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Northwest Atlantic Fisheries Organization

Report of the Scientific Council Meeting

01 -14 June 2018
Halifax, Nova Scotia

NAFO
Dartmouth, Nova Scotia, Canada
2018

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Scientific Council June Meeting Participants
01 – 14 June 2018

Scientific Council Participants 2018

Scientific Council Chairs

From left to right: Eugene Colbourne (Interim Chair of STACFEN), Brian Healey (Chair of Scientific Council), Karen Dwyer (Chair of STACFIS), Tom Blasdale (Scientific Council Coordinator), Carmen Fernandez (Vice-Chair of Scientific Council and Chair of STACREC), and Margaret Treble (Chair of STACPUB)

REPORT OF SCIENTIFIC COUNCIL MEETING
01 -14 June 2018

Chair: Brian Healey Rapporteur: Tom Blasdale

I.PLENARY SESSIONS

The Scientific Council met at the Sobey Building, Saint Mary's University, Halifax, NS, Canada, during 01 – 14 June 2018, to consider the various matters in its Agenda. Representatives attended from Canada, Denmark (in respect of Faroe Islands and Greenland), the European Union (Portugal, Spain, the United Kingdom) Japan, the Russian Federation and the United States of America. Observers from the Ecology Action Centre and the Shark Alliance 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 2018. The provisional agenda was **adopted** with modification. The Scientific Council Coordinator was appointed the rapporteur.

The opening session was adjourned at 1100 hours on 01 June 2018. Several sessions were held throughout the course of the meeting to deal with specific items on the agenda. The Council considered and **adopted** the STACFEN report on 8 June 2018, and the STACPUB, STACFIS and STACREC reports on 13 June 2018.

The concluding session was called to order at 0830 hours on 14 June 2018.

The Council considered and **adopted** the report the Scientific Council Report of this meeting of 01 -14 June 2018. 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 14 June 2018.

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 2017

Recommendations from 2017 are considered in the relevant section of this report.

III.FISHERIES ENVIRONMENT

The Council **adopted** the Report of the Standing Committee on Fisheries Environment (STACFEN), as presented by the Interim Chair, Eugene Colbourne. 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 Secretariat support for an invited speaker to address emerging issues and concerns for the NAFO Convention Area during the 2019 STACFEN Meeting.

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 Secretariat remove the WG-ESA report from the SC Reports (Redbook) and instead include a hyperlink to the report. This will address SC transparency and communication objectives. The Joint NAFO Commission-Scientific Council documents can remain in the Meeting Proceedings of the Commission.*
- STACPUB **recommends** that the Secretariat provide a summary of the 2018 ASFA Board Meeting for the June 2019 STACPUB meeting and that the Secretariat continue to submit SC documents and publications to the ASFA database.
- STACPUB **recommends** that *the Secretariat explore ways to make SC meeting documents from previous meetings available on the SharePoint.*
- STACPUB **recommends** that *the Secretariat provide a group email on the Designated Experts webpage.*
- STACPUB **recommends** that *the Secretariat and the Chair of STACPUB work intersessionally to develop a set of guidelines for the SCS documents, including consideration of the national research reports, and present these for review by STACPUB in June 2019.*
- *STACPUB* recommends *that the Secretariat include a link to the Guidelines in the January letter to ensure SC members are informed as to the requirements determined by SC for these documents.*

V.RESEARCH COORDINATION

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

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

- In 2016, STACREC discussed whether STACFIS catch estimates used in stock assessments should be made available on the NAFO website. Meeting 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 progress, STACREC **recommended** that *the SC chair should initiate discussion with the chairs of FC and GC during the Sept 2016 Annual Meeting. Due to high workload, no progress has occurred to date.*

  In September 2017, it was agreed that the SC Chair would discuss the issue with the NAFO Executive Secretary and the Commission chair to request adding this note of clarification to the STATLANT 21A webpage. STACREC reiterates this **recommendation**.

- STACREC recommends that all surveys should aim to examine redfish composition at the species level, while recognising that this may not always be achievable due to trade-offs between different activities and aims of surveys.

VI.FISHERIES SCIENCE

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

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

VII.MANAGEMENT ADVICE AND RESPONSES TO SPECIAL REQUESTS

1. The NAFO Commission

The Commission requests are given in Annex 1.

The Scientific Council noted the Commission requests for advice on Northern shrimp (Northern shrimp in Div. 3M and Divs. 3LNO (Item 1)) will be undertaken during the Scientific Council meeting on 17 to 23 October 2018.

a) Request for Advice on TACs and Other Management Measures

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

Cod in Division 3M Advice June 2018 for 2019

Recommendation for 2019

Scientific Council notes that the strong year classes of 2009 to 2011 are dominant in the current SSB. Subsequent recruitments are much lower, therefore substantial declines in stock size are expected over the medium term under any option.

For 2019, SC recommends a catch of no more than 20 796 t (yield at ¾ F_{lim}).

Catches above ¾ F_{lim} increase the risk of being below B_{lim} in the medium term.

Management objectives

A management strategy evaluation process has been initiated for this stock by 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	🟢	$F<F_{lim}$
Apply Precautionary Approach	🟢	F_{lim} and B_{lim} defined, HCR in development
Minimise harmful impacts on living marine resources and ecosystems	🟡	VME closures in effect, no specific measures.
Preserve marine biodiversity	⚪	Cannot be evaluated

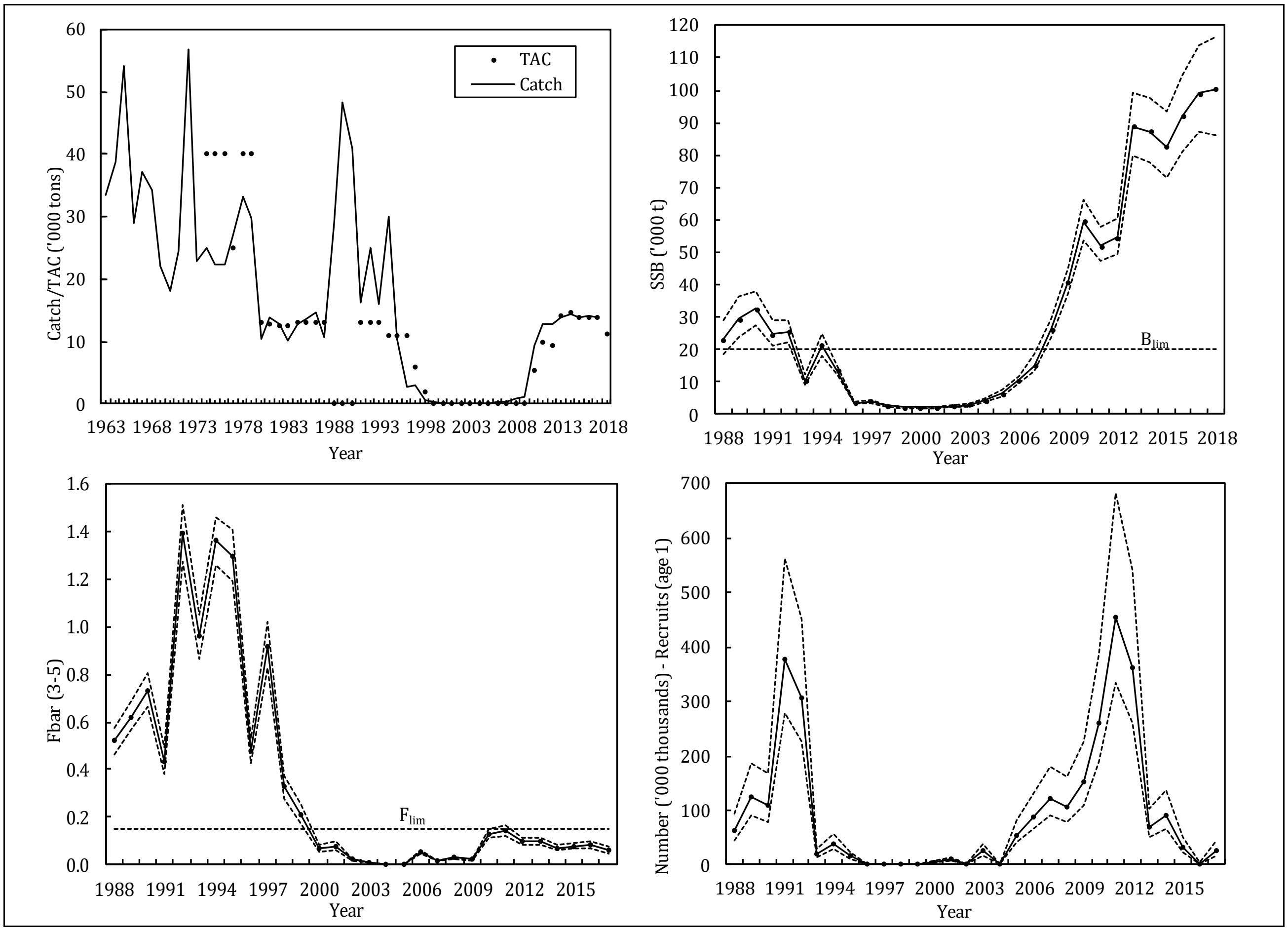
🟢	OK
🟡	Intermediate
🔴	Not accomplished
⚪	Unknown

Management unit

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

Stock status

Current SSB is estimated to be well above B_{lim}. However, since 2015 recruitment has been very low. F increased in 2010 with the re-opening of the fishery although it has remained below F_{lim} (0.153) since 2000.



Reference points

B_{lim}: 20 000 t of spawning biomass (Scientific Council, 2018).
$F_{lim} = F_{30\%SPR}$: 0.153 (Scientific Council, 2018)

Projections

	B		SSB		Yield
	Median and 90% CI				
$F_{bar}=F_{lim}$ (median=0.15)					
2018	108705	(94014 - 125180)	100343	(86263- 116383)	11145
2019	95351	(80800 - 111466)	90123	(76337 - 106201)	26502
2020	51428	(40481 - 64418)	47805	(37198 - 60396)	14260
2021	29467	(20160 - 40273)	26392	(17815 - 36684)	
$F_{bar}=3/4F_{lim}$ (median=0.12)					
2018	108705	(94014 - 125180)	100343	(86263- 116383)	11145
2019	95351	(80800 - 111466)	90123	(76337 - 106201)	20796
2020	56533	(45623 - 69596)	52867	(42341 - 65526)	12359
2021	35407	(26166 - 46024)	32204	(23660 - 42420)	
$F_{bar}=F_{2015-2017}$ (median=0.07)					
2018	108705	(94014 - 125180)	100343	(86263- 116383)	11145
2019	95351	(80800 - 111466)	90123	(76337 - 106201)	13863
2020	62796	(51855 - 75854)	59056	(48509 - 71796)	9191
2021	43374	(34048 - 54034)	39963	(31485 - 50314)	

	Yield			$P(B < B_{lim})$				$P(F > F_{lim})$			
	2018	2019	2020	2018	2019	2020	2021	2018	2019	2020	$P(B_{21} > B_{18})$
$F_{lim} = 0.15$	11145	26502	14260	<1%	<1%	<1%	13%	<1%	50%	50%	<1%
$3/4F_{lim} = 0.12$	11145	20796	12359	<1%	<1%	<1%	1%	<1%	1%	5%	<1%
$F_{2015\text{-}2017} = 0.07$	11145	13863	9191	<1%	<1%	<1%	<1%	<1%	<1%	<1%	<1%

Although advice is given only for 2019, projection results are shown to 2021 to illustrate the medium term implications.

The results indicate that under all scenarios total biomass and SSB during the projected years will decrease sharply. The probability of SSB being below B_{lim} in 2020 is very low (<1%) in all cases. For both $F_{2015\text{-}2017}$ and ¾ F_{lim}, the probability of SSB being below B_{lim} in 2021 is very low (≤1%). However, the probability of being below B_{lim} is 13% if $F = F_{lim}$. The probability of SSB in 2020 or 2021 being above that in 2018 is <1%

Under 3/4 F_{lim} and $F_{2015\text{-}2017}$, the probability of F exceeding F_{lim} is less than or equal to 5%.

Under all scenarios, the projected Yield increases in 2019, but decreases again for 2020.

Assessment

A new Bayesian SCAA model was used as the basis for the assessment of this stock for the first time. This model was approved during the 2018 3M cod benchmark. As a result of poor reliability of catch data prior to 1988, the assessment was conducted from 1988 to 2017.

The results of the Bayesian SCAA model have changed the perception of recent stock size compared to previous assessments. The level of M is higher than that in previous assessments; this may result in higher changes in stock abundance estimates from year to year and also in projections. Higher stock abundance is derived from the Bayesian SCAA, especially since 2010, which implies a higher level of SSB and a lower level of F. Recruitment is estimated at very low levels over the last years, which implies that the SSB is projected to decrease in the near future.

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

Human impact

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

Biological and environmental interactions

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

Fishery

Cod is caught in directed trawl and longline fisheries and as bycatch in the directed redfish fishery by trawlers. The fishery is regulated by quota.

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

,000 tons	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
TAC	ndf	5.5	10.0	9.3	14.1	14.5	13.8	13.9	13.9	11.1
STATLANT 21	1.2	5.2	10.0	9.1	13.5	14.4	12.8	13.8	13.9	
STACFIS	1.2	9.3	12.8	12.8	14.0	14.3	13.8	14.0	13.9	

ndf – no directed fishing

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.

Sources of information

SCS Doc. 18/05, 18/07, 18/08, 18/09, 18/13, 18/14, 18/18; SCR Doc. 95/73, 18/08, 18/38; and NAFO/GC Doc 08/3.

American Plaice in Divisions 3LNO

Advice June 2018 for 2019-2021

Recommendation for 2019-2021

> SSB remains below B_{lim}, therefore Scientific Council recommends that, in accordance with the rebuilding plan, there should be no directed fishing on American plaice in Div. 3LNO in 2019, 2020, and 2021. Bycatches of American plaice should be kept to the lowest possible level and restricted to unavoidable bycatch in fisheries directing for other species.

Management objectives

In 2011 FC adopted an "Interim 3LNO American Plaice Conservation Plan and Rebuilding Strategy" (FC Doc. 11/21). There is a Harvest Control Rule (HCR) in place for this stock.

Convention objectives	*Status*	*Comment/consideration*
Restore to or maintain at B_{msy}	🔴	B<B_{lim}
Eliminate overfishing	🟡	No directed fishery, current bycatches are delaying recovery
Apply Precautionary Approach	🟢	Reference points defined
Minimise harmful impacts on living marine resources and ecosystems	🟡	VME closures in effect, no specific measures.
Preserve marine biodiversity	⚪	Cannot be evaluated

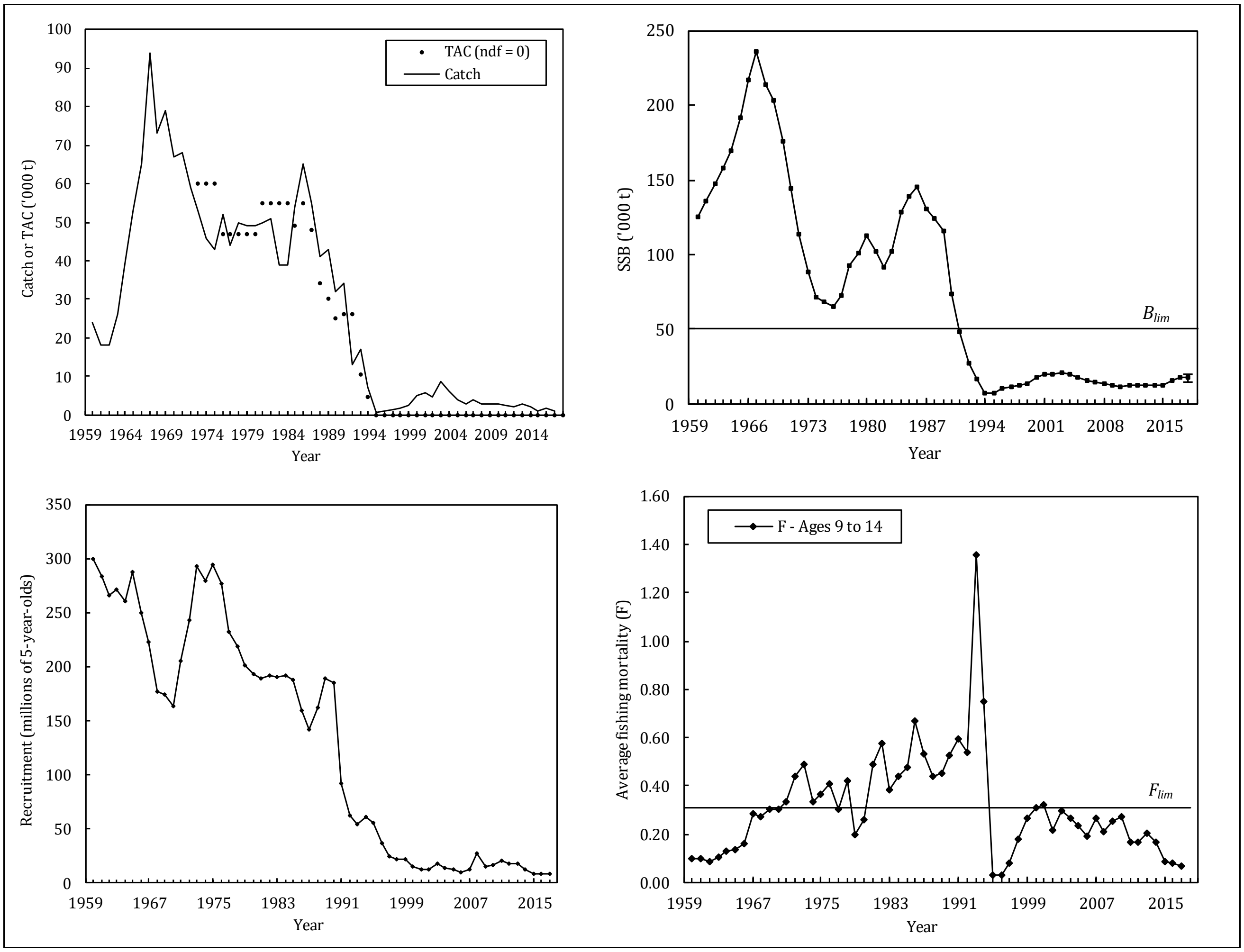
🟢	OK
🟡	Intermediate
🔴	Not accomplished
⚪	Unknown

Management unit

The management unit is NAFO Divisions 3LNO. The stock is distributed throughout Div. 3LNO but historically most of the biomass was found in Div. 3L

Stock status

The stock remains low compared to historic levels and is presently at 34% of the B_{lim} level. Recruitment has been low since the late 1980s, but Canadian surveys indicate a large number of pre-recruits in Div. 3L in recent years. Current estimates of fishing mortality are very low.



Reference points

B_{lim}: 50 000 t of spawning biomass (Scientific Council Report, 2003)
B_{msy}: 242 000 t of spawning biomass (Scientific Council Report 2011)
F_{lim}: 0.31 (Scientific Council Report, 2011)

Projections

	SSB('000 t)	**Yield (t)**
	Median (90% CI)	
	F = 0	
2019	17.0 (14.6, 19.8)	-
2020	18.0 (15.5, 21.0)	-
2021	19.5 (16.6, 23.0)	-
2022	21.1 (18.0, 25.3)	-
	$F_{2015-2017}$ = 0.08	
2019	17.0 (14.7, 19.7)	1542
2020	16.7 (14.4, 19.5)	1538
2021	16.9 (14.5, 19.9)	1567
2022	17.2 (14.8, 20.7)	1594

Fishing Mortality	Yield				P(SSB<B_{lim})				P(SSB_{2022}>SSB_{2018})
	2019	2020	2021	2022	2019	2020	2021	2022	
F = 0	-	-	-	-	>99%	>99%	>99%	>99%	99%
$F_{2015-2017}$ = 0.08	1542	1538	1567	1594	>99%	>99%	>99%	>99%	47%

Simulations were carried out to examine the trajectory of the stock under 2 scenarios of fishing mortality: F = 0 and F= $F_{2015-2017}$ (0.08). SSB was projected to have a probability of >0.99 of being less than B_{lim} by the start of 2022 under both fishing mortality scenarios. Under the F=0 scenario, there is a 99% probability that SSB in 2022 will be greater than in 2018, however this is reduced to 47% probability under F status-quo. Even very low levels of F are inhibiting growth of the stock.

Assessment

An analytical assessment using the ADAPTive framework tuned to the Canadian 3LNO spring, Canadian 3LNO autumn and the EU-Spain Div. 3NO survey.

Given the low potential for stock growth, the next full assessment is scheduled for 2021.

Human impact

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

Biological and environmental interactions

Capelin and sandlance as well as other fish and invertebrates are important prey items for American plaice. There has been a decrease in age at 50% maturity over time, possibly brought about by some interaction between fishing pressure and environmental/ecosystem changes during that period. The Grand Bank (3LNO) EPU is currently experiencing low productivity conditions and biomass has declined across multiple trophic levels and stocks since 2014.

Fishery

The stock has been under moratorium since 1995. American plaice in recent years is caught as bycatch mainly in otter trawl fisheries of Yellowtail Flounder, skate, Greenland Halibut and redfish. In 2015 and 2016,

STATLANT 21A data was used for Canadian fisheries and Daily Catch Records (DCR) for fisheries in the NRA. Catches for 2017 were obtained from CESAG estimates.
Recent catch estimates and TACs are:

	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
TAC	ndf	ndf	ndf	ndf	ndf	ndf	ndf	ndf	ndf	ndf
STATLANT 21	1.8	1.5	1.2	1.3	2.2	1.4	1.1	1.7	1.2	
STACFIS	3.0	2.9	2.4[1]	2.1[1]	3.0[1]	2.3[1]	1.1[2]	1.7[2]	1.2	

ndf No directed fishing.

[1] Catch was estimated using fishing effort ratio applied to 2010 STACFIS catch.

[2] Catch was estimated using STATLANT 21 data for Canadian fisheries and Daily Catch Reports for fisheries in the NRA.

Effects of the fishery on the ecosystem

No specific information is available. There is no directed fishery for this stock. General impacts of fishing gears on the ecosystem should be considered. Areas within Divs. 3LNO have been closed to protect sponges and coral.

Special Comments

There is a tendency to overestimate SSB and underestimate F in the assessment model. In the current assessment there is a substantial downwards (47%) revision of the SSB in 2016, relative to the 2016 assessment.

Sources of information

SCS Doc. 18/05, 18/06, 18/07, 18/08, 18/13, 18/14, 18/15; SCR Doc. 18/11, 18/17, 18/18, 18/19; FC Doc. 11/21.

Thorny Skate in Divisions 3LNO and Subdiv. 3Ps

Advice June 2018 for 2019-2020

Recommendation for 2019-2020

The stock has been stable at recent catch levels (approximately 4 060 t, 2013 - 2017) however, given the low resilience to fishing mortality and higher historic stock levels, Scientific Council advises no increase in catches.

Management objectives

No explicit management plan or management objectives defined by the 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	🟢	B_{lim} defined from survey indices
Minimise harmful impacts on living marine resources and ecosystems	🟡	No specific measures, general VME closures in effect
Preserve marine biodiversity	⚪	Cannot be evaluated

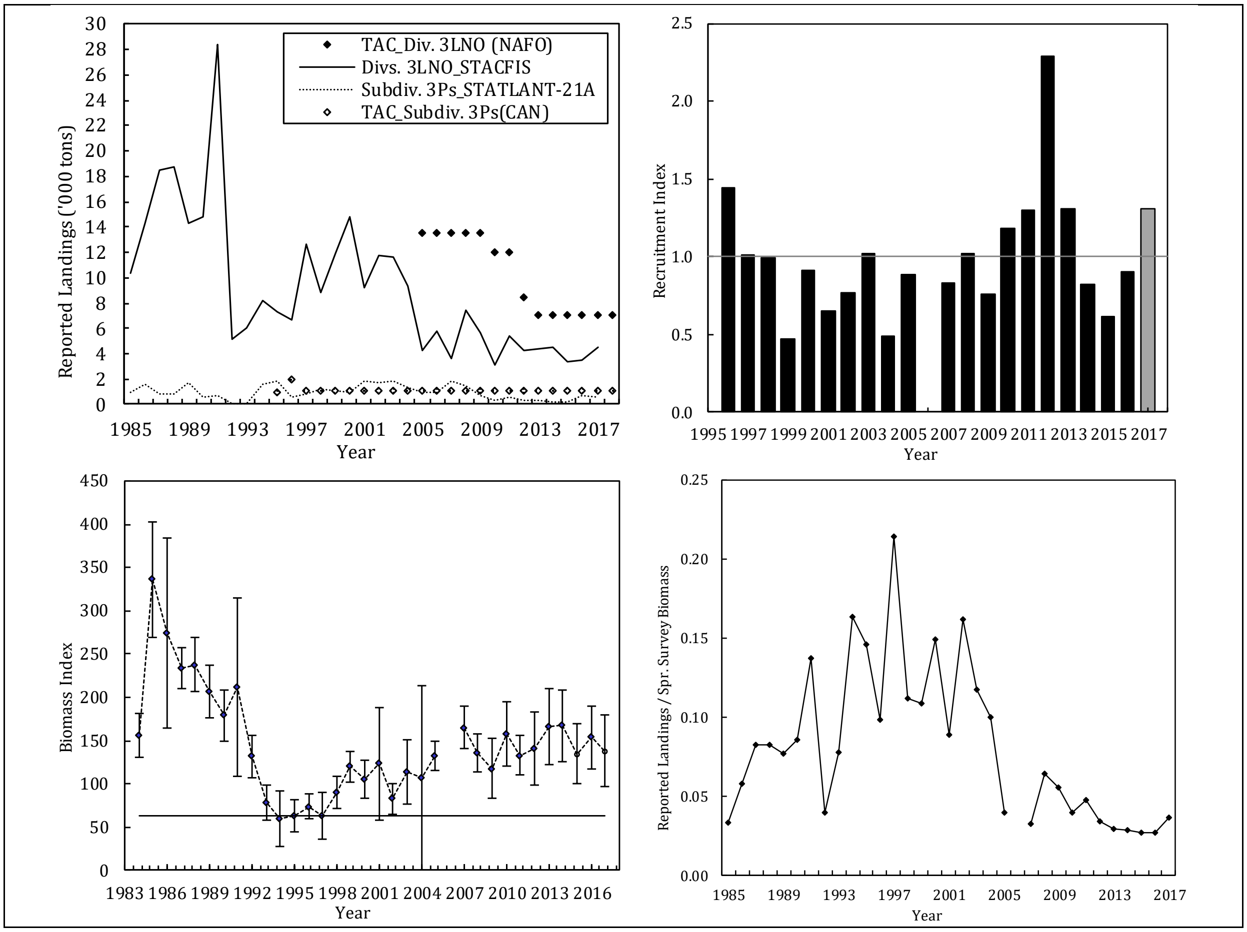
🟢	OK
🟡	Intermediate
🔴	Not accomplished
⚪	Unknown

Management unit

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

Stock status

The stock is currently above $B_{lim.}$ The probability that the current biomass is above B_{lim} is >95%. Total survey biomass in Divs 3LNOPs has remained stable since 2007. Recruitment in 2017 was above average. Fishing mortality is currently low.



Reference points

B_{lim} defined from survey indices as B_{loss}; NAFO 2015

Assessment

Based upon a qualitative evaluation of stock biomass trends and recruitment indices, the assessment is considered data limited and as such associated with a relatively high uncertainty. Input data are research survey indices and fishery data. The next full assessment of this stock is planned for 2020.

Human impact

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

Biology and Environmental interactions

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

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

Fishery

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

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

	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Div. 3LNO:										
TAC	13.5	12	12	8.5	7	7	7	7	7	7
STATLANT 21	5.7	5.4	5.5	4.3	4.4	4.5	3.3	3.5	4.2	
STACFIS	5.6	3.1	5.4	4.3	4.4	4.5	3.4	3.5	4.5	

Effects of the fishery on the ecosystem

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

Special comments

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

Sources of Information

SCR Doc. 14/23, 15/40, 18/13,17,18,27; SCS Doc. 18/07,08,13,15.

Yellowtail flounder in Divisions 3LNO

Advice June 2018 for 2019-2021

Recommendation for 2019 to 2021

At a fishing mortality of 85% *Fmsy*, catches of 24 900 t, 22 500 t, and 21 100 t in 2019 to 2021, respectively, have less than a 30% risk of exceeding *Flim*. At these yields the stock is projected to have an 82% probability of remaining above *Bmsy.*

Management objectives

No explicit management plan or management objectives are defined by the Commission. General convention objectives (NAFO/GC Doc 08/3) are applied. Advice is provided in the context of the Precautionary Approach Framework (NAFO/FC 04/18).

Convention objectives	*Status*	*Comment/consideration*
Restore to or maintain at B_{msy}	🟢	$B>B_{msy}$
Eliminate overfishing	🟢	$F<F_{lim}$
Apply Precautionary Approach	🟢	Stock in the safe zone of PA framework
Minimise harmful impacts on living marine resources and ecosystems	🟡	By-catch regulations in place for moratorium stocks, general VME closures in effect
Preserve marine biodiversity	⚪	Cannot be evaluated

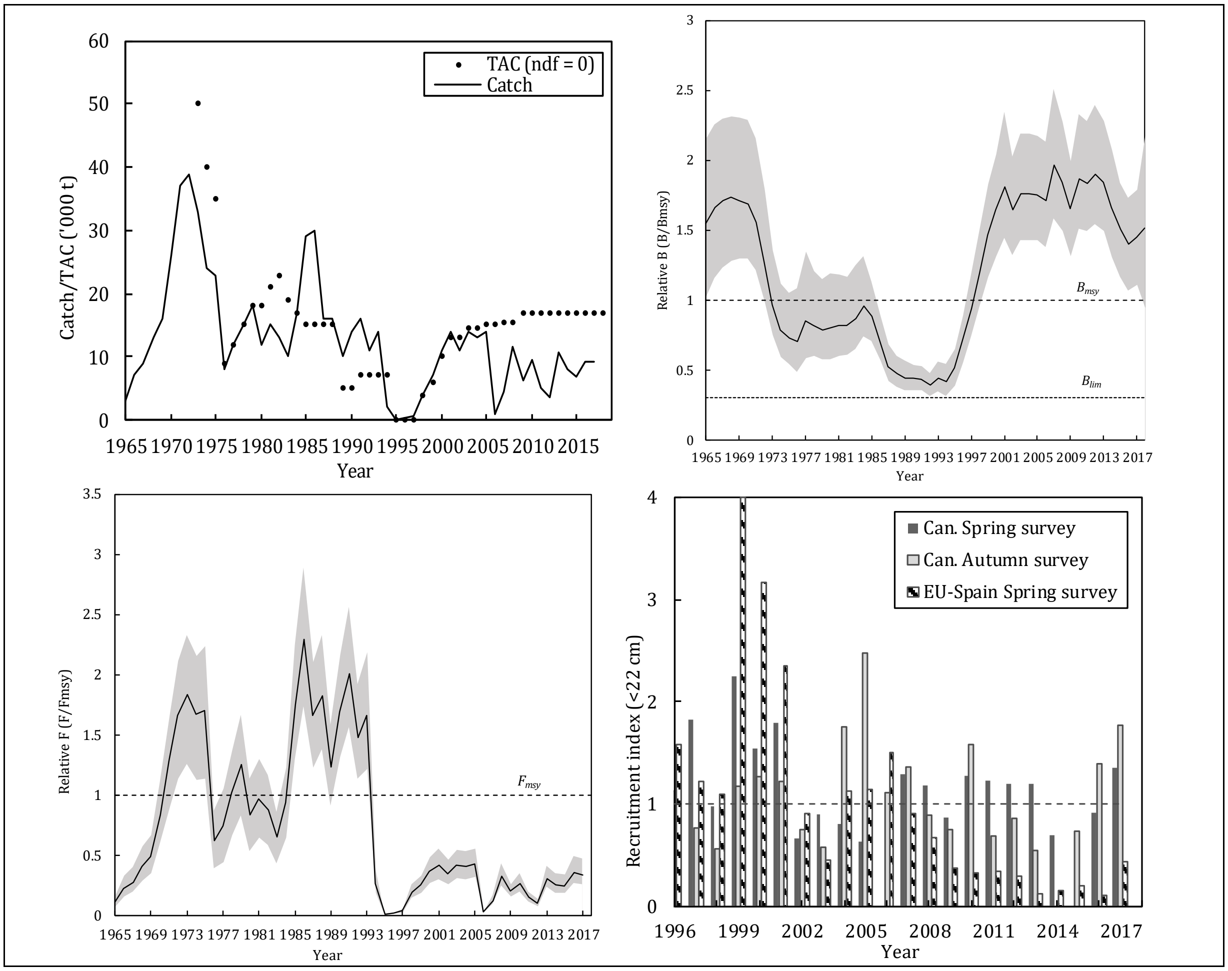
🟢 OK
🟡 Intermediate
🔴 Not accomplished
⚪ Unknown

Management unit

The stock occurs in Divisions 3LNO, mainly concentrated on the southern Grand Bank and is recruited from the Southeast Shoal area nursery ground.

Stock status

The stock size has steadily increased since 1994 and is presently 1.5 times B_{msy} (B_{msy}=87.63 Kt). There is very low (<1%) risk of the stock being below B_{msy} or F being above F_{msy}. Recent recruitment appears higher than average.



Reference points

B_{lim} is 30% B_{msy} and F_{lim} is F_{msy} (NAFO 2004 p 133).

Projections

Projections with catch in 2018 = avg catch 2013-2017 (8 800 t)		
Year	Yield ('000t) median	Projected relative Biomass(B/B_{msy}) median (90% CL)
$F_{status\ quo}$ = 0.07		
2019	9.14	1.56 (1.07, 2.1)
2020	9.30	1.59 (1.09, 2.14)
2021	9.41	1.62 (1.11, 2.17)
2022		1.63 (1.12, 2.19)
2/3 F_{MSY} = 0.14		
2019	19.52	1.56 (1.07, 2.1)
2020	18.41	1.47 (0.99, 2)
2021	17.77	1.42 (0.93, 1.96)
2022		1.39 (0.89, 1.93)
85% F_{MSY} =0.18		
2019	24.88	1.56 (1.07, 2.1)
2020	22.49	1.41 (0.94, 1.94)
2021	21.09	1.32 (0.85, 1.86)
2022		1.27 (0.77, 1.82)
F_{MSY} =0.21		
2019	29.28	1.56 (1.07, 2.1)
2020	25.50	1.36 (0.9, 1.88)
2021	23.37	1.25 (0.77, 1.79)
2022		1.17 (0.67, 1.73)

	Yield ('000t)			P($F>F_{lim}$)			P($B>B_{lim}$)				P($B>B_{msy}$)				
	2019	2020	2021	2019	2020	2021	2019	2020	2021	2022	2019	2020	2021	2022	P($B_{2022}>B_{2018}$)
$F_{status\ quo}$ = 0.07	9.14	9.30	9.41	<1%	<1%	<1%	<1%	<1%	<1%	<1%	3%	3%	3%	2%	62%
2/3 F_{MSY} = 0.14	19.52	18.41	17.77	6%	7%	8%	<1%	<1%	<1%	<1%	3%	5%	7%	10%	37%
85% F_{MSY} = 0.18	24.88	22.49	21.09	25%	25%	27%	<1%	<1%	<1%	<1%	3%	7%	12%	18%	28%
F_{MSY} = 0.21	29.28	25.50	23.37	50%	50%	50%	<1%	<1%	<1%	<1%	3%	9%	18%	27%	22%

Projections were conducted assuming catch in 2018 to be the average of that in 2013-2017, followed by constant fishing mortality from 2019-2021 at either $F_{status\ quo}$, 2/3 F_{msy}, 85% F_{msy}, and F_{msy}. Fishing at F_{msy} would first lead to a considerable yield in 2019, but yields are then projected to decline in the medium term with catch at 2/3 F_{msy}, 85% F_{msy} , and F_{msy}. The risk of biomass being below B_{lim} is less than 1% in all years for each scenario. The probability that biomass in 2022 is greater than B_{2018} is 0.62, 0.37, 0.28 and 0.22 for $F_{status\ quo}$, 2/3 F_{msy}, 85% F_{msy}, and F_{msy} respectively.

Assessment

A Bayesian surplus production model was used for the first time and results were comparable to the previous assessment. Input data comes from research surveys and the fishery.

The next assessment is planned for 2021.

Human impact

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

Biology and Environmental interactions

As stock size increased from the low level in the mid-90s, the stock expanded northward and continues to occupy this wider distribution. This expansion of the stock coincided with warmer temperatures; temperatures continue to warm, and will likely not limit the stock distribution in the near future.

Despite the increase in stock size observed since the mid-90s, the average length at which 50% of fish are mature has been lower for both males and females in the recent period. There also seems to have been a slight downward trend in weight at length since 1996. The cause of these changes is unknown.

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

Fishery
Yellowtail flounder is caught in a directed trawl fishery and as by-catch in other trawl fisheries. The fishery is regulated by quota and minimum size restrictions. Catches in recent years have been low due to industry-related factors. American plaice and cod are taken as by-catch in the yellowtail fishery. There is a 15% by-catch restriction on American plaice and a 4% limit on cod.

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

	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
TAC	17	17	17	17	17	17	17	17	17	17
STATLANT 21	5.5	9.1	5.2	3.1	10.7	8.0	6.7	8.3	9.2	
STACFIS	6.2	9.4	5.2	3.1	10.7	8.0	6.9	9.3	9.2	

Effects of the fishery on the ecosystem
Fishing intensity on yellowtail flounder has impacts on Div. 3NO cod and Div. 3LNO American plaice through by-catch. General impacts of fishing gears on the ecosystem should also be considered. Areas within Divs. 3LNO have been closed to protect sponge and coral.

Special comments
Catch of yellowtail flounder has been below TAC in recent years. Management decisions on this stock should also take into consideration impacts on other fisheries. Increased catch of yellowtail flounder may increase by-catch of Div. 3NO cod and Div. 3LNO American plaice.

Sources of information
SCR 11/34, 18/012, 18/017, 18/036, 18/038, 18/048; SCS 18/05, 18/06, 18/07, 18/08, 18/13, 18/14, 18/15; NAFO/GC Doc 08/3 NAFO/FC 04/18.

Cod in Divisions 3NO

Advice June 2018 for 2019 - 2021

Recommendation for 2019 – 2021

No directed fishing in 2019 to 2021 to allow for stock rebuilding. By-catches of cod in fisheries targeting other species should be kept at the lowest possible level. Projections of the stock were not performed, but given the poor strength of all year classes subsequent to 2006, the stock will not reach B_{lim} in the next three years.

Management objectives

General convention objectives are applied in conjunction with an Interim Conservation Plan and Rebuilding Strategy adopted in 2011 (NAFO/FC Doc. 11/22). The long-term objective of this plan is to achieve and to maintain the spawning stock biomass in the "safe zone" of the NAFO PA framework (FC Doc. 04/18), and at or near B_{msy}.

Convention objectives	*Status*	*Comment/consideration*
Restore to or maintain at B_{msy}	🔴	$B < B_{lim}$
Eliminate overfishing	🟢	F is very low, $F < F_{lim}$
Apply Precautionary Approach	🟢	B_{lim} and F_{lim} established, no directed fishery.
Minimise harmful impacts on living marine resources and ecosystems	🟢	No directed fishery
Preserve marine biodiversity	⚪	Cannot be evaluated

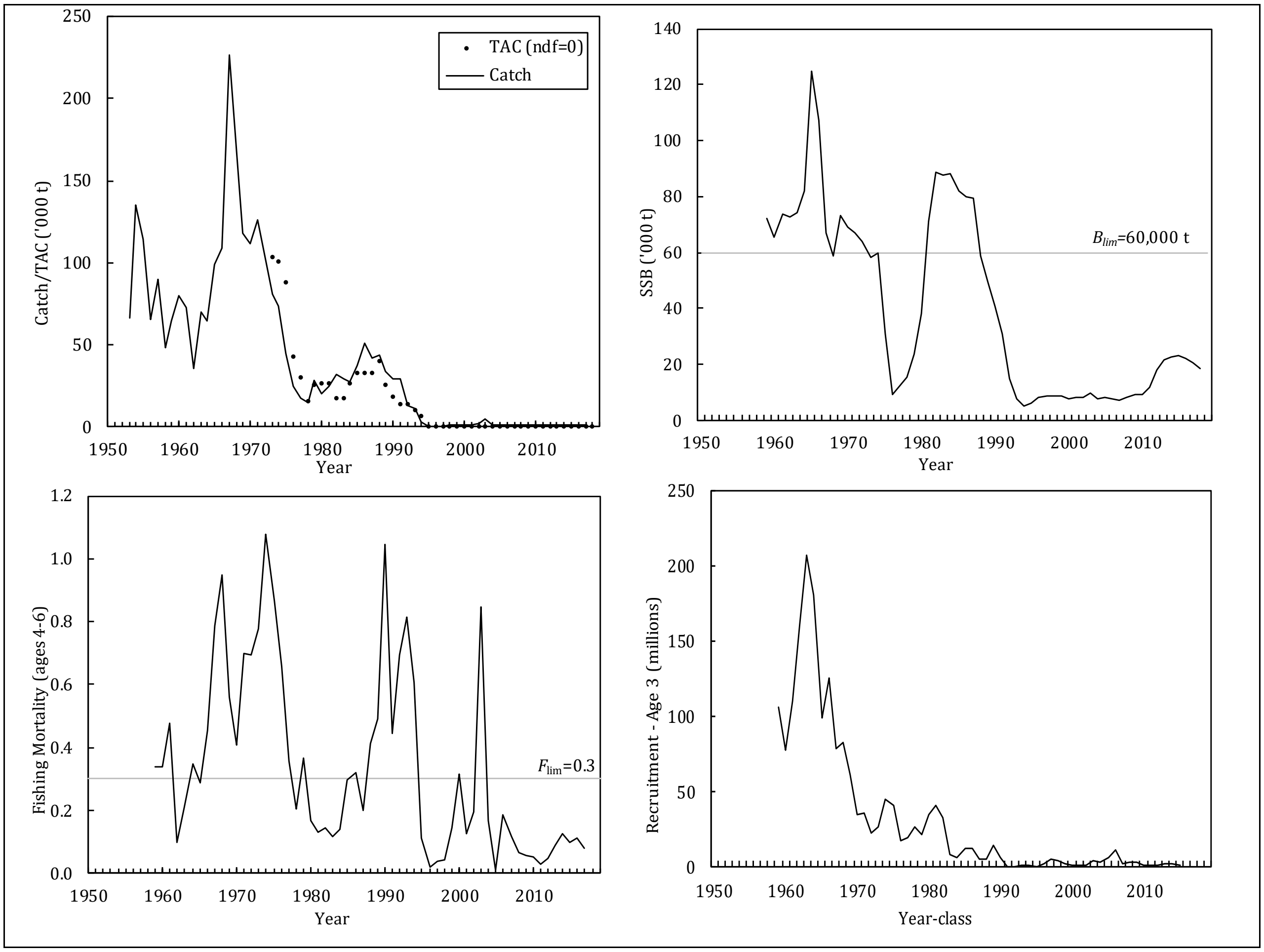
🟢	OK
🟡	Intermediate
🔴	Not accomplished
⚪	Unknown

Management unit

The stock occurs in Divs. 3NO, with fish occupying shallow parts of the bank, particularly the southeast shoal area (Div. 3N) in summer and on the slopes of the bank in winter.

Stock status

The spawning biomass increased noticeably between 2010 and 2015 but has subsequently declined and the 2018 estimate of 18,537 t represents only 31% of B_{lim} (60,000 t). The 2006 year class remains relatively strong and at age 12 in 2018 makes up more than half of the estimated SSB. Subsequent year classes are much weaker, suggesting that the medium-term prospects for the stock are not good. Fishing mortality values over the past decade have been low and well below F_{lim} (0.3).



Reference points

B_{lim} :	60 000 t of spawning biomass (SC, 1999)
F_{lim} (=F_{msy}):	0.3 (SC, 2011).

Projections

A decision was made to not project the stock forward because the 2006 year class, which in 2018 is age 12 and makes up more than half of the estimated SSB, will no longer be part of the virtual population starting in 2019. This is a limitation of the current model formulation which ends at age 12 (i.e. there is no plus group) and any attempt to project the stock forward would be characterized by the 'artificial' removal of this strong year class from the population. Revising the assessment model to incorporate a plus group is considered of high priority for this assessment going forward. Although projections of the stock were not performed, the poor strength of year classes subsequent to 2006 suggests that the medium-term prospects for the stock are not good.

Assessment

A sequential population analysis model was used, and the results were consistent with the previous assessment. Input data comes from research surveys and commercial removals.

The next assessment is planned for 2021.

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

Biology and Environmental interactions
Productivity of this stock was above average during the warm 1960s. During the cold 1990s, productivity was very low and surplus production was near zero. The Grand Bank (3LNO) EPU is currently experiencing low productivity conditions and biomass has declined across multiple trophic levels and stocks since 2014.

Fishery
A moratorium was implemented in 1994. Catches since that time are by-catch in other fisheries.

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

	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
TAC	ndf	ndf	ndf	ndf	ndf	ndf	ndf	ndf	ndf	ndf
STATLANT 21	0.6	0.8	0.8	0.7	1.1	0.7	0.5	0.6	0.6	
STACFIS	1.1	0.9	0.8	0.7	1.1	0.7	0.6	0.7	0.6	

ndf : No directed fishery

Effects of the fishery on the ecosystem
No specific information is available. There is no directed fishery for this stock. General impacts of fishing gears on the ecosystem should be considered. Areas of Divs. 3NO have been closed to protect sponges and corals.

Special comments
Recent stock trends in SSB differ between this and the previous (2015) assessment. The previous assessment estimated SSB in 2015 to be 64% of B_{lim}, whereas the current estimate for 2015 is only 39% of B_{lim}. Differences result from the fact that weights at age for 2015 (i.e. the terminal year) in the 2015 assessment were simply the average of the three previous years, whereas the current assessment uses actual estimates of weights at age for 2015 that were not available at the time of the previous assessment. These new weights at age for 2015 are much lower than the mean values used in the previous assessment and largely contribute to /the lower estimates of SSB.

Sources of information
SCR Docs. 18/11, 17, 28; SCS Docs. 18/5, 6, 7, 8, 13, 14, 15

Capelin in Divisions 3NO

Advice June 2018 for 2019 - 2021

Recommendation for 2019-2021
No directed fishery.

Management objectives

No explicit management plan or management objectives defined by the Commission. General convention objectives (GC Doc. 08-03) are applied. Advice is based on qualitative evaluation of biomass indices in relation to historic levels.

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

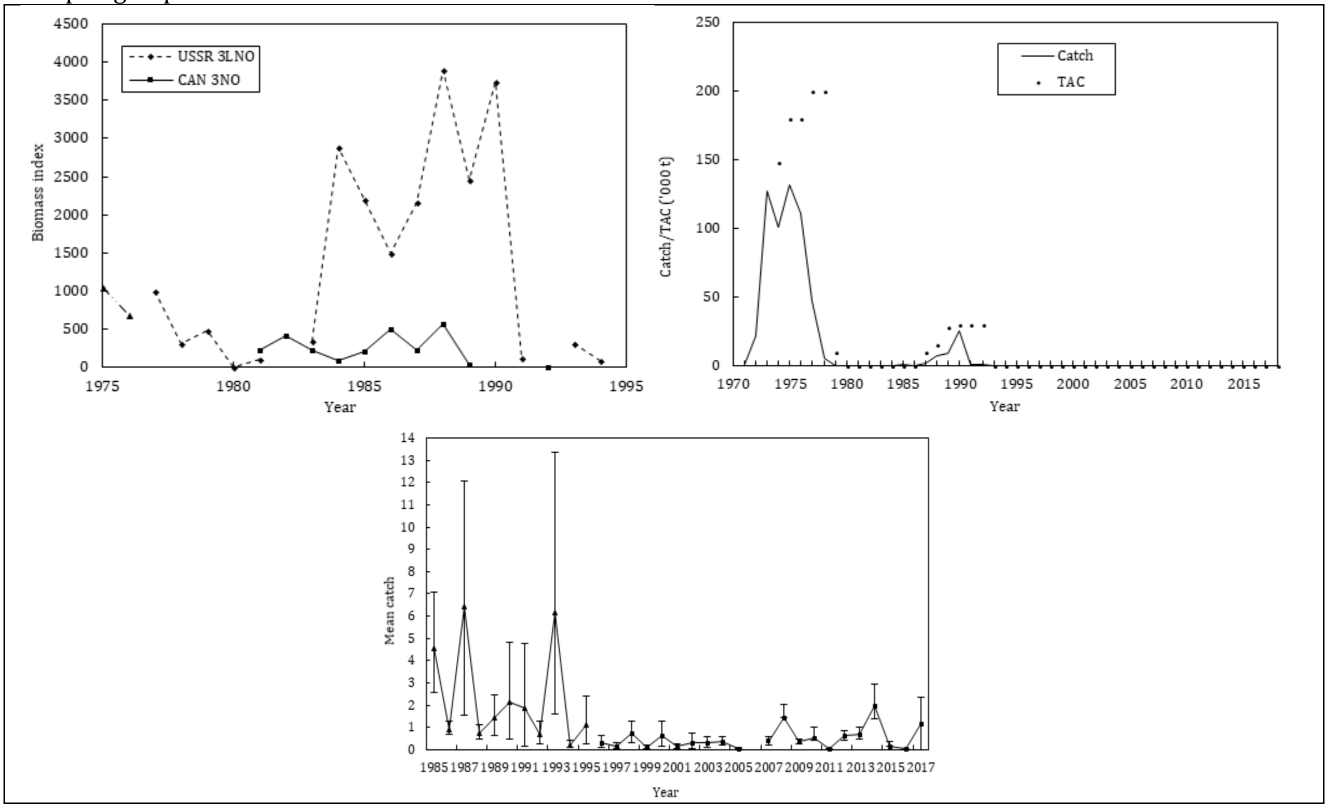
🟢 OK
🟠 Intermediate
🔴 Not accomplished
⚪ Unknown

Management unit

The capelin stock is distributed in Div. 3NO, mainly on the Grand Bank.

Stock status

Acoustic surveys series terminated in 1994 indicated a stock at a low level. Although biomass indices have increased in recent years, bottom trawl surveys are not considered a satisfactory basis for a stock assessment of a pelagic species.



Reference points

Not defined.

Projections

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

Assessment

Assessment was based on evaluation of trends in acoustic survey data (1975 – 1994) and bottom trawl surveys (1995 – 2017). Bottom-trawling is not a satisfactory basis for a stock assessment of a pelagic species. The assessment is only indicative of major changes in abundance.

Next full assessment is scheduled for 2021.

Human impact

Low fishery related mortality due to moratorium and low bycatch in other fisheries. Other sources (e.g. pollution, shipping, oil industry) are considered minor.

Biological and Environmental Interactions

Changes in growth, maturity and recruitment are linked to temperature on the Grand Banks. The Grand Bank (3LNO) EPU is currently experiencing low productivity conditions and biomass has declined across multiple trophic levels and stocks since 2014.

Fishery

Capelin was caught in a directed trawl fishery. There is low bycatch in other trawl fisheries. The directed fishery was closed in 1992 and the closure has continued through 2017. 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. In 2017, 11t of discards were reported. Recent catch estimates and TACs (t) are as follows:

	2009	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**
TAC	ndf	ndf	ndf	ndf	ndf	ndf	ndf	ndf	ndf	ndf
STATLANT 21	0	0	0	0	0	1	0	5	0	

ndf no directed fishing

Effects of the fishery on the ecosystem

No fishery.

Special comments

Bottom-trawling is not a satisfactory basis for a stock assessment of a pelagic species and survey results are indicative only. Investigations to evaluate the status of capelin stock should utilize trawl acoustic surveys to allow comparison with historical time series.

Source of Information

SCR Doc. 18/046, SCS Doc. 18/007

Alfonsino in Division 6G

Advice June 2018 for 2019-2021

Recommendation for 2019, 2020 and 2021

Due to lack of abundance or exploitation data, no reliable stock assessment can be conducted. Scientific Council is unable to advise on an appropriate TAC for 2019, 2020 and 2021.

As previously recommended, 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.

Management objectives

No explicit management plan or management objectives defined by the Commission. General convention objectives (NAFO/GC Doc 08/3) are applied. At present this stock is unregulated.

Convention objectives	*Status*	*Comment/consideration*
Restore to or maintain at Bmsy	○	Cannot be evaluated
Eliminate overfishing	○	Unknown F level
Apply Precautionary Approach	○	Reference points not defined
Minimize harmful impacts on living marine resources and ecosystems	○	Unknown gear impact
Preserve marine biological biodiversity	○	Cannot be evaluated

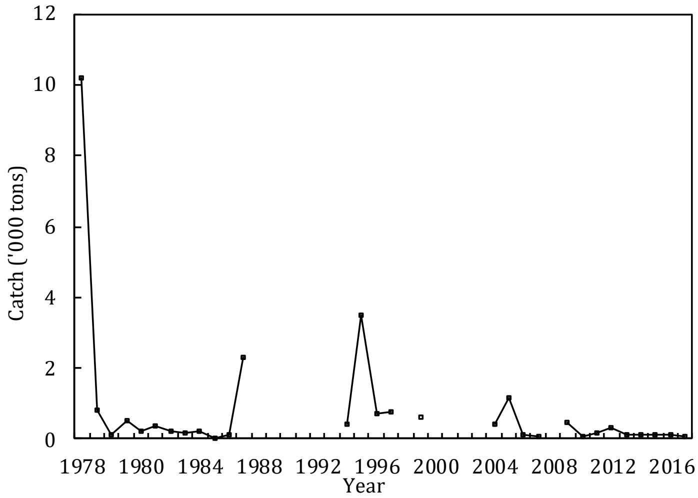
🟢 OK
🟡 Intermediate
🔴 Not accomplished
○ Unknown

Management unit

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.

Stock status

Presently unknown. The only available information on biomass covers a period ending in 1995.



Projections

No projections can be conducted.

Reference points

Not defined.

Assessment
No analytical or survey based assessment were possible at the moment due to the lack of updated data. The most reliable present data available are the catch time series.

With the available data an attempt has been made to estimate a sustainable level of catches in Kükenthal seamount with different methods. The results show different levels of MSY depending on the methods. The methods based on catch information are more optimistic than those based on the commercial CPUEs. However, these results are not considered reliable and therefore MSY catch is unknown.

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

Environmental impact
Limited information is available.

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

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

Based on the information collected in the 2004 Spanish experimental survey in Corner Rise, a directed commercial fishery had been conducted since 2005 by Spanish vessels. Since 2006 virtually all the effort has been made in the Kükenthal seamount with pelagic trawl gear.

Recent catch estimates (ton) are as follows:

	2009	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**
STATLANT 21	0	53	0	77	118	112	298	0	51
STACFIS	479	52	152	302	114	118	122	127	55

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

Sources of Information
SCS Doc. 18/07 SCR 18/22, 15/06 and 15/18

b) Monitoring of Stocks for which Multi-year Advice was Provided in 2016 or 2017

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

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

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

Recommendation for White Hake in Divisions 3NO and Subdiv. 3Ps for 2018-2019: Given the absence of strong recruitment, catches of white hake in 3NO should not increase.

Recommendation for Redfish in Div. 3O for 2017- 2019: 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 Witch flounder Divs. 2J3KL for 2017- 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. In addition, a new Limit Reference Point (LRP) was set for Witch Flounder in NAFO Divs. 2J+3KL (SCR Doc. 18/30). The previous LRP considered the survey biomass in 1984 (B_{MAX}) to represent B_0, with B_{LIM} subsequently set at 15% B_{MAX}. However, given the catch history of the stock, biomass in 1984 is not considered to reflect an unexploited state, and based on recommendation from the NAFO Study Group on Limit Reference Points (SCS Doc. 04/12), 15% B_{MAX} is not an appropriate reference point for this stock.

Scientific Council agreed that this period from 1983-1984 is more likely to reflect B_{MSY} than $B_{0.}$ A proxy for B_{MSY} was therefore accepted as the mean of the survey biomass indices from the 1983-84 autumn RV surveys. Following recommendations from in SCS Doc. 04/12, B_{LIM} is calculated as 30% of the B_{MSY} proxy (B_{LIM} = 19 000t; SCR Doc. 18/30). The stock is at 90% of B_{LIM} in 2017.

Recommendation for Witch flounder Divs. 3NO: *Was reassessed in 2018 under Scientific Council's own initiative. See pages 82-85.*

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.

c) Special Requests for Management Advice

i) Greenland halibut in SA2 + Divs. 3KLMNO: Monitor the status annually to determine whether exceptional circumstances are occurring (Item 2)

The management strategy for Greenland halibut in Subarea 2+Div. 3KLMNO will be implemented initially for 6 years beginning in 2018. Acknowledging that an Exceptional Circumstances Protocol will be developed for this stock in 2018, the Commission requests the Scientific Council to monitor the status annually to determine whether exceptional circumstances are occurring. Scientific Council should also perform an "update assessment" in 2020. If either the annual monitoring or the update assessment indicates that exceptional circumstances are occurring, the exceptional circumstances protocol will provide guidance on what steps should be taken.

Scientific Council notes that it has not been requested to provide advice based on the Harvest Control Rule for Greenland halibut in Subarea 2+Div. 3KLMNO and that the Exceptional Circumstances Protocol will not be finalized until the 2018 Annual meeting. The SC provides advice based on the HCR for 2019 but does not address exceptional circumstances (See VII.1.c.III)

The TAC for 2019 derived from the HCR is 16521 t.

A new HCR for Greenland halibut in Subarea 2+Div. 3KLMNO was adopted by the Commission in 2017. The HCR has two components: target based and slope based.

Target based (t)

The basic harvest control rule (HCR) is:

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

where TAC_y is the TAC recommended for year y, γ is the "response strength" tuning parameter, J_y is a composite measure of the immediate past level in the mean weight per tow from surveys (I_y^i) that are available to use for calculations for year y; five survey series are used, with i = 1, 2, 3, 4 and 5 corresponding respectively to Canada Fall 2J3K, EU 3M 0-1400m, Canada Spring 3LNO, EU 3NO and Canada Fall 3LNO:

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

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

$$J_{current}^i = \frac{1}{q} \sum_{y'=y-q}^{y-1} I_{y'}^i \tag{3}$$

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

Note the assumption that when a TAC is set in year y for year y+1, indices will not at that time yet be available for the current year y.

Slope based (s)

The basic harvest control rule (HCR) is:

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

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

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

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

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

For the target and slope based combination:

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

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

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

and

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

The control parameters for the adopted MP are shown in Table i.2 with a starting TAC of 16 500 t in 2018. Missing survey values are treated as missing in the calculation of the rule as in the MSE.

Table i.1. The weights given to each survey in obtaining composite indices of abundance are proportional to the inverse squared values of the survey error standard deviations σ^i listed below.

Survey	$\boldsymbol{\sigma^i}$
Canada Fall 2J3K	0.22
EU 3M 0-1400m	0.21
Canada Spring 3LNO	0.49
EU 3NO	0.38
Canada Fall 3LNO	0.26

Table i.2. Control parameter values for the MP. The parameters α and X were adjusted to achieve a median biomass equal to B_{msy} for the exploitable component of the resource biomass in 2037.

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

Table i.3. Data used in the calculation of the TAC for 2019. Last row corresponds to the target level of each survey as per equation (4).

	Survey				
	Canada Fall 2J3K	EU 3M 0-1400m	Canada Fall 3LNO	EU 3NO	Canada Spring 3LNO
2013	29.64	19.11	2.6	5.46	0.73
2014	33.34	23.92		6.24	0.66
2015	22.29	47.52	0.9	9.49	
2016	18.54	28.3	1.3	8.8	0.66
2017	15.1	42.67	1.3	16.63	
J^{i}_{target}	25.12	25.19	1.71	6.61	1.02

The TAC for 2019 was calculated based on the HCR. The target based component was 16736.9 and the slope based component was 16305.6 resulting in a computed TAC of 16521 t for 2019. This is not greater than a 10% increase and so the constraint is not applied.

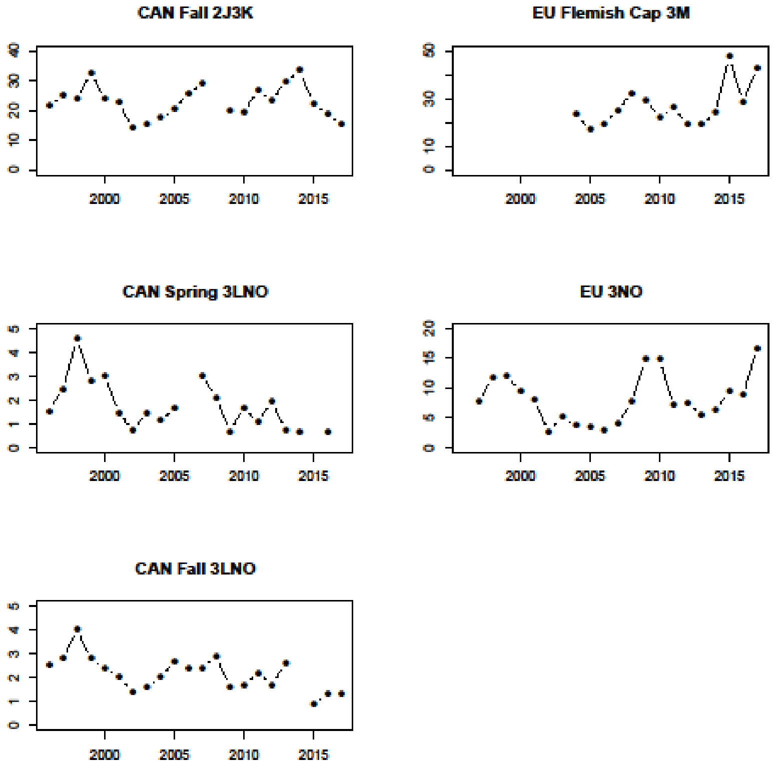


Fig. i.1. Input for Greenland Halibut in Subarea 2 + Divisions 3KLMNO Harvest Control Rule. Survey data come from Canadian fall surveys in Divs. 2J3K, Canadian spring surveys in Divs. 3LNO (2015 and 2017 surveys incomplete and not used in the calculation of the HCR), the Canadian fall survey in Divs.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

SC notes a divergence in trends of the survey series. This divergence could be the result of movement of fish. SC is limited in its ability to understand or account for possible movements in its advice. SC **recommends** that tagging and/or telemetry studies be undertaken to help elucidate movement of 2+3KLMNO Greenland halibut and that the combination of different survey series be investigated.

ii) Conduct a full assessment of 3LN Redfish (Item 3)

The Fisheries Commission adopted in 2014 an MSE approach for Redfish in Division 3LN (FC Doc. 14/24). This approach uses a Harvest Control Rule (HCR) designed to reach 18 100 t of annual catch by 2019-2020 through a stepwise biennial catch increase, with the same amount of increase every two years.

The Commission request Scientific Council to conduct a full assessment in 2018 to evaluate the effect of removals in 2016 and 2017 on stock status.

Scientific Council responded:

SC conducted the 2018 full assessment of Redfish in Division 3LN and evaluated the impact of the implementation of the adopted MS on the state of the stock. At the beginning of 2018 the stock was still in the safe zone, with a probability of biomass being above B_{msy} > 90%. The probability of biomass being below B_{lim} and fishing mortality being above F_{msy} is < 1%.

A short term catch projection followed the assessment, in order to quantify the likelihood of the stock sustaining the approved 2019-2020 MS catches (18 100 t in both years). There is > 90% probability that TACs agreed within the adopted management strategy for 2019 to 2020 will maintain biomass at the beginning of 2021 above B_{msy}, while the probability of biomass being below B_{lim} is <1%. The probability that biomass will grow from the beginning of 2018 to the beginning of 2021 is low (38.5%). The probability of fishing mortality by the end of 2020 being above F_{msy} is 1.6%.

iii) Develop criteria for the identification of exceptional circumstances under the Greenland halibut 2+3KLMNO management strategy (Item 4)

The Commission requests the Scientific Council to develop criteria for the identification of exceptional circumstances under the Greenland halibut 2+3KLMNO management strategy, this should take into account the issues noted by the WG-RBMS (COM-SC WP 17-06), to support the development of an exceptional circumstances protocol and provide its recommendations to the WG-RBMS meeting planned for August 2018.

Scientific Council responded:

The Council responded to each of the issues noted in the September 2017 report of RBMS. Below, specific guidance has been given in some cases (i.e. thresholds for determining whether Exceptional Circumstances have occurred) whereas in others expert judgement will have to be applied on a case by case basis. In the latter, determination as to whether to trigger Exceptional Circumstances will be case specific and is not specified a priori (will be developed at such time).

Annual monitoring:

Five survey series are used to compute the annual TAC using the adopted Management Procedure (MP). Reflective of the estimated precision indicated for each index, it was agreed that Exceptional Circumstances would be triggered if, in a five-year period, more than one value is missing from a survey with relatively high weighting (the Canadian Fall 2J3K, Canadian Fall 3LNO and EU 3M surveys), or, if more than two values are missing from a survey with relatively low weighting (the Canadian Spring 3LNO and EU-Spain 3NO surveys).

The composite survey index (*Jy* in the MP) will be calculated and annually compared against the 80%, 90% and 95% probability envelopes projected by the base case operating models from SSM and SCAA under the accepted MP. Exceptional Circumstances will be triggered if the observed composite index in a given year is above or below the 90% probability envelope.

Scientific Council will also monitor the five survey indices relative to the 80%, 90% and 95% probability envelopes projected by the base case operating models for each survey. Finally, as an approximate means of monitoring the status of recruitment, Scientific Council will assess survey data at age 4 (age before recruitment to fishery) compared to its series mean. Expert judgement will determine whether Exceptional Circumstances are occurring.

Catches will be monitored annually by Scientific Council and deviations from the TAC calculated using the MP will be assessed. Expert judgement will determine whether Exceptional Circumstances are occurring.

TACs established that are not generated from the MP will constitute an Exceptional Circumstance.

Assessment based indicators:

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

If this protocol is adopted, the role of the SC when Exceptional Circumstances have been declared will be to:

1. comment on the severity of the Exceptional Circumstance identified
2. advise on options with respect to the MP and TAC
3. if required and, if possible, provide updated TAC advice (i.e. not using the MP)
4. if necessary, advise on an earlier review of the MP

The decision on any management response will be for the Commission, based on SC advice.

The response to this request is structured around the guidance listed in the RBMS report of Sept 2017 (COM-SC WP 17-06):

- Clear determination of how missing data points required for input to the HCR should be filled and specification of the number of missing surveys that would trigger Exceptional Circumstances.

To compute the annual TAC from the HCR, survey values over a five-year period are required to inform on current resource status. This five year period moves forward each year as successive TACs are generated via the MP. Within the MSE, the individual survey biomass series are weighted differently, reflective of the estimated precision indicated for each index. Considering these weightings, it was agreed that Exceptional Circumstances would be triggered if, in a five-year period, more than one value is missing from a survey with relatively high weighting (Canadian Fall 2J3K, Canadian Fall 3LNO and EU 3M surveys) or more than two values are missing from a survey with relatively low weighting (Canadian Spring 3LNO and EU-Spain 3NO surveys). It was noted that the Canadian Spring 3LNO series is, at present, missing values in 2015 and 2017 and the Canadian Fall 3LNO series is missing a value in 2014. When computing the HCR, missing values will not be filled, but simply omitted from the calculations of means and regression slopes.

- Note elements that are based on data that are available to SC as part of its annual monitoring (survey results) as well as others that are based on less frequent update assessments, e.g. estimates recruitment, biomass or fishing mortality.

Scientific Council will continue to monitor the catch statistics and an array of survey indices for Greenland halibut on an annual basis. Indices will be calculated from available and pertinent surveys, namely the Canadian Fall 2J3K, Canadian Spring 3LNO, EU 3M, Canadian Fall 3LNO and EU-Spain 3NO surveys. Trends in abundance at length and, if available, abundance at age will also be analyzed using data from these surveys. Total catch (SC catches, currently from CESAG) will be monitored and compared against the TAC.

- Identify the indices that the MSE indicated to be more important to monitor in regard to the determination of Exceptional Circumstances, e.g. the factors that were indicated to have greater influence in the robustness trials. This links to the consideration of a suite of primary and secondary indicators.

Scientific Council agreed to use the terminology annual and assessment-based indicators instead of primary and secondary indicators. Tolerances of deviations of these annual and assessment-based indicators from MSE projections are outlined below.

By virtue of the design of the MSE, the most important indices to monitor while the MP is being applied are those generated by the five surveys which were used to test the accepted MP. It is also paramount to monitor future catches in relation to those recommended by the MP. Both catch statistics and survey indices will be available on an annual basis and it was therefore agreed that these values will be used on an annual basis to assess Exceptional Circumstances. Regarding robustness, trials conducted in the MSE indicated sensitivity to a low recruitment scenario. It was agreed that, at present, the most reliable way to assess recruitment is to apply a formal assessment model, such as the base case operating models used in the MSE. The status of future recruitment relative to projections produced under the accepted MP will therefore be assessed when assessment model runs are required. This ideally requires further research to determine the expected variance for such estimates of recent recruitment when compared to operating model projections. A comparison of assessment model outputs for other quantities (e.g. exploitable biomass, fishing mortality) with operating model projections will also be taken into account qualitatively.

Annual indicators:

- If sufficient survey data are available (see above), a composite index (J_y as in the MP) will be calculated and compared against the 80%, 90% and 95% probability envelopes projected by the base case operating models from SSM and SCAA under the accepted MP. Exceptional Circumstances will be triggered if the observed composite index in a given year is above or below the 90% probability envelope.
- Scientific Council will also monitor the five survey indices relative to the 80%, 90% and 95% probability envelopes projected by the base case operating models for each survey. Finally, as an approximate means of monitoring the status of recruitment, Scientific Council will assess survey data at age 4 (age before recruitment to fishery) compared to its series mean. Expert opinion will be needed to determine whether trends are of concern.
- Catches will be monitored annually by Scientific Council and deviations from the TAC calculated using the MP will be assessed.
- TACs established that are not generated from the MP will constitute an Exceptional Circumstance.

Assessment-based indicators:

- A comparison of assessment model outputs for recruitment, exploitable biomass, fishing mortality with operating model projections (base case) will also be taken into account qualitatively. Notwithstanding some technical issues regarding the comparison of the simulated distributions against updated assessments, it was agreed that SC will compare the estimated median of the assessment with the 95% CI from the base case of SSM and SCAA for the above quantities.
- Consider an appropriate balance between specificity vs flexibility in defining Exceptional Circumstances.
- The robustness of the Exceptional Circumstances protocol should ensure that their application is triggered only when necessary.

The combined use of probability envelopes and expert judgment noted in the above monitoring of annual and assessment-based indicators provides a balance between specific and flexible decision making when defining Exceptional Circumstances.

Probability levels, where specified, have been chosen with a view to a low probability of unnecessarily declaring Exceptional Circumstances.

- Evaluation of recruitment signals should be a key consideration, given some concern within the Working Group over poorer performance of the proposed rule under a low recruitment scenario.

As noted above, the most accurate assessment of the status of recruitment will be obtained from an assessment model and, as such, this is an indicator that will only be available when an assessment model is run. Indicators of recruitment obtained by the surveys will be assessed annually and further research will be conducted on the efficacy of utilizing survey-based indices of recruitment as a reasonable indicator of recruitment.

When Exceptional Circumstances have been declared, the SC will:

1. comment on the severity of the Exceptional Circumstance identified
2. advise on options with respect to the MP and TAC
3. if required and, if possible, provide updated TAC advice (i.e. not using the MP)
4. if necessary, advise on an earlier review of the MP

iv) Benchmark assessment of the 3M Cod and workplan for MSE (Item 5)

The Commission requests the Scientific Council to implement processes to conduct a full benchmark assessment of the 3M Cod in line with the work plan (FC-SC Doc. 17-02, Annex 3) and the steps of the work plan relevant to the SC for progression of the 3M Cod Management Strategy Evaluation for 2019.

Scientific Council responded:

Scientific Council completed a benchmark assessment of Div. 3M cod in April 2018. A new assessment model was adopted by SC and applied to assess the stock during the June meeting and provide advice for 2019.

Progress has been made in decision-making for technical elements of the MSE. However, SC noted that the timeline for the MSE does not specify when some key decisions will be taken. The timing to establish the management objectives, performance statistics and the associated risk thresholds for each are still undetermined. This should be a priority point of discussion during the RBMS meeting in August of 2018 if the MSE is to be completed by September 2019.

I. Benchmark Assessment of Cod in Div. 3M

The 3M Cod NAFO Benchmark process began in March 2018 with a Scientific Council Webex meeting on the data available to perform the assessment of Div. 3M cod. The benchmark was held in Lisbon (Portugal) from 9th to 13th April 2018. Members of the Secretariat of NAFO and members of two Contracting Parties of NAFO (Canada and EU) attended the meeting, as well as three external experts invited by NAFO (Carmen Fernández, Jim Ianelli and Mike Palmer) and a stakeholder representative. The Benchmark final report is not available yet but is expected to be completed by July.

SC considered numerous model formulations of single species population models (Bayesian XSA, Bayesian SCAA and SAM) as well a multispecies model based on GADGET (GADCAP project; see also Section VI. 6. b of this report). Model results and diagnostics of all methods were explored, though the majority of the meeting time was focused on fine-tuning the SCAA model structure. The purpose of the additional SCAA analyses conducted during the meeting was to either i) investigate the appropriateness of model assumptions, or, ii) to mitigate issues noted in initial runs.

Different formulations of the models in some cases gave very different results and often indicated lack of fit to the data. In choosing a model to use as the basis for stock assessment, the meeting focused on the Bayesian XSA and SCAA. The final two runs of the Bayesian XSA (R7) and SCAA (R37) showed better fit to the survey data and results of the two models were similar to each other. The greater flexibility of the SCAA was considered to be an advantage over the XSA, making it a more powerful assessment tool. In addition, more testing was conducted of the SCAA during the benchmark than of the other models. Considering all of these issues SC recommended a Bayesian SCAA model with structure similar to run 37 to form the basis of the assessment for this stock in June 2018, pending some sensitivity analyses (modifications to the prior distributions aiming to increase robustness) that were subsequently presented during the June SC meeting.

This work was completed and the model structure, including the modifications to the prior distributions, was adopted by SC and applied to assess the stock and provide advice for 2019.

II. 3M Cod MSE workplan

SC reviewed the steps of the work plan relevant to the SC for progression of the 3M Cod Management Strategy Evaluation for 2019. It has been decided to hold the RBMS meeting in August of this year. However, when the cod 3M MSE calendar was designed, it did not specify when the management objectives and risk thresholds would be specified. The completion of the MSE process is contingent on these decisions, and the management objectives, the performance statistics and the associated risk thresholds for each are still undetermined. This should be a priority point of discussion during the RBMS meeting in August of 2018 if the MSE is to be completed by September 2019.To minimize delays, and also based on the results of the NAFO Cod Div. 3M Benchmark, the SC discussed some points of the Cod Div. 3M MSE and agreed the following:

The data used in the SC June 2018 Cod 3M assessment (over the time frame 1988-2017) will be used to conduct the MSE. If during the MSE process the age-length key from the Flemish Cap survey of 2017 becomes available, this should be included in the input data set.

The base case reference operating model (OM) will be the model assessment approved in the 2018 June SC meeting. The development of other OMs to be tested will take into account the following guidelines:

- Possible OMs with alternative M priors and/or CVs
- Possible OMs with different groups of qs if necessary.
- Model scenarios with alternative assumptions on recruitment.
- Possible OMs considering auto-correlated, inter-correlated and/or density-dependent impacts on weights and maturities.

The period over which the simulations will be carried out will be 20 years. MSE performance statistics should reflect short, medium and long term objectives.

The observation model to generate the future data should take in account the auto-correlation of the survey indices.

Reference points should be determined by each operating model independently and should be consistent within each. The reference points should be based on Maximum Sustainable yield (MSY), if possible. If $F_{30\%SPR}$ is used as a proxy for F_{MSY}, a decision will be required on the appropriate data period to use in estimating $F_{30\%SPR}$ (magnitude is sensitive to this given the significant changes in biological parameters for 3M cod).

Possible guidelines from the SC to develop HCR. SC recommends applying the same guideline for the 3M cod expressed by WG-RBMS during the Greenland halibut MSE process (NAFO/FC-SC Doc. 17-02). Consistent with these guidelines, a model free HCR should be considered. It should also be considered whether to use abundance or biomass indices in the rule.

Some of the previous topics will be reviewed and decided at the next meeting of the RBMS in August. Revisions to the cod 3M MSE timeline – if required – should also be discussed during the coming RBMS meeting.

v) Continue evaluation of the impact of scientific trawl surveys on VME in closed areas, and the effect of excluding surveys from these areas on stock assessments. (Item 6)

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

SC notes that due to workload, the length and age-disaggregated analyses related to the EU surveys were not yet carried out, but the intention is to complete this task prior to the next SC meeting in June 2019 assuming necessary resources are made available.

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

SC reiterates its recommendation in 2017 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.

To provide an update on the progress of this work, SC considered an overview of all analysis conducted on this subject since the request was first raised by WGEAFFM during its 2015 meeting.

In 2016, SC (SCS Doc 16/21) conducted an analysis of the spatial overlap of significant catches of VME indicator species in survey trawls from; **(i.)** NAFO closed areas, **(ii.)** areas inside the VME polygons, but outside closed areas, **(iii.)** areas outside of closures and outside VME polygons. It was found that the vast majority of significant catches of VME indicator species - and the highest rate of such catches - occur in the areas covered by current closures.

SC is aware of the Canadian plans to close 10% of its marine area by 2020 and this has not been included in the current review of impacts.

In both 2016 and 2017, SC reviewed the consequences of excluding survey tows within the current closures to evaluate impacts on biomass indices for stocks assessed by SC. The results show minimal impact on estimates of survey biomass and trends for all the assessed species with the exception of Roughhead grenadier and Greenland halibut. For these species the difference in biomass indices (with and without hauls in closed areas) is more noticeable, but the trends were similar to the original index. Furthermore, an analysis of the length and age-disaggregated survey indices for these species was conducted for the Canadian survey data, and the results were indistinguishable. It was concluded that the impact of excluding the closed areas from future Canadian surveys would enhance protection of VME while not compromising the ability to determine stock status of NAFO-managed resources.

Due to workload issues, the length and age-disaggregated analyses related to the EU surveys were not carried out in 2017, but the intention is to complete this task prior to the next SC meeting in June 2019 assuming necessary resources are made available.

The Commission may wish to consider investigating among contracting parties the possibility or feasibility of implementing non-destructive regular monitoring (e.g. camera surveys) within the closed areas to compensate for any loss of information related to the exclusion of trawl surveys on VMEs closures.

vi) Implement the Action plan for progression in the management and minimization of Bycatch and discards (Item 7)

The Commission requests the Scientific Council to implement the steps of the Action plan relevant to the SC for progression in the management and minimization of Bycatch and discards (NAFO/COM Doc. 17-26)

SC discussed the Action Plan developed by WG-BDS and noted that most of the items will be worked on over the next few years and also noted where work has been done in the past. Work on this request will continue in 2019.

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

Action point 2.2. Specific issues by time, area, depth, fleet and fishery
Identification of species under NAFO catch or effort limits with high survivability rates. AM 2020 SC

This would require at a minimum a literature search and potentially discard mortality experiments. WG-BDS has made a recommendation: *That the Commission include in its request for advice to Scientific Council at the 2018 meeting the task identified under Section 2.2 of the Action Plan*;

Action point 3.1. Moratoria species
Identify moratoria stocks where the level of bycatch/discards may be impeding recovery SC (with BDS) AM2021

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

Action point 3.2. Areas where there is a risk of causing serious harm to by-catch species
Identify areas, times and fisheries where by-catch and discards, notably of moratoria species, that have a higher rate of occurrence. SC (with BDS) AM2021

This item should include the Secretariat and should examine several years of haul by haul data as well as observer data. Some work has been done in the past examining landed bycatch in various fisheries and a preliminary look at the haul by haul data for 2016 was presented at BDS in 2017. WG-BDS has made a recommendation for the Secretariat to develop a workplan for these analyses by AM 2018.

Action point 4.2. Fishery-specific solutions

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

Action point 4.3 Identification of best practices
Best practices / possible mitigation measures to avoid by-catch per time, area, depth, fleet and fishery. BDS SC AM 2020

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

vii) Conduct a full assessment on 3M golden Redfish in 2019 (Item 8)

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

Scientific Council responded:

In 2017, due to lack of time, the request for a full assessment on 3M golden Redfish was deferred. Nevertheless in 2017, as in previous years, advice for 2018-2019 for golden Redfish was given indirectly based on the Div. 3M beaked redfish assessment (advice of 3M Redfish has a percentage of golden Redfish). Since the next Div. 3M beaked Redfish full assessment will be in June 2019, SC will conduct a full assessment on 3M golden Redfish at that time, consistent with the timing of the Commission Request.

viii) Provide further guidance on the implementation of an ecosystem approach and application of the Ecosystem Road Map (Item 9)

The Commission requests the Scientific Council provide further guidance on the implementation of an ecosystem approach and application of the NAFO Roadmap, through examples of how advice compares to single species stock assessment, including additional factors to be considered and integrating trophic level interactions and climate change predictions.

The Scientific Council Responded:

As further guidance on the implementation of an ecosystem approach and application of the NAFO Roadmap, SC notes that Total Catch Ceilings (TCCs) aim to provide information for ecosystem-level strategic management advice that can complement stock-level tactical advice. In principle, once TCCs can be estimated with sufficient reliability and precision, these should provide an ecosystem context to evaluate the recommendations that emerge across stocks, and could serve to address questions not considered as part of single species assessments (e.g., tradeoffs).

Accordingly, SC requests the Commission consider developing options by which ecosystem considerations can be operationally integrated into fisheries management advice through consideration of the risk of damage or deterioration of the ecosystem, whilst recognizing the uncertainties associated with integrating ecosystem effects on stock status and trends. Formation of an *ad hoc* COM-SC working group, consisting of a sub-group of members of WGEAFFM, to identify a mechanism (or framework) by which ecosystem considerations could be integrated into fisheries management advice and which would provide a basis for SC (WG-ESA) to investigate further options for the implementation of the NAFO Roadmap.

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

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

Ecosystem Summary Sheets

Design of ecosystem summaries was based on the objectives and general principles stated in the NAFO convention. The design aims to mirror the basic objectives that underlie the structure of the stock summary sheets, but in a manner that recognizes how environmental conditions and ecosystem structure affect NAFO's ability to report on the objectives and principles of the convention. Ecosystem summary assessments should be carried at medium-term intervals (3-5 years).

Summary sheets are intended to provide a synoptic overview of a suite of ecological features and management measures at the EPU level, where information is summarized in terms of their state and trends. Elements within the ecological features group provide information on environmental conditions, productivity at different trophic levels, ecosystem structure, as well as vulnerable habitats and depleted species. Elements within the management measures group provide information of the relationship of the state variables relative to management framework and objectives.

Summary sheets provide strategic level advice on the state of the ecosystem. Extensive occurrence of below normal, negatively trending and/or poor conditions or in the effectiveness of management measures should point to movement toward more risk-averse management actions.

A colour-coding traffic light scheme for the state and trends of the ecological feature and management measure elements of the Ecosystem Summary Sheets (ESS) was developed in order to parallel the stock summary sheets (Table viii.1).

Table viii.1. Colour scheme for ecosystem summary sheet and the corresponding criteria for assignment to each category for the status and trends. For ecological features, contributing elements time series should be standardized to zero mean and unit standard deviation relative to an appropriate reference period.

	Ecological Features		**Management Measures**	
	Status	**Trend**	**Status**	**Trend**
Green	The state over the last 5 years is consistent with conditions observed/estimated during high productivity/high resilience periods (mean > 0.5 SD).	The trend over the last 5 years indicates consistent improving of the state/condition (trend > 1 SD/5 y or >20% increase in state).	Good. Current management measures are delivering the desired results.	Good. Management measures over the last 5 years are improving conditions; moving towards/maintaining the desired results.
Yellow	The state over the last 5 years is consistent with conditions observed/estimated during average productivity/average resilience periods.	The trend over the last 5 years does not indicate any consistent change of the state/condition.	Uncertain. Current management measures appear to have limited ability to deliver the desired results.	Uncertain. Management measures over the last 5 years are not improving conditions; no clear movement towards achieving the desired results.
Red	The state over the last 5 years is consistent with conditions observed/estimated during low productivity/low resilience periods (mean < -0.5 SD).	The trend over the last 5 years indicates consistent deterioration of the state/condition (trend < -1 SD/5 y or >-20% decline in state).	Poor. Current management measures appear insufficient to deliver the expected results or no management measure is in place.	Poor. Management measures over the last 5 years are not effective or no management measure is in place; conditions are moving away/deteriorating from the desired results.
Grey	Unknown - insufficient data to assess or assessment pending.	Unknown - insufficient data to assess or assessment pending.	Unknown - insufficient data to assess or assessment pending	Unknown - insufficient data to assess or assessment pending

As a way of example, SC developed and populated an initial ecosystem summary sheet for the Grand Bank (3LNO), one of the EPUs being used as pilot ecosystems for the implementation of the Roadmap for the period 2013-2017. These ecosystem summary sheets are expected to be refined, updated over time, and this first exercise will provide grounds for discussion with the Commission on what needs to be improved to make these ecosystem summary sheets more useful for decision-making. For example, additional consideration could be given to the interpretation of the Trend measures based on the scoring of the associated Status indicator. It is recognized that a Trend scoring of Stable could have a different interpretation if Status is positive or negative.

An ***example*** of a case study, including an example of the ecosystem-level recommendation and the tabular summary of the state of the 3LNO EPU is presented below, and a summary narrative follows the table and figures. Data are available to implement ESS for EPUs 2J3K and 3M.

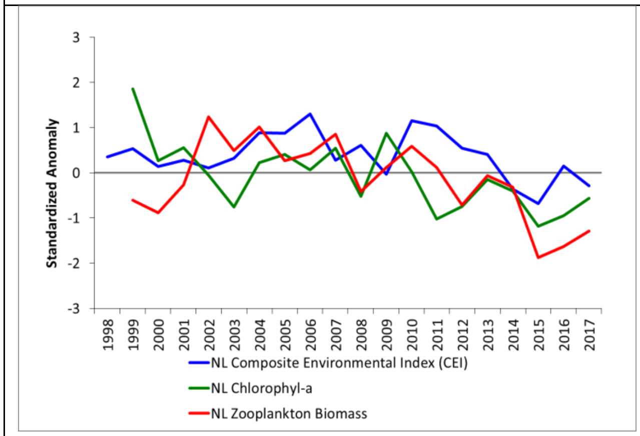
Example recommendation: The Grand Bank (3LNO) EPU is currently experiencing low productivity conditions and biomass declines across multiple trophic levels and stocks. Although reduced productivity appears to be driven by bottom-up processes, current aggregate catches for piscivore species have been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

ECOLOGICAL FEATURES					
Convention Principle					**Comment**
a		**Ecosystem status and trends (long-term sustainability)**	**S**	**T**	**Summary of state (S) and trend (T)**
	1	Physical Environment	🟨	🟨	No clear 5-yr trend but notable 10-yr cooling trend
	2	Primary Productivity	🟥	🟨	Reduced nutrients, phytoplankton standing stocks and productivity.
	3	Secondary Productivity	🟥	🟥	Reduced total zooplankton biomass, with increased abundance of small-sized taxa.
	4	Fish productivity	🟥	🟥	Declines in total, finfish, and shellfish biomass across all functional feeding groups since 2013-14. Overall biomass below pre-collapse levels.
	5	Community composition	🟨	🟨	Shellfish has declined in dominance, but piscivores have yet to regain their pre-collapse dominance.
b		**Ecosystem productivity level and functioning**			**Summary of state (S) and trend (T)**
	1	Current Fisheries Production Potential	🟥	🟥	Total biomass further declined from 50% to ~30% of the estimated pre-collapse level.
	2	Status of key forage components	🟥	🟥	Reduced levels of capelin, sandlance, arctic cod, and shrimp.
	3	Signals of food web disruption	🟨	🟥	Diet composition variable of key predators (cod and turbot), declining trend in stomach content weights.
e		**State of biological diversity**			**Summary of indicators**
	1	Status of VMEs	▨	▨	Metrics to quantify VME state and change of state in recent period need to be developed.
	2	Species depletion	▨	▨	Proportion of depleted species (<20% of maximum) based on survey indices. Work in development.
MANAGEMENT MEASURES					
Convention Principle					**Comment**
c/d		**Precautionary Aspects**	**S**	**T**	**Summary of metrics on level of management action**
	1	Total Catch Ceilings (TCC) and catches	🟥	🟥	Indications of ecosystem overfishing. Piscivores catches have been exceeding their TCC; suspension-feeding benthos exceed it in 2016.
	2	Multispecies and/or environmental interactions	🟥	🟥	No explicit consideration of species interactions and/or environmental drivers.
	3	Production potential of single species	🟨	🟨	Only 60% of managed stocks are supporting fisheries; some stocks have declining abundance trends.
d/e		**Minimize harmful impacts of fishing on ecosystems**			**Summary of metrics on level of management action**
	1	Level of protection of VMEs	🟨	🟩	Some VMEs without protection. Protection has improved. Fishing does not intrude in closed areas.
	2	Level of protection of exploited species	🟨	🟩	Total Catch Ceilings have been developed; 70% of managed stocks have LRPs or HCRs, but some stocks only have survey-based LRPs; No multispecies assessment are in place.

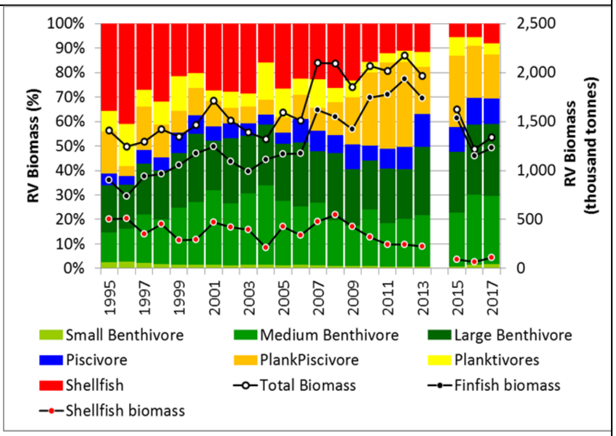
d/f	**Assess significance of incidental mortality in fishing operations**				**Summary of metrics on level of management action**
	1	By-catch level across fisheries			Integrative indicators/analyses need to be developed.
	2	By-catch of depleted species			Integrative indicators/analyses need to be developed for non-target taxa. This should include listed species.
CONSIDERATIONS OF SPECIAL CONCERN (outside mandate of NAFO Convention)					
Human Activities other than fisheries					**Comment**
	1	Oil and gas activities			There are four offshore production fields on the Grand Bank and intense exploration activities along the eastern shelf break and Flemish Pass.
	2	Pollution			…
	3	…			…

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

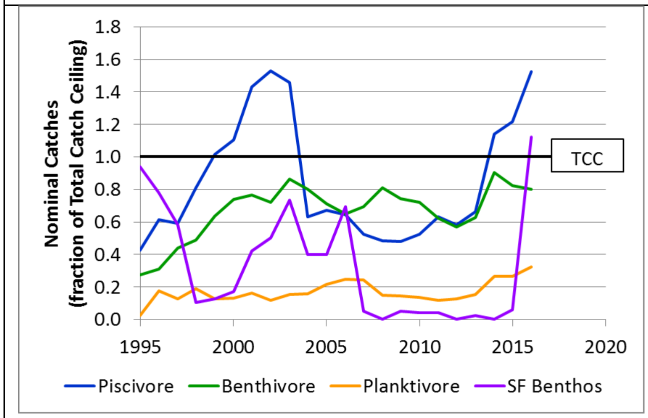
PHYSICAL ENVIRONMENT AND LOWER TROPHIC LEVELS



FISH COMMUNITY COMPOSITION AND BIOMASS



ECOSYSTEM AGGREGATE CATCHES



BY-CATCH IMPACTS

To be defined

3LNO EXAMPLE Ecosystem Status Narrative

ECOLOGICAL FEATURES

Ecosystem Status and Trends

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

Ecosystem productivity level and functioning

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

State of biological diversity

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

MANAGEMENT MEASURES

Precautionary Principles

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

Minimize harmful impacts of fishing on ecosystems

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

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

Assess significance of incidental mortality in fishing operations

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

OTHER CONSIDERATIONS

Human activities other than fishing

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

Update of Total Catch Ceilings (TCC) in NAFO Ecosystem Production Units (EPUs)

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

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

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

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

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

Accordingly, SC requests the Commission consider developing options by which ecosystem considerations can be operationally integrated into fisheries management advice through consideration of the risk of damage or deterioration of the ecosystem, whilst recognizing the uncertainties associated with integrating ecosystem effects on stock status and trends. Formation of an ad hoc COM-SC working group to identify a range options would provide a basis for SC (WGESA) to investigate further options for the implementation of the NAFO Roadmap.

When TCC guidelines were first introduced, the Grand Bank (3LNO) and Newfoundland Shelf (2J3K) EPUs were considered to be under stress, and the TCC estimates included a penalty factor of 50% to reflect their reduced productivity. Given the declines in total biomass observed since 2013-2014, these penalty factors, which are based on the ratio between current total biomass and the median levels observed prior the collapse in the late 1980s and early 1990s, were re-evaluated. The results indicated further reductions in productivity, prompting an increase in the penalty factors to 60% and 70% for the Newfoundland Shelf (2J3K) and the

Grand Bank (3LNO) respectively to reflect the more recent productivity conditions. The re-evaluation of the productivity state for the Flemish Cap (3M) EPU is still pending. Based on these considerations, together with some improved EPP model parameters, the TCC guidelines were updated (Table viii.2).

Table viii.2. Updated guidelines for Total Catch Ceilings (TCC) for the Flemish Cap (3M), Grand Bank (3LNO), and Newfoundland Shelf (2J3K) Ecosystem Production Units (EPUs) based on the estimated distributions of the Fisheries Production Potential (FPP) for these areas, and the application of penalty factors when required. TCCs are provided for each fishable model node (piscivores, benthivores, planktivores, and suspension feeding (SF) benthos), and the Standard Demersal Components (SDC) aggregate which is the summation of piscivores and benthivores nodes, and includes traditional groundfish stocks as well as shellfish species.

	Total Catch Ceiling (TCC) (25th percentile of the adjusted FPP distribution) in thousand tonnes per year			Median (50th percentile of the adjusted FPP distribution) in thousand tonnes per year		
	NL Shelf (2J3K)	Grand Bank (3LNO)	Flemish Cap (3M)	NL Shelf (2J3K)	Grand Bank (3LNO)	Flemish Cap (3M)
Area (thousand km^2)	254.319	311.646	58.412			
Penalty factor	0.6	0.7	0.0	0.6	0.7	0.0
EPP Node or Aggregate						
Piscivores	17.67	20.58	12.48	24.67	28.68	17.35
Benthivores	51.65	58.15	35.23	84.07	96.87	58.50
Planktivores	70.10	81.95	49.03	100.13	115.52	69.31
SF Benthos	12.76	13.69	8.03	19.85	21.42	12.62
SDC	69.32	78.73	47.71	108.74	125.55	75.84

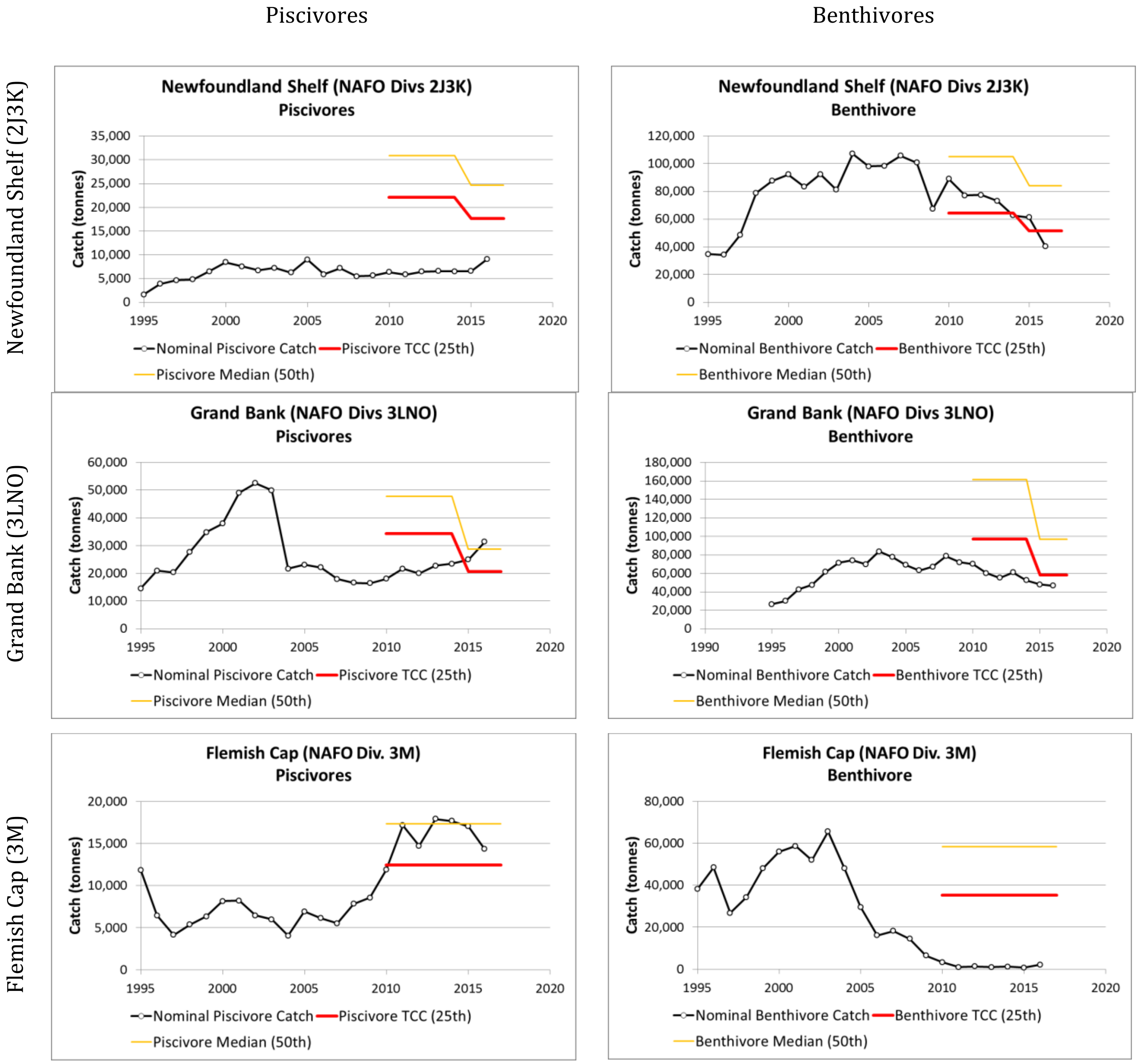


Fig. viii.1. Comparisons between nominal catches and the updated TCC levels for Piscivores and Benthivores in the Newfoundland Shelf (2J3K), Grand Bank (3LNO), and Flemish Cap (3M) EPUs. The reductions in TCCs after 2014 for the EPUs in the NL bioregion are linked to the declines in total biomass observed in these EPUs, and which under the assumption of a relatively constant ecosystem-level P/B ratio, is an indicator of reduced ecosystem productivity.

In order to compare nominal catches with TCC values, it is necessary to recognize that production for individual target species is associated to different EPP nodes due to diet changes linked to different life history stages. Although work on these aspects is ongoing, an initial fractionation for Atlantic cod and redfish was implemented in 2017. Earlier analyses indicated that assigning 100% of Greenland halibut to the piscivore node seemed reasonable.

The comparison of nominal catches against TCC levels (Fig. viii.1) indicates that fisheries in the Flemish Cap (3M) continue to be highly concentrated on piscivores (cod and redfish), and have been consistently above the

TCC level since 2010. From this perspective, this EPU can be considered to be experiencing ecosystem overfishing.

The Newfoundland Shelf (2J3K) has fisheries targeting piscivores and benthivores nodes, but catches are more concentrated on benthivores (shrimp and snow crab), which have been above the estimated TCC levels for many years. Even though most recent catch levels have dropped below the TCC, it is likely that this ecosystem may have also experienced ecosystem overfishing.

The Grand Bank (3LNO) has fisheries more evenly distributed between piscivores and benthivores, which have been below the estimated TCCs over the last 10 years. However, the further reduced productivity in this EPU, in combination with the increasing trend in piscivore catches, indicates that this EPU could be moving into ecosystem overfishing.

It is also worth highlighting that the Grand Bank (3LNO) is the only EPU with significant catches of suspension feeding benthos among the EPUs considered here. Catches consist mostly of surf clam, and seem to follow boom-bust patterns of change in occurrence (Fig. viii.2). Catches have been virtually nil since the late 2000s, but suddenly spiked in 2016 to the levels observed during the 2002-2006 period. Given the reduction in TCC levels after 2014, the 2016 catches are slightly above the estimated TCC. However, the estimation of TCC for SF Benthos includes an assumption that only 10% of the production of this group is composed by species of commercial value, so ephemeral overshooting of the TCC for this group may be less critical than for other fishable nodes (e.g. piscivores, and benthivores).

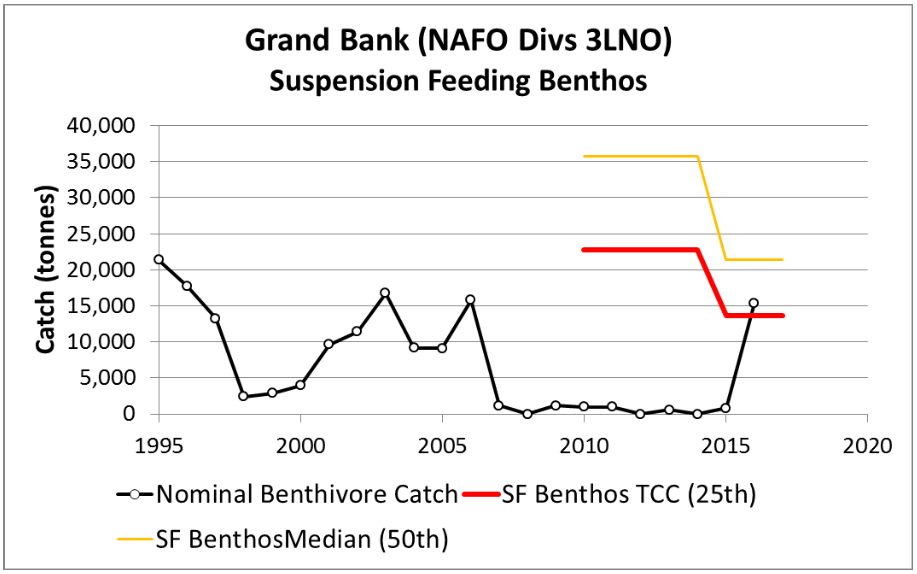


Fig. viii.2. Comparison between nominal catches and the updated TCC levels for Suspension Feeding (SF) Benthos in the Grand Bank (3LNO) EPU. The reductions in TCCs after 2014 is linked to the decline in total biomass observed in this EPU, and which under the assumption of a relatively constant ecosystem-level P/B ratio, is an indicator of reduced ecosystem productivity.

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.

References:

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

ix) Assessment of NAFO bottom fisheries (item 10)

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

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

Scientific Council responded:

SC made further progress in assessing the overlap of NAFO fisheries with VME through an analysis of haul-by-haul log-book data in combination with VMS data. Such analysis significantly improves the spatial definition of specific fishing areas within the NAFO footprint. **SC recommends** that *the door spread of fishing gear is required for the estimation of swept area calculations, and this should be added to Annex II.M, 1B standardized observer report template for trawl gear information.*

Furthermore, SC has made progress in developing models and methodological approaches which assess the functional significance of VMEs and the estimation of recovery rates of different VME indicator species.

Updated analysis (including new data) has been performed on non-coral and non-sponge VME indicator species and further work is planned on defining non-coral and non-sponge VME ahead of the re-assessment of VME fishery closures in 2020.

Overlap of NAFO fisheries with VME

Haul-by-haul logbook data was merged with the vessel monitoring system (VMS) data to provide a more accurate measure of when vessels are trawling. It also allowed each haul to be assigned to a fishery directed at a specific species. The haul-by-haul effort maps are considered to be an improvement over past effort maps derived from a 1 – 5 knot speed filter as they remove spurious effort points (Fig. ix.1). Overall, the areas represented by the logbook haul-time filter method and the simple speed filter method show fishing activities in the same general areas with similar patterns of intensity, but with the new method, there are fewer cells displaying fishing effort within the vulnerable marine ecosystem (VME) closures. Mapping of trawl tracks would potentially enable a more accurate estimate of sea bed impacts and would facilitate more accurate swept area estimates to be performed. However, information on gear dimensions (especially the parts of the gear that contact the seabed, e.g. ground rope and trawl doors) are required to enable these calculations to be undertaken. SC recommends the inclusion of fishing gear dimensions relevant for the estimation of swept area calculations (door spread) could be included in Annex II.M, 1B standardized observer report template for trawl gear information.

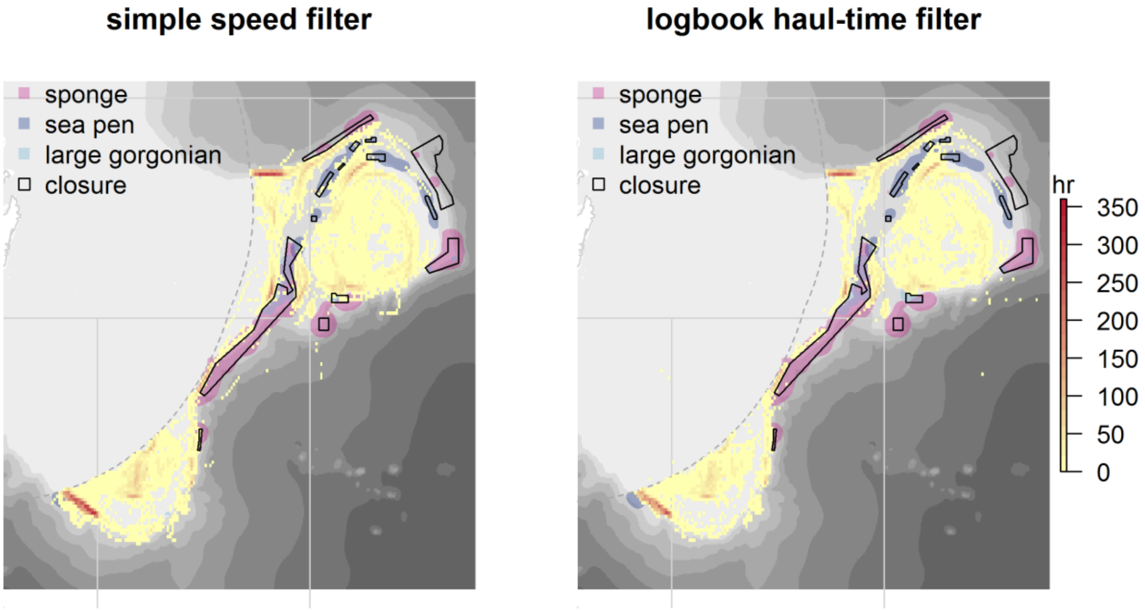


Fig. ix.1. Cumulative fishing effort maps (hours fished per cell) from 2016 VMS and logbook data produced by two different methods. Left: VMS data was filtered for speeds within 1-5 knots, right: VMS was filtered if it was within the reported fishing time interval in the logbook.

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

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

Maintain effort to assess all six of the FAO criteria

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

Furthermore, work was initiated on the application of biological traits analysis to help determine the functional significance of VMEs in the NAFO regulatory area to help address FAO criteria V. Essentially, by quantifying how taxa interact with their environment, a number of important processes (e.g. bioturbation) can be associated with VME habitat or production functions and these, rather than the VME species assemblages, can be used to define and quantify the significance of potential bottom fishing impacts.

Non-sponge and non-coral VMEs

Updated biomass and habitat analyses for sea squirts and bryozoans suggest a contiguous habitat being formed by the significant catches of these non-coral and non-sponge VME indicator species, particularly by the sea squirts (Boltenia; Fig. ix.2). Additional information on the distribution of fishing effort and other habitat data (e.g. surficial geology layers) will be examined to determine the extent and distribution of significant concentrations of these non-coral and non-sponge species prior to the reassessment of the VME fishery closures in 2020.

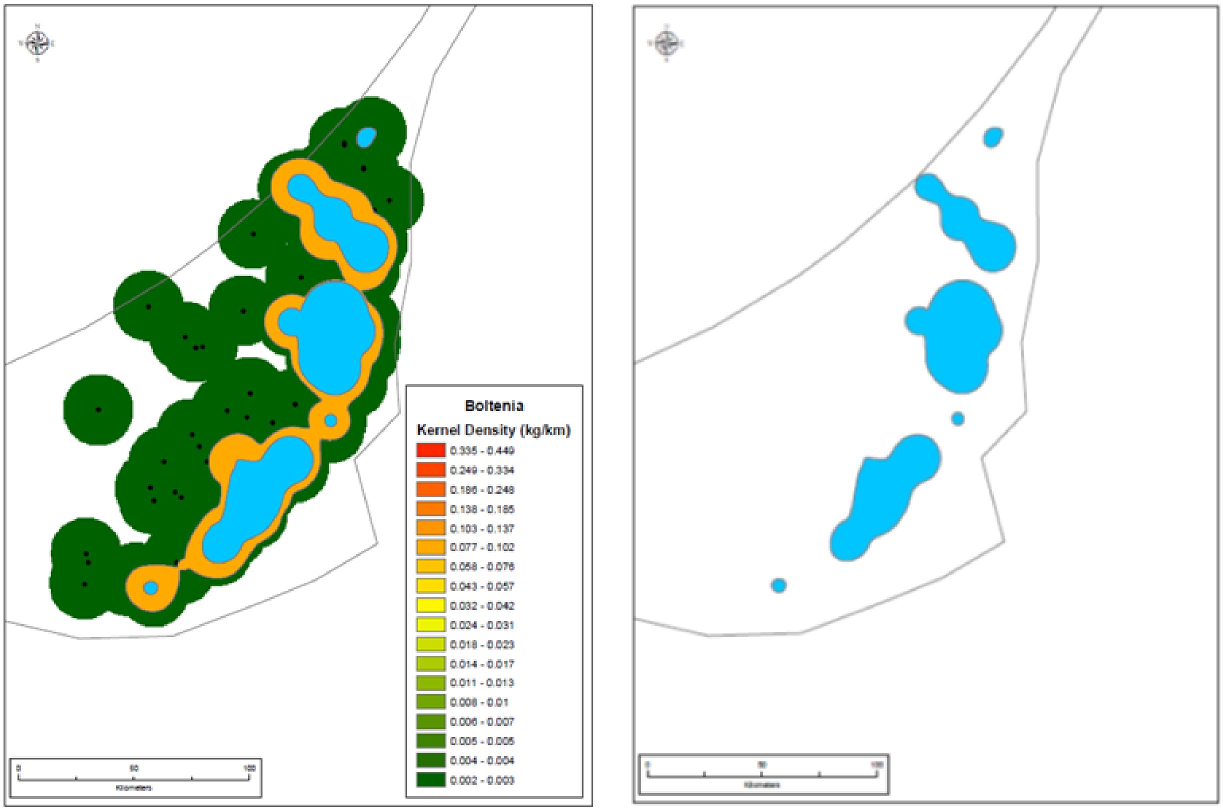


Fig. ix.2. Spatial configuration of KDE-derived polygons showing difference in area between polygons calculated with thresholds of the 0.2 kg *Boltenia* catch (orange) and 0.3 kg *Boltenia* catch (light blue). The 0.3 kg threshold was chosen as the threshold denoting the *Boltenia* habitat (right panel).

x) Continue progress on the NAFO PA Framework (Item 11)

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

Scientific Council responded:

There has been no progress since the review of the PA framework in September 2017. Earlier progress was made in the context of Precautionary Approach elements of an ecosystem approach to management. As a result of heavy workloads and limited capacity, Scientific Council will be unable to complete this review by September 2018 and encourages participation of additional quantitative experts in an effort to make progress.

The Precautionary Approach to Fisheries Management Working Group (PAF-WG) met by WebEx in March 2016 to consider terms of reference agreed by the joint FC-SC Working Group on Risk Based Management Strategies (WG-RBMS) in 2015, including a review of the existing NAFO PA framework and a comparative review of equivalent frameworks used in other organizations. In April 2016, WG-RBMS reviewed progress on this task and established a timeline for the completion of the work of the PAF Working Group (FC-SC WP-RBMS 16/03). However, SC reviewed this timeline in September 2016 and noted that it was likely to be impacted by the prioritization of the Greenland halibut MSE. Given the complexities of the issues involved, SC agreed that a dedicated workshop would be required, which should include external experts in the field and would not be possible within the agreed timeframe.

In November 2016, 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. It was noted that the precautionary approach as defined under the FAO guidelines 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. SC reviewed this work during its 2017 September meeting; however, due to time constraints, it has not been possible to make any further progress since that time.

xi) Review and develop advice for Greenland sharks (Somniosus microcephalus) (Item 12)

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. Given that longevity of the Greenland shark is the highest ever documented for any vertebrate and life history traits are extremely conservative (longevity = 392 ± 120 years; age-at maturity = 156 ± 22 years; low fecundity) for this species, SC *recommends* that retention and landings be prohibited. SC *recommends* requiring live release of captured Greenland sharks to minimize mortality, and the promotion of safe handling practices by fishers. SC also suggests that where appropriate, gear restrictions and modifications, and/or spatial and temporal closures of areas of high bycatch, be implemented to reduce the incidence of Greenland shark bycatch. SC *recommends* improving on the reporting of all sharks by species within the NAFO Convention Area, and with the collection of shark numbers, measurements (when feasible without causing undue harm) and recording of sex data and discard disposition (i.e., dead or alive) by fishery observers in all fisheries in the NAFO Convention Area. Due to the unknown status of the stock relative to B_{lim}, and the conservative life history traits, SC **recommends** that *management actions should keep fishing mortality as close to zero as possible to ensure that there will be a very low probability biomass will decline within the foreseeable future.*

Introduction

Biology and life history of Greenland sharks was reviewed by SC in 2017. It must be reiterated that Greenland sharks have an extremely conservative life history. Longevity was recently estimated to be the highest documented for any vertebrate, at 392 ± 120 y, with maturity estimated to occur at 156 ± 22 y (Nilsen et al., 2016). 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. Fecundity is also considered to be low (Castro 2011).

Additional information reviewed in 2018 discussed recent satellite telemetry studies that indicate broad scale movements of Greenland sharks throughout the NAFO Regulatory Area. 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. In addition, tagged sharks from Davis Strait traveled as much as 1 615 km from the tagging site and tagged individuals exhibited midwater swimming, e.g. tag depth of 1 100 m in water depth of 4 km. Individuals tagged in coastal Nunavut travelled to the west coast of Greenland (Hussey et al., 2018). Recent and ongoing telemetry data reveal coordinated movements (seasonal migration) through commercial fishing areas (Hussey et al., 2018; Hussey et al., unpublished data).

As well, recent evidence suggests that inshore fjords may be important habitats for small sharks (Hussey et al. 2014) and densities vary considerably among stations sampled (Devine et al. 2018), suggesting aggregative behavior in some areas. Mature females have been frequently documented in Southwest Greenland but are rarely seen in other areas (Nielsen et al. 2014).

Fisheries

Fisheries for Greenland shark have occurred in the past (e.g. Norway, Greenland and Iceland). Historically, high catches have been recorded in Norway and Greenland, driven by the liver oil and skin markets. Landings in Norway peaked in 1948 at 58,000 sharks. However, this estimate was based on an extrapolation from barrels of crude shark liver oil, which may be imprecise due to various factors (e.g. sex and species differences). Reports of landed amounts of liver in Greenland, converted to number of sharks, was historically estimated to be 15 000 to 30 000 sharks annually from 1850 to 1895, increasing to 30 000 to 45 000 in most years from 1895 to 1938 for North Greenland alone (Oldenow 1942; Mattox 1973). 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 fisheries 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). However, even today Greenland sharks are still used to some extent for dogfood in North Greenland. As no sharks or shark products are landed to factories, the utilized sharks originate either from directed subsistence fishery or from the utilization of bycatches in other fisheries. In some areas, Greenland shark are caught for subsistence and cultural purposes (e.g. Iceland).

Fisheries Bycatch

There is currently no directed commercial fishery for Greenland shark in the NAFO Convention Area but the STATLANT 21 data during 2002-2017 indicated that some incidental catches were landed. Despite the lack of accurate estimates of total removals owing to unknown discard levels, reported incidental catch has increased between 2002 and 2017 from 2 t to 71 t, respectively (Fig. xi.1). There was incidental catch prior to 2002, however, reporting of catches from Flag States was not mandatory prior to that time. It should be noted that numbers of Greenland sharks are generally not reported and weights are estimated visually by crew/observers or extrapolated from fin length measurements. Therefore, any estimates of numbers presented are generally either minimum catches based on the number of reports, as each report must be at least 1 shark (if identified properly), or a conversion from weight to length based on some sort of assumed relationship between the two.

NAFO Regulatory Area

Recent NAFO observer data were summarized for all Flag States fishing in the NRA from 2014-2017 (Figs. xi.2 and xi.3). Without accounting for variable fishing effort, bycatch numbers of Greenland shark were highest (43%) in the Greenland halibut bottom trawl fishery, mainly in Division 3L, followed by the Atlantic halibut longline fishery (26%), mainly in Division 3N, then the redfish bottom trawl fishery (19%), mainly in Divisions 3N and 3M. The same three directed fisheries, in the same order, comprised 53%, 27% and 8%, respectively, of the total Greenland shark bycatch weight.

Most of the longline catches in Division 3N occurred at depths of 200-1,200 m (mainly 400-800 m), with only a few longline catches on the Flemish Cap at depths of 800-1,200 m. Bottom trawl catches of Greenland sharks were more widespread in the NRA and occurred in Divisions 3LMNO, but were mainly concentrated in 3L and 3M at depths of 400-1,400 m and 300-1,000 m, respectively.

The minimum numbers and weight of Greenland shark bycatch in the Greenland halibut bottom trawl fishery has steadily increased every year since 2014 (Table xi.1). Although the minimum number and weight of Greenland sharks caught in the Atlantic halibut longline fishery increased between 2014 and 2016, bycatch decreased in 2017 (Table xi.2). Although discard mortality for bottom trawls is unknown, it is high for individuals that become entangled in longlines and are improperly handled (MacNeil et al. 2012).

CANADA

An update of Greenland shark bycatch records from the Canadian At-Sea Observer (ASO) program was shown (Figure xi.4). While influenced by the level of ASO coverage, which is quite variable, Greenland Sharks are commonly observed in Baffin Bay and Davis Strait, on the Newfoundland shelf, and on edge of the Grand Banks. Greenland sharks are also observed in the Gulf of St. Lawrence and in shallower waters of the St Lawrence estuary. Greenland Shark bycatch has declined from historic levels, and mostly occurred in shrimp (trawl) and Greenland halibut (bottom trawl, gillnet and longline) fisheries. Introduction of the Nordmore grate in 1994 in the Canadian shrimp fishery significantly reduced the bycatch of Greenland Sharks and various other groundfish species. Occurrences of bycatch are also observed in other fisheries for a diversity of species and using various gear types.

A positive relationship between fishing effort (number of sets) and the bycatch of Greenland shark was observed for data from the Greenland halibut trawl fishery in Subarea 0 (SCR 18/41). The proportion of Greenland sharks that were dead upon release was notably higher with bottom trawls (~36%) compared to longlines (~16%). The biomass of Greenland shark caught in bottom trawl sets increases with set duration and the percentage of Greenland sharks that are alive when released decreases with both trawl set duration and total catch weight (SCR 18/41).

Bycatch records presented from scientific sampling from exploratory Greenland halibut longline fisheries in the Eastern Canadian Arctic Archipelago further indicate high inshore abundance in the summer, with 120 Greenland sharks caught in 31 fishing sets over 2014-2016 at depths ranging from 300-850m.

USA

Greenland shark catch data from the National Marine Fisheries Service were summarized and included longline fishery logbooks, fishery observer programs, recreational shark tournaments, and tagging programs. No sharks were caught in any East Coast longline fishery. A total of 13 Greenland sharks were caught off the U.S. East Coast during 1962-2017: seven recorded by NEFSC Observer Program (Fig. xi.5) and six from the NMFS Cooperative Shark Tagging Program. However, most fisheries in this area only occur at depths of up to approximately 400 m. The measured total length range for five of the females was 183-427 cm. All but one individual were caught in bottom trawls. Seven fish were caught at depths between 206 m and 313 m where the surface water temperatures were very warm, 25.6-26.7^{o}C. Previous studies suggested that higher numbers of Greenland sharks may be present in deeper water off the U.S. East Coast but most U.S. research surveys and fisheries do not occur in these areas. During 1962-2017, a total of 89 Greenland sharks were tagged by NMFS Cooperative Shark Tagging Program partners throughout the North Atlantic, and one was recaptured. Six of these individuals were tagged off the U.S. East Coast and five of the tagged individuals are shown in Fig. xi.5. An additional individual was tagged further north in the Gulf of Maine off Gloucester, MA.

GREENLAND

From 2015-2017, 144 t were recorded as discarded bycatch in the NAFO Subarea 1 offshore fishery. Sorting grids are mandatory for shrimp trawlers operating both inshore and offshore in Greenland and indeed none of the reported bycatches were from shrimp trawlers. In Greenland, the top openings of the shrimp trawls are big enough to allow large sharks to pass through the trawl and therefore releasing the shark without harm. All of the reported bycatches were from trawlers targeting other fish species and in a few cases from offshore longliners. Unreported catch of Greenland sharks could potentially originate from the small boat fishery in the inshore areas targeting Greenland halibut. However, from both shark surveys, fish surveys and numerous personal accounts, it is known that shark distribution is not random in the inshore areas in Greenland and that most encounters are minimized simply by avoiding known shark areas. Furthermore, a large proportion of the Greenland halibut are targeted with thin 1mm or 3 mm nylon mainline, with ordinary hook size 6, 7, or 8, or size 10 or 11 circle hooks, attached to a 1 mm leader. Therefore, most encounters should result in a lost hook or longline, rather than a landed bycatch. Whereas small boats and sea ice fishery during the winter use light gear, autoliners and gillnets use more powerful gear and may be more exposed to bycatches of sharks.

Data from Scientific Surveys

CANADA

The Canadian trawl surveys of the Newfoundland Shelf and the Grand Bank caught Greenland sharks in 63 sets from 1960-2016 (Fig. xi.6). Additional surveys in the Northern Gulf of St. Lawrence captured 6 sharks, while surveys in the southern Gulf and Scotian Shelf did not capture Greenland sharks (Fig. xi.6). Trawl surveys in NAFO Subarea 0 caught 92 individuals in 4213 sets at depths from 400-1500m from 2004-2017, and inshore longline surveys caught 127 Greenland sharks in 186 sets from 2004-2017 (Fig. xi.7) suggesting abundance may be greater in inshore areas along the coast of Baffin Island.

Length data and weight estimates were available for most of the sharks caught in the offshore Subarea 0 surveys, with length ranging from 81 cm to 364 cm and weight from 5 kg to 600 kg. Lengths varied from 100 cm to 400 cm in the inshore longline surveys.

USA

Data from all annual research bottom trawl surveys (1963-2017) and coastal shark longline surveys (1986-2017) conducted along the U.S. East Coast were examined for Greenland shark catches. No sharks were caught in these surveys. However, the surveys in this area only occur at depths of up to approximately 400 m.

EU-SPAIN & PORTUGAL

In 2017, information was presented for the EU-Spain 3L and 3NO surveys as well as the EU 3M survey. A total of 8 Greenland sharks were caught over all the years of these surveys (1988-2017).

GREENLAND

Surveys carried out by Greenland in 1A-F caught 206 individuals, out of 15,909 sets, from 1988 to 2017. Highest catches occurred during the gillnet surveys in NAFO Div. 1A, where 62 individuals were captured from 2014 to 2017. Length varied from 50-550cm with the sharks predominantly within the 300-450 range. Nielsen et al. (2014) found that females were in the larger 300-550 cm range while smaller males ranged from 80-350 cm.

Potential management measures

Greenland sharks warrant precautionary consideration due to their extremely delayed maturity and low fecundity. The IUCN Red List Shark Specialist Group assessed Greenland shark 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 and potential for high post-release survival. A prohibition on retention and directed fishing for Greenland sharks is advised, along with the implementation of bycatch reduction measures. Currently, the NAFO Conservation and Enforcement Measures (CEM), requires only reporting catches of sharks and prohibits the removal of shark fins on-board vessels, or the retention on-board, transhipment and landing of shark fins fully detached from a carcass. The promotion of safe handling practices to improve post-release survival is also recommended.

In addition to a prohibition on any directed fishery for Greenland sharks such as those adopted by other RFMO's, a key to the reduction of Greenland shark bycatch is improving the reporting of bycatch through better data collection and species identification. Mandatory reporting of all Greenland shark bycatch, including discards, by commercial and recreational fisheries and increased coverage of relevant fisheries by adequately trained ASOs, will lead to the development of effective bycatch mitigation policies and measures. Furthermore, training commercial fishers in safe handling and release practices for live shark bycatch is critical to reducing the mortality of sharks in commercial fisheries.

For other shark species, management measures implemented have included: temporal and/or spatial closures to fishing (e.g., of shark "hot spots" such as seasonal nurseries or mating areas); gear restrictions or modifications; restrictions on bait type; shark bycatch limits (e.g., reduced bycatch-to-target species ratio, illegal possession/landings/sales of particular shark species); or reductions in fishing effort (e.g., shortening durations for trawling, reducing soak times for gillnets and longlines, restricting the number and size of vessels allowed in a fishery). In otter trawl fisheries, rigid excluder devices that allow marine turtles and large sharks to escape upwards through the net significantly reduce shark bycatch (Brewer *et al.* 2006), and should be mandated for use in trawl fisheries that are known for capturing many sharks incidentally.

Modifications to longline gear have been shown to reduce Greenland shark bycatch in commercial fisheries; Woll *et al.* (2001) found that circle hooks reduced gut-hooking in sharks, while outperforming commonly used EZ-hooks in capturing the target species (Greenland halibut) in this fishery. However, SMART (Selective Magnetic and Repellent-Treated) hook deterrents have been shown to be ineffective for reducing Greenland shark bycatch (Grant et al. 2018*a*). Another potentially effective gear modification involves reducing gangion breaking strength on longlines, effectively releasing Greenland shark bycatch after hooking while remaining intact with the target species (Greenland halibut; based on the significant size differential between both species) (Grant *et al.* 2018*b*).

A recently concluded study shows that post-release survival of long-line caught sharks is quite high for this species, even in cases of severe entanglement (Watanabe et al., in press). High post-release survival depends on several key factors, specifically: 1) Safe handling practices must be employed during release (e.g. hooks should be removed carefully or cut free, so as to not break the jaw during dehooking; gear should be cut away from entangled sharks, rather than tails cut to free the gear), 2) To reduce incidence of cannibalism, which is commonly reported throughout the range of fisheries interactions (Hussey, unpublished data; SCR 18/44), soak times need to be reduced and dense aggregations must be avoided, and 3) Individuals caught with the mainline wrapped around the caudal peduncle should not be lifted out of the water, in order to avoid severe damage to the peduncle. Survival of Greenland shark has been found to decrease with increased trawl duration and depth (Fig. xi.8), therefore restriction on set durations may help to limit bycatch mortality.

Recommendations

A quantitative assessment of the status of the Greenland shark population in NAFO waters would require much more knowledge about the species' life history and population dynamics than currently exists. For example, accounting of total fishery removals needs to be improved. Catch of Greenland sharks have not been consistently reported to the Secretariat by Contracting Parties, based on data from the STATLANT 21 Database. Bycatch numbers and more biological data should be collected by at sea observers. A Greenland shark identification sheet (e.g., FAO Species Identification Sheet) and photos, if provided to all fishery observers, would be helpful for accurate species identification. In addition, observer instructions regarding collection of the following data would be useful for stock status assessment purposes: number and estimated weight of each shark caught per haul or set, catch disposition, and measured total length if possible without causing excessive stress to the animal. Currently, the number of sharks caught per haul or set is infrequently recorded in the "comments" section of the haul catch log. Catch weight per haul or set is generally estimated by the Captain but the number of individuals caught is needed to determine the numbers of fishery removals. The collection of measured rather than estimated total length data is preferred when feasible. Sex should be recorded when possible and calcification of male claspers is useful for determining sexual maturity. Photo verification would be helpful in this regard. Tagging and release of caught Greenland sharks by ASOs would also be useful for determining discard survival rates and migration patterns.

General recommendations include:

- Improve reporting of all sharks by species within the NAFO Convention Area.
- Improve collection of Greenland shark numbers, measurements (when feasible without causing undue harm) and recording of sex data and discard disposition (i.e., dead or alive) by fishery observers in all fisheries in the NAFO Convention Area.
- Conduct discard mortality studies for longline gear and bottom trawls
- Undertake studies to better understand reproductive potential, abundance, and movements and distribution of Greenland sharks
- To inform potential spatial and/or temporal fishery management measures, further research on movements, diel vertical migrations and distribution of Greenland shark is required to better understand factors such as migration, nursery areas, population structure, and connectivity.

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Figures

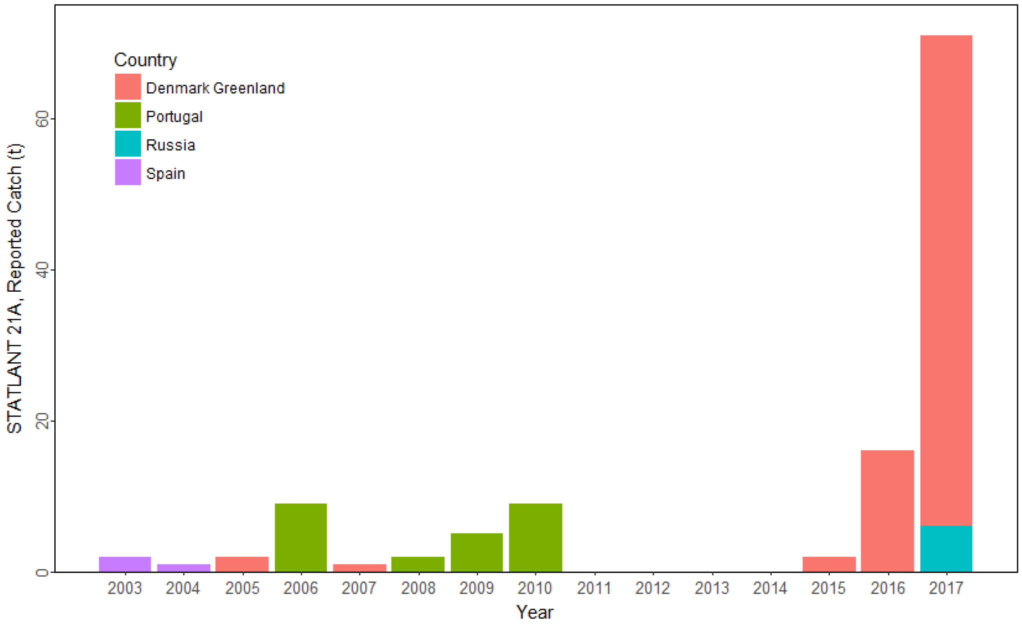


Fig. xi.1. Nominal catches (t) of Greenland shark reported by Flag States to the NAFO Secretariat during 2003-2017 (Source: STATLANT 21A Database). Note: Reporting of shark bycatch from Flag States was not mandatory prior to 2002.

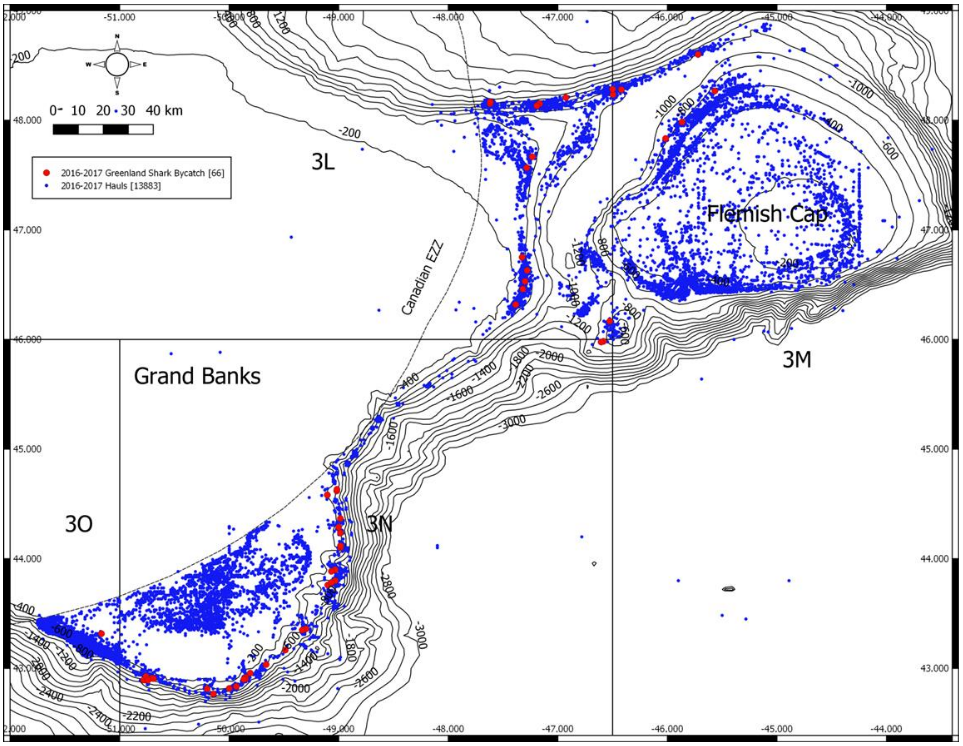


Fig. xi.2. Presence(red)/absence(blue) of Greenland shark catches in longline and bottom trawls hauls that occurred in the NAFO Regulatory Area during 2016-2017 based on data from the NAFO Observer Program.

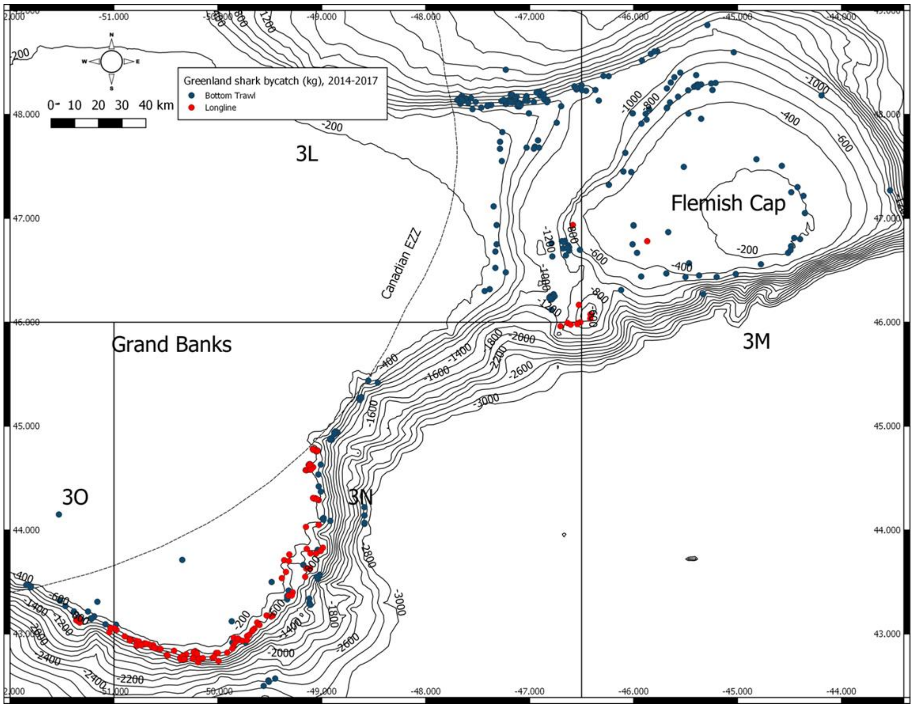


Fig. xi.3. Presence of Greenland shark catches in longline (red dots) and bottom trawl (blue dots) hauls that occurred in the NAFO Regulatory Area during 2014-2017 based on data from the NAFO Observer Program.

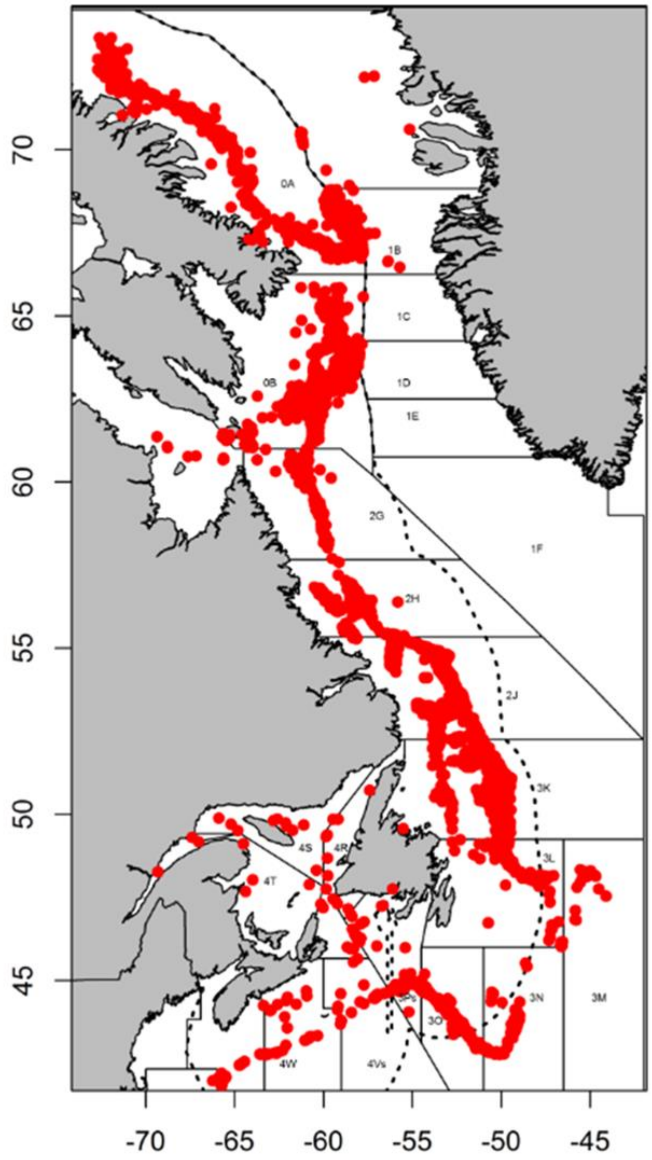


Fig. xi.4. Greenland shark occurrences in the Canadian At-Sea Observer program (1985-2016).

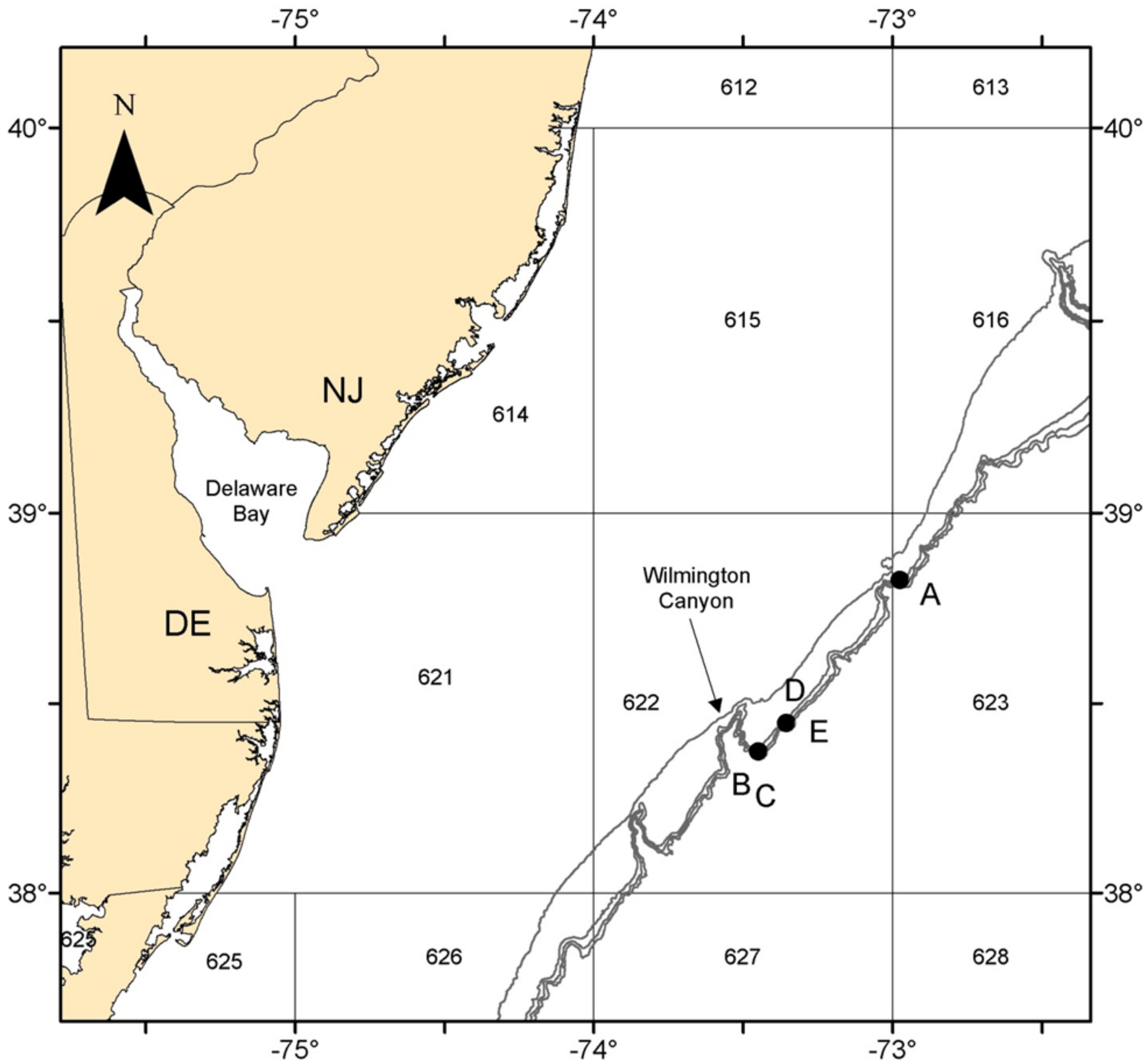


Fig. xi.5. Locations of the five Greenland sharks recorded as bycatch in U.S. East Coast fisheries that operated between the Gulf of Maine and Cape Hatteras, North Carolina during 1989-2017. Data source: Northeast Fisheries Observer Program Database, 1989-2017.

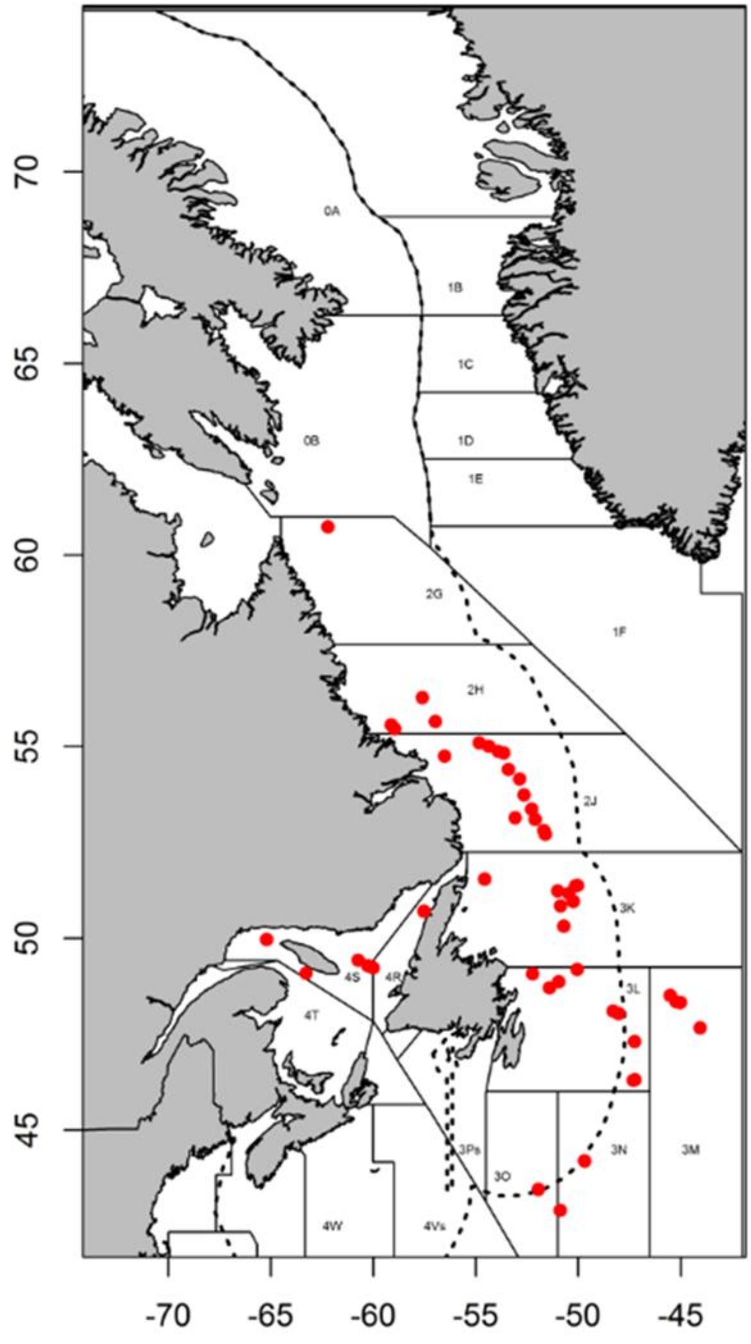


Fig. xi.6. Greenland shark occurrences in various Canadian surveys in the Gulf of St. Lawrence, the Grand Banks and Newfoundland Shelf from 1960-2016.

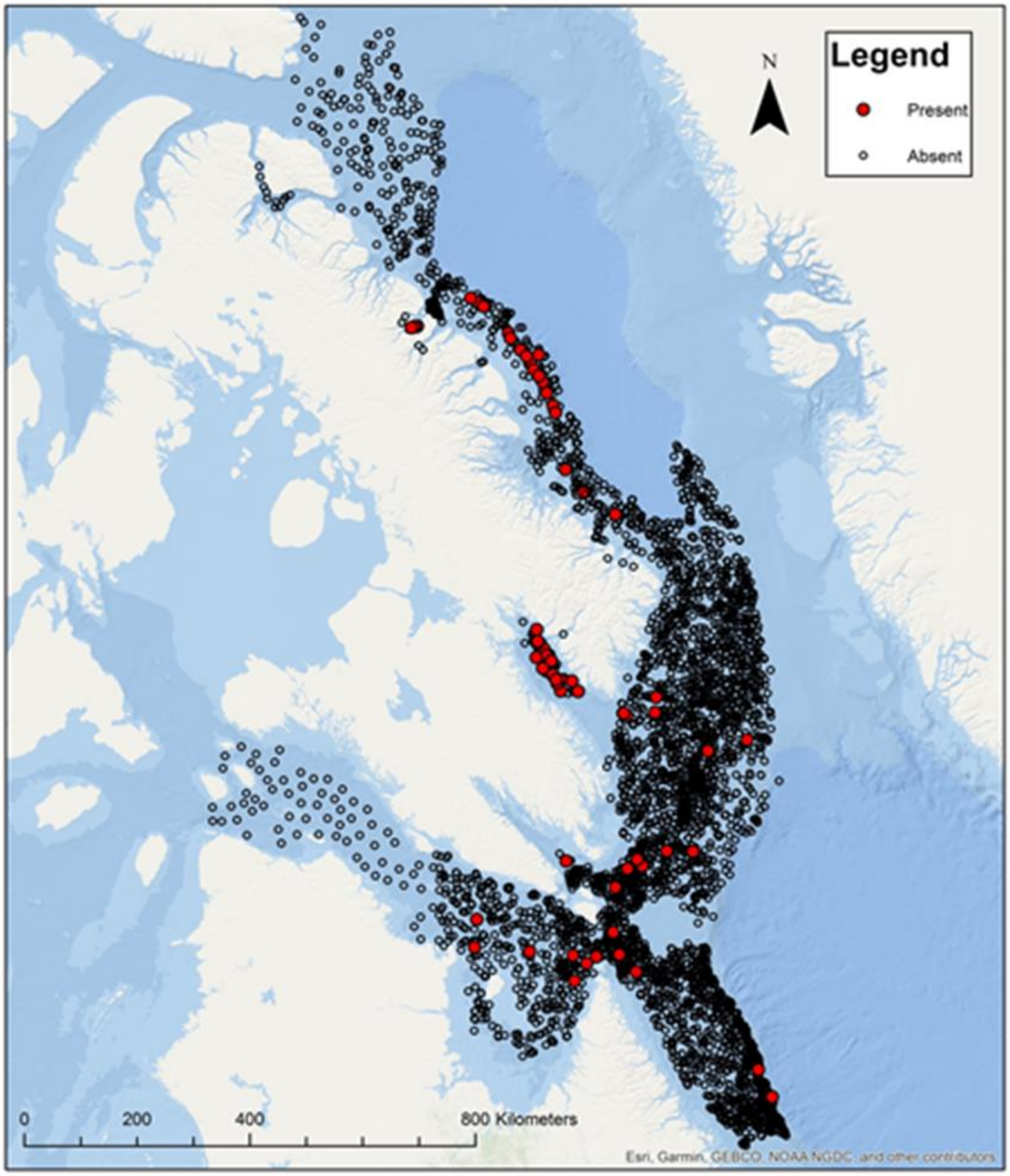


Fig.xi.7. Presence and absence of Greenland sharks in DFO longline (2010-2017) and trawl (2004-2014) survey data. Red circles indicate Greenland shark catches, open circles indicate fishing sets that did not capture Greenland sharks.

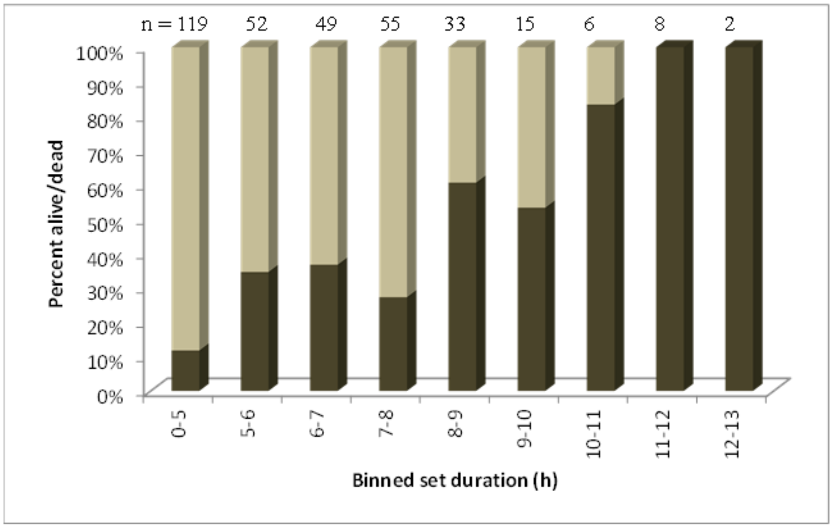


Fig. xi.8. Greenland shark bycatch that was alive (tan) and reported as dead (dark brown) when discarded as it relates to set duration (hours) of trawling.

Table xi.1. Minimum numbers of Greenland sharks caught in the NAFO Regulatory Area in bottom trawls, by target species, based on NAFO observer data from 2014-2017.

	Minimum Number					**Estimated Catch (t)**				
Dominant Species Captured	**2014**	**2015**	**2016**	**2017**	**Total**	**2014**	**2015**	**2016**	**2017**	**Total**
Greenland halibut	20	42	49	96	207	11.2	29.8	65.5	162.6	269.0
Redfishes	10	5	38	39	92	7.1	4.2	43.8	84.7	139.7
Cod	3	2	10	4	19	3.8	1.1	23.1	4.5	32.5
Greenland shark		1		3	4		0.5		3.0	3.5
Skates			2	2	4			5.5	2.7	8.2
Silver hake				1	1				2.0	2.0
Roughhead grenadier	1				1	1.2				1.2
Total	**34**	**50**	**99**	**145**	**328**	**23.4**	**35.5**	**137.8**	**259.4**	**456.1**

Table xi.2. Minimum numbers and estimated weight (t) of Greenland sharks caught in the NAFO Regulatory Area on longlines, by target species, based on NAFO observer data from 2014-2017.

	Minimum Number					**Estimated Catch (t)**				
Dominant Species Captured	**2014**	**2015**	**2016**	**2017**	**Total**	**2014**	**2015**	**2016**	**2017**	**Total**
Atlantic halibut	23	42	38	24	127	6.9	11.8	9.6	14.8	43.1
White hake	5			5	10	1.4			3.5	4.9
Thorny skate	8	1			9	2.3	1.4			3.6
Northern wolffish				6	6				3.7	3.7
Roughhead grenadier	5				5	1.1				1.1
Cod			1		1			0.2		0.2
Total	**41**	**43**	**39**	**35**	**158**	**11.7**	**13.2**	**9.9**	**21.9**	**56.6**

xii) Continue work on the SWOT analysis (Item 13)

The Commission requests the Scientific Council continue on a Strengths, Weaknesses, Opportunities and Threats (SWOT) analysis. The strategy and the mid and long-term objectives and tasks in view of NAFO's amended convention objectives should be developed jointly with the Commission. The plan should define for each strategic objective goals, tasks and measurable targets.

Scientific Council Responded:

Scientific Council accomplished the first part of the request in 2017, completing the SWOT analysis. SC was not able to start to develop a strategic scientific plan with mid and long term objectives and with individual objective goals, tasks and measurable targets due to workload of SC and noted that this should done in conjunction with the Commission. The findings of the ongoing Performance Review will also give more insight as to what a plan could include.

2. Coastal States

a) Request by Denmark (on behalf of Greenland) for advice on management in 2019 of certain stocks in Subareas 0 and 1 (Annex 2)

i) Advice on Golden redfish, demersal deepsea redfish, Atlantic wolffish and spotted wolffish was given in 2017 for 2018-2020.

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

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

Recommendation for 2018 - 2020 Atlantic wolffish: The Scientific Council advises that there should be no directed fishery. **Spotted wolffish:** The Scientific Council advises that the TAC should not exceed 975 tonnes.

ii) Greenland halibut in Div. 1A (inshore) (Item 3)

Advice on Greenland Halibut in Division 1A inshore was in 2016 given for 2017-2018. Denmark (on behalf of Greenland) requests the Scientific Council before December 2018 to provide advice on the scientific basis for management of inshore Greenland Halibut (*Reinhardtius hippoglossoides*) in Division 1A.

Scientific Council responded:

Greenland halibut in Division 1A inshore - Disko Bay

Advice June 2018 for 2019-2020

Recommendation for 2019 - 2020
The Scientific Council advises that the TAC should not exceed 5120 tons.

Management objectives

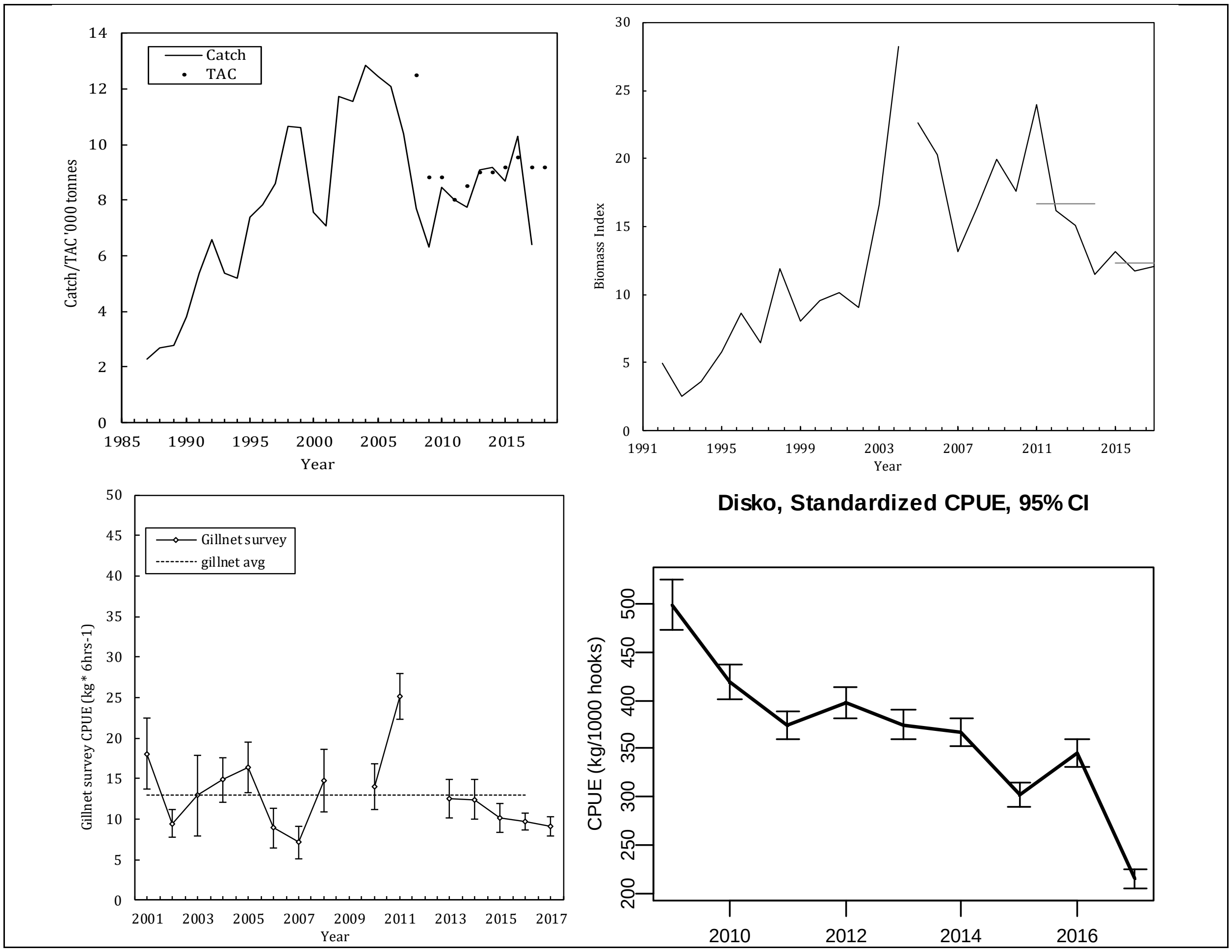
No explicit management plan or management objectives have been defined by the Government of Greenland.

Management unit

The stocks are believed to recruit from the Subarea 0+ 1 offshore spawning stock (in the Davis Strait) and there is little migration between each of the separate inshore populations and offshore stocks in SA 0 and 1. Separate advice is given for each area in Subarea 1A inshore.

Stock status

Length in the landings has gradually decreased over 10 to 15 years. In spite of the 2017 reduction in catch, the number of fish landed remains high. The Gillnet survey CPUE has gradually decreased and remained below average levels in the most recent 3-5 years. The trawl survey biomass index has gradually decreased since 2005, with the lowest values found in the most recent 4 years. The commercial CPUE for longline vessels has more than halved since 2009. Recruits are mainly received from offshore stocks and recruitment remains high.



Reference points
Could not be established.

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

The next assessment is planned for 2020.

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

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

Fishery
Catches increased in the 1980s, peaked from 2004 to 2006 at more than 12 000 t, but then decreased substantially. From 2009, catches gradually increased and reached 10 760 t in 2016, before decreasing to 6409t in 2017.

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

	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
TAC	8.8	8.8	8.0	8.0	9.0	9.0	9.2	9.7	9.2	9.2
STACFIS	6.3	8.4	8.0	7.8	9.1	9.2	8.7	10.8	6.4	

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

Basis for advice
A quantitative assessment of risk at various catch options is not possible for this stock. The application of the ICES guidance on data-limited stocks (DLS) method 3.2 (ICES 2012a and 2012b, ICES 2014) using the Greenland shrimp and fish survey was used by SC in 2016 as the basis for advice on Greenland Halibut in the Disko Bay. This rule was applied again to generate the current advice.

$C_{y+1}=advice_{recent}*r$
where r=mean of biomass index (2015-2017)/ mean of biomass index (2011-2014).

Should changes in excess of +- 20% be generated using this rule, a 20% cap is applied. A first year precautionary buffer was not applied, since the stock is considered to receive recruits from the offshore area and is not regarded as reproductively impaired.

For 2018, r= mean of biomass index (2015-2017)/ mean of biomass index (2011-2014)=0.73. Therefore the 20% reduction cap is applied and the advised TAC is 6400*0.80=5120 t.

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

Sources of Information
SCR Doc. 18/023 032 and 035 and; SCS Doc. 18/010.

Greenland halibut in Division 1A inshore—Upernavik

Advice June 2018 for 2019-2020

Recommendation for 2019 - 2020

All available indicators have declined under current levels of removals.

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

Management objectives

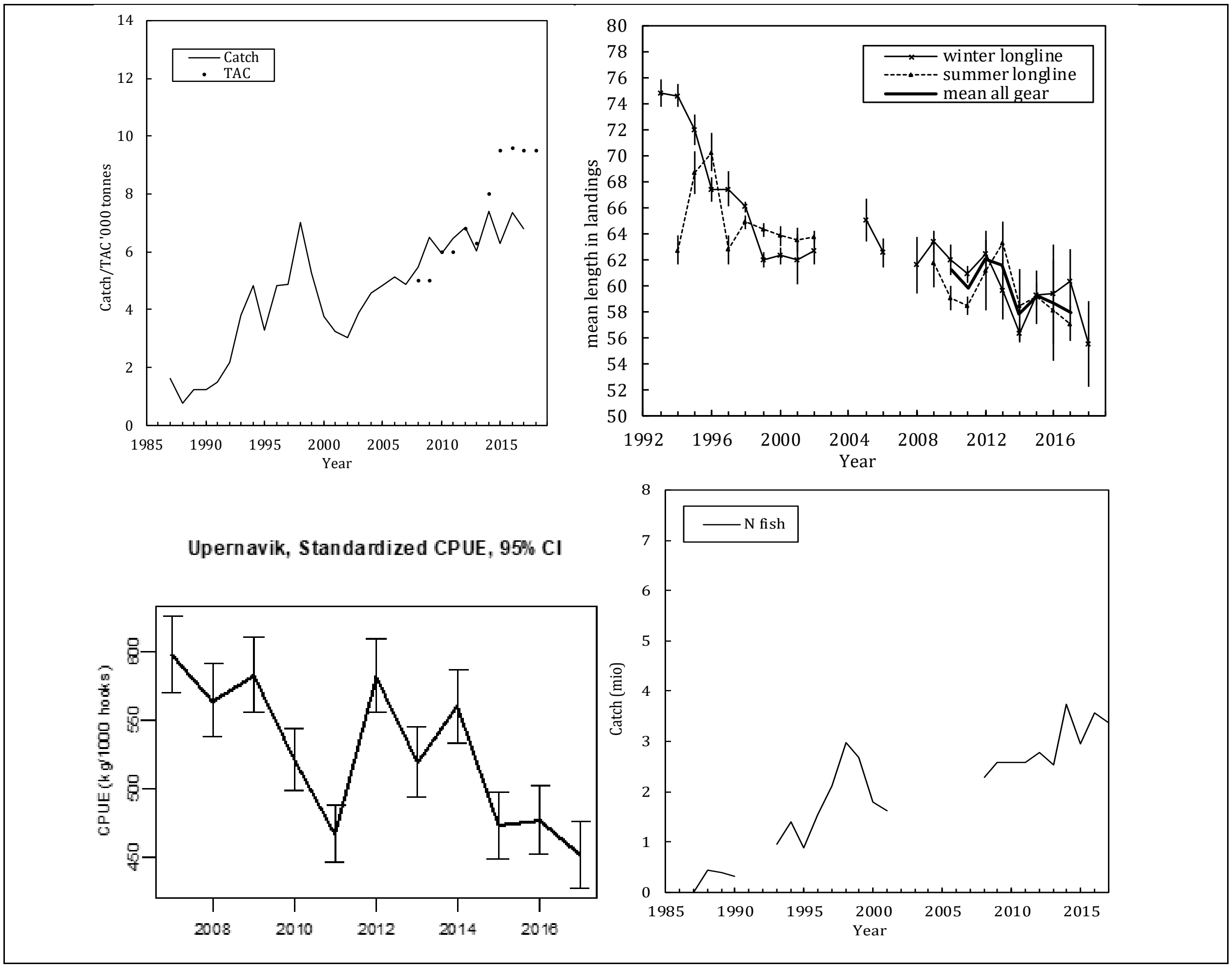
No explicit management plan or management objectives have been defined by the Government of Greenland.

Management unit

The stocks are believed to recruit from the Subarea 0+ 1 offshore spawning stock (in the Davis Strait) and there is little migration between each of the separate inshore populations and offshore stocks in SA 0 and 1. Separate advice is given for each area in Subarea 1A inshore.

Stock status

The catch in tons and in number of fish has been record high since 2014. The gillnet survey CPUE showed fish in the size range 30-65 cm. Mean length in the landings decreased in the 1990s, but stabilized from 1999 to 2009. Since then length in the landings have decreased further to 56-58 cm. The standardized longline CPUE index reveal a gradual decreasing CPUE with the most recent 3 years being among the lowest observed.



Reference points
Could not be established.

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

The next assessment is planned for 2020.

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

Environmental impact
Unknown

Fishery
Catches increased from the mid 1980's and peaked in 1998 at a level of 7 000 t. Landings then decreased sharply, but during the past 15 years, they have gradually returned to the higher level. Average catch in the most recent 5 years has been 6 800 t.

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

	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
TAC	5.0	6.0	6.5	6.5	8.0	9.5	9.5	9.5	9.5	9.5
STACFIS	6.5	5.9	6.5	6.8	6.0	7.4	6.3	7.4	6.8	

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

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

Sources of Information
SCR Doc. 18/023, 032, 035; SCS Doc. 18/010.

Greenland halibut in Division 1A inshore – Uummannaq

Advice June 2018 for 2019-2020

Recommendation for 2019 - 2020

All available indicators have declined under current levels of removals.

Scientific Council recommends catch should not exceed 5 800 t. This is a reduction over the previous advice accounting for the reduction in mean individual size in the recent catches.

Management objectives

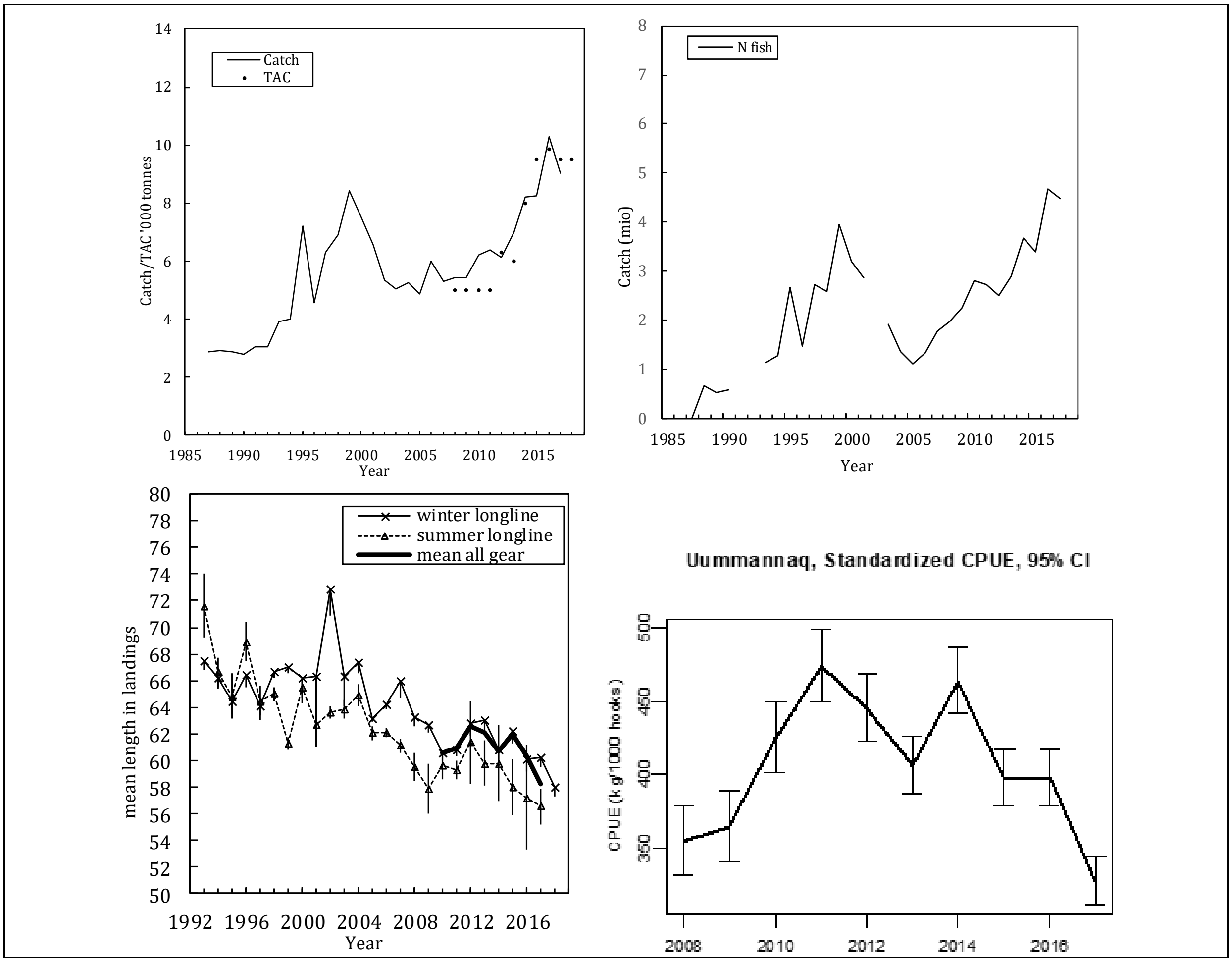
No explicit management plan or management objectives have been defined by the Government of Greenland.

Management unit

The stocks are believed to recruit from the Subarea 0 + 1 offshore spawning stock (in the Davis Strait) and there is little migration between each of the separate inshore populations and offshore stocks in SA 0 and 1. Separate advice is given for each area in Subarea 1A inshore.

Stock status

The catch in tons and in number of fish has been record high in 2016 and 2017. The gillnet survey CPUE showed considerable numbers in the interval 40-70 cm. Mean length in the landings has gradually decreased, particularly in the recent 3 years. From 2011, the standardized commercial longline CPUE index decreased gradually, with 2017 the lowest level observed in the time series.



Reference points
Could not be established.

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

The next assessment is planned for 2020.

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

Environmental impact
Unknown

Fishery
Catches in the Uummannaq fjord gradually increased from the 1980's reaching 8425 in 1999, but then decreased and remained between 5000 and 6000 t from 2002 to 2009. After 2009 catches gradually increased reaching 10 305 t in 2016. In 2017, 9049 t were caught in the area.

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

	2009	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**
TAC	5.0	5.0	6.0	6.0	7.4	8.4	9.5	9.9	9.5	9.5
STACFIS	5.4	6.2	6.4	6.1	7.0	8.2	8.2	10.3	9.0	

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

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

Sources of Information
SCR Doc. 18/023, 032, 035; SCS Doc. 18/010.

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 2019 and for as many years ahead as data allows for.

The Scientific Council deferred responding to this request to the SC/NIPAG meeting in October 2018.

b) Request by Canada and Denmark (Greenland) for Advice on Management in 2019

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:

Greenland halibut in SA 0 + Div. 1A Offshore and Div. 1B-1F

Advice June 2018 for 2019 and 2020

Recommendation for 2019 and 2020

Scientific Council advises that there is a low risk of Greenland halibut in Subarea 0 + 1A (offshore) and 1B-F being below B_{lim} if the TAC for 2019 and 2020 does not exceed 36 370 t.

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

Management objectives

Canada and Greenland adopted a total allowable catch (TAC) of 32,300 t in 2018. Canada requests that the stock status should be evaluated in the context of management requirements for long-term sustainability and the advice provided should be consistent with the precautionary approach.

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

🟢 OK
🟠 Intermediate

Management unit

The Greenland halibut stock in Subarea 0 + Div. 1A (offshore) and Div. 1B-1F is part of a larger population complex distributed throughout the Northwest Atlantic. In Subareas 0 and 1, two separate assessments are conducted on this species. In addition, since 2002, advice for the Subarea 0 +Div. 1A (offshore) and Div. 1B-1F stock has been given separately for the northern area (Div. 0A and Div. 1AB) and the southern area (Div. 0B and 1C-F).

Stock status

The combined Div. 0A-South + Divs. 1CD biomass index remains above B_{lim}. The index was relatively stable until 2014 then increased between 2014 and 2016. The decline observed in 2017 is a result of a decline in the 0A-South survey biomass. Recruitment has been increasing in recent years, and in 2017 was one of the highest in the time series.

Reference points

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

Assessment

The assessment is qualitative with input from research surveys (biomass and abundance indices, a recruitment index, and length disaggregated survey indices) and fishery data (catch per unit effort and length frequencies).

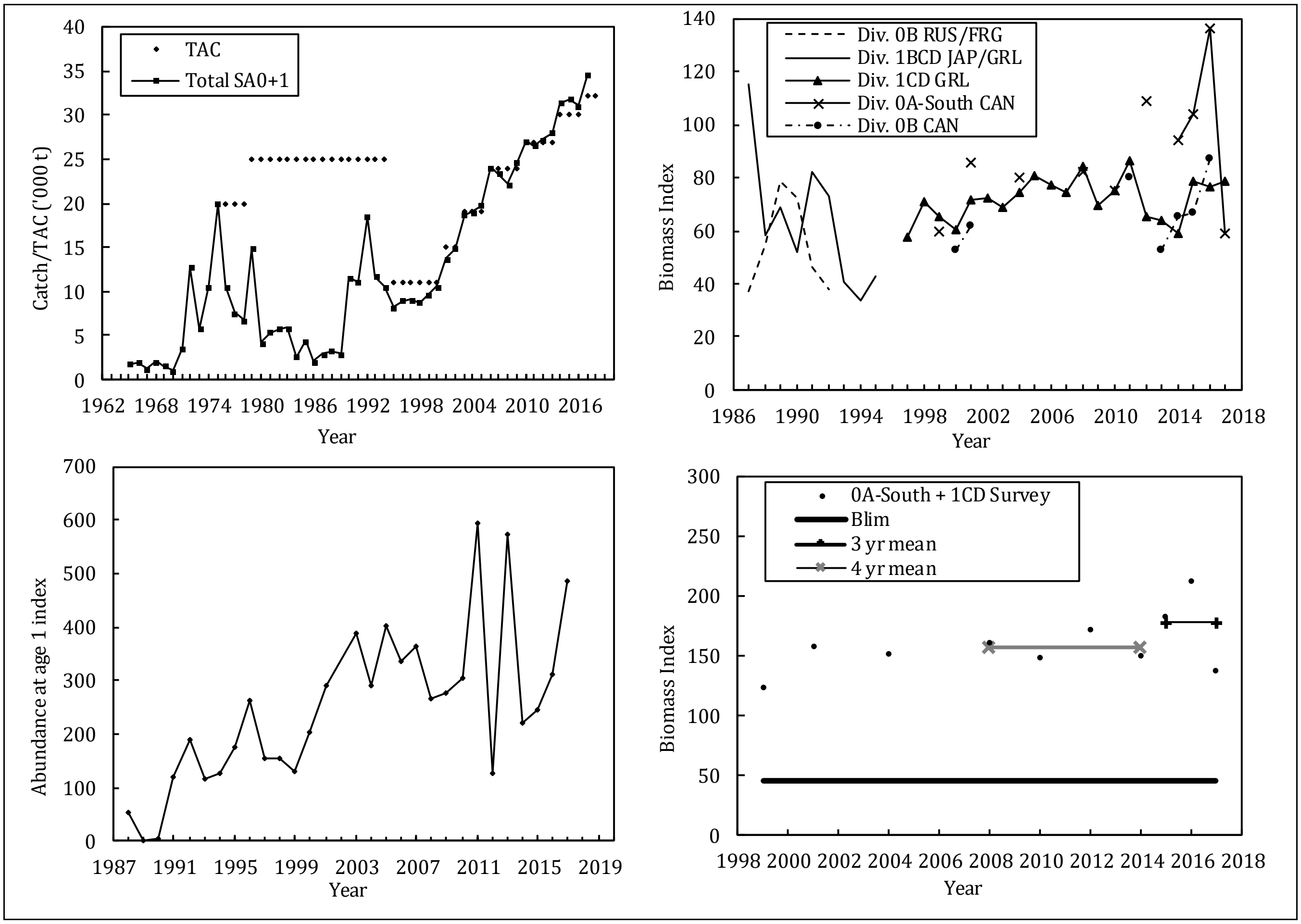
The next assessment is expected to be in 2020.

Human impact

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

Biology and Environmental interactions

No specific studies were reviewed during this assessment



Fishery

Catches were first reported in 1964. Catches increased from 1989 to 1992 due to a new trawl fishery in Div. 0B with participation by Canada, Norway, Russia and Faeroe Islands and an expansion of the 1CD fishery with participation by Japan, Norway and Faeroe Islands. Catch declined from 1992 to 1995 primarily due to a reduction of effort by non-Canadian fleets in Div. 0B. Since 1995 catches have been near the TAC and increasing in step with increases in the TAC, with catches reaching a high of 34,661 t in 2017.

Recent catch and TACs ('000 t)

	2009	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**
TAC	24	27	27	27	27	30	30	30	32.3	32.3
SA 0	12	13	13	13	13	15	14	14	16	
SA 1	13	13	14	14	15	16	17	17	18	
Total STACFIS[1,2]	25	26	27	27	28	31	31	31	35	

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

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

Effects of the fishery on the ecosystem

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

Basis for Advice

A quantitative assessment of risk at various catch options is not possible for this stock. Therefore it is not possible to quantitatively evaluate the sustainability of the TAC. In 2016 the ICES Harvest Control Rule 3.2 for data limited stocks was accepted as a basis for giving TAC advice. This method was used again to provide the following advice for the next two years.

$C_{y+1}=Catch_{advised}*r$
where r=index mean for 2015-2017/index mean for 2008, 2010, 2012, 2014
=1.126
$Catch_{advised}$ = 32,300 t (catch advised for 2017 and 2018 and subsequently implemented as the TAC).

Catch in 2019 and 2020=32,300 t* 1.126
=36,370 t

Special comments

The vessel that has conducted surveys in SA 0+1 since 1997 has been retired and there will be no survey in 2018. Also, it will not be possible to calibrate this survey series with the next survey that is expected to begin in 2019. The absence of a continuous survey series may constrain the ability of SC to assess/provide advice on this stock in coming years and furthermore, SC may be unable to evaluate the impact of the advised TAC.

Sources of information

SCR Doc. 18/15, 21, 32, 40; SCS Doc. 18/10, 13

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 2018 to provide advice on the scientific basis for management of Northern shrimp (Pandalus borealis) in Subarea 0 and 1 in 2019 and for as many years ahead as data allows for.

The Scientific Council deferred responding to this request to the SC/NIPAG meeting in October 2018.

3. Scientific Council Advice of its own Accord

Scientific Council completed the necessary work to provide advice on two items of its own accord. Though advice for witch flounder in Divs. 3NO was given in 2017 for 2018 and 2019, the Council indicated "*Because of the uncertainty and proximity to limit reference points the next full assessment is rescheduled for 2018*". Additionally, it was noted that the current sea pen closure Area 14 expires at the end of 2018. Thus, the Council updated its previous analysis using recent data and has provided advice to facilitate the work of WG-EAFFM during its August 2018 meeting.

a) Witch flounder in Divisions 3NO

Witch flounder in Divisions 3NO

Advice June 2018 for 2019-2020

Recommendation for 2019 and 2020

The probability of being below B_{lim} in 2021 ranges from 15% to 24% amongst the tested scenarios. The NAFO PA framework specifies that there should be a very low probability of being below B_{lim}.

SC recommends that there be no directed fishing in 2019 and 2020.

Management objectives

The Commission adopted a total allowable catch (TAC) of 1,116 t in 2018. General convention objectives (GC Doc. 08/3) are applied.

Convention objectives	***Status***	***Comment/consideration***
Restore to or maintain at B_{msy}	🔴	$B_{2018} < B_{msy}$
Eliminate overfishing	🟢	$F < F_{msy}$
Apply Precautionary Approach	🟢	Increased risk of $B<B_{lim}$
Minimise harmful impacts on living marine resources and ecosystems	🟡	VME closures in effect, no specific measures.
Preserve marine biodiversity	⚪	Cannot be evaluated

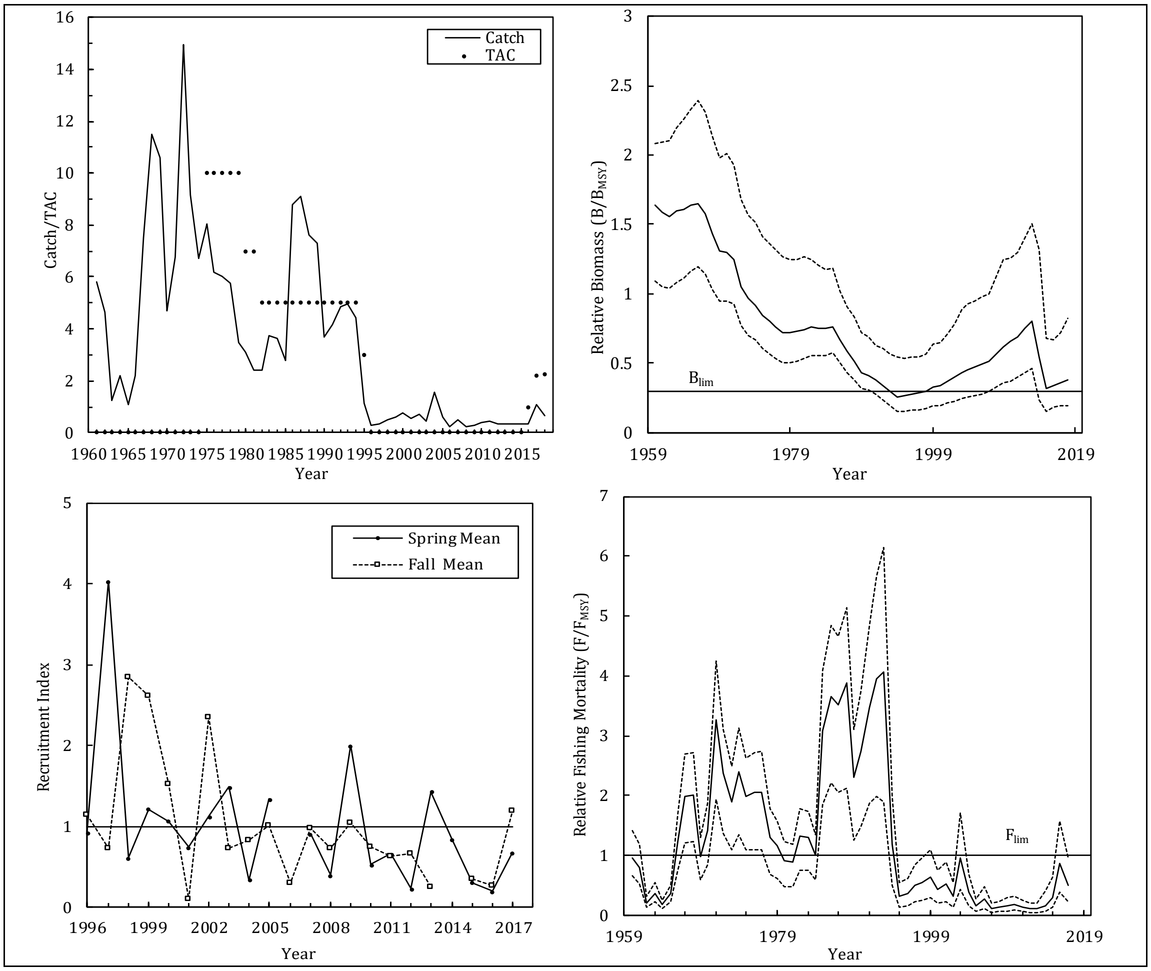
🟢	OK
🟡	Intermediate
🔴	Not accomplished
⚪	Unknown

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 2013 and is now at 37% B_{msy}. (B_{msy} = 60 000 t). There is presently a 29% risk of the stock being below B_{lim} and a 4% risk of F being above F_{lim}. Recruitment in 2017 surveys increased in the fall to a value just above the time series mean while those in the spring increased to a value approaching the time series mean.



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 2018 was equal to the TAC of 1,116 t (which produces F_{2018}). This assumption was based on reported catches to the end of April 2018 of almost 600 t. The probability that F > F_{lim} in 2018 is 30% at a catch of 1 116 t. The probability of F>F_{lim} ranged from 7 to 50% for the catch scenarios tested. The population is projected to grow under all scenarios and the probability that the biomass in 2021 is greater than the biomass in 2018 is greater than 60% in all scenarios. The population is projected to remain below B_{MSY} for all levels of F examined with a probability of greater than 90%. The probability of projected biomass being below B_{lim} by 2021 was 19 to 24% in all catch scenarios examined and was 15% by 2021 in the F=0 scenario.

	Projections with catch in 2018 = 1 116 t	
	Median	Median (90% CI)
F=0	Projected Yield (t)	Projected Relative Biomass (B_y /B_{msy})
2019	0	0.39 (0.19, 0.91)
2020	0	0.43 (0.21, 1.02)
2021		0.48 (0.23, 1.12)
F_{2017}=0.03	Projected Yield (t)	Projected Relative Biomass (B_y /B_{msy})
2019	740	0.39 (0.19, 0.91)
2020	792	0.42 (0.20, 1.00)
2021		0.45 (0.20, 1.09)
2/3 F_{msy}=0.04	Projected Yield (t)	Projected Relative Biomass (B_y /B_{msy})
2019	979	0.39 (0.19, 0.91)
2020	1035	0.42 (0.19, 0.99)
2021		0.44 (0.19, 1.08)
85% F_{msy}=0.05	Projected Yield (t)	Projected Relative Biomass (B_y /B_{msy})
2019	1248	0.39 (0.19, 0.91)
2020	1306	0.41 (0.19, 0.99)
2021		0.43 (0.19, 1.06)
F_{msy}=0.06	Projected Yield (t)	Projected Relative Biomass (B_y /B_{msy})
2019	1468	0.39 (0.19, 0.91)
2020	1522	0.41 (0.19, 0.98)
2021		0.42 (0.18, 1.05)

Projected yield (t) and the risk of F> F_{lim}, B<B_{lim} and B<B_{MSY} and probability of stock growth (B2021>B2018) under projected F values of F=0, F2017, 2/3 F_{MSY}, 85% F_{MSY}, and F_{MSY}.

	Yield 2019	Yield 2020	P(F>F_{lim})		P(B<B_{lim})			P(B<B_{MSY})			P(B_{2021}>B_{2018})
			2019	2020	2019	2020	2021	2019	2020	2021	
F=0	0	0	0	0	26%	20%	15%	96%	95%	93%	72%
F2017=0.03	740	792	7%	8%	26%	22%	19%	96%	95%	93%	67%
2/3 Fmsy=0.04	979	1035	19%	20%	26%	23%	21%	96%	95%	94%	65%
85%Fmsy=0.05	1248	1306	36%	37%	26%	24%	23%	96%	95%	94%	63%
Fmsy=0.06	1468	1522	50%	50%	26%	25%	24%	96%	95%	94%	61%

Assessment

This stock is assessed utilizing a surplus production model in a Bayesian framework. A full assessment was conducted in 2017 and 2018.

The input data were catch from 1960-2017, Canadian spring survey series from 1984-1990, Canadian spring survey series from 1991-2017 (no 2006) and the Canadian autumn survey series from 1990-2017 (no 2014).

The next assessment is planned for 2020.

Human impact

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

Biological and environmental interactions

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

Fishery

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

Recent catch estimates and TACs are:

	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
TAC	ndf	ndf	Ndf	ndf	ndf	ndf	ndf	1.0	2.2	2.2	1.1
STATLANT 21	0.2	0.1	0.4	0.4	0.3	0.3	0.3	0.4	1.0	0.6	
STACFIS	0.3	0.4	0.4	0.4	0.3	0.3	0.3	0.4	1.1	0.7	

*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

This advice is given by SC on its own accord in light of the special comment in 2017 (*Because of the uncertainty and proximity to limit reference points the next full assessment is rescheduled for 2018*).

Sources of Information

SCR Docs 18/14, 18/03, 18/05, 18/25; SCS Docs. 18/05, 18/06, 18/07, 18/08 ; NAFO/GC Doc 08/3.

b) Sea pen closure (Area 14)

The current sea pen closure Area 14 expires at the end of 2018. To facilitate the work of WG-EAFFM at its August meeting in 2018 an updated analysis of sea pen biomass was conducted to re-evaluate the status of sea pen VME on the eastern area of the Flemish Cap and to address some of the concerns over the stability of the polygons used to inform the sea pen closed area (Area 14).

Following an updated analysis with additional sea pen biomass records (2014 – 2017), SC concludes there is very little change in the overall distribution of sea pen VME found on the eastern area of the Flemish cap.

Considering the data set used in the 2013 Kernel Density Estimate (KDE) analysis, plus an additional 123 new sea pen biomass records from the Canadian and EU surveys conducted from 2014 to 2017, an updated KDE surface was created and the area of successive density polygons calculated using the same methods as conducted in 2013. A density threshold of 1.4 kg was independently determined to identify significant concentration of sea pens in the 2013 assessment, and again in the up-dated analysis conducted in the present assessment (Fig. 3b.1). When compared with the previous analysis (NAFO, 2013), there is very little change in the overall distribution of the sea pen VME found on the eastern area of the Flemish cap (Fig. 3b.2).

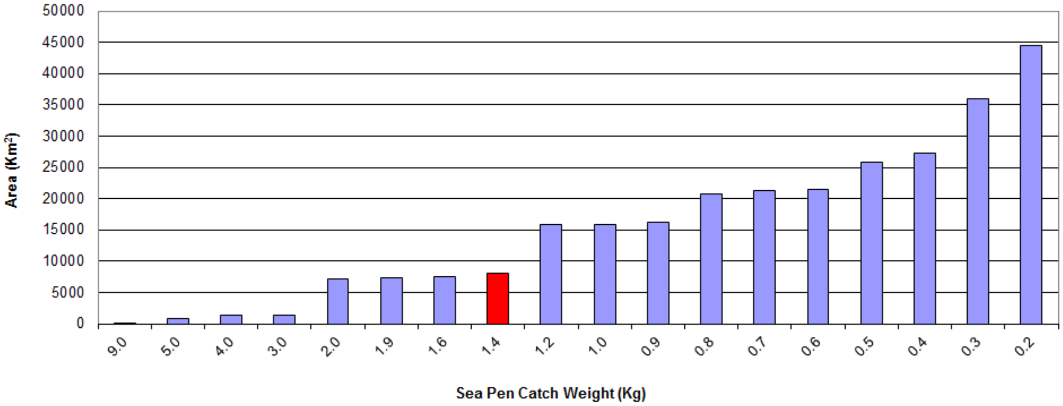


Fig. 3b.1. Area occupied by successive equal density thresholds (sea pen catch weight in kilograms) associated with the up-dated KDE analysis. Red bar indicates the density threshold used to identify significant concentrations of sea pens.

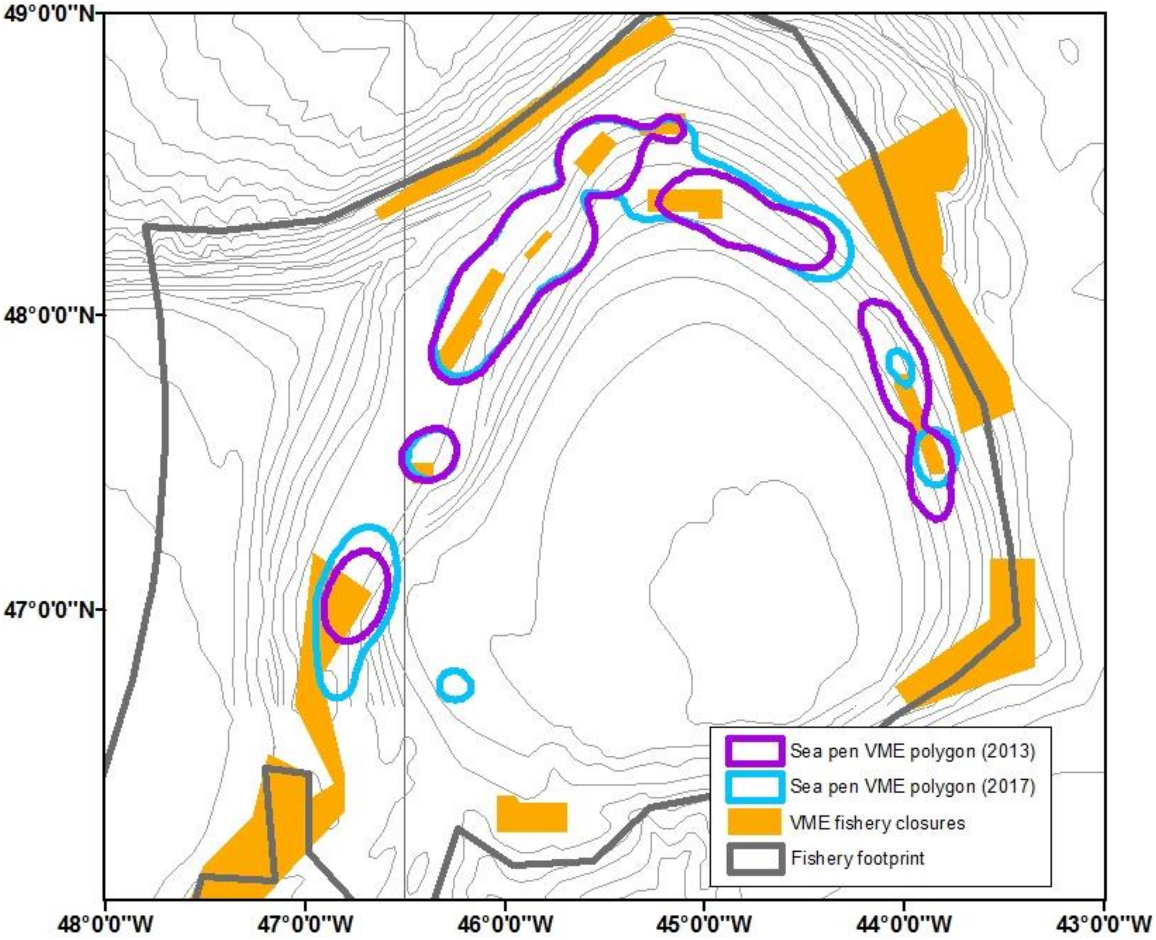


Fig. 3b.2. Comparison of sea pen VMEs determined from the present analysis (blue) with those produced from the earlier analysis (purple; NAFO, 2013). The fishing footprint is shown in outline as are the current sea pen VME fishery closures associated with the Flemish Cap.

VIII.REVIEW OF FUTURE MEETINGS ARRANGEMENTS

1. Scientific Council, 17 – 21 Sep 2018

Scientific Council noted the Scientific Council meeting will be held in Tallinn, Estonia, 17-21 September 2018.

2. Scientific Council, (in conjunction with NIPAG), 17 – 23 Oct 2018

Scientific Council noted that the Scientific Council shrimp advice meeting will be held at the NAFO Secretariat, Dartmouth, Nova Scotia, Canada, 17 – 23 October, 2018.

3. WG-ESA, 13- 22 Nov, 2018

The Working Group on Ecosystem Science and Assessment will meet at the NAFO Secretariat, Dartmouth, Nova Scotia, Canada, 13-22 November, 2018.

4. Scientific Council, June 2019

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

5. Scientific Council (in conjunction with NIPAG), 2019

Dates and location to be determined.

6. Scientific Council, Sep 2019

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

7. Scientific Council, June 2020

Scientific Council agreed that its June meeting will be held 30 May - 12 June 2020. at Saint Mary's University, Halifax.

8. NAFO/ICES Joint Groups

a) NIPAG, 17 – 23 Oct 2018

Scientific Council noted the NIPAG meeting will be held at the NAFO Secretariat, Dartmouth, Nova Scotia, Canada, 17 – 23 October, 2018.

b) NIPAG, 2019

Dates and location to be determined. .

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

Dates and location to be determined. .

d) WG-HARP, 2018

The report of the 2017 WGHARP meeting is not available and the date and location of the next meeting are unknown.

9. Commission- Scientific Council Joint Working Groups

a) WG-RBMS

The joint SC-Commission Working Group on Risk Based Management Systems (WGRBMS) will be held in NEAFC Headquarters 13-14 August 2018

b) WG-EAFFM

The joint SC-Commission Working Group on the Ecosystem approach to Fisheries Management (WG-EAFFM) will be held in NEAFC headquarters, London, UK, 16-17 August 2018

c) CESAG

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

IX.ARRANGEMENTS FOR SPECIAL SESSIONS

1. Topics of Future Special Sessions

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

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

Scientific Council has received an invitation to co-host with ICES and PICES an International Symposium on "Shellfish Resources and Invaders of the North" that will be held 5-7 November 2019 in Tromsø, Norway. Scientific Council **recommends** that *travel funding be provided for a NAFO co-convener to participate in this meeting.*

X.MEETING REPORTS

1. Working Group on Ecosystem Science and Assessment (WG-ESA) - SCS Doc. 17/21

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 10th meeting on 7-16 November 2017 at NAFO Headquarters, Dartmouth, Canada.

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 the Commission (COM), which typically involves short to medium-terms analysis, aligned to Roadmap priorities.

WGESA revised and updated 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, 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 10th meeting of WGESA:

Theme 1: Spatial consideration

ToR 1.1. Update of Vulnerable Marine Ecosystem Indicator Taxa in the NAFO Conservation and Enforcement Measures

ToR 1.2. Discussion on updating Kernel Density Estimation (KDE) analysis and Species Distribution Models (SDMs) for VME indicator species especially for sea pens

ToR 1.3. Continue to work on non-sponge and coral VMEs (e.g. bryozoan and sea squirts) to prepare for the next reassessment of bottom fisheries.

ToR 1.4. Discussion on workplan and timetable for reassessment of VME fishery closures including seamount closures for 2020 assessment.

Theme 2: Status, functioning and dynamics of NAFO marine ecosystems.

ToR 2.0. Update on recent and relevant research related to status, functioning and dynamics of ecosystems in the NAFO area.

ToR 2.1. NEREIDA: Initial Analysis of Sea Pen VME Resilience in the NAFO Regulatory Area.

ToR 2.2. Assessment of NAFO bottom fisheries. [COM Request #10 – assessment of bottom fisheries]

ToR 2.3. Progress on expanded single species, multispecies and ecosystem production potential modelling.

ToR 2.4. Review of oceanographic and ecosystem status conditions in the NRA.

Theme 3: Practical application of EAFM

ToR 3.0. Update on recent and relevant research related to the application of ecosystem knowledge for fisheries management in the NAFO area.

ToR 3.1. Development and application of the EAF Roadmap. [COM Request #9]

ToR 3.2. Develop draft summary sheets at ecosystem level [COM Request #9 - Continued development of ecosystem summary sheets (ESS)]

ToR 3.3. Consideration of stock recruitment patterns through the application of EAFM [Com. Request #9]

ToR 3.4. Developments to assess overlap of NAFO fisheries with VME to evaluate fishery specific impacts in addition to the cumulative impacts. [Com. Request #10 – assessment of bottom fisheries]

ToR 3.5. Update on 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. [Com. Request #6]

ToR 3.6. Update development in the use of non-destructive sampling techniques to monitor VMEs and options for integrating with existing survey trawl data.

ToR 3.7. Develop a workplan to consider clearer objective ranking processes and options for objective weighting criteria for the overall assessment of SAI and risk of SAI. [Com. Request #10 – assessment of bottom fisheries]

Theme 4: Specific Requests

No requests other than those already identified and addressed above.

In addressing **ToR 1**, the most recent Spanish and Canadian trawl survey VME indicator species biomass records were mapped, and added to the existing VME indicator species data-set. This data forms the basis for the re-assessment of the VME and VME fishery closures to be conducted in 2020. The last review of deep-water marine invertebrate taxa found in the NAFO Regulatory Area (NRA) evaluated against the FAO criteria for vulnerable marine ecosystem (VME) indicator designation occurred in 2011. Since the assessment in 2011, additional information has become available on the taxonomy, presence, ecological function, and life history characteristics of benthic marine fauna found in the NRA, which most likely calls for a re-assessment of the current list of VME Indicator Species in Annex 1.E of the NAFO Conservation and Enforcement Measures (NCEM).

Under **ToR 2**, two relevant EU research projects, e.g. ATLAS and SponGES, which involve NAFO scientific experts, were presented. The emerging view is that deep-sea sponges play a major role in biogeochemical cycling and in the marine food web. SponGES Work Package 4 (WP4) on Ecosystem Function, Services and Goods, aims to increase our knowledge on 1) the impact of sponge grounds on benthic-pelagic coupling of major biogeochemical cycles of ocean nutrients silicon, nitrogen, and carbon, 2) on the marine food web, and 3) on deep-sea ecosystem metabolism (i.e., productivity and respiration). In situ and ex situ experimentation will be conducted on the dominant species of the different sponge grounds, including Geodia and other astrophorid species that are found in the NAFO Regulatory Area. Such quantitative information would be useful in models currently being developed by WG-ESA members to evaluate the impact of significant adverse impacts of fishing to ecosystem function of VME in the NAFO Regulatory Area. The 4 overarching objectives of ATLAS are to, i. ADVANCE our understanding of deep Atlantic marine ecosystems and populations; ii. IMPROVE our capacity to monitor, model and predict shifts in deep-water ecosystems and populations, iii. TRANSFORM new data, tools and understanding into effective ocean governance, iv. SCENARIO-TEST and develop science-led, cost-effective adaptive management strategies that stimulate Blue Growth. Under this project Species Distribution Models (SDMs) for the Anthoptilum sp. deep-water pennatulacean coral for Flemish Cap Case Study have been carried out by Centro Oceanográfico de Vigo (Flemish Cap Case Study coordinator) in close collaboration with Centro Oceanográfico de Murcia (iSEAS project) and these models will provide some useful evidence for review as part of the assessment of NAFO VME closures and re-assessment of NAFO bottom fisheries.

Under **ToR 2 & 3**, WG-ESA considered information from several research initiatives that involve multispecies or ecosystem modelling to evaluate options to move forward in the implementation of the NAFO Roadmap. One important EU project “Multispecies Fisheries Assessment for NAFO” is financed by the EU DG-MARE and will have an overall duration of 21 months, starting in July 2017, and involves several research agencies (WMR, IEO, AZTI, CEFAS and MRAG). There are high capacity requirements to move this project forward but continued funding should allow an important contribution to move implementation of the Roadmap forward. The purpose is to provide a comprehensive overview (from the economic and ecological perspective) of how multispecies assessments would fit into the scientific and decision-making processes within NAFO and to develop specific analyses and techniques on a case study, the Flemish Cap, for potential practical implementations for the multispecies approach. Two presentations of different statistical approaches provided important examples of how environment and/or ecological processes and relationships affecting marine resources can be identified and may serve either for short-term [1-3 year] and intermediate term [3-5 year] forecasts of population trends as well as identify hypotheses to be further investigated through dynamic modelling. Discussion about the use of Ecopath with Ecosim in support of Ecosystem-based Fisheries Management highlighted the need for quantitative, process- and species-based model, representing trophic flows in the ecosystem. Currently, a model for the Grand Bank area (3LNO) is under development as part of the CoArc (A transatlantic innovation arena for sustainable development in the Arctic) project. In addition, a minimum realistic multispecies (MRM) model is also being developed for this Ecosystem Production Unit (EPU). Such models provide opportunities to address questions dealing with ecological interactions, evaluate ecosystem effects of fishing, explore management policy options, and model effects of environmental changes. These projects have moderate-to-high capacity requirements but there is capacity within NAFO contributors to move forward within the pilot areas of the Roadmap. There will be report of the progress of both these projects at the next meeting of WG-ESA, and the needs to transfer their structure to other EPUs will be evaluated. Finally, operational models for the North Sea and Georges Bank were described in detail to demonstrate their capacity to provide evaluation of complex species and fishery interactions and evaluate ecosystem effects of fishing, explore management policy options and consequences, model effect of environmental changes. Such undertakings have very high value but equally significant capacity, resource and data requirements. WG-ESA will continue to monitor progress of these initiatives but it is unlikely that research of this complexity will be undertaken to move implementation of the Roadmap forward. The outcomes of all modelling efforts will have to be compared with the outcomes from combined single species assessments from the case study EPUs to provide a basis for evaluation of how the information from the three tiers can be considered in the provision of advice.

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

On 5th March 2018, the joint ICES/NAFO Working Group on Deep-water Ecology (WGDEC), chaired by Neil Golding (UK) and attended by sixteen members (eleven in person, three via WebEx video conferencing and two via correspondence), met at the Northwest Atlantic Fisheries Organisation (NAFO) HQ in Dartmouth, Nova Scotia, to consider the Terms of Reference listed below:

a) Collate new information on the distribution of vulnerable habitats as well as important benthic species and communities in the North Atlantic and adjacent waters, archive appropriately using the ICES VME Database, and disseminate via the Working Group report and ICES VME Data Portal. In addition, prepare spatial layers and a list of areas where VMEs are likely to occur in the Northeast Atlantic, in particular in areas deeper than 800 m.

b) Provide all available new information on the distribution of vulnerable habitats (VMEs) in the NEAFC Convention Area. In addition, provide new information on location of habitats sensitive to particular fishing activities (i.e. vulnerable marine ecosystems, VMEs) within EU waters;

c) Summarize existing knowledge of ecosystem functioning of deep-sea benthic communities and habitats and the ecosystem roles of chemical/physical structures such as vents, seeps, seamounts, canyons, etc.;

d) Review how vulnerable marine ecosystems (VMEs) have been defined previously (e.g. from other RFMOs or States) and through the use of case studies for specific VMEs (e.g. seapen fields and cold-water coral reefs), suggest a procedure and consider approaches relevant to the available data and species of the NE Atlantic for developing a biological basis for defining how VMEs are identified, which will allow us in future to have an ecological basis for determining when a VME indicator record (or group of) transitions into a VME;

e) Propose parameters for use within the VME database that would serve to remove the effect of the passage of time in the evaluation of confidence in the weighting system, associated with each data entry. In addition, consider anthropogenic impacts that might be used to reintroduce uncertainty in such records

WGDEC was requested to provide all new information on the distribution of vulnerable marine ecosystems (VMEs) in the North Atlantic. A total of 14 417 new records were submitted through the ICES VME data call in 2017/2018 (a combination of VME indicator and VME habitat records) and included within the ICES VME database; 113 for the NEAFC Regulatory Area (RA), 14 298 for the Exclusive Economic Zones (EEZs) of ICES Member Countries and six for the NAFO RA. A substantial contribution of new information on VMEs was made by Canada with 13 745 VME habitat and indicator records submitted. All records from the VME database were also presented as outputs from the VME weighting system, showing the likelihood of VMEs being encountered on the seabed along with an associated confidence assessment.

This year, WGDEC was also requested to provide a list of areas and spatial layers, where VMEs occur, or are likely to occur, with respect to implementation of the EU deep-sea access regulation. To identify areas where VME occur, a data review was undertaken initially from the ICES VME database. However, in some EU waters the VME database is impoverished with respect to data on VME occurrence, and as such in these areas, data from the VME database was supplemented with data from peer reviewed literature and the OSPAR 2015 database. To identify areas where VME are likely to occur, WGDEC used the outputs of the VME weighting algorithm. The group focused on those c-squares which have been identified as having a ‘high’ VME index with an associated ‘high’ or ‘medium’ confidence. Data relevant to this ToR were identified from seven ICES reporting areas: IV, V, VI, VII, VIII, IX and X. Results were presented as maps within the report as well as the provision of spatial layers to ICES and on the VME data portal.

To follow on from work undertaken in 2015, WGDEC continued to investigate the latest scientific literature on the ecosystem functioning of VMEs, and of deep-sea benthic ecosystems more widely. This review is not exhaustive, but represents an overview of the key insights from new investigations on ecosystem functionality in the deep sea.

To ensure consistency in how WGDEC interpret new evidence of VME submitted to the VME database, and to identify if/when we can consider groups of VME indicator records as bona fide VME, WGDEC 2018 undertook a review of how to better define VMEs under NEAFC using existing approaches. The review considered approaches used by other RFMOs including NAFO and the South Pacific Regional Fisheries Management Organization (SPRFMO). It also provided recommendations on potential approaches for the VME habitat types; hydrothermal vents, cold seeps, coral gardens, cold-water coral reefs and seamounts. WGDEC identified aspects of the VME weighting algorithm that could be modified in future in light of new research on the vulnerability of deep-sea communities.

Finally, WGDEC identified the need to improve links with the General Fisheries Commission for the Mediterranean (GFCM) Working Group on Vulnerable Marine Ecosystems, which was established in 2017, potentially through WGDEC participation at the GFCM WGVME and vice versa, and sharing of information and tools of relevance.

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

CESAG met By WebEx on 21 November 2017, 12 March 2018 and 26 April 2018. The substantial items for all of these meetings were the NAFO catch estimation methodologies study (see STACREC report section V.8.b) and the estimation of catches by application of the agreed "CDAG" method (NAFO FC-SC Doc. 17-01 Appendix 3) to all NAFO managed stocks. Following consideration of Working papers presented by the Secretariat showing the catches of all NAFO managed stocks derived by this method, splitting catches (where possible) by division and comparing catch estimates using the CDAG method with those derived from daily catch reports it was agreed that the catches estimated using the CDAG method should be recommended to be used in stock assessments this year.

4. Meetings attended by the Secretariat

Deferred until September.

XI.REVIEW OF SCIENTIFIC COUNCIL WORKING PROCEDURES/PROTOCOL

1. General Plan of Work for September 2018 Annual Meeting

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

2. Other matters

a) Timeline for reporting of advice

It was agreed that text finalized during the meeting can be distributed immediately after the meeting.

b) Timeframe for completion of reports

Deferred until September.

c) Attendance of observers in SC meetings

Deferred until September.

d) Meeting participation by WebEx

In some recent meetings, major contributions have been made by WebEx, and in some cases these covered technical issues that could have caused significant problems had the work being presented turned out to be a key part of the meeting outcome. While SC would not wish to lose the opportunity for people who would not otherwise be able to attend, a decision needs to be made regarding what type of contribution can be made by WebEx. It was agreed that individuals who wish to participate in meetings by WebEx must inform the meeting chairs well in advance of the meeting dates. Scientific Council executive will have discretion to decide whether participation by WebEx will be appropriate. Any complex issues should be addressed in person if it is at all possible, for example, except under exceptional circumstances, no assessment based on an analytical model would be accepted by WebEx. If people present by WebEx, they should be made aware in advance that there is the possibility that their work may not be accepted.

XII.OTHER MATTERS

1. Designated Experts

The list of Designated Experts can be found below:

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

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

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

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

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

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

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

American plaice in Div. 3M	Ricardo Alpoim	ralpoim@ipma.pt
Golden redfish in Div. 3M	Ricardo Alpoim	ralpoim@ipma.pt
Redfish in Div. 3M	Antonio Avila de Melo	amelo@ipma.pt
Redfish in Div. 3LN	Antonio Avila de Melo	amelo@ipma.pt

From the Greenland Institute of Natural Resources, Nuuk, Greenland

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

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

Capelin in Div. 3NO	Ivan Tretiakov	tis@pinro.ru

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

Northern Shortfin Squid in SA 3 & 4	Lisa Hendrickson	lisa.hendrickson@noaa.gov

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

No award was presented in 2018.

4. Budget Items

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

5. Canadian Assessment of northern cod

The most recent assessment of Northern Cod (2018) from Fisheries and Oceans Canada was presented to Scientific Council for information. A state-space population dynamics model (Northern Cod Assessment Model, NCAM) was used to assess the stock and this model integrates much of the existing information about the productivity of the stock (DFO, 2016), such as information from DFO research vessel (RV) autumn trawl surveys, Sentinel surveys, inshore acoustic surveys, fishery catch age compositions, and partial fishery landings, and tagging. The 2018 assessment indicated that spawning stock biomass (SSB) has increased from 26 Kt in 2005 to 315 Kt (95% CI, 224-445 Kt) in 2018, down from 441 Kt in 2017. Spawning stock biomass has been well into the critical zone of the Canadian Precautionary Approach Framework since the stock collapse, and although it increased in 2017 to 52% of Blim, it has declined to 37% of Blim in 2018 (95% CI, 27-51%). Recruitment (age 2) in the 1990s and 2000s has been poor compared to the 1980s, but improved slightly in the last decade and the average number of age 2s from the 2011-13 year classes corresponds to about 25% of those observed in year classes of the 1980s.
Both fishing mortality and natural mortality increased from 2015 to 2017 but fishing mortality on ages 5+ is low, at 0.02. Much of the decline in SSB from 2016 to 2017 was driven by the estimate of natural mortality (M) increasing from 0.34 in 2015 to 0.74 in 2017. Low availability of capelin, declining mean weights at age and poor condition of cod also point to evidence of low productivity of the stock and ecosystem in general.

Total reported landings in 2017 were 12,707 t (compared with 4,435 t in 2015) from the stewardship fishery, 173 t from the inshore Sentinel survey, and 143 t of bycatch of cod in other fisheries (including outside 200 miles). There are no requirements to report recreational fishery landings. However, tagging data was used to provide an estimate of the magnitude of the recreational fishery. Recreational catch based on tagging returns was estimated to be about 25% of the stewardship fishery landings during 2016-17.

SC endorsed the conclusions of the assessment results but given the resource status, expressed concern about large increases in catch from 2015 to 2017 while the fishery is under moratorium. In addition, SC expressed further concern about the magnitude of natural mortality compared to fishing mortality as estimated by the NCAM model and were encouraged that the assessment research recommendations include ongoing investigation on this subject.

XIII.ADOPTION OF COMMITTEE REPORTS

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

XIV.SCIENTIFIC COUNCIL RECOMMENDATIONS TO THE COMMISSION

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

XV.ADOPTION OF SCIENTIFIC COUNCIL REPORT

At its concluding session on 14 June 2018, 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 14 June 2018.

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

Chair: Eugene Colbourne Rapporteur: David Bélanger

The Committee met at the Sobey School of Business (Unilever Lounge), Saint Mary's University, 903 Robie St., Halifax, NS, Canada, on June 1st, 2018, 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, and Spain), European Commission, Russian Federation, and USA.

1. Opening

The Chair opened the meeting by welcoming participants to this June 2018 Meeting of STACFEN.

The Committee adopted the agenda and discussed the work plan and noted the following documents would be reviewed: SCR Doc. 18/05, 18/06, 18/07, 18/09, 18/10, 18/14, 18/34, 18/49

2. Appointment of Rapporteur

David Bélanger (Canada) was appointed rapporteur.

3. Adoption of the Agenda

The provisional agenda was adopted with no further modifications.

4. Review of Recommendations in 2017

- 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.*

STATUS: Due to the delay confirming STACFEN chair for the June 2018 meeting no attempts were made to attract an invited speaker for this meeting. 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 ongoing between STACFEN and STACFIS Chairs on environmental data integration into the various stock assessments.

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

A workshop was convened to gather zooplankton ecologists and modellers, along with physical oceanographers and biogeochemical modellers, from governmental (DFO, NOAA/NMFS) and academic institutions from the NE US, Nova Scotia, New Brunswick, Quebec and Newfoundland.

The main theme of the workshop was to consider the large scale ecosystem and plankton community changes since 2010. The principle conclusions were: (1) Models that describe the spatial distribution of *Calanus finmarchicus* are mature enough to forecast shifts in distribution in relation to remotely sensed data (temperature, chlorophyll *a*) and climate project models (2) Bioenergetic models of growth, development and energy storage of *C. finmarchicus* (and *Calanus hyperboreus*) are being coupled with regional circulation models (3) Major variations in life history traits (growth, mortality, energy reserves, phenology) have been detected in the Gulf of St. Lawrence and on the Newfoundland and Scotian Shelves and (4) There is a pronounced need for a regional biogeochemical model (nutrients, phytoplankton, microzooplankton, microbial loop) for the western Atlantic to couple with mesozooplankton models.

5. Oceanography and Science Data (OSD) Report for 2017 SCR 18/034.

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, all NAFO member countries are requested to provide MEDS with all marine environmental data collected in the NAFO convention area for the preceding years.

Provision of a meaningful report to the Council for its meeting in June 2018 required the submission to MEDS of a completed oceanographic inventory form for data collected in 2017, and oceanographic data pertinent to the NAFO Convention Area, for all stations occupied in the year prior to 2017. 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.

The 2017 report and the tables below summaries the various types and quantity of oceanographic data collected in the NAFO Convention Area and acquired by MEDS from January 2017 to May of 2018.

Data observed in NAFO Convention Area in 2017 and acquired from January 2017 to May 2018.

Data Type	Platform Type	Counts/Duration
Oceanographic profiles	Autonomous Drifting	11291* profiles from 170 platforms
	Moorings	15* profiles from 3 platforms**
	Ship	5411 profiles (2050 CTD; 1608 CTD*; 1059 bottle and 695 XBT* profiles) from at least 30 ships
Surface/near-surface observations	Ship (thermosalinograph)	15168* obs. from 2 ships
	Drifting buoys	456042* obs. from 200 buoys
	Moored buoys	117456* obs. from 17 buoys**
	Fixed platforms	101188* obs. from 3 platforms
	Water level gauges	25 sites, avg. ~1 year each
Sub-surface observations	Moored CTD, waves, ADCP	6 time series, seasonal (~5 months avg each)

*Data formatted for real-time transmission

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

Data observed prior to 2017 in NAFO Convention Area and acquired between January 2017 and May 2018.

Data Type	Platform Type	Counts/Duration
Oceanographic profiles	Ship	6870 profiles (2954 CTD + 3435 bottle** profiles) format least 17 ships
Sub-surface observations	Moored CTD, waves, ADCP	4 time series (3X 1 year and 1X 5 years)

*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.

6. Highlights of Climate and Environmental Conditions by NAFO Sub-Area for 2017

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

- *The North Atlantic Oscillation index (NAO), a key indicator of climate conditions over the North Atlantic and much of the NAFO convention area, remained in a weak positive phase in 2017. As a* *consequence,arctic air outflow in the northwest Atlantic during the winter months moderated in 2017, compared to that in 2015 when the NAO was at a record high.*

- *The annual mean air temperature at Nuuk in West Greenland was 0.6°C above the long term mean (1981-2010) in 2017.*
- *Surface air temperatures over much of the Labrador Sea were above normal, particularly during the winter (1.6 SD) and through the fall period.*
- *Annual air temperatures over Labrador (at Cartwright) were slightly above normal (0.3°C, 0.2 SD) and over Newfoundland (at St. John's) they were near normal at 0.1°C (0.1 SD).*
- *Overall, 2017 ranked as the 9th 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 0.5°C (0.8 SD) above normal at Boston to 1.0°C (1.3 SD) above normal at Shearwater.*
- *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, similar to conditions in 2016.*
- *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 slightly below normal conditions in 2016 (-0.3 SD)and 2017 (-0.4 SD).*
- *There were 1008 icebergs detected south of 48°N on the Northern Grand Bank in 2017, slightly above the long term mean of 767 by 0.4 SD.*
- *Ice coverage and volume on the Scotian Shelf in 2015 were above the average, unlike the preceding four years (2010-2013) which had extremely low coverage and volume. In 2016 and again in 2017, sea ice was almost entirely absent from the Scotian Shelf.*

b) Ocean Climate Indices (Sub-Area 1)

- *Average water temperatures at Fyllas Bank Station 2 (0-40 m depth) off West Greenland in June/July experienced a significant increase with temperatures 1.9°C/0.9°C (2.4/1.1 SD) higher than normal in 2016 and 2017, respectively.*
- *Average salinity at Fyllas Bank Station 2 (0-40 m depth) off West Greenland however was near normal in 2017 at 0.07 (0.33 SD).*
- *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. No data were available for the fall of 2017.*
- *In 2017, temperature and salinity values of the Irminger Sea Water in the 75-200 m layer at Cape Desolation Station 3 were 5.3°C and 34.90, which were 0.6°C and 0.02 above the long-term mean, respectively.*
- *In 2017, temperature and salinity values of the fresh Polar Water component of the West Greenland current between 0-50 m depth on Fyllas Bank Station 4 were 0.8°C and 0.22 above normal, respectively.*

c) Ocean Climate Indices (Sub-Area 2 Labrador Sea)

- *Sea Surface Temperatures over much of the Labrador Sea were mostly above normal, particularly during the winter when they were 1.4 SD above normal.*
- *The 2017, winter convection in the Labrador Sea exceeded 2000 m making it the 5th consecutive year of increasing convection or increased production of Labrador Sea water.*

d) Ocean Climate Indices (Sub-Area 2 and 3 NL Shelf)

- *Annual sea surface temperatures (SST) were mostly below or near-normal from Hudson Strait (-1.5 SD lowest observed), eastern Newfoundland Shelf, Flemish Cap and Grand Banks. St. Pierre and Green Banks (+0.3 SD) and Flemish Pass (+1.1 SD) were exceptions.*
- *The annual surface temperature anomaly at Station 27 was +0.4°C or 0.6 SD above normal, similar to 2016.*
- *The annual bottom (176 m) temperature anomaly at Station 27 was -0.2°C or 0.6 SD below normal, similar to 2016.*
- *The annual surface salinity anomaly at Station 27 was -0.4 or -1.6 SD below normal.*

- *The annual bottom (176 m) salinity anomaly at Station 27 was -0.12 or -1.6 SD below normal.*
- *The annual water column average (0-176 m) temperature and salinity anomaly at Station 27 was +0.03°C and -0.16 or -0.1 and –1.6 SD different from normal, respectively.*
- *The summer area of CIL (<0°C) water on the Grand Banks, eastern Newfoundland, northeast Newfoundland Shelf and southern Labrador was 22.7, 26.2, 66.9 and 33.2 km^2 or -0.6, +0.1, +0.8 and +0.8 SD different from normal, respectively.*
- *The averaged spring bottom temperature in NAFO Div. 3P was about 2.7℃, or 0.2℃ (0.4 SD) above normal, a significant decrease from 2 SD above normal in 2016.*
- *The spatially averaged spring and fall bottom temperature in NAFO Divs. 3LNO was 1.4° (-0.2 SD) and 1.3°C (-1.2 SD), respectively.*
- *The spatially averaged fall bottom temperature in 2J was about normal at 2.6°C (+0.1 SD).*
- *In 3K, the spatially averaged fall bottom temperature was 2.3°C or 0.03 SD below normal.*
- *A composite climate index for the NL region derived from 28 meteorological, ice and ocean temperature and salinity time series returned to slightly below normal (15th lowest). In 2015 it was the 7th lowest in 67 years and the lowest since 1993.*

e) Ocean Climate Indices (Division 3M, Flemish Cap)

- *Annual sea surface temperatures (SST) around the Flemish Cap increased over the previous two years but remained at -0.5°C below normal in 2017.*
- *Average bottom temperatures based on the EU summer survey around the Flemish Cap were about normal (-0.1 SD) in 2017.*
- *The spatial extent of the CIL (<3°C) covered over 80% of the Flemish Cap area during the summer 2017 EU survey with average thickness of about 66 m or about 15 m thicker than normal.*
- *During the summer of 2017, both the CIL minimum and average observed core temperature over the Flemish Cap was slightly above normal, a significant increase over the record cold values observed in 2015.*

f) Ocean Climate Indices (Sub-Area 4, Scotian Shelf)

- *Annual SST anomalies on the Scotian Shelf during 2017 ranged from +0.7°C (+1.2 SD) in Cabot Strait to +1.9°C (+3 SD) in the Western Scotian Shelf area. All 8 sub-areas examined had SST above average with 4 of 8 areas ≥2 SD*
- *In 2017 the July bottom temperature anomalies on the Scotian Shelf in NAFO Divisions 4Vn, 4Vs, 4W and 4X were 0.7°C (1.6 SD), 1.3°C (1.9 SD), 0.8°C (1.1 SD) and 1.6°C (2.2 SD) above normal, respectively.*
- *In 2017, the annual temperature anomalies depicting different water masses were +1.1°C (+3.3 SD) for Cabot Strait 200-300 m (the 2nd highest), +0.4°C (+0.7 SD) for Misaine Bank at 100 m, +1.5°C (+1.8 SD) for Emerald Basin at 250 m (2nd highest) and +1.6°C (+3 SD) for Georges Basin at 200 m (a record high).*

- *The CIL (T<4°C) volume on the Scotian Shelf in 2017 was below normal by 0.8 SD, the 21st lowest in 44 years.*
- *The climate index, a composite of 20 selected, normalized temperature time series on the Scotian Shelf, averaged +1.7 SD, making 2017 the 3rd warmest year in the last 48 years. The warmest occurred in 2012 at +2.7 SD and the 2nd warmest was in 2016 at +2.1 SD.*

g) Ocean Climate Indices (Sub-Area 5 and 6, Northeast USA Shelf)

- *On the Northeast U.S. shelf, 2017 was characterized by warmer than average conditions across the region.*
- *Fall water temperatures were notably warm across the NEUS Shelf, consistent with anomalously warm air temperatures.*
- *Near bottom waters in the eastern Gulf of Maine were more than 1 SD warmer and saltier than average throughout the year.*
- *Deep waters entering the Gulf of Maine were predominantly warm and salty, except in June when relatively cool, very fresh waters were observed in the Northeast Channel.*
- *Warm winter air temperatures and the late onset of storms suppressed winter mixing in the western Gulf of Maine, leading to warmer Gulf of Maine intermediate water mass.*

- *Slope waters entering the Gulf of Maine through the Northeast Channel were anomalously warm and salty, consistent with the properties of Warm Slope Water derived from subtropical origins.*

h) Biological and Chemical Indices (Sub-Area 2-5, NL Shelf, Gulf of St. Lawrence, Scotian Shelf and Gulf of Maine)

- *Nitrate inventories in the upper (0-50m) water-column were near normal in 2017 compared to the 1999-2015 climatology throughout the NW Atlantic with the exception of larger positive and negative anomalies on the SE Grand Bank (3LNO) and in the Bay of Fundy (4X), respectively.*
- *Deeper (50-150 m) nitrate inventories were near normal throughout the surveyed area in 2017 except in the Cabot Strait and on the Scotian Shelf (3P4VWX) where deep nitrate concentrations continued well below normal for a second consecutive year.*
- *Chlorophyll a standing stock was below normal on the Grand Bank (3LNMO) and the eastern Scotian Shelf (4VW), above normal in the southern GSL (4T), and near normal in other NAFO divisions.*
- *Chlorophyll a biomass was positively correlated with shallow nitrate concentrations at a zonal scale (NAFO Subareas 2, 3, 4), and positively correlated with 1-year lag deep nitrate concentrations at the regional scale on the NL Shelf (2J3KLMNO) suggesting regulation of phytoplankton production through nitrate availability across the NW Atlantic.*
- *Spring bloom phytoplankton magnitude (total production) and amplitude on the eastern Canadian Shelf (NAFO Subarea 2-5) in 2017 continued below the long-term climatology for a third consecutive year.*
- *Spring bloom peak timing was delayed compared to the long-term climatology in the Labrador Sea as well as on the Grand Bank and the Scotian Shelf, but earlier than normal on the West Greenland and Labrador (1F2HJ) shelves, as well as in the northern GSL (4RS) and the Cabot Strait.*
- *Zooplankton abundance in Subarea 2-4 (both copepods and non-copepods) showed a general decline in 2017, especially in the GSL, compared to the record-high values for the time series observed in 2016.*
- *Zooplankton biomass in 2017 remained well below normal across the surveyed area for a third consecutive year since the time series record-low observed in 2015.*
- *The general trends in Pseudocalanus spp. abundance reflected the pattern of change in total copepod abundance, whereas abundance of the larger copepod Calanus finmarchicus generally tracked the pattern of change in zooplankton biomass.*
- *The importance of regional scale linkages between climatic conditions, nutrient concentrations and ocean primary and secondary production was highlighted by different correlation patterns observed at the zonal (Subarea 2, 3, 4)) and regional (2J3LMNO) scale.*

7. Results of Ocean Climate and Physical, Biological and Chemical Oceanographic Studies in the NAFO Convention Area in 2017

The North Atlantic Oscillation (NAO) index, as defined by Rogers (1984), is the difference in winter (December, January and February) sea level atmospheric pressures (SLP) between the Azores and Iceland and is often a measure of the strength of the winter westerly and north westerly winds over the Northwest Atlantic. A high (positive phase) NAO index occurs from an intensification of the Icelandic Low and Azores High. This favours strong northwest winds, cold air and sea temperatures and heavy ice conditions on the NL Shelf regions. Analysis have shown that variability in the NAO can account for a significant portion of the variability in key ocean climate indices, including Labrador Sea convection and the cold-intermediate-layer (CIL) water mass overlying much of the Newfoundland and Labrador continental Shelf. In 2017, the NAO index declined from the record high of 2015 but remained in a positive phase for the 4th consecutive year at 0.3 SD above the long term mean. A modulating factor observed in 2017 was the spatial patterns of the SLP fields, with the Icelandic Low shifted westward towards Greenland and the Labrador Sea and the centre of the Azores High displaced eastward towards Europe. As a consequence, arctic air outflow to the Northwest Atlantic during the winter months of 2017 decreased over the previous year, resulting in higher winter air temperatures over much of the NAFO convention area including the Labrador Sea and Newfoundland and Labrador and adjacent shelf regions.

Subareas 0 and 1. Reviews of meteorological, sea ice and hydrographic and atmospheric conditions in West Greenland in 2017 were presented in **SCR Doc. 18/05 and 18/06**.

Hydrographic conditions were monitored at 10 hydrographic standard sections in June/July 2017 across the continental shelf off West Greenland. The West Greenland Current carries water northward along the West Greenland continental slope and consists of three components: a cold, fresh and near inshore surface component referred to as Coastal Water (CW), a saltier, warmer and deeper offshore component referred to as Subpolar Mode Water (SPMW). The West Greenland Current is part of the cyclonic Subpolar Gyre and thus subject to hydrographic variations at different time-scales associated with variability of the gyre, local and regional atmospheric conditions.

West Greenland usually experiences colder than normal conditions when the NAO index is positive; however in 2017, the annual mean air temperature at Nuuk was 0.6°C above the long-term mean. Average water properties between 0 and 50 m depth at Fyllas Bank Station 4 in June/July are used to monitor the variability of the Coastal Water (CW) component of the West Greenland Current. After a near-record high temperature in 2016, the temperature in 2017 experienced a decrease to levels characteristic for the decade; with temperatures 0.8°C higher than the long-term mean. Conversely, the salinity of the CW resumed its positive trend, which started around 1970. In 2017 salinity was 0.22 above its long-term mean. Average water properties between 0 and 40 m depth at Fyllas Bank Station 2 in June/July have previously been used to monitor the variability of the sea surface waters off West Greenland. After a negative temperature trend from 2005 to 2015, the temperature in 2017 was higher than normal, a trend that started in 2016 attaining levels similar to those observed in the mid-2000s; with temperatures 0.9°C higher than normal. The salinity of the sea surface layer continued its slightly negative trend, which started around 1970. In 2017, salinity was 0.07 above its long-term mean. Temperature and salinity of the SPMW component of the West Greenland Current started to increase towards the end of the 1990s, coinciding with changes in the Subpolar Gyre where warm and saline water from the Subtropical Gyre entered the Subpolar Gyre. In July 2017, water temperature in the 75–200 m layer at Cape Desolation Station 3 was 5.3°C and salinity was 34.90, i.e. 0.6°C and 0.02 above the long-term mean, respectively.

SPMW sometimes referred to as Atlantic Water or Irminger Sea Water with salinity greater than 34.95, were only observed at stations on the Cape Farewell section off the west coast off Greenland in July 2017. Waters with salinities in the range 34.88 to 34.95 could be followed from the Cape Farewell section in the south (59°N) to the Sisimiut section in the north at 66°N. North of the Sisimiut section, the SPMW core becomes gradually colder and fresher with distance. Core properties of the SPMW at Upernavik section (~73°N) measured at Upernavik 5300 m depth to 2.4°C and 34.47 temperature and salinity respectively. The highest temperature observed off the west coast off Greenland during June/July 2017 was at the Cape Farwell section at the surface in the SPMW mass core. This water mass is associated with the subduction processes which occur in the area around Cape Farewell when SPMW leaves the Irminger Sea and enters the Labrador Sea. The lowest temperature observed off the west coast off Greenland during June/July 2017 was north of the Sisimiut section and was associated with Baffin Bay Polar Water.

Oceanographic observations from the fall survey of West Greenland Waters including the Fyllas Bank and Cape Desolation sections were unavailable to severe weather conditions in 2017.

Subareas 1 and 2. A review of physical, chemical and biological oceanographic conditions over the Labrador Sea in 2017 was presented.

The Atlantic Zone Off-Shelf Monitoring Program (AZOMP) provides observations on ocean climate and plankton variability affecting regional climate and ecosystems in the NAFO Convention area including the Labrador Sea in Sub-Areas 1 and 2. Due to the lack of a research vessel the regular spring (May) survey of the Labrador Sea area was cancelled resulting in limited physical, chemical and biological data, relying essentially on satellite remote sensing, ARGO float temperature and salinity profiles and re-analysis of data products.

In the Labrador Sea, surface heat losses in winter result in the formation of dense waters, which drive the global ocean overturning circulation and ventilation of the deep layers. In the winter of 2016-17, as in the previous winter, the mid to high latitudes of the North Atlantic experienced more moderate surface heat loss in the region than in the winter of 2014-2015 which was characterized by the highest heat losses in more than two decades. Despite the weaker heat loss from the ocean to the atmosphere in the following two years, the water column preconditioning caused by convective mixing in the previous years led nevertheless to the most significant formation, in terms of volume and depth, of Labrador Sea Water (LSW) since 1994. Similar to 2016, the temperature and salinity profiles obtained by the Argo floats show that the winter mixed layer and hence convection in the central Labrador Sea reached below 2000 m in 2017, exceeding the mixed layer depths of 1600 and 1700 m in 2014 and 2015, respectively. The 2017 vintage of LSW is associated with low temperature (< 3.3°C) and salinity (< 34.86) between 1000 and 1700 m. The winter convection in 2016 and the one that followed it last year (2017) are arguably the deepest since the record of 2400 m in 1994, and the resulting LSW year class is one of the largest ever observed outside of the early 1990s. This also suggests that the strong winter convection in 2017 further added to increased gas (dissolved oxygen, anthropogenic gases, and carbon dioxide) uptakes and consequently respective gas concentrations in the Labrador Sea in the lower part of the 0-2000 m layer, but this could not be confirmed from direct ship-based measurements.

In order to be able to measure the ocean colour using satellite imagery, you need a cloud free sky, however the Labrador Sea region tends to be generally cloudy, particularly in the spring. In fact, over a period of 5 weeks running form end of April to early June, the percent coverage of good data in the central basin of the Labrador Sea region never reach over 20% for any of the seven days composite and most of the pixels with valid data were provided by the northeast corner of the sub-area examined. Missing an important portion of the bloom initiation phase makes it impossible to estimate its magnitude. Onset was typically early in both other regions (Labrador Shelf and West Greenland Shelf) but while the duration did compensate on the Greenland Shelf to bring the magnitude relatively high, the situation was reversed on the Labrador Shelf with a relatively lower than average phytoplankton bloom. Therefore due to poor data quality the remotely sensed ocean colour failed to provide reliable and meaningful estimation of the chlorophyll bloom parameters for the Central Labrador Sea region during the spring of 2017. As a result of the cancellation of the spring research survey, we were not able to update the rate of decline in pH, previously reported as a mean rate of -0.002 per year from 1994 to 2016, nor was it possible to assess the state of *Calanus finmarchicus*, the dominant mesozooplankton in the western and central region of the Labrador Sea, following the record lows reported in 2016.

Subareas 2, 3 and 4. A description of the physical oceanographic environment on the Newfoundland and Labrador Shelf and Scotian Shelf was presented in **SCR Doc. 18/09 and 18/49.**

The atmospheric pressure fields associated with a weak NAO resulted in reduced arctic air outflow in the northwest Atlantic during the winter months of 2017 and as a consequence winter air temperatures were near-normal, however they were below normal during the spring months. Sea ice extent across the Newfoundland and Labrador Shelf between 45-55°N, although above normal during late spring, was below the long-term mean in 2017. In the inshore regions along the east and northeast coast of Newfoundland sea ice duration was up to 15-60 days longer than normal. Sea ice in these regions disappeared by mid-June which ranged from 15-45 days later than normal depending on the area. Annual sea-surface temperature (SST based on infrared satellite imagery) trends on the Newfoundland and Labrador Shelf, while showing an increase of about 1°C since the early 1980s, were mostly below normal during 2017, driven largely by very cold spring conditions. In 2017, the annual bottom (176 m) temperature/salinity at the inshore monitoring site (Station 27) was below normal by -0.6/-1.5 standard deviations (SD), respectively. Observations from the summer AZMP oceanographic survey indicated that the area of cold-intermediate-layer (CIL <0°C) water overlying the northeast Newfoundland and southern Labrador shelf increased over 2016 to about 1 standard deviation above normal, implying more extensive cold winter chilled water throughout the region. Labrador Current transport through the Flemish Section remained high during the spring (13.5 Sv) but decreased to lower than normal during the summer (4.6 Sv). Summer transport through the Seal Island section was higher than normal in 2017 at 12 Sv. The spatially averaged bottom temperature during the spring in 3Ps remained slightly above normal, a significant decrease over the 33-year record high in 2016. In Divs. 3LNO spring bottom temperatures were about normal. The spatially averaged bottom temperature during the fall in 2J and 3K show an increasing trend since the early 1990s of about 1°C, reaching a peak of >2 SD above normal in 2011. Oceanographic data from the fall 2017 multi-species surveys in NAFO Divisions 3LNO indicate bottom temperatures were about 1.2 standard deviations (SD) below normal. In Divisions 2J and 3K fall bottom temperatures continued to decrease from the record high in 2011 to about normal conditions in 2017. A standardized composite climate index for the Northwest Atlantic derived from 28 time series of meteorological, ice, water mass areas and ocean temperature and salinity conditions since 1950 reached a record low (cold) value in 1991. Since then it shows a warming trend that reached a peak in 2010 and thereafter decreased to mostly below normal conditions (cold/fresh) during the past 4 years. The 2015 value was the 7th lowest in 68 years of observations and the lowest value since 1993, while the 2017 value was the 15th lowest.

On the Scotian Shelf, Bay of Fundy and the Gulf of Maine regions air temperature anomalies were positive for all 6 sites examined, Sydney +0.7°C (+0.8 SD), Sable Island +0.8°C (+1.2 SD), Shearwater +1.0°C (+1.3SD), Yarmouth +0.9°C (+1.4 SD), Saint John +0.6°C (+0.8 SD) and Boston +0.5°C (+0.8 SD. Overall these values were the 9th warmest in 117 years with the warmest occurring in 2012. The 2017 January to April average ice volume on the Scotian Shelf was the 9th lowest on record with nearly no ice present, similar to conditions in 2010-2013 period that had extremely low coverage and volume. In 2016 it was the 3rd lowest, unlike 2015 which was above normal. Annual SST anomalies on the Scotian Shelf were positive for all 8 sub-areas examined during 2017 ranging from+0.7°C (+1.2 SD) in Cabot Strait to +1.9°C (+3 SD) in the Western Scotian Shelf area. All 8 sub-areas had anomalies ≥1 SD with 4 of 8 areas ≥2.0 SD above normal. In 2017, the annual temperature anomalies depicting different water masses on the Scotian Shelf were +1.1°C (+3.3 SD) for Cabot Strait 200-300 m (the 2nd highest), +0.4°C (+0.7 SD) for Misaine Bank at 100 m, +1.5°C (+1.8 SD) for Emerald Basin at 250 m (2nd highest) and +1.6°C (+3 SD) for Georges Basin at 200 m (a record high). The spatially averaged bottom temperatures based on the July multi-species survey for 4Vn, 4Vs, 4W and 4X were 0.7°C (1.6 SD), 1.3°C (1.9 SD), 0.8°C (1.1 SD) and 1.6°C (2.2 SD) above normal, respectively. In 2017 4Vn was the 4th warmest year, 4Vs was 5th warmest and 4X was the 4th warmest year. A composite index consisting of 20 ocean temperature time series from surface to bottom across the region indicate that 2017 was the 3rd warmest of 48 years of observations with an averaged normalized anomaly of +1.7 SD relative to the 1981-2010 period. The warmest occurred in 2012 at +2.7 SD and the 2nd warmest was in 2016 at +2.1 SD. In general, the physical oceanographic conditions on the Scotian Shelf and in the eastern Gulf of Maine and adjacent offshore areas indicate that 2017 was an extremely warm year with a fairly uniform distribution of anomalies throughout the region.

Division 3M, Flemish Cap. A description of the physical oceanographic environment on the Flemish Cap was presented in **SCR Doc. 18/10**.

An analysis of infrared satellite imagery around the Flemish Cap indicates that annual sea-surface temperatures (SST) increased over the previous two years but remained at -0.5°C below normal in 2017. Annual water column temperatures were -1.2°C, -0.3°C, -0.5°C and -0.2°C below normal at depths of 5, 50 and 100 m and bottom, respectively. The results from seasonal surveys along the standard Flemish Cap section at 47°N show the development of a well-defined cold-intermediate layer (CIL) with T<3°C that penetrated to the bottom during the fall (December) survey in 2017. Water column temperatures along the section were predominately above normal in the upper layers during spring (April) and below normal in most areas during the summer and fall when values as low as -2° below normal were observed. Bottom temperatures below 200 m depth were generally near the long term mean. The corresponding salinity cross-sections show near-normal values except for a strong negative anomaly during the summer on the Flemish Pass side of the Cap where values reached >0.5 below normal. The spatial extent of the CIL (<3°C) covered over 80% of the area during the summer 2017 EU survey with average thickness of about 66 m or about 15 m thicker than normal. During the summer of 2017, both the CIL minimum and average observed core temperature was slightly above normal, a significant increase over the record cold values observed in 2015. A composite climate index derived from several metrics based on the EU summer survey show a cooling trend since 2012 that reached a record low in 2015 but has since moderated with 2016 and 2017 returning to near-normal conditions over most of the water column. In general, data from four surveys in NAFO division 3M on the Flemish Cap during the past several years captured a significant event highlighted by an unprecedented cold-fresh water mass over the Flemish Cap that peaked in 2015. Both geostrophic current estimates and direct ADCP measurements showed a very dynamic circulation pattern in 2015 with record high southward flowing LC water over the Cap. In 2017, the circulation pattern was completely different with northward flowing water dominating and temperature and salinity conditions returning to near-normal values over most of the water column except in the near-surface layer where temperature values remained below normal.

Subareas 2 - 5. Biological Oceanographic Conditions in the Northwest Atlantic During 2017 was presented in **SCR Doc. 18/007.**

Biological and chemical data were collected in 2017 as part of the Atlantic Zone Monitoring Program (AZMP) from coastal high frequency monitoring stations, seasonal cross-shelf sections as well as data from ships of opportunity on 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). These data are used to 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. All time series are presented in terms of anomalies relative to the 1999-2015 climatology. In general, 2017 nitrate inventories in the upper (0-50m) water column were near normal throughout the Northwest Atlantic with the exception of higher positive anomalies on the southeastern Grand Banks (3LNO) and the western Scotian Shelf (4Vs), and negative anomaly at the high frequency sampling station Prince 5 in the Bay of Fundy (4X). The deeper (50-150m) nitrate inventories remained mostly near to below normal on the Newfoundland and Labrador Shelves and on the Grand Banks. The depleted inventories of deep nitrate observed on most of the Scotian shelf in 2015 continued to decline in all NAFO Divisions (4VWX) in 2017. The chlorophyll-*a* inventories were above normal in the Gulf of St. Lawrence and below normal on the southeastern Grand Banks (including Flemish Cap) and the Scotian Shelf in 2017. Variation in shallow and deep composite indices of nitrate concentration and chlorophyll a biomass showed similar trends during the 1999-2017 time series suggesting regulation of phytoplankton productivity through nitrate availability throughout the zone. The spring bloom magnitude and amplitude in 2017 continued below climatology in virtually all statistical sub-regions on the Canadian continental Shelves and in the Gulf of St. Lawrence, and above or near normal in the Labrador Sea. Spring bloom peak timing occurred later than normal in the Labrador Sea and on the NL and the Scotian shelves and varied in the Gulf of St. Lawrence, whereas bloom duration stayed near normal throughout the study area except for a markedly longer bloom in the NW Gulf of St. Lawrence. The abundance of the small copepod *Pseudocalanus* spp. remained high on the NL Shelf but declined in the Gulf of St. Lawrence and on the Scotian Shelf, while the abundance of the large copepod *Calanus finmarchicus* remained below normal in most NAFO Divisions from northern Labrador (2J) to the western Scotian Shelf (4X). Despite the generally near to above normal abundance of total copepods and the high abundance of non-copepods throughout the study area in 2017, total zooplankton biomass remained unusually low for the 3rd consecutive year. Finally, significant correlations between climate, ocean chemistry and phytoplankton and zooplankton standing stocks anomaly time series were observed at both zonal (Northwest Atlantic) and regional (NL Shelf) scale.

Subareas 5 and 6. A description of hydrographic conditions on the Northeast United States Continental Shelf during 2017 was presented in **SCR Doc. 18/14**.

An overview is presented of the atmospheric and oceanographic conditions on the Northeast U.S. Continental Shelf during 2017.

The Northeast United States (NEUS) Continental Shelf extends from the southern tip of Nova Scotia, Canada, south westward through the Gulf of Maine and the Middle Atlantic Bight, to Cape Hatteras, North Carolina. Hydrographic conditions along the NEUS Shelf are mainly determined by the relative proportion of two main sources of water entering the region: cold/fresh arctic-origin water advected by the coastal boundary current from the north and warmer, more saline slope waters residing offshore of the shelf break. This analysis utilizes hydrographic observations collected by the operational oceanography programs of the Northeast Fisheries Science Centre (NEFSC), which represents the most comprehensive consistently sampled ongoing environmental record within the region. Overall, 2017 was characterized by warmer than average conditions across the region. Fall water temperatures were notably warm, consistent with anomalously warm air temperatures. The upper 30 meters throughout the Middle Atlantic Bight were more saline than normal, particularly during winter and spring, while surface waters in the Gulf of Maine were regionally delineated, with persistent salty conditions in the east and fresh conditions in the west. Observations indicate that rings and eddies in the Slope Sea facilitated cross-shelf flow, setting up localized anomalies in the northern Middle Atlantic Bight during spring and in the deep Northeast Channel during early summer. Overall, deep (slope) waters entering the Gulf of Maine were predominantly warmer and saltier than average, and their temperature and salinity suggest a subtropical source. Near bottom waters in the eastern Gulf of Maine were more than one standard deviation warmer and saltier than average throughout the year, while the western Gulf of Maine was consistently warm and fresh. Warm winter air temperatures together with the late onset of winter storms suppressed mixing in the western Gulf of Maine, leading to warmer Gulf of Maine intermediate water. In general the observations suggest that the Northeast U.S. Continental Shelf has been warming at a rate of about 0.03-0.05°C/year since 1977, with significant inter-annual variations in temperature and salinity superimposed on this trend.

8. Interdisciplinary Studies

An important role of STACFEN, in addition to providing climate and environmental summaries for the NAFO Convention Area, is to determine the response of fish and invertebrate stocks to the changes in the physical and biological oceanographic environment. It is felt that a greater emphasis should be placed on these activities within STACFEN and the committee recommends that further studies be directed toward integration of environmental information with changes in the distribution and abundance of resource populations.

The following interdisciplinary study was presented by Dr. Frédéric Cyr at the June 2018 meeting along with an abstract summarizing the findings.

Decadal environmental changes in the Newfoundland and Labrador ecosystem.

Newfoundland and Labrador (NL) shelves are located on a crossroads of the Atlantic meridional overturning circulation (AMOC), and are therefore specially affected by climatic-scale changes in large-scale ocean circulation. Such circulation changes impact not only the regional climate, but also the overall water masses composition, with consequences on physical conditions, nutrient availability, oxygen content, etc. Although of global significance (e.g., for fish habitats), the details of these changes are still largely unknown in the oceanographic community. Systematic hydrographic observations of this system have been carried out by Canada and other countries since 1948. In Canada the observational program was reinforced in 1999 with the creation of the Atlantic Zone Monitoring Program (AZMP), ensuring enhanced seasonal coverage and new biogeochemical observations. Here we review 7 decades of oceanic observations, with an emphasis on low frequency variability and cycles. Results suggest, for example, that the cold intermediate layer (CIL), a cold mid-depth layer that is a key feature of the NL ecosystem, exhibited profound changes during the last 70 years. For example, the 15 years period between the early 60's and mid-70's was anomalously warm compared to the rest of the time series. This warm period was followed by a cold period that spanned the mid-80's to mid-90's, a period during which the summer CIL core temperature dropped by nearly 2°C on average. Historical salinity records also suggest that fresher waters are found on the shelves during warmer years, and vice-versa. These cycles also match relatively well the low-pass filtered winter North Atlantic Oscillation (NAO) and, to a lesser extent, the Atlantic Multidecadal Oscillation (AMO). In more recent years, the analysis of biogeochemical data acquired since 1999 (e.g., the Nitrate/Phosphate ratio) suggests that the water masses composition is changing towards less Arctic waters flowing on the shelves. This is concurrent with a reduction in nutrients concentration and primary production on the NL shelves since about 2010. These observations appear counter-intuitive since the Arctic Ocean Oscillation (AOO) is negative for this period, which would rather suggest more nutrient-rich water leaving the Arctic and entering the NL shelves.

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

In 2003 STACFEN began production of web based annual climate status summary pages to describe environmental conditions during the previous year. These pages for the NAFO area include 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 2017 will be made available from Subarea 1, West Greenland, Subareas 2-3, Grand Banks, Flemish Cap and Labrador Sea/Shelf, Subareas 4-5, Scotian Shelf and Gulf of Maine, and Subareas 5-6, Georges Bank and Gulf of Maine.

Since the implementation of the new NAFO web site the secretariat has provided google metrics/analytics to evaluate site traffic on the climate pages. The results show low overall access up to May of 2018. It was decided that despite low overall site traffic, the climate pages will be updated in the interim to include 2017 climate information.

There was discussion during the STACFEN meeting regarding several points, including the ongoing utility of the annual climate status report on the NAFO website, changes to its format to improve the presentation and reduce overall workload, climate pages visibility on the NAFO web site and the inclusion of biogeochemical trends within the convention area.

10. Environmental Indices (Implementation in the Assessment Process)

An important role of STACFEN, in addition to providing climate summaries, is to determine the response of fish and invertebrate stocks and the fishery to the changes in the environment, as well as to provide advice on how relationships between climate and marine production may be used to help improve the assessment process. While there were no directed studies in this regard considered at this June meeting it was noted that the committee continues to provide time series of ocean climate and lower trophic levels indicators for several stock areas including West Greenland, Flemish Cap, Grand Banks and widely distributed stocks that include the Scotian Shelf. These indices are based on composites of available physical, biological and chemical data for each area and are included in the stock status reports of STACFIS.

11. The Formulation of Recommendations Based on Environmental Conditions

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

12. National Representatives

Currently, the National Representatives for hydrographic data submissions are: E. Valdes (Cuba), M. Ouellet (Canada), Vacant (Denmark), J.-C Mahé, (France), Vacant (Germany), Vacant (Japan), H. Sagen (Norway), J. Janusz (Poland), Vacant (Portugal), E. Tel (Spain), L. J. Rickards (United Kingdom), and P, Fratantoni (USA), K.V. Drevetniak (Russia). The following countries collected data in the NAFO Convention area in the last 5 years: Canada, USA, France, Spain, Denmark, Norway, Germany and Ireland. It is noted that some countries data sets are obtained from international data repositories such as ICES Oceanographic Databases, World Ocean Database (NOAA) and SeaDataNet. It was noted that the list of National Representatives has several vacancies and has not been updated in many years. The Secretariat will facilitate the updating of this list (where required) prior to the next STACFEN meeting.

13. Other Matters

A consensus was reached to continue with holding the STACFEN meeting the first day of the annual June Scientific Council Meeting occurring on Friday May 31, 2019. 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.

At the 2002 June meeting it was recommended that STACFEN Chair, or designate, be included in the presentation of scientific advice from the Scientific Council to the Fisheries Commission at their annual September meeting every 5 years, and more frequently if significantly large changes in the environment are observed. It was noted that the last such presentation was made at the 2012 annual NAFO meeting. A discussion was had regarding the presentation of recent climate trends in the convention area at the upcoming NAFO 40th Annual Meeting 17-21 September, 2018 in Tallinn, Estonia. For the upcoming annual meeting it was suggest that an update of recent climate information in the main NAFO stock areas be included in the SC's presentation of advice to the Fisheries Commission. It was also noted that the Working Group on Ecosystem Science and Assessment (WG-ESA) will also include environmental information that will be presented at the NAFO annual meeting.

14. Adjournment

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

The meeting was adjourned at 17:00 on 1 June 2018.

The SC chair expressed gratitude to Eugene Colbourne (Canada) for serving as the Interim Chair of STACFEN on short notice and wished him well in his approaching retirement. Ricardo Alpoim (EU Representative) also thanked Eugene for replacing the EU-nominated STACFEN chair.

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 1 June-14 June 2018, to consider publications and communications related topics and report on various matters referred to it by the Scientific Council. Representatives attended from Canada, Denmark (in respect of Greenland), European Union (UK, Portugal, and Spain), Faroe Islands, 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 2017

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 needed. *https://www.nafo.int/Science/Designated-Experts*

STATUS: This has been implemented.

- 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.

STATUS: This has been implemented. The species sheets have been updated and are now online. https://www.nafo.int/Science/Species

- 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.

STATUS: These have been monitored by the NAFO Secretariat. The Google Analytics show that:

- The period monitored was July 2017 – 24 May, 2018
- There is a total of 4,656 webpages on the NAFO public domain
- The fact sheets ranked second **(22,716)** in page views and 20th (734) in unique page views for the domain https://www.nafo.int/Science/Species
- The unique page view criteria is more accurate in that it represents page visits by an individual or web crawler. E.g. a person visited a page 50 times in one day, but it counted as one visit or unique page view.
- It is not known whether this data represents actual people viewing the web pages or automated web-crawlers.
- Visitors to the fact sheets originated from: Canada, USA, Spain, UK, Portugal, Belgium, Russia, Japan, India, and Norway.

5. Review of Publications

a) Journal of Northwest Atlantic Fishery Science (JNAFS)

Volume 49, Regular issue, contained three articles. 120 copies were printed in December 2017 and mailed in late January 2018.

Volume 50, Regular issue, has two papers submitted with two others expected.

b) Scientific Council Studies

There was one submission for the Studies No. 48 in 2017.

TRUE, E. 2017. Annual Temperature Curves in Twelve Regions of the Gulf of Maine 1985–2013. Scientific Council Studies, 48: 1–11. doi:10.2960/S.v48.m1.

c) Scientific Council Reports

Eight copies of a sample 2017 NAFO Scientific Council Report were printed in May, which included all SC Reports. This sample included a few changes:

- The WG-ESA report was included;
- The Joint Commission- Scientific Council reports were omitted. They would still be included in the Meeting Proceedings of the Commission. In previous years, they were in both reports;
- The standing committee reports have been compiled as separate PDFs. This alleviates dual citations for the same report (i.e. the citation for the report itself and the citation of the report in the SC Report book); and
- Recommended citations for each standing committee report can be found below the table of contents for each report.

This sample SC Report was reviewed by Scientific Council. The Secretariat indicated that due to the size of the SC Report book, decisions need to be made as to what should be included in the SC Report. Options include:

- Previous Approach - WG-ESA report is not included and Joint Commission-SC Working Group reports are included (without annexes);
- Publish the SC Reports in two volumes; or
- Create a new compilation/series for the Joint Commission- SC Working Group Reports.

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

The Secretariat will prepare the standard number of Redbooks for meeting and archive purposes (See Rules of Procedure Rule 8.4 - p. 18) and the 2017 volume will be available online and in print in early summer 2018.

6. Other Matters

a) ASFA

The Secretariat continues to submit all science publications and documents to the Fisheries Aquatic Sciences and Fisheries Abstracts (ASFA), managed by the United Nations Food and Agriculture Organization. This includes *The Journal of the Northwest Atlantic Fisheries*, SC Reports, and SC Research Documents for 2017. 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.

The Environmental Information: Use and Influence (EIUI) research team from Dalhousie University has assisted the ASFA Impact Evaluation Working Group (IEWG) to assess the impact if ASFA were to cease operations. Questions asked were: Does an abstracting and indexing service have a place in present marine research and policy development? Does ASFA meet the needs of its potential users or are there comparable alternatives that meet their needs? A case study was conducted based on ASFA records for the Bay of Fundy (Maritimes Canada).They found that librarians and institutes are aware of its relevance, but user communities may not have the same level of knowledge? The subscription services cost can be high and there can be compatibility issues with the publication platform (e.g. ProQuest (Summon)). The inclusion of grey literature and the benefits of a controlled metadata vocabulary (ASFIS) were cited as important features of ASFA.

STACPUB discussed the relevance of the ASFA service and whether NAFO should continue to participate and submit our papers and reports. Various SC members indicated that ASFA is still relevant because it specializes in fisheries and aquatic information (including smaller journals and grey literature) whereas other searches, such as Google Scholar and Web of Science are broad based and provide results that are not always relevant. The researcher can also easily download references from ASFA. If ASFA wants to remain relevant, an advertising campaign to promote it to a wider and younger audience may be helpful. The technology should also be modernized to remain up-to-date with other databases.

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

b) Citation / Reference Software

The Secretariat was asked to explore citation and reference software that could be used for all publications and documents. Currently, a citation link is available for the *Journal of Northwest Atlantic Fishery Science*. This was created in 2018 and is currently being implemented. The Secretariat noted that it could cost more and take more staff time to implement this feature for all documents.

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

c) SharePoint

Since the implementation of the new version of SharePoint previous meeting folders containing working papers, documents, presentations, data, etc. have not been accessible through SharePoint. STACPUB members would like to see meeting documents accessible through the SharePoint. This would help members understand the history of the work of the various standing committees and their decisions. Some members also mentioned a system of 'versioning' for the reports and documents similar to what is done at ICES and/or using a system, such as Git (a free open sourced version control system for documents https://git-scm.com/) could be considered.

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

d) DE Group email for website

Some members requested that the Designated Experts list of emails on the NAFO website be compiled into a group email for quick and easy use. https://www.nafo.int/Science/Designated-Experts

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

e) SCR and SCS Guidelines

It was noted that some SCR documents do not adhere to the guidelines for SCR preparation. A hyperlink to a PDF of the Guidelines to Authors for SCR documents is available on the NAFO website https://www.nafo.int/Library/Science/SC-Documents. SC members asked if there were guidelines for SCS documents and were advised by the Secretariat that there weren't any. It was suggested that a set of guidelines for SCS documents would be useful, to help standardize contents of these documents as well. It was suggested that the Secretariat consider sending the SCR Guidelines to Contracting Parties along with the annual January letter that is sent to SC members to prepare for the SC June meeting.

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

STACPUB **recommends** *that the Secretariat include a link to the Guidelines in the January letter to ensure SC members are informed as to the requirements determined by SC for these documents.*

7. Adjournment

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

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

Chair: Carmen Fernandez Rapporteur: 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 (UK, Portugal and Spain), Japan, Russian Federation and United States of America. The Scientific Council Coordinator and other members of the Secretariat were in attendance.

1. Opening

The Chair opened the meeting at 14:00 hours on 2 June 2018, 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 Chair

In May 2018, the Scientific Council appointed Carmen Fernández as chair of STACREC.

3. Appointment of Rapporteur

Ivan Tretiakov was appointed as rapporteur.

4. Review of previous recommendations and new recommendations in 2018

a) Tagging (recommendation from 2015)

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

This recommendation was made in 2015. In June 2017, STACREC noted that the Secretariat had made some progress in planning a dedicated web page through which information relating to tagging studies (eg, action to be taken on catching a tagged fish) could be disseminated to fishers. In September 2017, the STACREC chair informally discussed with the STACTIC chair the potential of providing information on research programs which rely on commercial (including mark-recapture studies), and it was then recommended that intersessional discussion should continue to determine a suitable method to notify fishing fleets of such research activities. Due to workload issues, this intersessional discussion did not take place.

Lack of time prevented STACREC from discussing this issue in the June 2018 meeting. However, the STACREC chair, the SC chair and the NAFO Secretariat SC coordinator discussed it informally and considered that:

- The NAFO Secretariat could prepare a webpage providing all information on research activities of which the fishing fleets should be aware (chiefly, tagging programmes). Fishing fleets should be made aware of this webpage and of the fact that up to date information would always be available there.
- Additionally, the NAFO observers would also notify the fishing fleets, particularly when new items were uploaded to the webpage. The Android application for NAFO observers currently under development by the NAFO Secretariat could provide a direct link to the webpage and raise alerts when new relevant items were uploaded to the webpage.

These options, and possibly others, will be discussed during the STACREC meeting in September 2018 and STACREC will issue a recommendation at that time.

b) Availability of STACFIS catch estimates (recommendation from 2016)

In 2016, STACREC discussed whether STACFIS catch estimates used in stock assessments should be made available on the NAFO website. Meeting 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 progress, STACREC **recommended** that *the SC chair should initiate discussion with the chairs of FC and GC during the Sept 2016 Annual Meeting. Due to high workload, no progress has occurred to date.*

In September 2017, it was agreed that the SC Chair would discuss the issue with the NAFO Executive Secretary and the Commission chair to request adding this note of clarification to the STATLANT 21A webpage. STACREC reiterates this **recommendation**.

c) Analysis of sampling rates and combining multiple surveys (recommendations from 2015 and 2017)

In 2015, STACREC **recommended** that *an analysis of sampling rates be conducted to evaluate the impact on the precision of survey estimates.*

This recommendation has not been fully addressed so far. In June 2017 STACREC noted that work was progressing and reiterated the recommendation.

As a separate aspect, in September 2017 STACREC discussed *possibilities for combining multiple surveys in different areas and at different times of the year to produce aggregate indices*. It was then agreed that intersessionally and in the 2018 meetings, SC members would investigate combined surveys in operation elsewhere (eg. ICES International Bottom Trawl Survey (IBTS)). It was then also agreed to investigate the possibility of bringing an invited speaker with expertise in IBTS to the STACFIS meeting in 2018.

During presentations of 2017 research activities at the June 2018 SC meeting, issues of reduced survey coverage (typically due to lack of resources to deal with aspects such as e.g. technical problems with vessels, bad weather, or because vessels and personnel were engaged in new scientific research activities elsewhere) arose again. Participants considered that the two topics identified in earlier years, *i.e. how to deal with reduced survey coverage / reduced sampling rates, and possibilities for combining multiple surveys to produce aggregate indices of stock abundance*, would together constitute a relevant topic for a future workshop or a future special session. It was decided to consider this item under SC Agenda point IX ("Arrangements for Special Sessions") and outcomes are reported in that section of the SC report.

d) Separation of redfish by species in surveys (new recommendation in 2018)

During presentations of scientific survey results, it was noted that most of the surveys conducted (except for the EU-3M survey in recent years) record redfish without separating by species. Several reasons for this were given by some meeting participants, namely, similar species biology, unclear population structure, lack of an agreed methodology for species identification that all surveys would use in a consistent manner, and lack of time and resources in some surveys to take on additional tasks. STACREC considered that separating by species is always a better approach from the scientific standpoint, but also recognised the issues raised.

Therefore, STACREC **recommends** *that all surveys should aim to examine redfish composition at the species level, while recognising that this may not always be achievable due to trade-offs between different activities and aims of surveys.*

This discussion, including all species caught in surveys, should continue next year.

5. Fishery Statistics

a) Progress report on Secretariat activities in 2017/2018

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. Dates of receipt of STATLANT 21A and 21B reports for 2014-2017 up to 14 June 2018

Country/component	STATLANT 21A (deadline, 1 May)			STATLANT 21B (deadline, 31 August)		
	2015	2016	2017	2014	2015	2016
CAN-CA	4 May 16	30 May 17	31 May 18	24 Apr 15	4 May 16	30 May 17
CAN-SF	31 May 16	28 Apr 17	05 May 18	31Aug 15	30 Aug 16	7 Sep 17
CAN-G	18 May 16	26 May 17	30 Apr 18	4 Sep 15	30 Aug 16	16 Aug 17
CAN-NL	21 Apr 16	26 Apr 17	17 May 18		29 Aug 16	29 Aug 17
CAN-Q						
CUB						
E/BUL						
E/EST	20 Apr 16	22 May 17	04 May 18	14 Aug 15	23 Aug 16	30 Aug
E/DNK		23 May 17	23 Apr 18	4 Sep 15	15 Jun 16	31 Aug
E/FRA						
E/DEU	28 Apr 16	25 Apr 17	25 Apr 18	4 Sep 15	29 Aug 16	31 Aug
E/LVA	10 Mar 16	20 Apr 17				
E/LTU		9 May 17	24 Apr 18			31 May 17
EU/POL				21 Sep 15		
E/PRT	26 Apr 16	19 Apr 17	20 Apr 18	3 Sep 15	23 Aug 16	29 Aug 17
E/ESP	5 May 16	31 May 17	30 May 18	7 Sep 15	5 Aug 16	7 Aug 17
E/GBR		25 Apr 17	31 May 18			
FRO	26 May 16	2 May 17	18 May 18	7 Jul 15	1 Jun 16	09 Jun
GRL	30 Apr 16	1 May 17	30 Apr 18	1 Sep 15	30 Aug 16	22 Aug 17
ISL						
JPN		19 Apr 17	01 May 18			30 Aug 17
KOR						
NOR	26 Apr 16	4 May 17	23 Apr 18	17 Mar 16	29 Aug 16	25 Aug 18
RUS	20 May 16	11 May 17	04 May 18	2 Jul 15	1 Sep 16	21 Jul 17
USA	19 Jul 16					
FRA-SP	25 Apr 16	25 May 17	18 May 18	6 Jul 15	8 Jun 16	
UKR						

ii) Presentation of catch estimates from daily catch reports and STATLANT 21A and 21B

This is addressed under Agenda Item 2 of the STACFIS report

6. Research Activities

a) Biological Sampling

i) Report on activities in 2017/2018

STACREC reviewed the list of Biological Sampling Data for 2017 (SCS Doc. 18/12) prepared by the Secretariat and noted that any updates will be inserted during the summer. The SCS Document will be finalized for the September 2018 Meeting.

ii) Report by National Representatives on commercial sampling conducted

Canada-Newfoundland (SCS Doc. 18/15, 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 2 + Div. 3KLMNO), Atlantic salmon (SA 2+3+4), Arctic char (SA 2), Atlantic cod (Div. 2GH, Div. 2J+3KL, Div. 3NO, Subdiv. 3Ps), American plaice (SA 2 + Div. 3K, Div. 3LNO, Subdiv. 3Ps), witch flounder (Div. 2J3KL, 3NO, 3Ps), yellowtail flounder (Div. 3LNO), redfish (Subarea 2 + Div. 3K, 3LN, 3O, 3P4V), northern shrimp (Subarea 2 + Div. 3KLMNO), Iceland scallop (Div. 2HJ, Div. 3LNO, Subdiv. 3Ps, Div. 4R), sea scallop (Div. 3L, Subdiv. 3Ps), snow crab (Div. 2J+3KLNO, Subdiv. 3Ps, Div. 4R), squid (SA 3), thorny skate (Div. 3LNOPs), white hake (Div. 3NOPs), lobster (SA 2+3+4), capelin (SA 2 + Div. 3KL), and marine mammals (SA 2,3, and 4). A provisional sampling report for 2017 was not yet generated for submission to the Secretariat but will be forwarded as soon as possible.

Denmark/Faroe Islands (SCS 18/09):

Data on catch rates were obtained from trawl and longline fisheries in NAFO Div 3M for Atlantic cod (*Gadus morhua*) from 2015 to 2017 (n=380, NAFO-observers). Length frequencies (NAFO-observers and crew members) were also available from 2014 to 2017 (13388 individuals). In addition weight measurements were taken by crew members in 2014, 2015 and 2017 (n=45).

Denmark/Greenland (SCR 18/40, SCS 18/10):

Data on catch rates were obtained from trawl, gillnet and longline fisheries in NAFO Div 1A-F for Artic char, Atlantic salmon, Atlantic cod, capelin, snowcrab, Greenland halibut, lumpfish, redfish, roundnose grenadier, scallops, Northern shrimp and wolffish. Length frequencies were available for Greenland halibut and for cod from Greenland trawl fishery in Div. 1CD, from the longline fishery in 1AB and 1CD, and from the longline and gillnet fishery 1A inshore, and for redfish taken as by-catch from the gillnet fishery in 1A inshore and from the longline fishery in 1CD. A total of 418 length samples were taken, and 61902 individuals including Greenland halibut, cod and redfish were measured, in NAFO Div. 1-F. A total of 1322 otoliths in 1A-D and 1692 otoliths in 1F were collected from cod.

EU-Portugal (NAFO SCS Doc 18/08):

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

EU-Spain (NAFO SCS Doc. 18/07):

A total of 10 Spanish trawlers operated in Div. 3LMNO NAFO Regulatory Area (NRA) during 2017, amounting to 1,025 days (15,101 hours) of fishing effort. Total catches for all species combined in Div. 3LMNO were 14,118 tons. In addition to NAFO observers (NAFO Observers Program), 8 IEO scientific observers were onboard Spanish vessels, comprising a total of 329 observed fishing days, around 32% coverage of the total Spanish effort. Besides recording catches, discards and effort, these observers carried out biological sampling of the main species taken in the catch. For Greenland halibut, roughhead grenadier, American plaice and cod this includes recording weight at length, sex-ratio, maturity stages, performing stomach contents analyses and collecting material for reproductive studies. Otoliths of these four species were also taken for age determination. In 2017, 483 length samples were taken, with 57,988 individuals of different species examined to obtain the length distributions.

One Spanish trawler operated during 2017 in Div. 6G NAFO Regulatory Area using a midwater trawl gear. The fishing effort of this trawler was 12 days (68 hours). The most important species in catches was the Alfonsino (*Beryx splendens*). In 2017, 16 length samples were taken, with 2,264 Alfonsino individuals examined to obtain the length distributions. During 2017 and 2018, 688 individuals were examined to obtain the relationship between the fork and total length.

Japan (SCS Doc. 18/06):

In 2017, one Japanese otter trawler operated in Div. 3L, 3M, 3N and 3O (February - November). The total number of trips, hauls and fishing hours were 10 (trips), 306 (hauls) and 2,193 (hours) respectively. The total catch (13 species) including discards was 2,595 tons. Target species were Greenland halibut (Div. 3L), redfish (Div. 3LMO) and yellowtail flounder (Div. 3N). Number of size measurement for Greenland halibut (Div. 3L), redfish (Div. 3LMO) and yellowtail flounder (Div. 3N) were 3,000, 1,300 and 2,530 respectively. For further details, refer to the National Report (SCS Doc. 18/06).

Russia (SCS Doc. 18/13):

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), Skates (Div. 3LMNO). 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), Blue wolffish (Divs. 3LMO), Spotted wollfish (Divs. 3LMO), Atlantic wolffish (Divs. 3LO), Blue antimora (Divs. 3LM), Silver hake (Div. 3O). Age-length distribution for Greenland halibut in Divs. 3LMN, *S. mentella* and *S. fasciatus* in Divs. 3LN, as well as statistics on marine mammal occurrences and VME indicator species catches, are also available.

USA (SCS 17-012 and 18-014):

The bycatches of species caught in the NAFO Regulatory Area were described in individual species sections or in a table if not included in the 37 stocks. Lengths were taken for Div. 3LNO yellowtail flounder, Div. 3LNO American plaice, and 3NO cod in 2017 but were not summarized. A summary of the lengths taken for these stocks from 2012-2016 were summarized last year.

b) Biological Surveys

i) Review of survey activities in 2017 (by National Representatives and Designated Experts)

Canada - Newfoundland (SCR Doc. 18/017):

Research survey activities carried out by Canada (Newfoundland and Labrador 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 2017 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 2017 spring survey in Div. 3LNOPs continued a time series begun in 1971. It was conducted from April to mid June, and consisted of 350 successful tows (478 planned) covering 97 of 129 planned strata to a maximum depth of 732m by the research vessel CCGS Alfred Needler. Substantive mechanical issues with the Canadian Research Vessels resulted in very poor coverage of Div. 3L in 2017. Only 32 of the 142 planned sets and six of the 38 strata that are in the spring survey design for Div. 3L were completed successfully. This marks the second time in three years that the spring survey coverage of Div. 3L has been very poor. In 2015, only 56 out of 142 sets were completed and a total of 82 strata were missed.

The 2017 autumn survey was conducted from mid September to mid December in Divs. 2HJ3KLNO, and consisted of 621 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 11 deepwater strata in Div. 2H and 13 deepwater strata in Div. 3L. The 2017 survey marked the third time in the last four years that the deepwater strata in Div. 2H have not been covered and the fifth time in six years that the deepwater strata in Div. 3L have not been completed.

STACREC noted concern over deficiencies in the spatial coverage of the Canadian surveys in recent years, and the impact on the ability to detect signal from noise in regards to evaluating trends in biomass and abundance of various species. Poor coverage in the 2017 Canadian Spring survey has meant that indices from this survey could not be used for redfish in Divs. 3LN, American plaice in Divs. 3LNO, Witch flounder in Divs. 2J3KL, and Greenland halibut in SA2+Divs. 3KLMNO. The reduced survey coverage is generally considered to have led to increased, albeit unquantified, uncertainty with respect to the provision of scientific advice. In addition to impacts on individual stock assessments, deficiencies in survey coverage also add uncertainty to the results of research on environmental (STACFEN) trends and ecosystem status, functioning and productivity (WG-ESA).

Canada - Central and Arctic Region (SCR 18/015):

A multi-species survey was completed in Div. 0A-South (to approximately 72ºN) in collaboration with the Greenland Institute of Natural Resources RV Pâmiut, during October 27 to November 8, 2017. The Alfredo trawl (140 mm mesh with a 30 mm mesh liner in the cod end) was used and depth strata distributed between 400 m and 1500 m. Stations assigned to the northern portion of the depth strata could not be completed in 2017 due to ice conditions. However, these stations were randomly re-assigned to the southern portions of the depth strata and 74 of 77 planned stations were complete. Oceanographic variables (temperature, salinity and depth) were measured during each tow using a trawl mounted conductivity, temperature, and depth sensor. Fixed stations along the Broughton Island transect line were also sampled for oceanographic variables. However, ice blocked access to the oceanographic stations along the Cape Christian line. Total and depth stratified biomass and abundance estimates, and length frequency were compiled for Greenland halibut.

Denmark/Greenland (SCR 18/05, 18, 21, 32, 35):

Two hydrographic cruises were carried out across the continental shelf off West Greenland to sample 10 standard sections. First cruise was onboard RV Paamiut from 3rd June to 29th June (stations in NAFO Div. 1A-C), and second cruise was onboard the Danish naval vessel Tulugaq, from 3rd July to 19th July 2017 (stations in NAFO Div.1C-F). Data from three offshore stations were taken to document changes in hydrographic conditions off Southwest Greenland (NAFO Div 1D-F). Results were presented as a Scientific Council Research Document.

The Greenland Shrimp and Fish trawl survey in West Greenland in NAFO Div. 1A-F (100- 600 m) was initiated in 1988. In 2017, it was carried out between May 28 – July 18, on board RV Paamiut using the Cosmos gear with a mesh size 20 mesh liner in the cod-end. The survey follows a buffered stratified random sampling. A total of 253 valid hauls were conducted. Survey results including biomass and abundance indices for Greenland halibut, cod, deep sea redfish, golden redfish, American plaice, Atlantic wolfish, spotted wolfish, and thorny skate were presented as Scientific Council Research Documents.

The Greenland deep sea survey in NAFO Div. 1CD (400-1500 m) was initiated in 1997, following a buffered stratified random sampling. In 2017, the survey was conducted from October 10th to October 21st on board R/V Paamiut. The gear used an Alfredo III trawl with a mesh size on 140 mm and a 30-mm mesh-liner in the cod-end. A total of 53 valid hauls out of 70 planned hauls were conducted. Survey results including mean catch, mean number, biomass and abundance indices, and length frequencies for Greenland halibut, roundnose grenadier, roughhead grenadier, and deep see redfish were presented as Scientific Council Research Documents.

The Greenland halibut gillnet surveys in 1A inshore was initiated in 2001 in the Disko Bay. The survey normally covers 4 transects and each gillnet setting is compiled of five different nets with differing mesh size (46, 55, 60, 70 and 90 mm half mesh). From 2013 to 2015, the surveys in Uummannaq and Upernavik gradually changed from longline surveys to gillnet surveys. In 2017, 125 gillnet stations were set. Results were presented as a Scientific Research Document.

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

The Spanish bottom trawl survey in NAFO Regulatory Area Div. 3NO was conducted from 15th of May to the 12nd of June 2017 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 113 valid hauls were taken within a depth range of 45-1480 m according to a stratified random design. A hydrographic profile was casted in each fishing station. 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 2017, 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 21th to August 8th. 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 103 and 4 of them were null. Survey results, including abundance indices and length distributions of the main commercial species, are presented as Scientific Council Research documents. Survey results for Div. 3LNO of the northern shrimp (*Pandalus borealis*) were presented in SCR 17/065. Ninety-nine hydrographic profile samplings were made in a depth range of 98-1420 m.

The EU bottom trawl survey in Flemish Cap (Div. 3M) was carried out on board R/V Vizconde de Eza using the usual survey gear (Lofoten) from June 13rd to July 19th 2017. The area surveyed was Flemish Cap Bank to depths up to 800 fathoms (1460 m) following the same procedure as in previous years. The number of hauls was 184 and three of them were null. Survey results including abundance indices of the main commercial species and age distributions for American plaice, roughhead grenadier and Greenland halibut are presented as a Scientific Council Research document. Flemish Cap survey results for Northern shrimp (*Pandalus borealis*) were presented in SCR 17/064.

VME data from the 2017 EU (Spain and Portugal) bottom trawl groundfish surveys in NAFO Regulatory Area (Divs. 3LMNO):

New data on deep-water corals and sponges were presented from the 2017 EU and the EU (Spain and Portugal) bottom trawl groundfish surveys. The data was made available to the NAFO WGESA to improve mapping of Vulnerable Marine Ecosystem (VME) species in the NAFO Regulatory Area (Divs. 3LMNO).

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

Sponges: For the EU 2017 data, sponges were recorded in 142 of the total tows (35.4% of the total tows analyzed), with depths ranging between 54 and 1338 m, and average depth of 494 m. Significant catches of sponge (≥ 75 kg/tow) were found in five EU tows. Three of these catches were located in the eastern part of the Flemish Cap; the other two were located in the Flemish Pass area inside the Kernel Density (KDE) sponge polygon. Sponge catches for these tows ranged between 145 and 7113 kg.

Large Gorgonians: For the EU 2017 data, large gorgonians were recorded in 12 tows (3% of total tows analyzed), with depths ranging between 342 and 1285 m, and average depth of 845 m. Significant catches of large gorgonians (≥ 0.6 kg/tow) were found in one EU tow. This catch was located in the Flemish Pass area inside the corresponding KDE polygon but outside the actual closed area number 2.

Small Gorgonians: For the EU 2017 data, small gorgonians were recorded in 55 tows (13 % of total tows analyzed), with depths ranging between 224 and 1434 m, and average of 927 m. Significant catches (> 0.15 kg/tow) were recorded in three tows (0.75% of the total tows) located at the Tail of the Grand Banks, outside of the actual closed areas with depths between 611 and 1369 m.

Sea Pens: For the EU 2017 data, sea pens were recorded in 140 tows (34.9% of total tows analyzed), with depths ranging between 242 and 1434 m, and average depth of 884 m. Significant catches (> 1.4 kg/tow) were recorded in three tows (1.52 - 2.21 kg), two of them were located north of Flemish Cap and inside the corresponding VME KDE polygon. The other one was located southwest of Flemish Cap, outside the KDE polygon.

USA (SCS Doc. 18/014):

The US conducted a spring survey in 2017 covering NAFO Subareas 4, 5 and 6 aboard the FSV Henry B. Bigelow. All planned strata were covered and the survey was conducted in a normal time frame. The US conducted an autumn survey in 2017 covering NAFO Subareas 4, and 5 aboard the FSV Pisces because an engine was being replaced on the FSV HB Bigelow. All planned strata on Georges Bank were covered as were most for the Gulf of Maine. No strata in Southern New England or the Mid-Atlantic were covered since the FSV Pisces did not arrive until October. The timing for the areas covered was similar to that in the past.

ii) Surveys planned for 2018 and early 2019

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

c) Tagging Activities in 2017 and early 2018

Information was presented and representatives were requested to review and update before finalization of an SCS document in September (SCS 18/11).

d) Other Research Activities

i) Trial to study the effectiveness of a Sort V grid in the Atlantic cod fishery in NAFO division 3M

STACREC was made aware of an industry cod selectivity study in Div. 3M to prevent catches of cod below minimum landing size (MLS) (41 cm).

Following FC encouraging Contracting Parties to carry out selectivity experiments with sorting grids in the Div. 3M cod fishery, the UK freezer vessel "Kirkella H7" (The Fish Producers' Organisation Ltd) carried out a selectivity campaign in 2016 and another one in 2017, aimed at studying the use of sorting grids in the cod fishery of Flemish Cap (Div. 3M). The results from 2016 were presented to STACREC in 2016, whereas the presentation this year related to the results from 2017.

Only a low number of sets was made in 2016 at depths shallower than 300 meters; in those sets, fourteen undersized fish were caught, all of which were caught in the trawl using no grid. In waters deeper than 300 m, no undersized cod was caught in 2016 in either of the gear types (with or without sorting grid), and length frequency was fairly consistent between the two gear types. In 2017, only waters deeper than 390 m were covered in the campaign, and no undersized cod was caught with or without sorting grid.

STACREC concluded that, from the results of these campaigns alone, it is not possible to draw a definitive conclusion about the utility of sorting grids in this fishery. The data collected in these campaigns present coverage problems relative to the entire range of depths where the fishery is carried out. Based on information from other fisheries, it is generally recognised that sorting grids could be useful to reduce catches of small fish, but if studies in the NAFO area were to proceed, they should be scientifically designed, ideally in collaboration with SC, to ensure that results are representative (i.e. have appropriate coverage of depth and other aspects of the fishery) and can fully address the question asked.

ii) Progress report on EU ATLAS project – Flemish Cap Case study:

A presentation was given on Species Distribution Models (SDMs) for sea pen corals in the Flemish Cap and Flemish Pass area (Northwest Atlantic Ocean). A summary of the presentation follows:

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. The Instituto Español de Oceanografía (Centro Oceanográfico de Vigo) is the coordinator of the ATLAS Case Study No 11, which includes Flemish Cap and Flemish Pass area (3LM NAFO Divisions).

Species Distribution Models (SDMs) for *Anthoptilum grandiflorum* and *Funiculina quadrangularis* deep-water pennatulacean coral for Flemish Cap and Flemish Pass area have been carried out by Centro Oceanográfico de Vigo in close collaboration with Centro Oceanográfico de Murcia (iSEAS project).

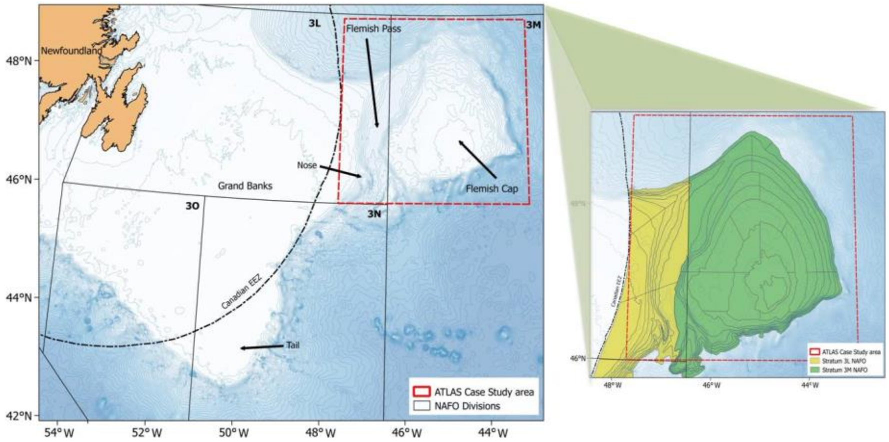


Fig. 1. ATLAS Case Study area (Flemish Cap and Flemish Pass) is located in 3LM NAFO Divisions.

Regarding SDMs, different modeling algorithms were presented to classify the probability of habitat suitability for *Anthoptilum grandiflorum* and *Funiculina quadrangularis* as a function of a set of environmental variables. The environmental variables used in the analysis were: i) <u>Oceanographic variables</u>: Bottom Temperature; Bottom Salinity; Mixed layer depth; Bottom Current Speed and Bottom Current Speed Components (U and V); ii) <u>Bathymetric features</u>: Bathymetry, Slope, Orientation of the seabed, sediment texture and gravel.

Preliminary tests using three different models, namely, MAXENT (Maximum Entropy model), Generalized Additive Model (GAM) and Random Forest (RF) were run.

The objective was to identify potentially complex linear and non-linear relationships in multi-dimensional environmental space and to predict the distribution of *Anthoptilum grandiflorum* and *Funiculina quadrangularis* deep-water pennatulacean in unsampled locations of the Case Study area.

Once the three SDMs algorithms were run, model averaging was applied. Sometimes, this combination (averaging) could give better predictions than single models, as different SDM algorithms can produce different geographic predictions and, therefore, resultant conservation strategies, even when using the same data.

Maps showing the probability of habitat suitability for *A. grandiflorum* and *F. quadrangularis* in the Flemish Cap and Flemish Pass were presented together with model prediction performance statistics (AUC; Specificity; Sensitivity, TSS and correlation of the different models) in order to assess the accuracy of the different SDMs implemented.

Results showed that *A. grandiflorum* and *F. quadrangularis* exhibit specific habitat preferences and spatial patterns in response to environmental variables (mainly bathymetry, bottom temperature, sediment texture and U component of current speed).

This work is the updated version of the work presented during the 10th WG-ESA and should be considered as an approach for the creation of sea pen VME species distribution maps and habitat distribution models (SDMs and HSMs), used to improve our understanding of their biodiversity in the Flemish Cap and Flemish Pass areas.

STACREC appreciated receiving this progress report, and the WG-ESA co-chair present at the meeting commended the progress this project is making and the positive contribution this type of work and engagement in WGESA is providing.

A comment made about the work presented was that the inclusion of fishing effort in the set of predictor variables would seem to be relevant and it was asked whether this had been attempted in the analysis. The author responded that they intend to include the fishing effort layer as a new predictor variable in future work to be presented during the 11th WGESA meeting, as it is considered that fishing effort information could be important for improving the predictions from the different models.

7. Review of SCR and SCS Documents

USA (SCS Doc. 18-014):

The report described catches and survey indices of 37 stocks of groundfish, invertebrates and elasmobranchs. Of note, 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 cooperative research included work to estimate the efficiency of the survey net and a longline survey in the Gulf of Maine. Other studies included age and growth, food habits, tagging studies, and observer trips. A description of the method for estimating catches in the observer program used both in US waters and in the NRA was given.

"Proposals for the exploitation strategy of the Flemish Cap redfish stock" (SCR 18-045):

The document (by V. Korzhev and M. Pochtar) was presented at the STACREC meeting. A summary of the presentation follows:

The object of the study is redfish species of the Flemish Cap Bank in NAFO Div.3M, the Northwest Atlantic statistical area. The aim of the work is to develop proposals for a management strategy for the redfish fishery based on a population dynamics model that incorporates dependence of model parameters on environmental factors.

Procedures for modelling the average weight and recruitment of redfish depending on the change in the size of the stock and environmental factors, are developed using multiple stepwise regression methods. The estimation of the optimum yield of redfishes and the exploitation rate in the long-term was carried out, while maintaining the spawning stock within safe biological limits with the use of a precautionary approach, under different values of the predicted recruitment.

It is shown that the main strategy for managing the fishery of redfish species is to maintain the spawning stock at a level of 30-40 x 10^3 t. The exploitation rate (fishing mortality) should be set in the range of Fmsy-Fmax (0.08-0.21), depending on the average recruitment abundance in the last 6 years. With this exploitation, the long-term average annual catch can be 10-16 x 10^3 t, and the stock of redfish will be within biological safe limits. The analysis made can be used to determine the strategy for exploiting the Flemish Cap Bank redfish stock, the grounds for establishing the TAC for 2019-2020, 10.5 x 10^3 t, and the possibility of further increasing the yield to 12-16 x 10^3 t .

STACREC noted that, given the technical complexity of this work, at this stage it could only offer comments to the presentation but was not able to provide an in-depth review of the methods or technical aspects of the work. However, the overall impression was that this work represented a good progression from last year. The following comments were made:

Concern was raised about the fact that all redfish is considered together in this analysis, i.e. without separating by species. It was noted that the same was the case in the current version of the multispecies GadCap model for the Flemish Cap area. By contrast, the Scientific Council separates beaked redfish (*S. mentella* and *S. fasciatus*) from golden redfish (*S. norvegicus*) in the provision of catch advice for redfish in Division 3M, because of the different biological features of these species, and STACREC recommended this year that all surveys should aim to separate redfish by species. To be in line with the SC decision for the provision of catch advice for redfish in Division 3M, this type of modelling should be developed for beaked and golden redfish separately.

It was also noted that assumptions about future recruitment should be inspected carefully, as the assumptions currently made in this analysis (Ricker stock-recruitment with uncorrelated annual stochastic deviations) do not appear to be realistic. Recruitment is likely to be highly correlated over time and, in redfish stocks, it is fairly common to see occasional very high year classes followed by extended periods of continuously low recruitment. Recruitment assumptions are always strongly influential in the results of long-term simulation analyses and the assumptions made so far in this analysis appear to be likely overoptimistic.

A question was asked about how the environmental variables used in the analysis were generated in the projection years. The question could not be answered at this point, as the scientists that conducted the work were not present at the meeting.

STACREC agreed that WG-RBMS should be made aware of the existence of this work.

8. Other Matters

Concern was raised during STACREC discussions about the low quality of data in general in recent years. Once again, there were survey coverage problems in 2017 that led to missing indices (e.g. the Canadian Spring 3LNO survey 2017 index) in several stock assessments. There were also sampling issues pertaining to the length and age composition of commercial catches for some stocks, and no age-length key specific to year 2017 was available for the 3M cod stock assessment or for redfish in 3M. Although specific impacts have not been quantified, it is obvious that data defficiencies add uncertainty and reduce the quality of the advice the SC is able to provide.

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

Designated Experts were reminded to provide the stock assessment data to the Secretariat. It was agreed to store the files on the meeting SharePoint under a folder entitled “DATA”.

b) NAFO Catch Estimates Methodology Study

STACREC was informed that NAFO has contracted MRAG Americas, Inc. to complete a catch data methodology study. This study will conclude later this year and provide a documented description of the methodologies in place by all actors involved in the process of obtaining haul catch estimates in the four data-gathering processes identified (differences in estimates of the catch found in different sources such as logbooks data, scientific observer's data, compliance observer's data and inspection on board reports data). The contracted study group will provide NAFO a summary document regarding the development of common best practices to estimate catches. Members of the project team attended the Scientific Council meeting, provided a presentation, and conducted interviews with several Scientific Council members. The project is expected to conclude by the end of 2018.

9. 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 10:00 hours on 14 June 2018.

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

Co-Chairs: Karen Dwyer 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 2018, 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, Karen Dwyer (Canada) opened the meeting by welcoming participants. The agenda was reviewed and a plan of work developed for the meeting. In accordance with the Scientific Council plan of work, designated reviewers were assigned for each stock for which an interim monitoring update was scheduled (see SC Report). The provisional agenda was adopted with minor changes.

II. General Review

1. Review of Recommendations in 2017

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

2. General Review of Catches and Fishing Activity

The co-Chair of the Catch Estimation Strategy Advisory Group (CESAG) Katherine Sosebee (USA), introduced the work of CESAG leading up to this meeting. The NAFO Secretariat presented the catch estimates developed by CESAG in COM-SC CESAG-WP 18-01 (Rev.2), noting that the supplementary data that went into the analyses are also available for SC to review. The Secretariat noted that the catches were estimated based on the strategy outlined in Annex 1 of COM-SC Doc. 17-08. The strategy relies heavily on the port inspection data as well as the daily catch report data, and is applied on a trip by trip basis. For trips that overlapped calendar years (e.g. began in December 2016 and ended in January 2017), the catches have been estimated for the 2017 calendar year only. The Secretariat also highlighted COM-SC CESAG-WP 18-02 and COM-SC CESAG-WP 18-03, which contain supplementary data analyses that may be of interest to SC members.

SC members noted that some stocks rely on gear type to develop the assessments, and the current catch estimation strategy does not contain that information. The Secretariat noted that gear type would be possible to include in the strategy, but that getting the level of detail to include mesh size may not be possible with the existing data sets available. SC members stressed the importance of mesh size information and agreed it that this should be something reviewed by CESAG at their next meeting. It was also noted that the values in the daily catch reports, CESAG strategy, and STATLANT are all very similar, which raised the question of data quality considering the discrepancies between these data sources in previous years. Nonetheless, it was pointed out that official catch statistics are improving, based on changes to the reporting requirements such as data being reported on a haul-by-haul basis and the timeline for reporting for Vessel Monitoring System (VMS) is shortened. SC members also raised the issue that on the NAFO Website, it states that STATLANT 21 are the official catch statistics of NAFO, but that the SC has not always used STATLANT data in their assessments, and that there should be a footnote included on the NAFO Website to explain this. There was also a discussion on the utility of creating a database of all past catch estimates used in the SC assessments.

STACFIS **recommends** that *catch information should be made available by country, division, quarter and gear type including mesh size*

3. Invited Speaker

The invited speaker of STACFIS for 2018 was Dr. Alida Bundy from the Bedford Institute of Oceanography (BIO), Fisheries and Oceans Canada (DFO), Dartmouth, NS. The abstract of the Dr. Bundy's presentation is provided below:

Science in Support of Ecosystem-based Fisheries Management

Alida Bundy, BIO, DFO

Fisheries organisations globally are adopting an ecosystem approach to management of fisheries and oceans. There are a range of acronyms and descriptions for an ecosystem approach that essentially boil down to "a holistic, place based framework that seeks to sustain fisheries and other services that humans want and need by maintaining healthy, productive, and resilient ecosystems" (Ecosystem based Fisheries Management – EBFM- definition, Lenfest Ecosystem Task Force 2017). This talk focussed on two approaches to providing science advice for EBFM, extended single species modelling and ecosystem modelling. These have the potential to contribute to all three tiers of the NAFO Roadmap.

Extended single species modelling – the results of a recent review of the extent to which ecosystem considerations are incorporated into stock assessments conducted for Canadian fisheries was presented. The review considered 178 stock assessments and three broad categories of environmental drivers: Climate drivers, which characterizes long-term (multi-year) variations and trends in regional or large-scale processes; Oceanographic drivers, which can be strongly associated with climate variability, but which also often includes elements of short-term and/or regional variability and Ecological drivers consist of trophic interactions, and habitat requirements or associations for the purpose of this review. Main conclusions were that 21% of assessments included quantitative approaches to include climate, oceanographic and ecological variables into the assessment and that 87% appeared in advice.

Ecosystem Modelling - The Ecopath and Ecosim modelling framework (EwE) is composed of a mass balance model (Ecopath, Christensen and Walters 2004) from which temporal and spatial dynamic simulations can be developed (Walters et al. 1997, 1999, Christensen and Walters 2004). EwE is a quantitative, process- and species-based model, representing trophic flows in the ecosystem. It has been widely applied, being used to address ecological questions, evaluate ecosystem effects of fishing, explore management policy options, analyse the impact and placement of marine protected areas, model effect of environmental changes and it facilitates end-to-end model construction. It was primarily developed as a tool-box to help answer 'what if' questions about policy that could not be addressed with single-species assessment models (Pauly et al., 2000; Christensen and Walters, 2004, 2011). Here, the EwE was briefly outlined, some examples of its use for ecosystem-based fisheries management (EBFM) described and recent developments noted. Recently, EwE has been modularised, and the code made freely available so that uses can adapt the code and also develop packages (plugins) to add to the model (Steenbeek et al. 2016). This has made the EwE Framework into an extremely versatile tool to support EBFM. Highlighted was a recent application of EwE to evaluate the North Sea Multi-Annual Plan (Mackinson et al. 2018).

In relation to the NAFO Roadmap, this presentation illustrated (i) extended single species approaches being used within DFO that can contribute to Tier 3 of the NAFO framework, and (ii) EwE, which can be used to estimate single species, single species with species interactions MSYs and multispecies MSYs that can be used to address all three Tiers of the NAFO road map, with the latter providing an estimate of an overall catch cap or ceiling.

There are multiple EwE models that have been developed for the NAFO region including the northeast USA, the Scotian Shelf (east and west), the Gulf of St Lawrence (north and south) and Newfoundland-Labrador. New work has started on the EwE models for Newfoundland-Labrador as a result of the CoArc (A transatlantic innovation arena for sustainable development in the Arctic) project, which could contribute to the SC WGESA work and the NAFO Roadmap.

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Comments and discussion

The presentation was well received by SC participants, and a useful exchange of ideas ensued. Highlights of this discussion included the importance of explicitly distinguishing between strategic and tactical management and how these levels require different management measures. The role of minimum realistic multispecies models was also discussed to bridge the gap from ecosystem models aimed at strategic advice and the tactical advice level typical of traditional stock-assessments.

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 and 2017.
- Total production of the spring bloom (magnitude) remained above normal in 2017 but declined from the record-high observed in 2015.
- Spring bloom peak timing was delayed in 2016 and 2017 compared to the reference period

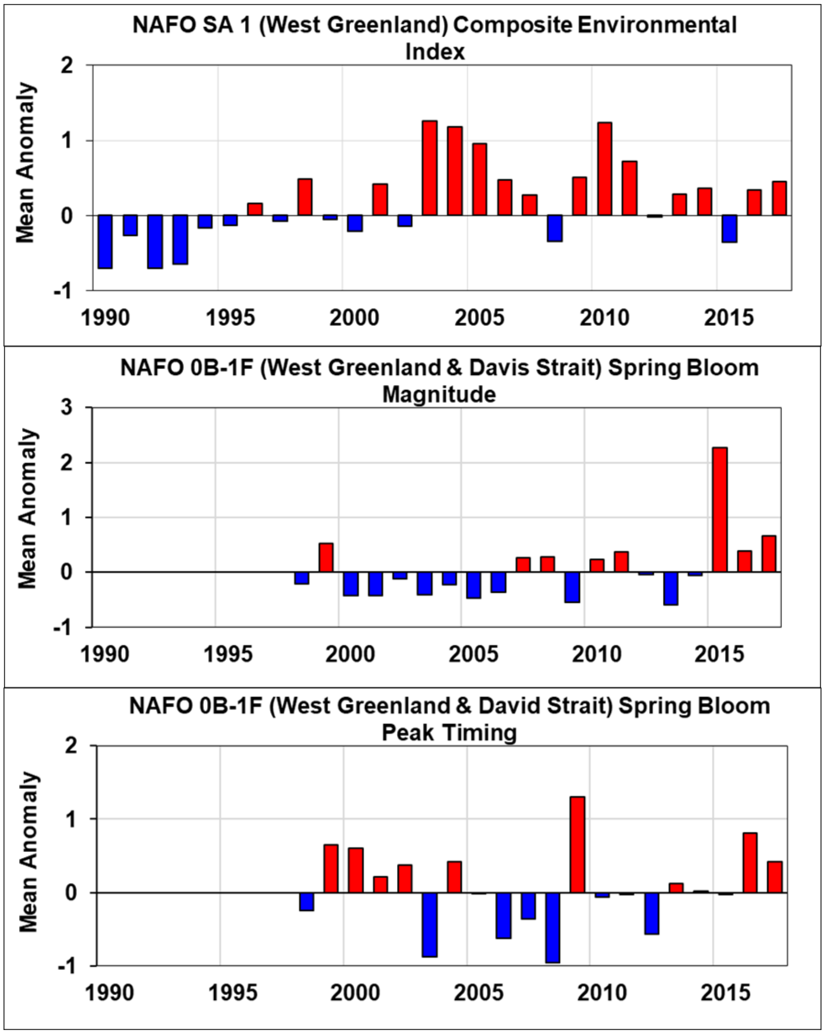


Fig. A1. Composite environmental index for NAFO Subarea 1 (West Greenland) derived from meteorological and physical oceanographic (water temperature, salinity) conditions during 1990-2017 (top panel). Phytoplankton spring bloom magnitude (middle panel) and the peak timing (bottom panel) in NAFO div 0B1F during 1998-2017. Positive/negative anomalies indicate conditions above/below (or late/early timing) the long-term average for the reference period. All anomalies are mean standardized anomaly and were calculated using the following reference periods: environmental index: 1981-2010; Spring bloom indices (magnitude and peak timing): 1998-2015.

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 1, top panel). 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. Spring bloom total production (magnitude) has remained above the 1998-2015 long-term average since the record-high observed in 2015 (Figure 1, middle panel). Ocean colour remote sensing imagery indicated widespread surface blooms throughout the Labrador Sea and West Greenland during April-May in 2015, with reduced spatial extent and later timing in 2016-2017. The timing of the spring bloom maximum was delayed in 2016-2017 after being close to normal since 2010, excepting for one early bloom in 2012 (Figure 1, bottom panel). Air temperatures in 2017 over West Greenland and much of the Labrador Sea region were above normal by 0.6 SD at Nuuk. In 2017, temperature and salinity values of the Irminger Sea Water in the 75-200 m layer at Cape Desolation Station 3 were 5.3°C and 34.90, which were 0.6°C and 0.02 above the long-term mean, respectively. Average water temperatures at Fyllas Bank Station 2 (0-40 m depth) off West Greenland in June/July experienced a significant increase with temperatures 1.9°C/0.9°C (2.4/1.1 SD) higher than normal in 2016 and 2017, respectively.

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

(SCR Doc. 18/15, 21, 32, 40; SCS Doc. 18/10, 13)

a) Introduction

The Greenland halibut stock in Subarea 0 + Div. 1A offshore and Div. 1B-1F is part of a larger population complex distributed throughout the Northwest Atlantic (Roy et al 2014). The assessment is qualitative, and has since 2014 been based on an index of survey biomass that covers Divisions 0A-South and 1CD (ICES 2013). The surveys are conducted by the same vessel and gear during the fall which allowed for a simple addition of the survey estimates to create the index. An index based harvest control rule was accepted as the basis for TAC advice in 2016.

Greenland halibut in Subarea 0+1, including 1A inshore, came under quota regulation in 1976 when a TAC of 20 000 t was established. TAC was increased to 25 000 t in 1979. In 1994 analysis of tagging and other biological information resulted in the creation of separate management areas for inshore Div. 1A and Subarea 0+1A (offshore) and 1B-F. The portion of the TAC allocated to Subarea 0+1A (offshore) and 1B-F was 11 000 t and the TAC remained at this level from 1995-2001, during which time the TAC was fished almost exclusively in Div. 0B and Div. 1CD. A series of surveys took place during 1999-2004 in areas of Div. 0A and 1AB that had not been surveyed before resulting in an expansion of the fishery into these northern divisions between 2001 and 2006.

The vessel that conducted the surveys has been retired and there will be no survey in 2018. Also, it will not be possible to calibrate this survey series with the next survey that is expected to begin in 2019. The absence of a continuous survey series may constrain the ability of STACFIS to assess/provide advice on this stock in coming years and furthermore, STACFIS may be unable to evaluate the impact of the advised TAC.

Recent catch and TACs ('000 t)

	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
TAC	24	27	27	27	27	30	30	30	32.3	32.3
SA 0	12	13	13	13	13	15	14	14	16	
SA 1	13	13	14	14	15	16	17	17	18	
Total STACFIS[1,2]	25	26	27	27	28	31	31	31	35	

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

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

i) Description of the Fishery

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

Catches were first reported in 1964 and rose to 20,027 t in 1975 before declining to 2,031 t in 1986. Catches increased from 2,927 t in 1989 to 18,457 t in 1992 due to a new trawl fishery in Div. 0B with participation by Canada, Norway, Russia and Faeroe Islands and an expansion of the 1CD fishery with participation by Japan, Norway and Faeroe Islands. Catch declined from 1992 to 1995 primarily due to a reduction of effort by non-Canadian fleets in Div. 0B. Since 1995 catches have been near the TAC, increasing in step with increases in the TAC, with catches reaching a high of 34,661 t in 2017 (Fig. 1.1).

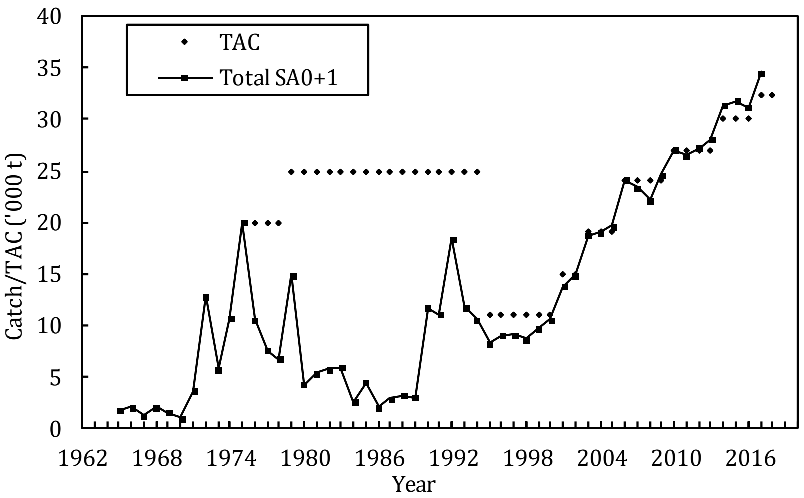


Fig. 1.1. Greenland halibut in Subarea 0 + Div. 1A (offshore) and Div. 1B-F: catches and TACs.

b) Data Overview

i) Commercial fishery

In 2017 length frequencies were available from Greenland and Russian Federation trawl fisheries in Div. 1AB, Norway, Greenland and Russian Federation trawl fisheries in Div. 1CD, and from Canadian gillnet and trawl fisheries in Div. 0A B.

In Div. 1AB the modal length has varied from 50 to 52 cm in the Greenlandic trawl fishery while the Russian trawl fishery has had slightly lower modes ranging from 45 to 50 cm in most years. Length frequencies in Greenland, Norway and Russian fisheries in Div. 1CD had modes between 47- 50 cm for most years prior to about 2014, since then the length frequencies have had a greater proportion of larger fish with modes between 50-55 cm.

During 2015-2017 modal lengths have varied between 46-50 cm in the trawl fishery in Div. 0A and in Div. 0B they have been stable at 50 cm. There tends to be a larger proportion of fish <50 cm in the Div. 0A trawl length frequency compared to Div. 0B. Modes in the Div. 0A gillnet fishery have been stable at 58 cm during 2015-2017 while the modes for Div. 0B during 2015 and 2016 were 64 cm (no data available for 2017).

The standardized CPUE for SA0+1A (offshore trawl) and 1B-F combined has been increasing since 1997, and since 2015 has been greater than the previous high levels observed at the beginning of the time series (Fig 1.2).

The standardized CPUE for gillnets has been increasing since the series began in 2003 but since 2015 has been relatively stable (Fig. 1.3).

It is not known how the technical development of fishing gear or vessel changes in the fleets have influenced the catch rates for example, the fishermen have in recent years started to bait the gill nets. Also, there are indications that the coding of trawl gear type in the log books is not always reliable. Such changes can influence the estimation of the catch rates, therefore, the catch rates should be interpreted with caution.

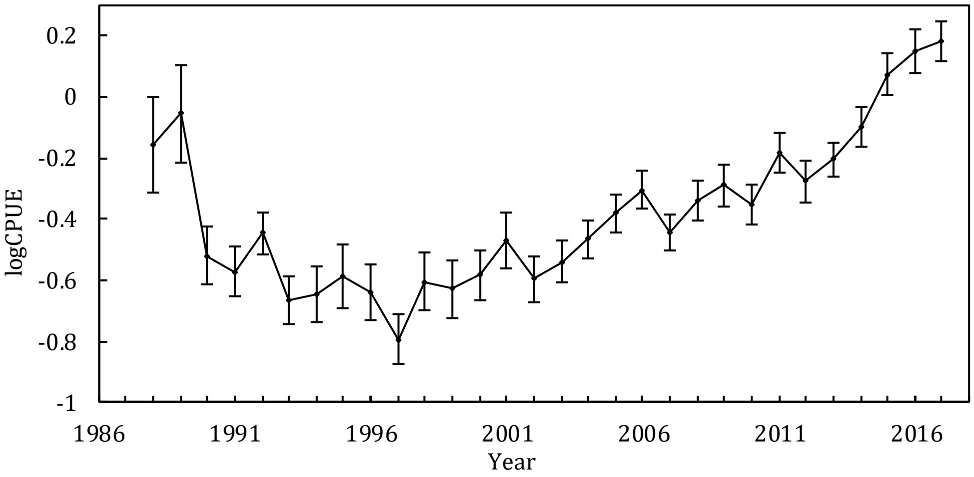


Fig. 1.2. Greenland halibut in Subarea 0 + Div. 1A (offshore) and Div. 1B-F. Combined standardized trawler log CPUE for all divisions with ± S.E.

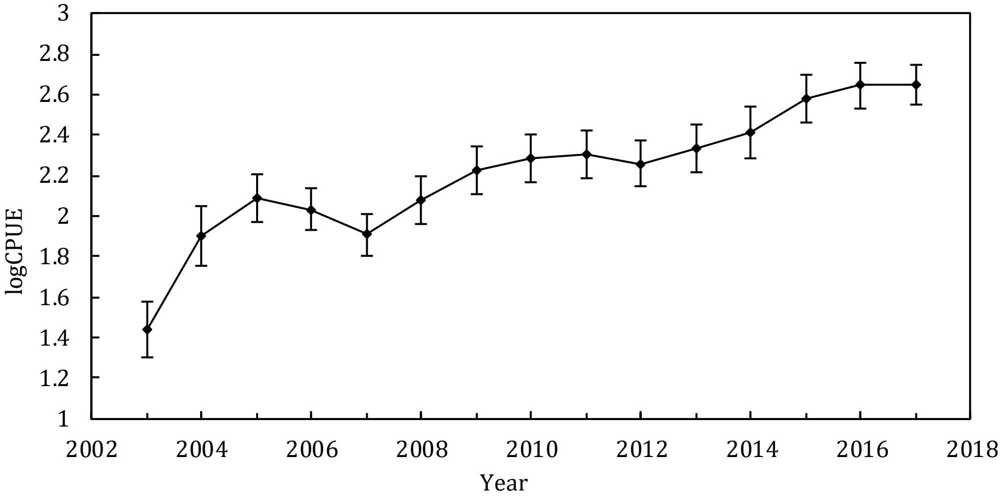


Fig. 1.3. Greenland halibut in Subarea 0 + Div. 1A (offshore) and Div. 1B-F: Standardized gillnet log CPUE for Subarea 0, with ±S.E.

ii) Research surveys

Greenland deep sea surveys in Div. 1CD. Since 1997 Greenland has conducted stratified random bottom trawl surveys during September-October in NAFO Div. 1CD, from 400 to 1500 m. The index of biomass in Div. 1CD in 2017 was similar to levels seen in 2015 and 2016 and above the time series average (Fig. 4). The abundance index in 2017 is also similar to levels seen in 2016 and 2017. The overall length distribution (weighted by stratum area) has been dominated by a mode at 51cm since 2006, an increase from a mode of 45 cm observed in 2000.

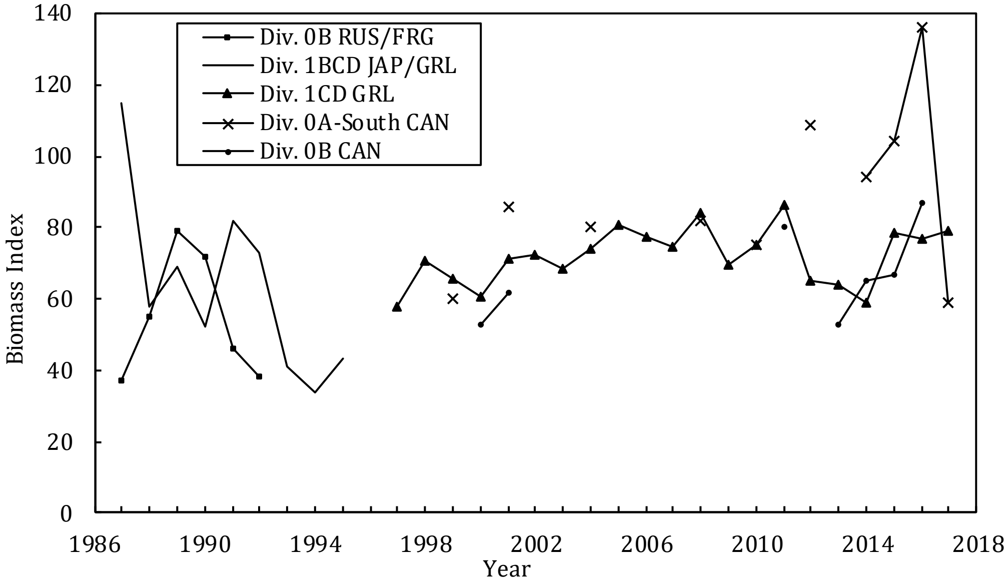


Fig. 1.4. Greenland halibut in Subarea 0 + Div. 1A (offshore) and Div. 1B-F: biomass indices from bottom trawl surveys. A survey in Div. 0A in 2006 is not included due to poor coverage.

Canada deep sea survey in Div. 0A-South. A stratified-random otter trawl survey has been conducted in southern 0A (0A-South) (to approximately 72° N) during late September to early November in 1999, 2001, every two years from 2004 to 2014, and annually since then. Biomass in Div. 0A-South had varied with an increasing trend from 1999 to 2016 followed by a marked decline in 2017 (Fig. 1.4). Abundance followed a similar pattern. The 2017 survey missed stations assigned to the most northern portion of the depth strata due to ice conditions but is still considered representative. In 2016 biomass estimates across depths 801 m to 1200 m were the highest in the time series but in 2017 biomass at all depths had changed; 1201-1500 m depths had the highest or second highest biomass in the time series while all other depths were at the lowest or near lowest levels. The overall length distribution in 2017 ranged from 12 cm to 90 cm with modes observed at 27 and 45 cm, up from 42 cm observed in 2015 and 2016.

Canada deep sea surveys in Div. 0B. A stratified-random otter trawl survey was conducted in September-October in Div. 0B in 2000, 2001, 2011, and annually from 2013-2016. Biomass and abundance for Div. 0B in 2016 were similar to previous highs observed in 2011 (Fig. 1.4). Overall lengths in 2016 ranged from 6 cm to 99 cm with modes at 18 and 51 cm. Modal length has increased over the time series from a mode of 45 cm observed in 2001.

Greenland shrimp and fish survey in Div. 1A-1F. Since 1988 surveys with a shrimp trawl have been conducted off West Greenland during July-September, from 100 to 600 m. The survey covers the area between 59° N and 72° 30' N (Div. 1A-1F) from 100 m to 600m. Clear modes can be found in the length distribution at 12-15 cm and 23 cm, corresponding to ages 1 and 2, allowing for the development of a recruitment index from this survey using the Petersen method.

c) Estimation of Parameters

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

d) Assessment Results

i) Subarea 0 + Division 1A (offshore) + Divisions 1B-1F

Commercial CPUE indices: A standardized CPUE index for all trawlers fishing in SA 0+1 has been increasing since 1997. For gillnets in SA0 the index has been increasing since the beginning of the time series in 2003 but since 2015 has been relatively stable. However, CPUE is known to have limitations as an index of population status.

Biomass: The Div. 0A-South+Div. 1CD combined survey biomass index had been relatively stable from 1999 to 2014 (Fig. 1.5). Since 2014 the index has been more variable with a time series high in 2016 and a level near the series low in 2017, with all values remaining above B_{lim}.

Recruitment: The general trend in estimated biomass of age 1 Greenland halibut in the offshore and inshore areas combined was generally increasing from 1988 to 2003, followed by a decline to 2010 and since then the index has been variable with series high values observed in 2011, 2013 and 2017 (Fig. 1.6).

Length distribution in surveys: Length frequencies in the Div. 0A-South survey are variable across years, sometimes with multiple modes (e.g. 27 cm and 45 cm in 2017). A trend to increased numbers of larger fish was observed in Div. 0A-South from 1999 to 2004 and 2008 to 2014. Length frequencies for the Div. 1CD survey have a greater proportion of fish at larger sizes and the length distribution has been dominated by a mode at 51cm since 2006, an increase from a mode of 45 cm observed in 2000.

State of the Stock: The combined Div. 0A + Divs. 1CD biomass index remains above B_{lim}. The index was relatively stable until 2014 then increased between 2014 and 2016. The decline observed in 2017 is a result of a decline in the 0A-South survey biomass. Recruitment has been increasing in recent years, and in 2017 was one of the highest in the time series.

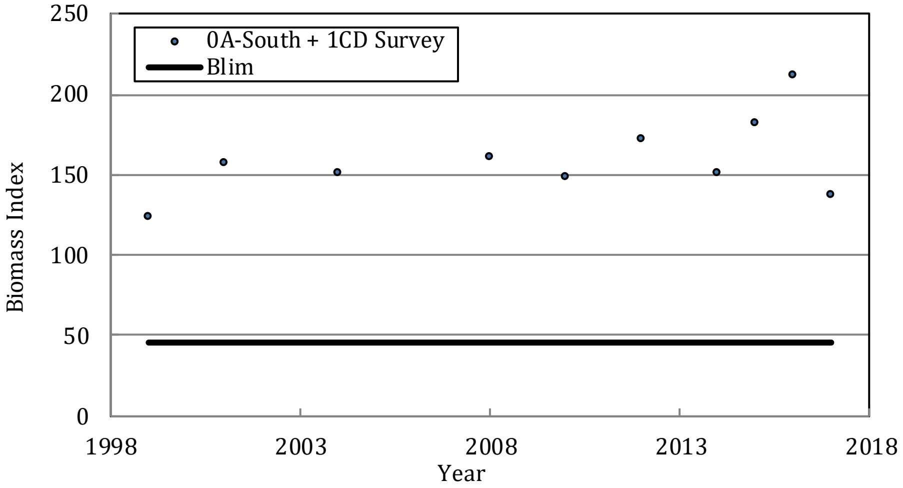


Fig. 1.5. Greenland halibut in Subarea 0 + Div. 1A (offshore) and Div. 1B-F: Biomass trends in Div. 0A-South and Div. 1CD and the proxy for B_{lim}.

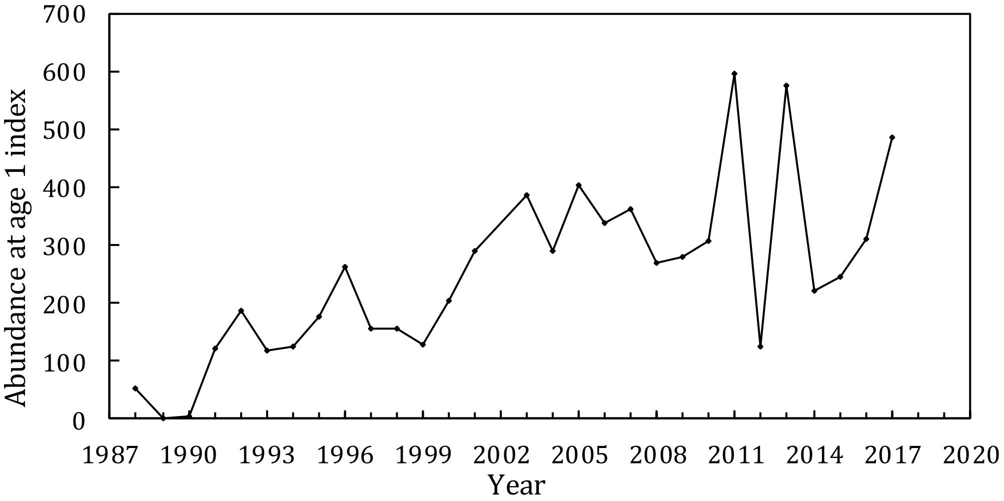


Fig. 1.6. Greenland halibut in Subarea 0 + Div. 1A (offshore) and Div. 1B-F: recruitment index at age 1 derived from the Greenland Shrimp and Fish Survey.

e) Precautionary Reference Points

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

The next full assessment of this stock is expected to be in 2020.

f) Recommendations:

In 2017 STACFIS **recommended** that *for Greenland halibut in SA0 + Div. 1A (offshore) and 1B-F by-catch in Div. 0B should be estimated based on survey data and compared to the by-catch estimated by observers in order to evaluate of the estimation of by-catch in Div. 1CD based on surveys*.

STATUS: No progress in 2017 and will not be carried forward in 2018.

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

g) References

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

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

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

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

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

2. Greenland halibut Div. 1A inshore.

(SCR Doc. 18/023 032 035 SCS Doc. 18/10)

a) Introduction

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

i) Catch history

The inshore fishery for Greenland halibut developed in the beginning of the twentieth century, with the introduction of the longline to Greenland in 1910. Catches remained at a lower level until the 1980s, but increased substantially thereafter. The fishery is conducted mainly with longlines and gillnets from small vessels, open boats and through holes in the sea ice during the winter months. Quota regulations were introduced as a shared quota for all vessels in 2008. In 2012, the TAC was split in two components with ITQ's for vessels and shared quota for small open boats. In 2014, the Government of Greenland set "quota free" areas within each subarea, and in these areas, catches were not drawn from the total quota, although still included in landing statistics. Sorting grids have been mandatory since 2002 in the offshore shrimp fishery in West Greenland and in the inshore areas from 2011. In 2017, mesh size in gillnets were reduced to 95mm half mesh. Besides the three main areas, a fishery is slowly developing in the Qaanaaq fjord (77 degrees North) since 2011.

Disko Bay: Catches increased in the 1980s, peaked from 2004 to 2006 at more than 12 000 t, but then decreased substantially. From 2009, catches gradually increased and reached 10 760 t in 2016, before decreasing to 6409t in 2017 (Table 2.1 and fig 2.1).

Uummannaq: Catches in the Uummannaq fjord gradually increased from the 1980s reaching 8425 in 1999, but then decreased and remained between 5000 and 6000 t from 2002 to 2009. After 2009 catches gradually increased reaching 10 305 t in 2016. In 2017, 9049 t were caught in the area (Table 2.1 and fig 2.1).

Upernavik: Catches increased from the mid 1980s and peaked in 1998 at a level of 7 000 t. Landings then decreased sharply, but during the past 15 years, they have gradually returned to the higher level. Average catch in the most recent 5 years has been 6 800 t (Table 2.1 and fig 2.1).

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

	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Disko Bay – TAC	8.8	8.8	8.0	8.0	9.0	9.0	9.2	9.7	9.2	9.2
Disko Bay - Catch	6.3	8.5	8.00	7.8	9.1	9.2	8.7	10.8	6.4	
Uummannaq - TAC	5.0	5.0	6.0	6.0	7.5	8.4	9.5	9.6	9.5	9.5
Uummannaq - Catch	5.5	6.2	6.4	6.1	7.0	8.2	8.2	10.3	9.1	
Upernavik - TAC	5.0	6.0	6.5	6.5	8.0	9.5	9.5	9.6	9.5	9.5
Upernavik - Catch	6.5	5.9	6.5	6.8	6.0	7.4	6.3	7.4	6.8	
Qaanaaq - Catch			0.0	0.1	0.0	0.1	0.1	0.1	0.2	
STACFIS Total	18.3	20.6	20.9	20.8	22.1	24.9	23.3	28.6	22.5	

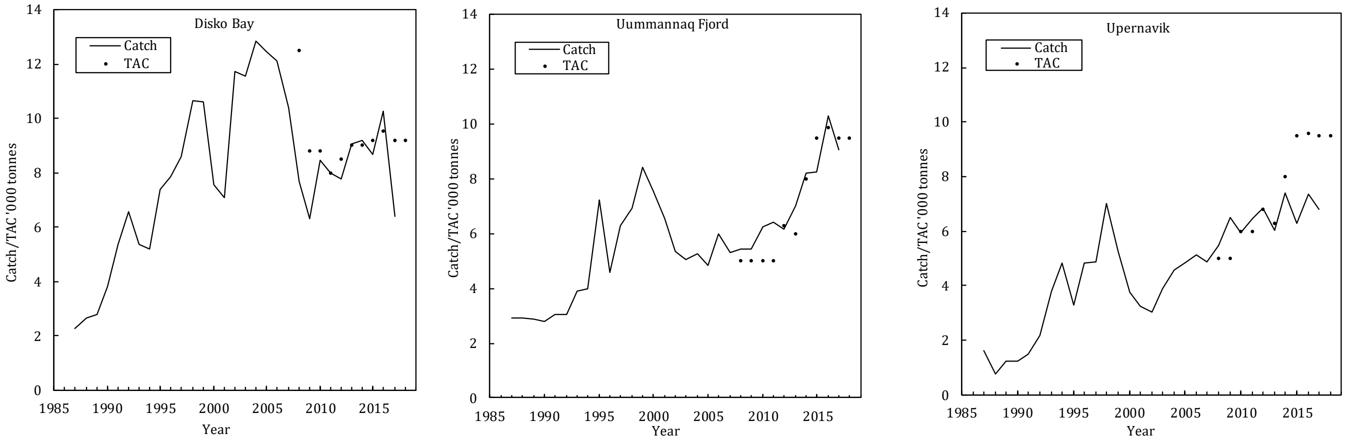


Fig 2.1. Greenland halibut in Division 1A inshore: Greenland halibut catches and TAC in t in Disko Bay, Uummannaq and Upernavik.

b) Data overview

i) Commercial fishery data

Length frequencies from factory landings are available since 1993. These data were used to calculate the mean length in the landings by season, gear and a year overall mean accounting for season, gear and area (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 fishing ground. Glacier ice limits the access to the deep areas of the Ilulissat Icefjord (Kangia) during the summer, causing the difference between the summer and winter fishery mean length. However, in most years total catch from Kangia is between 5-10% of the total catch. The increase in mean length in the winter fishery in the last two years is due to access to the deep areas of the Ilulissat Icefjord as a result of less glacier ice. Furthermore, the length distributions in the gillnet fishery, typically constituting 15-30% of total landings, has shifted to smaller fish since 2009, indicating a shift to finer meshed (illegal) gillnets.

In **Uummannaq,** the length distributions in the commercial landings have gradually decreased since 1993, but at a higher rate in the recent years. Since there is little difference between summer and winter fishing grounds, only small differences in the summer and winter length distributions are observed. Few incidents of use of fine meshed gillnets has been observed and the mean length in the gillnet landings remain high. The decrease observed in the gillnet landings in 2018, could be related to the lowering of the minimum mesh size to 95 mm.

In **Upernavik,** the mean length in the commercial landings decreased from 1993 to 1998. From 1999 to 2009, the mean length in the longline fishery remained constant, but has since then decreased further. The mean length in the gillnet fishery has also gradually been decreasing in recent years which could besides changes in the stock, also be due to increased use of illegal finer mesh gillnets (80mm) or the lowered minimum mesh size in the commercial gillnets to 95mm.

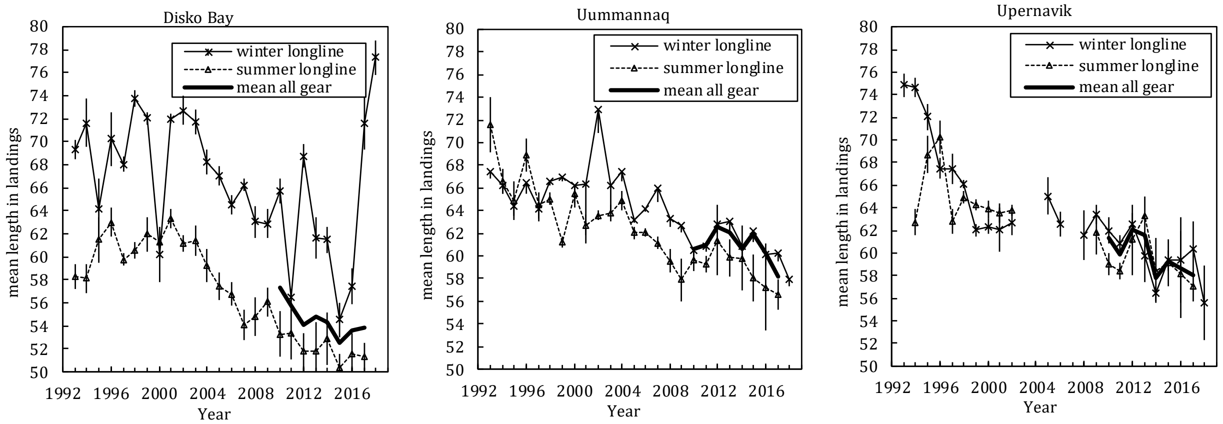


Fig. 2.2. Greenland halibut in Division 1A inshore: mean length in landings from longline fishery by season (summer and winter) and overall mean taking account of fishing ground, season and gear.

Catch numbers. Although catch in tonnes decreased in the Disko Bay in 2016, estimated catch in numbers are still at the level of the previous high catches (fig 2.3). In both Uummannaq and Upernavik, current catch in numbers are at a record high level in recent years.

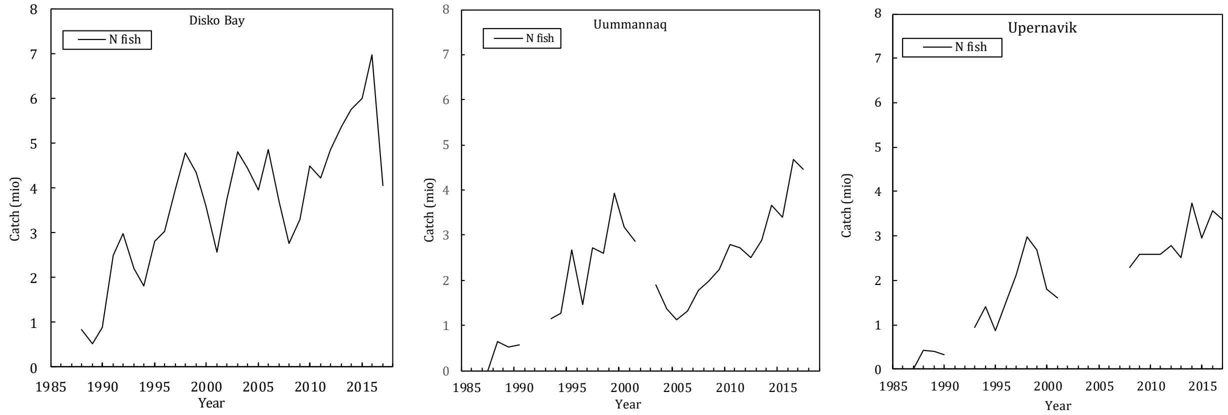


Fig. 2.3. Greenland halibut in Division 1A inshore: Greenland halibut catch in million individuals.

CPUE index based on logbooks. Logbooks have been mandatory for vessels larger than 30 ft since 2008. A general linear model (GLM) with year, month and boat as factors was applied to fit the longline and gillnet logCPUE available. Due to uncertainty about mesh size, the Gillnet CPUE was not used in the assessment. Only longline setting with more than 200 hooks were included to omit obvious outlier values and limit the influence of data potential errors on the analysis. CPUE observations were log-transformed prior to the GLM analysis. Least-mean square estimates were used as standardized CPUE series. (Fig 2.4).

In the **Disko Bay,** the standardized CPUE series show a decreasing trend since 2009, and a substantial decrease in 2017.

In **Uummannaq**, the initial years (2008-2010) were based on fewer observations. From 2011, the CPUE index decreased slightly but a sharp decrease in CPUE was observed in 2017 to the lowest value observed.

In **Upernavik,** The GLM model CPUE reveal a gradual decreasing CPUE with the most recent 3 years being among the lowest observed

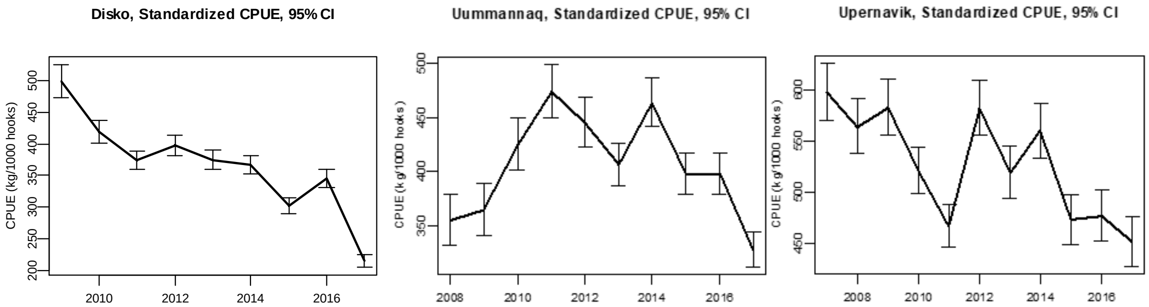


Fig 2.4 Standardized mean and 95% CI of longline CPUE in Disko bay (left), Uummannaq (center) and Upernavik (right).

ii) Research survey data

The Greenland shrimp and fish survey (NAFO Div. 1A-F from 100 to 600 m) also covers the Disko bay. Separate abundance and biomass indices and length frequencies has been calculated for the Disko bay part of the survey (fig 2.5).

The Disko Bay part of Greenland Shrimp and Fish Survey indicated an increasing abundance trend during the 1990s and high abundances (mainly age 1) were found from 1998 to 2005. After 2006, the abundance indices returned to the lower levels with the exception of the high abundances identified in 2011 and 2013.

A recruitment index was estimated using the Petersen method.

The index reveals high recruitment in the Disko Bay in 2011 and 2013 and in the nearby offshore area in 2017. Although recruitment seems to vary from year to year, this does not seem to be the case at age two or three. There is weak correlation between age one and older ages in subsequent 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.

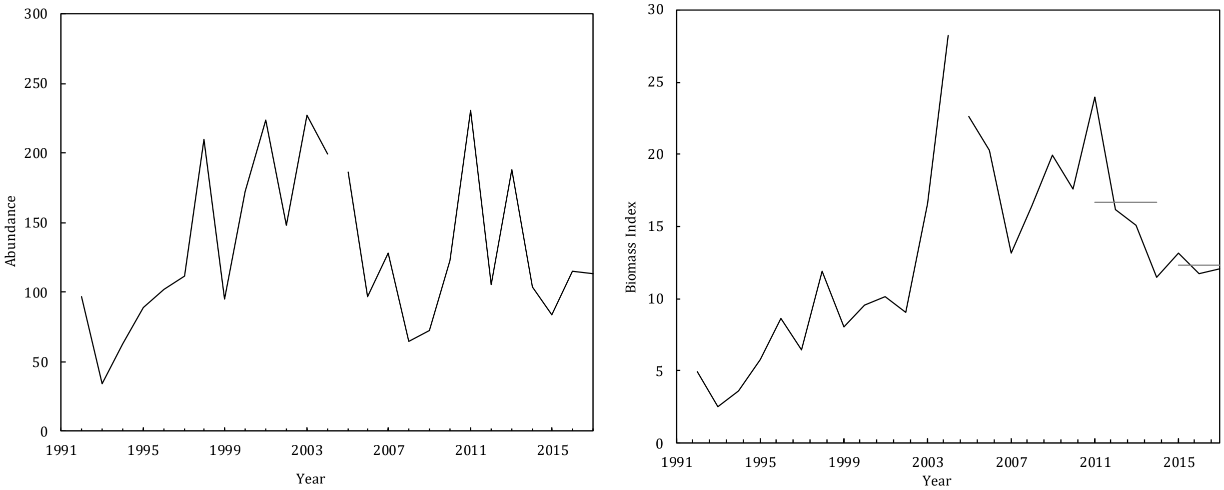


Fig 2.5. Greenland halibut in Division 1A inshore: Abundance and biomass indices in the Disko bay from the Greenland Shrimp Fish trawl survey.

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

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 (fig 2.6). Since 2013, the Gillnet survey NPUE and CPUE has gradually decreased and remained below average levels in the most recent 4 years. The apparent correlation between the gillnet survey NPUE and the number of Greenland halibut larger than 35 cm in the trawl survey implies a level of agreement between the surveys, although both surveys show large year to year variation. A larger mesh size added in 2016 did not impact the overall length distribution in the Disko bay, indicating few larger individuals in the surveyed area (55-70 cm)

The Uummannaq gillnet survey was performed using the same method and setup as in the Disko Bay. It it is not possible to draw any conclusions about the trends in the survey due to a low number of stations prior to 2015. The number of fish caught in the Uummannaq survey is higher and the individual sizes are much larger than the Disko Bay and therefore the CPUE is about 2.5 times as high as observed in the Disko Bay (fig 2.7). The size distribution in the survey reveals fewer fishery in the range 30-40 cm but far more fish in the range 40-70cm. A larger mesh size added in 2016 caught high numbers of Greenland halibut in the size range 55-70 cm in Uummannaq.

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

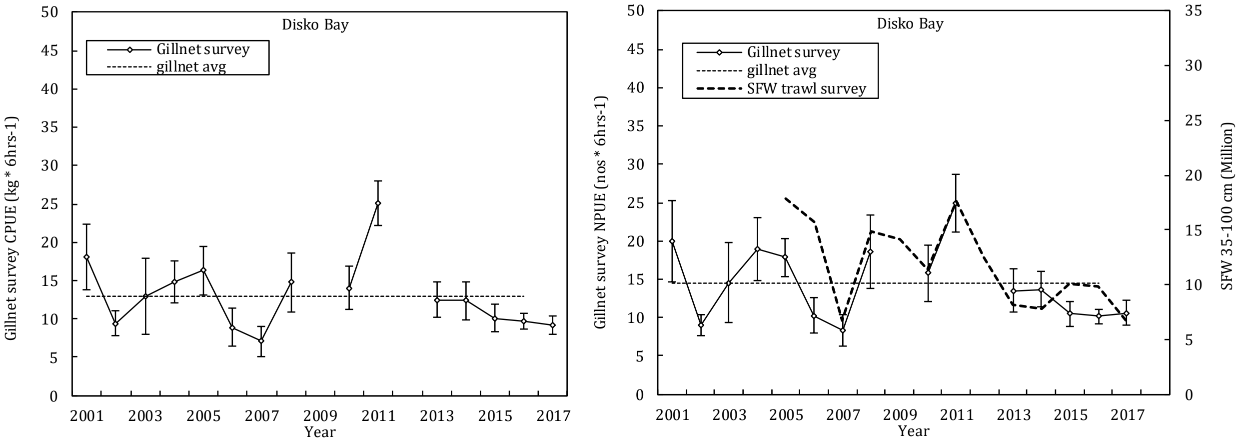


Fig 2.6. Greenland halibut in Division 1A inshore: Gillnet survey CPUE and NPUE +/-SE.

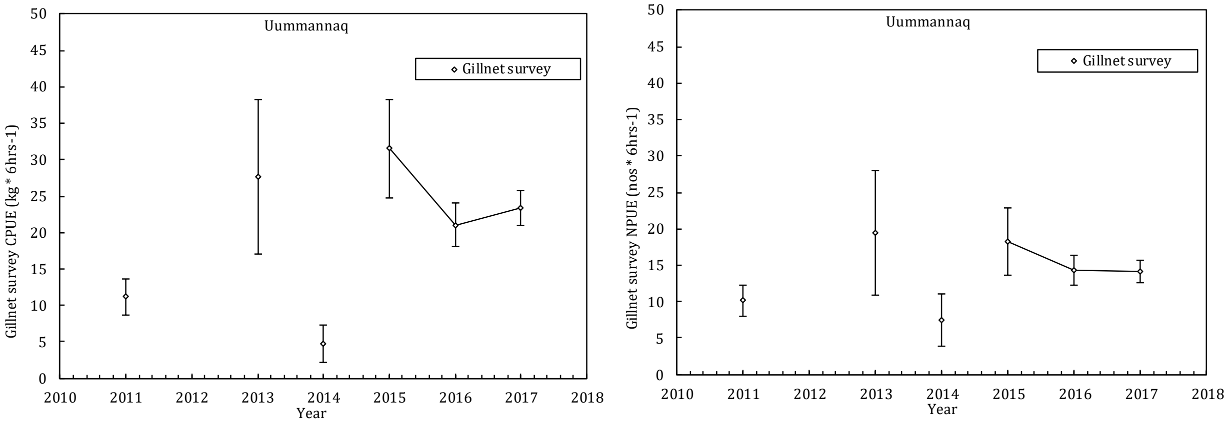


Fig 2.7. Greenland halibut in Division 1A inshore: Gillnet survey CPUE and NPUE +/-SE.

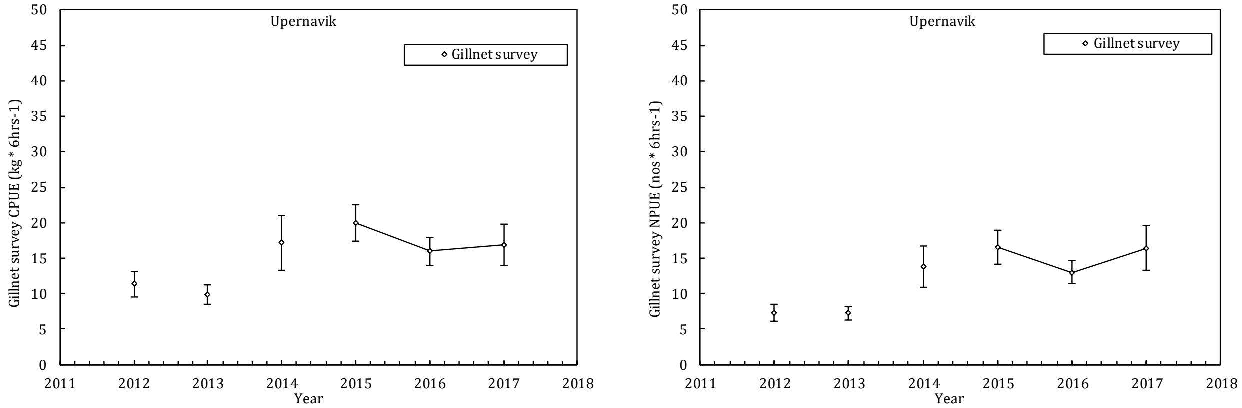


Fig 2.8. Greenland halibut in Division 1A inshore: Gillnet survey CPUE and NPUE +/-SE.

iii) Biological studies

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

iv) Environmental studies

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

c) Assessment results:

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

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

Disko Bay

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

Fishing mortality: Unknown

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

State of the stock: Length in the landings has gradually decreased over 10 to 15 years. In spite of the 2017 reduction in catch, the number of fish landed remains high. The Gillnet survey CPUE has gradually decreased and remained below average levels in the most recent 3-5 years. The trawl survey biomass index has gradually decreased since 2005, with the lowest values found in the most recent 4 years. The commercial CPUE for longline vessels has more than halved since 2009. Recruits are mainly received from offshore stocks and recruitment remains high.

Uummannaq:

Biomass: Unknown.

Fishing mortality: Unknown.

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

State of the stock:
The catch in tons and in number of fish has been record high in 2016 and 2017. The gillnet survey CPUE showed considerable numbers in the interval 40-70 cm. Mean length in the landings has gradually decreased, particularly in the recent 3 years. From 2011, the standardized commercial longline CPUE index decreased gradually, with 2017 the lowest level observed in the time series.

Upernavik:

Biomass: Unknown.

Fishing mortality: Unknown.

Recruitment: The recruitment index of age one Greenland halibut has gradually been decreasing in division 1AN, west of the Upernavik area. The gillnet survey reveals pre-fishery recruits in the 30-40 cm size range at a level comparable to the Disko Bay.
State of the stock: The catch in tons and in number of fish has been record high since 2014. The gillnet survey CPUE showed fish in the size range 30-65 cm. Mean length in the landings decreased in the 1990s, but stabilized from 1999 to 2009. Since then length in the landings have decreased further to 56-58 cm. The standardized longline CPUE index reveal a gradual decreasing CPUE with the most recent 3 years being among the lowest observed.

The next assessment is planned for 2020.

3. Roundnose Grenadier (*Coryphaenoides rupestris*) in SAs 0 and 1 (no update)

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

Interim Monitoring Report (SCR Doc. 88/12, 96/36, 07/88, 17/039, 18/032; SCS Doc. 18/10)

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 suggests decade long concentrations of redfish in both areas.

i) Fisheries and Catches

Both redfish species are included in the catch statistics, since no species-specific data are available. Greenland operates the quota uptake by categorising the catches in three types of redfish: 1) fish caught by bottom trawl and longlines on the bottom are considered *Sebastes Norvegicus*. 2), fish caught 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. marinus* and *S. mentella*.

The fishery targeting demersal redfish in SA1 increased during the 1950s and peaked in 1962 at more than 60 000 t. Catches then decreased and have remained below 1 000 tons per year after 1986 with few exceptions. However, catches are 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 2017, 65 t was reported as by-catch in offshore fisheries (1 tons from shrimp trawlers) and 157 t was taken inshore mainly as a bycatch in cod and Greenland halibut fisheries (Fig 4.1).

Recent catches ('000 tons) are as follows:

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

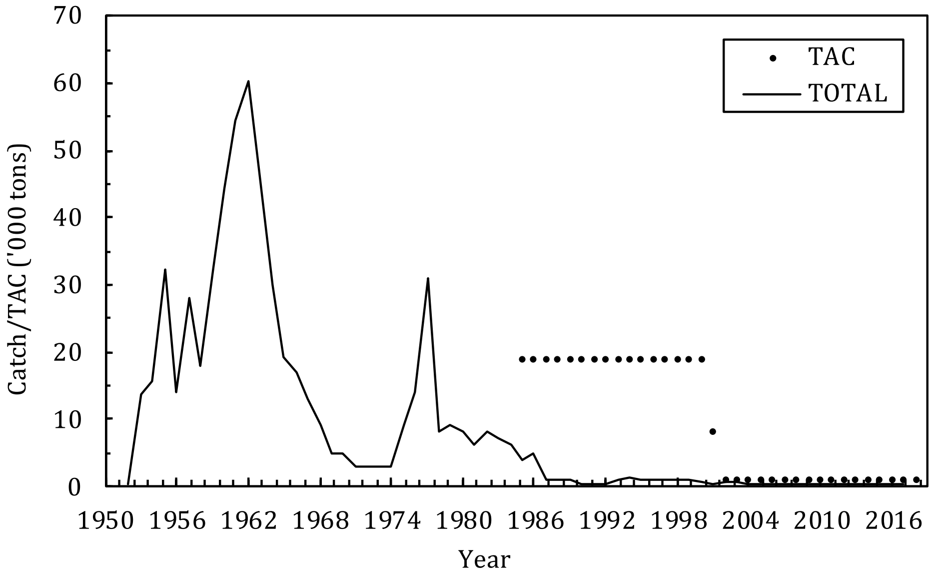


Fig. 4.1. Demersal redfish in Subarea 1: catches and TAC.

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.

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 breaking the index. In 2017, the EU-Germany survey had few stations in West Greenland and the index is not updated. Besides the recent surveys, a joint Greenland-Japan survey (Shinkai Maru, -1500m, NAFO 1B-D, 1987-1995) existed with somewhat overlapping the areas and depths as the present Greenland deep-sea survey.

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. The survey had low coverage in both 2016 and 2017 (only 7 tows in 2017). **The Greenland shrimp and fish survey** biomass index for golden redfish increased substantially since 2011 (fig 4.2). The peaks observed in 2016 are caused by few single hauls accounting for most of the year's estimate; in 2016, more than 80% of the biomass derives from a single haul in division 1E consisting of large Golden redfish at lengths between 45 and 70 cm. This was not the case in 2017 and the index returned to lower levels.

Demersal deep-sea redfish (*Sebastes mentella*)

The EU-Germany survey biomass index has fluctuated at a low level throughout the time series (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 remained at a higher level since 2008 (Fig 4.3). T**he Greenland shrimp and fish survey** biomass index for deep-sea redfish steadily increased after 2006 and the 2016 indices were among the highest observed (Fig 4.3). However, the high 2016 biomass index was caused by a single haul in division 1D of large redfish between 25 and 40 cm. In 2017, there were no such large hauls in the survey and the index returned to lower levels.

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. Data from the Greenland Shrimp and fish survey in East Greenland, which could potentially supply West Greenland with recruits (as known for other species such as Atlantic Cod and Haddock) reveal that new significant incoming year classes of redfish have not been observed since 2010.

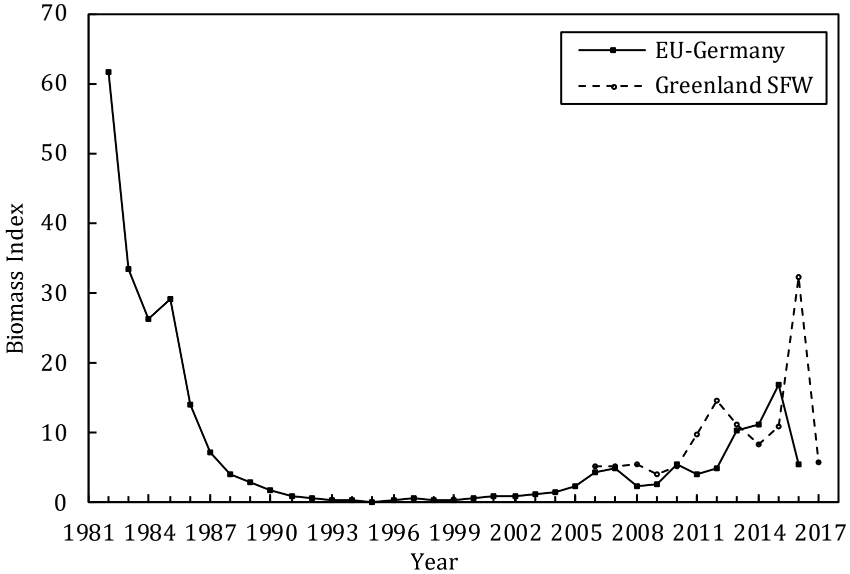


Fig. 4.2. Golden redfish biomass indices in the EU-Germany survey (1C-F) and the Greenland shrimp and fish survey (1A-F).

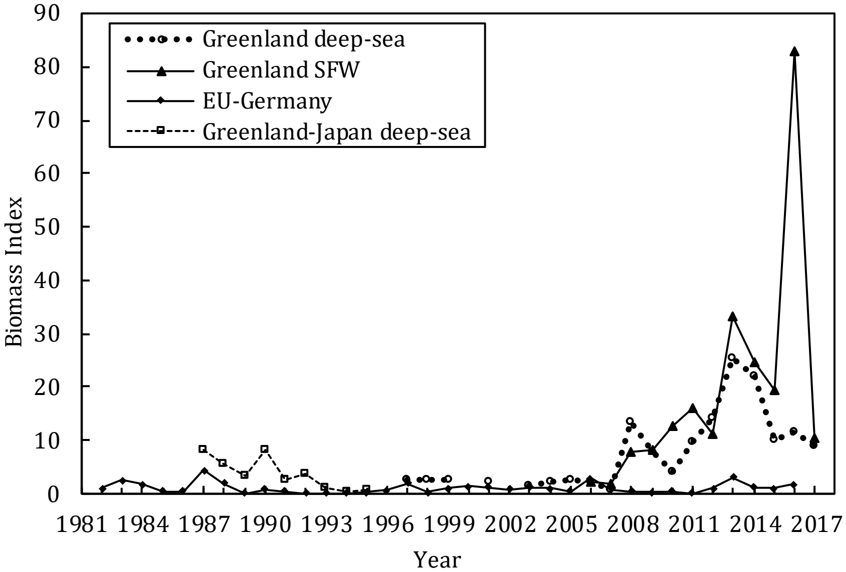


Fig. 4.3. Demersal deep-sea redfish survey biomass from the Greenland shrimp and fish survey (1A-F), the Greenland deep-sea survey (1CD), the EU-Germany survey (1C-F) and the Greenland-Japan survey (1B-D).

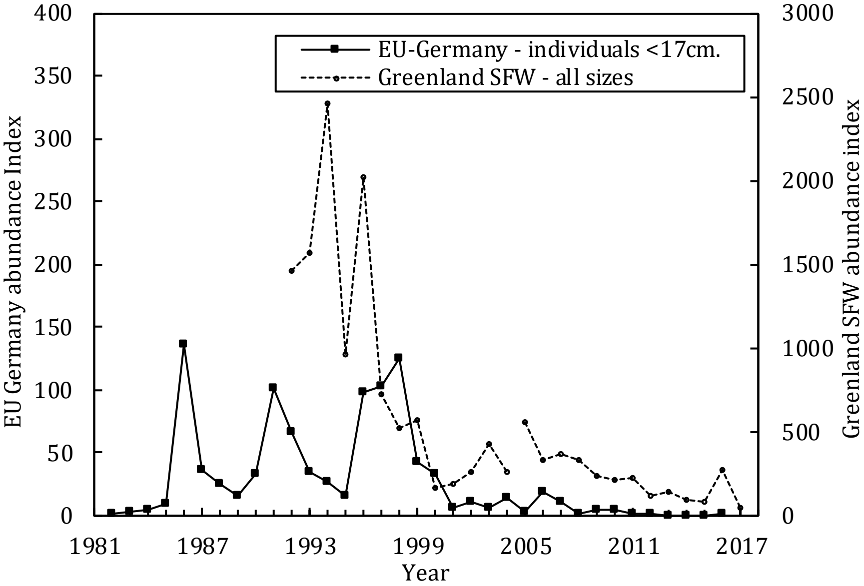


Fig. 4.4. Juvenile redfish abundance indices (deep-sea redfish and golden redfish) for the EU-Germany survey (1C-F), and the Greenland shrimp and fish survey (1A-F, all sizes).

c) Conclusion

Golden redfish - *Sebastes Norvegicus*

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

Deep-sea redfish - *Sebastes mentella*

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

The next assessment is planned for 2020.

5. 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 Subarea 1

(SCR Doc. 80/VI/72, 77, 96/036, 07/88, 17/036, 18/032; SCS Doc. 18/10)

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 (0-400 m) than spotted wolffish (0-600 m).

i) Fisheries and catches.

Wolffish are mostly taken as a bycatch in other fisheries and directed fishery mostly occurs when access to more economically interesting species are limited. Although spotted wolffish and Atlantic wolffish are easily distinguishable from one another, the two species are rarely separated in catch statistics. The commercial fishery for wolffish in West Greenland increased during the 1950s and wolffish was initially targeted in the coastal areas. With the failing cod fishery off West Greenland, trawlers started targeting Atlantic wolffish on the banks off West Greenland and from 1974-1976 reported landings from trawlers were around 3,000 tons per year (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 2017, inshore landings of wolffish decreased to 156 tons and offshore reported catches increased to 82 t mainly taken as bycatch in cod fishery in 1D and 1E.

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

	2009	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**
Atlantic wolffish TAC							1.0	1.0	1.0	1.0
Spotted wolffish TAC							1.0	1.03	1.0	0.9
Wolffish TAC	1	1	1	1	1	1	2.0	2.0	2.0	1.8
STATLANT 21	0.1	0.0	0.8	1.0	0.9	0.9	0.4	0.2	0.2	
STACFIS	1.2	1.3	0.8	1.0	0.9	0.9	0.4	0.2	0.2	

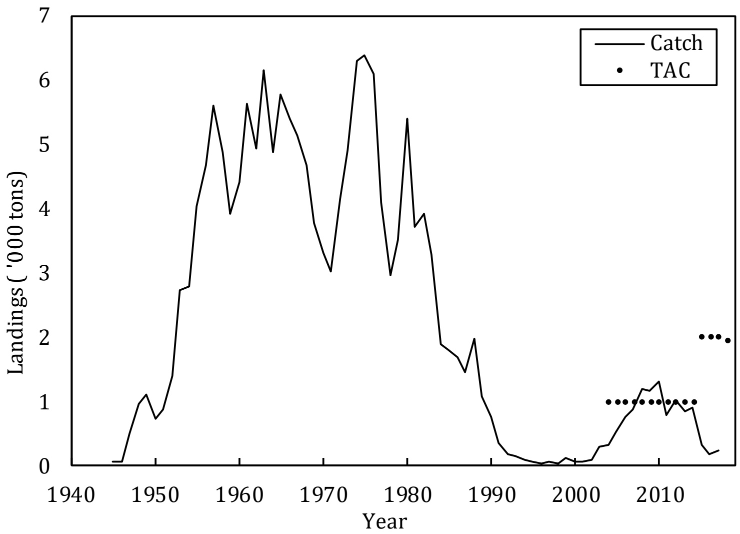


Fig 5.1. Wolffish in Subarea 1: Catches and TACs for Atlantic wolffish and spotted wolffish combined from 1945 to 2017.

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 (RV Walther Herwig III, 0-400m, NAFO 1C-F, ICES XIV, since 1982) has a longer time series but only covers the southern part of the West Greenland shelf. The Greenland shrimp and fish survey (RV 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, although none covers the main inshore fishing areas. 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. The EU-Germany survey had very few stations in 2017 and the index has not been updated. 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). 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. The decrease observed after 2005 may be related to changes in the surveyed area (Fig 5.2).

The Greenland shrimp and fish survey biomass indices were at low levels during the 1990s, but increased slightly from 2002 and until the gear change in 2004. After 2005, the biomass index increases further in the Greenland shrimp and fish survey (Fig 5.2). Abundance indices in the Greenland shrimp and fish survey increased until the gear change in 2004 (Fig 5.2). 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 5.3). After 2002, the survey biomass increased and the recent indices are at the level observed in the beginning of the 1980's. Although highly variable, the abundance index has gradually increased since the mid 1990s (Fig 5.3).

The Greenland shrimp and fish survey biomass index, were at low levels during the 1990s, but increased from 2002. After the gear change in 2005, survey biomass has increased substantially (Fig 5.3). The abundance index gradually increased both before and after the gear change and the indices seems well connected. (Fig 5.3).

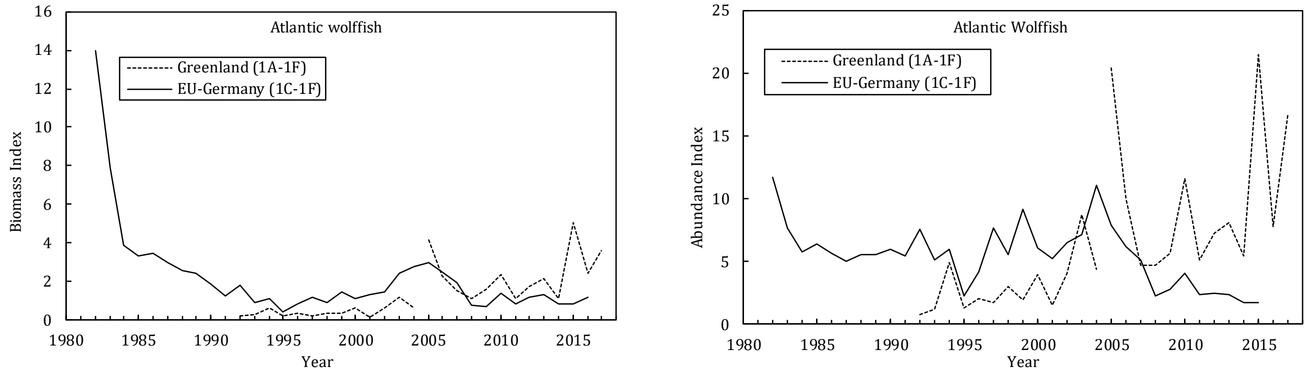


Fig. 5.2. Atlantic wolffish survey biomass index (left) and abundance index (right) from the surveys.

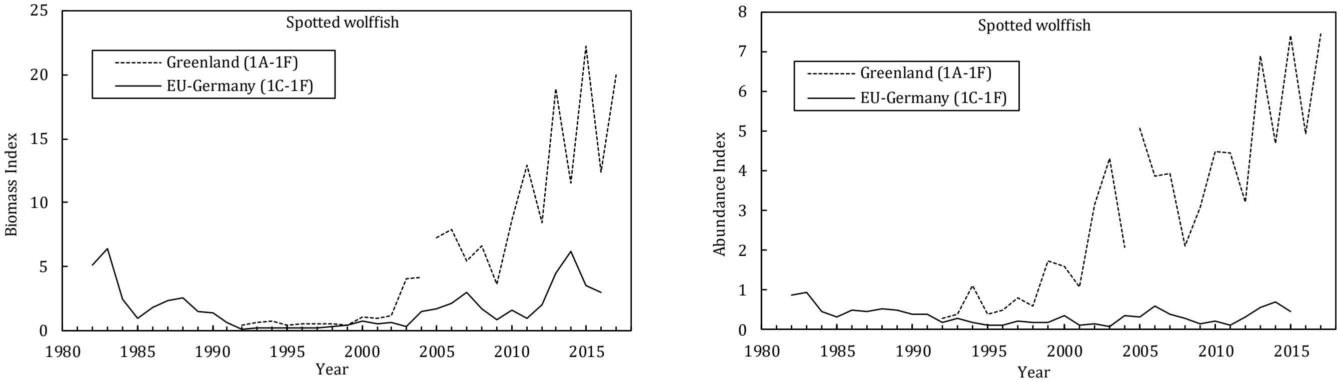


Fig. 5.3. Spotted wolffish survey biomass index (left) and abundance index (right) from the surveys.

c) Conclusion

Atlantic wolffish

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

Spotted wolffish

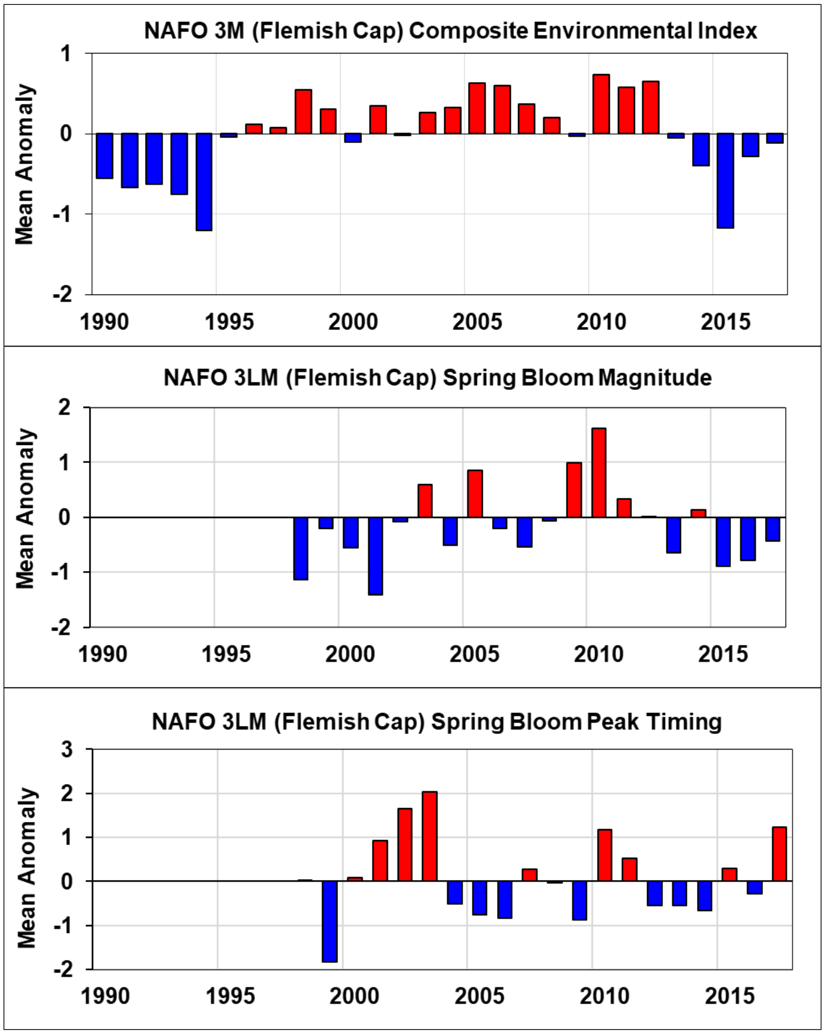
This stock underwent full assessment in 2017. The ICES Harvest Control Rule 3.2 for data limited stocks combined with the survey index from the Greenland shrimp and fish survey has been used to formulate the advice since 2017. Although the survey indices were increasing, the advice was reduced to 975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

The next assessment is planned for 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.Conditions moderated significantly in 2017.
- Total production of the spring bloom (magnitude) on the Flemish Cap has remained below normal in 2017 for a third consecutive year. The timing of the spring bloom was delayed in 2017 transitioning from predominately early onset since 2012 compared to the reference period.
- The zooplankton abundance index has remained above normal since 2010 but biomass was below normal for a third consecutive year since a record-low observed in 2015.



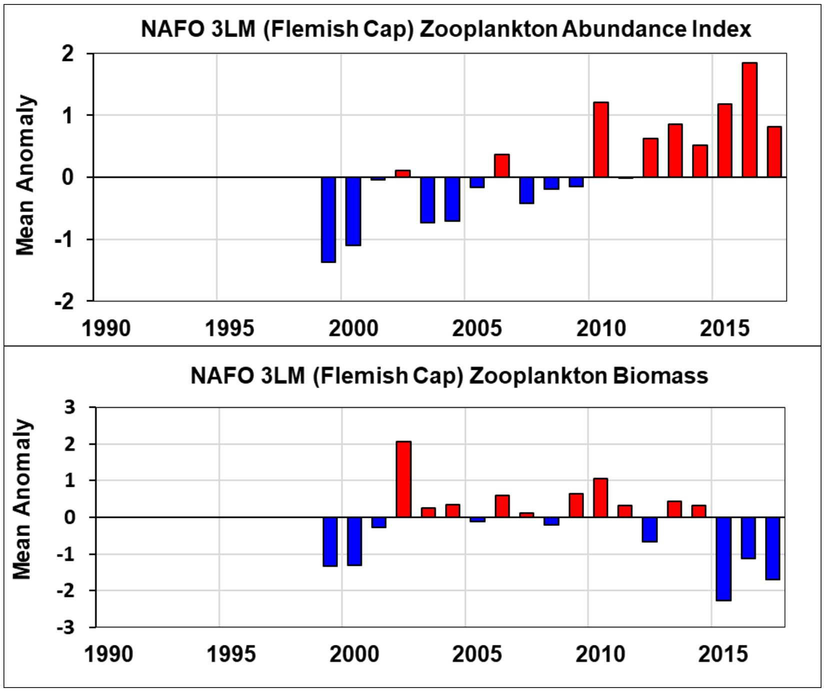


Fig. B1. Composite environmental index for NAFO Div. 3M derived from meteorological and physical oceanographic (water temperature, and salinity) conditions during 1990-2017 (top panel). Phytoplankton spring bloom magnitude (2nd panel) and peak timing (3rd panel) in NAFO Div. 3LM during 1998-2017. Composite zooplankton abundance index derived from copepod (total copepods, Calanus finmarchicus, Pseucalanus spp.) and non-copepod abundances (4th panel), and zooplankton biomass anomaly (5th panel) in NAFO Div. 3LM during 1999-2017. Positive/negative anomalies indicate conditions above/below (or late/early timing) the long-term average for the reference period. All anomalies are mean standardized anomaly calculated using the following reference periods: climate index: 1981-2010; phytoplankton indices (magnitude and peak timing): 1998-2015; zooplankton (abundance and biomass) indices: 1999-2015.

Environmental Overview

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

Ocean Climate and Ecosystem Indicators

The composite climate index in Subarea 3 (Div. 3M) has remained above normal since the mid-1990's although the index has declined sequentially since 2013 reaching a 22-year record-low in 2015. The composite index remained below normal in 2016 but moderated to just slightly below normal in 2017 (Figure 1, top panel). Spring bloom total production (magnitude) reached a record-high in 2010 but has remained near or below normal since 2012 (Figure 1, 2nd panel). Spring bloom peak timing was delayed in 2017 after five years of mostly early blooms (Figure 1, 3rd panel). The composite zooplankton abundance index decreased in 2017 after reaching a record high in 2016, but has remained above normal since 2010 (Figure 1, 4th panel). Zooplankton biomass was below normal in 2017 for a third consecutive year since a record-low observed in 2015 (Figure 1 5th panel). This represents a severe decline in zooplankton biomass after thirteen years (2002-2014) of mostly above normal conditions. In 2017 temperature and salinity conditions returned to near-normal values over most of the water column except in the near-surface layer where temperature values remained below normal including a significant layer of CIL water with T<3°C. Near surface values were about 1 SD below normal and at the bottom they were about normal. Current measurements showed a very dynamic circulation pattern in 2015 with record high southward flowing LC water over the Cap but in 2017 the circulation pattern was dominated by a weak incoherent anticyclonic flow with a general northward flow through 47° N.

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

(SCS Doc. 18/05, 18/07, 18/08, 18/09, 18/13, 18/14, 18/18 and SCR 95/73, 18/08, 18/38)

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. Total annual catches from 1996 to 2010 were very small compared with previous years.

The mean reported catch was 32 000 t from 1963 to 1979 with high inter annual variability. Reported catches declined after 1980, when a TAC of 13 000 t was established, but Scientific Council regularly expressed its concern about the reliability of some catches reported in the period since 1963, particularly those since 1980. Alternative estimates of the annual total catch since 1988 were made available in 1995 (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 directed fishery was closed and catches were estimated in that year as 353 t, most of them taken by non-Contracting Parties according to Canadian Surveillance reports. Fleets of non-Contacting Parties did not participate in the fishery since 2000. Annual bycatches between 2000 and 2005 were estimated to be below 60 t, increasing to 339 and 345 t in 2006 and 2007, respectively. In 2008 and 2009 catches increased to 889 and 1 161 t, respectively. From the reopening of the fishery in 2010, catches increased until 2013 to the TAC value, and remained at this level since.

In 2018 a 3M cod benchmark meeting was held by the Scientific Council. Changes in the input data and in the model assessment were made. Input data were reviewed and the initial year was changed from 1972 to 1988. As a result of this change, the Canadian survey is no longer incorporated as tuning in the assessment. A Bayesian SCAA was approved as the basis of the assessment replacing the Bayesian XSA used to assess the stock between 1988 and 2017.

Recent catches ('000 tons) are as follow:

,000 tons	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
TAC	ndf	5.5	10.0	9.3	14.1	14.5	13.8	13.9	13.9	11.1
STATLANT 21	1.2	5.2	10.0	9.1	13.5	14.4	12.8	13.8	13.9	
STACFIS	1.2	9.3	12.8	12.8	14.0	14.3	13.8	14.0	13.9	

ndf No directed fishery

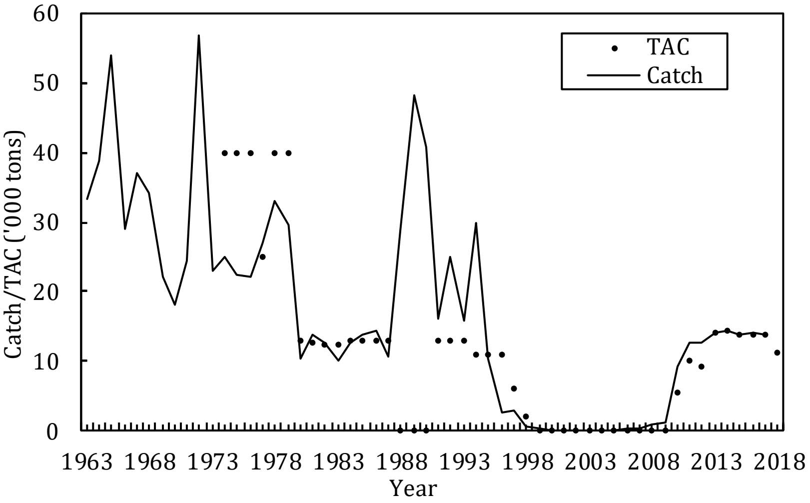


Fig. 6.1. Cod in Division 3M: STACFIS catches and TAC.

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 2014, and has decreased since. The growth of the strong year classes since 2005 contributed to the increase in the biomass. Abundance rapidly increased between 2005 and 2011, decreasing since 2012. The difference in timing of the peaks in biomass and abundance over 2011-2017 is driven by the very large 2009 and 2010 year classes.

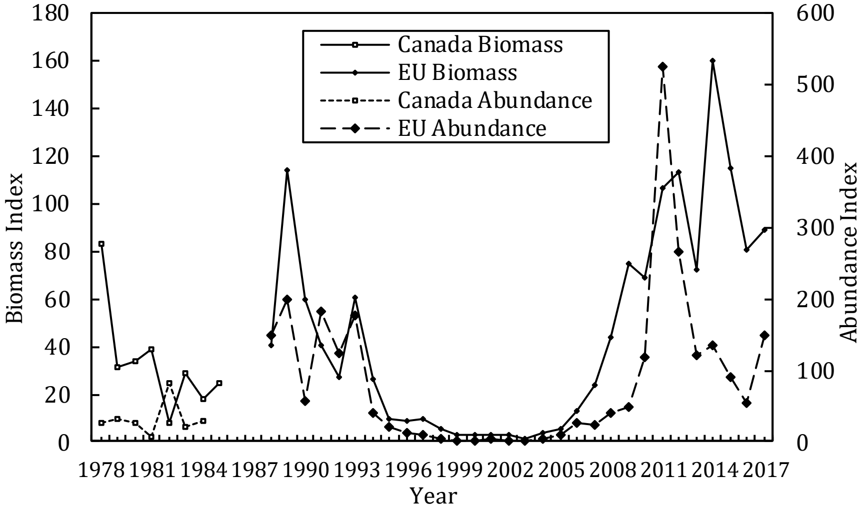


Fig. 6.2. Cod in Division 3M: Survey abundance and biomass estimates from Canadian survey (1978-1985) and EU-Flemish Cap survey (1988-2017).

ii) Recruitment

The recruitment index (age 1) from the Canadian survey was estimated at low levels except for 1982 and 1983. After several series of above average recruitments during 1988-1992, the EU Flemish Cap survey indicates poor recruitments during 1996-2004, even obtaining an observed zero value in 2002. From 2005 to 2012 increased recruitments were observed. In particular, the age 1 index in 2011 is by far the largest in the EU series (Fig. 6.3; note that the level of both surveys is different in the two y-axis). From 2013 the recruitment index dropped to a level similar to the beginning of the recovery of the stock, being in 2016 among the lowest levels observed in the series.

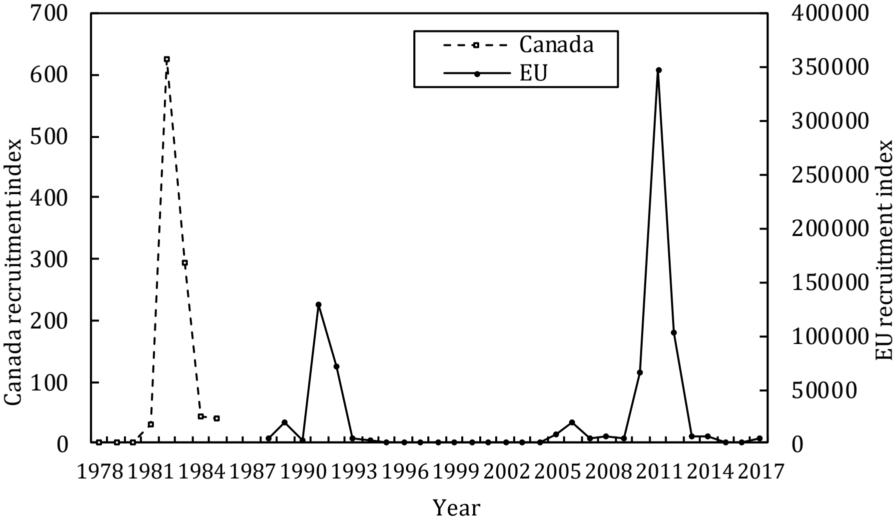


Fig. 6.3. Cod in Division 3M: Number at age 1 in the Canadian survey (1978-1985) and EU survey (1988-2017).

iii) Fishery data

In 2017 nine countries fished cod in Div. 3M, trawlers from EU-Estonia, EU-Portugal, EU-Spain, EU-UK, Japan, Norway and Russia and longliners from Faroe Islands and USA.

Length and age compositions from the commercial catches are available from 1972 to 2017 with the exception of the 2002 to 2005 period. Since 2010, length information was available for the major participants in the fishery. In 2017 there were length distributions from EU-Estonia, EU-Portugal, EU-Spain, Faroe Islands and Russia (Fig. 6.4). The mean in the length composition for EU-Estonia was 60 cm, being 64 cm for EU-Portugal, 57 cm for EU-Spain, 76 cm for the Faroese longliners and 67 cm for Russia. The mean in the total commercial catch length distribution was 64 cm with a length range of 22-136 cm. Since 2013, the commercial catch at age data has been generated using ALKs from the EU survey. In 2017, this ALK was not available so the EU survey 2016 ALK was used. In 2017, age 6 was the most abundant in the catch.

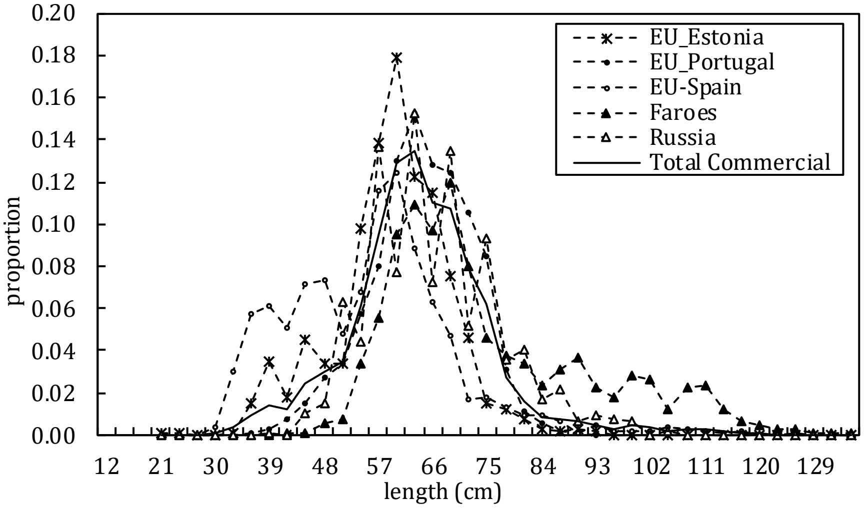


Fig. 6.4. Cod in Division 3M: Length distribution of the commercial catches in 2017.

iv) Biological parameters

In 2017, mean weights-at age in the stock and the catch were derived from the 2016 EU survey ALK. Mean weight-at-age in both have been decreasing continuously since the reopening of the fishery, reaching the minimum for ages 4 to 8 in 2015-2017 (Fig. 6.5 and 6.6).

Maturity ogives are available from the surveys for almost all years between 1978 and 2017. 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). Maturity data were not available for 2017 so the maturity ogive from 2016 was used.

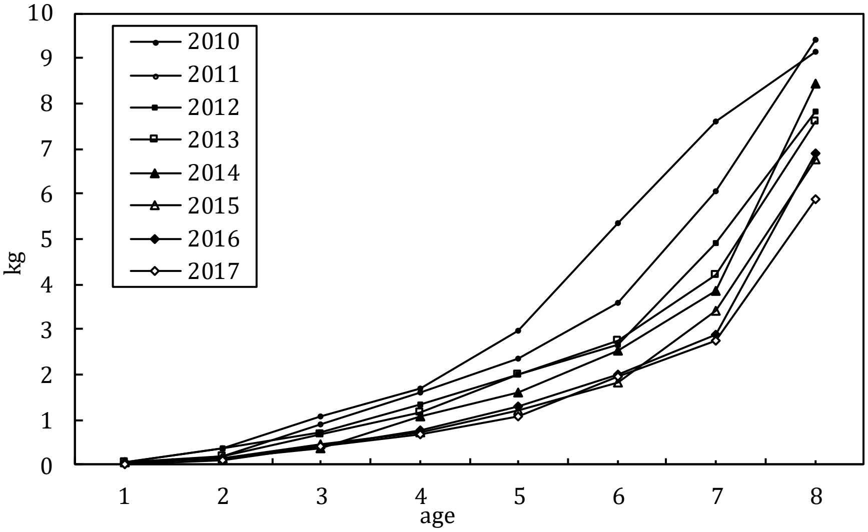


Fig. 6.5. Cod in Division 3M: Mean weight-at-age in the stock for the 2010-2017 surveys.

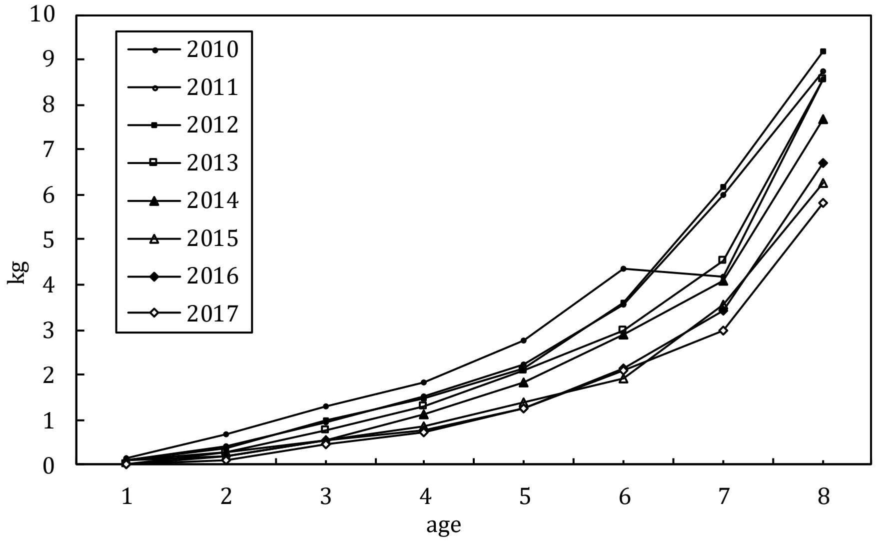


Fig. 6.6. Cod in Division 3M: Mean weight-at-age in the catch for 2010-2017.

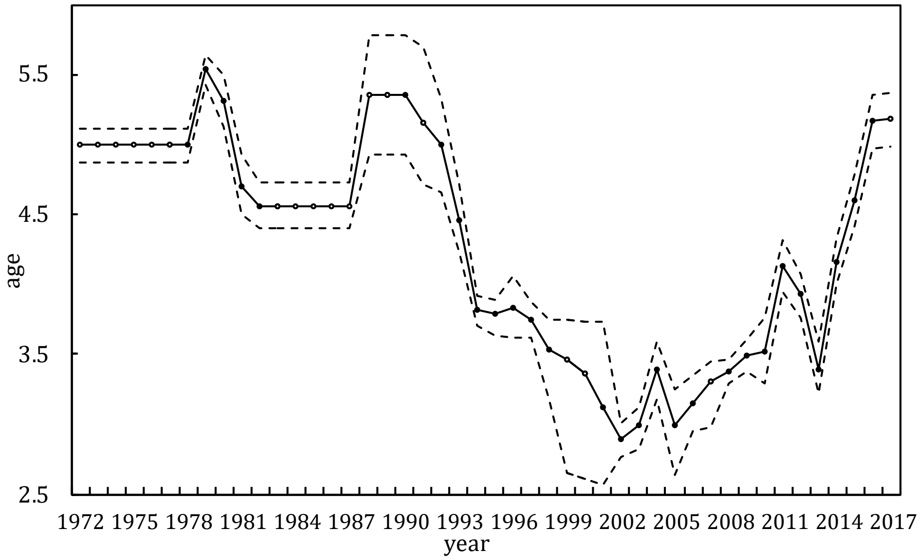


Fig. 6.7. Cod in Division 3M: Age at 50% maturity (median and 90% confidence intervals) from Canadian survey (1978-1985) and EU-Flemish Cap survey (1988-2017). Interpolated years are represented in white circles.

c) Estimation of Parameters

A new Bayesian SCAA model was used as the basis for the assessment of this stock for the first time. This model was approved during the 2018 3M cod benchmark (SCS doc 18/18). Model settings are presented in detail in SCR 18/42. As a result of poor reliability of catch data prior to 1988 it was decided during the April 2018 benchmark that the assessment was conducted from 1988 to 2017. Input data and settings are as follows:

Catch data: catch numbers and mean weight at age for 1988-2017, except for 2002-2005, for which only total catch is available. STACFIS estimates for total catch were used.

Tuning: numbers at age from EU Flemish Cap survey (1988-2017).

Ages: from 1 to 8+

Catchability analysis: dependent on stock size for age 1, estimated independently for ages 1 to 3 and for 4+ as a group.

Natural Mortality: M was set via a lognormal prior constant over years and variable through ages. Prior median is based on a mean of estimates from several methods (SCS-doc. 18/18)

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

Additional priors: for recruitment in all the years, for the number-at-age for ages 2-8+ in the first year, for a year factor for F (*f*), for selectivity (*rC*), and for the natural mortality.

Likelihood components: for total catch, for catch numbers-at-age and numbers-at-age of the survey.

The model components are defined as follows:

Input data	**Model component**	**Parameters**
R 1988-2017	$LN\left(medrec, cvrec\right)$	*medrec*=45000, *cvrec*=10
N(1988,a), a=2-8+	Ages 2-7 $LN\left(median = medrec \times e^{-\sum_{age=1}^{a-1} M(age)+medFsurv(age)}, cv = cvsurv\right)$ Ages 8+ $LN\left(median = medrec \times \frac{e^{-\sum_{age=1}^{A-1}\left(M(age)+medFsurv(age)\right)}}{1-e^{-M(A+)+medFsurv(A+)}}, cv = cvsurv\right)$	*medFsurv*(1,…,7)={0.0001, 0.1, 0.5, 0.7, 0.7, 0.7, 0.7} *cvsurv*=10
f(y) y=1988-2017	Year 1988 $LN\left(median = medf\,,\ cv = cvf\ \right)$ Years 1989-2017 $LN\left(median = AR(1)\, over\ f\,,\ cv = cvf\ \right)$	*medf*=0.2, *cvf*=4
rC(y,a), a=2,8+ 1988-2017	Year 1988 $LN\left(median = medrC\left(a\right),\ cv = cvrC\left(a\right)\right)$ Years 1989-2017 $LN\left(median = last\ year\ rC,\ cv = cvrCcond\right)$	*medrC*(a)=c(0.01,0.3,0.6,0.9,1,1,1), *cvrC*(a)=c(4,4,4,4,4,4) *cvrCcond*=0.2
Total Catch 1988-2017	$LN\left(median = \sum_{age=1}^{A+} mu.C\left(y,age\right) wcatch\left(y,age\right),\ cv = cvcW\right)$ $mu.C\left(y,a\right) = N\left(y,a\right)\left(1-e^{-Z(y,a)}\right)\frac{F\left(y,a\right)}{Z\left(y,a\right)}$	*cvCW=0.077*
Catch Numbers at age, a=2,8+ 1988-2107	$LN\left(median = mu.C\left(y,a\right),\ cv = cv.C\right)$	*cv.C*=0.2

EU Survey Indices (I)	$I(y) \sim LN\left(median = \mu(y,a),\ cv = cvEU\right)$ $\mu(y,a) = q(a)\left(N(y,a)\dfrac{e^{-\alpha Z(y,a)} - e^{-\beta Z(y,a)}}{(\beta-\alpha)Z(y,a)}\right)^{\gamma(a)}$ $\gamma(a)\begin{cases} \sim N(\text{mean}=1, \text{variance}=0.25),\ if\ a=1 \\ =1,\ if\ a \geq 2 \end{cases}$ $\log(q(a)) \sim N(\text{mean}=0, \text{variance}=5)$	I is the survey abundance index q is the survey catchability at age N is the stock abundance index *cvEU*=0.3 α = 0.5, β = 0.58 (survey made in July) Z is the total mortality
M	$M \sim LN(medM, cvM)$	*MedM*=c(1.26,0.65,0.44,0.35,0.30,0.27,0.24,0.24 *cvM*=0.15

d) Assessment Results

The results of the new Bayesian SCAA model have changed the perception of recent stock size compared to previous assessments. The level of M is higher than that in previous assessments; this may result in higher changes in stock abundance estimates from year to year and also in projections. Higher stock abundance is derived from the Bayesian SCAA, especially since 2010, which implies a higher level of SSB and a lower level of F. Recruitment is estimated at very low levels over the last years, which implies that the SSB is projected to decrease in the near future.

Total Biomass and Abundance: Estimated total biomass and abundance showed an increasing trend since 2006 until 2012, reaching a higher biomass level than before the collapse of the stock in mid 1990s. Since then a decreasing trend can be observed, with the greater decrease observed in abundance. The biomass value is at the highest level of the total period biomass, but abundance is below the mean (Fig. 6.8). The total aggregate abundance has declined in recent years as a consequence of lower recruitment since 2012 while the strong year classes of 2009 to 2011 have grown and dominate the biomass.

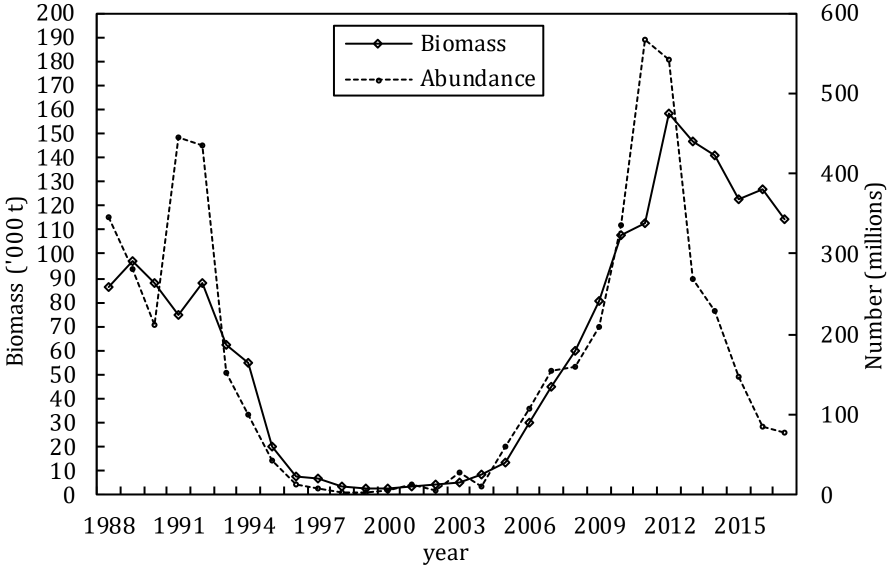


Fig. 6.8. Cod in Div. 3M: Biomass and Abundance estimates.

Spawning stock biomass: Estimated median SSB (Fig. 6.9) increased since 2005 to the highest value of the time series in 2017. This increase is due to several abundant year classes. The probability of being below B_{lim} (20 000 t; see below, section g) in 2017 is very low (<1%).

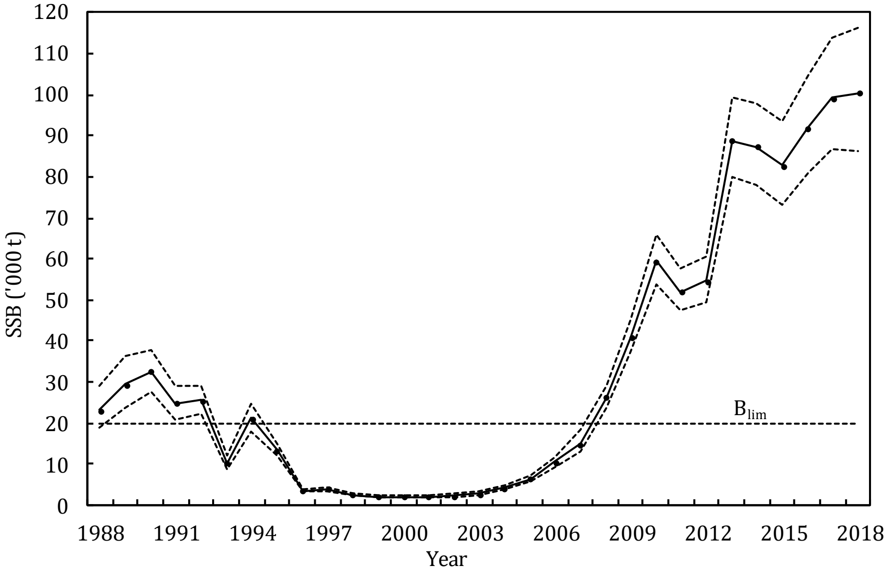


Fig. 6.9. Cod in Div. 3M: Median and 90% probability intervals SSB estimates. The horizontal dashed line is the B_{lim} level of 20 000 t.

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 2015 recruitment has been very low (Fig. 6.10).

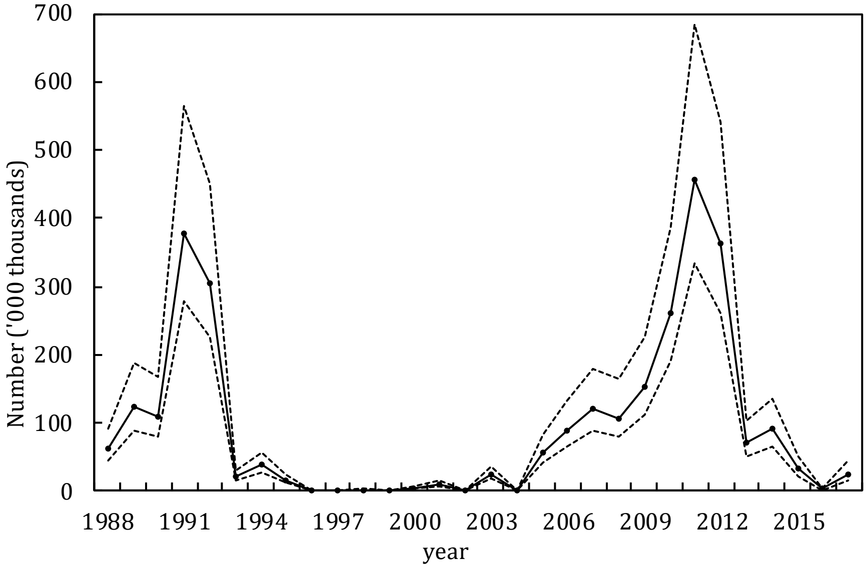


Fig. 6.10. Cod in Div. 3M: Recruitment (age 1) estimates and 90% probability.

Fishing mortality: F increased in 2010 with the re-opening of the fishery although it has remained below F_{lim} (0.153) since 2000 (see below, section g) (Fig. 6.11).

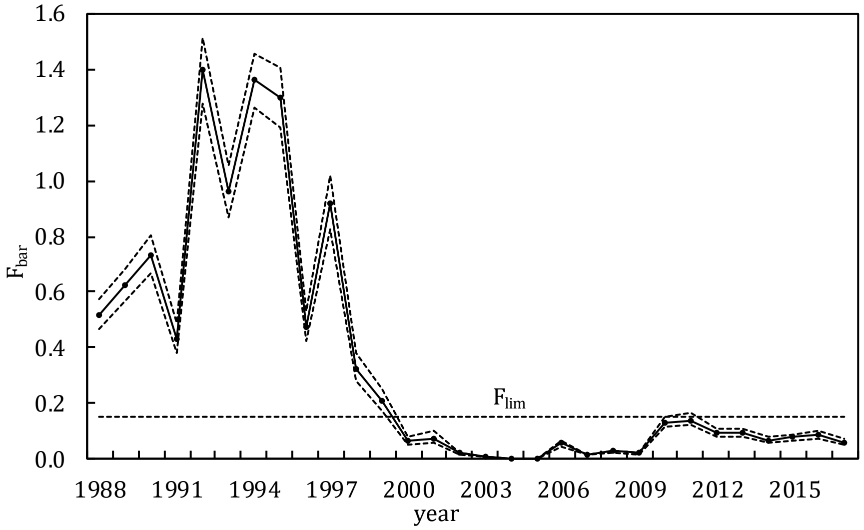


Fig. 6.11. Cod in Div. 3M: F_{bar} (ages 3-5) estimates and 90% probability intervals. The horizontal dashed line is the F_{lim} (0.153).

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

Age	1	2	3	4	5	6	7	8+
Posterior	1.35	0.62	0.37	0.26	0.27	0.35	0.31	0.38

e) Retrospective analysis

A five-year 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 F_{bar} at ages 3-5.

Retrospective analysis shows revisions in the recruitment, mainly regarding the highest values of recruitment in the years 2009 to 2011, but no patterns are evident in recent years (Fig. 6.12). There is a tendency to over-estimate SSB in recent years as the two most abundant year-classes are revised downwards (Fig. 6.13). There is very little evidence of a retrospective pattern in F (Fig. 6.14).

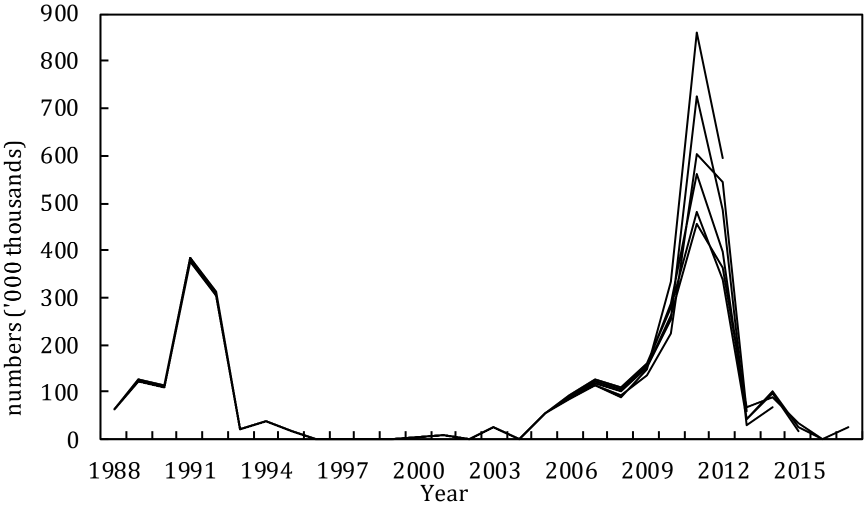


Fig. 6.12. Cod in Div. 3M: Retrospective results for recruitment.

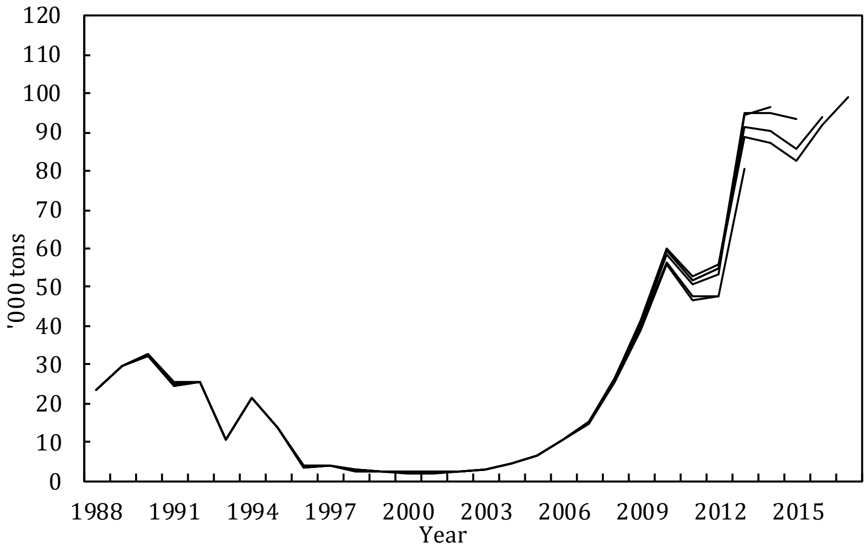


Fig. 6.13. Cod in Div. 3M: Retrospective results for SSB.

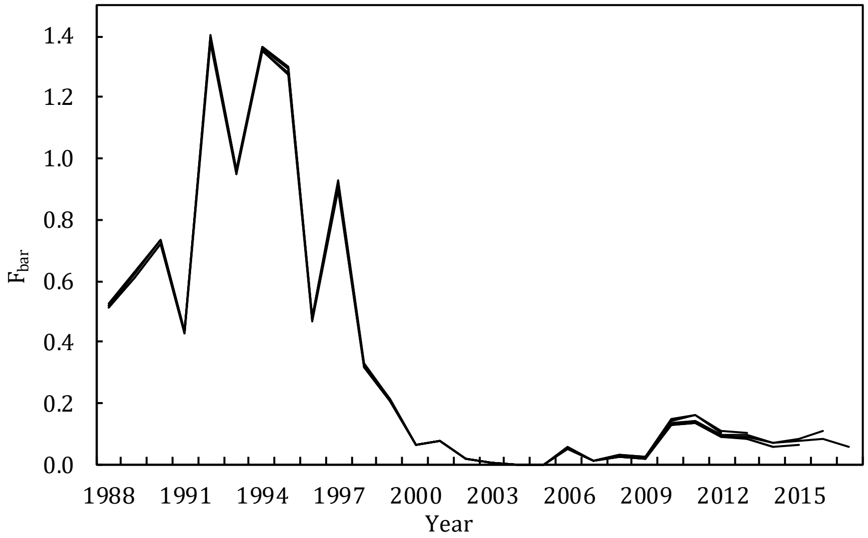


Fig. 6.14. Cod in Div. 3M: Retrospective results for average fishing mortality.

f) State of the stock

Current SSB is estimated to be well above B_{lim}. However, since 2015 recruitment has been very low.

F increased in 2010 with the re-opening of the fishery although it has remained below F_{lim} (0.153) since 2000.

g) Reference Points

The new assessment results were used to estimate limit reference points. The stock recruit scatter was examined to find an SSB below which no good recruitments have been observed (Fig. 6.15). This SSB (20 000 t) was set as B_{lim}. Fig. 6.16 shows a stock-F_{bar} plot. F_{lim} was estimated based on $F_{30\%SPR}$ calculated with the 2015-2017 data as 0.153. This period was chosen due to the rapid change in biological parameters in the stock.

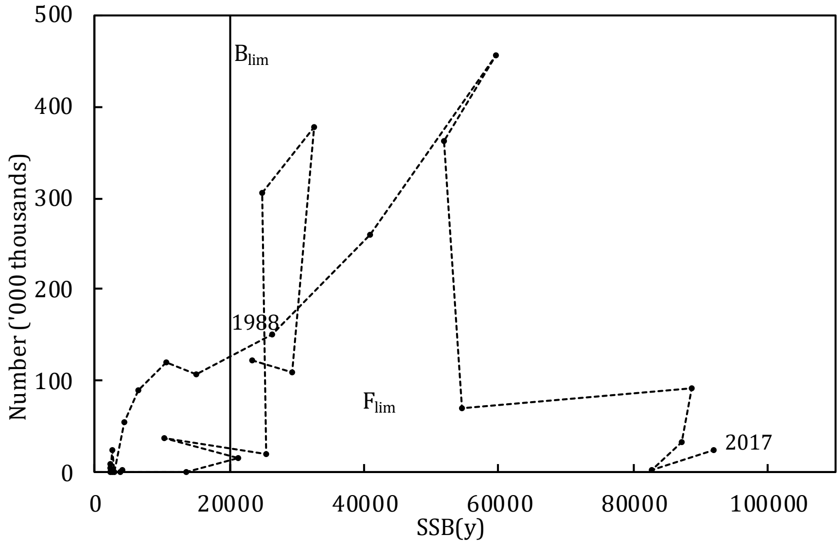


Fig. 6.15. Cod in Div. 3M: Stock-Recruitment (posterior medians) plot. B_{lim} is plotted in the graph.

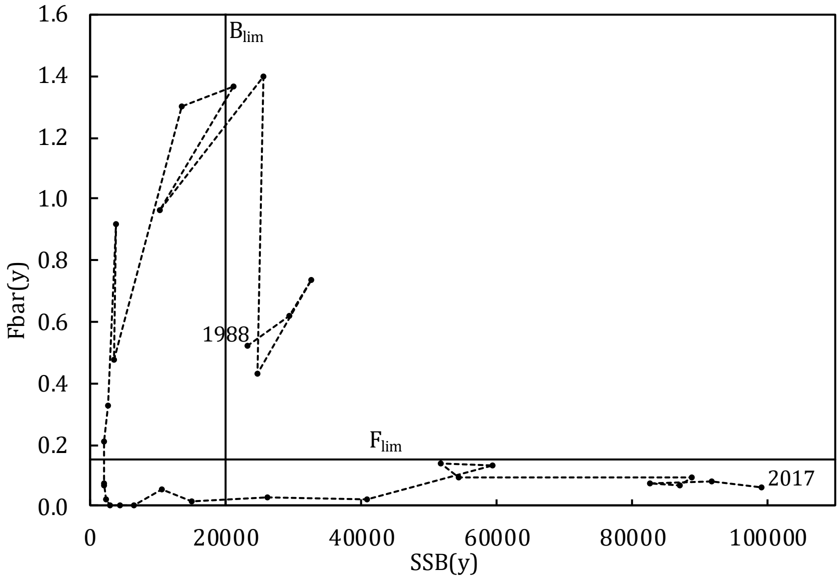


Fig. 6.16. Cod in Div. 3M: Stock-F_{bar}(3-5) (posterior medians) plot. B_{lim} and F_{lim} are plotted in the graph.

h) Stock projections

The same method as last year was used to calculate the projections and the risk. Stochastic projections of the stock dynamics from 2018 to 2021 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 2018: estimated from the assessment.

Recruitments for 2018-2021: Recruits per spawner were drawn randomly from 2014-2016. The 2017 value was omitted due to uncertainty in estimating the recruitment.

Maturity ogive for 2018-2021: 2016 maturity ogive.

Natural mortality for 2018-2021: 2017 natural mortality from the assessment results.

Weight-at-age in stock and weight-at-age in catch for 2018-2021: 2017 weight-at-age.

PR at age for 2018-2021: Mean of the last three years (2015-2017) PRs.

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

(*Scenario 1*) $F_{bar}=F_{lim}$ (median value = 0.153).

(*Scenario 2*) $F_{bar}=3/4F_{lim}$ (median value = 0.115).

(*Scenario 3*) $F_{bar}=F_{statusquo}$ (median value = 0.073).

All scenarios assumed that the Yield for 2018 is the established TAC (11 145 t). $F_{statusquo}$ was established as the mean fishing mortality over 2015-2017.

The results indicate that under all scenarios total biomass and SSB during the projected years will decrease sharply (Fig. 6.17 and 6.18). The probability of SSB being below B_{lim} in 2020 is very low (<1%) in all cases. For both $F_{2015\text{-}2017}$ and ¾ F_{lim}, the probability of SSB being below B_{lim} in 2021 is very low (≤1%). However, the probability of being below B_{lim} is 13% if F = F_{lim}. The probability of SSB in 2020 and 2021 being above that in 2018 is <1%.

Under 3/4 F_{lim} and F(2015-2017), the probability of F exceeding F_{lim} is less than or equal to 5%.

Under all scenarios, the projected Yield increases in 2019, but decreases again for 2020.

Results of the projections are summarized in the following table:

	B		SSB		Yield
	Median and 90% CI				
			$F_{bar}=F_{lim}$ (median=0.15)		
2018	108705	(94014 - 125180)	100343	(86263- 116383)	11145
2019	95351	(80800 - 111466)	90123	(76337 - 106201)	26502
2020	51428	(40481 - 64418)	47805	(37198 - 60396)	14260
2021	29467	(20160 - 40273)	26392	(17815 - 36684)	
			$F_{bar}=3/4F_{lim}$ (median=0.12)		
2018	108705	(94014 - 125180)	100343	(86263- 116383)	11145
2019	95351	(80800 - 111466)	90123	(76337 - 106201)	20796
2020	56533	(45623 - 69596)	52867	(42341 - 65526)	12359
2021	35407	(26166 - 46024)	32204	(23660 - 42420)	
			$F_{bar}=F_{2015\text{-}2017}$ (median=0.07)		
2018	108705	(94014 - 125180)	100343	(86263- 116383)	11145
2019	95351	(80800 - 111466)	90123	(76337 - 106201)	13863
2020	62796	(51855 - 75854)	59056	(48509 - 71796)	9191
2021	43374	(34048 - 54034)	39963	(31485 - 50314)	

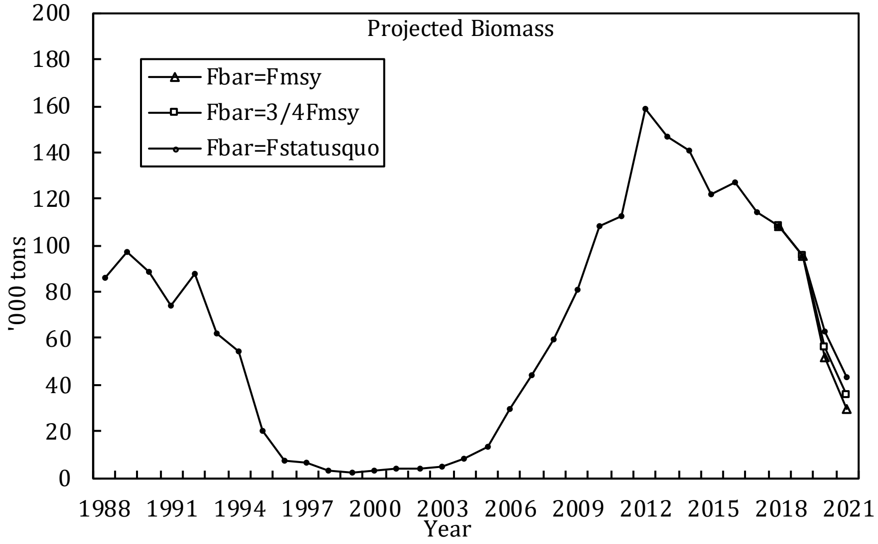


Fig. 6.17. Cod in Div. 3M: Projected Total Biomass under all the Scenarios.

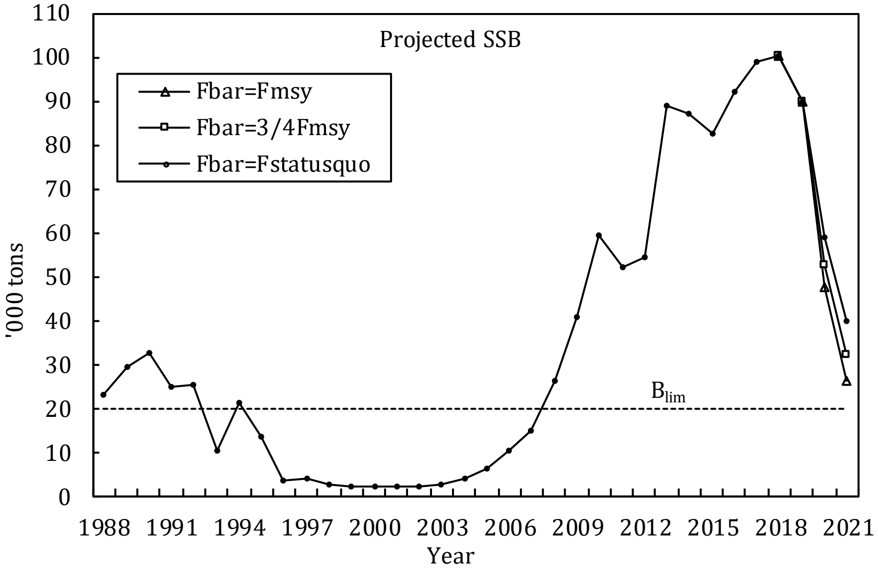


Fig. 6.18. Cod in Div. 3M: Projected SSB under all the Scenarios

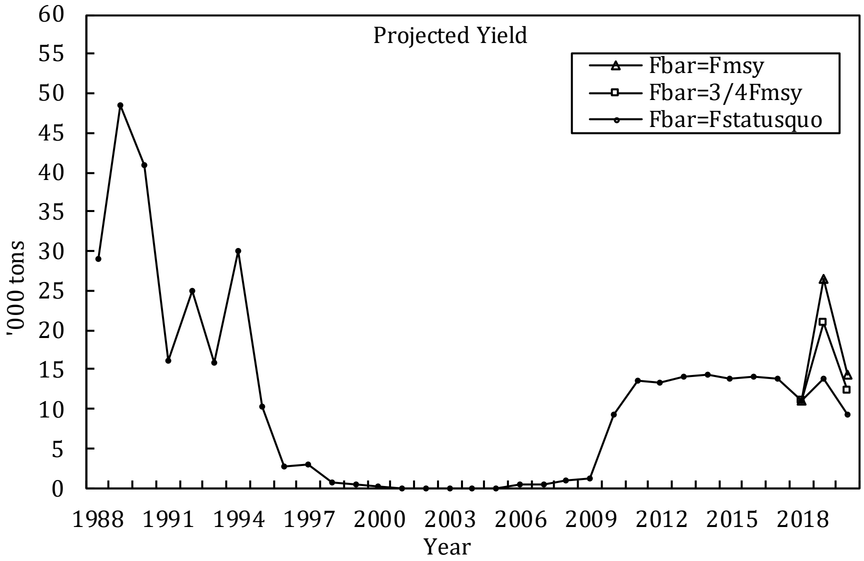


Fig. 6.19. Cod in Div. 3M: Projected removals under all the Scenarios

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})			
	2018	2019	2020	2018	2019	2020	2021	2018	2019	2020	P(B_{21}> B_{18})
F_{lim} = 0.15	11145	26502	14260	<1%	<1%	<1%	13%	<1%	50%	50%	<1%
3/4F_{lim} = 0.12	11145	20796	12359	<1%	<1%	<1%	1%	<1%	1%	5%	<1%
$F_{2015-2017}$ = 0.07	11145	13863	9191	<1%	<1%	<1%	<1%	<1%	<1%	<1%	<1%

i) Research recommendations

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

STATUS: An age-readers Workshop was held in November 2017 in order to reconcile the differences among age-readers of this stock. Much progress in understanding where the differences between the commercial and survey ALKs come from were made but still need more research to completely know the problem.

STACFIS **encouraged** to *all Contracting Parties to provide length distribution samples from the commercial vessels fishing 3M cod.*

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

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

SCR Doc. 18/008, 18/024, 18/025; SCS Doc. 18/05, 18/06, 18/07, 18/08, 18/13)

a) Introduction

There are three species of redfish that are commercially fished on Flemish Cap; deep-sea redfish (*Sebastes mentella*), golden redfish (*Sebastes marinus*) and Acadian redfish (*Sebastes fasciatus*). The term beaked redfish is used for *S. mentella* and *S. fasciatus* combined. Because of difficulties with identification and separation, all three species are reported together as 'redfish' in the commercial fishery. All stocks have both pelagic and demersal concentrations and long recruitment process to the bottom. Redfish species are long lived with slow growth.

i) Description of the fishery

The redfish fishery in Div. 3M increased from 20 000 tons in 1985 to 81 000 tons in 1990, falling continuously since then until 1998-1999, when a minimum catch around 1100 tons was recorded mostly as by-catch of the Greenland halibut fishery. An increase of the fishing effort directed to Div. 3M redfish is observed 2005 onwards basically pursued by Portuguese bottom trawl and Russia bottom and pelagic trawl. Part of this fishing effort has been deployed on shallower depths above 300m and is associated with the increase of cod catches and reopening of the Flemish Cap cod fishery in 2010.

STACFIS catch estimates were available till 2010. Over 2006-2010 an average annual bias of 15% plus was recorded between SACFIS catch estimate and STATLANT nominal catch. In order to mitigate the lack of independent catch data a 15% surplus was added to the STATLANT catch of each fleet between 2011 and 2014. For 2015 and 2016 the annual catch was given by the Daily Catch Reports (DCRs) by country provided by the NAFO Secretariat. The 2017 annual catch has been estimated with the CDAG method, presented on 20 April 2018 by the NAFO Joint Commission-Scientific Council Catch Estimation Strategy Advisory Group (COM-SC CESAG, 2018).

The STACFIS catch estimates (1989-2010), the inflated STALANT catch (2011-2014), the catch from the DCRs (2015-2016) and CEDAG (2017) are the sources of information for the 3M redfish landings.

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

	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
TAC	8.5	10.0	10.0	6.5	6.5	6.5	6.7	7.0	7.0	10.5
STATLANT 21 A	8.7	8.5	9.7	6.7	6.8	6.4	6.9	6.6	7.1	
STACFIS Total catch[1]	11.3	8.5	11.1	7.6	7.8	7.4	6.9	6.6	7.1	
STACFIS Catch[2]	3.7	5.4	9.0	5.9	5.2	4.6	5.2	6.2		

[1] STACFIS total catch on 2011-2015 based on the average 2006-2010 bias.

[2] STACFIS beaked redfish catch estimate, based on beaked redfish proportions on observed catch.

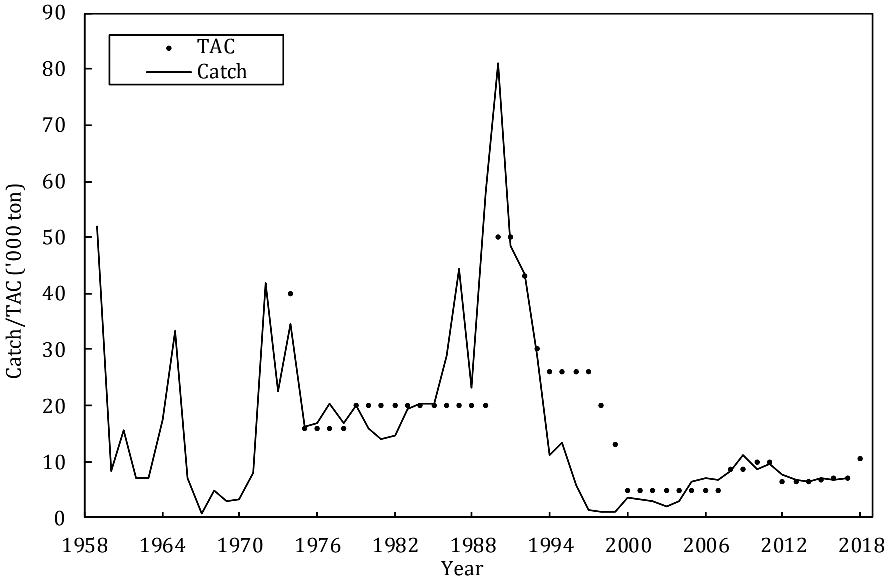


Fig. 7.1. Redfish in Div. 3M: catches and TACs.

b) Data Overview

ii) Research surveys

Flemish Cap Survey: Despite a sequence of abundant year classes and a low exploitation regime over almost twenty years, survey results suggest that the beaked redfish stock increased sharply from 2004 to 2006 and then declined rapidly over the second half of the 2000s. Such unexpected shifts in the stock dynamics can only be attributed to mortality other than fishing mortality. From the survey results for 2015 to 2017, the decline appeared to have been halted. But the stock has remained near its historical average level, due to a combination of poor recruitment and natural mortalities higher than the levels accepted for this stock between 2006 and 2014.

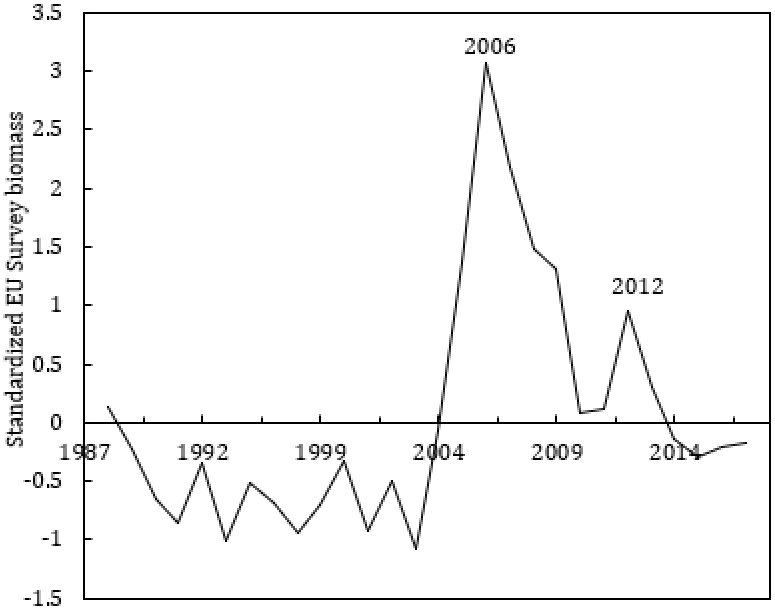


Fig. 7.2. Beaked redfish in Div. 3M: surveys standardized total biomass index (1988 – 2017)

c) Conclusions

The perception of the stock status has not changed.

The next assessment is planned for 2019.

d) Research recommendations

STACFIS **recommended** that, *in order to confirm 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 and to the size structure of the redfish most affected by cod predation, the existing feeding data from the past EU surveys be analyzed and made available.*

STATUS: Research work in progress.

STACFIS reiterated its **recommendation** that *the important line of ecosystem research based on the feeding sampling routine of the EU survey catch be done on an annual basis.*

STATUS: This recommendation has not yet been addressed.

8. American Plaice (*Hippoglossoides platessoides*) in Div.3M

Interim Monitoring Report (SCR Doc. 18/008; SCS Doc 18/08, 13)

a) Introduction

A total catch of 157 tons (156 tons landed and 1 tons discarded) was reported for 2017 (Fig. 8.1).

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

	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
TAC	ndf	ndf	ndf	ndf	ndf	ndf	ndf	ndf	ndf	ndf
STATLANT 21	0.1	0.2	0.1	0.1	0.2	0.2	0.2	0.2	0.2	
STACFIS	0.1	0.1	0.1	0.1	0.1	0.2	0.3	0.2	0.2	

ndf No directed fishing.

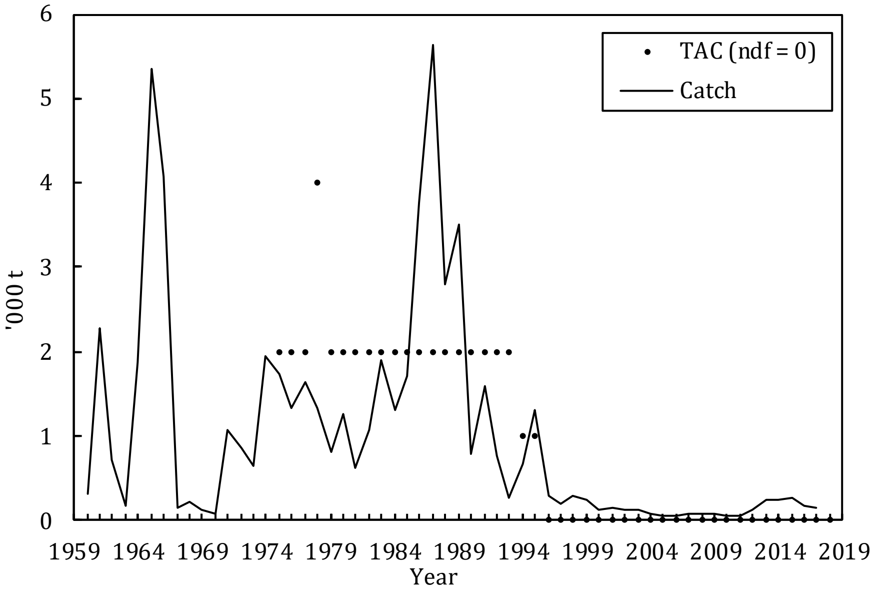
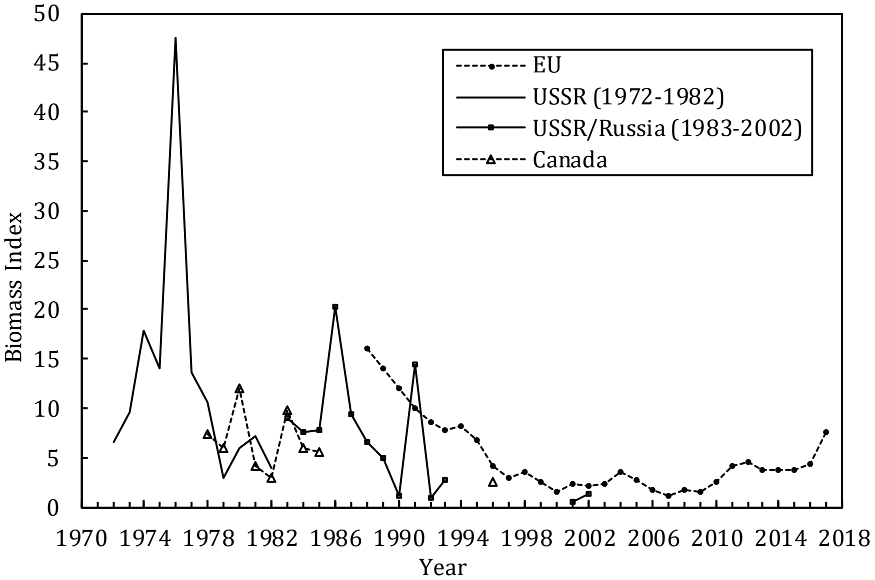


Fig. 8.1. American plaice in Div. 3M: STACFIS catches and TACs. No directed fishing is plotted as 0 TAC.

b) Data Overview

The EU bottom trawl survey on Flemish Cap was conducted during 2017. The survey estimates improved in recent years, but remained at low levels (Fig. 8.2).

All of the 1991 to 2005 year classes are estimated to be weak. Since 2006 the recruitment improved, particularly the 2006 year class.



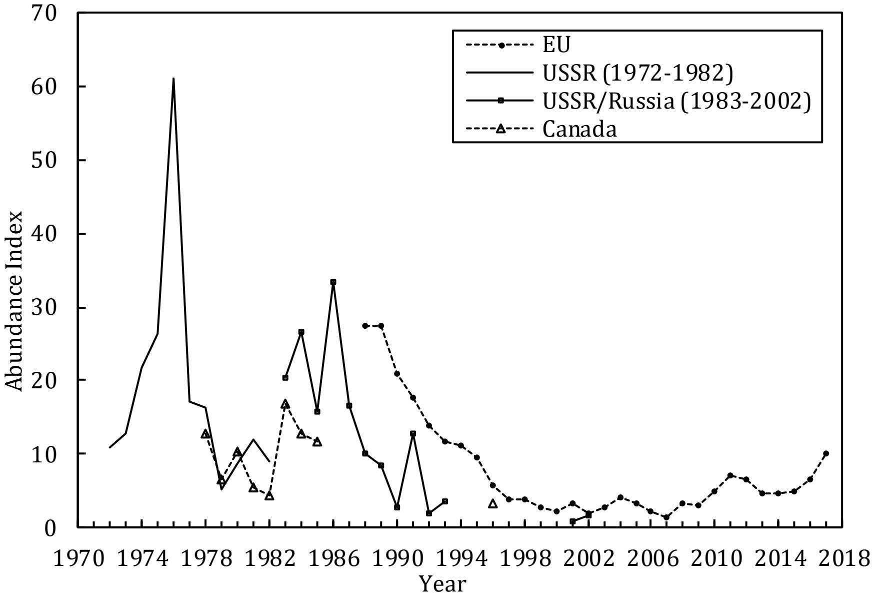


Fig. 8.2. American plaice in Div. 3M: trends in survey biomass and abundance indices. EU survey data prior to 2003 have been converted to *RV Vizconde Eza* equivalents.

c) Conclusion

Although the stock has increased slightly in recent years due to improve recruitment since 2009 (2006 year-class) it continues to be in a poor condition. Although the level of catches since 1996 is low, all the analysis indicates that this stock remains at a low level. There is no major change to the perception of the stock status.

d) Research recommendations

STACFIS **recommends** that *several input frameworks be explored in both models (such as: q's; M (e.g. in relation to $F_{0.1}$); ages dependent of the stock size; the proxies and its distribution in the VPA-type Bayesian model).*

No progress was made this year. STACFIS recommends that the work continue in order to explore the possibility of using the results to estimate stock size and to calculate reference points. Other types of models should also be explored.

Due to the recent recruitment improvement at low SSB, STACFIS **recommends** *exploring the Stock/Recruitment relationship and Blim.*

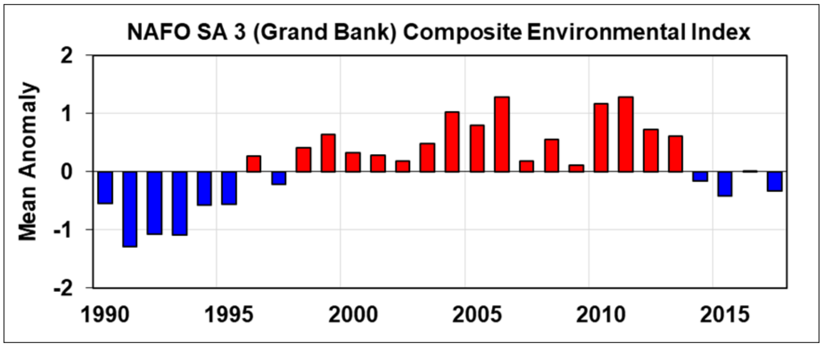
With the income of recent good year-classes at low SSB it is not possible at the moment to define a SSB/R relationship.

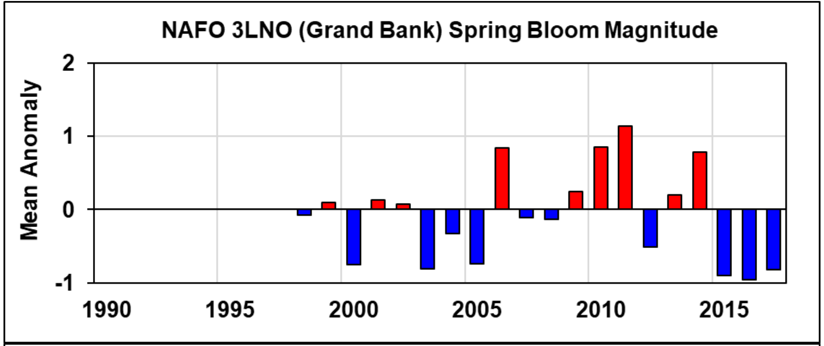
The next assessment is planned for 2020.

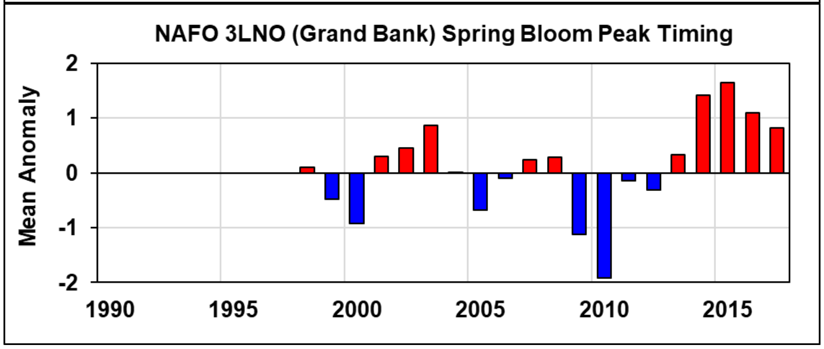
C. STOCKS ON THE GRAND BANK: SA 3 AND DIVS.3LNO

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 with below normal conditions in 2017, similar to 2015.
- The total production (magnitude) of the spring bloom remained well below normal in 2017 for a third consecutive year. The past three years have yielded the lowest anomalies of the time series including a record-low in 2016.
- Spring bloom peak timing was later than normal for the reference period for the fifth consecutive year.
- The composite zooplankton abundance index has remained above normal since 2009, with a record-high in 2016.During the same period, the zooplankton biomass index has remained near or below normal.


NAFO SA 3 (Grand Bank) Composite Environmental Index


NAFO 3LNO (Grand Bank) Spring Bloom Magnitude


NAFO 3LNO (Grand Bank) Spring Bloom Peak Timing

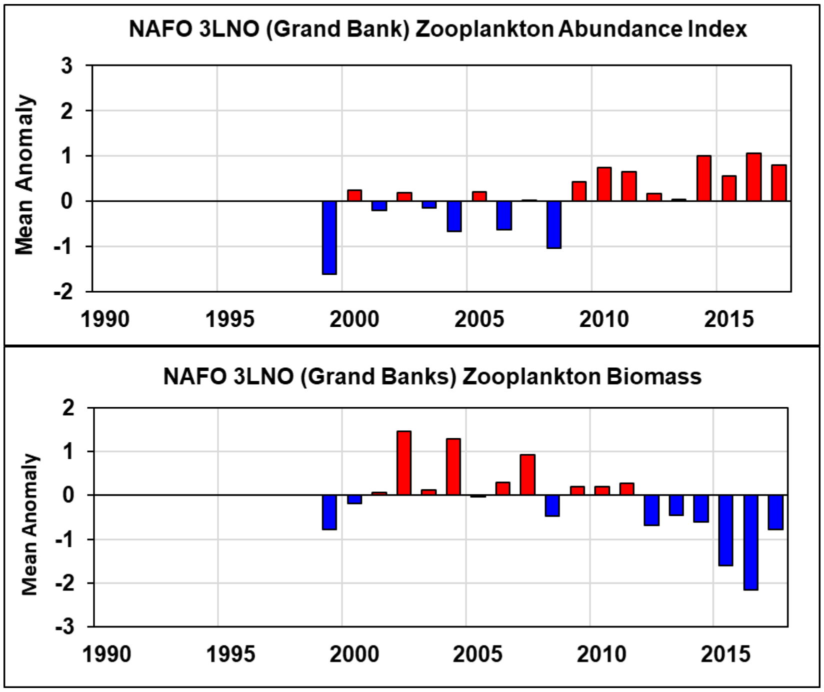


Fig. C1. Environmental composite index for NAFO Div. 3LNO derived from meteorological and physical oceanographic (sea ice, water temperature, salinity and CIL area) conditions during 1990-2017 (top panel). Phytoplankton spring bloom magnitude (2nd panel) and peak timing (3rd panel) in NAFO Div. 3LNO during 1998-2017. Zooplankton abundance composite index (4th panel) derived from copepod (total copepods, *Calanus finmarchicus*, *Pseucalanus* spp.) and non-copepod abundances (5th panel), and zooplankton biomass anomaly (5th panel) in NAFO Div. 3LNO during 1999-2017. Positive/negative anomalies indicate conditions above/below (or late/early timing) the long-term average for the reference period. All anomalies are mean standardized anomaly calculated using the following reference periods: climate index: 1981-2010; phytoplankton indices (magnitude and peak timing): 1998-2015; zooplankton (abundance and biomass) indices: 1999-2015.

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 <0ºC 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 - 4ºC, 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 - 8ºC 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, rebounded to normal conditions in 2016 but returned to a negative value in 2017 (Figure 1, top panel). Spring bloom total production (magnitude) bloom remained well below normal in 2017 for a third consecutive year, yielding the lowest anomalies of the time series including a record-low in 2016. This contrasts with nine years of near to above normal phytoplankton production observed between 2006 and 2014 (Figure 1, 2nd panel). Despite a steady anomaly decrease since a record-high in 2015, spring bloom peak timing was later than normal for a 5th consecutive year (Figure 1, 3rd panel). The zooplankton abundance index has remained above normal since 2009, with a record-high in 2016 (Figure 1, 4th panel). During this period, zooplankton biomass has remained mostly below normal with the two lowest values of the time series observed in 2015 and 2016 (Figure 1, 5th panel. At Station 27 off St. John's (considered representative of most of the northern Grand Banks) the annual bottom (176 m) temperature/salinity anomalies were -0.2°C/-0.12 (0.6/1.6 SD) 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 below about normal during the summer of 2017 by -0.6 SD. The spatially averaged spring and fall bottom temperature in NAFO Divs. 3LNO was 1.4° (-0.2 SD) and 1.3°C (-1.2 SD), respectively.

9. Cod (*Gadus morhua*) in NAFO Divs. 3NO

SCR 18/11,17,28; SCS 18/5,6,7,8,13,14,15)

a) Introduction

This stock has been under moratorium to directed fishing since February 1994. Since the moratorium catch increased from 170 t in 1995, peaked at about 4 800 t in 2003 and has been between 600 t and 1100 t since that time. The catch in 2017 was 637 t.

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

	2009	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**
TAC	ndf	ndf	ndf	ndf	ndf	ndf	ndf	ndf	ndf	ndf
STATLANT 21	0.6	0.8	0.8	0.7	1.1	0.7	0.5	0.6	0.6	
STACFIS	1.1	0.9	0.8	0.7	1.1	0.7	0.6	0.7	0.6	

ndf : No directed fishery

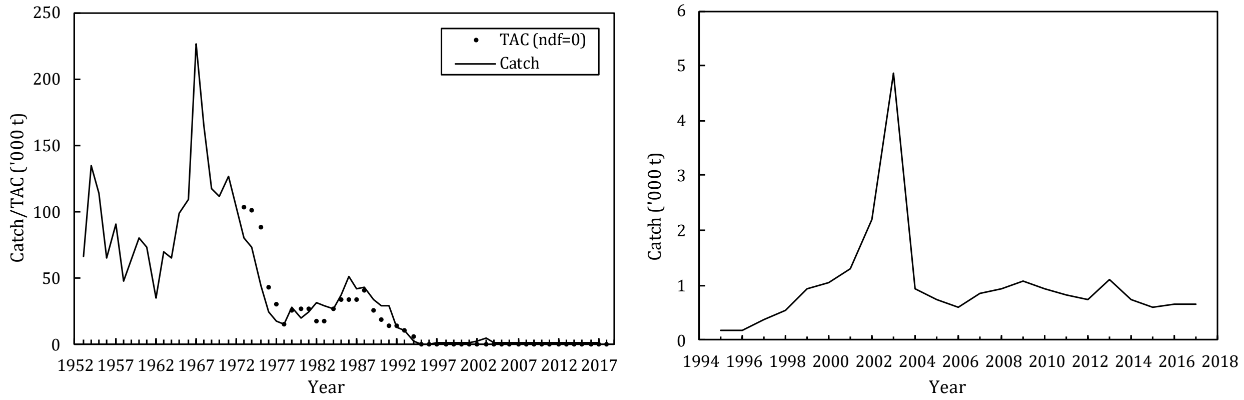


Fig. 9.1. Cod in Div. 3NO: total catches and TACs. Panel at right highlights catches during the moratorium on directed fishing.

b) Data Overview

This assessment utilizes commercial catch at age data for 1959-2017 along with data from Canadian spring (1984-2017), autumn (1990-2017), and juvenile (1989-1994) surveys. As per previous assessments, trends in the EU-Spain survey were presented but not used as input to the assessment model.

i) Commercial fishery data

Catch-at-age. The calculation of catch numbers and weights at-age in recent years has been complicated by low sampling of bycatch. This has led to concern over the reliability of catch at age estimates and ultimately added an unquantified level of uncertainty to the assessment results. Specifically, there were no Canadian length data available for 2015-2017 and no Portuguese sampling for 2017. In these instances, EU-Spain length frequencies were applied to catches. For 2015-2016, length sampling was available from both EU-Spain and EU-Portugal. The catch-at-age for all fleets was constructed by applying Canadian survey age length keys. Results indicate that the most abundant ages in the commercial catch were 3-6 in 2015, 3-5 in 2016, and 3-4 in 2017.

ii) Research survey data

Canadian bottom trawl surveys. The spring survey biomass index declined from 1984 to 1995 and has generally remained low since that time (Fig. 9.2). There was an increase in biomass during 2011-2014 but indices have subsequently declined again and the 2017 biomass index is the lowest in the time series. Trends in biomass are similar for the spring and autumn surveys and trends in abundance and biomass are similar except for 2011-2014, when biomass increased while abundance remained stable (Fig. 9.2).

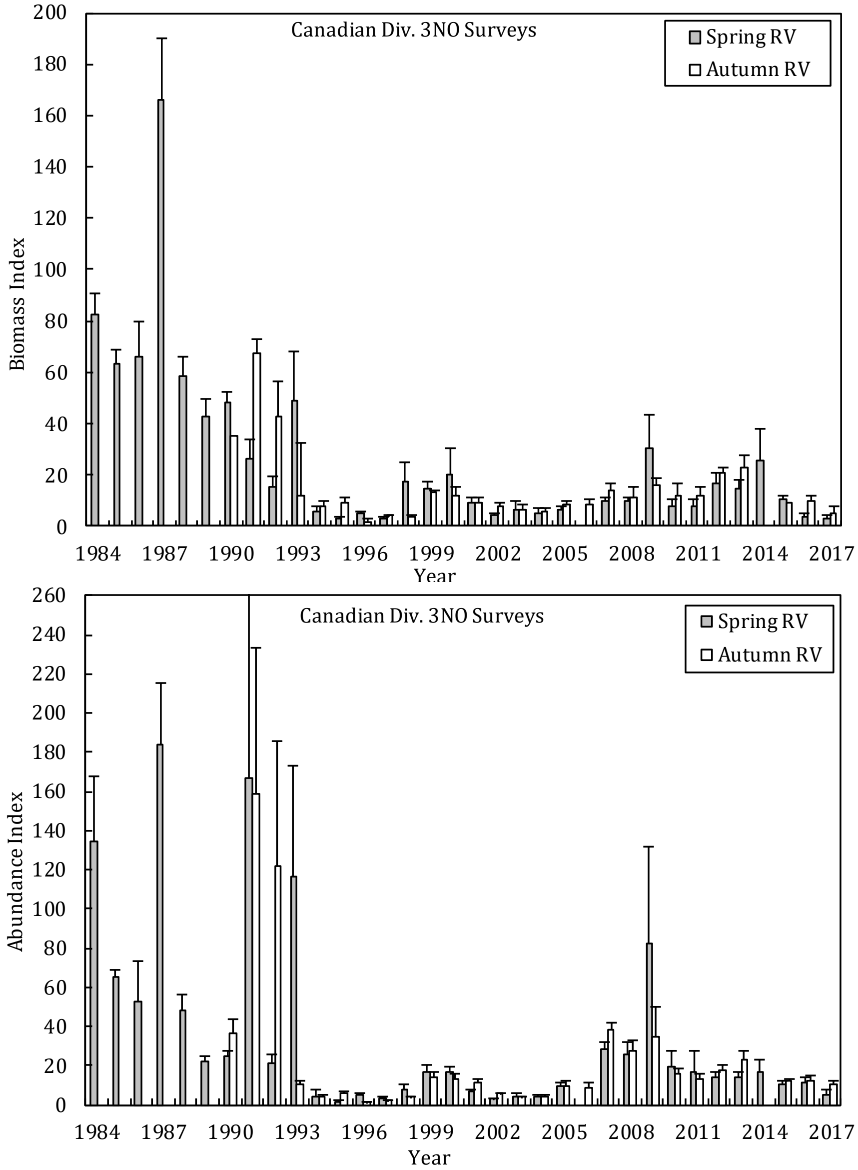


Fig. 9.2. Cod in Div. 3NO: survey biomass and abundance indices (+ 1 sd) from Canadian Spring and autumn surveys.

Canadian juvenile surveys. The index increased from 1989 to 1991, and declined steadily from 1992 to 1994 (Fig. 9.3).

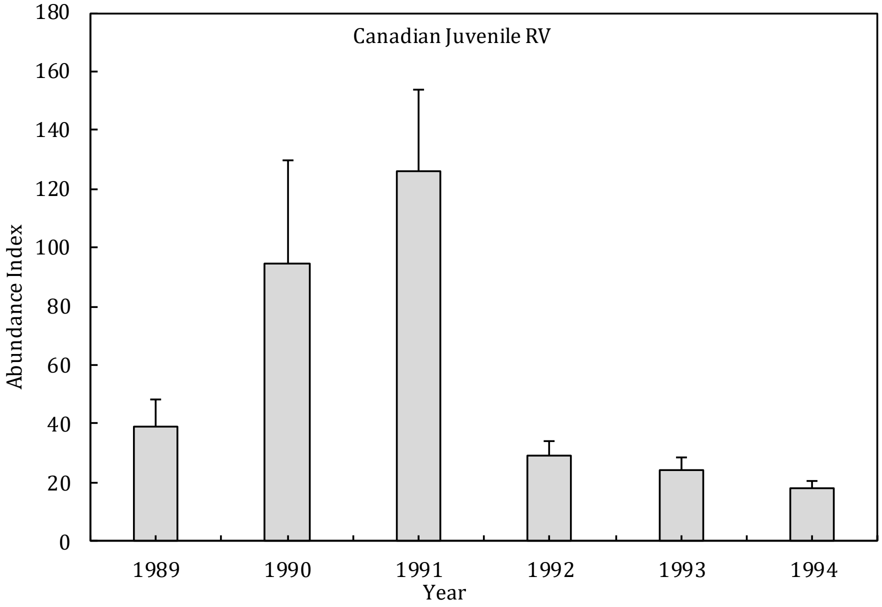


Fig. 9.3. Cod in Div. 3NO: survey abundance index (+ 1 sd) from Canadian Juvenile surveys.

EU-Spain Div. 3NO surveys. The biomass index was relatively low and stable from 1997-2005 with the exception of 1998 and 2001 (Fig. 9.4). There was a considerable increase in the index from 2008-2011, followed by a decline to 2013. In 2014, the index increased to the highest value in the time series but has continually decreased in subsequent years.

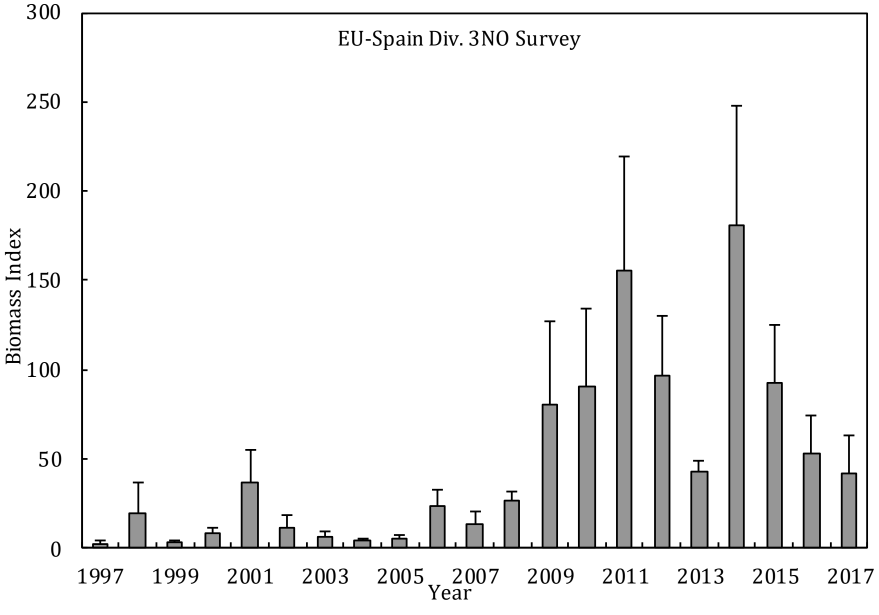


Fig. 9.4. Cod in Div. 3NO: survey biomass index (+ 1 sd) from EU-Spain Div. 3NO surveys.

iii) Biological Studies

Maturity-at-age

Annual proportion mature is modeled by cohort. The estimated age at 50% maturity (A50) ranged between 5.6 and 7.4 years for cohorts produced from the 1950s to 1980s. Age at 50% maturity declined for cohorts between 1980 and the late 1990s from approximately 6.8 to 4.5 years. Since that time estimates of A50 have been variable, with the most recent estimable cohorts (2009-2011) ranging from 5.0 to 5.4 years.

c) Estimation of Parameters

Sequential population analysis (SPA)

An ADAPT was applied to catch-at-age calibrated with the Canadian spring, autumn and juvenile survey data (ages 2-10). The SPA formulation estimated numbers at ages 3-12 in 2018, age 12 from 1994-2017 and survey catchabilities at ages 2-10 for each survey. In the estimation, an *F*-constraint was applied to age 12 from 1959-93 by assuming that fishing mortality was equal to the average fishing mortality over ages 6-9. Natural mortality was assumed fixed at 0.2 for all years and ages. The mean square error of the model fit was 0.611.

d) Assessment Results

Biomass: The SPA results calibrated with the three Canadian survey indices indicate that the spawning stock was at an extremely low level in 1994 and remained stable at a low level to 2010. SSB increased to 2015 but has subsequently declined and the 2018 estimate of 18,537 t represents only 31% of B_{lim} (60,000 t).

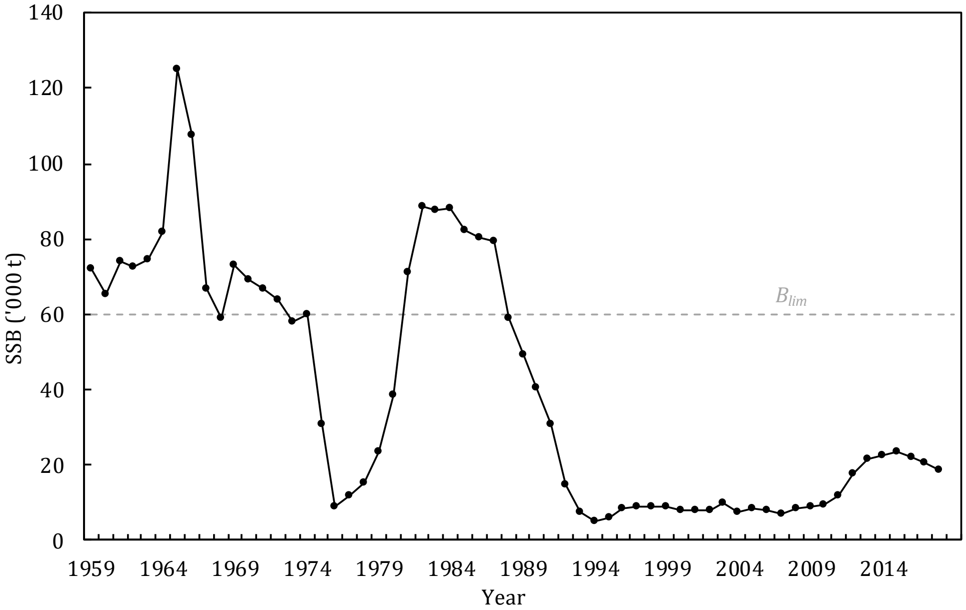


Fig. 9.5. Cod in Div. 3NO: time trend of spawner stock biomass (SSB) from the SPA.

Recruitment: The 2005-2006 year classes were estimated to have the highest levels of recruitment in the past two decades, with levels comparable to those from the mid - late 1980s but well below historic values (Fig. 9.6). Estimated recruitment has not been as strong for subsequent year classes.

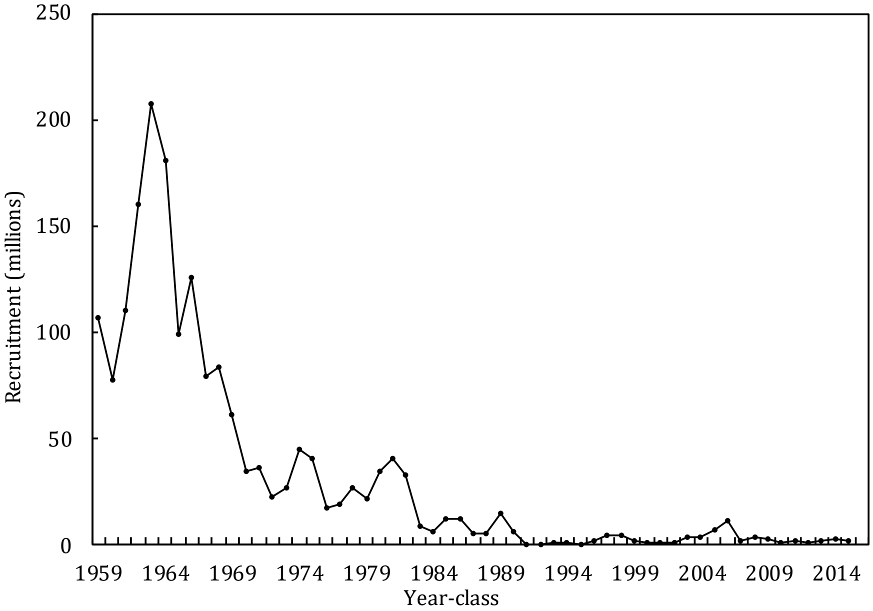


Fig. 9.6. Cod in Div. 3NO: time trend of recruitment (age 3) from the SPA.

Fishing mortality: Fishing mortality was low in the early years of the moratorium but then increased and peaked in 2003 (Fig. 9.7). Fishing mortality over the past decade has been amongst the lowest values in the time series and well below F_{lim}.

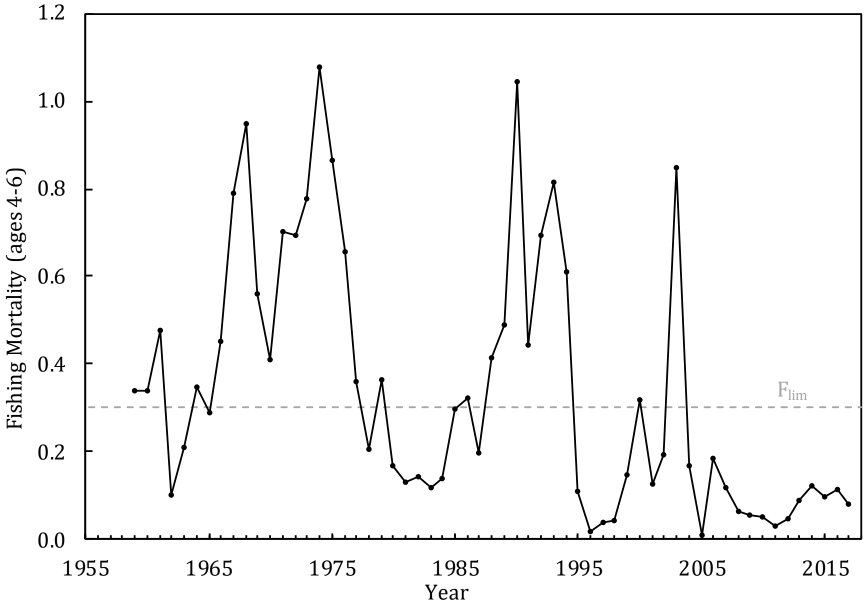


Fig. 9.7. Cod in Div. 3NO: time trend of average fishing mortalities from the SPA.

STACFIS notes that recent stock trends in SSB differ between this and the previous (2015) assessment. The previous assessment estimated SSB in 2015 to be 64% of Blim, whereas the current estimate for 2015 is only 39% of Blim. Differences result from the fact that weights at age for 2015 (i.e. the terminal year) in the 2015 assessment were simply the average of the three previous years, whereas the current assessment uses actual estimates of weights at age for 2015 that were not available at the time of the previous assessment. These new weights at age for 2015 are much lower than the mean values used in the previous assessment and result in lower estimates of SSB.

e) State of the Stock

The spawning biomass increased noticeably between 2010 and 2015 but has subsequently declined and the 2018 estimate of 18,537 t represents only 31% of Blim (60,000 t). The 2006 year class remains relatively strong and at age 12 in 2018 makes up more than half of the estimated SSB. Subsequent year classes are much weaker, suggesting that the medium-term prospects for the stock are not good. Fishing mortality values over the past decade have been low and well below F_{lim} (0.3).

f) Retrospective Analysis

A retrospective analysis was conducted to investigate whether there were systematic trends in the estimates of population size. A 5-year period was chosen to evaluate, whereby a complete year of data was removed in succession from the model but the formulation remained the same. Retrospective patterns were relatively small, but with a tendency for overestimation of SSB (Fig. 9.8).

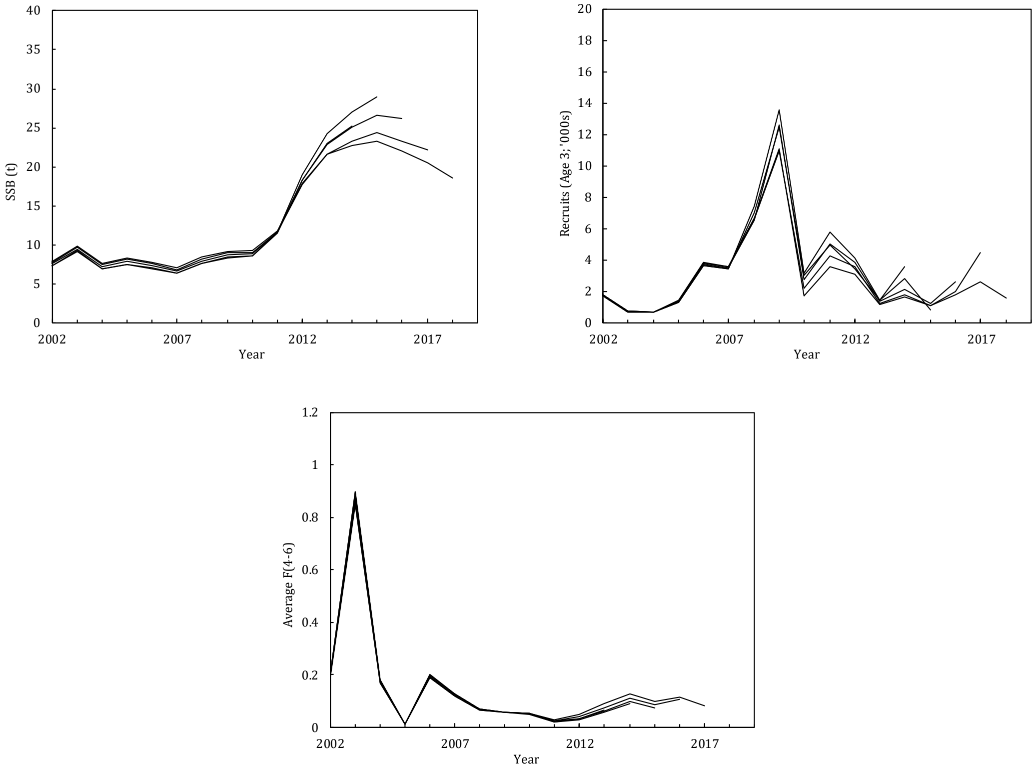


Fig. 9.8. Cod in Div. 3NO: Five-year retrospective analysis of SSB, age 3 recruitment and average F on ages 4-6.

g) Reference Points

Mean fishing mortality for ages 4-6 in 2017 was estimated to be 0.08, well below the F_{lim} of 0.3 (Fig. 9.9). The current estimate of B_{lim} is 60,000 t, the point below which only poor recruitment has been observed. SSB in 2018 is estimated to be 18,537 t which is 31% of B_{lim}.

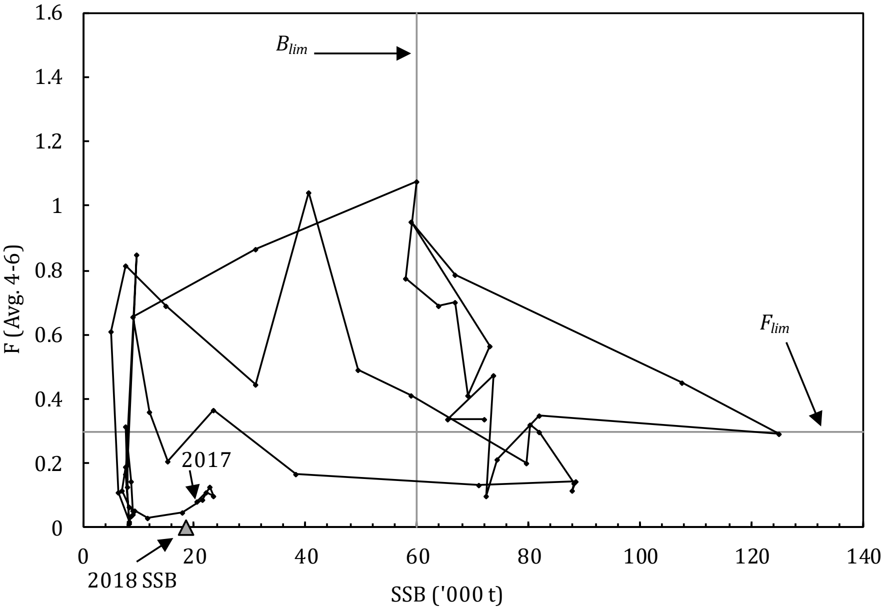


Fig. 9.9. Cod in Div. 3NO: stock trajectory (1959-2017) within the NAFO PA framework.

h) Short-Term Considerations – Stochastic Projections

A decision was made to not project the stock forward because the 2006 year class, which in 2018 is age 12 and makes up more than half of the estimated SSB, will no longer be part of the virtual population starting in 2019. This is a limitation of the current model formulation which ends at age 12 (i.e. there is no plus group) and any attempt to project the stock forward would be characterized by the 'artificial' removal of this strong year class from the population. Revising the assessment model to incorporate a plus group is considered of high priority for this assessment going forward. Although projections of the stock were not performed, the poor strength of year classes subsequent to 2006 suggests that the medium-term prospects for the stock are not good.

The next assessment is planned for 2021.

i) Research Recommendations:

STACFIS **recommends** *as a priority investigating the potential use of a plus group in the assessment of Divs. 3NO cod.*

STATUS: Work is ongoing to reconstruct catch-at-age with a plus-group for all years.

STACFIS **recommends** *continuing to monitor the consistency in trends between the Canadian and EU-Spain surveys.*

STATUS: Work is ongoing to examine the consistency among surveys and will continue in future assessments.

STACFIS **recommends** *investigating the removal of the pre-1995 Canadian autumn assessment points for an improvement in model fit / residual pattern.*

10. Redfish (*Sebastes mentella* and *Sebastes* fasciatus) in Divs. 3L and 3N

(SCR Doc. 18/012, 18/017, 18/018, 18/033; SCS Doc. 18/05, 18/06, 18/07, 18/08, 18/13)

a) Introduction

There are two species of redfish in Divisions 3L and 3N, the deep-sea redfish (*Sebastes mentella)* and the Acadian redfish (*Sebastes fasciatus*) that have been commercially fished and reported collectively as redfish in fishery statistics. Both species, occurring on Div. 3LN and managed as a single stock, don't belong to isolated local populations but, on the contrary, are part of a large Northwest Atlantic complex ranging from the Gulf of Maine to south of Baffin Island.

Between 1959 and 1960 reported catches drop from 44600 to 26600 t, oscillating over the next 25 years (1960-1985) around an average level of 21000 t. Catches rose afterwards to a 79000 t high in 1987 and fell steadily to a 450 t minimum reached in 1996. Catches remained at a low level (450-3 000 t) until 2009. The NAFO Fisheries Commission implemented a moratorium on directed fishing for this stock between 1998 and 2009. The fishery reopened in 2010 with a TAC of 3500 t. The Fisheries Commission endorsed the Scientific Council recommendations from 2011 onwards and catches increased, being at 11 800t in 2017, the highest level recorded since 1993 (Table 1, Fig. 1). Since the reopening in 2010 Canada, followed by Russia and EU-Portugal are the main partners of a fishery mostly deployed northwards, in Div. 3L.

A management strategy has been adopted for this stock based on a stepwise rule with biennial catch increases over the years 2015 to 2020 (NAFO/COM Doc. 18-01, NCEM)

	2009	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**
TAC	ndf	3.5	6	6	6.5	6.5	10.4	10.4	14.2	14.2
STATLANT 21	0.3	3.1	5.4	4.3	5.2	5.7	10.2	8.5	11.9	
STACFIS	1.1	4.1	5.4	4.3	6.2	5.7	10.2	8.5	11.8	

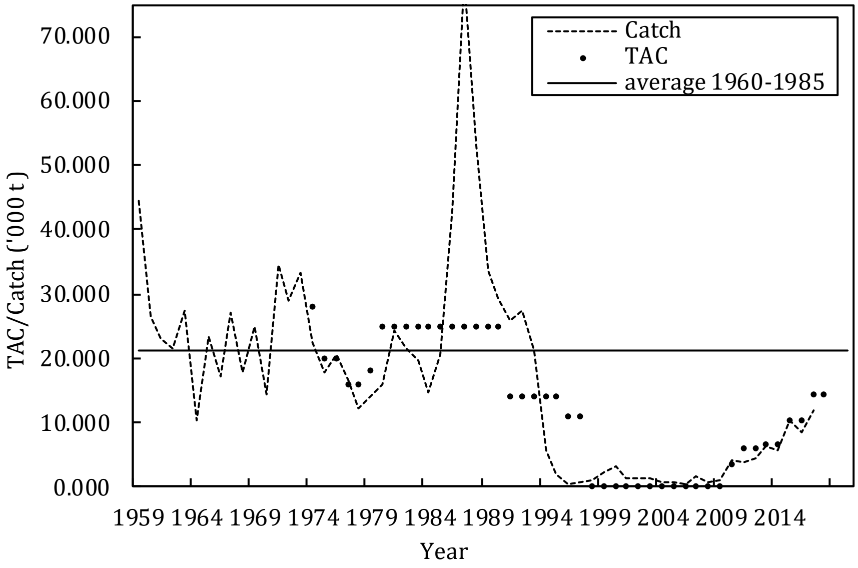


Fig. 10.1. Redfish in Div. 3LN: catches and TACs (No directed fishing is plotted as zero TAC)

b) Input Data

i) Commercial fishery data

Most of the commercial length sampling data available for the Div. 3LN beaked redfish stocks came, since 1990, from the Portuguese fisheries. Length sampling data from EU-Spain and from Russia were used to estimate the length composition of the by-catch for those fleets in several years. Above average mean lengths, an apparently stable catch at length with no clear trends towards smaller or larger length groups and proportions in numbers of small redfish (< 20cm) usually below 1%, are observed on most of the years of the 1990-2005 interval. Well below average mean lengths coupled with in excess of 10% of small redfish under 20cm in the catch occurred afterwards on most years between 2006 and 2015. And average proportion of small redfish in the commercial catch rose from 1.0% (1990-2005) to 13.9% (2006-2015).

However proportion of small redfish fell to 6.1% in 2016 and again to 2.3% in 2017 while the mean length in the catch gradually increased, approaching the overall 1990-2017 mean. Larger sizes are recently the bulk of the catch.

An important increase in the numbers of small redfish in the catch can reflect the income of one or more good recruitments but, on the contrary, a noticeable decline on this indicator, as observed on recent years, can signal that year classes coming in the fishery are now below average or even weak. And that exploitable stock is again basically relying on the survival of the year classes already recruited.

Research survey data

From 1978 to 1993, several stratified-random bottom trawl surveys have been conducted by Canada in various years and seasons in Div. 3L and in Div. 3N. Only those surveys where strata at depths greater than 366m were sampled are included.

Since 1991 two Canadian series of annual stratified-random surveys covered both Div. 3L and Div. 3N on a regular annual basis: a spring survey (May-Jun.) and an autumn survey (Sep.-Oct. 3N/Nov.-Dec. 3L for most years). No survey was carried out in spring 2006 and in autumn 2014 in Div. 3N. The coverage of Div. 3L was poor in the 2015 Canadian spring survey nonetheless this survey was included in the assessment. Again in the spring of 2017 there were problems with 3L survey coverage and none of the 3L strata in the redfish index were sampled, so last year is not included in the 3LN Canadian spring survey data set.

Since 1983 Russian bottom trawl surveys in NAFO Div. 3LMNO changed to stratified-random, following the Canadian stratification for Sub area 3. In 1992 and 1994 Russian survey was carried out only in Div. 3L. In 1995, the Russian bottom trawl series in NAFO Sub area 3 was discontinued.

In 1995 EU-Spain started a new stratified-random bottom trawl spring (May-June) survey in NAFO Regulatory Area of Div. 3NO. The Div. 3N EU-Spain spring survey series (1995-2017) has been included in the assessment framework since 2010. The EU-Spain survey in Div. 3L of NAFO Regulatory Area (Flemish Pass) was initiated by EU-Spain in 2003. However only in 2006, for the first time, an adequate prospecting survey was conducted in Division 3L. This survey is included in the assessment framework since 2016.

See section c) for details of which surveys are used in the assessment. Details on the two Canadian survey series, as well as on the Russian series and the two Spanish surveys can be found on previous assessment reports.

The survey biomass series used in the assessment framework and the female SSB survey series were standardized to zero mean and unit standard deviation and so presented on Figure 10.2. From the late 1970s to the beginning of the 1990s Canadian surveys in Div. 3L and Russian bottom trawl surveys in Div. 3LN suggest that stock size suffered a substantial reduction. Redfish bottom biomass from surveys in Div. 3LN remained well below average level over the 1990's and early 2000's, but since 1997 those indices start to show some dynamics of increase. Clear increases of survey biomass are evident in 2007-2015, but, with the exception of the 2016 Canadian 3LN spring, the other ongoing surveys went down in 2016-2017.

Both 1991-2017 Canadian spring and autumn standardized female SSB survey series for Div. 3LN have trends concurrent to their correspondent biomass series (Fig. 10.2).

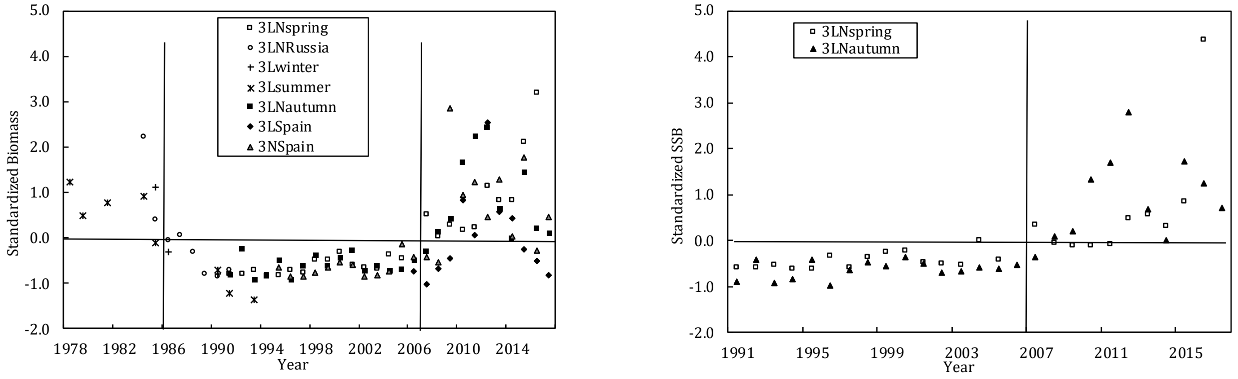


Fig. 10.2. Redfish in Div. 3LN: standardized survey biomass (1978-2017, left panel) and female spawning biomass (1991-2017, right panel). Each series standardized to zero mean and unit standard deviation. Vertical bars indicate periods when indices cross average levels.

During the first half of the 1990's, on both surveys, the length anomalies were negative or slightly positive. Mean lengths on most of the years between 1996 and 2007 (spring survey) or 2006 (autumn survey) were above the mean, reflecting a shift on the stock length structure to larger individuals. Between 2007-2008 and 2011-2012 mean lengths generally fall and stay below average (Fig. 10.3), just as observed on the commercial catch at length, suggesting the occurrence of good recruitments by the late 2000's.

On 2016-2017, from Canadian surveys, mean length in the stock increased but the numbers of fish =>20cm declined. This is not only observed in the stock but in commercial catch as well.

All these indicators suggest that the stock is not is not growing, and has either reach a stable level or is making a downward turn.

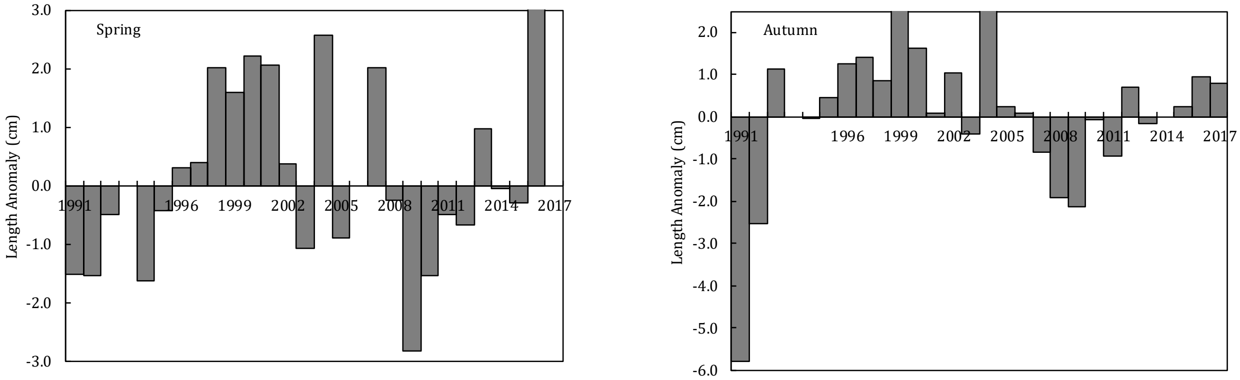


Fig. 10.3. Redfish in Div. 3LN: annual anomalies of the mean length in the spring and autumn survey, 1991-2017.

Recruitment

Between 2006-2007 and 2009-2010 the recruitment index (numbers of redfish < 20cm) increased rapidly both in commercial catch and Canadian surveys, reaching by then maximum values. The recruitment index drops fast on the following years and is at low levels since 2014-2015 (Fig. 10.4).

Nevertheless, unusual high numbers of very small redfish pre recruits (5-12cm) have been observed on recent years (2015-2017) on Canadian spring and autumn surveys.

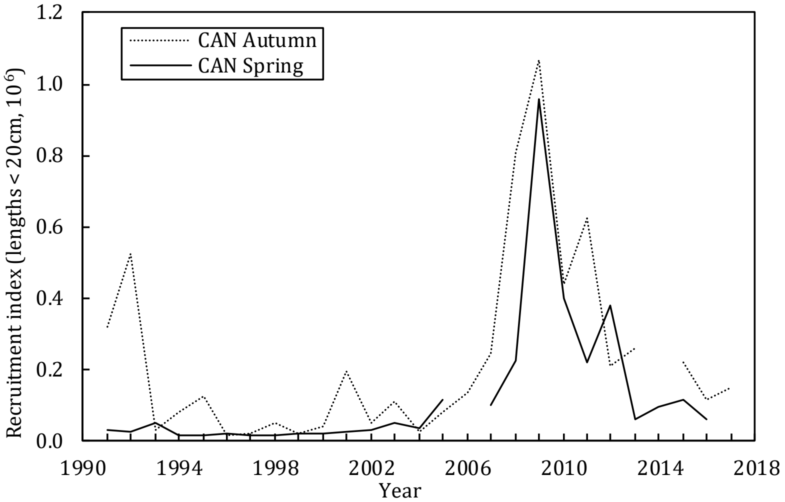


Fig. 10.4. Redfish in Divs. 3LN: Recruitment index (lengths < 20 cm) from spring and autumn Canadian rv surveys in NAFO 3LN, 1991-2017.

c) Assessment Results

A non-equilibrium surplus production model (ASPIC; Prager, 1994) is used to assess the status of the stock since 2008. Until 2012 the model was adjusted to an array of Canadian, Russian and Spanish surveys series arranged under the formulation adopted by STACFIS. However the model showed an increasingly poor fit to recent survey biomass increases observed from the second half of the 2000's onwards on all the ongoing surveys. Selective elimination of outliers, in order to get a picture in line with the perception of the stock history from commercial and survey data trends, was no longer a valid option, as reflected in a STACFIS research recommendation on this matter (NAFO, 2012).

In the 2014 assessment the purpose was to reach an inclusive approach that would incorporate most, if not all, of the surveys points available for the two divisions while at the same time delivering a "realistic" output in line with the perception of stock and fishery dynamics given by historical commercial and survey data. From exploratory analysis the better framework to run the 2014 assessment had MSY fixed at a user starting guess of 21000 t. This *MSY proxy* is the average level of sustained catch for the 1960-1985 interval, when the stock experienced an apparent stability, suggested either by the STATLANT CPUE series or available surveys, before declining in response to a sudden rise of catch level. This framework also kept negative correlated STATLANT CPUE series and all "outliers" in their respective survey series, while Canadian autumn surveys on Div. 3L and Div. 3N were assembled in a single 3LN Canadian autumn series. While fixing the MSY level is not common, it was justified in this case as levels generated from models that freely estimated B_{msy} were unrealistic (estimating MSYs of more than 100 000 tonnes). Therefore MSY was fixed in the model and the results are conditioned on this assumption.

This assessment keeps the selected arrangement of input series considered on 2016 the better framework to run the redfish 3LN ASPIC: with MSY fixed at 1960-1985 average catch, the suite of survey time series already approved for the 2014 assessment, updated and now including the 3L Spanish survey.

The input series of this assessment are:

I1 (Statlant CPUE and catch)	Statlant cpue for Div. 3LN,$_{\text{1959-1994}}$ & catch for Div. 3LN $_{\text{1959-2017}}$
I2 (3LN spring survey)	Canadian spring survey biomass for Div. 3LN, $_{\text{1991-2005, 2007-2016}}$
I3 (3LN autumn survey)	Canadian autumn survey biomass for Div. 3LN, $_{\text{1991-2017}}$
I4 (3LN Power russian survey)	Russian spring survey biomass for Div. 3LN , $_{\text{1984-1991 (Power and Vaskov,1992)}}$
I5 (3L winter survey)	Canadian winter survey biomass for Div. 3L, $_{\text{1985-1986 and 1990}}$
I6 (3L summer survey)	Canadian summer survey biomass for Div. 3L$_{\text{, 1978-1979, 1981,1984-1985, 1990-1991and 1993}}$
I7 (3L autumn survey)	Canadian autumn survey biomass for Div. 3L, $_{\text{1985-1986, 1990}}$
I8$_a$ (3N spring spanish survey$_{\text{long}}$)	Spanish survey biomass for Div. 3N, $_{\text{1995-2017}}$
I9 (3L summer spanish survey)	Spanish survey biomass for Div. 3L, $_{\text{2006-2017}}$

All 1959-2010 catches used in this assessment are the catches adopted by STACFIS for this stock. The 2011-2016 catches were taken from the NAFO STATLANT 21 data base. Last year's catch (2017) was estimated with the CEDAG method and given by the NAFO Joint Commission-Scientific Council Catch Estimation Strategy Advisory Group (COM-SC CESAG, 2018).

In this assessment the ASPIC version 7.03 (Prager, 2015) fit the logistic form of the production model (Schaefer, 1954). The model requires from the user a set of initial definitions/starting guesses/constraints that need to be specified in the input file. Control parameters are kept from the 2014 and 2016 assessments and line-by-line details of all input settings can be found on the correspondent reports.

However, problems were found this year on the run of ASPIC boot with too many trials replaced due to *q*'s and B1/K estimates at their bounds. At the start of the 2018 assessment the user guess catchabilities (*q*'s) of the nine input data sets stayed as follows:

- STATLANT CPUE, 9.007E-06 (*q* of STATLANT CPUE for Div. 3M redfish ASPIC assessment, Ávila de Melo *et al.* 2003);
- spring survey on Div. 3LN combined, 1;
- autumn survey on Div. 3LN, 1;

- Russian survey on Div. 3LN combined, 1;
- winter survey on Div. 3L, 0.322 (average 1991-2009 3L/3LN spring survey biomass ratio times average 1991-2009 spring 3LN/autumn 3LN survey biomass ratio);
- summer and autumn survey on Div. 3L and Spanish survey on this division 0.275 (average 1991-2009 3L/3LN autumn survey biomass ratio);
- Spanish survey on Div. 3N 0.759 (average 1991-2009 3N/3LN Canadian autumn survey biomass ratio).

But taking into account the problems found, the user guess catchabilities for each of the 9 data sets were found by a 3 steps proceeding:

1 *q* user guess = average ratio survey biomass (one division)/survey total biomass (two divisions)
or 1.00E+00 in the case of q for two divisions combined ## q (starting guesses -- 1 per data series)
9.01E-06 1.00E+00 1.00E+00 1.00E+00 3.22E-01 2.75E-01 2.75E-01 7.59E-01 2.75E-01

2 *q* user guess = q max bound of ASPIC.fit run with *q* user guess 1
9.01E-04 6.00E+00 6.00E+00 6.00E+00 1.20E+00 1.20E+00 1.20E+00 4.55E+00 1.20E+00

3 *q* user guess= q estimate of ASPIC.fit run with *q* user guess 2
1.50E-05 8.85E-01 8.85E-01 3.17E-01 2.49E-01 1.03E+00 2.30E-01 8.75E-01 6.61E-01

From this stage on the *q*'s at step 3 were the user guess that started all runs of the 2018 assessment.

ASPIC2018 run first on deterministic (FIT) mode. Key results, and relative biomass and fishing mortality trajectories are presented on Table 10.1 and Fig. 10.5 respectively in comparison with the same results from previous 2014 and 2016 assessments.

Table 10.1. ASPIC2018 versus ASPIC 2016 and ASPIC 2014: comparison of main results from deterministic run. (*same input framework but ASPIC 2014 without 3L Spain survey, ASPIC 2016 and 2018 with 3L Spain survey*)

	MSY(1)	*B1/K*	*Fmsy*	*Flastyear/Fmsy*	*Ye* (2)	*Bmsy*	*B* (3) */Bmsy*
ASPIC2018	*21000*	**0.6976**	**0.1122**	0.3759	15600	**187100**	1.5070
ASPIC2016	*21000*	**0.6874**	**0.1116**	0.3640	17820	**188200**	1.3890
ASPIC2014	*21000*	0.6764	0.1097	0.2136	18120	191500	1.3710

(1) fixed at the starting guess.

(2) estimate for 2014 from ASPIC2014, estimate for 2016 from ASPIC 2016 and estimate for 2018 from ASPIC 2018.

(3) at the beginning of 2014 from ASPIC2014, at the beginning of 2016 from ASPIC 2016 and at the beginning of 2018 from ASPIC 2018

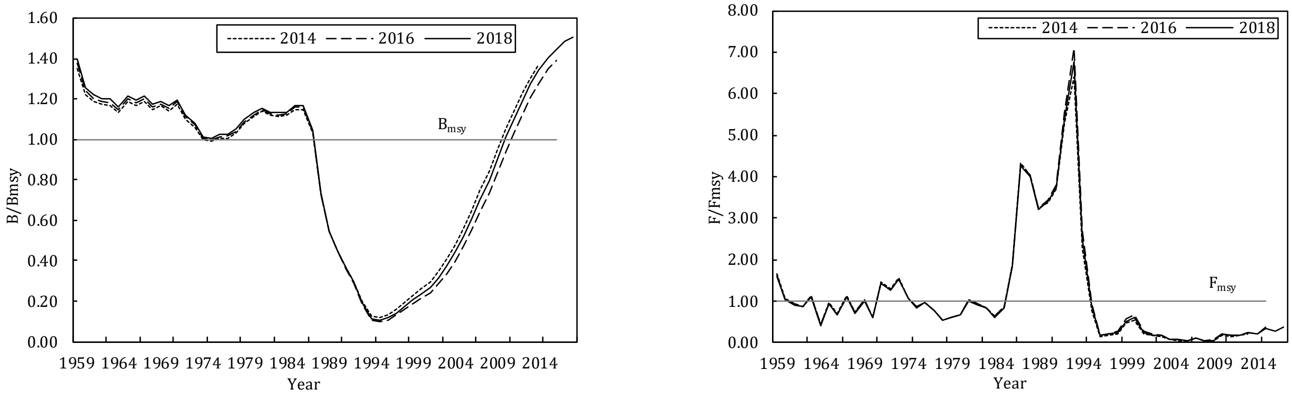


Fig. 10.5. Redfish in Divs. 3LN*: B/B_{msy}* (left) and *F/F_{msy}* (right) from ASPIC$_{fit}$ 2018 versus ASPIC$_{fit}$ 2016 and ASPIC$_{fit}$ 2014 assessments.

In terms of biomass dynamics results showed a good nearness index, crossing twice *B_{msy}* and presenting good contrast. Besides no correlation between series with a very small number of pair-wise observations, 3L Spanish don't fit with 3LN spring survey and is poorly correlated with 3N Spanish as well. But in turn 3L Spanish has a good correlation with 3LN autumn survey, both declining on 2016-2017, so despite the caveats the survey stayed.

From the correlations between series and between model results and respective data sets it is clear at this stage the existing of two conflicting trends, one upwards based on the 3LN spring and another downwards pulled by the 3LN autumn survey, with the help of the 3L Spain set.

As a consequence of these conflicting trends, correlation among input series generally decrease and unfitness of the model to the main surveys increased from last 2016 assessment.

To investigate whether or not there was statistical evidence of model mis-specification, the Wald-Wolfowitz runs-test was carried out on the residuals of the fits of the surplus production model to the four abundance indices that cover recent years: 3LSpain, 3NSpain, 3LNautumn and 3LNspring. The respective p-values under the hypothesis of independence of the residuals for each of these series were respectively 0.030, 0.670, 0.313 and 0.369, i.e. only for the 3LSpain series is the hypothesis of independence of residuals rejected at the 5% level, which would in turn indicate model mis-specification. This supported the acceptance of the model.

There was good consistency within results and trends between the three last assessments (2014, 2016 and 2018) with stock biomass increasing well above *B_{msy}* and a fishing mortality still kept well below *F_{msy}*.

A summary of estimates from bootstrap analysis are presented in Table 10.2.

Table 10.2. ASPIC2018 main results from bootstrap analysis

	ASPIC	Point	Bias-corrected approximate confidence limits				Inter-quartile	Relative
Param. name	assessment	estimate	80% lower	80% upper	60% lower	60% upper	range	IQ range
B1/K	2018	0.6976	0.5683	1.0900	0.5984	0.8817	0.2186	0.3130
MSY	2018	21000	NA	NA	NA	NA		
Ye Last year+1	2018	15600	12040	20330	12890	19060	4907	0.3150
Bmsy	2018	187100	166200	226100	172200	212200	33940	0.1810
Fmsy	2018	0.1122	0.0929	0.1264	0.0990	0.1220	0.0195	0.1740
B Last year+1/Bmsy	2018	1.5070	**1.1560**	1.6540	**1.3000**	1.6220	0.2433	0.1610
F Last year/Fmsy	2018	0.3759	0.3403	**0.4955**	0.3477	**0.4385**	0.0675	0.1800
Yield Last year+1/MSY	2018	0.7426	0.5735	0.9682	0.6137	0.9078	0.2337	0.3150

Bootstrap results reiterate a stock at the beginning of 2018 with a very high probability to be above *Bmsy* and a fishing mortality in 2017 with a very high probability to be well below *F_{msy}* . The maximum observed sustainable yield (*MSY*) of 21 000 t can be a long term sustainable yield if fishing mortality stands at a level of 0.112/year. The correspondent B_{msy} for this stock is at the level of 187 000 t.

Catch versus surplus production trajectories are presented in Fig. 10.5. Between 1960 and 1985 catches form a scattered cloud of points around the surplus production curve. In 1986-1987, catches rose well above surplus production and, though declining continuously since then, were still above equilibrium yield in 1993. Catch has dropped well below surplus production in 1995 and from 2010 onwards has been slowly increasing, but is still below the equilibrium yield line.

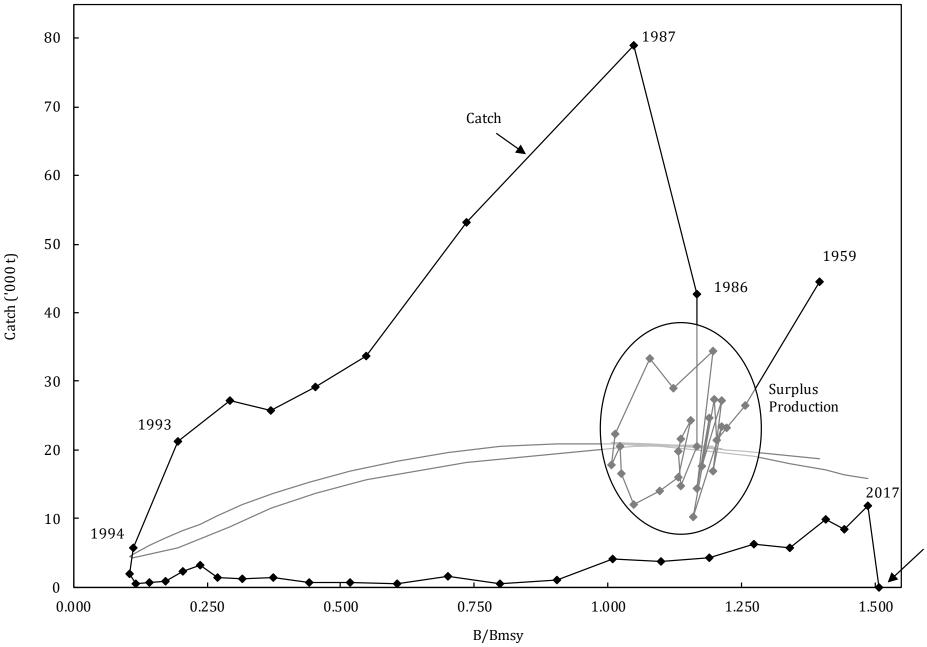


Fig. 10.6. Redfish in Div. 3LN: Catch versus Surplus Production from $\text{ASPIC}_{\text{fit}}$ 2018.

Biomass: Slightly above B_{msy} for most of the former years up to 1985. Declined from B_{msy} in 1986 to 10% B_{msy} in 1995, when a minimum stock size is recorded. Over the moratorium years biomass was allowed to recover and at the beginning of 2018 biomass is predicted to be 1.5 x B_{msy}. The probability of being above B_{msy} is very high (>90%). At the beginning of 2018, the probability of being below B_{lim} is less than 1% (see section d).

Fishing mortality: Fishing mortality has been low to very low since 1996 but has slightly increased since the reopening of the fishery in 2010. On 2017 fishing mortality was estimated to be at 0.38 x F_{msy}, and the probability of being above F_{msy} is very low. At the beginning of 2017, the probability of being above F_{msy} is less than 1%.

Recruitment: From commercial catch and Canadian survey length data (numbers of redfish < 20cm) there are no signs of recent recruitment (2014 – 2017) of above average year classes to the exploitable stock. Nevertheless, unusual high numbers of very small redfish pre recruits (5-12cm) have been observed on recent years (2015-2017) on Canadian spring and autumn surveys.

State of stock: The stock is currently in the safe zone of the NAFO precautionary approach framework and is estimated to be at 1.5 x $B_{msy.}$ There is a very low risk of the stock being below B_{lim}. Fishing mortality is well below F_{msy} (0.36 x F_{msy}), and the probability of being above F_{lim} (= F_{msy}) is very low. Recent recruitment appears to be low.

d) Short term catch projection under the actual management strategy

The Risk-Based Management Strategy (MS) for 3LN Redfish adopted by the Fisheries Commission on the 36th Annual Meeting – September 2014 (Ávila de Melo *et al*., 2014; FC Working Paper 14/23), was designed to reach 18 100 t of annual catch by 2019-2020. It is based on a Harvest Control Rule (HCR) that predicts a stepwise biennial catch increase, with the same amount of increase every two years, between 2015 and 2020 (18 100 t was the equilibrium yield in 2014 given by the 2014 assessment, carried out under the assumption of an MSY of 21 000 t).

The present assessment evaluated the impact of the implementation of this new MS on the state of the stock and found 3LN redfish at the beginning of 2018 standing on its safe zone, with biomass above B_{msy} , after fishing mortality being kept well below F_{msy} during 2017.

The short term catch projection following the assessment should quantify the likelihood of the stock 1) to be exploited below F_{msy} until the end of 2020, assuming that the 2018 TAC will be effectively taken and the 2019-2020 catch will reach the HCR 2019-2020 TAC of 18 100 t and 2) to arrive to the beginning of 2021 still on the safe zone above B_{msy} .

ASPICP, the ASPIC auxiliary program for projections, provided point estimates (with associated bias corrected 80% and 50% confidence limits) of biomass and fishing mortality for the assessment time interval, 1959-2017, extended to the projection years, 2018-2021, with 2018 catch at the present TAC and either with the 2019-2020 at the 2019-2020 HCR TAC (18 100 t) or at status quo TAC (14 200 t). So the two 2018-2020 catch projection options considered were:

1) HCR option 2018: 14 200 t or 2) the status quo 2017 TAC option 2018: 14 200 t
2019: 18 100 t 2019: 14 200 t
2020: 18 100 t 2020: 14 200 t

The ASPICP results for the HCR option are presented in Fig. 10.7a and 10.67b, as regards relative 1959-2021 biomass and 1959-2020 fishing mortality trajectories.

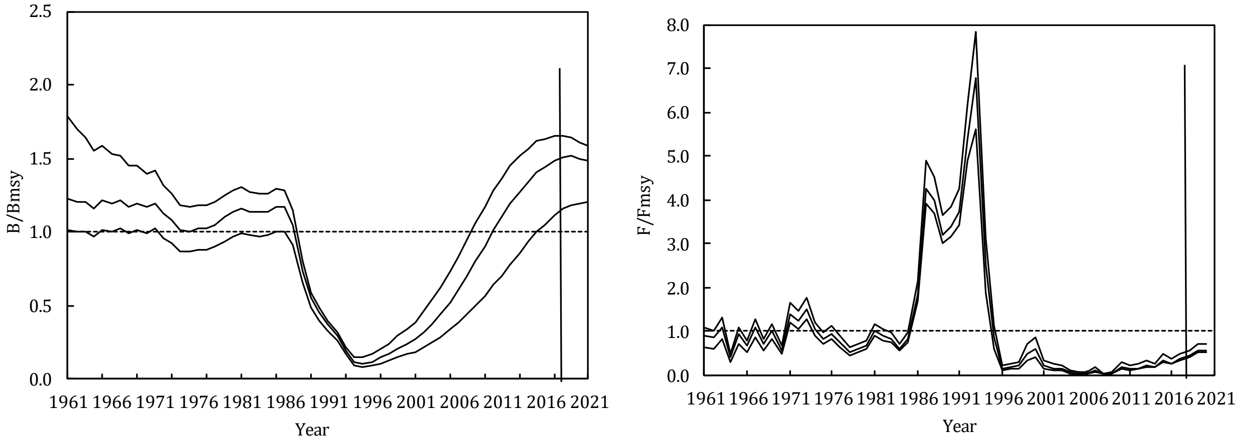


Fig. 10.7. Redfish in Div. 3LN: B/B_{msy} (left) and F/F_{msy} (right) point estimates trajectories with approximate 80% bias corrected CLs from ASPICP 2018 (HCR option).

Comparisons of results with the two options are presented in Table 10.3 and Fig. 10.8 (for B_{msy} 2018-2021).

Table 10.3. Redfish in Div. 3LN: short term catch projections. The 10th, point estimate, and 90th percentiles of projected B/B_{msy} , F/F_{msy} are shown, for projected 2019-2018 HCR and status quo TAC catch.

2018-2020 catch at HCR TAC	percentiles		
Year	10	point estimate	90
BIOMASS RELATIVE TO Bmsy			
2018	1.156	1.507	1.654
2019	1.186	1.514	1.642
2020	1.196	1.501	1.610
2021	1.206	1.489	1.584
FISHING MORTALITY RELATIVE TO Fmsy			
2018	0.410	0.448	0.576
2019	0.530	0.572	0.722
2020	0.540	0.577	0.716

2018-2020 catch at 2017 TAC	percentiles		
Year	10	point estimate	90
BIOMASS RELATIVE TO Bmsy			
2018	1.156	1.507	1.654
2019	1.186	1.514	1.642
2020	1.214	1.521	1.632
2021	1.238	1.526	1.623
FISHING MORTALITY RELATIVE TO Fmsy			
2018	0.410	0.448	0.576
2019	0.413	0.446	0.562
2020	0.416	0.444	0.551

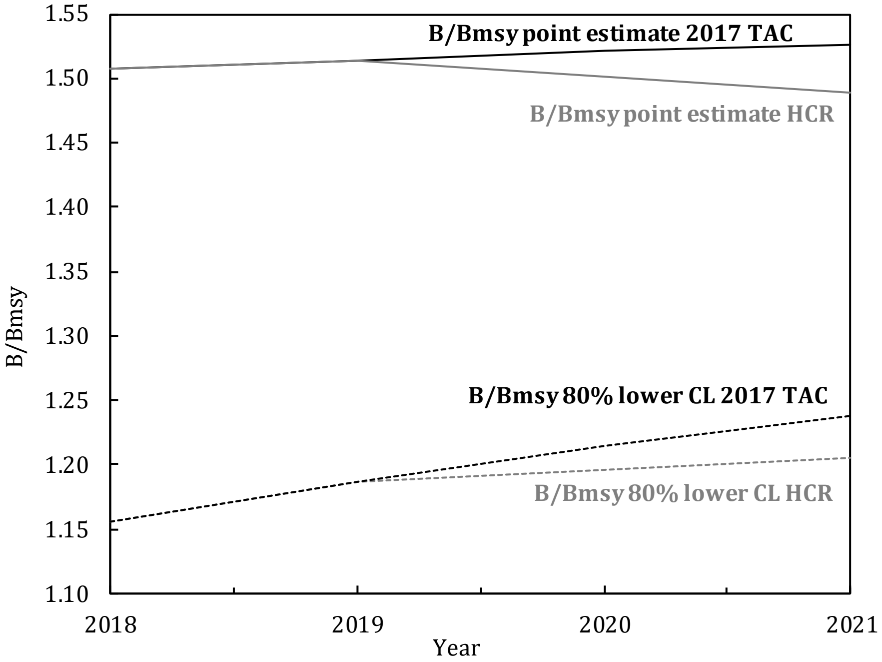


Fig 10.8. B/Bmsy 2018-2021 projections under red 3LN HCR versus status quo 2017 TAC.

Either the HCR predicted catch increase or catch at status quo 2017 TAC on 2019 and 2020 will maintain biomass at the beginning of 2021 above B_{msy} while keeping fishing mortality till the end of 2020 below F_{msy} with > 90% probability. Also the probability of $B_{2021} < B_{lim}$ or $F_{2020} > F_{lim}$ is <0.1 for both catch options, except for 2020 fishing mortality under the HCR TAC catch, which has an associated probability of $F_{2020} > F_{lim}$ slightly above (1.6%). Status quo TAC on 2019-2020 will allow a biomass marginal growth, but roughly keeping biomass at its present level, and will avoid the beginning of a marginal biomass decline predicted by the HCR option (that has been already suggested by the majority of recent observed data).

Table 10.4. Redfish in Div. 3LN: Risk assessment under 14 200 t and 18 100 t catches in 2019-2020 scenarios.

HCR (Yield)			P(F>Flim) = P(F>F_{MSY})			P(B< Blim)				P(B<B_{MSY})				
2018	2019	2020	2018	2019	2020	2018	2019	2020	2021	2018	2019	2020	2021	P(B_{2021} > B_{2018})
14200 t	14200 t	14200 t	<1%	<1%	<1%	<1%	<1%	<1%	<1%	5.7%	4.8%	4%	3.3%	66.4%
14200 t	18100 t	18100 t	<1%	1.7%	1.6%	<1%	<1%	<1%	<1%	5.7%	4.8%	4.1%	4%	38.5%

Under status quo TAC catch (14 200 t) there is a high probability (66.4%) that biomass will grow from the beginning of 2018 to the beginning of 2021. But the probability of a 2018-2021 biomass increase under a 2019-2020 catch at the 2019-2020 HCR TAC (18 100 t) is low (38.5%) (Table 10.4).

e) Reference Points

The ASPIC point estimate results were put under the precautionary framework (Fig. 10.9). The trajectory presented shows a stock within B_{msy} - 1.2 B_{msy} under exploitation around F_{msy} through 25 years in a row (1960-1985). The stock rapidly declined afterwards to well below B_{msy} when fishing mortality rises to well above F_{msy} (1987-1994). Fishing mortality dropped to well below F_{msy} in 1996, being kept at a very low to low level ever since. Biomass gradually reaches and surpasses B_{msy} several years after (2011-2012). The stock is presently in the safe zone.

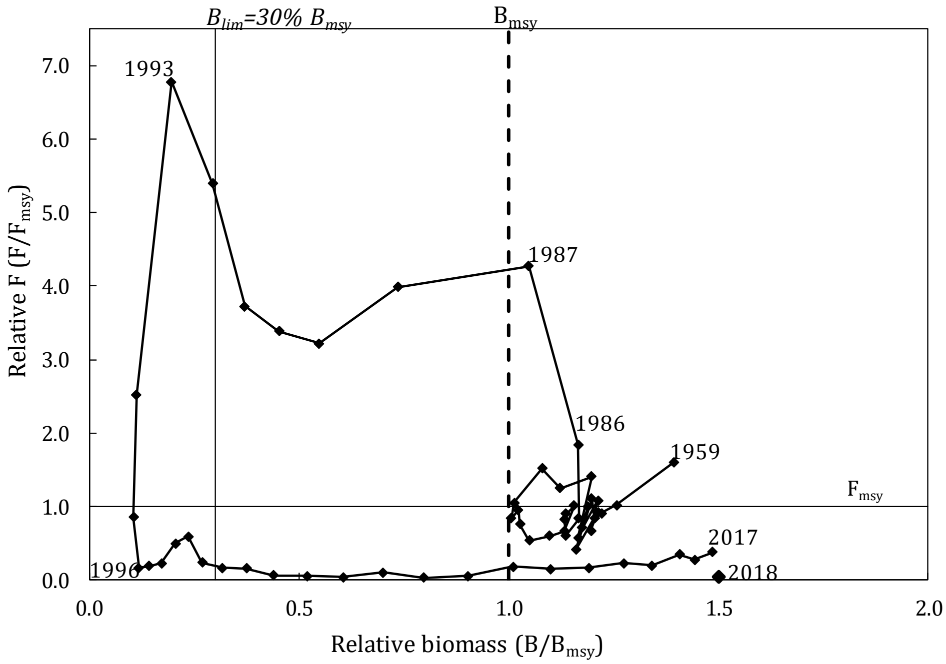


Fig. 10.9. Redfish in Div. 3LN: stock trajectory under a precautionary framework for $ASPIC_{fit}$ 2018.

The next full assessment of this stock will be in 2020.

f) Research recommendations

STACFIS **recommends** *exploration of sensitivity runs of input surveys on the ASPIC formulation for this stock.*

STACFIS **recommends** that *alternate models be explored for this stock.*

11. American plaice (Hippoglossoides *platessoides*) in NAFO Divs. 3LNO

(SCS Doc. 18/05, 18/06, 18/07, 18/08, 18/13, 18/14, 18/15; SCR Doc. 18/11, 18/17, 18/18, 18/19)

a) Introduction

The majority of the catch has been taken by offshore otter trawlers. There was no directed fishing in 1994 and there has been a moratorium since 1995. Landings from by-catch increased until 2003, after which they began to decline. STACFIS agreed catches were 1 664t in 2016 and 1 172t in 2017 (Fig. 11.1). In 2016 and 2017, American Plaice were taken as by-catch mainly in the Canadian Yellowtail Flounder fishery, EU-Spain and EU-Portugal skate, redfish and Greenland Halibut fisheries.

Recent nominal catches and TACs ('000 t) are as follows:

	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
TAC	ndf	ndf	ndf	ndf	ndf	ndf	ndf	ndf	ndf	ndf
STATLANT 21	1.8	1.5	1.2	1.3	2.2	1.4	1.1	1.7	1.2	
STACFIS	3.0	2.9	2.4[1]	2.1[1]	3.0[1]	2.3[1]	1.1[2]	1.7[2]	1.2	

ndf No directed fishing.

[1] Catch was estimated using fishing effort ratio applied to 2010 STACFIS catch.

[2] Catch was estimated using STATLANT 21 data for Canadian fisheries and Daily Catch Records for fisheries in the NRA.

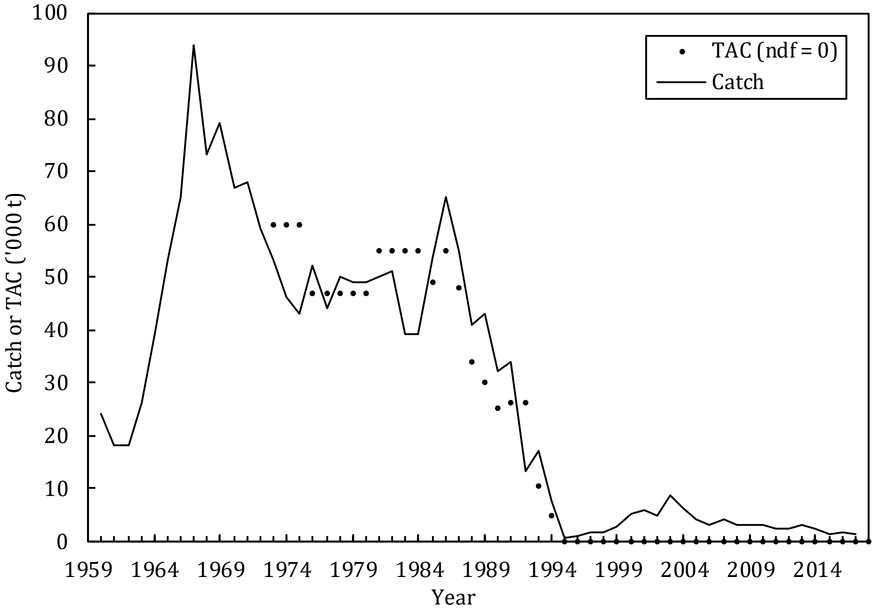


Fig. 11.1. American Plaice in Div. 3LNO: estimated catches and TACs. No directed fishing is plotted as 0 TAC.

b) Input Data

Biomass and abundance data were available from: annual Canadian spring (1985-2016) and autumn (1990-2017) bottom trawl surveys; and EU-Spain surveys in the NAFO Regulatory Area of Div. 3NO (1995-2017). EU-Spain surveys in 1995 and 1996 were incomplete and are not considered further. The Canadian spring survey in 2006 did not adequately cover many of the strata in Divisions 3NO. In 2015 and 2017, the Canadian spring survey did not adequately cover all of the strata in Div. 3L. Sensitivity analysis indicated that a large proportion of abundance indices at certain ages were likely to have been missed by these surveys. Likewise, in 2004, coverage of strata from Div. 3L in the Canadian autumn survey was incomplete, and in 2014 there was no coverage of Divs. 3NO. Therefore the 2006, 2015 and 2017 Canadian spring survey and the 2004 and 2014 Canadian autumn survey results were not used in the assessment. Age data from Canadian bycatch as well as length frequencies from EU-Portugal, and EU-Spain, bycatch were available for 2016-17.

i) Commercial fishery data

Catch and effort. Catch estimates for 2015-2016 were derived from Daily Catch Records. Catches for 2017 were obtained from CESAG estimates. There were no recent catch per unit effort data available.

Catch-at-age.

There was age sampling of the 2016-2017 bycatch in the Canadian fishery and length sampling of bycatch in the Canadian, EU-Spain, EU-Portugal fisheries. Total catch-at-age for all years was produced by applying Canadian survey age-length keys to length frequencies collected each year by countries with adequate sampling and adding it to the catch-at-age calculated for Canada. This total was adjusted to include catch for which there were no sampling data from Contracting Parties such as Japan, Estonia, Russia, and United States. The 2017 catch at age was calculated using age-length keys from 2016 to non-Canadian catches, as a survey ALK for the most recent year was not available due to an incomplete Canadian spring survey in 2017. Issues have been reported regarding the quality and coverage of Canadian commercial sampling in recent years.

ii) Research survey data

Canadian stratified-random bottom trawl surveys.

Biomass and abundance estimates for Div. 3LNO from the spring survey declined during the late 1980s-early 1990s. Both biomass and abundance have fluctuated since 1996 with a slight increase over the period until 2014 (Fig. 11.2). In 2016 there was a decline in both abundance and biomass, with the biomass index reaching the lowest level since 1995.

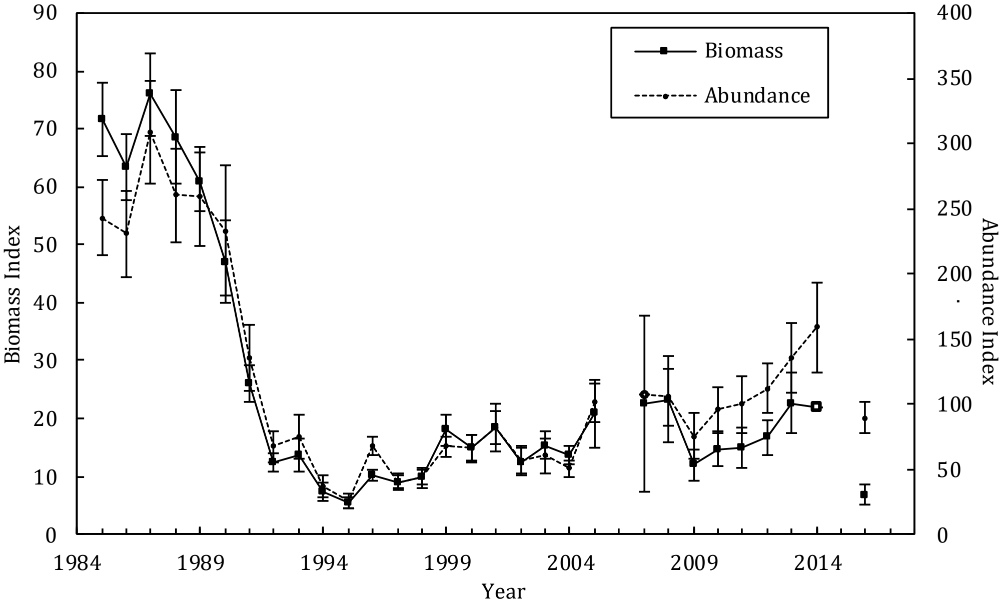


Fig. 11.2. American Plaice in Div. 3LNO: biomass and abundance indices with approximate 95% confidence intervals from Canadian spring surveys. Data prior to 1996 are Campelen equivalents and since then are Campelen. Open symbols represent years where CIs extend to negative values.

Biomass and abundance indices from the autumn survey declined from 1990 to the early-mid 1990s. Both indices showed an increasing trend from 1995 to 2015, but have since declined (Fig. 11.3). The trends observed are similar to the Canadian spring surveys.

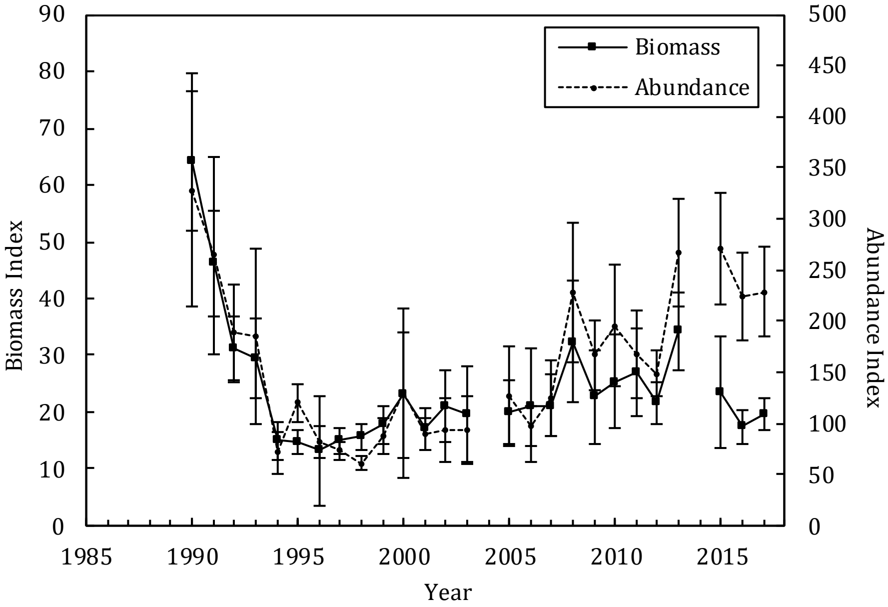


Fig. 11.3. American Plaice in Div. 3LNO: biomass and abundance indices with approximate 95% confidence intervals from autumn surveys. Data prior to 1996 are Campelen equivalents and since then are Campelen.

Stock distribution for Canadian Surveys.

Historically the largest portion of this stock was located in Div. 3L, but the highest declines in survey indices were experienced in this region. Biomass was more heavily concentrated in Div. 3N since 2000, but this Division showed the greatest decline over the last 3 years, with fall survey biomass highest in 3L in 2017. There has also been a substantial increase in abundance in Div. 3L, with spring and fall survey abundance in this Division at the highest levels observed since 1990. This increase is concentrated in ages ≤5.

EU-Spain Div. 3NO Survey.

Numbers at age (1997 to present) are used in the assessment model. In 2001, the vessel (CV *Playa de Menduiña*) and gear (*Pedreira*) were replaced by the RV *Vizconde de Eza* using a *Campelen* trawl. Annual Canadian spring RV age length keys were applied to EU-Spain length frequency data (separate sexes, mean number per tow) to get numbers at age except in 2006 where there were problems with the Canadian spring survey and the combined 1997-2005 age length keys were applied to the 2006 data. In 2015 and 2017, Canadian spring surveys were not completed, so ALKs from the previous year (2014 and 2016, respectively) were applied. Estimates of both indices from the EU-Spain survey varied without trend from the start of the time series to 2013, but have declined since then (Fig. 11.4).

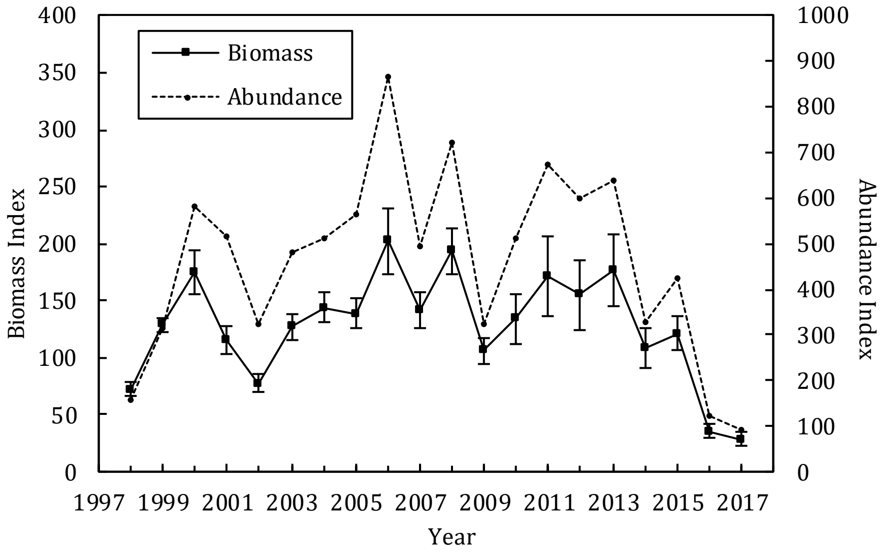


Fig. 11.4. American Plaice in Div. 3LNO: biomass and abundance indices from the EU-Spain Div. 3NO survey (Data prior to 2001 are Campelen equivalents and since then are Campelen).

The abundance of fish <5 years old in both the Canadian spring and fall surveys has been increasing since the late 1990s (Fig. 11.5). This indicates above-average pre-recruitment. However, there are some inconsistencies among surveys, with the high number of pre-recruits observed in the Canadian surveys not being seen in the EU-Spain survey (Fig. 11.5). This is likely due to differences in survey coverage, as the greatest abundances of young fish in recent Canadian surveys have been observed in Div. 3L.

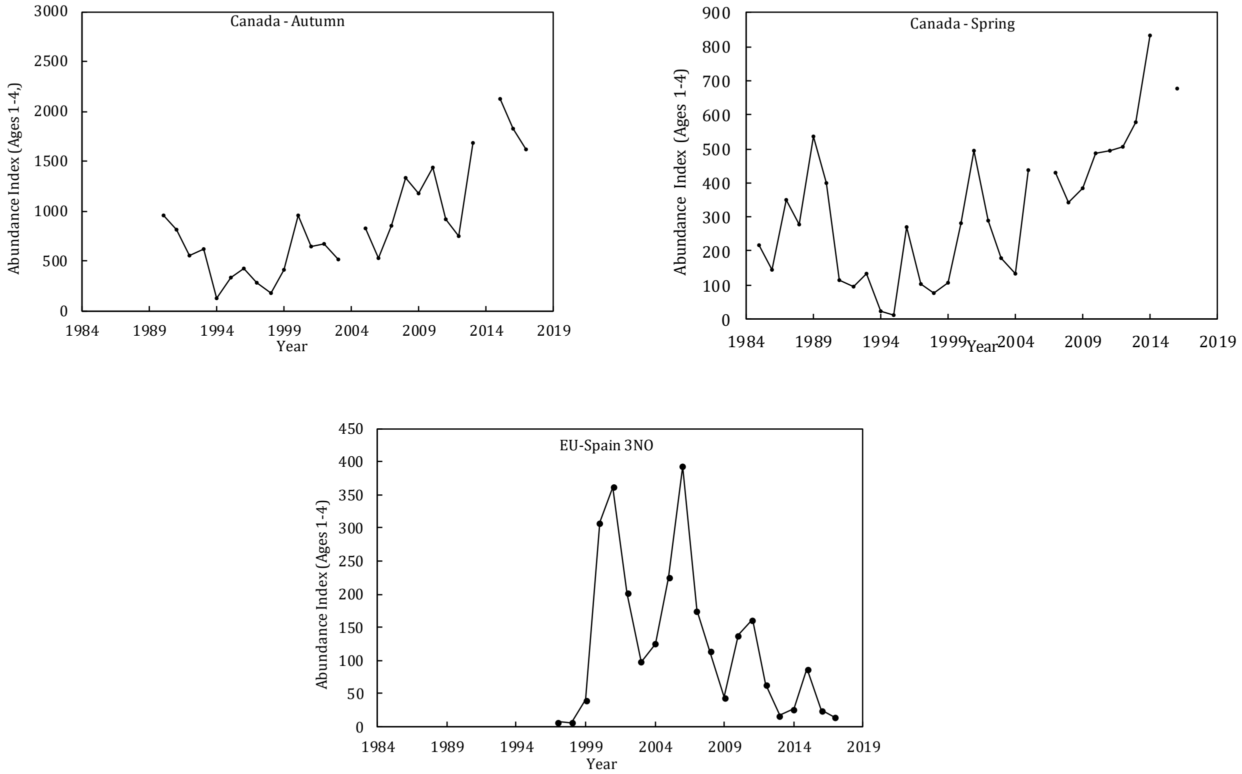


Fig. 11.5. American Plaice in Div. 3LNO: comparison of abundance indices of ages 1-4 from Canadian autumn and spring, and EU-Spain surveys (Canadian data prior to 1996 are Campelen equivalents and since then are Campelen).

iii) Biological studies

Maturity. Age at 50% maturity (A_{50}) has declined since the 1960s and 1970s from 6 to 4 years for males and 11 years to 8 years for females for the most recent cohort.

Size-at-age. Mean weights-at-age and mean lengths-at-age were calculated for male and female American Plaice for Div. 3LNO using spring survey data from 1990 to 2016. Means were calculated accounting for the length stratified sampling design. Although there is variation in both length and weight-at-age there is little indication of any long-term trend for either males or females. However, weight has been lower for females since about 2010.

c) Estimation of Parameters

Catch estimates for 2011-2013 were derived from STATLANT 21 data for Divs. 3L and 3O. For Div. 3N, effort from NAFO observers and logbook data was used where possible with the assumption that CPUE has not changed substantially from 2010. STACFIS determined that STATLANT 21 could not provide a reliable estimate of catch in 2014, and decided to estimate catch for 2014 using the same method employed for 2011-2013. STACFIS recommended the use of STATLANT 21 catch for Canadian fisheries and Daily Catch Records for fisheries in the NRA to estimate catch from 2015 and 2016.

An analytical assessment using the ADAPTive framework tuned to the Canadian spring, Canadian autumn and the EU-Spain Div. 3NO survey was used. The virtual population analysis (VPA) was conducted based on the 2014 and 2016 assessment formulation with catch-at-age and survey information from the following:

- Catch at age (1960-2017) (ages 5-15+);
- Canadian spring RV survey (1985-2016) (no 2006, 2015, 2017 values) (ages 5-14);
- Canadian autumn RV survey (1990-2017) (no 2004 or 2014 values) (ages 5-14); and
- EU-Spanish Div. 3NO survey (1998-2017) (ages 5-14).

There is a plus group at age 15 in the catch-at-age and the ratio of F on the plus group to F on the last true age was set at 1.0 across all years. Natural mortality (M) was assumed to be 0.2 on all ages except from 1989-1996, where M was assumed to be 0.53 on all ages.

Sensitivity analyses were completed examining the impact of changing the F ratio assumption in the VPA. The base model described above assumes a constant F ratio from 1.0 from the last true age to the plus group in all years. The impact of this assumption on model fit and results was examined by completing several different model runs with varying F-ratio assumptions, with the F-ratio allowed to (1) vary in each year from 2000 to present, (2) vary in each year from 2010 to present, and (3) vary in 3 groups (2010-2012, 2013-2014, 2015-2017). Mean squared error of the model was found to decrease relative to the base model in all of these F-ratio scenarios, and changes in the retrospective pattern were observed. Estimates of the F ratio to the plus group were generally different than 1.0. However, perception of the state of the stock and its trajectory were consistent among all runs, including the base model. Therefore STACFIS agreed on the use of the base model for this assessment, and further exploration of the F ratio assumption was recommended going forward.

d) Assessment Results

The mean square of the residuals from the model was 0.46; however there was some indication of auto-correlation in the residuals. Relative errors on the population estimates ranged from 0.13 to 0.49. The relative errors on the catchabilities (q) were all less than 0.16.

The VPA analyses showed that population abundance and biomass declined fairly steadily from the mid-1970s to 1995. Biomass and abundance have been relatively stable at a low level since around 2000 (Fig 11.6). Average F on ages 9 to 14 showed an increasing trend from about 1965 to 1985. There was a large unexplained peak in F in 1993. F increased from 1995 to 2001 and has since declined (Fig. 11.7).

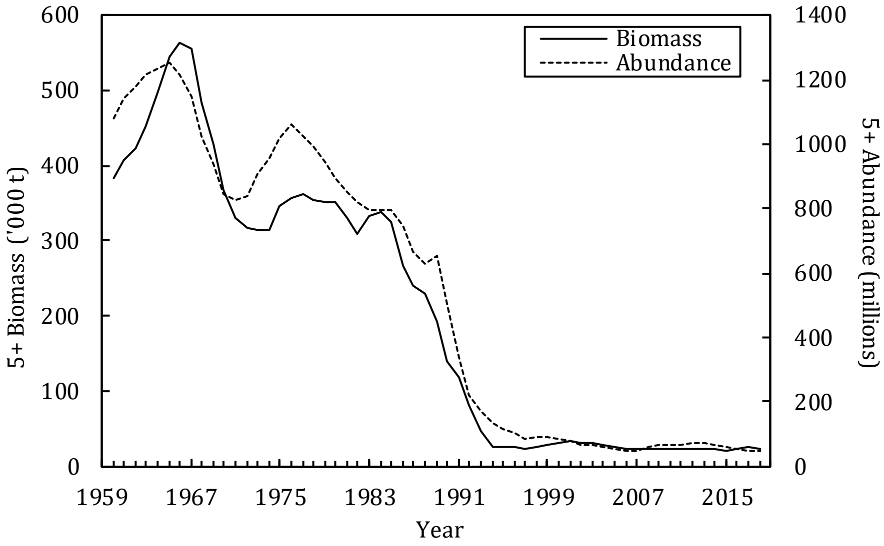


Fig. 11.6. American Plaice in Div. 3LNO: population abundance and biomass from VPA

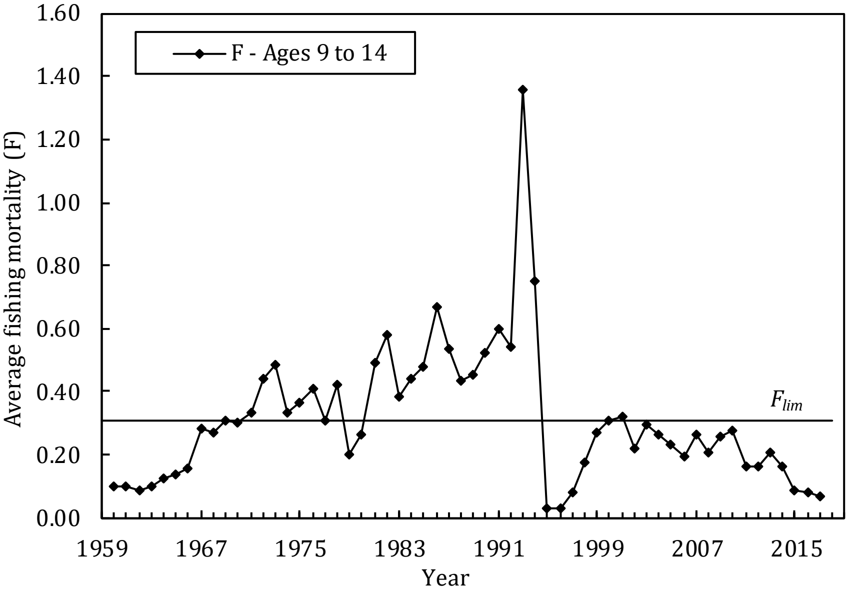


Fig. 11.7. American Plaice in Div. 3LNO: average fishing mortality from VPA.

Spawning stock biomass has shown 2 peaks, one in the mid-1960s and another in the early to mid-1980s. It declined to a very low level (less than 10 000 t) in 1994 and 1995 (Fig. 11.8). Since then, SSB increased slightly to the early 2000s, and has since varied at a low level. Stock weights at age have generally declined since the early 2000s, but have increased slightly over the last three years. Spawning stock biomass in the current year was estimated at 17, 300 t (about 35% of B_{lim}). Estimated recruitment at age 5 indicates there have been no year-classes above the long term average since the mid-1980s (Fig. 11.9).

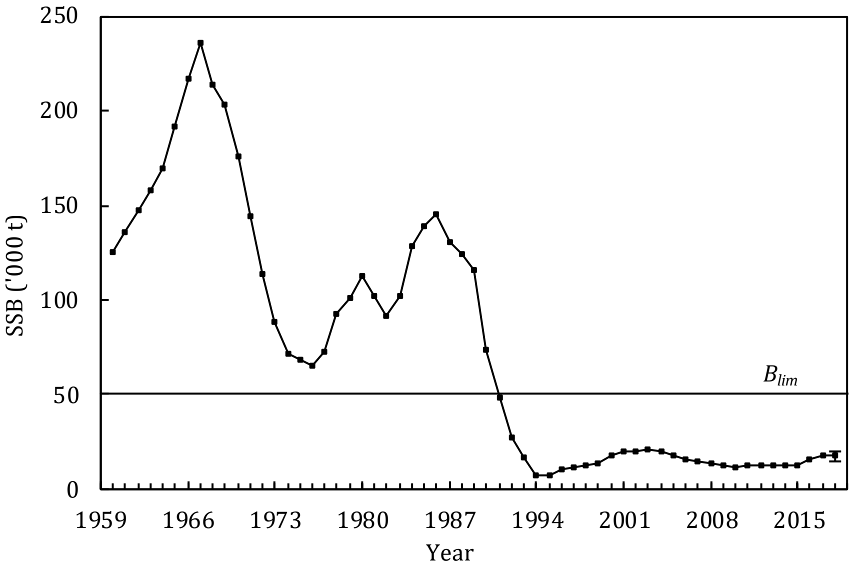


Fig. 11.8. American Plaice in Div. 3LNO: spawning stock biomass from VPA. Error bars on the 2018 SSB are approximate 90% confidence intervals.

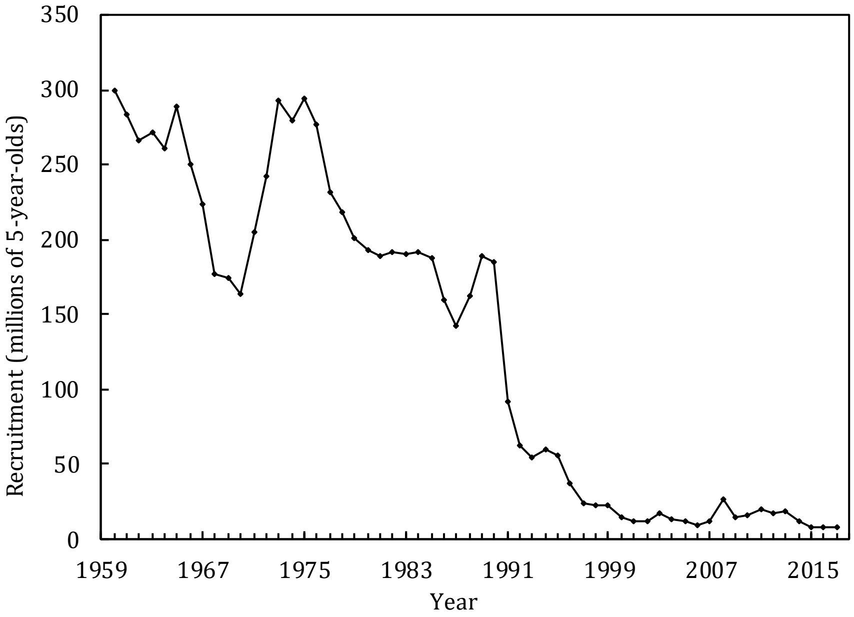


Fig. 11.9. American Plaice in Div. 3LNO: recruits (at age 5) from VPA.

There is a tendency to overestimate SSB and underestimate F in the assessment model. In the current assessment there is a substantial downwards revision of the SSB in 2016, relative the 2016 assessment.

e) State of the Stock

The stock remains low compared to historic levels and is presently at 34% of the B_{lim} level. Recruitment has been low since the late 1980, but Canadian surveys indicate a large number of pre-recruits in Div 3L in recent years. Current estimates of fishing mortality are low.

Spawning stock biomass: SSB declined to the lowest estimated level in 1994 and 1995, and then increased slightly to 2001, though remaining well below historic levels. SSB has varied at a low level since this time, and is currently at 17 300t. B_{lim} for this stock is 50 000 t. Probability that $B<B_{\text{lim}}$ is greater than 95%.

Recruitment: Overall, recruitment has been low since the late 1980s. However, there are indications of increasing numbers of pre-recruits in recent Canadian surveys.

Fishing mortality: Fishing mortality on ages 9 to 14 has generally declined since 2001 and is now at a very low level (estimated in 2017 at 0.065).

f) Retrospective patterns

A five year retrospective analysis was conducted by sequentially removing one year of data from the input data set (Fig. 11.10). There is a large retrospective pattern present in this assessment which indicates that abundance and SSB have generally been overestimated (by an average of 19% year-over-year since 2014 on the terminal year of the model) and F underestimated (23% year-over-year).

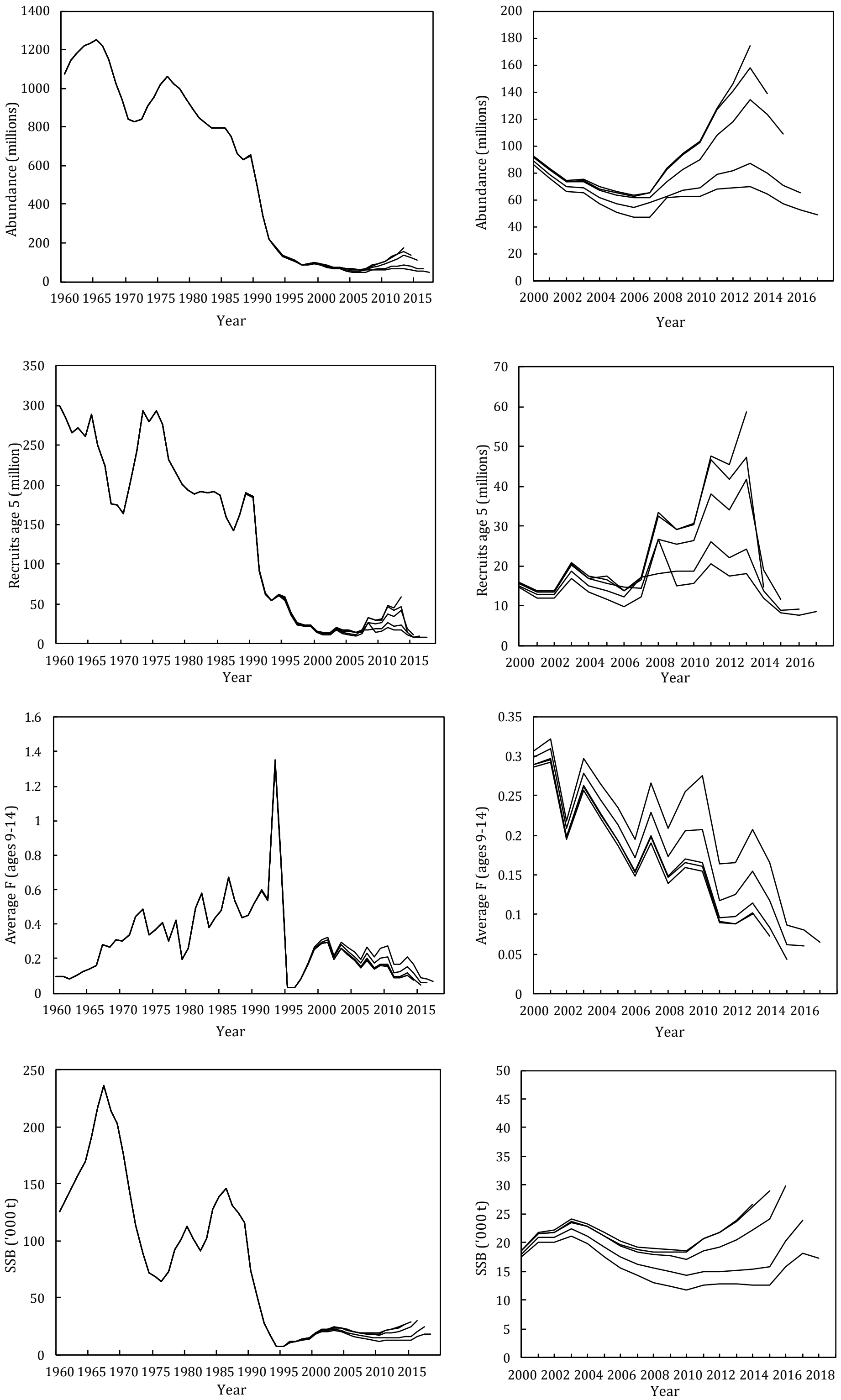


Fig 11.10. American Plaice in Div. 3LNO: retrospective analysis of population numbers, recruitment (age 5), average *F* (ages 9-14), and SSB.

g) Precautionary Reference Points

An examination of the stock recruit scatter shows that good recruitment has rarely been observed in this stock at SSB below 50 000 t and this is currently the best estimate of B_{lim}. In 2011 STACFIS adopted F_{lim} of 0.3 consistent with stock history and dynamics for this stock. The stock is currently below B_{lim} and current fishing mortality is below F_{lim} (Fig. 11.11).

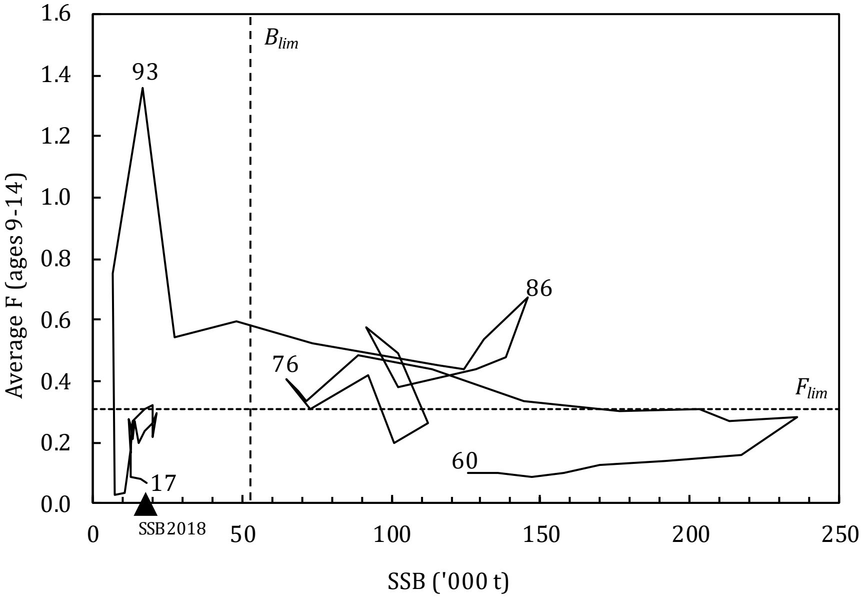


Fig. 11.11. American Plaice in Div. 3LNO: stock trajectory within the NAFO PA framework. The 2018 SSB estimate is indicated by the triangle on the x-axis.

h) Short Term Considerations

Simulations were carried out to examine the trajectory of the stock under 2 scenarios of fishing mortality: F = 0 and F= $F_{2015-2017}$ (0.08). The three year average was chosen rather than the value for 2017 because of the retrospective pattern.

For these simulations the results of the VPA and the covariance of these population estimates were used. Table 11.1 outlines the assumptions used for the projections.

Table 11.1 American Plaice in Div. 3LNO: Assumptions used for stochastic projections.

Age	Estimate of 2018 population numbers ('000)	Relative error on population estimate	Weight-at-age mid-year (avg. 2015-2017)	Weight-at-age beginning of year (avg. 2015-2017)	Maturity-at-age (avg. 2015-2017)	PR rescaled relative to ages 9-14 (avg. 2015-2017)
5			0.17	0.16	0.01	0.14
6	6967.2	0.492	0.24	0.19	0.03	0.36
7	4964.4	0.316	0.31	0.27	0.16	0.69
8	4144.8	0.279	0.42	0.35	0.54	0.92
9	4519.9	0.257	0.52	0.46	0.82	0.81
10	5440.7	0.225	0.61	0.54	0.92	1.01
11	3741.0	0.217	0.73	0.65	0.97	1.25
12	2938.8	0.214	0.90	0.80	0.99	1.14
13	1435.9	0.223	1.11	0.98	1.00	0.90
14	861.7	0.230	1.16	1.11	1.00	0.89
15+	3324.0	0.125	1.68	1.41	1.00	0.89

Simulations were limited to a 4-year period. Recruitment was resampled from all historical recruitments produced from SSB<B_{lim}. The simulations contained a plus group at age 15.

SSB was projected to have a probability of >0.99 of being less than B_{lim} by the start of 2022 under both fishing mortality scenarios. Under the F=0 scenario, there is a 99% probability that SSB in 2022 will be greater than in 2018, however this is reduced to 47% probability under F status-quo. Even very low levels of F are inhibiting growth of the stock.

Under status quo fishing mortality ($F_{2015-2017}$), projected removals are stable from 2019 to 2022 at around 1500 tons.

Table 11.2 American Plaice in Div. 3LNO: Results of stochastic projections under various fishing mortality options. Labels p05, p50 and p95 refer to 5th, 50th and 95th percentiles of each quantity.

	SSB('000 t)	**Yield (t)**
	Median (90% CI)	
	F = 0	
2019	17.0 (14.6, 19.8)	-
2020	18.0 (15.5, 21.0)	-
2021	19.5 (16.6, 23.0)	-
2022	21.1 (18.0, 25.3)	-
	$F_{2015-2017}$ = 0.08	
2019	17.0 (14.7, 19.7)	1542
2020	16.7 (14.4, 19.5)	1538
2021	16.9 (14.5, 19.9)	1567
2022	17.2 (14.8, 20.7)	1594

Table 11.3 American Plaice in Div. 3LNO: Risk assessment under F = 0 and $F_{2015-2017}$ of the probability of being below B_{lim}. Yield (t) is median projected value.

Fishing Mortality	Yield				P(SSB<B_{lim})				P(SSB_{2022}>SSB_{2018})
	2019	2020	2021	2022	2019	2020	2021	2022	
F = 0	-	-	-	-	>99%	>99%	>99%	>99%	99%
$F_{2013-2015}$= 0.08	1542	1538	1567	1594	>99%	>99%	>99%	>99%	47%

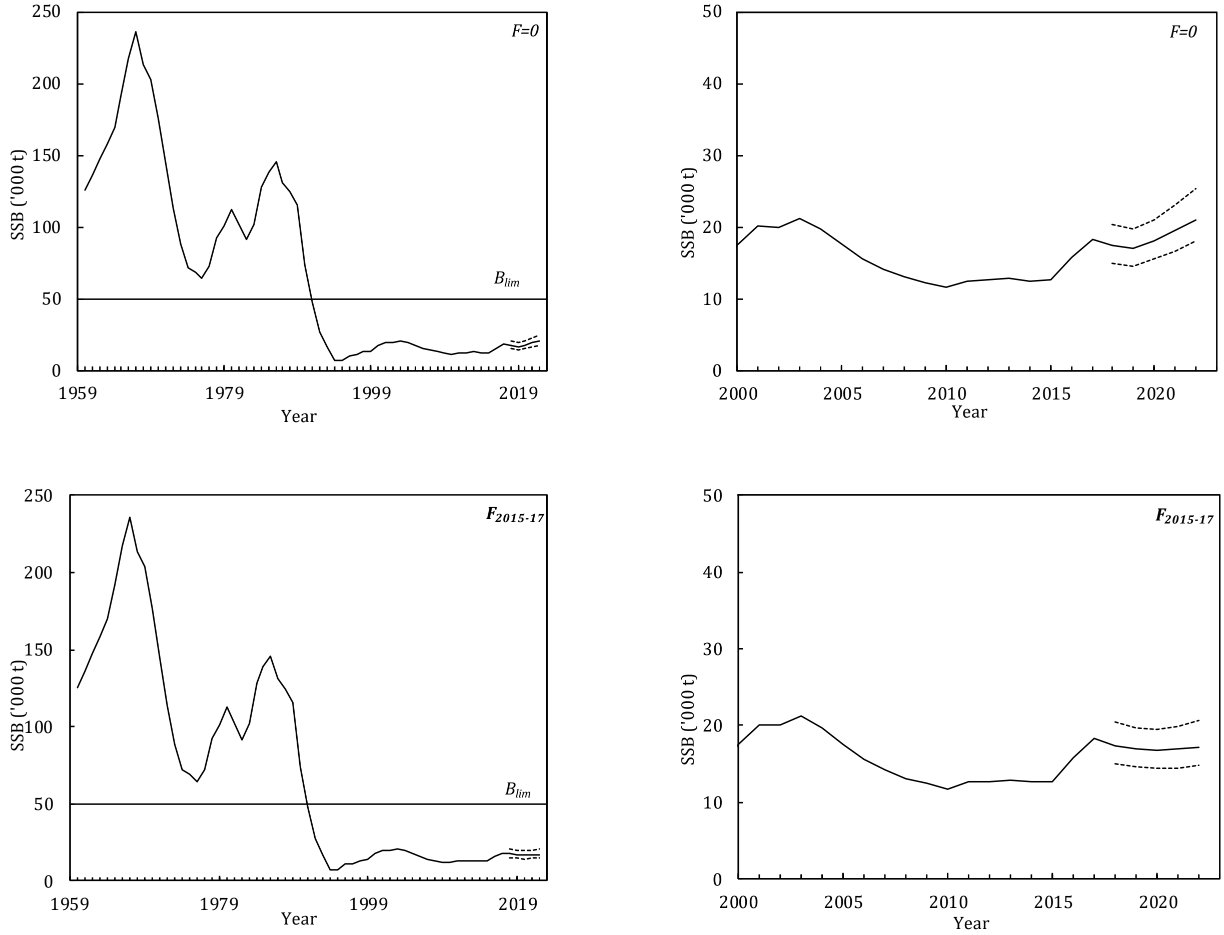


Fig. 11.12 American plaice in Div. 3LNO: Spawning stock biomass from projections along with 5th and 95th percentiles (dotted lines) for F=0 (top) and $F_{2015-17}$ (bottom). Figures on the left show the entire time series, and on the right since 2000.

Given the low potential for stock growth, the next full assessment is scheduled for 2021.

i) Research Recommendations

STACFIS **recommended** that *investigations be undertaken to compare ages obtained by current and former Canadian age readers.*

STATUS: Work is ongoing. This recommendation is reiterated.

STACFIS **recommends** that *investigations be undertaken to examine the retrospective pattern and take steps to improve the model.*

STATUS: Sensitivity analysis was completed examining the impact of changing the model assumptions about the F-ratio on the plus group. These exploratory runs had varying impacts on the retrospective pattern and residuals in the model, and will be explored further. Work is ongoing. The recommendation is reiterated.

STACFIS **recommended** that *investigations be undertaken to reexamine which survey indices are included in the model.*

12. Yellowtail Flounder (*Limanda ferruginea*) in Divisions 3L, 3N and 3O

(SCR 18/012, 18/017, 18/036, 18/038, 18/048; SCS 18/05, 18/06, 18/07, 18/08, 18/13, 18/14, 18/15)

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 2017, catches were higher, ranging from 6 900 t to 10 700 t.

Recent catches and TACs ('000 tons) are as follows:

	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
TAC	17	17	17	17	17	17	17	17	17	17
STATLANT 21	5.5	9.1	5.2	3.1	10.7	8.0	6.7	8.3	9.2	
STACFIS	6.2	9.4	5.2	3.1	10.7	8.0	6.9	9.3	9.2	

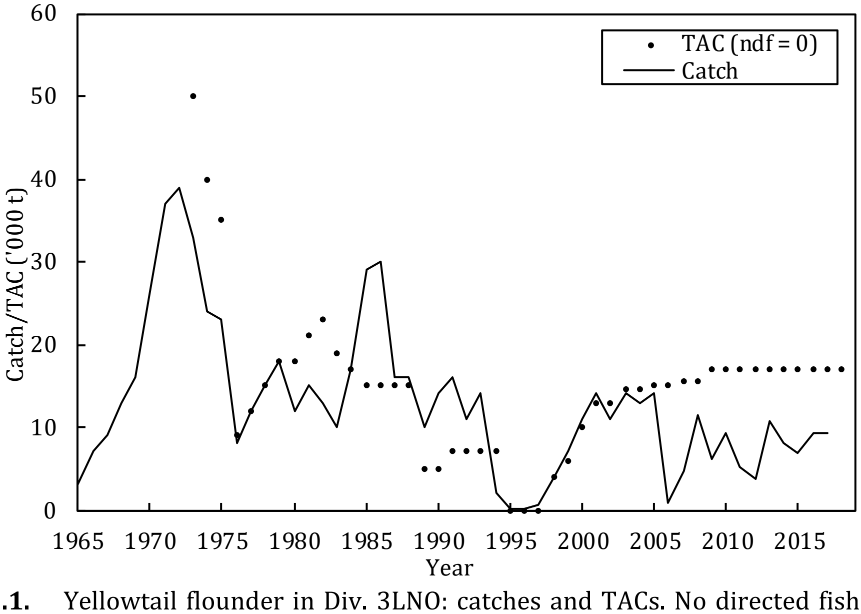


Fig. 12.1. Yellowtail flounder in Div. 3LNO: catches and TACs. No directed fishing is plotted as 0 TAC.

b) Data Overview

i) Research survey data

Canadian stratified-random spring surveys. Although variable, the spring survey biomass index increased from 1995 to 1999 and since fluctuated at a high level to 2012. The spring biomass index then declined to 2016, but increased slightly in 2017. The 2006 and 2015 surveys did not cover the stock area and are not considered representative.

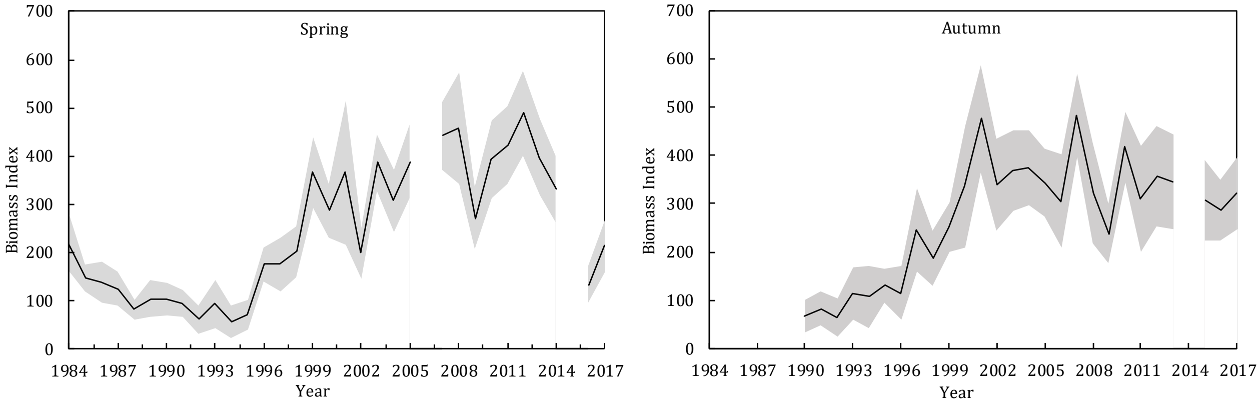


Fig.12.2. Yellowtail flounder in Div. 3LNO: indices of biomass with approx 95% confidence intervals, from Canadian spring and autumn surveys. Values are Campelen units or, prior to autumn 1995, Campelen equivalent units. The 2014 Canadian autumn, 2015 and 2016 spring surveys were incomplete.

Canadian stratified-random autumn surveys. The autumn survey biomass index for Div. 3LNO increased steadily from the early-1990s to 2001, and although variable, it remained relatively high since then (Fig. 12.2). This survey did not show the decline in biomass seen in the other surveys during the recent years. The 2014 survey was incomplete due to problems with the research vessel, and results are not considered representative.

EU-Spain stratified-random spring surveys in the NAFO Regulatory Area of Div. 3NO. The biomass index of yellowtail flounder increased sharply up to 1999 and remained relatively stable until 2013. Since then, biomass estimates have declined and the 2017 estimate is lower than those seen in nearly two decades (Fig. 12.3). Results are in general agreement with the Canadian series which covers the entire stock area.

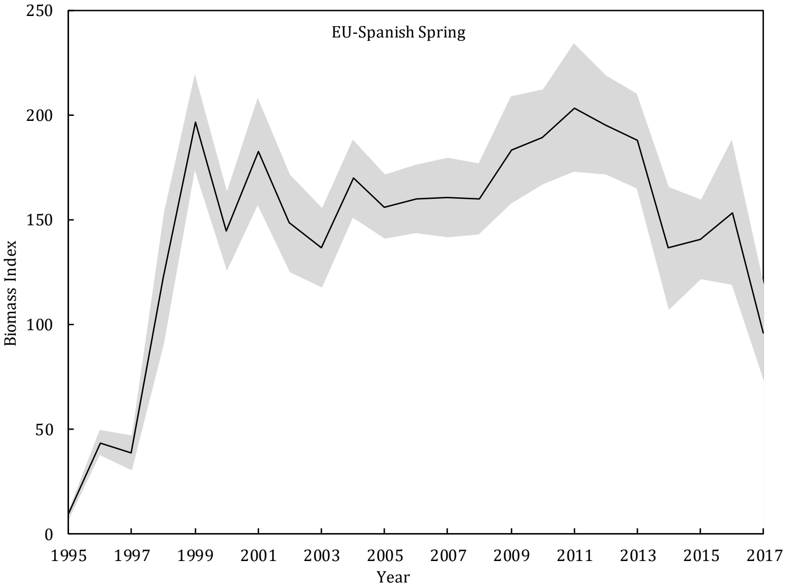


Fig.12.3. Yellowtail flounder in Div. 3LNO: index of biomass from the EU-Spain spring surveys in the Regulatory Area of Div. 3NO ±1SD. Values are Campelen units or, prior to 2001, Campelen equivalent units.

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 1999-2017 surveys than from 1984-1995, and the stock has continued to occupy the northern portion of its range in Div. 3L, similar to the mid-1980s when overall stock size was also relatively large. The vast majority of the stock is found in waters shallower than 93 m in both seasons.

c) Estimation of Parameters.

The previous assessment used a non-equilibrium surplus production model (ASPIC version7.02; Prager 2015) to estimate parameters for yellowtail flounder in Divs 3LNO. In the 2017 interim monitoring of this stock, concerns were raised about the insensitivity of ASPIC to respond to recent downward trends observed in survey indices. An exploration of the ASPIC model formulation confirmed that the ASPIC view of the stock trends does not react to known changes in the input tuning series. STACFIS did not accept the updated model formulation using ASPIC. Alternate production models were presented, including a Bayesian formulation (Meyer and Millar 1999) and a SPiCT model (stochastic surplus production model in continuous time; Pedersen & Berg 2017), both of which used the same input series: Catch data (1965-2017, Russian spring surveys (1984-91), Canadian spring (Yankee) surveys (1971-82), Canadian spring (1984-2017 omitting 2006 and 2015) surveys, Canadian autumn (1990-2017 omitting 2014) surveys and the EU-Spain spring (1995-2017) surveys. The Bayesian model (with wide priors) was accepted as the assessment model for the stock, based on a good model fit, insensitivity to starting priors and the model fit better to the observed downward trends in recent indices that were of concern using the ASPIC model. 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 ~ dunif(0.01,1)	uniform (0.01 to 1)
Carrying capacity	K~dlnorm(2.703,0.2167)	lognormal (mean, precision)
Survey catchability	q ~dgamma(1,1)	gamma(shape, rate)
Process error	sigma ~ dunif(0,5) isigma2= sigma^{-2}	uniform(0 to 5)
Observation error	tau~dgamma(1,1) itau2 = 1/tau	gamma(shape, rate)

d) Assessment Results

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. Although no clear trend in recruitment is evident, the number of small fish has increased in the Canadian spring and fall surveys from 2015, and in 2017, is above the 1996-2017 average. The spring survey by EU-Spain has shown lower than average numbers of small fish since 2006.

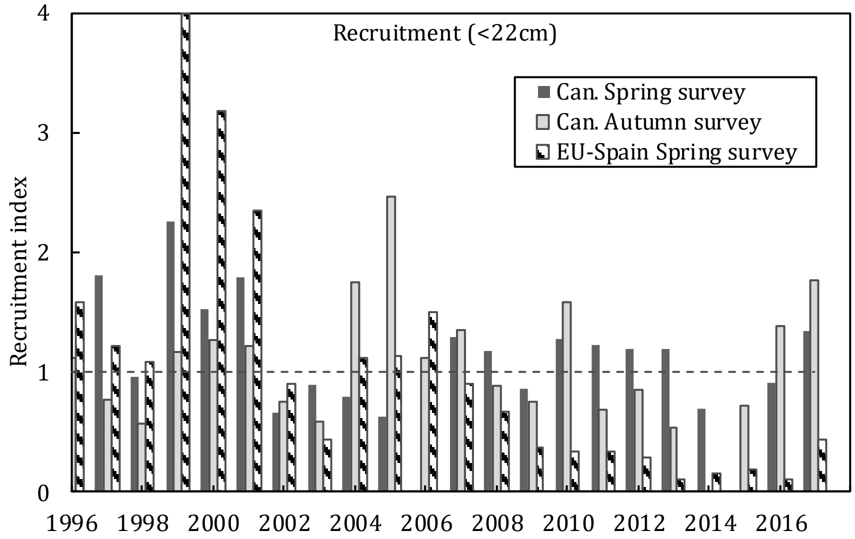


Fig.12.4. Yellowtail flounder in Div. 3LNO: Juvenile abundance indices from spring and autumn surveys by Canada and spring surveys by EU-Spain. Each series is scaled to its mean (horizontal line).

Bayesian Stock Production Model: Results from the accepted Bayesian surplus production model are broadly similar in scale and trend to the 2015 assessment results and the model better captures the downward trends in recent indices. The stock size increased rapidly after the moratorium in the mid-1990s, levelled off from 2001-2012, and although it has declined in recent years, has remained above B_{msy}. Estimates from the model suggests that a maximum sustainable yield (*MSY*) of 18 760 tons can be produced by total stock biomass of 87 630 tons (B_{msy}) at a fishing mortality rate (F_{msy}) of 0.21.

Biomass: The analysis showed that relative population size (B/B_{msy}) was below 1.0 from 1973 to 1997. Relative biomass from the production model increased from 1994 to 2001, remained stable until 2012 and then declined to 2016, although it is estimated to be 1.5 times B_{msy} in 2018 (Fig. 12.5).

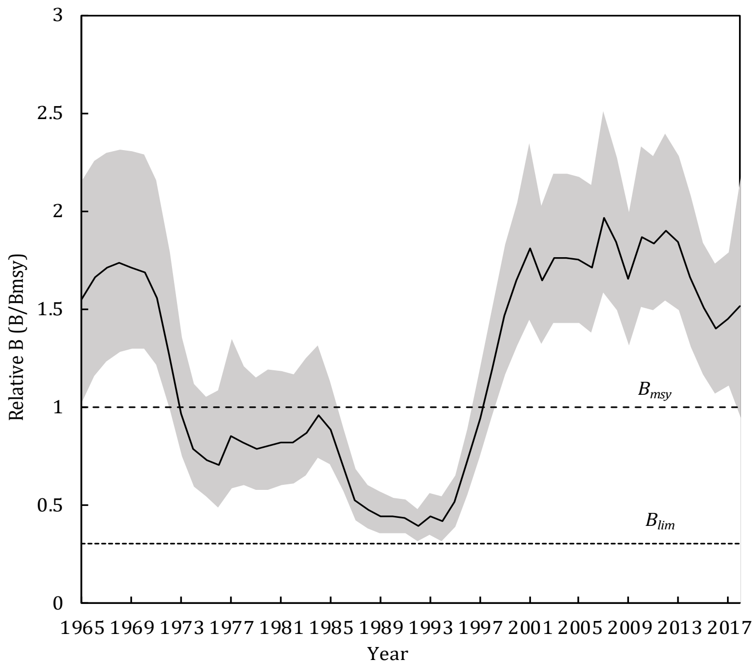


Fig. 12.5. Yellowtail flounder in Div. 3LNO: relative biomass trends with approximate 90% confidence intervals.

Fishing Mortality: Relative fishing mortality rate (F/F_{msy}) was above 1.0, in particular from the mid-1980s to early-1990s when the catches exceeded or doubled the recommended TACs (Fig. 12.6). F has been below F_{msy} since 1993. From 2013-2017 F averaged about 30% of F_{msy}.

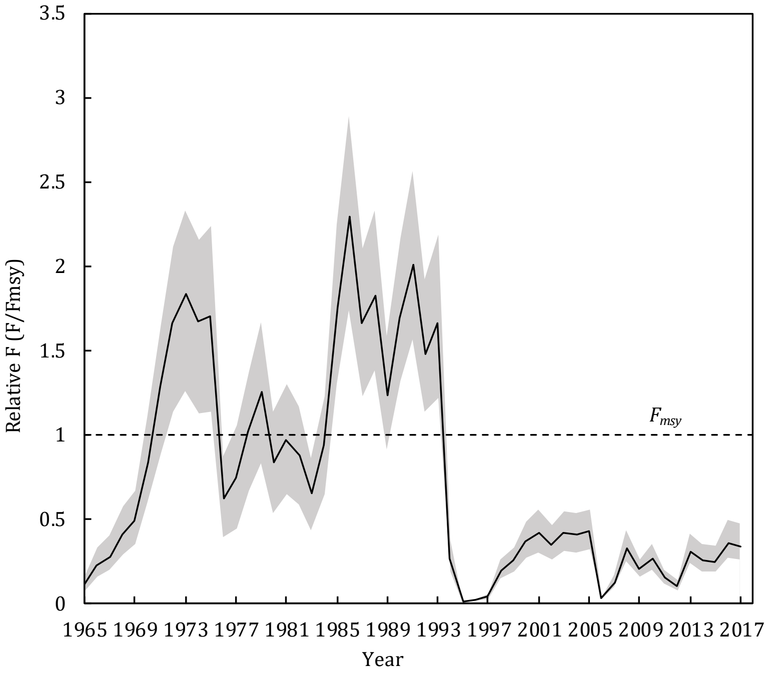


Fig. 12.6. Yellowtail flounder in Div. 3LNO: relative fishing mortality trends with approximate 90% confidence intervals.

e) State of the Stock

The stock size has steadily increased since 1994 and is presently 1.5 times B_{msy} (B_{msy}=87.63). There is very low risk (<1%) of the stock being below B_{msy} or F being above F_{msy}. Recent recruitment appears to be higher than average.

In many years since the moratorium (1994-97), the catch remained below the estimated surplus production levels and has been low enough to allow the stock to grow (Fig 12.7).

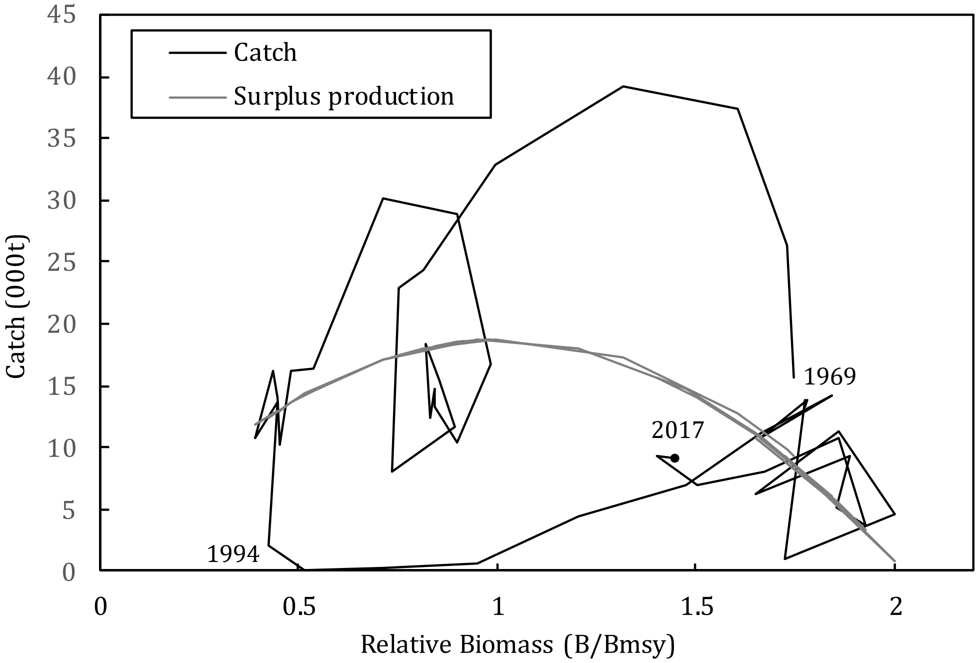


Fig. 12.7. Yellowtail flounder in Div. 3LNO: catch trajectory.

f) Medium Term Considerations:

Medium-term projections were carried forward to the year 2022, and because the catch has been lower than TAC in many recent years, catch in 2018 was assumed to be the average of that in 2013-2017 catch (8 800 t). Constant fishing mortality was applied from 2019-2022 at several levels of F ($F_{status\ quo}$, 2/3 F_{msy}, and 85% F_{msy}, and F_{msy}).

F_{msy} was estimated to be 0.21. Fishing at F_{msy} would first lead to a considerable yield in 2019, but yields are then projected to decline in the medium term with catch at 2/3 F_{msy}, 85% F_{msy} , and F_{msy} (Table 12.1; Fig. 12.8). At the end of the projection period, the risk of biomass being below B_{lim} is less than 1% in all cases.

The probability that $F > F_{lim}$ $(=F_{msy})$ in 2019-2021 was less than .01 for the $F_{status\ quo}$ projection (Table 12.2). At 2/3 F_{msy}, the probability that F > F_{lim} was between .05 and .10 in the medium term. Projected at the level of 85% F_{lim}, the probability that F > F_{lim} is approximately 0.25 and for F_{msy} projections, this probability increased to 0.50. For biomass projections, in all scenarios for 2018-2022, the probability of biomass being below B_{lim} was less than 0.01. The probability that biomass in 2022 is greater than B_{2018} is 0.62, 0.37, 0.28 and 0.22 for $F_{status\ quo}$, 2/3 F_{msy}, 85% F_{msy}, and F_{msy} respectively.

Table 12.1. Medium-term projections for yellowtail flounder. Estimates and 90% confidence interval for yield and relative biomass B/B_{msy}, are shown, for projected F values of $F_{status\ quo}$, 2/3 F_{msy}, 85%F_{msy} and F_{msy}. Catch in 2018 was assumed at 8 800 t (average catch 2013-2017).

Projections with catch in 2018 = avg catch 2013-2017 (8 800 t)		
Year	Yield ('000t) median	Projected relative Biomass(B/B_{msy}) median (90% CL)
$F_{status\ quo}$ = 0.07		
2019	9.14	1.56 (1.07, 2.1)
2020	9.30	1.59 (1.09, 2.14)
2021	9.41	1.62 (1.11, 2.17)
2022		1.63 (1.12, 2.19)
2/3 F_{MSY} = 0.14		
2019	19.52	1.56 (1.07, 2.1)
2020	18.41	1.47 (0.99, 2)
2021	17.77	1.42 (0.93, 1.96)
2022		1.39 (0.89, 1.93)
85% F_{MSY} =0.18		
2019	24.88	1.56 (1.07, 2.1)
2020	22.49	1.41 (0.94, 1.94)
2021	21.09	1.32 (0.85, 1.86)
2022		1.27 (0.77, 1.82)
F_{MSY} =0.21		
2019	29.28	1.56 (1.07, 2.1)
2020	25.50	1.36 (0.9, 1.88)
2021	23.37	1.25 (0.77, 1.79)
2022		1.17 (0.67, 1.73)

Table 12.2. Yield (000 t) and risk (%) of $B_y<B_{msy}$ and $F_y>F_{msy}$ ($F_{lim}=F_{msy}$) at projected F values of $F_{status\ quo}$, 2/3 F_{msy}, 85% F_{msy} and F_{msy}. Catch in 2018 was assumed at 8 800 t (average catch 2013-2017).

	Yield ('000t)			**P($F>F_{lim}$)**			**P($B>B_{lim}$)**				**P($B>B_{msy}$)**				
	2019	**2020**	**2021**	**2019**	**2020**	**2021**	**2019**	**2020**	**2021**	**2022**	**2019**	**2020**	**2021**	**2022**	**P($B_{2022}>B_{2018}$)**
$F_{status\ quo}$ = 0.07	9.14	9.30	9.41	<1%	<1%	<1%	<1%	<1%	<1%	<1%	3%	3%	3%	2%	62%
2/3 F_{MSY} = 0.14	19.52	18.41	17.77	6%	7%	8%	<1%	<1%	<1%	<1%	3%	5%	7%	10%	37%
85% F_{MSY} = 0.18	24.88	22.49	21.09	25%	25%	27%	<1%	<1%	<1%	<1%	3%	7%	12%	18%	28%
F_{MSY} = 0.21	29.28	25.50	23.37	50%	50%	50%	<1%	<1%	<1%	<1%	3%	9%	18%	27%	22%

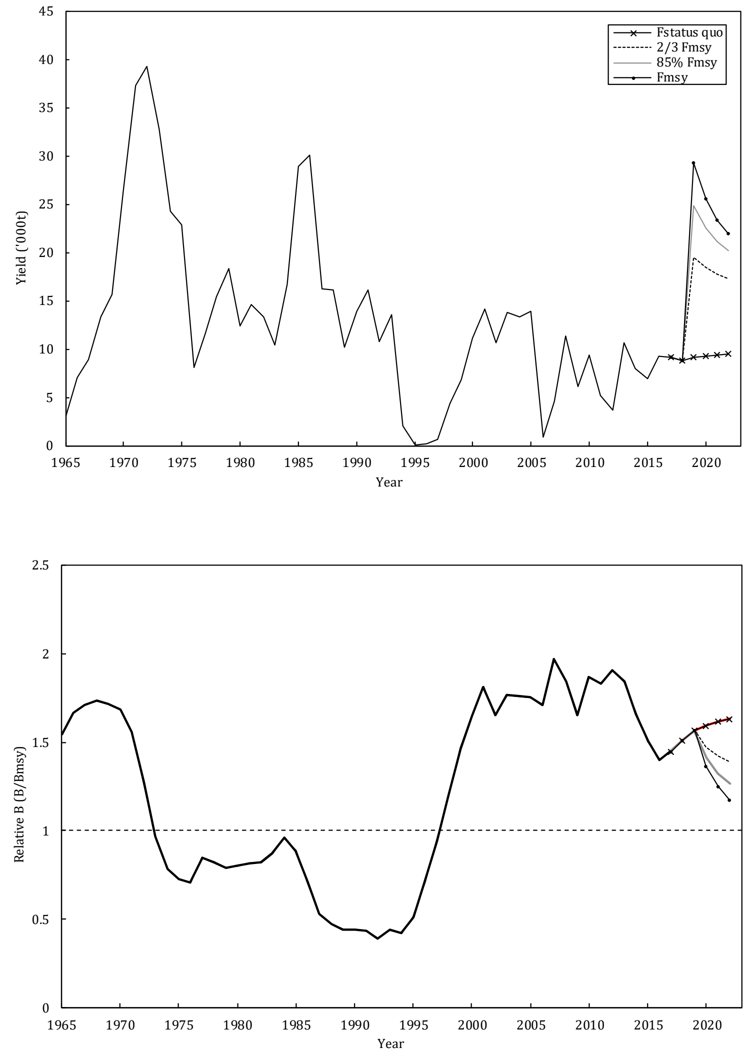


Fig. 12.8. Yellowtail flounder in Div. 3LNO: stochastic projections from 2018-2022 at four levels of *F* (status quo, 2/3 F_{msy}, 85% F_{msy} and F_{msy}). Top panel shows projected yield and lower panel is projected relative biomass ratios (B/B_{msy}).

g) Reference Points:

The stock is presently 1.5 times B_{msy} (B_{msy}=87.63) and *F* is below F_{msy} (Fig. 12.9). Scientific Council considers that 30% B_{msy} is a suitable limit reference point (B_{lim}) for stocks where a production model is used. At present, the risk of the stock being below B_{lim} = 30% B_{msy} is very low (<1%).

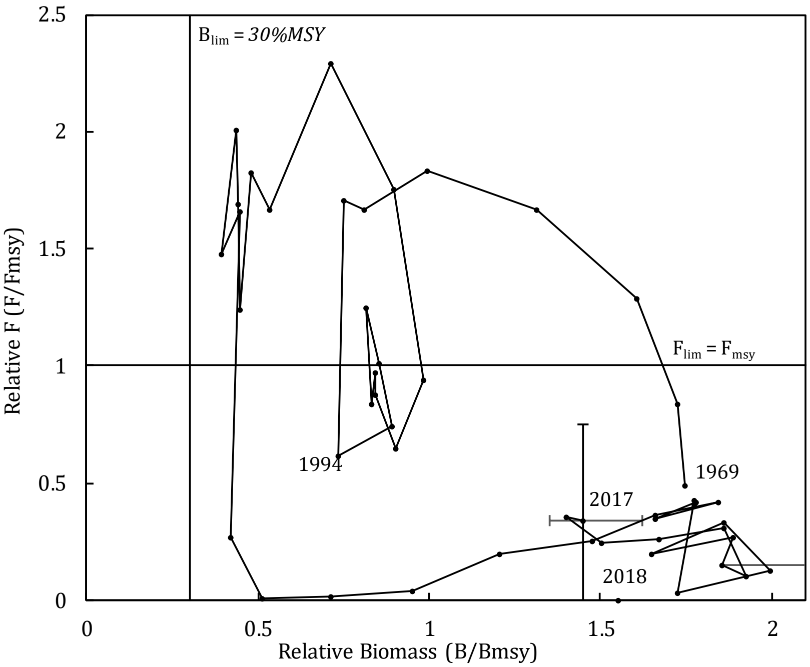


Fig. 12.9. Yellowtail flounder in Div. 3LNO: stock trajectory estimated in the surplus production analysis, under a precautionary approach framework.

Currently the biomass is estimated to be above B_{lim} and F, below F_{lim} (=F_{msy}) with high probability, so the stock is in the safe zone as defined in the NAFO Precautionary Approach Framework.

The next assessment is planned for 2021.

h) Recommendation

In 2017, STACFIS **recommended** *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.*

STATUS: Sensitivity of the ASPIC formulation to observed declines in survey indices was explored and this formulation was found to be unresponsive to changing indices. Alternate production models were examined, and a Bayesian model, which fit the trends in the indices better, was accepted on which to base advice for this stock.

i) References

Meyer, R. and R.B. Millar. 1999. Bayesian stock assessment using a state-space implementation of the delay difference model. Can. J. Fish. Aquat. Sci. 56: 37-52.

Pedersen, M. W. and Berg, C. W. 2017 A stochastic surplus production model in continuous time. Fish Fish, 18: 226-243.

Prager, M. H. 2015. User's Guide for ASPIC Suite, Version 7: A Stock–Production Model Incorporating Covariates and Auxiliary programs. Prager Consulting Portland, Oregon, USA. 33p.

13. Witch Flounder (*Glyptocephalus cynoglossus*) in Divs 3N and 3O

(Full assessment report. SCR Docs 18/14 18/15, 18/03, 18/05, 18/25, 18/53; SCS Docs. 18/05, 18/06, 18/07, 18/08, 18/13)

a) Introduction

This stock underwent full assessment in 2014 based on survey indices, and in 2015 and 2017 utilizing a surplus production model in a Bayesian framework. 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 2017 total catch was estimated to be 656 t.

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**	**2018**
TAC	ndf	ndf	ndf	ndf	ndf	ndf	ndf	1.0	2.2	2.2	1.1
STATLANT 21A	0.2	0.1	0.4	0.4	0.3	0.3	0.3	0.4	1.0	0.6	
STACFIS	0.3	0.4	0.4	0.4	0.3	0.3	0.3	0.4	1.1	0.7	

ndf = no directed fishery.

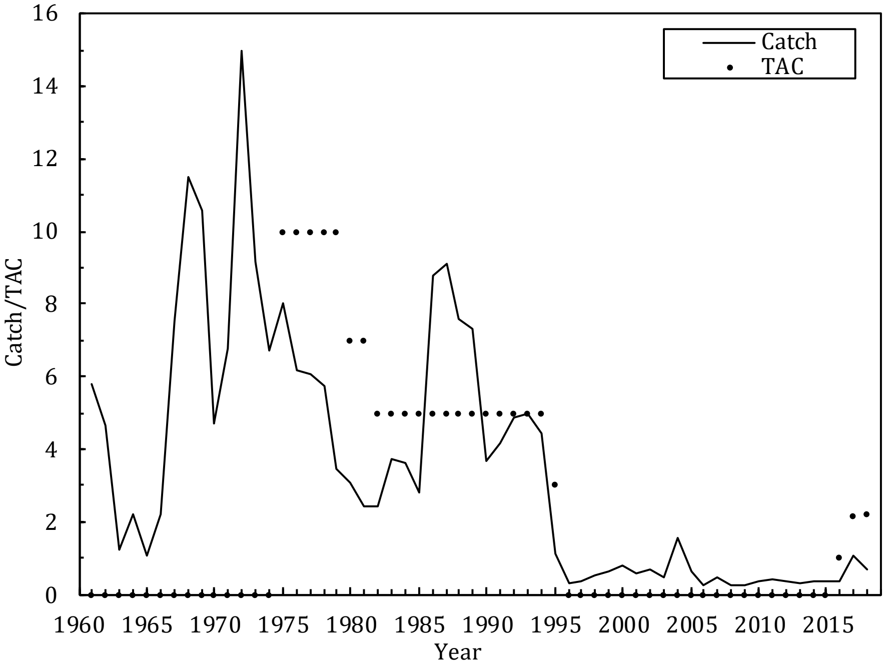


Fig. 13.1. Witch flounder in Divs. 3NO (1960-2017): Catch and TAC ('000 tonnes).

b) Data Overview

i) Commercial fishery data

Length frequencies. Length frequencies were available from observer data for Canadian witch flounder directed and bycatch fisheries in NAFO Div. 3O in 2017**.** Canadian data indicated the catch and bycatch 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, in 2017 (Fig. 13.2). The Spanish data (SCS 18/04) from Divs. 3NO indicated most of the witch flounder catch and bycatch was between 28 and 46 cm in length (Fig. 13.2).

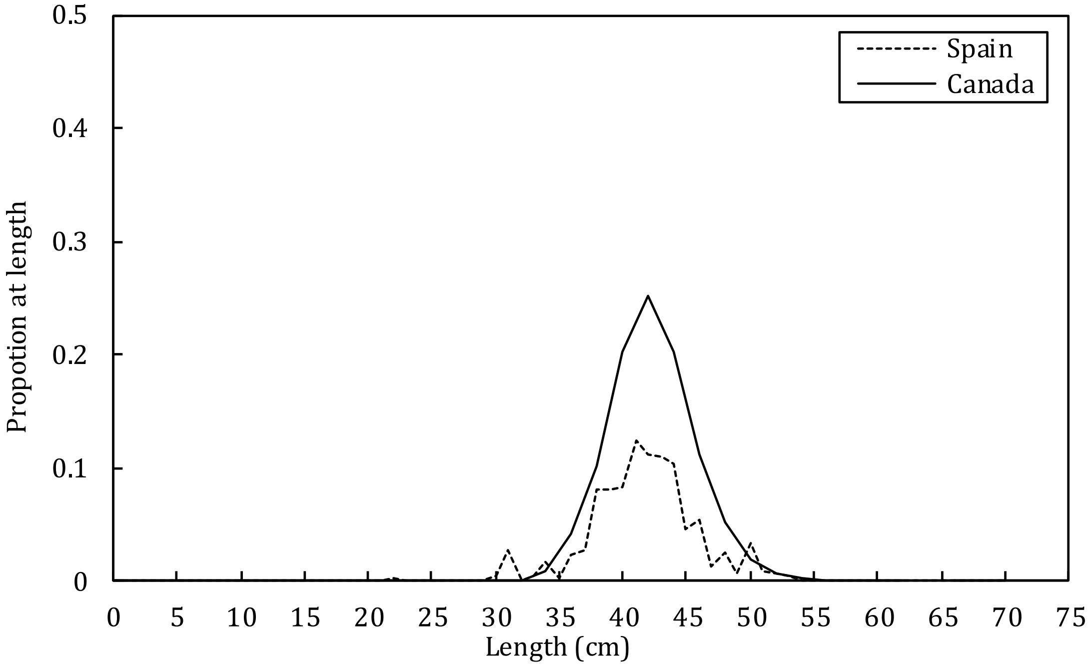


Fig. 13.2. Witch flounder length frequency (cm) distributions for Canada (NAFO Div. 3O) and Spain (NAFO Divs. 3NO) commercial bycatch and directed fisheries in 2017.

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 (Fig. 13.3). Biomass indices declined substantially from a high in 2013 to a value 49% of the time series average in 2015. Biomass indices increased slightly in 2016 to a value of 78% of the time series mean and in 2017 to a value equivalent to the time series mean (Fig. 13.3).

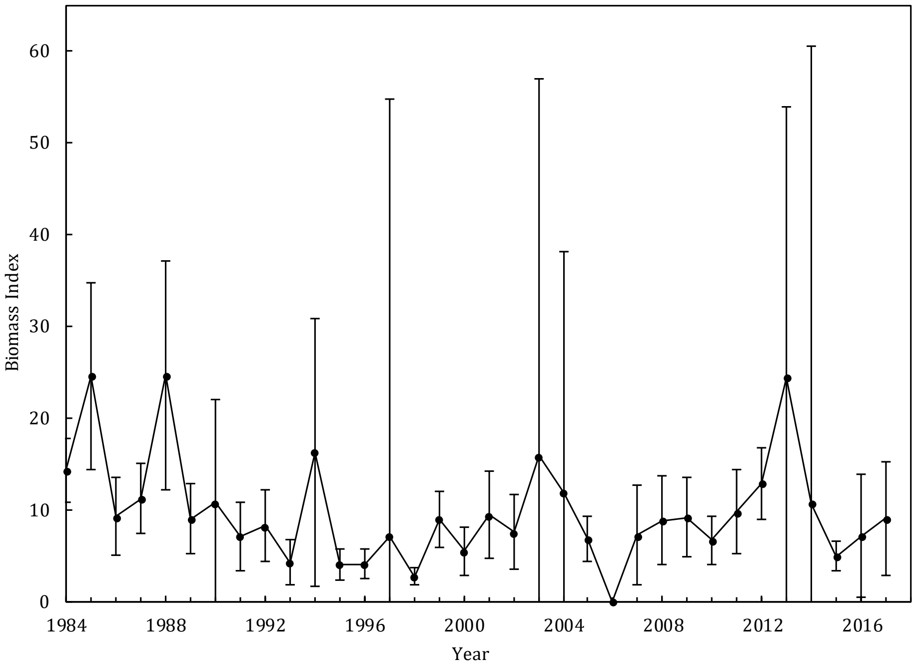


Fig. 13.3. Witch flounder length frequency (cm) distributions for Canada (NAFO Div. 3O) and Spain (NAFO Divs. 3NO) commercial bycatch and directed fisheries in 2017.

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). Biomass indices in 2017 increased slightly to a level 64% of the time series mean.

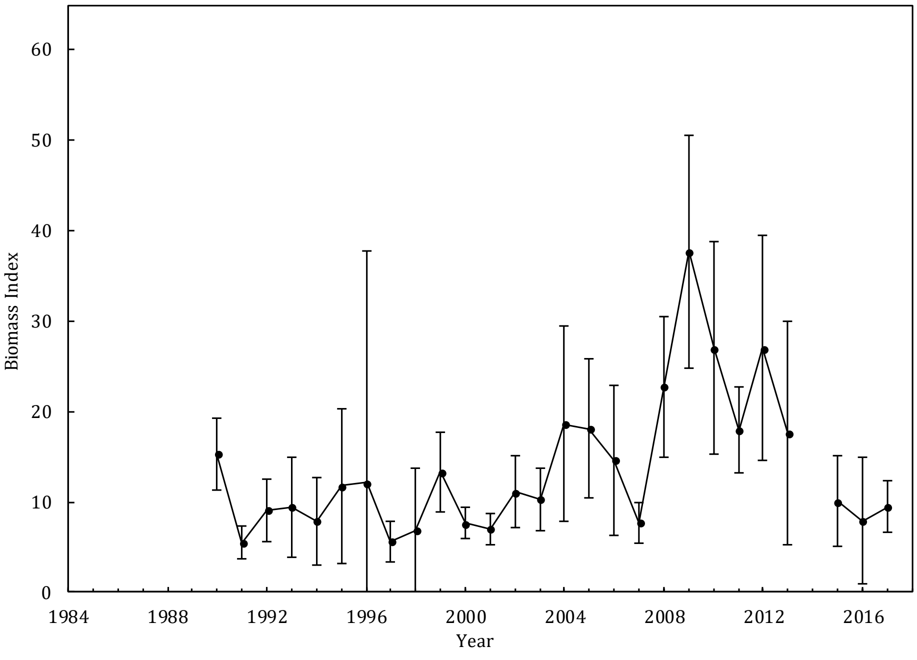


Fig. 13.4. Witch flounder in Divs. 3NO: biomass indices ('000 t) from Canadian autumn surveys 1990-2017 (95% confidence limits are given). Values are Campelen units or, prior to 1996, Campelen equivalent units.

EU-Spain RV spring survey. Surveys have been conducted annually from 1995 to 2017 by EU-Spain in the NAFO Regulatory Area in Divs. 3NO to a maximum depth of 1,450 m (since 1998). In 2001, the vessel (*Playa de Menduiña*) and survey gear (Pedreira) were replaced by the R/V *Vizconde de Eza* using a Campelen trawl (NAFO SCR 05/25). Data for witch flounder prior to 2001 have not been converted and therefore data from the two time series cannot be compared. In the Pedreira series, the biomass increased from 1995-2000 but declined in 2001. In the Campelen series, the biomass index increased from 2014 to 2017. (Fig. 13.5).

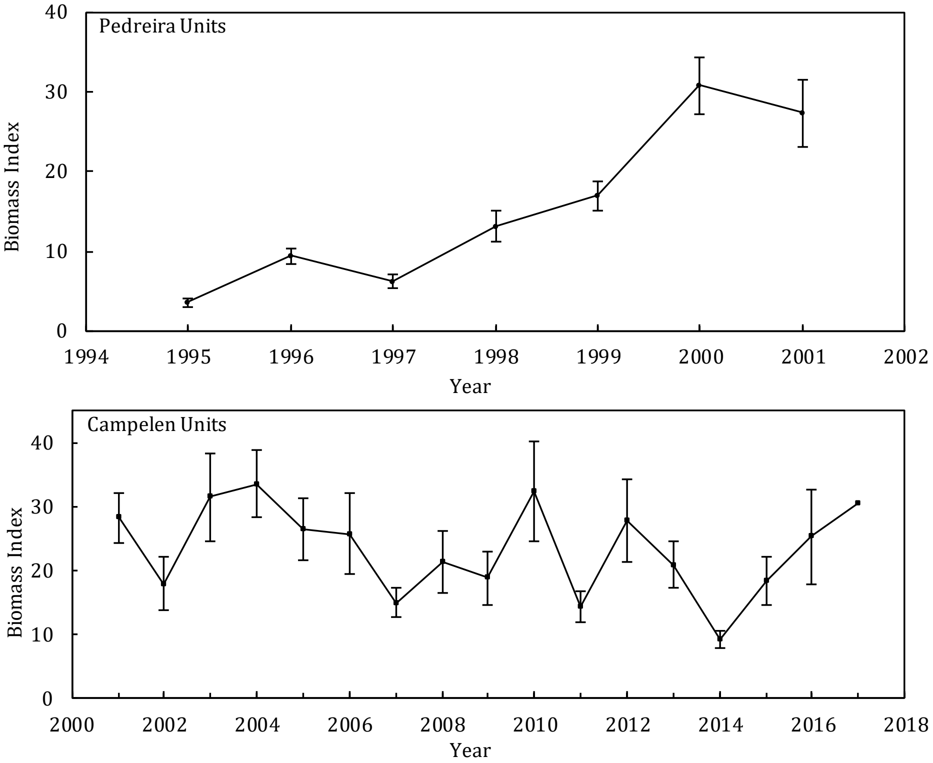


Fig. 13.5. Witch flounder in Divs. 3NO: biomass indices from EU-Spanish Div. 3NO spring surveys (± 1 standard deviation). Data from 1995-2001 is in Pedreira units; data from 2001-2017 are Campelen units. Both values are presented for 2001.

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 (Fig. 13.6). However, since 2007 there has been an increase in the number of larger fish in the 40-45 cm range except for an anomalous 30-35 cm range encountered in 2014 (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 2017 the size range has generally increased with more fish in the 38-40 cm range (Fig 13.6). 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 spring series and from 2005 -2006 in the Spanish spring series (Fig. 13.6). A distinctive recruitment peak in the 10 cm range was also evident in the 2017 Canadian autumn rv survey (Fig. 13.6).

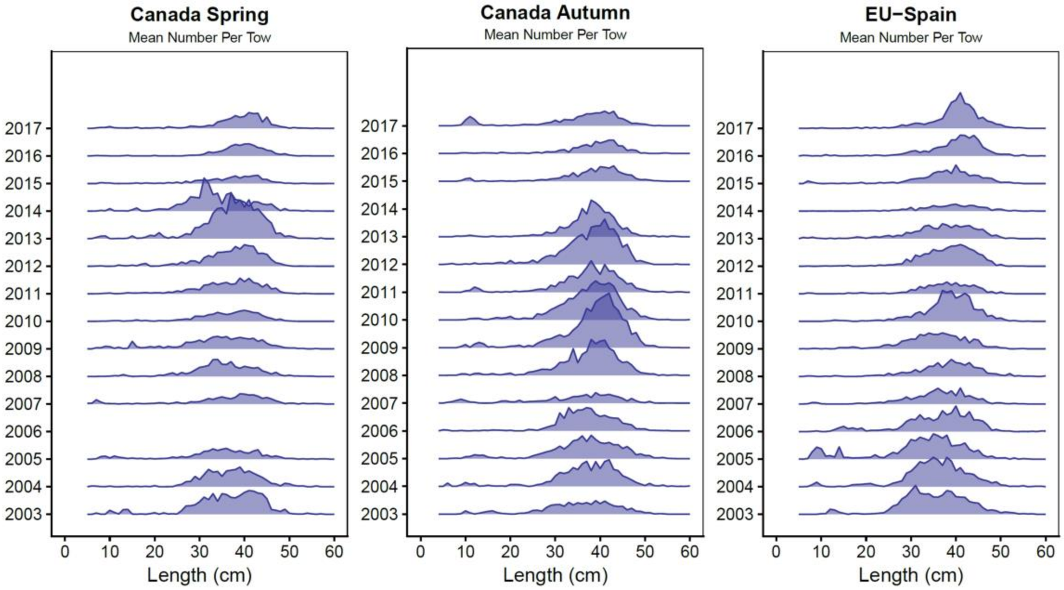


Fig. 13.6. Length frequencies (abundance at length) of witch flounder from spring Canadian (2003-2017) and Spanish (2003-2017) rv surveys in NAFO Divs.3NO. No Canadian survey data was available in spring 2006 or autumn 2014.

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 1960-2017, Canadian spring survey series from 1984-1990, Canadian spring survey series from 1991-2017 (no 2006) and the Canadian autumn survey series from 1990-2017 (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)

The formulation used in the 2017 assessment of this stock had very large process error and this process error had trend. In addition, the model predicted fall survey indices were above the observations in the last 3 years. The survey indices have been declining faster than can be explained by the process being modelled. To account for this a change was made to the model to allow process error to increase in 2014, 2015 and 2016 compared to the rest of the years (the sigma parameter was increased by 1 in those years).

This resulted in large process error in 2014 and 2015 but much smaller overall process error with no trend and a better fit to the fall survey index. This change to the formulation is a way to account for an apparent change in state of the population that is not captured in the process being modelled. There is increased structural uncertainty which is not reflected in the overall uncertainty used in the projections of stock status. The decline in biomass from 2014 to 2016 estimated using the present formulation is consistent with declines in other fish species on the Grand Bank and with changes in other components of the ecosystem.

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 (Fig. 13.7). Recruitment in spring and fall surveys in 2016 approached the lowest of the time series (Fig. 13.7). Recruitment in 2017 surveys increased in the fall to a value just above the time series mean while those in the spring increased to a value approaching the time series mean (Fig.13.7).

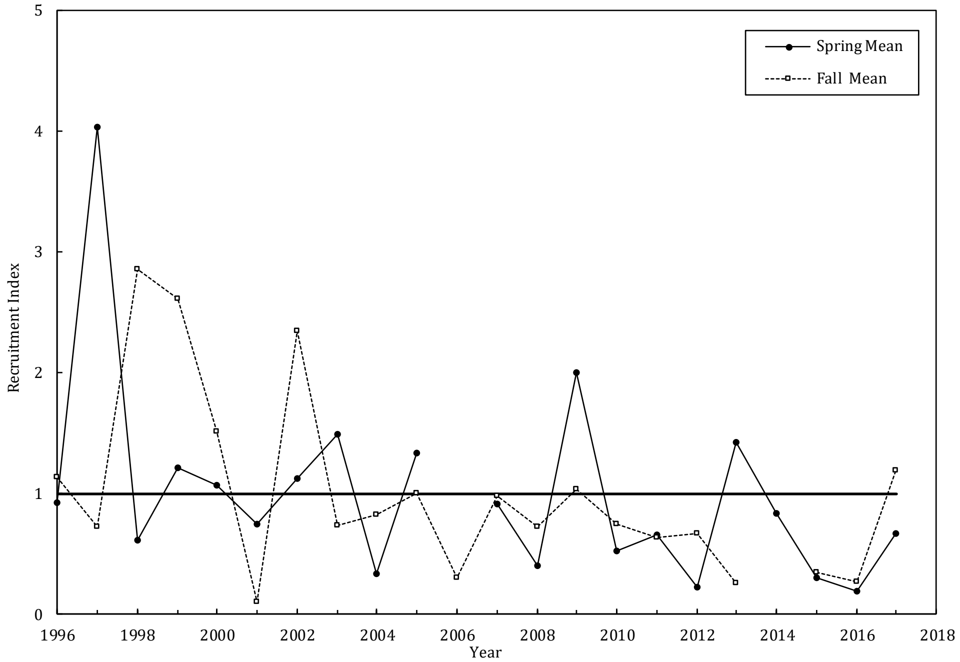


Fig. 13.7. Recruitment index of witch flounder (<21cm) from spring and fall Canadian rv surveys in NAFO Divs.3NO 1996-2017. No survey data available in fall 2014 or spring 2006.

Stock Production Model: The surplus production model results indicate that stock size decreased from the late 1960s to the late 1990s and then increased from 1999 to 2013. There was a large decline from 2013 to 2015. The model suggests that a maximum sustainable yield (*MSY*) of 3 774 (2 252 - 5 690) tonnes can be produced by total stock biomass of 59 910 (37 910 - 81 910) tonnes (B_{msy}) at a fishing mortality rate (F_{msy}) of 0.06 (0.04-0.12) (Fig. 13.8).

Biomass: The analysis showed that relative population size (median B/B_{msy}) was below B_{lim}=30%B_{MSY} from 1993-1998 (Fig. 13.8). Biomass in 2018 is 0.37 of B_{MSY} with a probability of being below B_{lim} of 0.29.

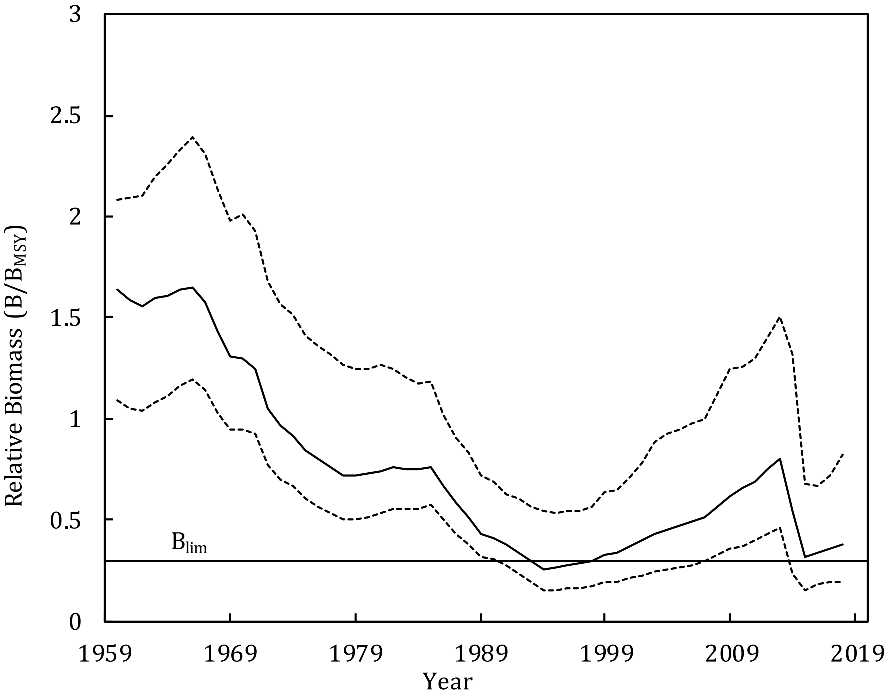


Fig. 13.8. Witch flounder in Divs. 3NO. Median relative biomass (*Biomass/*B_{MSY}) with 90% credible intervals from 1960-2018. The horizontal line is $B_{lim}=30\%B_{MSY}$.

Fishing Mortality: Relative fishing mortality rate (median F/F_{msy}) was mostly above 1.0 from the late 1960s to the mid-1990s (Fig. 13.9). *F* has been below F_{msy} since the moratorium implemented in 1995. Median *F* was estimated to be 50% of F_{msy} with a very low probability of being above F_{msy} in 2017.

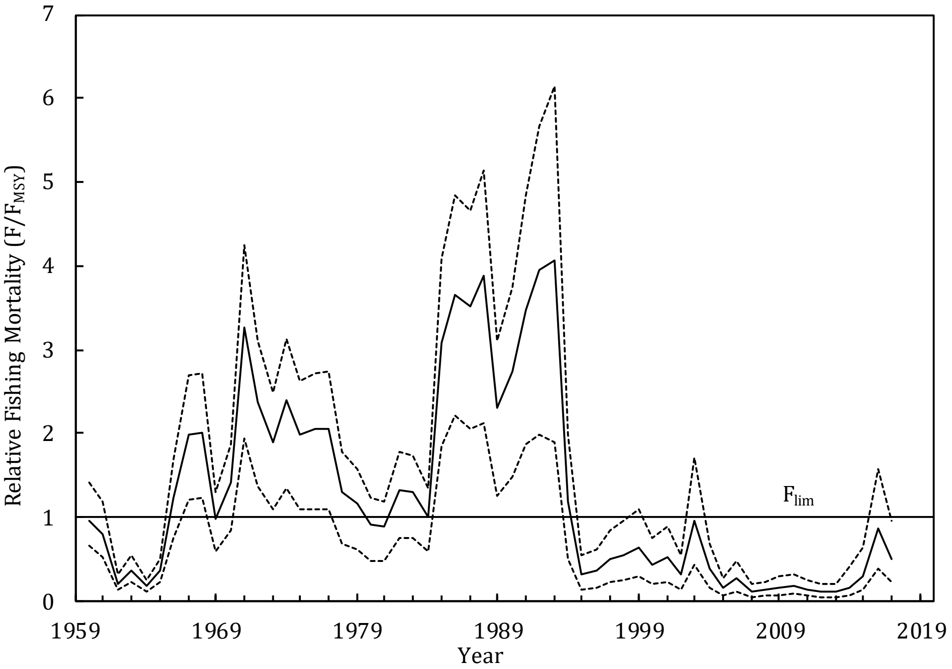


Fig. 13.9. Witch flounder in Divs. 3NO. Median relative fishing mortality (F/F_{MSY}) with 90% credible intervals from 1960-2017. The horizontal line is $F_{lim}=F_{MSY}$.

e) State of the Stock

The stock size increased since 1999 to about 2010 and then declined after 2013 and is now at 37% B_{msy} (B_{msy} = 60 000 t). There is presently a 29% risk of the stock being below B_{lim} and a 4% risk of F being above F_{lim}. Recruitment in 2017 surveys increased in the fall to a value just above the time series mean while those in the spring increased to a value approaching the time series mean (Fig. 13.7).

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 2021. All projections assumed that the catch in 2018 was equal to the TAC of 1 116 t (which produces F_{2018}). This assumption was based on reported catches to the end of April 2018 of almost 600 t. This was followed by constant fishing mortality for 2019 and 2020 at several levels of F ($F=0$, F_{2017}, 2/3 F_{MSY}, 85% F_{MSY}, and F_{MSY}).

The probability that F > F_{lim} in 2018 is 30% at a catch of 1 116 t. The probability of F>F_{lim} ranged from 7 to 50% for the catch scenarios tested (Table 13.2, 13.3). The population is projected to grow under all scenarios (Fig. 13.10) and the probability that the biomass in 2021 is greater than the biomass in 2018 is greater than 60% in all scenarios. The population is projected to remain below B_{MSY} for all levels of F examined with a probability of greater than 90%. The probability of projected biomass being below B_{lim} by 2021 was 19 to 24% in all catch scenarios examined and was 15% by 2021 in the F=0 scenario.

Table 13.10. Medium-term projections for witch flounder. The median projected yield and 5th, 50th and 95th percentiles of relative biomass B/B_{msy}, are shown, for projected F values of $F=0$, F_{2017}, 2/3 F_{msy}, 85% F_{msy} and F_{msy}.

	Projections with catch in 2018 = 1 116 t	
	Median	Median (90% CI)
F=0	Projected Yield (t)	Projected Relative Biomass (B_y /B_{msy})
2019	0	0.39 (0.19, 0.91)
2020	0	0.43 (0.21, 1.02)
2021		0.48 (0.23, 1.12)
F_{2017}=0.03	Projected Yield (t)	Projected Relative Biomass (B_y /B_{msy})
2019	740	0.39 (0.19, 0.91)
2020	792	0.42 (0.20, 1.00)
2021		0.45 (0.20, 1.09)
2/3 F_{msy}=0.04	Projected Yield (t)	Projected Relative Biomass (B_y /B_{msy})
2019	979	0.39 (0.19, 0.91)
2020	1035	0.42 (0.19, 0.99)
2021		0.44 (0.19, 1.08)
85% F_{msy}=0.05	Projected Yield (t)	Projected Relative Biomass (B_y /B_{msy})
2019	1248	0.39 (0.19, 0.91)
2020	1306	0.41 (0.19, 0.99)
2021		0.43 (0.19, 1.06)
F_{msy}=0.06	Projected Yield (t)	Projected Relative Biomass (B_y /B_{msy})
2019	1468	0.39 (0.19, 0.91)
2020	1522	0.41 (0.19, 0.98)
2021		0.42 (0.18, 1.05)

Table 13.3. Projected yield (t) and the risk of F> F_{lim}, B<B_{lim} and B<B_{MSY} and probability of stock growth (B_{2021}>B_{2018}) under projected F values of F=0, F2017, 2/3 F_{MSY}, 85% F_{MSY}, and F_{MSY}.

	Yield 2019	Yield 2020	P(F>F_{lim})		P(B<B_{lim})			P(B<B_{MSY})			P(B_{2021}>B_{2018})
			2019	2020	2019	2020	2021	2019	2020	2021	
F=0	0	0	0	0	26%	20%	15%	96%	95%	93%	72%
F2017=0.03	740	792	7%	8%	26%	22%	19%	96%	95%	93%	67%
2/3 Fmsy=0.04	979	1035	19%	20%	26%	23%	21%	96%	95%	94%	65%
85%Fmsy=0.05	1248	1306	36%	37%	26%	24%	23%	96%	95%	94%	63%
Fmsy=0.06	1468	1522	50%	50%	26%	25%	24%	96%	95%	94%	61%

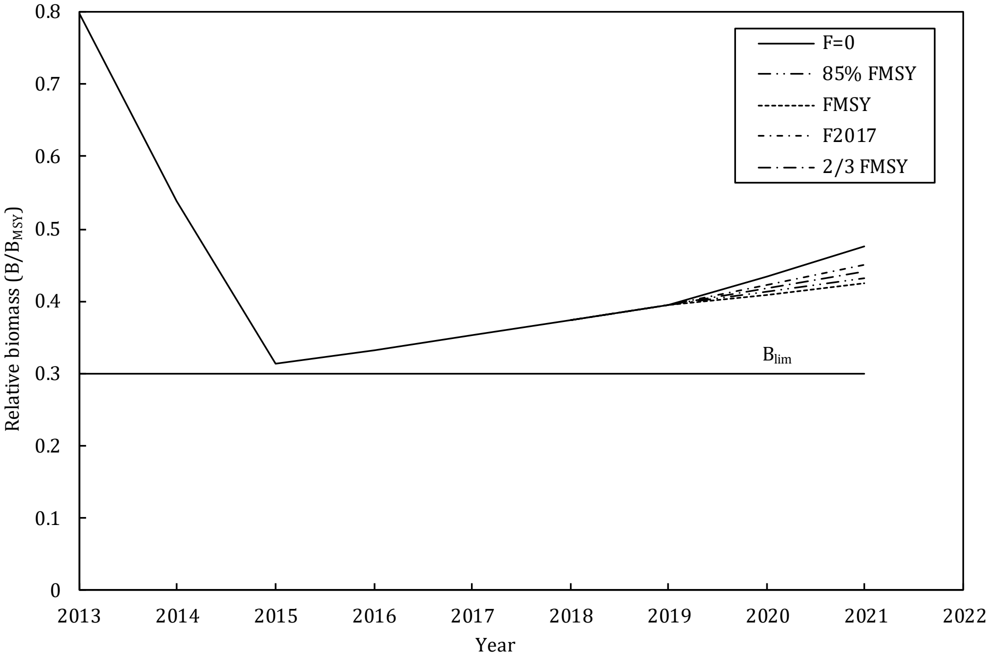


Fig. 13.10. Witch flounder in Divs. 3NO: medium term projections of relative biomass (B/B_{msy}) at five levels of F (F=0, F2017, 2/3 F_{msy}, 85% F_{msy} and F_{msy}). A catch of 1,116 t is assumed in 2018.

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 0.29 and above F_{lim} is 0.04 (Fig. 13.11).

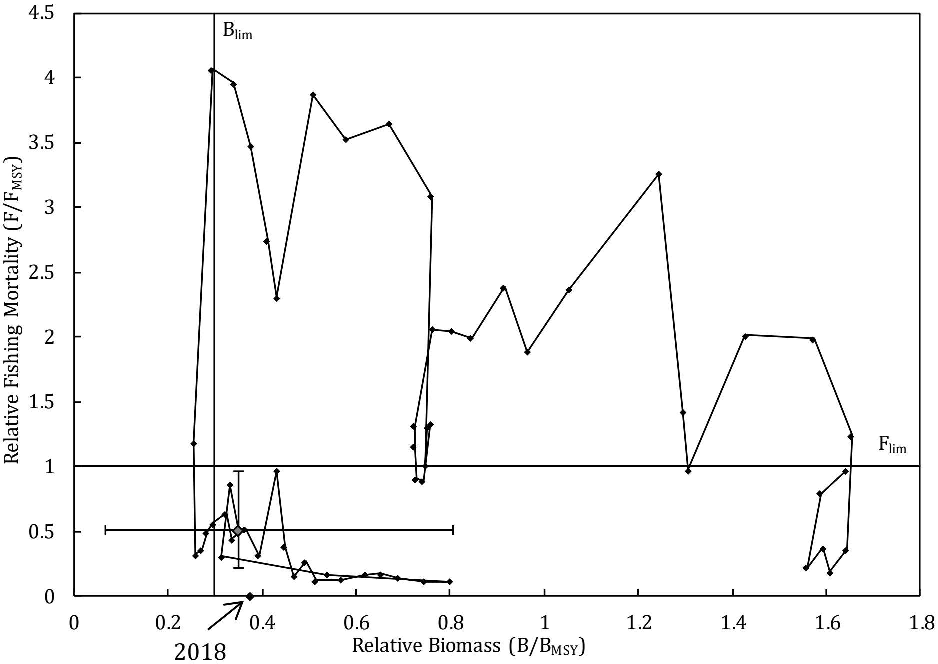


Fig.13.11. Witch flounder in Divs. 3NO: stock trajectory estimated in the surplus production analysis, under a precautionary approach framework.

h) Recommendations

STACFIS **recommends** *that the prior distributions be further explored for the surplus production model for witch flounder in Div. 3NO.*

Length frequency distributions for this stock do not show evidence of recruitment during the period when the stock was increasing. STACFIS **recommends** that *recruitment to this stock be further investigated, including the distribution of small fish throughout the 3LNOPs area.*

The next assessment is planned for 2020.

14. Capelin (Mallotus *villosus*) in Divs. 3NO

(SCR Doc. 18/046, SCS Doc. 18/007)

a) Introduction

The fishery for capelin started in 1971 and catch was highest in the mid-1970s with a maximum catch of 132 000 t in 1975. The directed fishery was closed in 1992 and the closure has continued through 2017 (Fig. 14.1). 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. 11 t of discards was reported by CESAG in 2017. Nominal catches (t), TAC's ('000 t) and STACFIS (t) are as follows:

	2009	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**
TAC	ndf	ndf	ndf	ndf	ndf	ndf	ndf	ndf	ndf	ndf
STATLANT 21	0	0	0	0	0	1	0	5	0	

ndf no directed fishing

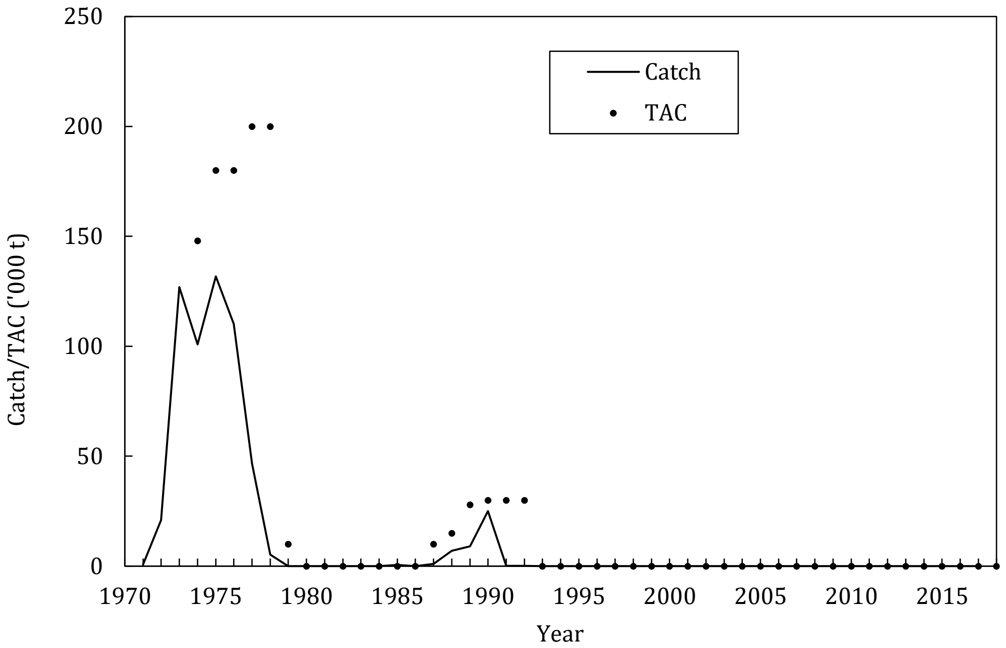


Fig. 14.1. Capelin in Div. 3NO: catches and TACs.

b) Data Overview

i) Commercial catches data

For the recent period, only catches from Spain for 2017 is available. In this year 300 kg was caught. Based on samples taken from catches, mean capelin length (combined sex) was 14 cm for Div. 3O and 13 cm for Div. 3N.

ii) Research survey data

Acoustic surveys of the capelin stock in Divisions 3NO were conducted by the USSR/Russia in 1975-1994 and Canada in 1981-1992. Now, it is difficult to compare the results of these surveys since most of Russian suveys covered Divisions 3LNO. Maximum stock size was registered in 1988 and then an abrupt decline was observed after 1990 (Fig.14.2).

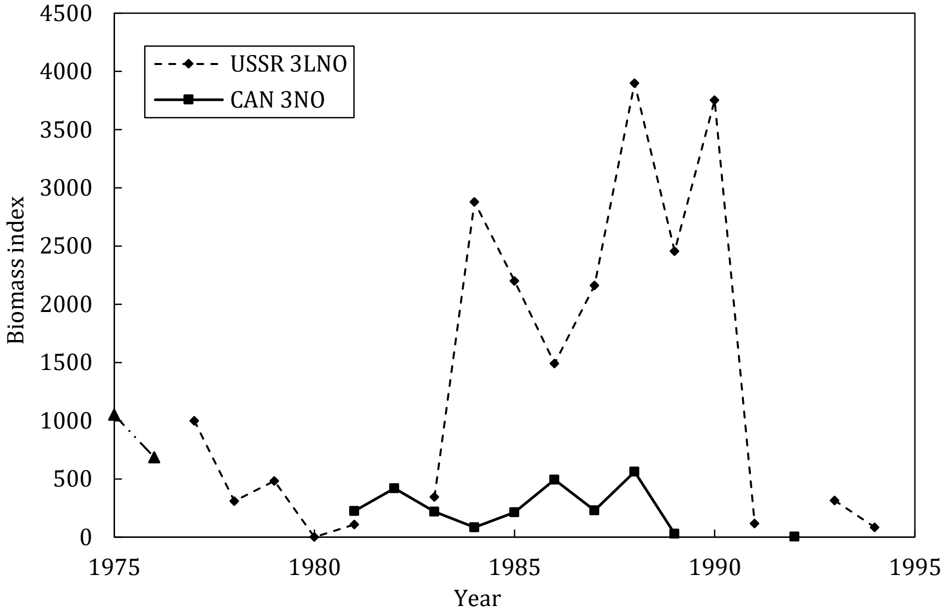


Fig. 14.2. Estimate of capelin stock according to the data of Russian and Canadian acoustic survey in 1975-1994

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 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 only indicator of stock dynamics presently available may be capelin biomass indices obtained during Canadian stratified-random spring trawl surveys. In 1996-2017, when a Campelen trawl was used as a sampling gear, survey biomass index of capelin in Div. 3NO varied from 3.8 to 227 Kt (Fig.14.3), and the average value for this period is 42.5 Kt. In 2005, survey biomass index of capelin in Div. 3NO was 3.9 Kt, the lowest level since 1996; estimates in 2006 are not compatible because of poor cover in that year. In 2008 the biomass index sharply increased to 114 Kt and decreased in next three years to the level of 4.1 Kt in 2011. In 2013 biomass index was 74.9 Kt and it's considerably increased in 2014 to the highest level of the entire period – 227 Kt. In 2015-2016 biomass indices declined to the historical minimum 3.8 Kt and increased again to 78.7 Kt in 2017.

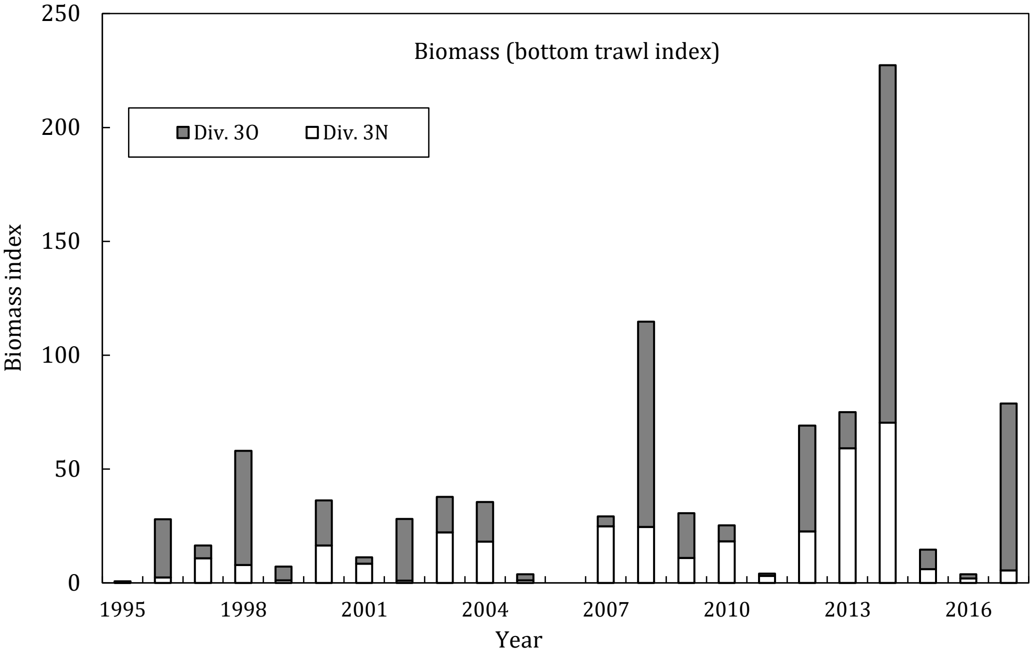


Fig. 14.3. Capelin in Div. 3NO: survey biomass index from Canadian spring surveys in 1996-2017

Data from EU-Spain trawl surveys in Divs. 3NO for 1995-2017 is also available (Fig. 14.4). Data from 1997-2000 are transformed C/V "Playa de Menduíña" to be comparable with the 2002-2017 R/V "Vizconde de Eza" data. For this period stratified mean catches varied between 0.001 and 0.15 t. Survey catches reached its maximum value in 2012 and declined in next 5 years for the level of 0.005 t in 2017.

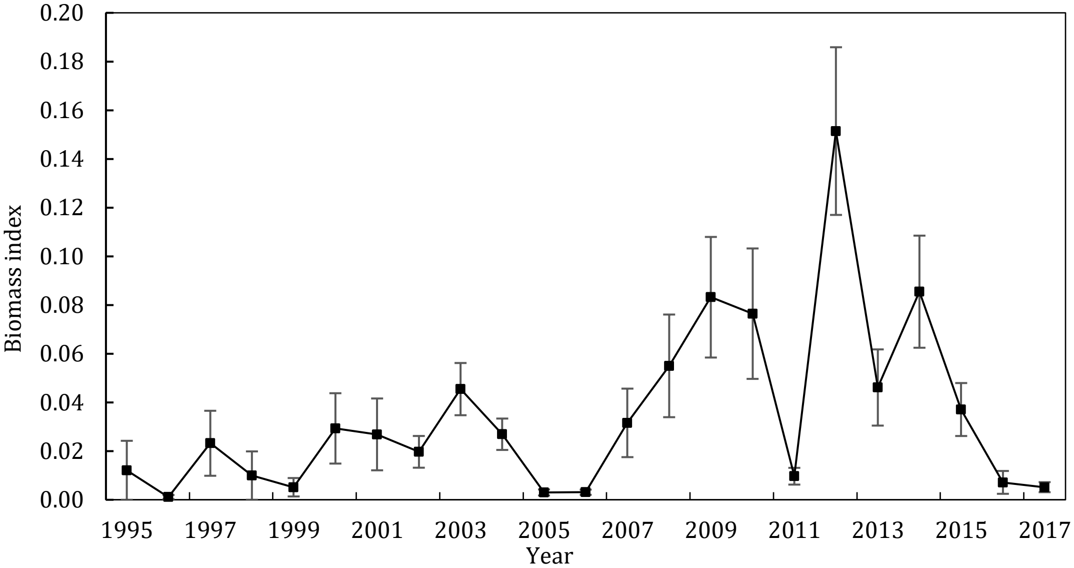


Fig. 14.4. Biomass index and standard deviations of capelin (1995-2017) based on EU-Spain trawl surveys. 1997-2000 data are transformed C/V "Playa de Menduíña" data. 2002-2017 data are original from R/V "Vizconde de Eza". In 2001, there are data form the two vessels.

Survey estimates of capelin biomass shows very similar trend as catches, with the same peaks. In 2012 maximum biomass level was observed. It was 134 th. t. For the period 2015-2017 biomass sharply declined from 32 Kt to 4 Kt.

c) Estimation of Stock Parameters

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 1990-2017. 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 1996-2017, the mean catch varied between 0.05 and 2 t/km^2. In 2017 this value was 1.2 t/km^2 (Fig. 14.5).

Bottom-trawling is not a satisfactory basis for a stock assessment of a pelagic species and survey results are indicative only.

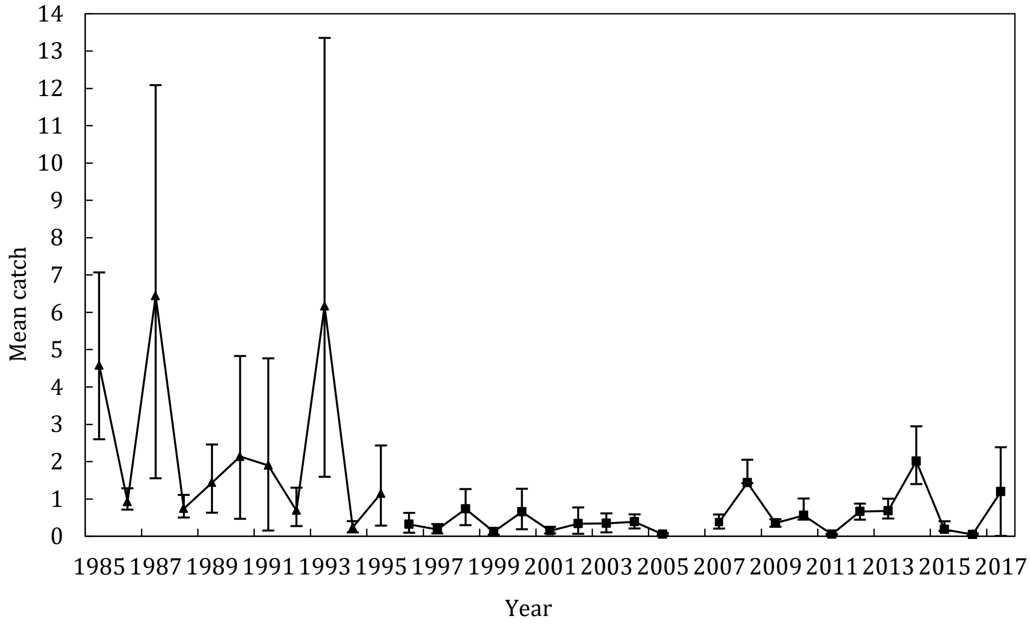


Fig. 14.5. Capelin in Div. 3NO: mean catch from Canadian spring surveys in 1985-2017. Estimates prior to 1996 are from Engel and from 1996-2017 are from Campelen.

d) Assessment Results

Acoustic surveys series terminated in 1994 indicated a stock at a low level. Although biomass indices have increased in recent years, bottom trawl surveys are not considered a satisfactory basis for a stock assessment of a pelagic species.

e) Precautionary Reference Points

STACFIS is not in a position to determine biological reference points for capelin in Div. 3NO.

f) 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 assessment is planned for 2021.

15. Redfish (Sebastes mentella and Sebastes fasciatus) in Div. 3O

Interim Monitoring Report (SCR Doc. 18/12; SCS Doc. 18/ 05, 06, 07, 09, 13, 15)

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 tons for 2005-2008 and has remained at that level. This TAC applies to the entire area of Div. 3O. The stock was most recently assessed in 2016.

Nominal catches have ranged between 3 000 tons and 35 000 tons since 1960 and have been highly variable with several distinct periods of rapid increase and decrease (Fig. 15.1). Up to 1986 catches averaged 13 000 tons, increased rapidly and peaked at 35 000 tons in 1988, then declined to 5 100 tons by 1997. Catches totaled 20 000 tons in 2001, then it declined to 4 000 tons in 2008. Catch was relatively stable between 7500 t and 9000 t during the recent period (2013 to 2017). Catch was 7500 tons in 2017.

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

	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
TAC	20	20	20	20	20	20	20	20	20	20
STATLANT 21	6.3	6.5	6.0	6.4	7.5	7.6	7.9	8.9	7.5	
STACFIS	6.4	5.2	6.0	6.4	7.5	7.6	8.4	9.0	7.5	

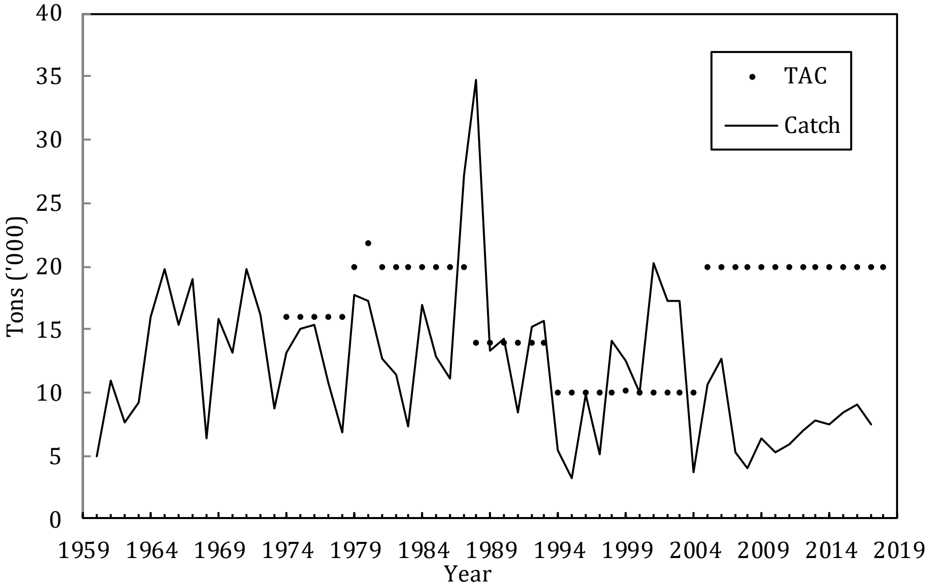


Fig. 15.1. Redfish in Div. 3O: Catches and TACs. TACs prior to 2004 applied only to Canadian waters.

b) Data Overview

i) Surveys

Canadian spring and autumn surveys were conducted in Div. 3O during 2017. 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 and 2017 near the time-series low. For the spring and autumn series, the 2017 biomass indices were 46% and 28% respectively, of the average values over 2010-2012. Since 2012, trends in abundance indices were very similar to those in biomass indices.

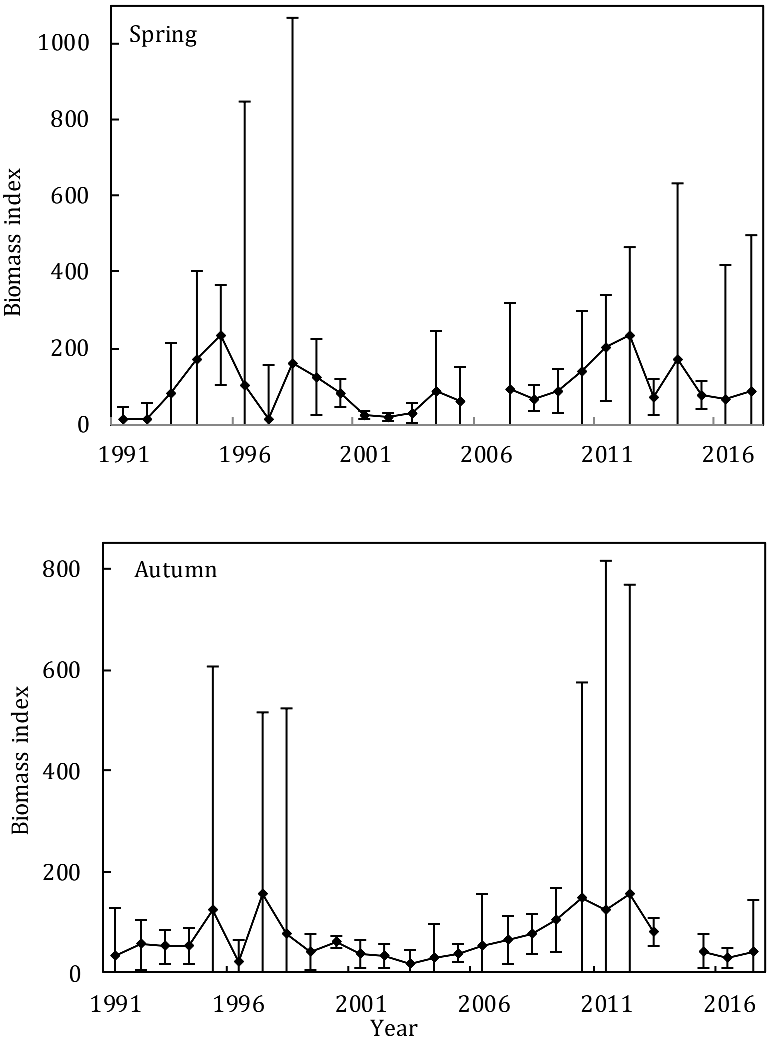


Fig. 15.2. Redfish in Div. 3O: Survey biomass indices from Canadian RV surveys in Div. 3O (Campelen equivalent estimates prior to autumn 1995)

c) Estimation of Stock Parameters

There is no assessment model for this stock and survey indices are used to assess stock status.

d) Catch/Biomass ratio

A fishing mortality proxy was derived from the ratio of catch in year "n" to the average of the Canadian Spring (year n) and Autumn (year = n-1) survey biomass. Since 1998, the fishing mortality proxy was highest from

2001 to 2003, with a secondary peak in 2006, and lowest during the period 2007 to 2014. The fishing mortality proxy increased during the 2014 to 2016 period but values have remained below the 2006 secondary peak since 2014.

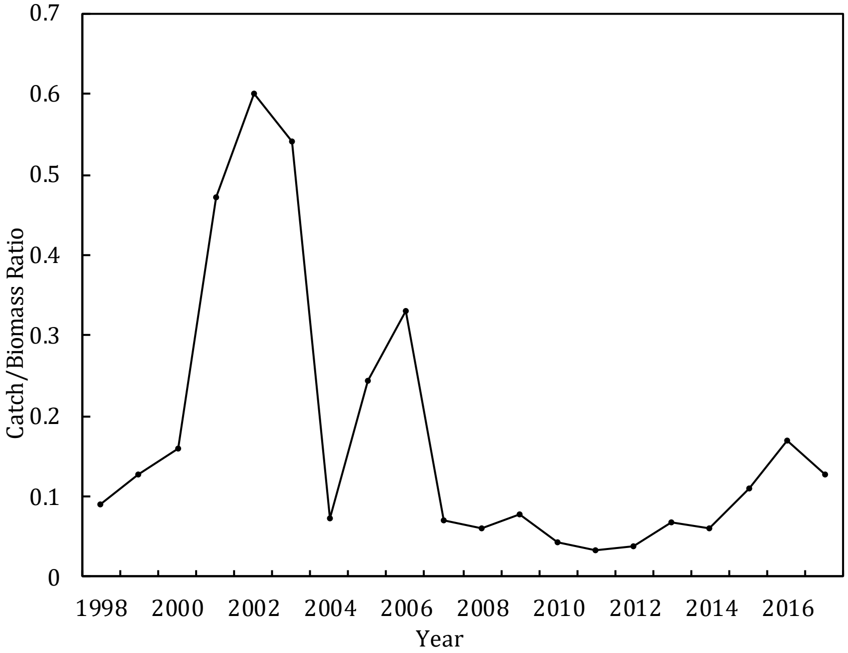


Fig. 15.3. Redfish in Div. 3O: Catch/survey biomass ratios for Div. 3O. Biomass was calculated as the average survey biomass between spring (n) and autumn (n-1) for year (n) in which catch was taken. The 2006 and 2014 values of biomass come from the autumn and spring surveys respectively.

e) Conclusion

Catches increased from 2010 to 2016 as a dominant recruitment pulse entered the fishery but catch decreased slightly in 2017. Spring and fall Canadian survey indices were near the time-series peaks during 2010 to 2012, but values have generally decreased since then, and both the 2016 and 2017 fall values were 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, but moderately higher values have been observed since then.** Given the high variability in the survey indices and the long life-span of redfish, there is nothing to indicate a change in the status of the stock.

The next assessment is planned for 2019.

f) 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

(SCR Doc. 18/13,17,18,27 SCS Doc. 18/07,08,13,15)

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 (Fig. 16.1). This TAC was lowered to 12 000 t for 2010-2011, and to 8 500 tons for 2012. The TAC was further reduced to 7 000 t for 2013-2018. In Subdiv. 3Ps, Canada established a TAC of 1 050 tons in 1997, which has not changed.

Catches from the NRA of Divs. 3LNO increased in the mid-1980s with the commencement of a directed fishery for Thorny Skate (Fig. 16.1). The main participants in this new fishery were Spain, 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-21A). From 1992-1995, catches of Thorny Skate declined to an average of 7 554 t; however, there are substantial uncertainties concerning reported skate catches prior to 1996. Average STACFIS-agreed catch for Divs. 3LNO in 2010-2016 was 4 063 t, and for Subdiv. 3Ps 373 t. STACFIS catch in 2017 totaled 4 463 t for Divs. 3LNO and 605 t for Subdiv. 3Ps.

Recent nominal catches and TACs (000 tons) in Divs. 3LNO and Subdiv. 3Ps are as follows:

	2009	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**
Divs. 3LNO:										
TAC	13.5	12	12	8.5	7	7	7	7	7	7
STATLANT-21A	5.7	5.4	5.5	4.3	4.4	4.5	3.3	3.5	4.2	
STACFIS	5.6	3.1	5.4	4.3	4.4	4.5	3.4	3.5	4.5	
Subdiv. 3Ps:										
TAC	1.05	1.05	1.05	1.05	1.05	1.05	1.05	1.05	1.05	1.05
STATLANT-21A	0.6	0.3	0.5	0.4	0.3	0.2	0.2	0.7	0.6	
Divs. 3LNOPs:										
STATLANT-21A	6.3	5.7	6.1	4.6	4.6	4.7	3.6	4.1	4.8	
STACFIS	6.2	3.4	5.9	4.6	4.6	4.7	3.7	4.1	5.1	

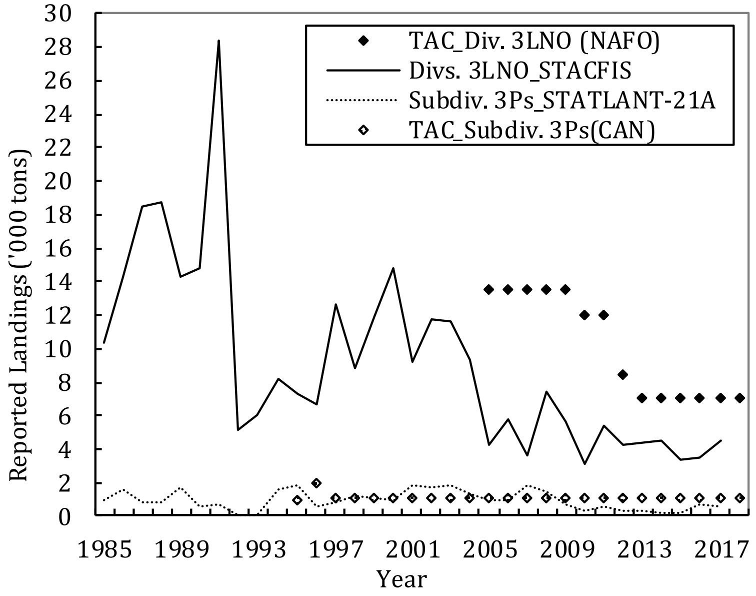


Fig. 16.1. Thorny Skate in Divs. 3LNO and Subdiv. 3Ps, 1985-2017: reported landings and TAC.

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, 1997-2017), EU-Portugal (2002-2004, 2006-2011, 2013, 2017), Russia (1998-2008, 2011-2012, 2015-2016), and Canada (1994-2008, 2010, 2012-2017).

From skate-directed trawl fisheries (280 mm mesh) in the NRA of Divs. 3LNO over 2011-2017, EU-Spain reported 19-97 cm TL skates (mode 48cm), with a small number of young-of-the-year (<21 cm) caught in 2013-2014 and 2017. In 2013 using 280 mm mesh, EU-Portugal caught 26-85 cm skates (mode: 49-50 cm) in Div. 3N.

In trawl fisheries targeting other species (130-135 mm mesh) in Div. 3LNO (NRA), EU-Portugal reported skate bycatch ranging from 30-84 cm TL (modes: 60, 76 cm) in 2011, a 25-84 cm range (modes: 49, 70 cm) in 2013, and 46-88 cm (mode: 72 cm) in 2017. Russian trawlers in the Div. 3L Greenland Halibut fishery reported 33-78 cm skates (mean=67 cm) in 2012, and a 35-82 cm range in 2013. In the Div. 3LO redfish fishery, Russia reported 58-84 cm skates in 2013-2014 (2013 mean=72 cm; 2014 mean=61 cm), a 35-89 cm range (mean=60.8 cm in Div. 3L; mean=68.0 cm in Div. 3O) in 2015, and 39-71 cm TL (mean=47.2 cm) in 2016. In 2014, Canadian longliners directing for Atlantic Cod in Subdiv. 3Ps caught 53-87 cm skates (mode: 72 cm). Thorny Skates caught in the Div. 0B+2GHJ3K shrimp fisheries (using a size-selective groundfish excluder) ranged between 9-41 cm in 2015, and 2016. In the Div. 3L redfish fishery, skates varied between 27-93 cm in 2016 and 2017. Canadian trawlers in the Div. 3NO Yellowtail Flounder fishery in 2016 and 2017 caught 24-101 cm (modes: 42 cm, 72 cm) and 25-91 cm skates (modes: 58 cm, 74 cm), respectively. In 2017, skates trawled in the Div. 3O Witch Flounder fishery ranged between 42-100 cm (mode: 80 cm).

No standardized commercial catch per unit effort (CPUE) exists for Thorny Skate.

ii) Research surveys

Canadian spring surveys. Stratified-random research surveys have been conducted by Canada in Divs. 3LNO and Subdiv. 3Ps in spring; using a Yankee 41.5 otter trawl in 1972-1982, an Engel 145 otter trawl in 1984-1995, and a Campelen 1800 shrimp trawl in 1996-2017. 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. In 2015 and 2017, several strata were not sampled in Div. 3L, thus potentially impacting biomass and abundance estimates of Thorny Skate.

Indices for Divs. 3LNOPs in 1972-1982 (Yankee series) fluctuated without trend (Fig. 16.2a).

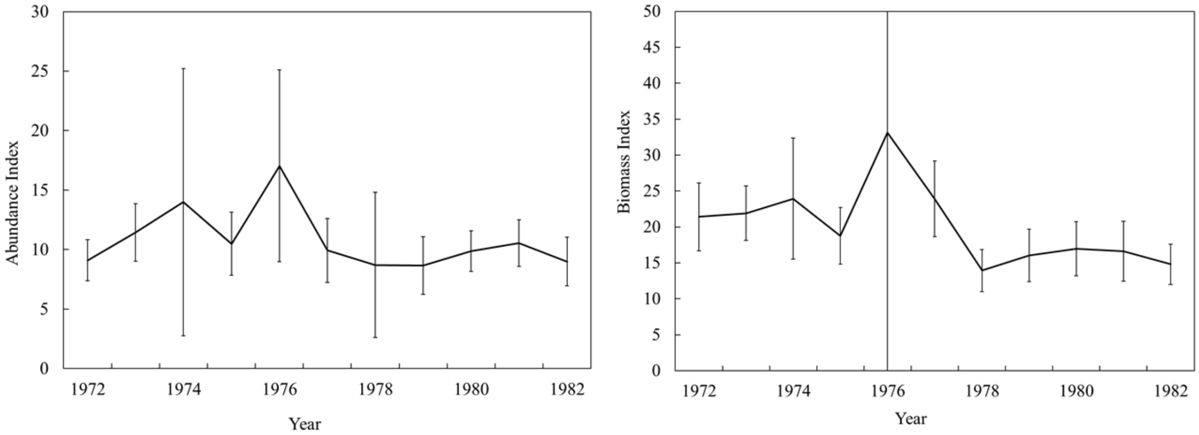


Fig. 16.2a. Thorny Skate in Divs. 3LNOPs, 1972-1983: abundance (left panel) and biomass (right panel) indices from Canadian spring surveys.

Survey coverage was poor in the Canadian spring survey in Div. 3L in 2017. The missing strata typically contain ~5-10% of the total biomass in years when these strata are surveyed; therefore, the most recent point on the biomass index may be an underestimate. Total survey biomass in Divs. 3LNOPs has remained stable since 2007.

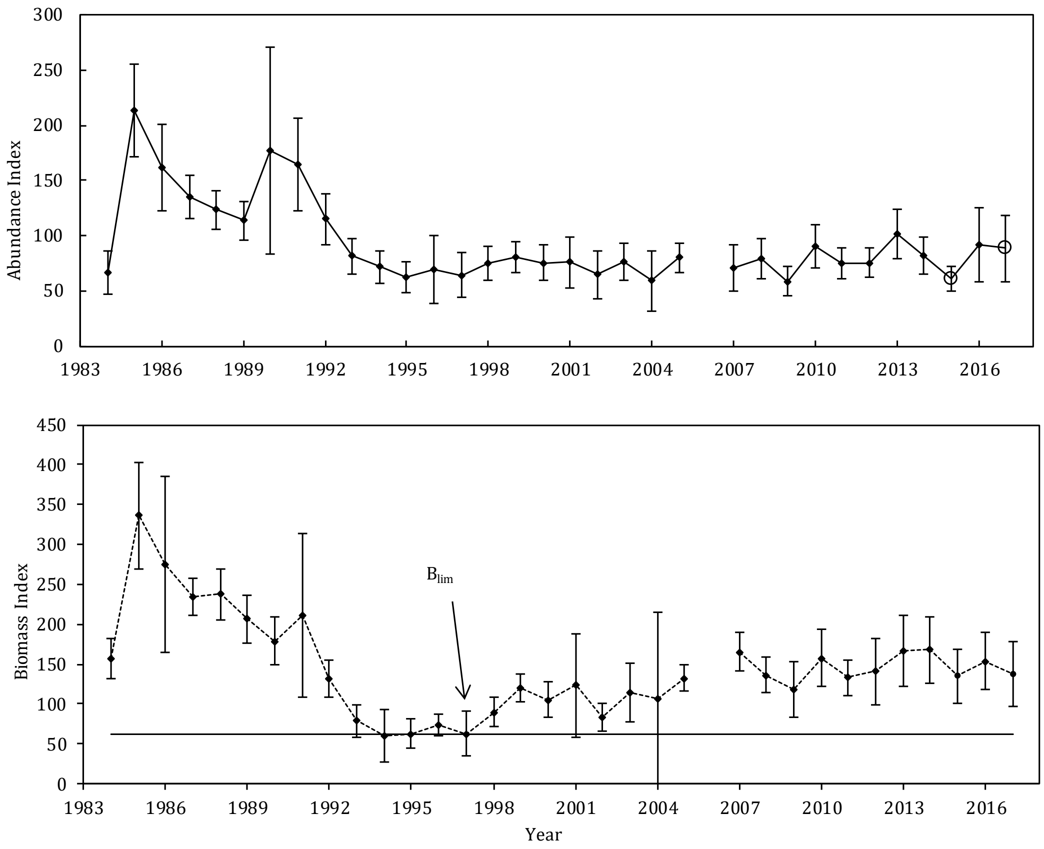


Fig. 16.2b. Thorny Skate in Divs. 3LNOPs, 1984-2017: abundance (top panel) and biomass (bottom panel) indices from Canadian spring surveys. Suveys in 2015 and 2017(open circles) were incomplete.

Canadian autumn surveys. Stratified-random research surveys have been conducted by Canada in Divs. 3LNO in the autumn, using an Engel 145 otter trawl in 1990-1994 and a Campelen 1800 shrimp trawl in 1995-2017, 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.

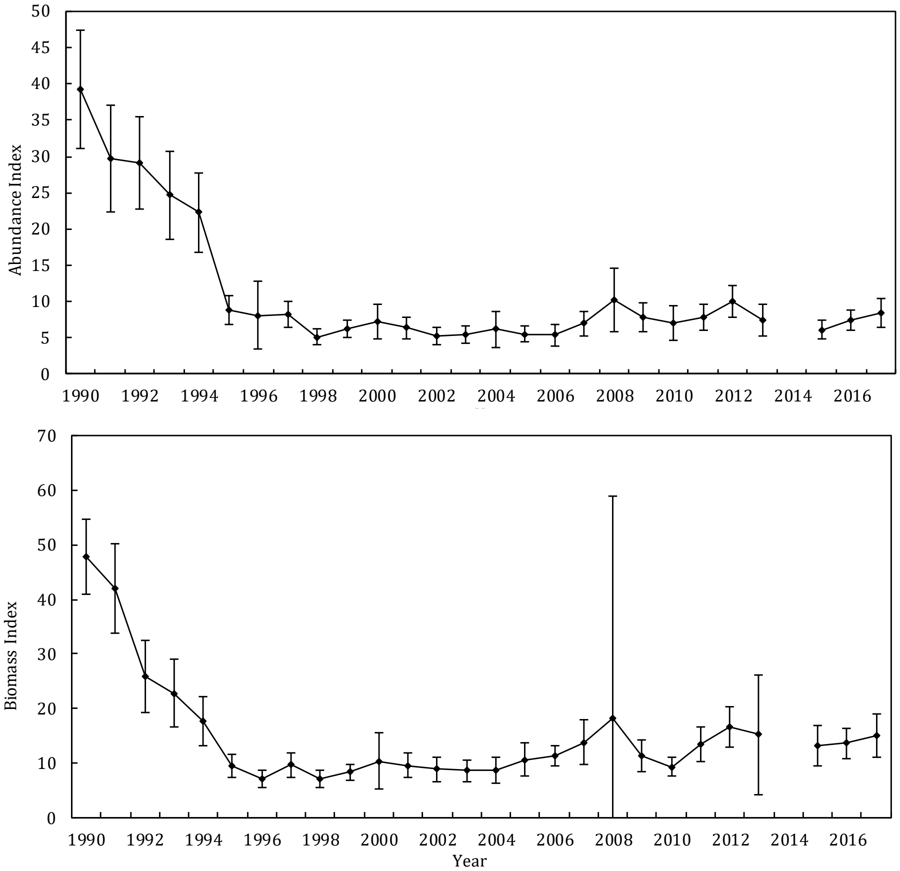


Fig. 16.3. Thorny Skate in Divs. 3LNOPs, 1990-2017: abundance (top panel) and biomass (bottom panel) indices from Canadian autumn surveys.

EU-Spain Divs. 3NO Survey. EU-Spain survey indices (Campelen or equivalent) are available for 1997-2017. 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.

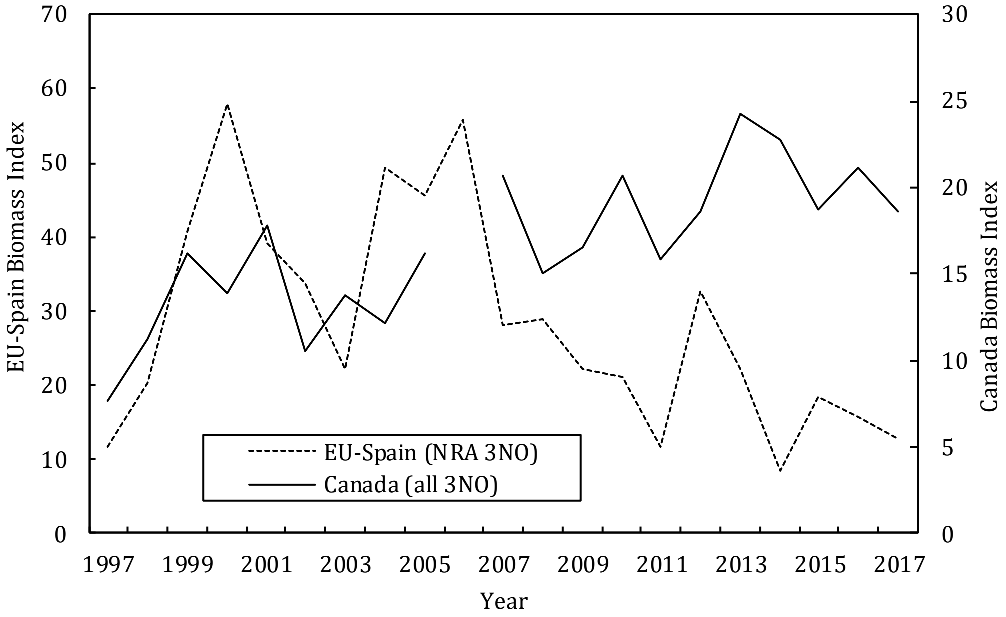


Fig. 16.4. Thorny Skate in Divs. 3LNOPs, 1997-2017: biomass indices from the EU-Spain survey and the Canadian spring survey.

EU-Spain Div. 3L survey. EU-Spain survey indices (Campelen trawl) are available for 2003-2017 (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.

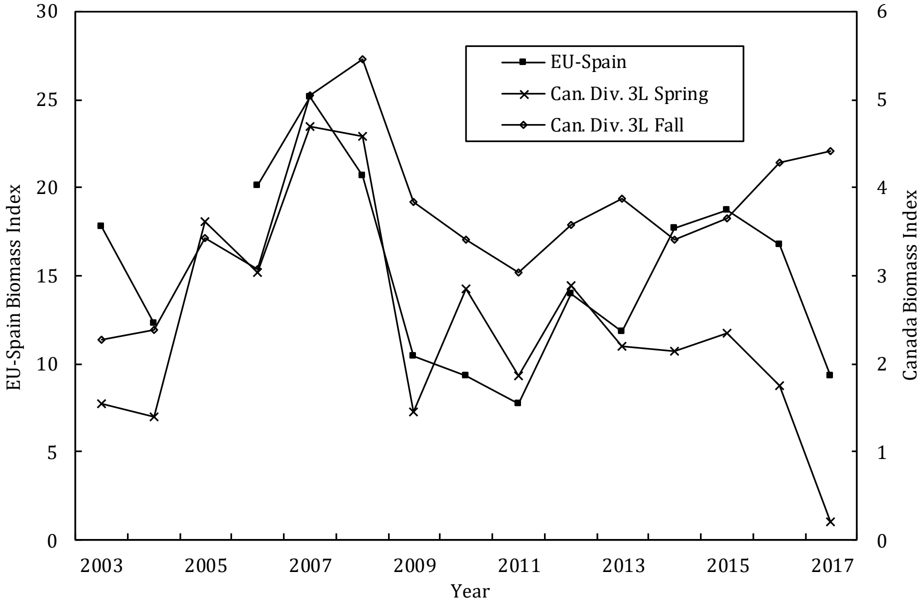


Fig. 16.5. Thorny Skate in Div. 3LNOPs, 2003-2017: Biomass indices from EU-Spain Div. 3L survey and the Canadian spring and autumn surveys of Div. 3L. The Canadian spring survey in Div. 3L was incomplete in 2017.

iii) Biological studies

Based on Canadian Campelen spring surveys in Divs. 3LNOPs, various life stages of Thorny Skate underwent different changes in abundance over time. In 1996-2017, the abundance of Thorny Skate recruits (5-20 cm TL) and immature skates increased since 2010, and estimates of mature skates fluctuated along an increasing trend.

Recruitment index (skate<21 cm) has been below average in 1997-2007 (Fig. 16.6). The index was above average during 2010-2013. Recruitment declined to below average in 2014-2016, then increased to 1.3 in 2017. This increase in 2017, occurred despite the missing survey strata, which in previous years (2009-16) contained on average 10% of the Thorny Skate recruits. Thorny Skates have low fecundity and long reproductive cycles, which result in low intrinsic rates of increase and impart low resilience to fishing mortality.

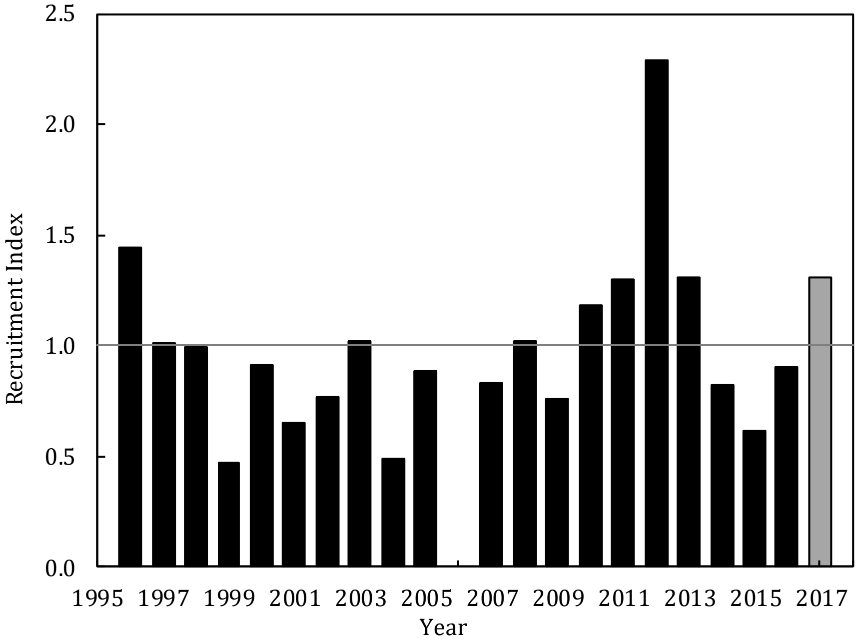


Fig. 16.6. Thorny Skate in Divs. 3LNOPs, 1996-2017: Standardized recruitment index for less than 21 cm TL males and females (combined) from Canadian Campelen spring surveys. The horizontal line depicts the standardized average recruitment for 1996-2017. The Canadian spring survey in Div. 3L was incomplete in 2017.

c) Estimation of Parameters

Relative F (STACFIS-agreed commercial landings/Canadian spring survey biomass) in Divs. 3LNO declined since the mid-1990s, and is currently low. Relative fishing mortality in Subdiv. 3Ps has also been low in recent years.

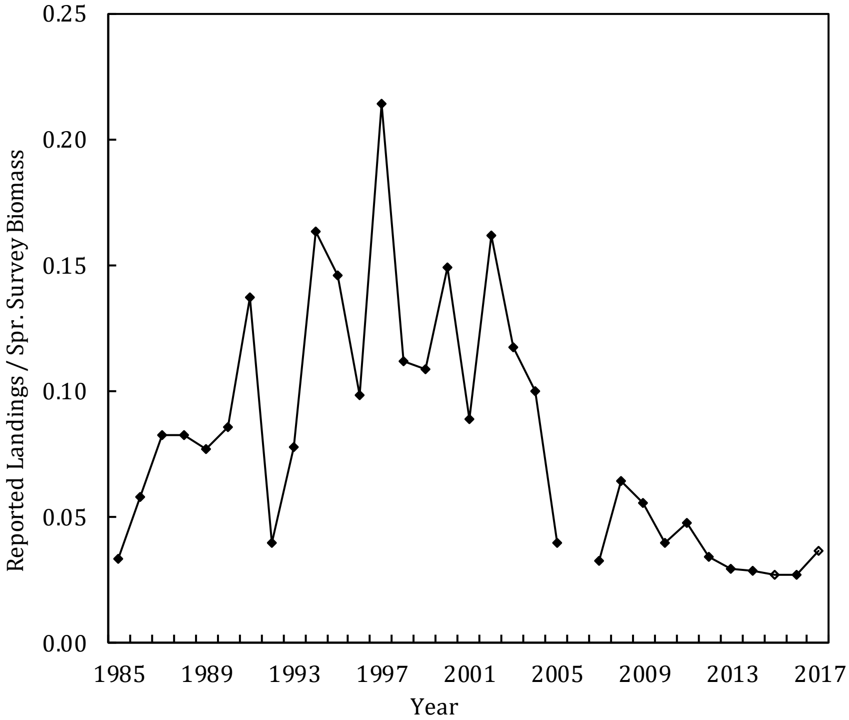


Fig. 16.7. Thorny Skate in Divs. 3LNOPs, 1985-2017: estimates of Relative F from STACFIS-agreed commercial landings/Canadian spring survey biomass. The Canadian spring survey in Div. 3L was incomplete in 2017.

d) Assessment Results

Assessment Results: No analytical assessment was performed.

The Canadian Spring survey is considered the primary indicator of the status of this stock due to its spatial and temporal coverage.

Biomass: Biomass of this stock has been increasing very slowly from low levels since the mid-1990s. For comparable periods, the pattern from the Canadian fall research survey was similar.

Fishing Mortality: Relative F (STACFIS-agreed commercial landings/Canadian spring survey biomass) in Divs. 3LNOPs declined since the mid-1990s, and is currently low.

Recruitment: Recruitment has been below average over 1997-2007. Recruitment was above average during 2010-2013, but declined to below average in 2014-2016. Recruitment in 2017 was above average.

State of the Stock: The stock is currently above $B_{lim.}$ The probability that the current biomass is above B_{lim} is >95%. Total survey biomass in Divs. 3LNOPs has remained stable since 2007. Recruitment in 2017 was above average. Fishing mortality is currently low.

e) Reference Points

Limit reference points based on B_{loss}, which represents the lowest value for the Canadian spring survey conducted with Campelen survey gear, were accepted in 2015 as a proxy for B_{lim} (Fig. 16.8).

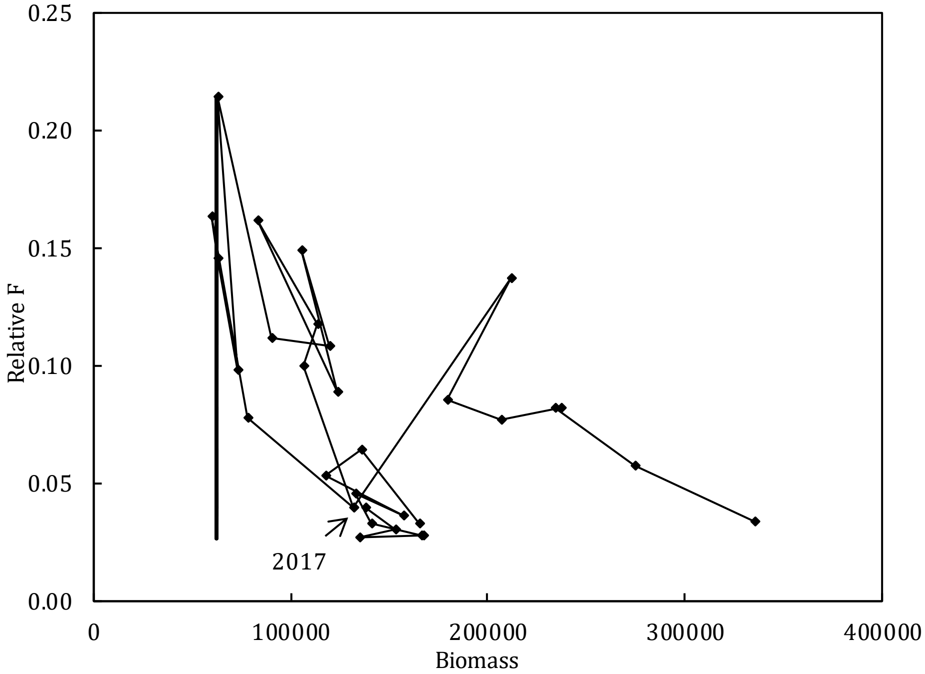


Fig. 16.8. Thorny Skate in Divs. 3LNOPs, 1985-2017: stock trajectory under a precautionary approach framework.

f) Research Recommendations

STACFIS **recommended** that *further work be conducted on development of a quantitative stock model.*

STATUS: Work ongoing. STACFIS reiterated this recommendation.

STACFIS **recommended** that *survey indices be investigated to compare catch rates in relation to depth in the spring and fall surveys, stock distribution, and comparison between Divs. 3LNO and Subdiv. 3Ps~~.~~*

STATUS: completed.

The next full assessment is planned for 2020.

17. White Hake (*Urophycis tenuis*) in Divs 3N, 3O, and Subdiv. 3Ps

Interim Monitoring Report (SCR Doc. 18/013, 17; SCS Doc. 18/07, 08)

a) Introduction

The advice requested by Fisheries Commission is for NAFO Div. 3NO. Previous studies indicated that White Hake constitute a single unit in Div. 3NOPs, and that fish younger than 1 year, 2+ juveniles, and mature adults distribute at different locations within Div. 3NO and Subdiv. 3Ps. This movement of fish of different stages between areas must be considered when assessing the status of White Hake in Div. 3NO. Therefore, an assessment of Div. 3NO White Hake is conducted with information on Subdiv. 3Ps included.

In 1988, Canada commenced a directed fishery for White Hake in Div. 3NO and Subdiv. 3Ps. All Canadian landings prior to 1988 were as bycatch in various groundfish fisheries. EU-Spain and EU-Portugal commenced a directed fishery in 2002, and Russia in 2003, in the NAFO Regulatory Area (NRA) of Div. 3NO; resulting in the 2003-2004 peak in landings. In 2003-2004, 14% of the total landings of White Hake in Div. 3NO and Subdiv. 3Ps were taken by Canada, but increased to 93% by 2006; primarily due to the absence of a directed fishery for this species by other countries.

A TAC for White Hake was first implemented by Fisheries Commission in 2005 at 8 500 tons, and was then reduced to 6 000 t for 2010 and 2011. The 5 000 t TAC in Div. 3NO for 2012 was further reduced to 1 000 t for 2013-2018. Canada has implemented a TAC of 500 t for Subdiv. 3Ps for 2018-2020.

From 1970-2009, White Hake catches in Div. 3NO fluctuated, averaging approximately 2 000 t, exceeding 5 000 t in only three years during that period. Catches peaked in 1987 at 8 061 t (Fig. 17.1). With the restriction of fishing by other countries to areas outside Canada's Exclusive Economic Zone in 1992, non-Canadian catches fell to zero. Average catch was low in 1995-2001 (422 t), then increased to 6 718 t in 2002 and 4 823 t in 2003; following recruitment of the large 1999 year-class. STACFIS-agreed catches decreased to an average of 386 t in 2008-2012. Catches averaged 342 t over the period 2013-2016. STACFIS catch in 2017 was as 512 t in Div. 3NO.

Commercial catches of White Hake in Subdiv. 3Ps were less variable, averaging 1 114 t in 1985-93, then decreasing to an average of 619 t in 1994-2002 (Fig. 17.1). Subsequently, catches increased to an average of 1 374 t in 2003-2007, then decreased to a 368-t average in 2008-2012. Catches averaged 327 t over the period 2013-2016. Catch in 2017 was reported as 308 t in Subdiv. 3Ps.

Recent reported landings and TACs (000 tons) in NAFO Div. 3NO and Subdiv. 3Ps are as follows:

	2009	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**
Div. 3NO:										
TAC	8.5	6	6	5	1[1]	1[1]	1[1]	1[1]	1[1]	1[1]
STATLANT 21	0.5	0.3	0.2	0.1	0.2	0.3	.4	.4	.5	
STACFIS	0.4	0.2	0.2	0.1	0.2	0.3	.5	.4	.5	
Subdiv. 3Ps:										
TAC										.5
STATLANT 21	0.4	0.4	0.2	0.2	0.2	0.4	.3	.4	.3	

[1] May change in season. See NAFO FC Doc. 13/01 quota table.

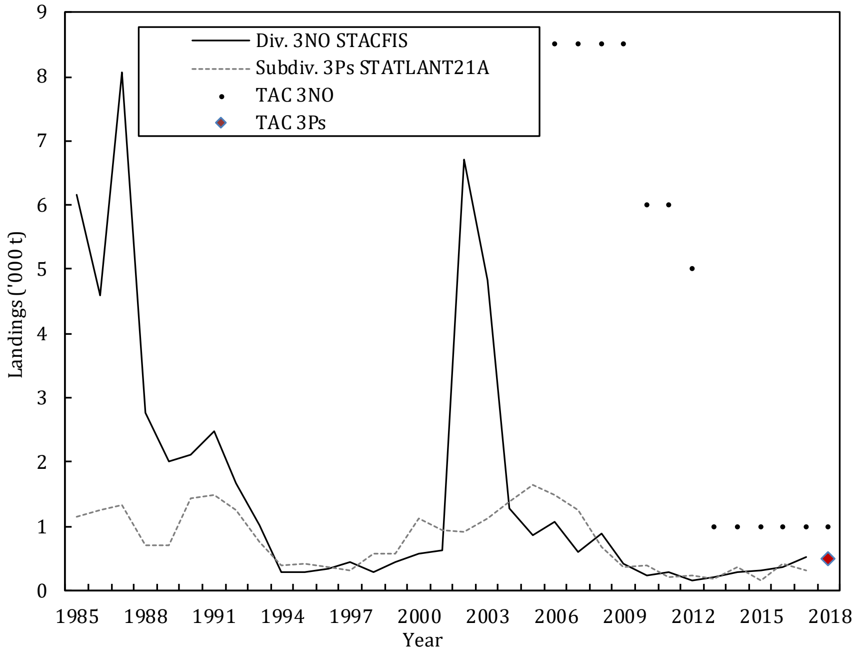


Fig. 17.1. White Hake in Division 3NO and Subdivision 3Ps: Total catch of White Hake in NAFO Division 3NO (STACFIS) and Subdivision 3Ps (STATLANT-21A). The Total Allowable Catch (TAC) in Subdiv. 3Ps and the NRA of Divs. 3NO is also indicated on the graph.

b) Data Overview

i) Research survey data

Canadian stratified-random bottom trawl surveys. Data from spring research surveys in NAFO Div. 3N, 3O, and winter-spring surveys in Subdiv. 3Ps were available from 1972 to 2017. 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 fall surveys in Div. 3NO were available from 1990 to 2017. 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. In Subdiv. 3Ps, survey timing changed from winter to spring during 1993. Canadian fall surveys in Div. 3NO were conducted with an Engel 145 trawl from 1990 to 1994, and a Campelen 1800 trawl from 1995-2017. 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 Fig. 17.2a. In 2003-2010, 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 peak observed over 2000-2001. In recent years, spring abundance of White Hake increased slightly in 2011, but declined to low and stable levels over 2012-2017. Biomass of this stock increased in 2000, due to the very large 1999 year-class. Subsequently, the biomass index decreased gradually, and has remained stable since 2007.

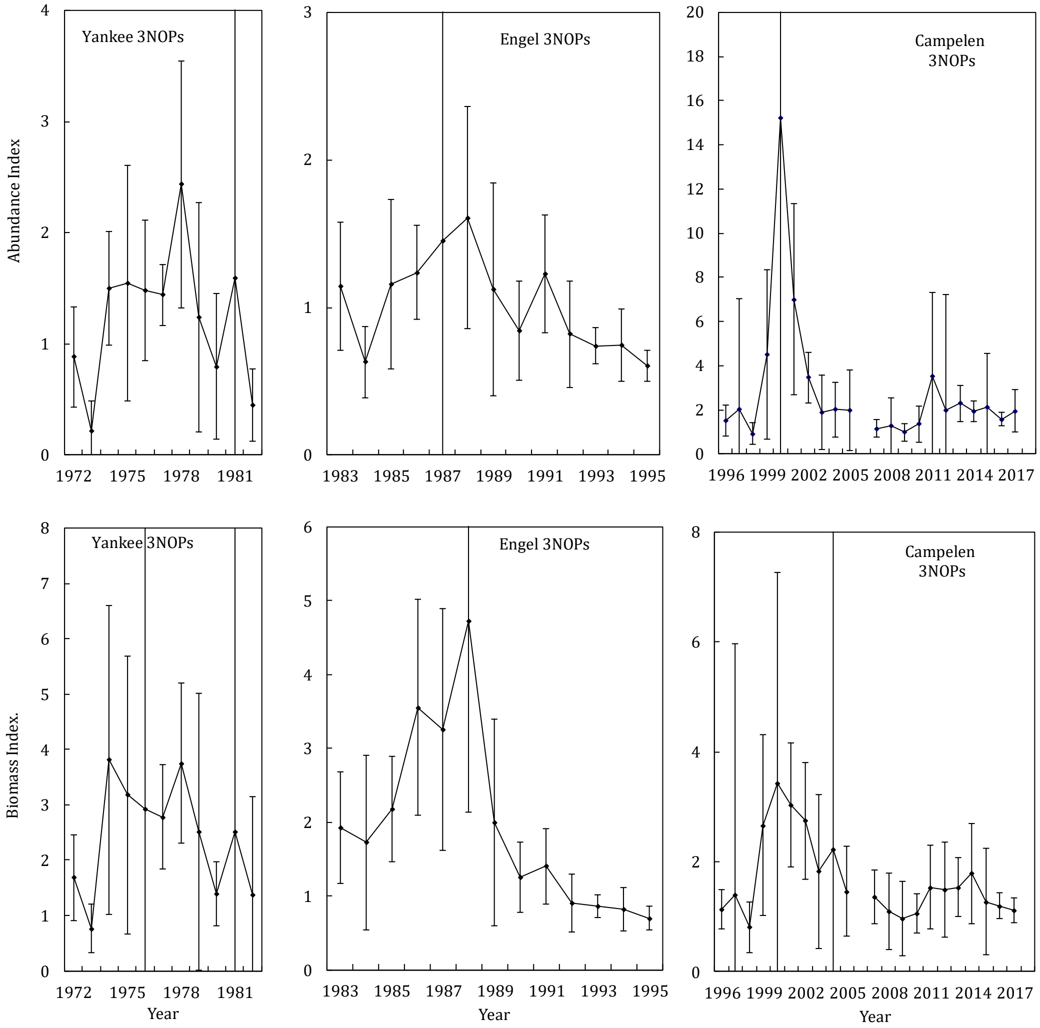


Fig. 17.2a. White Hake in Div. 3NO and Subdiv. 3Ps: abundance (top panels) and biomass (bottom panels) indices from Canadian winter-spring research surveys, 1972-2017. Estimates from 2006 are not shown, since survey coverage in that year was incomplete. Yankee, Engel, and Campelen time series are not standardized, and are presented on separate panels. Error bars are 95% confidence limits. The bounds of the error bars in 1976, 1981, 1987 and 2000 in some panels extend above and below the graph limits.

Canadian fall surveys of Div. 3NO (Fig. 17.2b) have the peak in abundance reflected by the very large 1999 year-class. Fall abundance indices then declined to levels similar to those observed during 1996-1998 until 2010. In recent years, biomass appears stable, while abundance seems to have increased slightly. This survey was not completed in 2014.

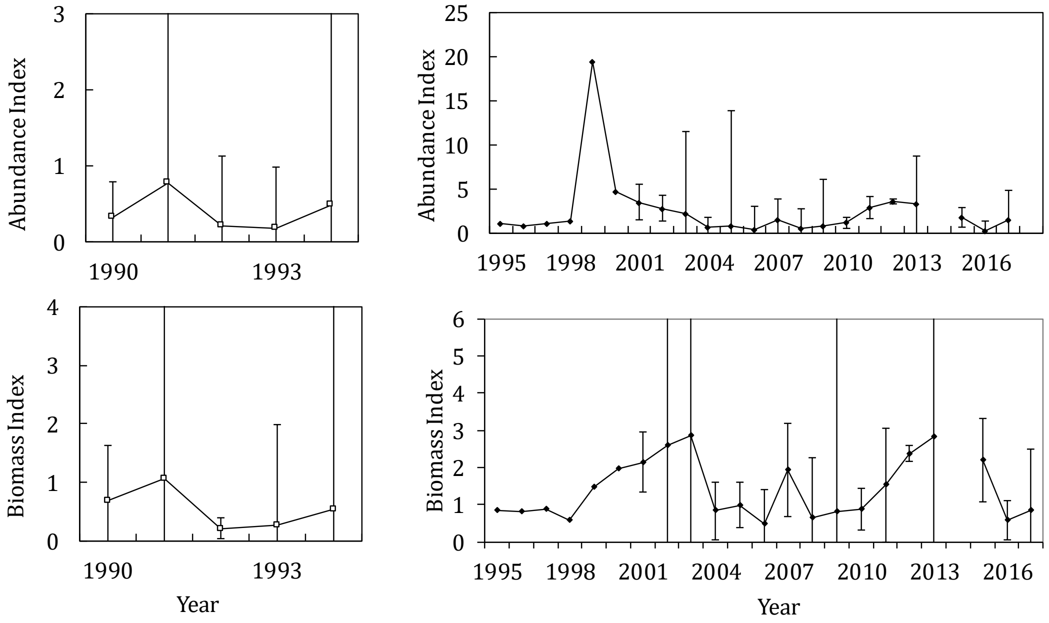


Fig. 17.2b White Hake in Div. 3NO: abundance (top panel) and biomass indices (bottom panel) from Canadian fall surveys, 1990-2017. Engel (■, 1990-1994) and Campelen (♦, 1995-2013) time series are not standardized. Estimates from 2014 are not shown, since survey coverage in that year was incomplete. Error bars are 95% confidence limits. The bounds of the error bars in 1991, 1994, 2002, 2003, 2009 and 2013 in some panels extend above and 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 2017 (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, which is similar to that of the Canadian spring survey index (Fig. 17.3). From 2014-2015, these surveys have been characterized by opposing trends: the EU-Spain index decreased in 2014, before increasing in 2015; the Canadian spring survey index increased in 2014, before decreasing in 2015. In 2017, both indices have declined from the 2016 estimates.

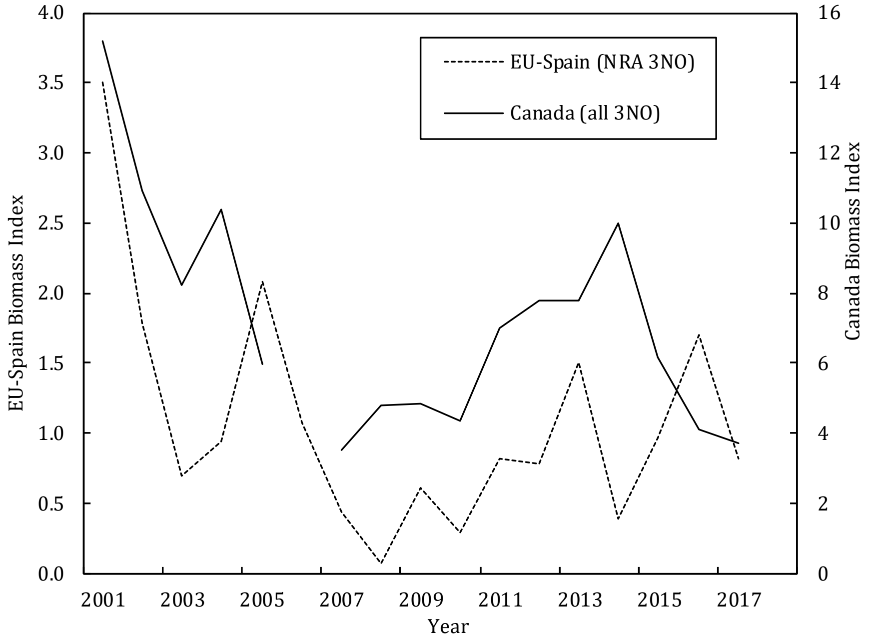


Fig. 17.3. White Hake in the NRA of Div. 3NO: Biomass indices from EU-Spain Campelen spring surveys in 2001-2017 compared to Canadian spring survey indices in all of Div. 3NO. Estimates from 2006 Canadian survey are not shown, since survey coverage in that year was incomplete.

Recruitment. In Canadian spring research surveys, the number of White Hake less than 27 cm in length is assumed to be an index of recruitment at age 1. The recruitment index in 2000 was very large, but no large value has been observed during 2001-2017 (Fig. 17.6). The index of recruitment for 2011 was comparable to that seen in 1999, and a smaller peak in 2013 was similar to one in 2005.

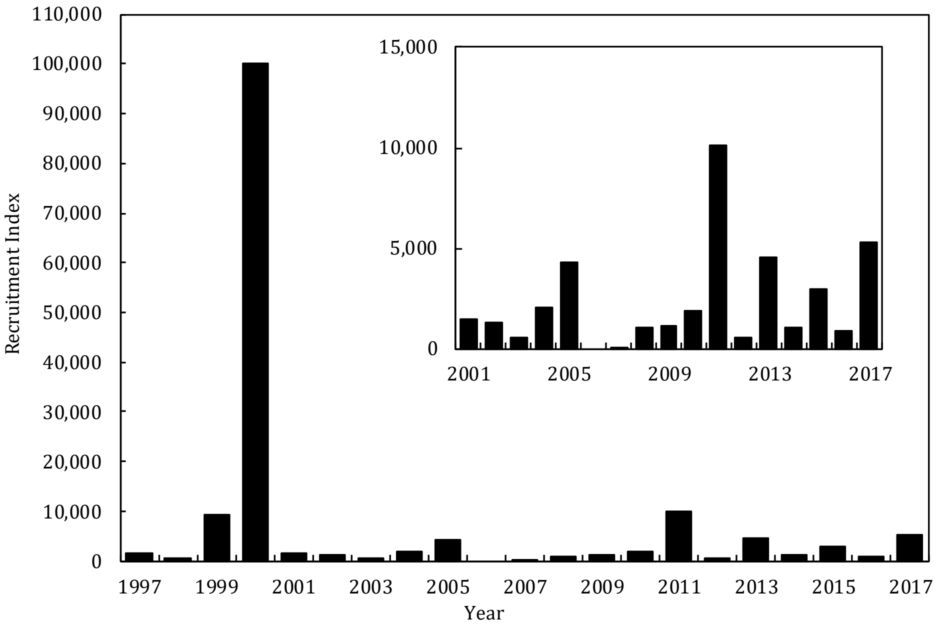


Fig. 17.4. White Hake in Div. 3NO and Subdiv. 3Ps: recruitment index for age 1 males and females (combined) from Canadian Campelen spring surveys in Divs. 3NO and Subdiv. 3Ps in 1997-2017. Estimates from 2006 are not shown, since survey coverage in that year was incomplete. Inset plot depicts 2001-2017 on a smaller scale.

c) Conclusion

Based on current information there is no significant change in the status of this stock. Stock biomass remains at relatively low levels, and no large recruitment events have been observed since 2000.

d) Research Recommendations

STACFIS **recommended** that *age determination should be conducted on otolith samples collected during annual Canadian surveys (1972-2009+); thereby allowing age-based analyses of this population.*

Otoliths are being collected but have yet to be 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 on this recommendation. STACFIS reiterates this recommendation.

STACFIS **recommended** that *work continue on the development of population models and reference point proxies.*

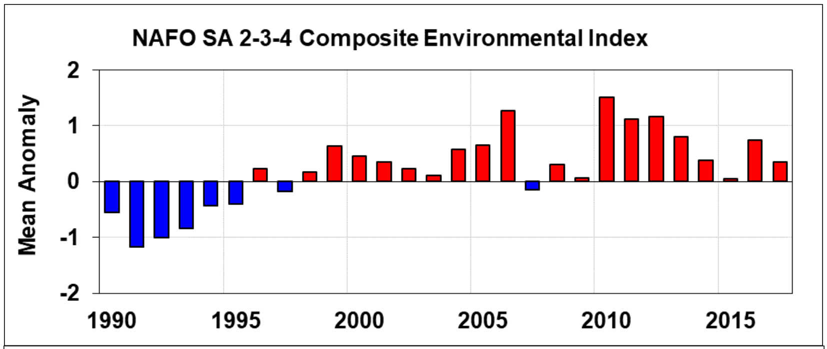
No progress on this recommendation. STACFIS reiterates this recommendation.

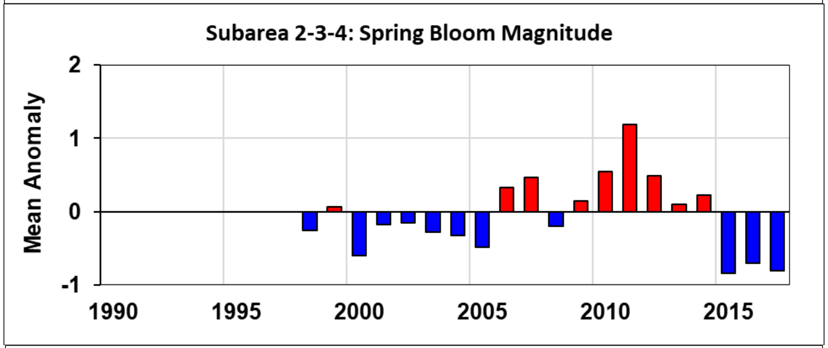
The next assessment is planned for 2019.

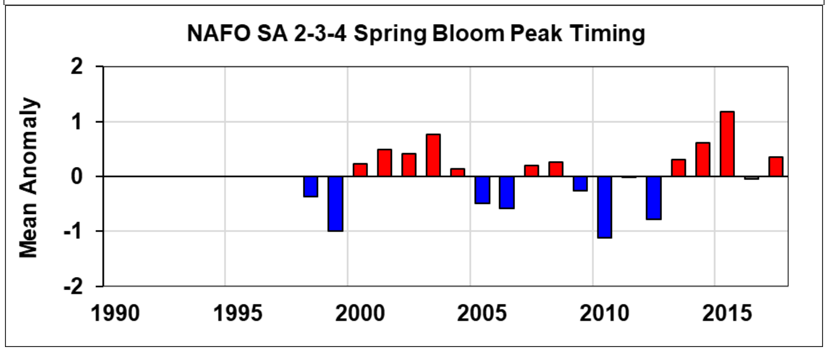
D. WIDELY DISTRIBUTED STOCKS: SA 2, SA 3 AND SA 4

Recent Conditions in Ocean Climate and Lower Trophic Levels

- Ocean climate composite index based on data from Labrador to the Scotian Shelf (SA2-4) has remained above normal since 2010, but has experienced a declining trend since then.
- Spring bloom total production (magnitude) was at its lowest during the past three years (2015-2017). Peak timing has remained mostly above normal since 2013 indicating a generalized delayed onset of the phytoplankton spring bloom along the on the Atlantic Canadian Shelf in recent years.
- The composite zooplankton abundance index was back to normal in 2017 after three consecutive years with well above normal anomalies from 2014-2016.
- The composite zooplankton biomass index remained well below normal throughout SA 2-3-4 for a third consecutive year since a record low in 2015.


NAFO SA 2-3-4 Composite Environmental Index


Subarea 2-3-4: Spring Bloom Magnitude


NAFO SA 2-3-4 Spring Bloom Peak Timing

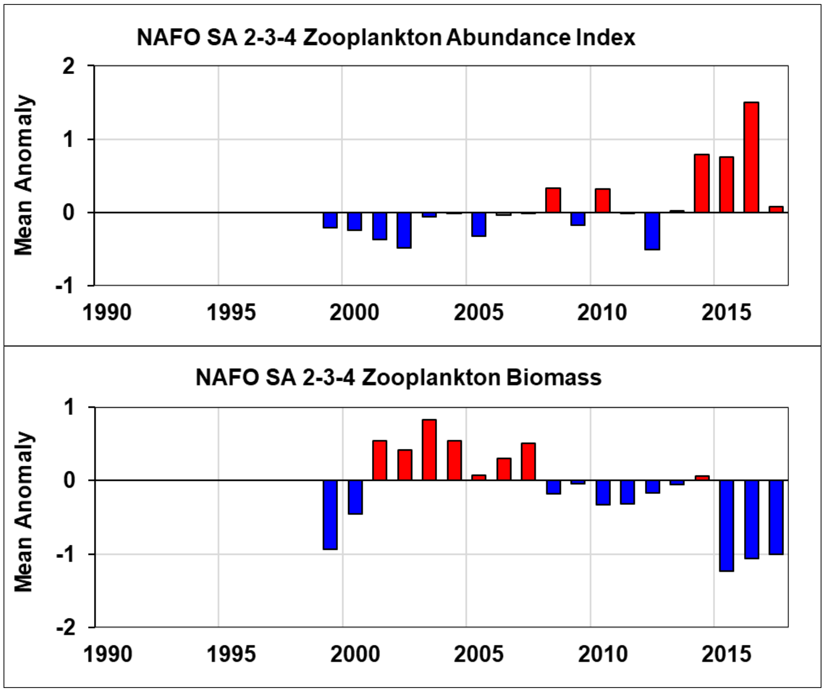


Fig.D1. Composite environmental index for NAFO Subarea 2-3-4 derived from meteorological and physical oceanographic (sea ice, water temperature, salinity) conditions during 1990-2017 (top panel). Phytoplankton spring bloom magnitude (2nd panel) and peak timing (3rd panel) in NAFO Subarea 2-3-4 during 1998-2017. Composite zooplankton abundance index derived from copepod (total copepods, *Calanus finmarchicus*, *Pseucalanus* spp.) and non-copepod abundances (4th panel), and zooplankton biomass anomaly (5th panel) in NAFO Subarea 2-3-4 during 1999-2017. Positive/negative anomalies indicate conditions above/below (or late/early timing) the long-term average for the reference period. All anomalies are mean standardized anomaly calculated using the following reference period: climate index: 1981-2010; phytoplankton indices (magnitude and peak timing): 1998-2015; zooplankton (abundance and biomass) indices: 1999-2015.

Environmental Overview

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

Temperature and salinity conditions in the Scotian Shelf, Bay of Fundy and Gulf of Maine regions are determined by many processes: heat transfer between the ocean and atmosphere, inflow from the Gulf of St.

Lawrence supplemented by flow from the Newfoundland Shelf, exchange with offshore slope waters, local mixing, freshwater runoff, direct precipitation and melting of sea-ice. The Nova Scotia Current is the dominant inflow, originating in the Gulf of St. Lawrence and entering the region through Cabot Strait. The Current, whose path is strongly affected by topography, has a general southwestward drift over the Scotian Shelf and continues into the Gulf of Maine where it contributes to the counter-clockwise mean circulation. The properties of shelf waters are modified by mixing with offshore waters from the continental slope. These offshore waters are generally of two types, Warm Slope Water, with temperatures in the range of 8-13^{o}C and salinities from 34.7-35.6, and Labrador Slope Water, with temperatures from 3.5^{o}C to 8^{o}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 experienced a general declining trend but has remained above normal in 2017 (Figure 1, top panel). Spring bloom total production (magnitude) was at its lowest during the past three years after reaching a record-low for the time series in 2015 (Figure 1, 2nd panel). Peak timing has remained mostly above normal since 2013 indicating a generalized delayed onset of the phytoplankton spring bloom along the on the Atlantic Canadian Shelf during recent years (Figure 1, 3rd panel). Zooplankton abundance was back to normal in 2017 after staying well above normal during 2014-2015 with three consecutive highest anomalies recorded for the time series (Figure 1, 4th panel). The composite zooplankton biomass index remained well below normal throughout SA 2-3-4 for a third consecutive year since a record low in 2015. (Figure 1, 5th panel). The opposite trends in zooplankton abundance and biomass observed throughout the Atlantic Canadian shelf during the since 2015 indicate a generalized reduction in zooplankton size in the study area. Information on the taxonomic composition of zooplankton, i.e. the reduction in abundance of the larger grazing calanoid copepod *Calanus finmarchicus* along with a substantial increase in the smaller *Pseudocalanus* spp copepods, supports these results.

The spatially averaged fall bottom temperature off southern Labrador in 2J was 2.6°C (+0.1 SD above normal) and in 3K it was 2.3°C (0.03 SD below normal). The spatially averaged spring and fall bottom temperature in NAFO Divs. 3LNO was 1.4° (-0.2 SD) and 1.3°C (-1.2 SD), respectively. The averaged spring bottom temperature in NAFO Div. 3P was about 2.7°C, about 0.4 SD above normal, a significant decrease from 2 SD above normal in 2016. A composite climate index for the NL region derived from 28 meteorological, ice and ocean temperature and salinity time series from the NL region returned to slightly below normal (15th lowest in 68 years). In 2015 it was the 7th lowest in 68 years and the lowest since 1993. In 2017, bottom temperatures anomalies on the Scotian Shelf in NAFO Divisions 4Vn, 4Vs, 4W and 4X were 0.7°C (1.6 SD), 1.3°C (1.9 SD), 0.8°C (1.1 SD) and 1.6°C (2.2 SD) above normal, respectively. A composite index for the Scotian Shelf region based on 20 selected, normalized temperature time series averaged +1.7 standard deviations (SD) above normal, making 2017 the 3rd warmest year in the last 48 years.

18. Roughhead Grenadier (*Macrourus berglax*) in SA 2 and 3

(SCS Doc. 18/05, 18/07, 18/13 and 18/08, and SCR 18/8, 18/13, 18/17, 18/18)

a) Introduction

The stock structure of this species in the North Atlantic remains unclear because there is little information on the number of different populations that may exist and the relationships between them. Roughhead grenadier is distributed throughout NAFO Subareas 0 to 3 in depths between 300 and 2 000 m. However, for assessment purposes, NAFO Scientific Council considers the population of Subareas 2 and 3 as a single stock.

A substantial part of the grenadier catches in Subarea 3 previously reported as roundnose grenadier was actually roughhead grenadier. To correct the catch statistics STACFIS (NAFO SCR 98/57) revised and approved roughhead grenadier catch statistics since 1987. In the period 2007-2012, catches for Subarea 2+3 roughhead grenadier were stable at levels around one thousand tons. From 2013-2017 catches were lower and in the last years were around 300-400 ton (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. There is no TAC for this stock.

Recent catches ('000 tons) are as follow:

	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
STATLANT 21A	0.4	0.7	0.8	1.0	1.3	0.4	0.6	0.2	0.1	0.1
STACFIS	0.8	0.6	0.9	1.0	1.3	0.4	0.6	0.2	0.3	0.4

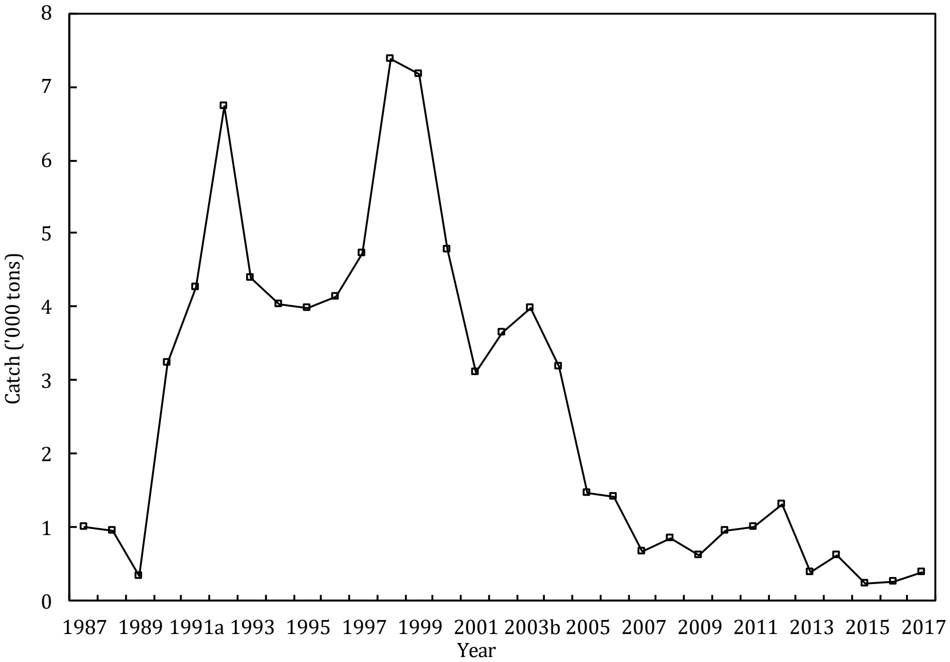


Fig. 18.1. Roughhead grenadier in Subareas 2+3: STACFIS catches.

b) Data Overview

i) Surveys

There are no survey indices available covering the total distribution, in depth and area, of this stock. According to other information, this species is predominately at depths ranging from 800 to 1500 m, therefore the best survey indicators of stock biomass should be the series extending to 1500 meters depth as they cover the depth distribution of Roughhead grenadier fairly well. Figure 18.2 presents the biomass indices for the following series: Canadian fall 2J+3K Engel (1978-1994, Series 1) and Canadian fall 2J+3K Campelen (1995-2017, Series 2), EU 3NO (1997-2017), EU 3L (2006-2017) and EU Flemish Cap (to1400 m; 2004-2017). 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 period 2013-2016, the information from the different indices was noisy and contradictory; some indices showed an increase while others continued to decline. In 2017 all indices, except the EU 3L, show an increase with respect to 2016.

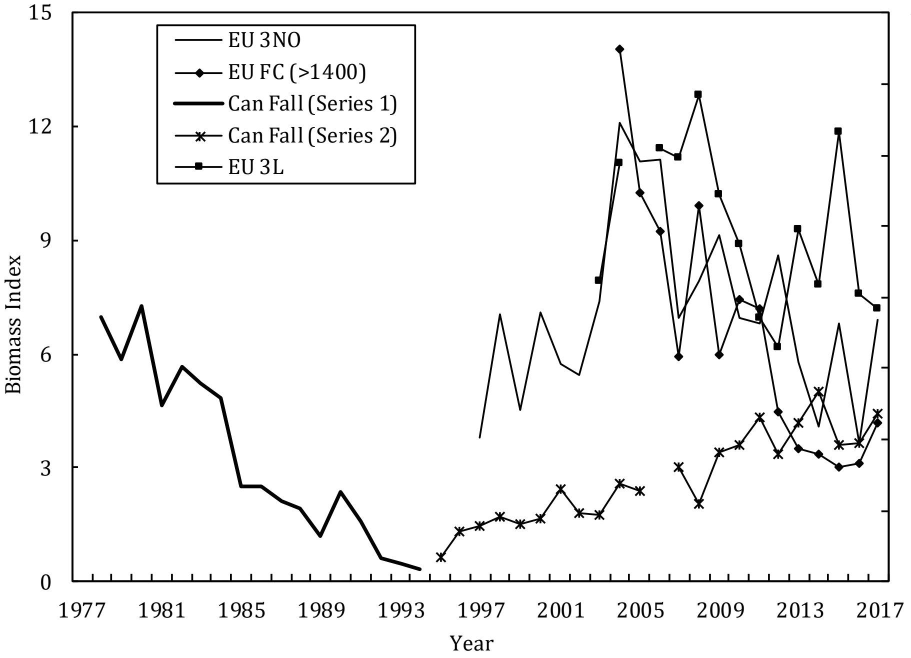


Fig. 18.2. Roughhead grenadier in Subareas 2+3: Survey biomass indices.

The catch-biomass (C/B) ratios showed a clear declining trend from 1995-2005 and since then have been stable at low levels (Fig. 18.3).The (C/B) ratio remained low since 2008 despite the decline of many of the survey biomass indices because catch levels since 2007 are very low.

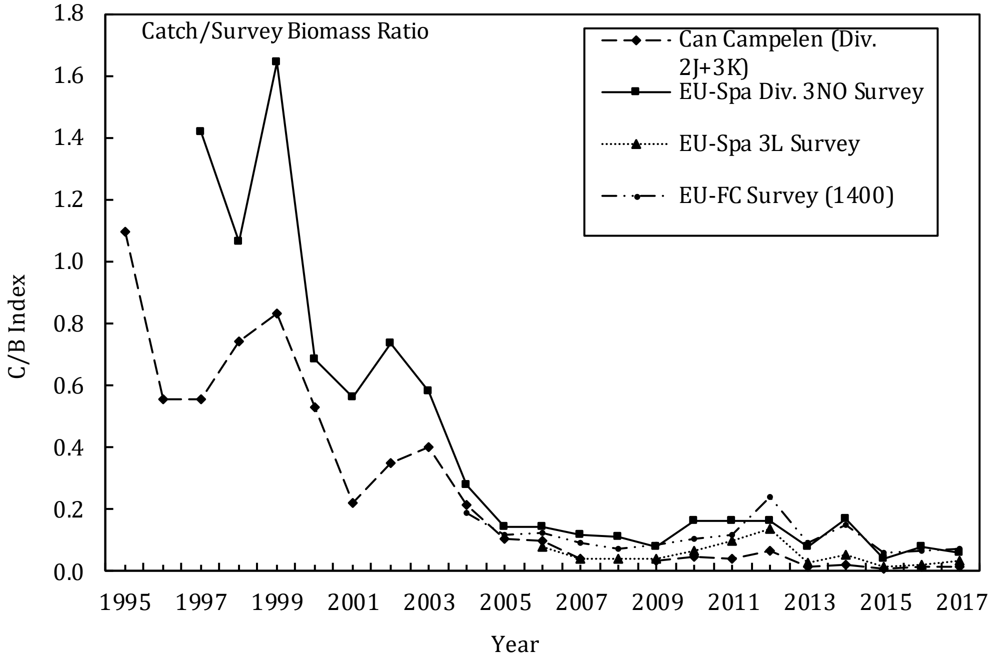


Fig. 18.3. Roughhead grenadier in Subareas 2+3: catch/biomass indices based upon Canadian Autumn (Campelen series), EU-Spanish Div. 3NO, EU-Spanish 3L and EU-Flemish Cap (to1400 m depth) surveys.

c) Conclusion

The information from different indices in the most recent period is contradictory and noisy. However, in 2017 all indices, except the EU 3L, show an increase with respect to 2016. Fishing mortality indices have remained at low levels since 2005. Based on overall indices for the current year, there is no change in the status of the stock.

The next assessment is planned for 2019.

19. Witch Flounder (*Glyptocephalus cynoglossus*) in Divs. 2J+3KL

Interim Monitoring Report (SCS Docs. 04/12, 18/05, 18/06, 18/07, 18/08; SCR 16/61, 18/19; 18/30)

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 tons, and from 2005-2017, catches averaged less than 160 tons. Catches are primarily from the Canadian Greenland Halibut fishery.

Recent catches and TACs ('000 tons) are as follows:

	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
TAC	ndf	ndf	ndf	ndf	ndf	ndf	ndf	ndf	ndf	ndf
STATLANT 21	0.1	0.2	0.2	0.2	0.2	0.2	0.2	0.1	0.1	
STACFIS	0.1	0.2	0.2	0.2	0.2	0.2	0.2	0.1	0.1	

ndf no directed fishing.

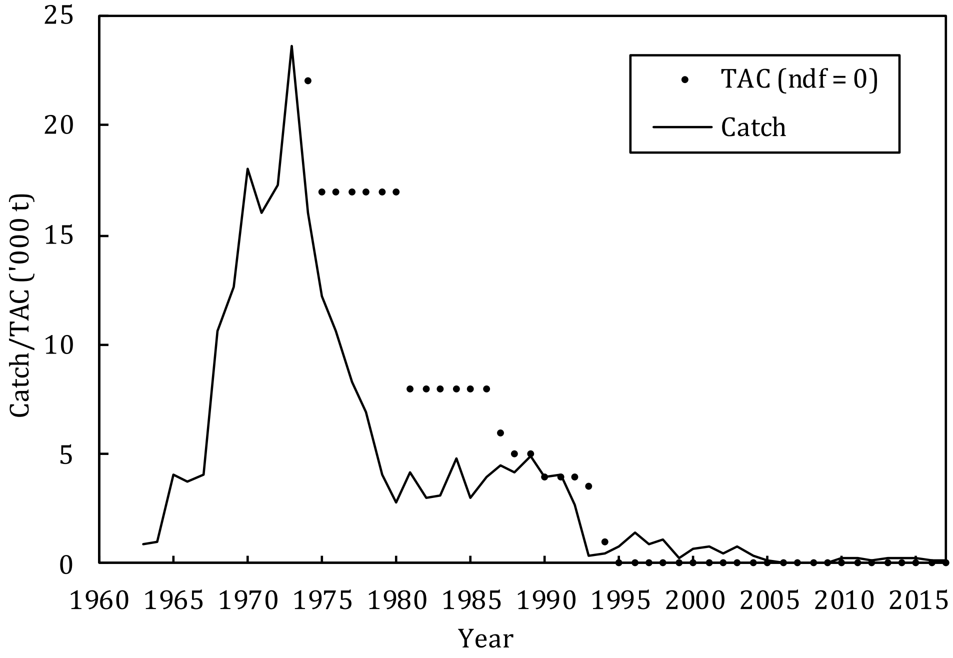


Fig. 19.1. Witch flounder in Div. 2J, 3K and 3L: catches and TAC.

b) Data Overview

i) Surveys

Canadian autumn surveys were conducted in Divs. 2J, 3K and 3L beginning in 1977, 1978 and 1983 respectively and continued to 2017 (Fig 19.2). The survey biomass estimates showed a rapid decline from the mid-80s to 1995, remained at very low levels and then showed a general increasing trend from 2003 to 2017.

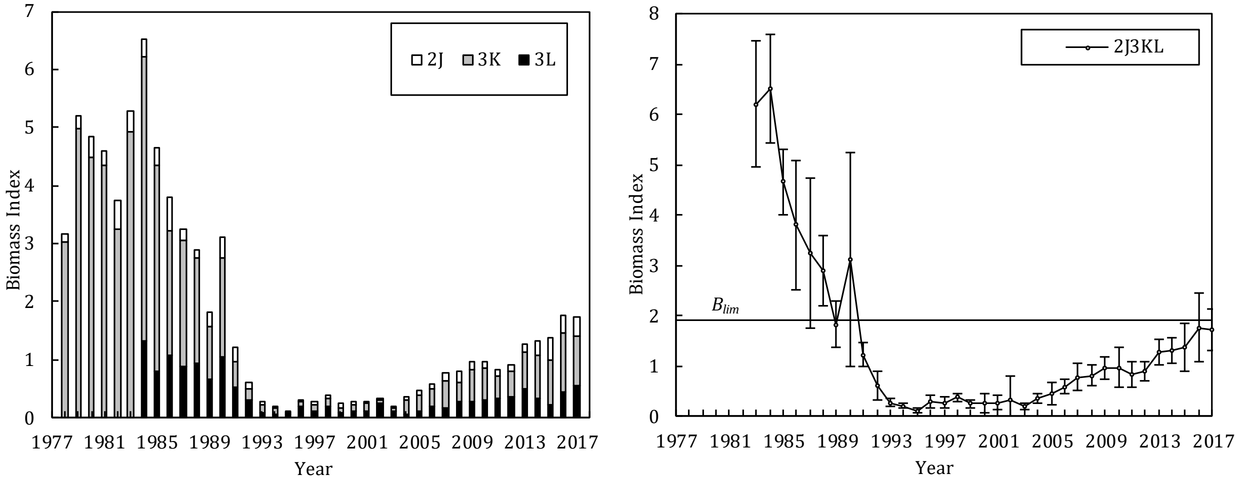


Fig. 19.2. Witch flounder in Div. 2J, 3K and 3L: Index of biomass from Canadian autumn surveys by Division (left panel) and overall with 95% confidence limits (right panel). Values are Campelen units or, prior to 1995, Campelen equivalent units.

c) Limit Reference Point

A new Limit Reference Point (LRP) was set for Witch Flounder in NAFO Divs. 2J+3KL (SCR Doc. 18/30). The previous LRP considered the survey biomass in 1984 (B_{MAX}) to represent B_0, with B_{LIM} subsequently set at 15% B_{MAX}. However, given the catch history of the stock, biomass in 1984 is not considered to reflect an unexploited state, and based on recommendation from the NAFO Study Group on Limit Reference Points (SCS Doc. 04/12), 15% B_{MAX} is not an appropriate reference point for this stock.

Survey indices indicate that stock biomass was stable within each of Divs. 2J, 3K, and 3L from the start of each survey time series (1977, 1979, 1983, respectively), through to the early to mid-1980s. The time series for the combined area of 2J+3KL begins in 1983, and was stable in 1983-1984 at the highest level within the time series (1983-2017). Scientific Council agreed that this period from 1983-1984 is more likely to reflect B_{MSY} than $B_{0.}$ A proxy for B_{MSY} was therefore accepted as the mean of the survey biomass indices from the 1983-84 autumn RV surveys. Following recommendations from in SCS Doc. 04/12, B_{LIM} is calculated as 30% of the B_{MSY} proxy (B_{LIM} = 19 000t; SCR Doc. 18/30). In 2017, the stock is estimated to be at 90% B_{LIM}.

d) Conclusion

There was an increase in the survey biomass index from 2003 to 2017, nevertheless, the stock remains below $B_{lim,}$, with a probability of 0.82 of being below B_{lim} in 2017. Based on survey indices for the current year, there is nothing to indicate a change in the status of the stock.

The next assessment is planned for 2019.

20. Greenland Halibut (*Reinhardtius hippoglossoides*) in SA 2 + Divs. 3KLMNO

(Interim monitoring report, SCR Doc. 18/8, 11, 17, 19, 47; SCS Doc. 18/05, 06, 07, 8, 13, 14, 15; FC Doc. 03/13, 10/12, 13/23, 16/20; Com Doc 17/11)

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). The TAC in 2018 is based on the HCR adopted in 2017 (Com Doc 17/17). Catch exceeded the TAC in every year from 2004 to 2014 but was similar to the TAC in 2015 through 2017.

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

	2009	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**
TAC	16	16	17.2^{1}	16.3^{1}	15.5^{1}	15.4^{1}	15.6^{1}	14.8^{1}	14.8^{2}	16.5^{3}
STATLANT 21	14.7	15.7	15.7	15.2	15.6	15.6	14.9	14.8	14.7	
STACFIS	23.2	26.2	24.2	23.0	20.0	21.4	15.3	14.9	14.8	

^{1} – TAC generated from HCR

^{2} – TAC equal to 2016

^{3} – TAC generated from HCR adopted September 2017

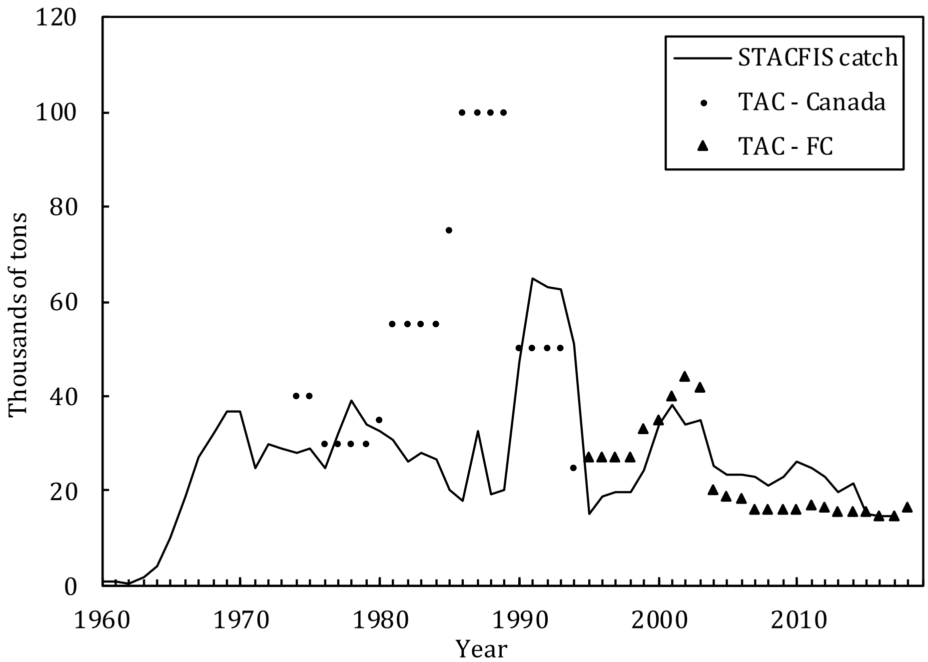


Fig. 20.1. Greenland halibut in Subarea 2 + Div. 3KLMNO: TACs and STACFIS catches.

b) Input Data

Standardized estimates of CPUE were available from fisheries conducted by EU- Spain, EU-Portugal and Canada. Abundance and biomass indices were available from research vessel surveys by Canada in Div. 2+3KLMNO (1978-2017), EU in Div. 3M (1988-2017), EU-Spain in Div. 3NO (1995-2017) and EU-Spain in Div. 3L (2003-2017). Different years are examined to represent population trends from the different surveys. For the Canadian fall survey in Divs. 2J3K the years are 1978-2017 (excluding 2008); from the Canadian spring survey in Divs. 3LNO 1996-2016 (excluding 2006 and 2015, 2017 not included due to survey coverage issues); for the Canadian fall survey to 730 m from 1996-2017 (excluding 2014 when the survey was incomplete); for the survey in Div. 3M to 700 m 1988-2017, and to 1400 m 2004-2017; for the survey by EU-Spain in Div. 3L 2006-2017; and for the survey by EU-Spain in Divs. 3NO 1997-2017. 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. Since then the CPUE has increased to a peak in 2016 before declining in 2017.

Analyses of catch-rates of Portuguese otter trawlers fishing in the NRA of Div. 3LMNO over 1988-2017 show that the CPUE has been variable but at a high level since 2006, reaching a time series high in 2016 before declining in 2017.

Analyses of data from the Spanish fishery show that the CPUE has been variable at a high level since 2006, reaching a time series high in 2016 and 2017.

In general, for the Russian fishery, the catch rate ranged from 5.2 t to 33.9 t and averaged 18.2 t per fishing vessel day. These catch rates are higher than those in 2016 and 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 2007-2017 than in the period of the 1990s to the mid 2000s.

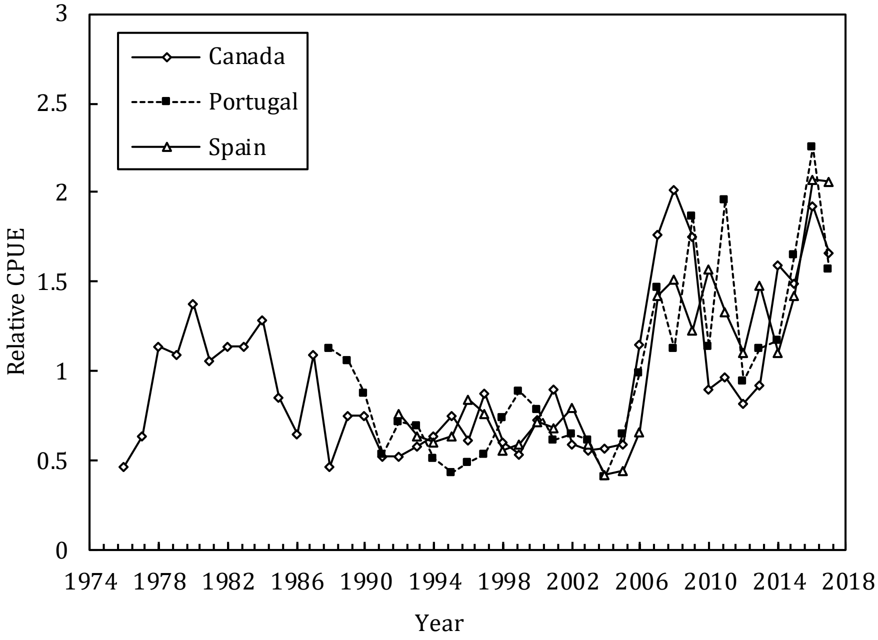


Fig. 20.2. Greenland halibut in Subarea 2 + Div. 3KLMNO: standardized CPUE from Canadian, Portuguese and Spanish trawlers. (Each standardized CPUE series is scaled to its 1992-2017 average)

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 2017 fishery were provided by EU-Spain, EU-Portugal, EU-Estonia, Russia and Japan. Ageing information was available for the Spanish, and Russian fisheries. Weights were available from EU-Spain, EU-Portugal, and EU-Estonia.

ii) Research survey data

STACFIS reiterated that most research vessel survey series providing information on the abundance of Greenland halibut are deficient in various ways and to varying degrees. Variation in divisional and depth coverage creates problems in comparing results 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 increased substantially from 2010-2014 to levels near those of the early part of the time series. However, the index declined substantially from 2015 to 2017. The abundance index was stable through the 1980s, but increased substantially in the mid-1990s, again due to the presence of the 1993-1995 year-classes. After this, abundance declined to the late 1990s and had been relatively stable except for the decline in 2005. Following improved estimates of abundance in 2010 and 2011, the 2012 to 2017 indices are considerably lower.

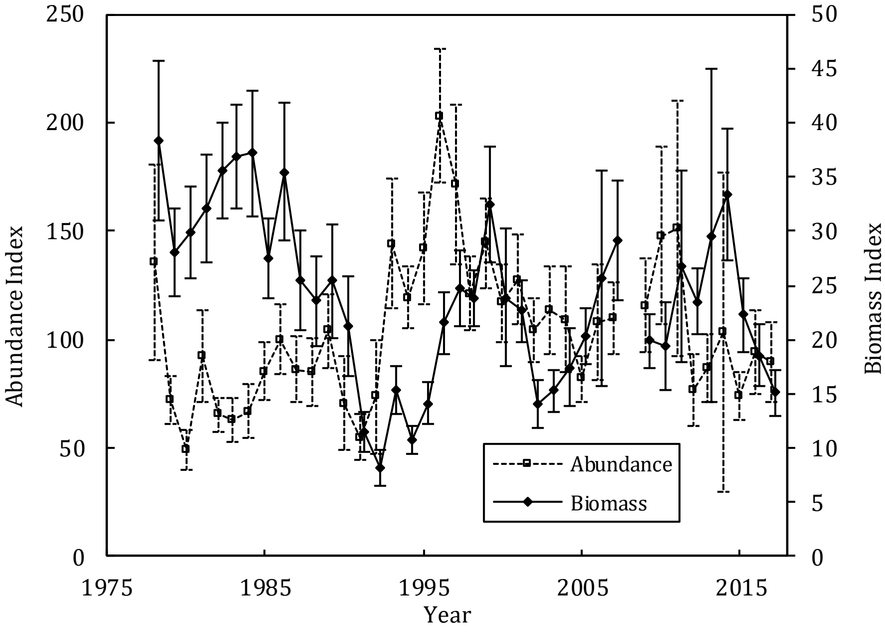


Fig. 20.3. Greenland halibut in Subarea 2 + Div. 3KLMNO: biomass and abundance indices (with 95% CI) from Canadian autumn surveys in Div. 2J and 3K. The 2008 survey was not completed.

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 and 2017 surveys were incomplete and are not considered representative of the population.

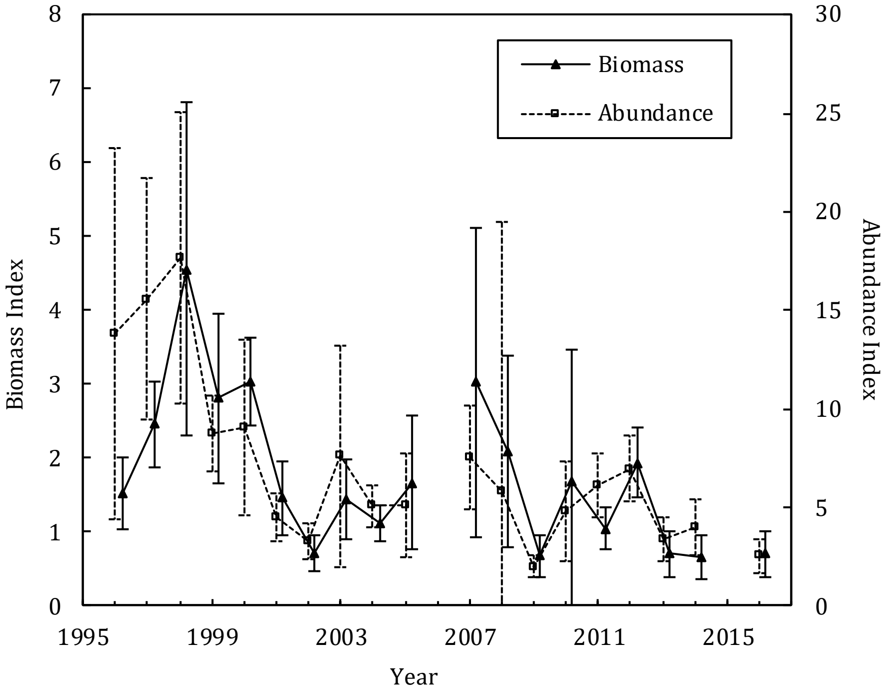


Fig. 20.4. Greenland halibut in Subarea 2 + Div. 3KLMNO: biomass and abundance indices (with 95% CI) from Canadian spring surveys in Div. 3LNO.

Canadian stratified-random autumn surveys in Div. 3LNO. Time series of abundance and biomass were developed from the Canadian autumn surveys from 1995-2017 to a depth of 730 m. The abundance index from the Canadian autumn surveys in Div. 3LNO (Fig. 20.5) declined from relatively high values in the late 1990s and has been relatively low in most years thereafter. The biomass index declined from 1998 to 2002 and then increased to 2005, to a level near that of the beginning of the time series. From 2015-2017, biomass was 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.

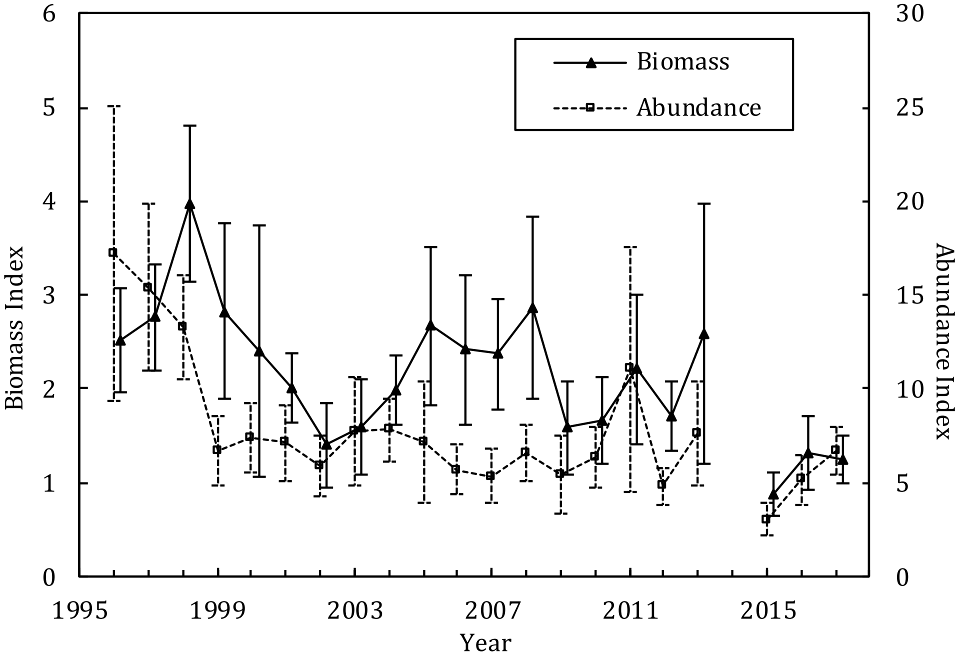


Fig. 20.5 Greenland halibut in Subarea 2 + Div. 3KLMNO: biomass and abundance indices (with 95% CIs) from Canadian autumn surveys in Div. 3LNO.

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 2017 the index remained well below the series average. The Flemish Cap survey was extended to cover depths down to 1460 m beginning in 2004. Biomass estimates over the full depth range doubled over 2005-2008 but then declined to below the time-series average in 2012 and 2013. From 2015-2017 the index has been variable but above the average of the time series, with 2015 and 2017 being the highest in the series.

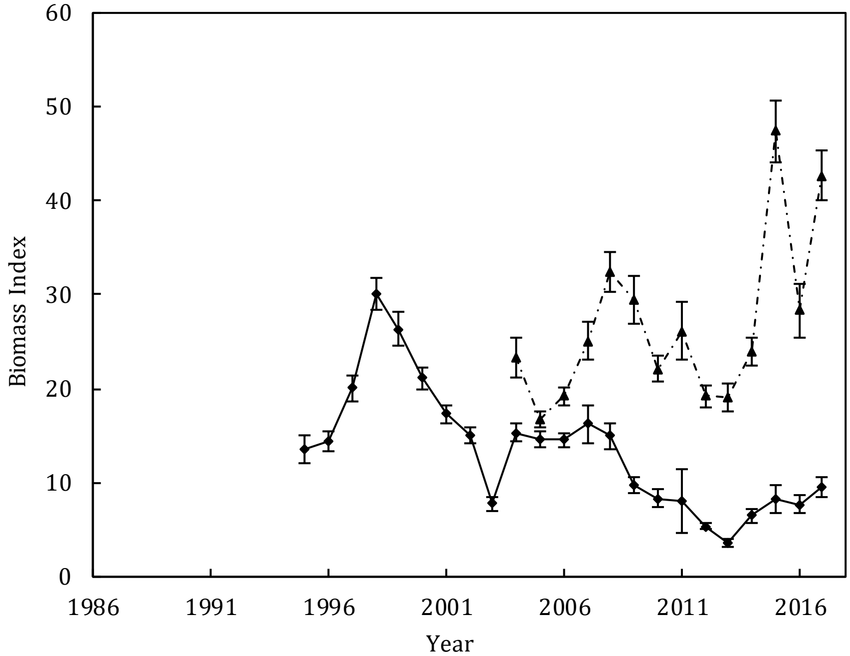


Fig. 20.6. Greenland halibut in Subarea 2 + Div. 3KLMNO: Biomass index (± 1 S.E.) from EU Flemish Cap surveys in Div. 3M. Solid line: biomass index for depths <730 m. Dashed line: biomass index for all depths <1460 m.

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 has increased since 2013 to a time series high in 2017. 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 to a time series high in 2017.

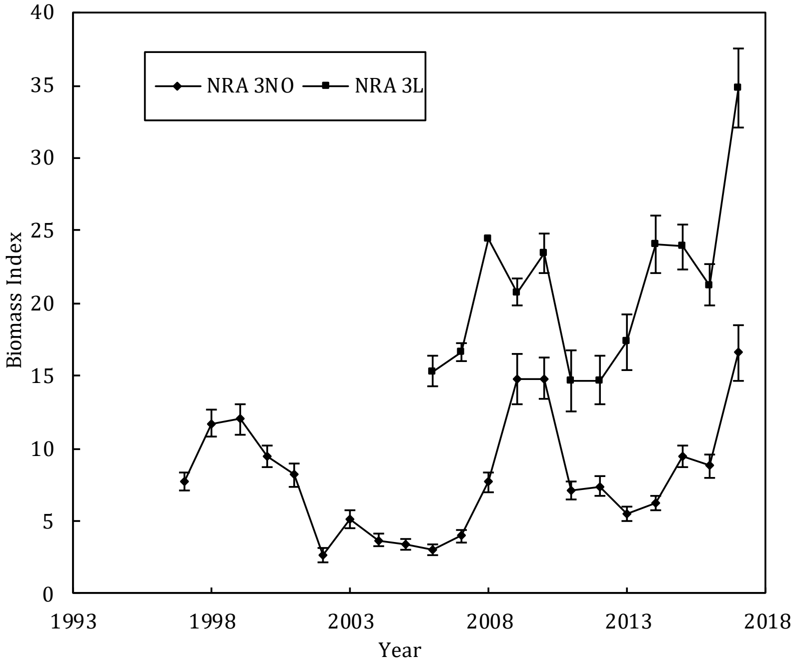


Fig. 20.7. Greenland halibut in Subarea 2 + Div. 3KLMNO: biomass index (±1 SE) from EU-Spain spring surveys in the NRA of Div. 3NO and Div. 3L.

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. Since 2014 there is a clear divergence with the surveys in the NRA (including 3M) increased to well above their time series averages while the Canadian surveys have been lower than their respective time series average. The overall trend since 2007 is unclear, but the 3 of 4 surveys that start in the mid 1990s, are only about 70% of their average in 2016.

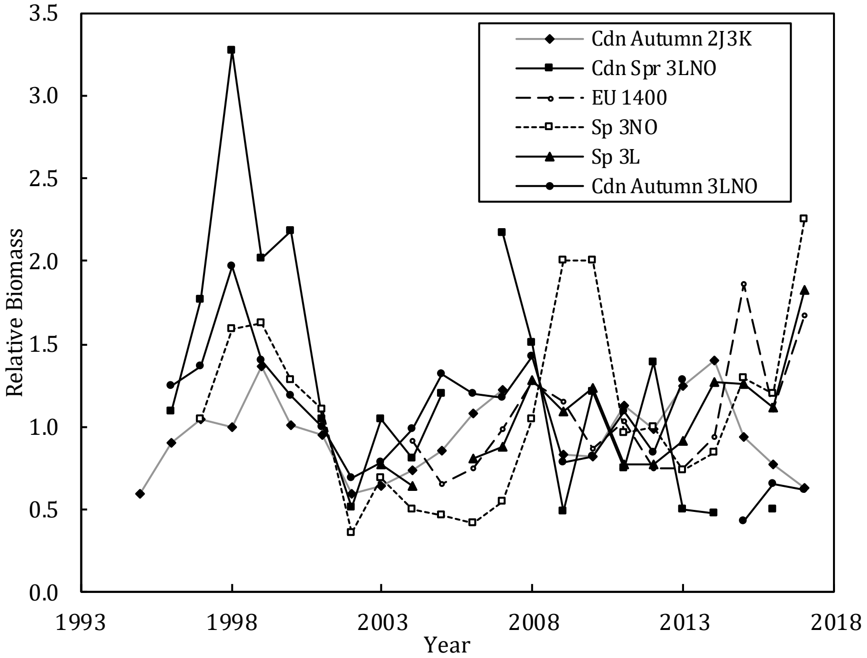


Fig. 20.8. Greenland halibut in Subarea 2 + Div. 3KLMNO: Relative biomass indices from Canadian autumn surveys in Div. 2J3K, Canadian spring surveys in Div. 3LNO, Canadian autumn surveys in Div. 3LNO, EU survey of Flemish Cap, and EU-Spain surveys of the NRA of Div. 3NO. Each series is scaled to its 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.

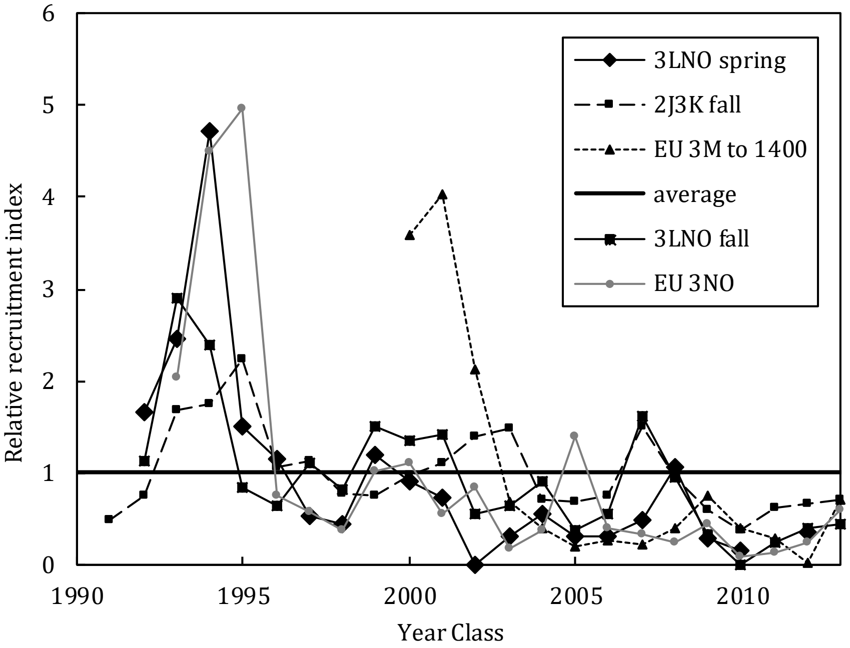


Fig. 20.9. Greenland halibut in Subarea 2 + Div. 3KLMNO: Relative recruitment indices from Canadian autumn surveys in Div. 2J3K, Canadian spring surveys in Div. 3LNO, and EU survey of Flemish Cap. Each series is scaled to its average and the average line is shown.

c) Assessment results

Biomass: Survey data from 2011-2017 are variable which complicates the interpretation of overall status. The five surveys that are used in the HCR show differing trends over this period. Three of the surveys have declined and are low in 2017, while two have increased and are at a time series high in 2017.

Recruitment: Results of all surveys indicate that recruitment (age 4) has been below average since 2009.

Fishing Mortality: Unknown. Catch was equal to the TAC in 2017.

State of the stock: Survey results in recent years show greater divergence which complicates interpretation of overall status. The slope for three of the five indices used in the HCR was negative while two were positive. Similarly 3 are below their 2011-2015 average and two are above.

d) Reference points

Precautionary approach reference points have not been determined for this stock at this time.

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.A. Mid-Atlantic Fishery Management Council, respectively. The stock assessment is data-poor and annual biomass projections are not currently possible. Indices of relative biomass and mean body weight were computed using data from the Div. 4VWX surveys conducted during July by the Canada Department of Fisheries and Oceans. These indices were used to assess whether the Subareas 3+4 stock component was at a low or high productivity level during the previous year. The Subareas 3+4 nominal catch divided by the Div. 4VWX biomass index was used to assess annual relative exploitation rates.

b) Data Overview

Since 1999, there has been no directed fishery for *Illex* in Subarea 4 and most of the catches from Subareas 3+4, for most years during 1999-2011, were from the Subarea 3 inshore jig fishery. There were no catches from Subarea 3 during 2013-2015. During 1999-2011, catches from Subareas 3+4 were low during most years (average = 1 077 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 were less than 50 t during 2012-2015 and reached the lowest level in the time series (since 1953) during 2015 (14 t). Thereafter, catches increased to 379 t in 2017, but remained well below the 1982-2016 average catch (2 510 t) for the 1982-2016 low productivity period.

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

	2009	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**
TAC SA 3+4	34	34	34	34	34	34	34	34	34	34
STATLANT 21 SA 3+4	0.7	0.1[1]	0.1[1]	<0.1[1]	<0.1[1]	<0.1[1]	<0.1[1]	0.2[1]	0.4[1]	
STATLANT 21 SA 5+6[2]										
STACFIS SA 3+4	0.2	0.1	0.1	<0.1	<0.1	<0.1	<0.1	0.2	0.4	
STACFIS SA 5+6[2]	18.4	15.8	18.8	11.7	3.8	8.8	2.4	6.7	22.5	
STACFIS Total SA 3-6	19.1	15.9	18.9	11.7	3.8	8.8	2.4	6.8	22.9	

[1] Includes amounts (< 0.1 t to 18 t during 2010-2011 and 0.2 t to 31 t during 2012-2017) 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.

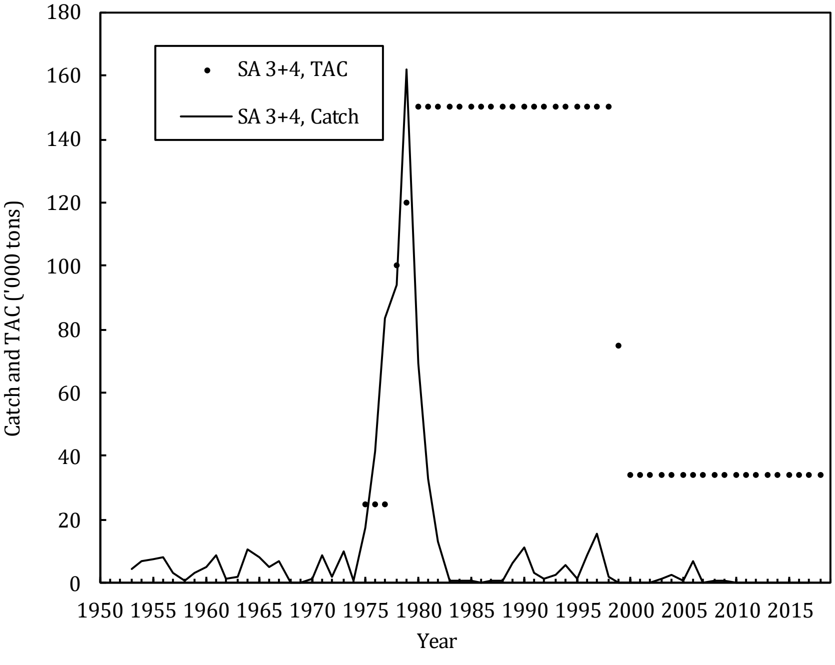


Fig. 21.1. Northern shortfin squid in Subareas 3+4: nominal catches and TACs.

Relative biomass indices, derived using data from the Canadian surveys conducted during July in Div. 4VWX, fluctuated widely after 2003 (Fig. 21.2). Biomass indices generally declined between 2004 and 2013, from a level near the high productivity period mean to the lowest level on record, respectively. During 2010-2016, biomass indices were below the low productivity period average of 2.6, but then increased in 2017 to 16.1; the second highest level of the time series and above the high productivity period average of 13.2. However, previous years of high biomass (i.e., 1992, 2004 and 2006) during the low productivity period were followed by much lower indices. If the post-1981 episodic trend holds, persistence of the high biomass index is unlikely in 2018.

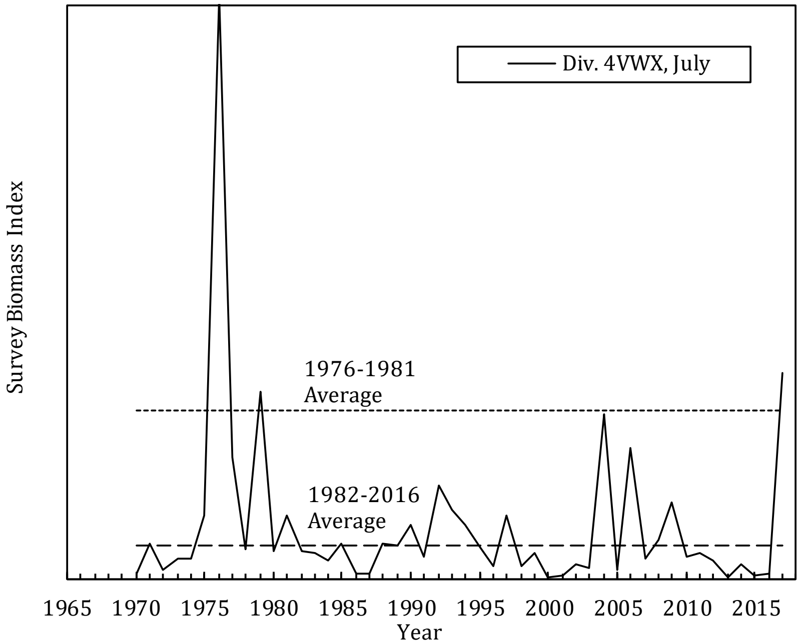


Fig. 21.2. Northern shortfin squid in Subareas 3+4: survey biomass indices from the July survey in Div. 4VWX.

Since 1982, mean body weight of squid caught during the July Div. 4VWX surveys fluctuated widely around the mean for the 1982-2016 low productivity period (80 g, Fig. 21.3). Mean body weight increased from the lowest level of the time series in 1983 (27 g) to the third 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 declined to the fourth lowest level of the time series in 2016 (37 g). During 2017, mean body weight increased to 134 g, which was slightly below the 2006 low productivity period peak (137 g).

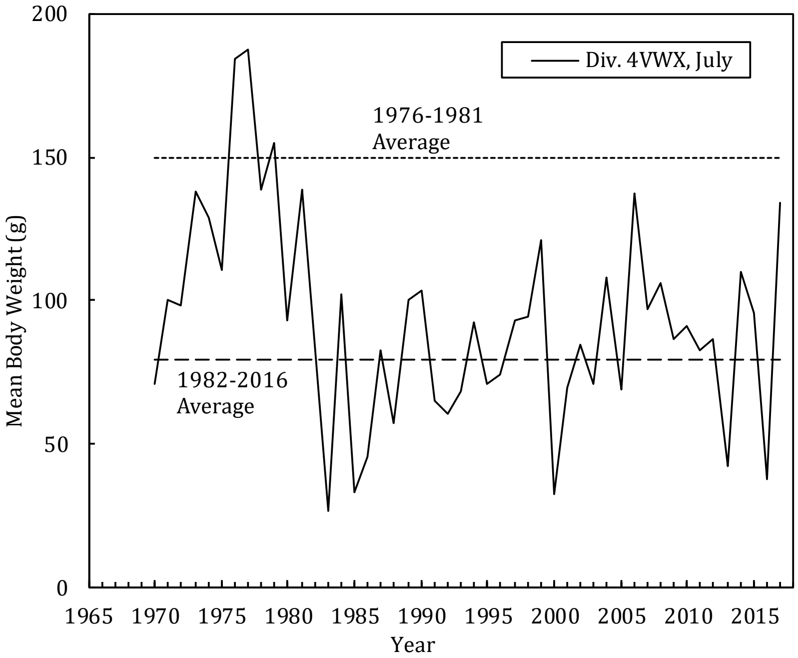


Fig. 21.3. Northern shortfin squid in Subareas 3+4: mean body weights of squid from the July survey in Div. 4VWX.

Catch/biomass ratios (SA 3+4 nominal catch/Division 4VWX July survey biomass index) / 10 000) have been well below the 1982-2016 mean (0.12) during most years since 2001 and the ratio was < 0.01 in 2017 (Fig. 21.4).

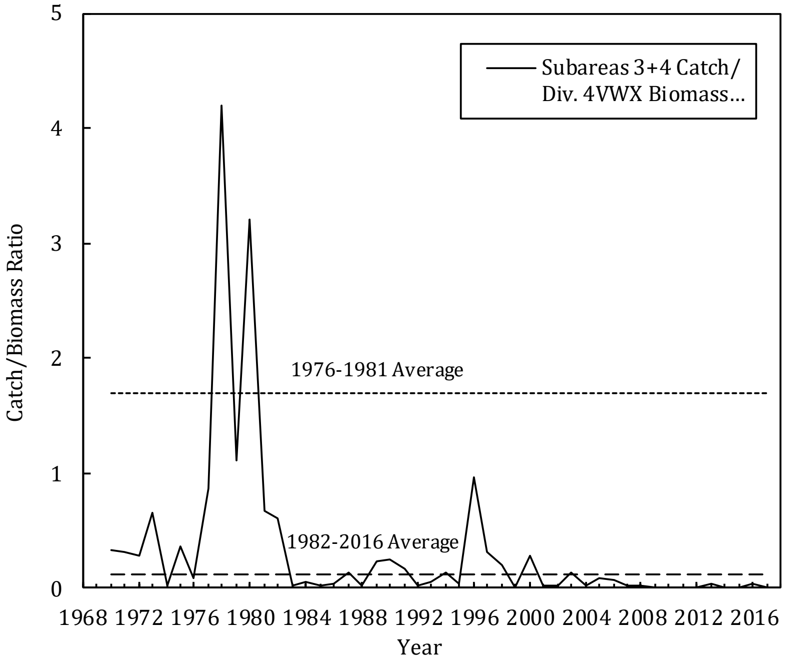


Fig. 21.4. Northern shortfin squid in Subareas 3+4: catch/biomass ratios (SA 3+4 nominal catch/Division 4VWX July survey biomass index) / 10 000).

c) Conclusion

Since 1999, there has been no directed fishery in Subarea 4 and there were no catches in Subarea 3 during 2013-2015. The highest catch since 1999 occurred during 2006, when 20.5% (6 982 t) of the current quota of 34 000 t was harvested, but since 2007 only 0.04% to 2.1% of the quota has been harvested each year. Biomass indices from the July Div. 4VWX surveys have been below the 1982-2016 mean since 2010, but increased in 2017 (16.1 kg per tow) to the second highest level of the time series and was 22% higher than the high productivity period average (13.2 kg per tow during 1976-1981). Mean body weight also increased in 2017 (134 g), but remained below the high productivity period average of 150 g. The high increase in the biomass index during 2017 did not translate into similarly high catches in the Subarea 3 fishery and catch/biomass ratios have been well below the 1982-2016 low productivity period average since 2004. If the post-1981 episodic trend holds, persistence of the high biomass and mean body weight indices are unlikely in 2018. Regardless, the Subarea 3 fishery only harvested a minor percentage (1.1%) of the 2017 quota despite the very high biomass index.

The next assessment is planned 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 Subarea 6

(SCS Doc. 18/07 SCR 18/22, 15/06 and 15/18)

a) Introduction

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

Most published growth studies suggest maximum life span between 10 and 20 years. The observed variability in the maximum age / length depends on the geographic region. Sexual maturation was found to begin at age 2 and at a mean length of 18 cm. By age 5–6 years, all individuals were mature at 25–30 cm fork length. On the Corner Rise Seamounts, alfonsino were observed to spawn from May-June to August-September.

Natural mortality (M) value is uncertain. M estimates for alfonsino in Chile using five empirical methods give a range between 0.1 and 0.28 (Gili *et al.*, 2002).

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.

Alfonsino fishery is not regulated in NAFO.

b) Description of the Fishery

Historically, catches of alfonsino in the NAFO Regulatory Area (NRA) have been reported from Div. 6E-H, although the bulk of those catches were made in the Corner Rise area. The development of the Corner Rise fishery was initiated in 1976, when, according to the unofficial data, Russian vessels caught over 10,000 t, mainly splendid alfonsino. Commercial aggregations of alfonsino on the Corner Rise (34-37°N, 47-53°W) (Fig. 22.1) have been found on three seamounts. Two of them named "Perspektivnaya" (known also as "Kükenthal") and "Vybornaya" ("C-3") are located in NRA. One more bank named "Rezervnaya" ("Milne Edwards") is located in the Central Western Atlantic.

Russian vessels fished in this area in different periods between 1976 and 1999 using pelagic trawls. There are no statistics on Russian fishery on separate seamounts, but, in accordance with the approximate estimation, the Kükenthal was considered to be the most important ground where 50-70% of the total catch was taken. Also, the fishery was carried out on the C-3 and Milne Edwards banks, where the catches were 15-25% of the total yield each.

Based on the information collected in the 2004 Spanish experimental survey in Corner Rise, a directed commercial fishery had been conducted since 2005 by Spanish vessels. Since 2006 virtually all the effort has been made in the Kükenthal seamount with pelagic trawl gear.

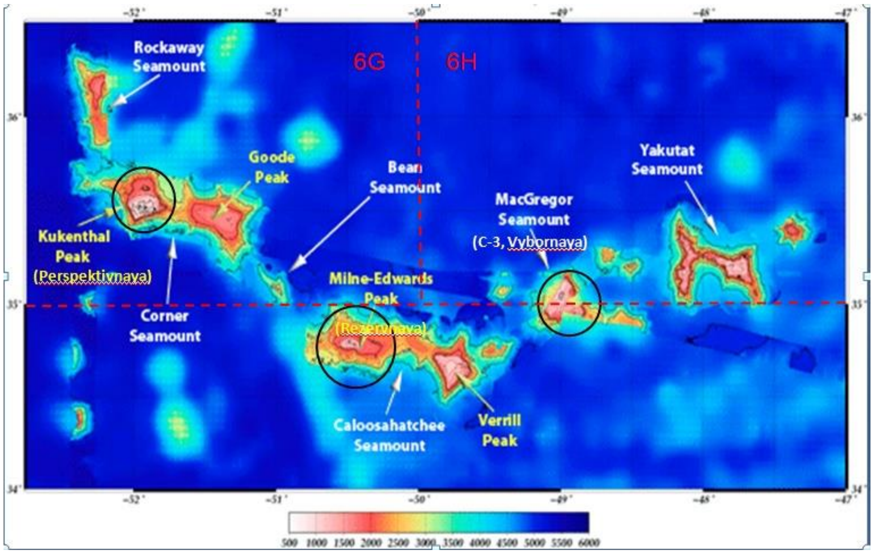


Fig. 22.1. Location of the Corner Rise seamount complex in relation to NAFO Div. 6G-H. The dotted line (35 degrees) is the southern limit of the NRA.

c) Commercial fishery data

The Russian fishery started in 1976 with a catch of 10 200 t (Fig. 22.2). Thereafter the catches ranged between 10 and 3 500 t. There was no fishing effort from 1988-1993, 1998 and 2000-2003. From 2004 until now, a fishery in Kükenthal seamount was conducted by Spanish vessels using a pelagic trawl gear, where catches have ranged between 52 and 1 187 t, with no fishery in 2008 (Table 22.1; Fig. 22.2).

Table 1. Recent catches (tons), effort and CPUE (Kg/hr fished) for the alfonsino fishery on Kükenthal Peak (Div. 6G).

Year	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**
Catch (t)	0	479	52	152	302	114	118	122	127	55
Effort (days on ground)	0	28	4	9	22	17	15	13	16	12
Effort (hours fished)	0	167	66	68	165	87	117	92	116	68
CPUE (Kg/hour)		2868	788	2235	1830	1310	1009	1326	1095	809
Effort (vessels)	0	1	1	1	1	1	2	2	1	1

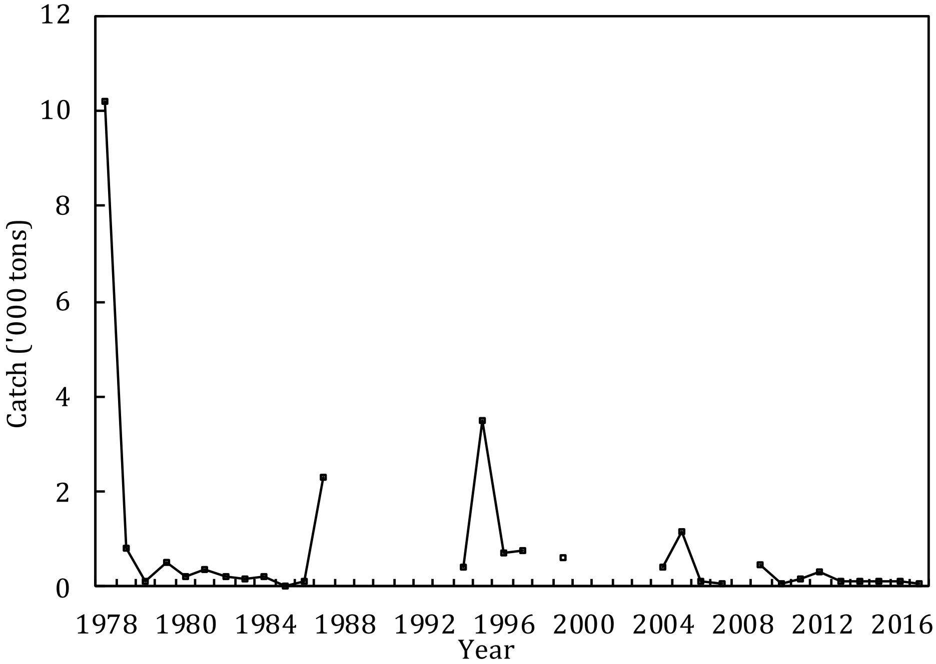
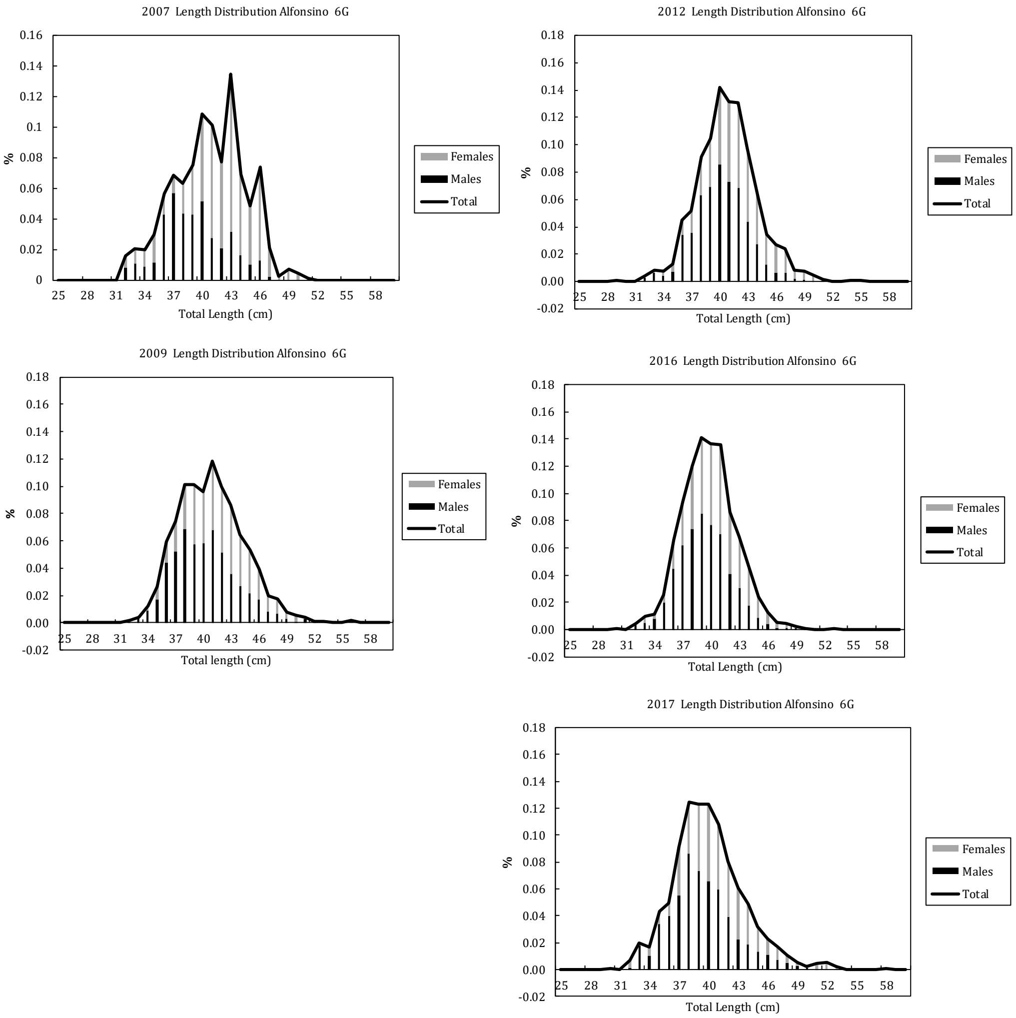


Fig. 22.2. Alfonsino catches from Div. 6G.

Fig. 22.3 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. The 2007 size distributions have been transformed to the total length using fork length/total length relationship presented by Gonzalez-Costas (2018). It can be observed that these length distributions are stable and quite similar. Catches in all years are in the 30-50 cm range with a mode around 40 cm.



2007 Length Distribution Alfonsino 6G

2012 Length Distribution Alfonsino 6G

2009 Length Distribution Alfonsino 6G

2016 Length Distribution Alfonsino 6G

2017 Length Distribution Alfonsino 6G

Fig. 22.3. Length distributions of alfonsino Kükenthal Peak (Div. 6G) catches.

d) Commercial CPUEs

As a consequence of the alfonsino fishery characteristics, the species' association with seamounts and their aggregation behaviour, the utility of the commercial CPUE series as an indicator of the stock status is considered to be questionable.

Depending on the data, there are different series of commercial CPUEs that show slight different trends. Fig. 22.4 shows the LN(CPUE) obtained with the information of the NAFO observers and Scientific Observers. The indices based on the NAFO observers data shows a clear decreasing trend since the restart of the fishery in 2005 while the Scientific Observers CPUE information shows a more stable situation in last years.

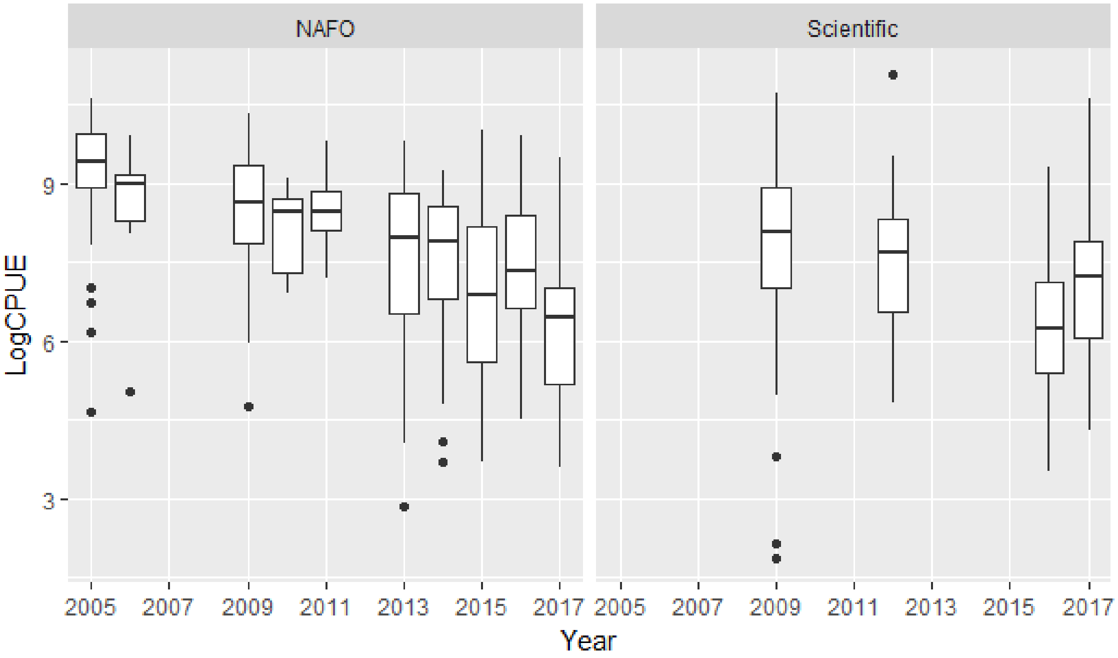


Fig. 22.4. LN CPUE (kg/hour fished) for the Kükenthal Peak (Div. 6G) midwater trawl fishery based on the NAFO Observers (left) and Scientific Observers data (right).

e) Surveys

The only available information on biomass covers a period ending in 1995. The alfonsino biomass estimated on Corner Rise with this data was around 11,000-12,000 t. It should be taken into consideration that the data with a time limitation of mainly 20-30 years were used for the calculations mentioned above. Based on this information; the greatest biomass of mature alfonsino (distribution depths of 400-950 m) was registered on the Kükenthal seamount (40%). On the C-3 (30%) and Milne Edwards seamounts (30%), the biomass was lower.

f) Assessment

With the available data an attempt has been made to estimate a sustainable level of catches in Kükenthal seamount with different methods (Depletion-Adjusted Average Catch, Only Reliable Catch Stocks and Replacement Yield). The results show different levels of MSY depending on the methods. The methods based on catch information are more optimistic than those based on the commercial CPUEs. STACFIS considers these results as unreliable and therefore MSY catch is unknown.

Not analytical or survey based assessment were possible at the moment due to the lack of updated data. The most reliable present data available are the catch time series.

g) Conclusion

No reliable assessment can be presented for this stock. The only estimate of biomass is based on surveys ending in 1995. Due to lack of abundance or exploitation information, an analytical or survey based assessment was not possible. The relationship between CPUE and stock size is uncertain.

The next full assessment of the stock is scheduled for 2021.

h) Research Recommendations

SC **recommends** that *fisheries independent information should be collected on 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 2018. This task has been deferred to the September SC meeting.

2. GADCAP Project Update

Multispecies model GadCap: Update and potential use for scientific advice as part of the EU SC05 project "Multispecies Fisheries Assessment for NAFO".

Multispecies modelling is an essential part of the NAFO roadmap for an Ecosystem Approach to Fisheries management, connecting the "Ecosystem" tier with the "Single species" tier. Aware of the importance of contributing in the development of this EAF roadmap, the EU DG-MARE launched in 2017 the project SC05 "Multispecies Fisheries Assessment for NAFO", to identify and develop potential alternatives to implement a multispecies approach in NAFO, with the Flemish Cap as a case study. As part of this project the multispecies model GadCap, considering the Flemish Cap cod, redfish and shrimp interdependent dynamics over the period 1988-2012, has been updated and improved. All the databases supporting the likelihood components in the model have been extended to 2016 to ensure that the data used in GadCap is comparable to the data used in the cod, redfish and shrimp single species assessment methods. Different components of the model have been improved; for example the groupings of years with the same model fit for growth and maturity, the inclusion of a new longline fleet for cod, re-estimation of the suitability parameters, or inclusion of new data bases with the survey index at age or the mean weight at age. Pérez-Rodríguez and González-Troncoso (2018) describe the improvements in relation to the version delivered in 2016. Model diagnostics, estimates of population abundance, biomass as well as predation and fishing mortality are presented.

Estimates of natural mortality at age by year from the updated version of GadCap have been used in the development of the management strategy evaluation (MSE) for cod Div 3M. The estimated natural mortalities for cod from GadCap were used to inform decisions about M in the proposed operating models for the MSE project. Different approaches to estimate the residual natural mortality were explored: survey catch curves, longevity method and likelihood score selection. Final estimates of M were ultimately used to reoptimize the GadCap model parameters and a final matrix of M was used in the 3M cod benchmark.

The next step is to examine the potential use of multispecies models in the implementation of a multispecies approach to fisheries management in NAFO, specifically the assemblage of a multispecies MSE where the GadCap multispecies model will be used as an operating model (msMSE). The resulting multispecies MSE framework will be used for a preliminary assessment of the ecological and economic consequences of different management strategies. Potential alternative multispecies reference points and HCRs as well as single species based HCRs can be tested within this msMSE framework, evaluating the impacts and yields both for the target species and the key interacting species. Different alternatives are available, from a whole MSE framework incorporating uncertainty in different elements of the management procedure, to a more simple approach where GadCap is the only model used to test different management strategies. The project will evaluate the potential to develop and use these different configurations, and produce an initial configuration of the multispecies MSE framework for the Flemish Cap.

References:

Pérez-Rodríguez, A. and González-Costas, F., 2018. Estimates of natural predation and residual mortality for the Flemish Cap cod. NAFO SCR Doc. 18/26.

Pérez-Rodríguez, A. and González-Troncoso, D., 2018. Update of the Flemish Cap multispecies model GadCap as part of the EU SC05 project: "Multispecies Fisheries Assessment for NAFO". NAFO SCR Doc 18/24.

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 14 June 2018.

APPENDIX V. AGENDA - SCIENTIFIC COUNCIL MEETING, 1-14 JUNE 2018

I. Opening (Scientific Council Chair: Brian Healey)
  1. Appointment of Rapporteur
  2 Presentation and Report of Proxy Votes
  3. Adoption of Agenda
  4. Attendance of Observers
  5. Appointment of Committee Chairs and Designated Experts
  6. Plan of Work
  7. Housekeeping issues

II. Review of Scientific Council Recommendations in 2017

III. Fisheries Environment (STACFEN)
  1. Opening
  2. Appointment of Chair
  3. Appointment of Rapporteur
  4. Adoption of Agenda
  5. Review of Recommendations in 2017
  6. Department of Fisheries and Oceans Canada, Oceans Science Branch, Marine Environmental Data Section (MEDS) (formerly ISDM) Report for 2017
  7. Review of the physical, biological and chemical environment in the NAFO Convention Area during 2017
  8. Interdisciplinary studies
  9. Formulation of recommendations based on environmental conditions during 2017
  10. National Representatives
  11. Other Matters
  12. Adjournment

IV. Publications (STACPUB Chair: Margaret Treble)
  1. Opening
  2. Appointment of Rapporteur
  3. Adoption of Agenda
  4. Review of Recommendations in 2017
  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)
  1. Opening
  2. Appointment of Chair
  3. Appointment of Rapporteur
  4. Review of Recommendations in 2017
  5. Fishery Statistics

  - a) Progress report on Secretariat activities in 2017/2018
    - i) Presentation of catch estimates from daily catch reports and STATLANT 21A and 21B
- 6 Research Activities
  - a) Biological sampling
    - i) Report on activities in 2017/2018
    - 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 2017 (by National Representatives and Designated Experts)
    - ii) Surveys planned for 2018 and early 2019
  - c) Tagging activities
  - d) Other research activities
- 7. Review of SCR and SCS Documents
- 8. Other Matters
  - a) Summary of progress on previous recommendations
  - b) NAFO Catch Estimates Methodology Study
- 9. Adjournment

VI. Fisheries Science (STACFIS Chair: Karen Dwyer)

- 1. Opening
- 2. General Review of Catches and Fishing Activity
- 3. Invited speaker
- 4. Stock Assessments
  - 1. Greenland halibut (*Reinhardtius hippoglossoides*) in SA 0, Div. 1A offshore and Div. 1B-F (fully assessed)
  - 2. Greenland halibut (*Reinhardtius hippoglossoides*) Div. 1A inshore (fully assessed)
  - 3.
  - 4. Demersal Redfish (*Sebastes* spp.) in SA 1 (monitor)
  - 5 Other Demersal fish in SA 1
  - 5a. Wolffish in Subarea 1 (monitor)
  - 6. Cod (*Gadus morhua*) in Div. 3M (fully assessed)
  - 7a. Redfish (*Sebastes mentella* and *Sebastes fasciatus*) in Div. 3M (monitor)
  - 7b. Golden redfish (*Sebastes norvegicus* aka *S. marinus*) in Div. 3M (monitor)
  - 8. American plaice (*Hippoglossoides platessoides*) in Div. 3M (monitor)
  - 9. Cod (*Gadus morhua*) in NAFO Div. 3NO (fully assessed)
  - 10. Redfish (*Sebastes mentella* and *Sebastes fasciatus*) in Divs. 3L and 3N (fully assessed)
  - 11. American plaice (*Hippoglossoides platessoides*) in Div. 3LNO (fully assessed)
  - 12. Yellowtail flounder (*Limanda ferruginea*) in Div. 3LNO (fully assessed)
  - 13. Witch flounder (*Glyptocephalus cynoglossus*) in Div. 3NO (fully assessed)
  - 14. Capelin (*Mallotus villosus*) in Div. 3NO (fully assessed)
  - 15. Redfish (*Sebastes mentella* and *Sebastes fasciatus*) in Div. 3O (monitor)
  - 16. Thorny skate (*Amblyraja radiata*) in Div. 3LNO and Subdiv. 3PS (fully assessed)
  - 17. White hake (*Urophycis tenuis*) in Div. 3NO and Subdiv. 3PS (monitor)
  - 18. Roughhead grenadier (*Macrourus berglax*) in Subareas 2 and 3 (monitor)
  - 19. Witch flounder (*Glyptocephalus cynoglossus*) in Div. 2J+3KL (monitor)
  - 20. Greenland halibut (*Reinhardtius hippoglossoides*) in SA 2 + Div. 3KLMNO (monitor)
  - 21. Northern shortfin squid (*Illex illecebrosus*) in Subareas 3+4 (monitor)
  - 22. Splendid alfonsino (*Beryx splendens*) in SA 6 (fully assessed)

5. Stocks under a Management Strategy Evaluation
   a) Greenland halibut in SA 2 and Div. 3KLMNO
   b) 3LN redfish
6. Other Matters
   a) FIRMS Classification for NAFO Stocks
   b) Other Business
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 2019</u>
      - Cod in Div. 3M
      <u>For 2019 and 2020</u>
      - American Plaice in Divs. 3LNO
      - Thorny Skate in Divs. 3LNO
      <u>For 2019, 2020 and 2021</u>
      - Yellowtail flounder in Divs. 3LNO
      - Cod in Divs. 3NO
      - Capelin in Divs. 3NO
      - Alfonsino stocks in the NAFO Regulatory Area
   b) Monitoring of Stocks for which Multi-year Advice was provided in 2016 or 2017 (Item 1)
      - Redfish in Div. 3M
      - American Plaice in Divs. 3M
      - Witch flounder in Divs. 3NO
      - Redfish in Div. 3O
      - White hake Div. 3NO and Subdiv. 3PS
      - Roughhead grenadier in Subareas 2 and 3
      - Witch flounder in Div. 2J+3KL
      - Northern shortfin squid in Subareas 3+4

   c) Special Requests for Management Advice
      i) Greenland halibut in SA2 + Divs. 3KLMNO: Monitor the status annually to determine whether exceptional circumstances are occurring (Item 2)
      ii) Conduct a full assessment of 3LN Redfish (Item 3)
      iii) Develop criteria for the identification of exceptional circumstances under the Greenland halibut 2+3KLMNO management strategy (Item 4)
      iv) Benchmark assessment of the 3M Cod and workplan for MSE (Item 5)
      v) Continue the evaluation of trawl surveys on VMEs (Item 6)
      vi) Implement the Action plan for progression in the management and minimization of Bycatch and discards (Item 7)
      vii) Conduct a full assessment on 3M golden Redfish in 2019 (Item 8)
      viii) Provide further guidance on the implementation of an ecosystem approach and application of the Ecosystem Road Map (Item 9)
      ix) Assessment of NAFO bottom fisheries (item 10)
      x) Continue progress on the NAFO PA Framework (Item 11)
      xi) Review and develop advice for Greenland sharks (*Somniosus microcephalus)* (Item 12)

        - xii) Continue work on the SWOT analysis (Item 13)
    2. Coastal States
        a) Request by Denmark (Greenland) for Advice on Management in 2019 (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 & 5)
        b) Request by Canada and Greenland for Advice on Management in 2019 (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), 2018
2. Scientific Council, 17 – 21 Sep. 2018
3. Scientific Council, June 2019
4. Scientific Council (in conjunction with NIPAG), 2019
5. Scientific Council, Sep. 2019
6. NAFO/ICES Joint Groups
    a) NIPAG, 2018
    b) NIPAG, 2019
7. WG-ESA, 13 – 22 Nov. 2018
8. WG-DEC
9. WG-HARP

IX. Arrangements for Special Sessions
1. Topics for future Special Sessions
2. ICES/PICES shellfish symposium

X. Meeting Reports
1. Working Group on Ecosystem Science and Assessment (WG-ESA), Nov. 2017
2. Report from ICES-NAFO Working Group on Deepwater Ecosystems (WG-DEC), Mar. 2018
3. Report from Joint COM-SC Working Group on Catch Estimation Strategy Advisory Group (CESAG), Nov. 2017, March and April 2018
4. Meetings attended by the Secretariat

XI. Review of Scientific Council Working Procedures/Protocol
1. General Plan of Work for September 2018 Annual Meeting
2. Other Matters
    Timeline for reporting of SC results/advice following meetings
    Timeframe for completion of meeting reports
    Attendance of observers in SC meetings (restricted vs open meetings)
    Meeting participation by WebEx

XII. Other Matters
1. Designated Experts
2. Stock Assessment spreadsheets
3. Scientific Merit Awards
4. Budget items

5. Other Business
    Canadian assessment of northern cod

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, 01-14 June 2018

Date	Time	Schedule
01 June (Friday)	0900	Registration, network connection
	0900-0930	SC Executive
	1000-1030	SC Opening
	1100-1200	STACFEN
	1200-1300	Break
	1300-1800	STACFEN
02 June (Saturday)	0900-1200	Scientific Council/STACFIS
	1300-1800	STACFIS
	1830-2030	Scientific Council Reception
03 June (Sunday)	No meetings	
04 June (Monday)	0900-1200	STACPUB
	1300-1800	Scientific Council/STACFIS
	1830-2030	STACFIS
05 June (Tuesday)	0900-1800	STACREC
06 June (Wednesday)	0900-1200	STACFIS
	1300-1800	STACFIS
07 June (Thursday)	0900-1800	STACFIS
08 June (Friday)	0900-1800	STACFIS
09 June (Saturday)	0900-1800	STACFIS Reports
10 June (Sunday)	No meetings	
11 June (Monday)	0830	Scientific Council Executive
	0900-1800	Scientific Council (Standing Committee Reports)
12 June (Tuesday)	0900-1800	Scientific Council
13 June (Wednesday)	0900-1800	Scientific Council
14 June (Thursday)	0900-1800	Scientific Council (advice and adoption of reports)

ANNEX 1. FISHERIES COMMISSION'S REQUEST FOR SCIENTIFIC ADVICE ON MANAGEMENT IN 2019 AND BEYOND OF CERTAIN STOCKS IN SUBAREAS 2, 3 AND 4 AND OTHER MATTERS

Following a request from the Scientific Council, the Commission agreed that items 1, 3, 4, 5, and 12 should be the priority for the June 2018 Scientific Council meeting.

1. The Commission requests that the Scientific Council provide advice for the management of the fish stocks below according to the assessment frequency presented below. 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
Cod in Div. 3M	American plaice in Div. 3LNO Redfish in Div. 3M Northern shrimp in Div. 3M Northern shrimp in Div. 3LNO Thorny skate in Div. 3LNO White hake in Div. 3NO Witch flounder in Div. 3NO Redfish 3LN	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 Div. 2J+3KL Yellowtail flounder in Div. 3LNO Greenland halibut 2+3KLMNO Splendid alfonsino in SA 6

To implement this schedule of assessments, the Scientific Council is requested to conduct a full assessment of these stocks as follows:

In 2018, advice should be provided for 2019 for Cod in Div. 3M and shrimp in Div. 3M.

In 2018, advice should be provided for 2019 and 2020 for, American Plaice in 3LNO, and Thorny Skate in 3LNO.

In 2018, advice should be provided for 2019, 2020 and 2021 for Yellowtail Flounder in 3LNO, Cod in 3NO, and Capelin in 3NO and for alfonsino stocks in the NAFO Regulatory Area.

Advice should be provided using the guidance provided in **Annexes A or B as appropriate**, or using the predetermined Harvest Control Rules in the cases where they exist (currently 3LN Redfish and Greenland halibut 2+3KLMNO).

The Commission also requests the Scientific Council to continue to monitor the status of all other stocks annually and, should a significant change be observed in stock status (e.g. from surveys) or in bycatch in other fisheries, provide updated advice as appropriate.

2. The management strategy for Greenland halibut in Subarea 2+Div. 3KLMNO will be implemented initially for 6 years beginning in 2018. Acknowledging that an Exceptional Circumstances Protocol is will be developed for this stock in 2018 (see item 3 below), the Commission requests the Scientific Council to monitor the status annually to determine whether exceptional circumstances are occurring. Scientific Council should also perform an "update assessment" in 2020. If either the annual monitoring or the update assessment indicates that exceptional circumstances are occurring, the exceptional circumstances protocol will provide guidance on what steps should be taken.
3. The Commission requests the Scientific Council conduct a full assessment of 3LN Redfish to evaluate the effect of the removals.
4. The Commission requests the Scientific Council to develop criteria for the identification of exceptional circumstances under the Greenland halibut 2+3KLMNO management strategy, this should take into account the issues noted by the WG-RBMS (COM-SC WP 17-06), to support the development of an exceptional circumstances protocol and provide its recommendations to the WG-RBMS meeting planned for August 2018.

5. The Commission requests the Scientific Council to implement processes to conduct a full benchmark assessment of the 3M Cod in line with the work plan (FC-SC Doc. 17-02, Annex 3) and the steps of the work plan relevant to the SC for progression of the 3M Cod Management Strategy Evaluation for 2019.
6. The Commission requests that Scientific Council continue its evaluation of the impact of scientific trawl surveys on VME in closed areas, and the effect of excluding surveys from these areas on stock assessments.
7. The Commission requests the Scientific Council to implement the steps of the Action plan relevant to the SC for progression in the management and minimization of Bycatch and discards (COM WP 17-35).
8. The Commission requests the Scientific Council to conduct a full assessment on 3M golden Redfish in 2019 and, acknowledging that there are three species of redfish that exist in 3M and are difficult to separate in the catch, provide advice on the implications for catch reporting and stock management.
9. The Commission requests the Scientific Council provide further guidance on the implementation of an ecosystem approach and application of the Ecosystem Road Map, through examples of how advice compares to single species stock assessment, including additional factors to be considered and integrating trophic level interactions and climate change predictions.
10. In relation to the assessment of NAFO bottom fisheries, the Commission endorsed the next re-assessment in 2021 and that the Scientific Council should:
    - Assess the overlap of NAFO fisheries with VME to evaluate fishery specific impacts in addition to the cumulative impacts;
    - Consider clearer objective ranking processes and options for objective weighting criteria for the overall assessment of significant adverse impacts and the risk of future adverse impacts;
    - Maintain efforts to assess all of the six FAO criteria (Article 18 of the FAO International Guidelines for the Management of Deep Sea Fisheries in the High Seas) including the three FAO functional SAI criteria which could not be evaluated in the current assessment (recovery potential, ecosystem function alteration, and impact relative to habitat use duration of VME indicator species).
    - Continue to work on non-sponge and coral VMEs (for example bryozoan and sea squirts) to prepare for the next assessment.
11. The Commission requests the Scientific Council to continue progression on the review of the NAFO PA Framework.
12. The Commission requests the Scientific Council, by their 2018 annual meeting engage with relevant experts as needed, review additional information beyond what was provided in 2017, 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 Commission.
13. The Commission requests the Scientific Council continue on a Strengths, Weaknesses, Opportunities and Threats (SWOT) analysis. The strategy and the mid and long-term objectives and tasks in view of NAFO's amended convention objectives should be developed jointly with the Commission. The plan should define for each strategic objective goals, tasks and measurable targets.

ANNEX A: Guidance for providing advice on Stocks Assessed with an Analytical Model

The Commission request the Scientific Council to consider the following in assessing and projecting future stock levels for those stocks listed above. These evaluations should provide the information necessary for the Fisheries Commission to consider the balance between risks and yield levels, in determining its management of these stocks:

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_{2017}, F_{2017}, 125% F_{2017},

- For stocks under a moratorium to direct fishing: F_{2017}, 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(B2020 > B2016)
F in 2017 and following years*	Yield 2018 (50%)	Yield 2019 (50%)	Yield 2020 (50%)	2018	2019	2020	2018	2019	2020		2018	2019	2020	2018	2019	2020		
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_{2017}	t	t	t	%	%	%	%	%	%		%	%	%	%	%	%		%
F_{2017}	t	t	t	%	%	%	%	%	%		%	%	%	%	%	%		%
1.25 X F_{2017}	t	t	t	%	%	%	%	%	%		%	%	%	%	%	%		%
F=0	t	t	t	%	%	%	%	%	%		%	%	%	%	%	%		%

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_{2017}, F_{2017}, 125% F_{2017},
- For stocks under a moratorium to direct fishing: F_{2017}, 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(B2020 > B2016)
F in 2017 and following years*	Yield 2018	Yield 2019	Yield 2020	2018	2019	2020	2018	2019	2020	2018	2019	2020	2018	2019	2020	
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_{2017}	t	t	t	%	%	%	%	%	%	%	%	%	%	%	%	%
F_{2017}	t	t	t	%	%	%	%	%	%	%	%	%	%	%	%	%
1.25 X F_{2017}	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 2019 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 June 2017 given for 2018-2020. Consequently, the Scientific Council is requested to continue its monitoring of the above stocks and provide updated advice as appropriate in the event of significant changes in stock levels. Furthermore, the Scientific Council is asked to advice on any other management measures it deems appropriate to ensure the sustainability of these resources.

a) **Greenland Halibut, offshore:** For Greenland Halibut in subareas 0 + 1 advice was in 2016 given for 2017 and 2018. Subject to the concurrence of Canada as regards to Subareas 0 and 1, Denmark (on behalf of Greenland) requests the Scientific Council before December 2018 to provide advice on the scientific basis for management of offshore Greenland Halibut (*Reinhardtius hippoglossoides*) in the following areas:

- a. The offshore areas of NAFO Division 0A and Division 1 A + 1 B
- b. NAFO Division 0B and 1C-F.
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- The Scientific Council is also asked to advise on any other management measures it deems appropriate to ensure the sustainability of these resources.
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2. 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 before December 2018 to provide advice on the scientific basis for management of inshore Greenland Halibut (*Reinhardtius hippoglossoides*) in Division 1A.

3. Northern Shrimp, West Greenland: Subject to the concurrence of Canada as regards Subarea 0 and 1, Denmark (on behalf of Greenland) requests the Scientific Council before December 2018 to provide advice on the scientific basis for management of Northern Shrimp *(Pandalus borealis)* in Subarea 0 and 1 in 2019 and for as many years ahead as data allows for.

4. Northern Shrimp. East Greenland: Furthermore, the Scientific Council is in cooperation with ICES requested to provide advice on the scientific basis for management of Northern Shrimp *(Pandalus borealis)* in Denmark Strait and adjacent waters east of southern Greenland in 2019 and for as many years ahead as data allows for.

ANNEX 3. REQUESTS FOR ADVICE FROM CANADA FOR 2019

1. Greenland halibut (Subareas 0 and 1)

The Scientific Council is requested to provide an overall assessment of status and trends in the total stock area throughout its range and to specifically advise on TAC levels for 2019 and 2020, separately, for Greenland halibut in Divisions OA + 1 A (offshore) and 1 B, and Divisions OB+ 1 C-F[1]. The Scientific Council is also asked to provide advice on any other management measures it deems appropriate to ensure the sustainability of these resources.

a) It is noted that at this time only general biological advice and/or catch data are available, few standard criteria exist on which to base advice. 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 and include likely risk considerations and implications as much as possible, including risks of maintaining current TAC levels and any risks and available details of observations that would support an increase or decrease in the TAC.[2]

The following graphs should be presented, for one or several surveys, for the longest time-period possible:

- Historical catches;
- Abundance and biomass indices;
- Age or size range chosen to represent the spawning population;
- Age or size range chosen to represent the exploited population;
- Recruitment proxy or index for an age or size-range chosen to represent the recruiting population;
- Fishing mortality proxy, such as the ratio of reported commercial catches to a measure of the exploited population; and
- Stock trajectory against reference points.

Any other information the Scientific Council deems relevant should also be provided.

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[1] The Scientific Council has noted previously that there is no biological basis for conducting separate assessments for Greenland halibut throughout Subareas 0-3, but has advised that separate TACs be maintained for different areas of the distribution of Greenland halibut.

[2] Canada encourages the Scientific Council to continue to explore opportunities to develop risk-based advice in the future, including the implications of increases in the TAC (e.g. by l 0, 15 or 25%), noting that data conditions do not allow for such advice at this time.

APPENDIX VI. LIST OF SCR AND SCS DOCUMENTS

SCR Documents			
Doc No.	**Serial No**	**Author(s)**	**Title**
SCR Doc. 18-001	N6778	F. Gonzalez-Costas, D. Gonzalez-Troncoso, A. Ávila de Melo and R. Alpoim	3M cod assessment input data
SCR Doc. 18-002	N6779	Marga Andrés, Dorleta Garcia, Agurtzane Urtizberea	Model-free HCR: literature review for NAFO Cod 3M
SCR Doc. 18-003	N6780	F. Gonzalez-Costas and D. Gonzalez-Troncoso	Cod 3M Natural Mortality
SCR Doc. 18-004	N6781	Thomas Brunel	Exploratory assessment of the cod 3M stock using SAM
SCR Doc. 18-005	N6782	John Mortensen	Report on hydrographic conditions off Southwest Greenland June/July 2017
SCR Doc. 18-006	N6789	Boris Cisewski	Atmospheric conditions over West Greenland in 2017
SCR Doc. 18-007	N6790	D. Bélanger, G. Maillet, P. Pepin, B. Casault, C. Johnson, S. Plourde, P.S. Galbraith, L. Devine, M. Scarratt, M. Blais, E. Head, C. Caverhill, E. Devred, J. Spry, A. Cogswell, L. St-Amand, S. Fraser, G. Doyle, A. Robar, J. Hingdon, J. Holden, C. Porter, E. Colbourne	Biological Oceanographic Conditions in the Northwest Atlantic During 2017
SCR Doc. 18-008	N6792	Diana González Troncoso, José Miguel Casas Sánchez, Rafael Bañón and Mónica Mandado	Results from Bottom Trawl Survey on Flemish Cap of June-July 2017
SCR Doc. 18-009	N6793	E. Colbourne, J. Holden, S. Snook, S. Lewis, F. Cyr, D. Senciall, W. Bailey and J. Higdon	Physical Oceanographic Environment on the Newfoundland and Labrador Shelf in NAFO Subareas 2 and 3 during 2017
SCR Doc. 18-010	N6794	E. Colbourne, A. Perez-Rodriguez, A. Cabrero and G. Gonzalez-Nuevo	Ocean Climate Variability on the Flemish Cap in NAFO Subdivision 3M during 2017
SCR Doc. 18-011	N6795	Diana González-Troncoso, Ana Gago, Lupe Ramilo and Esther Román	Results for Greenland halibut, American plaice and Atlantic cod of the Spanish survey in NAFO Div. 3NO for the period 1997-2017
SCR Doc. 18-012	N6796	Diana González-Troncoso, Ana Gago and Lupe Ramilo	Yellowtail flounder, redfish (*Sebastes* spp.) and witch flounder indices from the Spanish Survey conducted in Divisions 3NO of the NAFO Regulatory Area
SCR Doc. 18-013	N6797	Diana González-Troncoso, Ana Gago and Lupe Ramilo	Biomass and length distribution for roughhead grenadier, thorny skate and white hake from the surveys conducted by Spain in NAFO 3NO
SCR Doc. 18-014	N6798	Paula Fratantoni	Hydrographic Conditions on the Northeast United States Continental Shelf in 2017 – NAFO Subareas 5 and 6
SCR Doc. 18-015	N6799	M. A. Treble	Report on Greenland halibut caught during the 2017 trawl survey in Divisions 0A

SCR Doc. 18-016	N6800	Lisa C. Hendrickson	Greenland shark (*Somniosus microcephalus*) catches off the U.S. East Coast based on data from data from research surveys, fishery observer programs, logbooks and tagging programs conducted by the U.S. National Marine Fisheries Service
SCR Doc. 18-017	N6801	Rideout and Ings	Temporal And Spatial Coverage Of Canadian (Newfoundland And Labrador Region) Spring And Autumn Multi-Species RV Bottom Trawl Surveys, With An Emphasis On Surveys Conducted In 2017
SCR Doc. 18-018	N6802	Román, E., D. González-Troncoso and M. Alvarez	Results for the Atlantic cod, roughhead grenadier, redfish, thorny skate and black dogfish of the Spanish Survey in NAFO Div 3L for the period 2003-2017.
SCR Doc. 18-019	N6803	Román, E., C. González-Iglesias and D. González-Troncoso	Results for the Spanish Survey in the NAFO Regulatory Area of Division 3L for the period 2003-2017
SCR Doc. 18-020	N6804	Lisa C. Hendrickson, Jana Aker, Sebastian Glindtvad and Tom Blasdale	Greenland shark (*Somniosus microcephalus*) catches in fisheries conducted in the Northwest Atlantic Fisheries Organization Regulatory Area
SCR Doc. 18-021	N6805	Adriana Nogueira and O.A. Jorgensen	Results for Greenland halibut survey in NAFO Divisions 1C-1D for the period 1997-2017
SCR Doc. 18-022	N6806	Fernando González-Costas	Assessment of Splendid alfonsino (*Beryx splendens*) in NAFO Subarea 6
SCR Doc. 18-023	N6807	Frank Rigét and Rasmus Nygaard	An analyses of logbooks of Greenland Halibut Stock Component in NAFO Division 1A Inshore.
SCR Doc. 18-024	N6808	A. Pérez-Rodríguez, D. González-Troncoso	Update of the Flemish Cap multispecies model GadCap as part of the EU SC05 project: "Multispecies Fisheries Assessment for NAFO
SCR Doc. 18-025	N6809	A. Pérez-Rodríguez F. González-Costas	Estimates of natural predation and residual mortality for the Flemish Cap cod
SCR Doc. 18-026	N6810	Simpson et al.	Distribution and Analysis of Canadian Greenland Shark (Somniosus microcephalus) bycatch in the NAFO Regulatory Area
SCR Doc. 18-027	N6811	Simpson et al.	Assessment of Thorny Skate (*Amblyraja radiata* Donovan, 1808) in NAFO Divisions 3LNO and Sub. 3Ps
SCR Doc. 18-028	N6812	R.M. Rideout et al.	An Assessment of the Cod Stock in NAFO Divisions 3NO
SCR Doc. 18-029	N6815	Diana González-Troncoso, Carmen Fernández and Fernando González-Costas	Bayesian XSA model for the 3M cod
SCR Doc. 18-030	N6816	Diana González-Troncoso, Carmen Fernández and Fernando González-Costas	Bayesian SCAA model for the 3M cod
SCR Doc. 18-031	N6817	Sampedro, P; Garabana, D; Saborido-Rey, F	Validation of Cod maturity ogive in NAFO 3M. Effect of the reproductive cycle moment on ogive estimation
SCR Doc. 18-032	N6820	Rasmus Nygaard and Adriana Nogueira	Biomass and Abundance of Demersal Fish Stocks off West and East Greenland estimated from the Greenland Institute of Natural resources (GINR) Shrimp and Fish Survey (SFW), 1990-2017.
SCR Doc. 18-033	N6822	A. M. Ávila de Melo , R. Alpoim , D. González Troncoso , F. González and M. Pochtar	The status of redfish (*S. mentella* and *S. fasciatus*) in Divisions 3LN at present and the likelihood its follow up in the near future (under the ongoing the Management Strategy or a status quo TAC scenario)
SCR Doc. 18-034	N6823	Mathieu Ouellet	NAFO STACFEN Report 2017
SCR Doc. 18-035REV	N6825	Rasmus Nygaard	Trawl, gillnet and longline survey results from surveys conducted by the Greenland Institute of Natural Resources in NAFO Division 1A Inshore

SCR Doc. 18-036	N6826	D. Maddock Parsons, J. Morgan and R. Rideout	Divisions 3LNO Yellowtail Flounder (*Limanda ferruginea*) in the 2015-2017 Canadian Stratified Bottom Trawl Surveys
SCR Doc. 18-037	N6827	Rasmus Hedeholm, Rasmus Nygaard and Adriana Nogueira	Greenland shark in Greenland waters in NAFO Subarea 1 and ICES XIV.
SCR Doc. 18-038	N6828	Dawn Maddock Parsons, Joanne Morgan and Brian Healey	Assessment of NAFO Div. 3LNO Yellowtail Flounder
SCR Doc. 18-039	N6829	L. Wheeland, K. Dwyer, J. Morgan, R. Rideout, and R. Rogers	Assessment of American Plaice in Div. 3LNO
SCR Doc. 18-040	N6830	M. A. Treble and A Nogueria	Assessment of the Greenland Halibut Stock Component in NAFO Subarea 0 + Division 1A (Offshore) and Divisions 1B-1F
SCR Doc. 18-041	N6831	J.L. Bryk, K.J. Hedges and M.A. Treble	Summary of Greenland Shark (*Somniosus microcephalus*) catch in Greenland Halibut (*Reinhardtius hippoglossoides)* fisheries and scientific surveys conducted in NAFO Subarea 0
SCR Doc. 18-042	N6833	Diana González-Troncoso, Carmen Fernández and Fernando González-Costas	Assessment of the Cod Stock in NAFO Division 3M
SCR Doc. 18-043	N6834	Rasmus Nygaard	An assessment of the Greenland Halibut Stock Component in NAFO Division 1A Inshore.
SCR Doc. 18-044	N6835	L. Wheeland and B. Devine	Bycatch of Greenland Shark (*Somniosus microcephalus*) from inshore exploratory fisheries adjacent to NAFO Division 0
SCR Doc. 18-045	N6836	V. Korzhev and M. Pochtar	Proposals for the exploitation strategy of the Flemish Cap redfish stock
SCR Doc. 18-046	N6838	I.S. Tretyakov	Capelin Stock Assessment in NAFO Divisions 3NO Based on Data from Trawl Surveys
SCR Doc. 18-047	N6842	M.J. Morgan	Greenland halibut (*Reinhardtius hippoglossoides*) in NAFO Subarea 2 and Divisions 3KLMNO: stock trends based on annual Canadian research vessel survey results.
SCR Doc. 18-048	N6843	Dawn Maddock Parsons	Yellowtail exploratory modelling
SCR Doc. 18-049	N6844	D. Hebert and R. G. Pettipas	Physical Oceanographic Conditions on the Scotian Shelf and in the eastern Gulf of Maine (NAFO Divisions 4V,W, X) during 2017
SCR Doc. 18-050	N6845	Laura Wheeland	Limit reference point for Witch Flounder in NAFO Divisions 2J+3KL
SCR Doc. 18-051	N6847	A. Ávila de Melo and R. Alpoim	On 3M cod natural mortality: a proposal for a separable approach over recent years (2005-2017)
SCR Doc. 18-052	N6848	E. Lee, J. Morgan, R. M. Rideout, B. Rogers	An assessment of the witch flounder resource in NAFO Divisions 3NO

SCS Documents

Doc No.	Serial No	Author	Title
SCS Doc. 18-01	N6773		COM Requests to SC
SCS Doc. 18-02	N6776		Denmark (on behalf of Greenland) Requests for Scientific Advice on Management in 2019 of Certain Stocks in Subarea 0 and 1.
SCS Doc. 18-03	N6777		Canada Request for Coastal State Advice - 2019
SCS Doc. 18-04	N6783		Report of the review of input data for 3M Cod benchmark assessment
SCS Doc. 18-05	N6784	K.Hubel	Estonian Research Report for 2017
SCS Doc. 18-06	N6786	Japan	Japan Research Report for June 2017
SCS Doc. 18-07	N6787	F. González-Costas, G. Ramilo, E. Román, J. Lorenzo, A. Gago, D. González-Troncoso and M. Sacau.	Spanish Research Report for 2017
SCS Doc. 18-08	N6788	J. Vargas, R. Alpoim, E. Santos and A. M. Ávila de Melo	Portuguese Research Report for 2017
SCS Doc. 18-09	N6791	Luis Ridao Cruz	Faroese Research Report 2017
SCS Doc. 18-10	N6819	Greenland Institute of Natural Resources	Denmark/Greenland Research Report for 2017
SCS Doc. 18-11	N6819	NAFO	Tagging 2017
SCS Doc. 18-12	N6821	NAFO	List of Biological Sampling Data for 2017
SCS Doc. 18-13	N6824	K. Fomin and M.Pochtar	Russian Research Report for 2017
SCS Doc. 18-14	N6832	M.L. Traver and K.A. Sosebee	United States Research Report for 2017
SCS Doc. 18-15	N6837	Canada	Canadian Research Report
SCS Doc. 18-16	N6839	NAFO	Available Data from the Commercial Fisheries Related to Stock Assessment (2017) and Inventory of Biological Surveys Conducted in the NAFO Area in 2017 and Biological Surveys Planned for 2018 and Early-2019
SCS Doc. 18-17	N6840	NAFO	A Compilation of Research Vessel Surveys on a Stock-by-stock Basis
SCS Doc. 18-18	N6841	NAFO	Cod Benchmark Report, 9-13 April 2018
SCS Doc. 18-19	N6849	NAFO	Report of the Scientific Council June Meeting, 01-14 June 2018

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