ISSN-0250-6416

NORTHWEST ATLANTIC
FISHERIES ORGANIZATION

Scientific Council Reports
2020

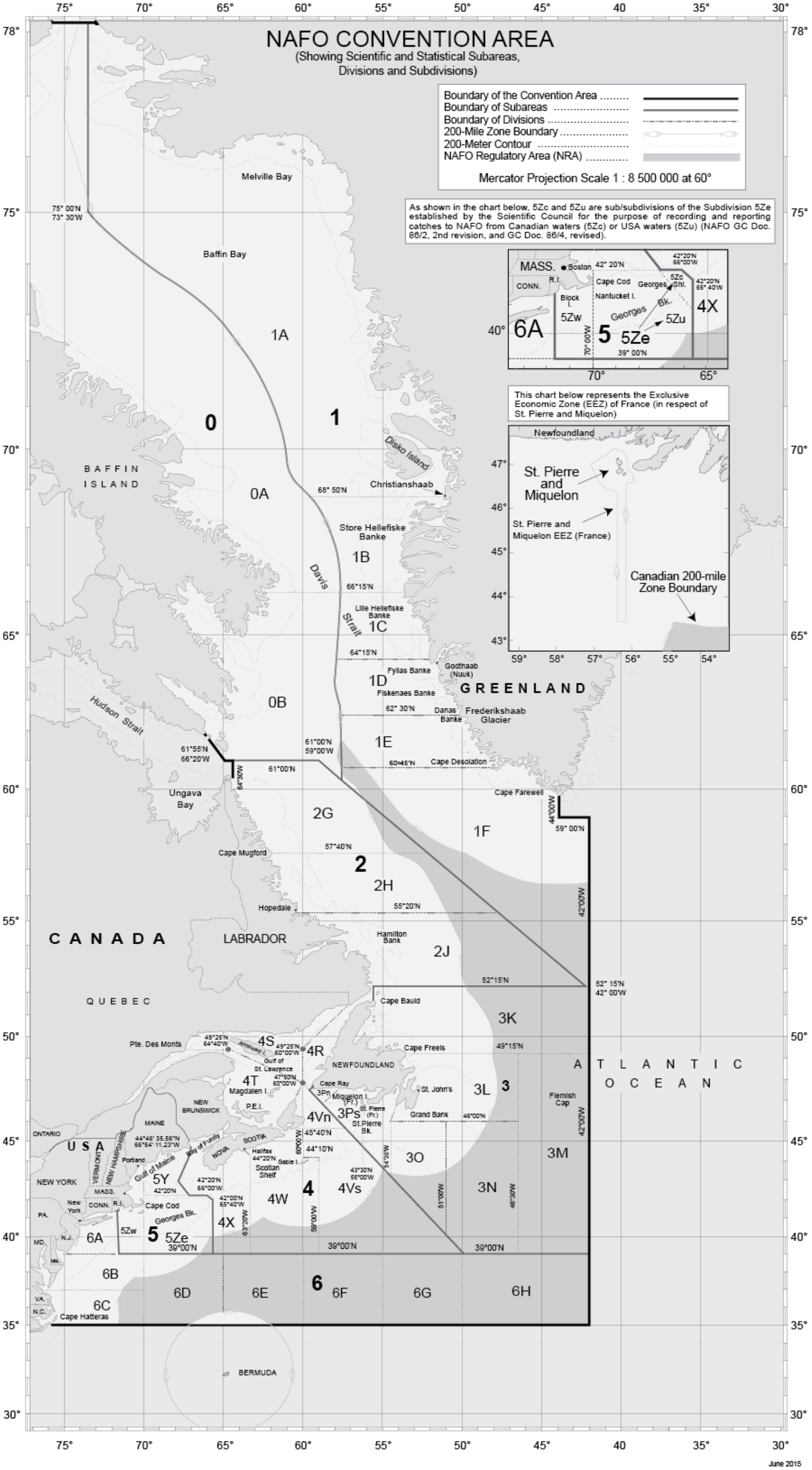
Printed and Distributed by:
Northwest Atlantic Fisheries Organization
1601 Lower Water Street, Suite 401
Halifax, Nova Scotia, Canada B3J 3P6
Tel.: (902) 468-5590
E-mail: info@nafo.int • Website: www.nafo.int

May 2021

PREFACE

This forty-second issue of *NAFO Scientific Council Reports* containing reports of Scientific Council Meetings held in 2020, is compiled in six sections: **Part A** –NAFO Scientific Council Planning Meeting, 02 April 2020 **Part B** –NAFO Scientific Council Meeting, 28 May –12 June 2020; **Part C** – NAFO Scientific Council Meeting in conjunction with NIPAG, 14 September 2020; **Part D** NAFO Scientific Council Meeting 21 – 25 September 2020 **Part E** – NAFO Scientific Council Shrimp Meeting, 26 – 30 October 2020; **Part F –** NAFO/ICES *Pandalus* Assessment Group (NIPAG) Meeting, 26 – 30 October 2020; **Part G** –the Agendas; Requests; Lists of Research and Summary Documents; List of Representatives, Advisers, Experts and Observers; Merit Awards; and List of Recommendations relevant to Parts A-F.

For the meeting report of the NAFO Scientific Council Working Group on Ecosystem Science and Assessment (WG-ESA), visit the NAFO website.



As shown in the chart below, 5Zc and 5Zu are sub/subdivisions of the Subdivision 5Ze established by the Scientific Council for the purpose of recording and reporting catches to NAFO from Canadian waters (5Zc) or USA waters (5Zu) (NAFO GC Doc. 86/2, 2nd revision, and GC Doc. 86/4, revised).

This chart below represents the Exclusive Economic Zone (EEZ) of France (in respect of St. Pierre and Miquelon)

CONTENTS

PART A: REPORT OF THE SCIENTIFIC COUNCIL MEETING

28 May -12 June 2020
By correspondence

Recommended Citation:

NAFO. 2020. Report of the Scientific Council, 28 May -12 June 2020. NAFO SCS Doc. 20/14

REPORT OF SCIENTIFIC COUNCIL MEETING
28 May -12 June 2020

Chair: Carmen Fernandez Rapporteur: Tom Blasdale

I. PLENARY SESSIONS

The Scientific Council (SC) met by correspondence from 28 May to 12 June 2020 to consider the various matters in its agenda. Representatives attended from Canada, Denmark (in respect of Faroe Islands and Greenland), the European Union, Japan, the Russian Federation, Ukraine and the United States of America. Observers from the Ecology Action Centre, Sustainable Fisheries Greenland, and Oceans North were also present. The Executive Secretary, Scientific Council Coordinator and other members of the Secretariat were in attendance.

Dr. Hugues Benoît participated as an external reviewer for the work on Greenland halibut in NAFO Subareas 0 and 1 and also provided expertise on the Commission request on survivability of discards. Dr. Andrew Kenny participated invited by the SC chair to provide expertise on various requests focused on ecosystem aspects.

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

The Council was called to order at 08:00 Halifax time (11:00 UTC) on 28 May 2020. The provisional agenda was **adopted** and the Scientific Council Coordinator was appointed the rapporteur. The opening session was adjourned at 12:30 on 28 May 2020.

Several sessions were held throughout the course of the meeting to deal with specific items on the agenda.

Because of having to meet by correspondence, with participants located in many different time zones, it was only possible to meet (by WebEx) from 08:00 to 13:00 (Halifax time), and this limited the amount of work that could be achieved in the meeting. The work, therefore, focused on items identified as priority level 1 in the SC report from April 2 (SCS Doc. 20/04) and as described in the agenda attached in Appendix V. The meeting also managed to provide responses to some requests identified as priority level 2.

SC plans to hold an additional meeting, by correspondence, during September 15-17, aiming to address some of the requests deferred from the June meeting. However, SC noted that changes might still occur, e.g. depending on potential feedback that might be received from the Commission. Details of the SC plan of work for September are described in Section XI of this report.

The stock of witch flounder in NAFO Div. 3NO was assessed by SC this year of its own accord, and advice provided for 2021 and 2022. This was necessary to avoid a conflict in the multi-year assessment schedule in 2021, when 3LNO Yellowtail Flounder and 3NO Witch Flounder had both been planned (the same Designated Expert is responsible for both stocks). In recognition of the fact that the Commission has agreed a TAC for 2021, a second set of projections is provided in the summary sheet this year, where this second set of projections assume that catches in 2021 are equal to the TAC and considers alternative catch options only for 2022.

The concluding session was called to order at 08:00 on 12 June 2020.

The Council considered and **adopted** the Scientific Council Report of this meeting of 28 May -12 June 2020. 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 14:00 h on 12 June 2020.

The limitations of meeting by correspondence also implied that the reports of the Standing Committee on Fisheries Environment (STACFEN) and the Standing Committee on Fisheries Science (STACFIS) could only be formally **adopted** by correspondence, at a later date in June (STACFEN report) or July (STACFIS report) 2020. These reports are included as Appendices I and IV, respectively.

The reports of the Standing Committee on Research Coordination (STACREC) and the Standing Committee on Publications (STACPUB) were deferred until September.

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 2019

Recommendations from 2019 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) by correspondence as presented by the Chair, Miguel Caetano. The full report of STACFEN is in Appendix I.

STACFEN made the following recommendations, which were **endorsed** by the Scientific Council:

- STACFEN **recommends** consideration of Secretariat support for an invited speaker to address emerging issues and concerns for the NAFO Convention Area during the 2021 STACFEN Meeting.

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

- NAFO usually convenes a symposium on environmental issues every 10 years, with the last one held in 2011 as "ICES/NAFO Symposium on the Variability of the North Atlantic and its Marine Ecosystems during 2000-2009". STACFEN suggested that the forthcoming ICES Symposium (2021) could take the place of the next NAFO symposium. STACFEN therefore **recommended** *that Scientific Council support participation and possible co-sponsorship*.

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

IV. PUBLICATIONS

The Report of the Standing Committee on Publications (STACPUB) is deferred until the September meeting of SC.

V. RESEARCH COORDINATION

The Report of the Standing Committee on Research Coordination (STACREC) is deferred until the September meeting of SC.

VI. FISHERIES SCIENCE

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

VII. MANAGEMENT ADVICE AND RESPONSES TO SPECIAL REQUESTS

1. The NAFO Commission

The Commission requests are given in Annex 1.

For Northern shrimp in Div. 3M, advice for 2021 will be drafted during a WebEx scheduled to occur prior to the Annual Meeting of 21 – 25 September 2020. The WebEx meeting will last 1 day and will likely be on September 11 or September 14 (subject to confirmation). For Northern shrimp in Divs. 3LNO, SC provided advice (in 2019) for 2020 and 2021.

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 States, 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 2020 for 2021

Recommendation for 2021

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 very near future under any fishing scenario.

Yield of less than or equal to 1 000 tonnes in 2021 results in a very low probability (≤10%) of SSB being below B_{lim} in 2022 and a very low probability of exceeding F_{lim}. For any catch over 1 000 tonnes, the probability of being below B_{lim} exceeds the NAFO Precautionary Approach guidelines.

Management objectives

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

Convention objectives	***Status***	***Comment/consideration***
Restore to or maintain at B_{msy}	🟡	Stock above B_{lim} in 2020. B_{msy} is unknown
Eliminate overfishing	🔴	$F>F_{lim}$ in 2019
Apply Precautionary Approach	🟢	F_{lim} and B_{lim} defined
Minimise harmful impacts on living marine resources and ecosystems	🟡	VME closures in effect, no specific measures
Preserve marine biodiversity	○	Cannot be evaluated

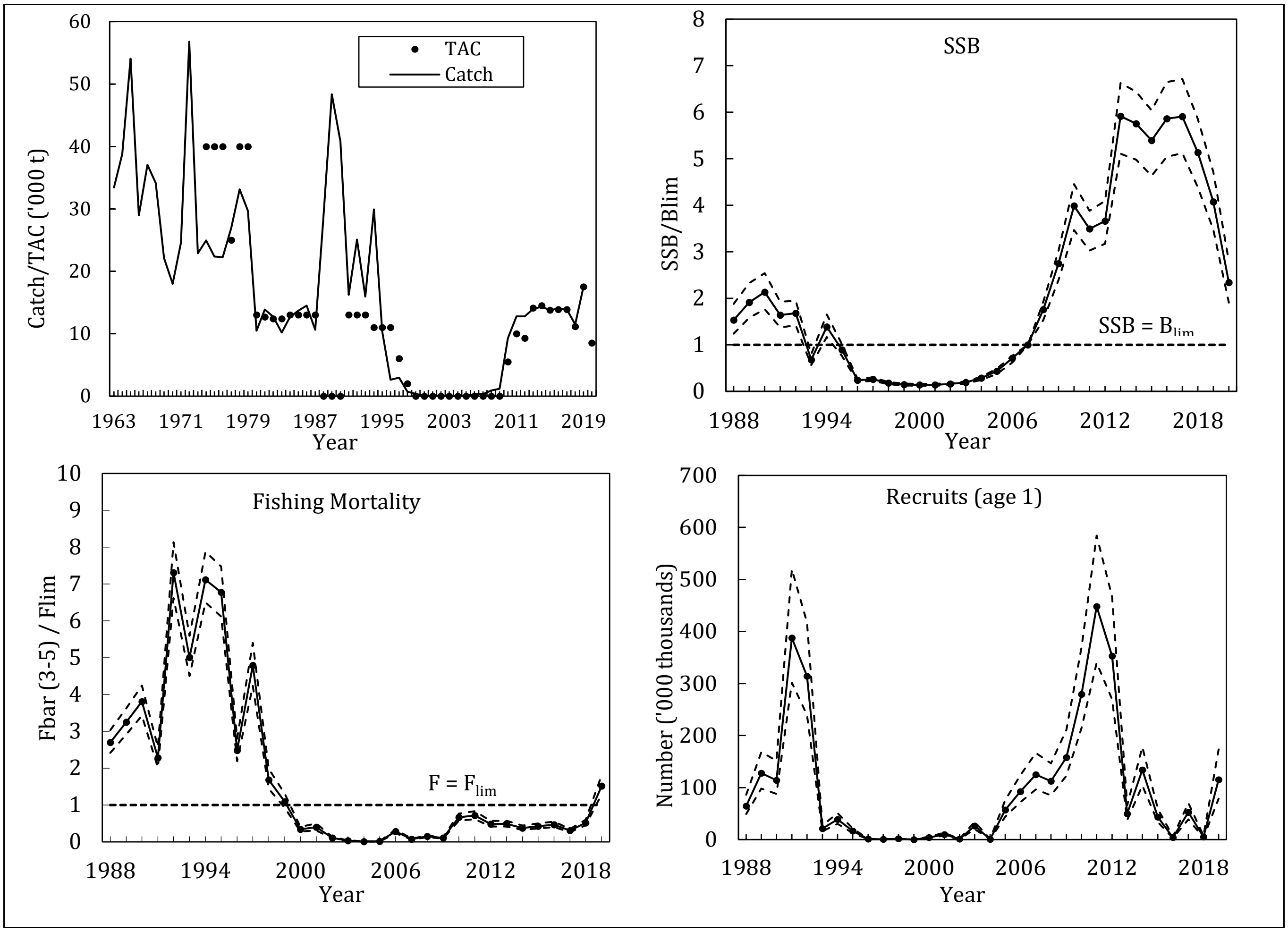
🟢	OK
🟡	Intermediate
🔴	Not accomplished
○	Unknown

Management unit

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

Stock status

Current SSB is estimated to be above B_{lim} (median 15 271 t) although it is declining rapidly and is expected to continue its decline in the near future due to poor recruitment between 2015 and 2018. F increased in 2010 with the re-opening of the fishery although until 2018 it was below F_{lim} (median 0.191). In 2019, F increased to a level above F_{lim}.



Reference points

$B_{lim} = SSB_{2007}$: Median = 15 271 tonnes of spawning biomass (Scientific Council, 2020).

$F_{lim} = F_{30\%SPR}$: Median = 0.191 (Scientific Council, 2020)

Projections

	B		SSB		Yield
	Median and 80% CI				
F_{bar}=3/4F_{lim} (median=0.143)					
2020	48777	(42258 - 55350)	35725	(30140 - 41365)	8531
2021	35857	(30252 - 41757)	23121	(18576 - 27867)	5595
2022	26786	(21764 - 32499)	15472	(11920 - 19144)	4622
2023	19902	(15130 - 25556)	14280	(10838 - 18316)	
F_{bar}=0					
2020	48777	(42258 - 55350)	35725	(30140 - 41365)	8531
2021	35857	(30252 - 41757)	23121	(18576 - 27867)	0
2022	32245	(27255 - 37930)	20159	(16445 - 23914)	0
2023	28937	(24157 - 34759)	22321	(18764 - 26370)	
Catch=1000 tons					
2020	48777	(42258 - 55350)	35725	(30140 - 41365)	8531
2021	35857	(30252 - 41757)	23121	(18576 - 27867)	1000
2022	31265	(26251 - 36956)	19317	(15655 - 23065)	1000
2023	27176	(22347 - 32982)	20743	(17192 - 24760)	
Catch=3000 tons					
2020	48777	(42258 - 55350)	35725	(30140 - 41365)	8531
2021	35857	(30252 - 41757)	23121	(18576 - 27867)	3000
2022	29305	(24278 - 35017)	17616	(13964 - 21334)	3000
2023	23596	(18837 - 29285)	17549	(14040 - 21560)	

	Yield			$P(B < B_{lim})$				$P(F > F_{lim})$			
	2020	2021	2022	2020	2021	2022	2023	2020	2021	2022	$P(B_{23} > B_{20})$
3/4Flim = 0.143	8531	5595	4622	<1%	1%	50%	62%	4%	5%	6%	<1%
F=0	8531	0	0	<1%	1%	6%	1%	4%	0%	0%	<1%
Catch=1000t	8531	1000	1000	<1%	1%	10%	4%	4%	<1%	<1%	<1%
Catch=3000t	8531	3000	3000	<1%	1%	24%	24%	4%	<1%	<1%	<1%

Although advice is given only for 2021, projection results are shown to 2023 to illustrate the medium-term implications.

The results indicate that under all scenarios, total biomass during the projected years will decrease sharply, while the SSB will increase slightly in 2023 with the F=0 and the Catch=1 000 tonnes scenarios. The probability of SSB being below B_{lim} in 2022 and 2023 is very high (≥24%) in the scenarios with F_{bar}=3/4F_{lim} and Catch=3 000 tonnes, while being very low (≤10%) in the rest of the cases. The probability of SSB in 2023 being above that in 2020 is <1%.

Under all scenarios, the probability of F exceeding F_{lim} is less than or equal to 6% in 2021 and 2022.

Assessment

A Bayesian SCAA model was used as the basis for the assessment of this stock with data from 1988 to 2019.

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

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 tonnes) are as follows:

,000 tons	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
TAC	5.5	10.0	9.3	14.1	14.5	13.8	13.9	13.9	11.1	17.5	8.5
STATLANT 21	5.2	10.0	9.1	13.5	14.4	12.8	13.8	13.9	10.5	13.0	
STACFIS	9.3	12.8	12.8	13.985	14.3	13.8	14.0	13.9	11.5	17.5	

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 coral.

Special comment

The stock is declining very rapidly and is expected to be at very low levels during the next few years.

Sources of information

SCS Doc. 20/06, 20/07, 20/08, 20/09 and SCR Doc. 20/11, 20/31.

American plaice in Division 3M

Advice June 2020 for 2021 – 2023

Recommendation for 2021 - 2023

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

Management objectives

No explicit management plan or management objectives defined by the Commission. Convention general principles are applied.

Convention objectives	*Status*	*Comment/consideration*
Restore to or maintain at B_{msy}	🔴	B_{msy} unknown, stock at a low level
Eliminate overfishing	🟢	No directed fishing. Fishing mortality thought to be low
Apply Precautionary Approach	🔴	Reference points not defined. No HCRs
Minimise harmful impacts on living marine resources and ecosystems	🟡	VME closures in effect, no specific measures.
Preserve marine biodiversity	⚪	Cannot be evaluated

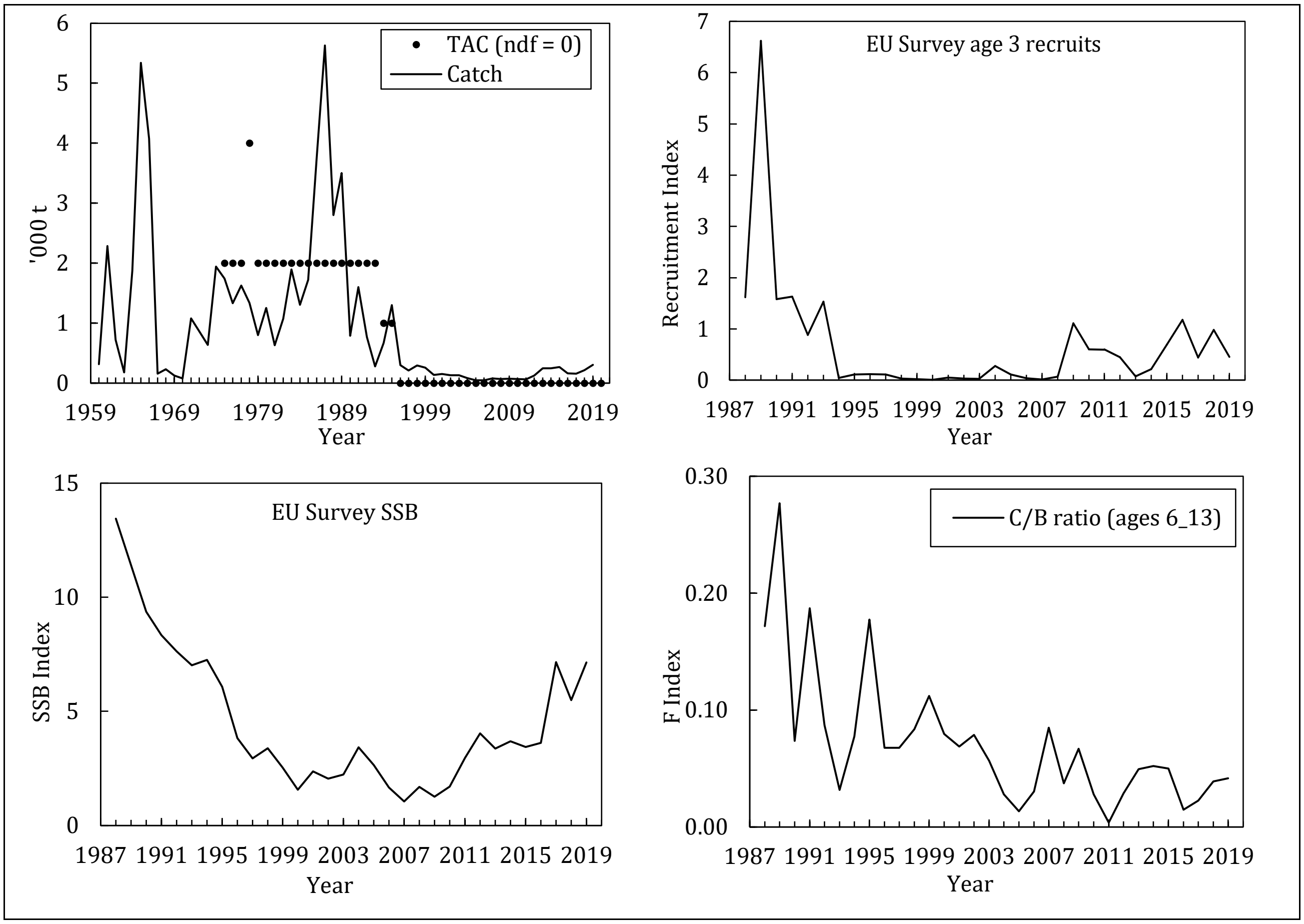
🟢	OK
🟡	Intermediate
🔴	Not accomplished
⚪	Unknown

Management unit

The American plaice stock in Flemish Cap (Div. 3M) is considered to be a distinct population.

Stock status

The stock has increased in recent years due to improved recruitment (at age 3) since 2009, and recovered to the levels of the mid 1990s, when the fishery was closed. Both catches and F remain low, although slightly higher catches are observed since 2013.



Reference points

Scientific Council is not in a position to provide proxies for biomass or fishing mortality reference points at this time.

Projections

Quantitative assessment of risk at various catch options is not possible at this time.

Assessment

This assessment is based upon a qualitative evaluation of research vessel survey series and bycatch data from commercial fisheries.

The next full assessment is planned for 2023.

Human impact

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

Biological and environmental interactions

The stock occurs mainly at depths shallower than 600 m on Flemish Cap. Main stomach contents are echinoderms, shrimp and hyperiids.

Fishery

American plaice is caught as bycatch in otter trawl fisheries, mainly the cod and redfish fisheries. From 1979 to 1993 a TAC of 2 000 tonnes was in effect for this stock. A reduction to 1 000 tonnes was agreed for 1994 and 1995 and a moratorium was agreed to thereafter.

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

	2011	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**
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	0.3	
STACFIS	0.1	0.1	0.2	0.2	0.3	0.2	0.2	0.2	0.3	

ndf - no directed fishing.

Effects of the fishery on the ecosystem

No directed fishery. General impacts of fishing gear on the ecosystem should be considered.

Special comments

No special comments

Sources of information

SCR Doc. 05/29; 20/11, 39; SCS Doc. 18/8, 13; 19/9; 20/7, 9, 13

Thorny skate in Divisions 3LNO and Subdivision 3Ps

Advice June 2020 for 2021-2022

Recommendation for 2021-2022

The stock has been stable at recent catch levels (approximately 3 511 tonnes, 2015 - 2019). However, given the low resilience of this species and higher historic stock levels, Scientific Council advises no increase in catches.

Management objectives

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

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

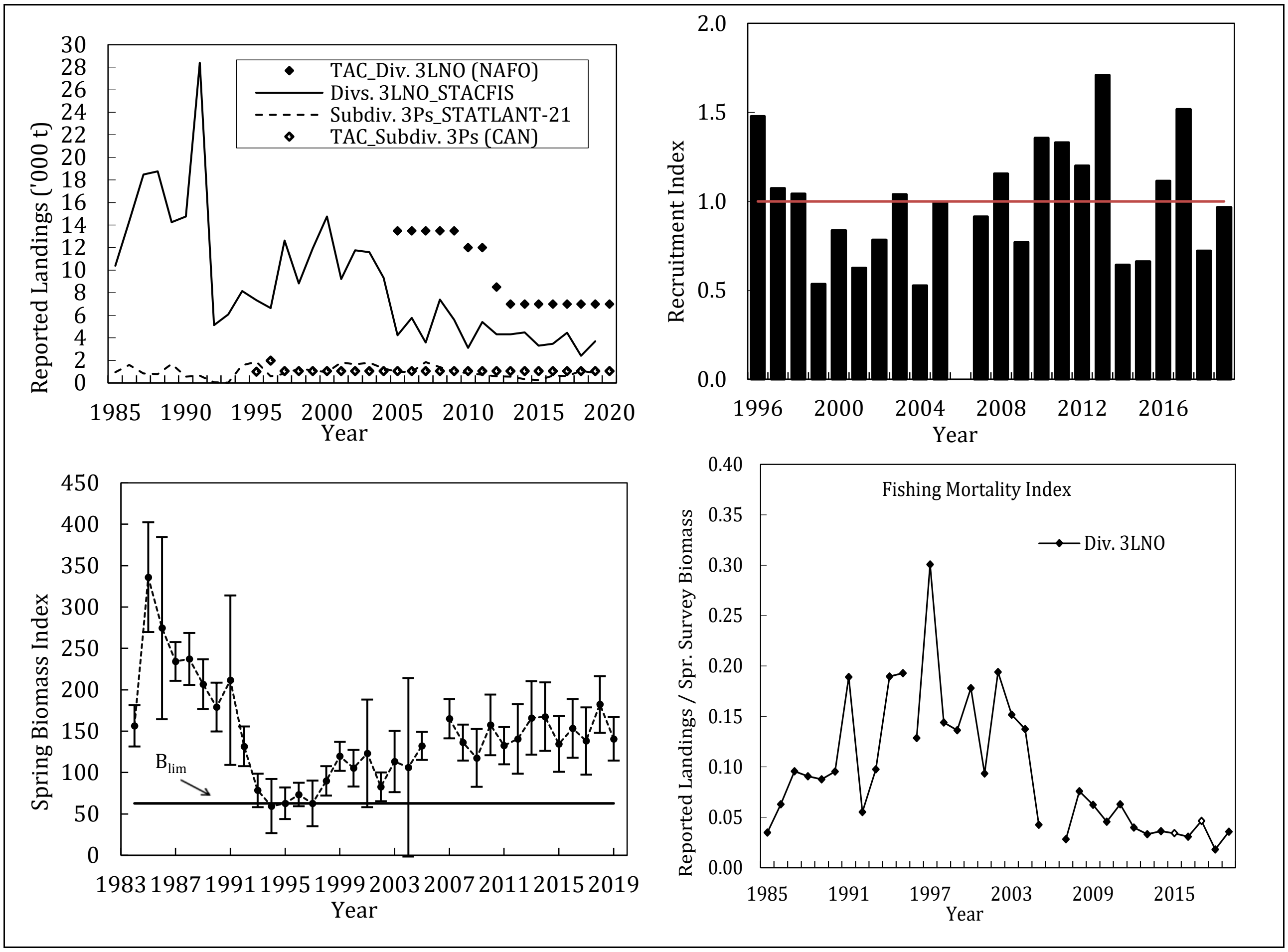
🟢	OK
🟡	Intermediate
🔴	Not accomplished
⚪	Unknown

Management unit

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

Stock status

The stock is currently above $B_{lim.}$ The probability that the current biomass is above B_{lim} is >95%. Total survey biomass in Divs 3LNOPs has remained stable since 2007 but is still lower than the levels observed at the end of the 1980s. Recruitment in 2017 was above average but declined to below average in 2018 and was average in 2019. Fishing mortality is currently low.



Reference points

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

Assessment

Based upon a qualitative evaluation of stock biomass trends and recruitment indices. The assessment is considered data limited and, as such, associated with a relatively high uncertainty. Input data are research survey indices and fishery data. The next full assessment of this stock will be in 2022.

Human impact

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

Biology and Environmental interactions

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

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

Fishery

Thorny skate is caught in directed gillnet, trawl and long-line fisheries. In directed thorny skate fisheries, Atlantic cod, monkfish, American plaice and other species are landed as bycatch. In turn, thorny skate are also caught as bycatch in gillnet, trawl and long-line fisheries directing for other species. The fishery in NAFO division 3LNO is regulated by quota. Catches are well below the TAC because Canada has not been fishing on this stock.

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

	2011	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**
Div. 3LNO:										
TAC	12	8.5	7	7	7	7	7	7	7	7
STATLANT 21	5.5	4.3	4.4	4.5	3.3	3.5	4.2	1.5	3.7	
STACFIS	5.4	4.3	4.4	4.5	3.4	3.5	4.5	2.4	3.7	

Effects of the fishery on the ecosystem

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

Special comments

The life history characteristics of thorny skate result in low rates of population growth and are thought to lead to low resilience to harvesting if the stock becomes depleted to low levels.

Sources of Information

SCR Doc. 14/23.15/40,20/04,10,14,41; SCS Doc. 20/07,09,13

Monitoring of Stocks for which Multi-year Advice was Provided in 2018 or 2019

Interim monitoring for northern shortfin squid (*Illex illecebrosus*) in Subareas 3+4 will be carried out in September 2020). Interim monitoring updates of other stocks assessed in prior years were conducted and Scientific Council reiterates its previous advice as follows:

Recommendation for redfish in Divisions 3M for 2020 and 2021: SC advises that catches should not exceed $F_{0.1}$ 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.

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 Div. 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 yellowtail flounder in Divisions 3LNO for 2019-2021: At a fishing mortality of 85% F_{msy}, catches of 24 900 tonnes, 22 500 tonnes, and 21 100 tonnes 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}.

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

Recommendation for redfish in Division 3O 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 tonnes 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.

Recommendation for white hake in Divisions 3NO and Subdivision 3Ps 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.

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

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

Special Requests for Management Advice

Due to time constraints, Scientific Council was not able to address Commission requests number 3, 4, 9, 10, 13, 14, 16 and 18 during the June meeting. These requests will be addressed, to the extent possible, in September during the Annual Meeting and/or in an additional meeting (by correspondence) during September 15-17. Scientific Council members will work intersessionally to complete the work as far as possible prior to the September meeting.

Request number 15 was addressed by Scientific Council during the SC/NIPAG meeting in November 2019 and the response can be found in SCS Doc. 19/23.

i) Greenland halibut in SA2 + Divs. 3KLMNO: conduct an update assessment, compute the TAC using the agreed HCR and determine whether exceptional circumstances are occurring (COM request #2)

The Commission requests the Scientific Council to conduct an update assessment of Greenland halibut in Subarea 2+Div. 3KLMNO and 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 2021 derived from the HCR is 16 498 tonnes.

SC advises that Exceptional Circumstances are not occurring.

The SC conducted update assessments, given the addition of three more years of data (2017-2019) to the base case SCAA and SSM models. Estimates of quantities such as recruitment, exploitable biomass, and average *F* hardly changed from values estimated in 2017.

An HCR for Greenland halibut in Subarea 2+Div. 3KLMNO was adopted by the Commission in 2017. The HCR has two components: target based and slope based. The full set of control parameters for the adopted HCR are shown in Table i.1 with a starting TAC of 16 500 tonnes in 2018. All data inputs used to calculate the TAC for 2021 are shown in Table i.2.

*Target based (**t**)*

The target harvest control rule (HCR) is:

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

where TAC_y is the TAC recommended for year y, γ is the “response strength” tuning parameter, J_y is a composite measure of the immediate past level in the mean weight per tow from surveys (I_y^i) that are available to use for calculations for year y; 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-Spain 3NO and Canada Fall 3LNO:

$$J_y = \sum_{i=1}^{5} \frac{1}{{\sigma^i}^2} \frac{J_{current,y}^i}{J_{target}^i} \Big/ \sum_{i=1}^{5} \frac{1}{{\sigma^i}^2} \qquad (2)$$

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

$$J_{current,y}^i = \frac{1}{q} \sum_{y'=y-q}^{y-1} I_{y'}^i \qquad (3)$$

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

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

*Slope based (**s**)*

The slope harvest control rule (HCR) is:

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

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

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

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

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

For the target and slope based combination:

1) $\text{TAC}_{y+1}^{target}$ is computed from equation (1),

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

3) $\text{TAC}_{y+1} = (\text{TAC}_{y+1}^{target} + \text{TAC}_{y+1}^{slope})/2$

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

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

and

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

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

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

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

Table i.2. Data used in the calculation of the TAC for 2021. 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.

	Canada Fall 2J3K	Canada Fall 3LNO	Canada Spring 3LNO	EU-Spain 3NO	EU 3M 0-1400m
2011	26.74	2.21	1.05	7.09	26.15
2012	23.50	1.71	1.94	7.37	19.20
2013	29.65	2.59	0.73	5.46	19.11
2014	33.34		0.66	6.24	23.92
2015	22.29	0.87		9.49	47.52
2016	18.54	1.31	0.66	8.80	28.30
2017	15.10	1.25		16.63	42.66
2018	17.05	1.89	1.88	7.88	29.80
2019	16.28	1.87	1.45	8.82	16.89
s^{i}_{2020}	-0.07	0.19	0.30	-0.03	-0.20
$J^{i}_{current, 2020}$	16.15	1.67	1.66	11.11	29.79
J^{i}_{target}*	26.34	1.79	1.06	6.93	26.42
σ^{i}	0.22	0.26	0.49	0.38	0.21
		TAC_{2020}	16 926 tonnes	TAC^{target}_{2021}	16 940 tonnes
		s_{2020}	-0.03	TAC^{slope}_{2021}	16 056 tonnes
		J_{2020}	1.01	TAC_{2021}	16 498 tonnes

* A mis-specification of α (previously 0.927, corrected 0.972) meant that incorrect J_{target} values were applied to calculate the TAC for 2019 and 2020. This error had a negligible impact on the TAC calculations (< 0.5%; SCR Doc. 20/042). Correct J_{target} values are used here.

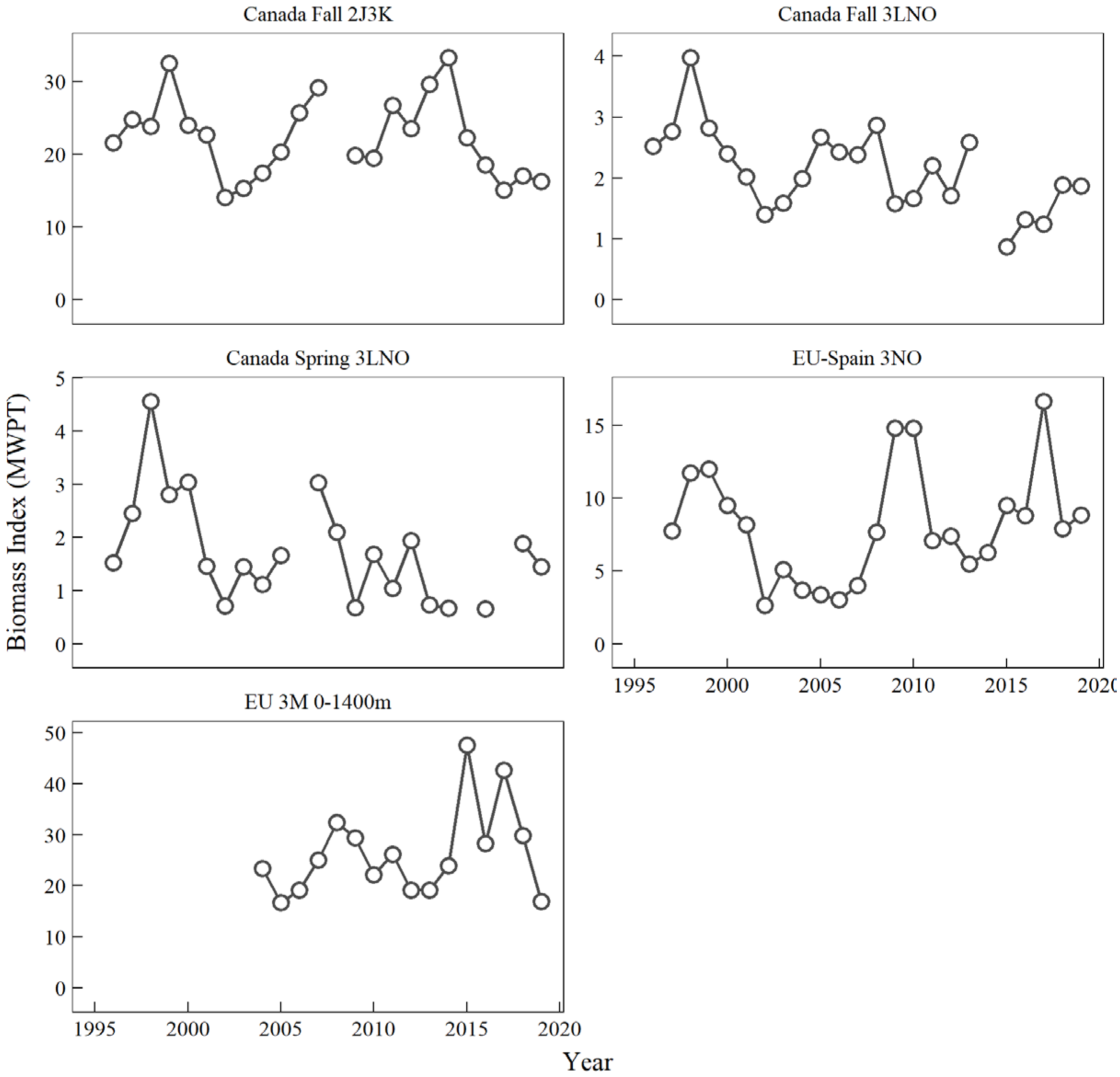


Figure. i.1. Input for the Greenland Halibut in Subarea 2 + Divisions 3KLMNO Harvest Control Rule. Survey data come from Canadian fall surveys in Divs. 2J3K, Canadian spring surveys in Divs. 3LNO (2015 and 2017 surveys were incomplete and not used in the calculation of the TAC using the HCR), Canadian fall surveys in Divs. 3LNO, EU Flemish Cap surveys (to 1400m depth) in Div. 3M and EU-Spain 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:

1. Missing survey data:

- *More than one value missing, in a five-year period, from a survey with relatively high weighting in the HCR (Canadian Fall 2J3K, Canadian Fall 3LNO, and EU 3M surveys);*
- *More than two values missing, in a five-year period, from a survey with relatively low weighting in the HCR (Canadian Spring 3LNO and EU-Spain 3NO surveys);*

SC notes that the Canadian fall 2J3K was incomplete in 2019. Areas that were missed are inhabited by Greenland halibut. However, the unavailability of the strata missed in 2019 had minimal impact on the mean weight per tow indices used in the HCR (see SCR Doc. 20/004). It was therefore agreed that the 2019 Canadian fall 2J3K index would be included in the calculation of the TAC using the HCR. Therefore, Exceptional Circumstances do not presently arise from missing survey data.

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

The composite survey index has remained within the 90% probability envelopes from the base case SCAA operating model (Figure i.2). Incomplete documentation regarding the SSM projections have precluded the same comparison using the SSM probability envelopes in 2019. Consequently, a thorough review of the SSM MSE simulations has been conducted and several issues have been identified and resolved (summarized below). A provisional reconstruction of the SSM base case simulation is presented in Figure i.3 and the composite survey indices are above the 90% probability envelopes, though exceeding these values is not a conservation concern. Given the composite index remains within the 90% probability envelope from the SCAA and has been above the 90% probability envelope from the reconstructed SSM projections, SC considers that this does not constitute Exceptional Circumstances.

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

The TAC established for 2020 was generated from the MP. This does not constitute Exceptional Circumstances.

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

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

Survey indices from the past three years are within the 80% probability envelopes from the base case SCAA operating model except for the EU 3M survey and the EU-Spain 3NO survey in 2017, both of which were above the 90% but within the 95% probability envelope (Figure i.2). Likewise, most recent survey indices are within the 80% probability envelopes from the reconstructed SSM projections, however, some observations are above the 95% envelopes (EU 3M 0-1400m in 2017, Canada Spring 3LNO in 2018 and EU-Spain 3NO in 2017; Figure i.3). All indices from 2019 are within the 80% probability envelopes from both models. This does not constitute Exceptional Circumstances.

2. 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 returned to average levels following six years of below average recruitment (Figure i.4). SC considers that this does not constitute Exceptional Circumstances at this time; however, this remains a concern given the long period of below average recruitment.

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

The TAC for 2019 was 16 521 tonnes. The catch in 2019 was 16 481 tonnes (<0.3% difference). SC considers that this does not constitute Exceptional Circumstances.

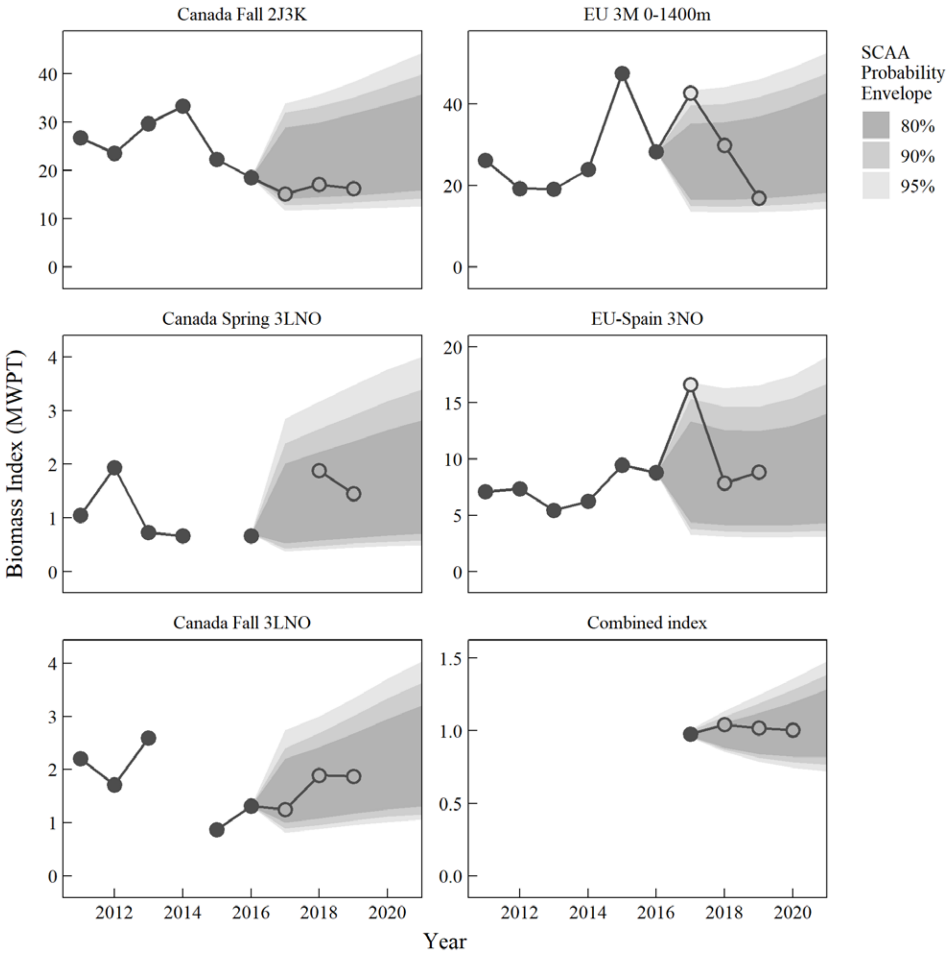


Figure. i.2. Greenland Halibut in Subarea 2 + Divisions 3KLMNO. Mean weight per tow from Canadian fall surveys in Divs. 2J3K, Canadian spring surveys in Divs. 3LNO (2015 and 2017 surveys incomplete and not used in the calculation of the HCR), Canadian fall surveys in Divs. 3LNO, EU Flemish Cap surveys (to 1400m depth) in Div 3M and EU-Spain surveys in 3NO. The figure also shows the combined index used in the target based component of the HCR. For the survey and combined indices, 80%, 90% and 95% probability envelopes from the SCAA base case simulation are shown. Index values observed from 2017 onward are shown using open circles.

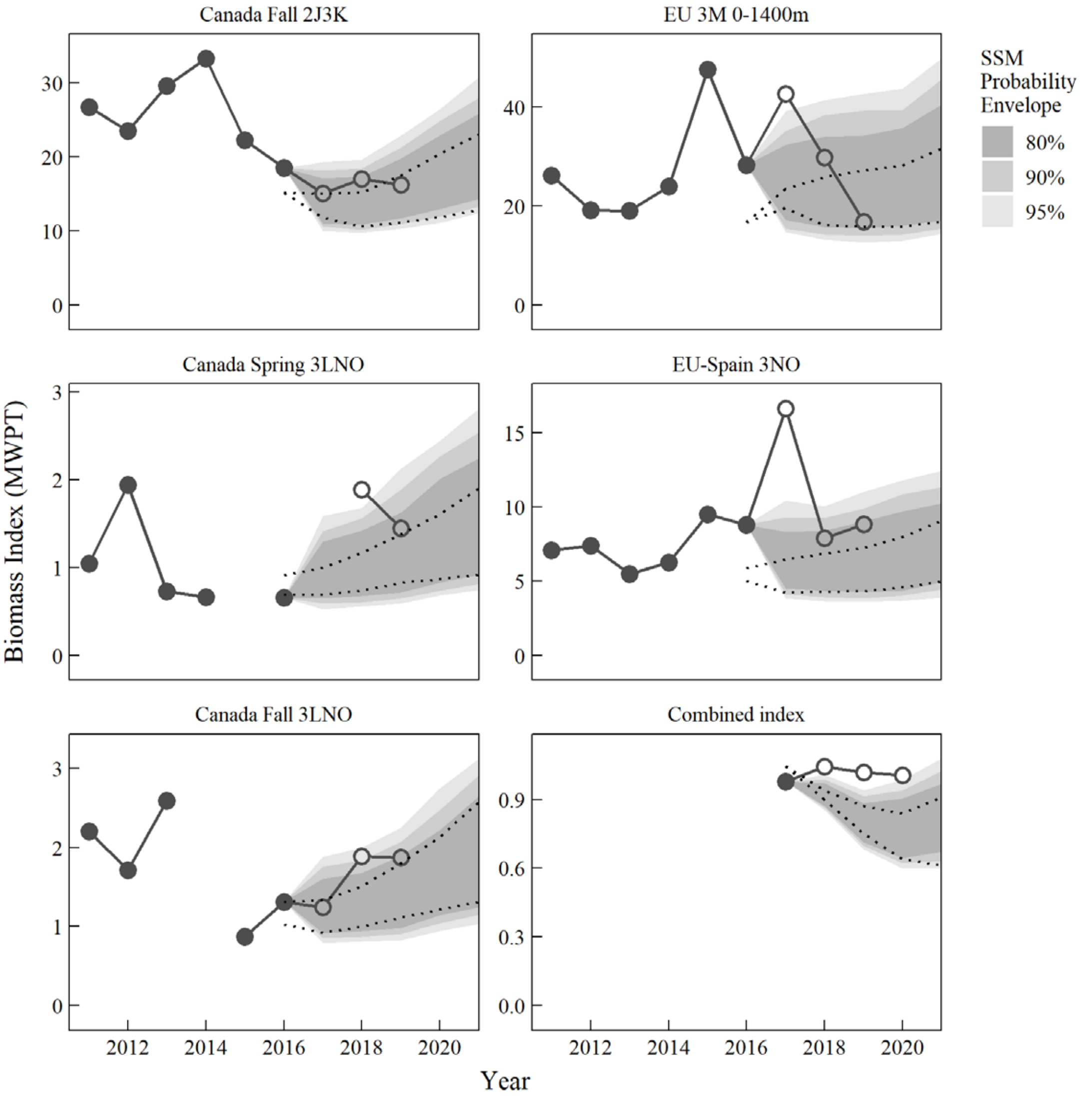


Figure. i.3. Greenland Halibut in Subarea 2 + Divisions 3KLMNO. Mean weight per tow from Canadian fall surveys in Divs. 2J3K, Canadian spring surveys in Divs. 3LNO (2015 and 2017 surveys incomplete and not used in the calculation of the HCR), Canadian fall surveys in Divs. 3LNO, EU Flemish Cap surveys (to 1400m depth) in Div 3M and EU-Spain surveys in 3NO. The figure also shows the combined index used in the target based component of the HCR. For the survey and combined indices, 80%, 90% and 95% probability envelopes from a provisional reconstruction of the SSM base case simulation are shown. Index values observed from 2017 onward are shown using open circles. The dotted lines are 95% probability envelopes from the initial SSM base case simulation, which are now known to have been incorrect (see text).

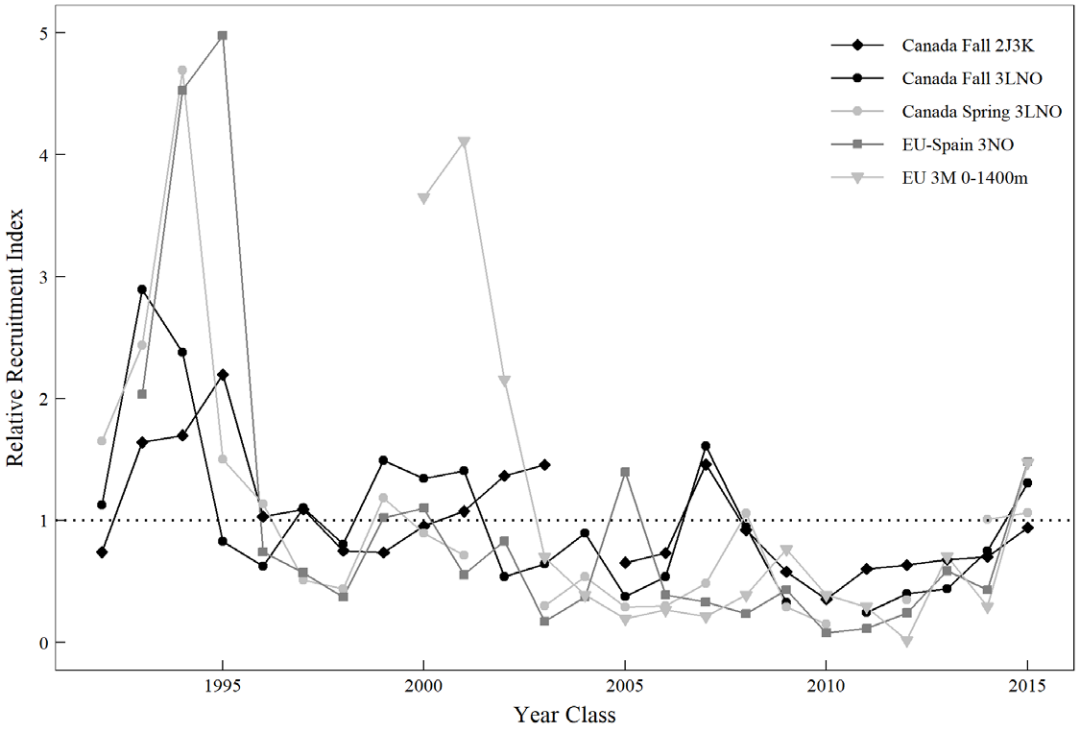


Figure. i.4. Greenland Halibut in Subarea 2 + Divisions 3KLMNO. Relative recruitment (age 4) indices from Canadian fall surveys in Div. 2J3K, Canadian spring surveys in Div. 3LNO, Canadian fall surveys in Div. 3LNO, EU-Spain survey in 3NO and EU survey of Flemish Cap. Each series is scaled to its average,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

Update assessment

In addition to the agreed annual indicators of Exceptional Circumstances, SC agreed to evaluate assessment-based indicators of Exceptional Circumstances following an update assessment of the stock. Specifically:

- *A comparison of assessment model outputs for recruitment, exploitable biomass, and fishing mortality with operating model projections (base case) will also be taken into account qualitatively. Notwithstanding some technical issues regarding the comparison of the simulated distributions against updated assessments, it was agreed that SC will compare the estimated median of the assessment with the 95% Confidence Interval from the base case of SSM and SCAA for the above quantities. Expert judgement will determine whether Exceptional Circumstances are occurring* (SCS Doc. 18/19).

Following the addition of three more years of data (2017-2019) to the base case SCAA and SSM models, estimates of quantities such as recruitment, exploitable biomass, and average F have hardly changed from values estimated in 2017 (i.e. there were no large retrospective revisions in the estimates prior to 2016; Figures i.5 and i.6). Recent estimates from the SCAA are broadly consistent with predictions from the 2017 MSE process; specifically, all estimates are within the 95% probability envelopes with the exception of average F, which in 2017 fell below the 95% probability envelope (Figure i.5). Fishing mortality in the last two years has increased to slightly below F_{MSY} in 2019. Current estimates of recruitment, exploitable biomass and average F all fall within the 95% probability envelopes from the reconstructed SSM simulation (Figures i.6). SC considers that this does not constitute Exceptional Circumstances.

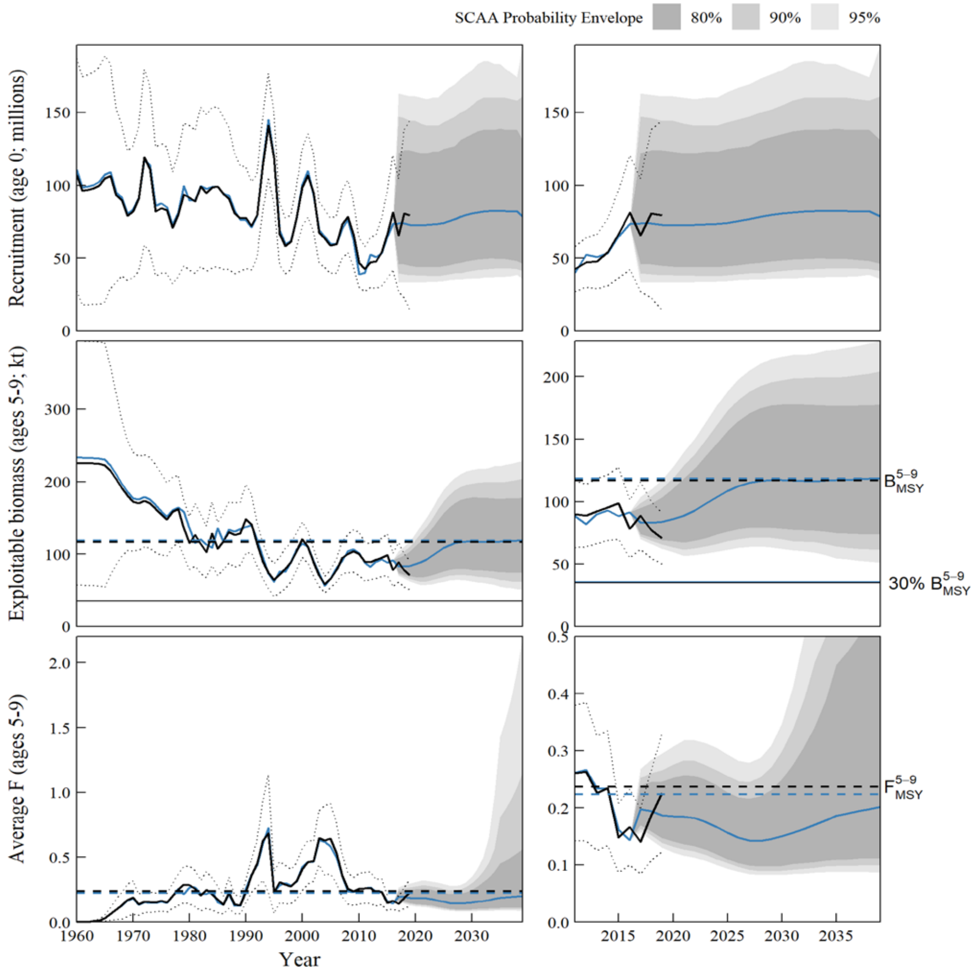


Figure. i.5. Greenland Halibut in Subarea 2 + Divisions 3KLMNO. Base case SCAA model: Trends in recruitment (age 0; millions), exploitable biomass (ages 5-9; kt), and average F (ages 5-9). Blue lines represent values from the 2017 MSE with the base case SCAA, whereas black lines indicate values from 2020 update assessment. Shown are: historical (1960-2019) estimates with 95% CIs (thin dotted lines) from the 2020 update assessment, as well as medians and 80%, 90% and 95% probability envelopes (grey shaded areas) projected from the 2017 MSE simulations (with the base case SCAA) under the adopted HCR. Finally, horizontal lines indicate reference points (B_{MSY}^{5-9}, 30% B_{MSY}^{5-9}, F_{MSY}^{5-9}) from both the 2017 MSE base case SCAA (blue) and those calculated from the 2020 update assessment (black).

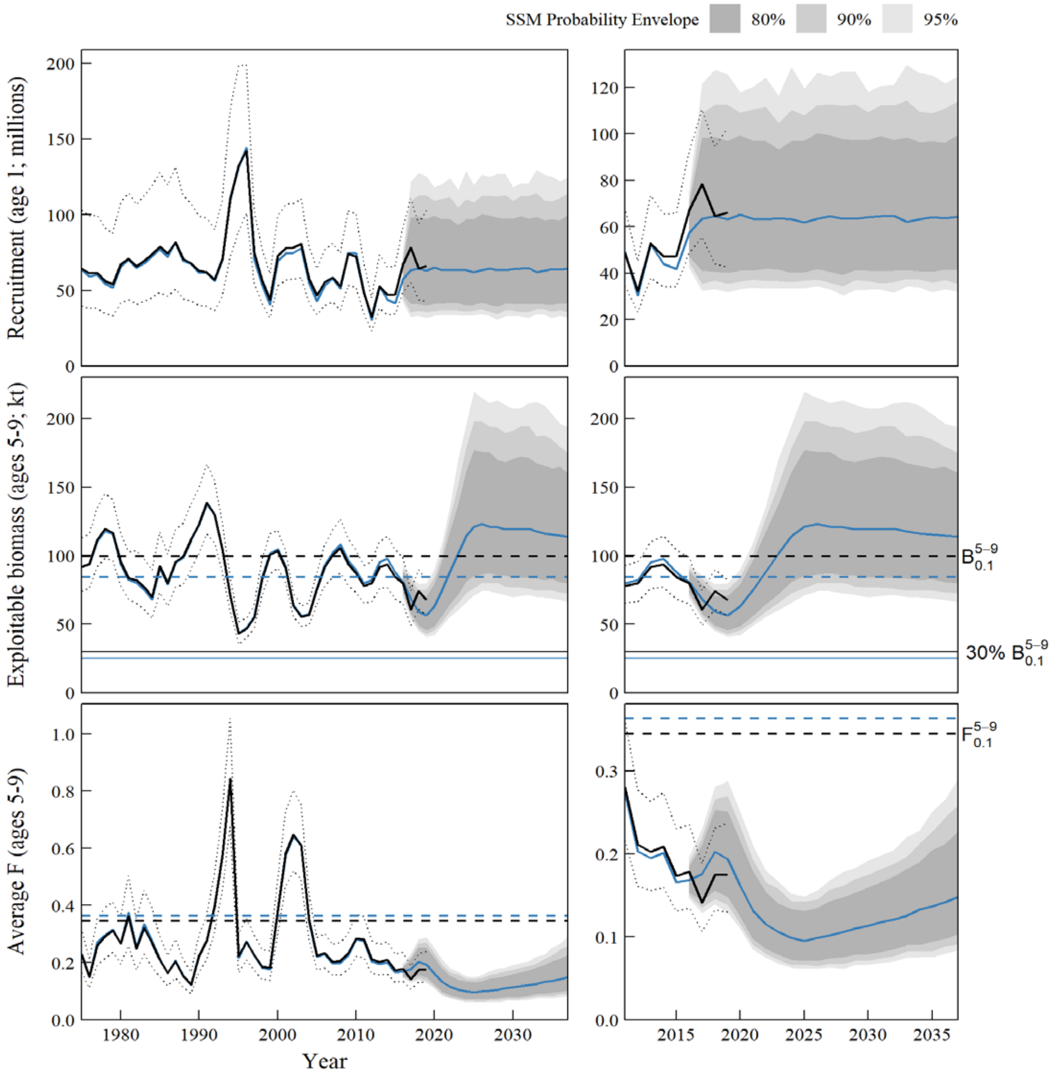


Figure i.6. Greenland Halibut in Subarea 2 + Divisions 3KLMNO. Base case SSM model: Trends in recruitment (age 1; millions), exploitable biomass (ages 5-9; kt), and average F (ages 5-9). Blue lines represent values from the 2017 MSE (reconstituted following correction of errors) with the base case SSM, whereas black lines indicate values from 2020 update assessment. Shown are: historical (1960-2019) estimates with 95% CIs (thin dotted lines) from the 2020 update assessment, as well as medians and 80%, 90% and 95% probability envelopes (grey shaded areas) projected from the 2017 MSE simulations (with the base case SSM) under the adopted HCR. Finally, horizontal lines indicate reference points ($B_{0.1}^{5-9}$, 30% $B_{0.1}^{5-9}$, $F_{0.1}^{5-9}$) from both the preliminary reconstruction of the 2017 MSE base case SSM (blue) and those calculated from the 2020 update assessment (black).

Revisiting the SSM MSE simulations

Unexpected discrepancies between terminal survey indices and the projections from the SSM was the first sign that there were critical flaws in the implementation of the SSM portion of the MSE. These discrepancies are shown in Figure i.3; the dotted lines are the original SSM projections and they should start at the 2016 observations. A lack of documentation prevented SC from verifying the calculations at the June 2019 meeting and, as such, the probability envelopes from the SSM projections could not be used at that meeting to assess exceptional circumstances. This issue triggered a review of the code used to provide the SSM MSE simulations and the following issues were identified:

1. **Observation error:** the simulation began in 2016 at indices predicted by the SSM rather than the actual observation, and future indices were simulated without observation error.
2. **Process error:** the simulation was initialized without process error in the first year (2016), implying that numbers at age in the first year were known without error, and error applied in the projections were sampled from the process errors estimated by the SSM instead of being sampled from a normal distribution.
3. **HCR:** both the target and slope based components of the accepted HCR were mis-specified. Target values were calculated by year rather than by survey and using predicted indices rather than the actual observations. For the slope-based rule, the variance instead of the inverse variance was applied when calculating the weighted measure of recent survey trends. Finally, indexing errors meant that indices from the wrong years were being used to calculate the TAC.

These issues change the structure and function of the model. In an attempt to reconstruct the intended projections, the issues above were rectified and revised probability envelopes were calculated for the base case operating model; these values are used in Figure i.3 and Figure i.6. The original and reconstructed SSM probability envelopes are compared in Figure i.7. Two main differences are noticeable. First, the addition of observation error creates wider probability envelopes in the current simulation for all the survey indices. Second, yields reached higher levels in the original simulations, leading to a decline in biomass. This difference is likely caused by the mis-specification of the HCR in the original simulation.

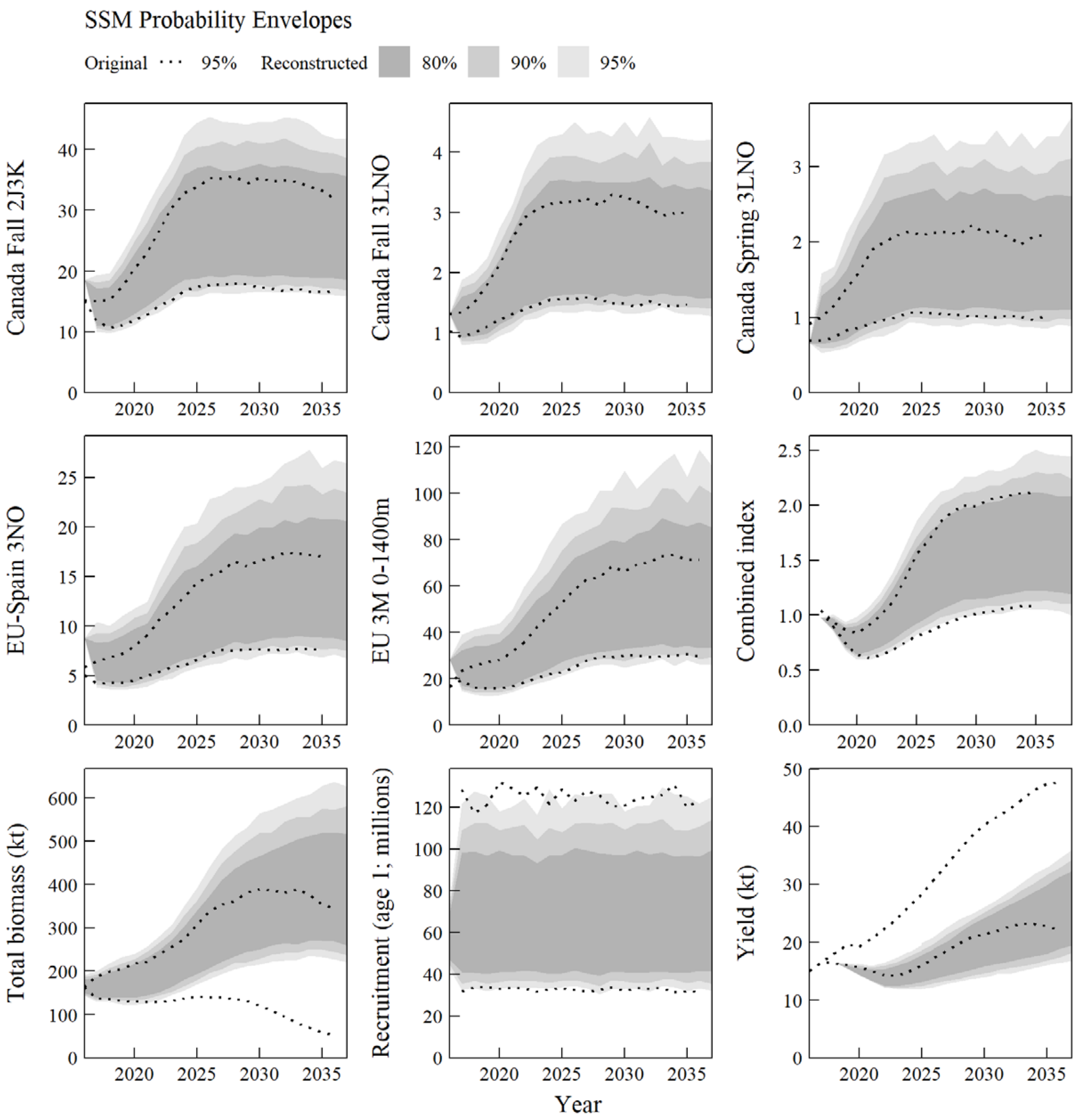


Figure. i.7. Greenland Halibut in Subarea 2 + Divisions 3KLMNO. Probability envelopes from the original (dotted lines; 95% probability envelope only) and reconstructed (shaded areas; 80%, 90% and 95% probability envelopes) SSM base case simulations of the Canadian and EU survey indices, combined index, total biomass (kt), recruitment (age 1; millions), and yield (kt). The original simulations are now known to have been incorrect (see text).

Performance statistics were also revisited following the revision of the simulation. Reference points were required for this task; however, it was not possible to verify or reproduce the reference points used in the initial MSE because of a lack of documentation on the agreed approach. Revised reference points were therefore calculated and, assuming mean levels of age 1 recruitment estimated by the SSM, deterministic equilibrium estimates of $F_{0.1}$ and $B_{0.1}$ were preliminarily chosen as proxies for F_{MSY} and B_{MSY}, respectively. Performance statistics from the original simulation are also shown in Table i.3 and, as expected given the projections, there appears to be greater yields in this simulation as well as a greater risk of not reaching biomass targets. Relatively poor performance is likely a reflection of mis-specifications of the accepted HCR, which, under the reconstructed simulations, appears to be performing well.

With the reference point gaps filled, SC notes that these further base case SSM simulations were found to meet all performance criteria (Table i.3).

Table i.3. Performance statistics from the original and reconstructed SSM MSE simulations applying the HCR adopted in 2017. Statistics from the original simulation are likely flawed as several implementation errors have been identified (see text). Note that $B_{0.1}^{5-9}$ and $F_{0.1}^{5-9}$ were estimated using the reconstructed 2017 base case SSM simulations, and these values were used as proxies for B_{MSY} and F_{MSY}, respectively. The basis of the original 2017 estimates of B_{MSY} and F_{MSY} are unknown. Also note that all other B and F metrics pertain to ages 5-9, except for those with sp as a superscript which represents ages 10+.

Management objective	Perf. stats	Criteria	Original		Reconstructed	
1. Restore to within a prescribed period of time or maintain at B_{MSY}	B_{2037} / B_{MSY}	Median (80% PI)	1.00	(0.64, 1.50)	1.35	(0.94, 1.90)
	$B_{2037} < B_{MSY}$	Proportion ≤ 0.5	0.50		0.14	
	$B_{2022} < 0.8\ B_{MSY}$	Proportion ≤ 0.25	0.57		0.13	
	$B_{2037} < 0.8\ B_{MSY}$	Proportion ≤ 0.25	0.27		0.03	
2. The risk of failure to meet the B_{MSY} target and interim biomass targets within a prescribed period of time should be kept moderately low	B_{lowest} / B_{MSY}	Median (80% PI)	0.56	(0.43, 0.69)	0.64	(0.52, 0.76)
	B_{2022} / B_{2018}	Proportion < Ω = 0.25	0.13		0.07	
3. Low risk of exceeding F_{MSY} (for each year y between 2018 to 2037, if more than 30% of the simulations had $F_y > F_{MSY}$, count 1, i.e. maximum value for this metric is 20)	$(F_{2018-2037} > F_{MSY}) > 0.3$	Count	8.00		0.00	
4. Very low risk of going below an established threshold (for each year y between 2018 to 2037, if more than 10% of the simulations had $B_y < 0.3\ B_{MSY}$, then we count (i.e. maximum value for this metric is 20)	B^{sp}_{2037} / B^{sp}_{2018}	Median (80% PI)	1.59	(0.92, 2.54)	2.17	(1.46, 3.24)
	B_{2037} / B_{2018}	Median (80% PI)	1.58	(0.96, 2.61)	1.91	(1.27, 2.93)
	$(B_{2018-2037} < 0.3\ B_{MSY}) > 0.1$	Count	0.00		0.00	
	B_{lowest} / $B_{MSY} < 0.3$	Proportion ≤ 0.1	0.01		0.00	
5. Maximize yield in the short, medium and long term	avC: 2018-2020	Median (80% PI)	16.49	(16.38, 16.66)	15.55	(15.48, 15.94)
	avC: 2018-2037	Median (80% PI)	19.03	(15.94, 24.97)	18.53	(15.83, 21.38)
6. The risk of steep decline of stock biomass should be kept moderately low	$B_{2022} < 0.75\ B_{2018}$	Proportion < β = 0.11	0.00		0.00	
7. Keep inter annual TAC variation below 'an established threshold'	AAV: 2018-2037	Median (80% PI)	3%	(2%, 5%)	5%	(4%, 6%)
8. Proportion of the catch consisting of 10+ fish	Average 2018-2037	Median (80% PI)	0.12	(0.11, 0.13)	0.21	(0.18, 0.25)

ii) Continue the evaluation of scientific trawl surveys in VME closed areas (COM request #3)

Due to time constraints, SC was not able to address this request during the June meeting and it is deferred until September 2020 or June 2021.

iii) Identify discard species/stocks with high survivability rates (COM request #4)

Due to time constraints, SC was not able to address this request during the June meeting and it is deferred until September 2020.

iv) continue to refine work under the ecosystem approach (COM request #5)

The Commission requests the Scientific Council to continue to refine its work under the Ecosystem Approach and report on these results to both the WGEAFFM and WGRBMS.

Scientific Council responded:

The NAFO Roadmap toward an Ecosystem Approach to Fisheries is organized around two general components dealing with a) sustainability of the fisheries exploitation (i.e. impacts on fished stocks), from an ecosystem (Tier 1), multispecies (Tier 2) and single species (Tier 3) perspective, and b) the effects of fishing on other ecosystem elements (i.e. impacts of fishing on habitats). In practice, work toward implementing Tier 1 principles has involved, among other things, the development of guidance for aggregated total catches based on Ecosystem Production Potential (EPP) models. To address existing concerns about the reliability of this approach, SC conducted a detailed review of the EPP model, the process used to derive the Fishery Production Potential (FPP), the adjustment for ecosystem productivity conditions that renders the current FPP (FPPc), and the associated Total Catch Index (TCI) which serves as an operational metric in the guidance for total catches.

Results indicate that the EPP model provides a good approximation to ecosystem production, that it is necessary to consider basic food web structure and energy pathways to adequately track how primary production becomes fisheries production, and that this model can provide a first order approximation to the production potential of trophic guilds relevant to fisheries. SC also notes that total FPP estimates are consistent with MSY estimates from aggregate biomass surplus production models from 12 Northern hemisphere marine ecosystems, including the Newfoundland Shelf. This coherence with independent analyses gives further support to FPP and TCI as a reliable basis for the provision of strategic (3-5yr) guidance. Furthermore, the results also indicate that catches above TCI levels are more often associated with negative biomass trends in functional guilds, particularly when catches were 2-5 times greater than TCI guidance. This indicates that TCIs perform reasonably well at mapping catch levels associated with negative trends in growth of functional guilds among ecosystem units.

SC notes that the overall results of the analyses are promising, and **recommends** that, *as an interim measure in the implementation of the NAFO Roadmap, the particular circumstances in the state of stocks and the potential consequences to fishery sustainability be considered and addressed in management decisions when the combined TACs can result in overall catches about two-fold greater than the TCI guidance. Total catches above TCIs would require more frequent ecosystem monitoring/reporting*. SC also **recommends** *the development of simulation-based analyses (Management Strategy Evaluation, or analogous processes), to evaluate the reliability of specific decision rules for species-aggregated catch levels based on the TCI, though recognizing that this will be a complex exercise requiring considerable time, resources and stakeholder involvement, and hence the need for interim measures as indicated above.* Furthermore, SC **recommends** that *priority be given for the development of multispecies dynamic models to a) complement the recommended simulation-based exercises and investigate the consequences of time-dependent dynamics on the operational reliability of the TCIs as guidance for ecosystem-level advice, and b) contribute to the development of tools toward implementation of the Tier-2 level of the Roadmap.*

The NAFO Roadmap is organized around two general components dealing with a) sustainability of the fisheries exploitation (i.e. impacts on fished stocks) and b) the effects of fishing on other ecosystem elements (i.e. impacts of fishing on habitats).

Defining sustainable exploitation levels within an ecosystem approach is addressed through a three-tiered process. Tier 1 outlines the need to provide ecosystem-level guidance dealing with total fisheries exploitation based on the overall productivity and state of the ecosystems being fished. Tier 2 is the stage where models of multispecies interactions would be used to inform the allocation of fisheries production among a set of target stocks, taking into account predation and competition. Tier 3 involves single-species stock assessment, where the harvest rates derived in Tiers 1–2 are further examined to ensure single-species sustainability. Taken together, exploitation levels are defined by sequentially examining sustainability at nested levels of ecological organization (i.e. ecosystem, multispecies, and stock).

In practice, work toward implementing Tier 1 of the NAFO Roadmap has involved, among other things, the development of guidance for aggregated total catches based on a model of Ecosystem Production Potential (EPP). The NAFO Commission (COM) and Scientific Council (SC) joint Working Group on the Ecosystem Approach Framework to Fisheries Management (WGEAFFM) has raised concerns about the underlying reliability of the Ecosystem Production Potential (EPP) model. Given these concerns, consolidating previous analyses with a clear outline of the underlying assumptions of the EPP model and their potential impact on predictions, SC committed to:

1. Assess whether the 25th percentile of the Fishery Production Potential (FPP) distribution is an appropriate precautionary metric to define Total Catch Indices (TCI; i.e. fishery overall production capability).
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 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.

In support of SC work on this topic, WGESA addressed these points at its 2019 meeting. While some specific elements still remain to be fully explored due to workload issues and availability of resources (e.g. dynamic version of EPP model), the substance of the concerns raised was thoroughly investigated.

Ecosystem Production Potential (EPP) models are simple network models that track the production generated by primary producers up the food web with the premise that the primary production generated by phytoplankton is the ultimate limit for fish production in the marine ecosystem (Figure iv.1). Estimates of EPP are based on 10,000 Monte Carlo simulations that yield a distribution of expectations for all model nodes (i.e. trophic levels, functional feeding guilds).

The EPP model assumes that the ecosystem is fully functional, i.e. that there is sufficient biomass in each node to fully utilize the production flowing into the node, and hence making the node's own production fully available to upper trophic level nodes. If this is not the case, the actual production in the node would be constrained by its ability to process/utilize lower trophic levels production, and hence, the realized ecosystem production would be less than that estimated by the EPP model. This would mean that ecosystem productivity is somewhat impaired, and the ecosystem is not fully functional.

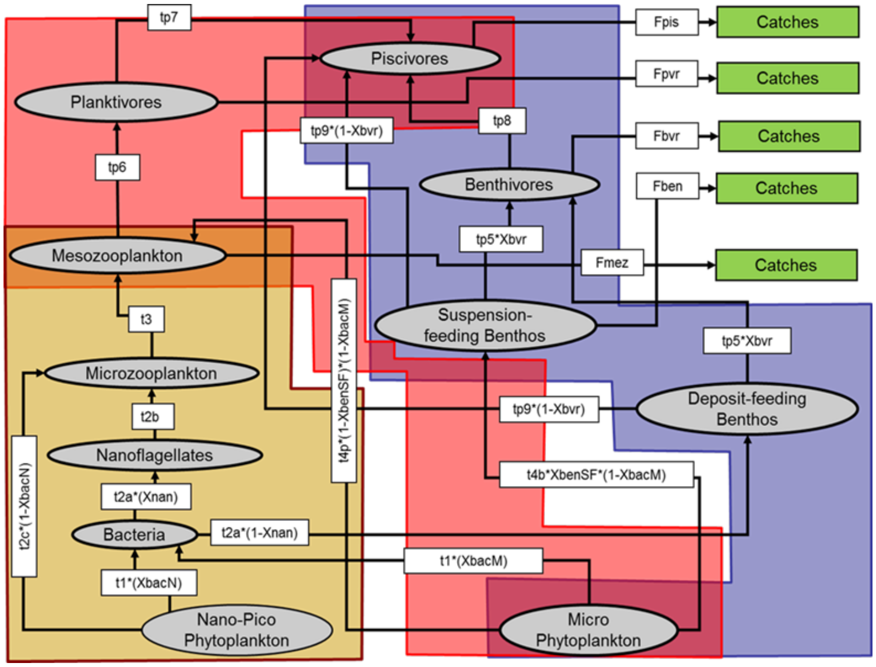


Figure iv.1. Structure of the EPP model. Ovals represent nodes [functional feeding guilds], and arrows indicate the trophic flows between nodes. The boxed equations along the flows indicate the parameters/factors in each flow (i.e. transfer efficiency, transfer efficiency multiplied by fraction available, or exploitation rate). The red, blue, and brown backgrounds indicate the pelagic, benthic, and microbial loop energy pathways. The current model allows fishing on five (5) nodes [functional guilds], mesozooplankton, planktivores, suspension feeding benthos, benthivores, and piscivores, but mesozooplankton are not harvested in NAFO ecosystems. The EPP model is implemented as a Monte Carlo simulation to account for the uncertainty in all inputs and model parameters. Transfer efficiencies outside the microbial loop are modeled using beta distributions derived from a compilation of 35 models of Arcto-Boreal ecosystems and 58 models of Temperate ecosystems. The main model input is size-partitioned primary production derived from remote sensing data and associated analyses.

Total ecosystem production is highly dominated by production associated with the microbial loop, with production associated with fisheries being orders of magnitude less than that of lower trophic levels. Four nodes in the EPP model contain species targeted or of potential importance to fisheries: piscivores, benthivores (e.g. many flatfish, small fish taxa, shellfish), plantktivores (e.g. capelin, herring, juvenile groundfish) and suspension-feeding benthos (e.g. scallops, clams).

SC notes that correlations of biomass fluctuations among nodes and within pathways reveal that energy flow within microbial loop and pelagic pathways is highly coherent but much more diffuse in the benthic pathway. Production of mesozooplankton and deposit feeding benthos is strongly linked to production of microplankton, and production of important fishable nodes (i.e. planktivores, benthivores, and piscivores) is strongly linked with these two lower trophic levels. From a fisheries perspective, SC notes that it is necessary to consider food web structure and energy pathways to adequately track how primary production (PP) affects fisheries production.

A comprehensive examination of the structural uncertainty of the EPP model focussed on topological changes affecting the microbial loop because it dominates ecosystem productivity, and can therefore affect all trophic nodes relevant to fisheries. Weakening the microbial loop boosts suspension-feeding benthos production, but has negative impacts on deposit-feeding benthos. A stronger microbial loop generally reduces productivity in the pelagic pathway, and consequently planktivores and piscivores. SC notes that overall, the EPP model captures basic ecosystem features reasonably, and hence can provide a first order approximation to the production potential of trophic guilds relevant to fisheries.

Application of EPP to fisheries advice

Using these estimates for the provision of fisheries advice in NAFO requires: [1] defining what is a sustainable catch level (FPP) in the context of an EPP model; [2] evaluating the level of ecosystem functionality and, if required, scale the model results based on the current ecosystem state; and [3] presenting results in line with NAFO management principles and frameworks.

Iverson's (1990) study supports the hypothesis that fish production is "controlled by the amount of new nitrogen incorporated into phytoplankton biomass" (e.g. upwelling, winter mixing), the *f*-ratio. Because of the strong reliance of production of the principal fishable nodes (i.e. planktivores, benthivores and piscivores) on energy flow from microplankton that is highly dependent on new nitrogen, through mesozooplankton and suspension feeding benthos nodes, Rosenberg et al. (2014) compiled estimates of the fraction of microplankton for 54 Large Marine Ecosystems around the world and concluded that the upper limit for sustainable fishing in the context of the EPP model is of ~20%. On this basis, estimates of FPP were produced for three Ecosystem Production Units (EPU) within the NAFO Convention Area: the Newfoundland Shelf (2J3K – 577,000 tonnes), the Grand Bank (3LNO – 889,000 tonnes) and the Flemish Cap (3M – 157,000 tonnes). SC notes that traditional groundfish and shellfish fisheries represent slightly less than half of these total yields, with piscivores yielding around 10% of total (Figure iv.2).

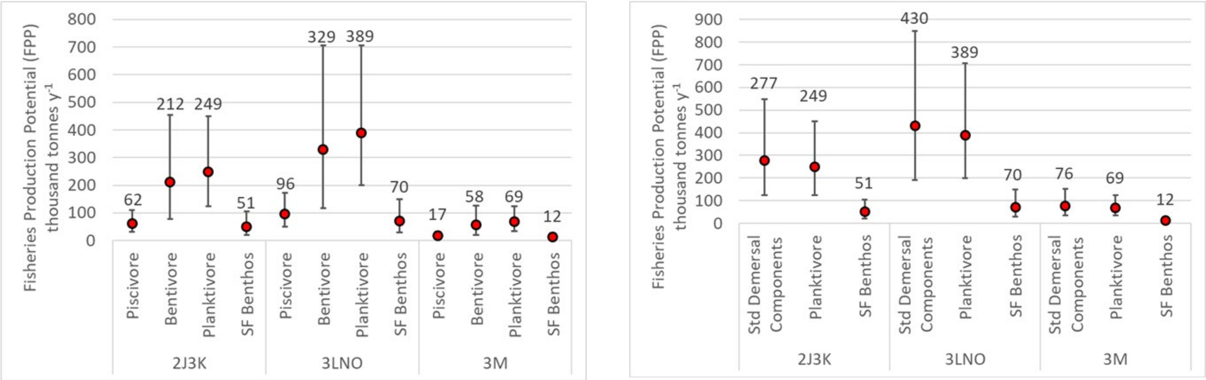


Figure iv.2. Fisheries Production Potential (FPP) for the Newfoundland Shelf (2J3K), Grand Bank (3LNO), and Flemish Cap (3M) EPUs. Left: FPP by fishable node (i.e. functional guild), Right: FPP with piscivore and benthivore nodes aggregated into Standard Demersal Components (SDC). Red dots indicate the medians, whiskers the 10-90% range, and the numbers above are the numerical value of the medians. Differences in magnitude among EPUs are mostly the result of the areal extent of different ecosystems. All estimates assume full ecosystem functionality.

SC notes that estimates of total FPP (2J3K – 2.27 t km^{-2} yr^{-1}, 3LNO – 2.82 t km^{-2} yr^{-1}, 3M – 2.72 t km^{-2} yr^{-1}) are consistent with MSY estimates from aggregate biomass surplus production models from 12 Northern hemisphere marine ecosystems, including the Newfoundland Shelf (1-5 t km^{-2} yr^{-1}). Exploitation rates (F_{msy}) were mostly close to 0.2 yr^{-1} (range: 0.1-0.4 yr^{-1}) (Bundy et al., 2012), consistent with the sustainable fishing at F=20% as derived from the *f*-ratio.

While FPP estimates assume that the ecosystem is fully functional and relatively stable, real ecosystems are often far from equilibrium (Figure iv.3). The Flemish Cap appears to have maintained a relatively stable total biomass over time. However, the Newfoundland Shelf (2J3K) and Grand Bank (3LNO) EPUs currently have total biomass levels that are far lower than the ones observed in the 1980s. As a result, FPP estimates need to be adjusted to reflect their reduced productivity state based on the assumption of an overall constant production/biomass ratio. Trajectories of total RV Biomass, as fractions of the median of total RV Biomass between 1981-1985 for 2J3K and 1985-1987 for 3LNO, were used to define a penalty scheme to adjust FPP estimates (Figure iv.3), assuming that these ecosystems were fully functional prior to the reduction in their productivity, to yield estimates of Current Fisheries Production Potential (FPPc).

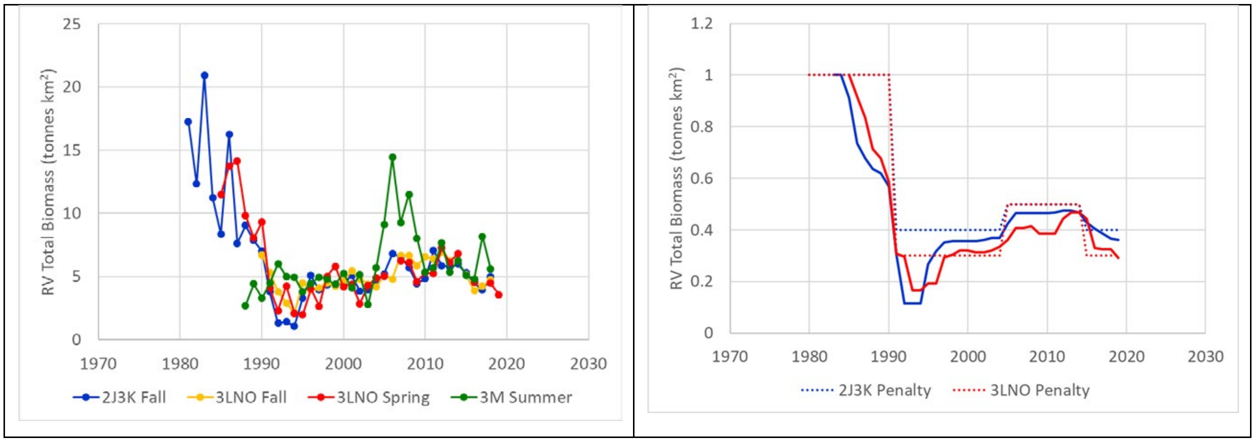


Figure iv.3. Left panel: Total RV Biomass Density indices for the Newfoundland Shelf (2J3K) (Fall), the Grand Bank (3LNO) (Spring and Fall), and Flemish Cap (3M) (Summer). The 2J3K and 3LNO series have been scaled pre-1995/1996 to correct for changes in the survey gear in DFO surveys. Right panel: Running medians of penalty scheme (full lines), where 1 corresponds a fully functional ecosystem, used to adjust FPP estimates for current productivity state, with the abstracted penalty scheme (dotted lines) that was applied to the analyses.

The NAFO Precautionary Approach (PA) states that the probability of exceeding a maximum sustainable exploitation rate should be low, nominally characterized by a low probability at around 20% (NAFO, 2004 – note the PA is currently under review). Following a similar rationale, a simple way to ensure that the probability of exceeding FPPc is low is to use the 25th percentile of the FPPc distribution as the operational threshold for evaluating if total catches are within the ecosystem-level sustainability envelope, which provides guidance for the Total Catch Index (TCI). On average, the current 50th percentile of the FPPc distribution is 50% greater than the value of the 25th percentile (range: 39-68%).

Total Catch Indices (TCIs) and Guidance for Total Catches

It is important to recognize that estimates of FPPc and TCIs are intended as strategic metrics capturing signals integrated over a period of time (e.g. 3-5 years), and that changes in ecosystem trends and productivity are not solely related to fishing. For TCIs to provide effective guidance for total catches for each functional guild, fishing above these levels should erode ecosystem functionality with consequent declines in biomass at the functional guild level. This expectation was evaluated by comparing standardized growth rates for the piscivore and benthivore guilds for 3 EPUs (Newfoundland Shelf (2J3K), Grand Bank (3LNO) and Flemish Cap (3M)) with the corresponding catch/TCI ratios. SC notes that results of the analysis indicate that catches above TCI levels are more often associated with negative biomass trends in functional guild biomass, particularly when catches are 2-5 times greater than the TCI guidance. Catch levels below the TCI guidance show a fairly even distribution of positive and negative biomass trends, indicative that factors other than fisheries are also affecting productivity of fishery guilds (Figure iv.4).

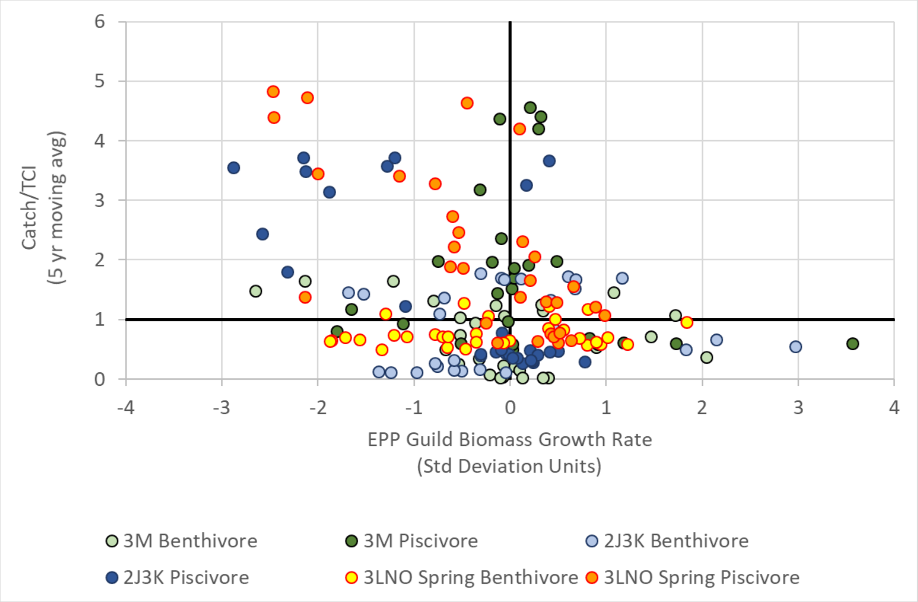


Figure iv.4. Relationship between functional guild biomass trends (growth rate) and catch levels expressed as a fraction of the corresponding Total Catch Index (TCI) for the piscivore and benthivore guilds in the Newfoundland Shelf (2J3K), Grand Bank (3LNO) and Flemish Cap (3M) EPUs from 1981 onwards. Catch/TCI levels below 1 indicate sustainable exploitation levels from the perspective of TCI.

SC notes that the overall results of all analyses are promising and indicate that TCIs perform reasonably well at mapping catch levels associated with negative trends in growth of functional guilds among ecosystem units. SC **recommends** that, *as an interim measure in the implementation of the Roadmap (Koen-Alonso et al. 2019), the particular circumstances in the state of stocks and the potential consequences to fishery sustainability be considered and addressed in management decisions when the combined TACs can result in overall catches about two-fold greater than the TCI guidance. Total catches above TCIs would require more frequent ecosystem monitoring/reporting*. SC also **recommends** *the development of simulation-based analyses (Management Strategy Evaluation, or analogous processes), to evaluate the reliability of specific decision rules for species-aggregated catch levels based on the TCI, though recognizing that this will be a complex exercise requiring considerable time, resources and stakeholder involvement, and hence the need for interim measures.* Furthermore, SC **recommends** that *priority be given for the development of dynamic multispecies models to a) complement the recommended simulation-based analyses and investigate the consequences of time-dependent dynamics on the operational reliability of the TCIs as guidance for ecosystem-level advice, and b) contribute toward implementation of the Tier-2 level of the Roadmap (Koen-Alonso et al. 2019, and NAFO references therein).*

References

Bundy, A., E.C. Bohaboy, D.O. Hjermann, F.J. Mueter, C. Fu, and J.S. Link. 2012. Common patterns, common drivers: comparative analysis of aggregate surplus production across ecosystems. *Marine Ecology Progress Series*. 459:203-218.

Iverson, R.L. 1990. Control of marine fish production. *Limnology and Oceanography*. 35:1593-1604.

Koen-Alonso, M., P. Pepin, M.J. Fogarty, A. Kenny, and E. Kenchington. 2019. The Northwest Atlantic Fisheries Organization Roadmap for the development and implementation of an Ecosystem Approach to Fisheries: structure, state of development, and challenges. *Marine Policy*. 100:342-352.

NAFO. 2004. NAFO Precautionary Approach Framework. *NAFO FC Document*. 04/18:1-5.

Rosenberg, A., M. Fogarty, A. Cooper, M. Dickey-Collas, E. Fulton, N. Gutiérrez, K. Hyde, and *e. al*. 2014. Developing new approaches to global stock status assessment and fishery production potential of the seas. *In* FAO Fisheries and Aquaculture Circular Vol. 1086. FAO, Rome, Italy.

v) *assessment of NAFO bottom fisheries in 2021 (COM request #6)*

In relation to the assessment of NAFO bottom fisheries in 2021, 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.

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 2018 and in establishing VMS data analysis procedures to generate standardized vessel trawl-track data products. Such analysis significantly improves the spatial definition of specific fishing areas within the NAFO footprint.

Furthermore, SC has made progress in developing models and methodological approaches which assess the functional significance of VMEs, including the definition and development of SAI assessment metrics that can be applied to assess all six FAO SAI assessment criteria.

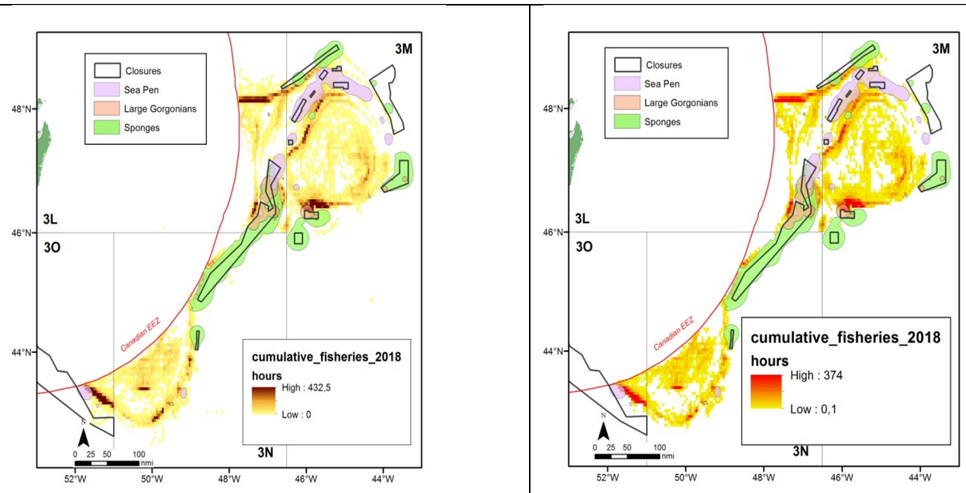
SC concludes that the weighting of assessment metrics that contribute to the SAI criteria will most likely be determined by expert judgement in the overall assessment of SAI.

Updated analysis (including new data) has been performed on non-coral and non-sponge VME indicator species which was presented in response to COM Request #7 (review of VME) in the present report.

SC noted and agreed that the spatial extent of the present VME and SAI assessment is restricted to the NRA. SC agrees that in preparation for the next review (after 2021) of VME fishery closures, VMEs and SAI, the precise spatial scope for the assessment must be defined and agreed.

a) Overlap of NAFO fisheries with VME (analysis undertaken by EU NEREIDA research).

Following methods reported by SC in 2019 (SCS19-20) an updated analysis using 2018 VMS and haul-by-haul logbook data were integrated to provide a more accurate map of fishing effort (Figure v.1), which greatly reduces the number of spurious VMS pings included in the analysis. For the assessment of the overlap of specific fisheries with VME (as part of the SAI assessment in 2021) all available logbook and VMS data in the NRA from 2016. This is distinct from the SAI analysis which will use all available VMS data from 2010 – 2019 to assess VME impacted, at risk and protected. This information will be presented in addition to basic information related to each directed fishery defined by stock and gear type (as defined previously), e.g., the types of fishing conducted, range of vessel powers (kW), range of vessel lengths, depth range of fishing, gear type including typical dimensions, target and bycatch species and the spatial distribution of fishing effort. SC will further consider this requirement in September in order to finalize the specification of data and information to be included in the directed fishery summaries.



(A) Simple speed filter

(B) Logbook haul-time filter

Figure v.1. Cumulative fishing effort maps (hours fished per cell) from 2018 VMS and logbook data produced by two different methods. (A): VMS data was filtered for speeds within 1-5 knots, (B): VMS was filtered if it was within the reported fishing time interval in the logbook.

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

During the 1st assessment of bottom fisheries conducted by SC in 2016 (SCS 16/14 Rev) a table of SAI assessment metrics was developed and applied in accordance with the FAO guidelines for the assessment of SAI (FAO, 2009). One of the limitations of this approach, noted previously by SC, is that all metrics applied to each VME have equal weight, when it is likely that some of the metrics are likely to have greater significance for the assessment of SAI than others. In addition, the *rationale* for assigning the categories of 'high, moderate and low' to VME-specific metric values was not clear.

Consideration of the ranking of SAI assessment metrics

The SAI assessment is based on the consideration of the six criteria defined by the FAO VME Guidelines, namely: **i**. the intensity or severity of the impact at the specific site being affected; **ii.** the spatial extent of the impact relative to the availability of the habitat type affected, **iii**. the sensitivity/vulnerability of the ecosystem to the impact; **iv**. the ability of an ecosystem to recover from harm, and the rate of such recovery, **v.** the extent to which ecosystem functions may be altered by the impact; and **vi.** the timing and duration of the impact relative to the period in which a species needs the habitat during one or more of its life history stages.

A full list of SAI assessment metrics was compiled, including metrics to assess the functional aspects of VME (FAO SAI criteria IV – VI) for which the 2016 assessment was more limited (SCS 16/14). SC then evaluated the full list of metrics against the FAO criteria, noting that the first two SAI criteria are essentially directly related to the management of the fishing activity and therefore their status and trend will largely drive the responses in the remaining 4 criteria (Table v.1). SC concludes that the weighting of assessment metrics that contribute to the SAI criteria will most likely be determined by expert judgement in the overall assessment of SAI.

Table v1. Full list of SAI criteria (FAO, 2009) with respect to an expanded list of assessment metrics to be applied to the reassessment of bottom fisheries in 2021. Full definitions of metrics can be found in (WGESA 2019)

	SAI criteria FAO					
Assessment Metrics	I	II	III	IV	V	VI
Area/Biomass at low risk	x	x		x		
Area/Biomass impacted	x	x				x
Area/Biomass at high risk	x	x				
Number of overlapping VMEs			x		x	
Index of VME sensitivity			x	x		
Index of fishing stability	x	x				
Index of risk of VME fragmentation	x	x				
Index of functional sensitivity			x	x	x	
Functional Area at low risk	x	x		x		
Functional Area impacted	x	x			x	x
Functional Area at high risk	x	x			x	
VME connectivity	x	x	x	x		

Consideration of the assignment of 'high, moderate and low' categories to VME specific metric values

In the 1st assessment of SAI (SCS 16/14 Rev), three categories of assessment were applied to each metric value, namely, 'high, moderate and low'. The limits used to define the categories were selected to highlight the relative differences between the VME specific metrics. SC notes that this issue has been addressed in relation to the review of VMEs (see SC response to COM Request #7 in the present report) and the definition of categories used to assess the status of VMEs. Therefore, to ensure consistency between the review of VME and the assessment of SAI the same categories will be applied to the assessment of SAI in 2021.

c) 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**. This criterion requires that a functional ecosystem scale be defined, and SC endorsed the use of the Ecosystem Production Units (EPU) as the basic spatial scale for defining the VME and the assessment of ecosystem-level impacts, while recognizing that smaller units may be ecologically justified for some assessment metrics, and that larger scales may be necessary for some analyses involving connectivity. SC noted and agreed that the spatial extent of the present VME and SAI assessment is restricted to the NRA. SC agrees that in preparation for the next review (after 2021) of VME fishery closures, VMEs and SAI that the precise spatial scope for the assessment must be defined and agreed.

The approaches being developed rely on: i. developing empirical models which utilise observed cumulative VME indicator biomass in response to observed levels of fishing effort, ii. developing a spatially explicit agent-based model to simulate the life history of sea pens, and iii. direct statistical testing of the impact of fishing on ecosystem functions such as biodiversity, bioturbation, benthic pelagic coupling, and habitat provision.

SC noted that the sensitivity analysis performed on the empirically driven resilience model suggests that estimates of fishing ***trawl-line density*** and the ***speed of trawling*** are particularly important in determining the impact and subsequent estimates of recovery time for sea pen VMEs. Therefore, SC has initiated new VMS data assessment procedures to ensure standardized VMS fishing effort (trawl track-based) data products can be generated.

SC notes the progress made to initiate the application of biological traits analysis to help determine the functional significance of VMEs in the NAFO regulatory area and to help address FAO criteria **v**. 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.

The following workplan has been proposed to finalize the development of the full list of assessment metrics in readiness for their application to assess bottom fishing SAI on VMEs in 2021:

1. Define KDE polygons and thresholds for functions (bioturbation, nutrient cycling, structure forming, functional diversity).
2. Up-date cumulative biomass *vs* fishing effort plots for ALL VMEs using new fishing effort and biomass data.
3. Create new cumulative functional (biomass) *vs* fishing effort plots for each function (bioturbation, nutrient cycling, structure forming, functional diversity) from trawl data.
4. Calculate SAI using VME and Functional polygon areas and biomass to quantify the 3 risk/impact categories (low risk, high risk, impacted).
5. Assess the spatial/temporal relationship between fish, invertebrates, VME indicator species and VMEs using multivariate approaches.
6. Up-date description of NRA fisheries – maps and tables.
7. Develop new VME fragmentation index.
8. Connectivity of VMEs Index.
9. VME buffer zones.
10. Up-date literature review of VME recovery rates.

vi) Re-assessment of VME closures (COM request #7)

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

Scientific Council responded:

In following the 5-year cycle defined in the NCEM, an update of VME information, and a review of the VME closures in the NRA was undertaken. The VME update included the review of general information, incorporation of new data acquired since the last review in 2014, and the use of this information for delineating updated VME polygons. The assessment of the adequacy of the closures involved the same general criteria used in the first review, but improved on it by incorporating connectivity into the evaluation, and by developing a structured approach to the assessment criteria based on coverage and connectivity which is consistent with the approach being used for the next assessment of SAI in 2021.

Results indicate that Black Coral does form aggregations in the NRA. Accordingly, SC **recommends** the *inclusion of this taxa in the NCEM VME indicator species list.*

The review of the adequacy on closures indicates that large gorgonian and sponge VMEs have generally incomplete to good protection by closures, and management action on these VMEs is **recommended as desirable to beneficial**. *Conversely, black coral and sea pen VME have poor protection, and erect bryozoans, sea squirt and small gorgonian VMEs have inadequate protection by closures; management action for these VMEs is* **recommended as essential**. SC also reviewed the closures for VME elements (i.e. seamounts), and in line with the changes already implemented for the New England seamounts, SC **recommends** *updating the boundaries of the closures for the Corner Rise and Newfoundland seamounts to better capture the connectivity within these seamount chains.*

SC agrees that in preparation for the next review (after 2021) of VME fishery closures, VMEs and SAI, the precise spatial scope for the assessment must be defined and agreed

The current review of VME fishery closures and VME follows the same methodological approach as applied during the 1st review conducted by NAFO in 2014 (SCS14-17). The principal data source used for the present assessment was the scientific research vessel trawl catches (Table vi.1) in the NRA. The present data set includes an additional 2394 trawl catch samples since the last assessment was conducted.

Table vi.1. Data sources from contracting party research vessel surveys.

Programme	Period	NAFO Division	Gear	Mesh size in codend liner (mm)	Trawl duration (min)	Average wingspread (m)
EU Spain 3NO Survey	2002 - 2019	3NO	Campelen 1800	20	30	24.2 – 31.9
EU Flemish Cap Survey	2003 - 2019	3M	Lofoten	35	30	13.89
EU Spain 3L Survey (IEO)	2003 - 2019	3L	Campelen 1800	20	30	24.2 – 31.9
Canada 3LN) Multi-species Surveys	1995 - 2019	3LNO	Campelen 1800	12.7	15	15 - 20

Definitions, used by SC in the present assessment, for VME (i.e. a habitat), VME indicator species (i.e. a taxa that defines the habitat) and VME elements (i.e. features that are known or likely to contain a VME), follow those as used in the 1st review (SCS14-17). The principal method used to quantitatively determine the location and spatial extent of VMEs is kernel density estimate analysis (KDE) which is our current best approach to determining the location and spatial extent of VMEs. This analysis identifies "hotspots" in the biomass distribution derived from research vessel trawl survey data, by looking at natural breaks in the spatial distribution associated with changes in local density. These natural breaks allow defining of significant area polygons (Scientific Council Report 19/058). Following previously established practice (SCS14-17) species distribution models were used to modify the boundaries of the KDE polygons where they extended into unsuitable habitat (low probability of occurrence).

KDE analysis was applied to the following VME indicator species, including Black Coral:

1. Large sized sponges
2. Sea pens
3. Large gorgonian coral
4. Small gorgonian coral
5. Sea squirts
6. Erect bryozoans
7. Black coral

SC notes although Black Coral was assessed as meeting the vulnerable characteristics which define a VME indicator species in 2008 (SCS 08/10), it was not included in the initial formal list of VME indicator species in the NCEM (2013). This was because at that time the limited available data indicated that Black Coral did not form clear spatial aggregations and therefore significant concentrations of Black Coral could not be defined. However, since 2014 the addition of more than 2000 trawl survey samples into the present analysis reveals that Black Coral does indeed form spatial aggregations in the NRA and, therefore, significant concentrations of Black Coral can now be defined and VME identified. SC **recommends** that *Black Coral be added to the NCEM list of VME indicator species.*

SC conducted the review in two parts, namely; i. an assessment of the adequacy of protection for each VME type (including Black Corals), and ii. a review of the adequacy of the current closures (including sea pen Area 14).

In 2014, the adequacy of closures themselves was mainly evaluated based on coverage, while a broader set of criteria was used to help define priorities for management actions, e.g.:

1. the proportion of the VME area/biomass that is protected.
2. areas with no current protection.
3. multiple VME presence, e.g. overlapping VMEs.
4. proximity to an existing closed area as this may imply continuity of the habitats.
5. proximity to high fishing activity which could endanger the VME (increased risk of impact).

Many of these criteria were later included in the assessment of SAI (SCS 16/14).

Based on the experience gained during the first cycle of review of closures and assessment of SAI, and to address earlier concerns about the need for a more systematic approach to evaluate closures, SC developed a structured set of criteria to assess the adequacy of closures, and the associated need for management action. These criteria were based on expert judgement and were developed prior to the evaluation of closures to prevent any possible bias. The developed framework included, in addition to coverage, information on VME connectivity, and was constructed to ensure consistency with the approach being implemented to assess SAI (Table vi.2).

Table vi.2. Definition of categories used to assess the protection status of VMEs. Status definitions (Assessment) are based on definitions from the online Oxford English Dictionary: Good – To be desired or approved of; Adequate – Satisfactory or acceptable in quantity or quality; Incomplete – Not having the necessary or appropriate parts; Limited – Restricted in size, amount or extent; Poor – Of low or inferior standard or quality; Inadequate – Lacking in quality or quantity required.

Assessment	Proportion of VME Protected	Projected Connectivity Among Closures	Recommended Management Action
Good	> 60% VME	Good connectivity among closures	Beneficial
Adequate	> 60% VME	Limited connectivity or redundancy	
Incomplete	60% - 30% VME	Good connectivity among closures	Desirable
Limited	60% - 30% VME	Limited connectivity or redundancy	
Poor	30% - 15% VME	Limited connectivity or redundancy	Essential
Inadequate	< 15% VME	Limited connectivity or redundancy	

Assessment of adequacy of VME protection across all closures

In general, there was good spatial congruence between the 2013 and 2019 analyses as can be observed by comparing the spatial extent of VME polygons for the two assessment periods (Figure vi.1). Most VMEs have increased in area (Table vi.3) with the exception of erect bryozoans where a change in the KDE search radius enabled by the new data reduced the VME area, but this is considered to be as a result of significant additional data, and that it is likely that no actual increase or decrease in the area or biomass of VME has been realized between the two assessment periods. The increase in area for the small gorgonian corals is supported by new data from the 3O surveys and associated with an increase in KDE search radius.

SC also notes that Black Coral VME tends to overlap with sea pen VME, especially in areas off the Flemish Cap.

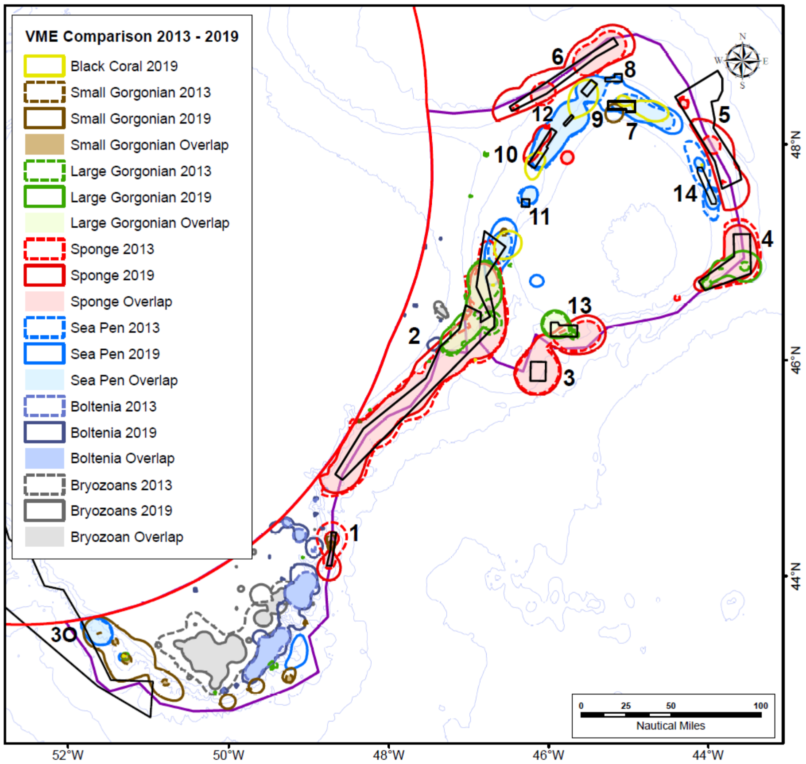


Figure vi.1. Overview map of the location of VME taxa (large-sized sponges, sea pens, small gorgonian corals, large gorgonian corals, erect bryozoans, sea squirts (*Boltenia ovifera*), and black corals) in the NRA, colour coded by taxon. For all taxa the polygons determined from the 2013 analysis are shown in dashed line and compared with those from the 2019 analyses in solid lines. Areas of overlap are shaded. The closed areas are indicated in black outline and their numbers shown near the closure. Solid purple line is the fishing footprint.

Table vi.3. Significant concentration threshold (kg) from research vessel catches and total area (km^2) of VME polygons derived from kernel density estimation and species distribution modelling techniques in 2019 and 2013. Also shown is the percent change in polygon area between 2019 and 2013 and the proportion of VME area and biomass protected inside the closed areas in 2019 and also area and biomass protected inside closed areas and any part of the VME located outside of the fishing footprint (Area 14 is included in this calculation; removing it would result in only a small decrease in area/biomass of sea pen and black coral protection). This distinction reflects the difference in protection granted by closures (full protection) from locations outside the fishing footprint, which could eventually become open to fishing under an exploratory fishing protocol.

Common Name	Research Vessel Catch Threshold (kg)		Area of VME in (km^2)		Change in Area between 2019 & 2013 (%)	Proportion of VME Area Protected by Closed Areas in 2019 (%)	Proportion of VME Biomass Protected by Closed Areas in 2019 (%)	Proportion of VME Area Protected by Closed Areas and/or outside the Fishing Footprint in 2019 (%)	Proportion of VME Biomass Protected by Closed Areas and/or outside the Fishing Footprint in 2019 (%)
	2019	**2013**	**2019**	**2013**					
Large-sized sponges	100	75	24,218	19,824	22	39	57	64	70
Sea pens	1.3	1.4	8,498	6,983	22	17	18	17	18
Large gorgonian corals	0.6	0.6	5,007	3,506	43	55	57	61	58
Small gorgonian corals	0.2	0.15*	4,540	307	1,377	4	1	4	1
Sea squirts	0.35	0.3	4,077	2,193	86	0	0	0	0
Erect bryozoans	0.2	0.2	3,491	6,587	-47	0.14	0.01	0.14	0.01
Black corals**	0.4	-	2,631	-	-	17	16	17	17

Applying the assessment criteria (Table vi.2) to these results, in conjunction with the assessment criteria described previously, an overall assessment for each VME type was performed (Table vi.4).

Table vi.4. Re-assessment of NAFO VME types. Overall assessment and recommendations for management action (see Table vi.3) for each VME type considering their overall protection, ranked by assessment and need for management action based on the biomass protected inside closed areas and any part of the VME located outside of the fishing footprint.

VME Type	Overall Assessment (biomass)	Recommended Management Action
Small Gorgonian Corals	Inadequate	Essential
Sea Squirts (Boltenia ovifera)	Inadequate	Essential
Erect Bryozoans	Inadequate	Essential
Black Coral	Poor	Essential
Sea Pens	Poor	Essential
Large Gorgonian Corals	Incomplete	Desirable
Large-Sized Sponges	Good	Beneficial

SC noted that the spatial extent of the present VME assessment is restricted to the NRA, which in the case of VME present on the tail of the Grand Bank (e.g. sea squirts and erect bryozoans) may be insufficient to perform a complete assessment of their spatial extent and adequacy of the VME closures. SC agrees that in preparation for the next review (after 2021) of VME fishery closures, VMEs and SAI that the precise spatial scope for the assessment must be defined and agreed.

Assessment of adequacy of VME closures by region

For each of the existing closed areas in the NRA an assessment of the effectiveness of the closure, with justification, has been undertaken by SC (SCS Doc. 19/25).

Division 3O Coral Closure and Area 1 Tail of the Bank

SC notes that the 3O closure was the first coral closure in NAFO and delineated through an *ad hoc* process that involved assessing available records, expert knowledge, and management considerations (SCS 13/24). This closure extends into depths not commonly covered by research surveys. Records of VME indicator taxa within this closure typically encompass the shallower areas inside Canadian waters, but there are no similar records in the NRA portion of the closure, which only contains VME elements (i.e. canyons) likely to contain VMEs (Figure vi.2, SCS 14/17). However, sea pen and small gorgonian VME overlap in this region and are found immediately adjacent to the existing 3O closure shallow boundary along with cerianthid anemone records, and smaller large gorgonian coral and black coral VME (Figure vi.2). The absence of protection for erect bryozoans, sea squirts, sea pens and small gorgonian corals in this region is notable. It appears that there are areas with limited fishing activity in close proximity to parts of the VMEs (Figure vi.3 and Figure vi.4).

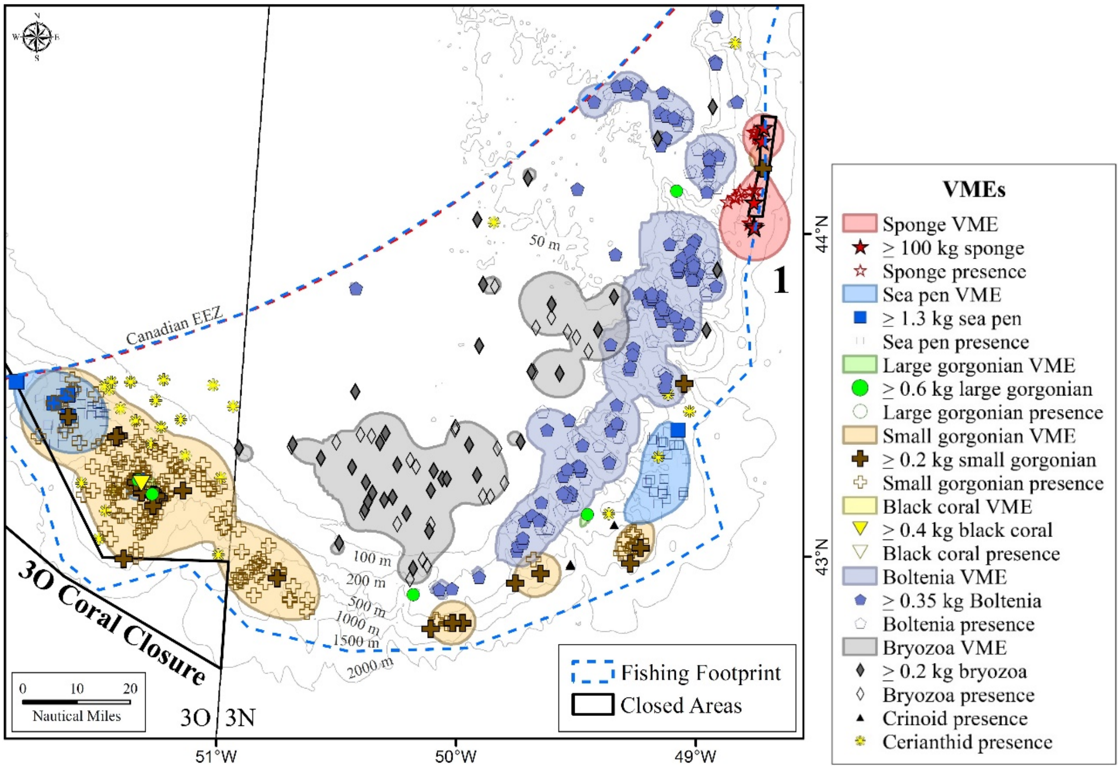


Figure vi.2. Area of 3O Coral Closure and Area 1. VMEs and VME indicator species.

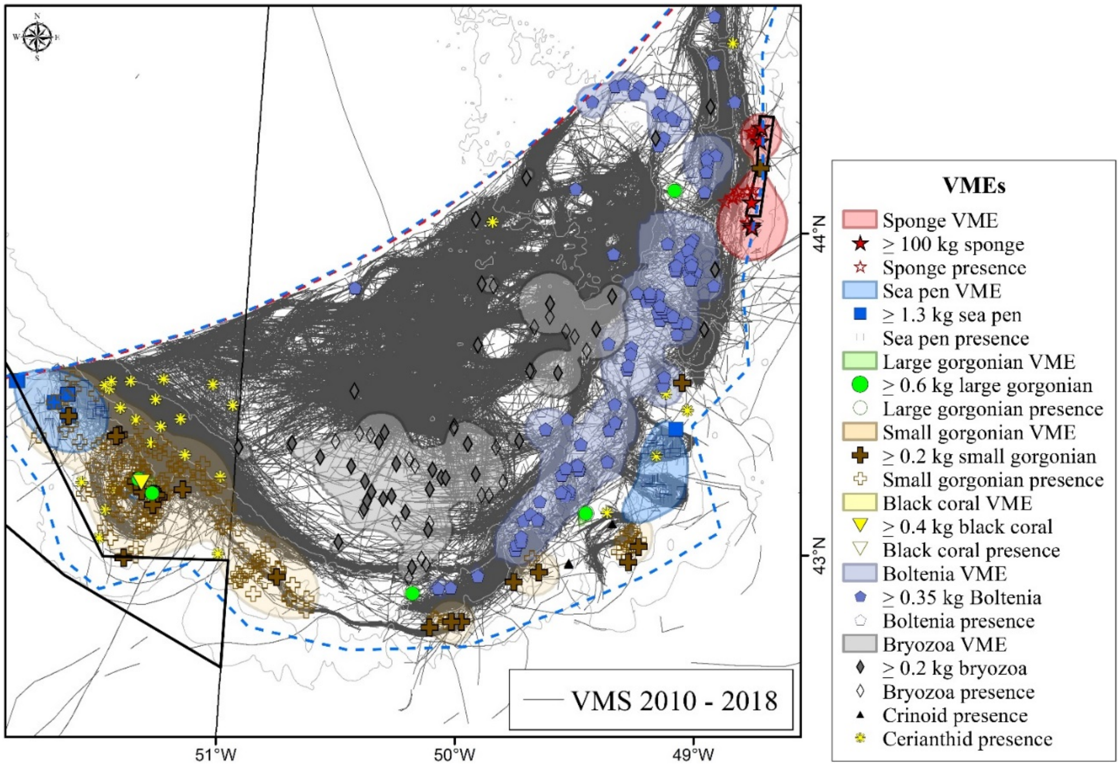


Figure vi.3. Area of 3O Coral Closure and Area 1. VMEs and VME indicator species with VMS fishing data (2010-2018)

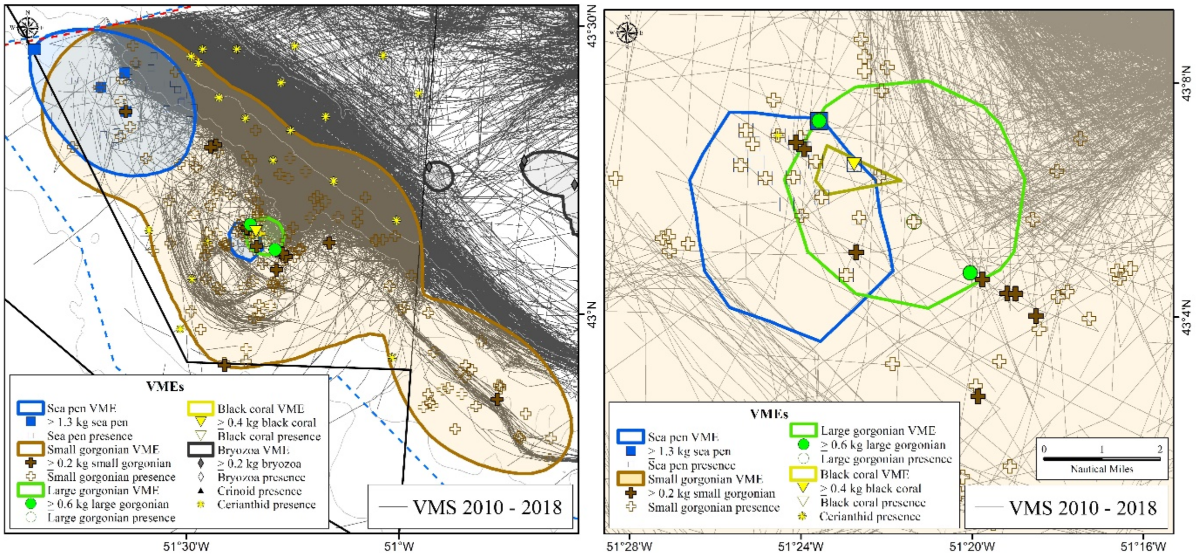


Figure vi.4. Area of 3O Coral Closure. Close up of VME and VME indicator species with VMS fishing data (2010-2018). The area of overlap between VMEs for sea pens, large gorgonian corals and black corals in the small gorgonian coral VME is shown in the right panel.

Areas 4-12 Flemish Cap and Sackville Spur Including Area 14

SC notes that Areas 7, 9, 10, 12, 14 all have two or three types of VME overlapping within their boundaries or surrounds and are comparatively small in area (when compared to sponge and large gorgonian VME closures, Areas 4, 5 and 6) (Figure vi.5a). The connectivity between Areas 7, 9, 10, 12, 14 is limited and Area 7 and Area 14 are locations where the glass sponge *Asconema foliata* is also predicted to occur with high probability (Figure vi.5c) as is predicted high species density (Figure vi.5d). Significant areas of sea pen and black coral VME remain unprotected and in areas of very low fishing activity (based upon VMS data analysed between 2010 – 2018) (Figure vi.5b).

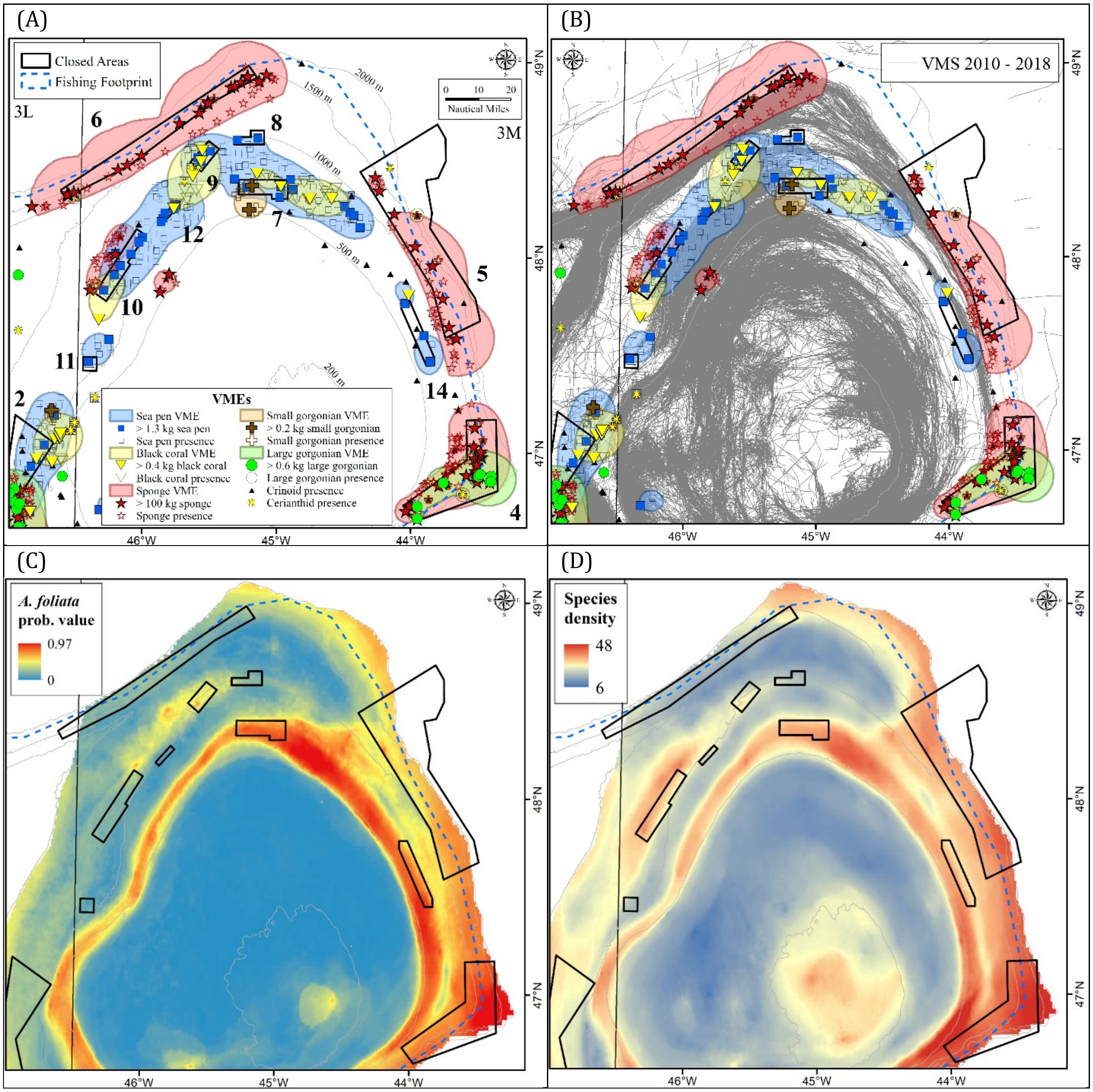


Figure vi.5. Areas 4-12 Flemish Cap and Sackville Spur Including Area 14. (A) distribution of VMEs and VME indicator species. (B) distribution of VMEs and VME indicator species in relation to VMS fishing data (2010-2018). (D) Asconema foliata glass sponge probability of occurrence. (D) predicted species density (number of benthic invertebrate taxa per RV trawl set).

Seamounts

In accordance with changes made to the New England seamount closure in 2017 (Figure vi.6), SC has revised the boundaries of the Corner Rise and Newfoundland seamount closures to maintain connectivity across the seamount chains and to complete the protection of all vulnerable seamounts in the NRA. The 2019 General Bathymetric Chart of the Oceans (GEBCO) was used to draw the bathymetric contour lines to inform which seamounts previously identified (Kim and Wessel, 2011) were shallower than 2000 m depth (Figures vi.7 and vi.8). For the Orphan Knoll seamount closure new research with ROVs has reconfirmed the presence of VMEs (EU Horizon 2020 project SponGES). SC concludes that the available information supported the continued designation of all existing seamount areas as VMEs.

The proposed boundary changes for the seamount closures represent a net increase of 10706 km² for the Corner Rise seamount closure, and a net decrease of 1826 km² for the Newfoundland seamount closure. These areas were calculated using a NAD 83 Zone 22 projection.

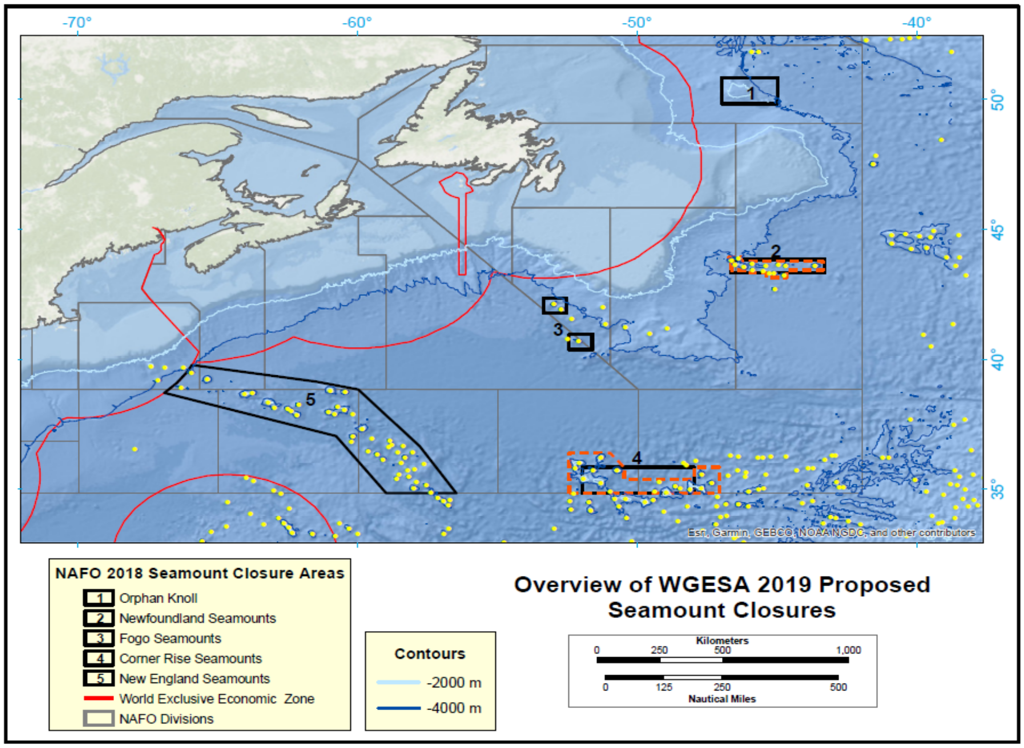
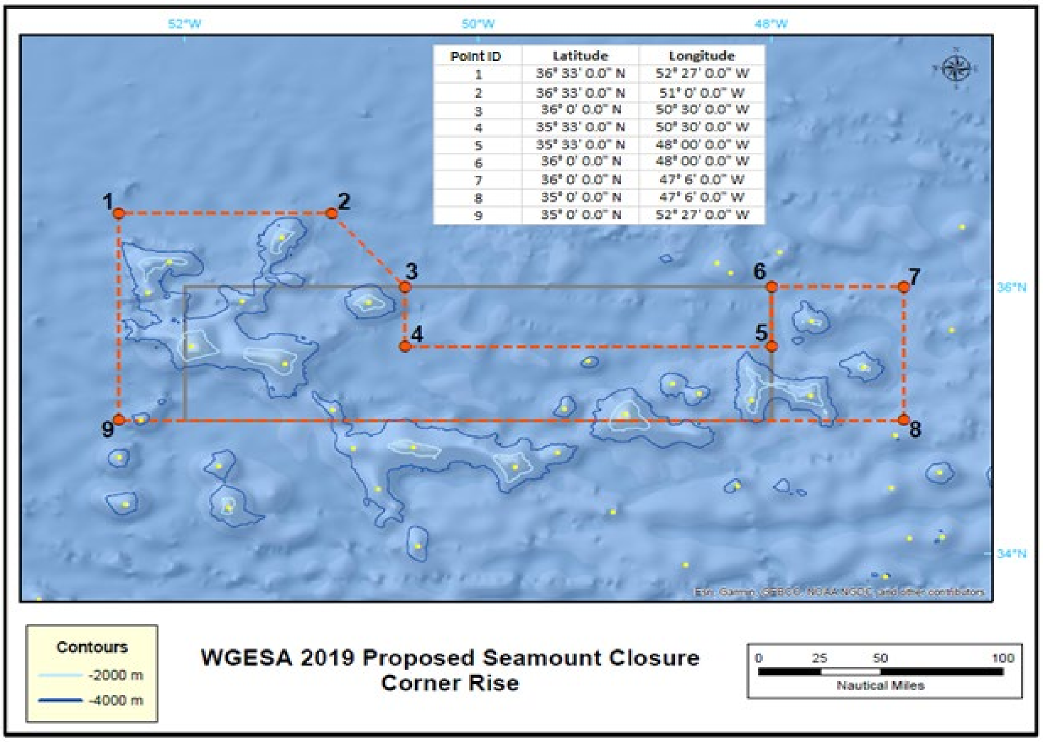
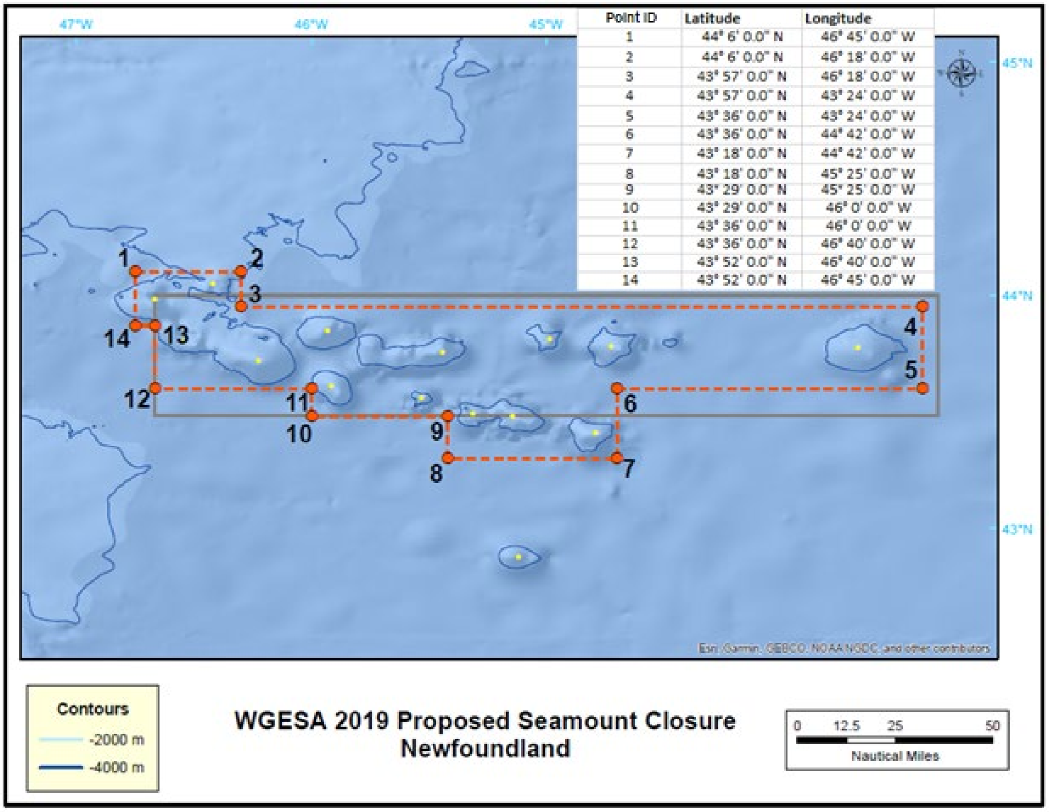


Figure vi.6. Location of the 5 seamount areas in NAFO with closures indicated in black outline. SC recommended changes to Areas 2 (Newfoundland Seamounts) and 4 (Corner Rise Seamounts). Yellow dots represent all the seamounts (source Kim and Wessel, 2011).



Point ID	Latitude	Longitude
1	36° 33' 0.0" N	52° 27' 0.0" W
2	36° 33' 0.0" N	51° 0' 0.0" W
3	36° 0' 0.0" N	50° 30' 0.0" W
4	35° 33' 0.0" N	50° 30' 0.0" W
5	35° 33' 0.0" N	48° 00' 0.0" W
6	36° 0' 0.0" N	48° 00' 0.0" W
7	36° 0' 0.0" N	47° 6' 0.0" W
8	35° 0' 0.0" N	47° 6' 0.0" W
9	35° 0' 0.0" N	52° 27' 0.0" W

Figure vi.7. Close up of the current closed area to protect VMEs on the Corner Rise Seamounts (grey outline), with proposed boundary changes to capture the unprotected seamounts nearby (red dashed line). Yellow dots indicate seamounts (source Kim and Wessel, 2011), light blue line represents the 2000 m depth contour, the dark blue line represents the 4000 m depth contour. Associated co-ordinates for the new boundary are listed. Note that the seamounts to the south of the bounding box are in the WECAFC area where they are listed as VMEs.



Point ID	Latitude	Longitude
1	44° 6' 0.0" N	46° 45' 0.0" W
2	44° 6' 0.0" N	46° 18' 0.0" W
3	43° 57' 0.0" N	46° 18' 0.0" W
4	43° 57' 0.0" N	43° 24' 0.0" W
5	43° 36' 0.0" N	43° 24' 0.0" W
6	43° 36' 0.0" N	44° 42' 0.0" W
7	43° 18' 0.0" N	44° 42' 0.0" W
8	43° 18' 0.0" N	45° 25' 0.0" W
9	43° 29' 0.0" N	45° 25' 0.0" W
10	43° 29' 0.0" N	46° 0' 0.0" W
11	43° 36' 0.0" N	46° 0' 0.0" W
12	43° 36' 0.0" N	46° 40' 0.0" W
13	43° 52' 0.0" N	46° 40' 0.0" W
14	43° 52' 0.0" N	46° 45' 0.0" W

Figure vi.8. Close up of the current closed area to protect VMEs on the Newfoundland Seamounts (grey outline), with proposed boundary changes to capture the unprotected seamounts nearby (red dashed line). Yellow dots indicate seamounts (source Kim and Wessel, 2011), blue line represents the 4000 m depth contour. Associated co-ordinates for the new boundary are listed.

Overall assessment by region and need of management action

The assessment has been conducted on a regional basis and the results are ranked and summarized in Table vi.5, with emphasis on the VMEs of concern.

Table vi.5. Re-assessment of NAFO closed areas. Overview of recommendations and need for management action for VMEs of concern (see Table vi.3) for regionally-specific assessments of the effectiveness of the closed areas, all ranked by need for management action.

Existing VME Closure	**Overall Assessment (biomass)**	**Recommended Management Action**	**Comments (VME of concern)**
Division 3O Coral Closure and Area 1 Tail of the Bank	Inadequate	Essential	Small Gorgonian Bryozoans Sea squirts
Areas 4-12* Flemish Cap and Sackville Spur Including Area 14	Poor	Essential	Black Coral and Sea Pen
Area 2 Flemish Pass, Areas 3, 13* Beothuk Knoll	Incomplete	Desirable	Large Gorgonians
Seamounts	Incomplete	Desirable	-

* Areas 1, 3-6,13 are focused on Sponges and are of less concern (Table vi.3). Large Gorgonians in Area 4 are within the closed area.

The highest priority regions for management action, where fishery closures to protect VME are assessed to be 'inadequate' or 'poor', are, i. Division 3O Coral Closure and Area 1 Tail of the Bank, and ii. Areas 4-12 Flemish Cap and Sackville Spur Including Area 14.

vii) continue progress on the NAFO PA Framework review (COM request #8)

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

Scientific Council responded:

SC compared the PA frameworks from a number of jurisdictions in the North Atlantic (PA Revision, ToR 3), and laid out a plan to address the other two Terms of Reference. In the development of the various framework components, consideration will be given to solutions for the full range of data availability with the goal that most of the PA framework elements could be adopted for all stocks. While this revision of the NAFO PAF is intended to retain its single-species focus, whenever appropriate, the proposed solutions will be informed by the ecosystem principles contained in the NAFO Roadmap for an Ecosystem Approach. SC emphasized that continued progression on the review is dependent on commitments from Contracting Parties to provide the necessary resources.

In response to the Commission request to continue progression of the review of the NAFO PA Framework, which the Commission has identified as high priority, the SC, after meeting by WebEx, agreed to resume the work of the SC Precautionary Approach Working Group (WG-PAF). The WG-PAF was created by recommendation of the WG-RBMS in 2015.

Scope of the review of the NAFO Precautionary Approach Framework (PAF) adopted by the Fisheries Commission (FC-Doc. 15-19) and discussed by the SC Precautionary Approach Working Group as its Terms of Reference (SCS Doc. 16/15).

1. To clarify the following elements:
    a. To confirm/review the NAFO PA reference points definition in page 3 NAFO/FC Doc. 04/18.
    b. To confirm/review the NAFO management strategies and courses of action, including risk levels, on page 3 NAFO FC/Doc. 04/18
    c. Distinction between MSY and limit/target related reference points.
    d. Analysis in support of the development of other reference points (e.g. targets, buffers).
    e. To review the methods for the calculation and interpretation of risk and the quantification and qualification of uncertainties related to them.
    f. For stocks where risk analyses are not possible, provide options on how to establish buffer reference points on a stock by stock basis.
    g. Determine the conditions for when/if reference points should change and/or be re-evaluated.
2. Consider how a revised PA can fit within an ecosystem approach.
3. In reviewing the NAFO PAF the WG will also take into consideration other precautionary approach frameworks with a focus in the north Atlantic.

SC reviewed the progress of the WG-PA to date. This review included consideration of PA frameworks in other jurisdictions of the Atlantic to inform the considerations required under ToR 3. This work provided summary comparisons among PA Frameworks from the North Atlantic (eg. ICES, Canada, USA, with NAFO), and compiled information, ideas, and illustrative proposals on how SC could approach the update of the NAFO PAF. This was the first step in revising NAFO's PAF. Based on the ensuing discussion, SC laid out a plan to address the other two Terms of Reference.

ToR 1 is focused on operational and implementation aspects and does not inform context and/or objectives. The context and objectives provided by the NAFO Convention, and the documents referred within it, remain valid. Six NAFO principles support the objective of ensuring long term sustainable use of fishery resources. These principles include promoting the optimum utilization and long-term sustainability of fishery resources, adopting measures to ensure that fishery resources are maintained at or restored to levels capable of producing maximum sustainable yield and adopting measures to minimize harmful impact on living resources and marine ecosystems.

ToR 2 asks for consideration of how a revised PAF can fit within an Ecosystem Approach, which is consistent with the new convention which calls for an Ecosystem Approach to Fisheries Management (EAFM). The NAFO Roadmap provides the template that NAFO is following to implement an ecosystem approach. Therefore, SC WG-PA will consider these principles when addressing ToR 1, trying to develop meaningful connection points between ToR 1 and ToR 2 whenever possible.

While PA frameworks are generally constructed around the "best assessment" concept, meaning that advice is based on the model that is understood to best represent the stock dynamics, NAFO and other jurisdictions are increasingly using Management Strategy Evaluation (MSE) to design and test management procedures which are more robust to model/structural uncertainty in order to achieve PA objectives. NAFO SC expects to continue carrying out MSEs to address the objectives of any revised PA framework, based on needs, and where time and resources permit.

Items in ToR 1 can be defined under three general headings, dealing with:

- Mapping objectives. This involves items a), c), and g), where conceptual questions are presented that address how the framework would represent basic convention objectives. Item a) reviews definitions, item c) explores the role of MSY-based reference points as limits and /or targets, and item g) asks about the conditions under which the reference points may need changing (keeping them constant may hinder the ability of the framework to achieve its objectives).

- Structural aspects of the framework. This involves items b) and d), which ask about the structure of the framework; which reference points are to be considered, how they are going to be used, and how risk is considered in the design of the framework.
- Quantification of uncertainty and risk. This involves items e) and f), which directly address the analytical methods in which risk is estimated and applied, including tiered approaches taking into account data quality/availability. This last point is also related to the structural aspects described under the previous heading. Where probabilities are estimated to inform on risk, these should be based on the statistical estimation of imprecision for the best assessment, or through the development of management procedures within MSE exercises.

The review of the PA framework will be approached in a structured and sequential way by addressing conceptual issues first, and second addressing the more operational aspects. The overarching EAFM umbrella will be given consideration at every step, by examining how the proposed solutions align with the principles laid out in the NAFO Roadmap. This will allow for the development of an updated PA framework in which there would be connection points to the ideas embedded in the Roadmap. Without being prescriptive, that could constitute the basic link between ToR 1 and 2 and foster a parallel treatment of both ToRs.

In the development of the various framework components, consideration will be given to solutions for the full range of data availability with the goal that most of the PA framework elements could be adopted for all stocks.

More specifically:

a) Discuss MSY reference points first, both in relation to being a limit or target, and taking into account the conditions when MSY reference points should change and/or be re-evaluated. To the extent possible, this exercise will include early exploration of how the ecosystem analyses related with setting F_{msy} across fisheries, that single species F_{msy} depend on species interactions, and changes in productivity.

b) Define whether or not fishing mortality and biomass reference points need to be functionally related. This is a key element in terms of consistency within the framework; if the answer is yes, the logic is self-evident, but if not, there needs to be a solid rationale (e.g. why the F that renders B_{lim} is not F_{lim}).

c) Implement a *weight of evidence* approach to tabulate the arguments for and against alternative options. The evidence and rationale to support the various options should be articulated to inform and document the discussion and decisions.

d) The structural elements can be addressed based on the results of the conceptual discussion. Once a conclusion has been reached on whether F_{msy}/B_{msy} are targets or limits, the other reference points and structural/operational elements can be developed accordingly. At this stage, practical considerations could be the focus, for example, what elements of the existing framework have worked (or not), or which ones may be redundant given current techniques (e.g. do we need buffers if advice is based on estimated risk/uncertainty?).

e) Consider quantity/quality of data availability as part of the revision of the PA framework, and the possibility of defining assessment tiers based on data availability.

The revised PA will attempt to integrate the ecosystem approach elements where possible now, and be designed in such a way that ecosystem approach elements can be added more fulsomely at a later stage, when the ecosystem approach is further developed and NAFO has some experience integrating it into decision making. It was also recognized that a number of the overarching concepts apply equally to both ToRs, which will foster some initial integration of ecosystem approach aspects in this revised framework. It is anticipated that ToRs 1 and 2 will not be fully integrated simultaneously in the current PA revision, but will be more so with each new iteration of the NAFO PA framework.

Under this approach, the questions posed can be sequentially explored, where the early answers provide constraints for the subsequent questions as follows:

Mapping objectives

a) Should MSY-based reference points conceptually be considered targets or limits?
b) Do fishing mortality and biomass reference points need to be logically connected within the framework? For example, does F_{lim} need to be directly linked to B_{lim}? (According to the cross jurisdictional analysis F_{lim} can be related to F_{msy} and to the biomass objective, as opposed to the biomass limit).
c) Should B_{lim} be defined as is currently done (0.3^*B_{msy} or based on an impaired recruitment argument)? While this approach is common to most PAs, is it consistent with results from prior questions?
d) Is there a need for a target biomass to be defined or is F_{target} sufficient?

Structural aspects

a) Determine the actions to be taken based on reference B_{target} as well as on B_{lim}, as it is done now in the NAFO PA.
b) Consider defining a biomass level below B_{target} and above B_{lim} to define an overfished state. This type of biomass reference exists in other PA frameworks.
c) Consideration of appropriate reference points for fishing mortality.

Quantification of uncertainty and risk

a) Consider the estimation issues associated with the use of low probabilities that rely on tails of probability distribution of biomass and mortalities. It may be more appropriate to work with means/medians of distributions (i.e. the risk tolerance could be established in development of the biomass reference points and how far they are from each other).
b) The PA should consider all 3 tiered levels of stocks (eg. 1. Analytical assessment; 2. Survey-based assessment; 3. Catch information only) defined according to the availability of the data.

SC would ask that the Commission understand that dedicated resources must come from Contracting Parties, in terms of money, people and time, and that this plan likely requires the engagement of external expertise as well as dedicated SC members with experience in NAFO PA application.

Implementation of the revised PA framework is both a science and management responsibility. SC is taking the first step at a proposed work plan and scoping the issues that need resolving, but the development of the revised PA framework will require iterative steps between SC, WG-RBMS, and the Commission.

Initial work plan

A small group of scientists would be responsible for carrying out this work during a 2-year period going from November 2020 to October 2022. They would have to dedicate substantial work time over this period of time and would report to SC. This group would include some current SC members, possibly other scientists from Contracting Parties, and likely an external contractor(s), given SC workload concerns.

Proposed work plan:

- Review of and proposal for ToRs related to mapping objectives. Deadline for results to SC: June 2021
- Review of and proposal for ToRs related to structural aspects and quantification of uncertainty and risk. Deadline for results to SC: November 2021
- Both 1 and 2 would need to cover the data continuum, so that the framework could be applied to all NAFO stocks (data rich and data poor).
- Workshop of SC (including the group of scientists), around March 2022, to address the entire ToR and make a proposal of revision of the NAFO PA framework (to be later reviewed by the WG-RBMS).
- WG-RBMS 2022, based on the SC review work, would propose a new framework for the NAFO PA, to be considered by the NAFO Commission in September 2022.
- Consider broad associated implications for stocks managed using a Management Procedure (HCR) based on a MSE.

After approval of the framework by the NAFO Commission, a second SC workshop would be held to develop the guidelines (including the group of scientists) to support the implementation of the new NAFO PA framework, (between September 2022 and April 2023). The workshop would include case studies for reference points for, at least, several data-rich and data-poor stocks.

viii) Identify areas and times where bycatch and discards of Greenland sharks have a higher rate of occurrence (COM request #9)

Due to time constraints, SC was not able to address this request during the June meeting and it is deferred until September 2020.

ix) Develop a 3-5 year work plan (COM request #10)

Due to time constraints, SC was not able to address this request during the June meeting and it is deferred until September 2020.

x) Update assessment and projections for 3LN redfish (COM request #11)

The Commission requests that Scientific Council do an update assessment for 3LN redfish and five year projections (2021 to 2025) to evaluate the impact of annual removals at 18 100 tonnes against the performance statistics from NCEM Annex I.H: If this level of catch does not result in fulfilling these performance statistics, SC should advise the level of catch that would.

Scientific Council responded:

SC conducted an update assessment of Redfish in Division 3LN followed by five-year projections (2021 to 2025) to evaluate the impact of annual removals at 18 100 tonnes on stock biomass and fishing mortality in relation to B_{lim}, B_{msy} and F_{msy} by 2026. At the beginning of 2020 the stock was in the safe zone, with a probability of biomass being above $B_{msy} > 90\%$, and with the probabilities of biomass being below B_{lim} and fishing mortality being above F_{msy} less than 1%.

Annual catch of 18 100 tonnes during 2021 - 2025 will maintain biomass above B_{msy} at the beginning of 2026 with very high probability (> 90%). Also the probability of $B_{2026} < B_{lim}$ or $F_{2025} > F_{msy}$ is <1% if the 2020 HCR TAC is maintained during 2021-2025.

However, the probability of $B_{2026} > B_{2020}$ is close to being very low (12%), and most likely in the medium term this catch level will trigger a marginal biomass decline already suggested by the majority of recent observed data. In general, recent recruitment appears to be low. Despite these circumstances, the stock is projected to remain in the safe zone.

Scientific Council will continue to assess this stock on a 2 year schedule.

xi) ecosystem summary sheet for 3LNO (COM request #12)

The Commission request that the Scientific Council present the Ecosystem Summary Sheet for 3LNO for presentation to the Commission at the 2020 Annual Meeting.

Scientific Council responded:

SC **recommends** that *the NAFO Secretariat request the information (i.e. percentage of non-NAFO managed stocks that are in condition of supporting fisheries; trends in abundance of stocks under moratoria; fraction of VME biomass/area under protection; level of fishing effort exerted within unprotected VME habitats; tonnage of discards in each and across fisheries) from Canada and ICCAT (International Commission for the Conservation of Atlantic Tunas) for stocks in or migrating through the 3LNO Ecosystem Production Unit.*

SC **will move toward** undertaking a joint Workshop with ICES (International Council for the Exploration of the Sea) as part of a peer review of North Atlantic ecosystems. The workshop should involve a simultaneous meeting of SC to agree on recommendations from the assessment of ecosystem status.

The amended NAFO Convention came into force in 2017 and commits the organization to apply an ecosystem approach to fisheries management in the Northwest Atlantic through implementation of its Roadmap for an

Ecosystem Approach to Fisheries (EAF) (Koen-Alonso et al. 2019, and NAFO references therein). The NAFO Roadmap requires integrating information beyond single-species, providing managers with an integrative perspective at the ecosystem level. Development of Ecosystem Summary Sheets (ESSs) is part of this process. Analogous to current Stock Summary Sheets, ESSs are intended to provide a synoptic perspective on the state of NAFO ecosystems and their management regime, aligning with the general principles adopted by NAFO in chapter III of the amended NAFO Convention. Assessment of Ecological Features and Management Measures are grouped under corresponding elements of the Convention Principles. In addition, the ESSs are to report on other considerations outside the mandate of the NAFO Convention.

ESSs are intended as a tool for strategic assessment, advice, and planning, and should be updated every 3-5 years. The assessment considers average state over the last 5 years (S – Status) and the trend during that period (T – Trend) (Tables xi.1 and xi.2).

The ESS for the 3LNO Ecosystem Production Unit (EPU) has been completed based on material from the 2019 meetings of Scientific Council and the Working Group on Ecosystem Science and Assessment. SC is still developing methodologies to assess the frequency and magnitude of observations of VME-defining taxa and benthic communities within the VME habitat outside defined VME protection zones. Trends in key benthic species and communities from regular surveys will be available in the future for a limited period (2010 onward) but the data are currently being curated. Trends in marine mammal abundance could not be evaluated because the status of most species are not assessed. No quantitative data on seabird abundance was available to the working group. Discard levels across fisheries were only available for the most recent period (2015-2018).

Metrics to assess non-NAFO Fisheries and non-NAFO VME protection are currently being developed and will be reported in future assessments. SC **recommends** that *the NAFO Secretariat request the information (i.e. percentage of non-NAFO managed stocks that are in condition of supporting fisheries; trends in abundance of stocks under moratoria; fraction of VME biomass/area under protection; level of fishing effort exerted within unprotected VME habitats; tonnage of discards in each and across fisheries) from Canada and ICCAT (International Commission for the Conservation of Atlantic Tunas) for stocks in or migrating through the 3LNO EPU.*

SC agreed to a consensus draft ESS for the 3LNO EPU. However, SC noted that the performance review panel recommended that we continue to peer review our methods and make these assessments available. Owing to the complexity of the information contained in the ESS and the diverse expertise required to provide peer review of its content, SC **will move toward** undertaking a joint Workshop with ICES (International Council for the Exploration of the Seas) as part of a review of North Atlantic ecosystems. ICES currently performs integrated ecosystem assessments (IEAs) for a number of ecoregions. The workshop should involve a simultaneous meeting of SC to agree on recommendations from the assessment of ecosystem status.

References

Koen-Alonso, M., P. Pepin, M.J. Fogarty, A. Kenny, and E. Kenchington. 2019. The Northwest Atlantic Fisheries Organization Roadmap for the development and implementation of an Ecosystem Approach to Fisheries: structure, state of development, and challenges. *Marine Policy*. 100:342-352.

Table xi.1. Colour scheme for the ecological features of the ecosystem summary sheet and the corresponding criteria for assignment to each category for the status and trends. Time series for the contributing elements were standardized to zero mean and unit standard deviation relative to an appropriate reference period.

	Ecological Features	
	Status	Trend
Green	The state over the last 5 years is consistent with conditions observed/estimated during high productivity/high resilience periods (mean > 0.5 SD)	The trend over the last 5 years indicates consistent improving of the state/condition (trend > 1 SD/5 y or >20% increase in state)
Yellow	The state over the last 5 years is consistent with conditions observed/estimated during average productivity/average resilience periods	The trend over the last 5 years does not indicate any consistent change of the state/condition
Red	The state over the last 5 years is consistent with conditions observed/estimated during low productivity/low resilience periods (mean < -0.5 SD)	The trend over the last 5 years indicates consistent deterioration of the state/condition (trend < -1 SD/5 y or >-20% decline in state)
Grey	Unknown - insufficient data to assess or assessment pending	Unknown - insufficient data to assess or assessment pending

Table xi.2. Colour scheme for the management measures of the ecosystem summary sheet and the corresponding criteria for assignment to each category for the status and trends.

	Management Measures	
	Status	Trend
Green	Good. Current management measures are delivering the desired results.	Good. Management measures over the last 5 years are improving conditions; moving towards/maintaining the desired results.
Yellow	Uncertain. Current management measures appear to have limited ability to deliver the desired results.	Uncertain. Management measures over the last 5 years are not improving conditions; no clear movement towards achieving the desired results.
Red	Poor. Current management measures appear insufficient to deliver the expected results or no management measure is in place.	Poor. Management measures over the last 5 years are not effective or no management measure is in place; conditions are moving away/deteriorating from the desired results.
Grey	Unknown - insufficient data to assess or assessment pending	Unknown - insufficient data to assess or assessment pending

3LNO Ecosystem Status Summary Sheet

ECOLOGICAL FEATURES					
Convention Principle					**Comment**
A	**Ecosystem status and trends (long-term sustainability)**		**S**	**T**	**Summary of multiple trends/state**
	1	Physical Environment	🟨	🟨	Near or slightly above normal over the last 5 years but no clear trend over the last 5-yr
	2	Primary Productivity	🟩	🟨	Nutrient indices are near normal, phytoplankton standing stocks has recovered from a prolonged below normal state and are now above normal. All indices are dominated by cyclic changes with no clear trend.
	3	Secondary Productivity	🟨	🟨	Zooplankton biomass is now above normal following a prolonged period below normal state. The abundance of large zooplankton taxa has been below normal since 2013.
	4	Fish productivity	🟥	🟥	Total finfish and shellfish biomass has been declining since 2013-14. Overall biomass is below pre-collapse levels. Average weight of individuals in the survey has declined since the early 2000s.
	5	Community composition	🟨	🟨	Shellfish has declined in relative dominance, but piscivores have yet to regain their pre-collapse dominance.
B	**Ecosystem productivity level and functioning**		**S**	**T**	**Summary of multiple trends/state**
	1	Current Fisheries Production Potential	🟥	🟥	Since 2013-2014, total biomass declined from 50% to ~30% of the estimated pre-collapse level.
	2	Status of key forage components	🟥	🟥	Reduced levels of capelin, sand lance, and shrimp.
	3	Signals of food web disruption	🟨	🟥	Diet variable, declining trend in stomach content weights.
E	**State of biological diversity**		**S**	**T**	**Summary of multiple trends/state**
	1	Status of VMEs	🟨	🟨	Additional survey data between 2013 and 2019 has improved the delineation of VMEs and resulted in a general increase in both VME area and biomass. These changes are not thought to represent changes in population densities.
	2	Status of non-commercial species	🟨	🟩	Based on 22 non-commercial species from the multispecies surveys, 40% are below 20% of their historical maximum biomass levels. This has declined from higher levels in 2015.

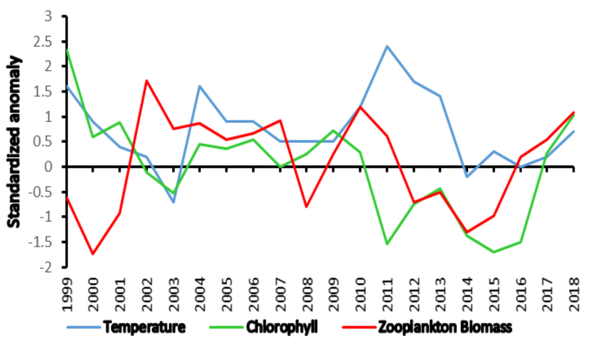
MANAGEMENT MEASURES					
Convention Principle					**Comment**
C/D	**Apply Precautionary Principle**		**S**	**T**	**Summary of metrics on level of management action**
	1	Total Catch Indices (TCI) and catches	🟥	🟥	Piscivores catches have exceeded the 25th percentile of the Fishery Production Potential estimates since 2015; catches of suspension feeding benthos exceed it in 2018.
	2	Multispecies and/or environmental interactions	🟥	🟥	No explicit consideration of species interactions and/or environmental drivers in stock assessments.
	3	Production potential of single species	🟨	🟨	Only 60% of NAFO managed stocks are in condition of supporting fisheries; some stocks have declining trends.
D/E	**Minimize harmful impacts of fishing on ecosystems**		**S**	**T**	**Summary of metrics on level of management action**
	1	Level of protection of VMEs by closed areas or outside fishing footprint	🟥	🟥	Biomass and area of VMEs has increased between 2013 and 2019 as a result of improved delineation of areas of high concentration with increased data. The fraction of biomass under protection by closed areas has declined and is generally low. Several VMEs have limited protection. Fishing with bottom contacting gears does not intrude in closed areas. Part of the VMEs are located outside the fishing footprint.
	2	Level of protection of exploited species	🟨	🟨	Total Catch Index (TCI) guidelines, based on the 25th percentile of the Fishery Production Potential model estimates, have been developed. LRPs or HCRs are available for 70% of managed stocks. No multispecies assessments are in place.
D/F	**Assess significance of incidental mortality in fishing operations**		**S**	**T**	**Summary of metrics on level of management action**
	1	Discard level across fisheries	🟨	🟨	Total discards increased during 2014-2018, with the greatest tonnage occurring in the Greenland halibut fishery. In terms of percentage of total catch from a fishery, discards were generally greater than 40% in the Atlantic halibut fishery. For each stock, the percentage of reported discards relative to total catch for that stock was generally less than 8%.

	2	Incidental catch of depleted and protected species	🟩	🟩	Wolffish are the most prevalent incidental catch taxa in fisheries in the EPU. Generally the incidental catch of wolffish in 3LNO fisheries is very low (less than 0.01% of survey biomass) but highly variable.
OTHER CONSIDERATIONS (outside mandate of NAFO Convention)					
Human Activities other than fisheries			**S**	**T**	**Comment**
	1	Oil and gas activities			As of 2019, there are four offshore production fields on the Grand Bank and extensive exploration activities along the eastern shelf break and Flemish Pass. The total area of licenses[1] has increased 8.3-fold from 2014 to 2019. There have been ten reported incidents between 2015 and 2019, with a major oil spill in 2018, and one that extended into the NRA in 2019. A proposed development project in the Flemish Pass overlaps with fishing grounds. It is expected, based on current exploration leases and development projections that oil and gas exploration activities may increase in the NRA until at least 2030.
	2	Pollution			There is low occurrence and density of seabed litter in 3L. The primary source of litter is from both NAFO-managed and non-NAFO managed fisheries. Data for 3NO are not currently available. Standardized protocols for litter data collection have been developed and await approval and implementation during EU surveys.
Fisheries not managed by NAFO			**S**	**T**	**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*

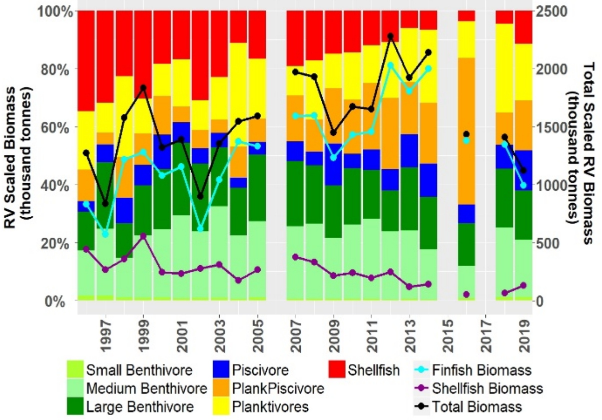
---

[1] License types: Exploration, Significant Discovery and Production

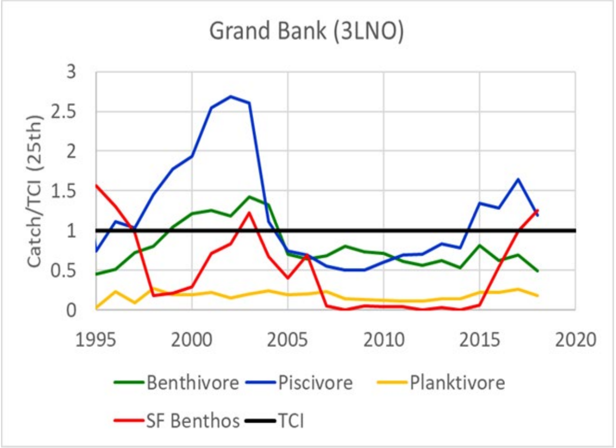
PHYSICAL ENVIRONMENT AND LOWER TROPHIC LEVELS



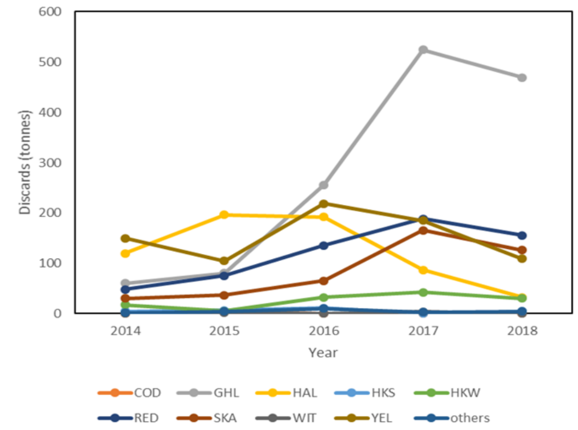
FISH COMMUNITY COMPOSITION AND BIOMASS



ECOSYSTEM AGGREGATE CATCHES



BY-CATCH IMPACTS



3LNO Ecosystem Status Narrative

The Grand Bank (3LNO) EPU is currently experiencing low productivity conditions and declines in biomass of upper trophic levels and fish stocks. Although reduced productivity appears to be driven by bottom-up processes, current aggregate catches for piscivore species have been increasing during the last 10 years and exceed the TCI guidance. Reductions in piscivore catch levels should be considered; most piscivore catches consist of redfish, Greenland halibut, and Atlantic cod.

ECOLOGICAL FEATURES

Ecosystem Status and Trends

The last 5 years have been characterized by increased levels of nutrients, phytoplankton indices, and total zooplankton biomass. Small-sized zooplankton have significantly increased in abundance but the larger, lipid-rich taxa that are the preferred prey of forage fish have been below normal since 2013. 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 since 1995, 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. Multispecies surveys indicate that after the regime shift in the late 1980 and early 1990, this ecosystem never regained its pre-collapse biomass level. Improved conditions between the mid-2000s and early 2010s allowed a build-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, principally capelin. Since 2013, forage species have declined, and a reduction in total multispecies biomass to ~30-40% 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 here to Vulnerable Marine Ecosystems (VMEs) and the number of non-commercial fish species considered depleted owing to availability of appropriate analyses. Although identification and delineation of VMEs is being done for the NRA, it is difficult to assess their status given the absence of a defined baseline and the unquantified impacts from historical fishing activities. The status of non-commercial species indicates that 40% of 22 taxa have biomasses that are below 20% of their historical maximum biomass for the period 1985-2018, but demonstrates an improvement from higher levels in 2015.

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 increasing since 2007 and were above their Total Catch Index guidance (TCI – defined as the 25th percentile of the Fishery Production Potential model estimates) from 2015-onward. Piscivore catches are mostly composed of redfish, Greenland halibut, Atlantic cod, and white hake. Catches of suspension feeding benthos (mostly surf clams) were above their TCI guidance in 2018.

Sixty percent of the NAFO managed stocks in the Grand Bank are open to directed fishing, and some of the stocks not supporting fisheries are showing declining trends in abundance indices. Impacts of either species interactions or environmental drivers are not currently being considered in the provision of single species harvest advice or management of those fisheries.

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 on the Grand Bank are currently protected with dedicated closures. However, the 3O coral closure does not provide protection for the identified VMEs in that area as appropriate depths were not included within the boundary of the closure. Closures protect 59% of the large-sized sponge VME biomass, 22% of sea pen VME biomass and 56% of large gorgonian coral VME biomass in 3LNO. Non-coral and non-sponge VMEs were identified and areas of high concentration have been delineated on the tail of the Grand Bank. Only 18% of black coral biomass are currently protected by closures for other taxa, and less than 1% or less of small gorgonian corals, sea squirts and erect bryozoans biomass are protected. The fishing footprint offers some protection beyond the boundaries of the closed areas for large-sized sponges and large gorgonians.

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 studies are available, there are no multispecies assessments to inform on considerations of trade-offs among fisheries and no stock-assessment explicitly considers either species interactions or environmental factors as drivers.

Assess significance of incidental mortality in fishing operations

Total discards demonstrated a general increase during the period 2014-2018, peaking at ~1200 tonnes in 2017 in the NRA. Total discards were greatest in the fishery for Greenland halibut. As a fraction of total catches, discards were generally below 8% of the total catch. Discards proportions were highest in the fisheries for Atlantic halibut and white hake.

Generally the incidental catch of at-risk wolffish in 3LNO fisheries is very low (less than 0.01% of survey biomass) but highly variable. While wolffish are caught in many different gear types, historically landings were greater in bottom trawl gear than in gillnet or longline gears. In addition, while of Northern and Spotted Wolffish dominate the catches in NAFO division 3L, Atlantic Wolffish are the dominant species in NAFO divisions 3NO.

OTHER CONSIDERATIONS

Human activities other than fishing

As of 2019, there are four offshore production fields on in 3LNO and intense exploration activities along the eastern shelf break and Flemish Pass. The total area of licenses[2] has increased 8.3-fold from 2014 to 2019. There have been several reported incidents between 2015 and 2019, with a spill of 250,000 L in 2018 and one extending into the NRA in 2019. A proposed development project in Flemish Pass overlaps fishing grounds. It is expected, based on current exploration leases and development projections that oil and gas exploration activities will increase until at least 2030.

There is low occurrence and density of seabed litter in 3L, with NAFO and non-NAFO fisheries the primary source. Data for 3NO are not currently available. Standardized protocols for seabed litter data collection have been developed and await approval and implementation during EU surveys.

---

[2] License types: Exploration, Significant Discovery and Production. Exploration licences represent the greatest contributors to total area of oil and gas activities.

xii) Review submitted protocols for a survey methodology to inform the assessment of splendid alfonsino (COM request #13)

Due to time constraints, SC was not able to address this request during the June meeting and it is deferred until September 2020.

xiii) Presentation of the stock assessment and the scientific advice of Cod 2J3KL (Canada), Witch 2J3KL (Canada) and Pelagic Sebastes mentella (ICES Divisions V, XII and XIV; NAFO 1) (COM request #14)

Due to time constraints, SC was not able to address this request during the June meeting and it is deferred until September 2020.

xiv) Provide updates on relevant research related to the potential impact of activities other than fishing in the Convention Area (COM request #16)

Due to time constraints, SC was not able to address this request during the June meeting and it is deferred until September 2020.

xv) Measures to improve the productivity of 3M Cod (COM request #17)

The Commission requests the Scientific Council to provide advice on gear, including sorting grids, area and time-based measures that can be used to protect and improve the productivity of the 3M cod stock.

Scientific Council responded:

> The SC responded to the Commission in 2015 and 2019 regarding sorting grids to reduce possible by-catches and discards. No new advice is provided here with respect to sorting grids.
>
> Area/season closures have been suggested as a tool to support fisheries management, particularly for areas/seasons where key life history stages are highly aggregated (e.g. spawning aggregations). In the case of 3M cod, most of the catch occurs during the first quarter of the year, and is comprised primarily of spawning fish. SC advises that a seasonal closure (no directed fishery on 3M cod during the first quarter of the year) would protect spawning activity, reducing the number of spawning fish that are captured and allowing them to spawn before becoming available to the fishery. However, there is no clear evidence that protecting spawning fish directly translates into increased recruitment/productivity. In addition, changes in the behavior of the fishing fleets in response to a seasonal closure, and the resulting impact on the overall ecosystem (e.g. changes in the fishing grounds, by-catch of juveniles and other species, and impacts on benthic habitats), would need to be closely monitored in order to ensure that any such closure was not having unintended negative consequences. The scale of these consequences is expected to be lower for low TACs. The implementation of these measures should be accompanied by a clear definition of the objectives (to determine if and how closure effectiveness could be monitored) and a monitoring plan to study the impact that these measures may have on the fishery and ecosystem.

In 2014, the Fisheries Commission requested the Scientific Council *to analyse and provide advice on management measures that could improve selectivity in the Div. 3M cod and Div. 3M redfish fisheries in the Flemish Cap in order to reduce possible by-catches and discards.* Based on an examination of work carried out in the Barents Sea, Scientific Council responded that *the implementation of sorting-grids in the Div. 3M cod fishery gear will reduce catch of small and immature individuals of cod. These devices would to a large extent prevent catches of individuals less than the Minimum Landing Size (41 cm) and have the advantage also of reducing redfish by-catches and thereby reduce discards. It is estimated that by introducing sorting grids, the actual Fmsy value and the equilibrium yield (catches) would increase but it should have a small impact in the equilibrium Spawning Stock Biomass. To quantify these improvements more precisely, selectivity experiments with the modified gears need to be performed in the Flemish Cap area* (NAFO, 2015).

In 2020, the SC analyzed data from the commercial cod fishery in Div. 3M. These analyses suggest that catches of cod in Div. 3M are made mainly in the first quarter of the year and are comprised primarily of spawning fish. The cod trawl fishery in the first quarter is concentrated in a fairly small area where catch rates (CPUE) are higher and fish mean sizes are larger than in other areas/seasons, likely representing a major spawning area. This concentration of catches in a given area is less clear in the cod longline fishery.

Area/season closures have been suggested as a tool to support fisheries management, particularly for areas/seasons where key life history stages are highly aggregated (e.g. nursery or spawning areas). In the case of 3M cod, the fact that the directed fishery primarily targets spatially-limited spawning aggregations in the first quarter of the year suggests that a seasonal closure of this area could reduce the number of fish captured during spawning. Nevertheless, there are different works that indicate that, even in these cases, it is better and more practical, from the point of view of its implementation and control, to have seasonal closures rather than small area closures. However, the consequences that such closures may ultimately have on the productivity of the 3M cod stock, the behavior and economics of the fishing fleets, and the resulting impact on the overall ecosystem, are largely unknown. Implementation of a spawning closure would likely result in fishing effort being reallocated to other areas/seasons, which could influence other key life stages (e.g. juveniles), species (e.g. incidental catches), and/or impacts on benthic habitats (i.e. by forcing the fishery into areas/seasons that were previously less fished and/or require increased effort to achieve a comparable catch). The scale of these consequences, however, is expected to be lower for low TACs and will be directly dependent on the level of effort. The implementation of these measures should be accompanied by a clear definition of the objectives (to determine if and how closure effectiveness could be monitored) and a monitoring plan to study the impact that these measures may have on the fishery and ecosystem.

xvi) Information on sea turtles, sea birds, and marine mammals that are present in NAFO Regulatory Area (COM request #18)

Due to time constraints, SC was not able to address this request during the June meeting and it is deferred until September 2020.

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)

The Scientific Council responded:

Recommendation for 2021 - 2023

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

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

Management objectives

No explicit management plan or management objectives have been defined by the Government of Greenland.

Management unit

These two species are managed together as a single unit. Survey data reveal an almost continuous distribution of both species from East Greenland to West Greenland; both areas had geographically distinct fisheries historically. However, the degree of connectivity between the two areas is unknown.

Stock status

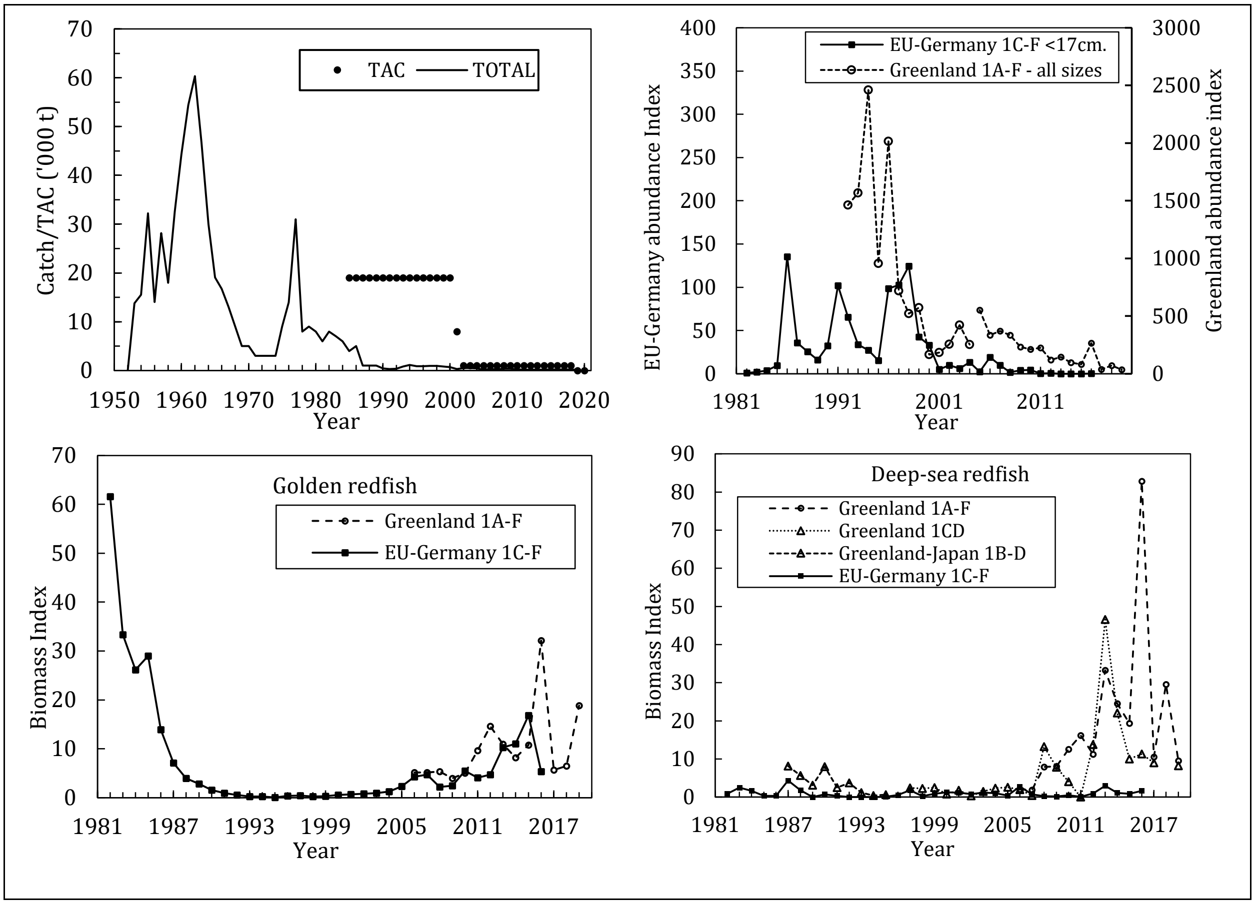
Catches of the stock have been very low since the 1990s.

Golden redfish

Survey indices indicate that the biomass remains far below historical levels. Recruitment has been poor for two decades and failing during the most recent decade. The overall stable biomass in recent years is the result of somatic growth or immigration balancing the limited fishery and natural mortality in the remaining stock.

Deep-sea redfish

Both the Greenland Shrimp and Fish survey (Div. 1A-F) and the Greenland deep-sea survey (Div. 1CD) indicate a decreasing biomass index of deep-sea redfish in the recent 4-7 years. Recruitment has been poor for two decades. No new incoming year classes have been identified during the trawl surveys in either East Greenland (EU-Germany survey), West Greenland offshore (EU-Germany survey and survey in Div. 1A-F), or inshore (Survey in Div. 1A-F) during the recent decade.



Reference points

Could not be established.

Assessment

No analytical assessment was performed. The assessment was based upon a qualitative evaluation of survey indices, length composition in surveys, and historical fishery. The assessment is considered data-limited and with relatively high uncertainty, as surveys do not fully cover the distribution of the stock

Human impact

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

Environmental impact

Unknown

Fishery

The proportions of golden and deep-sea redfish in the historical catches are unknown. The catches of redfish peaked in the 1960s at 60 000 tonnes, but gradually decreased during the 1970s and 1980s. A significant unreported bycatch of redfish was likely taken during the 1980s and 1990s in the fishery targeting shrimp. With the implementation of sorting grids in the shrimp fishery in 2002, catches and bycatch of redfish are considered to be very low.

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

	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
TAC	1	1	1	1	1	1	1	1	1	0	0
STATLANT 21	0	0.2	0.12	0.16	0.25	0.19	0.16	0.23	0.19	0.095	
STACFIS	0.3	0.2	0.16	0.17	0.17	0.26	0.17	0.24	0.19	0.14	

Effects of the fishery on the ecosystem

There is currently no significant directed fishery in West Greenland. Recent landings of redfish are bycatches taken in other fisheries: mainly longline, gillnet or jigging in the inshore and coastal areas, and trawl in the offshore areas.

Basis for Advice

Survey indices were used to evaluate the stock.

Special comments

The higher biomasses of both redfish species observed in the surveys since around 2008 could be a consequence of either increased survival of redfish after the implementation of sorting grids in the shrimp fishery and/or migration of redfish from nearby areas. Current stock delineation may not be appropriate.

Although the Shrimp and Fish survey experienced vessel changes in 2018 and 2019, the indices are considered to be comparable with those from earlier years. The deep-sea survey in 1CD also experienced a vessel change in 2019, for which it has been shown that gear performance parameters remained constant with both vessels at depths < 700 m. Since both redfish are found mainly at depths < 600 m during this survey, results are also considered comparable.

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

Sources of Information

SCR Doc. 20/003, 006, 012, 016 and 045; SCS Doc. 20/12.

Wolffish in Subarea 1

Advice June 2020 for 2021 - 2023

Recommendation for 2021 - 2023

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

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

Management objectives

No explicit management plan or management objectives have been defined by the Government of Greenland.

Management unit

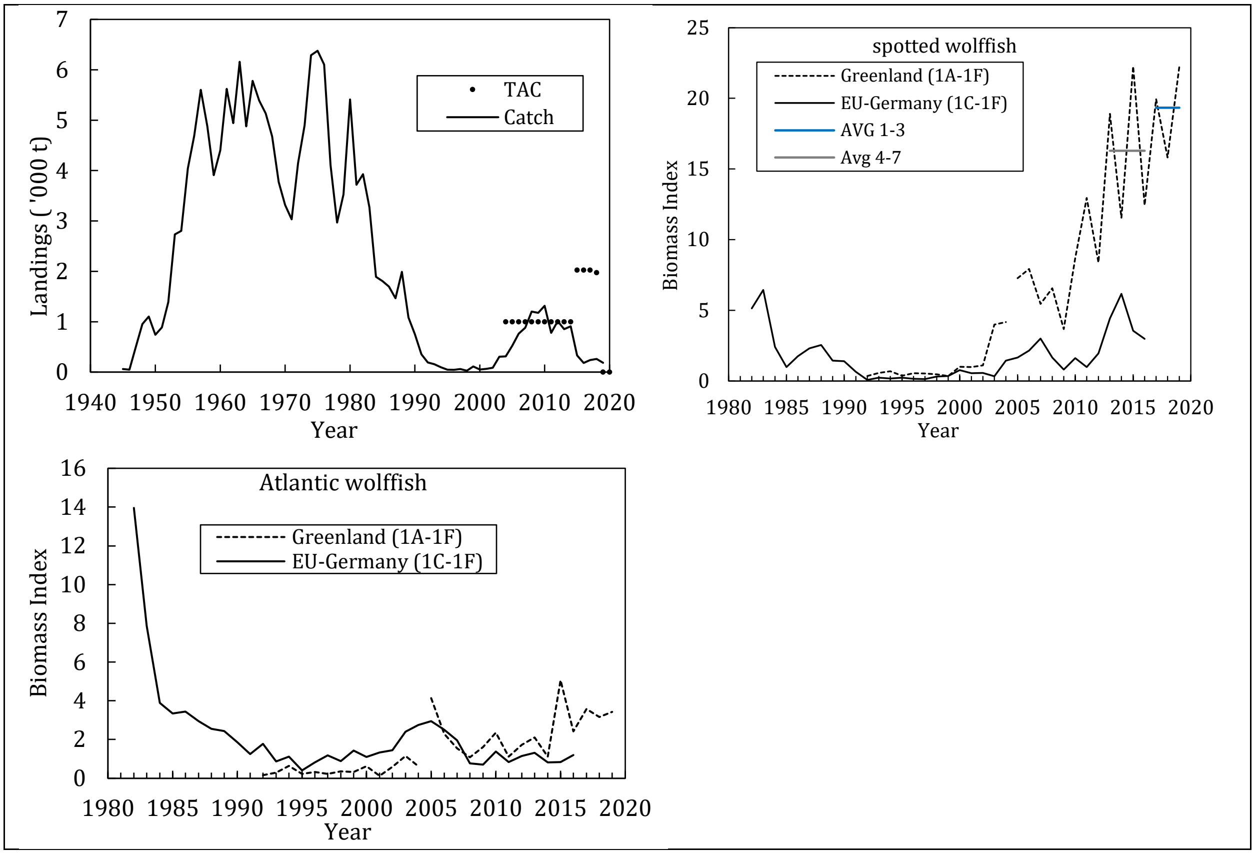
Atlantic wolffish is known to be more connected to the offshore banks in South and West Greenland and is considered a single unit.

Spotted wolffish is found in all areas, both inshore and offshore, but is known to be the dominating species in the coastal regions and the fjords in South, West and North Greenland. It is presumed to be a single stock.

Stock status

Atlantic wolffish: The survey biomass and abundance indices continued to increase in the Greenland Shrimp and Fish survey; however, the EU-Germany indices remain low (to 2016). As the EU-Germany survey and the Greenland shrimp and fish survey in the overlapping period were around the same level, it seems reasonable to assume that the biomass remains below the level of the 1980s.

Spotted wolffish: Survey indices suggest continued stock growth. Although the catches were below the TAC from 2015-2018, there is no indication that the decreasing catches were related to a decrease in the stock. The average biomass index in the Greenland Shrimp and Fish survey is 19% higher in the recent 3 years (2017-2019) compared to the preceeding 4 year period.



Reference points
Could not be established.

Assessment

No analytical assessment was performed. The assessment is based upon a qualitative evaluation of survey indices, length composition in surveys, and fishery data. The assessment is considered data limited and with relatively high uncertainty, as surveys do not fully cover the distribution of the stock.

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

Environmental impact
Unknown

Fishery

Wolffish are primarily taken in a directed longline fishery or as a bycatch in longline, gillnet or trawl fisheries. Prior to 2015, TACs were set for wolffish with species combined, but since 2016 separate TACs have been set for spotted and for Atlantic wolffish. The proportions of Atlantic wolffish and spotted wolffish in the catches are unknown, but there is little doubt that spotted wolffish constitutes the majority of recent landings, since the fishery takes place in the coastal areas and the fjords, where spotted wolffish is known to be the dominating species. Furthermore, the majority of the Atlantic wolffish observed in surveys are smaller than normal commercial sizes, whereas spotted wolffish between 70 and 110 cm are plentiful.

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

	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Atlantic wolffish TAC					1.0	1.0	1.0	1.0	0	0
Spotted wolffish TAC					1.025	1.025	1.025	1.025	0	0
Wolffish TAC	1.0	1.0	1.0	1.0	2.025	2.025	2.025	2.025	0	0
STATLANT 21	0.8	1.0	0.9	0.9	0.4	0.2	0.3	0.3	0.2	
STACFIS	0.8	1.0	0.9	0.9	0.4	0.2	0.3	0.3	0.2	

Effects of the fishery on the ecosystem

Wolffish in the area are targeted with longlines, selecting mainly adult fish and with low environmental impact.

Basis for Advice

Atlantic wolffish
Survey indices were used to evaluate the stock.

Spotted wolffish
Survey indices were used to evaluate the stock. The ICES Harvest Control Rule (HCR) 3.2 for data limited stocks was used as a basis for giving TAC advice; the ratio of the mean of the survey index over the last three years (2017-2019) and over the preceding four years (2013-2016) is equal to 1.1877. The survey index used in this calculation was the Greenland Shrimp and Fish survey as its distribution was appropriate to the distribution of the stock. Application of this HCR starts from the previously advised catch (975 tonnes), resulting in catches of no more than 975 x 1.1877 = 1158 tonnes.

Special comments
The ICES HCR for data limited stocks was first applied to spotted wolffish in 2017. A 1st year 'precautionary buffer' of 20% reduction was applied in 2017.

The harvest control rule is based on modifying the previous advice based on the stock trends observed in the survey. If advised catches are not taken, this can lead to increases in recommended catches as long as the stock increases. If the divergence between the observed and advised catches continues, this could lead to unsustainable advice, and therefore application of this rule may need to be reevaluated in the future.

The two species are not usually separated in the landings. Given the different status of the Atlantic and spotted wolffish stocks, SC recommends speciation of the landings for these two species.

Sources of Information
SCR Doc. 14/028, 20/006, 012, 040; SCS Doc. 20/12.

Greenland halibut in Division 1A inshore - Upernavik

Advice June 2020 for 2021 – 2022

Recommendation for 2021 - 2022

Scientific Council recommends that catch should not exceed 5 068 tonnes. This is a reduction over the previous advice accounting for the reduction in mean individual size in the recent catches

Management objectives

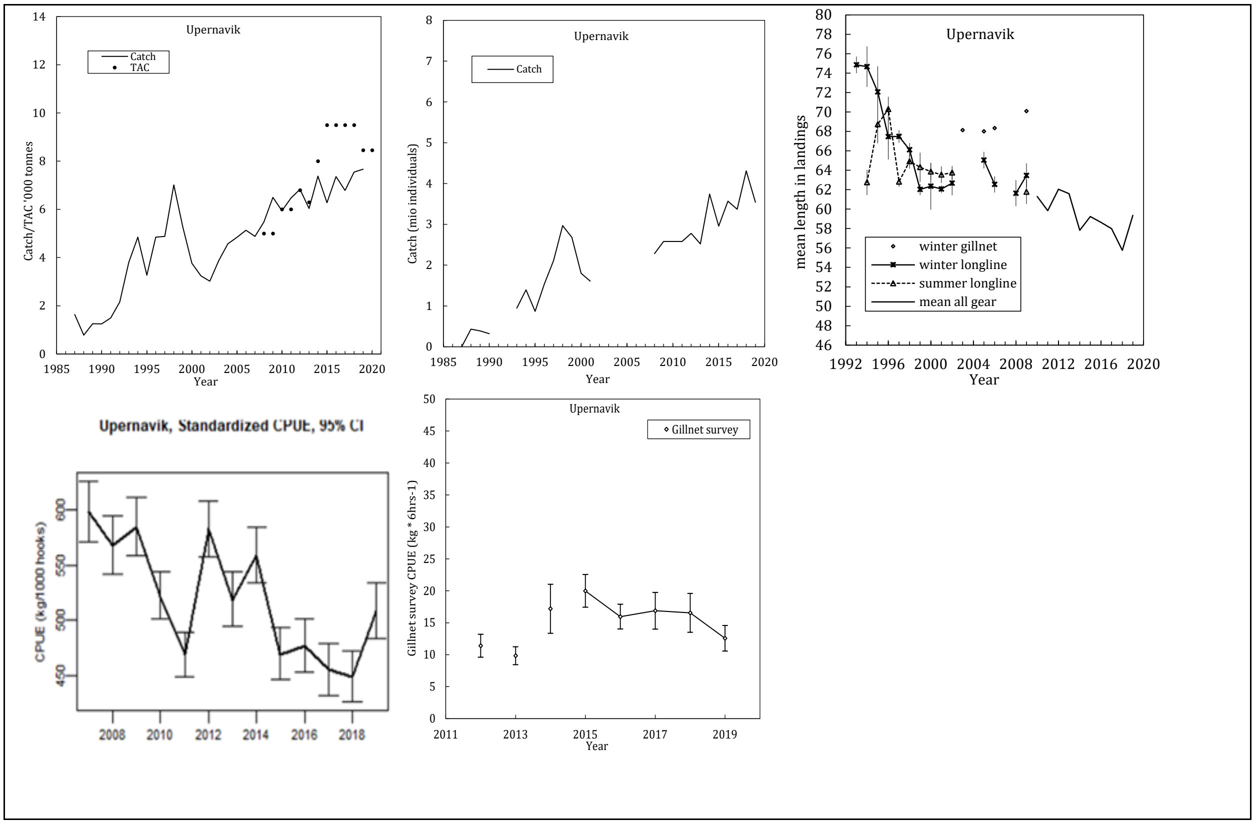
No explicit management plan or management objectives have been defined by the Government of Greenland.

Management unit

The three stocks in Div. 1A inshore fjords (Disko Bay, Uummanaq and Upernavik) are believed to recruit from the Subarea 0+1 offshore spawning stock (in the Davis Strait) and there is little migration between the separate areas and the stock in SA 0+1 offshore. Separate advice is given for each management unit in Subarea 1A inshore.

Stock status

The catch in tonnes and in numbers of fish has been record high since 2014. Mean length in the fish landings decreased in the 1990s but stabilized from 1999 to 2009. Since then, until 2018, length in the fish landings has decreased from 74-76 cm to 56-58 cm. The mean length increased in 2019, but this value is questionable because the sample size was smaller than usual. The standardized longline CPUE index decreased until 2018 reaching the lowest value of the time series. CPUE increased in 2019 but remains within the decreasing trend for year to year variation. The gillnet survey has shown some stability since 2015. The decrease observed in 2019 is uncertain due to a lower number of stations than usual.



Reference points

Could not be established.

Assessment

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

Human impact

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

Environmental impact

Unknown

Fishery

Catches increased from the mid 1980s and peaked in 1998 at a level of 7 000 t. Landings then decreased sharply, but during the past 15 years, they have gradually returned to a higher level. Average catch in the most recent 5 years has been 7 169 t.

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

	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
TAC	6.5	6.5	8	9.5	9.5	9.5	9.5	9.5	8.5	8.5
STACFIS	6.5	6.8	6	7.4	6.3	7.4	6.8	7.5	7.6	

Effects of the fishery on the ecosystem

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

Special comments

The ICES Harvest Control Rule 3.2 for data-limited stocks could not be used since the survey time series was too short to be applied.

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

Sources of Information

SCR Doc. 20/006, 016 , 043; SCS Doc. 20/012.

Greenland halibut in Division 1A inshore - Uummannaq

Advice June 2020 for 2021 – 2022

Recommendation for 2021 - 2022

Scientific Council recommends that catch should not exceed 5153 tonnes. This recommendation is a reduction over the previous advice accounting for the decrease in the mean size in the recent catches.

Management objectives

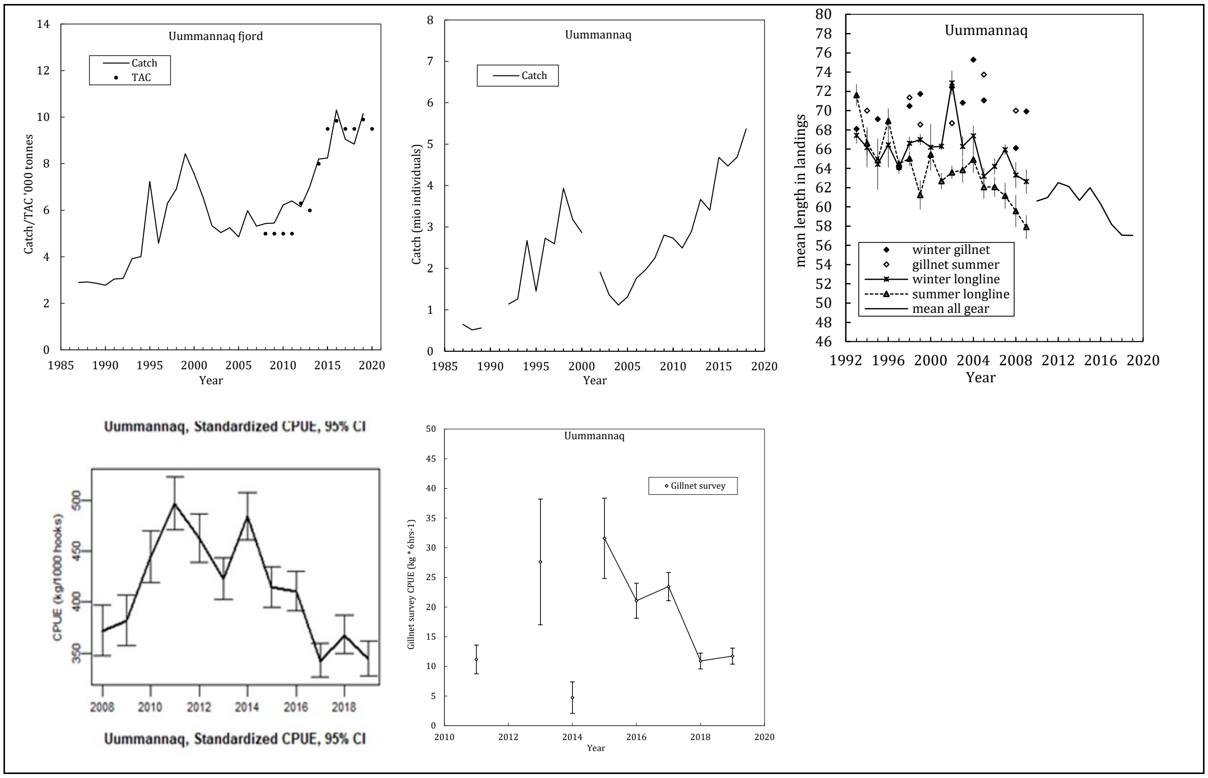
No explicit management plan or management objectives has been defined by the Government of Greenland.

Management unit

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

Stock status

The catch in tonnes and numbers of fish has been increasing since 2009, reaching record high values in 2016 and 2019. Mean length in the landings has gradually decreased. From 2011, the standardized commercial longline CPUE index decreased gradually, being 2017 and 2019 the years with the lowest values observed in the time series. The gillnet survey has shown a substantial decrease in CPUE due to a lower number of large fish in the survey, until 2018, and it remained almost stable in 2019.



Reference points

Could not be established.

Assessment

No analytical assessment was performed. Mean length in the landings, commercial CPUE, and survey indices were considered the best information to monitor the stock.

Human impact

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

Environmental impact

Unknown

Fishery

Catches in the Uummannaq fjord gradually increased from the 1980s, reaching 8425 t in 1999, but then decreased and remained between 5000 t and 6000 t from 2002 to 2009. Since 2009 catches gradually increased, reaching 10 243 t in 2019, the second-highest value of the time series.

Recent catch estimates (‘000 tonnes) are as follows:

	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
TAC	6	6	7.4	8.4	9.5	9.9	9.5	9.5	9.9	9.5
STACFIS	6.4	6.1	7	8.2	8.2	10.3	9	8.8	10.2	

Effects of the fishery on the ecosystem

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

Special comments

The ICES Harvest Control Rule 3.2 for data-limited stocks was not be used since the survey time-series is still relatively short.

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

Sources of Information

SCR Doc. 20/006, 016, 043; SCS Doc. 20/12.

Greenland halibut in Division 1A inshore - Disko Bay

Advice June 2020 for 2021 – 2022

Recommendation for 2021 - 2022

The Scientific Council advises that the TAC should not exceed 4346 tonnes.

Management objectives

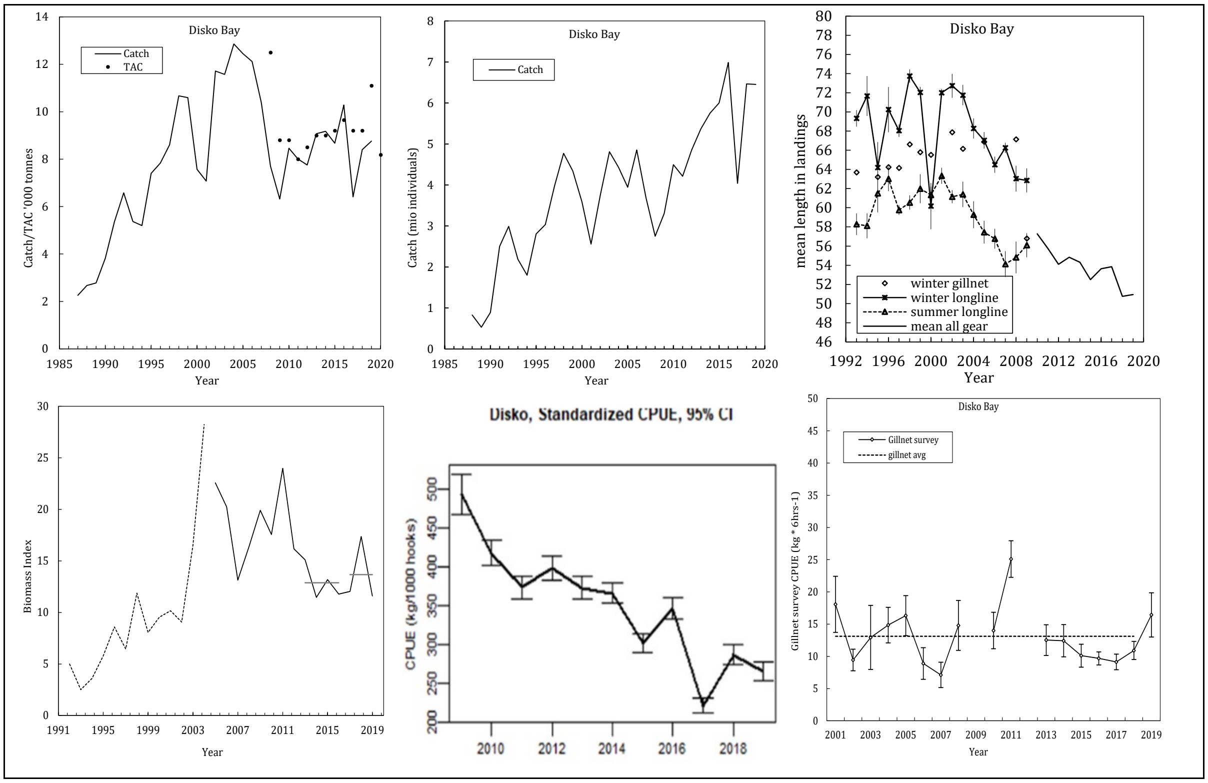
No explicit management plan or management objectives has been defined by the Government of Greenland.

Management unit

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

Stock status

Mean length of the fish landed has gradually decreased over 10 to 15 years. Although the catches have remained at a level of around 8 400 t per year in the recent decade, the number fish caught has gradually increased due to a decrease in the size in the landings. The number of fish landed remains high. The trawl survey biomass index has gradually decreased since 2009, with few years falling outside the decreasing trend. The commercial CPUE for longline vessels has decreased by about 50% since 2009. The Gillnet survey CPUE, originally designed for pre-fishery recruits, indicate stable recruitment at higher ages. The gillnet survey index in 2019 was above the average levels, but the comparability of the 2019 value with the earlier time series is questionable.



Reference points

Could not be established.

Assessment

No analytical assessment was performed. Mean length in the landings, survey indices and commercial CPUE was considered the best information to monitor the stock.

The next assessment is planned for 2022.

Human impact

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

Environmental impact

Since 1997 bottom temperatures have remained stable at a level of 2-3 degrees in the Disko Bay.

Fishery

Catches increased in the 1980s, peaked from 2004 to 2006 at more than 12 000 tonnes, but then decreased substantially. From 2009, catches gradually increased, reaching 8 759 tonnes in 2019.

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

	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
TAC	8	8	9	9	9.2	9.7	9.2	9.2	11.1	8.2
STACFIS	8	7.8	9.1	9.2	8.7	10.8	6.4	8.4	8.8	

Effects of the fishery on the ecosystem

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

Basis for advice

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

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

where r=index mean for 2017-2019/index mean for 2013-2016 = 1.061

Should changes in excess of +- 20% be generated using this rule, a 20% cap is applied. In 2016 or 2018, no precautionary buffer was applied. Since both the mean length in the fish landings and the commercial CPUE's have decreased in both 2018 and 2019 and stock status relative to reference points is unknown, a PA buffer (i.e. a 0.8 factor) was applied this year. This results in the following advised catch:

$advice_{recent}$ = 5120 tonnes (catch advised for 2019 and 2020).

Catch in 2021 and 2022 = $advice_{recent}$* r * PA buffer = 5120 tonnes * 1.061 * 0.8 = 4346 tonnes

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

Special comments

Although the index provided by the Greenland shrimp and fish trawl survey experienced vessel changes in 2018 and 2019, the results are considered to be comparable with those from earlier years.

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

Sources of Information

SCR Doc. 20/006, 016, 043; SCS Doc. 20/012.

Greenland halibut in Subarea 1 Division 1BC inshore

Advice June 2020 for 2021 – 2022

Recommendation for 2021 and 2022

The Scientific Council recommends that catch in each of the years 2021 and 2022 should not exceed 300 tonnes, which corresponds to the Depletion Corrected Average Catch (DCAC).

Management objectives

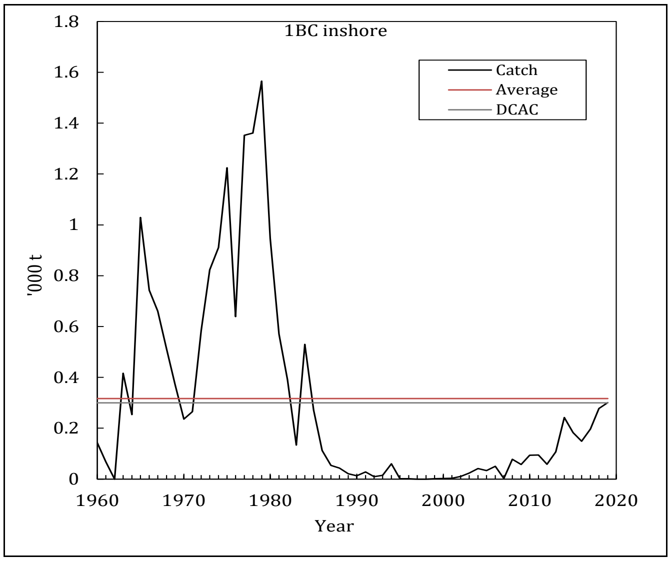
No explicit management plan or management objectives have been defined by the Government of Greenland.

Management unit

The stocks are believed to recruit from the offshore spawning stock in Subarea 0+1 (the Davis Strait) or offshore spawning stock in ICES Subareas 5, 6, 12 and 14 (East Greenland-Iceland-Faroes). There is little migration of adults between the fjords and the stock in SA 0 + 1 offshore. Fjords are assigned to a NAFO division based on the location of the mouth of each fjord. Combined catch advice is given for all fjords within the specified management unit.

Stock status

The catch was at a low level for two decades from the end of the 1980's. During the recent decade the catch has gradually increased to the estimated sustainable level of catch.



Reference points

The Depletion Corrected Average Catch method was used to estimate a sustainable level of catch.

Projections

Quantitative assessment of risk at various catch options is not possible at this time.

Assessment

The assessment is considered data limited and as such associated with a relatively high uncertainty. The assessment is based upon a catch history from 1960 to 2019. During this period the stock has gone through a period of intensive fishery and 3 decades of rebuilding. There are currently no survey data and commercial data is limited.

The next assessment is planned for 2022.

Human impact

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

Biological and environmental interactions

No specific studies were reviewed during this assessment.

Fishery

Catches increased in the area from the 1960's reaching more than 1,000 tonnes in 1965. Catches decreased thereafter but returned to a higher level from 1973 to 1980. After this intense fishing period, catches decreased and were almost non-existing for two decades from 1987. From 2008, catches have gradually increased, reaching 300 tonnes in 2019.

A TAC has not previously been set for the stocks in Divisions 1B to 1F inshore. The fishery has never been quota regulated.

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

	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
TAC										
STACFIS	95	58	107	242	183	149	197	278	301	

Effects of the fishery on the ecosystem

Greenland halibut in the area is targeted with longlines only in deep water and on muddy bottom. The gear is light with low risk of bycatch of birds and marine mammals and with low impact on the seabed.

Special comments

Until 2020 this stock was considered to be part of the stock in SA 0 + 1 offshore .

Available data until June 1st indicated a 30% reduction in catch compared to 2019, but the catches remain within the level observed within the recent 4 seasons. ICES DLS Guidance report 2012 p. 19-21 suggest a method to provide advice from the sustainable level catch estimated by the DCAC model. The method uses two scenarios and an adaptation period of 3-5 years following a ”fast down”– ”slow up” (catches should decrease to the DCAC value quickly if they are above it and could increase slowly towards it if below) approach taking into account that stocks with a low biomass cannot sustain MSY.

Sources of information

SCR Doc. 20/006 020 038 043; SCS Doc. 20/012.

Recommendation for 2021 and 2022

The Scientific council recommends a reduction of catches in this area to reach the 398 tonnes, corresponding to the Depletion Corrected Average Catch (DCAC), by 2023. The SC recommends to reduce catches to 647 tonnes in 2021 and 522 tonnes in 2022.

Management objectives

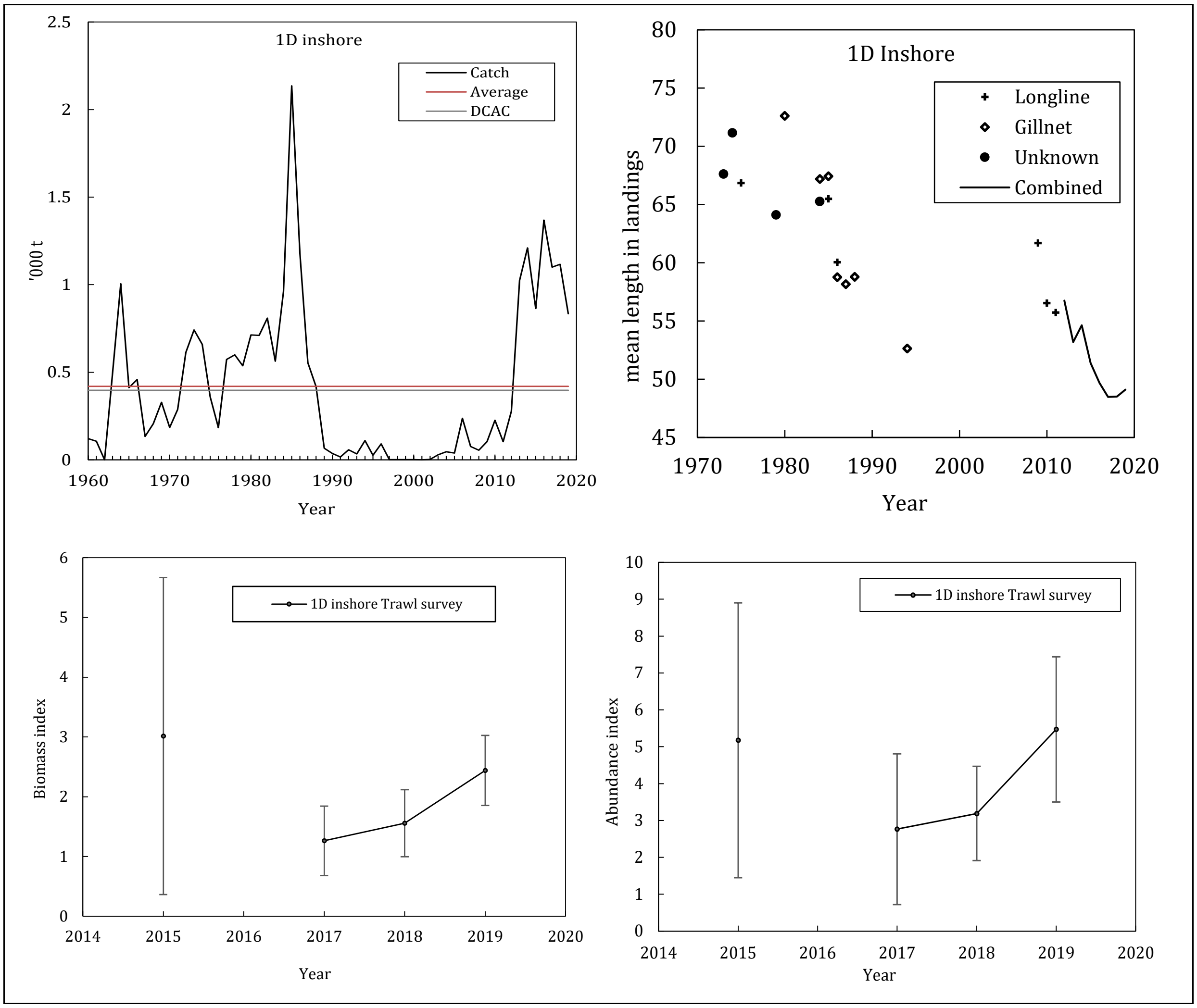
No explicit management plan or management objectives have been defined by the Government of Greenland.

Management unit

The stock in the fjords in Division 1D are believed to recruit from the offshore spawning stock in ICES Subareas 5, 6, 12 and 14 (East Greenland-Iceland-Faroes). There is little migration of adults between the fjords and the stock in SA 0 + 1 offshore. The stock is furthermore believed to be constituted of several isolated fjord stocks, with little migration between the fjords. Fjords are assigned to a NAFO division based on the location of the mouth of each fjord. Combined catch advice is given for all fjords within the specified management unit.

Stock status

The catch was at a low level for two decades from the end of the 1980's. Since 2013 the catches have been about twice as high as the DCAC estimated sustainable level of catch. During this period, a decrease in size composition in the catch has been observed. The trawl survey for Greenland halibut in the fjords in 1D indicated a decrease in the number of fish in the commercial size range since 2015. However, the biomass indices in the survey increased from 2017 to 2019, due to higher numbers of pre fishery recruits in the range 30-40 cm. The survey furthermore indicated presence of recruits in the area although the stocks are believed to be dependent on recruitment from the stock in ICES Subareas 5, 6, 12 and14.



Reference points

The Depletion Corrected Average Catch method was used to estimate a sustainable level of catch.

Projections

Quantitative assessment of risk at various catch options is not possible at this time.

Assessment

The assessment is considered data limited and as such associated with a relatively high uncertainty. The assessment is based upon a catch history from 1960 to 2019. During this period the stock has gone through a period of intensive fishery and 3 decades of rebuilding. The assessment is further supported by a trawl survey (since 2015) and length frequencies from the fishery are available from 1973 to present.

The next assessment is planned for 2022.

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

Biological and environmental interactions
No specific studies were reviewed during this assessment

Fishery

Catches in 1D inshore were around 500 tonnes annually from 1966 to the end the 1980’s, peaking in 1985 with 2,136 tonnes. After this intense fishing period, the fishery was virtually non-existing for two decades. From 2003 catches gradually increased, reaching 1,369 tonnes in 2016. In 2019, the catch decreased to 834 tonnes from 1117 tonnes in the preceding year. A TAC has not previously been set for the stock in Division 1D inshore. The fishery has never been quota regulated.

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

	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
TAC										
STACFIS	104	277	1,024	1,211	864	1,369	1,100	1,117	834	

Effects of the fishery on the ecosystem

Greenland halibut in the area is targeted with longlines only in deep water and on muddy bottom. The gear is light, with low risk of bycatch of birds and marine mammals and with low impact on the seabed.

Special comments

Until 2020 this stock was considered to be part of the stock in SA 0 + 1 offshore.

ICES DLS Guidance report 2012 p. 19-21 suggests a method to provide advice from the sustainable level catch estimated by the DCAC model. The method uses two senarios and an adaptation period of 3-5 years following a ”fast down” – ”slow up” (catches should decrease to the DCAC value quickly if they are above it and could increase slowly towards it if below) approach taking into account that stocks with a low biomass cannot sustain MSY.

Available data until June 1st indicated a 7.5% reduction in catch in 2020 compared to 2019. Assuming the same degree of catch reduction through the year, the full year catch for 2020 is estimated to be 771 tonnes. SC recommends reducing catches from the 2020 level to the DCAC estimated catch (398 tonnes) by 2023, a decrease of 124 tonnes per year over the next three years. This results in catches of 647 tonnes in 2021 and 522 tonnes in 2022

Sources of information

SCR Doc. 20/ 003, 006, 020, 038, 043; SCS Doc. 20/012.

Greenland halibut in Subarea 1 Division 1EF inshore

Advice June 2020 for 2021 – 2022

Recommendation for 2021 and 2022

The Scientific Council recommends a reduction of catches in this area to reach 222 tonnes, corresponding to the Depletion Corrected Average Catch (DCAC), over a period of three years (2021-2023).

Management objectives

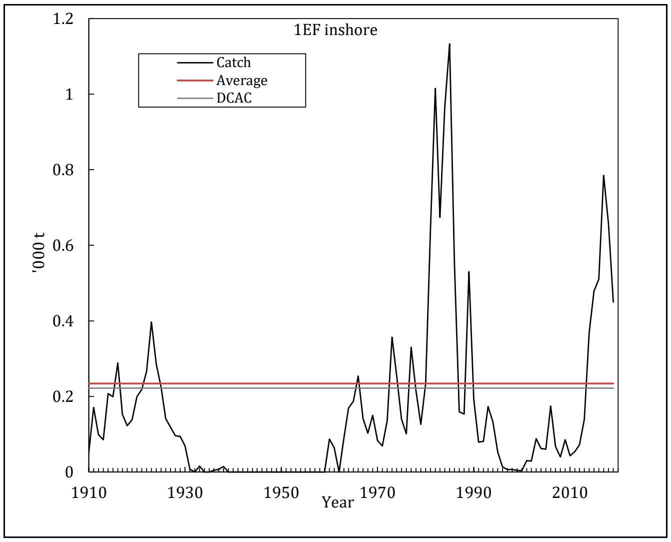
No explicit management plan or management objectives have been defined by the Government of Greenland.

Management unit

The stocks in the fjords in Division 1EF are believed to recruit from the offshore spawning stock in ICES Subarea 14 (Denmark Strait). There is little migration of adults between the fjords and offshore stocks in SA 0 and 1. The stock is furthermore believed to be constituted of several isolated fjord stocks with little migration between the fjords. Fjords are assigned to a NAFO division based on the location of the mouth of each fjord. Combined catch advice is given for all fjords within the specified management unit.

Stock status

The catch was at a low level for two decades from the end of the 1980's. Since 2014 the catches have been about 2-3 times higher than the DCAC estimated sustainable level of catch.



Reference points

The Depletion Corrected Average Catch method was used to estimate a sustainable level of catch.

Projections

Quantitative assessment of risk at various catch options is not possible at this time.

Assessment

The assessment is considered data limited and as such associated with a relatively high uncertainty. The assessment is based upon a catch history from 1910-1930 and 1960 to 2019. During this period the stock has gone through 3 periods of fishery and 2 periods of low catches. There are currently no survey data and commercial data is limited.

The next full assessment is planned for 2022.

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

Biological and environmental interactions
No specific studies were reviewed during this assessment.

Fishery

A fishery for Greenland halibut took place from 1910-1931 in Division 1F and from 1919 to 1939 in Division 1E. No data are available from 1940 to 1960. From 1960 catches gradually increased and were around 1,000 tonnes per year from 1982 to 1985. From 1990 and the following two decades the average catches were just around 60 t per year, but since 2014 annual catches have been at 400-800 tonnes per year. A TAC has not previously been set for the stocks in Divisions 1B to 1F inshore. The fishery has never been quota regulated.

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

	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
TAC										
STACFIS	54	72	139	368	479	510	785	657	450	

Effects of the fishery on the ecosystem

Greenland halibut in the area is targeted with longlines only in deep water and on muddy bottom. The gear is light, with low risk of bycatch of birds and marine mammals and with low impact on the seabed. Bycatch of Greenland sharks can be a concern in the area.

Special comments

Until 2020 this stock was considered to be part of the stock in SA 0 + 1 offshore

ICES DLS Guidance report 2012 p. 19-21 suggest a method to provide advice from the sustainable level catch estimated by the DCAC model. The method uses two scenarios and an adaptation period of 3-5 years following a ”fast down” – ”slow up” (catches should decrease to the DCAC value quickly if they are above it and could increase slowly towards it if below) approach taking into account that stocks with a low biomass cannot sustain MSY.

Available data until June 1st indicated a 50% reduction in catch in 2020 compared to 2019. Assuming the same degree of catch reduction through the year, the full year catch for 2020 is assumed to be 218 tonnes. This is very close to the estimated DCAC value (222 tonnes). If the observed catch in 2020 was substantially higher than this value, then a stepped reduction in catch should be implemented so as to reach 222 tonnes by 2023. Catch in Division 1E is currently far below the most recent 4 seasons, whereas Division 1F is similar to the low 2019 season.

Sources of information

SCR Doc. 20/006, 020, 038, 043; SCS Doc. 20/012.

Request by Canada and Denmark (Greenland) for Advice on Management in 2020 *(Annex 2, Item 3; Annex 3, Item 1)*

Scientific Council responded:

Greenland halibut in Subarea 0+1 (offshore)

Advice June 2020 for 2021 – 2022

Recommendation for 2021 and 2022

Scientific Council advises that there is a low risk of Greenland halibut in Subarea 0 + 1 being below B_{lim} if the TAC for 2021 and 2022 remains at 36 370 tonnes.

This year, for the first time, this catch advice is exclusive of catches taken in the inshore areas of Divisions 1B-F, for which separate advice is provided.

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

Management objectives

Canada and Greenland adopted a total allowable catch (TAC) of 36 370 t for 2019 and 2020. Canada requests that 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.

Convention objectives	***Status***	***Comment/consideration***
Apply Precautionary Approach	🟢	Stock well above B_{lim}
Minimise harmful impacts on living marine resources and ecosystems	🟡	Fishing closures are in effect in SA0 and Div. 1A. No specific measures.

🟢 OK

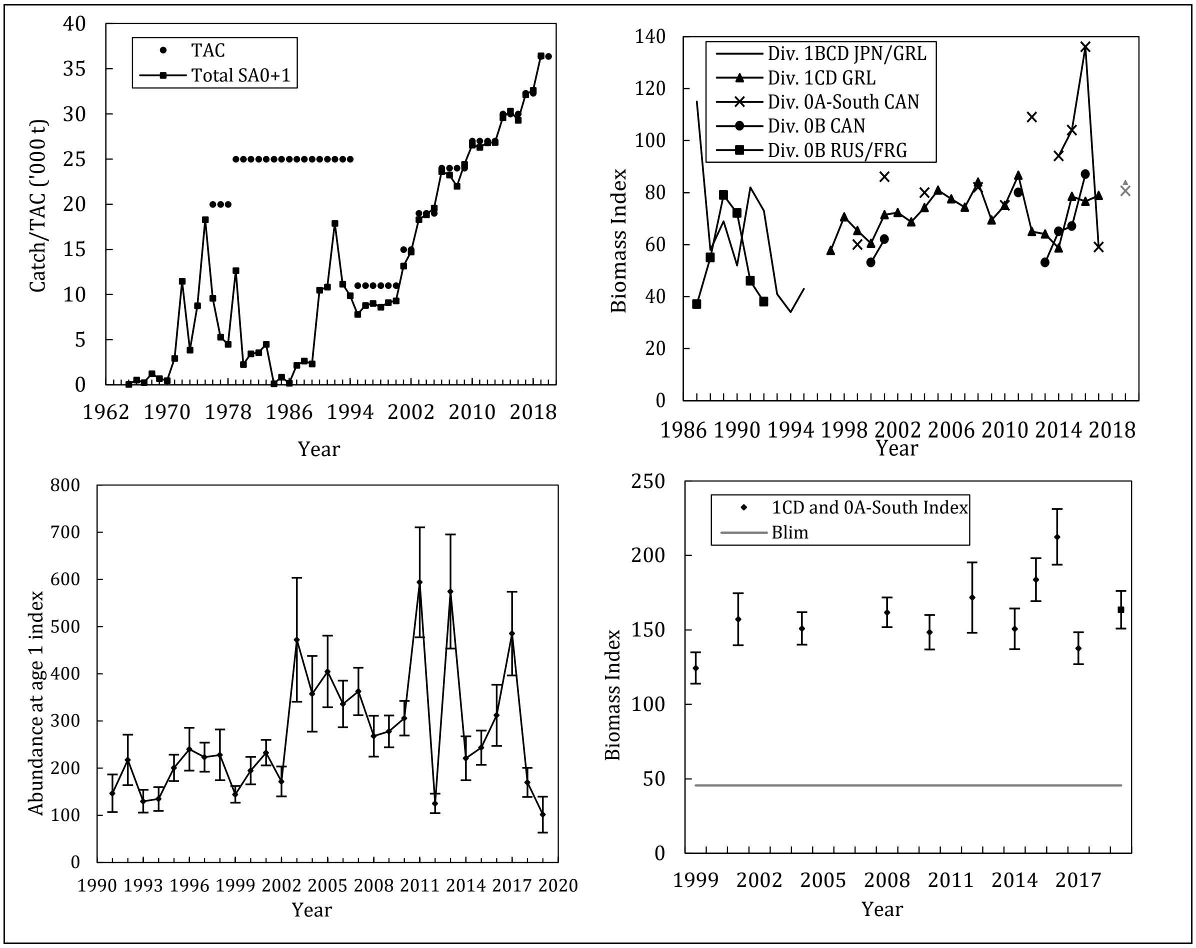
🟡 Intermediate

Management unit

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

Stock status

The combined 1CD and 0A-South biomass index has been above B_{lim} throughout the time series, 1999 to 2017. The combined biomass index is not available for 2018, and the 2019 value is not used to assess stock status because its comparability with the earlier time series is questionable. The index of age 1 in the last two years is considerably lower than in previous years, however, there have been high abundances in 2011, 2013 and 2017. It is unclear if the age 1 abundance index is representative of future recruitment but it is considered to contribute to the perception of overall stock status.



Reference points

Age-based or production models were not available for estimation of precautionary reference points. In 2014 a preliminary proxy for B_{lim} was set as 30% of the mean for the combined 0A-South + 1CD survey biomass index for years 1999 to 2012.

Assessment

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

The next assessment is expected to be in 2022.

Human impact

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

Biology and Environmental interactions

No specific studies were reviewed during this assessment

Fishery

Catches were first reported in 1964. Catches increased from 1989 to 1992 due to a new trawl fishery in Div. 0B with participation by Canada, Norway, Russia and Faeroe Islands and an expansion of the Div. 1CD fishery with participation by Japan, Norway and Faeroe Islands. Catch declined from 1992 to 1995 primarily due to a reduction of effort by non-Canadian fleets in Div. 0B. Since 1995 catches have been near the TAC and increasing in step with increases in the TAC, with catches reaching a high of 36 446 tonnes in 2019.

Recent catch and TACs ('000 tonnes)

	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
TAC	27	27	27	30	30	30	32.3	32.3	36.4	36.4
SA 0	13.2	13.3	13.4	14.9	15.4	14.1	15.9	16.4	18.4	
SA 1	13.1	13.5	13.5	14.7	14.9	15.2	16.2	16.2	18.0	
Total STACFIS[1]	26.3	26.8	26.9	29.6	30.3	29.3	32.1	32.6	36.4	

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

Effects of the fishery on the ecosystem

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

Basis for Advice

A quantitative assessment of risk at various catch options is not possible for this stock; therefore, it is not possible to quantitatively evaluate the sustainability of the TAC. There was no biomass index available for 2018 and there is uncertainty in the comparability of the 2019 estimate, therefore, the ICES Harvest Control Rule 3.2 for data limited stocks was not applied. TAC advice in 2020 is based on a qualitative review of available data.

Special comments

The research vessel that had been used to conduct 0A-South and 1CD surveys from 1997 to 2017 was retired and there was no survey in 2018. A survey was conducted in 2019 with a commercial vessel, however, data reviewed suggest the change in vessel had an effect on the catchability at depths > 700 m, where Greenland halibut are known to be abundant. In addition the earlier timing of the 0A-South survey in 2019 likely resulted in an unknown portion of the stock being beyond the survey area. As a result the comparability between 2019 and previous surveys is questionable and the results were not recommended for use in the 2020 assessment.

Although the survey used to provide the age 1 abundance index also experienced vessel changes in 2018 and 2019, the results are considered to be comparable with those from earlier years.

Sources of information

SCR 20/06, 07, 12, 15, 18, 19, 32, 34, 37; SCS Doc. 20/10, 12, 13)

2020 Canadian Request:

Canada again encourages the Scientific Council to continue exploring opportunities to develop risk-based advice, including the implications of catch differing from the TAC (e.g. +/- 5-15%) on the stock's long-term trajectory.

Response: A quantitative assessment of risk at various catch options is not possible for this data limited stock that is assessed using a qualitative assessment of biomass and abundance indices. Whereas differences of up to 5% are unlikely to pose a risk to the stock at this time, systematic exceedances of the TAC may not be sustainable in the medium to long term.

2020 Denmark (Greenland) Request for advice:

The Scientific Council is requested to consider the possibility for providing a separate advice for 1 B-1 F inshore.

Response: Scientific Council reviewed data on Greenland halibut tagging research, parasitology and historical catches by month for fjord areas within Divisions 1B-F. Offshore movement appears to be limited and linked primarily to areas in the Denmark Strait. In addition, these inshore fjord fisheries have undergone cycles in catch levels on the scale of 1 to 2 decades, suggesting local depletion of offshore recruitment in sink, or primarily sink stocks. Scientific Council concluded that advice could be provided for these inshore stock components, separate from the larger Subarea 0 and 1 offshore stock component. Advice for divisions 1B-1F inshore is given in section VII.2.a.

3. Scientific Council Advice of its own accord

a) Witch flounder in Divisions 3NO

Recommendation for 2021 and 2022

There is more than a 10% probability of the stock being below B_{lim} in 2021 (11%). For 2022 and 2023 this probability ranges from 7% to 11% for scenarios with fishing mortality greater than zero. 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 considers that there is not sufficient evidence that the stock would be able to sustain a fishery at this time and recommends that there be no directed fishing in 2021 and 2022.

Management objectives

The Commission adopted a total allowable catch (TAC) of 1 175 tonnes for 2020 and 2021. Convention General Principles are applied.

Convention General Principles	*Status*	*Comment/consideration*
Restore to or maintain at B_{msy}	🔴	Probability of $B_{2020} < B_{msy}$ = 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

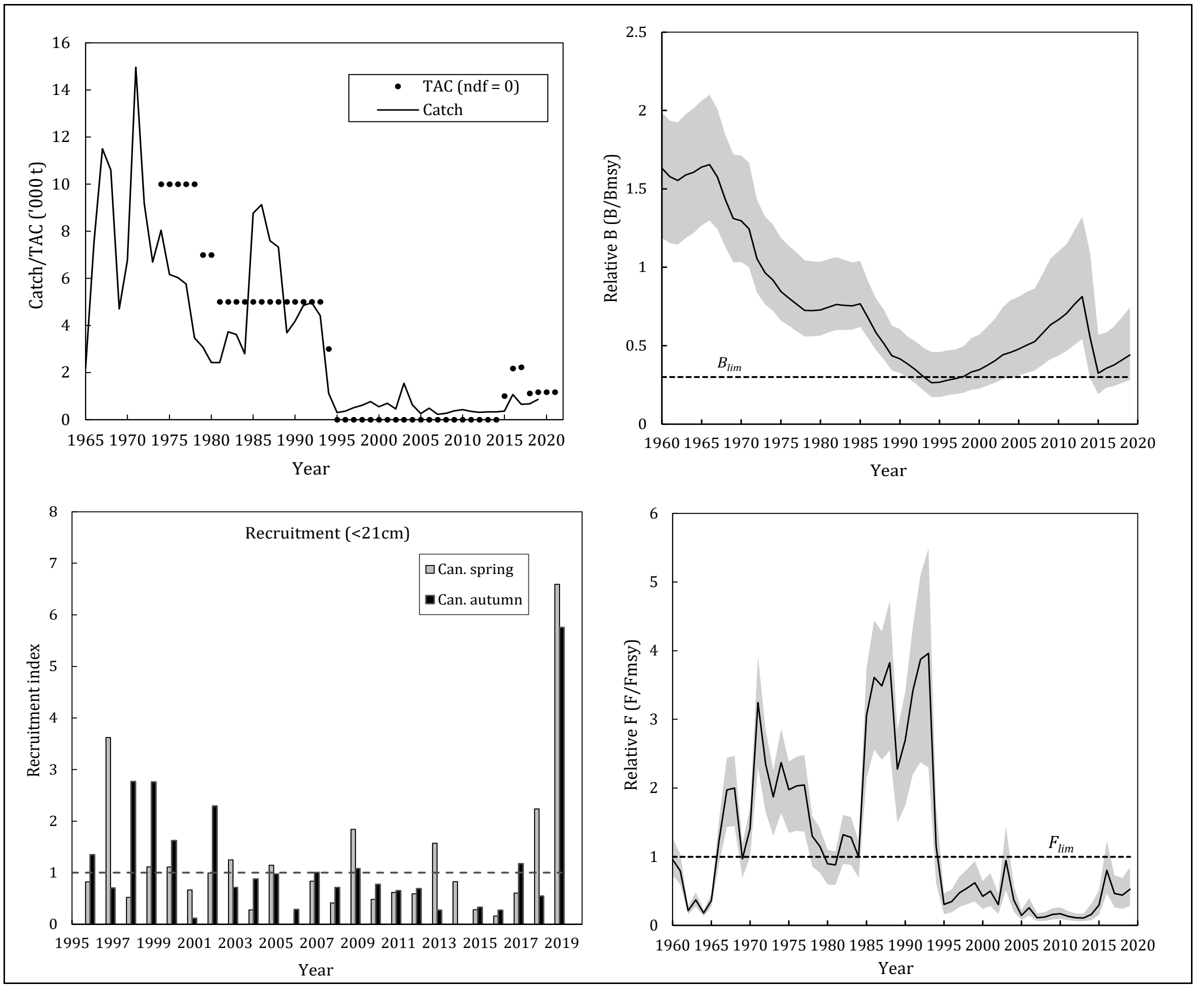
🟢	OK
🟡	Intermediate
🔴	Not accomplished
⚪	Unknown

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



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

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

Projected yield (tonnes) and the risk of $F > F_{lim}$, $B<B_{lim}$ and $B<B_{msy}$ and probability of stock growth ($B_{2023}>B_{2020}$) under projected F values of F=0, F_{2019}, 2/3 F_{msy}, 85% F_{msy}, and F_{msy}, and two levels of catch (800 tonnes and 1 175 tonnes), for the two sets of projections, are presented in the following tables.

Projections with catch in 2020 = TAC (1 175 t)		
Year	Yield (t) median	Projected relative Biomass(B/B_{msy}) median (80% CL)
F0		
2021	0	0.49 (0.30, 0.89)
2022	0	0.53 (0.32, 0.97)
2023		0.58 (0.35, 1.06)
Catch 800 t		
2021	800	0.49 (0.30, 0.90)
2022	800	0.52 (0.31, 0.97)
2023		0.54 (0.31, 1.03)
F_{2019} = 0.033		
2021	957	0.49 (0.30, 0.89)
2022	1011	0.52 (0.31, 0.96)
2023		0.55 (0.32, 1.03)
Catch 1 175t		
2021	1175	0.49 (0.30, 0.90)
2022	1175	0.52 (0.31, 0.97)
2023		0.54 (0.31, 1.03)
2/3 F_{msy} = 0.042		
2021	1212	0.49 (0.29, 0.89)
2022	1281	0.51 (0.30, 0.96)
2023		0.54 (0.31, 1.02)
85% F_{msy} =0.054		
2021	1554	0.49 (0.30, 0.89)
2022	1615	0.51 (0.30, 0.95)
2023		0.53 (0.30, 1.01)
F_{msy} =0.063		
2021	1823	0.49 (0.30, 0.88)
2022	1879	0.50 (0.29, 0.94)
2023		0.52 (0.29, 0.99)

Projections with catch in 2020 and 2021 = TAC (1 175t)		
Year	Yield (t) median	Projected relative Biomass(B/B_{msy}) median (80% CL)
F0		
2021	1175	0.49 (0.30, 0.89)
2022	0	0.52 (0.31, 0.96)
2023		0.56 (0.33, 1.05)
Catch 800 t		
2021	1175	0.49 (0.30, 0.89)
2022	800	0.52 (0.31, 0.96)
2023		0.56 (0.33, 1.04)
F_{2019} = 0.033		
2021	1175	0.49 (0.30, 0.89)
2022	1006	0.52 (0.31, 0.96)
2023		0.55 (0.32, 1.03)
Catch 1 175t		
2021	1175	0.49 (0.30, 0.90)
2022	1175	0.52 (0.31, 0.97)
2023		0.54 (0.31, 1.03)
2/3 F_{msy} = 0.042		
2021	1175	0.49 (0.30, 0.89)
2022	1285	0.52 (0.31, 0.96)
2023		0.54 (0.31, 1.02)
85% F_{msy} =0.054		
2021	1175	0.49 (0.30, 0.89)
2022	1638	0.52 (0.31, 0.96)
2023		0.54 (0.31, 1.01)
F_{msy} =0.063		
2021	1175	0.49 (0.30, 0.89)
2022	1928	0.52 (0.31, 0.96)
2023		0.53 (0.30, 1.01)

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

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

Assessment

This stock is assessed utilizing a surplus production model in a Bayesian framework. Full assessments were conducted in 2017, 2018 and 2019. Due to workload issues and the schedule of stocks assessed on a multi-year basis, which would create considerable difficulties for assessing the stock in 2021, a full assessment was conducted in 2020 by SC of its own accord.

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

The next assessment is planned for 2022.

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 ('000 tonnes) are:

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

ndf = no directed fishery.

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

Sources of Information

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

VIII. REVIEW OF FUTURE MEETINGS ARRANGEMENTS

1. Scientific Council (in conjunction with NIPAG) September 2020 (date to be determined)

Scientific Council (in conjunction with NIPAG) will meet by WebEx in September, before the Annual Meeting, to update the assessment of 3M shrimp and provide advice for 2021. The meeting will last 1 day and will likely take place on either September 11 or September 14, subject to confirmation. For 3LNO shrimp, SC provided advice in 2019 for both 2020 and 2021 (SCS Doc. 19/21).

2. Scientific Council, September 2020

Regular September meeting:

The Scientific Council September 2020 meeting is scheduled to be held in Halifax, Nova Scotia, Canada, from 21 to 25 September 2020. Due to the ongoing COVID-19 pandemic, it is possible that this meeting may be held by correspondence.

Extra September meeting (by correspondence):

SC plans to hold an additional meeting, by correspondence, during September 15-17, aiming to address some of the requests deferred from the June meeting. However, SC noted that changes might still occur, e.g. depending on potential feedback that might be received from the Commission

Details of the SC plan of work for September are described in Section XI.

3. Scientific Council (in conjunction with NIPAG), 27 October to 2 November 2020

The Scientific Council shrimp advice meeting will be held from 27 October to 2 November 2020, venue to be determined.

4. WG-ESA, 19- 28 November, 2020

The Working Group on Ecosystem Science and Assessment (WG-ESA) will meet at the NAFO Secretariat, Nova Scotia, Canada, from 17 to 26 November 2020.

5. Scientific Council, June 2021

Scientific Council June 2020 meeting will be held in Halifax. Nova Scotia, Canada from 28 May to 10 June 2021,

6. Scientific Council (in conjunction with NIPAG), 2021

Dates and location to be determined.

7. Scientific Council, September 2021

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. NAFO/ICES Joint Groups

a) NIPAG, 27 October to 2 November 2020

The joint NAFO/ICES *Pandalus* Assessment Group meeting will be held will be held from 27 October to 2 November 2020, venue to be determined.

NIPAG, 2021

Dates and location to be determined.

ICES – NAFO Working Group on Deep-water Ecosystem, 2021

Dates and location to be determined.

WG-HARP

The date and location of the next ICES/NAFO/NAMMCO Working Group on Harp and Hooded Seals (WGHARP) meeting are unknown.

9. Commission- Scientific Council Joint Working Groups

a) WG-RBMS August 2020

The joint SC-Commission Working Group on Risk Based Management Systems (WG-RBMS) will be held by correspondence on 20-21 August 2020.

WG-EAFFM August 2020

The joint SC-Commission Working Group on the Ecosystem approach to Fisheries Management (WG-EAFFM) will be held by correspondence on 17-19 August 2020.

SC noted that, following the withdrawal of the UK from the European Union, Andy Kenny is not presently able to serve as co-Chair for this group, given that the UK is not a Contracting Party of NAFO at this point. As an interim measure, it was agreed that the SC Chair will act as WG-EAFFM co-Chair for this meeting only.

CESAG

The next meeting of the Catch Estimation Strategy Advisory Group (CESAG) will be in February 2021 via WebEx.

IX. ARRANGEMENTS FOR SPECIAL SESSIONS

1. Topics of Future Special Sessions

The following proposal for a symposium in 2021, was presented to SC by the STACFEN Chair. The idea would be to offer sponsorship as well as participation in the organization of the event, if possible and if this was agreeable to ICES. SC expressed support for this proposal and endorsed the recommendation made by STACFEN in this regard (see Section III of this report).

Proposal:

Subject

Budget availability to co-sponsor a symposium on STACFEN-oceanography at 2021

Background

STACFEN has organized or co-organized a symposium every 10 years, focused on the significant environmental changes on a decade scale. The link https://www.nafo.int/Science/Research/Conferences allows viewing the history of NAFO symposia. In 2002 a symposium regarding decadal oceanographic conditions in the NAFO Convention Area was organized: https://www.nafo.int/Science/Conferences/mini-symposium-on-hydrographic-variability-in-nafo-waters-june-2002 whereas in 2011 the following symposium was organized jointly with ICES http://www.ieo-santander.net/ices-symposium2011/conference_abstracts.php

Following the same time scale, another symposium should occur in 2021. ICES is again organizing a Symposium with focus on Decadal Hydro-Biological Variability of the North Atlantic for the decade 2010-2019, to be held in Bergen-Norway in October 2021. This brings the possibility of mirroring the joint NAFO/ICES structure of 2011.

Symposium description

The ICES Symposium will be the 4th one of an ICES series and will contribute to the recently promoted United Nations Decade of Ocean Science for Sustainable Development (2021-2030). It will summarize the status at the beginning of the decade and looking forward into the coming decade. In general, the main challenge will be to summarize and explain the hydro-biological variability observed during the decade of 2010-2019 in relation to longer time variability or change, and to quantify the interactions between the variability and change in the ocean environment with variability in plankton, fish, mammals and seabirds in the North Atlantic marine ecosystems. The symposium will be organized in three thematic sessions: Development of ocean climate; Impacts of climate variability on marine ecosystems; and The coming decade.

Benefits for the NAFO community

The joint organization brings added value for the knowledge of decadal oceanographic variations in the NAFO area integrated into the North Atlantic region. One of the direct advantages is to promote evaluation of the oceanographic changes in the wider spatial context of the North Atlantic. The participation of NAFO researchers in the organizing committee will promote a wider interplay between different scientific approaches relevant to NAFO-STACFEN. Furthermore, contributions from participants may generate new insights and discussion within STACFEN regarding the integration of environmental information into the stock assessment process. The co-sponsorship may allow a discount on the registration fees for some NAFO participants.

If the SC considers that a presentation of work bringing up-to-date climate information in the main NAFO stock areas to the Commission at their annual September meeting in 2021 would be relevant, then the work developed for the above-cited symposium would form the basis of that presentation.

Amount requested

Ten thousand (10 000) Canadian dollars is the approximate value to co-sponsor a symposium.

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 19-28 November 2019 in Dartmouth, Nova Scotia was presented by its co-Chairs Pierre Pepin (Canada) and Andrew Kenny (formerly EU).

2. ICES/NAFO/NAMMCO Working Group on Harp and Hooded Seals (WGHARP)

The report of the 2019 meeting is available and main findings will be presented to SC in September.

XI. REVIEW OF SCIENTIFIC COUNCIL WORKING PROCEDURES/PROTOCOL

a) General plan of work for September:

A brief discussion took place at the end of the June SC meeting, in which SC concluded that it would be appropriate to schedule an extra 3-day meeting in September, by correspondence, in the week immediately prior to the NAFO Commission Annual Meeting. The extra meeting would aim to provide responses to some of the requests that could not be addressed in June.

The table below contains the plan of work agreed by SC, albeit noting that changes might still occur, e.g. depending on potential feedback that might be received from the Commission.

Points of note:

- "September (extra)" means extra SC meeting, to be held by correspondence on September 15-17; results would be available for presentation to the Commission at the Annual Meeting.
- "September (regular)" means regular SC September meeting (September 21-25); results would not be available for presentation to the Commission at the Annual Meeting.
- The work marked as "September (extra)" should be conducted intersessionally and presented in the September (extra) meeting. To make efficient use of this extra but short meeting (lasting only 3 days), SC agreed that the work should be presented in very advanced form, including, whenever possible, already a first draft of the SC response. SC identified teams of scientists to lead the work on each of these requests, but also agreed that no substantial additional amount of work would be expected from anyone between June and September. Therefore, the requests in the table will be addressed based on the material currently available plus, potentially, a small amount of additional development that the scientists involved may be able to undertake before September.
- This plan will be communicated in a letter to the Commission, for their information and potential feedback.

REQUEST NUMBER	SC RESPONSE SCHEDULED FOR:	NOTES:
4 (Discard survival)	September (extra)	A draft SC response has already been prepared. It is available on SharePoint (Working Folders ➔ 4_COMReq). No further work required for September.
18 (Sea mammals, turtles, birds)	September (extra)	A simple response will be prepared, similar to WGESA's approach (2019 report) for sea mammals and turtles
13 (Alfonsino survey)	September (extra)	SCR 20-036 and presentation are already available on SharePoint. The SC response needs to be prepared.
14 (assessments cod and witch 2J3KL & Pelagic S. mentella ICES)	September (extra)	Some background materials are available on SharePoint (Working Folders ➔ 14_COMReq). Background materials must be completed. Reasonably in-depth presentations of the assessments and advice should be provided for SC's consideration and a summary response prepared by SC.
9 (Areas and times with high bycatch and discards of Greenland shark)	September (extra)	SC will aim to conduct some analyses based on recently digitised records and a response needs to be prepared.
10 (3-5 yr workplan)	September (extra & regular)	Needs updating with main items identified for next 3 years
16 (Updates from research on activities other than fishing)	September (extra)	Work has been conducted by WGESA (2019 report). The SC response needs to be prepared.
3 (Excluding scientific trawl surveys from VME closed areas)	September (extra) or June 2021 ?? (flexible)	Work from SC and WGESA is available from earlier years. The work needs to be finalised (in September 2020 or June 2021)
Items on which SC has to work in September (regular):		
PAF review	Further elaboration of work plan for the next 1-2 years	
Other outstanding matters from June:		
STACREC report	To be reviewed and adopted in September (regular).	
STACPUB report	To be reviewed and adopted in September (regular).	

XII. OTHER MATTERS

1. A tribute to Vladimir Babayan (10.03.1945 – 10.06.2020)

Scientific Council was informed of the passing of Russian colleague, Vladimir Konstantinovich Babayan a Russian eminent scientist in fisheries science, age 75, on June 10, 2020 in Moscow.

Vladimir was born on March 10, 1945 in Krasnodar, Russia. He graduated from the Moscow State Institute of Electronic Engineering (MIEM) in 1969. In 2002 he defended his thesis: «Methodology improving for total allowable catch (TAC) estimating using the example of Okhotomorkiy pollock».

Vladimir began to work at Russian Federal Research Institute of Fisheries and Oceanography (VNIRO) in 1970. Over 50 years of professional activity Vladimir devoted to improving the methodological and mathematical support for the stock assessment and sustainable use of aquatic living resources. He made a great personal contribution to the development and implementation of a modern sustainable fisheries methodology in Russian fisheries management system.

On the account of V. Babayan more than 80 scientific works of both conceptual and important practical importance, large number of copyright certificates and packages used in the calculation of TAC. His monograph «A Precautionary approach to assessment of total allowable catch» (2000) is a fundamental work in the stock assessment field and made a huge contribution to Russian fisheries science.

The high level of professional competence, excellent knowledge of English and diplomacy allowed to Vladimir to take part at working groups and scientific committees meetings of ICSEAF, ICES, NAFO and the International Commission on Aquatic Bioresources of the Caspian Sea. Many years he was the head of Russian delegation in NAFO Scientific Council meeting. Thanks to extensive knowledge and experience, Vladimir for many years led the Russian Annual Workshop of stock assessment methodology.

Vladimir Babayan was not only an outstanding scientist and leader, but an irreplaceable mentor and friend who could give a valuable advice in any situation. His untimely death is an incalculable loss for relatives and friends, scientists, colleagues and pupil over the world. The bright memory of Vladimir, as a wise, extremely honest and non-indifferent person and a real professional in science, will keep in our hearts forever.

2. Budget Items

SC budget will be reviewed intersessionally by the SC Chair and Secretariat for inclusion in the Secretariat's budget paper for the Annual meeting in September 2020. An indicative budget required to co-sponsor a symposium on STACFEN-oceanography in 2021 has been noted in Section IX of this report.

3. 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	Dawn Maddock Parsons	dawn.parsons@dfo-mpo.gc.ca
Yellowtail flounder in Div. 3LNO	Dawn Maddock Parsons	dawn.parsons@dfo-mpo.gc.ca
Greenland halibut in SA 2+3KLMNO	Paul Regular	paul.regular@dfo-mpo.gc.ca
Northern shrimp in Div. 3LNO	Katherine Skanes	katherine.skanes@dfo-mpo.gc.ca
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	margaret.treble@dfo-mpo.gc.ca

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

Roughhead grenadier in SA 2+3	Fernando Gonzalez-Costas	fernando.gonzalez@ieo.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 inshore	Rasmus Nygaard	rany@natur.gl
Greenland halibut in Div. 1BC inshore	Rasmus Nygaard	rany@natur.gl
Greenland halibut in Div. 1D inshore	Rasmus Nygaard	rany@natur.gl
Greenland halibut in Div. 1EF inshore	Rasmus Nygaard	rany@natur.gl
Northern shrimp in SA 0+1	AnnDorte Burmeister	anndorte@natur.gl
Northern shrimp in Denmark Strait	Frank Rigét	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

XIII. ADOPTION OF COMMITTEE REPORTS

The limitations of meeting by correspondence implied that the reports of the Standing Committee on Fisheries Environment (STACFEN) and the Standing Committee on Fisheries Science (STACFIS) could only be formally adopted by correspondence, later in the month of June (STACFEN report) or July (STACFIS report). The adopted reports are included as Appendices I and IV, respectively.

The reports of the Standing Committee on Research Coordination (STACREC) and the Standing Committee on Publications (STACPUB) were deferred until September.

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 12 June 2020, the Council considered the draft report of this meeting, and adopted the report. The usual understanding that the report remains in draft form for about 2 weeks, and that during this period the Chair and the Secretariat may incorporate minor edits (after proof-reading) on the usual strict understanding there should be no substantive changes, is applied.

XVI. ADJOURNMENT

The Chair thanked the participants for their hard work and cooperation, noting the particularly difficult circumstances of this year's meeting. The Chair thanked the Secretariat for their valuable support. There being no other business the meeting was adjourned at 14:00 on 12 June 2020.

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

Chair: Miguel Caetano

Due to ongoing restriction relating to the COVID-19 pandemic, the Committee met on 28th May 2020 by correspondence and videoconference to consider environment-related topics and report to it by the Scientific Council. Representatives attended from Canada, Denmark (in respect of Faroe Islands and Greenland), European Union (Estonia, Portugal, Spain), Japan, Russian Federation, Ukraine and US.

1. Opening

The Chair opened the meeting by welcoming participants to this June 2020 Meeting of STACFEN.

The Committee noted the following documents would be reviewed: SCR Doc. 20/017, 20/018, 20/019, 20/020, 20/024, 20/035, 20/037.

2. Appointment of Rapporteur

Due to the meeting characteristics it was established that no rapporteur was appointed.

3. Adoption of the Agenda

Due to the meeting characteristics it was established by SC a general agenda.

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: STACFEN was unable to secure a guest speaker for the June 2020 meeting due to ongoing restriction relating to the COVID-19 pandemic. This recommendation is **reiterated** and STACFEN will endeavor to have an invited speaker next year.

Contributions from past speakers have generated new insights and discussion within the committee regarding the integration of environmental information into the stock assessment process.

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

5. Oceanography and Science Data (OSD) Report for 2019 SCR 20/024

The Marine Environmental Data Section (MEDS) of the Oceans Science Branch of Fisheries and Oceans Canada serves as the Regional Environmental Data Center for NAFO. As part of this role, MEDS provides an annual inventory of environmental data collected in the NAFO Convention Area to the NAFO subcommittee for the environment (STACFEN), including inventories and maps of physical oceanographic observations such as ocean profiles, near-surface thermosalinographs, drifting buoys, currents, waves, tides and water level measurements for the previous calendar year. Reporting includes data and information from NAFO member countries where these are provided to the data center. The data of highest priority are those from the standard sections and stations, as described in NAFO SCR DOC., No. 1, Serial N 1432, 9p. Data 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 2019

Data Type	**Platform Type**	**Counts/Duration**
Oceanographic profiles	Autonomous drifting (Argo)	4348* profiles from 184 platforms
	Moorings (Viking)	1151* profiles from 6 platforms**
	Gliders	3038* profiles from 11 platforms
	Ship	3226 profiles (826 CTD; 1830 CTD*; and 570 XBT* profiles) from at least 21 ships
Surface/near-surface observations	Ship (thermosalinograph)	12904* obs. from 1 ship
	Drifting buoys	307473* obs. from 184 buoys
	Moored buoys	242445* obs. from 20 buoys**
	Fixed platforms	60312* obs. from 3 platforms
	Water level gauges	12 sites, avg. ~1 year each

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

Data observed prior to 2018 in NAFO Convention Area and acquired between January 2019 and May 2020

Data Type	**Platform Type**	**Counts/Duration**
Oceanographic profiles	Ship	8996 profiles (3869 CTD + 1258 bottle + 175 XBT profiles) from 17 ships

*Data formatted for real-time transmission

6. Highlights of Climate and Environmental Conditions by NAFO Sub-Area for 2019

Summary information on recent ocean climate conditions and lower tropic levels was compiled for Sub-area 0+1, Division 3M, Divisions 3LNO and Sub-areas 2, 3 and 4. This information, together with relevant ocean climate and ecosystem indicators is presented in the respective sections of the STACFIS report (Appendix IV).

7. Review of the physical, biological and chemical environment in the NAFO Convention Area during 2019

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 Newfoundland 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 water mass overlying much of the Newfoundland and Labrador continental Shelf.

a) Sub-area 1. Report on hydrographic conditions off Southwest Greenland June 2019 (SCR Doc. 20/019).

Hydrographic conditions were monitored at 8 hydrographic standard sections in June 2019 across the continental shelf off West Greenland. The northernmost section was 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.

Sub-area 1. Hydrographic conditions off West Greenland in 2019 (SCR Doc. 20/018).

An overview of the atmospheric and hydrographic conditions off West Greenland in autumn 2019 is presented. In winter 2018/2019, the NAO index was positive (2.09) for the sixth consecutive winter. The annual mean air temperature at Nuuk Weather Station in West Greenland was 0.4°C in 2019, which was 1.8°C above the long-term mean (1981-2010). The core properties of the water masses of the West Greenland Current are monitored at two standard NAFO/ICES sections across the western shelf and continental slope of Greenland near Cape Desolation and Fyllas Bank. However, the Fyllas Bank Section had to be abandoned due to severe weather conditions in autumn 2019. The properties of the Irminger Sea Water are monitored in the 75-200 m layer at Cape Desolation Station 3. In 2019, the water temperature and the salinity in the 75-200 m layer at this station were 5.98°C and 34.92, which was 0.26°C above and 0.01 below the long-term mean, respectively. The properties of the North Atlantic Deep Water (NADW) in the Deep Boundary Current west of Greenland are monitored at 2000 m depth at Cape Desolation Station 3. In 2019, the temperature and salinity of the NADW were 3.11°C and 34.92 and were 0.22°C and 0.01 above the long-term mean, respectively.

Sub-areas 1 and 2. Meteorological, Sea Ice, and Physical Oceanographic Conditions in the Labrador Sea during 2019 (SCR Doc. 20/037)

The winter (December-March) NAO index in 2019 was above-normal. However, a low atmospheric pressure anomaly in the Labrador Sea in winter resulted in above-normal air temperatures, while sea surface temperatures were near-normal in winter and above-normal in spring. Sea ice extent anomalies in winter and spring were generally negative, except for a near-normal winter anomaly on the central Labrador Shelf. In the Labrador Sea, intense vertical mixing induced by high surface heat losses in winter results in the formation of a characteristic dense water mass, Labrador Sea Water, which consequently spreads across the ocean ventilating its deep layers and essentially driving the global ocean overturning circulation. The most remarkable event in the entire history of oceanographic observations in the North Atlantic was the production of a record cold dense deep gas-saturated voluminous class of Labrador Sea Water between the late 1980s and mid-1990s. Over about 20 years that followed this well-documented water mass development, the sea was gradually warming gaining more saline and less dense waters. In the winter of 2015, the Labrador Sea incurred the highest heat loss in more than two decades. However, the four following winters showed a significant reduction in the respective net surface heat losses, remaining above-normal in 2016 and 2017, and then declining to near-normal in 2018 and 2019. Despite the persistent decline in the surface cooling since 2015, the water column preconditioned by deep convection in the previous winters eased further deepening of convective mixing in the subsequent winters. As a result, in the period from 2014 to 2018, winter convection progressively deepened from 1600 to 2000 m, respectively, becoming the deepest since the winter of 1994 which in turn was the deepest (2500 m) convection on the 80-year record. In turn, the Labrador Sea Water formed by the convective mixing that deepened in each of the five winters preceding 2019 was the largest since the mid-1990s. If in the winter of 2018, convection continued to deepen despite a near-normal surface heat loss in the same winter, in the winter that followed, a comparable heat loss brought much weaker convection, reversing the multiyear trend in convection depth and implying that the effect of preconditioning of the water column by previous convections declined in the present case. Indeed, the temperature and salinity profiles collected by research vessels and profiling Argo floats in the central Labrador Sea indicate that the 2019 winter convection was shallower than in the previous five years. It reached the depth of about 1400 m in the western part of the Labrador Basin, and only about 1000 m in the central and eastern parts based on the 2019 ship survey section plots and individual Argo float profiles. Composite salinity profiles indicate the depth of winter convection on the order of 1200-1300 m. The near-normal winter convection in the winter of 2019 further added to gas (dissolved oxygen, anthropogenic gases, and carbon dioxide) uptake and consequently respective gas concentrations in the Labrador Sea in the upper 1000 m layer, while the deeper layer shows a decrease. In 2018, the upper, 15-100 m, layer of the central Labrador Sea steadily cooling since 2010 was the coldest since 2000. In the following year, this layer warmed by 0.5°C raising its temperature to above-normal. In 2011, the intermediate, 200-2000 m, layer reached its warmest state since 1972, and then started to cool. The cooling of this intermediate layer that followed was a direct result of persistently deepening convection during the winters from 2012 through 2018. The warming of the upper and intermediate layers of the Labrador Sea in the following year concurs with the reduced heat loss and shallow convection in the winter of 2019. With respect to interdecadal variability, the Labrador Sea completed a cooling cycle, 2012-2018, similar to those observed during 1987-1994 and in the late 1950s. Each of these cooling events coincided with the strengthening of winter convection and production of large volumes of Labrador Sea Water. Bedford Institute of Oceanography North Atlantic model simulations suggests that the transport of the Labrador Current decreased between 1995 and 2014, but has since increased slightly. A weakening trend of the Atlantic Meridional Overturning Circulation (AMOC) since the mid-1990s is obtained in this model hindcast. Continuing weakening of the AMOC in recent years led to the weakest AMOC since 1990.

Sub-areas 2, 3 and 4. Environmental and Physical Oceanographic Conditions on the Eastern Canadian shelves during 2019 (SCR Doc. 20/020).

Oceanographic and meteorological observations in NAFO Sub-areas 2, 3 and 4 during 2019 are presented and referenced to their long-term (1981-2010) averages. The winter North Atlantic Oscillation (NAO) index, a key indicator of the direction and intensity of the winter wind field patterns over the Northwest Atlantic was positive for a 6th consecutive year (since 2012, only 2013 was negative). The air temperatures across the NW Atlantic were warm in the Arctic, between normal and colder than normal on the Newfoundland and Labrador and Scotian Shelf, and warmer than normal in Boston on the coast of the Gulf of Maine. The sea ice volume across the Newfoundland and Labrador shelf was slightly below normal, characterized by a large negative anomaly in March-April, which also led to an early retreat on Newfoundland shelf. Annual sea surface temperature across the NAFO subareas 2, 3 and 4 was below normal overall for the zone for the first time since 1992, yet they would have been near normal if not for tropical storm Dorian that mixed heat deep into the water column. Observations from the summer Atlantic Zone Off-Shelf Monitoring Program oceanographic survey indicate that after a predominance of colder than average conditions since 2012, the volume of the cold intermediate layer (CIL, <0°C) reduced along Bonavista and Flemish Cap section in 2019 (CIL along Seal Island section was normal this year but was reduced in 2018). The spatially averaged bottom temperature in 3LNOP divisions during the spring was close to normal, except along the slopes of the Grand Banks where it was above normal. For the fall, the bottom temperature in 2HJ3KLNO divisions was also above normal, especially in 2J (+1.1 SD) and 3K (+1.0 SD). Deep water temperatures on the Scotian shelf were very warm: record high in Cabot Strait (nearly 5SD above the climatology) and Emerald Basin, and second warmest year in George Basin. The Labrador Current transport index along the Labrador and northern Newfoundland slope in 2019 was back to normal after the 2018 record high since the beginning of the time series that started in 1993.

Sub-areas 2, 3, 4 and 5. Biogeochemical oceanographic conditions in the Northwest Atlantic (NAFO subareas 2-3-4) during 2019 (SCR Doc. 20/035).

Biogeochemical variables collected in 2019 from coastal high-frequency monitoring stations and seasonal (spring, summer and fall) sampling of standard oceanographic sections covering the Newfoundland and Labrador (NL) shelves, the Flemish Cap (FC), the Grand Bank (GB), the Southern Newfoundland, the Scotian Shelf (SS) and the Gulf of St. Lawrence (GSL) are presented and referenced to earlier periods when available. We review interannual variations in phytoplankton spring bloom indices as well as nitrate (50-150 m), chlorophyll a (0-100 m), and zooplankton abundance and biomass inventories collected during the 2019 Atlantic Zone Monitoring Program (AZMP). Spring bloom timing and duration were near normal in all regions except on the Newfoundland Shelf and the GB where earlier and longer-than-normal blooms were observed. Bloom magnitude was below normal in all regions, especially in the GSL where spring production reached a record low after several consecutive years of above-normal production. In general, nitrate inventories increased on the NL shelves and the FC in 2019 compared to the previous year but remained low on the GB and the SS. Chlorophyll inventories were mostly above normal on the NL shelves, the GB, and the GSL, and near to below normal on the SS. The abundance of copepod and non-copepod zooplankton were near to above normal in all regions although no data were available for the Labrador Shelf, the GB, and the Southern Newfoundland for this report. Copepod abundance increased from below to near or above-normal levels on the SS in 2019 compared to 2018. The abundance of large *Calanus finmarchicus* copepods was mainly near normal in 2019 which represented an increase compared to the previous year. The abundance of small *Pseudocalanus spp*. copepods was near to above normal in all regions in 2019, continuing an increasing trend observed since 1999. Zooplankton biomass was near to below normal in most regions. The low biomass on the NL shelves and the GB in 2019 contrasted with above normal-levels observed in 2018. However, biomass indices for these regions were calculated on partial datasets and the general pattern for 2019 may change when all data become available.

Sub-areas 5 and 6. Hydrographic Conditions on the Northeast United States Continental Shelf in 2019 (SCR Doc. 20/017).

An overview is presented of the atmospheric and oceanographic conditions on the Northeast U.S. Continental Shelf during 2019. 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, 2019 was characterized by warmer than average water temperatures observed across the entire Northeast US Shelf, with enhanced warming observed near the bottom. Extreme warm anomalies observed in the northern Middle Atlantic Bight are linked to warm-core Gulf Stream rings and consistent with observations of increased ring formation since 2010. Deep (slope) waters entering the Gulf of Maine continue to be warmer and saltier than average, marking a full decade that southern source waters have dominated the slope water composition in the region. The Cold Intermediate Layer in the western Gulf of Maine consisted of a narrower band of colder water compared with climatology, while the underlying water mass was warmer and fresher than normal.

8. The Formulation of Recommendations Based on Environmental Conditions

STACFEN **recommends** *consideration of Secretariat support for an invited speaker to address emerging issues and concerns for the NAFO Convention Area during the 2021 STACFEN Meetin*g.

Contributions from invited speakers may generated new insights and discussion within the committee regarding integration of environmental information into the stock assessment process.

NAFO usually convenes a symposium on environmental issues every 10 years, and as the last one was held in 2011 as “ICES/NAFO Symposium on the Variability of the North Atlantic and its Marine Ecosystems during 2000-2009". STACFEN suggested that the forthcoming ICES Symposium (2021) could take the place of the next NAFO symposium. STACFEN therefore **recommended** that *Scientific Council to support participation and possible co-sponsorship*.

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

9. National Representatives

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

10. Other Matters

No other subject was discussed.

11. Adjournment

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

The meeting was adjourned at 10:00 on 28 May 2020.

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

The report of STACPUB was deferred to September.

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

The report of STACREC was deferred to September.

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

Chair: Katherine Sosebee Rapporteurs: Various

I. OPENING

The Committee met by correspondence from 28 May to 12 June 2020 to consider and report on matters referred to it by the Scientific Council, particularly those pertaining to the provision of scientific advice on certain fish stocks. Representatives attended from Canada, Denmark (in respect of Faroe Islands and Greenland), the European Union, Japan, the Russian Federation, Ukraine and the United States of America. Observers from the Ecology Action Centre, and Food, Sustainable Fisheries Greenland, and Oceans North were also present. The Executive Secretary, Scientific Council Coordinator and other members of the Secretariat were in attendance.

The Chair, Katherine Sosebee (USA) opened the meeting by welcoming participants. The agenda was reviewed and a plan of work developed for the meeting in accordance with the Scientific Council plan of work. The provisional agenda was adopted with minor changes.

Owing to the limited time available during the meeting, it was not possible to consider drafts of report sections in plenary. Following presentation and discussion of the assessments, Designated Experts produced drafts of their respective report sections offline and uploaded them to the Scientific Council SharePoint. Committee members were given the opportunity to comment before the approval of these report sections. As in previous years, designated reviewers were assigned for each stock for which an interim monitoring update was scheduled (see SC Report).

Dr. Hugues Benoît participated as an external reviewer for the work on Greenland halibut in NAFO Subareas 0 and 1.

II. GENERAL REVIEW

1. Review of Recommendations in 2019

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

2. General Review of Catches and Fishing Activity

The NAFO Secretariat presented the catch estimates developed by CESAG in COM-SC CESAG-WP 20-05 (Rev) 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. Following the recommendation from STACFIS in 2018 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 Secretariat made changes to the method in order to provide catch estimates of broken down by quarter and gear type. It is not possible to provide catch estimates disaggregated by mesh size at present because this information is not included in daily catch reports or port inspections on which the CESAG estimates are based.

In response to the suggestion of SC members last year, catch data were provided for all species.

It was also noted that a number of contracting parties had not submitted catch submissions for 2019 at the time of the meeting, therefore many of the STATLANT 21A catches reported in the catch tables in this report should be considered provisional.

3. External Review

The invited external reviewer for STACFIS in 2020 was Dr Hugues Benoît from Fisheries and Oceans Canada (Mont-Joli). Following discussions in Scientific Council in consultation with Dr Benoît, it was agreed that the review would focus on two stocks: Greenland halibut in Subareas 0 + 1 (offshore) and Greenland halibut in Subarea 1 (A-F) inshore. The reviews are as follows:

Greenland halibut (Subarea 0 + 1A (offshore) and 1B-F, June 2020: Reviewer comments by Dr Hugues Benoît.

The text below constitutes a simple summary of comments provided to the assessment leads leading up to and during the assessment meeting as part of a number of interventions.

Assessment of the offshore stock

The assessment of Greenland halibut (GH) in subareas 0 and 1 is empirical and based principally on bottom-trawl surveys in NAFO area 0 and in area 1 and information from the commercial fishery.

The surveys in 2019 were undertaken by an uncalibrated vessel and took place several weeks earlier than any previous year. The distribution of GH with respect to depth and distance from shore was different from past years and there was evidence that a potentially important portion of the stock was distributed outside the survey area. This, combined with evidence that the characteristics of the trawl while fishing were also different in 2019, led to the decision to exclude the 2019 survey from the assessment, which I fully support. Analyses of past survey data revealed that the seasonal timing of surveys has also varied, albeit to a smaller extent, in the past and appears to have been associated with differences among years in the spatial distribution of GH, likely associated with seasonal shifts in distribution. Given this sensitivity it will be important that the survey be conducted at consistent dates in the future and ideally across the range of depths occupied by GH to best ensure that an interannually consistent portion of the stock is found within the survey areas such that the survey indices remain proportional to abundance.

The assessment presented an index of young fish purported to be a recruitment index. It was pointed out that no evidence had been presented, cited or was otherwise evident in the document that the trends were related to recruitment to larger sizes/older ages. The term ‘recruitment index’ may therefore be misleading. Furthermore, the calculation of the index was not clear and made reference to the Peterson method, which was not familiar to me and probably others, in this context at least (it is commonly known for the analysis of mark-recapture data). Uncertainty in the estimates was not presented.

Empirical assessments often review trends in biological indicators of stock health other than survey abundance indices, such as changes in survey size composition, size ratios and maturation characteristics. I was surprised to see little mention of these characteristics even though this information is collected. Reviewing this information seems particularly relevant as the fishery appears to select for a non-negligible portion of fish that may not be mature.

Empirical assessments also typically present estimates of relative harvest rate, often as landings over survey biomass. If the survey provides a proportional index of abundance (which this survey has historically been assumed to), trends in harvest rate should reflect trends in fishing mortality. Furthermore, the magnitude of the harvest rate can, in some instances, provide an indicator of whether fishing mortality is sustainable; if survey biomass constitutes a minimum estimate and if harvest rates are low, then fishing mortality is also likely to be low.

The assessment estimates a standardize catch-per-unit-effort (CPUE) time series, although trends in it are not interpreted because it is not considered reliable. If this is the case, then why present it? Other assessment present CPUE as an index of fishery performance rather that abundance, which often serves to facilitate industry buy-in to the assessment process and to promote collaboration with the scientific team. If these considerations are not relevant for this assessment, the relevance of presenting the CPUE should be reassessed. Given that this has been a developing fishery, expertise and technology have likely improved over time rendering it next to impossible to define a consistent unit of effort. How then can one distinguish increasing innovation and increasing stock size in an increasing CPUE? Notwithstanding these considerations, the assessment did not present or mention any validation for the CPUE estimation. Could the effects of the model be considered strictly additive (i.e., no interactions)? Were model assumptions met? Was the design matrix for the vessel effects adequate and reasonably balanced? Violation of one or more of these sorts of things can impact the trend and individual standard errors for the series.

Knowledge about the dynamics of the Greenland halibut in the fjords in NAFO subarea 1B to 1F inshore to justify treating these as a separate stock from the offshore in 0/1

Most stocks are at least roughly defined from a biological basis to reflect a population, but are often also delineated based on the practicalities of fishery management. The considerations presented at the meeting were almost exclusively biological, implying that maintaining the integrity of population processes was the key motivator for this work. However, it was somewhat difficult to assess the relevance of the different pieces of evidence brought forward because the burden of proof of stock attribution to the offshore versus inshore was neither defined or implied. For example, was it necessary to demonstrate with high probability that the inshore fish have little or association with the offshore? The question is relevant because many of the lines of evidence that were advanced could be interpreted as natal homing despite offshore spawning, and spatial discontinuities in distribution appear largely depth related rather than simply geographical. Furthermore because the tagging data were not analysed with respect to the seasons of deployment and recapture, it was not possible in my view to refute the homing hypothesis. However, if the burden of proof is reversed, or if the level of proof is lessen, then the data presented could be consistent with distinct inshore stocks, perhaps associated with offshore stocks east of Greenland.

A notable element in the working paper is a very pronounced and rapid decline in the size composition of landings in 1CD, and in other areas (if I recall correctly). The causes of these declines can be manifold, but should be of particular concern if they are related to fishing, or if they could impact future fishing opportunities. I recommend that the assessment team undertake an evaluation of the weight of evidence for different hypotheses, which could include an increase in recruitment, a decline in growth, an increase in total mortality (fishing and/or natural), and a change in selectivity and/or availability.

Assessment of GH in the South West Greenland fjords division 1BC, 1D and 1EF

The assessment was based on the depletion-corrected average catch method (DCAC). I have little expertise in DCAC, other than what I have read generally, but offer the following general comments. Overall I think there are some important inconsistencies with the choice of approach could have been clarified:

- If the assumption that GH in these fjords constitute merely sink populations, as I understood was the proposal, then the concept of sustainable yield that is implied by the DCAC doesn't apply. You cannot recruitment overfish purely sink populations since there is no feedback from stock to recruitment; instead you are dealing with an inventory management problem of optimizing yield with respect to somatic growth, *M* and possible size-dependent market demand (economic yield-per-recruit). DCAC is therefore probably not the best method to provide catch advice.
- The DCAC is dependent on an equilibrium assumption. Possible depletion/collapse of these stocks in the 1990s and 2000s, and recent declines in size composition of catches seems inconsistent with that assumption.
- It appears that there is a fair amount of both fishery dependent and independent data for at least Disko Bay, which begs the question of why those data aren't better utilized.
- I am surprised by the choice of SD values in table 2. M is considered relatively quite uncertain, while it is probably not <u>that</u> badly known (given observed maximum ages for GHL in the subarea an M=0.15 is probably not unreasonable), meanwhile the Fmsy/M ratio is probably equally or less well know yet is considered relatively much more certain. Furthermore, a value of 1 for that ratio is inconsistent with accepted sustainable values, which tend to be <=0.8. Notwithstanding these comments, I didn't see any results that reflected these stochastic values, only deterministic results based on scenarios (Table 3, where I can only assume individual parameter values were altered assuming all the others were at their nominal value).
- I am not sure the following statement in the working paper is correct in general and in the present case: 'The-DCAC advice can to some extent be considered conservative, as the estimated sustainable catch will always be less the average catch for the total timeseries with unregulated fishery'. It will only be conservative if the depletion period is not included in the catch data used to make the estimate (at least based on my understanding of DCAC) and the stock is at equilibrium.

III. STOCKS ASSESSMENTS

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

Recent Conditions in Ocean Climate and Lower Trophic Levels

- The ocean climate index in Subareas 0-1 was at its highest value since the record-high of 2010, and the third highest since the beginning of the time series in 1985.
- The initiation of the spring bloom was delayed for a second consecutive year in 2019 compared to the 1998-2015 climatology.
- Total spring bloom production (magnitude) was below normal in 2019

Environmental Overview

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

Ocean Climate and Ecosystem Indicators

The ocean climate index in Subareas 0-1 has been predominantly above normal or near-normal since the early 2000s, except for 2015 and 2018 that were below and slightly below normal, respectively (Figure A1.A). In 2019, the index was at its highest value since the record high of 2010, and at its thirds highest value since the beginning of the time series in 1985. Before the warm period of the last decade, cold conditions persisted in the early to mid-1990s. The timing of the spring bloom transitioned from later to earlier than normal between 1998 and 2007. Spring bloom timing has shown a general trend of increasingly later initiation since the late 2000s with few exceptions of early timing observed in 2011, 2015, and 2017. The initiation of the spring bloom (Figure A1.B) occurred later than normal for a second consecutive year in 2019. Spring bloom magnitude (Figure A1.C) was mostly near normal between 1998 and 2007. Both below and above normal spring production occurred during that period but no clear pattern was observed. There was a general trend of increasing spring production since the record low in 2007. However, spring bloom magnitude in 2019 was back to below normal with the second-lowest anomaly of the time series. In general, early blooms are associated with high spring production and vice versa (Figure A1.B, A1.C).

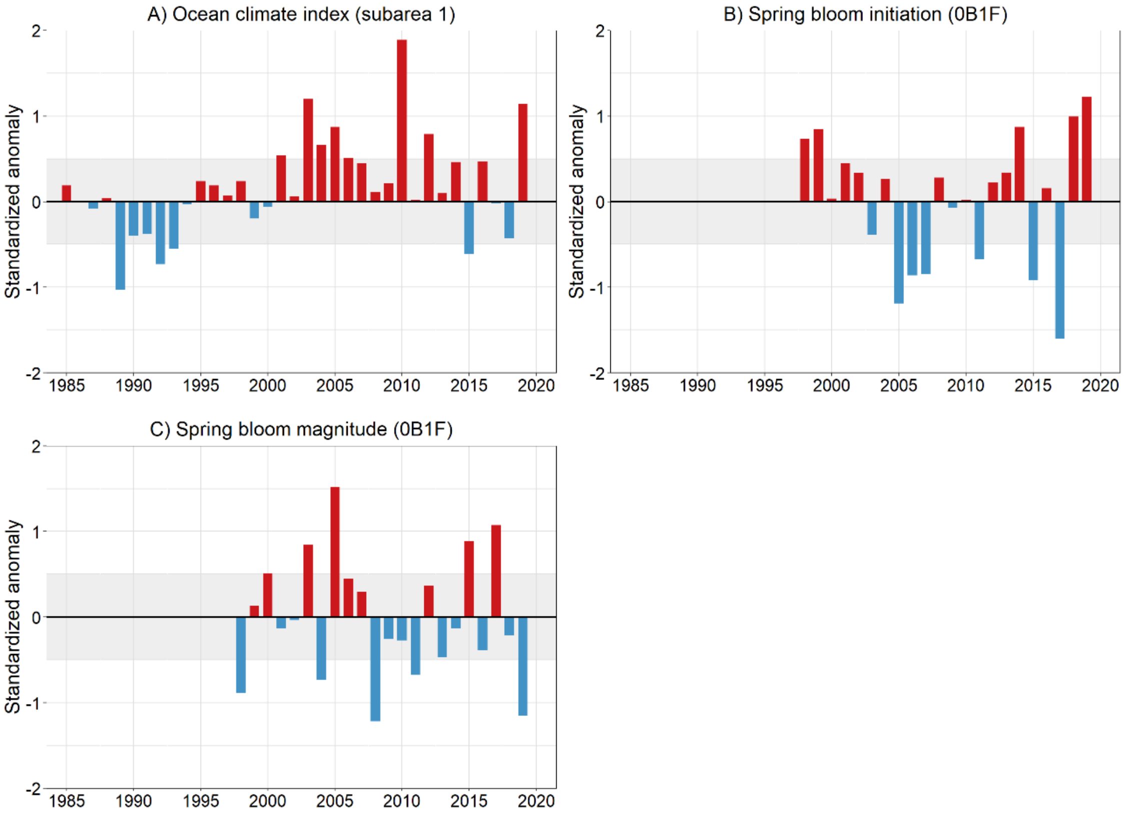


Figure A1. Environmental indices for NAFO Subareas 0 and 1 during 1990-2019. The climate index (A) for Subareas 0 and 1 is the average of 7 individual time series of standardized ocean temperature anomalies: sea surface temperatures (SSTs) for West Greenland Shelf, North and Central Labrador Sea and Hudson Strait, 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, and air temperatures in Nuuk (Greenland) and Iqaluit (Baffin Island). Geographical boxes used for SSTs are presented in Cyr *et al*. (2019) and air temperature time series are presented in Cyr *et al*. (2020). 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 initiation (B) and magnitude (C) indices for the 1998-2019 period are derived from three satellite boxes located in NAFO Div. 0B (Hudson Strait) and 2H1F (Labrador Sea) and 1F (Greenland Shelf) (see SCR Doc. 20/035 for box location). Positive/negative anomalies indicate above/below (or late/early timing) normal conditions, 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 (shaded area) are considered near-normal conditions.

1. Greenland halibut (*Reinhardtius hippoglossoides*) in Subarea 0 and 1 (offshore)

(SCR Doc. 20/06, 07, 12, 15, 18, 19, 32, 34, 37; SCS Doc. 20/10, 12, 13)

a) Introduction

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

The assessment is qualitative, and since 2014 has been based on an index of survey biomass that combines Divisions 0A-South and 1CD surveys (ICES 2013). The surveys are conducted by the same vessel and gear during the fall which allows for a combination of the survey results. An index based harvest control rule was accepted as the basis for TAC advice in 2016.

The vessel that conducted surveys from 1997 to 2017 has been retired and a new research vessel is expected to be available in 2021. No survey was conducted in 2018 and a commercial vessel was used for the 2019 survey. This change in vessel has had an effect on gear performance such that the 2019 index is not directly comparable to previous years. Also, earlier timing for the 0A-South survey in 2019 introduced additional uncertainty to the comparability of this index. As a result the use of the previously accepted harvest control rule is compromised and the 2019 assessment and advice are based on a qualitative review of available survey and fisheries data. The absence of a continuous survey series limits the assessment and STACFIS may be unable to evaluate the impact of the advised TAC.

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

	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
TAC	27	27	27	30	30	30	32.3	32.3	36.4	36.4
SA 0	13.2	13.3	13.4	14.9	15.4	14.1	15.9	16.4	18.4	
SA 1	13.1	13.5	13.5	14.7	14.9	15.2	16.2	16.2	18.0	
Total STACFIS[1]	26.3	26.8	26.9	29.6	30.3	29.3	32.1	32.6	36.4	

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

i) Description of the Fishery

Bottom otter trawl gear is used by most fleets in the Subarea 1 fishery. There have been longline vessels occasionally in the offshore, however gillnet gear is not allowed. The Subarea 0 fishery is a mix of trawl and gillnet (between 30-40% of the catch in recent years) with the occasional use of longline. The trawlers in both Subareas have been using both single and double trawl configurations since about 2000. The gillnet fishery in Subarea 0 began in 2005 and has been using baited gillnets since about 2015. Baiting gillnets has been shown to increase catch rates (Bayse and Grant 2020).

Catches were first reported in 1964 and rose to 20,027 t in 1975 before declining to 2,031 t in 1986. Catches increased from 1989 to 1992 (reaching a level of 17,888 t) due to a new trawl fishery in Div. 0B with participation by Canada, Norway, Russia and Faeroe Islands and an expansion of the 1CD fishery with participation by Japan, Norway and Faeroe Islands. Catch declined from 1992 to 1995 primarily due to a reduction of effort by non-Canadian fleets in Div. 0B. Since 1995 catches have been near the TAC, increasing in step with increases in the TAC, with catches reaching a high of 36,446 t in 2019 (Figure 1.1).

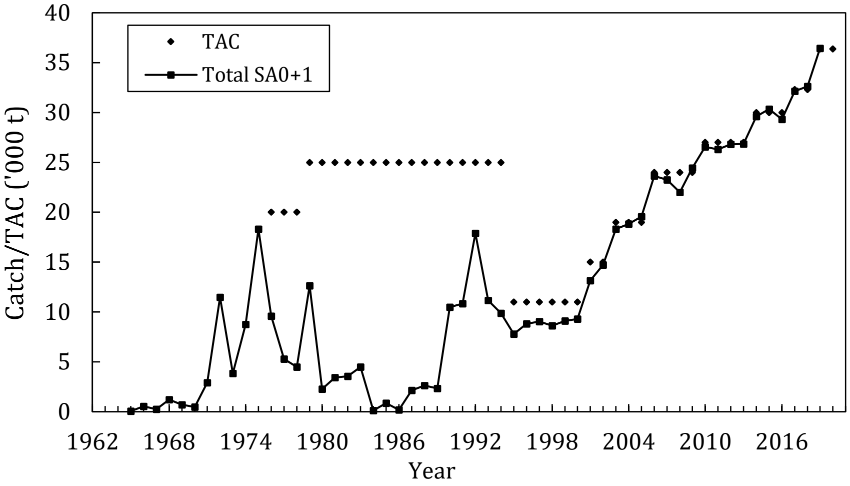


Figure 1.1. Greenland halibut in Subarea 0 and 1 (offshore): catches and TACs.

b) Data Overview

i) Commercial fishery

In 2019 length frequencies were available from Greenland and Russian Federation trawl fisheries in Div. 1AB, Norway, Greenland, German, and Russian Federation trawl fisheries in Div. 1CD, and from Canadian gillnet and trawl fisheries in Div. 0AB.

The length frequency data have been combined to produce an overview for Baffin Bay (0A+1AB) and Davis Strait (0B and 1CD) portions of the stock area, given these areas have shown differences in size components in both surveys and fisheries. In 0A+1AB fisheries lengths ranged from about 20 cm to 90 cm with a mode fluctuating between 45 cm and 51 cm. In 0B+1CD fisheries lengths ranged from about 30 cm to 100 cm with a mode varying between 45 and 53 cm. Overall the SA0+1 length frequency had a mode that varied between 49 cm and 51 cm, with 51 cm observed since 2015.

Lengths sampled from the longline fishery in Subarea 1 have ranged from about 40 cm to 100 cm with a mode that has been relatively stable around 55 cm. Lengths sampled in the SA0 gillnet fishery have ranged from approximately 40 cm to 90 cm with a mode prior to 2014 of approximately 61 cm that has since varied around 59 cm.

It is not known how the technical development of fishing gear or vessel changes in the fleets have influenced the catch rates, for example, the expansion of the fishery into new grounds in the northern portion of the stock area (0A and 1AB) and the learning that takes place can affect catch rates over time. Also, the SA0 gillnet fishery began baiting gill nets around 2015 and it is currently not possible to identify which sets used bait and which did not. Such changes can influence the estimation of the catch rates, therefore, the standardized catch rates that have been presented in previous assessments are not considered informative and have not been included in the assessment. This does not preclude consideration of new research using CPUE if future assessments find it has value.

ii) Research surveys

The survey timing was earlier in the season by about 6 weeks and this could have had an effect on distribution of fish available to the surveys in 2019 compared to previous years. Generalized Additive Models (GAMs) were used to examine the abundance relative to depth and distance from shore for the survey time series (Wheeland et al. 2020). There was no indication of a difference in distribution for the 2019 1CD survey that would impact its comparability to the previous time series. However, abundance in the 0A-South survey was highest in the shallowest areas, farthest inshore. Survey biomass in the shallowest strata was significantly greater than in previous years, and fish in these strata were larger in 2019. Greenland halibut distribution is known to extend inshore, with inshore/offshore movements, therefore this analysis suggests an unknown proportion of the stock may have been beyond the 0A-South survey in 2019 and it is not considered comparable.

The effect of the vessel change on the 2019 survey was examined by looking at gear performance parameters, (e.g. net height and door distance) and survey length frequency of fish 35-70 cm and >70 cm (Nogueira and Treble 2020). Mean net height differed between the R/V Paamiut and the C/V Helga Maria by 23% – 27% and door spread by -7% and -10% in the 0A-South and 1CD surveys, respectively. Further examination of mean net height and door spread suggest the R/V Paamiut could have been fishing with better bottom contact in deep water, and this could have an effect on catchability, particularly for Greenland halibut that associated with the bottom and are known to increase in abundance with depth.

Based on these analyses the comparability of the 2019 survey indices are considered questionable and are not used in the 2020 assessment.

Surveys began in SA0 and SA1 in the mid 1980s with surveys conducted in 0B by Russia and the Democratic Republic of Germany and in 1BCD jointly by Greenland and Japan. Since 1997 surveys have been conducted in 0B and 0A-South by Canada and in 1CD by Greenland using the same research vessel (Figure 1.2).

The combined 1CD and 0A-South survey biomass was relatively stable from 1999 to 2014 (Figure 1.3). There was an increase in 2016 followed by a decrease in 2017. Abundance followed a similar trend. The overall length distribution ranges from about 5 cm to 100 cm. Modal lengths have shifted from 42 cm and 43 cm during 1999 and 2001, respectively to a high of 51 cm in 2015. Secondary modes were clearly present in 2008 and 2012-2017.

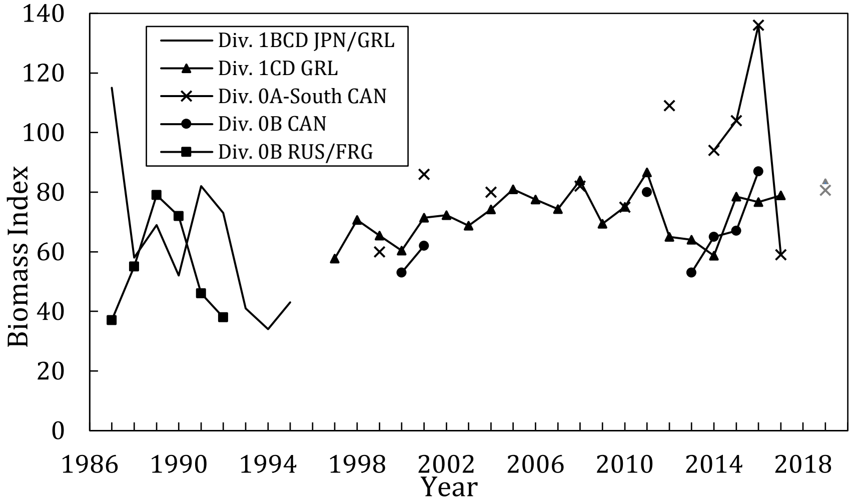


Figure 1.2. Greenland halibut in Subarea 0 and 1(offshore): biomass indices from bottom trawl surveys. A survey in Div. 0A in 2006 is not included due to poor coverage.

Since 1988 surveys with a shrimp trawl have been conducted off West Greenland during July-September. The survey covers the area between 59° N and 72° 30' N (Div. 1A-1F) from 50 m to 600m. This survey also experienced vessel changes in 2018 and 2019, however, the results are considered to be comparable with those from earlier years. Clear modes can be found in the length distribution at 12-15 cm and 23 cm, corresponding to ages 1 and 2, allowing for the development of an index of age 1 Greenland halibut using the Petersen method.

c) Estimation of Parameters

Several attempts to model the stock dynamics have been tried over the years using methods such as Yield per Recruit Analysis, XSA, ASPIC and Schaefer surplus production model. None have been accepted.

d) Assessment Results

i) Subarea 0 and 1 (offshore)

Biomass: The 0A-South+Div. 1CD combined survey biomass index had been relatively stable from 1999 to 2014 (Figure 1.3). Since 2014 the index has been more variable with a time series high in 2016 and a level near the series low in 2017, with all values remaining above B_{lim}.

Recruitment: The general trend in estimated biomass of age 1 Greenland halibut in the offshore and inshore areas combined has been used as a proxy for recruitment. Since 2003 the index has had an overall declining trend with the exception of three years with high levels of abundance (2011, 2013 and 2017). The index of age 1 in the last two years is considerably lower than in previous years (Figure 1.4). It is unclear if the age 1 abundance index is linked to spawning stock biomass and representative of future recruitment. However, it is considered to contribute to the perception of overall stock status.

Length distribution in surveys: Length frequency distribution in the 1CD and 0A-South combined survey have had an increase in abundance in larger fish with modal length shifting from 49 to 51 cm during the last 10 years.

State of the Stock: The combined 1CD and 0A-South biomass index has been above B_{lim} throughout the time series, 1999 to 2017. The combined biomass index is not available for 2018, and the 2019 value is not used to assess stock status because its comparability with the earlier time series is questionable. The index of age 1 in the last two years is considerably lower than in previous years, however, there have been high abundances in 2011, 2013 and 2017. It is unclear if the age 1 abundance index is representative of future recruitment but it is considered to contribute to the perception of overall stock status.

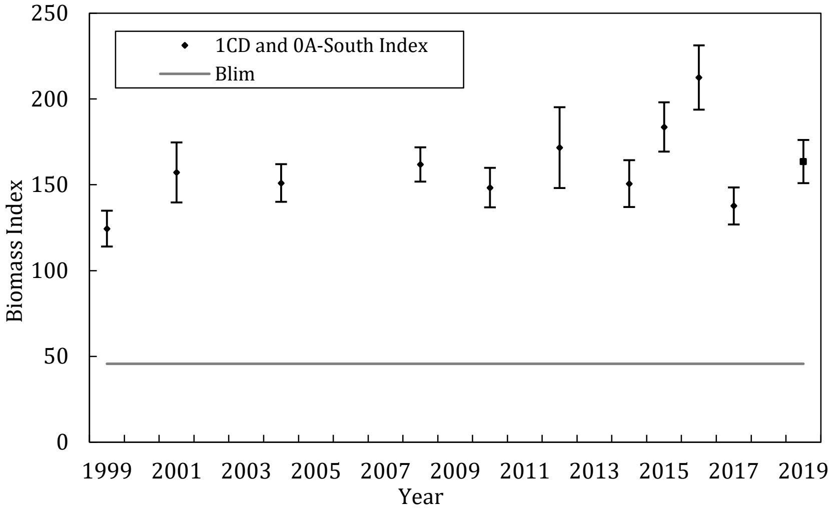


Figure 1.3. Greenland halibut in Subarea 0 and 1 (offshore): Biomass trends in Div. 0A-South and Div. 1CD and the proxy for B_{lim}.

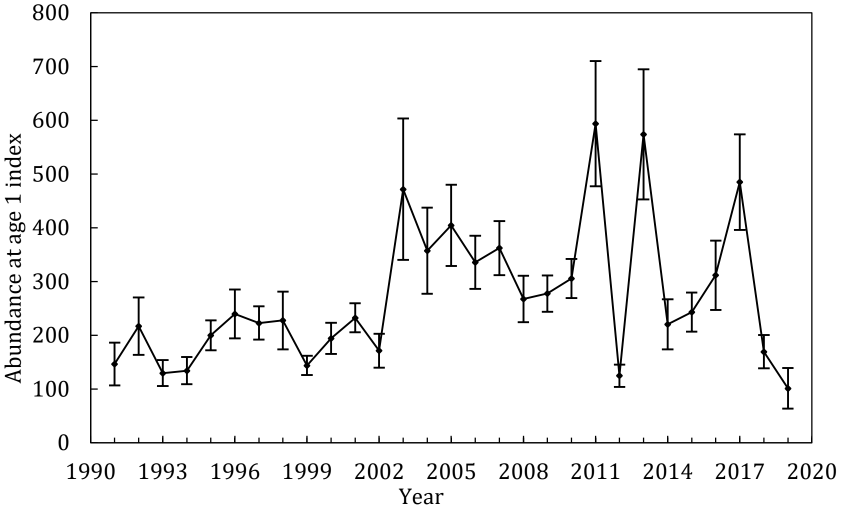


Figure 1.4. Greenland halibut in Subarea 0 and 1 (offshore) and Div. 1B-F: index at age 1 derived from the Greenland Shrimp and Fish Survey.

e) Precautionary Reference Points

Age-based or production models were not available for estimation of precautionary reference points. In 2014 a preliminary proxy for B_{lim} was set as 30% of the mean for the combined 0A-South + Div. 1CD survey biomass index for years 1999 to 2012 (Figure 1.5).

The next full assessment of this stock is expected to be in 2022.

f) Recommendations:

In 2018 STACFIS **recommended** that *the CPUE data be explored and the General Linear Model examined to better understand the observed trends.*

STATUS: No progress in 2020 but will be carried forward to 2022.

There is a question as to the representativeness of the abundance at age 1 (from the 1A-F survey) as an index of recruitment, or stock status, for the SA 0 and 1 offshore stock. *STACFIS recommends* exploring the use of the overall 1A-F survey biomass as an index of stock status instead of only the age 1 portion of this survey.

References

Bayse S. M. and S. M. Grant. 2020. Effect of baiting gillnets in the Canadian Greenland halibut fishery. Fish Manag Ecol. 00:1–8. https://doi.org/10.1111/fme.12434

ICES 2012a. Report of the Workshop 3 on Implementing the ICES F_{msy} Framework. ICES WKFRAME3 Report 2012, ICES Advisory Committee, ICES CM 2012/ACOM:39, 29 pp.

ICES 2012b. ICES Implementation of Advice for Data-limited Stocks in 2012 in its 2012 Advice. ICES DLS Guidance Report 2012, ICES CM 2012/ACOM:68, 40 pp.

ICES 2013. Report of the benchmark on Greenland halibut stocks (WKBUT). ICES CM 2013/ACOM:44. 74pp.

ICES 2014. Report of the Workshop on the Development of Quantitative Assessment Methodologies based on LIFE-history traits, exploitation characteristics, and other relevant parameters for data-limited stocks (WKLIFE IV), 27–31 October 2014, Lisbon, Portugal. ICES CM 2014/ACOM:54. 223 pp.

Nogueira, A. and Treble, M. A. 2020. Comparison of vessels used and survey timing for the 1CD and 0A-South deep-water surveys and the 1A-F west Greenland shelf surveys. NAFO SCR 20/15, Ser. No. N7060. 45 pp.

Wheeland, L. J., Novaczek, E., Treble, M. A. and Nogueira, A. 2020. Impacts of survey timing on distribution and indices of GHL in NAFO Div. 0A and Divs. 1CD. NAFO SCR 20/32. 18 pp.

Roy, D., D. C. Hardie, M. A. Treble, J. D. Reist and D. E. Ruzzante. 2014. Evidence of high gene flow in a locally adapted species: the paradox of Greenland Halibut (Reinhardtius hippoglossoides) panmixia in the Northwest Atlantic. Canadian Journal of Fisheries and Aquatic Science 71: 763-774.

2. Greenland halibut Subarea 1 inshore.

(SCR Doc. 20/003 006 016 034 043 044 SCS Doc. 20/12)

a) Introduction

The fishery in Subarea 1 inshore mainly takes place in in Division 1A in the Disko Bay, the Uummannaq fjord and the Fjords surrounding Upernavik. Further North a fishery is slowly developing in the Qaanaaq fjord. The fishery in Divisions 1B to 1F is comparably smaller than the fishery in Division 1A and never been quota regulated. 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 six areas on a two-year basis and a separate TAC is set for each of the inshore areas in Division 1A.

i) Catch history

The inshore fishery for Greenland halibut developed in 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.

In Division 1A inshore, the fishery is conducted with longlines or 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 in two components with ITQ's for vessels and shared quota for small open boats. In 2014, the Government of Greenland set "quota free" areas within each subarea, and in these areas, catches were not drawn from the total quota, although still included in landing statistics. Sorting grids have been mandatory since 2002 in the offshore shrimp fishery at West Greenland and in the inshore shrimp fishery (Disko Bay) from 2011. Trawl fishery is not allowed in the Uummannaq fjord and Upernavik area. 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). In Divisions 1B to 1F the fishery is conducted with longlines only.

1A 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. From 2009, catches gradually increased, reaching 8 759 t in 2019. (Table 2.1 and Figure 2.1).

1A 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 2019 catches reached 10 243 t, the second-highest value of the time series (Table 2.1 and Figure 2.1).

1A Upernavik: Catches increased from the mid1980s 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. Average catch in the most recent 5 years has been 7 169 t (Table 2.1 and Figure 2.1).

1BC Sisimiut Maniitsoq area: Catches increased in the area from the 1960s reaching more than 1 000 t in 1965. Catches decreased thereafter but returned to a higher level from 1973 to 1980. After this intense fishing period, catches decreased and were almost non-existent for two decades after 1987. From 2008, catches have gradually increased reaching 300 t in 2019.

1D Nuuk area: Catches in 1D inshore were around 500 t annually from 1966 to the end the 1980s and peaking in 1985 with 2 136 t. After this intense fishing period, the fishery was virtually non-existent for two decades. From 2003 catches gradually increased, reaching 1 369 t in 2016. In 2019, the catch decreased to 834 t from 1 117 t in the preceding year.

1EF Paamiut Qaqortoq area: A fishery for Greenland halibut took place from 1910-1931 in Division 1F and from 1919 to 1939 in Division 1E. No data are available from 1940 to 1960. From 1960 catches gradually increased and were around 1 000 t/year from 1982 to 1985. From 1990 and the following two decades the average catches were just around 60 t/year but since 2014 annual catches have been at 400-800 t/year.

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

	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
1A Qaanaaq - Catch	0.02	0.05	0.01	0.13	0.14	0.14	0.211	0.252	0.221	
1A Upernavik - TAC	6.50	6.50	7.95	9.50	9.50	9.50	9.50	9.50	8.46	8.46
1A Upernavik - Catch	6.47	6.83	6.04	7.38	6.27	7.36	6.78	7.55	7.67	
1A Uummannaq - TAC	6.00	6.00	7.45	8.38	9.50	9.85	9.50	9.50	9.90	9.50
1A Uummannaq - catch	6.40	6.13	7.01	8.20	8.24	10.30	9.05	8.84	10.2	
1A Disko Bay – TAC	8.00	8.00	9.00	9.00	9.20	9.65	9.20	9.20	11.08	8.18
1A Disko Bay - Catch	8.00	7.76	9.07	9.18	8.67	10. 76	6.41	8.40	8.76	
1BC Sis Man - TAC	-	-	-	-	-	-	-	-	-	-
1BC Sis Man - Catch	0.095	0.058	0.107	0.242	0.183	0.149	0.197	0.278	0.301	
1D Nuuk - TAC	-	-	-	-	-	-	-	-	-	-
1D Nuuk - Catch	0.104	0.277	1.024	1.211	0.864	1.369	1.100	1.117	0.834	
1 EF Paa – Qar -TAC	-	-	-	-	-	-	-	-	-	-
1EF Paa – Qar -Catch	0.054	0.072	0.139	0.368	0.479	0.510	0.785	0.657	0.450	
STACFIS Total	21.38	21.17	23.40	26.71	24.86	30.59	24.53	27.09	28.38	

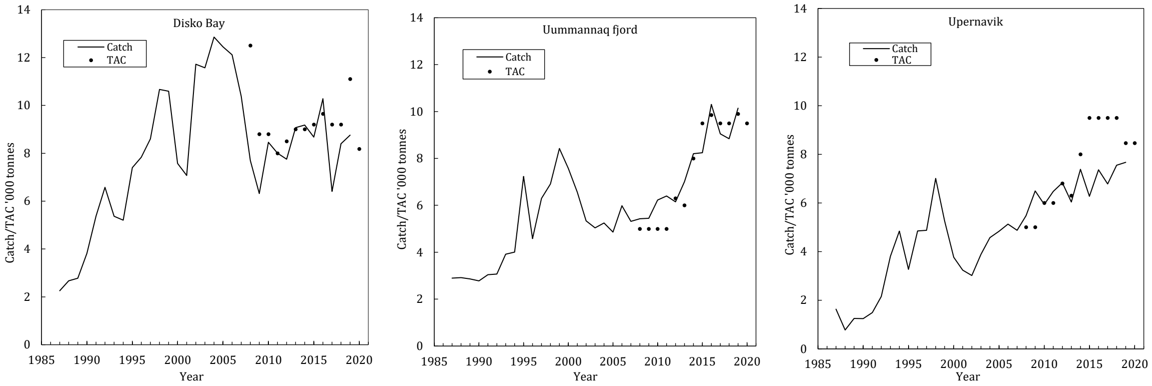


Figure 2.1. Greenland halibut in Division 1A inshore: Greenland halibut catches and TAC in t in Disko Bay, Uummannaq and Upernavik.

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 an annual mean accounting for season, gear and area (Figure 2.2).

In 1A Disko Bay, 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 **1A 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 **1A Upernavik,** the mean length in the commercial landings decreased from 1993 to 1998. From 1999 to 2009, the mean length in the longline fishery remained constant, but has since then decreased further.

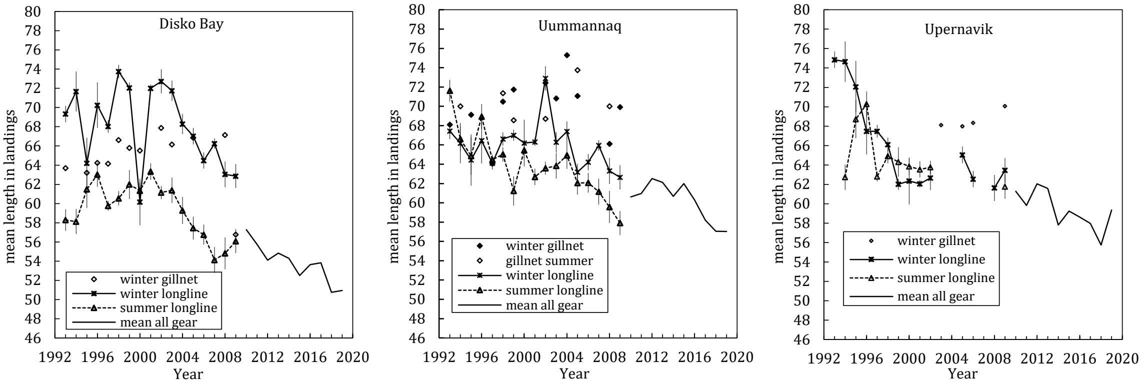


Figure. 2.2. Greenland halibut in Division 1A inshore: mean length in landings from longline fishery by season (summer and winter) and overall mean taking account of fishing ground, season and gear.

In **1D Nuuk** area, the mean length in the commercial landings gradually decreased from the 1970s to the 1980s and again since 2011 (Figure 2.3)

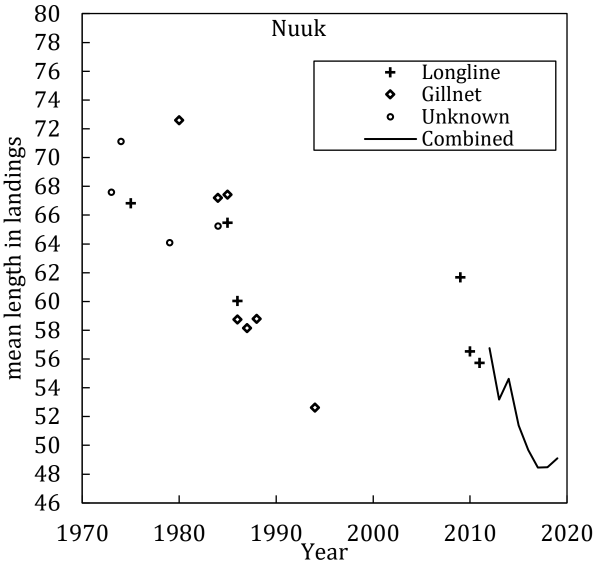


Figure 2.3. Greenland halibut in Division 1D inshore: mean length in landings and overall mean taking account of fishing ground, season and gear.

Catch numbers. Although catch in tonnes decreased in the Disko Bay in 2016, estimated catch in numbers are still at the level of the previous high catches (Figure 2.4). In both Uummannaq and Upernavik, current catch in numbers are at a record high level in recent years.

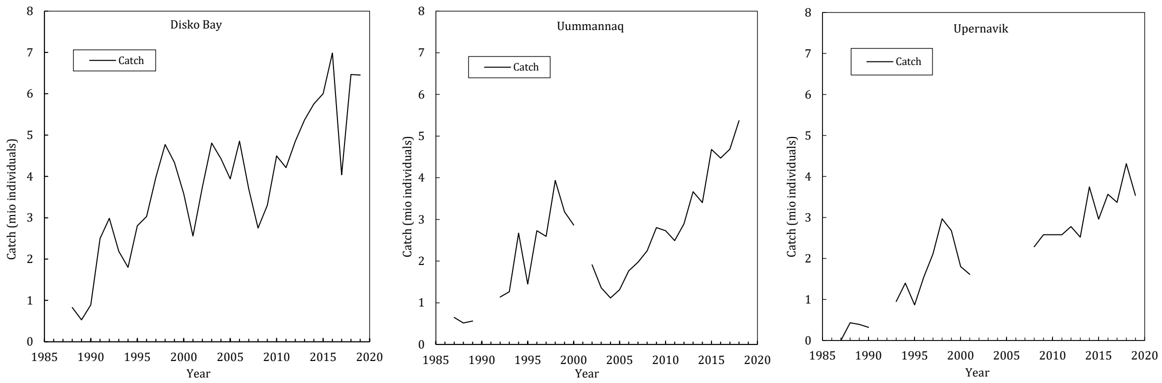


Figure 2.4. Greenland halibut in Division 1A inshore: Greenland halibut catch in million individuals.

The Depletion Corrected Average Catch method was used to estimate a sustainable level of catch for the areas 1BC, 1D, and 1EF (Figure 2.5). The method can be applied when a sufficiently long catch history of decades or more is available on stocks that has never experienced quota regulations.

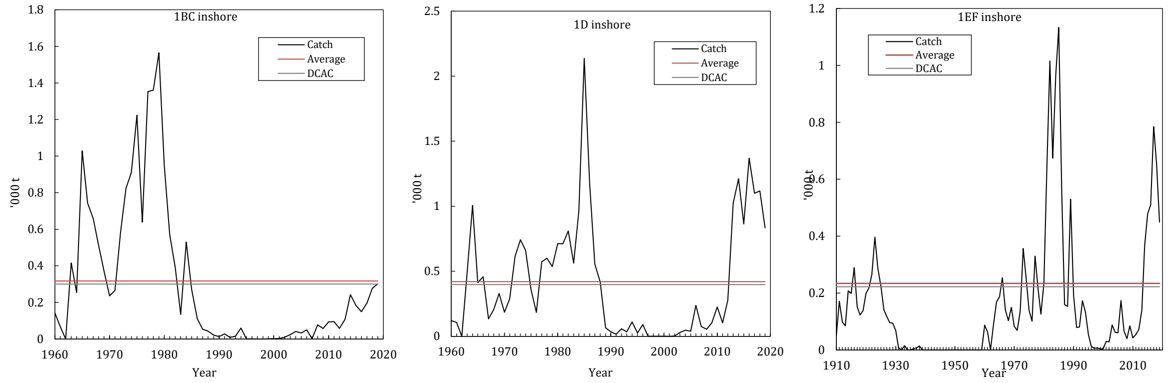


Figure 2.5. Greenland halibut in Division 1BC, 1D and 1EF inshore. Greenland halibut catch, estimated DCAC sustainable catch and average catch.

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. Due to uncertainty about mesh size, the Gillnet CPUE was not used in the assessment. Only longline setting with more than 200 hooks were included to omit obvious outlier values and limit the influence of data potential errors on the analysis. CPUE observations were log-transformed prior to the GLM analysis. Least-mean square estimates were used as standardized CPUE series. (Figure 2.6).

In **1A Disko Bay,** the standardized CPUE series show a decreasing trend since 2009.

In **1A Uummannaq**, the initial years (2008-2010) were based on fewer observations. From 2011, the CPUE index decreased gradually and the three most recent years are the lowest observed in the time series.

In **1A Upernavik,** The CPUE index reveal a gradual decreasing the 2015 to 2018 indices being among the lowest observed. The index increased in 2019, although remaining within the decreasing trend observed since 2007.

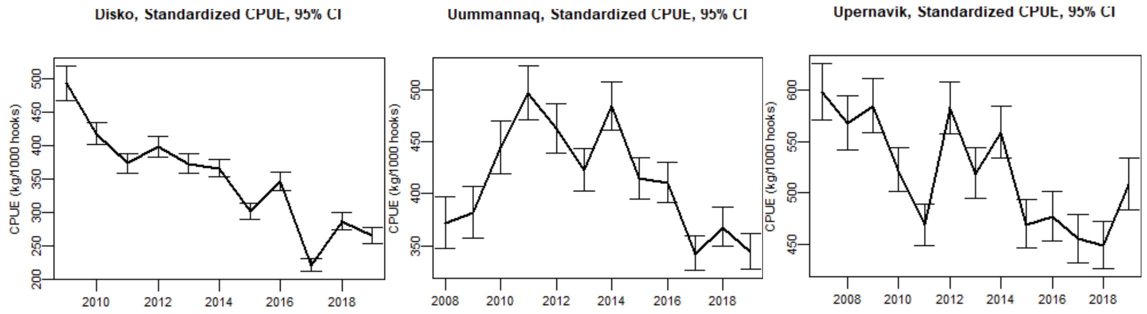


Figure 2.6 Standardized mean and 95% CI of longline CPUE in Disko bay (left), Uummannaq (center) and Upernavik (right).

ii) Research survey data

The Greenland shrimp and fish survey (NAFO Div. 1A-F from 100 to 600 m) also covers the Disko bay. Separate abundance and biomass indices and length frequencies has been calculated for the Disko bay part of the survey (Figure 2.7).

The **1A 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 with the exception of the high abundances identified in 2011 and 2013.

The biomass indices in the trawl survey indicate a steady increase during the 1990's, with a substantial increase observed in 2003 and 2004. After the gear change in 2005, the biomass index has been in a decreasing trend with the lowest values found in the most recent 4 years.

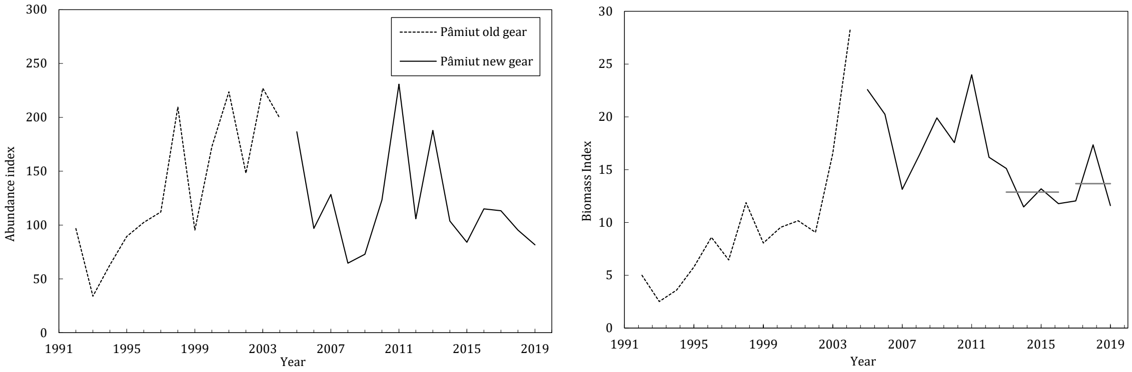


Figure 2.7. Greenland halibut in Division 1A inshore: Abundance and biomass indices in the Disko bay from the Greenland Shrimp Fish trawl survey.

A similar trawl survey was initiated in 2015 in the fjords near **1D Nuuk** (godthåbsfjord and Ameralik fjord). The trawl survey indicated increasing abundance and biomass in 2019, mainly due to higher numbers of pre-fishery recruits from 30 to 40 cm (Figure 2.8).

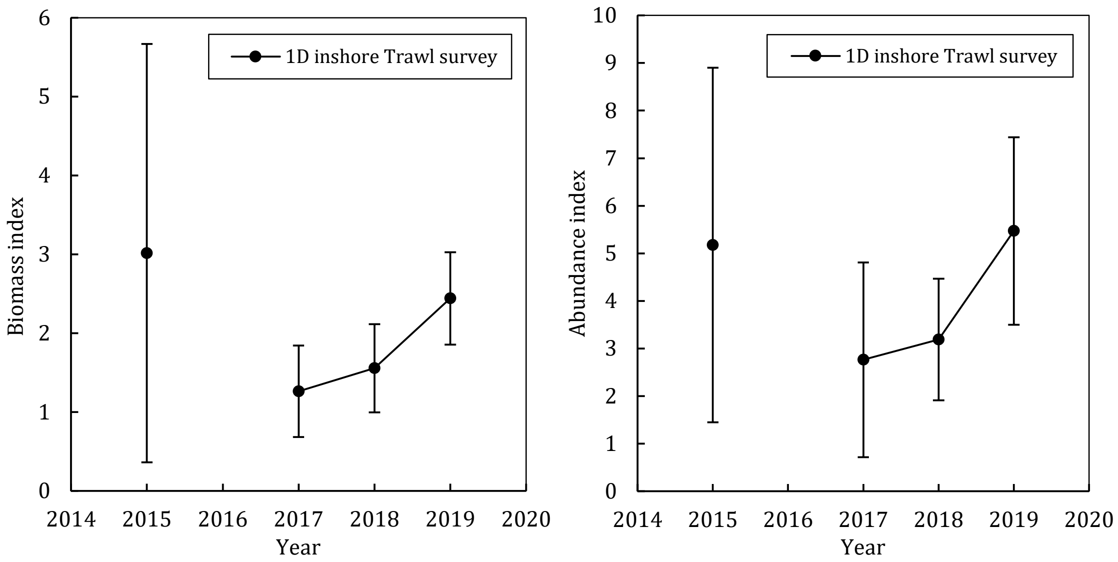


Figure 2.8. Greenland halibut in Division 1D inshore: Abundance and biomass indices in inshore trawl survey in Division 1D.

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 and NPUE indices.

The **1A Disko Bay** gillnet survey indicated low levels of pre-fishery recruits in 2006 and 2007, but returned to above average levels in 2008 to 2011 (Figure 2.9). Since 2013, the Gillnet survey NPUE and CPUE has gradually decreased and remained below average levels until 2018. In 2019, the survey was limited to stations in the important commercial areas, causing the increase in the index. 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 the Disko bay, indicating few larger individuals in the surveyed area (55-70 cm).

The **1A Uummannaq** gillnet survey was performed using the same method and setup as in the Disko Bay. The gillnet survey showed a substantial decrease in CPUE due to a lower number of large fish in the survey, until 2018, and it remained almost stable in 2019. (Figure 2.10)

The **1A Upernavik** gillnet survey was performed using the same method and setup as in the Disko Bay. The gillnet survey showed some stability since 2015. The decrease observed in 2019 is uncertain due to a lower number of stations than usual. (Figure 2.11)

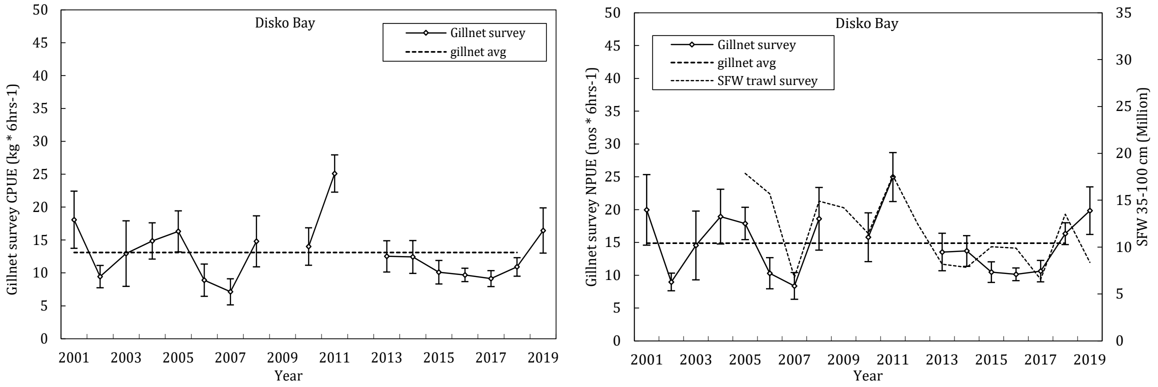


Figure 2.9. Greenland halibut in Division 1A inshore: Gillnet survey CPUE and NPUE +/-SE.

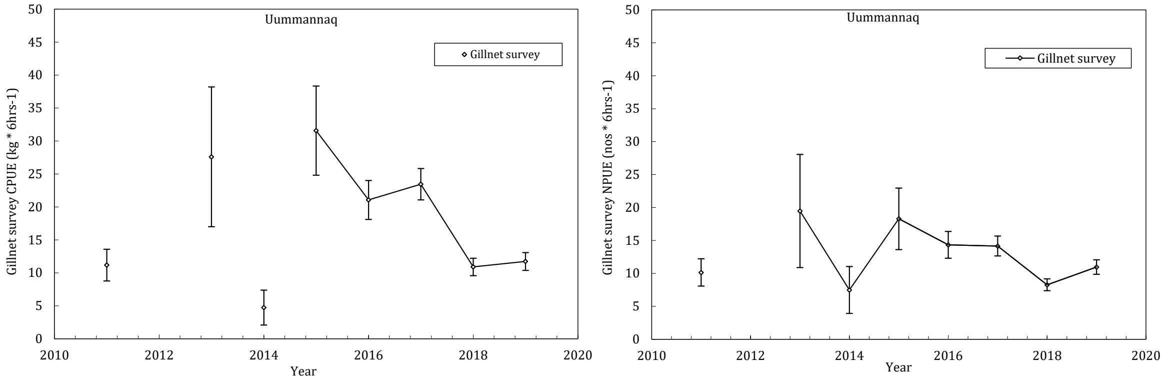


Figure. 2.10. Greenland halibut in Division 1A inshore: Gillnet survey CPUE and NPUE +/-SE.

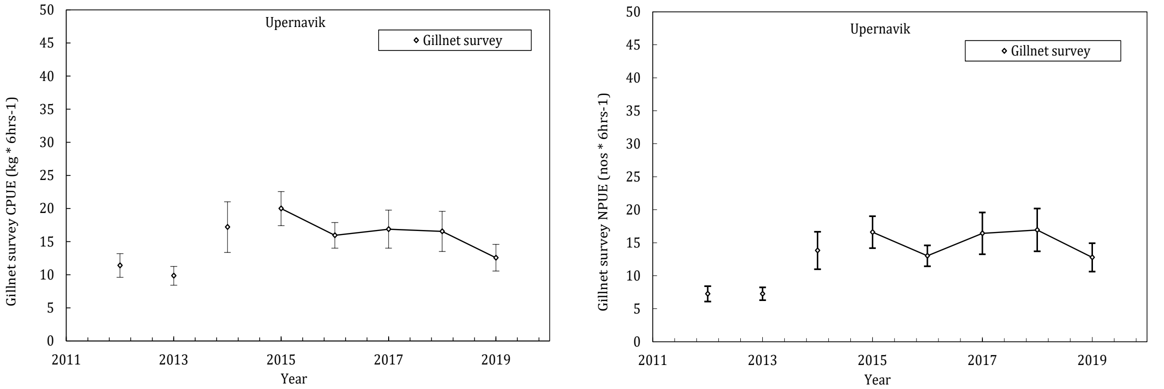


Figure 2.11. Greenland halibut in Division 1A inshore: Gillnet survey CPUE and NPUE +/-SE.

iii) Biological studies

Based on 221 females collected in Uummannaq in 2018, length at 50% maturity (L_{50}) for females was estimated to be 77 cm (visual inspection as described in WKBUT 2013). This is similar to the other studies in fjords in East Greenland and larger than females from offshore areas (Gundersen et al. 2013).

iv) Environmental studies

Deeper water bottom temperatures have been measured in surveys since 1991. A temperature increase from 1 C to 2-3 degrees occurred in 1997 along the west coast of Greenland and inside the Disko Bay. The temperature increase has been related to both glacier acceleration and increased growth of one-year-old Greenland halibut. Since 1997, bottom temperatures have remained stable at a level of 2 to 3 ºC in the Disko Bay.

c) Assessment results:

Age based analysis are not available for these stocks due to the challenges concerning age determination for Greenland halibut. Therefore, the assessments were based on survey biomass index in 1A Disko Bay and commercial data in 1A Uummannaq and 1A Upernavik.

In divisions 1BC, 1D and 1EF, Depletion Corrected Average Catch was used to estimate a sustainable level of Catch. The estimation of DCAC was only possible in these areas since the stocks in the fjords south of the Disko Bay have gone through periods of increased fishery, local depletions and rebuilding without any quotas limiting the fishery.

Assessment: No analytical assessment could be performed for any of the stocks.

d) State of the stock

1A Disko Bay

Biomass: CPUE is used as an index of biomass and has gradually decreased and remained below average levels in the most recent 3-5 years. The trawl survey biomass index has gradually decreased since 2005, with the lowest values found in 4 of the most recent 5 years.

Fishing mortality: Unknown

Recruitment: The recruitment index of age one Greenland halibut has been variable in recent years with series high values observed in 2011 and 2013 and in the nearby offshore area in 2017. However, there is weak correlation between age one and older ages in subsequent years. The trawl survey indicates a steady high supply of recruits to the area and the gillnet survey indicates an annual presence of pre-fishery recruits (30-40 cm) in the Disko Bay.

State of the stock: Mean length of the fish landed has gradually decreased over 10 to 15 years. Although the catches have remained at a level of around 8 400 t per year in the recent decade, the number fish caught has gradually increased due to a decrease in the size in the landings. The number of fish landed remains high. The trawl survey biomass index has gradually decreased since 2009, with few years falling outside the decreasing trend. The commercial CPUE for longline vessels has decreased by about 50% since 2009. The Gillnet survey CPUE, originally designed for pre-fishery recruits, indicate stable recruitment at higher ages. The gillnet survey index in 2019 was above the average levels, but the comparability of the 2019 value with the earlier time series is questionable.

1A Uummannaq:

Biomass: Unknown.

Fishing mortality: Unknown.

Recruitment: The recruitment index of age one Greenland halibut has been high in the nearby offshore areas in 2011, 2013 and 2017. The size distribution in the gillnet survey finds some pre-fishery recruits in the 30-40 cm size range.

State of the stock: The catch in tonnes and numbers of fish has been increasing since 2009, reaching record high values in 2016 and 2019. Mean length in the landings has gradually decreased. From 2011, the standardized commercial longline CPUE index decreased gradually, being 2017 and 2019 the years with the lowest values observed in the time series. The gillnet survey has shown a substantial decrease in CPUE due to a lower number of large fish in the survey, until 2018, and it remained almost stable in 2019.

1A Upernavik:

Biomass: Unknown.

Fishing mortality: Unknown.

Recruitment: The recruitment index of age one Greenland halibut has gradually been decreasing in division 1AN, west of the Upernavik area. The gillnet survey reveals pre-fishery recruits in the 30-40 cm size range at a level comparable to the Disko Bay.

State of the stock: The catch in tonnes and in numbers of fish has been record high since 2014. Mean length in the fish landings decreased in the 1990s but stabilized from 1999 to 2009. Since then, until 2018, length in the fish landings has decreased from 74-76 cm to 56-58 cm. The mean length increased in 2019, but this value is questionable because the sample size was smaller than usual. The standardized longline CPUE index decreased until 2018 reaching the lowest value of the time series. CPUE increased in 2019 but remains within the decreasing trend for year to year variation. The gillnet survey has shown some stability since 2015. The decrease observed in 2019 is uncertain due to a lower number of stations than usual.

1BC Sisimiut - Maniitsoq area

Biomass: Unknown

Fishing mortality: Unknown

Recruitment: Unknown. The stocks are believed to be dependent on recruitment from the spawning stock in The Davis strait.

State of the stock: The catch was at a low level for two decades from the end of the 1980's. During the recent decade, the catch has gradually increased to the estimated sustainable level of catch.

1D Nuuk area

Biomass: Unknown

Fishing mortality: Unknown

Recruitment: The trawl survey revealed presence of several year classes of recruits and found higher numbers of pre fishery recruits in the range 30-40 cm, in the 2019 survey.

State of the stock: The catch was at a low level for two decades from the end of the 1980's. Since 2013 the catches have been about twice as high at the DCAC estimated sustainable level of catch. During this period, a decrease in size composition in the catch has been observed. The trawl survey for Greenland halibut in the fjords in 1D indicated a decrease in the number of fish in the commercial size range since 2015. However, the biomass indices in the survey increased from 2017 to 2019, due to higher numbers of pre fishery recruits in the range 30-40 cm. The survey furthermore indicated presence of recruits in the area although the stocks are believed to be dependent on recruitment from the the stock ICES Subarea 5, 6, 12 and14.

1EF Paamiut - Qaqortoq area

Biomass: Unknown

Fishing mortality: Unknown

Recruitment: Unknown. The stocks are believed to be dependent on recruitment from the stock in ICES Subarea 5, 6, 12 and14

State of the stock: The catch was at a low level for two decades from the end of the 1980's. Since 2014 the catches have been about 2-3 times higher than the DCAC estimated sustainable level of catch.

These stocks will next be assessed in 2022

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

(SCR Doc. 88/12, 96/36, 07/88, 20/003 006 012 016; SCS Doc. 20/12)

a) Introduction

There are two demersal redfish species of commercial importance in subarea 1, golden redfish (*Sebastes norvegicus*) 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 show decade long occurrence 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. Redfish caught by bottom trawl and longlines on the bottom are considered *Sebastes norvegicus* (REG). Redfish caught pelagic are considered *Sebastes mentella* (REB)*.* Redfish caught as by-catch in the shrimp fishery are named *Sebastes sp* (RED). 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. marinus* 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 uncertain with evidence of cod being misreported as redfish and other species in the 1970s, and by-catches of redfish in the shrimp fishery likely underestimated in the 1970's to 2001. Bycatch of redfish was estimated to be more than 14,000 t in 1988 and 4,000 t in 1994 yet reported catches are much lower in these years. To reduce the amount of fish taken in the trawl fishery targeting shrimp, sorting grids have been used since 2002. Studies of bycatches and poor recruitment has since then limited the bycatch of redfish in the shrimp fishery to very low levels. In 2019, 31 t was reported as by-catch in offshore fisheries (less than 1 tons from shrimp trawlers) and 111 t were landed to factories mainly taken as bycatch in other fisheries from small vessels and open boat targeting cod and Greenland halibut (Figure 3.1).

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

	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
TAC	1	1	1	1	1	1	1	1	1	0	0
STATLANT 21	0	0.2	0.12	0.16	0.25	0.19	0.16	0.23	0.19	0.09	
STACFIS	0.3	0.2	0.16	0.17	0.17	0.26	0.17	0.24	0.19	0.14	

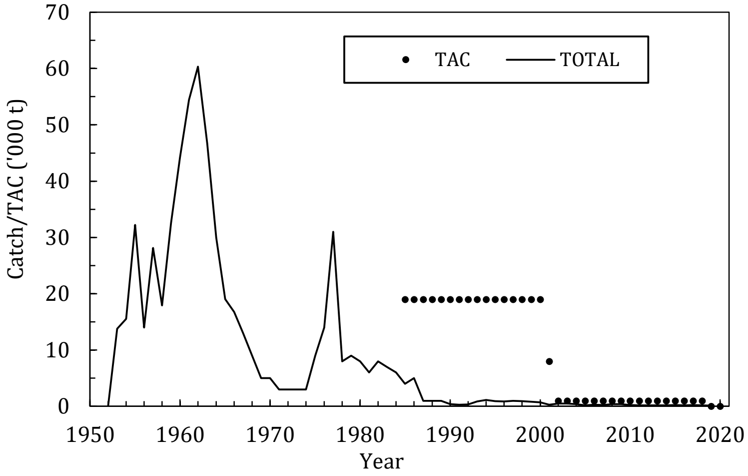


Figure 3.1. Demersal redfish in Subarea 1: catches and TAC.

b) Data overview

i) Commercial fishery data

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 during the historic intensive fishery. 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, little data of recent species or size composition in the landings are available. Logbooks and factory landings data were available.

ii) Research survey data

There are five ongoing surveys of relevance for 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 since 1998) and the Greenland shrimp and fish survey (Pâmiut, 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 with 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. Due to research vessel decommission, chartered commercial vessels using the research vessel gear and riggings has been used to update the indices in the Greenland shrimp and fish survey in 2018 and 2019. The EU-Germany survey has a longer time series, but have had low coverage in West Greenland since 2016. Furthermore, A gillnet survey in the Disko bay and the Uummannaq fjord in Division 1A inshore and a Trawl survey in the Godthåbs fjord and Ameralik fjord in Division 1D inshore provides information on species composition in the recent landings. 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.

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 peaking in 2015 when the index reached the highest level observed since 1986. In **the Greenland shrimp and fish survey,** golden redfish biomass was stable from 2006-2010 but increased gradually until 2016. The 2017 and 2018 biomass indices were however close to the 2006-2011 level. The increasing biomass observed from 2011-2016 occurred division 1E and 1F and was often caused by one or 2 hauls containing larger individuals contributing more than half the total West Greenland biomass. In 2016, a single haul in division 1E consisted of large golden redfish between 45-70 cm and provided 80% of the total biomass estimate. In 2019, the biomass index reached the second highest value observed since 2006, but this was attributed to two hauls, one in division 1C (60%) and one in division 1B (12%). the rest of the biomass being distributed from 1A including the Disko bay to 1F in South Greenland. The gillnet surveys in Division 1A inshore supported that the redfish in this area were almost exclusively Golden redfish. This was not the case in Division 1D inshore.

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 has been 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 high. About 80-95% of the redfish biomass in the trawl survey in Division 1D inshore since 2015 has been deep-sea redfish.

Juvenile redfish (both species combined)

The EU-Germany survey regularly found juvenile redfish from 1984 to 2000. After 2000, the abundance of juvenile redfish has decreased to a low level and has remained low since then (Figure 3.3). **The Greenland shrimp and fish survey** initially had high levels of juvenile redfish in the survey. The total abundance of both species combined can be regarded as a recruitment index, since the Greenland Shrimp and Fish survey normally catches high numbers of small redfish in the fine meshed shrimp trawl used for the survey. From 1992 to 1999, high numbers of redfish recruits were observed annually, but the index gradually decreased and remained low until 2004. After the gear change in 2005, the abundance index gradually decreased (Figure 3.3). Length distributions reveal that the increase in survey biomass observed in 2016 is primarily large mature redfish and not recruits. Length distributions of redfish in the surveys furthermore reveals a complete lack of new year classes since 2009 (lack of redfish less than 20 (age 1 to 4) cm since 2013) in West Greenland. The stocks 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 incoming year classes of redfish have not been observed since 2011 in either the Greenland Shrimp and fish survey (2008-2016) nor the EU-Germany survey in East Greenland in 2019 (not shown). Spawning females have been observed in the inshore trawl survey in division 1D in April and May.

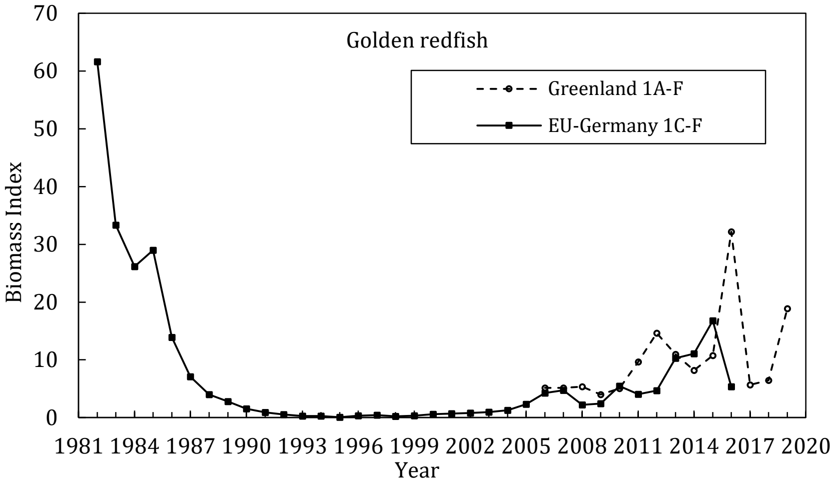


Figure 3.2. Golden redfish biomass indices in the EU-Germany survey (1C-F) and the Greenland shrimp and fish survey (1A-F).

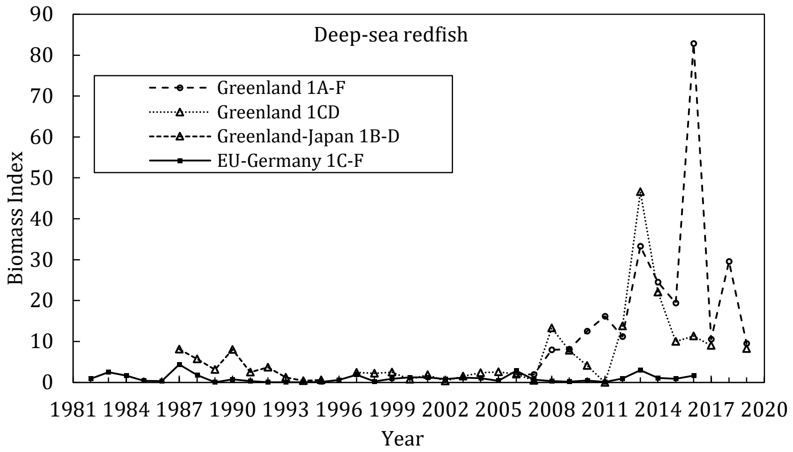


Figure 3.3. Demersal deep-sea redfish survey biomass from the Greenland shrimp and fish survey (1A-F), the Greenland deep-sea survey (1CD), the EU-Germany survey (1C-F) and the Greenland-Japan survey (1B-D).

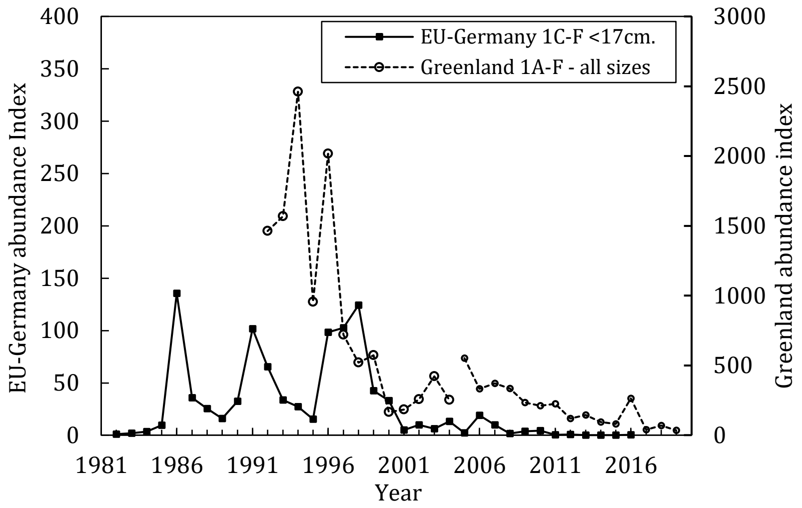


Figure 3.4. Juvenile redfish abundance indices (deep-sea redfish and golden redfish) for the EU-Germany survey (1C-F, <17cm), and the Greenland shrimp and fish survey (1A-F, all sizes).

c) Assessment results

Assessment: No analytical assessment could be performed for any of the stocks.

d) State of the stock

Golden redfish - *Sebastes norvegicus*

Biomass: The EU-Germany and Greenland Shrimp and fish survey have revealed a slightly increasing biomass of golden redfish from 2005 to 2015. Updated indices in the Greenland shrimp and fish survey (until 2019) and the EU-Germany survey (until 2016) has indicated that the biomass remains near the 2015 level. It can therefore be assumed that the biomass is still far below the 1980s level.

Fishing mortality: Unknown

Recruitment: Both the EU-Germany survey and the Greenland Shrimp and Fish survey indicates poor recruitment during the past two decades. In the Greenland shrimp and fish survey, virtually no new incoming year classes have been observed during the recent decade in West Greenland and East Greenland.

State of the stock: Survey indices indicate that the biomass remains far below historical levels. Recruitment has been poor for two decades and failing during the most recent decade. The overall stable biomass in recent years is the result of somatic growth or immigration balancing the limited fishery and natural mortality in the remaining stock.

Deep-sea redfish - *Sebastes mentella*

Biomass: The Greenland-Japan survey indicate that the biomass decreased from 1987 to 1995. The Greenland deep survey and the Greenland Shrimp and fish survey both indicated that the biomass remained low until 2007. Both the Greenland deep-sea survey and the Greenland shrimp and fish survey agree that the biomass of deep-sea redfish increased from 2008 to 2013/2017, but the biomass indices have decreased in the recent 4-7 years.

Fishing mortality: Unknown

Recruitment: Both the EU-Germany survey and the Greenland Shrimp and Fish survey indicates poor recruitment during the past two decades. In the Greenland shrimp and fish survey, virtually no new incoming year classes have been observed during the recent decade in West Greenland and East Greenland (lack of 1-4 year old fish less than 20 cm since 2013) and inshore in Division 1D.

State of the stock: Both the Greenland Shrimp and Fish survey (Div. 1A-F) and the Greenland deep-sea survey (Div. 1CD) indicate a decreasing biomass index of deep-sea redfish in the recent 4-7 years. Recruitment has been poor for two decades. No new incoming year classes have been identified during the trawl surveys in either East Greenland (EU-Germany survey), West Greenland offshore (EU-Germany survey and survey in Div. 1A-F), or inshore (Survey in Div. 1A-F) during the recent decade.

This stock will next be assessed in 2023.

4. Wolffish in Subarea 1

(SCR Doc. 80/VI/72 77 96/036 07/88 17/036 19/008, 20/06, 20/40; SCS Doc. 20/12)

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 (50-400m) than spotted wolffish (50-600m).

i) 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 4.1). 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. In 2015, reported catches have decreased and the lower catch level has continued until 2019 with just 190 t. It is reasonable to assume that the decrease is related to fishery targeting more profitable species, limiting catches to exploited bycatch only.

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

	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Atlantic wolffish TAC					1.00	1.00	1.00	1.00	0	
Spotted wolffish TAC					1.025	1.025	1.025	1.025	0	
Combined wolffish TAC	1	1	1	1	2.025	2.025	2.025	2.025	0	0
STATLANT 21	0.8	1.0	0.9	0.9	0.40	0.24	0.24	0.27	0.2	
STACFIS	0.78	1.0	0.9	0.9	0.40	0.20	0.24	0.26	0.2	

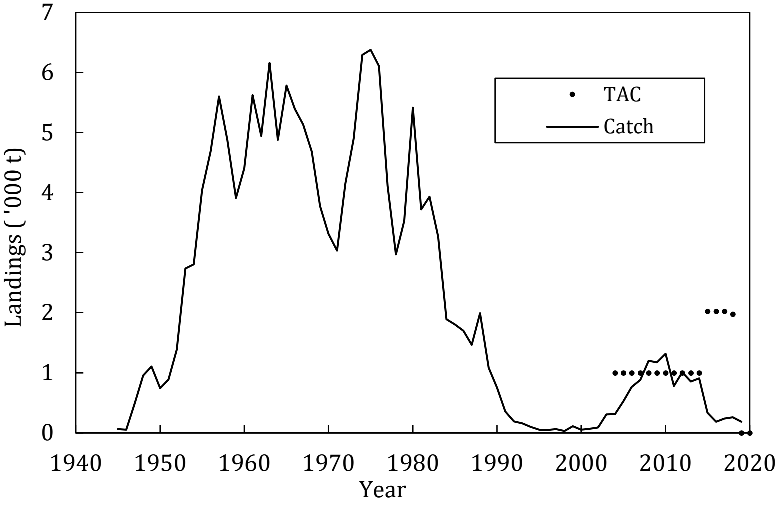


Figure 4.1. Wolffish in Subarea 1: Catches and TACs for Atlantic wolffish and spotted wolffish combined from 1945 to 2019.

b) Input data

i) Research survey data

The EU-Germany survey (RV Walther Herwig III, 0-400m, NAFO 1C-F, ICES XIV, since 1982) covers the southern part of the West Greenland shelf. The survey was cancelled in 2018 and had low coverage in West Greenland in 2017 and 2019.

The Greenland shrimp and fish survey (RV Pâmiut, 50-600m, NAFO 1A-F (South Greenland to 72N), 1992-2017, ICES 14 (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 commercial vessels using Pâmiut gear has been used to update indices in 2018 and 2019. Although the Shrimp and Fish survey experiences change vessel in 2018 and 2019, analysis of trawl performance have indicated that the indices are considered to be comparable. The Greenland shrimp and fish survey has a more appropriate geographical coverage in relation to wolffish, although none covers the inshore areas. Both surveys cover the main depth distribution of wolffish.

Atlantic wolffish:

The EU-Germany survey biomass index decreased significantly in the 1980s (Figure 4.2). From 2002 to 2005 biomass index increased to above average levels, but thereafter returned to the low levels observed during the 1990s. The index has not been updated since 2016, due to low coverage and survey cancellation. Abundance index in the EU-Germany survey decreased from the beginning of the time series, in 1982 to 1984, since then it remained stable with slightly increasing level from 2002 until 2005. After 2005, the abundance index 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 indix was at low levels during the 1990s, but increased slightly from 2002 and until the gear change in 2004. After 2005, the biomass index has gradually increased from 2006 onwards peaking in 2015 (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 peaking in 2015. The increase in abundance has been observed in divisions 1A-B, outside the EU-Germany survey area.

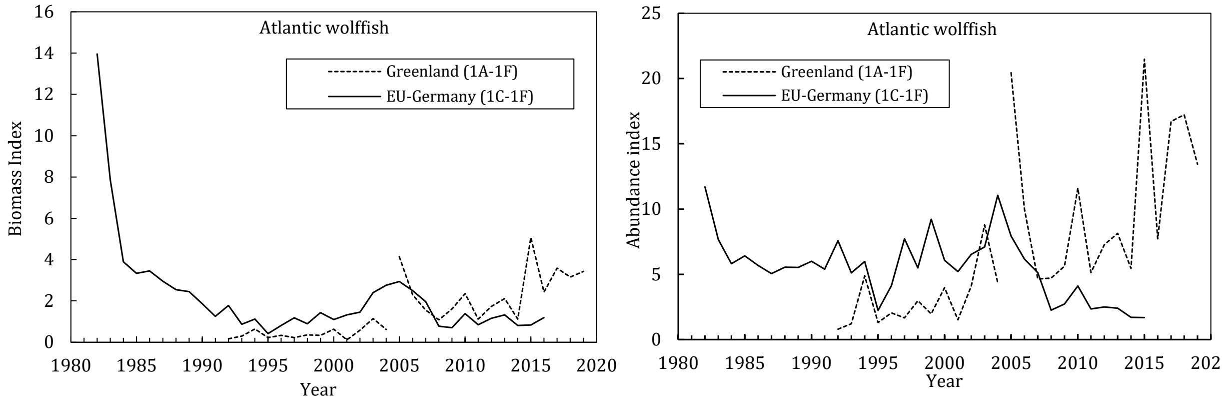


Figure 4.2. Atlantic wolffish survey biomass index (left) and abundance index (right) from the surveys.

Spotted wolffish:

The EU-Germany survey biomass index decreased from 1982 to 1984 and remained at low levels during the 1990s (Figure 4.3). From 2004, the survey biomass increased, and the recent indices were at the level observed at the beginning of the 1980s. Although highly variable, the abundance index has gradually increased since the mid 1990s (Figure 4.3).

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

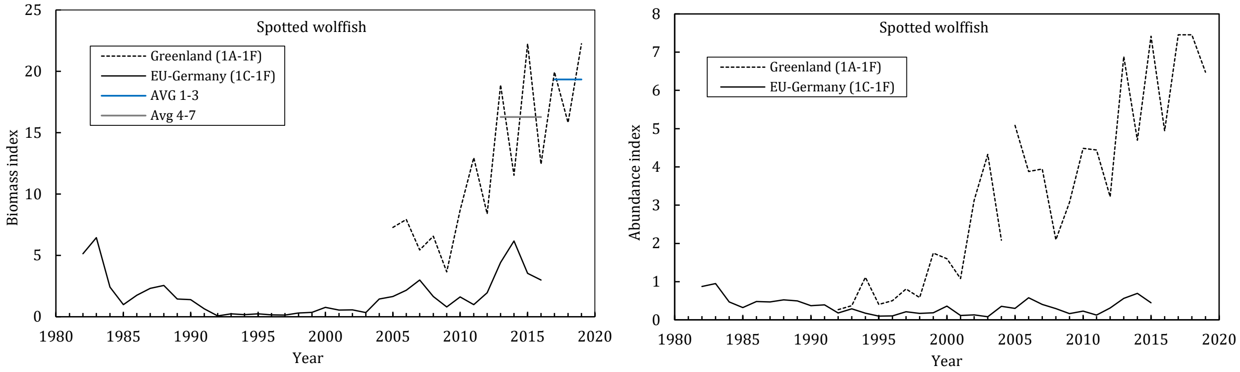


Figure. 4.3. Spotted wolffish survey biomass index (left) and abundance index (right) from the surveys.

c) Assessment results

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 index 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.

Biomass: The biomass index of the EU-Germany survey was far below the initial values in 2016. The survey biomass and abundance indices continue to increase in the Greenland Shrimp and fish survey.

Fishing mortality: Unknown

Recruitment: The higher survey abundance indices in 4 of the most recent 5 years, indicate better recruitment than during the preceding decade

State of the stock: The survey biomass and abundance indices continued to increase in the Greenland Shrimp and fish survey; however, the EU-Germany indices remained low (to 2016). As the EU-Germany survey and the Greenland shrimp and fish survey in the overlapping period were around the same level, it seems reasonable to assume that the biomass remains below the level of the 1980s

Spotted wolffish

Biomass: The biomass indices of the EU-Germany survey and the Greenland shrimp and fish survey were at a low level during the 1990s. From 2004 to 2016, the biomass index has gradually increased in the EU-Germany survey. The gradually increasing biomass was also observed in the Greenland shrimp and fish survey from 2002 to 2004 and after the gear change from 2005 to 2019.

Fishing mortality: Unknown

Recruitment: The Greenland shrimp and fish survey, indicate higher numbers of recruits from 2013 to 2019 observed as increasing numbers of spotted wolffish less than 40 cm.

State of the stock: Survey indices suggest continued stock growth. Although the catches were below the TAC from 2015-2018, there is no indication that the decreasing catches were related to a decrease in the stock. The average biomass index in the Greenland Shrimp and fish survey is 19% higher in the recent 3 years (2017-2019) compared to the preceding 4-year period.

These stocks will next be assessed in 2024.

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

Recent Conditions in Ocean Climate and Lower Trophic Levels

- The ocean climate index in 3M was normal between 2016 and 2019. Before that, 2015 was at its lowest value since 1993, while 2012 was marked by a record high.
- Spring bloom initiation was near normal in 2019 for a third consecutive year. Spring bloom magnitude was below normal in 2019 for the first time since 2015.
- The abundance of copepod and non-copepod zooplankton was above normal in 2019 with the 3rd and 2nd highest anomaly of the time series, respectively.
- Zooplankton biomass was below normal 2019 for the first time since 2014. It was the 3rd lowest anomaly of the time series

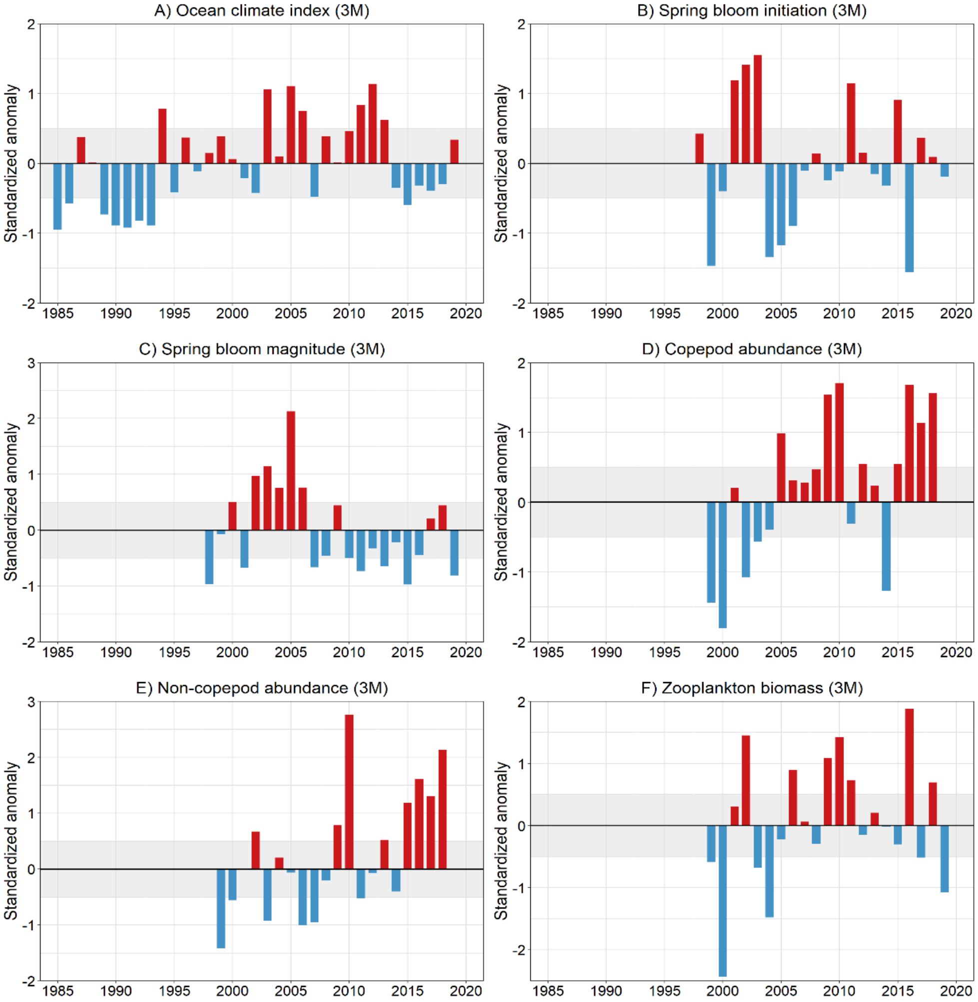


Figure B1. Environmental indices for Flemish Cap (in NAFO Div. 3M) during 1990-2019. The ocean climate index (A) for Flemish Cap is the average of 3 time-series of standardized ocean temperature anomalies: sea surface temperatures (SSTs) in Div. 3M, mean temperature over the offshore portion of Flemish Cap hydrographic section (stations FC-15 to FC-35) summer mean bottom temperature over the cap. SSTs and observations along the Flemish Cap hydrographic section are presented in Cyr et al. (2020). Bottom temperatures are derived using the same procedure used in Cyr et al. (2020), 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. Spring bloom initiation (B) and magnitude (C) indices for the 1998-2019 period are derived from two satellite Ocean Colour boxes (Flemish Pass, and Flemish Cap; see SCR Doc. 20/035 for box location). Zooplankton abundance (D & E) and biomass (F) indices for the 1999-2019 period are derived from a subset of 10 stations along the Flemish Cap Atlantic Zone Monitoring Program oceanographic section covering the Flemish Pass, the Flemish Cap, and the outer shelf break. 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 with the following reference periods: ocean climate index, 1981-2010; phytoplankton indices (magnitude and peak timing): 1998-2015; zooplankton indices (copepod, non-copepod, and biomass): 1999-2015. Anomalies within ± 0.5 SD (shaded area) are considered normal conditions.

Environmental Overview

Ocean Climate and Ecosystem Indicators

The ocean climate index in Division 3M (Figure B1.A) has remained mostly above normal between about 2003 and 2013. After the record-high of 2012, the index gradually decreased reaching in 2015 its lowest value since 1993. The index was however normal during the period 2016-2019, with only 2019 being on the positive side. Spring bloom initiation has been oscillating between short period (2-3 years) of earlier and later timing between 1998 and 2007. The timing of the spring bloom has remained mostly near normal since with the exceptions of two late blooms in 2011 and 2015, and the earliest bloom of the time series in 2016. Spring bloom initiation (Figure B1.B) in 2019 was near normal for a 3rd consecutive year. Spring bloom magnitude (Figure B1.C) was mainly above normal through the first half of the 2000s before decreasing to near or below normal levels through 2019. Spring production was below normal in 2019 after three consecutive years of near-normal levels. The abundance of copepod (Figure B1.D) and non-copepod (Figure B1.E) zooplankton showed a general increasing trend since the beginning of the time series. Copepod abundance was above normal in 2019 for a third consecutive year after a period of near-normal levels during the early 2010s. The abundance of non-copepods was above normal in 2019 for a 4th consecutive year and presented the second highest anomaly of the time series. Zooplankton biomass (Figure B1.F) showed a generally increasing trend between 1999 and 2010. Biomass then decreased throughout the 2010s except for the record-high biomass observed in 2016 and the above normal level observed in 2018.

5. Cod 3M (*Gadus morhua*) in Division 3M

(SCS Doc. 20/06, 20/07, 20/08, 20/09 and SCR Doc. 20/11, 20/31)

a) Introduction

The cod fishery on Flemish Cap has traditionally been a directed fishery by Portuguese trawlers and gillnetters, Spanish pair-trawlers and Faroese longliners. Cod has also been taken as bycatch in the directed redfish fishery by Portuguese trawlers. Estimated bycatch in shrimp fisheries is low. 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 5.1), 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.

Recent catches ('000 tonnes) are as follow:

,000 tons	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
TAC	5.5	10.0	9.3	14.1	14.5	13.8	13.9	13.9	11.1	17.5	8.5
STATLANT 21	5.2	10.0	9.1	13.5	14.4	12.8	13.8	13.9	10.5	13.0	
STACFIS	9.3	12.8	12.8	13.985	14.3	13.8	14.0	13.9	11.5	17.5	

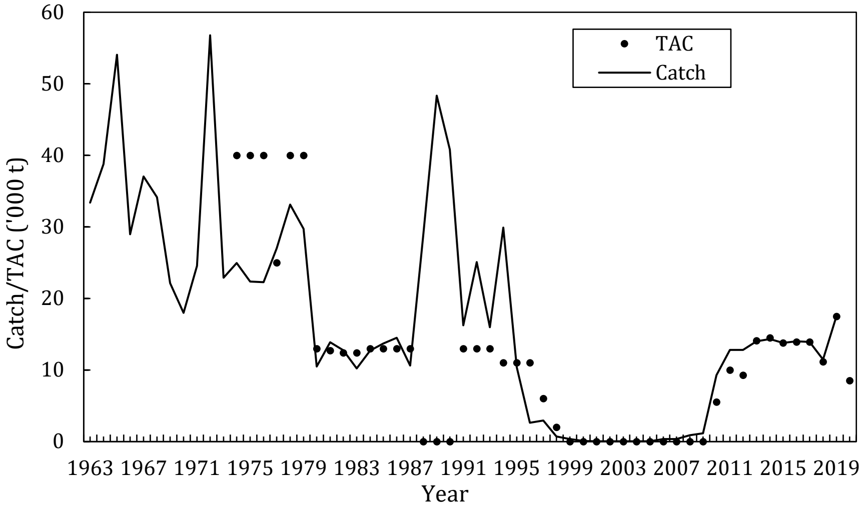


Figure 5.1. Cod in Division 3M: STACFIS catches and TAC.

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 can be seen until 1985, reaching the lowest level in 1982 (Figure 5.2).

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.

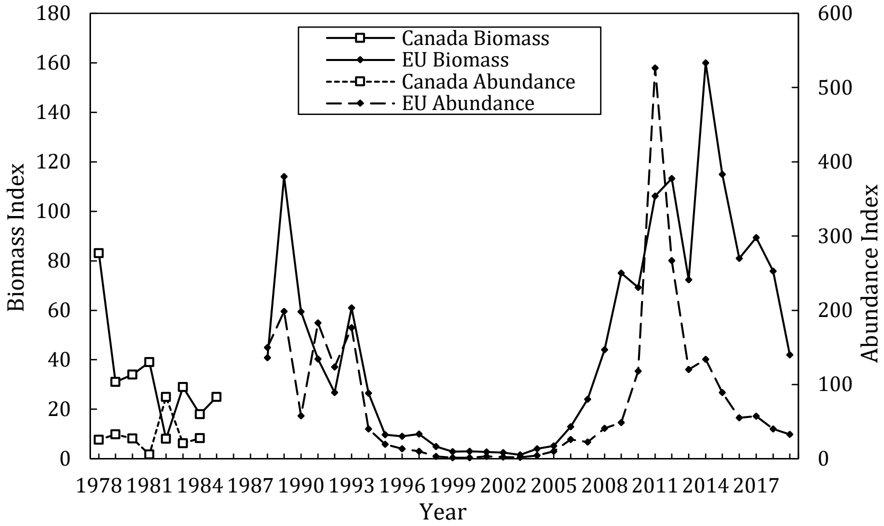


Figure 5.2. Cod in Division 3M: Survey abundance and biomass estimates from Canadian survey (1978-1985) and EU Flemish Cap survey (1988-2019).

ii) Recruitment

The recruitment index (age 1) from the Canadian survey was estimated at low levels except for 1982 and 1983. After several series of above average recruitments during 1988-1992, the EU Flemish Cap survey indicated 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, and a promising increase in 2019.

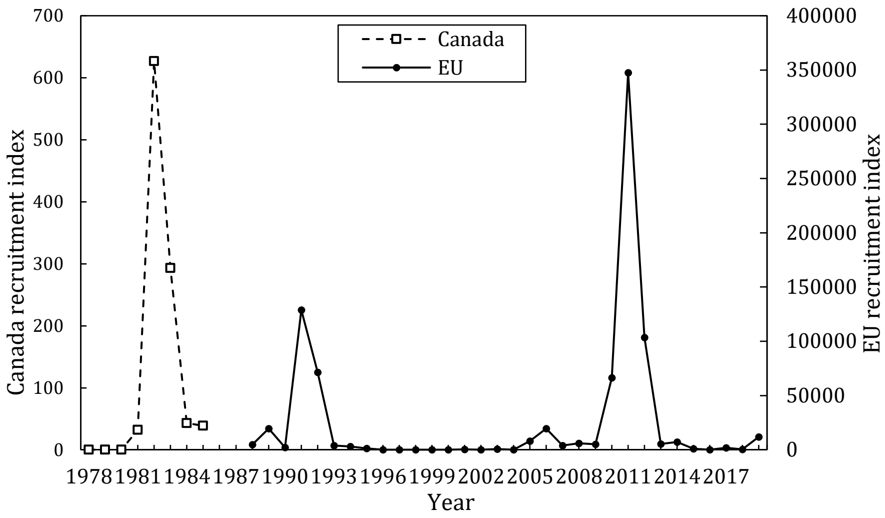


Figure 5.3. Cod in Division 3M: Number at age 1 in the Canadian survey (1978-1985) and EU survey (1988-2019).

iii) Fishery data

In 2019 eight countries fished cod in Div. 3M, trawlers from EU-Estonia, EU-Portugal, EU-Spain, Norway, Japan, Russia and St Pierre and Miquelon and longliners from Faroe Islands.

Length and age compositions from the commercial catches are available from 1972 to 2019 with the exception of the 2002 to 2005 period. Since 2010, length information was available for the major participants in the fishery. In 2019 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 62 cm, being 57 cm for EU-Portugal, 65 cm for EU-Spain, 63 cm for Norway and 74 cm for the Faroese longliners. The mean in the total commercial catch length distribution was 62 cm with a length range of 35-135 cm. Since 2013, the commercial catch at age data has been generated using ALKs from the EU survey. In 2018, ages 7 and 8+ were the most abundant in the catch, being age 6 in 2019.

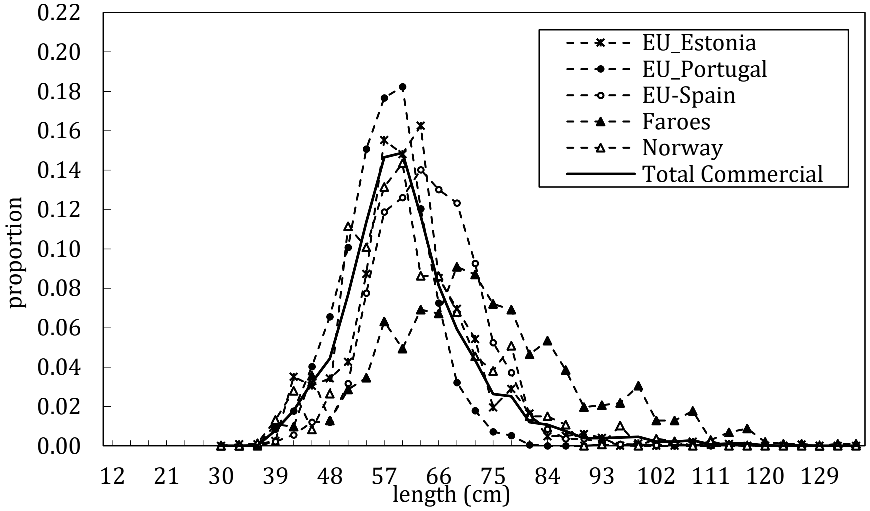


Figure 5.4. Cod in Division 3M: Length distribution of the commercial catches in 2019.

iv) Biological parameters

The 2019 indices were derived from the 2019 EU survey ALK. Mean weight-at-age in the stock and in the catch have been decreasing continuously since the reopening of the fishery, reaching the minimum for ages 4 to 8 in 2015-2017. In 2019, all the ages increased or remained quite stable their weight except ages 7 and 8 (Figures. 5.5 and 5.6).

Maturity ogives are available from the EU Flemish Cap survey for almost all years between 1988 and 2019. These were modelled using a Bayesian framework with missing values replaced with interpolations from adjacent years. There was a continuous decline of the A50 (age at which 50% of fish are mature), going from above 5 years old in the late 1980s to just below 3 years old in 2002 and 2003. Since 2005 there has been an increase in the A50, concurrently with the increase of the survey biomass, with the value in 2019 at the levels observed before 1990 (4.8 years old) (Figure 5.7).

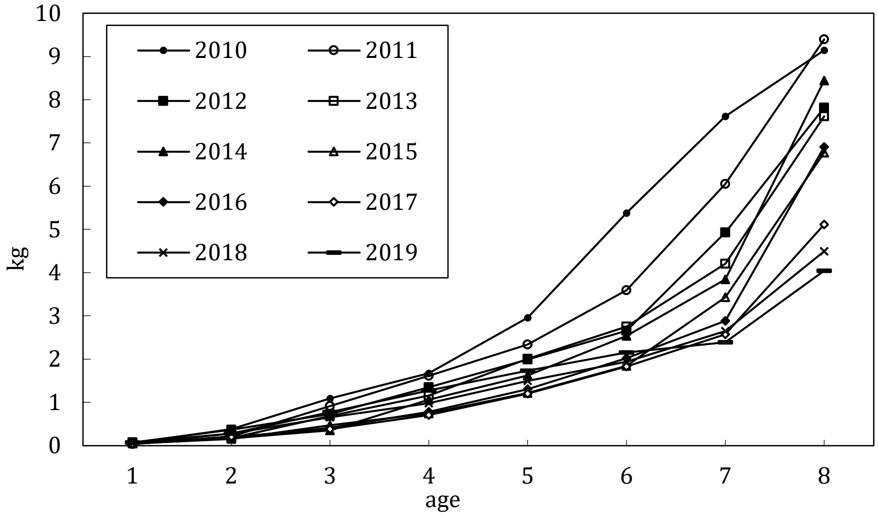


Figure 5.5. Cod in Division 3M: Mean weight-at-age in the stock for the 2010-2019 surveys.

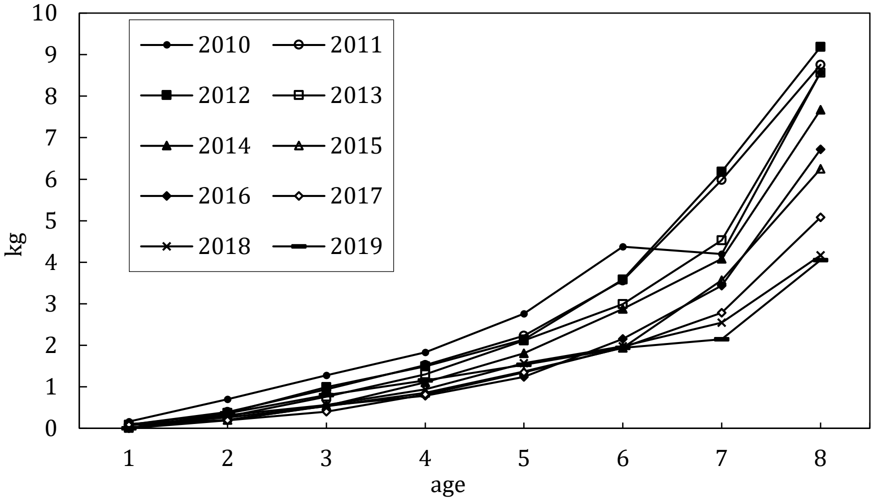


Figure 5.6. Cod in Division 3M: Mean weight-at-age in the catch for 2010-2019.

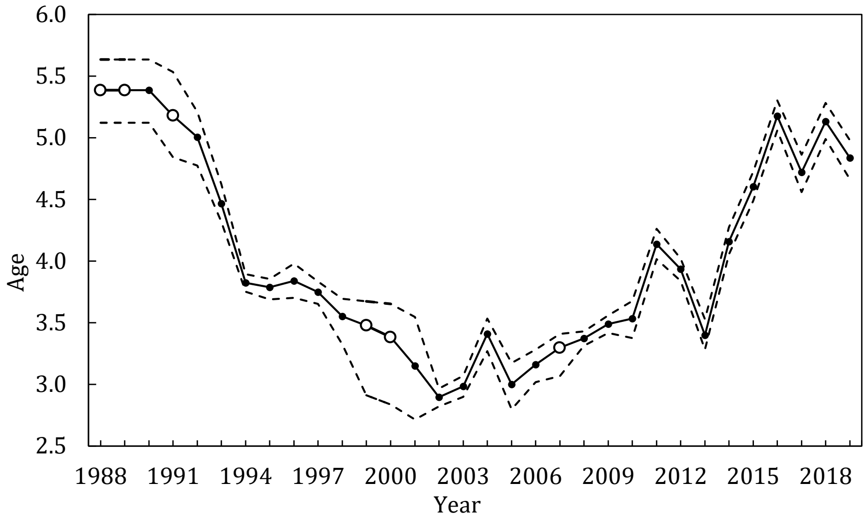


Figure 5.7. Cod in Division 3M: Age at 50% maturity (median and 90% confidence intervals) from Canadian survey (1978-1985) and EU-Flemish Cap survey (1988-2019). Interpolated years are represented in white circles.

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 1988-2019, 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 (1988-2019).

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 1988-2019	$LN\left(medrec,cvrec\right)$	*medrec*=45000, *cvrec*=10
N(1988,a), a=2-8+	Ages 2-7 $LN\left(median=medrec\times e^{-\sum_{age=1}^{a-1}M\left(age\right)+medFsurv\left(age\right)},cv=cvsurv\right)$ Ages 8+ $LN\left(median=medrec\times\frac{e^{-\sum_{age=1}^{A-1}\left(M\left(age\right)+medFsurv\left(age\right)\right)}}{1-e^{-M\left(A+\right)+medFsurv\left(A+\right)}},cv=cvsurv\right)$	*medFsurv*(1,…,7)={0.0001, 0.1, 0.5, 0.7, 0.7, 0.7, 0.7} *cvsurv*=10
f(y) y=1988-2019	Year 1988 $LN\left(median=medf,\ cv=cvf\right)$ Years 1989-2019 $LN\left(median=AR(1)\,over\,f,\ cv=cvf\right)$	*medf*=0.2, *cvf*=4
rC(y,a), a=2,8+ 1988-2019	Year 1988 $LN\left(median=medrC\left(a\right),\ cv=cvrC\left(a\right)\right)$ Years 1989-2019 $LN\left(median=last\ year\ rC,\ cv=cvrCcond\right)$	*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 1988-2019	$LN\left(median=\sum_{age=1}^{A+}mu.C\left(y,age\right)wcatch\left(y,age\right),\ cv=cvcW\right)$ $mu.C\left(y,a\right)=N\left(y,a\right)\left(1-e^{-Z\left(y,a\right)}\right)\frac{F\left(y,a\right)}{Z\left(y,a\right)}$	*cvCW=0.077*
Catch Numbers at age, a=2,8+ 1988-2019	$LN\left(median=mu.C\left(y,a\right),\ cv=cv.C\right)$	*cv.C*=0.2
EU Survey Indices (I) 1988-2019	$I(y)\sim LN\left(median=\mu(y,a),\ cv=cvEU\right)$ $\mu(y,a)=q(a)\left(N(y,a)\frac{e^{-\alpha Z(y,a)}-e^{-\beta Z(y,a)}}{\left(\beta-\alpha\right)Z(y,a)}\right)^{\gamma(a)}$ $\gamma(a)\begin{cases}\sim N(\text{mean}=1,\text{variance}=0.25),\ if\ a=1\\=1,\ if\ a\geq 2\end{cases}$ $\log(q(a))\sim N(\text{mean}=0,\text{variance}=5)$	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 73% to levels observed prior to the closure of the fishery. Median biomass has also declined, but to a lesser extent (by 49%) as the strong year classes of 2009 to 2011 have grown and dominate the biomass (Figure 5.8).

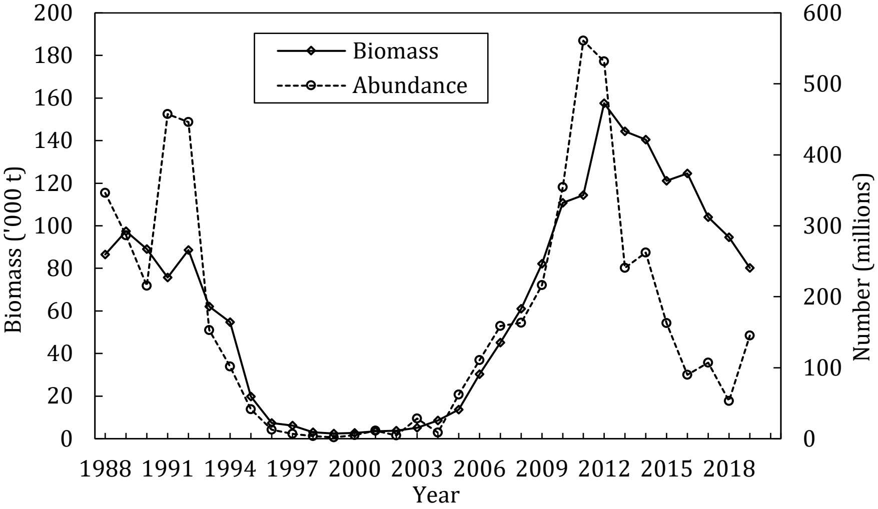


Figure 5.8. Cod in Div. 3M: Biomass and Abundance estimates.

Spawning stock biomass: Estimated median SSB over B_{lim} (Figure 5.9) 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 15 271 t; see below, section g) in 2020 is very low (1%). SSB in 2020 was calculated using the numbers estimated by the assessment at the beginning of 2020, applying the maturity ogive and mean weight at age in stock from 2019.

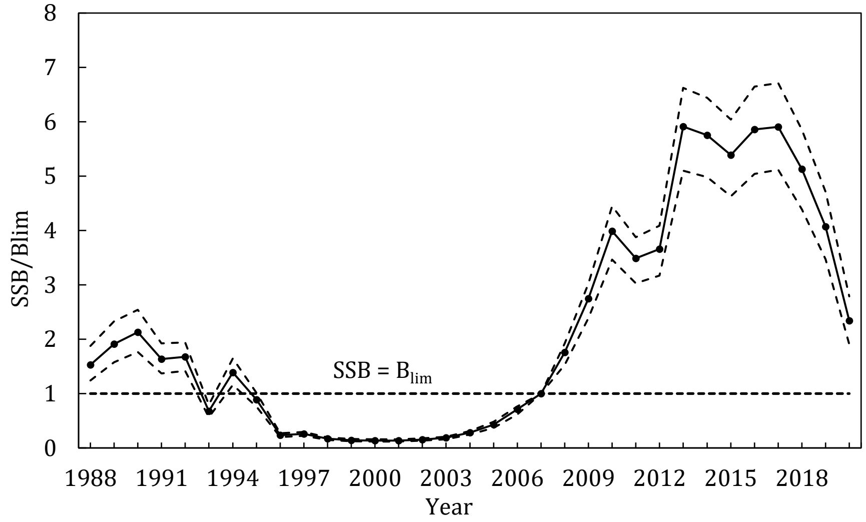


Figure 5.9. Cod in Div. 3M: Median and 80% probability intervals SSB/B_{lim} estimates. The horizontal dashed line corresponds to SSB = B_{lim}.

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. Between 2015 and 2018 recruitment was very low, with an increase in 2019 (Figure 5.10).

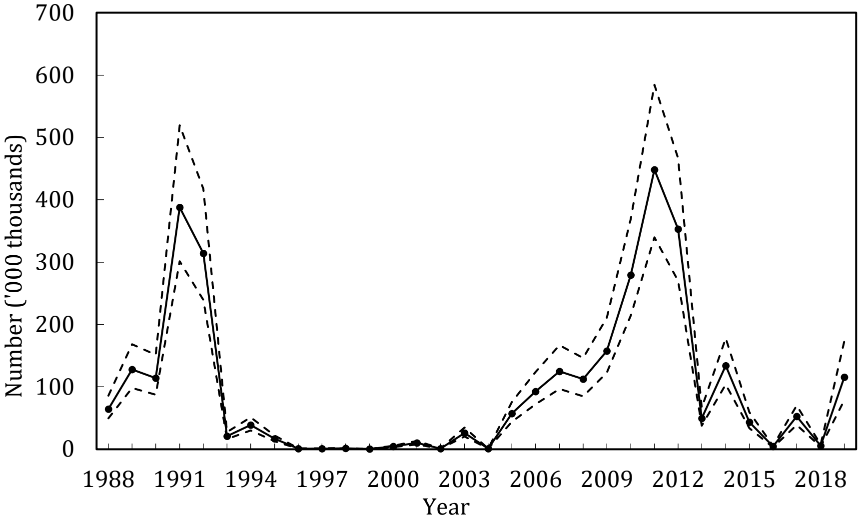


Figure 5.10. Cod in Div. 3M: Recruitment (age 1) estimates and 80% probability.

Fishing mortality: F increased in 2010 with the re-opening of the fishery although it was below F_{lim} (0.191, see below, section g) until 2018. In 2019, F increased, being above F_{lim} (Figure 5.11).

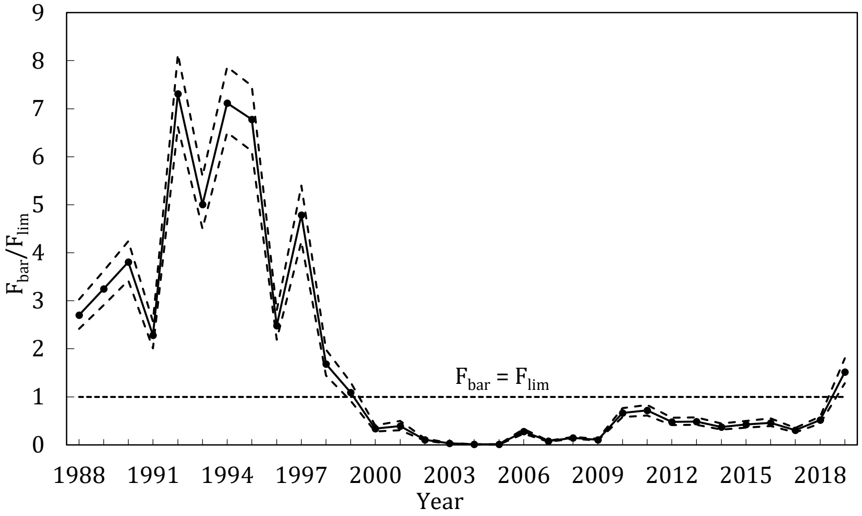


Figure 5.11. Cod in Div. 3M: F_{bar} (ages 3-5) estimates and 80% probability intervals. The horizontal dashed line corresponds to $F = F_{lim}$.

Natural mortality: The posterior median of M by age estimated by the model was:

Age	1	2	3	4	5	6	7	8
Posterior	1.38	0.61	0.36	0.26	0.27	0.38	0.33	0.39

e) Retrospective analysis

A five-years retrospective analysis with the Bayesian model was conducted by eliminating successive years of catch and survey data. Figures 5.12 to 5.14 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 5.12). These revisions lead to revisions in the SSB. There is very little evidence of a retrospective pattern in F (Figures 5.13 and 5.14).

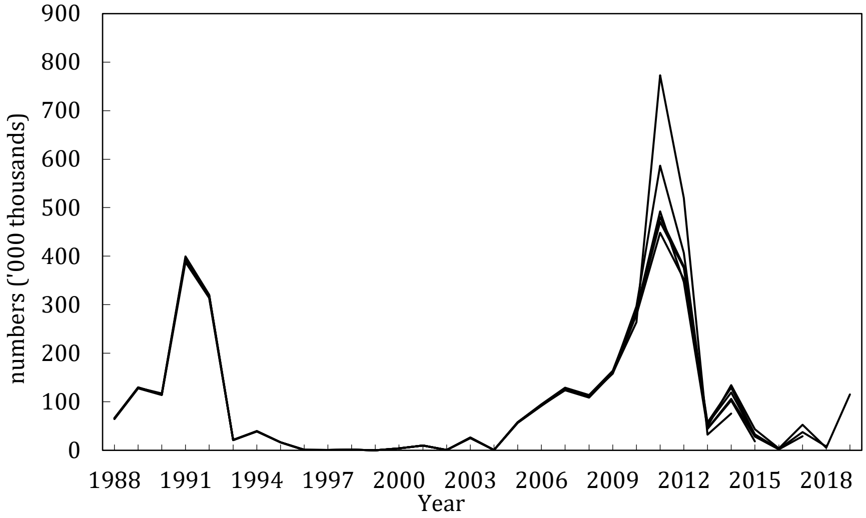


Figure 5.12. Cod in Div. 3M: Retrospective results for recruitment.

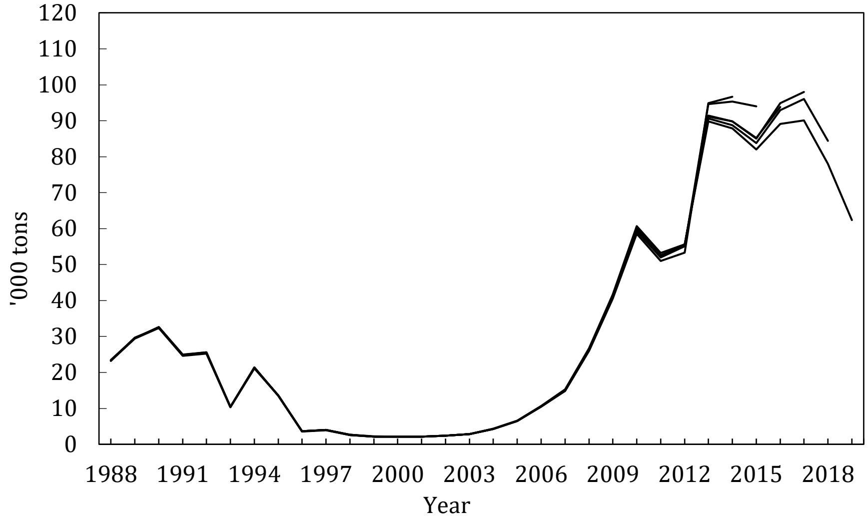


Figure 5.13. Cod in Div. 3M: Retrospective results for SSB.

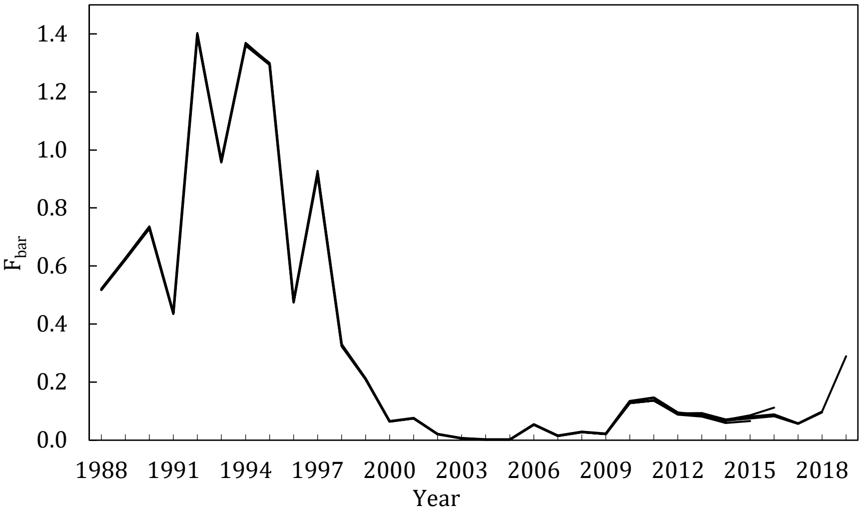


Figure 5.14. Cod in Div. 3M: Retrospective results for average fishing mortality.

f) State of the stock

Current SSB is estimated to be above *Blim* (median 15 271 t) although it is declining rapidly and is expected to continue its decline in the near future due to poor recruitment between 2015 and 2018.

F increased in 2010 with the re-opening of the fishery although until 2018 it was below *Flim* (median 0.191). In 2019, *F* increased to a level above *Flim*.

g) Reference Points

Blim was estimated as the 2007 SSB, being its median value15 271 tons (Figure 5.15). *Flim* was estimated based on $F_{30\%SPR}$ calculated with the mean 2017-2019 input data as 0.191 (median value) (Figure 5.16).

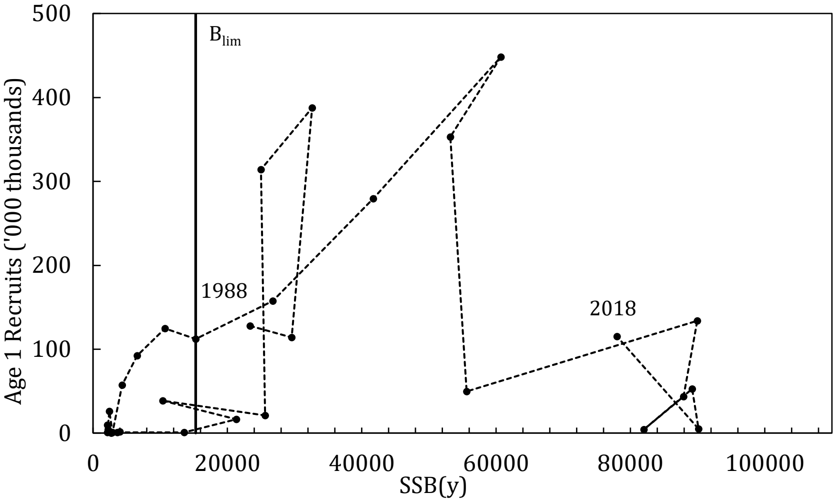


Figure 5.15. Cod in Div. 3M: Stock-Recruitment age 1 (posterior medians) plot. *Blim* is plotted in the graph.

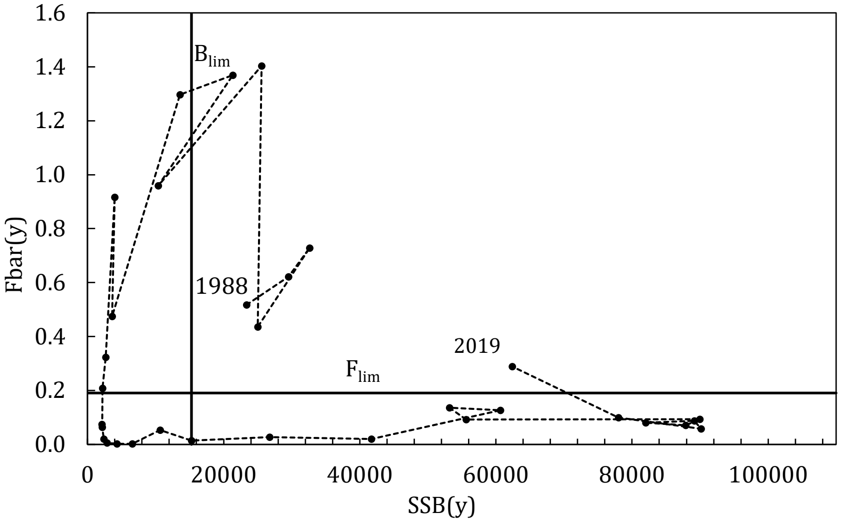


Figure 5.16. Cod in Div. 3M: Stock-F_{bar}(3-5) (posterior medians) plot. B_{lim} and F_{lim} are plotted in the graph.

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 2020 to the start of 2024 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 2020: estimated from the assessment.

Recruitments for 2020-2023: Recruits per spawner were drawn randomly from 2016-2018.

Maturity ogive for 2020-2023: Mean of the last three years (2017-2019) maturity ogive.

Natural mortality for 2020-2023: 2019 natural mortality from the assessment results.

Weight-at-age in stock and weight-at-age in catch for 2020-2023: Mean of the last three years (2017-2019) weight-at-age.

PR at age for 2020-2023: Mean of the last three years (2017-2019) PRs.

F_{bar}*(ages 3-5)*: Four scenarios were considered:

(*Scenario 1*) F_{bar}=3/4F_{lim} (median value = 0.143).

(*Scenario 2*) F_{bar}=0 (no catch).

(*Scenario 3*) Catch in 2021-2023=1000 tons.

(*Scenario 4*) Catch in 2021-2023=3000 tons.

All scenarios assumed that the Yield for 2020 is the established TAC (8 531 t).

The results indicate that under all scenarios, total biomass during the projected years will decrease sharply (Figure 6.17), while the SSB will increase slightly in 2023 and 2024 with the F=0 and the Catch=1000t scenarios (Figure 6.18). The probability of SSB being below B_{lim} in 2022 and 2023 is very high (≥24%) in the scenarios with F_{bar}=3/4F_{lim} and Catch=3000t, being very low (≤10%) in the rest of the cases. The probability of SSB in 2023 being above that in 2020 is <1%.

Under all scenarios, the probability of F exceeding F_{lim} is less than or equal to 6%.

Under 3/4F_{lim}, the projected Yield has a decreasing trend in the projected years (2021-2023).

Results of the projections are summarized in the following table:

	B		SSB		Yield
	Median and 80% CI				
F_{bar}=3/4F_{lim} (median=0.143)					
2020	48777	(42258 - 55350)	35725	(30140 - 41365)	8531
2021	35857	(30252 - 41757)	23121	(18576 - 27867)	5595
2022	26786	(21764 - 32499)	15472	(11920 - 19144)	4622
2023	19902	(15130 - 25556)	14280	(10838 - 18316)	3494
2024	15396	(10877 - 21078)	13556	(9424 - 18349)	
F_{bar}=0					
2020	48777	(42258 - 55350)	35725	(30140 - 41365)	8531
2021	35857	(30252 - 41757)	23121	(18576 - 27867)	0
2022	32245	(27255 - 37930)	20159	(16445 - 23914)	0
2023	28937	(24157 - 34759)	22321	(18764 - 26370)	0
2024	27386	(22667 - 33174)	25006	(20842 - 29872)	
Catch=1000 tons					
2020	48777	(42258 - 55350)	35725	(30140 - 41365)	8531
2021	35857	(30252 - 41757)	23121	(18576 - 27867)	1000
2022	31265	(26251 - 36956)	19317	(15655 - 23065)	1000
2023	27176	(22347 - 32982)	20743	(17192 - 24760)	1000
2024	24680	(19993 - 30474)	22430	(18278 - 27230)	
Catch=3000 tons					
2020	48777	(42258 - 55350)	35725	(30140 - 41365)	8531
2021	35857	(30252 - 41757)	23121	(18576 - 27867)	3000
2022	29305	(24278 - 35017)	17616	(13964 - 21334)	3000
2023	23596	(18837 - 29285)	17549	(14040 - 21560)	3000
2024	19249	(14646 - 24980)	17264	(13095 - 22048)	

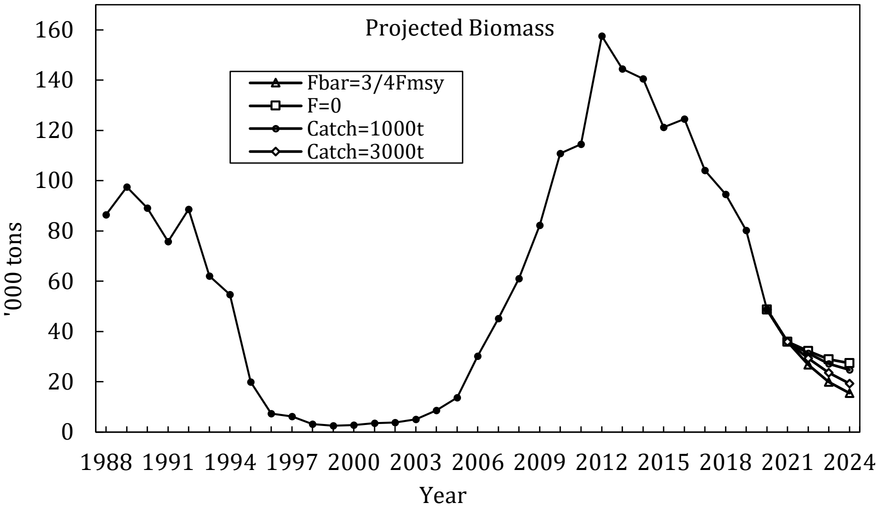


Figure 5.17. Cod in Div. 3M: Projected Total Biomass under all the Scenarios.

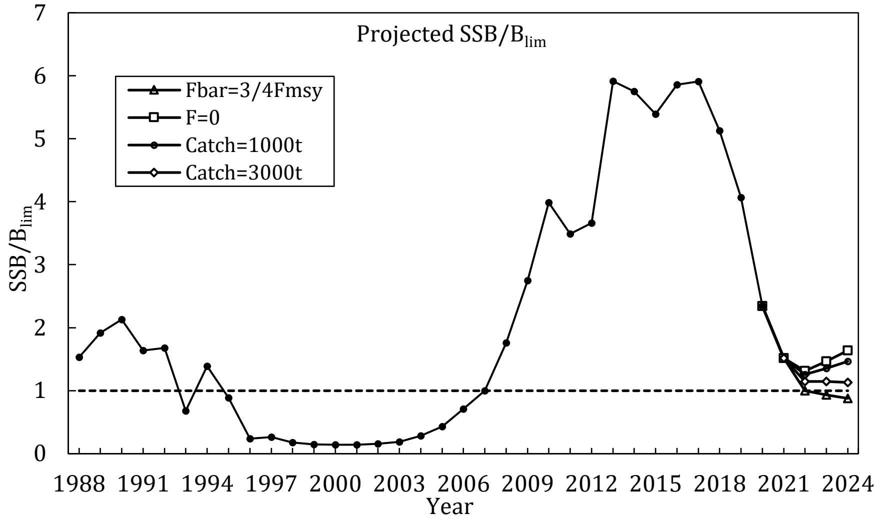


Figure 5.18. Cod in Div. 3M: Projected SSB under all the Scenarios

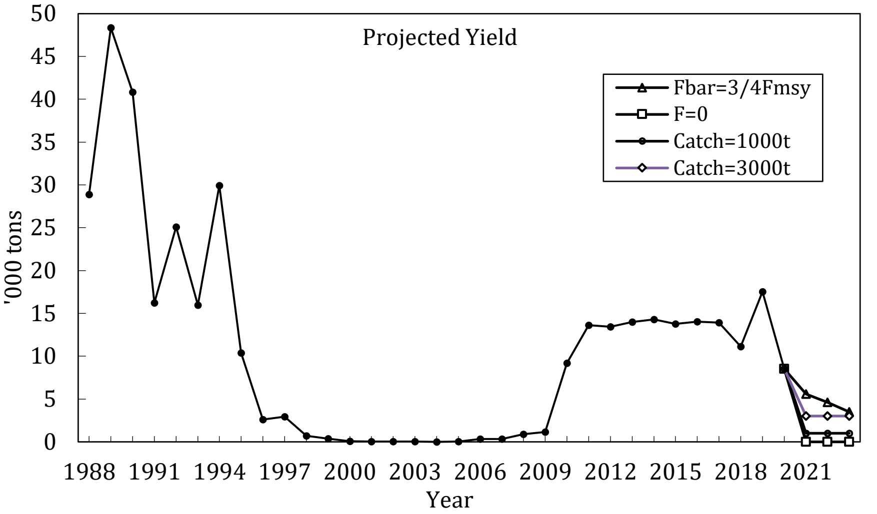


Figure 5.19. Cod in Div. 3M: Projected removals under all the Scenarios

The risk of each scenario is presented in the following table:

	Yield			$P(B < B_{lim})$				$P(F > F_{lim})$			
	2020	2021	2022	2020	2021	2022	2023	2020	2021	2022	$P(B_{23} > B_{20})$
3/4Flim = 0.143	8531	5595	4622	<1%	1%	50%	62%	4%	5%	6%	<1%
F=0	8531	0	0	<1%	1%	6%	1%	4%	0%	0%	<1%
Catch=1000t	8531	1000	1000	<1%	1%	10%	4%	4%	<1%	<1%	<1%
Catch=3000t	8531	3000	3000	<1%	1%	24%	24%	4%	<1%	<1%	<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. Much progress in understanding where the differences between the commercial and survey ALKs come from was made but still needs more research to completely know the problem. No progress since then was made. NAFO reiterates this recommendation.

STACFIS **encouraged** to *all Contracting Parties to provide length distribution samples from the commercial vessels fishing 3M cod*.

STATUS: NAFO reiterates this recommendation.

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

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

(SCR Doc. 19/016, 20/011; SCS Doc. 20/05, 20/06, 20/07, 20/09, 20/13)

Interim Monitoring Report

a) Introduction

There are three species of redfish that are commercially fished on Flemish Cap; deep-sea redfish (*Sebastes mentella*), golden redfish (*Sebastes norvegicus*) and Acadian redfish (*Sebastes fasciatus*). The term beaked redfish is used for *S. mentella* and *S. fasciatus* combined. Because of difficulties with identification and separation, all three species are reported together as 'redfish' in the commercial fishery. All stocks have both pelagic and demersal concentrations and long recruitment process to the bottom. Redfish species are long lived with slow growth.

i) Description of the fishery

The redfish fishery in Div. 3M increased from 20 000 tons in 1985 to 81 000 tons in 1990, falling continuously since then until 1998-1999, when a minimum catch around 1100 tons was recorded mostly as by-catch of the Greenland halibut fishery. An increase of the fishing effort directed to Div. 3M redfish is observed 2005 onwards basically pursued by Portuguese bottom trawl and Russia bottom and pelagic trawl. Part of this fishing effort has been deployed on shallower depths above 300m and is associated with the increase of cod catches and reopening of the Flemish Cap cod fishery in 2010.

STACFIS catch estimates were available till 2010. Over 2006-2010 an average annual bias of 15% plus was recorded between SACFIS catch estimate and STATLANT nominal catch. In order to mitigate the lack of independent catch data a 15% surplus has been added to the STATLANT catch of each fleet between 2011 and 2014. For 2015 the annual catch was given by the Daily Catch Reports (DCR's) by country provided by the NAFO Secretariat. For 2016 catch was calculated using the CDAG Estimation Strategy (NAFO Regulatory Area Only). The 2017 - 2019 catch estimates were obtained with the application of the CESAG method. The 1989-2019 catch estimates from those different sources are accepted as the 3M redfish landings.

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

	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
TAC	10.0	6.5	6.5	6.5	6.7	7.0	7.0	10.5	10.5	8.6
STATLANT 21	9.7	5.4	6.8	6.4	6.9	6.6	7.1	10.5	10.5	
STACFIS Total catch[1]	11.1	6.2	7.8	7.4	6.9	6.6	7.1	10.5	10.5	
STACFIS Catch[2]	9.0	6.3	5.2	4.6	5.2	6.2	6.9	10.3	10.2	

[1] STACFIS total catch on 2011-2014 based on the average 2006-2010 bias.

[2] STACFIS beaked redfish catch estimate, based on beaked redfish proportions on observed catch.

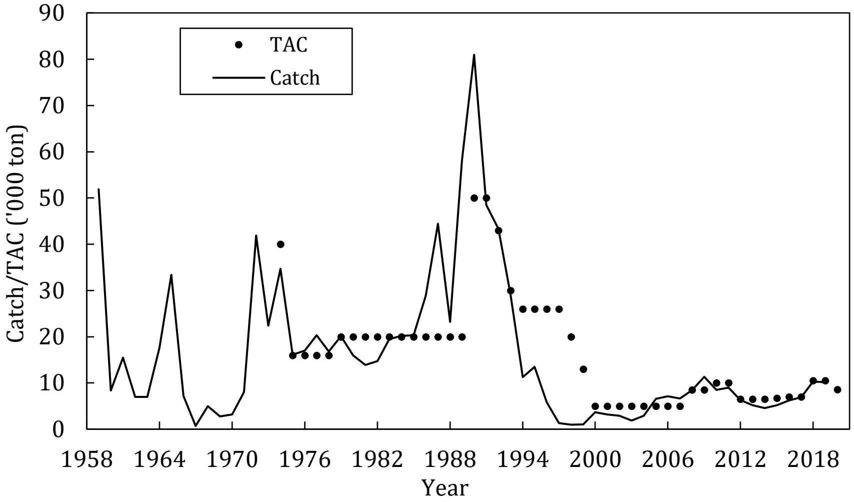


Figure 6.1. Redfish in Div. 3M: catches and TACs.

b) Data Overview

i) Research surveys

Flemish Cap Survey: Despite a sequence of abundant year classes and a low exploitation regime over almost twenty years, survey results suggest that the beaked redfish stock increased sharply from 2004 to 2006 and then declined rapidly over the second half of the 2000's. Such unexpected shift on the stock dynamics can only be attributed to mortality other than fishing mortality. Spawning stock biomass has remained high in recent years while exploitable biomass and abundance are declining since 2012 (Figure 6.2). There has been very low recruitment at age four in most recent years.

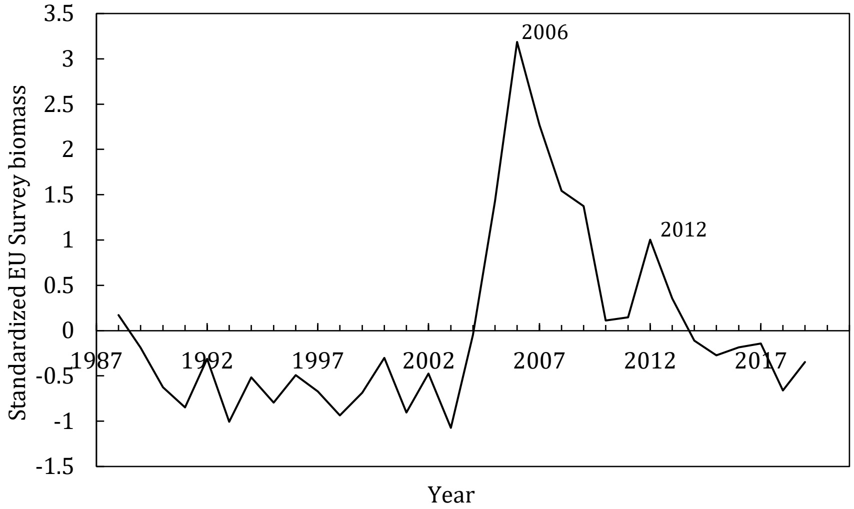


Figure 6.2. Beaked redfish in Div. 3M: survey standardized total biomass index (1988-2019).

c) Conclusions

The perception of the stock status has not changed.

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

7. Golden Redfish (*Sebastes norvegicus*) in Division 3M

(SCR Doc. 19/016, 19/035, 20/011; SCS Doc. 20/05, 20/06, 20/07, 20/09, 20/13)

Interim Monitoring Report

a) Introduction

There are three species of redfish that are commercially fished on Flemish Cap; deep-sea redfish (*Sebastes mentella*), golden redfish (*Sebastes norvegicus*) and Acadian redfish (*Sebastes fasciatus*). The term beaked redfish is used for *S. mentella* and *S. fasciatus* combined. Because of difficulties with identification and separation, all three species are reported together as 'redfish' in the commercial fishery. All stocks have both pelagic and demersal concentrations and long recruitment process to the bottom. Redfish species are long lived with slow growth.

The separation of the three species is 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 also applied in assessments of beaked redfish.

i) Description of the fishery

Catches of golden redfish in Division 3M increased from 1,158 tonnes in 2006 to a peak of 7,662 tonnes in 2009. In 2010, catches decreased and remained relatively stable until 2014 between 2,000 and 3,000 tonnes. After 2014, catches decreased continuously, being from 2016 to 2018 at residual levels (148 tonnes in 2018). In 2019 provisional catches of golden redfish are 259 tonnes. EU-Portugal, EU-Spain, the Russian Federation and EU-Estonia are responsible for the bulk of the redfish landings over the last two decades.

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

	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
TAC[1]	10.0	6.5	6.5	6.5	6.7	7.0	7.0	10.5	10.5	8.6
STATLANT 21[1]	9.7	5.4	6.8	6.4	6.9	6.6	7.1	10.5	10.5	
STACFIS Total catch[2]	11.1	6.2	7.8	7.4	6.9	6.6	7.1	10.5	10.5	
STACFIS Catch[3]	2.1	1.9	2.6	2.9	1.7	0.4	0.3	0.1	0.3	

[1] TAC, STATLANT 21 and STACFIS Total catch refer to all three redfish species combined.

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

[3] STACFIS golden redfish catch estimate, based on golden redfish proportions on observed catch.

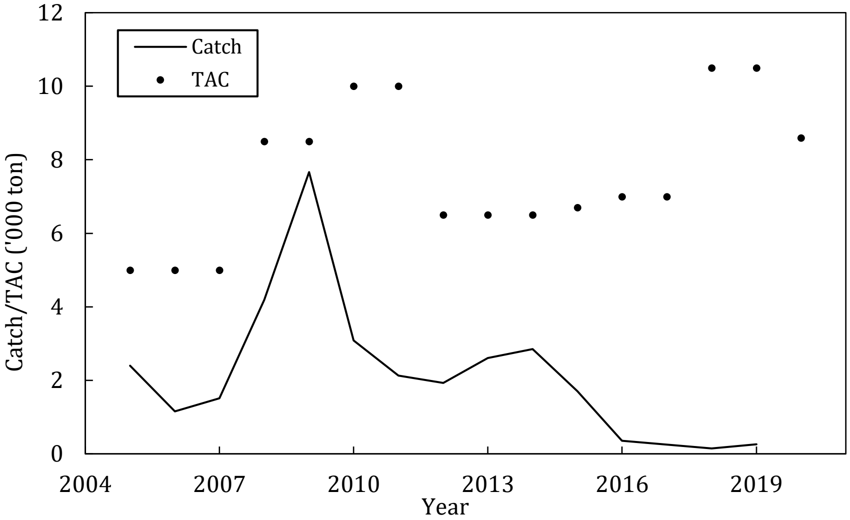


Figure 7.1. Golden redfish in Div. 3M: Golden redfish catches and TACs of all three redfish species combined.

b) Data Overview

i) Research surveys

The 1988-2019 EU survey biomass and abundance indices for golden redfish are presented in Figure 7.2. 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 2019 are at very low levels. Survey results are noisy, with the characteristic variance of redfish indices, but broad trends show through the noise.

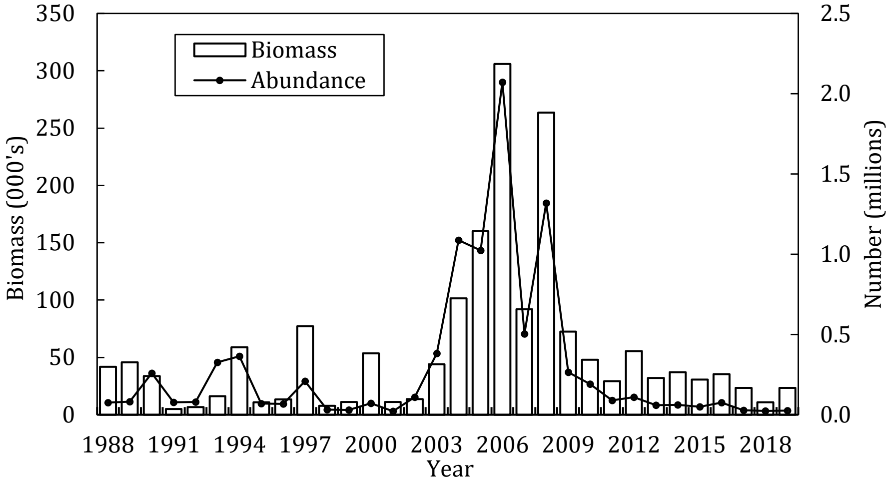


Figure 7.2. Golden redfish in Div. 3M: EU biomass and abundance indices, 1988-2019.

c) Conclusions

The perception of the stock status has not changed.

Given the current situation of the stock, it was not considered appropriate to apply any assessment model or to give advice for golden redfish separately. Nevertheless, as in previous years, advice for golden redfish is given indirectly based on the Div. 3M beaked redfish assessment (advice of 3M redfish applies the current percentage of golden redfish). SC will continue to monitor the golden redfish stock status and provide advice as part of the beaked redfish advice.

The next assessment of the stock is planned when the dynamic of the stock changes.

8. American Plaice (*Hippoglossoides platessoides*) in Division 3M

(SCR Doc. 05/29; 20/11, 39; SCS Doc. 18/8, 13; 19/9; 20/7, 9, 13)

a) Introduction

The American plaice stock occurs mainly at depths shallower than 600 m on Flemish Cap. Catches are taken mainly by otter trawl, primarily in a bycatch fishery since 1992.

Nominal catches during 1960 to 1973 varied with a peak of about 5 341 tonnes in 1965. Catches of this stock became regulated in 1974 and ranged from 275 tonnes (1993) to 5 600 tonnes (1987) until 1996. Since 1997 catches have remained low and declined to a historical minimum in 2012 (63 tonnes). Catches increased in recent years, oscillating between 120 and 300 tonnes and are taken as bycatch partially in the Div.3M cod fishery

From 1979 to 1993 a TAC of 2 000 tonnes was in effect for this stock. A reduction to 1 000 tonnes was agreed for 1994 and 1995 and a moratorium was agreed to thereafter (Figure 8.1).

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

	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
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	0.3	
STACFIS	0.1	0.1	0.2	0.2	0.3	0.2	0.2	0.2	0.3	

ndf No directed fishing.

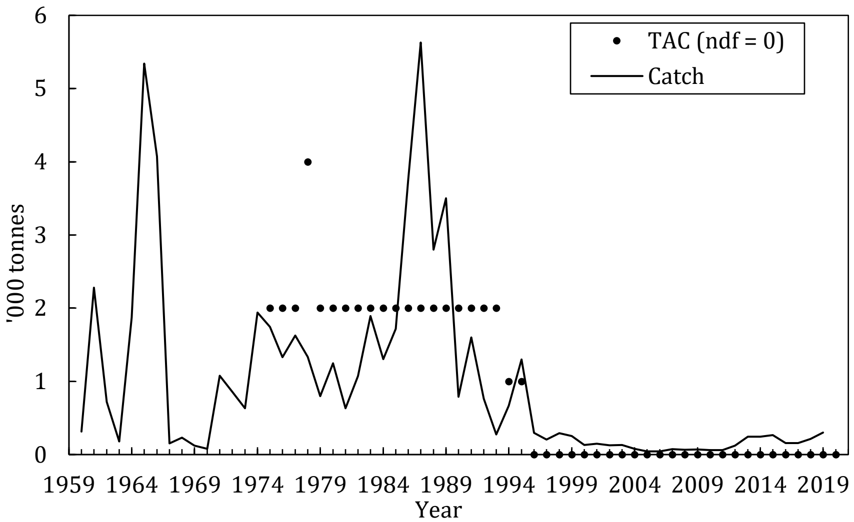


Figure 8.1. American plaice in Div. 3M: STACFIS catches and TACs. No directed fishing is plotted as 0 TAC.

b) Input Data

i) Commercial fishery data

EU-Portugal provided length composition data for the 2017, 2018 and 2019 trawl catches. EU-Spain provided length composition data for the 2019 trawl catches. Russia provided length composition data for the 2017 and 2019 trawl catches, the Portuguese 2019 length frequency was not used due to the low number of individuals sampled. The length frequencies were used to estimate the length and age compositions for the 2017-2019 total catch. There is no dominant age in catches between 2017 and 2019, with catches distributed mainly between the ages of 4 to 12.

ii) Research survey data

The series of research surveys conducted by the EU since 1988 were continued in July 2019. In June 2003 a new Spanish research vessel, the RV Vizconde de Eza replaced the RV Cornide de Saavedra that had carried out the EU survey series with the exception of the years of 1989 and 1990. In order to preserve the full use of the 1988-2002 survey indices, the original mean catch per tow, biomass and abundance at length distributions for American plaice have been converted to the new vessel units so that each former time series could be comparable with the new indices obtain with the RV Vizconde de Eza. The methodology used to convert the series was accepted by STACFIS in 2005 (SCR 05/29). The results of the calibration show that the RV Vizconde de Eza is 33% more efficient than the RV Cornide de Saavedra in catching American plaice.

USSR/Russia conducted surveys from 1972 to 1993 with two additional surveys conducted in 2001 and 2002. From 1972 to 1982 the USSR survey used a fixed-station design. Since 1983 USSR/Russia adopted a stratified random survey design and the USSR surveys for 1972 to 1982 were post-stratified for comparison to the new survey series. Canada conducted research vessel surveys from 1978 to 1985, and a single survey was conducted in 1996.

Although the USSR/Russia survey series (1972-1993) shows high variability, there was a decreasing trend during 1986-93. Abundance and biomass from the USSR/Russia survey in 2001 were the lowest of the series. Canadian survey biomass and abundance between 1978 and 1985 varied without trend at a level similar to that seen in the USSR/Russia survey and in 1996 were similar to estimates from the EU survey (Figure 8.2). The EU survey series had a continuous decreasing trend in abundance and biomass from the beginning of the series to 2000 and has remained low. The 2007 abundance and biomass were the lowest of the series. Since 2008, due to improved recruitment, biomass and abundance indices increased. The EU's survey biomass shows a faster upward trend than the abundance, due to the growth of existing year classes. In recent years the stock recovered to the levels of mid 90´s, when the fishery was closed.

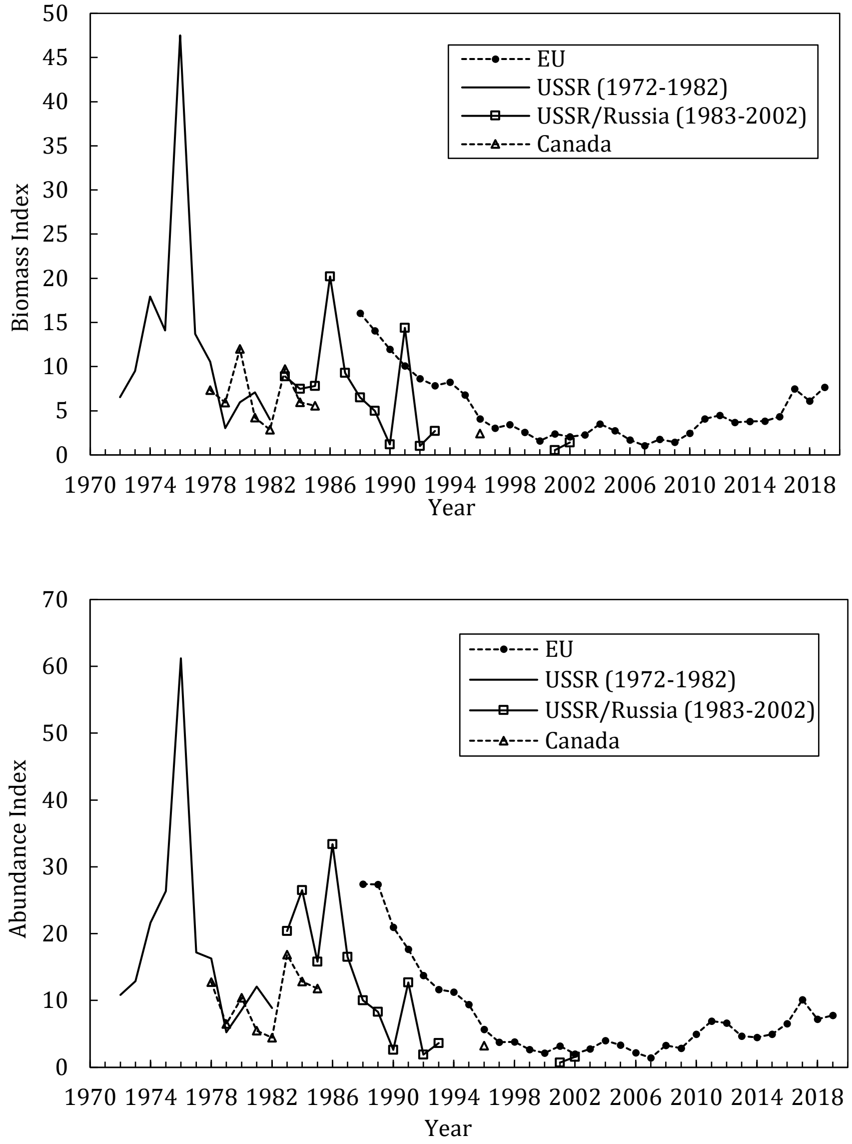


Figure 8.2. American plaice in Div. 3M: trends in survey biomass and abundance indices. EU survey data prior to 2003 have been converted to RV Vizconde Eza equivalents.

Ages 7, 6 and 4 corresponding to the 2012, 2013 and 2015 year-classes respectively, were dominant in the 2019 EU survey. Between 2006 and the 1990 year-class, the recruitment was very poor as shown by EU survey indices.

An index of spawning stock biomass (50% of age 5 and 100% of age 6 plus) from the EU survey series declined from 1988 to 2000 and has remained low. A minimum was recorded in 2007. During 2010-2012 the index increased and then stabilized till 2016 around 3 500 tonnes as the strong 2006 year class entered the SSB. From 2016 to 2019 this index increased to around 7 000 tonnes with the entering of new year classes. However, there are few fish aged 16 or older.

c) Estimation of Parameters

A fishing mortality index (*F*) is given by the catch and EU survey biomass ratio for ages fully recruited to the fishery.

A partial recruitment vector for American plaice in Div. 3M was revised assuming flat topped partial recruitment and adjusting a relative mean index-at-age to a general logistic curve. This index was derived by determining the ratio between the 1988-2019 age composition of the catch and American plaice EU survey abundance. Both data sets were standardized to numbers-per-thousand prior to analysis.

In the last assessment in 2017, extensive exploratory analyses were conducted to investigate the impact of changing: 1) the first age in the assessment (age 1 or 4); 2) the first year of the tuning fleet (1998 or 1994); 3) splitting the tuning series in two (1988-1993 and 1994-2016); 4) or changing M from 0.2 to 0.15. The XSA with age 4 onwards, M=0.15 and splitting the tuning fleet showed better diagnostics, but they are highly dependent on the input sets and show a strong retrospective pattern. In this year assessment no further exploratory analysis was done and the XSA was updated by adding the 2017, 2018 and 2019 data, although it shows a better retrospective pattern, the model behavior didn´t changed and it is still highly dependent on the input sets (such as M input, since F is too low). (Figure 8.3)

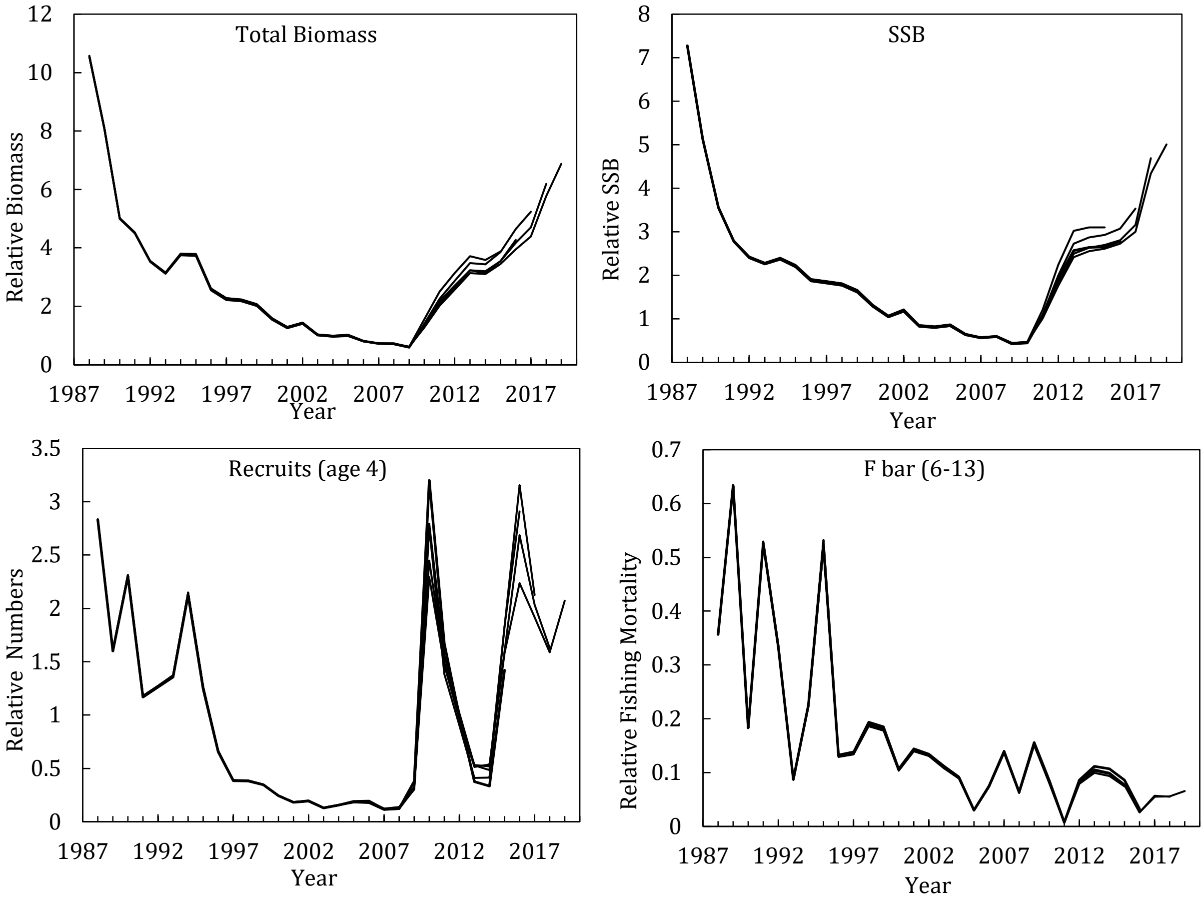


Figure 8.3. American plaice in Div. 3M: XSA retrospective analysis, last year 2016-2010: biomass, spawning stock biomass, average fishing mortality (ages 6-13) and recruitment (age 4).

The VPA-type Bayesian model with all data (ages 1-16+, tuning from 1988-2016) run in the last assessment was updated with the 2017-2019 data and run with M=0.1.5 with the same c.v. (0.05). The model runs used the following input sets:

Catch data: catch numbers and mean weight at age for 1988-2019.

Catchability analysis: dependent on stock size for age 4.

Priors: for survivors at age at the end of the final assessment year, for survivors from the last true age at the end of every year, for numbers at age of the survey and for the natural mortality.

The VPA-type Bayesian model results indicated a dependency on the chosen priors and their distribution.

None of the analyses (XSA or VPA-type Bayesian model) were accepted as a basis to estimate stock size. Nevertheless, the XSA was chosen to illustrate trends in the stock (Figure 8.4).

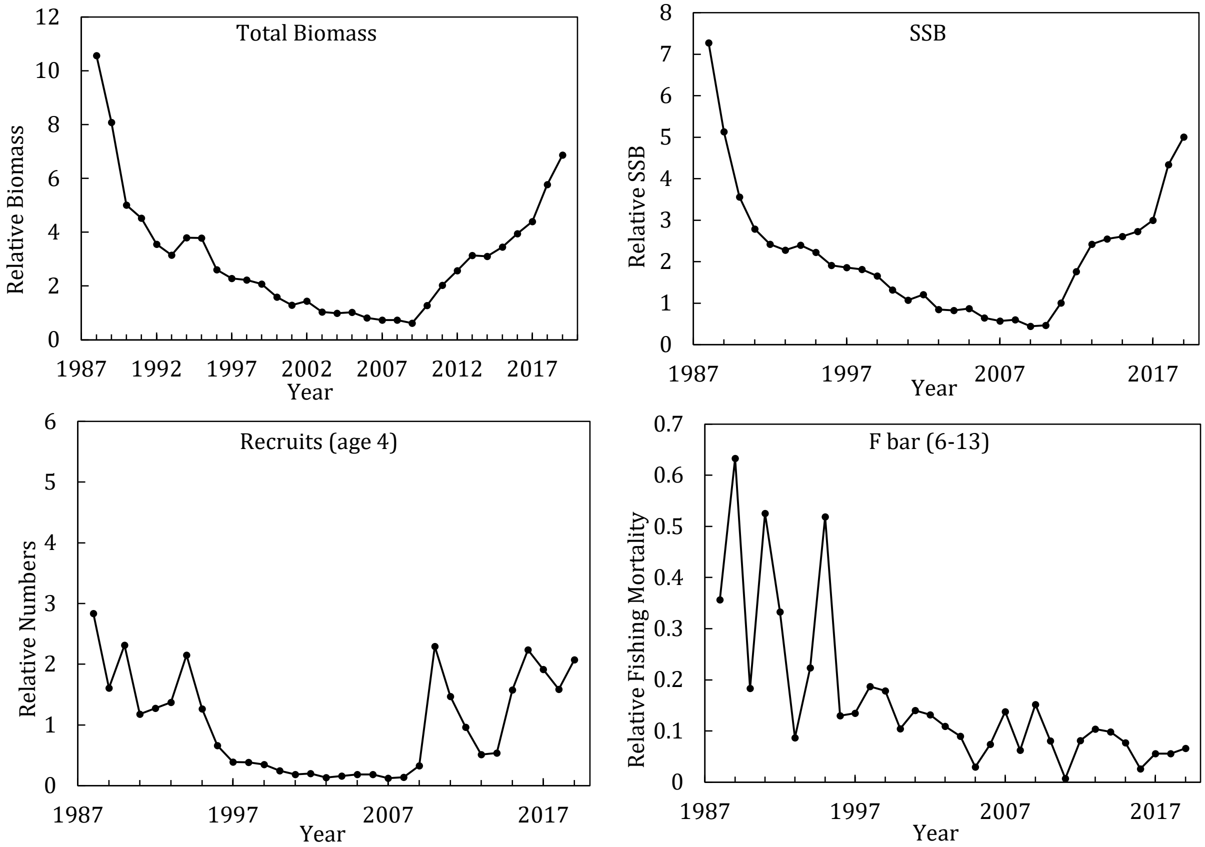


Figure 8.4. American plaice in Div. 3M: stock trends in the XSA exploratory assessment.

d) Illustrative XSA and Surveys results

Both fishing mortality index (C/B) and XSA fishing mortality declined from the mid-1980s to the mid-2000s (Figure 8.5). Since 2011 fluctuated at or below 0.1. In recent years *F* has increased.

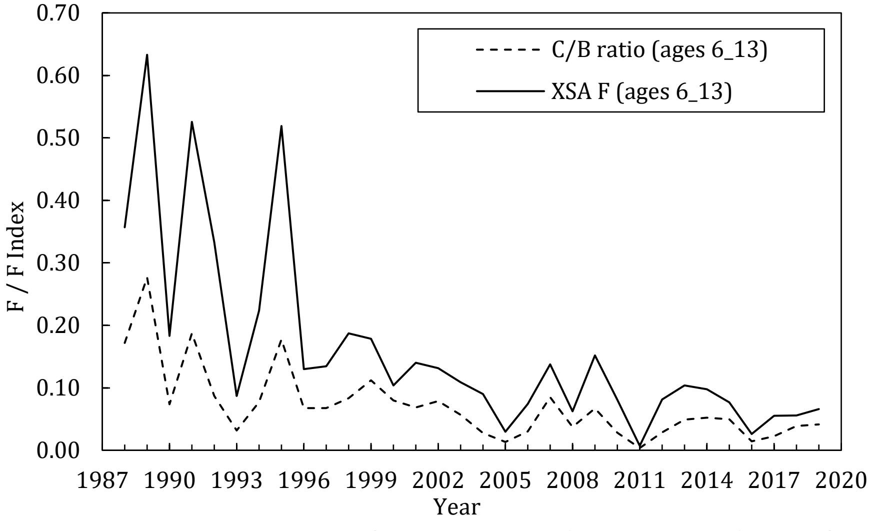


Figure 8.5. American plaice in Div. 3M: fishing mortality (catch/biomass) index from EU survey (ages 6-13) and XSA estimated fishing mortality (ages 6-13).

The EU survey and illustrative XSA indicates only poor recruitment from 1991 to 2005 year class. SSB recorded a minimum in 2007. During 2010-2012 SSB increased and then stabilized till 2016 as the strong 2006 year class entered the SSB. From 2016 to 2019 SSB recovered, as total biomass, to the levels of mid 90´s, when the fishery was closed (Figure 8.6). However, there are few fish aged 16 or older.

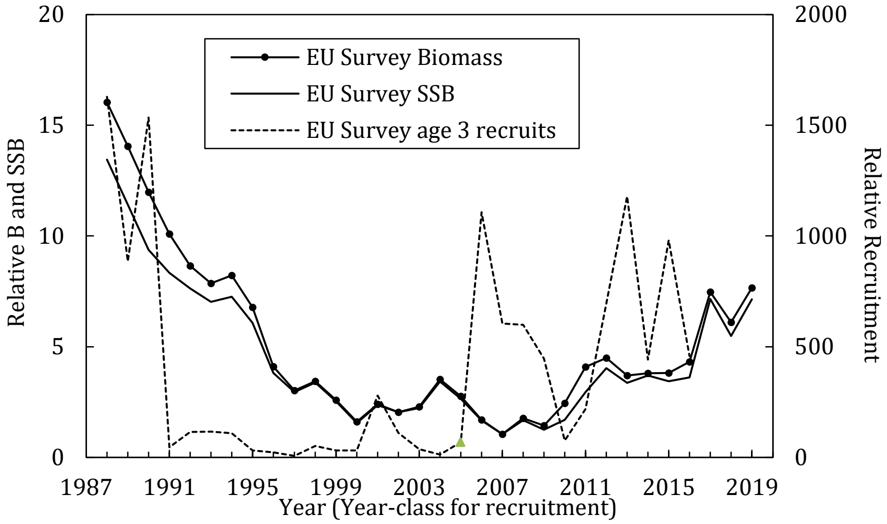


Figure 8.6. American plaice in Div. 3M: biomass, spawning stock biomass (SSB) and corresponding recruitment (age 3) from the EU Survey.

e) Assessment Results

This stock is assessed based upon a qualitative evaluation of stock survey biomass trends and recruitment indices. The XSA was used to illustrate trends in the stock.

Biomass: Stock biomass and SSB recorded a minimum in 2007, due to consistent year-to-year recruitment failure from the 1991 to 2005 year-classes. Stock biomass and SSB increased from 2007 to 2012 and have remained stable at a relatively low level. From 2016 to 2019 both biomasses recovered, to the levels of mid 90´s, when the fishery was closed (Figure 8.6).

Fishing Mortality: Fishing mortality index (C/B) declined from the mid-1980s to the mid-2000s and since 2000 fluctuated at or below 0.1. In recent years *F* has increased.

Recruitment: All of the 1991 to 2005 year-classes are estimated to be weak. Since 2006 the recruitment improved, particularly the 2006, 2012, 2013 and 2015 year classes.

State of the Stock: The stock has increased in recent years due to improved recruitment (at age 3) since 2009, and recovered to the levels of the mid 1990s, when the fishery was closed. Both catches and F remain low, although slightly higher catches are observed since 2013.

f) Reference Points

STACFIS is not able to provide proxies for biomass reference points at this time.

The fishing mortality proxy (Catch/Biomass index) remains low, as the spawning stock biomass increases (Figure 8.7).

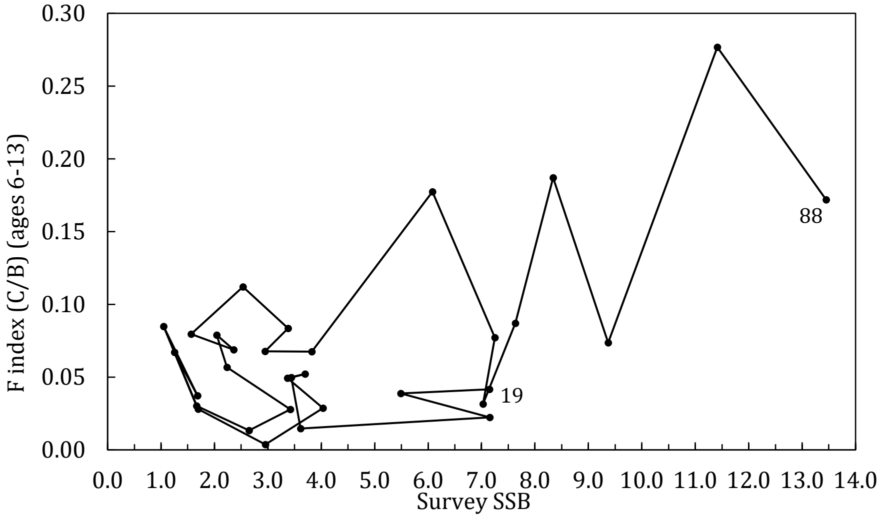


Figure 8.7. American plaice in Div. 3M: stock trajectory within the NAFO PA framework.

The following set of parameters was used for the yield-per-recruit analysis: M = 0.2 or 0.15; exploitation pattern described above; maturity of 50% at age 5 and 100% at age 6 plus; and an average mean weights-at-age in the catch and in the stock for the period 1988-2019. This analysis gave:

For $M = 0.2$, $F_{0.1} = 0.161$ and $F_{max} = 0.337$.

For $M = 0.15$, $F_{0.1} = 0.124$ and $F_{max} = 0.248$.

g) Research Recommendations

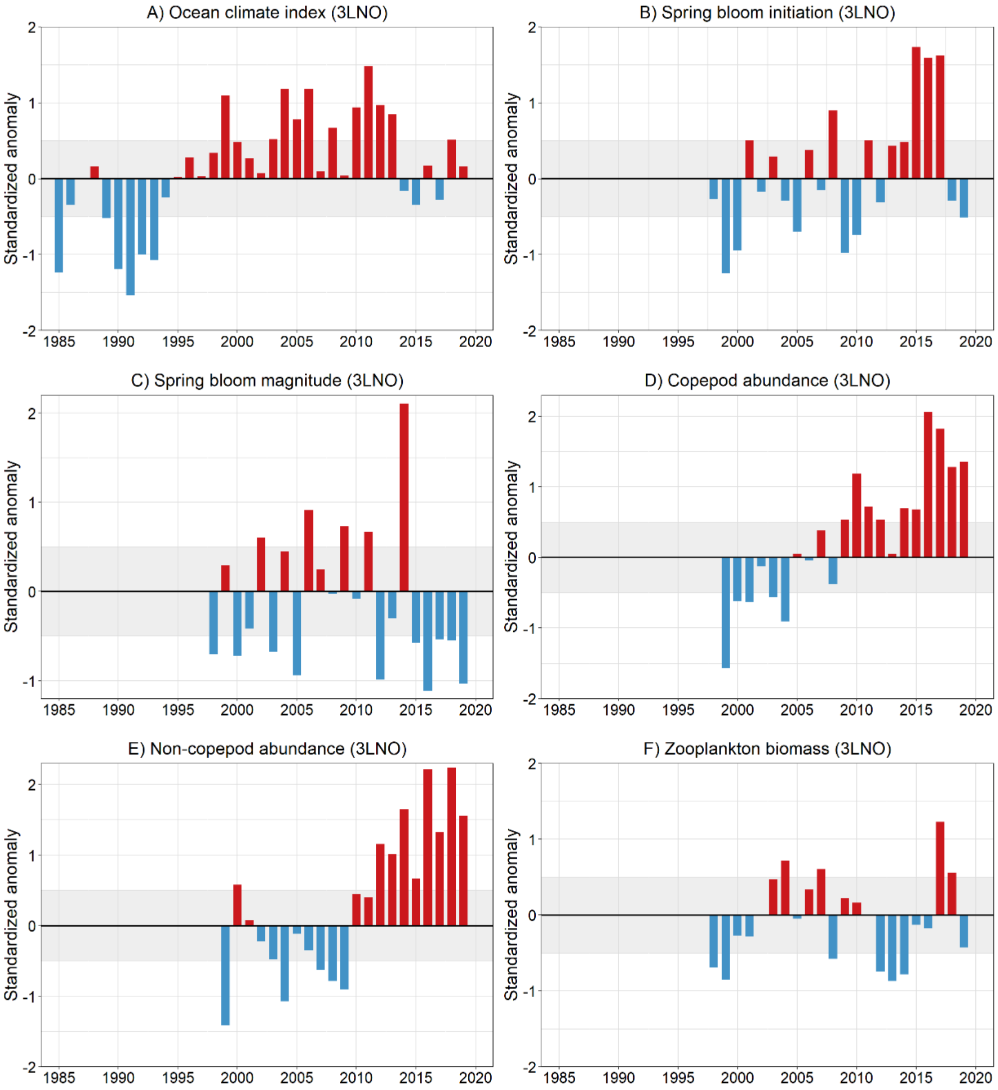
STACFIS **recommends** that *other types of models should also be explored, and that Div. 3M American plaice stock be a candidate for an assessment benchmark together with the Div. 3LNO American plaice stock or other flatfish stocks.*

This stock will be full assessed in 2023.

C. STOCKS ON THE GRAND BANKS (NAFO DIVISIONS 3LNO)

Recent Conditions in Ocean Climate and Lower Trophic Levels

- After a decade of above-average ocean temperatures in NAFO Divs. 3LNO - Grand Bank, the climate index was normal between 2014 and 2019
- Spring bloom initiation was near normal in 2019 for a 2nd consecutive year after the three latest bloom of the time series. Spring bloom magnitude in 2019 was below normal with the second-lowest anomaly of the time series.
- The abundance of copepod was above normal in 2019 for a 6th consecutive year. Non-copepod abundance was also above normal for the 8th consecutive year.
- Zooplankton biomass returned to near normal in 2019 after two years of above normal levels.
- a



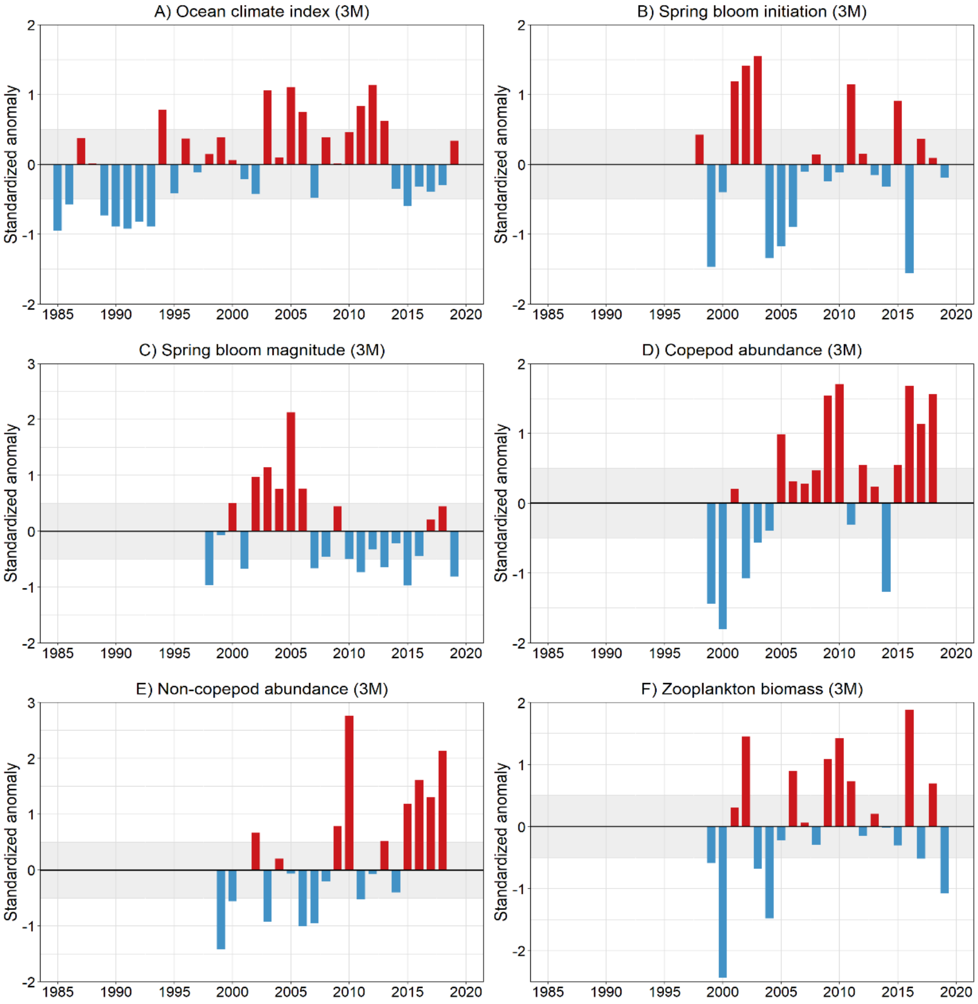


Figure C1. Environmental indices for NAFO Divisions 3LNO during 1990-2019. The ocean climate index (A) is the average of 12 individual time series of standardized ocean temperature anomalies: sea surface temperatures (SSTs) for Divs. 3L, 3N and 3O, vertically average ocean temperature (0-176 m) at Station 27, mean temperature and CIL volumes over standard hydrographic sections Seal Island, Bonavista and inshore Flemish Cap (FC-01 to FC-20), and mean bottom temperature in 3LNO for spring and fall. All these variables are presented in Cyr et al. (2020). Phytoplankton spring bloom magnitude (B) and duration (C) indices for the 1998-2019 period are derived from three satellite Ocean Colour boxes (Avalon Channel, Hibernia, and Southeast Shoal; see SCR Doc. 20/035 for box location). Zooplankton abundance copepod and non-copepod) and biomass (D & E) indices for the 1999-2019 period are derived from two cross-shelf oceanographic sections (Flemish Cap [3LN portion only] and Southeastern Grand Banks) and one coastal high-frequency sampling station (Station 27). 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 with 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 (shaded area) are considered normal conditions.

Environmental Overview

The water masses 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. These are formed during winter and last throughout the year until the late fall. The 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 (Figure C1.A) has remained mostly above normal between the late 1990s and 2013, reaching a peak in 2011. The index has returned to normal conditions between 2014 and 2019, with 2018 being the warmest of this 6th-year time series. A general trend towards later spring blooms (Figure C1.B) has been observed since 1998. However, spring bloom timing was back to near normal for a second consecutive year in 2019 after 3 years of late blooms. Spring bloom magnitude (Figure C1.C) oscillated between positive and negative anomalies with observable trends between 1998 and 2014. Bloom magnitude has remained below normal since 2015 with the second-lowest spring production of the time series observed in 2019. The abundance of copepod (Figure C1.D) and non-copepod (Figure C1.E) zooplankton showed strong increasing trends since the beginning of the time series. The abundance of copepods was above normal for a 6th consecutive year in 2019 with third highest anomaly of the time series. The abundance of non-copepods was also above normal for the 8th consecutive year in 2019. Zooplankton biomass (Figure C1.F) has been oscillating between periods of negative and positive anomalies throughout the time series with no strong departure from normal conditions except in 2017 when biomass reached a time series record high. Zooplankton biomass returned to near normal values in 2019 after two years of above normal levels.

9. Cod (*Gadus morhua*) in NAFO Division 3NO

(SCR 20/2,4,8; SCS 20/5,6,7,8,9,11,13)

Interim monitoring report

a) Introduction

This stock has been under moratorium to directed fishing since February 1994. Total bycatch during the moratorium increased from 170 t in 1995, peaked at about 4 800 t in 2003 and has been between 400 t and 1100 t since that time. The bycatch in 2019 was 526 t.

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

	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
TAC	ndf	ndf	ndf	ndf	ndf	ndf	ndf	ndf	ndf	ndf
STATLANT 21	0.8	0.7	1.1	0.7	0.5	0.6	0.6	0.3	0.5	
STACFIS	0.8	0.7	1.1	0.7	0.6	0.7	0.6	0.4	0.5	

ndf : No directed fishery

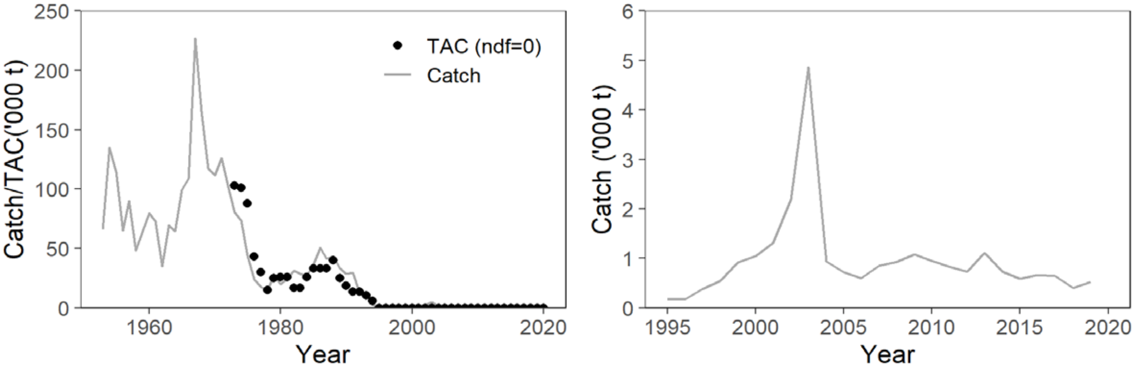


Figure 9.1. Cod in Div. 3NO: total catches and TACs. Panel at right highlights catches during the moratorium on directed fishing.

b) Data Overview

Canadian bottom trawl surveys. The spring survey biomass index declined from 1984 to 1995 and has generally remained low since that time (Figure 9.2). There was an increase in biomass during 2011-2014 but indices have subsequently declined and the 2017-2019 biomass indices were among the lowest in the time series. The trend in the autumn survey biomass index was similar to the spring series (Figure 9.2).

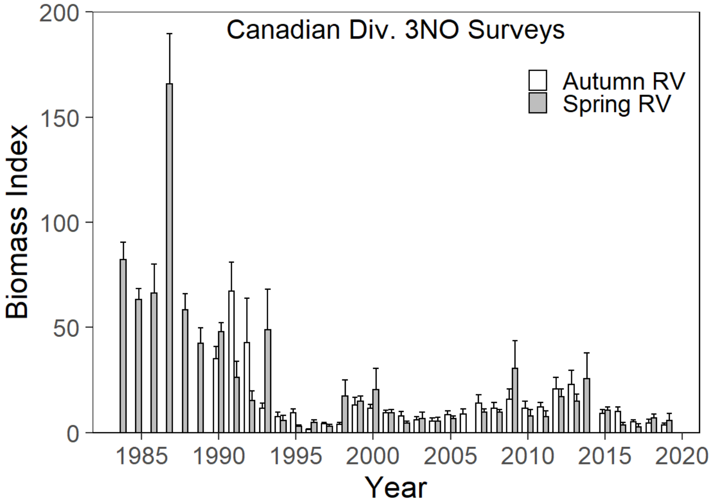


Figure 9.2. Cod in Div. 3NO: survey biomass index (+ 1 sd) from Canadian spring (grey) and autumn (white) research surveys.

EU-Spain Div. 3NO surveys. The biomass index was relatively low and stable from 1997-2008 with the exception of 1998 and 2001 (Figure 9.3). There was a considerable increase in the index from 2009-2011, followed by a decline to 2013. In 2014, the index increased to the highest value in the time series but has continually decreased in subsequent years. The 2019 index is the lowest since 2005.

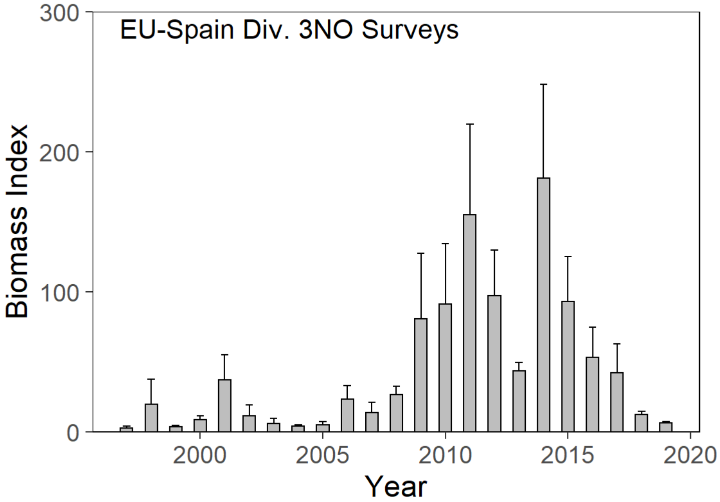


Figure 9.3. Cod in Div. 3NO: survey biomass index (+ 1 sd) from EU-Spain Div. 3NO surveys.

c) Conclusion

The most recent analytical assessment (2018) concluded that SSB was well below B_{lim} (60 000 t) in 2017. Canadian and EU-Spain survey indices for 2018 and 2019 have remained similar or declined relative to 2017. Overall, the 2019 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.

10. Redfish (*Sebastes mentella* and *Sebastes fasciatus*) in Divisions 3L and 3N.

(SCR Doc. 20/002, 20/004, 2020/009, 20/014, 20/033; SCS Doc. 20/07, 20/09, 20/13)

a) Introduction

There are two species of redfish in Divisions 3L and 3N, the deep-sea redfish (*Sebastes mentella)* and the Acadian redfish (*Sebastes fasciatus*) that have been commercially fished and reported collectively as redfish in fishery statistics. Both species, occurring on Div. 3LN and managed as a single stock, do not belong to isolated local populations but, on the contrary, are part of a large Northwest Atlantic complex ranging from the Gulf of Maine to south of Baffin Island.

Between 1959 and 1960 reported catches dropped from 44 600 to 26 600 t, oscillating over the next 25 years (1960-1985) around an average level of 21 000 t. Catches rose afterwards to a high of 79 000 t in 1987 and fell steadily to a 450 t minimum reached in 1996. Catches remained at a low level (450-3 000 t) until 2009. The NAFO Fisheries Commission implemented a moratorium on directed fishing for this stock between 1998 and 2009. The fishery reopened in 2010 with a TAC of 3 500 t. The Fisheries Commission endorsed the Scientific Council recommendations from 2011 onwards and catches increased, being at 13 050 t in 2019, the highest level recorded since 1993 (Table 1, Figure 10.1). Since the reopening in 2010, Canada, followed by Russia and EU-Portugal are the main partners of a fishery mostly deployed northwards in Div. 3L until 2018, but evenly split between the two divisions last year. A management strategy has been adopted for this stock based on a stepwise rule with biennial catch increases over the years 2015 to 2020 (NAFO/COM Doc. 18-01, NCEM)

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

	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
TAC	6	6	6.5	6.5	10.4	10.4	14.2	14.2	18.1	18.1
STATLANT 21	5.4	4.3	6.2	5.7	10.2	8.5	11.9	11.5	13.0	
STACFIS	5.4	4.3	6.2	5.7	10.2	8.5	11.8	11.3	13.1	

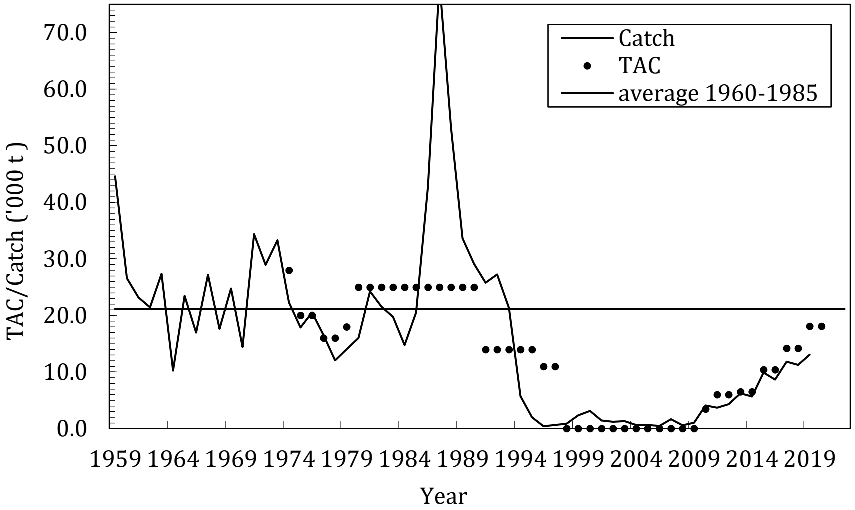


Figure 10.1. Redfish in Div. 3LN: catches and TACs (No directed fishing is plotted as zero TAC)

b) Input Data

i) Commercial fishery data

Most of the commercial length sampling data available for the Div. 3LN beaked redfish stocks since 1990 comes from the Portuguese fisheries. Length sampling data from EU-Spain and from Russia were used to estimate the length composition of the by-catch for those fleets in several years. Above average mean lengths, an apparently stable catch at length with no clear trends towards smaller or larger length groups and proportions in numbers of small redfish (< 20cm) usually below 1%, are observed on most of the years of the 1990-2005 interval. Well below average mean lengths coupled with in excess of 10% of small redfish in the catch occurred afterwards on most years between 2006 and 2016, but fell to 0.7% on average over the last 3 years (2017-2019). At the same time mean length in the catch roughly increased 2.3cm, with larger sizes being recently the bulk of the catch.

An important increase in the numbers of small redfish in the catch can reflect the arrival of one or more good recruitments but, on the contrary, a noticeable decline on this indicator, as observed on recent years, can signal that year classes coming in the fishery are now below average or even weak.

ii) Research survey data

From 1978 to 1993, several stratified-random bottom trawl surveys were conducted by Canada in various years and seasons in Div. 3L and in Div. 3N. Only those surveys where strata at depths greater than 366m were sampled are included.

Since 1991 two Canadian series of annual stratified-random surveys covered both Div. 3L and Div. 3N on a regular annual basis: a spring survey (May-Jun.) and an autumn survey (Sep.-Oct. 3N/Nov.-Dec. 3L for most years). No survey was carried out in spring 2006 and in autumn 2014 in Div. 3N. Again, in the spring of 2017 there were problems with 3L survey coverage and none of the 3L strata in the redfish index were sampled. Therefore, 2006 and 2017 are not included in the 3LN Canadian spring survey data set or in the 2014 autumn survey data set.

The poor coverage of Div. 3L by Canadian spring survey has little impact on redfish strata so this survey was included in the assessment. Again in the spring of 2017 there were problems with 3L survey coverage and none of the 3L strata in the redfish index were sampled, so 2017 is not included in the 3LN Canadian spring survey data set.

Since 1983 Russian bottom trawl surveys in NAFO Div. 3LMNO changed to stratified-random, following the Canadian stratification for Sub area 3. In 1992 and 1994 Russian survey was carried out only in Div. 3L. In 1995, the Russian bottom trawl series in NAFO Sub area 3 was discontinued.

In 1995 EU-Spain started a stratified-random bottom trawl spring (May-June) survey in NAFO Regulatory Area of Div. 3NO. The Div. 3N EU-Spain spring survey series (1995-2017) has been included in the assessment framework since 2010. The EU-Spain survey in Div. 3L of NAFO Regulatory Area (Flemish Pass) was initiated by EU-Spain in 2003. However only in 2006, for the first time, an adequate prospecting survey was conducted in Division 3L in terms of a representative coverage of all strata in this division. This survey is included in the assessment framework since then.

See section c) for details of which surveys are used in the assessment. Details on the two Canadian survey series, as well as on the Russian series and the two Spanish surveys can be found on previous assessment reports.

The survey biomass series used in the assessment framework and the female SSB survey series were standardized to zero mean and unit standard deviation and so presented on Figure 10.2. From the late 1970s to the beginning of the 1990s Canadian surveys in Div. 3L and Russian bottom trawl surveys in Div. 3LN suggest that stock size suffered a substantial reduction. Redfish bottom biomass from surveys in Div. 3LN remained well below average level over the 1990's and early 2000's, but since 1997 those indices start to show some dynamics of increase. Clear increases of survey biomass are evident in 2007-2015 but biomass went down and/or stabilize between 2016 and 2019.

Both Canadian spring and autumn standardized female SSB survey series for Div. 3LN have trends concurrent to their correspondent biomass series from 1991-2015 (Figure 10.2). More recently (2016-2019) however all SSB indices were kept at or above average, which is not the case for survey biomass.

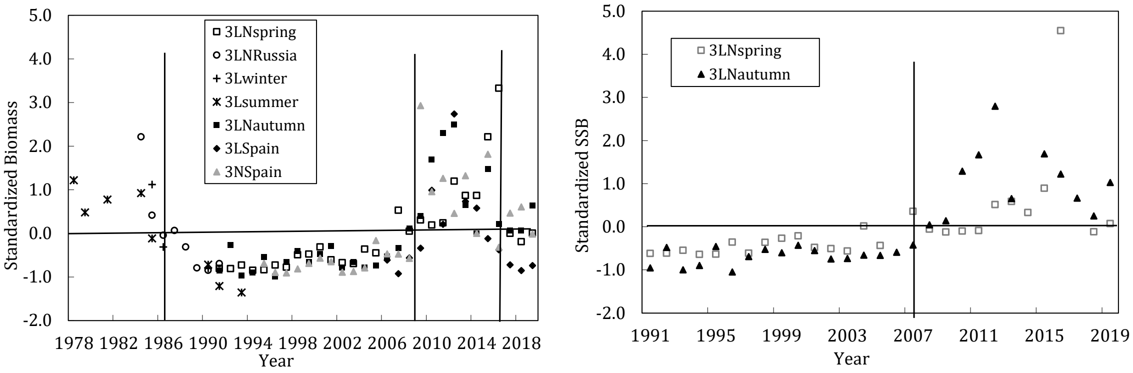


Figure 10.2. Redfish in Div. 3LN: standardized survey biomass (1978-2019, left panel) and female spawning biomass (1991-2019, right panel). Each series standardized to zero mean and unit standard deviation. Vertical bars indicate periods when indices cross average levels.

During the first half of the 1990's, on both surveys, the length anomalies were negative or slightly positive. Mean lengths on most of the years between 1996 and 2007 (spring survey) or 2006 (autumn survey) were above the mean, reflecting a shift on the stock length structure to larger individuals. Between 2007-2008 and 2011-2012 mean lengths generally fall and stay below average (Figure 10.3), just as observed on the commercial catch at length, suggesting the occurrence of good recruitments by the late 2000's.

On 2016-2019, from Canadian surveys, mean length in the stock increased but the numbers of fish =>20cm declined.

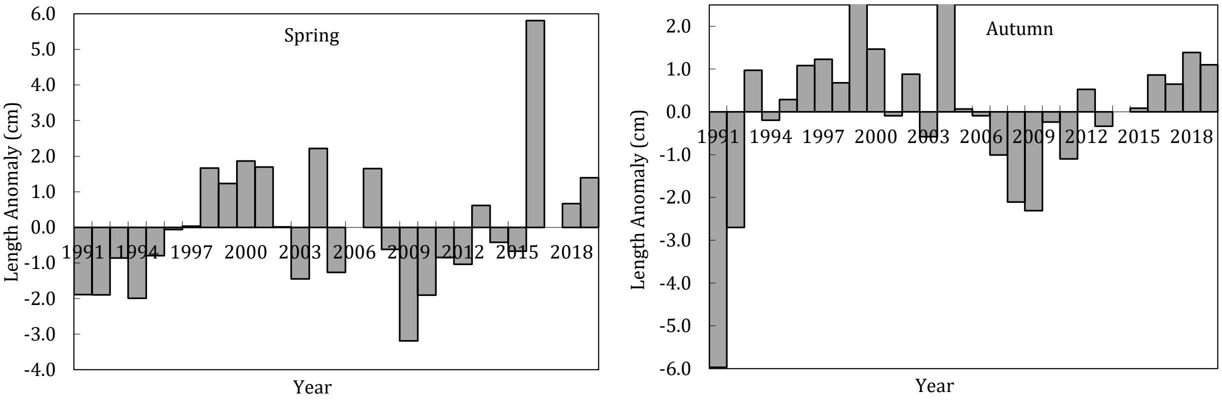


Figure 10.3. Redfish in Div. 3LN: annual anomalies of the mean length in the spring and autumn survey, 1991-2019.

iii) Recruitment

Between 2006-2007 and 2009-2010 the recruitment index (numbers of redfish < 20cm) increased rapidly both in commercial catch and Canadian surveys, reaching by then maximum values. The recruitment index drops fast on the following years and is at lower levels since 2014-2015 (Figure 10.4).

Nevertheless, unusual high numbers of very small redfish pre recruits (5-10cm) have been observed on recent years (2015-2017) on Canadian spring and autumn surveys.

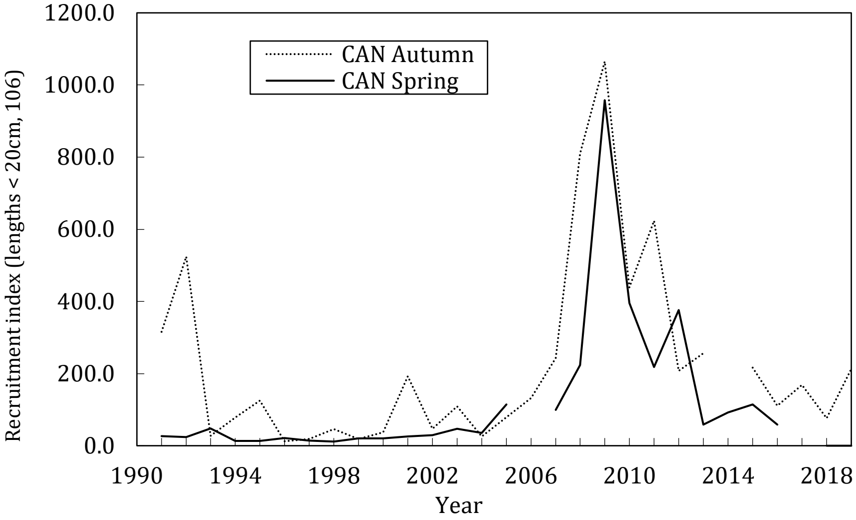


Figure 10.4. Redfish in Divs. 3LN: Recruitment index (lengths < 20 cm) from spring and autumn Canadian surveys in NAFO 3LN, 1991-2019.

c) Assessment Results

A non-equilibrium surplus production model (ASPIC; Prager, 1994) is used to assess the status of the stock since 2008. Until 2012 the model was adjusted to an array of Canadian, Russian and Spanish surveys series arranged under the formulation adopted by STACFIS. However the model showed an increasingly poor fit to recent survey biomass increases observed from the second half of the 2000's onwards on all the ongoing surveys. Selective elimination of outliers, in order to get a picture in line with the perception of the stock history from commercial and survey data trends, was no longer a valid option, as reflected in a STACFIS research recommendation on this matter (NAFO, 2012).

In the 2014 assessment the purpose was to reach an inclusive approach that would incorporate most, if not all, of the surveys points available for the two divisions while at the same time delivering a "realistic" output in line with the perception of stock and fishery dynamics given by historical commercial and survey data. Following a series of exploratory analysis, the 2014 assessment had MSY fixed at a 21000 t. This *MSY proxy* is the average level of sustained catch for the 1960-1985 interval, when the stock experienced an apparent stability, suggested either by the STATLANT CPUE series or available surveys, before declining in response to a sudden rise of catch level. This framework also kept negative correlated STATLANT CPUE series and all "outliers" in their respective survey series, while Canadian autumn surveys on Div. 3L and Div. 3N were assembled in a single 3LN Canadian autumn series. While fixing the MSY level is not common, it was justified in this case as levels generated from models that freely estimated B_{msy} were unrealistic (estimating MSY's of more than 100 000 tons). Therefore MSY was fixed in the model and the results are conditioned on this assumption.

The input series of this assessment are:

I1 (Statlant CPUE and catch)	Statlant cpue for Div. 3LN,1959-1994 and catch for Div. 3LN 1959-2019
I2 (3LN spring survey)	Canadian spring survey biomass for Div. 3LN, 1991-2005, 2007-2016, 2018-2019
I3 (3LN autumn survey)	Canadian autumn survey biomass for Div. 3LN, 1991-2013, 2015-2019
I4 (3LN Power russian survey)	Russian spring survey biomass for Div. 3LN , 1984-1991 (Power and Vaskov,1992)
I5 (3L winter survey)	Canadian winter survey biomass for Div. 3L, 1985-1986 and 1990
I6 (3L summer survey)	Canadian summer survey biomass for Div. 3L, 1978-1979, 1981,1984-1985, 1990-1991and 1993
I7 (3L autumn survey)	Canadian autumn survey biomass for Div. 3L, 1985-1986, 1990
I8 (3N spring spanish survey)	Spanish survey biomass for Div. 3N, 1995-2019
I9 (3L summer spanish survey)	Spanish survey biomass for Div. 3L, 2006-2019

The 1959-2010 catches used are the catches adopted by STACFIS for this stock. The 2011-2016 catches were taken from the NAFO STATLANT 21 data base. The 2017 catch was estimated with the CDAG method (COM-SC CESAG-WP 18-01 (Rev.2)) whereas the CESAG method provided the catch estimates for 2018 and 2019 (COM-SC CESAG-WP 19-03 (Revised) and COM-SC CESAG-WP 20-05 (Revised), respectively).

In this assessment the ASPIC version 7.03 (Prager, 2015) fit the logistic form of the production model (Schaefer, 1954). The model requires from the user a set of initial definitions/starting guesses/constraints that need to be specified in the input file. Control parameters are kept from the 2014 and 2016 assessments and line-by-line details of all input settings can be found on the correspondent reports. User guess catchabilities for the nine input series that support the assessment were the estimate catchabilities from 2018 ASPICfit.

ASPIC2020 run first on deterministic (FIT) mode. Key results, and relative biomass and fishing mortality trajectories are presented on Table 10.1 and Figure 10.5 respectively in comparison with the same results from previous 2016 and 2018 assessments.

Table 10.1. ASPIC2020 versus ASPIC 2018 and ASPIC 2016: comparison of main results from deterministic run.

	MSY[(1)]	*B1/K*	*Fmsy*	*Flastyear/Fmsy*	*Ye*[(2)]	*Bmsy*	*B*[(3)]*/Bmsy*
ASPIC 2020	*21000*	**0.7204**	**0.1136**	0.3917	13730	**184900**	1.5880
ASPIC 2018	*21000*	**0.6976**	**0.1122**	0.3759	15600	**187100**	1.5070
ASPIC 2016	*21000*	0.6874	0.1116	0.3640	17820	188200	1.3890

(1) fixed at the starting guess

(2) estimate for 2016 from ASPIC2016, estimate for 2018 from ASPIC 2018 and estimate for 2020 from ASPIC 2020

(3) at the beginning of 2016 from ASPIC2016, at the beginning of 2018 from ASPIC 2018 and at the beginning of 2020 from ASPIC 2020

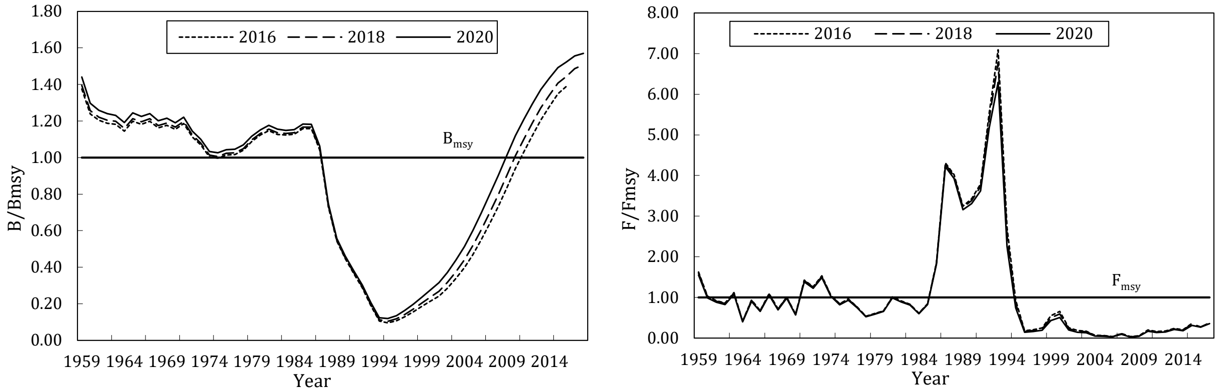


Figure 10.5. Redfish in Divs. 3LN*:* B/B_{msy} (left) and F/F_{msy} (right) from ASPIC$_{fit}$ 2020 versus ASPIC$_{fit}$ 2018 and ASPIC$_{fit}$ 2016 assessments.

In terms of biomass dynamics results showed a good nearness index, crossing twice B_{msy} and presenting good contrast. As regards correlation among input series, all three short 3L survey series from the 1980's – early 1990's have good correlations with the Russian survey covering the same period of stock decline. As for the ongoing surveys, correlations among series are relatively good between Canadian 3LN spring and autumn, between the 3N and 3L Spanish surveys and also between both Spanish and Canadian 3LN autumn.

Correlation between observed series and expected model results continue to be in general average to weak. A long time interval (61 years) and a variety high number of survey data sets (8 surveys, differing in time, season and covered area) are unavoidable obstacles difficult to overcome, and will always negatively impact the diagnostics of ASPICfit compared to shorter indices with greater consistency.

To investigate whether or not there was statistical evidence of model mis-specification, the Wald-Wolfowitz runs-test was carried out on the residuals of the fits of the surplus production model to the four abundance indices that cover recent years: 3LSpain, 3NSpain, 3LNautumn and 3LNspring. The respective p-values under the null hypothesis of independence of the residuals for each of these series were respectively 0.028, 0.545, 0.216, and 0.128, i.e. only for the 3LSpain series is the hypothesis of independence of residuals rejected at the 5% level, which would in turn indicate model mis-specification. This supported the acceptance of the model.

There was good consistency within results and trends between the three last assessments (2016, 2018 and 2020) with stock biomass increasing well above B_{msy} and a fishing mortality still kept well below F_{msy}.

A summary of estimates from bootstrap analysis are presented in Table 10.2.

Table 10.2. ASPIC2020 main results from bootstrap analysis

	ASPIC	Point	Bias-corrected approximate confidence limits				Inter-quartile	Relative
Param. name	assessment	estimate	80% lower	80% upper	60% lower	60% upper	range	IQ range
B1/K	2020	0.7204	0.5817	1.2410	0.6189	0.9961	0.2944	0.4090
MSY	2020	21000	NA	NA	NA	NA		
Ye Last year+1	2020	15600	12040	20330	12890	19060	4907	0.3150
Bmsy	2020	184900	165100	222100	169200	206700	31160	0.1690
Fmsy	2020	0.1136	0.0946	0.1272	0.1016	0.1241	0.0190	0.1670
B Last year+1/Bmsy	2020	1.5880	**1.3770**	1.6710	**1.4710**	1.6540	0.1387	0.0870
F Last year/Fmsy	2020	0.3917	0.3708	**0.4553**	0.3751	**0.4251**	0.0374	0.0950
Yield Last year+1/MSY	2020	0.6540	0.5494	0.8582	0.5729	0.7788	0.1595	0.2440

Bootstrap results reiterate a stock at the beginning of 2020 with a very high probability (>90%) to be above B_{msy} and a 2019 fishing mortality below F_{msy} with a very high probability (>90%). The maximum observed sustainable yield (*MSY*) of 21 000 t can be a long term sustainable yield if fishing mortality stands at a level of 0.114/year. The correspondent B_{msy} for this stock is at the level of 185 000 t.

Catch versus surplus production trajectories are presented in Figure 10.5. Between 1960 and 1985 catches form a scattered cloud of points around the surplus production curve. In 1986-1987, catches rose well above surplus production and, though declining continuously since then, were still above equilibrium yield in 1993. Catch has dropped well below surplus production in 1995 and from 2010 onwards has been slowly increasing towards surplus production. By 2019 equilibrium yield was almost reached.

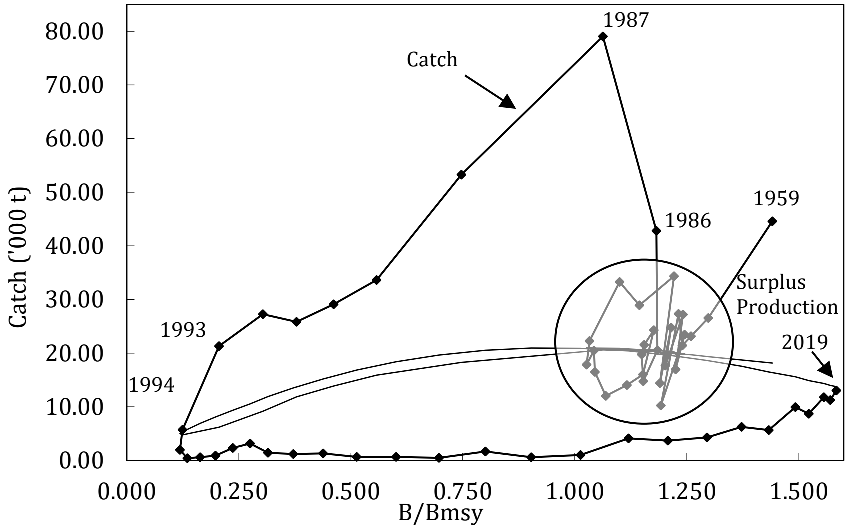


Figure 10.6. Redfish in Div. 3LN: Catch versus Surplus Production from ASPIC$_{fit}$ 2020.

Biomass: Slightly above B_{msy} for most of the former years up to 1985. Declined from B_{msy} in 1986 to 12% B_{msy} in 1995, when a minimum stock size is recorded. Over the moratorium years biomass was allowed to recover and at the beginning of 2020 biomass is predicted to be near 1.6 x B_{msy}. The probability of being above B_{msy} is very high (>90%). At the beginning of 2020, the probability of being below B_{lim} is less than 1% (see section d).

Fishing mortality: Fishing mortality has been low to very low since 1996 but has moderately increased since the reopening of the fishery in 2010. On 2019 fishing mortality was estimated to be at 0.39 x F_{msy}, and the probability of being above F_{msy} is very low. On 2019, the probability of being above F_{msy} is less than 1%.

Recruitment: From commercial catch and Canadian survey length data (numbers of redfish < 20cm) there are no signs of recent recruitment (2014 – 2019) of above average year classes to the exploitable stock. Nevertheless, unusual high numbers of very small redfish pre recruits (5-10cm) have been observed on recent years (2015-2017) on Canadian spring and autumn surveys.

State of stock: The stock is currently in the safe zone of the NAFO precautionary approach framework and is estimated to be at 1.59 x $B_{msy.}$ There is a very low risk (<10%) of the stock being below B_{lim}. Fishing mortality is well below F_{msy} (0.39 x F_{msy}), and the probability of being above F_{lim} (= F_{msy}) is very low (<10%). Recent recruitment appears to be low.

d) Short term catch projection under the actual management strategy

The Risk-Based Management Strategy (MS) for 3LN Redfish adopted by the Fisheries Commission on the 36th Annual Meeting – September 2014 (Ávila de Melo *et al*., 2014; FC Working Paper 14/23, NCEM annex I.H), was designed to reach 18 100 t of annual catch by 2019-2020 (18 100 t was the equilibrium yield in 2014 given by the 2014 assessment, carried out under the assumption of an MSY of 21 000 t). It is based on a Harvest Control Rule (HCR) that implemented a stepwise biennial catch increase, with the same amount of increase every two years, between 2015 and 2020.

Since then, the following assessments monitored the impact of the MS on the stock, though between 2015 and 2019 catches never reached the predicted TAC´s, or even the correspondent Ye's (equilibrium yields). Meanwhile, based on the results of bi-annual assessments, the biomass in recent years (2015-2020) is well above B_{msy} and fishing mortalities well below F_{msy} at a very high probability level (>90%).

The medium term catch projections (2021-2025) aimed to quantify the likelihood of the stock to be exploited below F_{msy} until 2025 and arrive at the beginning of 2026 still above B_{msy} under two catch options. The first projection drives the stock under a 2021-2025 catch at the HCR 2019-2020 TAC of 18 100 t (*status quo* HCR2020 option), while the second option drives the stock under a lower 2021-2025 catch ceiling of 13 730 t, the equilibrium yield available at present (Ye_{2020} option). A second option is justified by recent observed data suggesting that stock is not growing and recruitment is poor. Both scenarios assume that the 2020 TAC of 18 100 t will be effectively taken.

ASPICP, the ASPIC auxiliary program for projections, provided point estimates (with associated bias corrected 80% and 50% confidence limits) of biomass and fishing mortality for the assessment time interval, 1959-2019, extended to the projection years, 2020-2025, with 2020 catch at the present TAC and either with the 2021-2025 catch at the HCR 2020 (18 100 t) or at 2020 *Ye* (13 730 t).

The ASPICP results for the HCR 2020 option are presented in Figure 10.7a and 10.7b, as regards relative 1959-2026 biomass and 1959-2025 fishing mortality trajectories.

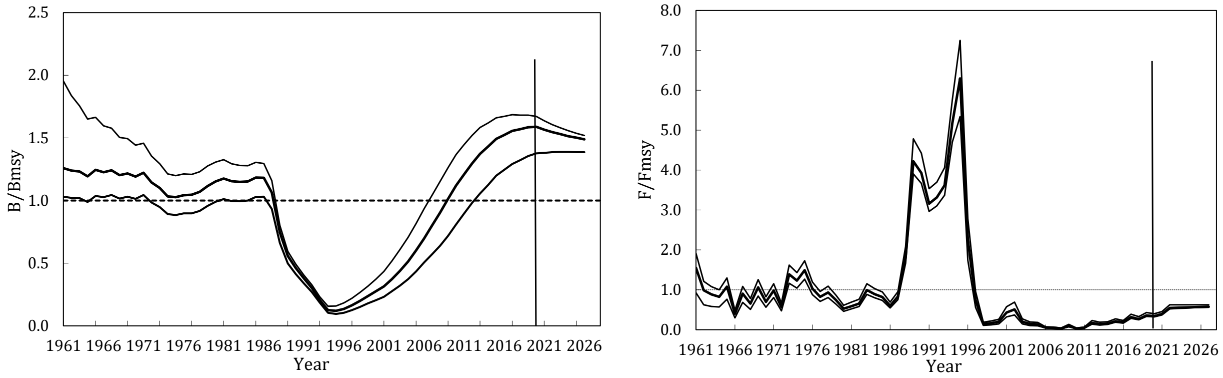


Figure 10.7. Redfish in Div. 3LN: B/B_{msy} (left) and F/F_{msy} (right) point estimates trajectories with approximate 80% bias corrected CLs from ASPICP 2020 (HCR 2020 option).

Comparisons of results with the two options are presented in Table 10.3 and Figure 10.8 (for B_{msy} 2020-2026).

Table 10.3. Redfish in Div. 3LN: short term catch projections. The 10th, point estimate, and 90th percentiles of projected B/B_{msy} , F/F_{msy} are shown, for projected 2021-2025 HCR 2020 TAC or at 2020 *Ye* catch.

2021-2026 catch at HCR TAC 18 100 t	percentiles		
Year	10	point estimate	90
BIOMASS RELATIVE TO Bmsy			
2020	1.377	1.588	1.671
2021	1.380	1.566	1.636
2022	1.385	1.547	1.606
2023	1.387	1.530	1.580
2024	1.387	1.514	1.557
2025	1.386	1.501	1.537
2026	1.385	1.489	1.520
FISHING MORTALITY RELATIVE TO Fmsy			
2020	0.547	0.547	0.625
2021	0.554	0.554	0.624
2022	0.561	0.561	0.622
2023	0.566	0.566	0.621
2024	0.572	0.572	0.622
2025	0.577	0.577	0.622

2021-2026 catch at 2020 Ye 13 730 t	percentiles		
Year	10	point estimate	90
BIOMASS RELATIVE TO Bmsy			
2020	1.377	1.588	1.671
2021	1.380	1.566	1.636
2022	1.400	1.569	1.629
2023	1.417	1.571	1.624
2024	1.435	1.573	1.619
2025	1.450	1.575	1.615
2026	1.463	1.577	1.611
FISHING MORTALITY RELATIVE TO Fmsy			
2020	0.547	0.5466	0.6249
2021	0.417	0.4171	0.4702
2022	0.416	0.4164	0.4641
2023	0.416	0.4158	0.4583
2024	0.415	0.4153	0.4531
2025	0.415	0.4148	0.4488

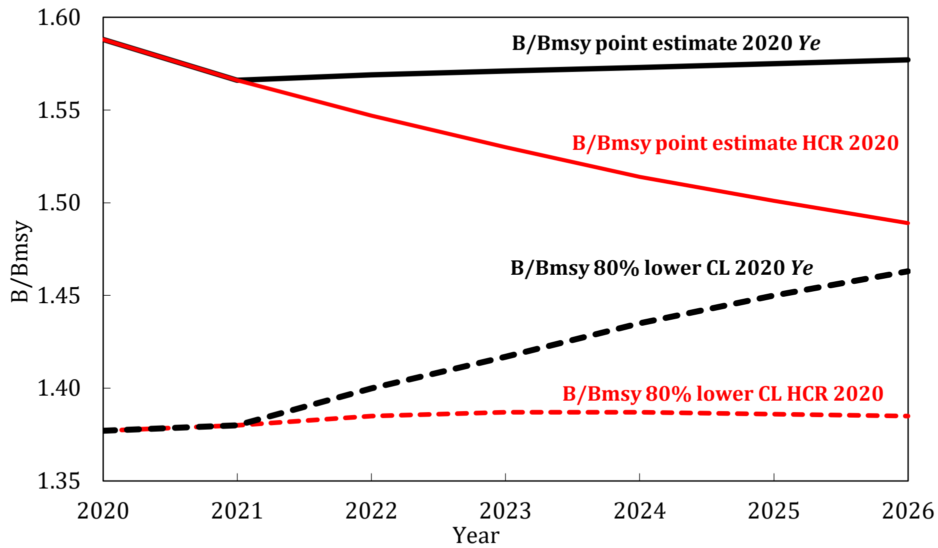


Figure 10.8. *B/Bmsy* 2020-2026 projections under HCR 2020 TAC versus 2020 *Ye*. Both options assume that the 2020 TAC of 18 100 t will be effectively taken.

Either the HCR 2020 TAC or catch at 2020 *Ye* on 2021 - 2025 will maintain biomass at the beginning of 2026 above B_{msy} while keeping fishing mortality till the end of 2025 below F_{msy} with > 90% probability (Table 10.4). Also the probability of $B_{2026} < B_{lim}$ or $F_{2025} > F_{lim}$ is <1% for both catch options. Catch on 2021-2025 at 2020 *Ye* will keep biomass roughly at its present level, and will avoid the beginning of a marginal biomass decline predicted by the HCR 2020 option (that has been already suggested by the majority of recent observed data).

Table 10.4. Redfish in Div. 3LN: Risk assessment under 18 100 t and 13 730 t catches in 2021-2025 scenarios.

HCR (Yield)						P(F>Flim) = P(F>FMSY)					
2020	2021	2022	2023	2024	2025	2020	2021	2022	2023	2024	2025
18100 t	18100 t	18100 t	18100 t	18100 t	18100 t	<1%	<1%	<1%	<1%	<1%	<1%
13730 t	13730 t	13730 t	13730 t	13730 t	13730 t	<1%	<1%	<1%	<1%	<1%	<1%

HCR (Yield)						P(B< Blim)						
2020	2021	2022	2023	2024	2025	2020	2021	2022	2023	2024	2025	2026
18100 t	18100 t	18100 t	18100 t	18100 t	18100 t	<1%	<1%	<1%	<1%	<1%	<1%	<1%
13730 t	13730 t	13730 t	13730 t	13730 t	13730 t	<1%	<1%	<1%	<1%	<1%	<1%	<1%

HCR (Yield)						P(B<BMSY)							
2020	2021	2022	2023	2024	2025	2020	2021	2022	2023	2024	2025	2026	P(B2026> B2020)
18100 t	18100 t	18100 t	18100 t	18100 t	18100 t	1.4%	1.4%	1.2%	1.1%	1.1%	1%	1%	12%
13730 t	13730 t	13730 t	13730 t	13730 t	13730 t	1.4%	1.4%	1.1%	1%	<1%	<1%	<1%	45.6%

e) Reference Points

The ASPIC point estimate results were put under the precautionary framework (Figure 10.9). The trajectory presented shows a stock within B_{msy} - 1.3 B_{msy} under exploitation around F_{msy} through 25 years in a row (1960-1985). The stock rapidly declined afterwards to well below B_{msy} when fishing mortality rises to well above F_{msy} (1987-1994). Fishing mortality dropped to well below F_{msy} in 1996, being kept at very low to low to level ever since. Biomass gradually reaches and surpasses B_{msy} several years after (2009). The stock is presently in the safe zone.

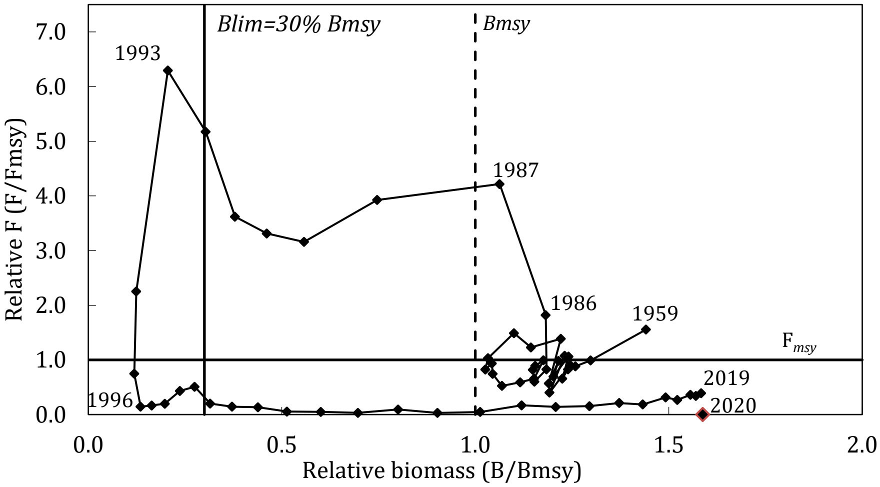


Figure 10.9. Redfish in Div. 3LN: stock trajectory under a precautionary framework for ASPIC$_{fit}$ 2020.

The next full assessment of this stock will be in 2022.

f) Research recommendations

STACFIS **recommends** that *alternate models be explored for this stock.*

11. American plaice (Hippoglossoides *platessoides*) in NAFO Divisions 3LNO

(SCR 20/04; 20/02, 20/08, 20/13, SCS 20/07, 20/09, 20/11, 20/13)

Interim Monitoring Report

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 002t in 2018 and 1 248t in 2019 (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:

	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
TAC	Ndf	ndf	ndf	Ndf	ndf	ndf	ndf	ndf	ndf	ndf
STATLANT 21	1.2	1.3	2.2	1.4	1.1	1.0	1.1	0.8		
STACFIS	2.4[1]	2.1[1]	3.0[1]	2.3[1]	1.1[2]	1.7[2]	1.2	1.0	1.2	

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.

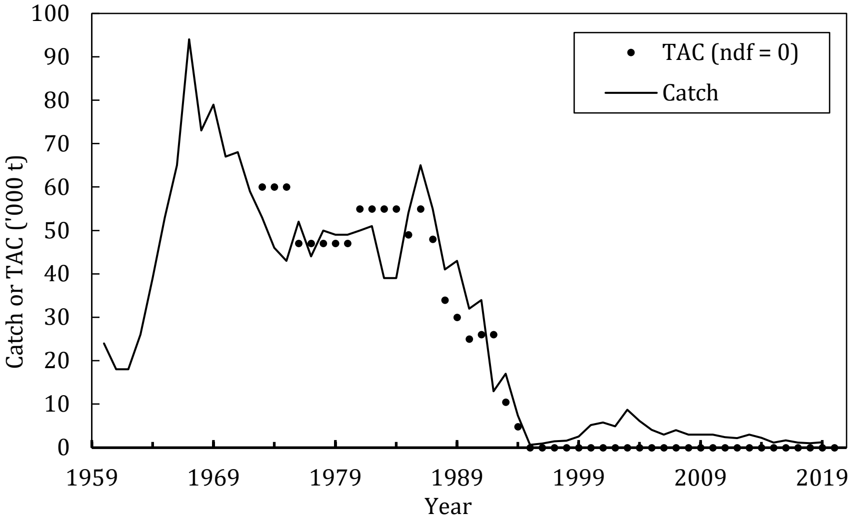


Figure 11.1. American plaice in Div. 3LNO: estimated catches and TACs. No directed fishing (ndf) is plotted as 0 TAC.

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. Spring estimates of biomass and abundance in 2019 are the lowest since 1995 and 1998, respectively.

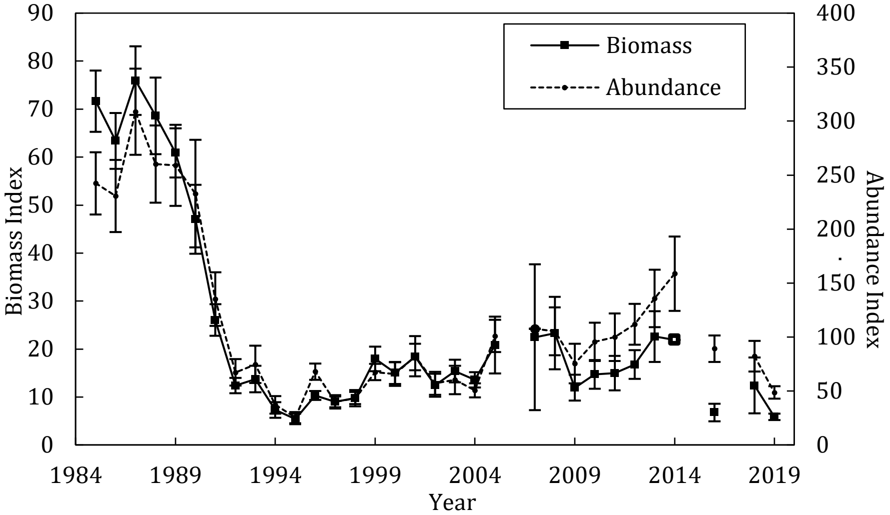


Figure 11.2. American plaice in Div. 3LNO: biomass and abundance indices with approximate 95% confidence intervals from Canadian spring surveys. Data prior to 1996 are Campelen equivalents and since then are Campelen. Open symbols represent years where CIs extend to negative values.

Canadian autumn survey. Autumn survey points for 2004 and 2014 are excluded due to incomplete coverage of Div. 3L and 3NO, respectively. 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 2019. Biomass indices also declined after 2013 and have been below average since 2015.

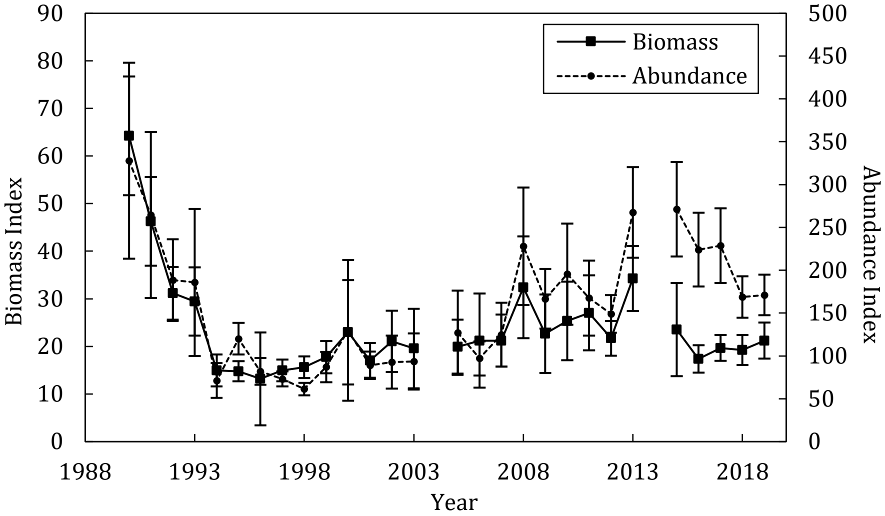


Figure 11.3. American plaice in Div. 3LNO: biomass and abundance indices with approximate 95% confidence intervals from Canadian autumn surveys. Data prior to 1996 are Campelen equivalents and since then are Campelen.

EU-Spain Div. 3NO Survey. From 1998-2019, surveys have been conducted annually by EU-Spain in the Regulatory Area in Div. 3NO. The biomass and abundance indices varied without trend for most of the time series but then declined from 2011. The 2019 estimates of biomass and abundance are the lowest in the time series.

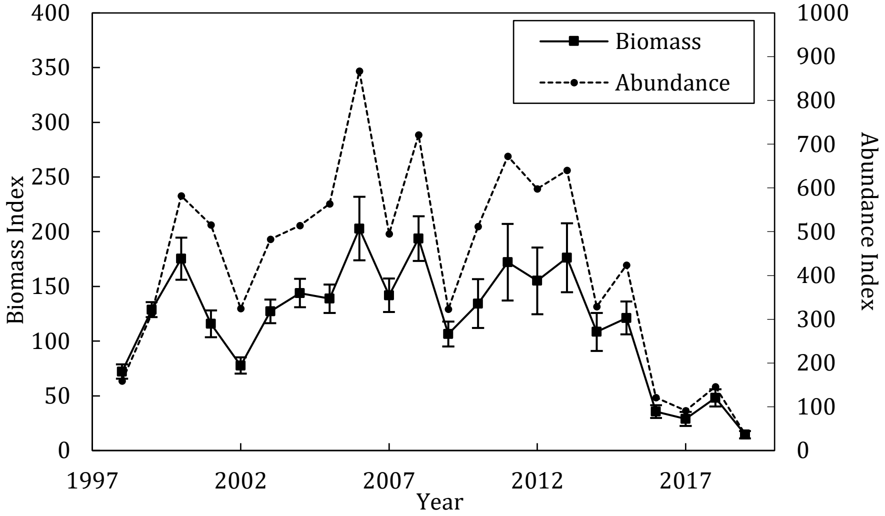


Figure 11.4. American plaice in Div. 3LNO: biomass and abundance indices from the EU-Spain Div. 3NO survey (Data prior to 2001 are Campelen equivalents and since then are Campelen).

EU-Spain Div. 3L Survey. From 2003-2019, 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 2019.

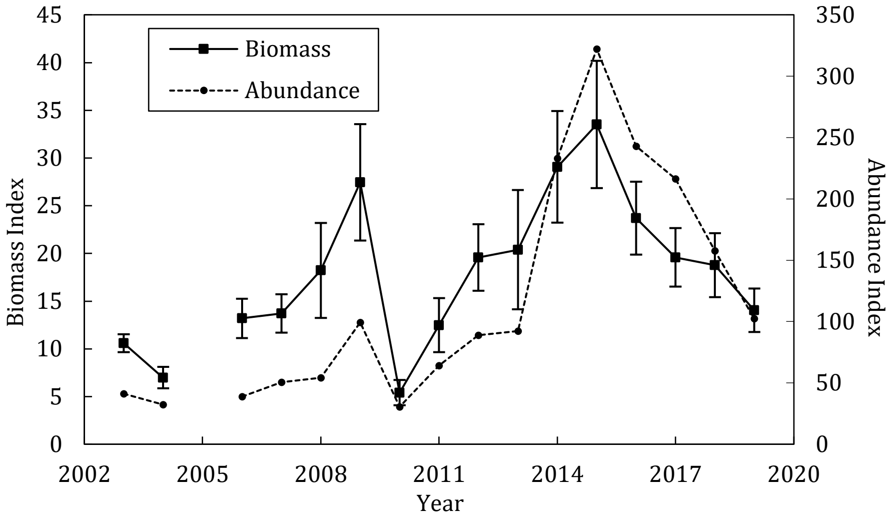


Figure 11.5. American plaice in Div. 3LNO: biomass and abundance indices from the EU-Spain Div. 3L survey.

c) Conclusion

Based on available data, there is nothing to indicate a change in the status of the stock since the 2018 assessment.

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

d) Research Recommendations

STACFIS **recommends** that *investigations be undertaken to compare ages obtained by current and former Canadian age readers.*

STATUS: Work is ongoing. This recommendation is reiterated.

STACFIS **recommends** that *investigations be undertaken to examine the retrospective pattern and take steps to improve the model.*

STATUS: Sensitivity analysis was completed during the 2018 assessment examining the impact of changing the model assumptions about the F-ratio on the plus group, and this 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

(SCR 20/002, 20/009; SCS 20/05, 20/06, 20/07, 20/09, 20/11)

Interim Monitoring Report

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. The catch in 2006 was only 930 t, due to corporate restructuring and a labour dispute in the Canadian fishing industry. Since then, catches have continued to be influenced by industry related factors, remaining below the TAC and in some years, have been very low. In 2019, catches totalled 11 900 t.

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

	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
TAC [1]	17	17	17	17	17	17	17	17	17	17
STATLANT 21	5.2	3.1	10.7	8.0	6.7	8.3	9.0	8.7	12.8	
STACFIS	5.2	3.1	10.7	8.0	6.9	9.3	9.0	8.7	12.8	

[1] SC recommended any TAC up to 85% F_{msy} in 2009-2021.

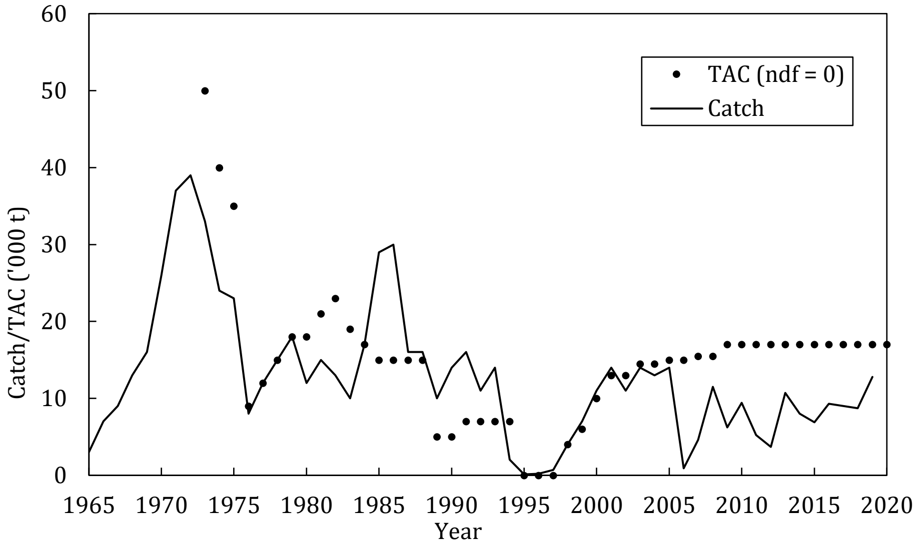


Figure 12.1. Yellowtail flounder in **Divs. 3LNO**: catches and TACs. No directed fishing is plotted as 0 TAC.

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. Although the 2006 and 2015 surveys did not cover the stock area, the average biomass in strata missed by these surveys in years since 1995 has been below 10% of the total biomass estimate.

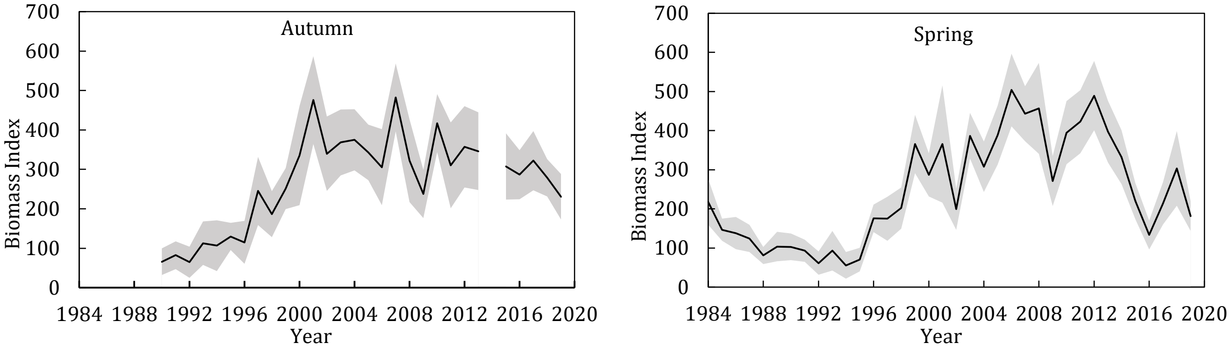


Figure 12.2. Yellowtail flounder in **Divs. 3LNO**: indices of biomass with approximate 95% confidence intervals, from Canadian spring and autumn surveys. Values are Campelen units or, prior to autumn 1995, Campelen equivalent units. The 2014 Canadian autumn survey was incomplete and not considered representative.

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 has remained relatively high. (Figure 12.2). This survey did not show the decline in biomass seen in the other surveys during the recent years. The 2014 survey was incomplete due to problems with the research vessel. Ninety-three percent of the biomass estimate in surveys since 1995 was found in the strata missed in 2014, and therefore survey results in this year are not considered representative.

EU-Spain stratified-random spring surveys in the NAFO Regulatory Area of Div. 3NO. The biomass index of yellowtail flounder increased sharply up to 1999 and remained relatively stable until 2013. Since then, biomass estimates declined to a 20 year low in 2019 (Figure 12.3). Results are in general agreement with the Canadian series which covers the entire stock area.

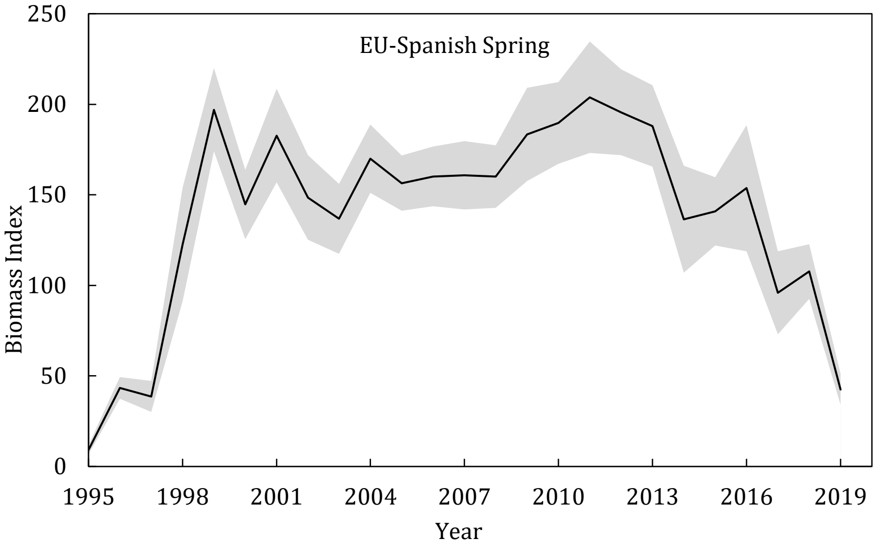


Figure 12.3. Yellowtail flounder in **Divs. 3LNO**: index of biomass from the EU-Spain spring surveys in the Regulatory Area of Divs. 3NO ±1SD. Values are Campelen units or, prior to 2001, Campelen equivalent units.

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 1999-2019 surveys than from 1984-1995, and the stock has continued to occupy the northern portion of its range in Div. 3L, similar to the mid-1980s when overall stock size was also relatively large. The vast majority of the stock is found in waters shallower than 93 m in both seasons.

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

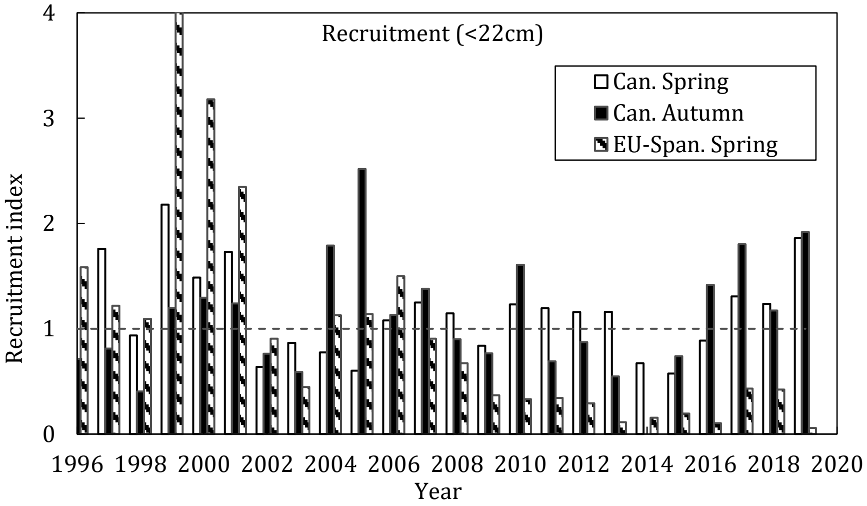


Figure 12.4. Yellowtail flounder **in Divs. 3LNO**: Juvenile abundance indices from spring and autumn surveys by Canada (Can.) and spring surveys by EU-Spain. Each series is scaled to its mean (horizontal line).

c) Conclusion

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

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

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

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

a) Introduction

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

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

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

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

ndf = no directed fishery.

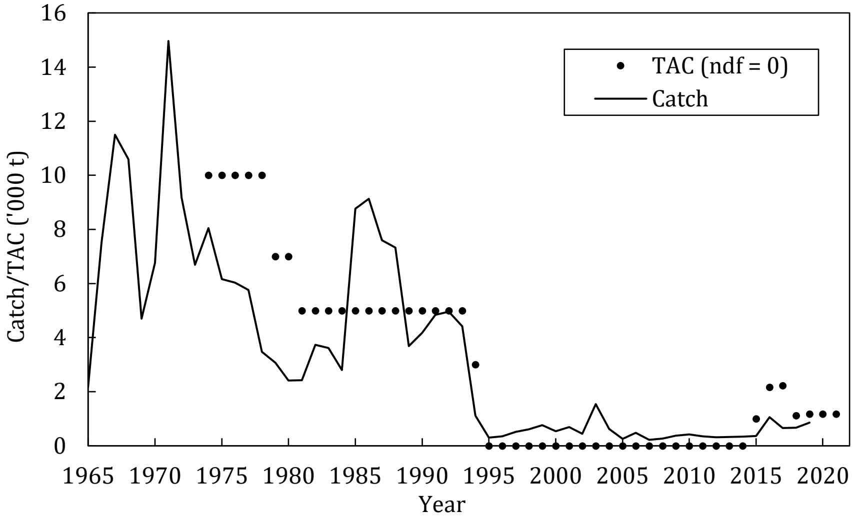


Figure 13.1. Witch flounder in Divs. 3NO (1960-2021): Catch and TAC (‘000 tonnes).

b) Data Overview

i) Commercial fishery data

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

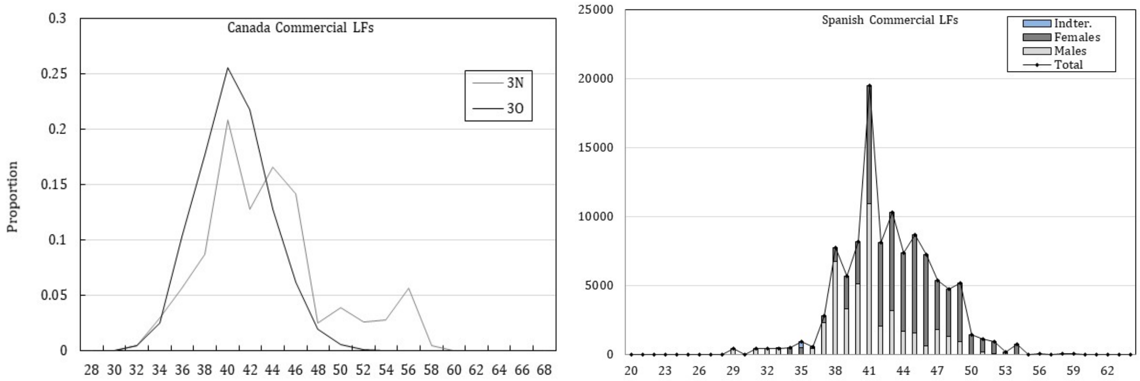


Figure 13.2. Witch flounder length frequency (cm) distributions for Canada and Spain (NAFO Divs. 3NO) commercial bycatch and directed fisheries in 2019.

ii) Research survey data

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

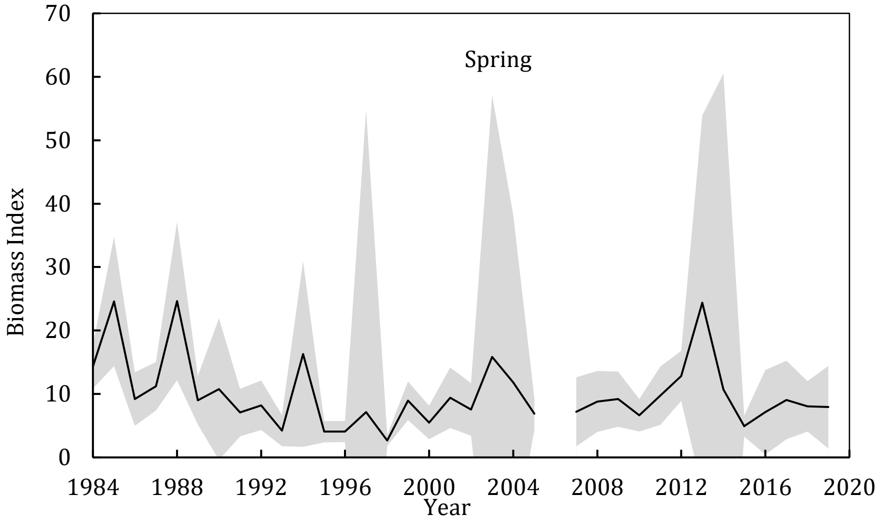


Figure 13.3. Witch flounder in NAFO Divs. 3NO: survey biomass indices from Canadian spring surveys 1984-2019 (95% confidence limits are given). Values are Campelen units or, prior to 1996, Campelen equivalent units.

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

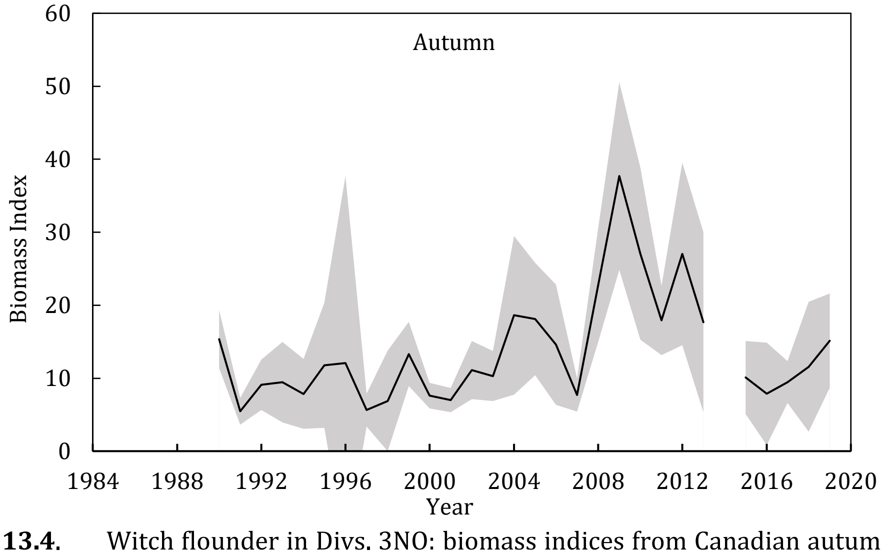


Figure 13.4. Witch flounder in Divs. 3NO: biomass indices from Canadian autumn surveys 1990-2019 (95% confidence limits are given). Values are Campelen units or, prior to 1996, Campelen equivalent units.

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

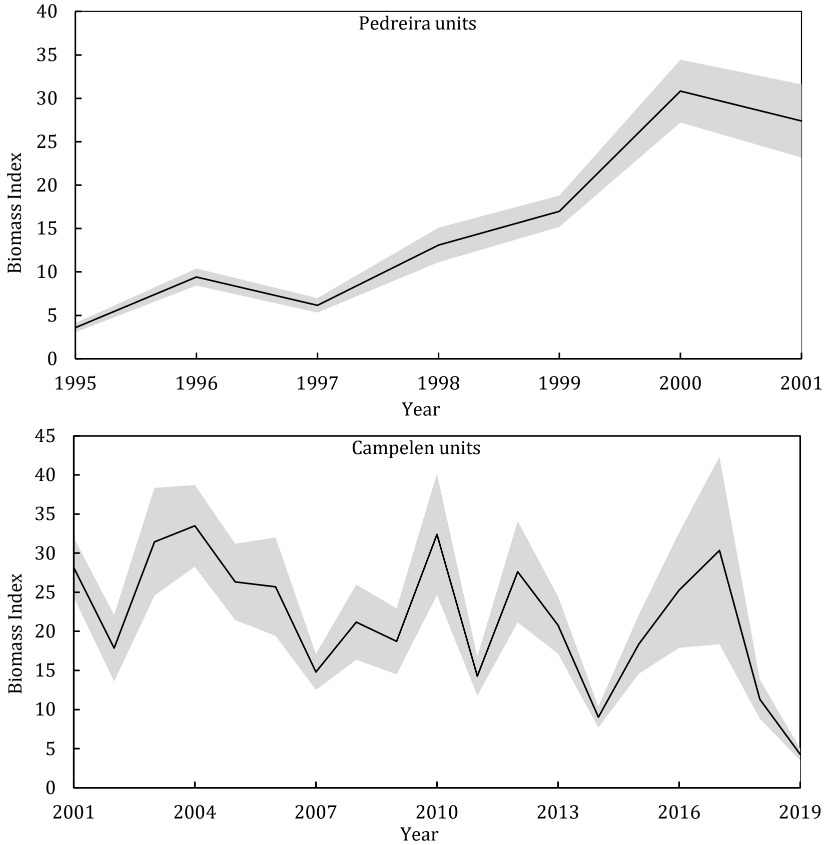


Figure 13.5. Witch flounder in Divs. 3NO: biomass indices from EU-Spanish Div. 3NO spring surveys (± 1 standard deviation). Data from 1995-2001 is in Pedreira units; data from 2001-2019 are Campelen units. Both values are presented for 2001.

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

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

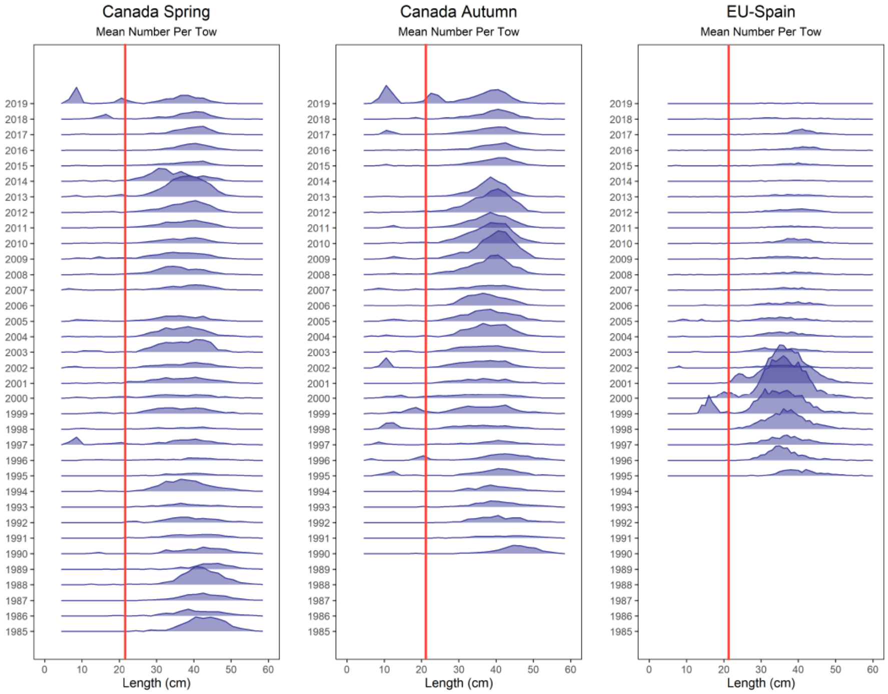


Figure 13.6. Length frequencies (abundance at length) of witch flounder from spring Canadian (1996-2019), autumn Canadian (1996 to 2019) and Spanish (2002-2019) RV surveys in NAFO Divs.3NO. No Canadian survey data was available in spring 2006 or autumn 2014. Vertical line represents the length at which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

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

c) Estimation of Parameters

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

The priors used in the model were:

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

d) State of the Stock

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

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

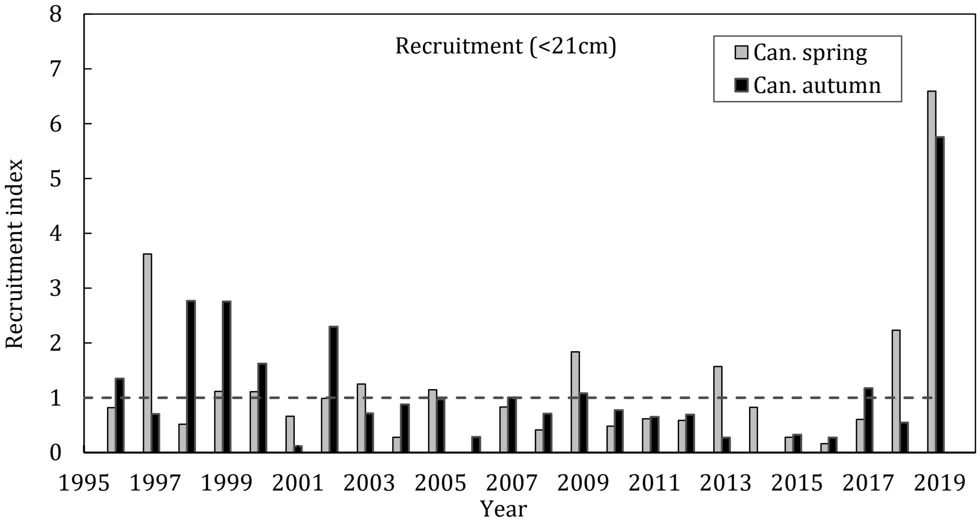


Figure 13.7. Recruitment index of witch flounder (<21cm) from spring and autumn Canadian RV surveys in NAFO Divs.3NO 1996-2019. No survey data available in autumn 2014 or spring 2006.

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

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

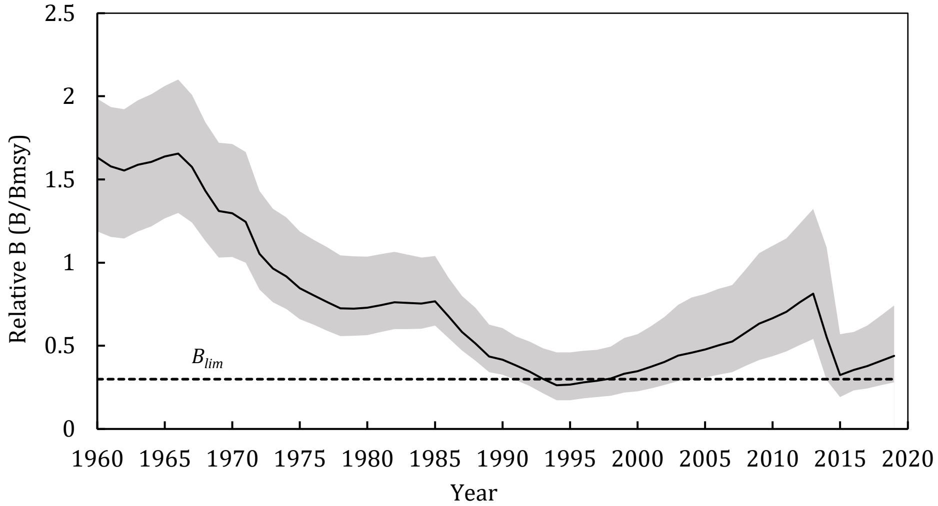


Figure 13.8. Witch flounder in Divs. 3NO. Median relative biomass (*Biomass*/B_{msy}) with 80% credible intervals from 1960-2019. The horizontal line is B_{lim}=30%B_{msy}.

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

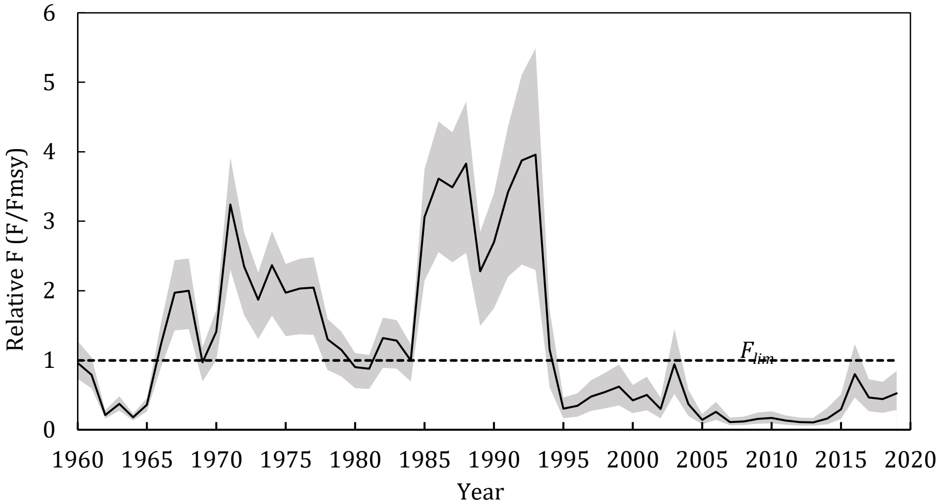


Figure 13.9. Witch flounder in Divs. 3NO. Median relative fishing mortality (F/F_{msy}) with 80% credible intervals from 1960-2019. The horizontal line is F_{lim}=F_{msy}.

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

e) Medium Term Considerations

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

The probability that $F > F_{lim}$ in 2020 is 16% at a catch of 1 175 t. The probability of $F>F_{lim}$ ranged from 2 to 50% for the catch scenarios tested (Table 13.1, 13.2). The population is projected to grow under all scenarios (Figure 13.10) and the probability that the biomass in 2023 is greater than the biomass in 2020 is greater than 60% in all scenarios. The population is projected to remain below B_{msy} through to the beginning of 2023 for all levels of *F* examined with a probability of greater than 88%. The probability of projected biomass being below B_{lim} by 2023 was 7 to 11% in all catch scenarios examined and was 4% by 2023 in the F=0 scenario.

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

Table 13.1. Medium-term projections for witch flounder under two scenarios: catch in 2020=TAC (1 175t) and catch in 2020 and 2021=TAC (1 175 t). The 10th, 50th and 90th percentiles of catch and relative biomass B/B_{msy}, are shown, for projected *F* values of *F=0*, F_{2019}, 2/3 F_{msy}, 85% F_{msy}, F_{msy}., and two levels of catch (Average 2016-2019=800 t and TAC= 1 175 t).

Projections with catch in 2020 = TAC (1 175 t)		
Year	Yield (t) median	Projected relative Biomass(B/B_{msy}) median (80% CL)
F0		
2021	0	0.49 (0.30, 0.89)
2022	0	0.53 (0.32, 0.97)
2023		0.58 (0.35, 1.06)
Catch 800 t		
2021	800	0.49 (0.30, 0.90)
2022	800	0.52 (0.31, 0.97)
2023		0.54 (0.31, 1.03)
F_{2019} = 0.033		
2021	957	0.49 (0.30, 0.89)
2022	1011	0.52 (0.31, 0.96)
2023		0.55 (0.32, 1.03)
Catch 1 175t		
2021	1175	0.49 (0.30, 0.90)
2022	1175	0.52 (0.31, 0.97)
2023		0.54 (0.31, 1.03)
2/3 F_{msy} = 0.042		
2021	1212	0.49 (0.29, 0.89)
2022	1281	0.51 (0.30, 0.96)
2023		0.54 (0.31, 1.02)
85% F_{msy} =0.054		
2021	1554	0.49 (0.30, 0.89)
2022	1615	0.51 (0.30, 0.95)
2023		0.53 (0.30, 1.01)
F_{msy} =0.063		
2021	1823	0.49 (0.30, 0.88)
2022	1879	0.50 (0.29, 0.94)
2023		0.52 (0.29, 0.99)

Projections with catch in 2020 and 2021 = TAC (1 175t)		
Year	Yield (t) median	Projected relative Biomass(B/B_{msy}) median (80% CL)
F0		
2021	1175	0.49 (0.30, 0.89)
2022	0	0.52 (0.31, 0.96)
2023		0.56 (0.33, 1.05)
Catch 800 t		
2021	1175	0.49 (0.30, 0.89)
2022	800	0.52 (0.31, 0.96)
2023		0.56 (0.33, 1.04)
F_{2019} = 0.033		
2021	1175	0.49 (0.30, 0.89)
2022	1006	0.52 (0.31, 0.96)
2023		0.55 (0.32, 1.03)
Catch 1 175t		
2021	1175	0.49 (0.30, 0.90)
2022	1175	0.52 (0.31, 0.97)
2023		0.54 (0.31, 1.03)
2/3 F_{msy} = 0.042		
2021	1175	0.49 (0.30, 0.89)
2022	1285	0.52 (0.31, 0.96)
2023		0.54 (0.31, 1.02)
85% F_{msy} =0.054		
2021	1175	0.49 (0.30, 0.89)
2022	1638	0.52 (0.31, 0.96)
2023		0.54 (0.31, 1.01)
F_{msy} =0.063		
2021	1175	0.49 (0.30, 0.89)
2022	1928	0.52 (0.31, 0.96)
2023		0.53 (0.30, 1.01)

Table 13.2. Projected yield (t) and the risk of $F > F_{lim}$, $B<B_{lim}$ and $B<B_{MSY}$ and probability of stock growth (B2023>B2020) under projected F values of $F=0$, F_{2019}, 2/3 F_{msy}, 85% F_{msy}, F_{msy}., and two levels of catch (Average 2016-2019=800 t and TAC= 1 175 t). Two scenarios are shown: catch in 2020=TAC (1 175t) and catch in 2020 and 2021=TAC (1 175 t).

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

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

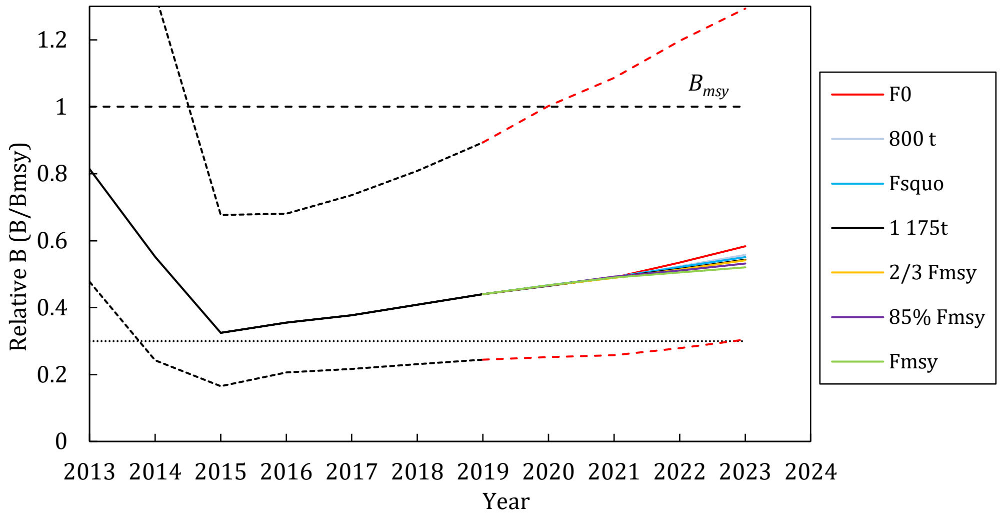


Figure 13.10. Witch flounder in Divs. 3NO: medium term projections of relative biomass (B/B_{msy}) at five levels of F (F=0, F_{2019}, 2/3 F_{msy}, 85% F_{msy} and F_{msy}) and two levels of catch (avg 2016-2019=800 t and TAC 1 175 t). A catch of 1 175 t is assumed in 2020. The 10th and 90th credible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

f) Reference Points

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

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

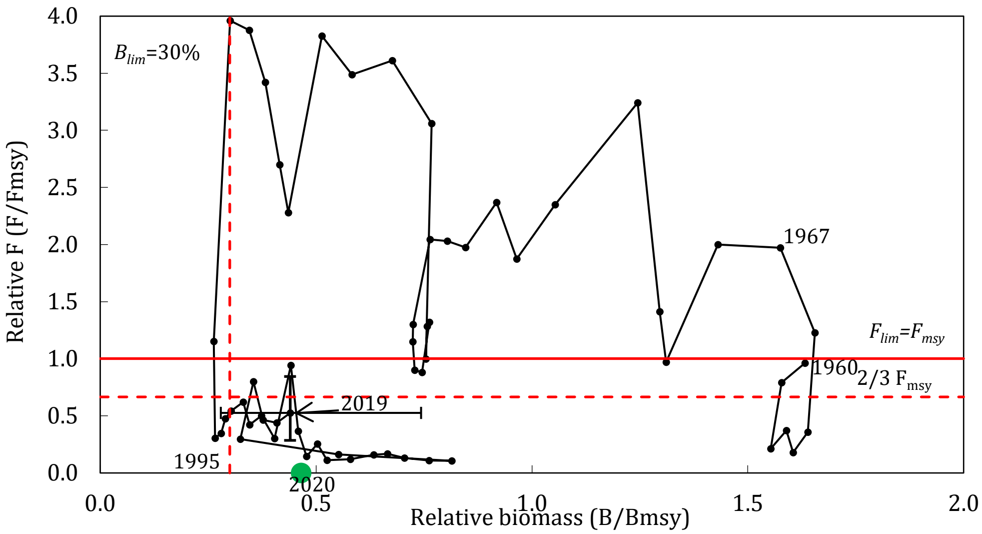


Figure 13.11. Witch flounder in Divs. 3NO: stock trajectory estimated in the surplus production analysis, under a precautionary approach framework.

g) Recommendations

The next assessment will be in 2022.

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

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

Interim Monitoring Report

a) Introduction

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

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

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

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

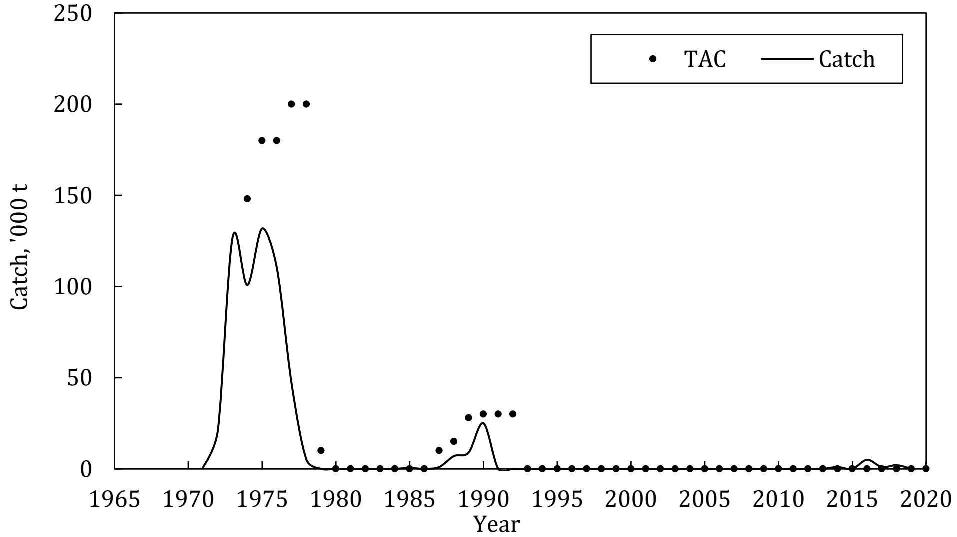


Figure 14.1. Capelin in Div. 3NO: catches and TACs.

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. However, this recommendation has not been acted upon. Available indicators of stock dynamics currently include the capelin biomass index from Canadian spring stratified-random bottom trawl surveys. This index varied greatly from 1995-2019 without any clear trend, however, three of the highest values have been observed in the most recent ten years of the time series (Figure 14.2). In 2016, the biomass indices declined to the historical minimum of 3.8 thousand tons. After increasing to 78.7 thousand tons in 2017, the index has decreased to 45.7 thousand tons in 2018. In 2019, further decrease was indicated, to 17.3 thousand tons.

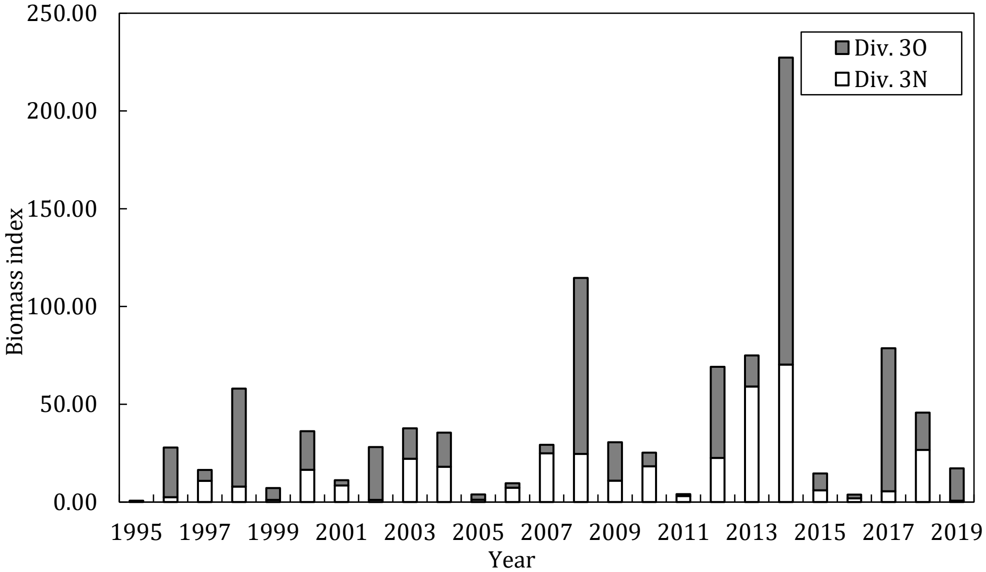


Figure 14.2. Capelin in Div. 3NO: survey biomass index (bottom trawl) from Canadian spring survey in 1995-2019.

Data from EU-Spain trawl surveys in Divs. 3NO for 1995-2019 are also available (Figure 14.3). Data from 1995-2000 are from the C/V "Playa de Menduíña", transformed to be comparable with the 2001-2019 R/V "Vizconde de Eza"data.

Survey estimates of capelin biomass show the maximum biomass level in 2012 (151.4 thousand tons). For the period of 2014-2017 biomass sharply declined from 85.5 thousand tons to 5.2 thousand tons. For 2018-2019, biomass has exhibited a simlar tendency to that at the early 2000s, rising to the level of 27.8-19.8 thousand tons.4

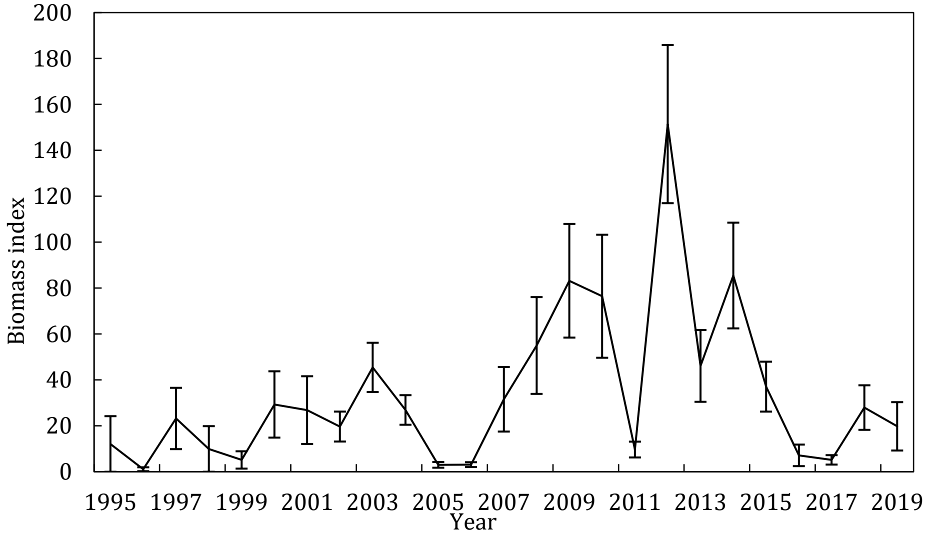


Figure 14.3. Biomass index and standard deviations of capelin (1995-2019) based on EU-Spain trawl 3NO surveys.

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) Precautionary Reference Points

STACFIS is not in a position to determine biological reference points for capelin in Div. 3NO.

e) 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. 19/002, 009; SCS Doc. 19/ 06, 07, 09, 11, 13)

Interim Monitoring Report

a) Introduction

There are two species of redfish that have been commercially fished in Div. 3O; the deep-sea redfish *(Sebastes mentella)* and the Acadian redfish *(Sebastes fasciatus*). The external characteristics are very similar, making them difficult to distinguish, and as a consequence they are reported collectively as "redfish" in the commercial fishery statistics and RV surveys. Within Canada's fishery zone, redfish in Div. 3O have been under TAC regulation since 1974 and with a minimum size limit of 22 cm since 1995. Catch was only regulated by mesh magnitude in the NRA of Div. 3O prior to the Fisheries Commission adopting a TAC in 2004. Initially, TAC was implemented at a level of 20 000 tons for 2005-2008 and has remained at that level. This TAC applies to the entire area of Div. 3O. The stock was most recently assessed in 2019.

Nominal catches have ranged between 3 000 tons and 35 000 tons since 1960 and have been highly variable with several distinct periods of rapid increase and decrease (Fig. 15.1). Up to 1986 catches averaged 13 000 tons, increased rapidly and peaked at 35 000 tons in 1988, then declined to 5 100 tons by 1997. Catches totaled 20 000 tons in 2001, then it declined to 4 000 tons in 2008. Catch was relatively stable between 6100 t and 9000 t during the recent period (2013 to 2019). Catch was 6500 tons in 2019.

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

	2011	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**
TAC	20	20	20	20	20	20	20	20	20	20
STATLANT 21	6.0	7.0	7.8	7.5	7.9	8.6	7.3	4.3		
STACFIS	6.0	7.0	7.8	7.5	8.4	9.0	7.5	6.1	6.5	

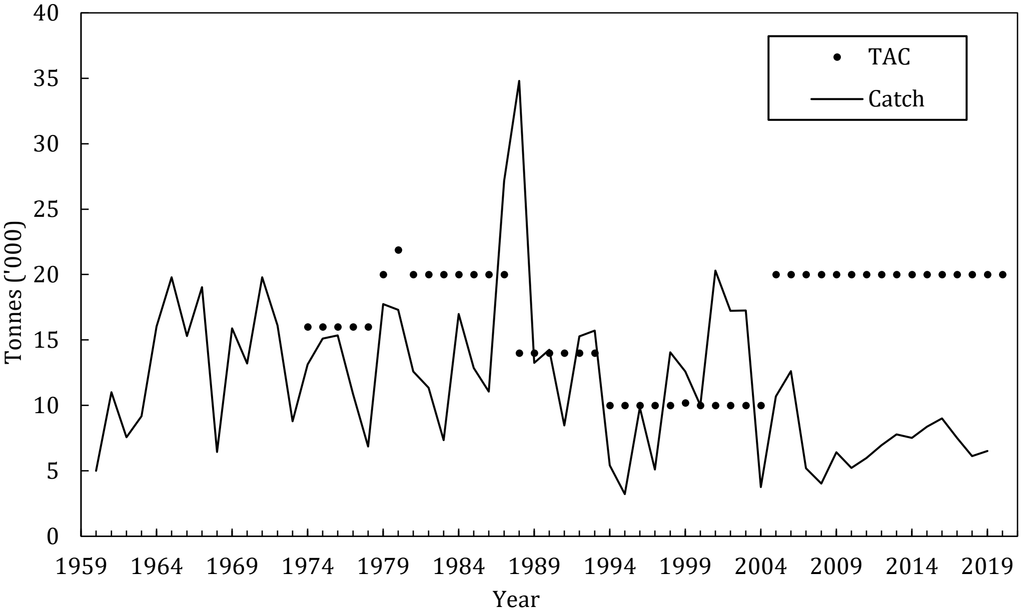


Figure 15.1. Redfish in Div. 3O: Catches and TACs. TACs prior to 2004 applied only to Canadian waters.

b) Data Overview

Surveys

Canadian spring and autumn surveys plus the EU-Spain survey were conducted in 3O during 2019. The Canadian spring survey index was generally at or above the time-series mean during two periods, the mid to late 1990s and during 2009 to 2015. The 2018 and 2019 values were well below the time-series average. The Canadian autumn surveys and the EU-Spain survey generally support the pattern of the Canadian spring survey index, with similar normalized biomass values observed for 2019 in the Canadian Spring and autumn surveys. However, the EU-Spain value was well below the mean in 2018 and 2019 (Figure. 15.2).

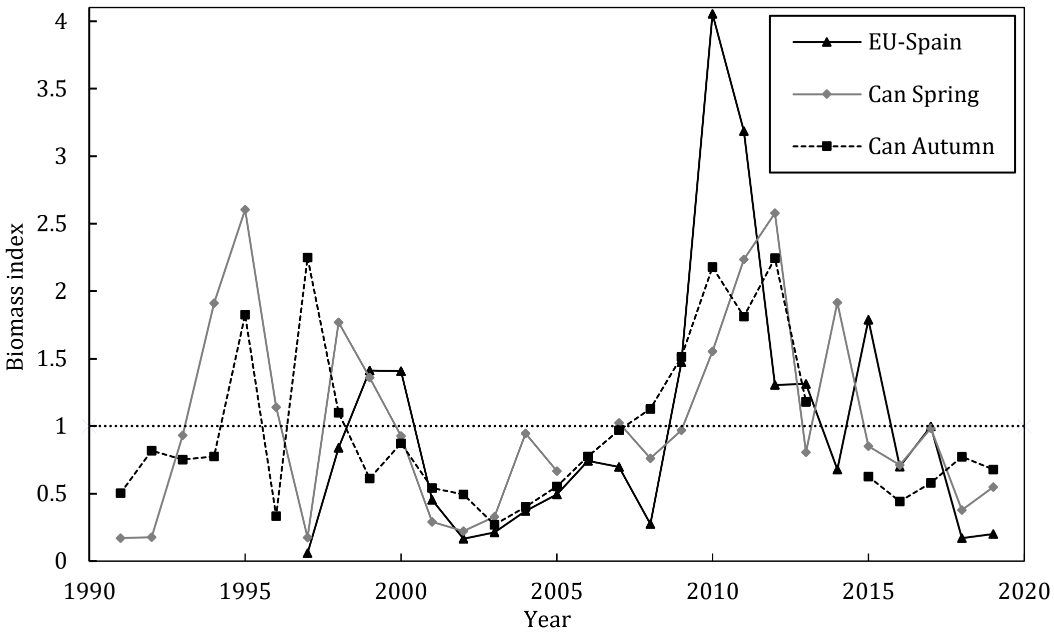


Figure 15.2. Redfish in Div. 3O: Survey biomass indices from Canada (Campelen equivalent estimates prior to autumn 1995) and EU-Spain. Indices were normalized by dividing by their time-series means over 1997-2019.

c) Estimation of Stock Parameters

There is no assessment model for this stock and survey indices are used to assess stock status.

Catch/Biomass ratio

A fishing mortality proxy was derived from the ratio of catch in year "n" to the average of the Canadian Spring (year n) and Autumn (year = n-1) survey biomass. Since 1998, the fishing mortality proxy was highest from 2001 to 2003, with a secondary peak in 2006, and lowest during the period 2007 to 2014. The fishing mortality proxy increased during the 2014 to 2016 period but values have remained stable since 2016, below the 2006 secondary peak.

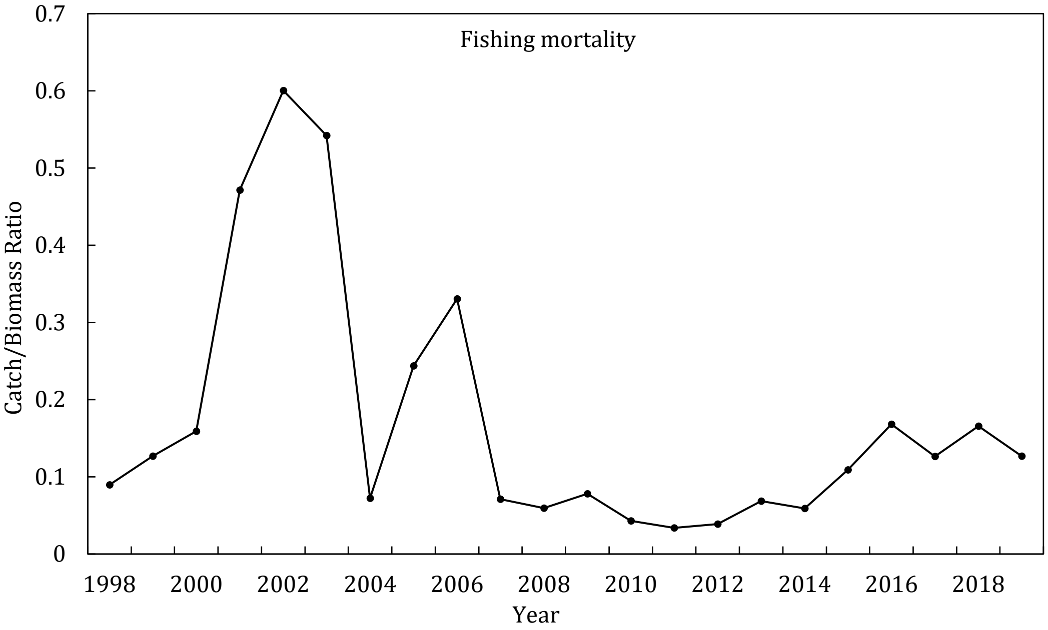


Figure 15.3. Redfish in Div. 3O: Catch/survey biomass ratios for Div. 3O. Biomass was calculated as the average survey biomass between spring (n) and autumn (n-1) for year (n) in which catch was taken. The 2006 and 2014 values of biomass come from the autumn and spring surveys respectively.

d) Conclusion

Catches increased from 2010 to 2016 as a dominant recruitment pulse entered the fishery but catch has decreased since then. All three survey indices (Canadian spring and fall, EU-Spain) were near the time-series peaks during 2010 to 2011, but values have generally decreased since 2012, and all index values for 2019 were below their time-series averages. Persistent and high variability in the biomass indices makes it difficult to reconcile year-to-year changes. The fishing mortality proxy was at the lowest levels of the time series during 2007 to 2014, but moderately higher values have been observed since then. Given the high variability in the survey indices and the long life-span of redfish, there is nothing to indicate a change in the status of the stock.

The next full assessment of the stock is scheduled for 2022.

e) Research Recommendations

In 2019, STACFIS **recommended** that *for Redfish in Div. 3O, work continue on developing an assessment model for the stock. Aging should be conducted for redfish sampled during select years to support model development.*

STATUS: No progress has been made.

16. Thorny Skate (*Amblyraja radiata*) in Divisions 3L, 3N, 3O and Subdivision 3Ps

(SCR Doc. 20/04,10,14,41; SCS Doc. 20/07,09,13)

a) Introduction

Thorny skate on the Grand Banks was first assessed by Canada in 1999 for the stock unit 3LNOPs. Subsequent Canadian assessments also provided advice for Divs. 3LNOPs. However, Subdivision 3Ps is presently managed as a separate unit by Canada and France in their respective EEZs, and Divs. 3LNO in the NAFO Regulatory Area (NRA) is managed by NAFO. Based on this species' continuous distribution and the lack of physical barriers between Divs. 3LNO and Subdiv. 3Ps, thorny skate in Divs. 3LNOPs is considered to constitute a single stock.

i) 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. Thus, the skate fishery on the Grand Banks can be considered a fishery for thorny skate. In 2005, NAFO Fisheries Commission established a Total Allowable Catch (TAC) of 13 500 t for thorny skate in the NRA of Divs. 3LNO (Figure 16.1). This TAC was lowered to 12 000 t for 2010-2011, and to 8 500 tons for 2012. The TAC was further reduced to 7 000 t for 2013-2020. In Subdiv. 3Ps, Canada established a TAC of 1 050 tons in 1997, which has not changed.

Catches from the NRA of Divs. 3LNO increased in the mid-1980s with the commencement of a directed fishery for thorny skate (Figure 16.1). The main participants in this new fishery were Spain, Portugal, USSR, and the Republic of Korea. Reported landings from all countries in Divs. 3LNOPs over 1985-1991 averaged 17 058 t; with a peak of 28 408 t in 1991 (STATLANT-21A). From 1992-1995, catches of thorny skate declined to an average of 7 554 t; however, there are substantial uncertainties concerning reported skate catches prior to 1996. Average STACFIS-agreed catch for Divs. 3LNO in 2012-2018 was 3 831 t, and 460 t for Subdiv. 3Ps. STACFIS catch in 2019 totaled 3 697 t for Divs. 3LNO, and 889 t for Subdiv. 3Ps.

Recent catches and TACs (‘000 tonnes) were as follows:

	2010	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**
Divs. 3LNO:											
TAC	12	12	8.5	7	7	7	7	7	7	7	7
STATLANT-21A	5.4	5.5	4.3	4.3	4.5	3.3	3.5	4.2	1.5	3.7	
STACFIS	3.1	5.4	4.3	4.3	4.5	3.3	3.5	4.5	2.4	3.7	
Subdiv. 3Ps:											
TAC	1.05	1.05	1.05	1.05	1.05	1.05	1.05	1.05	1.05	1.05	1.05
STATLANT-21A	0.9	0.7	0.6	0.6	0.3	0.2	0.7	0.6	1.1	.9	
Divs. 3LNOPs:											
STATLANT-21A	6.2	6.3	4.9	4.9	4.8	3.6	4.1	4.8	2.3	4.6	
STACFIS	4.0	6.1	4.8	5.0	4.8	3.6	4.1	5.1	3.5	4.6	

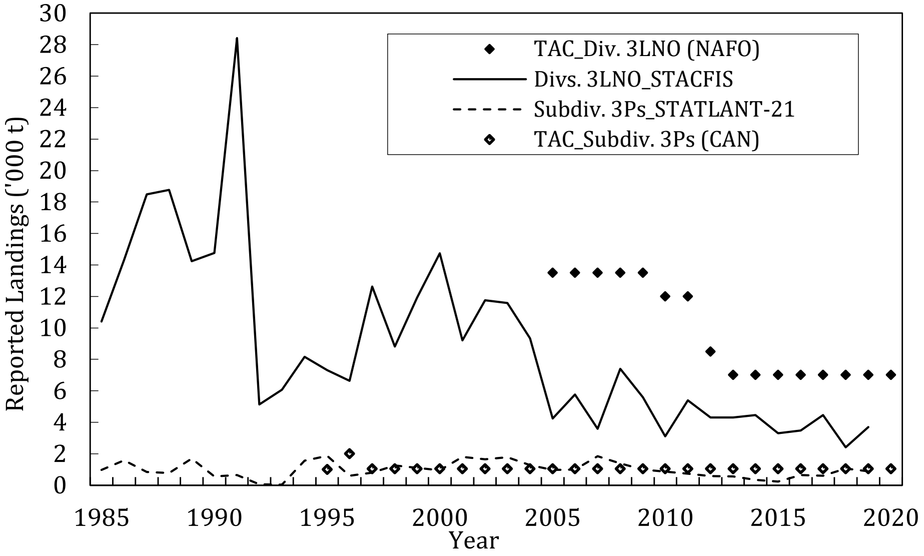


Figure 16.1. Thorny skate in Divs. 3LNO and Subdiv. 3Ps, 1985-2019: total reported landings and TACs.

b) Data Overview

i) Commercial fisheries

Thorny skates from either commercial or research survey catches are currently not aged.

Commercial length frequencies of skates were available for EU-Spain (1985-1991, 1997-2019), EU-Portugal (2002-2004, 2006-2011, 2013, 2017-2019), Russia (1998-2008, 2011-2012, 2015-2019), and Canada (1994-2008, 2010, 2012-2019).

From skate-directed trawl fisheries (280 mm mesh) in the NRA of Divs. 3LNO over 2012-2019, EU-Spain reported 15-100 cm TL skates, with a small number of young-of-the-year (≤21 cm) caught in 2013-2014 and 2017-2018. In 2013, EU-Portugal caught 26-85 cm skates (mode: 49-50 cm) using 280 mm mesh in Div. 3N.

In trawl fisheries targeting other species (130-135 mm mesh) in Div. 3LNO (NRA) over 2013-2019, EU-Portugal reported skate bycatch ranging from 25-88 cm TL, including modes of 46-49, 60-64, and 72-76 cm. EU-Portugal did not sample Divs. 3LNO skate bycatch in 2014-2016 and 2018, while EU-Spain have not done so since 2009. Russian trawlers in the Div. 3LN Greenland Halibut fishery reported 24-78 cm skates in 2012. In the Div. 3LO redfish fishery, Russia reported 35-89 cm skates in 2013-2016, and sampled only 5 and 14 specimens in 2017 and 2018 (respectively). In 2019, Russia reported the capture of thorny skates (31-87 cm)in Div. 3L averaging 56.1 cm. In Div. 3N and 3O respectively, Russia captured skates that comprised individuals ranging from 31-95 cm (average 64.0 cm), and 15-92 cm (average 70.7 cm). In the Div. 3L redfish fishery, skates varied between 27-93 cm in 2016-2019, including modes of 35-40, 56, 62-66, and 72-82 cm. Canadian trawlers in the Div. 3NO Yellowtail Flounder fishery in 2016-2019 caught 24-101 cm thorny skates. In 2017, skates trawled in the Div. 3O Witch Flounder fishery ranged between 42-100 cm (mode: 80 cm). Skates trawled in the Divs. 2J3KL Greenland Halibut fishery in 2018 varied between 31-88 cm (modes of 48, 53, and 63 cm).

No standardized commercial catch per unit effort (CPUE) exists for thorny skate.

ii) 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 1983-1995, and a Campelen 1800 shrimp trawl in 1996-2019. Subdiv. 3Ps was not surveyed in 2006, nor was the deeper portion of Divs. 3NO, due to mechanical difficulties on Canadian research vessels. In 2015 and 2017, several strata were not sampled in Div. 3L, thus impacting biomass and abundance estimates of thorny skate.

Indices for Divs. 3LNOPs in 1972-1982 (Yankee series) fluctuated without trend (Figure 16.2a).

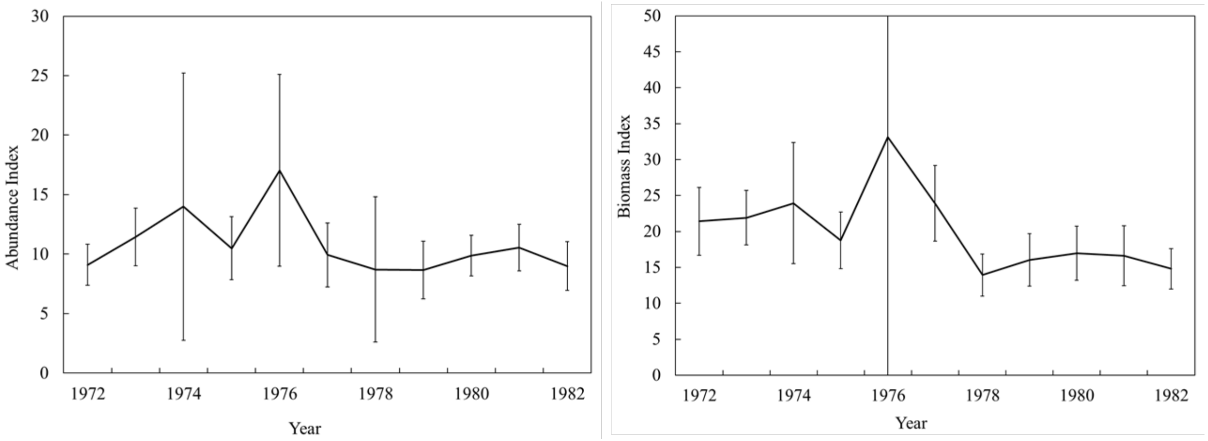


Figure 16.2a. Thorny skate in Divs. 3LNOPs, 1972-1982: abundance (left panel) and biomass (right panel) indices from Canadian spring surveys.

Survey coverage was poor in the Canadian spring survey of Div. 3L in 2017. The missing strata typically contain ~10% on average of the total biomass in years when these strata are surveyed; therefore, the 2017 biomass index may be an underestimate (Figure 16.2b). Total survey biomass in Divs. 3LNOPs has fluctuated, but remained stable at low levels since 2007.

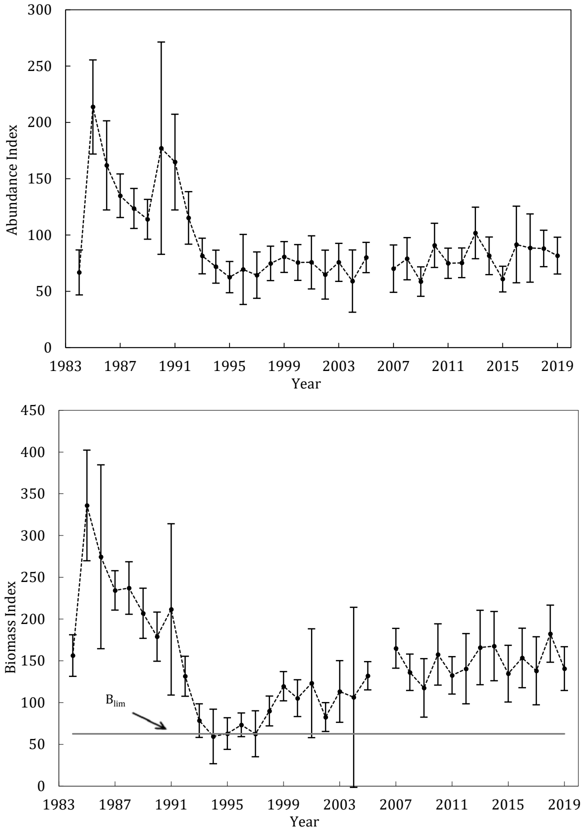


Figure 16.2b. Thorny skate in Divs. 3LNOPs, 1984-2019: abundance (top panel) and biomass (bottom panel) indices from Canadian spring surveys. Horizontal line represents *B_{lim}*. Surveys in 2015 and 2017 (open circles) were incomplete.

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 1995-2019, 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 surveyed in 2014, nor deep-water strata (>732 m) of Div. 3L in 2015, and 2017-2018; 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.

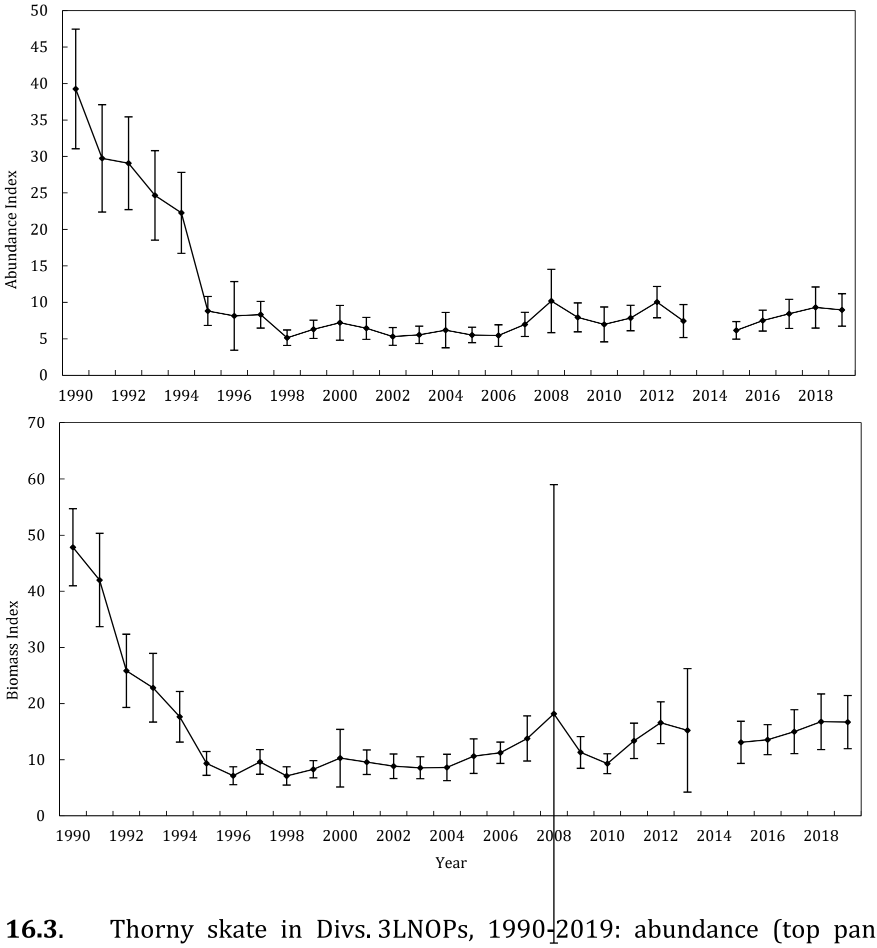


Figure 16.3. Thorny skate in Divs. 3LNOPs, 1990-2019: abundance (top panel) and biomass (bottom panel) indices from Canadian autumn surveys. Divs. 3NO were not sampled in 2014, nor deep-water strata of Div. 3L in 2015, and 2017-2018.

EU-Spain Divs. 3NO Survey. EU-Spain survey indices (Campelen or equivalent) are available for 1997-2019. The survey only occurs in the NAFO Regulatory Area, thus not sampling the entire Divisions. The biomass trajectory from the EU-Spain surveys was similar to that of the Canadian spring surveys until 2006 (Figure 16.4). Since 2007, the two indices diverged: with an overall increase in the Canadian survey and a declining trend in the EU-Spain index to its lowest value in 2019.

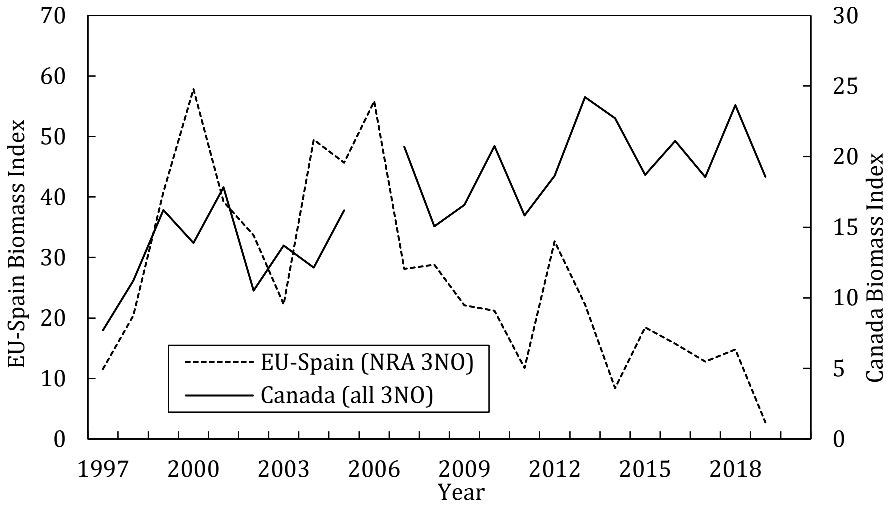


Figure 16.4. Thorny skate in Divs. 3LNOPs, 1997-2019: biomass indices from the EU-Spain survey and the Canadian spring survey.

EU-Spain Div. 3L survey. EU-Spain survey indices (Campelen trawl) are available for 2003-2019 (excluding 2005). The survey only occurs in the NAFO Regulatory Area (Flemish Pass), thus not sampling the entire Division. Both the EU-Spain and Canadian autumn Div. 3L biomass indices generally declined from 2007-2011, while the Canadian spring index was more variable during this period (Figure 16.5). The Canadian autumn biomass index followed an increasing trend since 2011, while the Canadian spring index fluctuated at lower levels. The EU-Spain index has been following a declining trend since 2015.

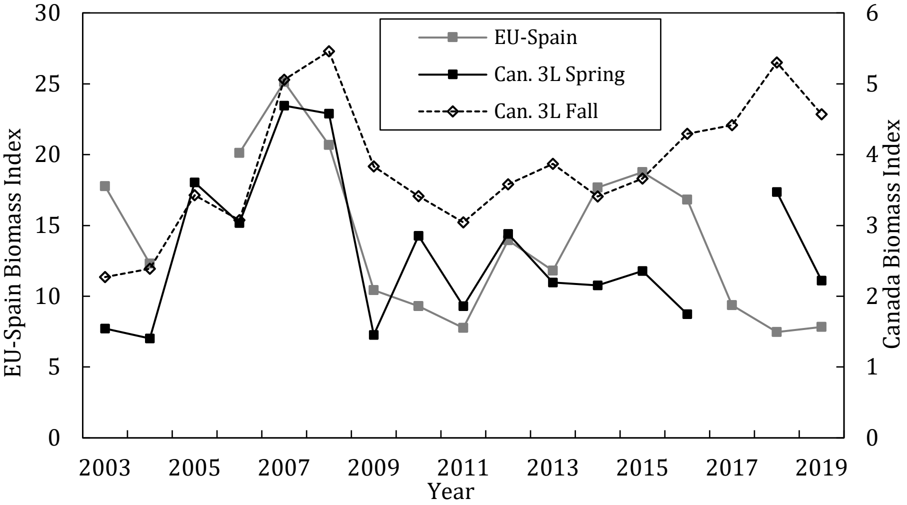


Figure 16.5. Thorny skate in Div. 3LNOPs, 2003-2019: Biomass indices from EU-Spain Div. 3L survey and the Canadian spring and autumn surveys of Div. 3L. The Canadian spring survey in Div. 3L was incomplete in 2015 and 2017.

iii) Biological studies

Recruitment index (skate ≤21 cm TL) was below average in 1999-2002 (Figure 16.6). The index was above average during 2010-2013. Recruitment declined to below average in 2014-2015, then increased to 1.3 in 2017. This increase in 2017 was observed despite the missing Div. 3L survey strata which, in 2009-2016, contained on average 10% of the thorny skate recruits. This index was below average in 2018, and average in 2019. Life history traits of late maturity, low fecundity, and long reproductive cycles result in low intrinsic rates of increase, and impart low resilience to fishing mortality for this species.

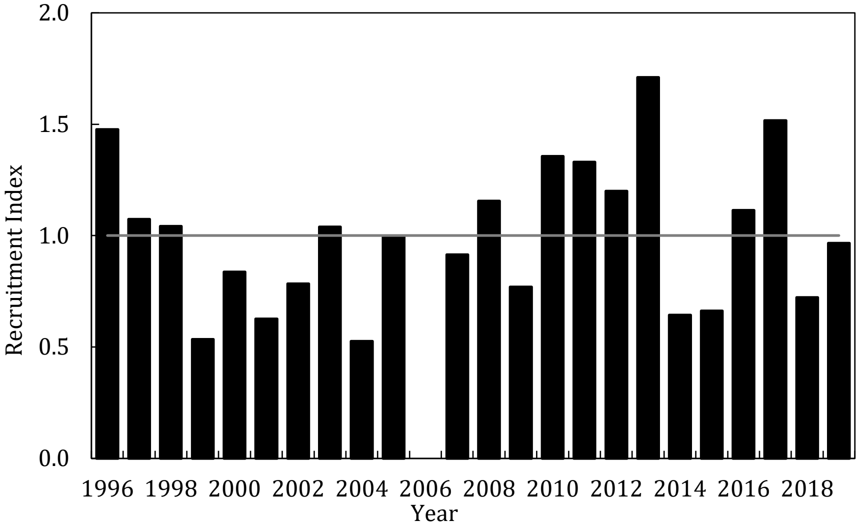


Figure 16.6. Thorny skate in Divs. 3LNOPs, 1996-2019: Standardized recruitment index for ≤21 cm TL males and females (combined) from Canadian Campelen spring surveys. Horizontal line depicts the standardized average recruitment for 1996-2019. The survey was incomplete in 2017.

c) Estimation of Parameters

Relative F (STACFIS-agreed commercial landings/Canadian spring survey biomass) in Divs. 3LNO declined over the late-1990s, and is currently low. Relative fishing mortality in Subdiv. 3Ps has also been low in recent years.

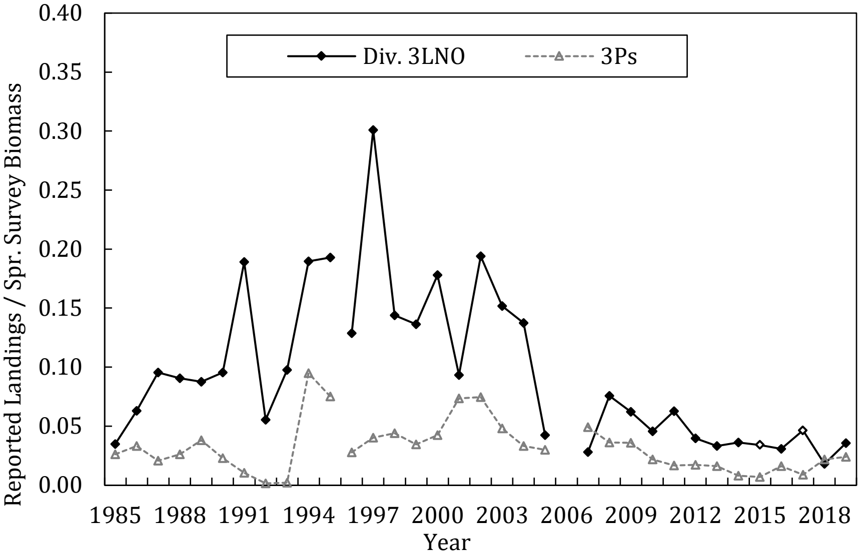


Figure 16.7. Thorny skate in Divs. 3LNO and Subdiv. 3Ps, 1985-2019: estimates of Relative F from STACFIS-agreed commercial landings/Canadian spring survey biomass. was incomplete in 2015 and 2017 (open circles).

d) Assessment Results

Assessment Results: No analytical assessment was performed.

The Canadian spring survey is considered the primary indicator of the status of this stock, due to its spatial and temporal coverage.

Biomass: Biomass of this stock has remained stable at low levels since 2007. For comparable periods, the pattern from the Canadian autumn research survey was similar.

Fishing Mortality: Relative F (STACFIS-agreed commercial landings/Canadian spring survey biomass) in Divs. 3LNOPs declined since the mid-1990s, and is currently low.

Recruitment: Recruitment has been below average over 1997-2007. Recruitment was above average during 2010-2013, but declined to below average in 2014-2016. Recruitment in 2016-2017 was above average, but declined to below average in 2018, and was average in 2019.

State of the Stock: The stock is currently above $B_{lim.}$ The probability that the current biomass is above B_{lim} is >95%. Total survey biomass in Divs 3LNOPs has remained stable since 2007 but is still lower than the levels observed at the end of the 1980s. Recruitment in 2017 was above average but declined to below average in 2018 and was average in 2019. Fishing mortality is currently low.

e) Reference Points

Limit reference points based on B_{loss}, which represents the lowest value for the Canadian spring survey conducted with Campelen survey gear, were accepted in 2015 as a proxy for B_{lim} (Figure 16.8).

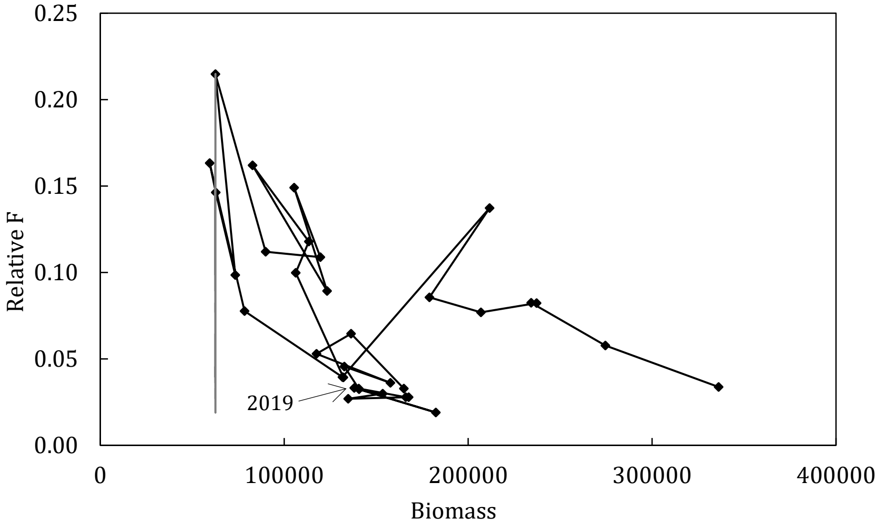


Figure 16.8. Thorny skate in Divs. 3LNOPs, 1985-2019: stock trajectory under a precautionary approach framework.

f) Research Recommendations

STACFIS **recommended** that *further work be conducted on development of a quantitative stock model.*

STATUS: Work ongoing. STACFIS reiterated this recommendation.

The next full assessment is planned for 2022.

17. White hake (*Urophycis tenuis*) in Divisions 3N, 3O, and Subdivision 3Ps

(SCR Doc. 20/02,10; SCS Doc. 20/07,11)

Interim Monitoring Report

a) Introduction

The advice requested by Fisheries Commission is for NAFO Div. 3NO. Previous studies indicated that White Hake constitute a single unit in Div. 3NOPs, and that fish younger than 1 year, 2+ juveniles, and mature adults distribute at different locations within Div. 3NO and Subdiv. 3Ps. This movement of fish of different life stages between areas must be considered when assessing the status of White Hake in Div. 3NO. Therefore, an assessment of Div. 3NO White Hake is conducted with information on Subdiv. 3Ps included.

In 1988, Canada commenced a directed fishery for White Hake in Div. 3NO and Subdiv. 3Ps. All Canadian landings prior to 1988 were as bycatch in various groundfish fisheries. EU-Spain and EU-Portugal commenced a directed fishery in 2002, and Russia in 2003, in the NAFO Regulatory Area (NRA) of Div. 3NO; resulting in the 2003-2004 peak in landings. In 2003-2004, 14% of the total landings of White Hake in Div. 3NO and Subdiv. 3Ps were taken by Canada, but increased to 93% by 2006; primarily due to the absence of a directed fishery for this species by other countries.

A TAC for White Hake was first implemented by Fisheries Commission in 2005 at 8 500 tons, and was then reduced to 6 000 t for 2010 and 2011. The 5 000 t TAC in Div. 3NO for 2012 was further reduced to 1 000 t for 2013-2020. Canada implemented a TAC of 500 t for Subdiv. 3Ps for 2018-2020.

From 1970-2009, White Hake catches in Div. 3NO fluctuated, averaging approximately 2 000 t, exceeding 5 000 t in only three years during that period. Catches peaked in 1987 at 8 061 t (Figure 17.1). With the restriction of fishing by other countries to areas outside Canada's Exclusive Economic Zone in 1992, non-Canadian catches fell to zero. Average catch was low in 1995-2001 (422 t), then increased to 6 718 t in 2002 and 4 823 t in 2003; following recruitment of the large 1999 year-class. STACFIS-agreed catches in Divisions 3NO decreased to an average of 333 t over the period 2009-2018. STACFIS catch in 2019 was 304 t in Div. 3NO.

Commercial catches of White Hake in Subdiv. 3Ps were less variable, averaging 1 114 t in 1985-93, then decreasing to an average of 619 t in 1994-2002 (Figure 17.1). Subsequently, catches increased to an average of 1 374 t in 2003-2007, then decreased to a 310 t average in 2008-2018. Catch in 2019 was reported as 186 t in Subdiv. 3Ps

Recent reported landings and TACs (000 tons) in NAFO Div. 3NO and Subdiv. 3Ps are as follows:

	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Div. 3NO:										
TAC	6	5	1[1]	1[1]	1[1]	1[1]	1[1]	1[1]	1[1]	1[1]
STATLANT 21	0.2	0.1	0.2	0.3	.4	.4	.5	.3	.3	
STACFIS	0.2	0.1	0.2	0.3	.5	.4	.5	.4	.3	
Subdiv. 3Ps:								.5	.5	.5
STATLANT 21	0.2	0.2	0.2	0.4	.3	.4	.3	.3	.2	

[1] May change in season. See NAFO FC Doc. 13/01 quota table.

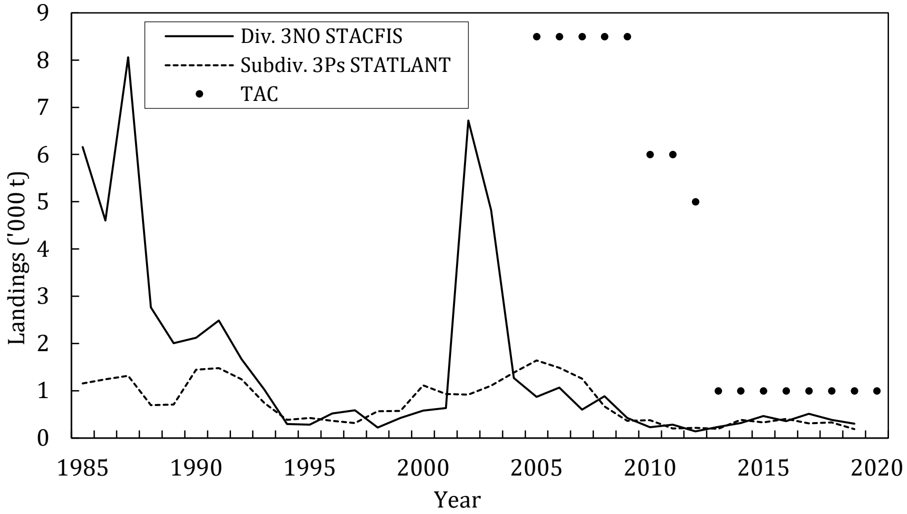


Figure 17.1. White Hake in Division 3NO and Subdivision 3Ps: Total catch of White Hake in NAFO Division 3NO (STACFIS) and Subdivision 3Ps (STATLANT-21A). The Total Allowable Catch (TAC) in the NRA of Divs. 3NO is also indicated on the graph.

b) Data Overview

i) Research survey data

Canadian stratified-random bottom trawl surveys. Data from spring research surveys in NAFO Div. 3N, 3O, and Subdiv. 3Ps were available from 1972 to 2019. 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 2019, 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 1995-2019. There are no survey catch rate conversion factors between trawls for white hake; thus each gear type is presented as a separate time series.

Abundance and biomass indices of white hake from the Canadian spring research surveys in Div. 3NOPs are presented in Figure 17.2a. From 2007-2019, the population remained at a level similar to that previously observed in the Campelen time series for 1996-1998. The dominant feature of the white hake abundance time series was the very large peak observed over 2000-2001. In recent years, spring abundance of white hake increased in 2011, but declined to relatively stable levels over 2012-2018. In 2019, the abundance index of white hake has exhibited a strong increase comparable to that observed in 1999. Biomass of this stock increased in 2000, generated by the very large 1999 year-class. Subsequently, the biomass index decreased until 2009, and has since been relatively stable.

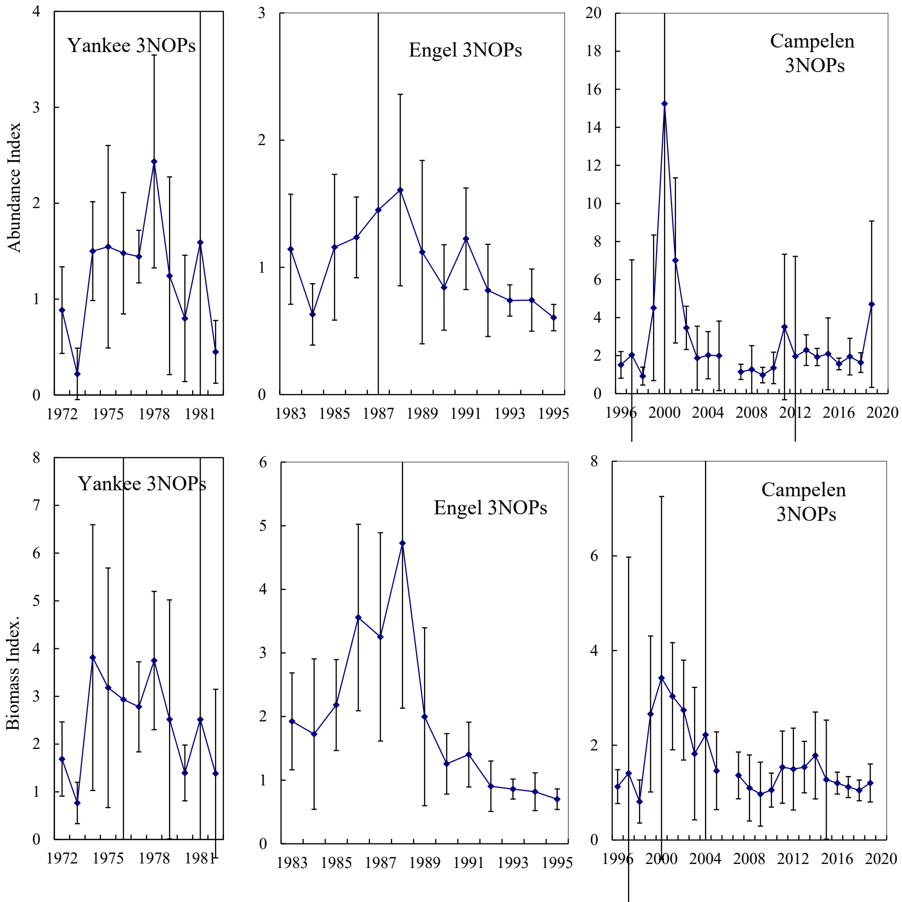


Figure 17.2a. White Hake in Div. 3NO and Subdiv. 3Ps: abundance (top panels) and biomass (bottom panels) indices from Canadian winter-spring research surveys, 1972-2019. Estimates from 2006 are not shown, since survey coverage in that year was incomplete. Yankee, Engel, and Campelen time series are not standardized, and are presented on separate panels. Error bars are 95% confidence limits. The bounds of the error bars in some panels extend above/below the graph limits.

Canadian autumn surveys of Div. 3NO have the peak in abundance represented by the very large 1999 year-class (Figure 17.2b). Autumn indices then declined to levels similar to those observed during 1996-1998. In recent years, both biomass and abundance appear to have been variable without trend. This survey was not completed in 2014.

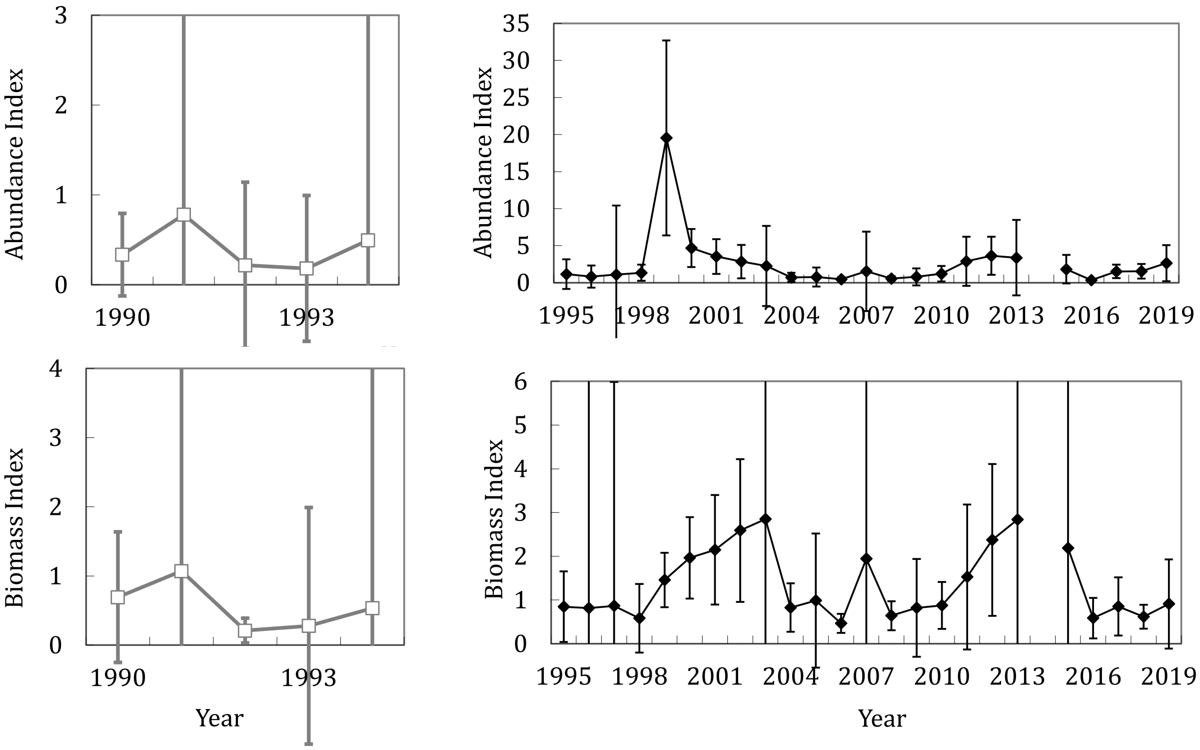


Figure 17.2b. White Hake in Div. 3NO: abundance (top panel) and biomass indices (bottom panel) from Canadian fall surveys, 1990-2019. Engel (□, 1990-1994) and Campelen (♦, 1995-2013) time series are not standardized. Estimates from 2014 are not shown, since survey coverage in that year was incomplete. Error bars are 95% confidence limits. The bounds of the error bars in some panels extend above/below the graph limits.

EU-Spanish stratified-random bottom trawl surveys in the NRA. EU-Spain biomass indices in the NAFO Regulatory Area (NRA) of Div. 3NO were available for white hake from 2001 to 2019 (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 from 2016 to 2019 to a similar level as observed in 2008, while in 2019 the Canadian index increased.

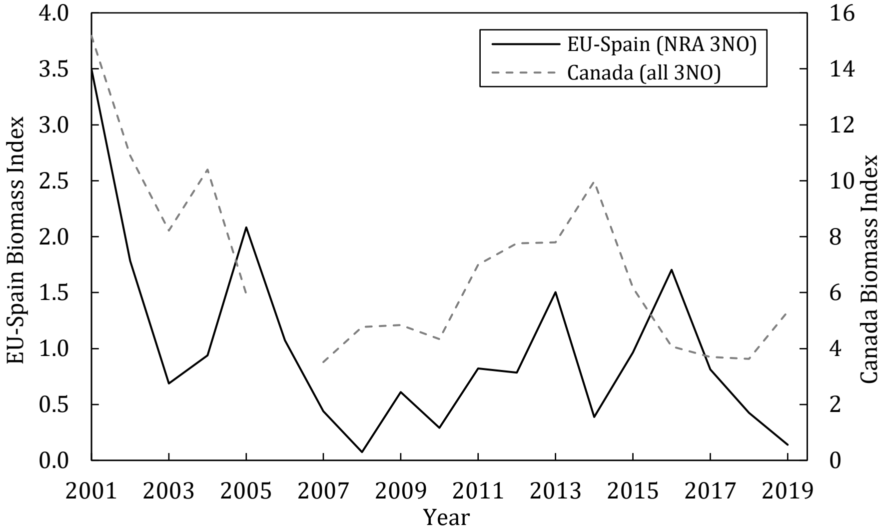


Figure 17.3. Biomass indices from EU-Spain spring 3NO surveys in 2001-2019 in the NRA compared to Canadian spring survey indices in all of Div. 3NO. Estimates from 2006 Canadian survey are not shown, since survey coverage in that year was incomplete.

Recruitment. In Canadian spring research surveys, the number of white hake less than 27 cm in length is assumed to be an index of recruitment at Age 1. The recruitment index in 2000 was very large, but no large value has been observed during 2001-2019 (Figure 17.6). Recruitment was higher in 2011 and in 2019, but not comparable to the very high recruitment observed in 2000.

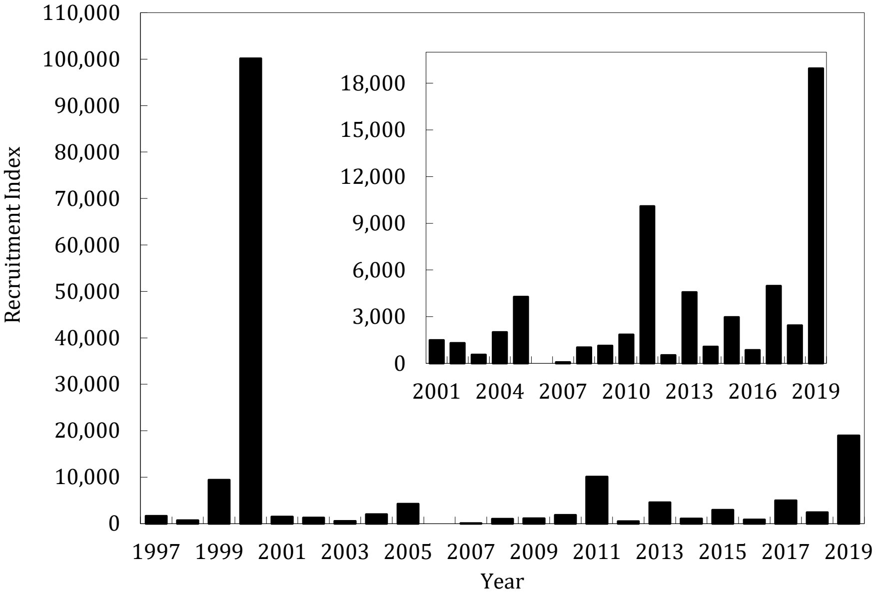


Figure 17.4. White Hake in Div. 3NO and Subdiv. 3Ps: recruitment index for Age 1 males and females (combined) from Canadian Campelen spring surveys in Divs. 3NO and Subdiv. 3Ps n 1997-2019. Estimates from 2006 are not shown, since survey coverage in that year was incomplete. Inset plot depicts 2001-2019 on a smaller scale.

c) Conclusion

Based on current information there is no significant change in the status of this stock. Stock biomass remains at relatively low levels, and no large recruitments have been observed since 2000.

d) Research Recommendations

STACFIS **recommended** that *age determination should be conducted on otolith samples collected during annual Canadian surveys (1972-2016+); thereby allowing age-based analyses of this population.*

Otoliths are being collected but have not been aged. STACFIS reiterates this recommendation.

STACFIS **recommended** that *survey conversion factors between the Engel and Campelen gear be investigated for this stock.*

No progress, STACFIS reiterates this recommendation.

STACFIS **recommended** that *work continue on the development of population models and reference point proxies*.

Various formulations of a surplus production model in a Bayesian framework were explored and work is continuing.

D. WIDELY DISTRIBUTED STOCKS: SUBAREA 2, SUBAREA 3 AND SUBAREA 4

Recent Conditions in Ocean Climate and Lower Trophic Levels

- Driven mostly by warm temperature in SA 4, the ocean climate index based on data from the Labrador Shelf to the Scotian Shelf (SA2-4) has remained mostly warmer than normal since early 2010, with its highest value in 2012. In 2019, SA-2 was normal, SA-3 below normal and SA-4 above normal.
- Spring bloom initiation anomalies in 2019 were negative (earlier bloom) on the Newfoundland Shelf and The Grand Bank (SA 3), and positive (later bloom) on the Scotian Shelf and in the Gulf of St. Lawrence (SA 4) but did not depart from normal conditions (± 0.5 SD).
- Spring bloom magnitude anomalies in 2019 were negative (lower production) on the Newfoundland Shelf and the Grand Bank (SA 3) and on the Scotian Shelf and the Gulf of St. Lawrence (SA 4) but did not depart much from normal conditions (± 0.5 SD).
- The abundance of copepod and non-copepod zooplankton showed positive anomalies across the Northwest Atlantic (SA 2-4) in 2019.
- Zooplankton biomass in 2019 showed a positive anomaly on the Labrador Shelf (SA 2), and negative anomalies on the Newfoundland Shelf, the Grand Banks, the Scotian Shelf, and in the Gulf of St. Lawrence (SA 3-4)

Environmental Overview

The water mass characteristics of the 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 3-4°C and salinities in the range of 34-34.75. On average bottom temperatures remain < 0°C over most of the northern Grand Banks but increase to 1-4°C in southern regions and along the slopes of the banks below 200 m. North of the Grand Bank, in Div. 3K, bottom temperatures are generally warmer (1-3oC) 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

A cumulative climate index for NAFO sub-areas 2, 3 and 4 (from the Labrador Shelf to the Scotian Shelf) is presented in Figure D1.A. After a somewhat cold period from the late 1980s to the early 1990s, the index has remained relatively high since about 2010. Years 2012, 2014, 2017, 2015 and 2016 (ranked in this order) are the warmest anomalies since 1985. In 2019, the cumulative index was however average but characterized by warm conditions in SA-4 and cold conditions in SA-3. Spring bloom initiation (Figure D1.B) oscillated between earlier (negative anomalies) and later (positive anomalies) sowing no long-term trend throughout the time series. Spring bloom timing anomalies in 2019 were negative on the Newfoundland Shelf and the Grand Banks (SA 3) and positive on the Scotian Shelf and in the Gulf of St. Lawrence (SA 4) but did not depart from normal conditions (± 0.05 SD). Spring Bloom magnitude (Figure D1.C) transitioned from mostly positive anomalies from 1998-2006 to almost exclusively negative anomalies afterwards in all subareas. Spring bloom magnitude anomalies in 2019 were negative (lower production) on the Newfoundland Shelf and the Grand Bank (SA 3) and on the Scotian Shelf and the Gulf of St. Lawrence (SA 4) but did not depart much from normal conditions (± 0.5 SD). Limited satellite coverage in SA 2 in 2019 due to sea ice and clouds did not allow calculation of spring bloom indices for that region.

The abundance of copepod (Figure D1.D) and non-copepod Figure D1.E) zooplankton showed large-scale increasing trends throughout the time series. Copepod abundance increased markedly on the Newfoundland Shelf and the Grand Banks (SA 3) during the late 2010s. Positive anomalies in copepod abundance were observed across all subareas in 2019 with the second highest cumulated index of the time series. The abundance of non-copepod has markedly increased in all subareas since the late 2000s with positive anomalies across the Northwest Atlantic since 2013, including in 2019. Large scale trend in zooplankton biomass (Figure D1.F) shows an increase during the late 1990s and early 2000s, followed by an overall decrease between 2002 and 2015. Zooplankton biomass. Zooplankton biomass has been increasing during the late 2010s, especially on the Labrador Shelf (SA 2) and on the Newfoundland Shelf and the Grand Bank (SA 3). Zooplankton abundance anomalies in 2019 were positive in SA 2 and negative in SA 2 and SA 3.

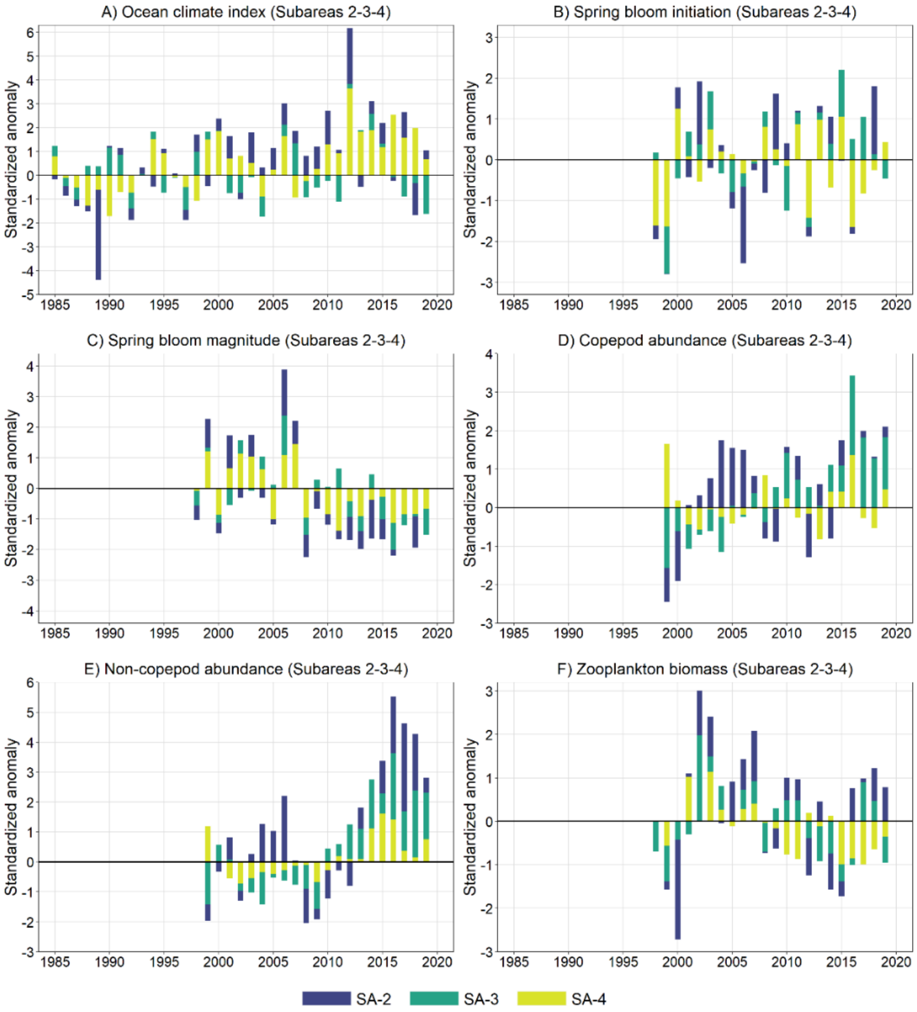


Figure D1. Environmental indices for NAFO Sub-areas 2 to 4 during 1990-2019. The ocean climate index (A) is presented as a stack bar plot for Subareas 2, 3 and 4. The standardized anomalies for SA2 are the result of the average of 8 individual time series: Sea surface temperatures (SST) in Divs. 2G, 2H and 2J, bottom temperatures in 2H and 2J in the fall, mean temperature and CIL volumes over the hydrographic section Seal Island and the air temperature in Cartwright (Labrador). For SA3, 16 individual time series are used: SSTs in Divs. 3K, 3L, 3M, 3N, 3O and 3P, vertically average ocean temperature at Station 27 (0-176 m), mean temperature and CIL volumes over hydrographic sections Bonavista and Flemish Cap, mean bottom temperature in 3LNO (spring and fall) and 3M (summer) and air temperature in St. John's and Bonavista (Newfoundland). For SA4, 10 individual time series are used: SSTs in Divs. 4Vn, 4Vs, 4W and 4X, vertically average ocean temperature at Station Prince-5 (0-90 m), surface (0-50 m) and bottom (150 m) temperature at Station Halifax-2, bottom temperature in 4VWX (summer), deep (150-200m) temperatures in the Northeast Channel (NEC) and nea-surface (0-30 m)temperatures in the Gulf of Maine (GoM). Most of these data are presented in Cyr *et al*. (2020), 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 1998-2019 period are derived from 17 satellite Ocean Colour boxes distributed across NAFO subarea 2 (Hudson Strait, Northern Labrador Shelf, Hamilton Bank), 3 (St. Anthony Basin, Northeast Newfoundland Shelf, Avalon Channel, Hibernia, Flemish Pass, Flemish Cap, Southeast Shoal, Green-St. Pierre Bank), and 4 (Northwest Golf of saint Lawrence-GSL, Northeast GSL, Magdalen Shallows, Eastern Scotian Shelf, Central Scotian Shelf, Western Scotian Shelf) (see SCR Doc. 20/035 for box location). Zooplankton abundance (D) and biomass (E) indices for the 1999-2018 period are derived from 18 standard oceanographic cross-shelf sections and five high-frequency coastal sampling stations distributed across NAFO subarea 2 (Beachy Island, Makkovik Bank, 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). 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 with 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 are considered normal conditions.

18. Roughhead Grenadier (*Macrourus berglax*) in Subareas 2 and 3

(SCS Doc. 18/05, 18/07, 20/07 and 20/09, and SCR 98/57, 20/02, 20/04, 20/10, 20/11 and 20/14)

Interim Monitoring Report

a) Introduction

The stock structure of this species in the North Atlantic remains unclear because there is little information on the number of different populations that may exist and the relationships between them. Roughhead grenadier is distributed throughout NAFO Subareas 0 to 3 in depths between 300 and 2 000 m. However, for assessment purposes, NAFO Scientific Council considers the population of Subareas 2 and 3 as a single stock.

A substantial part of the grenadier catches in Subarea 3 previously reported as roundnose grenadier was actually roughhead grenadier. To correct the catch statistics STACFIS (NAFO SCR 98/57) revised and approved roughhead grenadier catch statistics since 1987. In the period 2007-2012, catches for Subarea 2+3 roughhead grenadier were stable at levels around one thousand tons. In the period 2013-2019 catches were at a lower level and in the last years were around 400 ton (Figure 18.1). Most of the catches were taken in Divs. 3LMN by Spain, Portugal, Estonia and Russia fleets. In the catch series available, less than 2% of the yearly catch has been taken in Subarea 2. There is no TAC for this stock.

Recent catches ('000 tonnes) are as follow:

	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
STATLANT 21	0.8	1.0	1.3	0.4	0.6	0.2	0.1	0.1	0.1	0.2
STACFIS	0.9	1.0	1.3	0.4	0.6	0.2	0.3	0.4	0.5	0.4

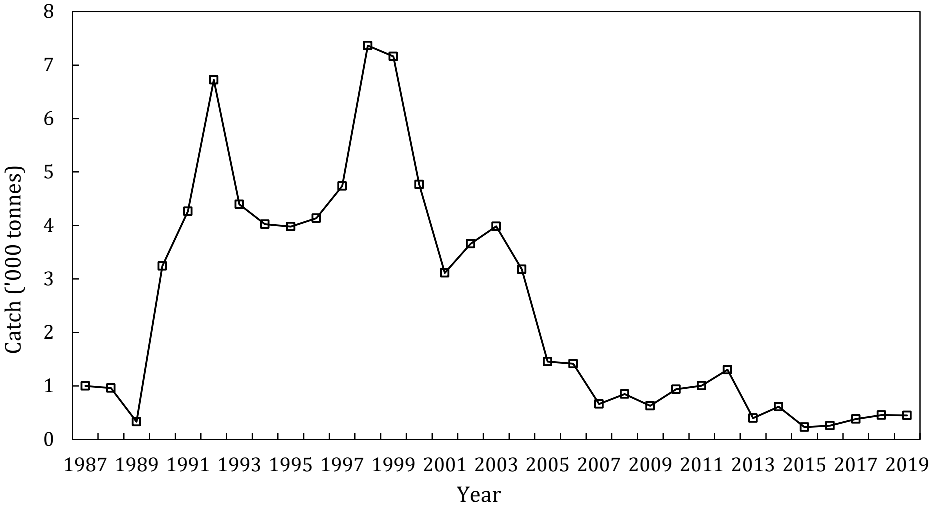


Figure 18.1. Roughhead grenadier in Subareas 2+3: STACFIS catches.

b) Data Overview

i) Surveys

There are no survey indices available covering the total distribution, in depth and area, of this stock. According to other information, this species is predominately at depths ranging from 800 to 1500 m, therefore the best survey indicators of stock biomass should be the series extending to 1500 meters depth as they cover the depth distribution of roughhead grenadier fairly well. Figure 18.2 presents the biomass indices for the following series: Canadian fall 2J+3K Engel (1978-1994) and Canadian fall 2J+3K Campelen (1995-2019,), EU 3NO (1997-2019), EU 3L (2006-2019) and EU Flemish Cap (to1400 m; 2004-2019). Survey coverage deficiencies within Divs. 2J3K were such that the 2008, 2018 and 2019 index from Canadian fall Divs. 2J3K could not be considered comparable to that of the other years. Survey biomass indices showed a general increasing trend in the period 1995-2004. Although the indices are variable across the past decade, there is a general decreasing trend with the exception of the Canadian 2J3K survey, which has increased.

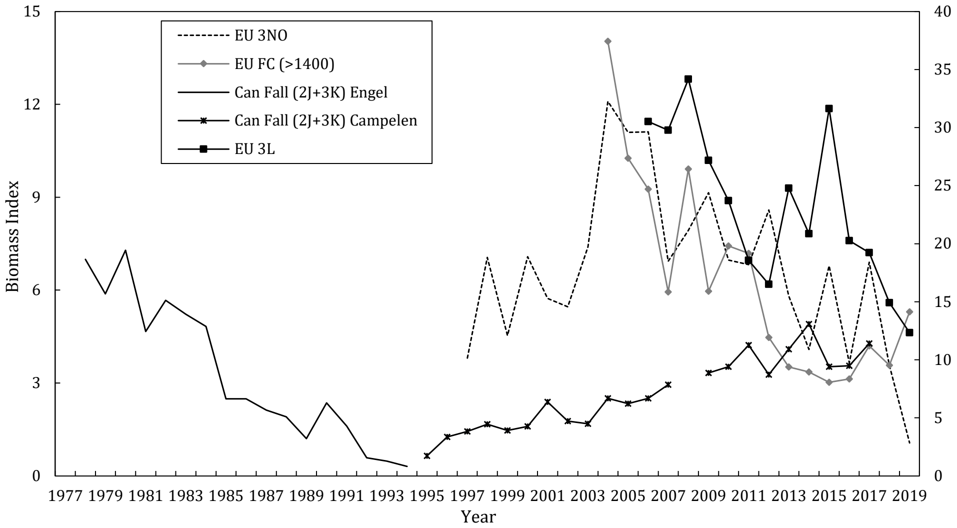


Figure 18.2. Roughhead grenadier in Subareas 2+3: Survey biomass indices.

The catch-biomass (C/B) ratios showed a clear declining trend from 1995-2005 and since then have been stable at low levels with the exception of the of the 3NO survey index in the year 2019 (Figure 18.3) .The (C/B) ratio remained low since 2008 despite the decline of many of the survey biomass indices because catch levels since 2007 are very low.

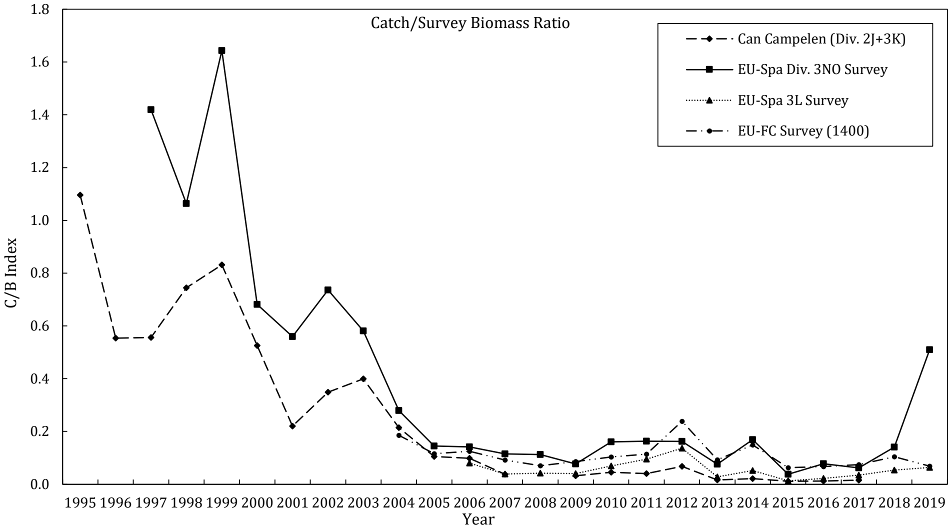


Figure 18.3. Roughhead grenadier in Subareas 2+3: catch/biomass indices based upon Canadian Autumn (Campelen series), EU-Spanish Div. 3NO, EU-Spanish 3L and EU-Flemish Cap (to1400 m depth) surveys.

c) Conclusion

Although the indices are variable across the whole time series, there is a general decrease over the past decade with the exception of the Canadian 2J3K survey, which has increased. Fishing mortality indices have remained at low levels since 2005 with the exception of the of the 3NO survey index in the year 2019. Based on overall indices for the current year, there is no change in the status of the stock.

This stock will be monitored in future by interim monitoring reports until such time conditions change to warrant a full assessment.

19. Greenland Halibut (*Reinhardtius hippoglossoides*) in Subarea 2 + Divisions 3KLMNO

(SCR Doc. 12/19, 17/46, 20/30, 20/47, 20/48, 20/49, 20/50; SCS Doc. 18/19; FC Doc. 03/13, 10/12, 13/23, 16/20)

a) Introduction

i) Fishery and Catches:

TACs prior to 1995 were set autonomously by Canada; subsequent TACs have been established by NAFO Fisheries Commission (FC). Catches increased sharply in 1990 due to a developing fishery in the NAFO Regulatory Area in 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. The STACFIS estimate of catch for 2010 was 26 170 t (64% over-run). In 2010, Fisheries Commission implemented a survey-based Management Procedure, which incorporates a harvest control rule (HCR) (FC Doc. 10/12) to generate annual TACs over at least 2011-2014. 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). TACs since 2018 have been 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 to 2019.

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

	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
TAC	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]	16.9[3]
STATLANT 21	15.7	15.2	15.6	15.6	14.9	14.8	14.7	11.7	--	--
STACFIS	25.0	23.0	20.0	21.4	15.3	14.9	14.8	16.6	16.5	--

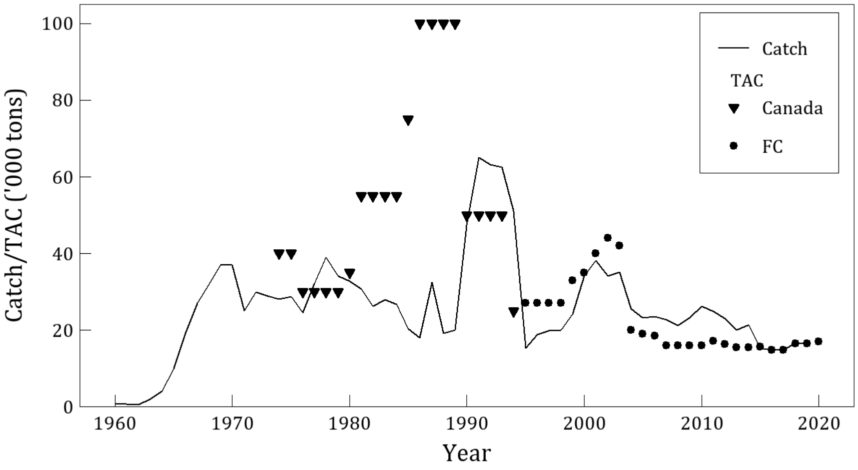


Figure 19.1. Greenland halibut in Subarea 2 + Div. 3KLMNO: TACs and STACFIS catches.

b) Input Data

Abundance and biomass indices were available from research vessel surveys by Canada in Div. 2+3KLMNO (1978-2019), EU in Div. 3M (1988-2019) and EU-Spain in Div. 3NO (1995-2019). Different years are examined to represent population trends from the different surveys. For the Canadian fall survey in Divs. 2J3K the years are 1978-2019 (excluding 2008); from the Canadian spring survey in Divs. 3LNO 1996-2019 (excluding 2006 and 2015, 2017 not included due to survey coverage issues); for the Canadian fall survey to 730 m from 1996-2019 (excluding 2014 when the survey was incomplete); for the survey in Div. 3M to 700 m 1988-2019, and to 1400 m 2004-2019; and for the survey by EU-Spain in Divs. 3NO 1997-2019. Commercial catch-at-age data were available from 1975-2019.

i) Commercial fishery data

Catch-at-age and mean weights-at-age: Length samples of the 2019 fishery were provided by EU-Spain, EU-Portugal, EU-Estonia, Russia and Japan. Ageing information was available for the Spanish and Russian fisheries, but commercial aging data from the Canadian fishery were not available in 2019 as the COVID-19 pandemic prevented the completion of otolith reading (SCR Doc. 20/49). Weights were available from EU-Spain, EU-Portugal, and EU-Estonia.

ii) Research survey data

STACFIS reiterated that most research vessel survey series providing information on the abundance of Greenland halibut are deficient in various ways and to varying degrees. Variation in divisional and depth coverage creates problems in comparing results from different years (SCR Doc. 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 index provides the longest time series of abundance and biomass indices (Figure 19.2) 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. 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, abundance declined to the late 1990s and had been relatively stable except for the decline in 2005. Following improved estimates of abundance in 2010 and 2011, the 2012 to 2019 indices are considerably lower.

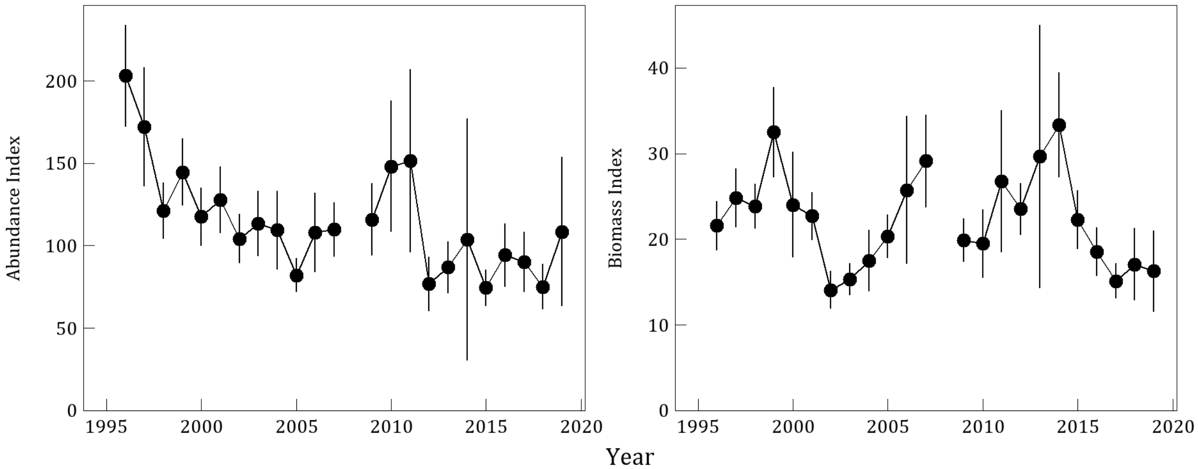


Figure 19.2. Greenland halibut in Subarea 2 + Div. 3KLMNO: abundance (left) and biomass (right) indices (with 95% CI) from Canadian autumn surveys in Div. 2J and 3K. The 2008 survey was not completed.

Canadian stratified-random spring surveys in Div. 3LNO: Abundance and biomass indices from the Canadian spring surveys in Div. 3LNO (Figure 19.3) declined from relatively high values in the late 1990s and has 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. Abundance and biomass indices from 2018 and 2019 have increased from 2016 levels.

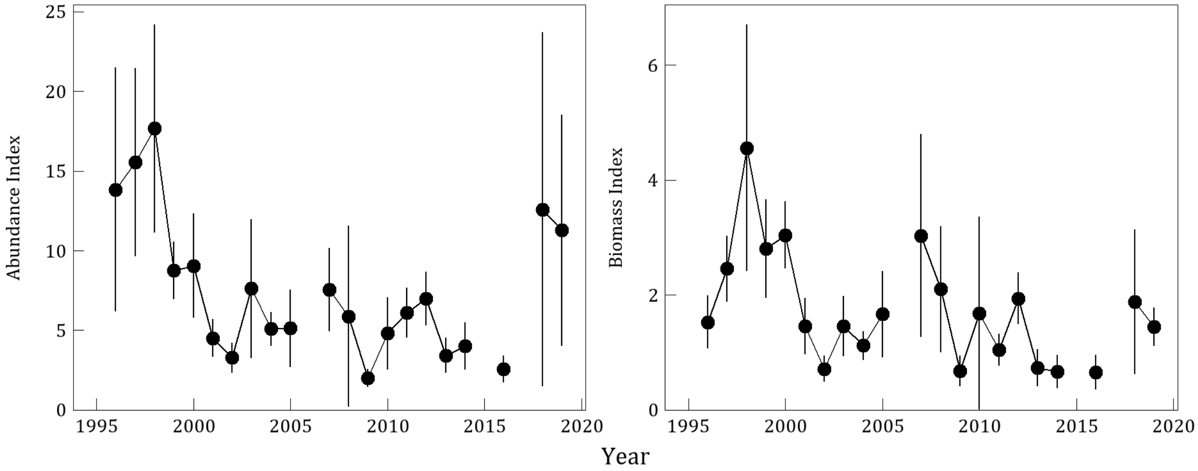


Figure 19.3. Greenland halibut in Subarea 2 + Div. 3KLMNO: abundance (left) and biomass (right) indices (with 95% CI) from Canadian spring surveys in Div. 3LNO.

Canadian stratified-random autumn surveys in Div. 3LNO: Time series of abundance and biomass were developed from the Canadian autumn surveys from 1995-2019 to a depth of 730 m. The abundance index from the Canadian autumn surveys in Div. 3LNO (Figure 19.4) declined from relatively high values in the late 1990s and has been relatively low in most years thereafter. The biomass index declined from 1998 to 2002 and then increased to 2005, to a level near that of the beginning of the time series. Abundance and biomass indices have been increasing since 2015; the abundance index has increased above levels observed between 1999-2010 and the biomass index has reached levels near those between 2009-2012. The 2014 survey was incomplete and is not considered compatible with the rest of the series.

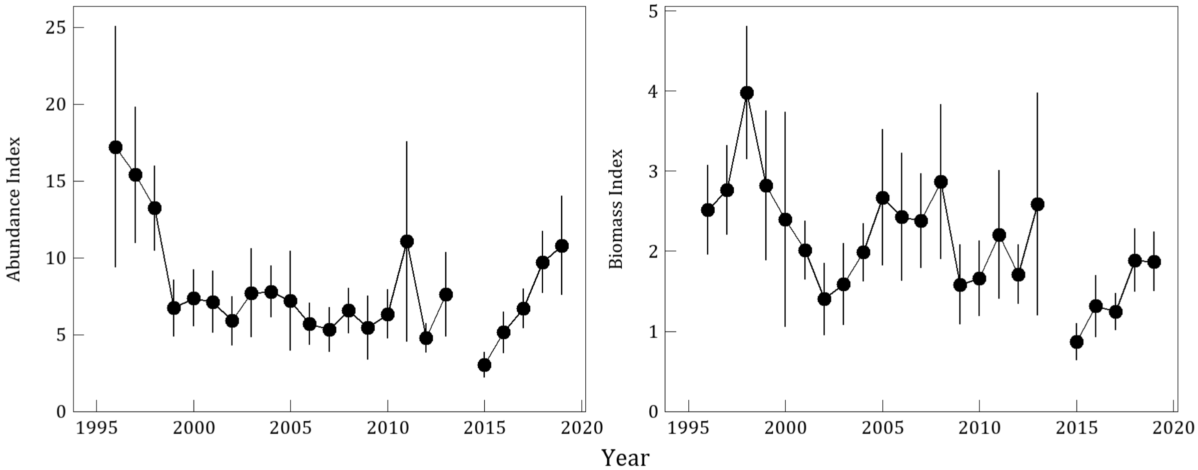


Figure 19.4. Greenland halibut in Subarea 2 + Div. 3KLMNO: abundance (left) and biomass (right) indices (with 95% CI) from Canadian autumn surveys in Div. 3LNO.

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, increased in the 1988 to 1998 period (Figure 19.5) to a maximum value in 1998. This biomass index declined continually over 1998-2002. The 2002 - 2008 results were relatively stable, with the exception of an anomalously low value in 2003. From 2009 to 2013 the index decreased to its lowest observed value. From 2014 to 2017 the index remained well below the series average. The Flemish Cap survey was extended to cover depths down to 1460 m beginning in

2004. Biomass estimates over the full depth range doubled over 2005-2008 but then declined to below the time series average in 2012 and 2013. From 2015-2017 the index has been variable but above the average of the time series, with 2015 and 2017 being the highest in the series. The index has since declined, dropping below the time series average in 2019.

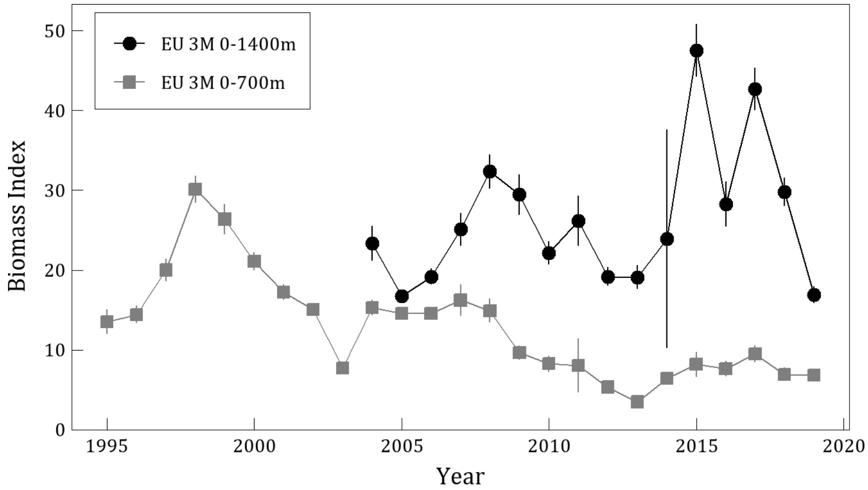


Figure 19.5. Greenland halibut in Subarea 2 + Div. 3KLMNO: Biomass index (± 1 S.E.) from EU Flemish Cap surveys in Div. 3M. Grey squares: biomass index for depths <730 m. Black circles: biomass index for all depths <1460 m.

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 19.6) but increased four-fold over 2006-2009. The survey index has increased since 2013 to a time series high in 2017; however, the index declined closer to the time series average in 2018 and 2019. The biomass index for the survey of the NRA in Div. 3L increased from 2006 to 2008. After declining to lower levels in 2011 and 2012 it increased to a time series high in 2017, declining substantially in 2018 and increased again in 2019.

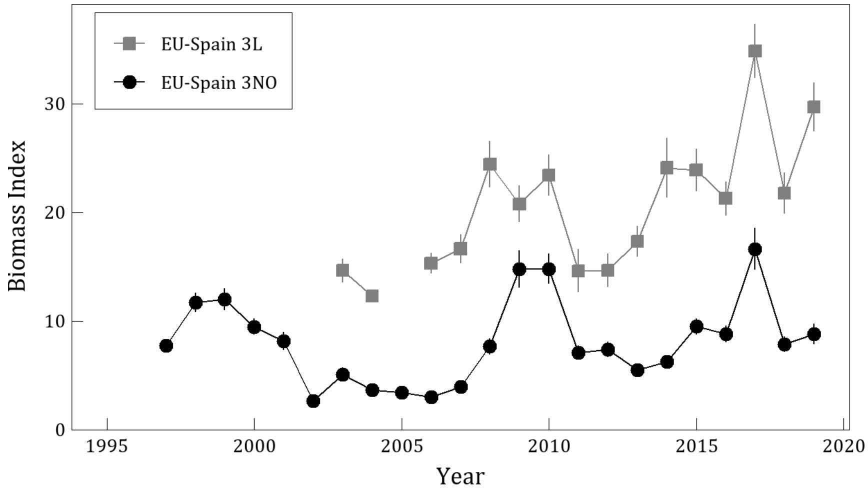


Figure 19.6. Greenland halibut in Subarea 2 + Div. 3KLMNO: biomass index (±1 SE) from EU-Spain spring surveys in the NRA of Div. 3NO and Div. 3L.

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 the majority of catches are taken. Over 1995-2007, indices from the majority of the surveys generally provided a consistent signal in stock biomass (Figure 19.7). 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) having increased to well above their time series averages while the Canadian surveys have been lower than their respective time series average. The overall trend since 2007 is unclear.

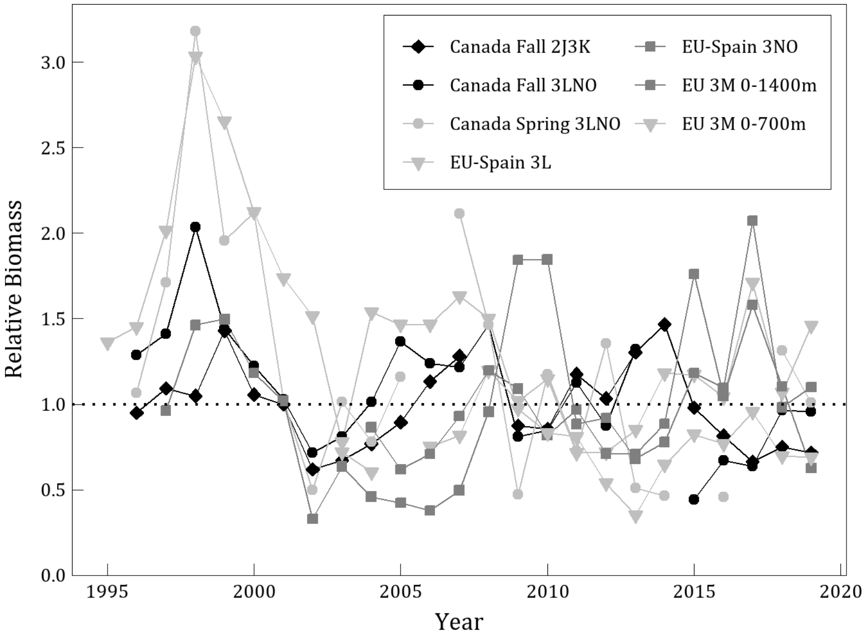


Figure 19.7. Greenland halibut in Subarea 2 + Div. 3KLMNO: Relative biomass indices from Canadian autumn surveys in Div. 2J3K, Canadian spring surveys in Div. 3LNO, Canadian autumn surveys in Div. 3LNO, EU survey of Flemish Cap, and EU-Spain surveys of the NRA of Div. 3NO. Each series is scaled to its average and the average line is shown as thin dotted line.

Recruitment from surveys.

Abundance indices at age 4 from surveys were examined as a measure of recruitment. Year classes from all surveys were above average between 1993-1994 and below average between 2009-2013. After three very large year classes of 2000-2002 in the EU survey of Div. 3M, abundance at age 4 fell below average for 12 years. Estimates of the most recent year class are above the time series average in four out of five surveys examined.

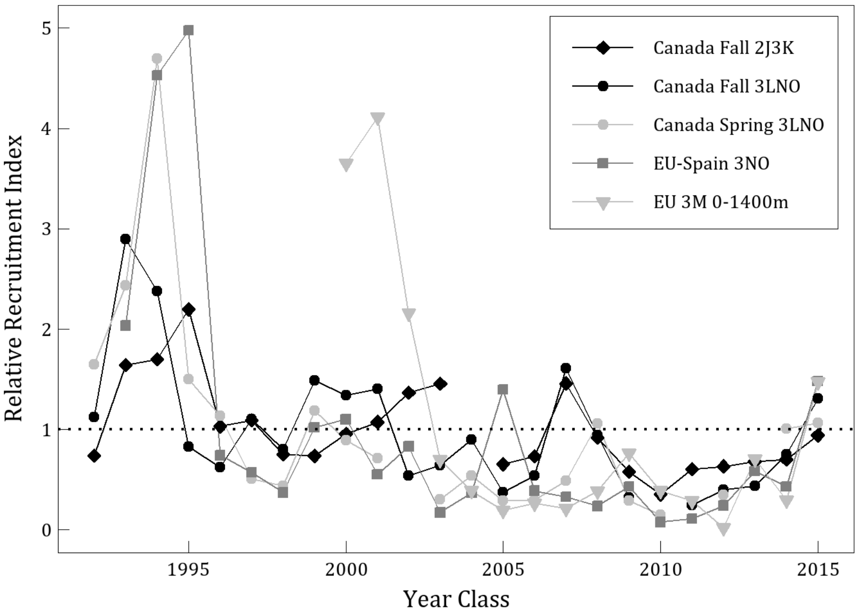


Figure 19.8. Greenland halibut in Subarea 2 + Div. 3KLMNO: Relative recruitment indices from Canadian autumn surveys in Div. 2J3K, Canadian spring surveys in Div. 3LNO, and EU survey of Flemish Cap. Each series is scaled to its average and the average line is shown as thin dotted line.

c) Estimation of Parameters

Two assessment models were developed to support the management strategy evaluation (MSE) conducted in 2017 for the Greenland halibut stock in Subarea 2 + Div. 3KLMNO: 1) a statistical-catch-at-age (SCAA) model, and 2) a state-space model (SSM). For this year's update assessment, three years of data were added to the base case formulations. Both models used the following inputs: catch-at-age from 1975-2019, Canadian fall Div. 2J3K survey numbers at age 1996-2019, Canadian spring Div. 3LNO survey numbers at age 1996-2019, EU Div. 3M survey 0-700 m numbers at age 1995-2003, EU Div. 3M survey 0-1400 m numbers at age 2004-2019, EU-Spain Div. 3NO survey numbers at age 1997-2019, and Canadian fall Div. 3LNO 0-730m survey numbers at age 1996-2019. Due to concerns regarding the validity of recent catch and survey data, several tests were conducted to evaluate the sensitivity of both models to these inputs (SCR Doc. 20/30REV, 20/50). Results were virtually indistinguishable across most sensitivity tests, deviating marginally only when important and likely un-biased survey data were excluded from the SSM. Outputs from base case implementations of these model tests are given below.

i) Statistical catch-at-age

The SCAA methodology is based on standard Baranov numbers-at-age dynamics fitted assuming observation error only in the data and process parameter values which are fixed over time. It is described in Appendix A of SCR Doc. 20/30REV. Key features and settings of the base case formulation include:

- In addition to the inputs specified above the SCAA used total catches over 1960-2019 and total biomass indices from the surveys specified above.
- Stock-recruit function: Beverton-Holt with an input steepness h = 0.8 and log-normal variability with σ_R = 0.4.
- Natural mortality: fixed at M = 0.12 for all ages.
- The assessment commences in 1960: initial numbers-at-age is estimated by way of two estimable parameters reflecting a number of recruits informed by a "prior" around the pre-exploitation equilibrium and a negative exponential (constant total mortality) decline.
- Maximum data plus group of 10+ (model plus group is 14+, with aggregation used in fitting to the data).
- Weight-at-age for 10+ applies to all older fish.
- Commercial selectivity-at-age is modelled by double-normal distributions.
- Periods over which the estimated commercial selectivity is unchanged: 1960-1989, 1990-1995, 1996-2003 and 2004+.
- All survey selectivities, apart from the EU 3M survey, are modelled by double normal distributions. For the EU 3M survey, selectivities are estimated separately for ages 1-9 and 4-10 depending on the depth range covered.
- The penalised negative log likelihood minimized in the model fit includes contributions from the survey indices of abundance (taken to be log-normally distributed with the associated variances and catchability coefficients estimated in the fitting process) , the proportion-at-age information (surveys and commercial catches) and annual catches, as well as penalties related to stock-recruitment residuals and the starting recruitment in 1960 (see above).
- The "sqrt(p)" approach is used for the commercial and survey proportions-at-age in the negative log-likelihood.
- The multiplicative weight given to the age-proportion data relative to the survey indices in the negative log-likelihood is w_{CAA} = 0.2.

ii) State-space model

The SSM is a variation of the northern cod assessment model (NCAM) developed by Cadigan (2015) that follows the style of the state-space assessment model (SAM) developed by Nielsen and Berg (2014). The core of this model is similar to other age-structured assessment models since the population dynamics involve a basic cohort model with a plus group and it fits catch using the Baranov catch equation. Key features and settings include:

- Natural mortality fixed at M = 0.12.
- Variation between reported landings and their model predicted values (σ_L) = 0.1.
- Plus group age = 10.
- Starting year for the survey data = 1995.
- Starting year for the landings data = 1975.
- Zeros in mean catch at age from the survey indices and catch at age from catch statistics are replaced with 0.005 and 0.5, respectively, and these values are treated as an upper limit in the likelihood. This predicates that zero observations are not true zeros, rather they are below the detection limit of the sampling programs.
- Like all state-space models, this model attempts to differentiate process error and observation error.
- Fishing mortality is modelled as an autoregressive process with autocorrelation assumed across both ages and years. In other words, Greenland halibut of similar ages and periods are assumed to experience similar levels of fishing mortality.
- Recruitment is modelled as a random effect as there was no clear sign of a stock-recruitment relationship.
- Catch at age proportions are modelled using continuation ratio logits.

d) Assessment Results

The primary purpose of the update assessment was to determine whether the stock is deviating from the expected trajectory while being managed using the current HCR. Specifically, SC agreed to conduct the following check to determine if Exceptional Circumstances are occurring:

"A comparison of assessment model outputs for recruitment, exploitable biomass, and fishing mortality with operating model projections (base case) will also be taken into account qualitatively. Notwithstanding some technical issues regarding the comparison of the simulated distributions against updated assessments, it was agreed that SC will compare the estimated median of the assessment with the 95% Confidence Interval from the base case of SSM and SCAA for the above quantities. Expert judgement will determine whether Exceptional Circumstances are occurring" (SCS Doc. 18/19).

i) Statistical catch-at-age

Following the addition of the three more years of data to the base case SCAA model, trends in the stock have hardly changed from those estimated in 2017 (SCR Doc. 20/30REV; Figure 19.9). The most recent estimates of recruitment and exploitable biomass are consistent with predictions from the 2017 MSE process (Figure 19.9). There was a small drop in average F below the 95% probability envelope in the 2017; however, the 2018 and 2019 estimates fall within the 80% envelope.

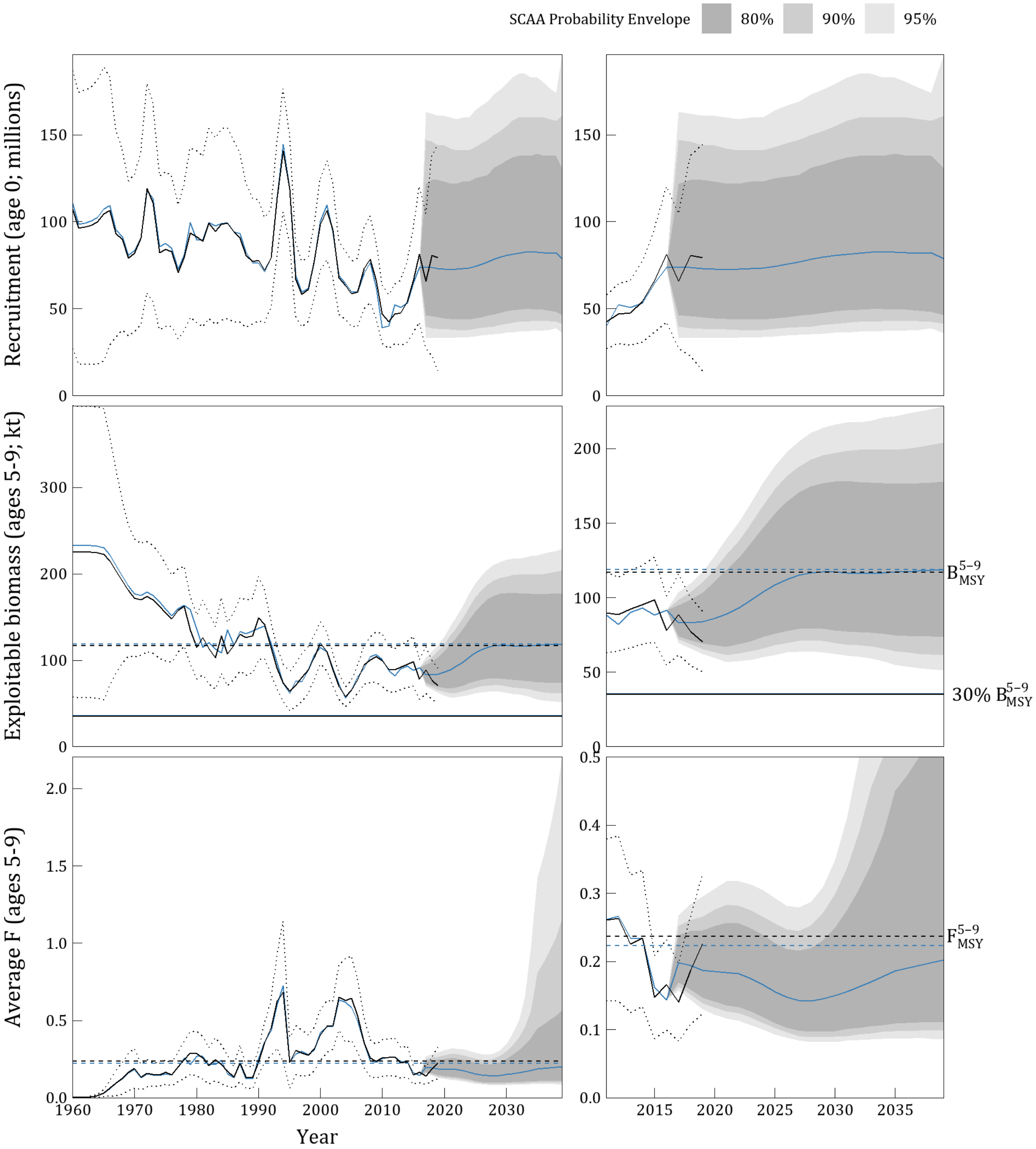


Figure 19.9. Greenland Halibut in Subarea 2 + Divisions 3KLMNO. Base case SCAA model: Trends in recruitment (age 0; millions), exploitable biomass (ages 5-9; kt), and average F (ages 5-9). Blue lines represent values from the 2017 MSE with the base case SCAA, whereas black lines indicate values from 2020 update assessment. Shown are: historical (1960-2019) estimates with 95% CIs (thin dotted lines) from the 2020 update assessment, as well as medians and 80%, 90% and 95% probability envelopes (grey shaded areas) projected from the 2017 MSE simulations (with the base case SCAA) under the adopted HCR. Finally, horizontal lines indicate reference points (B_{MSY}^{5-9}, 30% B_{MSY}^{5-9}, F_{MSY}^{5-9}) from both the 2017 MSE base case SCAA (blue) and those calculated from the 2020 update assessment (black).

ii) State-space model

Like the SCAA, a retrospective analysis of the SSM indicates that model estimates are stable in recent years (SCR Doc. 20/50), including those obtained in 2017 when this model was first utilized as part of the MSE process (Figure 19.10). Unfortunately, issues identified with the initial SSM MSE simulations make comparisons with current estimates moot. Following guidance from documents produced during the MSE process, the SSM simulation code was modified in an attempt to generate the intended projection results (SCR Doc. 20/50). Using the revised simulations, it is evident that the accepted management procedure met key performance statistics. Current estimates of recruitment, exploitable biomass, and average F from the base case SSM also fall within the 95% probability envelopes for the revised simulations (Figure 19.10).

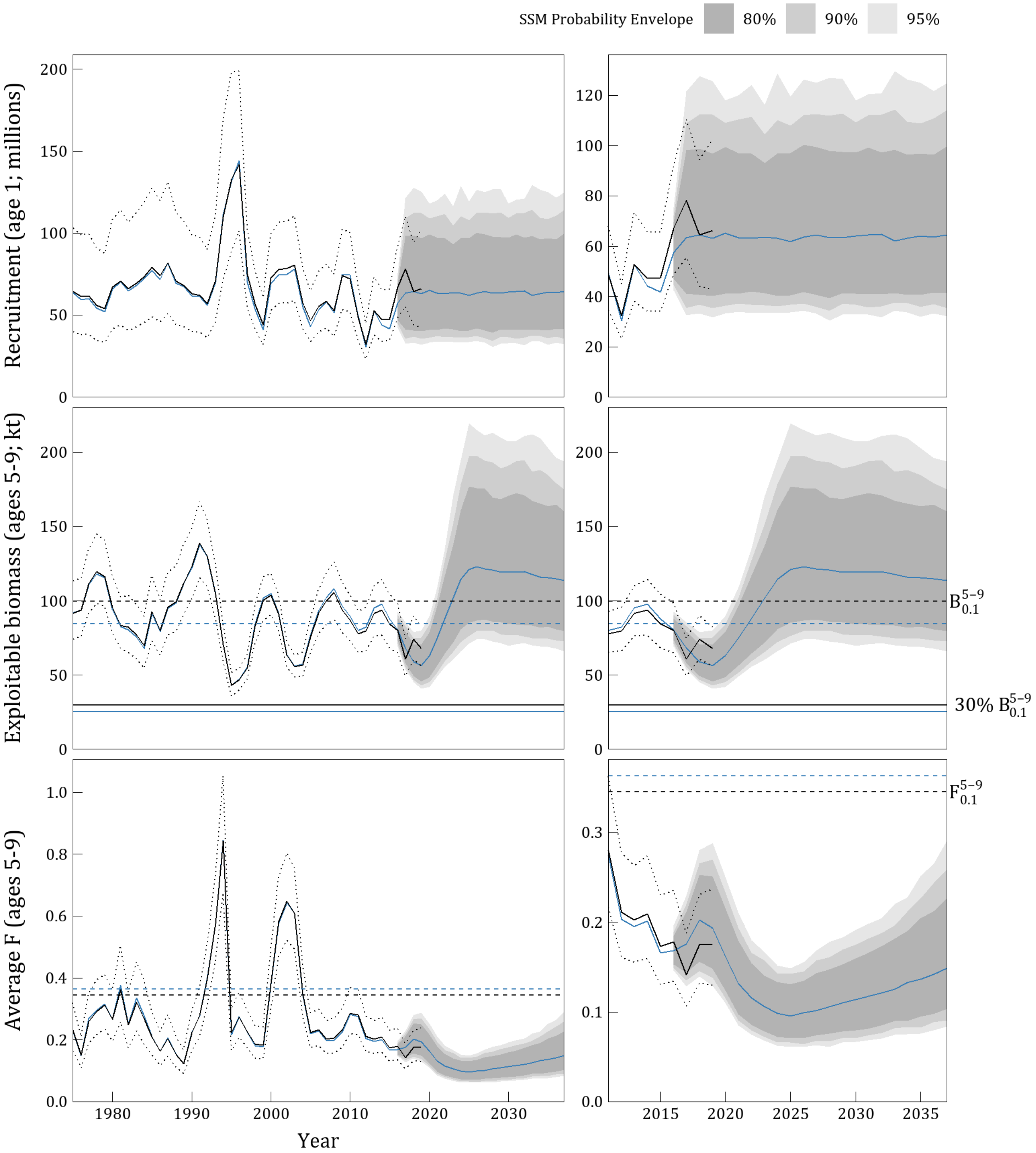


Figure 19.10. Greenland Halibut in Subarea 2 + Divisions 3KLMNO. Base case SSM model: Trends in recruitment (age 1; millions), exploitable biomass (ages 5-9; kt), and average F (ages 5-9). Blue lines represent values from the 2017 MSE (reconstituted following correction of errors) with the base case SSM, whereas black lines indicate values from 2020 update assessment. Shown are: historical (1960-2019) estimates with 95% CIs (thin dotted lines) from the 2020 update assessment, as well as medians and 80%, 90% and 95% probability envelopes (grey shaded areas) projected from the 2017 MSE simulations (with the base case SSM) under the adopted HCR. Finally, horizontal lines indicate reference points ($B_{0.1}^{5-9}$, 30% $B_{0.1}^{5-9}$, $F_{0.1}^{5-9}$) from both the preliminary reconstruction of the 2017 MSE base case SSM (blue) and those calculated from the 2020 update assessment (black).

e) State of the Stock

Recent recruitment has generally increased according to both models (estimates of age 0s have increased since 2010 in the SCAA and age 1s have increased since 2012 in the SSM) and 2019 estimates are near the time series average. Current results from both the SCAA and SSM indicate that there are few signs that the stock is deviating from the expected trajectory while being managed using the current Management Procedure.

As part of the management strategy evaluation process of 2017, reference points were developed using each model to test a series of performance metrics. Though these reference points have been defined, neither have been accepted for use as B_{lim}. The SSM reference points, in particular, were not calculated using explicit links between stock size and recruitment and, as such, they should not be used to define the stock size below which productivity is seriously impaired. Reference points that follow definitions under NAFOs Precautionary Approach Framework require further research and review.

f) Reference points

i) Statistical catch-at-age

MSY reference points were calculated using a Beverton Holt stock recruit relationship. Reference points were estimated using data up to 2016, as part of the 2017 MSE process, and these values were updated using data up to 2019 for the update assessment of 2020. Commercial selectivity equal to the selectivity in the last commercial selectivity period for the SCAA and weight-at-age was taken as the average over the last 10 years. The maximum penalized likelihood estimates for the parameters of the stock-recruitment relationship and for selectivities were used for this evaluation. CVs for MSY and B_{MSY}^{5-9} were found from the Hessian associated with the assessment. Note that these are conditional on the calculated value of F_{MSY}^{5-9}. For full details see SCR 17/46. The following reference points were determined using the SCAA:

	F_{MSY}^{5-9}	B_{MSY}^{5-9}
2017	0.223	119 kt
2020	0.237	117 kt

The 2017 values were used to evaluate several performance criteria during the 2017 MSE process.

ii) State-space model

Exploratory analyses and initial modelling of the dynamics of the Greenland halibut stock from NAFO Subarea 2 and Divisions 3KLMNO showed little sign of a stock-recruitment relationship. Recruitment was therefore treated as a random effect in the SSM. This formulation, however, precluded the standard analytical approach to calculating F_{MSY} from stock-recruitment curves. Yield per recruit analyses were used to determine F_{max}^{5-9} and $F_{0.1}^{5-9}$: the whole time series averages of recruitment, 10 year averages of weight at age and three year averages of selectivity at age were used in the analyses. These were used to project the population out 100 years to obtain deterministic estimates of F_{max}^{5-9} and $F_{0.1}^{5-9}$. An optimization function was used to profile across a range of F^{5-9} values to find the point at which the yield is maximized. For full details see SCR 20/48. The following provisional reference points were determined using the SSM:

	$F_{0.1}^{5-9}$	$B_{0.1}^{5-9}$
2017	0.363	84 kt
2020	0.345	100 kt

The 2017 values were used as proxies for B_{MSY}^{5-9} and F_{MSY}^{5-9} to evaluate several preformance criteria using the revised SSM MSE simulations (SCR 20/47).

g) Research recommendation

The divergence in survey indices could be the result of movement of fish or because of transient age effects as a result of changing recruitment when different surveys cover differing age-ranges. STACFIS **recommends** that *tagging and/or telemetry studies be undertaken to help elucidate movement of 2+3KLMNO Greenland halibut.*

Precautionary approach reference points have not been determined for this stock. STACFIS **recommends** that *reference points are investigated during the next full assessment and MSE review process.*

The next full assessment and MSE review is planned for 2023.

h) References

Cadigan, N. G. (2015). A state-space stock assessment model for northern cod, including under-reported catches and variable natural mortality rates. *Canadian Journal of Fisheries and Aquatic Sciences*, *73*(2), 296–308.

Nielsen, A., and Berg, C. W. (2014). Estimation of time-varying selectivity in stock assessments using state-space models. *Fisheries Research*, *158*, 96–101.

20. Splendid alfonsino (*Beryx splendens*) in Subareas 6

(SCR 15/06 and SCS Doc. 19/20 and 20/07 and NAFO/COM Doc. 20/01)

Interim Monitoring Report

a) Introduction

Alfonsino is distributed over a wide area which may be composed of several populations. Alfonsino is an oceanic demersal species which forms distinct aggregations, at 300–950 m depth, on top of seamounts in the North Atlantic. Stock structure in NAFO Area is unknown. Until more complete data on stock structure is obtained it is considered that separate populations live on each seamount of Div 6G.

Most published growth studies suggest maximum life span between 10 and 20 years. The observed variability in the maximum age / length depends on the geographic region. Sexual maturation was found to begin at age 2 and at a mean length of 18 cm. By age 5–6 years, all individuals were mature at 25–30 cm fork length. On the Corner Rise Seamounts, alfonsino were observed to spawn from May-June to August-September.

As a consequence of the species' association with seamounts, their life-history, and their aggregation behaviour, this species is easily overexploited and can only sustain low rates of exploitation.

i) 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 "Kükenthal" (also known as "Perspektivnaya") and "C-3" ("Vybornaya") are located in NRA. One more bank named "Milne Edwards" ("Rezervnaya") is located in the Central Western Atlantic.

Russian vessels fished these areas during some periods between 1976 and 1999 using pelagic trawls. A directed commercial fishery had been conducted since 2005 by Spanish vessels. Since 2006 virtually all the effort has been made in the Kükenthal seamount with pelagic trawl gear.

Fishery was closed in 2020 based on scientific advice that the stock was depleted.

ii) Commercial fishery data

The Russian fishery started in 1976 with a catch of 10 200 t (Figure 22.1). Thereafter the catches ranged between 10 and 3 500 t. There was no fishing effort from 1988-1993, 1998 and 2000 – 2003. From 2005 to present, an alfonsino directed fishery in Kükenthal seamount was conducted by Spanish vessels using a pelagic trawl gear, where catches have ranged between 1 and 1 187 t, with no fishery in 2008.

Recent catches (tonnes), effort and CPUE (Kg/hr fished) for the alfonsino fishery on Kukenthal Peak.

Year	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Catch (t)	52	152	302	114	118	122	127	51	2	1
Effort (days)	4	9	22	17	15	13	16	12	8	8
Effort (hours fished)	66	68	165	87	117	92	116	68	33	33
CPUE (Kg/hour)	788	2235	1830	1310	1009	1326	1095	750	61	42
Effort (vessels)	1	1	1	1	2	2	1	1	1	1

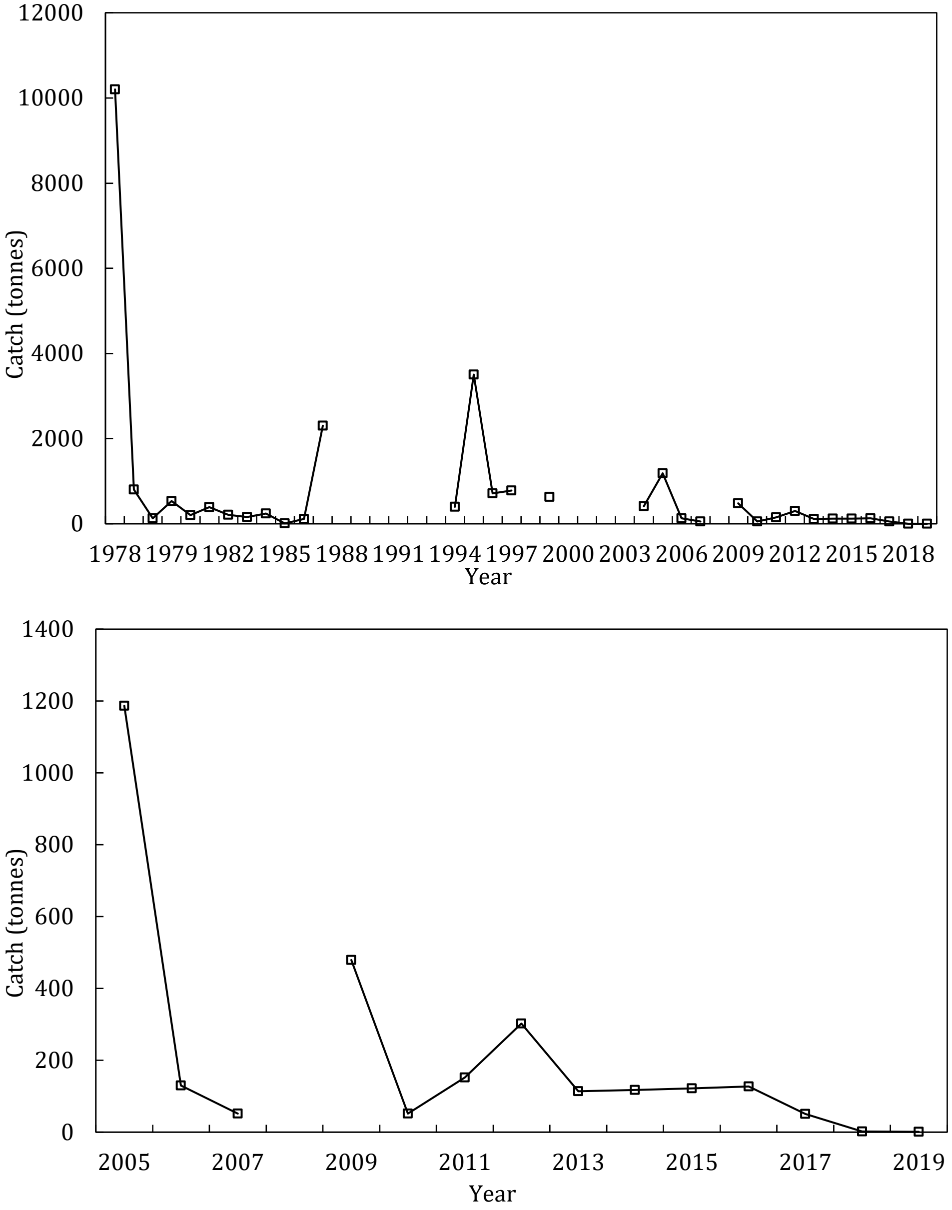
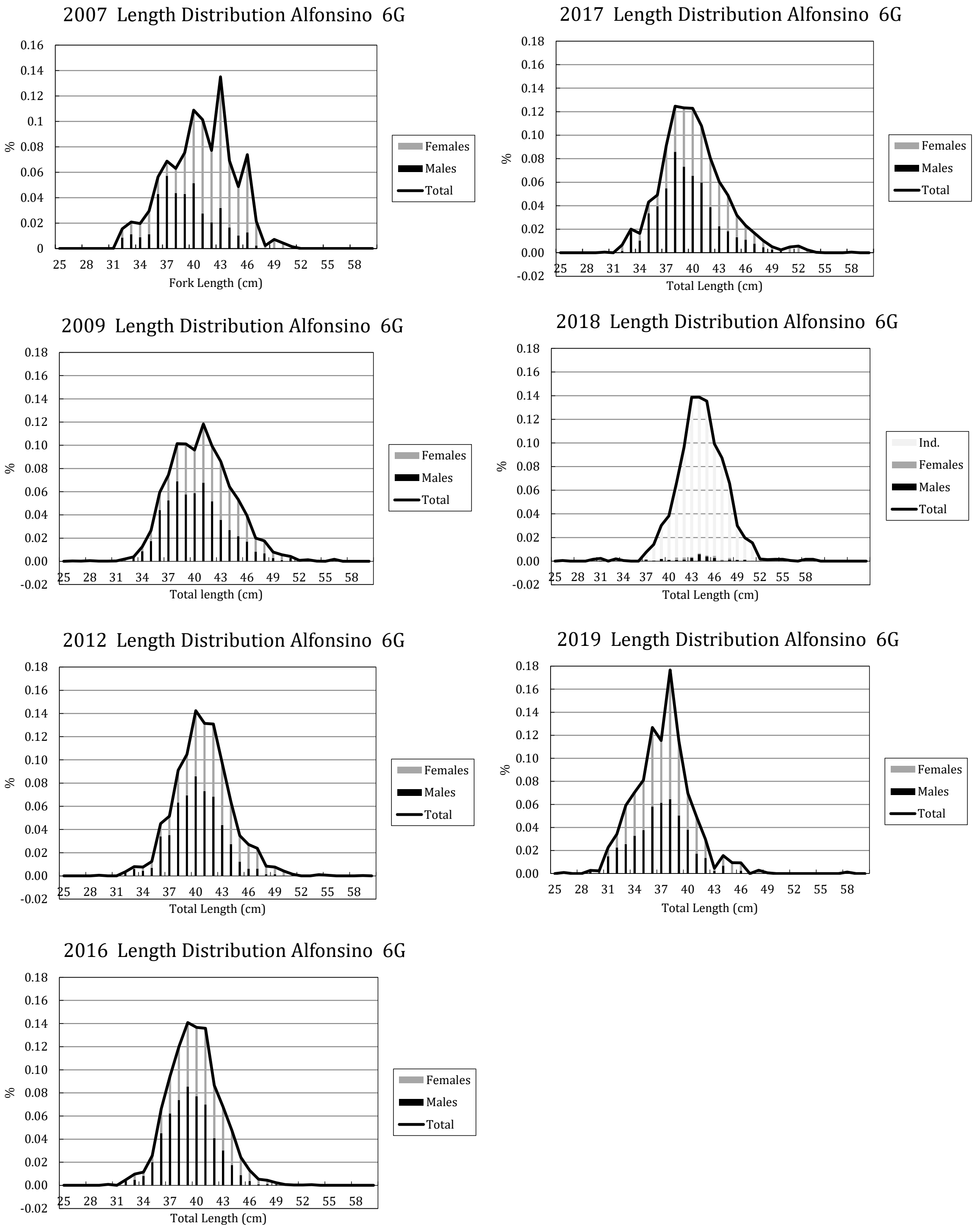


Figure 20.1. Alfonsino catches from Div. 6G. Top panel illustrates the whole catch series (1978-2019) and bottom panel illustrates the catch series since 2005.

The available commercial length distributions in percentage by year (2007, 2009, 2012 and 2016-2019) are presented in Figure 22.2. It can be observed in the period 2007-2018 that these length distributions have a slight decrease in the mode over time. Catches in this period are in the 30-50 cm range with a mode around or bigger than 40 cm. The 2019 length distribution shows a smaller range with a mode around 38 cm.


2007 Length Distribution Alfonsino 6G

2017 Length Distribution Alfonsino 6G

2009 Length Distribution Alfonsino 6G

2018 Length Distribution Alfonsino 6G

2012 Length Distribution Alfonsino 6G

2019 Length Distribution Alfonsino 6G

2016 Length Distribution Alfonsino 6G

Figure 20.2. Length distributions of alfonsino catches from Div. 6G.

b) Data Overview

i) 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.

c) Conclusion

No analytical or survey based assessment were possible. The most recent assessment, in 2019, concluded that the stock appears to be depleted. Overall, the 2019 information 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) Special comments

Periods of decline in catches have been observed several times in the past after several years of fishing. In the past, catches have increased after a period of low/no removals however, it is unknown if this corresponded to stock recovery. In the absence of new data (eg. from an exploratory fishery or survey) there will be no basis to update the present assessment.

e) Research Recommendations

SC **recommended** in 2019 that *fishery independent information should be collected on this stock, and especially important given the fishery is closed and there will not be CPUE or any other fishery independent information to monitor whether there is any recovery.* For this purpose, a possible acoustic survey plan has been presented to be discussed by the SC.

IV. OTHER MATTERS

1. FIRMS Classification for NAFO Stocks

Due to lack of time, STACFIS did not review the assessments of stocks managed by NAFO in June 2020. This task has been deferred to the September SC meeting.

2. Other Business

No additional items were discussed.

V. ADJOURNMENT

The meeting was adjourned on 12 June 2020

PART B: REPORT OF THE SCIENTIFIC COUNCIL (IN CONJUNCTION WITH NIPAG) MEETING

14 September 2020
by WebEx

Recommended Citation:

NAFO. 2020. Report of the Scientific Council (in conjunction with NIPAG) Meeting, 14 September 2020, WebEx. NAFO SCS Doc. 20/22.

REPORT OF THE SCIENTIFIC COUNCIL MEETING
14 September 2020, via WebEx

Chair: Carmen Fernandez Rapporteur: Tom Blasdale

1. Opening

Scientific Council, in conjunction with the NAFO/ICES *Pandalus* Assessment Group, met by WebEx on 14 September 2020, to formulate management advice for northern shrimp in NAFO Divisions 3M. Representatives attended from Canada, Denmark (in respect of the Faroe Islands and Greenland), the European Union, France (in respect of St. Pierre et Miquelon), Iceland, Norway and the Russian Federation and Ukraine. A full list of participants is included in Appendix V.

The Chair, Carmen Fernandez, opened the meeting 08:00 Halifax time (12:00 UTC) by welcoming participants. The provisional agenda was adopted as circulated. The Scientific Council Coordinator was appointed as rapporteur.

2. Review of relevant recommendations and advice from 2019

There were no general recommendations. SC agreed that relevant stock-by-stock recommendations from previous years would be reviewed during the presentation of a stock assessment the status presented in the relevant sections of the NIPAG report

3. Formulation of Advice

The response from the Scientific Council is:

a) Northern Shrimp in Division 3M

Advice September 2020 for 2021

Recommendation

The stock has increased from very low levels since 2014 and is now above Blim.

There are indications of improved recruitment in the 2020 survey data. These small shrimp could potentially add to the fishable stock in 2021 and 2022. Considering the uncertainty about the future recruitments and the response of the resource to resumed exploitation, Scientific Council advises that the catch in 2021 should not exceed the 2009 level (5 448 tonnes).

Management objectives

No explicit management plan or management objectives defined by the Commission. Convention general principles are applied. Advice is based on qualitative evaluation of biomass indices in relation to historic levels, and provided in the context of the precautionary approach framework (FC Doc. 04/18).

Convention objectives	*Status*	*Comment/consideration*
Restore to or maintain at B_{msy}	🟠	Stock above B_{lim}. B_{msy} is unknown.
Eliminate overfishing	🟢	No fishery during 2011 – 2019. Small direct fishery possible in 2020.
Apply Precautionary Approach	🟠	B_{lim} defined. No fishing mortality reference point defined
Minimise harmful impacts on living marine resources and ecosystems	🟢	VME closures in effect, sorting grids mandatory
Preserve marine biodiversity	⚪	Cannot be evaluated

🟢 OK

🟠 Intermediate

🔴 Not accomplished

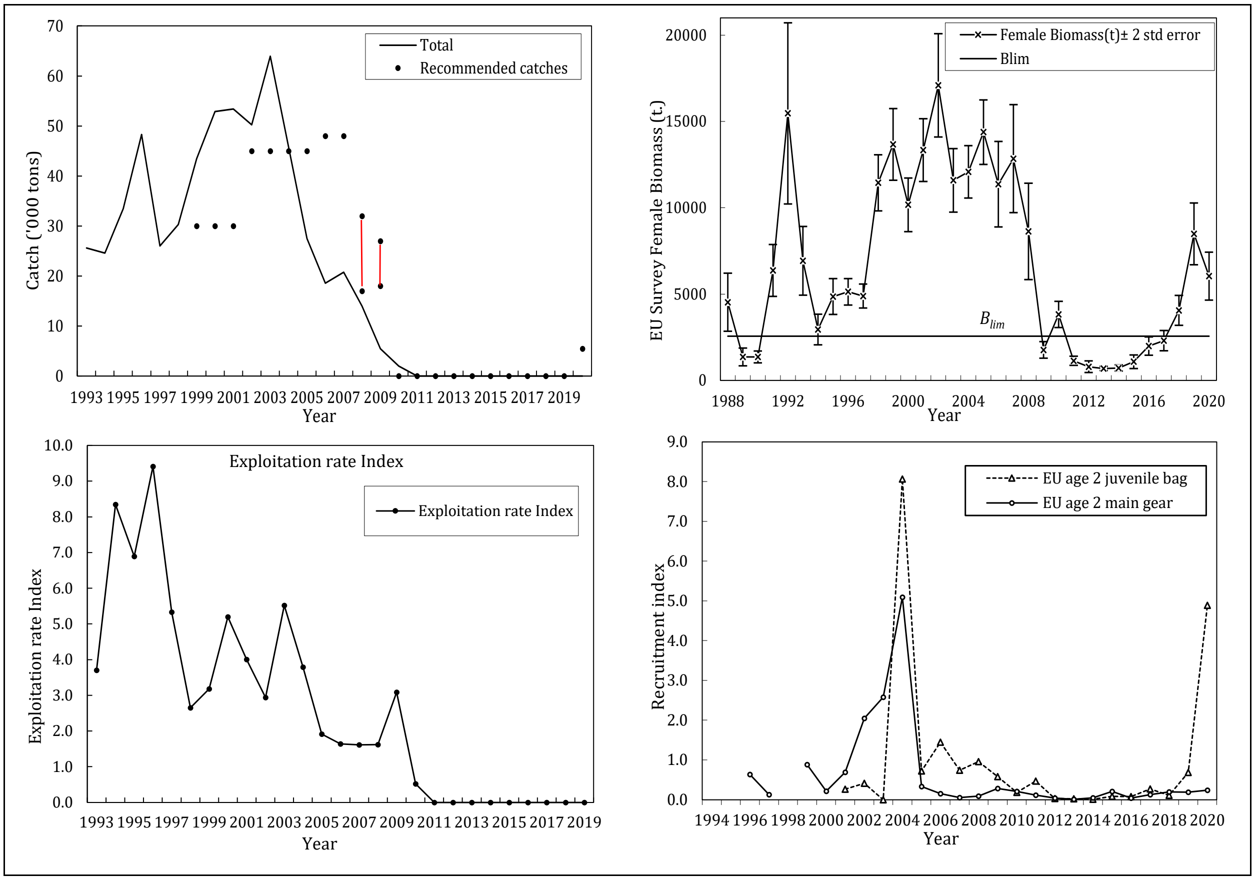
⚪ Unknown

Management unit

The Northern Shrimp stock on Flemish Cap is considered to be a separate population.

Stock status

The stock has increased since 2014, and in 2020 it has a very low probability (<2.5%) of being below B_{lim}. Recruitment has been poor during the last decade; however, with an overall increasing trend. There are indications of improved recruitment in 2020. Preliminary information from 2020 indicates very low fishing effort, and therefore very low exploitation rate, in the first half of the year



Reference points

Scientific Council considers that a female survey biomass index of 15% of its maximum observed level provides a proxy for B_{lim} (SCS Doc. 04/12).

Projections

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

Assessment

No analytical assessment is available. Evaluation of stock status is based upon fishery and research survey data.

The next assessment will take place prior to the NAFO Annual Meeting in September 2021.

Human impact

Mainly fishery related mortality and low bycatch in other fisheries. Other sources (e.g. pollution, shipping, oil-industry) are considered minor.

Biological and Environmental Interactions

Multispecies models (Pérez-Rodríguez et al. 2016, Pérez-Rodríguez and D. González-Troncoso 2018) suggest that predation by cod and redfish, together with fishing, were the main factors driving the shrimp stock to the collapse after 2007. In the most recent years, decreasing redfish and cod stocks have likely resulted in reduced predation mortality on shrimp, consistent with a period of increase in the shrimp stock.

Results of modelling suggest that, in unexploited conditions, cod and redfish would be expected to be a highly dominant component of the system, and high shrimp stock sizes like the ones observed in the 1998 – 2007 period would not be a stable feature in the Flemish Cap.

Fishery

This fishery is effort-regulated. The effort allocations were reduced by 50% in 2010 and a moratorium was imposed in 2011. The fishery was reopened in 2020. Fishing effort and catches have been close to zero in the first half of 2020. Recent catches and agreed effort by the NAFO Commission were as follows:

	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
NIPAG	2 000	0	0	0	0	0	0	0	0	0	0[1]
STATLANT 21	1976	0	0	0	0	0	0	0	0	0	
Effort (Agreed Days)	5227	0	0	0	0	0	0	0	0	0	2640
SC Recommended Catches (tonnes)	ndf	ndf	ndf	ndf	ndf	ndf	ndf	ndf	ndf	ndf	5448

[1] preliminary catch during the first half of 2020

Effects of the fishery on the ecosystem

The fishery was closed to directed fishing beginning from 2011 to 2019.

Special comment

In September 2019, the Commission asked the SC to advise on the possible sustainable management methods for northern shrimp in div. 3M, including quota, fishing effort, periods or other technical measures. In its response, SC recommends that the management of 3M shrimp be converted from the existing “effort regulation” to “catch regulation” in line with all other stocks in the NAFO Regulatory Area. Full detail of the response is available in SCS Doc. 19-023.

Source of Information

SCR Doc. 20/051

4. Adjournment

There being no other business, the meeting closed at 14:30 ADT on 14 September 2020

APPENDIX I. REPORT OF THE NAFO/ICES *PANDALUS* ASSESSMENT GROUP (NIPAG)

Chairs: Katherine Sosebee and Ole Ritzau Eigaard Rapporteur: Tom Blasdale

I. OPENING

NIPAG met be WebEx on 14 September 2020 to assess stocks of northern shrimp in NAFO divisions 3M. Representatives attended from Canada, Denmark (in respect of the Faroe Islands and Greenland), the European Union, France (in respect of St. Pierre et Miquelon), Iceland, Norway and the Russian Federation and Ukraine. A full list of participants is included in Appendix V.

The co-Chairs, Katherine Sosebee (STACFIS chair) and Ole Ritzau Eigaard (ICES chair) opened the meeting by welcoming participants. The provisional agenda was adopted as circulated. The Scientific Council Coordinator was appointed as rapporteur.

II. STOCKS ASSESSMENTS

1. Northern Shrimp (*Pandalus borealis*) on the Flemish Cap (NAFO Div. 3M)

(SCR Doc. 20/051)

a) Environmental Overview

Recent Conditions in Ocean Climate and Lower Trophic Levels

- The ocean climate index in 3M was normal between 2016 and 2019. Before that, 2015 was at its lowest value since 1993, while 2012 was marked by a record high.
- Spring bloom initiation was near normal in 2019 for a third consecutive year. Spring bloom magnitude was below normal in 2019 for the first time since 2015.
- The abundance of copepod and non-copepod zooplankton was above normal in 2019 with the 3rd and 2nd highest anomaly of the time series, respectively.
- Zooplankton biomass was below normal 2019 for the first time since 2014. It was the 3rd lowest anomaly of the time series

Ocean Climate and Ecosystem Indicators

The ocean climate index in Division 3M (Figure 1.1.A) has remained mostly above normal between about 2003 and 2013. After the record-high of 2012, the index gradually decreased reaching in 2015 its lowest value since 1993. The index was however normal during the period 2016-2019, with only 2019 being on the positive side. Spring bloom initiation has been oscillating between short period (2-3 years) of earlier and later timing between 1998 and 2007. The timing of the spring bloom has remained mostly near normal since with the exceptions of two late blooms in 2011 and 2015, and the earliest bloom of the time series in 2016. Spring bloom initiation (Figure 1.1.B) in 2019 was near normal for a 3rd consecutive year. Spring bloom magnitude (Figure 1.1.C) was mainly above normal through the first half of the 2000s before decreasing to near or below normal levels through 2019. Spring production was below normal in 2019 after three consecutive years of near-normal levels. The abundance of copepod (Figure 1.1.D) and non-copepod (Figure 1.1.E) zooplankton showed a general increasing trend since the beginning of the time series. Copepod abundance was above normal in 2019 for a third consecutive year after a period of near-normal levels during the early 2010s. The abundance of non-copepods was above normal in 2019 for a 4th consecutive year and presented the second highest anomaly of the time series. Zooplankton biomass (Figure 1.1.F) showed a generally increasing trend between 1999 and 2010. Biomass then decreased throughout the 2010s except for the record-high biomass observed in 2016 and the above normal level observed in 2018.

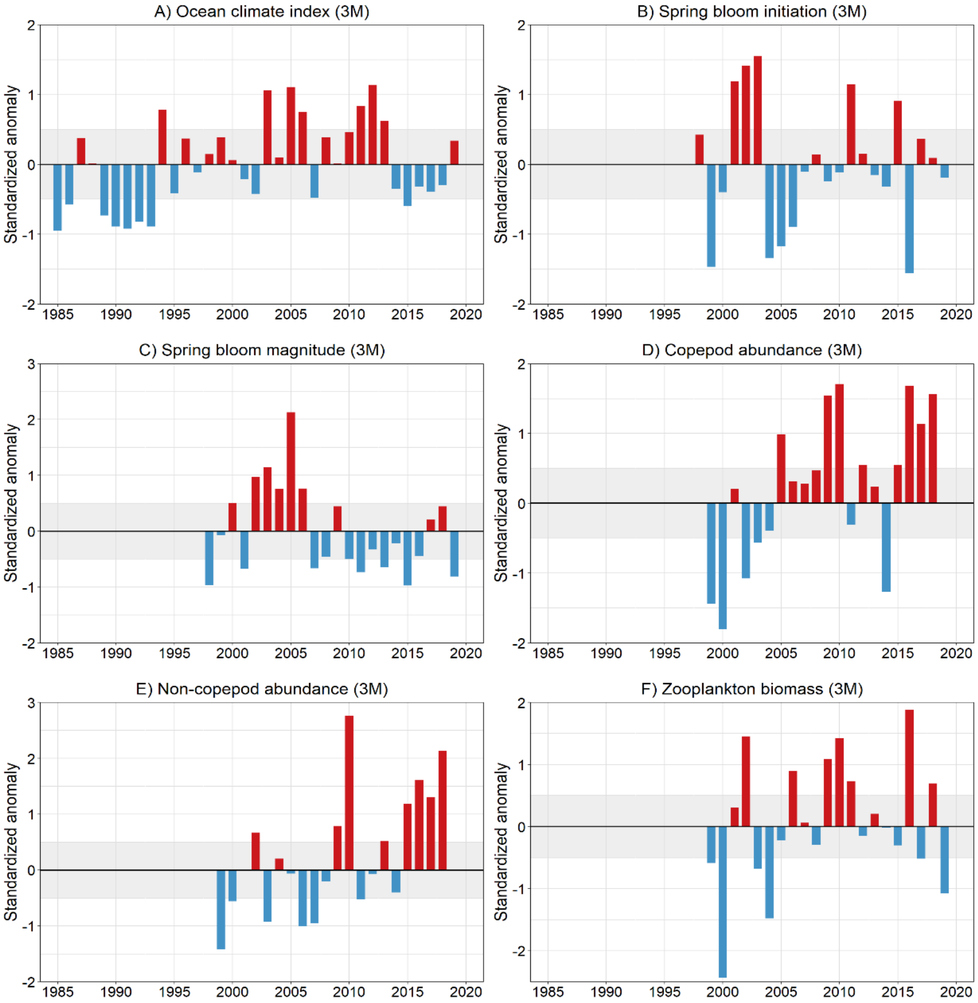


Figure 1.1. Environmental indices for Flemish Cap (in NAFO Div. 3M) during 1990-2019. The ocean climate index (A) for Flemish Cap is the average of 3 time-series of standardized ocean temperature anomalies: sea surface temperatures (SSTs) in Div. 3M, mean temperature over the offshore portion of Flemish Cap hydrographic section (stations FC-15 to FC-35) summer mean bottom temperature over the cap. SSTs and observations along the Flemish Cap hydrographic section are presented in Cyr et al. (2020). Bottom temperatures are derived using the same procedure used in Cyr et al. (2020), 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. Spring bloom initiation (B) and magnitude (C) indices for the 1998-2019 period are derived from two satellite Ocean Colour boxes (Flemish Pass, and Flemish Cap; see SCR Doc. 20/035 for box location). Zooplankton abundance (D & E) and biomass (F) indices for the 1999-2019 period are derived from a subset of 10 stations along the Flemish Cap Atlantic Zone Monitoring Program oceanographic section covering the Flemish Pass, the Flemish Cap, and the outer shelf break. 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 with the following reference periods: ocean climate index, 1981-2010; phytoplankton indices (magnitude and peak timing): 1998-2015; zooplankton indices (copepod, non-copepod, and biomass): 1999-2015. Anomalies within ± 0.5 SD (shaded area) are considered normal conditions.

b) Introduction

The shrimp fishery in Div. 3M began in 1993. Catches peaked at over 60 000 t in 2003 and declined thereafter. A moratorium was imposed from 2011 to 2019.

Fishery and catches:. This stock is under effort regulations. The fishery was reopened in 2020 after nine years under moratorium with 2640 fishing days. The effort directed to the shrimp fishery and catches in the first half of 2020 were very low (2 days). Recent catches and effort agreed by the NAFO Commission were as follows (ndf=no directed fishery):

	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
NIPAG	5000	2000	0	0	0	0	0	0	0	0	0	0[1]
STATLANT 21	5374	1976	0	0	0	0	0	0	0	0	0	
SC Recommended Catches	18000–27000	ndf	ndf	ndf	ndf	ndf	ndf	ndf	ndf	ndf	Ndf	5448
Effort[2] (Agreed Days)	10555	5227	0	0	0	0	0	0	0	0	0	2640

1 Preliminary in the first half of 2020
2 Effort regulated

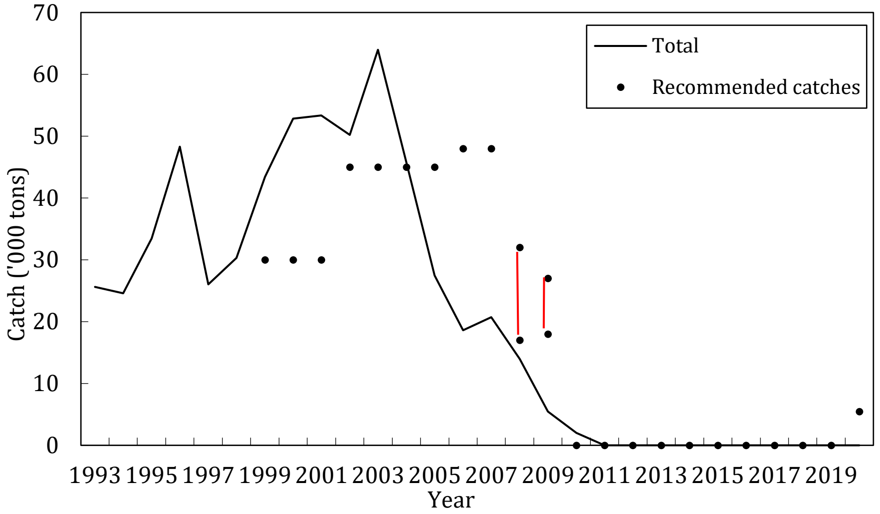


Figure. 1.2. Shrimp in Div. 3M: Catches (t) of shrimp on Flemish Cap and catches recommended in the period 1993-2020.

c) Input Data

i) Commercial fishery data

Time series of size and sex composition data were available mainly from Iceland and Faroes between 1993 and 2005. Because of the moratorium catch and effort data have not been available from 2011 to 2019, and therefore the standardized CPUE series has not been extended.

In 2020, although the shrimp fishery was reopened, length and sex composition from commercial catches were not available due to very low effort and very low catches carried out.

ii) Research Survey Data

EU Bottom Trawl Research Survey. Stratified-random trawl surveys have been conducted on Flemish Cap by the EU in July from 1988 to 2020. A new vessel was introduced in 2003 which continued to use the same trawl employed since 1988. In addition, there were differences in cod-end mesh sizes utilized in the 1994 and 1998 surveys that have likely resulted in biased estimates of total survey biomass. Nevertheless, for this assessment, the series prior to 2003 were converted into comparable units with the new vessel using the methods accepted by STACFIS in 2004 (NAFO 2004 SC Rep., SCR Doc. 04/77).

d) Assessment

No analytical assessment is available. Evaluation of stock status is based upon interpretation of commercial fishery information and research survey data.

SSB: The survey female biomass index was stable at a high level from 1998 to 2007, and subsequently declined until 2014. Since 2015 the biomass index increased successively and in 2019 the estimated female biomass was well above B_{lim}. In 2020 the female biomass experienced some decrease but remains above $B_{lim.}$ The probability that B_{2020} is below B_{lim} is very low (<2.5%).

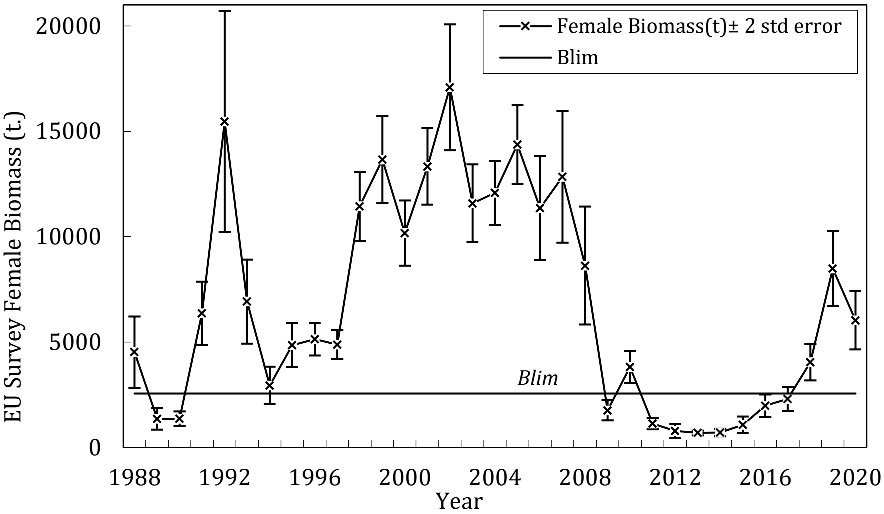


Figure. 1.3. Shrimp in Div. 3M: Female biomass index from EU trawl surveys, 1988-2020. Error bars are 2 std. err.

Recruitment: Age estimation was carried out using Rmix library from the preliminary shrimp length distribution and growth rates in the first three years allow the identification of cohorts. Considering the abundance at age 2 as indicator of recruitment, all year-classes from the 2002 cohort to 2017 have been weak from the main gear and from small mesh juvenile bag attached to the net (Figure 1.3). The recruitment index (age 2), however, has been increasing since the lowest observed in 2014. There are indications of improved recruitment in 2020 (Figure 1.4).

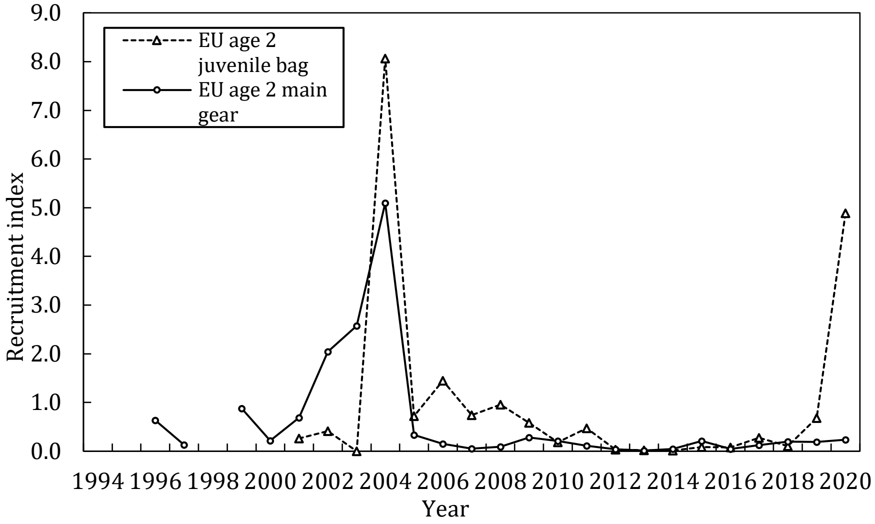


Figure 1.4. Shrimp in Div. 3M: Abundance indices at age 2 from the EU survey. Each series was standardized to its mean.

Exploitation rate: Because of low catches, followed by the moratorium, the exploitation rate index declined to zero and has remained at that level since 2011. Preliminary information from 2020 indicates very low fishing effort, and therefore very low exploitation rate, in the first half of the year.

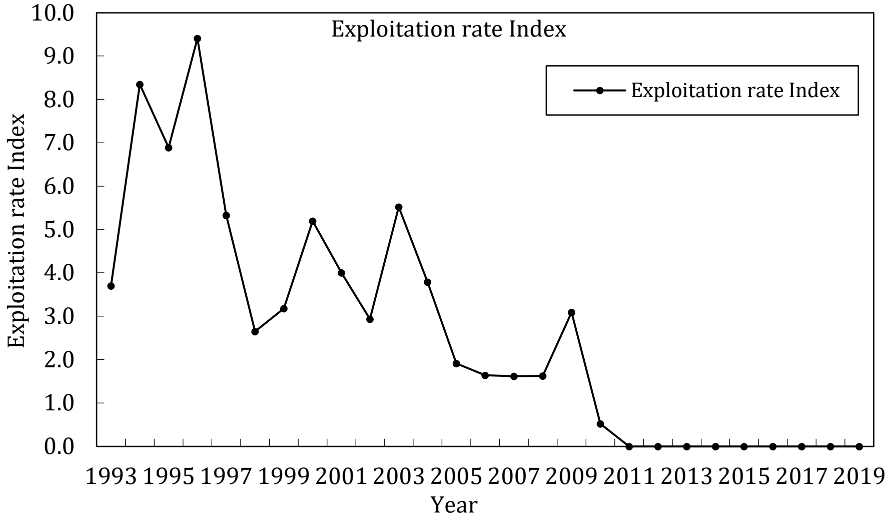


Figure. 1.5. Shrimp in Div. 3M exploitation rate index as derived by catch divided by the EU survey biomass index of the same year.

e) State of the stock

The stock has increased since 2014, and in 2020, the stock has a very low probability *(<2.5%)* of being below *Blim*. Recruitment has been poor during the last decade however with an overall increasing trend.. There are indications of improved recruitment in 2020. Preliminary information from 2020 indicates very low fishing effort, and therefore very low exploitation rate, in the first half of the year

f) Reference Points

A limit reference point for fishing mortality has not been defined. Scientific Council considers that a female survey biomass index of 15% of its maximum observed level provides a proxy for B_{lim}. This corresponds to an index value of 2 564 t (Figure 1.6).

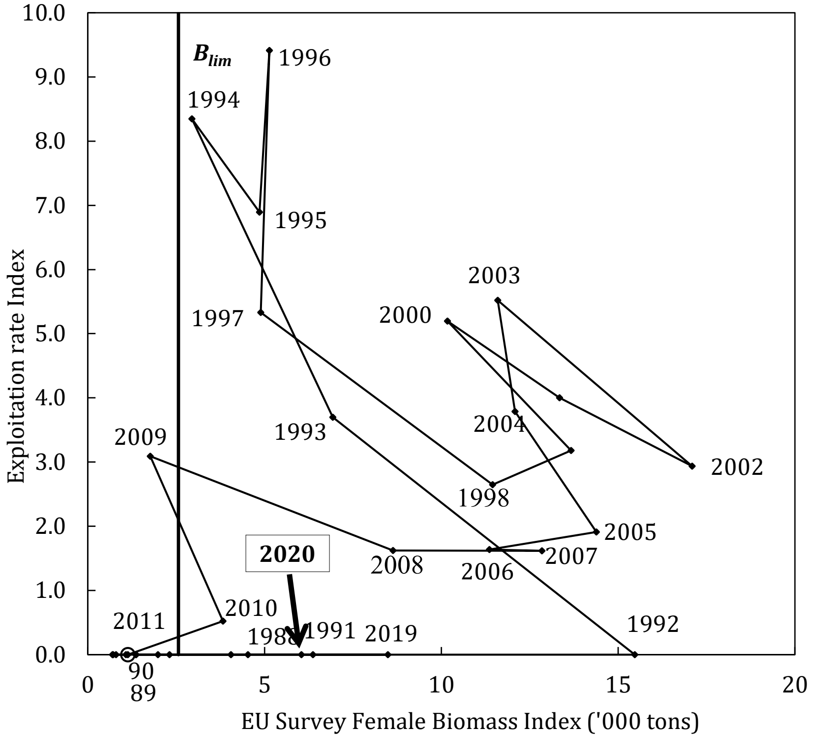


Figure 1.6. Exploitation rate index plotted against female biomass index from EU survey. Line denoting B_{lim} is drawn where biomass is 15% of the maximum point in 2002.

g) Ecosystem considerations

The drastic decline of shrimp biomass around 2008-2010 correlates with an increase of both cod and redfish in Div. 3M. It is uncertain whether this represents a causal relationship and/or covariance as a result of some environmental factor.

Multispecies models (Pérez-Rodríguez et al. 2016, Pérez-Rodriguez and D. González-Troncoso 2018), suggest that predation by cod and redfish, together with fishing, have been the main factors driving the shrimp stock to the collapse after 2007. In the most recent years, decreasing redfish and cod stocks have likely resulted in reduced predation mortality on shrimp, consistent with a period of increase in the shrimp stock.

Results of modelling suggest that, in unexploited conditions, cod and redfish would be expected to be a highly dominant component of the system, and high shrimp stock sizes like the ones observed in the 1998 – 2007 period would not be a stable feature in the Flemish Cap.

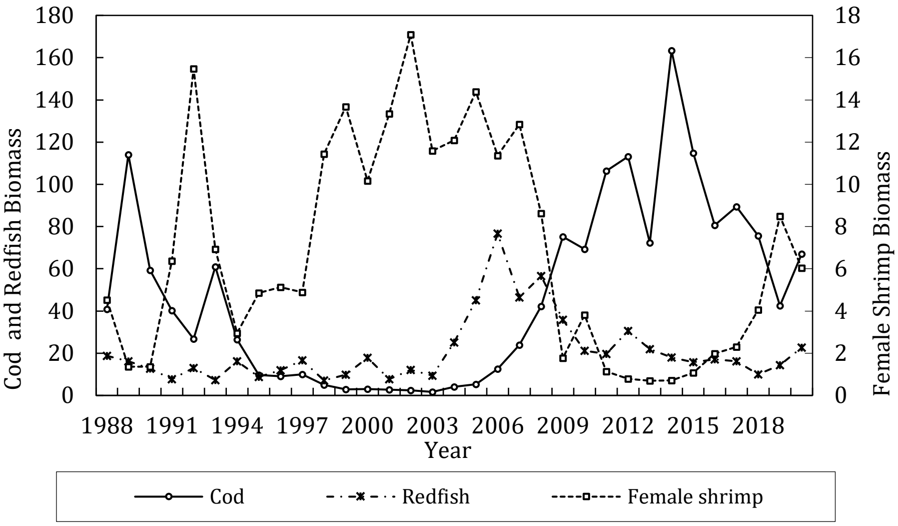


Figure 1.7 Shrimp in Div. 3M: Cod, Redfish and Female shrimp biomass from EU trawl surveys, 1988-2020. 2020 cod and redfish data are preliminary.

h) Research Recommendations

For Northern Shrimp in Div. 3M NIPAG **recommended in 2016** that *further exploration of the relationship between shrimp, cod and the environment be continued in WGESA and NIPAG encourages the shrimp experts to be involved in this work.*

STATUS: No progress from last year.

In 2019, NIPAG **recommended** that *in future years NIPAG should investigate the options to implement an analytical assessment for this stock. Models to explore could include SPiCT, Stock Synthesis (as applied for Northern shrimp in Skagerrak and Norwegian Deep), or other length-based models.*

STATUS: progress will be updated at NIPAG 2020

In 2019, NIPAG **recommended** that *this stock be considered for a benchmark workshop in conjunction with the benchmark of the Skagerrak and Barents Sea stocks anticipated for 2020/21. The NIPAG 2020 meeting will be utilized for a workshop to clarify the data situation and potential assessment models.*

STATUS: progress will be updated at NIPAG 2020

The next assessment will take place prior the NAFO Annual Meeting in September 2021.

References

Pérez-Rodirguez, A. and D. González-Troncoso. 2018. Update of the Flemish Cap multispecies model GadCap as part of the EU SC05 project: “Multispecies Fisheries Assessment for NAFO”, NAFO SCR Doc.18/024, serial No.N6808

PART C: REPORT OF THE SCIENTIFIC COUNCIL MEETING

via WebEx

21-25 September 2020

Recommended Citation:

NAFO. 2020. Report of the Scientific Council, 21 - 25 September 2020, via WebEx. NAFO SCS Doc. 20/19.

Scientific Council Annual Meeting Participants

21- 25 September 2020

SC participants from left to right:

First row: Dayna Bell MacCallum, Margaret Treble, Laura Wheeland, Mark Simpson, Carmen Fernández

Second row: Diana González Troncoso, Irene Garrido, Miguel Caetano, José Miguel Casas Sanchez, Karen Dwyer, Lisa Hendrickson

Third row: Kenji Taki, Martha Krohn, Antonio Ávila de Melo, Ricardo Alpoim, Alexei Orlov, Konstantin Fomin, Natalia Petukhova

Fourth row: Tom Blasdale, Andrew Kenny, Katherine Sosebee, Pablo Duran Muñoz, Liivika Näks

Missing from photo: Fernando González, Kalvi Hubel, Carsten Hvingel, Brian Healey, Cristina Ribeiro, Mariano Koen-Alonso, Pierre Pepin, Tom Nishida, Mar Sacau, Chris Darby, Lisa Readdy, Luis Ridao Cruz, Herlé Goraguer

REPORT OF SCIENTIFIC COUNCIL MEETING

21-25 September 2020

Chair: Carmen Fernandez Rapporteur: Tom Blasdale

I. PLENARY SESSIONS

The Scientific Council (SC) met by correspondence from 21 to 25 September 2020 to consider the various matters in its agenda. Representatives attended from Canada, Denmark (in respect of Faroe Islands and Greenland), the European Union, France (in respect of St. Pierre et Miquelon), Japan, Norway, the Russian Federation, the United Kingdom and the United States of America. The Executive Secretary, Scientific Council Coordinator and other members of the Secretariat were in attendance.

The Council was called to order at 08:00 Halifax time (11:00 UTC) on 21 September 2020. The provisional agenda was **adopted** and the Scientific Council Coordinator was appointed the rapporteur. The opening session was adjourned at 13:00 h on 21 September 2020.

The Council and its Standing Committees met through 21-25 September 2020 to address various items in its agenda. The Council considered and adopted the reports of the STACPUB, STACREC and STACFIS Standing Committees on 24 September 2020.

The final session was called to order at 08:00 on 25 September 2020 and the Scientific Council agreed that the report of this meeting would be finalized by correspondence. The meeting was adjourned at 13:00 hours on 25 September 2020.

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

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

II. REVIEW OF SCIENTIFIC COUNCIL RECOMMENDATIONS

There were no Scientific Council recommendation requiring immediate attention at this meeting. A detailed review of recommendations was deferred to the June 2021 meeting.

III. JOINT SESSION OF COMMISSION AND SCIENTIFIC COUNCIL

The Commission and Scientific Council met in joint sessions on 21 and 22 September to discuss the 2018 NAFO performance review, the Scientific Council's response to requests for advice from the Commission, the reports of the joint SC/Commission Working Groups and other matters of common interest.

1. Implementation of 2018 Performance Review Recommendations

The Chair of the Commission, Stéphane Artano (France in respect of St. Pierre et Miquelon), referred the meeting to Commission Working Paper 22, update of the action plan for the recommendations. There was no further discussion of the working paper.

2. Presentation of Scientific Advice by the Chair of the Scientific Council

a) Response of the Scientific Council to the Commission's Request for Scientific Advice

The Chair of the Scientific Council (SC) presented the scientific advice formulated during the SC meeting in June 2020 (SCS Doc 20-14), except for northern shrimp in Division 3M which was formulated in September during an intersessional NAFO/ICES *Pandalus* Assessment Group (NIPAG) meeting (SCS Doc 20/22).

Due to the COVID-19 situation, SC was unable to address all of the Commission's requests during its June meeting and instead focused on those requests that were identified as priorities by the Commission. Consequently, several requests (Com. Requests 3, 4, 9, 16, 17,18) were deferred to be addressed in 2021. The SC chair advised the Commission that it may be possible to address some of these requests during the present meeting, but that it is likely that some will have to be carried over to 2021. SC requested that the Commission indicate, when formulating their request for advice in 2021, whether they still wish to receive responses to these deferred requests, and to bear in mind the additional work generated by these requests when formulating new requests.

b) Feedback to the Scientific Council Regarding the Advice and its Work during this Meeting

Feedback questions relating to 3M cod were submitted in advance of the meeting by the EU and Denmark (in respect of Faroes and Greenland). These were adopted by the Commission and referred to SC. A further question, also relating to 3M cod was submitted by the EU during the course of the meeting.

The Commission questions and SC responses are presented in section VII.2. of this report.

c) Other issues as determined by the Chairs of the Commission and Scientific Council

No issues were discussed under this item.

3. Meeting Reports of the Joint Commission–Scientific Council Working Groups

a) Working Group on Improving Efficiency of NAFO Working Group Process (E-WG), 2020

The report was presented by NAFO Executive Secretary, Fred Kingston. The Working Group agreed on the following recommendation via correspondence:

- 22 February – 05 March
- 19 April – 30 April
- 12 July – 23 July

Contracting Parties are not obliged to schedule meetings during these periods, but these dates may help in future planning of intersessional meetings.

This WG will continue under the same ToR next year.

The recommendations of E-WG were adopted by the Commission.

b) Joint Commission–Scientific Council Working Group on Risk-based Management Strategies (WG-RBMS), February and August 2020

The co-Chairs of WG-RBMS, Jacqueline Perry (Canada) and Fernando Gonzalez (EU), presented the work of WG-RBMS over its two meetings in 2020 (COM-SC Docs 20-01 and 20-04).

Key issues discussed during these two meetings included:

- The review of the NAFO Precautionary Approach framework
- 3LN redfish Conservation Plan and Harvest Control Rule
- Greenland Halibut MSE

- 3M Cod MSE

During the February meeting, WG-RBMS considered the Terms of Reference (ToR) for the PA review *(SCS Doc 16/15)* and agreed that these ToRs should continue to guide the work, noting that while the issues were previously discussed, many remained unresolved. The WG agreed on a plan for future work including the suggestion that the SC be asked to reconvene the NAFO Scientific Council Precautionary Approach Working Group (PA-WG). PA-WG was subsequently reconvened and held several meetings in 2020, reporting its progress to the SC's June meeting. In the August meeting WG-RBMS considered recommendations from the SC's June meeting, and further developed the workplan (involving the SC, WG-RBMS and the Commission) initially proposed by SC.

In 2020 WG-RBMS **recommends** that:

- **In relation to the Precautionary Approach Framework revision, the Commission endorses the workplan and funding proposal developed by WG-RBMS at their August meeting (COM-SC Doc 20-04).**
- **In relation to 3LN redfish Conservation Plan and Harvest Control Rule (Annex I.H of the NAFO CEM):**

a) **the Commission requests the Scientific Council to provide guidance on the process of conducting of a full review/evaluation of the management strategy at the end of the 7-year implementation period.**

b) **the Commission adopts a TAC of 18 100 t for 3LN Redfish, applicable for 2021 and 2022.**

c) **the Risk-based Management Strategy for 3LN Redfish outlined in Annex I.H of NAFO CEM be updated in accordance with Annex 5 of the WG-RBMS August meeting report (COM-SC Doc 20-04).**

The recommendations of WG-RBMS were adopted by the Commission.

c) Joint Commission–Scientific Council Working Group on Ecosystems Approach Framework to Fisheries Management (WG-EAFFM), August 2020

WG-EAFFM co-Chair Elizabethann Mencher (USA) presented the August 2020 report and recommendations (COM-SC Doc. 20-03). Three items were prioritized for the August meeting:

- *Work related to VMEs, including closed areas and progress on the 2021 re-assessment processes*
- *Progress of the work on the application of the Ecosystem Approach to Fisheries (EAF) Road Map*
- *Next steps for the review of Chapter 2 of the CEM*

In 2020 WG-EAFFM **recommends** that:

- **In relation to the re-assessment of VME closures, and acknowledging the Scientific Council advice regarding the status of VMEs, all closures listed in Chapter 2, Article 17, "Area Restrictions for Bottom Fishing Activities" are rolled over for one year.**
- **Black Coral taxa (Antipatharia) are added to the VME indicator species list. Consequently, Annex IE, part VI of the NAFO CEM "List of VME Indicator Species" should be appropriately amended.**
- **In relation to the 2021 re-assessment of bottom fishing as well as the discussion on the VME fishery closures, the Commission requests that Scientific Council provide input and analysis of potential management options, with the goal of supporting meaningful and effective discussions between scientists and managers at the 2021 WG-EAFFM meeting.**
- **The Commission, through STACTIC, insert a footnote in Annex II.N Fishing Logbook Information by Haul of the NAFO CEM, to clarify and match the definition of Start and End time of fishing in Annex II.M**
- **In relation to the Scientific Council's first recommendation with respect to COM request #5 and recognizing the limited nature of the 2020 virtual working group meeting, the Commission, through the WG-EAFFM, continue to consider this recommendation in 2021, and develop options of how ecosystem advice could**

inform management decisions, an issue which is directly linked to the results of the foreseen EAFM roadmap workshop.

- **Additionally, the Commission request the Scientific Council to continue its work to develop models that support implementation of Tier 2 of the EAFM Roadmap.**
- **In relation to the development of the ecosystem summary sheets, in particular consideration of non-fishery related activities, the Commission request Contracting Parties to proactively provide any relevant research to inform the Scientific Council's work, as well as identify scientific and management experts in non-fisheries related sectors to participate in Scientific Council and WG-EAFFM discussions. Further, that the Secretariat and the Scientific Council work with other international organizations, such as the FAO and ICES, to bring in additional expertise to inform the Scientific Council's work.**
- **In relation to Chapter 2, Article 24 of the CEM: STACTIC review the implementation of that chapter, and suggest, as necessary, any revisions to WG-EAFFM with a view to improve the effectiveness of management measures; and the Commission request the Scientific Council to also review the effectiveness of Chapter 2 from a scientific perspective and to report back at the 2022 WG-EAFFM meeting. Consequently, Article 24 of the CEM should read: the provisions of this Chapter shall be reviewed by the Commission at its Annual Meeting no later than 2022.**

In response to the recommendations, the EU expressed concern regarding the inclusion of new taxa in the VME list.

Canada suggested that the Ecosystem Approach workshop should be held in the first half of 2021 even if it is not possible to hold a face to face meeting.

The recommendations of WG-EAFFM were adopted by the Commission.

d) Joint Commission–Scientific Council Catch Estimation Strategy Advisory Group (CESAG), 2020

CESAG co-Chair, Kathrine Sosebee presented the report of various meetings of CESAG to the Commission.

In February 2020, CESAG examined preliminary catch estimates produced by the Secretariat, which incorporated gear and quarter but not mesh size. In April, the WG agreed finalized catch estimates for 2019, which were passed to SC on May 1.

In 2020 CESAG **recommends** that**:**

- **the Commission request STACTIC to review the haul by haul reporting template (Annex II.N of the NAFO CEM) and investigate the practicality of adding the codend mesh size or hook size to the reporting requirements.**
- **the Commission request STACTIC to continue to review current measures relating to reporting of catch by NAFO Division to identify and implement improvements which ensure the most reliable information is available for catch estimation, recognizing its importance in stock assessments.**
- **a meeting be held in February 2021 to review and discuss the MRAG report recommendations for potential further enhancements to the CESAG methodology of catch estimation.**

The recommendations of CESAG were adopted by the Commission.

4. Formulation of Request to the Scientific Council for Scientific Advice on the Management in 2022 and Beyond of Certain Stocks in Subareas 2,3, and 4 and Other Matters

In accordance with the procedure outlined in FC Doc. 12-26, a steering committee was formed to assist in the drafting of the Commission request. The committee consisted of the SC Coordinator, Leigh Edgar (Canada), Martha Krohn (Canada) and Cristina Ribeiro (EU). The committee met be correspondence during the week, presenting a draft of the Commission's requests to SC on 24 September.

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 I.

V. RESEARCH COORDINATION

The Council adopted the Report of the Standing Committee on Research Coordination (STACREC) as presented by the Chair, Karen Dwyer. The full report of STACREC is in Appendix II.

VI. FISHERIES SCIENCE

The Council adopted the Report of the Standing Committee on Fisheries Science (STACFIS) as presented by the Chair, Katherine Sosebee. The full report of STACFIS is at Appendix III.

VII. REQUESTS FROM THE COMMISSION

1. Requests deferred from the June Meeting

Because of the difficult meeting circumstances SC encountered this year, caused by the pandemic situation, requests # 3, 4, 9, 10, 13, 14, 16 and 18 (in NAFO/COM Doc. 19-29) could not be addressed by SC at its June meeting. For requests # 4, 14 and 16, the SC was able to provide a response in the September meeting (see responses below, although there was no time to present request # 4 in the Commission meeting); for the other requests this was not possible and a progress report is presented below.

i) Continue the evaluation of scientific trawl surveys in VME closed areas (COM request #3)

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

The following progress update was presented to SC in September:

Work for the EU Flemish Cap and the Canadian autumn and spring surveys is available from previous years:

NAFO SCR 16/40: Effect in mean catch and biomass index of removing stations in the closed Coral, Sponge and sea pen Protection Areas in the design of the EU Flemish Cap survey.

NAFO SCR 17/27: Examining the impact that excluding RV surveys from coral and sponge protection areas in Divisions 3LNO would have on Canadian RV survey trends for NAFO-managed fish stocks.

The work planned afterwards to complete this task did not occur as a result of other work commitments until September 2019. It was then agreed that this work would be completed in time for the June 2020 SC meeting, but due to the COVID-19 pandemic circumstances, this was not possible and the response to this request has been postponed to June 2021.

It is important to know the possible differences that may occur in the observed composition at length/age of the NAFO stocks from the trawl surveys, if these surveys are included or excluded from the VME closed areas. Up to now, studies have been made only for biomass indices in the case of the EU Flemish Cap survey, and biomass and length distribution in the case of the Canadian surveys. No work for the EU-Spain surveys in 3NO and 3L has been performed. More knowledge is necessary in this matter.

A workplan is developed from now to June 2021, in order to ensure that the work is finished by the June 2021 SC meeting.

1. Studies in the length and age distribution of the stocks in the EU Flemish Cap survey. An R script has been developed and is almost finished, in order to have the length/age abundance of the Flemish Cap stocks with and without the VME closed areas. An SCR will be presented in June 2021.
2. Studies in the biomass, length and age distribution of the EU-Spain surveys in 3NO and 3L. The same R script as in the case of the Flemish Cap survey is almost finished, in order to present the results for these two surveys. One or two SCRs will be presented with the results in June 2021.
3. Studies in the Canadian surveys. A review process evaluating both the impacts of science surveys on VMEs and the consequences of excluding surveys from VMEs on stock assessment/ecosystem data time series is being conducted by Canada in October 5-9. Since Canadian surveys cover both Canadian and NAFO closures and since many stocks extend across both the Canadian EEZ and the NRA, the analyses for this meeting will include both Canadian and NAFO closures. So, the outcomes of this meeting will be pertinent to both Canada and NAFO. An update on this meeting could be provided at the 2021 June SC meeting.

If the surveys are excluded from the VME closed areas, studies about possible options for non-destructive regular monitoring within closed areas will be necessary.

ii) Identify discard species/stocks with high survivability rates (COM request #4)

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), giving priority in 2020 to the identification of discard species/ stocks listed in Annex I.A. and Annex I.B of the NCEM with high survivability rates.

Scientific Council responded:

There are few discard survival rate studies involving NAFO fisheries and the species / stocks listed in Annex I.A. and Annex I.B of the NCEM. SC also notes that there is no clear definition of what is considered 'high survivability' rate.

The survival of discarded specimens depends on a multitude of factors related to both the biology and habitat of the species, as well as the conditions of their capture and subsequent release. As a consequence, discard survivability values from a given fishery can not be extrapolated to different fisheries. Furthermore, many of the existing discard survivability studies have been criticized for lacking appropriate experimental controls and/or for having experimental conditions that do not replicate real world conditions sufficiently well.

In order to know the survival of discards from NAFO fisheries, specific studies would need to be designed and carried out. SC notes that the design and development of these studies with the appropriate methodology would be quite complex and require considerable financial and technical means.

There are few discard survival rate studies involving NAFO fisheries and species / stocks listed in Annex I.A. and Annex I.B of the NCEM. To determine the species with high survivability rates, a literature review has been carried out focusing on the species / stocks (NCEM Annex I.A. and Annex I.B) and fisheries (trawl and longliners) that are conducted within the NRA. SC notes that there is no clear definition of what is considered 'high survivability' rate. The EU Scientific, Economic and Technical Committee for Fisheries (STECF, 2016) has highlighted that this is a subjective term that involves trade-offs between different management and societal objectives, driven by the management priority for that fishery at that particular time (e.g., improving stock sustainability; improving financial viability; or avoiding waste).

There are several published reviews summarizing the discard survival in other parts of the world (Broadburst *et al.*, 2006; Revill, 2012; Ellis *et al.*, 2017). Most of the studies were made in the field involving towed gears and took place in north Atlantic regions. An overview of the studied species in EU waters, their survival rates and corresponding references has been presented by Rihan *et al.* (2019). Many of the studies have been criticized for lacking appropriate experimental controls and/or for having experimental conditions that do not replicate real world conditions sufficiently, therefore failing to adequately describe the potential variability in survival at the fishery scale or the impact of the method used to estimate the survival rate (STECF 2014, 2015, 2016). Other related reviews compiled studies on the factors influencing mortality of discards (Davis, 2002; Davis and Ryer, 2003; Suuronen, 2005). Most studies agree that discard mortality varies considerably according to (a) species biology: body size, sex, presence/absence of swim bladder, fish condition, tolerance to stress, catch volume and composition; (b) environmental conditions: exposure to air, temperature of water and air, exposure to direct light, and depth fished (pressure and temperature change experienced by the fish); as well as with (c) fishing technical factors: nature of the gear (pot, gillnet, longline, mobile gear), deployment and retrieval of gear, towing speed and duration, handling procedure and duration. The interaction between these factors results in cumulative impacts on discarded fish and resulting survivorship. Much of the research work done on survival has been containment-based and focused on short-term survival (≤ 72 hours) and there is evidence that short-term survival studies may underestimate long-term survival by as much as 50% (Sangster *et al.* 1996). Studies indicate substantial variation in long-term survivorship, characterized either by a rapid initial decrease in survival before stabilizing, or a continual decline (Benoît *et al.* 2012). An additional variable source of discard mortality is introduced by predation by marine mammals (e.g. Couperus 1994), avian predators (Votier *et al.* 2004), and/or other fish upon release of discarded fish. Discards survival studies are increasingly using electronic tagging technology to track discarded fish and assess survival over a longer term period under real-world conditions (Capizzano *et al.*, 2016 and Capizzano *et al.*, 2019).

Due to the large number of factors that affect discard survivability, there can be significant variation in the survival rates of discarded species within individual studies (e.g. Revill, 2012). There are also large variations in a species' discard survival rate reported between studies. These large variations make it difficult to use values from a study in a particular fishery in other similar fisheries. Catchpole *et al.* (2017) reached a similar conclusion and reported that, due to the limited number of survival rate estimates available in the literature, it may be difficult for the time being to extrapolate values across fisheries or gear types and areas, and that more studies are needed to cover a larger scope of gears, species and areas. As the quality of existing studies can be quite variable, the ICES science group on Methods for Estimating Discard Survival recommended and adopted the use of critical review methodology to screen studies before their results are used, notably in meta-analyses (see e.g. ICES 2015, and other reports of the group).

Table 1.1 shows estimated discard survival rates for species in Annex I.A. and Annex I.B of the NCEM, or analogous species, from different studies carried out, especially in the North Atlantic, with similar gears to those used in the NRA. These species are grouped using similar biological characteristics: flatfish, gadoids, deep-sea species, skates and rays, redfish, crustaceans, molluscs and small pelagics. The reported survival rates are highly variable, even within the same species, and depend on many factors beyond those associated with the biology of the species. However, when encountered in similar fisheries, flatfish may generally be expected to have higher discard survivability than gadoids, while survival of redfish discards is considered negligible. The general characteristics of survivability for these groups of species are summarized below.

Survival of flatfish, including the following species / stocks listed in Annex I.A. and Annex I.B: American plaice, Yellowtail flounder, Witch flounder and Greenland halibut.

Discard survival of flatfish is considered to be higher than the survival of gadoids, due to the absence of swim bladder in adult stages; flatfishes are relatively less sensitive to the effect of changes in pressure. This may also indicate a less significant impact of the depth fished on survival of flatfish relative to round fish. Species of flatfish, for example, appear to have relatively good chances of survival (Kelle, 1976; Van Beek *et al.*, 1990), although there is substantial variation within and among flatfish species. One study indicates flatfish survival rates from trawl discards in the Western Baltic range from 0% to 100%, and may only be considered "high" (defined as >75% in this study; Kraak *et al.* 2019) in some species during the first quarter of the year (January-

March). Flatfish may be more sensitive than round fish to suffocation in the codend of trawls from pressure on the operculum (Davis, 2002), although at least some flatfish species have low metabolic rates (associated with their more sedentary lifestyle), which may allow enhanced resistance to temporary air exposure during handling (Benoît *et al.*, 2013). The overall characteristics of flatfish make them a candidate for a variety of measures that could reduce discard mortality (Davis and Ryer, 2003).

Discard survival of Greenland halibut has not been quantified, but would be expected to be influenced by similar factors as those affecting other flatfish described here, as well as those relevant for deep-sea species (see below).

Survival of gadoids, including the following species / stocks listed in Annex I.A. and Annex I.B: Cod and White hake.

Fish with gas bladders generally experience significant mortality upon capture in fishing gear. There are studies suggesting that decompression may not be fatal in all cases; however, injuries produced by over inflation of the gas bladder in other organs may be irreversible and lead to death. Discard survival rate studies are mainly focused on cod and show a significant variability depending on the type of gear used.

There are some specific studies on the survival rate of Atlantic cod (Palmer *et al.*, 2011). The factors affecting the mortality and survival of fish discarded by both commercial and recreational fisheries are numerous and complex, as is the case in other species. Many of the studies published on discard mortality utilized short-term studies to estimate the impacts in very controlled environments. Mortality estimates range from near 0 to 100%, with a mean in the range of 40-80%, depending on gear type and study.

Survival of small pelagics, including the following species / stocks listed in Annex I.A. and Annex I.B: Capelin.

Discard survival rates of small pelagics have not been studied broadly. There are not many available studies of discard survival of these species and very few with trawling gear typical of the fisheries in which capelin is caught in the NRA. Major problems in these fisheries are mortalities related to crowding and slipping (Lockwood *et al.*, 1983).

Discard survival from purse seines may be relatively high, as indicated by a recent experiment carried out in the Basque purse seine fleet (Arregi *et al.*, 2013). In this fishery, the use of technological equipment for fish handling has showed to be potentially effective in achieving high survival rates for some discarded species.

Experiments have been carried out with mackerel (Huse and Vold, 2010), horse mackerel, anchovy, and sardine, with survival rates higher than 50% for all species. It is worth highlighting that, in all cases, survival rates for horse mackerel were higher than 89%. Mortality rates of discarded herring varied between fisheries, with survivorship tending to be lower in trawls than in purse seines, and depending on season and size.

Survival of deep-water species, including the following species / stocks listed in Annex I.A. and Annex I.B: Alfonsino.

There is little information on survivability of discarded deep-sea fish in the literature. The majority of the studies carried out relate to sharks (Skomal & Mandelman 2012; Brooks *et al.*, 2015). When deep-sea species are captured, the changes in pressure imply that most species caught and subsequently discarded will not survive (Large *et al.*, 2003). Despite this general conclusion, there are species, like hagfish, that appear to survive quite well (Benoît *et al.* 2013), and those species lacking swim bladders may be expected to have relatively higher survival rates.

Survival of skates and rays, including the following species / stocks listed in Annex I.A. and Annex I.B: Skates.

There are several published reviews summarizing discard survivability of skates and rays (Broadburst *et al.*, 2006; Revill, 2012; Ellis et al 2017). One of the most relevant studies on discards survivability of rays with trawl gear in the northwest Atlantic have been carried out by Benoît *et al.* (2012) and Mandelman *et al.* (2012).

Survivability has been shown to vary by gear (Dapp et al. 2016), though great variability in survival rates has also been observed for different species for the same gear (Knotek *et al.*, 2018). Different survival studies of discards of these species were analyzed in Europe and their main conclusion was that these species have discard survival rates between 64% and 79% across all gears (STECF-17-21).

Survival of redfish

There is not much information on the survival of redfish discards in the North Atlantic. However, redfish (*Sebastes spp.*) have a closed swim bladder that expands uncontrollably when these fish are brought to the surface quickly; therefore, discarded redfish have been attributed a mortality rate approaching 100% (COSEWIC 2009; Rummer and Bennett 2005; Starr *et al.* 2002).

Survival of crustacean and molluscs, including the following species stocks listed in Annex I.A. and Annex I.B: Shrimp and Squid (*Illex*).

The survival rate of crustaceans largely depends on the extent of the physical damage caused by the fishing and sorting activities (Wassenberg and Hill, 1989). Discards of benthic crustaceans and molluscs tend to have a higher survival rate if discarded in the location in which they are caught.

Potential experiments to study discard survival rates.

ICES has been one of the organizations that has most studied methods to estimate survival rates of discards in recent times, with the goal of advising on the best approaches to produce accurate and robust estimates. ICES established a science group on Methods for Estimating Discard Survival (WKMEDS), referred to earlier in this document, which met multiple times since 2014, to provide guidance on methods to quantify discard survival robustly. Rihan *et al.* (2019) includes a brief summary of the different steps taken by this working group to develop methodologies for estimating survival rates of discards.

WKMEDS published its first draft, to provide guidance on how to quantify discard survival robustly, in April 2014 (ICES 2014). WKMEDS recommended: (i) assessments should be representative of discarded catch and practices, ideally at a fishery, gear type or area scale; (ii) methods should avoid biasing results through observation-induced mortality, and wherever possible demonstrated with appropriate controls; and (iii) the monitoring period should be sufficiently long to observe any delayed mortality attributable to the catch-and-discarding process.

To quantify lethal stress and discard survival, three methodologies were identified: captive observation, tagging/biotelemetry techniques, and vitality/reflex assessments (ICES 2014). In captive observation studies, samples of animals are selected from the discarded catch and monitored to provide estimates of survival rates. Tagging/biotelemetry techniques use tagging technologies to monitor post-release mortality of (tagged) organisms. Vitality assessments quantify the health of organisms at the time of discarding. By combining vitality assessments with one or both of the other two techniques, the at-capture condition may be correlated with an individual's likelihood of post-release survival (Davis 2010). Depending on the strength of such a correlation, a vitality index may be used as a proxy for survival (e.g., Barkley and Cadrin 2012; Morfin *et al.* 2017). The WKMEDS group also developed protocols for systematically reviewing survival assessments and meta-analysing survival data.

The SC notes that the design and development of discard survivability studies with the appropriate methodology is quite complex and requires considerable financial and technical means. For this reason, it is suggested that discard mortality studies only be undertaken for NAFO fisheries if a specific conservation concern is noted based on discard rates and/or stock trajectories.

Table 1.1 Estimated discard survival rates for species in Annex I.A. and Annex I.B of the NCEM, or analogous species. Studies highlighted in Grey indicate discard survival studies carried out in the NAFO Area that include species listed in Annex I.A. and Annex I.B caught with gear similar to those used in the NAFO fisheries.

Species	Gear	Area	Survivor Rate	Comments	Author
American plaice	Trawl	Gulf of St. Lawrence	52%	14-110h holding time	Benoit et al. (2012)
			0%-78%		Jean (2011)
			4%-88%	Various conditions/quality of fish held for 48hrs	Benoit et al. (2010)
		Northeast USA	17%-29%	(3 hr tows) after 72 hrs	Carr et al. (1995)
			44%-66%	44% in summer and 66% in spring at 24 hrs	Robinson and Carr (1993)
		Canada	0%-5%		Powles (1969)
	Shrimp trawl	Northeast USA	40%-97%		Ross and Hokenson (1997)
		Gulf of Maine	81%	1-2 hrs holding tank, avian predation after thrown back also mentioned in study with separate percentages	Hokenson and Ross (1993)
	Longline	Gulf of St. Lawrence	80%	estimate different species of fish	Benoit and Hurlbut (2010)
	Gillnet	Gulf of St. Lawrence	76%	estimate different species of fish	Benoit and Hurlbut (2010)
	RV otter trawl	North Sea	0%-54%	after 84 hours	Van Beek et al. (1990)
Yellowtail flounder	Trawl	New England	30%–60%		Barkley and Cadrin (2012)
		Northeast USA	66%-69%	(3 hr tows) after 72 hrs	Carr et al. (1995)
		Northeast USA	87%	87% in spring at 24 hrs	Robinson and Carr (1993)
	Shrimp trawl	Gulf of Maine	99%	1-2 hrs holding tank, avian predation after thrown back also mentioned in study with separate percentages	Hokenson and Ross (1993)

Witch flounder	trawl	Gulf of St. Lawrence	-	14-110h holding time, no survivor % estimated since only 29 individuals and only 1 of vitatlity class one. Fish usually in poor condition	Benoit et al. (2012)
			50%-75%	Various conditions/quality of fish held for 48hrs	Benoit et al. (2010)
	Shrimp trawl	Northeastern USA	36%-93%		Ross and Hokenson (1997)
		Gulf of Maine	71%	1-2 hrs holding tank, avian predation after thrown back also mentioned in study with separate percentages	Hokenson and Ross (1993)
European plaice	Otter trawl	ICES waters	43%-78%	Compilation of recent studies by different authors	Oliver, M., & McHugh, M. (2018)
	Beam trawlers	ICES waters	12%-35%		Uhlmann, S. et al. (2018)
	otter trawl	North Sea			Van Beek et al. (1990)
Summer flounder	trawl	Eastern US	18%	used telemetry	Yergey et al. (2012)
Cod	Trawl	Gulf of St. Lawrence	32%	14-110h holding time	Benoit et al. (2012)
		Gulf of St. Lawrence	20%-80%		Jean (2011)
		Gulf of St. Lawrence	2%-65%	Various conditions/quality of fish held for 48hrs	Benoit et al. (2010)
		Northeast USA	0%-25%	after 72 hrs for all treatments	Carr et al. (1995)
		Northeast USA	13%-51%	summer=13%, spring=51%	Robinson and Carr (1993)
	Shrimp trawl	Gulf of Maine	64%	1-2 hrs holding tank, avian predation after thrown back also mentioned in study with separate percentages	Hokenson and Ross (1993)
	Longline	Gulf of St. Lawrence	59%	short-term survival (<48 hours)	Benoit and Hurlbut (2010)

		US North West Atlantic	22%-47%	mean = 31% after 72 hrs (range = 22-47%)	Millikien et al. (2009)
	Trawl	North Sea	1%	small fish unaffected since not retained, a percentage of market size fish (39%) sustained serious injuries (eg. spinal fracture) that would affect long term health and survival	de Haan et al. (2016)
		North Sea	66%	88 hrs	Depestele et al. (2014)
		Barents Sea	99.7%	6 days after codend escape	Ingolfsson et al. (2007)
		North Sea	0%	15 min on deck	Evans et al. (1994)
		Norway	>=90%	at 12-16 days after codend escape	Soldal et al. (1993)
	Longline	North west Atlantic	31%-100%	3 day holding cages	Milliken et al. (2009)
			31%-81%	Lower temperatures and shallower depths	Rudolph et al. (2006)
	Handline/pots/otter trawl	/	91%	*gear types not significantly different. Study also included t-bar tags, fish held for 5 days	Brattey and Cadigan (2004)
	Handline	North of Iceland	57%	undersized cod: 32-54% mortality based on water depth, held in cages 4-9 days	Palsson et al. (2003)
	Rod and reel (rec)	Gulf of Maine	83.50%		Capizzano et al. (2016)
	Lab to simulate Danish seine	Lab	25%	10 min of air exposure	Humbostad et al. (2009)
White hake	trawl	Gulf of St. Lawrence	50%-100%	Various conditions/quality of fish held for 48hrs	Benoit et al. (2010)
	Longline	Gulf of St. Lawrence	87%	estimate different species of fish	Benoit and Hurlbut (2010)
		New England	22%-47%	various sizes and hook/injuries, paper also looks at seagull predation on undersized cod	Milliken et al. (1999)

Haddock	otter trawl	Northwest Atlantic	18%-85%		Beamish (1966)
Skates	Trawl	Gulf of St. Lawrence		various estimates rates over many years for different sp.	Benoit (2013)
		Gulf of Maine	77%	Amblyraja radiata	Mandelman et al. (2012)
		Gulf of St. Lawrence	97%	14-110h holding time	Benoit et al. (2012)
		Gulf of St. Lawrence	65% (43%-80%)	Raja sp, estimate different species of fish	Benoit et al. (2012)
		Gulf of St. Lawrence	42%-100%	Various conditions/quality of fish held for 48hrs	Benoit et al. (2010)
	Longline	Gulf of St. Lawrence	42%-100%	Raja sp, estimate different species of fish	Benoit and Hurlbut (2010)
	Trawl	North Sea	81%		Bird et al. (2018)
		Bristol Channel	57%-69%	See Enever et al. (2009)	Catchpole et al. (2017)
		North Sea	72%	Raja sp	Depestele et al. (2014)
		Western Channel	24%-84%	Different species	Ellis et al. (2012)
		VII ICES	55%-87%	Different skates species	Enever et al. (2009)
		UK waters	59%		Kaiser and Spencer (1995)
winter skate	sink gillnet	North Atlantic (US)	83%-89%	Mortality (11%=female, 17=male. 170hr hold time)	Sulikowski et al. (2018)
Redfish	hook-and-line	USA Pacific	70%-100%	USA Pacific Sebastes spp.	Hannah et al. (2012)
		USA Pacific	68%	21 spp. USA Pacific Sebastes. Various survival rates based on various traumas. 68% for 10 min hold after capture as well as 2day recompressed	Jarvis et al. (2008)
Shrimp	Shrimp beam trawl	Portugal	58%-100%	Misc. crustacea	Cabral et al. (2002)
	Fish beam trawl	UK	55%-100%	Misc. crustacea	Kaiser and Spencer (1995)

	Shrimp trawl	Australia	46%-100%	Misc. crustacea	Wassenberg and Hill (1993)
		Australia	33%-80%	Misc. crustacea	Hill and Wassenberg (1990)
		Australia	85%	Misc. Crustacea,survival after 8 hrs of sorting	Wassenberg and Hill (1989)
Spot prawn	lab experiment	USA Pacific	0%-100%	various exposure times and dropping from hieghts	Stoner (2012)
Crangon shrimp	beam trawl	Portugal	0%-96%	various sorting times, temperatures and tow times	Gamito (2003)
	shrimp trawl	UK	77%-80%	study is on undersized shrimp, includes seabird predation	Lancaster et al. (2002)
	shrimp trawl	Australia	65%	juvenile prawns	MacBeth et al. (2006)
Squid	beam trawl	U.K.	87%-100%	Mollusc in general	Kaiser and Spencer (1995)
	Shrimp trawl	Australia	100%	Mollusc in general	Wassenberg and Hill (1993)
squid – *Loligo*	trawl	Australia	2%	10 min exposure on deck	Hill and Wassenberg (1990)
Cephalopods general	shrimp trawl	Australia	55%	45% floating after discard (mortality)	Hill and Wassenberg (2000)
Herring	trawl		0%-56%	size dependant. 14 day observation in holding cages	Suuronen et al. 1996c
			12%-89%	codend escapees. 7 day post capture observations	Suuronen et al. 1996a
	purse seine simulation	North sea	40%-93%	various experiments with varying loss of scales	Olsen et al. (2012)
			1.6%-52%	Different stocking/crowding densities	Tenningen et al. (2012)
	seine and handline		45%-91%	season dependant - gear used as control for above experiment. 14 day observation in holding cages	Suuronen et al. 1996c

			87%-91%	held in cages 9-16 days. Control for above experiment	Suuronen et al. 1996a
Mackerel	purse seine		10%-50%	various stocking densities tested, 48 hr observation time	Lockwood et al. (1983)
Sardine	purse seine	Portugal	<20->80%	on month observation time, high variability between trials for % survival	Marcalo et al (2008)
General discussion on discard mortality					Benoit et al. (2020)
					Cook et al. (2019)
					Rihan et al (2019)
					Benoit et al. (2015)
					Knotek et al. (2015)
				Sub lethal effects examined	Wilson et al. (2014)
				review of studies if considered predation of discards	Raby et al. (2014)
				time to mortality experiments in air	Benoit et al. (2013)
					Revill (2012)
					Broadhurst et al. (2006)
				review of studies on collateral fishing mortality from towed gear	Ryer et al. (2004)
				review on discard mortality and studies	Davis (2002)

REFERENCES

Arregi, L. Onandia, I. Ferarios, J.M. and Ruiz J. (2013), Evaluación de la adecuación de la operativa de la flota de cerco con motivo de la entrada en vigor de la restricción del descarte en la nueva PPC (SAILKATU). Informe AZTI-Tecnalia para OPEGUI. 47 p

Barkley, A. S., and Cadrin, S. X. 2012. Discard mortality estimation of yellowtail flounder using reflex action mortality predictors. Transactions of the American Fisheries Society, 141(3), 638–644. doi:10.1080/00028487.2012.683477

Beamish, F. W. H. (1966). Muscular fatigue and mortality in haddock, Melanogrammus aeglefinus, caught by otter trawl. Journal of the Fisheries Board of Canada, 23(10), 1507-1521.

Benoît, H. P., Hurlbut, T., & Chassé, J. (2010). Assessing the factors influencing discard mortality of demersal fishes using a semi-quantitative indicator of survival potential. Fisheries Research, 106(3), 436-447.

Benoît, H.P., and Hurlbut, T, (2010). Incidental catch, discards and potential post-release survival of fish captured in fixed-gear groundfish fisheries in NAFO 4T (Estuary and southern Gulf of St. Lawrence) DFO Can. Sci. Advis. Sec. Res. Doc. 2010/031. iv + 21 p.

Benoit, H. P., Hurlbut, T., Chassé, J. & Jonsen, I. D. (2012). Estimating fishery-scale rates of discard mortality using conditional reasoning. Fisheries Research 125, 318–330.

Benoît, H. P. (2013). Two decades of annual landed and discarded catches of three southern Gulf of St Lawrence skate species estimated under multiple sources of uncertainty. ICES Journal of Marine Science, 70(3), 554-563.

Benoît, H.P., Plante, S., Kroiz, M., Hurlbut, T., (2013). A comparative analysis of marine fish species susceptibilities to discard mortality: effects of environmental factors, individual traits, and phylogeny. ICES J. Mar. Sci. 70, 99–113.

Benoît, H. P., Capizzano, C. W., Knotek, R. J., Rudders, D. B., Sulikowski, J. A., Dean, M. J., ... & Mandelman, J. W. (2015). A generalized model for longitudinal short-and long-term mortality data for commercial fishery discards and recreational fishery catch-and-releases. ICES Journal of Marine Science, 72(6), 1834-1847.

Benoît, H. P., Morfin, M., & Capizzano, C. W. (2020). Improved estimation of discard mortality rates with in situ experiments involving electronic and traditional tagging. Fisheries Research, 221, 105398.

Brattey, J., & Cadigan, N. (2004). Estimation of short-term tagging mortality of adult Atlantic cod (Gadus morhua). Fisheries research, 66(2-3), 223-233.

Broadhurst, M. K., Suuronen, P., & Hulme, A. (2006). Estimating collateral mortality from towed fishing gear. Fish and Fisheries, 7(3), 180-218.

Brooks EJ, Brooks AM, Williams S, Jordan LK and others (2015) First description of deep-water elasmobranch assemblages in the Exuma Sound, The Bahamas. Deep Sea Res II 115: 81−91.

Cabral, H.N., Teixeira, C.M., Gamito, R. et al. Importance of discards of a beam trawl fishery as input of organic matter into nursery areas within the Tagus estuary. Hydrobiologia 475, 449–455 (2002). https://doi.org/10.1023/A:1020359913694

Capizzano, C. W., Mandelman, J. W., Hoffman, W. S., Dean, M. J., Zemeckis, D. R., Benoit, H. P., ... & Langan, J. A. (2016). Estimating and mitigating the discard mortality of Atlantic cod (Gadus morhua) in the Gulf of Maine recreational rod-and-reel fishery. ICES Journal of Marine Science, 73(9), 2342-2355.

Capizzano, Connor & Mandelman, John & Hoffman, William & Dean, Micah & Zemeckis, Douglas & Benoît, Hugues & Kneebone, Jeff & Jones, Emily & Stettner, Marc & Buchan, Nicholas & Langan, Joseph & Sulikowski, James. (2016). Estimating and mitigating the discard mortality of Atlantic cod (Gadus morhua) in the Gulf of Maine recreational rod-and-reel fishery. ICES Journal of Marine Science: Journal du Conseil. 73. fsw058. 10.1093/icesjms/fsw058.

Capizzano, C.W., Zemeckis, D.R., Hoffman, W.S., Benoît, H.P., Jones, E., Dean, M.J., Ribblett, N., Sulikowski, J.A. and Mandelman, J.W. (2019), Fishery-Scale Discard Mortality Rate Estimate for Haddock in the Gulf of Maine Recreational Fishery. North Am J Fish Manage, 39: 964-979. doi:10.1002/nafm.10328Carr, H. A., M. Farrington, J. Harris, and M. Lutcavage. 1995. Juvenile bycatch and codend escapee survival in the Northeast groundfish industry, assessment and mitigation. A report of the New England Aquarium to NOAA pursuant to NOAA Award No. NA36FD0091. 95 pp.

Carr, H. A., M. Farrington, J. Harris, and M. Lutcavage. 1995. Juvenile bycatch and codend escapee survival in the Northeast groundfish industry, assessment and mitigation. A report of the New England Aquarium to NOAA pursuant to NOAA Award No. NA36FD0091. 95 pp.

Catchpole, Serena Wright, Victoria Bendall, Stuart Hetherington, Peter Randall, Elizabeth Ross, Ana Ribiero Santos, Jim Ellis, Jochen Depestele (ILVO), Suzanna Neville (2017). Ray Discard Survival. Enhancing evidence of the discard survival of ray species. Lowestoft: CEFAS.

Catchpole, T.L., Ribero-Santos, A., Mangi, S.C., Hedley, C., Gray, T.S. (2017). The challenges of the landing obligation in the EU fisheries. Marine policy, 82, 76-86.

Cook, K. V., Reid, A. J., Patterson, D. A., Robinson, K. A., Chapman, J. M., Hinch, S. G., & Cooke, S. J. (2019). A synthesis to understand responses to capture stressors among fish discarded from commercial fisheries and options for mitigating their severity. Fish and Fisheries, 20(1), 25-43.

COSEWIC. 2009. COSEWIC Assessment and status report on the darkblotched rockfish Sebastes crameri in Canada. COSEWIC. vii + 48 p.

Couperus, A.S. 1994. Killer whales (Orcinus orca) scavenging on discards of freezer tralwers north east of the Shetland islands. Aquatic Mammals, 20.1: 47-51

Dapp, D.R., Walker, T.I., Huveneers, C., and Reina, R.D. 2016. Respiratory mode and gear type are important determinants of elasmobranch immediate and post-release mortality

Davis M.W. (2002), Key principles for understanding fish by-catch discard mortality. Canadian Journal of Fisheries and Aquatic Sciences 59, 1834–1843.

Davis, M.W. (2010). Fish stress and mortality can be predicted using reflex impairment. Fish and Fisheries 11:1–11. https://doi.org/10.1111/j.1467-2979.2009.00331.x.

Davis M.W., Ryer C.H. (2003), Understanding fish by-catch discard and escapee mortality. AFSC Quartely report, 2003. 9 pp.

De Haan, D., Fosseidengen, J. E., Fjelldal, P. G., Burggraaf, D., & Rijnsdorp, A. D. (2016). Pulse trawl fishing: characteristics of the electrical stimulation and the effect on behaviour and injuries of Atlantic cod (Gadus morhua). ICES Journal of Marine Science, 73(6), 1557-1569.

Depestele, J., Desender, M., Benoˆıt, H. P., Polet, H. & Vincx, M. (2014). Short-term survival of discarded target fish and non-target invertebrate species in the “eurocutter” beam trawl fishery of the southern North Sea. Fisheries Research 154, 82–92.

Ellis, J. R., McCully, S. R., Silva, J. F., Catchpole, T. L., Goldsmith, D., Bendall, V. and Burt, G. 2012. Assessing discard mortality of commercially caught skates (Rajidae) - validation of experimental rusults. DEFRA Report MB5202, 142 pp.

Ellis, J.R., McCully Phillips, S.R., and Poisson, F. 2017. A review of capture and post-release mortality of elasmobranchs 10.1111/jfb.13197. Journal of Fish Biology, 90(3): 653-722.

Enever, R., Catchpole, T. L., Ellis, J. R. & Grant, A. (2009). The survival of skates (Rajidae) caught by demersal trawlers fishing in UK waters. Fisheries Research 97, 72–76.

Evans, S. M., Hunter, J. E., & Wahju, R. I. (1994). Composition and fate of the catch and bycatch in the Farne Deep (North Sea) Nephrops fishery. ICES Journal of Marine Science, 51(2), 155-168.

Gamito, R., & Cabral, H. (2003). Mortality of brown-shrimp discards from the beam trawl fishery in the Tagus estuary, Portugal. Fisheries Research, 63(3), 423-427.

Hannah, R.W., Rankin, P.S., Blume, M.T.O. (2012) Use of a Novel Cage System to Measure Postrecompression Survival of Northeast Pacific Rockfish. Marine and Coastal Fisheries 4, 46-56.

Hill, B. J., & Wassenberg, T. J. (1990). Fate of discards from prawn trawlers in Torres Strait. Marine and Freshwater Research, 41(1), 53-64.

Hill, B. J., & Wassenberg, T. J. (2000). The probable fate of discards from prawn trawlers fishing near coral reefs: A study in the northern Great Barrier Reef, Australia. Fisheries Research, 48(3), 277-286.

Hokenson, S., Ross, M. (1993). Finfish by catch mortality in the Gulf of Maine northern shrimp fishery. NAFO Scientific Council Meeting. NAFO SCR doc 93/124. Serial No. N2318.

Humborstad, O. B., Davis, M. W., & Løkkeborg, S. (2009). Reflex impairment as a measure of vitality and survival potential of Atlantic cod (Gadus morhua). Fishery Bulletin, 107(3), 395-402.

Huse H., Vold A. (2010), Mortality of mackerel (Scomber scombrus L.) after after pursing and slipping from a purse seine. Fisheries Research 106, 54-59.

ICES. (2014). Report of the workshop on methods for estimating discard survival (WKMEDS) (ICES CM 2014/ACOM:51, p. 114). 17–21 February 2014, ICES HQ, Copenhagen, Denmark.

ICES. (2015). Report of the Workshop on Methods for Estimating Discard Survival 3 (WKMEDS 3), 20-24 April 2015, London, UK. ICES CM 2015\ACOM:39. 47 pp.

Ingolfsson, O. A., A. V. Soldal, I. Huse, and M. Breen. In Press. Escape mortality of cod, saithe, and haddock in a Barents Sea trawl fishery. ICES J. Mar. Sci.

Jarvis, E. T., & Lowe, C. G. (2008). The effects of barotrauma on the catch-and-release survival of southern California nearshore and shelf rockfish (Scorpaenidae, Sebastes spp.). Canadian Journal of Fisheries and Aquatic Sciences, 65(7), 1286-1296.

Jean, Yves. (2011). Discards of Fish at Sea by Northern New Brunswick Draggers. Journal of the Fisheries Research Board of Canada. 20. 497-524. 10.1139/f63-038.

Kaiser, M. J. & Spencer, B. E. (1995). Survival of by-catch from a beam trawl. Marine Ecology Progress Series 126, 31–38.

Kelle, V.W. (1976), Sterblichkeit untermasziger Plattfische im Beifang der Garnelenfischerei. Meeresforschung, 25: 77–89.

Knotek, R. J., Gill, S. M., Rudders, D. B., Mandelman, J. W., Benoît, H. P., & Sulikowski, J. A. (2015). The development of a low cost refrigerated flow-through seawater system for at-sea estimation of post-release mortality. Fisheries Research, 170, 152-157.

Knotek, Ryan J., David B. Rudders, John W. Mandelman, Hugues P. Benoît, James A. Sulikowski, (2018) The survival of rajids discarded in the New England scallop dredge fisheries, Fisheries Research, Volume 198, 2018, Pages 50-62.

Kraak, S.B.M, Velasco, A., Fröse, U., Krumme, U. 2019. Prediction of delayed mortality using vitality scores and reflexes, as well as catch, processing, and post-release conditions: evidence from discarded flatfish in the Western Baltic trawl fishery, ICES Journal of Marine Science, 76(1): 330–341,

Lancaster, J., & Frid, C. L. (2002). The fate of discarded juvenile brown shrimps (Crangon crangon) in the Solway Firth UK fishery. Fisheries Research, 58(1), 95-107.

Large, P.A., Hammer, C. and Bergstad, O.A. (2003), Deep-water Fisheries of the Northeast Atlantic: II Assessment and Management Approaches. Journal of Northwest Atlantic Fishery Science, 31: 151-163.

Lockwood S.J., Pawson M.G., Eaton D.R. (1983), The effects of crowding on mackerel (Scomber scombrus, L.): Physical condition and mortality. Fisheries Research 2:129-147.

Macbeth, W. G., Broadhurst, M. K., Paterson, B. D., & Wooden, M. E. (2006). Reducing the short-term mortality of juvenile school prawns (Metapenaeus macleayi) discarded during trawling. ICES Journal of Marine Science, 63(5), 831-839.

Mandelman, J. W., Cicia, A. M., Ingram, G. W. Jr., Driggers, W. B. III, Coutre, K. M. & Sulikowski, J. A. (2012). Short-term post-release mortality of skates (family Rajidae) discarded in a western North Atlantic commercial otter trawl fishery. Fisheries Research 139, 76–84.

Marçalo, A., Pousão-Ferreira, P., Mateus, L., Duarte Correia, J. H., & Stratoudakis, Y. (2008). Sardine early survival, physical condition and stress after introduction to captivity. Journal of Fish Biology, 72(1), 103-120.

Milliken, H. O., Carr, H. A., Farrington, M., & Lent, E. (1999). Survival of Atlantic cod (Gadus morhua) in the Northwest Atlantic longline fishery. Marine Technology Society Journal, 33(2), 19-24.

Morfin, M., Kopp, D., Benoît, H.P., Méhault, S., Randall, P., Foster, R., et al. (2017). Survival of European plaice discarded from coastal otter trawl fisheries in the English Channel. Journal of Environmental Management, 204(1), 404–412. https://doi.org/10.1016/j.jenvman.2017.08.046.

Oliver, M., & McHugh, M. (2018). Draft report: plaice survivability in the Irish otter trawl fishery targeting fish species. BIM.

Olsen, R. E., Oppedal, F., Tenningen, M., & Vold, A. (2012). Physiological response and mortality caused by scale loss in Atlantic herring. Fisheries Research, 129, 21-27.

Palmer MC, Hawkins AE, Traver M, Brooks EN. 2011. A review of factors affecting the survival of Gulf of Maine Atlantic cod (Gadus morhua) discarded at-sea. SAW 53 Gulf of Maine cod data meeting working paper 1.

Pálsson, Ó. K., Einarsson, H. A., & Björnsson, H. (2003). Survival experiments of undersized cod in a hand-line fishery at Iceland. Fisheries Research, 61(1-3), 73-86.

Powles, P. (1969). Size Changes, Mortality, and Equilibrium Yields in an Exploited Stock of American Plaice (Hippoglossoides platessoides). Journal of the Fisheries Research Board of Canada. 26. 1205-1235. 10.1139/f69-109.

Raby, G. D., Packer, J. R., Danylchuk, A. J., & Cooke, S. J. (2014). The understudied and underappreciated role of predation in the mortality of fish released from fishing gears. Fish and Fisheries, 15(3), 489-505.

Revill, A., 2012. Survival of discarded fish. A rapid review of studies on discard survival rates. DG MARE A2. Request For Services Commitment No. S12.615631

Rihan D., Uhlmann S.S., Ulrich C., Breen M., Catchpole T. (2019) Requirements for Documentation, Data Collection and Scientific Evaluations. In: Uhlmann S., Ulrich C., Kennelly S. (eds) The European Landing Obligation. Springer, Cham: https://doi.org/10.1007/978-3-030-03308-8_3

Robinson, W.E., and H.A. Carr, H.A. 1993. Assessment of juvenile bycatch survivability in the Northeast fishing industry. A Report of the New England Aquarium to NOAA. NOAA award No. NA16FL0068, 42 p.

Ross, Michael & Hokenson, Steven. (1997). Short-Term Mortality of Discarded Finfish Bycatch in the Gulf of Maine Fishery for Northern Shrimp Pandalus borealis. North American Journal of Fisheries Management - NORTH AM J FISH MANAGE. 17. 902-909. 10.1577/1548-8675(1997)017<0902:STMODF>2.3.CO;2.

Rudolph, T., J. Pappalardo, M. Sanderson, H. Milliken and M. Farrington. 2006. Survival of sub-legal Atlantic cod in the Northwest Atlantic longline fishery. NEC Grant 04-827, 30 pp.

Rummer, J.L., and Bennett, W.A. 2005. Physiological effects of swim bladder overexpansion and catastrophic decompression on red snapper. Trans. Amer. Fish. Soc. 134(6): 1457-1470.

Ryer, C. H. (2004). Laboratory evidence for behavioural impairment of fish escaping trawls: a review. ICES Journal of Marine Science, 61(7), 1157-1164.

Sangster GI, Lehmann K, Breen M. 1996. Commercial fishing experiments to assess the survival of haddock and whiting after escape from four sizes of diamond mesh cod-ends. Fisheries Research 25 (1996) 323-345.

Scientific, Technical and Economic Committee for Fisheries (STECF) – 46th Plenary Meeting Report (PLEN-14-02). (2014). Publications Office of the European Union, Luxembourg, EUR 26810 EN, JRC 91540, (p. 117).

Scientific, Technical and Economic Committee for Fisheries (STECF) – Landing Obligation – Part 5 (demersal species for NWW, SWW and North Sea) (STECF-15-10). (2015). Publications Office of the European Union, Luxembourg, EUR 27407 EN, JRC 96949, (p. 62).

Scientific, Technical and Economic Committee for Fisheries (STECF) – Evaluation of the landing obligation joint recommendations (STECF-16-10). (2016). Publications Office of the European Union, Luxembourg; EUR 27758 EN; https://doi.org/10.2788/59074.

Scientific, Technical and Economic Committee for Fisheries (STECF) – Long-term management of skates and rays (STECF-17-21). Publications Office of the European Union, Luxembourg, 2017, ISBN 978-92-79-67493-8, doi:10.2760/44133, JRC109366

Skomal GB, Mandelman JW (2012) The physiological response to anthropogenic stressors in marine elasmobranch fishes: a review with a focus on the secondary response. Comp Biochem Physiol A Mol Integr Physiol 162: 146–155

Soldal, A.V., A. Engås, and B. Isaksen. 1993. Survival of gadoids that escape from a demersal trawl. ICES Mar. Sci. Symp. 196: 62-67.

Starr, R.M., Heine, J.N., Felton, J.M, and Cailliet, G.M. 2002. Movements of bocaccio (Sebastes paucispinis) and greenspotted (S. chlorostictus) rockfishes in a Monterey submarine canyon: Implications for the design of marine reserves. Fish. Bull. 100: 324-337.

Stoner, A. W. (2012). Evaluating vitality and predicting mortality in spot prawn, Pandalus platyceros, using reflex behaviors. Fisheries Research, 119, 108-114.

Sulikowski, J. A., Benoît, H. P., Capizzano, C. W., Knotek, R. J., Mandelman, J. W., Platz, T., & Rudders, D. B. (2018). Evaluating the condition and discard mortality of winter skate, Leucoraja ocellata, following capture and handling in the Atlantic monkfish (Lophius americanus) sink gillnet fishery. Fisheries Research, 198, 159-164.

Suuronen, P. 2005. Mortality of fish escaping trawl gears. FAO Tech. Pap. Rome, FAO. 72. p.

Suuronen, P., Erickson, D.L., and Orrensalo, A. 1996a. Mortality of herring escaping from pelagic trawl codends. Fish. Res. 25: 305–321.

Suuronen, P., Perez-Comas, J.A., Lehtonen, E., and Tschernij, V. 1996c. Size-related mortality of herring (Clupea harengus L.) escaping through a rigid sorting grid and trawl codend meshes. ICES J. Mar. Sci. 53: 691–700.

Tenningen, M., Vold, A., & Olsen, R. E. (2012). The response of herring to high crowding densities in purse-seines: survival and stress reaction. ICES Journal of Marine Science, 69(8), 1523-1531.

Tom Catchpole, Serena Wright, Victoria Bendall, Stuart Hetherington, Peter Randall, Elizabeth Ross, Ana Ribiero Santos, Jim Ellis, Jochen Depestele (ILVO), Suzanna Neville (2017). Ray Discard Survival. Enhancing evidence of the discard survival of ray species. Lowestoft: CEFAS.

Uhlmann, S., Ampe, B., van Bogaert, N., Vanderperren, E., Torreele, E., and Polet, H. 2018. Survival of plaice caught and discarded by Belgian beam trawlers. Confidential internal nota requested by ir. Marc Welvaert. Flanders Research Institute for Agriculture, Fisheries and Food (ILVO), Oostende, Belgium. pp22.

Van Beek, F., Van Leeuwen, P. , Rijnsdorp, A.D. (1990), On the survival of plaice and sole discards in the otter-trawl and beam-trawl fisheries in the North Sea.Netherlands Journal of Sea Research 26(1): 151-160.

Van Beek, F.A., P.I. Van Leeuwen, and A.D. Rijnsdorp. 1990. On the survival of plaice and sole discards in the otter-trawl and beam-trawl fisheries in the North Sea. Nether. J. Sea Res., 26:151-160.

Votier, S., Furness, R., Bearhop, S. et al. Changes in fisheries discard rates and seabird communities. Nature 427, 727–730 (2004).

Wassenberg, T. J., & Hill, B. J. (1989). The effect of trawling and subsequent handling on the survival rates of the by-catch of prawn trawlers in Moreton Bay, Australia. Fisheries Research, 7(1-2), 99-110.

Wassenberg, T.J. & and Hill, B.J. 1993. Selection of the appropriate duration of experiments to measure the survival of animals discarded from trawlers. Fish. Res. 14:343-352

Wassenberg, T.J. & Hill, B.J. 1989. The effect of trawling and subsequent handling on the survival rates of the bycatch of prawn trawlers in Moreton Bay, Australia. Fisheries Research, 7:99-110.

Wilson, S. M., Raby, G. D., Burnett, N. J., Hinch, S. G., & Cooke, S. J. (2014). Looking beyond the mortality of bycatch: sublethal effects of incidental capture on marine animals. Biological Conservation, 171, 61-72.

Yergey, M. E., Grothues, T. M., Able, K. W., Crawford, C., & DeCristofer, K. (2012). Evaluating discard mortality of summer flounder (Paralichthys dentatus) in I33the commercial trawl fishery: developing acoustic telemetry techniques. Fisheries Research, 115, 72-81.I28

iii) Identify areas and times where bycatch and discards of Greenland sharks have a higher rate of occurrence (COM request #9)

This request was deferred until June 2021

iv) Develop a 3-5 year work plan (COM request #10)

Due to time limitations, this was only discussed briefly in the meeting. Progress on this will continue in 2021.

v) Review submitted protocols for a survey methodology to inform the assessment of splendid alfonsino (COM request #13)

The SC notes that in relation to Commission request 13 on protocols for a survey methodology to inform the assessment of Splendid Alfonsino, an SCR (SCR 20/36) has been presented with a sampling plan for an acoustic survey of Kükenthal Peak (NAFO Division 6G) to quantify alfonsino (*Beryx splendens*) biomass, abundance and size composition. Due to the current COVID situation, the SCR has not been reviewed by the SC at its June or September 2020 meetings and it is postponed to the next meeting in June 2021. The SCR is available for review by SC members, who are requested to send comments and suggestions to the authors before March 2021.

vi) Presentation of the stock assessment and the scientific advice of Cod 2J3KL (Canada), Witch 2J3KL (Canada) and Pelagic Sebastes mentella (ICES Divisions V, XII and XIV; NAFO 1) (COM request #14)

Presentation of the stock assessment and the scientific advice of Cod 2J3KL (Canada), Witch 2J3KL (Canada) and Pelagic Sebastes mentella (ICES Divisions V, XII and XIV; NAFO 1) (COM request #14)

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

Scientific council responded:

Cod in Divisions 2J3KL

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

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

The 2019 stock assessment reported that the Northern cod spawning stock biomass (SSB) remained at 48% (95% CI = 37-63%) of the Limit Reference Point, in the Critical Zone of DFO's PA framework (DFO 2009; DFO 2019b) (Figure 1.2). SSB was 398 Kt in 2019 (95% CI = 306-518 Kt).

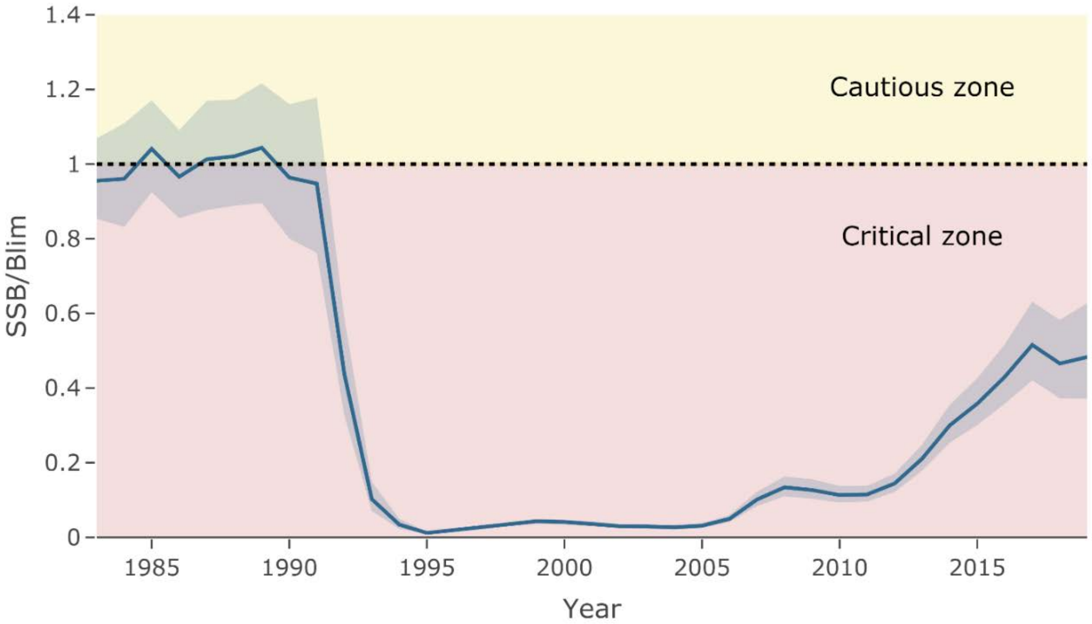


Figure 1.1. SSB/B_{lim} for Northern cod from NCAM (1983-2019) from the 2019 assessment.

The advice from this assessment stated: “Consistency with the DFO decision-making framework incorporating the precautionary approach requires that removals from all sources must be kept at the lowest possible level until the stock clears the critical zone”. Projections carried out at that time with six catch scenarios ranging from zero to 1.3 times the model estimated catch for 2018 (13,796 t) indicated that the probability that SSB would reach the LRP by 2022 ranged between 6-9%.

In 2020, the global COVID-19 pandemic disrupted the full stock assessment scheduled for March 24-27 (DFO 2020 draft). Instead, a stock update was conducted remotely in lieu of a full assessment. The assessment model (NCAM) and associated projections were not run as part of this stock update.

Ecosystem conditions in the Newfoundland Shelf and Northern Grand Bank (NAFO Divs. 2J3KL) are indicative of limited productivity of the fish community. Total RV ecosystem biomass level remains much lower than prior to the ecosystem collapse in the early-1990s.

Recent declines in average cod stomach content weights as well as reductions in capelin and shrimp in the diet, coupled with an apparent relative increase in cannibalism, point to a limitation in food availability. With capelin forecasted to decline in 2020, cod productivity will likely be negatively impacted.

Annual average removals from the commercial (stewardship) fishery were 11,000 t over 2016-2019 (Figure 1.1) and removals from recreational catches were 1900 t (estimated from tagging data) over the same time period.

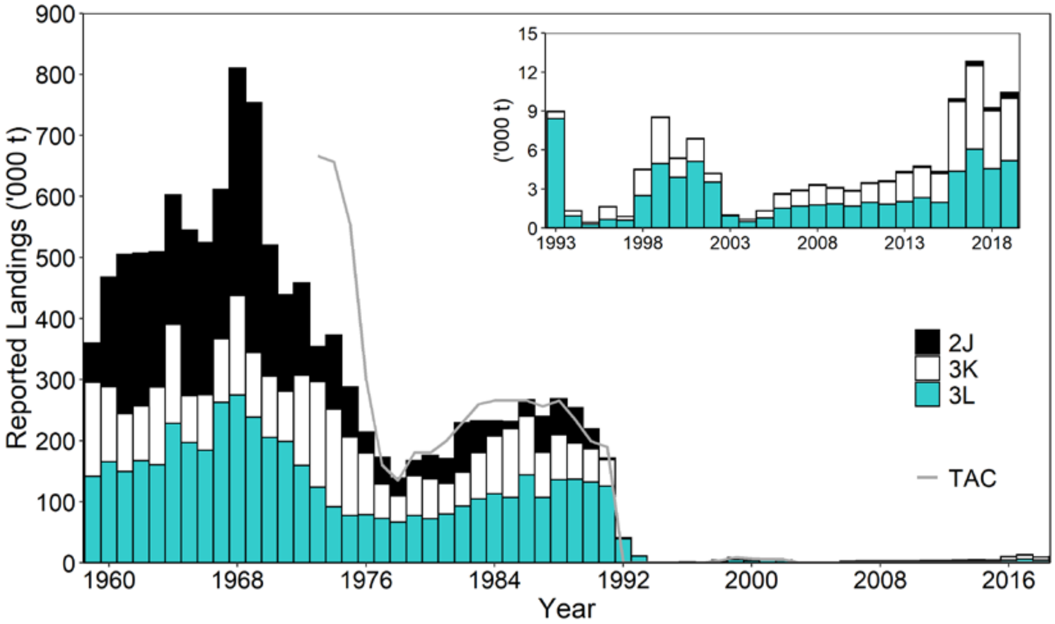


Figure 1.2. Landings (bars) and TAC (lines) for Atlantic Cod in Div. 2J3KL by Division from 1959 to 2019 (and inset plot show 1993-2019).

The fall 2019 observed RV cod survey biomass falls in the range of expected values based on projected values from NCAM from the March 2019 assessment (Figure 1.4).

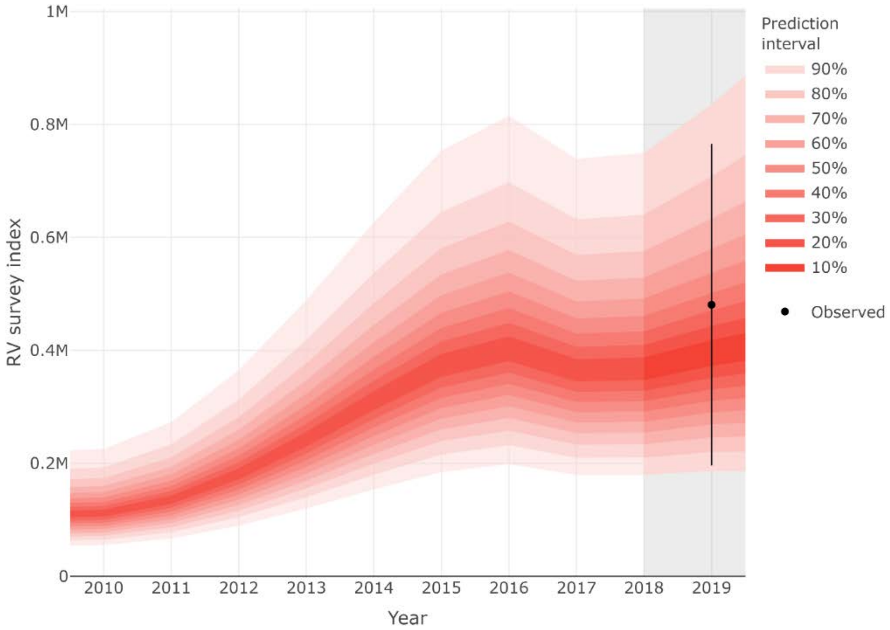


Figure 1.3. NCAM projected RV survey indices with prediction intervals (red envelope) from the 2019 stock assessment with observed RV biomass (black circles with 95% Confidence Intervals).

However, RV cod survey biomass indices increased between 2011-2016 and have subsequently leveled off, remaining low relative to the 1980s. Sentinel cod survey index increased from the early-2000s to 2014 but has since decreased.

Under current ecosystem conditions and recent levels of catch, the lack of increase in cod survey indices since 2016 suggests that stock growth may have stalled.

The 2020 stock update was consistent with the advice from the 2019 assessment; removals from all sources must be kept at the lowest possible levels.

SC comments

Scientific Council **endorsed** the conclusions of both the assessment results and advice. SC asked for some clarification on the objectives and management measures from the stewardship fishery, given that catches are occurring.

References

Cadigan, N. G. 2016. A state-space stock assessment model for Northern cod, including under-reported catches and variable natural mortality rates. Can. J. Fish. Aquat. Sci. 73(2): 296-308.

Cadigan, N. 2016. Updates to a Northern cod (*Gadus morhua*) state-space integration assessment model. DFO Can. Sci. Advis. Sec. Res. Doc. 2016/022. v + 58p.

DFO. 2009. A fishery decision-making framework incorporating the Precautionary Approach.

DFO. 2010. Proceedings of the Newfoundland and Labrador Regional Atlantic Cod Framework Meeting: Reference Points and Projection Methods for Newfoundland cod stocks; November 22-26, 2010. DFO Can. Sci. Advis. Sec. Proceed. Ser. 2010/053.

DFO. 2019a. Evaluation of the Limit Reference Point for Northern cod (NAFO Divisions 2J3KL). DFO Can. Sci. Advis. Sec. Sci. Advis. Rep. 2019/058.

DFO. 2019b. Stock assessment of Northern (2J3KL) cod in 2019. DFO Can. Sci. Advis. Sec. Sci. Advis. Rep. 2019/050.

DFO 2020. DRAFT 2020 Stock status update for Northern cod. DFO Can. Sci. Advis. Sec. Sci. Res. Rep. 2020/xx

Witch flounder in Divisions 2J3KL

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

The last assessment of witch flounder in NAFO Divs. 2J3KL was completed by Fisheries and Oceans Canada (DFO) in May, 2018 (DFO 2019, Wheeland et al. 2019). This stock has been under moratorium in Canadian waters since 1995, and in the NAFO regulatory area since 1998. Bycatch of witch flounder averaged 106 t annually from 2015-19 (Figure 1.4), and is primarily taken in the Canadian Greenland halibut fishery.

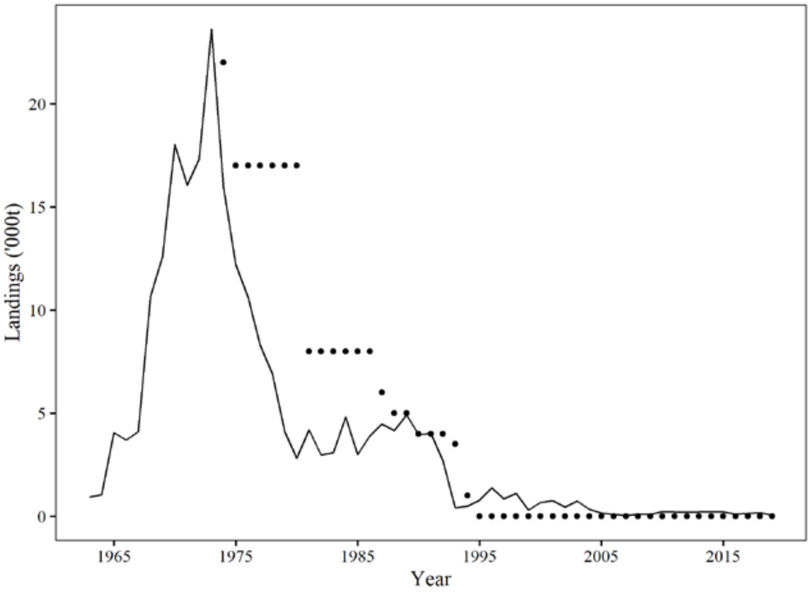


Figure 1.4. Landings (1963-2019, line) and TAC (points) for witch flounder in Div. 2J3KL.

The assessment of this stock is based on indices from Canadian-autumn RV surveys of NAFO Div. 2J3KL, and commercial catch (by-catch) data. A biomass Limit Reference Point (LRP) within the Canadian PA framework is set at B_{LIM} = 0.4 B_{MSY}-proxy, where the B_{MSY}-proxy is the average survey biomass of years 1983-1984 (DFO 2019). In 2016 and 2017, indices of biomass (Figure 1.5) and abundance reached the highest levels since 1990, but remained below the levels of the mid-1980s. Abundance of fish <23cm indicates improved recruitment since 2013 (Figure 1.6). B_{2017} was below the LRP, and the stock is in the Critical Zone of the Canadian Precautionary Approach framework. Consistency with the DFO decision-making framework incorporating the precautionary approach requires that removals from all sources must be kept at the lowest possible level until the stock clears the critical zone.

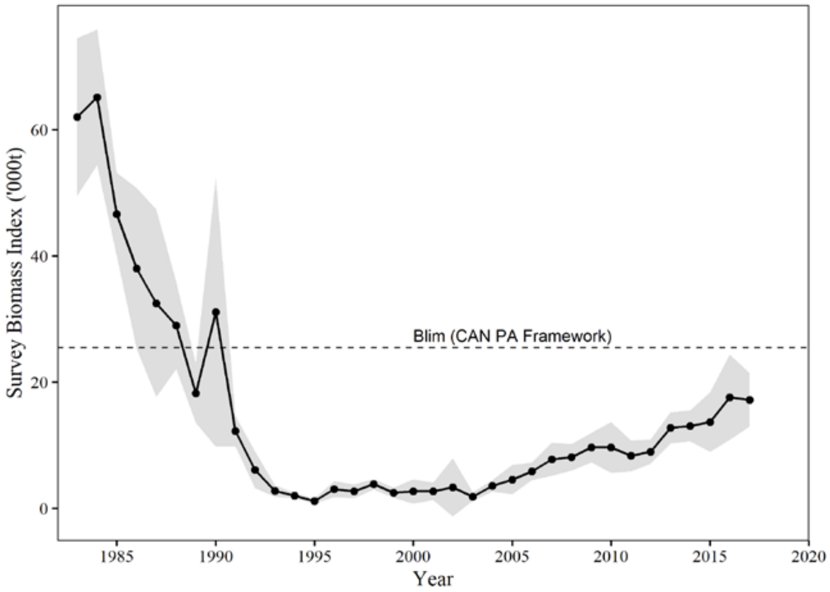


Figure 1.5. Survey biomass for witch flounder in Div. 2J3KL (1983-2017), shaded area represents the 95% CI. Horizontal line indicates B_{LIM} (40% B_{MSY}-proxy) under the Canadian PA framework.

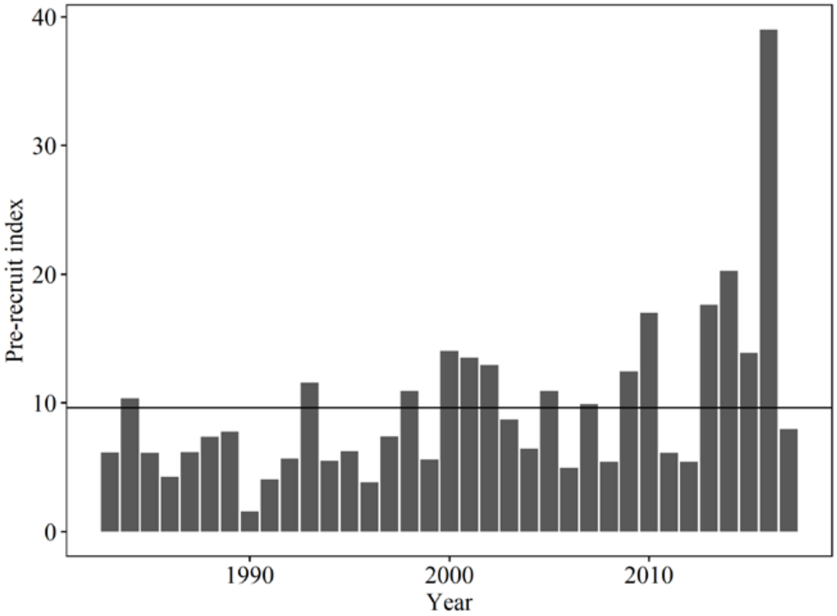


Figure 1.6. Pre-recruit index (abundance <23cm) for witch flounder in NAFO Div. 2J3KL (1983 to 2017). Horizontal line indicates the time series mean.

A full assessment by Canada-DFO of this stock is planned for early 2022. In years between full assessments survey biomass trajectory is monitored (see DFO 2019 for details on the agreed procedure) to determine if there is a need for an assessment. Survey indices from 2018 and 2019 have not been fully peer reviewed at this time, but an assessment has not been triggered.

SC comments

Scientific Council **endorsed** the conclusions of both the assessment results and advice. Scientific Council **noted** that a Limit Reference Point is also defined under the NAFO PA framework based on the B_{MSY}-proxy at the average survey biomass of years 1983-1984 (SCR Doc. 18-050 , NAFO SCS 18-19). However, under the NAFO framework B_{LIM} is set at 0.3 B_{MSY}-proxy. As of 2018 (the time of the last interim monitoring report from NAFO SC and the last Canada-DFO assessment) the stock remained below the LRP under both frameworks, and advice indicated no directed fishing for this stock.

References

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

Pelagic Sebastes mentella in ICES Divisions V, XII and XIV and NAFO Subarea 1

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

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

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

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

The last ICES assessment of the two stocks ("Shallow Pelagic" and "Deep Pelagic" stocks) was in 2019. The stock relevant to NAFO is the shallower stock since is the one that extents more to the NAFO areas, catches of the Deep Pelagic stock are scarce or null in NAFO areas (Figure 1.7).

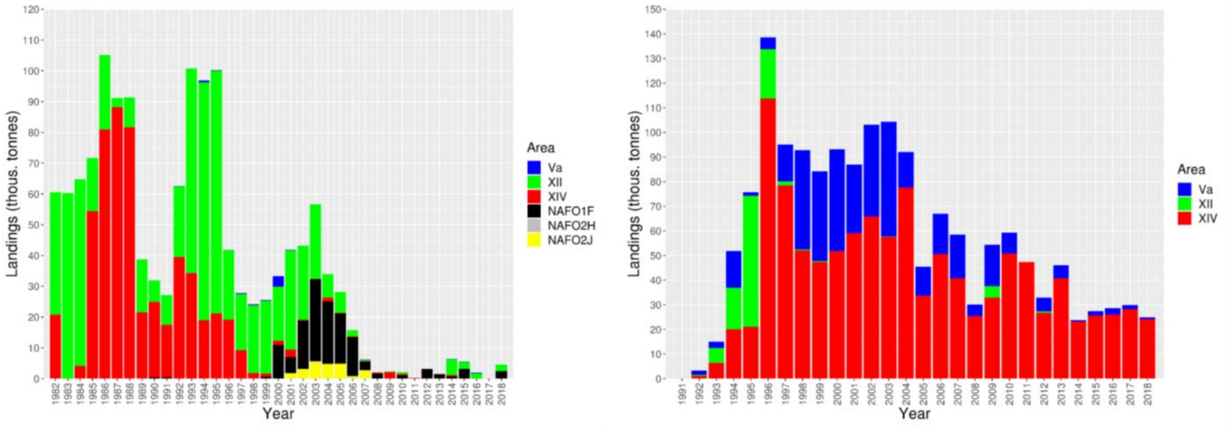


Figure 1.7. Catches of shallow pelagic stock (left panel) and deep pelagic stock (right panel) by area.

Acoustic surveys are conducted on pelagic redfish in the Irminger Sea and adjacent waters. An international trawl-acoustic survey (conducted by Iceland, Germany and Russia with Norway participating also in 2001) was carried out biennially 1999 – 2015 and then in 2018. The next survey is planned for 2021.

"Shallow pelagic" Stock Assessment

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

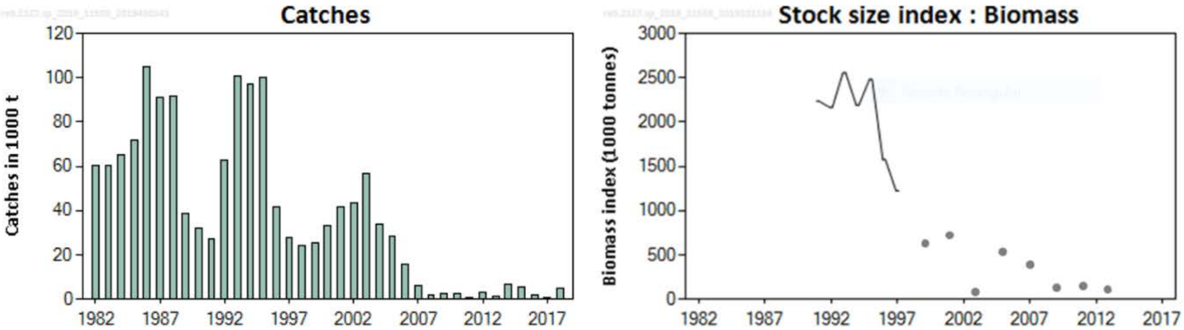


Figure 1.8. Beaked redfish in ICES subareas 5, 12, and 14 and in NAFO subareas 1 and 2 (shallow pelagic stock < 500 m). Left: Catch over time in thousand tonnes. Right: Stock size index (biomass) from the acoustic survey (in tonnes) in the Irminger Sea and adjacent waters. The line represents yearly values from 1991 to 1997 and points represent the international trawl-acoustic survey since 1999 (insufficient survey coverage after 2013).

The last available biomass index from the acoustic survey in 2013 indicates that the stock has declined to less than 5% of the estimates at the beginning of the survey time-series in the early 1990s (Figure 1.8). The exploitation rate for this stock is unknown.

ICES has advised that when the precautionary approach is applied, there should be zero catch in each of the years 2020 and 2021.

“Deep pelagic” Stock Assessment

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

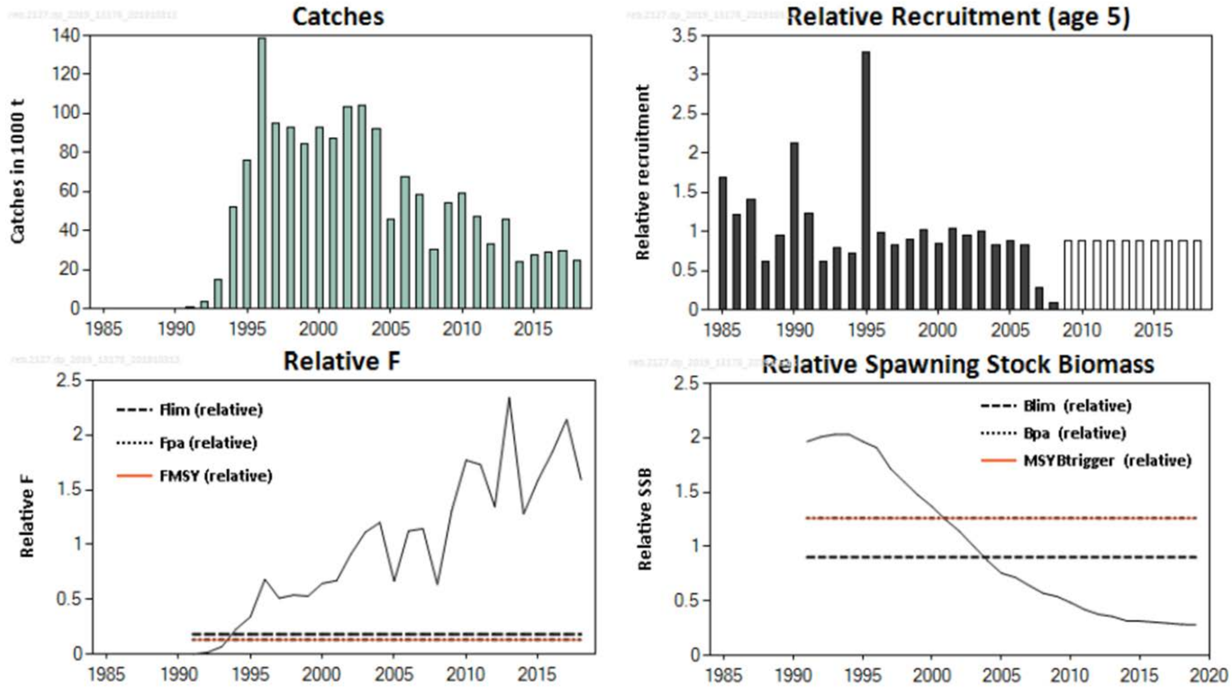


Figure 1.9. Beaked redfish in ICES subareas 5, 12, and 14 and in NAFO subareas 1 and 2 (deep pelagic stock > 500 m). Top left: Catches (thousand tonnes). Top right: Relative recruitment (R) at age 5. Relative recruitment (R) since 2009 is assumed to be at the geometric mean of 1985–2008. Bottom left: Relative fishing mortality (F). Bottom right: Relative spawning-stock biomass (SSB). R, F, and SSB are expressed relative to the average of the time-series (1985–2018 for R, 1991–2018 for F, and 1991–2019 for SSB).

The spawning-stock biomass (SSB) has been declining since the mid-1990s and has been below B_{lim} since 2005. The fishing mortality (F) shows an increasing trend since the beginning of the fishery in 1991. The F has been above F_{MSY} since 1994 and above F_{lim} since 1995. Recruitment (R) estimates were stable between 1996 and 2006. Recruitment estimates in 2007 and 2008 were low.

ICES has advised that when the MSY approach is applied, there should be zero catch in each of the years 2020 and 2021.

ICES comments relating to both “shallow” and “deep” pelagic stocks

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

In recent years ICES has not obtained catch estimates disaggregated by depth from all countries (ICES, 2019). ICES **recommends** that all countries should report depth information on a haul basis, in accordance with the NEAFC logbook format. Action is needed through NEAFC and NAFO to provide ICES with timely and complete information that may lead to more reliable catch statistics.

SC Comments

Scientific Council **endorsed** the conclusions of both the ICES assessment results and its advice. NAFO SC will work with the Secretariat to clarify the comment about catch information made by ICES in relation to NAFO.

References and source of information

ICES 2019: ICES. 2019. North Western Working Group (NWWG). ICES Scientific Reports. 1:14. 830 pp. http://doi.org/10.17895/ices.pub.5298.

ICES 2020: ICES. 2020. North Western Working Group (NWWG). Draft Report. ICES Scientific Reports. 2:51. 431 pp. http://doi.org/10.17895/ices.pub.6051.

ICES Advice 2019 – reb.2127.dp – https://doi.org/10.17895/ices.advice.5606.

ICES Advice 2019 – reb.2127.sp – https://doi.org/10.17895/ices.advice.5607.

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

vii) Updates on the potential impact of activities other than fishing (COM request #16)

Continue to monitor and provide updates resulting from relevant research related to the potential impact of activities other than fishing in the Convention Area (for example via EU ATLAS project), and where possible to consider these results in the on-going modular approach concerning the development of Ecosystem Summary Sheets".

Scientific Council Responded:

SC conducted a preliminary assessment of seabed litter recovered from EU-Spain groundfish survey trawls in Division 3L. Results indicate a generally low occurrence and density of seabed litter with only 8.3% of the total hauls having seabed litter present, however, 62% of the seabed litter sampled were identified as being associated with both NAFO managed and non-managed fishing activities. To facilitate the on-going monitoring and assessment of seabed litter in the NAFO area, SC recommends to the Commission that standardized protocols for seabed marine litter data collection should be implemented by all Contracting Parties as part of their groundfish surveys.

SC reiterates its prior advice that there are a number of activities occurring in the NAFO Area (especially oil and gas activities) which have the potential to impact fisheries resources and the ecosystem, and that current expertise within SC WG-ESA in particular, and SC in general, is insufficient to fully assess the long term, cumulative impacts of these activities on the wider marine ecosystem and specifically VMEs.

SC notes that while there is an apparent significant spatial conflict between oil and gas exploration and proposed production activities, fisheries and VME in the Flemish Pass area, activities other than fishing occurring in the NRA are not formally, nor regularly reported to SC.

Furthermore, SC notes that in terms of trends of oil and gas activities, it is expected (based on current exploration leases and development projections) that oil and gas exploration activities are forecast to increase in the NRA until at least 2030.

Results from studies presented here, based on the EU ATLAS project and publicly available information, have been included where appropriate into the current 3LNO Ecosystem Summary Sheet (ESS), noting that periodic up-dates in the ESS of these activities is dependent on the significant commitment from Contracting

Parties (CPs) to provide the necessary expertise to evaluate the potential conflict between activities and the potential consequences or impacts of incidents associated with oil and gas activities.

Seabed litter in NAFO Division 3L

To assess the potential extent and magnitude of seabed litter in the NAFO Regulatory Area, SC reviewed the results of a pilot study conducted under the EU ATLAS project which analyzed an extensive database based on EU-Spain groundfish surveys in Division 3L (García-Alegre *et al.,* 2020). A total of 1,169 trawls were analyzed for the 2006-2017 period, ranging from 104 m to 1478 m depth. Litter items retained in the bottom trawl hauls were examined and recorded using a standardized litter monitoring protocol. Results indicate a generally low occurrence and density of seabed litter with only 8.3% of the total hauls having litter present with mean densities of 1.4 ± 0.4 items/km^2 and an average weight of 10.6 ± 5.2 kg/km^2. The highest densities of seabed litter were found in the deepest areas located in the Flemish Pass channel and down the northeastern flank of the Grand Bank. Fisheries were the principal source of seabed litter; 61.9 % of the hauls with litter present were fishery related (Fig. 1). In most cases litter consisted of small fragments of rope but in some, litter consisted of entire traps or nets. Plastics, metal, and other anthropogenic litter were the next most abundant categories. **SC recommends** to the Commission that *standardized protocols for seabed litter data collection should be implemented by all Contracting Parties as part of their groundfish surveys conducted in NAFO Regulatory Area. Implementation of such protocols would allow the regular monitoring and assessment of the spatial and temporal distribution of seabed litter.*

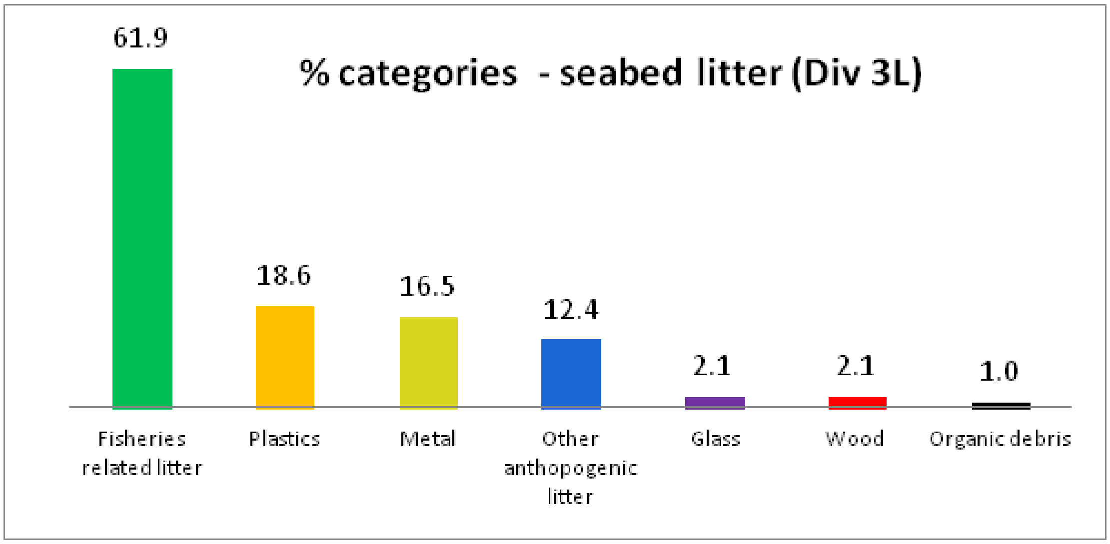


Figure 1.10. Percentage of the occurrence of the different litter categories by trawls with litter presence.

ATLAS Project: updates on potential impact of activities other than fishing - oil and gas

ATLAS (www.eu-atlas.org) is a multidisciplinary international project funded by the EU Horizon 2020 program. ATLAS is testing a generic Marine Spatial Planning (MSP) framework developed by the EU FP7 MESMA project to assess theoretical spatially managed areas (SMAs) in all 12 of the ATLAS Case Studies, one of which is the Flemish Cap/Flemish Pass within the NRA. Studies have shown the impacts of fishing on VMEs (NAFO 2016), while oil and gas can have detrimental environmental effects during each of the main phases of exploration, production, and decommissioning (Cordes et al., 2016), but the impact has not been assessed within the NRA.

The present MSP exercise (Durán Muñoz *et al.,* 2020) pays special attention to the apparent significant spatial overlap between oil and gas exploration and proposed production activities, fisheries and VME in the Flemish Pass area, as well as to the potential conflicts between users of the marine space (e.g. reduction of fishing opportunities) and between users and the environment (Fig. 2). This map reveals the overlap (and potential conflicts) between different regulatory and jurisdictional frameworks (e.g. areas closed to bottom fishing are currently open to oil and gas exploration and production).

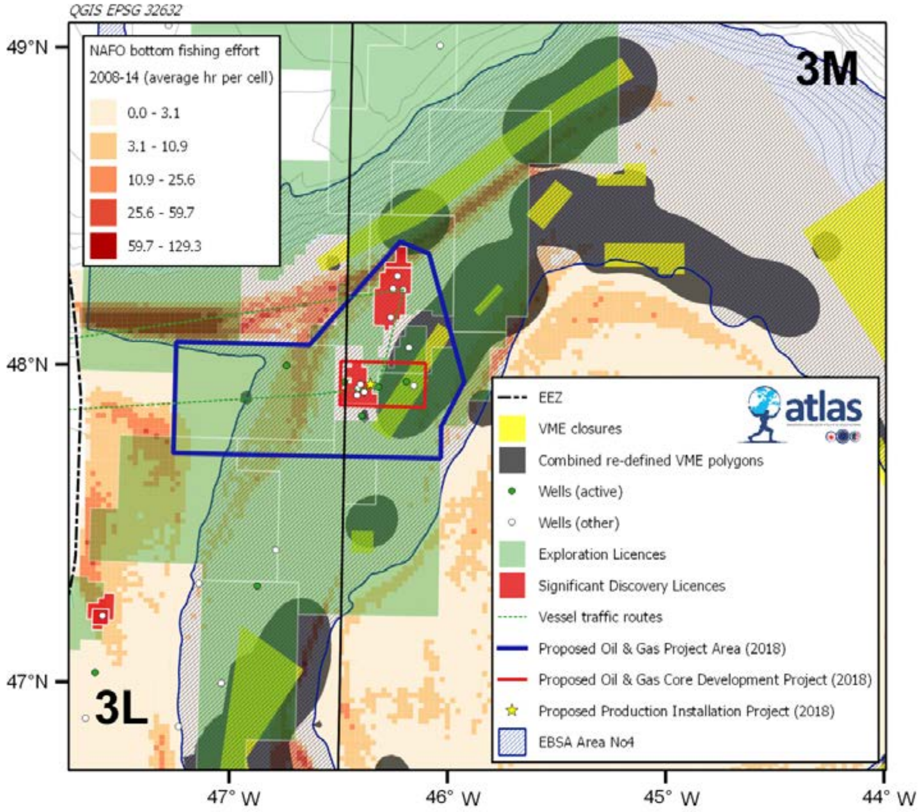


Figure 1.11. Map of the Flemish Cap-Flemish Pass area (Div. 3LM) showing the potential conflicts between different users of the marine space (e.g. oil and gas vs. fisheries) and between users and environment (oil and gas vs. VMEs). The yellow star indicates the location of the proposed production installation within the Bay du Nord Development Project (outlined in blue). Sources (2018): NAFO, C-NLOPB and CBD.

Synthesis of offshore petroleum activities in 3KLMN

Offshore petroleum activities have been occurring in NAFO divisions 3KLMN for decades. The first drilling activities began in the 1960s, reservoirs were discovered in the 1970s and by 1997 the first oil producing platform (Hibernia) began operation. Today the most intense offshore activity is concentrated in 3L with four petroleum producing platforms assembled in the Jeanne d'Arc basin area. 3KMN is currently subject to exploration activity only, except for the relatively recent significant development licenses located in the Bay du Nord area in 3M (Fig. 3).

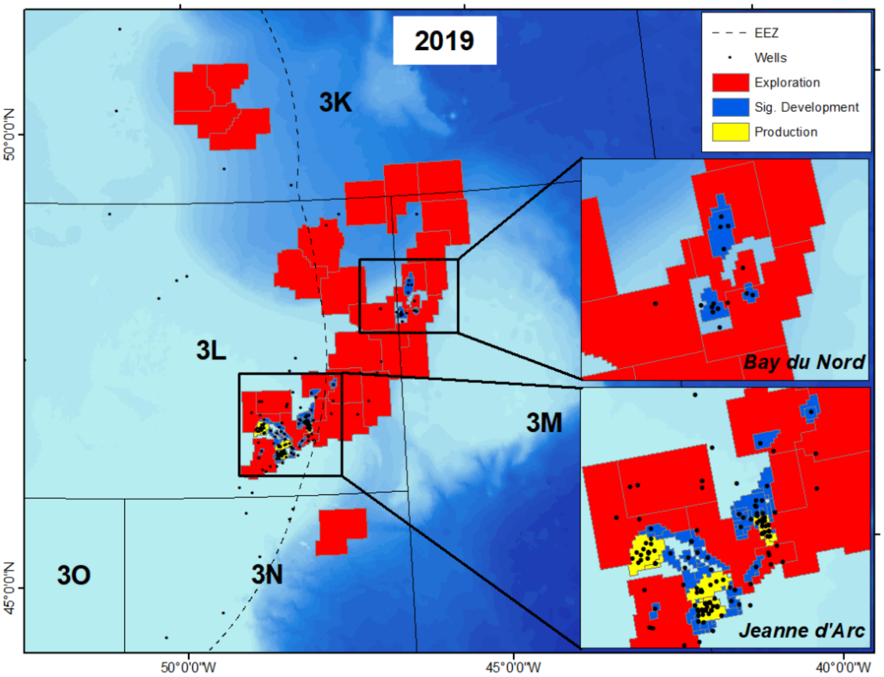


Figure 1.12. Offshore licenses and wells in 3KLMN (2019)

The number of wells and licensed areas over time in 3KLMN is shown in Fig. 4 using data obtained from the Canada-Newfoundland Labrador Offshore Petroleum Board (C -NLOPB).

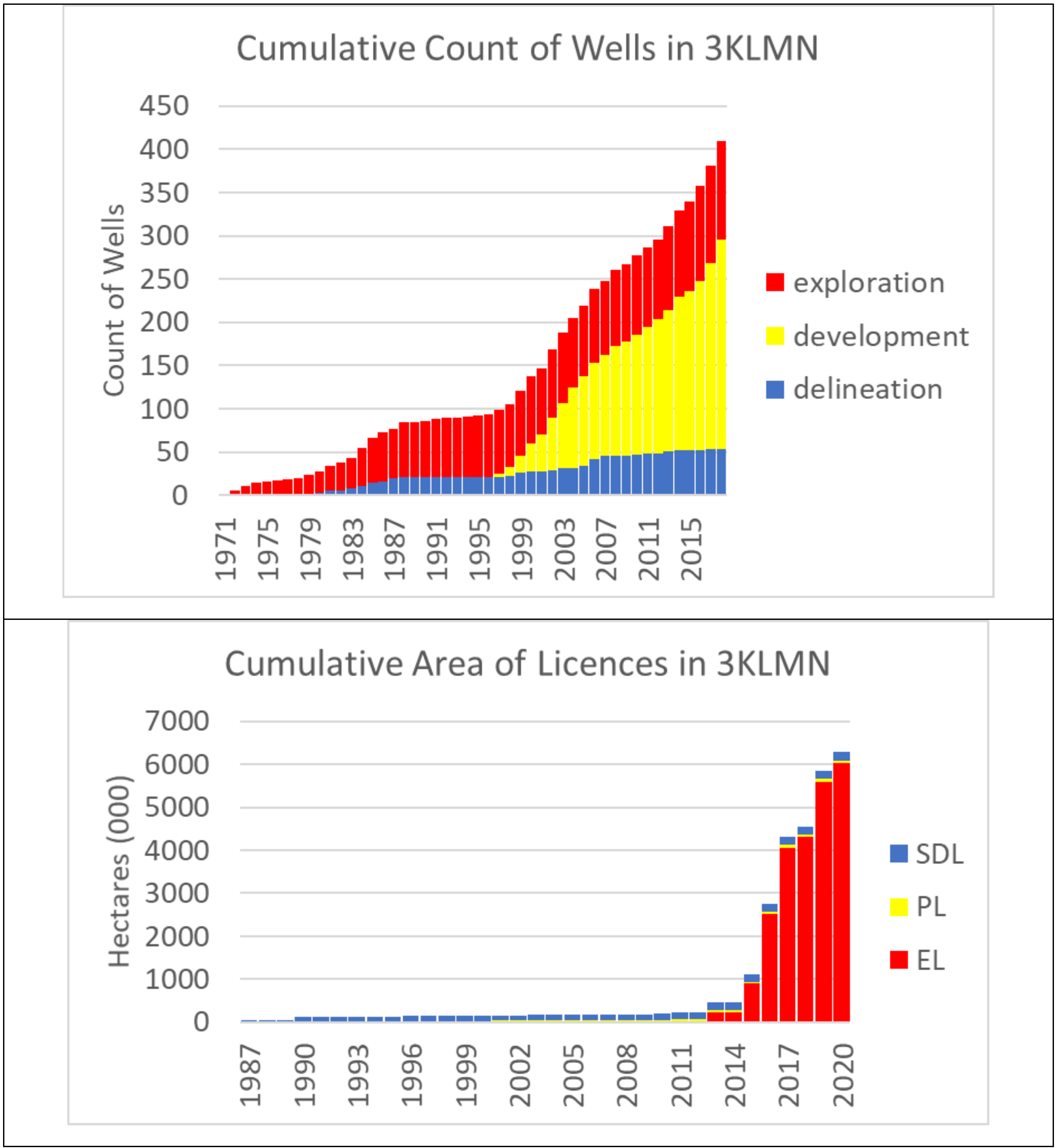


Figure 1.13. Cumulative number of offshore wells (top) and cumulative area of offshore licenses (bottom) in the 3KLMN region (source: www.cnlopb.ca). EL (exploration licenses), PL (production licenses), SDL (significant development licenses).

SC notes an increasing trend in oil and gas activities since the early 2000's and that this trend it is expected (based on current exploration licenses and development projections) to increase in the NRA until at least 2030. As of 2019, there are four offshore production fields on the Grand Banks and intense exploration activities along the eastern shelf break and Flemish Pass. Furthermore, during the period 2015-2019 there have been ten reported incidents of different types, with a major oil spill reported in 2018 (250,000 litres), and one in 2019 that occurred in the EEZ of the coastal state but extended into the NAFO Regulatory Area.

Results presented here have been included where appropriate into the current 3LNO Ecosystem Summary Sheet (ESS), noting that periodic up-dates in the ESS of these activities is dependent on the significant commitment from Contracting Parties (CPs) to provide the necessary expertise to evaluate the potential conflict between activities and the potential consequences or impacts of incidents associated with oil and gas activities.

References

Cordes, E.E., Jones, D.O.B., Schlacher, T.A., Amon, D.J., Bernardino, A.F., Brooke, S., Carney, R., DeLeo, D.M., Dunlop, K.M., Escobar-Briones, E.G., Gates, A.R., Génio, L., Gobin, J., Henry, L.-A., Herrera, S., Hoyt, S., Joye, M., Kark, S., Mestre, N.C., Metaxas, A., Pfeifer, S., Sink, K., Sweetman, A.K., Witte, U. (2016). Environmental impacts of the deep-water oil and gas industry: a review to guide management strategies. Frontiers in Environmental Science 4. 10.3389/fenvs.2016.00058.

Durán Muñoz, P., Sacau, M., Román-Marcote, E. and García-Alegre, A. (2020). A theoretical exercise of Marine Spatial Planning in the Flemish Cap and Flemish Pass (NAFO Divs. 3LM): implications for fisheries management in the high seas. NAFO SCR Doc. 20/022. pp 25.

García-Alegre A., Román-Marcote E., Gago J., González-Nuevo G., Sacau M., Durán Muñoz P. (2020). Seabed litter distribution in the high-seas of the Flemish Pass area (NW Atlantic). Sci. Mar. 84(1): 93-101. https://doi.org/10.3989/scimar.04945.27A.

NAFO (2016). Report of the Scientific Council Meeting, 03 -16 June 2016, Halifax, Nova Scotia. NAFO SCS Doc. 16/14 Rev.

viii) Information on sea turtles, sea birds, and marine mammals that are present in NAFO Regulatory Area (COM request #18)

Scientific Council noted that WG-ESA, in their November 2019, prepared a draft response covering marine mammals and turtles, but not seabirds (SCS Doc. 19-25). SC agreed the following plan for finalizing the response to this request by June 2021:

- SC seabird experts (and any other needed participants) will plan to have a virtual meeting towards the end of 2020 (possibly WG-ESA in November 2020) to:
  - Exchange what information is available and discuss in light of currently available information in the response on marine mammals and turtles.
  - Plan what level of information will be included in the response for seabirds
  - Divide the work appropriately and plan a future virtual meeting to discuss progress during the first quarter of 2021.
- By April 2021 have draft seabird text to be combined with existing text on marine mammals and turtles.
- Finalize response to present to SC in June 2021.

2. Requests Received from the Commission during the Annual Meeting

i) Regarding 3M cod: From European Union (COM WP 20-12)

The COM in its request for scientific advice for 2021 asked the Scientific Council to provide advice on gear, including sorting grids, area and time-based measures that could be used to protect and improve the productivity of the 3M cod stock.

*With respects to the area closures, the Scientific Council in its June meeting responded to this COM request by advising that: "… **a seasonal closure** (no directed fishery on 3M cod during the first quarter of the year) would **protect spawning activity**, reducing the number of spawning fish that are captured and allowing them to spawn before becoming available to the fishery."*

*In its response the SC further advised that "The implementation of such measures should be **accompanied by a clear definition of the objectives** (determine if and how closure effectiveness could be monitored) and a **monitoring plan** to study the impact that these measures may have on the fishery and ecosystem."*

As regards the two points highlighted above from the SC response, the EU would like to seek further guidance from the Scientific Council on the following points:

1. *Should the seasonal closure of directed fisheries for 3M cod during the first quarter of the year be extended to the full Flemish cap area - NAFO division 3M - or should this prohibition instead, cover a particular area within the NAFO division 3M where the cod spawning biomass is likely to aggregate?*

   In the latter case, then the EU requests the SC to provide additional elements, based on the best available data, as to where the target fishery should be prohibited in light of the information available to identify the area for time/area closure.

Scientific Council responded:

There is no simple and general answer to which type of closure is better; the optimal closure design would be expected to depend on a multiplicity of factors. There are different opinions in the literature on the best type of closure to consider: seasonal, by area, or by area / season, although closure of a wide area seems to have the most support. Eero et al. (2019) concluded that "designing relatively small area closures appropriately is highly complex and data demanding and may involve trade-offs between positive and negative impacts on the stock. Seasonal closures covering most of the stock distribution during the spawning time are more robust to data limitations, and less likely to be counterproductive if sub-optimally designed."

In the case of 3M cod, it seems clear that the spawning season is the first quarter of the year. While there is no research vessel survey information during this part of the year, some general inferences can be made from commercial fisheries data. The cod trawl fishery in the first quarter is concentrated in a fairly small area where catch rates (CPUE) are higher and mean size of fish is larger than in other areas/seasons, likely indicating a major spawning area. However, the data from the cod longline fishery do not show any clear spatial concentration in its activity. Therefore, even if the trawl fishery allows identifying some important spawning areas, the limited spatial coverage of this fishery prevents from assuming that these are the only spawning areas within the Flemish Cap. Given the difficulty in identifying all spawning areas, the limited spatial distribution of this stock (restricted to the Flemish Cap), and the assumed objective of protecting the spawning activity of this stock, it is more appropriate to close the entire Flemish Cap to the fishery targeting cod during the identified spawning season than to close smaller areas. This option also has operational advantages in terms of simplicity of implementation and surveillance. It also reduces the effects of any displacement of fishing activity into areas with immature and recruiting fish.

In conclusion, the SC considers that, if a spawning closure is agreed, a total closure of the cod fishery in Flemish Cap during the first quarter of the year would be the preferred option to protect spawning activity based on the available data.

2. *What monitoring plan, besides the regular scientific campaigns and data collection programs carried out by CPs, would the SC advise to be put in place, considering the objective of the closures is to protect spawning biomass, to reduce spawning disturbance and therefore **contributing to decrease fishing mortality** and concomitantly **increase stock abundance?***

Scientific Council responded:

As the SC noted in its June report, the seasonal closure would protect spawning activity, reducing the number of spawning fish that are captured, and allowing them to spawn before becoming available to the fishery, but the spawning biomass itself is not protected by the closure (as the fish may still be caught in other quarters of the year). Therefore, a spawning closure will not result in decreases to fishing mortality.

Furthermore, while in principle improved recruitment might result from a spawning closure, there is no clear evidence that protecting fish during spawning directly translates into increases in recruitment/productivity, particularly at this time of low productivity of the stock.

If any closure is established, SC advises that it will be necessary to conduct ongoing analysis of the Flemish Cap cod fishery data in order to monitor the consequences of the management decisions (including the analysis of the redistribution of the fishing effort along the year and its potential effects on ecosystems, the variation of the cod catch composition in lengths/ages, and the bycatch levels of other fish species, benthos in general, and VME taxa in particular).

3. If flanking measures were adopted, such as:

  i. time/area closure during the first quarter, with the objective as detailed in point 2; and
  ii. the implementation of sorting-grids in the Div. 3M cod fishery gear, with the objective of reduce catch of small and immature individuals of cod;

how would that affect the projections for total biomass under the different scenarios for the projected years and notably would there be catches beyond 1000 t where the probability of being below B_{lim}, beyond the year 2021, would remain within the NAFO Precautionary Approach guidelines?

Scientific Council responded:

SC advises that the suggested measures would not allow for catches above 1 000 t in 2021 without exceeding the PA framework limits in 2022.

If a seasonal closure proves to be effective in improving recruitment, it would affect the level of future recruitment, and hence, its effects on the stock would be observed in the medium / long-term; however, it would have little or no impact on short-term projections (2 years). In the short-term, this measure might result in lower average catch weights (as fish would be heavier in the first quarter, i.e. at spawning time, than in later quarters of the year) than used in the projections performed by SC in June. This, in turn, and assuming no other confounding effect would simultaneously occur, would also imply that a larger number of fish would need to be caught in order to reach the TAC, which is set in weight.

The implementation of sorting grids, which mainly affect the exploitation pattern of younger ages, would be expected to have a more immediate effect on the stock, because it would improve the protection of young fish by delaying their recruitment into the fishery. If the relatively good recruitment observed in 2019 (2018 cohort) holds true, implementation of sorting grids would increase the selection mean length and reduce the catch of the 2018 cohort in 2021 (when those fish will be of age 3), aiding in the recovery of the stock in the short-term.

SC is not at this point able to quantify the full effect of implementing these management measures.

ii) Regarding cod in 3M: From Denmark (in respect of the Faroe Islands and Greenland) (COM WP 20-17)

In its recommendation on 3M Cod for 2021, the SC notes again this year, as it did in its 2019 advice, that the strong year classes of 2009 to 2011 are dominant in the current SSB, but that subsequent recruitments (2012-2018) are much lower, leading to recent substantial declines in stock size and expectations that this will continue in the very near future under any fishing scenario.

At the same time, the SC report indicates a clear increase in recruitment to the stock in 2019, as shown in the graph on page 8 of the SC report (NAFO SCS Doc. 20/14). This has not, however, been taken into consideration in this year's SC advice when projecting the development of the SSB and calculating the probabilities of different fishing levels reaching or exceeding Blim and Flim in 2021, 2022 and 2023.

Although there is uncertainty in recruitment estimates for the current assessment year, the most recent survey data also suggests an increase in stock biomass for 2020 as a consequence of improved recruitment in 2019. As such, there are signs indicating that the decline in the stock in the coming years might not be as severe as the current projections indicate.

- *The Scientific Council is therefore requested to provide supplementary advice on the projected scenarios, taking into account the documented increase in recruitment in 2019.*

Scientific Council responded:

The current request notes that "the most recent survey data also suggests an increase in stock biomass in 2020 as a consequence of improved recruitment in 2019". SC understands this comment refers to the results of the 2020 EU survey in Division 3M. In this regard, SC notes that the results from the 2020 survey for the cod stock are preliminary, there has been no opportunity to subject them to sufficient quality checks or to any type of scientific analysis. As such, SC notes that it is too early to draw conclusions from those (preliminary) values at this stage.

The 3M cod stock assessment conducted by SC in June 2020 (SCS Doc. 20-14) is based on data until the end of year 2019. This followed the standard procedure for the assessment of this stock. The assessment does indeed indicate an increase in recruitment (age 1) in 2019, by comparison with the recruitment of previous years (2015-2018), which has been very low.

During the 2020 June SC meeting, the estimated value of recruitment (age 1) in 2019 was used to calculate stock abundance and biomass in 2019, as well as abundance at age 2 in 2020; in this respect, it was taken into account in the projections and included in the calculation of projected SSB in future years.

However, the recruitment assumed for the projected years (2020, 2021 and 2022) during the June SC meeting was taken from the Recruits per Spawner derived from the estimated recruitment for years 2016-2018 and not from the estimate of recruitment in 2019. This is the common procedure for most stock assessments, since the estimate of recruitment for the most recent year included in the stock assessment is more uncertain than the estimates of recruitment for earlier years, because information about cohort abundance is gained as more ages of the cohort are observed.

Despite the uncertainty of the 2019 recruitment estimate, and only to address the current request, a sensitivity analysis of the 3M cod projection has been performed, where the assumed recruitment for the projected years (2020, 2021, 2022) was taken from the Recruits per Spawner derived from the estimated recruitment of years 2017-2019. The results are virtually identical to those from the June projections and do not change the Scientific Council's perception of the recent dynamics of the 3M cod stock, since the recruitment in the projected years has very little impact on short-term forecasts, because small fish contribute very little to the fishery catches or the SSB.

iii) From European Union regarding 3M cod:

In its advice on TAC for COD 3M the SC has based its response in results from short-term projection (3years) with four fishing mortality levels; namely 2/3Flim, F=0, catch=1000t and catch=3000t.

The EU would like to request the SC the preparation of short-term projections for additional catch levels, notably catch levels between 1000t up to 1500t, and intermediate catch levels within 100 tons steps.

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.*

Scientific Council responded:

SC has conducted projections for catch levels between 500 t and 1500 t, at 100 t intervals, and the results are presented below.

SC notes that, although it is technically possible to conduct projections for any catch level and this has now been done for the additional catch levels requested, the uncertainty that exists in the projections of this stock prevents the SC from being able to reliably differentiate (based on scientific information) between fine-scale catch scenarios. SC does not consider that the resolution of the assessment framework in terms of risk-of-going-below-B_{lim} in relation to TAC predictions to be as fine as 100 tons.

	B		SSB		Yield
	Median and 80% CI				
	Catch=500 tons				
2020	48698	(42129 - 55567)	35738	(30117 - 41335)	8531
2021	35740	(30110 - 41951)	23110	(18574 - 27833)	500
2022	31624	(26499 - 37490)	19687	(16045 - 23502)	500
2023	28141	(23344 - 33786)	21528	(18030 - 25623)	
	Catch=600 tons				
2020	48698	(42129 - 55567)	35738	(30117 - 41335)	8531
2021	35740	(30110 - 41951)	23110	(18574 - 27833)	600
2022	31527	(26398 - 37390)	19644	(15968 - 23387)	600
2023	27960	(23170 - 33603)	21338	(17822 - 25480)	
	Catch=700 tons				
2020	48698	(42129 - 55567)	35738	(30117 - 41335)	8531
2021	35740	(30110 - 41951)	23110	(18574 - 27833)	700
2022	31430	(26299 - 37294)	19528	(15899 - 23311)	700
2023	27778	(22996 - 33421)	21168	(17674 - 25263)	
	Catch=800 tons				
2020	48698	(42129 - 55567)	35738	(30117 - 41335)	8531
2021	35740	(30110 - 41951)	23110	(18574 - 27833)	800
2022	31330	(26198 - 37196)	19428	(15824 - 23189)	800
2023	27595	(22823 - 33234)	21009	(17517 - 25132)	
	Catch=900 tons				
2020	48698	(42129 - 55567)	35738	(30117 - 41335)	8531
2021	35740	(30110 - 41951)	23110	(18574 - 27833)	900
2022	31236	(26099 - 37100)	19382	(15750 - 23145)	900
2023	27412	(22656 - 33053)	20878	(17402 - 24955)	
	Catch=1000 tons				
2020	48698	(42129 - 55567)	35738	(30117 - 41335)	8531
2021	35740	(30110 - 41951)	23110	(18574 - 27833)	1000
2022	31132	(25996 - 37004)	19282	(15658 - 23080)	1000
2023	27230	(22475 - 32877)	20679	(17248 - 24831)	
	Catch=1100 tons				
2020	48698	(42129 - 55567)	35738	(30117 - 41335)	8531
2021	35740	(30110 - 41951)	23110	(18574 - 27833)	1100
2022	31036	(25899 - 36901)	19188	(15512 - 22980)	1100
2023	27056	(22305 - 32690)	20528	(17066 - 24661)	
	Catch=1200 tons				
2020	48698	(42129 - 55567)	35738	(30117 - 41335)	8531
2021	35740	(30110 - 41951)	23110	(18574 - 27833)	1200
2022	30936	(25797 - 36806)	19126	(15443 - 22874)	1200
2023	26877	(22127 - 32505)	20391	(16915 - 24511)	
	Catch=1300 tons				
2020	48698	(42129 - 55567)	35738	(30117 - 41335)	8531
2021	35740	(30110 - 41951)	23110	(18574 - 27833)	1300
2022	30838	(25700 - 36709)	19032	(15379 - 22795)	1300
2023	26696	(21951 - 32315)	20207	(16724 - 24313)	
	Catch=1400 tons				
2020	48698	(42129 - 55567)	35738	(30117 - 41335)	8531
2021	35740	(30110 - 41951)	23110	(18574 - 27833)	1400
2022	30743	(25602 - 36611)	18950	(15274 - 22730)	1400
2023	26519	(21772 - 32140)	20058	(16535 - 24161)	
	Catch=1500 tons				
2020	48698	(42129 - 55567)	35738	(30117 - 41335)	8531
2021	35740	(30110 - 41951)	23110	(18574 - 27833)	1500
2022	30641	(25497 - 36516)	18840	(15217 - 22615)	1500
2023	26340	(21592 - 31957)	19888	(16437 - 24047)	

	Yield			$P(SSB < B_{lim})$				$P(F > F_{lim})$			
	2020	2021	2022	2020	2021	2022	2023	2020	2021	2022	$P(SSB_{23} > SSB_{20})$
Catch=500t	8531	500	500	<1%	1%	8%	3%	4%	<1%	<1%	<1%
Catch=600t	8531	600	600	<1%	1%	8%	3%	4%	<1%	<1%	<1%
Catch=700t	8531	700	700	<1%	1%	9%	3%	4%	<1%	<1%	<1%
Catch=800t	8531	800	800	<1%	1%	9%	3%	4%	<1%	<1%	<1%
Catch=900t	8531	900	900	<1%	1%	9%	4%	4%	<1%	<1%	<1%
Catch=1000t	8531	1000	1000	<1%	1%	10%	4%	4%	<1%	<1%	<1%
Catch=1100t	8531	1100	1100	<1%	1%	10%	4%	4%	<1%	<1%	<1%
Catch=1200t	8531	1200	1200	<1%	1%	11%	5%	4%	<1%	<1%	<1%
Catch=1300t	8531	1300	1300	<1%	1%	11%	5%	4%	<1%	<1%	<1%
Catch=1400t	8531	1400	1400	<1%	1%	12%	6%	4%	<1%	<1%	<1%
Catch=1500t	8531	1500	1500	<1%	1%	13%	7%	4%	<1%	<1%	<1%

1

3. Further SC on COM request #6: Assessment of NAFO bottom fisheries in 2021

Although SC prepared a response to this request during the June SC meeting, and this response was presented to the Commission by the SC Chair, further work (with a view on the final response that SC will provide in 2021) was conducted by SC at its September meeting. A summary is presented here:

<u>Assess the overlap of NAFO fisheries with VME to evaluate fishery specific impacts in addition to the cumulative impacts:</u>

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 2016 to 2018 and in establishing VMS data analysis procedures to generate standardized vessel trawl-track data products. Such analysis significantly improves the spatial definition of specific fishing areas within the NAFO footprint, reducing the number of spurious VMS pings included in the analysis.

SC recommends that NAFO Secretariat compile basic information (see Table 1.2) related to each directed fishery defined by stock and gear type (as defined previously), e.g., the types of fishing conducted, range of vessel powers (kW), range of vessel lengths, depth range of fishing, gear type including typical dimensions, target and bycatch species, and the spatial distribution of fishing effort (CEM Annex II.M. Part 1; Part 2 and Part 4 and Annex II.N). In the case of longline fisheries, collection and compilation of additional information (see Table 1.3) would be crucial to start the process of defining a more precise fishing footprint. This information would help improving knowledge about a longline representative fishing footprint since with the information that is currently available, it is not possible to obtain the real footprint for this fishery.

Table 1.2. TRAWL GEAR

Types of fishing conducted
Range of vessel powers (kW)
Range of vessel lengths
Depth range of fishing
Gear type (including dimensions)
Target and bycatch species
Spatial distribution of fishing effort

Table 1.3. LONGLINE

	Start line set					**End line set**					**Start line haul**					**End line haul**				
Line set number	Date	Time	Lat	Lon	Depth	Date	Time	Lat	Lon	Depth	Date	Time	Lat	Lon	Depth	Date	Time	Lat	Lon	Depth

Line set number	
Type of bottom longline used: automatic/manual	
Main Line length	
Line material	
Line diameter	
Number of hooks set	
Number of hooks lost	
Hook type	
Hook size	
Type of baits used	

4. Update on progress on the NAFO PA Framework review (COM request #8)

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

SC in June tasked a small subgroup to develop a funding proposal for submission to the EU in November 2020 to support work towards the review of the NAFO PA framework. The proposal prepared by the subgroup follows the workplan agreed by WG-RBMS at its August 2020 meeting (COM-SC Doc. 20-04) and covers the contracting of three external experts and organization of two workshops for scientists and managers to take place in March 2022 and late 2022/early 2023 respectively.

The work of this subgroup was presented to SC for discussion and to provide guidance for further development. In addition to a pro-forma standard grant application form, the sub-group drafted terms of reference for independent experts based on the SC PAF review working plan.

The terms of reference were discussed during the meeting and some suggestions were made:

- Provide a specific workplan for the experts and broader terms of reference for the working group.
- Define the different levels of involvement of the external experts, one of whom will co-Chair the technical group and will participate in all actions while the other external experts will provide inputs at all stages of the process, but will not follow day-to-day developments as closely.
- Broaden terms of reference making them less directive
- The working group will carry out a and b of each item
- external participates in c of each item with the working group

SC members agreed to provide additional comment to the WG-PAF Chair and the SC WG-RBMS co-Chair about the grant application or the terms of reference for the external experts within 2 weeks of closure of the SC meeting, i.e. no later than October 10.

VIII. MEETING REPORTS

a) Joint Commission – Scientific Council Working Group on the Ecosystem Approach Framework to Fisheries Management (WG-EAFFM)

This joint working group met by correspondence during 17–19 August 2019 and was co-chaired by Elizabethann Mencher (USA) and Carmen Fernandez (Chair of SC). The Scientific Council was advised of progress of this group by the co-chairs in their presentation of the report to the joint session of Commission and Scientific Council (see section III of this report).

SC elected Andrew Kenny (UK) as co-chair of WG-EAFFM, replacing the Chair of SC (who acted as co-chair of WG-EAFFM for the August meeting in an interim role).

b) Joint Commission–Scientific Council Working Group on Risk-based Management Strategies (WG-RBMS)

This joint working group met by correspondence on 6 February and during 20-21 August 2020. Both meetings were co-chaired by Jaqueline Perry (Canada) and Fernando González (EU). The Scientific Council was advised of progress of this group by the co-chairs in their presentation of the report to the joint session of Commission and Scientific Council (see section III of this report).

c) Joint Commission-Scientific Council Catch Estimation Strategy Advisory Group (CESAG).

CESAG met by correspondence on 24 April 2020, co-chaired by Katherine Sosebee (Scientific Council, USA) and Temur Tairov (Commission, Russian Federation). The report was presented to the Commission by Katherine Sosebee. Scientific Council deferred consideration of this report until its June 2020 meeting.

d) ICES/NAFO Working Group on Deep-water Ecology (WG-DEC)

WG-DEC met by correspondence during 4-8 May 2020 and was attended by Ellen Kenchington and Lindsay Beazley (Canada) representing NAFO. The report of WG-DEC was not finalized in time for the present meeting and discussion of this WG was deferred to June SC meeting, 2021.

e) ICES/NAFO/NAMMCO Working Group on Harp and Hooded Seals (WG-HARP)

Discussion of this working group was deferred to June 2021

IX. REVIEW OF FUTURE MEETING ARRANGEMENTS

1. Scientific Council meetings

a) Scientific Council, (in conjunction with NIPAG), 26 October to 2 November 2020

The Scientific Council shrimp advice meeting will be held by WebEx from 26 October to 2 November 2020 (excluding the weekend).

b) WG-ESA, 17- 26, November 2020

The Working Group on Ecosystem Science and Assessment (WG-ESA) meeting will be held by WebEx from 17 to 26 November 2020.

c) Scientific Council, June 2021

The Scientific Council meeting in June 2021 meeting is currently scheduled to be held in Halifax, Nova Scotia, Canada from 28 May to 10 June 2021,

d) Scientific Council (in conjunction with NIPAG), 2021

Dates and location to be determined.

e) Scientific Council, September 2021

The Annual meeting is currently scheduled to be held 21- 25 September 2021, in Halifax, Nova Scotia, unless an invitation to host the meeting is extended by a Contracting Party.

2. NAFO/ICES Joint Groups

a) NIPAG, 26 October to 2 November 2020

The joint NAFO/ICES *Pandalus* Assessment Group meeting will be held by WebEx from 26 October to 2 November 2020 (excluding the weekend).

b) NIPAG, 2021

Dates and location to be determined.

c) ICES – NAFO Working Group on Deep-water Ecosystem, 2021

Dates and location to be determined.

d) ICES/NAFO/NAMMCO WG-HARP

The date and location of the next ICES/NAFO/NAMMCO Working Group on Harp and Hooded Seals (WGHARP) meeting are unknown.

X. FUTURE SPECIAL SESSIONS

1. Progress on NAFO participation in the symposium "4th Decadal Variability of the North Atlantic and its Marine Ecosystems: 2010-2019"

The STACFEN Chair, Miguel Caetano, presented the following progress update:

The meeting is organised by ICES and will be held on 26-28 October 2021, in Bergen (Norway). STACFEN members Frederic Cyr and Paula Fratantoni have proposed a joint organization that brings added value for the knowledge of decadal oceanographic variations in the NAFO area, integrated in the North Atlantic region. One of the direct advantages is to promote evaluation of the oceanographic changes in the wider spatial context of the North Atlantic. The contributions from participants may generate new insights and discussion within STACFEN regarding the integration of environmental information into the stock assessment process.

These STACFEN members are also part of the Scientific Steering and Organizing Committees of the symposium.

The ICES symposium committee provided positive feedback on the NAFO participation in the organization of the Decadal Symposium. The committee also agreed to include NAFO in the name of the event from their first announcement, as "ICES/NAFO 4th Joint Symposium on Decadal Variability of the North Atlantic and its Marine Ecosystems: 2010-2019". Additionally, a proposal will be submitted for a NAFO scientist to act as a keynote speaker in the event. A list of three possible scientists was discussed and will be submitted to the Symposium Steering Committee.

<u>Symposium short description:</u>

> The Symposium will be the 4th one of an ICES series and will contribute to the recently promoted United Nations Decade of Ocean Science for Sustainable Development (2021-2030). It will summarize the status at the beginning of the decade and looking forward into the coming decade. In general, the main challenge will be to summarize and explain the hydro-biological variability observed during the decade of 2010-2019 in relation to longer term variability or change, and to quantify the interactions between the variability and change in the ocean environment with variability in plankton, fish, mammals and seabirds in the North Atlantic marine ecosystems. The symposium will be organized in three thematic sessions: Development of ocean climate; Impacts of climate variability on marine ecosystems; and the coming decade.

2. Information concerning Flatfish Symposium 2020

The SC Coordinator informed SC that, due to covid-19, the flatfish symposium will be postponed until 2021. All details will remain the same except the dates, which now are November 14-20, 2021.

3. Other potential future topics

No other proposals were received.

XI. OTHER MATTERS

1. Presentation of NAFO Scientific Merit Award to António Ávila de Melo

NAFO Scientific Council (SC) was pleased to present a Scientific Merit Award to António Ávila de Melo (EU-Portugal), to acknowledge and celebrate his contributions to SC over his career as a Research Scientist.

António has served the SC in numerous capacities, including his tenure as chair of the SC subcommittee STACREC (1992-1993) and his role as a Designated Expert (DE) for Div. 3M (since 1996) and 3LN (since 2003) redfish stocks. He has provided significant contributions over more than 3 decades to the assessment of various stocks, always aiming to help ensure their stability and the sustainability of the fisheries that rely on them.

António Ávila de Melo with longtime NAFO colleague, friend, and fellow redfish fan, Don Power, at the NAFO Annual Meeting in Montréal, Canada, September 2017.

In addition, António was one of two research scientists at the Portuguese fisheries institute responsible for the establishment of a Portuguese research team for the NAFO area, which has been active since 1988, and the Flemish Cap project, that also started in 1988. Since that time, António has participated in numerous other NAFO related projects and research surveys and was responsible for training several junior researchers.

António's knowledge, experience, guidance, patience and sympathy with both scientists and administrators were essential to the SC's work and crucial to the transmission of the SC's message. SC members congratulated António for his thorough and passionate contributions to the assessment of redfish stocks and to the general functioning of SC within NAFO. They thanked him for his wisdom and offered their good wishes for the future, hoping that he will continue to share with others his scientific knowledge, as well as his passion for music and for life as a whole.

XII. ADJOURNMENT

The meeting was adjourned at 13:00 on 25 September 2020.

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

Chair: Margaret Treble Contributor: Alexis Pacey

The Committee met by Webex, on Sept. 21-25, 2020, 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 (Portugal, and Spain), Japan, the Russian Federation, United Kingdom, and the United States of America. The Scientific Council Coordinator was in attendance as were other members of the Secretariat staff.

1. Opening

The Chair opened the meeting by welcoming the participants.

2. Appointment of Rapporteur

Alexis Pacey (NAFO Secretariat) was appointed rapporteur.

3. Adoption of Agenda

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

STATUS: This is still in progress. A draft has been prepared (scwp20-014) and comments are welcome.

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

STATUS: This is still in progress. Finding a system that would allow citations to be easily uploaded to reference management software is ongoing. There is the possibility of having Crossref DOIs linked to the relevant datasets in DataCite by adding the DataCite DOIs in the metadata of the publications.

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

STATUS: This has been implemented. There is a table in the instructions-for-authors that describes the various formats suitable 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*.

STATUS: This has been implemented. There is a set of instructions developed by Anna Wall, NAFO intern, that explains and instructs "run-to-code" for figure preparations. This is suitable for R Statistical and Sigmaplot. It is on the JNAFS site with the instructions for authors and has been distributed to Scientific Council Designated Experts.

5. Review of Publications

a) Journal of Northwest Atlantic Fishery Science (JNAFS)

Volume 50-Regular issue: This volume was published in December 2019. Currently, Volume 51 has six articles in review with associate editors or in the revision/re-submit stage with the authors, and one is in production soon to be published.

b) NAFO Scientific Council Reports

The NAFO Scientific Council Reports 2019 (Redbook) volume (451 pages) was published May 2020 online. Ten copies of the Report will be printed with spiral binding.

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 from September 2018-August 2019 (338 pages) and are printed and distributed in September 2019. Five copies were made with a spiral binding.

e) ASFA

Most science publications and documents have been submitted to ASFA as of March 31, 2020. This includes The *Journal of Northwest Atlantic Fishery Science* and SC Research/Summary Documents for 2019.

f) Poster/Information Materials

Recent updates to SC & fishery management procedures re: Cycle of Advice, as well as the SC poster have been completed.

6. Other Matters

a) ASFA 2019 Board Meeting

The Senior Publications/Web Manager did not attend the 47th Annual Meeting of the Aquatic Sciences and Fisheries Abstracts (ASFA) Advisory Board.

b) JNAFS Editorial Board

We have welcomed another associate editor to the JNAFS editorial team. Dr David Deslauriers is a Professor of fish ecology and physiology at the Institute of Marine Sciences at the University of Québec at Rimouski (UQAR). Dr. Deslauriers' research specialization includes; bioenergetics, ecological modeling, freshwater and marine ecosystems.

JNAFS AEs are currently partitioned into general review expertise categories. We are top-heavy in the Fisheries Biology category, which really also includes stock assessment and perhaps ecology. There was a proposal to do away with the expertise categories and just list all of the AEs alphabetically. After some discussion STACPUB **recommends** that *the Associate Editors be surveyed to determine if they would agree to have the expertise categories removed from their profiles on the JNAFS website*.

c) Website link to PDFs

The Senior Pupblications/Web Manager continues to look for improvements to our ability to have easy access to reports and JNAFS articles.

7. Adjournment

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

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

Chair: Karen Dwyer Rapporteur : Tom Blasdale

1. Opening

The Committee did not meet in June 2020, due to the disruption caused by the COVID-19 pandemic. The SC meeting was preceded by a Webex on May 11, attended by relegates from the EU, Canada, Denmark in respect of Faroes and Greenland and the USA, during which information on biological surveys in the NRA were presented. In addition, there was a presentation on Canadian survey coverage and whether it was appropriate for use in various assessments using the guidelines set out in STACREC (NAFO 2019). This meeting was attended by the 2020 external reviewer, Hugues Benoit.

2. Appointment of Rapporteur

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

3. Review of previous recommendations from 2019 and new recommendations from 2020

Previous recommendations were not examined at the June meeting and no new recommendations were made in 2020 due to constraints to the meeting from Covid-19.

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

In 2015, STACREC **recommended** that *an analysis of sampling rates be conducted to evaluate the impact on the precision of survey estimates.* As a separate aspect, in September 2017 STACREC discussed *possibilities for combining multiple surveys in different areas and at different times of the year to produce aggregate indices*.

In September 2019, it *was agreed that a speaker on this general topic would be invited to the June 2020 SC meeting, and the STACREC chair will take the lead in arranging this invitation.* However, due to the pandemic, it was not possible to have an invited speaker in June. However, a Canadian scientist attended the ICES WKUSER workshop (Workshop on Unavoidable Survey Effort Reduction) in January 2020 and presented information on survey coverage issues. Feedback from this meeting will be presented to STACREC in June 2021. The full report is available at: ICES. 2020. ICES Workshop on unavoidable survey effort reduction (WKUSER).

ICES Scientific Reports. 2:72. 92pp. http://doi.org/10.17895/ices.pub.7453

In 2019, 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.

It has been suggested that an added guideline might be: For age groups where there is a greater than 10% difference between total survey biomass in the survey strata missed that year in the index used (total or mean numbers), then it should be excluded from the model, if the model can handle missing values. However, there was no time to discuss this at the June 2020 meeting and therefore this discussion will be deferred to June 2021.

All other recommendations will be deferred to next year (2021).

4. Fishery Statistics

a) Progress report on Secretariat activities in 2019/2020

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 reports for 2017-2019 and 21B reports for 2017-2019 received prior to September 2020

Country/component	STATLANT 21A (deadline, 1 May)			STATLANT 21B (deadline, 31 August)		
	2017	2018	2019	2017	2018	2019
CAN-CA	31 May 18		9 Jun 20	31 May 18		
CAN-SF	05 May 18	29 Apr 19	17 Apr 20	11 Sep 18	30 Aug 19	2 Jul 20
CAN-G	30 Apr 18		14 May 20	24 Aug 18	23 Aug 19	
CAN-NL	17 May 18	17 May 19	30 Apr 20	7 Jun 18	4 Sep 19	31 Aug 20
CAN-Q						
CUB						
E/BUL						
E/EST	04 May 18	30 Apr 19	30 Apr 20	13 Sep 18	17 Dec 19	31 Aug 20
E/DNK	23 Apr 18	1 May 19	26 May 20	03 Sep 18	27 Aug 19	21 Aug 20
E/FRA						
E/DEU	25 Apr 18	30 Apr 19	18 May 20	30 Aug 18	19 Sep 19	02 Jul 20
E/LVA		24 Apr 19				
E/LTU	24 Apr 18	24 Apr 19		24 Apr 18	1 July 19	
EU/POL						
E/PRT	20 Apr 18	30 Apr 19	29 May 20	03 Sep 18	19 Sep 19	31 Aug 20
E/ESP	30 May 18		14 May 20	02 Aug 18	12 Dec 19	24 Jun 20
E/GBR	31 May 18			24 Jul 18		

FRO	18 May 18	22 May 19	3 Jun 20		18 May 19	22 Sep 20
GRL	30 Apr 18	29 Apr 19	24 Apr 20		22 Aug 19	25 Aug 20
ISL						
JPN	01 May 18	23 Apr 19	8 May 20	31 Aug	30 Aug 19	28 Aug 20
KOR						
NOR	23 Apr 18	25 Apr 19	27 May 20	16 Aug 18	26 Aug 19	08 Sep 20
RUS	04 May 18	14 May 19	27 May 20		20 Aug 19	25 Aug 20
USA	10 Jul 18	10 Jun 19				
FRA-SP	18 May 18	14 Mar 19	8 May 20	5 Jul 18		
UKR						

5. Research Activities

a) Biological Sampling

i) Report on activities in 2019/2020

STACREC reviewed the list of Biological Sampling Data for 2019 prepared by the Secretariat and noted that any updates will be inserted during the summer. The SCS Document will be finalized for the September 2020 Meeting.

ii) Report by National Representatives on commercial sampling conducted

Canada-Newfoundland (SCS Doc. 20/11, 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. This format of this report was changed for 2020 and now follows the format of research reports carried out by other Contracting Parties. STACREC recommended scientists review this to determine its utility.

Denmark/Faroe Islands (SCS 20/08):

Data on catch rates were obtained from trawl and longline fisheries in NAFO Div 3M for Atlantic cod from 2014 to 2019 (n=1219, NAFO-observers). Length frequencies (NAFO-observers and crew members) were also available from 2014 to 2019 (number of samples, n=219). In addition, weight measurements were taken by crew members from 2014 to 2019 (n=83). The fishery has been conducted exclusively by longliners since 2017.

Denmark/Greenland (SCR 19/32, SCS 20/12):

Data on catch rates were obtained from trawl, gillnet, and longline fisheries in NAFO Div 1A-F for Arctic 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

(1AB, 1CD), longline (1A and 1D inshore), and gillnet (1A inshore) fisheries; for cod trawl offshore (Div. 1C and 1E), longline (1A and 1D inshore, 1D, 1D, 1E and 1F), gillnet (1A and 1D inshore), handline (1CD inshore); and pound nets (inshore 1B-D) fisheries. 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 20/10):

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

EU-Estonia (NAFO SCS Doc. 20/06) :

Catch rate data was obtained from two fishing vessels in Subarea 3. The main target species were redfish, cod and Greenland halibut. NAFO observers took length samples of these species and yellowtail flounder.

EU-Portugal (NAFO SCS Doc. 20/09):

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. 20/07):

A total of 10 Spanish trawlers operated in Div. 3LMNO NAFO Regulatory Area (NRA) during 2019, amounting to 1,264 days (18,686 hours) of fishing effort. Total catches for all species combined in Div. 3LMNO were 16,124 tons. In addition to NAFO observers (NAFO Observers Program), 7 IEO scientific observers were onboard Spanish vessels, comprising a total of 257 observed fishing days, around 20% 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 content analyses and collecting material for reproductive studies. Otoliths of these four species were also taken for age determination. In 2019, 376 length samples were taken, with 45,831 individuals of different species examined to obtain the length distributions.

One Spanish trawler operated during 2019 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* and Greenland shark *(Somniosus microcephalus)*. In 2019, 19 length samples were taken, with 683 Alfonsino individuals examined to obtain the length distributions.

Japan (NAFO SCS Doc. 20/05):

In 2018, one Japanese otter trawler operated in Div. 3L, 3M, 3N and 3O. The total catch (10 species) including discards was 2,789 tons. Target species (main fishing Divisions) (catch) were Greenland halibut (3L) (1,075 tons), redfish (3LM) (1,058 tons) and yellowtail flounder (3N) (348 tons). Number of size measurement for Greenland halibut, redfish and yellowtail flounder were 2,250, 5,693 and 750 respectively.

Russia (NAFO SCS Doc. 20/13):

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), witch flounder (Div. 3LMNO), roughhead grenadier (Div. 3LM), roundnose grenadier (Div. 3LN), white hake (Div. 3NO) and 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) and 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. 20/18):

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 Maine and Georges Bank haddock decreased while still remaining above average. Barndoor skate decreased from a time series high but remained high. Research on the environment, plankton, finfishes, marine mammals, and apex predators were described. Descriptions of cooperative research included a longline survey in the Gulf of Maine and shark tagging. Other studies included age and growth, food habits, tagging studies and observer trips.

b) Biological Surveys

i) Review of survey activities in 2019 and early 2020 (by National Representatives and Designated Experts)

A Webex meeting was held May 11 to review the survey activities and data by contracting parties prior to the Scientific Council meeting in June and to evaluate whether the survey coverage was useful for stocks; in particular Greenland halibut. The change in vessel to complete surveys off Canada/Greenland was also discussed.

Canada – Newfoundland and Labrador (SCR Doc. 20/02, 04, 05):

Research survey activities carried out by Canada (Newfoundland and Labrador Region) were summarized, and stock-specific details were provided. The major multispecies stratified-random surveys carried out by Canada in 2019 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 2019 spring survey in Div. 3LNOPs continued a time series begun in 1971. It was conducted from late April to mid-June, and consisted of 451 successful tows (478 planned) covering 128 of 129 planned strata, to a maximum depth of 732m, by the research vessels CCGS Alfred Needler and CCGS Teleost. Coverage of Div. 3L has been incomplete in three of the last six years.

The 2019 autumn survey was conducted from mid-September to mid-December in Divs. 2HJ3KLNO, and consisted of 486 tows (674 planned) covering only 158 of 208 planned strata to a maximum depth of 1500m in 2HJ3KL and 732m in 3NO. In the 2019 Canadian autumn survey there were major coverage issues, with a total of 50 incomplete strata (primarily in deep-water on the edge of the shelf) in NAFO Divs. 2HJ and 3KL. Some of the shallower strata had only the minimum number of sets covered, reducing the precision of estimates.

STACREC noted continued 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 2019 Canadian spring survey were considered minor (a single missed strata) and did not warrant removing this data point from relevant assessments conducted in 2020. In the 2019 Canadian autumn survey, however, there were major coverage issues, with a total of 50 incomplete strata. As these missed strata were primarily in deep-water (>750m) on the edge of the shelf, they had little to no influence on survey indices for most of the fish resources assessed by NAFO SC (3NO cod, 3LNO American plaice, 3LNO yellowtail flounder, 3NO witch flounder, 3LN redfish, 3O redfish, 3NOPs white hake, 3LNOPs thorny skate) which occupy shallower waters. The missed strata, however, typically accounted for most of the biomass index (~75%) for roughhead grenadier and therefore the 2019 autumn survey should not be used in future assessments of this stock. For Greenland halibut, the 2019 autumn survey point for Divs. 2J3K was considered “questionable” since an average of 12% of the survey biomass was found in the missed strata in previous years. Further examination revealed that MWPT was only minimally influenced (1%) by the incomplete strata and therefore the 2019 data point for Divs. 2J3K should be considered suitable for the harvest control rule currently being used for this stock. However, differential biases in the age-disaggregated data (with younger ages biased high and older ages, including the 10+ age group, biased low) and trends over time in the extent of the bias for some ages (especially for older ages) caused by the strata missed in 2019 raise concerns about the use of the 2019 data for any age-based assessment model. It was decided that sensitivity tests should be run on the indices/ages for each model.

Canada – Subarea 0A (SCR 20/07)

A multi-species bottom trawl survey of southern 0A (0A-South) (to approximately 72° N) was carried out in the Northwest Atlantic Fisheries Organization Subarea 0 during August 15-25, 2019. This is the earliest the survey has been conducted, about 6 weeks earlier compared to most previous surveys, and 10 weeks earlier than the 2017 survey (Treble 2018). The FV Helga Maria was chartered to conduct the 2019 survey, following the 2018 retirement of the RV Pâmiut. The Alfredo III trawl gear remained unchanged and was used at randomly selected stations between 400 and 1500 m. Deep-water surveys began in 0A-South in 1999 and were completed every second year between 2004 and 2014, then annually between 2015 and 2017. Surveys in 0B have been less frequent: 2000, 2001, 2011 and 2013 to 2016.

STACREC discussed the change in fishing vessels used to carry out the survey and whether the 2019 indices were comparable, especially in light of the earlier time period. The data reviewed suggested the change in vessel had an effect on the catchability at depths > 700 m, where Greenland halibut are known to be abundant. In addition, the earlier timing of the 0A-South survey in 2019 likely resulted in an unknown portion of the stock being beyond the survey area. As a result the comparability between 2019 and previous surveys is questionable and the results were not recommended for use in the 2020 assessment.

However, although the survey used to provide the age 1 abundance index also experienced vessel changes in 2018 and 2019, the results are considered to be comparable with those from earlier years.

Denmark/Greenland (SCR 20/03, 06, 12, 15):

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 2019, several vessels conducted the survey: from 1991 to 2017, the surveys were conducted onboard RV Paamiut, with chartered commercial vessels of similar size used from 1988-1990 and 2018 (Sjudarberg), and 2019 (Helga Maria). All the standard gear from the research vessel Pâmiut (such as cosmos trawl, doors, all equipment such as bridles, Marport sensors on doors, headlines, etc.) were used on the chartered commercial vessels in attempt to make the survey identical as possible. No survey was conducted in East Greenland in 2018 and 2019. The survey was carried out between June and July, onboard FV Helga Maria 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 198 valid hauls were conducted. Survey results including biomass and abundance indices for Greenland halibut, cod, deep sea redfish, golden redfish, American plaice, Atlantic wolfish, spotted wolfish and thorny skate were presented as Scientific Council Research Documents.

STACREC noted that a different vessel was used for the 2018 surveys and another in 2019. After discussion, indices are considered to be comparable with those from earlier because it was shown that gear performance parameters remained constant at depths < 700 m (but not > 700 m). Therefore the indices were utilized for redfish but not Greenland halibut in Subarea 0A or offshore 1A and 1B.

The Greenland halibut gillnet survey 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 2011 to 2015, the surveys in Uummannaq and Upernavik gradually changed from longline surveys to gillnet surveys. In 2019, 107 gillnet stations were set. Results are presented as Scientific Research Document.

EU-Spain and EU-Portugal (SCR 20/08, 09, 10, 11, 12 13):

The Spanish bottom trawl survey in NAFO Regulatory Area Div. 3NO was conducted from June 8th to 24th 2019 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 115 valid hauls were taken within a depth range of 47-1450 m according to a stratified random design. A hydrographic profile was cast 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 2019, 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 August 3rd to 23rd. 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 96. 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 120-1359 m.

The EU (Spain and Portugal) bottom trawl survey in Flemish Cap (Div. 3M) was carried out on board R/V Vizconde de Eza using the usual survey gear (Lofoten) from July 1st to 27th, 2019. 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 successful hauls was 180. 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 2019 EU (Spain and Portugal) bottom trawl groundfish surveys in NAFO Regulatory Area (Divs. 3LMNO):

New data on deep-water corals and sponges were analyzed from the 2019 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: were recorded in 100 of the 395 tows (25.3% of the total tows analyzed), with depths ranging between 156 - 1359 m. Significant catches of sponge (≥ 75 kg/tow) were found in three tows. Two of these catches were located in Flemish Pass area inside the KDE sponge polygon and inside closure area number 2. The third record was found besides closed area number 13 inside the KDE sponge polygon. Sponge catches for these tows ranged between 134.21 - 289.77 kg.

Large Gorgonians: were recorded in 6 of the 395 tows (1.52% of total tows analyzed), with depths ranging between 207 - 1155 m. None of the tows have significant catches of large gorgonians (≥ 0.6 kg/tow).

Small Gorgonians: Small gorgonians were recorded in 41 tows (10.37 % of total tows analyzed), with depths ranging between 262 - 1438 m. No significant catches (> 0.15 kg/tow) were recorded.

Sea Pens: Sea pens were recorded in 122 tows (30.88% of total tows analyzed), with depths ranging between 109 - 1438 m. No significant catches (> 1.4 kg/tow) were recorded.

USA (SCS Doc. 20/18):

The USA conducted a spring survey in 2019 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 2019 covering NAFO Subareas 4, 5, and 6 aboard the FSV *Henry B. Bigelow*. All planned strata were covered and the timing of the areas covered was similar to that in the past. Biomass indices were presented for 33 stocks and abundance for the two squid stocks.

c) Other Research Activities

No items were reported for this section.

6. Other Matters

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

During the 2019 STACREC meeting, it was suggested that there should be a better organized process for requesting and submitting data for stock assessment and other processes, such as National Research Reports. There was no time to discuss this during this meeting, but it is an item to be discussed in a future STACREC meeting.

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

Discussions on the above information has been ongoing for the past two years and further discussion will continue in June 2021.

National Research Reports:

STACREC concluded that these reports are useful and they should continue to be produced. At the September Annual Meeting in 2019, it was determined that the format of the National Research Reports has not changed since ICNAF and this format could be updated based on what SC members felt worked best. The Canadian Research Report used a different format in June 2020, but there was no time to discuss its utility. 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.

Further discussion will be deferred until June 2021.

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: STACREC will continue to develop a format for these tables. It was agreed in 2019 that STACREC members preferred Excel spreadsheets rather than text files.

Serial No.	SCS Doc.	Title
N6962	SCS Doc. 19/16	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
N6963	SCS Doc. 19/17	Tagging 2018
N6964	SCS Doc. 19/18	List of Biological Sampling Data for 2018
N6965	SCS Doc. 19/19	A Compilation of Research Vessel Surveys on a Stock-by-stock Basis
N7106	SCS Doc. 20/16	List of Biological Sampling Data for 2019
N7105	SCS Doc. 20/15	Available Data from the Commercial Fisheries Related to Stock Assessment (2019) and Inventory of Biological Surveys Conducted in the NAFO Area in 2019 and Biological Surveys Planned for 2020 and Early-2021
N7107	SCS Doc. 20/17	A Compilation of Research Vessel Surveys on a Stock-by-stock Basis

7. 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 24 September 2020.

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

Chair: Katherine Sosebee Rapporteur: Tom Blasdale

I. OPENING

The Committee met by correspondence from 21 to 25 September 2020 to consider the various matters in its agenda. Representatives attended from Canada, Denmark (in respect of Faroe Islands and Greenland), the European Union, France (in respect of St. Pierre et Miquelon) Japan, Norway, the Russian Federation, the United Kingdom and the United States of America. The Executive Secretary, Scientific Council Coordinator and other members of the Secretariat were in attendance.

II. ASSESSMENTS DEFERRED FROM THE JUNE 2020 MEETING.

1. Northern Shortfin Squid (*Illex illecebrosus*) in Subareas 3+4

Interim Monitoring Report (SCR Doc. 98/59, 75; 6/45; 16/21, 34REV; 19/ 42; 20/2, 10REV, 11)

a) Introduction

Illex illecebrosus has a lifespan of less than one year and is considered a single stock throughout its range from Newfoundland to Florida, in NAFO Subareas 2-6. However, the Subareas 3+4 and Subareas 5+6 stock components are assessed and managed separately by NAFO and the U.S.A. Mid-Atlantic Fishery Management Council, respectively. The Canada Department of Fisheries and Oceans (DFO) has not implemented a management plan for *Illex* fisheries that occur within their Exclusive Economic Zone (EEZ) in Subarea 3, the commercial and recreational inshore jig fisheries, and Subarea 4 (the historical Scotian Shelf fishery). The small *Illex* fishery that occurs off St. Pierre et Miquelon within the EEZ of France (in respect of St. Pierre et Miquelon) is also not managed. The stock assessment is data-poor and in-season stock assessments and annual biomass projections are not currently possible. Therefore, as of 2019, the SA 3+4 *Illex* assessments have been conducted in September instead of June to be able to incorporate the Div. 4VWX July survey indices for the current year. Indices of relative biomass and mean body weight were computed using data from the Div. 4VWX surveys conducted by the DFO. These indices were used to assess stock status (i.e., whether the Subareas 3+4 stock component was at a low or high productivity level) during the current year. The Subareas 3+4 nominal catch divided by the Div. 4VWX biomass index was used to assess annual relative exploitation rates. Such rates can only be computed through year *t*-1 because squid catch data for the current year were not available for SA 3+4 in time for presentation of the assessment results at the September Annual Meeting.

b) Data Overview

Since 1999, there has been no directed fishery for *Illex* in Subarea 4 and most of the catches from Subareas 3+4 have been from the Subarea 3 inshore jig fishery. There were no catches from Subarea 3 during 2013-2015. During 1999-2011, catches from Subareas 3+4 were low during most years (average = 1 078 t), compared to catches during 1976-1981 (average = 80 645 t), and ranged between about 57 t in 2001 to 6 981 t in 2006 (Figure 1.1). Catches in Subareas 3+4 were less than 50 t during 2012-2015 and reached the lowest level in the time series (since 1953) during 2015 (14 t). Thereafter, catches increased to 2 734 t in 2019 (of which 186 t were harvested in the NRA), the highest since 2006, but were only slightly above the average catch (2 510 t) for the 1982-2016 low productivity period. During 2000-2019, when the Subareas 3+4 TAC was 34 000 t, 2.7% of the TAC was harvested on average, with a peak of 20.5% in 2006. The majority of the catches during this period were harvested in Subarea 3 within the Canadian EEZ by the inshore jig fishery.

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

	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
TAC SA 3+4	34	34	34	34	34	34	34	34	34	34
STATLANT 21 SA 3+4	0.1[1]	0.1[1]	<0.1[1]	<0.1[1]	<0.1[1]	<0.1[1]	0.2[1]	0.4[1]	<0.1[1]	2.7[1]
STATLANT 21 SA 5+6[2]										
STACFIS SA 3+4	0.1	0.1	<0.1	<0.1	<0.1	<0.1	0.2	0.4	1.5	2.7
STACFIS SA 5+6[2]	15.8	18.8	11.7	3.8	8.8	2.4	6.7	22.5	24.1	27.1
STACFIS Total SA 3-6[3]	15.9	18.9	11.7	3.8	8.8	2.4	6.8	22.9	25.6	29.8

[1] Includes amounts (< 0.1 t to 18 t during 2010-2011 and 0.2 t to 47 t during 2012-2019) reported as 'Unspecified Squid' from Subarea 4 because they were likely *I. illecebrosus* based on the geographic distribution of each species.

[2] Catches from Subareas 5+6 are included because there is no basis for considering separate stocks in Subareas 3+4 and Subareas 5+6.

[3] STACFIS Total SA 3-6 catches were computed as catches harvested in the NRA (NAFO CESAG database) plus catches recorded in the USA and CA (Newfoundland and Maritimes Regions) commercial catch databases.

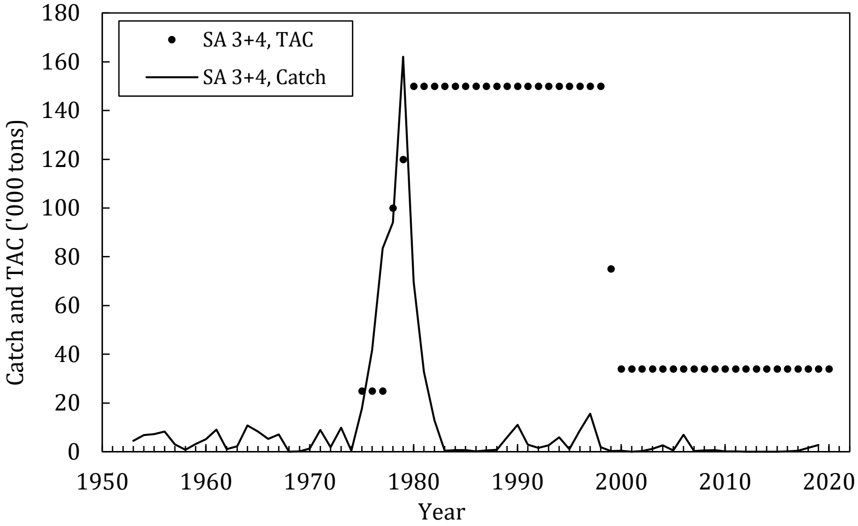


Figure. 1.1. Northern shortfin squid in Subareas 3+4: nominal catches and TACs.

Relative biomass indices, derived using data from the Canadian surveys conducted during July in Div. 4VWX, fluctuated widely after 2003 (Figure. 1.2). Biomass indices generally declined between 2004 and 2013, from a level near the high productivity period mean of 13.2 to the lowest level on record, respectively. During 2014-2016, biomass indices remained much lower than the 1982-2016 low productivity period average of 2.6, but then increased in 2017 to 16.1; the third highest level of the time series and greater than the 1976-1981 high productivity period average. However, since 1982, each year of high biomass (i.e., 1992, 2004 and 2006) during the low productivity period was followed by a much lower biomass level. Persistence of high biomass levels in 2018 could not be confirmed because a biomass index was not computed due to inadequate sampling of a majority of the *Illex* strata set because of survey vessel mechanical problems. However, the 2019 biomass index which was included in the 2019 September assessment, indicated that biomass was twice as high (32.1) as the 2017 index and was the second highest value in the time series. However, during 2020, the biomass index (8.2) decreased to a level below the high productivity period average (but remained higher than all but two of the biomass indices during 1982-2016).

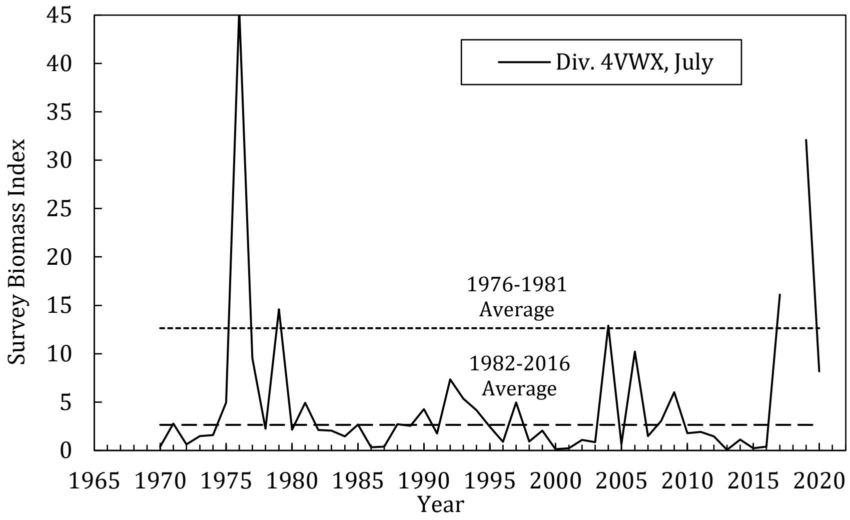


Figure. 1.2. Northern shortfin squid in Subareas 3+4: survey biomass indices from the July survey in Div. 4VWX.

The mean body weight of squid caught during the July Div. 4VWX surveys averaged 150 g during the 1976-1981 high productivity period (1976-1981) and 80 g during the low productivity period (1982-2016). Mean body weight increased from the lowest level of the time series in 1983 (27 g) to the second highest level of the low productivity period (121 g) in 1999 (Figure. 1.3). Between 2000 and 2006, mean body weight increased to a low productivity period peak of 137 g, but then gradually declined to 42 g in 2013. Following wide fluctuations around the low productivity average during 2014-2016, mean body weight increased to a level similar to 2006 in 2017 (134 g). For the reason explained above, mean body weight was not computed for 2018, so it is unknown whether mean body weight was above the high productivity period average for two consecutive years. During the 2019 assessment, the Scientific Council noted that the 2019 mean body weight (163 g) was above high productivity period average for the first time since 1979 and concluded that the status of the Subareas 3+4 stock component may be moving toward a high productivity period. However, this level of high biomass did not persist for a second year; instead mean body weight dropped below the high productivity average to 123 g in 2020 (but remained higher than all but one year during 1982-2016).

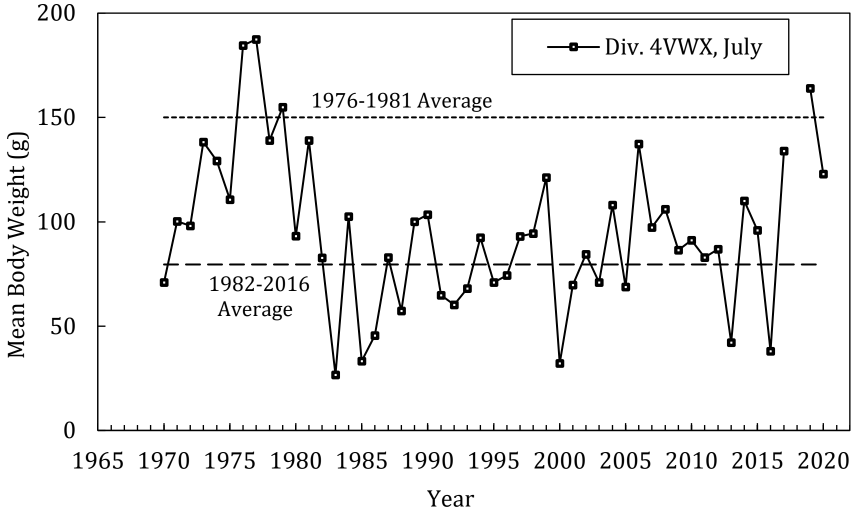


Figure. 1.3. Northern shortfin squid in Subareas 3+4: mean body weights of squid from the July survey in Div. 4VWX.

Catch/biomass ratios (SA 3+4 nominal catch/Division 4VWX July survey biomass index) / 10 000) were much lower than the 1982-2016 mean (0.12) during most years since 2001 and the ratio was 0.01 in 2019 (Figure. 1.4). The 2020 ratio could not be computed because the Subareas 3+4 catches were not available for SA 3+4 in time for the preparation of this assessment.

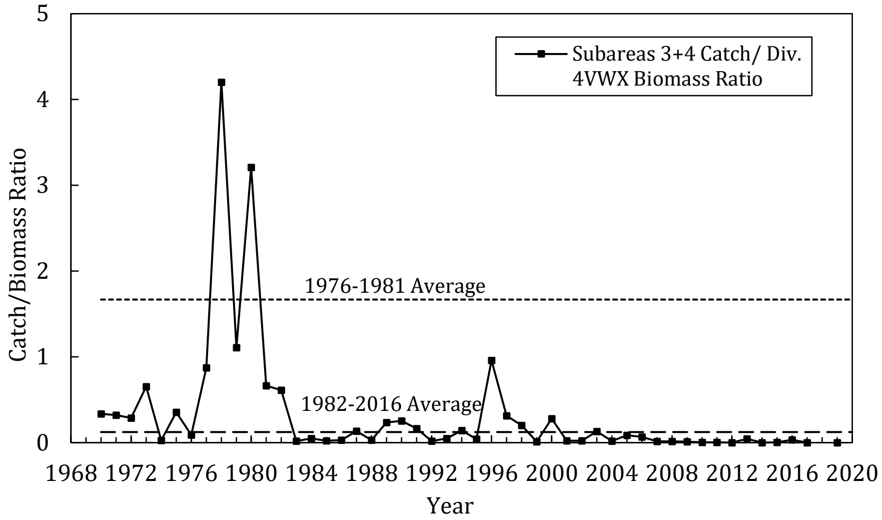


Figure. 1.4. Northern shortfin squid in Subareas 3+4: catch/biomass ratios (SA 3+4 nominal catch/Division 4VWX July survey biomass index) / 10 000).

c) Conclusion

In 2019, the Scientific Council concluded that the Subareas 3+4 stock component may be moving toward a high productivity period based on the fact that the 2017 and 2019 biomass indices and the 2019 mean body weight index were above their respective high productivity period means. However, without the 2018 survey indices, the SC could not determine whether similarly high values persisted for two consecutive years, and therefore, recommended (and the Commission adopted) status quo catch advice of 34 000 t; the maximum TAC adopted for low productivity years.

The high biomass and mean body weight indices of 2019 did not persist in 2020, and instead declined to levels midway between their respective low and high productivity period means. However, the 2020 values of both indices were greater than most of the values for 1982-2016. Unless catches were under-reported, the high biomass indices in 2017 and 2019 did not translate into similarly high catches in the Subarea 3+4 fisheries; instead relative exploitation rates continued to remain extremely low during these years. The reason for the low exploitation rates during these two years was not due to a TAC constraint. During 2000-2019, only 2.7% of the 34 000 t TAC was harvested on average, with a maximum of 20.5% in 2006. Since 2000, most of the Subareas 3+4 catches were harvested in Subarea 3 within the Canadian EEZ, by the inshore jig fishery, rather than from within the NRA.

In combination, the large decrease in biomass and mean body size indices, from above the high productivity period average in 2019 to below it in 2020, and the continued low exploitation rates in recent years do not support an increase in the status quo catch advice (34 000 t).

The next assessment is planned for 2022.

d) Research Recommendation

In 2013, STACFIS **recommended** that *gear/vessel conversion factors be computed to standardize the 1970-2003 relative abundance and biomass indices from the July Div. 4VWX surveys.*

STATUS: No progress has been made.

III. OTHER MATTERS

1. Nomination of Designated Experts

There were no changes to the current Designated Experts for stocks.

2. Other matters

a) Review of SCR and SCS Documents

No SCRs were submitted to this meeting.

b) FIRMS Classification for NAFO Stocks

STACFIS reiterates that the Stock Classification system is not intended as a means to convey the scientific advice to the Commission, and should not be used as such. Its purpose is to respond to a request by FIRMS to provide such a classification for their purposes. The category choices do not fully describe the status of some stocks. Scientific advice to the Commission is to be found in the Scientific Council report in the summary sheet for each stock.

Stock Size (incl. structure)	Fishing Mortality			
	None–Low	Moderate	High	Unknown
Virgin–Large	3LNO Yellowtail Flounder 3LN Redfish			
Intermediate	3M Northern shrimp[3] SA3+4 Northern shortfin squid	SA0+1 Northern shrimp[1] DS Northern shrimp[1] SA 0+1 (Offshore) Greenland halibut 3M Redfish[3] SA2+3KLMNO Greenland halibut	3M cod	Greenland halibut in Disko Bay[2] SA1 American Plaice SA1 Spotted Wolffish
Small	3NOPs White hake 3NO Witch flounder 3LNOPs Thorny skate			Greenland halibut in Uummannaq[2] Greenland halibut in Upernavik[2]
Depleted	3M American plaice 3LNO American plaice 3NO Cod 3LNO Northern shrimp			SA1 Redfish SA1 Atlantic Wolffish
Unknown	SA2+3 Roughhead grenadier 3NO Capelin 3O Redfish	1B-C Greenland halibut Inshore	1D Greenland halibut Inshore 1E-F Greenland halibut Inshore	6G Alfonsino

[1] Shrimp will be re-assessed at the SC shrimp meeting in November 2019

[2] Assessed as Greenland halibut in Div. 1A inshore

[3] Fishing mortality may not be the main driver of biomass for Div. 3M Shrimp and Redfish

c) Other business

i) Invited speaker

In 2019, STACFIS discussed having an invited speaker attend the June 2020 Scientific Council meeting, in conjunction with STACREC on the topic of combining surveys for the purpose of developing more fulsome indices wherever possible. This person may also be an external reviewer for the meeting.

Hughes Benoît was invited to perform this role in 2020 but due to the Pandemic situation it was not possible for him to give the talk. The SC chair will invite Dr. Benoît to give this talk in June 2021.

IV. ADJOURNMENT

The meeting was adjourned on 25 September 2020.

PART D: REPORT OF THE SCIENTIFIC COUNCIL SHRIMP MEETING

via WebEx

26 – 30 October 2020

Recommended Citation:

NAFO. 2020. Report of the NAFO Scientific Council Shrimp Meeting, 26 – 30 October 2020, via WebEx. NAFO SCS Doc. 20/20.

SC-NIPAG Participants 2020

SC-NIPAG participants from left to right:

First row Dayna Bell MacCallum, Tom Blasdale, Carsten Hvingel, AnnDorte Burmeister, Ole Ritzau Eigaard.

Second row: CarmenFernández, Fabian Zimmermann, Frank Rigét, Guldborg Søvik, José Miguel Casas Sanchez

Third row: Kalvi Hubel, Katherine Skanes, Katherine Sosebee, Mark Simpson, Susan Thompson

Fourth row: Tanja Buch, Valeriy Paramonov, Wojciech Walkusz

Missing from photo: Brittany Beauchamp, Aleksei Stesko, Rui Catarino

Report of the Scientific Council Meeting
26 – 30 October 2020

Chair: Carmen Fernández Rapporteur: Tom Blasdale

I. PLENARY SESSIONS

The Scientific Council met by correspondence from 26 to 30 October 2020 to consider the various matters in its Agenda. Representatives attended from Canada, Denmark (in respect of Greenland), European Union, Norway, Russian Federation, Ukraine and the United States of America. The NAFO Scientific Council Coordinator and Scientific Information Administrator were also in attendance.

The opening session of the Council was called to order at 08:00 (Halifax time, UTC - 3 hours) on 26 October. The Chair welcomed representatives, advisers and experts to the opening session of Scientific Council. The Chair noted that the primary reason for this meeting was to provide advice on shrimp stocks based on the assessments provided by the joint NAFO/ICES *Pandalus* Assessment Group (NIPAG). It was further noted that advice for the 3M stock was given in September 2020 (SCS Doc. 20/22) and hence no further assessment would be carried out in the present meeting. ICES members of NIPAG were granted observer status at the Scientific Council meeting, and the Chair wished all NIPAG members a productive and successful meeting.

The Scientific Council Coordinator, Tom Blasdale, was appointed Rapporteur.

Several sessions were held throughout the course of the meeting to deal with specific items on the agenda. The concluding session was convened at 08:00 30 October 2020 when the Council then considered and adopted Sections III.1–4 of the “Report of the NAFO/ICES *Pandalus* Assessment Group” (NAFO SCS Doc. 20/21). The Council, having considered the results of the assessments of the NAFO stocks, provided advice and recommendations.

The meeting was adjourned at 13:00 on 30 October 2020.

The revised Agenda, List of Research (SCR) and Summary (SCS) Documents, and the List of Representatives, Advisers and Experts, are given in Appendix I, II and III, respectively.

II. REVIEW OF RECOMMENDATIONS IN 2019

These were reviewed in the appropriate sections of the NIPAG report.

III. NAFO/ICES *PANDALUS* ASSESSMENT GROUP

In 2020, NIPAG fully assessed two stocks of relevance to NAFO: northern shrimp in Subareas 0 and 1, and northern shrimp in Denmark Strait and off East Greenland. The Scientific Council summary sheets, conclusions and advice for these stocks are presented in Section IV of this report.

Additionally, NIPAG reviewed assessments for one stock for which advice was given in September 2020 (SCS Doc. 20/22): Northern shrimp in NAFO Division 3M. The full NIPAG report is available in NAFO SCS Doc. 20/21.

IV. FORMULATION OF ADVICE (SEE ANNEXES 1, 2 AND 3)

1. Request from the Commission

Advice for shrimp in Division 3M was provided by the Scientific Council in September 2020. No further requests were considered in October 2020.

2. Requests from Coastal States

a) Northern shrimp in Subarea 1 and Div. 0A

Advice November 2020 for 2021

Recommendation

In line with Greenland's stated management objective of maintaining a mortality risk of no more than 35% (subject to a risk of biomass being below B_{lim} of less than 1%), Scientific Council advises that catches in 2021 should not exceed 115 000 t.

With regard to the Canadian harvest strategy, Scientific Council notes that catches of 115 000 t in each of the years 2021 to 2023 would result in less than 35% risk of exceeding Z_{msy} in 2021 and 2022 and exactly 35% risk of exceeding Z_{msy} in 2023.

Management Objectives

A management plan and management objectives have been defined by the Government of Greenland in 2018. The objective is to maintain a mortality risk of no more than 35% of exceeding Z_{msy} (subject to a risk of biomass being below B_{lim} of less than 1%). Canada has a harvest strategy with the objective to maintain the stock in the Healthy Zone (>80% of Bmsy); when the biomass is above 80% of B_{msy}, the risk of being above Z_{msy} should be less than 35%, based on the 3-year projections. Advice was also drafted to be consistent with the NAFO precautionary approach (FC Doc. 04-12).

Objective	***Status***	***Comment/consideration***
Apply Precautionary Approach	●	Stock status is both estimated and forecast relative to precautionary reference points

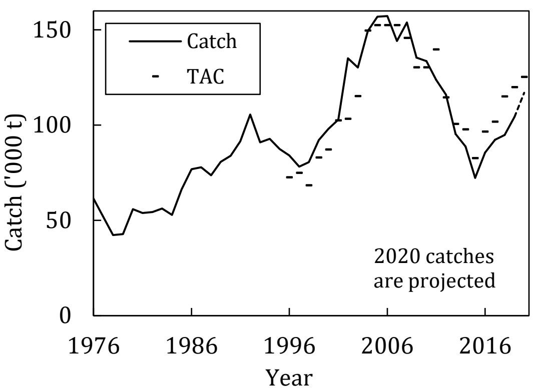
● OK

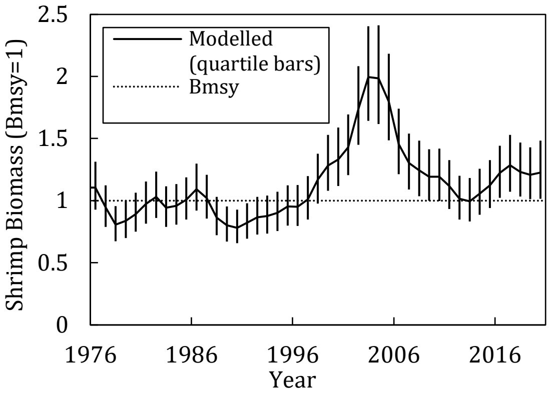
Management unit

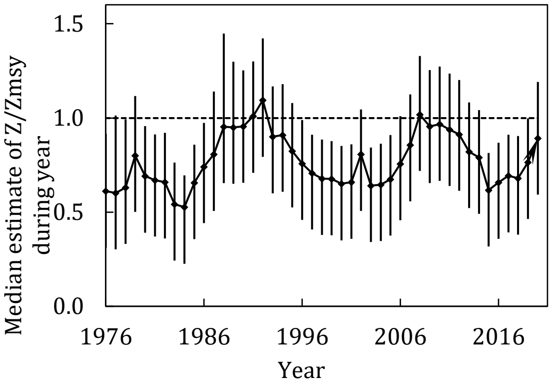
The stock, considered distinct from all others, is distributed throughout Subarea 1, extends into Div. 0A east of 60°30'W, and is assessed as a single stock. In 2019, 98% of the landings were from Greenland.

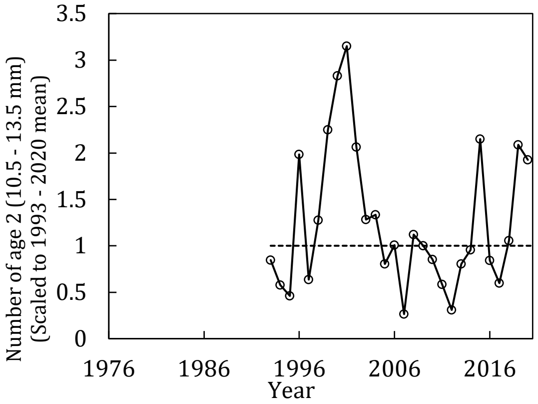
Stock status

Biomass at the end of 2020 is above B_{msy} and the probability of being below B_{lim} is very low (<1%). The probability of mortality in 2020 being above Z_{msy} is 40%. Recruitment (number of age-2 shrimp) in 2020 is above average.









Reference points

B_{lim} has been established as 30% B_{msy}, and Z_{msy} (fishery and cod predation) has been set as the mortality reference point (FC Doc. 04-18). B_{msy} and Z_{msy} are estimated directly from the assessment model.

Projections

Predicted probabilities of transgressing precautionary reference points in 2021 – 2023 under eight catch options and subject to predation by a cod stock with an effective biomass of 7 Kt.

7 000 t cod	**Catch option ('000 tons)**							
Risk of:	**95**	**100**	**105**	**110**	**115**	**120**	**125**	**130**
falling below Bmsy end 2021 (%)	24	24	25	27	26	27	27	28
falling below Bmsy end 2022 (%)	25	25	27	28	29	29	30	31
falling below Bmsy end 2023 (%)	25	26	28	30	31	32	33	33
falling below Blim end 2021 (%)	0	0	0	0	0	0	0	0
falling below Blim end 2022 (%)	0	0	0	0	0	0	0	0
falling below Blim end 2023 (%)	0	0	0	0	0	0	0	0
exceeding Zmsy in 2021 (%)	19	22	26	30	33	37	40	44
exceeding Zmsy in 2022 (%)	19	22	27	31	34	39	42	45
exceeding Zmsy in 2023 (%)	20	23	28	32	35	39	43	46
falling below Bmsy 80% end 2021 (%)	8	8	9	9	9	9	10	9
falling below Bmsy 80% end 2022 (%)	9	10	11	11	11	12	13	13
falling below Bmsy 80% end 2023 (%)	10	10	12	12	13	14	16	17

Assessment

Advice is based on risk analysis coming from a quantitative model. The analytical assessment was run in 2020 with revised treatment of the input data (SCR Doc. 20-56, 20-58) and with updated data series.

The next assessment is scheduled for 2021.

Human impact

Mortality related to the fishery has been documented. Other human sources (e.g. pollution, shipping, oil-industry) are considered minor.

Biological and Environmental Interactions

Cod is an important predator on shrimp. This assessment incorporates this interaction. Other predation is likely but not explicitly considered. Shrimps might be important predators on, for example, fish eggs and larvae.

Fishery

Shrimps are caught in a directed trawl fishery. Bycatch of fish in the shrimp fishery is around 1% by weight. The fishery is regulated by TAC.

Recent catches and TACs (t) have been as follows:

	2011	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**
Enacted TAC[1]	139 583	114 425	100 596[1]	97 649[1]	82 561[1]	96 426[1]	101 706[1]	114 876[1]	119 875[1]	125 229[1]
STATLANT 21	123 195	114 970	91 802	88 834	71 779	84 303	91 725	91 869	102 706	
NIPAG	123 989	115 977	95 381	88 765	72 256	85 527	92 584	94 878	*104 314*	*117 000[2]*

[1] Sum of TACs autonomously set by Canada and Greenland.

[2] Projected to year end

Effects of the fishery on the ecosystem

Measures to reduce effects of the fishery on the ecosystem include area closures, moving rules and gear modifications to reduce damage to benthic communities and reduce bycatch.

Special comment

From 1993 to 2010 the Greenlandic survey in the Canadian area (SFA1) was conducted annually. In that period, average biomass in that area was 2% of the total biomass estimated in Subarea 1 and Div. 0A. Since 2011, due to ice cover, there has only been sporadic information from the Greenlandic survey in the Canadian area (SFA1). The area was surveyed only in 2013 and 2017. In 2013, the biomass in that area (SFA1) was less than 1% of the total estimated biomass in Subarea 1 and Div. 0A, whereas it was about 2% in 2017.

Source of Information SCS Doc 13/04, FC Docs 04-18, SCR Docs 20-53, 54, 55, 56, 57, 58.

b) Northern shrimp in Denmark Strait and off East Greenland

Advice November 2020 for 2021

Recommendation

The available information indicates the stock has increased in recent years. Scientific Council advises that fishing mortality should not increase in 2021. On this basis, the catch in 2021 should not exceed 3000 t, corresponding to the projected catch in 2020.

Management objectives

No explicit management plan or management objectives have been defined by the Government of Greenland. Advice was drafted to be consistent with the NAFO precautionary approach (FC Doc 04-12).

Objective	*Status*	*Comment/consideration*
Apply Precautionary Approach	🟡	B_{lim} is defined. No fishing mortality reference is defined.

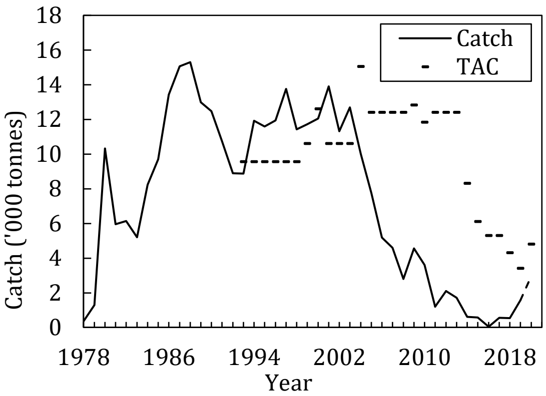
🟡 Intermediate

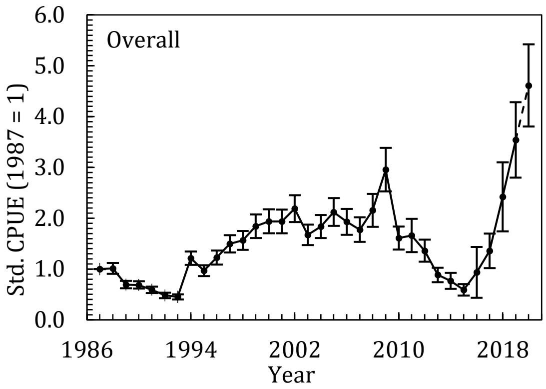
Management unit

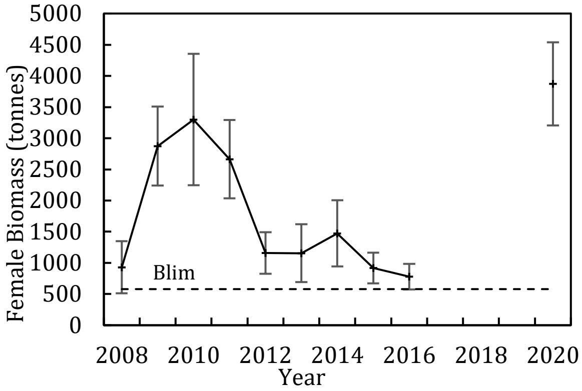
The shrimp stock is distributed off East Greenland in ICES Div. 14b and 5a and is assessed as a single population.

Stock status

The stock in 2020 is at a high level. The survey biomass in 2020 is the highest observed since the beginning of the survey, in 2008. The commercial CPUE in 2020 is also the highest since the beginning of the time series, in 1986. There is no recruitment index available for this stock, few juvenile shrimps are caught in the survey area.







Reference points

Scientific Council considers that 15% of the maximum survey female biomass provides a proxy for B_{lim}. The record high survey biomass found in 2020 results in B_{lim} = 580 t.

Projections

Quantitative assessment of risk at various catch options is not possible for this stock currently.

Assessment

A survey was conducted in 2020 after three years with no survey data. The survey biomass was the highest since the survey started in 2008. The standardized commercial CPUE has increased since 2015 and was at a historical high level in 2020. The survey biomass in 2020 is concentrated in a fairly small geographical area and the recent fishing effort concentrates in the same general area. Recent fishing effort has been relatively low, so this CPUE may not reflect stock status for the entire stock distribution area.

An analytical assessment model (surplus production model, SPiCT), using both the commercial and the survey CPUE, was investigated this year. Results can be found in the NIPAG report (SCS 20/021). The model results indicated a healthy stock status; however, the model needs to be further explored next year.

Human impact

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

Biological and Environmental Interactions

Cod is an important predator on shrimp. The cod stock has generally been decreasing in East Greenland waters since 2014.

Fishery

Shrimp is caught in a directed trawl fishery. The fishery is regulated by TAC and bycatch reduction measures include move-on rules and Nordmøre grates.

Recent catches and TAC (t) were as follows:

	2011	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**
Enacted TAC	12 400	12 400	12 400	8 300	6 100	5 300	5 300	4 300	3 384	4 750
SC Recommended TAC	12 400	12 400	12 400	2 000	2 000	2 000	2 000	2 000	2 000	2 000
NIPAG	1 199	2 109	1 717	622	576	49	561	547	1 580	2 839[1]

[1] To July 2020

Effects of the fishery on the ecosystem

Measures to reduce effects of the fishery on the ecosystem include move-on rules to protect sponges and corals.

Source of Information

SCR Doc. 20-059, 20-060, 20-061.

V. OTHER MATTERS

1. Scheduling of Future Meetings

a) Scientific Council Meetings

i) Scientific Council Shrimp Meeting September 2021

The 2021 Scientific Council shrimp meeting will be held in Copenhagen, Denmark 8-14 September 2021. There will an additional meeting by WebEx in November 2021 to provide advice on shrimp in East Greenland (ICES Div. 14b and 5a).

b) NAFO/ICES Joint Working Groups

i) NIPAG, October/November 2020

Thie2021 NIPAG meeting will be held in Copenhagen, Denmark 8-14 September 2021.

2. Topics for Future Special Sessions

No special session were proposed

3. Other Business

No other business was discussed.

VI. ADOPTION OF SCIENTIFIC COUNCIL AND NIPAG REPORTS

The Council at its session on 30 October 2020 considered and adopted Sections III.1-4 of the "Report of the NAFO/ICES *Pandalus* Assessment Group" (NAFO SCS Doc. 20/21). The Scientific Council then considered and adopted its own report of the October 2020 meeting subject to editorial changes after the meeting.

VII. ADJOURNMENT

The NIPAG meeting was adjourned at 13:00 on 30 October 2020. The Chairs thanked all participants, especially the designated experts, for their hard work. The Chair thanked the NAFO and ICES Secretariats for all of their logistical support. The report was adopted at the close of the meeting, subject to editorial changes after the meeting.

PART E: NAFO/ICES *PANDALUS* ASSESSMENT GROUP MEETING (NIPAG)

via WebEx

26 to 30 October 2020

Contents

Recommended Citation:

NAFO/ICES. 2020. Report of the NAFO/ICES *Pandalus* Assessment Group Meeting, 26 - 30 October 2020, WebEx. NAFO SCS Doc. 20/21.

---

[1] For citation purposes, page 55 in original document.

[2] For citation purposes, page 55 in original document.

[3] For citation purposes, page 66 in original document.

[4] For citation purposes, page 85 in original document.

NIPAG Participants 2020

NIPAG participants from left to right:

First row Dayna Bell MacCallum, Tom Blasdale, Carsten Hvingel, AnnDorte Burmeister, Ole Ritzau Eigaard.

Second row: CarmenFernández**,** Fabian Zimmermann, Frank Rigét, Guldborg Søvik, José Miguel Casas Sanchez

Third row: Kalvi Hubel, Katherine Skanes, Katherine Sosebee, Mark Simpson, Susan Thompson

Fourth row: Tanja Buch, Valeriy Paramonov, Wojciech Walkusz

Missing from photo: Brittany Beauchamp, Aleksei Stesko, Rui Catarino

Report of the NIPAG Meeting

26 to 30 October 2020

Co-Chairs: Katherine Sosebee, Ole Ritzau Eigaard. Rapporteur: Tom Blasdale

I. OPENING

The NAFO/ICES *Pandalus* Assessment Group (NIPAG) met by correspondence from 26 to 30 October 2020 to consider stock assessments referred to it by the Scientific Council of NAFO and by the ICES Advisory Committee. Representatives attended from Canada, Denmark (in respect of Greenland), European Union, Norway, Russian Federation, Ukraine and the United States of America. The NAFO Scientific Council Coordinator and Scientific Information Administrator were also in attendance.

II. GENERAL REVIEW

1. Review of Research Recommendations in 2019

Recommendations applicable to individual stocks are given under each stock in the "stock assessments" section of this report.

2. Review of Catches

Catches and catch histories were reviewed on a stock-by-stock basis in connection with each stock.

III. STOCK ASSESSMENTS

1. Northern shrimp (*Pandalus borealis*) on the Flemish Cap (NAFO Div. 3M)

This stock was assessed during the 14 September 2020 meeting of the Scientific Council in conjunction with NIPAG (NAFO SCS Doc. 20/22). NIPAG reviewed the assessment during the present meeting. There were no further recommendations.

2. Northern shrimp (*Pandalus borealis*) on the Grand Bank (NAFO Divs. 3LNO)

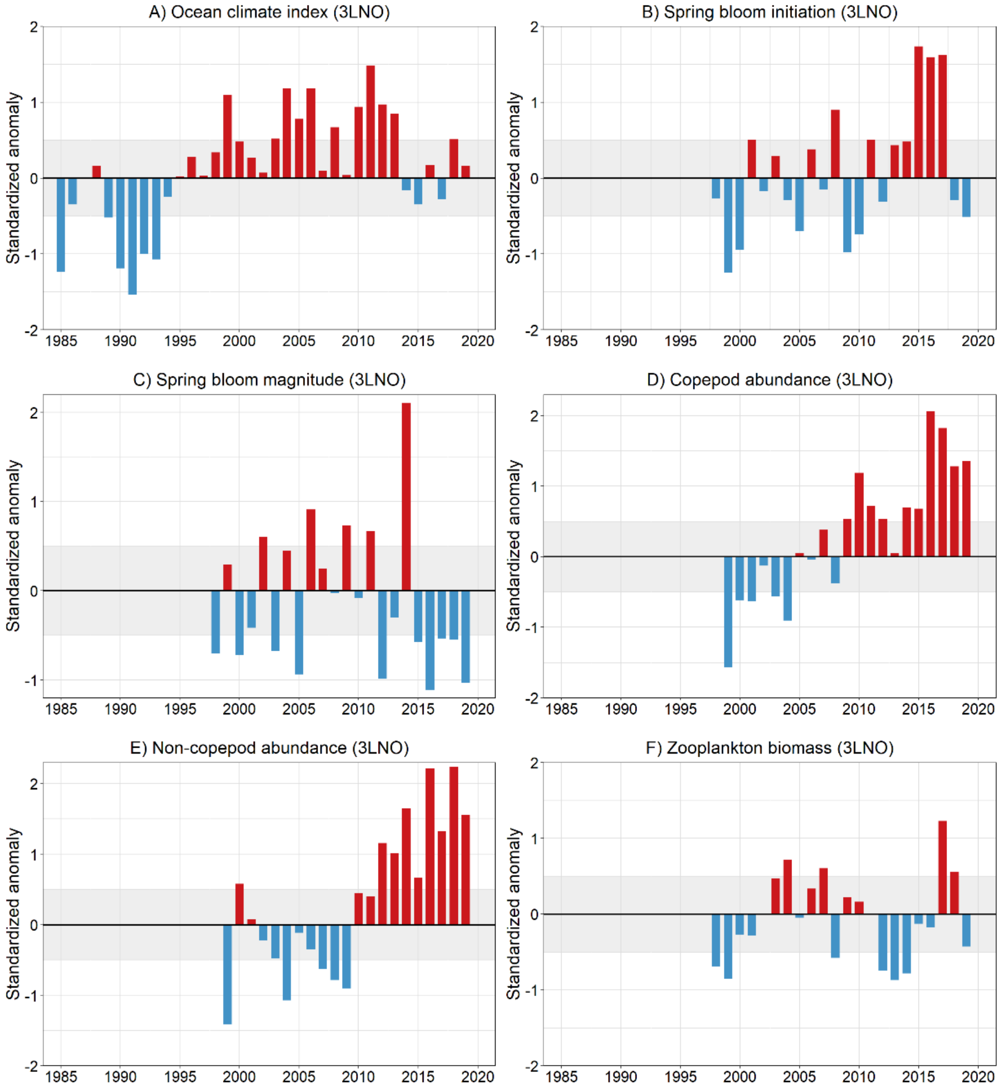
Interim monitoring report

(SCR Docs. 04/012, 20/059, 20/060, 20/061)

Environmental Overview

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.


A) Ocean climate index (3LNO)
B) Spring bloom initiation (3LNO)
C) Spring bloom magnitude (3LNO)
D) Copepod abundance (3LNO)
E) Non-copepod abundance (3LNO)
F) Zooplankton biomass (3LNO)
Standardized anomaly
2
1
0
-1
-2
1985
1990
1995
2000
2005
2010
2015
2020

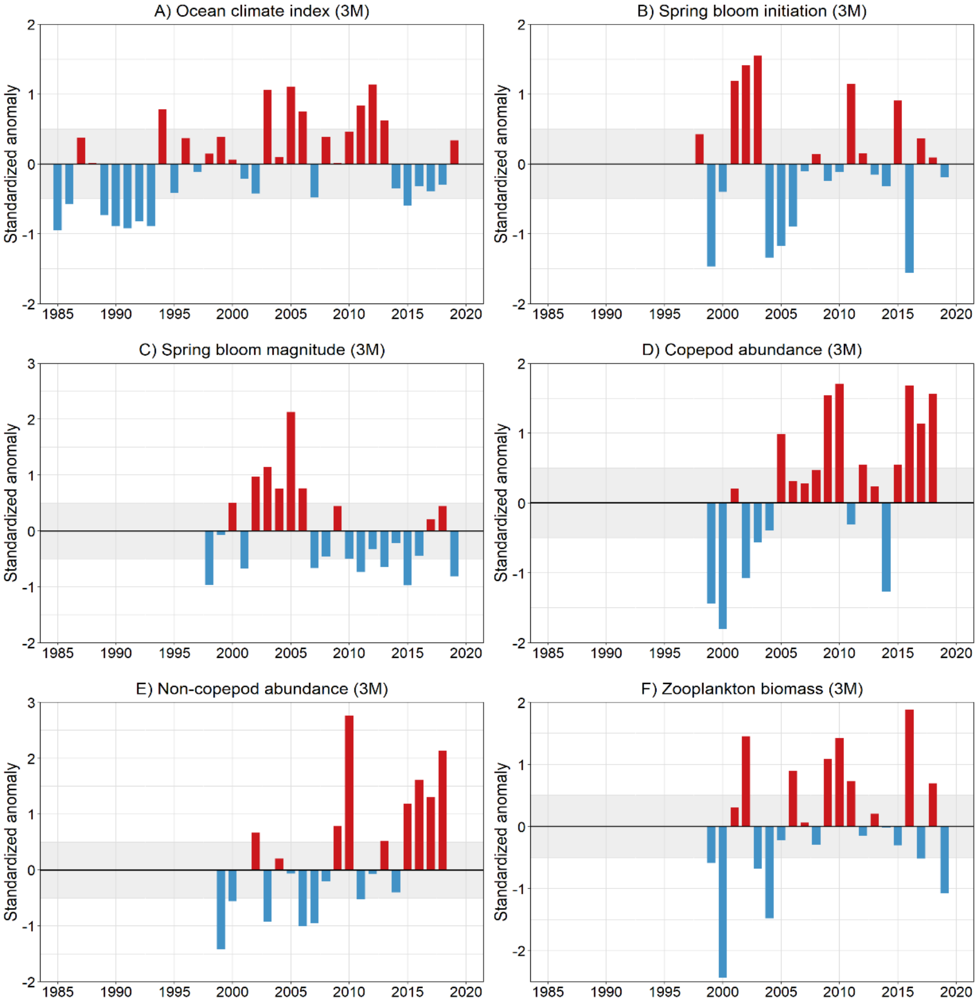


Figure 2.1. Environmental indices for NAFO Divisions 3LNO during 1990-2019. The ocean climate index (A) is the average of 12 individual time series of standardized ocean temperature anomalies: sea surface temperatures (SSTs) for Divs. 3L, 3N and 3O, vertically average ocean temperature (0-176 m) at Station 27, mean temperature and CIL volumes over standard hydrographic sections Seal Island, Bonavista and inshore Flemish Cap (FC-01 to FC-20), and mean bottom temperature in 3LNO for spring and fall. All these variables are presented in Cyr et al. (2020). Phytoplankton spring bloom magnitude (B) and duration (C) indices for the 1998-2019 period are derived from three satellite Ocean Colour boxes (Avalon Channel, Hibernia, and Southeast Shoal; see SCR Doc. 20/035 for box location). Zooplankton abundance copepod and non-copepod) and biomass (D & E) indices for the 1999-2019 period are derived from two cross-shelf oceanographic sections (Flemish Cap [3LN portion only] and Southeastern Grand Banks) and one coastal high-frequency sampling station (Station 27). 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 with 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 (shaded area) are considered normal conditions.

The water masses 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. These are formed during winter and last throughout the year until the late fall. The 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 (Figure 2.1.A) has remained mostly above normal between the late 1990s and 2013, reaching a peak in 2011. The index has returned to normal conditions between 2014 and 2019, with 2018 being the warmest of this 6th-year time series. A general trend towards later spring blooms (Figure 2.1.B) has been observed since 1998. However, spring bloom timing was back to near normal for a second consecutive year in 2019 after 3 years of late blooms. Spring bloom magnitude (Figure 2.1.C) oscillated between positive and negative anomalies with observable trends between 1998 and 2014. Bloom magnitude has remained below normal since 2015 with the second-lowest spring production of the time series observed in 2019. The abundance of copepod (Figure 2.1.D) and non-copepod (Figure 2.1.E) zooplankton showed strong increasing trends since the beginning of the time series. The abundance of copepods was above normal for a 6th consecutive year in 2019 with third highest anomaly of the time series. The abundance of non-copepods was also above normal for the 8th consecutive year in 2019. Zooplankton biomass (Figure 2.1.F) has been oscillating between periods of negative and positive anomalies throughout the time series with no strong departure from normal conditions except in 2017 when biomass reached a time series record high. Zooplankton biomass returned to near normal values in 2019 after two years of above normal levels

a) Introduction

This shrimp stock is distributed around the edge of the Grand Bank, mainly in Div. 3L. The fishery began in 1993 and came under TAC control in 2000 with a 6 000 t TAC. Annual TACs were raised several times between 2000 and 2009 reaching a level of 30 000 t for 2009 and 2010. The TAC was then reduced annually until no directed fishing (ndf) was implemented in 2015 to 2020 (Fig. 2.2). The TAC entries in the table below include autonomous TACs from Denmark (in respect of the Faroe Islands and Greenland) and STATLANT 21 entries.

Recent catches and TACs (t) for shrimp in Div. 3LNO (total) are as follows:

	2011	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**
TAC[1]	20971	13108	9393	4697	ndf	ndf	ndf	ndf	ndf	ndf
STATLANT 21	13013	10099	7919	2282	0	0	0	0	0	
NIPAG[2]	12900	10108	8647	2289	0	0	0	0	0	

[1] Includes autonomous TAC as set by Denmark (in respect of the Faroe Islands and Greenland).

[2] NIPAG catch estimates have been updated using various data sources (see p. 13, SCR. 14/048).

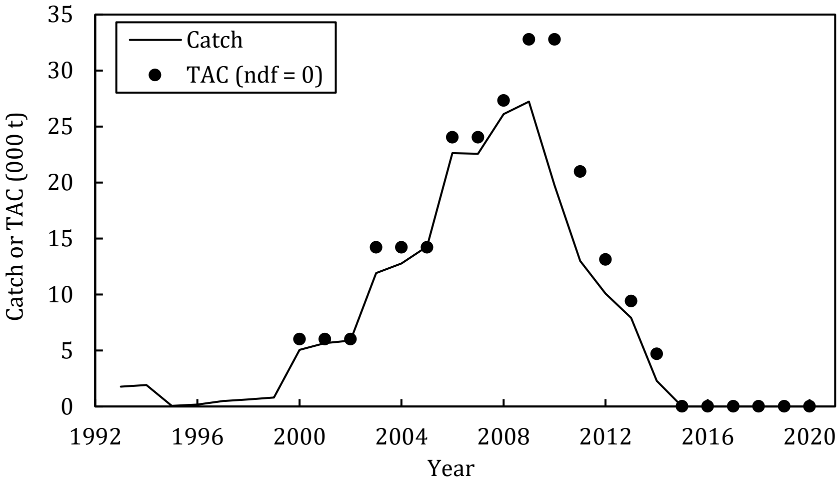


Figure 2.2. Shrimp in Div. 3LNO: Catches and TAC. The TAC illustrated includes the autonomous quotas set by Denmark (in respect of the Faroe Islands and Greenland). No directed fishing is plotted as zero TAC.

b) Input data

i) Commercial fishery data

Effort and CPUE. Catch and effort data have been available from Canadian vessel logbooks and observer records since 2000; however there was no fishery from 2015 to present.

ii) Research survey data

Canadian multi-species trawl survey. Canada has conducted stratified-random surveys in Div. 3LNO, using a Campelen 1800 shrimp trawl for spring (1999–2019) and autumn (1996–2019). The autumn survey in 2004, and the spring surveys in 2015, 2017-2018 and 2020 were incomplete and therefore could not be used to produce biomass indices for Div. 3LNO. The autumn 2014 survey only surveyed Div. 3L, however since about 95% of the biomass in Div. 3LNO comes from Div. 3L annually, it was considered useful as a proxy for Div. 3LNO for 2014.

Spanish multi-species trawl survey. EU-Spain has been conducting a stratified-random survey in the NAFO Regulatory Area (NRA) part of Div. 3L since 2003 and in the NRA part of Div. 3NO since 1995. Data are collected with a Campelen 1800 trawl. There was no EU-Spain Div. 3L survey in 2005 or Div. 3LNO survey in 2020.

c) Assessment results

No analytical assessment is available. Evaluation of stock status is currently based upon interpretation of research survey data.

Biomass indices. In Canadian surveys, about 95% of the biomass was found in Div. 3L, distributed mainly along the northeast slope in depths from 185 to 550 m. Total, fishable (shrimp with carapace length > 17mm) and female (SSB) biomass and abundance indices follow the same trend throughout the survey time series. There was an overall increase in both the autumn and spring indices to 2007 after which they decreased by over 95% to amongst the lowest levels in the autumn time-series in 2019 and the second lowest level in the spring time-series in 2019 (Figure 2.3).

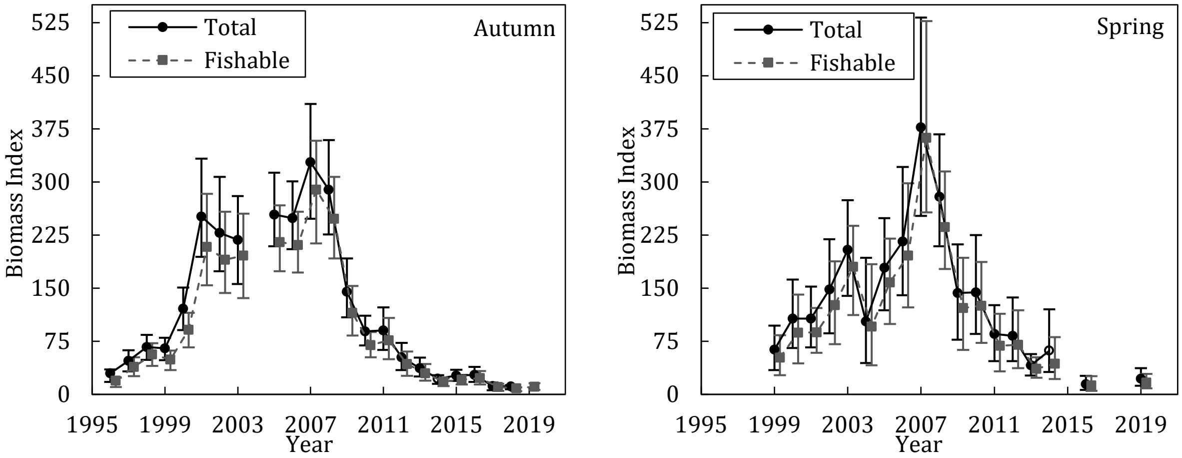


Figure 2.3. Shrimp in Div. 3LNO: Total and fishable biomass index estimates from Canadian autumn and spring multi-species surveys (with 95% confidence intervals). The 2014 autumn index is for Div. 3L only. There are no available biomass index estimates for spring 2015, 2017-2018 or 2020.

EU-Spain survey biomass indices for Div. 3L and Divs. 3NO, within the NRA only, increased from 2003 to 2008 followed by a 93% decrease by 2012 remaining near that level through 2019 (Figure 2.4).

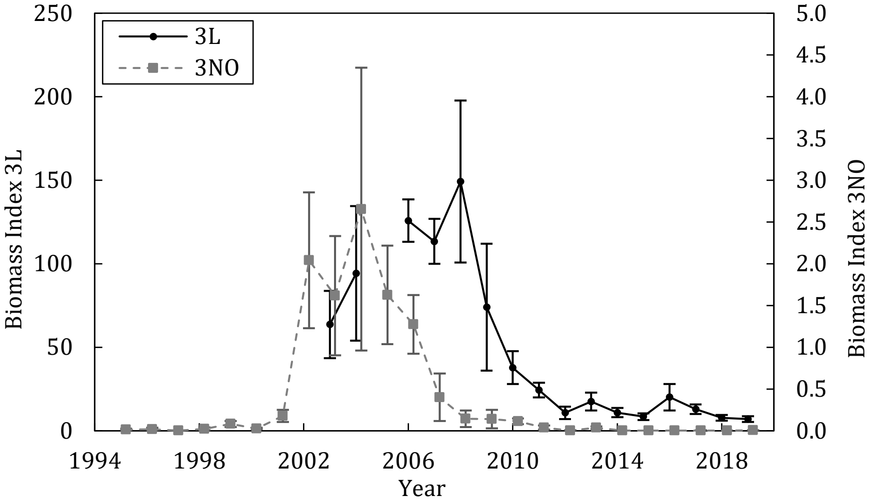


Figure 2.4. Shrimp in Div. 3LNO: Total biomass index estimates from EU - Spain multi-species surveys (± 1 SE) in the NAFO Regulatory Area (NRA) of Div. 3LNO. There are no available biomass index estimates for 2020.

Stock Composition. Both males and females showed a broad distribution of lengths in recent surveys indicating the presence of more than one year class (Figure 2.5).

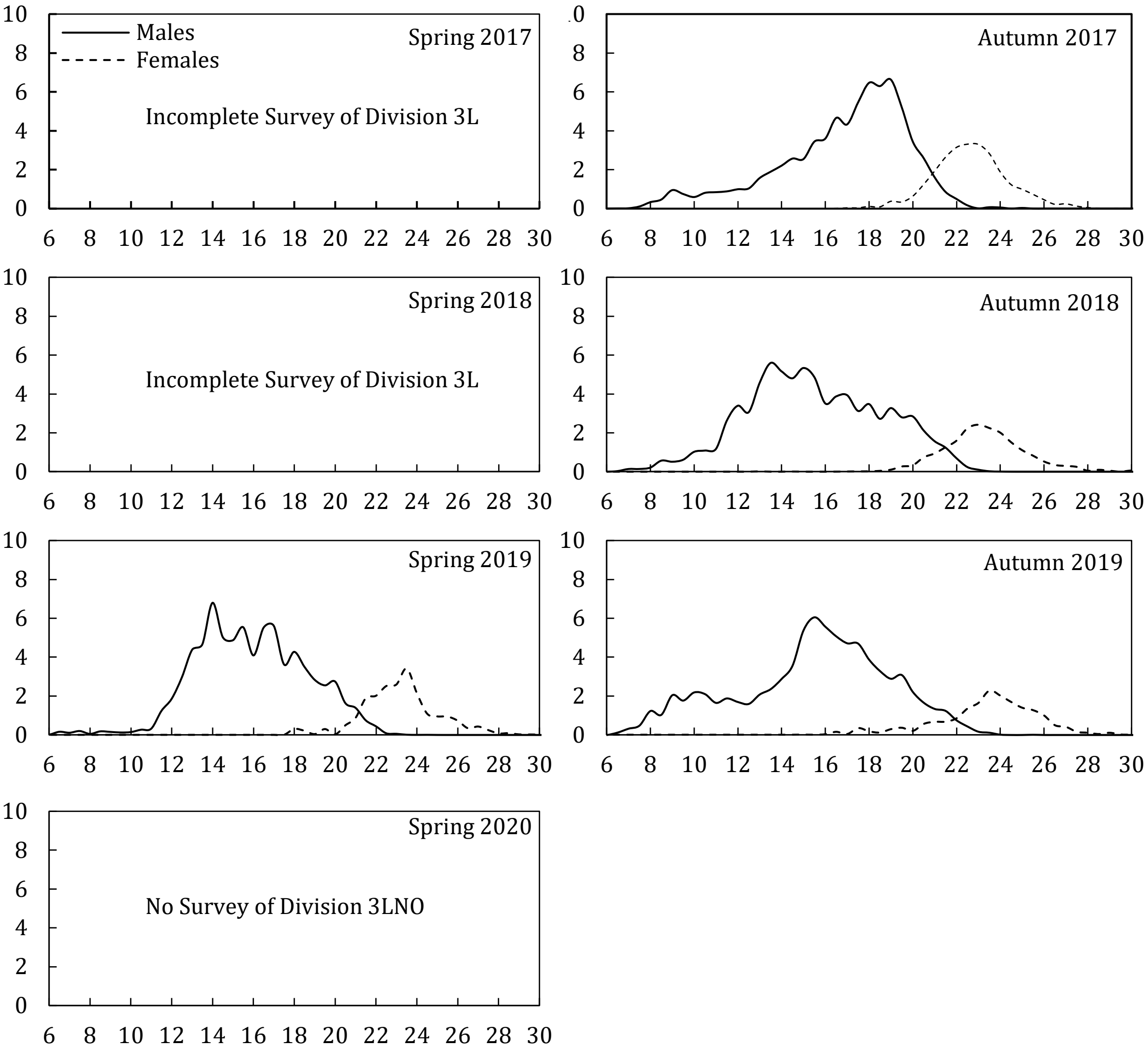


Figure 2.5. Shrimp in Div. 3LNO: Composition of survey catches (percentage at length) from Canadian spring and autumn multi-species survey data. No data for spring 2017-2018 or 2020.

Recruitment indices. Recruitment indices were based upon abundance indices of shrimp with carapace lengths of 11.5 – 17 mm from Canadian multi-species survey data. The 2006 – 2008 indices were among the highest in both spring and autumn time-series but have since declined to the lowest levels in the survey time series (Figure 2.6).

Research on transport of larval shrimp (Le Corre et al.) indicates that most larvae that originate in Div. 3L are transported out of that division. Additionally, it was found that most recruitment in Div. 3L originates further north of the area. The results of this research have not yet been quantified in order to develop a more comprehensive recruitment index for Div. 3LNO.

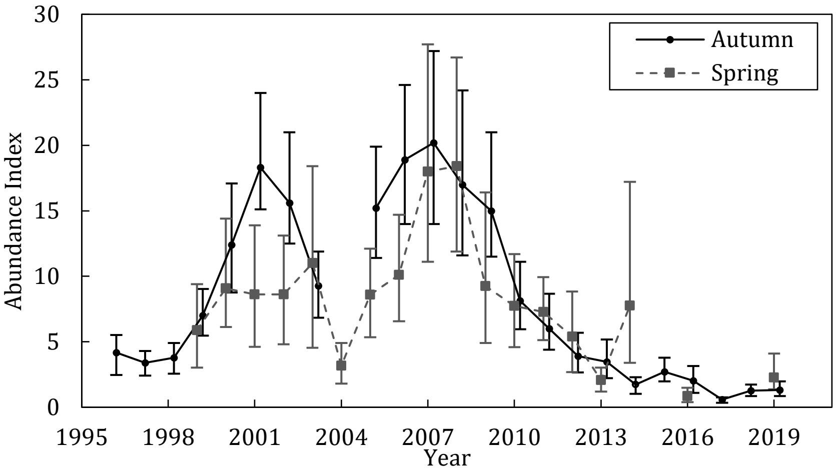


Figure 2.6. Shrimp in Div. 3LNO: Indices of recruitment-sized shrimp based on abundance of shrimp with 11.5 – 17 mm carapace lengths from Canadian spring and autumn multi-species surveys. Error bars represent 95% confidence intervals. The autumn index for 2014 is for Div. 3L only.

Exploitation index. An index of exploitation was derived by dividing the catch in a given year by the fishable biomass index from the previous autumn survey. The exploitation index generally increased throughout the course of the fishery until dropping sharply in 2014 (Figure 2.7). Since there was no directed fishing in 2015-2020, the exploitation index is zero for that period of time. Mortality due to bycatch during other fisheries is unknown.

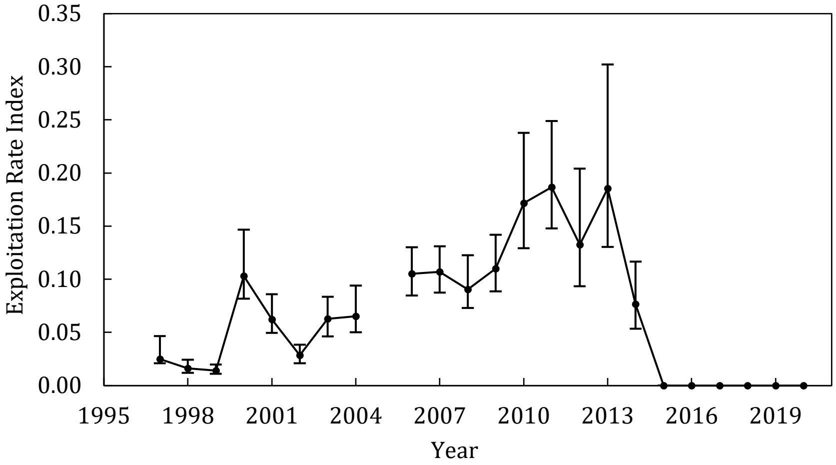


Figure 2.7. Shrimp in Div. 3LNO: Exploitation indices calculated as a year's catch divided by the previous year's autumn fishable biomass index. Error bars (calculated based on estimates of fishable biomass index) indicate 95% confidence intervals.

d) Reference points.

The point at which a valid index of female spawning stock size has declined to 15% of its highest observed value is considered to be B_{lim} (SCS Doc. 04/12). In 2020 the risk of being below B_{lim} was greater than 95% (Figure 2.8). A limit reference point for fishing mortality has not been defined.

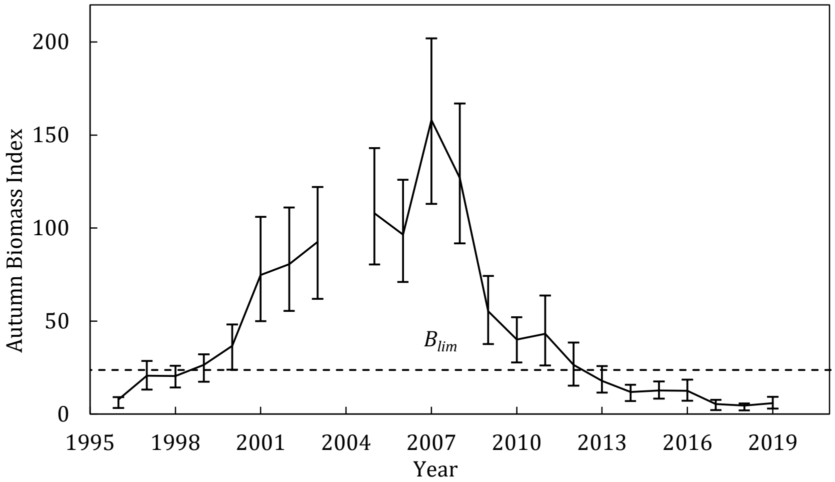


Figure 2.8. Shrimp in Div. 3LNO: Autumn female spawning stock biomass index (SSB) and B_{lim}. B_{lim} is defined as 15% of the maximum autumn female biomass over the time-series. Error bars indicate 95% confidence intervals. The autumn index for 2014 is for Div. 3L only.

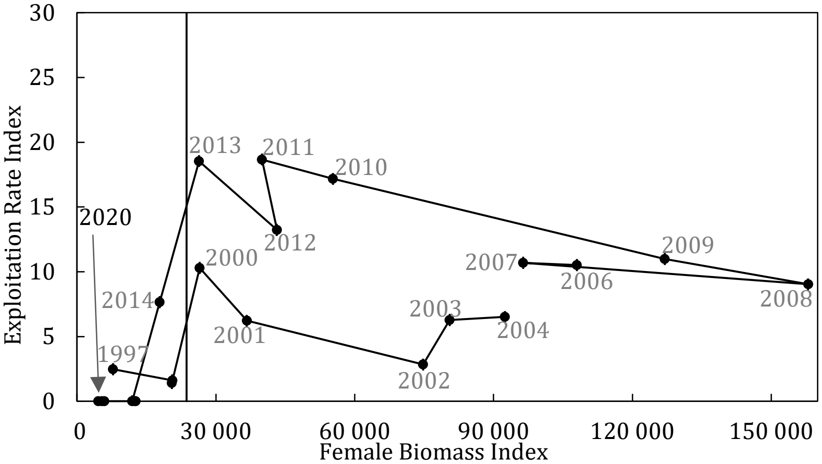


Figure 2.9. Shrimp in Div. 3LNO: Exploitation rate vs female SSB index from Canadian autumn survey. Vertical line denotes B_{lim}.

e) State of the stock

Biomass. Spring and autumn biomass indices have decreased considerably since 2007 and are among the lowest levels in the time series.

Recruitment. Recruitment indices have decreased since 2008 to the lowest levels in the time series.

Exploitation. The index of exploitation has been zero since 2015.

State of the Stock. Currently the risk of the stock being below B_{lim} is greater than 95%. There is no indication of improved recruitment.

f) Ecosystem considerations

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

g) Research recommendations

NIPAG **recommended in 2015** that *ecosystem information related to the role of shrimp as prey in the Grand Bank (i.e. 3LNO) Ecosystem be presented to NIPAG.*

Status: No new information was available to the current meeting and this recommendation is reiterated.

NIPAG **recommends in 2018** that *further work on the development of a recruitment index for Div. 3LNO be completed.*

Status: While it was anticipated that a length based model would improve knowledge of a recruitment index for Div. 3LNO, that work has not been successfully completed. Hence this recommendation is reiterated.

References

Le Corre N, Pepin P, Han G, Ma Z, Snelgrove PVR. Assessing connectivity patterns among management units of the Newfoundland and Labrador shrimp population. *Fish Oceanogr*. 2018;00:1–20. https://doi.org/10.1111/fog.12401 (in press).

3. Northern shrimp (*Pandalus borealis*) off West Greenland (NAFO SA 0 and SA 1)

(SCR Docs. 04/075, 04/076, 08/006, 11/053, 11/058, 12/044, 13/054, 20/053, 20/054, 20/055, 20/056, 20/057, 20/058)

Environmental overview

Recent Conditions in Ocean Climate and Lower Trophic Levels

- The ocean climate index in Subareas 0-1 was at its highest value since the record-high of 2010, and the third highest since the beginning of the time series in 1985.
- The initiation of the spring bloom was delayed for a second consecutive year in 2019 compared to the 1998-2015 climatology.
- Total spring bloom production (magnitude) was below normal in 2019

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

Ocean Climate and Ecosystem Indicators

The ocean climate index in Subareas 0-1 has been predominantly above normal or near-normal since the early 2000s, except for 2015 and 2018 that were below and slightly below normal, respectively (Figure 3.1.A). In 2019, the index was at its highest value since the record high of 2010, and at its thirds highest value since the beginning of the time series in 1985. Before the warm period of the last decade, cold conditions persisted in the early to mid-1990s. The timing of the spring bloom transitioned from later to earlier than normal between 1998 and 2007. Spring bloom timing has shown a general trend of increasingly later initiation since the late 2000s with few exceptions of early timing observed in 2011, 2015, and 2017. The initiation of the spring bloom (Figure 3.1.B) occurred later than normal for a second consecutive year in 2019. Spring bloom magnitude (Figure 3.1.C) was mostly near normal between 1998 and 2007. Both below and above normal spring production occurred during that period but no clear pattern was observed. There was a general trend of increasing spring production since the record low in 2007. However, spring bloom magnitude in 2019 was back to below normal with the second-lowest anomaly of the time series. In general, early blooms are associated with high spring production and vice versa (Figure 3.1.B, 3.1.C).

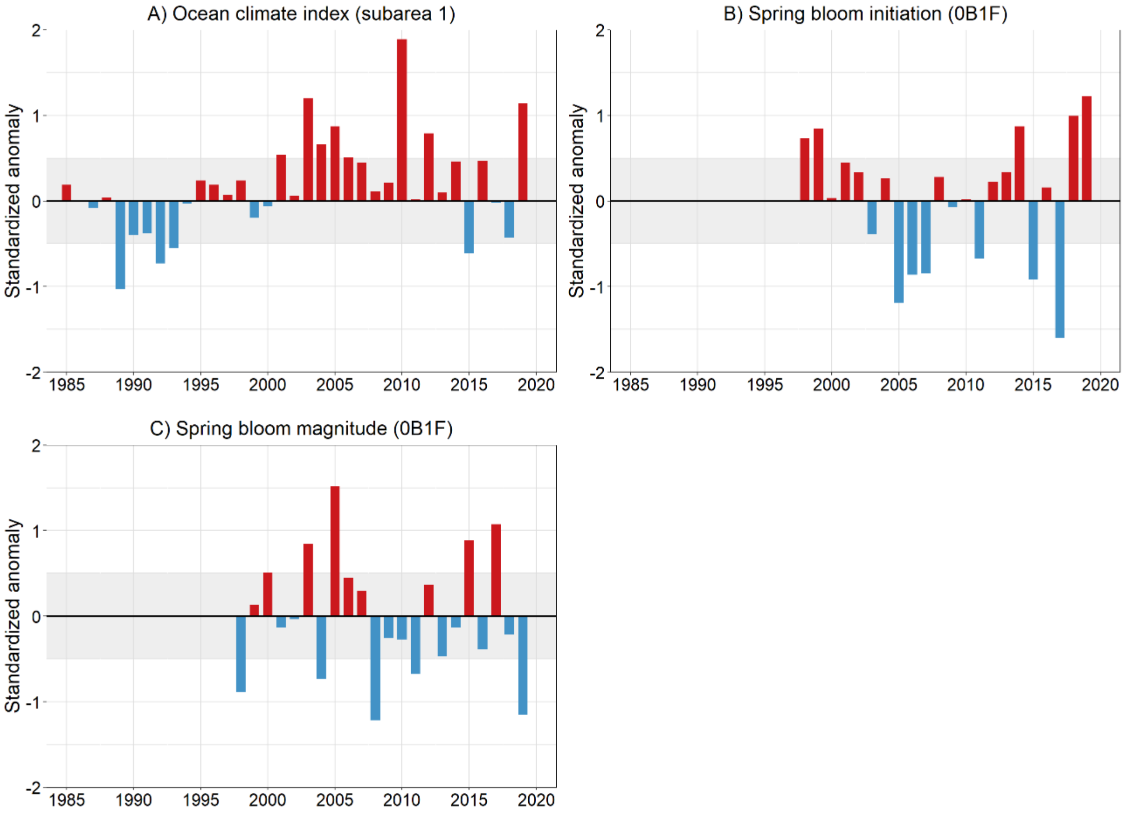


Figure 3.1. Environmental indices for NAFO Subareas 0 and 1 during 1990-2019. The climate index (A) for Subareas 0 and 1 is the average of 7 individual time series of standardized ocean temperature anomalies: sea surface temperatures (SSTs) for West Greenland Shelf, North and Central Labrador Sea and Hudson Strait, 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, and air temperatures in Nuuk (Greenland) and Iqaluit (Baffin Island). Geographical boxes used for SSTs are presented in Cyr *et al*. (2019) and air temperature time series are presented in Cyr *et al.* (2020). 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 initiation (B) and magnitude (C) indices for the 1998-2019 period are derived from three satellite boxes located in NAFO Div. 0B (Hudson Strait) and 2H1F (Labrador Sea) and 1F (Greenland Shelf) (see SCR Doc. 20/035 for box location). Positive/negative anomalies indicate above/below (or late/early timing) normal conditions, 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 (shaded area) are considered near-normal conditions.

a) Introduction

The shrimp stock off West Greenland is distributed mainly in NAFO Subarea 1 (Greenland EEZ), but a small part of the habitat, and of the stock, intrudes into the eastern edge of Div. 0A (Canadian EEZ). Canada has defined 'Shrimp Fishing Area 1' (Canadian SFA1), to be the part of Div. 0A lying east of 60°30'W, i.e. east of the deepest water in this part of Davis Strait.

The stock is assessed as a single population. The Greenland fishery exploits the stock in Subarea 1 (Div. 1A– 1F). The Canadian fishery has been limited to Div. 0A.

Four fleets, one from Canada and three from Greenland (Kongelige Grønlandske Handel (KGH) fleet fishing from 1976 to 1990, the offshore fleet and coastal fleet) have participated in the fishery since the late 1970s. The Canadian fleet and the Greenland offshore fleets have been restricted by areas and quotas since 1977. The Greenland coastal fleet has privileged access to inshore areas (primarily Disko Bay and Vaigat in the north, and Julianehåb Bay in the south). Coastal licenses were originally given only to vessels under 80 tons, but in recent years larger vessels have entered the coastal fishery. Greenland allocates a quota to EU vessels in Subarea 1; this quota is usually fished by a single vessel which, for analyses, is treated as part of the Greenland offshore fleet. Mesh size is at least 40 mm in both Greenland, and Canada. Most trawlers in Greenland use mesh size at 44 mm. Sorting grids to reduce bycatch of fish are required in both of the Greenland fleets and in the Canadian fleet. Discarding of shrimps is prohibited.

The enacted TAC for Greenland Waters in 2020 was set at 110 000 t and for Canadian Waters, 15 229 t.

Greenland requires that logbooks catch is recorded as live weight. For shrimps sold to on-shore processing plants, a former allowance for crushed and broken shrimps in reckoning quota draw-downs was abolished in 2011 to bring the total catch live weight into closer agreement with the enacted TAC. Since 2012, *Pandalus montagui* has been included among the species protected by a 'moving rule' to limit bycatch and there are no licenses issued for directed fishing on it (SCR Doc. 20/054). Instructions for reporting *P. montagui* in logbooks were changed in 2011, to improve the reporting of these catches.

The table of recent catches was updated (SCR Doc. 20/054, 20/055). Total catch increased from about 10 000 t in the early 1970s to more than 105 000 t in 1992 (Figure 3.2). Actions by the Greenlandic authorities to reduce effort, as well as fishing opportunities elsewhere for the Canadian fleet, caused catches to decrease to about 80 000 t by 1998. Total catches increased to an average over 150 000 t in 2005 to 2008 but have since decreased to 72 256 t in 2015. Since 2016, the catches have been increasing in conjunction with increasing TACs and was in 2019, 104 440 t. The projected catch for 2020 is 117 000 t. The projected catch for Canada from Div. 0A in 2020 is expected to be in the region of 2 000 t.

Recent catches, projected catch for 2020 and recommended and enacted TACs (t) for northern shrimp in Subarea 1 and Div. 0A (east of 60°30'W) are as follows:

	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
TAC										
Advised	120 000	90 000	80 000	80 000	60 000	90 000	90 000	105 000	105 000	110 000
Enacted[1]	139 583	114 425	100 596	97 649	82 561	96 426	101 706	114 873	119 875	125 229
Catches (NIPAG)										
SA 1	122 659	115 965	95 379	88 765	72 254	84 356	89 369	93 189	101 997	115 000[2]
Div. 0A	1 330	12	2	0	2	1 171	3 215	1 689	2 463	2 000[2]
TOTAL	123 989	115 977	95 381	88 765	72 256	85 527	92 584	94 878	104 440	117 000[2]
STATLANT 21										
SA 1	122 061	114 958	91 800	88 834	71 777	82 922	88 947	90 457	100 990	
Div. 0A	1134	12	2	0	2	1 381	2 778	1 412	1716	

1Canada and Greenland set independent and autonomous TACs

2 Projected total catches for the year.

Until 1988 the fishing grounds in Div. 1B were the most important. The offshore fishery subsequently expanded southward, and after 1990 catches in Div. 1C–D, taken together, began to exceed those in Div. 1B. However, since 1998 catch and effort in southern West Greenland have continually decreased, and since 2008 effort in Div. 1F has been virtually nil (SCR Doc. 20/054). The fishery has moved north and, since 2009, at least 35% of the total catch was taken in Div. 1A.

In 2002–2005 the Canadian catch was stable at 6000 to 7000 t - about 4–5% of the total - but since 2007 fishing effort has been sporadic and catches variable, averaging about 1750 t in 2007–11 and from 2012 to 2015 catches in Div. 0A did not exceed 5 t (SCR Doc. 20/054). In 2016 fishing increased in the Canadian EEZ and from 2016 to 2020, Canadian catches averaged about 2000 t.

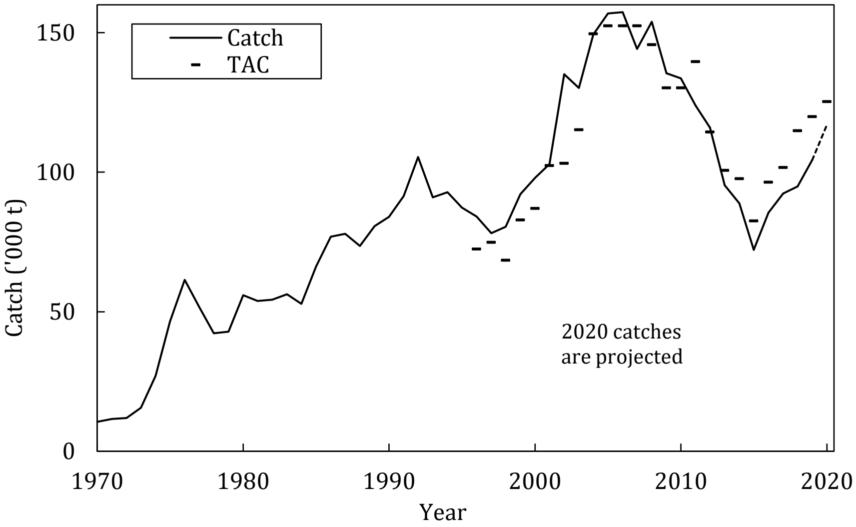


Figure 3.2. Northern shrimp in Subarea 1 and Div. 0A: Enacted TACs and total catches (2020 expected for the year).

b) Input data

i) Fisheries Data

Fishing effort and CPUE. Catch and effort data from the fishery were available from Greenland logbooks for Subarea 1 (SCR Doc. 20/054). In recent years both the distribution of the Greenland fishery and fishing power have changed significantly: for example, larger vessels have been allowed in a limited part of coastal areas; the coastal fleet has fished outside Disko Bay; the offshore fleet now commonly uses double trawls. Furthermore, quota transfers between the two fleets are now allowed. Catch data before 2004 were under-reported, which was corrected in 2008.

CPUEs were standardized by linearized multiplicative models including terms for vessel, month, gear type, year, and statistical area. Standardized CPUE series were done separately for three different fleets (Figure 3.3); the early offshore fleet fishing in Div. 1A and part of 1B (KGH-index, 1976-1990), the present offshore fleet fishing in Subarea 1 (1987-2020) and the coastal fleet fishing in coastal and inshore areas (1989-2020). CPUE for the Canadian fleet fishing in Div. 0A has not been updated because it is not possible to receive new logbook information from Canada. In the recent three years the CPUE of the coastal fleet has slightly decreased while the CPUE of the offshore fleet increased from 2016 to 2017 and dropped little in 2018 and remained stable in 2019.

The three CPUE series are combined by assuming they all reflect the overall biomass series scaled by a constant fleet factor, and that the errors had mean zero and variances inversely proportional to the fishing ground of the fleet. The estimation was done in a Bayesian framework.

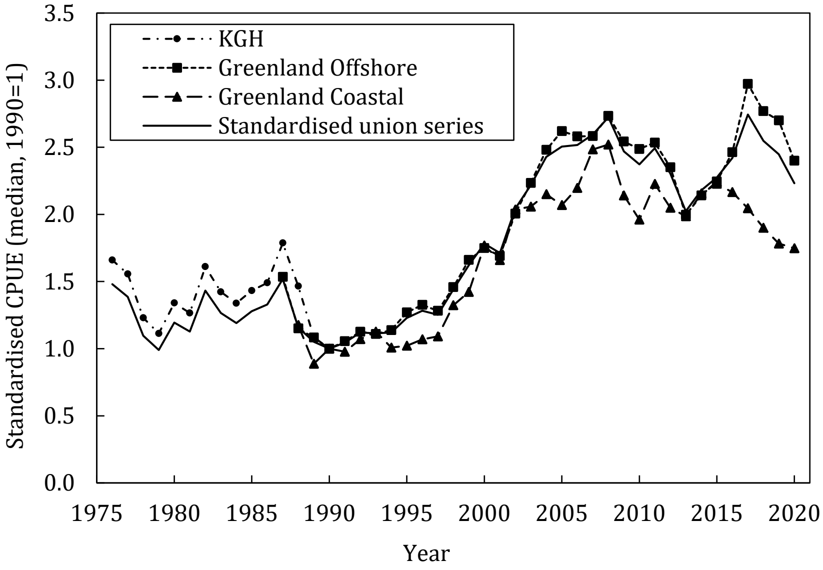


Figure 3.3. Northern shrimp in Subarea 1 and Div 0A: Standardized CPUE index series 1976–2020.

The distribution of catch and effort among statistical areas was summarized using Simpson's diversity index to calculate an 'effective' number of statistical areas being fished as an index of how widely the fishery is distributed (Figure 3.4). The 'effective' number of statistical areas being fished in Subarea 1 reached a plateau in 1992–2003. The range of the fishery has since contracted northwards, and the 'effective' number of statistical areas being fished has decreased.

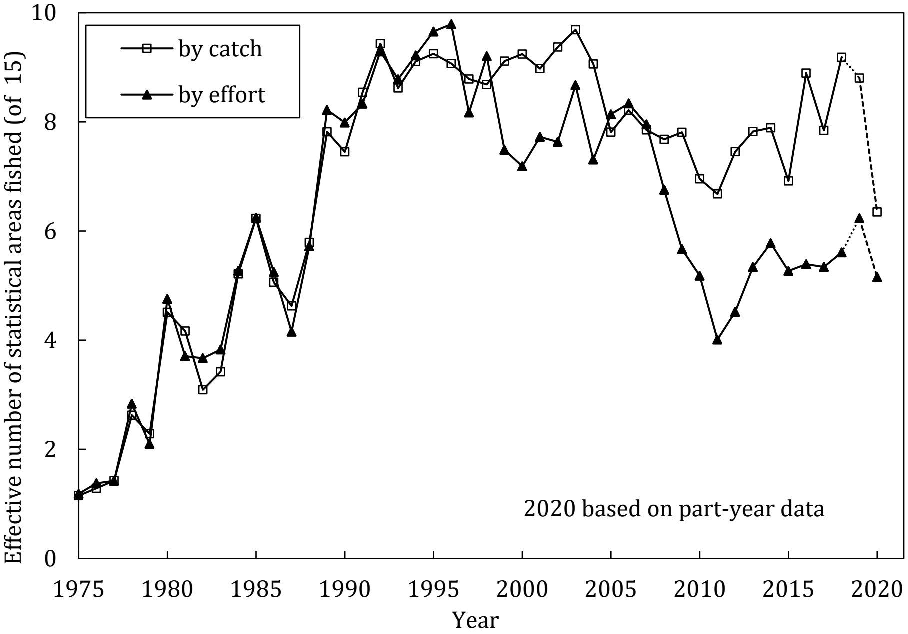


Figure 3.4. Northern shrimp in Subarea 1 and Div. 0A: Indices for the distribution of the Greenland fishery between statistical areas in 1975–2020.

Catch composition. There is no biological sampling program from the fishery that is adequate to provide catch composition data to the assessment.

ii) Research survey data

Greenland trawl survey. Stratified semi-systematic trawl surveys designed primarily to estimate shrimp stock biomass have been conducted since 1988 in offshore areas and since 1991 also inshore in Subarea 1 (SCR Doc. 20/053). From 1993, the survey was extended southwards into Div. 1E and 1F. A cod-end liner of 22 mm stretched mesh has been used since 1993. From its inception until 1998 the survey used 60-min. tows, but since 2005 all tows have lasted 15 min. In 1988 to 2005 the *Skjervøy 3000* survey trawl used was replaced by a *Cosmos 2000* with rock-hopper ground gear, calibration trials were conducted, and the earlier data were adjusted.

In 2018 and 2019-2020, the annual trawl survey was conducted with two different chartered vessels during the same time period as the usual survey. All the standard gear from the research vessel Paamiut (such as cosmos trawl, doors, all equipment such as bridles etc., Marport sensors on doors and headlines) were used and all the standard research protocols were followed in an attempt to make the surveys as comparable as possible to earlier surveys. At least two crew members from Paamiut participated in each of the surveys. NIPAG therefore assumed that the 2018 and 2019-2020 results were directly comparable with the previous surveys. A more detailed description is available in SCR Docs. 20/053.

The survey average bottom temperature increased from about 1.7°C in 1990–93 to about 3.1°C in 1997–2014 but has since declined to 2.5° in 2019 and remained stable in 2020 (SCR Doc. 20/053). About 80% of the survey biomass estimate is in water 200–400 m deep throughout the time series. Since 2001 most of the biomass has been in water 200–300 m deep (SCR Doc. 20/053). The proportion of survey biomass in Div. 1E–F has been low in recent years and the distribution of survey biomass, like that of the fishery, has become more northerly.

Biomass. The survey index of total biomass remained fairly stable from 1988 to 1997. It then increased by, on average, 19%/yr until 2003, when it reached 316% of the 1997 value. Subsequent values were consecutively lower, with the second lowest level in the last 20 years occurring in 2014 (Figure 3.5) (SCR Doc. 20/053). Over the past 5 years biomass has increased and was in 2020 210% of the low 2014 level. Offshore regions comprise 82% of the total survey biomass, and 18% is inshore in Disko Bay and Vaigat. The inshore regions have far higher densities and is almost three times as high as offshore (Figure 3.5) (SCR Doc. 20/053).

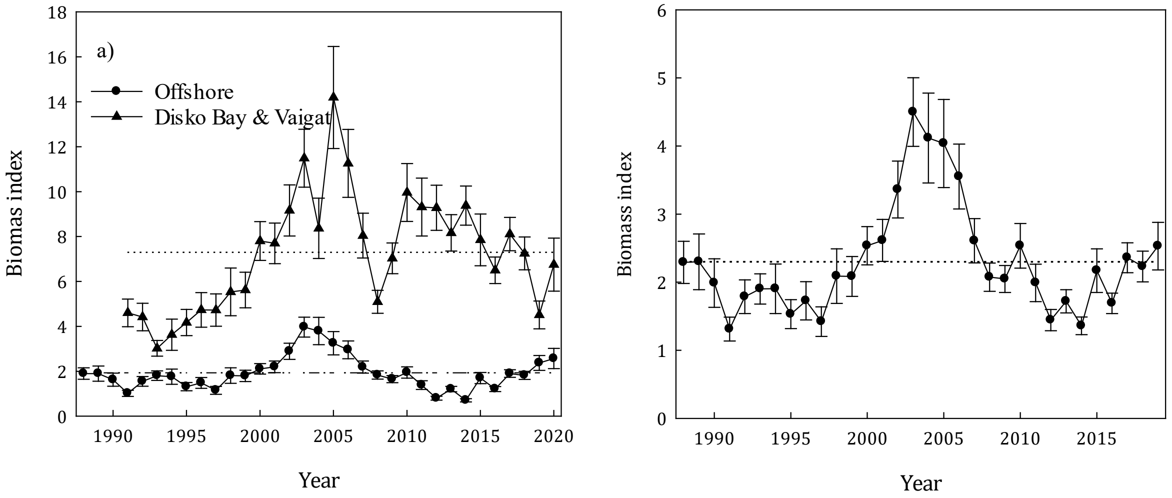


Figure 3.5. Northern shrimp in Subarea 1 and Div. 0A: Biomass index (survey mean catch rates) inshore and offshore (left panel) and overall (right panel) 1988–2020 (error bars 1 SE). Horizontal lines are the series average.

Length and sex composition (SCR 20/053). In 2020, in Disko Bay regions the proportion of fishable males of survey increased, to a level close to its 15-year median. In offshore regions the proportion declined little to a value above its 15-year lower quartile. Like in most recent years, females compose a high proportion of survey and fishable biomass index in both regions, however close to their 15-year lower quartile offshore, but above and at their 15-year upper quartile in Disko Bay (SCR Doc. 20/056).

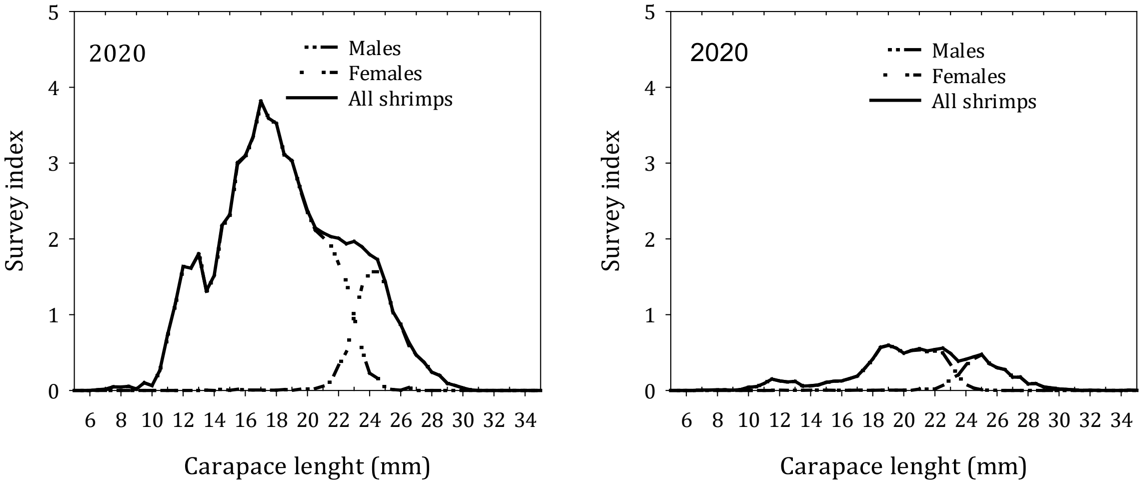


Figure 3.6. Northern Shrimp in Subarea 1 and Div. 0A: Survey mean catch rates at length in offshore regions (left) and Disko Bay & Vaigat (right) at the West Greenland trawl survey in 2020.

Recruitment. The number at age-2 (10.5 to 13.5 mm) reached a peak in 2000 and 2001 and has since declined to a much lower level, with three high values in 2015, 2019 and 2020. The pre-recruit index (14–16.5 mm, expected to recruit to next year's fishable biomass) had high values in 2002 -2005 (except in 2004) and has since fluctuated at a lower level, with relatively high values in 1999-2000 and again in 2015, 2017 and 2020 (SCR Doc. 20/053, 20/056) (Figure 3.7). Numbers of age-2 and pre-recruits in 2020 are above the 1993 to 2020 average, respectively.

Linear regression has shown a significant relationship between the number of age-2 shrimp, pre-recruits and the fishable biomass with a lag of 2, 3 or 4 years. The correlation was strongest (R^2 = 0.64) between number of age-2 shrimp and the fishable biomass 4 years later (SCR doc 20/053), whereas the correlation was strongest (R^2 = 0.68) between pre-recruits and fishable biomass 1 year later (SCR doc 20/057). Furthermore, there was also a significant relationship between number of age-2 shrimp and the number of pre-recruits 2-years later (R^2 = 0.52) (SCR doc 20/057).

The stock composition in Disko Bay has historically been characterized by a higher proportion of young shrimps than that offshore, exceptions were in 2017, 2019 and 2020, where younger shrimps offshore were much higher in numbers and relative to survey biomass. Both in 2019 and 2020, numbers of age 2-shrimps relative to survey biomass are much higher among offshore regions than inshore, where numbers of age-2 shrimps were record low (SCR Doc. 20/053, 20/056). Numbers of pre-recruits relative to survey biomass were considerably lower inshore than offshore regions (SCR Doc. 20/053, 20/056).

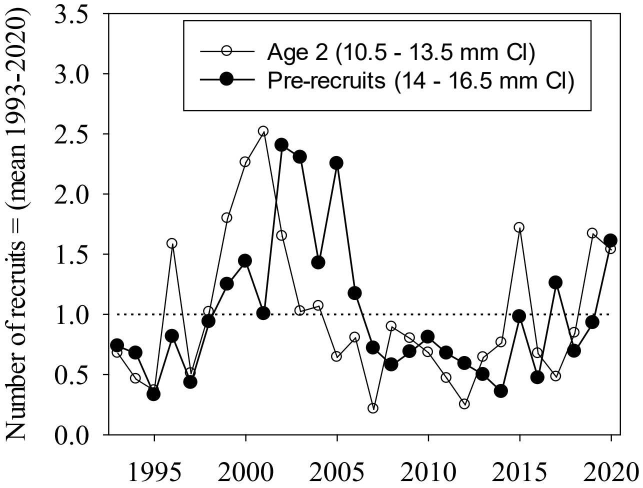


Figure 3.7. Northern shrimp in Subarea 1 and Div. 0A: Survey index of numbers at age 2 (10.5 - 13.5 mm) and index of number of pre-recruits (14-16.5 mm), 1993-2020. Indices are standardized to the series mean.

Predation index. Four distinct stocks of Atlantic cod, spawning variously in inshore and offshore West Greenland, East Greenland, and Iceland, mix at different life stages on the West Greenland banks. They are subject to different influences, oceanographic and others, including drift of pelagic larval stages from east to west. The resulting dynamics are unpredictable both for the individual stocks and for their combination.

The overall cod-stock biomass index, used within the shrimp assessment model, was from 2020 modelled in a state-space assessment model (SAM) (SCR-Doc. 20/058) and based on catch at age in the commercial fishery and the Greenland trawl survey (Skjærvøj and Cosmos trawl).

Indices of cod biomass are adjusted by a measure of the overlap between the stocks of cod and shrimps in order to obtain an index of 'effective' cod biomass, which is entered in the assessment model (SCR-Doc. 14/062). Currently the cod stock at West Greenland is at a low level compared to the period before the collapse in the beginning of 1990s, but has since 2010 shown a slow, but progressive increases and has remained almost stable since 2015. The index of its overlap with the shrimp stock decline to an average below the serial value. This resulted in a 2020 'effective cod biomass' index of 7 kt, compared with 7.5 kt in 2019 (recalculated from 21 kt in 2019 due to exclusion of the German survey series from the SAM model) (Figure 3.8) (SCR Doc. 16/042, 16/047, SCR Doc. 20/056, SCR Doc. 20/058).

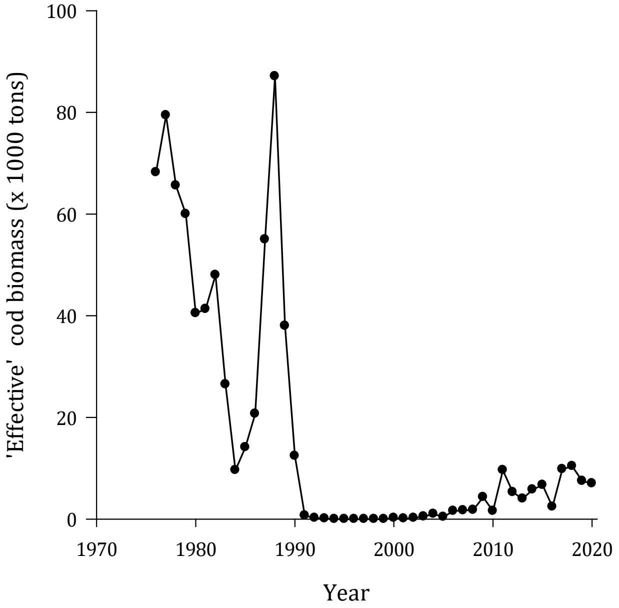


Figure 3.8. Indices of the ‘effective’ cod biomass in Subarea 1 and Div. 0A 1976 - 2020 (measure of the potential predation pressure by cod on shrimps).

c) Assessment

A Schaefer surplus-production model of population dynamics was fitted to series of CPUE, catch, and survey biomass indices (SCR Doc. 20/056). The model includes a term for predation by Atlantic cod. Total shrimp catches for 2020 are expected to be 117 000 t.

In 2017 NIPAG noted concern about the degree of instability in MSY estimates in successive assessments. To solve this problem, two changes were made. Firstly, the time window was changed from 30- year to the entire time series from 1976 to 2018. Secondly, the time invariant catchability in the CPUE time series was changed to a time variant by including two periods with different catchability.

A more comprehensive description of the evaluation and changes of the model are available in SCR Doc. 18/060. These changes have been included in the assessment since 2018 and have resulted in increased stability of the model parameters and a much-improved retrospective pattern (Figure 3.10).

Estimates of stock-dynamic parameters from fitting a Schaefer stock-production model to 45 years’ data are given in Table 3.1. Median values from the 2019 assessment are provided for comparison. The modelled biomass (Figure 3.9a) was relatively low and stable until the late 1990s, when it started a rapid increase, doubling by 2004. Modelled biomass steadily declined from 2004 to 2013 but has since slightly increased. The median biomass has been above B_{msy} since the late 1990s except from 2013 to 2014. Mortality has generally been close to or below Z_{msy} during the modelled period (Figure 3.9b). Estimates of total mortality have increased in the most recent years. Assuming catches of 117 000 t, total mortality in 2020 is estimated to be below Z_{msy} with probability of $Z_{2020} > Z_{msy}$ = 40%. Biomass at the end of 2020 is projected to be close to the 2019 value and above B_{msy}. The probability of the biomass at the end of 2020 being below B_{msy} is 24% and the probability of being below B_{lim} is very low (<1%).

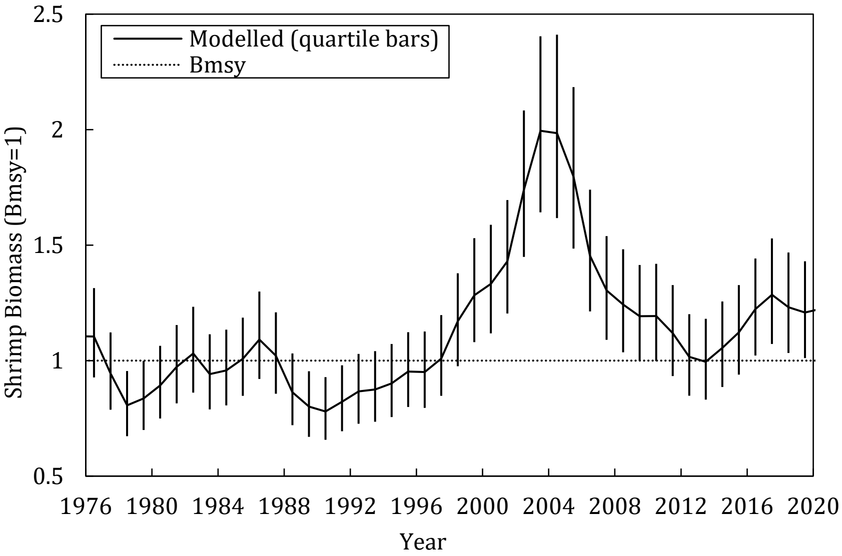


Figure 3.9a. Northern shrimp in SA 1 and Div. 0A: Relative stock biomass with quartile error bars 1976–2020. Dotted line corresponds to $B = B_{msy}$.

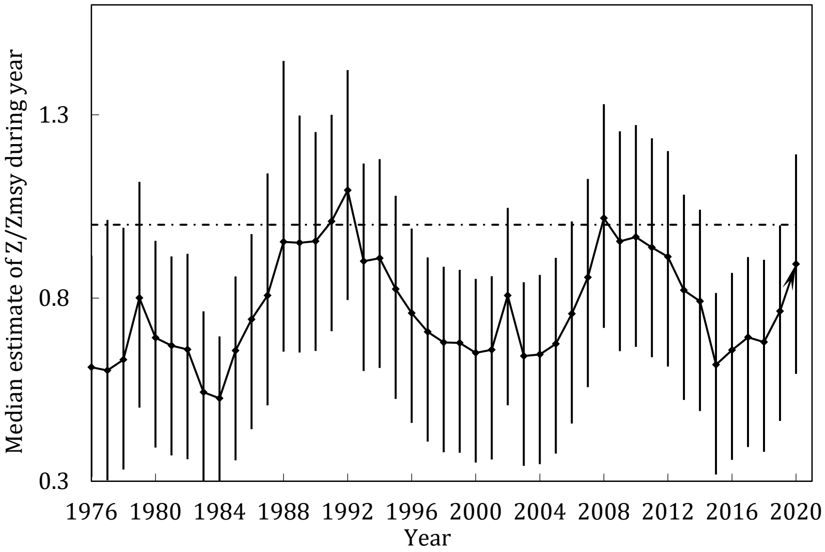


Figure3.9b. Northern shrimp in SA 1 and Div. 0A: Trajectory of the median modelled estimate of mortality relative to Z_{msy} during the year, 1976–2020 with quartile error bars.

Table 3.1. Estimates of stock-dynamic and parameters from fitting a Schaefer stock-production model to 44 years' data on the West Greenland stock of the northern shrimp in 2020. The median (2019) column shows results from last year's assessment.

	Mean	S.D.	25%	Median	75%	Est. mode	Median (2019)
Max.sustainable yield	135.3	56.6	103.1	123.0	153.3	98.4	121.6
B/Bmsy, end current year (proj.)(%)	126.3	34.2	101.4	122.5	148.2	114.9	126.3
Biomass risk, end current year(%)	23.6	42.5	–	–	–	–	–
Z/Zmsy, current year (proj.)(%)	–	–	61.7	89.3	119.2	–	80.1
Carrying capacity	3444	1981	1931	2896	4522	1800	2999
Max. sustainable yield ratio (%)	10.0	5.4	6.1	9.0	12.9	7.1	8.6
Survey catchability (%)	18.9	13.2	9.5	15.4	24.5	8.2	14.8
CPUE(1) catchability	1.1	0.8	0.6	0.9	1.4	0.5	0.9
CPUE(2) catchability	1.7	1.2	0.9	1.4	2.3	0.7	1.4
Effective cod biomass 2020 (Kt)	9.1	18.1	5.2	7.0	8.9	2.8	20.9
$P_{50\%}$ *(prey biomass index with consumption 50% of max.)*	4.1	7.2	0.2	1.3	4.6	-4.3	1.2
V_{max} *(maximum consumption per cod)*	2.0	2.3	0.4	0.9	2.6	-1.1	0.8
CV of process (%)	13.1	2.9	11.2	13.0	14.9	12.7	13.8
CV of survey fit (%)	17.6	3.2	15.3	17.2	19.5	16.6	16.2
CV of CPUE (1) fit (%)	7.0	1.5	5.9	6.7	7.7	6.2	6.7
CV of CPUE (2) fit (%)	7.6	2.4	5.8	7.0	8.6	5.7	6.8

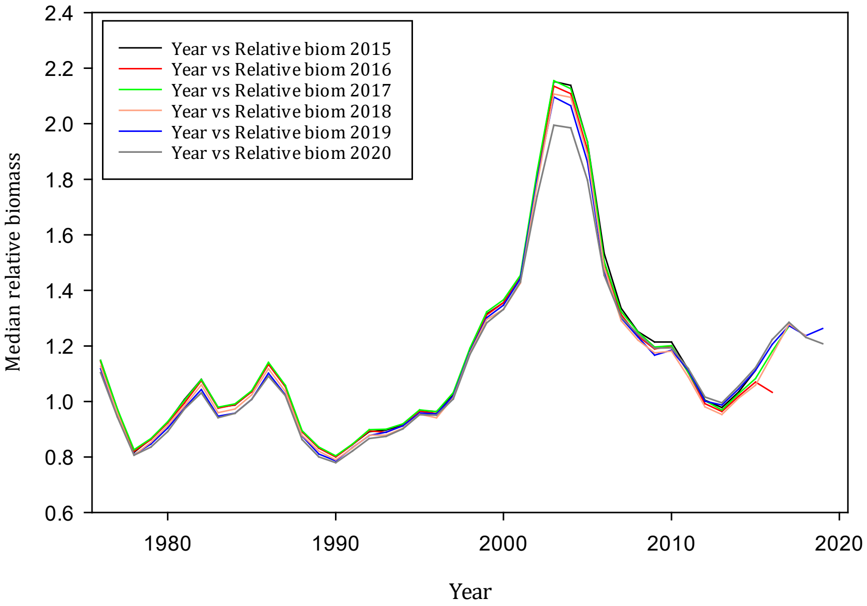


Figure 3.10. Retrospective plots of the relative biomass B/B_{msy} 2015 to 2020. Mohn's rho is estimated to – 0.024.

A six-year retrospective analysis was performed (Figure 3.10) and results were found to be quite stable.

d) Reference points

B_{lim} has been established as 30% B_{msy}, and Z_{msy} (fishery and cod predation) has been set as the mortality reference point. B_{msy} and Z_{msy} are estimated directly from the assessment model.

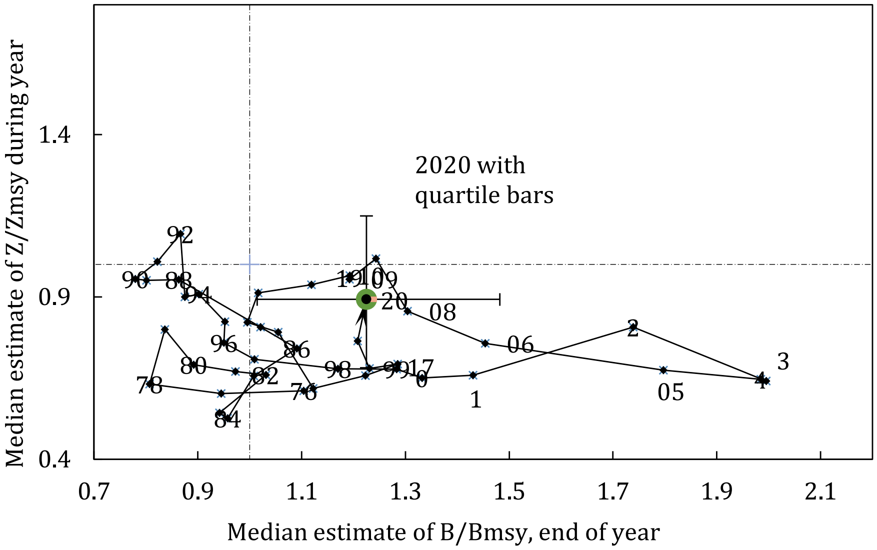


Figure 3.11. Northern shrimp in Subarea 1 and Div. 0A: Trajectory of relative biomass and relative mortality, 1976–2020.

e) State of the stock

Biomass. Biomass at the end of 2020 is above B_{msy} and the probability of being below B_{lim} is very low (<1%).

Mortality. Assuming catches of 117 000 t and an 'effective cod biomass' of 7 kt, the probability of being above Z_{msy} is 40%.

Recruitment. Both numbers of age-2 and numbers of pre-recruits in 2020 are above the 1993 to 2020 average.

State of the Stock. Biomass at the end of 2020 is above B_{msy} and the probability of being below B_{lim} is very low (<1%). The probability of mortality in 2020 being above Z_{msy} is 40%. Recruitment (number of age-2 shrimp) in 2020 is above average.

f) Projections

Three years projections for years 2021–2023 under eight catch options and subject to predation by the cod stock with an 'effective' biomass of 7 kt (the estimated value for 2020 was 7 Kt) were evaluated. Additional projections assuming 'effective' cod biomasses of 5 kt, and 9 kt were conducted but results indicated small differences in risk probabilities (SCR Doc 20/056).

7 000 t cod	**Catch option ('000 tons)**							
Risk of:	**95**	**100**	**105**	**110**	**115**	**120**	**125**	**130**
falling below Bmsy end 2021 (%)	24	24	25	27	26	27	27	28
falling below Bmsy end 2022 (%)	25	25	27	28	29	29	30	31
falling below Bmsy end 2023 (%)	25	26	28	30	31	32	33	33
falling below Blim end 2021 (%)	0	0	0	0	0	0	0	0
falling below Blim end 2022 (%)	0	0	0	0	0	0	0	0
falling below Blim end 2023 (%)	0	0	0	0	0	0	0	0
exceeding Zmsy in 2021 (%)	19	22	26	30	33	37	40	44
exceeding Zmsy in 2022 (%)	19	22	27	31	34	39	42	45
exceeding Zmsy in 2023 (%)	20	23	28	32	35	39	43	46
falling below Bmsy 80% end 2021 (%)	8	8	9	9	9	9	10	9
falling below Bmsy 80% end 2022 (%)	9	10	11	11	11	12	13	13
falling below Bmsy 80% end 2023 (%)	10	10	12	12	13	14	16	17

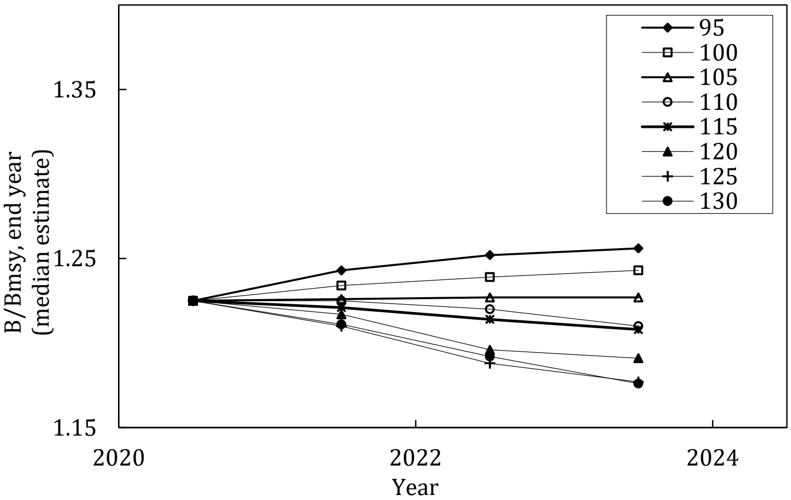


Figure 3.12. Northern shrimp in Subarea 1 and Div. 0A: Median estimates of year-end biomass trajectory for 2021–2023 with annual catches at 95 –130 kt. and an 'effective' cod stock assumed at 7 kt.

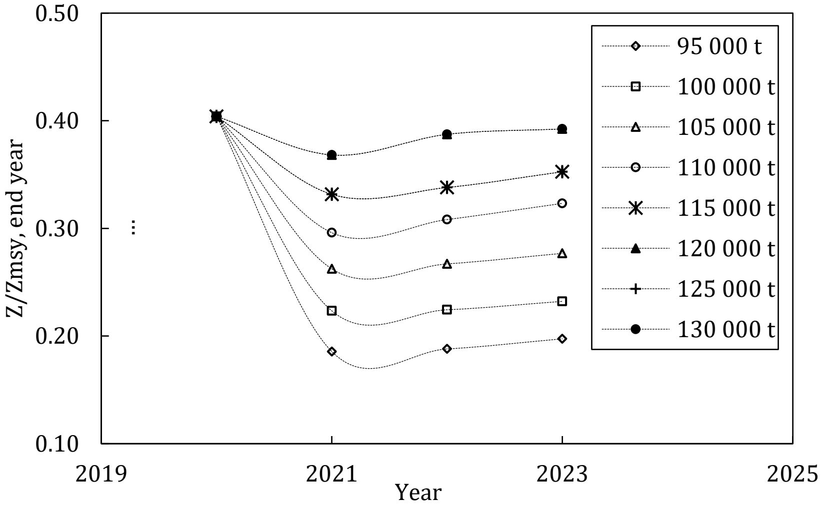


Figure 3.13. Northern shrimp in Subarea 1 and Div. 0A: Risks of transgressing mortality and biomass precautionary limits with annual catches at 95–130 kt projected for 2021–23 with an 'effective' cod stock assumed at 7 kt.

g) Research recommendations

- NIPAG **recommended** in 2016 that *genetic stock structure in West and East Greenland should be further explored.*

Status: No progress; this recommendation will not be progressed further at present.

- NIPAG **recommended** in 2018 that *random sampling of the catches be conducted to provide catch composition data to the assessment.*

Status: In progress; this recommendation is reiterated.

- NIPAG **recommends** that *diagnostics of the model should be further explored.*

4. Northern shrimp (*Pandalus borealis*) in the Denmark Strait and off East Greenland (ICES Div. 14b and 5a)

(SCR Docs. 04/012, 20/059, 20/060, 20/061)

a) Introduction

Northern shrimp off East Greenland in ICES Div. 14b and 5a is assessed as a single population.

A multinational fleet exploits the stock. During the recent ten years, vessels from Greenland, EU, the Faroe Islands and Norway have fished in the Greenland EEZ. Only Icelandic vessels are allowed to fish in the Icelandic EEZ. At any time of the year access to these fishing grounds depends strongly on ice conditions.

In the Greenland EEZ, the minimum permitted mesh size in the cod-end is 40 mm but most trawlers used 44 mm in the cod-end. The fishery is managed by catch quotas allocated to national fleets. In the Icelandic EEZ, the mesh size is 40 mm and there are no catch limits, however, there have been no catches by Iceland after 2005. In both EEZs, sorting grids with 22-mm bar spacing to reduce by-catch of fish are mandatory. Discarding of shrimp is prohibited in both areas.

The fishery started in 1978 and during the period 1985 to 2003 the total catches fluctuated between 9 000 t and 15 000 t. Between 2004 and 2016 the total catch decreased to 49 t in 2016. Catches have since then increased to 1576 t in 2019 (Figure 4.1). Since 2012, no or very little fishery has taken place in the southern area.

Catches in the first half year of 2020 were 2839 based on logbooks. Since 2014, the fishing effort have been concentrated in a relatively small area.

Recent catches and TACs (t) for shrimp in in the Denmark Strait and off East Greenland (ICES Div. XIVb and Va) are as follows:

	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020[1]
Recommended TAC, total area	12 400	12 400	12 400	2 000	2 000	2 000	2 000	2 000	2 000	2 000
Actual TAC, Greenland	12 400	12 400	12 400	8 300	6 100	5 300	5 300	4 300	3 384	4 750
North of 65°N, Greenland EEZ	1 145	1 893	1 714	622	576	49	561	547	1 578	2 836
North of 65°N, Iceland EEZ	0	0	0	0	0	0	0	0	0	0
North of 65°N, total	1 145	1 893	1 714	622	576	49	561	547	1 578	2 836
South of 65°N, Greenland EEZ	53	215	3	0	0	0	0	0	2	1
TOTAL NIPAG	1 199	2 109	1 717	622	576	49	561	547	1 580	2 839

[1] Catches until July 2020

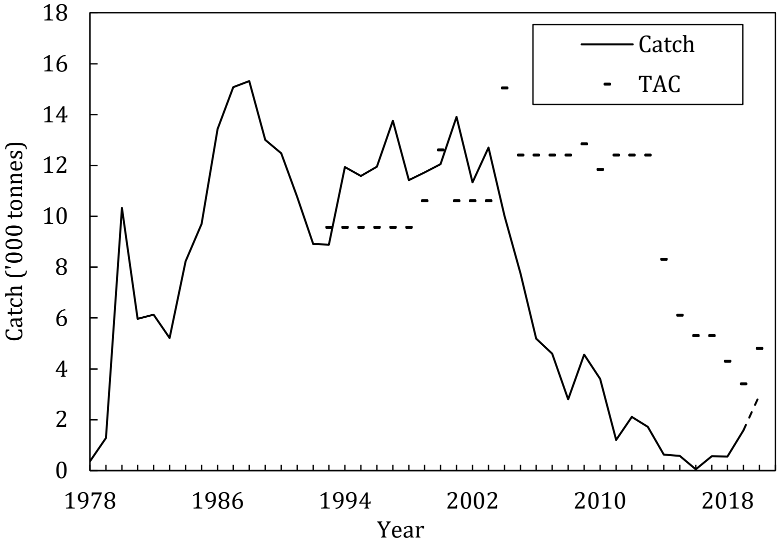


Figure 4.1. Shrimp in Denmark Strait and off East Greenland: Catch and TAC (2020 catches until July).

b) Input data

i) Commercial fishery data

Fishing effort and CPUE. Data on catch and effort (hours fished) on a haul by haul basis from logbooks from Greenland, Iceland, Faroe Islands and EU since 1980 and from Norway since 2000 are used. Since 2004, more than 60% of all hauls were performed with double trawl, and both single and double trawl are included in the standardized catch rate calculations.

Catches and corresponding effort are compiled by year for the two areas, north and south of 65°N. Standardised Catch-Per-Unit-Effort (CPUE) was calculated and applied to the total catch of the year to estimate the total annual standardised effort (SCR doc 020/059).

The overall CPUE index increased from 1993 to 2009, followed by a continuous decline to a low value in 2014 and has been increasing since 2014 (Figure 4.2), reaching a record high level in the first half of 2020, which may indicate an improvement of the stock state. However, the estimates for these years are based on relatively low fishing effort (from 300 fishing hours in 2016 to 3000 fishing hours in first half of 2020) and concentrated in a relatively small area north of 65^0N and west of 30^0W. As most of the fishing has been conducted in the northern area the overall CPUE index is dominated by the CPUE index for this area (Figure 4.2 and Figure 4.3). In the southern area a standardized catch rate series increased until 1998, and then fluctuated without a trend until 2012 (Figure 4.4). No index for the southern area has been calculated since 2012 due to a low number of hauls.

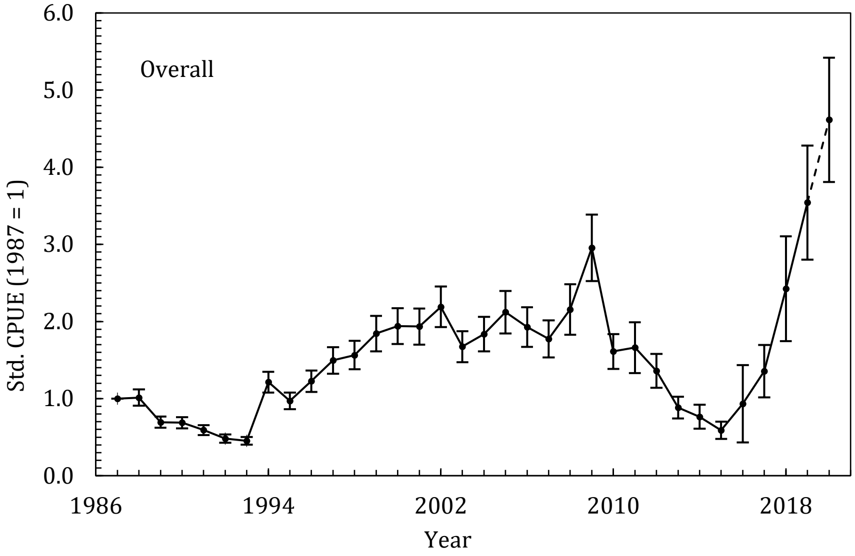


Figure 4.2. Shrimp in Denmark Strait and off East Greenland: Annual standardized CPUE index (1987 = 1) with ± 1 SE combined for the total area. 2020 data until July (grey dotted line).

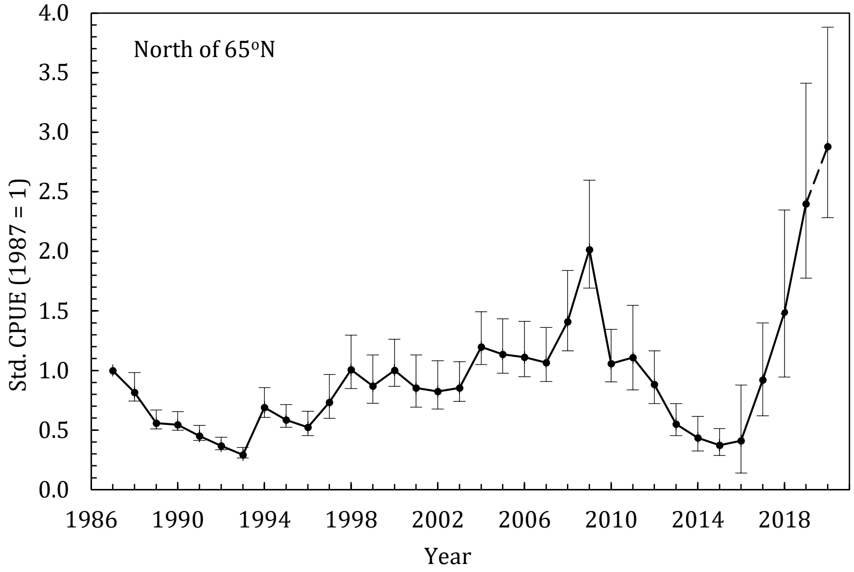


Figure 4.3. Shrimp in Denmark Strait and off East Greenland: Annual standardized CPUE (1987 = 1) with ±1 SE fishing north of 65°N. 2020 data until July (grey dotted line).

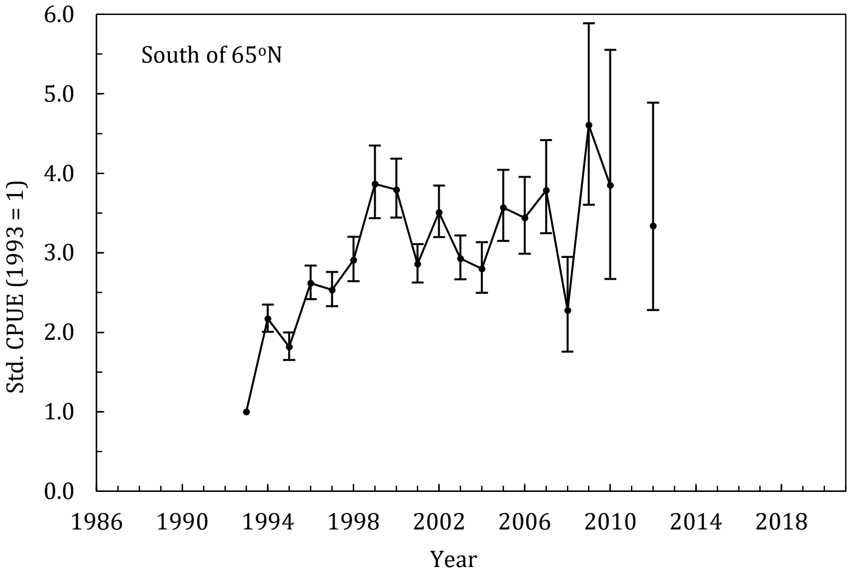


Figure 4.4. Shrimp in Denmark Strait and off East Greenland: Annual standardized CPUE (1993 = 1) with ±1 SE fishing south of 65°N (no data for the area since 2010/2012).

Standardized effort index time series (catch divided by standardized CPUE) as a proxy for exploitation rate for the total area shows a decreasing trend since 1993. Recent levels are the lowest of the time series (Figure 4.5). The 2016 to 2020 levels of exploitation rate may be biased given the issues on CPUE described above.

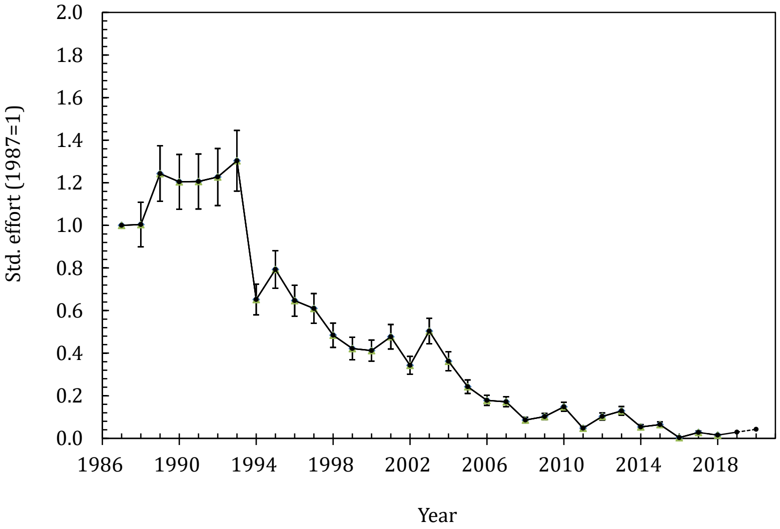


Figure 4.5. Shrimp in Denmark Strait and off East Greenland: Annual standardized effort indices, as a proxy for exploitation rate (± 1 SE; 1987 = 1), combined for the total area (2020 effort until July).

ii) Research survey data

Trawl surveys have been conducted to assess the stock status of northern shrimp in the East Greenland area since 2008 (SCR doc 20/060). Due to lack of research vessel, no survey was conducted in the period 2017 to 2019. In 2020 the survey was conducted with the chartered fishing vessel *Helga Maria* using the same gear configuration (SCR Doc. 20-53 and 20-060). Smaller geographical areas were also surveyed in 1985-1988

(Norwegian survey) and in 1989-1996 (Greenlandic survey). The historical surveys are not directly comparable with the recent survey due to different areas covered, survey technique and trawling gear.

Biomass. The survey biomass index decreased from 2009 to 2012 and then remained at a low level until 2016, there are no estimates for the years 2017-2019. The 2020 estimate is the highest in the timeseries (Figure 4.6).

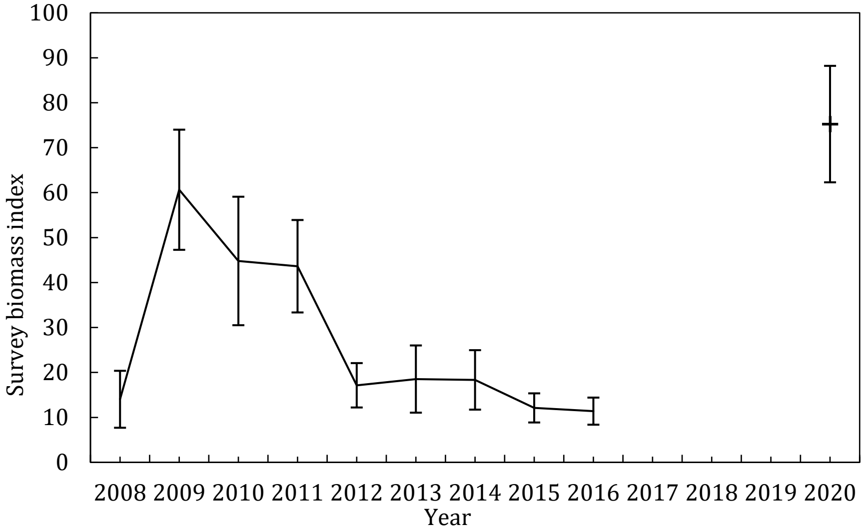


Figure 4.6. Shrimp in Denmark Strait and off East Greenland: Survey biomass index from 2008- 2016 and 2020 (± 1 SE). No survey was carried out in the period 2017 to 2019.

The surveys conducted since 2008 indicate that the shrimp stock is concentrated in the area north of 65°N (Figure 4.7).

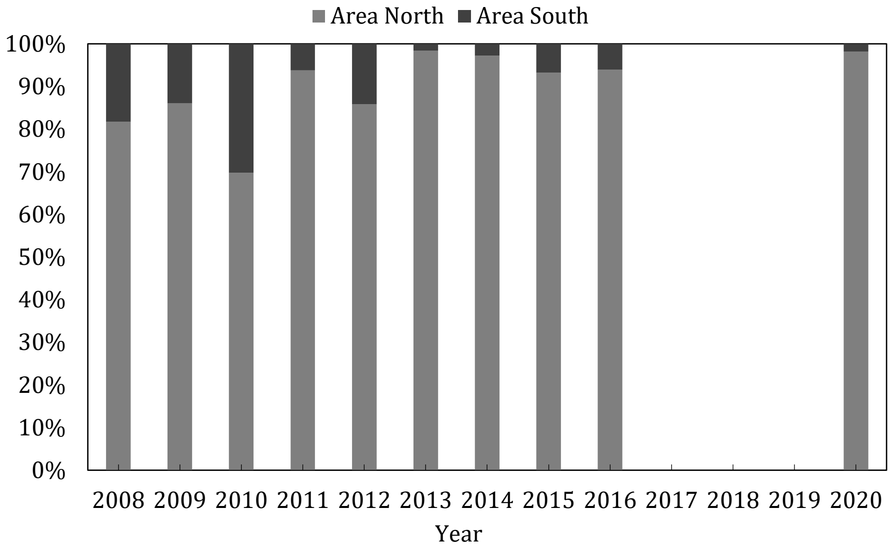


Figure 4.7. Shrimp in Denmark Strait and off East Greenland: Distribution of survey biomass north and south of 65°N (in %) from 2008-2016 and 2020. No survey was carried out in the period 2017 to 2019.

Stock composition. The demography in East Greenland consists of roughly equal proportions of males and females in most years. The proportion of females fluctuates between 40-60% all years except 2009 and 2020. In 2020 36.9 % of the biomass was female, the second lowest in the time series (SCR doc 20/060). In 2020 there may have been some issues regarding the classification of primiparous and multiparous females. The analysis was carried out on the combined female biomass.

Very few males smaller than 20 mm CL are caught in the survey (Figure 4.8). Scarcity of smaller shrimp in the survey area stresses that the total area of distribution and recruitment patterns of the stock are still unknown.

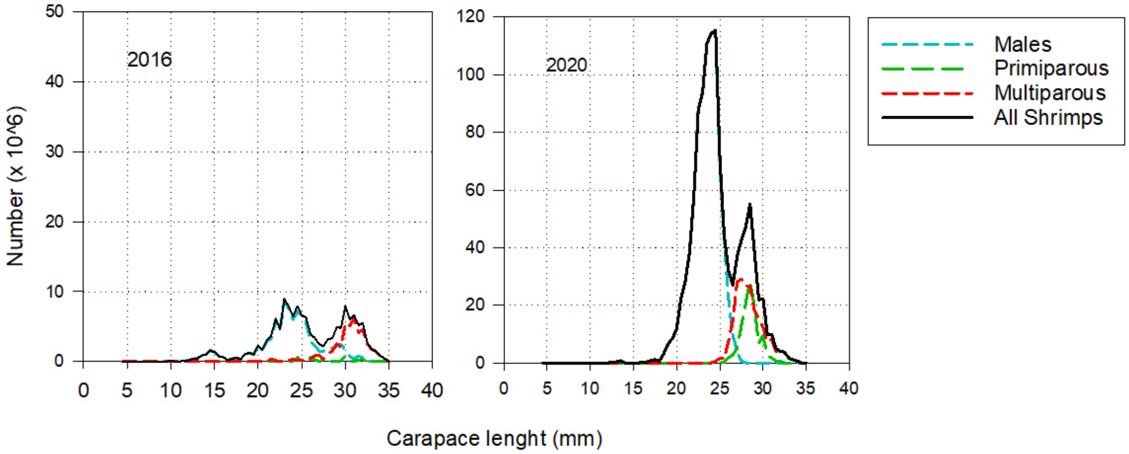


Figure 4.8. Shrimp in Denmark Strait and off East Greenland: Numbers of shrimp by length group (CL) in the total survey area in 2016 and 2020. No survey was carried out in the period 2017 to 2019.

c) Assessment results

In 2020 a surplus production model (SPiCT) was used for preliminary assessment of the stock. Evaluation of stock status is based upon interpretation of commercial fishery and research survey data. The trends in the survey and the standardized CPUE have been rather similar since the start of the survey. In 2020 historical high survey biomass and standardised CPUE were seen and may indicate an improvement of the shrimp density, however, this may not reflect overall stock status as both the CPUE and the survey biomass were driven by a relative restricted area in Q1.

Applying the SPiCT surplus model as a preliminary analytical assessment tools showed that B/B_{MSY} is well above 1 and F/F_{MSY} is well below 1 indicating a healthy stock status (Figure 4.8, SCR Doc 20/061).

NIPAG consider this as being indicative results and the SPiCT model should be further explored for this stock, including adding risk levels for different catch projection scenarios.

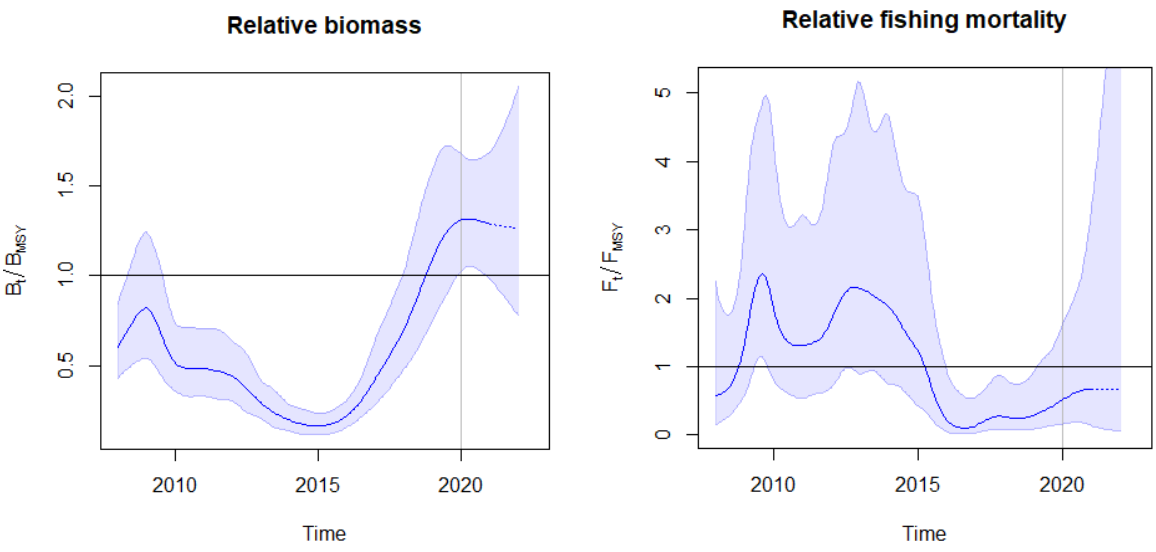


Figure 4.8. Plot of the estimated relative biomass (B_t/B_{MSY}) and relative fishing mortality (F_t/F_{MSY}) through time.

Projections.

Below is shown forecast for 2021 for seven scenarios.

Predictions:

	C	B	F	Bt/Bmsy	Ft/Fmsy	perc.dB	perc.dF
1. Keep current catch	2 966	7 371.3	0.403	1.235	0.756	-4.2	12.1
2. Keep current F	2 735.9	7 551.6	0.359	1.265	0.675	-1.8	0
3. Fish at Fmsy	3 821.3	6 774.8	0.533	1.135	1	-11.9	48.2
4. No fishing	3.1	9 039.1	0	1.514	0.001	17.5	-99.9
5. Reduce F 25%	2 113.4	7 944.7	0.27	1.331	0.506	3.3	-25
6. Increase F 25%	3 317.6	7 150.4	0.449	1.198	0.844	-7	25
7. MSY advice rule	3 821.3	6 774.8	0.533	1.135	1	-11.9	48.2

d) Reference points

Scientific Council considers that 15% of the maximum survey female biomass provides a proxy for B_{lim}. In 2020 B_{lim} was recalculated based on new high survey female biomass from 2020 survey (Figure 4.2).

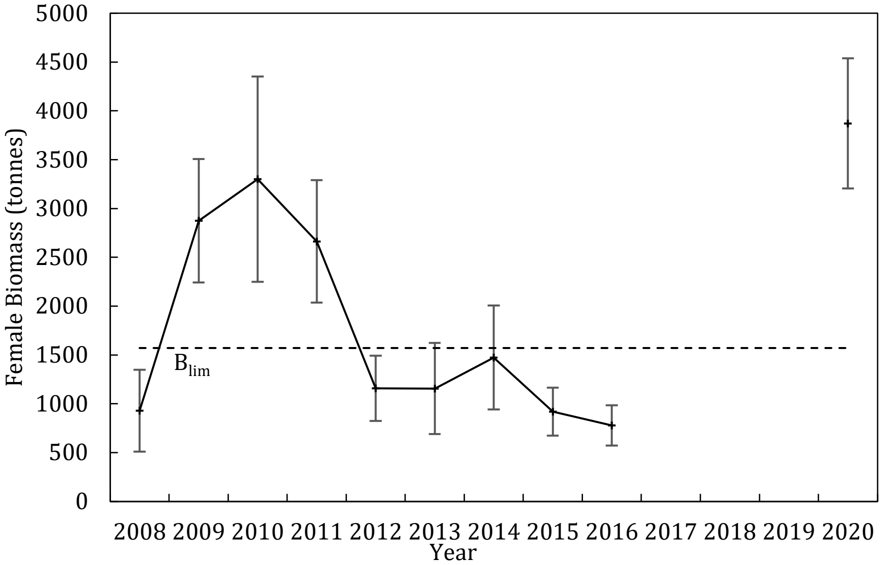


Figure 4.9. Shrimp in Denmark Strait and off East Greenland: Spawning stock biomass index (SSB) ±SE from 2008-2016 and 2020, and B_{lim} estimated as 15% of maximum survey female biomass. No survey was carried out in the period 2017 to 2019.

e) State of the stock

CPUE: The CPUE index declined continuously from its highest point in 2009 to a low value in 2014 and has been increasing since then (Figure 4.2). Estimates for the period 2016 to 2020 are based on fishing in a relatively small area and may not reflect the state of the total stock.

Recruitment. No recruitment estimates were available.

Biomass. The survey biomass index decreased by around 80% from 2010 to 2016. No survey was conducted in the period 2017 to 2019. The survey biomass in 2020 is the highest observed.

Exploitation rate. Since the mid-1990s the exploitation rate index based on standardized commercial effort has decreased, currently reaching the lowest levels seen in the time series. The 2016 to 2020 levels of exploitation rate may be biased given the issues on CPUE described above.

State of the stock. The stock in 2020 is at a high level. The survey biomass in 2020 is the highest observed since the beginning of the survey, in 2008. The commercial CPUE in 2020 is also the highest since the beginning of the time series, in 1986. There is no recruitment index available for this stock, few juvenile shrimps are caught in the survey area.

f) Research recommendations

- NIPAG **recommended** in 2016 that *genetic stock structure in West and East Greenland should be further explored.*

Status: No progress; this recommendation will not be progressed further at present.

- NIPAG **recommends** in 2020 that: *further model exploration should be carried out, including adding risk levels for different catch projection scenarios.*

5. Northern shrimp (*Pandalus borealis*) in the Skagerrak and Norwegian Deep (ICES Subdivision 27.3a.20 and the eastern part of Division 27.4a)

This stock was assessed by a subgroup of NIPAG during 25–27 February 2019 at ICES HQ in Copenhagen. The report is included as Appendix VII to this report. NIPAG reviewed the assessment during the present meeting. There were no further recommendations.

6. Northern shrimp (*Pandalus borealis*) in the Barents Sea (ICES Subareas 1 and 2)

Background documentation (equivalent to stock annex) is found in SCR Docs. 20/65, 66,67; 70; 08/56, 07/86, 7506/64.

a) Introduction

Northern shrimp (*Pandalus borealis*) in the Barents Sea and in the Svalbard fishery protection zone (ICES Subareas 1 and 2) is considered as one stock (Figure 6.1). Norwegian and Russian vessels exploit the stock in the entire area, while vessels from other nations are restricted to the Svalbard fishery zone and the "Loop Hole" (Figure 6.1).

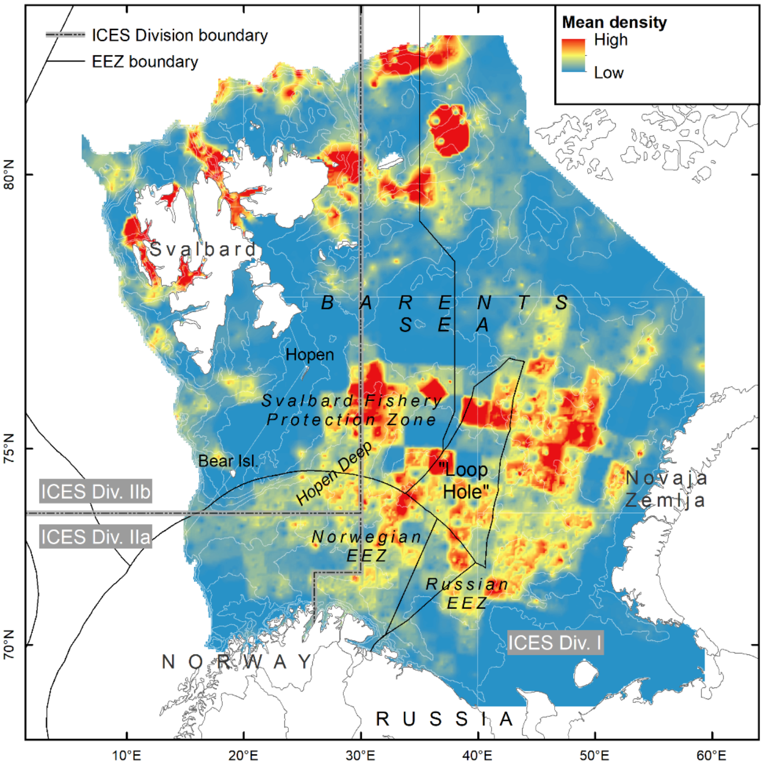


Figure 6.1. Shrimp in ICES SA 1 and 2: Stock distribution (Mean survey density index (kg/km2) from the joint Norwegian-Russian survey).

Norwegian vessels initiated the fishery in 1970. As the fishery developed, vessels from several nations joined and catches increased rapidly (Figure 6.2). Vessels from Norway, Russia, Iceland, Greenland, Faeroes and the EU participate in this fishery on a regular basis.

There is no overall TAC established for this stock. The fishery is partly regulated by effort control (Norwegian and Svalbard zone), and a TAC in the Russian zone only. Licenses are required for the Russian and Norwegian vessels. In the Norwegian and Svalbard zones, the fishing activity of these license holders is constrained only by bycatch regulations whereas the activity of third country fleets operating in the Svalbard zone is also restricted by the number of effective fishing days and the number of vessels by country. The minimum stretched mesh size is 35 mm. Bycatch is limited by mandatory sorting grids and by the temporary closing of areas where excessive bycatch of juvenile cod, haddock, Greenland halibut, redfish or shrimp <15 mm CL is registered.

Catch. Catches have increased from 20 000 t in 2013 to 76 083 tons in 2019 and are predicted to reach 53000 tons by the end of 2020.

Table 6.1. Shrimp in ICES SA 1 and 2: Recent catches in metric tonnes, as used by NIPAG for the assessment.

	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020[1]
Recommended TAC	60 000	60 000	60 000	60 000	70 000	70 000	70 000	70 000	70 000	150000
Norway	19928	14158	8846	10234	16618	10896	7010	23100	23925	16500
Russia	0	0	1067	741	1151	2460	3849	12561	28078	21000
Others	10298	10598	9336	9989	16252	16223	19582	20025	24083	15500
Total	30226	24756	19249	20964	34022	29609	30441	55911	76 083	53000

[1] Catches projected to the end of the year.

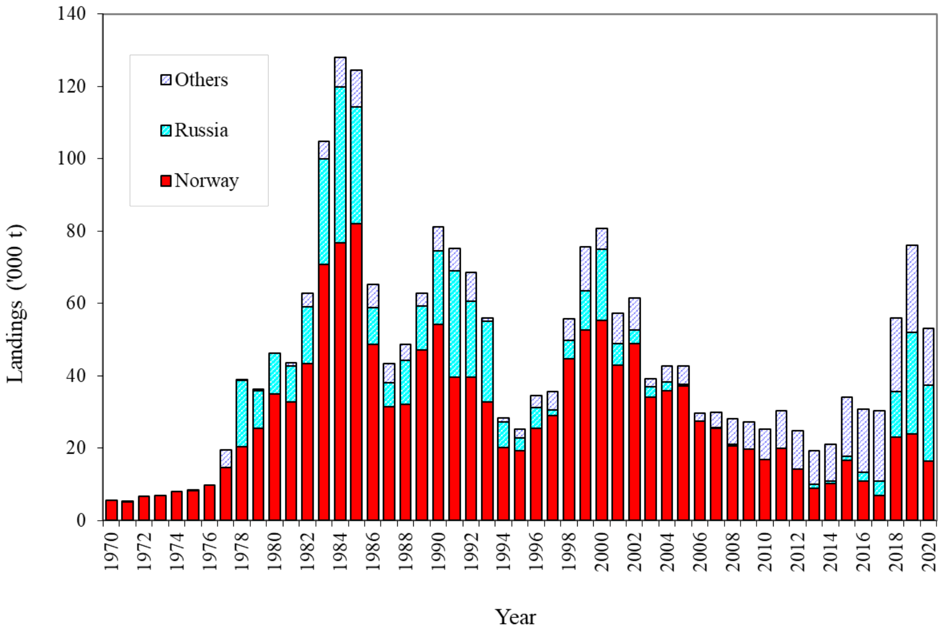


Figure 6.2. Shrimp in ICES SA 1 and 2: Total catches (2020 projected to the end of the year).

Discards and bycatch and ecosystem effects. Discard of shrimp cannot be quantified but is believed to be small as the fishery is not limited by quotas. Bycatch rates of other species are estimated from at-sea inspections and research surveys and are corrected for differences in gear selection pattern (ICES 2018a). Area-specific bycatch rates are then multiplied by the corresponding shrimp catches from logbooks to give an overall bycatch estimate. Revised and updated discards estimates (1983–2017) of cod, haddock and redfish juveniles in the Norwegian commercial shrimp fishery in the Barents Sea were available in 2018 (Figure 6.3). Since the introduction of the Nordmøre sorting grid in 1992, only small individuals of cod, haddock, Greenland halibut, and redfish, in the 5–25 cm size range, are caught as bycatch.

In 2017, specific information on bycatch from EU-Estonia based on onboard scientific observers was presented. They indicated 2.9% by weight of fish discards and 0.6% discards of shrimp.

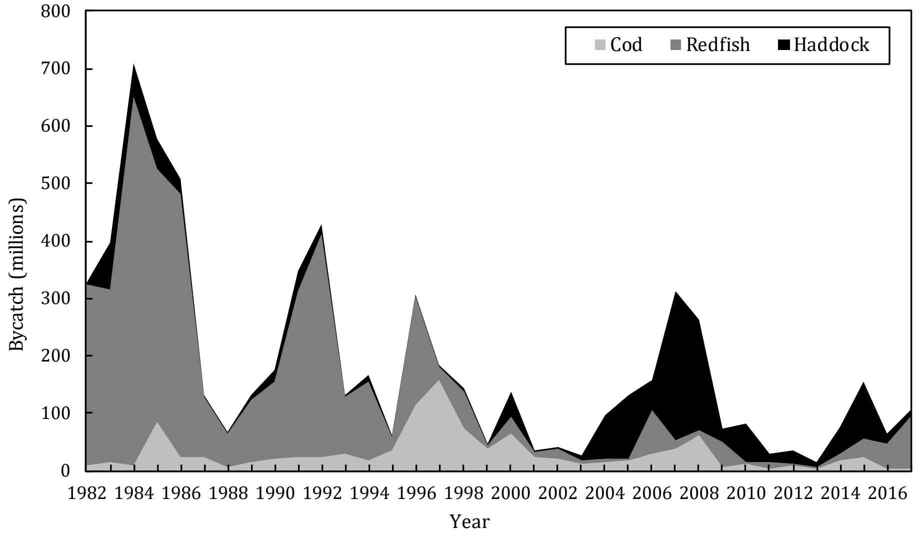


Figure 6.3. Shrimp in ICES SA 1 and 2: Estimated bycatch of cod, haddock and redfish in the Norwegian shrimp fishery (million individuals). The sorting grid was introduced in 1992 and has been mandatory since and following that, the vast majority of bycatch is assumed to have been juveniles.

b) Input data

i) Commercial fishery data

Logbook data are normally available only from the Norwegian fleet, but 2017 data was also available from the EU-Estonia fleet. In 2020 summary catch and effort data was received from Poland, Latvia and Estonia. In addition, information was provided by Russia in SCR Doc. 20-063, including information on catch distribution and standardized catch rates in 2020.

A major restructuring of the Norwegian shrimp fishing fleet towards fewer and larger vessels took place during the late-1990s through the early 2000s (Figure 6.4). Until 1996, the fishery was conducted using single trawls only. Double and triple trawls were then introduced. An individual vessel may alternate between single and multiple trawling depending on what is appropriate on given fishing grounds.

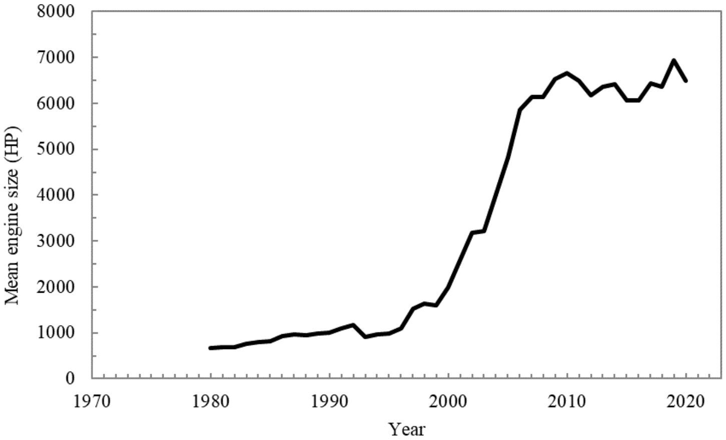


Figure 6.4. Shrimp in ICES SA 1 and 2: Mean engine power (HP) weighted by trawl-time (Norwegian vessels).

The fishery takes place throughout the year but may in some years be seasonally restricted by ice conditions. The lowest effort is generally in October through March, the highest in May to August.

The fishery was originally conducted mainly in the central Barents Sea and on the Svalbard Shelf along with the Goose Bank (southeast Barents Sea). Norwegian logbook data since 2009 show decreased activity in the Hopen Deep and around Svalbard, coupled with increased effort further east in international waters (the "Loop Hole") (Figure 6.5). Information from the Norwegian industry points to decreasing catch rates and more frequent area closures due to bycatch of juvenile fish on the traditional shrimp fishing grounds as the main reasons for the observed change in fishing pattern.

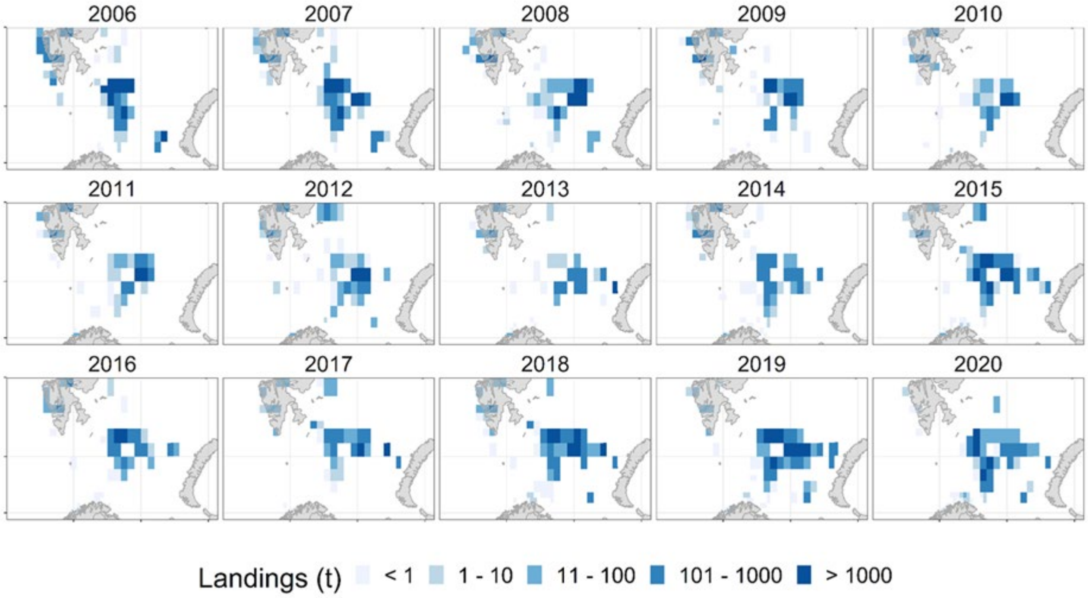


Figure 6.5. Shrimp in ICES SA 1 and 2: Distribution of catches by Norwegian vessels since 2000 based on logbook information. 2020 includes only data until September.

The Soviet/Russian fishery for the northern shrimp in the Barents Sea started in 1978. Catches peaked in 1983-1985 and varied in subsequent years (Fig. 6.2) In 2009-2012, the Russian fishery for shrimp came to a full stop. Following a restructuring of the fleet catches have again increased and are projected to reach 21000 tons by the end of 2020.

In the early 2000s, the Russian fishery was mainly conducted in the open part of the Barents Sea and the Svalbard area (Fig. 6.6). With the resumption of fishery in 2013, the main fishing grounds were shifted eastward. Currently fishing occurs in the Russian EEZ in the areas of the Novaya Zemlya Bank, the Perseus Upland, Cape Zhelaniya and Cape Sukhoi Nos. The main fishing period is March to September; however, some vessels fish all year round.

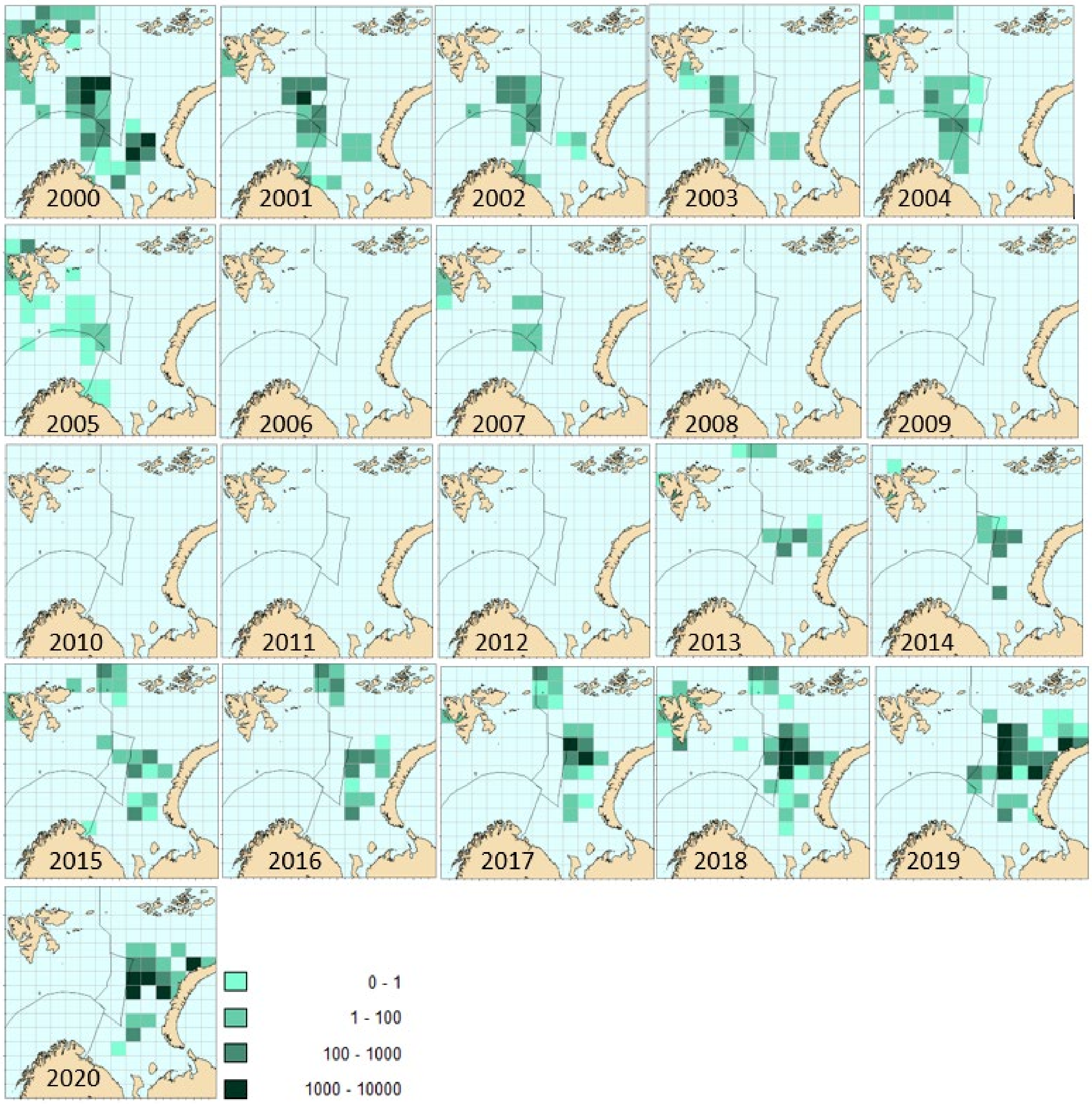


Figure 6.6. Distribution of catches by Russian vessels since 2000 based on logbook information. (2020 only data until September)

A standardized CPUE index based on a generalized linear model (GLM) that took area, depth, gear, and month into account, was stable from 2000 to 2015 and then increased (Fig. 6.7). From a maximum in 2019 it decreased by 23% in 2020. This standardized CPUE, being new and not fully evaluated by NIPAG was at this point not used as input to the assessment model. However, it was noted that in the period since 2016 when the Russian shrimp fishery was revived, the trajectory of this index series (Fig. 6.7) was in good agreement with that seen in the survey (Fig. 6.11). The inclusion of this index should be further considered at the up-coming benchmark.

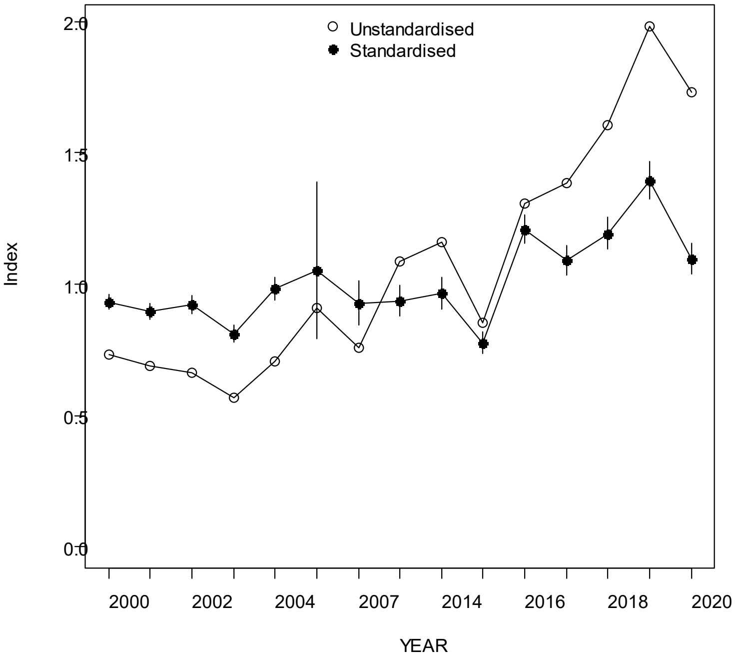


Figure 6.7. Unstandardized (geometric mean of annual observations) and standardized (year coefficients from GLM) CPUE indices for Russian shrimp fishery. Error bars indicate +2 s.e. Each series has been normalized to a geometric mean of 1.

Norwegian logbook data were used in a GLM to calculate standardized annual catch rate indices (SCR Doc. 19/56). The GLM used to derive the CPUE indices included the following variables: (1) vessel, (2) season (month), (3) area (five survey strata), and (4) gear type (single, double or triple trawl). The resulting series provides an index of the fishable biomass of shrimp ≥17 mm CL, *i.e.* females and older males (Figure 6.8). The minimum commercial size in this fishery is 15mm.

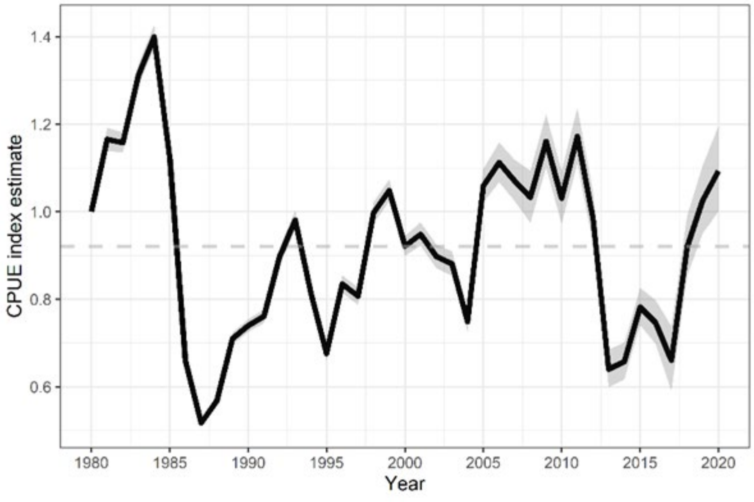


Figure 6.8. Shrimp in ICES SA 1 and 2: Standardized CPUE based on Norwegian data. Black line indicates the mean estimate, the shaded area the 95% confidence intervals.

The Norwegian logbook data on which the CPUE index is based represents fishing activity from most of the stock distribution area. However, in recent years the portion of total catches taken by Norway has been halved and now only represents about one third of the total catches.

In last year's assessment (2019) the 2018 and 2019 index values were record high. Input data and model diagnostics were scrutinized but there was at that time not found anything to indicate errors or model deficiencies. For this year's calculation the code for vessel filtering and GLM fit was revised. The CPUE index used in last year's assessment was determined to be overestimated due to incomplete data and filtering issues (Fig. 6.9). The correction of the CPUE index reduced current CPUE to levels that correspond better with past trends, and subsequently resulted in stock estimates that align more closely with historic patterns.

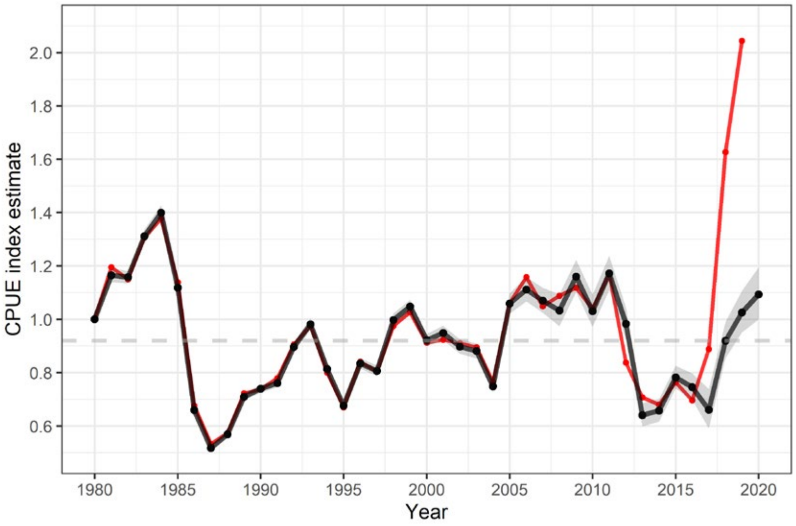


Figure 6.9. Shrimp in ICES SA 1 and 2: Comparison of standardized CPUE (Norwegian data) from the 2019 assessment (red line) and the revised version for this year's assessment (black line).

ii) Research survey data

Russian and Norwegian surveys were conducted in their respective EEZs of the Barents Sea from 1982 to 2005 to assess the status of the northern shrimp stock (SCR Docs. 06/70, 07/75, 14/51, 15/52). In 2004, these surveys were replaced by a joint Norwegian-Russian "Ecosystem survey" in August/September, which monitors shrimp along with a multitude of other ecosystem variables in the Barents Sea and around Svalbard (SCR Docs.14/55, 7/68).

Biomass. The biomass indices of survey 1 and 2 have fluctuated without trend over their respective time periods covered (Figure 6.12). The most recent survey series (survey 3) has increased substantially since a low in 2016 to reach its highest value in 2019. However, the 2020 value is down again close to the 2016 value. In general, the entire survey area of the Ecosystem survey (survey 3 in Figure 6.12) is covered in all years, however, due to heavy ice conditions in 2014 the northern part of the area (stratum 3, see SCR Doc. 17/68) was not covered. For the 2004-2013 survey period this area accounts for on average 13% of the biomass (range: 8-27%). The 2014 biomass for stratum 3 was estimated by calculating the average ratio of biomass density in stratum 3 to biomass density in the remaining survey area for the 2009-2013 period and applying this average to the density of the 2014 surveyed area. Estimates of variance for stratum 3 was taken as the variance of the 2009-2013 estimates for stratum 3. A similar method incorporating 2015 to 2017 data was used to compensate for missing coverage due to vessel malfunction of stratum 5 and stratum 4 in 2018 and 2019 respectively.

In the 2020 the Russian part of the survey area (about 50%) was not finalized before the start of this assessment due to technical issues (Fig. 6.10). This part of the survey is expected to be finalized later in the year. NIPAG discussed whether to exclude this data point from the assessment or use the existing partial survey data to estimate a biomass index value for the entire area. As the partial data from the Norwegian survey area and information from the Russian fishery (figure 6.7) both indicated a significant decline in biomass as compared to 2019, NIPAG decided to reconstruct a total biomass estimate for 2020 for use as input in the assessment model. The biomass index value was constructed as follows: a time-series of biomass estimates for the area covered by the 2020 survey was produced for the entire survey time series. The proportion of total biomass situated in this partial survey area was then calculated (Fig. 6.11). The mean of these proportions (60.3%) was then applied to the partial 2020 estimate (220 kt*100/60.3) giving a total 2020 biomass index value of 365 kt. The variance was taken as the mean variance of the 2010-2019 series times two. The resulting survey series is shown in Fig. 6.12 and the spatial distribution in Fig. 6.13.

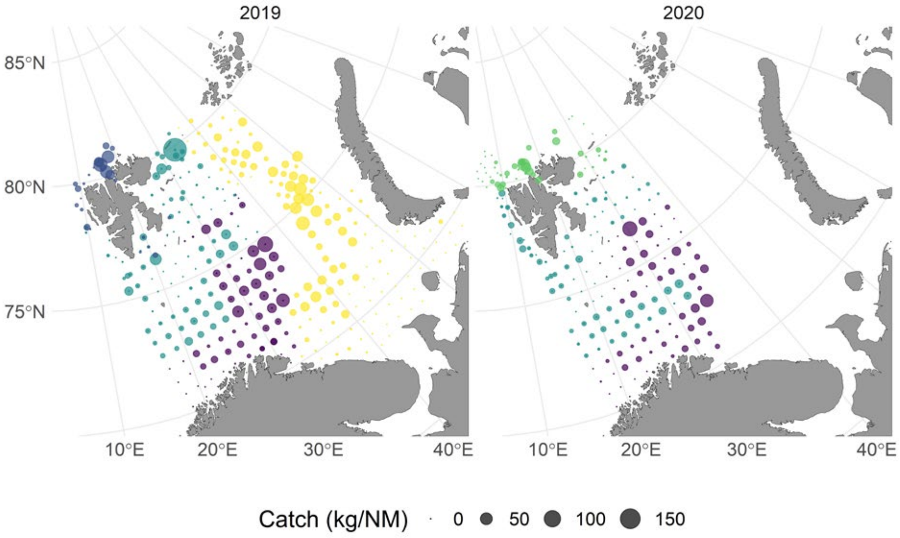


Figure 6.10. Survey coverage 2019 and 2020. Dots are scaled to the registered catches of shrimp, colors indicate different survey vessels.

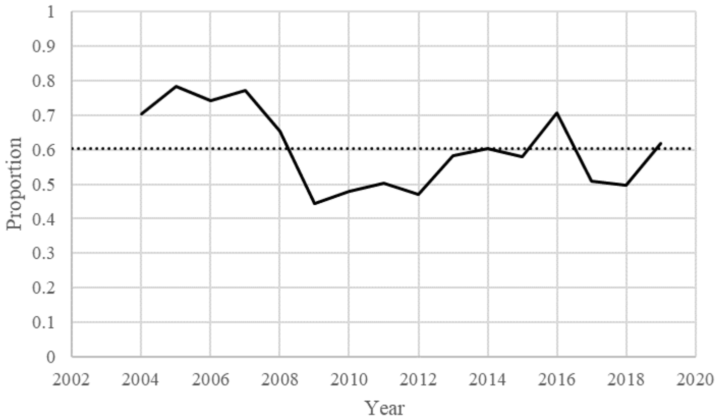


Figure 6.11. Proportion of total biomass found in the partial area covered by the 2020 survey. Dotted line is the mean of the series (60.3%).

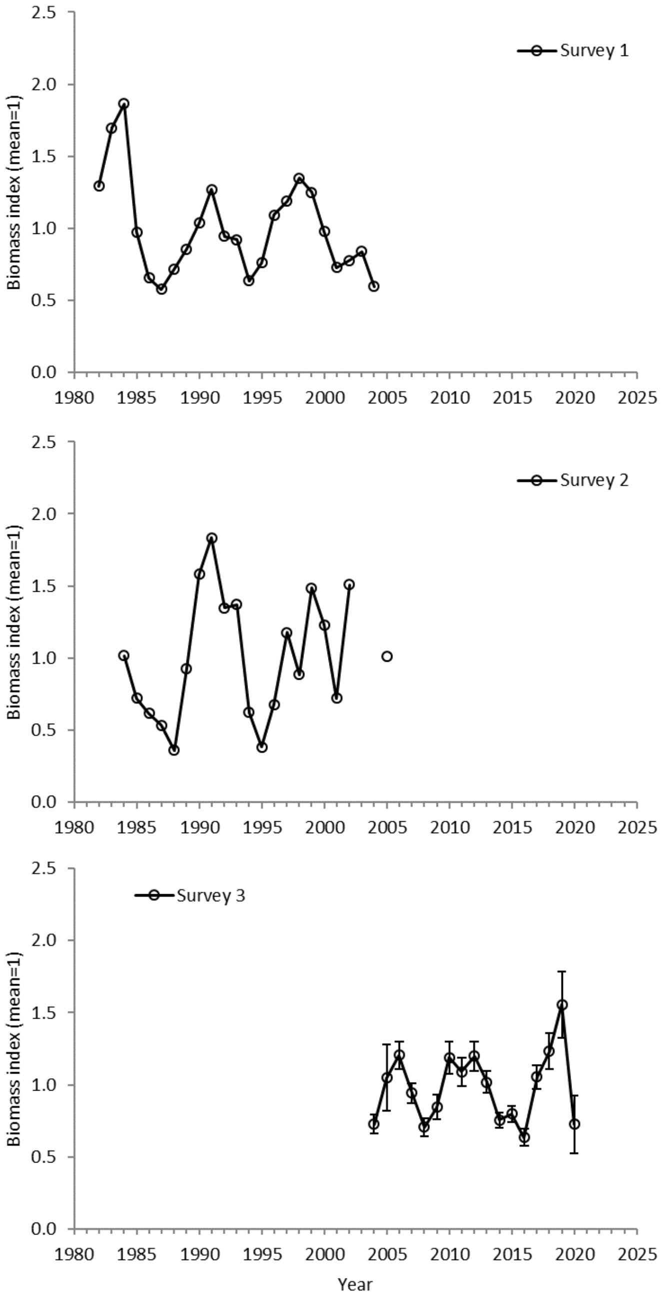


Figure 6.12. Shrimp in ICES SA 1 and 2: Indices of total stock biomass from the (1) 1982-2004 Norwegian shrimp survey, (2) the 1984-2005 Russian survey, and (3) the joint Russian-Norwegian ecosystem survey since 2004. Error bars represent 1 SE.

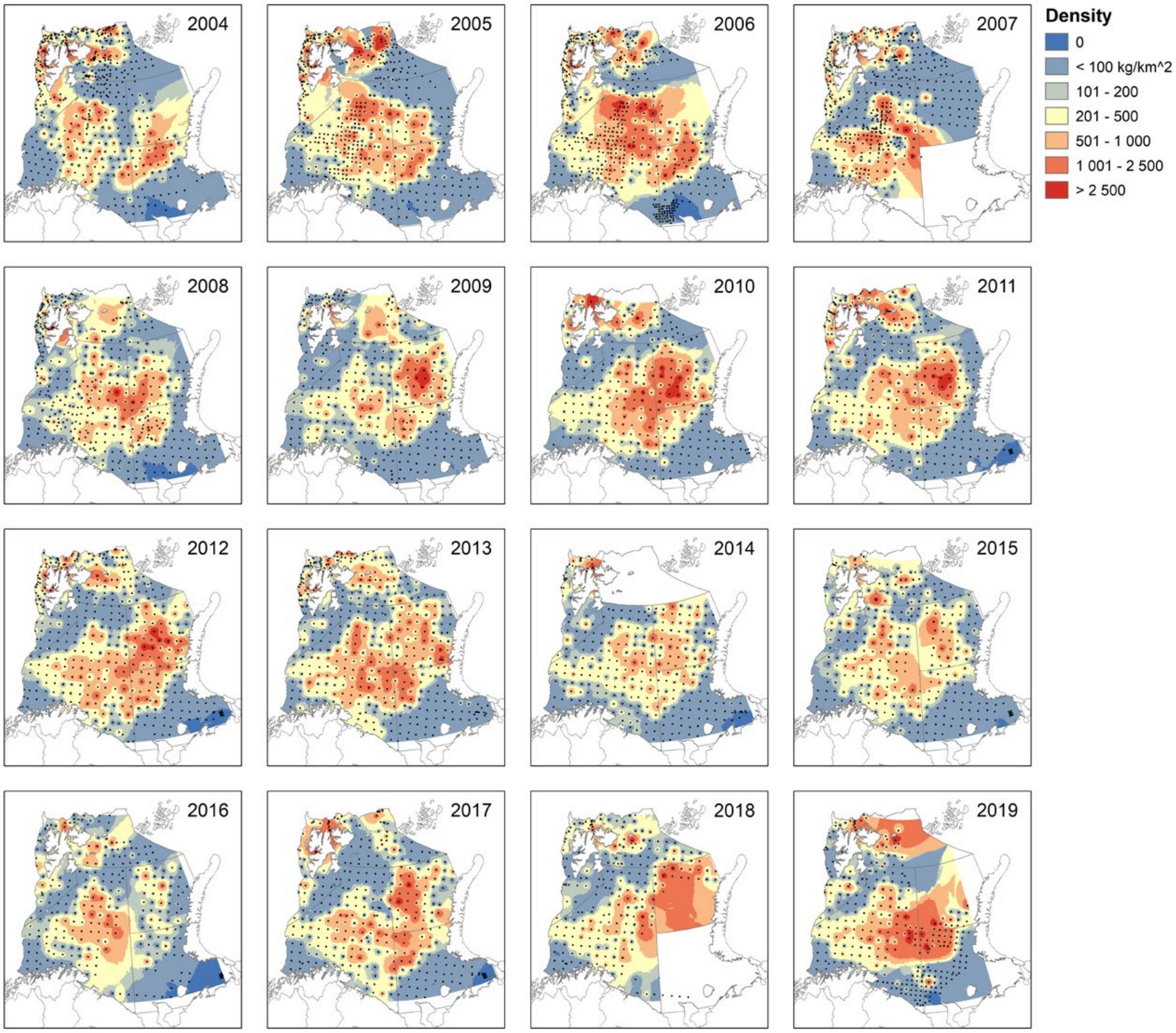


Figure 6.13. Shrimp in ICES SA 1 and 2: shrimp density (kg/km2) as calculated from the Ecosystem survey data since 2004 (no data for stratum 3 in 2014 due to ice conditions; no data for stratum 5 in 2018 and 4 in 2019 due to vessel malfunction; for survey 2020 see text and Fig. 6.10.

Recruitment indices. No information is included as data are not available since 2013. Length distribution data from the Estonian fishery and survey data from the Norwegian EEZ were investigated during the meeting and these gave some indication of good recruitment in 2015 and 2019, however, NIPAG deferred further analysis to the upcoming benchmark.

c) Assessment

The modelling framework introduced in 2006 (SCR Doc. 06/64) was used for the assessment. Model settings were the same as those used in previous years. However, the observation error for the 2020 survey data point was assumed to be twice that of the remaining series, taking into account that the survey only covered about 50% of the distribution area.

Within this model, parameters relevant for the assessment and management of the stock are estimated, based on a stochastic version of a surplus-production model. The model is formulated in a state-space framework and

Bayesian methods are used to derive "posterior" probability density distributions of the parameters (SCR Doc. 20/066).

The model synthesized information from input priors, four independent series of shrimp biomass indices and one series of shrimp catch. The biomass indices were: a standardized series of annual fishery catch rates for 1980–2020 (Figure 6.6, SCR Doc. 20/067); and trawl-survey biomass indices for 1982–2004, 1984–2005 and for 2004–2020 (Figure 6.7, SCR Doc. 20/065). These indices were scaled to true biomass by individual catchability parameters, q_j, and lognormal observation errors were applied. Total reported catch in ICES Div. 1 and 2 since 1970 was used as yield data (Figure 6.2, SCR Doc. 20/067). The fishery being without major discarding problems or variable misreporting, reported catches were entered into the model as error-free.

Biomass, B, was thus measured relative to the biomass that would yield Maximum Sustainable Yield, B_{msy}. The estimated fishing mortality, F, refers to the removal of biomass by fishing and is scaled to the fishing mortality at MSY, F_{msy}. The state equation describing stock dynamics took the form:

$$P_{t+1} = \left(P_t - \frac{C_t}{B_{MSY}} + \frac{2\,MSY\,P_t}{B_{MSY}} \left(1 - \frac{P_t}{2} \right) \right) \cdot \exp(\nu_t)$$

where P_t is the stock biomass relative to biomass at *MSY* ($P_t = B_t/B_{msy}$) in year t. This frames the range of stock biomass on a relative scale where $B_{msy} = 1$ and the carrying capacity (K) equals 2. The 'process errors', v, are normally, independently and identically distributed with mean 0 and variance σ_P^2.

The observation equations had lognormal errors, ω, κ, η and ε, for the series of standardised CPUE ($CPUE_t$), Norwegian shrimp survey ($survR_t$), The Russian shrimp survey ($survRu_t$) and joint ecosystem survey ($survE_t$) respectively giving:

$$CPUE_t = q_C B_{MSY} P_t \exp(\omega_t)\,,\ survR_t = q_R B_{MSY} P_t \exp(\kappa_t)\,,\ survRu_t = q_{Ru} B_{MSY} P_t \exp(\eta_t)\,,\ survE_t = q_E B_{MSY} P_t \exp(\varepsilon_t)$$

The observation error terms, ω, κ, η and ε are treated as normally, independently and identically distributed with mean 0 and variances σ_C^2, σ_R^2, σ_{Ru}^2 and σ_E^2 respectively.

Summaries of the estimated posterior probability distributions of selected parameters are shown in Table 6.2. Values are similar to the ones estimated in previous assessments. K could not be well estimated from the data alone and its posterior will depend somewhat on the chosen prior. For the estimates of relative stock size relaxing the K-prior did not have much effect (SCR Doc. 07/76) except for a slight increase in uncertainty. However, the posterior for *MSY* is sensitive as K is correlated with *MSY*: in particular, the right-hand side of the posterior distribution is widened while the left-hand side seems pretty well determined by the data. The mode of the distribution of *MSY* is around 150 kt and would likely be a best point estimate of this parameter.

Table 6.2. Shrimp in ICES SA 1 and 2: Summary of parameter estimates: mean, standard deviation (sd) and quartiles of the posterior distributions of selected parameters estimated in the 2020 assessment (symbols are as in the text; *r* = intrinsic growth rate, P_0 = the 'initial" stock biomass in 1969) and the median values from the 2019 assessment.

	Mean	sd	25 %	Median	75 %	Median (2019)
MSY (ktons), maximum sustainable yield	223	119	126	204	307	160
K (ktons), carying capacity	2978	1517	1870	2686	3757	2664
r, intrinsic growth rate	0.33	0.15	0.22	0.32	0.42	0.26
q_R, catchability of survey 2	0.13	0.08	0.07	0.11	0.16	0.12
q_{Ru}, catchability of survey 1	0.33	0.21	0.19	0.27	0.40	0.31
q_E, catchability of survey 3	0.20	0.13	0.12	0.17	0.25	0.18
q_C, catchability of CPUE index	4.7E-04	3.0E-04	2.7E-04	3.8E-04	5.8E-04	4.5E-04
P_0, initial relative biomass (1969)	1.50	0.26	1.33	1.51	1.68	1.50
P_{2020}, relative biomass in 2020	1.90	0.47	1.59	1.86	2.16	2.37
σ_R, coefficient of variation for survey 2	0.17	0.03	0.15	0.17	0.19	0.17
σ_{Ru}, coefficient of variation for survey 1	0.34	0.05	0.30	0.34	0.37	0.33
σ_E, coefficient of variation for survey 3	0.19	0.04	0.17	0.19	0.22	0.16
σ_C, coefficient of variation for CPUE index	0.13	0.02	0.12	0.13	0.15	0.14
σ_P, coefficient of variation for process	0.19	0.03	0.17	0.18	0.20	0.20

Reference points. Four reference points are considered (buffer reference points are obsolete as probability of transgressing the PA limit reference points can be calculated directly):

	Type	Value	Technical basis
MSY approach	$B_{trigger}$	$0.5B_{MSY}$	Approximately corresponding to 10th percentile of the B_{msy} estimate (NIPAG 2010)
	F_{MSY}		Resulting from the assessment model.
Precautionary approach	B_{lim}	$0.3B_{MSY}$	The *B* where production is reduced to 50% *MSY* (NIPAG 2006)
	F_{lim}	$1.7F_{MSY}$	The *F* that drives the stock to B_{lim}

The results of this year's assessment are at large consistent with those of previous years (model introduced in 2006). The conclusions on stock status drawn from the model have been found on investigation to largely be insensitive to the setting of the priors for initial stock biomass and carrying capacity (SCR Docs. 06/64 and 07/76).

Stock size and fishing mortality*.* A steep decline in stock biomass in the mid-1980s was noted following some years with high catches and the median relative biomass almost dropped to the *Bmsy*-level (Figure 6.14, upper). Since the late 1980s, however, the stock has varied with a slightly increasing trend including a noticeable increase in the most recent years. The estimated risk of stock biomass being below $B_{trigger}$ by the end of 2020 is less than 1% (Table 6.3). The median estimate of fishing mortality has remained below F_{msy} throughout the history of the fishery (Figure 6.14 lower). In 2020, there is a less than 5% risk of the *F* being above F_{msy} (Table 6.3).

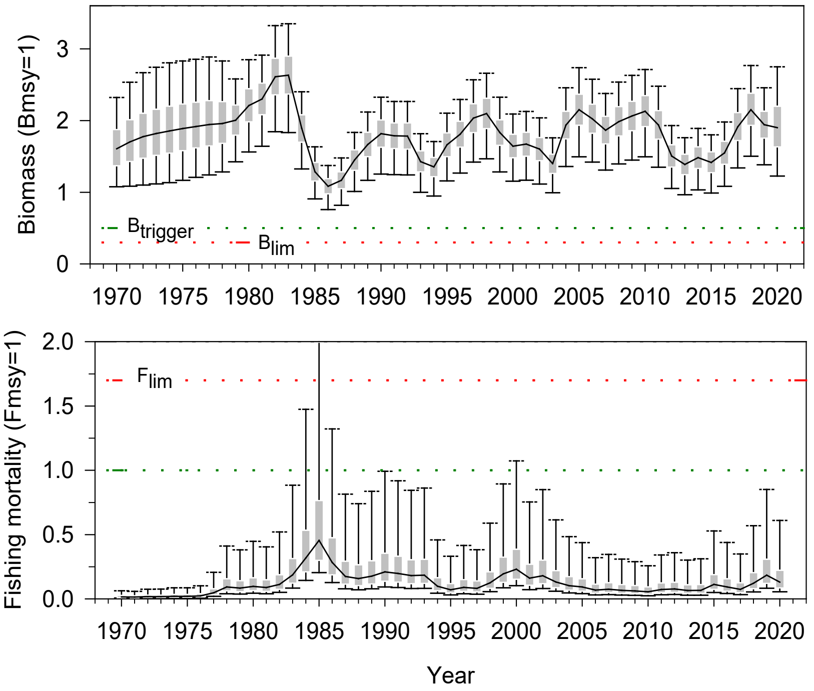


Figure 6.14. Shrimp in ICES SA 1 and 2: Estimated relative biomass (B/B_{msy}) and fishing mortality (F/F_{msy}) since 1970. Boxes represent inter-quartile ranges and the solid black line in the middle of each box is the median; the arms of each box cover the central 90% of the distribution. The broken lines indicate *MSY* and precautionary approach reference points.

Table 6.3. Shrimp in ICES SA 1 and 2: Stock status for 2019 and projected to the end of 2020.

Status	2019	2020*
Risk of falling below B_{lim}	0.0 %	0.0 %
Risk of falling below $B_{trigger}$	0.1 %	0.1 %
Risk of exceeding F_{MSY}	3.9 %	2.2 %
Risk of exceeding F_{lim}	1.6 %	1.0 %
Stock size (B/Bmsy), median	1.90	1.86
Fishing mortality (F/Fmsy),	0.19	0.14

*Predicted catch = 53ktons

Projections. Catch advice at the median of F_{msy} (ICES MSY approach) would imply no more than 266 kt – way outside the catch history of the fishery. Given that the right-hand side of the probability distributions of the yield at the F_{msy} is less well estimated, NIPAG considers it more appropriate to apply the mode as a point estimate of yield at F_{msy}. This mode is at 140 kt. Assuming a catch of 53 kt for 2020, catch options up to 140 kt for 2021 have low risks of exceeding F_{msy} (<16%), F_{lim} (<7%), and of going below $B_{trigger}$ (<1%) by the end of 2021 (Table 6.4) and all these options are likely to maintain the stock above B_{msy}.

Table 6.4. Shrimp in ICES SA 1 and 2: Predictions of risk and stock status associated with optional catch levels for 2021.

	Catch option 2020 (ktons)						Yield at Fmsy (mode)	Yield at Fmsy (median)
	60	70	80	90	100	110	140	266
Risk of falling below B_{lim}	0.0 %	0.0 %	0.0 %	0.0 %	0.0 %	0.0 %	0.4 %	1.5 %
Risk of falling below $B_{trigger}$	0.2 %	0.2 %	0.2 %	0.2 %	0.2 %	0.2 %	0.9 %	3.9 %
Risk of exceeding F_{MSY}	3.0 %	4.1 %	5.0 %	6.3 %	7.5 %	9.3 %	15.2 %	50 %
Risk of exceeding F_{lim}	1.3 %	1.7 %	2.1 %	2.5 %	3.1 %	3.7 %	6.4 %	24 %
Stock size (B/Bmsy), median	1.83	1.83	1.83	1.81	1.80	1.79	1.74	1.57
Fishing mortality (F/Fmsy),	0.16	0.19	0.21	0.24	0.27	0.30	0.41	1.00

d) Environmental conditions

Since the 1980s, the Barents Sea has gone from a situation with high fishing pressure, cold conditions and low demersal fish stock levels, to the current situation with high levels of demersal fish stocks, reduced fishing pressure and warm conditions.

The capelin stock has declined again after a recovery in 2017 and has likely fallen below B*lim*. Cod biomass has decreased in recent years following a peak around 2013 but is still at a relatively high level. With the recent decrease in capelin and cod abundance remaining on historically high levels, predation pressure on shrimp may be relatively high. The levels of environmental and organic pollution in the Barents Sea are generally low and do not exceed threshold limits or global background levels. More detailed information can be found in ICES (2018b)

Temperature. In the ecosystem survey, shrimps were only caught in areas where bottom temperatures were above 0°C. Highest shrimp densities were observed between zero and 4°C, while the limit of their upper temperature preference appears to lie at about 6-8°C. The warming of the western Barents Sea coincides with the shift in shrimp distribution eastwards (Figure 6.8), thus temperature is probably a factor in explaining the observed changes in spatial distribution.

Predation. Both stock development and the rate at which changes might take place can be affected by changes in predation, in particular by cod, which has been documented as capable of consuming large amounts of shrimp. Continuing investigations to include cod predation as an explicit effect in the assessment model have so far not been successful; it has not been possible to establish a relationship between the density of cod and the stock dynamics of shrimp. The cod stock in the Barents Sea has decreased but remained at a relatively high level during the recent ten years. If predation on shrimp was to increase rapidly beyond the range previously experienced, the shrimp stock might decrease in size more than the model results have indicated as likely.

Recruitment, and reaction time of the assessment model. The model used is best at projecting trends in stock development but estimates and uses long-term averages of stock dynamic parameters. Large and/or sudden changes in recruitment or mortality may therefore be underestimated in model predictions which seems to be exemplified by the 2018-19 abrupt increase in stock biomass.

Model performance. The model was able to produce good simulations of the observed data (Figure 6.15). The differences between observed values of biomass indices and the corresponding values predicted by the model were checked numerically (SCR Doc 20/066). They were found generally not to include excessively large deviations.

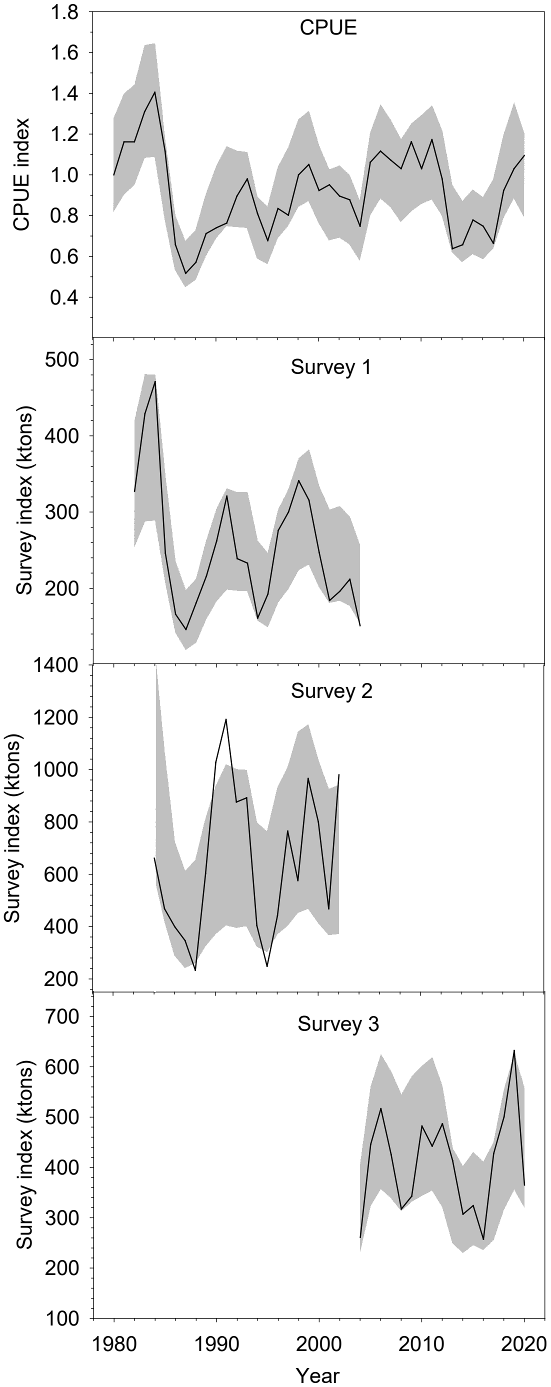


Figure 6.15. Shrimp in ICES SA 1 and 2: Observed (solid line) and estimated (shaded) series of the included biomass indices: the standardized catch-per-unit-effort (CPUE), the 1982–2004 Norwegian shrimp survey (survey 1), the 1984 to 2005 Russian survey (Survey 2) and the Joint Norwegian-Russian Ecosystem Survey (survey 3) since 2004. Grey shaded areas cover the 80% probability interval of their posteriors.

The model did have a tendency to be too pessimistic regarding the final years during the stock increase since 2015 to 2014 (Figure 6.16), but all of these were well inside the updated estimated probability distributions the following year. The model only slightly underestimated the decline from 2019 to 2020. A simple calculation of Mohn's rho based on the point estimates (medians) for five years is -0.15.

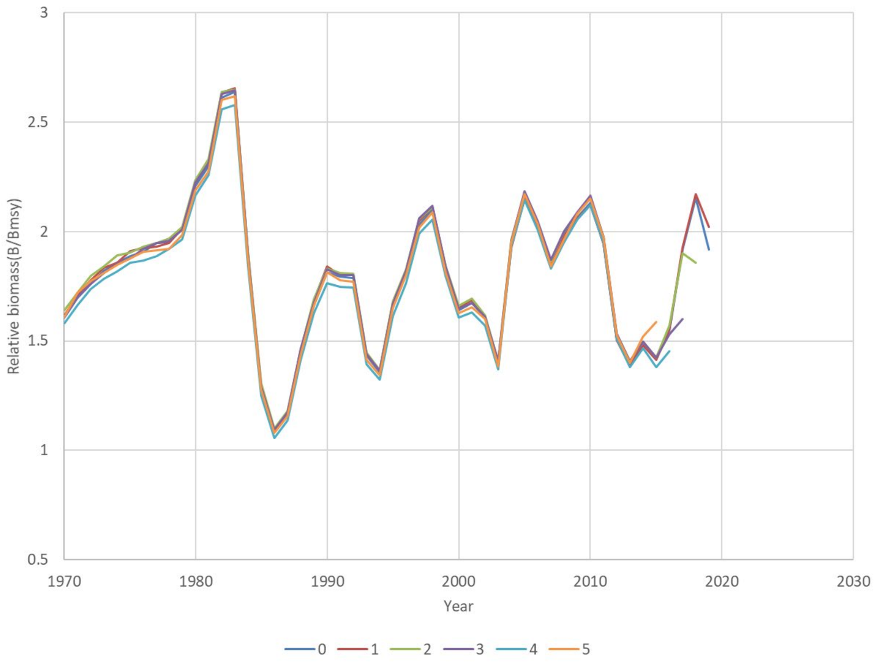


Figure 6.16. Shrimp in ICES SA 1 and 2: Retrospective plot of median relative biomass (B/B_{msy}). Relative biomass series are estimated by consecutively leaving out from 0 to 10 years of data.

A correction of the CPUE index in this year's assessment has resulted in a re-alignment with the stock trajectories estimated before 2019 as compared to the 2019 assessment. However, the incomplete survey coverage remains a source of uncertainty

e) State of the stock

Biomass. Stock biomass has been above $B_{trigger}$ throughout the history of the fishery. The probability that the biomass at the end of 2020 is below $B_{trigger}$ is less than 1%.

Mortality. Fishing mortality is likely to have remained below F_{msy} throughout the history of the fishery. In 2020 there is 1% risk of fishing mortality exceeding F_{lim}.

Recruitment. No explicit information was available but there were some indications of good recent recruitment from preliminary investigation of observer and survey data.

State of the Stock. The Stock is estimated to be well above B_{msy} and exploited sustainably.

f) Research recommendations

- The assessment procedure used has been in place since 2006 and in 2016 NIPAG **recommended** that *it be considered for a benchmark workshop in near future, no later than 2019*.

Status: Reiterated. NIPAG **recommends** the *benchmark to be as soon as possible*. The fishery has expanded since 2014 and catches by countries other than Norway have increased to account for about 65% of the total. In 2016, NIPAG therefore **recommended** that *available data (logbook data and catch samples) from the participating nations be made available to NIPAG.*

Status: In progress. An official data call has been made. This recommendation is reiterated.

- In 2017, NIPAG *recommended* that *a recruitment index should be developed for this stock.*

Status: planned as part of upcoming benchmark. This recommendation is reiterated.

- In 2017, NIPAG **recommended** that *the information regarding catch effort and bycatch from the Estonian commercial fishery should be further analysed e.g. CPUE data explored as a potential index of biomass.*

Status: In progress. This recommendation is reiterated.

Reference list

ICES. 2018a. Report of the Arctic Fisheries Working Group (AFWG), 18–24 April 2018, Ispra, Italy. ICES CM 2018/ACOM:06. 859 pp

ICES. 2018b. Interim Report of the Working Group on the Integrated Assessments of theBarents Sea (WGIBAR). ICES WGIBAR REPORT 9-12 March 2018. Tromsø, Norway. ICES CM 2018/IEASG:04. 210 pp.

7. Northern shrimp (*Pandalus borealis*) in the Fladen Ground (ICES division IVa)

From the 1960s up to around 2000 a significant shrimp fishery exploited the shrimp stock on the Fladen Ground in the northern North Sea. A short description of the fishery is given, as a shrimp fishery could be resumed in this area in the future. The landings from the Fladen Ground have been recorded since 1970. Total reported landings have fluctuated between zero and 9 000 t (Fig. 7.1). The Danish fleet has accounted for the majority of these landings, while the Scottish fleet has landed a smaller portion. The fishery took place mainly during the first half of the year, with the highest activity in the second quarter.

Since 1998 landings decreased steadily and since 2004 the Fladen Ground fishery has been virtually non-existent. Interview information from the fishing industry obtained in 2004 gave the explanation that this decline was caused by low shrimp abundance, low prices on the small shrimp which are characteristic of the Fladen Ground, and high fuel prices. The stock has not been surveyed for many years, and the decline in this fishery may reflect a decline in the stock.

There have been minor Danish, Scottish and Norwegian landings of Northern shrimp from the Fladen Ground stock since 2011, mainly taken as bycatch in the Norway pout fishery. Denmark landed 17 tons from shrimp trawls in 2015.

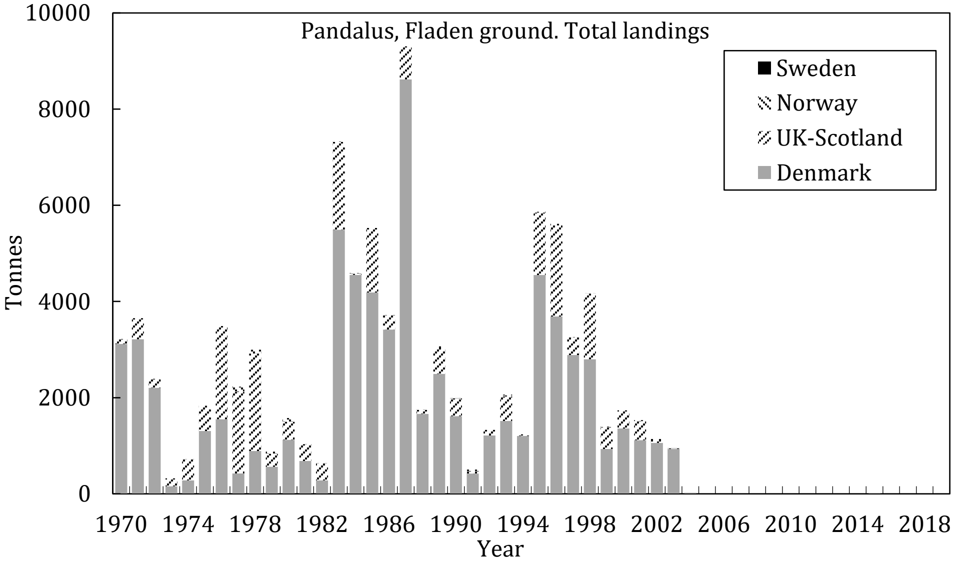


Figure 7.1. Northern shrimp in Fladen Ground: Landings by country and total.

IV. OTHER BUSINESS

1. FIRMS classification for NAFO shrimp stocks

The table as agreed during the September SC meeting was updated with the agreed classifications for the northern shrimp stocks assessed this year.

The Stock Classification system is not intended as a means to convey the scientific advice to the Commission and should not be used as such. Its purpose is to respond to a request by FIRMS to provide such a classification for their purposes. The category choices do not fully describe the status of some stocks. Scientific advice to the Commission is to be found in the Scientific Council report in the summary sheet for each stock.

Stock Size (incl. structure)	Fishing Mortality			
	None–Low	Moderate	High	Unknown
Virgin–Large	3LNO Yellowtail Flounder 3LN Redfish			
Intermediate	3M Northern shrimp[3] SA3+4 Northern shortfin squid	SA0+1 Northern shrimp[1] DS Northern shrimp[1] SA 0+1 (Offshore) Greenland halibut 3M Redfish[3] SA2+3KLMNO Greenland halibut	3M cod	Greenland halibut in Disko Bay[2] SA1 American Plaice SA1 Spotted Wolffish
Small	3NOPs White hake 3NO Witch flounder 3LNOPs Thorny skate			Greenland halibut in Uummannaq[2] Greenland halibut in Upernavik[2]
Depleted	3M American plaice 3LNO American plaice 3NO Cod 3LNO Northern shrimp			SA1 Redfish SA1 Atlantic Wolffish
Unknown	SA2+3 Roughhead grenadier 3NO Capelin 3O Redfish	1B-C Greenland halibut Inshore	1D Greenland halibut Inshore 1E-F Greenland halibut Inshore	6G Alfonsino

[1] Shrimp will be re-assessed at the SC shrimp meeting in November 2019

[2] Assessed as Greenland halibut in Div. 1A inshore

[3] Fishing mortality may not be the main driver of biomass for Div. 3M Shrimp and Redfish

2. Date and place for the next NIPAG meeting

As agreed at the 2018 meeting, NIPAG reassessed the timing of meetings in view of differing requirements for timing of advice and availability of survey data. The main considerations were as follows:

- In future years, advice for the Barents Sea stock will be required by late summer to accommodate the Norway/Russia Fisheries Commission meeting which takes place in October. It would be preferable to have the meeting in late November to allow inclusion of autumn survey data but, if the meeting is held earlier, it would be possible to do an update before Norway/Russia Commission meeting.
- There will be a survey of East Greenland with a new research vessel in mid-October 2021 so holding the meeting late November would be ideal for that stock. The timing of the East Greenland survey in

future years is uncertain but could be in the summer. The West Greenland survey will be August, as usual.

- The Skagerrak stock will continue to be assessed during February/March. This will be considered as a full NIPAG meeting, and meeting times will be arranged to allow full participation in North American time zones.
- As in the last two years, the NAFO Commission will require advice for the NAFO 3M stock to be available for their Annual Meeting starting 20 September. The EU Flemish Cap survey will be completed in late July but, due to the time taken for the vessel to return to Spain and the summer holiday season, it is not expected that the data would be available before the end of August.

In view of the experience gained in holding meetings by WebEx during the current pandemic, the group considered the possibility of conducting the majority of future meetings by WebEx, which would allow the possibility that multiple meetings could be held at different times of year. Under this option, full face to face would only occur every two or three years. Most NIPAG members considered it preferable to maintain the current arrangement of holding annual face to face meeting with additional meetings for stock that cannot be accommodated within the normal schedule. This allows for more thorough peer review than could be achieved through WebEx meetings.

It was agreed that the main 2021 NIPAG meeting will be held 8-14 September (including Saturday) in Copenhagen. It will be necessary to assess the 3M stock early in the meeting to allow the advice to be ready well in advance of the NAFO Annual Meeting.

There will be an additional NIPAG meeting by Webex in November to assess the east Greenland stock. Work on this stock during the September meeting will focus on developing the assessment model for this stock using available data.

3. Benchmark preparation

NIPAG reviewed the benchmark planning document drafted in 2019. This is attached to this report as appendix VIII.

NIPAG reviewed a draft timetable for the benchmark as follows:

2020:	NIPAG meeting and formulation of work plan towards data workshop and benchmark meetings for 3M, Barents Sea and Skagerrak (present meeting).
2021:	Data compilation workshop (3 days prior to the NIPAG meeting)
2022:	Benchmark to be held in conjunction with the NIPAG (PANDSKND) meeting in February/March.
2022:	there may be a meeting in summer or autumn to revise the management plan (MSE) for the NSSK stock

A data call will be drafted by ICES and NAFO secretariats and forwarded the relevant stock assessors for review prior to being issued, likely in January 2021. ICES secretariat will forward a link to the ICES benchmark issues list to NIPAG members with instruction on what needs to be done.

A decision will be taken by ICES in March 2021 on whether this benchmark will go ahead

V. ADJOURNMENT

The NIPAG meeting was adjourned at 1300 hours on 30 October 2020. The Co-Chairs thanked all participants, especially the designated experts and stock coordinators, for their hard work. The Co-Chairs thanked the NAFO and ICES Secretariats for all of their logistical support. The report was adopted at the close of the meeting, subject to a period for editorial changes.

APPENDIX II. ICES TERMS OF REFERENCE FOR NIPAG

1. Generic ToRs for Regional and Species Working Groups

This resolution was approved 1 October 2019

2019/2/FRSG01

The following ToRs apply to: AFWG, HAWG, NWWG, NIPAG, WGWIDE, WGBAST, WGBFAS, WGNSSK, WGCSE, WGDEEP, WGBIE, WGEEL, WGEF, WGHANSA and WGNAS.

The working group should focus on:

a. Consider and comment on Ecosystem and Fisheries overviews where available;

b. For the aim of providing input for the Fisheries Overviews, consider and comment for the fisheries relevant to the working group on:

  i. descriptions of ecosystem impacts of fisheries

  ii. descriptions of developments and recent changes to the fisheries

  iii. mixed fisheries considerations, and

  iv. emerging issues of relevance for the management of the fisheries;

c. Conduct an assessment on the stock(s) to be addressed in 2020 using the method (analytical, forecast or trends indicators) as described in the stock annex and produce a **brief** report of the work carried out regarding the stock, summarising where the item is relevant:

  i. Input data and examination of data quality;

  ii. Where misreporting of catches is significant, provide qualitative and where possible quantitative information and describe the methods used to obtain the information;

  iii. For relevant stocks (i.e., all stocks with catches in the NEAFC Regulatory Area) estimate the percentage of the total catch that has been taken in the NEAFC Regulatory Area in 2019.

  iv. Estimate MSY proxy reference points for the category 3 and 4 stocks

  v. The developments in spawning stock biomass, total stock biomass, fishing mortality, catches (wanted and unwanted landings and discards) using the method described in the stock annex;

  vi. The state of the stocks against relevant reference points;

  vii. Catch scenarios for next year(s) for the stocks for which ICES has been requested to provide advice on fishing opportunities;

  viii. Historical and analytical performance of the assessment and catch options with a succinct description of quality issues with these. For the analytical performance of category 1 and 2 age-structured assessment, report the mean Mohn's rho (assessment retrospective analysis) values for R, SSB and F. The WG report should include a plot of this retrospective analysis. The values should be calculated in accordance with the "Guidance for completing ToR viii) of the Generic ToRs for Regional and Species Working Groups - Retrospective bias in assessment" and reported using the ICES application for this purpose.

d. Produce a first draft of the advice on the stocks under considerations according to ACOM guidelines.

e. Review progress on benchmark processes of relevance to the Expert Group;

f. Prepare the data calls for the next year update assessment and for planned data evaluation workshops;

g. Identify research needs of relevance for the work of the Expert Group.

h. Review and update information regarding operational issues and research priorities and the Fisheries Resources Steering Group SharePoint site.

i. Take 15 minutes, and fill a line in the audit spread sheet 'Monitor and alert for changes in ecosystem/fisheries productivity'; for stocks with less information that do not fit into this approach (e.g. higher categories >3) briefly note in the report where and how productivity, species interactions, habitat and distributional changes, including those related to climate-change, have been considered in the advice.

Information of the stocks to be considered by each Expert Group is available here.

APPENDIX VII. ASSESSMENT OF NORTHERN SHRIMP (*PANDALUS BOREALIS*) IN THE SKAGERRAK AND NORWEGIAN DEEP

a) Executive summary

PandSKND, a subgroup of the NAFO/ICES *Pandalus* Assessment Group (NIPAG), met 20–21 February 2020 at ICES HQ in Copenhagen to assess the *Pandalus* stock in divisions 3a and 4a east. Experts attended from Norway, Sweden and Denmark (Chair: Ole Ritzau Eigaard, Denmark) and the objective was to assess stock status and to draft advice according to the current EU and Norway Long-term Management Strategy (LTMS). The LTMS requires ICES to provide both an update in-year TAC advice for 2020 and an initial TAC advice for the first two quarters of 2021.

The length-based Stock Synthesis (SS3) statistical framework was used to assess status of the stock based on updated input data (commercial catches for 2019 and survey catches from January 2020). The assessment demonstrated that the spawning–stock biomass (SSB) declined after 2008 and has fluctuated at a lower level since then. SSB in 2020 is between MSY-$B_{trigger}$ and B_{lim}. Fishing mortality (F) has been above F_{MSY} in all years since 2011, except in 2015, 2018 and 2019. Recruitment has been below average since 2008, except for the 2013 year class.

In accordance with the LTMS reference points and Harvest Control Rules, the subgroup suggests that catches in 2020 should be no more than 8736 tonnes and that catches for the first two quarters of 2021 should be no more than 4552 tonnes. This corresponds to a 31% reduction of the initial catch advice for 2020 and a 0.2% increase for the 2021 catch advice. The main reason for this change is that the realized 2019 catches were 29% higher than advised catches (7944 t compared to 6163 t) due to banking from 2018 (768 t), discarding (368 t), lack of correction for the loss in weight due to on-board boiling (approximately 463 t) and catching more than the TAC (approximately 180 t).

SS3 model diagnostics of the assessment did not indicate any issues with the model fit. There is a positive retrospective bias in SSB and recruitment, and a negative retrospective bias in F, but these are all within the acceptable range (Mohns Rho threshold values) of requiring no action.

Expert group information

Expert group name	Joint NAFO/ICES *Pandalus* Assessment Working Group (NIPAG)
Expert group cycle	Annual
Year cycle started	2020
Reporting year in cycle	1/1
Chair	Ole Ritzau Eigaard, Denmark
Meeting venue and dates	20–21 February 2020 (six participants)

5. Northern shrimp (*Pandalus borealis*) in the Skagerrak and Norwegian Deep (ICES Subdivision 27.3a.20 and the eastern part of Division 27.4a)

Background documentation is found in SCR Docs. 08/75; 13/68, 74; 14/66; 20/01 and in the ICES Stock Annex.

a) Introduction

The shrimp in ICES Division 27.3.a (Skagerrak and Kattegat) and the eastern part of Division 27.4.a (Norwegian Deep) are assessed as one stock and are exploited by Norway, Denmark and Sweden. Shrimp fisheries expanded significantly in the early 1960s. By 1970, the landings had reached 5000 t and in 1981 they exceeded 10 000 t.

Since 1992, the shrimp fishery has been regulated by a TAC (Figure 5.1, Table 5.1). The overall TAC is shared according to historical landings, giving Norway 59%, Denmark 27%, and Sweden 14% between 2011 and 2019. The advised TACs were until 2002 based on catch predictions. In 2003, the cohort-based assessment was abandoned and no catch predictions were available. The advised TACs were therefore based on perceived stock development in relation to recent landings until 2013, when an assessment based on a stock production model was introduced for this stock. Thereafter, a new length-based assessment model was agreed on in a benchmark in January 2016 (ICES, 2016a).

The shrimp fishery is also regulated by a minimum mesh size (35 mm stretched), and by restrictions in the amount of landed bycatch. Sorting grids are mandatory in the whole area (see below). In 2009, an EU ban on high-grading was implemented and since 2016, the EU landing obligation applies for *Pandalus* in 27.3.a and 27.4.a. Norway has had a discard ban for many years.

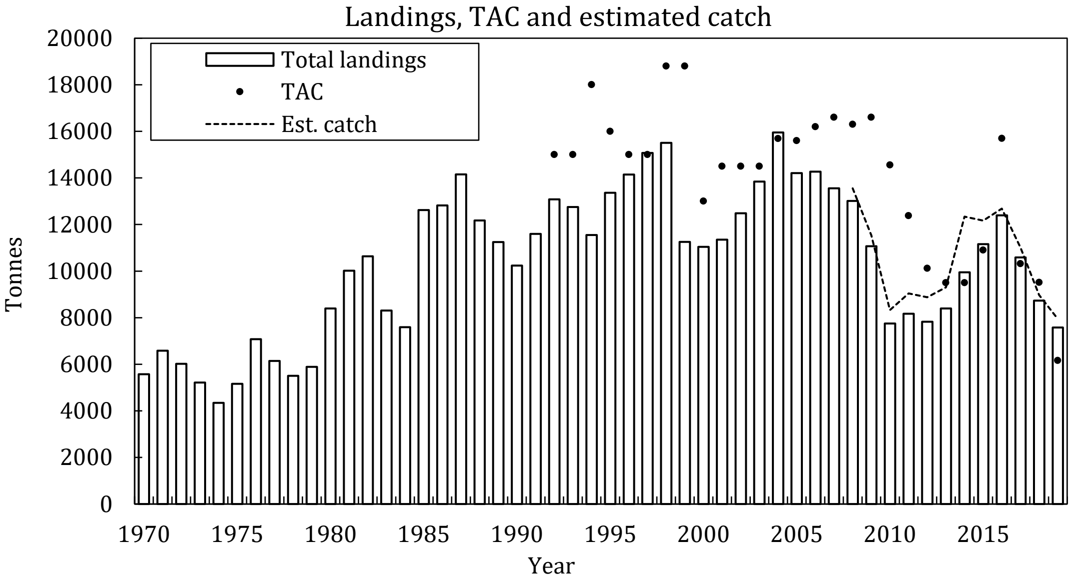


Figure 5.1. Northern shrimp in Skagerrak and Norwegian Deep: TAC, total landings by all fleets, and total estimated catch including estimated Swedish discards for 2008–2019, and Norwegian and Danish discards for 2009–2019.

Table 5.1. Northern shrimp in Skagerrak and Norwegian deep: TACs, landings, and estimated discards and catches (t).

Year	2009	2010	2011	2012	2013	2014	2015	2016[1]	2017	2018	2019
Advised TAC[2]	15000	13000	8800	*	5800	6000	10900	13721	10316	8571	6163
Agreed TAC	16600	14558	12380	10115	9500	9500	10900	15696	10316	8900	6163
Denmark landings	2224	1301	1601	1454	2026	2432	2709	1997	2173	1863	2058
Norway landings	6362	4673	4800	4852	5179	6123	6808	8305	6778	5493	4414
Sweden landings	2483	1781	1768	1521	1191	1397	1644	2095	1634	1374	1105
Total landings	11069	7755	8169	7827	8396	9952	11161	12397	10585	8730	7577
Est. Swedish discards	337	386	504	671	265	572	325	87	99	114	106
Est. Norw. Discards	94	133	247	292	459	1289	476	162	114	115	178
Est. Danish discards	36	53	123	88	185	526	204	35	206	12	83
Total catch	11536	8327	9043	8878	9305	12339	12166	12681	11004	8971	7944

[1] Advised and agreed TACs from October 2015 were changed in March 2016 following the benchmark assessment.

[2] From 2014, TAC advice has been given for catches.

The Danish and Norwegian fleets have undergone major restructuring during the last 25 years. In Denmark, the number of vessels targeting shrimp has decreased from 138 in 1987 to only eight in 2019. The efficiency of the fleet has increased due to the introduction of twin trawls and increased trawl size.

In Norway, the number of vessels participating in the shrimp fishery has decreased from 423 in 1995 to 184 in 2019. Twin trawls were introduced around 2002, and in 2011–2019 were used by more than half of the Norwegian trawlers longer than 15 meters.

The Swedish specialized shrimp fleet (landings of shrimp larger than 10 t per year) has decreased from more than 60 vessels in 1995–1997 to below 30 in 2018–2019. There has not been any major change in single trawl size or design, but during the last ten years, the landings of the twin trawlers have increased from 7 to over 60% (recent four years) of the total Swedish *Pandalus* landings.

Landings and discards. Total landings have varied between 7500 and 16 000 t during the last 30 years. In the Swedish and Norwegian fisheries, approximately 50% of catches (large shrimp) are boiled at sea, and almost all catches are landed in homeports. The Danish vessels are boiling approximately 35% of the shrimp on board and landing the product in Sweden to obtain a better price. The rest is landed fresh in homeports. In the total catch estimates, the boiled fraction of the landings has been raised by a factor of 1.13 to correct for weight loss caused by boiling. Total catches, estimated as the sum of landings and discards, decreased from 2008 to 2012, to 8800 t, and then increased to around 12 600 t in 2016. In the recent three years, catches have again decreased, to around 7900 t in 2019 (Table 5.1 and Figure 5.1).

Shrimps may be discarded to replace small and medium-sized, lower-value shrimps with larger and more profitable ones (“high-grading”). Since 2016, shrimp <15 mm CL are marketable, but fetch a lower price than medium-sized shrimp. The Swedish fishery has often been constrained by the national quota, which may have resulted in high-grading. Based on on-board sampling by observers, discards in the Swedish fisheries were estimated to be between 12 and 31% of total catch for 2008–2015, and Danish discards were estimated to be between 2 and 18% for 2009–2015. In 2016, due to the landing obligation, discarding decreased to 4 and 2% in Sweden and Denmark respectively. In 2019, the discard percentages were 9 and 4%, respectively. In 2017 to 2019, approximately 80% of the Swedish landings were caught with mesh sizes of at least 45 mm. From 2009 to 2016, Norwegian discards in Skagerrak were estimated by applying the Danish discards-to-landings ratio to the Norwegian landings. In 2017, Norwegian discards were estimated by comparing length–frequency distributions of on-board samples of unsorted catches with samples from landings. In 2018, an error in a script was discovered, and upon correcting this, the method was no longer considered appropriate (rendering negative discards). Thus, the working group estimated the 2018 discards based on data from the Norwegian Reference fleet, and updated the 2017 discards using the same type of data. Discards in the Norwegian fisheries have been estimated to be between 2 and 4% of total catch for 2017–2019.

Bycatch and ecosystem effects. Shrimp fisheries in the Norwegian Deep and Skagerrak have bycatches of 10–23% (by weight) of commercially valuable species, which are legal to land if quotas allow (Table 5.2). Since 1997, trawls used in Swedish national waters must be equipped with a Nordmøre grid, with a bar spacing of 19 mm, which excludes fish >approximately 20 cm length from the catch. Landings delivered by vessels using grids comprise 95–99% of shrimp (Table 5.2). Following an agreement between EU and Norway, the Nordmøre grid has been mandatory since 1st February 2013 in all shrimp fisheries in Skagerrak (except Norwegian national waters within the 4 nm limit where the grid became mandatory in 2019). From 1st of January 2015, the grid has also been mandatory in shrimp fisheries in the North Sea south of 62˚N. If the fish quotas allow, it is legal to use a fish retention device of 120 mm square mesh tunnel at the grid's fish outlet.

Table 5.2. Northern shrimp in Skagerrak and Norwegian Deep: Bycatch landings by the *Pandalus* fishery in 2019. Combined data from Danish and Swedish logbooks and Norwegian sale slips (t).

Species	SD IIIa, grid		SD IIIa, grid+fish tunnel		SD IVa East, grid+fish tunnel	
	Landings (t)	% of total landings	Landings (t)	% of total landings	Landings (t)	% of total landings
Pandalus	295.5	97.1	4942.5	77.4	1256.0	74.6
Norway lobster	4.0	1.3	28.9	0.5	4.6	0.3
Anglerfish	0.1	0.0	104.9	1.6	48.5	2.9
Whiting	0.1	0.0	3.8	0.1	2.3	0.1
Haddock	0.1	0.0	33.0	0.5	12.1	0.7
Hake	0.0	0.0	21.2	0.3	20.3	1.2
Ling	0.0	0.0	46.9	0.7	27.4	1.6
Saithe	0.8	0.3	682.0	1.7	141.4	8.4
Witch flounder	0.2	0.1	47.2	0.7	1.9	0.1
Norway pout	2.5	0.8	19.3	0.3	4.5	0.3
Cod	0.4	0.1	294.3	4.6	59.1	3.5
Other marketable fish	0.8	0.3	158.1	2.5	105.9	6.3

The use of a fish retention device also prevents the escape of larger individuals of non-commercial species. Deep-sea species such as roundnose grenadier, rabbitfish, and sharks are frequently caught in shrimp trawls in the deeper parts of Skagerrak and the Norwegian Deep. No quantitative data on this mainly discarded catch are available and the impact on stocks is difficult to assess.

Catches of demersal fish species in the Campelen-trawl of the Norwegian annual shrimp survey covering Skagerrak and the Norwegian Deep (see below) give an indication of the level of potential bycatch of non-commercial species in shrimp trawls (Table 5.3 and Figure 5.2).

The catches of demersal fish in the Campelen-trawl are also used to calculate an index of potential shrimp predators. The large interannual variation in this predator biomass index is mainly due to variations in the indices of saithe, blue whiting and roundnose grenadier, which in some years are important components. The catch of these species depends to some extent on which survey stations are trawled, as the largest densities of saithe are found in shallow water and roundnose grenadier is found in deep water. The peak in 2013 was due to a high abundance of both saithe and blue whiting. An index of potential shrimp predators without these three species fluctuated without trend from 2007 to 2015, was at a higher level in 2017-2019, but decreased again in 2020 (Figure 5.2; the 2016 survey data were omitted, see below).

Table 5.3. Northern shrimp in Skagerrak and Norwegian Deep: Estimated indices of predator biomass (catch in t per square nautical mile) from the Norwegian shrimp survey in 2007–2020. The 2016 survey data have been omitted (see text for details).

Species													
English	Latin	2008	2009	2010	2011	2012	2013	2014	2015	2017	2018	2019	2020
Blue whiting	*Micromesistius poutassou*	0.12	1.21	0.27	0.62	3.30	29.03	1.88	5.25	31.18	6.38	19.68	13.04
Saithe	*Pollachius virens*	208.32	53.89	18.53	7.52	5.66	112.80	14.13	8.56	9.71	12.87	5.77	1.88
Cod	*Gadus morhua*	0.78	2.01	1.79	1.66	1.26	1.69	2.92	2.37	2.00	2.05	2.58	0.58
Roundnose grenadier	*Coryphaenoides rupestris*	19.02	19.03	10.05	4.99	4.43	1.97	2.90	1.46	1.41	2.17	2.10	3.53
Rabbit fish	*Chimaera monstrosa*	3.41	3.26	3.51	2.73	2.22	3.05	3.90	2.19	5.99	5.03	5.40	4.35
Haddock	*Melanogrammus aeglefinus*	1.85	3.18	3.46	5.82	5.75	5.18	2.15	2.60	1.86	1.51	0.97	1.15
Redfish	*Scorpaenidae*	0.26	0.43	0.80	1.02	0.37	0.47	0.48	0.20	0.53	0.97	0.82	0.31
Velvet belly	*Etmopterus spinax*	1.95	2.42	2.52	1.47	1.59	2.67	1.91	2.51	4.19	3.85	4.34	2.92
Skates, rays	*Rajidae*	0.64	0.17	0.60	0.88	0.98	1.00	2.25	1.69	1.64	1.20	1.76	0.65
Long rough dab	*Hippoglossoides platessoides*	0.42	0.28	0.47	0.51	0.56	0.56	1.17	1.45	0.94	0.81	1.02	0.34
Hake	*Merluccius merluccius*	0.64	2.56	1.60	0.56	0.52	1.06	0.69	0.59	1.24	1.66	0.91	1.00
Angler	*Lophius piscatorius*	0.87	1.25	1.70	0.92	0.17	0.65	0.75	0.58	1.13	0.57	1.12	0.71
Witch	*Glyptocephalus cynoglossus*	0.54	0.16	0.13	0.24	0.29	0.27	0.35	1.38	0.47	0.17	0.16	0.19
Dogfish	*Squalus acanthias*	0.28	0.14	0.11	0.21	0.60	1.02	1.00	0.36	0.42	0.45	0.43	0.26
Black-mouthed dogfish	*Galeus melastomus*	0.05	0.15	0.09	0.09	0.09	0.12	0.11	0.35	0.26	0.24	0.24	0.35
Whiting	*Merlangius merlangus*	1.35	3.02	2.42	3.07	1.64	2.02	3.38	1.59	2.60	4.56	5.20	2.62

Species													
English	Latin	2008	2009	2010	2011	2012	2013	2014	2015	2017	2018	2019	2020
Blue Ling	*Molva dypterygia*	0	0	0	0	0	0.01	0.01	0.03	0.01	0.03	0.02	0.25
Ling	*Molva molva*	0.34	0.79	0.64	0.24	0.17	0.22	0.32	0.63	0.90	0.99	1.09	0.41
Four-bearded rockling	*Rhinonemus cimbrius*	0.04	0.03	0.05	0.03	0.09	0.04	0.06	0.12	0.04	0.05	0.09	0.05
Cusk	*Brosme brosme*	0.02	0.05	0.13	0.29	0.04	0.10	0.05	0.19	0	0.14	0.38	0.02
Halibut	*Hippoglossus hippoglossus*	3.88	0.09	0.20	0.05	0.19	0	0	0.10	0.16	0.09	0.24	0.29
Pollack	*Pollachius pollachius*	0.03	0.13	0.12	0.15	0.07	0.24	0.65	0.23	0.10	0.15	0.22	0.19
Greater forkbeard	*Phycis blennoides*	0	0.01	0.04	0.02	0.05	0.06	0.12	0.05	0.18	0.22	0.2	0.07
Total		244.81	94.26	49.23	33.09	30.04	164.23	41.18	34.48	66.96	46.16	54.74	35.16
Total (except saithe and roundnose grenadier)		17.47	21.34	20.65	20.58	19.95	49.46	24.15	24.46	55.84	31.12	46.87	29.75

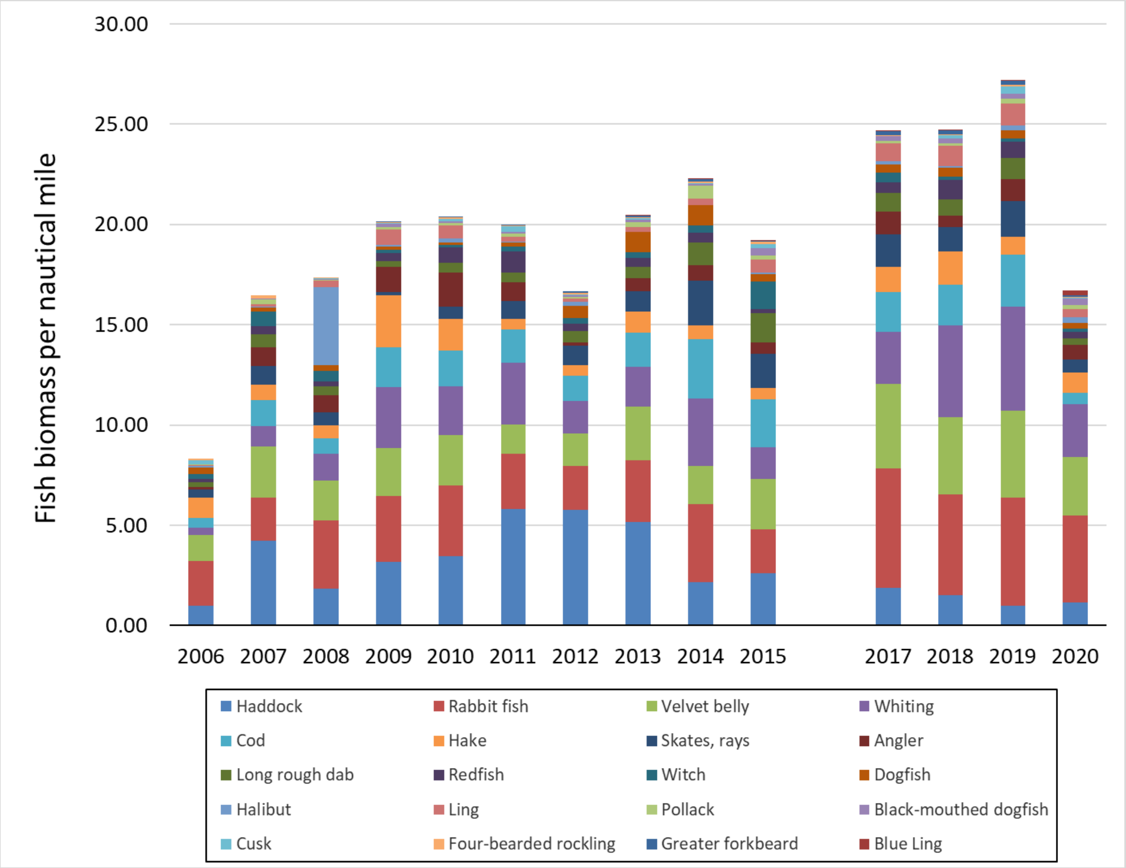


Figure 5.2. Northern shrimp in Skagerrak and Norwegian Deep: Estimated indices of predator biomass (catch in t per square nautical mile) from the Norwegian shrimp survey in 2006–2020 excluding saithe, roundnose grenadier and blue whiting. The 2016 survey data have been omitted (see text for details).

b) Input data

i) Fishery data

Danish, Swedish and Norwegian catch and effort data from logbooks have been analysed and standardised (SCR Doc. 08/75). All three series increased from 2012 until 2015, but have decreased since (Figure 5.3).

Time-series of standardised effort indices from Norway and Denmark have been fluctuating without any clear trend since the late 1990s while the Swedish standardised effort has decreased (Figure 5.4).

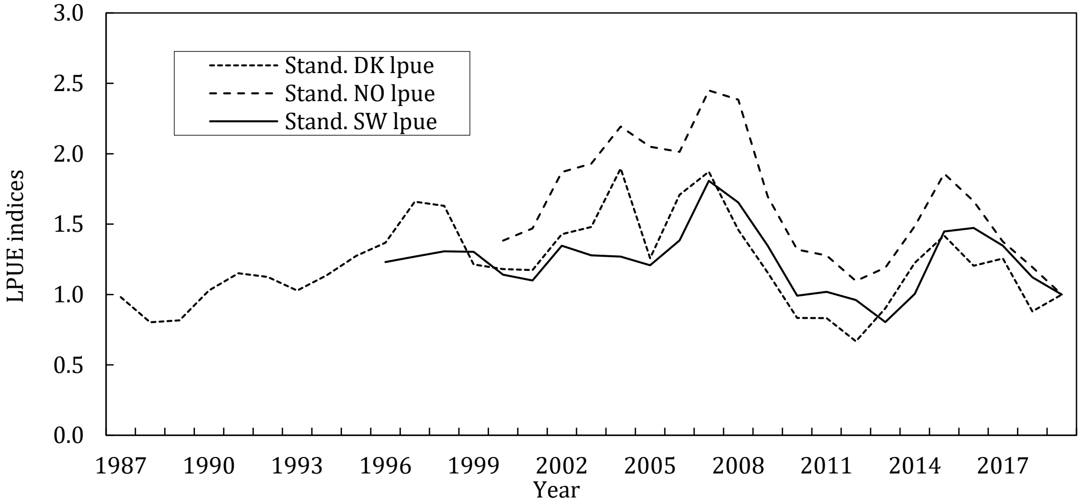


Figure 5.3. Northern shrimp in Skagerrak and Norwegian Deep: Danish, Norwegian and Swedish standardised landings per unit of effort (LPUE) until 2019. Each series is standardised to its final year.

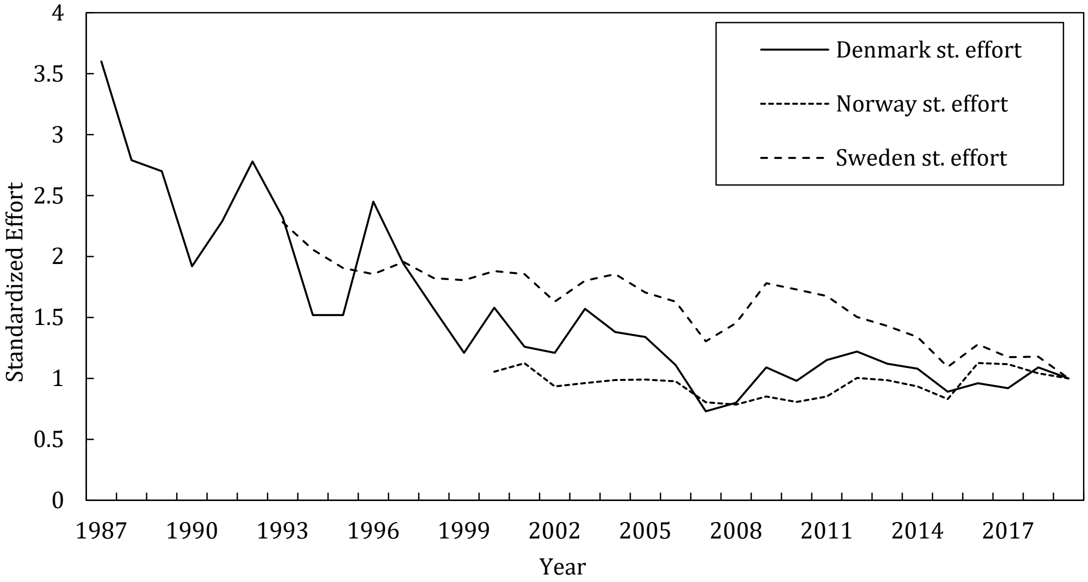


Figure 5.4. Northern shrimp in Skagerrak and Norwegian Deep: Estimated standardised effort until 2019. Each series is standardised to its final year.

Sampling of catches. Length frequencies of the commercial catches from 1985 to 2019 have been obtained by sampling. The samples also provide information on sex distribution and maturity. Numbers-at-length are input data to the length-based assessment model for this stock (see below).

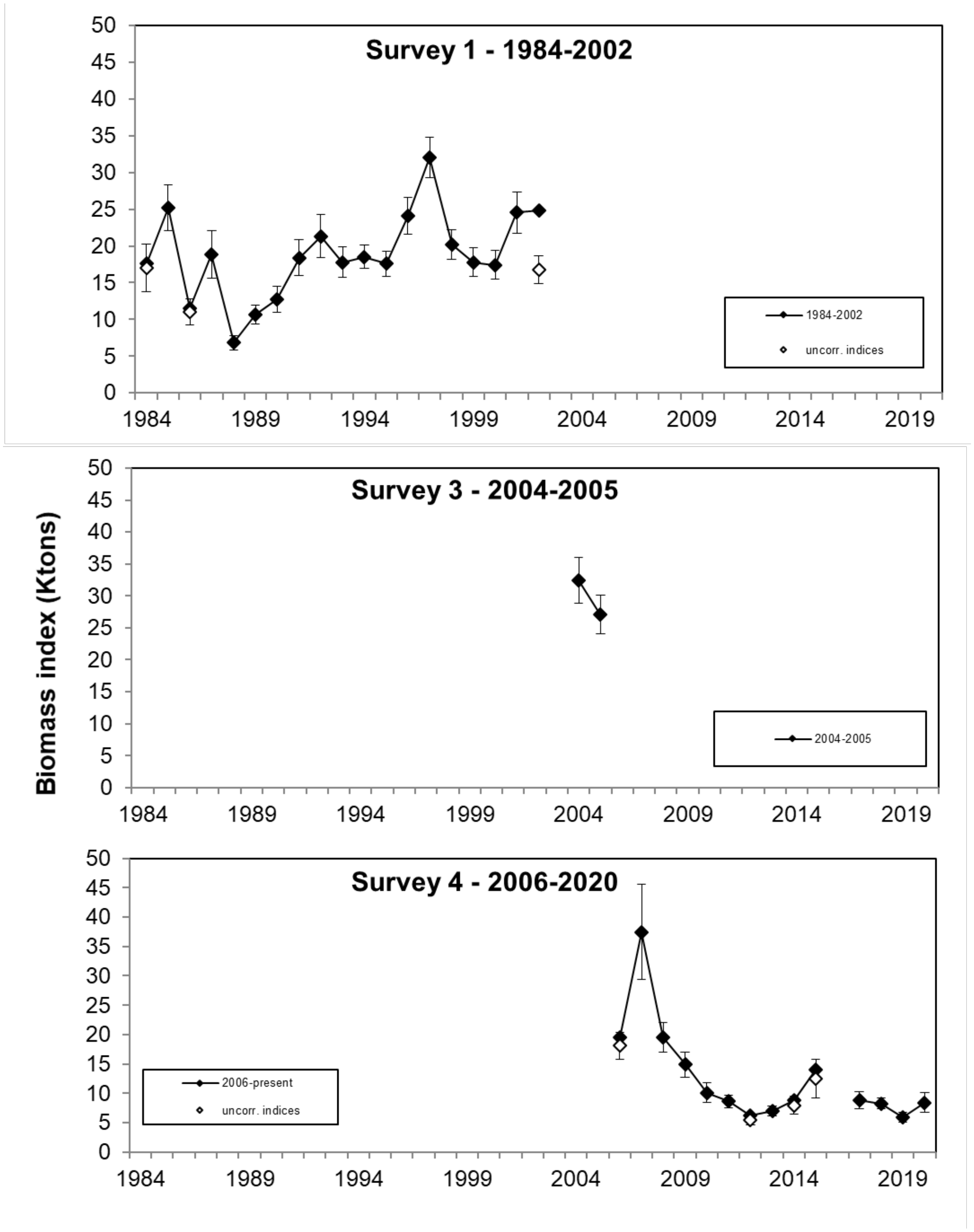
ii) Survey data

The Norwegian shrimp survey went through large changes in vessel, gear and timing in 2002–2006, resulting in four indices: Survey 1: October/November 1984–2002 with Campelen trawl; Survey 2: October/November 2003 with shrimp trawl 1420; Survey 3: May/June 2004–2005 with Campelen trawl; and Survey 4: January/February 2006–present with Campelen trawl.

Due to time and weather restrictions, not all survey strata have been covered in all years. The following years have missing strata: 1984, 1986, 2002, 2006, 2012, 2014, and 2015 (Figure 5.5). The index of total biomass for these years has been standardised by applying the missing strata's mean portion of the total biomass (averaged over all years within a time-series with complete coverage) to the total biomass of the year. The corrected indices increased by 3–12%, except for the corrected 2002 biomass value which increased by 48%. However, total numbers-at-length have not yet been standardised, which means that the length-based model (see below) uses un-standardized survey data. This implies that the total numbers-at-length from years with incomplete survey coverage are underestimated.

In 2016, there were technical problems with the survey trawl (unequal wire lengths of the trawl gear) and this year's data have therefore been omitted from the time-series.

The biomass peaked in 2007, then declined until 2012. The index thereafter increased until 2015, then decreased to the fourth time-series' lowest observed level in 2019, and then increased slightly in 2020 (Figure 5.5). The survey time-series has not been standardised for variability of factors such as swept volume, spatial coverage and trawling speed, which might add uncertainty to the stock estimates. A recruitment index has been calculated for the fourth survey time-series as the abundance of age 1 shrimp. The recruitment index declined from 2007 to 2010, and has since fluctuated at a lower level except for a peak in 2014 (Figure 5.6). The 2019 year class is estimated to be below the median of the fourth time-series.



Survey 1 - 1984-2002

Survey 3 - 2004-2005

Survey 4 - 2006-2020

Figure 5.5. Northern shrimp in Skagerrak and Norwegian Deep: Estimated survey biomass index in 1984–2020. The point estimate of 2003 is not shown. The 2016 survey data have been omitted (see text for details).

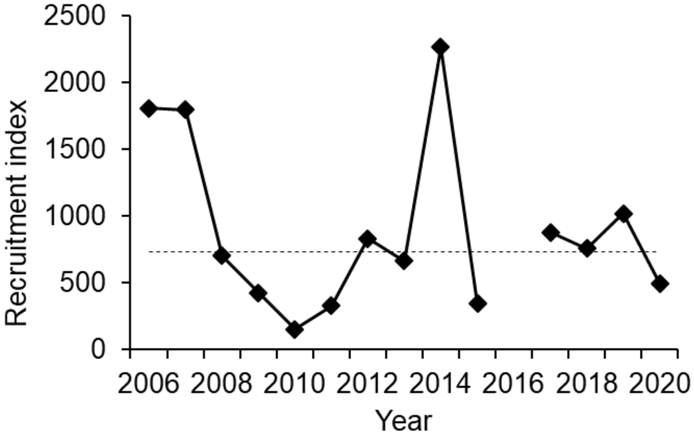


Figure 5.6. Northern shrimp in Skagerrak and Norwegian Deep: Estimated recruitment index, 2006–2020. The horizontal line is the median of the time-series. The 2016 survey data have been omitted (see text for details).

In 2020 it was discovered that the SS3-model has been run with a partly incorrect survey data time-series (numbers-at-lengths for the years 1988, 1995, 1998–2001, and 2006–2009). When corrected the total numbers-at-lengths increased by 0.4 to 6.4%, except for the year 1988 when the corrected number was 31.1% higher. This correction only brought about very marginal changes in the assessment model outputs of F and SSB (Figure 5.7), which do not affect the assessment results or the reference points.

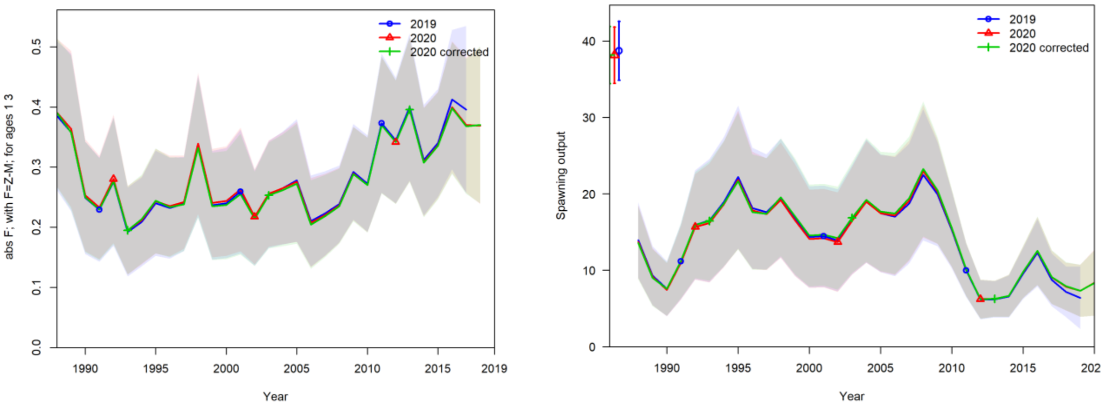


Figure 5.7. Northern shrimp in Skagerrak and Norwegian Deep: F and SSB assessment results for model runs with corrected survey data (2020 corrected) and un-corrected data (2019, 2020). It should be noted that values of F shown in this figure are not directly comparable to the F in the standard graphs of the assessment output in Figure 5.9 (as the figures here are from the standard output of r4SS). Here, F is presented as an average weighted by the number of shrimp in the age classes of F_{bar} ages 1 to 3.

c) Model

The stock assessment was benchmarked in January 2016 (ICES, 2016). At the benchmark it was decided that a length-based Stock Synthesis (SS3) statistical framework (ICES, 2016, and references therein) should replace the surplus production model (SCR Doc. 15/059) used since 2013, to assess status of the stock and form a basis for advice. New reference points were also defined at the 2016 benchmark (ICES, 2016).

As part of a Management Strategy Evaluation (MSE) in 2017, ICES reviewed the MSY reference points for this stock (ICES, 2017a). The analysis resulted in an update of the F_{MSY} value to $F_{MSY} = 0.60$ (previously 0.62), whereas MSY $B_{trigger} = 9900$ t remained unchanged (see below).

d) Assessment results

SS3 model diagnostics of this year's run do not indicate any issues with the model fit. There is a small positive retrospective pattern in SSB and a negative retrospective pattern in F, but the patterns are within the acceptable range of requiring no action. (See section below on model retrospective).

e) Sensitivity analysis

The benchmark in 2016 (ICES, 2016) recognized the uncertainty in the current assumption of M = 0.75 to the assessment, which is based on estimates from the Barents Sea in the 1990s (Barenboim *et al.*, 1991), and recommended that the sensitivity of model outputs and catch advice to the specifications of M should be explored. Preliminary sensitivity analyses of the assessment model regarding different levels of M carried out at the 2016 NIPAG meeting, showed that M = 0.90 did not change the perception of the current level of F and SSB relative to the reference points of F_{MSY} and MSY $B_{trigger}$ compared with M = 0.75 (base model) (Figure 5.8). However, shrimp in the Norwegian Deep/Skagerrak are considered to have a lifespan of only about half of that of shrimp in the Barents Sea and it is therefore likely that M could be substantially higher and outside the 0.75–0.90 range explored. Previous analyses of different M assumptions for this stock (SCR 14/66) provide support for this hypothesis. NIPAG was not in a position at the meeting to fully explore the sensitivity to the M assumption used and stresses the importance of further investigations to be conducted well in advance of the next proposed benchmark in 2020–2021.

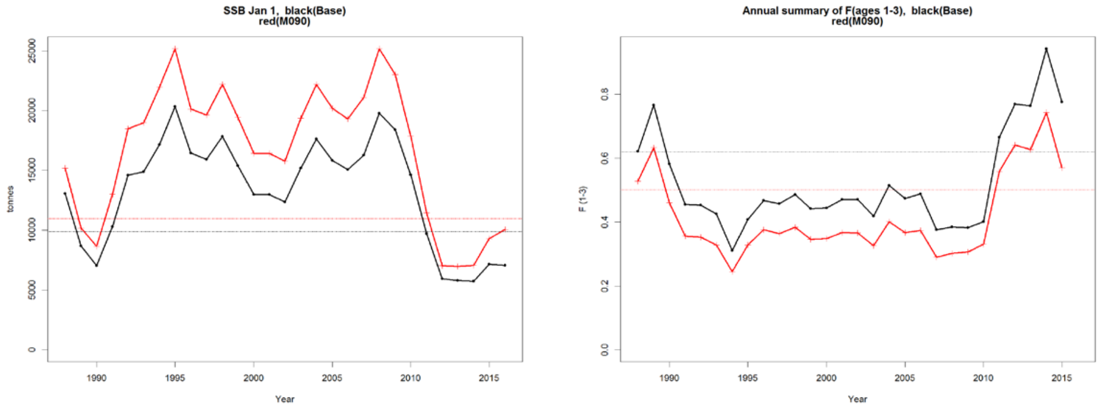


Figure 5.8._Northern shrimp in Skagerrak and Norwegian Deep: F and SSB assessment results for natural mortality M = 0.75 (base model, black) and M = 0.90 (red). The horizontal lines indicate MSY $B_{trigger}$ (left panel) and F_{MSY} (right panel) values for each of the two M-levels.

f) Historical stock trends and recruitment

Historical stock trends are shown in Figure 5.9.

Since 2008, when SSB was 23 270 t, which is the highest SSB estimate of the time-series, the SSB decreased to the time-series low of 6211 t in 2012. The SSB then increased up to 2016, but decreased again to 7331 t in 2019, which is between B_{pa} and B_{lim} of 6300 t. The SSB in 2020 is 8319 t.

SS3 models recruitment as the abundance of the 0-group. A series of lower recruitment years since 2008, with the exception of year 2013 and 2018, should be noted. During this period of lower recruitment, the estimates of SSB were also for some years historically low and close to or below B_{lim}. The uncertainty around the estimate of recruitment in the terminal year of the assessment is generally relatively large. The reason for this is that the model has not yet fully seen the recruits in the commercial catch data (catch data are until and including the terminal year) but only in the survey data (collected with a smaller meshed survey trawl in January the terminal year +1).

Fishing mortality (F) for ages 1 to 3 remained relatively stable from the beginning of the 1990s to about 2010. After 2010, F increased steeply to 0.74 in 2014, which is the highest observed value of the time-series. F has been above F_{MSY} in all years since 2011, except in 2015, 2018 and 2019. F in 2019 is 0.53.

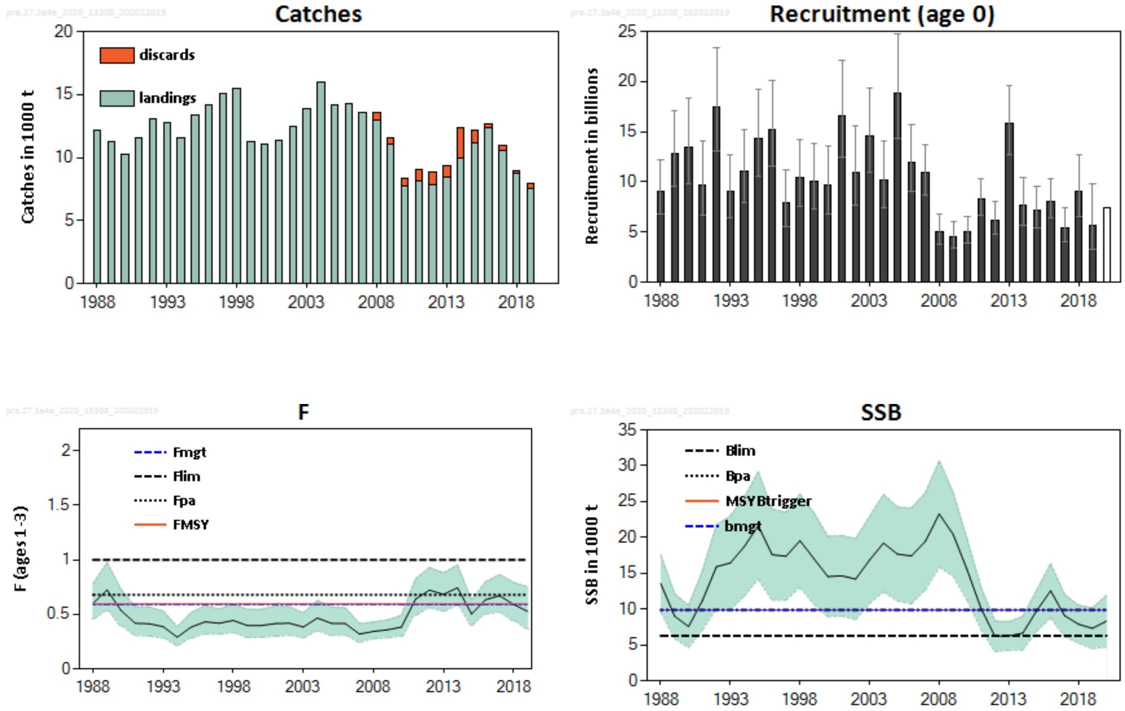


Figure 5.9. Northern shrimp in Skagerrak and Norwegian Deep: Summary assessment output. Total catch, including estimated discards since 2008 (tonnes) and F, SSB and R assessment results. SSB and R are depicted with 90% confidence intervals. The assumed recruitment value (geometric mean of the last ten years) for 2019 is unshaded.

g) Model retrospective

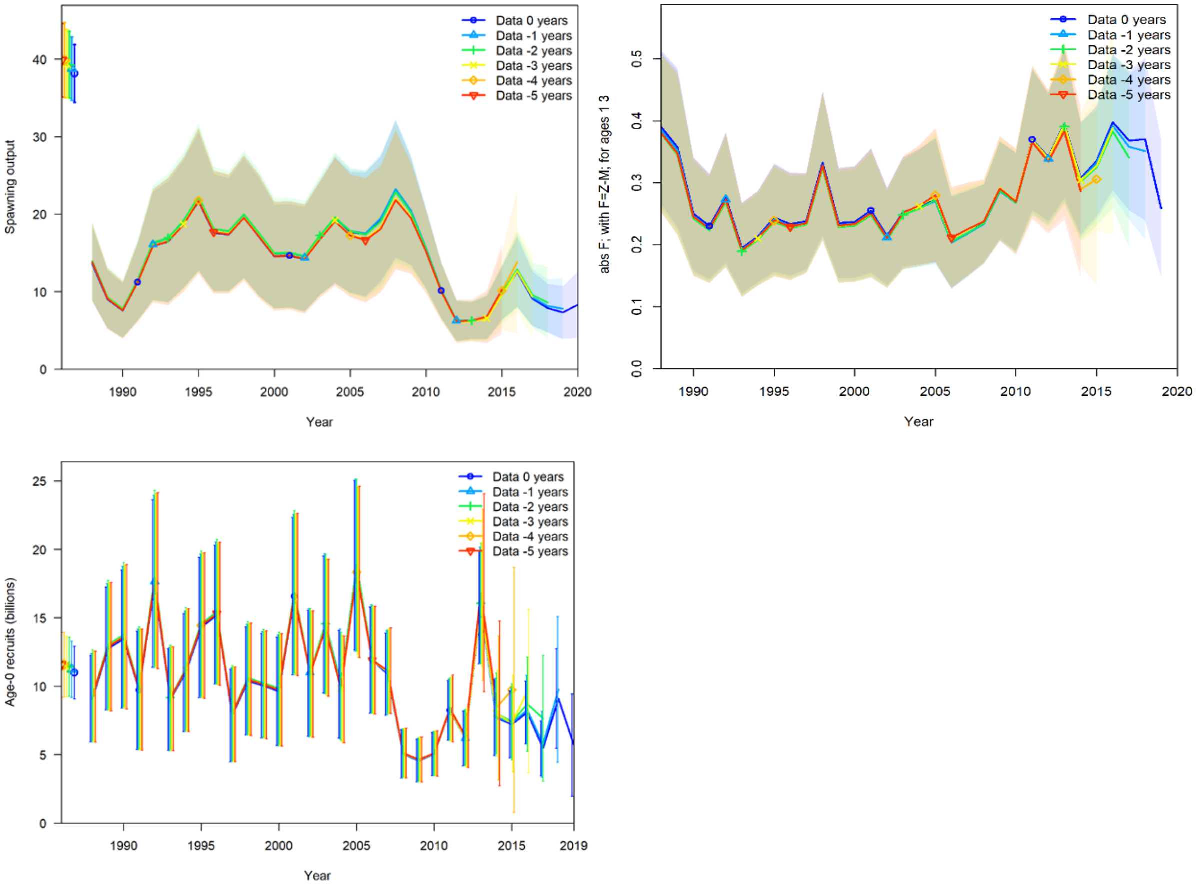


Figure 5.10. Northern shrimp in Skagerrak and Norwegian Deep: Model retrospective of SSB, F (ages 1–3) and R. It should be noted that values of F shown in these figures are not directly comparable to the F in Figure 5.9 (as the figures here are from the standard output of r4SS). Here, F is presented as an average weighted by the number of shrimp in the age classes of F_{bar} ages 1 to 3.

Model retrospectives for the assessment are shown in Figure 5.10. There is a negligible retrospective pattern for the more recent part of the time-series of SSB, with a small tendency to overestimate SSB. There is a moderate tendency to underestimate F. Recruitment is somewhat overestimated by the model (Figure 5.10), meaning that the previous year classes have been revised downwards. Figure 5.11 presenting the retrospective patterns in estimation of recruitment deviations shows that two years of observing a cohort is necessary to estimate it with low uncertainty.

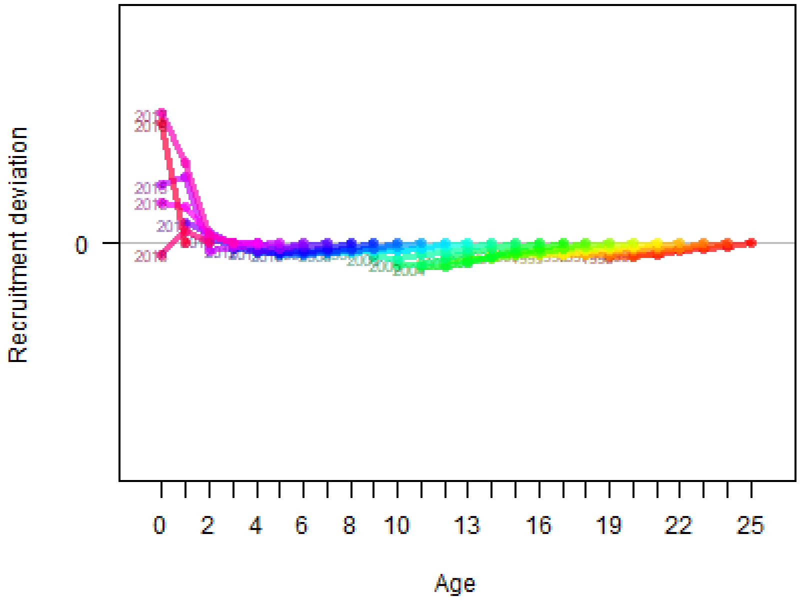


Figure 5.11. Northern shrimp in Skagerrak and Norwegian Deep: Model retrospective patterns in the estimation of recruitment deviations.

h) New long-term management strategy

In April 2018 following an ICES management strategy evaluation (ICES, 2017a), a long-term management strategy was agreed between EU and Norway (Anon., 2018):

Values for BMGT (BTRIGGER) and FTARGET are fixed at levels of 9900 t and 0.59, respectively and the TAC will be established for each calendar year (from January 1st to December 31st).

- *By end of the year N-1, a preliminary TAC will be adopted by the Parties based on ICES catch forecast for the six first months of the year N, released in March of year N-1.*
- *The Parties will establish the final TAC for the entire year N in light of the ICES catch advice released in March of year N.*

When establishing the preliminary and the final TACs the following rules shall apply:

a) When the SSB at the start of the year is estimated at or above BMGT the Parties will fix a TAC consistent with a fishing mortality rate of FTARGET.

b) When the SSB at the start of the year is estimated below BMGT, the Parties will fix a TAC consistent with a fishing mortality rate of FTARGET x (SSB/BMGT).

The TAC will include all removals made from the stock.

When SSB is estimated to be at or above BMGT, the TAC derived from paragraph (a) can be deviated with up to 10% according to the agreed "banking and borrowing" scheme described in Annex III of the agreed record (Anon., 2018).

The LTMS will be applicable from 1st of January 2019 onwards.

The management strategy shall be revised by the end of 2021 or following the next ICES benchmark of the stock.

The advised TAC for the first two quarters of year N is based on multiplying the full TAC from the short-term forecast for year N with the average proportion of quarterly catches ([Q1+Q2]/[Q1+Q2+Q3+Q4]) from the previous five years.

When the EU and Norway LTMS is fully implemented in 2019, it will rely on annual ICES advice issued in March. In the current transition phase the clients have requested ICES to issue an advice for the first two quarters of 2019, based on the LTMS, in October 2018.

i) Reference points

The reference points were computed at the benchmark in January 2016 based on the definition of the *Pandalus* stock as being a medium-lived species (ICES, 2016a; Table 5.4).

In 2009, ICES adopted a "Maximal Sustainable Yield (MSY) framework" (ACOM. ICES Advice, 2016. Book 1. Section 1.2) for deriving advice. It considers two reference points: F_{MSY} and MSY $B_{trigger}$. (Table 5.4). Under the ICES PA two reference points are also required; B_{lim} and B_{pa} (Table 5.4). B_{lim} was set to B_{loss}, which is the lowest observed value of the time-series estimated at the benchmark in 2016.

Two new reference points were computed as part of the MSE, F_{MGT} (F_{target}) and B_{MGT} ($B_{trigger}$) (ICES, 2017a). As part of the MSE, ICES also reviewed the MSY reference points for this stock, applying the stock-specific assessment/advice error settings developed for this *Pandalus* stock as part of the management strategy evaluation work. Applying the ICES guidelines (ICES, 2017b) for the calculation of reference points, the analysis resulted in an update of the F_{MSY} value to F_{MSY} = 0.60 (previously 0.62), whereas MSY $B_{trigger}$ = 9900 t remained unchanged. The lower Ftarget (F_{MGT}) for the HCR compared to the F_{MSY} is due primarily to the more stringent risk criterion of the HCR.

Table 5.4. Northern shrimp in Skagerrak and Norwegian Deep: Reference points, values, and their technical basis.

Framework	Reference point	Value	Technical basis
MSY approach	MSY $B_{trigger}$	9900 t	The 5th percentile of the equilibrium distribution of SSB when fishing at F_{MSY}, constrained to be no less than B_{pa}
	F_{MSY}	0.60	The F that maximizes median equilibrium yield (defining yield as the total catch)
Precautionary approach	B_{lim}	6300 t	B_{loss} (lowest observed SSB in the benchmark assessment 2016)
	B_{pa}	9900 t	$B_{lim} \times \exp(1.645 \times \sigma)$, where $\sigma = 0.27$
	F_{lim}	1.00	The F that leads to 50% probability of SSB < B_{lim}
	F_{pa}	0.68	$F_{lim} \times \exp(-1.645 \times \sigma)$, where $\sigma = 0.23$
Management plan	B_{MGT}	9900 t	The 5th percentile of the equilibrium distribution of SSB when fishing at F_{MGT}, constrained to be no less than B_{pa}
	F_{MGT}	0.59	The F that maximizes median equilibrium yield (defining yield as the total catch)

j) Catch scenarios

In accordance with the requirements of the LTMS, two sets of catch scenarios were provided; i) updated catch scenarios for the full year 2020 and ii) catch scenarios for the first semester of 2021.

Table 5.5. Northern shrimp in Skagerrak and Norwegian Deep: The basis for the updated catch scenarios for 2020.

Variable	Value	Notes
F2019	0.53	Corresponds to the estimated catches in 2019
SSB2020	8319	SSB beginning of 2020 (in tonnes)
R2020	7 442 212	GM 2010–2019 (in thousands)
Catches 2019	7944	Landings and estimated discards (in tonnes)

Given the new 2020 datapoint for the survey time-series and an estimated catch of 7944 t in 2019, updated catch scenarios were provided for 2020 (Table 5.6). The advised TAC for 2020 is 8736 tonnes.

Table 5.6. Northern shrimp in Skagerrak and Norwegian Deep: Updated catch scenarios for 2019.

Basis	Total catch (2020)	Ftotal (2020)	SSB (2021)	% SSB change *	% TAC change **	% advice change ***
LTMS: F = F_{MGT} x (SSB_{2020}/ MSY $B_{trigger}$)	8736	0.50	8867	6.6	41.7	41.7
Other scenarios						
MSY approach: F = F_{MSY} × (SSB_{2020}/ MSY $B_{trigger}$)	8736	0.50	8867	6.6	41.7	41.7
F = 0	0	0	14940	79.6	-100.0	-100.0
F_{pa}	10932	0.68	7432	-10.7	77.4	77.4
F_{MSY}	9999	0.6	8035	-3.4	62.2	62.2
FMSY lower	7917	0.44	9414	13.2	28.5	28.5
FMSY upper	11362	0.72	7157	-14.0	84.4	84.4
Flim	13997	1	5524	-33.6	127.1	127.1
F2019	9127	0.53	8607	3.5	48.1	48.1
FMGT	9883	0.59	8111	-2.5	60.4	60.4
SSB2021 = BPA = Btrigger	7198	0.39	9898	19.0	16.8	16.8
SSB2021 = Blim	12728	0.86	6300	-24.3	106.5	106.5

*** * SSB_{2021} relative to SSB_{2020}.**
**** Advised catch in 2020 relative to TACs in 2019 (6163 t). Note that NO and DK banked 523 t and 245 t, respectively, from 2018. These catches are not included in the TAC change.**
***** Advised catch in 2020 relative to advice value 2019 (6163 t).**

The inclusion of the most recent survey data (2020) and catch data (2019) results in decline in SSB_{2020} and the reduction in catches advised.

Table 5.7. Northern shrimp in Skagerrak and Norwegian Deep: The basis for the 1st semester catch-scenarios for 2021.

Variable	**Value**	**Notes**
F_{2020}	0.49	Corresponds to the catch forecast for 2020
SSB_{2021}	9105	SSB beginning of 2021 (in tonnes) from assessment model, including 2020 catches
R_{2021}	7 464 504	GM 2010–2019 (in thousands) from assessment model, including 2020 catches
Catches 2020	8736	Catch forecast for 2020 (in tonnes)

Table 5.8. Northern shrimp in Skagerrak and Norwegian Deep: Catch scenarios for 1st semester in 2021.

Basis	**Total catch (2021)**	**Q1 and Q2 catch (2021) ^**	**F_{total} (2021)**	**SSB (2022)**	**% SSB change ***	**% TAC change ****	**% advice change ****
LTMS: $F = F_{MGT} \times (SSB_{2021}/ \text{MSY } B_{trigger})$	8753	4552	0.54	8206	-9.9	0.2	0.2
			Other scenarios				
MSY approach: $F = F_{MSY} \times (SSB_{2021}/ \text{MSY } B_{trigger})$	8875	4615	0.55	8130	-10.7	1.6	1.6
F = 0	0	0	0	13981	53.6	-100.0	-100.0
F_{pa}	10353	5384	0.68	7229	-20.6	18.5	18.5
F_{MSY}	9461	4920	0.60	7770	-14.7	8.3	8.3
$F_{MSY\ lower}$	7472	3885	0.44	9009	-1.1	-14.5	-14.5
$F_{MSY\ upper}$	10769	5600	0.72	6981	-23.3	23.3	23.3
F_{lim}	13311	6922	1	5521	-39.4	52.4	52.4
F_{2020}	8132	4229	0.49	8593	-5.6	-6.9	-6.9
F_{MGT}	9352	4863	0.59	7837	-13.9	7.1	7.1
$SSB_{2022} = B_{pa} = B_{trigger}$	6083	3163	0.34	9899	8.7	-30.4	-30.4
$SSB_{2022} = B_{lim}$	11933	6205	0.84	6300	-30.8	36.6	36.6

*** SSB_{2022} relative to SSB_{2021}.**
**** Advised catch in 2021 relative to advised catch in 2020 (8736 t).**
^ Total catch 2021 x average proportion of catch taken in the first two quarters of 2015–2019 (0.52).

The first semester (Q1 and Q2) catch scenarios for 2021 are based on multiplying the full TAC from the short-term forecast for 2021 with the average proportion of quarterly catches from the previous five years, which gives a factor of 0.52. When applied to the full 2021 advised TAC of 8753 t this results in an advised TAC for the first two quarters of 2021 of 4552 t.

The advice is in line with the previous year.

It should be noted that the predictive power of the model seems rather high. Last year's assessment predicted particularly well the levels of F and SSB given a certain level of catch. In 2019, at catches equal to the realized catches (i.e. 7944.4 t in 2019), the model predicted an SSB in 2020 only 7% larger than the assessed SSB in 2019 and an F only 2% lower than the assessed F in 2019.

k) State of the stock

Mortality. Fishing mortality (F) has been above F_{MSY} in all years since 2011, except in 2015, 2018 and 2019.

Biomass. The spawning–stock biomass (SSB) declined after 2008 and has fluctuated at a lower level since then.

Recruitment. Recruitment has been below average since 2008, except for the 2013 year class.

State of the Stock. At the beginning of 2020, the stock is estimated to be below MSY $B_{trigger}$ and between B_{pa} and B_{lim}. Recruitment is estimated to be below average in 2019. Fishing mortality was below F_{MGT}, F_{MSY} and F_{pa} in 2019.

Yield. According to the new long-term management strategy, catches in 2020 should be no more than 8736 tonnes and in the two first quarters of 2021 no more than 4552 tonnes.

l) Research recommendations

NIPAG **recommended** in 2010–2014 that *differences in recruitment and stock abundance between Skagerrak and the Norwegian Deep should be explored.*

Status: No progress has been made. NIPAG reiterates this recommendation.

NIPAG **recommended** in 2016 that *seasonal patterns of spatial distribution resulting from the migration of different age and sex classes should be investigated, as well as seasonal patterns of LPUE in the three fisheries, particularly the reason why LPUE for a given year increases when we have the full year's data compared to the LPUE from only the first 5–6 months.*

Status: Spatial patterns in *Pandalus* distribution of the different age and sex classes has not been addressed and with the current sampling regime it is unlikely this can be addressed in the near future. However, spatial distribution of LPUE will be addressed at the proposed benchmark for 2021.

NIPAG **recommended** in 2016 that *age determination and validation using sections of eyestalks should continue and results used to refine the life-history knowledge of the stock including age–length relationship and natural mortality assumption.*

Status: This work is ongoing.

NIPAG **recommended** in 2016 that *a full benchmark for this stock, including a data compilation workshop, be conducted in the near future and no later than 2020.*

Status: This recommendation is reiterated.

References

Anon. 2018. Agreed Record of Fisheries Consultations between the European Union and Norway for 2018. 25. April 2018.

Berenboim, B.I., Korzhev, V.A., Tretjak, V.L. and Sheveleva, G.K. 1991. On methods of stock assessment and evaluation of TAC for shrimp *Pandalus borealis* in the Barents Sea. ICES C.M. 1991/K:15. 22 pp.

ICES. 2016. Report of the Benchmark Workshop on *Pandalus borealis* in Skagerrak and Norwegian Deep Sea (WKPAND), 20–22 January 2016, Bergen, Norway. ICES CM 2016/ACOM:39. 72 pp.

ICES. 2017a. Report on the Long-term Management Strategy Evaluation for Northern Shrimp (*Pandalus borealis*) in Division 4.a East and Subdivision 20 (PandLTMS). October–November 2017, ICES CM 2017/ACOM:52. 182 pp.

ICES. 2017b. ICES fisheries management reference points for category 1 and 2 stocks. In Report of the ICES Advisory Committee, 2017. ICES Advice 2017 Technical Guidelines, Book 12, 12.4.3.1, DOI: 10.17895/ices.pub.3036.

List of participants

Name	Address	Country	E-mail
Mikaela Bergenius	SLU-Aqua	Sweden	mikaela.bergenius@slu.se
Ole Ritzau Eigaard Chair	DTU Aqua Section for Fisheries Advice	Denmark	ore@aqua.dtu.dk
Guldborg Søvik	Institute of Marine Research	Norway	guldborg.soevik@hi.no
Carsten Hvingel (WebEx)	Institute of Marine Research	Norway	carsten.hvingel@hi.no
Mats Ulmestrand	SLU-Aqua	Sweden	mats.ulmestrand@slu.se
Alessandro Orio	SLU-Aqua	Sweden	alessandro.orio@slu.se

APPENDIX VIII. ICES BENCHMARK PRIORITIZATION SCORING SHEET FOR NIPAG, NOVEMBER 2020

SCORE	**Criteria 1 – Need to improve the quality of the previous assessment to provide advice** Weight: 0.4	**Criteria 2 – Opportunity to improve the assessment** Weight: 0.3	**Criteria 3 – Management importance** Attributes: a) Advice on fishing opportunities is requested for the stock. b) Stock is the object of an agreed management plan. c) Stock is the object of a directed fishery. d) Stock is included in a mixed fishery analysis, is a likely choke stock, or the object of a pelagic fishery (meets 1 of the 3) Weight: 0.1	**Criteria 4 – Perceived stock status** Weight: 0.1	**Criteria 5 - Time since previous benchmark** Weight: 0.1
5	Assessment judged to be inadequate to provide advice (e.g., bias, stock id, unreliable catches, major change in biological processes/productivity)	New approaches and new data sources will be available for the stock, and these are likely to address issues or change perception of stock dynamics	All attributes	Most likely below B_{lim}, or stock is in rapid decline, or state of the stock unknown	Stock has never been benchmarked
4	Assessment has high potential & priority to be upgraded to Cat. 1 from Cat. 3 or to Cat. 3 from Cat. 5 and 6	New data sources or corrections in data, or new methods will be available for the stock, and these are likely to address issues or change perception of stock dynamics	3 attributes	Between $B_{lim}$and $MSYB_{trigger}$	Stock has been benchmarked 10 years or more ago
3	Assessment judged to have substantial deficiencies (models and/or data) but considered acceptable	Some improvement in data /modelling approaches will be available, and unclear whether they will address issues or change perceptions	2 attributes	About $MSYB_{trigger}$	Stock has been benchmarked between 5 and <10 years ago

2	Assessment has no substantial or only minor issues	Minor improvement in data or methods will be available	1 attributes	Above $MSYB_{trigger}$	Stock has been benchmarked between 1 and < 5 years ago
1	Assessment has no obvious issues	No change in data or models will be available	No attributes	Near highest on record	Stock was benchmarked in the last year

SCORING SHEET for: **NIPAG**

Date: November 2020

Scored by: NIPAG

Stock Name	Criteria 1	Criteria 2	Criteria 3	Criteria 4	Criteria 5
Example stock xxx	3 Provide reason(s) for the rating, referring if possible to the issues list.	4 Provide reason(s), list the main data or approaches improvements (if applicable, include expected year that data will be available)	4 List attributes (e.g., a, c, d)	3 Indicate the basis for the determination (e.g. estimate from the advice issued in year x, survey index series, expert opinion, etc).	1 If a benchmark has been conducted indicate the year and reference to the benchmark report.
Pra.27.1-2	3 Big retrospective pattern in recent years. Current effort data come from a small portion of the total fishery and we need to incorporate data from other fisheries. Need to re-analyze survey data for possible indices of recruitment need to develop a statistically coherent method to account for missing	4 If recruitment indices can be generated and CPUE data from all fleets are available, this is expected to reduce the retrospective problem. Explore the potential of age and/or size segregated models. Explore inclusion of explicit terms for natural mortality, eg. predation from cod etc. and the influence of other	3 a, c the importance of this fishery has increased greatly in recent years and a management plan is needed and is under development.	1 Assessment in 2020	5

Stock Name	**Criteria 1**	**Criteria 2**	**Criteria 3**	**Criteria 4**	**Criteria 5**
Example stock xxx	3 Provide reason(s) for the rating, referring if possible to the issues list.	4 Provide reason(s), list the main data or approaches improvements (if applicable, include expected year that data will be available)	4 List attributes (e.g., a, c, d)	3 Indicate the basis for the determination (e.g. estimate from the advice issued in year x, survey index series, expert opinion, etc).	1 If a benchmark has been conducted indicate the year and reference to the benchmark report.
	survey coverage Need to incorporate information on recruitment in the assessment model.	ecosystem parameters.			
Pra.27.3a4a	3 The advice is very dependent on M, both for the estimations of the reference point and stock status. M assumptions are crude and very poorly substantiated. Model tends to over-estimate recruitment in the final year. B_{lim} is defined a B_{loss} and this may be inappropriate.	4 A new approach to calculating the survey index is available and this needs to be explored and approved at the benchmark. Catches will be split by fleet and area. Correcting for missing survey data in some years using a statistical model. Alternative methods are currently	4 a,b,c	4 From the 2020 advice	2 2016, but there was not a data workshop

Stock Name	**Criteria 1**	**Criteria 2**	**Criteria 3**	**Criteria 4**	**Criteria 5**
Example stock xxx	3 Provide reason(s) for the rating, referring if possible to the issues list.	4 Provide reason(s), list the main data or approaches improvements (if applicable, include expected year that data will be available)	4 List attributes (e.g., a, c, d)	3 Indicate the basis for the determination (e.g. estimate from the advice issued in year x, survey index series, expert opinion, etc).	1 If a benchmark has been conducted indicate the year and reference to the benchmark report.
		under development Work has been done to estimate M from unfished fjords.			
NAFO 3M shrimp	4 The fishery has been reopened after 9 years. The assessment is based on survey index only. There has never been an analytical assessment but the data may allow for some kind of model.	5 see answer to criterion 1. New assessment approaches using the survey data as well as new logbook and observer data will be available.	4 a,c	4 based on survey index only. B is considered to be above B_{lim} but $B_{trigger}$ is not defined for NAFO stocks.	5 While this is not an ICES stock, all the countries fishing the stock are ICES members and it would be beneficial to share experience in benchmarking the stock together with the ICES stocks.

PART F: MISCELLANEOUS

I.A- NAFO SCIENTIFIC COUNCIL MEETING, 28 MAY – 12 JUNE 2020– AGENDA

Scientific Council Meeting, 28 May-12 June 2020

(By correspondence)

The meeting will be held from Monday to Friday. Weekends will not be working days.

Note:

- For STACFEN, STACPUB and STACREC (items III, IV and V below), the Committee Chairs will produce a draft of the report offline and upload it to the Scientific Council SharePoint, either in June or September, depending on workload. Scientific Council will be informed and given the opportunity to comment before the approval of these reports.
- The same working procedure will be applied to some of the STACFIS and Scientific Council items. All stock assessments and other scientific work directly used in responding to this year's requests for advice will be presented in plenary sessions by WebEx.

I. Opening (Scientific Council Chair: Carmen Fernández)
   1. Appointment of Rapporteur
   2 Presentation and Report of Proxy Votes
   3. Adoption of Agenda
   4. Attendance of Observers
   5. Appointment of Designated Experts
   6. Plan of Work
   7. Housekeeping issues

II. Review of Scientific Council Recommendations in 2019

III. Fisheries Environment (STACFEN Chair: Miguel Caetano)
   1. Opening
   2. Appointment of Rapporteur
   3. Adoption of Agenda
   4. Review of Recommendations in 2019
   5. Department of Fisheries and Oceans Canada, Oceans Science Branch, Marine Environmental Data Section (MEDS) Report for 2019
   6. Review of the physical, biological and chemical environment in the NAFO Convention Area during 2019
   7. Interdisciplinary studies
   8. Formulation of recommendations based on environmental conditions during 2019
   9. Other Matters
   10. Adjournment

IV. Publications (STACPUB Chair: Margaret Treble)
   1. Opening
   2. Appointment of Rapporteur
   3. Adoption of Agenda
   4. Review of Recommendations in 2019
   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: Karen Dwyer)

1. Opening
3. Appointment of Rapporteur
4. Review of Recommendations in 2019
5. Fishery Statistics
    - a) Progress report on Secretariat activities in 2019/2020
        - i) Presentation of catch estimates from the CESAG, daily catch reports and STATLANT 21A and 21B
6 Research Activities
    - a) Biological sampling
        - i) Report on activities in 2019/2020
        - ii) Report by National Representatives on commercial sampling conducted
        - iii) Report on data availability for stock assessments (by Designated Experts)
    - b) Biological surveys
        - i) Review of survey activities in 2019 and early 2020 (by National Representatives and Designated Experts)
        - ii) Surveys planned for 2020 and early 2021
    - c) Tagging activities
    - d) Other research activities
7. Review of SCR and SCS Documents
8. Other Matters
    - a) Summary of progress on previous recommendations
    - b) NAFO Catch Estimates Methodology Study
9. Adjournment

VI. Fisheries Science (STACFIS Chair: Katherine Sosebee)

1. Opening
2. General Review of Catches and Fishing Activity
3. Stock Assessments
    1. Greenland halibut (*Reinhardtius hippoglossoides*) in SA 0, Div. 1A offshore and Div. 1B-F (full assessment)
    2. Greenland halibut (*Reinhardtius hippoglossoides*) Div. 1A inshore (full assessment)
    3. Demersal Redfish (*Sebastes* spp.) in SA 1 (full assessment)
    4. Demersal deep-sea redfish (*Sebastes* spp.) in SA 1 (full assessment)
    5. Wolffish in Subarea 1 (full assessment)
    6. Cod (*Gadus morhua*) in Div. 3M (full assessment)
    7. Redfish (*Sebastes mentella* and *Sebastes fasciatus*) in Div. 3M (Monitor)
    8. American plaice (*Hippoglossoides platessoides*) in Div. 3M (Full assessment)
    9. Cod (*Gadus morhua*) in NAFO Div. 3NO (Monitor)
    10. Redfish (*Sebastes mentella* and *Sebastes fasciatus*) in Divs. 3L and 3N (Update assessment: Comm request #11)
    11. Golden redfish (Sebastes norvegicus) in Div. 3M (Monitor)
    12. American plaice (*Hippoglossoides platessoides*) in Div. 3LNO (monitor)

13. Yellowtail flounder (*Limanda ferruginea*) in Div. 3LNO (monitor)
14. Witch flounder (*Glyptocephalus cynoglossus*) in Div. 3NO (Full assessment)
15. Capelin (*Mallotus villosus*) in Div. 3NO (monitor)
16. Redfish (*Sebastes mentella* and *Sebastes fasciatus*) in Div. 3O (monitor)
17. Thorny skate (*Amblyraja radiata*) in Div. 3LNO and Subdiv. 3PS (full assessment)
18. White hake (*Urophycis tenuis*) in Div. 3NO and Subdiv. 3PS (monitor)
19. Roughhead grenadier (*Macrourus berglax*) in Subareas 2 and 3 (monitor)
20. Greenland halibut (*Reinhardtius hippoglossoides*) in SA 2 + Div. 3KLMNO (under management strategy: Update assessment, COM request #2)
21. Northern shortfin squid (*Illex illecebrosus*) in Subareas 3+4 (monitor, deferred to September)
22. Splendid alfonsino (*Beryx splendens*) in SA 6

4. Other Matters
    a) FIRMS Classification for NAFO Stocks (Note: expected to be deferred to September)
    b) Other Business
5. Adjournment

VII. Management Advice and Responses to Special Requests (See Annex 1)

SC has agreed a priority order for the requests, with the following meaning (where September refers to a potential SC meeting taking place around September 14-18):

Priority level	**Schedule for SC addressing the request**
1	June, as top priority
2	June, as next level of priority
3	Preferably June, but could be delayed to September if no time in June
4	September (unless progress in June was unexpectedly fast)
5	Flexible (June, September, or June 2021)

1. NAFO Commission (Annex 1)
    - a) Request for Advice on TACs and Other Management Measures (request #1, Annex 1) [note: Priority level 1 for all of them]
        - <u>For 2021</u>
        - - Cod in Div. 3M
        - <u>For 2021 and 2022</u>
        - -Thorny Skate in 3LNO
        - - Witch flounder in Div. 3NO [note: SC will do this of its own accord, because of practical working arrangements in connection with change of Designated Expert]
        - <u>For 2021, 2022 and 2023</u>
        - - American Plaice in 3M

    - b) Monitoring of Stocks for which Multi-year Advice was provided in 2018 or 2019 (request #1) [note: Priority level 1 for all of them, except squid]
        - - Redfish in Div. 3M
        - - Golden redfish in Div. 3M
        - - Cod (*Gadus morhua*) in NAFO Div. 3NO
        - - Yellowtail flounder in Divs. 3LNO
        - - American Plaice in Divs. 3LNO
        - - Capelin in Divs. 3NO
        - - Alfonsino stocks in the NAFO Regulatory Area
        - - Roughhead grenadier in Subareas 2 and 3
        - - White hake (*Urophycis tenuis*) in Div. 3NO and Subdiv. 3PS
        - - Northern shortfin squid (*Illex illecebrosus*) in Subareas 3+4 [note: to be done in September]

    - c) Special Requests for Management Advice
        - i) Greenland halibut in SA2 + Divs. 3KLMNO: conduct an update assessment, compute the TAC using the agreed HCR and determine whether exceptional circumstances are occurring (request #2) [note: Priority level 1]
        - ii) continue the evaluation of scientific trawl surveys in VME closed areas (request #3) [note: Priority level 5]
        - iii) identify discard species/stocks with high survivability rates (request #4) [note: Priority level 3]

    - iv) continue to refine work under the ecosystem approach (request #5) [note: Priority level 1]
    - v) assessment of NAFO bottom fisheries in 2021 (request #6) [note: Priority level 2]
    - vi) re-assessment of VME closures (request #7) [note: Priority level 1]
    - vii) continue progress on the NAFO PA Framework review (request #8) [note: Priority level 1]
    - viii) identify areas and times where bycatch and discards of Greenland sharks have a higher rate of occurrence (request #9) [note: Priority level 3]
    - ix) develop a 3-5 year work plan (request #10) [note: Priority level 4]
    - x) update assessment and projections for 3LN redfish (request #11) [note: Priority level 1]
    - xi) ecosystem summary sheet for 3LNO (request #12) [note: Priority level 1]
    - xii) review submitted protocols for a survey methodology to inform the assessment of splendid alfonsino (request #13) [note: Priority level 3]
    - xii) presentation of the stock assessment and the scientific advice of Cod 2J3KL (Canada), Witch 2J3KL (Canada) and Pelagic Sebastes mentella (ICES Divisions V, XII and XIV; NAFO 1) (request #14) [note: Priority level 2 (cod and witch) and 4 (redfish)]
    - xiii) provide updates on relevant research related to the potential impact of activities other than fishing in the Convention Area (request #16) [note: Priority level 3]
    - xiv) measures to improve the productivity of 3M Cod (request #17) [note: Priority level 2]
    - xv) information on sea turtles, sea birds, and marine mammals that are present in NAFO Regulatory Area (request #18) [note: Priority level 2 (initial discussion and guidance) and 4 (finalize)]

  - 2. Coastal States
    - a) Request by Denmark (Greenland) for Advice on Management in 2021 (Annex 2)
      - i) Golden redfish, demersal deep-sea redfish, Atlantic wolffish and spotted wolfish (Item 1) [note: Priority level 1]
      - ii) Greenland halibut, inshore, Northwest Greenland (Item 3) [note: Priority level 1]
    - b) Request by Canada and Denmark (Greenland) for Advice on Management in 2021 (Annex 2, Annex 3)
      - i) Greenland halibut in Div. 0A and the offshore area of Div. 1A, plus Div. 1B-F (Annex 2, Item 2; Annex 3, Item 1) [note: Priority level 1]

VIII. Review of Future Meetings Arrangements

  1. Scientific Council, 1 day around 10–14 September, by WebEx, advice on 3M shrimp
  2. Scientific Council, 21 – 25 Sep. 2020 (potentially extending to dates around 14–18 Sep.)
  3. Scientific Council (in conjunction with NIPAG), 27 Oct.–02 Nov. 2020
  4. Scientific Council, June 2021
  5. Scientific Council, Sep. 2021
  6. Scientific Council (in conjunction with NIPAG), 2021
  7. WG-ESA, Nov. 2020
  8. NAFO/ICES Joint Groups
     - a) NIPAG, 2020
     - b) NIPAG, 2021

c) WG-DEC
d) WG-HARP

IX. Arrangements for Special Sessions
1. Topics for future Special Sessions (Note: expected to be deferred to September)

X. Meeting Reports
1. Working Group on Ecosystem Science and Assessment (WG-ESA), Nov. 2019
2. Report from ICES-NAFO Working Group on Deepwater Ecosystems (WG-DEC), 2019
3. Report from ICES/NAFO/NAMMCO Working Group on Harp and Hooded Seals (WGHARP), 2019
4. Report from Joint COM-SC Working Group on Catch Estimation Strategy Advisory Group (CESAG), March and April 2020
5. Meetings attended by the Secretariat

XI. Review of Scientific Council Working Procedures/Protocol
1. General Plan of Work for September 2020 Annual Meeting
2. Priority actions for Scientific Council from the Performance Review Panel WG (adopted by the NAFO Commission in September 2019):
   - peer review process for the science underlying the SC advice, applied consistently to all SC science used in advice [note: to be discussed by SC in June if time permits, otherwise in September]

XII. Other Matters
1. Designated Experts
2. Budget items
3. Other Business

XIII. Adoption of Committee Reports
1. STACFEN
2. STACREC
3. STACPUB
4. STACFIS

XIV. Scientific Council Recommendations to Commission

XV. Adoption of Scientific Council Report

XVI. Adjournment

III.B – NAFO SCIENTIFIC COUNCIL MEETING (IN CONJUNCTION WITH NIPAG), 14 SEPTEMBER 2020– AGENDAS

SCIENTIFIC COUNCIL MEETING, 14 September 2020 via WebEx

1. Opening (Chair: Carmen Fernandez)
    a. Appointment of Rapporteur
    b. Adoption of Agenda
    c. Plan of Work
2. Review of Relevant Advice from 2019
3. Formulation of Advice
    a. Northern shrimp in Div. 3M
5. Adjournment

NAFO/ICES *PANDALUS* ASSESSMENT GROUP, 14 September 2020 via WebEx

1. Opening (Co-chairs Kathrine Sosebee and Ole Ritzau Eigaard)
    a. Appointment of Rapporteur
    b. Adoption of Agenda
2. General review
    a. Review of Relevant Recommendations in 2019
    b. Presentation of New Survey Data in 2020
3. Stock Assessments
    a. Northern shrimp (Div. 3M)
4. Other Business
5. Adjournment

IV.C – NAFO SCIENTIFIC COUNCIL MEETING, 21 – 25 SEPTEMBER 2020– AGENDA

Note: items listed under agenda item VII.1 (*Requests/advice requested by the Commission (in NAFO/COM Doc. 19-29) deferred from the June 2020 Scientific Council Meeting*), will be addressed as far as possible during this meeting. However, due to time and other constraints, it is likely that many will be deferred to the June 2021 Scientific Council meeting. If the NAFO Commission communicates that responses from Scientific Council on these requests are needed for consideration at the 2020 Annual Meeting or before June 2021, additional meeting days may be added during September 15-17 2020.

Provisional Agenda

I. Plenary Session

1. Opening
2. Appointment of Rapporteur
3. Adoption of Agenda
4. Plan of Work

II. Review of Scientific Council Recommendations

III. Joint Session of Commission and Scientific Council

1. Implementation of 2018 Performance Review Panel recommendations
2. Presentation of scientific advice by the Chair of the Scientific Council
    - a) Response of the Scientific Council to the Commission's request for scientific advice
    - b) Feedback to the SC regarding the advice and its work during this meeting
    - c) Other issues as determined by the Chair of the Commission and of the Scientific Council
3. Meeting Reports and Recommendations of the Joint Commission–Scientific Council Working Groups
    - a) Working Group on Improving Efficiency of NAFO Working Group Process (E-WG), 2020
    - b) Joint Commission–Scientific Council Working Group on Risk-based Management Strategies (WG-RBMS), August 2020
    - c) Joint Commission–Scientific Council Working Group on Ecosystems Approach Framework to Fisheries Management (WG-EAFFM), August 2020
    - d) Joint Commission–Scientific Council Catch Estimation Strategy Advisory Group (CESAG), 2020 (no discussion required)
4. Formulation of Request to the Scientific Council for Scientific Advice on Management in 2022 and Beyond of Certain Stocks in Subareas 2, 3 and 4 and Other Matters

IV. Publications (STACPUB Chair: Margaret Treble)

Opening

Appointment of Rapporteur

Adoption of Agenda

Review of Recommendations in 2019

Review of Publications

a) Annual Summary

  - i) Journal of Northwest Atlantic Fishery Science (JNAFS)
  - ii) Scientific Council Studies
  - iii) Scientific Council Reports

Other Matters

Adjournment

V. Research Coordination (STACREC Chair: Karen Dwyer)

1. Opening
3. Appointment of Rapporteur
4. Review of Recommendations in 2019
5. Fishery Statistics
    - a) Progress report on Secretariat activities in 2019/2020
        - i) Presentation of catch estimates from the CESAG, daily catch reports and STATLANT 21A and 21B

6 Research Activities

- a) Biological sampling
    - i) Report on activities in 2019/2020
    - ii) Report by National Representatives on commercial sampling conducted
    - iii) Report on data availability for stock assessments (by Designated Experts)
- b) Biological surveys
    - i) Review of survey activities in 2019 and early 2020 (by National Representatives and Designated Experts)
    - ii) Surveys planned for 2020 and early 2021
- c) Tagging activities
- d) Other research activities

7. Review of SCR and SCS Documents
8. Other Matters

   - a) Summary of progress on previous recommendations
   - b) NAFO Catch Estimates Methodology Study

9. Adjournment

VI. Fisheries Science

1. Opening
2. Nomination of Designated Experts
3. Other Matters
   - a) Review of SCR and SCS Documents
   - b) Assessments deferred from the June meeting
     - i) Northern shortfin squid in SA 3+4 (interim monitoring report)
   - c) Review of FIRMS classification of NAFO stocks
   - d) Other Business

VII. Requests from the Commission

Requests/advice requested by the Commission (in NAFO/COM Doc. 19-29) deferred from the June 2020 Scientific Council Meeting

Continue the evaluation of scientific trawl surveys in VME closed areas (COM request #3)

Identify discard species/stocks with high survivability rates (COM request #4)

Identify areas and times where bycatch and discards of Greenland sharks have a higher rate of occurrence (COM request #9)

Develop a 3-5 year work plan (COM request #10)

Review submitted protocols for a survey methodology to inform the assessment of splendid alfonsino (COM request #13)

Presentation of the stock assessment and the scientific advice of Cod 2J3KL (Canada), Witch 2J3KL (Canada) and Pelagic *Sebastes mentella* (ICES Divisions V, XII and XIV; NAFO 1) (COM request #14)

Provide updates on relevant research related to the potential impact of activities other than fishing in the Convention Area (COM request #16)

Information on sea turtles, sea birds, and marine mammals that are present in NAFO Regulatory Area (COM request #18)

Ad hoc Requests from Current Meeting

Further progress on items related to COM requests (in NAFO/COM Doc. 19-29)

COM request #6: assessment of NAFO bottom fisheries in 2021

With regards to the overlap of NAFO fisheries with VME, Scientific Council should finalize the specification of data and information to be included in the directed fishery summaries

COM request #8: NAFO PA Framework review

Scientific Council should further elaborate on the work plan for the next 1-2 years

VIII. Review of Future Meeting Arrangements

IX. Future Special Sessions

1. Progress on 2021 symposium with ICES on Decadal Hydro-Biological Variability of the North Atlantic for the decade 2010-2019

2. Information concerning Flatfish Symposium 2020

X. Other Matters

Meeting reports

a) ICES/NAFO Working Group on Deep-water Ecology (WGDEC)

b) ICES/NAFO/NAMMCO Working Group on Harp and Hooded Seals (WGHARP)

XI. Adoption of Reports

1. Committee Reports of STACPUB, STACFIS and STACREC

2. Report of Scientific Council

XI. Adjournment

V.D – NAFO SCIENTIFIC COUNCIL SHRIMP MEETING, 26 – 30 OCTOBER 2020 –REVISED AGENDA

By WebEx
26 October – 02 November 2020 (excluding weekend)

Daily hours (Halifax time, Canada): 7:30 to 13:00 h

I. Opening (Chair: Carmen Fernández)

    1. Appointment of Rapporteur
    2. Adoption of Agenda
    3. Attendance of Observers
    4. Plan of Work

II. Review of Recommendations in 2019

III. NAFO/ICES Pandalus Assessment Group (Co-chairs Katherine Sosebee and Ole Ritzau Eigaard)

IV. Formulation of Advice (see Annexes 1–3)

    1. Requests from Coastal States (Items 5 and 6 of Annex 3, item 2 of Annex 3)
        a. Northern shrimp (Subareas 0 and 1)
        b. Northern shrimp (in Denmark Strait and off East Greenland)

V. Other Matters

    1. Scheduling of Future Meetings
    2. Topics for Future Special Sessions
    3. Other Business

VI. Adoption of Scientific Council and NIPAG Reports

VII. Adjournment

VI.E – NAFO/ICES *PANDALUS* ASSESSMENT GROUP MEETING (NIPAG), 26 - 30 OCTOBER 2020 – AGENDA

By WebEx
27 October – 02 November 2020

I. Opening (Co-chairs Katherine Sosebee and Ole Ritzau Eigaard)

  1. Appointment of Rapporteur

  2. Adoption of Agenda

  3. Plan of Work

II. General Review

  1. Review of Recommendations in 2019

  2. Review of Catches

III. Stock Assessments

Northern shrimp (NAFO Division 3M) (review of assessment September 2020 and new survey data analysis)
Northern Shrimp (NAFO Divisions 3LNO) (interim monitoring)
Northern shrimp (NAFO Subareas 0 and 1) (full assessment)
Northern shrimp (in Denmark Strait and off East Greenland) (full assessment)
Northern shrimp in the Skagerrak andNorwegian Deep (ICES Subdivision 27.3a.20 and the eastern part ofDivision 27.4a) (review of assessment February 2020)
Northern Shrimp in Barents Sea and Svalbard area (ICES Sub-areas I & II) (full assessment)
Northern shrimp in Fladen Ground (ICES Division IVa) (full assessment)

IV. Other Business

  1. FIRMS Classification for NAFO Shrimp Stocks
  2. Benchmark planning
  3. Scheduling of future meetings

V. Adjournment

VII.THE COMMISSION'S REQUEST FOR SCIENTIFIC ADVICE ON MANAGEMENT IN 2021 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, 7, 8 and 11 should be the priority for the June 2020 Scientific Council meeting.

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 White Hake in Div. 3NO	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 Cod in Div. 3NO 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 2020, advice should be provided for 2021 for Cod in 3M 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 2020 Annual Meeting.

In 2020, advice should be provided for 2021 and 2022 for: Thorny Skate in 3LNO,

In 2020, advice should be provided for 2021, 2022 and 2023 for: American Plaice in 3M,

Advice should be provided using the guidance provided in **Annexes A or B as appropriate**, or using the predetermined Harvest Control Rules in the cases where they exist, currently Greenland halibut 2+3KLMNO.

The Commission also requests the Scientific Council to continue to monitor the status of all other stocks annually and, should a significant change be observed in stock status (e.g. from surveys) or in bycatch in other fisheries, provide updated advice as appropriate.

2. The Commission requests the Scientific Council to conduct an update assessment of Greenland halibut in Subarea 2+Div 3KLMNO and 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.

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

4. 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), giving priority in 2020 to the identification of discard species/ stocks listed in Annex I.A. and Annex I.B of the NCEM with high survivability rates.

5. The Commission requests the Scientific Council to continue to refine its work under the Ecosystem Approach and report on these results to both the WGEAFFM and WGRBMS.

6. In relation to the assessment of NAFO bottom fisheries in 2021, 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.

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

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

9. The Commission requests Scientific Council continue to work with WG- BDS and the Secretariat 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.

10. The Commission requests Scientific Council to continue to develop a 3-5 year work plan, which reflects requests arising from the 2019 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.

11. The Commission requests that Scientific Council do an update assessment for 3LN redfish and five year projections (2021 to 2025) to evaluate the impact of annual removals at 18 100 tonnes against the performance statistics from NCEM Annex I.H: If this level of catch does not result in fulfilling these performance statistics, SC should advise the level of catch that would.

12. The Commission request that the Scientific Council present the Ecosystem Summary Sheet for 3LNO for presentation to the Commission at the 2020 Annual Meeting.

13. The Commission request the Scientific Council review submitted protocols for a survey methodology to inform the assessment of Splendid Alfonsino. The Scientific Council to report on the outcome of this work at next Commission annual meeting.

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

15. The Commission to ask the Scientific Council to advise on the possible sustainable management methods for northern shrimp in Div. 3M, including quota, fishing effort, periods, reporting or other technical measures. This advice should be provided before the intersessional work by the end of this year.

16. The Commission requests Scientific Council to continue to monitor and provide updates resulting from relevant research related to the potential impact of activities other than fishing in the Convention Area (for example via EU ATLAS project), and where possible to consider these results in the on-going modular approach concerning the development of Ecosystem Summary Sheets.

17. The Commission requests the Scientific Council to provide advice on gear, including sorting grids, area and time-based measures that can be used to protect and improve the productivity of the 3M Cod stock.

18. The Commission requests the Scientific Council to provide information to the Commission at its next annual meeting on sea turtles, sea birds, and marine mammals that are present in NAFO Regulatory Area based on available data.

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_{2019}, F_{2019}, 125% F_{2019},
    - For stocks under a moratorium to direct fishing: F_{2019}, 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(B2022 > B2018)
F in 2019 and following years*	Yield 2020 (50%)	Yield 2021 (50%)	Yield 2022 (50%)	2020	2021	2022	2020	2021	2022		2020	2021	2022	2020	2021	2022		
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_{2019}, F_{2019}, 125% F_{2019},
   - For stocks under a moratorium to direct fishing: F_{2019}, 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(B2022 > B2018)
F in 2019 and following years*	Yield 2020	Yield 2021	Yield 2022	2020	2021	2022	2020	2021	2022		2020	2021	2022	2020	2021	2022		
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.

VIII.DENMARK (ON BEHALF OF GREENLAND) COASTAL STATE REQUEST FOR SCIENTIFIC ADVICE - 2021

Denmark (on behalf of Greenland) requests scientific advice on management in 2020 of Certain Stocks in NAFO Subarea O and 1. Denmark (on behalf of Greenland) requests the Scientific Council for advice on the following species:

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 2017 given for 2018-2020. Denmark (on behalf of Greenland) requests the Scientific Council to provide advice on appropriate TAC levels for 2021 to 2023.

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 provide advice on appropriate TAC levels for 2021 to 2022. in 1) the offshore areas of NAFO Division OA and Division 1 A plus Division 1 B and 2) NAFO Division OB plus Divisions 1C-1F. The Scientific Council is also asked to advice on any other management measures it deems appropriate to ensure the sustainability of these resources. The Scientific Council is requested to consider the possibility for providing a separate advice for 1 B-1 F inshore.

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 provide advice on appropriate TAC levels for 2021 to 2022.

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 2020 to provide advice on the scientific basis for management of Northern Shrimp (Panda/us borea/is) in Subarea O and 1 in 2021 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 (Panda/us borea/is) in Denmark Strait and adjacent waters east of southern Greenland in 2021 and for as many years ahead as data allows for

X.CANADA'S REQUEST FOR COASTAL STATE ADVICE - 2021

1. Greenland halibut (Subarea 0 + 1A (offshore) and 1B-F)

The Scientific Council is requested to provide an overall assessment of status and trends in the total stock area throughout its range and to specifically advise on TAC levels for 2021 and 2022[1]. The stock status should be evaluated in the context of management requirements for long-term sustainability and the advice provided should be consistent with NAFO's Precautionary Approach Framework.

Canada again encourages the Scientific Council to continue exploring opportunities to develop risk-based advice, including the implications of catch differing from the TAC (e.g. +/- 5-15%) on the stock's long-term trajectory.

2. Shrimp (Subarea 1 and Division 0A)

Canada requests the Scientific Council to consider the following options in assessing and projecting future stock levels for Shrimp in Subarea 1 and Division 0A:

The status of the stock should be determined and risk-based advice provided for catch options corresponding to Z_{msy}, in 5,000-10,000t increments (subject to the discretion of Scientific Council), with forecasts for 2021-2025, if possible. These options should be evaluated in relation to Canada's Harvest Strategy (attached) and NAFO's Precautionary Approach Framework, and presented in the form of risk analyses related to B_{msy}, 80% B_{msy}, B_{lim} (30% B_{msy}) and Z_{msy}.

Presentation of the results should include graphs and/or tables related to the following:

- Historical and current yield, biomass relative to B_{msy}, total mortality relative to Z_{msy}, and recruitment (or proxy) levels for the longest time period possible;
- Total mortality (Z) and fishable biomass for a range of projected catch options (as noted above) for the years 2021 to 2025 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} (30% B_{msy}), and of being above Z_{msy} based on the 3-year projections, consistent with the Harvest Decision Rules in Canada's Harvest Strategy; and
- Total area fished for the longest time period possible.

Please provide the advice relative to Canada's Harvest Strategy as part of the formal advice (i.e., grey box in the advice summary sheet).

---

[1] The Scientific Council has noted previously that there is no biological basis for conducting separate assessments for Greenland halibut throughout Subareas 0-3, but has advised that separate TACs be maintained for different areas of the distribution of Greenland halibut.

XI.LIST OF SCR AND SCS DOCUMENTS – 2020

SCR Documents

Doc No.	Serial No	Author	Title
SCR Doc. 20-001	N7032	G. Søvik and T. H. Thangstad	Results of the Norwegian Bottom Trawl Survey for Northern Shrimp (Pandalus borealis)in Skagerrak and the Norwegian Deep (ICES Divisions 3.a and 4.a East) in 2020
SCR Doc. 20-002	N7041	R. M. Rideout and 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 2019
SCR Doc. 20-003	N7044	Rasmus Nygaard, Søren L. Post, Anja Retzel, Karl Zinglersen, Lars Heilmann, Sofie R. Jeremiassen, Signe Jeremiassen, Louise Mølgaard and Jørgen Sethsen.	Biomass and Abundance of Demersal Fish Stocks in the Nuuk fjord.
SCR Doc. 20-004	N7046	R.M. Rideout	Do spatial coverage issues in the 2019 Canadian (NL) RV bottom trawl surveys influence the suitability of survey indices for use in NAFO stock assessments?
SCR Doc. 20-005	N7047	P.M Regular, R.M. Rideout, D.W. Ings	Impact of missed strata on abundance-at-age estimates of Greenland halibut from the Canadian fall 2J3K and spring 3LNO surveys in 2018
SCR Doc. 20-006	N7048	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), 1990-2019.
SCR Doc. 20-007	N7051	M. A. Treble	Report on Greenland halibut caught during the 2019 trawl survey in Divisions 0A
SCR Doc. 20-008	N7052	Diana González-Troncoso, Irene Garrido, Ana Gago, Esther Román and Lupe Ramilo	Results for Greenland halibut, American plaice and Atlantic cod of the Spanish survey in NAFO Div. 3NO for the period 1997-2019
SCR Doc. 20-009	N7053	Diana González-Troncoso, Ana Gago and Irene Garrido	Yellowtail flounder, redfish (Sebastes spp.) and witch flounder indices from the Spanish Survey conducted in Divisions 3NO of the NAFO Regulatory Area
SCR Doc. 20-010	N7054	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. 20-011	N7055	Diana González Troncoso, Jose Miguel Casas Sánchez and Mónica Mandado	Results from Bottom Trawl Survey on Flemish Cap of June-July 2019
SCR Doc. 20-012	N7056	Adriana Nogueira and Daniel Estévez-Barcia	Results for Greenland halibut survey in NAFO Divisions 1C-1D for the period 1997-2019
SCR Doc. 20-013	N7057	Esther Román-Marcote, Concepción González-Iglesias and Diana González-Troncoso	Results for the Spanish Survey in the NAFO Regulatory Area of Division 3L for the period 2003-2019

SCR Doc. 20-014	N7059	Esther Román-Marcote, 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 2003-2019
SCR Doc. 20-015REV3	N7060	A. Nogueira and M. Treble	Comparison of vessels used and survey timing for the 1CD and 0A-South deep-water surveysand the 1A-F west Greenland shelf surveys
SCR Doc. 20-016	N7061	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. 20-017	N7062	Paula Fratantoni	Hydrographic Conditions on the Northeast United States Continental Shelf in 2019 – NAFO Subareas 5 and 6
SCR Doc. 20-018	N7063	Boris Cisewski	Hydrographic conditions off West Greenland in 2019
SCR Doc. 20-019	N7065	John Mortensen	Report on hydrographic conditions off Southwest Greenland June 2019
SCR Doc. 20-020REV	N7066	F. Cyr, P. S. Galbraith, C. Layton, D. Hebert	Environmental and Physical Oceanographic Conditions on the Eastern Canadian shelves (NAFO Sub-areas 2, 3 and 4) during 2019.
SCR Doc. 20-021	N7067	Irene Garrido, Fernando González-Costas, Diana González-Troncoso, Ricardo Alpoim and Dolores Garabana	3M cod possible technical measures: spatial / temporal closures
SCR Doc. 20-022	N7068	Durán Muñoz, P., Sacau, M., Román-Marcote, E. and García-Alegre, A.	A theoretical exercise of Marine Spatial Planning in the Flemish Cap and Flemish Pass (NAFO Divs. 3LM): implications for fisheries management in the high seas
SCR Doc. 20-023REV	N7069	E. Román-Marcote, P. Durán Muñoz and M. Sacau	Preliminary information from EU-Spain surveys in Div 3L regarding Commission request #18: "Provide information to the Commission at its next annual meeting on sea turtles, seabirds, and marine mammals that are present in NAFO Regulatory Area based on available data"
SCR Doc. 20-024	N7070	Isabelle Gaboury	NAFO STACFEN (MEDS) Report 2019
SCR Doc. 20-030REV	N7078	Rademeyer and Butterworth	Updated SCAA Base Case Assessment for Greenland Halibut
SCR Doc. 20-031REV	N7079	Diana González-Troncoso, Carmen Fernández and Fernando González-Costas	Assessment of the Cod Stock in NAFO Division 3M
SCR Doc. 20-032REV	N7080	L.J. Wheeland, E. Novaczek, M. A. Treble, A. Nogueira	Impacts of survey timing on distribution and indices of Greenland halibut in NAFO Div. 0A and Divs. 1CD
SCR Doc. 20-033REV2	N7081	A. M. Ávila de Melo, Nuno Brites, R. Alpoim, D. González Troncoso, F. González and M. Pochtar	The status of redfish (S. mentella and S. fasciatus) in Divisions 3LN and two medium term scenarios (when recruitment is low, Risk Based Management Strategy or common sense?)
SCR Doc. 20-034	N7082	Rasmus Nygaard, Adriana Nogueira and Karl Zinglersen	Knowledge about the dynamics of the Greenland halibut in the fjords in NAFO subarea 1B to 1F inshore
SCR Doc. 20-035	N7083	D. Bélanger, P. Pepin, G. Maillet	Biogeochemical oceanographic conditions in the Northwest Atlantic (NAFO subareas 2-3-4) during 2019

SCR Doc. 20-036	N7084	Pablo Carrera and Fernando González-Costas	Sampling Plan for an Acoustic Survey of Kükenthal Peak (NAFO Division 6G) to Quantify Alfonsino (Beryx splendens) Biomass, Abundance and Size Composition
SCR Doc. 20-037	N7085	Igor Yashayaev, Ingrid Peterson, and Zeliang Wang	Meteorological, Sea Ice, and Physical Oceanographic Conditions in the Labrador Sea during 2019
SCR Doc. 20-038	N7086	M. A. Treble and A Nogueira	Assessment of the Greenland Halibut Stock Component in NAFO Subarea 0 + Division 1A (Offshore) and Divisions 1B-1F
SCR Doc. 20-039	N7087	R. Alpoim	An Assessment of American Plaice (Hippoglossoides platessoides) in NAFO Division 3M
SCR Doc. 20-040	N7088	Rasmus Nygaard	Assessment of wolffish in NAFO subarea 1
SCR Doc. 20-041	N7089	M.R. Simpson, and C.M. Miri	Assessment of Thorny Skate (Amblyraja radiata Donovan, 1808) in NAFO Divisions 3LNO and Subdivision 3Ps
SCR Doc. 20-042	N7090	Paul Regular, Rebecca Rademeyer, Divya Varkey, Doug Butterworth, Carmen Fernandez	Correcting mis-calculated values of J_target for use in the Greenland halibut HCR
SCR Doc. 20-043	N7091	Rasmus Nygaard	An assessment of the stocks of Greenland halibut in the South West Greenland fjords division 1BC, 1D and 1EF all located in NAFO subarea 1, using the Depletion Corrected Average Catch model.
SCR Doc. 20-044	N7092	Rasmus Nygaard	Commercial data for the Greenland Halibut Stock Component in NAFO Division 1A Inshore.
SCR Doc. 20-045	N7093	Rasmus Nygaard	Assessment of Demersal Redfish in NAFO Subarea 1
SCR Doc. 20-046	N7094	D. Maddock Parsons, B. Rogers, and R. Rideout	An assessment of the witch flounder resource in NAFO Divisions 3NO
SCR Doc. 20-047	N7095	D.A. Varkey, P.M. Regular, R. Kumar, N. Gullage, B. Healey, D.W. Ings, K. Lewis, K. Dwyer	Review and revamp of the SSM-based Management Strategy Evaluation for Greenland halibut stock in NAFO Subarea 2 and Divisions 3KLMNO
SCR Doc. 20-048	N7096	D.A. Varkey, R. Kumar, P.M Regular, N. Gullage	Performance metrics based on the state-space stock assessment model for Greenland halibut stock in NAFO Subarea 2 and Divisions 3KLMNO
SCR Doc. 20-049	N7097	D. W. Ings	Catch at age for SA 2 + Div 3KLMNO Greenland halibut during 2017 to 2019
SCR Doc. 20-050	N7098	Paul M. Regular	Update of Base Case SSM for Greenland Halibut in NAFO Subarea 2 and Divisions 3KLMNO
SCR Doc. 20-051	N7102	J.M. Casas Sánchez and M. Álvarez	Division 3M Northern shrimp (Pandalus borealis) – Interim Monitoring Update
SCR Doc. 20-052	N7126	Heino Fock, Karl-Michael Werner and Christoph Stransky	Survey results of the German bottom trawl survey 1982-2019 with special reference to years 2016 - 2019
SCR Doc. 20-053	N7127	Burmeister and Riget	The West Greenland trawl survey for Pandalus borealis, 2020, with reference to earlier results.
SCR Doc. 20-054	N7128	Burmeister and Riget	The Fishery for Northern Shrimp (Pandalus borealis) off West Greenland, 1970–2020
SCR Doc. 20-055	N7129	Burmeister	Catch Table Update for the West Greenland Shrimp Fishery

SCR Doc. 20-056	N7130	Burmeister and Riget	A provisional Assessment of the shrimp stock off West Greenland in 2020
SCR Doc. 20-057	N7131	Burmeister and Riget	Relationship between abundance of age-2 shrimps, pre-recruits and fishable biomass two to four years later
SCR Doc. 20-058	N7132	Riget and Burmeister	Estimation of the cod biomass by SAM and its implication for the assessment of Northern Shrimp (Pandalus borealis) in West Greenland.
SCR Doc. 20-059	N7133	Riget	The Fishery for Northern Shrimp (Pandalus borealis) in Denmark Strait / off East Greenland 1978 – 2020.
SCR Doc. 20-060	N7134	Buch	Results of the Greenland Bottom Trawl Survey for Northern shrimp (Pandalus borealis) Off East Greenland (ICES Subarea XIV b), 2008-2020
SCR Doc. 20-061	N7135	Riget, Burmeister and Buch	Applying a stochastic surplus production model (SPiCT) to the East Greenland Stock of Northern Shrimp
SCR Doc. 20-062	N7136	Burmeister	Reply to the Canadian request for advice of shrimps in Subarea 0 and 1.
SCR Doc. 20-063	N7137	Sergey Bakanev	Russian fishery for the northern shrimp (Pandalus borealis) in the Barents Sea in 2000-2020
SCR Doc. 20-064	N7138	J. M. Casas	Northern Shrimp (Pandalus borealis) on Flemish Cap Surveys 2020
SCR Doc. 20-065	N7139	Carsten Hvingel, Fabian Zimmermann and Trude H. Thangstad	Research survey results pertaining to northern shrimp (Pandalus borealis) in the Barents Sea and Svalbard area 2004-2020
SCR Doc. 20-066	N7140	Carsten Hvingel and Fabian Zimmermann	Shrimp (Pandalus borealis) in the Barents Sea – Stock assessment 2020
SCR Doc. 20-067	N7141	Carsten Hvingel, Trude H. Thangstad and Fabian Zimmermann	The Norwegian fishery for northern shrimp (Pandalus borealis) in the Barents Sea and round Svalbard 1970-2020
SCR Doc. 20-068	N7144	Irene Garrido, Fernando González-Costas and Diana González-Troncoso	Analysis of the NAFO VMS and logbook data
SCR Doc. 20-069	N7145	Sacau, M., Durán-Muñoz, P., Garrido, I and Baldó, F.	Improvements in the methodology to study the bottom fishing footprint in the NRA using VMS and logbook data
SCR Doc. 20-070	N7146	Sacau, M.1, Neves, B.M.2 and Durán-Muñoz, P 1	New preliminary data on VME encounters in NAFO Regulatory Area (Div. 3M) from EU-Spain and Portugal Groundfish Surveys (2020) and Canadian surveys
SCR Doc. 20-071	N7149	E. Kenchington, C. Lirette, F.J. Murillo, A.-L. Downie, A. Kenny, M. Koen-Alonso, Mar Sacau Cuadrado, Hannah Munro	Kernel Density Analysis and Mapping of Ecosystem Functions in the NAFO Regulatory Area
SCR Doc. 20-072	N7150	C. Lirette, E. Kenchington, F.J. Murillo, A.-L. Downie, A. Kenny	Biomass Estimates for Vulnerable Marine Ecosystems in the NAFO Regulatory Area

SCS Documents			
Doc No.	**Serial No**	**Author**	**Title**
SCS Doc. 20/01	N7034	NAFO	The Commission's Request for Scientific Advice on Management in 2021 and Beyond of Certain Stocks in Subareas 2, 3 and 4 and Other Matters
SCS Doc. 20/02	N7035	Canada	Canada's Request for Coastal State Advice - 2021
SCS Doc. 20/03	N7036	Denmark (on behalf of Greenland)	Denmark (on behalf of Greenland) Coastal State Request for Scientific Advice - 2021
SCS Doc. 20/04	N7038	NAFO	Report of the NAFO Scientific Council Planning Meeting, 2 April 2020
SCS Doc. 20/05	N7039	Japan	National Research Report of Japan (2020)
SCS Doc. 20/06	N7040	K Hubel	Estonian Research Report for 2019
SCS Doc. 20/07	N7045	F. González-Costas, G. Ramilo, E. Román, J. Lorenzo, A. Gago, D. González-Troncoso, M. Sacau, P. Duran, M. Casas and J. L. del Rio	Spanish Research Report for 2019
SCS Doc. 20/08	N7049	Luis Ridao Cruz	Faroese Research Report 2019
SCS Doc. 20/09	N7050	J. Vargas, R. Alpoim, E. Santos and A. M. Ávila de Melo	Portuguese Research Report for 2019
SCS Doc. 20/10	N7058	H. O. Fock and C. Stransky	German Research Report for 2019
SCS Doc. 20/11	N7064	Bob Rogers and Mark Simpson	Canadian Research Report for 2019
SCS Doc. 20/12	N7076	Greenland Institute of Natural Resources	Denmark/Greenland Research Report for 2019
SCS Doc. 20/13	N7077	Konstantin Fomin and Maria Pochtar	Russian Research Report for 2019
SCS Doc. 20/14	N7099	NAFO	Report of the June Scientific Council Meeting, 28 May - 12 June 2020
SCS Doc. 20/15	N7105	NAFO	Available Data from the Commercial Fisheries Related to Stock Assessment (2019) and Inventory of Biological Surveys Conducted in the NAFO Area in 2019 and Biological Surveys Planned for 2020 and Early-2021
SCS Doc. 20/16	N7106	NAFO	List of Biological Sampling Data for 2019
SCS Doc. 20/17	N7107	NAFO	A Compilation of Research Vessel Surveys on a Stock-bystock Basis
SCS Doc. 20/18	N7108	K.A. Sosebee	United States Research Report for 2019
SCS Doc. 20/19	N7123	NAFO	SC September Report
SCS Doc. 20/20	N7142	NAFO	SC Shrimp Report 26-30 October 2020
SCS Doc. 20/21	N7143	NAFO/ICES	NAFO/ICES Pandalus Assessment Group Report, 26-30 October 2020
SCS Doc. 20/22	N7147	NAFO	SC Shrimp (in conjunction with NIPAG) Report, 14 September 2020
SCS Doc. 20/23		NAFO	Report of the Scientific Council Working Group on Ecosystem Science and Assessment (WG-ESA), November 2020

XII.LIST OF REPRESENTATIVES, ADVISERS, EXPERTS AND OBSERVERS, 2020

A	Scientific Council Planning Meeting, 02 April 2020
B	Scientific Council Meeting, 28 May - 12 June 2020
C	Scientific Council Meeting (in conjunction with NIPAG), 14 September 2020
D	Scientific Council Meeting, 21 - 25 September 2020
E	NAFO/ICES *Pandalus* Assessment Group Meeting, 26 – 30 October 2020
F	Scientific Council Shrimp Meeting, 26 – 30 October 2020

CANADA							
Beauchamp, Brittany	Fisheries and Oceans Canada, Northwest Atlantic Fisheries Centre, P.O. Box 5667, St John's, NL A1C 5X1 Email:brittany.beauchamp@dfo-mpo.gc.ca			C		E	F
Bélanger, David	Fisheries & Oceans Canada, P.O. Box 5667, St. John's, NL A1C 5X1 E-mail: david.belanger@dfo-mpo.gc.ca	A	B				
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	A	B				
Dwyer, Karen *Chair of STACREC and vice-Chair of Scientific Council*	Science Br., Fisheries & Oceans Canada, P.O. Box 5667, St. John's, NL A1C 5X1 Phone: +709-772-0573 – E-mail: karen.dwyer@dfo-mpo.gc.ca	A	B	C	D		
Gadboury, Isabelle	E-mail: Isabelle.gadboury@dfo-mpo.gc.ca		B				
Healey, Brian P.	Science Br., Fisheries & Oceans Canada, P.O. Box 5667, St. John's, NL A1C 5X1 Phone: +709-772-8674 – E-mail: brian.healey@dfo-mpo.gc.ca		B		D		
Ings, Danny	Science Br., Fisheries & Oceans Canada, P.O. Box 5667, St. John's, NL A1C 5X1 E-mail: danny.ings@dfo-mpo.gc.ca	A	B				
Kenchington, Ellen	Fisheries and Oceans Canada, Dartmouth, NS E-mail: ellen.kenchington@dfo-mpo.gc.ca		B				
Koen-Alonso, Mariano	Science Br., Fisheries & Oceans Canada, P.O. Box 5667, St. John's, NL A1C 5X1 Phone: +709-772-2047 – E-mail: mariano.koen-alonso@dfo-mpo.gc.ca	A	B		D		
Krohn, Martha	Senior Science Advisor, Fisheries & Oceans Canada, 200 Kent Street, Ottawa, ON K1A 0E6, Canada Tel.: +613-998-4234 – E-mail: martha.krohn@ dfo-mpo.gc.ca	A	B		D		
Lewis, Keith	E-mail: keith.lewis@dfo-mpo.gc.ca		B				
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	A	B				
Novaczek, Emilie	E-mail: emilie.novaczek@dfo-mpo.gc.ca		B				
Pepin, Pierre	Fisheries and Oceans Canada, Northwest Atlantic Fisheries Centre, P.O. Box 5667, St John's, NL A1C 5X1 E-mail: pierre.pepin@dfo-mpo.gc.ca	A	B	C	D		

Regular, Paul	Science Branch, Fisheries & Oceans Canada, P.O. Box 5667, 80 East White Hills Road, St. John's, NL A1C 5X1 Email: paul.regular@dfo-mpo.gc.ca	A	B				
Rideout, Rick	Science Br., Fisheries & Oceans Canada, P.O. Box 5667, St. John's, NL A1C 5X1 Phone: +709-772-6975 – E-mail: rick.rideout@dfo-mpo.gc.ca		B				
Ringuette, Marc	Fisheries & Oceans Canada, BIO, P. O. Box 1006, Dartmouth, N.S. B2Y 4A2 Tel.: +902-426-2001 E-mail: marc.ringuette@dfo-mpo.gc.ca	A					
Rogers, Bob	Fishereies & Oceans Canada, P.O. Box 5667, St. John's, NL A1C 5X1 E-Mail: bob.rogers@dfo-mpo.gc.ca	A	B				
Simpson, Mark R.	Science Br., Fisheries & Oceans Canada, P.O. Box 5667, St. John's, NL A1C 5X1 Phone: +709-772-4841 – E-mail: mark.r.simpson@dfo-mpo.gc.ca	A	B	C	D	E	F
Skanes, Katherine	Fisheries and Oceans Canada, Northwest Atlantic Fisheries Centre, P.O. Box 5667, St John's, NL A1C 5X1 Phone +709 772 7343 - Email:katherine.skanes@dfo-mpo.gc.ca			C		E	F
Thompson, Susan	Science Advisor, Fish Population Science Fisheries and Oceans Canada / Government of Canada Phone : 343-998-3982 - Email :Susan.Thompson@dfo-mpo.gc.ca			C		E	F
Treble, Margaret *Chair of STACPUB*	Fisheries & Oceans Canada, Freshwater Inst., 501 University Cres., Winnipeg, MT R3T 2N6 Phone: +204-984-0985 – E-mail: margaret.treble@dfo-mpo.gc.ca	A	B		D		
Varkey, Divya	E-mail: divya.varkey@fo-mpo.gc.ca		B				
Walkusz, Wojciech	Fisheries and Oceans Canada, Winnipeg, Manitoba Email: wojciech.walkusz@dfo-mpo.gc.ca					E	F
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	A	B		D		
DENMARK (IN RESPECT OF FAROE ISLANDS AND GREENLAND)							
Buch,Tanja	Greenland Institute of Natural Resources, P. O. Box 570. GL-3900, Nuuk Tel: +299 36 1200 -Email: tabb@natur.gl			C		E	F
Burmeister, AnnDorte	Greenland Institute of Natural Resources, P. O. Box 570. GL-3900, Nuuk Phone: +299 36 1200 - Email: anndorte@natur.gl			C		E	F
Nogueira Gassent, Adriana	Scientist, Department of Fish and Shellfish, Greenland Institute of Natural Resources, Box 570 3900, Nuuk Tel: +299 361280 – Email: adno@natur.gl	A	B				
Nygaard, Rasmus	Greenland Institute of Natural Resources, P.O. Box 570, DK-3900 Nuuk, Greenland Tel.: +299 361200 - E-mail : rany@natur.gl	A	B				
Ridao Cruz, Luis	Faroe Marine Research Institute, FO-100 Tórshavn, Faroe Islands Tel: (+298) 353 900 – E-mail: luisr@hav.fo	A	B	C	D		
Rigét, Frank	Greenland Institute of Natural Resources, P. O. Box 570. GL-3900, Nuuk Phone +299 36 1200 – Email: frri@natur.gl			C		E	F

EUROPEAN UNION							
Alpoim, Ricardo	Instituto Portugues do Mar e da Atmosfera, Rua Alfredo Magalhães Ramalho, nº6, 1495-006 Lisboa, Portugal Phone: +351 21 302 7000 – E-mail: ralpoim@ipma.pt	A	B		D		
Ávila de Melo, António	Instituto Portugues do Mar e da Atmosfera, Rua Alfredo Magalhães Ramalho, nº6, 1495-006 Lisboa, Portugal Phone: +351 21 302 7000 – E-mail: amelo@ipma.pt		B		D		
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	A	B		D		
Carrera López, Pablo	Instituto Español de Oceanografia, Subida A Radiofaro, 50, 36390 Vigo (Pontevedra), Spain E-mail: pablo.carrera@ieo.es		B				
Casas Sanchez, José Miguel	Instituto Español de Oceanografia, Subida A Radiofaro, 50, 36390 Vigo (Pontevedra), Spain Email: mikel.casas@ ieo.es			C	D	E	F
Durán Muñoz, Pablo	Instituto Español de Oceanografia, Subida A Radiofaro, 50, 36390 Vigo (Pontevedra), Spain E-mail: pablo.duran@ieo.es		B		D		
Fernández, Carmen *Chair of Scientific Council*	Instituto Español de Oceanografía (IEO),Madrid, Spain. Email: carmen.fernandez@ieo.es	A	B	C	D	E	F
Garrido Fernandez, Irene	E-mail: irenegarridof@hotmail.com		B		D		
Gonzalez-Troncoso, Diana	Instituto Español de Oceanografia, Subida A Radiofaro, 50, 36390 Vigo (Pontevedra), Spain Phone: +34 9 86 49 2111 – E-mail: diana.gonzalez@ieo.es	A	B		D		
Gonzalez-Costas, Fernando	Instituto Español de Oceanografia, Subida A Radiofaro, 50, 36390 Vigo (Pontevedra), Spain Phone: +34 9 86 49 2111 – E-mail: fernando.gonzalez@ieo.es	A	B		D		
Hubel, Kalvi	Estonian Marine Institute, Tartu Ülikool, Vanemuise 46a, Tartu, 51014 Phone: +3725563 8283 - Email: kalvi.hubel@ut.ee			C		E	F
Mendes, Hugo	Instituto Portugues do Mar e da Atmosfera, I.P., Av. de Brasilia, 1449-006 Lisbon, Portugal E-mail: hmendes@ipma.pt		B				
Näks, Liivika	Head of the Unit of Ocean Fisheries, Estonian Marine Institute, University of Tartu. E-mail: liivika.naks@ut.ee		B	C	D		
Ribeiro, Cristina	DG MARE, Rue Joseph II, 99, B-1049 Brussels, Belgium Tel: +39 3668934792 Email: cristina-ribeiro@ec.europa.eu	A	B	C	D		
Ritzau Eigaard, Ole *NIPAG co-Chair*	DTU-AQUA Technical University of Denmark, Charlottenlund Slot, DK-2920, Charlottenlund Email: ore@aqua.dtu.dk			C		E	F
Sacau-Cuadrado, Mar	Instituto Español de Oceanografia, Subida A Radiofaro, 50, 36390 Vigo (Pontevedra), Spain Phone: +34 98 649 2111 – Email: mar.sacau@vi.ieo.es	A			D		
FRANCE (IN RESPECT OF ST. PIERRE ET MIQUELON)							
Goraguer, Herlé	French Research Institute for Exploitation of the Sea (IFREMER), Quai de l'Alysse, BP 4240, 97500, St. Pierre et Miquelon - Phone: +05 08 41 30 83 – Email: herle.goraguer@ifremer.fr			C	D		

ICELAND							
Jónsdóttir, Ingibjörg	Marine and Freshwater Research Institute, Fornubúðum 5, 220 Hafnarfjörður, Iceland Tel: +354 575 2000 Email: ingibjorg.g.jonsdottir@hafogvatn.is			C			
JAPAN							
Butterworth, Doug S.	Emeritus Professor, Department of Mathematics and Applied Mathematics, University ofCape Town, Rondebosch 7701 South Africa Tel: +27 21 650 2343 – E-mail: doug.butterworth@uct.ac.za	A	B				
Nishida, Tsutomu	National Research Institute of Far Seas Fisheries, 5-7-1, Orido, Shimizu-ward, Shizuoka City, 424-8633 Phone: +81 54 336-6052 – E-mail: tnishida@affrc.go.jp	A	B		D		
Rademeyer, Rebecca	Research Associate, Department of Mathematics and Applied Mathematics, University of Cape Town Email: Rebecca.rademeyer@gmail.com	A					
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		B		D		
NORWAY							
Hvingel, Carsten	Institute of Marine Research, P.O. Box 1870, N-5817 Tromsø, Norway Phone: +47 77609750 – E-mail: carsten.hvingel@imr.no			C	D	E	F
Søvik, Guldborg	Institute of Marine Research, P.O. Box 1870, N-5817 Bergen Phone +47 5523 5348 – Email: guldborg.soevik@imr.no					E	F
Zimmermann, Fabian	Institute of Marine Research, P.O. Box 1870, N-5817 Bergen Email: fabian.zimmermann@hi.no			C		E	F
RUSSIAN FEDERATION							
Bakanev, Sergey	Knipovich Polar Research Institute of Marine Fisheries and Oceanography (PINRO), 6 Knipovich St., Murmansk 183763 E-mail: bakanev@pinro.ru			C			
Belyaev, Vladimir	Russian Federal Research Institute of Fisheries & Oceanography (VNIRO), K. 17, V. Krasnoselskaya, Moscow, 107140 E-mail: belsea@inbox.ru		B				
Fomin, Konstantin	Knipovich Polar Research Institute of Marine Fisheries and Oceanography (PINRO), 6 Knipovich St., Murmansk 183763 Phone: +7 8152 436 177 –– E-mail:fomin@pinro.ru	A	B	C	D		
Orlov, Alexey	Russian Federal Research Institute of Fisheries & Oceanography (VNIRO), K. 17, V. Krasnoselskaya, Moscow, 107140 E-mail: orlov@vniro.ru		B	C	D		
Petukhova, Natalya	Russian Federal Research Institute of Fisheries & Oceanography (VNIRO), K. 17, V. Krasnoselskaya, Moscow, 107140 E-mail: ng_petukhova@mail.ru		B	C	D		
Stesko, Aleksei	Russian Federal Research Institute of Fisheries & Oceanography (VNIRO), K. 17, V. Krasnoselskaya, Moscow, 107140					E	F
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		B				

UKRAINE							
Demianenko, Kostiantyn	Deputy Director on Science, Institute of Fisheries and Marine Ecology (IFME), State Agency of Fisheries of Ukraine, Consulska str. 8, Berdiansk, 71118 Ukraine, Tel/Fax 380 6153 36604 E-mail: s.erinaco@gmail.com; s_erinaco@ukr.net		B	C			
Didenko, Alexander	Senior Research Scientists, National Academy of Agrarian Sciences of Ukraine, Kiev, Ukraine E-mail: al_didenko@yahoo.com		B				
Paramonov, Valerii	Scientist, Institute of Fisheries and Marine Ecology (IFME), State Agency of Fisheries of Ukraine Consulska str. 8, Berdiansk, 71118 Ukraine Tel/Fax 380 6153 36604 E-mail: paramonov@i.ua		B			E	F
UNITED KINGDOM							
Darby, Chris	CEFAS, Lowestoft Laboratory, Lowestoft, UK E-mail: chris.darby@cefas.co.uk				D		
Kenny, Andrew	CEFAS, Lowestoft Laboratory, Lowestoft, UK E-mail: andrew.kenny@cefas.co.uk				D		
Readdy, Lisa	CEFAS, Lowestoft Laboratory, Lowestoft, UK E-mail: lisa.readdy@cefas.co.uk				D		
UNITED STATES OF AMERICA							
Hendrickson, Lisa	National Marine Fisheries Service, NEFSC, 166 Water St., Woods Hole, MA 02543 E-mail: lisa.hendrickson@noaa.gov	A			D		
Sosebee, Katherine *Chair of STACFIS & NIPAG co-Chair*	National Marine Fisheries Service, NEFSC, 166 Water St., Woods Hole, MA 02543 Phone: +508-495-2372 – E-mail: katherine.sosebee@noaa.gov	A	B	C	D	E	F
EXTERNAL EXPERTS							
Benoît, Hugues	E-mail: hugues.benoit@dfo-mpo.gc.ca		B				
Kenny, Andrew	CEFAS, Lowestoft Laboratory, Lowestoft, UK E-mail: andrew.kenny@cefas.co.uk		B				
Rademeyer, Rebecca	Research Associate, Department of Mathematics and Applied Mathematics, University of Cape Town Email: Rebecca.rademeyer@gmail.com		B				
ICES SECRETARIAT							
Catarino, Rui	Advisory Programme Professional Officer , ICES Secretariat, Copenhagen, Denmark Email: rui.catarino@ices.dk					E	F
OBSERVERS							
Arnold, Shannon	Ecology Action Centre, 2705 Fern Lane, Halifax, NS, B3K 4L3 Tel.: +902 446-4840		B				
Fuller, Susanna	Oceans North, Halifax Office, Halifax, NS, Canada E-mail: susannafuller@oceansnorth.ca		B				
Hedeholm, Rasmus	Sustainable Fisheries Greenland, Nuuk, Greenland E-mail: sfg@sfg.gl		B				

NAFO SECRETARIAT		
Kingston, Fred	Executive Secretary	fkingston@nafo.int
Aker, Jana	Senior Fisheries Information Administrator	jaker@nafo.int
Bell MacCallum, Dayna	Scientific Information Administrator	dbell@nafo.int
Blasdale, Tom	Scientific Council Coordinator	tblasdale@nafo.int
Federizon, Ricardo	Senior Fisheries Commission Coordinator	rfederizon@nafo.int
Goodick, Stan	Deputy Executive Secretary/Senior Finance and Staff Administrator	sgoodick@nafo.int
Guile, Sarah	Office Administrator	sguile@nafo.int
Kendall, Matthew	IT Manager	mkendall@nafo.int
Laycock, DJ	Database Developer/Programmer Analyst	dlaycock@nafo.int
LeFort, Lisa	Executive Assistant	llefort@nafo.int
Pacey, Alexis	Senior Publications/Web Manager	apacey@nafo.int
Singer, Shala	Office Administrator (term)	

XIII.MERIT AWARDS

Year	Recipient	Institute
2009	Ralph Mayo	NMFS Woods Hole, MA, USA
2010	Dr. Manfred Stein	Institut fur Seefischerei, Hamburg, Germany
2011	Dr. Vladimir Rikhter	AtlantNIRO, Kaliningrad
2013	Bill Brodie	DFO, St. John’s, NL, Canada
2013	Jean-Claude Mahé	IFREMER Lorient, France
2013	Antonio Vázquez	Spain, European Union
2014	Fred Serchuk	Northeast Fisheries Science Center (NEFSC), USA
2016	Mariano Koen-Alonso	DFO, St. John’s, NL, Canada
2017	Eugene Colbourne	DFO, Dartmouth, NS, Canada
2017	Don Power	DFO, St. John’s, NL, Canada
2018	*No awards were presented in 2018*	
2019	Joanne Morgan	DFO, St. John’s, NL, Canada
2019	Brian Healey	DFO, St. John’s, NL, Canada
2019	Fernando Gonzalez-Costas	IEO, Vigo, Spain
2019	Diana Gonzalez-Troncoso	IEO, Vigo, Spain
2019	Carmen Fernández	IEO, Gijon, Spain
2019	Agurtzane Urtizberea	AZTI Pasaia Gipuzkoa, Spain
2020	António Ávila de Melo	IPMA, Lisbon, Portugal

XIV.LIST OF RECOMMENDATIONS IN 2020

From the Scientific Council June Meeting, 28 May – 12 June 2020

The recommendation made by STACFEN for the work of the Scientific Council as **endorsed** by the Council, are 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 2021 STACFEN Meeting.*

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

- NAFO usually convenes a symposium on environmental issues every 10 years, with the last one held in 2011 as "ICES/NAFO Symposium on the Variability of the North Atlantic and its Marine Ecosystems during 2000-2009". STACFEN suggested that the forthcoming ICES Symposium (2021) could take the place of the next NAFO symposium. STACFEN therefore **recommended** that *Scientific Council support participation and possible co-sponsorship.*

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

- The report of the Standing Committee on Publications (STACPUB) is deferred until the September meeting of SC.

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

- The report of the Standing Committee on Research Coordination (STACREC) is deferred until the September meeting of SC.

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

- The recommendations from STACFIS can be found in the STACFIS report.

From STACFIS:

1. Greenland halibut (*Reinhardtius hippoglossoides*) in Subarea 0 and 1 (offshore)

In 2018 STACFIS **recommended** that *the CPUE data be explored and the General Linear Model examined to better understand the observed trends.*

STATUS: No progress in 2020 but will be carried forward to 2022.

There is a question as to the representativeness of the abundance at age 1 (from the 1A-F survey) as an index of recruitment, or stock status, for the SA 0 and 1 offshore stock. STACFIS **recommends** *exploring the use of the overall 1A-F survey biomass as an index of stock status instead of only the age 1 portion of this survey*

5. Cod 3M (*Gadus morhua*) in Division 3M

STACFIS **recommended** that *an age reader comparison exercise be conducted.*

STATUS: An age-readers Workshop was held in November 2017 in order to reconcile the differences among age-readers of this stock. Much progress in understanding where the differences between the commercial and survey ALKs come from was made but still needs more research to completely know the problem. No progress since then was made. NAFO reiterates this recommendation.

STACFIS **encouraged** to *all Contracting Parties to provide length distribution samples from the commercial vessels fishing 3M cod.*

STATUS: NAFO reiterates this recommendation.

8. American Plaice (*Hippoglossoides platessoides*) in Division 3M

STACFIS **recommends** that *other types of models should also be explored, and that Div. 3M American plaice stock be a candidate for an assessment benchmark together with the Div. 3LNO American plaice stock or other flatfish stocks.*

Redfish (Sebastes mentella and Sebastes fasciatus) in Divisions 3L and 3N

STACFIS **recommends** that *alternate models be explored for this stock.*

American plaice (*Hippoglossoides platessoides*) in NAFO Divisions 3LNO

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.

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

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.*

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

In 2019, STACFIS **recommended** that *for Redfish in Div. 3O, work continue on developing an assessment model for the stock. Aging should be conducted for redfish sampled during select years to support model development.*

STATUS: No progress has been made.

Thorny skate (*Amblyraja radiata*) in Divisions 3L, 3N, 3O and Subdivision 3Ps

STACFIS **recommended** that *further work be conducted on development of a quantitative stock model.*

STATUS**:** Work ongoing. STACFIS reiterated this recommendation.

17. White Hake (*Urophycis tenuis*) in Divisions 3N, 3O, and Subdivision 3Ps

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 *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.

a. Greenland Halibut (*Reinhardtius hippoglossoides*) in Subarea 2 and Divisions 3KLMNO

The divergence in survey indices could be the result of movement of fish or because of transient age effects as a result of changing recruitment when different surveys cover differing age-ranges. STACFIS **recommends** that *tagging and/or telemetry studies be undertaken to help elucidate movement of 2+3KLMNO Greenland halibut.*

Precautionary approach reference points have not been determined for this stock. STACFIS **recommends** that *reference points are investigated during the next full assessment and MSE review process.*

b. Splendid alfonsino (*Beryx splendens*) in Subareas 6

SC **recommended** in 2019 that *fishery independent information should be collected on this stock, and especially important given the fishery is closed and there will not be CPUE or any other fishery independent information to monitor whether there is any recovery.* For this purpose, a possible acoustic survey plan has been presented to be discussed by the SC.

From the Scientific Council (in conjunction with NIPAG) Meeting, 14 September 2020

1. Northern shrimp (*Pandalus borealis*) on the Flemish Cap (NAFO Division 3M)

For Northern Shrimp in Div. 3M NIPAG **recommended in 2016** that *further exploration of the relationship between shrimp, cod and the environment be continued in WGESA and NIPAG encourages the shrimp experts to be involved in this work.*

STATUS: No progress from last year.

In 2019, NIPAG **recommended** that *in future years NIPAG should investigate the options to implement an analytical assessment for this stock. Models to explore could include SPiCT, Stock Synthesis (as applied for Northern shrimp in Skagerrak and Norwegian Deep), or other length based models.*

STATUS: progress will be updated at NIPAG 2020

In 2019, NIPAG **recommended** that *this stock be considered for a benchmark workshop in conjunction with the benchmark of the Skagerrak and Barents Sea stocks anticipated for 2020/21. The NIPAG 2020 meeting will be utilized for a workshop to clarify the data situation and potential assessment models.*

STATUS: progress will be updated at NIPAG 2020

From the Scientific Council Meeting, 21 -25 September 2020

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

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

STATUS: This is still in progress. A draft has been prepared (scwp20-014) and comments are welcome.

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

STATUS: This is still in progress. Finding a system that would allow citations to be easily uploaded to reference management software is ongoing. There is the possibility of having Crossref DOIs linked to the relevant datasets in DataCite by adding the DataCite DOIs in the metadata of the publications.

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

STATUS: This has been implemented. There is a table in the instructions-for-authors that describes the various formats suitable 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.*

STATUS: This has been implemented. There is a set of instructions developed by Anna Wall, NAFO intern, that explains and instructs "run-to-code" for figure preparations. This is suitable for R Statistical and Sigmaplot. It is on the JNAFS site with the instructions for authors and has been distributed to Scientific Council Designated Experts.

- JNAFS AEs are currently partitioned into general review expertise categories. We are top-heavy in the Fisheries Biology category, which really also includes stock assessment and perhaps ecology. There was a proposal to do away with the expertise categories and just list all of the AEs alphabetically. After some discussion STACPUB **recommends** that *the Associate Editors be surveyed to determine if they would agree to have the expertise categories removed from their profiles on the JNAFS website*

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

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

In 2015, STACREC **recommended** that *an analysis of sampling rates be conducted to evaluate the impact on the precision of survey estimates.* As a separate aspect, in September 2017 STACREC discussed *possibilities for combining multiple surveys in different areas and at different times of the year to produce aggregate indices*.

In September 2019, it *was agreed that a speaker on this general topic would be invited to the June 2020 SC meeting, and the STACREC chair will take the lead in arranging this invitation.* However, due to the pandemic, it was not possible to have an invited speaker in June. However, a Canadian scientist attended the ICES WKUSER workshop (Workshop on Unavoidable Survey Effort Reduction) in January 2020 and presented information on survey coverage issues. Feedback from this meeting will be presented to STACREC in June 2021. The full report is available at: ICES. 2020. ICES Workshop on unavoidable survey effort reduction (WKUSER).

ICES Scientific Reports. 2:72. 92pp. http://doi.org/10.17895/ices.pub.7453

In 2019, 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.

It has been suggested that an added guideline might be: For age groups where there is a greater than 10% difference between total survey biomass in the survey strata missed that year in the index used (total or mean numbers), then it should be excluded from the model, if the model can handle missing values. However, there was no time to discuss this at the June 2020 meeting and therefore this discussion will be deferred to June 2021.

All other recommendations will be deferred to next year (2021).

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

1. Northern Shortfin Squid (*Illex illecebrosus*) in Subareas 3+4

In 2013, STACFIS **recommended** that *gear/vessel conversion factors be computed to standardize the 1970-2003 relative abundance and biomass indices from the July Div. 4VWX surveys.*

STATUS: No progress has been made.

From the NAFO/ICES *Pandalus* Assessment Group (NIPAG) Meeting, 26 - 30 October 2020

2. Northern shrimp (*Pandalus borealis*) off West Greenland (NAFO SA 0 And SA 1)

- NIPAG **recommended in 2015** that *ecosystem information related to the role of shrimp as prey in the Grand Bank (i.e. 3LNO) Ecosystem be presented to NIPAG.*

Status: No new information was available to the current meeting and this recommendation is reiterated.

- NIPAG **recommends in 2018** that *further work on the development of a recruitment index for Div. 3LNO be completed.*

Status: While it was anticipated that a length based model would improve knowledge of a recruitment index for Div. 3LNO, that work has not been successfully completed. Hence this recommendation is reiterated.

3. Northern shrimp (*Pandalus borealis*) off West Greenland (NAFO SA 0 and SA 1)

- NIPAG **recommended** in 2016 that *genetic stock structure in West and East Greenland should be further explored.*

Status: No progress; this recommendation will not be progressed further at present.

- NIPAG **recommended** in 2018 that *random sampling of the catches be conducted to provide catch composition data to the assessment.*

Status: In progress; this recommendation is reiterated.

- NIPAG **recommends** that *diagnostics of the model should be further explored.*

4. Northern shrimp (*Pandalus borealis*) in the Denmark Strait and off East Greenland (ICES Div. XIVb and Va)

- NIPAG **recommended** in 2016 that *genetic stock structure in West and East Greenland should be further explored.*

Status: No progress; this recommendation will not be progressed further at present.

- NIPAG **recommends** in 2020 that: *further model exploration should be carried out, including adding risk levels for different catch projection scenarios.*

6. Northern shrimp (*Pandalus borealis*) in the Barents Sea (ICES Subareas 1 and 2)

- The assessment procedure used has been in place since 2006 and in 2016 NIPAG **recommended** that *it be considered for a benchmark workshop in near future, no later than 2019*.

Status: Reiterated. NIPAG **recommends** the *benchmark to be as soon as possible*. The fishery has expanded since 2014 and catches by countries other than Norway have increased to account for about 65% of the total. In 2016, NIPAG therefore **recommended** that *available data (logbook data and catch samples) from the participating nations be made available to NIPAG.*

Status: In progress. An official data call has been made. This recommendation is reiterated.

- In 2017, NIPAG *recommended* that *a recruitment index should be developed for this stock.*

Status: planned as part of upcoming benchmark. This recommendation is reiterated.

- In 2017, NIPAG **recommended** that *the information regarding catch effort and bycatch from the Estonian commercial fishery should be further analysed e.g. CPUE data explored as a potential index of biomass.*

Status: In progress. This recommendation is reiterated.