Serial No. N6718 NAFO SCS Doc. 17-16 REV.

Northwest Atlantic Fisheries Organization

Report of the Scientific Council Meeting

01 -15 June 2017
Halifax, Nova Scotia

NAFO
Dartmouth, Nova Scotia, Canada
2017

Report of the Scientific Council Meeting
01 -15 June 2017
Halifax, Nova Scotia

REPORT OF SCIENTIFIC COUNCIL MEETING
01 -15 June 2017

Chair: Kathy Sosebee Rapporteur: Tom Blasdale

I.PLENARY SESSIONS

The Scientific Council met at the Sobey Building, Saint Mary's University, Halifax, NS, Canada, during 01 – 15 June 2017, to consider the various matters in its Agenda. Representatives attended from Canada, Denmark (in respect of Faroe Islands and Greenland), the European Union (France, Germany (via WebEx), Portugal, Spain, the United Kingdom and the European Commission), Japan, the Russian Federation and the United States of America. Observers from the Ecology Action Centre and Dalhousie University were also present. The Executive Secretary, Scientific Council Coordinator and other members of the Secretariat were in attendance.

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

The Council was called to order at 1000 hours on 01 June 2017. The provisional agenda was **adopted** with modification. The Scientific Council Coordinator was appointed the rapporteur.

The Council was informed that the meeting was quorate and authorization had been received by the Executive Secretary for proxy votes from the European Union, Denmark (in respect of Faroe Islands and Greenland), Iceland, Japan, Republic of Korea, and Norway.

The opening session was adjourned at 1200 hours on 01 June 2017. Several sessions were held throughout the course of the meeting to deal with specific items on the agenda. The Council considered **adopted** the STACFEN report on 8 June 2017, and the STACPUB, STACFIS and STACREC reports on 15 June 2017.

The concluding session was called to order at 0830 hours on 15 June 2017.

The Council considered and **adopted** the report the Scientific Council Report of this meeting of 01 -15 June 2017. 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 1430 hours on 15 June 2017.

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

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

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

II.REVIEW OF SCIENTIFIC COUNCIL RECOMMENDATIONS IN 2016

The recommendation made by STACFEN for the work of the Scientific Council as **endorsed** by the Council in 2016 are as follows:

> STACFEN **recommends** *consideration of support for one invited speaker to address emerging issues and concerns for the NAFO Convention Area during the 2017 STACFEN Meeting.*

No appropriate invited speaker was identified for the 2017 meeting.

The recommendations made by STACREC for the work of the Scientific Council as **endorsed** by the Council in 2016, are as follows:

STACREC **recommends** that *the NAFO Secretariat develop a framework for communicating tagging study information to vessels from Contracting Parties and Coastal States fishing in the Convention Area (e.g., via a link to this information on the NAFO website homepage). A proposal on this recommendation will be tabled by the Secretariat for consideration at the Sept 2016 SC meeting.*

STACREC **recommended** *SC endorse this change to existing working procedure and seek funds required (travel and/or stipend depending on review type) to allow an external review to commence in advance of the June 2017 meeting. Terms of Reference for this review, as well as a list of which stocks should be reviewed and the process whereby reviewers will be selected will be considered by SC at its September 2017 meeting.*

These recommendations will be addressed by STACREC in 2017

III.FISHERIES ENVIRONMENT

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

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

STACFEN **recommends** *consideration of support for one invited speaker to address emerging issues and concerns for the NAFO Convention Area during the 2018 STACFEN Meeting*.

STACFEN **recommends** *support for, and requests an executive summary from, an upcoming meeting on calanoid copepod dynamics planned for 19-20 July, 2017.*

IV.PUBLICATIONS

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

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

STACPUB **recommends** that *the NAFO Secretariat check the Designated Expert list on a quarterly basis and update the public website as required.*

STACPUB **recommends** that *Designated Experts and other SC members review the fact sheets and provide the Secretariat with any updates or corrections to help refine the fact sheets.*

STACPUB **recommends** that *the Secretariat monitor the web traffic on the fact sheets using Google Analytics and provide the metrics at the 2018 STACPUB meeting.*

V.RESEARCH COORDINATION

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

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

STACREC **recommends** that *the NAFO Secretariat develop a framework for communicating tagging study information to vessels from Contracting Parties and Coastal States fishing in the Convention Area (e.g.,* *via a link to this information on the NAFO website homepage). A proposal on this recommendation will be tabled by the Secretariat for consideration at the Sept 2016 SC meeting.*

STACREC **recommends** that *an analysis of sampling rates be conducted to evaluate the impact on the precision of survey estimates.*

VI.FISHERIES SCIENCE

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

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

VII.MANAGEMENT ADVICE AND RESPONSES TO SPECIAL REQUESTS

1. Fisheries Commission

The Fisheries Commission requests are given in Annex 1.

The Scientific Council noted the Fisheries Commission requests for advice on Northern shrimp (Northern shrimp in Div. 3M and Divs. 3LNO (Item 1)) will be undertaken during the Scientific Council meeting on 27 September to 4 October 2017.

Due to lack of time, the assessment of cod in divisions 3NO was deferred and an interim monitoring report was produced. Timing of the next full assessment and advice will be discussed in the September SC meeting.

An assessment for Greenland halibut in Subarea 2 and Divisions. 3KLMNO was produced based on two population models. However, errors were discovered in the stock projection code for one of the two models (Statistical Catch at Age) following the meeting. Accordingly, advice was deferred and will be drafted in the September SC meeting.

Request for Advice on TACs and Other Management Measures

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

Cod in Division 3M Advice June 2017 for 2018

Recommendation for 2018

Scientific Council considers that yields at F_{lim} and $F_{2014\text{-}16}$ are not sustainable. For ¾ F_{lim}, the probability of F_{2018} exceeding F_{lim} is 35%. Under all projection scenarios, there is a relatively high probability of stock decline in the near term. Scientific Council recommends that the TAC be no more than the catch corresponding to ¾ F_{lim}, ie. 8182 t in 2018.

Management objectives

A management strategy evaluation process has been initiated for this stock by Fisheries Commission and Scientific Council but is not yet been finalized. At this moment general convention objectives (NAFO/GC Doc 08/3) are applied.

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

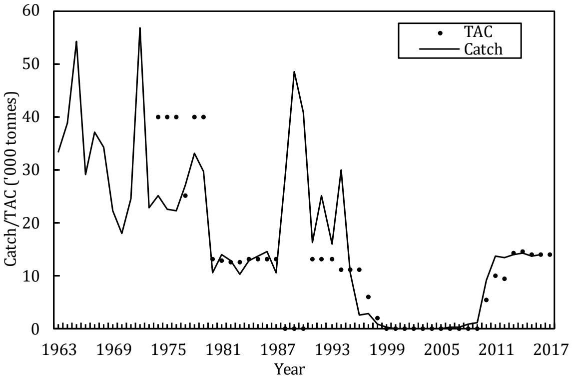
🟢	OK
🟡	Intermediate
🔴	Not accomplished
○	Unknown

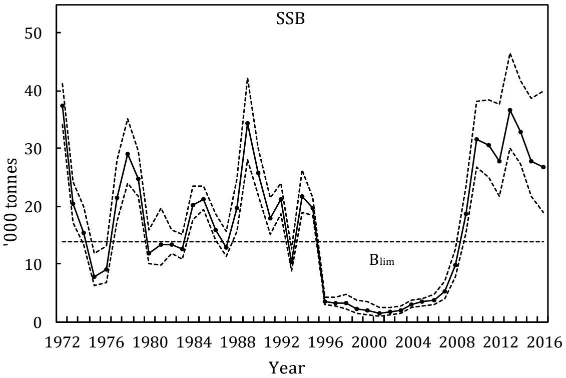
Management unit

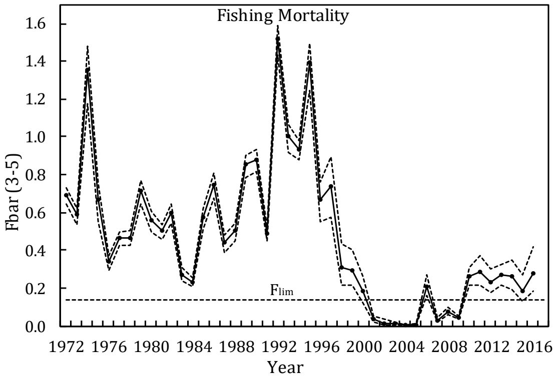
The cod stock in Flemish Cap (NAFO Div. 3M) is considered to be a separate population.

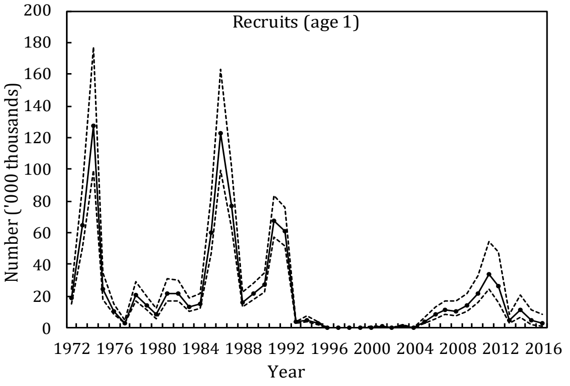
Stock status

Current SSB is estimated to be well above B_{lim}. However, since 2013 recruitment has decreased, and in 2016 was at levels similar to those observed during the period 1996 to 2004. Since 2010, F has remained stable at a level around twice F_{lim}.









Reference points

B_{lim}: 14 000 t of spawning biomass (Scientific Council, 2008).

$F_{lim} = F_{30\%SPR}$: 0.139 (using method applied by Scientific Council, 2014)

Projections

	B		SSB		Yield
	Median and 90% CI				
	$F_{bar}=F_{lim}$ (median=0.139)				
2017	36314	(23245 - 55649)	27187	(15371 - 45374)	13931
2018	30508	(12993 - 57331)	23634	(7923 - 49139)	10297
2019	27754	(4121 - 62281)	22913	(1799 - 55727)	
	$F_{bar}=3/4F_{lim}$ (median=0.104)				
2017	36314	(23245 - 55649)	27187	(15371 - 45374)	13931
2018	30508	(12993 - 57331)	23634	(7923 - 49139)	8182
2019	30703	(6907 - 65109)	25658	(3973 - 58324)	
	$F_{bar}=F_{2012-2014}$ (median=0.241)				
2017	36314	(23245 - 55649)	27187	(15371 - 45374)	13931
2018	30508	(12993 - 57331)	23634	(7923 - 49139)	15127
2019	21265	(1644 - 55804)	16653	(229 - 49345)	
	$F_{bar}=3/4F_{2012-2014}$ (median=0.180)				
2017	36314	(23245 - 55649)	27187	(15371 - 45374)	13931
2018	30508	(12993 - 57331)	23634	(7923 - 49139)	12435
2019	24854	(2298 - 59365)	20105	(320 - 52774)	

	Yield		$P(B < B_{lim})$			$P(F > F_{lim})$		
	2017	2018	2017	2018	2019	2017	2018	$P(B_{19} > B_{16})$
F_{lim}	13931	10297	3%	18%	27%	67%	50%	35%
$3/4F_{lim}$	13931	8182	3%	18%	21%	67%	35%	44%
$F_{2014-2016}$	13931	15127	3%	18%	43%	67%	76%	21%
$3/4F_{2014-2016}$	13931	12435	3%	18%	34%	67%	63%	28%

The results indicate that under all scenarios total biomass during the projected years will decrease. Under all scenarios the probability of being below B_{lim} at the beginning of 2019 is higher than 20% and the probability of F exceeding F_{lim} is at least 35%.

Assessment

A quantitative model introduced in 2008 was used (Scientific Council, 2008). Model settings were unchanged. Some concerns about the Bayesian model used in the assessment have been raised by Scientific Council. Scientific Council approved the assessment to perform the projections despite the issues encountered taking into account that the results of the assessment are in line with the survey trends. The impact of this issue will be studied in the April 2018 benchmark.

The next full assessment of this stock is planned for 2018.

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	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
TAC	ndf	ndf	5.5	10.0	9.3	14.1	14.5	13.8	13.9	13.9
STATLANT 21	0.4	1.2	5.3	9.8	9.0	11.2	10.5	12.8	13.8	
STACFIS	0.9	1.2	9.2	13.6	13.4	14.0	14.3	13.8	14.0	

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 comments

Given the trends in projected biomass and the fact that the stock will be benchmarked in 2018, Scientific Council considered one year projections only.

Sources of information

SCR Doc. 17/17, 17/24, 17/38; SCS Doc. 17/04, 17/05, 17/06, 17/09, 17/11, NAFO SC Reports 2014, 2008, NAFO/GC Doc 08/3

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

Recommendation for 2018 and 2019

In the short term (~2 years) the stock could sustain values of *F* at the current level corresponding to a TAC of 12 000 tonnes. However, under the present low recruitment regime, short term yields at levels higher than F0.1 (7 000 tonnes) are likely to induce medium term declines in abundance, exploitable biomass and spawning stock biomass. Therefore, if the objective is to maximize yields over the long term, TACs should be set at values closer to the lower end of the range 7 000 to 12 000 tonnes.

Management objectives

No explicit management plan or management objectives defined by Fisheries Commission. General convention objectives (NAFO/GC Doc 08/3) are applied.

Convention objectives	*Status*	*Comment/consideration*
Restore to or maintain at Bmsy	⚪	Bmsy unknown. Stock above historical average level
Eliminate overfishing	🟠	Fmsy unknown, catch at low level over past 21 years
Apply Precautionary Approach	🔴	Candidate reference points need to be confirmed.
Minimise harmful impacts on living marine resources and ecosystems	🟠	VME closures in effect, no specific measures, low bycatch reported.
Preserve marine biodiversity	⚪	Cannot be evaluated

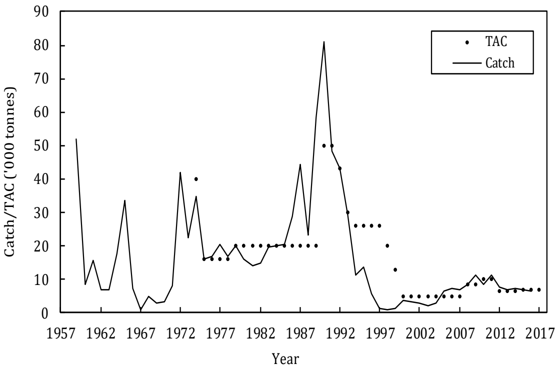
🟢	OK
🟠	Intermediate
🔴	Not accomplished
⚪	Unknown

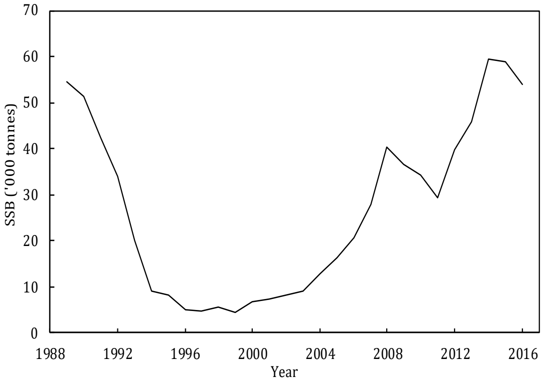
Management unit

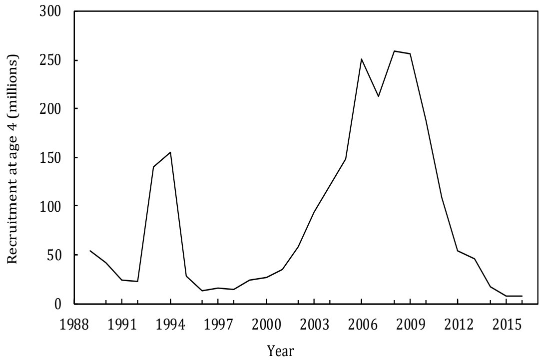
Catches of redfish in Div. 3M includes three species of the genus *Sebastes*; *S. mentella, S. marinus* (=*S. norvegicus*) and *S. fasciatus*. For management purposes they are considered as one stock (STACFIS 2017). Advice is based on data only for two species (*S. mentella* & *S fasciatus*), labeled as Beaked redfish.

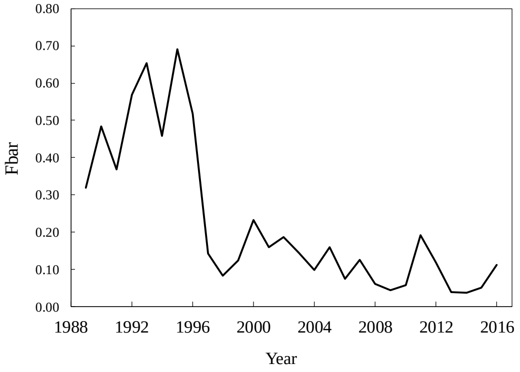
Stock status

As a result of high recruitment from 2002-2006, the stock currently has high biomass and spawning biomass but abundance and recruitment are declining. Year classes recruiting in 2015 and 2016 are among the lowest on record. Fishing mortality increased in 2015-2016 but is still low.









Reference points

No reference points have been adopted.

Assessment

Input data comes from EU Flemish Cap bottom trawl survey and the fishery and is considered good quality. A quantitative model (XSA) introduced in 2003 was used. Elevated natural mortality was assumed from 2006 to 2010 but was low (more typical of redfish) otherwise. In order to include an independent approach to natural mortality in the 2017 sensitivity M framework, the actual beaked redfish natural mortality has been estimated by a number of published models

The next full assessment of this stock will be in 2019.

Projections

Short term (2018-2019) stochastic projections were carried out for female spawning stock biomass (SSB) and catch, under most recent level of natural mortality and considering four options for fishing mortality (F0, Fstatusquo, F0.1 and Fmax). Projections were initialized at the beginning of 2018 assuming Fstatusquo during 2017. Recruitment entering in 2017 and 2018 is assumed constant at the geometric mean of below average recruitments (age 4 XSA, 1989-2014).

In all projections scenarios spawning biomass remains at relatively high levels.

SSB		F_0	F_{2016}	$F_{0.1}$	F_{max}
$2020_{50th\ \%\ ile}$		64977	53964	58437	53319
$2020_{25th\ \%\ ile}$		60681	50347	54611	49747
2016	54017				
Yield $_{beaked\ redfish}$		F0	F_{2016}	$F_{0.1}$	F_{max}
2018-2019			10248	5778	10230
2016	6232				
TAC		F0	F_{2016}	$F_{0.1}$	F_{max}
2018-2019			12092	**6817**	12070
2016	7000				

average beaked redfish proportion in the 2015-20163M redfish catch 0.85

	F_0	F_{2016}	$F_{0.1}$	F_{max}
P(SSB_{2020}>SSB_{2016})	>95%	~50%	75%	~50%

Human impact

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

Biology and Environmental Interactions

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

Fishery

Redfish is nowadays caught in bottom trawl fisheries at intermediate depths. In turn, redfish are also caught as bycatch in fisheries directed for cod and Greenland halibut. The fishery in NAFO Div. 3M is regulated by minimum mesh size and quota.

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

	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
TAC	5	8.5	10.0	10.0	6.5	6.5	6.5	6.7	7.0	7.0
STATLANT 21 A	7.9	8.7	8.2	9.7	5.4	6.8	6.4	6.9	6.6	
STACFIS Total catch[1,2]	8.5	11.3	8.5	11.1	6.2	7.8	7.4	6.9	6.6	
STACFIS Catch[2,3]	4.3	3.7	5.4	9.0	6.3	5.2	4.6	5.2	6.2	

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

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

[3] STACFIS beaked redfish catch

Effects of the fishery on the ecosystem

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

Sources of information: SCR Doc. 17/024, 032, 034, 038; SCS Doc. 17/ 04, 05, 09,011.

American plaice in Division 3M   Advice June 2017 for 2018 – 2020

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

Management objectives

No explicit management plan or management objectives defined by Fisheries Commission. General convention objectives (GC Doc. 08/3) 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

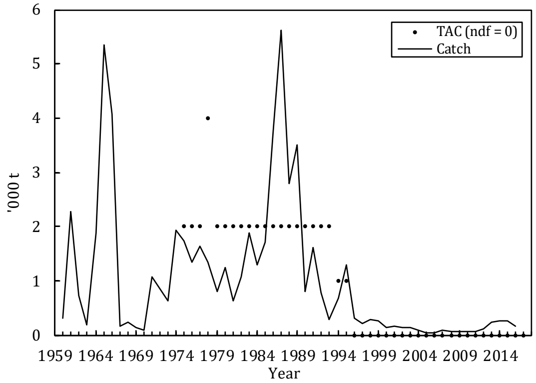
🟢 OK
🟡 Intermediate
🔴 Not accomplished
⚪ Unknown

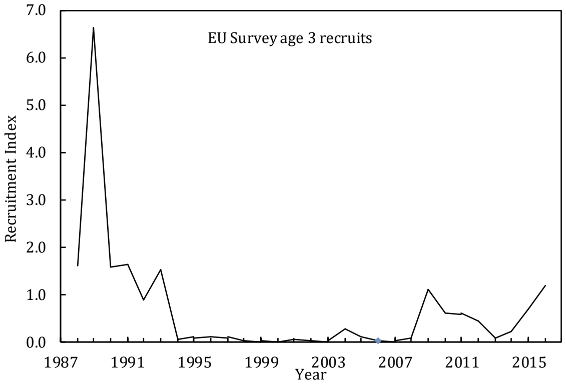
Management unit

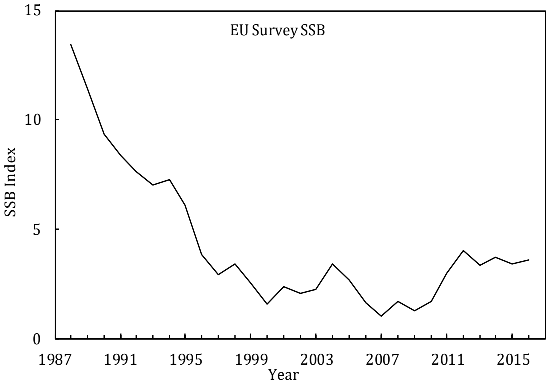
The American plaice stock in Flemish Cap (Div. 3M) is considered to be a distinct population.

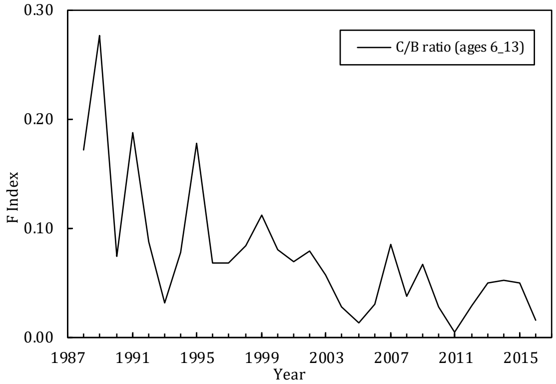
Stock status

The stock has increased slightly in recent years due to improved recruitment. Although the catches since 1996 have been low, this stock remains at a relatively low level.









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 a 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 2020.

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 t was in effect for this stock. A reduction to 1 000 t was agreed for 1994 and 1995 and a moratorium was agreed to thereafter.

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

	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
TAC	ndf	ndf	ndf	ndf	ndf	ndf	ndf	ndf	ndf	ndf
STATLANT 21	0.1	0.1	0.2	0.1	0.1	0.2	0.2	0.2	0.2	
STACFIS	0.1	0.1	0.1	0.1	0.1	0.2	0.2	0.3	0.2	

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; 17/24, 43; SCS Doc. 15/4, 5, 6, 7; 16/9; 17/4, 5, 6, 11

Witch Flounder in Divisions 3NO

Advice June 2017 for 2018 - 2019

Recommendation for 2018 and 2019

All projections resulted in a greater than 10% risk of being below B_{lim} in 2019 and 2020. The stock is estimated to have declined at the exploitation rate in 2016. Levels of fishing mortality above this result in a greater than 30% risk of F exceeding F_{lim}. Scientific Council advises that the exploitation rate in 2018 and 2019 should not exceed 2016 levels and therefore catch should not exceed 1116 t and 1175 t in 2018 and 2019 respectively.

Management objectives

The NAFO Fisheries Commission adopted a total allowable catch (TAC) of 2,225 t in 2017. Bycatches in commercial fisheries directed for other species should be kept to a minimum. General convention objectives (GC Doc. 08/3) are applied.

Convention objectives	*Status*	*Comment/consideration*
Restore to or maintain at B_{msy}	🟡	B decreasing. $B_{lim} < B_{2016} < B_{msy}$
Eliminate overfishing	🟢	$F < F_{msy}$
Apply Precautionary Approach	🟢	Stock in safe zone of PA Framework
Minimise harmful impacts on living marine resources and ecosystems	🟡	VME closures in effect, no specific measures.
Preserve marine biodiversity	⚪	Cannot be evaluated

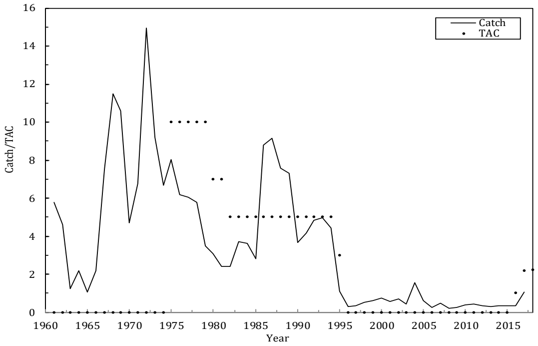
🟢	OK
🟡	Intermediate
🔴	Not accomplished
⚪	Unknown

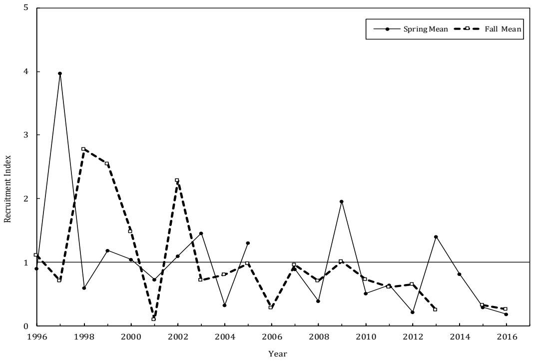
Management unit

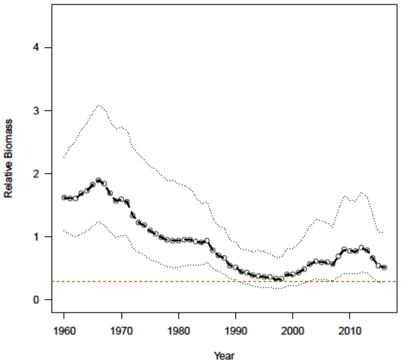
The management unit is NAFO Divisions 3NO. The stock mainly occurs in Div. 3O along the southwestern slopes of the Grand Bank. In most years the distribution is concentrated toward the slopes but in certain years, a higher percentage may be distributed in shallower water.

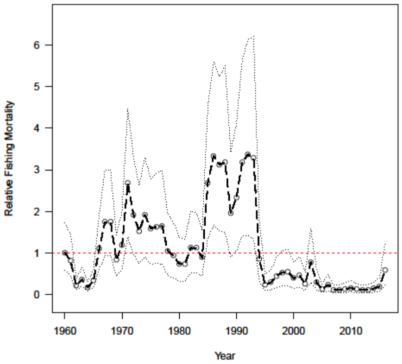
Stock status

The stock size increased since 1999 to about 2010 and then declined after 2012 and is now at 52% B_{msy}. There is 15% risk of the stock being below B_{lim} and a 19% risk of F being above F_{lim}. Recruitment since 2013 has been decreasing with survey estimates in 2016 approaching the lowest of 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.

All projections assumed that the catch in 2017 was equal to the TAC of 2 225 t (which produces F_{2017}). This was followed by constant fishing mortality for 2018 and 2019 at several levels of F (F_{2016}, 75% $\underline{F_{2016}}$, 125% F_{2016}, 2/3 F_{MSY}, 75% F_{MSY}, and 85% F_{MSY}). The probability that $F > F_{lim}$ in 2017 is 57% at a catch of 2 225 t. The population is projected to grow under all scenarios and the probability that the biomass in 2020 is greater than the biomass in 2016 is greater than 50% in all scenarios. The population is projected to remain below B_{MSY} for all levels of F examined with a probability of greater than 70%.

Yield (t) and risk of F> F_{lim}, B<B_{lim} and B<B_{MSY} for projected F values of F2016, 75% F2016, 125% F2016 2/3 F_{MSY}, 75% F_{MSY}, and 85% F_{MSY}.

	Yield 2018	Yield 2019	p>F_{lim}		p<B_{lim}			p<B_{MSY}			p2020> 2016
			2018	2019	2018	2019	2020	2018	2019	2020	
F=0					18%	16%	14%	79%	77%	70%	72%
75%F2016 =0.03	844	891	15%	16%	19%	18%	20%	80%	75%	72%	66%
F2016=0.04	1116	1175	24%	25%	19%	18%	17%	79%	76%	73%	65%
2/3 Fmsy=0.05 =125%F2016	1316	1384	31%	32%	19%	18%	19%	79%	76%	73%	63%
75%Fmsy=0.052	1468	1555	36%	37%	18%	19%	19%	79%	76%	73%	62%
85% Fmsy=0.06	1662	1745	42%	43%	19%	19%	20%	80%	77%	74%	60%

Assessment

This stock is assessed utilizing a surplus production model in a Bayesian framework. An interim monitoring report was provided in 2016

The input data were catch from 1960-2016, Canadian spring survey series from 1984-1990, Canadian spring survey series from 1991-2016 (no 2006) and the Canadian autumn survey series from 1990-2016 (no 2014).

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 southwestern slopes of the Grand Bank.

Fishery

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

Recent catch estimates and TACs are:

	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
TAC	ndf	ndf	ndf	ndf	ndf	ndf	ndf	1.0	2.2	2.2
STATLANT 21A	0.2	0.1	0.4	0.4	0.3	0.3	0.3	0.4	1.0	
STACFIS	0.3	0.4	0.4	0.4	0.3	0.3	0.3	0.4	1.1	

*ndf = no directed fishing

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

Because of the uncertainty and proximity to limit reference points, the next full assessment is rescheduled for 2018.

Sources of Information

SCR Docs 17/xxx, 020; SCS Docs. 17/04, 05, 11, xx; NAFO/GC Doc 08/3

White Hake in Divisions 3NO and Subdiv. 3Ps Advice June 2017 for 2018-19

Recommendation for 2018-2019
Given the absence of strong recruitment, catches of white hake in 3NO should not increase.

Management objectives

No explicit management plan or management objectives defined by Fisheries Commission. General convention objectives (NAFO/GC Doc 08/3) are applied. Advice is based on survey indices and catch trends in relation to estimates of recruitment.

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	🔴	Stock in safe zone of PA Framework
Minimise harmful impacts on living marine resources and ecosystems	🟠	No specific measures, general VME closures in effect.
Preserve marine biodiversity	⚪	Cannot be evaluated

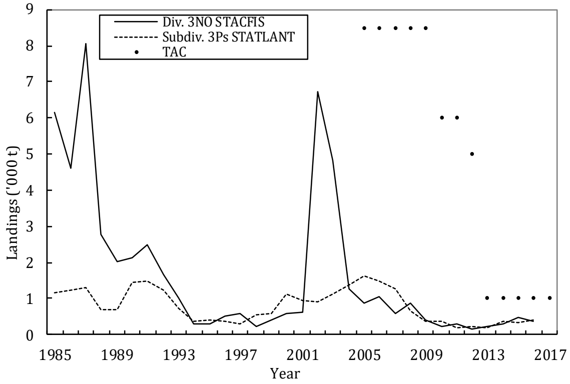
🟢	OK
🟠	Intermediate
🔴	Not accomplished
⚪	Unknown

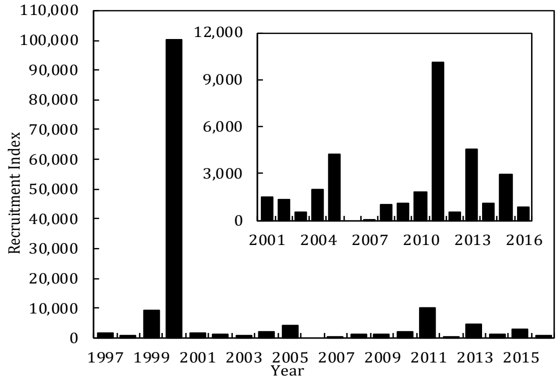
Management unit

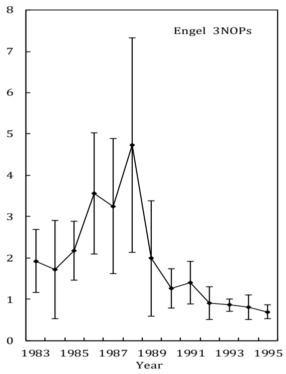
The management unit is confined to NAFO Div. 3NO, which is a portion of the stock that is distributed in NAFO Div. 3NO and Subdivision 3Ps.

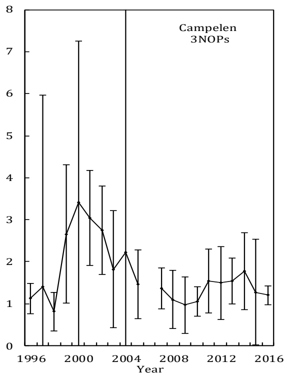
Stock status

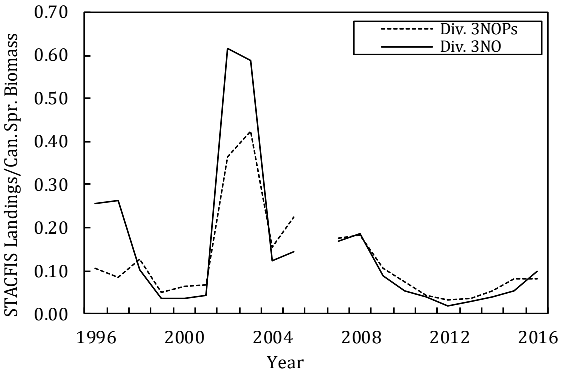
The stock biomass is at a low level. No large recruitments have been observed since 2000. Recruitment was higher in 2011, but not comparable to the very high recruitment observed in 2000. Fishing mortality is low.











Reference points

Not defined

Assessment

Based upon a qualitative evaluation of stock biomass trends and recruitment indices. The assessment is considered data limited and as such associated with a relatively high uncertainty. Input data are research survey indices and fishery data (STACFIS 2015).

The next full assessment of this stock will be in 2019.

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

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

White hake feed mostly on crustaceans and fish. Larger individuals are reported to be cannibalistic and to feed upon eggs and juveniles. In nearshore areas, white hake are also thought to predate on smaller juvenile cod. Predators of white hake include Atlantic cod, other fish species, Atlantic puffins, Arctic terns, other seabirds and seals.

Fishery

White hake are caught in directed gillnet, trawl and long-line fisheries. In directed white hake fisheries, Atlantic cod, black dogfish, monkfish and other species are landed as bycatch. In turn, white hake are also caught as bycatch in gillnet, trawl and long-line fisheries directing for other species. The fishery in NAFO division 3NO is regulated by quota.

Recent catch estimates and TACs (tonnes) are:

	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Div. 3NO:										
TAC	8.5	8.5	6	6	5	1	1	1	1	1[1]
STATLANT 21	0.9	0.5	0.3	0.2	0.1	0.2	0.3	0.4	0.4	
STACFIS	0.9	0.4	0.2	0.2	0.1	0.2	0.3	0.5	0.4	
Subdiv. 3Ps:										
STATLANT 21	0.7	0.4	0.4	0.2	0.2	0.2	0.4	0.3	0.4	

[1] May change in-season. See NAFO FC Doc. 17/01.

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

No special comments.

Sources of Information

SCR Doc. 17/13, 19, 33; SCS Doc. 17/04, 05, 11.

Monitoring of Stocks for which Multi-year Advice was Provided in 2015 or 2016

SC expresses concern that survey indices for several demersal fish stocks on the Grand Bank (NAFO Divisions 3LNO) have declined (sometimes sharply) over the last couple of years. These declines in specific demersal fish stocks are consistent with observed declines in overall finfish biomass in NAFO Div. 3LNO and with evidence of the onset of a declining trend in finfish abundance in NAFO Div. 2J3K (see Fig. 2 and 3 in STACFEN report for more detail.).

While these changes over multiple stocks are not fully understood, it is considered that these declines currently do not indicate a change in the status of the stocks for which multi-year advice was provided in 2016 that would require an update of the advice. Scientific Council will continue to closely monitor these trends.

Accordingly, Scientific Council reiterates its previous advice as follows:

Recommendation for cod in Divs. 3NO in 2016 – 2018: No directed fishing on cod in 2016 to 2018 to allow for continued stock rebuilding. By-catches of cod in fisheries targeting other species should be kept at the lowest possible level. Projections based on either F_{SQ} or F=0 suggest a >99% probability that the stock will remain below B_{lim} by 2018.

Recommendation for American plaice in Divs. 3LNO in 2017 and 2018: 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 2017 and 2018. 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 Divs. 3LNO in 2016, 2017 and 2018: Based on recent catch levels, fishing mortality up to 85% F_{msy} corresponding to a catch of 26300 t in 2016, 23600 t in 2017 and 22000 t in 2018 has low risk (5%) of exceeding F_{lim}, and is projected to maintain the stock well above B_{msy}

Recommendation for capelin in Divs. 3NO in 2016 – 2018: No directed fishery.

Recommendation for redfish in Division 3O in 2017 and 2018: 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 13 000 t since the 1960s and over the long term, catches at this level appear to have been sustainable. Scientific Council is unable to advise on an appropriate TAC for 2017, 2018 and 2019

Recommendation for thorny skate in Divisions 3LNO and Subdiv. 3Ps in 2017 and 2018: The stock has shown little improvement at recent catch levels (approximately 4 700 t, 2011 - 2015), therefore Scientific Council advises no increase in catches.

Recommendation for witch flounder in Divisions 2J + 3KL in 2017, 2018 and 2019: No directed fishery to allow for stock rebuilding. By-catches of witch flounder in other fisheries should be kept at the lowest possible level.

Recommendation for Northern short-finned squid in SA 3+4 in 2017,2018 and 2019: During 2015, the northern stock component remained in a state of low productivity. Therefore, the SC advice is a TAC of no more than 34 000 tonnes/yr

Recommendation for splendid alfonsino (*Beryx splendens*) in Subareas 6: Due to lack of abundance or exploitation data, no reliable stock assessment can be conducted.

To prevent extirpation of entire subpopulations of Alfonsino, fishing should not be allowed to expand above current levels on Kükenthal Peak (Div. 6G, part of the Corner Rise seamount chain) unless it can be demonstrated that such exploitation is sustainable, and fisheries on other seamounts should not be authorized.

In the absence of a stock assessment TAC recommendation is based on recent catch history (2009 – 2014). Scientific Council recommends exploitation should not exceed recent average levels of approximately 200 t or 16 days-on-ground (by a single standard vessel) on Kükenthal Peak, and no Alfonsino fishery on all other seamounts in the NRA. The sustainability of this level of removals is unknown.

Scientific Council also reiterates its advice provided in 2013 in the context of the Sargasso Sea and the protection of seamounts. (SC Report 2013, p310-315).

Special Requests for Management Advice

i) Implement relevant steps in the workplan for Greenland halibut in SA2 + Divs. 3KLMNO (Item 2)

The Fisheries Commission requests the SC to implement the steps of the work plan relevant to the SC for progression of the Greenland halibut Management Strategy Evaluation Review (FC Working Paper 16/11 Rev 2 adopted at the NAFO 2017 annual meeting).

Scientific Council responded:

SC has implemented the steps of the workplan and this work is described in the STACFIS report.

ii) Continue risk assessments for impacts of trawl surveys on VMEs in closed areas (Item 3)

FC requests that Scientific Council continue its risk assessment of scientific trawl surveys impact on VME in closed areas, and the effect of excluding surveys from these areas on stock assessments.

Scientific Council responded:

SC **recommends** that *scientific bottom trawl surveys in existing closed areas be avoided if possible and additional work be conducted as soon as possible to further evaluate the implications of excluding RV surveys in closed areas on stock assessment metrics*.

A spatial analysis and assessment of research vessel (RV) survey trawl catches was conducted on vulnerable marine ecosystem (VME) indicator species to evaluate the impact of the RV surveys on VME in closed areas. Three VME indicator species from RV trawl survey catches, sponge, sea pens, and large gorgonians, were evaluated using trawl data from 2002, 2005 and 2007, respectively. The sets were divided into three analytical regions and the frequency of sets catching each of the different VME indicator species above and below significant catch thresholds was assessed. The analytical regions are: i. trawls within the fishery footprint but are outside any identified VME polygons and closure areas, ii. trawls within the defined VME polygons (from 2014) but outside of the closures, and iii. trawls that fall only within the closed areas.

For each VME indicator species (Table 1), the percentage of the total number of sets occurring within each of the analytical regions that exceeded the significant catch threshold was enumerated. Most noteworthy, is that 40% of the significant catches of sponge (>75kg) occur within the sponge closure areas.

Table 1. Proportion of total number of catches within each analytical region (kg = total weight of the significant catches). (Significant catch thresholds noted under column headings for each on the VME indicator species)

n=number of significant catches of the total	Sea pens 1.4kg	Large Gorgonians 0.6kg	Sponge 75kg
Outside VME and Outside Closure (Region 1)	**0%** (n=3 of 3790) 6 kg	**0%** (n=0 of 3470) 0 kg	**0%** (n=4 of 3769) 4320 kg
Inside VME and Outside Closure (Region 2)	**6%** (n=14 of 231) 42 kg	**7%** (n=5 of 68) 53 kg	**4%** (n=13 of 322) 3772 kg
Inside Closure (Region 3)	**7%** (n=20 of 277) 71 kg	**8%** (n=19 of 225) 167 kg	**40%** (n=116 of 293) 126,714 kg

Additionally, selecting sets of significant catches only, the proportion of the significant catch sets which fall within each of the regions can be assessed (Table 2). For all VME the largest portion of the significant catches occur within the closure areas e.g. 87% (n=116) of all significant sponge catches are found inside the sponge closures.

Table 2. Proportion of significant catches within each analytical region.

n=number of significant sets	Sea pens (n=37)	Large Gorgonians (n=24)	Sponge (n=133)
Outside VME and Outside Closure (Region 1)	8% (n=3)	0%	3% (n=4)
Inside VME and Outside Closure (Region 2)	38% (n=14)	21% (n=5)	10% (n=13)
Inside Closure (Region 3)	54% (n=20)	79% (n=19)	87% (n=116)

Impact of removal of survey trawls on stock assessment metrics An analysis of the impact of excluding Canadian RV surveys from the NAFO closure areas on the assessment indices for NAFO-managed demersal fish stocks in Divisions 3LNO was performed. There are currently three closures completely within this area and a small portion of another closure (primarily located in Div. 3M) that protrudes into Div. 3L. The Canadian Spring and Autumn RV surveys were examined and the removal of any survey fishing sets that were located all or partially within these closed areas was performed and the survey biomass indices were recalculated. A total of 220 autumn survey sets since 1995 and 39 spring survey sets since 1996 were identified as being located within the closed areas. In general, however, the closed areas are deeper than the main distribution areas for Atlantic cod, American plaice, yellowtail flounder, witch flounder, redfish, thorny skate and white hake and removing the fishing sets located in these areas had little impact on survey indices. The impact on the survey indices for deep-water species like Greenland halibut and roughhead grenadier was also negligible (<1%) (Greenland halibut) or small (roughhead grenadier: annual differences ranged from 0-9% annually). Any observed differences did not influence the overall patterns in survey indices.

Because some deep strata are located almost entirely (85% or more) within the closed areas, SC also examined if the loss of these strata from the Canadian survey design would influence the size composition of Greenland halibut and roughhead grenadier in the survey data. The length frequency distributions were almost identical.

A comparable length or age based analysis is required for Spanish and EU survey data in the NAFO Regulatory Area in order to complete a full evaluation of the impact of removing sets on the stock assessment.

iii) Bycatch of cod, redfish and moratoria species from haul-by-haul data (Item 4)

The Fisheries Commission requests the SC, based on analysis of the 2016 haul by haul data and patterns of fishing activity, to examine relative levels of by-catch and discards of 3M cod/redfish, and stocks under moratoria in the different circumstances (e.g. fisheries areas, season, fleets, depths, timing).

Scientific Council responded:

SC were not able to address this request during the June 2017 meeting due to lack of time. The Secretariat will present their analysis directly to WG-BDS in July.

iv) Assessment of golden redfish in Div. 3M (Item 5)

The stock of redfish 3M covers catches of three *Sebastes* species and the scientific advice is based on data of only two species (*S. mentella* and *S. fasciatus*). Golden redfish, *Sebastes marinus* (aka *norvegicus*), represents part of the catch but has not yet been subject to a full assessment in NAFO. The Scientific Council is requested to conduct a full assessment on 3M golden Redfish in June 2017 .The Scientific Council is also requested to advice on the implications for the three species in terms of catch reporting and stock management.

Scientific Council responded:

Due to lack of time, this request is deferred until 2018. A roadmap for a full assessment of this stock will be discussed in September. As in previous years, advice for this stock is given indirectly based on the 3M beaked redfish assessment.

v) Assessment of NAFO bottom fisheries (Item 6)

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

a. Assess the overlap of NAFO fisheries with VME to evaluate fishery specific impacts in addition to the cumulative impacts;

b. Consider clearer objective ranking processes and options for objective weighting criteria for the overall assessment of risk;

c. Maintain efforts to assess all of the six FAO criteria (Article 18 of the FAO International Guidelines for the Management of Deep Sea Fisheries in the High Seas) including the three FAO functional SAI criteria which could not be evaluated in the current assessment (recovery potential, ecosystem function alteration, and impact relative to habitat use duration of VME indicator species).

d. Continue to work on non-sponge and coral VMEs (for example bryozoan and sea squirts) to prepare for the next assessment.

e. the SC further develop and compile identification guides for fishes (e.g. sharks and skates) that could be provided to observers.

Scientific Council responded:

In 2016 and 2017, Scientific Council made further progress on assessing the overlap of NAFO fisheries with VME based on Daily Catch Report. Continued work addressing the other parts of this request will be conducted in 2018, noting that progress can only be achieved with appropriate participation of experts.

SC **recommends** that *the request relating to the "development and compilation of identification guides for fishes (e.g. sharks and skates)" be removed as it was addressed last year (SC03-16 June 2016).*

Overlap of NAFO fisheries with VME

A simple preliminary analysis of fisheries-specific overlaps between eight fisheries (Table 3) and the 2014 NAFO VME polygons was conducted. The following areas (km^2) were calculated: a) each of the VME species specific polygons and a layer with all VMEs combined; b) the area that overlaps for all combinations of VMEs and individual fishery footprints expressed as the percent VME overlap by a given fishery. The areas of VME polygons (km^2) are: 27557 for all VMEs combined, 3505 for large gorgonians, 6983 for sea pens, and 19824 for sponges.

Table 3. Description of fisheries-specific footprint layers assessed. Also an "all fisheries" layer was created by merging together each of the individual fishery layers giving a total fishery footprint of 78460 km^2.

Directed species or taxa	Gear	Main NAFO Division	Years	Code	Footprint area (km^2)
Cod	Longline	3M	2012/13, 2014-2015	COD_LL	6472
Cod	Otter trawl	3M	2012-2015	COD_OTB	24998
Greenland halibut	Otter trawl	3LNM	2012-2015	GHL_3LNM	48794
Redfish	Otter trawl	3LNO	2012-2015	RED_3LNO	20960
Redfish	Otter trawl	3M	2012-2015	RED_3M	17739
Shrimp	Otter trawl	3LMNO	2013-2014	PRA_3LMNO	2968
Skate	Otter trawl	3LNO	2012-2015	SKA_3LNO	15148
Flounders	Otter trawl	3LNO	2012-2015	WYP_3LNO	6482

Preliminary results show there was no fishing in VME polygons for the cod longline and shrimp fisheries. The Greenland halibut fishery overlapped the largest amount of VME area compared to the other fisheries (more than double the area for the next largest fishery). The sponge VME had the largest absolute area overlapped by Greenland halibut fishing footprint (5059 km^2) representing 26% of the VME area. While sea pen VMEs had 3027 km^2 overlapped, this represented a greater proportion (43%) of their area. The other fisheries showed lower values of overlapping VME-fishery area than Greenland halibut. Each of the fisheries (except for WYP_3LNO) had some portion of its fishing footprint in each of the three VME types. For WYP_3LNO, the fishing footprint occurred over sponge VME and large gorgonian VME but not over sea pens. It should be noted that identification of different fisheries in this study is based on daily catch reports which may group several hauls with different target species.

An improvement in the above analysis will be conducted in the future including the use of new VME polygons that will be created in 2017 and the integration of commercial logbook haul-by-haul catch records with VMS data that will greatly improve the spatial resolution of the fishing effort and the differentiation between different fisheries.

Maintain effort to assess all six of the FAO criteria

The analysis in 2016 focused on methods to potentially evaluate the recovery potential and functional significance of sea pen VME. In addition, a review of the functional significance of other VME species (including sea pen) was initiated.

The method developed to evaluate recovery potential (or resilience) first calculates the actual area of trawling impact (swept area) by simulating seabed impact using known gear dimensions and a semi-randomized positioning of trawls following the bathymetric contours of the seabed (Fig. 1). The biomass of VME is assumed initially to be evenly distributed throughout the VME habitat. Following the pattern of simulated trawling impact (Fig. 1) the remaining biomass (observed from survey data) is associated with those areas least impacted. The subsequent calculation then relates the distribution of observed biomass to the time interval of impact as determined by the corresponding level of fishing effort.

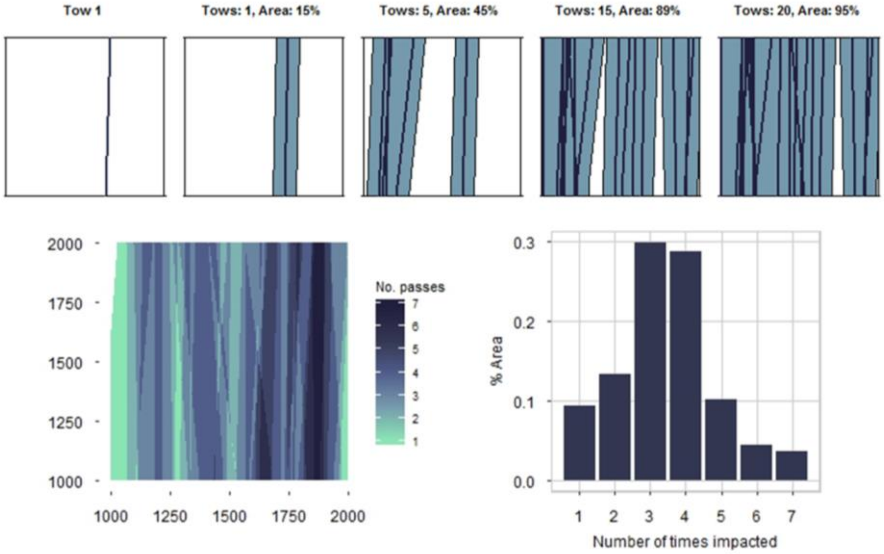


Fig. 1. Pattern of simulated trawling impact using an average gear width of 150 metres.

The average recovery time (for the observed level of biomass) is then determined by averaging over all the different categories of trawling impact and corresponding biomasses for a given level of fishing effort over time using the following equation:

$$\frac{\frac{tf_1}{2}+\frac{tf_2}{3}+\frac{tf_3}{4}.....\frac{tf_n}{n}}{f_1+f_2+f_3....f_n} = Ave.t_{recovery}$$

Where t is the time taken to impact at least once any part of the seabed within a 1 km^2 at a given level of fishing effort (hrs.yr^{-1}), $f_{1....n}$ is the area of seabed (and therefore biomass) impacted *1, 2, 3 etc.* times.

Applying this formula to the observed data we estimate that the level of fishing effort that it would take to accumulate 50% of the biomass (km^{-2}) from catches occurs at a fishing effort of 0.13 h km^{-2} yr^{-1}, and the time required to impact the seafloor at least once to be 20 years. The average time to recover 50% of sea pen biomass following removal by fishing is therefore:

$$\frac{\frac{20\times0.095}{2}+\frac{20\times0.13}{3}+\frac{20\times0.275}{4}}{0.095+0.13+0.275} = 4.6\ years$$

However, the method makes a number of significant assumptions (Table 3) and these will have an impact on the estimated recovery times. There are more sources of error in the present analysis which give rise to potentially shorter recovery times than may be expected, therefore the present estimate of 50% recovery sea pen biomass is likely to be >5 years.

Research conducted on the longevity of *Halipteris finmarchica* (Neves *et al*., 2015), reported it is a "slow-growing, relatively long-lived organism whose recovery from damage can take over 20 years". The current study calculates that 50% of the sea pen biomass (as a composite of several commonly occurring species, but including *Halipteris finmarchica*) may recover in a period of between 5 to 10 years, which is in agreement with existing findings.

There is evidence that sea pen fields most likely provide an important functional role in relation to commercial fish species, most notably *Sebastes* sp., the most important functions being the indirect provision of food and habitat utilized by *Sebastes* sp.

vi) Continue review of PA framework (Item 7)

The Fisheries Commission requests the SC to continue progression on the review of the NAFO PA Framework.

Scientific Council responded:

As a result of considerable workloads, Scientific Council was unable to make significant progress on its assessment of the PA Framework although some progress was made in the assessment of the PA Framework in the context of an ecosystem approach to management in 2016. Scientific Council will continue with its work but notes progress can only be achieved with appropriate participation of quantitative experts.

vii) Review information on Greenland sharks (Item 8)

The Fisheries Commission requests the Scientific Council, by their 2018 annual meeting engage with relevant experts as needed, review the available information on the life history, population status, and current fishing mortality of Greenland sharks (Somniosus microcephalus), on longevity and records of Greenland shark bycatch in NAFO fisheries, and develop advice for management, in line with the precautionary approach, for consideration by the Fisheries Commission.

Scientific Council responded:

Information on biology, distribution, survey catches and commercial bycatches were presented. More data will be presented in 2018 and advice given at that time.

The Greenland shark is a very large sleeper shark (Order: Squaliformes, Family: Somniosidae) commonly found in the high latitudes of the North Atlantic and Arctic waters. The full range of this species is unknown but several records from lower latitudes exist, e.g. Gulf of Mexico, Azores, Canary Islands. Depth records range from 0 to 3000 m, with an overall trend of increased depth at lower latitudes (tropical submergence). A recent phylogenetic study revealed that a small portion (7 of 277 samples analyzed) of Greenland sharks are hybridizing with Pacific sleeper sharks (*S. pacificus*), likely due to removal of ice barriers during the most recent period of glacial retreat (Walter et al., in review). Acoustic telemetry studies are ongoing to better describe the range and habitat affinity, as well as ontogenetic shifts in these factors (Davis et al., 2013). A recent satellite telemetry study (Campana et al., 2015) found that all individuals tagged in Davis Strait moved north into Baffin Bay after release while all individuals tagged on the Grand Banks moved south after release. Tagged sharks traveled as much as 1615 km from the tagging site and tagged individuals exhibited midwater swimming, e.g. tag depth of 1100 m in water depth of 4 km.

The basic biology of the Greenland shark is poorly described with reported sizes ranging from 42 to 640 cm (with anecdotal records exceeding 750 cm). Fecundity is unknown, however the report of a single gravid female containing 10 embryos in one uterus suggests low reproductive output (Castro, 2011). Confusion over fecundity estimates may arise from literature reports "thousands of ova" (oocytes) , but these authors were likely referencing previtellogenic (unyoked) oocytes. Yolked oocytes may be used as a proxy for fecundity in elasmobranchs, but previtellogenic oocytes should not be used to estimate fecundity as this count would include many ovulation events. Like most deep-water squaloids, the gestation period is unknown but assumed to be protracted as in the 2-year gestation of spiny dogfish (*Squalus acanthias*). Estimates of size at birth range from 42 to 100 cm, based on observations of free-swimming sharks, some with yolk reserves in the stomach (MacNeil et al., 2012). Juveniles are commonly reported from Canadian Arctic waters, Scandinavian fjords, and the Barents Sea (Davis et al., 2013; Rusyaeva and Orlov, 2013). Two small specimens (103 and 142 cm TL) collected on the mid-Atlantic ridge (~43° N) suggest that this area may also be important juvenile habitat (C. F. Cotton, unpublished data). Based on field observations, maturity is assumed to occur around 300 cm for males (Yano et al., 2007) and between 355 and 480 cm for females (MacNeil et al., 2012). Longevity was recently estimated to be extremely high at 392 ± 120 y, with maturity estimated to occur at 156 ± 22 y, based on radiocarbon dating of eye lens nuclei (Neilsen et al., 2016). These age estimates await verification using other ageing methods, which is standard practice for the first ageing study of any species. Tag return data from Hansen (1963) also suggest extreme longevity, with very slow growth (~0.5-1.0 cm/y) reported for juvenile sharks that were at liberty for up to 16 years. Diet consists of many species of fishes and invertebrates, predominantly Greenland halibut, skates (Rajidae), marine snails, and squid, as well as seals and a variety of carrion.

Reports of fishing catches were historically high for Greenland sharks, with Norwegian landings peaking in 1948 at 58,000 sharks, driven by the liver oil market. This estimate, however, was based on an extrapolation from barrels of crude shark liver oil, which may be imprecise due to sex-specific yields of liver oil. Additionally, the shark liver oil market is supplied by a combination of many different species (e.g. *Cetorhinus maximus*, *Centrophorus* spp., *Centroscymnus* spp., etc.), hence the extrapolation from liver oil to numbers of sharks harvested is questionable. With the advent of synthetic oil, the fishery substantially declined in the middle of the 20th century and landings have remained relatively low, ranging between 50 and 200 t per year (MacNeil et al., 2012). Currently, small-scale targeted fisheries exist in Greenland and Iceland to supply the demand for traditional dried and fermented meat, hákarl. The principle present-day fishery interaction is incidental catch, with no accurate bycatch estimates available. No stock assessment has ever been conducted for this species. The IUCN Red List Shark Specialist Group assessed this species as "Near Threatened" based primarily on the biological vulnerability associated with its conservative life history traits. Several RFMO's have issued prohibitions on other shark species based on their evaluation of biological vulnerability. Greenland sharks may warrant precautionary consideration due to the extreme longevity and low fecundity exhibited by this species.

Information was presented for the EU-Spain 3L and 3NO surveys as well as the EU 3M survey. A total of 8 Greenland shark were caught over all the years of these surveys. The Canadian surveys of the Newfoundland Shelf and the Grand Bank caught Greenland Sharks in 63 sets from 1960-2016 (Figure 1). Surveys in NAFO Subarea 0 caught 98 individuals from 2006-2016.

A map of the Newfoundland Region At Sea Observer program catches of Greenland Shark was shown (Figure 2). EU-Spain presented National Scientific observer reported catches.

Total reported catches from haul by haul catch reporting in the NAFO Regulatory Area in 2016 were shown (figure 3). Catches of Greenland shark were reported in 67 hauls: catches are reported by weight so it is not possible to determine the number of individual sharks caught. The map presented here includes retained and discarded catch by longline and bottom trawl.

More work will be conducted for 2018, including a closer examination of the survey data along with additions of other Canadian surveys (eg. 4RST, 4VW) and additional bycatch estimates.

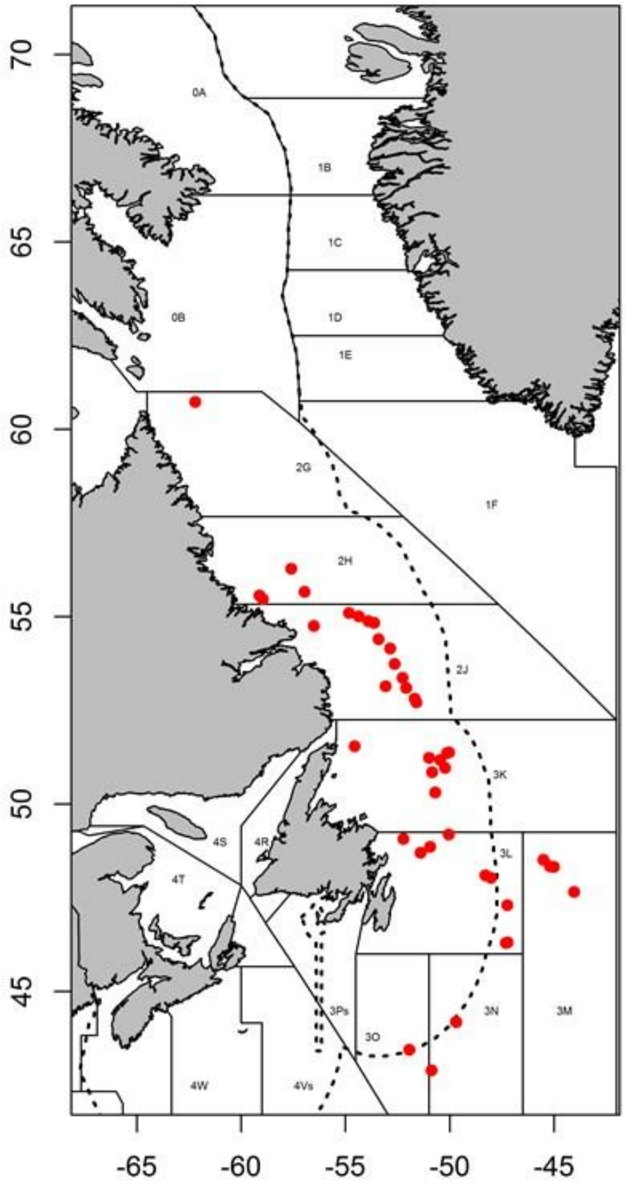


Fig. 1. Catches of Greenland sharks in the Canadian (DFO-NL) survey in NAFO Div. 2G-3Ps

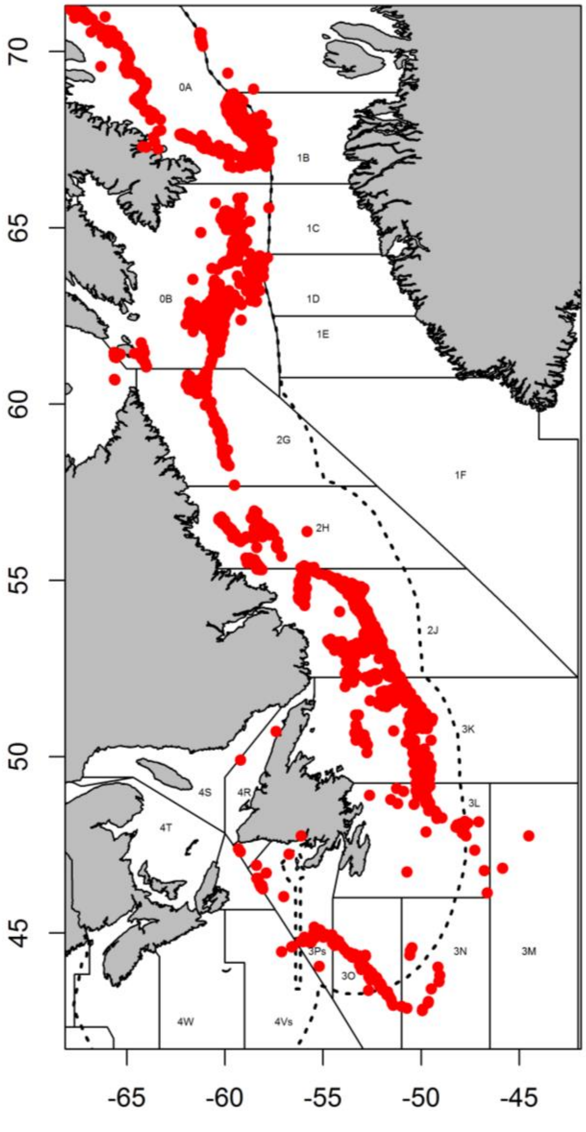


Fig. 2. Newfoundland Region At Sea Observer program catches of Greenland Shark

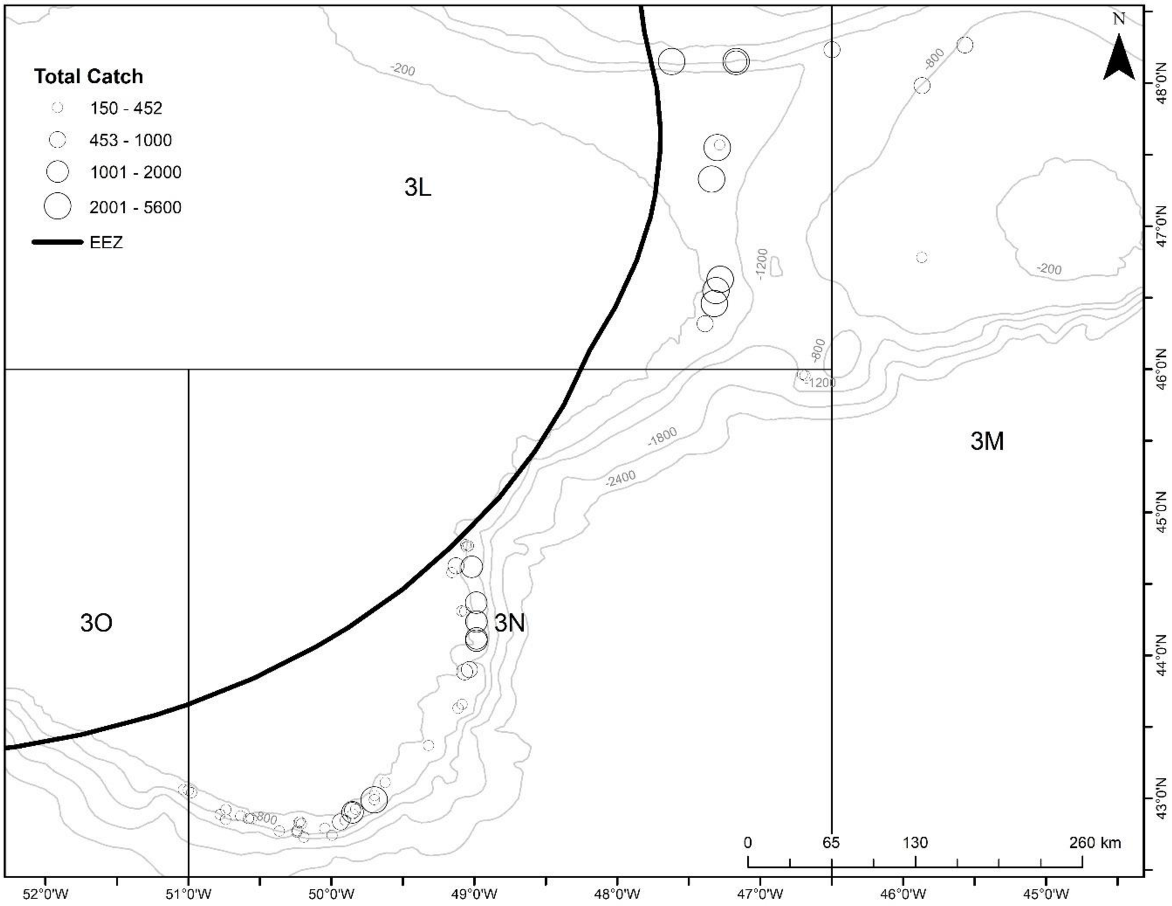


Fig. 3. Total reported catches of Greenland sharks from haul by haul catch reporting in the NAFO Regulatory Area in 2016

Literature cited:

Campana, S.E., A. T. Fisk, A. P. Klimley. 2015.Movements of Arctic and northwest Atlantic Greenland sharks (*Somniosus microcephalus*) monitored with archival satellite pop-up tags suggest long-range migrations. Deep-Sea Research II 115, 109–115.

Castro, J. I. 2011. The Sharks of North America. Oxford Press. 613 pp.

Davis, B., D. L. Vanderzwaag, A. Cosandey-Godin, N. E. Hussey, S. T. Kessel, B. Worm. 2013. The Conservation of the Greenland Shark (*Somniosus microcephalus*): Setting Scientific, Law, and Policy Coordinates for Avoiding a Species at Risk. Journal of International Wildlife Law & Policy, 16:300–330.

Hansen, P. M. (1963). Tagging experiments with the Greenland shark (*Somniosus microcephalus* (Bloch and Schneider)) in Subarea 1. International Commission Northwest Atlantic Fisheries Special Publication 4:172–175.

MacNeil, M. A., B. C. McMeans, N. E. Hussey, P. Vecsei, J. Svavarsson, K. M. Kovacs, C. Lydersen, M. A. Treble, G. B. Skomal, M. Ramsey and A. T. Fisk. 2012. Biology of the Greenland shark *Somniosus microcephalus*. Journal of Fish Biology 80, 991–1018.

Nielsen, J., R. B. Hedeholm, J. Heinemeier, P. G. Bushnell, J. S. Christiansen, J. Olsen, C. B. Ramsey, R. W. Brill, M. Simon, K. F. Steffensen, J. F. Steffensen. 2016. Eye lens radiocarbon reveals centuries of longevity in the Greenland shark (*Somniosus microcephalus*). Science 353 (6300):702-704.

Rusyaeva, S. M. and A. M. Orlov. 2013. Bycatches of the Greenland Shark *Somniosus microcephalus* (Squaliformes, Chondrichthyes) in the Barents Sea and the Adjacent Waters under Bottom Trawling Data. Journal of Ichthyology, 2013, Vol. 53(1): 111–115.

Walter, R.P., D. Roy, N.E. Hussey, + 15 authors. (in review). Origins of the Greenland Shark (*Somniosus microcephalus*): impacts of Ice-olation and Introgression.

Yano, K., J. D. Stevens, and L. J. V. Compagno. 2007. Distribution, reproduction and feeding of the Greenland shark Somniosus (Somniosus) microcephalus, with notes on two other sleeper sharks, Somniosus (Somniosus) pacificus and Somniosus (Somniosus) antarcticus. Journal of Fish Biology 70, 374–390.

viii) Start working on a Strength, Weaknesses, Opportunities and Threats (SWOT) analysis (Item 9)

Fisheries Commission requests the Scientific Council start working on and finalizing by SC 2018 a strategic scientific plan based on a Strength, Weaknesses, Opportunities and Threats (SWOT) analysis defining the strategy and the mid and long term objectives and tasks in view of NAFO's amended convention objectives. The plan should define for each strategic objective goals, tasks and measurable targets.

Scientific Council responded:

Considering the extremely tight agenda, the following very preliminary SWOT analysis was carried out based on a compilation of a questionnaire submitted to SC members. It should be noted that not all SC members responded. The summary at the end pulls out the key features.

<table>
<tr><th colspan="2">INTERNAL FACTORS</th></tr>
<tr><th>STRENGTHS (+)</th><th>WEAKNESSES (-)</th></tr>
<tr><td>HUMAN RESOURCES
1. People power: Highly skilled, dedicated SC members with excellent scientific expertise, experienced chairs managing different working groups, committed SC members, long tenure of the members who are willing to put in tremendous effort, NAFO SC coordinator…
WORKING METHODS
2. SC working methodology, dynamics and process are well established and predicable path for council members
3. Work well as a team in a friendly, respectful and cooperative working environment
4. Great capacity of compiling lots of information
5. Good coordination in the assessments
6. International connections
7. Good support from the Secretariat
8. Good collaboration with the Managers (FC SC Working Groups)
9. Iterative work (present, review, present etc) and All the stocks and environmental matters are take in the same meeting
10. Long meeting allowing a large amount of work to get covered.
SC RESULTS
11. SC outcomes taken as a reference in other RFMOs particularly on the relationship between sensitive habitats and fishing activities
12. The SC advice is mostly followed
13. Good reputation between different RFMOs
14. Scientific advice very relevant</td><td>CRITICAL MASS
1. Low critical mass in some topics and topics
EXTERNAL PARTICIPATION
2. Low external involvement: peer review of stock assessments (few workshops, benchmarks…) and low number of publications related with SC outcomes (prevents external participants' involvement…)
3. Difficult to incorporate new people, which reduces generational renewal.
4. The SC work (papers, meetings) are afforded little or no value by the National Scientific Institutions
5. Changes in the sequence of agenda items make it difficult for external participants to make plans to attend specific sections of the meeting
6. External contractors can carry out assessments, and this can be challenging if they are seen to have a conflict of interest
7. No managers present at the meeting to provide feedback on if the advice is useful
WORKLOAD
8. Short deadlines
9. Few members to take on the work of the many assessments and special requests/projects
10. Many meetings attended by the same persons.
11. Not clear distinction of the role of the SC participants in the FC SC working groups.
12. Issues go back and forth between the SC and the Working Groups.
AVAILABILITY OF THE REPORTS
13. Delay in the availability of the reports due to excessive workload</td></tr>
</table>

15. Reports and Advice are drafted by the time the meeting is over	14. Missed deadlines, and reporting requirements **WORKING METHODS** 15. Decisions have to be unanimous and sometimes is difficult to reach consensus 16. Quantitative capacity has diminished somewhat while the need for more complex models to meet objective for Management Strategy Evaluation and move to harvest control rules has increased. 17. Difficulties to actively participate in discussions due to work on other issues during the meeting. 18. Reviewing the text is time consuming but it does foster a shared understanding of an agreement on the advice, which is great. (so good and bad) 19. Most of the comments come from a subset of the people, it is an intimidating environment, because there is so much expertise 20. Some of the analyses are quite complex making it hard for all to contribute to the review. 21. "Set it its ways?" not sure if this is true, but is a risk for a group with low turnover 22. Some of the stocks do not have synoptic survey coverage

EXTERNAL FACTORS

OPPORTUNITIES (+)	THREATS (-)
OPTIMIZING RESOURCES 1. FC requests listed and prioritized (as SC cannot do everything at the same time delivering a quality final product) 2. Review the current work system with the aim of improving the efficiency of the work done. A lot of time is devoted to meetings and very little time for research and training **STRATEGIC RESEARCH PLAN** 3. SC multiannual plan (to better allocate or find resources for the medium term according to the priorities) 4. NAFO research strategy: Point out gaps, duplicities and synergies to maximize all contracting parties' efforts on research. As a final result NAFO should have a coherent approach on research efforts on the NAFO area 5. A clear strategic research plan agreed with the managers in which priorities and needs are established to carry them out **INCREASING COOPERATION** 6. Cooperation with other RFMOs to assure that common approaches are in place 7. Innovation networks and collaboration between contracting parties **DATA IMPROVEMENTS** 8. Tow by tow data availability 9. Improvement of data quality. Currently many data sources with poor quality. Better a single good source.	**WORKLOAD** 1. SC involvement (with the same SC members participation)in several Working Groups 2. A lot of work for a few people. Such work is not valued adequately and it is difficult to recruit new researchers 3. Very long meetings (15 days). It is very difficult to render 100% so long 4. Decreasing quality of work **UNREALISTIC REQUESTS** 5. The Fisheries Commission makes its requests without allocating means (people and money) to carry them out 6. Development of new PAF (Precautionary Approach Framework) 7. Implementation of the new NAFO Convention applying an ecosystem approach to fisheries management "including the ecosystem considerations within the provision of advice" **LOST EXPERTISE** 8. Unavailability of knowledgeable SC members 9. Potential loss of skilled people and long term experience as they retire **LIMITED SUPPORT** 10. Limited funding to attend the meetings 11. Lack of involvement of many contracting parties. In many meetings there are only 3 or 4 contracting parties **LOST OF SC AUTONOMY** 12. The SC should not have extra pressure to do its job and make its own decisions. 13. Need to rely on external expertise to advance work on MSE and harvest control rules for key stocks threatens ability for

10. Increasing new technology for better data interchange between researchers **REVIEW OF SC OUTCOMES** 11. Annual Scientific review (as with the Annual Compliance review from STACTIC) 12. Review of the quality of work of the SC. 13. To continuously improve the capacity of the assessments and analyses, and of the advice provided. **STRENGTHENING HUMAN RESOURCES** 14. Possibility to involve external scientists to improve the assessments. 15. New convention may lead to increased support from contracting parties to support the work of SC by assigning new/more staff to work on SC assessments and special requests/projects 16. New/junior participants to SC could bring knowledge of new methods for stock assessment 17. NAFO training courses 18. Council members to learn from each other. 19. Mentoring role for the most experienced scientists to teach others (which they do through the routine work) 20. Can attract reputable scientists to come and present, review, etc as NAFO offers them an opportunity to exchange with many experts at once.	ongoing/consistency of assessments i.e. we will have to regularly rely on external people to run the models

- Main SC strengths identified were: high dedication, knowledgeable and valuable SC members and well established working methods that give high quality final outputs.

- SC recognized the following weaknesses: Lack of critical mass, low external participation, high workload particularly considering the lack of human resources, the delay in the availability of the reports and the high internal standards on the working processes.

- The following opportunities were identified: the optimization of available resources, the development of a strategic research plan, increasing cooperation, data improvements, the review of the SC outcomes and the strengthening of human resources.

- Main threats are: High workload, non-realistic requests if considering capabilities of SC, the (past and upcoming) loss of expertise, the limited support in terms of financial and in human resources particularly from some Contracting Parties and the loss of SC autonomy.

This SWOT analysis has to be considered as work in progress. Responses from SC members will continue shaping the inputs, together with the identification of targets, how to achieve them and a deeper analysis will be carried out to provide a final strategic scientific plan in September 2018.

2. Coastal States

a) Request by Denmark (on behalf of Greenland) for advice on management in 2018 of certain stocks in Subareas 0 and 1

i) Golden redfish, demersal deep-sea redfish, Atlantic wolfish and spotted wolfish

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 2014 given for 2015-2017. Denmark (on behalf of Greenland) requests the Scientific for advice on these species.

Scientific Council responded:

Demersal Redfish in Subarea 1 Advice June 2017 for 2018-2020

Recommendation for 2018 - 2020

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

Management objectives

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

Management unit

These two species are managed 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.

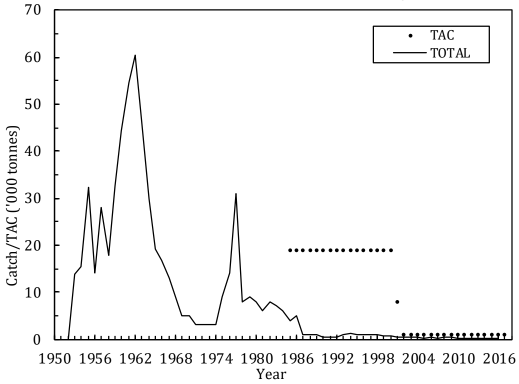
Stock status

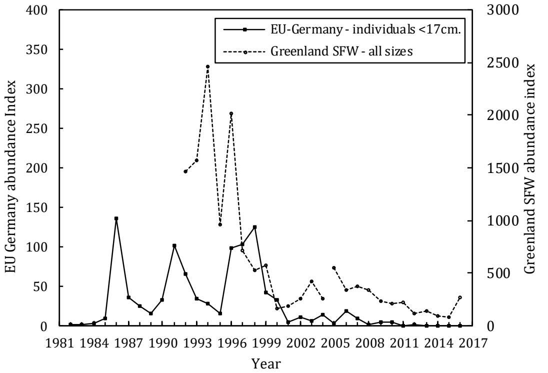
Golden redfish

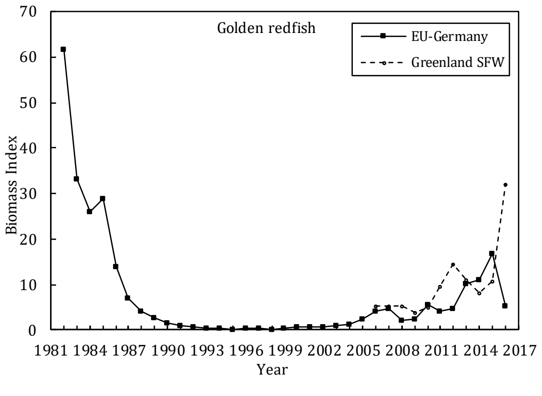
The EU-Germany and Greenland Shrimp and fish survey have revealed increasing biomass of golden redfish in the recent decade but divergent trends in 2016. However, the EU-Germany survey had low coverage in 2016. The EU-Germany survey is however still far below the 1980s biomass index, which was before the Greenland shrimp and fish survey was initiated. In the Greenland shrimp and fish survey, virtually no new incoming year classes have been observed since 2011 in West Greenland or in East Greenland waters in the recent 4-6 years.

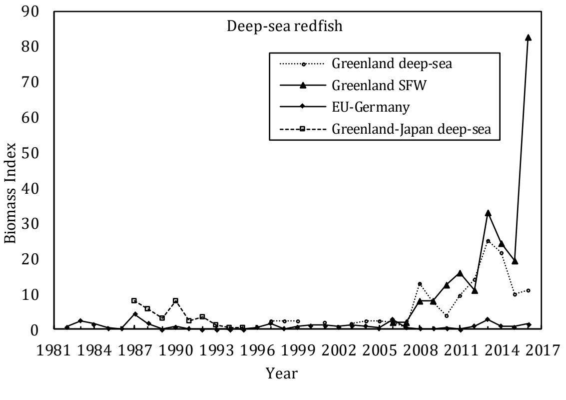
Deep-sea redfish

The Greenland-Japan survey indicates that the biomass decreased from 1987 to 1995. The Greenland deep survey indicates 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 has gradually been increasing since 2008. Recruitment has been at a very low level in the area for almost 2 decades. In the Greenland shrimp and fish survey, virtually no new incoming year classes have been observed since 2011 in West Greenland or in East Greenland waters in the recent 4-6 years.









Reference points

Could not be established.

Assessment

No analytical assessment was performed. Biomass and abundance indices from surveys were considered the best source of information.

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 historic 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 bycatch has been reduced.

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

	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
TAC	1	1	1	1	1	1	1	1	1	1	1
STATLANT 21	0.3	0	0.02	0	0.2	0.12	0.16	0.25	0.19	0.16	
STACFIS	0.3	0.4	0.4	0.3	0.2	0.16	0.17	0.17	0.26	0.17	

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.

Special comments

The increasing biomasses of both redfish species observed in the surveys 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.

Sources of Information

SCR Doc. 17/015 021 039 and; SCS Doc. 17/08.

Wolffish in Subarea 1 Advice June 2017 for 2018-2020

Recommendation for 2018 - 2020

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

Spotted wolffish: The Scientific Council advises that the TAC should not exceed 975 tonnes.

Management objectives

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

Management unit

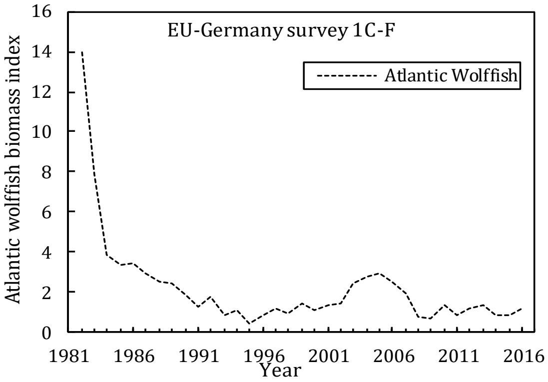
Atlantic wolffish is known to be more connected to the offshore banks in South and West Greenland and is considered a single unit.

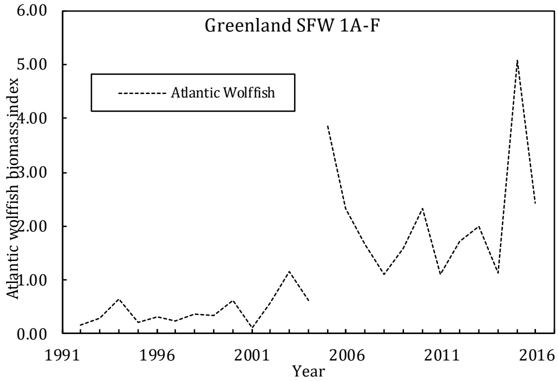
Spotted wolffish is found in all areas both inshore and offshore, but is known to be the dominating species in the coastal regions and the fjords in South, West and North Greenland. It is presumed to be a single stock.

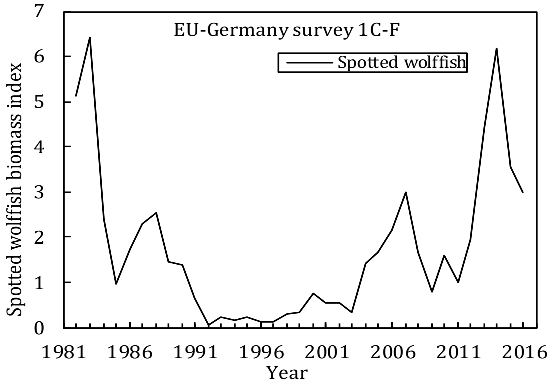
Stock status

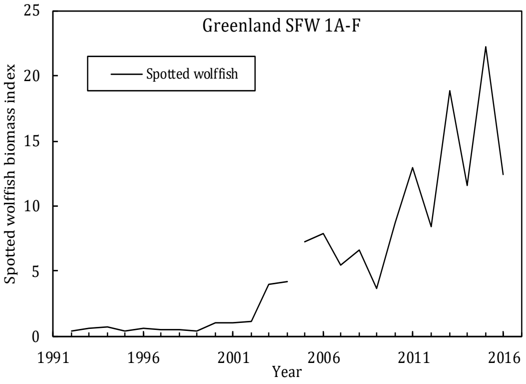
Atlantic wolffish: The biomass indices of the EU-Germany survey is far below the initial values.

Spotted wolffish: There is no sign that the recent decrease in the landings was caused by a decrease in the stock. The average of the EU-Germany survey biomass index for the recent 3 year is near the same level as in the 1982-1984 period. The Greenland Shrimp and fish survey biomass index average for the recent 3 years, is 19% higher than the prior 4 year period.









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 and historic 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

Wolffish are primarily taken in a directed longline fishery or as a bycatch in longline, gillnet or trawl fisheries. The proportions of Atlantic 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 (tonnes) are as follows:

	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Atlantic wolffish TAC								1.0	1.0	1000
Spotted wolffish TAC								1.025	1.025	1025
Wolffish TAC	1.0	1.0	1.0	1.0	1.0	1.0	1.0	2.025	2.025	2025
STATLANT 21	1.2	.05	0.009	.8	1.0	.9	.9	0.4	0.2	
STACFIS	1.2	1.1	1.3	.8	1.0	.9	.9	0.4	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.

Special comments

For spotted woffish, the ICES Harvest Control Rule 3.2 for data limited stocks was used as a basis for giving TAC advice (mean survey index y_{1-3}/mean y_{4-7}=1.19). The survey index used was the Greenland survey as its distribution was appropriate to the distribution of the stock. The 1st year 'precautionary buffer' of 20% reduction was applied.

Sources of Information

SCR Doc. 17/015 036 and; SCS Doc. 17/08.

ii) Greenland halibut in Div. 1A (inshore)

Advice on Greenland halibut in Division 1A inshore was in 2016 given for 2017 and 2018. Denmark (on behalf of Greenland) requests Scientific Council to continue to monitor the status, and should significant changes in the stock status be observed the Scientific Council is requested to provide updated advice for Greenland halibut as appropriate.

Scientific Council responded:

> The assessment (interim monitoring) found nothing to indicate a significant change in the status of this stock. Accordingly, Scientific Council therefore did not change the advice. The next full assessment of this stock will take place in 2018.

iii) Pandalus borealis east of Greenland and in the Denmark Strait (in conjunction with ICES) (Item 5)

Furthermore, the Scientific Council is in cooperation with ICES requested to provide advice on the scientific basis for management of Northern shrimp (Pandalus borealis) in Denmark Strait and adjacent waters east of southern Greenland in 2018 and for as many years ahead as data allows for.

The Scientific Council deferred responding to this request to the SC/NIPAG meeting in September 2017.

Request by Canada and Denmark (Greenland) for Advice on Management in 2016

i) Greenland **halibut** *in Div. 0A and the offshore areas of Div. 1A, plus Div. 1B (Annex 2, Item 3; Annex 3, Item 1)*

For Greenland halibut in Subareas 0 + 1 advice was in 2016 given for 2017 and 2018. Subject to the concurrence of Canada as regards Subareas 0 and 1, the Scientific Council is requested to continue to monitor the status, and should significant changes in the stock status be observed, the Scientific Council is requested to provide updated advice for Greenland halibut as appropriate in 1) the offshore areas of NAFO Division 0A and Division 1A plus Division 1B and 2) NAFO Division 0B plus Divisions 1C-1F. The Scientific Council is also asked to advise on any other management measures it deems appropriate to ensure the sustainability of these resources.

Scientific Council responded:

> The assessment (interim monitoring) found nothing to indicate a significant change in the status of these stocks. Accordingly, Scientific Council therefore did not change the advice. The next full assessment of this stock will take place in 2018.

ii) Pandalus borealis in Subareas 0 and 1

Subject to the concurrence of Canada as regards Subarea 0 and 1, Denmark (on behalf of Greenland) requests the Scientific Council before December 2017 to provide advice on the scientific basis for management of Northern shrimp (Pandalus borealis) in Subarea 0 and 1 in 2018 and for as many years ahead as data allows for.

The Scientific Council deferred responding to this request to the SC/NIPAG meeting in September 2017.

VIII.REVIEW OF FUTURE MEETINGS ARRANGEMENTS

1. Scientific Council, 18 – 22 Sep 2017

Scientific Council noted the Scientific Council meeting will be held at the Montréal Marriott Château Champlain in Montreal, Quebec, Canada, 18-22 September 2017.

2. Scientific Council, (in conjunction with NIPAG), 27 Sep – 04 Oct 2017

Scientific Council noted that the Scientific Council shrimp advice meeting will be held in Lysekil, Sweden, 27 September-04 October.

3. WG-ESA, 7- 16 Nov, 2017

The Working Group on Ecosystem Science and Assessment will meet at the NAFO Secretariat, Dartmouth, Nova Scotia, Canada, 7-16 November, 2017.

4. 3M Cod benchmark meeting, 9-13 April 2018

The location of this meeting is tentatively Lisbon, Portugal.

5. Scientific Council, June 2018

Scientific Council agreed that its June meeting will be held on 1 – 14 June 2018, at Saint Mary's University, Halifax.

6. Scientific Council (in conjunction with NIPAG), 2018

This meeting will be held at the NAFO Secretariat, dates to be determined.

7. Scientific Council, Sep 2018

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

8. Scientific Council, June 2019

Scientific Council agreed that its June meeting will be held 31 May - 13 June 2019. at Saint Mary's University, Halifax.

9. NAFO/ICES Joint Groups

a) NIPAG, 27 Sep – 04 Oct 2017

Scientific Council noted the NIPAG meeting will be held in Lysekil, Sweden, 27 September-04 October

b) NIPAG, 2018

This meeting will be held at the NAFO Headquarters, Dartmouth, Dates to be decided.

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

It is planned that this meeting will be held in NAFO headquarters, dates to be decided

d) WG-HARP, 2017

WG-HARP will continue its work by correspondence. The dates and location of the next meeting are undecided.

10. SC-COM joint working groups

a) WG-EAFFM

Will be held in NAFO headquarters 14 July 2017.

b) WG-RBMS

Will be held in NAFO Headquarters 11-13 July 2017.

c) WG-BDS

Will be held in NAFO headquarters 10th July 2017.

IX.ARRANGEMENTS FOR SPECIAL SESSIONS

1. Topics for Future Special Sessions

There were no proposals for a symposium.

X.MEETING REPORTS

1. Working Group on Ecosystem Science and Assessment (WG-ESA)

The NAFO SC Working Group on Ecosystem Science and Assessment (WGESA), formerly known as SC Working Group on Ecosystem Approaches to Fisheries Management (WGEAFM), had its 9th meeting on 7-17 November 2016 at the offices of Instituto Português do Mar e da Atmosfera (IPMA) in Lisbon, Portugal.

The work of WGESA can be described under two complementary contexts:

a) work intended to advance the Roadmap, which typically involves medium to long-term research, and

b) work intended to address specific requests from Scientific Council (SC) and/or Fisheries Commission (FC), which typically involves short to medium-terms analysis, aligned to roadmap priorities.

WGESA revised and up-dated its long-term ToRs in 2016 to be implemented at its 2017 meeting and thereafter, accordingly:

Theme 1: Spatial considerations

ToR 1. Update on identification and mapping of sensitive species and habitats in the NAFO area. In support of the Roadmap develop research and summarize new findings on the spatial structure and organisation of marine ecosystems with an emphasis on connectivity, exchanges and flows among ecosystem units in the NAFO Convention Area.

Theme 2: Status, functioning and dynamics of marine ecosystems

ToR 2. Develop research and summarize new findings on the status, functioning, and productivity of ecosystems (including modelling multi-species interactions) in the NAFO Convention Area.

Theme 3: Practical application EAFM

ToR 3. Develop research and summarize new findings on long-term monitoring of status and functioning of ecosystem units (including ecosystem summary sheets) and the application of ecosystem knowledge for the assessment of impacts and management of human activities in the NAFO Convention Area.

Theme 4: Specific requests

ToRs 4+. As generic ToRs, these are place-holders intended to be used when addressing expected additional requests from Scientific Council or Fisheries Commission that don’t fit in to the standing ToRs above.

The following ToRs were addressed at the 9th meeting of WGESA:

Theme 1: Spatial considerations

***ToR 1.1**. New preliminary data on VME in NAFO regulatory area (divs. 3LMNO) from bottom trawl groundfish surveys: 2016 from the EU and EU-Spanish surveys, and 2015 from the Canadian multispecies surveys.*

***ToR 1.2**. Update on the work of the Joint ICES/NAFO Working Group on Deep-water Ecology (WGDEC) – update from WGDEC Chair*

***ToR 1.3.** Update where appropriate boundaries of ecosystem- based management areas.*

***ToR 1.4**. Preliminary results of 2015 Canadian in situ photographic survey in the NAFO Regulatory Area*

***ToR 1.5**. Preliminary results of 2016 Canadian in situ photographic survey on Kelvin Seamount and review of available data in the context of seamount conservation*

Theme 2: Status, functioning and dynamics of marine ecosystems

***ToR 2.1.** Progress of analysis undertaken by EU NEREIDA funded research project [FC Request 6]*

***ToR 2.2.** Approaches for analysing VMS data to determine actual fishing effort and swept area impacts [FC Request 6]*

***ToR 2.3**. Updated analysis on Guidelines for Total Catch Ceilings (TCC) in NAFO Ecosystem Production Units (EPUs)*

***ToR 2.4**. Flemish cap multi-species model*

Theme 3: Practical application EAFM

***ToR 3.1**. Develop draft summary sheets at ecosystem level.*

***ToR 3.2**. Continue progression on the review of the NAFO PA Framework, [FC Request 7]*

***ToR 3.3**. Assess the overlap of NAFO fisheries with VME to evaluate fishery specific impacts in addition to the cumulative impacts. [FC Request 6]*

***ToR 3.4.** Consider clearer objective ranking processes and options for objective weighting criteria for the overall assessment of risk [FC Request 6]*

***ToR 3.5.** Maintain efforts to assess all of the six FAO criteria including the three FAO functional SAI criteria [FC request 6]*

***ToR 3.6.** Continue to work on non-sponge and coral VMEs (for example bryozoan and sea squirts) to prepare for the next assessment. [FC Request 6]*

***ToR 3.7.** Develop and compile identification guides for fishes (e.g. sharks and skates) that could be provided to observers. [FC Request 6]*

***ToR 3.8**. Plan to continue work on the risk assessment of scientific trawl surveys impact on VME in closed areas, and the effect of excluding surveys from these areas on stock assessments. [FC Request 3].*

***ToR 3.9**. Development in the use of non-destructive sampling techniques to monitor VMEs and options for integrating with existing survey trawl data. (General discussion)*

Theme 4: Specific requests

***ToRs 4+.** No requests other than those already identified and addressed above*

In addressing ***ToR 1***, an up-date of VME biomass records from Spanish trawl surveys in 2016 and Canadian trawl surveys in 2015 was made. It was noted that the VME polygon analysis using KDE analysis conducted in 2014 should be up-dated to include all the recent data from 2014 – 2016 surveys. The results of the updated VME KDE polygon analysis would be assessed at WGESA in 2017. Canadian research *in situ* photographic surveys in the NAFO Regulatory Area conducted in 2015 and 2016 demonstrate the utility of photographic techniques in quantifying VME species abundance under different habitat conditions, including impacts of fishing which was noted to be particularly important in further quantifying the functional criteria required in support of assessing SAI and the reassessment of bottom fisheries in 2021. New survey data from the New England 'Kelvin' seamount lying outside of the current closure shows an abundance of VME indicator species, notably large gorgonians and associated epifauna. In accordance with SC advice (NAFO 2014, p82), seamount closure boundaries should be revised to take account of seamount features at water depths < 2000 m which currently fall outside current closures. A possible extension to the New England Seamount closure to include the full extent of the 'Kelvin' seamount and to link with the existing US Northeast Canyons and Seamounts Marine National Monument marine closed area (Figure 1)

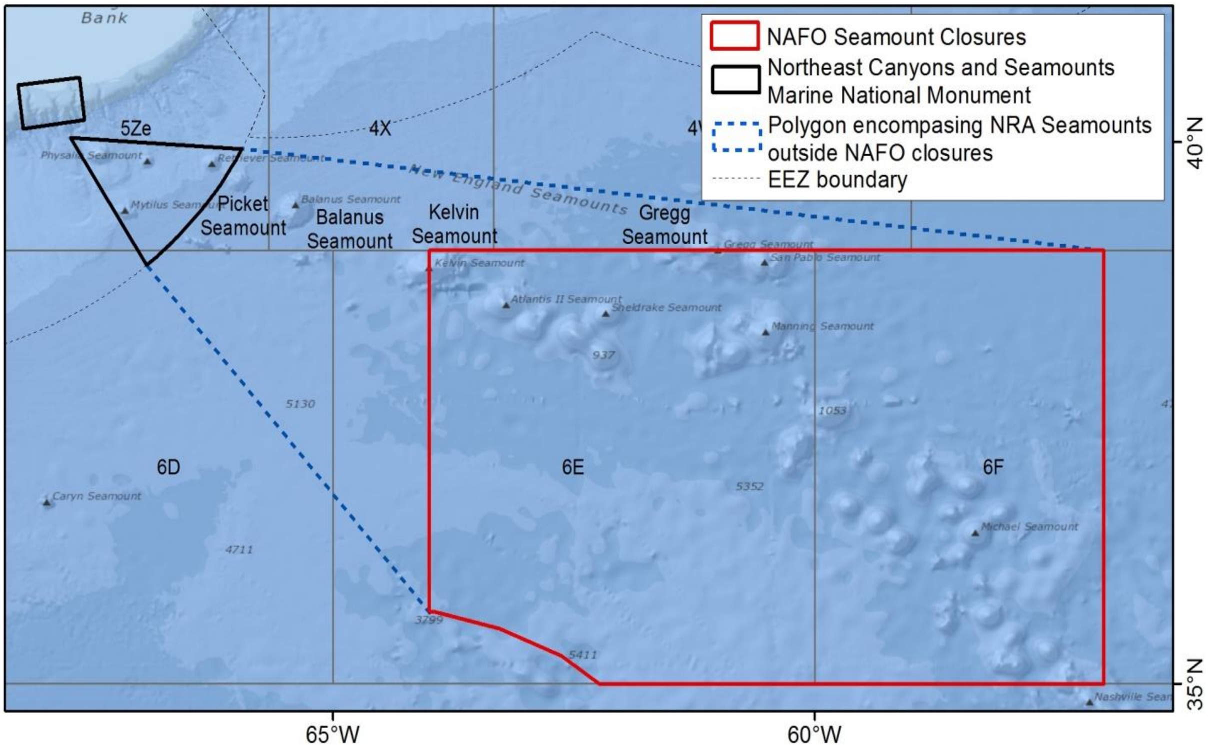


Fig. 1. NAFO Seamount Closures and Northeast Canyons and Seamounts Marine National Monument approved by the U.S. on September 15, 2016 (http://www.noaa.gov/news/first-marine-national-monument-created-in-atlantic). A polygon encompassing the seamounts of the NRA belonging to the New England complex and outside of the currently NAFO seamount closures is overlaid.

In addressing ***ToR 2*** WG-ESA worked to provide an updated analysis of the guidelines for Total Catch Ceilings (TCC) based on the report from SC June 2016 (NAFO 2016). Ecosystem production potential (EPP) models provide a minimum realistic food web representation of the flow of energy and production in a marine ecosystem. The refined model includes three major paths for energy flow: the pelagic component (traditional diatom-mesozooplankton-planktivore-piscovore path for energy transfer); the benthic component (includes suspension and deposit feedings, benthivores and piscivores); and the microbial loop (nana-pico phytoplankton, bacteria, flagellates and microzooplankton). Model performance was evaluated through a sensitivity analysis in which various pathways of energy flow were altered to evaluate the importance of their inclusion in model predictions. Uncertainty was included through Monte Carlo procedures applied to empirically derived distributions energy partitioning or transfer efficiency. Production along the pelagic pathway is highly correlated, while production along the benthic pathway is more diffuse. The microbial loop has a key role in supporting benthic production but has a minor role in supporting pelagic production. The dual channel of energy into the benthic pathway that benthic production (detritus to deposit feeders, and microplankton to suspension feeders) leads to complex responses to changes in production at lower trophic levels. Reduction of primary production expected under climate change reduces overall productivity in both pelagic and benthic pathways, with a major reduction in SF benthos and non-trivial reductions in benthivores and piscivores. Shifting towards nano-picoplankton, also anticipated under climate change, slightly enhances total heterotrophic production but the increase only translates into an important increase in microzooplankton production rather than upper trophic levels. The combined effects of lower production and a shift toward smaller phytoplankton would compound the potential impact of climate change by reducing fraction of what can be sustainably harvested because a lower fraction of total primary production fuelled by nitrate (new production).

Fishery production potential (FPP) was estimated based on the Rosenberg et al. (2014) who defined Maximum sustainable exploitation rate as $F=0.2$ (assuming 50% of pelagic production and 10% of suspension and deposit feeding benthos are from species of commercial value). Although the "low probability" of exceeding FPP is not defined in the NAFO PA framework, the 25% percentile of the distribution of simulation results can be used to define a Total Catch Ceiling (TCC) to ensure a low probability of exceeding ecosystem sustainability. The median of the distribution can provide an indication that total catches are highly likely to exceed sustainability levels. Penalties to TCCs can be applied in ecosystem production units (EPU) in which total biomass of higher trophic levels are well below historical levels. SC is pursuing EAF pilot exercises for the Newfoundland Shelf (2J3K), Grand Bank (3LNO), and Flemish Cap (3M) EPUs. TCCs were initially considered for the standard demersal components (SDC – all groundfish, shrimp and crab) and other fisheries (pelagics, suspension and deposit feeders). Although in all systems, current total catches are at or below the proposed TCC for the SDC aggregate, time series of catches shows that total were above the proposed LRPs in the 2000s. However, the SDC may mask imbalances between benthivores and piscivores, so the TCC was disaggregated based on the diet composition of the constituent species. This revealed that current catch levels currently within the sustainability envelope in the 2J3K and 3LNO EPUs but with little space for growth with perhaps the only exception of piscivores in 2J3K (Figure 2). In the 3M EPU, the overall catches at the SDC aggregate level appears well within sustainable bounds, this catch is severely biased towards piscivores (Figure 2). Sustainability at the ecosystem level may be in jeopardy. The results for 3M EPU indicate that considerations of multispecies interactions are required to properly assess the sustainability of the current catch levels.

Furthering implementation of Tier 1 of the Roadmap (i.e. TCC implementation) requires that cumulated TACs (and total catches) be routinely compiled, presented, and considered as part of the management process.

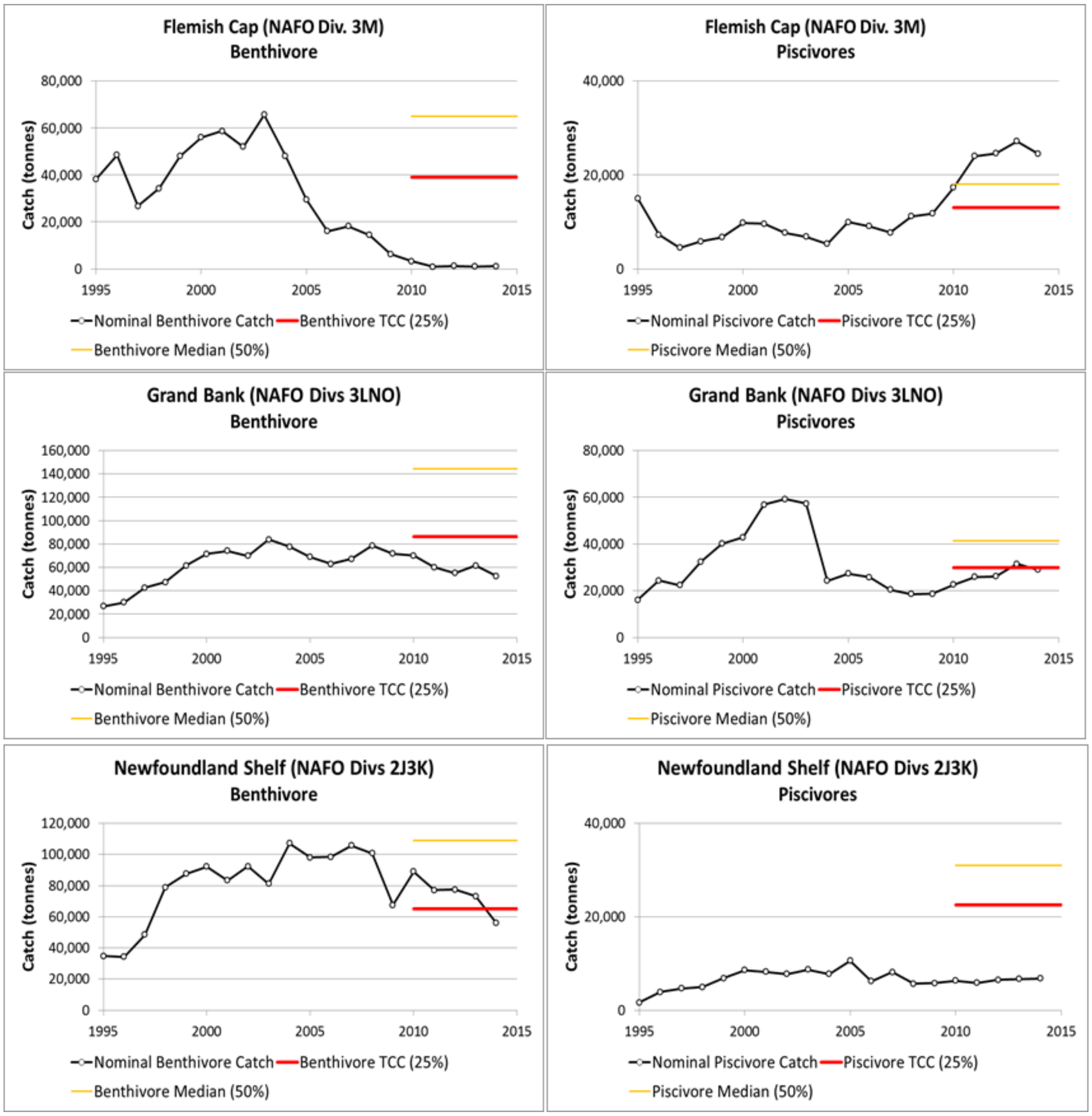


Fig. 2. Time series of catches from the Flemish Cap (NAFO Div. 3M), Grand Bank (NAFO Div. 3LNO) and Newfoundland Shelf (NAFO Div. 2J3K) for benthivores and piscivores. The total catch ceilings (25th percentiles of the projections) and the median projected catch for each component are presented in each panel.

In addition, WG-ESA under ***ToR 3*** progressed the development of the Flemish cap multi-species model. The development of multispecies models is a key requirement in delivering an Ecosystem Approach to Fisheries Management in the NAFO area. GadCap is a gadget multispecies model including the Flemish Cap cod, redfish and shrimp. In this work GadCap is used to explore the consequences in the yield and dynamic of these three interconnected stocks if different fishing scenarios would have been applied during the period 1988 - 2012. The influence of this management strategy in predation interactions and recruitment processes are assessed and compared with the observed trends for all three stocks. The results suggest that the collapse of cod wouldn´t have been avoided by reducing only the fishing pressure, but a different size selectivity would have been required as well. The higher level of biomass of cod would have led to lower biomass in redfish due to predation mortality, while the increase observed in shrimp in the mid-late 1990s would not have been avoided by any fishing scenario as result of the exceptional high recruitments and the low abundance of redfish. Improvements in the modelled interactions of cod-redfish would likely reduce the modelled cod predation mortality on redfish. The multispecies model allows the effect of different management strategies in specific and total yield in a system of strongly interconnected commercial species to be evaluated, and can be used to estimate adaptive reference points (F_{msy} and SSB_{msy}) under different environmental situations.

Also under ***ToR 3*** and in response to an SC request WG-ESA has initiated the development of ecosystem summary sheets (ESS). An initial framework for completion in 2017 has been proposed with summaries to consist of two elements. The first is based on measures of state (i.e. oceanographic, production, ecological features) and species interactions within each of the major Ecosystem Production Units that have been the focus of WGESA activities (i.e. Flemish Cap, Grand Banks, and Newfoundland Shelf). The second based on the relationship of the state variables relative to management framework and objectives. The design of the ESS aims to mirror the basic objectives that underlie the structure of the stock summary sheets. The ESS design must recognize how environmental conditions and ecosystem structure affect NAFO's ability to report on the objectives of the Convention. Ecosystem summary assessments should be carried at medium-term intervals (3-5 years).

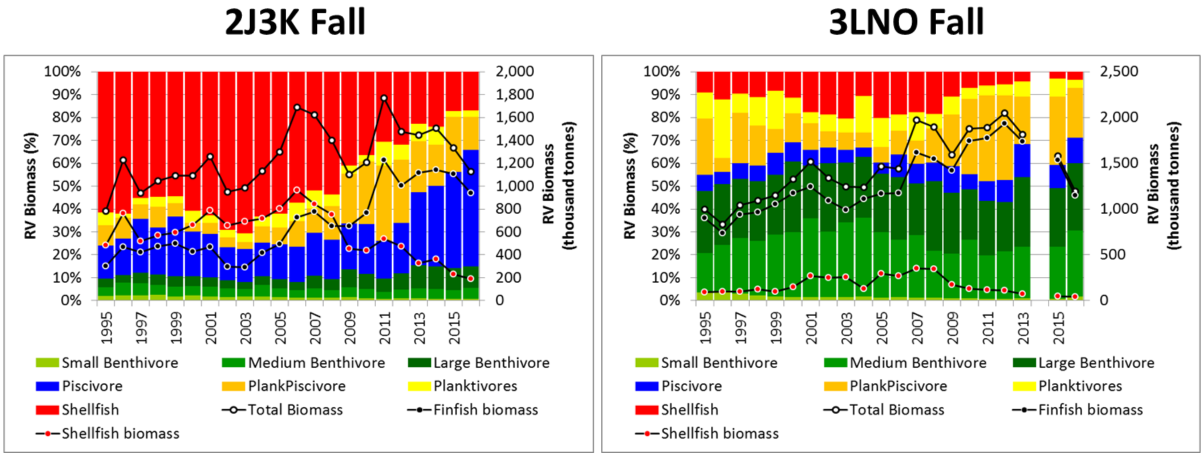
Six general principles based on the NAFO Convention were considered to define the essential components of the ESS: 1) Long-term sustainability of fisheries resources; 2) Integration of knowledge across trophic levels to ensure producing maximum ecosystem yield; 3) Take due account of the need to preserve marine biological diversity; 4) Application of the precautionary approach in accordance with Article 6 of the 1995 Agreement; 5) Minimize harmful impacts on ecosystems (e.g. protection of VMEs, benthic ecosystems, species of concern); and 6) Take due account to minimize impact of human activities on the marine ecosystem.

In 2017, WGESA will work to: 1) refine contributing elements and definitions for each objective; 2) Define limit reference metrics and reference periods (when applicable) for each contributing elements; and 3) Apply principles to case study in one EPU to identify issues with implementation and reporting.

Also under ***ToR 3*** WG-ESA considered a draft document from the PAF Working Group as the basis for discussion, concentrating on the section dealing with the PAF in the context of an ecosystem approach to management. Although low attendance at the WG meeting limited the breadth of the discussion and assessment of Ecosystem level PA principles, WG-ESA did identify several important issues. Precautionary approach as defined under the FAO guidelines are closely aligned with the Ecosystem Approach and NAFO "roadmap" could therefore be viewed as a tool for implementation of the PA at the Ecosystem Level because of the tiered approach to identifying limits and status at the ecosystem, multispecies and single species levels. Total Catch Ceiling (TCC) could be used to set a reference point for exploitation at the ecosystem level (Tier 1) based on FPP but further discussion is required to define the limit reference point (currently the 25th percentile of the frequency distribution from FPP calculations), as well as consideration of the changes in underlying state of the system (e.g. regime). From the perspective of single species stock assessment (Tier 3): more can be added to the NAFO PA to include a multi-species perspective in defining single species LRP, noting that the sum of single species stocks MSY within an ecosystem is often larger than the multi-species MSY for the same ecosystem. The stock-specific MSY from the multispecies perspective (Tier 2) will be a function of the specific multispecies objectives for the ecosystem but the available multi-species models are not sufficiently developed to guide detailed partitioning of catches within a multi-species PAF.

To date, WG-ESA has: 1) demonstrated the robustness of the delineation of Ecosystem Production Units (EPUs); 2) provided a comprehensive assessment of reliance of predictions on food web complexity and structure that should represent an essential foundational element that delimits overall production potential of higher trophic levels; and 3) reviewed a number of multispecies models for the NAFO region. Continued development of the NAFO Roadmap to EAM is closely linked to the review of the PAF and development of the Ecosystem Summary Sheets. This will require development of clear definitions of ecosystem and multispecies level objectives, or at least underlying principles desired by NAFO, in order to advise on precautionary principles and metrics that would serve to identify or limit risk and/or avoid harm. This can only be achieved with increased participation of individuals with quantitative capacity/skills from Contracting Parties, limit turnover of WG-ESA membership to allow development of multi-year goals, and ensure more extensive participation of WG-ESA members in the June SC meeting.

The importance of progressing on ecosystem and multi-species considerations is highlighted by the important changes noted in the Fall Canadian ecosystem survey which reveal important declines in finfish biomass in NAFO Div. 3LNO (~40% of the 2010-2013 level) and evidence of the onset of a declining trend in finfish abundance in NAFO Div. 2J3K (Figure 3). A similar trend was noted from the Spring Canadian ecosystem survey, which noted ~31% decline in finfish biomass from 2014 to 2016, and the summer EU survey of 3NO which noted a 74% decline in total finfish biomass since 2010.



2J3K Fall

3LNO Fall

Fig. 3. Time series of total, finfish and shellfish biomass (lines – see legend) estimated from Canadian surveys conducted in the fall from 1995-2016 from Ecosystem Production Units 2J3K and 3LNO. Bar graphs provide the relative biomass composition of functional feeding groups.

Finally, under ***ToR 3*** there was a discussion on non-destructive sampling techniques of VME. This is especially important considering that RV survey trawl sampling in VME closed areas is likely to become more limited in the future. Non-destructive sampling techniques include the use of underwater camera-based systems, but there would be trade-offs to consider in regard to obtaining adequate biological sampling. Another consideration was whether calibration of non-destructive surveys with bottom trawl surveys was possible to enable a combined series of data for monitoring purposes. The WG suggested an *ad hoc* WG could be established to explore the feasibility of non-destructive monitoring surveys with the aim of developing objectives for future monitoring as well as, to the extent possible, enable meaningful comparisons to existing bottom trawl surveys. Experts with experience of both sampling methods should be sought for the group.

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

On 20th March 2017, the joint ICES/NAFO Working Group on Deep-water Ecology (WGDEC), chaired by Neil Golding (UK) and attended by fourteen members (ten in person and four via WebEx video conferencing), met at ICES HQ, Copenhagen, to consider the Terms of Reference listed in Section 2.

WGDEC was requested to provide all new information on the distribution of vulnerable marine ecosystems (VMEs) in the North Atlantic. A total of 1193 new records were submitted through the ICES VME data call in 2017 and included within the ICES VME database; 44 for the NEAFC Regulatory Area (RA) and 1150 for the EEZs of ICES Member Countries. No records originated in the NAFO regulatory area. A substantial contribution of new information on VMEs was made by Iceland, with 949 VME indicator records submitted. With respect to new information relating to VMEs within the NEAFC RA, these records originated from two areas; the Hatton-Rockall Basin and Rockall Bank. There were three new observations of *bona fide* VME from the Hatton-Rockall Basin; a recommendation to extend the current Hatton-Rockall Basin bottom fishing closure was made. New VME indicator records were submitted for Rockall Bank; no recommendations were made to modify existing or recommend new closures.

For the first time, and for all areas considered by WG-DEC, all records from the VME database were presented as outputs from the VME weighting system, showing the likelihood of VMEs being encountered on the seabed along with an associated confidence assessment.

A member of the ICES Working Group on Spatial Fisheries Data (WG-SFD) worked with WGDEC and analyzed NEAFC VMS data from 2016. Plots of fishing effort for mobile bottom contact gear and static gear are shown for key areas where vulnerable seabed habitats are known to exist. Separate plots have also been shown for those vessels with no gear type registered.

The process by which WG-DEC considers new information on VMEs, identifies sensitive areas of the seabed, and if appropriate, proposes boundaries around these sensitive habitats has been outlined. A flow chart has been developed which neatly summarizes the process from beginning to end.

WG-DEC undertook an extensive review looking at the current understanding and knowledge of the connectivity of deep-sea populations, with a view to the management of deep-sea ecosystems.

WG-DEC commenced the development of a 'road map' to start exploring the concepts and outline the process for evaluating Good Environmental Status (GES) under the Marine Strategy Framework Directive. Work will continue during WGDEC 2018.

Finally, WG-DEC reported on the distribution of VME indicators and habitats with the Haddock Box closure, as well as reviewing the appropriateness of NEAFC bottom fishing closures defined in Annex 2 of NEAFC Regulation 19:2014. All closures were considered appropriate, but WGDEC stressed that this may be subject to change as new information on VME distribution comes to light in future.

3. Joint FC-SC Working Group on Risk Based Management Strategies (WG-RBMS)

Two of WG-RBMS were held in the first half of 2017: the first (07-09 February 2017, NEAFC Secretariat, London, UK) was the regularly scheduled meeting of this working group covering a range of business while the second (25-27 April 2017 Falmouth, MA, USA) was convened as an additional meeting to address matters relating to the Greenland halibut management strategy evaluation (MSE).

a) WG-RBMS meeting, 07-09 February 2017, NAFO Secretariat, Dartmouth, NS, Canada

The February meeting addressed four substantial agenda items: the timeline for the Revision of the NAFO PA Framework, the work Schedule for the 3M cod benchmark assessment, the Greenland halibut MSE and Recommendations to forward to FC and SC .

Timeline for the Revision of the NAFO PA Framework

A review of the work completed to date as well as the elements requiring study within Precautionary Approach Framework (PAF) was tabled. With respect to timelines, it was clear that many items which were intended to be completed by this time remain outstanding. Prior to the meeting of this WG scheduled for the summer, the chair of the PAF WG will consult with WG members on both capacity and revised timelines, and will report back to the this WG.

Work Schedule for the 3M Cod Benchmark Assessment

The work plan previously agreed to by this WG in April 2016 was modified during the Annual Meeting in September 2016. The timeline for the NAFO 3M Cod Benchmark Assessment and the NAFO 3M Cod Management Strategy Evaluation (MSE) have been delayed one year reflecting the priority attached to the Greenland halibut MSE review. The updated work schedule is presented in Annex 3 of FC-SC doc. 17-02.

Greenland halibut (GHL) Management Strategy Evaluation (MSE) Review

As part of the ongoing work detailed in the WG-RBMS developed a table containing a list of objectives (derived from the NAFO Convention objectives defined in resolution NAFO/GC Doc. 08-03), together with examples of what their potential corresponding Performance Targets (PT) might look like (See Table 1, FC-SC doc. 17-02).

WG-RBMS proposed the following guidelines intended to assist with the development of management procedures:

General

The SC must advise what data (e.g. survey-based abundance estimates, catches) may be considered for input to management strategies/HCR i.e., as well as which metric (exploitable biomass or total biomass or abundance) to evaluate.

Restrictions to minimum/maximum changes in the TAC in terms of percentages and absolute numbers should be considered either as part of the HCR or as part of a suite of performance statistics (there is an initial preference for the former because it provides a degree of certainty for the industry). These restrictions may differ depending on the direction of the change and/or status of the stock.

Recent annual catches (and specifically their differences from the TAC intended) should also be considered as possible inputs (i.e. implementation error) bearing in mind the difficulties in estimating catches.

For empirical HCRs

Several alternative forms of empirical HCRs should be considered.

Management strategies/HCR might be refined by addition of surveys to serve as indices of recruitment in addition to others serving as indices of exploitable biomass.

The existing management strategies/HCR (based on the average of the recent trend in abundance indices from three surveys to adjust the TAC) should again be considered.

Variants of that management strategies/HCR which modify its control parameter values (e.g. lambda), constraints and number of years and weighting of surveys in the “trend calculations” should also be considered.

For Model based HCRs

Model based rules should take into consideration that which was tested in the first Greenland halibut management strategy evaluation (SCR 09-37).

Recommendations to forward to FC and SC

The WG-RBMS recommends Fisheries Commission to:

Consider and endorse the updated plan for the 3M cod benchmark (Annex 3).

On Greenland halibut:

The WG-RBMS recommends Scientific Council to:

Take into account the guidance on Management Objectives and the formulation of the HCRs developed by this WG.

Reflect on potential updates to the Exceptional Circumstances Protocol

The WG-RBMS commits to:

Reflect on potential updates to the Exceptional Circumstances Protocol

Further recommendations on Greenland halibut were deferred to the next meeting scheduled for April 2017.

WG-RBMS meeting 25-27 April 2017, Falmouth, MA, USA

This was convened as an additional meeting to address matters relating to the Greenland halibut management strategy evaluation (MSE). As neither the co-chairs were able to attend the April meeting, Katherine Sosebee (USA) was elected as acting Chair. The report of this meeting was not completed at the start of the June SC, however an almost complete draft was made available to SC members and the report was finalized during the course of the meeting.

The April RBMS meeting addressed matters arising from the SC Meeting, 03-07 April 2017 in Vigo, Spain, continued progress develop candidate management procedures and/or harvest control rules (HCRs), finalized management objectives and their corresponding Performance Targets and associated Performance Statistics and provided advice for the development of further candidate management procedures.

The work on the revised management procedures is planned to proceed as follows:

- The existing central Candidate Harvest Control Rules (HCRs) (SCR 17-05) will be used to identify those OMs which have the greatest impact on performance – this is called the Reference Set
- A set of Candidate Management Procedures will be developed which are:

Tuned to the $P(B_Y < 0.3\ B_{MSY}) \leq 0.10$ criterion for the 2018-2037 period, with $P(B_{2037} < B_{MSY}) \leq 0.5$ as a desirable secondary criterion

Show good performance over the Reference Set

Have investigated alternative form, i.e. aspects such as the value of the gamma parameter in the current central Candidate Harvest Control Rules (HCRs)

- Since it is time-consuming and less-user-friendly for decision-makers to list values of performance statistics and provide plots for every combination of candidate management procedure and Operating Model (OM), discretion may be used by the Scientific Council to provide:

Full output for the preferred 2 or 3 Candidate Management procedures and the baseline plus a few members of the Reference Set of OMs

Reduced output for the remainder of the OMs of the Reference Set, plus any other HCRs for all the Reference Set of OMs

Tabular and summary comparative plot statistics for the remaining OMs

- If possible, results will be circulated to SC members a few days before the start of the SC meeting for possible requests for a few additional runs
- The table of Performance Statistics and Criteria agreed proposed in the February meeting was further defined (Table 2 in FC-SC doc. 17-03)

4. Report from ad hoc Joint Working Group on Catch Reporting (WG-CR) and the Joint Fisheries Commission-Scientific Council Working Group on Catch Reporting (CDAG)

The SC Chair presented the work done to date by WG-CR and CDAG.

WG-CR met in London on 20th January in conjunction with CDAG, followed by two further meetings of CDAG held by WebEx on 20th April and 18th May. The method for the estimation of catches of priority stocks (3LMNO Greenland halibut and 3LNO American plaice) developed by CDAG in 2016 (FC-SC doc 16-02) was further refined. During the May WebEx meeting it was decided that the possibility of using this method to estimate catches of other stocks should be explored and the Secretariat was tasked with apply the method to all stocks for presentation to SC at this meeting. This is further discussed in the STAFIS report.

5. Meetings attended by the Secretariat

a) ABNJ Deep Seas Project: 2016 World Wide Review of Bottom Fisheries in the High Seas, Rome (Italy), 3–5 May 2016

Scientific Council Coordinator, Tom Blasdale, attended the Areas Beyond National Jurisdiction (ABNJ) Deep Seas Project: 2016 World Wide Review of Bottom Fisheries in the High Seas. The meeting focused on updating the World Wide Review of Bottom Fisheries in the High Seas produced in 2008 to better reflect the current situation in the deep seas.

Resumed Review Conference on the United Nations Fish Stocks Agreement, New York (USA), 23–27 May 2016

Executive Secretary, Fred Kingston, attended two (2) days of the Resumed Review Conference on the United Nations Fish Stocks Agreement, 23–24 May, 2016.

ARVI International Conference on the Future of Fisheries, Vigo (Spain), 16 June 2016

Senior Fisheries Commission Coordinator, Ricardo Federizon, gave a presentation on the protection of VMEs in the NAFO Regulatory Area at the ARVI (Cooperative de Armadores de Pesca Del Puerto de Vigo) International Conference on the Future of Fisheries.

Committee on Fisheries (COFI) - 32nd Session, Italy (Rome), 11–15 July 2016

Executive Secretary, Fred Kingston, attended the 32nd Session of COFI - Committee on Fisheries. He also chaired a side event organized by the FAO on fishery statistics.

XI.REVIEW OF SCIENTIFIC COUNCIL WORKING PROCEDURES/PROTOCOL

1. General Plan of Work for September 2017 Annual Meeting

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

2. Other matters

No other issues were raised

XII.OTHER MATTERS

1. Designated Experts

The list of Designated Experts will be confirmed at the September meeting.

2. Stock Assessment Spreadsheets

It is requested that the stock assessment spreadsheets and input data be submitted to the Secretariat as soon after this June meeting as possible. The importance of this was reiterated by STACREC.

3. Presentation of NAFO Scientific Merit Award – Mr. Eugene Colbourne

In recognition of his leadership role as STACFEN Chair from 2002 to 2006 and his many contributions to this standing committee since the early 1990’s on advancing our understanding of ocean climate conditions and hydrographic variability with linkages to NAFO managed stocks in the NRA, Eugene Colbourne (Canada) was presented the NAFO Scientific Merit Award by Kathy Sosebee the NAFO Scientific Council Chair.

“Eugene has distinguished himself through active participation and publication of research reports on numerous ocean climate and hydrographic studies throughout the Northwest Atlantic that has spanned nearly 3 decades. He continues to lead the online NAFO Ocean Climate Status Summary for the Northwest Atlantic which provides an overview of physical and biological oceanographic conditions from all major NAFO Subareas. Eugene has contributed to a number of NAFO and ICES Symposia over the years investigating a variety of aspects of fisheries environment. He has also contributed to and led numerous oceanographic missions under less than ideal working conditions in the northwest Atlantic aboard a variety of research vessels. His commitment to attend NAFO Scientific Council Meetings and contribute to various standing committees has been long-standing for over two decades along with his dedication to STACFEN. His efforts and long-time contributions to environmental monitoring and effects on fisheries within the NAFO community are greatly appreciated.

On behalf of Scientific Council and the Secretariat, we extend our sincere appreciation to Eugene and thank him for his many contributions to this Council over the years”.

4. Budget Items

Review of the budget working paper was deferred to the September meeting.

XIII.ADOPTION OF COMMITTEE REPORTS

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

XIV.SCIENTIFIC COUNCIL RECOMMENDATIONS TO GENERAL COUNCIL AND FISHERIES COMMISSION

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

XV.ADOPTION OF SCIENTIFIC COUNCIL REPORT

At its concluding session on 15 June 2017, the Council considered the draft report of this meeting, and adopted the report with the understanding that the Chair and the Secretariat will incorporate later the text insertions related to plenary sessions and other modifications as discussed at plenary.

XVI.ADJOURNMENT

The Chair thanked the participants for their hard work and cooperation, noting particularly the efforts of the Designated Experts and the Standing Committee Chairs. The Chair thanked the Secretariat for their valuable support and St Mary's University for the excellent facilities. There being no other business the meeting was adjourned at 1400 hours on 15 June 2017.

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

Chair: Andrew Cogswell Rapporteur: Gary Maillet

The Committee met at the Sobey School of Business (Unilever Lounge), Saint Mary's University, 903 Robie St., Halifax, NS, Canada, on June 2nd, 2017, to consider environment-related topics and report on various matters referred to it by the Scientific Council. Representatives attended from Canada, Denmark (in respect of Greenland), European Union (Germany (via WebEx), Portugal, Spain and the European Commission), France, Russian Federation, and USA.

1. Highlights of Climate and Environmental Conditions in the NAFO Convention Area for 2016

a) Meteorological and Ice Conditions

- The North Atlantic Oscillation index (NAO), a key indicator of climate conditions over the North Atlantic, remained in a positive phase in 2016 (+0.5 standard deviation (SD)). As a consequence, arctic air outflow in the northwest Atlantic during the winter months was lower than during the record high NAO recorded in 2015.
- The annual mean air temperature at Nuuk Weather Station in West Greenland was 2°C above the long term mean (1981-2010) in 2016.
- Surface air temperatures over much of the Labrador Sea were above normal, particularly during the summer and through the fall period.
- Annual air temperatures over Labrador (at Cartwright) were slightly below normal (-0.3°C) and over Newfoundland (at St. John's) they were 0.6°C above normal.
- Overall, 2016 ranked as the 5th warmest year (air temperature) in the 117 year time series for the Scotian Shelf and Gulf of Maine. Air temperature anomalies were positive at all 6 sites examined ranging from 0.8 SD above normal at Shearwater to 2 SD above normal at Yarmouth.
- Air temperatures were also warmer than average over the north eastern United States (NEUS) continental shelf, with enhanced positive anomalies in winter and fall period.
- Sea ice extent on the NL shelf increased substantially during the winter of 2014, with the first positive (higher than normal extent) anomaly observed in 16 years, it was about normal in 2015 but returned to below normal conditions in 2016.
- There were 687 icebergs detected south of 48°N on the Northern Grand Bank in 2016, slightly below the long term mean of 767.
- Ice coverage and volume on the Scotian Shelf in 2015 were above the 1981 – 2010 average, unlike the preceding four years (2010-2013) which had extremely low coverage and volume. In 2016, sea ice was almost entirely absent from the Scotian Shelf.

Temperature and Salinity Conditions

- Average water temperatures at Fyllas Bank Station 2 (0 - 40 m depth) off West Greenland in June/July 2016 experienced a significant increase with temperatures 1.9°C higher than the long-term mean. Salinity however, was 0.45 below its long-term mean.
- Temperatures of the North Atlantic Deep Water (NADW) to the west of Greenland are monitored at 2000 m depth at Cape Desolation Station 3 were 0.1°C above the long-term mean in 2016.
- In 2016 temperature and salinity of the Irminger Sea Water in the 75-200 m layer at Cape Desolation Station 3 was 5.44°C and 34.84, which was 0.27°C and 0.08 below the long-term mean, respectively.
- The water properties between 0 - 50 m depth at Fyllas Bank Station 4 are used to monitor the variability of the fresh Polar Water component of the West Greenland current. After a temperature decrease in 2015, 2016 experienced a significant increase to levels which have not been observed since the start of monitoring in the 1980s; with temperatures 2.12°C higher than the long-term mean. In 2016 salinity was 0.29 below its long-term mean.
- The 2016 winter convection in the Labrador Sea exceeded 2000 m making it the 4th consecutive year of increasing convection or increased production of Labrador Sea water.
- The progressive cooling of the top 2000 m, and deep and intense winter mixing during the three consecutive winters of 2013-14, 2014-15 and 2015-16 have interrupted the general warming and

stratification-building trend that has persisted in the intermediate waters of the Labrador Sea since the mid-1990s.

- Annual sea surface temperatures (SST) were mostly below normal over the eastern Newfoundland Shelf, Flemish Cap and Grand Banks, except for St. Pierre and Green Banks where they were 0.8 SD above normal.
- The annual surface temperature anomaly at Station 27 was +0.4°C or 0.5 SD above normal.
- The annual bottom (176 m) temperature anomaly at Station 27 was -0.2°C or 0.4 SD below normal.
- The annual surface salinity anomaly at Station 27 was -0.02 or -0.1 SD below normal.
- The annual bottom (176 m) salinity anomaly at Station 27 was -0.1 or -1.4 SD below normal.
- The annual water column average (0-176 m) temperature and salinity anomaly at Station 27 was +0.3°C and -0.05 or +0.7 and -0.5 SD different from normal, respectively.
- The summer area of CIL (<0°C) water on the Grand Banks, eastern Newfoundland and southern Labrador was 26.2, 26.6 and 21.7 km2 or -0.1, 0.1, -0.7 SD different from normal, respectively.
- The averaged spring bottom temperature in NAFO Div. 3P was about 3.4°C, almost 1°C (2 SD) above normal, the highest since 1984.
- The spatially averaged spring and fall bottom temperature in NAFO Divs. 3LNO was about normal at 1.5° and 1.8°C, respectively.
- The spatially averaged fall bottom temperature in 2J was 2.8°C which was 1 SD above normal.
- In 3K, the spatially averaged fall bottom temperature was 2.4°C or 0.5 SD above normal.
- A composite climate index for the NL region derived from 28 meteorological, ice and ocean temperature and salinity time series returned to slightly above normal from the 7th lowest in 67 years and the lowest since 1993 in 2015.
- During 2016, water column temperature and salinity over the Flemish Cap were mostly below normal but increased over the cold conditions of 2015. Bottom temperatures ranged from 0.2°C below normal over the shallowest areas but were above normal in deeper waters.
- SST annual anomalies on the Scotian Shelf during 2016 ranged from+0.5^{o}C (+0.5 SD) in Cabot Strait to +1.7^{o}C (+1.6 SD) in the Bay of Fundy.
- In 2016, the annual bottom temperatures anomalies on the Scotian Shelf in NAFO Divisions 4Vn, 4Vs, 4W, 4X were +0.9°C (+2.1 SD), +1.5°C (+2.1 SD), +1.7°C (+2.3 SD) and +1.9°C (+2.6 SD) above normal, respectively.
- In 2016, the annual temperature anomalies were +1.9^{o}C (+3.6 SD) for Cabot Strait 200-300 m (the largest anomaly), +1.2^{o}C (+1.9 SD) for Misaine Bank at 100 m, +1.6^{o}C (+1.9 SD) for Emerald Basin at

250 m (a record high), +1.0°C (+1.2 SD) for Lurcher Shoals at 50 m and +1.4°C (+2.6 SD) for Georges Basin at 200 m (a record high).

- The CIL ($T<4^oC$) volume on the Scotian Shelf in 2016 was below normal by 1.2 SD, the 9th lowest in 43 years.
- The climate index, a composite of 18 selected, normalized temperature time series on the Scotian Shelf, averaged +2.1 standard deviations (SD), making 2016 the second warmest year in the last 47 years.
- On the Northeast U.S. shelf, 2016 was characterized by warming and generally more saline conditions across the region.
- Anomalously warm winter air temperatures over the Northeastern U.S. suppressed deep convective mixing in the western Gulf of Maine, resulting in warmer intermediate water mass.
- Slope waters entering the Gulf of Maine through the Northeast Channel were anomalously warm and salty, consistent with the properties characteristic of warm slope water derived from subtropical origins.
- Summer observations indicate that water from a Gulf Stream warm core ring intruded onto the shelf in the Middle Atlantic Bight and through deep channels into the Gulf of Maine, leading to anomalous warming across the outer shelf off southern New England and in the deep basins of the Gulf of Maine.

Biological and Chemical Conditions

- Shallow (<50m) nitrate inventories are mostly near to above normal in 2015-2016 over the southern Labrador and northeast Shelf (2J-3K) but transition to below normal throughout the Grand Bank, Gulf of St. Lawrence, and Scotian Shelf in 2016.
- The deeper (50-150m) nitrate inventories continue to remain below normal on the Grand Bank but have increased to near normal on northern transects (2J-3K). Deep inventories have generally declined over the Gulf of St. Lawrence and Scotian Shelf in Subarea 4.
- The chlorophyll *a* inventories inferred from the seasonal AZMP oceanographic surveys and fixed stations were variable throughout the Gulf of St. Lawrence and Scotian Shelf and remained below normal over the northern transects (2J to 3LNO) in 2016.
- An association between shallow and deep nitrate composite indices with the chlorophyll composite time series suggesting regulation of phytoplankton standing stock through nitrate availability across Subareas 2-4.
- Both the magnitude and amplitude metrics of the spring bloom inferred from satellite remote sensing were mostly below the long-term climatology over Subareas 2-5 and generally consistent with the observations from the Atlantic Zone Monitoring seasonal surveys.
- Some exceptionally intense spring blooms were observed across the Labrador Sea and Gulf of St. Lawrence in 2016.
- In 2016, the lower than normal abundance estimates of *C. finmarchicus* in May in all parts of the Labrador Sea may be largely attributable to the sampling date, which this year occurred prior to the spring bloom.
- The timing of the spring bloom demonstrated limited spatial coherence among Subareas, with later onset in the northern regions including the Labrador Sea and Greenland Shelf, near-normal on the Labrador Shelf (2H) and south to the northeast Newfoundland Shelf (3KL), with both large negative (early blooms) and positive (late blooms) anomalies throughout the Gulf of St. Lawrence, Scotian Shelf and Gulf of Maine.
- The abundance of key functional zooplankton groups dominated by copepods were generally higher in 2016 across the AZMP standard transects and fixed stations but the abundance of energy-rich *Calanus finmarchicus* was below normal throughout most of the zone.

2. Opening

The Chair opened the meeting by welcoming participants to this June 2017 Meeting of STACFEN.

The Committee adopted the agenda and discussed the work plan and noted the following documents would be reviewed: SCR Doc. 17/01, 17/07, 17/08, 17/09, 17/11, 17/12, 17/22, 17/29 and SCWP 17/19.

3. Appointment of Rapporteur

Gary Maillet (Canada) was appointed rapporteur.

4. Adoption of the Agenda

The provisional agenda was adopted with no further modifications.

5. Review of Recommendations in 2016

STACFEN **recommends** *consideration of support for one invited speaker to address emerging issues and concerns for the NAFO Convention Area during the 2017 STACFEN Meeting.*

STATUS: STACFEN was unable to secure a guest speaker for the June 2017 meeting despite numerous attempts. Contributions from past speakers have generated new insights and discussion within the committee regarding integration of environmental information into the stock assessment process. Further discussions are underway between STACFEN and STACFIS Chairs on environmental data integration into the various stock assessments. The need to ensure environmental data submissions are timely from contracting parties was also highlighted.

6. Oceanography and Science Data (OSD) Report for 2016 (SCR Doc. 17/22)

The Marine Environmental Data Section (MEDS) of the Oceans Science branch of DFO acts as Regional Environmental Data Center for NAFO. This role began in 1965 when the Canadian Oceanographic Data Centre started providing data management functions to ICNAF, and was subsequently formalized in 1975 by which time the CODC had become the Marine Environmental Data Service (MEDS). MEDS underwent several name changes from 2005 to 2016, it was known in the interim under acronyms such as ISDM and OSD.

In order for MEDS to carry out its responsibility of reporting to the Scientific Council, the Designated National Representatives selected by STACFEN are requested to provide MEDS with all marine environmental data collected in the Northwest Atlantic for the preceding years.

Provision of a meaningful report to the Council for its meeting in June 2017 required the submission to MEDS of a completed oceanographic inventory form for data collected in 2016, and oceanographic data pertinent to the NAFO Convention Area, for all stations occupied in the year prior to 2016. 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 on-line order form on the MEDS web site at http://www.meds-sdmm.dfo-mpo.gc.ca/isdm-gdsi/request-commande/form-eng.asp or by writing to Oceans Science branch, Fisheries and Oceans Canada, 12th Floor, 200 Kent St., Ottawa, Ont. Canada K1A 0E6.

Data observed in NAFO Convention Area in 2016 and acquired in 2016 and from January to May 2017

Data Type	Platform Type	Counts/Duration
Oceanographic profiles	autonomous platforms	7107* profiles from 146 platforms
	ship	5847 profiles (2973 CTD; 1093 CTD*; 110 bottle and 671 XBT profiles) from 19 ships
Surface/near-surface observations	ship (thermosalinograph)	15665* obs. from 2 ships
	drifting buoys	688423* obs. from 198 buoys
	moored buoys	167633* obs. from 26 buoys**
	fixed platforms	101438* obs. from 3 platforms
	water level gauges	22 sites, avg. ~1 year each
Sub-surface observations	moored current-meter, CTD, thermograph, ADCP	19 time series, ~314 days each

*Data formatted for real-time transmission

**All Canadian wave buoys described in this report measure waves

Data observed prior to 2016 in NAFO Convention Area and acquired in 2016 and from Jan to May 2017

Data Type	Platform Type	Counts/Duration
Oceanographic profiles	ship	2876 profiles (2686 CTD + 190 bottle** profiles) from 11 ships
Sub-surface observations	moored thermograph	18 time series, ~434 days each

*Data formatted for real-time transmission

**The amount of bottle data profiles measured prior to 2016 and loaded in BioChem in 2016 could not be fully assessed

7. Results of Ocean Climate and Physical, Biological and Chemical Oceanographic Studies in the NAFO Convention Area

A key indicator of ocean climate conditions, the North Atlantic Oscillation (NAO) index, declined from record high 2015 levels but remained slightly positive in 2016. Arctic outflow during the winter decreased from 2015 conditions, causing significant increases in air temperature for NL. The sea ice extent for the NL shelf returned to slightly below normal conditions, and little ice was observed on the Scotian Shelf.

Subareas 0 and 1. Reviews of meteorological, sea ice and hydrographic conditions in West Greenland in 2016 were presented in **SCR Doc. 17/01 and 17/07**.

In winter 2015/2016, the NAO index was positive (0.98). The annual mean air temperature at Nuuk weather station in West Greenland was 0.6°C in 2016, which was 2.0°C above the long-term mean (1981-2010). The core properties of the water masses of the West Greenland Current (WGC) are monitored annually 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 2016. The properties of the Irminger Sea Water (ISW) are monitored in the 75-200 m layer at Cape Desolation Station 3. In 2016, the water temperature and the salinity of the ISW was 5.44°C and 34.84, which was 0.27°C and 0.08 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. Since the beginning of the 1990s, temperature and salinity were decreasing and reached their minimum values in 1998 and 1997, respectively. After that, the temperature of the NADW revealed a positive trend until 2014, whereas its salinity rather stagnated between 2007 and 2014. In 2016, the temperature increased and salinity stagnated, and were 0.1°C and 0.02 above the long-term mean.

Hydrographic conditions were monitored at all 10 hydrographic standard sections and stations in June/July 2016 across the continental shelf off West Greenland. Three offshore stations were chosen to document changes in hydrographic conditions off Southwest Greenland. The coastal water showed temperatures above the long-term mean and in the higher end in the area south of the Sisimiut section. After a few years of relatively fresh subpolar mode water mass, salinity values at Cape Desolation 3 (75-200 m) have returned higher levels, similar to those observed over the past 15 years.

Subareas 1 and 2. A review of physical, chemical and biological oceanographic conditions over the Labrador Sea in 2016 was presented in **SCR Doc. 17/29**

In the winter of 2015-16, the mid-high latitude North Atlantic experienced more moderate surface heat loss than in the previous few years. Temperature, salinity and dissolved oxygen profiles show that the winter mixed layer and hence convective overturning in the central Labrador Sea reached deeper than 2000 m in 2016. The progressive cooling of the top 2000 m, and deep and intense winter mixing during the three consecutive winters of 2013-14, 2014-15 and 2015-16 have interrupted the general warming and stratification-building trend that has persisted in the intermediate waters of the Labrador Sea since the mid-1990s. The overall increase in TIC since 1994 is best described by a linear regression (R2 = 0.93) with a mean rate of 0.86 μmol kg^{-1} y^{-1}, whereas the decline in pH has also been linear, although more variable than TIC (R2 = 0.51), with a mean rate of -0.002 y^{-1}. Concentrations of the dissolved gases dichlorodifluoromethane (CFC-12) and sulphur hexafluoride (SF6) in the recent LSW class (formed and replenished during 2012-2016) had not changed significantly since 2015 despite an increase in the depth of convective mixing during 2016. These extreme atmospheric and physical ocean processes in the winter and spring of 2015-16 also had profound impacts on the biological properties of the Labrador Sea. Biweekly climatology of chlorophyll a constructed from a time series of remotely-sensed ocean colour from 2003 to 2016 indicates that the annual spring bloom of phytoplankton started at an average date but the duration of the bloom was lengthy again this year at a large spatial scale but the intensity of the bloom was not as strong as observed in 2015. The occurrence of a fall bloom again this year seems to indicate that this feature is becoming more the norm than the exception. *Calanus finmarchicus* dominates the meso-zooplankton throughout the central region of the Labrador Sea, while on the Labrador and Greenland shelves, *C. finmarchicus* show regional year-to-year variations in abundance that are generally related to regional differences in the timing of the life-cycle events and environmental conditions. Calanus spp. and other copepods may have benefitted from high phytoplankton availability during the entire growing season. In 2016, the lower than normal abundance estimates of *C. finmarchicus* in May in all parts of the Labrador Sea may be largely attributable to the sampling date, which this year occurred prior of the spring bloom.

Subareas 2, 3 and 4. A description of the physical oceanographic environment on the NL and Labrador Shelf and Scotian Shelf was presented in **SCR Doc. 17/09 and SCR Doc. 17/11**.

Oceanographic and meteorological observations in NAFO Sub-areas 2 and 3 during 2016 are presented referenced to their long-term (1981-2010) means. The North Atlantic Oscillation (NAO) Index, a key indicator of the direction and intensity of the winter wind field patterns over the Northwest Atlantic, remained in a positive phase during 2016; however, it was lower than in 2015. In addition, the spatial patterns of the associated atmospheric pressure fields resulted in a reduced arctic air outflow in the northwest Atlantic during the winter months. This resulted in higher than normal winter air temperatures in many areas. Sea ice extent, although above normal during March and April, was below normal overall during 2016. Annual sea-surface temperature (SST based on infrared satellite imagery) trends on the northeast Newfoundland Shelf while showing an increase of about 1ºC since the early 1980s were mostly below normal during 2016. The annual bottom (176 m) temperature/salinity at the inshore monitoring site (Station 27) was below normal by -0.7/-1.4 SD, respectively in 2016. The cold-intermediate layer (CIL; volume of <0ºC) during 2016 was below normal off southern Labrador (2J) but near normal on the northeast Newfoundland Shelf and Grand Bank (3KL). The volume of CIL water during the fall in NAFO Divisions 2J3KL from multi-species net-mounted CTD deployments was below normal. The spatially averaged spring bottom temperature in 3Ps was about 1ºC (2 SD) above normal, a 33-year record, while in 3LNO it was about normal. The spatially averaged bottom temperature during the fall in 2J and 3K show an increasing trend since the early 1990s of about 1ºC, reaching a peak of >2

SD above normal in 2011 and remaining above normal in 2016 by 0.5ºC and 0.3ºC, respectively. A standardized composite climate index for the Northwest Atlantic derived from meteorological, ice and ocean temperature and salinity time series since 1950 reached a record low value in 1991. Since then it shows an increasing trend with mostly above normal values except for 2014 and 2015, the latter being the 7th lowest in 67 years and the lowest value since 1993. Data from 2016 show a return to above normal conditions.

A review of the 2016 physical oceanographic conditions on the Scotian Shelf and in the eastern Gulf of Maine and adjacent offshore areas indicates that conditions corresponding to warmer than normal prevailed. The climate index, a composite of 18 selected, normalized time series, averaged +2.1 standard deviations (SD) making 2016 the second warmest year in the last 47 years. The anomalies did not show a strong spatial variation. Bottom temperatures were above normal with anomalies for NAFO Divisions 4Vn, 4Vs, 4W, 4X of +0.9°C (+2.1 SD), +1.5°C (+2.1 SD), +1.7°C (+2.3 SD), and +1.9°C (+2.6 SD) respectively. Compared to 2012, the year where record or near record bottom temperatures were observed, bottom temperatures were different by +0.4°C, +0.2°C, +0.0°C and -0.3°C in Divisions 4Vn, 4Vs, 4W and 4X, respectively.

Subareas 2 - 5. An investigation of the biological and chemical oceanographic conditions in 2016 was presented in **SCR Doc. 17/12.**

Biological and chemical variables collected in 2016 from coastal high frequency monitoring stations, semi-annual oceanographic transects, and ships of opportunity ranging from the Labrador-Newfoundland and Grand Banks Shelf (Subareas 2 and 3), extending west into the Gulf of St. Lawrence (Subarea 4) and further south along the Scotian Shelf and the Bay of Fundy (Subarea 4) and into the Gulf of Maine (Subarea 5) are presented and referenced to previous information from earlier periods when available. We review the inter-annual variations in inventories of nitrate, chlorophyll *a* and indices of the spring bloom inferred from satellite ocean colour imagery, as well as the abundance of major functional taxa of zooplankton collected as part of the 2015 Atlantic Zone Monitoring Program (AZMP). In general, nitrate inventories in the upper (0-50m) water-column were near to above normal compared to the 1999-2010 climatology throughout the northern Subareas but below normal from the southern Gulf of St. Lawrence down to the Scotian Shelf in 2015-2016. The deeper (50-150m) nitrate inventories continue to remain below normal on the Grand Bank but have increased to near normal on northern transects (3K-2J). The elevated inventories of deep nitrate observed in the Gulf of St. Lawrence and Scotian Shelf in 2015 declined in 2016, particularly on the western Scotian Shelf (4W-4X). The chlorophyll *a* inventories inferred from the seasonal AZMP oceanographic surveys and fixed stations were variable throughout the Gulf of St. Lawrence and Scotian Shelf and remained below normal over the northern transects (2J to 3LNO) in 2015-2016. We noted a positive linear relationship of changes in shallow and deep composite indices of nitrate with the chlorophyll composite time series suggesting regulation of phytoplankton productivity through nitrate availability throughout the zone. Both the magnitude and amplitude metrics of the spring bloom were mostly below the long-term climatology over the 25 Subareas and generally consistent with the observations from the Atlantic Zone Monitoring seasonal surveys in 2016. Some exceptional spring blooms were observed across the Labrador Sea and Gulf of St. Lawrence in 2016. The timing of the spring bloom varied with mixed results throughout the Subareas with later onset in the northern regions including the Labrador Sea and Greenland Shelf, near-normal on the Labrador Shelf (2H) and south to the northeast Newfoundland Shelf (3KL), with both large negative and positive anomalies throughout the Gulf of St. Lawrence, Scotian Shelf and Gulf of Maine. The abundance of key functional zooplankton groups were generally higher in 2015-2016 across the AZMP standard transects and fixed stations. The abundance of an important small grazer copepod (*Pseudocalanus spp*.) remained elevated as in previous years across the northern transects (2J) through the southern Gulf of St. Lawrence ((4T). The abundance of dominant copepods and non-copepods (mostly gelatinous and carnivorous zooplankton) were consistently higher across the entire zone. One exception to this general trend in abundance of key functional zooplankton groups is for the larger grazing copepod, *Calanus finmarchicus,* an important prey to a variety of different life stages of fish, with reduced standing stocks throughout the entire zone. Standing stocks of phytoplankton inferred from ship surveys and remote sensing did not appear to be related to changes in the abundance of zooplankton. Relationships between standing stocks of lower trophic levels and environmental conditions were assessed in the northern Subareas.

Subareas 5 and 6. A description of environmental information collected on the Northeast United States Continental Shelf during 2016 was presented in **SCR Doc. 17/08**.

An overview is presented of the atmospheric and oceanographic conditions on the Northeast U.S. Continental Shelf during 2016. 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, 2016 was characterized by warming and generally more saline conditions across the region. Deep (slope) waters entering the Gulf of Maine were warmer and saltier than average and their temperature and salinity suggest a subtropical source. Mixed layers in the western Gulf of Maine were minimal during the winter of 2016, presumably a consequence of anomalously warm air temperatures that persisted over the northeastern United States during winter and suppressed winter convective overturning in the western Gulf of Maine. By contrast, during late summer, observations indicate that Gulf Stream Warm Core Ring water intruded onto the shelf in the Middle Atlantic Bight and through deep channels into the Gulf of Maine, leading to anomalous warming across the outer shelf off southern New England and in the deep basins of the Gulf of Maine. Such episodic events have the potential to cause significant changes in the ecosystem, including changes in nutrient loading on the shelf, the seasonal elimination of critical habitats such as the cold pool and shelf-slope front, disruption of seasonal migration cues, and an increase in the concentration of offshore larval fish on the shelf.

8. An Update of the On-Line Annual Ocean Climate and Environmental Status Summary for the NAFO Convention Area

In 2003 STACFEN began production of an annual climate status report to describe environmental conditions during the previous year. This web-based annual summary for the NAFO area includes an overview that summarizes the overall general climate changes for the previous year and a regional overview that provided climate indices from each of the Subareas. The climate summary is updated by the NAFO Secretariat on an annual basis with contributions from each contracting country. Information for 2016 will be made available from Subarea 1, West Greenland, Subareas 2-3, Grand Banks and Labrador Sea/Shelf, Subareas 4-5, Scotian Shelf and Gulf of Maine, and Subareas 5-6, Georges Bank and Gulf of Maine.

In the “Other Matters” section of the STACFEN appendix to the June 2016 Report of the Scientific Council Meeting, it was suggested that once the revised NAFO website was developed that the Google metrics for the Annual Ocean Climate and Environmental Status Summary be tracked to evaluate the site traffic, timing and demographics for discussion at the June 2017 SC meeting.

Annual Climate Status Report and NAFO Website in **SCWP 17/19**.

There was considerable discussion during the SC June Meeting 2016 about the ongoing utility of the annual climate status report on the NAFO website. A canvas of SC members showed that it was not regularly accessed and the time required to generate content is significant. Unfortunately, at the time there were no website metrics available to make a decision about the future of this page(s). The NAFO Secretariat was in the process of creating a new website, a content management system (CMS) that would provide google metrics/analytics to evaluate traffic on the climate pages. In the interim, and prior to the September 2016 SC meeting, Eugene Colbourne, the NAFO Secretariat and STACFEN colleagues have generated content for this page as usual.

The NAFO Secretariat has been tracking these specific pages on the annual climate status report. The presentation included six months, since the revised NAFO website was launched in 17 October 2016 to 15 May 2017.

Below is a brief synopsis of the metrics:

- The climate summary pages rate #62 out of 3581 webpages for the NAFO website for overall visited pages (includes the modules).
- The total number of users for the entry page is 155 (not including repeat users).
- The total number of unique page views is 91 (unique page views is the number of sessions during which the specified page was viewed at least once. It is counted for each url and title combination.).
- Of these unique page views, 60% (54) come from Canada and 76% of those (41) originate from Nova Scotia.
- The average length that a user stays on the page is 14 seconds.

- 16 Entrances – indicates a user entering a specific page or url.
- Bounce rate is 56.25 % - percentage of single-page sessions in which there is no interaction with the user. The bounce rate can be good or bad, depending on the size of the site and its purpose.

It was concluded that despite low overall site traffic, largely dominated by the content provider's updates, that the site will be updated to include the 2016 environmental conditions. The site's metrics will be re-evaluated during the 2018 June SC meeting. It was suggested that a "bulletin" style template might be more a more appropriate and flexible summary that could be populated more or less automatically. Eugene Colbourne and Gary Maillet will draft a bulletin template in advance of the June 2018 SC meeting.

9. The Formulation of Recommendations Based on Environmental Conditions

STACFEN **recommends** *consideration of support for one invited speaker to address emerging issues and concerns for the NAFO Convention Area during the 2018 STACFEN Meeting.*

Contributions from past invited speakers have generated new insights and discussion within the committee regarding integration of environmental information into the stock assessment process. Further discussions are encouraged between STACFEN and STACFIS Chairs on environmental data integration into the various stock assessments. Additional consideration of integrating environmental trends from modelling studies was suggested to assist the committee work.

STACFEN **recommends** *support for, and requests an executive summary from, an upcoming meeting on calanoid copepod dynamics planned for 19-20 July, 2017.*

10. National Representatives

Currently, the National Representatives for hydrographic data submissions are: E. Valdes (Cuba), S. Demargerie (Canada), E. Buch (Denmark), J.-C Mahé, (France), F. Nast (Germany), **Vacant** (Japan), H. Sagen (Norway), J. Janusz (Poland), **Vacant** (Portugal), M. J. Garcia (Spain), L. J. Rickards (United Kingdom), and K. J. Schnebele (USA; retired; temporary USA contact P, Fratantoni). B.F. Prischepa from Russia was replaced by K.V. Drevetniak.

11. Other Matters

A consensus was reached to hold next year's STACFEN meeting on Friday June 1st, 2018. This timing should assist in achieving the objectives of the SC Meeting and will permit a wider discussion and generation of the various environmental composite indices for use in the STACFIS Report. The integrated ecosystem approach will require input of environmental information in order to understand regional variability and fishery production potential and will continue to benefit from availability of these data sources.

The STACFEN Chair expressed his regrets for not being able to provide the 5 year update of environmental conditions this year to the NAFO Fisheries Commission during the 39th Annual Meeting of NAFO, 18-22 September, 2017 in Montréal, Québec, Canada due to overlapping commitments. It was suggested that this update be postponed to the following year or whenever the next STACFEN Chair can arrange a summary.

12. Presentation of NAFO Scientific Merit Award – Mr. Eugene Colbourne

In recognition of his leadership role as STACFEN Chair from 2002 to 2006 and his many contributions to this standing committee since the early 1990's on advancing our understanding of ocean climate conditions and hydrographic variability with linkages to NAFO managed stocks in the NRA, Eugene Colbourne (Canada) was presented the NAFO Scientific Merit Award by Kathy Sosebee the NAFO Scientific Council Chair.

"Eugene has distinguished himself through active participation and publication of research reports on numerous ocean climate and hydrographic studies throughout the Northwest Atlantic that has spanned nearly 3 decades. He continues to lead the online NAFO Ocean Climate Status Summary for the Northwest Atlantic which provides an overview of physical and biological oceanographic conditions from all major NAFO Subareas. Eugene has contributed to a number of NAFO and ICES Symposia over the years investigating a variety of aspects of fisheries environment. He has also contributed to and led numerous oceanographic missions under less than ideal working conditions in the northwest Atlantic aboard a variety of research vessels. His commitment to attend NAFO Scientific Council Meetings and contribute to various standing committees has been long-standing for over two decades along with his dedication to STACFEN. His efforts and long-time contributions to environmental monitoring and effects on fisheries within the NAFO community are greatly appreciated.

On behalf of Scientific Council and the Secretariat, we extend our sincere appreciation to Eugene and thank him for his many contributions to this Council over the years".

13. Adjournment

Upon completing the agenda, the Chair thanked the STACFEN members for their excellent contributions, the Secretariat and the rapporteur for their support and contributions.

The meeting was adjourned at ~15:00 on 2 June 2017.

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

Chair: Margaret Treble Rapporteur: Alexis Pacey

The Committee met at the Sobey School of Business at Saint Mary's University, 903 Robie St. Halifax, NS, Canada, on the 31 May-15 June 2017, to consider publication-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 (France, Portugal, and Spain), Norway, Russian Federation, Japan and the United States of America. The Scientific Council Coordinator was in attendance as were other members of the Secretariat staff.

1. Opening

The Chair opened the meeting by welcoming the participants.

2. Appointment of Rapporteur

Alexis Pacey (NAFO Secretariat) was appointed rapporteur.

3. Adoption of Agenda

The Agenda as given in the Provisional Agenda distributed prior to the meeting was adopted.

4. Review of Recommendations in 2016

STACPUB **recommends** that *the NAFO website continue to provide e-mail links for the Scientific Council Designated Experts for each stock.*

STATUS: This has been implemented. They are currently available on the NAFO website. https://www.nafo.int/Science/Designated-Experts

STACPUB **recommends** that *the Secretariat investigate the development of popular advice web pages that would be interactive and appeal to a broader audience. Information on the species and stocks as well as maps of stock areas, fishing grounds and corresponding ecosystem areas could be included.*

STATUS: These are now available on the revised NAFO public website. They were available on the old website, but they were buried and out of date. The fact sheets are available in a table with a picture of the species, the common and Latin name, and the management area with a link to the summary sheets. These fact sheets have been revised and include general information about the stock, recent assessments, a map of management areas in the NAFO Regulatory Area (NRA), biological and environmental interactions, special comments if applicable and citations. They can be downloaded from the table. They are found here: https://www.nafo.int/Science/Species

5. Review of Publications

a) Journal of Northwest Atlantic Fishery Science (JNAFS)

Volume 48, Regular issue, contained four articles. Ten CDs and 130 printed copies were prepared in December 2016 and mailed in Jan. 2017.

Volume 49, Regular issue, has a total of five papers that have been submitted for publication. One paper is dormant, three others are in review and one is in production.

A new online submission process has been implemented. It is found on the CONTACT and INSTRUCTIONS webpages of JNAFS.

NAFO Scientific Council Reports

The 2016 NAFO Scientific Council Report was printed and distributed in April 2017. The Report was 450 pages in length and 30 copies were printed.

NAFO Scientific Council Studies

There were no submissions for the Studies volume in 2016.

ASFA

All science publications and documents have been submitted to ASFA as of May 31, 2017. This includes *The Journal of the Northwest Atlantic Fisheries*, SC Reports, and SC Research Documents for 2016. The Secretariat started indexing Scientific Council Summary (SCS) documents which contain reports of meetings of the Council, its Committees and Working Groups, national research reports, reports of meetings of other international organizations or matters relevant to the work of NAFO, and all research and statistical reports prepared for meetings by the NAFO Secretariat. This will be ongoing.

6. Other Matters

a) Citation links for JNAFS

It was mentioned during the intersessional year that the JNAFS website does not contain citation links for the articles. A few SC members asked if it were possible to provide a link on the JNAFS website that would create a reference list for ease of use in manuscript preparation. The NAFO Secretariat agreed to look into this and determine if it were possible to add this option to the JNAFS website.

Designated Experts (DE) email links on the website

Scientific Council members noted that the public website did not reflect recent changes in the list of Designated Experts. The Secretariat agreed to check the accuracy of the list and the email links on a regular basis.

STACPUB **recommends** that *the NAFO Secretariat check the Designated Expert list on a quarterly basis and update the public website as required*.

JNAFS promotions

The NAFO Secretariat commented on work to create a “Call for Papers” e-poster to promote JNAFS. This poster will be sent via email to SC members, contracting parties and other institutes to encourage authors to submit articles to the journal. A print poster will be produced to have available for exhibitions. The emphasis is on the journals FREE and OPEN-ACCESS policy.

Popular Advice Sheets

Stock fact sheets are now available on the NAFO website: https://www.nafo.int/Science/Species. They will need to be updated on a yearly basis. In addition, SC suggested that the Secretariat track visits to this page using Google Analytics. An analysis of whom and how many people view this page can be included.

STACPUB **recommends** that *Designated Experts and other SC members review the fact sheets and provide the Secretariat with any updates or corrections to help refine the fact sheets.*

STACPUB **recommends** that *the Secretariat monitor the web traffic on the fact sheets using Google Analytics and provide the metrics at the 2018 STACPUB meeting.*

Standardization of terminology for metric tonnes

A question was posed concerning terminology and accepted acronym for metric tonnes. After discussion it was confirmed that for NAFO publications ‘tonnes’ is the appropriate spelling and ‘t’ the corresponding acronym for use in our SC documents and reports.

NAFO website

Phase I of the website redesign was unveiled in mid-October 2017. It was received positively by most members and suggestions for making further improvements have been implemented. Phase III – ICNAF documentation and publications transfer took place in early 2017.

Phase II will address data classification/access rights. The *Ad hoc virtual Working Group* will continue to work inter-sessionally to develop standards and guidelines for access to documentation on secure portals contained in the NAFO Members’ area and NAFO Meetings SharePoint for review by STACFAD at the 2017 Annual Meeting. The objective is to be as transparent as practicable and discussion will include classification of documents that would require log-in credentials and degree of access for Observers. The Chairs of STACTIC, STACFAD and STACPUB will be consulted in the development of these guidelines.

7. Adjournment

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

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

Chair: Brian Healey Rapporteur: Ivan Tretiakov

The Committee met at Sobey's School of Business, Saint Mary's University, Halifax, NS, Canada, on various occasions throughout the meeting to discuss matters pertaining to statistics and research referred to it by the Scientific Council. Representatives attended from Canada, Denmark (Faroes & Greenland), European Union (Germany, Portugal and Spain), France (in respect of St. Pierre et Miquelon), Japan, Russian Federation and United States of America. The Scientific Council Coordinator and other members of the Secretariat were in attendance.

1. Opening

The Chair opened the meeting at 1400 hours on 3 June 2017, welcomed all the participants and thanked the Secretariat for providing support for the meeting. Several sessions were held throughout the course of the meeting to deal with specific items on the agenda.

2. Appointment of Rapporteur

Ivan Tretiakov was appointed as rapporteur.

3. Review of Recommendations in 2016

a) Tagging

In 2015, STACREC **recommended** that *the NAFO Secretariat develop a framework for communicating tagging study information to vessels from Contracting Parties and Coastal States fishing in the Convention Area (e.g., via a link to this information on the NAFO website homepage)*. No progress was made on this recommendation in 2015.

Due to high workload, this recommendation was not addressed in June 2017, however STACREC noted that the Secretariat has made some progress in planning a dedicated web page through which information relating to tagging studies (eg, action to be taked on catching a tagged fish) could be disseminated to fishers. STACREC *reiterated this recommendation*.

Availability of STACFIS catch estimates

In 2016, STACREC discussed whether STACFIS catch estimates used in stock assessments should be made available on the NAFO website. Participants noted several scientific studies (including work conducted at SC working groups) have been published assuming STATLANT data extracted from the NAFO website are the best estimates of removals for NAFO managed resources. It was noted that the former NAFO Statistical Bulletins published by NAFO contained text to notify researchers of discrepancies between STATLANT and STACFIS (see NAFO, 1996, p.9). It was suggested that similar notification be added to the STATLANT Extraction Tool webpage to avoid future confusion.

To facilitate this progress, STACREC **recommended** that *the SC chair initiate discussion with the chairs of FC and GC during the Sept 2016 Annual Meeting.*

Due to high workload, this was not addressed in September 2016 or June 2017. STACREC **reiterated this recommendation.** These discussions will be taken up prior to or during the Sept 2017 annual meeting.

Analysis of sampling rates

In 2015, STACREC **recommended** that *an analysis of sampling rates be conducted to evaluate the impact on the precision of survey estimates.* This was not addressed at either the 2016 or 2017 meetings but STACREC noted that work was progressing. Accordingly, STACREC reiterates its **recommendation** that *an analysis of sampling rates be conducted to evaluate the impact on the precision of survey estimates.*

Participation of reviewers.

STACREC **recommended** *SC endorse this change to existing working procedure and seek funds required (travel and/or stipend depending on review type) to allow an external review to commence in advance of the June 2017* *meeting. Terms of Reference for this review, as well as a list of which stocks should be reviewed and the process whereby reviewers will be selected will be considered by SC at its September 2017 meeting*.

Terms of Reference for External Review of NAFO Scientific Council Stock Assessments

Context

- NAFO Scientific Council (SC) recognizes that participation of external reviewers in assessments provides significant benefit, ensuring consistency with best practice and enhancing transparency of process.
- As agreed during its June 2016 meeting, NAFO SC plans to invite an external reviewer to be present for a portion of the SC meeting to review the assessment of one or two stocks. The reviewer is asked to write a report addressing the quality and soundness of the science, methods and results with regard to each component of the assessment.
- Where possible, consideration will be given to potential cooperation with other intergovernmental organisations and RFMOs
- Constructive comments are encouraged during the course of the stock assessment. Weaknesses should be identified and suggestions for improvement should be provided. The reviewers' broad level of experience should be applied to reviewing the assessment both in terms of identifying concerns and suggesting ways forward.

Terms of Reference for Review: Reviewers should be guided by, but not limited to the following:

Review of methodological approach

a) Are the data adequate and used properly, are the analyses and models transparent and carried out correctly, are the reference points appropriate and the conclusions /correct reasonable? Model diagnostics should be fully considered.
b) If any of the above are considered inappropriate, the report should include recommendations and justification for suitable alternatives. If alternatives cannot be identified, then the report should indicate that existing approaches are currently the best available.
c) The stock assessment should be reviewed for completeness, accuracy and reliability and information can be added when appropriate. Assessments should be considered on the basis of the NAFO guidance for providing stock assessment advice (attached below). There may also be specific requirements based on the Fisheries Commission (FC) request, which will also be provided where applicable.
d) Any additional analyses related to the stock assessment conducted by the external reviewer should be incorporated into the report. Details of those analyses (e.g., code, spreadsheets etc.) should be made available to the assessment scientists.
e) Errors of fact, analysis or interpretation should be identified.
f) Comments on the methodology, interpretations, and recommendations in the review must be provided.
g) Is uncertainty in the data and analysis adequately reflected?
h) Are there areas of research that are needed to improve the stock assessment?

Review of Scientific Advice

a) The review should address whether the assessment provides a scientifically credible basis for developing fishery management advice according to the FC guidance for providing advice.
b) Are the advice and recommendations justified given the assessment results?
c) Are the advice and recommendations provided in a clear manner?

Presentation of Review

Time will be provided during the SC meeting for the reviewer to present the key points of his/her review and the authors will have an opportunity to respond. Typically some of the comments should and can be addressed for the current assessment, while others may be carried forward as research recommendations for future assessments.

The reviewer would be required to present a short written summary of findings to SC. A copy of this review will be appended to the SC Report, which is citable. The review should be kept to key points, adding explanation as necessary. Editorial suggestions can be provided separately.

Travel Support

Travel support to and from the meeting will be provided. Hotel and taxi costs, as well as *per diem* rates for meals and incidentals will be covered by the NAFO Secretariat according to the Canadian National Joint Council Travel Directive .

Stipend

Stipend may be provided to the reviewer where external reviews are not part of the responsibilities associated with the reviewer's scientific position.

Stock assessments to be reviewed

On an annual basis, the SC will maintain a prioritized list of stocks for which an external review will be conducted. Consideration in prioritization will be given to:

- assessments for which there has been difficulty in developing a model with good diagnostics and or for which there is a range in views within the council of how the stock should be assessed
- Analytical assessments
- Assessments for which new modelling approaches are being considered
- Assessments for stocks which have open fisheries or are close to the Blim level
- Assessments for which advice is likely to change significantly

Selection of Invited Reviewers

On an annual basis, the SC chair will request of SC members nominations for individuals they feel are qualified to conduct a technical review of stock assessments. The SC executive committee will decide on the individual chosen in any year.

It was agreed by SC that, pending agreement of the budgetary support from the Commission in September 2017, this process will be initiated for the 3M cod benchmark in 2018.

4. Fishery Statistics

a) Progress report on Secretariat activities in 2015/2016

i) 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)

Table 1. Dates of receipt of STATLANT 21A and 21B reports for 2013-2016 up to 15 June 2017

Country/component	STATLANT 21A (deadline, 1 May)			STATLANT 21B (deadline, 31 August)		
	2014	2015	2016	2013	2014	2015
CAN-CA	24 Apr 15	4 May 16	30 May 17	30 Apr 14	24 Apr 15	4 May 16
CAN-SF	1 Jun 15	31 May 16	28 Apr 17	3 Jun 14	31Aug 15	30 Aug 16
CAN-G	14 May 15	18 May 16	26 May 17	14 May 15	4 Sep 15	30 Aug 16
CAN-NL	25 May 15	21 Apr 16	26 Apr 17	29 Aug 14		29 Aug 16
CAN-Q						
CUB						
E/BUL						
E/EST	28 Apr-15	20 Apr 16	22 May 17	29 Aug 14	14 Aug 15	23 Aug 16
E/DNK	21 May 15		23 May 17	21 Aug 14	4 Sep 15	15 Jun 16
E/FRA						
E/DEU	29 Apr 15	28 Apr 16	25 Apr 17	29 Aug 14	4 Sep 15	29 Aug 16
E/LVA	21 Apr 15	10 Mar 16	20 Apr 17			
E/LTU	21 May 15		9 May 17			
EU/POL	1 Jun 15				21 Sep 15	
E/PRT	8 May 15	26 Apr 16	19 Apr 17	29 Aug 14	3 Sep 15	23 Aug 16
E/ESP	21 May 15	5 May 16	31 May 17	25 Aug 14	7 Sep 15	5 Aug 16
E/GBR			25 Apr 17	20 Aug 14		
FRO	*	26 May 16	2 May 17	12 Jun 14	7 Jul 15	1 Jun 16
GRL	15 May 15	30 Apr 16	1 May 17	29 Aug 14	1 Sep 15	30 Aug 16
ISL	15 May 15			8 Sep 14		
JPN			19 Apr 17			
KOR						
NOR	7 May 15	26 Apr 16	4 May 17	26 Aug 14	17 Mar 16	29 Aug 16
RUS	21 Apr 15	20 May 16	11 May 17	28 Aug 14	2 Jul 15	1 Sep 16
USA	22 May 15	19 Jul 16				
FRA-SP	20 Apr 15	25 Apr 16	25 May 17	30 Jul 14	6 Jul 15	8 Jun 16
UKR						

* date of submission unknown

5. Research Activities

a) Biological Sampling

i) Report on activities in 2016/2017

STACREC reviewed the list of Biological Sampling Data for 2016 (SCS Doc. 17/14) prepared by the Secretariat and noted that any updates will be inserted during the summer, prior to finalizing the SCS Document which will be finalized for the September 2017 Meeting.

ii) Report by National Representatives on commercial sampling conducted

Canada-Newfoundland (SCS Doc. 17/13, 17/10, plus information 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 0 + 1 (except Div. 1A inshore), 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 2-4). A provisional sampling report for 2016 was not yet generated for submission to the Secretariat but will be forwarded as soon as possible. Sampling reports for 2013-2015 are also to be considered provisional due to data formatting and quality control issues as a result of implementing a new process for delivery of the Observer Program on April 1, 2013. It was noted that these issues have been satisfactorily sorted out and it is anticipated that the inventory will be updated and timely submissions of this data to the Secretariat will resume.

Denmark/Greenland (SCS Doc. 17/08, SCR 17/31): Length frequencies were available from the Greenland fishery in Div. 1AB and 1CD. CPUE data were available from the Greenland trawl fishery in Div. 1AB and 1CD and longline and gill net fishery inshore in Div. 1A.

EU-Portugal (NAFO SCS Doc 17/05): Data on catch rates were obtained from trawl catches for redfish and Greenland halibut (Div. 3LMNO), roughhead grenadier (Div. 3L), cod (Div. 3M), witch flounder, Atlantic halibut, white hake and silver hake (Div. 3O). Data on length composition of the catch were obtained for cod, redfish (S. mentella) and American plaice (Div. 3LMNO), witch flounder (Div. 3LMO), Greenland halibut (Div. 3LM), roughhead grenadier (Div. 3L), redfish (S. marinus) (Div. 3M) and white hake and haddock (Div. 3O).

EU-Spain (SCS 17/04)**:** A total of 11 Spanish trawlers operated in Div. 3LMNO NAFO Regulatory Area during 2016, amounting to 1,057 days (15,577 hours) of fishing effort. Total catches for all species combined in Div. 3LMNO were 12 950 tonnes in 2016.

In addition to NAFO observers (NAFO Observers Program), 8 IEO scientific observers were onboard Spanish vessels, comprising a total of 302 observed fishing days, around 29% coverage of the total Spanish effort. In 2016, 629 length samples were taken, with 64,256 individuals of different species examined to obtain the length distributions. Besides recording catches, discards and effort, these observers carried out biological sampling of the main species taken in the catch. For Greenland halibut, roughhead grenadier, American plaice and cod this includes recording weight at length, sex-ratio, maturity stages, performing stomach contents analyses and collecting material for reproductive studies. Otoliths of these four species were also taken for age determination. One Spanish trawler operated during 2016 in Div. 6G NAFO Regulatory Area using a midwater trawl gear. The fishing effort of this trawler was 16 days (116 hours). The most important species in catches was the *Beryx splendens*.

Russia (SCS Doc. 17/11): Catch rates were available from Greenland halibut (Divs. 1ACD, 3LMN, with bycatch statistics), Atlantic cod (Div. 3M), Redfish (Divs. 3LN, 3M, 3O, with bycatch statistics), Yellowtail flounder (Div. 3N). Length frequencies were obtained from Greenland halibut (Divs. 1CD, 3LM), Redfish (*Sebastes fasciatus* in Divs. 3NO, *S. mentella* in Divs. 3LMO, *S. marinus* in Divs. 3LMO), Roughhead grenadier (Divs. 3LM), Roundnose grenadier (Divs. 3LM), American plaice (Divs. 3MO), Witch flounder (Divs. 3LO), Atlantic cod (Divs. 3LMO), skates (*Amblyraja radiata* in Divs. 3MO, *A. hyperborea* in Div. 3L), White hake (Divs. 3LO), Blue wolffish (Divs. 3LMO), Atlantic wolffish (Divs. 3LO), Blue antimora (Divs. 3LM), Nezumia (Div. 3L), Atlantic halibut (Divs. 3LO). Age-length distribution for Greenland halibut in Divs. 3LM and *S. mentella* in Div. 3L, as well as statistics on marine mammal occurrences and VME indicator species catches, are also available.

Biological Surveys

i) Review of survey activities in 2016 (by National Representatives and Designated Experts)

Canada (SCR Doc. 17/044): Research survey activities carried out by Canada (Newfoundland Region) were summarized, and stock-specific details were provided in various research documents associated with the stock assessments. The major multispecies stratified-random surveys carried out by Canada in 2016 include a spring survey of Div. 3LNOPs, and an autumn survey of Div. 2HJ3KLNO. Both surveys were completed with the Campelen 1800 survey trawl.

The 2016 spring survey in Div. 3LNOPs continued a time series begun in 1971. It was conducted from April to late June, and consisted of 448 successful tows (478 planned) covering 126 of 129 planned strata to a maximum depth of 732m by the research vessel CCGS Teleost. This survey typically uses the CCGS Alfred Needler but mechanical issues caused the vessel to be unavailable for the entire spring survey. There were 3 strata not sampled, representing 0.4% of the survey area, and 21 of the remaining 126 strata received fewer sets than the planned allocation with 15 of those occurring in Div. 3Ps where only 156 of 178 planned sets were realized.

The 2016 autumn survey was conducted from late September to late December in Divs. 2HJ3KLNO, and consisted of 612 tows (674 planned) covering 186 of 208 planned strata to a maximum depth of 1500m in 2HJ3KL and 732m in 3NO. The reduction in sets was primarily due to mechanical issues that caused incomplete sampling in 7 strata in Divs. 2H (4), 3K (2) and 3O (1), and the eventual elimination of 15 deep water strata in 3L (>732m) near the end of the survey. Strata with incomplete sampling represented 3.8% of the Div. 2HJ3KLNO survey area. The vessel CCGS Teleost conducted work in the Div. 2HJ area to a maximum of 1500m and CCGS Alfred Needler conducted the 3LNO survey (< 732m), which continued a time series begun in 1977. Although both vessels shared work in Div. 3K, CCGS Teleost conducted over 80% of the sets (115 of 143).

Species-specific swept-area spring and autumn survey biomass indices were compiled for the Campelen 1800 trawl for all strata surveyed. No attempts were made to estimate biomass for any strata missed by the surveys. In broad terms for NAFO managed finfish stocks, the spring 3LNOPs surveys show declining trends over 2012-2016 for six stocks (Div. 3LNO American plaice, Div. 3LNO Yellowtail flounder, Div. 3NO cod, Div. 3NO witch flounder, Div. 3NO capelin and Div. 3O redfish), five stocks that were stable (Div. 3LNOPs Thorny skate, Div. 3NOPs White hake, Div. 3LNO Greenland halibut, Div. 3LNO Roughhead grenadier and Div. 3L Witch Flounder) and only one stock increasing (Div. 3LN redfish). The autumn surveys also showed declines for Div. 3NO cod, Div. 3NO witch flounder, Div. 3O redfish with the remainder more or less stable with the exception of an increasing trend for Div. 2J3KL witch flounder. STACREC noted these observations were consistent with the report of WGESA (see section X.1 of this report) which highlighted important declines in autumn finfish biomass in NAFO Div. 3LNO (~40% of the 2010-2013 level), and evidence of the onset of a declining trend in finfish abundance in NAFO Div. 2J3K. A similar trend was observed from the spring 3LNO survey, which noted ~31% decline in finfish biomass from 2014 to 2016.

The additional surveys conducted during 2016, directed at a number of species using a variety of designs and fishing gears, were described in detail in various documents. Results from Canadian oceanographic surveys in 2016 and earlier were discussed in detail in STACFEN.

STACREC noted the decline in the planned coverage and success rate of the Canadian surveys since 1995, particularly in the autumn, and expressed concern about the impact on the ability to detect signal from noise in regards to evaluating trends in biomass and abundance of various species. There are various reasons for this reduction over time (e.g. mechanical issues with vessels, increasingly bad weather, expanded sampling for ecosystem indicator species, budget constraints) but it is generally considered to have led to increased, albeit unquantified, uncertainty with respect to the provision of scientific advice. STACREC noted its 2015 recommendation "…that an analysis of sampling rates be conducted to evaluate the impact on the precision of survey estimates" was not addressed at this meeting but that work was progressing. Accordingly, STACREC reiterates its recommendation that an analysis of sampling rates be conducted to evaluate the impact on the precision of survey estimates.

Denmark/Greenland: The West Greenland standard oceanographic stations were surveyed in 2016 as in previous years **(SCR Doc. 17/001)**.

A series of annual stratified-random bottom trawl surveys, mainly aimed at shrimps, initiated in 1988 was continued in 2016. The gear was changed in this survey in 2005. No correction for this gear change has been made and the 2005 - 2015 time series is hence not directly comparable with 1988-2004 time series. In July-August 193 research trawl hauls were made in the main distribution area of the West Greenland shrimp stock, including the inshore areas in Disko Bay and Vaigat. The surveys also provide information on Greenland halibut, cod, demersal redfish, American plaice, Atlantic and spotted wolffish and thorny skate **(SCR Doc.17/015)**.

A Greenland deep sea trawl survey series for Greenland halibut was initiated in 1997. The survey is a continuing of the joint Japanese/Greenland survey carried out in the period 1987-95. In 1997-2016 the survey covered Div. 1C and 1D between the 3 nautical mile line and the midline against Canada at depths between 400 and 1 500 m. In 2013 only Div. 1D was covered by 27 hauls and the survey is and the survey is not considered reliable for estimating indices for stock status In 2016 70 valid hauls were made **(SCR Doc. 17/021)**.

A longline survey for Greenland halibut in the inshore areas of Disko Bay, Uummannaq and Upernavik was initiated in 1993. The longline survey was changed to a gillnet survey in the Disko Bay in 2001. Since 2011 experimental gillnet stations have been set in the Uummannaq and Upernavik area. In 2016, the gillnet survey was continued in the Disko bay although with 52 sets. The longline survey was finally changed to a gillnet survey in the Upernavik area (47 sets) and in the Uummannaq area (49 sets), where 18 longline sets also were made. Each gillnet was composed of four panels with different mesh size (46, 55, 60, 70 mm and 90 mm stretch meshes) as in Disko Bay **(SCR 17/030)**.

EU-Spain, EU-Portugal: (SCR 17/13, 16, 18, 19, 20, 24): The Spanish bottom trawl survey in NAFO Regulatory Area Div. 3NO was conducted from 23rd of May to the 21st of June 2016 on board the R/V Vizconde de Eza. The gear was a Campelen otter trawl with 20 mm mesh size in the cod-end. A total of 115 valid hauls were taken within a depth range of 45-1480 m according to a stratified random design. This year we implemented a grid for the hydrographic profiles, with sampling points at 15 nm intervals on the shallower area and radials on the slope, instead of casting the data logger in each fishing station. This system however did not quite work for this survey, as it requires additional steaming time that we cannot afford in terms of working hours. The results of this survey 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 2016, the bottom trawl survey in Flemish Pass (Div. 3L) was carried out on board R/V Vizconde de Eza using the usual survey gear (Campelen 1800) from July 28th to August 17th. 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 105 and 8 of them were nulls. Survey results are presented as Scientific Council Research documents. Survey results for Div. 3LNO of the northern shrimp (*Pandalus borealis*) were presented in SCR 16/052.

The EU bottom trawl survey in Flemish Cap (Div. 3M) was carried out on board R/V Vizconde de Eza using the usual survey gear (Lofoten) from June 22th to July 23th 2016. The area surveyed was Flemish Cap Bank to depths up to 800 fathoms (1460 m) following the same procedure as in previous years. The number of hauls was 182 and one of them was null. Survey results are presented as Scientific Council Research documents. Flemish Cap survey results for northern shrimp (*Pandalus borealis*) were presented in **SCR 16/051.**

NEREIDA Project: New data on deep-water corals and sponges were presented from the 2016 EU and EU-Spanish bottom trawl groundfish surveys for 2016, and 2015 fall Canadian multispecies surveys. The data was made available to the NAFO WGESA to improve the mapping of Vulnerable Marine 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. A total number of 480 bottom trawl hauls surveys were analyzed. Distribution maps of presence and catches above threshold for RV data of sponges, large gorgonians, small gorgonians and sea pens following the threshold were presented.

USA (SCS Doc. 17/012): The US conducted a spring survey in 2016 covering NAFO Subareas 4, 5 and 6 aboard the FSV Henry B. Bigelow. All planned strata were covered, however the survey started and ended at the latest dates in the time series. The US conducted an autumn survey in 2016 covering NAFO Subareas 4, 5 and 6 aboard the FSV Henry B. Bigelow. All planned strata were covered. Biomass indices were presented for 33 stocks and abundance for the two squid stocks.

Canadian Central and Arctic Region Survey (SCR 17/028): Canada (Central and Arctic Region) conducted a survey in Div. 0A-South (to approximately 72°N) and Div. 0B in collaboration with the Greenland Institute of Natural Resources RV Pâmiut during October 7 to November 5, 2016. The Alfredo trawl (140 mm mesh with a 30 mm mesh liner in the cod end) was used to conduct 76 valid tows in Div. 0A and 81 valid tows in Div. 0B over depth strata distributed between 400 m and 1500 m. Oceanographic stations at Cape Christian and Broughton Island were not sampled in 2016 due to survey time constraints. Oceanographic variables (temperature, salinity and depth) were measured during each tow using a trawl mounted conductivity, temperature, and depth sensor.

ii) Surveys planned for 2017 and early 2018

Information was presented and representatives were requested to review and update before finalization of an SCS document in September.

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

Designated Experts were reminded to provide available stock assessment data from commercial fisheries and research surveys to the Secretariat. It was agreed to store the files on the meeting SharePoint under a folder entitled "DATA".

Tagging Activities

Information was presented and representatives were requested to review and update before finalization of an SCS document in September.

Other Research Activities

No information was received.

6. Review of SCR and SCS Documents

USA (SCS Doc. 17-012): The report described catches and survey indices of 35 stocks of groundfish, invertebrates and elasmobranchs. Of note, the indices for both Georges Bank and Gulf of Maine haddock were record highs while the indices for Georges Bank and Southern New England yellowtail flounder were among the lowest values in the time series. Research on the environment, plankton, finfishes, marine mammals, and apex predators were described. Descriptions of cruises to explore areas for wind energy and to map deep sea corals in canyons off the southern edge of George Bank were given. Other studies included age and growth, food habits, and tagging studies. The number of observer trips by fishery was discussed as well as cooperative research with the industry. A description of the method for estimating catches in the observer program used both in US waters and in the NRA was given. The bycatches of species not included in the 37 stocks was given. A summary of lengths sampled in the NAFO Regulatory Area from 2012-2016on United States vessels was shown.

Simulation of the Flemish Cap bank redfish fishery taking into account dependence of the parameters on stock density (SCR 17/034REV): STACREC has considered the paper by Victor Korzhev and Maria Pochtar (PINRO, Murmansk) with proposals to enhance the management of redfish fishery taking into account relationship of parameters and stock density.

Simulation procedures of average mass and maturity ogive of redfish were developed depending on changes of a stock size. Limiting and buffer biological reference points of the redfish stock B_{lim}, B_{pa}. F_{tr}, F_{lim}, F_{max}, F_{med} and $F_{0.1}$ were estimated in order to use them for fisheries enhancement and development of fisheries management strategy.

Major population parameters: abundance, fishing biomass, spawning biomass, yield calculated with mean long-term values of fishing and natural mortality, as well as with actual 1989-2008 recruitments have good correspondence with XSA calculations. Two options of the Flemish Cap redfish fisheries optimization have been considered: maximum yield under exploitation with constant fishing mortality and fisheries optimization under abovementioned precautionary approach.

It has been shown that optimum mean annual catch depends on the recruitment value. It can be obtained if fishing mortality is 0,08 - 0,2 and it can compose 10,000-18,000 tonnes depending on the recruitment value. So that stock remains in biologically safe limits (spawning biomass is within the range of 20,000-40,000 tonnes).

STACREC noted that, despite the method being highly promising, the decision to include the three redfish species (*Sebastes mentella*, *S. fasciatus* and *S. marinus*) together in the simulation model is no longer considered appropriate as *S. marinus* is considered to behave differently from two other redfish species. This species will be assessed separately in the future.

7. Other Matters

a) EU project on 3M cod

Cod 3M Workshop Current Assessment and Projections Uncertainties (SCS 17/07): Fernando González-Costas presented the EU project "Support to a robust model assessment, benchmark and development of a management strategy evaluation for cod in NAFO Division 3M" Specific Contract No. 03 (SC03) under the Framework Contract EASME/EMFF/2016/008 Provision of Scientific Advice for Fisheries beyond EU Waters. The work will be conducted by several partners from the following Institutes: IEO, AZTI, CEFAS, IPMA, IMARES and MRAG. The purpose of this specific study is to provide the EU Directorate-General for Maritime Affairs and Fisheries (DG MARE) and the Northwest Atlantic Fisheries Organization (NAFO) Scientific Council with technical and scientific analysis to:

- -Address the shortcomings of the current assessment model.
- -Support the development of a benchmark process within NAFO.
- -Develop and test the robustness of various Harvest Control Rules (HCR) to achieve the management objectives to be established by the NAFO FC.

The following four tasks have been programmed to achieve the project objectives:

- Task 0. Project management. March 2017- December 2019
- Task 1. Organise a workshop focused on the current assessment model and the uncertainty in the projections for cod in Division 3M. March 2017- June 2017
- Task 2. Support the development of the benchmark assessment for cod in Div. 3M. July 2017- June 2018
- Task 3. Support the development of a multiannual management plan for cod in Div. 3M. July 2018- Dec 2019

The project runs from March 2017 to the end of 2019, so far Task 1 has been completed. STACREC was informed of the results of Task 1 (SCS 17/07) was presented: The results of the workshop included proposals regarding the assessment, projections and the appropriate method to estimate the risk. These proposals were presented in more detail in STACFIS.

In addition, the following recommendations regarding the planned 2018 Benchmark for 3M cod were developed:

- To further investigate inclusion of variability in the biological parameters (MWS, MWC, MO) used in the projections.
- Further investigate methods to calculate Flim.
- To explore the option to estimate M outside the stock assessment model
- Consider alternative ways of extending the plus group and how to solve the inconsistencies of its estimation in the assessment and projections.
- Study the appropriateness of the use of the catchability depend on abundance in the current model

STACREC appreciated receiving the report of this EU workshop, endorsed its recommendations and proposes to take them into account when SC developing the agenda of the NAFO 3M Cod Benchmark in 2018.

Greenland halibut age determination workshop

The Workshop on Age Reading of Greenland Halibut 2 (WKARGH2) was a joint ICES/NAFO workshop in Reykjavik, Iceland on 22–26 August 2016. This meeting was co-chaired by Karen Dwyer (Canada) and Groa Petursdottir (Iceland) and included 15 participants from four countries (Canada, Iceland, Greenland, and Norway). Two methods for ageing Greenland halibut in the North Atlantic were identified in the last WKARGH (2011); these are thin-sectioned left otolith (viewed with reflected light) and frozen whole right otolith (viewed with transmitted light) methods. The thin-sectioned left otolith is the method that has been chosen and validated for the Northwest Atlantic (for Subarea 2 + 3KLMNO and Subarea 0 stocks) using a combination of robust age validation techniques: bomb radiocarbon analysis, and chemical mark and recapture.

This meeting was convened to attempt to reach consensus on a method of age determination for Greenland halibut, to complete an exchange between age readers, and to determine whether ages from one or both methods could be used for stock assessment. New information was presented at the meeting which confirmed the full or partial validation of both methods. A comparison of methods using WebGR (image exchange software) occurred prior to the meeting and results indicated some bias between these methods, and low precision within the methods, but generally these differences were considered to be acceptable. It was recommended that either method could be used to provide age estimates for assessments with the caveat that an ageing error matrix (AEM) or a growth curve with error be provided for use in future stock assessments to account for the uncertainty in the age estimation. Several additional recommendations were made with the objective to improve precision and resolve the bias between methods. It was also concluded that some combination of methods would be acceptable, if for example it can be shown that two methods give similar results up to a certain age then either method could be applied for that age range (in the case of Greenland Halibut in Subarea 2 + 3KLMNO, using the whole otolith for estimating age up to age 9 and then using the thin section method from age 10 onwards is appropriate).

STACREC ***endorsed*** the following recommendations of ICES-WKARGH2:

- that *the use of ageing error matrices or growth curves with error in population models be explored.*
- *otoliths from OTC recaptured fish (both Northeast and Northwest regions) should be aged using both methods.*
- *age readers for specific stocks work together to develop plans to implement either method and conduct calibration exercises (i.e. exchange of digital images between readers for each method to improve precision).*

Following a discussion of the workshop findings, STACREC made the following ***recommendations*** for Greenland halibut stocks assessed by Scientific Council:

- *a subset of existing collect*

- *ions of otoliths from both surveys and commercial sampling of Greenland halibut be re-aged as recommended by the WGARGH2 in order to improve ageing information for use in the development of population models.*
- *studies of the natural mortality of Greenland halibut be conducted*.

EU ATLAS Project – Flemish Cap Case study

A Trans-Atlantic assessment and deep-water ecosystem-based spatial management plan for Europe: This four-year H2020 project started in May 2016 and aims to gather diverse new information on sensitive Atlantic ecosystems (including Vulnerable Marine Ecosystems and Ecologically or Biologically Sensitive Areas) to produce a step-change in our understanding of their connectivity, functioning and responses to future changes in human use and ocean climate. This is possible because ATLAS takes innovative approaches to its work and interweaves its objectives by placing business, policy and socio-economic development at the forefront with science.

ATLAS not only uses trans-Atlantic oceanographic arrays to understand and predict future change in living marine resources, but enhances their capacity with new sensors to make measurements directly relevant to ecosystem function. Research activities are focusing on waters 200-2000 m deep, where the greatest gaps in our understanding lie and certain populations and ecosystems are known to be under pressure. 25 deep sea cruises are already planned with more in development and several already having taken place in 2016. These cruises are providing data to study a network of 12 case studies spanning the Atlantic from the LoVe observatory located off the Lofoten and Vesterålen islands, Norway to the Davis Straight, Eastern Arctic. Ecosystems to be studied include sponge, cold-water coral, seamount and mid-ocean ridge systems.

PROJECT OBJECTIVES:

The 4 overarching objectives of ATLAS are to:

1. ADVANCE our understanding of deep Atlantic marine ecosystems and populations
2. IMPROVE our capacity to monitor, model and predict shifts in deep-water ecosystems and populations
3. TRANSFORM new data, tools and understanding into effective ocean governance.
4. SCENARIO-TEST and develop science-led, cost-effective adaptive management strategies that stimulate Blue Growth.

FLEMISH CAP CASE STUDY

(Coordinator: Instituto Español de Oceanografía, C. O de Vigo)

The Flemish Cap Case Study will provide the opportunity to collect information on the North Atlantic deep-water ecosystems, relevant to providing ecosystem-based advice needed for Blue Growth, improving the governance in Areas Beyond National Jurisdictions (ABJN) and promoting transatlantic collaboration.

Flemish Cap is an Oceanic Bank located in Areas Beyond National Jurisdiction (ABJN), within the Northwest Atlantic Fisheries Organization (NAFO) Regulatory Area and separated from the Grand Banks by the Flemish Pass (Figure 1). It is situated in a transition area between the cold-waters of the Labrador Current and warmer waters influenced by the Gulf Stream. It is mainly covered with soft sediments and there are stones scattered in the entire area. The main focal ecosystems are sponge grounds and cold-water corals (CWC). Most of Vulnerable Marine Ecosystem (VME) indicator species as well as the VMEs elements have already been mapped. Part of the area meets EBSA criteria. Flemish Cap includes important international fishing grounds and has the potential to become an important zone for oil, gas and bioprospecting. Current NAFO enforcement and conservation measures include catch and effort limitations, fisheries footprint, VMS, observers and closed areas to protect VMEs.

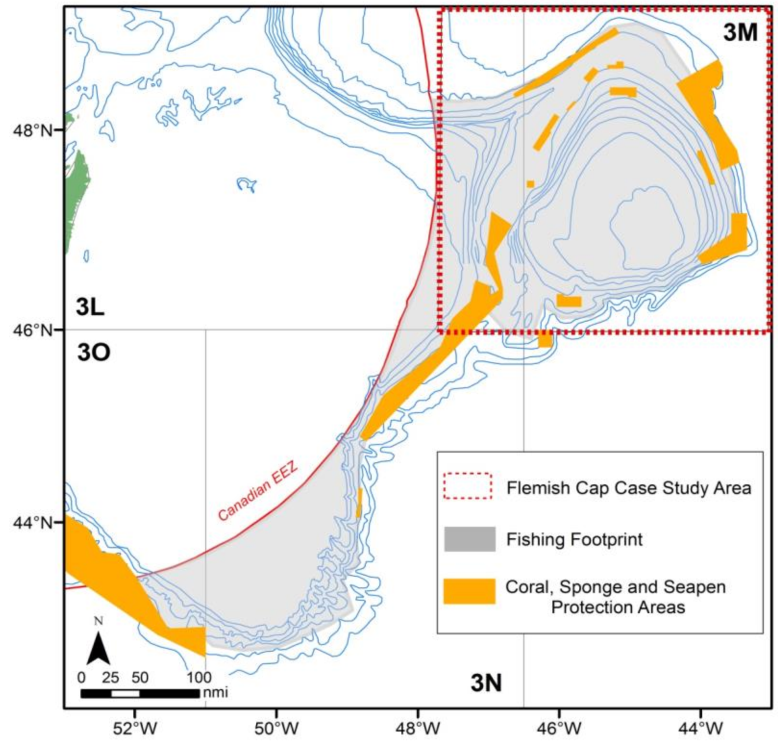


Fig 1. Flemish Cap Case Study Spatial Extent (red dashed line)

The main partners involved in this Case of Study are the Instituto Español de Oceanografía (IEO), Centro Oceanográfico de Vigo (**case study coordinator**), and Fisheries and Oceans Canada (DFO), Bedford Institute of Oceanography. Both have extensive experience (e.g. NEREIDA project) and have plans to develop future research in the area. Other partners could also participate.

Tasks to be carried out include: a study of biodiversity and biogeography (WP3); maritime spatial planning (WP6); policy integration to inform key agreements (WP7); and open science resources for stakeholders (WP8).

Existing information in this area covers several aspects namely: physical and chemical (e.g. bathymetry, CTD), habitat (e.g. habitat types, VMEs), biological components (e.g. fish, benthic invertebrates), and others (oil and gas). One of the more important datasets was collected under the NEREIDA programme (e.g. box corer/dredges, multibeam/TOPAS, CTD, benthic imagery), a Spanish-led international multidisciplinary project with the overall objective of better understanding VMEs and the impacts of bottom trawling in the NAFO Regulatory area.
Further details are available from: **www.eu-atlas.org**.

8. Adjournment

The Chair thanked the participants for their presentations to the Committee. Special thanks were extended to the rapporteur and the Scientific Council Coordinator and all other staff of the NAFO Secretariat for their invaluable assistance in preparation and distribution of documents. There being no other business the Chair adjourned the meeting at 1300 hours on 15 June 2017.

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

Co-Chairs: Joel Vigneau Rapporteurs: Various

I. OPENING

The Committee met at the Sobey School of Business, Saint Mary's University, Halifax, NS, Canada, from 1 to 15 June 2017, to consider and report on matters referred to it by the Scientific Council, particularly those pertaining to the provision of scientific advice on certain fish stocks. Representatives attended from Canada, Denmark (in respect of the Faroe Islands and Greenland), the European Union (France, Portugal, Spain and the United Kingdom), Japan , the Russian Federation, and the United States of America. Various members of the Committee, notably the designated stock experts, were significant in the preparation of the report considered by the Committee.

The Chair, Joel Vigneau (EU), opened the meeting by welcoming participants. The agenda was reviewed and a plan of work developed for the meeting. In accordance with the Scientific Council plan of work, designated reviewers were assigned for each stock for which an interim monitoring update was scheduled (see SC Report). The provisional agenda was adopted with minor changes.

II.GENERAL REVIEW

1. Changes in priorities and internal procedures for some stocks

In order to allow for sufficient time to progress on the important Greenland halibut MSE discussion, Scientific Council decided to modify the priorities and internal review procedures in response to the request for stock advice. The route taken was threefold:

1. The fully assessed stocks which do not have catch projections (redfish SA0+1, wolfish SA 1, American plaice 3M) were assessed and presented to the group for validation as per the normal procedure. The difference occurred in the STACFIS text reviewed like the Interim Monitoring Report, i.e. allocating two experts from the group to review the final assessment report. Summary sheets were done as usual.
2. The assessment of cod 3NO stock was deferred and an interim monitoring report was produced. The rationale was that the survey indices remain at a very low level and that the advice of no directed fishery would not change. Timing of the next full assessment will be discussed in September.
3. The new request for advice for golden redfish in 3M was deferred until 2018. The rationale was this new stock would need an in-depth review which needs to be prepared in advance of the meeting. A roadmap for a full assessment of this stock will be discussed in September. As in previous years, advice for this stock is given indirectly based on the 3M beaked redfish assessment by adjusting projected yields according to current proportion of S. marinus in the overall redfish catches.
4. An assessment for Greenland halibut in Subarea 2 and Divisions. 3KLMNO was produced based on two population models. However errors were discovered in the stock projection code for one of the two models (Statistical Catch at Age) following the meeting. Accordingly, advice was deferred will be drafted in the September SC meeting.

2. Review of Recommendations in 2016

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

3. General review of stocks and fisheries

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

CDAG held three meetings in 2016 to date, (London 20th January and two WebEx meetings 20th April and 18th May) where the method for the estimation of catches of priority stocks (3LMNO Greenland halibut, 3M cod and 3LNO American plaice) developed by CDAG in 2016 (FC-SC doc 16-02) was further refined. During the May

WebEx meeting, CDAG discussed the possibility of applying this method to all NAFO stocks, and it was decided that the secretariat should be requested to apply the method to all stocks in order to allow SC to determine whether this approach would be beneficial. Accordingly, the Secretariat presented 2016 catches for all stocks derived from three sources: STATLANT 21A, daily catch reports and the CDAG method. Comparison of data derived using the three methods showed that there was relatively little difference between them for any of the stocks. This is unsurprising since the level of port inspection for most stocks is low and consequently the majority of the data used when applying the CDAG method comes from the daily catch reports. Consequently, SC decided that daily catch reports should continue to be used as the primary source of catch data for stocks other than 3LMNO Greenland halibut, 3M cod and 3LNO American plaice.

4. Revised method to calculate projections

STACFIS discussed a new method to calculate the risk to address the shortcomings identified by the FC in 2015 about the Cod 3M advice. An example of how to calculate the risk in the projections has been presented with this new method based on 3M cod data (Fernandez *et al*, 2017).

To solve the problems previously encountered about the calculation of risks in projections, it was proposed to measure the risk associated with fishing an unique TAC instead of a distribution of TACs (catches) as was done in the past.

The advised catches are calculated by making a projection based on a distribution of F that gives us a possible catch distribution (one for each iteration). From this distribution the median is taken, which will be the unique Yield value that will be applied for all the iterations and that will give us another distribution of F (one F for each iteration) resulting from fishing this Yield. Then, the risk of exceeding Flim will be calculated by comparing F with Flim iteration by iteration.

STACFIS considers this procedure to measure the risk more appropriate for stocks assessed by assessment models with uncertainty than the one used until now since the stock management is done usually using a single TAC. STACFIS **recommend** that *this method should be applied to calculate the risk in the projections for these stocks.*

III.STOCK ASSESSMENTS

A. STOCKS OFF GREENLAND AND IN DAVIS STRAIT: SA0 AND SA1

Recent Conditions in Ocean Climate and Lower Trophic Levels

- The composite climate 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 a below normal state in 2015 before returning to near normal climatological conditions in 2016.
- The magnitude of the spring bloom reached a record-high in 2012 but has since declined and is below normal in 2016.
- The timing of the spring bloom in Subarea 0-1 was later but longer than normal in recent years but closer to normal conditions in 2016.

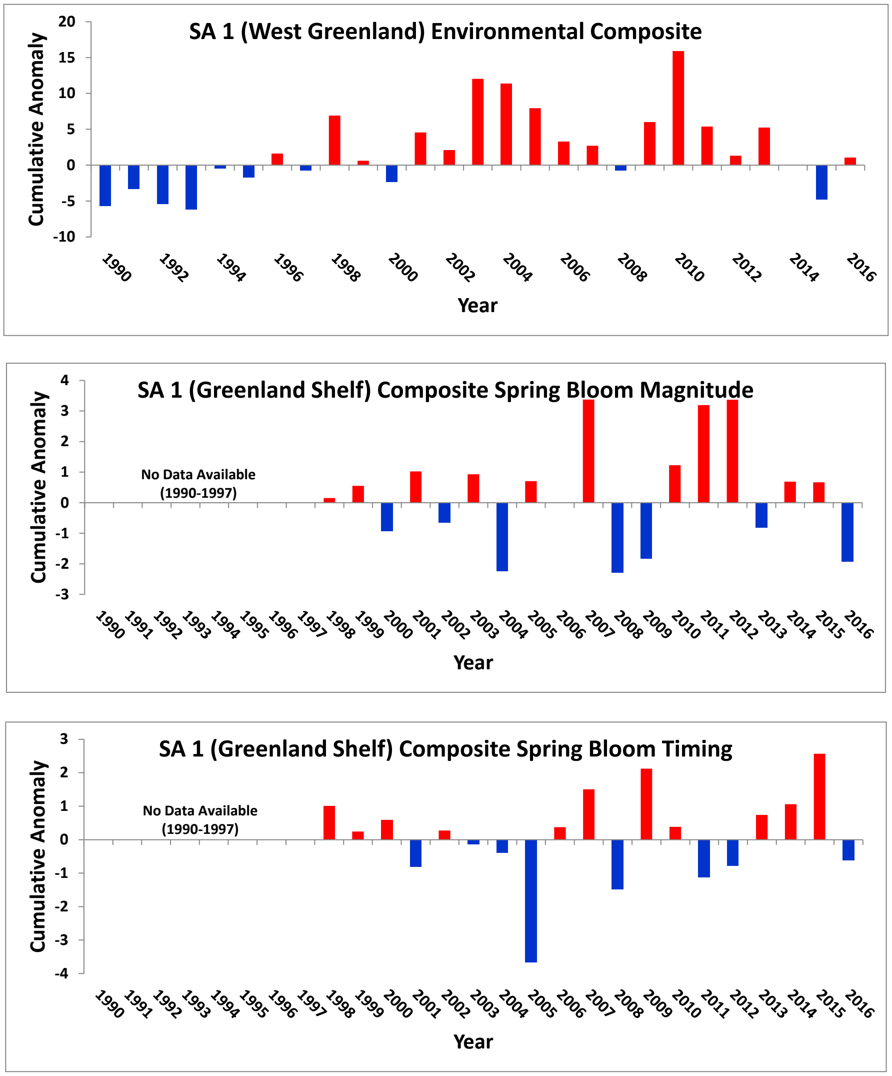


Fig. A.1. Composite climate index for NAFO Subarea 1 (West Greenland) derived by summing the standardized anomalies of meteorological and ocean conditions during 1990-2016 (top panel), composite of magnitude of the spring bloom (middle panel) and the peak time of the spring bloom (bottom panel) during 1990-2016. Annual anomalies near 0 indicate metric is near the climatological mean, positive anomalies indicating above normal levels while negative anomalies indicate below normal conditions.

Environmental Overview

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

Ocean Climate and Ecosystem Indicators

The composite climate index in Subarea 0-1 has remained mostly above normal since 2001. The peak in the series occurred in 2010 but has subsequently declined in recent years to near normal levels (Figure A.1). Cold, fresh conditions persisted in the early to mid-1990s followed by a general warming trend in the past decade with the exception of a brief cooling event in 2008 and 2015. The composite spring bloom index was below normal in 2016 after reaching near peak levels in 2007, 2011 and 2012 (Figure A.1). The timing of the spring bloom off the Greenland Shelf was slightly earlier in 2016 compared to previous years (Figure A.1). High interannual variability characterized both changes in magnitude and timing of the spring bloom in SA 1. Air temperatures over West Greenland and much of the Labrador Sea region were above normal during 2016. In 2016 temperature and salinity of the Irminger Sea Water in the 75-200 m layer off Cape Desolation was 5.4°C and 34.84, which was 0.3°C and 0.08 below the long-term mean, respectively. The water properties between 0 - 50 m depth at Fyllas Bank are used to monitor the variability of the fresh Polar Water component of the West Greenland current. After a temperature decrease in 2015, 2016 experienced a significant increase to levels which have not been observed since the start of monitoring in the 1980s; with temperatures 2.1°C higher than the long-term mean. In 2016 salinity was 0.29 below its long-term mean.

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

Interim Monitoring Report (SCR Docs 17/15, 21, 28; SCS Docs. 17/08, 17/11)

a) Introduction

A TAC for Greenland halibut in Subarea 0 + 1 (excluding Div. 1A inshore) was established in 1994, following the separation of the 1A inshore stock area from the offshore. Catches prior to 1994 varied with peaks in 1975 and 1992 of 20,000 t. Since 1994 catches have increased in response to increases in TAC from approximately 9,000 t to 31,000 t in 2016.

Table 1.1 Recent catches and TACs ('000 t) were updated to reflect changes in Statlant 21B are as follows:

	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
TAC	24	24	27	27	27	27	30	30	30	32.3
SA 0	10	12	13	13	13	13	15	15	14	
SA 1 offshore	12	12	13	13	13	13	15	15	15	
SA 1 inshore (Divs. 1C-F)	<1	<1	<1	<1	<1	1	2	2	2	
Total STATLANT 21[1]	22	25	27	27	27	28	31	32	31	

[1] Excluding inshore catches in Div. 1A and 0B (Cumberland Sound)

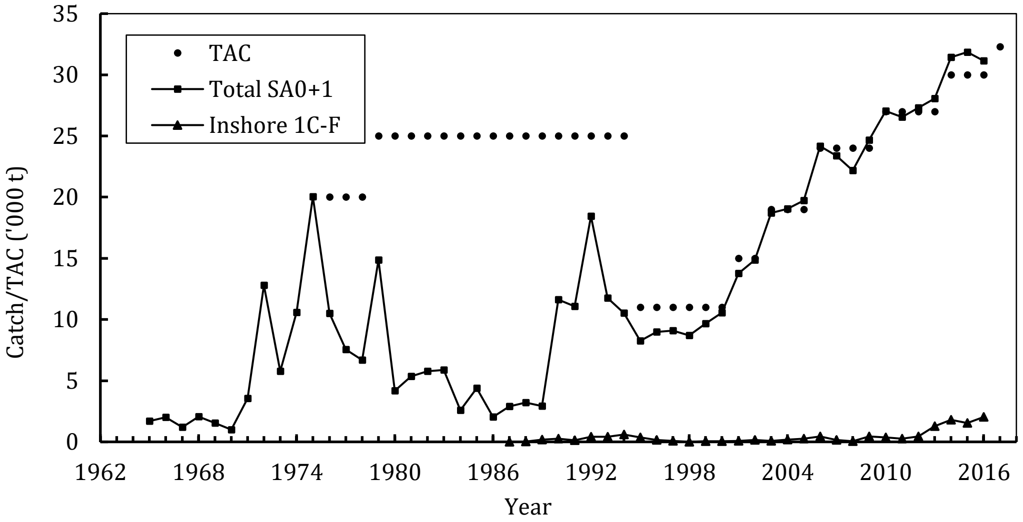


Fig. 1.1. Greenland halibut in Subareas 0+1 (excluding Div. 1A inshore): catches and TAC.

b) Data Overview

Greenland and Greenland-Japan Surveys. From 1987 to 1995 Japan and Greenland conducted a joint survey in Divs. 1BCD. In 1997 Greenland initiated a survey series covering Divs. 1CD. The biomass index, although variable, had shown a general increasing trend to 2011, declined over 2011-2014 but has since increased to near average levels for the time series.

Canada Surveys. Since 1999 Canada has conducted surveys in Subarea 0. Surveys in 0A-South (to 72^{o}N) have been completed in 1999, 2001, every second year between 2004 and 2014, and annually since then. The 2006 survey had poor coverage and was not considered valid. Surveys in 0B have been less frequent with surveys in 2000, 2001, 2011 and 2013-2016. The 0B index has been increasing since 2013 at levels comparable to the Greenland 1CD index. The 0A-South index has been variable with an overall increasing trend and in 2016 was the highest in the time series.

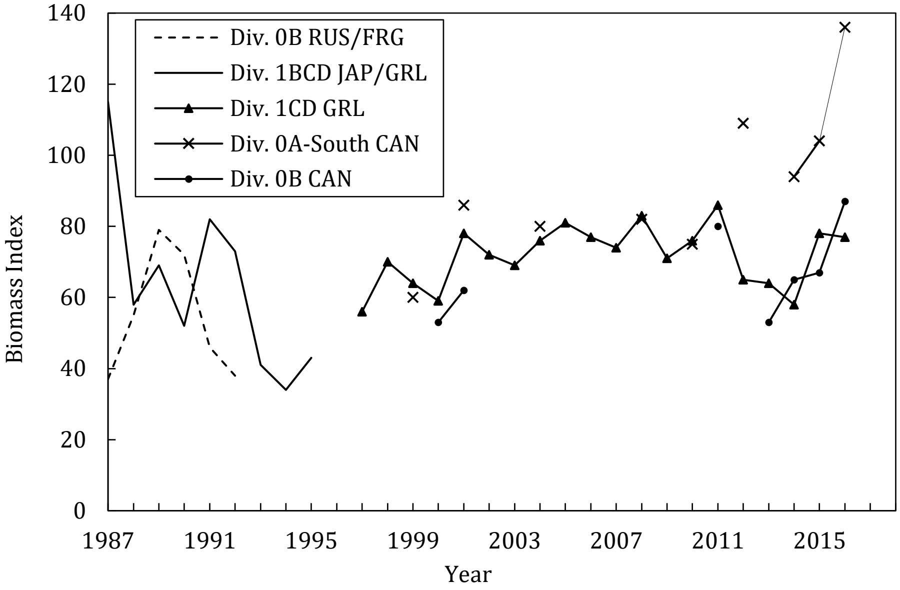


Fig. 1.2. Greenland halibut in Subareas 0+1 (excluding Div. 1A inshore): biomass indices from bottom trawl surveys. A survey in Div. 0A in 2006 is not included due to poor coverage.

Combined 0A-South and 1CD Survey Index. In 2014 STACFIS adopted a recommendation from the ICES Greenland halibut benchmark meeting (ICES 2013) to create a combined survey index with which to monitor the overall Subarea 0+1 (excluding Div. 1A inshore) stock. The surveys are conducted with the same vessel and gear during the fall which allowed for a simple addition of the survey estimates to create the index. This index was relatively stable until 2014 followed by increases in the last two years with the 2016 value 36% above the 1999-2015 series average. In 2014 a proxy for Blim was set as 30% of the mean of the 0A-South and 1CD biomass index for 1999 to 2012 (a period of stability in the index time series).

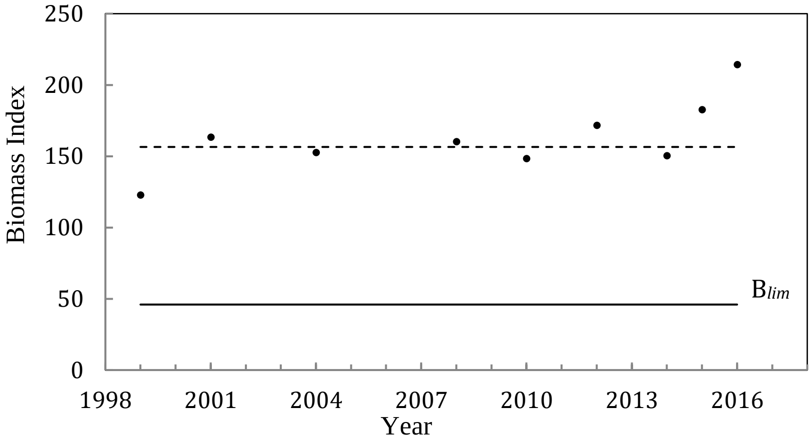


Fig. 1.3 Greenland halibut in Subarea 0+1 (excluding Div. 1A inshore): 0A-South and 1CD combined biomass index (circles), 1999-2015 series average (dashed line), and the proxy for B_{lim} (line).

Recruitment. The Petersen-method is used to assign Greenland halibut caught during the West Greenland shrimp survey to age 1, 2 and 3+ using length data. The number of 1 year old fish in the survey area, including Disko Bay, is used as an index of recruitment. Abundance of 1 year old fish increased from the early 1990s to a peak in 2000, then declined in 2001 and remained relatively stable until 2010 when a peak value similar to that in 2000 was observed. Since 2010 the index has been highly variable with above average recruitment in 2012 and 2014.

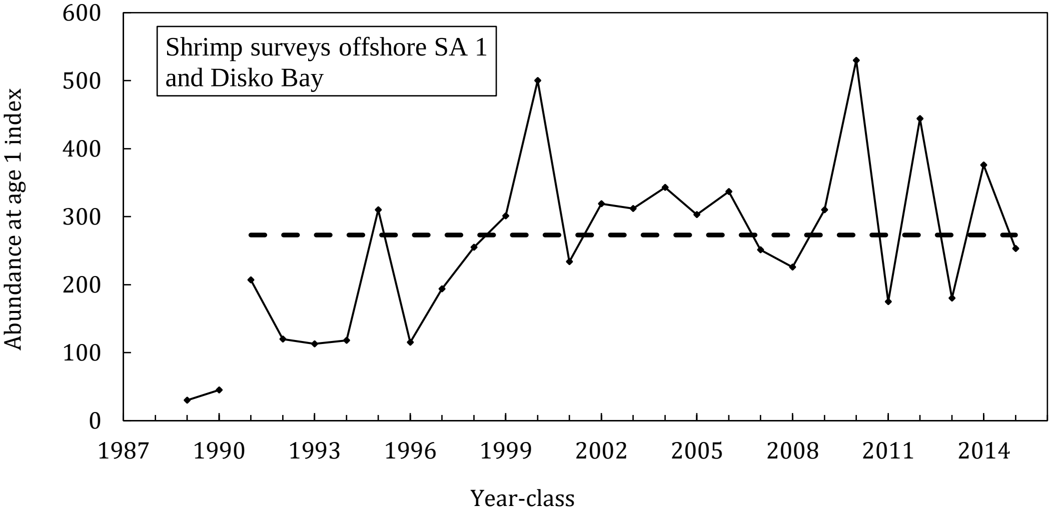


Fig. 1.4. Greenland halibut in Subareas 0+1: recruitment index at age 1 in Subarea 1 derived from the Greenland shrimp surveys. Note that the survey coverage was not complete in 1990 and 1991 therefore, the 1989 and 1990 year-classes are poorly estimated as age 1. The dashed line indicates the series average.

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

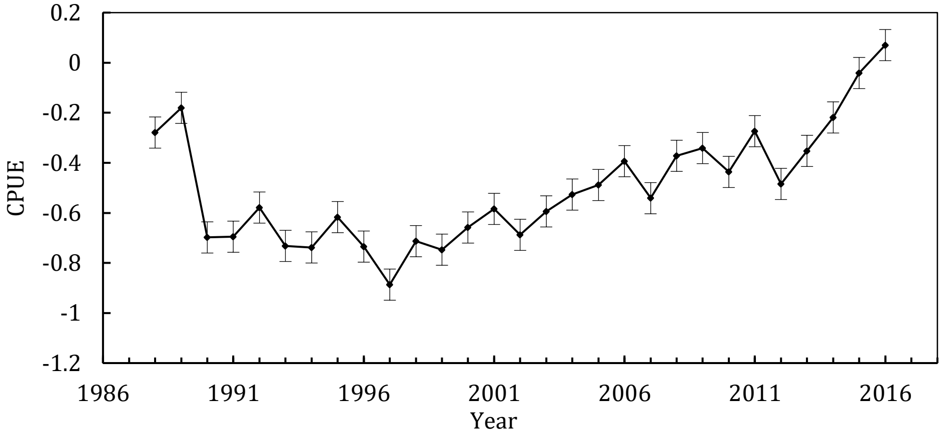


Fig. 1.5. Greenland halibut in Subareas 0+1 (excluding Div. 1A inshore). Combined standardized trawler CPUE from all Divisions with ±S.E.

c) Conclusion

This stock underwent full assessment in 2016 based on survey indices. This assessment indicated that the stock is above B_{lim} and has been relatively stable since 2001, with a slight increasing trend in recent years. Canada and Greenland request TAC advice separately for Div. 0A+1AB and Div. 0B+1C-F. In 2016 the ICES Harvest Control Rule 3.2 for data limited stocks was used to formulate the advice. Based on this information, Scientific Council advised a TAC for 2017 and 2018 of 17,150 t and 15,150 t, for Div. 0A+1AB and Div. 0B+1C-F, respectively.

Based on survey indices for the current year, the advice from the 2016 assessment is still considered valid.

The next full assessment of this stock is planned for 2018.

2. Greenland halibut Div. 1A inshore.

Interim monitoring report (SCR Doc. 17/015 027 037 SCS Doc. 17/08)

a) Introduction

Greenland halibut can be found in the waters around Greenland from the Qaanaaq district in North West Greenland to Ittoqqortoormiit in East Greenland, both offshore and inshore. Greenland halibut is targeted in most inshore areas, but the main inshore fishing grounds are the Disko Bay and the fjords surrounding Uummannaq and Upernavik. The stocks receive recruits from the spawning stock in the Davis Strait. There is little migration between the areas and offshore areas (Baffin Bay and Davis Strait). A separate advice is given for each subarea on a two year cycle and a separate TAC is set for each area.

b) 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 low until the 1980s but increased substantially thereafter. 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, "quota free" areas within each subarea were set by the Government of Greenland, 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 shrimp fishery conducted in the Disko bay and offshore in West Greenland. A dispensation from sorting grids was given in the inshore areas until 2011. Besides the three main areas, a fishery is slowly developing in the Qaanaaq fjord (77 North).

Disko Bay: Catches increased from in the 1980s, peaked from 2004 to 2006 at more than 12 000 tonnes but then decreased substantially. In the recent decade catches have increased and in 2016, total landings reached 10 760 tonnes (Fig 2.1).

Uummannaq: Catches increased in the 1980's and peaked in 1999 at more than 8000 t, but decreased, in the following years. In the recent decade total catch has increased violently reached a record high 10 304 tonnes in 2016 (Table 2.1 and fig 2.1).

Upernavik: Catches increased in 1980's and peaked in 1998 at a level of 7 000 t but decreased thereafter. During the last 15 years the catch has increased gradually and in 2016 reached 7 362 tonnes, only surpassed by 2015 (Table 2.1 and fig 2.1).

Recent catches and advice ('000 tonnes) are as follows:

	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Disko Bay – TAC	12.50	8.80	8.80	8.00	8.00	9.00	9.00	9.20	9.30	9.20
Disko Bay - Catch	7.70	6.32	8.46	8.00	7.76	9.07	9.18	8.67	10 76	
Uummannaq - TAC	5.00	5.00	5.00	6.00	6.00	7.45	8.38	9.50	9.60	9.50
Uummannaq - Catch	5.43	5.45	6.23	6.40	6.13	7.01	8.20	8.24	10.30	
Upernavik - TAC	5.00	5.00	6.00	6.50	6.50	7.95	9.50	9.50	9.60	9.50

Upernavik - Catch	5.48	6.50	5.94	6.47	6.83	6.04	7.38	6.27	7.36
Qaanaaq - Catch				0.02	0.05	0.01	0.13	0.14	0.14
STACFIS Total	18.60	18.27	20.63	20.89	20.79	22.13	24.89	23.33	28.57

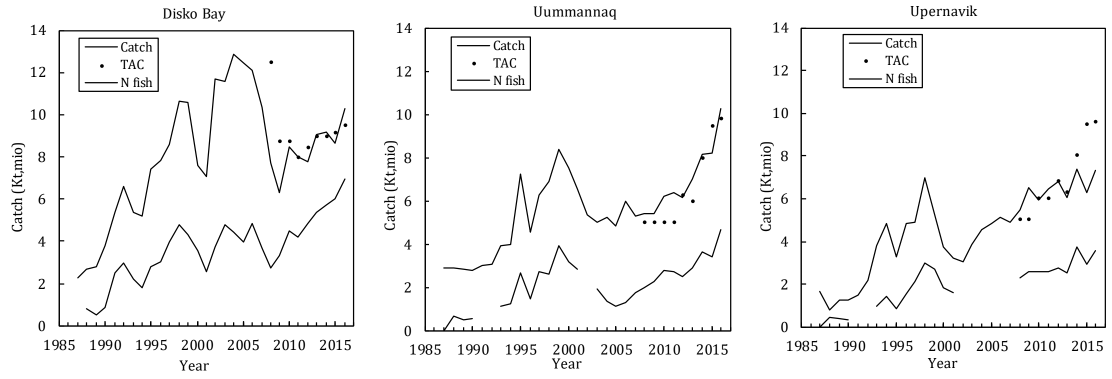


Fig 2.1. Greenland halibut in Division 1A inshore: Greenland halibut catches and TAC in t in Disko Bay, Uummannaq and Upernavik. Catch numbers are in million.

c) Input data

i) Commercial fishery data

Length frequencies from factory landings are available since 1993, and a mean length in the landings by season, gear and year as well as total weighted by season, gear and area have been calculated (fig 2.2).

In the 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 area. Glacier ice normally limits the access to the deep areas (Kangia and Torsukattak), causing the difference between the summer and winter fishery mean length. The continuous decrease suggests a true decrease in the adult stock rather than new year classes. The decreasing size can also be seen as a general shift of the length distribution towards smaller fish and a narrower distribution in the longline landings. Furthermore, the length distributions in the gillnet fishery has shifted to smaller fish since 2009, indicating a shift to finer meshed (illegal) gillnets.

In **Uummannaq,** the mean length in the landings have gradually decreased for two decades, but at a very slow rate. The overall yearly mean length in the landings weighted by gear has shown high stability in the most recent 6 years.

In **Upernavik,** the mean length in longline landings decreased until 1999, but then remained stable for almost two decades. However, mean length in both the longline fishery and in the overall mean length weighted by gear decreased in 2014, but have remained stable since then.

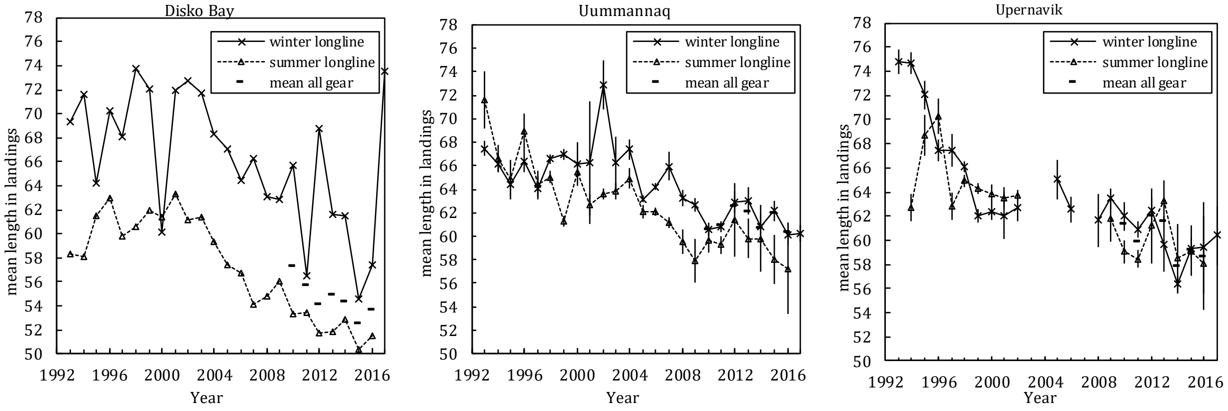


Fig. 2.2. Greenland halibut in Division 1A inshore: Mean length in landings from longline fishery by season and from longlines and gillnets weighted by total catch.

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 were applied to the longline and gillnet fishery logbook data since 2008. CPUE observations were log-transformed prior to the GLM analysis. Least-mean square estimates were used as standardized CPUE series (fig 2.3).

In the **Disko Bay,** the mean log-CPUE is showing a decreasing trend since 2009. Although increasing from 2015 to 2016 the overall trend is still decreasing. In **Uummannaq**, a change in the mean longline log-CPUE had occurred from 2015 to 2016, after it was at a somewhat higher level in the period from 2010 to 2014. In **Upernavik,** the longline CPUE has gradually decreased and 2015 and 2016 were at the lowest level observed in the period.

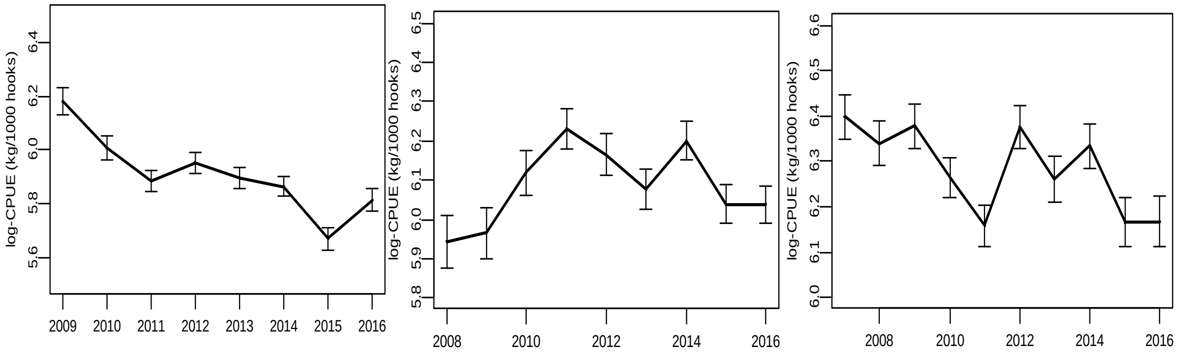


Fig 2.3 Standardized mean and 95% CI of longline CPUE in Disko bay (left), Uummannaq (center) and Upernavik (right).

ii) Research survey data

The Greenland shrimp and fish survey also covers the Disko bay. Separate abundance and biomass indices and length frequencies has been calculated for the Disko bay part of the survey (fig 2.4).

The Disko bay trawl survey has a dominance of juvenile Greenland halibut, although adult fish are also taken. Year to year variation in the number of one year old recruits, leads to high fluctuation in the abundance estimate, but has little influence on the biomass index. The trawl survey indicated increasing abundance 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 (2010 and 2012 YC). However, only the 2010 YC can be followed as larger than average in the following years. 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. The Greenland Shrimp and Fish survey also covers western side of the Uummannaq fjord and the shelf and trenches just west of Uummannaq and Upernavik. In these areas high numbers of recruits are also found.

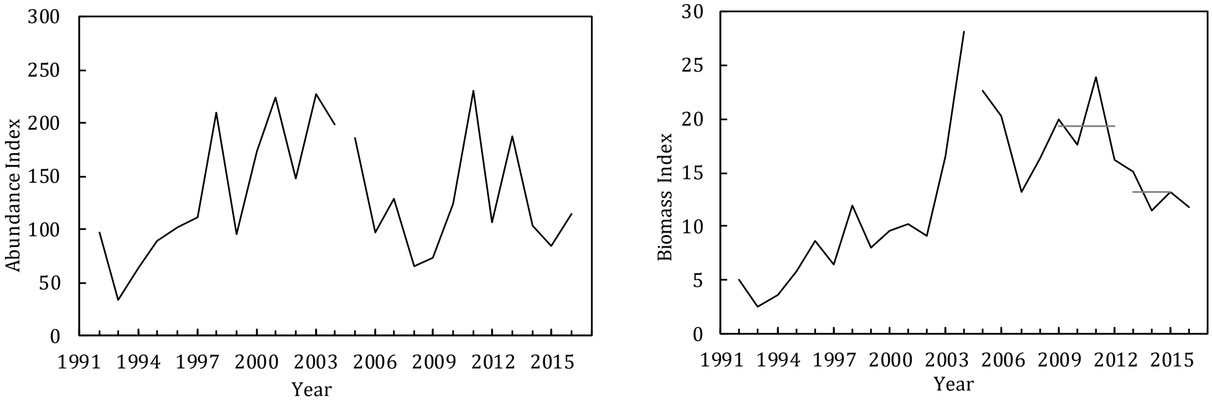


Fig 2.4. Greenland halibut in Division 1A inshore: Abundance and biomass indices in the Disko bay from the Greenland Shrimp Fish trawl survey.

Gillnet surveys were originally designed to target pre fishery recruits at lengths from 35-55 cm. Since the survey uses gillnets with narrow selection curves and normally catches the same sized fish, but in varying numbers, there is little difference between the trends of the CPUE and NPUE indices (fig 2.5)

The 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. Since 2013, indices have been below average, indicating lower levels of pre fishery recruits. The high correlation between the gillnet survey NPUE and the summed number of Greenland halibut larger than 35 cm in the trawl survey results, however adds credibility to both surveys. However, both surveys show large year to year variation, which could be due to shifts in the distribution of the stock within the area.

The Uummannaq gillnet survey was performed using the same method and setup as in the Disko bay. The overall trend in the survey could not be used due to a low number of stations prior to 2015. In 2015 and 2016, more stations resulted in a CPUE twice as high and an NPUE considerably higher than the long term mean in the Disko bay gillnet survey, indicating more fish and larger fish with considerable numbers in the interval 50-70 cm.

The Upernavik gillnet survey was performed using the same method and setup as in the Disko Bay. The number of stations were between 13 and 21 per year from 2012- 2014 increasing to 48 in 2015. The recent survey indices were higher than long-term mean in the Disko Bay gillnet although decreasing slightly from 2015 to 2016.

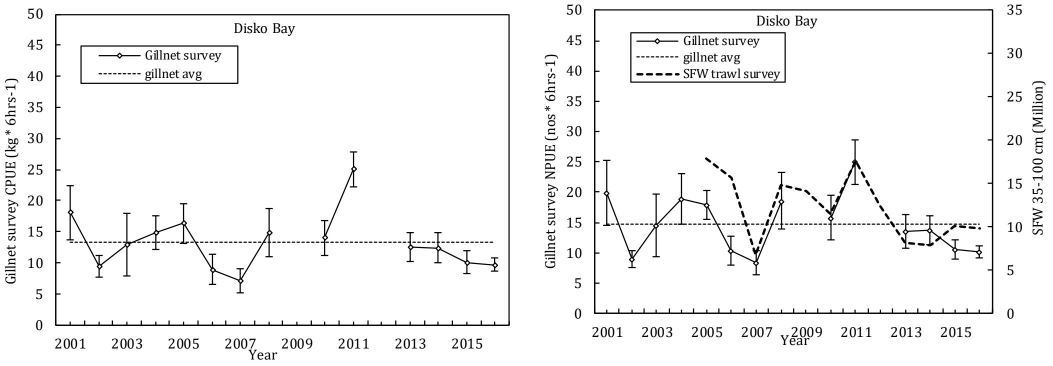


Fig 2.5. Greenland halibut in Division 1A inshore: Gillnet survey CPUE and NPUE +/-SE.

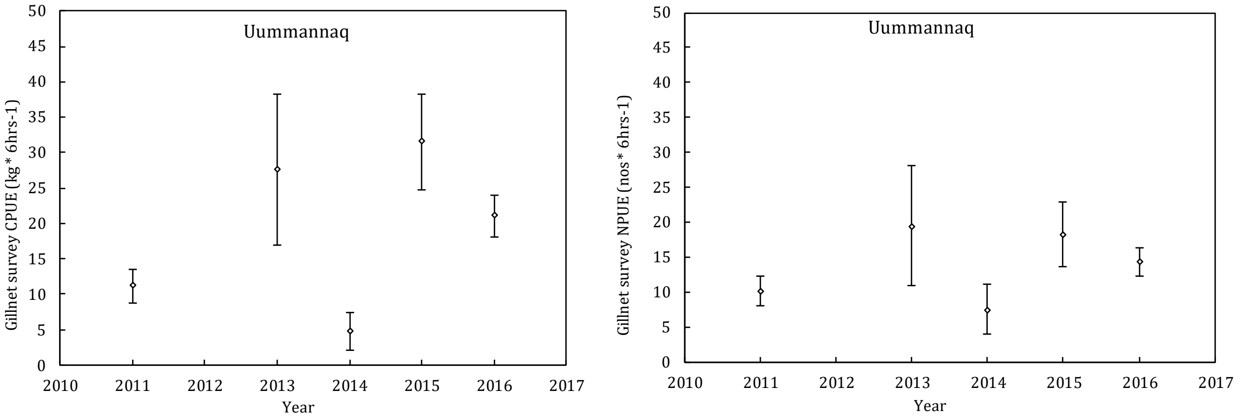


Fig 2.6. Greenland halibut in Division 1A inshore: Gillnet survey CPUE and NPUE +/-SE.

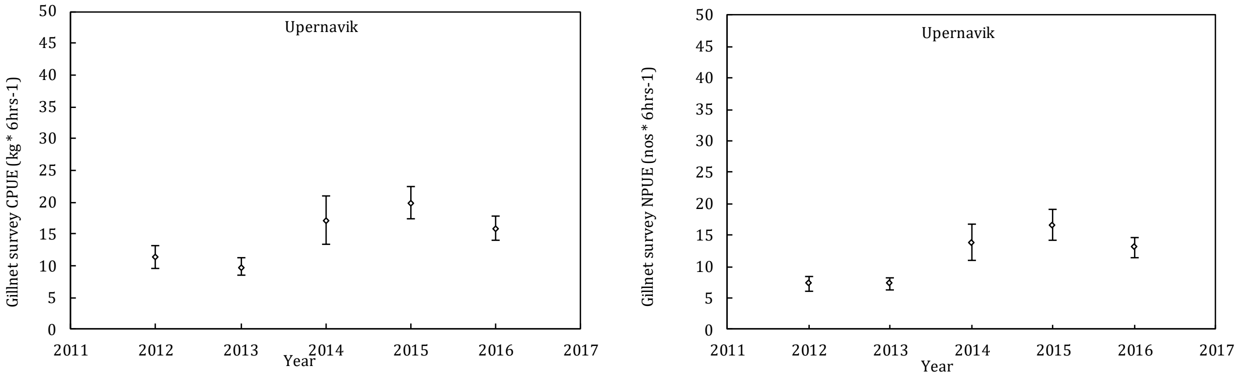


Fig 2.7. Greenland halibut in Division 1A inshore: Gillnet survey CPUE and NPUE +/-SE.

d) Assessment results:

Disko Bay

Based on the updated indices there is no indication of a significant change in the status of the stock. The trawl survey index has continued the overall decreasing trend. The gillnet survey remains below the long term mean. Length distributions in both the longline and gillnet fisheries are at the same level as in recent years. Although increasing in 2016, the longline mean CPUE series is within the overall decreasing trend.

Uummannaq

Based on the updated indices there is no indication of a significant change in the status of the stock. The mean log CPUE index has been relatively stable over time although decreasing slightly in 2015 and 2016. The gillnet survey CPUE still shows more and larger fish than the long-term average in Disko Bay, with considerable numbers in the interval 50-70 cm. Mean length in the landings has gradually decreased, but stabilized in the most recent years.

Upernavik:

Based on the updated indices there is no indication of a significant change in the status of the stock. The mean log CPUE index decreased gradually since 2008 and dropped further in 2015 and 2016. The gillnet survey CPUE was higher than long-term mean in the Disko Bay, gillnet although decreasing slightly from 2015 to 2016. The mean length in the landings decreased in 1990s then was stable until 2013. After a decreased in 2014, the mean length in the landings has remained stable

These stocks will next be assessed in 2018.

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

Full assessment report (SCR Doc. 88/12 96/36 07/88 17/015 021 039; SCS Doc. 17/008)

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 however suggest decade long concentrations of redfish in both areas.

Fisheries and Catches

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

The fishery targeting demersal redfish in SA1 increased during the 1950s and peaked in 1962 at more than 60 000 t. Catches then decreased and have remained below 1 000 tonnes per year after 1986 with few exceptions. However, catches are highly uncertain with evidence of cod being misreported as redfish and other species in the 1970s, and by-catches of redfish in the shrimp fishery not appearing in official statistics in some years. Bycatch of redfish was estimated to be more than 14 000 t in 1988 and 4 000 t in 1994. To reduce the amount of fish taken in the trawl fishery targeting shrimp, sorting grids have been used since 2002. In 2016, 25 t was reported as by-catch in offshore fisheries (1 tonnes from shrimp trawlers) and 140 t was taken inshore mainly as a bycatch in cod and Greenland halibut fisheries (Fig 4.1).

Recent catches ('000 tonnes) are as follows:

	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
TAC	1	1	1	1	1	1	1	1	1	1
STATLANT 21	0	0.02	0	0.2	0.12	0.16	0.25	0.19	0.16	
STACFIS	0.4	0.4	0.3	0.2	0.16	0.17	0.17	0.26	0.17	

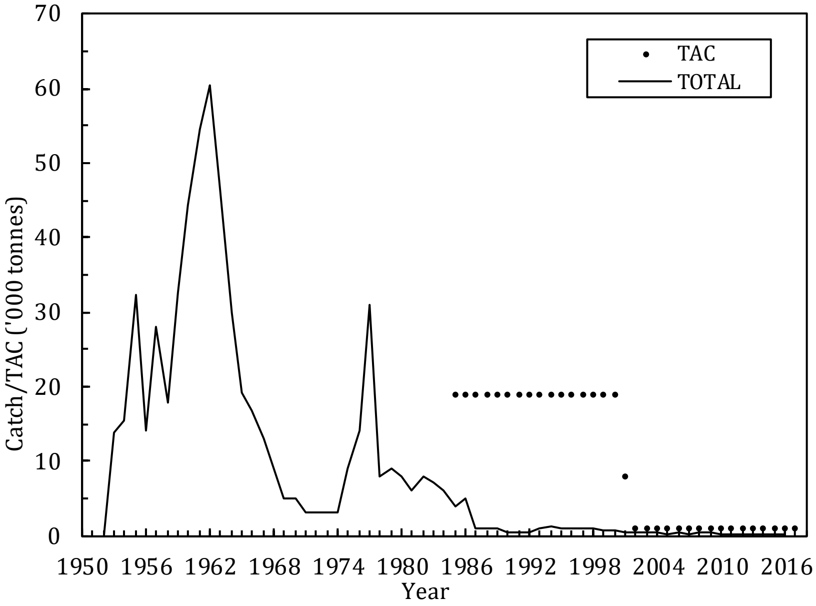


Fig. 4.1. Demersal redfish in Subarea 1: catches and TAC.

b) Data overview

i) Commercial fisheries

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

ii) Research surveys

There are three ongoing surveys covering the demersal redfish stocks in Subarea 1. The EU-Germany survey (Walther Herwig III, 0-400m, NAFO 1C-F, ICES XIV, since 1992), the Greenland deep-sea survey (Pâmiut, 400-1500m, NAFO 1CD 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 and has a more appropriate depth and geographical coverage in regards to redfish distribution, and covers the important nursery areas in 1B. However, no separation of redfish species was made prior to 2006 and the gear was changed in 2005 in the survey, thus braking the index. In 2016, the EU-Germany survey had low coverage, limited to the southern part of 1E and 1F. Biomass and abundance estimates were available from all three surveys in 2016 and length frequencies were available from the Greenland surveys. During the years, annual growth increments of 4 cm were indicated by repeated pronounced peaks in length compositions. 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 (fig 4.2). However, the survey has revealed increasing biomass indices of golden redfish (>17cm) since 2004 and the 2015 index reached the highest level observed since 1986. In 2016, the EU-Germany survey had 22 hauls and only covered 1F (17) and the southern part of division 1E (5). Therefore, the biomass estimate is likely underestimated in 2016.
- **The Greenland shrimp and fish survey** biomass index for golden redfish increased substantially since 2011 (fig 4.2). The peaks observed in 2013 and 2016 are caused by few single hauls accounting

for most of the year's estimate; in 2016, more than 80% of the biomass derives from a single haul in division 1E consisting of large golden redfish at lengths between 45 and 70 cm.

Demersal deep-sea redfish (*Sebastes mentella*)

- **The EU-Germany survey** biomass index has fluctuated at a low level throughout the time series (Fig 4.3). 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 (fig 4.3).
- **The Greenland deep-sea survey** (1CD) indices were at a low level from 1997 to 2007, but the biomass index has increased since then and remained at a higher level (Fig 4.3).
- **The Greenland shrimp and fish survey** biomass index for deep-sea redfish steadily increased after 2006 and the 2016 indices are the highest observed (fig 4.3). However, 70% of the 2016 biomass index came from a single haul in division 1D. Length frequencies by division in the 2016 survey revealed large redfish in the area at lengths between 25 and 40 cm.

Juvenile redfish (both species combined)

- **The EU-Germany survey** regularly found juvenile redfish from 1984 to 2000. After 2000, the abundance of juvenile redfish have decreased to a low level and has remained low since then (Fig 4.3).
- **The Greenland shrimp and fish survey** initially had high levels of juvenile redfish in the survey and the total abundance of both species combined can be regarded as a recruitment index. From 1992 to 1999, high numbers of redfish recruits were observed annually, but the index gradually decreased and remained low until 2004. After the gear change in 2005, the abundance index gradually decreased (fig 4.3). Length distributions reveal that the increase in survey biomass observed in 2016 is primarily large mature redfish and not recruits. Length distributions also reveal that since 2011, virtually no new incoming year classes have been observed in West Greenland. Recruitment in East Greenland which could potentially supply West Greenland with recruits (as known for other species such as cod, haddock), have also been low in the recent 4-6 years. Data from the Greenland shrimp and fish survey in East Greenland reveal that new significant incoming year classes of redfish have not been observed since 2010.

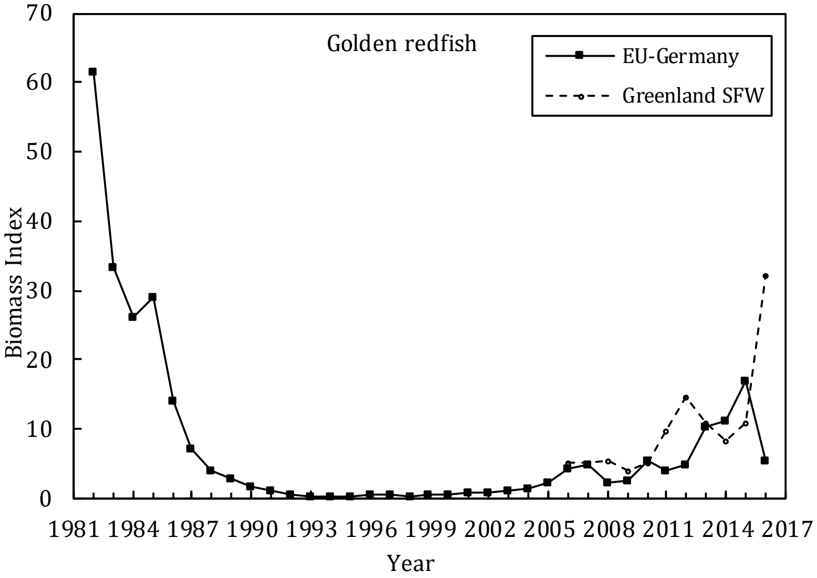


Fig. 4.2. Golden redfish biomass indices in the EU-Germany survey (1C-F) and the Greenland shrimp and fish survey (1A-F).

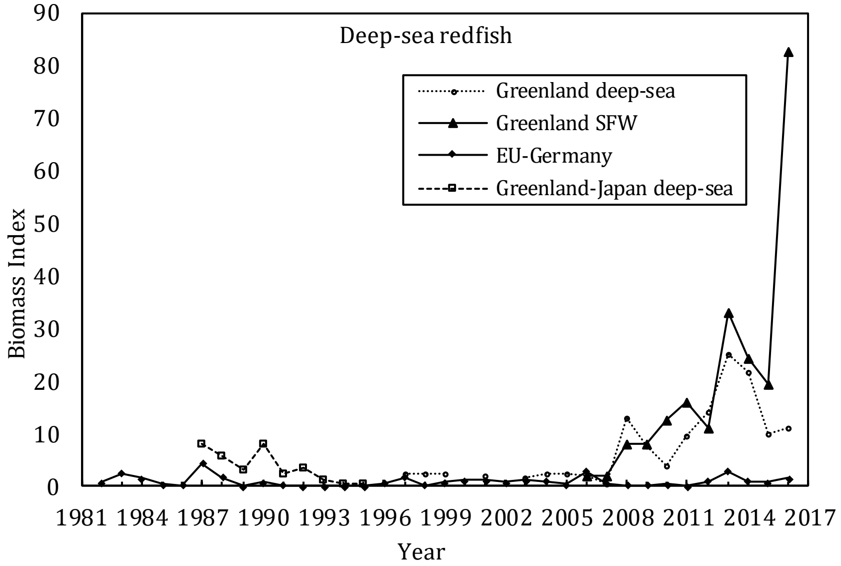


Fig. 4.3. Demersal deep-sea redfish survey biomass from the Greenland shrimp and fish survey (1A-F), the Greenland deep-sea survey (1CD), the EU-Germany survey (1C-F) and the Greenland-Japan survey (1B-D).

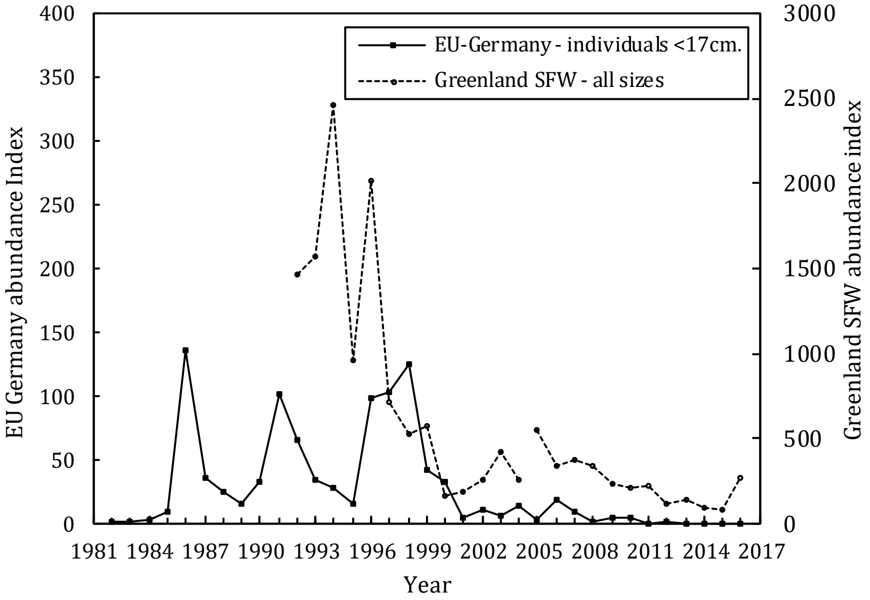


Fig. 4.4. Juvenile redfish abundance indices (deep-sea redfish and golden redfish) for the EU-Germany survey (1C-F), and the Greenland shrimp and fish survey (1A-F, all sizes).

c) Assessment results

Assessment results: No analytical assessment was performed.

Fishery and catches: The proportions of golden and deep-sea redfish in the historic 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 bycatch has been reduced.

i) Golden redfish - Sebastes norvegicus

Data: Biomass and abundance indices were available from the EU-Germany survey and the Greenland shrimp and fish survey. Logbooks and factory data were available.

Biomass: Survey indices in the EU-Germany survey and the Greenland shrimp and fish survey agree that the biomass of golden redfish in West Greenland has been increasing in the recent decade. The disagreement between the surveys in 2016 is likely related to low survey coverage in the EU Germany survey. The biomass is, however, still far below the 1980s level. The 1980s index values must have been obtained from a stock that was already smaller than historic levels, since the size reduction in the landings occurred during the 1960s and 1970's.

Fishing mortality: Unknown. The contribution to fishing mortality from bycatch of redfish in the shrimp trawls was reduced with the implementation of sorting grids in 2002.

Recruitment: Recruitment has been low for the last two decades in West Greenland and new year-classes have been close to absent since 2011 in West Greenland and since 2010 in East Greenland.

State of the stock:

The EU-Germany and Greenland shrimp and fish survey have revealed increasing biomass of golden redfish in the recent decade but divergent trends in 2016. However, the EU-Germany survey had low coverage in 2016. The EU-Germany survey is, however, still far below the 1980s biomass index, which was before the Greenland shrimp and fish survey was initiated. In the Greenland shrimp and fish survey, virtually no new incoming year classes have been observed since 2011 in West Greenland or in East Greenland waters in the recent 4-6 years.

ii) Deep-sea redfish - Sebastes mentella

Data: Biomass and abundance indices were available from the EU-Germany survey and the Greenland-Japan deep-sea survey. Biomass and abundance indices and length distributions were also available from the Greenland shrimp and fish survey and the Greenland deep-sea survey. Logbooks and factory data were available.

Biomass: The Greenland-Japan survey indicated that the biomass decreased from 1987 to 1995. The Greenland deep-sea survey indicated that the biomass remained low until 2007. Survey indices in the Greenland shrimp and fish survey and the Greenland deep-sea survey and the EU-Germany survey agree that the biomass of golden redfish in West Greenland has been increasing in the recent decade.

Fishing mortality: Unknown. The contribution to fishing mortality from bycatch of redfish in the shrimp trawls was reduced with the implementation of sorting grids in 2002.

Recruitment: Recruitment has been low for the last two decades and new year-classes have been absent since 2011 in West Greenland and since 2010 in East Greenland.

State of the stock:

The Greenland-Japan survey indicate that the biomass decreased from 1987 to 1995. The Greenland deep-sea survey indicate 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 has gradually been increasing since 2008. Recruitment has been at a very low level in the area for almost 2 decades. In the Greenland shrimp and fish survey, virtually no new incoming year classes have been observed since 2011 in West Greenland or in East Greenland waters in the recent 4-6 years.

This stock will next be assessed in 2020.

4. Other Finfish in SA 1

Before 2012, Denmark (on behalf of Greenland) requested advice for Atlantic wolffish, spotted wolffish, American plaice and thorny skate in subarea 1 under the term "other finfish". However, the requests of 2012 and 2013 no longer use this term, but strictly requests advice by species, and no longer requests advice for thorny skate. Therefore, the STACFIS report has been updated and advice for Atlantic wolffish, spotted wolffish and American plaice can now be found under their common names in section 5a and 5b.

5a. Wolffish in SA 1

Full assessment report (SCR Doc. 80/VI/72 77 96/036 07/88 17/015 036; SCS Doc. 17/008)

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 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 in the coastal areas and inside the fjords. Atlantic wolfish has a shallower depth distribution (0-400m) than spotted wolffish (0-600).

Fisheries and catches.

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 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 tonnes per year (Fig 5a.1). After 1980, the cod fishery gradually decreased in West Greenland and catches of wolffish also decreased during this period. To minimize by-catch in the shrimp fishery, offshore trawlers targeting shrimp have been equipped with grid separators since 2002 and inshore (Disko Bay) trawlers since 2011. After 2014, the reported catches have gradually decreased,. In 2016, reported catches decreased to 204 tonnes, of which 182 tonnes were landed to factories and 22 tonnes were taken as by-catch in the offshore fishery targeting cod and other species.

Recent nominal catches (000 tonnes) for wolffish.

	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Atlantic wolffish TAC								1.00	1.00	1.00
Spotted wolffish TAC								1.03	1.03	1.03
Wolffish TAC	1	1	1	1	1	1	1	2.03	2.03	2.03
STATLANT 21	1.20	0.05	0.01	0.75	1.01	858	0.91	0.40	0.24	
STACFIS	1.20	1.18	1.32	0.78	1.01	858	0.91	0.40	0.20	

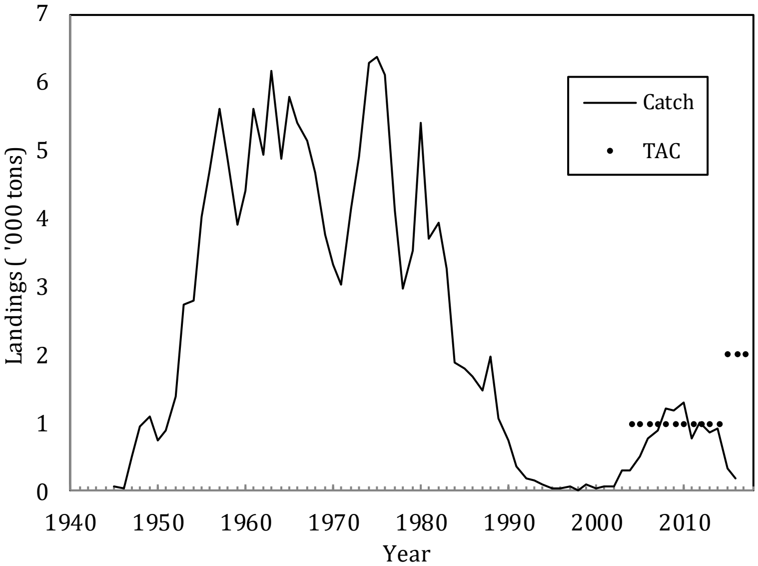


Fig 5.1. Wolffish in Subarea 1: Catches and TACs for Atlantic wolffish and spotted wolffish combined from 1945 to 2016.

b) Input data

i) Research survey data

There are two surveys partly covering the stocks of Atlantic wolffish and spotted wolffish in subarea 1. The EU-Germany survey (Walther Herwig III, 0-400m, NAFO 1C-F, ICES XIV, since 1982) has a longer time series but only covers the southern part of West Greenland. The Greenland shrimp and fish survey (Pâmiut, 0-600m, NAFO 1A-F, since 1992, ICES XIV since 2007) covers a larger geographical area and depth range. The Greenland shrimp and fish survey has a more appropriate geographical coverage in relation to wolffish but both surveys covers the main depth distribution of wolffish. The gear was changed in the Greenland shrimp and fish survey in 2005, thus interrupting the survey index. Both species are common in the fjords and the coastal areas and it seems unlikely that any of the surveys fully covers the distribution of either wolffish species.

Atlantic wolffish:

The EU-Germany survey biomass index decreased significantly in the 1980s (Fig. 5.2, left). From 2002 to 2005 biomass indices increased to above average levels, but thereafter returned to the low levels observed during the 1990s. Abundance indices in the EU-Germany survey decreased after 1982, but were at a stable and perhaps slightly increasing level until 2005. After 2005 abundance indices in this survey decreased to below average levels, but remained stable after 2008 (fig 5.2, right).

The Greenland shrimp and fish survey biomass indices were at low levels during the 1990s, but increased slightly from 2002 and until the gear change in 2004. After 2005, the biomass index increases further in the Greenland shrimp and fish survey (fig 5.3 left). Abundance indices in the Greenland shrimp and fish survey increased until the gear change in 2004 (Fig 5.3. right). The increasing abundance indices in the Greenland shrimp and fish survey is observed in division 1A-B, and therefore north of the EU-Germany survey area

Spotted wolffish:

The EU-Germany survey biomass index decreased from 1982 and were at low levels during the 1990s (fig 5.4, left). After 2002, the survey biomass increased and the recent indices are at the level observed in the beginning of the 1980's. Although highly variable, the abundance index has gradually increased since the mid 1990s (fig 5.4, right).

The Greenland shrimp and fish survey biomass index, was at low levels during the 1990s, but increased from 2002. After the gear change in 2005, survey biomass has increased substantially (fig 5.5, left). The abundance index gradually increased both before and after the gear change and the indices seems well connected. (Fig 5.5, right).

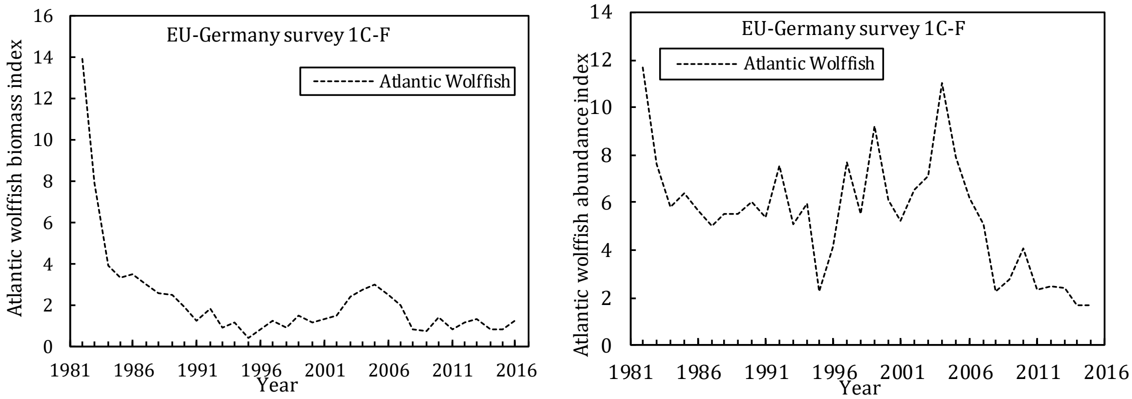


Fig. 5.2. Atlantic wolffish survey biomass index (left) and abundance index (right) from The EU-Germany survey.

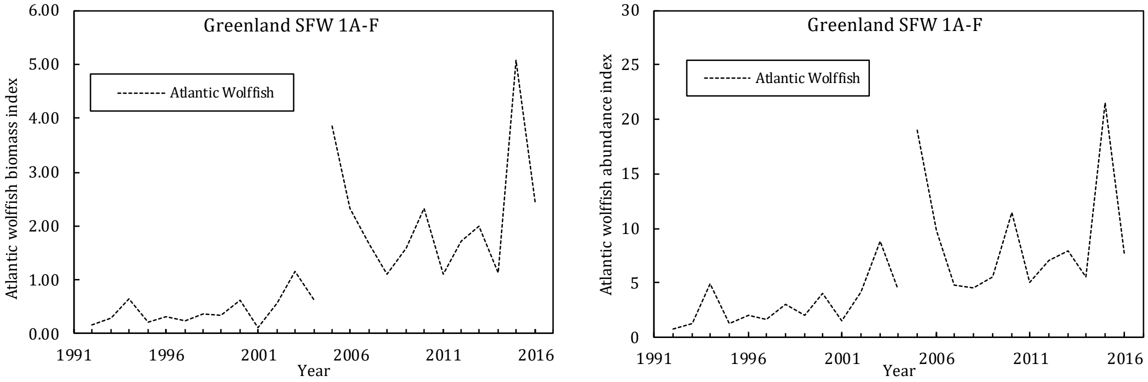


Fig. 5.3. Atlantic wolffish survey biomass index (left) and abundance index (right) from the Greenland shrimp and fish survey at West Greenland.

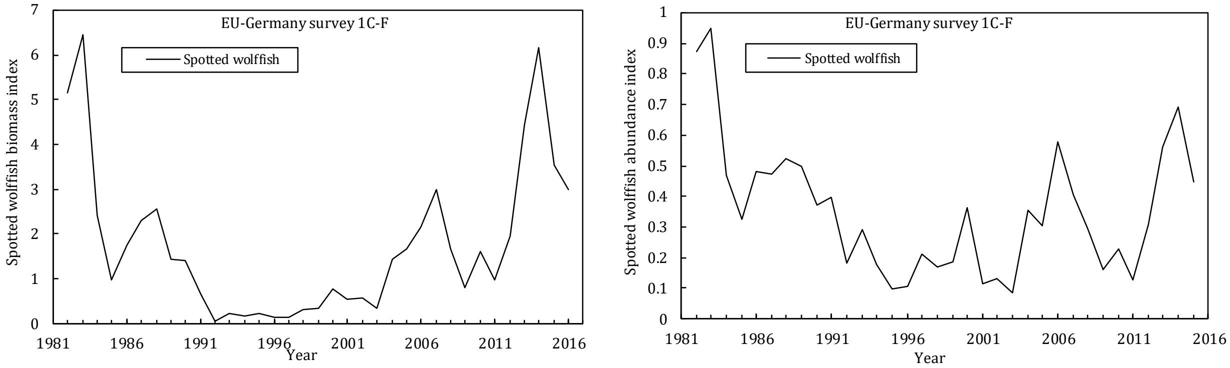


Fig. 5.4. Spotted wolffish survey biomass index (left) and abundance index (right) from The EU-Germany survey.

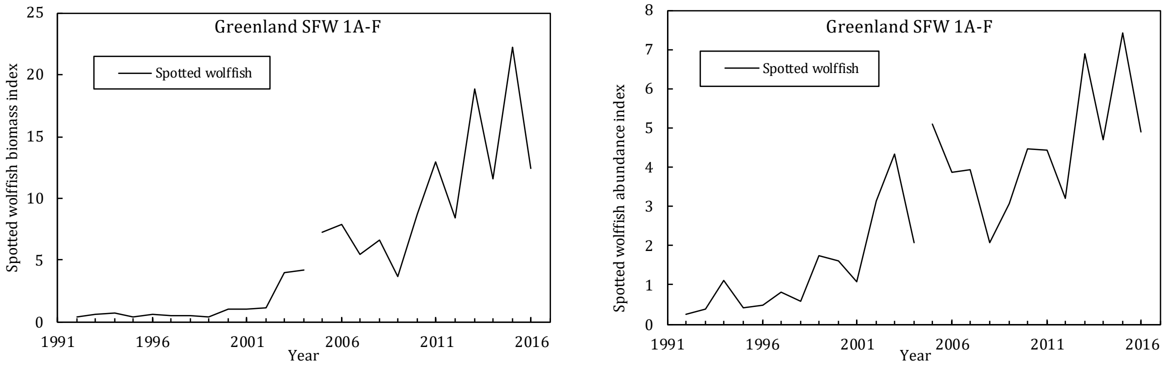


Fig. 5.5. Spotted wolffish survey biomass index (left) and abundance index (right) from the Greenland shrimp and fish survey in West Greenland.

c) Assessment results

Assessment results: No analytical assessment was performed.

Fishery and catches: The proportions of Atlantic and spotted wolffish 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.

Data: Biomass and abundance indices and length distributions were available from the EU-Germany survey and the Greenland shrimp and fish survey. Logbooks and factory data were available and used to map the distribution of the catches.

Atlantic wolffish

Biomass: The surveys do not fully agree about the recent development in the stock. However, the biomass index in the EU-Germany survey is far below the initial 1982-83 values and before the Greenland shrimp and fish survey was initiated.

Fishing mortality: Unknown. The contribution to fishing mortality from bycatch of Atlantic wolffish in the shrimp trawls is reduced with the implementation of sorting grids in 2002.

Recruitment: Unknown.

State of the stock: The low biomass indices of the EU-Germany survey indicates a stock at its lowest level in the historical time series.

Spotted wolffish

Biomass: The EU-Germany survey and the Greenland shrimp and fish survey agree that the biomass of spotted wolffish has been increasing during the recent decades and the increase has continued in recent years.

Fishing mortality: Unknown. The contribution to fishing mortality from bycatch of spotted wolffish in the shrimp trawls is reduced with the implementation of sorting grids in 2002.

Recruitment: Unknown. Higher than usual numbers of age 1 spotted wolffish has been observed in the Greenland shrimp and fish survey in the recent 4 years.

State of the stock: There is no sign that the recent decrease in the landings was caused by a decrease in the stock. The EU-Germany survey biomass index for the recent 3 years has been at the same level as in the 1982-1984 period. The Greenland Shrimp and fish survey biomass index average for the recent 3 years is 19% higher than the prior 4 year period.

These stocks will next be assessed in 2020.

B. STOCKS ON THE FLEMISH CAP: SA 3 AND DIV. 3M

Recent Conditions in Ocean Climate and Lower Trophic Levels

Ocean climate composite index in SA3 – Flemish Cap continue to remain below normal since 2014. The large negative anomalies observed in 2014-2016 are comparable with the previous cold period during the early-mid 1990's.

The magnitude of the spring bloom was at a record low in 2016 with mostly below normal levels since 2013. The timing of the spring bloom changed in 2016 from predominately early onset but shorter duration in 2011-2015 to later onset and longer duration compared to the reference period.

Despite the decline in ocean climate and bloom indices, the zooplankton index has remained well above normal since 2013.

The composite trophic index (integrating nutrients, phytoplankton and zooplankton indices) has tended to remain above normal in recent years but near the standard climatology in 2016.

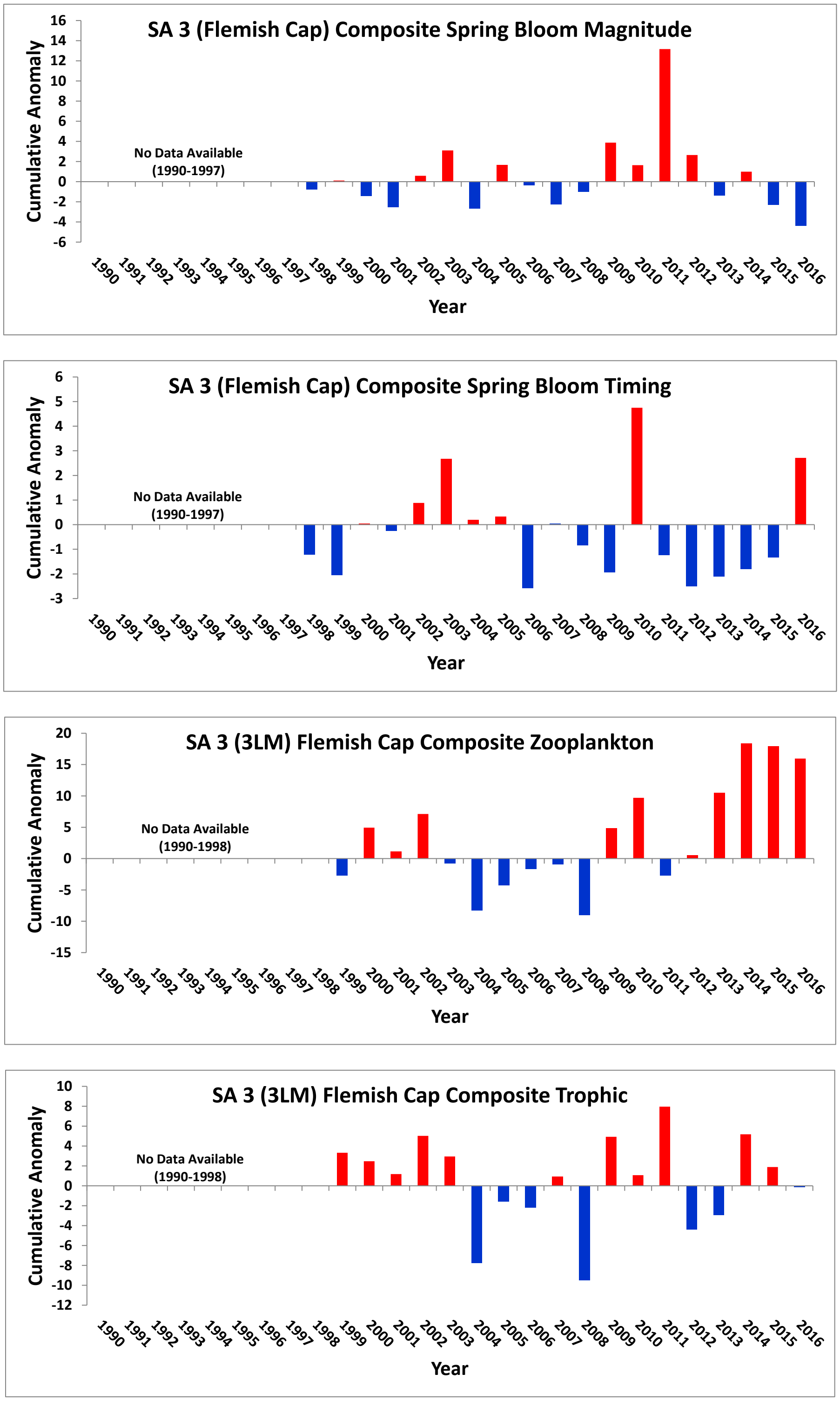


Fig. B.1. Composite climate index for NAFO Subarea 3 (Div. 3M; Flemish Cap) derived by summing the standardized anomalies of meteorological and ocean conditions during 1990-2016 (top panel), ocean colour (Divs. 3LM) composite of magnitude of the spring bloom (2'nd panel) and the peak time of the spring bloom (3'rd panel), composite zooplankton index (4'th panel) and composite trophic index (bottom panel) during 1990-2016. Annual anomalies near 0 indicate the metric is near the climatological mean, positive anomalies indicate above normal levels while negative anomalies indicate below normal conditions.

Environmental Overview

The water masses characteristic of the Flemish Cap area are a mixture of Labrador Current Slope Water and North Atlantic Current Water, generally warmer and saltier than the sub-polar Newfoundland Shelf waters with a temperature range of 3-4°C and salinities in the range of 34-34.75. The general circulation in the vicinity of the Flemish Cap consists of the offshore branch of the Labrador Current which flows through the Flemish Pass on the Grand Bank side and a jet that flows eastward north of the Cap and then southward east of the Cap. To the south, the Gulf Stream flows to the northeast to form the North Atlantic Current and influences waters around the southern areas of the Cap. In the absence of strong wind forcing the circulation over the central Flemish Cap is dominated by a topographically induced anti-cyclonic (clockwise) gyre. Variation in the abiotic environment is thought to influence the distribution and biological production of Newfoundland and Labrador Shelf and Slope waters, given the overlap between arctic, boreal, and temperate species. The elevated temperatures on the Cap as a result of relatively ice-free conditions, may allow longer growing seasons and permit higher rates of productivity of fish and invertebrates on a physiological basis compared to cooler conditions prevailing on the Grand Banks and along the western Slope waters. The entrainment of North Atlantic Current water around the Flemish Cap, rich in inorganic dissolved nutrients generally supports higher primary and secondary production compared with the adjacent shelf waters. The stability of this circulation pattern may also influence the retention of ichthyoplankton on the bank which may influence year-class strength of various fish and invertebrate species.

Ocean Climate and Ecosystem Indicators

The composite climate index in Subarea 3 (Div. 3M) has remained above normal since the mid-1990's although the index has declined sequentially since 2014 reaching a record-low in 2015 and remaining below normal in 2016 (Figure B.1). The composite spring bloom index (Div. 3LM) reached a record-high in 2011 but has subsequently declined in recent years to a record-low in 2016 (Figure B.1). The timing metrics of the spring bloom shifted from predominately early onset / short duration events since 2011 to late onset / longer duration in 2016. Despite the lower phytoplankton biomass, the composite zooplankton index (mainly composed of copepod and invertebrate plankton) has remained well above normal since 2013 (Figure B.1). The composite tropic index which combines nutrient inventories and standing stocks of phytoplankton and zooplankton was near the reference level in 2016 after above normal levels in 2014-2015 (Figure B.1). The composite trophic index reached a record-peak in 2011 and record-low in 2008. During 2016, water column temperature and salinity over the Flemish Cap were mostly below but increased over the record cold conditions of 2015. Near surface values were about 1°C below normal and at the bottom temperatures were about 0.2°C below normal over the shallowest areas but were above normal in deeper waters generally below 200 m depth.

6. Cod 3M (*Gadus morhua*) in Div. 3M

(SCS Doc. 17/04, 17/05, 17/06, 17/09, 17/11 and SCR 17/17, 17/24, 17/38)

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. Catches since 1996 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 (Fig. 6.1), including non-reported catches and catches from non-Contracting Parties.

Catches exceeded the TAC from 1988 to 1994, but were below the TAC from 1995 to 1998. In 1999 the direct 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. Those fleets were not observed since 2000. Yearly bycatches between 2000 and 2005 were 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 tons) are as follow:

,000 tons	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
TAC	ndf	ndf	5.5	10.0	9.3	14.1	14.5	13.8	13.9	13.9
STATLANT 21	0.4	1.2	5.2	10.0	9.1	13.5	14.4	12.8	13.8	
STACFIS	0.9	1.2	9.2	13.6	13.4	14.0	14.3	13.8	14.0	

ndf No directed fishery

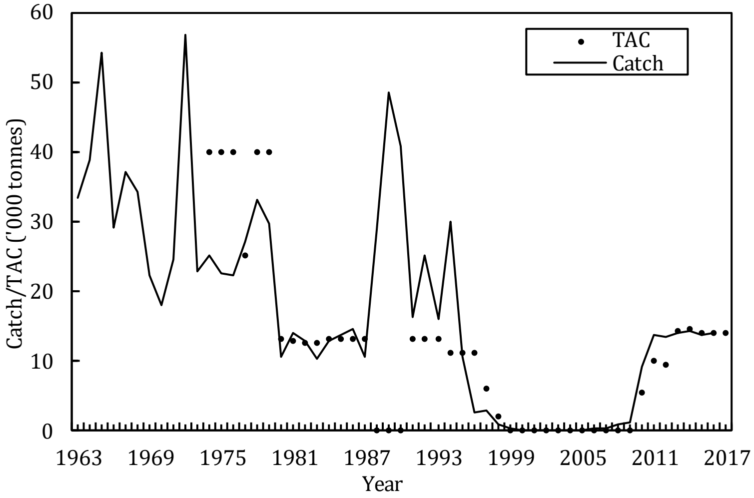


Fig. 6.1. Cod in Division 3M: STACFIS catches and TAC.

b) Data Overview

i) Research survey data

Canadian survey. Canada conducted research surveys on Flemish Cap from 1978 to 1985 on board the R/V *Gadus Atlantica*, fishing with a lined Engels 145 otter trawl. The surveys were conducted annually in January-February covering depths between 130 and 728 m.

From a high value in 1978, a general decrease in biomass and abundance can be seen until 1985, reaching the lowest level in 1982 (Fig. 6.2).

EU survey. The EU Flemish Cap survey has been conducted since 1988 in summer with a *Lofoten* gear type. The survey indices showed a general decline in biomass going from a peak value in 1989 to the lowest observed level in 2003. Biomass index increased from 2004 to 2012, especially from 2006. The growth of the strong year classes since 2005 contributed to the increase in the biomass. A substantial decrease in biomass was observed in 2013, although it remained at high level. In 2014 the biomass increased again reaching the maximum observed in the time series, decreasing since then until the 2013 level. Abundance rapidly increased between 2005 and 2011, decreasing since 2012. The different pattern between biomass and abundance over 2011-2016 is driven by the very large 2009 and 2010 year classes.

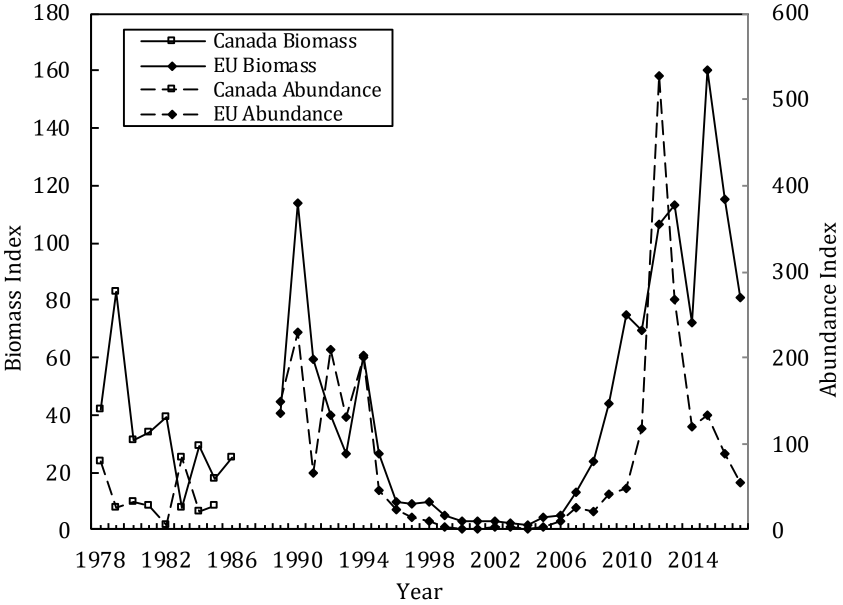


Fig. 6.2. Cod in Division 3M: Survey abundance and biomass estimates from Canadian survey (1978-1985) and EU-Flemish Cap survey (1998-2016).

ii) Recruitment

Abundance at age indices were available from the Canadian survey. The recruitment index (age 1) was estimated at low levels except for 1982 and 1983. After several series of above average recruitments (age 1) during 1988-1992, the EU Flemish Cap survey indicates poor recruitments during 1996-2004, even obtaining observed zero values in 2002 and 2004. 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 (Fig. 6.3; note that the level of both surveys is different in the two y-axis). From 2013 the recruitment index dropped to the level at the beginning of the recovery of the stock, declining further in 2016 to one of the lowest levels observed.

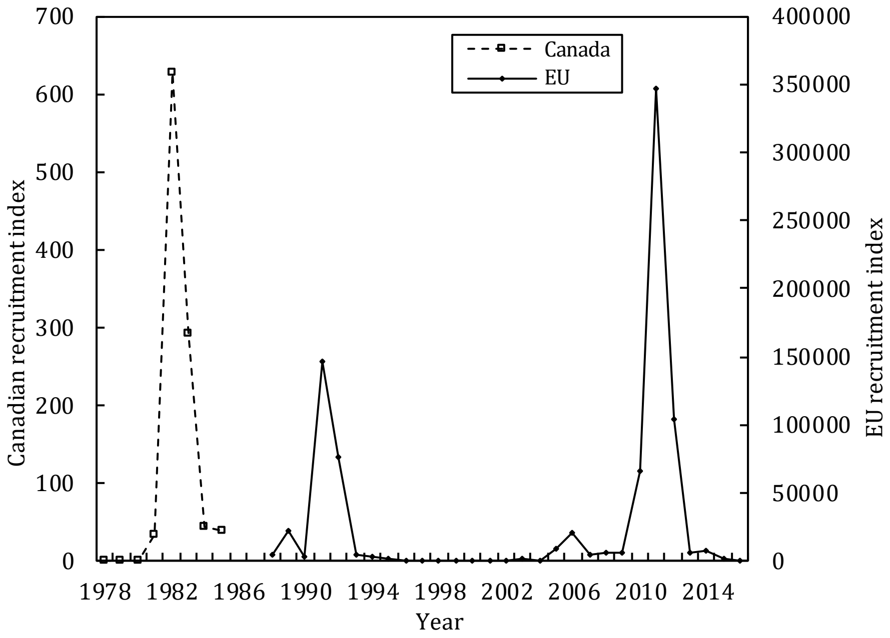


Fig. 6.3. Cod in Division 3M: Number at age 1 in the Canadian survey (1978-1985) and EU survey (1988-2016).

iii) Fishery data

In 2016 nine countries fished cod in Div. 3M, trawlers from Cuba, EU-Estonia, EU-Portugal, EU-Spain, EU-UK, Faroe Islands and Russia and longliners from Faroe Islands, Norway and USA.

Length and age compositions from the commercial catches are available from 1973 to 2016 with the exception of the 2002 to 2005 period. Since 2010, length information was available for the major participants in the fishery. In 2016 there were length distributions from EU-Estonia, EU-Portugal, EU-Spain, EU-UK, Faroe Islands (from trawlers and longliners) and Russia (Fig. 6.4). The mean in the length composition for EU-Estonia was 53 cm, being 51 cm for EU-Portugal, 54 cm for EU-Spain, 69 cm for EU-UK and for the Faroese trawlers, 73 cm for the Faroese longliners and 61 cm for Russia. The total commercial catch length distribution was in 56 cm and the mode at 39 cm in a length range of 25-139 cm. Using the EU survey 2016 ALK, age 5 was the most abundant in the catch.

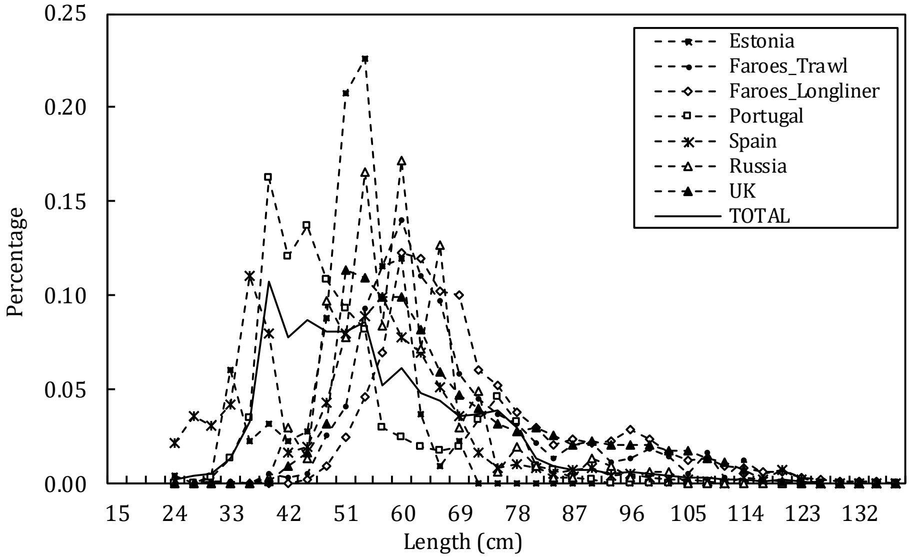


Fig. 6.4. Cod in Division 3M: Length distribution of the commercial catches in 2016.

iv) Biological parameters

Mean weight-at age in the stock was derived from the 2016 EU survey ALK. Mean weight-at-age in the stock has been decreasing continuously since the reopening of the fishery, reaching the minimum for ages 4 to 8 in 2015-2016 (Fig. 6.5).

As the mean weight-at-age in stock, the mean weight-at-age in the catch was derived from the 2016 EU survey ALK and it has been decreasing since the reopening of the fishery, reaching the minimum for ages 3 to 8 in 2015-2016 (Fig. 6.6).

Maturity ogive is available from the surveys for almost all years between 1978 and 2016. For the years in which no maturity information is available, interpolations with the surrounding years were made. There was a continuous decline of the A_{50} (age at which 50% of fish are mature), going from above 5 years old in the late 1980s to just below 3 years old in 2002 and 2003. Since 2005 there has been an increase in the A_{50}, concurrently with the increase of the survey biomass, with the value in 2016 at the levels observed before 1990 (5.2 years old) (Fig. 6.7).

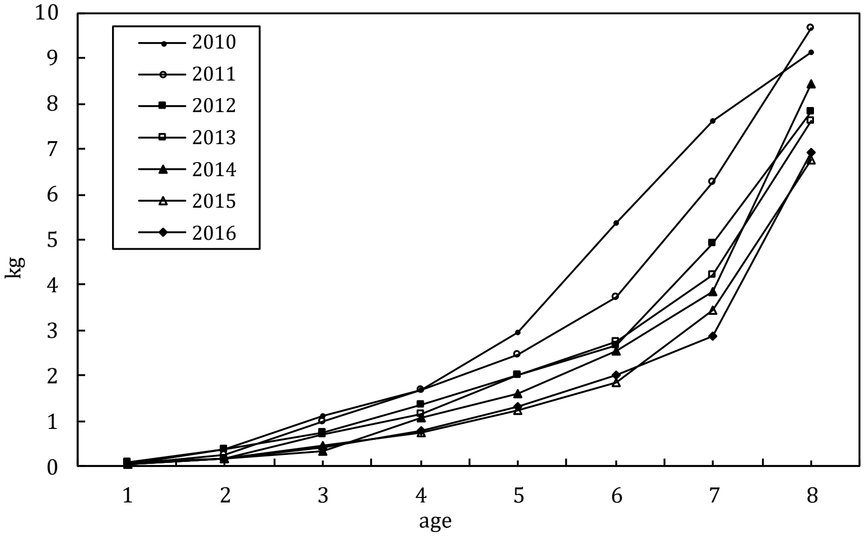


Fig. 6.5. Cod in Division 3M: Mean weight-at-age in the stock for the 2010-2016 surveys.

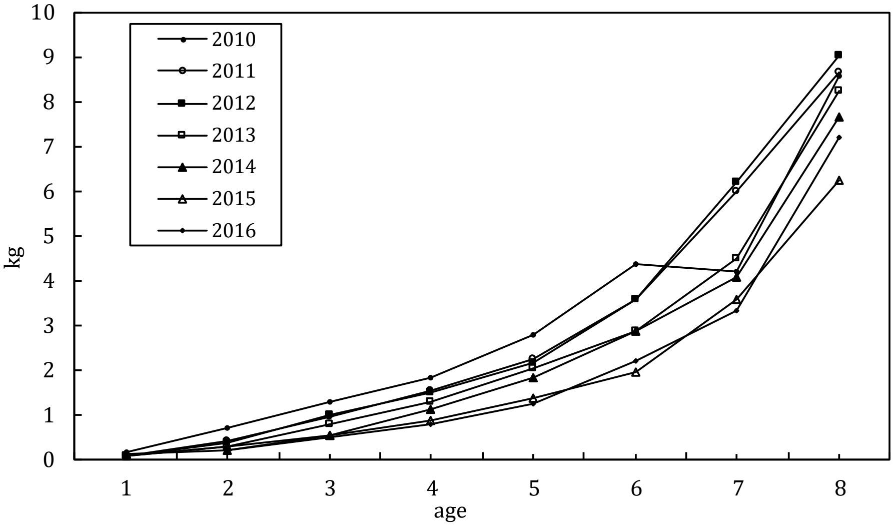


Fig. 6.6. Cod in Division 3M: Mean weight-at-age in the catch for 2010-2016.

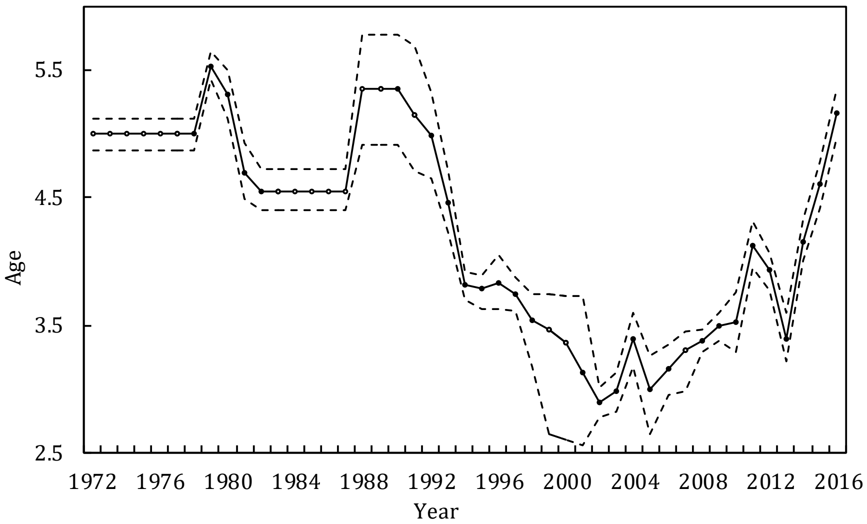


Fig. 6.7. Cod in Division 3M: Age of first maturity (median and 90% confidence intervals) from Canadian survey (1978-1985) and EU-Flemish Cap survey (1998-2016). Interpolated years are represented in white circles.

c) Estimation of Parameters

In 2008 onwards a VPA-type Bayesian model was used for the assessment of this stock. The settings for the model are the same as used in the 2015 assessment. Input data and settings are as follows:

Catch data: catch numbers and mean weight at age for 1972-2016, except for 2002-2005, for which only total catch is available. STACFIS estimates for total catch were used.

Tuning: numbers at age from the Canadian survey (1978-1985) and from EU Flemish Cap survey (1988-2016).

Ages: from 1 to 8+ in both cases.

Catchability analysis: dependent on stock size for ages 1 to 2.

Natural Mortality: M was set via a lognormal prior.

Maturity ogives: Modelled using a Bayesian framework and estimating the years with missing data from the years with data.

Additional priors: for survivors at age at the end of the final assessment year, for survivors from the last true age in every year, for fishing mortalities at age and total catch weight for years without catch numbers at age, for numbers at age of the survey and for the natural mortality. Prior distributions were set as in the 2015 assessment.

The priors are defined as follows:

Input data	Prior Model	Prior Parameters
Total Catch 2011-2012	$LN\left(median, sd\right)$	Median=9.46, sd=0.1313
Survivors(2016,a), a=1-6 Survivors(y,7), y=1972-2016	$LN\left(median = medrec \times e^{-medM-\sum_{age=1}^{a} medFsurv(age)}, cv = cvsurv\right)$	medrec=15000 medFsurv(1,…,7)={0.0001, 0.1, 0.5, 0.7, 0.7, 0.7, 0.7} cvsurv=1
F(y,a), a=1-7, y=2002-2005	$LN\left(median = medF(a),\ cv = cvF\right)$	medF=c(0.0001, 0.005, 0.01, 0.01, 0.01, 0.005, 0.005) cvsurv=0.7
Total Catch 2002-2005	$LN\left(median = CW_{\mathrm{mod}}(y),\ cv = cvCW\right)$	CW$_{\mathrm{mod}}$ is arised from the Baranov equation cvCW=0.05
Survey Indices: Canada and EU (I)	$I(y) \sim LN\left(median = \mu(y,a),\ cv = \sqrt{e^{\frac{1}{\psi(a)}} - 1}\right)$ $\mu(y,a) = q(a)\left(N(y,a)\frac{e^{-\alpha Z(y,a)} - e^{-\beta Z(y,a)}}{(\beta-\alpha)Z(y,a)}\right)^{\gamma(a)}$ $\gamma(a)\begin{cases}\sim N(\text{mean}=1, \text{variance}=0.25),\ if\ a=1,2\\ =1,\ if\ a \geq 3\end{cases}$ $\log(q(a)) \sim N(\text{mean}=0, \text{variance}=5)$ $\psi(a) \sim gamma(shape=2, rate=0.07)$	I is the survey abundance index q is the survey catchability at age N is the commercial abundance index α = 0.5, β = 0.58 for EU survey (survey made in July), and α = 0.08, β = 0.17 for Canadian survey (made in January-February) Z is the total mortality
M	$M \sim LN(\text{median}, cv)$	Median=0.218, cv=0.3

d) Assessment Results

Some concerns about the Bayesian model used in the assessment have been raised by STACFIS. The appropriateness of the priors used in the model, unchanged since 2008, was discussed. The robustness of the model with regards of changing the priors over the survivors was studied during the STACFIS meeting, but a deeper review is needed before changing model settings. STACFIS approved the assessment to perform the projections despite the issues encountered taking into account that the results of the assessment are in line with the survey trends. The impact of this issue will be studied in the 2018 benchmark.

Total Biomass and Abundance: Estimated total biomass and abundance showed an increasing trend since 2006 until 2012, reaching a biomass level similar to the pre-moratorium period. Since then a decreasing trend can be observed, with the greater decrease observed in abundance. The biomass value is around the level of the early 1990´s, while the abundance is at the level of the recovery of the stock in 2009 (Fig. 6.8).

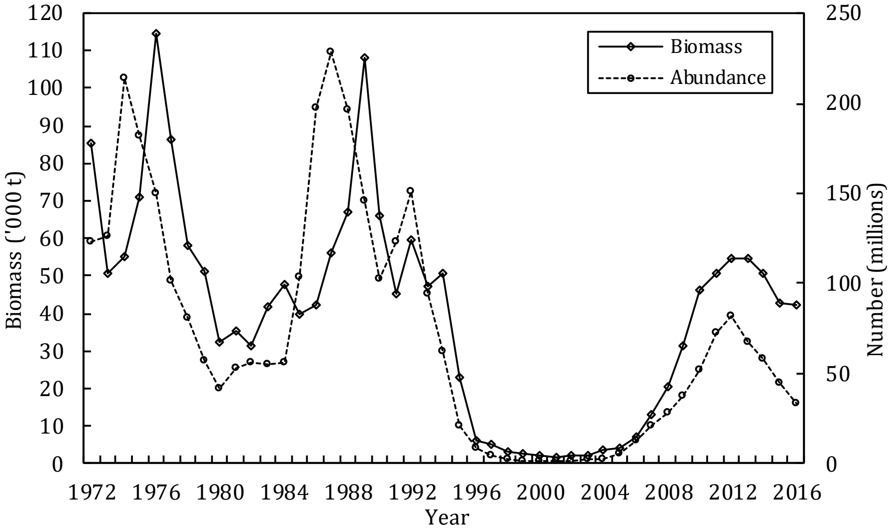


Fig. 6.8. Cod in Div. 3M: Biomass and Abundance estimates.

Spawning stock biomass: Estimated median SSB (Fig. 6.9) increased since 2005 to the highest value of the time series in 2013. This increase is due to several abundant year classes and their early maturity. Since then it has declined but with a very low probability (<1%) of being below B_{lim} (14 000 t).

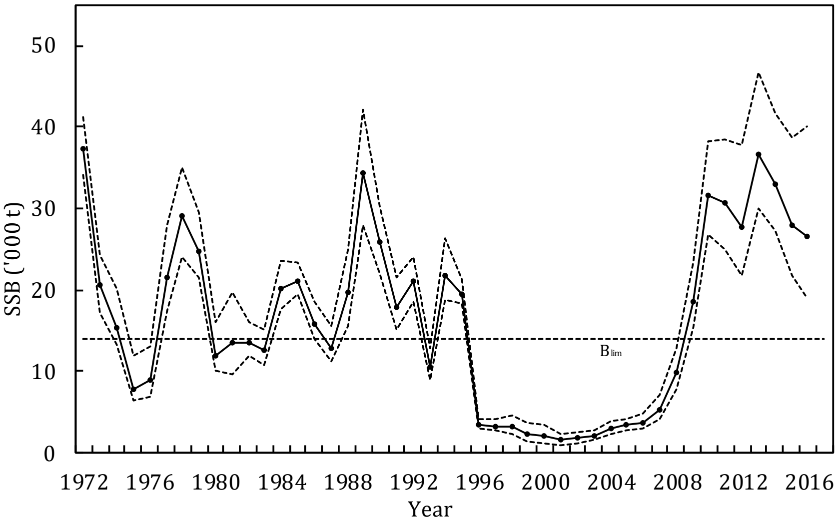


Fig. 6.9. Cod in Div. 3M: Median and 90% probability intervals SSB estimates. The horizontal dashed line is the B_{lim} level of 14 000 t.

Recruitment: After a series of recruitment failures between 1996 and 2004, values of recruitment at age 1 in 2005-2012 were higher, especially the 2011 and 2012 values. Since 2013 recruitment has decreased, reaching in 2016 low values as observed during the period 1996 to 2004 (Fig. 6.10).

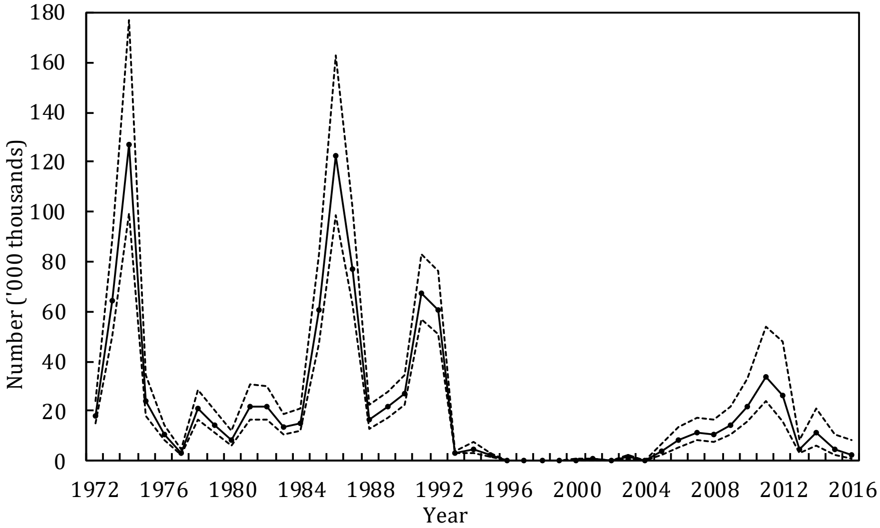


Fig. 6.10. Cod in Div. 3M: Recruitment (age 1) estimates and 90% probability.

Fishing mortality: F increased in 2010 with the opening of the fishery and it has remained stable since then at two times F_{lim} (mean $F_{2010-2016}$ =0.253) and below historical average (0.471) (Fig. 6.11).

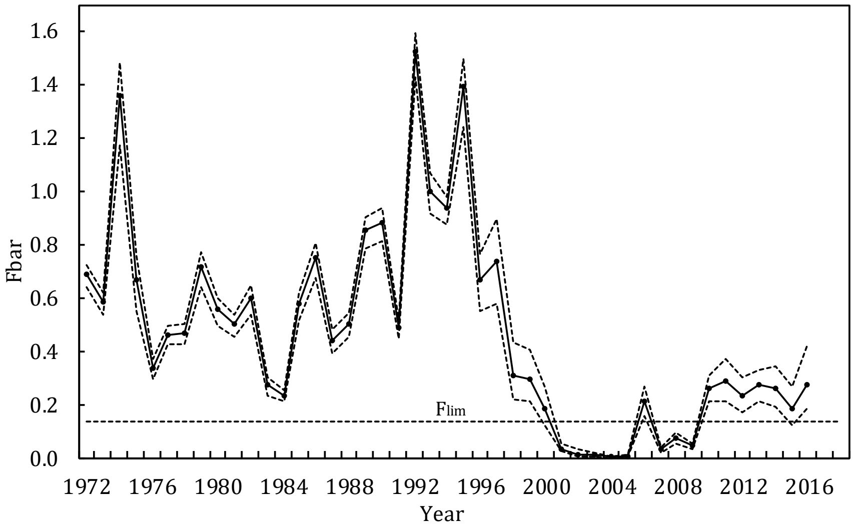


Fig. 6.11. Cod in Div. 3M: F_{bar} (ages 3-5) estimates and 90% probability intervals. The horizontal dashed line is the F_{lim} (0.139).

Natural mortality: The posterior median of M estimated by the model was 0.19.

e) Retrospective analysis

A five-years retrospective analysis with the Bayesian model was conducted by eliminating successive years of catch and survey data. Fig. 6.12 to 6.14 present the retrospective estimates for age 1 recruitment, SSB and Fbar 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 (Fig. 6.12 and Fig. 6.13). For SSB and F, retrospective analysis shows un-patterned changes (Fig. 6.14).

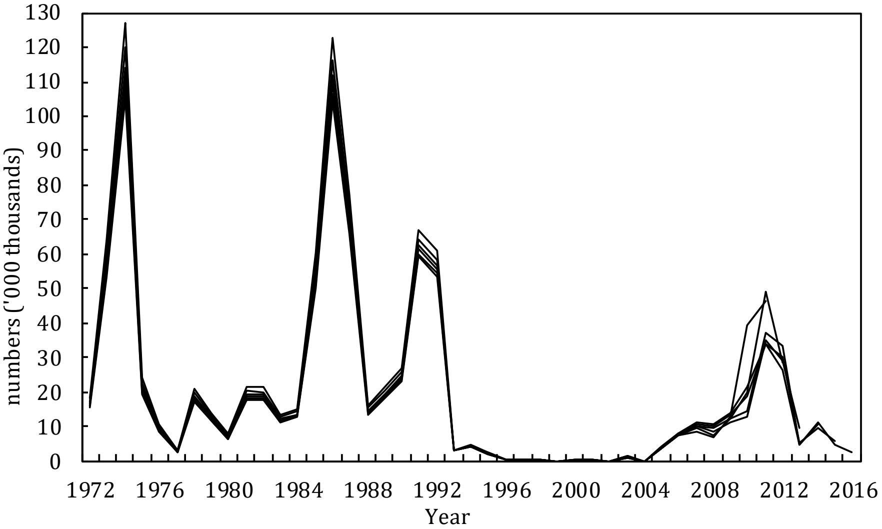


Fig. 6.12. Cod in Div. 3M: Retrospective results for recruitment.

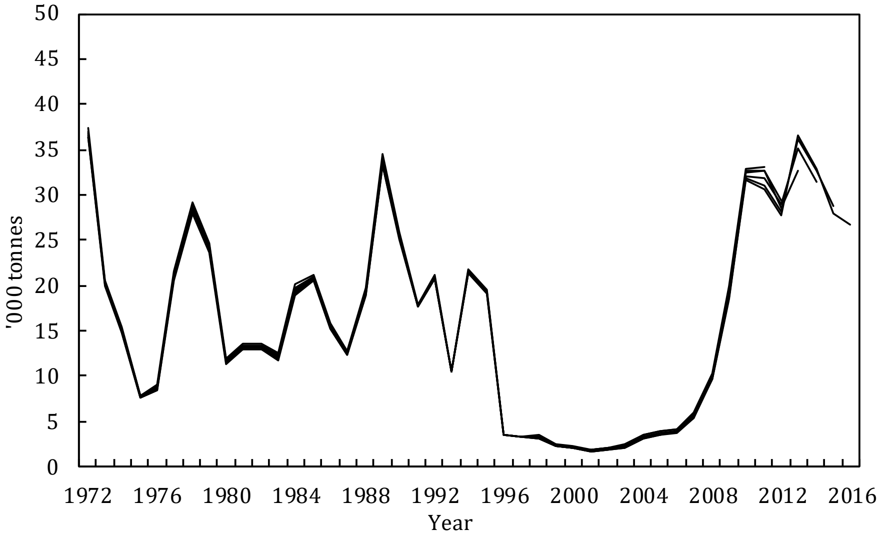


Fig. 6.13. Cod in Div. 3M: Retrospective results for SSB.

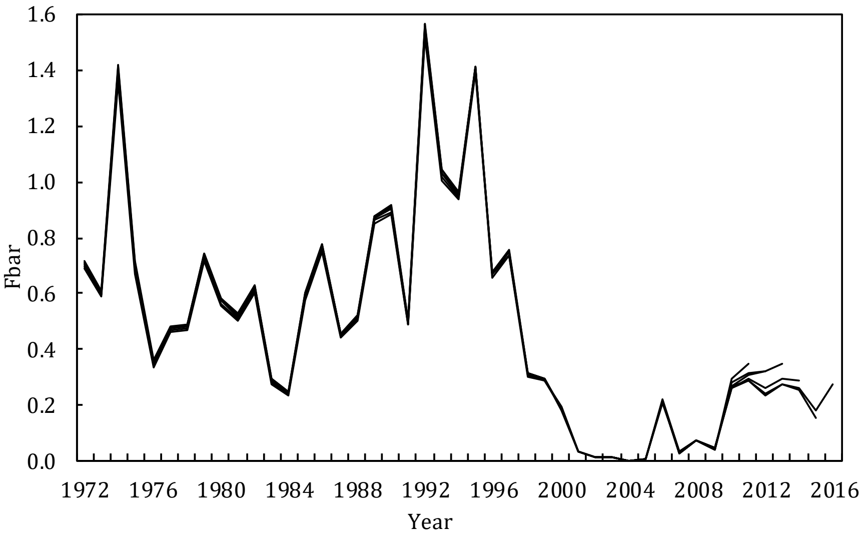


Fig. 6.14. Cod in Div. 3M: Retrospective results for average fishing mortality.

f) State of the stock

Current SSB is estimated to be well above B_{lim}. However, since 2013 recruitment has decreased, and in 2016 was at levels similar to those observed during the period 1996 to 2004.

Since 2010, F has remained stable at a level around twice F_{lim}.

g) Reference Points

STACFIS has previously estimated B_{lim} to be 14 000 t for this stock. SSB is above B_{lim} in 2016. Fig. 6.15 shows a stock-Fbar plot. F_{lim} (0.139) for this stock is $F_{30\%SPR}$ (NAFO, 2014).

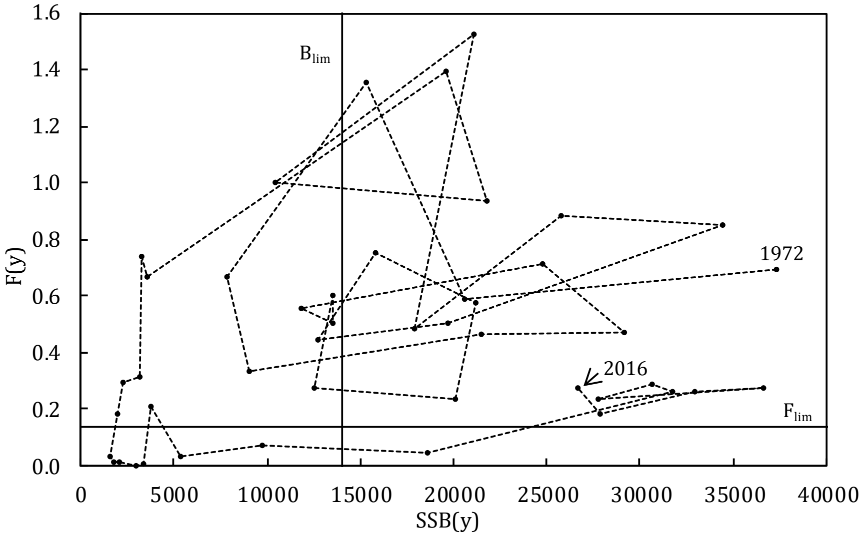


Fig. 6.15. Cod in Div. 3M: Stock-Fbar(3-5) (posterior medians) plot. B_{lim} and F_{lim} are plotted in the graph.

h) Stock projections

A new method to estimate the risk in the projections, that changes the way the number of individuals in the projected years are calculated, was approved by the Scientific Council. The new method solves some issues raised by the Fisheries Commission about the projections of the 3M cod by projecting a catch value instead of a distribution of catches (see Section II.4). Stochastic projections of the stock dynamics from 2017 to 2019 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 2017: estimated from the assessment.

Recruitments for 2017-2019: Recruits per spawner were drawn randomly from 2013-2015. The 2016 value was omitted due to uncertainty in estimating the recruitment.

Maturity ogive for 2017-2019: 2016 maturity ogive.

Natural mortality for 2017-2019: 2016 natural mortality from the assessment results.

Weight-at-age in stock and weight-at-age in catch for 2017-2019: 2016 weight-at-age.

PR at age for 2017-2018: Mean of the last three years (2014-2016) PRs.

F_{bar}*(ages 3-5)*: Four scenarios were considered:

(*Scenario 1*) $F_{bar}=F_{lim}$ (median value = 0.139).

(*Scenario 2*) $F_{bar}=3/4F_{lim}$ (median value = 0.104).

(*Scenario 3*) $F_{bar}=F_{statusquo}$ (median value = 0.241).

(*Scenario 4*) $F_{bar}=3/4F_{statusquo}$ (median value = 0.180).

All scenarios assumed that the Yield for 2017 is the established TAC (13 931 t). $F_{statusquo}$ was established as the mean fishing mortality over 2014-2016.

The results indicate that under all scenarios total biomass during the projected years will decrease (Fig. 6.16). In the case of the status quo, the SSB is projected to decrease steadily until 2019 to a value close to B_{lim} (the probability of being below B_{lim} = 43%). The other scenarios show less decrease, or at best, stability. In all the cases the probability of being below B_{lim} at the beginning of 2019 is higher than 21% (Fig. 6.18).

Given the trends in projected biomass and the fact that the stock will be benchmarked in 2018, STACFIS recommends presenting not more than one year of projections.

Under all scenarios the probability of F exceeding F_{lim} is at least 35%.

Results of the projections are summarized in the following table:

	B		SSB		Yield
	Median and 90% CI				
$F_{bar}=F_{lim}$ (median=0.139)					
2017	36314	(23245 - 55649)	27187	(15371 - 45374)	13931
2018	30508	(12993 - 57331)	23634	(7923 - 49139)	10297
2019	27754	(4121 - 62281)	22913	(1799 - 55727)	
$F_{bar}=3/4F_{lim}$ (median=0.104)					
2017	36314	(23245 - 55649)	27187	(15371 - 45374)	13931
2018	30508	(12993 - 57331)	23634	(7923 - 49139)	8182
2019	30703	(6907 - 65109)	25658	(3973 - 58324)	
$F_{bar}=F_{2012-2014}$ (median=0.241)					
2017	36314	(23245 - 55649)	27187	(15371 - 45374)	13931
2018	30508	(12993 - 57331)	23634	(7923 - 49139)	15127
2019	21265	(1644 - 55804)	16653	(229 - 49345)	
$F_{bar}=3/4F_{2012-2014}$ (median=0.180)					
2017	36314	(23245 - 55649)	27187	(15371 - 45374)	13931
2018	30508	(12993 - 57331)	23634	(7923 - 49139)	12435
2019	24854	(2298 - 59365)	20105	(320 - 52774)	

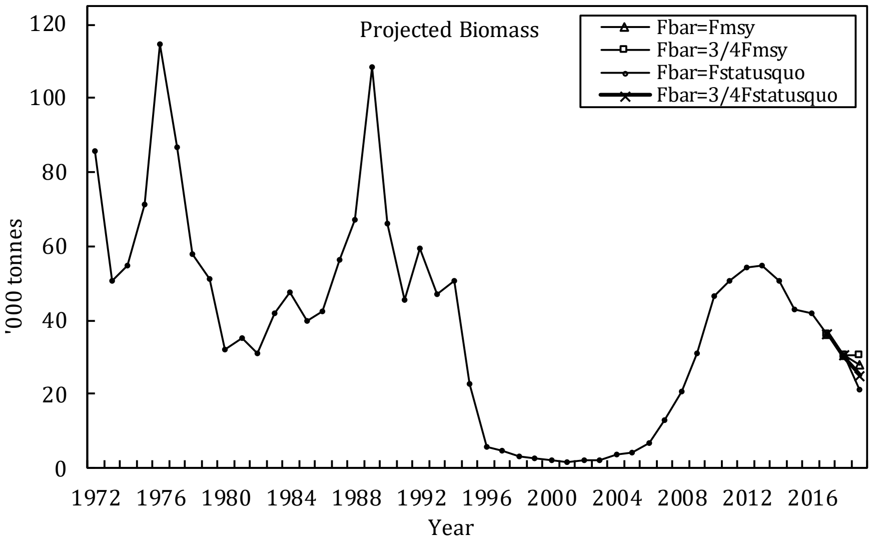


Fig. 6.16. Cod in Div. 3M: Projected Total Biomass under all the Scenarios.

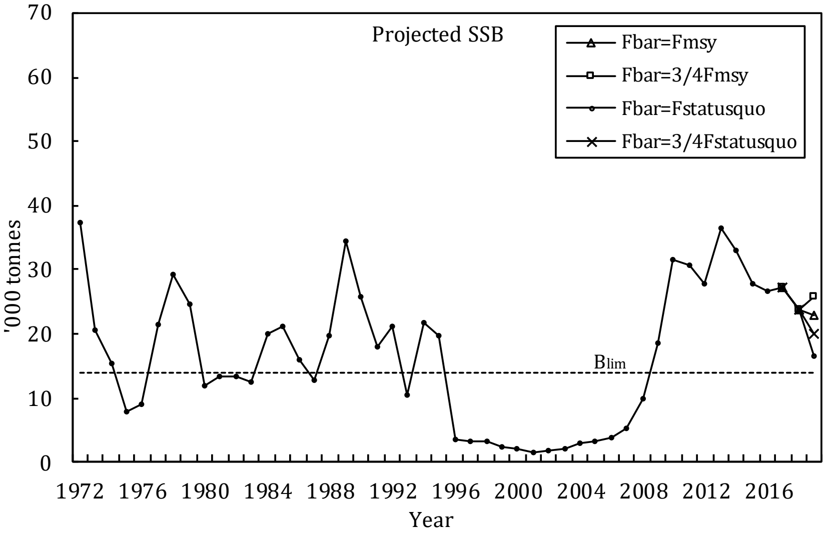


Fig. 6.17. Cod in Div. 3M: Projected SSB under all the Scenarios

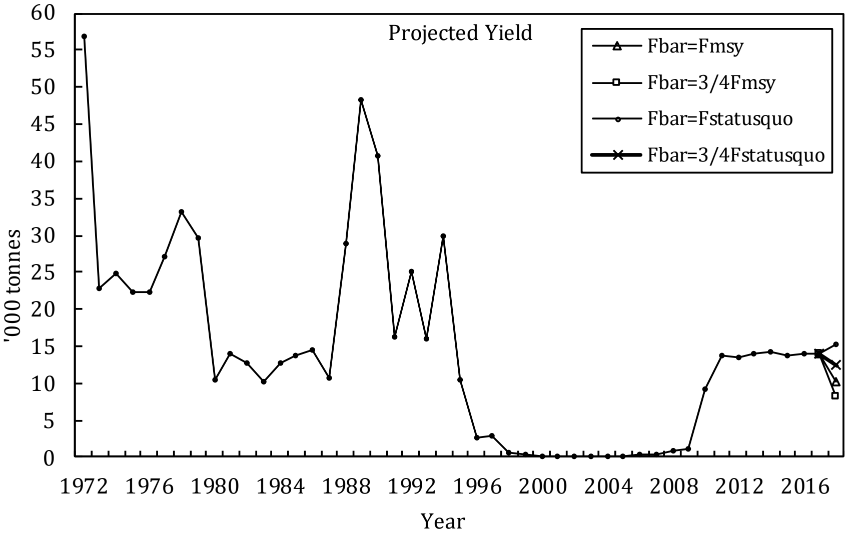


Fig. 6.18. Cod in Div. 3M: Projected removals under all the Scenarios

The risk of each scenario is presented in the following table, with the limit reference points for each case:

	Yield		$P(B < B_{lim})$			$P(F > F_{lim})$		
	2017	2018	2017	2018	2019	2017	2018	$P(B_{19} > B_{16})$
$F_{lim} = 0.139$	13931	10297	3%	18%	27%	67%	50%	35%
$3/4F_{lim} = 0.104$	13931	8182	3%	18%	21%	67%	35%	44%
$F_{2014\text{-}2016} = 0.241$	13931	15127	3%	18%	43%	67%	76%	21%
$3/4F_{2014\text{-}2016} = 0.180$	13931	12435	3%	18%	34%	67%	63%	28%

i) Research recommendations

STACFIS **recommended** that *an age reader comparison exercise be conducted.*

STATUS: No progress. An age-readers Workshop will be held in November 2017 in order to reconcile the differences among age-readers of this stock.

Although a benchmark for 3M cod was planned to be developed in April 2017, it was delayed in September 2016 by the Fisheries Commission. STACFIS **recommends** that *it is carried out in April 2018*.

The next full assessment for this stock will be in 2018.

7. Redfish (*Sebastes mentella* and *Sebastes fasciatus*) in Div.3M

(Full assessment report. SCR Doc. 17/024, 032, 034, 038; SCS Doc. 17/ 04, 05, 09,011).

a) Introduction

There are three species of redfish that are commercially fished on Flemish Cap; deep-sea redfish (*Sebastes mentella*), golden redfish (*Sebastes marinus = S. norvegicus*) and Acadian redfish (*Sebastes fasciatus*). The term beaked redfish is used for *S. mentella* and *S. fasciatus* combined. Because of difficulties with identification and separation, all three species are reported together as 'redfish' in the commercial fishery. All stocks have both pelagic and demersal behaviour as well as a long recruitment process to the bottom, extending to lengths up to 30-32 cm. All redfish species are long lived with slow growth. Female sexual maturity is reached at a median length of 26.5 cm for Acadian redfish, 30.1 cm for deep-sea redfish and 33.8 cm for golden redfish.

i) Description of the fishery

The redfish fishery in Div. 3M increased from 20,000 tonnes in 1985 to 81,000 tonnes in 1990, falling continuously since then until 1998-1999, when a minimum catch around 1,100 tonnes was recorded mostly as by-catch of the Greenland halibut fishery. Catch increased again in the 2000's, but at a much smaller scale than in the past and with a small proportion coming from directed redfish fisheries. A new golden redfish fishery occurred on the Flemish Cap bank from September 2005 onwards on shallower depths above 300m, basically pursued by Portuguese bottom trawl. Furthermore, the increase of bycatch following reopening of the Flemish Cap cod fishery in 2010 also contributed to the increase of redfish catch. EU-Portugal, EU-Spain, the Russian Federation and EU-Estonia states are responsible for the bulk of the redfish landings in 2015-2016, 6044 tonnes and 6505 tonnes respectively.

The increase of golden redfish catch from 2005 required a revision of catch estimates in order to split the total redfish catch from the major fleets in Div. 3M into golden and beaked redfish catches. The estimated catch of beaked redfish in 2015 and 2016 was 5243 and 6232 tonnes respectively.

Over the five years 2006-2010, an average annual bias of 15% plus was recorded between overall STACFIS catch estimate and overall STATLANT nominal catch. In order to mitigate the lack of scientific catch information a 15% surplus was added to the STATLANT catch of each fleet each year between 2011 and 2014. For 2015 and 2016 the annual catch was given by the Daily Catch Reports (DCR's) by country provided by the NAFO Secretariat. The STACFIS catch estimates (1989-2010), the inflated STALANT catch (2011-2014) and the catch from the DCR's (2015-2016) are the sources of information for the 3M redfish landings.

Recent TACs, catches and by-catch ('000 t) are as follows:

	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
TAC	5	8.5	10.0	10.0	6.5	6.5	6.5	6.7	7.0	7.0
STATLANT 21 A	7.9	8.7	8.2	9.7	5.4	6.8	6.4	6.9	6.6	
STACFIS Total catch[1,2]	8.5	11.3	8.5	11.1	6.2	7.8	7.4	6.9	6.6	
STACFIS Catch[2,3]	4.3	3.7	5.4	9.0	6.3	5.2	4.6	5.2	6.2	

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

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

[6] STACFIS beaked redfish catch

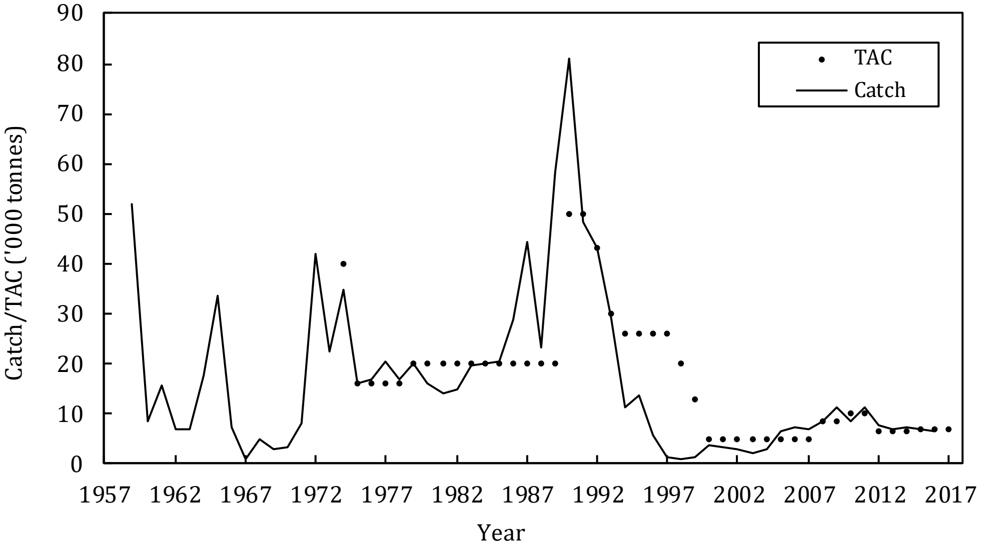


Fig. 7.1. Redfish in Div. 3M: total catches and TACs.

b) Input Data

The 3M redfish assessment is focused on beaked redfish, regarded as a management unit composed of two populations from two very similar species: the Flemish Cap *S. mentella* and *S. fasciatus*. The reason for this approach is the historical dominance of this group in the 3M redfish commercial catch. During the entire series of EU Flemish Cap surveys beaked redfish also represents the majority of redfish survey biomass (77%).

i) Commercial fishery and by-catch data

Sampling data. Most of the commercial sampling data available for the Div. 3M redfish stocks since 1989 are from the Portuguese fisheries. Length sampling data from Russia, Japan and Spain were also available for several years and used to estimate the length composition of the commercial catches for those fleets in those years. The annual length composition of the Portuguese trawl catch was applied to the rest of the commercial catches until 2014. However, in 2015 and 2016, most of the Portuguese sampling effort was made on beaked redfish catch from shallower depths than the ones traditionally associated with the redfish fishery, while Spanish sampling came from depths 300-700m, where most of the beaked redfish catch is expected to occur. So Spanish sampling substitute the Portuguese sampling as regards the length distributions of other countries beaked redfish estimated catches in the last couple of years. The available 1998-2016 3M beaked redfish commercial length weight relationships from the Portuguese commercial catch were used to compute the mean weights of all commercial catches and corresponding catch numbers at length.

Redfish by-catch in numbers at length for the Div. 3M shrimp fishery is available for 1993-2004, based on data collected on Canadian and Norwegian vessels. No bycatch information has been available since 2005. The commercial and bycatch length frequencies were summed to establish the total removals at length. These were converted to removals at age using the *S. mentella* age-length keys with both sexes combined from the 1990-2016 EU surveys. Annual length weight relationships derived from Portuguese commercial catch were used for determination of mean weights-at-age.

The 1999-2002 and 2005 cohorts dominated the overall catch through most years of the 2001-2012 interval. The 2009-2011 cohorts are the most abundant in the catch between 2014 and 2016.

ii) Research survey data

EU Flemish Cap bottom trawl survey

Survey biomass was calculated based on the abundance at length and annual length weight relationships from the EU bottom trawl survey for the period 1988-2016.

Age compositions for Div. 3M beaked redfish EU survey stock and mature female stock from 1989 to 2016 were obtained using the *S. mentella* age length keys mentioned above. Mean weights-at-age were determined using the EU survey annual length weight relationships.

Gonads from Flemish Cap beaked redfish were collected since 1994 though not every year. Maturity at length ogives from 1994 were used in previous assessments. New maturity at length ogives were estimated based on microscopic inspection of histological sections of gonads collected throughout 12 years between 1994 and 2016. Maturity data were combined for both species within each year and fitted to a logistic function. For the years in between, where data was missing, curve parameters were estimated as the weighted average of the adjacent years where maturity ogives were available. The new maturity at length results were used in the present assessment.

Survey results. The survey stock abundance and biomass declined in the first years of the survey and remained low until 2003. A sequence of above average year classes (2001-2005), including the strongest of the survey series (2002), coupled with high survival rates, lead the stock and its exploitable part to a maximum in 2006. Year class strength declined afterwards, and the lasts cohorts entering the exploitable stock are among the lowest at age 4 (2010, 2011 and 2012). Both spawning stock and exploitable biomass were high from the mid 2000s to 2009. Spawning stock biomass has remained high in recent years while exploitable biomass has declined to near average. (Figure. 7.2). The majority of survey indices went down while female spawning stock remained at relatively high levels, suggesting that the high mortality from sources other than fishing has more impact on the very young ages of the incoming cohorts than afterwards through the exploited ages of the beaked redfish life history.

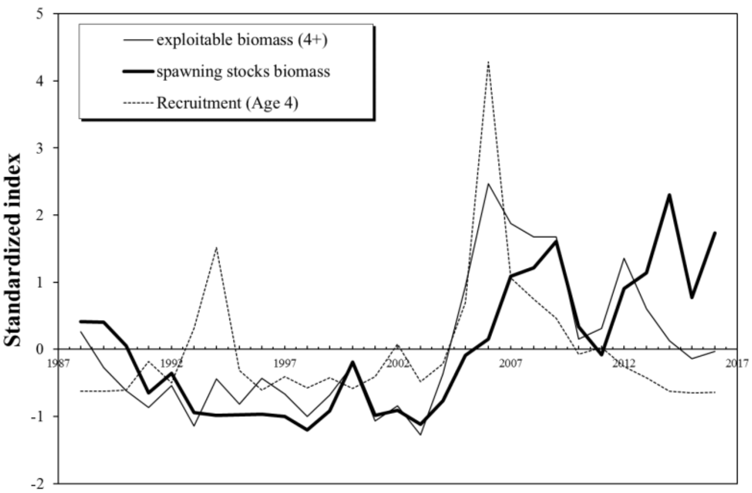


Fig. 7.2. Beaked redfish in Div. 3M: standardized biomass, female spawning biomass and recruitment at age abundance from EU surveys (1988-2016). Each series standardized to the mean and unit standard deviation.

iii) Natural mortality

In the mid 2000's, the Flemish Cap cod stock started recovering, not only in terms of abundance but also in terms of individual growth, leading to a continuous and steep increase of cod biomass between 2006 and 2013. There is a strong possibility that important increases in redfish consumption by cod are associated with this recovery leading to anomalously high levels (M> 0.1) of beaked redfish natural mortality, from 2006-2010.

Attempts to track changes on natural mortality have been made on previous assessments since 2011for a range of M candidates between 0.1 - 0.4. Having 2006 as the starting year for the sensitivity analysis, time windows of variable width were considered where the best M option should minimize the $SS \log q_{age}$ residuals and maximize correlation between exploitable survey abundance and XSA abundance. So far the approach to the actual magnitudes of M has been strictly dependent of beaked redfish survey indices, which in turn should capture the dynamics of the ensemble of the two redfish populations at times of very low recruitment, low exploitation and high predation.

The last 3M beaked redfish assessment STACFIS recommended that, *in order to quantify the most likely redfish depletion by cod on Flemish Cap, and be able to have an assessment independent approach to the magnitude of such impact ...work continue to investigate recent changes in natural mortality*.

In order to include an independent approach to natural mortality in the sensitivity M framework, the actual beaked redfish natural mortality has been estimated for two periods (2011-2016 and 2015-2016) by a number of different published models derived from cross-species comparative analyses, either by size/age-independent and size/age-dependent methods. For the two size/age-dependent methods, an average M from ages 4 to 15 was estimated. Length at age keys were combined for both beaked redfish species assembled according with the two intervals considered. Age length data from those keys was finally fitted to a von Bertalanffy growth model for each interval in order to get the growth input parameters of the natural mortality models for that interval.

c) Estimation of Parameters

The Extended Survivors Analysis (XSA) (Shepherd, 1999)[1] was used to estimate stock size. The month of peak spawning (larval extrusion) for Div. 3M *S. mentella*, was taken to be February, and was used for the estimate of

---

[1] SHEPHERD, J. G. 1999. Extended survivors analysis: an improved method for the analysis of catch-at-age data and abundance indices. *ICES J. Mar. Sci.*, **56**(5): 584-591.

the proportion of fishing mortality and natural mortality before spawning. EU survey abundance at age was used for calibration. The XSA model specifications are the same as in the assessment in 2015, and are given below:

Catch data from 1989 to 2016, ages 4 to 19+

Fleets	First year	Last year	First age	Last age
EU summer survey (Div. 3M)	1989	2016	4	18

Tapered time weighting not applied
Catchability independent of stock size for all ages
Catchability independent of age for all ages up to age 15
Terminal year survivor estimates not shrunk towards a mean F
Oldest age survivor estimates not shrunk towards the mean F of previous ages
Minimum standard error for population estimates from the last true age of each cohort age = 0.5

Before 2006 *M* remained at 0.1. The rationale to select the best options for natural mortality between 2006 and 2014 are thoroughly explained in the sensitivity analysis sections of previous assessments (NAFO SCS Doc. 15/12). A natural mortality of 0.4 was tuned to ages 4-6 between 2006 and 2010, and extended to all ages in 2009-2010. Since then natural mortality was assumed to be again an age independent parameter, and on 2011-2012 declined to 0.125, a level much closer to what is considered the magnitude of natural mortality on redfish stocks (0.1). However, on 2013-2014 the best fit to survey data implied again a marginal increase of *M to* 0.14.

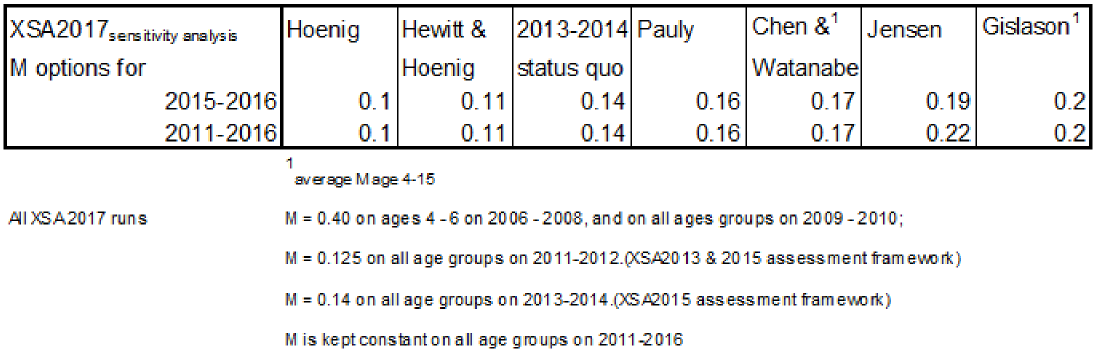
Based on survey data, cod biomass from the Flemish Cap has grown since 2006, reaching an historical high in 2014, while combined *S. mentella* and *S. fasciatus* declined as a single (beaked redfish) stock.

Cod survey biomass has substantially declined in 2015 and 2016 and so the predation pressure over the beaked redfish unit may have declined in the last couple of years. An independent evaluation of natural mortality has been therefore introduced, using several biological based models to estimate several M candidates, constant over age and time on two alternate time periods:

(1) 2015-2016, keeping the whole range of previously adopted M 's back in time or

(2) 2011-2016, assuming that after2010 M fell to a low level more or less constant.

The two sets of natural mortality candidates were then in contest for a better XSA fit to the 2011-2016 survey data, and the correspondent runs were labeled according their M input, as tabulated below:



$XSA2017_{sensitivity\ analysis}$ M options for	Hoenig	Hewitt & Hoenig	2013-2014 status quo	Pauly	Chen &[1] Watanabe	Jensen	Gislason[1]
2015-2016	0.1	0.11	0.14	0.16	0.17	0.19	0.2
2011-2016	0.1	0.11	0.14	0.16	0.17	0.22	0.2

[1] average M age 4-15

All XSA2017 runs

M = 0.40 on ages 4 - 6 on 2006 - 2008, and on all ages groups on 2009 - 2010;

M = 0.125 on all age groups on 2011-2012.(XSA2013 & 2015 assessment framework)

M = 0.14 on all age groups on 2013-2014.(XSA2015 assessment framework)

M is kept constant on all age groups on 2011-2016

The goodness of fit of the model runs to survey data is measured by the following diagnostics

1. Lower $SS \log q_{age}$ residuals on 2015-2016 (for which a “best” M option is needed in either time scenario);
2. Lower $SS \log q_{age}$ residuals back to 2011 (M decline from the anomalous high 2006-2010 level);

3. Higher correlation between exploitable (4+) survey abundance and XSA abundance over recent years (2011-2016).

Diagnostics results for these two sets of runs are shown below under a traffic light format.

Key diagnostics of seven sensitive XSA_{2017} runs ($M_{status\ quo}$ and a set of 2015-2016 "biological" M candidates)

	Hoenig	Hewitt & Hoenig	status quo	Pauly	Chen &Watanabe[1]	Jensen	Gislason[1]
$M_{2015-2016}$	**0.1**	**0.11**	**0.14**	**0.16**	**0.17**	**0.19**	**0.2**
SS log q $residuals_{2015-2016}$	6.68	6.70	6.82	6.92	6.96	7.10	7.15
SS log q $residuals_{2011-2016}$	23.08	23.14	23.38	23.55	23.66	23.83	23.93
XSA *versus* SURVEY $r^2_{2011-2016}$	0.897	0.894	0.887	0.883	0.880	0.875	0.872

Key diagnostics of seven sensitive XSA_{2017} runs ($M_{status\ quo}$ and a set of 2011-2016 "biological" M candidates)

	Hoenig	Hewitt & Hoenig	status quo	Pauly	Chen &Watanabe[1]	Gislason[1]	Jensen
$M_{2011-2016}$	**0.1**	**0.11**	**0.14**	**0.16**	**0.17**	**0.2**	**0.22**
SS log q $residuals_{2015-2016}$	6.76	6.74	6.80	6.96	7.05	7.50	7.95
SS log q $residuals_{2011-2016}$	23.02	23.08	23.49	23.85	24.16	25.13	26.01
XSA *versus* SURVEY $r^2_{2011-2016}$	0.886	0.887	0.887	0.886	0.886	0.883	0.881

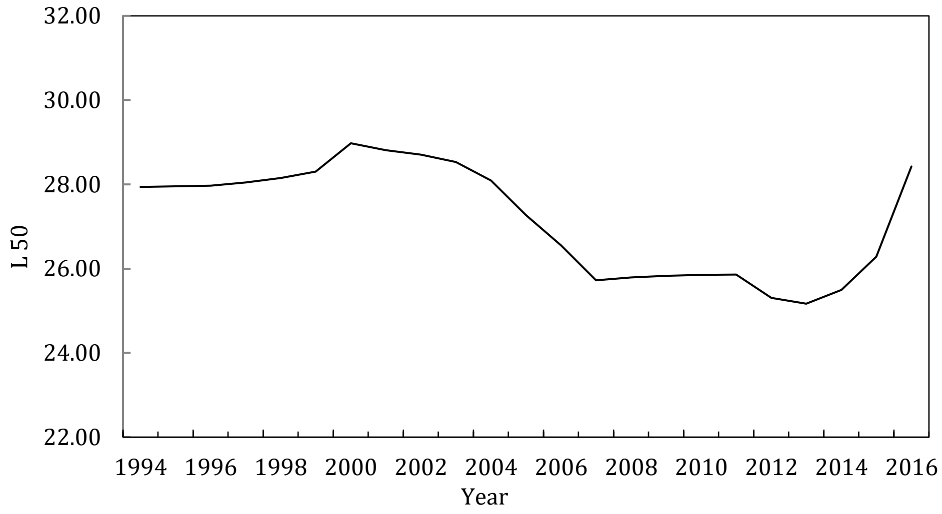


Fig. 7.3. Beaked redfish in Div.3M: mean length at maturity 1994-2016

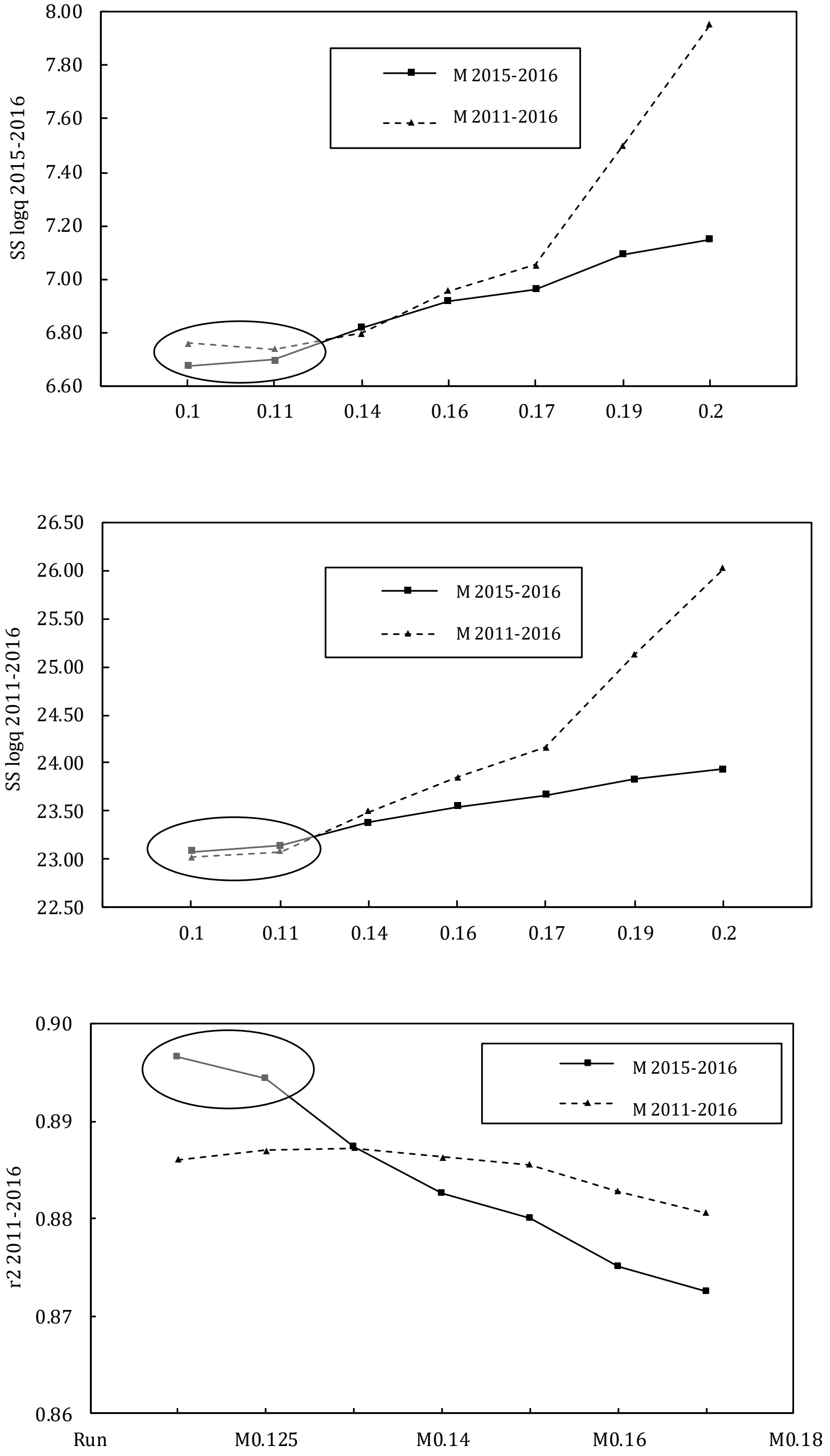
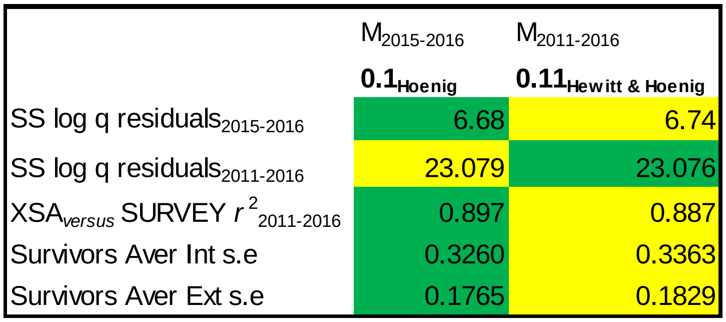


Fig. 7.4. Beaked redfish in Div. 3M: goodness of fit diagnostics of XSA$_{2017}$ for several 2011-2016 *M* options. Top panel is SS logq 2015-2016, middle panel is SS logq 2011-2016, lower panel is r^2 2011-2016. Dashed line = M fixed to 2011-2016 solid line = fixed M 2015-2016

Reduced M values of 0.1 and 0.11 showed lower $SS \log q_{age}$ and also higher correlations between XSA and survey results for the two last years. But correlation decrease to a lower level if the analysis is extended till 2011, showing little response if a constant M is considered between 2011 and 2016.

M 0.1 is the best 2015-2016 option if the previous 2011-2014 levels of natural mortality are kept and M 0.11 is the best 2011-2016 average level of natural mortality. The diagnostics were compared afterwards just for the two best options, complemented with the comparison of the respective (average) internal and external survivals at age standard errors. Diagnostics results for the two selected runs are shown below

Key and complementary diagnostics for the best runs of each set (best $M_{2015\text{-}2016}$ run versus best $M_{2011\text{-}2016}$ run)



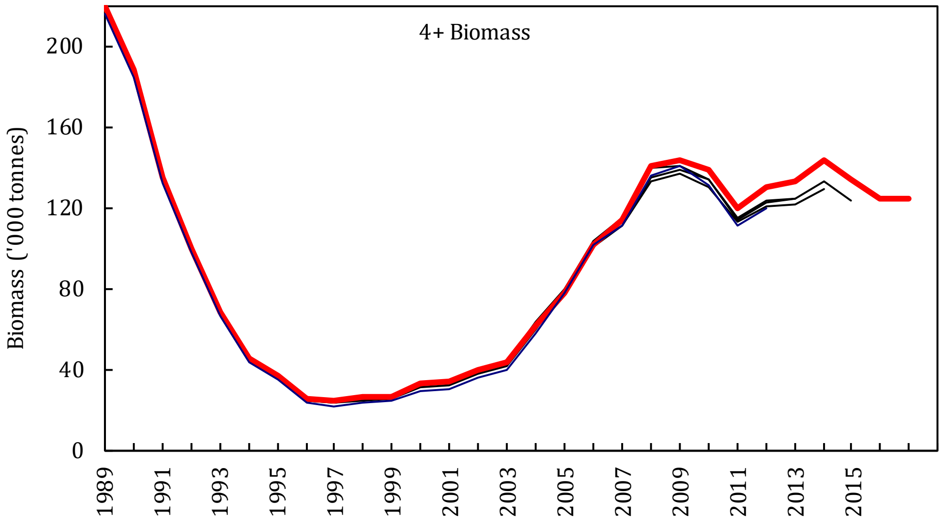
	$M_{2015\text{-}2016}$	$M_{2011\text{-}2016}$
	0.1$_{\text{Hoenig}}$	**0.11**$_{\text{Hewitt \& Hoenig}}$
SS log q residuals$_{2015\text{-}2016}$	6.68	6.74
SS log q residuals$_{2011\text{-}2016}$	23.079	23.076
XSA$_{versus}$ SURVEY $r^2_{2011\text{-}2016}$	0.897	0.887
Survivors Aver Int s.e	0.3260	0.3363
Survivors Aver Ext s.e	0.1765	0.1829

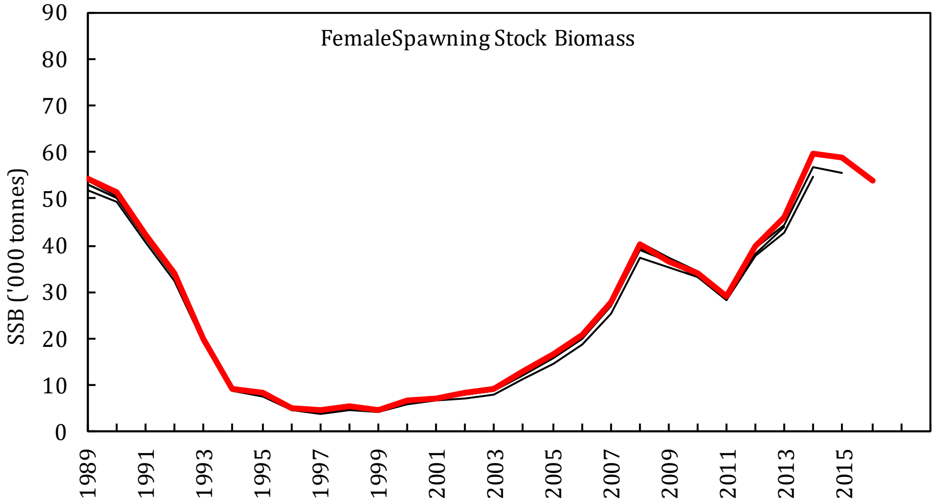
From the above traffic light frame, the left option diagnostics from the *M*0.1 2015-2016 run, keeping the 2011-2012 and 2013-2014 *M*'s stick to the previous adopted assessments (Ávila de Melo *et al*., 2013 and 2015), has a clear better outlook than the right option diagnostics from the *M*0.11 2011-2016 average level run. Therefore the 2017 XSA assessment has run with a mortality of 0.1 in 2015 and 2016 and keeping the previous natural mortality estimated from the past beaked redfish analytical assessments.

d) Assessment Results

The 2017 XSA diagnostics kept the main features from past assessments: high variability associated with mean catchabilities and survivors, namely at younger ages, together with a similar patchwork of *log q@age* residuals that remains with only small changes from its predecessors.

A retrospective XSA$_{2016\text{-}2012\ (\text{last year})}$ was carried out for checking patterns and magnitude of bias on the main results of recent assessments back in time (Fig. 7.4). Retrospective patterns of small magnitude are observed on exploitable, female spawning biomass and recruitment (underestimate) and average fishing mortality (overestimate). Exception to these consistent retrospective results is the high positive biases associated with the magnitude of the 2009-2011 year classes at age 4, as estimated in 2017 back to 2014. The very small size of these cohorts makes them difficult to quantify at their first age within the assessment, contributing to their high retrospective bias.


4+ Biomass
Biomass ('000 tonnes)
0
40
80
120
160
200
1989
1991
1993
1995
1997
1999
2001
2003
2005
2007
2009
2011
2013
2015


FemaleSpawning Stock Biomass
SSB ('000 tonnes)
0
10
20
30
40
50
60
70
80
90
1989
1991
1993
1995
1997
1999
2001
2003
2005
2007
2009
2011
2013
2015

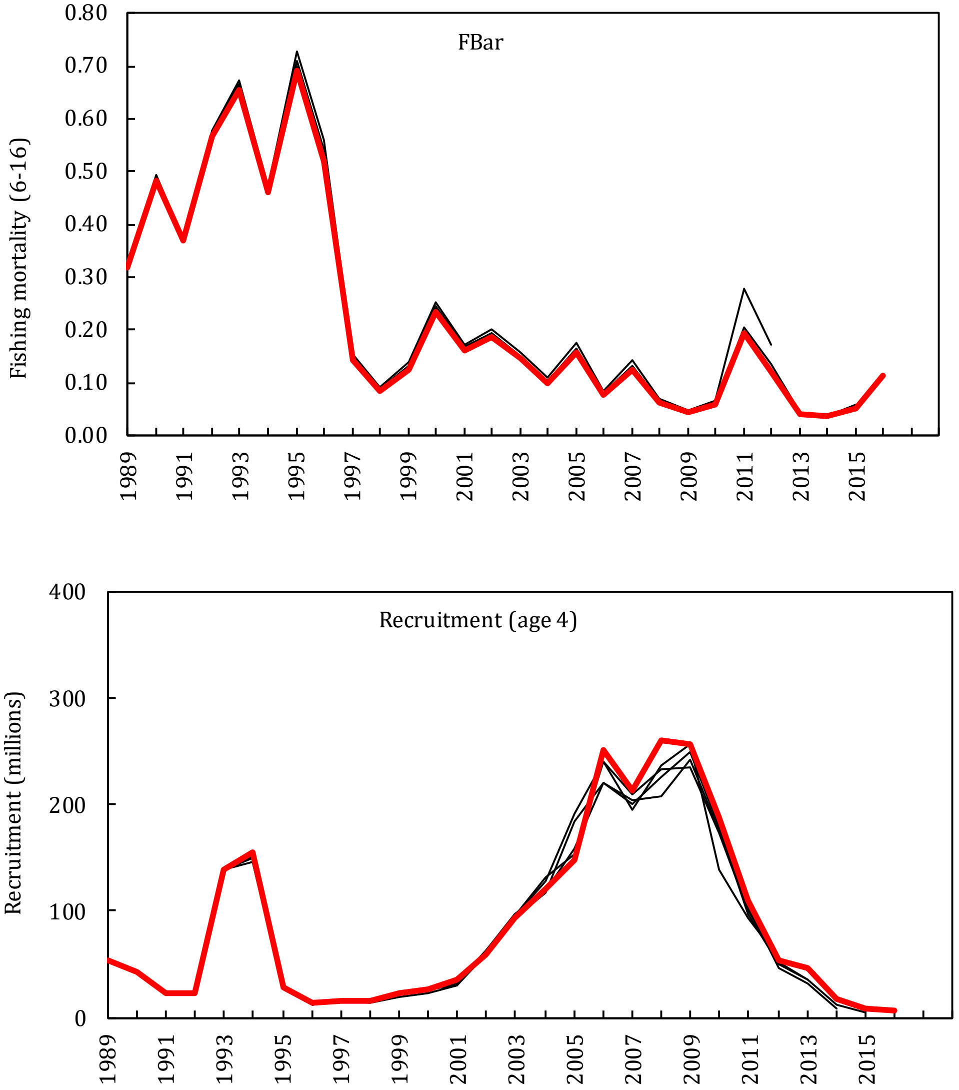


Fig. 7.5. Beaked redfish in Div. 3M: XSA retrospective analysis, last year 2016-2012: exploitable 4+ biomass, female spawning stock biomass, average fishing mortality (ages 6-16) and recruitment (age 4).

Taking into account the consistency of present assessment with the previous ones, the 2017 XSA assessment was accepted with 2015-2016 natural mortality at 0.1.

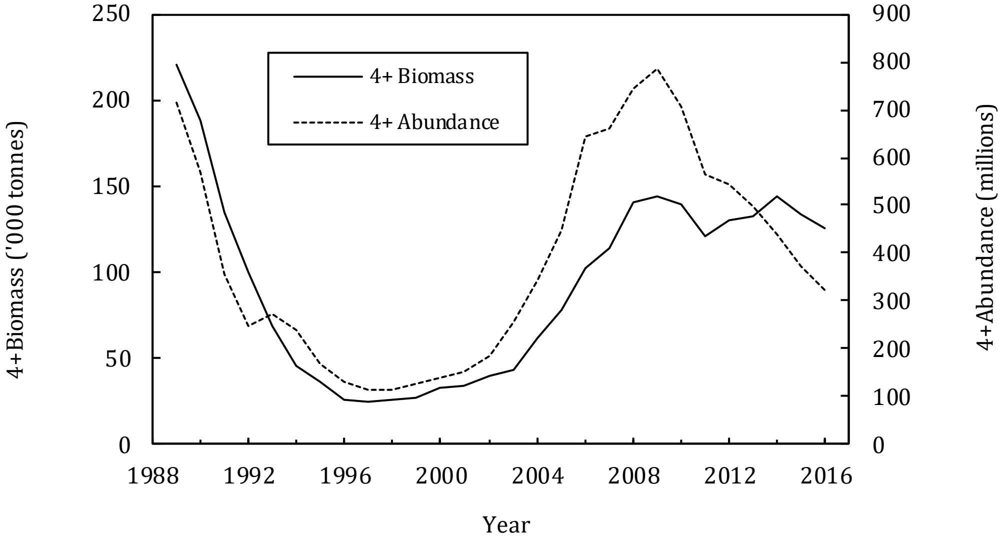


Fig. 7.6. Beaked redfish in Div. 3M: age 4+ biomass and age 4+ abundance from XSA.

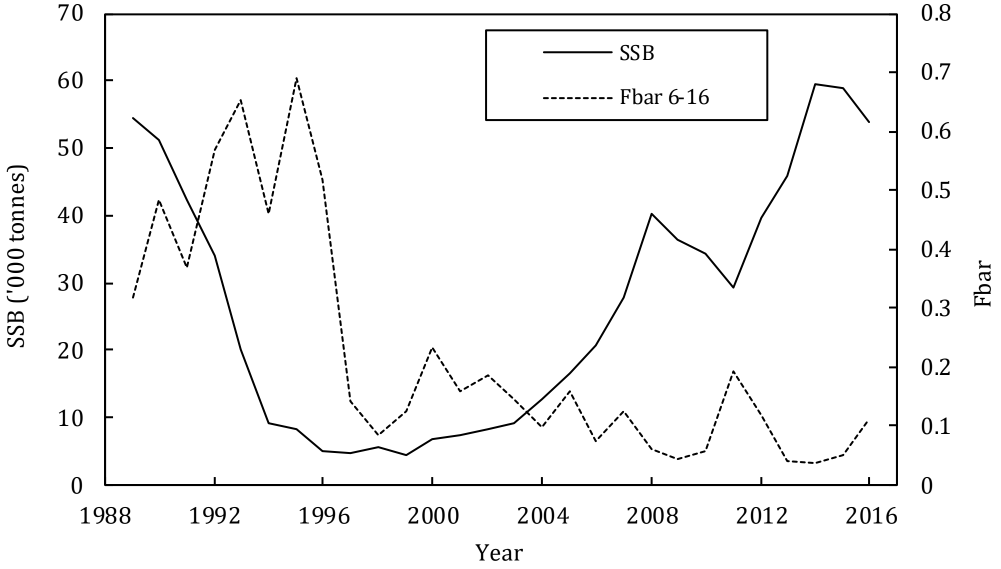


Fig. 7.7. Beaked redfish in Div. 3M: female spawning biomass and fishing mortality trends from XSA.

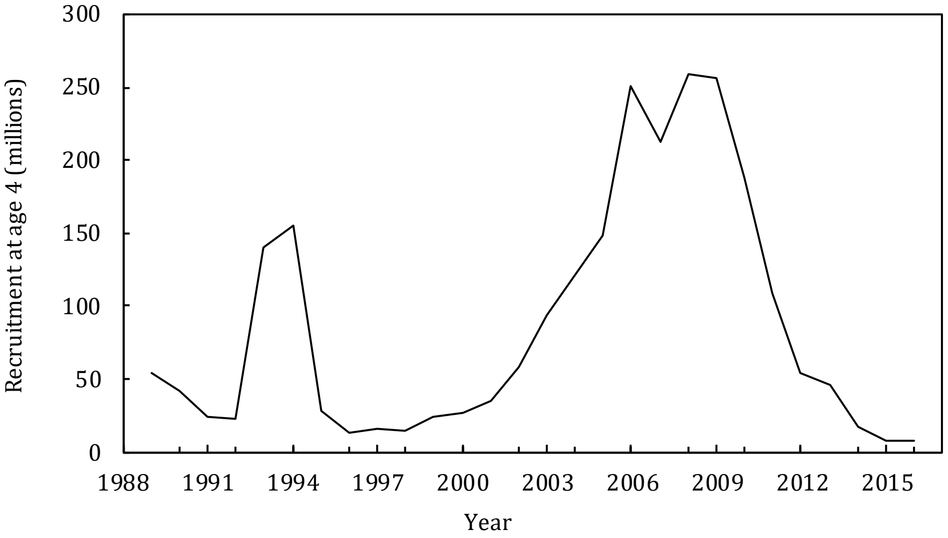


Fig. 7.8. Beaked redfish in Div. 3M: recruitment at age 4.

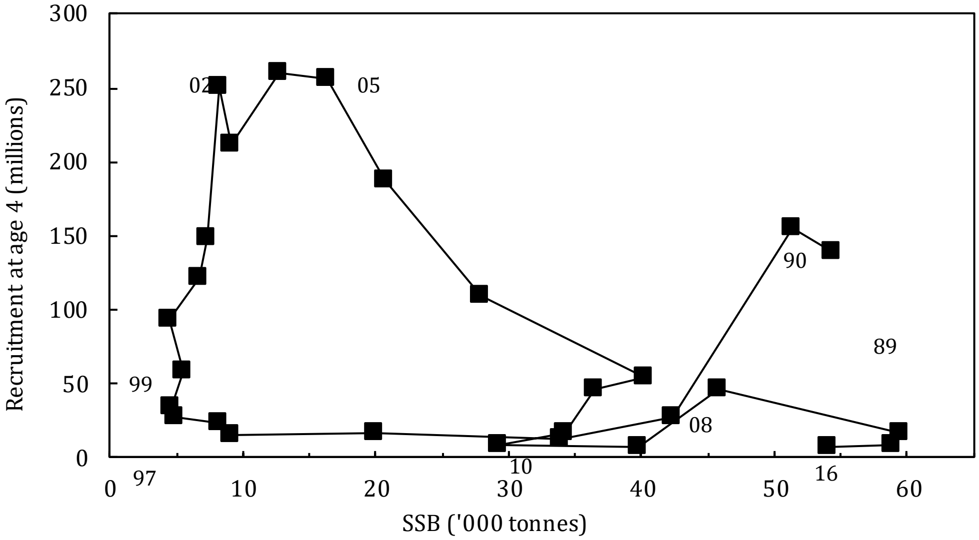


Fig. 7.9. Beaked redfish in Div. 3M: Stock/Recruitment plot (labels indicate age class).

Biomass and abundance (Fig. 7. 5): Experienced a steep decline from the 1989 until 1996. The exploitable stock was kept at a low level until the early 2000s, following years of low recruitment. Above average year classes coupled with high survival rates allowed a rapid growth of biomass and abundance since 2003 and sustained the biomass at a high level since 2008. From 2009 onwards abundance declined, although it remains in 2016 at a level above the 1990's low.

Spawning stock biomass (Fig. 7.6): SSB showed an increasing trend since the late 1990s and is now near its time series high

Fishing Mortality (Fig. 7.6)

1989-1993 very high commercial catches (at a maximum between 1989 and 1993) led to high fishing mortalities through the first half of the 1990's. Fishing mortality fell between 1996 and 1997 and has been low since then.

Recruitment (Fig. 7.7 and 7.8): The recruitment increased from 2002 until 2006 and remained at a high level until 2009, with the 2005 year class as the most abundant of the assessment interval. Recruitment to exploitable stock declined continuously since then and is now at the level of the weak year classes from the 1990's.

State of the stock: as a result of high recruitment from 2002-2006, the stock currently has high biomass and spawning biomass but abundance and recruitment are declining. Year classes recruiting in 2015 and 2016 are among the lowest on record. Fishing mortality increased in 2015-2016 but is still low.

e) Yield per recruit analysis

In order to get proxy's of F0.1 and Fmax in line with the most recent natural mortality estimate, a new yield per recruit analysis (*ypr*) with *M*= 0.10 was performed, with all other inputs averaged from the interval where beaked redfish natural mortality took off (2006-2016). Partial recruitment (PR) was assumed flat top at the last three (true) ages considered on the XSA, and a relative F @age 4-18 vector was given each year by the ratio of the F 's @age to $Fbar_{16-18}$. The average relative F @age vector was the adopted PR of this *ypr* analysis. In order to reduce the weight of the plus group on the final results, ages were virtually extended to age 29 with a plus group set at age 30. Mean weights and female maturity were kept constant and were the ones of the XSA 19 plus group.

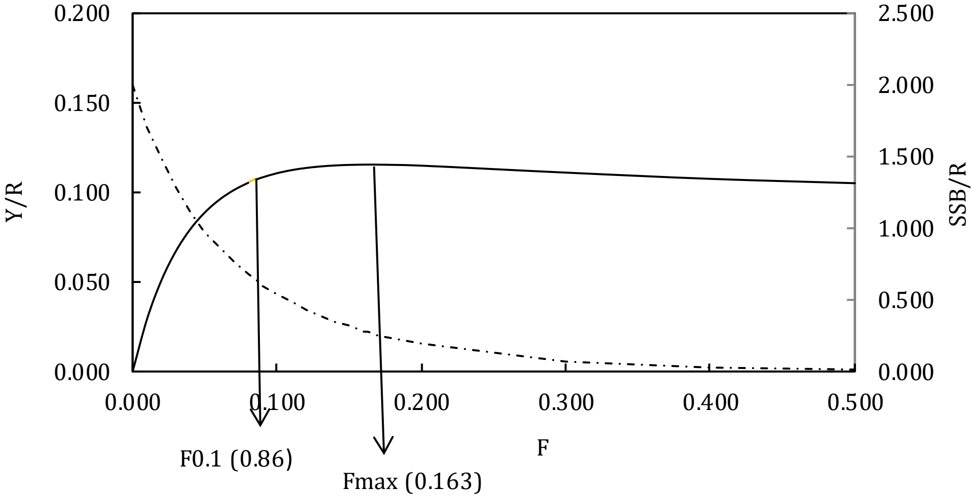


Fig. 7.9. Beaked redfish in Div. 3M: yield per recruit analysis at M=0.10 (2006-2016 average inputs)

As expected decreasing natural mortality led to deflated yield per recruit results, with $F_{0.1}$ =0.086 and $F_{\max}$ = 0.163 ($F_{bar16-18}$). These values have been used for short term projections. Taking into account the high variability on natural mortality and partial recruitment over the period considered deriving the inputs of this analysis, the results regarding F0.1 and Fmax are at the moment candidates to 3M beaked redfish fishing mortality reference points that still need to be confirmed in near future.

f) Short term projections

Short term (2018-2019) projections were carried out for female spawning stock biomass (SSB) and catch, under most recent level of natural mortality and considering four options for fishing mortality as follows:

1. No fishing, F_0
2. $F_{statusquo}$@age (last year $F_{bar6-16,2016}$ times average partial recruitment for the last three years)
3. $F_{0.1}$ and F_{max} under current natural mortality of 0.10

Projections were initialized at the beginning of 2018 assuming $F_{statusquo}$@age during 2017. Recruitment entering in 2017 and 2018 is assumed constant at the geometric mean of below average recruitments (age 4 XSA, 1989-2014).

Stochastic projections of yield and female spawning stock biomass (SSB) under the four *F* options were initialized with abundance for ages 5 and older at the beginning of 2018. The coefficients of variation for population@age at the beginning of 2018 was set as the internal standard errors from XSA diagnostics. For 2019 and 2020, recruitment was randomly resampled with residuals from the geometric mean of below average recruitments (age 4 XSA, 1989-2014). All other inputs at age are the last three year averages with associated errors at age.

Short term projections for female SSB (at beginning 2020, 50th% and 25th%ile) and average 2018-2019 yield (50th%ile) under the selected *F* options and *M* at 0.10 are summarized on the table below:

SSB		F_0	F_{2016}	$F_{0.1}$	F_{max}
$2020_{50th\ \%\ ile}$		64977	53964	58437	53319
$2020_{25th\ \%\ ile}$		60681	50347	54611	49747
2016	54017				
Yield $_{beaked\ redfish}$		F0	F_{2016}	$F_{0.1}$	F_{max}
2018-2019			10248	5778	10230
2016	6232				
TAC		F0	F_{2016}	$F_{0.1}$	F_{max}
2018-2019			12092	**6817**	12070
2016	7000				

average beaked redfish proportion in the 2015-20163M redfish catch 0.85

		F_0	F_{2016}	$F_{0.1}$	F_{max}
P(SSB_{2020}>SSB_{2016})		>95%	~50%	75%	~50%

From 50th and 25th percentile results $F_{0.1}$ is the only fishing mortality option suitable to pursue a management strategy that will keep SSB by the entry of 2020 at or above its present high of 54 000t.

At 50% probability the average beaked redfish predicted yield at $F_{0.1}$ in the next coming years corresponds to an overall redfish TAC in 2018-2019 of 6817 (keeping the actual average proportion of beaked redfish in the 3M redfish catch (85%) in 2018-2019), tonnes, a figure of very close to the actual TAC of 7,000 tonnes.

g) Reference Points

There are no accepted limit reference points for this stock. Yield per recruit reference points are not considered candidate reference points for this stock due to variability in natural mortality and partial recruitment.

The next full assessment for this stock is planned to be in 2019.

8. American Plaice (*Hippoglossoides platessoides*) in Div.3M

Full assessment report (SCR Doc. 05/29; 17/24, 43; SCS Doc. 15/4, 5, 6, 7; 16/9; 17/4, 5, 6, 11)

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 t in 1965. Catches of this stock became regulated in 1974 and ranged from 275 t (1993) to 5 600 t (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 270 t and are taken as bycatch partially in the Div.3M cod fishery

From 1979 to 1993 a TAC of 2 000 t was in effect for this stock. A reduction to 1 000 t was agreed for 1994 and 1995 and a moratorium was agreed to thereafter (Fig. 8.1).

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

	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
TAC	ndf	ndf	ndf	ndf	ndf	ndf	ndf	ndf	ndf	ndf
STATLANT 21	0.1	0.1	0.2	0.1	0.1	0.2	0.2	0.2	0.2	
STACFIS	0.1	0.1	0.1	0.1	0.1	0.2	0.2	0.3	0.2	

ndf No directed fishing.

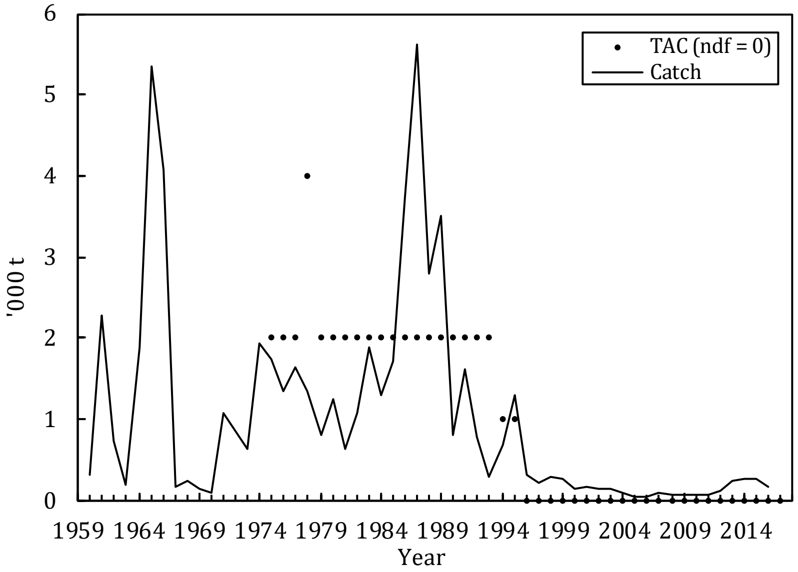


Fig. 8.1. American plaice in Div. 3M: STACFIS catches and TACs. No directed fishing is plotted as 0 TAC.

b) Input Data

i) Commercial fishery data

EU-Portugal provided length composition data for the 2014, 2015 and 2016 trawl catches. EU-Spain provided length composition data for the 2014 and 2016 trawl catches. Russia provided length composition data for the 2014 and 2016 trawl catches, the Russian 2016 length frequency was not used due to the low number of individuals sampled. EU-Estonia provided length composition data for the 2014 trawl catches. The length frequencies were used to estimate the length and age compositions for the 2014-2016 total catch. Ages 3 to 5 were the most abundant in the catches from 2014-2016.

ii) Research survey data

The series of research surveys conducted by the EU since 1988 were continued in July 2016. 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 (Fig. 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 since then. The 2007 abundance and biomass were the lowest of the series and the indices increased during 2009 to 2012 but have since remained stable at a relatively low level.

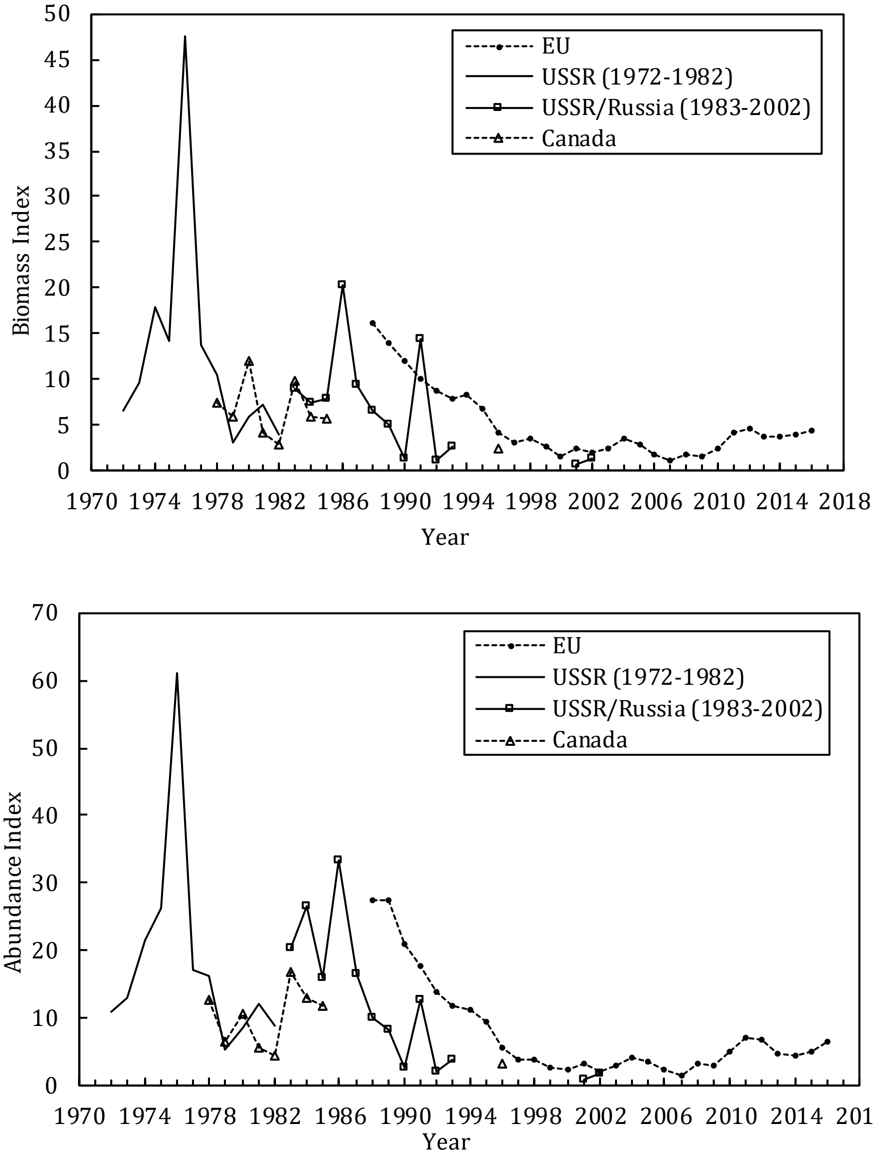


Fig. 8.2. American plaice in Div. 3M: trends in survey biomass and abundance indices. EU survey data prior to 2003 have been converted to RV Vizconde Eza equivalents.

Ages 10, 5, 4 and 3, corresponding to the 2006, 2011, 2012 and 2013 year-classes respectively, were dominant in the 2016 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 since then. A minimum was recorded in 2007. During 2010, 2011 and 2012 the indices increased and then stabilized around 3 500 t. as the strong 2006 year class entered the SSB. 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 1988-2016 age composition of the catch and American plaice EU survey abundance. Both data sets were standardized to numbers-per-thousand prior to analysis.

The XSA was updated by adding the 2014, 2015 and 2016 data. Further 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 (Fig. 8.3).

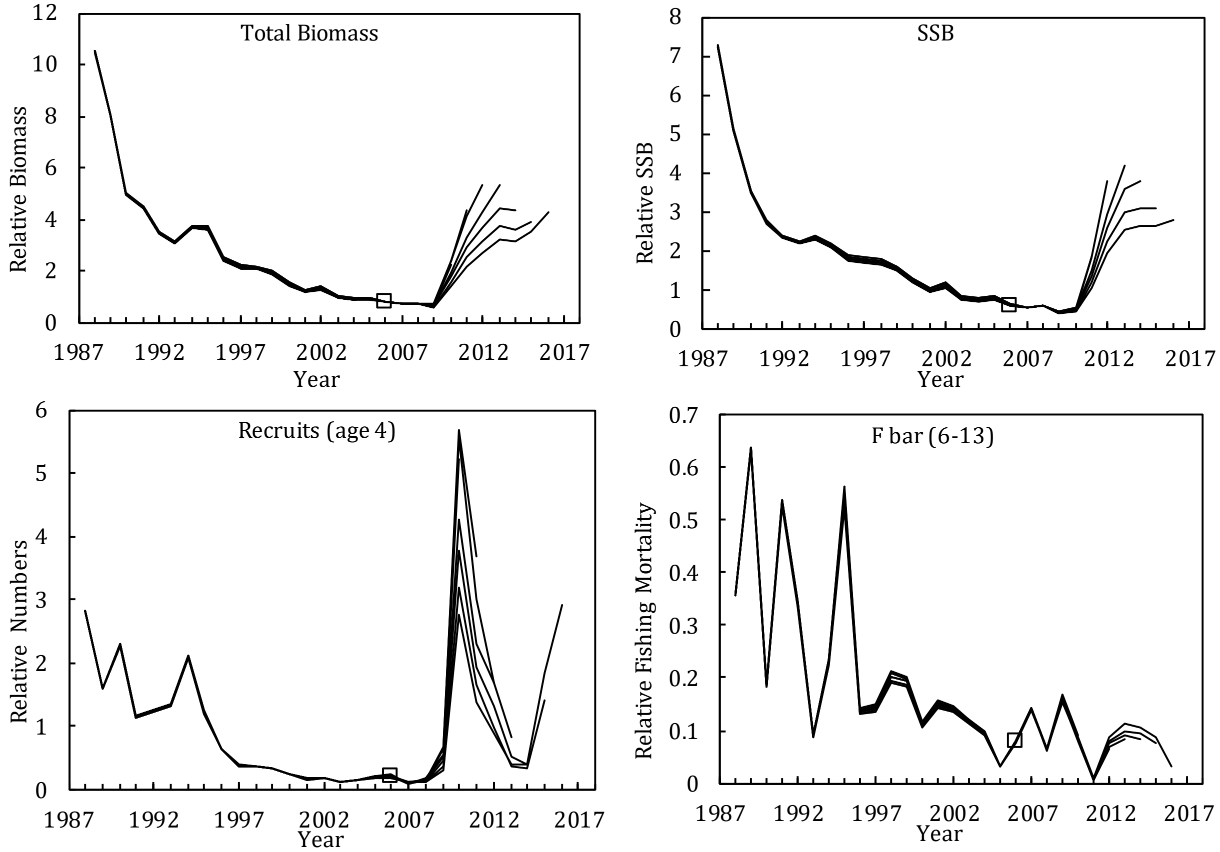


Fig. 8.3. American plaice in Div. 3M: XSA retrospective analysis, last year 2016-2010: biomass, spawning stock biomass, average fishing mortality (ages 6-13) and recruitment (age 4).

A VPA-type Bayesian model, the same used for the Div. 3M cod, was applied. As in XSA some variety of combinations of the input data and in the values of M were tested. All model runs used the following input sets:

Catch data: catch numbers and mean weight at age for 1988-2016.

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 with ages 4-16+, M = 0.15, split the tuning fleet in two periods: 1988-1993 and 1994-2016, was chosen to illustrate trends in the stock (Fig. 8.4).

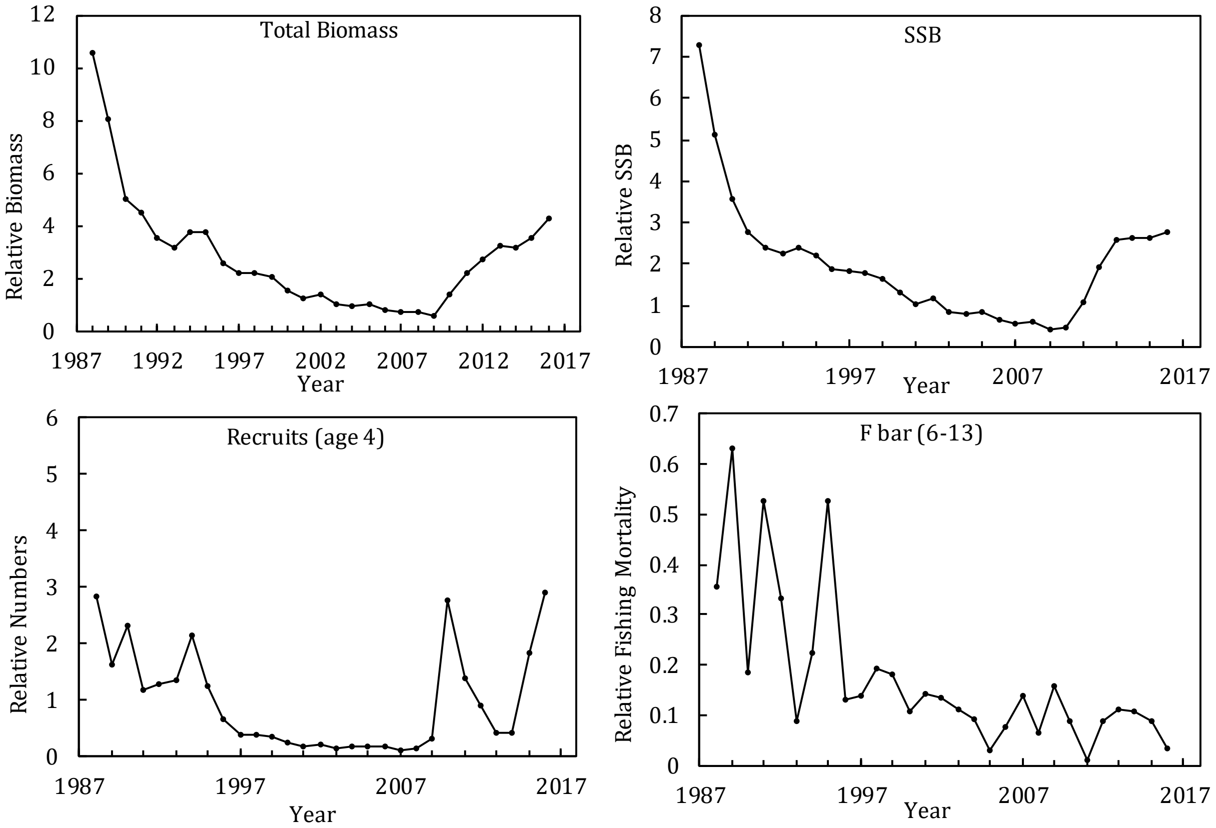


Fig. 8.4. American plaice in Div. 3M: stock trends in the XSA exploratory assessment.

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 (Fig. 8.5) then fluctuated at or below 0.1. In recent years *F* has decreased.

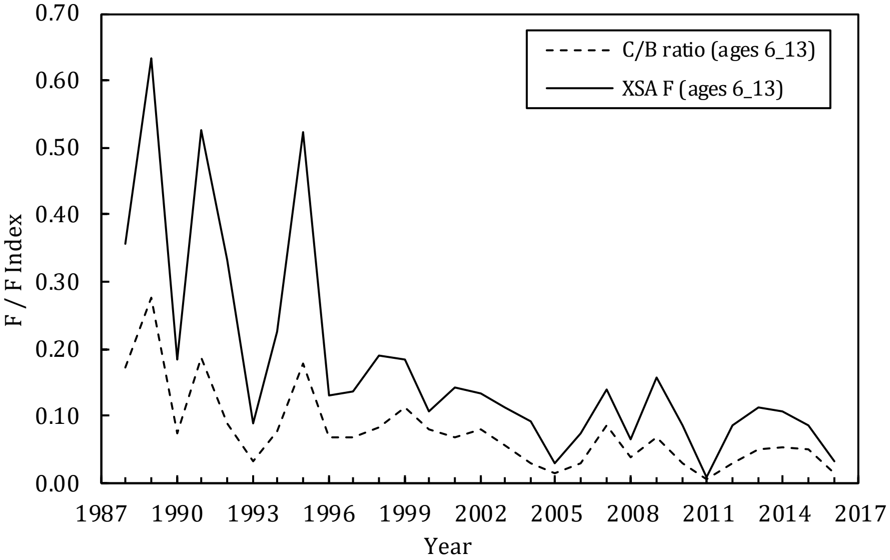


Fig. 8.5. American plaice in Div. 3M: fishing mortality (catch/biomass) index from EU survey (ages 6-13) and XSA estimated fishing mortality (ages 6-13).

The EU survey and illustrative XSA indicates a long range of poor recruitment from 1991 to 2005 year class. SSB recorded a minimum in 2007, in recent years SSB indices increase with the income of the strong 2006 year class in the SSB but in 2013 this increase seems to halt mainly as there were fewer older fish (ages 16+). Stock biomass increased in recent years due to the improved recruitment since 2006 (mainly due to the 2006 year class). SSB and Stock biomass are still at a relatively low level (Fig. 8.6).

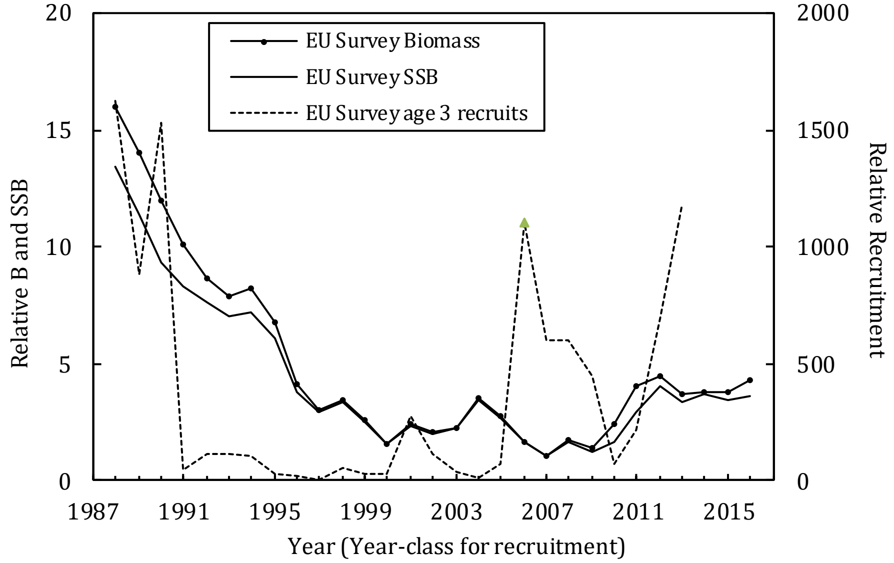


Fig. 8.6. American plaice in Div. 3M: biomass, spawning stock biomass (SSB) and corresponding recruitment (age 3) from the EU Survey.

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 since then.

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 decreased.

Recruitment: All of the 1991 to 2005 year-classes are estimated to be weak. Since 2006 the recruitment improved, particularly the 2006, 2012 and 2013 year classes.

State of the Stock: The stock has increased slightly in recent years due to improved recruitment since 2006, and although the catches are low since 1996, it continues to be in a poor condition.

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. Despite this, spawning stock biomass remains at a poor level (Fig. 8.7).

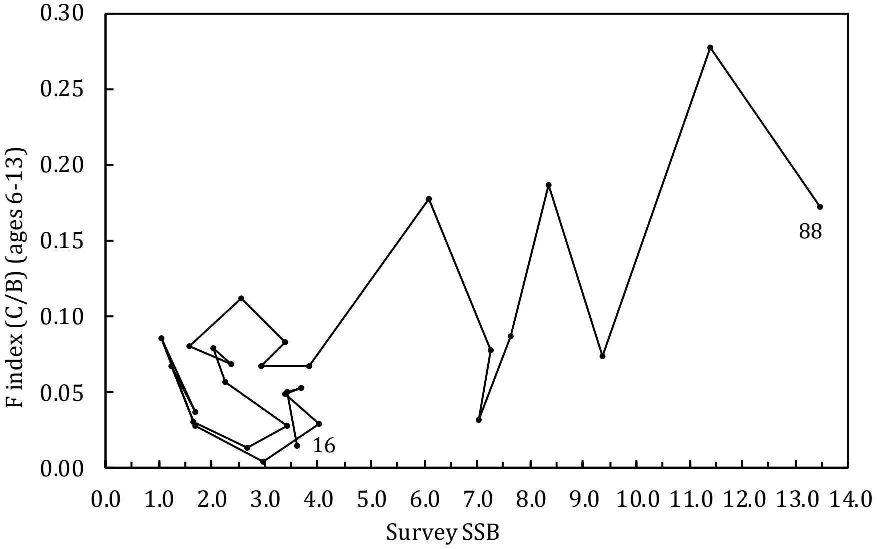


Fig. 8.7. American plaice in Div. 3M: stock trajectory within the NAFO PA framework.

The following set of parameters was used for the yield-per-recruit analysis: M = 0.2; 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 1988-2016. This analysis gave a F0.1 = 0.153 and a Fmax = 0.302.

g) Research Recommendations

STACFIS **recommends** that *several input frameworks be explored in both models (such as: q's; M (e.g. in relation to F0.1); ages dependent of the stock size; the proxies and its distribution in the VPA-type Bayesian model).*

This work is in progress and initial results were presented this year. STACFIS recommends that the work continue in order to explore the possibility of using the results to calculate reference points. Other types of models should also be explored.

Due to the recent improved recruitment at low SSB, STACFIS recommends to explore the Stock/Recruitment relationship and Blim.

With the income of recent good year-classes at low SSB it is not possible at the moment to define a SSB/R relationship.

This stock will be full assessed in 2020.

C. STOCKS ON THE GRAND BANK: SA 3 AND DIVS.3LNO

Recent Conditions in Ocean Climate and Lower Trophic Levels

- After a decade of above average ocean climate conditions in SA3 - Grand Bank, the trend in recent years shows signs of returning to colder conditions similar to the mid-1990's.
- the magnitude of the spring bloom has declined since the record-high observed in 2011 reaching a record-low in 2016. The timing indices indicate delayed onset but longer duration blooms since 2014.
- The composite zooplankton index has remained mostly above normal since 2009. Limited data prevented an updated value for 2016.
- The composite trophic index has declined in recent years from above average levels but reached the lowest level in the time series in 2016.

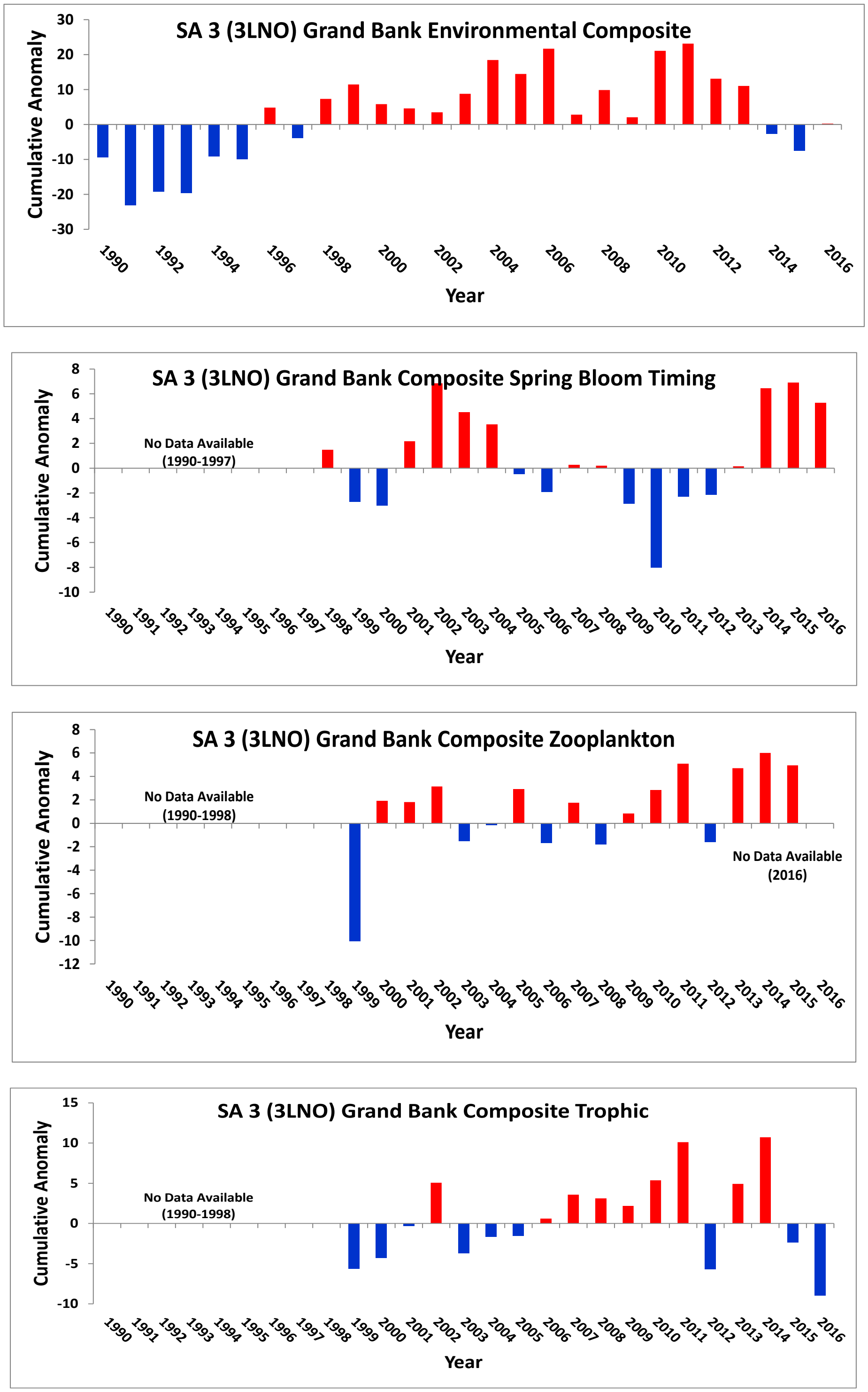


Fig. C.1. Composite ocean climate index for NAFO Subarea 3 (SA3 Divs. 3LNO) derived by summing the standardized anomalies (top panel; 2016 value is near normal) during 1990-2016, ocean colour composite of magnitude of the spring bloom (2'nd panel) and the peak time of the spring bloom (3'rd panel), composite zooplankton index (4'th panel) and composite trophic index (bottom panel) during 1990-2016. Annual anomalies near 0 indicate the metric is near the climatological mean, positive anomalies indicate above normal levels while negative anomalies indicate below normal conditions.

Environmental Overview

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

Ocean Climate and Ecosystem Indicators

The composite climate index in Subarea 3 (Divs. 3LNO) has remained well above normal since the late 1990s, reaching a peak in 2011 It has subsequently declined, reaching below normal conditions in 2015 but rebounded to normal conditions in 2016 (Figure C.1). Standing stocks of phytoplankton based on the composite spring bloom index declined in 2015-2016 after mostly positive anomalies observed since 2006 (Figure C.1). Reduced standing stocks of phytoplankton in recent years were combined with delayed timing of the spring bloom. Standing stocks of zooplankton based on the composite zooplankton index remain above normal since 2013 but limited sampling in 2016 in SA 3 prevented estimation of the annual anomaly (Figure C.1). The composite trophic index has generally declined in 2015-2016 after near record-levels in 2011 and 2014 (Figure C.1). At Station 27 off St. John's (considered representative of most of the northern Grand Banks) the annual surface and bottom (176 m) temperature anomalies were +0.4° and -0.2°C above/below normal, respectively. The vertical thickness of the layer of cold <0°C water (commonly referred as the cold-intermediate-layer or CIL on the Grand Banks) was about normal during the summer of 2016. The spatial averaged spring and fall bottom temperature in NAFO Divs. 3LNO was also about normal at 1.5° and 1.8°C, respectively.

9. Cod (*Gadus morhua*) in NAFO Divs. 3NO

Interim Monitoring Report (SCR 17/18,42; SCS Doc. 17/4,5,6,9,11)

a) Introduction

This stock has been under moratorium to directed fishing since February 1994. By-catch of cod during the moratorium increased from 170 t in 1995, peaked at about 4 800 t in 2003 and has been between 500 t and 1100 t since that time. The catch in 2016 was 666 t.

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

	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
TAC	ndf	ndf	ndf	ndf	ndf	ndf	ndf	ndf	ndf	ndf
STATLANT 21	0.7	0.6	0.8	0.8	0.7	1.1	0.7	0.5	0.6	
STACFIS	0.9	1.1	0.9	0.8	0.7	1.1	0.7	0.6	0.7	

ndf: no directed fishery

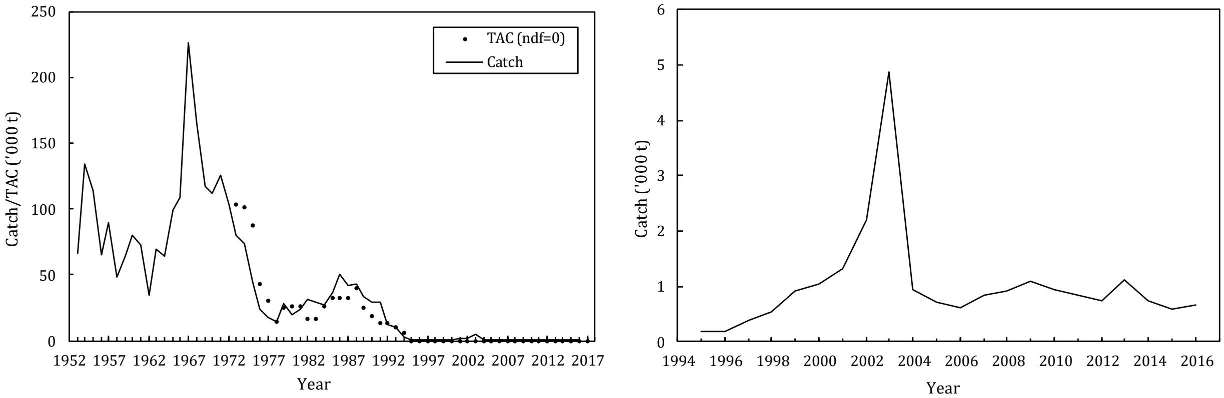


Fig. 9.1. Cod in Div. 3NO: total catches and TACs. Right panel highlights catches during the moratorium on directed fishing.

b) Data Overview

Canadian bottom trawl surveys. The spring survey biomass index declined from 1984 to the lowest level in 1995 (Fig. 9.2). The index remained low to 2011 with the exception of brief increases in 1998-2000 and in 2009. The index increased over 2012-2014, but declined considerably in 2015 and 2016. The trend in the autumn survey biomass index was similar to the spring series (Fig. 9.2).

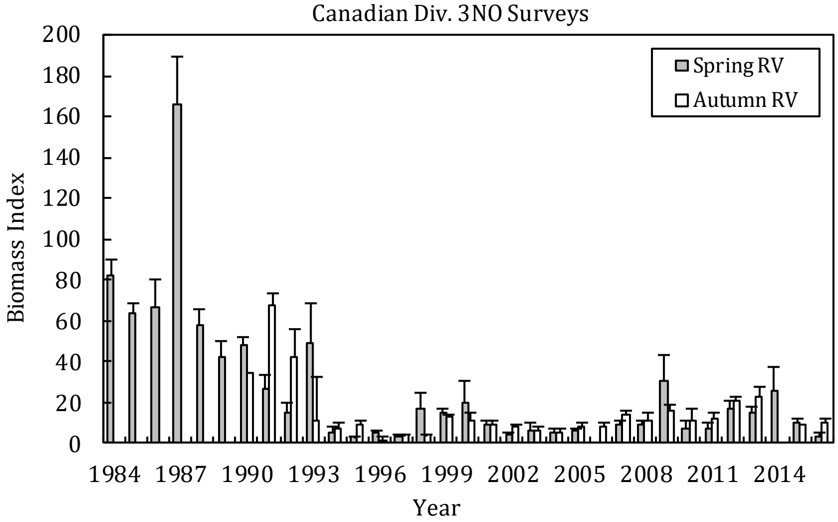


Fig. 9.2. Cod in Div. 3NO: survey biomass index (+ 1 s.d.) from Canadian spring and autumn research surveys.

EU-Spain bottom trawl survey. The biomass index from the EU-Spain stratified-random survey in the NRA portion of Div. 3NO was relatively low and stable from 1997-2008 (Fig. 9.3). There was a considerable increase in the index from 2009 to 2011, followed by a substantial decline in the next two years. The index reached its highest value in 2014 but has declined substantially through 2015-2016. Indices from this survey may not be suitable as indicators of overall stock trend since the survey covers only a small portion of the stock area and trends can be confounded by fish movement in and out of the area.

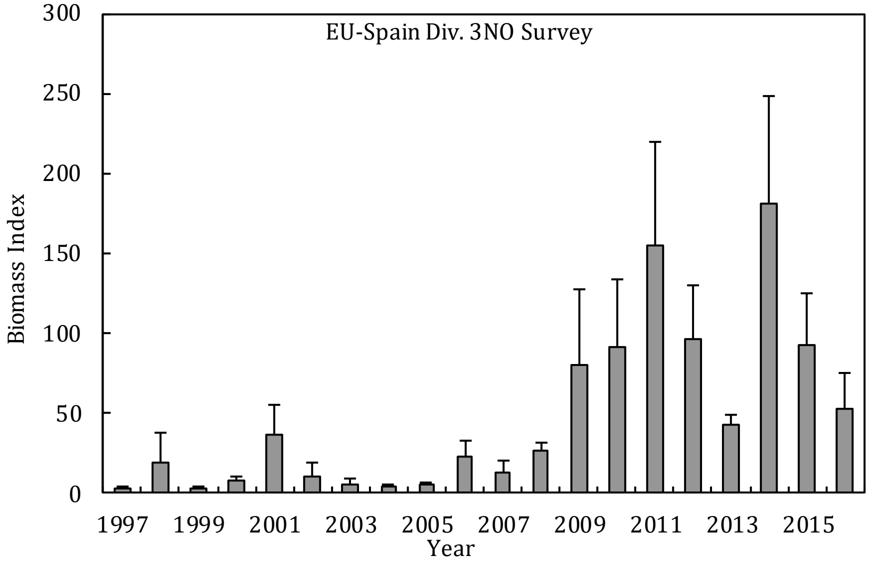


Fig. 9.3. Cod in Div. 3NO: survey biomass index (+ 1 s.d.) from EU-Spain surveys conducted in the NRA portion of Div. 3NO.

c) Conclusion

The most recent analytical assessment (2015) concluded that SSB was well below Blim (60 000 t) in 2014. Canadian and EU-Spain survey indices declined in 2015 and 2016, relative to 2014. Overall, the 2016 indices are not considered to indicate a significant change in the status of the stock.

The assessment in 2017 was not completed due to Scientific Council workload issues. The date for the next full assessment of this stock will be discussed in September 2017.

10. Redfish (*Sebastes mentella* and *Sebastes* fasciatus) in Divs. 3L and 3N

Interim Monitoring Report (SCR Doc. 17/16, 20 SCS Doc. 17/04, 05, 09, 011, 013)

a) Introduction

There are two species of redfish that have been commercially fished in Div. 3LN, the deep-sea redfish *(Sebastes mentella)* and the Acadian redfish *(Sebastes fasciatus*). The external characteristics are very similar, making them difficult to distinguish, and as a consequence they are reported collectively as "redfish" in the commercial fishery statistics and the surveys.

Catches declined to low levels in the early 1990s. From 1998-2009 a moratorium was in place. During that time catches were taken as by-catch primarily in Greenland halibut fisheries. With the reopening of the fishery in 2010 catches increased steadily, with removals of 9,900 t in 2015 and 8,500 t in 2016.

Recent nominal catches and TACs ('000 t) for redfish are as follows:

	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
TAC	ndf	ndf	3.5	6.0	6.0	6.5	6.5	10.4	10.4	14.2
STATLANT 21	0.4	0.3	3.1	5.4	4.3	6.3	5.8	9.9	8.5	
STACFIS	0.6	1.1	4.1	5.4	4.3	6.3	5.8	9.9	8.5	

ndf No directed fishing.

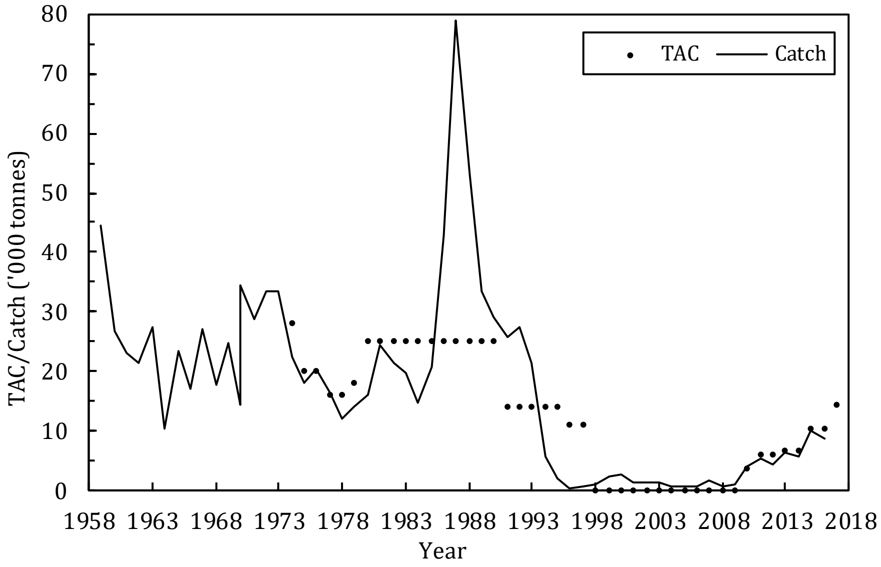


Fig. 10.1. Redfish in Div. 3LN: catches and TACs.

b) Data Overview

i) Research surveys

Most of the available surveys in Div. 3L and Div. 3N have been incorporated in the most recent assessment framework for this stock. These surveys are updated for 2016 and standardized in order to be presented on Fig. 10.2. The Spanish survey series in Div. 3L, is now included in the analysis, has also been standardized and presented.

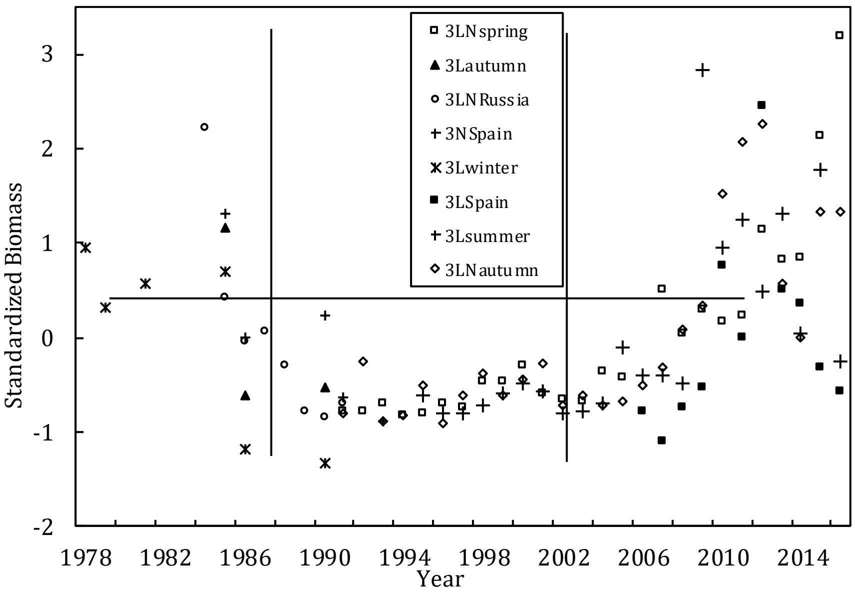


Fig. 10.2. Redfish in Div. 3LN: standardized survey biomass (1978-2016). Each series is standardized to the mean and unit standard deviation.

From the first half of the 1980s to the first half of the 1990s Canadian survey data in Div. 3L and Russian bottom trawl surveys in Div. 3LN suggests that stock size suffered a substantial reduction. Redfish survey bottom biomass in Div. 3LN remained well below average level until 1998 and started a discrete (and discontinuous) increase afterwards. A pronounced increase of the remaining biomass indices has been observed over the most recent years since 2006. Considering all available bottom trawl survey series occurring in Div. 3L and Div. 3N from 1978un til 2016, 100% of the biomass indices were at or above the average of their own series on 1978-1985, only 4% were positive on 1986-2005, increasing to 77% on 2006-2016. In 2016, Canadian Div. 3LN surveys remained high while while both EU Spain surveys (spring Div. 3N and summer Div. 3L) indicate declines.

c) Estimation of Stock Parameters

i) Relative exploitation

Ratios of catch to Canadian spring survey biomass were calculated for Div. 3L and Div. 3N combined and are considered a proxy of fishing mortality (Fig. 10.3). The spring survey series was chosen since is usually carried out on Div. 3L and Div. 3N during May till the beginning of June, and so can give an index of the average biomass at the middle of each year.

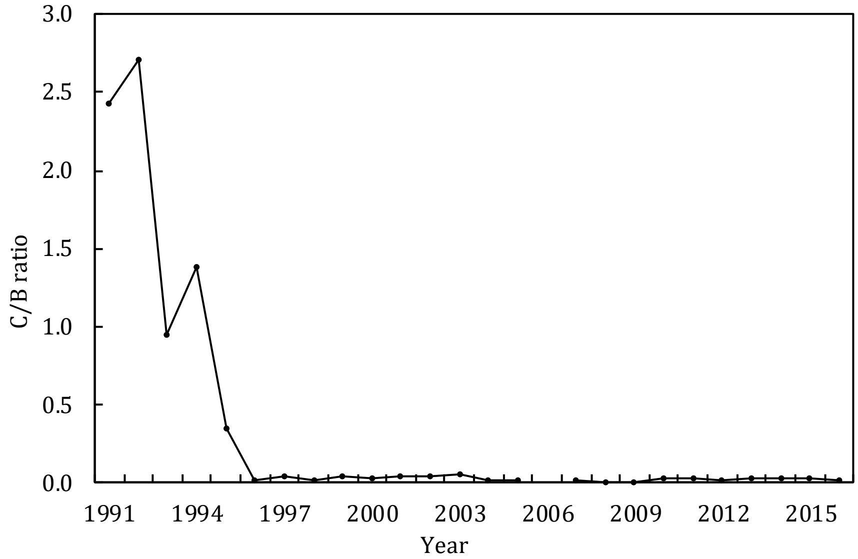


Fig. 10.3. Redfish in Div. 3LN: C/B ratio using STACFIS catch and Canadian spring survey biomass (1991-2016).

Catch/Biomass ratio declined from 1991 to 1996, with a drop between 1992 and 1993. From 1996 onwards this proxy of fishing mortality is kept at a level close to zero.

d) Conclusions

There is nothing to indicate a change in the status of the stock. The general increase of the catch since reopening of the fishery in 2010, have not altered the perception of the stock given by the available surveys and by the last assessment.

The next full assessment of this stock is planned for 2018.

11. American plaice (*Hippoglossoides platessoides*) in NAFO Divs. 3LNO

Interim Monitoring Report (SCR 17/13, 18, 27, 44; SCS 17/04, 05, 09, 11, 13)

a) Introduction

American plaice supported large fisheries from the 1960s to the 1980s. However, due to the collapse of the stock in the early 1990s, there was no directed fishing in 1994 and a moratorium was put in place in 1995. In recent years American plaice is caught as bycatch mainly in trawl fisheries of yellowtail flounder, skate, Greenland halibut and redfish. After the moratorium, catches reached a peak in 2003, but have been lower since then (Fig. 11.1). Catch estimates from 2011-2014 were based on ratios of fishing effort in those years to effort in 2010. In 2015 and 2016 catch was estimated using STATLANT 21 data for Canadian fisheries inside the 200-mile limit and Daily Catch Records for fisheries in the NRA. In 2016 catch was 1741 t (including 46 t of discards) (Fig. 11.1). In 2016, American plaice were taken as by-catch mainly in the Canadian yellowtail fishery (96% of Canadian fishery), and EU-Spain and EU-Portugal skate, redfish and Greenland halibut fisheries.

Recent nominal catches and TACs ('000 t) are as follows:

	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
TAC	ndf	ndf	ndf	ndf	ndf	ndf	ndf	ndf	ndf	ndf
STATLANT 21A	1.9	1.8	1.5	1.2	1.3	2.2	1.4	1.1	1.5	
STACFIS	2.5	3.0	2.9	2.4[1]	2.1[1]	3.0[1]	2.3[1]	1.1[2]	1.7[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.

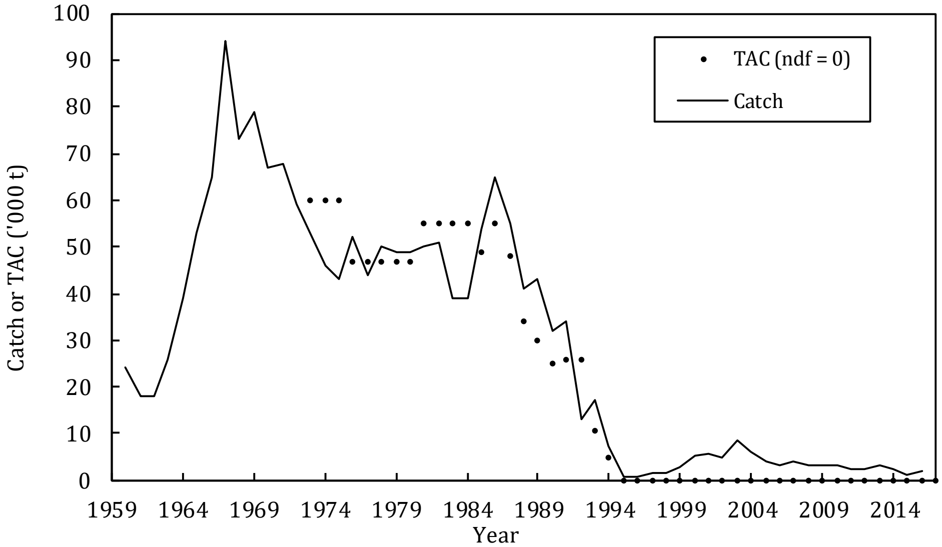


Fig. 11.1. American plaice in Div. 3LNO: catches and TACs. No directed fishing is plotted as 0 TAC.

b) Research Survey Data

Canadian spring survey. The Canadian spring survey in 2006 did not adequately cover many of the strata in Divisions 3NO. In 2015, the survey did not adequately cover all of the strata in Div. 3L. Biomass and abundance estimates from spring surveys for Div. 3LNO declined during the late 1980s-early 1990s. Biomass estimates have been generally increasing since the mid-1990s but there has been a sharp decline in 2016 (Fig. 11.2). The abundance index follows a similar trend.

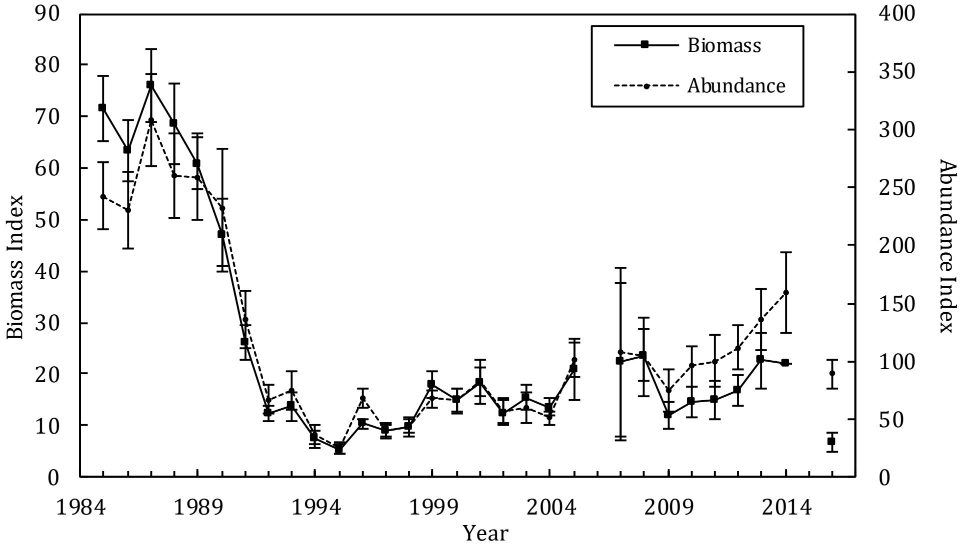


Fig. 11.2. American plaice in Div. 3LNO: biomass and abundance indices from Canadian spring surveys (data prior to 1996 are Campelen equivalents and since then are Campelen). Survey data was not adequate in 2006 or 2015.

Canadian autumn survey. In 2004, coverage of strata from Div. 3L in the Canadian autumn survey was incomplete, and in 2014 there was no coverage of Div. 3NO. Biomass and abundance indices from the autumn survey declined rapidly from 1990 to the mid-1990s and since then both abundance and biomass have been generally increasing. Both biomass and abundance indices in 2016 are down compared to the 2013 levels.

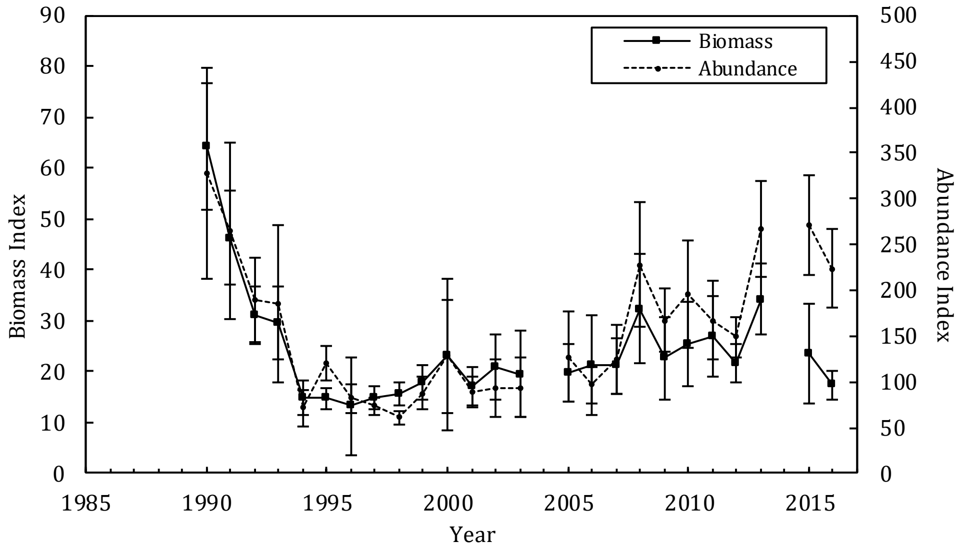


Fig. 11.3. American plaice in Div. 3LNO: biomass and abundance indices from Canadian autumn surveys (data prior to 1995 are Campelen equivalents and since then are Campelen). Survey data was not adequate in 2004 or 2014 due to missing strata.

EU-Spain Div. 3NO Survey. From 1998-2014, 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 to the lowest in the time series in 2016.

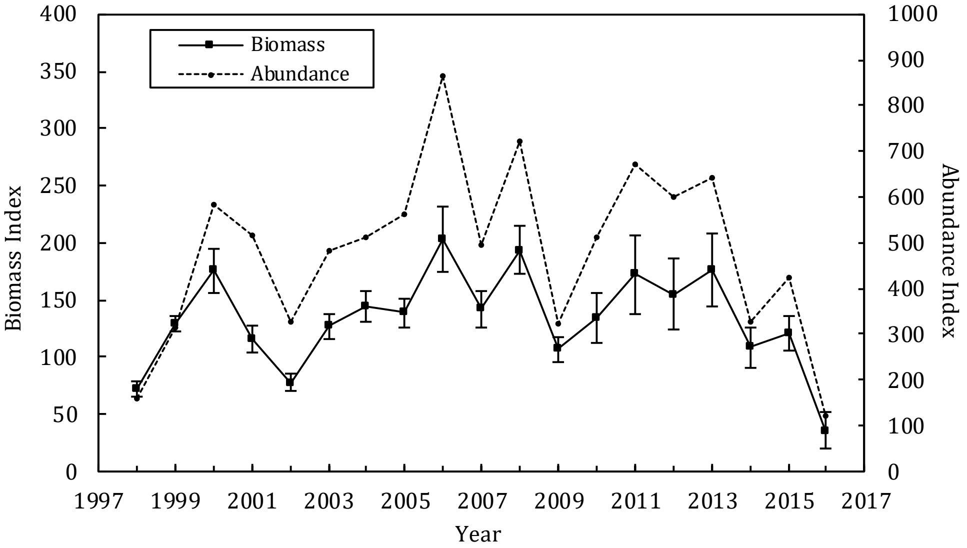


Fig. 11.4 American plaice in Div. 3LNO: biomass and abundance indices from the survey by EU-Spain (data prior to 2001 are Campelen equivalents and since then are Campelen).

c) Conclusion

Based on available data, there is nothing to indicate a change in the status of the stock since the 2016 assessment.

The next full assessment of this stock is planned for 2018.

d) Research Recommendations

STACFIS **recommended** that *investigations be undertaken to compare ages obtained by current and former Canadian age readers.*

STATUS: Work is ongoing.

STACFIS **recommends** that *investigations be undertaken to examine the retrospective pattern and take steps to improve the model.*

STATUS: No progress on this recommendation; models that incorporate uncertainty in the catch are being explored.

12. Yellowtail Flounder (*Limanda ferruginea*) in Divs. 3LNO

Interim Monitoring Report (SCR 17/20; SCS 17/04, 17/11)

a) Introduction

There was a moratorium on directed fishing from 1994 to 1997, and small catches were taken as by-catch in other fisheries. The fishery was re-opened in 1998 and catches increased from 4 400 t to 14 100 t in 2001 (Fig 12.1). Catches from 2001 to 2005 ranged from 11 000 t to 14 000 t. Since then, catches have been below the TAC and in some years, have been very low. The low catch in 2006 was due to corporate restructuring and a labour dispute in the Canadian fishing industry. Industry related factors continued to affect catches which remained well below the TAC in since 2007. However, from 2013 to 2016, catches were higher, ranging from 6 900 t to 10 700 t.

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

	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
TAC[1]	15.5	17	17	17	17	17	17	17	17	17
STATLANT 21	11.3	5.5	9.1	5.2	3.1	10.7	8.0	6.7	8.3	
STACFIS	11.4	6.2	9.4	5.2	3.1	10.7	8.0	6.9	9.3	

[1] SC recommended any TAC up to 85% F_{msy} in 2009-2017.

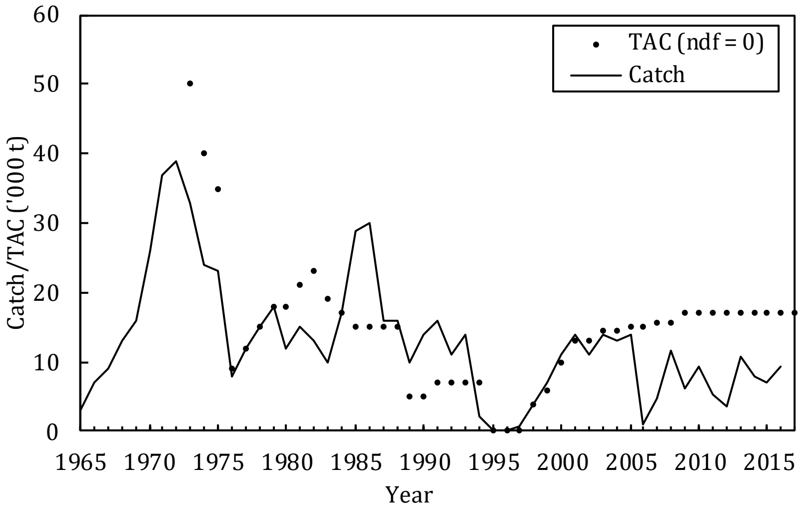


Fig. 12.1. Yellowtail flounder in **Divs. 3LNO**: catches and TACs. No directed fishing is plotted as 0 TAC.

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. The spring 2015 survey missed several important yellowtail strata in Div. 3L, thus the 2015 estimate is likely underestimated. The 2016 biomass estimate continued the declining trend observed since 2012.

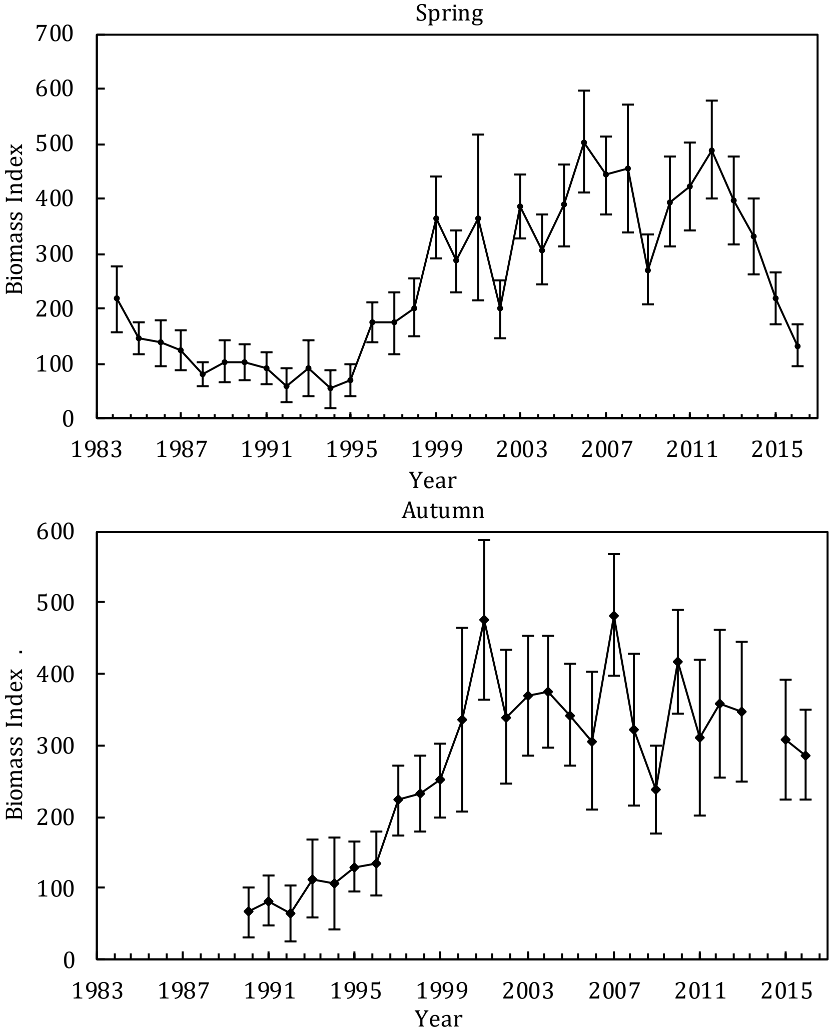


Fig.12.2. Yellowtail flounder in **Divs. 3LNO**: indices of biomass with approx 95% confidence intervals, from Canadian spring and autumn surveys. Values are Campelen units or, prior to autumn 1995, Campelen equivalent units. The 2014 Canadian autumn survey was incomplete.

Canadian stratified-random autumn surveys. The autumn survey biomass index for Divs. 3LNO increased steadily from the early-1990s to 2001, and although variable, it has remained relatively high since then (Fig. 12.2). The 2014 survey was incomplete due to problems with the research vessel.

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 since remained relatively stable, even though the 2014 to 2016 estimates are lower than the previous recent estimates (Fig. 12.3). Results in recent years, are not in agreement with the Canadian series which covers the entire stock area, as the EU-Spain spring survey shows an increasing trend (although imprecise) from 2013 while both Canadian surveys have declined from 2012 to 2016.

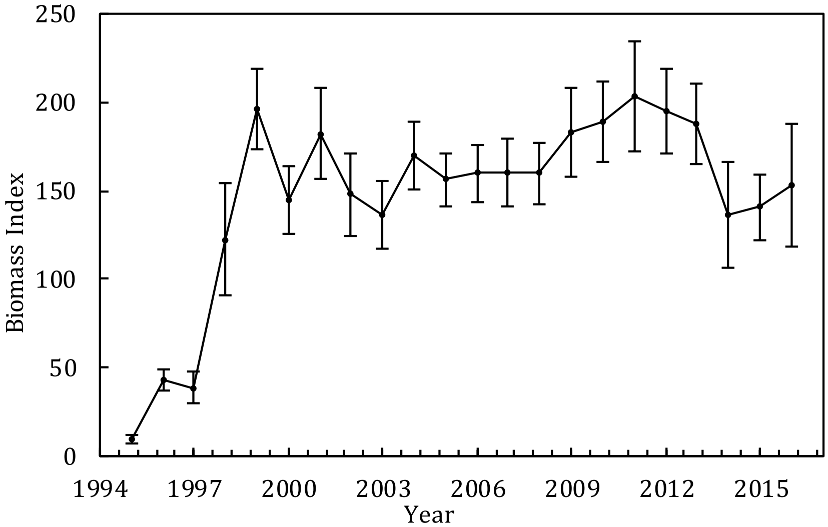


Fig.12.3. Yellowtail flounder in Divs. 3LNO: index of biomass from the EU-Spain spring surveys in the Regulatory Area of Divs. 3NO ±1SD. Values are Campelen units or, prior to 2001, Campelen equivalent units.

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 1999-2016 surveys than from 1984-1995. Although the stock had continued to occupy the northern portion of its range in Div. 3L in recent years, similar to the mid-1980s when overall stock size was also relatively large, in 2016 there was a decline in the 3L portion of the biomass of yellowtail flounder in the spring survey. 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 Fig. 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 in the last ten surveys.

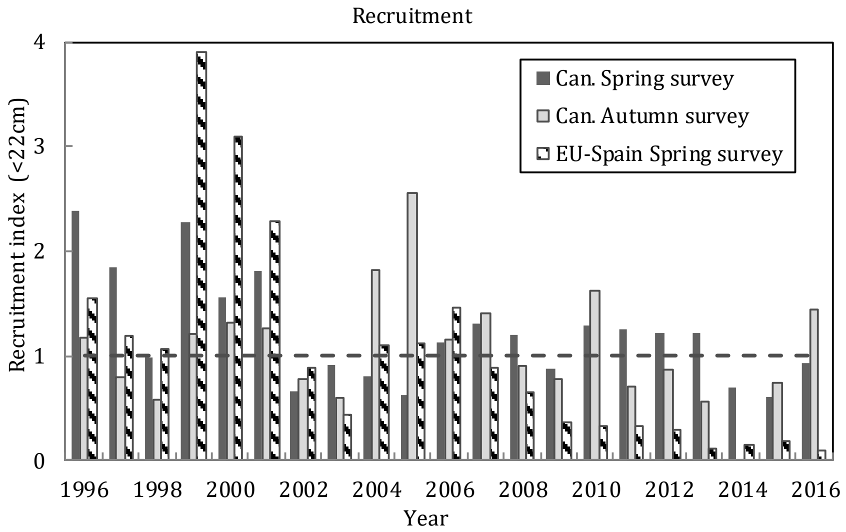


Fig.12.4. Yellowtail flounder **in Divs. 3LNO**: Juvenile abundance indices from spring and autumn surveys by Canada (Can.) and spring surveys by EU-Spain. Each series is scaled to its mean (horizontal line).

c) Conclusion

The most recent (2015) analytical assessment using a stock production model (ASPIC) concluded that the stock was above B_{msy} with a very low risk (<5%) of the stock being below B_{msy} or F being above F_{msy}. Overall, the 2016 survey indices are not considered to indicate a significant change in the status of the stock, although concerns were noted in the decline in biomass index and change in distribution shown in the Canadian Spring survey.

The next full assessment of this stock is planned for 2018.

d) Recommendation

Stock production models may be insensitive to drastic changes in survey indices in the most recent years, particularly if not associated with large changes in catch. STACFIS recommends further investigation of the stock production model formulation used to assess this stock and/or alternate models that would be more responsive to the indices for the next full assessment of this stock.

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

(Full assessment report. SCR Docs 17/020, 17/049, 05/25 SCS Docs. 17/04, 05, 11, 13)

a) Introduction

This stock underwent full assessment in 2014 based on survey indices, and in 2015 utilizing a surplus production model in a Bayesian framework. An interim monitoring report was provided in 2016. Witch flounder in Divs. 3NO was under moratorium to directed fishing from 1995 to 2014. Reported catches in the period 1972-84 ranged from a low of about 2,400 tonnes (t) in 1980 and 1981 to a high of about 9,200 t in 1972 (Fig. 13.1). Catches increased to around 9,000 t in the mid-1980s but then declined steadily to less than 1,200 t in 1995 when a moratorium was imposed on the stock. During the moratorium, bycatch averaged below 500 t. The NAFO Fisheries Commission reintroduced a 1,000 t TAC for 2015 and in 2015 set a TAC for 2016 and 2017 at 2,172 t and 2,225 t respectively. Not all Contracting Parties with quota resumed directed fishing for witch flounder. In 2016 the catch (a combination of directed and bycatch fisheries) was estimated to be 1,062t.

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

	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
TAC	ndf	ndf	ndf	ndf	ndf	ndf	ndf	1.0	2.2	2.2
STATLANT 21A	0.2	0.1	0.4	0.4	0.3	0.3	0.3	0.4	1.0	
STACFIS	0.3	0.4	0.4	0.4	0.3	0.3	0.3	0.4	1.1	

ndf = no directed fishery.

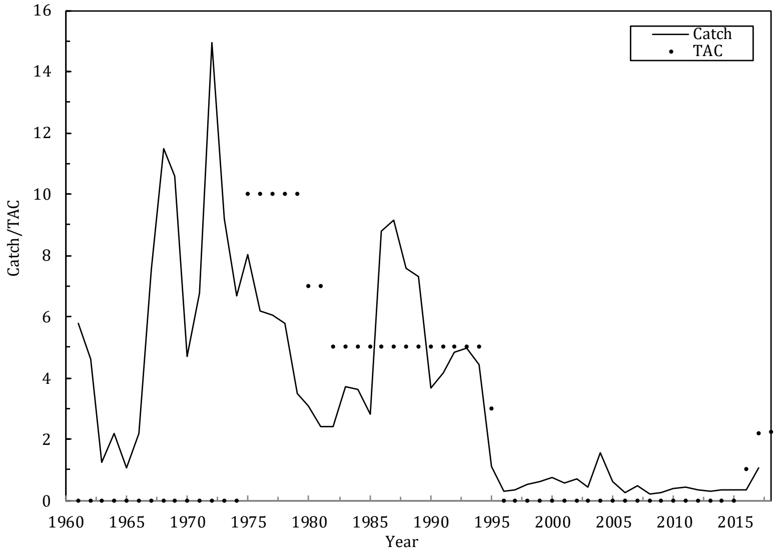


Fig. 13.1. Witch flounder in Divs. 3NO: Catch and TAC ('000 tonnes).

b) Data Overview

i) Commercial fishery data

Length frequencies. Length frequencies were available from observer data for Canadian witch flounder directed fisheries in NAFO Div. 3O in 2016. Canadian data indicated the catch ranged between 35 and 50 cm with a mean length of 42 cm (Fig. 13.2). Length frequencies were available from bycatches in directed fisheries for yellowtail flounder, redfish, Greenland halibut, and skate by Spain, Portugal, and Russia in 2016 (Fig. 13.2). The Spanish data (SCS 17/04) from Divs. 3NO indicated most of the witch flounder bycatch was between 28 and 46 cm in length. In the Portuguese data (SCS 17/05) for Div. 3O the witch flounder bycatch was dominated by lengths between 26 cm and 34 cm, with a mode at 32 cm and mean length of 31.7 cm (Fig. 13.2). In the Russian data (SCS 17/11) length frequencies of witch flounder bycatch in Div. 3O indicated the length ranged from 38 to 54 cm with a mean of 44.1 cm (Fig. 13.2).

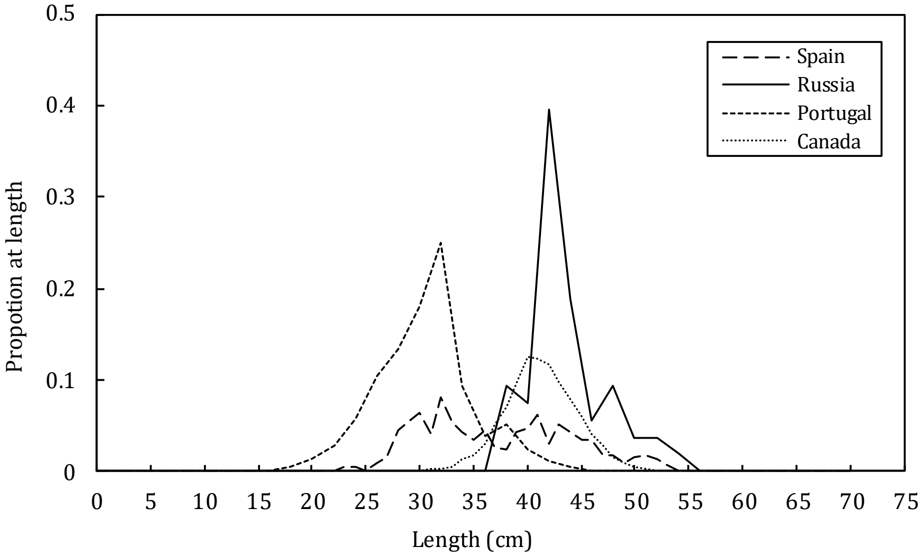


Fig. 13.2. Witch flounder length frequency (cm) distributions for Canada (NAFO Div. 3O), Spain (NAFO Divs. 3NO), Russia (NAFO Div. 3O), and Portugal (NAFO Div. 3O) commercial bycatch and directed fisheries in 2016.

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 values declined substantially from a high in 2013 to a value 49% of the time series average in 2015. Biomass values increased slightly in 2016 (Figure 13.3).

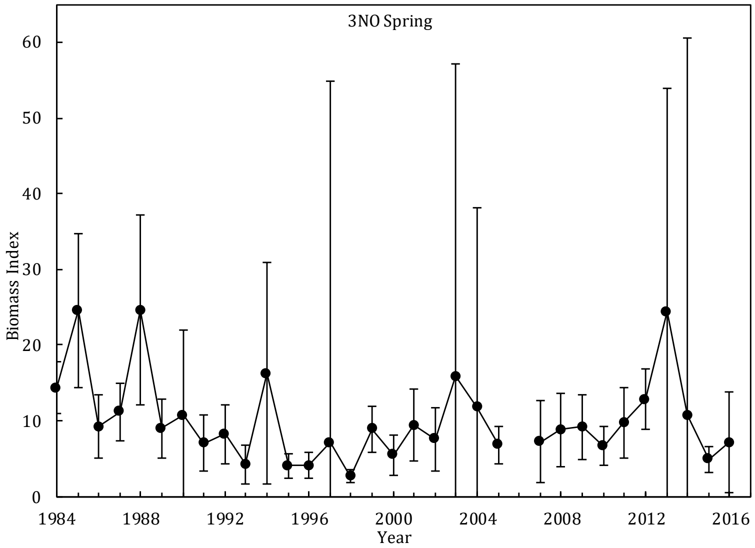


Fig. 13.3. Witch flounder in NAFO Divs. 3NO: survey biomass indices ('000 t) from Canadian spring surveys 1984-2016 (95% confidence limits are given). Values are Campelen units or, prior to 1996, Campelen equivalent units.

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 have declined since to 57% of the time series average in 2016 (Fig. 13.4).

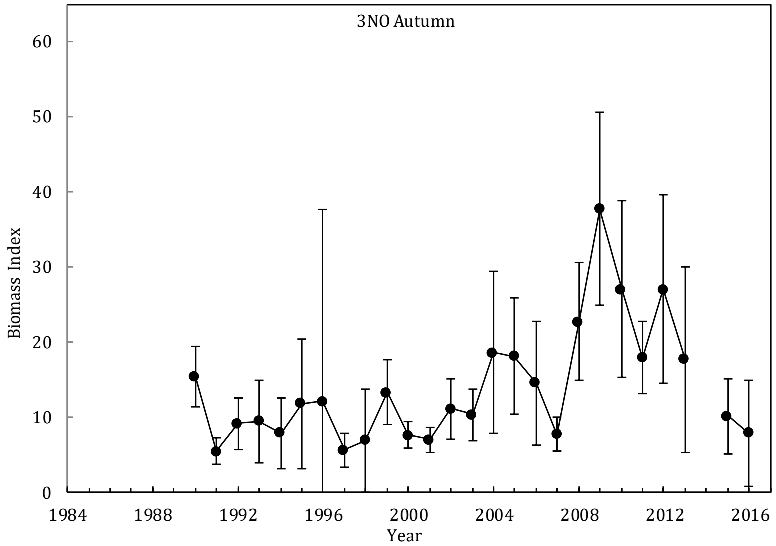


Fig. 13.4. Witch flounder in Divs. 3NO: biomass indices ('000 t) from Canadian autumn surveys 1990-2016 (95% confidence limits are given). Values are Campelen units or, prior to 1996, Campelen equivalent units.

EU-Spain RV spring survey. Surveys have been conducted annually from 1995 to 2016 by EU-Spain in the NAFO Regulatory Area in Divs. 3NO to a maximum depth of 1,450 m (since 1998). In 2001, the research vessel (R/V *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 index has varied without trend over the whole time series. (Fig.13.5).

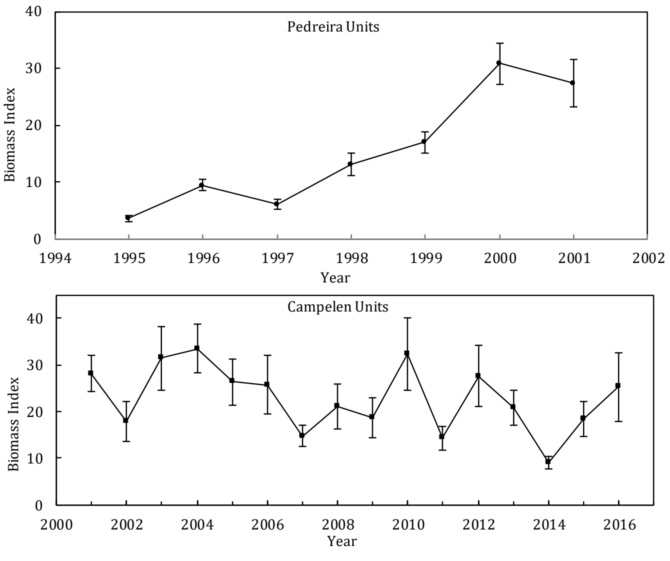
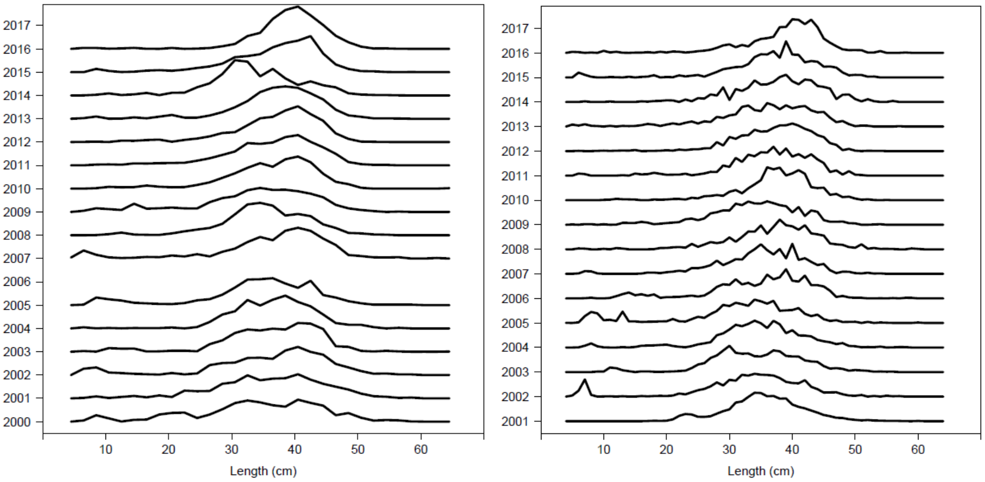


Fig. 13.5. Witch flounder in Divs. 3NO: biomass indices from EU-Spanish Div. 3NO spring surveys (± 1 standard deviation). Data from 1995-2001 is in Pedreira units; data from 2001-2016 are Campelen units. Both values are presented for 2001.

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. However, since 2007 there has been an increase in the number of larger fish in the 40-45 cm range except for an anomalous 30-35 cm range encountered in 2014 (Fig. 13.6). Abundance at length in the Spanish spring rv surveys was fairly consistent at 33-35 cm from 2001 to 2007 (a smaller range than the Canadian surveys during the same time period). From 2008 to 2016 the size range has generally increased with more fish in the 38-40 cm range. In 2016 the mode was 42 cm which was higher than the rest of the time series (Fig. 13.6).

There were a small number of distinctive peaks in the 5-15 cm range (recruitment year classes) in both surveys that were evident and could be followed through successive years. This included the periods from 2007 to 2009 in the Canadian series and from 2002-2003, and 2005 -2006 in the Spanish series (Fig. 13.6).



Canada 3NO Spring RV Surveys

Spain 3NO Spring RV Surveys

Figure 13.6. Length frequencies (abundance at length) of witch flounder from spring Canadian (2000-2016) and Spanish (2001-2016) rv surveys in NAFO Divs.3NO. No Canadian survey data was available in spring 2006.

Distribution. Analysis of distribution data from the surveys show that this stock is mainly distributed in Div. 3O along the southwestern slopes of the Grand Bank. In most years the distribution is concentrated toward the slopes but in certain years, an increased percentage may be distributed in shallower water. A 2014 analysis of Canadian biomass proportions by depth aggregated across survey years (spring 1984-2014 and fall 1990-2014) indicated that in Div. 3N both spring and fall biomass proportions were fairly evenly distributed over a depth range of 57-914 m while those in 3O were more restricted to a shallower depth range of 57-183m. Distributions of juvenile fish (less than 21 cm) were slightly more prevalent in shallower water during autumn surveys. It is possible however, that the juvenile distribution may be more related to the overall pattern of witch flounder being more widespread in shallower waters during the post-spawning autumn period. 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 surplus production model in a Bayesian framework was used for the assessment of this stock. The input data were catch from 1960-2016, Canadian spring survey series from 1984-1990, Canadian spring survey series from 1991-2016 (no 2006) and the Canadian autumn survey series from 1990-2016 (no 2014).

The priors used in the model were:

Initial population size	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 ~ dunif(0,10) isigma2= sigma^{-2}	uniform(0 to 10)
Observation error	tau~dgamma(1,1) itau2 = 1/tau	gamma(shape, rate)

d) Assessment Results

Recruitment: Recruitment (defined as fish less than 21cm) in both the spring and fall Canadian surveys although somewhat variable has generally been low since 2003. Recruitment in spring and fall surveys in 2016 approached the lowest of the time series (Figure 13.7).

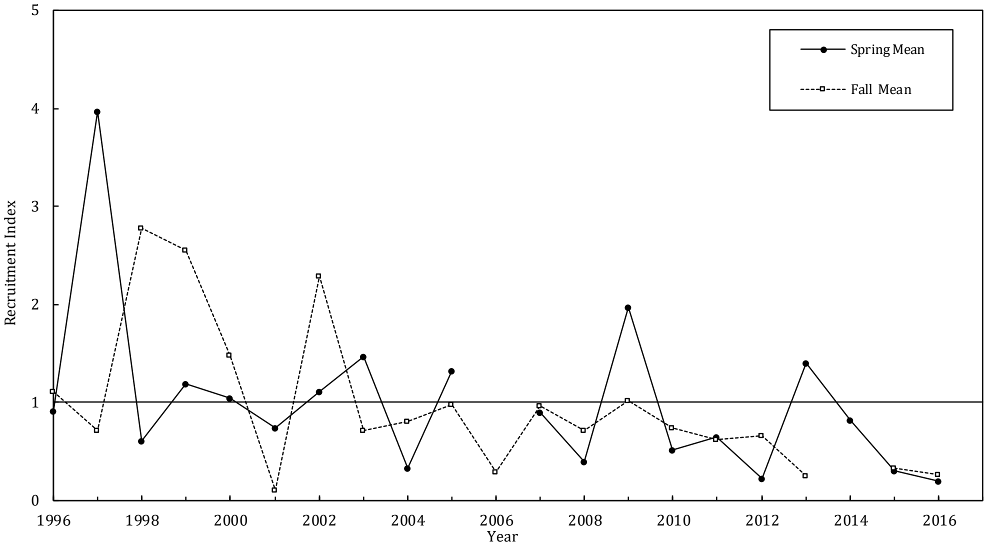


Fig.13.7. Recruitment index of witch flounder (<21cm) from spring and fall Canadian rv surveys in NAFO Divs.3NO 1995-2016. No survey data available in fall 2014 or spring 2006.

Stock Production Model: The surplus production model results indicate that stock size decreased from the late 1960s to the late 1990s and then increased from 1999 to 2010 but has since decreased. The model suggests that a maximum sustainable yield (*MSY*) of 3 641 (2 263-5 689) tonnes can be produced by total stock biomass of 50 010 (35 559-69 581) tonnes (B_{msy}) at a fishing mortality rate (F_{msy}) of 0.07 (0.04-0.13).

The model used is best at forecasting trends in stock development and less precise in predicting year-to-year changes. Although the stock is estimated to be above B_{lim}, recent declining trends in survey indices and low recruitment will be monitored in future years. Uncertainty around parameter estimates has increased compared to the 2015 assessment.

Biomass: The analysis showed that relative population size (median B/B_{msy}) was near $B_{lim}=30\%B_{MSY}$ from 1993-1998. Biomass has since increased to a level of 52% B_{MSY} in 2016 (Fig. 13.8). The probability of being below B_{lim} in 2016 is 0.15.

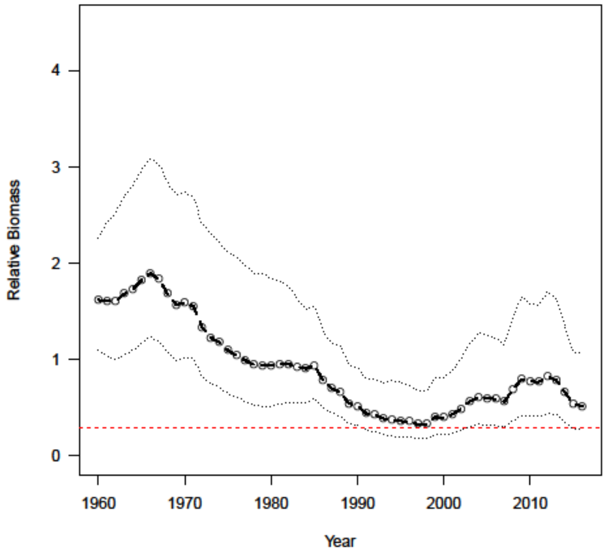


Fig. 13.8. Witch flounder in Divs. 3NO. Median relative biomass ($Biomass/B_{MSY}$) with 80% credible intervals. The horizontal dashed line is $B_{lim}=30\%B_{MSY}$.

Fishing Mortality: Relative fishing mortality rate (median F/F_{msy}) was mostly above 1.0 from the late 1960s to the mid-1990s (Fig. 13.9). F has been below F_{msy} since the moratorium implemented in 1995. Median F was estimated to be 59% of F_{msy} with a probability of 0.19 of being above F_{msy} in 2016.

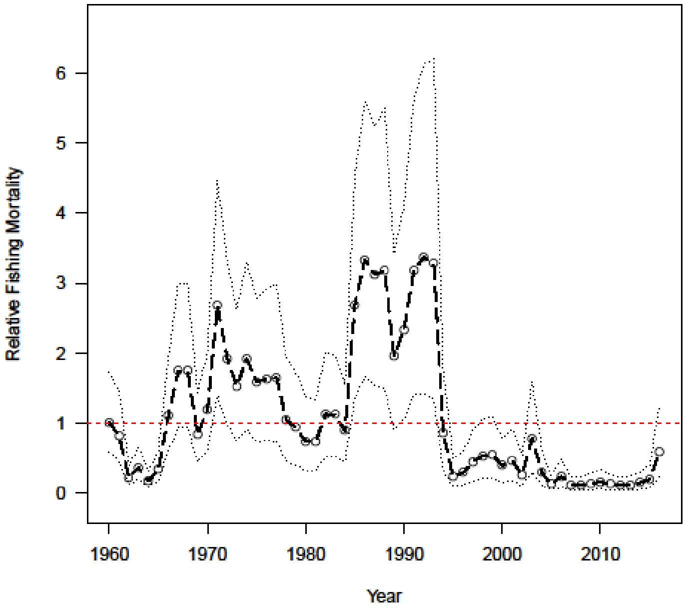


Fig. 13.9. Witch flounder in Divs. 3NO. Median relative fishing mortality (F/F_{MSY}) with 80% credible intervals. The dashed horizontal line is $F_{lim}=F_{MSY}$.

e) State of the Stock

The stock size increased since 1999 to about 2010 and then declined after 2012 and is now at 52% $B_{msy.}$ There is 15% risk of the stock being below B_{lim} and a 19% risk of F being above F_{lim}. Recruitment since 2013 has been decreasing with spring and fall values in 2016 approaching the lowest of the time series.

f) Medium Term Considerations

The posterior distributions (13500 samples) for r, K, sigma, and biomass and the production model equation were used to project the population to 2020. All projections assumed that the catch in 2017 was equal to the TAC of 2 225 t (which produces F_{2017}). This was followed by constant fishing mortality for 2018 and 2019 at several levels of F (F_{2016}, 75% $\underline{F_{2016}}$, 125% F_{2016}, 2/3 F_{MSY}, 75% F_{MSY}, and 85% F_{MSY}). The projections were made using a method agreed in STACFIS 2017

The probability that $F > F_{lim}$ in 2017 is 57% at a catch of 2 225 t (Table 13.2, 13.3). The probability of $F>F_{lim}$ ranged from 15 to 42% for the catch scenarios tested. The population is projected to grow under all scenarios (Fig. 13.10) and the probability that the biomass in 2020 is greater than the biomass in 2016 is greater than 50% in all scenarios. The population is projected to remain below B_{MSY} for all levels of F examined with a probability of greater than 70%. The probability of projected biomass being below Blim was about 20% in all catch scenarios examined and was 14% by 2020 in the F=0 scenario.

Table 13.2. Medium-term projections for witch flounder. Estimates and 80% confidence interval for yield and relative biomass B_y/B_{msy}, are shown, for projected F values of F_{2016}, 75% F2016, 125% F2016, 2/3 F_{msy}, 75% F_{msy} and 85%F_{msy}.

	Projections with catch in 2017 = 2 225 t	
	Projected Yield (t)	Projected Relative Biomass (B_y /B_{msy})
F=0	Projected Yield (t)	Projected Relative Biomass (B_y /B_{msy})
2018	0	0.57(0.22, 1.34)
2019	0	0.59(0.20, 1.45)
2020		0.69(0.25, 1.65)
75% F_{2016}=0.03	Projected Yield (t)	Projected Relative Biomass (B_y /B_{msy})
2018	844	0.57 (0.22, 1.35)
2019	891	0.61 (0.22, 1.47)
2020		0.65 (0.22, 1.59)
F_{2016}=0.04	Median	Median (80% CI)
2018	1126	0.57 (0.22, 1.35)
2019	1175	0.61 (0.22, 1.47)
2020		0.64 (0.21, 1.57)
2/3 F_{msy}=0.05 (=125%F2016)	Projected Yield (t)	Projected Relative Biomass (B_y /B_{msy})
2018	1316	0.57 (0.22, 1.33)
2019	1384	0.60 (0.21, 1.44)
2020		0.63 (0.20, 1.56)
75% F_{msy}=0.052	Projected Yield (t)	Projected Relative Biomass (B_y /B_{msy})
2018	1468	0.57 (0.22, 1.35)
2019	1555	0.60 (0.21, 1.46)
2020		0.62 (0.20, 1.56)
85% F_{msy}=0.06	Projected Yield (t)	Projected Relative Biomass (B_y /B_{msy})
2018	1662	0.57 (0.22, 1.34)
2019	1745	0.59 (0.20, 1.45)
2020		0.62 (0.19, 1.54)

Table 13.3. Yield (t) and risk of F> F_{lim}, B<B_{lim} and B<B_{MSY} for projected F values of F2016, 75% F2016, 125% F2016 2/3 F_{MSY}, 75% F_{MSY}, and 85% F_{MSY}.

	Yield 2018	Yield 2019	p>F_{lim}		p<B_{lim}			p<B_{MSY}			p2020> 2016
			2018	2019	2018	2019	2020	2018	2019	2020	
F=0					18%	16%	14%	79%	77%	70%	72%
75%F2016 =0.03	844	891	15%	16%	19%	18%	20%	80%	75%	72%	66%
F2016=0.04	1116	1175	24%	25%	19%	18%	17%	79%	76%	73%	65%
2/3 Fmsy=0.05 =125%F2016	1316	1384	31%	32%	19%	18%	19%	79%	76%	73%	63%
75%Fmsy=0.052	1468	1555	36%	37%	18%	19%	19%	79%	76%	73%	62%
85% Fmsy=0.06	1662	1745	42%	43%	19%	19%	20%	80%	77%	74%	60%

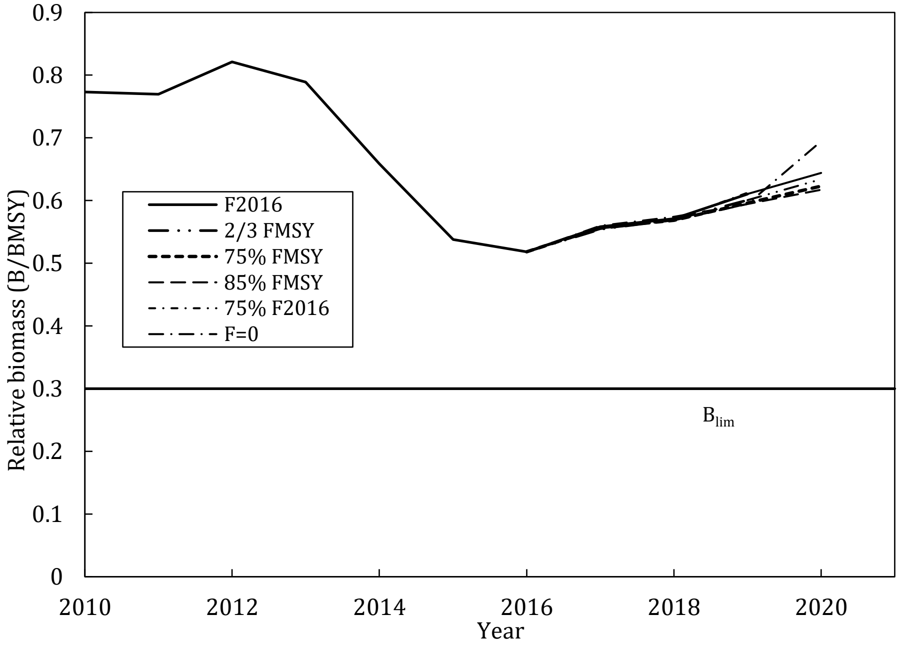


Fig. 13.10. Witch flounder in Divs. 3NO: medium term projections of relative biomass (B/B_{msy}) at six levels of F (F2016, 75% F2016, F=0, 2/3 F_{msy}, 75% and 85% F_{msy}). A catch of 2,225 t is assumed in 2017

g) Reference Points

Reference points are estimated from the surplus production model. Scientific Council considers that 30% B_{msy} is a suitable biomass limit reference point (B_{lim}) and F_{msy} a suitable fishing mortality limit reference point for stocks where a production model is used.

At present, the risk of the stock being below B_{lim} is 0.15 and above F_{lim} is 0.19 (Fig. 13.11).

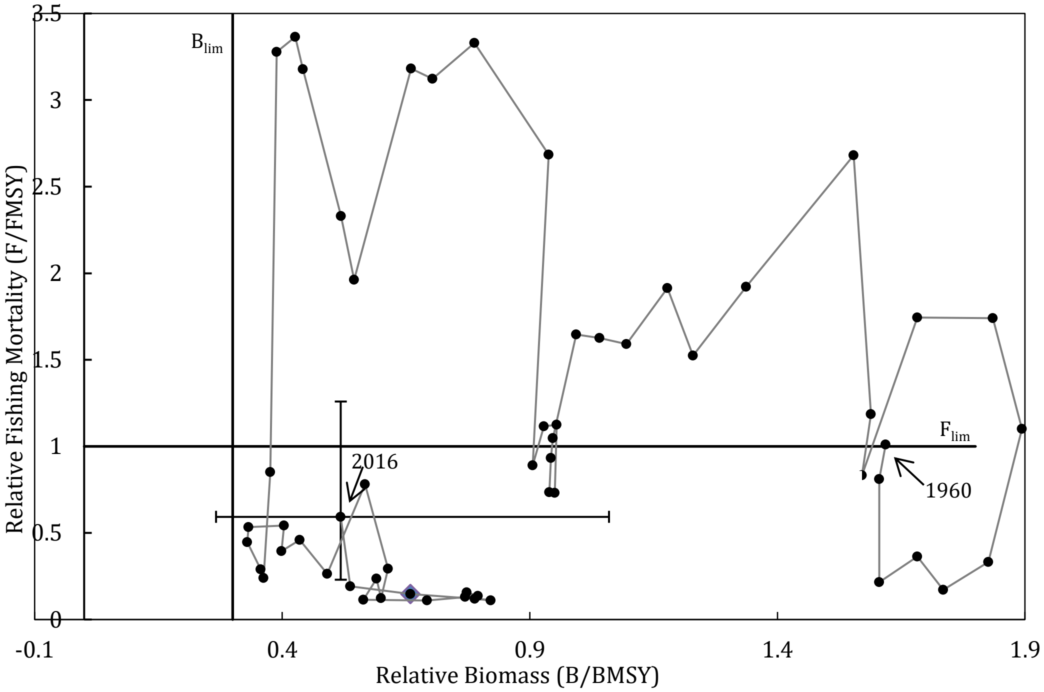


Fig.13.11. Witch flounder in Divs. 3NO: stock trajectory estimated in the surplus production analysis, under a precautionary approach framework (80% credible intervals are indicated for 2016).

Because of the uncertainty of the estimates and proximity to the limit reference points, the next full assessment of this stock is re-scheduled for 2018.

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

Interim Monitoring Report (SCS Doc. 17/009, SCR Doc. 17/044)

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 (Fig. 14.1). The stock has been under a moratorium to directed fishing since 1992. No catches have been reported for this stock from 1993 except 1 t of Spanish catch in 2014 and 5 t Estonian catch in 2016.

	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Recommended TAC	na	na	na	na	na	na	na	na	na	na
Catch[1]	0	0	0	0	0	0	1	0	5	

[1] No catch reported or estimated for this stock
na = no advice possible

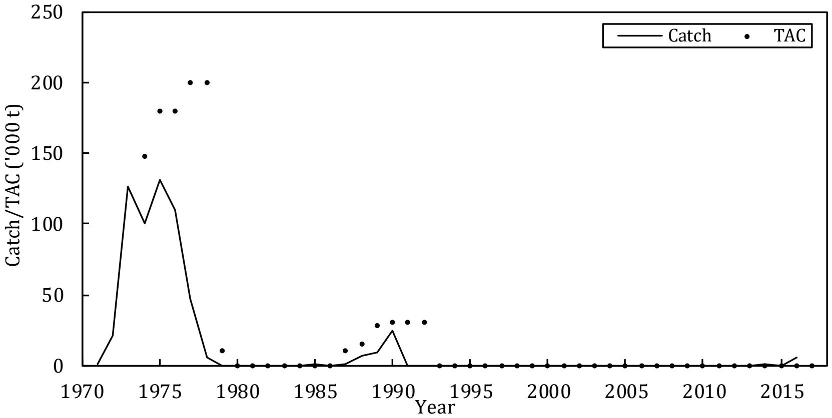


Fig. 14.1. Capelin in Div. 3NO: catches and TACs.

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. The best indicator of stock dynamics currently available is capelin biomass from Canadian spring stratified-random bottom trawl surveys. This index varied greatly from 1995-2016 without any clear trend, however, four of the highest values have been observed in the most recent ten years of the time series. In 2016 biomass indices declined to the historical minimum 3.8 thousand tonnes.

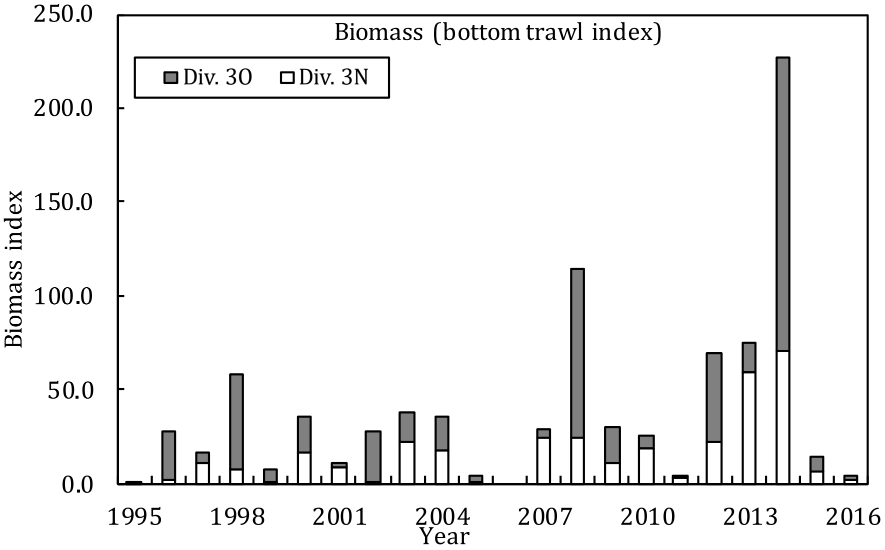


Fig. 14.2. Capelin in Div. 3NO: survey biomass index (bottom trawl) in 1995-2016.

c) Calibration Factors

In 2001, a comparative fishing trial was conducted by EU-Spain between the old research vessel C/V *Playa de Menduíña* and the new research vessel R/V *Vizconde de Eza* in order to calibrate the new ship. In 2003, the vessel that performs the EU survey in 3M changed from the R/V *Cornide de Saavedra* to R/V *Vizconde de Eza*. In 2003 and 2004, a series of 111 valid paired hauls was performed in order to convert the indices for 1988 to 2002 from the former vessel into the new vessel. Two different conversion methods were used in both surveys, one for biomass and another for length. The method used to convert the biomass indices was developed by Robson and calculates a Factor Power Correction by use of the catch per unit of effort (CPUE) observations for the two vessels. To convert the length distributions, a multiplicative model proposed by Warren was used.

Biomass for capelin during the 3NO survey was converted in 2016 (SCR 16/13). Due to the lack of length sampling, the length distribution could not be converted. The results of the catch calibration shows us that the new vessel is almost 14 times more efficient catching capelin that the old vessel.

d) Estimation of Stock Condition

Since interpolation by density of bottom trawl catches to the area of strata for pelagic fish species such as capelin can lead to significant deviation of the total biomass, the average value of all non-zero catches was used as an index for evaluation of the stock biomass in 1990-2016. However, if the proportion of zero and non-zero catches change, the index may not be comparable between years.

Survey catches were standardized to 1 km^2 for Engel and Campelen trawl data. Trawl sets which did not contain capelin were not included in the account. The confidence intervals around the average catch index were obtained by bootstrapping of standardized catch values. According to data from 1996-2016, the mean catch varied between 0.03 and 1.56 t/km^2. In 2016 this value was 0.039 t/km^2 (Fig. 14.3).

Bottom-trawling is not a satisfactory basis for a stock assessment of a pelagic species and survey results are indicative only.

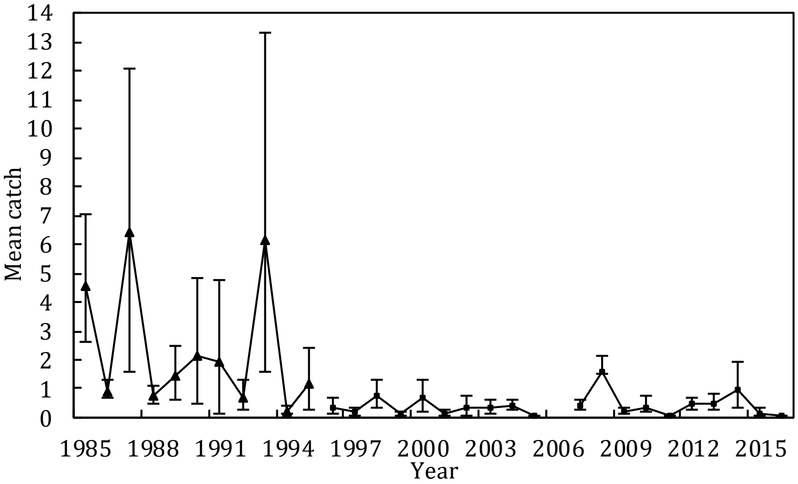


Fig. 14.3. Capelin in Div. 3NO: mean catch (t/km^2) in 1985-2016. Estimates prior to 1996 are from Engel (triangles) and from 1996-2016 are from Campelen (squares).

e) 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.

f) Precautionary Reference Points

STACFIS is not in a position to determine biological reference points for capelin in Div. 3NO.

g) 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 2018.

15. Redfish (Sebastes mentella and Sebastes fasciatus) in Div. 3O

Interim Monitoring Report (SCR Doc. 17/20; SCS Doc. 17/04, 05, 09,11)

a) Introduction

There are two species of redfish that have been commercially fished in Div. 3O; the deep-sea redfish *(Sebastes mentella)* and the Acadian redfish *(Sebastes 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 size 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 tonnes 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 2016.

Nominal catches have ranged between 3 000 tonnes and 35 000 tonnes 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 tonnes, increased rapidly and peaked at 35 000 tonnes in 1988, then declined to 5 100 tonnes by 1997. Catches totaled 20 000 tonnes in 2001, then it declined to 4 000 tonnes in 2008, but have been increasing since 2010. Catch was 9000 tonnes in 2016.

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

	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
TAC	20	20	20	20	20	20	20	20	20	20
STATLANT 21	5.1	6.3	6.5	6.0	6.4	7.5	76	7.9	8.9	
STACFIS	4.0	6.4	5.2	6.0	6.4	7.5	7.6	8.4	9.0	

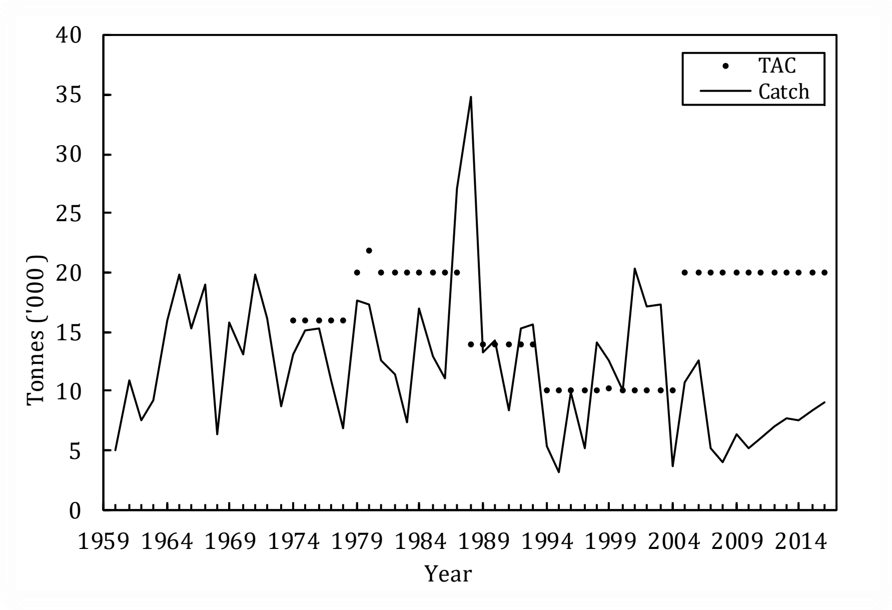


Fig. 15.1. Redfish in Div. 3O: Catches and TACs. TACs prior to 2004 applied only to Canadian waters.

b) Data Overview

Surveys

Canadian spring and autumn surveys were conducted in 3O during 2016. The spring biomass index increased steadily from 2008 to 2012, while the autumn biomass index increased from 2008 to 2010, then it remained stable to 2012. Both indices have decreased considerably since 2012 with the autumn index in 2016 near the time-series low. For the spring and autumn series, the 2016 biomass indices were 35% and 22% respectively, of the average values over 2010-2012. Since 2012, trends in abundance indices were very similar to those in biomass indices.

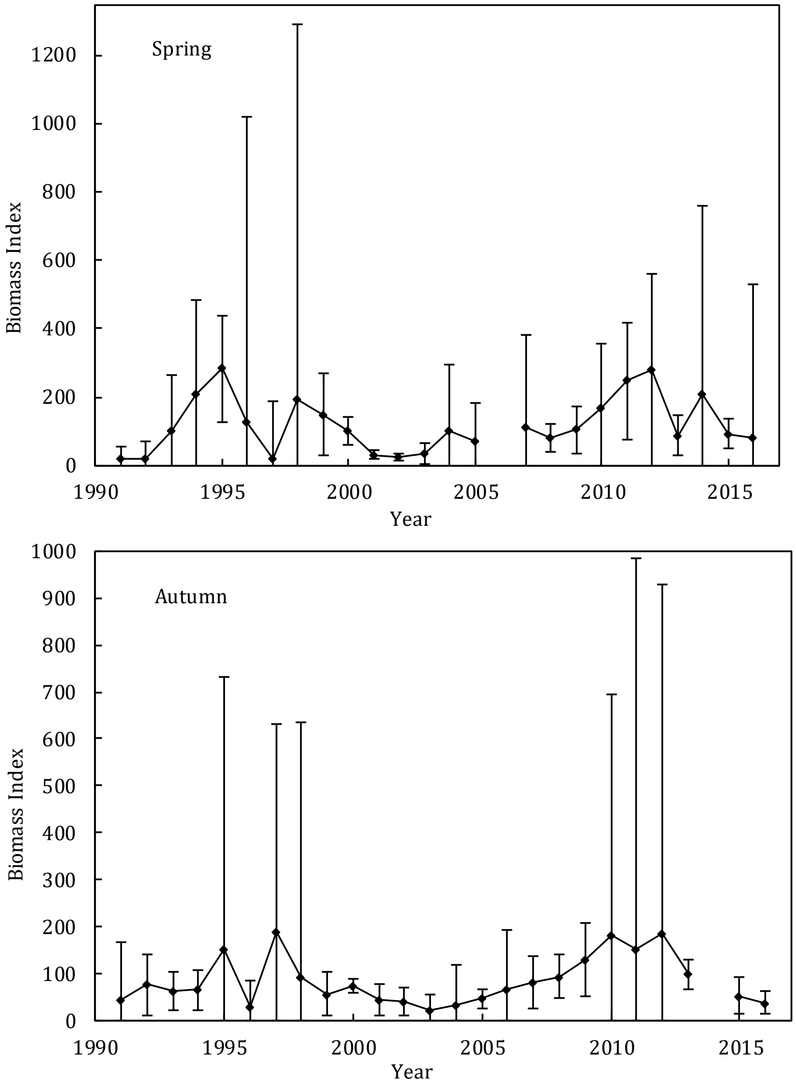


Fig. 15.2. Redfish in Div. 3O: Survey biomass indices from Canadian RV surveys in Div. 3O (Campelen equivalent estimates prior to autumn 1995)

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 from 2014 to 2016 but remained below the 2006 secondary peak.

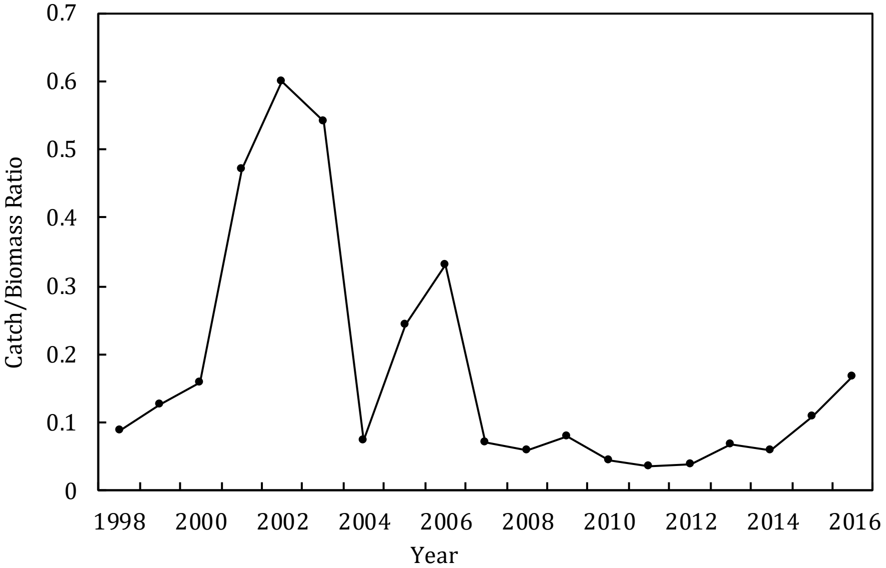


Fig. 15.3. Redfish in Div. 3O: Catch/survey biomass ratios for Div. 3O. Biomass was calculated as the average survey biomass between spring (n) and autumn (n-1) for year (n) in which catch was taken. The 2006 and 2014 values of biomass come from the autumn and spring surveys respectively.

d) Conclusion

Catches have been increasing since 2010 as a dominant recruitment pulse entered the fishery. Spring and fall Canadian survey indices were near the time-series peaks during 2010 to 2012, but values have generally decreased since then, and the 2016 fall value was near the time-series low. 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, then it increased through 2016.** 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 2019.

e) Research Recommendations

In 2016, STACFIS **recommended** that *for Redfish in Div. 3O, work continue on developing a recruitment index with sizes close to those recruiting to the fishery.*

STATUS: No progress has been made.

16. Thorny skate (*Amblyraja radiata*) in Divs 3L, 3N, 3O and Subdiv. 3Ps

Interim Monitoring Report (SCR Doc. 17/16, 19; SCS Doc. 17/04, 05)

a) Introduction

Thorny skate on the Grand Banks was first assessed by Canada for the stock unit 3LNOPs. Subsequent Canadian assessments also provided advice for Divs. 3LNOPs. However, Subdivision 3Ps is presently managed as a separate unit by Canada and France in their respective EEZs, 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.

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. This TAC was lowered to 12 000 t for 2010-2011, and to 8 500 tonnes for 2012. The TAC was further reduced to 7 000 t for 2013-2017. In Subdiv. 3Ps, Canada established a TAC of 1 050 tonnes in 1997, which has not changed.

Catches from the NRA of Divs. 3LNO increased in the mid-1980s with the commencement of a directed fishery for thorny skate. The main participants in this new fishery were EU-Spain, EU-Portugal, USSR, and the Republic of Korea. Catches from all countries in Divs. 3LNOPs over 1985-1991 averaged 17 058 t; with a peak of 28 408 t in 1991 (STATLANT-21). From 1992-1995, catches of thorny skate declined to an average of 7 554 t; however, there are substantial uncertainties concerning reported skate catches prior to 1996. Average STACFIS-agreed catch for Divs. 3LNO in 2009-2014 was 4 933 t. STACFIS catch in 2015 totaled 3404 t for Divs. 3LNO and 247 t for Subdiv. 3Ps. In 2016, STACFIS catch totaled 3470 t for Divs. 3LNO and 650 t for Subdiv. 3Ps.

Recent nominal catches and TACs (000 tonnes) in Divs. 3LNO and Subdiv. 3Ps are as follows:

	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Divs. 3LNO:										
TAC	13.5	13.5	12	12	8.5	7	7	7	7	7
STATLANT-21	7.1	5.7	5.4	5.5	4.3	4.4	4.5	3.3	3.5	
STACFIS	7.4	5.6	3.1	5.4	4.3	4.4	4.5	3.4	3.5	
Subdiv. 3Ps:										
TAC	1.05	1.05	1.05	1.05	1.05	1.05	1.05	1.05	1.05	
STATLANT-21	1.4	0.6	0.3	0.5	0.4	0.3	.2	.2	.7	
Divs. 3LNOPs:										
STATLANT-21	8.5	6.3	5.7	6.1	4.6	4.6	4.7	3.6	4.1	
STACFIS	8.8	6.2	3.4	5.9	4.6	4.6	4.7	3.7	4.1	

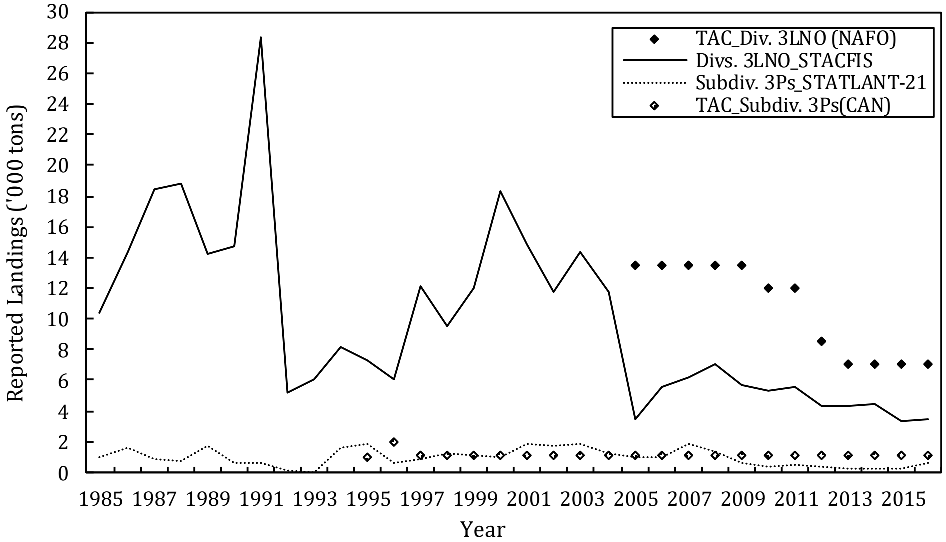


Fig. 16.1. Thorny skate in Divs. 3LNO and Subdiv. 3Ps, 1985-2016: reported landings and TAC

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, 1997-2016), EU-Portugal (2002-2004, 2006-2011, 2013), Russia (1998-2008, 2011-2015), and Canada (1994-2008, 2010, 2012-2016).

From skate-directed trawl fisheries (280 mm mesh) in the NRA of Divs. 3LNO in 2016, EU-Spain reported 25-101 cm TL skates. In trawl fisheries targeting other species (140-156 mm mesh), [Canadian trawlers directing for redfish in Div. 3L caught 22-44 cm skates (mode: 32 cm) in 2015, and 31–93 cm skates (mode: 36 cm) in 2016. In the Div. 3NO yellowtail flounder trawl fishery, Canada recorded 24-101 cm skates (modes: 40, 54, 61, 69, 83 cm) in 2016, and a small sample from the Atlantic cod longline fishery in Subdiv. 3Ps contained 61-72 cm skates. 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 1984-1995, and a Campelen 1800 shrimp trawl in 1996-2016. Subdiv. 3Ps was not surveyed in 2006, nor was the deeper portion (>103 m) of Divs. 3NO in that year, due to mechanical difficulties on Canadian research vessels. The survey in 2015 missed several strata in Div. 3L; however, this was considered inconsequential for assessing thorny skate abundance and biomass.

Indices for Divs. 3LNOPs in 1972-1982 (Yankee trawl) fluctuated without trend (Fig. 16.2a).

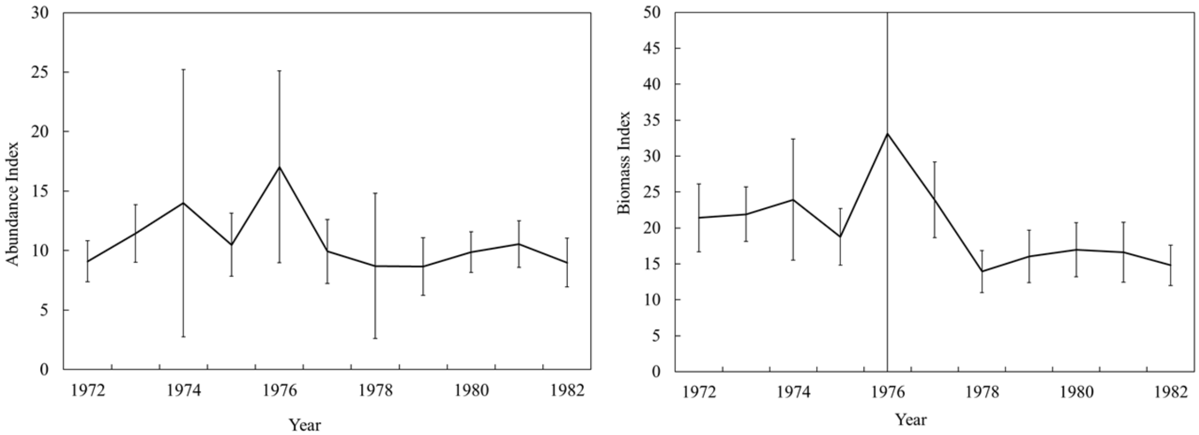


Fig. 16.2a. Thorny skate in Divs. 3LNOPs, 1972-1982: abundance (left panel) and biomass (right panel) indices from Canadian spring surveys.

Standardized mean number and mean weight (kg) per tow for Divs. 3LNOPs in 1984-2016 are presented in Figure 16.2b. Catch rates of thorny skate in Divs. 3LNOPs declined from the mid1980s until the early 1990s. Since 1997, biomass indices have been increasing very slowly from low levels, while abundance indices remain relatively stable at very low levels. Recent biomass estimates are above B_{lim} (Fig. 16.2b).

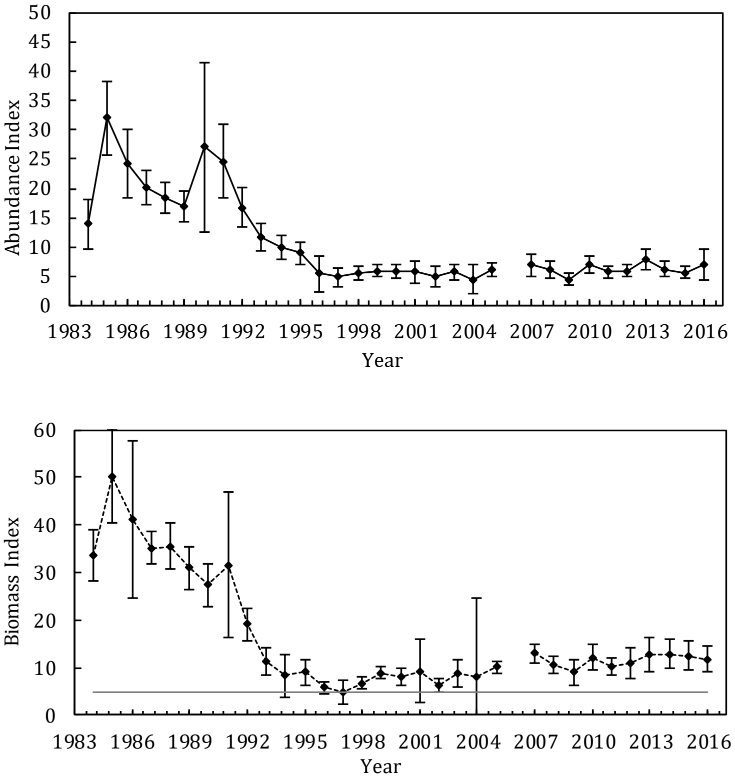


Fig. 16.2b. Thorny skate in Divs. 3LNOPs, 1984-2016: abundance (top panel) and biomass (bottom panel with B_{lim} shown [blue horizontal line]) indices from Canadian spring surveys.

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 1995-2016, 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 (Fig. 16.3). Divs. 3NO were not sampled in 2014 due to mechanical difficulties on Canadian research vessels. Autumn indices of abundance and biomass are, on average, higher than spring estimates. This is expected, because thorny skates are found deeper than the maximum depths surveyed in spring (~750 m), and are more deeply distributed during winter/spring.

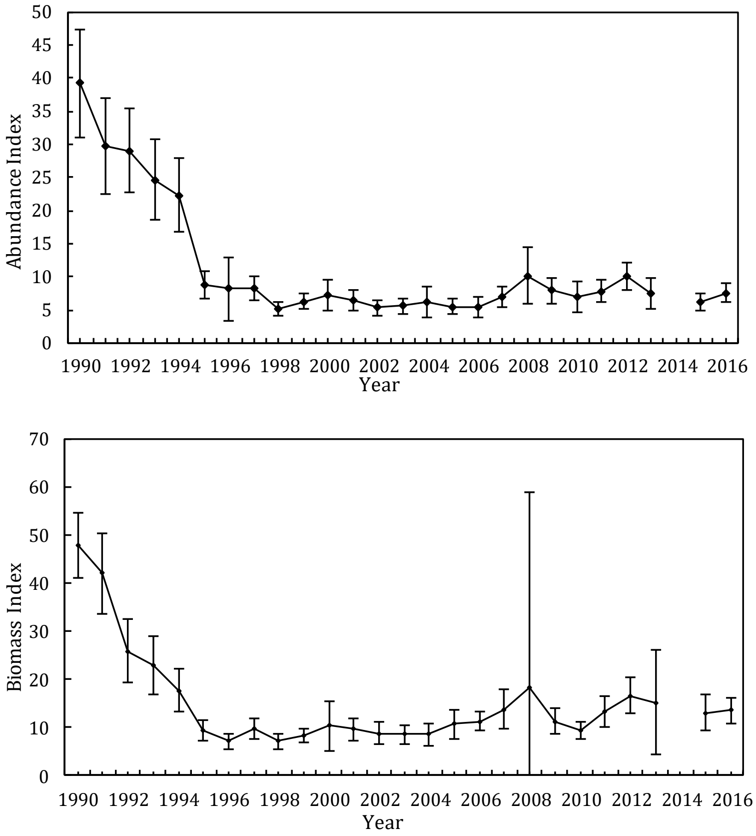


Fig. 16.3. Thorny skate in Divs. 3LNOPs: 1990-2016: abundance (top panel) and biomass (bottom panel) indices from Canadian autumn surveys.

EU-Spain Divs. 3NO Survey. EU-Spain survey indices (Campelen or equivalent) are available for 1997-2016. 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 (Fig. 16.4). Since 2007, the two indices diverged with an overall increase in the Canadian survey and a decline in the EU-Spain index.

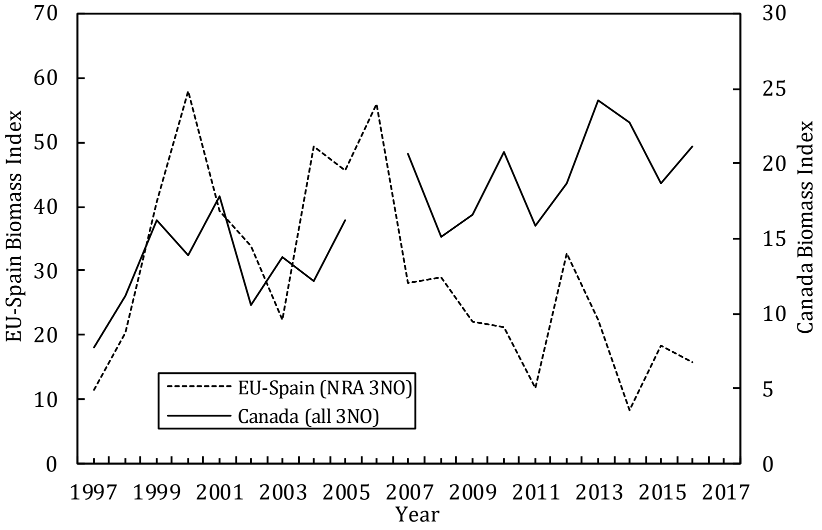


Fig. 16.4. Thorny skate in Divs. 3LNOPs: biomass indices from the EU-Spain survey and the Canadian spring survey in 1997-2016.

EU-Spain Div. 3L survey. EU-Spain survey indices (Campelen trawl) are available for 2003-2016 (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 (Fig. 16.5). Recent Canadian biomass estimates have been relatively stable since 2010, while the EU-Spain index has been increasing relative to 2011.

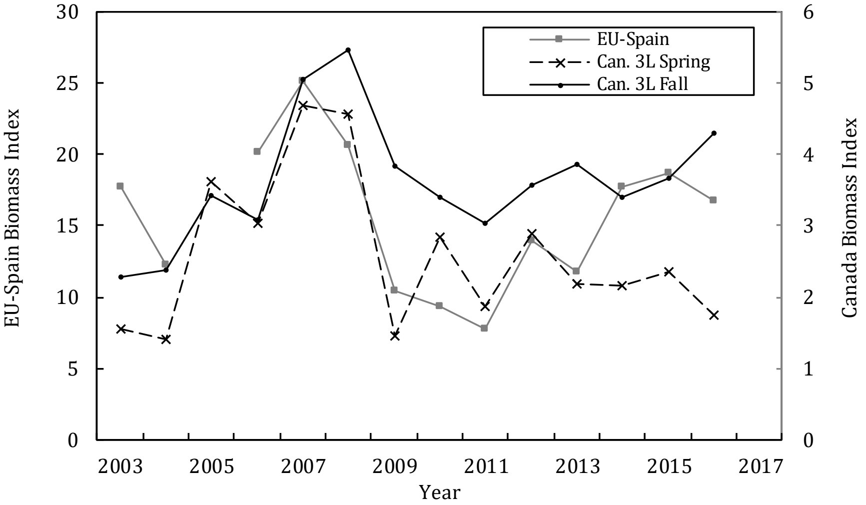


Fig. 16.5. Thorny skate in Div. 3LNOPs: Biomass indices from EU-Spain Div. 3L survey and the Canadian spring and autumn surveys of Div. 3L in 2003-2016.

c) Conclusion

With an update of abundance and biomass indices to 2016, there is nothing to indicate a significant change in the status of this stock.

The next full assessment of this stock is planned for 2018.

17. White Hake (*Urophycis tenuis*) in Divs 3N, 3O, and Subdiv. 3Ps

Full assessment report (SCR Doc. 17/13, 19, 33; SCS Doc. 17/04, 05, 11)

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 in Div. 3NO and Subdiv. 3Ps. This movement of fish of different life stages between areas must be considered when assessing the status of white hake in Div. 3NO. Therefore, an assessment of Div. 3NO white hake is conducted with information on Subdiv. 3Ps included.

Canada commenced a directed fishery for white hake in 1988 in Div. 3NO and Subdiv. 3Ps. All Canadian landings prior to 1988 were as bycatch in various groundfish fisheries. EU-Spain and EU-Portugal 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. There were no directed fisheries by EU-Spain in 2004 or by EU-Spain, EU-Portugal, or Russia in 2005-2014. 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 tonnes, and then reduced to 6 000 t for 2010-2011. The TAC in Div. 3NO for 2012 was 5 000 t, and 1 000 t for 2013-2017.

From 1970-2009, white hake landings in Div. 3NO fluctuated, averaging approximately 2 000 t, exceeding 5 000 t in only three years during that period. Landings peaked in 1987 at approximately 8 100 t (Fig. 17.1). With the restriction of fishing by other countries to areas outside Canada's 200-mile limit in 1992, non-

Canadian landings fell to zero. Landings were low in 1995-2001 (422-t average), then increased to 6 718 t in 2002 and 4 823 t in 2003; following recruitment of the large 1999 year-class. STACFIS-agreed catches decreased to an average of 357 t in 2008-2014. Catch in 2015 was reported as 464 t and 356 t in 2016.

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 (Fig. 17.1). Subsequently, catches increased to an average of 1 174 t in 2004-2007, then decreased to a 342-t average in 2008-2014. Catch in 2015 was reported as 331 t, and 400 t in 2016.

Recent reported landings and TACs (000 tonnes) in NAFO Div. 3NO and Subdiv. 3Ps are as follows:

	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Div. 3NO:										
TAC	8.5	8.5	6	6	5	1	1	1	1	1[1]
STATLANT-21	0.9	0.5	0.3	0.2	0.1	0.2	0.3	.4	.4	
STACFIS	0.9	0.4	0.2	0.2	0.1	0.2	0.3	.5	.4	
Subdiv. 3Ps:										
STATLANT-21	0.7	0.4	0.4	0.2	0.2	0.2	0.4	.3	.4	

[1] May change in-season. See NAFO NAFO FC Doc. 17/01

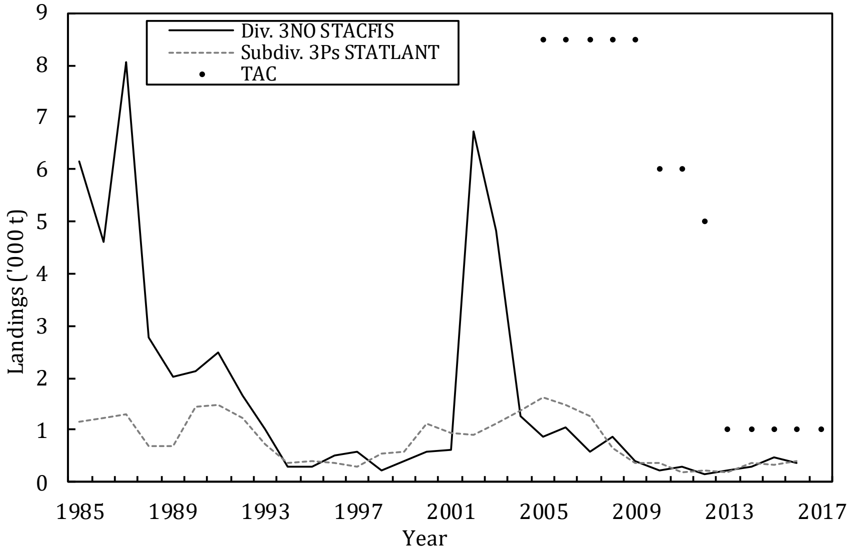


Fig. 17.1. White hake in Div. 3NO and Subdiv. 3Ps: Total catch of white hake in NAFO Division 3NO (STACFIS), and Subdivision 3Ps (STATLANT-21A). The Total Allowable Catch (TAC) in the NRA of Div. 3NO is also indicated on the graph.

b) Input Data

i) Commercial fishery data

Length composition. Length frequencies were available for Canada (1994-2016), EU-Spain (2002, 2004, 2012, 2014-2016), EU-Portugal (2003-2004, 2006-2016), and Russia (2000-2007, 2013-2016). Different length ranges appeared to be highly variable depending on gear types, years and areas. In the Canadian directed fishery in 2016, the length range caught by longlines in Div. 3O was 36-114 cm, although in Subdiv. 3Ps in 2013 the fishery caught a contracted range of 52-102 cm white hake. In 2015-2016, the Canadian witch flounder trawl fishery (152-155 mm mesh) in Div. 3O caught 34-110 cm white hake, while this fishery caught 49-87 cm fish in Subdiv. 3Ps. Sizes reported from bycatch in commercial trawls fishing in the NRA of Div. 3NO by EU-Spain in 2015 were 41-90 cm (280 mm mesh), and 15-81 cm (130 mm mesh) in 2016. EU-Portugal reported 27-69 cm fish in 2015 (130 mm mesh), and 30-65 cm fish in 2016. Russia reported 32-84 cm white hake in 2015, and 38-44 cm fish from a small sample in 2016.

ii) Research survey data

Canadian stratified-random bottom trawl surveys. Data from spring research surveys in NAFO Div. 3N, 3O, and Subdiv. 3Ps were available from 1972 to 2014. 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 2013, 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 1995-2016. 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 2003-2016, 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 2012-2016. Biomass of this stock increased in 2000, generated by the very large 1999 year-class. Subsequently, the biomass index decreased until 2009, and has since increased in 2014 to the average level observed over 1996-2014. Biomass declined slightly in 2015 and 2016.

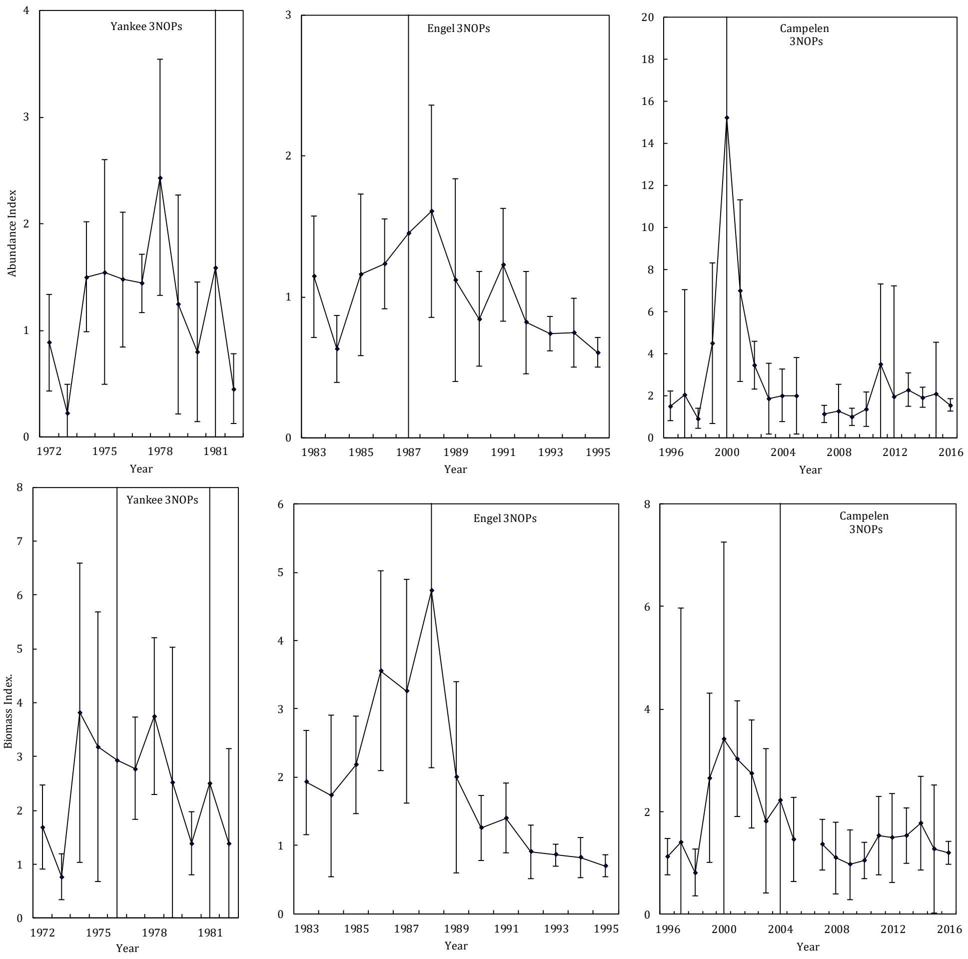


Fig. 17.2a. White hake in Div. 3NO and Subdiv. 3Ps: abundance (top panels) and biomass (bottom panels) indices from Canadian spring research surveys, 1972-2016. Estimates from 2006 are not shown, since survey coverage in that year was incomplete. Yankee, Engel, and Campelen time series are not standardized, and thus are presented on separate panels. Error bars are 95% confidence limits. The bounds of the error bars in 1976, 1981, 1987, 2000, 2012, and 2015 in some panels extend above/below the graph limits.

Canadian autumn surveys of Div. 3NO have the peak in abundance represented by the very large 1999 year-class (Fig. 17.2b). Autumn indices then declined to levels similar to those observed during 1996-1998 until 2010. In 2011-2013, both biomass and abundance appear to have slightly increased then declined over 2015-2016. This survey was not completed in 2014.

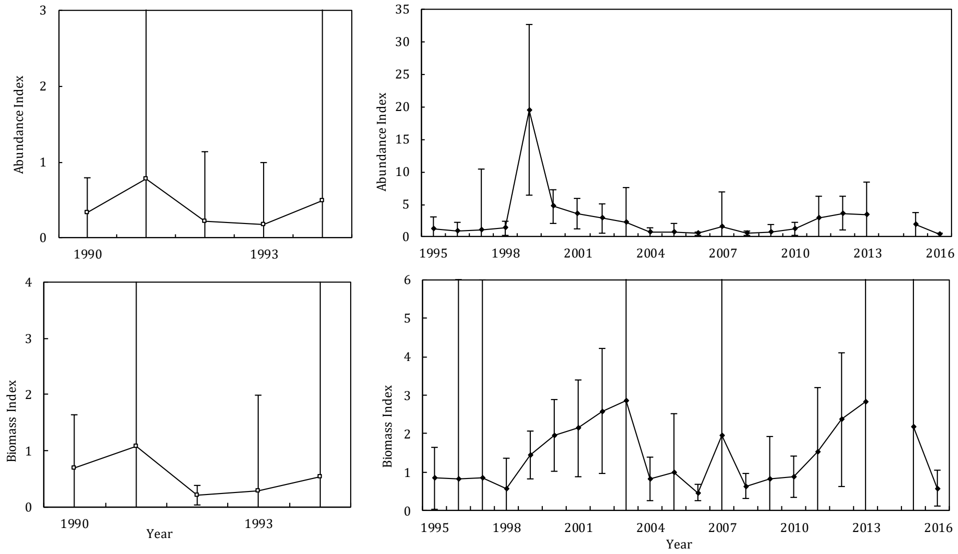


Fig. 17.2b. White hake in Div. 3NO: abundance (top panel) and biomass indices (bottom panel) from Canadian autumn surveys, 1990-2016. Engel (■, 1990-1994) and Campelen (♦, 1995-2016) time series are not standardized. Estimates from 2014 are not shown, since survey coverage in that year was incomplete. Error bars are 95% confidence limits. The bounds of the error bars in 1990-1994, 2002-2009, 2013, and 2016 in some panels extend above/below the graph limits.

EU-Spanish stratified-random bottom trawl surveys in the NRA. EU-Spain biomass indices in the NAFO Regulatory Area (NRA) of Div. 3NO were available for white hake from 2001 to 2016 (Fig. 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. 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 (Fig. 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.

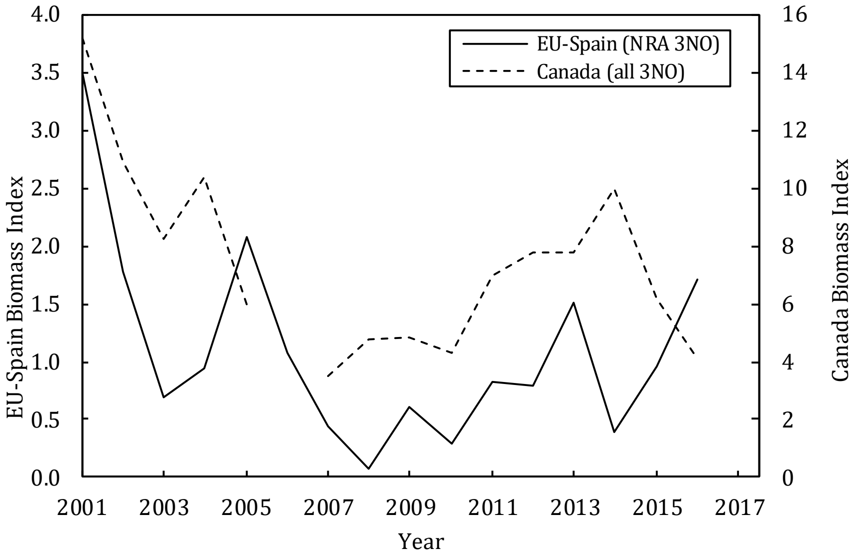


Fig. 17.3. White hake in the NRA of Div. 3NO: Biomass indices from EU-Spain Campelen spring surveys in 2001-2016 compared to Canadian spring survey indices in all of Div. 3NO. Estimates from 2006 Canadian survey are not shown, since survey coverage in that year was incomplete.

iii) Biological studies

Distribution. White hake in Div. 3NO and Subdiv. 3Ps are confined largely to an area associated with the warmest bottom temperatures (4-8°C) along the southwest edge of the Grand Banks, edge of the Laurentian Channel, and southwest coast of Newfoundland.

White hake distribute in different locations during various stages of their life cycle. Fish <26 cm in length (1st year fish) occur almost exclusively on the Grand Bank in shallow water. Juveniles (2+ years) are widely spread, and a high proportion of white hake in the Laurentian Channel area of Subdiv. 3Ps are juveniles. Mature adults concentrate on the southern slope of the Bank in Div. 3NO, and along the Laurentian Channel in Subdiv. 3Ps.

Maturity. Maturity at size was estimated for each sex separately, using Canadian Campelen spring survey data from 1996-2016 (Fig. 17.4). Length at 50% maturity (L_{50}) is different between sexes; with fifty percent of males maturing at 38 cm, and fifty percent of females maturing at 53 cm. However, L_{50} was very similar for each sex between Div. 3NO and Subdiv. 3Ps.

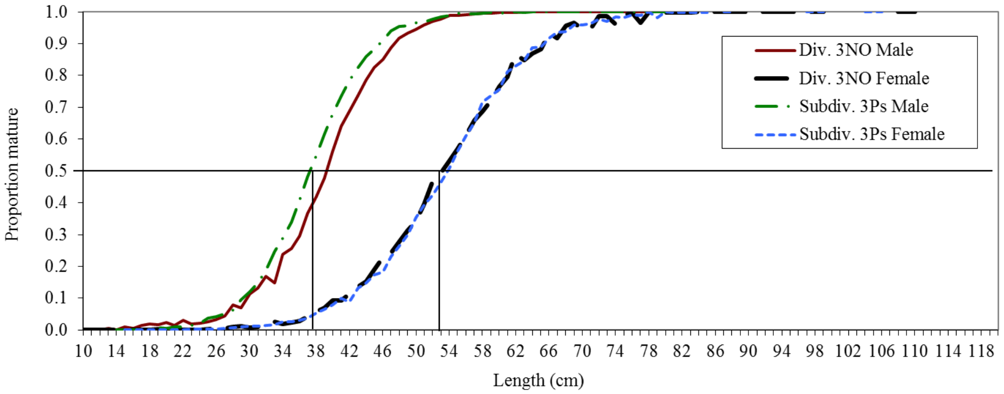


Fig. 17.4. White hake in Div. 3NO and Subdiv. 3Ps: ogives calculated for each sex from Canadian spring surveys, and averaged over 1996-2016 (excluding 2006).

Life stages. Canadian spring survey trends in abundance for 1996-2016 were staged based on length as one-year-olds (≤26 cm; YOY), 2+ juveniles (27-57 cm), and mature adults (58+ cm; Fig. 17.5). Recruitment of one-year-old male and female white hake was highest in 2000, and has since declined to a very low level in 2016. Immature white hake older than two years dominate the population. There are currently no indications of increased abundance of mature white hake.

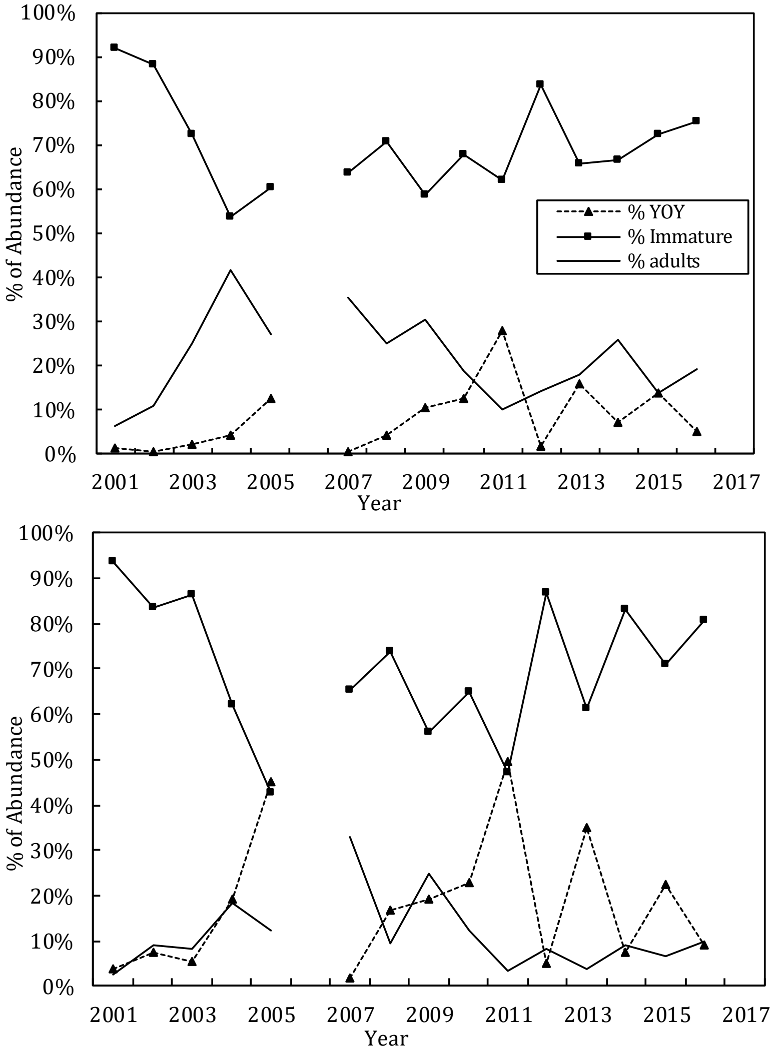


Fig. 17.5. White hake in Div. 3NO and Subdiv. 3Ps: proportion of stages in terms of abundance by sex (female, upper panel; male, lower panel) from Canadian Campelen spring survey data in 1996-2016. Estimates from 2006 are not shown, since survey coverage in that year was incomplete.

iv) Recruitment

In Canadian spring research surveys, the number of white hake less than 27 cm in length is assumed to be an index of recruitment at Age 1. The recruitment index in 2000 was very large, but no large value has been observed during 2001-2016 (Fig. 17.6). The index of recruitment for 2011 was comparable to that seen in 1999, and smaller peaks in 2013 and 2015 were similar to a small peak in 2005.

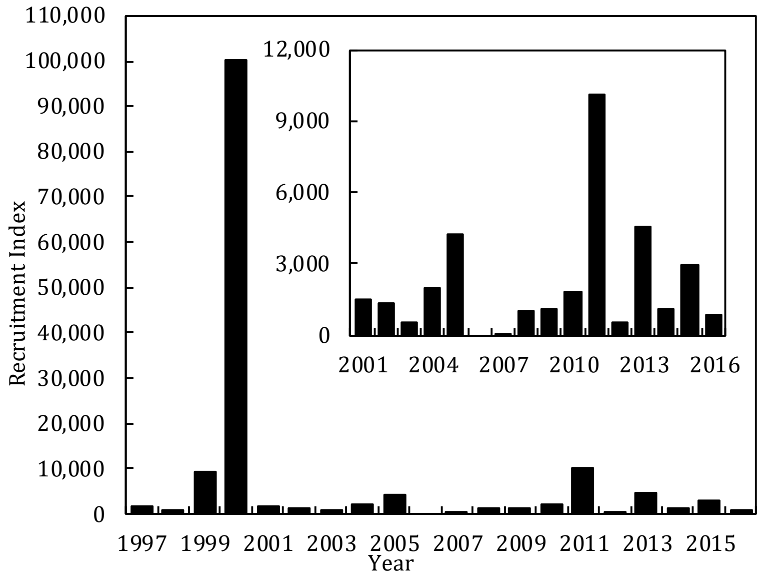


Fig. 17.6. White hake in Div. 3NO and Subdiv. 3Ps: recruitment index for age 1 males and females (combined) from Canadian Campelen spring surveys in Div. 3NO and Subdiv. 3Ps in 1997-2016. Estimates from 2006 are not shown, since survey coverage in that year was incomplete. Inset plot depicts 2001-2016 on a smaller scale.

c) Assessment Results

This stock is assessed based upon a qualitative evaluation of stock survey biomass trends and recruitment indices.

Biomass. Biomass of this stock increased in 1999 and 2000, generated by the large recruitment observed in those years. Subsequently, the biomass index decreased and has since remained variable but lower.

Recruitment. Recruitment in 2000 was very large, but no large year class has been observed since then. Recruitment was higher in 2011, but not comparable to the very high recruitment observed in 2000.

Relative *F* (commercial landings/Canadian spring survey biomass). Using STACFIS-agreed commercial landings and Canadian spring survey biomass index, estimates of relative *F* were calculated for white hake in Div. 3NO and Div. 3NOPs. Relative fishing mortality (Rel. *F*) has fluctuated, but increased considerably in 2002-2003 (Fig. 17.7). Relative *F* estimates have been low since 2010.

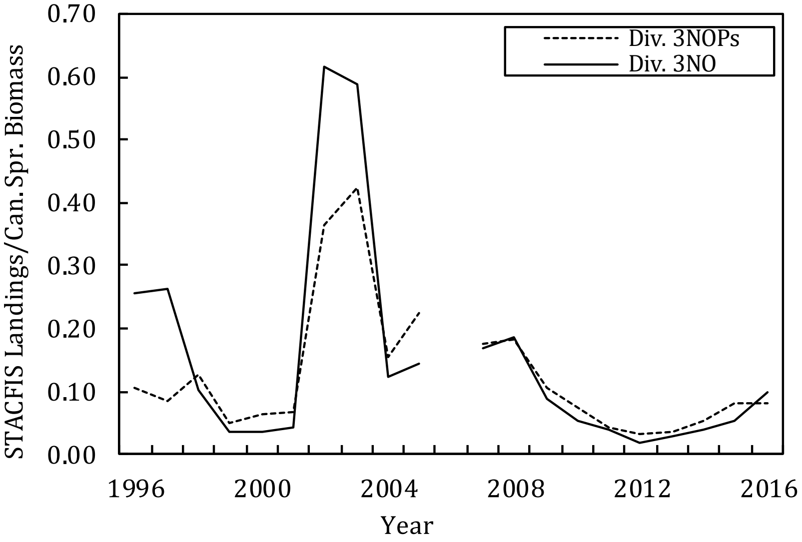


Fig. 17.7. White hake in Div. 3NO and Subdiv. 3Ps: estimates of relative *F* from STACFIS-agreed commercial landings/Canadian Campelen spring survey biomass (1996-2016). Estimates from 2006 are not shown, since survey coverage in that year was incomplete.

State of the stock. The stock biomass is at a low level. No large recruitments have been observed since 2000. Recruitment was higher in 2011, but not comparable to the very high recruitment observed in 2000. Fishing mortality is low.

d) Reference Points

No precautionary reference points have been established for this stock.

e) Research Recommendations

STACFIS **recommended** that *age determination should be conducted on otolith samples collected during annual Canadian surveys (1972-2016+); thereby allowing age-based analyses of this population.*

Otoliths are being collected, but have not been aged. STACFIS reiterates this recommendation.

STACFIS **recommended** that *the collection of information on commercial catches of white hake be continued and now include sampling for age, sex and maturity to determine if this is a recruitment fishery.*

No progress, 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.

The next full assessment of this stock is planned for 2019.

D. WIDELY DISTRIBUTED STOCKS: SA 2, SA 3 AND SA 4

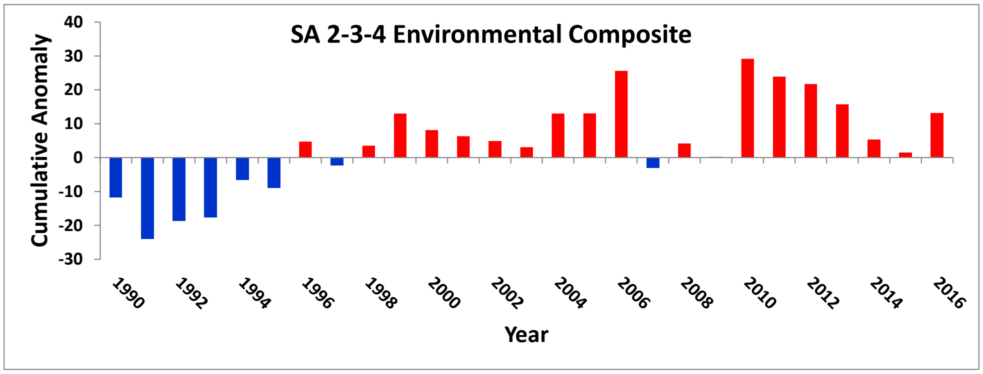
Recent Conditions in Ocean Climate and Lower Trophic Levels

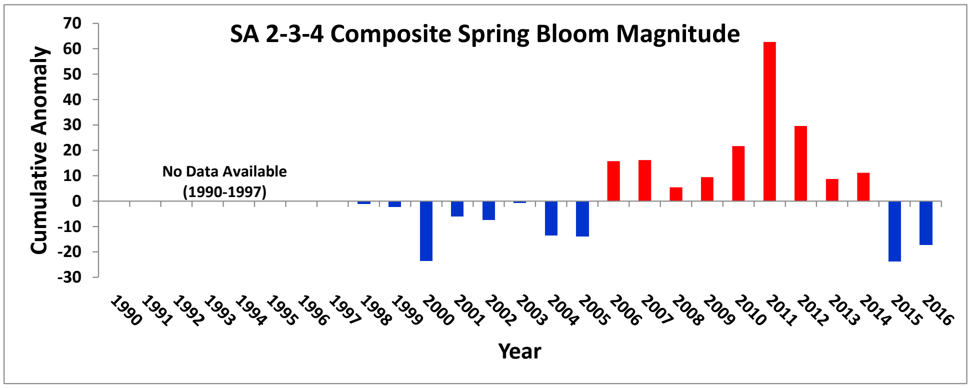
Ocean climate composite index across Labrador to the Scotian Shelf (SA2-4) has remained above normal since 2010, but declined to slightly above normal in 2015 before increasing again in 2016.

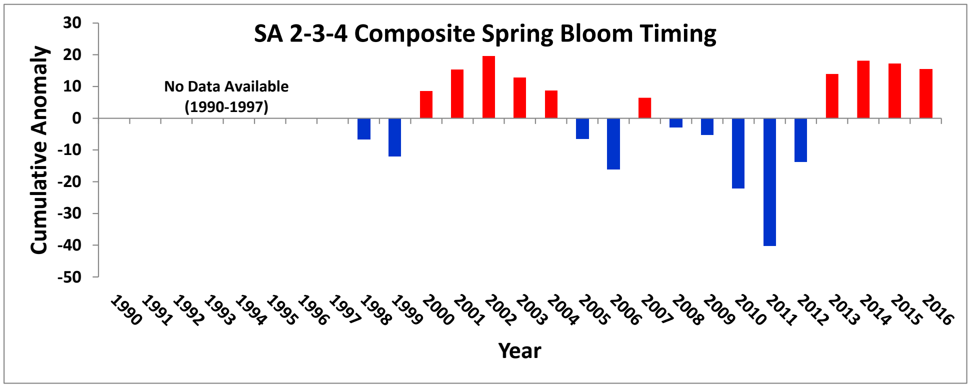
The magnitude of the spring bloom has remained below normal in recent years (2015-2016). The timing of the spring bloom has varied over the time series and currently showing delayed onset but longer duration blooms over the Subareas.

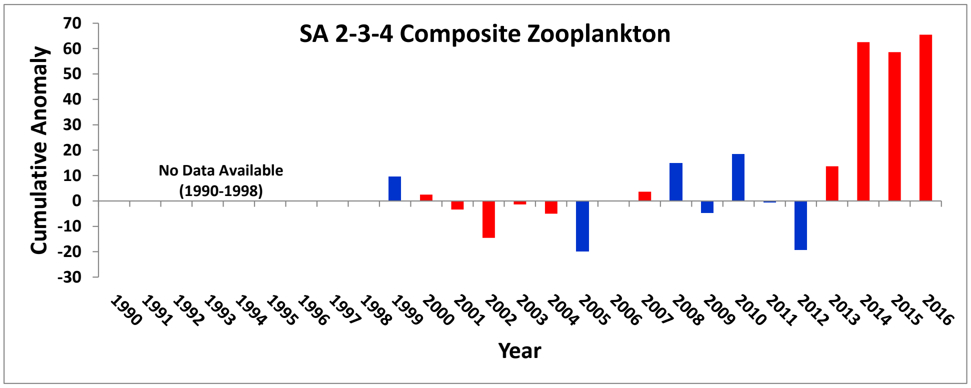
The composite zooplankton index increased abruptly in 2014 and continues to remain high into 2016 reaching a record-high.

The composite trophic index reached its highest level observed in the time series in 2014 and has declined subsequently through 2016.


SA 2-3-4 Environmental Composite
Cumulative Anomaly
40
30
20
10
0
-10
-20
-30
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
Year


SA 2-3-4 Composite Spring Bloom Magnitude
Cumulative Anomaly
No Data Available
(1990-1997)
70
60
50
40
30
20
10
0
-10
-20
-30
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
Year


SA 2-3-4 Composite Spring Bloom Timing
Cumulative Anomaly
No Data Available
(1990-1997)
30
20
10
0
-10
-20
-30
-40
-50
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
Year


SA 2-3-4 Composite Zooplankton
Cumulative Anomaly
No Data Available
(1990-1998)
70
60
50
40
30
20
10
0
-10
-20
-30
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
Year

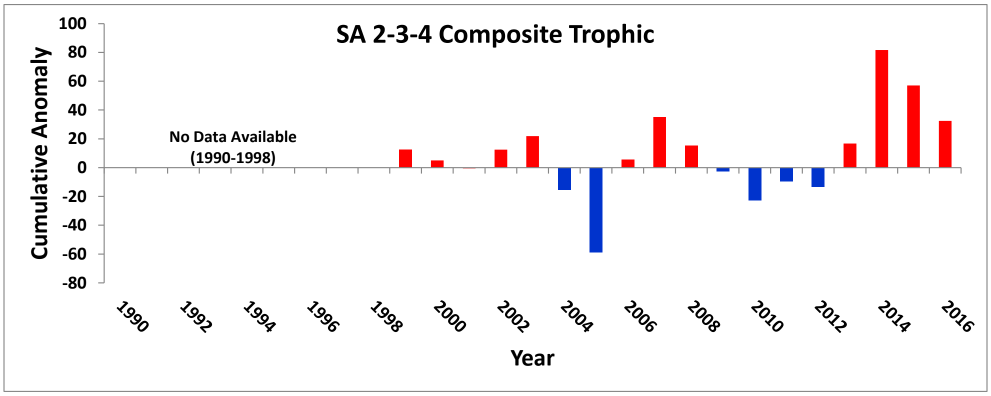


Fig. D.1. Composite ocean climate index for NAFO Subarea 2-3-4 (widely distributed stocks) derived by summing the standardized anomalies (top panel) during 1990-2016, ocean colour composite of magnitude of the spring bloom (2'nd panel) and the peak time of the spring bloom (3'rd panel), composite zooplankton index (4'th panel) and composite trophic index (bottom panel) during 1990-2016. Annual anomalies near 0 indicate the metric is near the climatological mean, positive anomalies indicate above normal levels while negative anomalies indicate below normal conditions.

Environmental Overview

The water mass characteristics of Newfoundland and Labrador Shelf are typical of sub-polar waters with a sub-surface temperature range of -1-2ºC 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 (1-3°C) except for the shallow inshore regions where they are mainly <0°C. In the deeper waters of the Flemish Pass and across the Flemish Cap bottom temperatures generally range from 3-4°C. Throughout most of the year the cold, relatively fresh water overlying the shelf is separated from the warmer higher-density water of the continental slope region by a strong temperature and density front. This winter-formed water mass is generally referred to as the Cold Intermediate Layer (CIL) and is considered a robust index of ocean climate conditions. In general, shelf water masses undergo seasonal modification in their properties due to the seasonal cycles of air-sea heat flux, wind-forced mixing and ice formation and melt, leading to intense vertical and horizontal gradients particularly along the frontal boundaries separating the shelf and slope water masses. Temperature and salinity conditions in the Scotian Shelf, Bay of Fundy and Gulf of Maine regions are determined by many processes: heat transfer between the ocean and atmosphere, inflow from the Gulf of St. Lawrence supplemented by flow from the Newfoundland Shelf, exchange with offshore slope waters, local mixing, freshwater runoff, direct precipitation and melting of sea-ice. The Nova Scotia Current is the dominant inflow, originating in the Gulf of St. Lawrence and entering the region through Cabot Strait. The Current, whose path is strongly affected by topography, has a general southwestward drift over the Scotian Shelf and continues into the Gulf of Maine where it contributes to the counter-clockwise mean circulation. The properties of shelf waters are modified by mixing with offshore waters from the continental slope. These offshore waters are generally of two types, Warm Slope Water, with temperatures in the range of 8-13°C and salinities from 34.7-35.6, and Labrador Slope Water, with temperatures from 3.5°C to 8°C and salinities from 34.3 to 35. Shelf water properties have large seasonal cycles, east-west and inshore-offshore gradients, and vary with depth.

Ocean Climate and Ecosystem Indicators

Ocean climate composite index from Labrador to the Scotian Shelf (SA 2-4) has remained above normal since 2010 following the extensive cold period in the early 1990s. In recent years, it has declined to slightly above normal in 2015 before increasing again in 2016 to above normal conditions (Figure D.1). The composite spring bloom index has declined in 2015-2016 compared to positive anomalies observed back to 2006 (Figure D.1). The timing index appears to show multi-year cycles between delayed onset of the spring bloom (2013-2016) compared to early onset (2008-2011). The composite zooplankton index has remained near record-high levels since 2014. This is related to remarkable positive anomalies for non-copepod taxa (e.g. gelatinuous zooplankton) observed throughout the northwest Atlantic (Figure D.1). The composite trophic index also increased in recent years related to a variety of contributions from the lower trophic levels Figure D.1).

The spatially averaged fall bottom temperature off southern Labrador in 2J was 2.8°C (1 SD above normal) and in 3K it was 2.4°C (0.5 SD above normal). The spatially averaged spring and fall bottom temperature in NAFO Divs. 3LNO was about normal at 1.5° and 1.8°C, respectively. The averaged spring bottom temperature in NAFO Div. 3P was about 3.4°C, almost 1°C (2 SD) above normal, the highest since 1984. A composite climate index for the NL region derived from 28 meteorological, ice and ocean temperature and salinity time series from the NL region was slightly above normal in 2016 an increase from the 7th lowest in 67 years and the lowest since 1993 in 2015. In 2016, the annual bottom temperatures anomalies on the Scotian Shelf in NAFO Divisions 4Vn, 4Vs, 4W, 4X were +0.9°C (+2.1 SD), +1.5°C (+2.1 SD), +1.7°C (+2.3 SD) and +1.9°C (+2.6 SD) above normal, respectively. A composite index for the Scotian Shelf region based on 18 selected, normalized temperature time series averaged +2.1 standard deviations (SD) above normal, making 2016 the second warmest year in the last 47 years.

18. Roughhead Grenadier (*Macrourus berglax*) in SA 2 and 3

Interim Monitoring Report (SCS Doc. 17/04, 17/05 and 17/11, and SCR 98/57, 17/16, 17/19 and 17/24)

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 tonnes. From 2013-2016 catches were lower and in the last two years were around 300 tonne (Fig. 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.

Recent catches ('000 tonnes) are as follow:

	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
STATLANT 21A	0.5	0.4	0.7	0.8	1.0	1.3	0.4	0.6	0.2	0.1
STACFIS	0.7	0.8	0.6	0.9	1.0	1.3	0.4	0.6	0.2	0.3

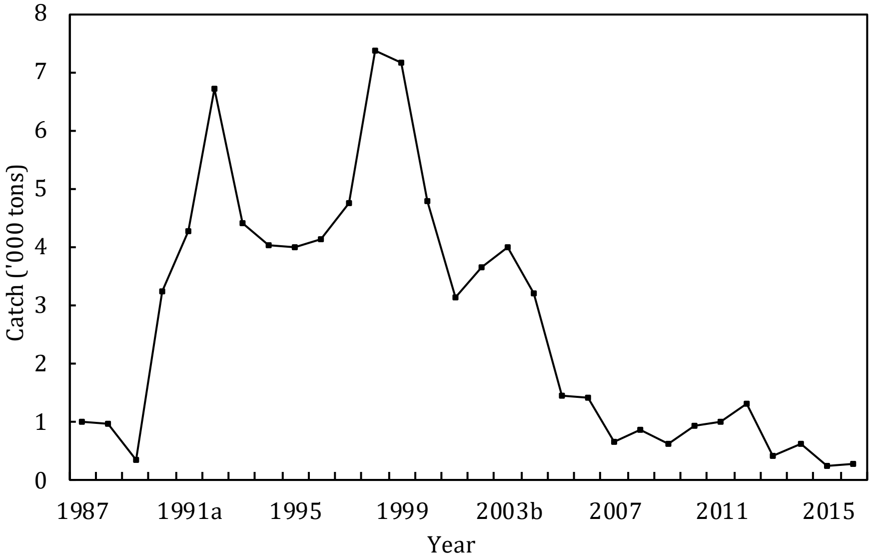


Fig. 18.1. Roughhead grenadier in Subareas 2+3: STACFIS catches.

b) Data Overview

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 predominant at depths ranging from 800 to 1500 m, therefore the best survey indicators of stock biomass should be the series extending to 1500 meters depth as they cover the depth distribution of roughhead grenadier fairly well. Figure 18.2 presents the biomass indices for the following series: Canadian fall 2J+3K Engel (1978-1994, Series 1) and Canadian fall 2J+3K Campelen (1995-2014, Series 2), EU 3NO (1997-2014), EU 3L (2006-2014) and EU Flemish Cap (to1400 m; 2004-2014). Survey biomass indices showed a general increasing trend in the period 1995-2004. From 2005-2012 all available indices showed a clear downward trend except the Canadian Fall (2J+3K) index. In the most recent period (2013-2016), the information from the different indices was noisy and contradictory; some indices showed an increase while others continued to decline.

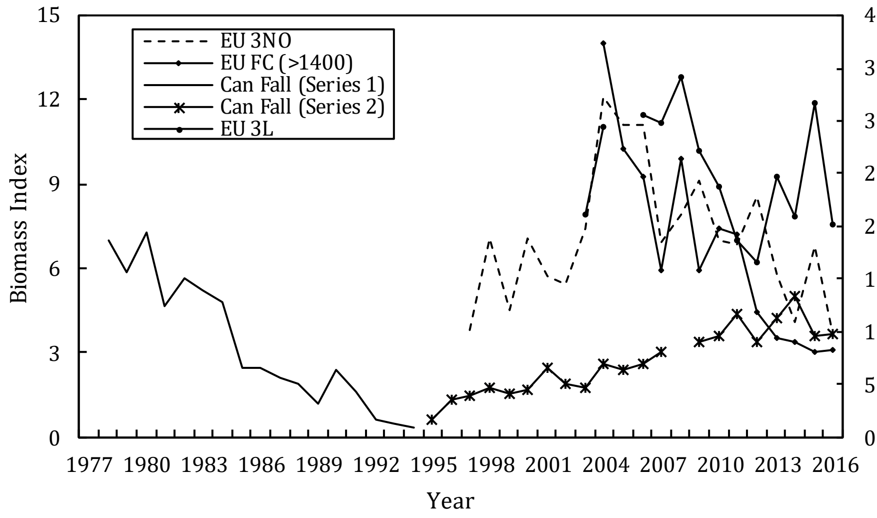


Fig. 18.2. Roughhead grenadier in Subareas 2+3: Survey biomass indices.

The catch-biomass (C/B) ratios showed a clear declining trend from 1995-2005 and since then have been stable at low levels (Figure 18.2).The (C/B) ratio remained low since 2008 despite the decline of many of the survey biomass indices because catch levels in the last years are very low.

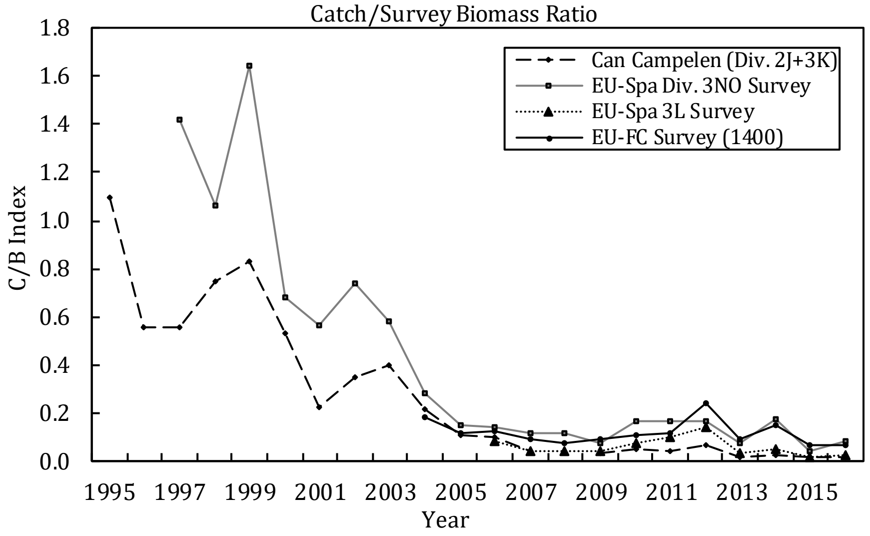


Fig. 18.3. Roughhead grenadier in Subareas 2+3: catch/biomass indices based upon Canadian Autumn (Campelen series), EU-Spanish Div. 3NO, EU-Spanish 3L and EU-Flemish Cap (to1400 m depth) surveys.

c) Conclusion

Based on overall indices for the current year, there is no significant change in the status of the stock: the information from different indices continues to be contradictory and noisy. Fishing mortality indices have remained at low levels since 2005.

The next full assessment of this stock is planned to be in 2019.

19. Witch Flounder (*Glyptocephalus cynoglossus*) in Divs. 2J+3KL

Interim Monitoring Report (SCR 16/15; SCS Docs. 17/04, 17/05)

a) Introduction

A moratorium on directed fishing on this stock was implemented in 1995 following drastic declines in catch from the mid-70s, and catches since then have been low levels of by-catch in other fisheries. From 1999 to 2004 catches were estimated to be very low, between 300 and 800 tonnes and from 2005-2016, catches averaged less than 200 tonnes.

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

	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Recommended 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	0.1	
STACFIS	0.1	0.1	0.2	0.2	0.2	0.2	0.2	0.2	0.1	

ndf= no directed fishing.

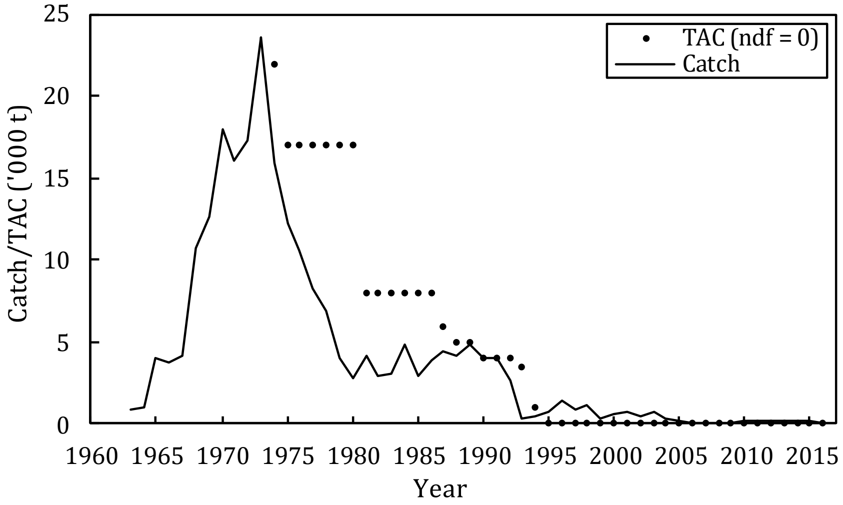


Fig. 19.1. Witch flounder in **Divs. 2J+3KL**: catches and TAC.

b) Data Overview

i) Surveys

Canadian surveys were conducted in Divs. 2J+3KL during autumn from 1977-2016 (Fig 19.2). Generally, the survey biomass estimates showed an increasing trend from 2003 to 2016, although estimates are imprecise. Survey coverage in Div. 3L began in 1984, but was incomplete in 2004 and 2005, and in 2008 there were substantial survey coverage deficiencies in Divs. 2J, 3K and 3L (SCR Doc. 09/012). Results in these years may, therefore, not be comparable to other years.

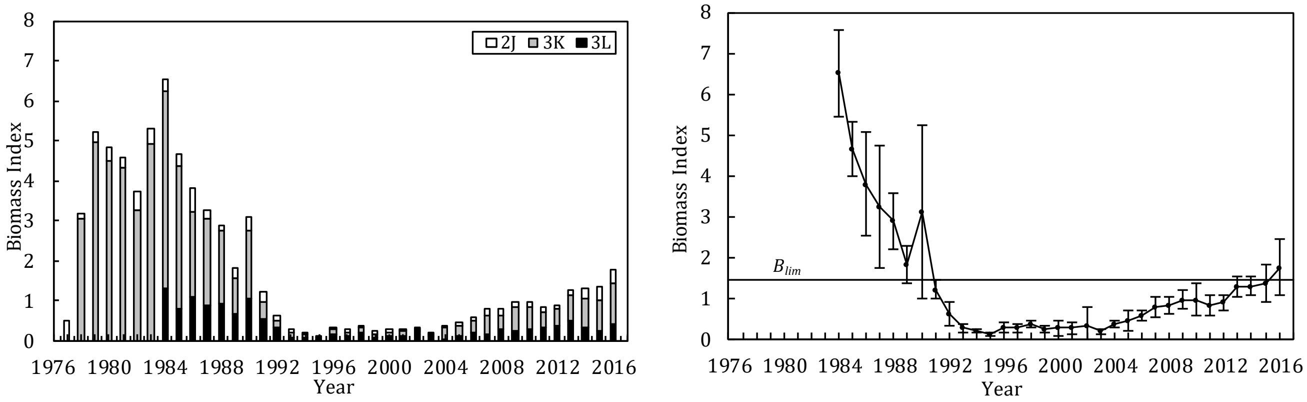


Fig. 19.2. Witch flounder in **Divs. 2J + 3KL**: Index of biomass from Canadian autumn surveys by Division (left panel) and overall with 95% confidence limits (right panel). Values are Campelen units or, prior to 1995, Campelen equivalent units.

c) Conclusion

There was a gradual increase in the survey biomass index from 2003 to 2016, and the 2016 estimate surpassed B_{lim} for the first time since 1990 (although there remains a 13% probability of the stock being below B_{lim}). Based on survey indices for the current year, there is nothing to indicate a change in the status of the stock.

The next full assessment of this stock is scheduled for 2019.

20. Greenland Halibut (*Reinhardtius hippoglossoides*) in SA 2 + Divs. 3KLMNO

Full Assessment Report (SCR Doc. 17/10, 13, 18, 24, 25, 26, 27, 45, 46, 48, 12/19; SCS Doc. 17/04, 05, 09, 11,13; FC Doc. 03/13, 10/12, 13/23, 16/20)

a) Introduction

Fishery and Catches: TACs prior to 1995 were set autonomously by Canada; subsequent TACs have been established by NAFO Fisheries Commission (FC). Catches increased sharply in 1990 due to a developing fishery in the NAFO Regulatory Area in 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 harvest control rule (FC Doc. 10/12) to generate annual TACs over at least 2011-2014. In 2013 Fisheries Commission extended this management approach to set the TACs for 2015 – 2017 (FC Doc. 13/23), but did not apply the HCR in 2017, rather setting the TAC equal to the 2016 TAC (FC Doc. 16/20. Catch exceeded the TAC in every year from 2004 to 2014 but was similar to the TAC in 2015 and 2016. See the general review of catches and fishing activity for an explanation of catch estimation from 2011-2016.

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

	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
TAC	16	16	16	17.2[1]	16.3[1]	15.5[1]	15.4[1]	15.6[1]	14.8[1]	14.8[2]
STATLANT 21	15.0	14.7	15.7	15.7	15.2	15.6	15.6	14.9	14.8	
STACFIS	21.2	23.2	26.2	24.9	23.0	20.0	21.4	15.3	14.9	

[1] – TAC generated from HCR

[2] – TAC equal to 2016

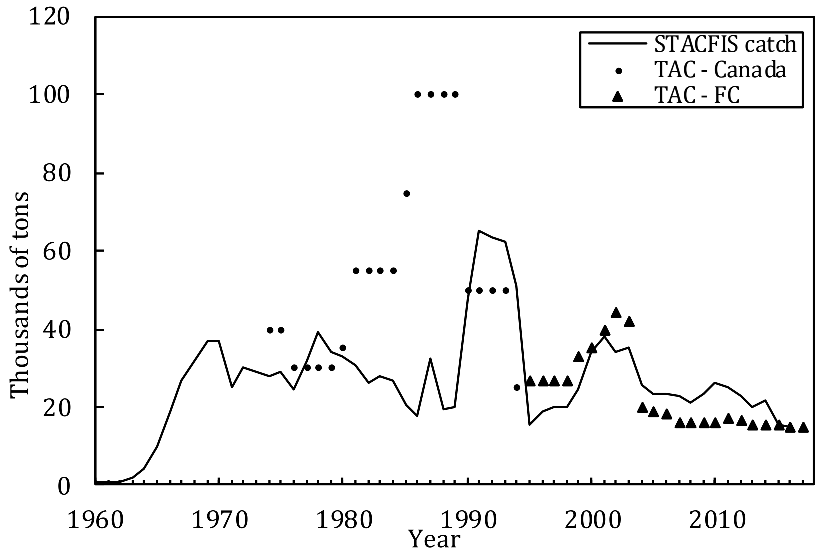


Fig. 20.1. Greenland halibut in Subarea 2 + Div. 3KLMNO: TACs and STACFIS catches.

Input Data

Standardized estimates of CPUE were available from fisheries conducted by EU- Spain, EU-Portugal and Canada. Abundance and biomass indices were available from research vessel surveys by Canada in Div. 2+3KLMNO (1978-2016), EU in Div. 3M (1988-2016), EU-Spain in Div. 3NO (1995-2016) and EU-Spain in Div. 3L (2003-2016). Different years are examined to represent population trends from the different surveys. For the Canadian fall survey in Divs. 2J3K the years are 1978-2016 (excluding 2008); from the Canadian spring survey in Divs. 3LNO 1996-2016 (excluding 2006 and 2015); for the survey in Div. 3M to 700 m 1988-2016, and to 1400 m 2004-2016; for the survey by EU-Spain in Div. 3L 2006-2016; and for the survey by EU-Spain in Divs. 3NO 1997-2016. A survey series was developed from the shallow portion of the Canadian fall survey to 730m from 1996-2016 (excluding 2014 when the survey was incomplete). Commercial catch-at-age data were available from 1975-2016.

i) Commercial fishery data

Catch and effort.

Analyses of otter trawl catch rates from Canadian vessels operating inside of the Canadian 200 mile limit indicated a general decline from the mid-1980s to the mid-1990s. The 2010 – 2012 estimates of standardized CPUE for Canadian otter-trawlers decreased substantially. It increased since 2012 to the 2007-2008 highest levels.

Analyses of catch-rates of Portuguese otter trawlers fishing in the NRA of Div. 3LMNO over 1988-2016 show that the CPUE has been variable but at a high level since 2006, reaching a time series high in 2016.

Analyses of data from the Spanish fishery show that the CPUE has been variable at a high level since 2006, reaching a time series high in 2016.

In general, for the Russian fishery, the catch rate per fishing vessel day in the area ranged from 2.0 t to 25.6 t and averaged 15.2 t per fishing vessel day and 0.95 t per hour of hauling. These catch rates are similar to those in 2015.

A comparison of the available standardized CPUE estimates from the Canadian, Spanish and Portuguese fleets indicates consistency in the timing and relative magnitude of change over the 2004-2007 period.(Fig 20.2). CPUE for all three countries is mainly higher from 2007-2016 than in the period of the 1990s to the mid 2000s.

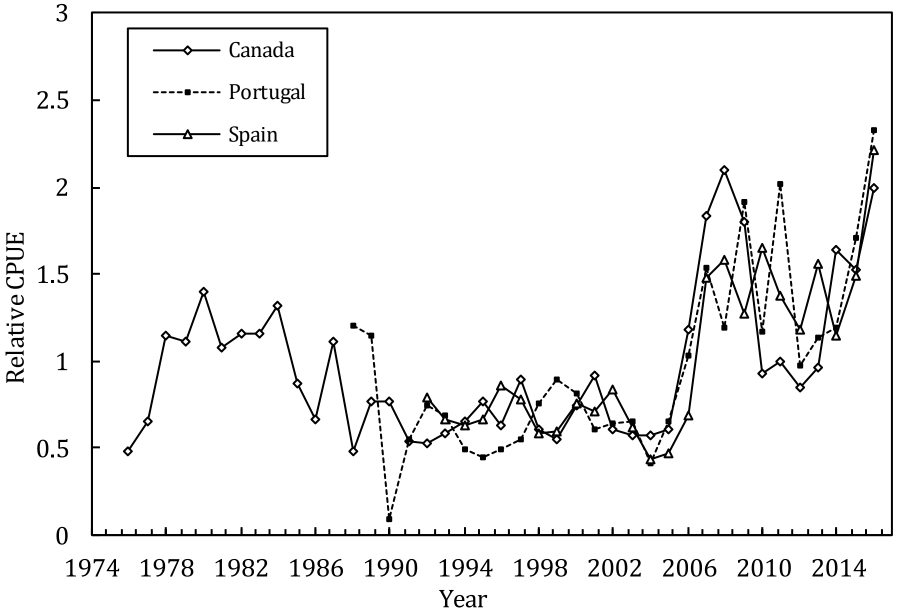


Fig. 20.2 Greenland halibut in Subarea 2 + Div. 3KLMNO: standardized CPUE from Canadian, Portuguese and Spanish trawlers. (Each standardized CPUE series is scaled to its 1992-2016 average)

Commercial catch per unit effort for Greenland halibut in Subarea 2 and Div. 3KLMNO is a measure of fishery performance. STACFIS previously recognized that trends in CPUE should not be used as indices of the trends in the stock. It is possible that by concentration of effort and/or concentration of Greenland halibut, commercial catch rates may remain stable or even increase as the stock declines.

Catch-at-age and mean weights-at-age. Length samples of the 2016 fishery were provided by EU-Spain, EU-Portugal, EU-Estonia, and Russia. Annual age length keys were available for the Spanish, Russian and Canadian fisheries. Catch-at-age values were calculated over 2011-2016 using the Canadian age length keys. In 2011-2014, ages 6-9 dominated the catch numbers, with 2015 dominated by ages 7-8. In 2016 the catch was predominately 8 year olds. Mean weight-at-age in the commercial catch was also calculated using annual Canadian age length keys. In 2011-2016 weight-at-age was similar to the time series mean for most ages, but above average for ages 8 and 9.

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 of different years (SCR Doc. 12/19). A single survey series which covers the entire stock area is not available. A subset of standardized (depth and area) stratified random survey indices have been used to monitor trends in resource status, and are described below.

Canadian stratified-random autumn surveys in Div. 2J and 3K. The Canadian autumn Div. 2J3K survey index provides the longest time-series of abundance and biomass indices (Fig. 20.3) for this resource. Biomass declined from relatively high estimates of the early 1980s to reach an all-time low in 1992. The index increased substantially due to the abundant 1993-1995 year-classes, but this increase was not sustained, with declines over 1999-2002. The index has increased substantially from 2010-2014 to levels near those of the early part of the time series. However, the index declined substantially in 2015 and again in 2016. 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 2016 indices are considerably lower.

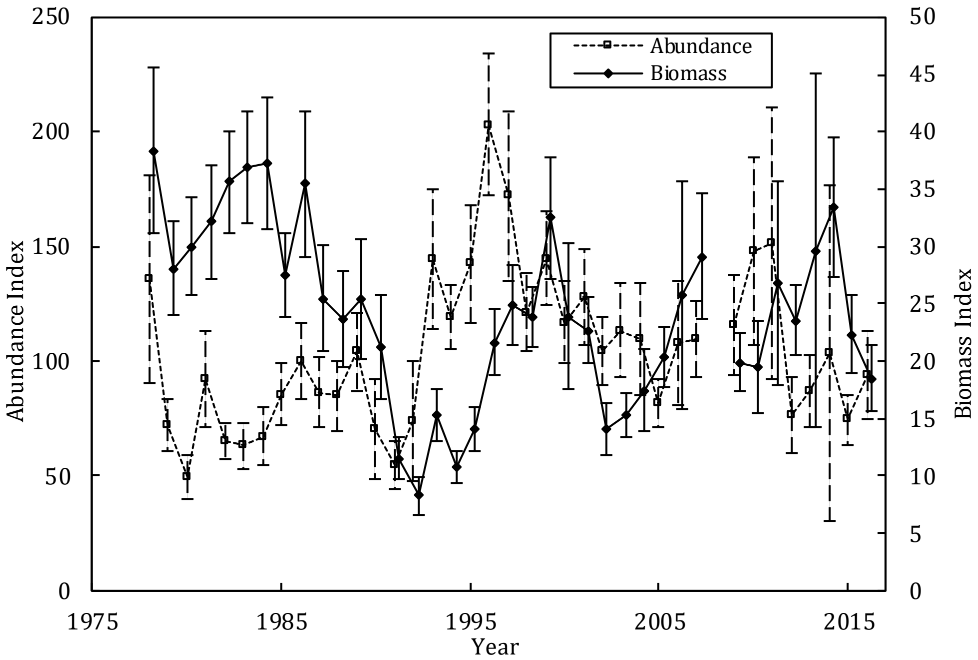


Fig. 20.3. Greenland halibut in Subarea 2 + Div. 3KLMNO: biomass and abundance indices (with 95% CI) from Canadian autumn surveys in Div. 2J and 3K. The 2008 survey was not completed.

Canadian stratified-random spring surveys in Div. 3LNO. Abundance and biomass indices from the Canadian spring surveys in Div. 3LNO (Fig. 20.4) 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 survey was incomplete and is not considered representative of the population.

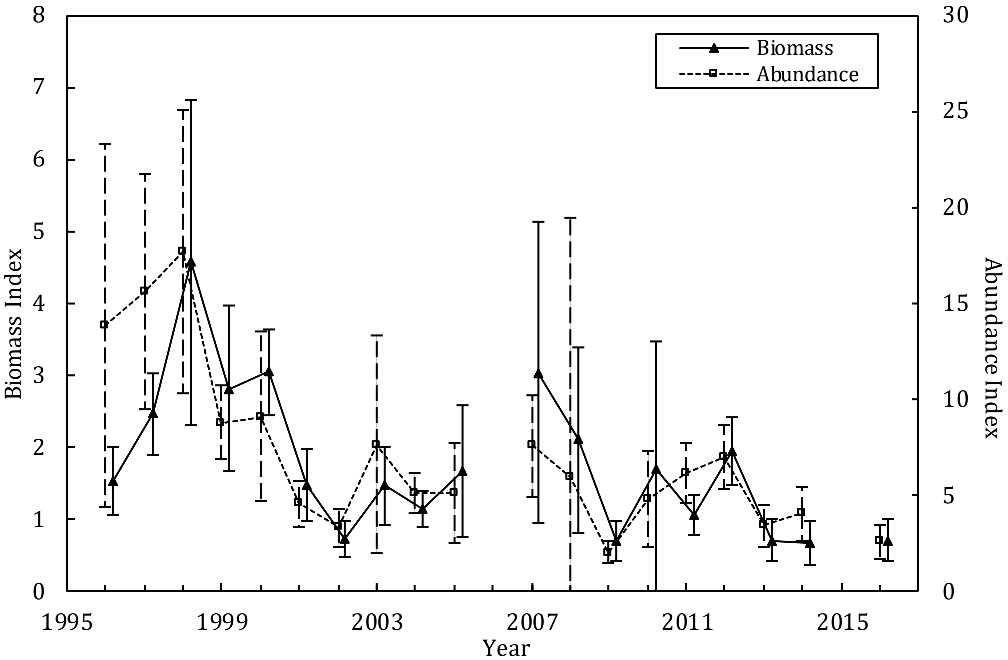


Fig. 20.4. Greenland halibut in Subarea 2 + Div. 3KLMNO: biomass and abundance indices (with 95% CI) from Canadian spring surveys in Div. 3LNO.

Canadian stratified-random autumn surveys in Div. 3LNO. Time series of abundance and biomass were developed from the Canadian autumn surveys from 1995-2016 to a depth of 730 m. The abundance index from the Canadian autumn surveys in Div. 3LNO (Fig. 20.X) 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. In 2015 and 2016, both abundance and biomass were lower than all other years in the time series. The 2014 survey was incomplete and is not considered compatible with the rest of the series.

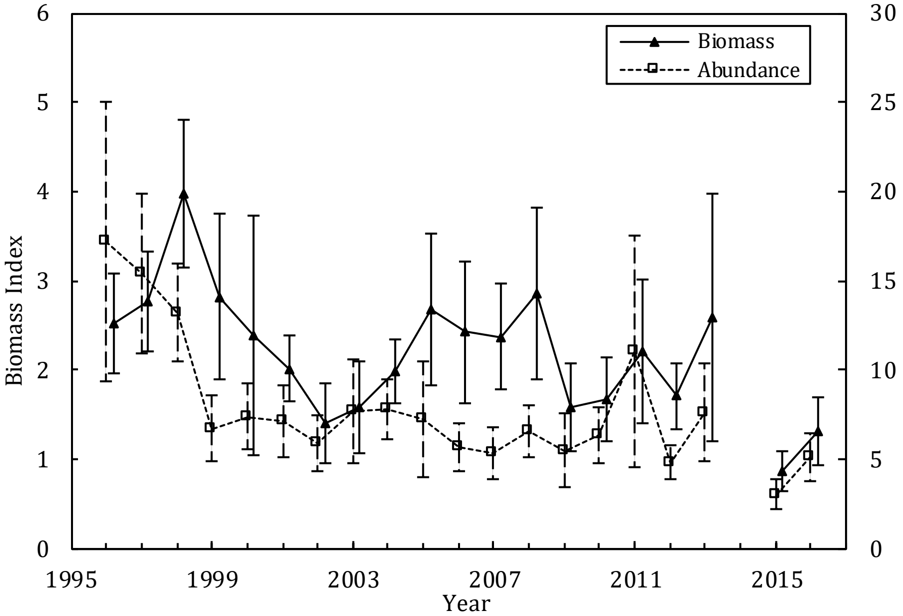


Fig. 20.5 Greenland halibut in Subarea 2 + Div. 3KLMNO: biomass and abundance indices (with 95% CIs) from Canadian autumn surveys in Div. 3LNO.

EU stratified-random surveys in Div. 3M (Flemish Cap). Surveys conducted by the EU in Div. 3M during summer indicate that the Greenland halibut biomass index in depths to 730 m, increased in the 1988 to 1998 period (Fig. 20.5) 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 2016 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. Following a large increase from 2014 to 2015 the index declined in 2016 to the levels 2008 and 2009.

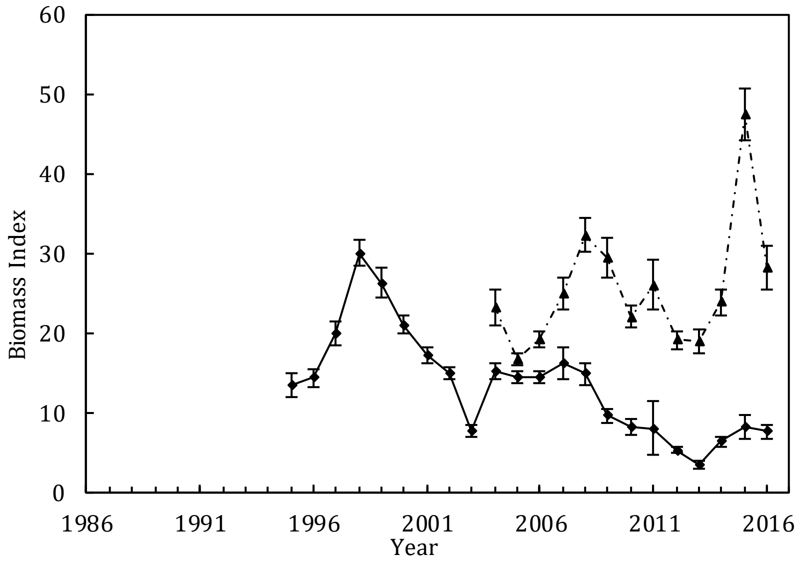


Fig. 20.6. Greenland halibut in Subarea 2 + Div. 3KLMNO: Biomass index (± 1 S.E.) from EU Flemish Cap surveys in Div. 3M. Solid line: biomass index for depths <730 m. Dashed line: biomass index for all depths <1460 m.

EU-Spain stratified-random surveys in NAFO Regulatory Area of Div. 3LNO. The biomass index for the survey of the NRA in Div. 3NO generally declined over 1999 to 2006 (Fig. 20.6) but increased four-fold over 2006-2009. The survey index from 2013-2014 was below average but increased to above average in 2015 and 2016. 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 has increased and 2014-2016 are among the highest in the series.

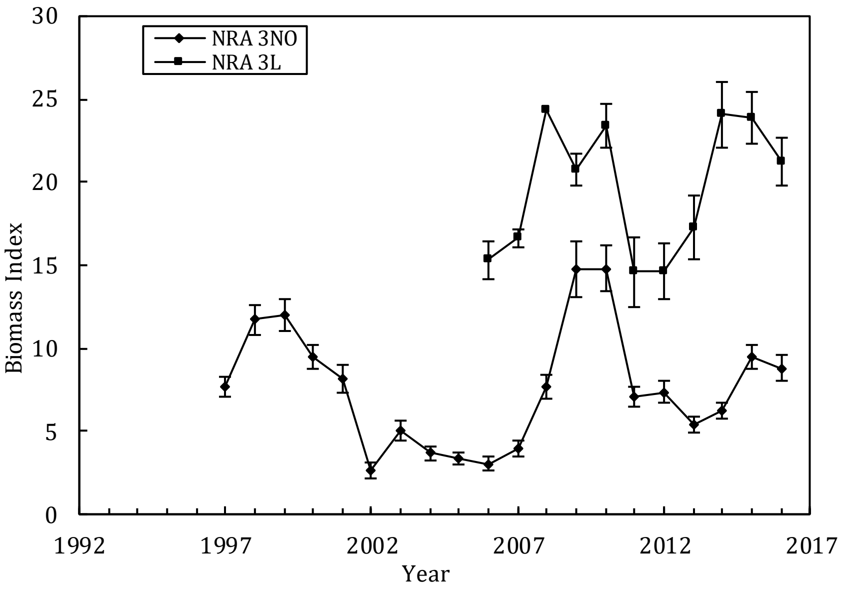


Fig. 20.7. Greenland halibut in Subarea 2 + Div. 3KLMNO: biomass index (±1 SE) from EU-Spain spring surveys in the NRA of Div. 3NO and Div. 3L.

Summary of research survey data trends. These surveys provide coverage of the majority of the spatial distribution of the stock and the area from which the majority of catches are taken. Over 1995-2007, indices from the majority of the surveys generally provided a consistent signal in stock biomass (Fig. 20.7). Results since 2007 show greater divergence which complicates interpretation of overall status. The overall trend since 2007 is unclear, but in 2016 the 3 of 4 surveys that start in the mid 1990s, are only about 70% of their average.

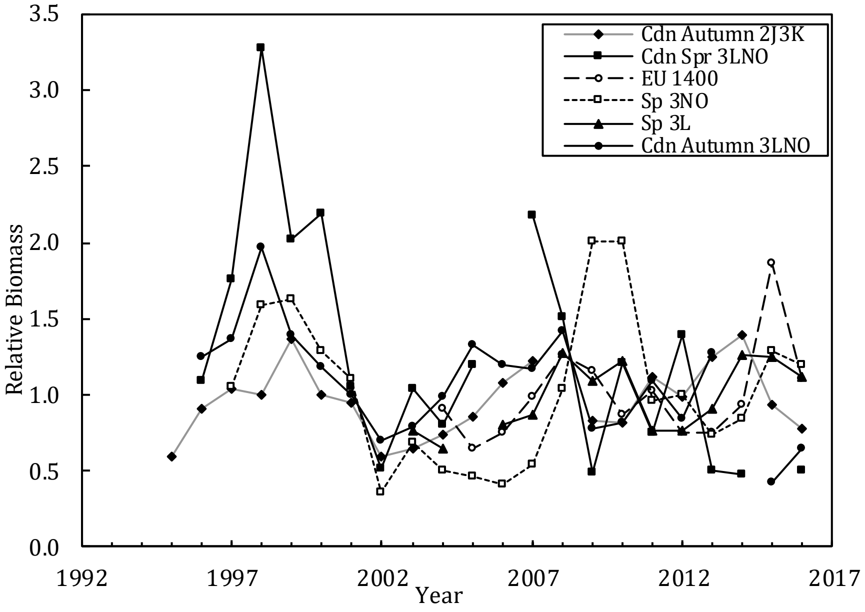


Fig. 20.8. Greenland halibut in Subarea 2 + Div. 3KLMNO: Relative biomass indices from Canadian autumn surveys in Div. 2J3K, Canadian spring surveys in Div. 3LNO, Canadian autumn surveys in Div. 3LNO, EU survey of Flemish Cap, and EU-Spain surveys of the NRA of Div. 3NO. Each series is scaled to its 2004-2016 average.

Recruitment from surveys

Abundance indices at age 4 from surveys were examined as a measure of recruitment. All the survey indices have low abundance at age 4 since the 2009 year class. Abundance at age 4 has been below average since the 2009 year class in the Canadian spring Divs. 3LNO survey and since the 2008 year class in the Canadian fall Divs. 2J3K survey. After 3 very large year classes of 2000-2002 in the EU survey of Div. 3M, abundance at age 4 has been below average. The abundance at age 4 in the EU Spain survey of Div. 3NO has been below average since the 2006 year class and in the Canadian Div. 3LNO fall survey since the 2008 year class.

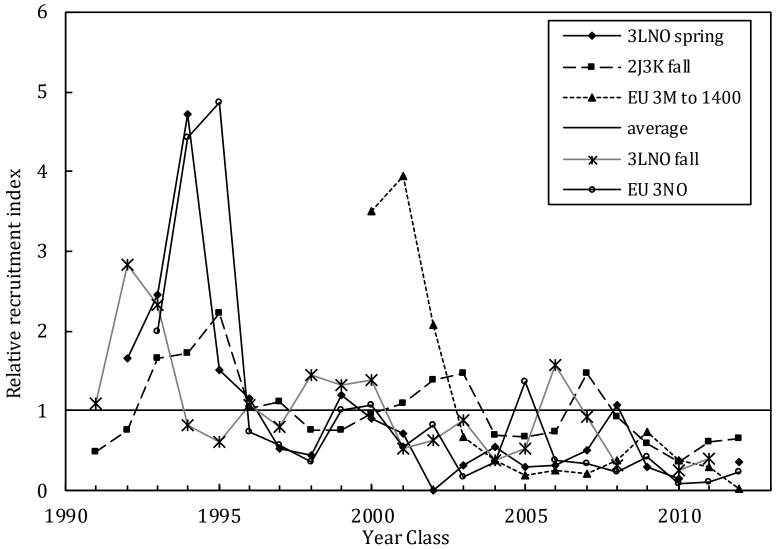


Fig. 20.9. Greenland halibut in Subarea 2 + Div. 3KLMNO: Relative recruitment indices from Canadian autumn surveys in Div. 2J3K, Canadian spring surveys in Div. 3LNO, and EU survey of Flemish Cap. Each series is scaled to its average and the average line is shown.

c) Estimation of Parameters

Numerous formulations of two assessment models were examined. A single formulation of each model was chosen to assess the status of the stock. Both models used as inputs: catch-at-age from 1975-2016, Canadian fall Div. 2J3K survey numbers at age 1996-2016, Canadian spring Div. 3LNO survey numbers at age 1996-2016, EU Div. 3M survey 0-700 m numbers at age 1995-2003, EU Div. 3M survey 0-1400 m numbers at age 2004-2016, EU-Spain Div. 3NO survey numbers at age 1997-2016, and Canadian fall Div. 3LNO 0-730m survey numbers at age 1996-2016. This series includes two additional surveys (Canadian fall Div. 3LNO, EU-Spain Div. 3NO) over the set used in past assessments of Greenland halibut. These surveys presumably provide additional information on stock status, and give better modeling diagnostics for the SSM model.

i) Statistical catch-at-age.

The Statistical Catch-at-Age (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 17-26. The following specifications apply to OM1a implementation on the full year range up to 2016 used to show projections:

- In addition to the inputs specified above the SCAA used total catch 1960-2016 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 $\sigma_R = 0.4$.
- Natural mortality: fixed at M=0.12 for all ages.
- The assessment commences in 1960: the initial numbers-at-age vector 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.
- The EU 3M survey selectivities are estimated separately for each age.
- Flat selectivity for the plus group for the EU 3M surveys.
- The penalised negative log likelihood minimised 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.
- Multiplicative weight given to the age-proportion data relative to the survey indices in the negative log-likelihood : W_{CAA}=0.2.

ii) SAM-style model

The SAM-style model (SSM) is 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_C) = 0.1
- Plus group = 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 were replaced with 0.005 and 0.5, respectively, and these values were treated as an upper limited 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 modeled 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 was modeled as a random effect as there was no clear sign of a stock-recruitment relationship
- Catch at age proportions were modelled using continuation ratio logits

d) Assessment results

SCAA Results

Recruitment: Recruitment has shown a general declining trend since the beginning of the time series. It has increased since 2010 but remains below the time series average.

Biomass: Spawning biomass (10+) has declined since the beginning of the time series and is estimated to be below SSB_{msy} since the late 1990's. There has been some increase in the SSB since 2010 and in 2016 it is estimated to be 104 300 t (27 000 – 180 900 t). Exploitable biomass (B_{5-9}) shows a similar trajectory and is estimated to be 91 510 t (62 410 – 120 610 t) in 2016, below B_{5-9msy}.

Fishing mortality: Fishing mortality was above F_{msy} from 1991 until 2014. Fishing mortality is estimated to be below F_{msy} in the last 2 years. In 2016 F is estimated to be 0.14 (0.08-0.20).

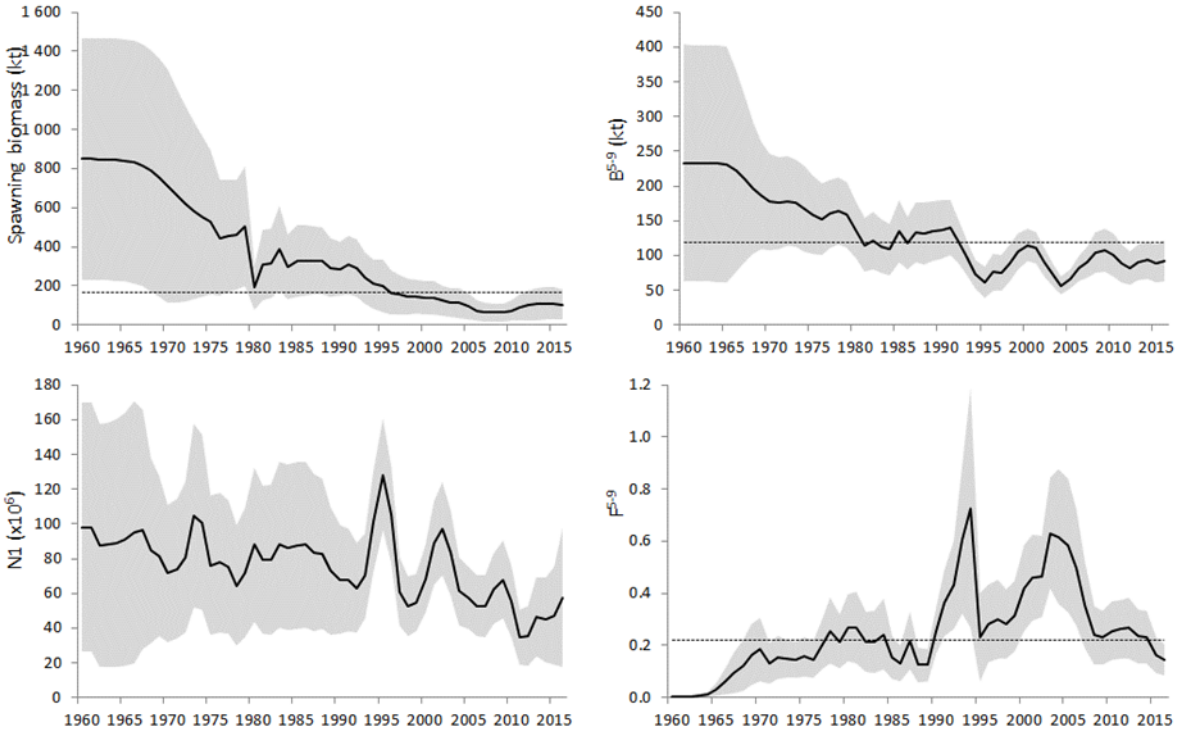


Fig. 20.10. Time trajectories of spawning (B^{10+}) and exploitable biomass (B^{5-9}), recruitment (N_{10}) and fishing mortality (F^{5-9}) for SCAA OM1a-2016. The black lines show the maximum likelihood estimate while the grey shading shows the 95% CIs. B_{MSY} and F_{MSY} are shown as horizontal dotted lines

SSM results

Recruitment: Recruitment has been variable with a large peak in the mid 1990s. It has increased since 2012 but remains below the time series average.

Biomass: Spawning biomass (10+) has been increasing since 2006. Exploitable biomass (B_{5-9}) has fluctuated over time without trend. In 2016 10+ biomass is estimated to be 67 900 t (113 515 - 232 622 t) while exploitable biomass was estimated at 61 129 t (49 924 – 74 851 t).

Fishing mortality: Fishing mortality had two peaks, one in the mid 1990s and one in the early 2000s. Fishing mortality is estimated to be below F_{msy} in the last 2 years, at 0.17 (0.13 – 0.23 t) in 2016.

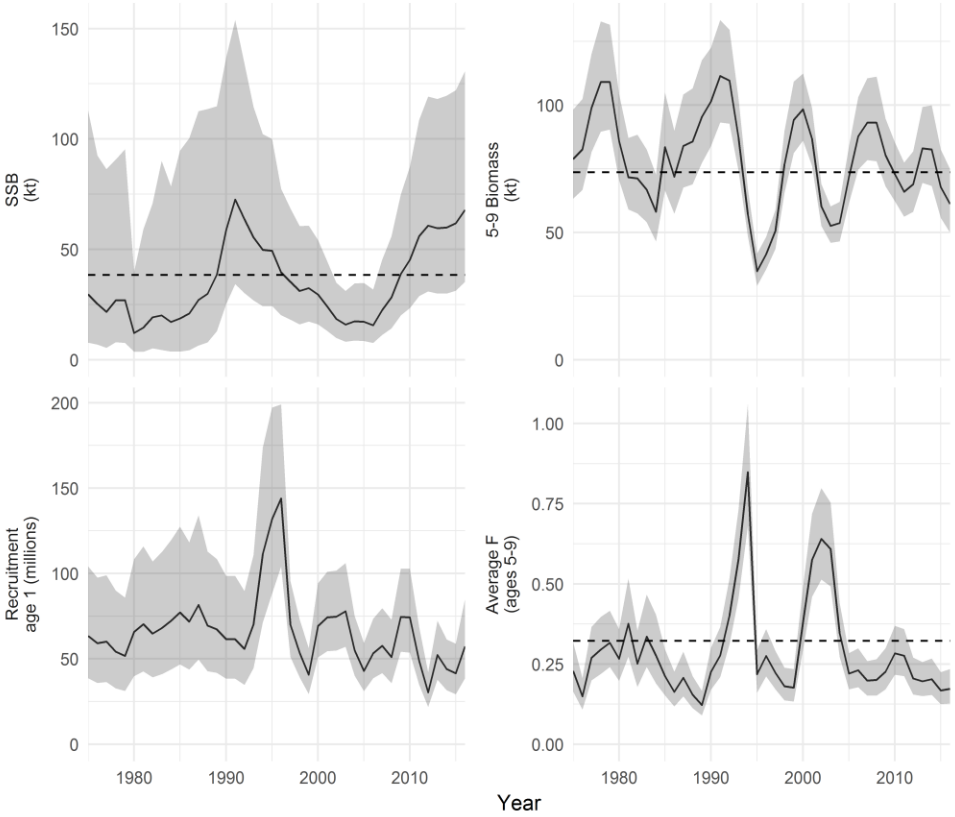


Fig. 20.11. Estimates of SSB, recruitment (age 1), exploitable biomass, and average F, with 95% confidence intervals (shaded area), from SSM model M1. Reference points are shown as dashed lines.

e) Retrospective analyses

SCAA

A 6 year retrospective analyses for SCAA was performed. There is no pattern in the retrospective. The main feature is a relatively large revision in all estimates for more recent years between 2012 and 2013 and for recruitment between 2015 and 2016.

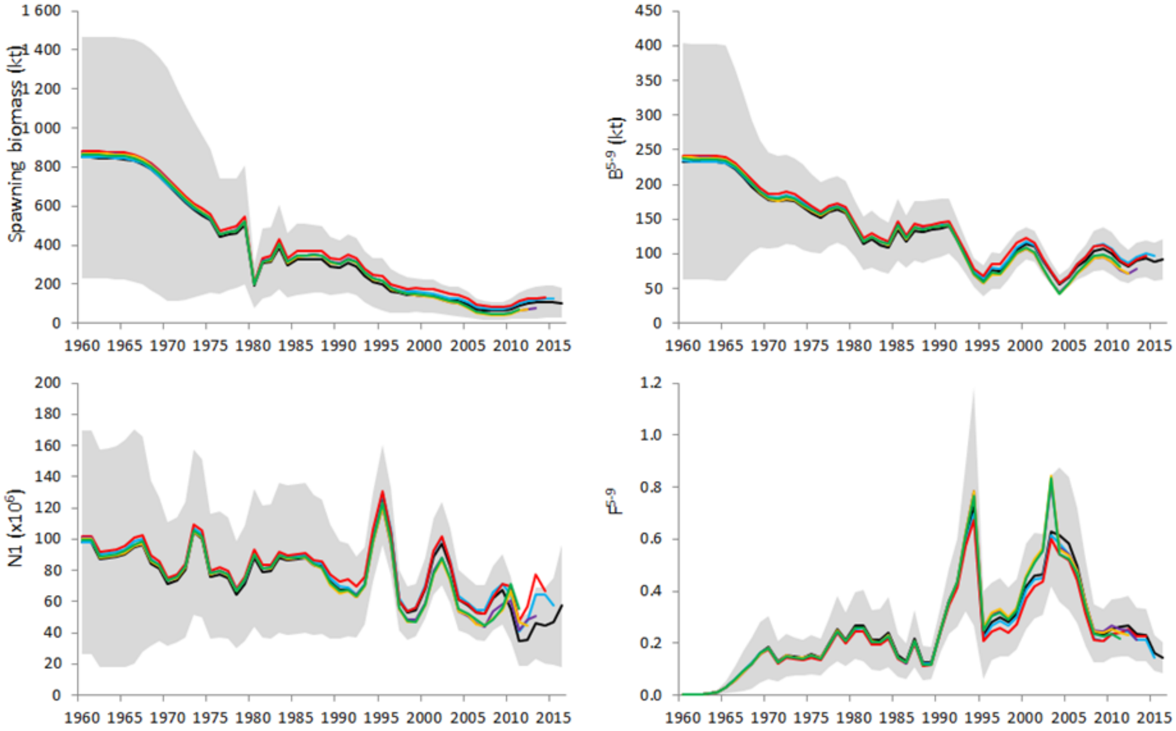


Fig. 20.12. Retrospective analysis for SCAA OM1a. with the grey shading showing the 95% CIs based on the 2016 assessment.

SSM

A 6 year retrospective analysis of the SSM showed that retrospective is generally small except for SSB (10+ biomass) and shows the trend for SSB to be underestimated.

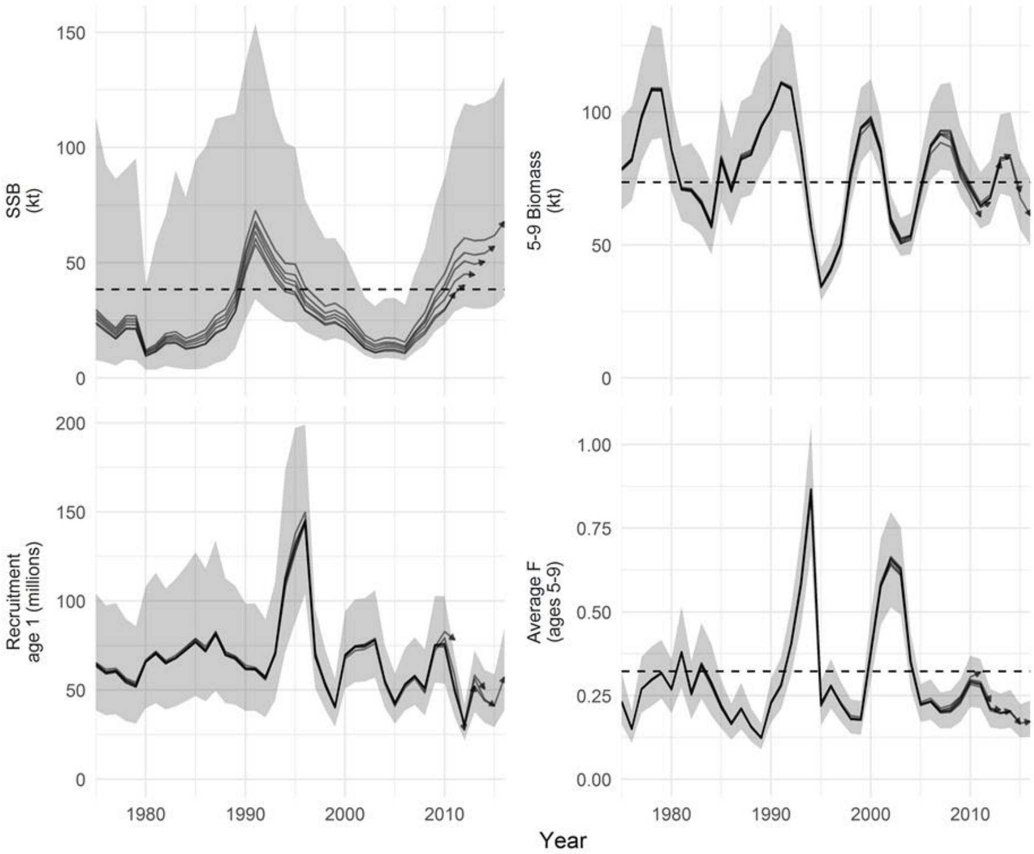


Fig. 20.13. Retrospective patterns in estimates of SSB, recruitment (age 1), exploitable biomass, and average F, with 95% confidence intervals from 2016 estimates (shaded area). Reference points are shown as dashed lines.

Comparison of model results

The trajectories of 10+ biomass are very different for the two models with SCAA estimating a much higher biomass throughout with a much steeper decline after 1975. This is in part because the SCAA is conditioned to start at a relatively high level in 1960. The 5-9 biomass is much more similar between the two models both in magnitude and trajectory. Estimates of fishing mortality and recruitment are similar between the two models in recent years.

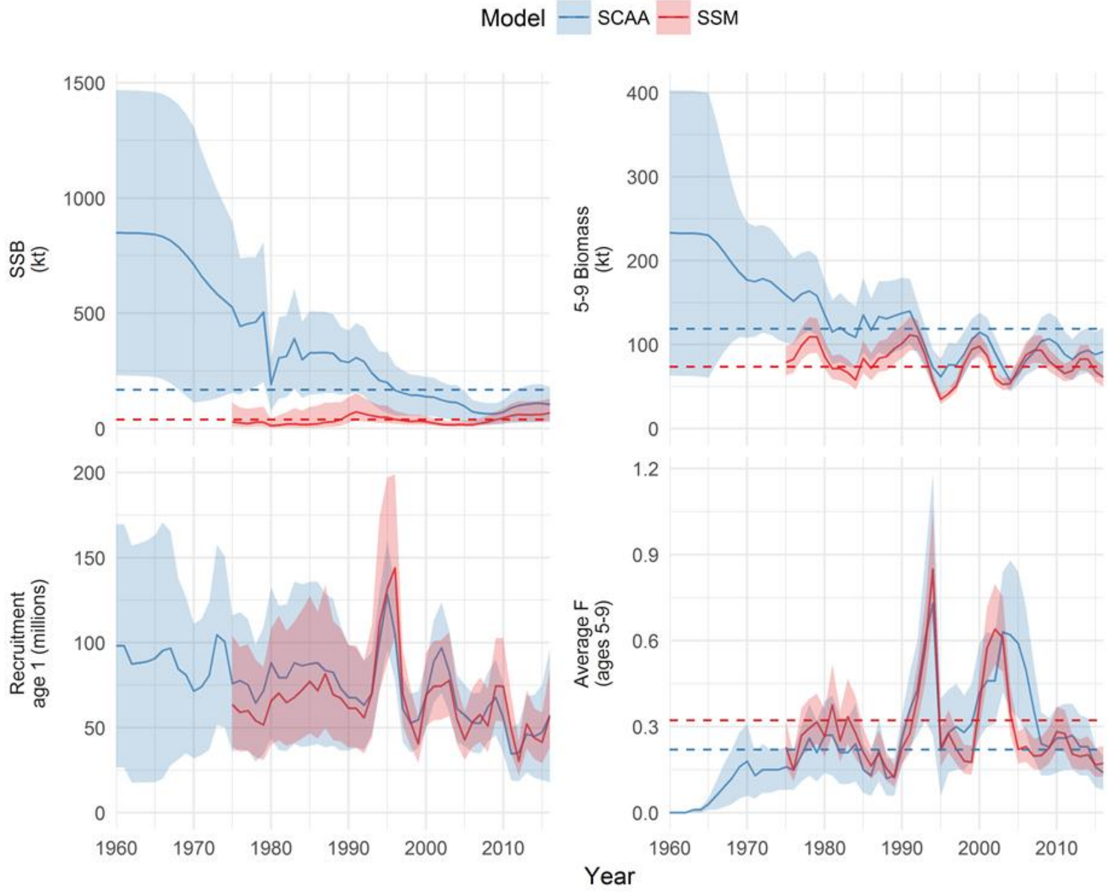


Fig. 20.14. Comparison of trends from a SCAA and SSM model of SSB, recruitment (age 1) and average F, with 95% confidence intervals (shaded area). B_{msy} and F_{msy} are shown as horizontal dashed lines.

f) State of the stock

Both models show age 5 to 9 biomass to be below B_{msy}^{5-9} and F to be below F_{msy} in 2016. The SCAA estimates 5 to 9 biomass to be 77 % of B_{msy}^{5-9} and F to be 64% ofF_{msy} . The SSM estimates 5 to 9 biomass to be 83 % of B_{msy}^{5-9} and F to be 53% ofF_{msy} . Recent recruitment has generally increased according to both models (since 2010 in the SCAA and since 2012 in the SSM) but remains below average.

g) Reference points

SCAA

MSY reference points were calculated using a Beverton Holt stock recruit relationship. Commercial selectivity equal to the selectivity in the last selectivity period for the SCAA and weight-at-age was taken as the average of the last 10 years (2006-2015). The maximum likelihood estimates for the parameters of the stock-recruitment relationship and for selectivities are used for this evaluation. CVs for *MSY* and B_{MSY} were found from the Hessian associated with the assessment. Note that they are conditional on the calculated value of F_{MSY}. For full details see SCR 17/46.

SSM

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} which was taken as a proxy for F_{MSY}^{5-9} . 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_{MSY}^{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 17/48

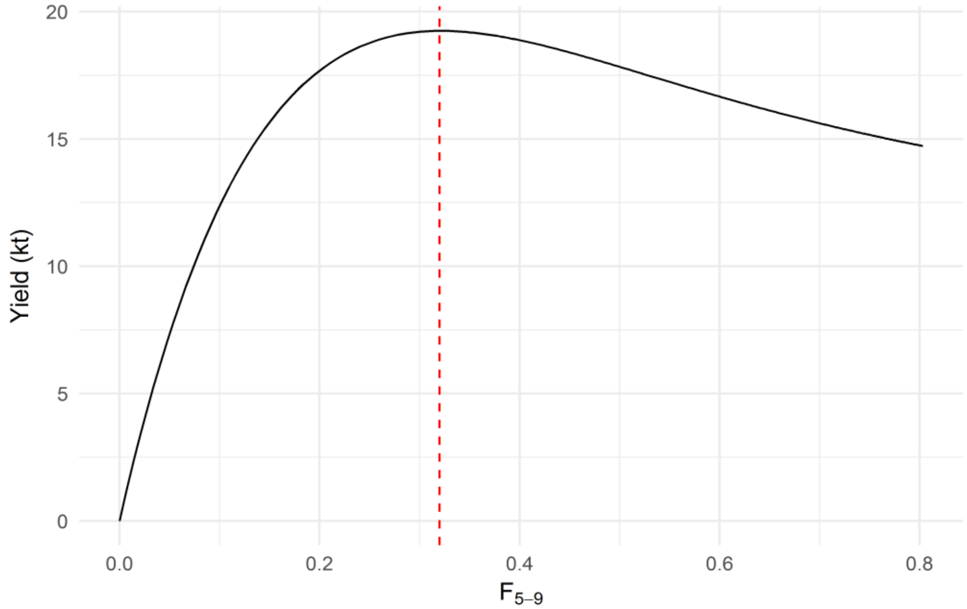


Fig. 20.15. Profile of yield across a range of F_{5-9} values. The dotted red line indicates an approximation to F_{MSY}^{5-9}

The following reference points were determined from the two models:

SCAA

	Estimate	95% CIs[1]	
B^{10+}_{MSY}	168.16 kt	(92.94;	243.38)
$B^{5\text{-}9}_{\mathrm{MSY}}$	118.62 kt	(92.90;	144.34)
MSY	26.52	(22.00;	31.04)
$F^{5\text{-}9}_{\mathrm{MSY}}$	0.22		

[1] Confidence intervals for the SCAA estimates are conditioned on the point estimate of FMSY

SSM

	Estimate	95% CI
B_{MSY}^{10+}	38.39 kt	(13.64, 108.04)
B_{MSY}^{5-9}	73.69 kt	(50.05, 108.37)
MSY	24.69 kt	(16.66, 36.60)
F_{MSY}^{5-9}	0.32	(0.23,0.44)

The timing of the next assessment is currently unknown as it is dependent on the completion of the ongoing MSE work.

References

Cadigan, Noel 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: 296–308.

Nielsen, Anders, and Casper W Berg. 2014. "Estimation of Time-Varying Selectivity in Stock Assessments Using State-Space Models." *Fisheries Research* 158. Elsevier: 96–101.

21. Northern Shortfin Squid (*Illex illecebrosus*) in SAs 3+4

Interim Monitoring Report (SCR Doc. 98/59; 98/75; 02/56; 16/34)

a) Introduction

The species has a lifespan of less than one year and is considered a single stock. However, the Subareas 3+4 and Subareas 5+6 stock components are assessed and managed separately by NAFO and the U.S. Mid-Atlantic Fishery Management Council, respectively. The stock assessment is data-poor. Indices of relative biomass and mean body weight, computed using data from the Div. 4VWX surveys conducted during July by the Canada Division of Fisheries and Oceans, were used to assess whether the Subareas 3+4 stock component was at a low or high productivity level during the previous year. Stock biomass projections are not currently possible. Relative fishing mortality indices, computed as the Subareas 3+4 nominal catch divided by the Div. 4VWX biomass ratio, were also used to assess stock status. Based on the trends in these three sets of indices, the Subareas 3+4 stock component was in a state of low productivity during 1982-2016.

Since 1999, there has been no directed fishery for *Illex* in Subarea 4 and most of the catches from Subareas 3+4, for most years during 1999-2011, were from the Subarea 3 inshore jig fishery. There were no catches from Subarea 3 during 2013-2016. During 1999-2011, catches from Subareas 3+4 were low during most years (average = 1 077 t), compared to catches during 1976-1981 (average = 80 645 t), and ranged between about 57 t in 2001 to about 7 000 t in 2006 (Fig. 21.1). Catches in Subareas 3+4 have been less than 50 t since 2012 and reached the lowest level in the time series (since 1953) during 2015 (14 t) and remained similarly low in 2016 (18 t).

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

	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
TAC SA 3+4	34	34	34	34	34	34	34	34	34	34
STATLANT 21 SA 3+4	0.5	0.7	0.1[1]	0.1[1]	<0.1[1]	<0.1[1]	<0.1[1]	<0.1[1]	<0.1[1]	
STATLANT 21 SA 5+6[2]										
STACFIS SA 3+4	0.5	0.2	0.1	0.1	<0.1	<0.1	<0.1	<0.1	<0.1	
STACFIS SA 5+6	15.9	18.4	15.8	18.8	11.7	3.8	8.8	2.4	6.7	
STACFIS Total SA 3-6	16.4	19.1	15.9	18.9	11.7	3.8	8.8	2.4	6.7	

[1] Includes amounts (< 0.1 t to 18 t during 2010-2011 and 0.2 t to 9 t during 2012-2016) reported as 'Unspecified Squid' from Subarea 4 because they were likely *I. illecebrosus*.

[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.

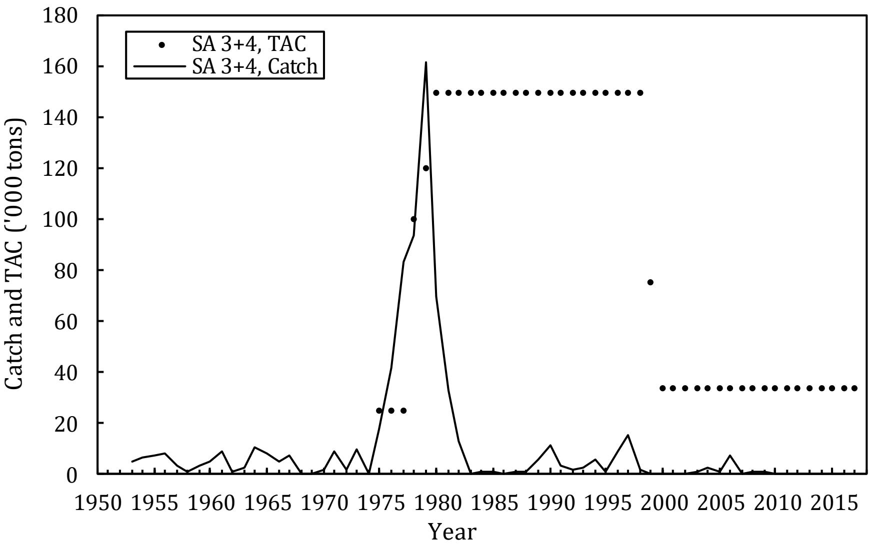


Fig. 21.1. Northern shortfin squid in Subareas 3+4: nominal catches and TACs.

b) Data Overview

Relative biomass indices, derived using data from the Canadian surveys conducted during July in Div. 4VWX, fluctuated widely after 2003 (Fig. 21.2). The third and fourth highest indices in the time series occurred during 2004 and 2006, respectively, but both years were followed by very low indices. Biomass indices generally declined between 2004 and 2013, from a low productivity period peak to the lowest level on record, respectively. Since 2010, biomass indices have been below the mean of the low productivity period (2.70 kg), and in 2016, the biomass index was 0.41 kg per tow.

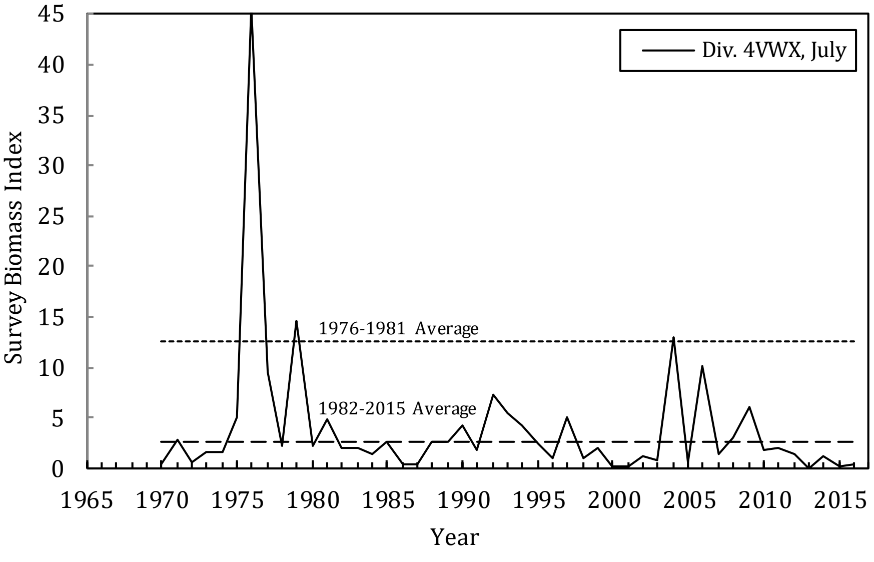


Fig. 21.2. Northern shortfin squid in Subareas 3+4: survey biomass indices from the July survey in Div. 4VWX.

Since 1982, mean body weight of squid caught during the July Div. 4VWX surveys fluctuated widely around the mean for the 1982-2015 low productivity period (81 g, Fig. 21.3). 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 Fig. 21.3). 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 an above-average increase during 2014-2015, mean body weight decreased to the fourth lowest level in the time series in 2016 (37 g).

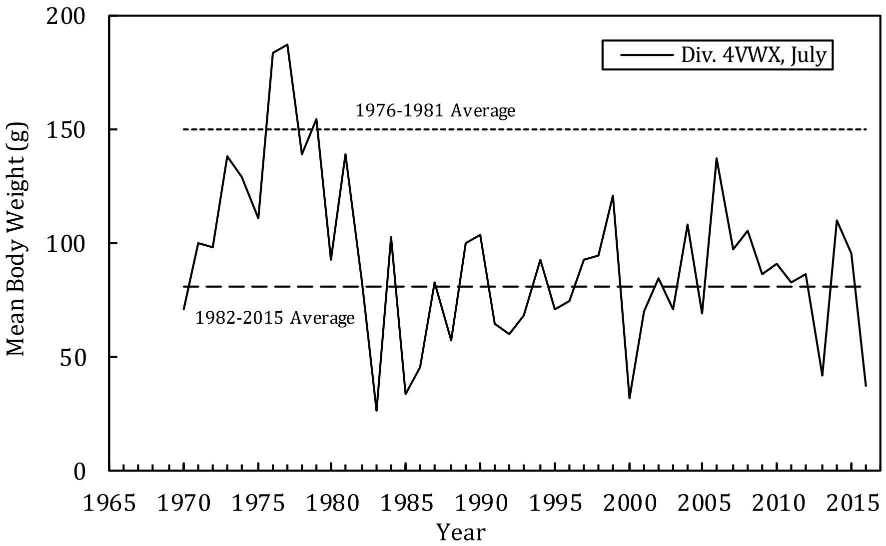


Fig. 21.3. Northern shortfin squid in Subareas 3+4: mean body weights of squid from the July survey in Div. 4VWX.

Catch/biomass ratios (SA 3+4 nominal catch/Division 4VWX July survey biomass index) / 10 000) have been well below the 1982-2015 mean (0.13) during most years since 2001 and the ratio was < 0.01 in 2016 (Fig. 21.4).

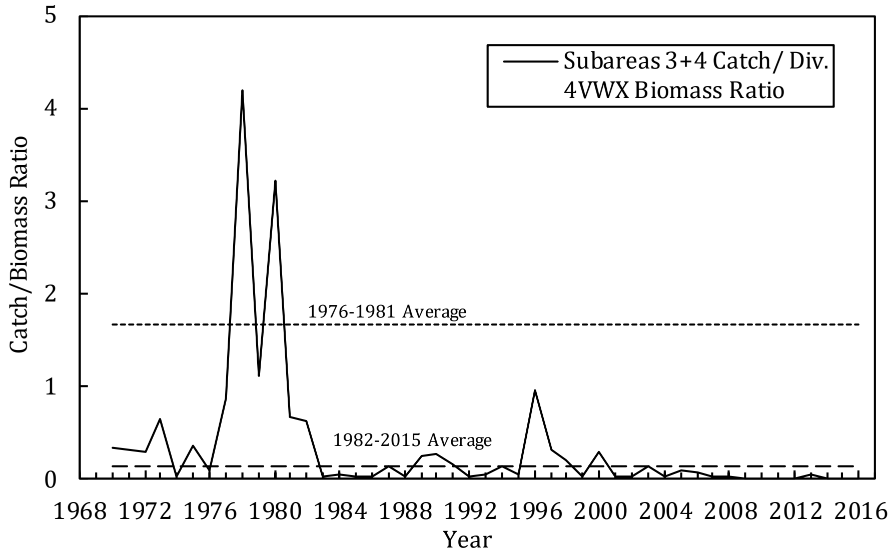


Fig. 21.4. Northern shortfin squid in Subareas 3+4: catch/biomass ratios (SA 3+4 nominal catch/Division 4VWX July survey biomass index) / 10 000).

c) Conclusion

Since 1999, there has been no directed fishery in Subarea 4, and there have been no catches in Subarea 3 since 2013. During 2016, the biomass index from the July Div. 4VWX survey (0.41 kg per tow) was well below the average for the 1982-2015 low productivity period (2.70 kg per tow). Mean body weight was also below the 1982-2015 average (81 g) in 2016 (37 g). Catch/biomass ratios have been well below the low productivity period mean during most years since 2001. Thus, in 2016, the stock remained in a state of low productivity.

The next full assessment of the stock is scheduled for 2019.

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.

22. Splendid alfonsino (*Beryx splendens*) in SA 6

(SCS Doc. 15/12 SCR 15/18 and SCS 17/04)

a) Introduction

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

Population dynamics are uncertain with recent estimates suggesting high longevity (>50 years), while other estimates suggest a longevity of about15 years. 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 behavior, this species is easily overexploited and can only sustain low rates of exploitation.

b) Commercial fishery data

Historically, catches of Alfonsino in the NAFO regulatory area have been reported by Russia from Divs. 6E-H from both midwater and bottom trawls. The Russian trawl fishery started in 1976 with a catch of 10 200 t (Fig. 22.1). Thereafter the number of vessels participating in the fishery ranged between 1 and 3, and catches ranged between 10 and 3 500 t. There was no fishing from 1988-1993 and 1997 – 2003. A fishery was conducted by Spanish trawlers from 2004 until now, where catches have ranged between 52 and 1 187 t, with no fishery in 2008 (Table 22.1; Fig.22.1).

Table 22.1. Recent catches (tonnes), effort and CPUE (Kg/hr fished) for the Spanish Alfonsino fishery on Kukenthal Peak.

Year	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Catch (t)	415	1187	130	52	0	479	52	152	302	114	118	122	127
Effort (days on ground)	50	29	6		0	28	4	9	22	17	15	13	16
Effort (hours fished)	104	162	44	16	0	167	66	68	165	87	117	92	116
CPUE (Kg/hour)	3990	7327	2955	3256		2868	788	2235	1830	1310	1009	1326	1095
Effort (vessels)	1	3	1	1	0	1	1	1	1	1	2	2	1

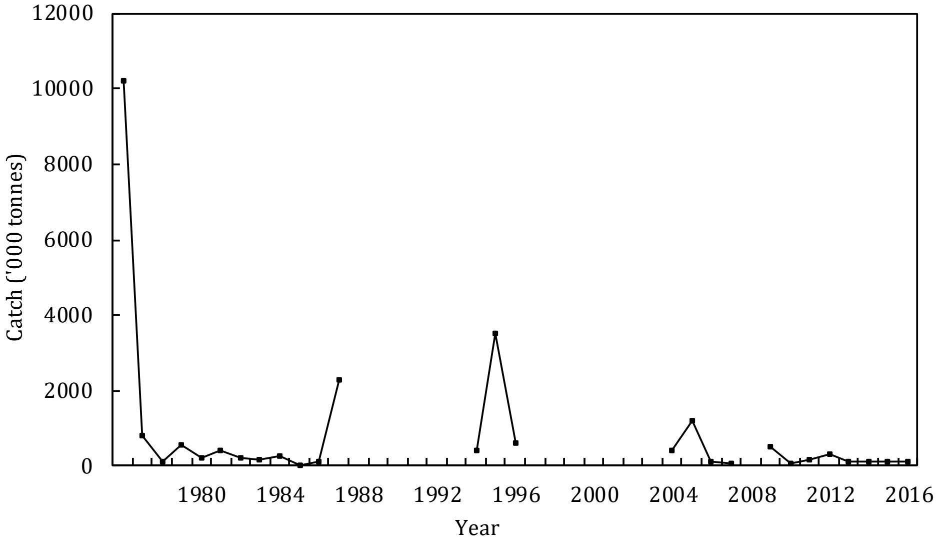


Fig.22.1. Alfonsino catches from Div. 6G.

Figure 22.1 1 shows CPUE (kg/hour) since 2004. The 2004 data came from a Spanish exploratory fishery. It can be observed a decrease trend till 2014 and after a stable CPUE level.

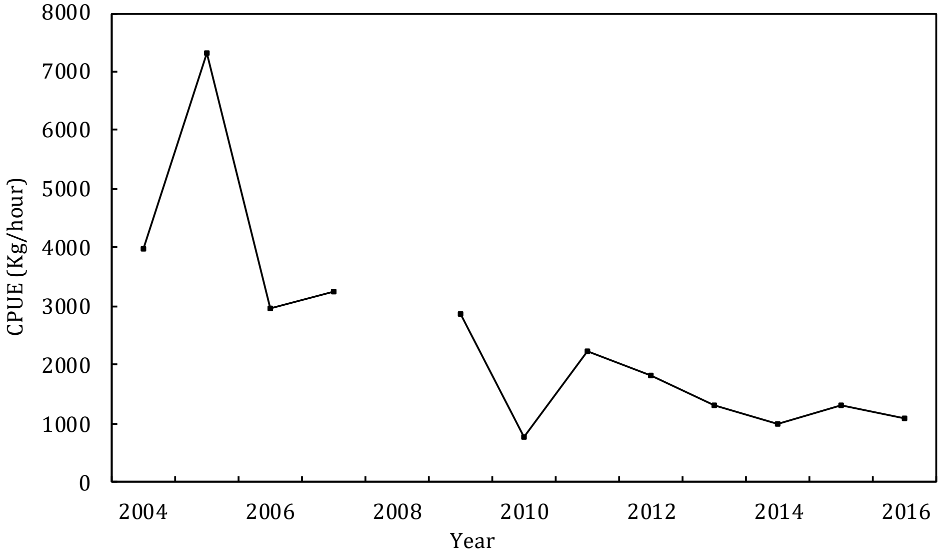


Fig. 22.2. CPUE (kg/hour fished) for the midwater trawl fishery that occurs on Kukenthal Peak (Div. 6G).

Figure 22.2 shows the length distribution in percentage by year since 2004. All length distribution samples were measured to the total length, except the 2007 samples that were measured to the fork. It can be observed that these length distributions are quite similar for all years. Catches in all years are in the 30-50 cm range with a mode around 40 cm.

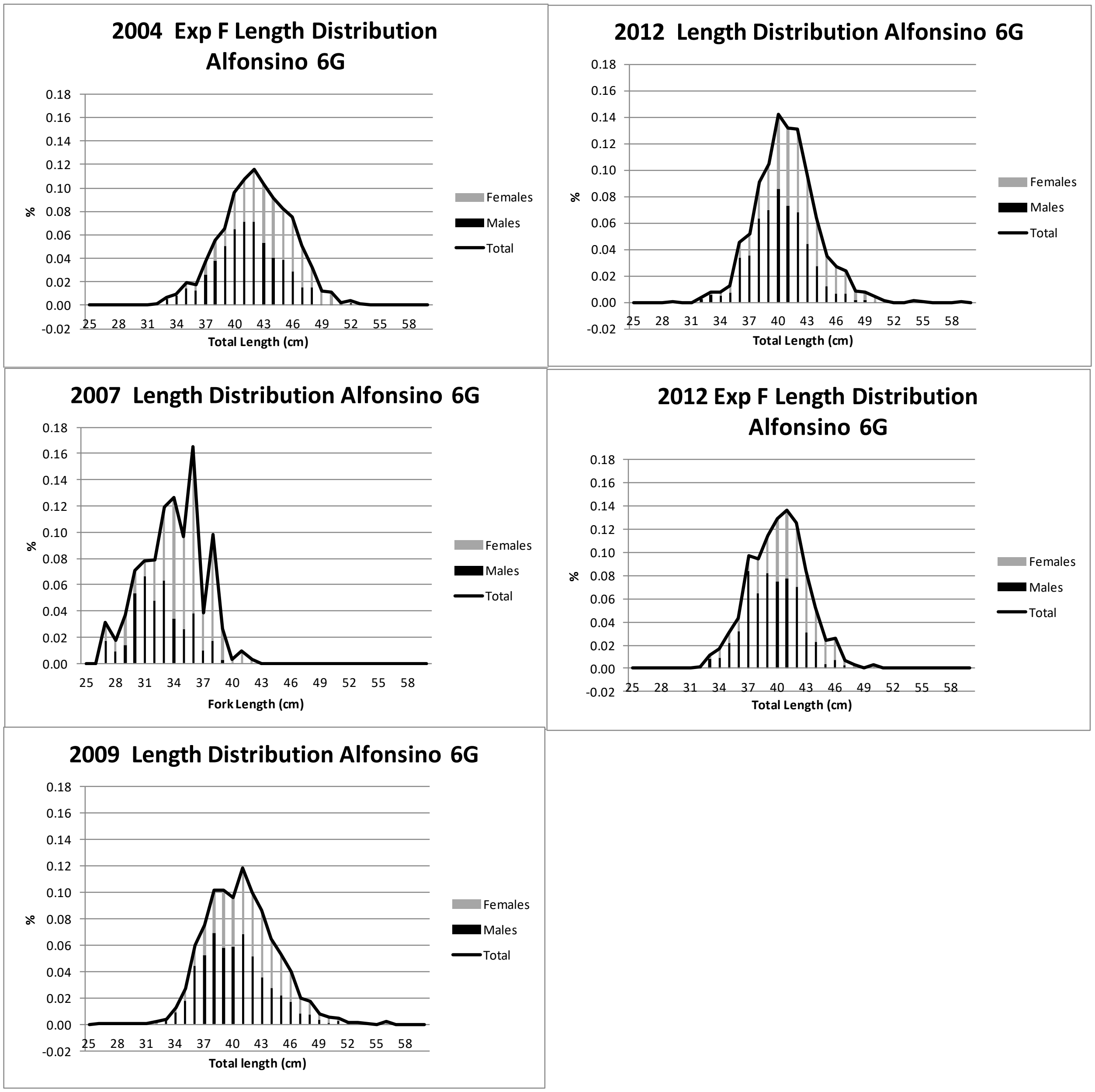


Fig. 3. Length distributions of alfonsino catches from Div. 6G.

c) Surveys

The latest estimate of biomass is outdated, based on surveys dating back to 1995, and there is no additional survey data available for the alfonsino resource on Kukenthal Peak.

d) Conclusion

No reliable assessment can be presented for this stock. The latest estimate of biomass is based on surveys dating back to 1995. Since then, only data on catches and effort are available. Due to lack of abundance or exploitation information, an analytical or survey based assessment was not possible.

There is currently no full assessment scheduled for this stock.

IV.STOCKS UNDER A MANAGEMENT STRATEGY EVALUATION

1. Greenland halibut in SA 2 and Divs. 3KLMNO

This stock is taken under D. Widely Distributed Stocks: SA 2, SA 3 and SA 4.

2. Redfish (*Sebastes mentella* and *Sebastes fasciatus*) in Divs. 3L and 3N

This stock is taken under B. Stocks on the Flemish Cap: SA 3 and Div. 3M

V.OTHER MATTERS

1. FIRMS Classification for NAFO Stocks

Due to lack of time, STACFIS did not review the assessments of stocks managed by NAFO in June 2017. This task has been deferred to the September SC meeting. Assessments reviewed in June 2016 are shown below. 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 Redfish[3] 3NO Witch flounder	SA0+1 Northern shrimp[1] DS Northern shrimp[1] 0&1A Offsh. & 1B–1F Greenland halibut	3M Cod	Greenland halibut in Uummannaq[2] Greenland halibut in Upernavik[2] Greenland halibut in Disko Bay[2] SA1 American Plaice SA1 Spotted Wolffish
Small	SA3+4 Northern shortfin squid 3NOPs White hake			3LNOPs Thorny skate SA2+3KLMNO Greenland halibut
Depleted	3M American plaice 3LNO American plaice 2J3KL Witch flounder 3NO Cod 3M Northern shrimp[1,3] 3LNO Northern shrimp[1]			SA1 Redfish SA0+1 Roundnose grenadier SA1 Atlantic Wolffish
Unknown	SA2+3 Roughhead grenadier 3NO Capelin 3O Redfish			SA2+3 Roundnose grenadier

[1] Shrimp will be re-assessed in September 2016

[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. Greenland Halibut in NAFO Subarea 2 and Divisions 3KLMNO Management Strategy Evaluation.

According to the timeline established by WG-RBMS Feb 2017 (FC/SC Doc 17/02) the tasks scheduled to be addressed by the June SC meeting were:

- Tabling of developers results
- Review of operating model fits
- Review of initial Candidate Management Strategies and/or HCRs results
- Initial discussion on trial plausibility
- Possibly add further trials and then finalize operating models and trials
- Cull initial Candidate Management Strategies and/or HCRs to a smaller set and summarize results

In accordance with the GHL-MSE timeline developed in London, UK in February 2017, SC had the following agenda items to address at the June meeting:

- Tabling of developers (SCAA and SSM) results
- Review of operating model fits
- Review of initial CMPs results
- Initial discussion on trial plausibility
- Possibly add further trials and then finalize operating models and trials
- Cull initial CMPs to a smaller set and summarize results.

Work on the above was initiated with the exception of discussion on trial plausibility. Considerations in conducting the MSE trials were related to, among others, target- and slope-based HCRs, alpha and gamma parameters, weighting of the different surveys used in the assessment, number of years (3) to average for composite stock size index, starting TAC, a 30% over-catch scenario, and maximum inter-annual TAC changes of 10% and 20%.

The meeting focused on progressing from the work carried out during the SC meeting in Vigo in April 2017 (SCS 17-15), addressing recommendations from the WG-RBMS London and Falmouth meetings (FS-SC doc17-02 and FC-SC doc17-32) and preparing for the next WG-RBMS meeting July 2017, in particular in proposing revised CMPS, OMS and reducing the overall OMs.

Issues and Concerns discussed by the SC on the current MSE process included:

- Timeline of the process (insufficient time to explore the amount of technical details)
- Process in which generating recruitment in future years
- Appropriate selectivities used for projection
- Exceptional circumstances not discussed, need to have a safety net

Tabling of developers results

Operating models tabled were: SCAA (SCR 17-002), SSM (17-010), XSA (SCR 17-040)

It was agreed to take forward the SCAA and SMM models with the following variants:

Retained Operating models (shown after the first entry as variants to baseline)	**SSM**	**SCAA**
Baseline: uses data including 2016 and the O3 set of surveys	X	X
Hockey-stick with flex point at 25% quantile of SSB (or as reasonably approximated)~~)~~	X	X
Post-hoc fitting of Beverton Holt curve, with h = 0.8.	X	
Continue development of internally fitted stock recruitment model	X	
Recruitment for the first 8 years at 0.5 of the level predicted by the recruitment method (mean recruitment or SR function)	X	X
Larger recruitment variability σ_R=0.6	X	X
SSM future dynamics, and with SSM numbers-at-age		X
Senescence: increase natural mortality from 0.12 to 0.5 in 10+	X	X
Future catches =130% TAC	X	X

It is possible that it will be necessary to have additional operating models that change more than one of the above factors. A decision on this should be taken after the results of the above are available. The intention is to have the results of these trials available for the RBMS meeting in July 2017. It was agreed to add one further performance statistic: the average annual catch of 10+ fish over the projection period.

Several additional operating model settings were discussed and eliminated from future consideration.

The following were agreed at the meeting to be excluded :

Operating models culled in final discussion
BH with h not 0.8
Survey set used as for previous MP
Force less doming in commercial or survey selectivities
M = 0.2
Decreasing natural mortality at age (0.12 at age10 to 0.5 at age 14+)
Wcaa = 0.1
Current numbers-at-age increased by 20%
Different future commercial selectivity
Zero future commercial selectivity on 10+

Review of initial Candidate Management Strategies and/or HCRs results

SC agreed that the following elements would be included in future Candidate Management Procedures trials:

- Target based procedure ($TAC_{y+1} = TAC_y\left(1 + \gamma_{up/down}\left(J_y - 1\right)\right)$)
- Test γ = c(0.5, 1)
- Previous slope based rule would also be tested in as comparative a manner as possible survey weighting.

Points were raised in discussion of the above related to the variance estimates for J, and that some surveys are better monitors of certain age ranges (generally younger) given the depth of those surveys. It was noted that there was very little difference in performance statistics between inverse variance and equal weighting of surveys and a decision to keep inverse variance weighting had been made.

- Number of years to average for composite stock size index: the agreed decision was 3
- Starting TAC in 2018 to initiate HCR: 15000 and 20000 t.
- Alpha parameter: tuned to baseline (median exploitable (5-9) biomass in 2037 = B_{msy}), and an alternative (tuned to overcatch scenario 30%, med B (5-9)=B_{msy} in 2037)
- Max interannual TAC change: 10% and 20%

3. Other Business

No additional items were discussed.

VI.ADJOURNMENT

STACFIS Chair thanked the Designated Experts for their competence and very hard work and the Secretariat for its great support. The Chair also noted the contributions of Designated Reviewers in providing detailed reviews of interim monitoring reports. The STACFIS Chair also thanked the Chair of Scientific Council, and the Scientific Council Coordinator for their support and help. The meeting was adjourned at 1400 on 16 June 2016.

APPENDIX V. AGENDA - SCIENTIFIC COUNCIL MEETING, 1-15 JUNE 2017

I. Opening (Scientific Council Chair: Kathy Sosebee)
  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 2016

III. Fisheries Environment (STACFEN Chair: Andrew Cogswell)
  1. Opening
  2. Appointment of Rapporteur
  3. Adoption of Agenda
  4. Review of Recommendations in 2016
  5. Department of Fisheries and Oceans Canada, Oceans Science Branch, Marine Environmental Data Section (MEDS) (formerly ISDM) Report for 2016
  6. Review of the physical, biological and chemical environment in the NAFO Convention Area during 2016
  7. Interdisciplinary studies
  8. Formulation of recommendations based on environmental conditions during 2016
  9. National Representatives
  10. Other Matters
  11. Adjournment

IV. Publications (STACPUB Chair: Margaret Treble)
  1. Opening
  2. Appointment of Rapporteur
  3. Adoption of Agenda
  4. Review of Recommendations in 2016
  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: Brian Healey)
  1. Opening
  2. Appointment of Rapporteur
  3. Review of Recommendations in 2016
  4. Fishery Statistics
    a) Progress report on Secretariat activities in 2016/2017
      i) Presentation of catch estimates from daily catch reports and STATLANT 21A and 21B

5. Research Activities
   a) Biological sampling
      i) Report on activities in 2016/2017
      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 2016 (by National Representatives and Designated Experts)
      ii) Surveys planned for 2017 and early 2018
   c) Tagging activities
   d) Other research activities
6. Review of SCR and SCS Documents
7. Other Matters
   a) Summary of progress on previous recommendations
   b) Stock Assessment Spreadsheets
   c) EU project on 3M cod
   d) Greenland halibut age determination workshop.
8. Adjournment

VI. Fisheries Science (STACFIS Chair: Joël Vigneau)
1. Opening
2. General Review of Catches and Fishing Activity
3. Invited speaker
4. Stock Assessments
   1. Greenland halibut (*Reinhardtius hippoglossoides*) in SA 0, Div. 1A offshore and Div. 1B-F (monitor)
   2. Greenland halibut (*Reinhardtius hippoglossoides*) Div. 1A inshore (monitor)
   4. Demersal redfish (*Sebastes* spp.) in SA 1 (fully assessed)
   5a. Wolffish in SA 1 (fully assessed)
   5b American plaice (*Hippoglossoides platessoides*) in SA 1(monitor)
   6. Cod (*Gadus morhua*) in Div. 3M (fully assessed)
   7. Redfish (*Sebastes mentella* and *Sebastes fasciatus*) in Div. 3M (fully assessed)
   7b Golden redfish (*Sebastes norvegicus* aka *S. marinus*) in Div. 3M (fully assessed – special request)
   8. American plaice (*Hippoglossoides platessoides*) in Div. 3M (fully assessed)
   9. Cod (*Gadus morhua*) in NAFO Divs. 3NO (fully assessed)
   10. Redfish (*Sebastes mentella* and *Sebastes fasciatus*) in Divs. 3L and 3N (monitor)
   11. American plaice (*Hippoglossoides platessoides*) in Divs. 3LNO (monitor)
   12. Yellowtail flounder (*Limanda ferruginea*) in Divs. 3LNO (monitor)
   13. Witch flounder (*Glyptocephalus cynoglossus*) in Divs. 3NO (fully assessed)
   14. Capelin (*Mallotus villosus*) in Divs. 3NO (monitor)
   15. Redfish (*Sebastes mentella* and *Sebastes fasciatus*) in Div. 3O (monitor)
   16. Thorny skate (*Amblyraja radiata*) in Divs. 3LNO and Subdiv. 3Ps (monitor)
   17. White hake (*Urophycis tenuis*) in Divs. 3NO and Subdiv. 3Ps (fully assessed)
   18. Roughhead grenadier (*Macrourus berglax*) in SAs 2 and 3 (monitor)
   19. Witch flounder (*Glyptocephalus cynoglossus*) in Divs. 2J+3KL (monitor)
   20. Greenland halibut (*Reinhardtius hippoglossoides*) in SA 2 + Divs. 3KLMNO (fully assessed)
   21. Northern shortfin squid (*Illex illecebrosus*) in SAs 3+4 (monitor)

5. Stocks under a Management Strategy
    a) Greenland halibut in SA 2 and Divs. 3KLMNO
    b) Redfish in Divs. 3LN

6. Other Matters
    a) FIRMS Classification for NAFO Stocks
    b) Other Business
        Scheduling of benchmarks
        External review process for SC advice.
7. Adjournment

VII. Management Advice and Responses to Special Requests
1. Fisheries Commission (Annex 1)
    a) Request for Advice on TACs and Other Management Measures (Item 1, Annex 1)
        <u>For 2018</u>
        - Cod in Div. 3M
        <u>For 2018 and 2019</u>
        - Redfish in Div. 3M
        - Witch flounder in Divs. 3NO
        - White hake in Divs. 3NO
        <u>For 2018, 2019 and 2020</u>
        - Cod in Divs. 3NO
        - American plaice in Div. 3M

    b) Monitoring of Stocks for which Multi-year Advice was provided in 2015 or 2016 (Item 1)
        - American Plaice in Divs. 3LNO
        - Yellowtail flounder in Divs. 3LNO
        - Capelin in Divs. 3NO
        - Redfish in Div. 3O
        - Thorny skate in Divs. 3LNOPs
        - Witch Flounder in Divs. 2J+3KL

    c) Special Requests for Management Advice
        i) Implement relevant steps in the workplan for Greenland halibut in SA2 + Divs. 3KLMNO (Item 2)
        ii) Continue risk assessments for impacts of trawl surveys on VME in closed areas (Item 3)
        iii) Bycatch of cod, redfish and moratoria species from haul-by-haul data (Item 4)
        iv) Assessment of golden redfish in Div. 3M (Item 5)
        v) Continue review of PA framework (Item 7)
        vi) Review information on Greenland sharks (Item 8)
        vii) Start working on a Strength, Weaknesses, Opportunities and Threats (SWOT) analysis (Item 9)
``   viii) Assessment of cod in Divs. 3NO

2. Coastal States
    a) Request by Denmark (Greenland) for Advice on Management in 2018 (Annex 2)
        i) Golden redfish, demersal deep-sea redfish, Atlantic wolffish and spotted wolfish (Item 1)

        - ii) *Pandalus borealis* east of Greenland and in the Denmark Strait (in conjunction with ICES). (Item 4)
    - b) Request by Canada and Greenland for Advice on Management in 2018 (Annex 2, Annex 3)
        - i) Greenland halibut in Div. 0A and the offshore area of Div. 1A, plus Div. 1B (Annex 2, Item 3; Annex 3, Item 1)
        - ii) *Pandalus borealis* in SA 0+1 (Annex 2, Item 5; Annex 3, Item 2)

VIII. Review of Future Meetings Arrangements

1. Scientific Council (in conjunction with NIPAG), 2017
2. Scientific Council, 18 – 22 Sep. 2017
3. Scientific Council, June 2018
4. Scientific Council (in conjunction with NIPAG), 2018
5. Scientific Council, Sep. 2018
6. NAFO/ICES Joint Groups
    - a) NIPAG, 2017
    - b) NIPAG, 2018
7. WG-ESA, 7 – 16 Nov. 2017
8. WG-DEC
9. WG-HARP
10. 3M Cod benchmark

IX. Arrangements for Special Sessions

1. Topics for future Special Sessions

X. Meeting Reports

1. Working Group on Ecosystem Science and Assessment (WG-ESA), Nov. 2016
2. Report from ICES-NAFO Working Group on Deep-water Ecosystems (WG-DEC), Mar. 2017
3. Report from Joint FC-SC Working Group on Risk Based Management Strategies (WG-RBMS), Feb. 2017 and Apr. 2017
4. Report from Joint FC-SC Working Group on Catch Reporting (WG-CR), Feb. 2017 and Apr. 2017
6. Meetings attended by the Secretariat

XI. Review of Scientific Council Working Procedures/Protocol

1. General Plan of Work for September 2017 Annual Meeting
2. Other Matters

XII. Other Matters

1. Designated Experts
2. Stock Assessment spreadsheets
3. Scientific Merit Awards
4. Budget items
5. Other Business

XIII. Adoption of Committee Reports

1. STACFEN
2. STACREC
3. STACPUB
4. STACFIS

XIV. Scientific Council Recommendations to General Council and Fisheries Commission

XV. Adoption of Scientific Council Report

XVI. Adjournment

PROVISIONAL TIMETABLE

Scientific Council Meeting, 01-15 June 2017

Date	Time	Schedule
01 June (Thursday)	0900	Registration, network connection
	0900-0930	SC Executive
	1000-1030	SC Opening
	1100-1200	STACFIS (Catch WG report, status of documentation, interim monitoring reports)
	1200-1300	Break
	1300-1800	STACFIS
02 June (Friday)	0900-1200	STACFEN
	1300-1800	Scientific Council/STACFIS
	1830-2030	Scientific Council Reception
03 June (Saturday)	0900-1200	STACPUB
	1300-1800	Scientific Council/STACFIS
	1830-2030	Scientific Council Reception
04 June (Sunday)	No meetings	
05 June (Monday)	0900-1800	STACREC
06 June (Tuesday)	0900-1200	STACFIS
	1300-1800	STACFIS
07 June (Wednesday)	0900-1800	STACFIS
08 June (Thursday)	0900-1800	STACFIS
09 June (Friday)	0900-1800	STACFIS Reports
10 June (Saturday)	0830	Scientific Council Executive
	0900-1800	Scientific Council (Standing Committee Reports)
11 June (Sunday)	No meetings	
12 June (Monday)	0900-1800	Scientific Council
13 June (Tuesday)	0900-1800	Scientific Council
14 June (Wednesday)	0900-1800	Scientific Council
15 June (Thursday)	0900-1800	Scientific Council (advice and adoption of Reports)

ANNEX 1. FISHERIES COMMISSION'S REQUEST FOR SCIENTIFIC ADVICE ON MANAGEMENT IN 2018 AND BEYOND OF CERTAIN STOCKS IN SUBAREAS 2, 3 AND 4 AND OTHER MATTERS

1. Fisheries Commission requests that the Scientific Council provide advice for the management of the fish stocks below according to the assessment frequency presented below. The advice should be provided as a range of management options and a risk analysis for each option (rather than a single TAC recommendation).

Yearly basis	Two year basis	Three year basis
Northern shrimp in Div. 3LNO Cod in Div. 3M	American plaice in Div. 3LNO Redfish in Div. 3M Northern shrimp in Div. 3M Thorny skate in Div. 3LNO White hake in Div. 3NO Witch flounder in Div. 3NO	American plaice in Div. 3M Capelin in Div. 3NO Cod in Div. 3NO Northern shortfin squid in SA 3+4 Redfish in Div. 3O Witch flounder in Div. 2J+3KL Yellowtail flounder in Div. 3LNO

To implement this schedule of assessments, the Scientific Council is requested to conduct the assessment of these stocks as follows:

In 2017, advice should be provided for 2018 for Northern shrimp in NAFO Div. 3LNO and Cod in Div 3M*.

In 2017, advice should be provided for 2018 and 2019 for ,Redfish in 3M, Witch flounder in 3NO, Shrimp in 3M and White hake in Div. 3NO

In 2017, advice should be provided for 2018, 2019 and 2020 for Cod in 3NO, American plaice in Div. 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.

The Fisheries Commission also requests the Scientific Council to continue to monitor the status of all these 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 Fisheries Commission requests the SC to implement the steps of the work plan relevant to the SC for progression of the Greenland halibut Management Strategy Evaluation Review (FC Working Paper 16/11 Rev 2 adopted at the NAFO 2017 annual meeting).
3. FC requests that Scientific Council continue its risk assessment of scientific trawl surveys impact on VME in closed areas, and the effect of excluding surveys from these areas on stock assessments.
4. The Fisheries Commission requests the SC, based on analysis of the 2016 haul by haul data and patterns of fishing activity, to examine relative levels of by-catch and discards of 3M cod/redfish, and stocks under moratoria in the different circumstances (e.g. fisheries areas, season, fleets, depths, timing).
5. The stock of redfish 3M covers catches of three Sebastes species and the scientific advice is based on data of only two species (S. mentella and S. fasciatus). Golden redfish, Sebastes marinus (aka norvegicus), represents part of the catch but has not yet been subject to a full assessment in NAFO. The Scientific Council is requested to conduct a full assessment on 3M golden Redfish in June 2017 .The Scientific Council is also requested to advice on the implications for the three species in terms of catch reporting and stock management.
6. In relation to the assessment of NAFO bottom fisheries , the Fisheries Commission endorsed the next re-assessment in 2021 and that the SC should:
    a. Assess the overlap of NAFO fisheries with VME to evaluate fishery specific impacts in addition to the cumulative impacts;
    b. Consider clearer objective ranking processes and options for objective weighting criteria for the overall assessment of risk;

   c. Maintain efforts to assess all of the six FAO criteria (Article 18 of the FAO International Guidelines for the Management of Deep Sea Fisheries in the High Seas) including the three FAO functional SAI criteria which could not be evaluated in the current assessment (recovery potential, ecosystem function alteration, and impact relative to habitat use duration of VME indicator species).

   d. Continue to work on non-sponge and coral VMEs (for example bryozoan and sea squirts) to prepare for the next assessment.

   e. the SC further develop and compile identification guides for fishes (e.g. sharks and skates) that could be provided to observers.

7. The Fisheries Commission requests the SC to continue progression on the review of the NAFO PA Framework.
8. Fisheries Commission requests the Scientific Council, by their 2018 annual meeting engage with relevant experts as needed, review the available information on the life history, population status, and current fishing mortality of Greenland sharks (Somniosus microcephalus), on longevity and records of Greenland shark bycatch in NAFO fisheries, and develop advice for management, in line with the precautionary approach, for consideration by the Fisheries Commission.
9. Fisheries Commission requests the Scientific Council start working on and finalizing by SC 2018 a strategic scientific plan based on a Strength, Weaknesses, Opportunities and Threats (SWOT) analysis defining the strategy and the mid and long term objectives and tasks in view of NAFO's amended convention objectives. The plan should define for each strategic objective goals, tasks and measurable targets.

* 3M Cod Benchmark process has been delayed at the request of the Fisheries Commission in favour of the Greenland Halibut MSE work plan

ANNEX A: Guidance for providing advice on Stocks Assessed with an Analytical Model

The Fisheries 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_{2016}, F_{2016}, 125% F_{2016},
- For stocks under a moratorium to direct fishing: F_{2016}, 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(B2019 > B2016)
F in 2017 and following years*	Yield 2018 (50%)	Yield 2019 (50%)	Yield 2020 (50%)	2017	2018	2019	2017	2018	2019	2017	2018	2019	2017	2018	2019	
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_{2016}	t	t	t	%	%	%	%	%	%	%	%	%	%	%	%	%
F_{2015}	t	t	t	%	%	%	%	%	%	%	%	%	%	%	%	%
1.25 X F_{2016}	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_{2016}, F_{2016}, 125% F_{2016},
- For stocks under a moratorium to direct fishing: F_{2015}, 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(B2019 > B2016)
F in 2017 and following years*	Yield 2018	Yield 2019	Yield 2020	2017	2018	2019	2017	2018	2019	2017	2018	2019	2017	2018	2019	
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_{2016}	t	t	t	%	%	%	%	%	%	%	%	%	%	%	%	%
F_{2015}	t	t	t	%	%	%	%	%	%	%	%	%	%	%	%	%
1.25 X F_{2016}	t	t	t	%	%	%	%	%	%	%	%	%	%	%	%	%

ANNEX B. Guidance for providing advice on Stocks Assessed without a Population Model

For those resources for which only general biological and/or catch data are available, few standard criteria exist on which to base advice. The stock status should be evaluated in the context of management requirements for long-term sustainability and the advice provided should be consistent with the precautionary approach.

The following graphs should be presented, for one or several surveys, for the longest time-period possible:

a) time trends of survey abundance estimates
b) an age or size range chosen to represent the spawning population
c) an age or size-range chosen to represent the exploited population
d) recruitment proxy or index for an age or size-range chosen to represent the recruiting population.
e) fishing mortality proxy, such as the ratio of reported commercial catches to a measure of the exploited population.
f) Stock trajectory against reference points

And any information the Scientific Council deems appropriate.

ANNEX 2. DENMARK (ON BEHALF OF GREENLAND) REQUEST FOR SCIENTIFIC ADVICE ON MANAGEMENT IN 2018 OF CERTAIN STOCKS IN SUBAREAS 0 AND 1

1. **Golden Redfish, Demersal deep-sea Redfish, Atlantic Wolffish and Spotted Wolffish:** Advice on Golden Redfish (Sebastes marinus), Demersal Deep-sea Redfish (Sebastes mentella), Atlantic Wolffish (Anarhichas lupus) and Spotted Wolffish (Anarhichas minor) in Subarea 1 was in 2014 given for 2015-2017. Denmark (on behalf of Greenland) requests the Scientific Council for advice on these species.
2. **Greenland Halibut, offshore: For Greenland Halibut in subareas O + 1 advice was in 2016 given for 2017 and 2018.** Subject to the concurrence of Canada as regards Subareas O and 1, the Scientific Council is requested to continue to monitor the status, and should significant changes in the stock status be observed the Scientific Council is requested to provide updated advice as appropriate for Greenland Halibut in 1) the offshore areas of NAFO Division OA and Division 1A plus Division 1B and 2) NAFO Division OB plus Divisions 1C-1F. The Scientific Council is also asked to advise on any other management measures it deems appropriate to ensure the sustainability of these resources.
3. **Greenland Halibut, inshore, Northwest Greenland:** Advice on Greenland Halibut in Division 1A inshore was in 2016 given for 2017-2018. Denmark (on behalf of Greenland) requests the Scientific Council to continue to monitor the status, and should significant changes in the stock status be observed the Scientific Council is requested to provide updated advice as appropriate.
4. **Northern Shrimp, West Greenland:** Subject to the concurrence of Canada as regards Subarea O and 1, Denmark (on behalf of Greenland) requests the Scientific Council before December 2017 to provide advice on the scientific basis for management of Northern Shrimp (Panda/us borealis) in Subarea O and 1 in 2018 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 borealis) in Denmark Strait and adjacent waters east of southern Greenland in 2018 and for as many years ahead as data allows for.

ANNEX 3. REQUESTS FOR ADVICE FROM CANADA

1. Greenland halibut (Subareas 0 and 1)

Advice on Greenland Halibut in Subareas 0 and 1 was provided in 2016 for 2017 and 2018. Therefore, Canada requests the Scientific Council to continue to monitor the status of this stock annually and, should a significant change be observed in stock status (e.g. from surveys) or in bycatches in other fisheries, provide updated advice as appropriate.

2. Shrimp (Divisions 0A and Subarea 1)

Canada requests the Scientific Council to consider the following options in assessing and projecting future stock levels for Shrimp in Subareas 0 and 1:

The status of the stock should be determined and management options evaluated for catch options ranging from 30,000 t to the catch corresponding to Z_{MSY}, in 5,000-10,000 t increments (subject to the discretion of Scientific Council), with forecasts for the next 5 years if possible. These options should be evaluated in relation to the Northwest Atlantic Fisheries Organization Precautionary Approach Framework and presented in the form of risk analyses related to the limit reference points B_{lim} and Z_{MSY}.

Presentation of the results should include graphs and/or tables related to the following:

- historical and current yield, biomass relative to B_{MSY}, total mortality relative to Z_{MSY}, and recruitment (or proxy) levels for the longest time period possible;
- total mortality (Z) and fishable biomass for a range of projected catch options (as noted above) for the years 2018 to 2022 if possible. Projections should include both catch options and a range of effective cod predation biomass levels considered appropriate by the Scientific Council. Results should include risk analyses of falling below: B_{MSY}, 80% B_{MSY} and B_{lim}, and of exceeding Z_{MSY};
- total area fished for the longest time period possible; and
- any other graph or table the Scientific Council deems relevant.

APPENDIX VI. LIST OF SCR AND SCS DOCUMENTS, 01 – 15 JUNE 2017

SCR Documents

Doc No.	Serial No	Author(s)	Title
SCR Doc. 17-001	N6641	J. Mortensen	Report on hydrographic conditions off Southwest Greenland June/July 2016
SCR Doc. 17-002	N6644	R. A. Rademeyer and D. S. Butterworth	Initial Applications of Statistical Catch-at-Age Assessment Methodology to the Greenland Halibut Resource
SCR Doc. 17-003	N6645	R. A. Rademeyer and D. S. Butterworth	Management Procedures for Greenland Halibut
SCR Doc. 17-004	N6648	A. Ávila de Melo	On the threshold of a XSA 2017 assessment of Greenland halibut on Div. 2J and Div. 3KLMNO: considerations on input framework and settings for an alternate approach to the 2010 assessment
SCR Doc. 17-005	N6649	R. A. Rademeyer and D. S. Butterworth	Examples of Management Procedure Outputs for Greenland Halibut
SCR Doc. 17-006	N6651	M. J. Morgan	Surplus production models in a Bayesian framework applied to Greenland halibut in SA2+Div 3KLMNO
SCR Doc. 17-007	N6652	B. Cisewski	Hydrographic conditions off West Greenland in 2016
SCR Doc. 17-008	N6653	P. Fratantoni	Hydrographic Conditions on the Northeast United States Continental Shelf in 2016 – NAFO Subareas 5 and 6
SCR Doc. 17-009	N6654	D. Herbert and R.G. Pettipas	Physical Oceanographic Conditions on the Scotian Shelf and in the eastern Gulf of Maine (NAFO Divisions 4V,W, X) during 2016
SCR Doc. 17-010	N6659	P. Regular, N. G. Cadigan, M. J. Morgan and B. P. Healey.	A Simple SAM-style State-Space Stock Assessment Model for Greenland Halibut in NAFO Subarea 2 and Divisions 3KLMNO
SCR Doc. 17-011	N6662	E. Colbourne, J. Holden, S. Lewis, D. Senciall, W. Bailey, S. Snook and J. Higdon	Physical Oceanographic Environment on the Newfoundland and Labrador Shelf in NAFO Subareas 2 and 3 during 2016
SCR Doc. 17-012	N6663	G. Maillet, P. Pepin, C. Johnson, S. Plourde, B. Casault, E. Devred, P.S. Galbraith, C. Caverhill, L. Devine, M. Scarratt, M. Starr, E. Head, J. Spry, C. Porter, A. Cogswell, J.F. St-Pierre, L. St-Amand, P. Joly, S. Fraser, G. Doyle, A. Robar, J. Higdon and H. Maass	Biological Oceanographic Conditions in the Northwest Atlantic During 2016
SCR Doc. 17-013	N6664	E. Román, C. González-Iglesias and D. González-Troncoso	Results for the Spanish Survey in the NAFO Regulatory Area of Division 3L for the period 2003-2016

SCR Doc. 17-014	N6666	H. Fock, K.-Michael Werner and C. Stransky	Survey effort in the German bottom trawl survey 1982-2016 with special reference to 2016 survey
SCR Doc. 17-015	N6667	R. Nygaard and O. Jørgensen	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), 1990-2016
SCR Doc. 17-016	N6668	E. Román, C.n González-Iglesias, D. González-Troncoso and M. 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 2003-2016
SCR Doc. 17-017	N6669	C. Fernández, D. González Troncoso, F. González-Costas, C. Hvingel, R. Alpoim, S. Cerviño, M. Mandado and A. Pérez	Cod 3M Projections: risk estimation and inputs
SCR Doc. 17-018	N6670	D. González-Troncoso, A. Gago, A. Nogueira and E. Román	Results for Greenland halibut, American plaice and Atlantic cod of the Spanish survey in NAFO Div. 3NO for the period 1997-2016
SCR Doc. 17-019	N6671	D. González-Troncoso, A. Gago and A. Nogueira	Biomass and length distribution for roughhead grenadier, thorny skate and white hake from the surveys conducted by Spain in NAFO 3NO
SCR Doc. 17-020	N6672	D. González-Troncoso, A. Gago and A. Nogueira	Yellowtail flounder, redfish (*Sebastes spp.*) and witch flounder indices from the Spanish Survey conducted in Divisions 3NO of the NAFO Regulatory Area
SCR Doc. 17-021	N6673	O.A. Jørgensen	Survey for Greenland Halibut in NAFO Divisions 1C-1D, 2016
SCR Doc. 17-022	N6674	M. Ouellet	NAFO STACFEN Report 2016
SCR Doc. 17-023	N6675	F. González-Costas and G. Ramilo	Greenland sharks (*Somniosus microcephalus*) Spanish data (Surveys and Fishery) in NAFO Regulatory Area.
SCR Doc. 17-024	N6676	J. M. Casas Sánchez and D. González Troncoso	Results from Bottom Trawl Survey on Flemish Cap of June-July 2016
SCR Doc. 17-025	N6677	D. Power	Standardized Catch Rate Indices for Greenland Halibut in SA2+3KLMNO
SCR Doc. 17-026	N6678	RA Rademeyer and DS Butterworth	Results for Initial Candidate Management Procedure Testing for Greenland Halibut
SCR Doc. 17-027	N6679	R.M. Rideout and N. Ollerhead	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
SCR Doc. 17-028	N6680	M. Treble	Report on Greenland halibut caught during the 2016 trawl survey in Divisions 0A and 0B
SCR Doc. 17-029	N6682	M. Ringuette	Conditions in the Lab Sea in 2016
SCR Doc. 17-030	N6683	R. Nygaard	Trawl, gillnet and longline survey results from surveys conducted by the Greenland Institute of Natural Resources in NAFO Division 1A Inshore

SCR Doc. 17-031	N6685	F. Rigét and R. Nygaard	Greenland Institute of Natural Resources, P.O. Box 570, 3900 Nuuk, Greenland
SCR Doc. 17-032	N6687	A. Ávila de Melo, F. Saborido-Rey, M. Fabeiro, S. Rábade, D. González Troncoso, F. González-Costas, M. Pochtar and R. Alpoim	An assessment of beaked redfish (*S. mentella and S. fasciatus*) in NAFO Division 3M, from a biological based approach to recent levels of natural mortality (2011-2016)
SCR Doc. 17-033	N6688	M. R. Simpson and C. M. Miri	An Assessment of White Hake (*Urophycis tenuis*, Mitchill 1815) in NAFO Divisions 3N, 3O, and Subdivision 3Ps
SCR Doc. 17-034	N6689	V. Korzhev and M. Pochtar	Simulation of The Flemish Cap Bank Redfish Fishery Taking Into Account Dependence Of The Parameters On Stock Density
SCR Doc. 17-035	N6690	R. A. Rademeyer and D. S. Butterworth	Statistical Catch-at-Age Operating Models for the Greenland Halibut Resource
SCR Doc. 17-036	N6691	R. Nygaard	Assessment of wolffish in NAFO subarea 1
SCR Doc. 17-037	N6692	R. A. Rademeyer and D. S. Butterworth	CMP projections under XSA in comparison to the SCAA baseline (OM0)
SCR Doc. 17-038	N6693	D. González-Troncoso	Assessment of the Cod Stock in NAFO Division 3M
SCR Doc. 17-039	N6694	R. Nygaard	Assessment of Demersal Redfish in NAFO Subarea 1
SCR Doc. 17-040	N6695	K. Dwyer and B. Healey	eXtended Survivor's Analysis (XSA) update runs for Greenland Halibut in SA 2 + Div. 3KLMNO
SCR Doc. 17-041	N6696	R. Nygaard	An assessment of Greenland Halibut Stock Component in NAFO Division 1A Inshore.
SCR Doc. 17-042	N6698	R.M. Rideout, D.W. Ings and J. Brattey	An Assessment of the Cod Stock in NAFO Divisions 3NO
SCR Doc. 17-043	N6699	R. Alpoim	3M American Plaice
SCR Doc. 17-044	N6700	R. M. Rideout, D. Power, D. W. Ings, L. Wheeland and B. P. Healey	Canadian multi-species bottom trawl surveys in NAFO subarea 2 + Divisions 3KLNO: Vessel performance, catch distribution and survey biomass trends of key finfish resources with emphasis on 2016.
SCR Doc. 17-045	N6701	M.J. Morgan and L. J. Wheeland	Greenland halibut (*Reinhardtius hippoglossoides*) in NAFO Subarea 2 and Divisions 3KLMNO: stock trends based on annual Canadian research vessel survey results

SCS Documents			
Doc No.	**Serial No**	**Author**	**Title**
SCS Doc. 17-01	N6637	NAFO	FC Requests to SC 2017
SCS Doc. 17-02	N6642	Denmark	Denmark (on behalf of Greenland) Requests for Scientific Advice on Management in 2018 of Certain Stocks in Subarea O and 1.
SCS Doc. 17-03	N6647	Canada	Canada's Request for Coastal State Advice - 2018
SCS Doc. 17-04	N6656	F. González-Costas, G. Ramilo, E. Román, A. Gago, M. Casas, M. Sacau, E. Guijarro D. González-Troncoso and. J. Lorenzo	Spanish Research Report for 2016
SCS Doc. 17-05	N6658	J. Vargas, R. Alpoim, E. Santos and A. M. Ávila de Melo	Portuguese Research Report for 2016
SCS Doc. 17-06	N6660	L. Ridao Cruz	Faroese Research Report for 2016
SCS Doc. 17-07	N6661	Centro Oceanográfico de Vigo	NAFO Cod 3M Workshop Current Assessment and Projection Uncertainties
SCS Doc. 17-08	N6665	Greenland Institute of Natural Resources	Denmark/Greenland Research Report for 2016
SCS Doc. 17-09	N6681	K.Hubel and S.Sirp	Estonian Research Report for 2016
SCS Doc. 17-10	N6684	NAFO Secretariat	Tagging 2016
SCS Doc. 17-11	N6686	K. Fomin and M.Pochtar	Russian Research Report for 2016
SCS Doc. 17-12	N6697	M.L. Traver and K.A. Sosebee	United States Research Report for 2016
SCS Doc. 17-13	N6704	D. Power and D. Richards	Canadian Research Report for 2016 Newfoundland and Labrador Region

APPENDIX VII. LIST OF PARTICPANTS, 01 – 15 JUNE 2017

CANADA	
Cogswell, Andrew	Fisheries & Oceans Canada, BIO, P. O. Box 1006, Dartmouth, N.S. B2Y 4A2 Tel.: +902-426-2030 - E-mail: Andrew.cogswell@dfo-mpo.gc.ca
Colbourne, Eugene	Science Branch, Fisheries & Oceans Canada, P.O. Box 5667, St. John's, NL. A1C 5X1 Tel.: +709-772-6106 - E-mail: eugene.colbourne@dfo-mpo.gc.ca
Cyr, Frederic	Science Branch, Fisheries & Oceans Canada, P.O. Box 5667, St. John's, NL. A1C 5X1 Tel.: +709-986-6622 - E-mail: Frederic.Cyr@dfo-mpo.gc.ca
Dwyer, Karen	Science Branch, Fisheries & Oceans Canada, P.O. Box 5667, St. John's, NL. A1C 5X1 Tel.: +709-772-0573 - E-mail: karen.dwyer@dfo-mpo.gc.ca
Healey, Brian	Science Branch, Fisheries & Oceans Canada, P.O. Box 5667, St. John's, NL. A1C 5X1 Tel.: +709-772-8674 - E-mail: brian.healey@dfo-mpo.gc.ca
Ings, Danny	Science Branch, Fisheries & Oceans Canada, P.O. Box 5667, St. John's, NL. A1C 5X1 E-mail: danny.ings@dfo-mpo.gc.ca
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
Lee, Eugene	Science Branch, Fisheries & Oceans Canada, P.O. Box 5667, St. John's, NL. A1C 5X1 E-mail: Eugene.lee@dfo-mpo.gc.ca
Maillet, Gary	Science Branch, Fisheries & Oceans Canada, P.O. Box 5667, St. John's, NL. A1C 5X1 Tel. +709-772-7675 - E-mail: gary.maillet@dfo-mpo.gc.ca
Maddock Parsons, Dawn	Science Branch, Fisheries & Oceans Canada, P.O. Box 5667, St. John's, NL. A1C 5X1 Tel. +709-772- 2495 - E-mail: Dawn.Parsons@dfo-mpo.gc.ca
Morgan, Joanne	Science Branch, Fisheries & Oceans Canada, P. O. Box 5667, St. John's, NL A1C 5X1 Tel.: +709-772-2261 - E-mail: joanne.morgan@dfo-mpo.gc.ca
Ouellet, Mathieu	Oceanography and Scientific Data branch (OSD) Fisheries and Oceans Canada (DFO) 200 Kent Street, Ottawa, ON, Canada K1A0E6 E-mail: info@dfo-mpo.gc.ca
Pepin, Pierre	Fisheries & Oceans Canada, P. O. Box 5667, St. John's, NL A1C 5X1 Email: pierre.pepin@dfo-mpo.gc.ca
Power, Don	Science Branch., Fisheries & Oceans Canada, P.O. Box 5667, St. John's, NL. A1C 5X1 Tel.: +709-772-4935 – E-mail: don.power@dfo-mpo.gc.ca
Regular, Paul	Research Scientist, Fisheries & Oceans Canada, P. O. Box 5667, St. John's, NL A1C 5X1 Tel.: 709-772-2067 – E-mail: paul.regular@dfo-mpo.gc.ca
Rideout, Rick	Science Branch, Fisheries & Oceans Canada, P.O. Box 5667, St. John's, NL. A1C 5X1 Tel.: +709-772-6975 – E-mail: rick.rideout@dfo-mpo.gc.ca
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
Simpson, Mark	Science Branch, Fisheries & Oceans Canada, P.O. Box 5667, St. John's, NL. A1C 5X1

	Tel.: +709-772-4841 - E-mail: mark.r.simpson@dfo-mpo.gc.ca
Treble, Margaret	Fisheries & Oceans Canada, Freshwater Inst., 501 University Cres., Winnipeg, MT R3T 2N6 Tel.: +204-984-0985 - E-mail: margaret.treble@dfo-mpo.gc.ca
Wheeland, Laura	Science Branch, Fisheries & Oceans Canada, P.O. Box 5667, St. John's, NL. A1C 5X1 Tel.: +709-687-8357 - E-mail: Laura.Wheeland@dfo-mpo.gc.ca
DENMARK (IN RESPECT OF FAROE ISLANDS + GREENLAND)	
Jørgensen, Ole	DTU-AQUA Technical University of Denmark, Charlottenlund Slot, DK-2920 Charlottenlund, Denmark Tel.: +45 3588 3300 - E-mail : olj@aqua.dtu.dk
Nogueira, Adriana	Greenland Institute of Natural Resources, P.O. Box 570, DK-3900 Nuuk, Greenland Tel.: +299 361200 - E-mail: adno@natur.gl
Nygaard, Rasmus	Greenland Institute of Natural Resources, P.O. Box 570, DK-3900 Nuuk, Greenland Tel.: +299 361200 - E-mail: rany@natur.gl
Ridao Cruz, Luis	Faroe Marine Research Institute, Nóatún 1, P.O. Box 3051, FO-110 Tórshavn, Faroe Islands Tel.: +298 353900 - E-mail: luisr@hav.fo
EUROPEAN UNION	
Alpoim, Ricardo	Instituto Portugues do Mar e da Atmosfera, Rua Alfredo Magalhães Ramalho, nº6, 1495-006 Lisboa, Portugal Tel: +351 213 02 70 00 – Email: ralpoim@ipma.pt
Ávila de Melo, António	Instituto Portugues do Mar e da Atmosfera, Rua Alfredo Magalhães Ramalho, nº6, 1495-006 Lisboa, Portugal Tel.: +351 21 302 7000 - E-mail: amelo@ipma.pt
Cisewski, Boris (via WebEx)	Institut fur Seefischerei, Palmaille 9, D-22767, Hamburg, Federal REpublic of Germany Tel.: +49 40 38905169 – E-mail: boris.cisewski@ti.bund.de
González-Troncoso, Diana	Instituto Español de Oceanografia, Aptdo 1552, E-36280 Vigo (Pontevedra), Spain Tel.: +34 9 86 49 2111 - E-mail: diana.gonzalez@ieo.es
González-Costas, Fernando	Instituto Español de Oceanografia, Aptdo 1552, E-36280 Vigo (Pontevedra), Spain Tel.: +34 9 86 49 2111 - E-mail: fernando.gonzalez@ieo.es
Kenny, Andrew	CEFAS, Lowestoft Laboratory, Lowestoft, UK E-mail: andrew.kenny@cefas.co.uk
Rodriguez-Alfaro, Sebastián	Policy/Scientific Officer, International Affairs, European Commission, Directorate General for Fisheries and Maritime Affairs (DG MARE.C3), Rue Joseph II, 99, 1000 Brussels, Belgium Tel.: +32 2 29 570 43 – E-mail: Sebastian.rodriguez-alfaro@ec.europa.eu
Sacau Cuadrado, Mar	Instituto Español de Oceanografia, Aptdo 1552, E-36280 Vigo (Pontevedra), Spain E-mail: mar.sacau@ieo.es

Vigneau, Joël	IFREMER, Station de Port-en-Bessin, P. O. Box 32, 14520 Port-en-Bessin, France Tel.: +33 231 515 600 - E-mail: joel.vigneau@ifremer.fr
JAPAN	
Butterworth, Doug S.	Emeritus Professor, Department of Mathematics and Applied Mathematics, University of Cape Town, Rondebosch 7701 South Africa Tel: +27 21 650 2343 – E-mail: doug.butterworth@uct.ac.za
Nishida, Tom	Associate Scientist, National Research Institute of Far Seas Fisheries, Agency, 5-7-1, Orido, Shimizu-Ward, Shizuoka-City, Shizuoka, Japan Tel: +81 (54) 336 5834– E-mail: tnishida@affrc.go.jp to
NORWAY	
Hvingel, Carsten	Institute of Marine Research, P.O. Box 1870, N-5817 Bergen, Norway Tel.: +47 77609750 – E-mail: carsten.hvingel@imr.no
RUSSIAN FEDERATION	
Babayan, Vladimir	Russian Federal Research Institute of Fisheries & Oceanography (VNIRO), K. 17, V. Krasnoselskaya, Moscow, 107140 Tel.: +499 264 9078 – E-mail: vbabayan@vniro.ru
Fomin, Konstantin	Knipovich Polar Research Institute of Marine Fisheries and Oceanography (PINRO), 6 Knipovich St., Murmansk 183763 Tel.: +7 8152 436 177 - E-mail:fomin@pinro.ru
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
Tretiakov, Ivan	Knipovich Polar Research Institute of Marine Fisheries and Oceanography (PINRO), 6 Knipovich St., Murmansk 183763 Tel.: +7 8152 47 2469 - E-mail: tis@pinro.ru
UNITED STATES OF AMERICA	
Cotton, Charles	Assistant Research Faculty, Florida State University Coastal and Marine Lab, 3618 Coastal Hwy 98 St. Teresa, FL 32358 Tel.: +850 697-4092 – E-mail: ccotton@fsu.edu
Fordham, Sonja	Shark Advocates International, c/o The Ocean Foundation, 1320 19th Street, NW, Fifth Floor, Washington, DC 20036, USA E-mail: info@sharkadvocates.org
Gardner, Susan	Deputy Science and Research Director, Northeast Fisheries Science Center, US Department of Commerce, NOAA Fisheries, 166 Water St., Woods Hole, Massachusetts 02543 Tel.: +508-495-2233 – E-mail: susan.gardner@noaa.gov
Hendrickson, Lisa	Research Fishery Biologist, National Marine Fisheries Service, National Oceanic and Atmospheric Administration (NOAA), 166 Water St., Woods Hole, MA 02543 E-mail: lisa.hendrickson@noaa.gov
Sosebee, Katherine	National Marine Fisheries Service, NEFSC, 166 Water St., Woods Hole, MA 02543 Tel.: +508-495-2372 - E-mail: katherine.sosebee@noaa.gov

EXPERTS/ADVISORS	
Konrad, Christoph	Senior Ecologist, Amec Foster Wheeler, 133 Crosbie Road, St. John's, NL A1B 1H3 Tel.: +709 722 7023 - E-mail: christoph.konrad@amecfw.com
Cadigan, Noel	Centre for Fisheries Ecosystems Research, Fisheries and Marine Institute of Memorial University of Newfoundland, P.O. Box 4920 St. John's, NL A1C 5R3, Canada Email: Noel.Cadigan@mi.mun.ca
OBSERVERS	
Cadman, Rachel	Dalhousie University, 6100 University Avenue, PO Box 15000, Halifax, NS, B3H 4R2 E-mail: r.cadman@dal.ca
McLeod, Ainslie	Ecology Action Centre, 2705 Fern Lane, Halifax, NS, B3K 4L3 E-mail: ainslie.mcleod@dal.ca
McNeil, Aaron	E-mail: a.macneil@dal.ca
Schleit, Katie	Ecology Action Centre, 2705 Fern Lane, Halifax, NS, B3K 4L3 Tel.: +902 446-4840 - E-mail: KSchleit@ecologyaction.ca
Soomai, Suzuette	Post Doctoral Fellow, Faculty of Management, Dalhousie University, Suite 4010, Kenneth C. Rowe Management Building, 6100 University Avenue, PO Box 15000, Halifax, Nova Scotia, B3H 4R2 E-mail: suzuette.soomai@dal.ca

NAFO SECRETARIAT		
Fred Kingston	Executive Secretary	fkingston@nafo.int
Tom Blasdale	Scientific Council Coordinator	tblasdale@nafo.int
Dayna Bell MacCallum	Scientific Information Administrator	dbell@nafo.int
Ricardo Federizon	Senior Fisheries Commission Coordinator	rfederizon@nafo.int
Jana Aker	Fisheries Information Administrator	jaker@nafo.int
Alexis Pacey	Publications Manager	apacey@nafo.int
Matthew Kendall	IT Manager	mkendall@nafo.int
Sarah Guile	Office Administrator	sguile@nafo.int