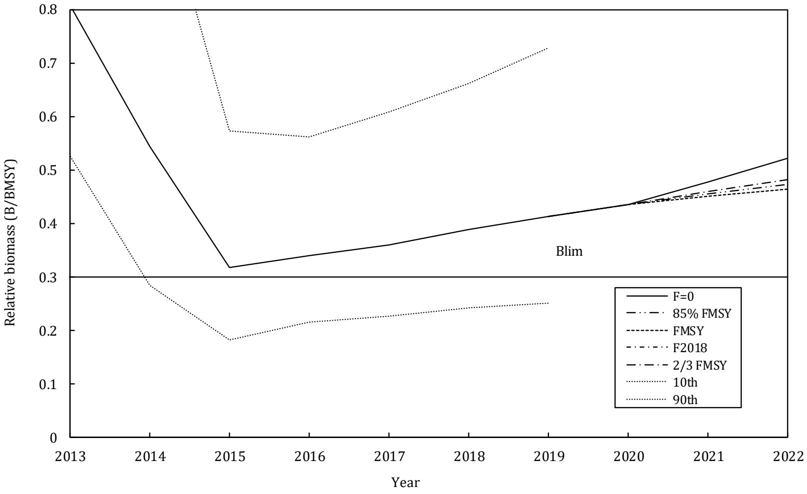


Figure 13.10. Witch flounder in Divs. 3NO: medium term projections of relative biomass (B/B_{msy}) at five levels of *F* (F=0, F2018, 2/3 F_{msy}, 85% F_{msy} and F_{msy}). A catch of 1,175 t is assumed in 2019. The 10th and 90th credible intervals are included for the model results up to 2019.

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 0.20 and above F_{lim} is 0.02 (Figure 13.11).

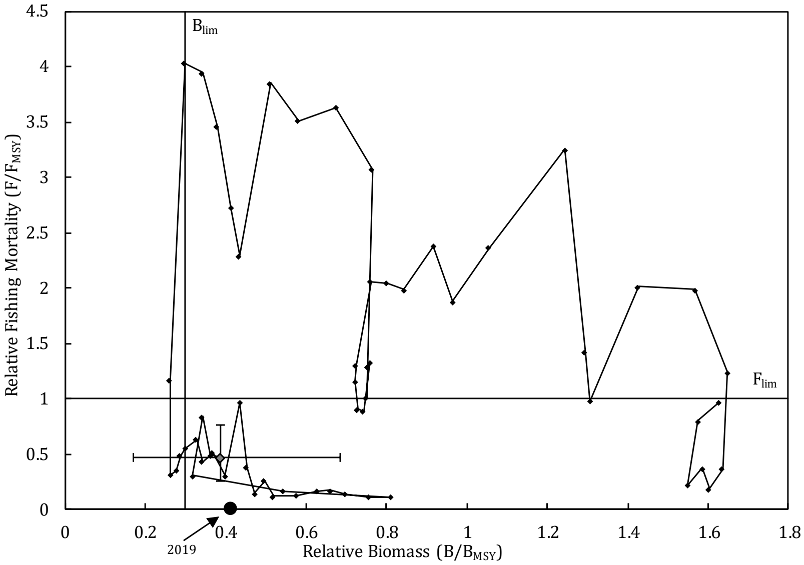


Figure 13.11. Witch flounder in Divs. 3NO: stock trajectory estimated in the surplus production analysis, under a precautionary approach framework.

h) Recommendations

STACFIS **recommends** that *the prior distributions be further explored for the surplus production model for witch flounder in Div. 3NO.*

Status: Completed - see section c).

STACFIS **recommends** that *further investigations be carried out to explore the appropriateness of the current recruitment indices.*

Status: Completed.

Maps of the distribution of fish less than 21cm in Canadian surveys were produced for the Div. 3LNO area. The distribution seems to be more or less continuous along the shelf edge. Correlations of the number of pre-recruits in each area showed that the number of pre-recruits in Div 3N and 3O were correlated with one another while the number of pre-recruits in Div. 3O was not correlated with that in the adjacent Subdiv. 3Ps. There was also no correlation between Div. 3N or Div. 3O and Div. 3L. However, length frequency distributions showed a consistent gap between about 20 cm and 30 cm. It is not known why fish of this size are not caught in the area (SCR 19/34).

The next assessment will be in 2021.

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

Interim Monitoring Report (SCR. 19/15, SCS. 19/06)

a) Introduction

The fishery for capelin started in 1971 and catches were high in the mid-1970s with a maximum catch of 132 000 t in 1975 (Figure 14.1). The stock has been under a moratorium to directed fishing since 1992. No catches have been reported from 1993 to 2013. Small catches (mostly discards) started appearing from 2014 to 2018, with an exception of 2015 as indicated below:

	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Recommended TAC	ndf	ndf	ndf	ndf	ndf	ndf	ndf	ndf	ndf	ndf	ndf	ndf
Catch (t)	0	0	0	0	0	0	1	0	5	1	2	

ndf = no directed fishery

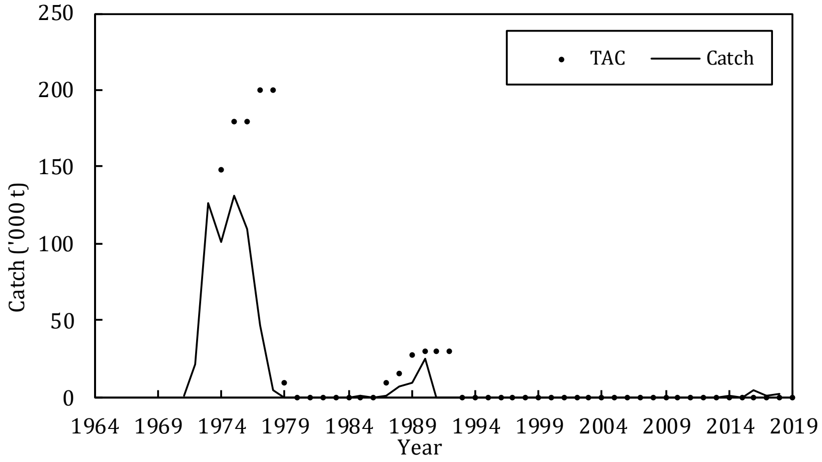


Figure 14.1. Capelin in Div. 3NO: catches and TACs.

b) Data Overview

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. Available indicators of stock dynamics currently include the capelin biomass index from Canadian spring stratified-random bottom trawl surveys. This index varied greatly from 1995-2018 without any clear trend, however, four of the highest values have been observed in the most recent ten years of the time series. In 2016, the biomass indices declined to the historical minimum. After increasing in 2017, the index decreased in 2018 (Figure 14.2).

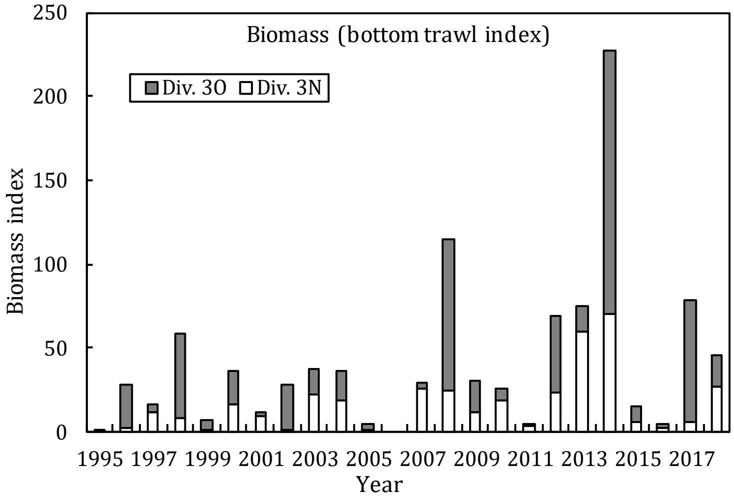


Figure 14.2. Capelin in Div. 3NO: survey biomass index (bottom trawl) from Canadian spring survey in 1995-2018.

Data from EU-Spain trawl surveys in Divs. 3NO for 1995-2018 are also available (Figure 14.3). Data from 1997-2000 are from the C/V "Playa de Menduíña", transformed to be comparable with the 2002-2018 R/V "Vizconde de Eza"data.

Survey estimates of capelin biomass show the maximum biomass level in 2012. For the period of 2015-2017 biomass sharply declined. For 2018, biomass has increased to a level similar to that in the early 2000s.

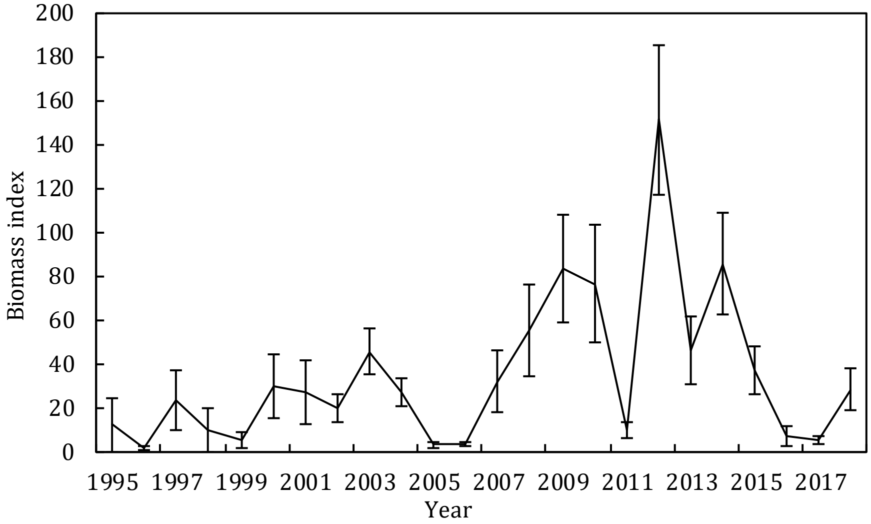


Figure 14.3. Biomass index and standard deviations of capelin (1995-2017) based on EU-Spain trawl surveys.

c) Assessment Results

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.*

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

15. Redfish (Sebastes mentella and Sebastes fasciatus) in Division 3O

(SCR Doc. 19/15, 18; SCS Doc. 19/6, 9, 10, 11)

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 fasciatu*s). 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 connection between Divs. 3LN and Div. 3O, for both species of redfish. 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 Div. 3O and 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.

i) Description of the fisheries and catches

The redfish fishery within the Canadian portion of Div. 3O has been under TAC regulation since 1974 and there has been a minimum size limit of 22 cm since 1995, while catch in the NRA portion of Div. 3O during that same time was regulated only by mesh size. A TAC was adopted by NAFO in September 2004. The TAC has been 20 000 tons during 2005-2019 and applies to the entire area of Div. 3O. Nominal catches have ranged between 3 000 tons and 35 000 tons since 1960 (Figure 15.1). Catches averaged 13 000 t up to 1986 and then increased to 27 000 t in 1987 and 35 000 t in 1988. Catches declined to 13 000 t in 1989, increased gradually to about 16 000 t in 1993 and declined further to about 3 000 t in 1995, partly due to reductions in foreign allocations within the Canadian fishery zone since 1993. Catches increased to 20 000 t by 2001, subsequently declined to 4000 t in 2008 and have been in the range of 6000 to 9000 t since 2009.

The redfish fishery in Div. 3O occurs primarily in the last three quarters of the year. Canadian, Portuguese, Russian and Spanish fleets have accounted for most of the catch and bottom trawling is the primary gear accounting for greater than 90% of the catch. The 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:

	2010	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**
TAC	20	20	20	20	20	20	20	20	20	20
STATLANT 21	6.5	6.0	7.0	7.8	7.5	7.9	8.6	7.3	4.3	
STACFIS	5.2	6.0	7.0	7.8	7.5	8.4	9.0	7.5	6.1	

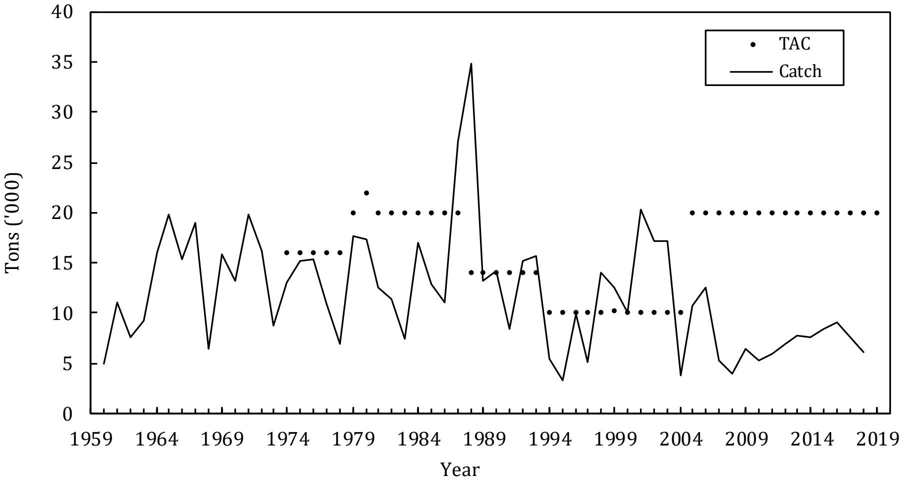


Figure 15.1. Redfish in Div. 3O: catches and TACs (from 1974 to 2004 applied to Canadian fisheries jurisdiction; from 2005 for entire Div. 3O area).

b) Input Data

Abundance, biomass and size distribution data, as well as mean numbers and weights (kg) per tow, were available from Canadian spring and autumn surveys for 1991-2018 and EU/Spain surveys in the NRA portion from 1997-2018. Length frequencies were available from sampling of the commercial catches from Portugal, Russia, Estonia, Spain and Canada in 2018.

i) Commercial fishery data

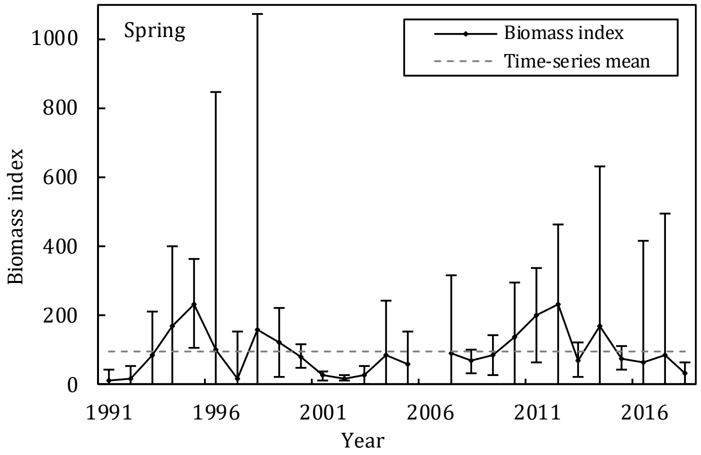
Redfish tend to form patchy aggregations that are at times very dense and in Div. 3O there is a limited amount of fishable area in deeper waters along the steep slope of the southwest Grand Bank where larger fish tend to be located.

Sampling of the redfish trawl fisheries was conducted by Russia, Spain, and Portugal during 2016 to 2018 and by Estonia during 2017 and 2018. There was no Canadian catch sampled in 2016, but bycatch from the witch flounder fishery was sampled during 2017 and 2018. Fleets generally fished depths between 90 and 610 m. Length frequencies were similar among participating countries during 2016 to 2018 with an overall size range of 7-42 cm. Modal length was 23 cm for most countries in 2016. Modal length increased to 24 cm in 2018, but sampling by Portugal included more smaller fish than other countries or the Canadian autumn rv survey.

ii) Research survey data

Abundance and biomass data, were available from Canadian spring and autumn stratified-random surveys during 1991-2018. In 2006, only autumn indices were available due to inadequate survey coverage in the spring survey. There was no autumn survey in 2014. The surveys currently cover depths to 732 m (400 fathoms). Until the autumn of 1995 these surveys were conducted with an Engel 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 2018. These surveys use the same stratification scheme as the Canadian surveys and the area of redfish habitat covered in Div. 3O is less than 8% compared to the Canadian surveys for strata to 732 m. 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.



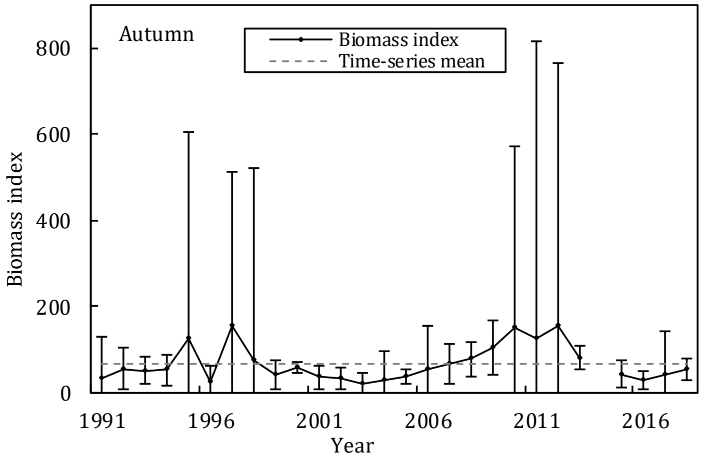


Figure 15.2. Redfish in Div. 3O: survey biomass indices from Canadian surveys (Campelen equivalent units for surveys prior to autumn 1995) with 95% confidence intervals. Dashed lines are time-series means.

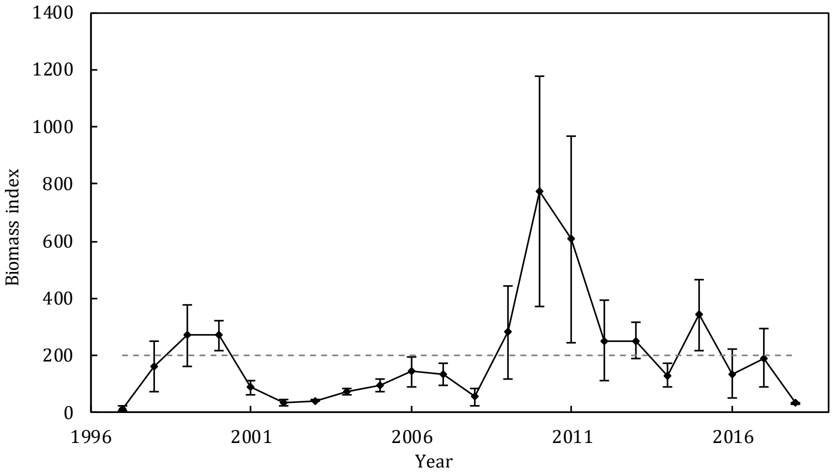


Figure 15.3. Redfish in Div. 3O: survey biomass indices (error bars are one standard deviation) from EU-Spain spring surveys (Campelen equivalent units for surveys prior to 2002). Dashed line is the series mean.

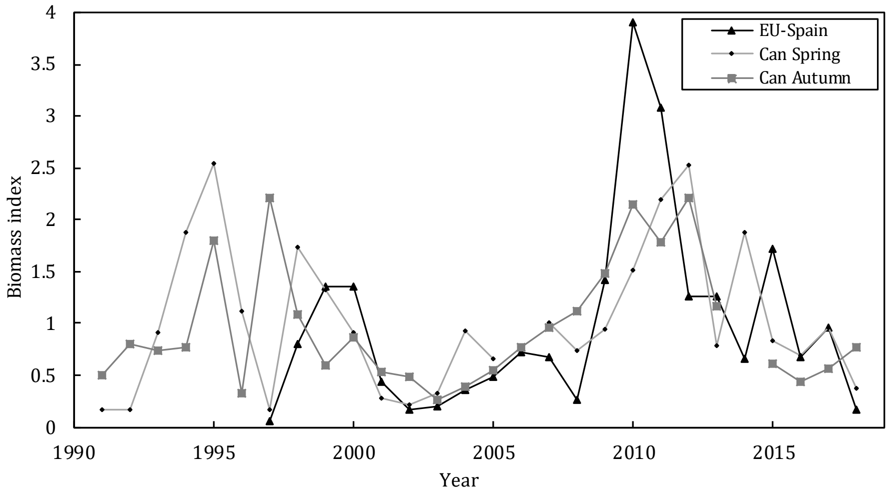


Figure 15.4. Redfish in Div. 3O: survey biomass indices from Canada (spring and autumn) and EU-Spain (starting in 1997). Indices were normalized by dividing by their time-series means over 1997-2018.

iii) Biomass Indices

Results of bottom trawl surveys for redfish in Div. 3O indicated a considerable amount of variability. It is difficult to interpret year to year changes. The Canadian spring survey index (Figure 15.2) was generally at or above the time-series mean during two periods, the mid to late 1990s and during 2009 to 2015. The 2018 value was well below the time-series average. The Canadian autumn surveys and the EU-Spain survey (Figure 15.3) generally support the pattern of the Canadian spring survey index, but the Canadian autumn 2018 value was near the time-series mean and the EU-Spain 2018 value was well below the mean (Figure 15.4).

iv) Recruitment

There is no accepted recruitment index for 3O redfish. No association was found between numbers of redfish at lengths sampled in the fishery (grouped over 15-17 cm and also 21-23 cm) or redfish biomass (group over lengths > 21 cm or those > 24 cm) and numbers of redfish at pre-recruit sizes (between 12 and 18 cm) during previous years. An early 2000s year class is the last apparent indication of recruitment.

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. As a result of incomplete survey coverage, the 2006 and 2014 estimates of fishing mortality were calculated using only the autumn and spring survey biomass respectively. 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 1998-2018.

Relative fishing mortality increased steadily from 1998 to 2002, remained high in 2003 but declined substantially in 2004 (Figure 15.5). In 2005, relative fishing mortality increased once more and was around the series average. The values for 2007-2014 were among the lowest in the time series. Fishing mortality increased slightly from 2014 to 2016, but returned to low values in 2018.

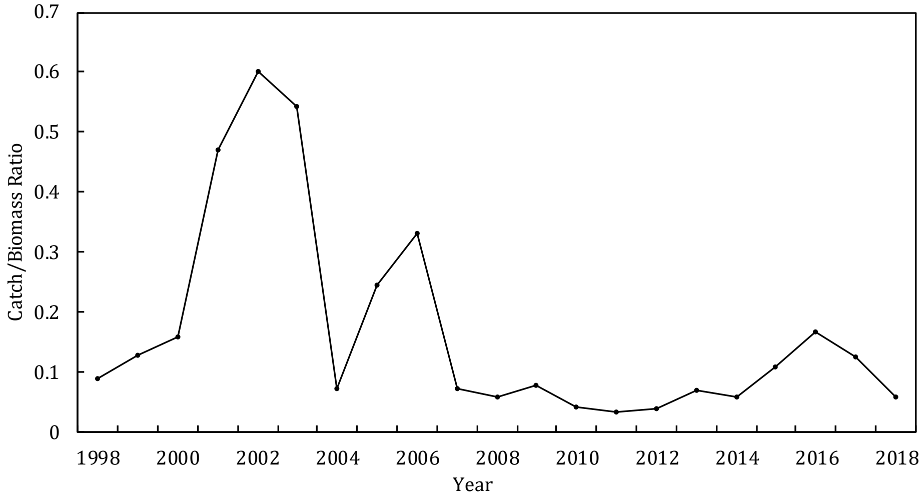


Figure 15.5. Redfish in Div. 3O: catch/survey biomass ratios.

ii) Size at maturity

Based on analyses of size at maturity for this stock from 1998 (L_{50} is about 28 cm for females and 21 cm for males) and with current catches dominated by lengths between 18 cm-27 cm, it is clear that the fishery is based mostly on immature fish.

d) Assessment Results

Biomass: Survey index values for the past three years were generally at or below their time series average compared to relatively high values observed in 2010 to 2012.

Fishing Mortality: Relative fishing mortality over the past decade has been relatively low compared to the period 2001-2006.

Recruitment: There is no recruitment index for this stock. An early 2000s year class is the last apparent indication of recruitment.

State of the Stock: Survey index values for the past three years were generally at or below their time series average compared to relatively high values observed in 2010 to 2012. Current fishing mortality is low and recent recruitment is unknown.

e) Reference Points:

There are no reference points for redfish in Div. 3O.

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.*

To investigate potential recruitment indices for Div. 3O redfish, Scientific Council was presented with an analysis of length frequency data from the Canadian spring (1996-2018) and autumn (1995-2018) surveys. No association was found between numbers of redfish at lengths sampled in the fishery (15-17 cm, 21-23 cm) or redfish survey biomass (> 21 cm or > 24 cm) and numbers of redfish at pre-recruit sizes (between 12 and 18 cm) during previous year. Failure of some pulses of young fish to track through to sizes caught in the fishery and uncertainty about recruitment from areas outside of Div. 3O prevented acceptance of a recruitment index.

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.*

The next full assessment will be in 2022.

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 3LNO and Subdivision 3Ps

Interim Monitoring Report (SCR Doc. 19/13,15,20; SCS Doc. 19/09,10,11)

a) Introduction

Thorny skate on the Grand Banks was first assessed by Canada 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. 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.

b) Catch History

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. The skate fishery on the Grand Banks is therefore considered a directed 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. 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 2013-2019. 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. The main participants in this new fishery were EU-Spain, EU-Portugal, USSR, and the Republic of Korea. Catches from all countries in Divs. 3LNOPs over 1985-1991 averaged 17 058 t; with a peak of 28 408 t in 1991 (STATLANT-21). 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 2013-2017 was 4 048 t and 481 t in Subdiv. 3Ps. STACFIS catch in 2018 totaled 2 412 t for Divs. 3LNO and 1 059 t for Subdiv. 3Ps.

Recent nominal catches and TACs (000 tons) in Divs. 3LNO and Subdiv. 3Ps are as follows:

	2010	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**
Divs. 3LNO:										
TAC	12	12	8.5	7	7	7	7	7	7	7
STATLANT-21	5.4	5.5	4.3	4.4	4.5	3.3	3.5	4.2	.1	
STACFIS	3.1	5.4	4.3	4.4	4.5	3.4	3.5	4.5	2.4	
Subdiv. 3Ps:										
TAC	1.05	1.05	1.05	1.05	1.05	1.05	1.05	1.05	1.05	1.05
STATLANT-21	0.3	0.5	0.4	0.3	.2	.2	.7	.6	1.06	
Divs. 3LNOPs:										
STATLANT-21	5.7	6.1	4.6	4.6	4.7	3.6	4.1	4.8	1.2	
STACFIS	3.4	5.9	4.6	4.6	4.7	3.7	4.1	5.1	3.6	

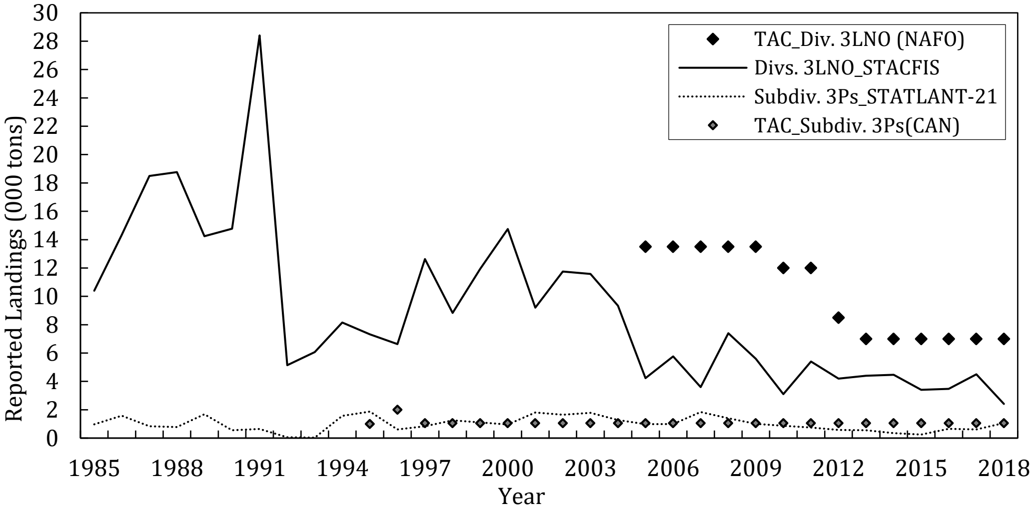


Figure. 16.1. Thorny skate in Divs. 3LNO and Subdiv. 3Ps, 1985-2018: reported landings and TAC.

c) Data Overview

i) Research surveys

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 1984-1995, and a Campelen 1800 shrimp trawl in 1996-2018. Subdiv. 3Ps was not surveyed in 2006, nor was the deeper portion (>103 m) of Divs. 3NO in that year, due to mechanical difficulties on Canadian research vessels. The survey in 2015 missed several strata in Div. 3L; however, this was considered inconsequential for assessing Thorny Skate abundance and biomass. Survey coverage was poor in the Canadian spring survey in Div. 3L in 2017. The missing strata typically contain ~5-10% of the total biomass in years when these strata are surveyed; therefore, the 2017 estimate of the biomass index may be an underestimate.

Indices for Divs. 3LNOPs in 1972-1982 (Yankee trawl) fluctuated without trend (Figure 16.2a).

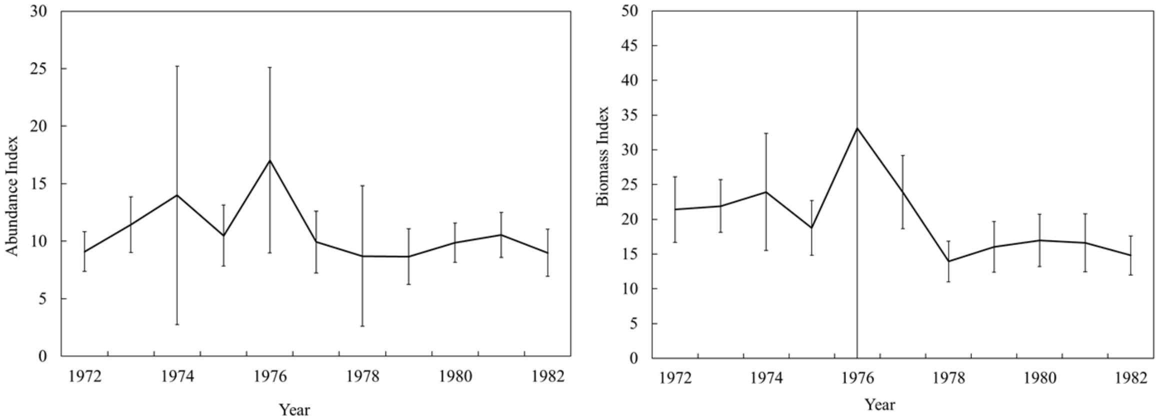


Figure 16.2a. Thorny skate in Divs. 3LNOPs, 1972-1982: abundance (left panel) and biomass (right panel) indices from Canadian spring surveys.

The abundance and biomass indices for Divs. 3LNOPs in 1984-2018 are presented in Figure 16.2b. Catch rates of thorny skate in Divs. 3LNOPs declined from the mid1980s until the early 1990s. Since 1997, biomass indices have been increasing very slowly from low levels, while abundance indices remain relatively stable at very low levels. Recent biomass estimates are above B_{lim} (Figure 16.2b).

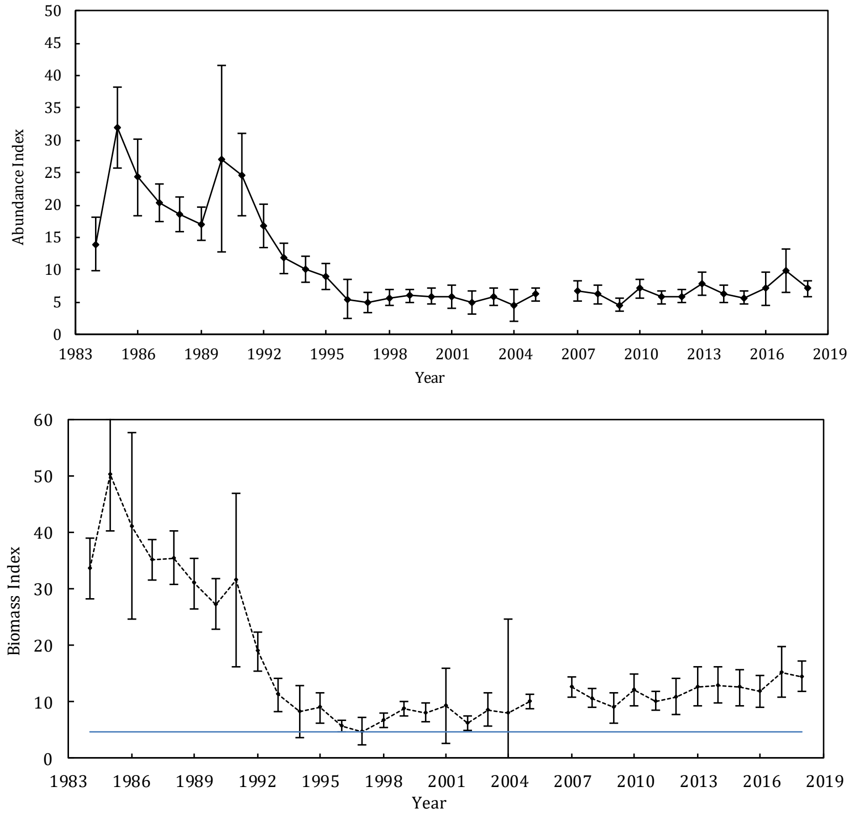


Figure. 16.2b. Thorny skate in Divs. 3LNOPs, 1984-2018: abundance (top panel) and biomass (bottom panel with B_{lim} shown [blue horizontal line]) indices from Canadian spring surveys. The survey in NAFO Div. 3L was incomplete in 2015 and 2017.

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 1995-2018, to depths of ~1 450 m.

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 sampled in 2014 due to mechanical difficulties on Canadian research vessels. 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.

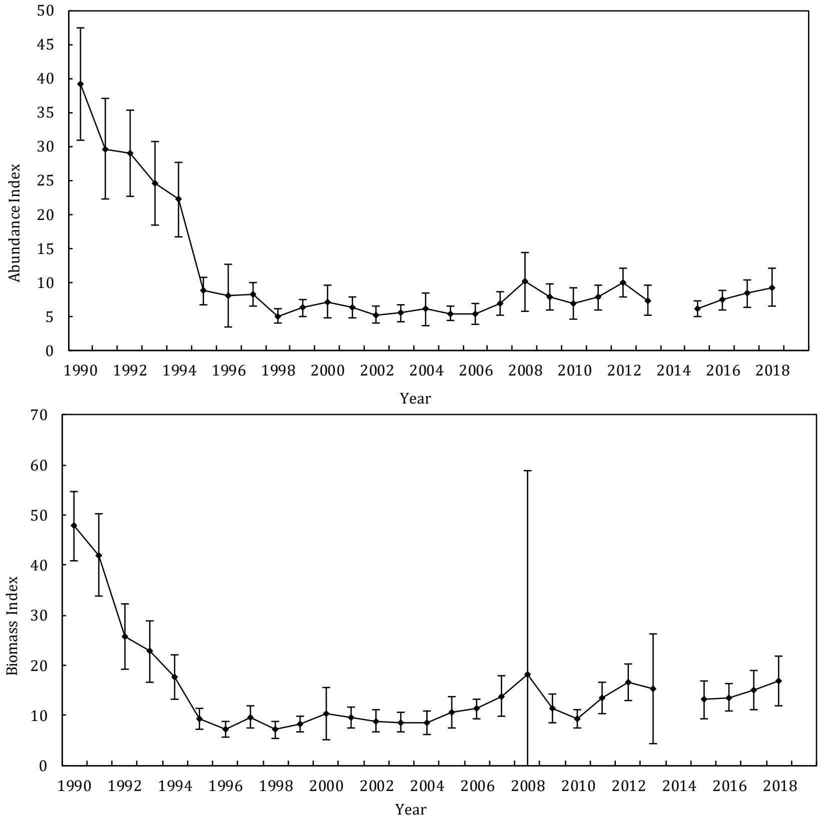


Figure 16.3. Thorny skate in Divs. 3LNOPs, 1990-2018: abundance (top panel) and biomass (bottom panel) indices from Canadian autumn surveys.

EU-Spain Divs. 3NO Survey. EU-Spain survey indices (Campelen or equivalent) are available for 1997-2018. The survey only occurs in the NAFO Regulatory Area, thus not sampling the entire Divisions. The biomass trajectory from the EU-Spain survey has generally decreased since 2004 while the Canadian survey has generally increased since 1997 (Figure 16.4).

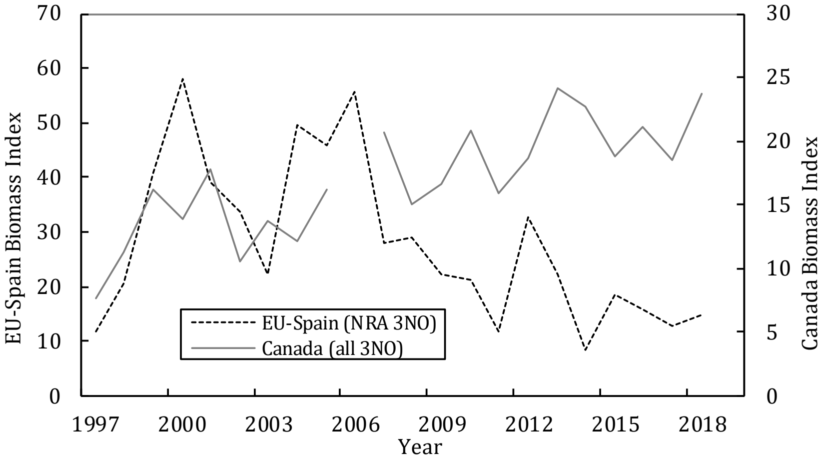


Figure 16.4. Thorny skate in Divs. 3LNOPs: biomass indices from the EU-Spain survey and the Canadian spring survey in 1997-2018. Canadian autumn survey indices are shown in figure 16.3.

EU-Spain Div. 3L survey. EU-Spain survey indices (Campelen trawl) are available for 2003-2018 (excluding 2005). The survey only occurs in the NAFO Regulatory Area of Div. 3L. 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 fall survey has generally increased since 2011 while the other surveys have largely varied without trend.

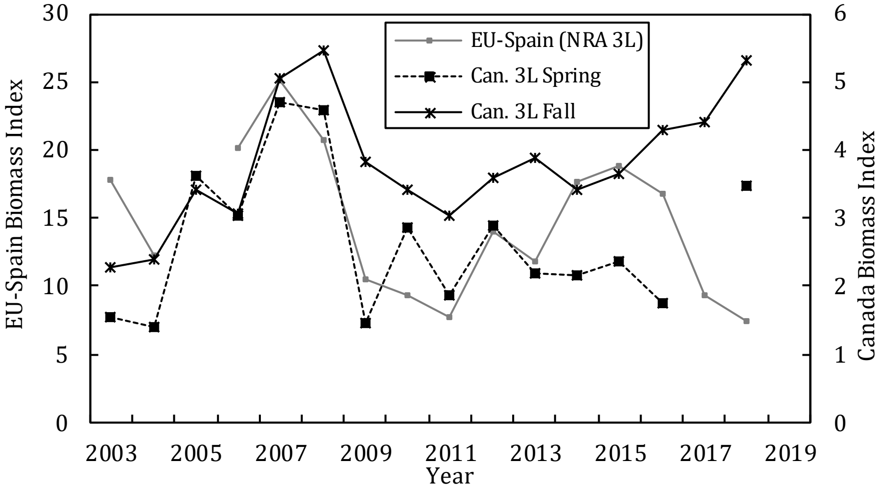


Figure 16.5. Thorny skate in Div. 3LNOPs: Biomass indices from EU-Spain Div. 3L survey and the Canadian spring and autumn surveys of Div. 3L in 2003-2018.

d) Conclusion

With an update of abundance and biomass indices to 2018, there is nothing to indicate a significant change in the status of this stock.

e) Research Recommendations

STACFIS **recommended** that *further work be conducted on development of a quantitative stock model.*

STATUS: Work ongoing. STACFIS reiterated this recommendation.

STACFIS **recommended** that *survey indices be investigated to compare catch rates in relation to depth in the spring and fall surveys, stock distribution, and comparison between Divs. 3LNO and Subdiv. 3Ps~~.~~*

STATUS: completed.

The next full assessment of this stock is planned for 2020.

17. White Hake (*Urophycis tenuis*) in Divisions 3NO and Subdivision 3Ps

(SCR Doc. 19/15,20,22; SCS Doc. 19/09,10,11)

a) Introduction

The advice requested by Fisheries Commission is for NAFO Div. 3NO. On the Grand Bank, white hake are near the northern limit of their range, concentrated along the southwest slope of the Grand Bank and experience episodic recruitment. 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 in 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.

Canada commenced a directed fishery for white hake in 1988 in Div. 3NO and Subdiv. 3Ps. All Canadian landings prior to 1988 were as bycatch in various groundfish fisheries. EU-Spain and EU-Portugal began 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 catches. There were no directed fisheries by EU-Spain in 2004 or by EU-Spain, EU-Portugal, or Russia in 2005-2018. 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 in Div. 3NO for white hake was first implemented by Fisheries Commission in 2005 at 8 500 tons, and then reduced to 6 000 t for 2010-2011. The TAC in Div. 3NO for 2012 was 5 000 t, and 1 000 t for 2013-2019. Canada has implemented a TAC of 500 t for Subdiv. 3Ps for 2018-2020.

From 1970-2009, white hake landings in Div. 3NO fluctuated, averaging approximately 2 000 t, exceeding 5 000 t in only three years during that period. Landings peaked in 1987 at approximately 8 100 t (Figure 17.1). With the restriction of fishing by other countries to areas outside Canada's 200-mile limit in 1992, non-Canadian landings fell to zero. Landings were low in 1995-2001 (422-t average), 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 decreased to an average of 369 t in 2008-2016. Catch in 2017 was reported as 512 t and 383 t in 2018.

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 1 174 t in 2004-2007, then decreased to a 348-t average in 2008-2016. Catch in 2017 was reported as 308 t, and 328 t in 2018.

Recent reported landings and TACs (000 tons) in NAFO Div. 3NO and Subdiv. 3Ps are as follows:

	2010	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**
Div. 3NO:										
TAC	6	6	5	1	1	1	1	1	1	1[1]
STATLANT-21	0.3	0.2	0.1	0.2	0.3	0.4	0.4	0.5	0.3	
STACFIS	0.2	0.2	0.1	0.2	0.3	0.5	0.4	0.5	0.4	
Subdiv. 3Ps:										
TAC									0.5	0.5
STATLANT-21	0.4	0.2	0.2	0.2	0.4	0.3	0.4	0.3	0.3	

[1] May change in-season. See NAFO COM Doc. 19/01

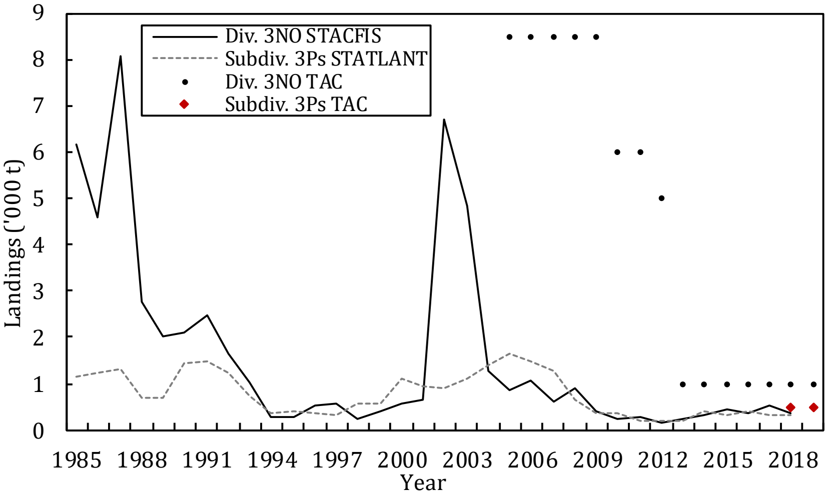


Figure 17.1. White hake in Div. 3NO and Subdiv. 3Ps: Total catch of white hake in NAFO Division 3NO (STACFIS), and Subdivision 3Ps (STATLANT-21A). The Total Allowable Catch (TAC) in the NRA of Div. 3NO is also indicated on the graph.

b) Input Data

i) Commercial fishery data

Length composition. Length frequencies were available for Canada (1994-2018), EU-Spain (2002, 2004, 2012, 2014-2018), EU-Portugal (2003-2004, 2006-2016), and Russia (2000-2007, 2013-2016). Different length ranges appeared to be highly variable depending on gear types, years and areas. In the Canadian directed fishery in 2016, the length range caught by longlines in Div. 3O was 36-114 cm. In 2017 and 2018, the Canadian longline fishery in Subdiv. 3Ps caught white hake ranging from 41-120 cm range. In 2015-2017, the Canadian witch flounder trawl fishery (152-155 mm mesh) in Div. 3O caught 34-110 cm white hake, while this fishery caught 49-87 cm fish in Subdiv. 3Ps. Sizes reported from bycatch in commercial trawls fishing in the NRA of Div. 3NO by EU-Spain in 2017 were 14-106 cm (280 mm mesh), and 29-104 cm (130 mm mesh). In 2018, EU-Spain reported 18-87 cm fish, with a mode of 38 cm in the 130 mm mesh gear. EU-Portugal reported 27-69 cm fish in 2015 (130 mm mesh), and 30-65 cm fish in 2016. Russia reported 32-84 cm white hake in 2015, and 38-44 cm fish from a small sample in 2016. Overall length sampling in recent years has been insufficient due to small sample sizes and there is no information available in 2017 and 2018 from Portuguese catches or 2018 Spanish catches from 280 mm mesh.

ii) 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 2018. 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. Data from autumn surveys in Div. 3NO were available from 1990 to 2018, due to mechanical difficulties the survey was not completed in 2014. 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 1995-2018. 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 2007-2018, 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. 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 increased in 2014, biomass declined slightly over 2015- 2018.

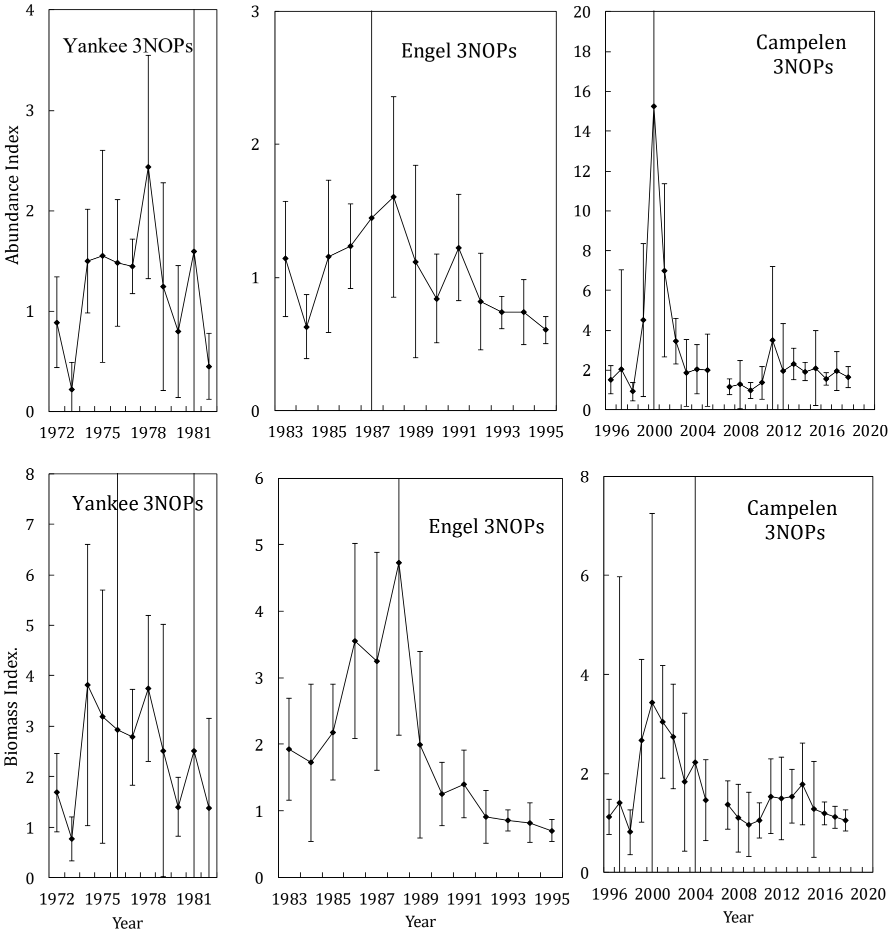


Figure 17.2a. White hake in Div. 3NO and Subdiv. 3Ps: abundance (top panels) and biomass (bottom panels) indices from Canadian spring research surveys, 1972-2018. Estimates from 2006 are not shown, since survey coverage in that year was incomplete. Yankee, Engel, and Campelen time series are not standardized, and thus are presented on separate panels. Error bars are 95% confidence limits. The bounds of the error bars in 1976, 1981, 1987, 2000, 2012, and 2015 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 until 2010. In 2011-2013, both biomass and abundance appear to have slightly increased then declined over 2015-2018. This survey was not completed in 2014.

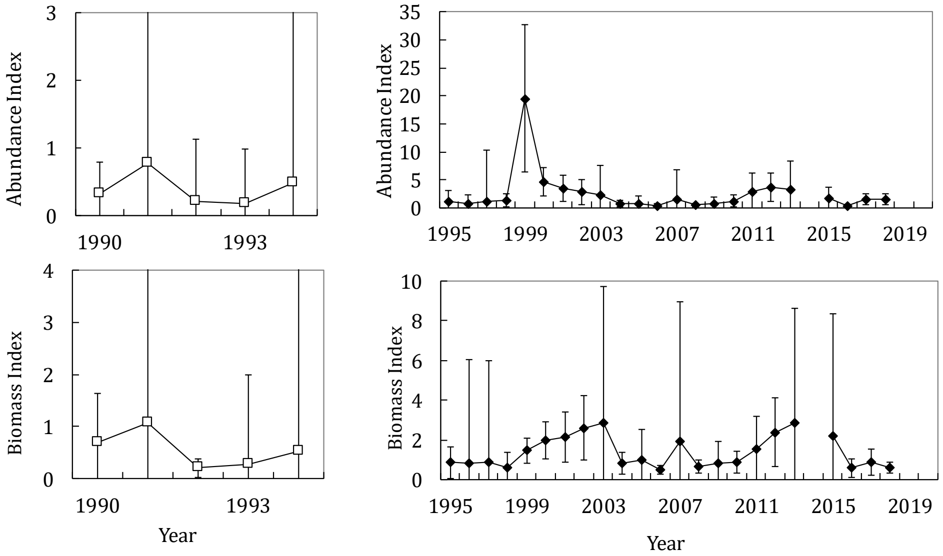


Figure 17.2b. White hake in Div. 3NO: abundance (top panel) and biomass indices (bottom panel) from Canadian autumn surveys, 1990-2018. Engel (☐, 1990-1994) and Campelen (◆, 1995-2018) time series are not standardized. Estimates from 2014 are not shown, since survey coverage in that year was incomplete. Error bars are 95% confidence limits. The bounds of the error bars in 1990-1994, 2002-2009, 2013, and 2016 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 2018 (Figure 17.3). 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 in 2017 and 2018 to a similar level as observed in 2014.

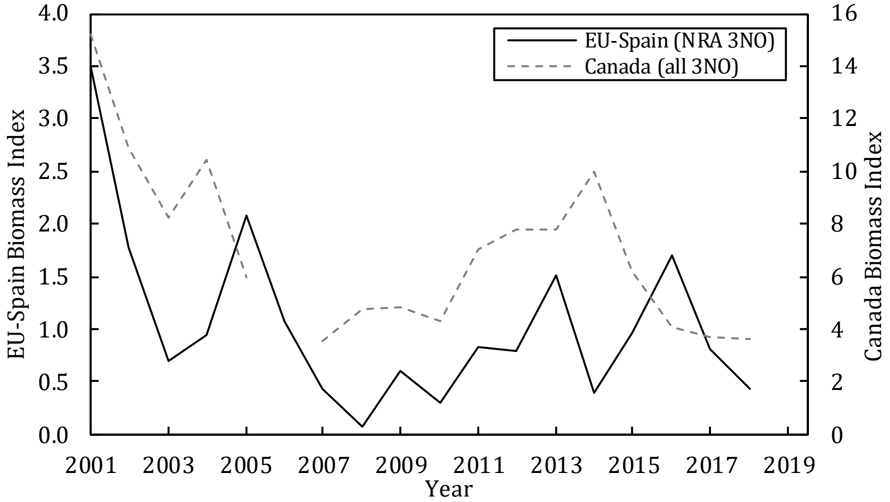


Figure 17.3. White hake in the NRA of Div. 3NO: Biomass indices from EU-Spain Campelen spring surveys in 2001-2018 compared to Canadian spring survey indices in all of Div. 3NO. Estimates from 2006 Canadian survey are not shown, since survey coverage in that year was incomplete.

iii) Biological studies

Distribution. White hake in Div. 3NO and Subdiv. 3Ps are confined largely to an area associated with the warmest bottom temperatures (4-8°C) along the southwest edge of the Grand Banks, edge of the Laurentian Channel, and southwest coast of Newfoundland.

White hake distribute in different locations during various stages of their life cycle. Fish <26 cm in length (1st year fish) occur almost exclusively on the Grand Bank in shallow water. Juveniles (2+ years) are widely spread, and a high proportion of white hake in the Laurentian Channel area of Subdiv. 3Ps are juveniles. Mature adults concentrate on the southern slope of the Bank in Div. 3NO, and along the Laurentian Channel in Subdiv. 3Ps.

Maturity. Maturity at size was estimated for each sex separately, using Canadian Campelen spring survey data from 1996-2018 (Figure 17.4). Length at 50% maturity (L_{50}) is different between sexes; with fifty percent of males maturing at 38 cm, and fifty percent of females maturing at 53 cm. However, L_{50} was very similar for each sex between Div. 3NO and Subdiv. 3Ps.

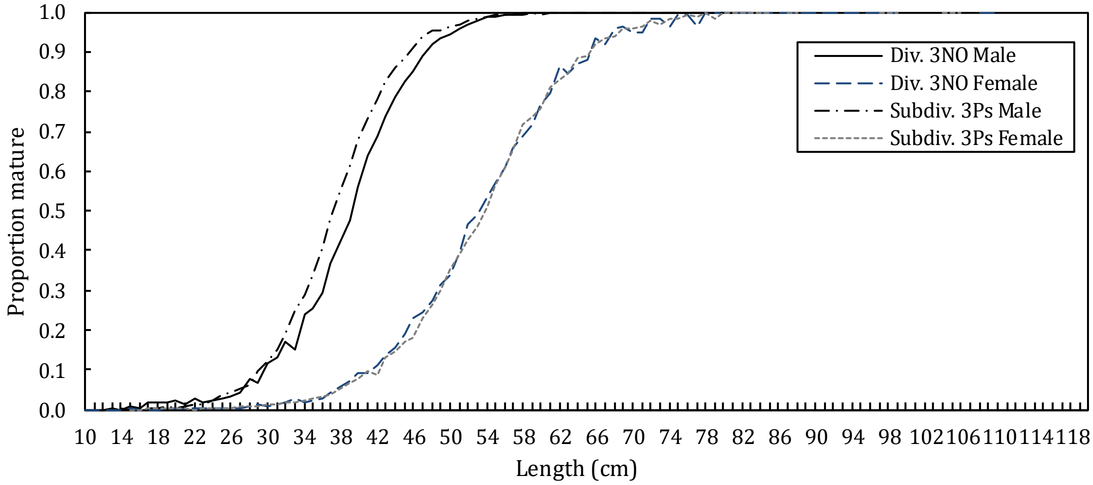


Figure 17.4. White hake in Div. 3NO and Subdiv. 3Ps: ogives calculated for each sex from Canadian spring surveys, and averaged over 1996-2018 (excluding 2006).

Life stages. Canadian spring survey trends in abundance for 1996-2018 were staged based on length as one-year-olds (≤26 cm; YOY), 2+ juveniles (27-57 cm), and mature adults (58+ cm; Figure 17.5). Recruitment of one-year-old male and female white hake was highest in 2000, and has since been variable at a very low level. Immature white hake older than two years dominate the population. There are currently no indications of increased abundance of mature white hake.

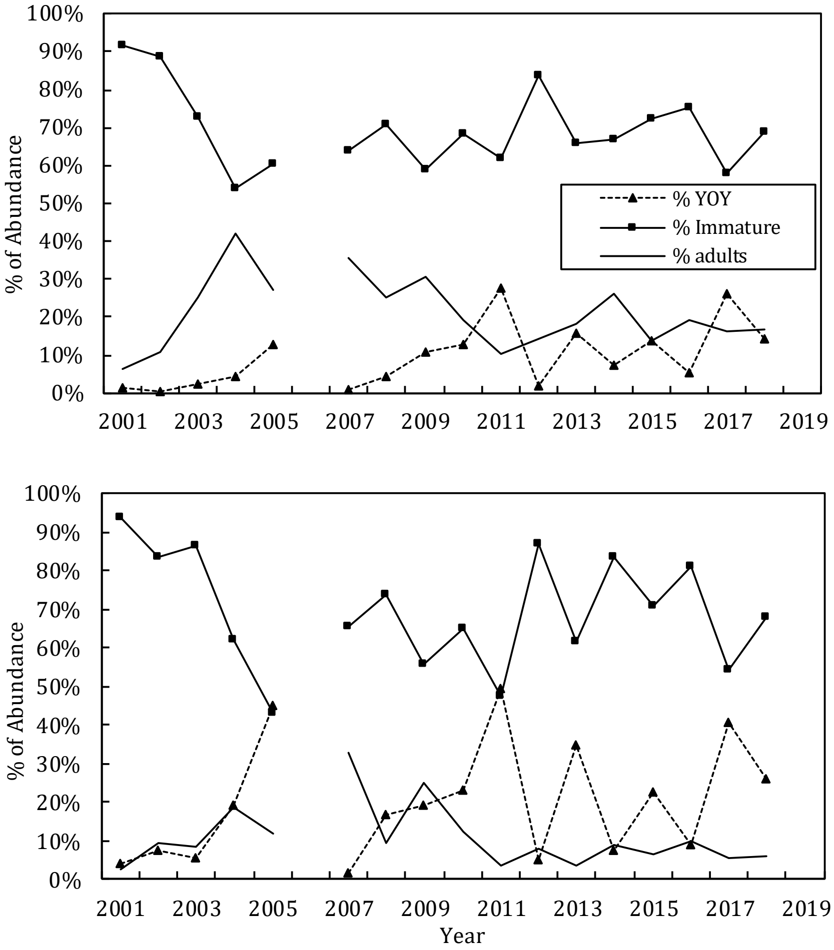


Figure 17.5. White hake in Div. 3NO and Subdiv. 3Ps: proportion of stages in terms of abundance by sex (female, upper panel; male, lower panel) from Canadian Campelen spring survey data in 1996-2018. Estimates from 2006 are not shown, since survey coverage in that year was incomplete.

iv) 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 2001-2018 (Figure 17.6). Recruitment was higher in 2011, but not comparable to the very high recruitment observed in 2000.

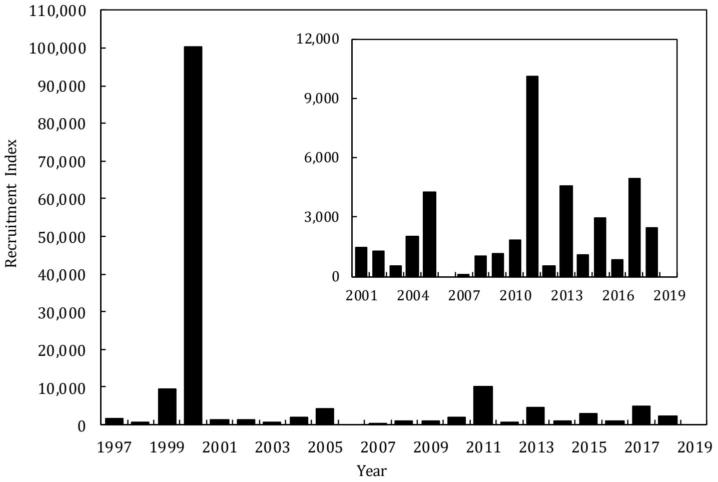


Figure 17.6. White hake in Div. 3NO and Subdiv. 3Ps: recruitment index for age 1 males and females (combined) from Canadian Campelen spring surveys in Div. 3NO and Subdiv. 3Ps in 1997-2018. Estimates from 2006 are not shown, since survey coverage in that year was incomplete. Inset plot depicts 2001-2018 on a smaller scale.

c) Assessment Results

This stock is assessed based upon a qualitative evaluation of stock survey biomass trends and recruitment indices.

Biomass. Biomass of this stock increased in 1999 and 2000, generated by the large recruitment observed in those years. Subsequently, the biomass index decreased and has since remained variable but lower.

Recruitment. Recruitment in 2000 was very large, but no large year class has been observed since then. Recruitment was higher in 2011, but not comparable to the very high recruitment observed in 2000.

Relative F (commercial landings/Canadian spring survey biomass). Using STACFIS-agreed commercial landings and Canadian spring survey biomass index, estimates of relative F were calculated for white hake in Div. 3NO and Div. 3NOPs. Relative fishing mortality has fluctuated, but increased considerably in 2002-2003 (Figure 17.7). Relative F estimates have been low since 2010.

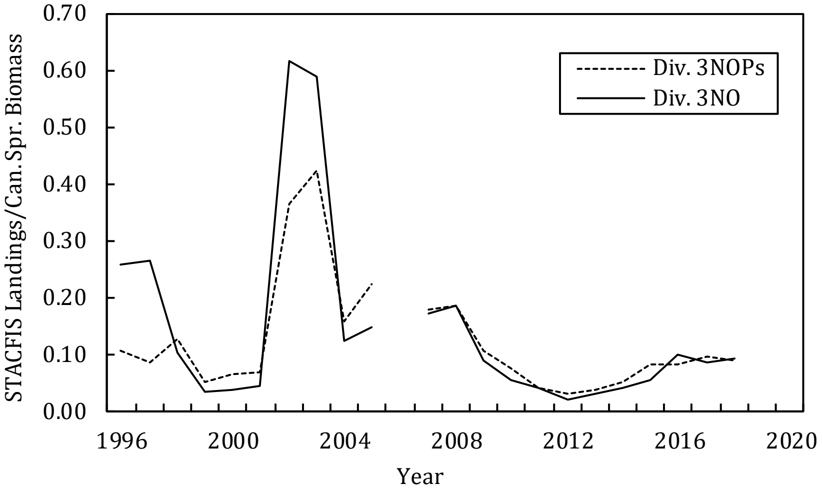


Figure 17.7. White hake in Div. 3NO and Subdiv. 3Ps: estimates of relative *F* from STACFIS-agreed commercial landings/Canadian Campelen spring survey biomass (1996-2018). Estimates from 2006 are not shown, since survey coverage in that year was incomplete.

State of the stock. The assessment is considered data limited and is associated with a relatively high uncertainty. Biomass of this stock increased in 1999 and 2000, generated by the large recruitment observed in those years. Subsequently, the biomass index decreased and has since remained variable but lower. No large recruitments have been observed since 2000. Fishing mortality is low.

d) Reference Points

No precautionary reference points have been established for this stock.

e) 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.*

Status: Otoliths are being collected, but have not been aged. STACFIS reiterates this recommendation.

STACFIS **recommended** that *the collection of information on commercial catches of white hake be continued and now include sampling for age, sex and maturity to determine if this is a recruitment fishery.*

Status: No progress in 2018 and will not be carried forward in 2019.

STACFIS **recommended** that *survey conversion factors between the Engel and Campelen gear be investigated for this stock.*

Status: No progress, STACFIS reiterates this recommendation.

STACFIS **recommended** that *work continue on the development of population models and reference point proxies.*

Status: Various formulations of a surplus production model in a Bayesian framework were explored and work is continuing.

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

D. WIDELY DISTRIBUTED STOCKS: SA 2, SA 3 AND SA 4

Recent Conditions in Ocean Climate and Lower Trophic Levels

- The ocean climate index based on data from Labrador to the Scotian Shelf (SA2-4) has remained mostly warmer than normal since 2010. Average spring bloom total production across NAFO subarea 2-3-4 was near normal in 2018 after three years of negative anomalies.
- Mean timing of spring bloom initiation was back to normal in 2018 after the early timing of 2016 and 2017.
- The zooplankton abundance index was above normal in 2018 for a 5th consecutive year.
- The zooplankton biomass index was below normal in 2018 for a 4th consecutive year.

Environmental Overview

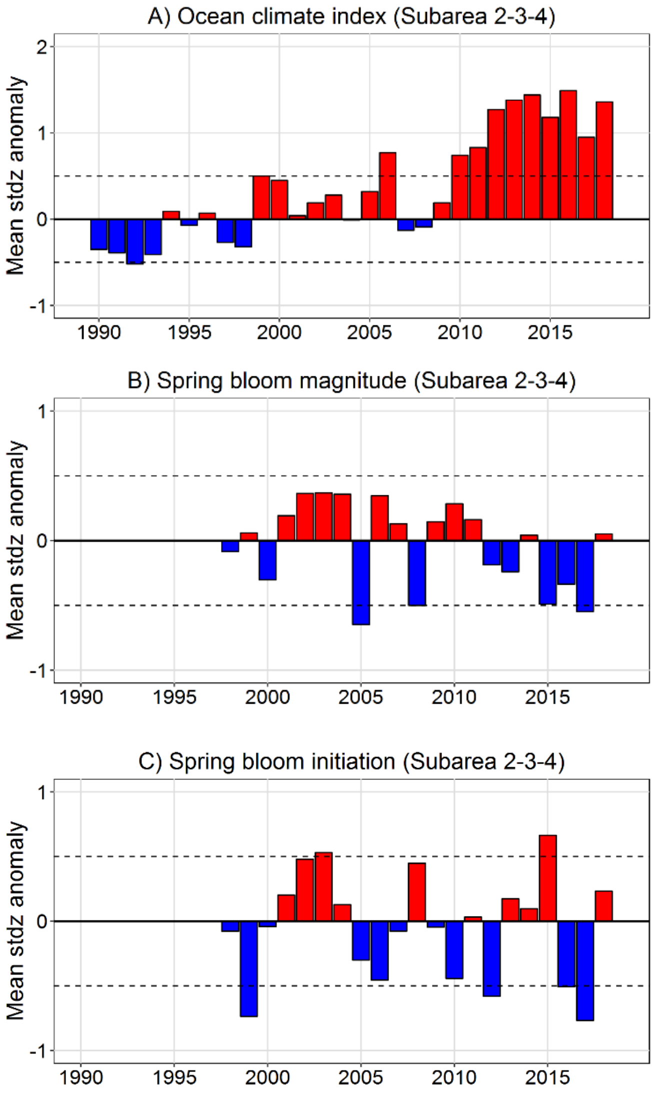
The water mass characteristics of Newfoundland and Labrador Shelf are typical of sub-polar waters with a sub-surface temperature range of -1-2ºC and salinities of 32-33.5. Labrador Slope Water flows southward along the shelf edge and into the Flemish Pass region, this water mass is generally warmer and saltier than the sub-polar shelf waters with a temperature range of 3º-4ºC and salinities in the range of 34-34.75. On average bottom temperatures remain <0ºC over most of the northern Grand Banks but increase to 1-4ºC 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 (1-3ºC) except for the shallow inshore regions where they are mainly <0ºC. In the deeper waters of the Flemish Pass and across the Flemish Cap bottom temperatures generally range from 3-4ºC. 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 8-13ºC and salinities from 34.7-35.6, and Labrador Slope Water, with temperatures from 3.5ºC to 8ºC 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

Ocean climate index (Figure 4A) from Labrador to the Scotian Shelf (SA 2-4), after a cold period in the early 1990s, has remained above normal since 2010. Years 2016, 2014, 2013 and 2018 (ranked in this order) are the warmest anomalies since 1949.

Mean spring bloom total production (magnitude) was near normal in 2018 (Figure 4, 2nd panel). after three years of negative anomalies reaching a record-low for the time series in 2017 (Figure 4B). Mean timing of spring bloom initiation was back to normal in 2018 after the early bloom observed in 2016 and 2017 (Figure 4C). Mean timing of the spring bloom remained mostly near normal since 1998 with only few slightly positive and negative anomalies observed throughout the 21-y time series.

Zooplankton abundance shows an overall increasing trend since the early 2000s with a marked increased after 2013. The zooplankton abundance index was above normal in 2018 for a 5th consecutive year (Figure 4D). Zooplankton biomass shows an overall decreasing trend since the early 2000s with a marked decline in biomass after 2014. Mean zooplankton biomass index was below normal in 2018 for 4th consecutive year (Figure 4E).


A) Ocean climate index (Subarea 2-3-4)
Mean stdz anomaly
2
1
0
-1
1990
1995
2000
2005
2010
2015
B) Spring bloom magnitude (Subarea 2-3-4)
Mean stdz anomaly
1
0
-1
1990
1995
2000
2005
2010
2015
C) Spring bloom initiation (Subarea 2-3-4)
Mean stdz anomaly
1
0
-1
1990
1995
2000
2005
2010
2015

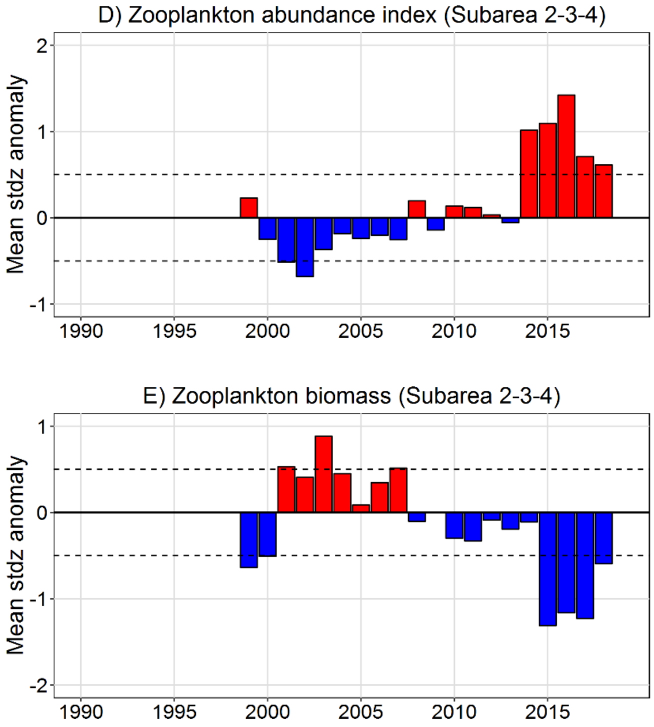


Figure 4. Environmental indices for NAFO Sub-areas 2 to 4 during 1990-2018. The ocean climate index (A) is the average of 16 individual time series of standardized ocean temperature anomalies: vertically average ocean temperature at Station 27 (0-176 m) and Station Prince-5 (0-90 m), surface (0-50 m) and bottom (150 m) temperature at Station Halifax-2, mean temperature and CIL volumes over standard hydrographic sections Seal Island, Bonavista and Flemish Cap, mean bottom temperature in 3LNO (spring and fall) and 3M and 4VWX (summer), deep (150-200m) temperatures in the Northeast Channel (NEC) and near surface (0-30 m) temperatures in the Gulf of Maine (GoM). Most of these data are presented in Cyr et al. (2019), expect temperatures for NEC and GoM that have been obtained from the ICES report on ocean climate (IROC; https://ocean.ices.dk/iroc/). Phytoplankton spring bloom magnitude (B) and duration (C) indices for the 1998-2018 period are derived from 21 satellite Ocean Colour boxes distributed across NAFO subarea 2 (Hudson Strait, Bravo, Hamilton Bank), 3 (St. Anthony Basin, Northeast Newfoundland Shelf, Avalon Channel, Hibernia, Flemish Pass, Southeast Shoal, Green-St. Pierre Bank), and 4 (Northwest GSL, Northeast GSL, Magdalen Shallows, Cabot Strait, Eastern Scotian Shelf, Western Bank, Central Scotian Shelf, Western Scotian Shelf, Lurcher Shoal, Geoges Bank). Zooplankton abundance (D) and biomass (E) indices for the 1999-2018 period are derived from 14 standard oceanographic cross-shelf sections and five high-frequency coastal sampling stations distributed across NAFO subarea 2 (Seal Island), 3 (Bonavista Bay, Flemish Cap, Southeastern Grand Banks, Station 27), and 4 (Eastern St. Lawrence, Sept-Îles, Southwest Anticosti, Bonne Bay, Central GSL, Magdalen Islands, Rimouski, Shediac Valley, Cabot Strait, Louisbourg, Halifax, Browns Bank, Halifax-2, Prince-5). The Zooplankton abundance index includes total copepod and non-copepod abundances. Positive/negative anomalies indicate conditions above/below (or late/early initiation) the long-term average for the reference period. All anomalies are mean standardized anomaly calculated using the following reference periods: ocean climate index, 1981-2010; phytoplankton indices (magnitude and peak timing): 1998-2015; zooplankton indices (abundance and biomass): 1999-2015. Anomalies within ±0.5 SD (horizontal dashed lines) are considered normal conditions.

18. Roughhead Grenadier (*Macrourus berglax*) in Subareas 2 and 3

(SCR Doc. 19/13, 15, 20, 21 and 23; SCS Doc. 19/09, 10 and 11)

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 their relationship. 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.

i) Description of the fisheries and catches

Roughhead grenadier is taken as by catch in the Greenland halibut fishery, mainly in NRA Divisions 3LMN. Most roughhead grenadier catches are taken by trawl and the only management regulation applicable to roughhead grenadier in the NRA is a general groundfish regulation requiring the use of a minimum 130 mm mesh size.

A substantial part of the grenadier catches in Subarea 3 previously reported as roundnose grenadier has been roughhead grenadier. To correct the catch statistics STACFIS revised and approved roughhead grenadier catch statistics since 1987. Catches increased sharply from 1989 (333 tons) to 1992 (6725 tons); since then until 1997 total catches have been around 4000 t. In 1998 and 1999 catches increased and were near the level of 7000 tons. In the period 2001–2004, catches decreased to 3000–4000 tons and to 1000 tons in 2007. In the period 2007-2012, annual catches have been around 1000 tonnes and since then catches have been about or less than 500 tonnes (Figure 18.1). Most of the catches were taken in Div. 3LMN by Spain, Portugal and Russia fleets. In the catch series available, less than 2% of the yearly catch has been taken in Subarea 2.

Recent catches ('000 tons) are as follow:

	2010	2011	2012	2013	2014	2015	2016	2017	2018
STATLANT 21	0.8	1.0	1.3	0.4	0.6	0.2	0.1	0.1	<0.1
STACFIS	0.9	1.0	1.3	0.4	0.6	0.2	0.3	0.4	0.5

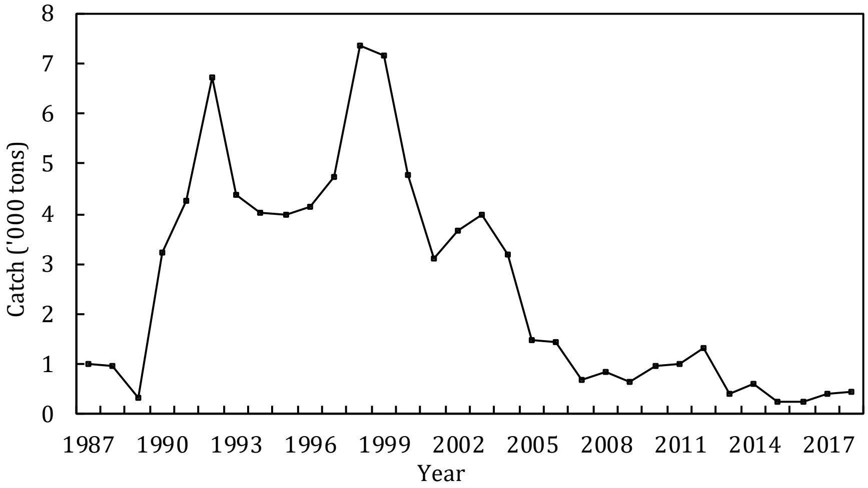


Figure 18.1. Roughhead grenadier in Subareas 2+3: total catches.

b) Input Data

i) Commercial fishery data

Length frequencies from the Spanish, Russian and Portuguese trawl catches in Divs 3LMNO are available in different years. Due to the growth differences between sexes, length and age data have been analyzed by sex. Catch-at-age data from the total catches in Divs. 3LMNO were obtained since 1992 applying an annual Spanish commercial ALK. In the period 2016-2017, most of annual catches are composed between ages 3 and 5, with a mode at age 4. These age distributions are lower than that observed in 2018 where the mode was between 5 and 6 years. The age distribution of 2018 was similar to those of the 2010-2015 years and a little smaller than those of the 2008-2009 period.

ii) Research survey data

Biomass indices for the roughhead grenadier Subareas 2 and 3 stock are available from various research surveys, with different depth and area coverage. None of them cover the total area and depth distribution of this stock.

Canadian autumn surveys. The estimates from 1995 onwards are not directly comparable with the previous time series because of the change in the survey gear. Taking into account the incomplete coverage of some strata in divisions 2GH and 3LMNO only the index of divisions 2J and 3K from both series (Engel and Campelen) are considered. Survey coverage deficiencies within Divs. 2J3K were such that the 2008 and 2018 index from Divs. 2J3K could not be considered comparable to that of the other years. The Engel series (1978-1994) present a clear decreasing trend since 1978 till 1994. The Campelen series shows an opposite trend, the index shows a general upward trend in the period 1995-2017 (Figure 18.2).

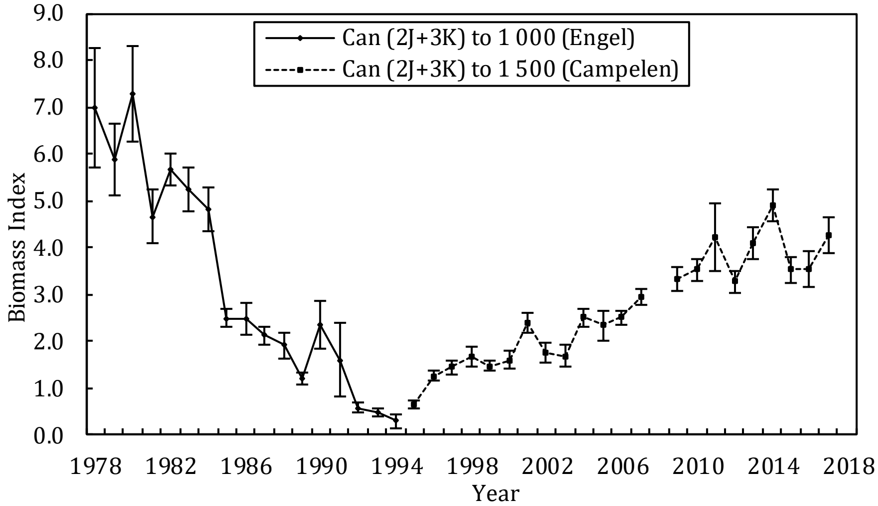


Figure 18.2. Roughhead grenadier in Subareas 2+3: biomass indices (+/- SE) from the Canadian autumn (Div. 2J3K) survey. Note that the two series used different survey gears and are not directly comparable.

Canadian spring surveys. Figure 18.3 shows the biomass index from this survey from 1996 until 2018. Operational difficulties in 2006 and 2015 resulted in incomplete coverage of the survey and the estimates for these years are not directly comparable. The coverage problems of this index in 2018 are considered not to significantly affect the roughhead grenadier biomass index. From 1996 to 2004, the biomass level does not present a clear trend. In 2005 and 2007, the biomass index had a big increase and from 2008 to 2018 it was more or less stable at similar level than the period 1996-2004. The index in the last three years rises and falls without a clear trend. Biomass estimates from the spring survey series are considerably lower than the ones obtained in the autumn series, as the spring surveys cover only the southern divisions and the shallower depths, where according to the Canadian deepwater survey information this species is less abundant.

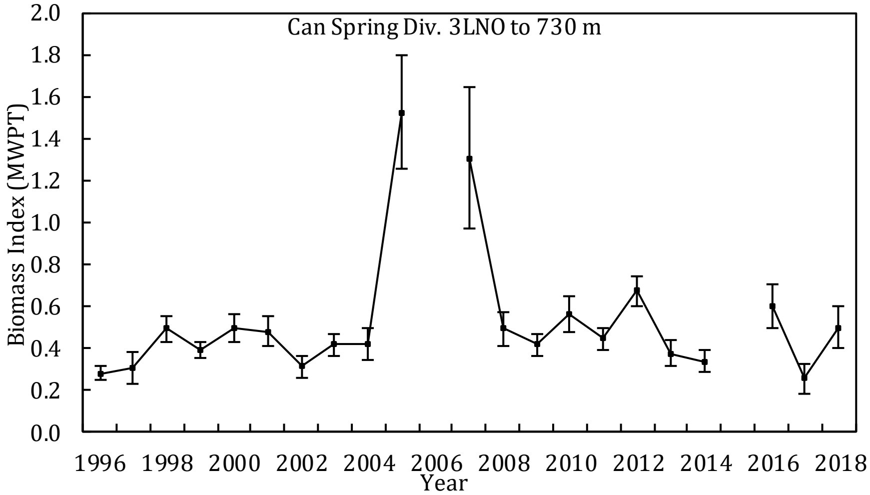


Figure 18.3. Roughhead grenadier in Subareas 2+3: biomass indices from the Canadian spring surveys.

Canadian deepwater survey: Canada conducted deepwater bottom trawl surveys (750 – 1500 m.) in 1991, 1994 and in 1995 in Divisions 3KLMN. Most of the biomass was taken in Div. 3L and 3M at depths more than 700 m, which confirms that the stock in those Divisions is distributed beyond the depths covered by the spring surveys in those Divisions.

EU (Spain and Portugal) Flemish Cap survey. Indices of biomass are presented for the full depth range over 2004 to 2018 and 0-730 m from 1991-2018 (Figure 18.4). The roughhead grenadier age composition from this survey series was presented. The 730 m biomass index presents a peak in 1993. From then until 2002, the biomass index was more or less stable. In the period 2003-2008 the biomass index was at a higher level but it was quite variable between years. Between 2009 and 2011 the index decreased and since then it is stable at low levels. The 1400 indices show a clear decreased trend since the beginning of the series (2004) until 2013 and since then it is stable at low levels.

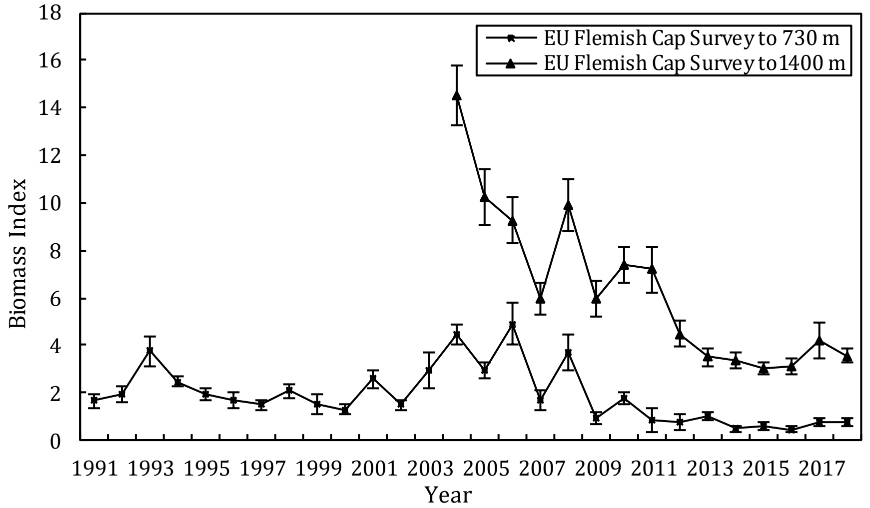


Figure 18.4. Roughhead grenadier in Subareas 2+3: biomass indices (+/- SE) from the EU Flemish Cap (Div. 3M) survey.

EU (Spain) Div. 3NO survey. From 1997 to 2002 the biomass index of this survey was stable. Since then it has increased and in the period 2004-2006 reached the maximum level and since then gradually declined. (Figure 18.5).

EU-Spanish 3L Survey (Flemish pass). The Roughhead grenadier biomass index from 2006 to 2008 was stable and since then presents a clear decreasing trend till 2012. In the period 2013-2015 the index increased to levels similar to the initial period. Between 2016 and 2018 the index shows a decreasing trend, reaching the minimum of the series in 2018. (Figure 18.5).

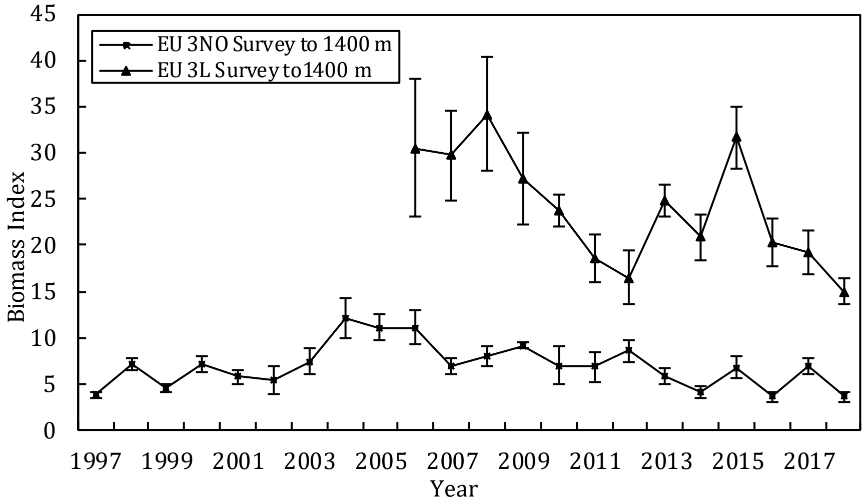


Figure 18.5. Roughhead grenadier in Subareas 2+3: biomass indices (+/- SE) from the EU-Spanish Div. 3NO and 3L surveys.

Summary of research surveys data trends. There are no available surveys indices covering the total distribution, in depth and area, of this stock. According to other information this species is predominant 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 18.6 presents the biomass indices for the following series: Canadian fall 2J+3K Engel (1978-1994) and Campelen (1995-2017), EU 3NO (1997-2018), EU 3L (2006-2018) and EU Flemish Cap to 1400 m (2004-2018). 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.

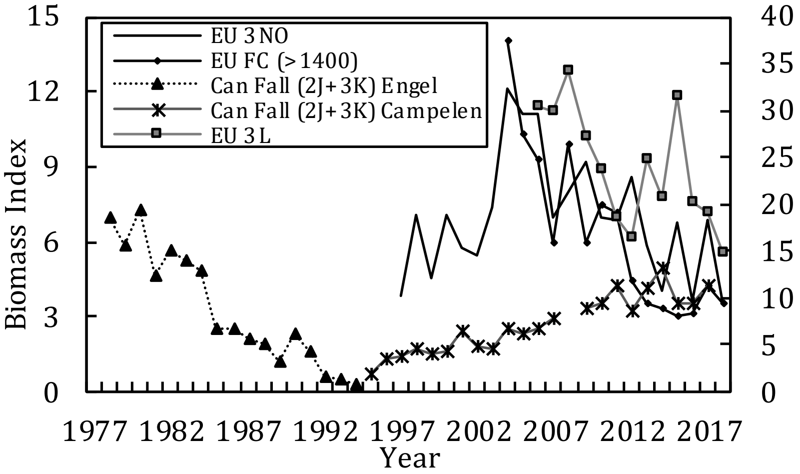


Figure 18.6. Roughhead grenadier in Subareas 2+3: Biomass indices for the Canadian fall 2J+3K Engel (1978-1994) and Campelen (1995-2017), EU 3NO (1997-2018), EU 3L (2006-2018) and EU Flemish Cap till 1400 m (2004-2018).

iii) Recruitment.

The estimated recruitment indices in size and age do not provide much information. Figure 18.7 presents the length distribution series for the EU Div. 3NO and Canadian fall surveys. It can be observed an increase in the abundance of small sizes (less than 10 cm) after 2010 until 2018. .

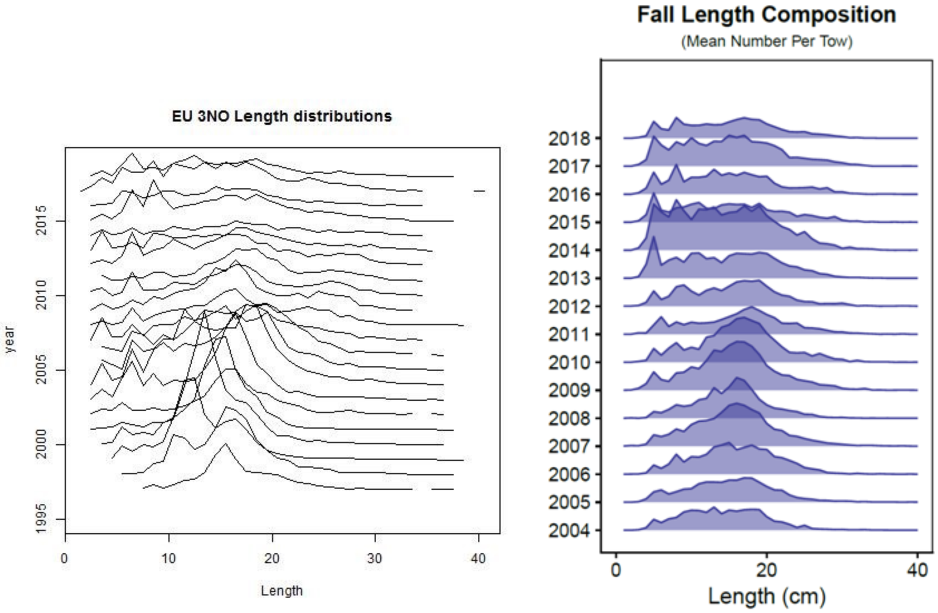


Figure 18.7. Roughhead grenadier in Subareas 2+3: Canadian fall (2J+3K) and the EU Div. 3NO surveys length distributions.

iv) Biological studies

Age and length structure information for commercial catches and surveys indices were provided. Age and length compositions of the catches show clear differences between sexes. The proportion of males in the catches decreased progressively as length or age increases.

A study about the roughhead grenadier reproductive biology including the evaluation of maturity ogive estimates was presented. It was observed a clear decrease in length at first maturity (L50) of females from 27.8 cm in the period 2005-2011 to 25.6 cm in the last four years. The age at first maturity, A50, varied between 13.1 and 15 years, and there is not an evident trend of change over the years. Special attention has been paid to atresia because of its potential impact on stock productivity.

c) Assessment Results

Biomass indices from the surveys with depth coverage to 1500 meters are considered as the best survey information to monitor trends in resource status because they cover the depth distribution of roughhead grenadier fairly well.

Biomass: 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: The total catch / biomass (C/B) ratios which are a proxy for fishing mortality, obtained using different biomass indices, show a clear decreasing trend from 1995 to 2007 and since then are more or less stable at very low level (Figure 18.8).

Recruitment: An increase in the abundance of small sizes fish (less than 10 cm) after 2010 until 2018 can be observed in the surveys.

State of the Stock: **T**here 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. An increase in the abundance of small sized fish (less than 10 cm) after 2010 until 2018 can be observed in the surveys.

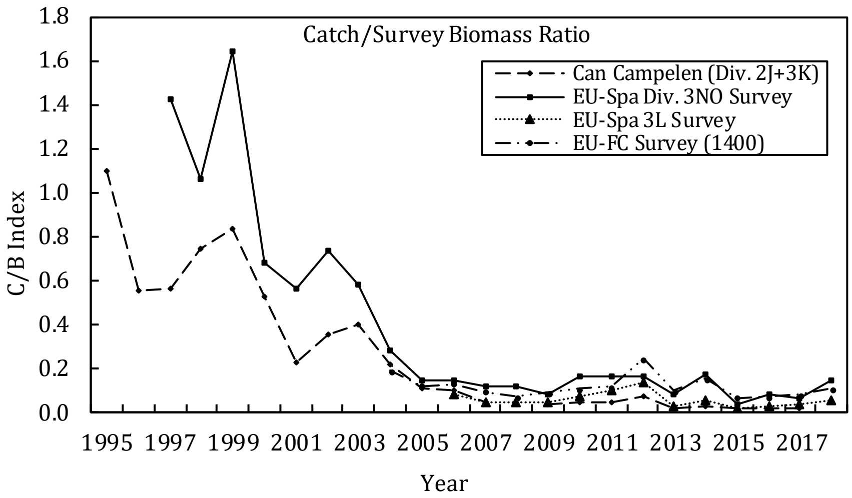


Figure 18.8. Roughhead grenadier in Subareas 2+3: catch/biomass survey indices based upon Canadian Autumn (Campelen series), EU-Spanish Div. 3NO, EU-Spanish 3L and EU-Flemish Cap till 1400 m.

d) Reference Points

STACFIS is not in a position to provide reference points at this time.

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 and Divisions 3KLMNO

a) Introduction

Fishery and Catches: TACs prior to 1995 were set autonomously by Canada; subsequent TACs have been established by the NAFO Commission. Catches increased sharply in 1990 due to a developing fishery in the NAFO Regulatory Area in Div. 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. In 2010, Fisheries Commission implemented a survey-based harvest control rule (FC Doc. 10/12) to generate annual TACs over at least 2011-2014. In 2013 Fisheries Commission extended this 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). The TAC in 2018 is based on the HCR adopted in 2017 (COM Doc 17/17). Catch exceeded the TAC in every year from 2004 to 2014 but was similar to the TAC in 2015 through 2018.

Recent catches and TACs ('000 t) are as follows:

	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
TAC	16	17.2[1]	16.3[1]	15.5[1]	15.4[1]	15.6[1]	14.8[1]	14.8[2]	16.5[3]	16.5[3]
STATLANT 21	15.7	15.7	15.2	15.6	15.6	14.9	14.8	14.7	11.7	
STACFIS	26.2	24.2	23.0	20.0	21.4	15.3	14.9	14.8	16.6	

[1] – TAC generated from HCR
[2] – TAC equal to 2016
[3] – TAC generated from HCR adopted September 2017

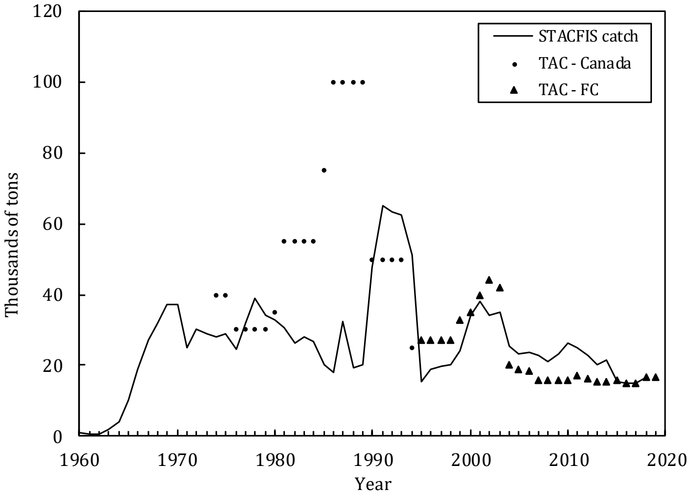


Figure 19.1. Greenland halibut in Subarea 2 + Div. 3KLMNO: TACs and STACFIS catches.

b) Input Data

Standardized estimates of CPUE were available from fisheries conducted by EU- Spain, EU-Portugal and Canada. Abundance and biomass indices were available from research vessel surveys by Canada in Div. 2+3KLMNO, EU in Div. 3M, EU-Spain in Div. 3NO and EU-Spain in Div. 3L. The Canadian autumn survey is divided into indices for Divs. 2J3K (1978-2018 - excluding 2008) and indices down to 730 m for Divs. 3LNO (1996-2018, excluding 2014 when the survey was incomplete), while the Canadian spring indices are for Divs. 3LNO (1996-2018, excluding 2006, 2015, and 2017 due to survey coverage issues). The EU survey in Div. 3M is divided into indices down to 700m (1988-2018), and to 1400 m (2004-2018). The EU-Spain surveys extend from 2006-2018 in Div. 3L and 1997-2018 in Divs. 3NO. Canadian autumn surveys in Div. 2J3K in 2018 and spring 3LNO in 2018 were incomplete but coverage is considered to be sufficient to be indicative of trends. However, the impact of the missed area on age composition should be investigated prior to use in an age structured model (see STACREC: Appendix III, section 7e). Commercial catch-at-age data were available from 1975-2018.

i) Commercial fishery data

Catch and effort.

Analyses of otter trawl catch rates from Canadian vessels operating inside of the Canadian 200 mile limit indicated a general decline from the mid-1980s to the mid-1990s and remained low until a large increase in the late 2000s. The 2010 – 2012 estimates of standardized CPUE for Canadian otter-trawlers decreased substantially. Since then the CPUE has increased to a peak in 2016 before declining to 2018.

Analyses of catch-rates of Portuguese otter trawlers fishing in the NRA of Div. 3LMNO over 1988-2017 show that the CPUE has been variable but at a high level since 2006, reaching a time series high in 2016 before declining to 2018.

Analyses of data from the Spanish fishery show that the CPUE has been variable at a high level since 2006, reaching a time series high in 2016 and 2017, declining to 2018.

In general, for the Russian fishery, the catch rate ranged from 6.2 t to 24.0 t and averaged 15.7 t per fishing vessel day. This catch rate is lower than the 2017 average of 18.2 t per day.

A comparison of the available standardized CPUE estimates from the Canadian, Spanish and Portuguese fleets indicates consistency in the timing and relative magnitude of change over the 2004-2007 period (Figure 19.2). CPUE for all three countries is mainly higher since 2007 than in the period of the 1990s to the mid 2000s. All CPUE estimates have declined from 2016-2018.

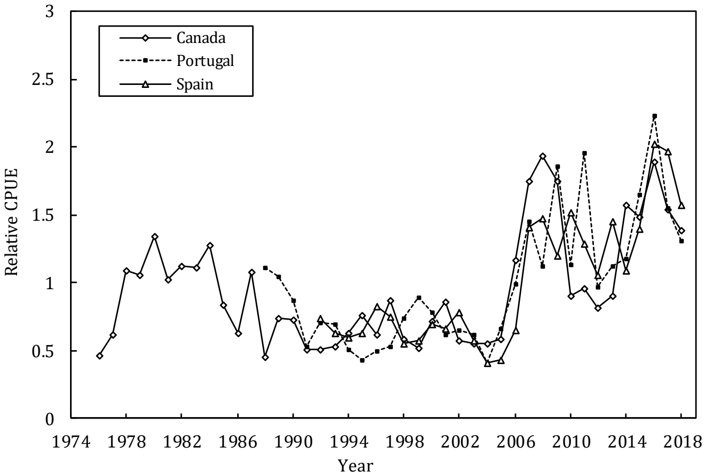


Figure 19.2. Greenland halibut in Subarea 2 + Div. 3KLMNO: standardized CPUE from Canadian, Portuguese and Spanish trawlers. (Each standardized CPUE series is scaled to its 1992-2018 average)

Commercial catch per unit effort for Greenland halibut in Subarea 2 and Div. 3KLMNO is a measure of fishery performance. STACFIS previously recognized that trends in CPUE should not be used as indices of the trends in the stock. It is possible that by concentration of effort and/or concentration of Greenland halibut, commercial catch rates may remain stable or even increase as the stock declines.

c) Catch-at-age and mean weights-at-age.

Length samples of the 2018 fishery were provided by Canada, EU-Spain, EU-Portugal, EU-Estonia, Russia and Japan. Ageing information was available for the Spanish, Canadian, Estonian, and Russian fisheries. Weights were available from EU-Spain, EU-Portugal, and EU-Estonia.

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 of different years (SCR Doc. 12/19). 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 Div. 2J and 3K. The Canadian autumn Div. 2J3K survey provides the longest time-series of abundance and biomass indices (Figure 19.3) for this resource. Biomass declined from relatively high estimates of the early 1980s to reach an all-time low in 1992. The index increased substantially due to the abundant 1993-1995 year-classes, but this increase was not sustained, with declines over 1999-2002. The index increased substantially from 2010-2014 to levels near those of the early part of the time series. However, the index declined substantially from 2015 to 2017, with biomass in 2018 being similar to 2017. The abundance index was stable through the 1980s, but increased substantially in the mid-1990s, again due to the presence of the 1993-1995 year-classes. After this, with the exception of 2010 and 2011, abundance has shown a general decline.

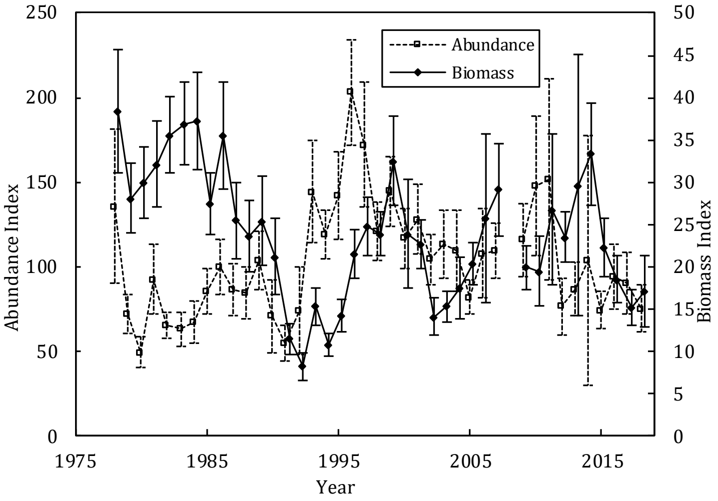


Figure 19.3. Greenland halibut in Subarea 2 + Div. 3KLMNO: biomass and abundance indices (with 95% CI) from Canadian autumn surveys in Div. 2J and 3K. The 2008 survey was not completed.

Canadian stratified-random spring surveys in Div. 3LNO. Abundance and biomass indices from the Canadian spring surveys in Div. 3LNO (Figure 19.4) declined from relatively high values in the late 1990s and have been relatively low in most years thereafter. In 2013, 2014, and 2016, both abundance and biomass were below the time-series average. The 2015 and 2017 surveys were incomplete and are not considered representative of the population. There was an increase in both abundance and biomass in 2018 but the confidence intervals are very wide.

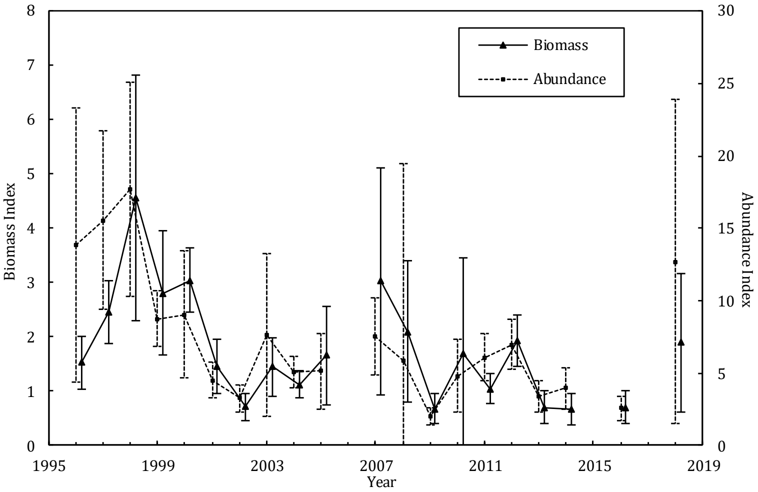


Figure 19.4. Greenland halibut in Subarea 2 + Div. 3KLMNO: biomass and abundance indices (with 95% CI) from Canadian spring surveys in Div. 3LNO.

Canadian stratified-random autumn surveys in Div. 3LNO. Time series of abundance and biomass were developed from the Canadian autumn surveys from 1995-2018 to a depth of 730 m. The abundance index (Figure 19.5) 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. From 2015-2018, biomass and abundance have been increasing from the low levels of 2015 and in 2018 abundance was above and biomass near their respective series averages. The 2014 survey was incomplete and is not considered compatible with the rest of the series.

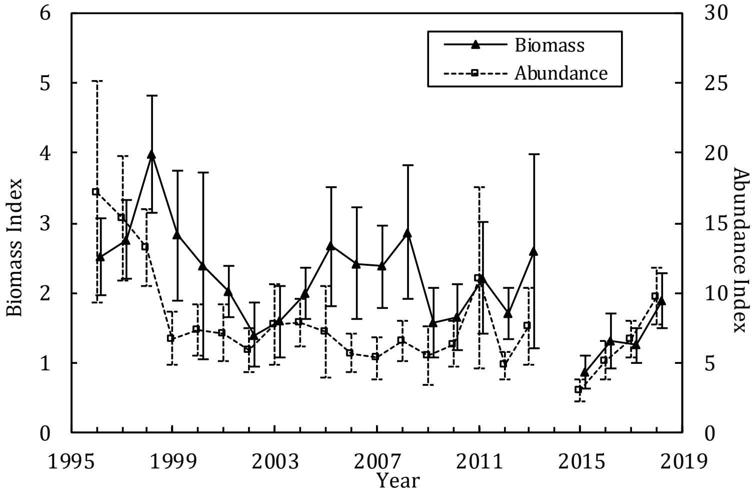


Figure 19.5 Greenland halibut in Subarea 2 + Div. 3KLMNO: biomass and abundance indices (with 95% CIs) from Canadian autumn surveys in Div. 3LNO.

EU stratified-random surveys in Div. 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, (Figure 19.6) increased to a maximum value in 1998. This biomass index has shown a more or less continuous decline since. 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 2015-2018 the index has been variable but above the average of the time series, with 2015 and 2017 being the highest in the series.

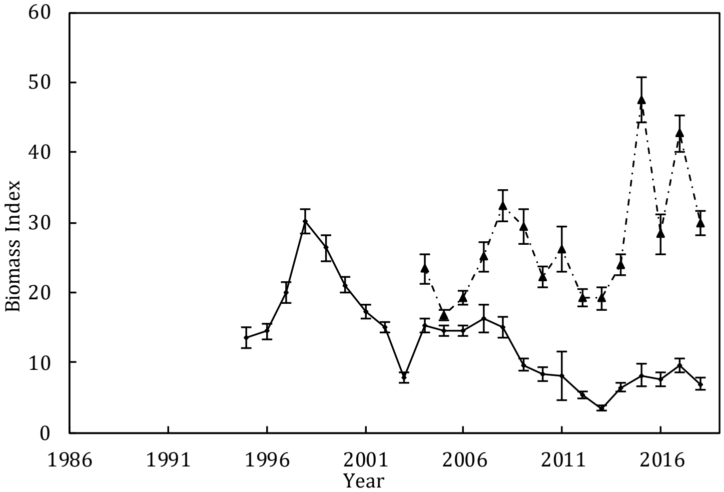


Figure 19.6. Greenland halibut in Subarea 2 + Div. 3KLMNO: Biomass index (± 1 S.E.) from EU Flemish Cap surveys in Div. 3M. Solid line: biomass index for depths <730 m. Dashed line: biomass index for all depths <1460 m.

EU-Spain stratified-random surveys in NAFO Regulatory Area of Div. 3LNO. The biomass index for the survey of the NRA in Div. 3NO generally declined over 1999 to 2006 (Figure 19.7) but increased four-fold over 2006-2009. The survey index increased since 2013 to a time series high in 2017 before declining substantially in 2018. 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 before declining substantially in 2018.

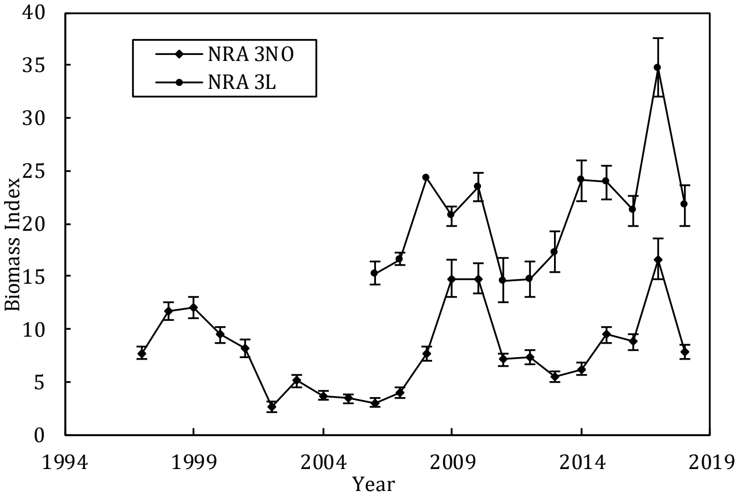


Figure 19.7. Greenland halibut in Subarea 2 + Div. 3KLMNO: biomass index (±1 SE) from EU-Spain spring surveys in the NRA of Div. 3NO and Div. 3L.

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 most of the catches are taken. Over 1995-2007, indices from the majority of the surveys generally provided a consistent signal in stock biomass (Figure 19.8). Results since 2007 show greater divergence which complicates interpretation of overall status. Since 2014 there is a clear divergence with the surveys in the NRA (including 3M) generally increasing and Canadian surveys declining. However, in 2018 there was a substantial decline in surveys conducted in the NRA while Canadian surveys increased.

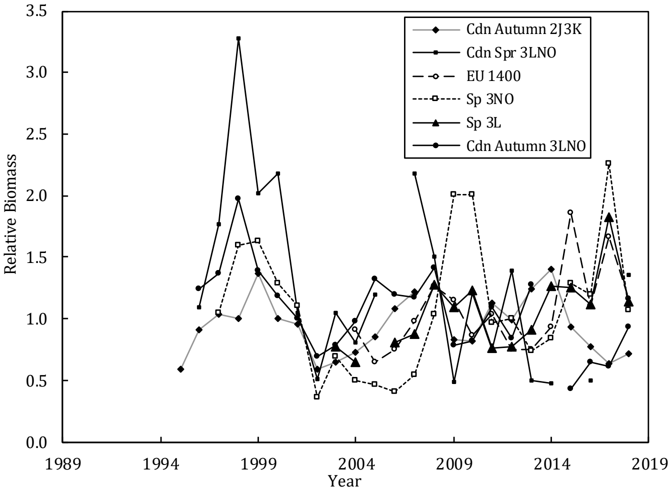


Figure 19.8. Greenland halibut in Subarea 2 + Div. 3KLMNO: Relative biomass indices from Canadian autumn surveys in Div. 2J3K, Canadian spring surveys in Div. 3LNO, Canadian autumn surveys in Div. 3LNO, EU survey of Flemish Cap, and EU-Spain surveys of the NRA of Div. 3NO. Each series is scaled to its 2004-2018 average.

Recruitment from surveys.

Abundance indices at age 4 from surveys were examined as a measure of recruitment (Figure 19.9). All the survey indices have low abundance at age 4 since the 2009 year class. Abundance at age 4 has been below average since the 2009 year class in the Canadian spring Divs. 3LNO survey and since the 2008 year class in the Canadian fall Divs. 2J3K survey. After 3 very large year classes of 2000-2002 in the EU survey of Div. 3M, abundance at age 4 has been below average. The abundance at age 4 in the EU Spain survey of Div. 3NO has been below average since the 2006 year class and in the Canadian Div. 3LNO fall survey since the 2008 year class.

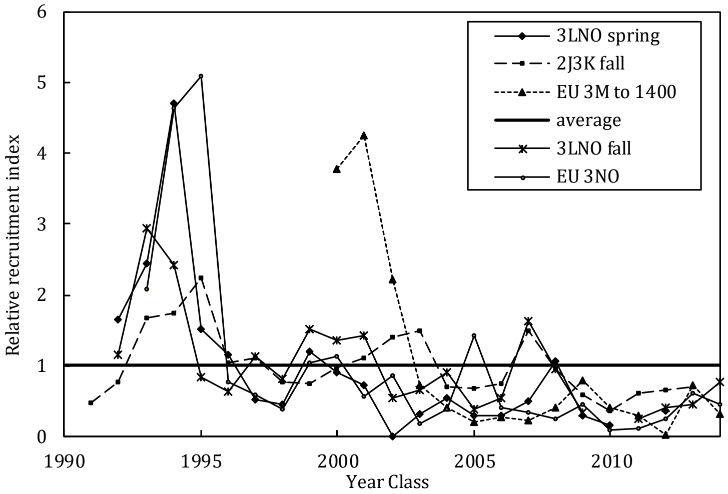


Figure 19.9. Greenland halibut in Subarea 2 + Div. 3KLMNO: Relative recruitment indices from Canadian autumn surveys in Div. 2J3K, Canadian spring surveys in Div. 3LNO, and EU survey of Flemish Cap. Each series is scaled to its average and the average line is shown.

d) Assessment Results

Biomass: Survey data from 2011-2018 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 2018, 3 of the five are above their time series average.

Recruitment: Results of all surveys indicate that recruitment (age 4) has been below average since 2009.

Fishing Mortality: Unknown. Catch exceeded the TAC in 2018 by less than 1%.

State of the stock: Survey results in recent years show greater divergence which complicates interpretation of overall status. The slope for four of the five indices used in the HCR was positive. The composite index calculated in 2018 was above the target for 3 of the five indices.

e) Reference points

Precautionary approach reference points have not been determined for this stock but will be investigated during the update of the assessment model in 2020.

f) Research recommendation

The divergence in survey indices could be the result of movement of fish. STACFIS **recommends** that tagging and/or telemetry studies be undertaken to help elucidate movement of 2+3KLMNO Greenland halibut and that the combination of different survey series be investigated.

20. Northern shortfin squid (*Illex illecebrosus*) in Subareas 3+4

This assessment is deferred until September 2019.

21. Splendid alfonsino (*Beryx splendens*) in Subarea 6

Interim Monitoring Report (SCR 15/06 and SCS Doc. 19/10)

a) Introduction

Alfonsino is distributed over a wide area which may be composed of several populations. Stock structure is unknown. Until more complete data on stock structure is obtained it is considered that separate populations live on each seamount. Alfonsino is an oceanic demersal species which form distinct aggregations, at 300–950 m depth, on top of seamounts in the North Atlantic.

Most published growth studies suggest a 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.

b) Description of the Fishery

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 "Perspektivnaya" (also known as "Kükenthal") and "Vybornaya" ("C-3") are located in the NRA. One more bank named "Rezervnaya" ("Milne Edwards") is located in the Central Western Atlantic.

Russian vessels fished in these area at different periods between 1976 and 1999 using pelagic trawls. A directed commercial fishery has been conducted since 2005 by Spanish vessels. Since 2006 virtually all the effort has been made in the Kükenthal seamount with pelagic trawl gear.

c) Commercial fishery data

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 2004 to present, an alfonsino directed fishery in Kükenthal seamount was conducted by Spanish vessels using a pelagic trawl gear, where catches have ranged between 2 and 1 187 t, with no fishery in 2008.

Table 1. Recent catches (tons), effort (hours fished), CPUE (Kg/hr fished) and number of vessels for the alfonsino fishery on Kükenthal Peak.

	2010	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**
STACFIS Catch (t)	52	152	302	114	118	122	127	51	2
Effort (days)	4	9	22	17	15	13	16	12	8
Effort (hours fished)	66	68	165	87	117	92	116	68	33
CPUE (Kg/hour)	788	2235	1830	1310	1009	1326	1095	809	61
Effort (vessels)	1	1	1	1	1	2	2	1	1

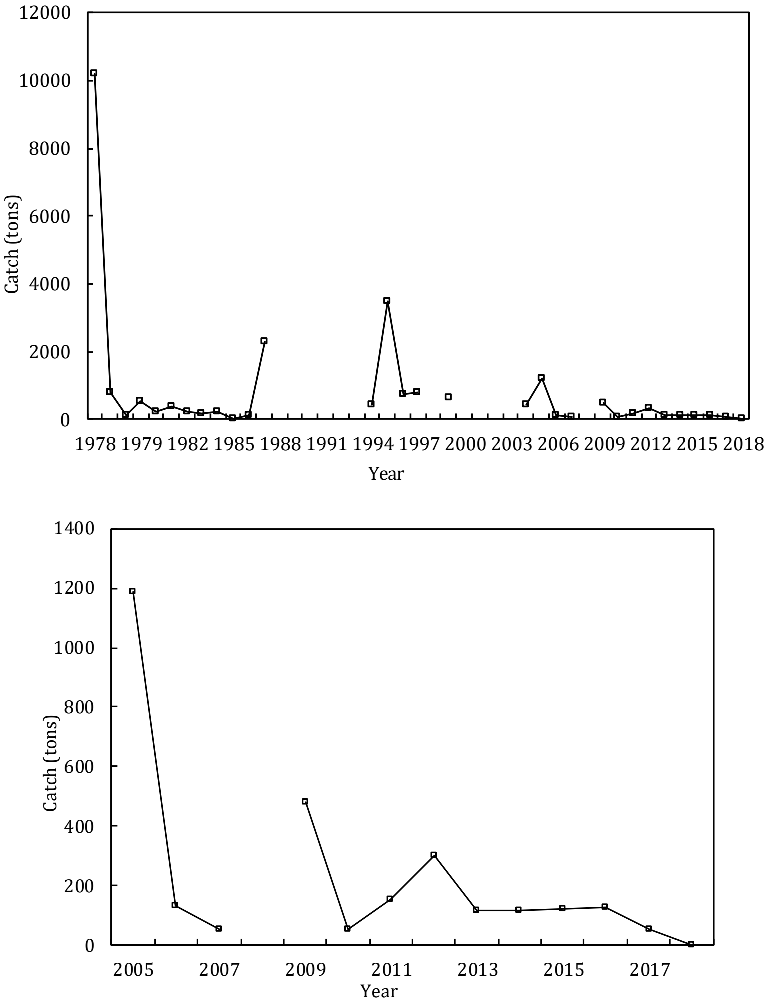


Figure 21.1. Alfonsino catches from Div. 6G. Top panel illustrates the whole catch series (1978-2018) and bottom panel illustrates the catch series since 2005.

Length distribution in percentage by year since 2004 are presented in Figure 21.2. It can be observed that these length distributions are stable and quite similar among years. Catches in all years are in the 30-50 cm range with a mode around 40 cm.

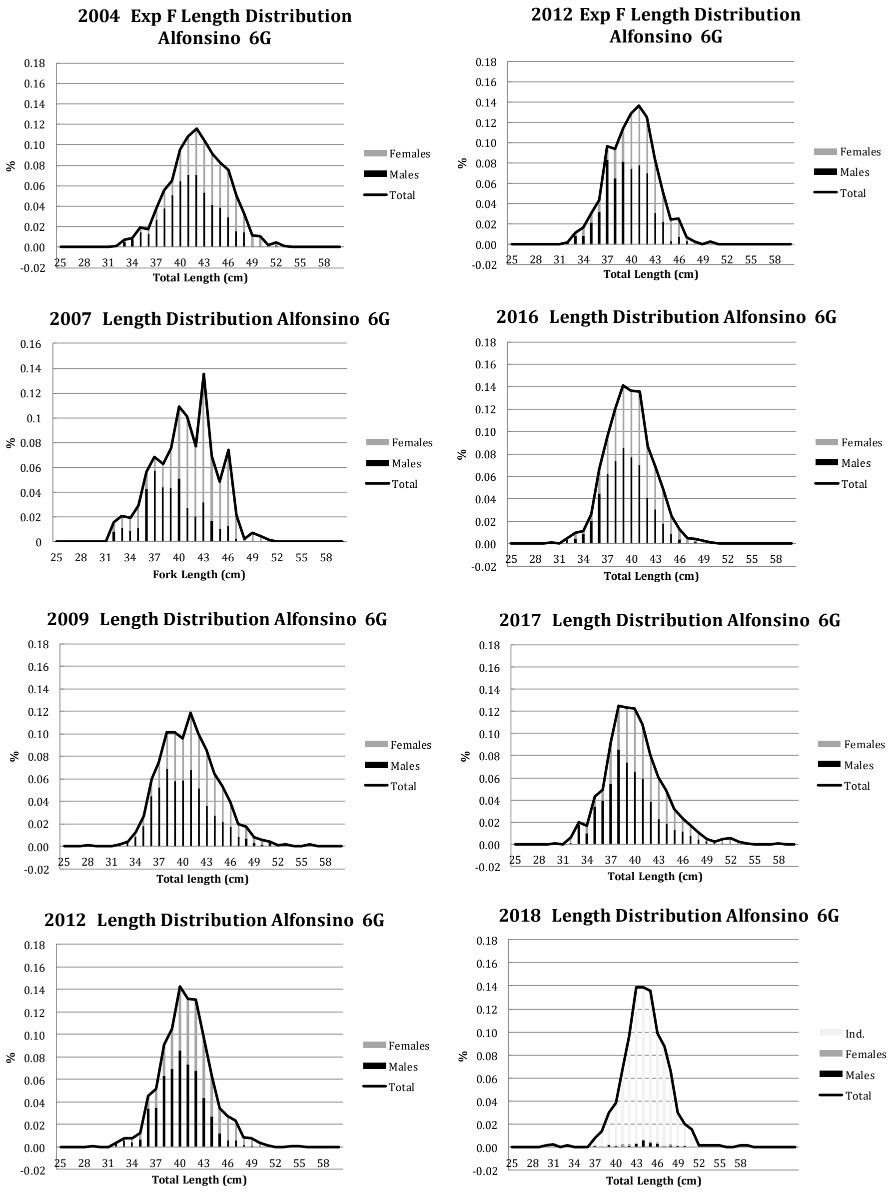


Figure 21.2. Length distributions of alfonsino catches from Div. 6G.

d) Surveys

The only information available is the retrospective data from Russian research, exploratory and fishing cruises presented by Vinnichenko (2015). 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 the data with a time limitation of mainly 20-30 years were 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.

e) Assessment

No analytical or survey based assessment were possible. The only data available at present are the catch and effort time series.

This species is easily overexploited and can only sustain low rates of exploitation. Despite the difficulties in interpreting CPUE data (Figure 21.3.) as an indicator of stock status, the reduction of catch levels in 2018 and the sharp decline in CPUE to the lowest observed level in 2018 (92 % lower than in 2017) indicate an apparent overfishing situation and that the stock may be depleted.

As a result of the substantial change in the 2018 fishery, SC decided to provide updated advice. See SC report section VII.3.

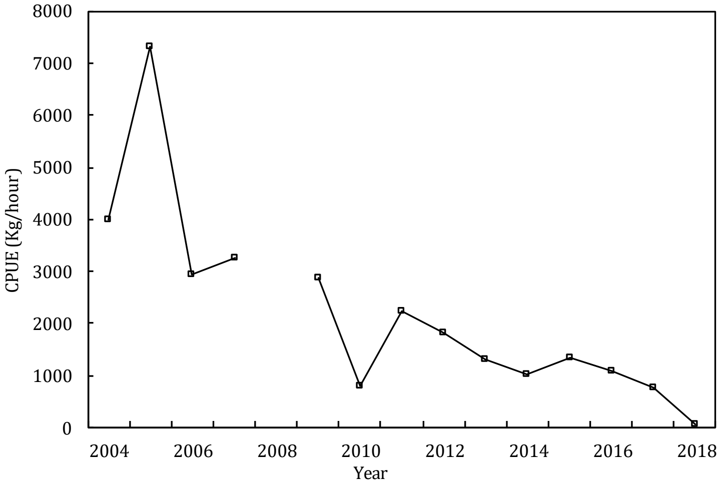


Figure 21.3. Alfonsino CPUE (Kg/h) in Kükenthal Peak since 2004.

f) Stock status

Appears to be depleted.

g) Special comments

The next assessment of this stock was previously scheduled for 2021. The SC is providing new advice this year due to the abrupt drop of catches and CPUE in the past year. Subject to data availability, the next assessment will be conducted according to the Commission request or if SC consider it is warranted.

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..

h) Research Recommendations

SC **recommends** that *fisheries independent information should be collected on this stock.*

References

Vinnichenko V. I. 2015. On stock size and fishery management of splendid alfonsino (Beryx splendens) on the Corner Rise Seamount. Serial No. N6425 NAFO SCR Doc. 15/006.

IV. STOCKS UNDER A MANAGEMENT STRATEGY EVALUATION

1. Greenland halibut in Subarea 2 and Divisions 3KLMNO

This stock is taken under D. Widely Distributed Stocks: SA 2, SA 3 and SA 4.

2. Redfish (*Sebastes mentella* and *Sebastes fasciatus*) in Divisions 3L and 3N

This stock is taken under B. Stocks on the Flemish Cap: SA 3 and Div. 3M

V. 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 2019. This task has been deferred to the September SC meeting.

2. Other Business

No additional items were discussed.

VI. ADJOURNMENT

STACFIS Chair thanked the Designated Experts for their competence and very hard work and the Secretariat for its great support. The Chair also noted the contributions of Designated Reviewers in providing detailed reviews of interim monitoring reports. The STACFIS Chair also thanked the Chair of Scientific Council, and the Scientific Council Coordinator for their support and help. The meeting was adjourned on 13 June 2019.

APPENDIX V. AGENDA - SCIENTIFIC COUNCIL MEETING, 31 MAY-13 JUNE 2019

I. Opening (Scientific Council Chair: Brian Healey)

1. Appointment of Rapporteur
2. Presentation and Report of Proxy Votes
3. Adoption of Agenda
4. Attendance of Observers
5. Appointment of Committee Chairs and Designated Experts
6. Plan of Work
7. Housekeeping issues

II. Review of Scientific Council Recommendations in 2018

III. Fisheries Environment (STACFEN Chair: Miguel Caetano)

1. Opening
2. Appointment of Rapporteur
3. Adoption of Agenda
4. Review of Recommendations in 2018
5. Invited speaker (to be confirmed)
6. Department of Fisheries and Oceans Canada, Oceans Science Branch, Marine Environmental Data Section (MEDS) Report for 2018
7. Review of the physical, biological and chemical environment in the NAFO Convention Area during 2018
8. Interdisciplinary studies
9. Formulation of recommendations based on environmental conditions during 2018
10. National Representatives
11. Other Matters
12. Adjournment

IV. Publications (STACPUB Chair: Margaret Treble)

1. Opening
2. Appointment of Rapporteur
3. Adoption of Agenda
4. Review of Recommendations in 2018
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: Carmen Fernandez)

1. Opening
2. Appointment of Rapporteur
3. Review of previous recommendations and new recommendations in 2019
4. Fishery Statistics
    a) Progress report on Secretariat activities in 2018/2019

5. Research Activities
    a) Biological sampling
        i) Report on activities in 2018/2019
        ii) Report by National Representatives on commercial sampling conducted
    b) Biological surveys
        i) Review of survey activities in 2018 and early 2019 (by National Representatives and Designated Experts)
        ii) Surveys planned for 2019 and early 2020
    c) Tagging activities in 2018 and early 2019
    d) Other research activities
6. Review of SCR and SCS Documents
7. Other Matters
    a) Report on data availability for stock assessments (by Designated Experts)
    b) Discussion of data etc. requests
    c) Discussion of stock assessment data holdings
    d) STACTIC observer survey
    e) FAO project deep sea fisheries in the ABNJ (Tony Thompson).
8. Adjournment

VI. Fisheries Science (STACFIS Chair: Karen Dwyer)

1. Opening
2. General Review of Catches and Fishing Activity
3. Invited speaker
4. Stock Assessments
    1. Greenland halibut (*Reinhardtius hippoglossoides*) in SA 0, Div. 1A offshore and Div. 1B-F (monitor)
    2. Greenland halibut (*Reinhardtius hippoglossoides*) Div. 1A inshore (monitor)

3. Demersal Redfish (Sebastes spp.) in SA 1 (monitor)
4. Wolffish in Subarea (Anarhichas spp.) in SA 1(monitor)
5 Golden redfish (*Sebastes norvegicus* aka *S. marinus*) in Div. 3M (full assessment: request #7)
6. Cod (*Gadus morhua*) in Div. 3M (Full)
7. Redfish (*Sebastes mentella* and *Sebastes fasciatus*) in Div. 3M (full assessment)
8. American plaice (*Hippoglossoides platessoides*) in Div. 3M (monitor)
9. Cod (*Gadus morhua*) in NAFO Div. 3NO (Monitor)
10. Redfish (*Sebastes mentella* and *Sebastes fasciatus*) in Divs. 3L and 3N (monitor)
11. American plaice (*Hippoglossoides platessoides*) in Div. 3LNO (monitor)
12. Yellowtail flounder (*Limanda ferruginea*) in Div. 3LNO (monitor)
13. Witch flounder (*Glyptocephalus cynoglossus*) in Div. 3NO (full assessment: request #2)
14. Capelin (*Mallotus villosus*) in Div. 3NO (monitor)
15. Redfish (*Sebastes mentella* and *Sebastes fasciatus*) in Div. 3O (full assessment)
16. Thorny skate (*Amblyraja radiata*) in Div. 3LNO and Subdiv. 3PS (monitor)
17. White hake (*Urophycis tenuis*) in Div. 3NO and Subdiv. 3PS (full assessment)
18. Roughhead grenadier (*Macrourus berglax*) in Subareas 2 and 3 (full)
19 Greenland halibut (*Reinhardtius hippoglossoides*) in SA 2 + Div. 3KLMNO (under management strategy: request #3)
20. Northern shortfin squid (*Illex illecebrosus*) in Subareas 3+4 (full assessment)
21. Splendid alfonsino (*Beryx splendens*) in SA 6 (monitor)

5. Stocks under a Management Strategy
   a) Greenland halibut in SA 2 and Div. 3KLMNO
   b) Redfish in Divs. 3L and 3N
6. Other Matters
   a) FIRMS Classification for NAFO Stocks
   b) Other Business
7. Adjournment

VII. Management Advice and Responses to Special Requests (See Annex 1)

1. Commission (Annex 1)
   a) Request for Advice on TACs and Other Management Measures (Item 1, Annex 1)

      For 2020

      - Cod in Div. 3M (subject to the outcomes of the MSE process)

      For 2020 and 2021

      - Redfish in Div. 3M

- White hake Div. 3NO and Subdiv. 3PS

For 2020, 2021 and 2022

- 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)

- American Plaice in Divs. 3M
- Yellowtail flounder in Divs. 3LNO
- Cod in Divs. 3NO
- Redfish in Divs. 3LN
- Capelin in Divs. 3NO
- Alfonsino stocks in the NAFO Regulatory Area
- Roughhead grenadier in Subareas 2 and 3
- Witch flounder in Div. 2J+3KL
- Thorny Skate in Divs. 3LNO
- American Plaice in Divs. 3LNO

c) Special Requests for Management Advice

i) Conduct a full assessment of Witch Flounder in Div. 3NO. The advice should be provided for 2020 and 2021 (Item 2)

ii) Greenland halibut in SA2 + Divs. 3KLMNO: Monitor the status annually to determine whether exceptional circumstances are occurring (Item 3)

iii) Implement agreed steps in the workplan for 3M cod MSE (Item 4)

iv) Continue the evaluation of trawl surveys on VMEs (Item 5)

v) Implement the steps of the action plan for progression in the management and minimization of Bycatch and discards (Item 6)

vi) Conduct a full assessment of 3M golden redfish (Item 7)

vii) Continue to refine work on the implementation of an ecosystem approach and application of the Ecosystem Approach Road Map (Item 8)

viii) Assessment of NAFO bottom fisheries (Item 9)

ix) Review the proposed revisions to CEM Annex I.E, Part VI (item 10)

x) Conduct a re-assessment of VME closures by 2020 (Item 11)

xi) Continue progress on the NAFO PA Framework (Item 12)

xii) Provide the map and coordinates of the Kükenthal Peak (Item 13)

xii) Work with WG- BDS to identify areas and times where bycatch and discards of Greenland sharks have a higher rate of occurrence. (Item 14)

- xiii) Provide regular updates on relevant research related to the potential impact of activities other than fishing in the Convention Area (Item 15)
- xiv) Develop a 3-5 year work plan for the Scientific Council (item 16)

2. Coastal States
   - a) Request by Denmark (Greenland) for Advice on Management in 2019 (Annex 2)
     - i) Monitoring of Stocks for which Multi-year Advice was provided in 2017 or 2018
     - ii) Special Request for Information on the Fishery of Northern Shrimp
   - b) Request by Canada and Greenland for Advice on Management in 2019 (Annex 2, Annex 3)
     - i) Monitoring of Stocks for which Multi-year Advice was provided in 2017 or 2018

VIII. Review of Future Meetings Arrangements

1. Scientific Council (in conjunction with NIPAG), 8 - 13 Nov. 2019
2. Scientific Council, 23 – 27 Sep. 2019
3. Scientific Council, June 2020
4. Scientific Council (in conjunction with NIPAG), 2020
5. Scientific Council, Sep. 2020
6. NAFO/ICES Joint Groups
   - a) NIPAG, 2019
   - b) NIPAG, 2020
7. WG-ESA, Nov. 2019
8. WG-DEC, 2020
9. WG-HARP 2-6 Sep 2019

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. 2018
2. Report from ICES-NAFO Working Group on Deepwater Ecosystems (WG-DEC), 3-7 June 2019
3. Report from Joint COM-SC Working Group on Catch Estimation Strategy Advisory Group (CESAG), March and April 2019
4. Meetings attended by the Secretariat
5. Performance Review implementation group
6. RBMS (April 2019)

7 SC 3M cod technical meeting

XI. Review of Scientific Council Working Procedures/Protocol

1. General Plan of Work for September 2019 Annual Meeting
2. Other Matters

XII. Other Matters

1. Archiving of assessment data
2. Scientific Merit Awards
3. Budget items
4. Other Business
    a) invitation to EAFM meeting in Rome (Mariano).

5. Review of progress on the 3M cod MSE
6. Election of chairs

XIII. Adoption of Committee Reports

1. STACFEN
2. STACREC
3. STACPUB
4. STACFIS

XIV. Scientific Council Recommendations to General Council and Commission

XV. Adoption of Scientific Council Report

XVI. Adjournment

ANNEX 1. THE COMMISSION'S REQUEST FOR SCIENTIFIC ADVICE ON MANAGEMENT IN 2020 AND BEYOND OF CERTAIN STOCKS IN SUBAREAS 2, 3 AND 4 AND OTHER MATTERS

Following a request from the Scientific Council, the Commission agreed that items 1, 2, 3, 4, and 12 should be the priority for the June 2019 Scientific Council meeting. Items 4 and 12 were identified as top priorities for Scientific Council subject to resources.

1. 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 (rather than a single TAC recommendation) and the actual risk level should be decided upon by managers.

Yearly basis	Two-year basis	Three-year basis
Cod in Div. 3M Northern shrimp in Div. 3M	Redfish in Div. 3M Northern shrimp in Div. 3LNO Thorny skate in Div. 3LNO Witch flounder in Div. 3NO Redfish in Div. 3LN	American Plaice in Div. 3LNO American Plaice in Div. 3M Capelin in Div. 3NO Northern shortfin squid in SA 3+4 Redfish in Div. 3O Yellowtail flounder in Div. 3LNO Greenland halibut in Div. 2+3KLMNO Splendid alfonsino in SA 6

To implement this schedule of assessments, the Scientific Council is requested to conduct a full assessment of these stocks as follows:

In 2019, advice should be provided for 2020 for Cod in 3M (subject to the outcomes of the Management Strategy Evaluation process) and Northern shrimp in 3M. With respect to Northern shrimp in 3M, SC is requested to provide its advice to the Commission prior to the 2019 Annual Meeting.

In 2019, advice should be provided for 2020 and 2021 for: Redfish in 3M, White hake in 3NO, and Northern shrimp in 3LNO.

In 2019, advice should be provided for 2020, 2021 and 2022 for: Northern shortfin squid in SA 3+4, and Redfish in 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 3LN Redfish and 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.

2. In 2019, the Commission requests Scientific Council to conduct a full assessment of Witch Flounder in Div. 3NO. The advice should be provided for 2020 and 2021.
3. The Commission requests the Scientific Council to monitor the status of Greenland halibut in Subarea 2+Div 3KLMNO annually to compute the TAC using the agreed HCR and determine whether exceptional circumstances are occurring. If exceptional circumstances are occurring, the exceptional circumstances protocol will provide guidance on what steps should be taken.
4. The Commission requests the Scientific Council to implement the steps as described in the revised calendar (COM/SC Doc. 18-02, Annex 4) relevant to the SC for progression of the 3M Cod Management Strategy Evaluation for 2019.
5. 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.

6. The Commission requests the Scientific Council to implement the steps of the Action plan relevant to the SC and in particular the tasks identified under section 2.2 of the Action Plan, for progression in the management and minimization of Bycatch and discards (COM Doc. 17-26).
7. The Commission requests Scientific Council to conduct a full assessment on 3M golden Redfish in 2019 and, acknowledging that there are three species of redfish that exist in 3M and are difficult to separate in the catch, provide advice on the implications for catch reporting and stock management.
8. The Commission requests the Scientific Council to continue to refine its work under the Ecosystem Approach Road Map, including testing the reliability of the ecosystem production potential model and other related models, and to report on these results to both the WG –EAFFM and WG- RBMS to further develop how it may apply to management decisions.
9. In relation to the assessment of NAFO bottom fisheries, the Commission endorsed the next re-assessment in 2021 and that the Scientific Council should:
    - Assess the overlap of NAFO fisheries with VME to evaluate fishery specific impacts in addition to the cumulative impacts;
    - Consider clearer objective ranking processes and options for objective weighting criteria for the overall assessment of significant adverse impacts and the risk of future adverse impacts;
    - Maintain efforts to assess all of the six FAO criteria (Article 18 of the FAO International Guidelines for the Management of Deep Sea Fisheries in the High Seas) including the three FAO functional SAI criteria which could not be evaluated in the current assessment (recovery potential, ecosystem function alteration, and impact relative to habitat use duration of VME indicator species).
    - Continue to work on non-sponge and coral VMEs (for example bryozoan and sea squirts) to prepare for the next assessment.
10. Review the proposed revisions to Annex I.E, Part VI as reflected in COM/SC WG –EAFFM WP 18-01, for consistency with the taxa list annexed to the VME guide and recommend updates as necessary.
11. The Commission requests Scientific Council to conduct a re-assessment of VME closures by 2020, including area #14.
12. The Commission requests the Scientific Council to continue progression on the review of the NAFO PA Framework.
13. According to the Scientific Advice for years 2019, 2020 and 2021, fishing should not be allowed to expand above current levels on Kükenthal Peak (Div. 6G, part of the Corner Rise seamount chain). To allow this recommendation to be enforceable the Commission requests the Scientific Council to provide the map and coordinates of the Kükenthal Peak.
14. The Commission requests Scientific Council work with WG- BDS to identify areas and times where bycatch and discards of Greenland sharks have a higher rate of occurrence. This work will support WG-BDS in developing appropriate management recommendations, including safe handling practises for live release of Greenland sharks, for consideration by the Commission at its 2021 Annual Meeting.
15. The Commission requests Scientific Council to monitor and provide regular updates on relevant research related to the potential impact of activities other than fishing in the Convention Area, such as oil exploration, shipping and recreational activities, and how they may impact the stocks and fisheries as well as biodiversity in the Regulatory Area.
16. The Commission requests Scientific Council to take the first steps to develop a 3-5 year work plan, which reflects requests arising from the 2018 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.

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}, 75% F_{2018}, F_{2018}, 125% F_{2018},
- For stocks under a moratorium to direct fishing: F_{2018}, 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(B2021 > B2017)
F in 2018 and following years*	Yield 2019 (50%)	Yield 2020 (50%)	Yield 2021 (50%)	2019	2020	2021	2019	2020	2021		2019	2020	2021	2019	2020	2021		
2/3 F_{msy}	t	t	t	%	%	%	%	%	%		%	%	%	%	%	%		%
3/4 F_{msy}	t	t	t	%	%	%	%	%	%		%	%	%	%	%	%		%
85% F_{msy}	t	t	t	%	%	%	%	%	%		%	%	%	%	%	%		%
F_{msy}	t	t	t	%	%	%	%	%	%		%	%	%	%	%	%		%
0.75 X F_{2018}	t	t	t	%	%	%	%	%	%		%	%	%	%	%	%		%
F_{2018}	t	t	t	%	%	%	%	%	%		%	%	%	%	%	%		%
1.25 X F_{2018}	t	t	t	%	%	%	%	%	%		%	%	%	%	%	%		%
F=0	t	t	t	%	%	%	%	%	%		%	%	%	%	%	%		%

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_{2018}, F_{2018}, 125% F_{2018},
- For stocks under a moratorium to direct fishing: F_{2018}, 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(B2021 > B2017)
F in 2018 and following years*	Yield 2019	Yield 2020	Yield 2021	2019	2020	2021	2019	2020	2021		2019	2020	2021	2019	2020	2021		
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 2020 OF CERTAIN STOCKS IN SUBAREA 0 AND 1.

1. **Golden Redfish, Demersal deep-sea Redfish, Atlantic Wolffish and Spotted Wolffish:** Advice on Golden Redfish (Sebastes marinus), Demersal Deep-Sea Redfish (Sebastes mentella), Atlantic Wolffish (Anarhichas lupus) and Spotted Wolffish (Anarhichas minor) in Subarea 1 was in June 2017 given for 2018-2020. Denmark (on behalf of Greenland) requests the Scientific Council to continue to monitor the status of the stock and should any significant changes in the stock status be observed, the Scientific Council is requested to provide updated advice as appropriate.

2. **Greenland Halibut, offshore:** For Greenland Halibut in subareas O + 1 advice was in 2018 given for 2019 and 2020. Subject to the concurrence of Canada as regards Subareas O and 1, the Scientific Council is requested to continue to monitor the status. Should significant changes in the stock status be observed the Scientific Council is requested to provide updated advice as appropriate for Greenland Halibut in 1) the offshore areas of NAFO Division OA and Division 1 A plus Division 1B and 2) NAFO Division OB plus Divisions 1 C-1F. The Scientific Council is also asked to advice on any other management measures it deems appropriate to ensure the sustainability of these resources.

3. **Greenland Halibut, inshore, Northwest Greenland:** Advice on Greenland Halibut in Division 1 A inshore was in 2018 given for 2019-2020. Denmark (on behalf of Greenland) requests the Scientific Council to continue to monitor the status, and should significant changes in the stock status be observed the Scientific Council is requested to provide updated advice as appropriate.

4. **Northern Shrimp, West Greenland:** Subject to the concurrence of Canada as regards Subarea O and 1, Denmark (on behalf of Greenland} requests the Scientific Council before December 2019 to provide advice on the scientific basis for management of Northern Shrimp (Panda/us borealis) in Subarea O and 1 in 2020 and for as many years ahead as data allows for.

5. **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 2020 and for as many years ahead as data allows for.

1. Coastal State Special Request for Scientific Advice for 2020

Denmark (on behalf of Greenland) hereby requests for scientific information on the fishery of Northern shrimp in NAFO Subareas Div OA in order to improve management of the shrimp stock.

- **Northern Shrimp in Subarea Div OA**

Canada is requested to inform on its fishery patterns since 2012 as well as the geographical distribution of its fishery in the same period.
With respect to:

- Geographical distribution of its fishery
- Total catch index
- Effort index
- Standardized CPUE index

ANNEX 3. REQUESTS FOR ADVICE FROM CANADA FOR 2020

Shrimp (Divisions OA and Subarea 1)

Canada requests the Scientific Council consider the following options in assessing and projecting future stock levels for Shrimp in Subareas O and I:

The status of the stock should be determined and management options evaluated for catch options ranging from 30,000 t to the catch corresponding to Z_{Msv}, in 5,000-10,000 t increments (subject to the discretion of Scientific Council), with forecasts for the next 5 years if possible. These options should be evaluated in relation to Canada's Harvest Strategy (attached) and the Northwest Atlantic Fisheries Organization Precautionary Approach Framework, and presented in the form of risk analyses related to the B_{MSY}. B_{lim} 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 2019 to 2023 if possible. 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}, and of being above Z_{MSY} based on the 3-year projections; and
- Total area fished for the longest time period possible.

Any other information the Scientific Council deems relevant should also be provided.

APPENDIX VI. PROVISIONAL TIMETABLE

Scientific Council Meeting, 31 May-13 June 2019

Date	Time	Schedule
31 May (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
01 June (Saturday)	0900-1200	STACFEN
	1300-1800	Scientific Council/STACFIS
	1830-2030	Scientific Council Reception/event
02 June (Sunday)	No meetings	
03 June (Monday)	0900-1200	STACPUB
	1300-1800	Scientific Council/STACFIS
04 June (Tuesday)	0900-1800	STACREC
05 June (Wednesday)	0900-1200	STACFIS
	1300-1800	STACFIS
06 June (Thursday)	0900-1800	STACFIS
07 June (Friday)	0900-1800	STACFIS
08 June (Saturday)	0900-1800	STACFIS Reports
09 June (Sunday)	No meetings	
10 June (Monday)	0830	Scientific Council Executive
	0900-1800	Scientific Council (Standing Committee Reports)
11 June (Tuesday)	0900-1800	Scientific Council
12 June (Wednesday)	0900-1800	Scientific Council
13 June (Thursday)	0900-1800	Scientific Council (advice and adoption of reports)

APPENDIX VII. EXPERTS FOR ASSESSMENT OF CERTAIN STOCKS

The Designated Experts for 2019 were:

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	Danny Ings	danny.ings@dfo-mpo.gc.ca
American Plaice in Div. 3LNO	Laura Wheeland	laura.wheeland@dfo-mpo.gc.ca
Witch flounder in Div. 3NO	Joanne Morgan	joanne.morgan@dfo-mpo.gc.ca
Yellowtail flounder in Div. 3LNO	Dawn Maddock Parsons	dawn.parsons@dfo-mpo.gc.ca
Greenland halibut in SA 2+3KLMNO	Joanne Morgan	joanne.morgan@dfo-mpo.gc.ca
Northern shrimp in Div. 3LNO	Katherine Skanes	katherine.skanes@dfo-mpo.gc.ca
Thorny skate in Div. 3LNO	Mark Simpson	mark.r.simpson@dfo-mpo.gc.ca
White hake in Div. 3NO	Mark Simpson	mark.r.simpson@dfo-mpo.gc.ca

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

Greenland halibut in SA 0+1	Margaret Treble	margart.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.es
Splendid alfonsino in Subarea 6	Fernando Gonzalez-Costas	fernando.gonzalez@ieo.es
Cod in Div. 3M	Diana Gonzalez-Troncoso	diana.gonzalez@ieo.es
Shrimp in Div. 3M	Jose Miguel Casas Sanchez	mikel.casas@ieo.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	Antonio Avila de Melo	amelo@ipma.pt
Redfish in Div. 3LN	Antonio Avila de Melo	amelo@ipma.pt

From the Greenland Institute of Natural Resources, Nuuk, Greenland

Redfish in SA1	Rasmus Nygaard	rany@natur.gl
Other Finfish in SA1	Rasmus Nygaard	rany@natur.gl
Greenland halibut in Div. 1A	Rasmus Nygaard	rany@natur.gl
Northern shrimp in SA 0+1	AnnDorte Burmeister	anndorte@natur.gl
Northern shrimp in Denmark Strait	Frank Riget	frri@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

APPENDIX VIII. LIST OF SCR AND SCS DOCUMENTS

SCR Documents			
Doc No.	**Serial No**	**Author(s)**	**Title**
SCR Doc. 19-001	N6903	González-Costas, F., D. González-Troncoso, C. Fernández, A. Urtizberea, R. Alpoim, A. Avila de Melo, J. De Oliveira, P. Apostolaki, T. Brunel, D. García	Potential Operating Models, Harvest Control Rules and Performance Statistics for the NAFO 3M Cod MSE.
SCR Doc. 19-002	N6904	Diana González-Troncoso and Antonio Ávila de Melo	3M cod MSE: Different OMs based on M calculated in steps
SCR Doc. 19-003	N6905	Thomas Brunel	Investigation of a growth model incorporating density-dependence for the Cod 3M management plan simulations.
SCR Doc. 19-004	N6906	González-Troncoso, D., González-Costas, F. and Fernández, C.	Estimation of the reference points for the different OMs in the Cod 3M MSE.
SCR Doc. 19-005	N6907	Carmen Fernández, Diana González-Troncoso, Fernando González-Costas, Thomas Brunel, Ricardo Alpoim, Antonio Ávila, Jose de Oliveria, Agurtzane Urtizberea and Panayiota Apostolaki	3M cod MSE: survey indices in the projection years
SCR Doc. 19-006	N6908	González-Troncoso, D.,	Specifications of the OMs and the projections for the 3M cod MSE
SCR Doc. 19-007	N6913	John Mortensen	Report on hydrographic conditions off Southwest Greenland June/July 2018
SCR Doc. 19-008	N6923	Rasmus Nygaard and Adriana Nogueira	Biomass and Abundance of Demersal Fish Stocks off West and East Greenland estimated from the Greenland Institute of Natural resources (GINR) Shrimp and Fish Survey (SFW), 1990-2018.
SCR Doc. 19-009	N6924	Paula Fratantoni	Hydrographic Conditions on the Northeast United States Continental Shelf in 2018 – NAFO Subareas 5 and 6
SCR Doc. 19-010	N6925	D. Bélanger, P. Pepin, G. Maillet, C. Johnson, E. Devred, B. Casault, C. Caverhill, S. Plourde, M. Blais	Biogeochemical oceanographic conditions in the Northwest Atlantic during 2018
SCR Doc. 19-011	N6926	F. Cyr, E. Colbourne, D. Hebert, R. Pettipas, P. S. Galbraith, G. Han, and S. Snook	Environmental and Physical Oceanographic Conditions during 2018 on the Eastern Canadian shelves (NAFO Sub-areas 2, 3 and 4)
SCR Doc. 19-012	N6927	Esther Román, Concepción González-Iglesias and Diana González-Troncoso	Results for the Spanish Survey in the NAFO Regulatory Area of Division 3L for the period 2003-2018
SCR Doc. 19-013	N6928	Esther Román, Diana González-Troncoso and Marisol Alvarez	Results for the Atlantic cod, roughhead grenadier, redfish, thorny skate and black dogfish of the Spanish Survey in the NAFO Div. 3L for the period 2003-2018

SCR Doc. 19-014	N6930	V. Korzhev and M. Pochtar	Proposals for redfish fishery regulation with occasional recruitment in the Flemish Cap Bank area
SCR Doc. 19-015	N6931	R.M. Rideout, D.W. Ings	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 2018
SCR Doc. 19-016	N6932	A. Ávila de Melo , F. Saborido-Rey , M. Fabeiro , Sonia Rábade, D. González Troncoso , F. González-Costas , M. Pochtar , and R. Alpoim	An assessment of beaked redfish (*S. mentella* and *S. fasciatus*) in NAFO Division 3M (including an update revision for the most recent level of natural mortality)
SCR Doc. 19-017	N6933	A. Pérez-Rodríguez, D. Howell and I.Umar	EU SC05 project: "Multispecies Fisheries Assessment for NAFO". Estimation of multispecies based HCRs and use of a multispecies MSE framework to assess the risk of collapse and the fishery-ecological trade-offs.
SCR Doc. 19-018	N6934	Diana González-Troncoso, Irene Garrido and Ana Gago	Yellowtail flounder, redfish (*Sebastes spp.*) and witch flounder indices from the Spanish Survey conducted in Divisions 3NO of the NAFO Regulatory Area
SCR Doc. 19-019	N6935	Diana González-Troncoso, Irene Garrido, Ana Gago and Esther Román	Results for Greenland halibut, American plaice and Atlantic cod of the Spanish survey in NAFO Div. 3NO for the period 1997-2018
SCR Doc. 19-020	N6936	Diana González-Troncoso, Irene Garrido and Ana Gago	Biomass and length distribution for roughhead grenadier, thorny skate, white hake and squid from the surveys conducted by Spain in NAFO 3NO
SCR Doc. 19-021	N6937	Diana González Troncoso, Ricardo Alpoim and Mónica Mandado	Results from Bottom Trawl Survey on Flemish Cap of June-July 2018
SCR Doc. 19-022	N6938	M.R. Simpson, R. Collins and C. Miri	An Assessment of White Hake (*Urophycis tenuis*, Mitchill 1815) in NAFO Divisions 3N, 3O, and Subdivision 3Ps
SCR Doc. 19-023	N6939	Fernando González-Costas	An assessment of NAFO roughhead grenadier Subarea 2 and 3 stock.
SCR Doc. 19-024	N6940	Katherine A. Sosebee, Paul Kostovick, and Nancy McHugh	Data Collection and Processing Protocols for the United States NEFSC Surveys, 1963-2018
SCR Doc. 19-025	N6941	Katherine A. Sosebee and Timothy J. Miller	A Summary of the Calibration Studies Conducted by the Northeast Fisheries Science Center for the Spring and Fall Groundfish Bottom Trawl Surveys
SCR Doc. 19-026	N6942	Diana González-Troncoso1, Carmen Fernández2 and Fernando González-Costas1	Assessment of the Cod Stock in NAFO Division 3M
SCR Doc. 19-027	N6943	Mathieu Ouellet	Inventory of environmental data collected in the NAFO Convention Area, 2018
SCR Doc. 19-028	N6944	F. González-Costas, D. González-Troncoso, C. Fernández and A. Urtizberea	Low recruitment 3M Cod Operating Model
SCR Doc. 19-029	N6945	M. Joanne Morgan and Mariano Koen-Alonso	Exploration of priors used in surplus production model in a Bayesian framework applied to witch flounder in NAFO Div. 3NO

SCR Doc. 19-030	N6946	F. González-Costas1 and G. Ramilo	Greenland sharks (*Somniosus microcephalus*) Spanish data (Surveys and Fishery) in NAFO Regulatory Area.
SCR Doc. 19-031	N6948	R.M. Rideout & L.J. Wheeland	In or out? A review of decisions made by Scientific Council to include or exclude Canadian survey data points with reduced spatial coverage.
SCR Doc. 19-032	N6949	Rasmus Nygaard	Commercial data for the Greenland Halibut Stock Component in NAFO Division 1A Inshore
SCR Doc. 19-033	N6950	Rasmus Nygaard	Trawl, gillnet and longline survey results from surveys conducted by the Greenland Institute of Natural Resources in NAFO Division 1A Inshore
SCR Doc. 19-034	N6951	B. Rogers and J. Morgan	An assessment of the witch flounder resource in NAFO Divisions 3NO
SCR Doc. 19-035	N6952	R. Alpoim et al	Assessment of Golden Redfish in 3M
SCR Doc. 19-036	N6954	M.J. Morgan, P.M. Regular and D.W. Ings	Greenland halibut (*Reinhardtius hippoglossoides*) in NAFO Subarea 2 and Divisions 3KLMNO: stock trends based on annual Canadian research vessel survey results and an update of the SAM style model
SCR Doc. 19-037	N6956	L. Wheeland1, M. Treble2, A. Nogueira3	Overview of sources of uncertainty in reported catches of Greenland shark *Somniosus microcephalus* within the NAFO Convention Area
SCR Doc. 19-038	N6959	D. W. Ings and R.M. Rideout	An Assessment of the Status of Redfish in NAFO Division 3O
SCR Doc. 19-039	N6960	Igor Yashayaev, Marc Ringuette, Ingrid Peterson, Zeliang Wang, Erica Head, Stephen Punshon, Emmanuel Devred, Kumiko Azetsu-Scott	Environmental Conditions in the Labrador Sea during 2018
SCR Doc. 19-040	N6961	Igor Yashayaev, Marc Ringuette, Ingrid Peterson, Zeliang Wang, Erica Head, Emmanuel Devred	Revisiting Environmental Conditions in the Labrador Sea during 2017

SCS Documents			
Doc No.	**Serial No**	**Author**	**Title**
SCS Doc. 19-01	N6902	NAFO	The Commission's Request for Scientific Advice on Management in 2019 and Beyond of Certain Stocks in Subareas 2, 3 and 4 and Other Matters
SCS Doc. 19-02	N6909	Greenland	Denmark (on behalf of Greenland) Requests for Scientific Advice on Management in 2020 of Certain Stocks in Subarea 0 and 1.
SCS Doc. 19-03	N6910	Canada	Canada Request for Coastal State Advice - 2020
SCS Doc. 19-04	N6911	NAFO	NAFO Scientific Council Flemish Cap (NAFO Div. 3M) Cod Stock Management Strategy Evaluation (MSE).
SCS Doc. 19-05	N6912	Greenland	Denmark (on behalf of Greenland) Special Request for Scientific Information for 2020
SCS Doc. 19-06	N6917	K. Hubel	Estonian Research Report for 2018
SCS Doc. 19-07	N6918	Luis Ridao Cruz	Faroese Research Report 2018
SCS Doc. 19-08	N6920	National Research Institute of Far Seas Fisheries (NRIFSF)	National Research Report of Japan (2019)
SCS Doc. 19-09	N6921	J. Vargas, R. Alpoim, E. Santos and A. M. Ávila de Melo	Portuguese Research Report for 2018
SCS Doc. 19-10	N6922	F. González-Costas, G. Ramilo, E. Román, J. Lorenzo, A. Gago, D. González-Troncoso, J. L. del Rio and M. Sacau	Spanish Research Report for 2018
SCS Doc. 19-11	N6929	Konstantin Fomin and Maria Pochtar	Russian Research Report 2018
SCS Doc. 19-12	N6947	Greenland Institute of Natural Resources	Denmark Greenland Research Report for 2018
SCS Doc. 19-13	N6953	B. Healey and E. Parrill	Canadian Research Report for 2018 Newfoundland and Labrador Region
SCS Doc. 19-14	N6955	H. O. Fock and C. Stransky	German Research Report for 2018
SCS Doc. 19-15	N6957	M.L. Traver and K.A. Sosebee	USA Research Report 2018
SCS Doc. 19-16	N6962	NAFO	Available Data from the Commercial Fisheries Related to Stock Assessment (2018) and Inventory of Biological Surveys Conducted in the NAFO Area in 2018 and Biological Surveys Planned for 2019 and Early-2020
SCS Doc. 19-17	N6963	NAFO	Tagging 2018
SCS Doc. 19-18	N6964	NAFO	List of Biological Sampling Data for 2018
SCS Doc. 19-19	N6965	NAFO	A Compilation of Research Vessel Surveys on a Stock-bystock Basis
SCS Doc. 19-20	N6966	NAFO	Report of the Scientific Council June Meeting, 31 May - 13 June 2019

APPENDIX IX. LIST OF PARTICIPANTS, 31 MAY – 13 JUNE 2019

CHAIR	
Healey, Brian	Science Br., Dept. of Fish. & Oceans, P.O. Box 5667, St. John's, NL A1C 5X1 Tel.: +709-772-8674 – E-mail: brian.healey@dfo-mpo.gc.ca
CANADA	
Bélanger, David	Fisheries & Oceans Canada, 46 Empire Ave. St. John's, NL. A1C 3E6 E-mail: david.belanger@dfo-mpo.gc.ca
Brickman, David	Fisheries & Oceans Canada, BIO, P. O. Box 1006, Dartmouth, N.S. B2Y 4A2 E-mail: david.brickman@dfo-mpo.gc.ca
Cyr, Frederic	Science Branch, Fisheries & Oceans Canada, P.O. Box 5667, St. John's, NL. A1C 5X1 Tel.: +709-986-6622 - E-mail: Frederic.Cyr@dfo-mpo.gc.ca
Dwyer, Karen Chair of STACFIS	Science Branch, Fisheries & Oceans Canada, P.O. Box 5667, St. John's, NL. A1C 5X1 Tel.: +709-772-0573 - E-mail: karen.dwyer@dfo-mpo.gc.ca
Ings, Danny	Science Branch, Fisheries & Oceans Canada, P.O. Box 5667, St. John's, NL. A1C 5X1 E-mail: danny.ings@dfo-mpo.gc.ca
Koen-Alonso, Mariano	Science Branch, Fisheries & Oceans Canada, P.O. Box 5667, St. John's, NL. A1C 5X1 E-mail: Mariano.Koen-Alonso@dfo-mpo.gc.ca
Krohn, Martha	Senior Science Advisor, Fisheries & Oceans Canada, 200 Kent Street, Ottawa, ON K1A 0E6, Tel.: +613-998-4234 – E-mail: martha.krohn@ dfo-mpo.gc.ca
Maddock Parsons, Dawn	Science Branch, Fisheries & Oceans Canada, P.O. Box 5667, St. John's, NL. A1C 5X1 Tel. +709-772- 2495 - E-mail: Dawn.Parsons@dfo-mpo.gc.ca
Morgan, Joanne	Science Branch, Fisheries & Oceans Canada, P. O. Box 5667, St. John's, NL A1C 5X1 Tel.: +709-772-2261 - E-mail: joanne.morgan@dfo-mpo.gc.ca
Ouellet, Mathieu	Advisor/Head, Marine Environmental Data Section (MEDS), Oceans Science Branch Fisheries and Oceans Canada, Ottawa Tel:+ 613-993-2401 – E-mail: mathieu.ouellet@dfo-mpo.gc.ca
Pepin, Pierre	Fisheries & Oceans Canada, P. O. Box 5667, St. John's, NL A1C 5X1 E-mail: pierre.pepin@dfo-mpo.gc.ca
Regular, Paul	Research Scientist, Fisheries & Oceans Canada, P. O. Box 5667, St. John's, NL A1C 5X1 Tel.: 709-772-2067 – E-mail: paul.regular@dfo-mpo.gc.ca
Rideout, Rick	Science Branch, Fisheries & Oceans Canada, P.O. Box 5667, St. John's, NL. A1C 5X1 Tel.: +709-772-6975 – E-mail: rick.rideout@dfo-mpo.gc.ca
Rogers, Bob	Fishereies & Oceans Canada, 304 Aspoch St, St. John's NL, A1E 4M4 Tel: +709-764-3647 – E-Mail: bob.rogers@dfo-mpo.gc.ca
Simpson, Mark	Science Branch, Fisheries & Oceans Canada, P.O. Box 5667, St. John's, NL. A1C5X1 Tel.: +709-772-4841 - E-mail: mark.r.simpson@dfo-mpo.gc.ca
Treble, Margaret Chair of STACPUB	Fisheries & Oceans Canada, Freshwater Inst., 501 University Cres., Winnipeg, MT Tel.: +204-984-0985 - E-mail: margaret.treble@dfo-mpo.gc.ca

Wheeland, Laura	Science Branch, Fisheries & Oceans Canada, P.O. Box 5667, St. John's, NL. A1C 5X1 Tel.: +709-687-8357 - E-mail: Laura.Wheeland@dfo-mpo.gc.ca
DENMARK (IN RESPECT OF FAROE ISLANDS + GREENLAND)	
Nogueira, Adriana	Greenland Institute of Natural Resources, P.O. Box 570, DK-3900 Nuuk, Greenland Tel.: +299 361200 - E-mail: adno@natur.gl
Ridao Cruz, Luis	Nóatún 1, P.O. Box 3051, FO-110 Tórshavn, Faroe Islands Tel.: +298 353900 - E-mail: luisr@hav.fo
EUROPEAN UNION	
Alpoim, Ricardo	Instituto Português do Mar e da Atmosfera, I. P., Av. de Brasilia, 1449-006 Lisbon, Portugal Tel.: +351 21 302 7000 - E-mail: ralpoim@ipma.pt
Ávila de Melo, António	Instituto Portugues do Mar e da Atmosfera, I.P., Av. de Brasilia, 1449-006 Lisbon, Portugal Tel.: +351 21 302 7000 - E-mail: amelo@ipma.pt
Caetano, Miguel Chair of STACFEN	Instituto Português do Mar e da Atmosfera (IPMA), Division of Oceanography and Marine Environment, Rua Alfredo Magalhães Ramalho, 6, 1495-165 Algés, Portugal Tel: +351 21 302 7070 – Email: mcaetano@ipma.pt
Fernandez, Carmen Vice-Chair of Scientific Council and Chair of STACREC	Instituto Español de Oceanografía (IEO). Avenida Príncipe de Asturias, 70 bis. 33212 Gijón, Spain. Tel: +34 (985) 308 672 - Email: carmen.fernandez@ieo.es
González-Troncoso, Diana	Instituto Español de Oceanografia, Aptdo 1552, E-36280 Vigo (Pontevedra), Spain Tel.: +34 9 86 49 2111 - E-mail: diana.gonzalez@ieo.es
González-Costas, Fernando	Instituto Español de Oceanografia, Aptdo 1552, E-36280 Vigo (Pontevedra), Spain Tel.: +34 9 86 49 2111 - E-mail: fernando.gonzalez@ieo.es
Kenny, Andrew	CEFAS, Lowestoft Laboratory, Lowestoft, UK E-mail: andrew.kenny@cefas.co.uk
Perez-Rodriguez, Alfonso	Institute of Marine Research, Bergen, Norway E-mail: alfonso.perez.rodriguez@hi.no
Ribeiro, Cristina	DG MARE, Rue Joseph II, 99, B-1049, Brussels, Belgium Tel: +32 2 298 1663 - Email: Cristina-RIBEIRO@ec.europa.eu
Urtizberea, Agurtzane	Advisor, AZTI, Spain Email: aurtizberea@azti.es
JAPAN	
Nishida, Tom	Associate Scientist, National Research Institute of Far Seas Fisheries, Agency, 5-7-1, Orido, Shimizu-Ward, Shizuoka-City, Shizuoka, Japan Tel: +81 (54) 336 5834– E-mail: tnishida@affrc.go.jp to
Taki, Kenji	Scientist, National Research Institute of Far Seas Fisheries, Agency, 5-7-1, Orido, Shimizu-Ward, Shizuoka-City, Shizuoka, Japan E-mail: takisan@fra.affrc.go.jp

RUSSIAN FEDERATION	
Fomin, Konstantin	Knipovich Polar Research Institute of Marine Fisheries and Oceanography (PINRO), 6 Knipovich St., Murmansk 183763 Tel.: +7 8152 436 177 – E-mail:fomin@pinro.ru
Orlov, Alexey	Russian Federal Research Institute of Fisheries & Oceanography (VNIRO), K. 17, V. Krasnoselskaya, Moscow, 107140 E-mail: orlov@vniro.ru
Tairov, Temur	Representative of the Federal Agency for Fisheries of the Russian Federation in Canada, 47 Windstone Close, Bedford, Nova Scotia, B4A4L4 Tel: +1 902 405 0655 – Email: temurtairov@mail.ru
UNITED STATES OF AMERICA	
Hendrickson, Lisa	National Marine Fisheries Service, NEFSC, 166 Water St., Woods Hole, MA 02543 E-mail: lisa.hendrickson@noaa.gov
Sosebee, Katherine	National Marine Fisheries Service, NEFSC, 166 Water St., Woods Hole, MA 02543 Tel.: +508-495-2372 - E-mail: katherine.sosebee@noaa.gov
EXTERNAL REVIEWER	
Howell, Daniel	Institute of Marine Research, Norway Email: Daniel.howell@hi.no
FOOD AND AGRICULTURE ORGANIZATION (FAO)	
Thompson, Anthony	Consultant, Food and Agriculture Organization of the United Nations E-mail: Anthony.Thompson@fao.org
NORTH PACIFIC FISHERIES COMMISSION (NPFC)	
Zavolokin, Alex	North Pacific Fisheries Commission (NPFC), 2F Hakuyo-Hall, Tokyo University of Marine Science and Technology 4-5-7 Konan, Minato-ku, Tokyo 108-8477 Japan Tel. +81-3-5479-8717 – Email: azavolokin@npfc.int
OBSERVERS	
Arnold, Shannon	Ecology Action Centre, 2705 Fern Lane, Halifax, NS, B3K 4L3 Tel.: +902 446-4840

NAFO SECRETARIAT		
Fred Kingston	Executive Secretary	fkingston@nafo.int
Tom Blasdale	Scientific Council Coordinator	tblasdale@nafo.int
Dayna Bell MacCallum	Scientific Information Administrator	dbell@nafo.int
Ricardo Federizon	Senior Fisheries Commission Coordinator	rfederizon@nafo.int
Jana Aker	Fisheries Information Administrator	jaker@nafo.int
Alexis Pacey	Senior Publications Manager	apacey@nafo.int
Matthew Kendall	IT Manager	mkendall@nafo.int
Sarah Guile	Office Administrator	sguile@nafo.int