Serial No. N6587 NAFO SCS Doc. 16-14 Rev.

Northwest Atlantic Fisheries Organization

Report of the Scientific Council Meeting

03 -16 June 2016
Halifax, Nova Scotia

NAFO
Dartmouth, Nova Scotia, Canada
2016

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REPORT OF SCIENTIFIC COUNCIL MEETING
03 -16 June 2016

Chair: Kathy Sosebee Rapporteur: Tom Blasdale

I. PLENARY SESSIONS

The Scientific Council met at the Sobey Building, Saint Mary's University, Halifax, NS, Canada, during 03 – 16 June 2016, to consider the various matters in its Agenda. Representatives attended from Canada, Denmark (in respect of Faroes and Greenland), the European Union (France, Germany (via WebEx), Portugal, Spain, the United Kingdom and the European Commission), Japan, the Russian Federation and the United States of America. Observers from the Ecology Action Centre and Dalhousie University were also present. The Executive Secretary, Scientific Council Coordinator and other members of the Secretariat were in attendance.

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

The Council was called to order at 1000 hours on 03 June 2016. The provisional agenda was **adopted** with modification. The Scientific Council Coordinator was appointed the rapporteur.

The Council was informed that the meeting was quorate and authorization had been received by the Executive Secretary for proxy votes from EU, Iceland, Norway, Ukraine and USA.

The opening session was adjourned at 1215 hours on 03 June 2016. Several sessions were held throughout the course of the meeting to deal with specific items on the agenda. The Council considered **adopted** the STACFEN report on 6 June 2016, and the STACPUB, STACFIS and STACREC reports on 16 June 2016.

The concluding session was called to order at 0830 hours on 16 June 2016.

The Council considered and **adopted** the report the Scientific Council Report of this meeting of 03 -16 June 2016. 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 16 June 2016.

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 2015

There were no recommendations to Scientific Council in 2015.

III. FISHERIES ENVIRONMENT

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

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

- STACFEN **recommends** *consideration of support for one invited speaker to address emerging issues and concerns for the NAFO Convention Area during the 2017 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 NAFO website continue to provide e-mail links for the Scientific Council Designated Experts for each stock.*

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

V. RESEARCH COORDINATION

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

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

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

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

VI. FISHERIES SCIENCE

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

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

VII. MANAGEMENT ADVICE AND RESPONSES TO SPECIAL REQUESTS

1. Fisheries Commission

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

The Scientific Council noted the Fisheries Commission requests for advice on Northern shrimp (Northern shrimp in Div. 3M and Divs. 3LNO (Item 1)) will be undertaken during the Scientific Council meeting on 7-14 September 2016.

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 Fisheries Commission or by the Scientific Council given recent stock developments.

American Plaice in Divisions 3LNO

Advice June 2016 for 2017-2018

Recommendation for 2017- 2018

SSB remains below B_{lim}, therefore Scientific Council recommends that, in accordance with the rebuilding plan, there should be no directed fishing on American plaice in Div. 3LNO in 2017 and 2018. Bycatches of American plaice should be kept to the lowest possible level and restricted to unavoidable bycatch in fisheries directing for other species.

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

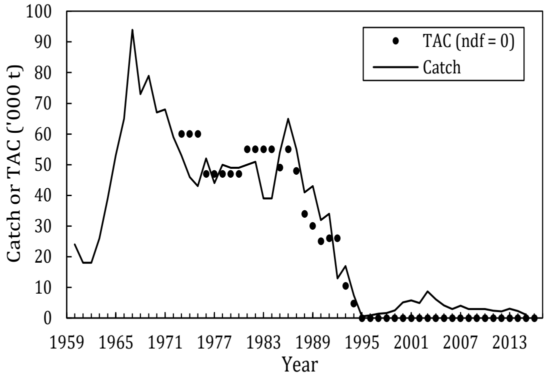
🟢	OK
🟡	Intermediate
🔴	Not accomplished
⚪	Unknown

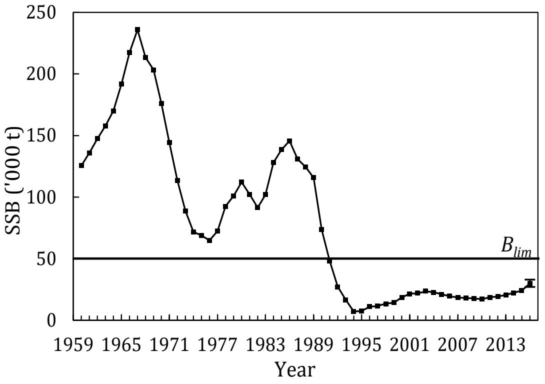
Management unit

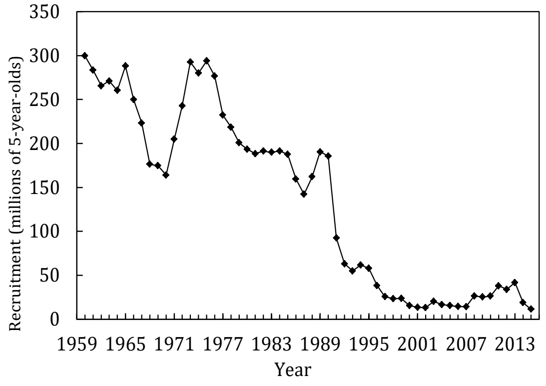
American plaice in Div. 3LNO is considered a separate stock.

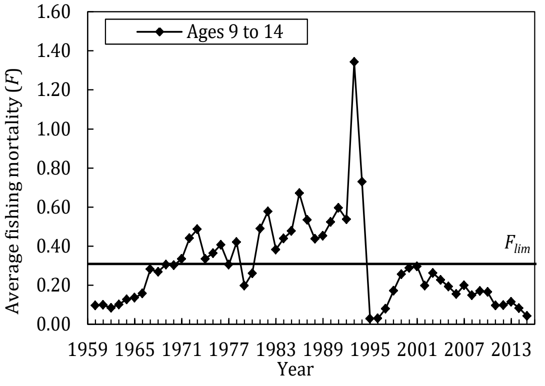
Stock status

The stock remains low compared to historic levels and, although SSB is increasing, it is still estimated to be below B_{lim}. Recruitment has been low since the late 1980s, but has shown an increasing trend from 2007-2013. This has been followed by lower recruitments in 2014 and 2015.









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

	F = 0		
	SSB ('000 t)		
	p10	p50	p90
2016	27	30	33
2017	32	35	39
2018	35	38	43
2019	37	41	46

	$F_{2013\text{-}15}$ = 0.08					
	SSB ('000 t)			Yield ('000 t)		
	p10	p50	p90	p10	p50	p90
2016	27	30	33	2.5	2.7	3.0
2017	29	32	36	2.6	2.8	3.1
2018	30	33	37	2.6	2.9	3.2
2019	30	33	37			

Fishing Mortality	Yield			P(SSB>B_{lim})			P(SSB_{2019}>SSB_{2016})
	2017	2018	2019	2017	2018	2019	
F = 0	-	-	-	<5%	<5%	<5%	>95%
$F_{2013\text{-}2015}$= 0.08	2744	2835	2906	<5%	<5%	<5%	>95%

SSB was projected to have a probability of >0.95 of being less than B_{lim} by the start of 2019 under both fishing mortality scenarios. However under each scenario there is a >0.95 probability that SSB in 2019 will be greater than in 2016.

Assessment

An analytical assessment using the ADAPTive framework tuned to the Canadian spring, Canadian autumn and the EU-Spain Div. 3NO survey was used. A virtual population analysis (VPA) was conducted based on the 2014 assessment formulation, with updated data.

The next full assessment is planned for 2018.

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.

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. To estimate catch for 2011-2014, for Div. 3N, information on effort from NAFO observers and logbook data was used where possible with the assumption that CPUE has not changed substantially from 2010. In 2015, STATLANT 21A data was used for Canadian fisheries and Daily Catch Records (DCR) for fisheries in the NRA.

Recent catch estimates and TACs are:

	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
TAC	ndf	ndf	ndf	ndf	ndf	ndf	ndf	ndf	ndf	ndf
STATLANT 21	1.5	1.9	1.8	1.5	1.2	1.3	2.2	1.4	1.1	
STACFIS	3.6	2.5	3.0	2.9	2.4[1]	2.1[1]	3.0[1]	2.3[1]	1.1[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.

Effects of the fishery on the ecosystem

No specific information is available. General impacts of fishing gears on the ecosystem should be considered. An area of Divs. 3LNO has been closed to protect sponge, seapens and coral.

Sources of information

SCS Doc. 16/5, 6, 8, 9, 10, 15; SCR Doc. 16/10, 12; 30 GC Doc. 08/3

Thorny Skate in Divisions 3LNO and Subdiv. 3Ps

Advice June 2016 for 2017-18

Recommendation for 2017-2018

The stock has shown little improvement at recent catch levels (approximately 4 700 t, 2011 - 2015), therefore Scientific Council advises no increase in catches.

Management objectives

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

Convention objectives	*Status*	*Comment/consideration*
Restore to or maintain at B_{msy}	🟡	B_{msy} unknown, stock at low level
Eliminate overfishing	🟡	F_{msy} unknown, fishing mortality is low
Apply Precautionary Approach	🟡	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 biological biodiversity	⚪	Cannot be evaluated

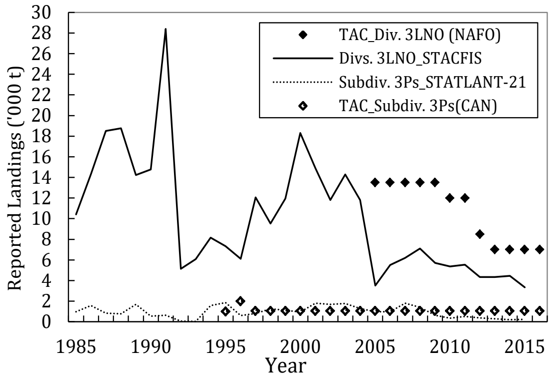
🟢 OK
🟡 Intermediate
🔴 Not accomplished
⚪ Unknown

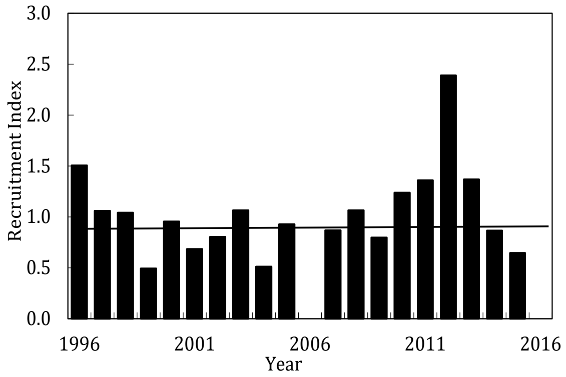
Management unit

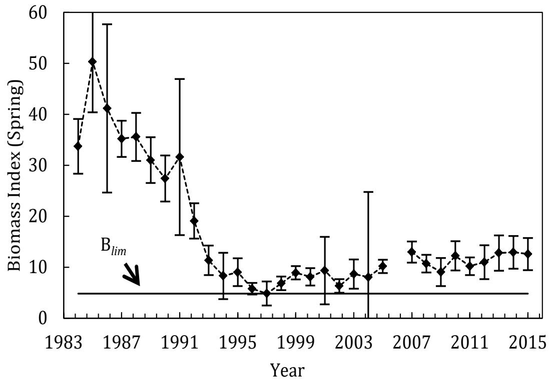
The management unit is confined to NAFO Div. 3LNO, which is a portion of the stock that is distributed in NAFO Div. 3LNO and Subdivision 3Ps.

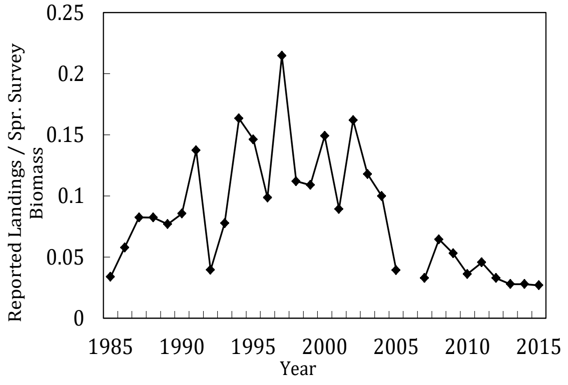
Stock status

The stock is currently above B_{lim}. The probability that the current biomass is above B_{lim} is 0.99. Stock biomass has been increasing very slowly from low levels since the mid-1990s. Recruitment declined below average in 2014-2015. Fishing mortality is currently low.









Reference points

B_{lim} defined from survey indices.

Assessment

Based upon a qualitative evaluation of stock biomass trends and recruitment indices, the assessment is considered data limited and as such associated with a relatively high uncertainty. Input data are research survey indices and fishery data. The next full assessment of this stock will be in 2018.

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.

Fishery

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

Recent catch estimates and TACs are:

	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Div. 3LNO:										
TAC	13.5	13.5	13.5	12	12	8.5	7	7	7	7
STATLANT 21	6.2	7.1	5.7	5.4	5.5	4.3	4.4	4.5	3.3	
STACFIS	3.6	7.4	5.6	3.1	5.4	4.3	4.4	4.5	3.4	

Effects of the fishery on the ecosystem

No specific information is available. General impacts of fishing gears on the ecosystem should be considered. Areas of Divs. 3LNO have been closed to protect sponge, sea pens and corals.

Special comments

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

Sources of Information

SCR Doc. 14/23, 15/40, 16/12, 16, 32; SCS Doc. 16/05, 09, 10.

Advice June 2016 for 2017-2019

Redfish in Division 3O

Recommendation 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

Management objectives

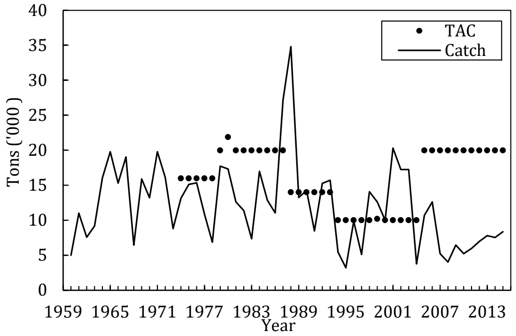
No explicit management plan or management objectives defined by Fisheries Commission. General convention objectives (GC Doc. 08/3) are applied. Advice is based on survey indices and catch trends. (the observation of a period of stable catches since the 1960s)

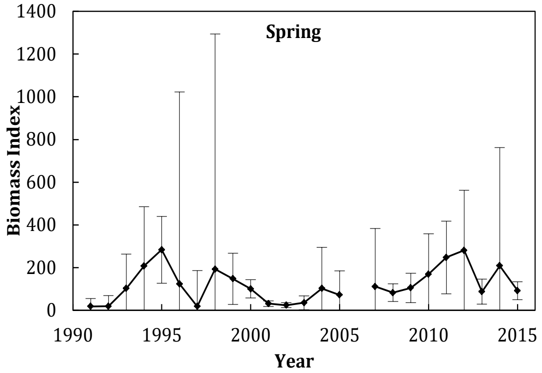
Convention objectives	Status	Comment/consideration
Restore to or maintain at B_{msy}	○	B_{msy} unknown, stock decreasing
Eliminate overfishing	🟢	Fishing mortality low
Apply Precautionary Approach	○	Reference points not defined
Minimise harmful impacts on living marine resources and ecosystems	🟢	VME closures in effect, low bycatch reported
Preserve marine biodiversity	○	Cannot be evaluated

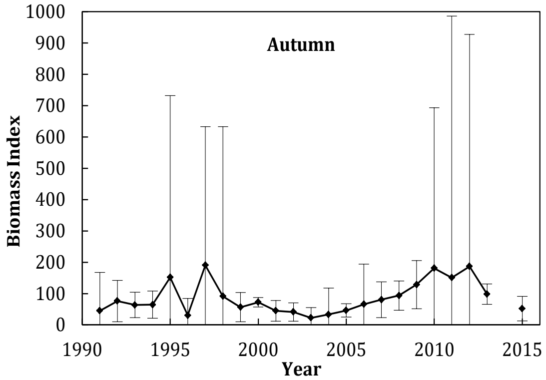
🟢	OK
🟡	Intermediate
🔴	Not accomplished
○	Unknown

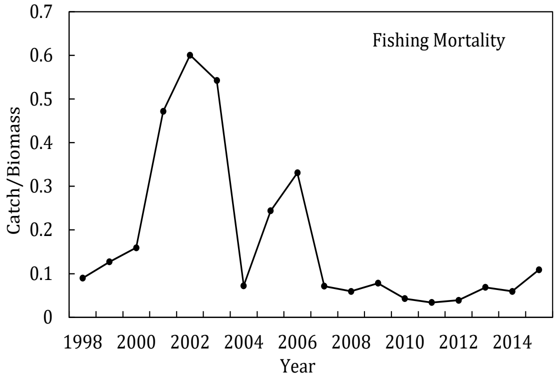
Management unit

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









Stock status

The stock appears to have decreased from near time series highs in 2012. Current fishing mortality appears low and recent recruitment appears to be low.

Reference points

Not defined.

Projections

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

Assessment

Based upon a qualitative evaluation of trends in stock biomass, fishing mortality proxy and recruitment. The assessment is considered data limited and as such associated with a relatively high uncertainty. Input data are research survey indices and fishery data (STACFIS 2016).

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

Human impact

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

Biological and environmental interactions

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

Fishery

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

Recent catch estimates and TACs are:

	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
TAC	20	20	20	20	20	20	20	20	20	20
STATLANT 21	7.5	5.1	6.3	6.5	6.0	7.0	7.8	7.5	7.9	
STACFIS	5.2	4.0	6.4	5.2	6.0	7.0	7.8	7.5	8.4	

Effects of the fishery on the ecosystem

No specific information is available. General impacts of fishing gears on the ecosystem should be considered. A large area of Div. 3O has been closed to protect corals.

Special comments

Length frequencies suggest that the 3O redfish fishery takes predominantly immature fish.

Sources of information

SCR Doc. 16/11, SCS Doc. 16/05, 08, 09, 10.

Advice June 2016 for 2017-2019

Witch flounder in Divisions 2J + 3KL

Recommendation 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.

Management objectives

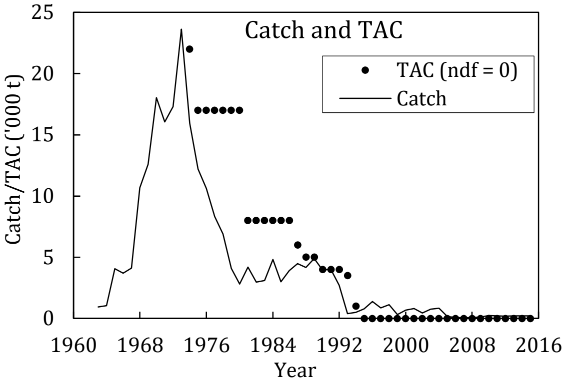
No explicit management plan or management objectives defined by Fisheries Commission. General convention objectives (GC Doc. 08/3) are applied. Advice is based on survey indices, catch trends and estimates of recruitment.

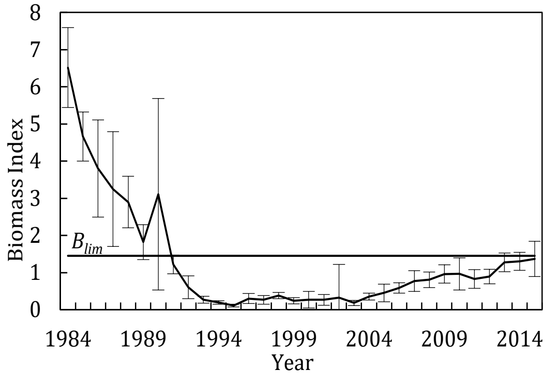
Convention objectives	Status	Comment/consideration
Restore to or maintain at B_{msy}	🔴	Stock below B_{lim}
Eliminate overfishing	🟢	No directed fishing
Apply Precautionary Approach	🟢	B_{lim} established. No directed fishing
Minimise harmful impacts on living marine resources and ecosystems	🟢	No directed fishing
Preserve marine biodiversity	🟢	No directed fishing

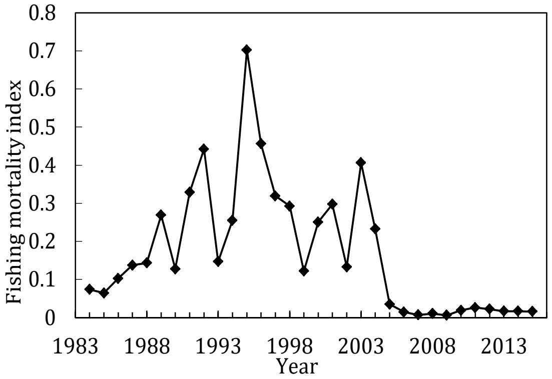
🟢 OK
🟡 Intermediate
🔴 Not accomplished
⚪ Unknown

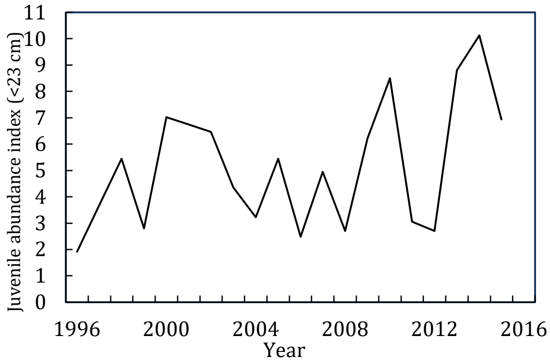
Management unit

The stock is widely distributed throughout the shelf area of Div. 2J3KL in deeper channels around the fishing banks, primarily in Div. 3K.









Stock status

The stock remains below B_{lim}. (The probability of biomass being below B_{lim} = 0.66) Recruitment during 2013 to 2015 was above average and fishing mortality is currently low.

Reference points

B_{lim} is 15% of the highest observed survey biomass, adjusted to the entire stock distribution (B_{1984}*1.48) (STACFIS 2010 p 193).

Projections

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

Assessment

Qualitative evaluation of trends in survey biomass indices relative to exploitation and recruitment information were used to assess the status of the stock. Next assessment is planned for 2019.

Human impact

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

Biological and environmental interactions

In the late 1970s and early 1980s witch flounder were widely distributed throughout the Div. 2J3KL shelf area in deeper channels around the fishing banks, and were more abundant in Div. 3K. By the mid-1980s they were rapidly disappearing and by the early 1990s had virtually disappeared from the area entirely except for some very small catches along the slope and more to the southern area. They now appear to be located along the deep continental slope area, both inside and outside the Canadian 200-mile fishery zone and in some deeper channels offshore.

Fishery

A moratorium was implemented in 1995 following drastic declines in catch from the mid-70s, and catches since then have been low levels of bycatch in other fisheries (e.g. Greenland halibut and redfish fisheries).

Recent catch estimates and TACs are:

	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
TAC	ndf	ndf	ndf	ndf	ndf	ndf	ndf	ndf	ndf	ndf
STATLANT 21	0.1	0.1	0.1	0.2	0.2	0.2	0.2	0.2	0.2	
STACFIS	0.1	0.1	0.1	0.2	0.2	0.2	0.2	0.2	0.2	

ndf = no directed fishery

Effects of the fishery on the ecosystem

No specific information is available. General impacts of fishing gears on the ecosystem should be considered. An area of Divs. 3L has been closed to protect sponge communities.

Special comments

Given the recent dynamics in the stock and the reliance on survey indices to evaluate stock status, Scientific Council recommends that a full assessment should not be conducted only because index values exceed B_{lim} during one or two subsequent years.

Sources of information

SCR Doc. 16/15, 16/20; SCS Doc. 16/5, 16/8, 16/9, 16/10

Advice June 2016 for 2017-2019

Northern short-finned squid in SA 3+4

Recommendation for 2017 - 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 tons/yr.

Management objectives

No explicit management objectives have been defined by Fisheries Commission. General Convention objectives (NAFO/GC Doc 08/3) are applied.

Convention objectives	Status	Comment/consideration
Restore to or maintain at B_{msy}	⚪	B_{msy} inappropriate given life history
Eliminate overfishing	⚪	Not quantifiable
Apply Precautionary Approach	🟡	Reference points based on productivity level
Minimize harmful impacts on living marine resources and ecosystems	🟢	VME closures in effect, no bycatch in SA 3 jig fishery, no SA 4 directed trawl fishery since 1999
Preserve marine biological biodiversity	⚪	Cannot be evaluated

🟢 OK

🟡 Intermediate

🔴 Not accomplished

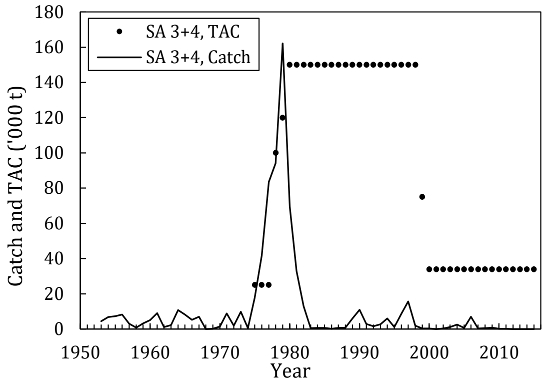
⚪ Unknown

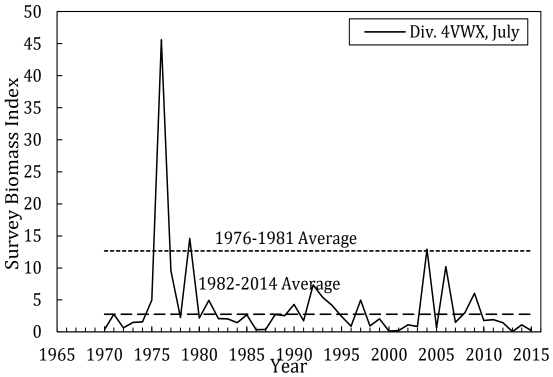
Management unit

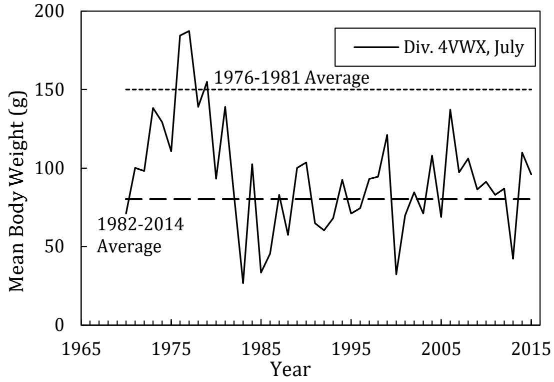
The species is assumed to constitute a single stock throughout its range in the Northwest Atlantic Ocean, from Newfoundland to Florida, including Subareas 2-6, but is managed as northern (Subareas 3+4) and southern stock components (Subareas 5+6) by NAFO and the USA, respectively. However, fishery removals in relation to the biomass levels of each stock component affect one another.

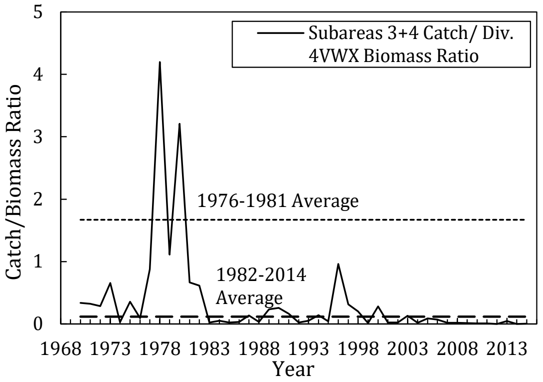
Stock status

During 2015, the northern stock component remained in a state of low productivity and the fishing mortality index was at the lowest level in the time series.









Reference points

Conventional reference points are inappropriate for squid stocks because of their unique life history. Two reference states, “high productivity” or “low productivity” states are defined by trends in stock biomass and mean body weight. Low productivity periods have an estimated potential annual yield of 19 000 tons to 34 000 tons. The potential yields of a high productivity state have not been determined**.**

Projections

Projections were not possible because, like most squid stocks, recruitment is highly variable and cannot currently be predicted.

Assessment

Assessment data were from the Division 4VWX July bottom trawl surveys and the catches in Subareas 3+4 (STACFIS Report 2016). The next assessment will occur in 2019. The assessment consisted of a comparison of average survey biomass indices and mean body weights, during high (1976 – 1981) and low (1982 – 2014) productivity periods, with the values of these indices during. Fishing mortality indices (catch/Div. 4VWX biomass index) were used to assess exploitation. Uncertainty in the assessment is high because of the species’ sub-annual lifespan and the fact that recruitment, occurrence of the species in the survey area, and growth rates are highly variable and greatly influenced by oceanographic conditions.

Human impacts

Fishery related mortality in SA 3+4 has been very low since 2006. Other sources (e.g. pollution, shipping, oil-industry) are undocumented.

Biology and Environmental Interactions

Recruitment for this species is highly variable, and the species is semelparous (spawns once during its lifetime then dies). A sufficient numbers of spawners must survive the fishery (spawner escapement) each year in order to ensure a high probability of successful recruitment during the subsequent year, to reduce the risk of stock collapse. Although environmental factors play a role in the recruitment process, such factors cannot be controlled or predicted. Ideally, fishing intensity should be such that spawner escapement is set at some target level which is above a minimum spawning stock biomass (SSBmin) threshold. Without the ability to estimate stock size in real-time during the fishing season, as well as before and after the fishing season, the TAC should be set at a conservative level in order to avoid recruitment overfishing.

Ocean climate effects have a strong influence on the distribution, growth rates, and recruitment of Northern shortfin squid. For example, variation in the latitudinal position of the Shelf Slope Front is related to efficiency of downstream dispersal by the Gulf Stream and increased survival of young stages.

This species is both an important prey and predator in the ecosystem. The natural mortality of this prey species, which is consumed by a wide range of cetacean, pinniped, avian, invertebrate, and finfish predators, is very high. Small Northern shortfin squid prey primarily upon crustaceans and larger squid prey primarily upon finfish, and during the fall, on smaller shortfin squid.

Fisheries

Prior to the mid-1980s, international bottom trawl and midwater trawl fleets participated in directed fisheries in Subareas 3, 4 and 5+6. Since 1999, there has been no directed fishery in Subarea 4, but some squid is taken as bycatch in the Canadian small-mesh bottom trawl fishery for silver hake. Directed fisheries currently consist of a Canadian inshore jig fishery in Subarea 3 and a small-mesh bottom trawl fishery in Subareas 5+6. There is no bycatch in the jig fishery. Fisheries that occur in Subareas 3+4 and Subareas 5+6 are regulated by two separate quotas (TACs).

Recent catch estimates and TACs are as follows:

	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
TAC SA 3+4	34	34	34	34	34	34	34	34	34	34
STATLANT21 SA 3+4	0.2	0.5	0.7	0.1	0.2	<0.1	0.1[1]	nd[2]	0.1	
STACFIS SA 3+4	0.2[3]	0.5	0.7	0.1[3]	0.1[3]	<0.1[3]	<0.1[3]	<0.1[3]	<0.1[3]	

[1] CA-Maritimes Region did not submit data during 2013-2015.

[2] No data submitted by CA-Maritimes or Scotia-Fundy Regions, but CA-Newfoundland catch was zero.

[3] Includes amounts, ranging from 0.001-18 t, reported as Unspecified Squid from Subarea 4.

Effects of the fishery on the ecosystem

The effects of the directed fisheries on the ecosystem are unknown, but are generally limited to June through November (depending on fishery Subarea) as a result of the species' migration patterns on and off the continental shelves. There has not been a directed fishery in Subarea 4 since 1999 and catches from the inshore jig fishery in Subarea 3, which is highly dependent on inshore squid availability, has been low since 2007.

Special comments

The assessment of this stock component may not reflect stock conditions during the three years for which management advice is given because the species has a sub-annual lifespan and the most recent year of data used in the assessment is always for two years prior.

Sources of information

SCR Doc. 98/59,75; 99/66; 06/45; 16/34

Roughhead grenadier in Subareas 2+3

Advice June 2016 for 2017-2019

Recommendation for 2017

Scientific council assesses this stock under its own initiative.

Management objectives

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

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

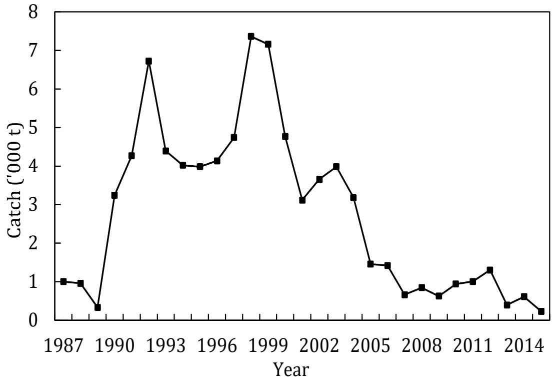
🟢	OK
🟠	Intermediate
🔴	Not accomplished
⚪	Unknown

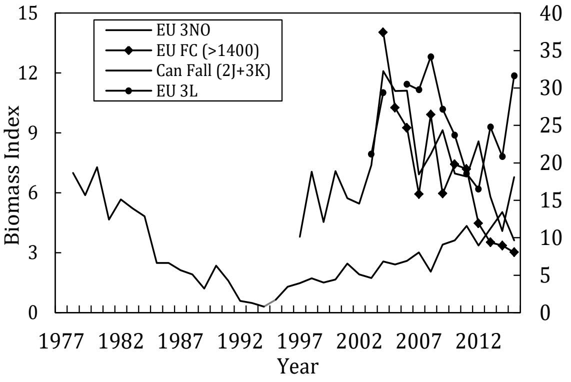
Management unit

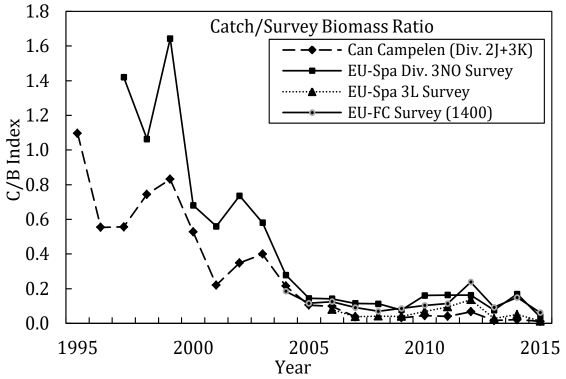
The stock structure of this species in the North Atlantic remains unclear. Roughhead grenadier is distributed throughout NAFO Subareas 0 to 3 in depths between 300 and 2000 m. However, for assessment purposes, NAFO Scientific Council considers the population of Subareas 2 and 3 as a single stock.

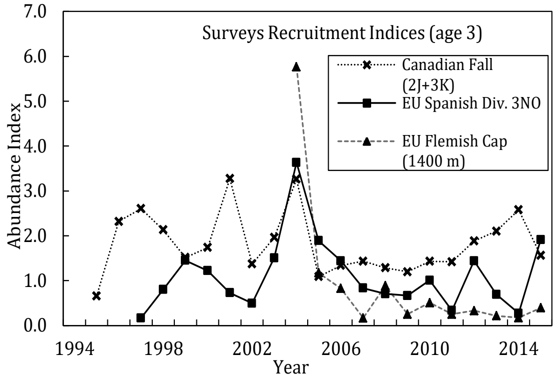
Stock status

Survey indices indicate a stable or declining stock in recent years. Fishing mortality indices have remained at low levels since 2005. Good recruitment is indicated in 2012 but indices of recruitments have high uncertainty.









Projections

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

Reference points

Not defined.

Assessment

Analytical assessments have not been accepted for this stock. Biomass indices from the surveys with depth coverage to 1400 meters are considered as the best survey information to monitor trends in resource status because they cover the depth distribution of roughhead grenadier fairly well.

Human impact

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

Environmental impact

A composite climate index for the Newfoundland and Labrador region decreased to the 7th lowest in 66 years, the lowest since 1993. The spatial extent of the Cold Intermediate Layer (CIL) (<3°C) covered the Flemish Cap survey area during the summer of 2015 for the first time since 1995 and average thickness of the CIL was the highest since 1993 at about 70 m thicker than normal. During the summer of 2015 the Flemish Cap CIL minimum observed core temperature was the coldest in the observational record at 2°C below normal. The average CIL temperature was also at a record low of 1°C below normal. It is unknown how these colder than usual conditions will influence the stock.

Fishery

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

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

	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
STATLANT 21	0.6	0.5	0.4	0.7	0.8	1	1.3	0.4	0.6	0.2
STACFIS	1.4	0.7	0.8	0.6	0.9	1	1.3	0.4	0.6	0.2

Effects of the fishery on the ecosystem

No specific information is available. General impacts of fishing gears on the ecosystem should be considered. A large area of Divs. 3LM has been closed to protect sponge, seapens and coral.

Special comments

This stock will be monitored in future by interim monitoring reports until such time conditions change to warrant a full assessment.

Sources of Information

SCR Doc. 16/12, 16, 22, 24, 26 and 28; SCS Doc. 16/05, 06, 08, 09 and 10.

b) Monitoring of Stocks for which Multi-year Advice was Provided in 2014 or 2015

The assessments (interim monitoring) found nothing to indicate a significant change in the status of the seven stocks for which multi-year advice was provided in 2015.

Accordingly, Scientific Council reiterates its previous advice as follows:

Recommendation for cod in Div. 3M in 2016 and 2017: Scientific Council considers that yields at $F_{2012-14}$ are not sustainable over the longer term. In $F_{2012-14}$ projections there is a very high probability (>97%) of F exceeding F_{lim}.

Yields at F_{lim} correspond to catches of 12 425 t in 2016 and 15 436 t in 2017. In keeping with the precautionary approach, Scientific Council recommends that the TAC be less than the catch corresponding to F_{lim}

Under both F_{lim} and $F_{2012-14}$ -based scenarios there is a very low probability (<1%) of SSB being below B_{lim}.

Recommendation for redfish in Div. 3M in 2016 and 2017: Recent decline in proportion of *S. mentella* and *S. fasciatus* allows a marginal increase in TAC in 2016-17 to 7000t, without changing the exploitation rate on these species and having the stock remain at a relatively high level.

Recommendation for American plaice in Div. 3M in 2015 - 2017: There should be no directed fishery on American plaice in Div. 3M in 2015, 2016 and 2017. Bycatch should be kept at the lowest possible level.

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

Recommendation for witch flounder in Divs. 3NO in 2016 and 2017: Scientific Council noted that this is a newly reopened fishery. Acceptable risk levels have not yet been specified, but to allow the stock to continue to increase towards B_{msy}, exploitation in 2016 and 2017 should not exceed ⅔ F_{msy}, corresponding to catches of 2172 t and 2225 t respectively. Catches at this level will have a 3% risk of exceeding F_{lim} and <1% risk of driving the stock below B_{lim}.

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

Recommendation for white hake in Divs. 3NO in 2016 - 2017: Given the absence of strong recruitment, catches of white hake in Divs. 3NO should not exceed their current levels of 100-300 t.

c) Special Requests for Management Advice

i) TAC Calculation for Greenland halibut in SA2 + Divs. 3KLMNO

The Fisheries Commission adopted in 2010 an MSE approach for Greenland halibut stock in Subarea 2 + Divisions 3KLMNO (FC WP 10/7). This approach considers a survey based harvest control rule (HCR) to set a TAC for this stock on an annual basis for an initial four year period. In 2013 Fisheries Commission extended this management approach to set the TACs for 2015 – 2017. The Fisheries Commission *requests the Scientific Council to:*

- *Monitor and update the survey slope and to compute the TAC according to HCR adopted by Fisheries Commission according to Annex 1 of FC Doc. 10/7.*

Scientific Council responded:

The TAC for 2017 derived from the HCR is 14 059 t.

As per the HCR adopted by the Fisheries Commission, survey slopes were computed using the most recent five years of survey data (2011-2015) and are illustrated below. The data series included in the HCR computation are the Canadian Fall Divs. 2J3K index, the Canadian Spring Divs. 3LNO index and the EU Flemish Cap index covering depths from 0-1400m. Averaging the individual survey slopes yields *slope*= - 0.0323. Therefore, the computed TAC is: 14 799*[1+2*(-0.0323)] = 13 842t. However, as this change exceeds 5%, the HCR constraint is activated and TAC2017 = 0.95*14799 = 14 059t

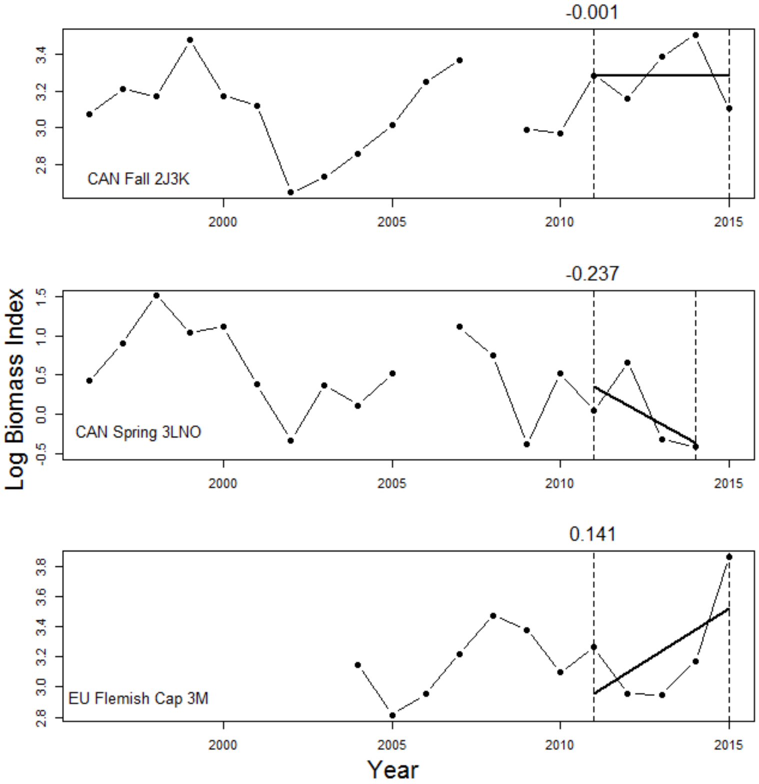


Fig. 1. Input for Greenland halibut in Subarea 2 + Divisions 3KLMNO Harvest Control Rule. Slopes are estimated from linear regression of log-scale biomass indices (mean weight per tow) over 2011-2015. Survey data come from Canadian fall surveys in Divs. 2J3K, Canadian spring surveys in Divs. 3LNO (2015 survey incomplete and not used in the calculation of the HCR) and EU Flemish Cap survey (to 1400m depth) in Div 3M.

ii) Greenland halibut exceptional circumstances

a) Advise on whether or not an exceptional circumstance is occurring.

According to the indicator based on surveys, exceptional circumstances are presently occurring, however, having a survey observation above the simulated distributions does not constitute a conservation concern.

The "primary indicators" used to determine if exceptional circumstances are occurring are catch and surveys. The observed values are compared to the simulated distributions from both SCAA-based operating models and XSA-based operating models. If the observed values are outside of the 90% confidence interval (i.e. outside 5th-95th percentiles) from the simulations presented to WGMSE during September 2010, then SC shall advise FC that exceptional circumstances are occurring.

STACFIS catch estimates for 2011, 2012, 2013, 2014 and 2015 are not available. Therefore, SC cannot compare observed catches to the simulated distributions, and is unable to determine if exceptional circumstances are occurring in respect to this indicator. SC notes the management strategy for Greenland halibut assumed that the simulated catches would exactly equal the TACs generated from the HCR. The 90% confidence intervals for the simulated 2015 catches range from 14661 to 19467 t in the XSA based OMs and in SCAA based OMs, from 13995 to 16929 t. The STATLANT catch for 2015 was 14988 t, against a TAC of 15578 t.

For the three surveys that comprise the input data to the HCR, the 2015 observed values were compared with composite distributions of simulated surveys for both SCAA-based and XSA-based operating models. The Canadian spring 3LNO survey in 2015 had insufficient coverage to be considered representative of the Greenland halibut population and the 2015 value was not used in the calculation of the HCR. Out of the four comparisons possible in 2015 (two surveys; two sets of operating models), there was one case (EU Flemish Cap survey for the XSA operating models) for which the observed survey index was above the 95th percentile. This does not constitute a conservation concern.

When exceptional circumstances are occurring there are five secondary indicators which should be considered:

1 Data Gaps. There is a data gap in the survey series used in the HCR. The Canadian spring 3LNO survey in 2015 had insufficient coverage to be considered representative of the Greenland halibut population and the 2015 value was not used in the calculation of the HCR.

2 Biological Parameters: No new information is available.

3,4&5. Recruitment, Fishing Mortality & Exploitable Biomass: Unable to update in relation to the 90% confidence intervals of the MSE as catches from 2011 – 2015 could not be estimated.

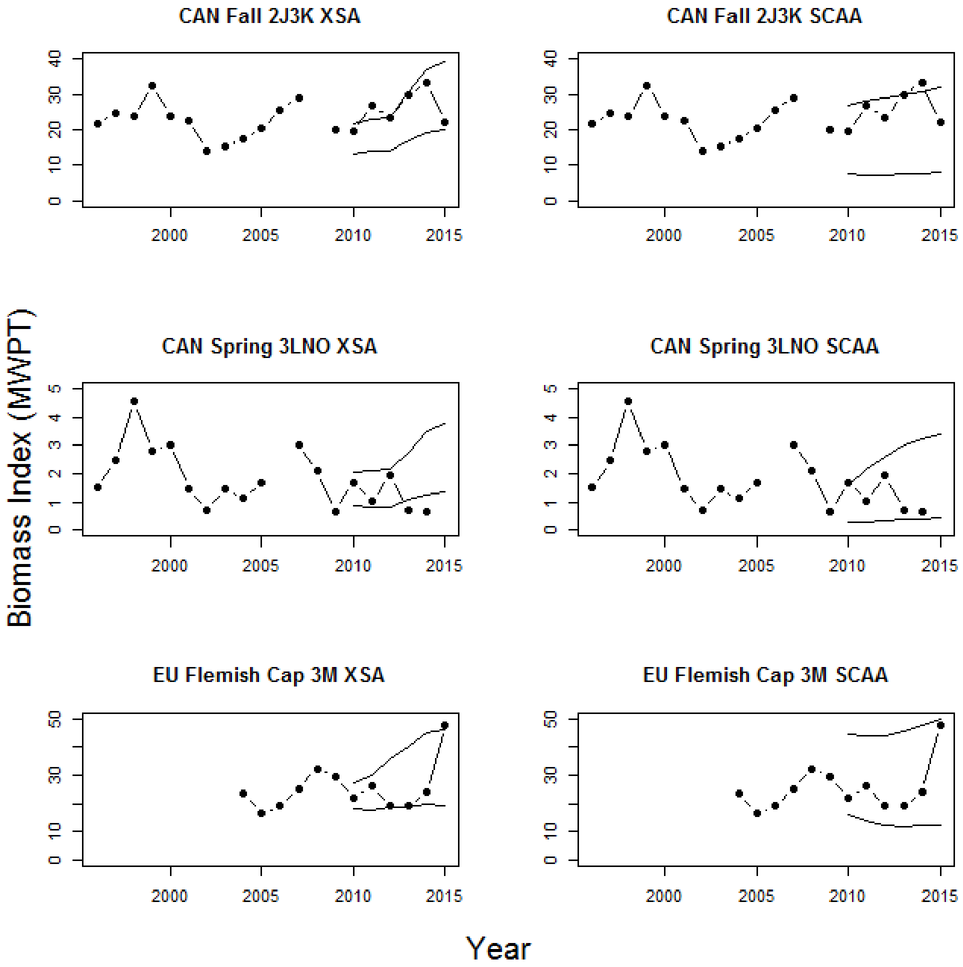


Fig 2. Observed surveys (lines with dots) and upper and lower 90% confidence intervals of surveys simulated (solid lines) in the MSE for Greenland Halibut in Subarea 2 + Divisions 3KLMNO. The panels on the left give the simulated surveys from the XSA operating models and on the right from the SCAA operating models

iii) Assessment of redfish in Divs. 3LN

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 biannual catch increase, with the same amount of increase every two years.

The Fisheries Commission request Scientific Council to conduct a full assessment in 2016 to evaluate the effect of removals in 2014 and 2015 on stock status.

Scientific Council responded:

SC conducted the 2016 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 2016, the stock was at or above B_{msy} and fishing mortality was well below F_{msy} during 2015. The probability of biomass being below B_{lim} or 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 2016-2018 MS catches. There is > 80% probability that TACs agreed within the adopted management strategy for 2016 to 2018 will maintain biomass at the beginning of 2019 above B_{msy}, while the probability of keeping fishing mortality until the end of 2018 below F_{msy} is > 99%. There is also >80% probability that biomass will grow from the beginning of 2016 to the beginning of 2019.*

iv) Risk assessments for SAI on VME elements and species

Fisheries Commission requests the Scientific Council to continue to develop work on Significant Adverse Impacts in support of the reassessment of NAFO bottom fishing activities required in 2016, specifically an assessment of the risk associated with bottom fishing activities on known and predicted VME species and elements in the NRA.

The Scientific Council responded:

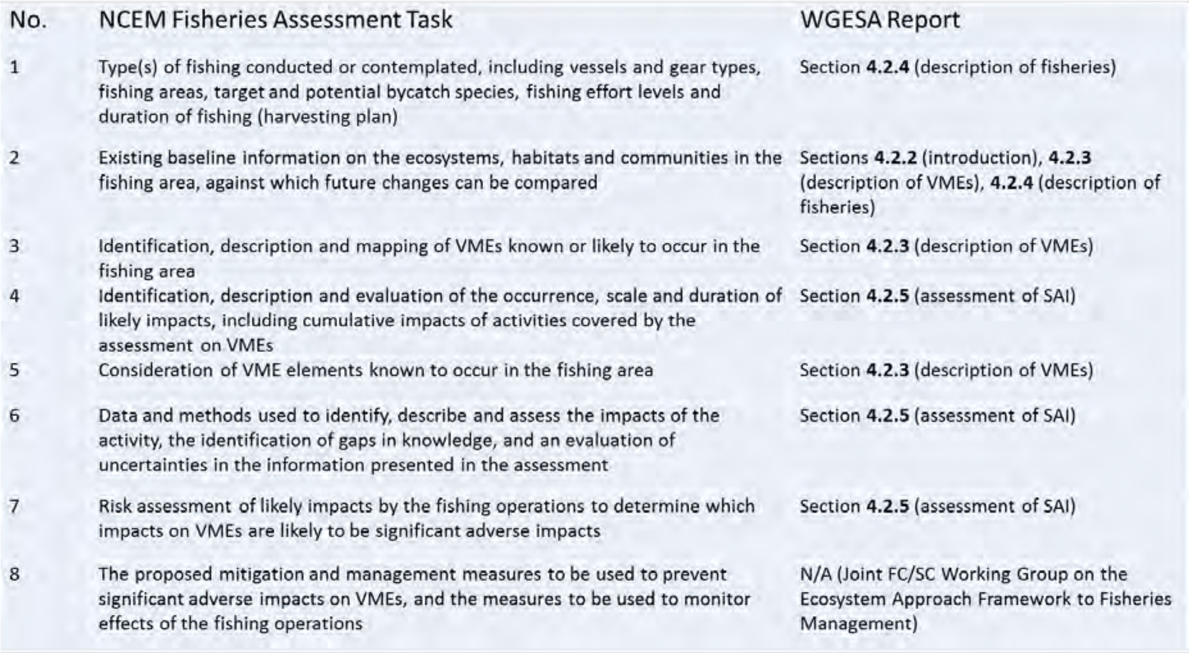
SC completed the assessment of the risk of Significant Adverse Impacts (SAIs) from bottom fishing activities on VMEs in the NRA. The results indicated that both large gorgonians and sponges VME have a low overall risk of SAI, while sea pen VMEs were assessed as having a high overall risk of SAI.

	Sponge		**Sea pen**		**Large gorgonian**	
SAI criteria	**Area**	**Biomass**	**Area**	**Biomass**	**Area**	**Biomass**
Low risk	Low	Low	High	Mod	Mod	Low
High risk	Low	Low	High	High	Low	Low
Impacted	Mod	Mod	High	High	High	Mod
VMEs overlapping	Mod		High		Low	
Index of Sensitivity	High		Mod		High	
Fragmentation	Low		High		Low	
Fishing area stability	Low		High		Low	
Overall risk of SAI	**Low**		**High**		**Low**	

The programme of work to deliver the reassessment of bottom fishing activities by 2016 was completed at the November meeting of WGESA in 2015. The assessment follows a number of suggested improvements to the method recommended by Scientific Council (June 2015) and FC-SC WGEAFFM (July 2015), specifically a) to take account of the **protection afforded to VME areas outside the NAFO fisheries footprint** in the calculation of the VME **area and biomass** at risk of bottom fishing impact; and b) to **refine VME kernel density analysis** polygon boundaries, taking into account current understanding of distribution patterns in relation to environmental variables.

The requirement for the assessment of bottom fishing activities in the NAFO regulatory area (NRA) was broadly defined in the NAFO Conservation and Enforcement Measures (NCEM; NAFO/FC Doc 13/1), which sets out a number of tasks for the assessment (see table below). These have been addressed with the exception of task 8, in the full assessment report (see Annex VIII).

NCEM bottom fisheries assessment issues and relevant sections of the present report in which they are addressed.



No.	NCEM Fisheries Assessment Task	WGESA Report
1	Type(s) of fishing conducted or contemplated, including vessels and gear types, fishing areas, target and potential bycatch species, fishing effort levels and duration of fishing (harvesting plan)	Section **4.2.4** (description of fisheries)
2	Existing baseline information on the ecosystems, habitats and communities in the fishing area, against which future changes can be compared	Sections **4.2.2** (introduction), **4.2.3** (description of VMEs), **4.2.4** (description of fisheries)
3	Identification, description and mapping of VMEs known or likely to occur in the fishing area	Section **4.2.3** (description of VMEs)
4	Identification, description and evaluation of the occurrence, scale and duration of likely impacts, including cumulative impacts of activities covered by the assessment on VMEs	Section **4.2.5** (assessment of SAI)
5	Consideration of VME elements known to occur in the fishing area	Section **4.2.3** (description of VMEs)
6	Data and methods used to identify, describe and assess the impacts of the activity, the identification of gaps in knowledge, and an evaluation of uncertainties in the information presented in the assessment	Section **4.2.5** (assessment of SAI)
7	Risk assessment of likely impacts by the fishing operations to determine which impacts on VMEs are likely to be significant adverse impacts	Section **4.2.5** (assessment of SAI)
8	The proposed mitigation and management measures to be used to prevent significant adverse impacts on VMEs, and the measures to be used to monitor effects of the fishing operations	N/A (Joint FC/SC Working Group on the Ecosystem Approach Framework to Fisheries Management)

VME polygon boundaries for sponge and large gorgonian were revised using a combination of SDM models parameterised with environmental data (Annex VIII, Section 4.2.3). This resulted in a 12% reduction in VME area for sponge and an 8% reduction in area for large gorgonian VME (Annex VIII, Figure 4.2.3.2.2). The sea pen VME extent remained the same as the KDE polygon extent on account of both sea pen SDM models overlapping in full with the sea pen KDE polygon.

SC highlights the usefulness of the fisheries template (Annex VIII; Section 4.2.4) which provides summary data on gear type, target species, fishing depths, vessel capacity and main non-target commercial by-catch species. In addition, fishery specific spatial effort maps covering a period of 4 years (2012 – 2015) are provided which will help to support the assessment of SAI in relation to functional considerations between VME habitat and commercial fisheries.

With respect to assessing SAI, a methodological framework to assess the interaction between fishing effort and VME biomass was developed, building upon and improving the analysis performed and reported on last year. Definitions of the assessed risk/impact categories were made, e.g. (i) VME at **low risk of impact** which correspond to the fishery closures (both inside and outside the fishing footprint) and all other potential VME areas outside the footprint; (ii) VME at **'high risk' of impact** (and therefore subject to potential SAI) which correspond to VME inside the fishing footprint (not closed to bottom fishing) not fished since 2008, and (iii) VME **impacted** which corresponds to VME areas inside the fishing footprint (not closed to bottom fishing) subject to high fishing effort for many years. These three risk/impact categories have been mapped for each VME by defining the levels of fishing effort which correspond to a significant impact on the biomass of each VME (Annex VIII, Figure 4.2.5.3.6). The risk/impact maps for each VME are shown below.

A set of five impact criteria relevant for assessing SAI were subsequently agreed and defined for application in the current assessment, these are; **i.** the proportion of area or biomass of VME assessed to be at low risk, high risk and impacted, **ii.** the number and area of overlapping VMEs, **iii.** the relative sensitivity of the VME, **iv.** fishing area stability, and **v.** the level of VME fragmentation. Each of these criteria, are defined in Annex VIII Table 4.2.5.3.3. The results are shown in the table below.

Quantitative evaluation of SAI criteria used in the present assessment of SAI for sponge, sea pen and large gorgonian VME in the NRA.

	Sponge		Sea pen		Large gorgonian	
SAI criteria	Area	Biomass	Area	Biomass	Area	Biomass
VME Low risk	65%	73%	16%	19%	56%	63%
VME High risk	14%	10%	46%	39%	12%	14%
VME Impacted	21%	17%	38%	42%	31%	23%
VMEs overlapping	11%		2%		74%	
Index of Sensitivity	0.3		0.5		0.1	
Fragmentation	1%		26%		2%	
Fishing area stability	32%		14%		21%	

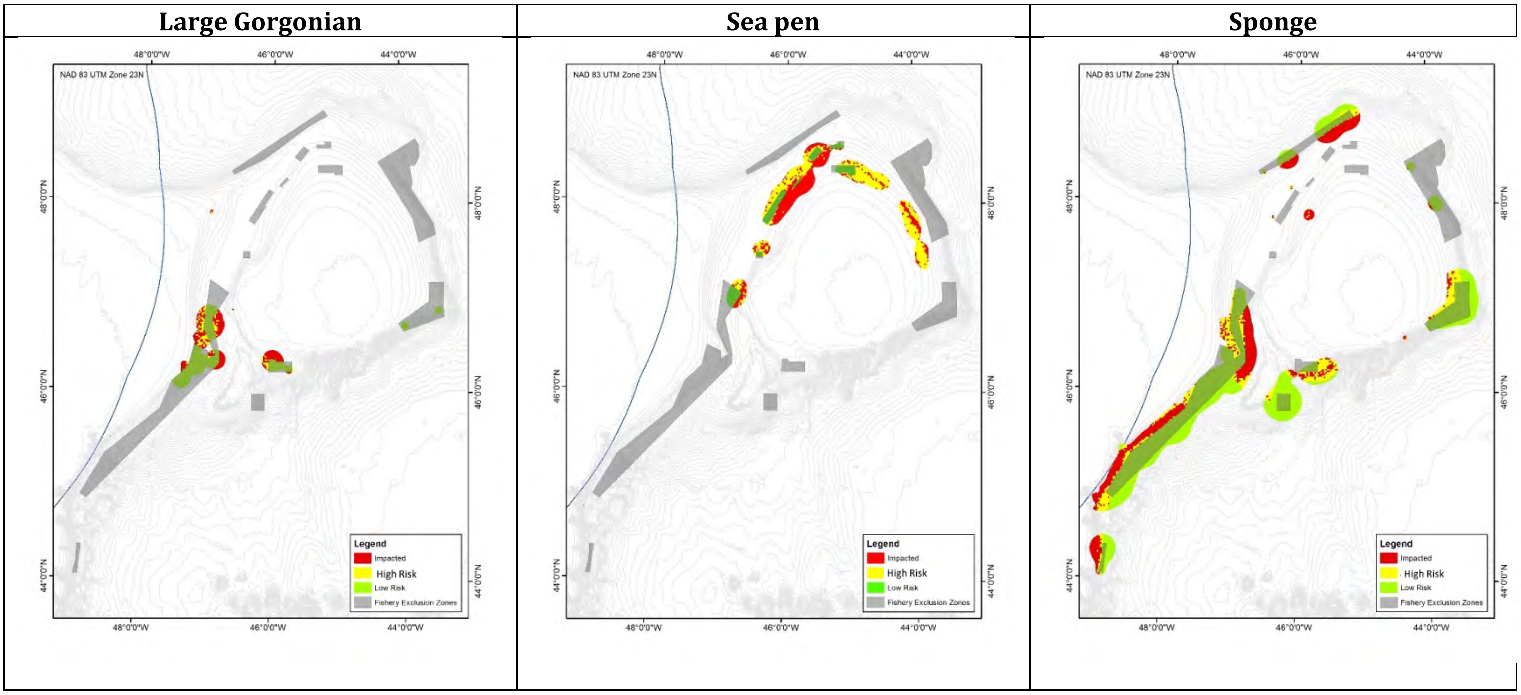
An expert comparative evaluation of these results (above) was undertaken such each result was assigned a relative risk score of SAI being realised (e.g., low, moderate and high risk). For example, if a VME has a large proportion of its area and/or biomass evaluated at low risk of impact then it would be assessed as having a relatively low risk score for SAI. By contrast, if a VME had a relatively high level of sensitivity (low fishing effort/biomass cut-off value) it would be assessed as having a high risk score of SAI. The overall results of the expert assessment of SAI are given in the table below.

Overall SAI risk scores for sponge, sea pen and large gorgonian VME in the NRA. The risk scores are relative (e.g, low, medium and high) and determined by expert evaluation.

	Sponge		**Sea pen**		**Large gorgonian**	
SAI criteria	**Area**	**Biomass**	**Area**	**Biomass**	**Area**	**Biomass**
Low risk	Low	Low	High	Mod	Mod	Low
High risk	Low	Low	High	High	Low	Low
Impacted	Mod	Mod	High	High	High	Mod
VMEs overlapping	Mod		High		Low	
Index of Sensitivity	High		Mod		High	
Fragmentation	Low		High		Low	
Fishing area stability	Low		High		Low	
Overall risk of SAI	**Low**		**High**		**Low**	

In conclusion, Sponge and Large gorgonian VMEs were assessed as having low overall risk of SAI. Conversely, sea pen VME is assessed to have been subject to SAI because of the relatively large area (38%) and relatively high biomass (42%) which has been impacted. However, the resilience of the sea pen VME is uncertain and among the VMEs assessed the sea pen is comparatively less sensitive to fishing pressure. The area at potential high risk of impact is also comparatively high on account of the relatively low proportion of the VME falling within closures. In addition, the habitat is relatively fragmented, is subject to relatively high fishing area instability and does not overlap with other VME types.

SC noted that the method could be improved by including an assessment of the amount of overlap between the specific fishery effort described in Annex VIII, section 4.2.4, and each of the VMEs. The current assessment only considered the first three SAI criteria from the FAO Guidelines: i) the intensity or severity of the impact at the specific site being affected, ii) The spatial extent of the impact relative to the availability of the habitat type affected, iii) the sensitivity/vulnerability of the ecosystem to the impact. However, wherever possible further work and methods should be developed to assess the remaining FAO SAI criteria iv - vi. These deal with functional aspects of VMEs, such as VME resilience and the role of VME as important habitat for commercial stocks (FAO, 2009). Improvements towards addressing and assessing these criteria would be expected to be included in the next assessment in 2021.


Large Gorgonian

Sea pen

Sponge

Fig.3. Impacted, high and low risk areas have been quantified for each VME using the corresponding cut-off values (see Annex VIII, section 4.2.5.)

v) Seamount VME Species guide

FC requests the Scientific Council consider widening the scope of the NAFO coral and sponge identification guides to include other relevant species on seamounts.

The Scientific Council responded:

> The NAFO VME coral and sponge identification guide was updated in 2015 to include other species defined as VME Indicator Species. Although the NAFO VME Guide continues to be focused on corals, sponges, and other benthic taxa, there are existing guides and catalogues that can be useful for identifying other species, like some skates and sharks, that could potentially be considered VME indicator species. SC has identified some of this relevant material, and recommends it is provided to NAFO observers in a usable format.

The NAFO VME coral and sponge identification guide has been updated to include other species defined as VME Indicator Species (Kenchington et al., 2015). In doing that, they revised the previous guides and combined them into a single volume with removable pages to facilitate updates. The guide is intended as a pictorial identification guide for VME indicator species commonly encountered within the NAFO fishing footprint on the Grand Banks of Newfoundland. Some taxa in the guide occur more broadly, including on seamounts. By-catch of cold-water corals from an EU-Spain Trawl Experimental Fishery developed during 2004 on three NAFO seamounts was examined (Murillo et al., 2008). Hauls were carried out over two peaks located in Divs. 6EF (New England Seamounts) and in Div. 6G (Corner Rise Seamounts) using "Pedreira" bottom trawl gear. Corals observed were the stony corals *Enallopsamia rostrata*, *Enallopsamia* sp., *Solenosmilia variabilis*, and *Madrepora oculata*, the gorgonian corals *Acanella eburnea*, *Placogorgia terceira*, *Lepidisis* sp., *Keratoisis* sp., *Thouarella grasshoffi*, *Metallogorgia melanotrichos*, and *Paragorgia johnsoni* and antipatharians (black corals).Of these only *Enallopsamia* was frequently recorded. The current guide already includes *Paragorgia johnsoni*, *Keratoisis* sp., and another species of *Acanella*.

Researchers from the USA have undertaken exploratory *in situ* surveys of some of the NRA seamounts and could add to NAFO's provisional list of VME Indicator Species. In keeping with the practice to date, rare corals and sponges have not been included and so if additions were to be made to the Guide at this time only *Enallopsamia* should be added, assuming that appropriate deck photos were collected. However, the WGESA recommends that scientists from the USA who participated on their seamount missions take the lead in suggesting additional species since they have recent expertise in this geographic area. Alternatively, additions could be made if exploratory fishing is undertaken, using the observer records which as of January 2016 will require all by-catch of VME indicator species to be recorded. The guide gives direction on contact information for species not currently in the guide but recorded at sea.

Improving species identification of species other than corals and sponges in NRA seamount fisheries

Currently, the NAFO list of VME Indicator Species is focused on corals and sponges, and includes a few other benthic taxa like sea squirts, crinoids, and bryozoans. In order to identify other potentially vulnerable species (e.g., some bony fishes and elasmobranchs), specifically species found on seamounts in the NAFO Regulatory Area (NRA), a list of species inhabiting the NRA seamounts would be required. Unfortunately, a fair number of bony fish and elasmobranch species caught on seamounts are not identified at the species level, making impossible to determine if these are rare species that may qualify as VME Indicator Species, or whether they are more common, widely distributed ones. To address this shortcoming, it will be necessary to improve upon the ability of NAFO Fishery Observers to identify catches in seamount fisheries to the species level. Rather than expand upon the NAFO's VME corals and sponges field guide, existing guides may be useful in this regard. Several existing species identification guides, created as part of the FAO's FishFinder Programme and those prepared by other organizations as well, are available at no cost and would be useful for improving the species identification ability of the observers. Some of this material is listed below. The existing list of species recorded during Canadian and European Union bottom trawl surveys conducted on the Flemish Cap (Vazquez et al. 2013), which includes depths up to 1,460 m, may also be useful in this regard.

Species identification guides useful to NAFO Fishery Observers working on vessels fishing on seamounts in the NAFO Regulatory Area.

1. *Corke, J. 2012. WWF Identification Guide to Sharks, Skates, Rays and Chimaeras of Atlantic Canada. WWF-Canada, WWF. available at:* http://awsassets.wwf.ca/downloads/identification_guide_to_sharks__skates__rays_and_chimaeras_of_atlantic_canada.pdf
2. *Kulka, D., C. Miri, and A. B. Thompson. 2007. Identification of wolffish, hake and rockling in the northwest Atlantic. NAFO Sci. Coun. Studies, 40: 1–4. doi:10.2960/S.v40.m1*
3. *The FAO FishFinder website which contains the following species identification guides relevant to fisheries is:* http://www.fao.org/fishery/org/fishfinder/3,6/en*. Identification guides that are especially relevant to species found in NAFO waters are highlighted in yellow.*
    - a. *Carpenter, K.E. (ed.) 2002. The living marine resources of the Western Central Atlantic. Volume 1: Introduction, molluscs, crustaceans, hagfishes, sharks, batoid fishes, and chimaeras. FAO Species Identification Guide for Fishery Purposes and American Society of Ichthyologists and Herpetologists Special Publication No. 5. Rome, FAO. pp. 1-600.*
    - b. *D.A. Ebert and M.F.W. Stehmann. 2013. Sharks, batoids, and chimaeras of the North Atlantic FAO Species Catalogue for Fishery Purposes. No. 7. Rome, FAO. 523 pp.*
    - c. *Stehmann, M. 2012. FAO. North Atlantic Batoids and Chimaeras Relevant to Fisheries Management. Rome, FAO. 84 cards (ISBN 978-92-5-107365-0)*
    - d. *Ebert, D. 2012. FAO. North Atlantic Sharks Relevant to Fisheries Management. Rome, FAO. 2012. 88 cards (ISBN 978-92-5-107366-7)*
    - e. *FAO CD-ROM. Species Catalogues. FAO Fisheries Synopsis No. 125, Vols. 1 to 18, 2006.*
    - f. *FAO CD-ROM. Sharks, rays and chimaeras. FAO Species Identification Publications Excerpts.*

Scientific Council **recommends** that *NAFO Fishery Observers be provided with copies of the species identification guides indicated below in order to improve the quality and quantity of at-sea identifications of bony fish and elasmobranch species caught in fisheries conducted on NRA seamounts. It would also be useful for the NAFO Secretariat to make additional searches for existing identification guides to complement (or supersede) the compiled selection. SC also recommends that NAFO Fishery Observers submit digital photos of specimens (with file names indicating date caught, trip ID and tow number) which they cannot identify and that observers submit these images with the catch report data from each trip.*

References

Kenchington, E., L. Beazley, F. J. Murillo, G. Tompkins MacDonald and E. Baker. 2015. Coral, Sponge, and Other Vulnerable Marine Ecosystem Indicator Identification Guide, NAFO Area. NAFO Scientific Council Studies, 2015. Number 47. Doi: 10.2960/.v47.m1.

Murillo, F.J., P. Duran Munoz, M. Mandado, T. Patrocinio and G. Fernandez. 2008. By-catch of cold-water corals from an Experimental Trawl Survey in three seamounts within NAFO Regulatory Area (Divs. 6EFG) during year 2004. NAFO SCR Doc. 08/11; Serial No. N5502, 5pp.

Vázquez, A., J. M. Casas and R. Alpoim. 2013. Protocols of the EU bottom trawl survey of Flemish Cap. NAFO SCR Doc. 13/021, Ser. No. N6174, 51 p.

vi) Risk assessments for impacts of trawl surveys on VME in closed areas

Fisheries Commission requests that SC considers options to expedite risk assessment of scientific trawl surveys impact on VME in closed areas, and the effect of excluding surveys from these areas on stock assessments.

Scientific Council responded:

A partial analysis was conducted to evaluate the impact of removing the closed areas on the indices of biomass derived from the EU survey in Div. 3M. 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 the biomass indices (with and without the hauls in the closed areas) is more noticeable but the trends were similar to the original index. Further investigation is required for abundance indices by length or age used in the assessments. If the closed areas are removed from the survey design, some of the strata may not be properly sampled, as almost all of their trawlable area is inside the closures. This study must be extended to other surveys conducted in the Regulatory Area in other Divisions.

The work reported here is an advance in our understanding of this issue. Further progress will require a significant amount of time. SC has not been able to develop a plan to expedite this work at present.

EU (Portugal and Spain) have conducted a trawl survey in NAFO Regulatory Area Div. 3M since 1988, to 700 m until 2003 (19 strata) and to 1400 m afterwards (32 strata). This survey was designed prior to implementation of any closed area and provide crucial data for several fish stock assessments, as well as they have provided significant information on the knowledge and definition of the closed areas in Division 3M. This survey has a stratified-random design over the total area of the Division to 1500m with sampling sites assigned at random and proportional to the stratum area. As such, the location of the hauls can eventually be inside of the closed areas.

Data from this survey during 1988-2015 were used to carry out this study. Survey indices were re-calculated by removing hauls that had a starting or ending position inside the closed areas. New mean catch per mile indices (strata with only one haul were included without its SD) were calculated and then converted into biomass using the revised total area less the closed areas. These calculations were made for the species assessed by the NAFO Scientific Council (Atlantic cod, American plaice, roughhead grenadier, shrimp, Greenland halibut, *Sebastes mentella* and *Sebastes fasciatus*) as well as for *Sebastes marinus* and *Sebastes sp* juveniles. Results were compared to those with all the hauls.

A total of 189 (~5%) of 4134 valid hauls in the time series were identified as falling within closed areas. This affected 13 strata. After removing the hauls in the closed areas, 40 year/stratum combinations had just one haul so that the variance could not be calculated.

Six strata have more than the 30% of their area within the closed areas. If the closed areas are removed from the survey design, some of these strata may not be properly sampled, as almost all their trawlable area is inside the closures.

Results of this initial component of the study show that for the shallower species (Atlantic cod, American plaice, shrimp and all the species of the genus *Sebastes*), removing the hauls in the closed areas had minimal impact on the biomass indices. For roughhead grenadier and Greenland halibut the difference in the biomass indices (with and without the hauls in the closed areas) is more noticeable but the trends were similar to the original index. In general the uncertainty is slightly higher if we remove the hauls inside the closed areas.

Other indices must be studied, such as the mean number and its distribution by length and/or age. These analyses should also be conducted for surveys in other Divisions that are affected by closed areas.

vii) Bycatch of cod, redfish and moratoria species from haul-by-haul data

FC requests SC, based on analysis of logbook data and patterns of fishing activity, to be conducted by the secretariat, to examine relative levels of bycatch and discards of 3M cod/redfish, and stocks under moratoria in the different circumstances (e.g. fisheries, area, season, fleets, depth, timing).

Scientific Council responded:

The 2015 haul-by-haul data are incomplete, since the requirement was to report only the top three species from each haul. SC considers the data to be not useful for the examination of bycatch. The requirement changed in 2016 and all species are now required to be reported. Therefore, SC will review the analysis at the June 2017 SC meeting.

In 2015, a regulation was put in place in the NRA that required vessels to submit data from their logbooks by haul. Unfortunately, this regulation was only for the top three species in each haul. These data are useful to look at directed catch. However, they are not useful to look at bycatch, particularly for species under moratoria. Most commercial hauls likely take more than three species. Data submission was also in various formats, making data handling difficult.

In 2016, this regulation was changed to require submission of all species caught in every haul. Submission formats were also somewhat standardized making it easier for the Secretariat to handle these data. SC will examine these data in 2017.

viii) Review F_{lim} value for Div. 3M Cod

It is difficult to match the current F_{lim} proxy with the 3M cod assessment results given by the 2015 Bayesian XSA assessment. These results were presented to SC in June and used for short term (2016-2017) projections under several F options (NAFO SCR 15/33 González-Troncoso, 2015); NAFO SC June 2015 Report). Focusing on the last assessment and projections, assuming at the same time a candidate F_{lim}= $F_{30\%SPR}$=0.131, they would imply that:

- *During the past five years (2010-2014) 3M cod has been exploited at an average F_{bar} level over two fold F_{lim}.*
- *While SSB was sustained at a high average level representing 87% of the highest estimated SSB of the 1972-2014 interval (36 7041 (sic) in 1972).*
- *The two highest year classes since 1992 occurred in 2011-2012.*

Under these circumstances the Scientific Council is requested to analyze whether the current F_{lim} value for 3M cod is currently underestimated and to revise if required the relevant fishing mortality and biomass reference points appropriately.

Scientific Council responded:

Scientific Council reiterates that the review of the F_{lim} is highly dependent of the revision of biological data for the cod benchmark and the PA Framework revision which is currently under discussion. Scientific Council endorsed the FC-SC WG-RBMS proposal that the best forum to carry out the F_{lim} review is the benchmark process, and will undertake this task during that process.

The NAFO Joint Fisheries Commission–Scientific Council Working Group on Risk-Based Management Strategies (FC-SC WG-RBMS) on its 2016 April meeting developed a detailed work plan for full benchmark assessment of the 3M cod stock (NAFO, 2016). It was noted that the work plan was designed to interrelate the different processes affecting management of this stock: the MSE, the FC Request to SC to organize a full benchmark assessment and to revise the F_{lim} value, and the PA Framework revision which is currently under discussion.

The FC-SC WG-RBMS proposed a tentative timeline to the NAFO 3M Cod Benchmark to be approved by Fisheries Commission and Scientific Council, this timeline will be address in section VII 1. c) xvi) Plan for of work for the benchmark process for Cod in Div. 3M (Item 16) of this report.

Point 1 of the proposed calendar is related to the calculation of F_{lim}: *The Scientific Council (SC), in **June 2016**, will approve the main assessment issues to be revised during the 3M Benchmark. Among those issues, there the FC request to the SC (request number 8, SC SCS Doc16/01) that the SC should, in 2016, analyse whether the current F_{lim} value for 3M cod is currently underestimated and to revise, if required, the relevant fishing mortality* *and biomass reference points appropriately. The RBMS WG recognizes that the best forum to carry out the F_{lim} review is the benchmark process, so it would be recommended to undertake this task during that process.*

Scientific Council reiterates that the review of the F_{lim} is highly dependent of the revision of biological data for the cod Benchmark and the PA Framework revision which is currently under discussion. Scientific Council endorsed the FC-SC WG-RBMS proposal that the best forum to carry out the F_{lim} review is the benchmark process, and will undertake this task during that process.

ix) Assessment of individual species components of Div. 3M Redfish

The stock of redfish 3M covers catches of three Sebastes species and the scientific advice is based on data of only two species (S. mentella and S. fasciatus). Golden redfish, Sebastes marinus (aka norvegicus), represents part of the catch but has not yet been subject to a full assessment in NAFO. The Scientific Council is requested to explore the possibility and options of an individual assessment of the golden redfish (S. marinus, aka norvegicus) and of including this species in the scientific advice for 2018-2019. The Scientific Council is also requested to advice on the implications for the three species in terms of catch reporting and stock management.

Scientific Council responded:

The next full assessment of the Beaked Redfish (*S. mentella* and *S. fasciatus*) in Div. 3M stock is schedule for June 2017. Scientific Council will endeavor a full assessment of the 3M golden redfish (*Sebastes marinus*) at that time.

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.

Up to the first half of the 2000's redfish catch basically corresponded to beaked redfish. But from 2005 onwards redfish catch on Division 3M became a blend of by-catch from cod fisheries at depths shallower than 300m (a mixture of golden and beaked redfish), catches between 300-700m (primarily beaked redfish) mainly taken in direct fisheries, and by-catch again below 700m, from Greenland halibut fisheries (100% beaked redfish).

Since 2005 Scientific Council split the total 3M redfish catches in to beaked redfish (*S. mentella* and *S. fasciatus*) and golden redfish (*Sebastes marinus*), which favored the feasibility of a 3M golden redfish (*Sebastes marinus*).

Scientific Council will endeavor a full assessment of the 3M golden redfish (*Sebastes marinus*) in the June 2017 meeting.

x) Appropriateness of survey coverage for Greenland halibut

As part of the Greenland halibut's MSE review scheduled for 2016-2017, the SC is asked to specifically monitor and evaluate Contracting Parties surveys with the aim of optimizing resources in order to avoid duplication of data, identify data gaps and streamline survey methodologies, so that all data is used in the assessment.

Scientific Council responded:

Most research vessel survey series providing information on the abundance of Greenland halibut are deficient in various ways and to varying degrees. A single survey series which covers the entire stock area is not available. However, together these surveys provide coverage of the majority of the spatial distribution of the stock and the area from which the majority of the catches are taken. Prior to any new assessment, data from all surveys need to be evaluated for internal consistency and compared for consistency across surveys. These analyses will determine if they provide appropriate input to a model of dynamics of the population

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. Together 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. In addition, all of these surveys provide information on a large number of species, used in numerous assessments.

Data are available from research vessel surveys by Canada in fall in Divs. 2J3K (1978-2015), in Div. 3L (1981-2015), Div. 3NO (1990-2015), by Canada in the spring in Divs. 3LNO (1975-2015), EU in Div. 3M to 700m (1988-2003), to 1400 m (2004-2015), EU-Spain in Div. 3NO (1995-2015) and EU-Spain in Div. 3L (2003-2015). There are also some surveys of other parts of the stock area over shorter periods of time.

The HCR uses only 3 of these surveys: the Canadian fall survey of 2J3K, the Canadian spring survey of 3LNO and the EU survey of 3M from 0-1400 m.

In the last accepted assessment (SCR 10/40) survey at age data were examined to determine which surveys provided the best input to the model. Many surveys were not included and the time series and age range of the other surveys was often shortened from that available. The following surveys were used: EU 0-1400 m ages 1-13, EU 0-700 m ages 1-12, Canada spring 3LNO 1996-2009 ages 1-8, Canada fall 1995-2009 ages 1-13.

Prior to any new assessment data from all surveys need to be evaluated for internal consistency and compared for consistency across surveys. These analyses will determine if they provide appropriate input to a model of dynamics of the population.

xi) Work plan for assessment of impacts other than fishing in the NAFO Regulatory Area

Article 23 NCEM foresees a reassessment of bottom fishing activities in 2016. The NAFO Roadmap for Developing an Ecosystem Approach to Fisheries extends the work of the Scientific Council to include the assessment of potential impacts of activities other than fishing. Also, impacts of human activities in ecosystems should not be analysed in isolation since cumulative effects might occur representing more than the sum of the individual factors. The Scientific Council is therefore requested to develop a work plan at its meeting in 2016 that will allow to address and analyse the potential impact of activities other than fishing (eg. oil and gas exploration, marine cables, ocean dumping, marine transportation) on NAFO VMEs, in particular VME closed areas.

The Scientific Council responded:

Scientific Council considers that developing the requested work plan is beyond its capacity and purview. It realizes the potential for negative impact of non-fisheries activities on VMEs within the NRA, and wants to highlight the complex science and governance issues that would need to be addressed to develop a comprehensive work plan. The recent report of exploratory drilling plans in one of the VME closed areas is a good example of the management and governance limitations involved. Council commends the General Council on its initiatives such as Information Exchange Arrangement on oil and gas activities in the NAFO Regulatory Area (GC Doc 15-04), and given the inter-institutional relationships and connectivity required to address the impacts of activities other than fishing on VMEs, sees the development and implementation of a work plan as a potential follow-up of those kinds of activities. Council emphasizes that governance issues are the main impediment for comprehensive protection of VMEs in the NRA, not the scientific knowledge about them.

In its 2015 Report, SC provided a summary of the activities other than fishing that could impact NAFO Fisheries and ecosystems. On the basis of that initial assessment, SC identified those sectors and activities that were considered priority given their potential for affecting VMEs in the NRA (Table 1).

These priority activities include several related to offshore oil and gas exploration and exploitation, including seismic surveys, releases of drilling wastes and produced water, and accidental events (spills) particularly near seabed releases of oil and gas. Current oil and gas activities are occurring in the vicinity of VMEs, and there is one report of exploratory drilling plans within one the NAFO VME closed areas (Area 10) for the spring-summer 2016 (NAFO GFS/16-137 of 09 May 2016). This indicates that activities other than fishing may already be having impacts on VMEs in the NRA. Also, downstream effects of these activities may impact sensitive species within the impacted VME and in other protected areas.

Marine mining, with an increasing interest in mineral and gas hydrate extraction from the deep sea, is targeting sea mounts, deep water muddy plains, and hydrothermal vents. These activities are not occurring in the NRA at the present time, but if developed, they may occur in the vicinity of VMEs, potentially in seamounts.

Litter and microplastics are now recognized to be ubiquitous in the world oceans and have been demonstrated to negatively affect benthic communities and filter feeders. The occurrence of litter and amount of microplastics associated with VMEs is unknown, but they may be having similar effect on the organisms associated with the VMEs. Preliminary information suggests that the incidence of litter in the Northwest Atlantic appears to be low in comparison with other regions.

Understanding the impacts of these activities on VMEs requires a wide range of analyses, expertise, and sources of data (Table 2). These types of analysis require a multidisciplinary approach involving biologists, geologists, physicists, chemists, engineers, just to name some key fields linked to the science aspects of the issues at hand. This full range of expertise is not currently available in SC or its working groups. Furthermore, properly designing a work plan to assess these potential impacts would require the science to be aligned with the range of plausible management options. The recent report of exploratory drilling plans in one of the VME closed areas is a good example of these management and governance limitations; in this case there was consistent and publicly available scientific information about the existence of the VME as a benthic habitat structure, its importance, and its protected status from bottom fishing activities, but all this knowledge appears to have had little influence on the planning of exploratory activities within the VME.

Table 1. Key sector and activities with higher potential for impacts on VMEs in the NRA.

Sector	Activity/Source
Offshore oil and gas (exploration)	Seismic surveys
Offshore oil and gas (exploration and exploitation)	Drilling waste disposal Produced water disposal Accidental events (subsea blowouts and spills)
Marine mining	Habitat disruption and destruction during minerals extraction Smothering from tailings disposal
Waste disposal	Litter (large size objects) Microplastics (<5mm)

Table 2. Synoptic list of information requirements for understanding and managing impacts of priority non-fishing activities on VMEs in the NRA

Offshore oil and gas:

- Seismic*:*
  - Effects on benthic organisms
  - Potential interactions with fisheries
  - Prevention and mitigations for protection of benthic organisms
- Effects of drilling wastes on VMEs
  - Fate and potential for long distance transport of particulates in near bottom currents
  - How the impact of drilling wastes vary with magnitude, duration,
  - Recovery potential of VMEs
- Effects of oil spills (particularly seafloor and deep-water releases) on VMEs
  - Impacts of oil on VMEs
  - Impacts of dispersants on VMEs
  - Understanding spill trajectories and patterns (e.g. deep-water modelling)
- Reef effects (human-built structures serve as substrate for benthic organisms)
  - Enhanced productivity, altered community structure and potential local contamination

Marine mining:

- Ecology of seamount communities and deep-water benthos (identification of VMEs in seamounts)
- Mapping of potential mining locations
- Understanding responses of benthic habitat communities to disruption/ destruction due to mining
  - Sensitivity
  - Recovery potential
- Prevention and mitigations

Wastes:

- Effects of litter on VMEs
  - Smothering
  - Altered substrate
- Effects of microplastics on corals and sponges
- Monitoring

Addressing these impacts involves a multitude of jurisdictions, regulatory frameworks, and organizations involved in the management of this multiplicity of sectors. Furthermore, NAFO regulatory authority is limited to fishing, so its ability to influence management measures to mitigate impacts from these non-fishing activities is extremely limited, as the recent report on drilling plans demonstrates. NAFO's ability relies on its capacity to liaise, inform, and coordinate its own activities with those of other management bodies. It would be expected these other sectors to have, within their respective mandates and jurisdictions, some requirements for minimizing environmental impacts, and promoting environmental stewardship and conservation.

Given all these constraints, SC considers it unrealistic to put together a specific work plan to assess the impacts of activities other than fishing on VMEs. Such a work plan would require coordinated action from a coalition of organizations and authorities within which NAFO would be only one contributing member.

Within a setting like this, SC can contribute expertise on VMEs, ecosystems, species interactions, and stocks dynamics, but more scientists from these other entities would be required to properly integrate the knowledge and expertise from the different disciplines and sectors. Developing a realistic work plan requires the joint effort from such multidisciplinary set of experts.

After much deliberation, SC considers that developing the requested work plan is beyond its capacity and purview. There are two key aspects that need to be addressed. One is the integration, and coordination of the different governance structures associated with the management of fishing and non-fishing activities. The other one is the consolidation of existing science, the identification of science gaps, and the design of research programs that can address those gaps in ways that are consistent with the existing management and governance structures. The science is fundamental to understand the potential impacts, but understanding the management structure is key for setting objectives that NAFO and these other sectoral management organizations can reasonably achieve.

Moving forward in a positive way would require a real commitment from all the organizations and sectors involved. Human and financial resources would be required, and the different organizations would also need to contribute by engaging their managers, scientists, but also legal experts into the process and this may require changes in their internal priorities. This level of action is something that NAFO needs to do at the full organization level. Given inter-institutional and inter-governmental aspects of the task, SC suggests General Council to look into fostering the creation of a muti-sector coalition to engage other management bodies and coordinate with them the possibility of developing the workplan.

xii) A full assessment of Greenland halibut in SA2 and Divs. 3KLMNO using both XSA and SCAA

The Fisheries Commission requests the Scientific Council to conduct a full assessment of Greenland halibut in Subarea 2 + Division 3KLMNO (using both XSA and SCAA1) and to consider the weighting of each survey as a first step to inform the 2017 MSE review.

Scientific Council responded

The lack of catch estimates for 2011-2015 prevented Scientific Council from conducting a full assessment of Greenland halibut in Subarea 2+ Division 3KLMNO at its June 2016 meeting. Data should be evaluated from all available surveys to determine what should be included in a new assessment. Considering it has been several years since the previous assessment, as well as the lack of consistent signals in the available surveys over this period, model choice and formulation need to be examined. This will be a complex and time consuming task. Scientific Council will endeavour to have a full assessment complete in advance of the September 2017 annual meeting.

Catch is an essential element of any analytical assessment. Scientific Council has been unable to estimate catch for Greenland halibut in Subarea 2+ Division 3KLMNO since 2010. This inhibits an analytical assessment of this stock. However, at its June 2016 meeting, a plan was developed to produce estimates of catch during its September 2016 meeting. Currently commercial otoliths used to produce age length keys are being read. When completed, and when catch estimates are available, catch at age for 2011 to 2015 will be constructed.

The last accepted assessment of this stock was conducted in 2010. Survey inputs to that assessment were: EU Div. 3M 0-1400 m 2004 -2009 ages 1-13, EU Div. 3M 0-700 m 1995-2003 ages 1-12, Canada spring Div. 3LNO 1996-2009 ages 1-8, Canada fall Div. 2J 3K 1996-2009 ages 1-13. These years and age ranges are only a subset of what is available from these surveys and were selected as input after extensive examination of survey data and testing of model formulations.

Since the last accepted assessment there have been several years of data collected in the surveys that served as input data. In addition there have been as many more years of data collected in the surveys by EU-Spain in the NRA portion of Div. 3L and Divs. 3NO which are currently not included in the assessment model. All data should be evaluated to determine what should be included in a new assessment. Furthermore, the lack of consistent signals in the available surveys will need to be carefully considered in a new assessment. Any possible weighting of surveys in the assessment would be examined as part of this process.

In addition to extensive analyses of survey data, model choice and formulation need to be examined. The formulation of the models used in the MSE (XSA and SCAA) may no longer be suitable with updated input data, and other model types may be more appropriate. This assessment should be conducted within Scientific Council. The last assessment indicated severe model fit issues (NAFO Scientific Council Report 2010 page 211). This problem may still persist and may prevent the acceptance of any analytical assessment.

Considering the above, conducting a full assessment of Greenland halibut in Subarea 2+ Division 3KLMNO is a complex and time consuming task. However, Scientific Council will endeavour to have a full assessment complete in advance of the September 2017 annual meeting.

xiii) How many SSB points above 30000 t are considered sufficient to conduct a review of B_{lim} of cod in 3NO?

The Fisheries Commission requests the Scientific Council to advise on how many SSB points above 30,000t are considered sufficient to conduct a review of B_{lim} of cod in 3NO.

SC notes that the number of SSB points required prior to re-evaluating B_{lim} will depend on the associated recruitment values and the overall pattern in the stock-recruit scatter and therefore a predetermined number of points cannot be specified at this time.

Within the 3NO Cod Conservation and Rebuilding Strategy (FC Doc. 13/01), the Fisheries Commission noted that it would request the Scientific Council to review in detail the limit reference point when the spawning stock biomass reached 30 000 t. As the stock approached this level in 2015, SC noted that “multiple stock-recruit points are required at SSB levels greater than 30,000 t prior to re-evaluation of this reference point as productivity at these levels of biomass is not well known” (SCS Doc. 15/12). In response to the current request from FC, SC notes that the number of SSB points required prior to re-evaluating B_{lim} will depend on the associated recruitment values and the overall pattern in the stock-recruit scatter and therefore a predetermined number of points cannot be specified at this time.

xiv) Survey biomass trends for Witch flounder in Div.3M

The Fisheries Commission request the Scientific Council to provide survey biomass trend(s) of witch flounder in Div. 3M for as long as data is available.

Scientific Council responded:

3M witch flounder biomass from the EU Flemish Cap survey in Division 3M is provided since 1988. The majority of the witch flounder biomass in Div. 3M is concentrated at depths less than 700 m. Since a minimum in 2002, the index has increased with large inter-annual variability. The maximum biomass was reached in 2012.

Biomass of 3M witch flounder is available from the EU-Flemish Cap survey in Division 3M, carried out every year during summer since 1988 using a *Lofoten* type gear. To 2002, the survey reached 700 m depth. In 2003, the vessel that performs the survey changed from the R/V *Cornide de Saavedra* to R/V *Vizconde de Eza* in order to extend the depth range of the survey until 1400 m. In 2003 and 2004, a series of 111 valid paired hauls was performed in order to convert the indices for 1988 to 2002 from the former vessel into the new vessel. Biomass indices were calibrated (SCR 16/21) in order to transform the time series of the former vessel into the new vessel, showing that the R/V *Vizconde de Eza* is 76% more efficient catching witch flounder than the R/V *Cornide de Saavedra*.

Results show that the majority of the witch flounder biomass index in Div. 3M is concentrated at depths less than 700 m. Since a minimum in 2002, the index has increased with large inter-annual variability. The maximum biomass was reached in 2012.

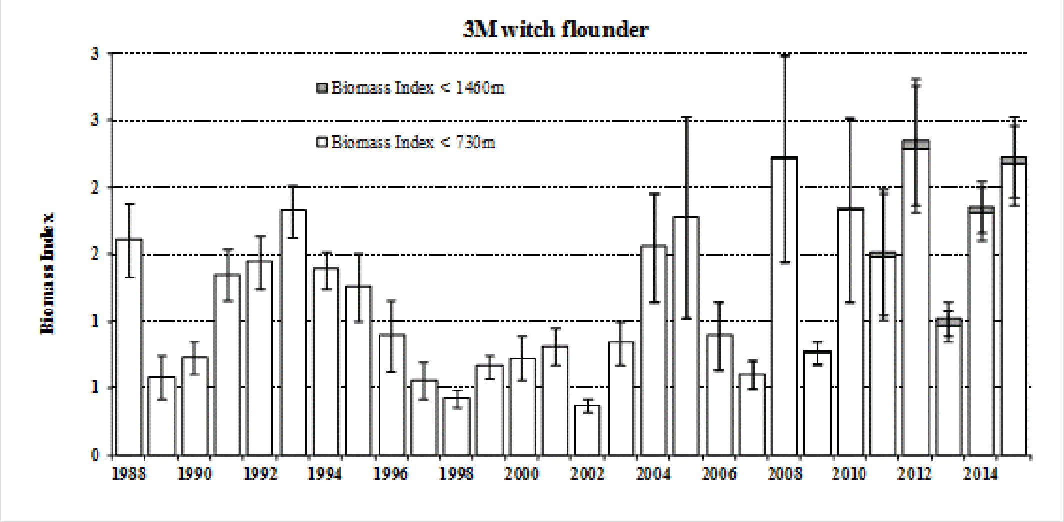


Fig.4. Biomass of 3M witch flounder is available from the EU-Flemish Cap survey in Division 3M

xv) Review Results of 2015 Canadian photographic surveys for non-coral and sponge VME indicator species

The Fisheries Commission requests the Scientific Council to review the results of the 2015 Canadian in situ photographic surveys for non-coral and sponge VME indicator species on Grand Bank (tail of Grand Bank) in relation to previous analyses presented in 2014 (that modelled their distribution using research vessel survey trawl by-catch data), and to identify areas of significant concentrations of non-coral and sponge VME indicator species using all available information.

Scientific Council responded:

SC recommends that the location of the significant catches, rather than the full kernel density polygon areas, be used to identify significant concentrations of these VME indicator species. The photographic surveys did not identify significant concentrations of either erect bryozoans or large sea squirts. These results indicate that the patch size of the non-coral and sponge VME indicator species is less than 1 km. These VME indicators require hard substrate to attach to. It is likely that areas with high catches are also areas with rocky outcrops or more extensive hard bottom. SC considered that the resolution of the kernel density polygons is too coarse for these taxa and detailed information of the surficial geology of the area would help to better define the habitats created by these species.

Large sea squirts and erect bryozoans were accepted as VME indicators by NAFO (NAFO, 2012). In 2013, WGESA collated the research vessel survey catch data for these taxa and presented a kernel density analysis for each, following previously established methods and assessment criteria (NAFO, 2013). The analysis performed well and threshold values were established for each taxon creating a number of polygons (Figure 5). However, WGESA recommend that *in situ* camera surveys be done to evaluate the nature of these areas given that nothing is known about the catchability of these taxa in the trawls (NAFO, 2013). Such ground-truthing of the models was done for the corals and sponges (Kenchington et al., 2014), leading to the adoption of the coral and sponge polygons as VMEs (NAFO, 2014). Until such ground-truthing could be done, WGESA referred to the kernel density-derived polygons for large sea squirts (*Boltenia ovifera* only) and erect bryozoans as “significant concentrations” (NAFO, 2013).

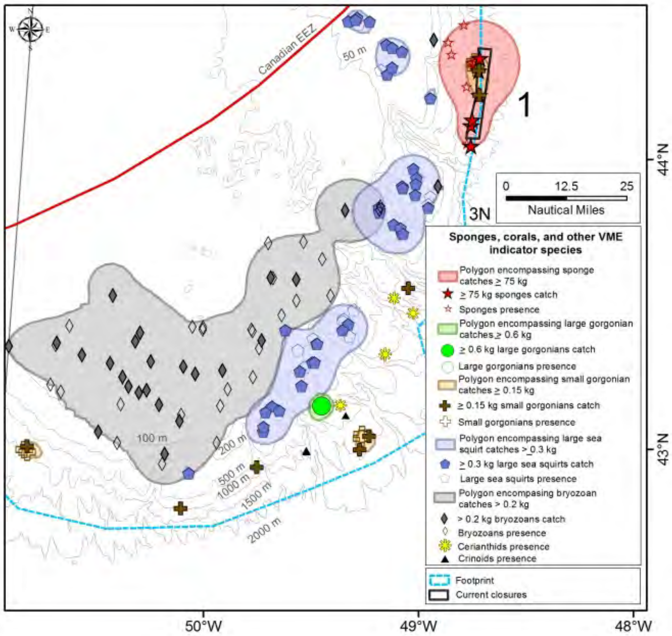


Fig.5. Location of significant concentrations of large sea squirts (encompassed by purple polygons) and erect bryozoans (encompassed by grey polygons) on the Tail of Grand Bank (Figure from NAFO, 2014).

Results from the 2015 Canadian in situ photographic survey

Fisheries and Oceans, Canada conducted in situ photographic surveys on the Tail of Grand Bank during June 2-18th, 2015. The mission, HUD2015-011: Identification & Characterization of Benthic VMEs and ESBAs on the Scotian Shelf, Grand Banks, and Laurentian Channel, used a drop camera system referred to as the 4KCam. Photos of the bottom were taken by raising and lowering the camera off the sea bed. Six transects were completed; five inside the polygons for significant concentrations of erect bryozoans or large sea squirts, where they were positioned over significant catches. The transect lines covered 7 km and 288 photos of good quality were collected. Detailed positions and a summary of these transects can be consulted in the WGESA report (NAFO, 2015).

Erect Bryozoan Polygon

Two transects were completed inside the polygon for erect bryozoans. Erect bryozoans (*Eucratea loricata*) were only recorded in the second transect, but these were small colonies, likely attached to broken shells and not forming turf habitat. The soft bottom of this area is not suitable for attachment and turf habitats are likely found on patches of hard substrate that are scattered throughout the area.

Large Sea Squirt Polygons

Three transects were completed inside the polygons for large sea squirts and one was run outside. The camera transects did not identify significant concentrations of large sea squirts.

New records from research trawl surveys

Erect Bryozoans

Nine significant catches of bryozoans (above the 0.2 kg threshold) were reported from the 3NO and 3L Spanish 2014 and 2015 surveys, carried out by Spanish Institute of Oceanography (EU-Spain), and one from the DFO NL Multispecies Surveys, carried out by Fisheries and Oceans, Canada. Five of the significant catches were within the polygons identified from the kernel analysis, and five outside. Several species could be recorded under the "bryozoans" category, although the species that constitute most of the biomass, mainly on the continental shelf of the Tail of the Grand Bank is the erect bryozoan *Eucratea loricata.* Exact positions of significant catches are provided in Table 2.

Large Sea Squirts

The Spanish 3NO Survey reported 4 significant catches of large sea squirts (above the 0.3 kg threshold, all the stalked tunicate *Boltenia ovifera*) from the 2014 and 2015 surveys, carried out by Spanish Institute of Oceanography, EU-Spain, three of which were within the polygons identified from the kernel analysis, and one outside. These locations appear to be associated with the flanks of canyons (VME elements) where there is likely greater hard substrate for attachment compared with higher on the bank. Exact positions of significant catches are provided in Table 3.

The differences in catches between the Spanish and Canadian surveys are likely related to higher effort, both in number of sets and duration, in the Spanish surveys.

Table 2. Start positions of significant RV catches of bryozoans with their corresponding weight.

Survey	Year	Start position		Weight (kg)
		Lat (N)	Lon (W)	
Spain 3NO Survey	2008	43° 12' 09.6"	50° 30' 29.4"	7.843
Spain 3NO Survey	2015	43° 40' 22.8"	49° 29' 57.6"	5.16
Spain 3NO Survey	2009	43° 09' 30"	50° 26' 43.2"	3.85
Spain 3NO Survey	2011	43° 06' 29.4"	50° 21' 48.0"	3.08
Spain 3NO Survey	2008	43° 12' 07.2"	49° 58' 37.8"	2.86
Spain 3NO Survey	2008	43° 04' 13.2"	50° 15' 55.2"	2.55
Spain 3NO Survey	2015	43° 59' 33.0"	50° 02' 33.0"	1.89
Spain 3NO Survey	2011	44° 22' 52.2"	49° 03' 26.4"	1.7625
Spain 3NO Survey	2015	43° 08' 48.0"	50° 10' 07.8"	1.504
Spain 3NO Survey	2008	43° 31' 49.8"	49° 39' 12.6"	1.47
Spain 3NO Survey	2007	43° 16' 60.0"	50° 23' 45.6"	1.45
Spain 3NO Survey	2011	43° 01' 09.0"	50° 09' 52.8"	1.41
Spain 3NO Survey	2007	43° 07' 36.0"	50° 24' 52.8"	1.362
Spain 3NO Survey	2008	43° 13' 05.4"	50° 19' 03.0"	1.28
Spain 3NO Survey	2009	43° 07' 02.4"	50° 19' 42.0"	0.962
Spain 3NO Survey	2015	43° 17' 40.2"	50° 01' 07.2"	0.894
Spain 3NO Survey	2015	43° 04' 21.6"	50° 26' 33.0"	0.776
Spain 3NO Survey	2009	43° 52' 34.8"	49° 00' 11.4"	0.741
Spain 3NO Survey	2011	42° 54' 07.2"	50° 13' 25.8"	0.62
Spain 3NO Survey	2011	43° 46' 39.6"	49° 26' 19.2"	0.62
Spain 3NO Survey	2007	43° 12' 26.4"	50° 09' 44.4"	0.476
Spain 3NO Survey	2015	43° 36' 09.0"	50° 00' 07.2"	0.45
Spain 3NO Survey	2007	43° 13' 28.8"	50° 38' 31.8"	0.444
Spain 3NO Survey	2011	43° 18' 49.8"	50° 22' 34.8"	0.437
Spain 3NO Survey	2008	43° 26' 13.2"	50° 30' 58.8"	0.426
Spain 3NO Survey	2015	43° 47' 37.2"	50° 00' 03.0"	0.402
Spain 3NO Survey	2014	43° 05' 52.2"	50° 25' 52.2"	0.37
Spain 3NO Survey	2008	43° 18' 48.6"	49° 48' 03.6"	0.33
Spain 3NO Survey	2008	43° 15' 38.4"	50° 45' 56.4"	0.3
Spain 3NO Survey	2011	43° 11' 03.0"	50° 06' 16.2"	0.297
Spain 3NO Survey	2015	46° 15' 45.6"	46° 52' 37.2"	0.252
Spain 3NO Survey	2008	43° 14' 16.8"	50° 59' 26.4"	0.251
Spain 3NO Survey	2011	42° 57' 51.0"	50° 32' 30.6"	0.246
Spain 3L Survey	2013	46° 23' 60.0"	47° 26' 09.0"	0.242
DFO NL Multispecies Surveys (Canada)	2013	43° 41' 18.0"	49° 02' 12.0"	0.23
Spain 3NO Survey	2013	43° 31' 53.4"	49° 46' 25.8"	0.227

Table 3. Start positions of significant RV catches of large sea squirts (specifically the stalk tunicate *Boltenia ovifera*) with their corresponding weight.

Survey	Year	Start position		Weight (kg)
		Lat (N)	Lon (W)	
Spain 3NO Survey	2015	43° 14' 09.6"	49° 35' 48.0"	6.05
Spain 3NO Survey	2009	43° 21' 50.4"	49° 25' 19.2"	4.55
Spain 3NO Survey	2012	43° 09' 52.2"	49° 36' 06.6"	4.5
Spain 3NO Survey	2013	43° 14' 52.8"	49° 32' 46.2"	3.52
Spain 3NO Survey	2012	43° 44' 15.0"	49° 12' 19.2"	2.8
Spain 3NO Survey	2009	43° 12' 52.2"	49° 36' 46.8"	2.79
Spain 3NO Survey	2009	43° 46' 36.0"	49° 16' 34.2"	2.6
Spain 3NO Survey	2009	43° 21' 12.6"	49° 41' 32.4"	2.41
Spain 3NO Survey	2010	44° 26' 10.8"	49° 26' 19.2"	2.35
Spain 3NO Survey	2011	43° 14' 52.2"	49° 33' 21.0"	2.167
Spain 3NO Survey	2008	43° 04' 29.4"	49° 41' 56.4"	2.06
Spain 3NO Survey	2011	43° 47' 05.4"	49° 16' 36.0"	1.88
Spain 3NO Survey	2014	43° 21' 42.6"	49° 25' 12.6"	1.85
Spain 3NO Survey	2012	43° 54' 03.6"	49° 06' 31.8"	1.74
Spain 3NO Survey	2009	43° 00' 57.6"	49° 46' 09.0"	1.702
Spain 3NO Survey	2007	43° 00' 01.8"	49° 46' 08.4"	1.58
Spain 3NO Survey	2007	44° 20' 09.0"	49° 12' 30.0"	1.52
Spain 3NO Survey	2013	43° 52' 15.0"	49° 10' 27.6"	1.5
Spain 3NO Survey	2010	44° 16' 43.8"	49° 15' 07.8"	1.197
Spain 3NO Survey	2012	43° 23' 10.8"	49° 23' 47.4"	1.102
Spain 3NO Survey	2012	44° 21' 21.0"	49° 17' 04.2"	1.06
Spain 3NO Survey	2007	43° 42' 28.2"	49° 09' 28.8"	1.03
Spain 3NO Survey	2009	42° 50' 27.0"	50° 06' 22.2"	0.904
Spain 3NO Survey	2009	44° 10' 44.4"	49° 03' 40.2"	0.898
Spain 3NO Survey	2012	44° 15' 10.8"	49° 16' 24.0"	0.84
Spain 3NO Survey	2013	44° 20' 48.0"	49° 15' 22.2"	0.743
Spain 3NO Survey	2012	43° 05' 13.8"	49° 44' 05.4"	0.665
Spain 3NO Survey	2008	43° 52' 52.8"	49° 06' 33.6"	0.612
Spain 3NO Survey	2012	44° 39' 42.6"	49° 03' 34.8"	0.6
Spain 3NO Survey	2015	44° 07' 00.6"	49° 03' 51.0"	0.587
Spain 3NO Survey	2014	43° 09' 01.2"	49° 35' 33.6"	0.576
Spain 3NO Survey	2010	43° 18' 46.2"	49° 32' 19.2"	0.555
Spain 3NO Survey	2010	43° 04' 03.0"	49° 45' 46.2"	0.512
Spain 3NO Survey	2011	44° 25' 57.0"	49° 22' 16.2"	0.441
Spain 3NO Survey	2007	43° 51' 52.2"	49° 10' 18.0"	0.43
Spain 3NO Survey	2012	43° 47' 39.6"	49° 16' 43.2"	0.429
Spain 3NO Survey	2009	44° 25' 49.2"	49° 28' 24.6"	0.379
Spain 3NO Survey	2011	43° 55' 58.8"	49° 07' 30.0"	0.378
Spain 3NO Survey	2010	43° 50' 34.8"	49° 06' 34.2"	0.373
Spain 3NO Survey	2013	43° 43' 35.4"	49° 10' 22.2"	0.351
Spain 3NO Survey	2009	43° 18' 44.4"	49° 32' 29.4"	0.325
Spain 3NO Survey	2008	44° 26' 36.0"	49° 25' 58.2"	0.32
Spain 3NO Survey	2011	43° 42' 25.8"	49° 09' 52.2"	0.32
Spain 3NO Survey	2009	43° 48' 07.2"	49° 02' 40.2"	0.3

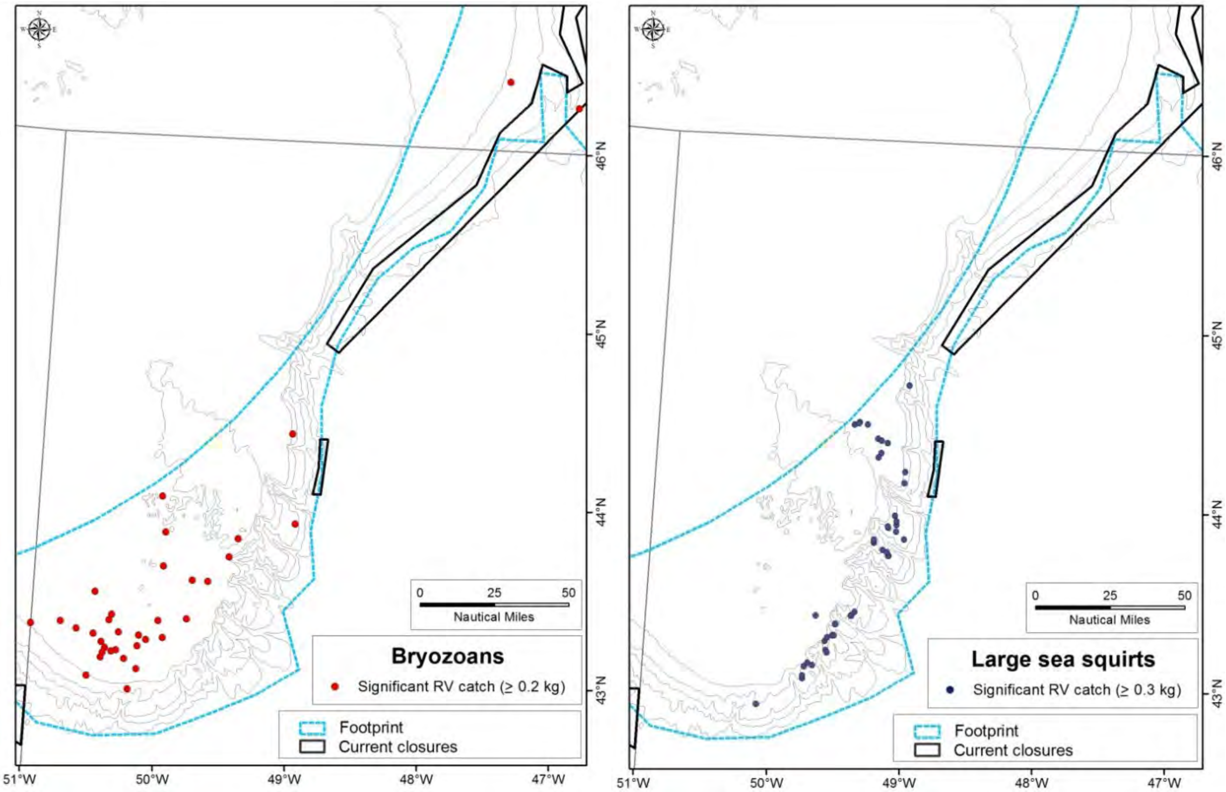


Fig.6. Left panel. Location of significant catches of bryozoans (above the 0.2 kg threshold). Right panel. Location of significant catches of large sea squirts (above the 0.3 kg threshold).

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xvi) Plan for work for the benchmark process for Cod in Div. 3M

Recognizing the importance of the 3M cod fishery to NAFO.

Mindful that even though the current SSB is well above B_{lim}, the recruitment of the two most recent years is low.

Noting that according to the Scientific Council stock assessment we are currently fishing only on two year-classes – once they are depleted in about two years time prospects for a continued fishery at the current level is not likely to be possible.

Further noting that recent assessment of the stock has shown some year-to-year instability and that estimation of risk levels associated with given fishing mortalities cannot be calculated at this time, which further adds to our concern for the future of this fishery and its management.

It is proposed that Scientific Council organize a full benchmark review of the 3M cod assessment in two stages: For 2016 Scientific Council will agree on a standardized approach and prepare a plan for the benchmark process at NAFO including required resources. For 2017 SC will review the benchmark assessment methodology for 3M cod.

SC endorsed the timeline proposed by WG-RBMS for the 3M cod benchmark assessment with minor editorial changes and discussed a plan for the benchmark process including the resources and expertise required to complete it. SC also discussed the main points to be reviewed during the benchmark. SC notes that in order for the benchmark to proceed, CPs must contribute scientific experts in relevant fields and must participate in the benchmark process as outlined in the calendar.

The NAFO Joint Fisheries Commission–Scientific Council Working Group on Risk-Based Management Strategies (FC-SC WG-RBMS) 2016 April meeting developed a detailed work plan for full benchmark assessment of this stock (NAFO, 2016). It was noted that the work plan was designed to interrelate the different processes related to the management of this stock: 1) the FC Request to SC to organize a full benchmark assessment, 2) Management Strategy Evaluation, 3) potential revision of the F_{lim} value, and 4) the NAFO PA Framework revision which is currently under discussion. The tentative timeline for the NAFO 3M Cod Benchmark and the NAFO 3M Cod MSE proposed by the FC-SC WG-RBMS was endorsed by the SC with some minor revisions:

NAFO 3M Cod Benchmark calendar

> *1. The Scientific Council (SC), in June 2016, will approve the main assessment issues to be revised during the 3M Benchmark. Among those issues, there is the FC request to the SC (request number 8, SC SCS Doc16/01) that the SC should, in 2016, analyse whether the current F_{lim} value for 3M cod is currently underestimated and to revise, if required, the relevant fishing mortality and biomass reference points appropriately. The RBMS WG recognized that the best forum to carry out the F_{lim} review is the benchmark process, so it would be recommended to undertake this task during that process.*
>
> *2. Before the end of 2016, all data needed for the NAFO 3M Cod assessment will be reviewed and compiled.*
>
> *3. Between June 2016 and March 2017 different teams of experts will be working on the issues identified in the 2016 June SC meeting. This would require commitment from the contracting Parties to provide human and financial resources. 4. The benchmark review meeting will be held in April 2017 conditional on the completion of the previous steps. The meeting should involve SC and external scientists.*
>
> *4. The June 2017 SC meeting will carry out a new assessment following the protocols proposed by the Benchmark. This assessment would inform the TAC decision for 2018 because the MSE may not be finalised before September 2017.*

NAFO 3M Cod MSE calendar

Progress in the MSE process is expected to happen after June 2017 following the completion of the 3M cod benchmark and the NAFO PAF review. The expected steps would be:

> *1. In June 2017 a new 3M Cod assessment will be presented, in accordance with the benchmark decisions. SC will then provide advice based on this assessment according to the FC request for advice.*
>
> *2. After September 2017, if the FC adopts new elements of the PAF, the RBMS WG should revise the management objectives of the 3M cod MSE accordingly.*
>
> *3. Between September 2017 and March 2018 different HCRs could be tested in order to see if they reach the established management objectives and results should be reviewed by WG-RBMS.*
>
> *4. In June 2018 the SC will review the 3M Cod MSE to enable a final the proposal of an HCR to be forwarded for approval by FC in September, 2018.*

If approved, this HCR will be applied to determine the TAC for 2019 and onward.

SC endorsed the FC-SC WG-RBMS proposed calendar for the 3M cod benchmark with minor changes and discussed a plan for the benchmark process at NAFO including required resources. SC also discussed the main points to be revised during the benchmark:

1. *Assessment Input Data:*
    - 1.1. *Data in general: CPs to contribute with all the national data at their disposal Work to be done by SC national representatives.*
    - 1.2. *Aging and Age/Length Keys (ALKs): investigate inconsistencies in age readings between readers and institutes. This investigation should include an exchange of otoliths. Based on this review, prepare a revised age/length data set to be used during the benchmark. Otolith exchange is being carried out by IEO, IIM and IPMA and it should be completed well before the benchmark.*
    - 1.3. *Study the variability in the biological parameters (i.e. age at maturity, mean weights, etc.) observed in recent years. Experts in cod biology and ecology (including those from outside SC) should be appointed by CPs.*
    - 1.4. *Prepare the available assessment input data taking in account the results of the above points. This will be carried out by FAMRI, IEO, IIM and IPMA*

2. *Model parameters:*
    - 2.1. *Explore the possibility of expanding the actual plus group.*
    - 2.2. *Explore the age/time variability in Natural mortality.*

These will be done by SC in collaboration with external experts.

3. *Assessment models:*
    - 3.1. *Update and review of the R code of the existing assessment model. This revision should include the conclusions of the PAF WG on the methods to calculate the risk. This task should be made by independent experts in R and Bayesian assessment models with the assistance of the 3M Designated Expert (DE) and it would be carried out during 2016*
    - 3.2. *Explore alternative assessment models including multi species models. Contracting Parties should provide expertise.*
    - 3.3. *Estimation of uncertainty in the projections. The PAF working group should carry out this task.*

4. *Review of the Limit Reference Points:*
    - 4.1. $B_{lim.}$
    - 4.2. F_{lim}*. The PAF working group should carry out these tasks.*

Proposed timetable to carry out the 3M Cod Benchmark:

1) Assessment Input Data		Sep	Oct	Nov	Dic	Ene	Feb	Mar	Abr
	1.1 Request for new data	■	■						
	1.2 ALKs	■	■	■					
	1.3 Biological Parameters	■	■	■					
	1.4 Data preparation				■	■			
2) Model parameters									
	2.1 Plus Group				■	■			
	2.2 Natural Mortality	■	■	■					
3) Assessment Models									
	3.1 Approved Model	■	■	■			■		
	3.2 Alternative models						■	■	
	3.3 Uncertanty projections			■	■	■			
4) Reference Points									
	4.1 Blim				■	■	■	■	
	4.2 Flim				■	■	■	■	
Benchmark									3-4 days

SC notes that in order for the benchmark to proceed, CPs must contribute scientific experts in relevant fields and must participate in the benchmark process as outlined in the calendar above.

Venue: invitations to host the meeting have been received from EU-Spain (Institute of Oceanography (IEO) Vigo) and Norway.

Meeting dates: 3-7 April 2017 (tentative)

SC will propose two external experts to attend the benchmark meeting as reviewers (pending funding). The STACFIS chair should coordinate the process and act as co-chair of the benchmark meeting.

2. Coastal States

a) Request by Denmark (on behalf of Greenland) for Advice on Management in 2015-2017

i) Roundnose grenadier in SA 0+1

For Roundnose grenadier in Subarea 0 + 1 advice was in 2014 given for 2015-2017. Denmark (on behalf of Greenland) requests the Scientific Council to continue to monitor the status of Roundnose grenadier in Subareas 0 and 1 annually, and should significant changes in the stock status be observed (e.g. from surveys) the Scientific Council is requested to provide updated advice as appropriate.

Scientific Council responded:

The assessments (interim monitoring) found nothing to indicate a significant change in the status of these stocks. Accordingly, Scientific Council therefore did not change the advice. The next full assessment of this stock will take place in 2017.

ii) Golden redfish, Demersal Deep-sea redfish, Atlantic wolfish, Spotted wolfish and American plaice in Subarea 1

Advice for golden redfish (Sebastes marinus), demersal deep-sea redfish (Sebastes mentella) American plaice (Hippoglossoides platessoides), Atlantic wolffish (Anarhichas lupus) and spotted wolffish (A. minor) in Subarea 1 was in 2014 given for 2015-2017. Denmark (on behalf of Greenland) requests the Scientific Council to continue to monitor the status of these species annually, and should significant changes in stock status be observed the Scientific Council is requested to provide updated advice as appropriate.

Scientific Council responded:

The assessments (interim monitoring) found nothing to indicate a significant change in the status of these stocks. Accordingly, Scientific Council therefore did not change the advice. The next full assessment of this stock will take place in 2017.

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

Advice for Greenland halibut in Div. 1A (inshore) was in 2014 given for 2015-2016. Denmark (on behalf of Greenland) requests the Scientific Council to continue to monitor the status of Greenland halibut in Div. 1A (inshore) for 2017-2018

Scientific Council responded:

Greenland halibut in Division 1A inshore - Disko Bay

Advice June 2016 for 2017-2018

Recommendation for 2017 - 2018
The Scientific Council advises that the TAC should not exceed 6400 tons.

Management objectives

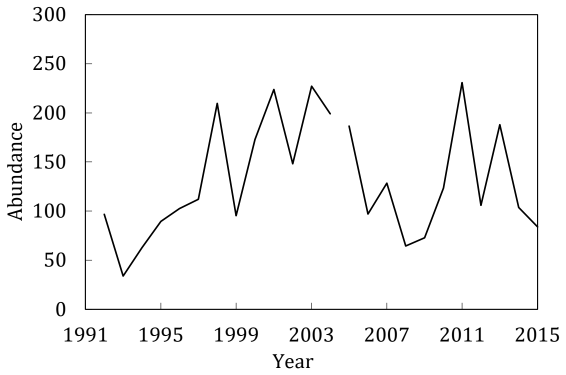
No explicit management plan or management objectives have been defined by the Government of Greenland.

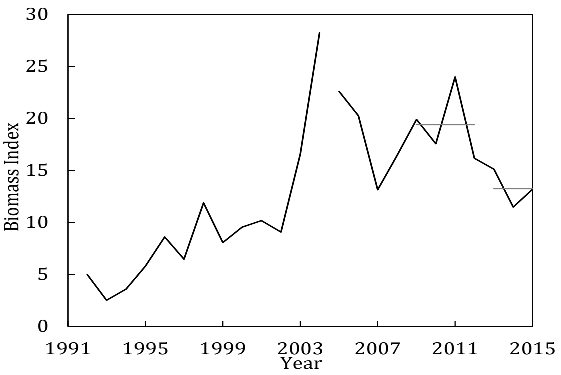
Management unit

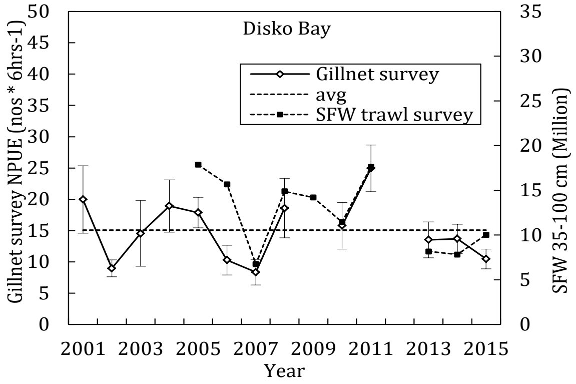
The stocks are believed to recruit from the Subarea 0 + 1 offshore spawning stock (in the Davis Strait) and there is little migration between the separate areas and offshore stocks in SA 0 and 1. Separate advice is given for each area in Subarea 1A inshore.

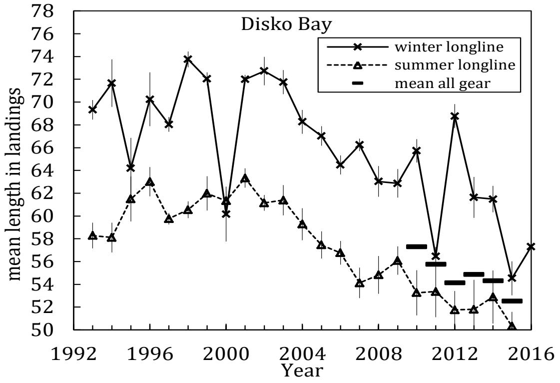
Stock status

Since the survey gear change in 2005, the trawl survey index has shown an overall decreasing trend. The gillnet survey has been below the long term mean in the most recent 3 years. Length distributions in both the longline and gillnet fisheries have shown a long-term shift towards smaller fish.









Reference points

Could not be established.

Assessment

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

Human impact

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

Environmental impact

Unknown

Fishery

Catches peaked in 2004 at around 12000 tons. After 2006, catches halved in just three years to 6300 tons in 2009, before increasing to 9177 tons in 2014. Catch in 2015 was 8674 t.

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

	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
TAC		12.5	8.8	8.8	8.0	8.0	9.0	9.0	9.2	9.5
STACFIS	10.000	7.7	6.3	8.4	8.0	7.8	9.1	9.2	8.7	

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.

Special comments

The ICES Harvest Control Rule 3.2 for data limited stocks was used as a basis for giving TAC advice (mean survey index y1-3/mean y4-7=0.68) applying a 20% 'uncertainty cap' and excluding the 'precautionary buffer'. The precautionary buffer was not used since the stock receives recruits from other areas and is not regarded as reproductively impaired. 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. 16/014 027 and 037 and; SCS Doc. 16/007.

Greenland halibut in Division 1A inshore - Upernavik

Advice June 2016 for 2017-2018

Recommendation for 2017 - 2018

Scientific Council recommends that there should be no increase in catches beyond the 2009-11 average (6300 t).

Management objectives

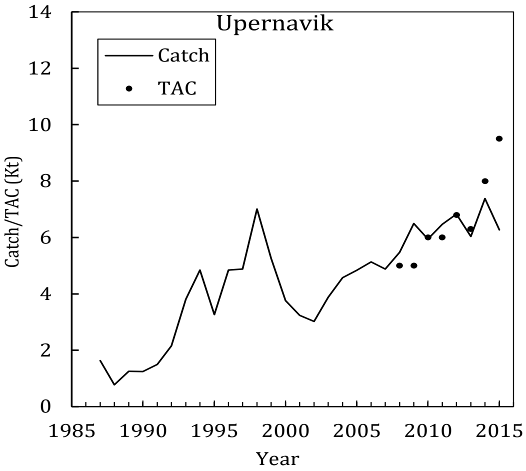
No explicit management plan or management objectives has been defined by the Government of Greenland.

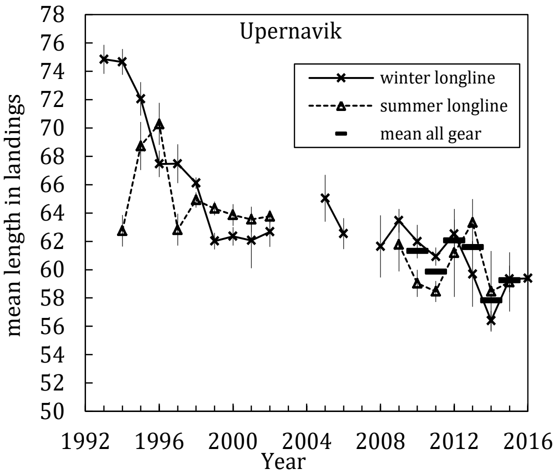
Management unit

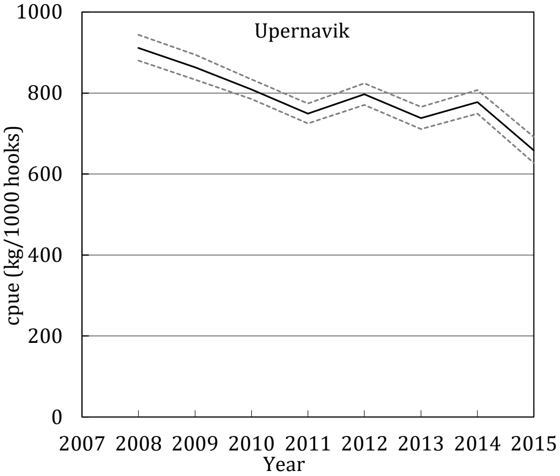
The stocks are believed to recruit from the Subarea 0 + 1 offshore spawning stock (in the Davis Strait) and there is little migration between the separate areas and offshore stocks in SA 0 and 1. Separate advice is given for each area in Subarea 1A inshore.

Stock status

The gillnet survey CPUE showed more fish and larger fish in 2015 than the long-term average in Disko Bay, with considerable numbers in the interval 50-70 cm. Mean length in the landings decreased in 1990s then was stable until 2013, since when it has declined further. The commercial CPUE index has shown an overall downward trend.







Reference points

Could not be established.

Assessment

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

Human impact

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

Environmental impact

Unknown

Fishery

Catches increased since 1985, with a peak of 7012 t in 1998 and a maximum of 7381 t in 2014. In 2015, catches were 6274 t.

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

	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
TAC		5.0	5.0	6.0	6.5	6.5	8.0	9.5	9.5	9.9
STACFIS	4.9	5.5	6.5	5.9	6.5	6.8	6.0	7.4	6.3	

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.

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. 16/014 027 and 037 and; SCS Doc. 16/007.

Greenland halibut in Division 1A inshore - Uummannaq

Advice June 2016 for 2017-2018

Recommendation for 2017 - 2018

Catches have increased substantially since 2002. Scientific Council therefore recommends that there should be no increase in catches beyond the 2007-15 average of 6500 t.

Management objectives

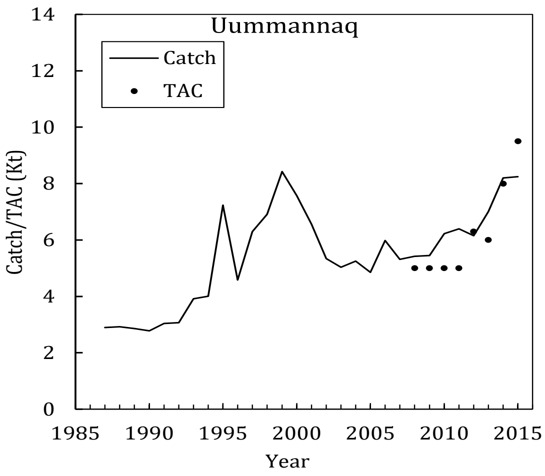
No explicit management plan or management objectives have been defined by the Government of Greenland.

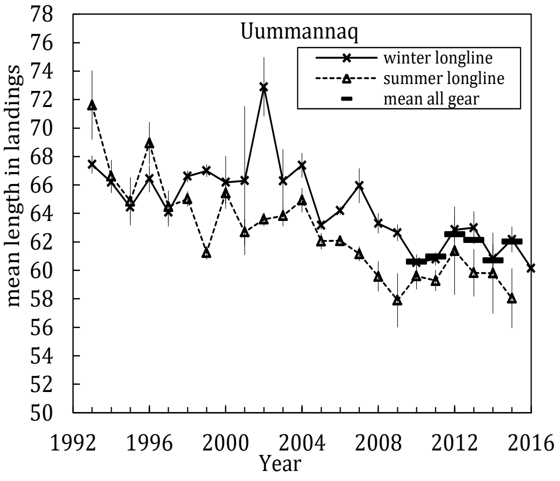
Management unit

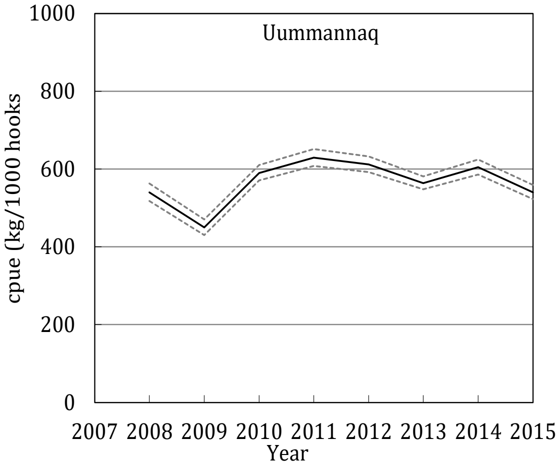
The stocks are believed to recruit from the Subarea 0 + 1 offshore spawning stock (in the Davis Strait) and there is little migration between the separate areas and offshore stocks in SA 0 and 1. Separate advice is given for each area in Subarea 1A inshore.

Stock status

The gillnet survey CPUE showed more fish and larger fish in 2015 than the long-term average in Disko Bay, with considerable numbers in the interval 50-70 cm. Mean length in the landings has gradually decreased, but stabilized in the most recent years. The commercial CPUE index has been relatively stable over the last 6 years.







Reference points

Could not be established.

Assessment

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

Human impact

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

Environmental impact

Unknown

Fishery

Catches increased since 1985, with a maximum of 8425 t in 1999. In 2015, catches were 8244 t.

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

	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
TAC		5.0	5.0	5.0	6.0	6.0	7.4	8.4	9.5	10.0
STACFIS	5.3	5.4	5.4	6.2	6.4	6.1	7.0	8.2	8.2	

Effects of the fishery on the ecosystem

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

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. 16/014 027 and 037 and; SCS Doc. 16/007.

iv) Pandalus borealis east of Greenland and in the Denmark Strait (in conjunction with ICES)

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 2017 and for as many years ahead as data allows for.

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

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

i) Greenland halibut in Div. 0A and the offshore areas of Div. 1A, plus Div. 1B

The Scientific Council is requested, subject to the concurrence of Denmark (on behalf of Greenland) as regards Subarea 1, 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 2016, separately, for Greenland halibut in Divs. 0A+1A (offshore) and 1B, and Divs. 0B+1C-F. The Scientific Council is also asked to provide advice on any other management measures it deems appropriate to ensure the sustainability of these resources.

The Scientific Council responded:

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

Advice June 2017 and 2018

Recommendation for 2017 and 2018

Div. 0A+1AB: Scientific Council advises that there is a low risk of Greenland halibut in Div. 0A and Div. 1AB being below B_{lim} if the TAC for 2017 and 2018 does not exceed 17150 t.

Div. 0B+1C-F: Scientific Council advises that there is a low risk of Greenland halibut in Div. 0B and Div. 1C-F being below B_{lim} if the TAC for 2017 and 2018 does not exceed 15150 t.

Management objectives

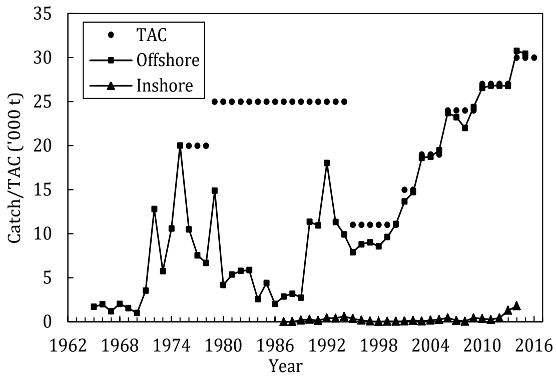
Canada requested Scientific Council to provide advice on this stock within the context of the NAFO Precautionary Approach Framework (SCS Doc 15/02).

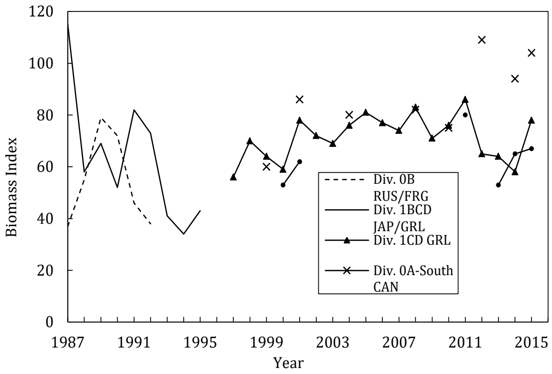
Convention objectives	*Status*	*Comment/consideration*
Apply Precautionary Approach	🟢	Stock well above B_{lim}

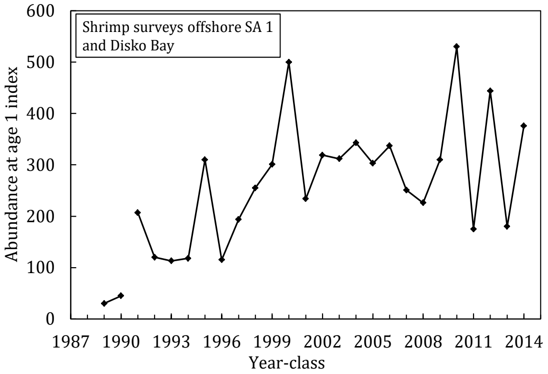
🟢 OK

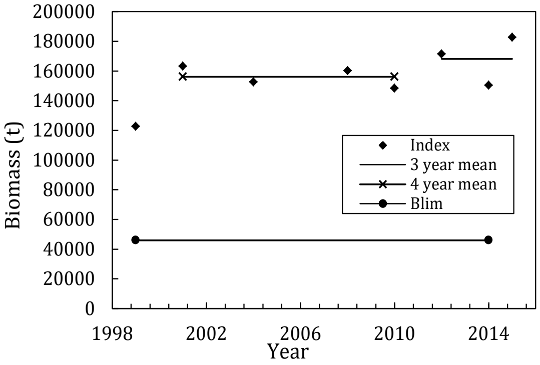
Management unit

The Greenland halibut stock in Subarea 0 + Div. 1A offshore and Div. 1B-1F is part of a population distributed in Davis Strait and southward to Subarea 3, however, two separate assessments are made on this population. 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

Overall the biomass (combined Div. 0A + Divs. 1CD index) has been relatively stable with a slight increasing trend in recent years and was well above B_{lim} in 2015.

Div. 0B+1C-F: The biomass index in Div. 0B has increased from 2013 to 2015 but levels are still below the high observed in 2011. The biomass index for Div. 1CD has been decreasing since 2011 and was in 2014 at the lowest level seen since 1997, but increased to a level above average for the time series in 2015. Length compositions in the catches and deep sea surveys have been stable in recent years.

Div. 0A+1AB: The biomass index has been variable with an increasing trend since 2010. Length compositions in the 1AB commercial catches have been relatively stable in recent years. The trend to increased numbers of larger fish observed in the 0A-South survey from 2008 to 2014 has stopped with a shift to smaller sizes (18-36 cm) in the length distribution for 2015. In the 0A fishery abundance at length declined in the 2015 trawl fishery, compared to 2013 and 2014, and in the gillnet fishery the proportion <62 cm has been increasing since 2013.

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 biomass index estimated for surveys conducted between 1997 and 2012 in Div. 1CD combined with surveys from 1999-2012 in Div. 0A-South to establish a proxy for B_{lim} for the entire stock.

Assessment

Based upon a qualitative evaluation of stock biomass trends compared to the limit reference point and recruitment indices. The assessment is considered data limited and as such associated with a relatively high uncertainty. Input data are research survey indices and fishery data (STACFIS 2016). If TACs are established for the next two years, the next full assessment of this stock is recommended for 2018.

Human impact

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

Biology and Environmental interactions

A study in 2015 showed that year class strength and abundance of Greenland halibut at West Greenland may be driven by environmental pulses.

Fishery

Catches have increased in response to increases in the TAC from approximately 10 000 t in the late 1990s to approximately 27000 t during 2010 to 2012 then increased to 32 000 t in 2014 and 2015. The TAC for 2016 is 30000 t.

Recent catch estimates and TACs are as follows:

	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
TAC	24	24	24	27	27	27	27	30	30	30
SA 0	11	11	12	13	13	13	13	15	15	
SA 1 exl. Div. 1A inshore	12	12	12	14	14	14	15	17	17	
Total STATLANT 21 [1]	22[2]	22	25	27	27	27	28	32	32	
Total STACFIS	23	23	25	27	27	27	28	32	32	

[1] Excluding inshore catches in Div. 1A

[2] Excluding 3565 reported by error from Div. 1D

Effects of the fishery on the ecosystem

The by catch in the commercial fishery for Greenland halibut in NAFO Div. 1CD was estimated based on information from ground fish surveys conducted by Greenland Institute of Natural Resources in the same area as the commercial fishery. The total by-catch in weight is estimated to be 13% of the total catch of Greenland halibut, comprised primarily of roughhead grenadier (*Macrourus berglax),* blue antimora *(Antimora rostrata)* and Agassizz's smoothhead (*Alepocephalus agassizzii)*. The conversion is based on a number of assumptions and the results should be considered as indicative.

A study has shown that the fishery in Div. 1CD has not affected the abundance of the nine most common by-catch species but a decrease in mean weight is observed for a number of the species. General impacts of fishing gears on the ecosystem should also be considered.

Special comments

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. The ICES Harvest Control Rule 3.2 for data limited stocks was accepted as a basis for giving TAC advice. 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. 16/04, 5, 14, 25, 29, SCS Doc. 16/07, 10;

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) further requests the Scientific Council before December 2016 to provide advice on the scientific basis for management of Northern shrimp (Pandalus borealis) in Subarea 0 and 1 in 2016 and for as many years ahead as data allows for.

Scientific Council deferred this advice to the September Scientific Council/NIPAG meeting.

VIII. REVIEW OF FUTURE MEETINGS ARRANGEMENTS

1. Scientific Council, (in conjunction with NIPAG), 7 – 14 Sep 2016

Scientific Council noted that the Scientific Council shrimp advice meeting will be held at the IMR, Bergen, Norway 7-14 September in advance of the 2016 Annual Meeting. The Council noted the NAFO stocks will be addressed first so that the advice will be available to NAFO Contracting Parties on Monday, 12 September, a week in advance of the Annual Meeting.

2. Scientific Council, 19 – 23 Sep 2016

Scientific Council noted the Scientific Council meeting will be held at the Convention Center Plaza America in Varadero, Cuba, 19-23 September 2016.

3. WG-ESA, 8- 17 Nov, 2016

The Working Group on Ecosystem Science and Assessment will meet at the IPMA, Lisbon, Portugal, 8-17 November, 2016.

4. Scientific Council, June 2017

Scientific Council agreed that its June meeting will be held on 1 – 15 June 2017, at Saint Mary's University, Halifax.

5. Scientific Council (in conjunction with NIPAG), Sep 2017

This meeting will be held NAFO Headquarters, Dartmouth, Canada, 6-13 September 2017.

6. Scientific Council, Sep 2017

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 2018

Scientific Council agreed that its June meeting will be held on 1 - 14 June 2018.

8. NAFO/ICES Joint Groups

a) NIPAG, 7-14 Sep 2016

Scientific Council noted the NIPAG meeting will be held at the IMR, Bergen, Norway, 7-14 September 2016.

b) NIPAG, 6 – 13 Sep 2017

This meeting will be held at the NAFO Headquarters, Dartmouth, 6-13 September 2017.

c) WG-DEC, 15 – 19 February 2017

The next meeting of the ICES – NAFO Working Group on Deep-water Ecosystems is scheduled to take place at ICES Headquarters, during 15 – 19 February 2016.

d) WG-HARP, 26-30 September 2016

WG-HARP will continue its work by correspondence. The next meeting of the ICES – NAFO Working Group on Harp and Hooded Seals is scheduled to take place in during 26-30 September 2016.

IX. ARRANGEMENTS FOR SPECIAL SESSIONS

1. Topics for Future Special Sessions

There was one proposal for a symposium. There was some initial discussion of this proposal and a final decision will be taken in September.

X. MEETING REPORTS

1. Working Group on Ecosystem Science and Assessment

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 8th meeting on 17-26 November 2015 at the NAFO Headquarters, Dartmouth, NS, Canada. The detailed outcomes of this meeting are reported in SCS 15/19.

The work of WGESA is organized around two complementary aspects:

a) work intended to advance the "Roadmap for the development of an ecosystem approach to fisheries (EAF) for NAFO" (Roadmap);

b) work intended to address specific requests from Scientific Council (SC) and/or Fisheries Commission (FC).

The overall activities of WGESA are guided by a set of long-term Terms of Reference (ToRs); at each meeting the work is focused on specific topics that fall under these long-term ToRs. These topics are selected on the basis of the overall state of progress of the different Roadmap components, the feedback required by SC on ecosystem-related issues, and the Requests made by FC and/or the FC/SC Working Groups to SC.

Following a request by the SC chair, WGESA organized its work for its 8th meeting so to provide input towards addressing four ecosystem-related Fisheries Commission requests (FC Requests 4, 5, 11, and 15). These FC requests were integrated into the long-term ToRs.

The final form of the ToRs addressed at the 8th WGESA meeting were:

Theme 1: Spatial considerations

ToR 1. Update on identification and mapping of sensitive species and habitats in the NAFO area.

ToR 1.1 (*includes* FC Request 15). Update on VME-related analyses and surveys.

ToR 2. Based on available biogeographic and ecological information, identify appropriate ecosystem-based management areas.

No work was carried out under this ToR.

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

ToR 3. Update on recent and relevant research related to status, functioning and dynamics of ecosystems in the NAFO area.

ToR 3.1. Progress on multispecies and ecosystem analyses.

ToR 3.2. Progress on expanded single species, multispecies and ecosystem production potential modelling.

Theme 3: Practical application of ecosystem knowledge to fisheries management

ToR 4. Update on recent and relevant research related to the application of ecosystem knowledge for fisheries management in the NAFO area.

ToR 4.1. Improving the effectiveness of the science advice process in NAFO.

ToR 4.2 (FC Request 4). Assessment of bottom fishing activities pertaining to the impacts on VMEs.

ToR 4.3 (FC Request 11). Work plan towards the assessment of potential impacts of activities other than fishing on NAFO VMEs.

ToR 5. Methods for the long-term monitoring of VME status and functioning.

ToR 5.1. Preliminary results on the use of non-destructive sampling to monitor VMEs

Theme 4: Specific requests

ToRs 6+. As generic ToRs, these are place-holders intended to be used when addressing expected additional requests from Scientific Council.

ToR 6.1 (FC Request 5). Update of NAFO VME Guide.

In addition to these ToRs, WGESA also explore options for a potential merger of WGESA with STACFEN, updated its long-term ToRs to better reflect the current state of development of the Roadmap, and discussed the renewal of its co-chairs.

In addressing ToR 1, WGESA continued the analysis of data emerging from the NEREIDA program, and updated VME information from the EU and Canadian surveys, including reports on VME and other benthic communities from the 2015 Amundsen expedition to the Arctic. As part of this ToR WGESA addressed FC Request 15 on the results of the Canadian photographic survey for non-coral and sponge VME indicator species on the Grand Bank conducted in 2015.

There was no work directed to ToR 2 during this meeting.

In addressing ToR 3, WGESA made progress on the study of fish communities in the tail of the Grand Bank and Flemish Cap, on the identification of optimal sets of ecosystem indicators using a comparative approach between the Grand Bank and Georges Bank, and updated the information on marine mammals in the Newfoundland and Labrador (NL) bioregion, including estimates of food consumed by key marine mammal species. Also addressed under this ToR were the study of food web structure in NL and Flemish Cap using stable isotopes and the update on ecosystem trends in NL. This last study highlighted the increasing dominance of silver hake among piscivores in the Grand Bank (3LNO) Ecosystem Production Unit (EPU), which appears associated with warmer environmental conditions. This phenomenon has no prior precedent in the Grand Bank, but based on trends observed in southern Newfoundland (3Ps), may have implications for the rebuilding of traditional groundfishes in this EPU.

Several modelling studies were also carried out under ToR 3. These studies included the report on progress of the modelling of Greenland halibut in an ecosystem context in Greenland waters, an extensive examination of the performance of the ongoing GADGET modelling exercise for key components of the Flemish Cap (cod, redfish, and shrimp), and an update of the Ecosystem Production Potential (EPP) modelling work, and its application to develop guidelines for Total Catch Ceilings (TCC). Other studies include a summary of ongoing multispecies and ecosystem modeling efforts in support of ecosystem-based management at the Northeast Fisheries Science Centre, NOAA, as well as research towards a broader incorporation of benthic communities and function into the NAFO Roadmap.

In addressing ToR 4, WGESA discussed results from a recent study on how science advice is used in decision-making in fisheries management organizations, and produced analyses aimed at addressing FC Request 4 and 11. The first one involved the final analysis of the assessment of bottom fishing activities in relation to the risk of Significant Adverse Impacts (SAIs) on VMEs in the NRA, and the second one was focused on the development of a preliminary work plan for the assessment of impacts by activities other than fishing on VMEs in the NRA.

In addressing ToR 5, WGESA examined the preliminary results on the use of non-destructive sampling to monitor VMEs, while under ToR 6 it addressed FC Request 5 related to the update of the NAFO VME guide. This last piece of work resulted in the production of an update NAFO VME Guide.

Beyond these ToRs, WGESA hosted a joint discussion session with STACFEN about the possibility of merging the two groups. The general conclusion was that the merger of STACFEN and WGESA is conceptually a great idea that would enhance the ability of SC to address ecosystem issues in general, and the implementation of the Roadmap in particular. However, the logistics and operational drawbacks involved prevented from finding a viable way for making the merger happen.

Given this outcome, the possibility of merging WGESA with ICES WGNARS was also explored. Conversations held after the WGESA meeting, including communications with ICES and discussions at the 2016 ICES WGNARS meeting concluded with the recommendation from ICES WGNARS for the chairs of both working groups to explore the viability of a merger during the coming year.

Considering the current state of development of the Roadmap, WGESA revised and updated its long-term ToRs. The updates were intended to reflect and capture the current topics and maturity of the Roadmap development process. The updated long-term ToRs proposed by WGESA were:

Theme 1: Spatial considerations

ToR 1. Develop research and summarize new findings on identification and mapping of benthic species, assemblages and habitats in the NAFO Convention area, including but not restricted to VMEs.

ToR 2. In support of the Roadmap, develop research and summarize new findings on the spatial structure and organization of marine ecosystems, with emphasis on connectivity, exchanges and flows among ecosystem units in the NAFO Convention Area.

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

ToR 3. Develop research and summarize new findings related to the linkages between environmental changes and variability on stocks, and community dynamics in NAFO ecosystem units.

ToR 4. Develop research and summarize new findings on the status, structure, trends, functioning, and productivity of ecosystems in the NAFO Convention Area.

Theme 3: Practical application of ecosystem knowledge to fisheries management

ToR 5. Develop research and summarize new findings on long-term monitoring of status and functioning of ecosystem units, and the application of ecosystem knowledge for the assessment of impacts and management of human activities in the NAFO Convention Area.

ToR 6. Develop ecosystem summaries for ecosystem units in the NAFO Convention Area as required, including the provision of information for assessments at the ecosystem, multispecies, and stock level.

Theme 4: Specific requests

ToRs 7+. As generic ToRs, these are place-holders intended to be used when addressing expected additional requests from Scientific Council.

Under these newly proposed ToRs, WGESA identified the following topics to be addressed at the 9th WGESA meeting:

Theme 1: Spatial considerations

ToR 1. Develop research and summarize new findings on identification and mapping of benthic species, assemblages and habitats in the NAFO Convention area, including but not restricted to VMEs.

- ***Update on VME data and VME distribution analyses.***

ToR 2. In support of the Roadmap, develop research and summarize new findings on the spatial structure and organization of marine ecosystems, with emphasis on connectivity, exchanges and flows among ecosystem units in the NAFO Convention Area.

- ***To be determined. No work is currently expected under this ToR.***

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

ToR 3. Develop research and summarize new findings related to the linkages between environmental changes and variability on stocks, and community dynamics in NAFO ecosystem units.

- ***Progress on habitat modelling of zooplankton communities.***

ToR 4. Develop research and summarize new findings on the status, structure, trends, functioning, and productivity of ecosystems in the NAFO Convention Area.

- ***Progress on expanded single species, and multispecies modelling.***
- ***Progress on multispecies and ecosystem analyses.***

Theme 3: Practical application of ecosystem knowledge to fisheries management

ToR 5. Develop research and summarize new findings on long-term monitoring of status and functioning of ecosystem units, and the application of ecosystem knowledge for the assessment of impacts and management of human activities in the NAFO Convention Area.

- ***Progress on the assessment of significant adverse impacts on VME groups not assessed on the 2016 assessment.***

ToR 6. Develop ecosystem summaries for ecosystem units in the NAFO Convention Area as required, including the provision of information for assessments at the ecosystem, multispecies, and stock level.

- ***Work towards developing summary sheets for NAFO ecosystem units.***
- ***Update Guidelines on Total Catch Ceilings for NAFO ecosystem units.***

Theme 4: Specific requests

ToRs 7+. As generic ToRs, these are place-holders intended to be used when addressing expected additional requests from Scientific Council.

- ***To be determined. No work is currently expected under this ToR.***

WGESA also discussed the renewal of its co-chairs. M. Koen-Alonso will step down as co-chair at the SC meeting during the Annual General Meeting in September 2016, while A. Kenny agreed to continue one more year as co-chair and he will be chairing the 2016 WGESA meeting. Unfortunately, there were no confirmed candidates to take over the chairing of WGESA, and the membership of the working group is declining. There are real concerns for the ability and capacity of WGESA to continue addressing its ToRs if this situation is not resolved.

In relation to the date and venue for the WGESA 9th meeting, the proposed dates are November 08-17, 2016. WGESA received an invitation from the Instituto Portugues do Mar e da Atmosfera (IPMA) to held its next meeting in Lisbon, Portugal. WGESA welcomed this invitation, and accepted it in principle, pending approval from SC. Ricardo Alpoim will be acting as local host for this meeting.

In closing his presentation to SC on the work done at WGESA, the outgoing co-chair M. Koen-Alonso, based on his personal experience and the work of WGESA, and by his own accord, suggested SC to consider the following as part of the implementation of the Roadmap:

- Develop summary sheets for ecosystem units, which can complement the stock-specific ones. WGESA could also look into the ecosystem aspects of the stock summary sheets (this was also included in the updated WGESA long-term ToRs).
- These ecosystem summaries could be presented at the SC June meeting as equivalent to full assessments every 3-5 years, with annual monitoring reports.
- Initially, these summaries could be focused on the pilot EAF EPUs, but it would be important to start building them for other NAFO ecosystems (e.g. Scotian Shelf, GSL, Gulf of Maine, Georges Bank, etc).
- SC could identified "Ecosystem Designated Experts" (EDEs) for these ecosystem units, with the expectation that those EDEs will attend the SC June meeting, help WGESA co-chairs on the delivery of the WGESA Report, and present the ecosystem level summaries.
- These EDEs would also increase the crossover of participation between WGESA and SC June meetings, including the connections with STACFEN (e.g. they could attend the 1st week of the SC meeting if they cannot attend the full meeting).

- The work on VMEs is maturing, and work on Tier 1 and Tier 2 of the Roadmap should take a more central stage. As part of this process total catches per EPU, and the associated cumulated TACs could be summarized by STACFIS, and report on how they stand against the estimated TCCs.
- As multispecies models get developed, EDEs could become the point people to handle the analysis, organization, compilation of the trade-offs in each ecosystem.
- It would also be important to keep in mind the Ecosystem-level productivity and multispecies interactions when discussing benchmark exercises and the review on NAFO Precautionary Approach.

Scientific Council considerations

Scientific Council took notice of the progress made by WGESA, and approved new long-term ToRs and the plans for the next meeting in November 08-17, 2016 at IPMA, Lisbon. On the basis of the WGESA work, SC agreed to put forward the updated analysis on Total Catch Ceilings (TCC) to FC/SC WGEAFFM for consideration towards the implementation of the Tier-1 of the Roadmap. In addition to the selected material used in its response to the FC Request 15, SC considered necessary to include in the SC report the full assessment of risk of significant adverse impacts on VMEs from bottom fishing activities. This decision is based on the requirement for this assessment to be completed every 5 years. SC also took notice on the outgoing co-chair suggestion, and will consider them as it see fit. Council also shared the concerns expressed by WGESA that accomplishing the new long-term ToRs, as well as further developments on the Roadmap, may be at risk given the lack of commitment towards taking the co-chair position and the decreasing WGESA membership.

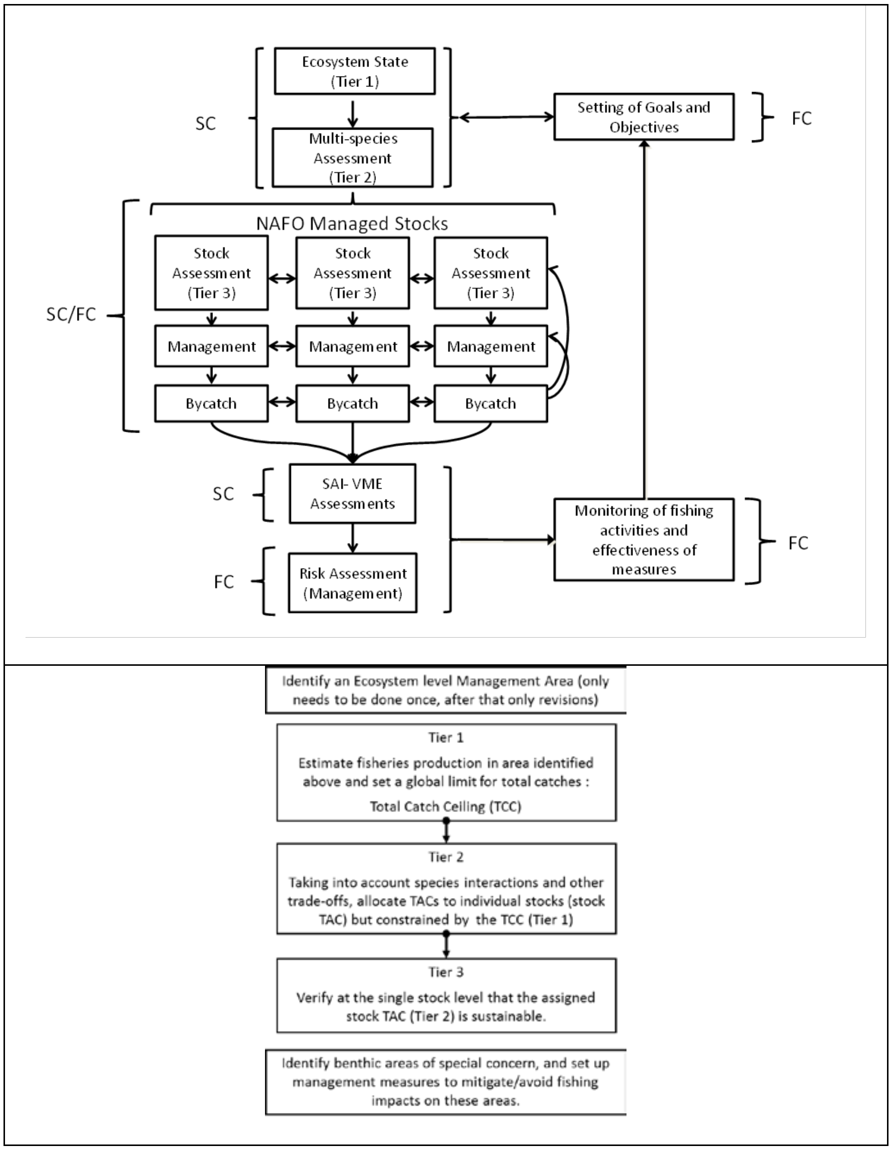
Advances towards the implementations of an Ecosystem Approach to Fisheries for NAFO

Total Catch Ceilings (TCC) guidelines: update, analysis, and implications

Introduction

The Roadmap is the plan that NAFO is following to implement an Ecosystem Approach to Fisheries (EAF) (Fig.7.1). As part of its development, three Ecosystem Production Units (EPUs) have been selected for the implementation of pilot EAF exercises. These EPUs are the Flemish Cap (3M), the Grand Bank (3LNO), and the Newfoundland Shelf (2J3K) (Fig. 7.2).

Within the Roadmap, sustainable levels of exploitation are defined following a nested 3-tiered process (Fig. 7.1). Tier 1 sets a limit for total catches at the EPU level. Tier 2 evaluates the sustainability of catch levels taking into account species interactions and other trade-offs, and under the constraint imposed by Tier 1. Tier 3 examines the sustainability of the catch levels defined by Tier 2 from the single-stock perspective (Fig. 7.1).



Identify an Ecosystem level Management Area (only needs to be done once, after that only revisions)

Tier 1

Estimate fisheries production in area identified above and set a global limit for total catches :

Total Catch Ceiling (TCC)

Tier 2

Taking into account species interactions and other trade-offs, allocate TACs to individual stocks (stock TAC) but constrained by the TCC (Tier 1)

Tier 3

Verify at the single stock level that the assigned stock TAC (Tier 2) is sustainable.

Identify benthic areas of special concern, and set up management measures to mitigate/avoid fishing impacts on these areas.

Fig.7.1. Current working template of the NAFO "Roadmap" (top), with a synoptic overview of the key steps required for using it (bottom). SC: Scientific Council, FC: Fisheries Commission, SAI: Significant Adverse Impact, VME: Vulnerable Marine Ecosystem.

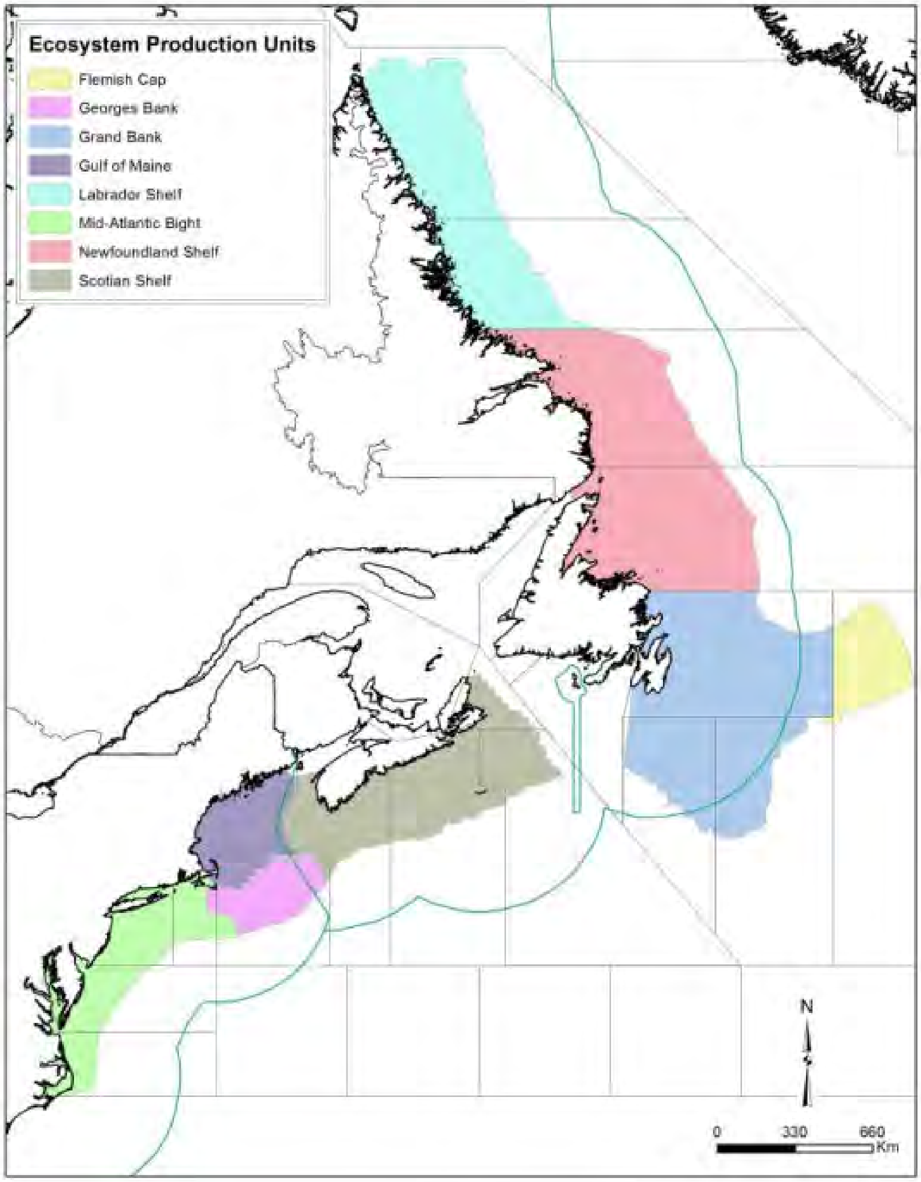


Fig.7.2. Ecosystem Production Units (EPUs) delineated within the NAFO Convention Area; these spatial units are focused on continental shelf ecosystems. These areas are proposed as candidate Ecosystem-level Management Areas. Pilot EAF exercises are been carried out for the Flemish Cap, Grand Bank, and Newfoundland Shelf EPUs.

In 2015, SC produced for the first time a set of Guidelines for Total Catch Ceilings (TCC) for the three EPUs that are currently being targeted for developing pilot EAF exercises. These guidelines were based on the Fisheries Production Potential (FPP) for these systems, estimated through Ecosystem Production Potential (EPP) models, in combination with an evaluation of current productivity state, coarsely approximated by the total biomass estimated in these EPUs from Research Vessel (RV) surveys, and considering the assumption of a relatively constant Biomass/Production (B/P) Ratio at the EPU scale.

This process indicated that the Flemish Cap appears to be producing at its maximum capacity, while the other EPUs still show impaired productivity, which led to use a penalty factor of 50% when setting the TCCs for these systems in the guidelines developed. Current TCC guidelines group FPP into "Standard Demersal Components" (SDC), which aggregates all traditional groundfish and shellfish commercial species, and "Other

Components" (OC), which captures pelagic and benthos species. Catches in the three pilot areas fall almost exclusively within the SDC aggregate.

Key to the process of building a reliable Tier 1 structure, it is the development of EPP models with an adequate level of resolution for the scales involved in this tier, as well as the definition of TCCs for the appropriate aggregates, which can conform to the requirements for Limit Reference Points (LRPs) in the context of the NAFO Precautionary Approach (PA).

SC continued working on improving the EPP models used in Tier 1, as well as on the rationale for using TCC as an LRP. SC also examined the level of resolution at with the TCC advice is provided, to explore if the additional insights can be gained by exploring more disaggregated TCC levels.

An updated Ecosystem Production Potential (EPP) model

In 2016, SC adopted an updated structure for the Ecosystem Production Potential (EPP) models (Fig. 7.3). Key changes in the updated model structure includes the discrimination of benthos into suspension-feeding and deposit-feeding benthos (allows for a better representation of the benthos production that sustain fisheries, the suspension-feeding benthos), the explicit consideration of nanoflagellates as a node within the microbial loop, a better representation of the bentho-pelagic coupling (link between bacterial production and deposit-feeding benthos), and the addition of the possibility for harvesting at the mesozooplankton trophic level (e.g. krill fisheries). Comparison runs with the previous model structure indicated very little difference in the productivity of most exploitable nodes, but highlighted an important increase in overall benthos productivity. From the perspective of the pilot EAF exercises being developed for the Flemish Cap, Grand Bank and Newfoundland Shelf EPUs, the differences between the two model configurations have only minor impacts, suggesting that production potential of upper trophic levels appears reasonably captured.

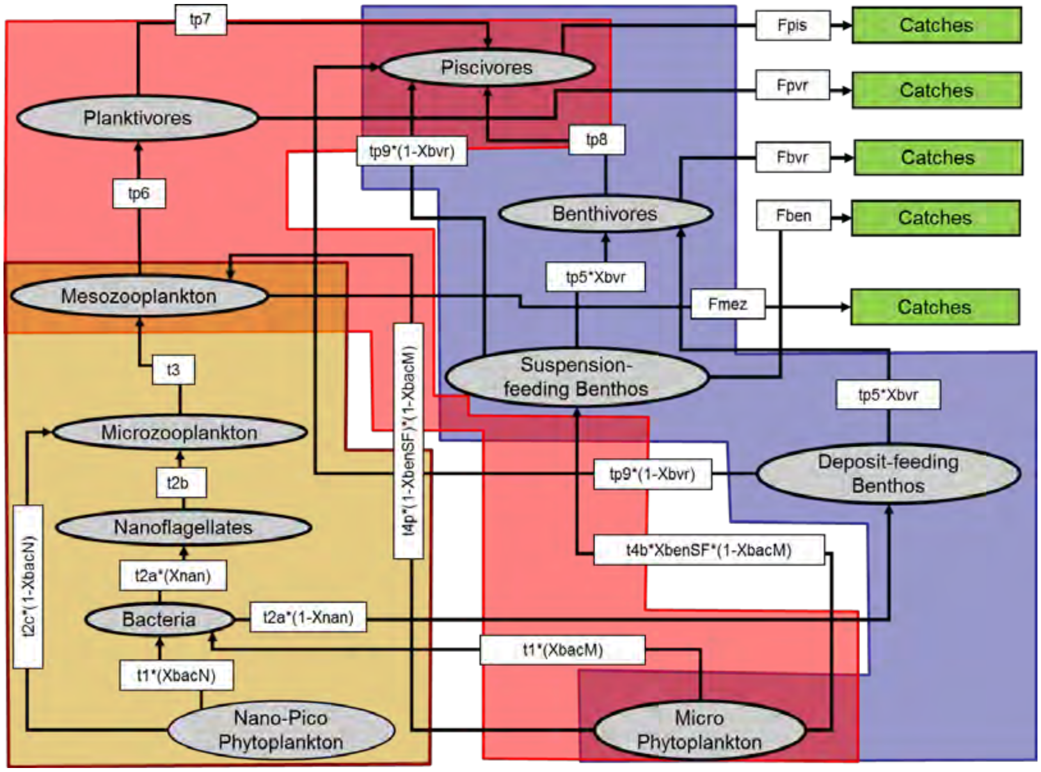


Fig. 7.3. Model structure for the updated EPP model. The labels in the arrows indicate the specific parameters regulating these connections. Although this model structure allows for estimating FPP on mesozooplankton (e.g. krill fisheries), all exercises have assumed no fishing on this model component. In terms of energy pathways, the blue background corresponds to the benthic pathway, the red one corresponds to the traditional pelagic pathway, and the brown one corresponds to the microbial loop.

Developing TCC as an ecosystem level Limit Reference Point (LRP)

The overall process to estimate FPP is summarized in Figure 7.4. Key to the estimation of FPP is the selection of an ecosystem-level exploitation rate that can be considered sustainable. The 2015 guidelines used a range of exploitation rates of 20-30%, where these values were proxies for the range of *f-ratio*, the ratio between new and total primary production, which has been suggested as an upper limit for sustainability in these kinds of analyses. Due to the scarcity of *f-ratio* estimates, it is common to use the ratio of microplankton to total primary production as a first-order approximation. Rosenberg et al. (2014) compiled microplankton/total production values for large marine ecosystems around the world. On this basis, the median of all these values was used as maximum sustainable exploitation rate for the model runs. This value was 20%.

Using this maximum exploitation rate, together with a similar suite of assumptions as in the 2015 guidelines (50% of pelagics, and 10% of suspension-feeding benthos are considered of commercial interest; the productivity of the Grand Bank and Newfoundland Shelf is impaired, so a 50% penalty was applied to these EPUs), an updated set of TCCs was generated.

These TCC estimates are not expected to be updated annually. The EPP models are not dynamic, and they should be used to set overall limits that can be revised periodically (e.g. every 3/5 years) to keep them reflecting the current productivity level of the ecosystem, but tracking short-term interannual variability is beyond the scope of these models. The resolution of analyses at the Tier 1 level is aimed to provide an overall envelope for sustainable levels of exploitation, not to provide precise figures. The goal is to get the overall magnitude right; the nested Tiers 2 and 3 are the ones that should narrow down exploitation rates.

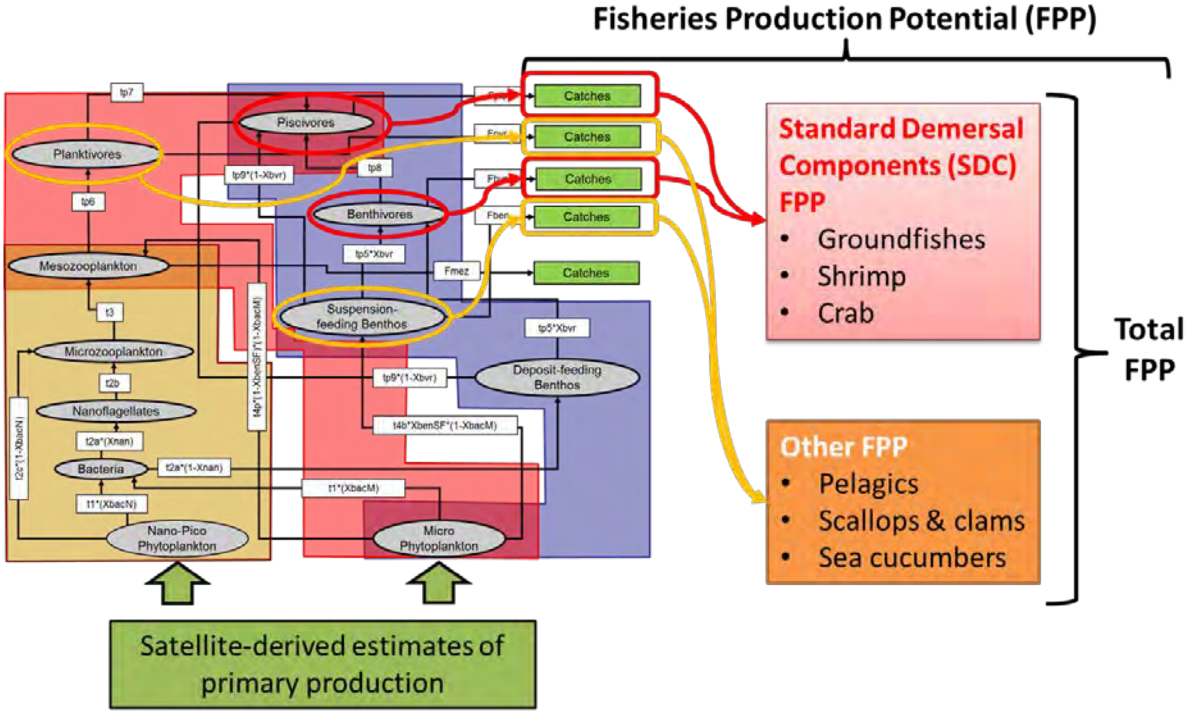


Fig. 7.4. Schematic depiction of the process to estimate FPP from the EPP model, including the discrimination between SDC and Other FPP.

TCC values represent upper limits for exploitation; fishing above TCC may hinder ecosystem functionality and cannot be considered sustainable. TCCs represent Limit Reference Points (LRPs). The NAFO Precautionary Approach (PA) requires having a low probability of exceeding any LRP (it uses 20% as an illustrative example). Since transfer efficiencies in the EPP model (Fig. 7.3) are modelled as distributions, the process defined in Fig. 7.4 renders distributions of FPP values. Therefore, these emergent FPP distributions can be used to define a LRP value that has a low probability of exceeding the actual maximum level of sustainable exploitation represented by the entire distribution. For example, if we choose the median of that distribution as LRP, then there is 50% probability that the true TCC value is above the selected LRP. This probability level cannot be considered a low probability. Furthermore, a LRP defined higher than the median of the distribution would not comply with **any** definition of "low probability" as required by the NAFO PA framework. Following this rationale, SC used the 25th percentile of the distribution as the value for the LRP. This level will ensure that, if catches actually get to the LRP level, there would still be a 75% probability that the catches have not exceeded the true underlying level of maximum sustainable exploitation. This would ensure that the LRP implemented is consistent with NAFO PA principles.

The estimated fisheries productivity was aggregated into SDC and Other Components (OC), and following the *rationale* described above, the 25th percentile of the TCC distributions was used as LRP guidelines for these aggregates (Table 4.1). For information the median is also presented. All current NAFO fisheries are targeting species within the SDC aggregate.

In the Flemish Cap (3M), there are NAFO managed fisheries, while in the Grand Bank (3LNO) and Newfoundland Shelf (2J3K) there is a combination of NAFO and DFO (Canada) managed fisheries. SC compared total catches in these EPUs with the proposed TCC Guidelines, including a preliminary compilation of the cumulated TACs in these ecosystem units, both from NAFO and DFO managed fisheries (Fig. 7.6). The cumulated TAC compilation was done under several assumptions (e.g. when a TAC is given for a stock that straddles across EPU boundaries, the fractions in the catches between EPUs was used to split the TAC between EPUs), so they should only be considered illustrative at the present time.

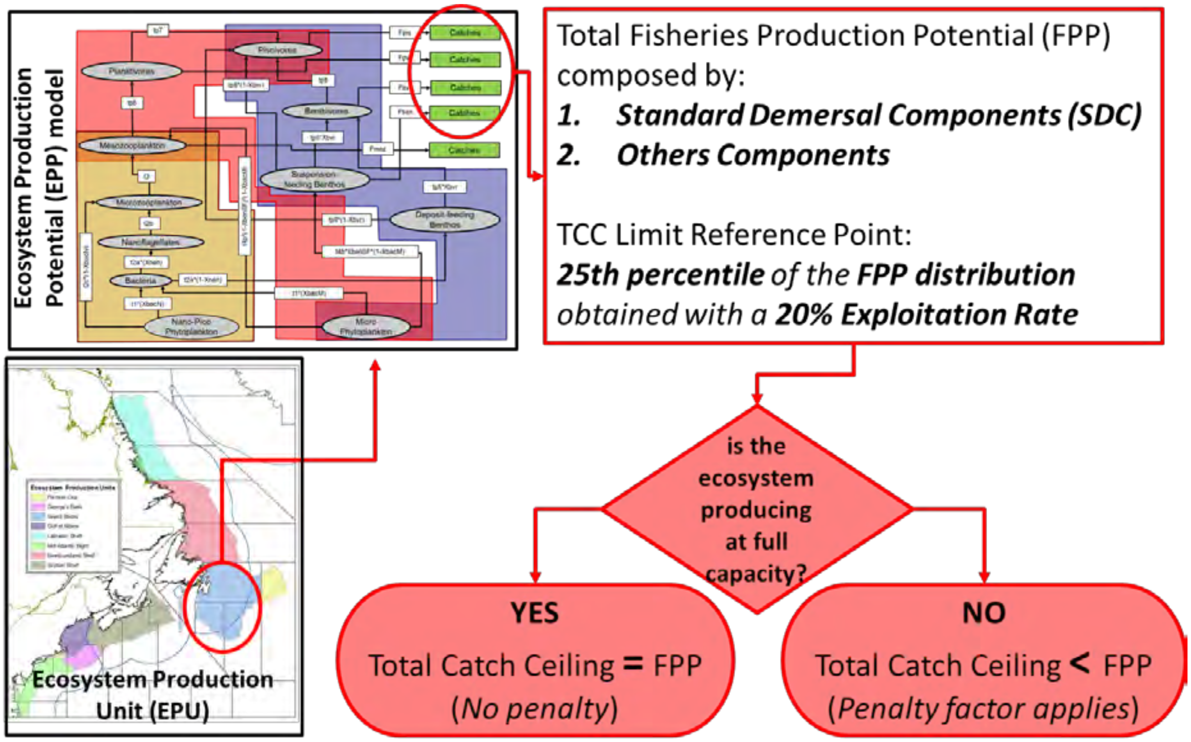


Fig. 7.5. Schematic depiction of the process to derive TCC LRPs from the FPP estimated using the EPP model, including the discrimination between SDC and Other FPP.

Table 4.1. Updated guidelines for Total Catch Ceilings (TCC) for the Flemish Cap (3M), Grand Bank (3LNO), and Newfoundland Shelf (2J3K) Ecosystem Production Units (EPUs). TCCs are provided for the Standard Demersal Components (SDC) and Other Components (OC) aggregates of species. SDC includes traditional groundfish stocks as well as shellfish species (e.g. Atlantic cod, Greenland halibut, American Plaice, Redfish, Yellowtail flounder, Witch flounder, Northern Shrimp, snow crab), while the OC includes pelagic and benthic species (e.g. capelin, herring, scallops, sea cucumbers).

	Standard Demersal Components (SDC)		**Other Components (OC)**	
	TCC LRP Guideline (25th percentile of TCC distribution)	Median (50th percentile of TCC distribution)	**TCC LRP Guideline** (25th percentile of TCC distribution)	Median (50th percentile of TCC distribution)
Flemish Cap EPU (3M)	**52,000 tonnes**	83,000 tonnes	**75,000 tonnes**	115,000 tonnes
Grand Bank EPU (3LNO) (penalty factor: 50%)	**116,000 tonnes**	186,000 tonnes	**170,000 tonnes**	259,000 tonnes
Newfoundland Shelf EPU (2J3K) (penalty factor: 50%)	**87,000 tonnes**	140,000 tonnes	**130,000 tonnes**	202,000 tonnes

The comparative analysis between catches and TCC levels for the Flemish Cap, Grand Bank, and Newfoundland Shelf indicates that total catches are currently at or below the LRP guideline level for the SDC aggregate. However, the time series of catches clearly shows that total catches have been above the LRP guideline in the 2000s, suggesting the overall exploitation levels of these ecosystem units has been until recently beyond what can be considered sustainable at ecosystem level. The preliminary comparison of the TCC LRP and cumulated TACs also shown that in the early 2010s, the cumulated TACs exceeded the LRP guideline, but in recent years these cumulated TACs have come down below the TCC LRP. Some of these reductions in total catches and cumulated TACs are associated with the declines in shrimp stocks and the closing of these fisheries.

These simple comparisons indicate that current total catches at SDC aggregate scale are within a sustainable envelope. From an SDC perspective, catches in the Flemish Cap appear well within a sustainable level, while catches in the Grand Bank and Newfoundland Shelf appear close to the LRP level, suggesting that total catches in these systems should not be increased.

Furthermore, it would important for furthering the implementation of the Tier 1 of the Roadmap, which would include managing against a TCC LRP, that cumulated TACs within these ecosystems units are routinely compiled, presented, and considered as part of the management process.

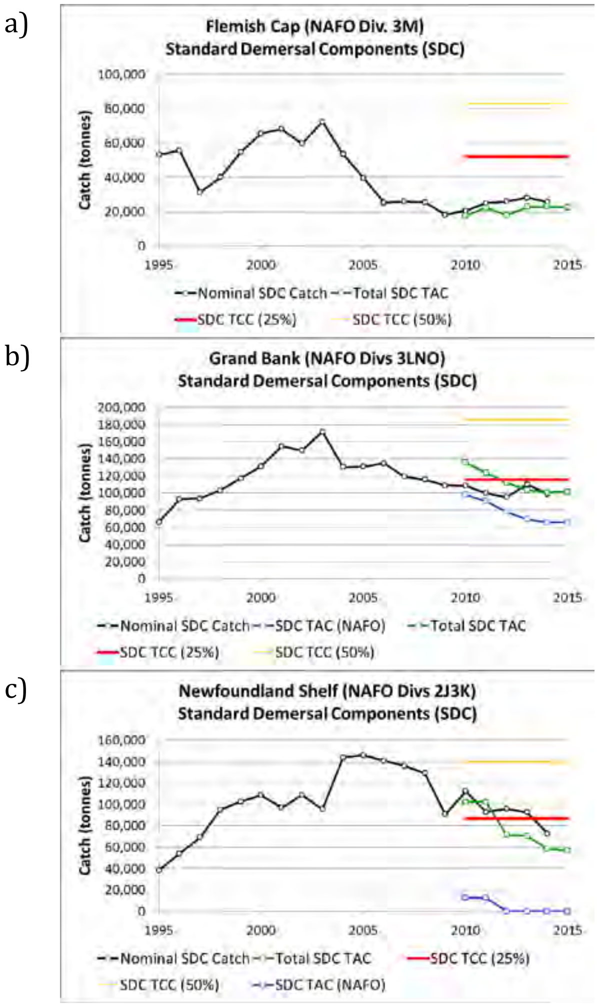


Fig.7.6. Comparisons of total nominal catches with the LRP Guideline (SDC TCC 25th percentile), the median of the TCC distribution (SDC TCC 50th percentile) and the cumulated Total and NAFO TACs corresponding to SDC stocks for a) the Flemish Cap, b) Grand Bank, and c) Newfoundland Shelf EPUs. The cumulated TAC values should be considered illustrative, and are subject to revision.

Preliminary exploration of TCC within the SDC aggregate

The EPP models provide a bird's eye view of the productivity at the ecosystem level. Even though most species can be coarsely assigned to the different nodes in the EPP models, reality is that many species actually spend stages/periods of their life history in different nodes. This is the rationale behind combining the piscivore and benthivore nodes within a single SDC aggregate for the purpose of advising on TCC values.

However, aggregating nodes has the potential drawback of hiding imbalances in the distribution of catches within an aggregate. For example, if all catches within SDC are directed to a single benthivore stock, the total catch level would appear as sustainable, even though the benthivore node itself and the specific stock being targeted would likely be overfished.

The Tiers 2 and 3 of the Roadmap are designed to address these issues, but until they are fully implemented and integrated, looking into TCC levels for each node can provide some insights on how sustainable the distribution of catches might be from an ecosystem level perspective. This exploration is possibly pushing the EPP models to their limit. We should be aware that we are exploring a scale and resolution for which ignoring those life history aspects that define how a stock productivity is partitioned among nodes would limit our ability of making strong inferences from the analysis. However, in the absence of Tier 2 models that could shed some light at this level, and considering that most fisheries are directed to adult fishes which would largely be producing within a given node, then this exploration can be useful for complementing the advice.

In this context, the TCC reference points were calculated for each one of the two nodes within SDC, piscivores and benthivores, and nominal catches were compared with them. These results are conditional to how some key commercial species have been assigned to the nodes in the EPP model (Table ##.2, Fig. ##.3). These assignations have been based on life history characteristics, as well as diet and stable isotope information, but they are not perfect. Depending on the specific stock, the actual matching of stock productivity within the assigned EPP node productivity would vary, and the analyses explored here assume a complete match.

Table 4.2. Assignations to EPP model nodes of key commercial species

Species	Node in EPP Model
American Plaice	Benthivore
Atlantic Cod	Piscivore
Capelin	Planktivore
Redfish	Piscivore
Greenland Halibut	Piscivore
Northern shrimp	Benthivore
Snow Crab	Benthivore
Witch Flounder	Benthivore
Yellowtail Flounder	Benthivore

The comparison between catches and TCC levels at the piscivore and benthivore node level clearly suggest that catches within the SDC aggregate appear unbalanced (Fig. 7.7). In the Flemish Cap EPU all catch is associated with piscivore node stocks (Fig. 7.7a); total catches are beyond the median TCC level estimated for this node, suggesting that piscivores are currently been overfished from an ecosystem scale perspective. Since a major driver of this result is the assignation of redfish to the piscivore node, and given the important trophic connection between cod and redfish in this EPU, the simple additive nature of this analysis would not be expected to fully reflect the overall implications for sustainability at the within node level. In these case, elucidating the full picture would require considering multispecies interactions.

In the Grand Bank EPU current catch levels appear reasonably balanced, with piscivores appearing fully exploited, and with some space for a small increase in catches on the benthivores node (Fig. 7.7b). However, this ecosystem shows a history of benthivores fully exploited since 2000, while piscivores show a period of important of overfishing between the late 1990s and mid 2000s (Fig. 7.7b).

In the case of the Newfoundland shelf EPU, catches also show indications of unbalance exploitation within the SDC aggregate during the last couple of decades. Benthivore catches have been consistently above the sustainability boundary at the EPP node level, only falling within it in 2014 (Fig. 7.7c). On the other hand, piscivore catches have been well within the sustainability envelope since the mid 1990s.

Overall, and taking into account these exploratory results together with the estimates catches and LRPs at the SDC aggregate level, it appears that current catch levels in the Grand Bank and the Newfoundland Shelf EPU are currently within the sustainability envelope, but with little space for growth with perhaps the only exception of piscivores in 2J3K.

The case of the Flemish Cap EPU is quite different. Overall catches at the SDC aggregate level appears well within sustainable bounds, but because this catch is severely biased towards piscivores, the sustainability at the ecosystem levels may be in jeopardy. To prevent impacts on this ecosystem unit, it would be advisable to moderate catches on cod, redfish or both.

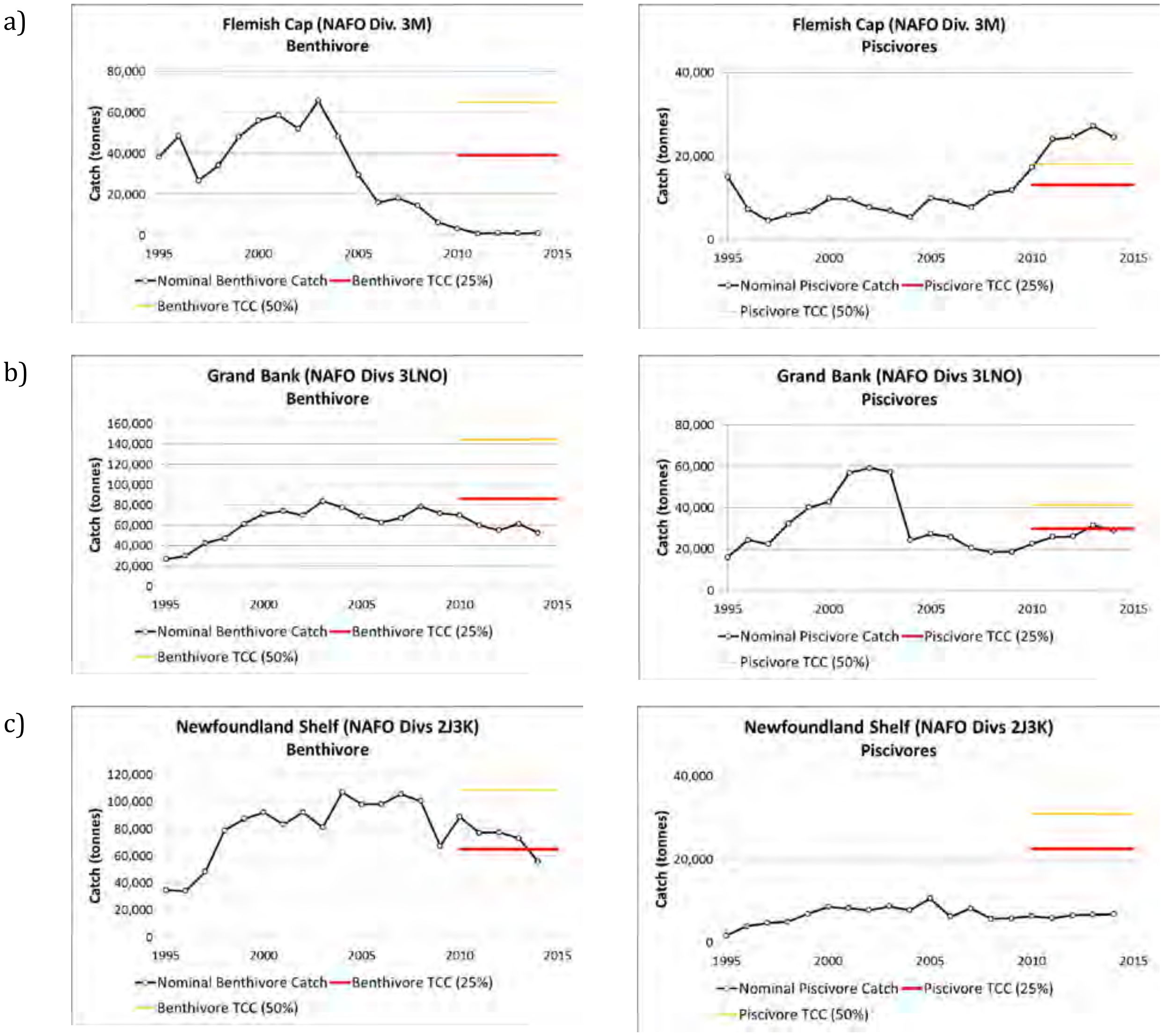


Fig. 7.7. Comparison of total nominal catches and TCC values at the scale of the piscivore and benthivores nodes in the EPP models. The two TCC values considered correspond to the 25th percentile of the TCC distribution (TCC 25%) (which correspond to the level of LRP guideline in the TCC guidelines), and the median of the TCC distribution (TCC 50%) for a) the Flemish Cap, b) Grand Bank, and c) Newfoundland Shelf EPUs.

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. and 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.

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

There was no NAFO participation in this meeting in 2016. The meeting report can be found on the ICES website.

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

The co-chair Carsten Hvingel presented the report of WG-RBMS to the Council. The WG provided timelines and suggestions for prioritization of the work for 1). The revision of the PA framework, 2). The 2J+3KLMNO Greenland halibut MSE review, 3). the 3M Cod Benchmark Assessment and MSE.

SC considerations and decisions:

Ad. 1). The revision of the PA framework: The SC will discuss the timeline for the PA framework review in September.

Ad. 2). The 2J+3KLMNO Greenland halibut MSE review: The SC noted that the timeline for the MSE review has to be changed since the assessment could not be done this year. It is likely that the timeline will be extended by at least one year. This assumes that catch is estimated by September and a new assessment conducted by June 2017 (see response to Item 12).

Ad. 3). the 3M Cod Benchmark Assessment and MSE: SC endorsed the timeline proposed by WG- RBMS for the 3M cod benchmark assessment with minor editorial changes and discussed a plan for the benchmark process including the resources and expertise required to complete it. SC also discussed the main points to be reviewed during the benchmark. SC notes that in order for the benchmark to proceed, CPs must contribute scientific experts in relevant fields and must participate in the benchmark process as outlined in the calendar.

4. Report from ad hoc Joint Working Group on Catch Reporting (WG-CDAG)

The SC Chair presented the work done to date by the CDAG. The Group had examined the various sources of data to estimates catch and made some direct comparisons for trips which had all sources of data available. The CDAG report was not final at the end of the SC meeting, so SC chair will make a presentation of the final text at the September SC meeting. The SC also reviewed a presentation on a proposed study to fully document the methodologies in place by all actors involved in the process of obtaining tow catch estimates in the four data-gathering processes identified, together with the development of a common standard protocol to estimate catches. The SC endorsed the study.

5. Meetings attended by the Secretariat

a) The Fisheries and Resources Monitoring System (FIRMS)

The Fisheries and Resources Monitoring System (FIRMS) Technical Working Group (TWG5) met for their fifth session over from the 29 February to 1 March, 2016 in Rome, Italy, at the FAO Headquarters. The meeting was opened and chaired by Marc Taconet, FIRMS Secretary. NAFO was represented by Dayna Bell, Scientific Information Administrator, and Mark Harley, Data Manager. The chair welcomed the FIRMS members from NAFO, the Commission for the Conservation of Antarctic Marine Living Resources (CCAMLR), the Food and Agricultural Organization of the United Nation, Fisheries and Aquaculture Department (FAO-FI), the Inter-American Tropical Tuna Commission (IATTC), and the South East Atlantic Fisheries Organization (SEAFO). Additionally, associate members and observers were welcomed from Western Central Atlantic Fishery Commission (WECAFC), the Fishery Committee for the Eastern Central Atlantic (CECAF), the FAO-FI, and the Organisation for Economic Co-operation and Development (OECD).

The issues focused on by the group were:

- The future perspectives for the FIRMS partnership. Specifically, the FIRMS target audience and FIRMS branding;
- Inventories minimum data requirement;
- The traffic light approach for the FIRMS State and Trend standard descriptors;
- FIRMS stocks and fisheries map viewer; and
- The Global Record of Stocks and Fisheries (GRSF).

The final report will become available on the FIRMS website (fao.firms.org) later in 2016.

b) FAO review of bottom fisheries in the High Seas

As part of FAO's ABNJ Deep Seas Project, FAO are updating their 2009 publication *Worldwide Review of Bottom Fisheries in the High Seas*. The aim is to update the information presented in the 2009 report with information relating to the years 2009 to 2015, highlighting changes that have occurred in the management regimes governing ABNJ bottom fisheries. Fisheries to be covered include those for bottom-associated species at all depths, not just those targeting deep-water species or using bottom contacting gears.

NAFO was represented by SC coordinator Tom Blasdale. Also present were representatives from NEAFC, CCAMLR, GFCM, NPFC, FAO and consultants Trevor Kenchington and Tony Thompson. A draft version of the report, including regional chapters (with the exception of regional chapters for the Northwest and Northeast Atlantic) was circulated in advance of the meeting. SEAFO, SPRFMO and SIOFA were unable to send representatives in person but instead, sent comments on the draft regional chapters for their respective regions. The purpose of this meeting was to:

- review and discuss a draft of the report, in particular, the regional chapters,
- Identify information that RFMO and other regional experts can contribute
- Agree a work plan going forward.

Because the chapter for the Northwest Atlantic had not been completed in time for the meeting, it was not possible to review text on this section however, the NAFO SC coordinator gave a short presentation on fisheries in Northwest Atlantic ABNJ which will inform the regional chapter when it is drafted.

A revised draft of the report will be presented to UNGA and circulated to RFMOs for review in August 2016 and it is expected that the final report will be published before the end of 2016.

XI. REVIEW OF SCIENTIFIC COUNCIL WORKING PROCEDURES/PROTOCOL

1. General Plan of Work for September 2016 Annual Meeting

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

2. Other matters

No other issues were raised

XII. OTHER MATTERS

1. Designated Experts

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

2. Stock Assessment Spreadsheets

It is requested that the stock assessment spreadsheets and input data be submitted to the Secretariat as soon after this June meeting as possible. The importance of this was reiterated by STACREC. The Secretariat will remind Designated Experts of this request by mid-July.

3. Scientific Merit Awards

No nominations were received.

4. Budget Items

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

XIII. ADOPTION OF COMMITTEE REPORTS

The Council, during the course of this meeting, reviewed the Standing Committee recommendations. Having considered each recommendation and also the text of the reports, the Council **adopted** the reports of

STACFEN, STACREC, STACPUB and STACFIS. It was noted that some text insertions and modifications as discussed at this Council plenary will be incorporated later by the Council Chair and the Secretariat.

XIV. SCIENTIFIC COUNCIL RECOMMENDATIONS TO GENERAL COUNCIL AND FISHERIES COMMISSION

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

XV. ADOPTION OF SCIENTIFIC COUNCIL REPORT

At its concluding session on 16 June 2016, 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 of 03 -16 June 2016 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 16 June 2016.

Appendix I. Report of the Standing Committee on Fisheries Environment (STACFEN)

Chair: Andrew Cogswell Rapporteur: Gary Maillet

The Committee met at the Sobey School of Business (Unilever Lounge), Saint Mary's University, 903 Robie St., Halifax, NS, Canada, on June 6, 2016, 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), France, Portugal, and Spain), Japan, Russian Federation, and USA.

Highlights of Climate and Environmental Conditions in the NAFO Convention Area for 2015

a) Meteorological and ice conditions

- The North Atlantic Oscillation Index, a key indicator of climate conditions on the NL Shelf, remained in a positive phase in 2015 at 2 SD above normal, a 120-year record. This resulted in strong arctic air outflow in the northwest Atlantic during the winter months and consequently lower than normal winter air temperatures.
- The annual mean air temperature at Nuuk weather station in West Greenland was -2.9°C in 2015, which was -1.5°C below the long-term mean (1981-2010).
- During the winter months, surface air temperatures in the Labrador Sea were -1.37 °C below normal.
- Arctic air outflow during the winter increased over the previous year causing a significant decrease in air temperatures (-0.7 to -1.5 SD below normal) over much of the NL region.
- Annual air temperatures over Labrador (at Cartwright) were below normal (-1.2 SD) as were annual anomalies from Iqaluit (-1.3 SD), Nuuk (-1.0 SD), Bonavista (-0.5 SD) and St. John's (-1.0 SD). The cumulative annual air temperature index for the five sites was below normal in 2015, reaching the lowest value since 1994.
- 2015 was ranked as the 35th warmest year (air temperature) for the 116 year time series for the Scotian Shelf and Gulf of Maine. While the cumulative annual anomaly was near normal, there was a strong seasonal signal at all locations, with an anomalously cool winter followed by an anomalously warm summer.
- In 2015, there was greater than normal ice cover in the north over Davis Strait and Northern Labrador Sea. Mostly drifting ice and approximately normal ice conditions on the Labrador Shelf.
- Sea ice on the NL shelf experienced the second consecutive year above normal extent. Prior to 2014, ice extent was below normal for 16 years. Monthly ice extent anomalies were larger than normal in March and April and slightly below normal for the remainder of the year.
- There were 1165 icebergs detected south of 48°N on the Northern Grand Bank in 2014 (0.6 SD above normal), the 12th highest count since 1900.
- For the second consecutive year, ice coverage and volume on the Scotian Shelf in 2015 were above the 1981 – 2010 average.

b) Temperature and salinity conditions

- Annual sea surface temperatures (SST) ranged from about normal to as much as 1 SD below normal in some areas of the Northwest Atlantic.
- In 2015, the water temperature and the salinity of the ISW was 5.4°C and 34.93, which was 0.31°C below and 0.01 above the long-term mean, respectively.
- In 2015, the temperature of the North Atlantic Deep Water (NADW – 2000 m) decreased and salinity increased, and were 0.03°C below and 0.02 above the long-term mean, ending a recent trend of increasing temperatures.
- After a positive temperature trend between 2009 and 2014, the June 2015 temperature at Fyllas Bank Station 4 experienced a significant drop to levels which have not been observed since the early 1990´s; with temperatures 0.84°C lower than the long-term mean (1981–2010, Tmean=1.69°C). Conversely, the salinity of the Coastal Water continued its positive trend, which started around 1970. In 2015 salinity was 0.29 above its long-term mean (Smean=33.27).
- Sea Surface temperature anomalies were negative in all regions of the Labrador Sea for most of the year.
- The 2015 convection (1850 m) is the deepest since the 2400 m record-deep convection observed in 1994. It produced the largest year class of Labrador Sea Water (or Labrador Sea Water year class) in the past two decades (21 years).
- Considerable seasonal variability in SST was observed at Station 27, with a strong negative anomaly during the spring and strong positive anomalies observed from June to late November.
- Annual bottom temperatures (176 m) at Station 27 were -0.2°C (0.7 SD) below normal, the lowest since 1995. Annual bottom salinity at Station 27 was -0.1 (1.4 SD) below the long-term mean.
- The area of the CIL (<0°C) on the Grand Banks during the spring was at its highest level on record (+2.2 SD) but warmed to near-normal by summer and below normal by late fall.
- Spatially averaged spring bottom temperatures in NAFO Div. 3P remained above normal by about 0.5°C (0.8 SD). Spring bottom temperatures in NAFO Divs. 3LNO were about normal. Fall bottom temperatures in 2J and 3K were slightly above normal by 0.2 and 0.7 SD, respectively, but slightly below normal (-0.4 SD) in 3LNO.
- A composite climate index for the NL region decreased to the 7th lowest in 66 years, the lowest since 1993.
- The spatial extent of the CIL (<3°C) covered the Flemish Cap survey area during the summer of 2015 for the first time since 1995 and average thickness of the CIL was the highest since 1993 at about 70 m thicker than normal.
- During the summer of 2015 the Flemish Cap CIL minimum observed core temperature was the coldest in the observational record at -2°C below normal. The average CIL temperature was also at a record low of -1°C below normal.
- SST annual anomalies on the Scotian Shelf were mostly positive (7 of 8 locations) in 2015, averaging 0.6 SD above normal. Temperature conditions were similar to 2014 levels with the exception of a decrease to below normal conditions in the Bay of Fundy.
- In 2015, the annual temperature anomaly at Prince 5 in Bay of Fundy was +0.3°C (+0.6 SD) and the salinity anomaly was +0.2 (+1.1 SD). These represent changes of -0.4°C and +0.1 from the 2014 values.
- In 2015, the observed CIL volume on the Scotian Shelf was 4100 km^3, 1.2 SD less than the 1981-2010 mean value of 5500 km^3, being the 7th lowest volume in the 42 years of surveys.
- The composite index indicated that 2015 was the fifth warmest of 46 years, with an averaged normalized anomaly of +1.2 SD relative to the 1981-2010 period.
- Relative to historical values, regional ocean temperatures across the NEUS shelf were warm during 2015. Annually, waters in the upper 30 meters were between 0.3-1.4°C warmer than normal everywhere, with the largest anomalies occurring in the Middle Atlantic Bight. Of the seasons sampled, warming was most pronounced during late-summer/early-fall, particularly in the Middle Atlantic Bight where regional temperature anomalies exceeded 2°C all the way to the bottom.

- The extreme temperature and salinity anomalies observed during summer and fall were presumably caused by a procession of Gulf Stream warm core rings, whose interaction with the topography at the shelf break drove an incursion of Gulf Stream water onto the shelf between spring and fall of this year
- Slope waters entering the Gulf of Maine through the Northeast Channel were anomalously warm and salty, consistent with the properties characteristic of Warm Slope Water derived from subtropical origins.

c) Biological and chemical conditions

- Corresponding to a sustained increase in Dissolved Inorganic Carbon, pH in the central part of the Labrador Basin continues to show a sustained rate of decline since 1996 in the newly ventilated water masses of the central part of the Labrador Basin (150 – 500 m).
- During the 2015 May AZOMP survey, there was a pattern of high phytoplankton abundance in the eastern half of the Labrador Sea.
- The anomalously low abundance of mesozooplankton observed in May of 2015 in the Labrador Sea was due to net clogging, almost from the base of the Labrador Shelf eastward to the Greenland Shelf, likely as a consequence of the exceptionally intense spring bloom.
- Deep (>50m) nitrate inventories continue to remain well below normal in 2014-2015 over the southern Labrador and Newfoundland Shelf and Grand Bank (ongoing since 2008) while levels have increased above the long-term mean throughout the Gulf of St. Lawrence and generally near or above normal along the Scotian Shelf.
- In general, the magnitude and amplitude of the spring bloom inferred from remote sensing data were significantly higher in northern sub-regions but lower over the Gulf of St. Lawrence and north-eastern Newfoundland Shelf and Grand Bank in 2015.
- The onset of the spring bloom was delayed over many of the sub-regions with the exception of northern areas and estuary in Gulf of St. Lawrence.
- Despite the extensive bloom over the Labrador Sea, the duration of the spring bloom was typically below normal compared to the reference climatology in 2015.
- A large increase in abundance of *Pseudocalanus* spp. was observed in 2015 over much of the northern transects and fixed stations and throughout the Gulf of St. Lawrence.
- A steady decline in the abundance in *C. finmarchicus* is continuing in 2015 and previous years throughout the northwest Atlantic.
- Total copepods and non-copepods functional groups show similar trends with a small increase over the time series except for Gulf of St. Lawrence with exceptional levels in 2014-2015.
- The biological composite index, summarizing combined lower trophic indices indicated the largest dynamic changes were associated with the Gulf of St. Lawrence while the smallest changes were observed on the Grand Bank – Flemish Cap.
- The composite index shows opposing trends between the Newfoundland and Labrador Shelves and Gulf of St. Lawrence – Scotian Shelf during the later time series.

1. Opening

The Chair opened the meeting by welcoming participants to this June 2015 Meeting of STACFEN.

The Committee adopted the agenda and discussed the work plan and noted the following documents would be reviewed: SCR Doc. 16/01, 16/02, 16/03, 16/06, 16/07, 16/08, 16/17, 16/18, 16/19.

2. Appointment of Rapporteur

Gary Maillet (Canada) was appointed rapporteur.

3. Adoption of the Agenda

The provisional agenda was adopted with no further modifications.

4. Review of Recommendations in 2015

STACFEN **recommends** *consideration of support for one invited speaker to address emerging issues and concerns for the NAFO Convention Area during the 2016 STACFEN Meeting.*

STATUS: An invited speaker was supported in 2016, discussing "Variations in Physical and Biological Environmental Conditions and their Impacts on Commercial Stock Dynamics in the Gulf of St. Lawrence". As well, there was a single interdisciplinary presentation by Dr. Pierre Pepin, who provided "An Update on Results from the Ocean Acidification Surveys of the Northwest Atlantic".

STACFEN **recommends** that *a sub-committee of STACFEN members be formed to discuss and draft a plan towards the reconfiguration and/or amalgamation of STACFEN and WGESA to be presented at the 2015 STACFEN Meeting.*

STATUS: Dr. Mariano Koen-Alonso provided an update (included in this appendix as an abstract) on the amalgamation discussions to date. To summarize, while the idea of a merger has merit, at least in the short-term logistical constraints will preclude merging WGESA and STACFEN. Nonetheless, it was generally agreed that further efforts to improve synergy between the 2 groups would benefit WGESA as it moves towards the implementation of the ecosystem approach to fisheries management roadmap.

STACFEN **recommends** that *a sub-committee of STACFEN members be formed to discuss the current state of Fisheries and Oceans Canada (DFO) Oceanographic Services (formerly ISDM and MEDS) data management responsibilities to NAFO and related mechanisms for the reporting of oceanographic data by member states and the subsequent means of accessing these data. It is recommended that the findings of these discussions be tabled at the 2015 STACFEN meeting and should represent a reasonable "road map" for data providers, data users, data managers and the NAFO Secretariat, given current requirements and in respect of the current human resource limitations to manage these requirements.*

STATUS: This subcommittee met on June 18th with Mathieu Ouellette, Neil Campbell, Dayna Bell, Pierre Pepin and Andrew Cogswell in attendance. Mathieu and Pierre were to discuss the issue during the Fisheries and Oceans Canada National Science Data Management Committee (NSDMC) meetings in Ottawa late in the summer of 2015, but this topic was not broached at the meeting. One of the recommendations arising from the meeting on the 18th of June, was that a detailed "data submission guidelines" document would be useful for Contracting Parties. These data submission guidelines will be drafted in advance of the September 2016 Scientific Council meeting for comment prior to broader circulation in advance of 2016 data submissions.

5. Invited Speaker

The Chair introduced this year's invited speaker Dr. Stéphane Plourde.

The following is an abstract of Dr. Plourde's presentation entitled "Variations in physical and biological environmental conditions and their impacts on commercial stocks dynamics in the Gulf of St. Lawrence."

Dr. Plourde presented results from on-going collaborative work showing the effect of environmental variability on the dynamics of various commercial stocks in the Gulf of St. Lawrence (GSL). Using a large set of Atlantic Zone Monitoring Program (AZMP) physical and zooplankton environmental indices, he first described the dominant modes of variability at the basis of the food web using Principal Components

Analyses (PCAs). The analyses revealed two principal modes of variability occurring at different temporal scales, and a strong link between physical forcing and the dynamics of key copepod species. Secondly, Generalized Additive Models (GAM) were used to explore how these environmental variations described with PCAs could influence individual condition (K) and recruitment success (Rs) of the mackerel stock in the GSL. Optimal GAMs, including variations in zooplankton abundance and phenology of key copepods, explained between 58-77% of mackerel stock parameters variability, illustrating the key role of zooplankton dynamics in modulating variations in mackerel K and Rs. Finally, Dr. Plourde showed how variations in other stocks dynamics such as herring are also associated to these physical and biological PCAs, suggesting that our multivariate environmental indices describe temporal variations of ecosystem-wide processes fundamental to several commercial stocks in the GSL.

6. Oceanography and Science Data (OSD) Report for 2015 (SCR Doc. 16/17)

The Oceans Science Branch (OSB) of DFO acts as Regional Environmental Data Center for NAFO. This role began in 1963 when the Canadian Oceanographic Data Centre (CODC) started providing data management functions to the International Commission for the Northwest Atlantic Fisheries (ICNAF), and was subsequently formalized in 1975 by which time the CODC had become the Marine Environmental Data Service (MEDS). The unit within MEDS responsible for the NAFO Regional Environmental Data Center function was later transferred to DFO branches known as Integrated Science Data Management (2005-2013), Oceanography and Scientific Data (2013-2014), Oceanographic Services (2014-2015) and Oceans Science (OS) (2015-current).

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

Provision of a meaningful report to the Council for its meeting in June 2016 required the submission to OSB of a completed oceanographic inventory form for data collected in 2015, and oceanographic data pertinent to the NAFO Convention Area, for all stations occupied in the year prior to 2015. The data of highest priority are those from the standard sections and stations, as described in NAFO SCR DOC., No. 1, Serial N 1432, 9p.

Data that have been formatted and archived at OS are available to all members upon request. Requests can be made by telephone (613) 990-6065, by e-mail to isdm-gdsi@dfo-mpo.gc.ca, by completing an on-line order form on the OSB web site at http://www.Meds-sdmm.dfo-mpo.gc.ca/isdm-gdsi/request-commande/form-eng.asp or by writing to Oceanographic Services, Fisheries and Oceans Canada, 12th Floor, 200 Kent St., Ottawa, Ont. Canada K1A 0E6.

Data observed in NAFO Convention Area in 2015 and acquired in 2015

Data Type	Platform Type	Counts/Duration
Oceanographic profiles	autonomous platforms	7926* profiles from 125 platforms
	ship**	6345 profiles (2877 +3441*) from over 28 platforms***
Surface/near-surface observations	ship (thermosalinograph)	5387* obs. from 1 ship
	drifting buoys	245744* obs. from 136 buoys
	moored buoys temp/waves	Over 47900* obs. from 10 buoys
	moored buoys temp/salt	108625* obs. from 15 buoys
	fixed platforms	90746* obs. from 3 platforms
	water level gauges	21 sites, avg. 1 year each
Sub-surface observations	Moored current-meter, CTD, thermograph, ADCP	18 time series at 7 sites, avg. 284 d each

*Data formatted for real-time transmission
**Statistics also include data measured by one Canadian helicopter
***Some ships do not identify themselves

Data observed prior to 2015 in NAFO Convention Area and acquired in 2015

Data Type	Platform Type	Counts/Duration
Oceanographic profiles	Ship	6377 profiles** (6190 + 187*) from over 30 platforms
Sub-surface observations	Moored thermograph	61 time series at 36 sites, average of 104 days each

*Data formatted for real-time transmission

**The amount of bottle data profiles measured prior to 2015 and loaded in a DFO database called BioChem, in 2015, could not be assessed

7. Conclusion of Discussions Surrounding the Reconfiguration and/or Amalgamation of STACFEN and WG-ESA

The idea of a merger between STACFEN and WG-ESA was considered by the sub-committee and through consultation with STACFEN and WG-ESA membership. Several e-mail exchanges between SC, STACFEN, WG-ESA chairs and the NAFO SC coordinator took place between June and September 2015. A summary of discussion to date was presented at SC in September of 2015 and to gauge interest in further pursuing the concept. While the feedback from SC was mixed, it was agreed that the plan merited further development in consultation with STACFEN and WG-ESA membership. A session to discuss this plan was held during the WGESA meeting in November of 2015. The overall consensus of the discussion regarding the merger indicated that while the idea was conceptually useful it was not logistically feasible to merge the two groups at this time. It was generally agreed that if the benefit of a merger were to be materialized, the entire schedule of NAFO SC meetings would require review. Despite its benefits, the merger would have costs, which based on the general feedback received, SC members were uncomfortable with.

The potential of a merger between WG-ESA and ICES WG-NARS was also discussed during the 2016 WG-NARS meeting in Falmouth, MA. The WG-NARS 2016 report states the following: *"WG-NARS has been informally collaborating with the NAFO WG-ESA, for which there is crossover in membership. There is a desire to assess the practicality and utility of merging the two groups formally, and this will be explored over the coming year."*

The current structure will likely be maintained until the SC can re-examine the viability of broader changes to the SC meetings schedule, or the idea of merging WG-ESA with other groups is abandoned altogether. This option does not address WG-ESA capacity issues, which are growing with increasing demands (e.g., lack of co-chair candidates and lack of expertise on topics of interest).

Over the interim, members of SC also suggested continuation of efforts to improve synergies between STACFEN and WG-ESA membership.

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

A key indicator of ocean climate conditions, the North Atlantic Oscillation (NAO) index, returned to a record positive phase during the winter of 2015. This is an intensification of conditions experienced in 2014 and contributed to strong arctic air outflow in the northwest Atlantic resulting in lower than normal winter air temperatures at most northern locations. As a result, the sea ice extent anomaly for the NL shelf was positive for the second consecutive year, as was the ice volume of the Scotian Shelf.

Subareas 0 and 1. Reviews of meteorological, sea ice and hydrographic conditions in West Greenland in 2015 were presented in **SCR Doc. 16/01 and 16/02**.

In winter 2014/2015, the NAO index was positive (3.56) representing the highest value since 1995. The annual mean air temperature at Nuuk weather station in West Greenland was -2.9°C in 2015, which was -1.5°C below the long-term mean (1981-2010). During October/November the core properties of the water masses of the West Greenland Current (WGC) are monitored at two standard NAFO/ICES sections across the western shelf and continental slope of Greenland near Cape Desolation and Fyllas Bank. The properties of the Irminger Sea Water (ISW) are monitored in the 75-200 m layer at Cape Desolation Station 3. In 2015, the water temperature and the salinity of the ISW was 5.4°C and 34.93, which was 0.31°C below and 0.01 above the long-term mean, respectively. The properties of the North Atlantic Deep Water (NADW) in the Deep Boundary Current west of Greenland are monitored at 2000 m depth at Cape Desolation Station 3. Since the beginning of the 1990s, temperature and salinity were decreasing and reached their minimum values in 1998 and 1997, respectively. After that, the temperature of the NADW revealed a positive trend until 2014, whereas its salinity rather stagnated between 2007 and 2014. In 2015, the temperature decreased and salinity increased, and they were 0.03°C below and 0.02 above the long-term mean. The water properties between 0 and 50 m depth at Fyllas Bank Station 4 are used to monitor the variability of the fresh Polar Water component of the West Greenland Current. In 2015, the temperature of this water mass was 2.31°C, which was 0.33°C below its long-term mean (1983-2010). The salinity decreased in 2015 and was 0.17 above its long-term mean.

Hydrographic conditions were monitored at 8 of 10 hydrographic standard sections in June 2015 across the continental shelf off West Greenland. The two southernmost standard sections were not occupied due to a string of low-pressure systems passing through the Cape Farewell area. Two of three offshore stations have been chosen to document changes in hydrographic conditions off Southwest Greenland. The coastal water showed temperatures below the long-term mean in the area south of the Sisimiut section. The lack of the Cape Desolation stations makes it difficult to state if the same tendency was observed in the subpolar mode water mass, though neighboring sections showed temperatures below those observed in 2014.

Subareas 1 and 2. A review of physical, chemical and biological oceanographic conditions over the Labrador Sea in 2015 was presented in **SCR Doc. 16/18**.

The Dec-Jan-Feb (DJF) composite North Atlantic Oscillation (NAO) index was strongly positive in 2015, the highest on record. During the winter convection season, the National Centers for Environmental Prediction (NCEP) reanalysis of surface air temperature indicated below normal temperature conditions with a negative anomaly ranging between 0 – 4°C in the Labrador Sea. Sea surface temperature anomalies (SST) estimated using bi-weekly Advanced Very High Resolution Radiometer (AVHRR) remote-sensed data in the central Labrador Sea were also below normal temperature at 0.458, 0.646, 0.438 and 1.188 ˚C respectively for the winter, spring, summer and fall seasons. The Labrador Shelf ice extent was slightly above normal in the months of January and March (reference period: 1981-2010); however, in the northern part of the Labrador Sea, the total sea ice extent in this region was slightly below normal in winter. Wintertime convection in 2015 reached 1850 m, which is even deeper than the 1600 m observed in 2014. DIC and pH are following their usual inverted pattern yielding a sustained decline rate in pH of 0.003 units per year since 1996. Silicate concentration in the newly ventilated layer is also decreasing, following the same trend as has been observed in the rest of the North-western Atlantic. Intense phytoplankton production in spring over the entire Labrador Basin leads to one of the highest primary production cycles observed since 1995. The apparent lower abundance of *Calanus finmarchicus* and other organisms in the mesozooplankton follow trends observed elsewhere, but may be exacerbate with nets clogging in most of the stations of the central Labrador Sea.

The large changes observed in biochemical variables raised a question about the need to consider water mass analysis to assist in an understanding of the dynamics observed over the Labrador Sea in 2015. The profile of anthropogenic gases was raised and how it might be linked to other biogeochemical tracers in the system and aid our understanding of mixing and water mass distribution.

Subareas 2, 3 and 4. A description of the physical oceanographic environment on the NL and Labrador Shelf and Scotian Shelf was presented in **SCR Doc. 16/06 and SCR Doc. 16/07**.

Oceanographic and meteorological observations in NAFO Sub-areas 2 and 3 during 2015 are presented referenced to their long-term (1981-2010) means. The North Atlantic Oscillation (NAO) Index, an indicator of the direction and intensity of the winter wind field patterns over the Northwest Atlantic, remained in a positive phase in 2015, reaching a record high resulting in a strong arctic air outflow in the northwest Atlantic during the winter months and consequently lower than normal winter air temperatures. Sea ice extent increased substantially during winter 2014 with the first positive anomaly (higher-than-normal extent) observed in 16 years and in 2015 the total extent was about normal except for March and April when it was above normal. Annual sea-surface temperatures (SST) based on infrared satellite imagery across the Newfoundland and Labrador Shelves ranged from near-normal to below normal in some areas. The cold-intermediate layer (CIL; volume of <0°C) in 2015 was at its highest level on record (since 1970) on the Grand Bank during the spring. The annual bottom (176 m) water temperature at the inshore monitoring station (Station 27) was below normal in 2015 by -0.7 standard deviations (SD), a significant decrease from the record high in 2011. Spring bottom temperatures in 3Ps remained above normal by about 0.5°C (0.8 SD) and were about normal on the Grand Banks. Fall bottom temperatures in 2J, 3K and 3LNO decreased from 2, 2.7, and 1.8 SD above normal in 2011 to 0.2 and 0.8 SD above normal in 2J and 3K and to -0.4 SD below normal in 3LNO in 2015, a significant decrease in the past 4 years. A standardized climate index derived from 28 meteorological, ice and ocean temperature and salinity time series declined for the 4th consecutive year, reaching the 7th lowest in 66 years and the lowest value since 1993.

A review of the 2015 physical oceanographic conditions on the Scotian Shelf and in the eastern Gulf of Maine and adjacent offshore areas indicates that conditions corresponding to warmer than normal prevailed. The climate index, a composite of 18 selected, normalized time series, averaged +1.2 standard deviations (SD) making 2015 the fifth warmest year in the last 46 years. The anomalies did not show a strong spatial variation. Bottom temperatures were above normal with anomalies for NAFO Divisions 4Vn, 4Vs, 4W, 4X of +0.9°C (+2.2 SD), +1.9°C (+2.8 SD), +1.6°C (+2.1 SD), and +0.9°C (+1.3 SD) respectively. Compared to 2012, the year where record or near record bottom temperatures were observed, bottom temperatures were different by -0.4°C, +0.7°C, -0.2°C and -1.3°C in Divisions 4Vn, 4Vs, 4W and 4X, respectively.

A description of physical oceanographic conditions on the Flemish Cap during 2015 was presented in **SCR Doc. 16/19.**

Oceanographic observations from seasonal surveys in NAFO Division 3M during 2015 are presented referenced to their long-term means. An analysis of infrared satellite imagery around the Flemish Cap indicates that annual sea-surface temperatures (SST) decreased to about -1.5°C below normal in 2015, the coldest value since 1985. Annual water column temperatures decreased to -3.3°C, -3.2°C, -1.1°C and -0.7°C below normal at depths of 10, 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 an intense cold-intermediate layer (CIL) with T<2°C over the Cap and reaching as low as 0°C during the summer of 2015. Water column temperatures along the section were predominately below normal during spring, summer and fall with values reached between -2° to -3°C below normal. The cold water penetrated to the bottom directly over the Cap with cold anomalies (~-1°C) restricted to the shallow portions of the area. The corresponding salinity cross-sections show relatively fresh upper layer shelf water with some areas <33.5 corresponding to generally fresher than normal conditions in most areas of the water column over the Cap. The spatial extent of the CIL (<3°C) covered the entire survey area during the summer of 2015 for the first time since 1995 and average thickness of the CIL was the highest since 1993 at about 70 m thicker than normal. During the summer of 2015 the CIL minimum observed core temperature was the coldest in the observational record at -2°C below normal. The average CIL temperature was also at a record low of -1°C below normal. In general, data from four surveys conducted in NAFO division 3M on the Flemish Cap during the spring, summer and fall of 2015 show a record cold-fresh water mass over the Flemish Cap that penetrated to the bottom habitat over the central shallow areas while the deeper bottom areas were dominated by warmer North Atlantic Water. The circulation pattern revealed by geostrophic current calculations was particularly dynamic in 2015, resulting in water properties dominated by Labrador Current Water trapped within the anticyclonic circulation around the Flemish Cap.

Subareas 2 - 5. An investigation of the biological and chemical oceanographic conditions in 2015 was presented in **SCR Doc. 16/08.**

Biological and chemical variables collected in 2015 from coastal high frequency monitoring stations, semi-annual oceanographic transects, and ships of opportunity ranging from the Labrador-Newfoundland and Grand Banks Shelf (Subareas 2 and 3), extending west into the Gulf of St. Lawrence (Subarea 4) and further south along the Scotian Shelf and the Bay of Fundy (Subarea 4) and into the Gulf of Maine (Subarea 5) are presented and referenced to previous information from earlier periods when available. We review the interannual variations in inventories of nitrate, chlorophyll *a* and indices of the spring bloom inferred from satellite ocean colour imagery, as well as the abundance of major functional taxa of zooplankton collected as part of the 2015 Atlantic Zone Monitoring Program (AZMP). In general, nitrate inventories in the upper (0-50m) water-column were near to above normal compared to the 1999-2010 climatology throughout the northern Subareas but below normal from the southern Gulf of St. Lawrence down to the Scotian Shelf in 2015. The deeper (50-150m) nitrate inventories continue to remain well below normal on the Grand Bank but now approaching near normal on northern transects to well above normal in the Gulf of St. Lawrence and

Scotian Shelf in 2015. The chlorophyll *a* inventories inferred from the seasonal AZMP oceanographic surveys and fixed stations were variable throughout the Subareas with below normal conditions over the northern transects (2J to 3LNO) and, generally near normal in the Gulf of St. Lawrence and Scotian Shelf (SA4) in 2015. An exceptional localized record-high chlorophyll *a* inventory was observed along the northeast Gulf of St. Lawrence transects in 2015. Satellite ocean colour imagery detected intense surface concentrations centered over a broad area across the Labrador Sea and West Greenland Shelf during May 2015. This intense, large-scale spring bloom was in contrast to lower biomass and limited surface blooms observed over the NW Atlantic Shelves in 2015. The timing of the spring bloom varied with earlier onset in the northern regions coincident with the intense event over the Labrador Sea, in comparison to delayed timing observed from the northeast Newfoundland Shelf and southwards. An unusual exceptional record-early bloom occurred in the estuary within GSL in 2015. Despite the record-high magnitude and amplitude of the spring bloom in 2015 over the Labrador Sea and West Greenland, the duration of the production cycle was shortened throughout the standard sub-regions in 2015 with only a few exceptions. The abundance of different functional zooplankton groups consisting of combined copepods, non-copepods, and a small grazing copepod (*Pseudocalanus spp*.), were all above normal compared to the standard reference period (1999-2010) in 2015. The abundance anomaly for the larger grazing copepod, *Calanus finmarchicus,* an important prey to a variety of different life stages of higher trophic levels, declined again in 2015 across the entire zone continuing a negative trend observed in earlier years. Development of a biological composite index time series incorporating lower trophic indices indicated the largest dynamic changes were associated with the Gulf of St. Lawrence while the smallest changes were observed on the Grand Bank – Flemish Cap. Further examination of the contributions of the various AZMP transects and fixed stations to the biological composite index revealed opposite trends between the LAB-NL and GSL-SS regions.

Subareas 5 and 6. A description of environmental information collected on the Northeast United States Continental Shelf during 2015 was presented in **SCR Doc. 16/03**.

An overview is presented of the atmospheric and oceanographic conditions on the Northeast U.S. Continental Shelf during 2015. The analysis utilizes hydrographic observations collected by the operational oceanography programs of the Northeast Fisheries Science Center (NEFSC), which represents the most comprehensive consistently sampled ongoing environmental record within the region. Overall, 2015 was characterized by warming, an increase in the seasonal range of temperature and generally more saline conditions across the region. Deep (slope) waters entering the Gulf of Maine were warmer and saltier than average and their temperature and salinity suggest a subtropical source. Mixed layers in the western Gulf of Maine were anomalously deep during the winter of 2015, presumably a consequence of anomalously cold air temperatures that persisted over the northeastern United States during winter. The vigorous mixing led to the formation of an anomalously thick layer of intermediate water extending to the bottom of Wilkinson Basin in the following spring. Finally, observations indicate that Gulf Stream water intruded onto the shelf in the Middle Atlantic Bight during late summer, leading to anomalous warming at the **shelf break** and in the upper 30 meters across the width of the shelf. Pycnocline gradients were enhanced and aligned with a shoreward protruding tongue of saline water. Such episodic events have the potential to cause significant changes in the ecosystem, including changes in nutrient loading on the shelf, the seasonal elimination of critical habitats such as the cold pool and shelf-slope front, disruption of seasonal migration cues, and an increase in the concentration of offshore larval fish on the shelf.

9. 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 studies were presented at the June 2016 Meeting along with relevant abstracts:

An Update on Results from the Ocean Acidification Surveys of the Northwest Atlantic. Authors: P. Pepin, K. Azetsu-Scott, M. Starr.

The Atlantic Basin Impacts and Vulnerability Assessment identified a gap in knowledge on the state of calcium carbonate mineral saturation and ocean acidity for the continental shelves. This is an important limitation in evaluating the potential risk of anticipated increase in ocean acidification to shellfish (e.g. mussels, scallops, clams) and invertebrate (e.g. crabs, shrimp, lobsters) fisheries. Here, we report on the results of a comprehensive survey of the saturation state (Ω) of seawater and pH to assess the potential of future changes on the Canadian continental shelves in the northwest Atlantic. Data were collected along 14 oceanographic sections that covered the Scotian Shelf, Gulf of St. Lawrence and Newfoundland and Labrador Shelves during the fall of 2014. In addition, we present information on the seasonal cycle of variation of the aragonite saturation state across the Flemish Cap section (47°N). Aragonite saturation levels were generally lowest in the cold intermediate layer but low oxygen concentrations were also associated with low aragonite saturation levels. Under saturation was observed on parts of the Grand Bank, on the inner portion of the eastern Scotian Shelf and throughout much of the Gulf of St. Lawrence. In terms of water mass characteristics, under saturation is most strongly associated with Newfoundland Slope water, the inner arm of the Labrador Current water and Gulf of St. Lawrence water. There is substantial seasonal variation in aragonite saturation levels along the Flemish Cap section as a result of fall/winter mixing of the water column and respiration below the summer mixed layer. The cold winter of 2015 resulted in an extensive area of aragonite under saturation that extend into the deep-waters of the Flemish Pass and across to the Flemish Cap for much of the year; these areas that were above the aragonite under saturation threshold in the fall of 2014. The results highlight gaps in general knowledge about ocean pH and calcium carbonate saturation on the Canadian Continental Shelf and adjacent waters and raise potentially important questions about the potential exposure and adaptability of marine organisms to seasonal or long-term changes in these features of marine ecosystems.

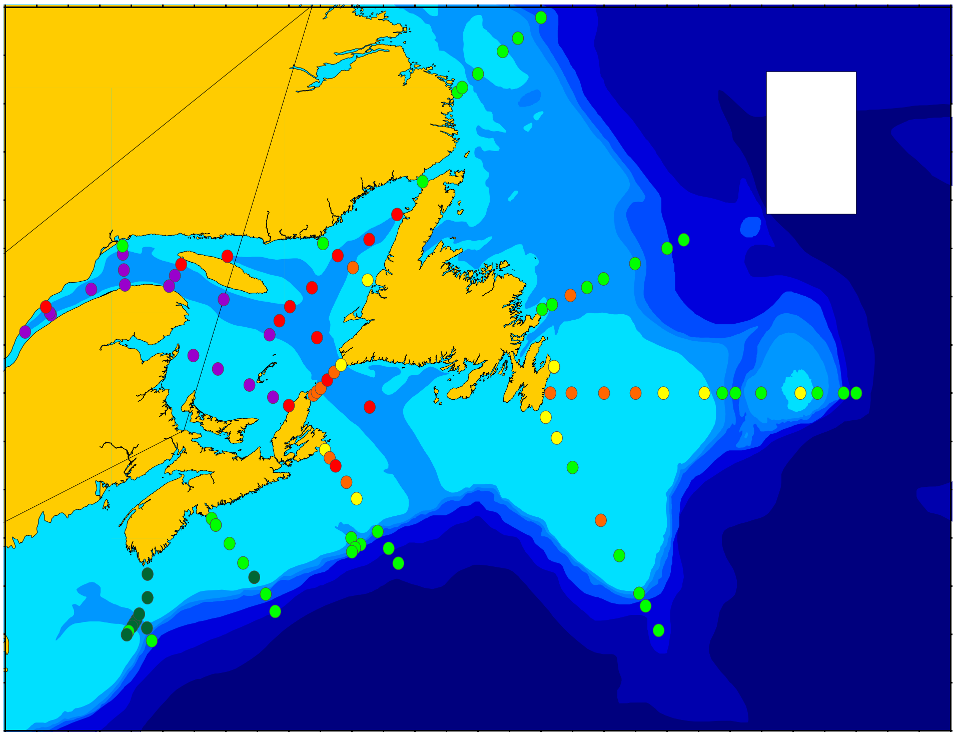


Fig. 1. Near bottom Aragonite saturation state determined during the AZMP Fall 2014 Oceanographic surveys (samples collected between 19 September and 7 December 2014).

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

In 2003 STACFEN began production of an annual climate status report to describe environmental conditions during the previous year. This web-based annual summary for the NAFO area includes an overview that summarizes the overall general climate changes for the previous year and a regional overview that provided climate indices from each of the Subareas. The climate summary is updated by the NAFO Secretariat on an annual basis with contributions from each contracting country. Information for 2015 will be made available from Subarea 1, West Greenland , Subareas 2-3, Grand Banks and Labrador Sea / Shelf , Subareas 4-5, Scotian Shelf and Gulf of Maine, and Subareas 5-6, Georges Bank and Gulf of Maine.

11. The Formulation of Recommendations Based on Environmental Conditions

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

12. National Representatives

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

13. Other Matters

There was considerable discussion about the ongoing utility of the annual climate status report on the NAFO website. A canvas of SC members showed that it was not regularly accessed and the time required to generate content is significant. Unfortunately, there are no website metrics currently available to make a decision about the future of this page. The NAFO Secretariat will be creating a new web interface that will provide google metrics to evaluate traffic. In the interim, and prior to the September SC meeting, Eugene Colbourne, the NAFO Secretariat and STACFEN colleagues will generate content for this page as usual. Traffic on the summary page will be reassessed during the 2017 STACFEN meeting and a decision will be made about its future.

It was agreed that prior to the 2016 September SC meeting, Mathieu Ouellette (DFO, OSB) will develop data submission guidelines for member states. These guidelines should be modified, adopted and implemented after the September meeting and circulated to Contracting Parties to assist with submission of oceanographic data prior to the STACFEN meeting in June 2017.

During the STACFEN 2015 meeting, there was unanimous support for moving the 2017 STACFEN meeting to Friday, June 2nd rather than the first Monday in June. This move will permit wider discussion of environmental indices with stock assessment results and should help with the ecosystem approach which requires input of environmental data to understand regional variability and fishery production potential.

14. Adjournment

Upon completing the agenda, the Chair thanked the STACFEN members for their excellent contributions, the Secretariat and the rapporteur for their support and contributions. Special thanks were again given to the invited speaker Dr. Stéphane Plourde (Institut Maurice-Lamontagne, Mont-Joli, QC, Canada), and contribution to the interdisciplinary session by Dr. Pierre Pepin (Northwest Atlantic Fisheries Centre, St. John's, NL, Canada).

The meeting was adjourned at ~16:30 on 6 June 2016.

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 3 June and 4 June 2016, to consider publication-related topics and report on various matters referred to it by the Scientific Council. Representatives attended from Canada, Denmark (in respect of Greenland), European Union (France, Germany, Portugal and Spain), Norway, Russian Federation, Japan and the United States of America. The Scientific Council Coordinator was in attendance as were other members of the Secretariat staff.

1. Opening

The Chair opened the meeting by welcoming the participants.

2. Appointment of Rapporteur

Alexis Pacey (NAFO Secretariat) was appointed rapporteur.

3. Adoption of Agenda

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

4. Review of Recommendations in 2015

STACPUB **recommends** that *the Secretariat contact WGESA for further instruction on the VME Guides in order to publish it for September 2015.*

STATUS: This has been implemented. It was published in October 2015.

STACPUB **recommend***s* that *Scientific Council consider holding another symposium and that a list of potential topics and themes be put forward.*

STATUS: Discussion took place at the NAFO Annual Meeting in September 2015. The conclusion was that the coordination of a symposium was a lot of work and that current Scientific Council members did not have the capacity to take on these additional responsibilities.

STACPUB **recommends** that *the NAFO Secretariat look into updating their current list of SC members and create a forum for the electronic exchange of ideas that is accessible to SC members.*

STATUS: This has been implemented. There is a Discussion Board set up on the SharePoint.

STACPUB **recommends** that *a committee (comprised of STACPUB chair, the General Editor and those Associate Editors who are available) be created to review and update the JNAFS website and that the NAFO Secretariat will implement the changes requested.*

STATUS: The committee was created and met in person at the end of the June 2015 meeting and continued dialogue by e-mail following that meeting. The INSTRUCTIONS for authors, the ABOUT tab and the SYMPOSIA tab were reviewed and updates made. The committee plans to meet during future June meetings to continue discussion of Journal matters.

5. Review of Publications

i. Journal of Northwest Atlantic Fishery Science (JNAFS)

Volume 47, Regular issue, comprised of five articles. There were 125 copies printed and 20 CDs mailed out in January 2016.

Volume 48, Regular issue, has a total of six papers that have been submitted for publication. One has been published (online); the five remaining are in the review process.

d) NAFO Scientific Council Studies

Number 47, *Coral, Sponge, and Other Vulnerable Marine Ecosystem Indicator Identification Guide, NAFO Area* by Kenchington, E., L. Beazley, F. J. Murillo, G. Tompkins MacDonald, E. Baker was published in October 2015.

200 copies were printed and are available upon request from the Secretariat. This work was a collaboration between WG-ESA (Scientific Council Working Group on Ecosystem Science and Assessment) and the Secretariat's publications department and is a combination of the 2009 *NAFO Coral Identification Guide* (Studies No. 42) and the 2010 *NAFO Sponge Identification Guide* (Studies No. 43) with the addition of newly discovered VME indicator species. The new book is printed on water resistant and tear-proof paper placed in a polyvinyl binder that will allow for future updates as new species are added.

e) NAFO Scientific Council Reports

The NAFO Scientific Council Reports 2015 (Redbook) was produced in April 2016. 35 copies of the Report have been printed.

f) ASFA

All science publications and documents have been submitted to ASFA as of May 31, 2016. This includes *The Journal of the Northwest Atlantic Fisheries*, SC Reports, and SC Research Documents for 2015.

The 44th Annual Meeting of the **Aquatic Sciences and Fisheries Abstracts (ASFA)** Advisory Board was co-hosted by NAFO and Dalhousie University's Environmental Information: Use and Influence Research Program, and took place from 5–9 October 2015 at Dalhousie University, Halifax, Nova Scotia, Canada. The meeting was opened by Mr. Fred Kingston, Executive Secretary, NAFO, and Dr. Bertrum MacDonald, Acting Dean, Faculty of Management, Dalhousie University. The Meeting was attended by 33 participants, representing 26 ASFA Partners and four observers. Mr Pettman (Freshwater Biological Association) chaired the meeting. The rapporteur was Ms. Wibley (FAO-ASFA Secretariat) assisted by Ms. Pacey (NAFO).

6. Other Matters

a) Preview of the new NAFO website

Alexis Pacey presented a preview of the new NAFO website via Webex. The redesign and development of a new website using a content management system (CMS) began in October 2015. The objective is to upgrade functionality and streamline content to create a more modern and user friendly website. The migration of content from the current website is under way and will continue through 2016. The members' pages will be upgraded and overhauled to maximize transparency and ease of use. The framesets will be eliminated to allow for simple direct linking. Some CPs offered to be part of the NAFO web team in order to provide feedback on this complex project. Many of the comments and suggestions that the NAFO Secretariat has received from surveys, comments and emails over the past five to six years regarding the current site were taken into account when designing the new platform. The presentation and views of the website were made available on SharePoint for SC members to review and any comments were to be posted on the Discussion Board or emailed to the Secretariat by July 31, 2016. The website will be showcased live at the 38th Annual Meeting in Cuba for all participants to view and interact with, and hopefully it will have addressed many of the concerns that NAFO members have had in the past with the NAFO web pages.

b) Designated Experts (DE) email links on the website

Scientific Council members discussed the pros and cons of providing e-mail links for the DEs for each stock on the current and future NAFO website. Most people did not have strong opinions about it. Very few DEs receive e-mails from the website, perhaps because it has been hard-to-find the list of the Scientific Council DEs. Some suggested having a group e-mail.

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

c) Symposium

The fact that NAFO has not hosted a symposium in many years was raised again at this meeting. It was noted that a symposium is beneficial in showcasing new research relevant to the NAFO area and would be of benefit to both NAFO SC and the Journal profile. The response to last years' recommendation to organize another symposium was reiterated. The SC Chair brought forward a request for NAFO to co-host a conference with ICES and PICES in winter 2017 or spring 2018 currently titled *Shellfish – Resources and Invaders of the North.* The request was for funding to support participation of two members from NAFO SC. The STACPUB Chair will ask the coordinators what plans they have for publishing the proceedings and if our JNAFS journal could be considered.

It was suggested by an SC member that the Journal consider creating a profile on Research Gate. The NAFO Secretariat will consider this option.

d) Popular Advice Sheets

It was noted by an SC member that NAFO does not have web pages that contain summaries of the stocks and advice that can be easily interpreted by the general public. The ICES popular advice web pages were given as a good example of this concept. Currently, the NAFO website contains links to the summary sheets but they are very technical. In addition, other information sheets on oceanographic conditions and ecosystem characteristics are difficult to find on the current NAFO website.

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

7. Adjournment

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

Appendix III. Report of the Standing Committee on Research Coordination (STACREC)

Chair: Brian Healey Rapporteur: Ivan Tretiakov

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

1. Opening

The Chair opened the meeting at 1400 hours on 3 June 2016, 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. The report was reviewed and adopted on 16 June.

2. Appointment of Rapporteur

Ivan Tretiakov was appointed as rapporteur.

3. Review of Recommendations in 2015

There were no recommendations from 2015.

4. Fishery Statistics

a) Progress report on Secretariat activities in 2015/2016

i) STATLANT 21A and 21B

In accordance with Rule 4.4 of the Rules of Procedure of the Scientific Council, as amended by Scientific Council in June 2006, the deadline dates for this year's submission of STATLANT 21A data and 21B data for the preceding year are 1 May and 31 August, respectively. The Secretariat produced a compilation of the countries that have submitted to STATLANT and made this available to the meeting (Table 4).

Table 1. Dates of receipt of STATLANT 21A and 21B reports for 2012-2015 up to 5 June 2016.

Country/component	STATLANT 21A (deadline, 1 May)			STATLANT 21B (deadline, 31 August)		
	2013	2014	2015	2012	2013	2014
CAN-CA	30 Apr 14	24 Apr 15	4 May 16	21 May 13	30 Apr 14	24 Apr 15
CAN-SF	30 May 17	1 Jun 15	31 May 16	6 Sep 13	3 Jun 14	31Aug 15
CAN-G	24 Dec 14	14 May 15	18 May 16	1 Sep 13	14 May 15	4 Sep 15
CAN-NL	30 Apr 14	25 May 15	21 Apr 16	9 Sep 13	29 Aug 14	
CAN-Q						
CUB						
E/BUL				21 May 13 (dnf)		
E/EST	22 May 14	28 Apr-15	20 Apr 16	1 Sep 13	29 Aug 14	14 Aug 15
E/DNK	21 Aug 14	21 May 15		9 Sep 13	21 Aug 14	4 Sep 15
E/FRA	22 May 14					
E/DEU	28 Apr 14	29 Apr 15	28 Apr 16	1 Sep 13	29 Aug 14	4 Sep 15
E/LVA		21 Apr 15 (dnf)	10 Mar 16 (dnf)	6 Sep 13		
E/LTU		21 May 15		23 Oct 13		
EU/POL		1 Jun 15				21 Sep 15
E/PRT	22 May 14	8 May 15	26 Apr 16	4 Oct 13	29 Aug 14	3 Sep 15
E/ESP	22 May 14	21 May 15	5 May 16	30 Aug 13	25 Aug 14	7 Sep 15
E/GBR	23 May 14			1 Sep 13	20 Aug 14	
FRO	12 Jun 14	*	26 May 16	2 Jun 13	12 Jun 14	7 Jul 15
GRL	5 May 14	15 May 15	30 Apr 16	9 Sep 13	29 Aug 14	1 Sep 15
ISL	23 May 14	15 May 15 (dnf)		23 May 13 (dnf)	8 Sep 14	
JPN				26 Apr 13		
KOR						
NOR	22 May 14	7 May 15	26 Apr 16	6 Sep 13	26 Aug 14	17 Mar 16
RUS	12 May 14	21 Apr 15	20 May 16	24 Oct 13	28 Aug 14	2 Jul 15
USA	29 May 14	22 May 15				
FRA-SP	30 Jul 14	20 Apr 15	25 Apr 16	9 Sep 13	30 Jul 14	6 Jul 15
UKR						

* date of submission unknown
dnf = did not fish.

ii) Availability of STACFIS catch estimates

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

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

5. Research Activities

a) Biological Sampling

i) Report on activities in 2015/2016

STACREC reviewed the list of Biological Sampling Data for 2016 (SCS Doc. 15/11) prepared by the Secretariat and noted that any updates will be inserted during the summer, prior to finalizing the SCS Document which will be finalized for the September 2016 Meeting.

ii) Report by National Representatives on commercial sampling conducted

Canada-Newfoundland: (SCS Doc. 16/11, 16/12, 15/11, 14/08 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 and available sampling for the following stocks/species: Greenland halibut (SA 0 + 1 (except Div. 1A inshore), SA 2 + Div. 3KLMNO), Atlantic salmon (SA 2+3+4), Arctic charr (SA 2), Atlantic cod (Div. 2GH, Div. 2J+3KL, Div. 3NO, Subdiv. 3Ps), American plaice (SA 2 + Div. 3K, Div. 3LNO, Subdiv. 3Ps), witch flounder (Div. 2J3KL, 3NO, 3Ps), yellowtail flounder (Div. 3LNO), redfish (Subarea 2 + Div. 3K, 3LN, 3O, 3P4V), northern shrimp (Subarea 2 + Div. 3KLMNO), Iceland scallop (Div. 2HJ, Div. 3LNO, Subdiv. 3Ps, Div. 4R), sea scallop (Div. 3L, Subdiv. 3Ps), snow crab (Div. 2J+3KLNO, Subdiv. 3Ps, Div. 4R), squid (SA 3), thorny skate (Div. 3LNOPs), white hake (Div. 3NOPs), lobster (SA 2+3+4), capelin (SA 2 + Div. 3KL), and marine mammals (SA 2-4). A provisional sampling report was not yet generated for submission to the Secretariat as of June 14 but will be forwarded as soon as possible. These data are provisional due to data formatting and quality control issues as a result of implementing a new process for delivery of the Observer Program on April 1, 2013. This provisional status applies to the 2015 sampling data, the 2014 sampling (SCS 15/11) and the 2013 sampling (SCS Doc. 14/08). Once these data are finalized, the inventory will be updated and STACREC and the Secretariat will be informed.

Denmark/Greenland (SCS Doc. 16/07): Length frequencies were available from the Greenland trawl fishery in Div. 1AB and 1CD. CPUE data were available from the Greenland trawl fishery in Div. 1AB and 1CD.

EU-Portugal (NAFO SCS Doc 16/09): Data on catch rates were obtained from trawl catches for redfish (Div. 3LMNO), Greenland halibut (Div. 3LM), cod (Div. 3M), witch flounder (Div. 3NO), thorny skate (Div. 3NO), roughhead grenadier (Div. 3LO) and white hake (Div. 3NO). Data on length composition of the catch were obtained for Cod (Div. 3LMNO), redfish *S. mentella* (Div. 3LMNO) American plaice (Div. 3LMNO), Greenland halibut (Div. 3LMO), witch flounder (Div. 3MNO), roughhead grenadier (Div. 3LM), redfish *S. marinus* (Div. 3M) and white hake (Div. 3O).

EU-Spain (SCS 16/05): A total of 12 Spanish trawlers operated in Div. 3LMNO NAFO Regulatory Area during 2015, amounting to 1,304 days (18,031 hours) of fishing effort. Total catches for all species combined in Div. 3LMNO were 15,336 tons in 2015. In addition to NAFO observers (NAFO Observers Program), 8 IEO scientific observers were onboard Spanish vessels, comprising a total of 320 observed fishing days, around 24% coverage of the total Spanish effort. In 2015, 476 length samples were taken, with 59,883 individuals of different species examined to obtain the length distributions. Besides recording catches, discards and effort, these observers carried out biological sampling of the main species taken in the catch. For Greenland halibut, roughhead grenadier, American plaice and cod this includes recording weight at length, sex-ratio, maturity stages, performing stomach contents analyses and collecting material for reproductive studies. Otoliths of these four species were also taken for age determination.

Two Spanish trawlers operated during 2015 in Div. 6G NAFO Regulatory Area using a midwater trawl gear. The fishing effort of these trawlers was 13 days (92 hours). The most important species in catches was the *Beryx splendens*. There were not available Spanish catches length distribution in Division 6G in 2015.

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

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

a) Biological Surveys

i) Review of survey activities in 2015 (by National Representatives and Designated Experts)

Canada (SCR Doc. 16/12): Research survey activities carried out by Canada (N) 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 2015 include a spring survey of Div. 3LNOPs, and an autumn survey of Div. 2HJ3KL.

The 2015 spring survey in Div. 3LNOPs was conducted from April to late June, and consisted of 375 successful tows (of 478 planned) covering 113 of 128 planned strata to a maximum depth of 732m with the Campelen 1800 survey trawl by the research vessel CCGS Alfred Needler. This survey continued a time series begun in 1971. The 103 set reduction primarily occurred in Div. 3L (only 56 of 142 planned sets conducted for a 61% reduction) due to mechanical issues with the vessel. There were 15 of 37 Div. 3L strata not sampled representing 43% of the survey area and 12 of the 22 remaining strata received less sets than planned allocation of sets.

The autumn survey was conducted from late September to late December in Divs. 2HJ3KLNO, and consisted of 604 tows (674 planned) covering 180 of 208 planned strata to a maximum depth of 1500m in Divs. 2HJ3KL and 732m in Divs. 3NO with the Campelen 1800 trawl. The reduction was due to a slow start to the survey that required *a priori* elimination of Div. 2H sets >500m leaving 13 strata un-sampled and the eventual elimination of 15 deep water strata in 3L >732m near the end of the survey. The vessel CCGS Teleost conducted the Div. 2HJ3KL (to a maximum of 1500m) and CCGS Alfred Needler conducted the 3LNO survey (< 732m), which continued a time series begun in 1977.

The additional surveys during 2015, directed at a number of species using a variety of designs and fishing gears, were described in detail in various documents. Results from Canadian oceanographic surveys in 2015 and earlier were discussed in detail in STACFEN.

STACREC noted the decline in the planned coverage and success rate of the Canadian surveys since 1995, particularly in the autumn, and again expressed concern about the impact on the ability to detect signal from noise in regards to evaluating trends in biomass and abundance of various species. There are various reasons for this reduction over time (e.g. mechanical issues with vessels, increasingly bad weather, expanded sampling for ecosystem indicator species, budget constraints) but it is generally considered to have led to increased, albeit unquantified, uncertainty with respect to the provision of scientific advice.

In addition, STACREC noted its 2015 recommendation "…that an analysis of sampling rates be conducted to evaluate the impact on the precision of survey estimates" was not addressed at this meeting but that work was progressing. Accordingly, STACREC reiterates its *recommendation* that an analysis of sampling rates be conducted to evaluate the impact on the precision of survey estimates.

Denmark/Greenland (SCR Doc. 16/002): The West Greenland standard oceanographic stations were surveyed in 2015 as in previous years The two southernmost transects were, however, not covered due to bad weather.

A series of annual stratified-random bottom trawl surveys, mainly aimed at shrimps, initiated in 1988 was continued in 2015. The gear was changed in this survey in 2005. No correction for this gear change has been made and the 2005 - 2015 time series is hence not directly comparable with 1988-2004 time series. In July-

August 221 research trawl hauls were made in the main distribution area of the West Greenland shrimp stock, including the inshore areas in Disko Bay and Vaigat. The surveys also provide information on Greenland halibut, cod, demersal redfish, American plaice, Atlantic and spotted wolffish and thorny skate (SCR Doc.16/014).

A Greenland deep sea trawl survey series for Greenland halibut was initiated in 1997. The survey is a continuing of the joint Japanese/Greenland survey carried out in the period 1987-95. In 1997-2015 the survey covered Div. 1C and 1D between the 3 nautical mile line and the 200 nautical mile line or the midline against Canada at depths between 400 and 1 500 m. In 2013 only Div. 1D was covered by 27 hauls and the survey is and the survey is not considered reliable for estimating indices for stock status . In 2015 67 valid hauls were made (SCR Doc. 16/004).

A longline survey for Greenland halibut in the inshore areas of Disko Bay, Uummannaq and Upernavik was initiated in 1993. The longline survey was changed to a gillnet survey in the Disko Bay in 2001. Since 2011 experimental gillnet stations have been set in the Uummannaq and Upernavik area. In 2015, the gillnet survey was continued in the Disko bay although with less stations (26 sets). The longline survey was finally changed to a gillnet survey in the Upernavik area (48 sets) and partly in the Uummannaq area (28 sets), where 18 longline sets also were made. Each gillnet was composed of four panels with different mesh size (46, 55, 60 and 70 mm stretch meshes) as in Disko Bay (SCR 16/027). In 2016 only gillnet surveys are planned inshore and to improve the surveys a 90 mm section will be added.

EU-Spain (SCS 16/10, 11, 12, 13, 15, 16): The Spanish bottom trawl survey in NAFO Regulatory Area Div. 3NO was conducted from 31 May to 19 June 2015 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 122 valid hauls and 127 hydrographic stations were taken within a depth range of 45-1480 m according to a stratified random design. 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 2015, the bottom trawl survey in Flemish Pass (Div. 3L) was carry out on board R/V Vizconde de Eza using the usual survey gear (Campelen 1800) from July 28th to August 17th. The area surveyed was Flemish Pass to depths up 800 fathoms (1463 m) following the same procedure as in previous years. The number of hauls was 104 and 7 of them were nulls. Survey results are presented as Scientific Council Research documents. Survey results for Div. 3LNO of the northern shrimp (Pandalus borealis) were presented in SCR 15/048.

The EU bottom trawl survey in Flemish Cap (Div. 3M) was carried out on board R/V Vizconde de Eza using the usual survey gear (Lofoten) from June 22th to July 23th 2015. The area surveyed was Flemish Cap Bank to depths up to 800 fathoms (1460 m) following the same procedure as in previous years. The number of hauls was 182 and one of them was null. Survey results are presented as Scientific Council Research documents. Flemish Cap survey results for northern shrimp (Pandalus borealis) were presented in SCR 15/047.

NEREIDA Project: New data on deep-water corals and sponges were presented based on Spain and Portugal/EU bottom trawl groundfish surveys for 2015 and the Canadian multispecies surveys for 2013-2015. The data was made available to the NAFO WGESA to improve the mapping of sensitive species in the NAFO Regulatory area (Divs. 3LMNO). “Significant” catches (according to the NAFO definition from groundfish surveys) of deep-water corals and sponges were provided and mapped together with the closed areas. A total number of 718 bottom trawl hauls surveys were analyzed. Distribution maps of presence and catches above threshold for RV data of sponges, large gorgonians, small gorgonians and sea pens following the thresholds were presented.

Additionally, the reports “NEREIDA rock dredge sample analysis in support of VME Assessment and Protection in the NAFO Regulatory Area” and “NEREIDA sample analysis to assess the risk of Significant Adverse Impacts on VME in the NRA” were submitted to NAFO and EU in December 2015. On the one hand, these reports present the results produced from the analysis of rock dredge invertebrate fauna acquired during the NEREIDA survey programme around the Flemish Cap and the Tail of the Grand Banks of Newfoundland (NAFO Regulatory Area) and on the other hand, present the results produced in order to improve the accuracy of habitat suitability models applied to deep sea VME indicator taxa, by accounting for the effect of fishing in the predictions. Some results from these analyses have been published in a peer reviewed scientific journal.

USA (USA (SCS Doc. 16/06): The US conducted a spring survey in 2015 covering NAFO Subareas 4, 5 and 6 aboard the FSV Henry B. Bigelow. All planned strata were covered. The US conducted an autumn survey in 2015 covering NAFO Subareas 4, 5 and 6 aboard the FSV Henry B. Bigelow. All planned strata were covered. Biomass indices were presented for 35 stocks and abundance for the two squid stocks.

ii) Surveys planned for 2016 and early 2017

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

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

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

b) Tagging Activities

i) Notification to Fishing and Research Survey vessels.

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

ii) Greenland Halibut Tagging in Divs. 3KL

Initial results from a Greenland Halibut tagging experiment conducted by Canada were reported to STACREC. Over 2012-2015, a total of 11,599 tagged fish were released in Divs. 3KL, most along the edge of the continental shelf. To date, 122 (1.05%) of these fish have been recaptured, over an area spanning much of the Northwest Atlantic.

For the 84 recaptures which included the capture location, the median (straight line) distance travelled was 221 km; however 11 of the recaptures have been located at distances exceeding 500 km from point of release. Furthermore, four of the recaptures were from outside of SA2+Divs. 3KLMNO, the management area within which these fish were released.

The extensive migrations documented are consistent with earlier studies on Greenland Halibut. While exchange between the current stock management boundaries is occurring, there is insufficient information to provide a basis to alter these boundaries.

Given that Greenland Halibut are a relatively long-lived species (age of maturity approximately 14 years), recaptures of the tagged fish are expected for several years into the future. STACREC encouraged further analysis as more results are obtained from this work.

c) Other Research Activities

b) Trial to study the effectiveness of a Sort V grid in a cod end whilst twin rigging for Atlantic Cod (Gadus morhua) 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, in February 2016 the UK freezer vessel "Kirkella H7" (The Fish Producers' Organisation Ltd) commenced 28 days of fishing in NAFO Div. 3M targeting cod. Due to adverse sea conditions during the trip the vessel was able to operate a twin rig for only 30 of the 93 total hauls.

Despite the low number of sets made at depth lower than 300 meters, the trial results look promising. The results show that fourteen undersized fish were measured and recorded, all being caught in the trawl using no grid. When operating in the shallower water the average length for all fish recorded was 51.9 cm in the cod end with no grid and 56.2 cm with the use of the sorting grid.

Noting the promise in this initial work, STACREC encouraged further work in collaboration with SC.

6. Review of SCR and SCS Documents

USA (SCS Doc. 16-06): The report described catches and survey indices of 37 stocks of groundfish, invertebrates and elasmobranchs. Of note, the index for Georges Bank haddock was a record high while the indices for Southern New England yellowtail flounder and southern silver hake were record lows. Research on the environment, plankton, finfishes, marine mammals, and apex predators were described. Descriptions of cruises to explore areas for wind energy and to map deep sea corals in canyons off the southern edge of George Bank were given. Other studies included age and growth, food habits, and tagging studies. The number of observer trips by fishery was discussed as well as cooperative research with the industry. A description of the method for estimating catches in the observer program used both in US waters and in the NRA was given. The bycatches of species not included in the 37 stocks was given.

GadCap: A multispecies model for the Flemish Cap cod, redfish and shrimp (SCR 16/035): Alfonso Pérez-Rodríguez presented the motivation and results of the postdoc project GadCap, financed by the EU Marie Slodowska-Curie actions in years 2014-2015, which have dealt with the development of a multispecies model for the Flemish Cap cod, redfish and shrimp (SCR 16/035). The presentation showed: 1) main features of the model structure and fit to the observed data; 2) population biomass, abundance and recruitment estimates; 3) predation and fishing mortality by age over the study period; 4) comparison with population estimates from the single species models and 5) preliminary estimates of multispecies MSY, F_{msy} and SSB. The main results allowed concluding that the Flemish Cap trophic interactions are a key component determining the dynamic of all the three modeled stocks and that disregarding the species interactions would lead to underestimates of natural mortality and overestimations of the exploitable biomass in short and long term projections. Despite being recognized that the model need still some more work before being used as support in the stock assessment, and the need of a thorough study of the stock-recruitment relationship, long term projections were run with 1000 different fishing mortality combination for all the three stocks, for which preliminary estimates of MSY, F_{msy} and SSB were made. These estimates showed the effect that the level of exploitations over a species (prey or predator) may have in the yield of other species in this system. As a last section in the presentation it was listed the main issues that will need to be addressed in the short and long term in order to improve the performance and usefulness of this multispecies model.

STACREC expressed continued interest in the results of this project and asked about the real possibilities of continuing with its development and the degree of relevance for stock assessment that this model may have. The author highlighted that due to the strong trophic interactions the Flemish Cap it is an ideal case study to continue with the development and application of the multispecies approach to fisheries management in the NAFO area, going even further by developing a MSE framework where the multispecies model is included as an operative model. It is unlikely that the author will have the ability to continue working in this project in the future. Some of the discussion included questions on the structure and performance of the model, like the need of splitting the redfish stock into beaked and golden redfish based in their different growth, ecological interactions and fishery. Some others provided interesting analysis of the diagnostics and population estimates, like the importance of considering a prey-predator functional response of type III that account for prey switching, which could be explored in the future. The multispecies approach to the estimation of MSY and associated parameters (the SSB and F_{msy} was presented) produced high interest among the SC members, and was highlighted as one of the interesting outputs from this model. The author recognized its relevance and pointed that its higher potential would be as part of a MSE framework. However he also stressed the need to consider these results as preliminary and not useful for scientific advice yet, pending of further improvement of the multispecies model and the stock-recruitment relationships used in the long term simulations. The capacity of this multispecies model to predict cannibalism under high recruitment levels and using these predictions in short term scientific advice was asked. It was argued that once all the parameters and functions that define the prey-predator suitability function have been properly defined, the multispecies model can predict the magnitude of all trophic interactions (including cannibalism) and estimates of predation mortality can be made, which could be used in single species models for short term projections scientific advice. Finally it was highlighted that one of the cornerstones problems in multispecies modeling is quantifying the bottom-up effects of prey on predator stocks through its effect on growth, survivorship and reproductive output. This is a long term work, but its inclusion in the multispecies model would make even more necessary the estimation of multispecies MSY due to the stronger prey-predator feedbacks.

Optimization of redfish fishery on the Flemish Cap Bank using biological target reference points (SCR 16/36): STACREC considered the work of Victor Korzhev and Maria Pochtar (PINRO, Murmansk) with proposals to optimize redfish fishery using biological reference points. Variability of biological reference points, $F_{0.1}$ and F_{max}, was studied using several historical periods of fishing characterized by different values of mean weight, maturation ogive and exploitation.

In order to optimize single species fishery of redfish on the Flemish Cap Bank the two approaches were applied:

1) determination of the maximal yield under the remained spawning biomass at the given level during the whole period of fishing (target size of the spawning stock);

2) determination of the maximal yield under maintaining the constant fishing mortality and exploitation model.

Analysis of yield per recruitment dependency as a function of fishing mortality for different exploitation periods of redfish stock on the Flemish Cap Bank, proved that estimations of biological references $F_{0.1}$ and F_{max} are stable and that there is an opportunity to use them while improving fishing. As of the calculations done, in any period of actual fishing going on at fishing mortality F that was higher than F_{max}, redfish biomass would decrease. High fishing mortality in 1989-2001 caused an abrupt decrease in redfish biomass. Redfish fishing at F of 0.14-0.18 throughout all periods was a stabilizing redfish stock, and maintaining fishing mortality at 0.08-0.12 (close to $F_{0.1}$) in 2004-2010 provided stock recovery. It seems probable that the best redfish catch level should be fixed at $F_{0.1}$ to F_{max} to provide its maximum possible yield and the stock to be sustainable; and that these references may be considered as candidates for fishing mortality values while regulating redfish fishing on the Flemish Cap Bank and estimating TAC.

Fishing optimization under the criterion of maintaining constant spawning biomass at a certain level proved that the criterion was practically reasonable. In the period of 1989-2014 such regulation could allow us to obtain the average annual yield higher than actual yield at any of the constant SSB values of 20,000 – 50,000 tons.

Fishing optimization under the criterion of maintaining constant fishing mortality showed great dependence of the results on the stock recruitment size. However, maximum average annual yield varies insignificantly from 18,000 to 20,000 tons at both actual values and recruitment depending on spawning stock value by the Ricker's equation. Fishing mortality value of about 0.2 provides maximum yield. Fishing at F higher than 0.3 results in an abrupt decrease in the average annual yield, fishing and spawning biomasses.

The forecasts of dynamics for redfish stock and the yield for the following 30 years (2015-2045) proves that with maintaining constant spawning biomass at 40,000 tons or constant fishing mortality at 0.2 with average long-term recruitment values, fishing stock would amount to 150,000 tons and average annual yield may be 16,500 tons. This turns out to be considerably higher than the yield of 7,000 tons currently advised by SC NAFO.

7. Other Matters

a) Summary of Progress on Previous Recommendations

In 2015, STACREC recommended that the NAFO Secretariat develop a framework for communicating tagging study information to vessels from Contracting Parties and Coastal States fishing in the Convention Area (e.g., via a link to this information on the NAFO website homepage). No progress was made on this recommendation in 2015. A proposal on this recommendation will be tabled by the Secretariat for consideration at the Sept 2016 SC meeting.

b) Stock Assessment Spreadsheets

Designated Experts were reminded to include their spreadsheets under the DATA tab on the SharePoint. It was agreed to at least start with the stocks that were fully assessed.

i) Presentation on EIUI Project Results

Elucidating the Role of Scientific Information in Decision-making for Fisheries Management

Dr. Suzuette Soomai (Environmental Information Use and Influence research initiative, Dalhousie University) presented the results of her doctoral research to STACREC:

Case studies of the role of scientific information in decision-making in DFO, NAFO, and FAO revealed the main drivers, barriers, and enablers to information use at the science-policy interface. The research in NAFO focused on Canada as a Contracting Party and represented by DFO. Data was collected in 2013-2014 during three month attachments within each organization. Seventy-eight interviews of scientists and decision-makers on their role in information production, communication, and use were conducted and 15 direct observations were made at science and advisory meetings.

The mandates of DFO and NAFO to manage fisheries drive the annual production of science for advice for operational management. The well-defined or formal process for producing scientific advice and making management decisions – DFO's Canadian Science Advisory Secretariat (CSAS) and the NAFO Fisheries Commission's Request for Advice – is a key factor in producing credible, relevant, and legitimate information for decision-making. The attributes of the scientific advice (credibility, relevance, and legitimacy) – characterised respectively by the authority of the organization, the coherence of scientific advice and management needs, and the involvement of multiple stakeholders in the information pathways – enhance its uptake in decision-making. Managers have become more science literate over time and trust relationships between scientists and managers promote iterative communication and improve understanding of science and management needs.

Aspects of organizational structure and culture in DFO, e.g., the disconnect between operational decision-making and strategic policy-making, and the different roles of scientists and managers, were identified as main barriers in the information pathways. Communicating risk and uncertainty was a greater concern for ecosystem advice compared with fisheries science largely due to the complexity of the issues involved. This poses a constraint to implementing the ecosystem approach to fisheries management. This challenge persists because the demand for scientific information in NAFO is driven by the need to manage fisheries.

To mitigate these barriers, structural changes within NAFO, such as the formation of joint Fisheries Commission and Scientific Council working groups, and overlapping membership of DFO, NAFO, and FAO working groups, facilitate increased and ongoing communication between managers and scientists. Such changes also ensure that the organizations keep pace with the growing complexity of fisheries management. The NAFO Secretariat also plays a "bridger" role to ensure communication between the Contracting Parties and also between the constituent bodies of NAFO. NGOs, acting as Observers, play a critically important role in NAFO and the national fisheries agencies of Contracting Parties by increasing attention given to complex issues, such as climate change impacts, at senior-decision-making levels.

The results showed the important role that information plays in decision-making. The interface in fisheries management is dynamic as it involves continuous interactions between scientific and decision-making groups and external stakeholders to enable efficient flow of information. Multiple interfaces exist within and among the three organizations. Knowledge of the information pathways can enable scientists and decision-makers to determine the most appropriate entry point and timing in the policy-making process and can guide other individuals and organizations who wish to contribute but are unfamiliar with the ways in which scientific information is communicated.

This presentation generated extensive discussion within STACREC on its findings, particularly on the role of scientists in explaining complex advice and/or results to managers. STACREC noticed, that, while conducting such research by different Contracting Parties, their position and national characteristics should be taken into account. Prepared scientific advice should be understandable to scientists, managers and fishery executives. STACREC considered that the managers often take into consideration other factors besides SC advice when making decisions. STACREC encouraged the author to consider presenting this work at future joint FC-SC working group meetings.

c) External Reviewers

STACREC discussed the utility of introducing external peer-review to future June SC meetings. It was recognized that external reviewers participate in many assessment and advisory forums worldwide and can provide significant benefit, ensuring consistency with best practice and enhancing transparency of process.

For stock assessments, the external peer-reviewer would provide comment on treatment of input data, the analytical methods applied and reference points. For other research relating to requests from FC, specific terms of reference for reviewers would be developed in advance. In all cases, the reviewer would be required to present a short summary of findings to SC and this review would be documented in the SC report.

Debate focused on the more effective of two potential options for conducting the external review: having a reviewer present for a portion of the SC meeting or to have the review conducted following the conclusion of the SC meeting from the available documentation. Without consensus on which route was preferred, it was agreed to proceed with one review of each type over the coming two years, after which a decision about future reviews would be made by SC.

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

8. Adjournment

The Chair thanked the participants for their presentations to the Committee. Special thanks were extended to the rapporteur and the Scientific Council Coordinator and all other staff of the NAFO Secretariat for their invaluable assistance in preparation and distribution of documents. There being no other business the Chair adjourned the meeting at 1300 hours on 16 June 2016.

Appendix IV. Report of the Standing Committee on Fisheries Science (STACFIS)

Co-Chairs: Joel Vigneau & Brian Healey Rapporteurs: Various

I. OPENING

The Committee met at the Sobey School of Business, Saint Mary's University, Halifax, NS, Canada, from 3 to 16 June 2016, to consider and report on matters referred to it by the Scientific Council, particularly those pertaining to the provision of scientific advice on certain fish stocks. Representatives attended from Canada, Denmark (in respect of the Faroe Islands and Greenland), the European Union (France, Portugal, Spain and the United Kingdom), Japan , the Russian Federation, and the United States of America. Various members of the Committee, notably the designated stock experts, were significant in the preparation of the report considered by the Committee.

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

II. GENERAL REVIEW

1. Review of Recommendations in 2015

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

STACFIS conducted a general review of catches in the NAFO SA 0–4 in 2015. NAFO Scientific Council (STACFIS) has estimated catch for its stock assessments for many years since the 1980s when large discrepancies were observed between various sources of catch information. The goal of this exercise was to use the most accurate information available to provide the best possible assessments and advice. STACFIS has had available estimates from different sources, but not for all fleets or from all Contracting Parties. These various sources of data have in many years led STACFIS to the conclusion that catch estimates from STATLANT have been unreliable for a number of stocks. Lack of catch estimates is hindering provision of advice for many stocks, and for other cases, the accuracy of assessment results and management advice rely on the assumption that the STATLANT data equals the annual landings, an assumption which can no longer be independently verified. However, key sources of other data have not been available to evaluate STATLANT data since 2011.

STACFIS noted the Ad hoc FC-SC Working Group on Catch Reporting (WG-CR) continues its mandate and that more detailed reporting requirements have been implemented within NAFO (e.g. catch reporting on a tow-by-tow basis introduced as of Jan 1 2015). It was also noted that a sub-group of WG-CR with technical expertise in the various data sources available to NAFO, the Catch Data Advisory Group (CDAG), had met several times in 2016 via video-conferencing to devise a methodology and guidance on catch validation to enable the Secretariat to provide catch estimates to SC in advance of this meeting. However, deliberations on a method to validate catch from available sources were still ongoing within CDAG at the time of this SC meeting and their report was not completed before the end of the SC meeting.

During the June 2016 SC meeting, the sources of catch information for 2015 were national research reports, STATLANT 21A data, Daily Catch Records (DCR) for fleets which operated in the NRA and port inspection data for Greenland Halibut. It was noted that STATLANT 21A data was not available for all contracting parties by the start of the meeting, therefore only data available as of 30 May was considered. Data on effort from VMS reporting were also available for 2015, and considered as a means to evaluate the plausibility of trends in recent catches reported within STATLANT21. To estimate the 2015 catches, STACFIS agreed to a general procedure whereby daily catch reports data (including discards) were accepted to estimate catch for all flag states operating in the NRA with STATLANT 21A data being used for Canadian fisheries, most of which is taken within its EEZ.

The 2014 assessment of American Plaice in Divs. 3LNO used an assumption of constant CPUE over 2011-2013 to estimate catch of some fleets, and adjusted the 2010 catch by the change in effort in each year to estimate the required catches. At that time it was noted that the assumption of constant CPUE should only stand for a limited number of years, but STACFIS decided to extend the method to 2014 since STATLANT 21 could not provide reliable estimate of catch for that year n. For 2015 STACFIS agreed to use DCR for fleets in the NRA and STATLANT 21 catch for Canadian fisheries. .

For Greenland halibut in SA 2 + 3KLMNO STACFIS agreed to a method to estimate catch in 2011 to 2014 that will be applied intersessionally to try to resolve this before the September 2016 meeting. The basis of this method is that VMS effort was considered the most reliable information available. The estimates of catches over a time period covering 2011-2014, will therefore depend on the estimation of appropriate commercial CPUEs. Scientific observer CPUEs were considered to be the best estimate of CPUE, but these are not available for all countries, for all considered years. For those countries that cannot produce an estimate of CPUE from scientific observer data for each year from 2011 to 2014, average CPUE from an earlier period will be used to fill any gaps. The period of averaging will be determined intersessionally giving consideration to trends in available CPUE values. For countries for which no scientific observer CPUE data is available, weighted average values for the relevant year from other flag states will be used.

For the Canadian gillnet fleet, STATLANT data will be used as the CPUE method was not considered reliable due to changes in fishing pattern (eg mesh size and baiting of nets) that cannot be accounted for in standardisation. For Canada, otter trawl estimates of CPUE based on scientific observer data, and the resulting catch values, will be used.

For 2015, it was proposed to use the method that will be recommended by CDAG.

Unavailability of accurate catch data also has implications on the potential to provide quantitative assessments for stocks that are currently assessed qualitatively. Several classes of population dynamics models will have poor diagnostics if the removals data are biased and are inconsistent with changes in survey trends. Consequently, estimation of population size and any resulting management options using biased catch data will be inaccurate.

III. STOCK ASSESSMENTS

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

(SCR Docs. 16/01, 02)

Recent Conditions in Ocean Climate and Lower Trophic Levels

●The composite climate index in Subarea 0-1 has remained mostly above normal with a peak in 2010 but has been in decline in recent years with a negative anomaly in 2015, indicating colder than normal conditions.

●The composite spring bloom index reached its 2nd highest peak in 2015 after several years of below normal conditions.

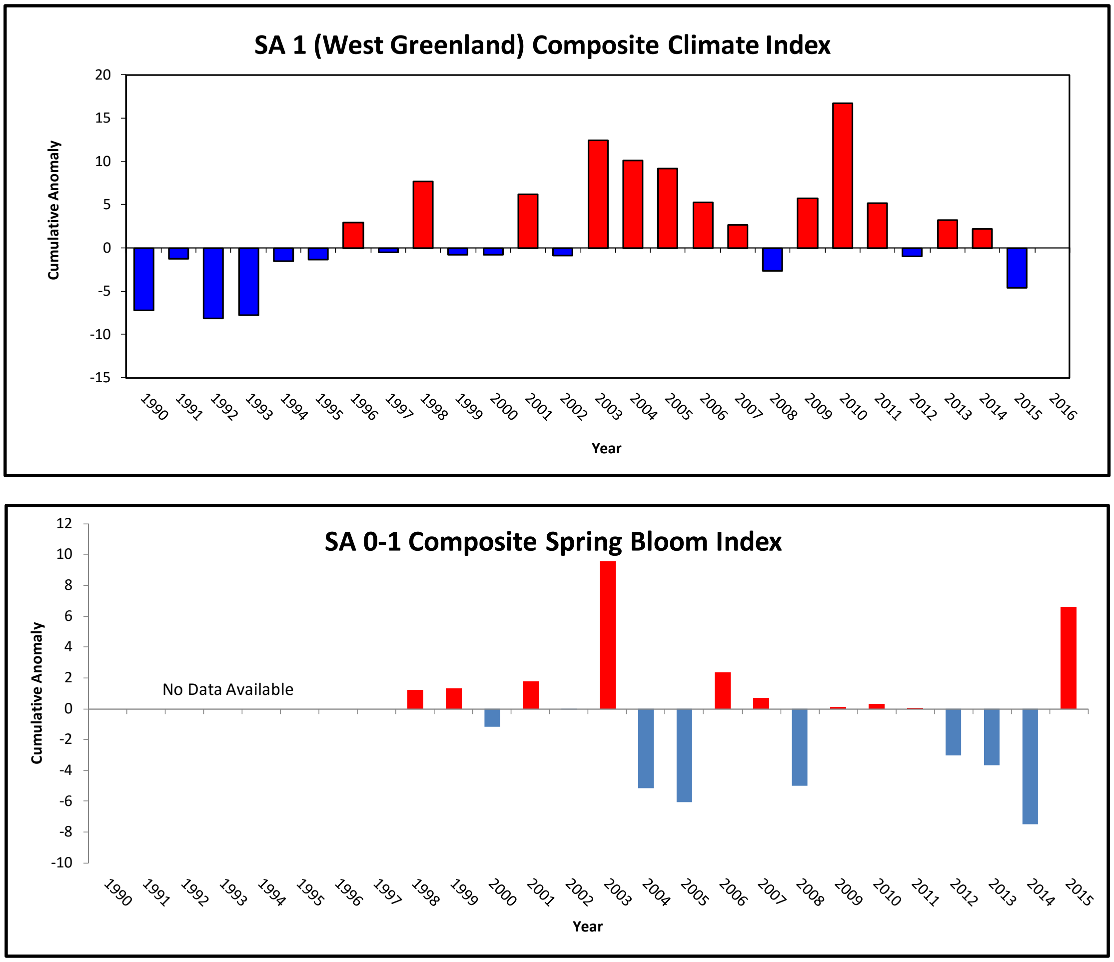


Fig. III. 1. Composite climate index for NAFO Subarea 1 (West Greenland) derived by summing the standardized anomalies of meteorological and ocean conditions during 1990-2015 (top panel), composite spring bloom (cumulative anomalies for magnitude and timing metrics of the spring bloom) index during 1998-2015 (bottom panel). Red bars are positive anomalies indicating above average levels while blue bars are negative anomalies indicating below average values.

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 shifted back to positive levels in 2013 from the slightly negative value the previous year. During the past several years the climate index showed positive anomalies reaching a record-high in 2010. (Figure III.1). Cold, fresh conditions persisted in the early to mid-1990’s followed by a general warming trend in the past decade with the exception of a brief cooling event in 2008. The composite spring bloom index remains below normal in 2014 consistent with observations in recent years. In winter 2012/13, the North Atlantic Oscillation (NAO) index was negative describing weakening westerlies over the North Atlantic Ocean. Often this results in warmer conditions over the West Greenland region which was also the case this winter with air temperature above normal. The time series of mid-June temperatures at Fylla Bank show temperatures 0.5°C above average conditions in 2013 and average salinities. The normalized near-surface salinity index and the presence of Polar Water were normal in 2013.

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

(SCR Doc. 16/04, 5, 14, 25, 29; SCS Doc. 16/07, 10)

a) Introduction

The Greenland halibut stock in Subarea 0 + Div. 1A offshore and Div. 1B-1F is part of a common stock distributed in Davis Strait and southward to Subarea 3. Since 2001 advice has been given separately for the northern area (Div. 0A and Div. 1AB) and the southern area (Div. 0B and Div. 1C-F).

A TAC was first established for SA 0+1, including Div. 1A inshore, in 1976 and set at 20 000 t. It increased to 25000 t in 1979 and remained at this level until 1994. In 1994 Scientific Council decided to make separate assessments and advice for the inshore area in Div. 1A and for SA 0 + Div. 1A offshore + Div.1B-1F. As a result the TAC for SA 0 + Div. 1A offshore + Div.1B-1F decreased to 11000 t and remained at this level until 2001. Between 2001 and 2014 the TAC increased to 30 000 t following a series of new surveys in previously unassessed areas of Div. 0A and 1AB and improving stock status in Div. 0B and 1CD. Since 2001 the TAC has been divided between Div. 0A+1AB and Div. 0B+1C-F with current levels of 16000 t for Div. 0A+1AB and 14000 t for Div. 0B+1CD (Fig. 1.1).

Catches in 0 + Div. 1A offshore + Div.1B-1F increased from low levels during the late 1960s to 20000 t in 1975 before declining and remaining relatively stable at approximately 4500 t during the 1980s. Catches increased again between 1989 and 1992, reaching a peak of almost 20000 t before declining to 11800 t in 1994. Catches were relatively stable at approximately 8500 t from 1995 to 2000 with almost all the catch coming from Div. 0B and Div. 1CD. Since then catches have increased to current levels of 32000 t with the TAC achieved in most years (Fig. 1.1).

The fishery in Subarea 0. Catches increased from 400 t in 1987 to 12 800 t in 1992 but decreased to 4 700 t in 1992 and stayed at that level until 2000. Prior to 2001 almost all the fishery has been taking place in Div. 0B and fishing occurred in only a few years between 1993 and 2000 with catches of less than 700 t in Div. 0A. In 2001 catches increased to 8 100 t due to increased effort in Div. 0A. Since then catches have increased gradually to 15 400 t in 2015 following increase in TAC mainly in Div. 0A but also in Div. 0B. In recent years all catches have been taken by vessels from Canada and approximately 1/3 has been taken by gill net and 2/3 by single and twin trawlers.

The fishery in Div. 1A offshore + Div. 1B-1F. In SA1 catches fluctuated between 1 800 and 5 700 t between 1987 and 2001 and almost all of the catches have been taken in Div. 1CD. A fishery was started in Div. 1AB in 2000 and catches increased gradually to 9 500 t in 2003. Catches remained at that level until 2005. Since then catches have increased gradually to 16 500 t in 2015 following increase in TAC mainly in Div. 1AB but also in Div. 1CD. In recent years the offshore fishery has been prosecuted by twin and single trawlers from Greenland, Norway, Russian Federation, Faroe Islands and EU (mainly Germany). Inshore catches in Div. 1B-1F has been around 200-300 t annually but increased from 440 t in 2012 to 1 800 t in 2014 mainly due to increased effort in Div. 1D. The inshore catches decreased to 1 500 t in 2015 (Fig. 1.1).

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

	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
TAC	24	24	24	27	27	27	27	30	30	30
SA 0	11	11	12	13	13	13	13	15	15	
SA 1 exl. Div. 1A inshore	12	12	12	14	14	14	15	17	17	
Total STATLANT 21 [1]	22[2]	22	25	27	27	27	28	32	32	
Total STACFIS	23	23	25	27	27	27	28	32	32	

[1] Excluding inshore catches in Div. 1A

[2] Excluding 3 565 reported by error from Div. 1D

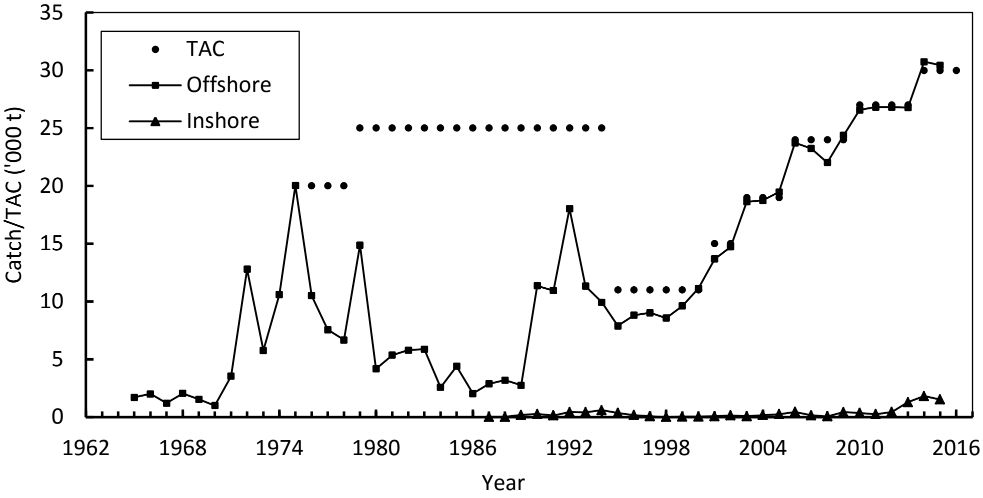


Fig. 1.1. Greenland halibut in Subareas 0+1 (excluding Div. 1A inshore): catches and TACs.

c) Input Data

b) *Commercial fishery data*

Length frequencies were available from the Canadian gill net and trawl fishery in Div. 0A and Div. 0B in 2015.

Modes in the 0A gill net fishery have shifted gradually from 62 cm in 2013 to 58 cm in 2015, while it has been stable in the fishery in Div. 0B at 62-64 cm. The modes have been at 48-50 cm in the trawl fishery in both Div. 0A and 0B in recent years. However, the proportion of fish at these sizes decreased in 0A and increased in 0B in 2015 compared to the 2013 and 2014 length frequencies.

Length frequencies were available from trawl fisheries by Greenland and Russian Federation in Div. 1AB and from Norway, Greenland and Russian Federation in Div. 1CD. In 2015 catch from Greenland and Russian Federation in Div. 1AB had modes at 52 cm and with more large fish than previously seen especially in the Russian fishery. In recent years the trawl catches have been dominated by fish of 44-52 cm. In Div. 1CD Norway, Greenland and Russian Federation catch length frequencies showed modes around 50-55 cm. The mode in catches has been between 49 and 55 cm for many years.

The standardized trawl CPUE series for Div. 0A+1AB combined has been stable since 2002 with an increasing trend since 2007 but decreased slightly in 2015 (Fig. 1.2). Catch rates before 2001 are from only one or two vessels fishing a small exploratory allocation and may not be directly comparable to subsequent years.

The standardized trawl CPUE series for Div. 0B+1CD combined was relatively stable from 1990-2004, increased from 2004-2009 then decreased between 2009 and 2012. CPUE has been increasing since 2013 and the 2015 estimate is the highest in the time series. (Fig.1.2). Catch rates in 1988 and 1989 are from one 4000 GT vessel fishing alone in the area and may not be directly comparable to subsequent years.

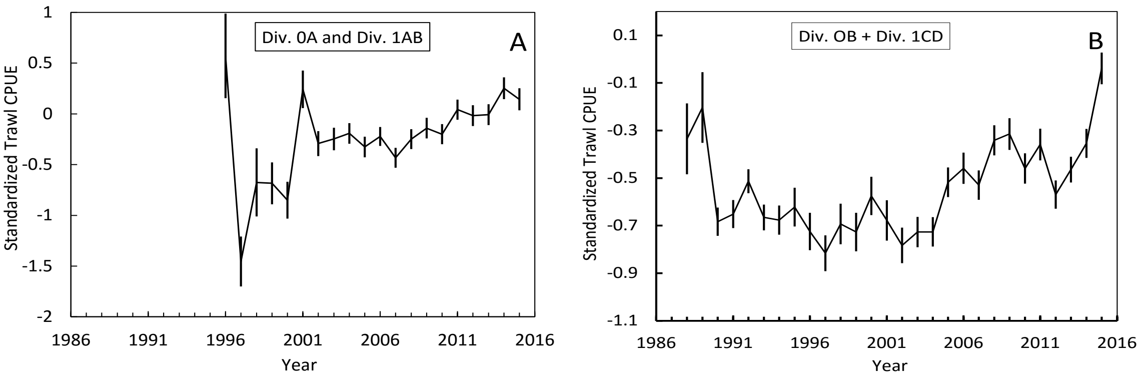


Fig. 1.2. Greenland halibut in Subareas 0+1 (excluding Div. 1A inshore): Combined standardized trawler CPUE ± S.E from Div. 0A and Div. 1AB (panel A) and Div. 0B and Div. 1CD (panel B)

A standardized CPUE index for all trawlers fishing in SA 0+1 increased between 2002 and 2006 and has been fluctuating with an increasing trend since then. The 2015 estimate was the largest in the time series (Fig. 1.3).

Standardized CPUE for gillnets in Div. 0A increased gradually from 2006-2011 and has been stable until 2014 but increased slightly in 2015 (Fig. 1.4).

Standardized CPUE for gill nets in Div. 0B has been gradually increasing since 2007 and was at the highest level in the time series in 2015 (Fig. 1.4).

It is not known how the technical development of fishing gear or vessel changes in the fleets has 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.

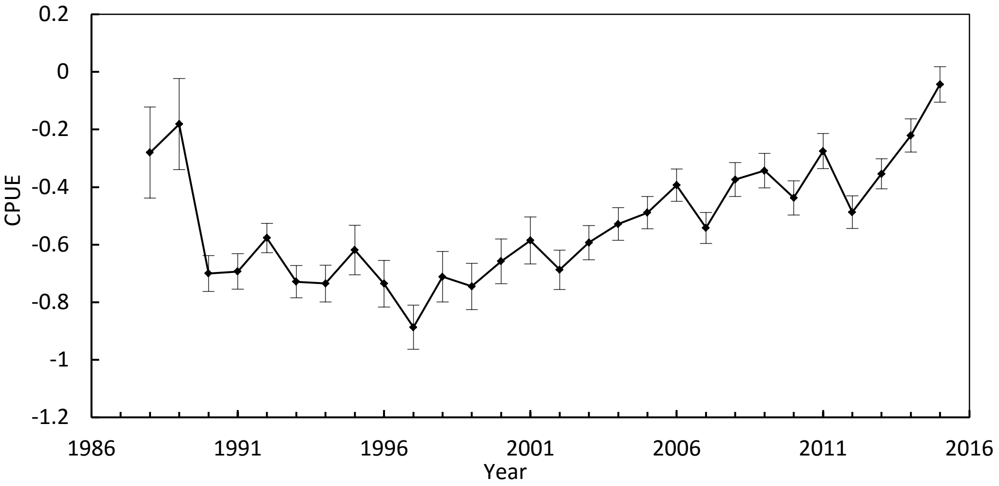


Fig. 1.3. Greenland halibut in Subareas 0+1 (excluding Div. 1A inshore). Combined standardized trawler CPUE from all divisions with ± S.E.

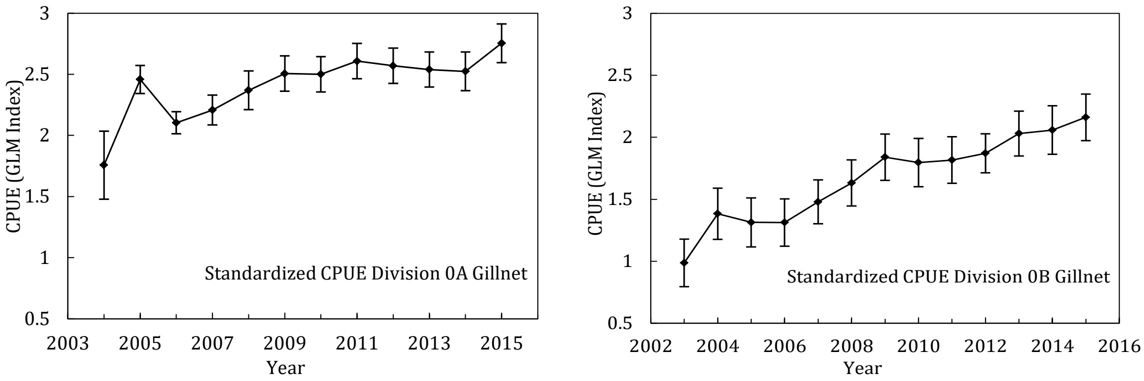


Fig. 1.4. Greenland halibut in Subareas 0+1 (excluding Div. 1A inshore): Standardized gillnet CPUE from Div. 0A (left) and Div. 0B (right).

ii) Research survey data

Japan-Greenland and Greenland deep sea surveys in Div. 1BCD. From 1987 to 1995 bottom trawl surveys were conducted in Div. 1BCD jointly by Japan and Greenland (the survey area was re-stratified and the biomass estimates were recalculated in 1997). The Japan-Greenland survey in 1987 only covered depths down to 1000 m and the biomass at depths 1000-1500 m is estimated by a GLM. In 1997 Greenland initiated a new survey series covering Div. 1CD. This index of trawlable biomass has been variable with a gradually increasing trend from 1997 to 2011, which was the highest in the time series. The biomass declined from 2011 to 2014, which was the lowest seen since 1997. The trawlable biomass has increased again in 2015 to a level above the average for the time series (Fig. 1.5). The trend in abundance generally follows the trend in biomass.

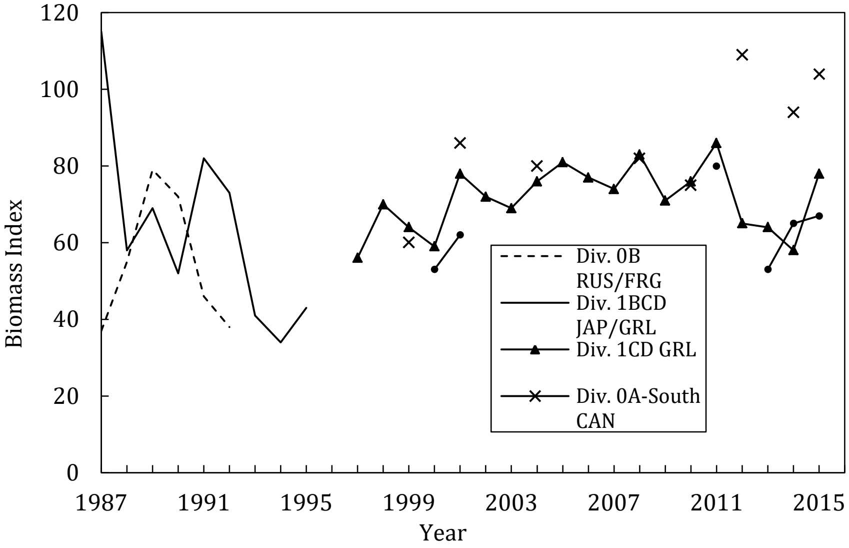


Fig. 1.5. Greenland halibut in Subareas 0+1 (excluding Div. 1A inshore): biomass indices from bottom trawl surveys. A survey in Div. 0A in 2006 is not included due to poor coverage.

Canada deep sea survey in Div. 0A-South. The survey biomass indices were recalculated in 2014 based on a new stratification scheme (SCR 15/030).The index of trawlable biomass for Div. 0A-South has been fluctuating with a slight increasing trend since 1999 while abundance has remained relatively stable. The 2012 estimate of biomass was the highest of the time series. The biomass index decreased slightly between 2012 and 2014 but increased again in 2015 (Fig. 1.5). The overall length distribution in 2015 ranged from 6 cm to 81 cm with modes observed at 18, 33 and 42 cm. A trend to increased numbers of larger fish was observed from 2008 to 2014 but in 2015 there was a shift to smaller sizes (18-36 cm) in the length distribution. The proportion of fish <45cm increased to 76%, compared to 64% and 54% in 2012 and 2014, respectively and may reflect recruitment of the abundant 2010 and 2012 year classes to the survey.

Canada deep sea surveys in Div. 0B. The survey biomass indices were recalculated in 2014 based on a new stratification scheme. Biomass has increased from 2013 to 2015 but levels are still below the 2011 value which is the highest in the short survey series (Fig. 1.5). The trend in abundance generally follows the trend in biomass in Div. 0B. Overall lengths in 2015 ranged from 6 cm to 96 cm with a mode at 48 cm, similar to that observed in previous surveys. 32% of fish were <45 cm, similar to that observed in 2011 and 2013.

Div. 0A-South and 1CD combined-stock index. The ICES Benchmark Workshop (ICES 2013) recommended combining the 0A-South and 1CD indices to create a single index with which to monitor the overall stock status. This recommendation was adopted by STACFIS in 2014. 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 (Fig. 1.7). The biomass index was relatively stable from 2001 to 2010 with a slight increasing trend since then.

Greenland shrimp and fish survey in Div. 1A-1F. Since 1988 annual surveys with a shrimp trawl have been conducted off West Greenland during July-September. The survey covers the area between 59ºN and 72º30'N (Div. 1A-1F), from the 3-mile limit to the 600-m depth contour line. The survey only covers a small fraction of the Greenland halibut distribution and catches mainly age one and age two Greenland halibut, therefore the biomass estimate is not used as a stock index but the survey is used to estimate a recruitment index for age one. The trawl was changed in 2005 but the 2005–2014 time series estimates are adjusted to the old 1989-2004 time series and the series are comparable.

The year class index of one-year-old fish in the total survey area, including Disko Bay, was variable for year classes 1989 to 1996 then increased to a peak in 2000 followed by a sharp decline in the 2001 year class. A period of relative stability during the 2000s was followed by an increase to the highest in the time series for the 2010 year class. Since then year class strengths have fluctuated with a couple of strong year classes including the 2014 year class. (Fig. 1.6).

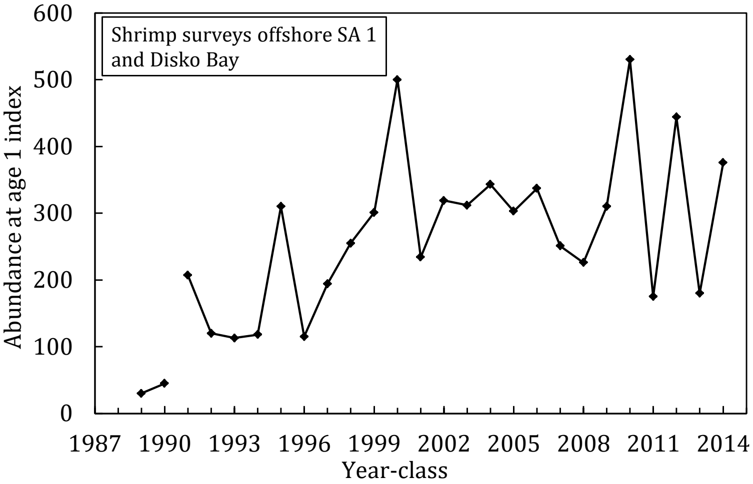


Fig. 1.6. Greenland halibut in Subareas 0+1: recruitment index at age 1 in Subarea 1 derived from the Greenland shrimp trawl surveys. Note that the survey coverage was not complete in 1990 and 1991 (the 1989 and 1990 year-classes are poorly estimated as age 1).

c) Estimation of Parameters

In 2014 a simple Schaefer model was tested on the Greenland halibut stock offshore in NAFO SA 0 and 1. The minimum data required for this model is a catch time series and a measure of the resilience of the species. Other input parameters that required a starting guess were the carrying capacity, the biomass as a fraction of the carrying capacity at both the beginning and end of the time series, and the growth rate. MSY was estimated to be between 19 000 and 23 000 t. Sensitivity tests showed that the estimation of MSY was heavily dependent on the guess of especially the biomass at the end of the time series and the growth rate. The model cannot become any more reliable unless we can improve the input parameter "guesses" through a better understanding of the stock dynamics and biology. Until then the outcome of the model is considered only indicative of stock status and not useful for estimating reference points. The model was not tested in 2016.

A survey approach to estimate catch level of Greenland halibut in SA 0+1. The assessment of Greenland halibut in Subarea 0 and 1A (offshore)+1B-F relies on several fishery independent survey indices. The application of the ICES guidance on data limited stocks (DLS) method 3.2 (ICES 2012a, 2012b, 2014) as the basis for the approach for advice on SA0+1 Greenland Halibut could be helpful in providing TAC advice.

ICES has developed and tested an empirical approach that uses the trend in the stock response to fishing pressure (ICES 2012a, Jardim et al. 2015). The empirical basis was given a generic expression:

$C_{y+1}=Catch_{recent}*r$:

$Catch_{recent}$ is the average catch over some period; r is the trend in development of the stock (normally SSB) over some period (e.g. 7 year time frame, r=mean of recent 3 year/mean of next 4 years).

Managers should determine the level of risk (change cap and precautionary buffer) but ICES has provided some guidance for those cases where management input is not available. A 20% change cap, used to limit the rate at which the TAC would change at any one time was recommended. However, it may be possible to consider a higher change cap when the stock is declining. A precautionary buffer or reduction factor (e.g. 20%) would be applied to r given certain stock conditions relative to reference points (e.g. if the stock is over-harvested or below target reference points).

Advice should not be made annually; it would apply over some period of time (e.g. 2-3 years) to allow for the delay between action (change in catch) and response (state of the stock). There would be interim assessments and advice on TAC could be given in interim years if a sudden change in stock status is observed.

In the case of Greenland halibut in Subarea 0 and 1 we are not able to estimate SSB (due to survey trawl selectivity). However, we have stock abundance indexes based on surveys that are used to assess the status of two portions of the stock area, Div. 0A-1AB (0A-south survey) and Div. 0B-1C-F (1CD survey). Given the long-lived life-history of Greenland halibut and the mixed gear nature of the fishery it was determined that a 7 survey time frame for the calculation of r would be most appropriate. It was noted that the precautionary factor need not apply in the case of SA0+1A (off shore) and 1B-F Greenland halibut given the stock is near the B_{msy} proxy and therefore well above B_{lim} and there have been several recent years with good recruitment.

There are seven surveys available from Div. 0A-South and Div. 1CD combined that cover a 14 year period 2001, 2004, 2008, 2010, 2012, 2014 and 2015 (the 2006 survey has been excluded due to very poor coverage).

Rate of increase (r) is estimated based on the mean biomass estimate from 2012, 2014, 2015 over the mean estimates from 2001, 2004, 2008, 2010 i.e r=1.077 (Fig. 1.7).

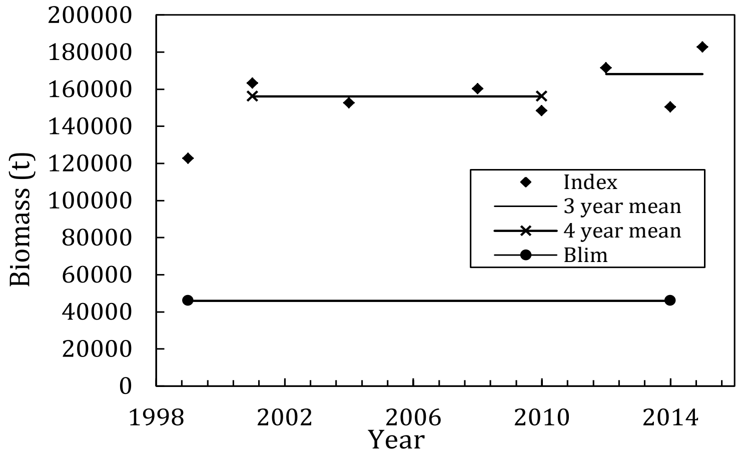


Fig. 1.7. Greenland halibut in Subareas 0+1: Biomass trends in Div. 0A-South and Div. 1CD and the proxy for B_{lim}.

d) Additional studies

The by catch in the commercial fishery for Greenland halibut in NAFO Div. 1CD was estimated based on information from ground fish surveys conducted by Greenland Institute of Natural Resources in the same area as the commercial fishery. The survey is conducted with a trawl with 30 mm in the cod end while the minimum mesh size in the cod end in the commercial trawls is 140 mm and the survey catches are converted to potential commercial by catches. The conversion is based on a number of assumptions and the results should be considered as indicative (see research recommendations). The total by-catch in weight is estimated to be 13% of the total catch of Greenland halibut. *Macrourus berglax* is the most abundant by catch species and constituted 3.2 % of the weight of Greenland halibut followed by *Antimora rostrata* (2.7%), *Alepocephalus agassizii* (2.0 %) and *Hydrolagus affinis* (1.2%). None of the remaining species constituted more than 1% of the weight of the Greenland halibut catches. The impact of the fishery for Greenland halibut on the stocks of the by-catch species seems, however, to be limited (Jørgensen et al. 2014).

e) Assessment Results

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

Fishery and Catches: Catches have increased in response to increases in the TAC from approximately 10000 t in the late 1990s to approximately 27000 t during 2010 to 2012 then increased to 32000 t in 2014 and remained at that level in 2015. The TAC is 30000 t in 2016.

Data: Biomass indices from deep sea surveys in 2015 were available from Div. 0A, Div. 0B and Div. 1CD. Further, biomass and recruitment data were available from shrimp surveys in Div. 1A-1F from 1989-2015. Length distributions were available from both surveys and the fishery in SA1. Unstandardized and standardized catch rates were available from Div. 0A, 0B, 1AB and 1CD.

Assessment: No analytical assessment could be performed.

Commercial CPUE indices. A standardized CPUE index for all trawlers fishing in SA 0+1 increased between 2002 and 2006 and has been fluctuating with an increasing trend since then. The 2015 estimate was the largest seen since 1990.

The standardized trawl CPUE series for Div. 0A+1AB combined has shown an increasing trend since 2007 but decreased slightly between 2014 and 2015.

The standardized trawl CPUE series for Div. 0B+1CD combined was relatively stable from 1990-2004, increased from 2004-2009 then decreased between 2009 and 2012 but increased again in 2013 - 2015 and is now the highest seen since 1989.The standardized CPUE for gillnets in Div. 0B has been gradually increasing since 2007 and in 2015 was at the highest level in the time series.

It is not clear how CPUE relates to stock status.

Biomass: The combined Div. 0A-South and 1CD index was relatively stable from 2001 to 2010 with a slight increasing trend since then.

Recruitment: A period of relative stability in the recruitment index (age one) during the 2000s was followed by an increase to the highest in the time series for the 2010 year class. Since then year class strength has fluctuated, with strong year classes in 2012 and 2014.

Fishing Mortality: Level not known.

State of the Stock: The biomass (combined Div. 0A + Divs. 1CD index) has been relatively stable with a slight increasing trend in recent years and was well above B_{lim} in 2015.

Div. 0B+1C-F: The biomass index in Div. 0B has increased from 2013 to 2015 but levels are still below the high observed in 2011. The biomass index for Div. 1CD has been decreasing since 2011 and was in 2014 at the lowest level seen since 1997, but increased to a level above average for the time series in 2015. Length compositions in the catches and deep sea surveys have been stable in recent years.

Div. 0A+1AB: The biomass index has been variable with an increasing trend since 2010. Length compositions in the 1AB commercial catches have been relatively stable in recent years. The trend to increased numbers of larger fish observed in the 0A-South survey from 2008 to 2014 has stopped with a shift to smaller sizes (18-36 cm) in the length distribution for 2015. In the 0A fishery abundance at length declined in the 2015 trawl fishery, compared to 2013 and 2014, and in the gillnet fishery the proportion <62 cm has been increasing since 2013.

f) 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 biomass index estimated for surveys conducted between 1997 and 2012 in Div. 1CD combined with surveys from 1999-2012 in Div. 0A-South to establish a proxy for B_{lim} for the entire stock (Fig. 1.7).

If TACs are established for the next two years, the next full assessment of this stock is recommended for 2018.

Recommendations: STACFIS recommended that for Greenland halibut in SA0 + div1A 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.

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2. Greenland Halibut (*Reinhardtius* hippoglossoides) Div. 1A inshore

(SCR Doc. 16/014 16/027 16/037 SCS Doc. 16/07)

a) Introduction

The inshore fishery for Greenland halibut developed in the beginning of the twentieth century, with the introduction of the longline to Greenland in 1910. Greenland halibut is targeted in most inshore areas, but the main areas are the Disko Bay and the districts surrounding Uummannaq and Upernavik. Total landings in Subarea 1A-inshore for the three areas combined were less than 1 000 tons until 1955 but gradually increased to 5 000 tons in the mid 1980s and reached 25 000 tons in 1999. Since then yearly catches have a level of 20 000 to 25 000 tons. The stocks are believed to recruit from the spawning stock in the Davis Strait and there is little migration between the areas and offshore. Advice is given for each subarea on a two year basis and a separate TAC is set for each area. Quota regulations were introduced as a shared quota for all vessels in 2008. In 2012, the TAC was split in two components with ITQ's for vessels and shared quota for small open boats. In 2014, "quota free" areas within each subarea were set by the Government of Greenland, and in these areas catches were not drawn from the total quota, although still included in landing statistics. The only other significant fishery in the area is the trawl fishery targeting shrimp in the Disko bay. In order to reduce the bycatches in the shrimp fishery, sorting grids have been mandatory since 2011. Besides the three main areas, a fishery is slowly developing in the Qaanaaq fjord, far north of the Upernavik area.

Disko Bay: Catches increased from about 2 000 t in the mid 1980's and peaked from 2004 to 2006 at more than 12 000 tons. After 2006 catches were halved in just three years without any restrictions on effort, TAC or reduced prices to explain the decrease. Catches have gradually increased since then, but decreased from 9177 tons in 2014 to 8674 tons in 2015(Fig 2.1).

Uummannaq: Catches increased from 3 000 tons in the mid 1980's and peaked in 1999 at more than 8000 t. Catches then decreased to a level of 5 000 t to 6 000 t. After 2005 catches in the area have gradually increased and were at 8244 t in 2015 (Table 2.1 and fig 2.1).

Upernavik: Catches increased from the mid 1980's and peaked in 1998 at a level of 7 000 t. This was followed by a period of decreasing catches, but since 2002 landings have gradually increased. In 2014, a record high 7,381 t were landed in the district, but in 2015 catches dropped to 6274 tons (Table 2.1 and fig 2.1).

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

	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Disko Bay – TAC		12.500	8.800	8.800	8.000	8.000	9.000	9.000	9.200	9.500
Disko Bay - Catch	10.000	7.700	6.321	8.458	8.005	7.755	9.073	9.177	8.674	
Uummannaq - TAC		5.000	5.000	5.000	6.000	6.000	7.450	8.379	9.500	10.000
Uummannaq - Catch	5.318	5.426	5.451	6.226	6.397	6.130	7.007	8.199	8.244	
Upernavik - TAC		5.000	5.000	6.000	6.500	6.500	7.950	9.500	9.500	9.900
Upernavik - Catch	4.877	5.478	6.497	5.941	6.471	6.830	6.039	7.381	6.274	
Qaanaaq - Catch					0.021	0.050	0.011	0.129	0.138	
STACFIS Total	20.194	18.603	18.270	20.626	20.894	20.786	22.130	24.886	23.330	

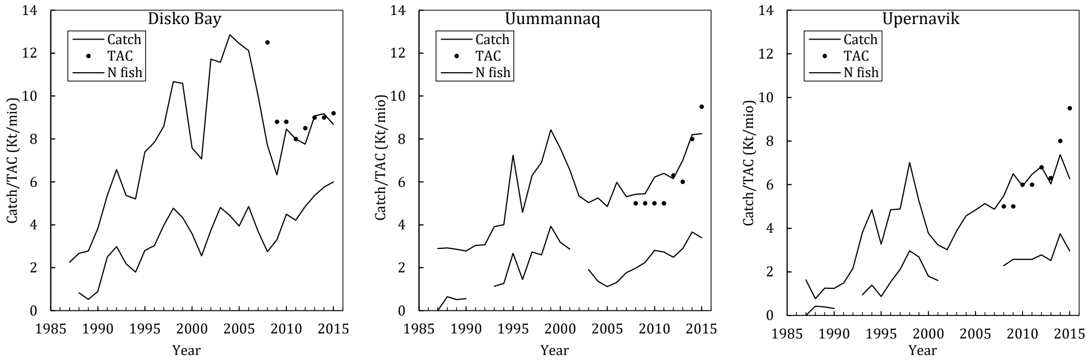


Fig 2.1. Greenland halibut in Division 1A inshore: Greenland halibut catches and TAC t in Disko Bay, Uummannaq and Upernavik. Catch numbers are in millions.

i) Input data

b) *Commercial fishery data*

Length frequencies from factory landings are available since 1993.

In the **Disko Bay,** Mean length in the landings gradually decreased for more than a decade in the area in both the winter longline fishery and the summer longline fishery and in the overall mean length weighted by gear and area (fig 2.2). Access to the deep Kangia ice fjord where large Greenland halibut are caught at greater depth is limited during the summer, causing the difference in summer and winter fishery mean length. The trends in mean size by season are however decreasing at the same rate over time and the persistent decrease suggests that the decrease was not due to new large incoming year classes but a true decrease in the adult stock. The decreasing size in the landings can also be seen as a general shift of the length distribution towards smaller fish and a narrower distribution in the longline landings (fig 2.3). Furthermore the length distributions in the gillnet fishery has shifted to smaller fish since 2009 indicating a commercial shift to smaller meshed gillnets.

In **Uummannaq,** the mean length in the landings have gradually decreased for two decades, but at a very slow rate. The overall yearly mean length in the landings weighted by gear has shown high stability in the most recent 6 years. (fig 2.2). The length distribution in the longline fishery reveals a wide size range of both small and large fish and a distribution not much different from a what it was a decade ago (fig 2.3).

In **Upernavik,** the mean length in longline landings decreased until 1999, but then remained stable for almost two decades. However, mean length in both the longline fishery and in the overall mean length weighted by gear decreased in both 2014 and 2015 (fig 2.2). The length frequencies from the longline landings reveal a shift towards smaller fish for two consecutive years in a row (fig 2.3). In the more recent years smaller sized fish have increasingly been landed in the area.

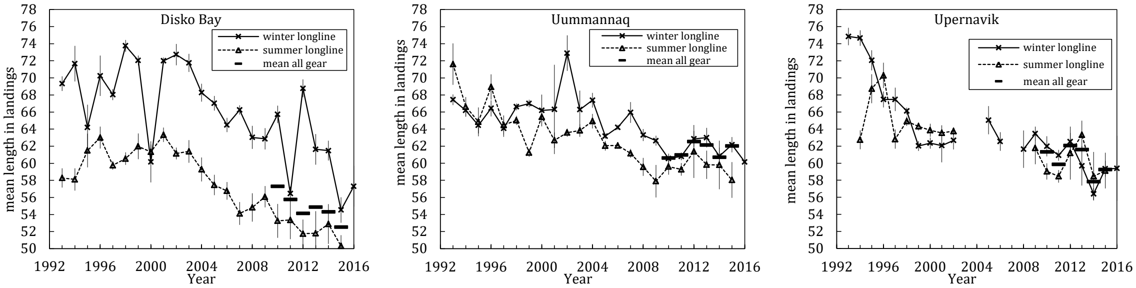


Fig. 2.2. Greenland halibut in Division 1A inshore: Mean length in landings from longline fishery by season and from longlines and gillnets weighted by total catch.

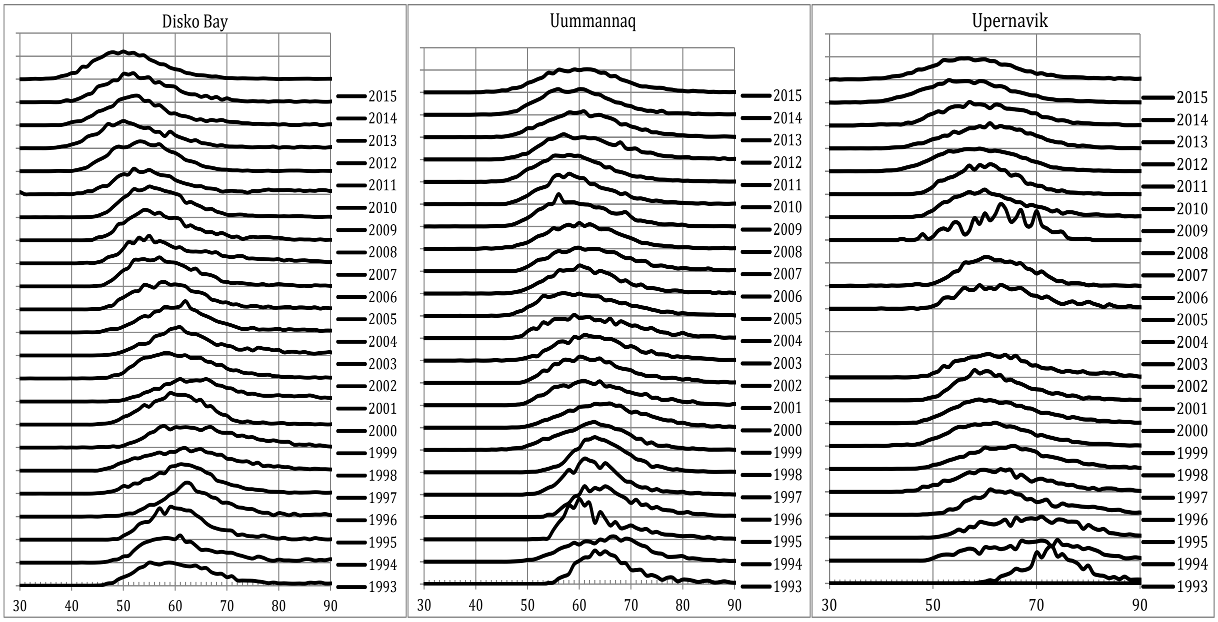


Fig. 2.3 Greenland halibut in Division 1A inshore: Length frequencies in longline landings (% of number measured).

CPUE index.

Haul by haul logbooks have been mandatory for vessels larger than 30ft since 2008, and from these data a standardized CPUE was constructed (fig 2.4). As in previous years the GLM model explained little of the variability in the data. In the **Disko Bay** the index reveals little year to year variation and a decrease in yield per effort since 2009 (fig 2.4). In **Uummannaq** the logbook CPUE index was based on fewer observations as fewer larger vessels are fishing in the area, but overall the CPUE index is stable over time with a slight decrease in 2015 (fig 2.4). In **Upernavik** the logbook CPUE index decreases further in 2015. But the index shows greater inter annual variation and a higher mean CPUE than observed in Uummannaq and Disko Bay (fig 2.4).

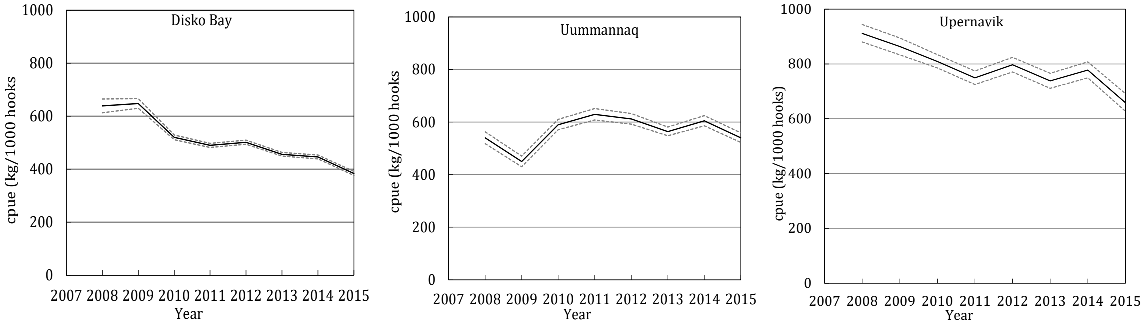


Fig 2.4. Greenland halibut in Division 1A inshore: Standardized longline logbook catch rates.

ii) Research survey data

The **Greenland shrimp and fish trawl survey in Disko Bay**: Since the Disko Bay and the shelf West and North of Disko are important nursery areas for Greenland halibut, almost 90 % of the Greenland halibut caught are juvenile less than 3 year old. Therefore year to year variation the recruitment leads to high fluctuation in the abundance estimate from the survey but incoming year classes have little influence on the biomass. The trawl survey in Disko Bay indicated increasing abundance during the 1990s and until 2004 (fig 2.5). After the gear change in 2005 the abundance decreased to low levels in 2008 and 2009, but since then the abundance index has returned to the previous high levels in 2011 and 2013, mainly caused by large 2010 and 2012 year classes. The biomass indices in the trawl survey indicate a steady increase during the 1990's, with a substantial increase observed in 2003 and 2004 (Fig 2.5). After the gear change in 2005 the biomass index has been in a decreasing trend with the two lowest values found in 2014-15 and 4 of the 5 lowest estimates found in the most recent 4 years (Fig 2.5). The trawl survey indicated increasing abundance during the 1990s and high abundances (mainly age 1) were found from 1998 to 2005. After 2006 the abundance indices returned to the lower levels with the exception of the high abundances identified in 2011 and 2013 (2010 and 2012 YC). The Greenland Shrimp and Fish survey covers western side of the Uummannaq fjord and the shelf and trenches just west of Uummannaq and Upernavik. The survey indicates a steady high supply of recruits to the area.

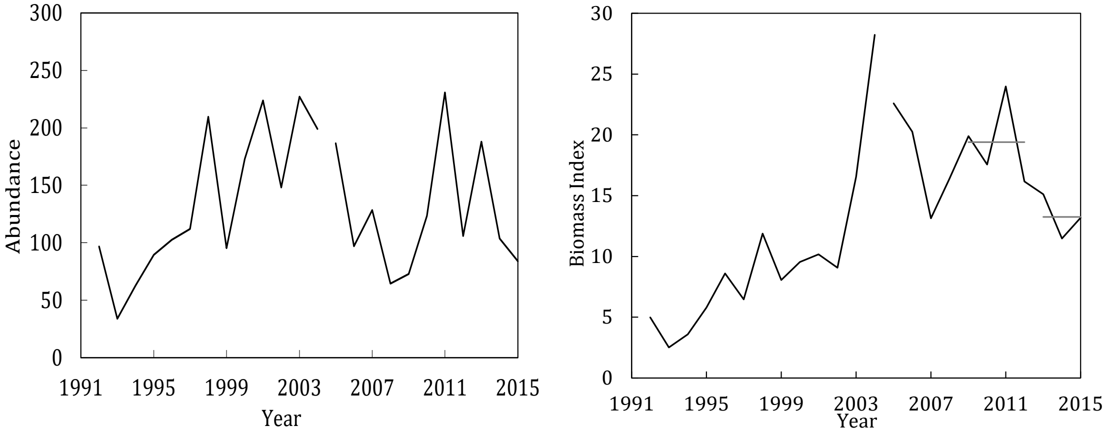


Fig 2.5. Greenland halibut in Division 1A inshore: Abundance and biomass indices in the Disko bay from the Greenland Shrimp Fish trawl survey.

The Disko Bay gillnet survey: The gillnet survey in the Disko bay was designed to target pre fishery recruits at lengths from 35-55 cm. Since the survey uses gillnets with narrow selection curves and normally catches the same sized fish but in varying numbers, there is little difference between the trends of the CPUE and NPUE indices (fig 2.6). The gillnet survey CPUE and NPUE indicated low levels of pre fishery recruits in 2006 and 2007, but returned to average levels in 2008. The survey CPUE and NPUE reached a record high in 2011, but was lower in 2013 and 2014. The 2012 survey was troubled with a defective gillnet section (60mm) and has been disregarded. The overall long-term stability in the gillnet survey could indicate a steady supply of pre-fishery recruits (35-50 cm) to the stock. From 2013 to 2015, the Gillnet survey NPUE has been below average levels, although in these years' fewer than normal stations were taken. The high correlation between the gillnet survey NPUE and the summed number of Greenland halibut larger than 35 cm in the trawl survey results, however adds credibility to both surveys (fig 2.6). In general, both surveys show large year to year variation, which could be due to shifts in the distribution of the stock within the area. It seems unlikely that the years with large changes in the indices, indicate a proportional change in the stock.

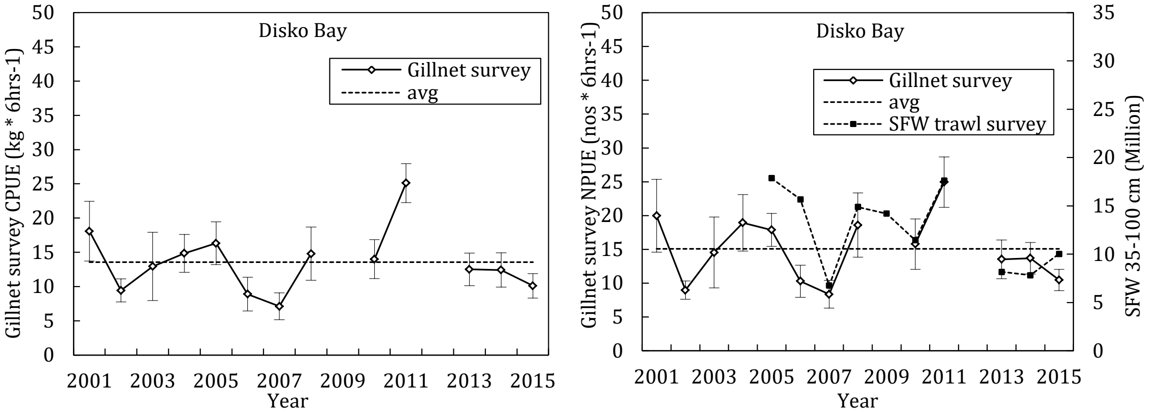


Fig 2.6. Greenland halibut in Division 1A inshore: Gillnet survey CPUE and NPUE +/-SE.

The Uummannaq gillnet survey

The survey was performed using the same method and setup as in the Disko bay. The overall trend in the survey could not be used due to a low number of stations prior to 2015. In 2015, 28 stations resulted in a CPUE 130% higher and an NPUE 20% higher than the long term mean in the Disko bay gillnet survey (Fig 2.7) indicating more fish and larger fish with considerable numbers in the interval 50-70 cm.

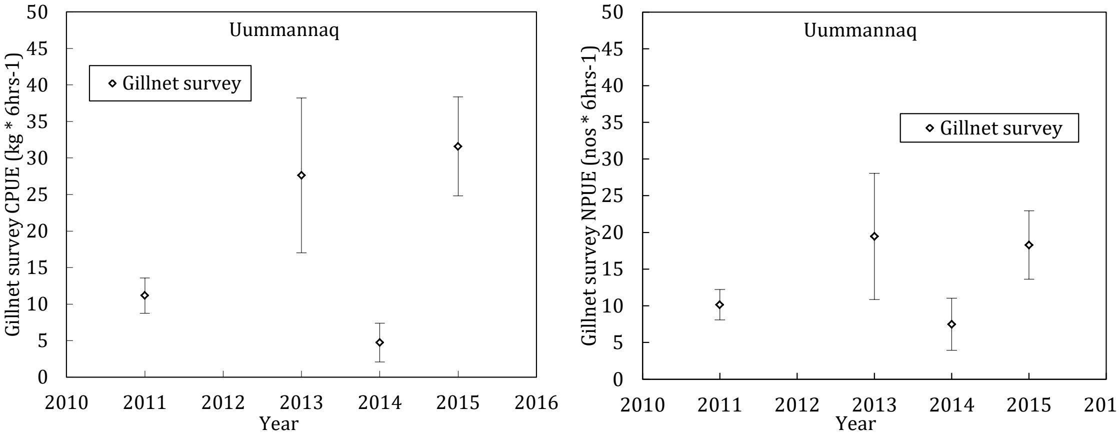


Fig 2.7. Greenland halibut in Division 1A inshore: Gillnet survey CPUE and NPUE +/-SE.

The Upernavik gillnet survey

The survey was performed using the same method and setup as in the Disko Bay. The number of stations were between 13 and 21 per year from 2012- 2014 increasing to 48 in 2015. The CPUE in the 2015 survey was 47% higher and the NPUE was 10 % higher than long-term mean in the Disko Bay gillnet survey (fig 2.8) indicating more and larger fish, with considerable numbers in the interval 50-70 cm.

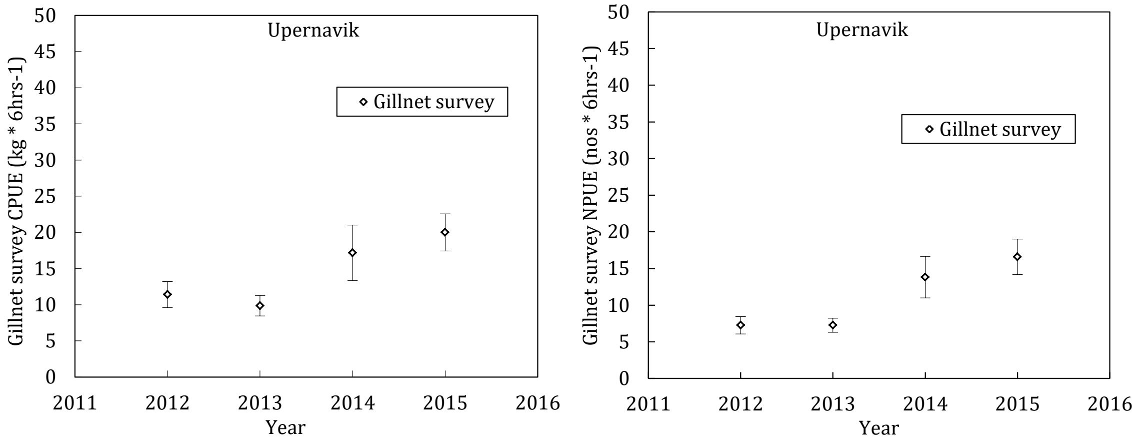


Fig 2.8. Greenland halibut in Division 1A inshore: Gillnet survey CPUE and NPUE +/-SE.

c) Assessment results:

Disko Bay

Fishery and Catches: Catches peaked in 2004 at around 12 000 tons. After 2006, catches halved in just three years to 6 300 tons in 2009, before increasing to 9177 tons in 2014. Catch in 2015 was 8674 t.

Data: Biomass indices from the Greenland shrimp and fish survey were available from the Disko Bay from 1991 to 2015. Gillnet survey CPUE and NPUE catch rates were available from 2001 to 2015. Length distributions were available from both surveys and fishery.

Assessment: No analytical assessment could be performed.

Commercial CPUE index: The commercial CPUE index has been continuously decreasing since 2009. It is unclear how CPUE relates to stock status.

Biomass: The biomass index in the Disko Bay trawl survey is in a decreasing trend with both the 2014 and 2015 indices being the lowest in a decade. The gillnet survey mainly targets pre-fishery recruits and the CPUE indices were slightly below average in the most recent 3 years. The decreasing standardized logbook CPUE indicates that the decrease is continuing in the area with the current level of catch.

Fishing mortality: Unknown. The contribution to fishing mortality from bycatch of Greenland halibut in the shrimp trawls is reduced with the implementation of sorting grids in the Disko Bay shrimp fishery in 2011.

Recruitment*:* Trawl survey results in the Disko Bay and in the nearby offshore areas West and North of the Disko Bay indicate large 2010, 2012 year classes and an overall high yearly supply of recruits.

State of the stock: Since the survey gear change in 2005, the trawl survey index has shown an overall decreasing trend. The gillnet survey has been below the long term mean in the most recent 3 years. Length distributions in both the longline and gillnet fisheries have shown a long-term shift towards smaller fish.

Uummannaq:

Fishery and Catches: Catches increased since 1985, with a maximum of 8 425 t in 1999. In 2015, catches were 8 244 t.

Data: Biomass indices from the Greenland shrimp and fish survey were available from the area in the western opening and on the shelf west of the fjord. Gillnet survey CPUE and NPUE catch rates from 2015 were available. Length distributions were available from both surveys and fishery.

Assessment: No analytical assessment could be performed.

Commercial CPUE index: The commercial CPUE index has been relatively stable but decreased slightly in 2015. It is Unclear how CPUE relates to stock status.

Biomass: Unknown

Fishing mortality: Unknown.

Recruitment: Trawl survey results from the nearby offshore areas west of the Ummannaq indicate a potentially high supply of recruitment to the area.

State of the stock: The gillnet survey CPUE showed more fish and larger fish in 2015 than the long-term average in Disko Bay, with considerable numbers in the interval 50-70 cm. Mean length in the landings has gradually decreased, but stabilized in the most recent years. The commercial CPUE index has been relatively stable over the last 6 years.

Upernavik:

Fishery and Catches: Catches increased since 1985, with a peak of 7 012 t in 1998 and a maximum of 7381 t in 2014. In 2015, catches were 6 274 t.

Data: Biomass indices from the Greenland shrimp and fish survey were available from the area just west of the Upernavik area. Gillnet survey CPUE and NPUE catch rates were available from 2012 in the area. Length distributions were available from both surveys and fishery.

Assessment: No analytical assessment could be performed.

Commercial CPUE index: The commercial CPUE index decreased gradually since 2008 and dropped further in 2015. The CPUE is however higher than in the Disko Bay and Uummannaq commercial CPUE. It is Unclear how CPUE relates to stock status.

Biomass: Unknown

***Fishing mortality**:* Unknown.

Recruitment: Trawl survey results from the nearby offshore areas west of the Upernavik indicate a potentially high recruitment to the area.

State of the stock: The gillnet survey CPUE showed more fish and larger fish in 2015 than the long-term average in Disko Bay, with considerable numbers in the interval 50-70 cm. Mean length in the landings decreased in 1990s then was stable until 2013, since when it has declined further. The commercial CPUE index has shown an overall downward trend.

These stocks will next be assessed in 2018

3. Roundnose Grenadier (*Coryphaenoides rupestris*) in SAs 0 and 1

(SCR Doc 16/004)

a) Introduction

There has been no directed fishery for roundnose grenadier in Subareas 0+1 since 1978. Since then roundnose grenadier has been taken as by-catch in the fishery for redfish and Greenland halibut. A total catch of 11 tons was estimated for 2015. Catches of roundnose grenadier have been reported from inshore areas and Div. 1A where roundnose grenadier does not occur (8 tons in 2015). These catches must be roughhead grenadier (*Macrourus berglax*) and were therefore excluded from totals for roundnose grenadier. It is also likely that catches from the offshore areas south of Div. 0A-1A reported as roundnose grenadier may include roughhead grenadier because their ranges overlap in these Divisions.

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

	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Agreed TAC									8.5	8.5
Recommended TAC	ndf	ndf	ndf	ndf	ndf	ndf	ndf	ndf	ndf	ndf
STATLANT 21	0.01	0.00	0.00	0.03	0.00	0.01	0.00	0.01	0.01	
STACFIS	0.03	0.00	0.00	0.03	0.00	0.01	0.00	0.01	0.01	

ndf : No directed fishing. No TAC set for 2007 – 2014.
TAC set autonomously by Greenland

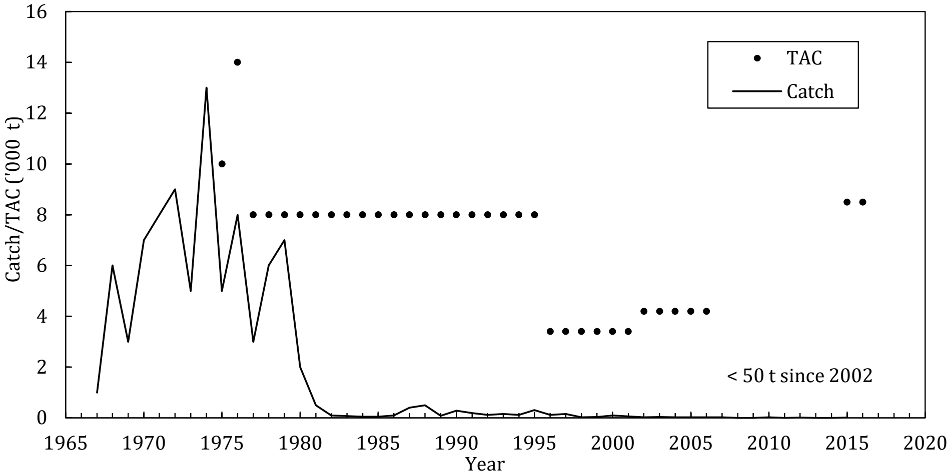


Fig. 3.1. Roundnose grenadier in Subareas 0+1: nominal catches and TACs. No TAC set for 2007-2014.

i) Data Overview

Research survey data

There has not been any survey that covers the entire area or the entire period. The various survey series available are not comparable. In the period 1987-1995, Japan in cooperation with Greenland has conducted bottom trawl research surveys in Subarea 1 covering depths down to 1 500 m. The survey area was restratified and the biomasses recalculated in 1997. Russia has in the period 1986-1992 conducted surveys covering Div. 0B and Div. 1CD at depths down to 1 250 m until 1988 and down to 1 500 from then on. The surveys took place in October-November. During 1997-2014 Greenland conducted surveys in September - November covering Div. 1CD at depths between 400 and 1500 m. Canada has conducted surveys in Div. 0B in 2000, 2001, 2011, 2013 - 2015 at depths down to 1 500 m. Furthermore, Canada and Greenland have conducted a number of surveys in Div. 0A and Div. 1A since 1999 but roundnose grenadier has very seldom been observed in those areas.

In the Greenland survey, the biomass index in Div. 1CD increased gradually between 2010 and 2012, but in 2013 - 2015, returned to the very low levels seen during 2003-2008. During 2015, almost all the biomass was found in Div. 1D at depths of 1 000 - 1 400 m and the fish were generally small, between 4 and 8 cm pre anal fin length.

The Canadian surveys in Div. 0B in 2000 and 2001 also showed very low biomasses. The biomass was not calculated in 2011, 2013 - 2015 but few roundnose grenadiers were recorded.

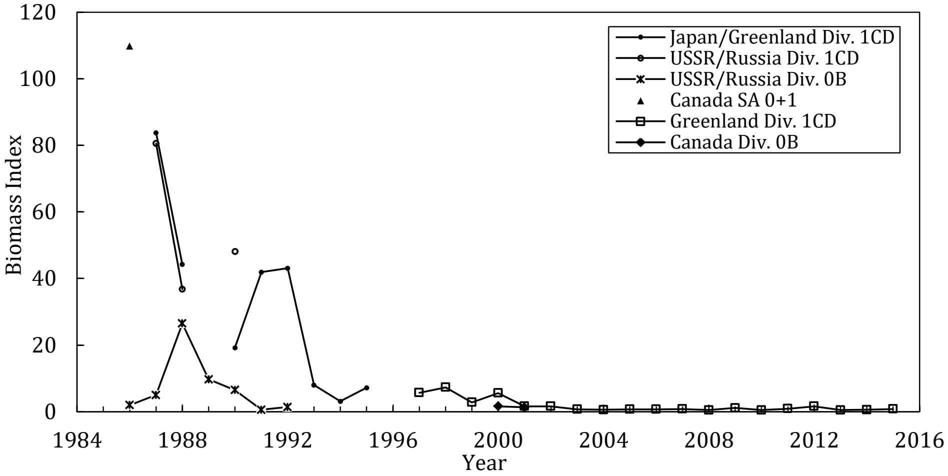


Fig. 3.2. Roundnose grenadier in Subareas 0+1: biomass estimates from Russian, Japan/ Greenland, Canadian and Greenland surveys in Div. 0B and Div. 1CD.

d) Conclusion

Despite the lack of a directed fishery since 1978, the biomass of roundnose grenadier has remained at very low levels since 1999. In 2015, the biomass index was similarly low, and therefore, there is no reason to consider that the status of the stock has changed. A TAC on 8 500 t was set autonomously by Greenland for 2015 and 2016.

The next full assessment of this stock will take place in 2017.

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

Interim Monitoring Report (SCR Doc. 88/12 96/36 07/88 16/003 16/014. SCS Doc. 16/007)

a) Introduction

There are two demersal redfish species of commercial importance in subarea 1, golden redfish (*Sebastes marinus*) and demersal deep-sea redfish (*Sebastes mentella*). Relationships to other north Atlantic redfish stocks are unclear. Both redfish species are included in the catch statistics, since no historic 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 surveys operating both offshore and inshore in West Greenland it is known that the demersal redfish found on the shelf and in the fjords are a mixture of *S. marinus* and *S. mentella*.

Fisheries and Catches

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 other years (e.g. 1988 1994) . To reduce the amount of fish taken in the trawl fishery targeting shrimp, sorting grids have been mandatory since 2001 (inshore by 2012), limiting bycatches of redfish smaller than 13 cm. In 2015, 5 t were reported as by-catch in the shrimp fishery, 21 tonnes were taken as by-catch in the offshore fishery targeting cod and Greenland halibut and 228 t were landed to factories, mostly from small vessels operating inshore (Fig 4.1).

Recent catches ('000 tons) are as follows:

	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
TAC	1	1	1	1	1	1	1	1	1	1	1
Statlant 21	0.4	0.3	0	0.02	0	0.2	0.12	0.16	0.25	0.19	
STACFIS	0.4	0.3	0.4	0.4	0.3	0.2	0.16	0.17	0.17	0.26	

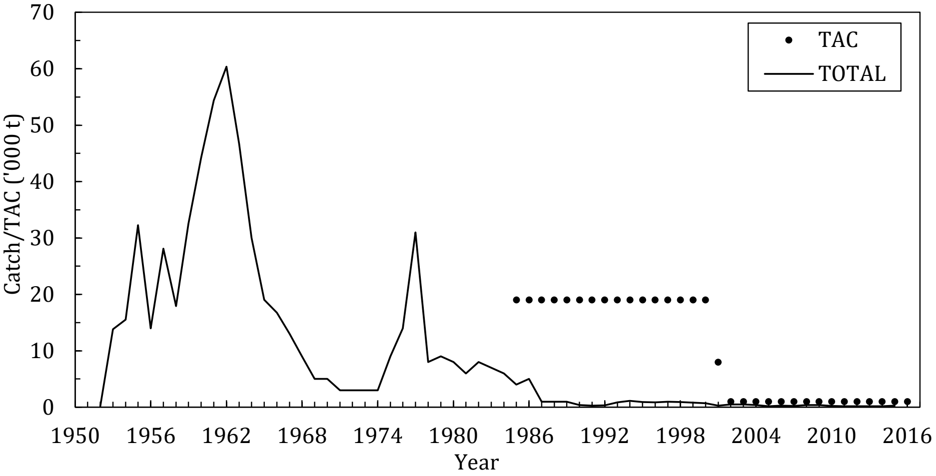


Fig. 4.1. Demersal redfish in Subarea 1: catches and TAC.

b) Data overview

b) *Commercial fishery data*

Mean length of golden redfish catches from sampling of EU-Germany commercial catches during 1962-90 revealed significant mean size reductions from 45 to 35 cm. There are no data available to estimate the size composition of catches of deep-sea redfish. Since redfish are mainly taken as by-catch no data of recent size composition in the landings are available.

ii) Research survey data

There are three recent surveys covering the demersal redfish stocks in Subarea 1. The EU-Germany survey (since 1982, 0-400m, 1Bs-F), the Greenland deep-water survey (since 1998, 400-1500m, 1CD) and the shallower Greenland Shrimp and Fish survey (since 1992, 0-600m, 1A-F). The latter has a more appropriate depth and geographical coverage in regards to redfish distribution, and covers the important recruitment areas in 1B. However, in this survey no separation of species were made prior to 2006 and the gear was changed in the Greenland Shrimp and Fish survey in 2005. Indices for redfish prior to 2005 have been converted to the new gear.

Golden redfish (*Sebastes Norvegicus*)

The biomass indices of the EU-Germany survey decreased in the 1980s and were at a very low level in the 1990s, but increased during the most recent decade (Fig 4.2). The biomass indices for golden redfish have been in an increasing trend since 2006 in the Greenland shrimp and fish survey. The majority of the biomass in the Greenland shrimp and fish survey have in recent years been located in the same areas covered by the EU-Germany survey. The combined impression of these surveys is a steadily increasing biomass of golden redfish (Fig 4.2).

Demersal deep-sea redfish (*Sebastes mentella*)

The biomass indices of the EU-Germany survey have fluctuated without trend throughout the time series, likely caused by limited depth overlap with deep-sea redfish (fig 4.3). The Greenland-Japan deep-sea survey (1BCD) biomass indices decreased from 1987 to 1995 (fig 4.3). The Greenland deep-water survey (1CD) indices were at a low level prior to 2007, but have gradually increased since then. The biomass indices in the

Greenland shrimp and fish survey also increased since 2007 (fig 4.3). The combined impression of these surveys is a steadily increasing biomass of deep-sea redfish (Fig 4.3).

Juvenile redfish (both species combined)

In the EU-Germany survey abundance indices of juvenile redfish (both species combined) has been at a very low level since 2001 (Fig 4.4). The Greenland Shrimp and Fish survey is dominated by juvenile redfish and abundance indices have decreased throughout the time series (figure 4.4). Therefore, recruitment of juvenile redfish remains poor in the area and the increasing biomass observed is likely a consequence of either increased survival of redfish and/or migration of redfish into subarea 1 from nearby areas.

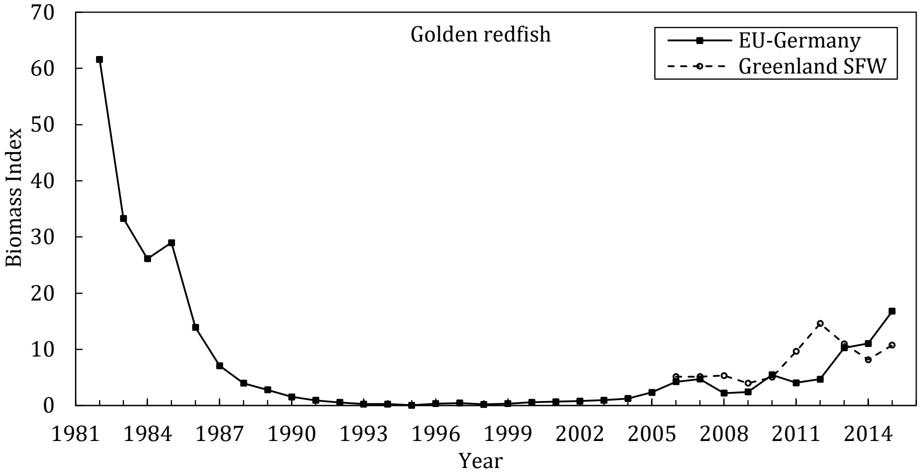


Fig. 4.2. Golden redfish biomass indices in the EU-Germany survey (1C-F) and the Greenland shrimp and fish survey (1A-F).

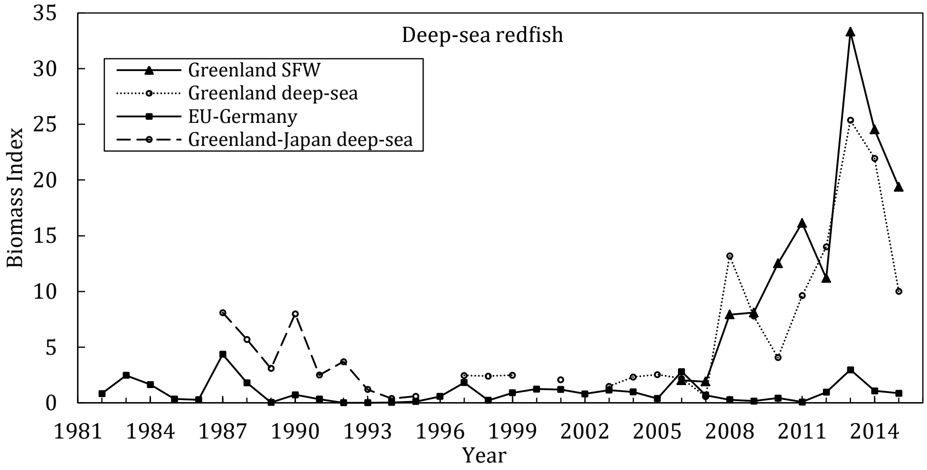


Fig. 4.3. Demersal deep-sea redfish survey biomass from the Greenland shrimp and fish survey (1A-F), the Greenland deep-sea survey (1CD), the EU-Germany survey (1C-F) and the Greenland-Japan deep-sea survey (1B-D).

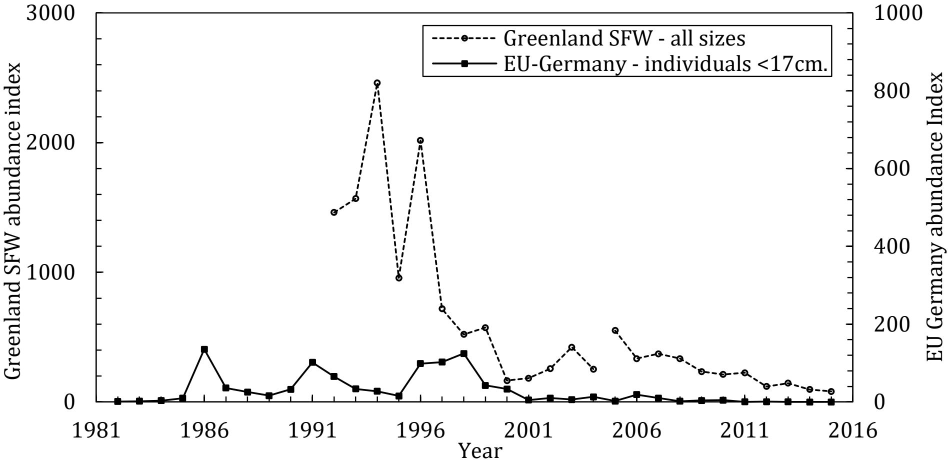


Fig. 4.4. Juvenile redfish abundance indices (deep-sea and golden redfish) for the EU-Germany survey (1C-F), and the Greenland Shrimp and Fish survey (1A-F, all sizes).

c) Conclusion

Golden redfish

Although the surveys agree that the biomass of Golden redfish is increasing, the indices are still far below historic levels. The surveys also agree that recruitment is still failing in the area. Based on the available data there is no indication of any change in the status of these stocks since the most recent assessment.

Demersal deep-sea redfish

The surveys agree that the biomass of deep-sea redfish is increasing in the area. The surveys also agree that recruitment is still failing in the area. Based on the available data there is no indication of any change in the status of these stocks since the most recent assessment.

d) Research Recommendations

STACFIS reiterated the **recommendation** that *the species composition and quantity of redfish discarded in the shrimp fishery in SA 1 be further investigated.*

No progress in 2015

This stock will next be assessed in 2017.

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 SA 1

Interim monitoring report (SCR Doc. 80/VI/72 77 96/036 07/88 16/014; SCS Doc. 16/007)

a) Introduction

Three species of wolffish occur in Greenland waters: Atlantic wolffish (*Anarhichas lupus*), spotted wolffish (*Anarhichas minor*) and Northern wolffish (*Anarhichas denticulatus*). Only the two first are of commercial interest. Atlantic wolffish has a more southern distribution and seems more connected to the shallow offshore banks. Spotted wolffish can be found in all divisions offshore and is the dominant species in the fjords. Although spotted wolffish and Atlantic wolffish are easily distinguishable from one another, distinction between the two species in catch statistics is rare. The commercial fishery for wolffish in West Greenland increased during the 1950s. 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 3000 tons per year (Fig 5a.1). The highest reported catches occurred in 1977-1979, but in these years mis-reporting was documented. After 1980, the cod fishery gradually decreased in West Greenland and catches of wolffish also decreased during this period. The recent catches of wolffish are mainly spotted wolffish landed by small vessels operating inshore. The current advice for 2015-2017 is 1,025 t for spotted wolffish set as the mean of the 2009 to 2013 catch and the advice is "no directed fishery" for Atlantic wolffish. To minimize by-catch in the shrimp fishery, offshore trawlers targeting shrimp have been equipped with grid separators since 2002 and inshore (Disko Bay) trawlers since 2011. In 2015, catches decreased to 400 tons (333 tons landed to factories and 65 tons as by-catch in the offshore fishery targeting cod), likely related to other more valuable species being targeted.

Recent nominal catches ('000 tons) for wolffish.

	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Atlantic wolffish TAC									1.0	1.0
Spotted wolffish TAC									1.0	1.0
Wolffish TAC	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	2.0	2.0
STATLANT 21	0.9	1.1	0	0	0.8	1.0	1.0	1.0	0.4	
STACFIS	0.9	1.1	1.1	1.3	0.8	1.0	0.8	0.9	0.4	

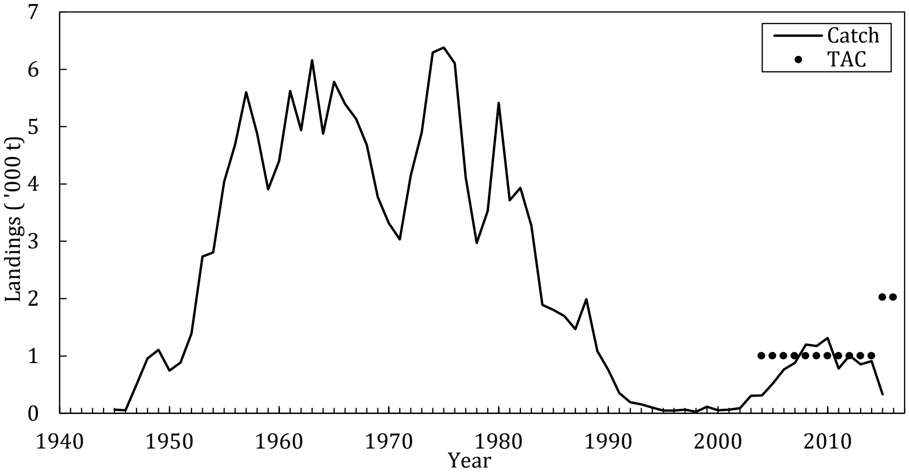


Fig 5a.1. Wolffish in Subarea 1: Catches and TACs for Atlantic wolffish and spotted wolffish combined from 1945 to 2015.

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 has a longer time series (since 1982, 1C-F, 0-400m) and the Greenland shrimp and fish survey (SFW) covers a larger geographical area and depth range (since 1992, 1A-F, 0-600m). The gear was changed in the Greenland shrimp and fish survey in 2005, to a more modern trawl with rock-hopper gear. None of the surveys fully covers the distribution of either wolffish species.

Atlantic wolffish:

Biomass indices decreased significantly in the 1980s in **the EU-Germany survey** (Fig. 5a.2, left). From 2002 to 2005 biomass indices increased to above average levels, but thereafter returned to the low levels observed during the 1990s. Abundance indices in the EU-Germany survey decreased after 1982, but were at a stable and perhaps slightly increasing level until 2005. After 2005 abundance indices in this survey decreased to below average levels, but remained stable after 2008 (fig 5a.2, right).

The Greenland shrimp and fish survey biomass indices were at low levels during the 1990s, but increased slightly from 2002 and until the gear change in 2004. After 2005, the biomass index increases further in the Greenland shrimp and fish survey (fig 5a.3 left). Abundance indices in the Greenland shrimp and fish survey increased until the gear change in 2004 (Fig 5a.3. right). The increasing abundance indices in the Greenland shrimp and fish survey is observed in division 1A-B, and therefore north of the EU-Germany survey area

Spotted wolffish:

Biomass indices decreased significantly in the 1980s in the **EU-Germany survey** and were at low levels during the 1990s (fig 5a.2, left). After 2002, survey biomass indices increased to the long term average and the 2013-2015 indices are the highest observed since 1983. Abundance indices in the EU-Germany survey decreased from 1982 to 1995, but has increased to levels not seen since 1991 (fig 5a.2, right).

Biomass indices in **the Greenland shrimp and fish survey** were at low levels during the 1990s, but increased in 2003 and 2004. After the gear change in 2005, survey biomass indices have increased substantially (fig 5a.3, left). In the Greenland shrimp and fish survey, abundance indices has gradually increased throughout the time series (Fig 5a.3, right).

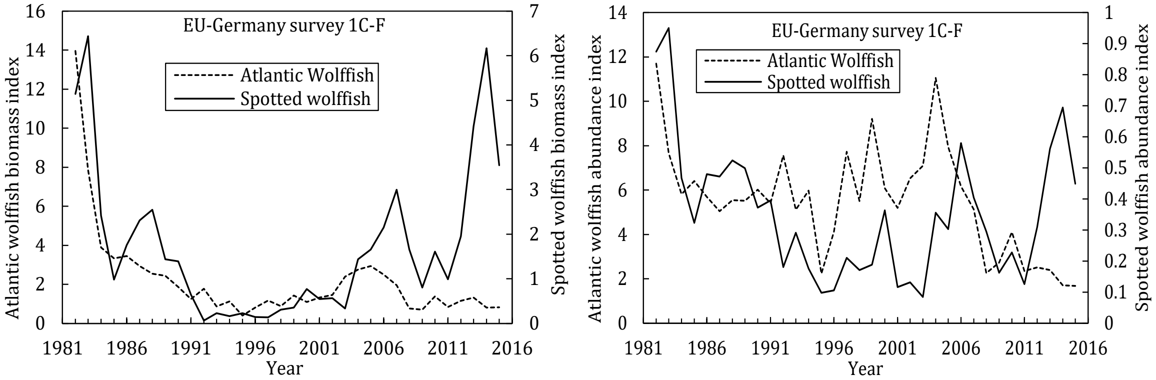


Fig. 5a.2. The EU-Germany survey in SA1: Biomass indices (left) and abundance indices (right).

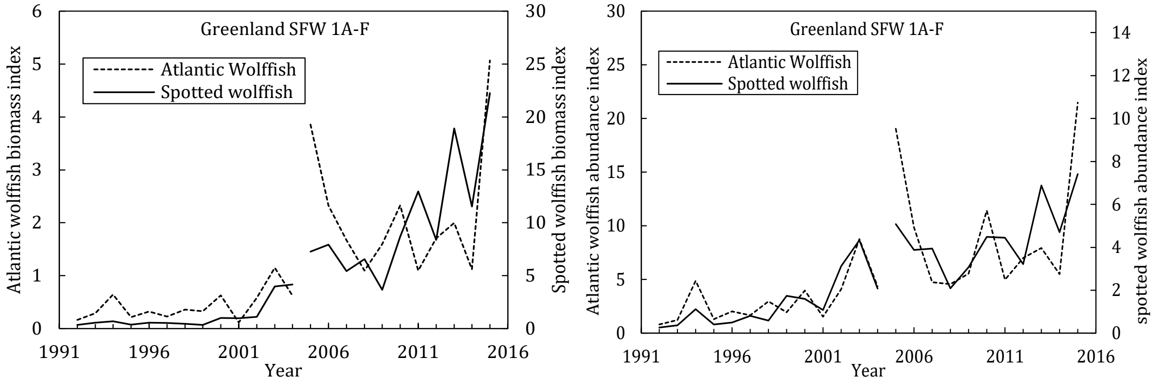


Fig. 5a.3. The Greenland shrimp and fish survey: biomass indices (left) and abundance indices (right).

e) Conclusion

Atlantic wolffish: The biomass and abundance indices are slowly increasing, but below average levels in the southern regions. The updated indices since the most recent assessment do not change the perception of the stock.

Spotted wolffish: Biomass indices continue to increase in both surveys, and the stock remains in an increasing trend.

These stocks will next be assessed in 2017.

5b. American plaice (*Hippoglossoides platessoides*) in SA 1

(SCR Doc. 80/VI/72 07/88 16/014 ; SCS Doc. 16/07)

a) Introduction

American plaice has been of very little commercial interest in Greenland at least for the past three decades. The highest reported catches occurred in 1977-1979, but in these years misreporting was documented where catches of cod were reported as other species. The catches of American plaice in these years are likely overestimated. Since the 1980s, American plaice in Subarea 1 have mainly been taken as a by-catch in fisheries targeting cod, redfish and shrimp and reported as unspecified by-catch. To reduce the number of juvenile fish discarded in the trawl fishery targeting shrimp, sorting grids have been mandatory since October 2000 (fully implemented offshore in 2002). The latest advice was given in 2014 and there was no directed fishery. In 2015, 1 ton of American plaice was reported in trawl logbooks from Division 1A.

Recent catches ('000 t) are as follows:

	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
STATLANT 21	0	0	0	0	0	0	0	0	0	0
STACFIS	0	0	0	0	0	0	0	0	0	0

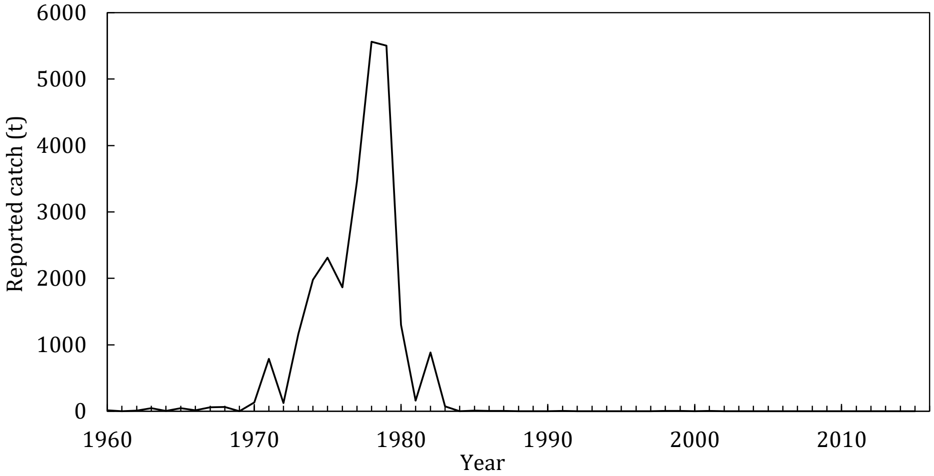


Fig 5b.1. American plaice in Subarea 1: Reported catches of American plaice from SA1 from 1960 to 2015.

b) Research survey data

There are two surveys partly covering the American plaice stock in subarea 1. The EU-Germany survey (0-400m, Divs.1C-F) and the Greenland Shrimp and Fish survey in West Greenland (0-600m, Divs. 1A-F). Biomass indices decreased during the 1980s in the EU-Germany survey, but increased after 2002 to slightly above the series average. After 2004 the biomass indices decreased and stabilized at a low level. The biomass indices in the Greenland Shrimp and fish survey increased from 1992 to the gear change in 2004. After 2005, the indices have fluctuated without a clear trend (Fig 5b.2). However, 75% of the total biomass and 84% of the abundance in the Greenland shrimp and fish survey was found in Divisions 1A-B and therefore north of the EU-Germany survey area.

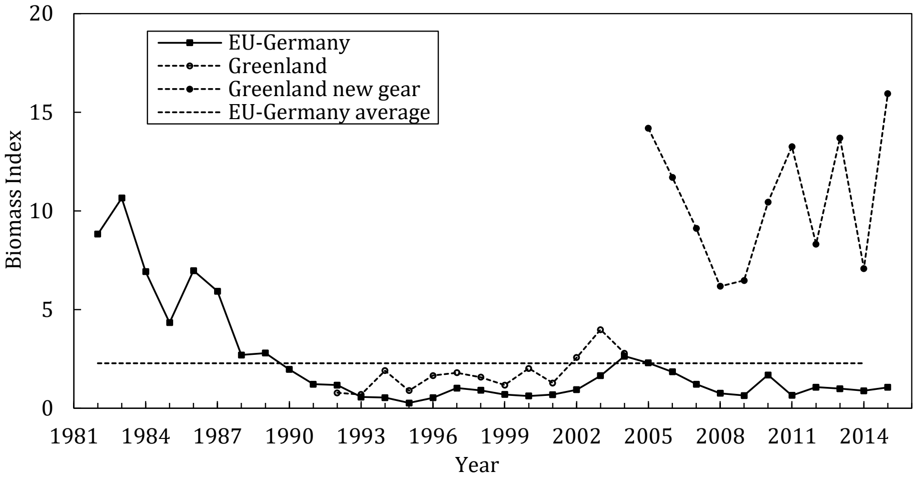


Fig. 5b.2. American plaice in Subarea 1: Biomass indices from the EU-Germany survey and the Greenland Shrimp and fish survey (SFW).

c) Conclusion

The biomass of the stock of American plaice in Subarea 1 is higher than it was in the 1990s, but remains below the levels of the 1980s. The updated indices do not change the perception of the stock since the most recent assessment.

d) Research Recommendation

STACFIS reiterated the **recommendation** that *the species composition and quantity of American plaice discarded in the shrimp fishery in SA1 be further investigated.*

- No progress

STACFIS reiterated the **recommendation** that *the distribution of these species in relation to the main shrimp-fishing grounds in SA1 be investigated, in order to further discover means of reducing the amount of discarded American plaice in the by-catch.*

- No progress

This stock will next be assessed in 2017.

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 decrease from peak levels in 2010. The large negative anomalies observed in 2014-2015 are comparable with the previous cold period during the early-mid 1990's.

●The composite spring bloom index in 3LM is also in decline in recent years with the lowest value in the time series observed in 2015.

● Despite the reduction in climate and bloom indices, the zooplankton index has remained above normal since 2009 and reached its highest level in 2015.

● The composite trophic index has tended to remain below normal in recent years.

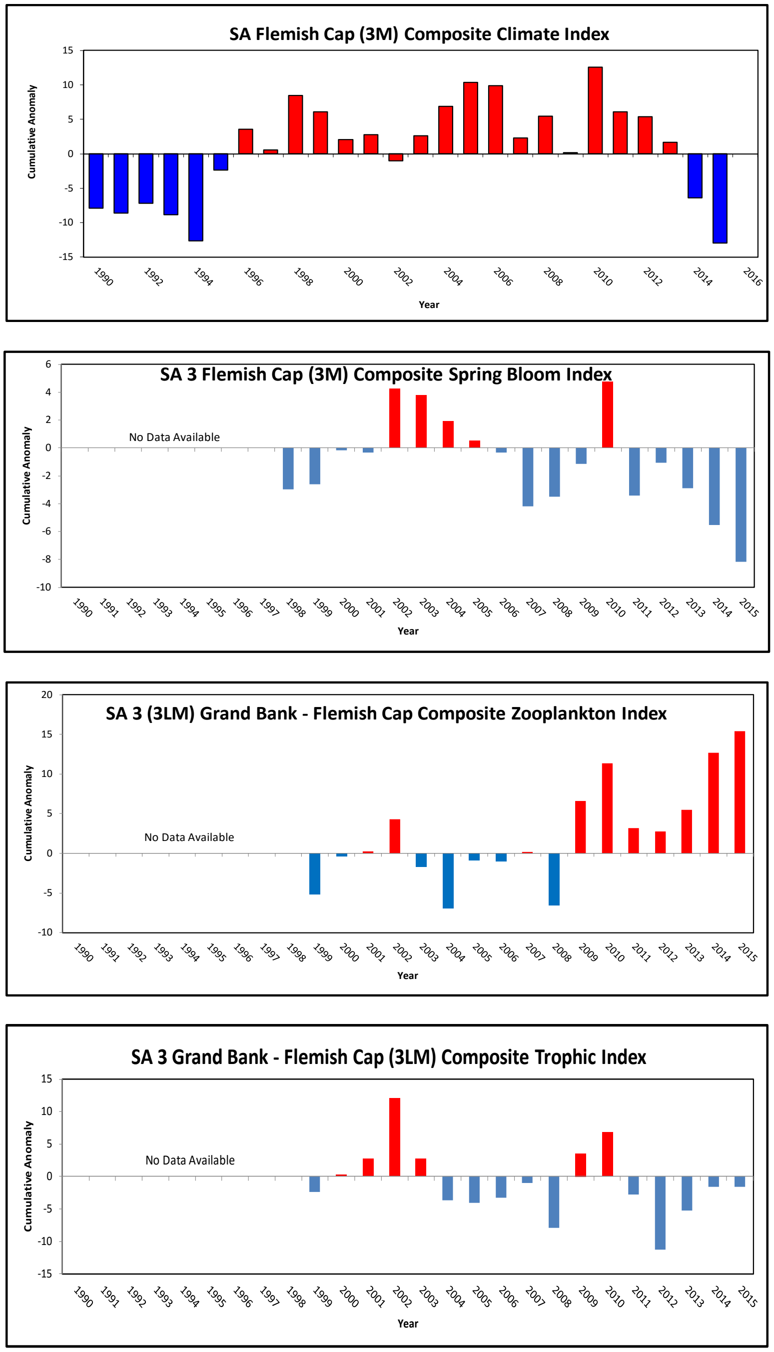


Figure III. 2 . Composite ocean climate index for NAFO Subarea 3 (Div. 3M) derived by summing the standardized anomalies during 1990-2014 (top panel), composite spring bloom (cumulative anomalies for magnitude and timing metrics of the spring bloom) index (Divs. 3LM) during 1998-2015 (2'nd panel), composite zooplankton (sum of the four functional plankton taxa) index during 1999-2015 (3'rd panel), and composite trophic (summed nutrient and standing stocks of phyto- and zooplankton indices) index (Divs. 3LM) during 1999-2015 (bottom panel). Red bars are positive anomalies indicating above average levels while blue bars are negative anomalies indicating below average values.

Environmental Overview

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

Ocean Climate and Ecosystem Indicators

The composite climate index in Subarea 3 (Div. 3M) has remained above normal since the mid-1990's although the index has declined sequentially since 2010 and now approaching near-normal conditions in 2013 (Figure III. 2). The composite spring bloom index (Div. 3LM) has declined in recent years (2013-2014) compared to positive anomalies observed throughout 2008 to 2012 (Figure III, 2). Despite the lower phytoplankton biomass, the composite zooplankton index (mainly composed of copepod and invertebrate plankton) reached a record-high level in 2014 and has remained at above normal levels since 2009 (Figure III, 2). The composite tropic index which combines nutrient inventories and standing stocks of phytoplankton and zooplankton, increased to its highest level in 2014 (Figure III, 2). Surface temperatures on the Flemish Cap were slightly above normal in 2013 with a standard deviation of 0.6. Bottom temperature anomalies across the Flemish Cap were similar to 2012 and ranged from 1-2 standard deviations above normal in 2013, and have remained high since 2008.

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

Interim Monitoring Report (SCS Doc. 16/05, 16/07, 16/08, 16/09, 16/10 and SCR 16/24)

a) Introduction

The cod fishery on Flemish Cap has traditionally been a directed fishery by Portuguese trawlers and gillnetters, Spanish pair-trawlers and Faroese longliners. Cod has also been taken as bycatch in the directed redfish fishery by Portuguese trawlers. Estimated bycatch in shrimp fisheries is low. Large numbers of small fish were caught by the trawl fishery in the past, particularly during 1992-1994. Catches since 1996 were very small compared with previous years.

The mean reported catch was 32000 t from 1963 to 1979 with high inter annual variability. Reported catches declined after 1980, when a TAC of 13000 t was established, but Scientific Council regularly expressed its concern about the reliability of some catches reported in the period since 1963, particularly those since 1980. Alternative estimates of the annual total catch since 1988 were made available in 1995 (Fig. 6.1), including non-reported catches and catches from non-Contracting Parties.

Catches exceeded the TAC from 1988 to 1994, but were below the TAC from 1995 to 1998. In 1999 the direct fishery was closed and catches were estimated in that year as 353 t, most of them taken by non-Contracting Parties according to Canadian Surveillance reports. Those fleets were not observed since 2000. Yearly bycatches between 2000 and 2005 were below 60 t, increasing to 339 and 345 t in 2006 and 2007, respectively. In 2008 and 2009 catches increased to 889 and 1 161 t, respectively. With the reopening of the fishery in 2010 a TAC of 5 500 t was set and a catch of 9 192 t was estimated by STACFIS. TACs of 10000 t, 9280 t, 14113 t, 14521 t and 13795 t were established from 2011 to 2015, respectively. Since 2011, alternative estimates of the annual total catch have not been available. The inconsistency between the information available to produce catch figures used in the previous assessments and that available for 2011-2015 has made impossible for STACFIS to provide the best assessments for some stocks. The assessment model of this stock was used to estimate the catches of 2011 and 2012, providing 13650 t for 2011 and 13 380 t for 2012. In 2013, the best available information for the catches of this stock was the Daily Catch Report data, giving a total catch of 13 985 t. In 2014, several sources (STATLANT 21A and DCR) resulted in an estimated STACFIS catch of 14290 t. In 2015, DCR were used as the best available estimates of catch, giving 13 785 tons of total catch. TAC for 2016 is 13 931 t.

A Bayesian-type VPA assessment was approved in 2008 by the SC for this species, having been used since then in the assessment of this stock.

Recent catches ('000 tons) are as follow:

	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
TAC	ndf	ndf	ndf	5.5	10.0	9.3	14.1	14.5	13.8	13.9
STATLANT 21	0.1	0.4	1.2	5.3	9.8	9.0	11.2	10.5	12.8	
STACFIS	0.3	0.9	1.2	9.2	13.6[1]	13.4[1]	14.0	14.3	13.8	

ndf No directed fishery

[1] See estimation of parameters (SCR 15/33)

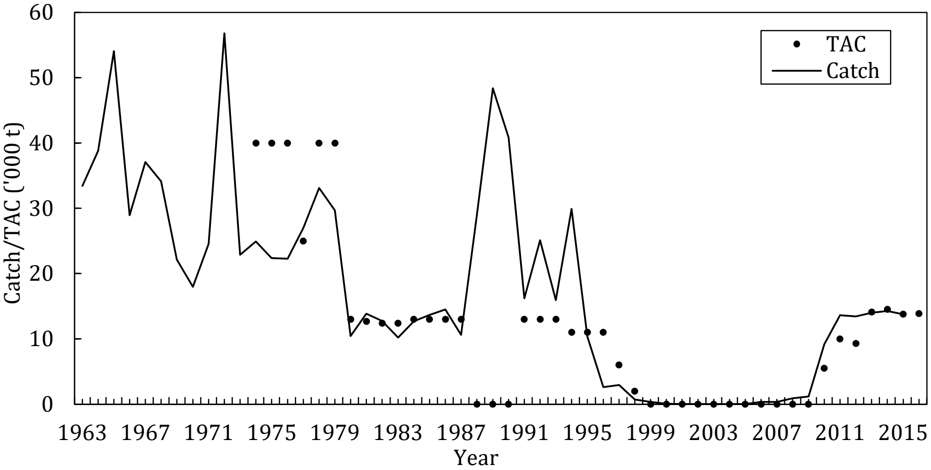


Fig. 6.1. Cod in Division 3M: STACFIS catches. Catch line includes estimates of misreported catches from 1988 to 2010 and estimates from the model for 2011 and 2012. No direct fishery is plotted as 0 TAC.

b) Data Overview

b) *Research survey data*

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

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

EU survey. The EU Flemish Cap survey has been conducted since 1988 in summer with a *Lofoten* gear type. The survey indices showed a general decline in biomass going from a peak value in 1989 to the lowest observed level in 2003. Biomass index increased from 2004 to 2012, especially from 2006. The growth of the strong year classes since 2005 contributed to the increase in the biomass. A substantial decrease in biomass was observed in 2013, although it remained at high level. In 2014 the biomass increased again reaching the maximum observed in the time series, decreasing in 2015 to the level of 2012. Abundance rapidly increased between 2005 and 2011, decreasing since 2012. The different pattern between biomass and abundance over 2011-2015 is driven by the very large 2009 and 2010 year classes.

Age-length key from the survey is available in 2015. Mean weight-at-age in the stock has been decreasing monotonously since the reopening of the fishery, reaching the minimum for ages 4 to 8 in 2015. The mean weight-at-age in the stock used in the last assessment in 2015 was the mean of the last three years (2012-2014), which is higher than the 2015 mean weight-at-age (Fig. 6.3). This affects the 2015-2018 SSB estimated in the last assessment.

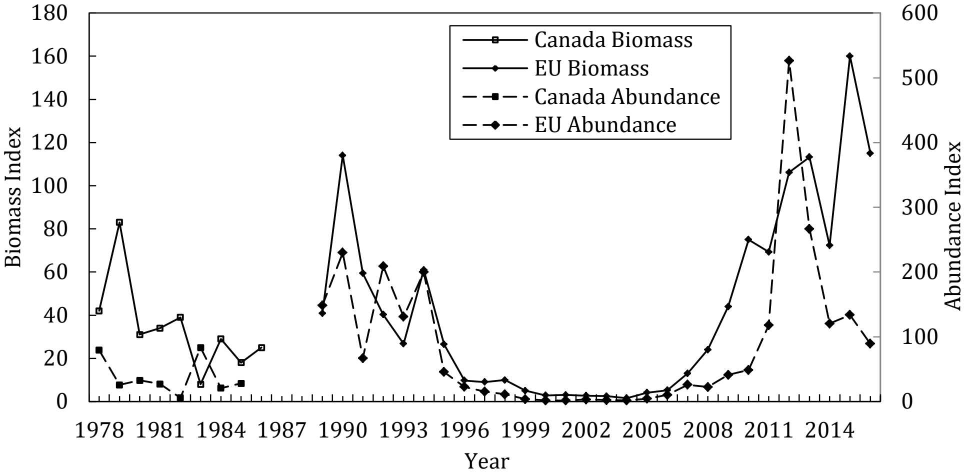


Fig. 6.2. Cod in Division 3M: Survey abundance and biomass estimates from Canadian survey (1978-1985) and EU-Flemish Cap survey (1998-2015).

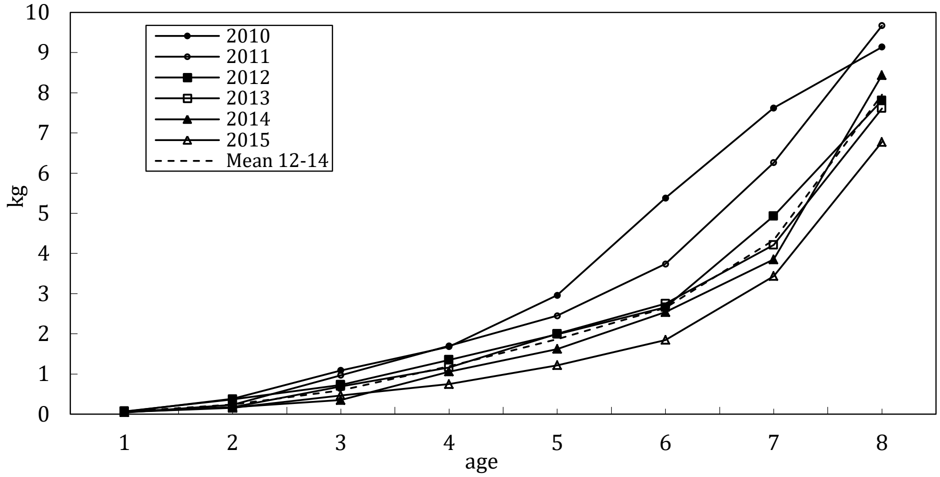


Fig. 6.3. Cod in Division 3M: Mean weight-at-age in the stock for the 2010-2015 surveys and 2012-2014 mean.

ii) Recruitment

Abundance at age indices were available from the Canadian survey. The recruitment index (age 1) was estimated at low levels except for 1982 and 1983. After several series of above average recruitments (age 1) during 1988-1992, the EU Flemish Cap survey indicates poor recruitments during 1996-2004, even obtaining observed zero values in 2002 and 2004. From 2005 to 2012 increased recruitments were observed. In particular, the age 1 index in 2011 is by far the largest in the EU series (Fig. 6.4; note that the level of both surveys is different in the two y-axis). From 2013 the recruitment index dropped to the level at the beginning of the recovery of the stock, declining further in 2015 reaching the 1995 level.

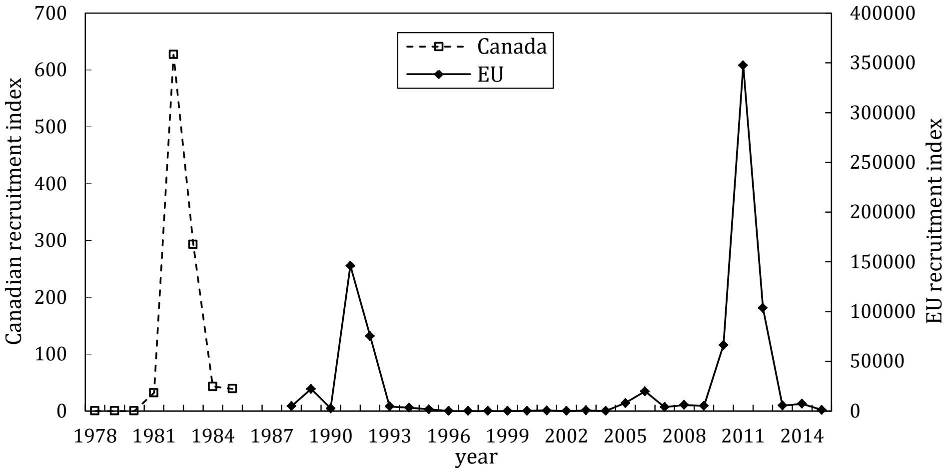


Fig. 6.4. Cod in Division 3M: Number at age 1 in the Canadian survey (1978-1985) and EU survey (1988-2015).

iii) Fishery data

In 2015 seven countries fished cod in Div. 3M, trawlers from EU-Estonia, EU-Portugal, EU-Spain, Faroe Islands and Russia and longliners from Faroe Islands, Norway and USA (only discards).

Length and age compositions from the commercial catches are available from 1973 to 2015 with the exception of the 2002 to 2005 period. Since 2010, with the fishery open, the sampling level has been adequate. In 2015 there were length distributions from EU-Estonia, EU-Portugal, EU-Spain, Faroe Islands (from trawlers and longliners) and Russia (Fig. 6.5). The mode in the length composition for EU-Estonia, EU-Spain and Faroes-trawler was around 57 cm, being 60 cm for Faroes-longliners and 54 for Russia. For Portugal there are two clear modes, one around 48 cm and the other around 39 cm. The survey has a mode at 42 cm. Catches from Portugal and Spain include discards. Using the survey 2015 ALK, age 6 was the most abundant in the catch. The mean weight-at-age in the catch has been decreasing monotonously since the reopening of the fishery, reaching the minimum for ages 3 to 8 in 2015. This affects the projected catch for 2016-2017 estimated in the last assessment in 2015 (Fig. 6.6).

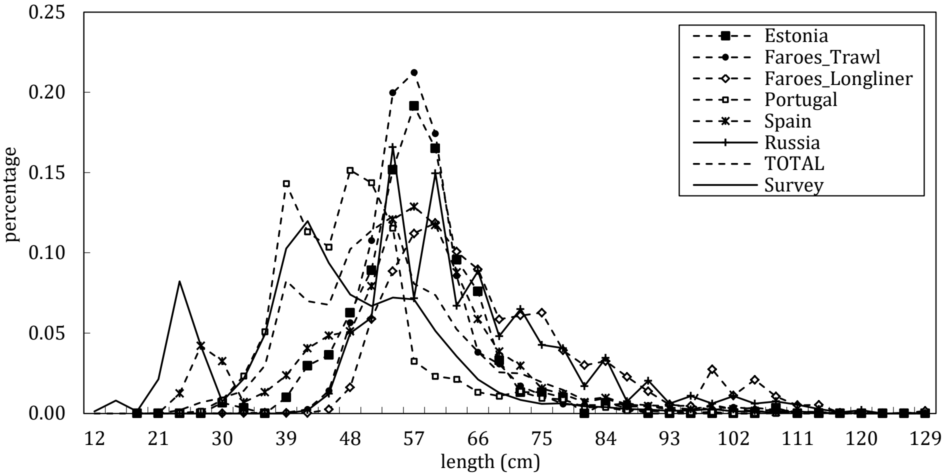


Fig. 6.5. Cod in Division 3M: Length distribution of the commercial catches in 2015.

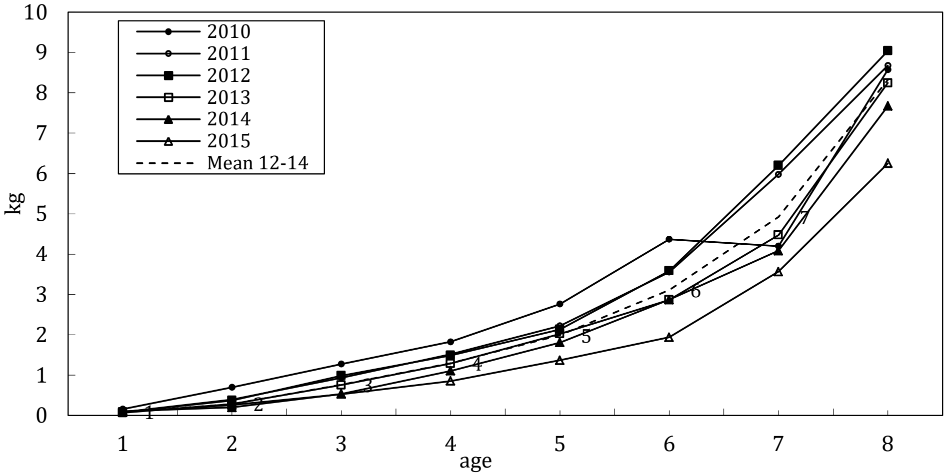


Fig. 6.6. Cod in Division 3M: Mean weight-at-age in the catch for 2010-2015 and 2012-2014 mean.

c) Conclusion

Although the survey biomass still has an overall increasing trend, survey abundance has decreased in the last years to the level of 2009-2010. This is mainly due to the decrease in the recruitment, which was in 2015 the lowest since 2004. Mean weight-at-age both in catch and in stock (having into account that the ALK is the same in both cases), has decreased during the last years reaching a minimum in all the ages except the youngest in 2015. This could affect the estimated SSB for 2015 as well as the TAC given for 2017 in the last assessment. Scientific Council considers that, despite these rapid changes, the changes are not significant and no new projections are necessary for this stock.

There is a benchmark of this species running until April 2017. The next full assessment of this stock is planned for June 2017.

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

Interim Monitoring Report (SCR Doc. 16/24, 36; SCS Doc. 16/05, 08, 09,10)

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 as well as a long recruitment process to the bottom. Redfish species are long lived with slow growth.

b) *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. A new golden redfish fishery occurred on the Flemish Cap bank from September 2005 onwards on shallower than 300m depth, basically pursued by Portuguese bottom trawl and Russia pelagic trawl. Furthermore, the increase of cod catches and reopening of the Flemish Cap cod fishery in 2010 also contributed to the increase of redfish catch that was kept within 6 000-10 000 t between 2006 and 2015. Reported catch since 2012 was stable between 6 500 t and 6 900 t.

The new golden redfish fishery implied a revision of catch estimates, in order to split 2005-2015 redfish catch from the major fleets on Div. 3M into golden and beaked redfish catches. The estimated catch of beaked redfish, based on beaked redfish proportions on observed catches, in 2013, 2014 and 2015 were 5 168 t, 4 561 t and 4 473 t respectively.

No STACFIS catch estimates were available for 2011-2014. Over the previous five years (2006-2010) an average annual bias of 15% plus was recorded between overall STACFIS catch estimate and overall STATLANT nominal catch. In order to mitigate the lack of scientific catch information a 15% surplus was added to the STATLANT catch of each fleet each year from 2011 to 2014. In 2015 STACFIS catches approved to use the Daily Catch Records as total catches for this stock.

On 2015 redfish catch was 6 935 t (6 935 t landed and 9 t discarded) while beaked redfish stayed at 4 473 t.

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

	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
TAC	5.0	5.0	8.5	10.0	10.0	6.5	6.5	6.5	6.7	7.0	7.0
STATLANT 21	5.6	7.9	8.7	8.5	9.7	6.7	6.8	6.5	6.9		
STACFIS Total catch[1]	6.7	8.5	11.3	8.5	11.1	7.6	7.8	7.4	6.9		
STACFIS Catch[2]	5.1	4.3	3.7	5.4	9.0	5.9	5.2	4.6	4.5		

[1] STACFIS total catch on 2011-2014 based on the average 2006-2010 bias.

[2] STACFIS beaked redfish catch estimate, based on beaked redfish proportions on observed catch.

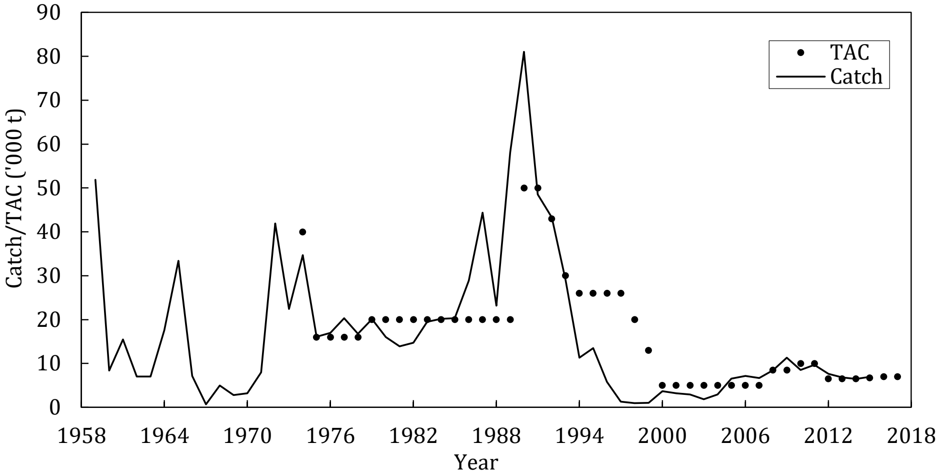


Fig. 7.1. Redfish in Div. 3M: catches and TACs.

i) Data Overview

i) Research surveys

Survey results.

EU Flemish Cap Survey: Despite a sequence of abundant year classes and a low exploitation regime over almost twenty years, survey results suggest that the beaked redfish stock increased sharply from 2004 to 2006 and then declined rapidly over the second half of the 2000's. Such unexpected shift on the stock dynamics is attributed to mortality other than fishing mortality. From the recent surveys results the decline appears to have been halted. The stock has remained near its historical average level in 2015, due to a combination of poor recruitment and natural mortalities higher than level usually accepted for this stock.

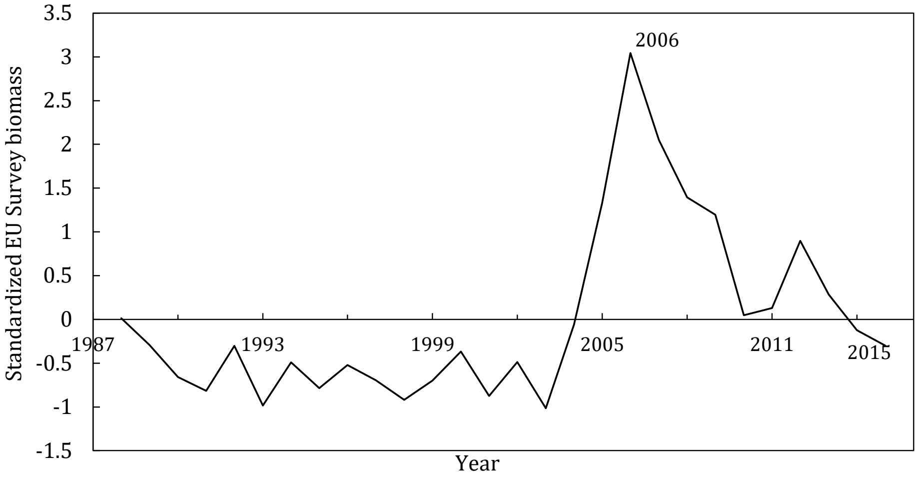


Fig. 7.2. Beaked redfish in Div. 3M: survey standardized total biomass index (1988-2015).

c) Conclusions

The perception of the stock status has not changed.

The next full assessment of the stock is planned for 2017.

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. 16/24; SCS Doc. 16/05, 08, 09, 10)

a) Introduction

A total catch of 268 tons (266 tons landed and 2 tons discarded) was reported for 2015 (Fig. 8.1).

Recent catches and TACs ('000 tons) are as follows:

	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Recommended TAC	ndf	ndf	ndf	ndf	ndf	ndf	ndf	ndf	ndf	ndf
TAC	ndf	ndf	ndf	ndf	ndf	ndf	ndf	ndf	ndf	ndf
STATLANT 21	0.1	0.1	0.1	0.1	0.1	0.2	0.2	0.2	0.2	
STACFIS	0.1	0.1	0.1	0.1	0.1	0.2	0.2	0.2	0.3	

ndf No directed fishing.

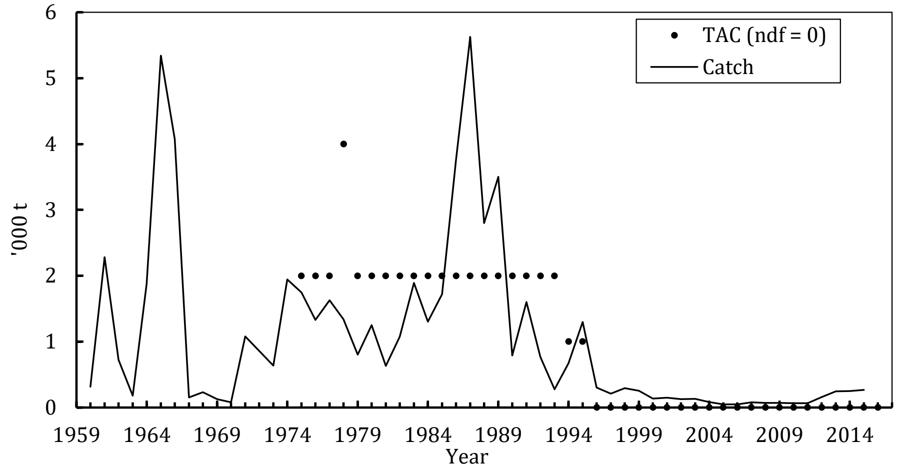


Fig. 8.1. American plaice in Div. 3M: nominal catches and agreed TACs (ndf is plotted as 0 TAC).

i) Data Overview

The EU bottom trawl survey on Flemish Cap was conducted during 2015. The survey estimates remained at low levels as previous years (Fig. 8.2 and 8.3).

All of the 1991 to 2005 year classes are estimated to be weak. Since 2006 the recruitment improved, particularly the 2006 year class.

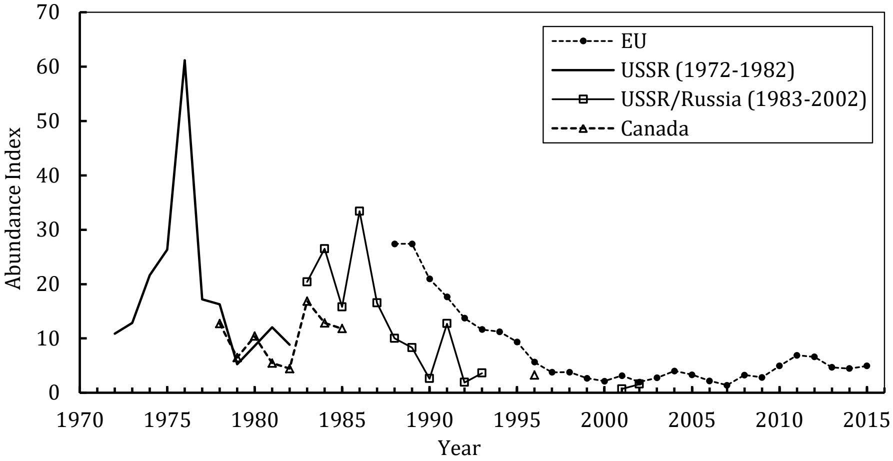


Fig. 8.2. American plaice in Div. 3M: trends in biomass index in the surveys.

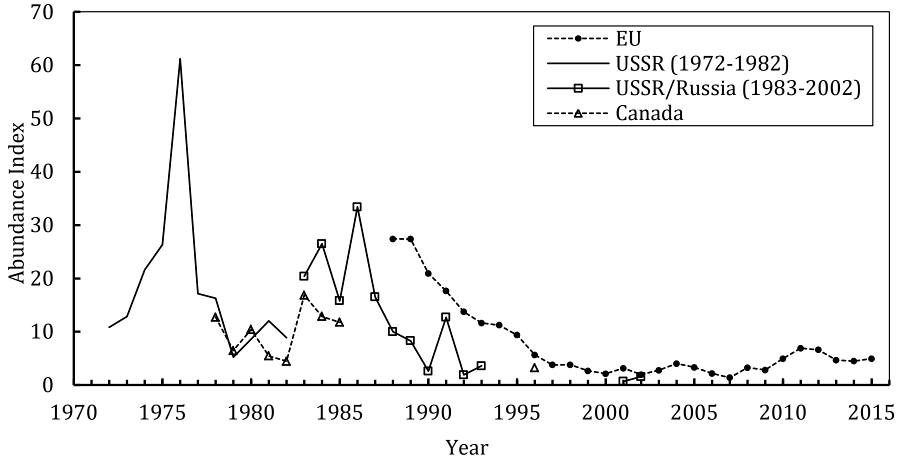


Fig. 8.3. American plaice in Div. 3M: trends in abundance index in the surveys.

e) Conclusion

Although the stock has increased slightly in recent years due to improved 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.

The next full assessment is expected to be in 2017.

f) Research Recommendations

STACFIS **recommends** that *several input frameworks be explored in both models (such as: q's; M (e.g. in relation to F0.1); ages dependent of the stock size; the proxies and its distribution in the VPA-type Bayesian model).*

Due to the recent improved recruitment at low SSB, STACFIS **recommends** *to explore the Stock/Recruitment relationship and $B_{lim.}$*

STATUS: Work is been done but no progress to report. All recommendations will be address during the next full assessment

C. STOCKS ON THE GRAND BANK: SA 3 AND DIVS.3LNO

Recent Conditions in Ocean Climate and Lower Trophic Levels

● Ocean climate composite index in SA3 - Grand Bank continues to shift downward from the record-high in 2011 with below normal conditions in 2014-2015.

●The composite spring bloom index shifts between positive and negative phases every 2-3 years and was below normal in 2015.

●The composite zooplankton index has remained consistently above normal since 2009.

●The composite trophic index also shows frequent phase shifts between positive and negative levels and reach the lowest level in the time series in 2015.

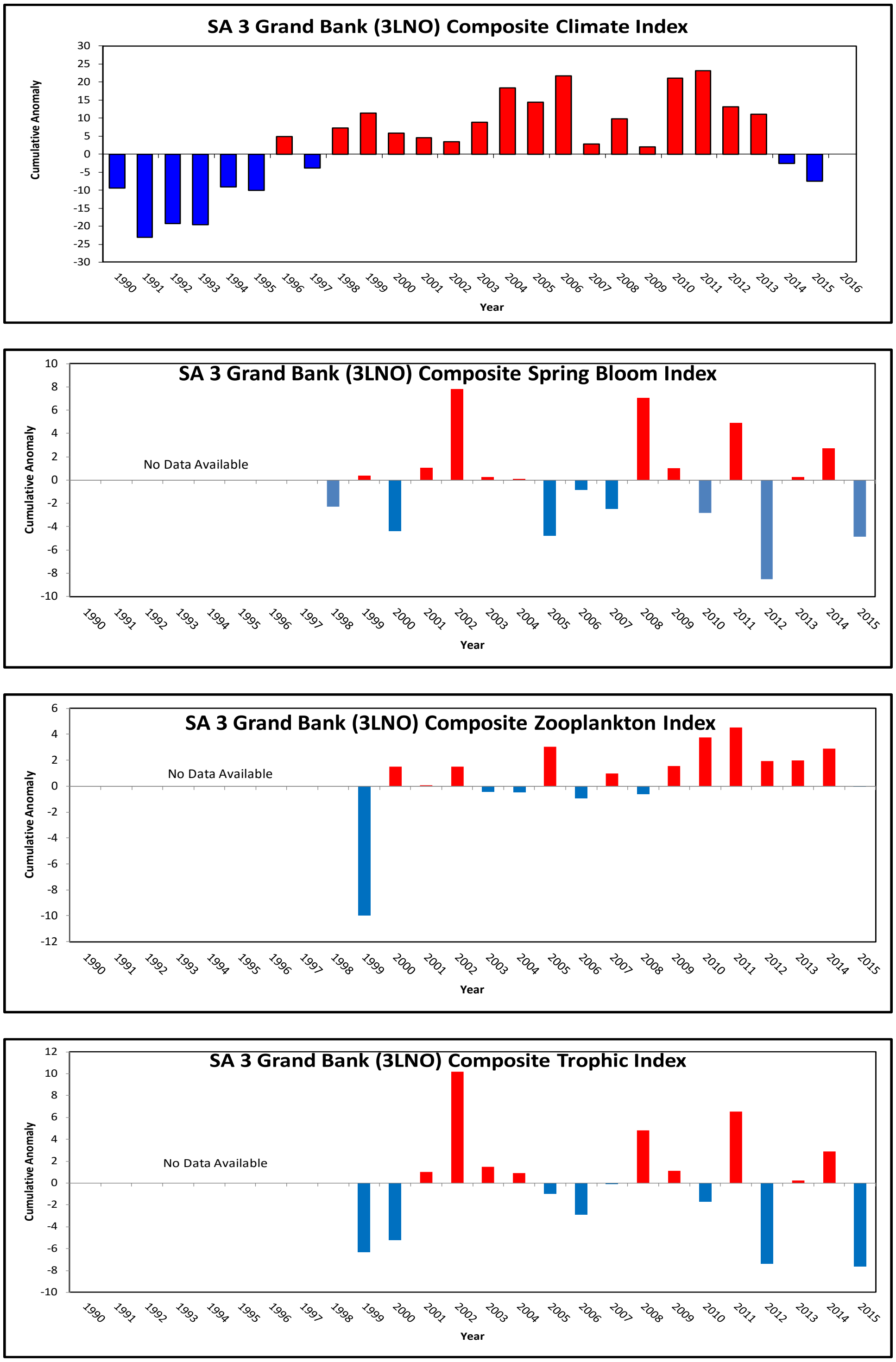


Fig. III.3. Composite ocean climate index for NAFO Subarea 3 (SA3 Divs. 3LNO) derived by summing the standardized anomalies (top panel) during 1990-2015, composite spring bloom (cumulative anomalies for magnitude and timing metrics of the spring bloom) index (Divs. 3LNO) during 1998-2015 (2'nd panel), composite zooplankton (summed functional plankton groups) index during 1999-2015 (3'rd panel), and composite trophic (summed nutrient and standing stocks of phyto- and zooplankton indices) index (bottom panel) during 1999-2015. Red bars are positive anomalies indicating above average levels while blue bars are negative anomalies indicating below average values.

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 spring and through to autumn. The winter-formed CIL water mass is a reliable index of ocean climate conditions in this area. Bottom temperatures increase to 1-4ºC in southern regions of 3NO 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) continues to remain above normal in 2013 but has declined in a pattern similar to Div. 3M in recent years (Figure III.3). Standing stocks of phytoplankton based on the composite spring bloom index has remained near average in 2013-2014 (Figure III.3). Standing stocks of zooplankton based on the composite zooplankton index remain above normal since 2009 (Figure III.3). The composite trophic index also has also remained near normal in recent years (Figure III.3).

The annual surface temperatures at Station 27 in Div. 3L continue to remain above normal reaching +1.6 SD (~1ºC) in 2013. Bottom temperatures at Station 27 remained stable at1.2 SD above normal from 2012. Vertically averaged temperatures were relatively stable at +1.1 SD from 2012.Surface salinities at Station 27 were near the long temp mean in 2013 while bottom salinities decreased to -1.4 SD below normal. The vertical thickness of the layer of cold <0ºC water (commonly referred as the cold-intermediate-layer or CIL on the shelf) increased to the mean of the time series in 2013. Spring bottom temperatures in NAFO Divs. 3LNO during 2013 were above normal and slightly less warm than the conditions of 2012. During the fall, bottom temperatures in 3LNO decreased and were near the long term mean of the time-series.

9. Cod (*Gadus morhua*) in Divs. 3NO

Interim Monitoring Report (SCR Doc. 16/10,20; SCS Doc. 16/05,06,08,09,10)

a) Introduction

This stock has been under moratorium to directed fishing since February 1994. By-catch of cod during the moratorium increased from 170 t in 1995, peaked at about 4 800 t in 2003 and has been between 500 t and 1100 t since that time. The catch in 2015 was 586 t (565 t landings, 21 t discards).

Recent TACs and catches ('000 tons) are as follows:

	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
TAC	ndf	ndf	ndf	ndf	ndf	ndf	ndf	ndf	ndf	ndf
STATLANT 21	0.7	0.7	0.6	0.8	0.8	0.7	1.1	0.7	0.6	
STACFIS	0.8	0.9	1.1	0.9	0.8	0.7	1.1	0.7	0.6	

ndf: No directed fishery

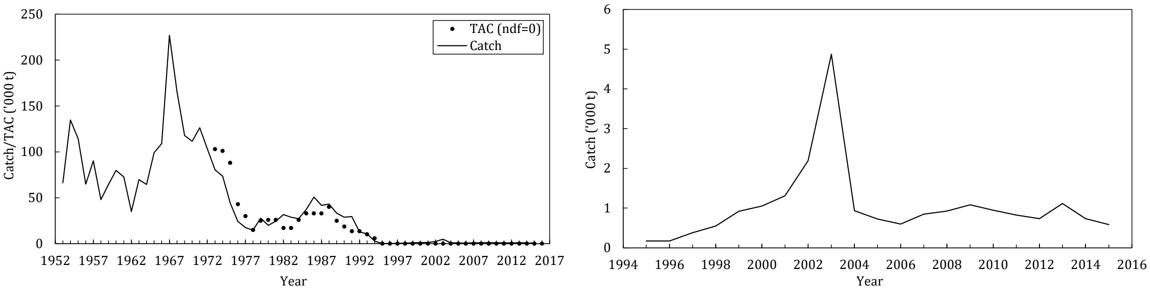


Fig. 9.1. Cod in Div. 3NO: total catches and TACs. Panel at right highlights catches during the moratorium on directed fishing.

b) Data Overview

Canadian bottom trawl surveys. The spring survey biomass index declined from 1984 to the lowest level in 1995 (Fig. 9.2). The index remained low to 2011 with the exception of brief increases in 1998-2000 and 2009. The index increased over 2012-2014 but declined again in 2015. The trend in the autumn survey biomass index was similar to the spring series (Fig. 9.2).

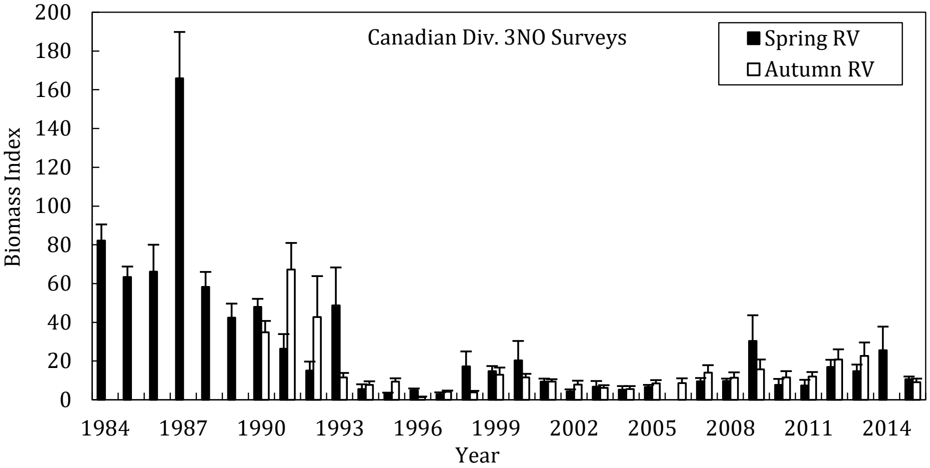


Fig. 9.2. Cod in Div. 3NO: survey biomass index (± 1 s.d.) from Canadian spring and autumn research surveys.

EU-Spain bottom trawl survey. The biomass index from the EU-Spain stratified-random survey in the NRA portion of Div. 3NO was relatively low and stable from 1997-2008 (Fig. 9.3). There was a considerable increase in the index from 2009 to 2011, followed by a substantial decline in the next two years. The index reached its highest value in 2014 but declined again in 2015. Indices from this survey may not be suitable as indicators of overall stock trend since the survey covers only a small portion of the stock area and trends can be confounded by fish movement in and out of the area.

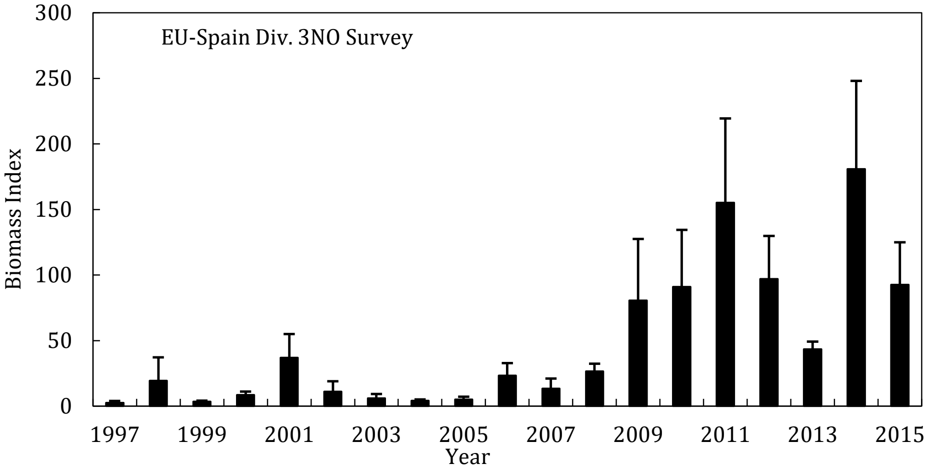


Fig. 9.3. Cod in Div. 3NO: survey biomass index (± 1 s.d.) from EU-Spain surveys conducted in the NRA portion of Div. 3NO.

c) Conclusion

The most recent analytical assessment (2015) concluded that SSB was well below B_{lim} (60 000 t) in 2014. Canadian and EU-Spain survey indices have declined for 2015 relative to 2014. Overall, the 2015 indices are not considered to indicate a significant change in the status of the stock.

The next full assessment of this stock will occur in 2017.

10. Redfish (*Sebastes mentella* and *Sebastes fasciatus*) in Divs. 3L and 3N

(SCR Doc. 16/11, 15, 20, 28, 33 ; SCS Doc. 16/05, 08, 09, 10)

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 the 2011 onwards and catches increased, being at 10 200t in 2015, 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 increasingly deployed northwards, in Div. 3L.

	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
TAC	ndf	ndf	ndf	3.5	6.0	6.0	6.5	6.5	10.4	10.4
STATLANT 21	0.2	0.4	0.3	3.1	5.4	4.3	6.2	5.7	10.2	
STACFIS	1.7	0.6	1.1	4.1	5.4	4.3	6.2	5.7	10.2	

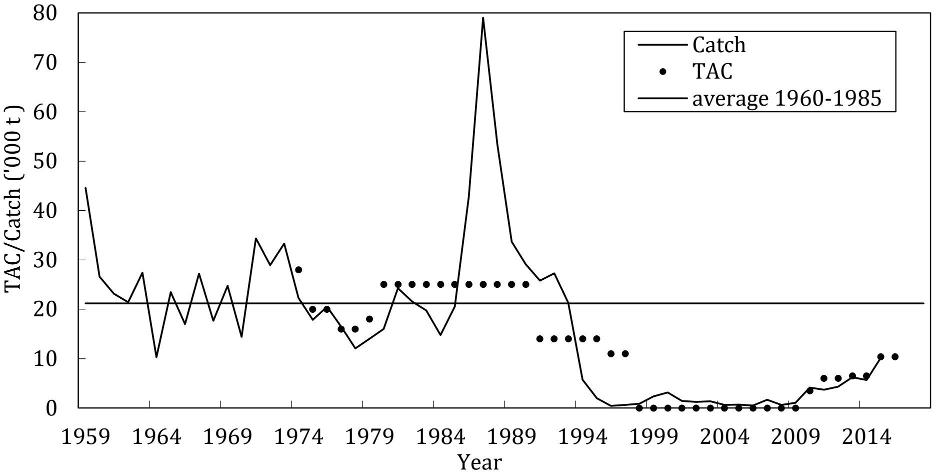


Fig. 10.1. Redfish in Div. 3LN: catches and TACs (No directed fishing is plotted as zero TAC)

b) Input Data

b) *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 usually below 1%, are observed on most of the years of the 1990-2005 interval. However, well below average mean lengths coupled with two digits proportions of small redfish under 20cm in the catch occurred afterwards on most years between 2006 and 2015. Under a low exploitation regime such events could reflect an average level of recruitment on recent years above the average low recruitment from the 1990's and first half of the 2000's.

ii) Research survey data

From 1978 onwards several stratified-random bottom trawl surveys have been conducted by Canada in various years and seasons in Div. 3L and in Div. 3N. 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 spring survey however, this was included in the assessment.

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 (1995-2015) 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.

Details on the two Canadian survey series, as well as on the Russian series and the two Spanish surveys can be found on previous assessments.

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 first half of the 1980s to the first half of the 1990s Canadian survey data in Div. 3L and Russian bottom trawl surveys in Div. 3LN suggests that stock size suffered a substantial reduction. Redfish survey bottom biomass in Div. 3LN remained well below average level until 1997 and started since then a discrete and discontinuous increase. A pronounced increase of the remaining biomass indices has been observed over the most recent years, 2007 onwards. Considering all available bottom trawl survey series occurring in Div. 3L and Div. 3N from 1978 till 2015, 100% of the biomass index values were above the average of their own series on 1978-1985, only 3% on 1986-2006, and 80% on 2007-2015.

Both 1991-2015 spring and autumn standardized female SSB series for Div. 3LN combined showed very similar patterns to correspondent survey biomass series.

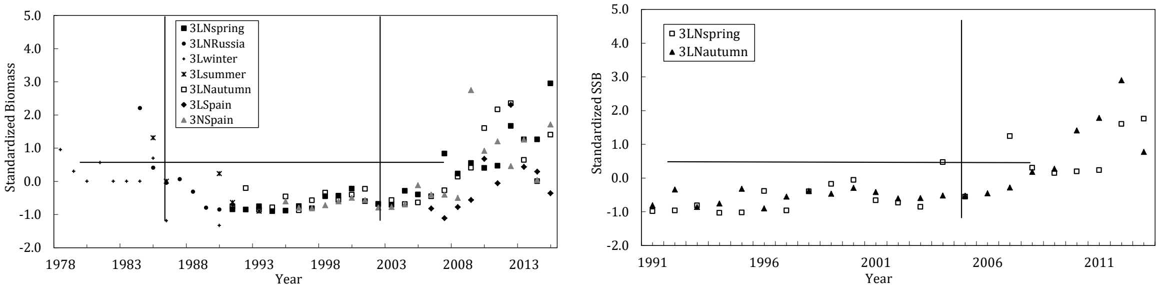


Fig. 10.2. Redfish in Div. 3LN: standardized survey biomass (1978-2015, left panel) and female spawning biomass (1991-2015, right panel). Each series standardized to zero mean and unit standard deviation. Vertical bars indicate periods when indices cross average levels.

During the first half of the 1990's in both survey series the length anomalies were negative or slightly positive. Mean lengths in most of the years between 1996 and 2006-2007 were above the mean in both survey series, reflecting a shift in the stock length structure to larger individuals. But after 2008 mean lengths generally fall to below average, just as observed in the commercial catch at length (Fig. 10.3), while larger sizes =>20cm increase their abundance as well, both in surveys and commercial catch. This most recent pattern in the length structure of surveys and commercial catch seems to confirm the occurrence of recent good recruitments, after a low productivity regime that prevailed for more than 15 years.

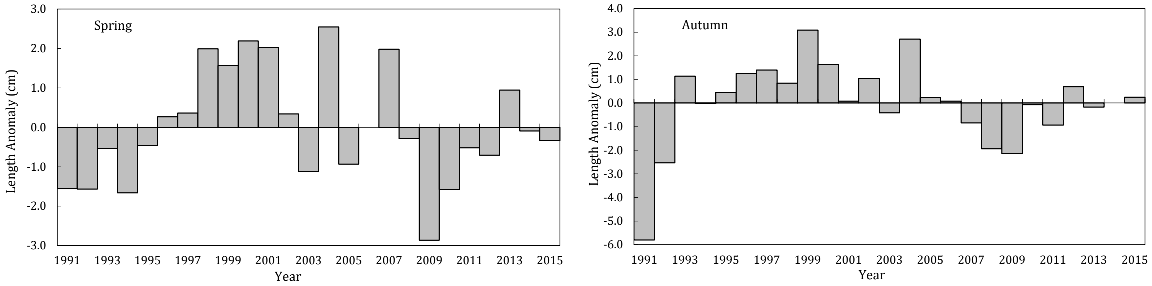


Fig. 10.3. Redfish in Div. 3LN: annual anomalies of the mean length on the spring and autumn survey, 1991-2015.

iii) Recruitment

There was a relatively good pulse of recruitment picked up in the 1991-1992 Canadian autumn survey in Div. 3LN in the range of 12-14 cm for 1991 and 15-18cm for 1992. From 2008 onwards commercial catch and Canadian survey length data indicate that the proportion of redfish smaller than 20cm has increased significantly.

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 to what is the perception of the stock history from commercial and survey data trends, was no longer a valid option, as reflected on the last 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, 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 (more than 100 000 tons). Therefore MSY was fixed in the model and the results are conditioned on this assumption.

The candidate input series to be included this year in the assessment are

I1 (Statlant CPUE and catch)	Statlant cpue for Div. 3LN,$_{1959-1994}$ & catch for Div. 3LN $_{1959-2015}$
I2 (3LN spring survey)	Canadian spring survey biomass for Div. 3LN, $_{1991-2005,\ 2007-2015}$
I3 (3LN autumn survey)	Canadian autumn survey biomass for Div. 3LN, $_{1991-2015}$
I4 (3LN Power russian survey)	Russian spring survey biomass for Div. 3LN , $_{1984-1991}$ $_{\text{(Power and Vaskov,1992)}}$
I5 (3L winter survey)	Canadian winter survey biomass for Div. 3L, $_{1985-1986\text{ and }1990}$
I6 (3L summer survey)	Canadian summer survey biomass for Div. 3L, $_{1978-1979,\ 1981,1984-1985,\ 1990-1991\text{and }1993}$
I7 (3L autumn survey)	Canadian autumn survey biomass for Div. 3L, $_{1985-1986,\ 1990}$
I8$_a$ (3N spring EU-Spain survey$_{long}$)	Eu-Spain survey biomass for Div. 3N, $_{1995-2015}$
I8$_b$ (3N spring EU-Spain survey$_{short}$)	Eu-Spain survey biomass for Div. 3N, $_{1995-2005}$
I9 (3L summer EU-Spain survey)	Eu-Spain survey biomass for Div. 3L, $_{2006-2015}$
I10 (3LN spring/summer spanish survey)	Eu-Spain survey biomass for Div. 3LN, $_{2006-2015}$

All 1959-2010 catches used in this assessment are the catches adopted by STACFIS for this stock. The 2011-2014 catches were taken from the NAFO STATLANT 21 data base. Last year's catch (2015) is provisional. In order to proceed on the threshold of the new 2014 approach the main features of the previous assessment input are kept in all input options considered in the present exploratory analysis: MSY fixed at 1960-1985 average catch, STATLANT CPUE series maintained, the 1991-2015 Canadian autumn surveys on Div. 3L and Div. 3N assembled in a single 3LN Canadian autumn series, and full length survey series used.

An evaluation of the possibility of including the EU-Spain 3L survey was conducted which led to three potential candidates for the 2016 assessment:

ASPIC2016$_a$ standard (approved 2014 assessment framework): input MSY fixed at 1960-1985 average catch, keep CPUE

ASPIC2016$_b$ plus 3LSpain: ASPIC 2016a standard plus 2006-2015 3L spanish survey

ASPIC2016$_c$ plus 3NSpain$_{short}$ and 3LNSpain: ASPIC 2016a standard with 3N short spanish survey (1995-2005) instead of 3N full survey plus the combined 2006-2015 3LN spanish survey series

An evaluation of excluding the incomplete 2015 Div 3LN spring suvey was conducted (for ASPIC 2016b) and difference in results was indistinguishable.

The approved 2014 assessment framework updated (**ASPIC2016$_a$** standard) and the same framework plus the 3L Spanish survey (**ASPIC2016$_b$** standard plus 3L Spanish survey) have better fit diagnostics. Both have small biases when comparing key parameters from these two assessments with the ones from 2014 (1.5-1.7% bias, Table 10.1), and very similar trajectories for relative biomass and fishing mortality (Fig's 10.4).

Table 10.1. Key parameters of three possible frameworks for ASPICfit 2016 assessment versus ASPICfit 2014 assessment

	MSY(1)	*B1/K*	F_{msy}	$F_{lastyear}/F_{msy}$	$Y_e(2)$	B_{msy}	$B(3)/B_{msy}$
ASPIC2016a	*21000*	**0.6868**	**0.1113**	0.3570	17380	**188700**	1.4150
ASPIC2016b	*21000*	**0.6874**	**0.1116**	0.3640	17820	**188200**	1.3890
ASPIC2016c	*21000*	**0.6301**	**0.1016**	0.3282	15100	**206700**	1.5300
ASPIC2014	*21000*	0.6764	0.1097	0.2136	18120	191500	1.3710

(1) fixed at the starting guess

(2) estimate in 2014 for ASPIC2014, estimate in 2016 for ASPIC 2016abc

(3) at the beginning of 2014 for ASPIC2014, at the beginning of 2016 for ASPIC 2016abc

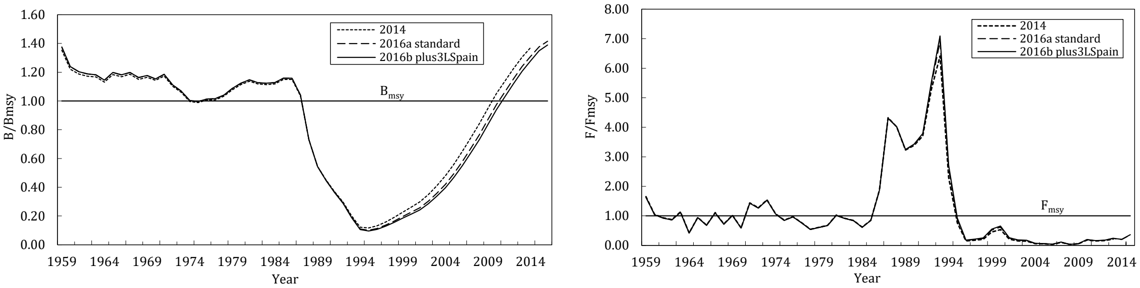


Fig. 10.4. Redfish in Divs. 3LN*:* B/B_{msy} and F/F_{msy} from ASPIC$_{fit}$ 2014 versus ASPIC$_{fit}$ 2016a and ASPIC$_{fit}$ 2016b assessments.

Assessment results for the two model formulations are summarised in Table 10.2, and show very similar outputs, with a very high probability that the stock is at or above B_{msy} under exploitation well below F_{msy} (see the table results on bold).

Nevertheless, looking to inter-quartile range, either as an absolute interval or relative to point estimate magnitude, all parameters showed narrower intervals for the bootstrap run with the input framework including the 3L Spanish survey (Table 10.2, two last columns on the far right). In other words, 50% variability width around point estimates shrinks if the assessment runs with the **ASPIC2016$_b$** input framework.

Table 10.2. ASPIC2016a standard versus ASPIC 2016b plus 3LSpain: comparison of main results from bootstrap analysis

Param. name	ASPIC assessment	Point estimate	Bias-corrected approximate confidence limits 80% lower	80% upper	60% lower	60% upper	Inter-quartile range	Relative IQ range
B1/K	2016a standard	0.6868	0.5630	1.1080	0.5931	0.8971	0.230	0.334
	2016b plus3LSpain	0.6874	0.5616	0.9718	0.5883	0.8164	0.1761	0.2560
MSY	2016a standard	21000	NA	NA	NA	NA		
	2016b plus3LSpain	21000	NA	NA	NA	NA		
Ye Last year+1	2016a standard	17380	12660	20820	13860	20400	5486	0.3160
	2016b plus3LSpain	17820	13550	20890	15060	20510	4678	0.2630
Bmsy	2016a standard	188700	166800	230300	171900	215500	34290	0.1820
	2016b plus3LSpain	188200	168900	228700	174600	215000	32430	0.1720
Fmsy	2016a standard	0.1113	0.0912	0.1259	0.0975	0.1222	0.0197	0.1770
	2016b plus3LSpain	0.1116	0.0918	0.1244	0.0977	0.1202	0.0183	0.1640
B Last year+1/Bmsy	2016a standard	1.4150	**1.0100**	1.6330	**1.1410**	1.5850	0.3561	0.2520
	2016b plus3LSpain	1.3890	**0.9991**	1.5950	**1.1370**	1.5320	0.3289	0.2370
F Last year/Fmsy	2016a standard	0.3570	0.3064	**0.5059**	0.3165	**0.4467**	0.1014	0.2840
	2016b plus3LSpain	0.3640	0.3142	**0.5087**	0.3279	**0.4467**	0.0977	0.2680
Yield Last year+1/MSY	2016a standard	0.8278	0.6029	0.9912	0.6599	0.9716	0.2613	0.3160
	2016b plus3LSpain	0.8485	0.6455	0.9949	0.7170	0.9765	0.2228	0.2626

So, from the present exploratory analysis, the better framework to run the redfish 3LN 2016 assessment is the 2nd candidate ASPIC 2016b: with MSY fixed at the 1960 to 1985 average catch and the rest of the approved 2014 framework updated and including the 3L EU-Spanish survey.

Different starting values for key parameters, different random number seeds and different magnitudes of last year surveys were used to test the robustness of the ASPIC$_{\text{fit}}$ 2016 formulation. The key parameters and seed related starting options arrived to the same or very similar solutions, showing that the ASPIC results given by the chosen formulation are insensitive to changes in initial value/default inputs chosen to initialize the assessment. Very small variability is induced on the trajectories of relative biomass and fishing mortality by variability in last year surveys, in line with the logistic model chosen for biomass growth.

The assessment was subsequently run in bootstrap mode (1000 trials) to measure variability around parameter point estimates using bootstrap methods to calculate 80% and 60% confidence limits. Bootstrap results confirm a stock at the beginning of 2016 with a >80% probability to be at or above B_{msy} and a fishing mortality in 2015 and below 50% F_{msy} (Table 10.3). Relative inter-quartile range tabulated on the two far right columns of this table with estimates from bootstrap analysis for the last two assessments (2014 in brackets) highlight the higher consistence of the 2016 assessment results when compared with the ones from 2014.

Table 10.3 Redfish in Divs. 3LN. ASPIC 2016 main results.

Param name	Point estimate	Bias-corrected approximate confidence limits 80% lower	80% upper	60% lower	60% upper	Inter-quartile range	Relative IQ range 2016	2014
B1/K	0.687	0.562	0.972	0.588	0.816	0.176	0.256	(0.295)
MSY	21000	NA	NA	NA	NA	NA	NA	
Fmsy	0.112	0.092	0.124	0.098	0.120	0.018	0.164	(0.190)
Ye(2016)	17820	13550	20890	15060	20510	4678	0.263	(0.271)
Y.(Fmsy)	28580	20980	32370	23720	31230	6244	0.218	(0.279)
Bmsy	188200	168900	228700	174600	215000	32430	0.172	(0.200)
B./Bmsy	1.389	0.999	1.595	1.137	1.532	0.329	0.237	(0.296)
F./Fmsy	0.364	0.314	0.509	0.328	0.447	0.098	0.268	(0.345)
Ye./MSY	0.849	0.646	0.995	0.717	0.977	0.223	0.263	(0.271)

ASPIC 2016 assessment results also confirm that 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 0.11/year. The correspondent B_{msy} for this stock is at the level of 190 000 t.

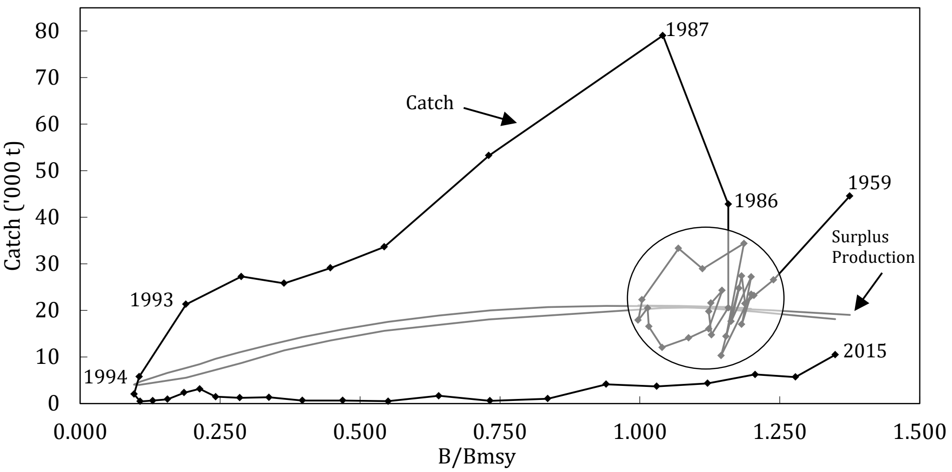


Fig. 10.5. Redfish in Div. 3LN: Catch versus Surplus Production from ASPIC$_{\text{fit}}$ 2016

Catch versus surplus production trajectories are presented in Fig. 10.5. From 1960 to 1985 catches form a scattered cloud of points around surplus production curve (highlighted in figure 10.5). In 1986-1987 catches increased well above the surplus production curve and, though declining continuously since then, were still above equilibrium yield in 1993. Catches have been well below to below surplus production levels since 1995.

Biomass: Slightly above B_{msy} for most of the former years up to 1985. Declined from B_{msy} in 1986 to 9.5-10% B_{msy} in 1994-1996, when a minimum stock size is recorded. Over the moratorium years biomass was allowed to recover and at the beginning of 2016 biomass is predicted to be 1.4 x B_{msy}. The probability to be at or above B_{msy} is high to very high. At the beginning of 2016, the probability of being below B_{lim} is less than 1%.

Fishing mortality: Fishing mortality has been low to very low since 1995 but has slightly increased since the reopening of the fishery in 2010. On 2015 fishing mortality was estimated to be at 0.36 x F_{msy}, and the probability of being above F_{msy} is very low. At the beginning of 2016, the probability of being above F_{msy} is less than 1%.

Recruitment: From commercial catch and Canadian survey length data there are signs of recent recruitment (2008 – 2015) of above average year classes to the exploitable stock.

State of stock : The stock is currently in in the safe zone of the NAFO precautionary approach framework and is estimated to be at 1.4 x $B_{msy.}$ There is a low to very low risk of the stock being below B_{msy}. Fishing mortality is well below F_{msy} (0.36 x F_{msy}), and the probability of being above F_{msy} is very low. Recent recruitment appears to be above average.

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 predicted a stepwise biannual catch increase, with the same amount of increase every two years, between 2015 and 2020 (18 100 t was the equilibrium yield in the 2014 given by the previous 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 2016 standing on its safe zone, with biomass at or above B_{msy} , after fishing mortality being kept well below F_{msy} during 2015. A short term catch projection followed the assessment, in order quantify the likelihood of the stock sustain the approved 2016-2018 MS catches and arrive "still safe" to the beginning of 2019.

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,1959-2015, extended to the projection years, 2016-2018, under the preset MS catch of:

2016: 10 400 t

2017: 14 200 t

2018: 14 200 t

The ASPICP results are presented in Fig. 10.6a and 10.6b, as regards relative 1959-2019 biomass and 1959-2018 fishing mortality trajectories, and on Table 10.4 as regards 2016-2018 catch projections.

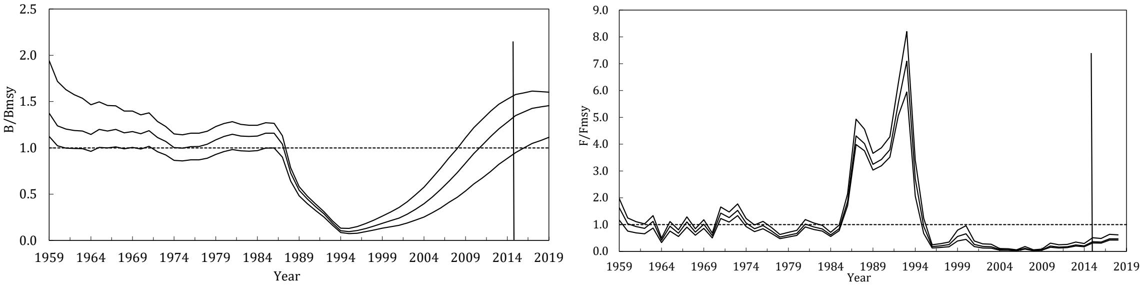


Fig. 10.6. Redfish in Div. 3LN: B/B_{msy} and F/F_{msy} point estimates trajectories with approximate 80% bias corrected CL's from ASPICP 2016.

Table 10.3. Redfish in Div. 3LN: short term catch projections. The 10th, point estimate (~50th), and 90th percentiles of projected B/B_{msy} , F/F_{msy} are shown, for projected 2016-2018 Management Strategy catch.

2016-2018 MS catch	percentiles		
Year	10	point estimate (~ 50)	90
BIOMASS RELATIVE TO Bmsy			
2016	0.999	1.389	1.595
2017	1.048	1.427	1.613
2018	1.079	1.442	1.607
2019	1.114	1.456	1.602
FISHING MORTALITY RELATIVE TO Fmsy			
2016	0.309	0.352	0.483
2017	0.420	0.471	0.636
2018	0.422	0.467	0.618

HCR (Yield)			$P(F>F_{lim}) = P(F>F_{msy})$			$P(B< B_{lim})$				$P(B<B_{msy})$				
2016	2017	2018	2016	2017	2018	2016	2017	2018	2019	2016	2017	2018	2019	$P(B_{2019} > B_{2016})$
10 400	14 200	14 200	<1%	<1%	<1%	<1%	<1%	<1%	<1%	6.8%	4.2%	3.4 %	2.4 %	88.5%

There is > 80 probability that TACs agreed within the adopted management strategy for 2016 to 2018 will maintain biomass at the beginning of 2019 above B_{msy} while keeping fishing mortality through 2018 below F_{msy} . There is also >80% probability that biomass will grow from the beginning of 2016 to the beginning of 2019.

e) Reference Points

The ASPIC point estimate results were put under the precautionary framework (Fig. 10.7). 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 low to very low level ever since. Biomass gradually approaches and surpasses B_{msy} several years after (2011-2012). The stock is presently in the safe zone.

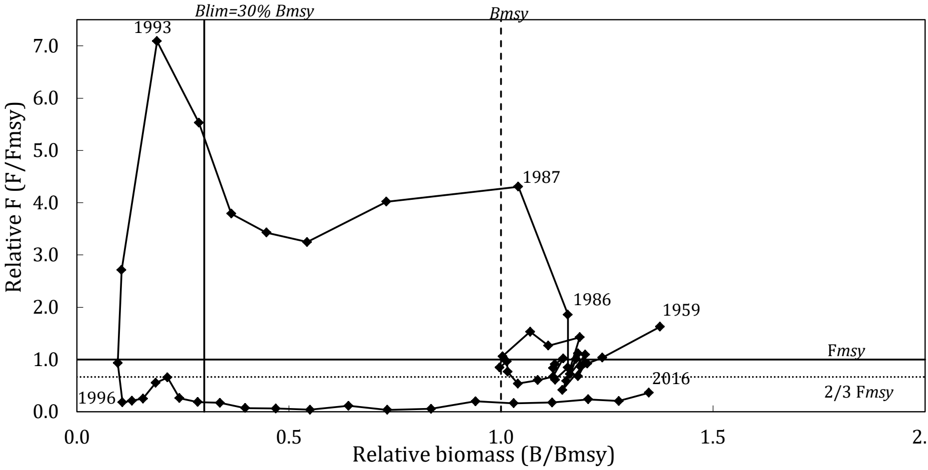


Fig. 10.7. Redfish in Div. 3LN: stock trajectory under a precautionary framework for $\text{ASPIC}_{\text{fit}}$ 2016.

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

11. American Plaice (*Hippoglossoides platessoides*) in Divs. 3LNO

(SCS Doc. 16/5, 6, 8, 9, 10, 15; SCR Doc. 16/10, 12, 30)

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. Catches increased until 2003, after which they began to decline. Total catch based on ratios of fishing effort in 2014 to effort in 2010 was 2265 tons and catch estimated from Daily Catch Records (DCR) in 2015 was 1149 t (including 34 t of discards). (Fig. 11.1) (see section c for more detail). In 2014 and 2015, American plaice were taken as by-catch mainly in the Canadian yellowtail fishery, EU-Spain and EU-Portugal skate, redfish and Greenland halibut fisheries.

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

	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
TAC	ndf	ndf	ndf	ndf	ndf	ndf	ndf	ndf	ndf	ndf
STATLANT 21	1.5	1.9	1.8	1.5	1.2	1.3	2.2	1.4	1.1	
STACFIS	3.6	2.5	3.0	2.9	2.4[1]	2.1[1]	3.0[1]	2.3[1]	1.1[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.

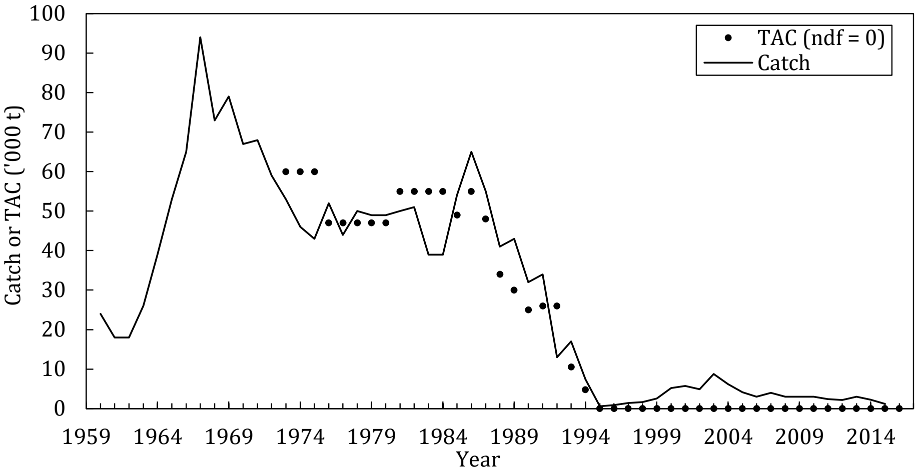


Fig. 11.1. American plaice in Div. 3LNO: estimated catches and TACs. No directed fishing is plotted as 0 TAC.

i) Input Data

Biomass and abundance data were available from: annual Canadian spring (1985-2014) and autumn (1990-2015) bottom trawl surveys; and EU-Spain surveys in the NAFO Regulatory Area of Div. 3NO (1995-2015). 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, 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 this survey. 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 and 2015 Canadian spring survey and the 2004 and 2014 autumn survey results were not used in the assessment. Age data from Canadian bycatch as well as length frequencies from EU-Portugal, EU-Spain, Russia and EU-Estonia bycatch were available for 2013-15.

b) *Commercial fishery data*

Catch and effort. There were no recent catch per unit effort data available.

Catch-at-age.

There was age sampling of the 2013-15 bycatch in the Canadian fishery and length sampling of bycatch in the Canadian, EU-Spain, EU-Portugal, EU-Estonia and Russian 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 France (SPM), Cuba and United States. The 2013 catch at age was updated to include Canadian length frequencies that had not been available last time the stock was assessed. The new length frequencies resulted in an increase in the proportion of young fish in the catch at age. Catch weights at age have been declining for a number of years. Issues have been reported regarding the quality and coverage of Canadian commercial sampling in recent years (SC report June 2015).

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 2008, followed by a drop in 2009 (Fig. 11.2). Since then, there has been a steady increase in biomass and abundance.

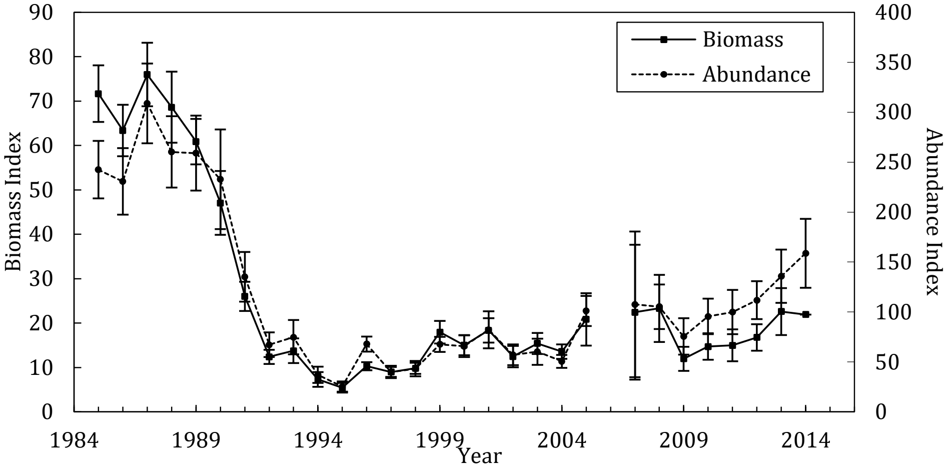


Fig. 11.2. American plaice in Div. 3LNO: biomass and abundance indices from Canadian spring surveys (Data prior to 1996 are Campelen equivalents and since then are Campelen).

Biomass and abundance indices from the autumn survey declined from 1990 to the early-mid 1990s. Both indices have shown an increasing trend since 1995 but remain well below the level of the early-1990s (Fig. 11.3). The trends observed are similar to the Canadian spring surveys.

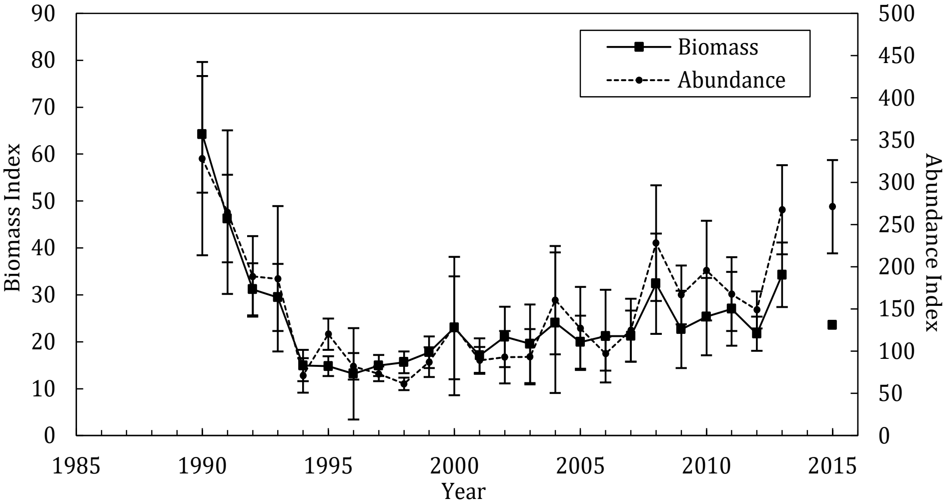


Fig. 11.3. American plaice in Div. 3LNO: biomass and abundance indices from autumn surveys (Data prior to 1995 are Campelen equivalents and since then are Campelen).

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 in recent years was more heavily concentrated in Div. 3N in the NAFO Regulatory Area and large catches in the surveys are still found there. There is some evidence that there has been an increase in abundance of young fish in Div. 3L.

EU-Spain Div. 3NO Survey.

In 2001, the vessel (CV *Playa de Menduiña*) and gear (*Pedreira*) were replaced by the RV *Vizconde de Eza* using a *Campelen* trawl. Numbers at age (1997 to present) are used in the assessment model. 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. Estimates of both indices from the EU-Spain survey varied without trend over the time series (Fig. 11.4).

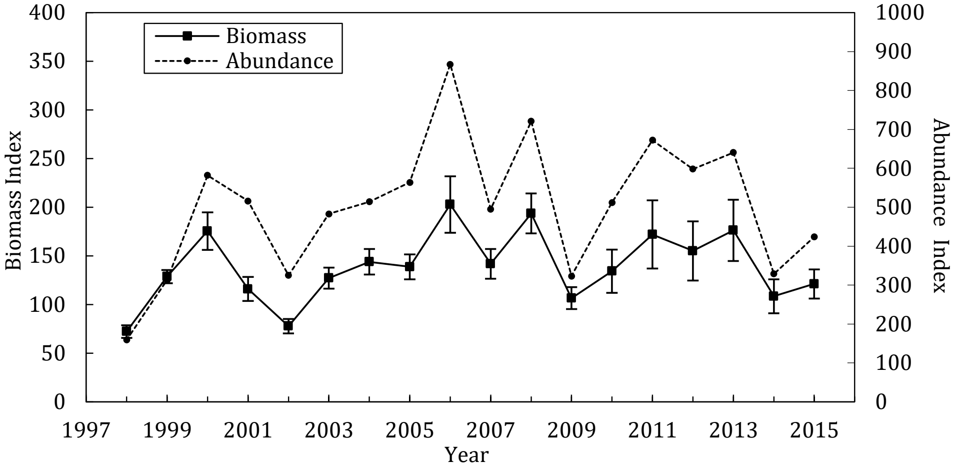


Fig. 11.4. American plaice in Div. 3LNO: biomass and abundance indices from the EU-Spain Div. 3NO survey (Data prior to 2001 are Campelen equivalents and since then are Campelen).

The abundance of fish <5 years old has increased in both the Canadian spring and fall surveys in recent years, and the proportion of the annual total they comprise has also been increasing (Fig. 11.5). This indicates above-average pre-recruitment. In addition, 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, probably due to differences in survey coverage and/or design (Fig. 11.5).

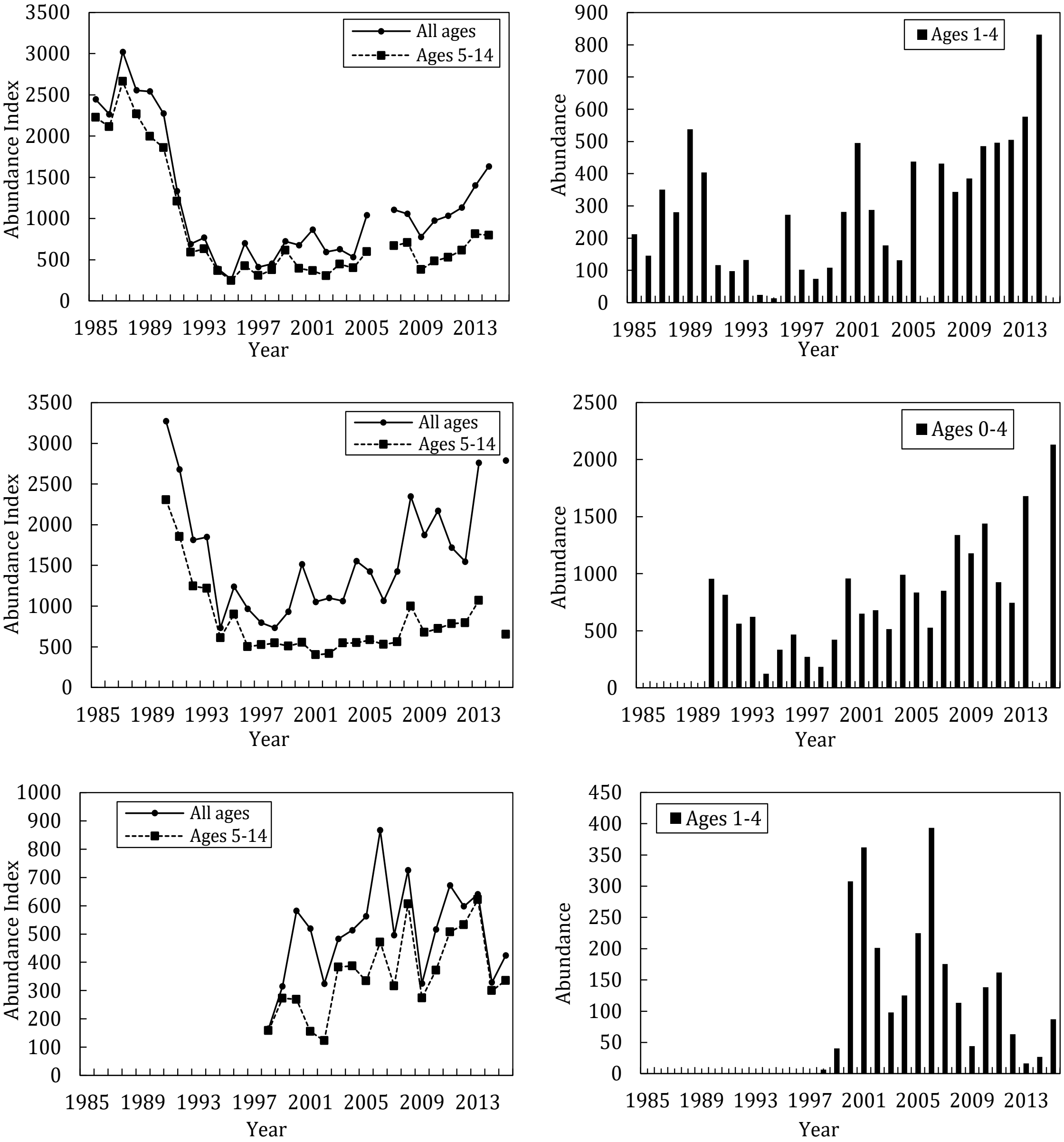


Fig. 11.5. American plaice in Div. 3LNO: comparison of total abundance indices from Canadian spring, fall and EU-Spain surveys with abundance from ages 5-14 (left) and abundance of fish less than five years old on right (Data prior to 1996 are Campelen equivalents and since then are Campelen).

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 2014. 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. Both weight and length was lower in 2014 for most ages for both males and females.

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.

A sensitivity analysis was run to examine the impact of using catch estimates in 2014 and 2015 from the 'effort method' (used from 2011-2013) and DCRs. Two alternate analyses using different catches were carried out: 1) effort method in 2014 and 2015 and 2) DCR in 2014 and 2015 and compared with the agreed catch estimates outlined above. There were no major differences in either model fit or model output estimates. The agreed catch scenario was used to describe stock trends (including projections). However STACFIS emphasized that if biases in catch exist over longer periods, the differences in outcomes would not be inconsequential and would very likely alter the perception of the stock.

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 assessment formulation with catch-at-age and survey information from the following:

- Catch at age (1960-2015) (ages 5-15+);
- Canadian spring RV survey (1985-2014) (no 2006 or 2015 value) (ages 5-14);
- Canadian autumn RV survey (1990-2015) (no 2004 or 2014 value) (ages 5-14); and
- EU-Spanish Div. 3NO survey (1998-2015) (ages 5-14).

There was 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 over 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.

d) Assessment Results

The mean square of the residuals from the model was 0.33; however there was some indication of auto-correlation in the residuals. Relative errors on the population estimates ranged from 0.11 to 0.42. The relative errors on the catchabilities (q) were all less than 0.2.

The VPA analyses showed that population abundance and biomass declined fairly steadily from the mid-1970s to 1995. Biomass and abundance have been slowly increasing over the last number of years (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).

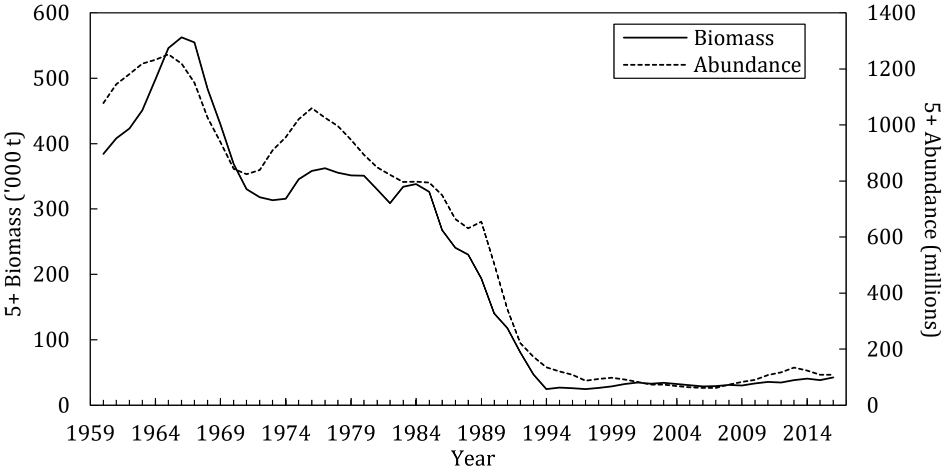


Fig. 11.6. American plaice in Div. 3LNO: population abundance and biomass from VPA

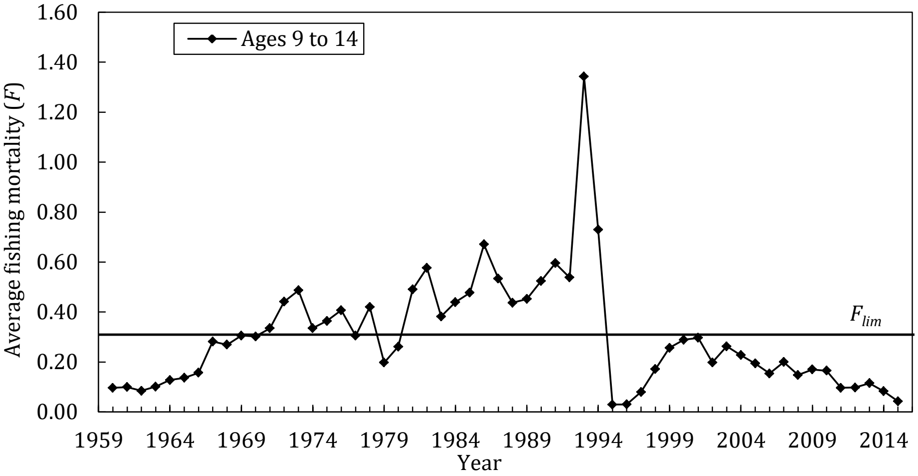


Fig. 11.7. American plaice in Div. 3LNO: average fishing mortality from VPA.

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 has been increasing slowly. Stock weights at age have declined over the last six years (values used in previous assessment revised for 2013 and 2014) (Fig. 11.9). Spawning stock biomass in the current year was estimated at 30, 000 t (about 60% 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. 11.10).

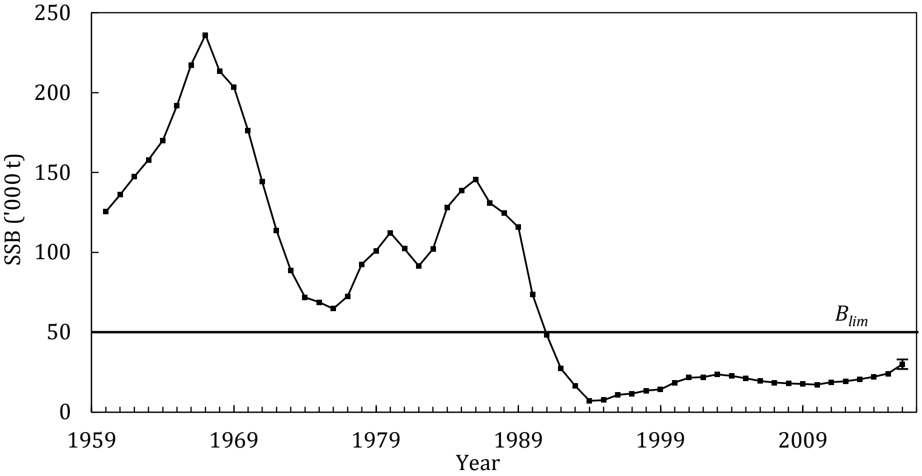


Fig. 11.8. American plaice in Div. 3LNO: spawning stock biomass from VPA. Error bars on the 2016 SSB are approximate 80% confidence intervals.

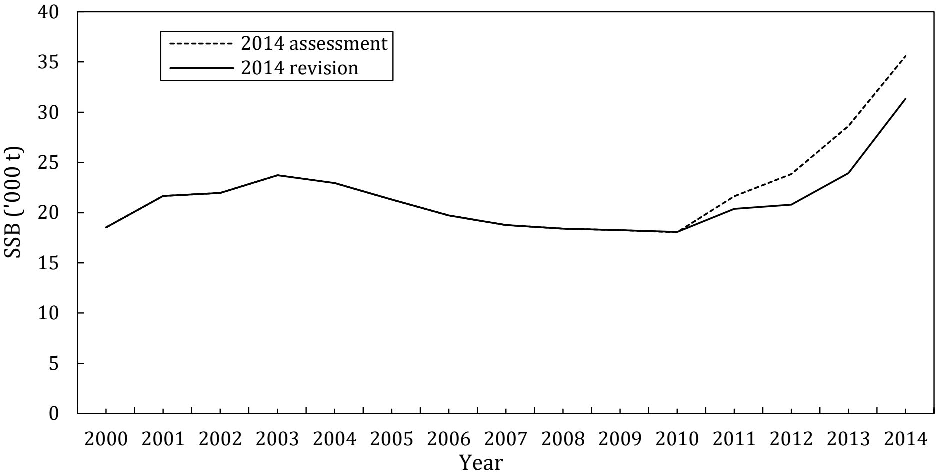
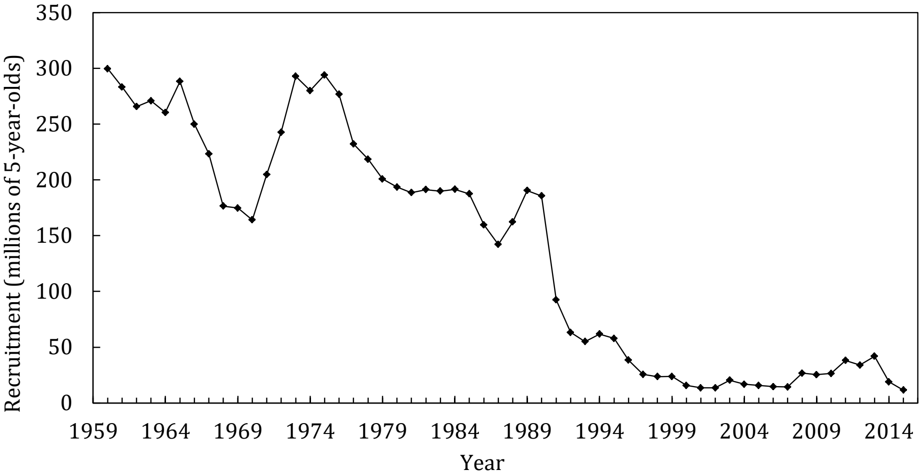


Fig. 11.9. American plaice in Div. 3LNO: comparison of spawning stock biomass estimates from 2014 and those estimates calculated using revised stock weights.



.Fig. 11.10. American plaice in Div. 3LNO: recruits (at age 5) from VPA.

STACFIS notes that the SSB projected during the 2014 assessment was larger than that estimated during the current assessment. The factors which contribute to this difference include: the population retrospective pattern (revised downwards), and a decrease in the weights and proportion mature at age. (The values assumed in the 2014 projections were higher than those based on recent data.)

e) State of the Stock

The stock remains low compared to historic levels and, although SSB is increasing, it is still estimated to be below B_{lim}. Recruitment has been low since the late 1980s, but has shown an increasing trend from 2007-2013. This has been followed by lower recruitments in 2014 and 2015

Spawning stock biomass: SSB declined to the lowest estimated level in 1994 and 1995. SSB has been increasing since then and is currently at 30, 000 t. B_{lim} for this stock is 50 000 t. Probability that $B<B_{lim}$ is greater than 95%.

Recruitment: Overall, recruitment has been low since the late 1980s, but has shown an increasing trend from 2007-2013. This has been followed by lower recruitments in 2014 and 2015. 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 2015 at 0.08).

f) Retrospective patterns

A five year retrospective analysis was conducted by sequentially removing one year of data from the input data set (Fig. 11.11). There is a retrospective pattern present in this assessment which indicates that abundance and SSB has generally been overestimated (average of 11% over four years) and F has been underestimated (average of 10% over four years).

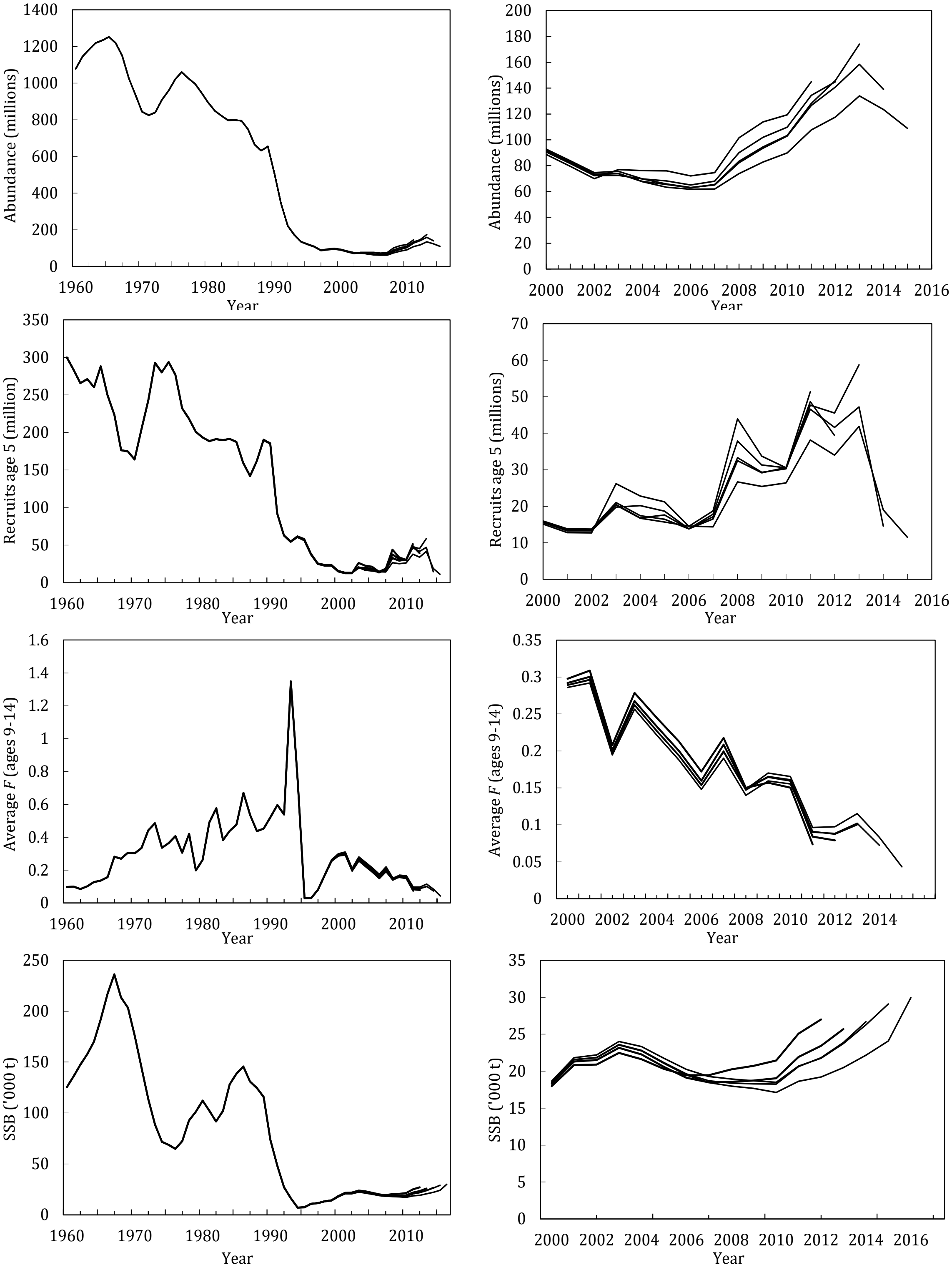


Fig 11.11 American plaice in Div. 3LNO: retrospective analysis of population numbers, recruitment (age 5), average *F* (ages 9-14), and SSB.

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. 11.12).

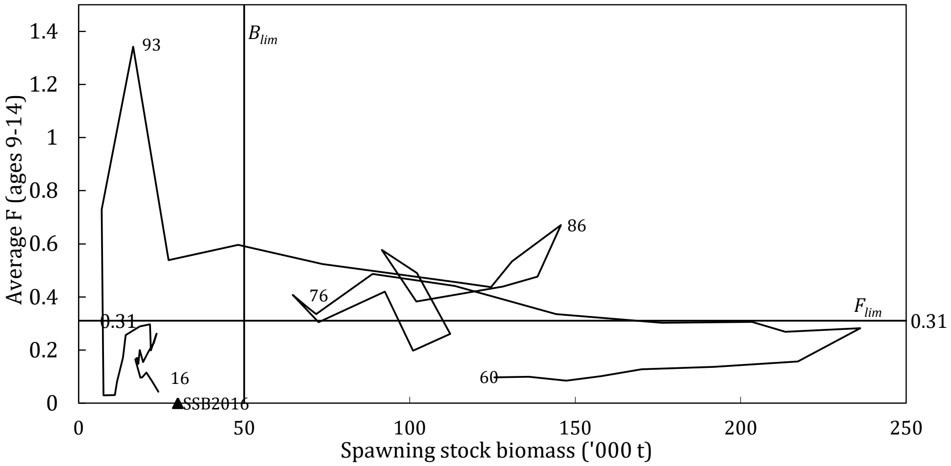


Fig. 11.12. American plaice in Div. 3LNO: stock trajectory within the NAFO PA framework. The 2016 SSB estimate is indicated by the triangle on the x-axis.

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= $F_{2013\text{-}2015}$ (0.08). The three year average was chosen rather than the value for 2015 because of the retrospective pattern.

For these simulations the results of the VPA and the covariance of these population estimates were used. The following assumptions were made:

Age	Estimate of 2016 population numbers ('000)	CV on population estimate	Weight-at-age mid-year (avg. 2013-2015)	Weight-at-age beginning of year (avg. 2013-2015)	Maturity-at-age (avg. 2013-2015)	Rescaled PR relative to ages 9-14 (avg. 2013-2015)
5			0.133	0.102	0.013	0.085
6	10289	0.423	0.216	0.177	0.048	0.213
7	13113	0.301	0.287	0.246	0.155	0.403
8	22862	0.230	0.389	0.335	0.426	0.690
9	14141	0.201	0.463	0.431	0.740	0.858
10	11882	0.184	0.575	0.534	0.916	0.943
11	5890	0.180	0.687	0.639	0.978	0.967
12	4157	0.175	0.860	0.790	0.996	1.046
13	3390	0.166	1.014	0.945	0.997	1.108
14	1236	0.176	1.163	1.089	0.999	1.077
15	3078	0.111	1.809	1.491	1.000	1.077

Simulations were limited to a 3-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 >0.95 of being less than B_{lim} by the start of 2019 under both fishing mortality scenarios. However under each scenario there is a >0.95 probability that SSB in 2019 will be greater than in 2016.

Under status quo fishing mortality ($F_{2013\text{-}2015}$), projected removals increase slightly in each year.

Table 11.1 American plaice in Div. 3LNO: Results of stochastic projections under various fishing mortality options. Labels p10, p50 and p90 refer to 10th, 50th and 90th percentiles of each quantity.

	F = 0		
	SSB ('000 t)		
	p10	p50	p90
2016	27	30	33
2017	32	35	39
2018	35	38	43
2019	37	41	46

	$F_{2013\text{-}15}$ = 0.08					
	SSB ('000 t)			Yield ('000 t)		
	p10	p50	p90	p10	p50	p90
2016	27	30	33	2.5	2.7	3.0
2017	29	32	36	2.6	2.8	3.1
2018	30	33	37	2.6	2.9	3.2
2019	30	33	37			

Table 11.2 American plaice in Div. 3LNO: Risk assessment under F =0 and $F_{2013\text{-}2015}$ of the probability of being below B_{lim}. Yield is median projected value.

		Yield			P(SSB>Blim)		
Fishing Mortality	2016	2017	2018	2017	2018	2019	P(SSB2019>SSB2016)
F = 0	-	-	-	<5%	<5%	<5%	>95%
F2013-2015= 0.08	2744	2835	2906	<5%	<5%	<5%	>95%

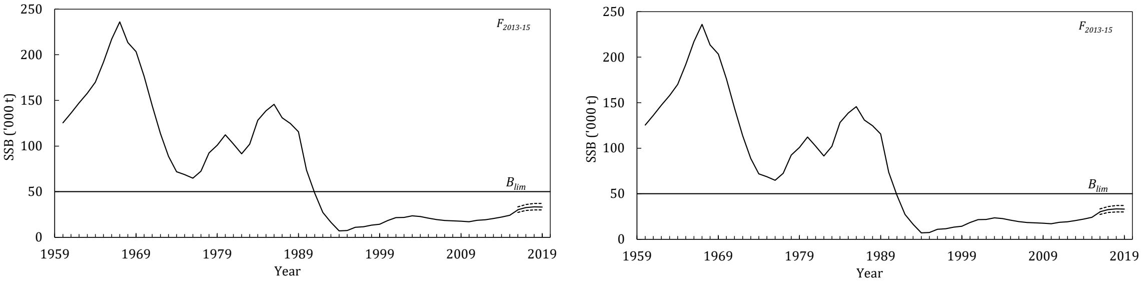


Fig. 11.13 American plaice in Div. 3LNO: Spawning stock biomass from projections along with 10th and 90th percentiles (dotted lines) for F=0 (left) and $F_{2013-15}$ (right).

The next full assessment of this stock is expected to be in 2018.

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: Work is ongoing. The recommendation is reiterated.

12. Yellowtail flounder (*Limanda ferruginea*) in Divs. 3LNO

Interim Monitoring Report (SCS 16/5 , 16/9, 16/10; SCR 16/11)

a) Introduction

There was a moratorium on directed fishing from 1994 to 1997, and small catches were taken as by-catch in other fisheries. The fishery was re-opened in 1998 and catches increased from 4 400 t to 14 100 t in 2001 (Fig 12.1). Catches from 2001 to 2005 ranged from 11 000 t to 14 000 t. Since then, catches have been below the TAC and in some years, have been very low. The low catch in 2006 was due to corporate restructuring and a labour dispute in the Canadian fishing industry. Industry related factors continued to affect catches which remained well below the TAC since 2007. However, from 2013 to 2015, catches were higher, ranging from 6 900 t to 10 700 t (2015: landings 6879 t, discards 32 t).

Recent catches and TACs ('000 tons) are as follows:

	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
TAC[1]	15.5	15.5	17	17	17	17	17	17	17	17
STATLANT 21	4.4	11.3	5.5	9.1	5.2	3.1	10.7	8.0	6.7	
STACFIS	4.6	11.4	6.2	9.4	5.2	3.1	10.7	8.0	6.9	

[1] SC recommended any TAC up to 85% F_{msy} in 2009-2015.

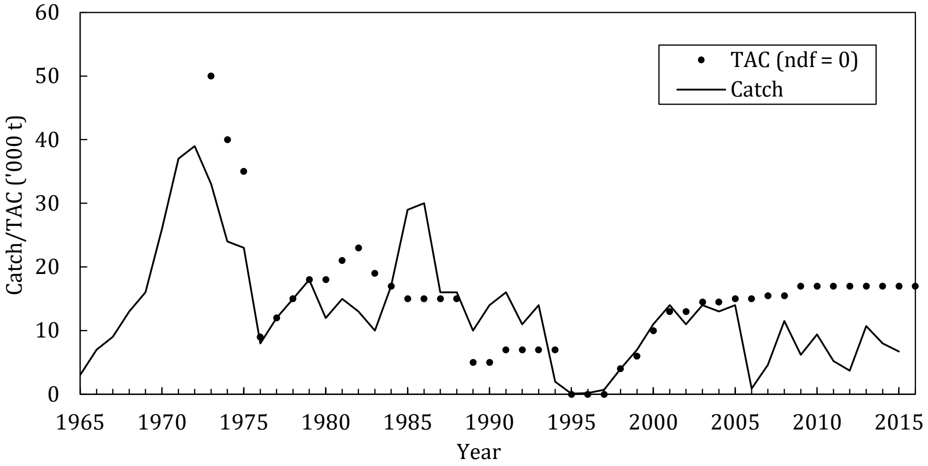
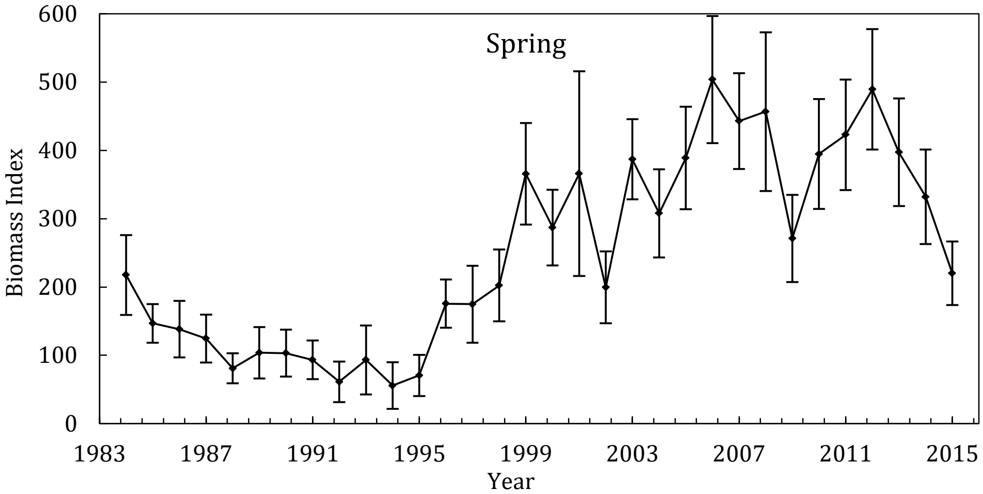


Fig. 12.1. Yellowtail flounder in Div. 3LNO: catches and TACs. No directed fishing is plotted as 0 TAC.

i) Data Overview

b) *Research survey data*

Canadian stratified-random spring surveys. Although variable, the spring survey biomass index increased from 1995 to 1999 and since fluctuated at a high level. The spring 2015 survey was incomplete.



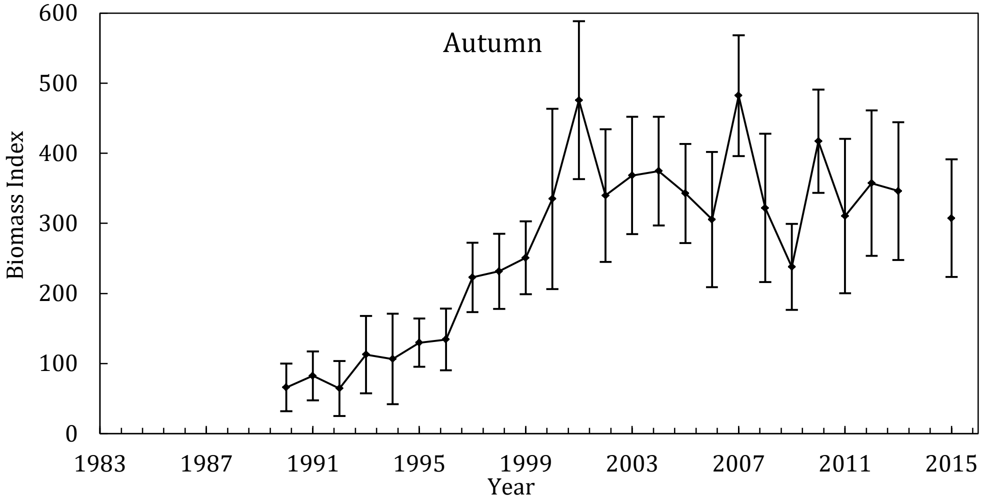


Fig.12.2. Yellowtail flounder in Div. 3LNO: indices of biomass with approx 95% confidence intervals, from Canadian spring and autumn surveys. Values are Campelen units or, prior to autumn 1995, Campelen equivalent units. The Canadian 2014 autumn and 2015 spring surveys were incomplete.

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 has remained relatively high since then (Fig. 12.2). The 2014 survey was incomplete due to problems with the research vessel.

EU-Spain stratified-random spring surveys in the NAFO Regulatory Area of Div. 3NO. The biomass index of yellowtail flounder increased sharply up to 1999 and since remained relatively stable, even though the 2014 and 2015 estimates are lower than the previous recent estimates (Fig. 12.3). Results are in general agreement with the Canadian series which covers the entire stock area.

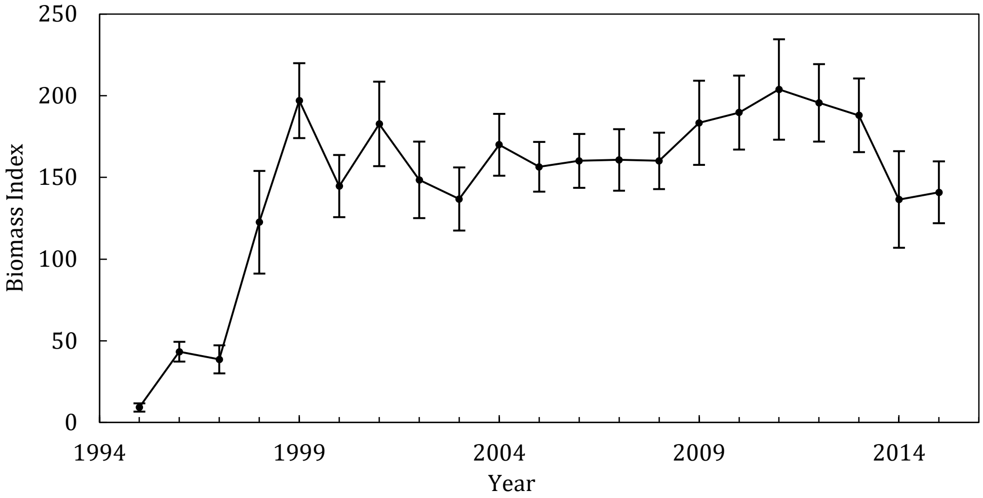


Fig.12.3. Yellowtail flounder in Div. 3LNO: index of biomass from the EU-Spain spring surveys in the Regulatory Area of Div. 3NO ±1SD. Values are Campelen units or, prior to 2001, Campelen equivalent units.

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 1999-2014 surveys than from 1984-1995, and the stock has continued to occupy the northern portion of its range in Div. 3L, similar to the mid-1980s when overall stock size was also relatively large. The vast majority of the stock is found in waters shallower than 93 m in both seasons.

Recruitment: Total numbers of juveniles (<22 cm) from spring and autumn surveys by Canada and spring surveys by EU-Spain are given in 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 was above the 1996-2015 average in the Canadian surveys of 2010, and the 2011-2013 Canadian spring surveys. However the Canadian 2014 spring and 2015 autumn surveys were below the time series average, and the spring survey by EU-Spain has shown lower than average numbers of small fish in the last nine surveys. Overall, recent recruitment appears to be lower than average.

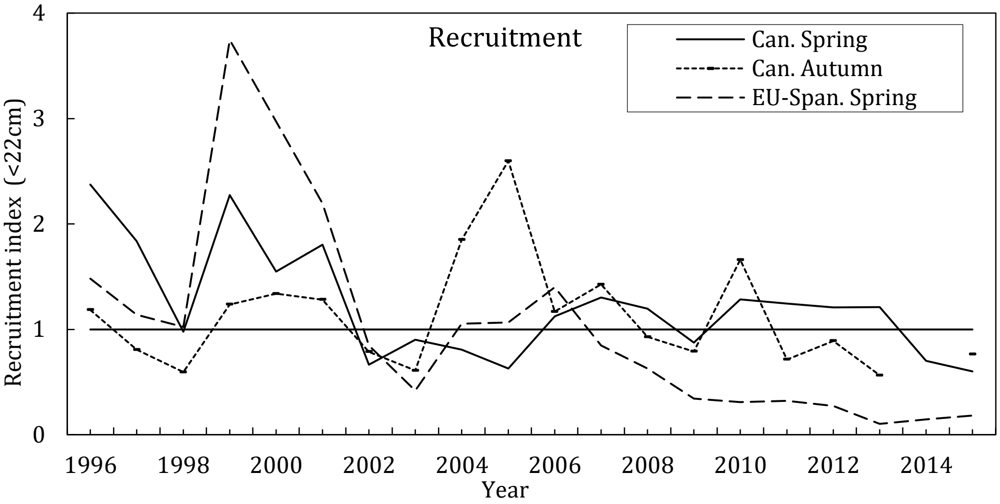


Fig.12.4. Yellowtail flounder in Div. 3LNO: Juvenile abundance indices from spring and autumn surveys by Canada (Can.) and spring surveys by EU-Spain. Each series is scaled to its mean (horizontal line).

c) Conclusion

The most recent analytical assessment (2015) concluded that the stock was above B_{msy} with a very low risk (<5%) of the stock being below B_{msy} or F being above F_{msy}. Overall, the 2015 survey indices are not considered to indicate a significant change in the status of the stock.

The next full assessment of this stock is scheduled for 2018, however the current TAC is only set for 2016 and 2017. Further discussion with FC will be required to determine whether a full assessment is required in 2017.

13. Witch Flounder (*Glyptocephalus cynoglossus*) in Divs. 3NO

Interim Monitoring Report (SCR Docs 16/11, 20, 28; SCS Docs. 16/05, 06, 08, 09, 10)

a) Introduction

Reported catches in the period 1972-84 ranged from a low of about 2,400 t in 1980 and 1981 to a high of about 9,200 t in 1972 (Table 13.1, 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 1994, when a moratorium was imposed on the stock. Since then, catches have averaged below 500 t. The NAFO Fisheries Commission reintroduced a 1,000 ton TAC for 2015 and in 2015 set a TAC for 2016 and 2017 at 2,172 t and 2,225 t respectively. In 2015 the catch was estimated to be 389 t (this includes 30 t of discards).

Table 13.1 Recent catches and TACs ('000 t) of witch flounder in NAFO Divs. 3NO

	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
TAC	ndf	ndf	ndf	ndf	ndf	ndf	ndf	ndf	1.0	2.2	2.2
STATLANT 21A	0.2	0.2	0.1	0.4	0.4	0.3	0.3	0.3	0.4	NA	NA
STACFIS	0.2	0.3	0.4	0.4	0.4	0.3	0.3	0.3	0.4	NA	NA

ndf = no directed fishery.

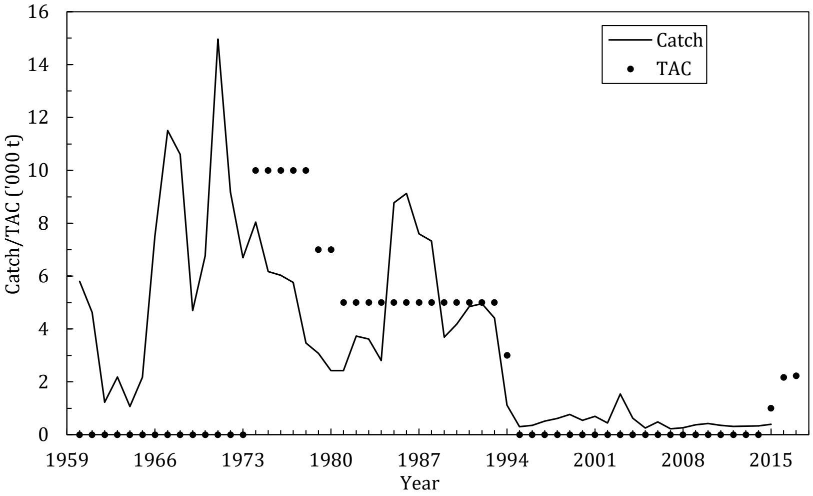


Fig. 13.1. Witch flounder in Divs. 3NO: Catches and TAC. No directed fishing is plotted as 0 TAC.

i) Data Overview

b) *Research survey data*

Canadian spring RV survey. Due to substantial coverage deficiencies values from 2006 are not presented. The biomass index, although variable, had shown a general decreasing trend from 1985 to 1998, a general increasing trend from 1998 to 2003, and a general decreasing trend from 2003 to 2010. From 2010 to 2013 the index increased to values near the series high from 1987 (Figure 13.2). Biomass values declined substantially from a high in 2013 to a value 105% of the time series average in 2014 and to a value 49% of the time series average in 2015.

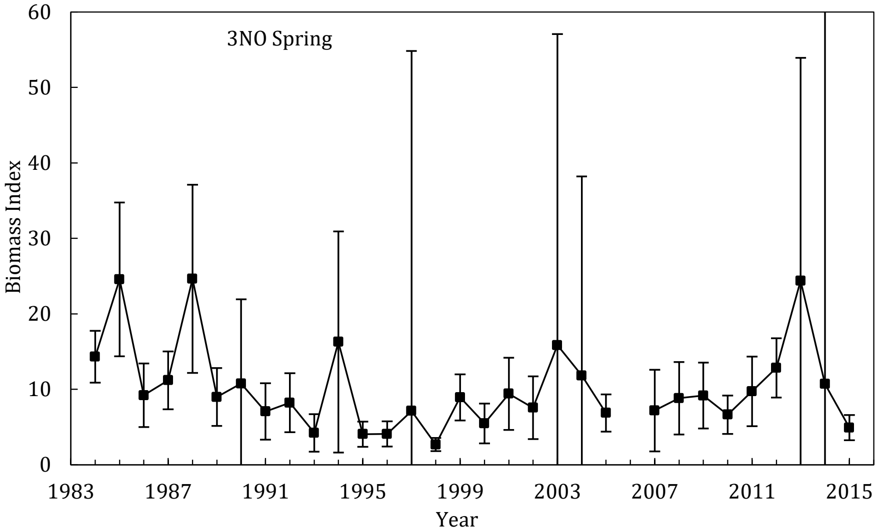


Fig. 13.2. Witch flounder in NAFO Divs. 3NO: survey biomass indices ('000 t) from Canadian spring surveys 1984-2015 (95% confidence limits are given). Values are Campelen units or, prior to 1996, Campelen equivalent units.

Canadian autumn RV survey. Due to operational difficulties there was no 2014 autumn survey. The biomass indices had shown a general increasing trend from 1996 to 2012 (Fig. 13.3). The index increased substantially from 2007 to 2009 exceeding the time series average by 270%. From 2013 to 2015 the biomass decreased substantially to a value 72% of the time series average.

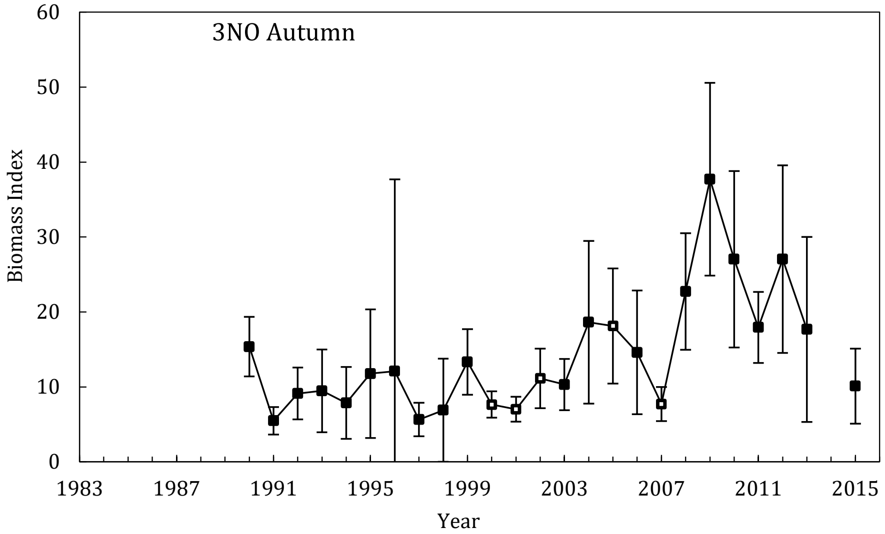


Fig. 13.3. Witch flounder in Divs. 3NO: biomass indices ('000 t) from Canadian autumn surveys 1990- 2015 (95% confidence limits are given). Values are Campelen units or, prior to 1995, Campelen equivalent units. Open square symbols indicate years in which more than 50% of the deep water (> 730 m) strata were covered by the survey.

EU-Spain RV spring survey. Surveys have been conducted annually from 1995 to 2015 by EU-Spain in the NAFO Regulatory Area in Divs. 3NO to a maximum depth of 1,462 m (since 1998). In 2001, the research vessel (R/V *Playa de Menduiña*) and survey gear (Pedreira) were replaced by the R/V *Vizconde de Eza* using a Campelen trawl (NAFO SCR 05/25). Data for witch flounder prior to 2001 have not been converted and therefore data from the two time series cannot be compared. In the Pedreira series, the biomass increased from 1995-2000 but declined in 2001. In the Campelen series, the biomass index has been somewhat variable but generally decreased from 2001 to 2007 (Figure 13.4). This was followed by an increase from 2007 to 2010 to levels near the previous series high of 2004. The biomass index from Spanish surveys in 2014 was the lowest of the 2001-2014 time series at just 40% of the time series mean. There was an increase in the biomass index from 2014 to 2015 to a value 81% of the time series mean (Figure 13.4).

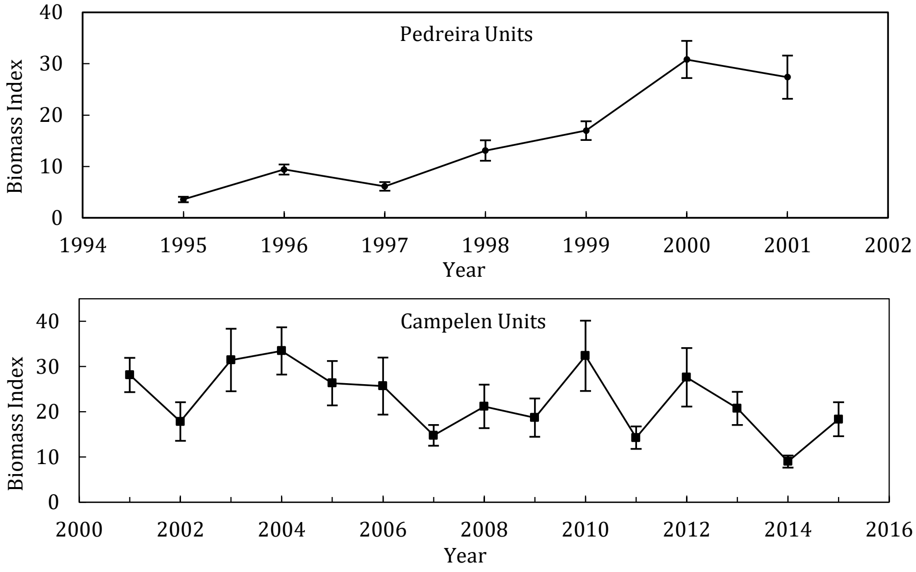


Fig. 13.4. Witch flounder in Divs. 3NO: biomass indices ('000 t) from EU-Spanish Div. 3NO spring surveys (± 1 standard deviation). Data from 1995-2001 is in Pedreira units; data from 2001-2015 are Campelen units. Both values are present for 2001.

c) Conclusion

This stock underwent full assessment in 2014 based on survey indices and in 2015 utilizing a surplus production model in a Bayesian framework. The 2015 assessment indicated that the stock steadily increased since 1999 and was at 81% B_{msy}. In 2015 the risk of the stock being below B_{lim} or above F_{lim} was concluded to be less than 1%. Based upon this information, the NAFO Fisheries Commission in 2015 set a TAC for 2016 and 2017 at 2,172 t and 2,225 t respectively.

Despite the 1,000 ton quota available, the catch reported for 2015 (389 t) was consistent with the bycatch range (300-400 t) reported since 2010.

Canadian spring and autumn survey biomass indices indicated a downward trend from 2012 to 2015. EU-Spain spring survey biomass indices indicated a similar downward trend from 2012 to 2014 but an increase from 2014 to 2015.

The advice from the 2015 assessment is still considered to be valid.

The next full assessment of this stock is planned for 2017.

14. Capelin (*Mallotus villosus*) in Divs. 3NO

Interim Monitoring Report (SCR Doc. 16/13, 21)

a) Introduction

The fishery for capelin started in 1971 and catches were high in the mid-1970s with a maximum catch of 132 000 t in 1975 (Fig. 14.1). The stock has been under a moratorium to directed fishing since 1992. No catches have been reported for this stock from 1993 except 2014 when a Spanish catch of 1 t was recorded.

	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Recommended TAC	na	na	na	na	na	na	na	na	na	na
Catch1	0	0	0	0	0	0	0	1	0	

[1] No catch reported or estimated for this stock
na = no advice possible

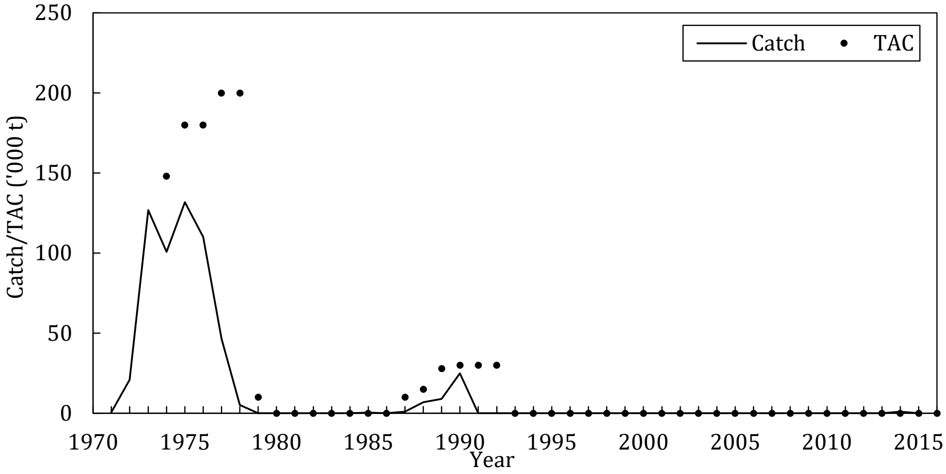


Fig. 14.1. Capelin in Div. 3NO: catches and TACs.

i) Data Overview

Trawl acoustic surveys of capelin on the Grand Bank previously conducted by Russia and Canada on a regular basis have not been repeated since 1995. In recent years, STACFIS has repeatedly recommended investigation of the capelin stock in Div. 3NO utilizing trawl-acoustic surveys to allow comparison with historical time series. However, this recommendation has not been acted upon. The best indicator of stock dynamics currently available is capelin biomass from Canadian spring stratified-random bottom trawl surveys. This index varied greatly over 1995-2015 without any clear trend. The time series maximum occurred in 2008 but the index declined rapidly over the next three years to one of the lowest values in the time series in 2011. In 2012 and 2013 the indices were again among the highest in the time series. In 2014 the indices were highest in the time series and then sharply decreased to the one of the lowest level in 2015.

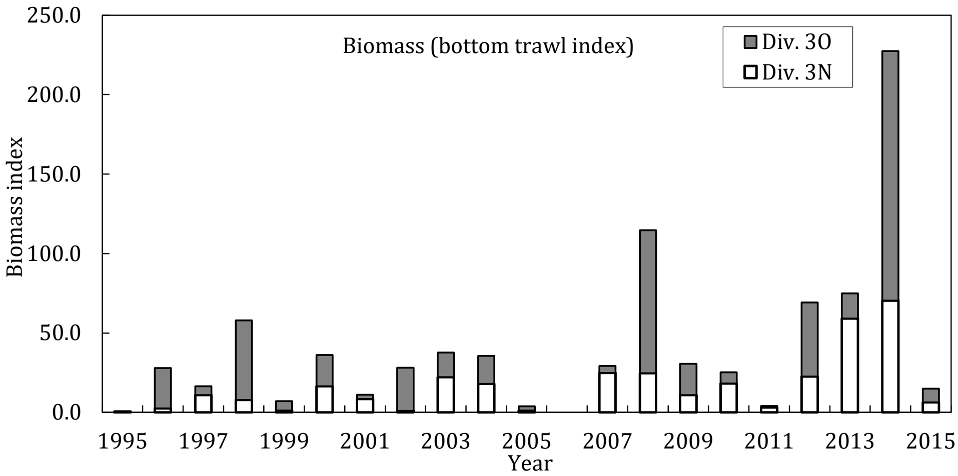


Fig. 14.2. Capelin in Div. 3NO: survey biomass index (bottom trawl) in 1995-2015.

d) Calibration Factors

In 2001, a comparative fishing trial was conducted by EU-Spain between the old research vessel C/V *Playa de Menduíña* and the new research vessel R/V *Vizconde de Eza* in order to calibrate the new ship. In 2003, the vessel that performs the EU survey in 3M changed from the R/V *Cornide de Saavedra* to R/V *Vizconde de Eza*. In 2003 and 2004, a series of 111 valid paired hauls was performed in order to convert the indices for 1988 to 2002 from the former vessel into the new vessel. Two different conversion methods were used in both surveys, one for biomass and another for lengths. The method used to convert the biomass indices was developed by Robson and calculates a Factor Power Correction by use of the catch per unit of effort (CPUE) observations for the two vessels. To convert the length distributions, a multiplicative model proposed by Warren was used.

Biomass for capelin during the 3NO survey was converted this year (SCR 16/13). Due to the lack of length sampling, the length distribution could not be converted. The results of the catch calibration shows us that the new vessel is almost 14 times more efficient catching capelin that the old vessel.

e) Estimation of Stock Condition

Since interpolation by density of bottom trawl catches to the area of strata for pelagic fish species such as capelin can lead to significant deviation of the total biomass, the average value of all non-zero catches was used as an index for evaluation of the stock biomass in 1990-2015. 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 1996-2015, the mean catch varied between 0.03 and 1.56. In 2015 this parameter was 0.13 (Fig. 14.3).

Bottom-trawling is not a satisfactory basis for a stock assessment of a pelagic species and survey results are indicative only.

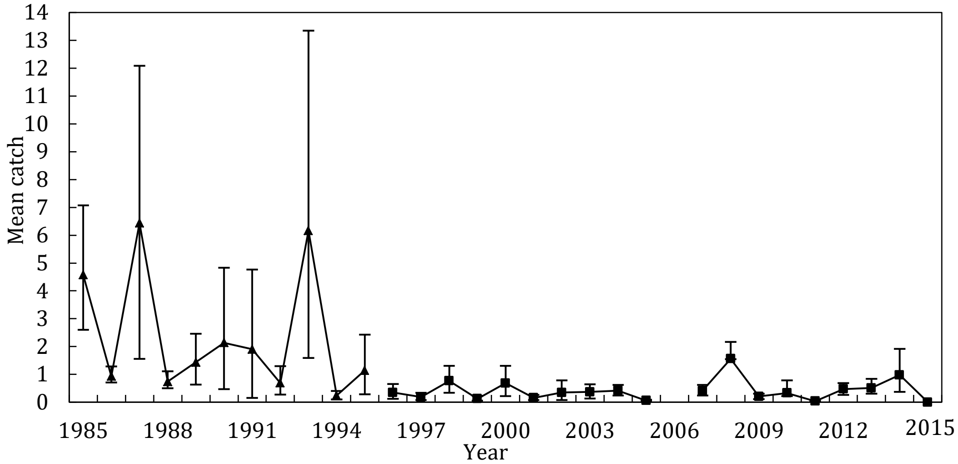


Fig. 14.3. Capelin in Div. 3N O: mean catch (t/km^2) in 1985-2015. Estimates prior to 1996 are from Engel and from 1996-2015 are from Campelen.

f) Assessment Results

An acoustic survey series that terminated in 1994 indicated a stock at a low level. Biomass indices from bottom trawl surveys since that time have not indicated any change in stock status, although the validity of such surveys for monitoring the dynamics of pelagic species is questionable.

g) Precautionary Reference Points

STACFIS is not in a position to determine biological reference points for capelin in Div. 3NO.

h) Research recommendations

STACFIS reiterates its **recommendation** *that initial investigations to evaluate the status of capelin in Div. 3NO should utilize trawl acoustic surveys to allow comparison with the historical time series.*

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

15. Redfish (*Sebastes mentella* and *Sebastes fasciatus*) in Div. 3O

(SCR Doc. 16/11,16/31; SCS Doc. 16/5, 8, 9, 10)

a) Introduction

There are two species of redfish that have been commercially fished in Div. 3O; the deep-sea redfish *(Sebastes mentella)* and the Acadian redfish *(Sebastes fasciatus*). The external characteristics are very similar, making them difficult to distinguish, and as a consequence they are reported collectively as "redfish" in the commercial fishery statistics. Most studies the Council has reviewed in the past have suggested a closer connection between Divs. 3LN and Div. 3O, for both species of redfish. A recent study (Valentin *et al.* 2015) showed that some juvenile *S. fasciatus* sampled in the Gulf of St. Lawrence had the genetic signature of adult redfish from Divs. 3LNO and southern 3Ps. These findings suggest that stock structure is not well understood for not only Div. 3O but also neighbouring redfish stocks. However, differences observed in population dynamics between Divs. 3LN and Div. 3O suggested that it would be prudent to keep Div. 3O as a separate management unit.

b) *Description of the fisheries and catches*

The redfish fishery within the Canadian portion of Div. 3O has been under TAC regulation since 1974 and a minimum size limit of 22 cm since 1995, while catch in the NRA portion of Div. 3O during that same time was regulated only by mesh size. A TAC was adopted by NAFO in September 2004. The TAC has been 20 000 tons from 2005-2015 and applies to the entire area of Div. 3O. Nominal catches have ranged between 3 000 tons and 35 000 tons since 1960 (Fig. 15.1). Catches averaged 13 000 t up to 1986 and then increased to 27 000 t in 1987 and 35 000 t in 1988. Catches declined to 13 000 t in 1989, increased gradually to about 16 000 t in 1993 and declined further to about 3 000 t in 1995, partly due to reductions in foreign allocations within the Canadian fishery zone since 1993. Catches increased to 20 000 t by 2001, subsequently declined to 4000 t in 2008 and have been in the range of 6000 to 8400 t since 2009.

The large redfish catches in 1987 and 1988 were due mainly to increased activity in the NRA by non-Contracting parties (NCPs). There has been no activity in the NRA by NCPs since 1994. From 1983-1996, estimates of under-reported catch ranged from 200 tons to 23 500 tons. There have also been estimates of over-reported catch in the recent period since 2000, with a maximum value of 4 300 t in 2003.

The redfish fishery in Div. 3O occurs primarily in the last three quarters of the year. Canadian, Portuguese, Russian and Spanish fleets have accounted for most of the catch and bottom trawling is the primary gear accounting for greater than 90% of the catch. The catch by midwater trawls is predominantly by Russia but there has been limited activity using this gear since 2004.

Nominal catches and TACs ('000 tons) for redfish in the recent period are as follows:

	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
TAC	20	20	20	20	20	20	20	20	20	20
STATLANT 21	7.5	5.1	6.3	6.5	6.0	7.0	7.8	7.5	7.9	
STACFIS	5.2	4.0	6.4	5.2	6.0	7.0	7.8	7.5	8.4	

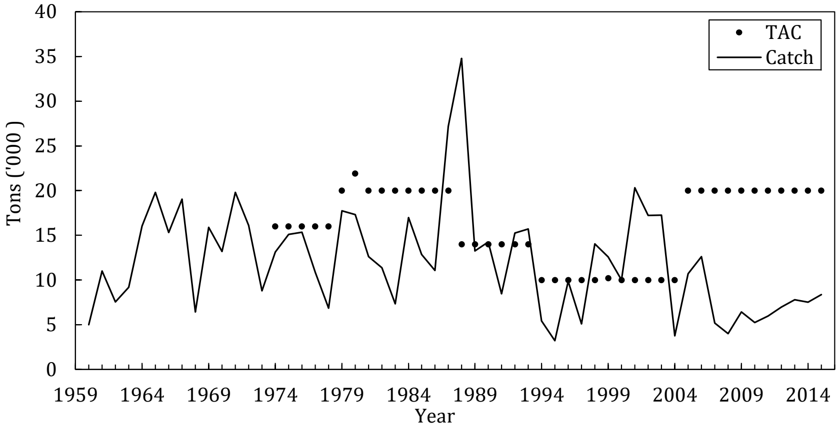


Fig. 15.1. Redfish in Div. 3O: catches and TACs (from 1974 to 2004 applied to Canadian fisheries jurisdiction; from 2005 for entire Div. 3O area).

i) Input Data

Abundance, biomass and size distribution data, as well as mean numbers and weights (kg) per tow, were available from Canadian spring and autumn surveys for 1991-2015 and EU/Spain surveys in the NRA portion from 1997-2015. Length frequencies were available from sampling of the commercial catches from Portugal, Russia, Estonia and Spain in 2015.

b) *Commercial fishery data*

Updated standardized CPUE series were not available for this stock. It is questionable whether catch rate indices are indicative of stock trends. Redfish tend to form patchy aggregations that are at times very dense and in Div. 3O there is a limited amount of fishable area in deeper waters along the steep slope of the southwest Grand Bank where larger fish tend to be located.

Sampling of the redfish trawl fisheries was conducted by Russia, Spain, and Portugal during 2013 to 2015 plus Estonia in 2015. There was no Canadian catch sampled in 2015. Fleets generally fished between 90 and 610 m. Length frequencies were similar among participating countries in 2013 with an overall size range of

7-40 cm and a modal length of 21-22 cm. Modal length was similar at 22-23 cm in 2015, although sampling by Portugal included more smaller fish than other countries.

ii) Research survey data

Abundance and biomass data, as well as mean numbers and weights (kg) per tow, were available from Canadian spring and autumn stratified-random surveys during 1991-2015. In 2006, only autumn indices were available due to inadequate survey coverage in the spring survey. There was no autumn survey in 2014. The surveys cover to depths of 732 m (400 fathoms) in spring and to 1 464 m (800 fathoms) in autumn. Until the autumn of 1995 these surveys were conducted with an Engels 145 high lift otter trawl. Thereafter a Campelen 1800 survey trawl was used. The Engel data were converted into Campelen equivalent units.

Data were available from EU-Spain spring surveys conducted in the NAFO Regulatory Area (NRA) of Div. 3O from 1995 to 2015. These surveys use the same stratification scheme as the Canadian surveys and the area of redfish habitat covered in Div. 3O is less than 8% compared to the Canadian surveys for strata <732m. Consequently the Canadian surveys are considered most representative of stock status. The EU-Spain surveys covered depths to 1500m (800 fathoms) with the exception of 1995-1996 when complete coverage was not achieved. Until 2001, these surveys were conducted using a Pedreira type bottom trawl and thereafter with a Campelen trawl similar to that used in Canadian surveys. The data prior to 2001 were converted into Campelen equivalent units.

Biomass Indices

Results of bottom trawl surveys for redfish in Div. 3O indicated a considerable amount of variability during the 1990's. This occurred between seasons and years. It is difficult to interpret year to year changes in the estimates in this period. The Canadian spring survey index (Fig. 15.2) increased steadily from the early 2000's to 2012, but has been variable at a lower level since then. The Canadian autumn surveys generally support the pattern of the spring survey index with a gradual and steady increase from 2003 to 2012 and lower values in 2013 and 2015.

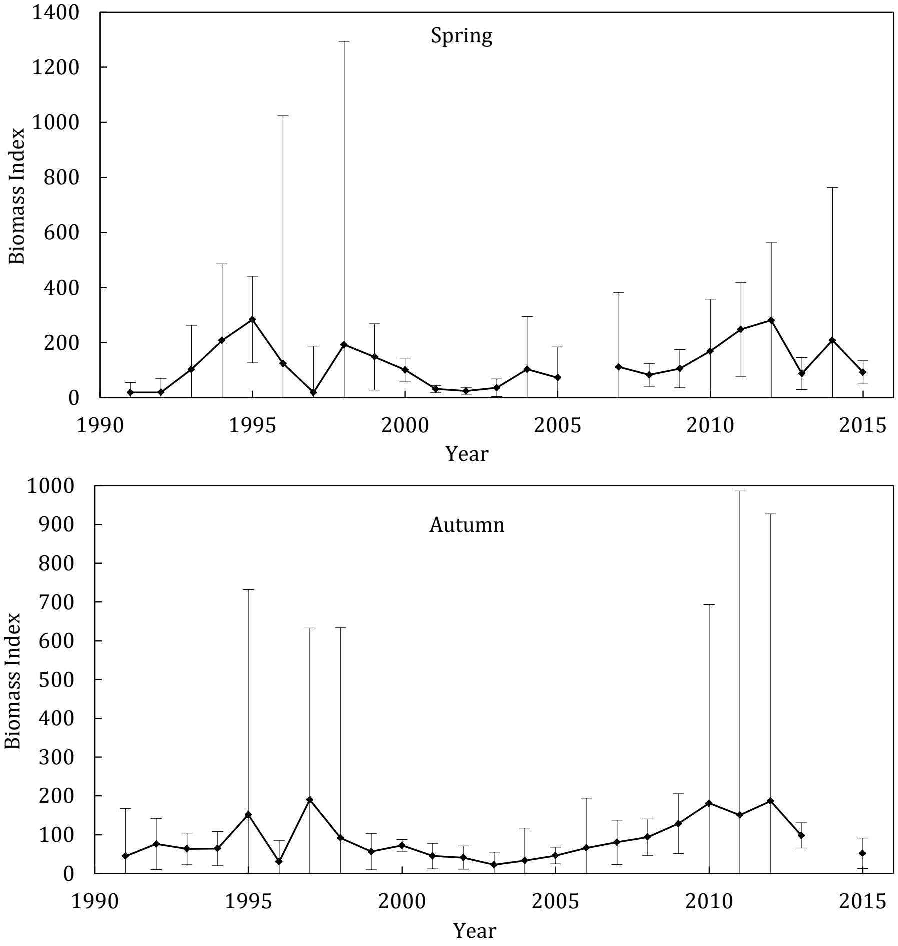


Fig. 15.2. Redfish in Div. 3O: survey biomass indices from Canadian surveys (Campelen equivalent units for surveys prior to autumn 1995) with 95% confidence intervals.

Six of the most recent seven biomass index values from the EU-Spain survey in Div. 3O were above the series mean however the index has declined from a peak in 2010 (Fig. 15.3).

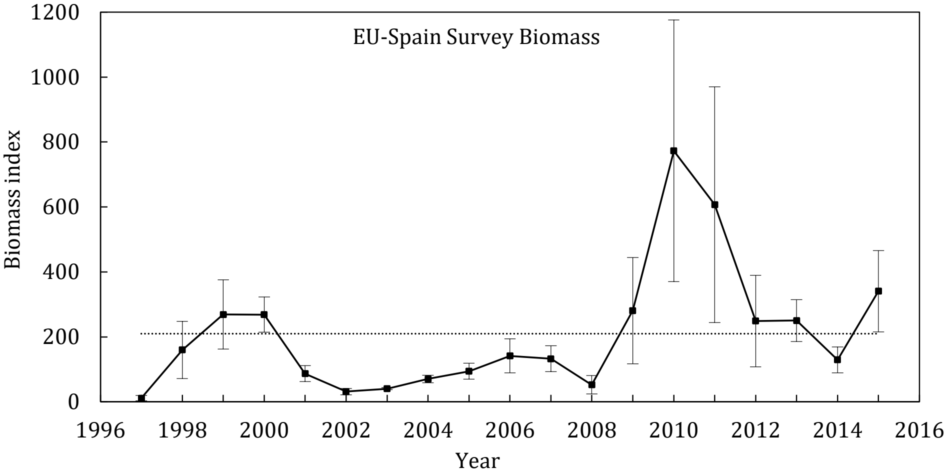


Fig. 15.3. Redfish in Div. 3O: survey biomass indices (error bars are one standard deviation) from EU-Spain spring surveys in Campelen equivalent units for surveys prior to 2002. Dashed line is the series mean.

Recruitment

The year class born in the early 2000's remains dominant in 2015 at 22-23 cm confirming initial observations of a relatively large pulse at 17cm in 2007 surveys (Fig. 15.4). This represents the best sign of recruitment in the population since the 1988 year-class and is presently of comparable abundance. Results are consistent among the Canadian spring, Canadian autumn and the EU-Spain surveys. In general, the annual persistence of modes in the range of 20cm – 25cm over the entire times series without consistent tracking at earlier sizes complicates the interpretation of population dynamics of redfish in Div. 3O.

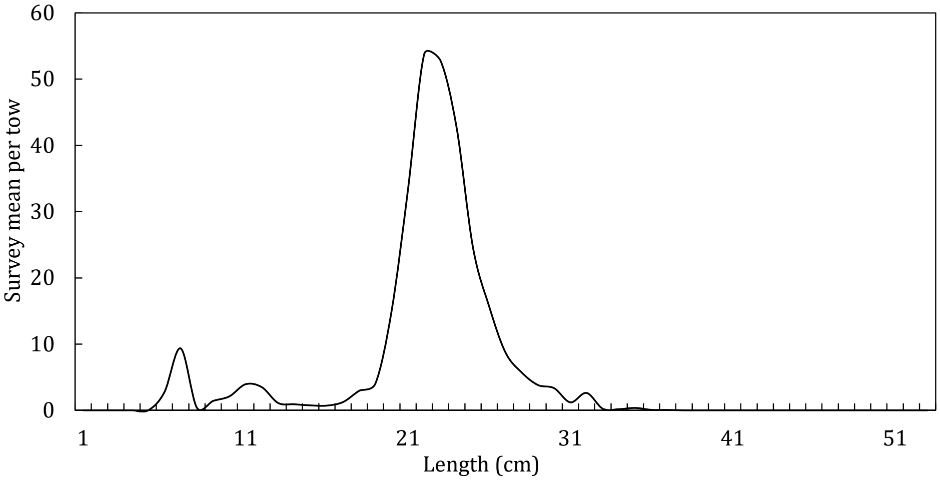


Fig. 15.4. Redfish in Div. 3O: Size distribution (stratified mean per tow) from the 2015 Canadian autumn survey.

c) Estimation of Stock Parameters

i) Non-Equilibrium Surplus Production Model (ASPIC)

During the previous assessment in 2013, the catch (1960-2012) and available survey biomass indices were utilized in a non-equilibrium surplus production model (ASPIC), but the results were not accepted by STACFIS. No production models were evaluated during this assessment.

ii) Fishing mortality

A fishing mortality proxy was derived from catch to biomass ratios. As most of the catch of the 1990s was taken in the last three quarters of the year, the catch in year "*n*" was divided by the average of the Canadian Spring (year = *n*) and Autumn (year = *n*-1) survey biomass estimates to better represent the relative biomass at the time of the year before the catch was taken. Prior to 1998 the catch was composed of fish greater than 25 cm which are not well represented in the survey catch. From 1998 to 2015, the fishery size composition more resembled the survey size composition. Accordingly, catch/biomass ratios were only calculated for the surveys from 1998-2015. The results (Fig. 15.5) suggest that relative fishing mortality increased steadily from 1998 to 2002 remained high in 2003 but declined substantially in 2004. In 2005, relative fishing mortality increased once more and was around the series average. The 2006 and 2014 estimates of fishing mortality were calculated using only the autumn and spring survey biomass respectively. The values for 2007-2015 were among the lowest in the time series.

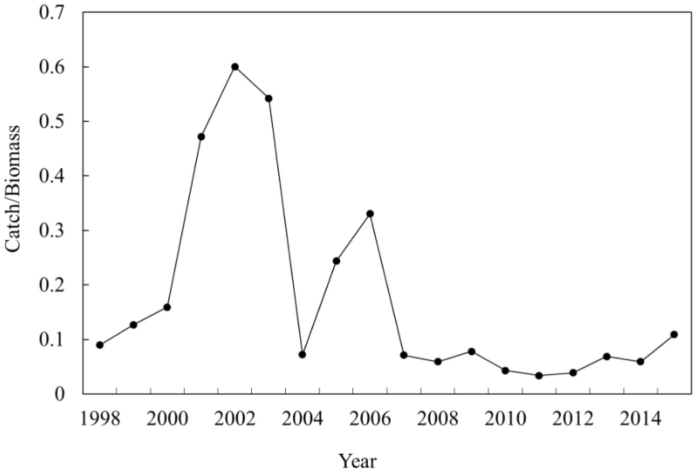


Fig. 15.5. Redfish in Div. 3O: catch/survey biomass ratios.

iii) Size at maturity

No new maturity at length data were available. However, based on previous analyses of size at maturity for this stock (L50 is about 28 cm for females and 21 cm for males) and with current catches dominated by lengths between 18cm-24 cm, it is clear that the fishery is based predominantly on immature fish.

d) Assessment Results

Biomass: Survey index values have declined from those observed in 2012 when values were near time-series highs.

Fishing Mortality: Catch/survey biomass index peaked in 2002 and has decreased since that time. Relative fishing mortality for 2010-2015 is among the lowest values in the time series.

Recruitment: The year class born in the early 2000's remains dominant in 2015 at 22-23 cm confirming initial observations of a relatively large pulse at 17cm in 2007 surveys. Subsequent recruitment appears to be lower.

State of the Stock: The stock appears to have decreased from near time-series highs in 2012. Current fishing mortality is low and recent recruitment appears low.

e) Reference Points:

There are no reference points for redfish in Div. 3O.

f) Recommendations

STACFIS **recommended** that for Redfish in Div. 3O, *a recruitment index be developed for this stock*

To investigate potential recruitment indices for Div. 3O redfish, Scientific Council was presented with an analysis of historical aging data (1984-2000) from the Canadian spring rv survey and available length frequency data from the Canadian spring (1984-2015) and autumn (1990-2015) surveys and the EU-Spain (1997-2015) survey. Of the potential options investigated, using length bins of 10-11 cm to delineate pre-recruits seemed most promising. However, failure of some pulses of young fish to track through to sizes caught in the fishery and uncertainty about recruitment from areas outside of Div. 3O prevented acceptance of a recruitment index.

STACFIS **recommended** that for Redfish in Div. 3O, work continue on developing a recruitment index with sizes close to those recruiting to the fishery.

The next full assessment will be in 2019.

References:

Valentin, A. E., D. Power and J-M Sévigny. 2015. Understanding recruitment patterns of historically strong year classes in redfish (*Sebastes* spp.): the importance of species identity, population structure and juvenile migration. Can. J. Fish. Aquat. Sci. 72: 1-11.

16. Thorny skate (*Amblyraja radiata*) in Divs. 3LNO and Subdiv. 3Ps

SCR Doc. 15/40,16/12,15,32; SCS Doc. 16/05,09,10)

a) Introduction

Thorny skate on the Grand Banks was first assessed by Canada for the stock unit 3LNOPs. Subsequent Canadian assessments also provided advice for Divs. 3LNOPs. However, Subdivision 3Ps is presently managed as a separate unit by Canada and France in their respective EEZs, and Divs. 3LNO in the NAFO Regulatory Area (NRA) is managed by NAFO. Based on this species' continuous distribution and the lack of physical barriers between Divs. 3LNO and Subdiv. 3Ps, Thorny skate in Divs. 3LNOPs is considered to constitute a single stock.

Catch History

Commercial catches of skates contain a mix of skate species. However, thorny skate dominates, comprising about 95% of skate species taken in Canadian and EU-Spain catches. Thus, the skate fishery on the Grand Banks can be considered a fishery for thorny skate. In 2005, NAFO Fisheries Commission established a Total Allowable Catch (TAC) of 13 500 t for thorny skate in the NRA of Divs. 3LNO. This TAC was lowered to 12 000 t for 2010-2011, and to 8 500 tons for 2012. The TAC was further reduced to 7 000 t for 2013-2016. In Subdiv. 3Ps, Canada established a TAC of 1 050 tons in 1997, which has not changed.

Catches from the NRA of Divs. 3LNO increased in the mid-1980s with the commencement of a directed fishery for thorny skate. The main participants in this new fishery were 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-21). From 1992-1995, catches of thorny skate declined to an average of 7 554 t; however, there are substantial uncertainties concerning reported skate catches prior to 1996. Average STACFIS-agreed catch for Divs. 3LNO in 2009-2014 was 4 933 t. STACFIS catch in 2015 totaled 3404 t (3382t landed, 22 t discarded) for Divs. 3LNO and 247 t for Subdiv. 3Ps.

Recent nominal catches and TACs (000 tons) in Divs. 3LNO and Subdiv. 3Ps are as follows:

	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Divs. 3LNO:										
TAC	13.5	13.5	13.5	12	12	8.5	7	7	7	7
STATLANT-21	6.2	7.1	5.7	5.4	5.5	4.3	4.4	4.5	3.3	
STACFIS	3.6	7.4	5.6	3.1	5.4	4.3	4.4	4.5	3.4	
Subdiv. 3Ps:										
TAC	1.05	1.05	1.05	1.05	1.05	1.05	1.05	1.05	1.05	1.05
STATLANT-21	1.8	1.4	0.6	0.3	0.5	0.4	0.3	.2	.2	
Divs. 3LNOPs:										
STATLANT-21	8.0	8.5	6.3	5.7	6.1	4.6	4.6	4.7	3.6	
STACFIS	5.4	8.8	6.2	3.4	5.9	4.6	4.6	4.7	3.7	

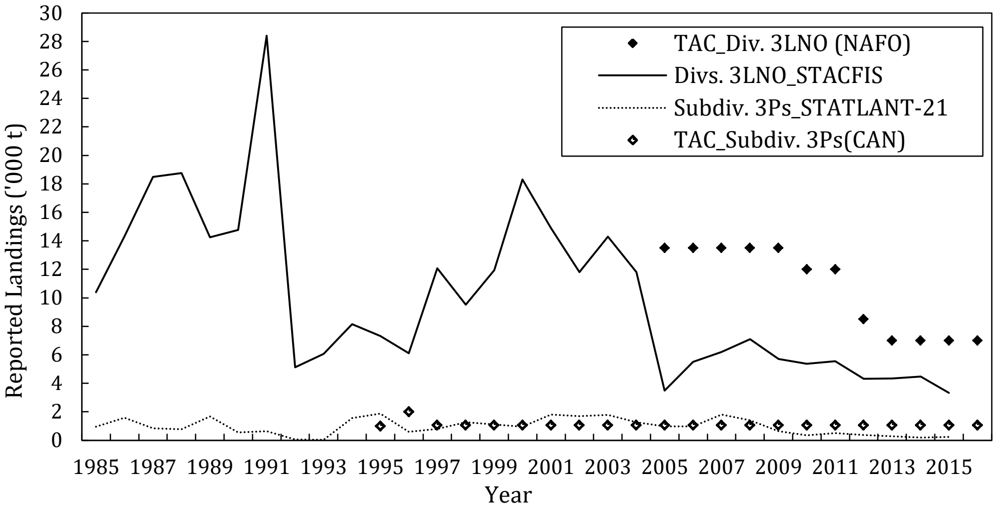


Fig. 16.1. Thorny Skate in Divs. 3LNO and Subdiv. 3Ps: reported landings and TAC: 1985-2015:

i) Data Overview

b) *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, 1997-2015), EU-Portugal (2002-2004, 2006-2011, 2013), Russia (1998-2008, 2011-2015), and Canada (1994-2008, 2010, 2012-2014).

From skate-directed trawl fisheries (280 mm mesh) in the NRA of Divs. 3LNO over 2011-2015, EU-Spain reported 15-97 cm TL skates, with a small number of young-of-the-year (<21 cm) caught in 2013-2014. In 2013 using 280 mm mesh, EU-Portugal caught 26-85 cm skates (mode: 49-50 cm).

In trawl fisheries targeting other species (130-135 mm mesh), EU-Portugal reported skate bycatch ranging from 30-84 cm TL (modes: 60, 76 cm) in 2011, and a 25-84 cm range (modes: 49, 70 cm) in 2013. Russian trawlers in the Div. 3L Greenland Halibut fishery reported 33-78 cm skates (mean=67 cm) in 2012, and 58-84 cm fish in the Div. 3L redfish fishery in 2013-2014 (2013 mean=72 cm; 2014 mean=61 cm). Skates trawled in the Div. 3L Greenland Halibut fishery in 2013 were 35-82 cm (modes: 44-45, 50, 62, 69, 72 cm). In 2014, Canadian longliners directing for Atlantic Cod in Subdiv. 3Ps caught 53-87 cm skates (mode: 72 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 1996-2015. Subdiv. 3Ps was not surveyed in 2006, nor was the deeper portion (>103 m) of Divs. 3NO in that year, due to mechanical difficulties on Canadian research vessels. The survey in 2015 missed several strata in Div. 3L. this was considered inconsequential for this species.

Indices for Divs. 3LNOPs in 1972-1982 (Yankee series) fluctuated without trend (Fig. 16.2a).

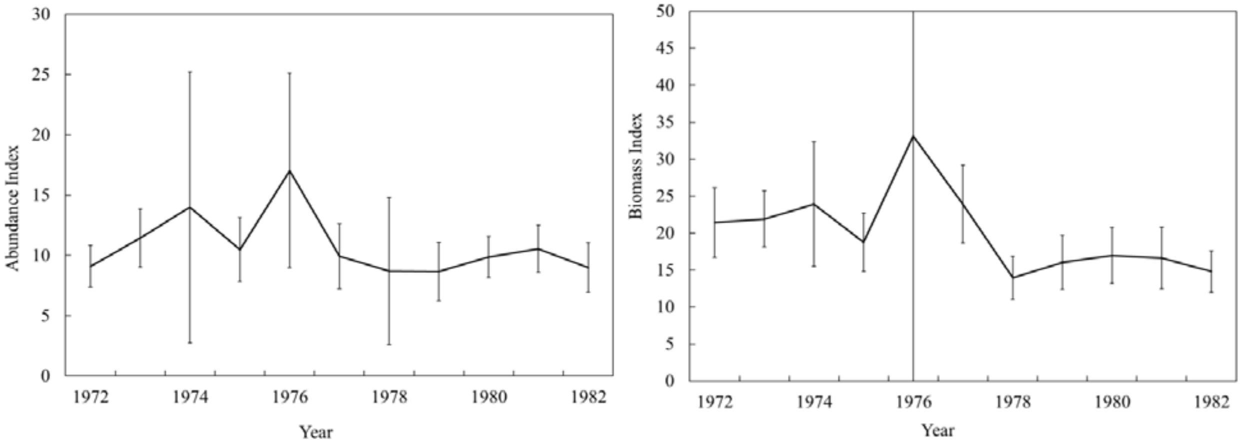


Fig. 16.2a. Thorny Skate in Divs. 3LNO and Subdiv. 3Ps: abundance (left panel) and biomass (right panel) indices from Canadian spring surveys 1972-1983.

Mean number and mean weight per tow for Divs. 3LNOPs in 1984-2015 are presented in Figure 16.2b. Catch rates of thorny skate in Divs. 3LNOPs declined from the mid1980s until the early 1990s. Since 1997, biomass indices have been increasing very slowly from low levels, while abundance indices remain relatively stable at very low levels.

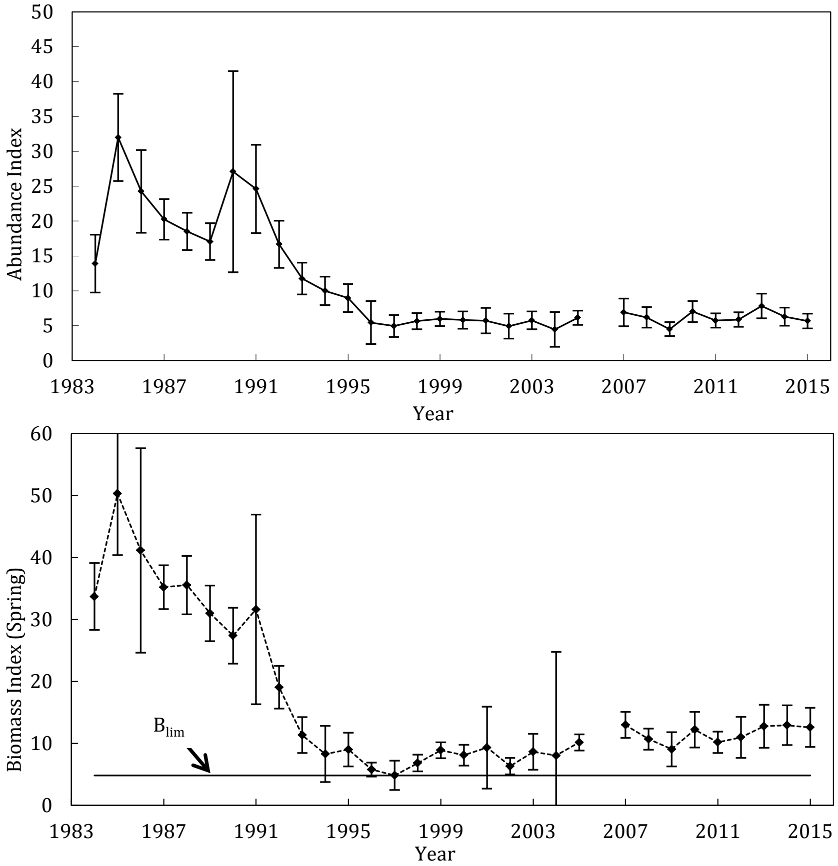


Fig. 16.2b. Thorny Skate in Divs. 3LNO and Subdiv. 3Ps: abundance (top panel) and biomass (bottom panel) indices from Canadian spring surveys: 1984-2015.

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 1995-2015, 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.

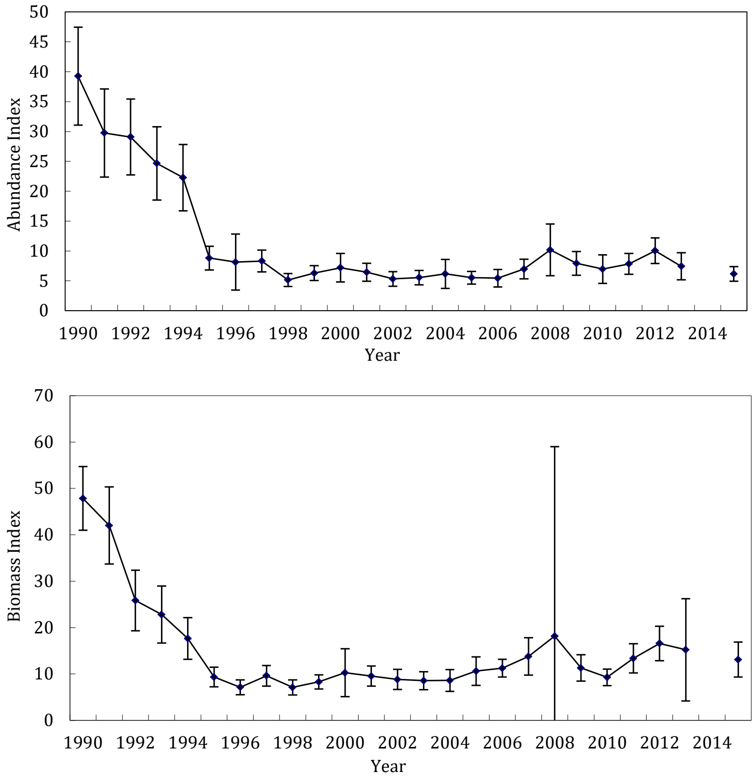


Fig. 16.3. Thorny skate in Div. 3LNOPs: abundance (top panel) and biomass (bottom panel) indices from Canadian autumn surveys: 1990-2015.

EU-Spain Divs. 3NO Survey. EU-Spain survey indices (Campelen or equivalent) are available for 1997-2015. The survey only occurs in the NAFO Regulatory Area, thus not sampling the entire Divisions. The biomass trajectory from the EU-Spain surveys was similar to that of the Canadian spring surveys until 2006 (Fig. 16.4). Since 2007, the two indices diverged with an overall increase in the Canadian survey and a decline in the EU-Spain index.

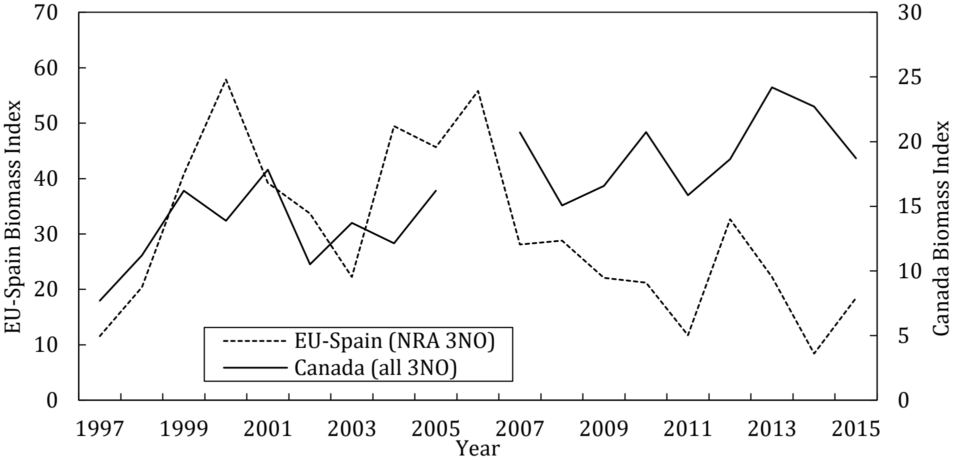


Fig. 16.4. Thorny skate in Divs. 3LNOPs: biomass indices from the EU-Spain survey and the Canadian spring survey in 1997-2015.

EU-Spain Div. 3L survey. EU-Spain survey indices (Campelen trawl) are available for 2003-2015 (excluding 2005). The survey only occurs in the NAFO Regulatory Area (Flemish Pass), thus not sampling the entire Division. Both the EU-Spain and Canadian autumn Div. 3L biomass indices generally declined from 2007-2011, while the Canadian spring index was more variable during this period (Fig. 16.5). Recent Canadian biomass estimates have been relatively stable since 2010, while the EU-Spain index has been increasing relative to 2011.

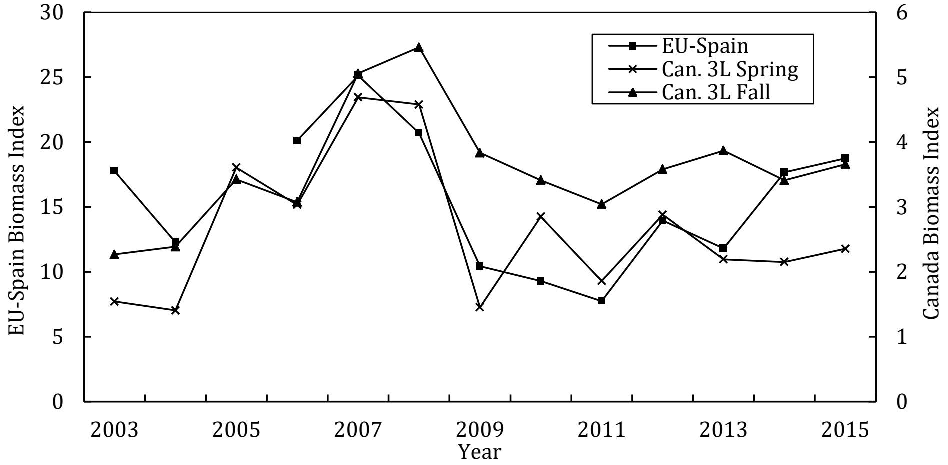


Fig. 16.5. Thorny skate in Div. 3LNOPs: Biomass indices from EU-Spain Div. 3L survey and the Canadian spring and autumn surveys of Div. 3L in 2003-2015.

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 1996-2015, 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. The index was above average during 2010-2013. Recruitment declined to below average in 2014-2015. Thorny Skates have low fecundity and long reproductive cycles, which result in low intrinsic rates of increase and impart low resilience to fishing mortality.

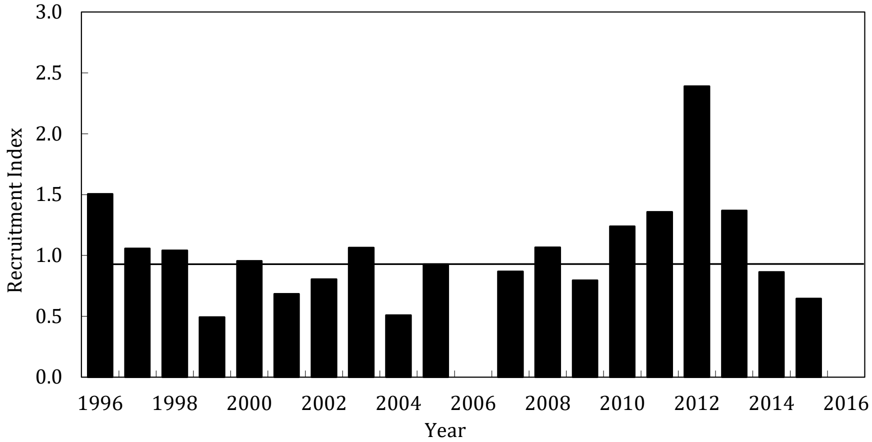


Fig. 16.6. Thorny skate in Divs. 3LNOPs: Standardized recruitment index for sub 21cm males and females (combined) from Canadian Campelen spring surveys in Divs. 3LNOPs.

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.

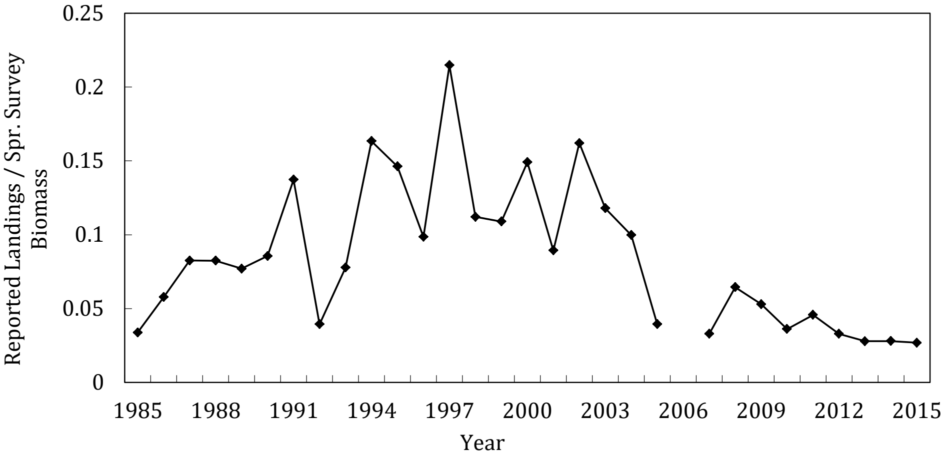


Fig. 16.7. Thorny skate in Divs. 3LNOPs:: estimates of Relative F from STACFIS-agreed commercial landings/Canadian spring survey biomass.

d) Assessment Results

Assessment Results: No analytical assessment was performed.

The Canadian Spring survey is considered as 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 in 1997-2007. Recruitment was above average during 2010-2013, but declined to below average in 2014-2015.

State of the Stock: The stock is currently above $B_{lim.}$ The probability that the current biomass is above B_{lim} is .99. Stock biomass has been increasing very slowly from low levels since the mid-1990s. Recruitment declined below average in 2014-2015. 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 the Campelen survey gear, were accepted in 2015 as a proxy for B_{lim} (Fig. 16.8).

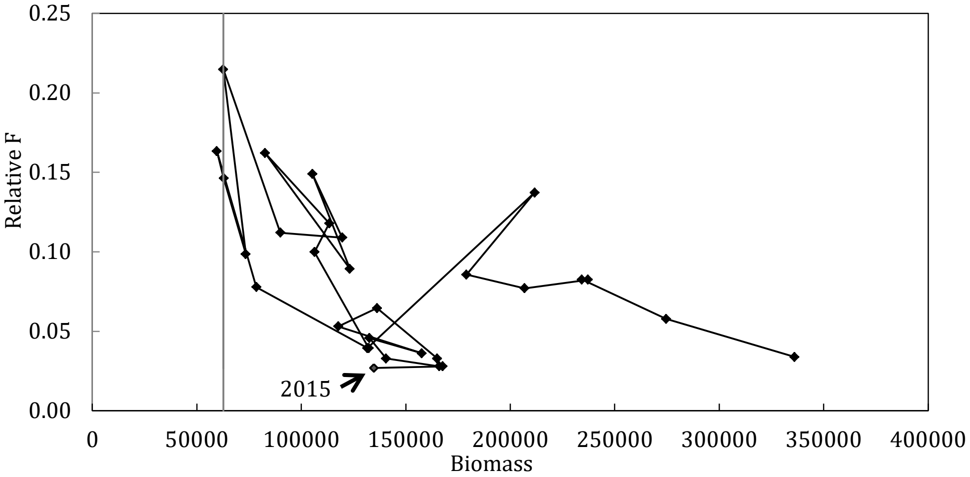


Fig. 16.8. Thorny skate in Divs. 3LNOPs: stock trajectory under a precautionary approach framework.

f) Research Recommendations

STACFIS **recommended** that *further work be conducted on development of a quantitative stock model*.

STATUS: Work has been done but no progress to report. 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: Work has been done but no progress to report. STACFIS reiterated this recommendation, with the addition of comparisons to also include Subdiv. 3Pn.

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

17. White Hake (*Urophycis tenuis*) in Divs. 3NO and Subdiv. 3Ps

Interim Monitoring Report (SCR Doc. 16/012,015,020, 028; SCS Doc. 16/005,009,010)

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.

Canada commenced a directed fishery for white hake in 1988 in Div. 3NO and Subdiv. 3Ps. All Canadian landings prior to 1988 were as bycatch in various groundfish fisheries. EU-Spain and EU-Portugal commenced a directed fishery in 2002, and Russia in 2003, in the NAFO Regulatory Area (NRA) of Div. 3NO; resulting in the 2003-2004 peak. 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 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 2013-2016.

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 200-mile limit 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 declined to 233 t and 314 t in 2013 and 2014 respectively in Div. 3NO. Catch in 2015 was reported as 464t (397 t landed, 67 t discarded).

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 declined to 191 t in 2013, and increased to 383 t in 2014. Catch in 2015 was reported as 335 t.

Recent reported landings and TACs (000 tons) in NAFO Div. 3NO and Subdiv. 3Ps are as follows:

	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Div. 3NO:										
TAC	8.5	8.5	8.5	6	6	5	1[1]	1[1]	1[1]	1
STATLANT 21	0.7	0.9	0.5	0.3	0.2	0.1	0.2	0.3	.4	
STACFIS	0.6	0.9	0.4	0.2	0.2	0.1	0.2	0.3	.5	
Subdiv. 3Ps:										
STATLANT 21	1.3	0.7	0.4	0.4	0.2	0.2	0.2	0.4	.3	

[1] May change in season. See NAFO FC Doc. 13/01 quota table.

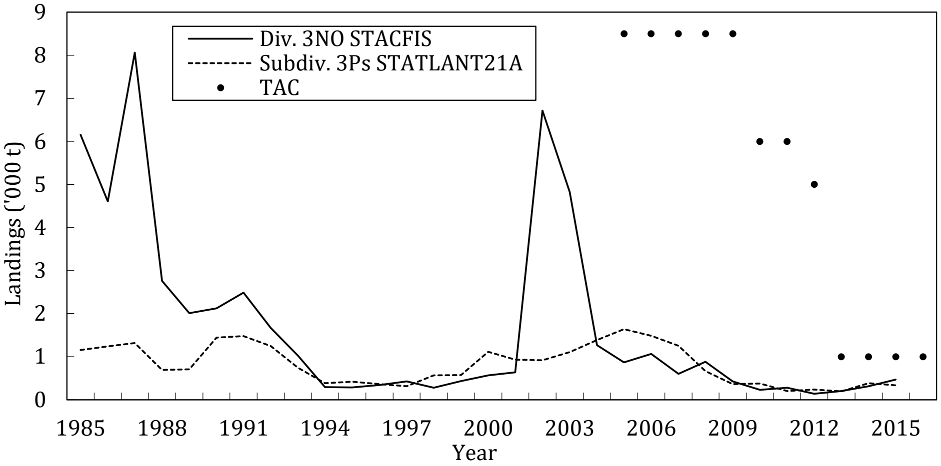


Fig. 17.1. White hake in Division 3NO and Subdivision 3Ps: Total catch of White Hake in NAFO Division 3NO (STACFIS) and Subdivision 3Ps (STATLANT-21A). The Total Allowable Catch (TAC) in the NRA of Divs. 3NO is also indicated on the graph.

i) Data Overview

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 2015. 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 2015. 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 1995-2015. 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 2012-2015. 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.

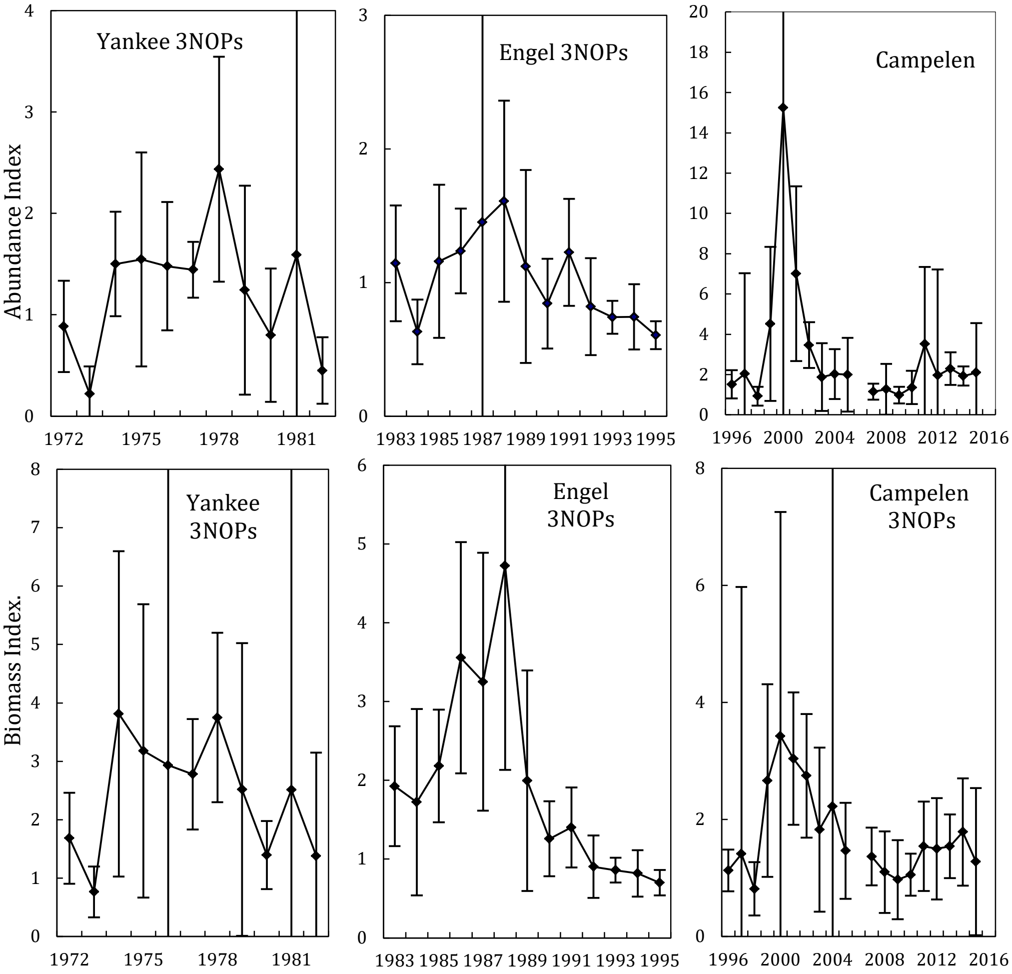


Fig. 17.2a. White hake in Div. 3NO and Subdiv. 3Ps: abundance (top panels) and biomass (bottom panels) indices from Canadian winter-spring research surveys, 1972-2015. Estimates from 2006 are not shown, since survey coverage in that year was incomplete. Yankee, Engel, and Campelen time series are not standardized, and are presented on separate panels. Error bars are 95% confidence limits. The bounds of the error bars in 976, 1981, 1987 and 2000 in some panels extend above/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.

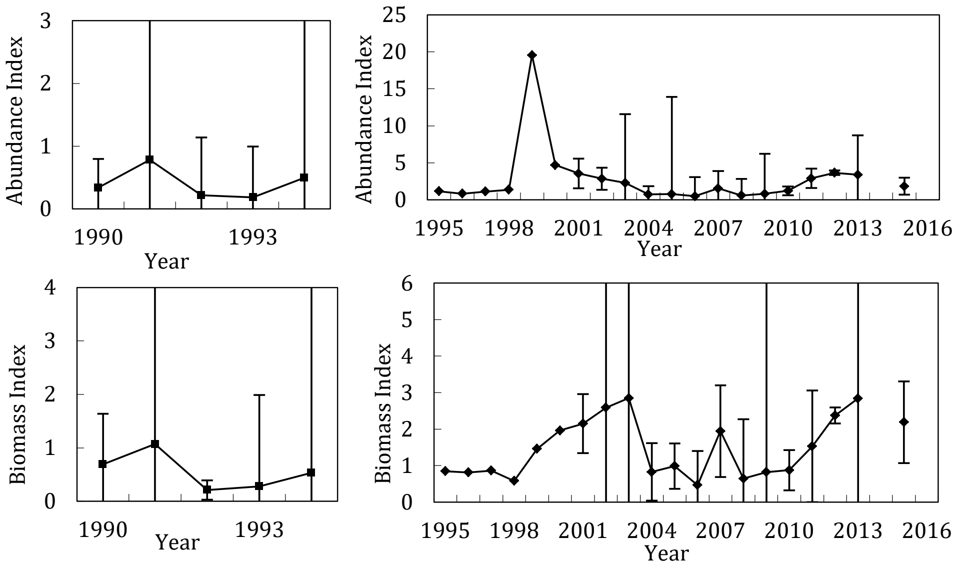


Fig. 17.2b White hake in Div. 3NO: abundance (top panel) and biomass indices (bottom panel) from Canadian fall surveys, 1990-2015. Engel (□, 1990-1994) and Campelen (♦, 1995-2013) time series are not standardized. Estimates from 2014 are not shown, since survey coverage in that year was incomplete. Error bars are 95% confidence limits. The bounds of the error bars in 1991, 1994, 2002, 2003, 2009 and 2013 in some panels extend above/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 2015 (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.

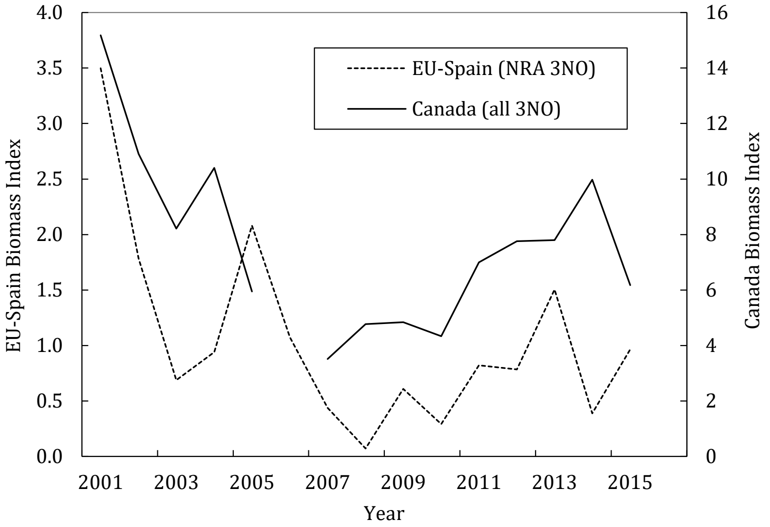


Fig. 17.3. White hake in the NRA of Div. 3NO: Biomass indices from EU-Spain Campelen spring surveys in 2001-2015 compared to Canadian spring survey indices in all of Div. 3NO. Estimates from 2006 Canadian survey are not shown, since survey coverage in that year was incomplete.

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 2001-2015 (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.

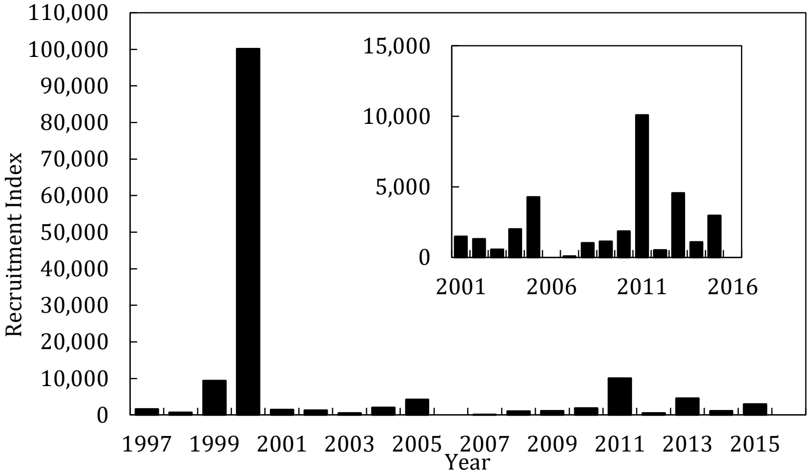


Fig. 17.4. White Hake in Div. 3NO and Subdiv. 3Ps: recruitment index for Age 1 males and females(combined) from Canadian Campelen spring surveys in Divs. 3NO and Subdiv. 3Ps n 1997-2015. Estimates from 2006 are not shown, since survey coverage in that year was incomplete. Inset plot depicts 2001-2015 on a smaller scale.

g) Conclusion

Based on current information there is no significant change in the status of this stock. Stock biomass remains at relatively low levels, and no large recruitments have been observed since 2000.

h) 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 full assessment of this stock is planned for 2017.

D. WIDELY DISTRIBUTED STOCKS: SA 2, SA 3 AND SA 4

Recent Conditions in Ocean Climate and Lower Trophic Levels

●Ocean climate composite index across Labrador to the Scotian Shelf (SA2-4) has remained well above normal since 2010 but has declined sequentially to near normal in 2015.

●The composite spring bloom index has alternated frequently between positive and negative levels throughout the time series and reached the highest level in 2015.

●The composite zooplankton reached its highest level in 2014 and continues to remain positive in 2015.

●The composite trophic index reached its highest level observed in the time series in 2015.

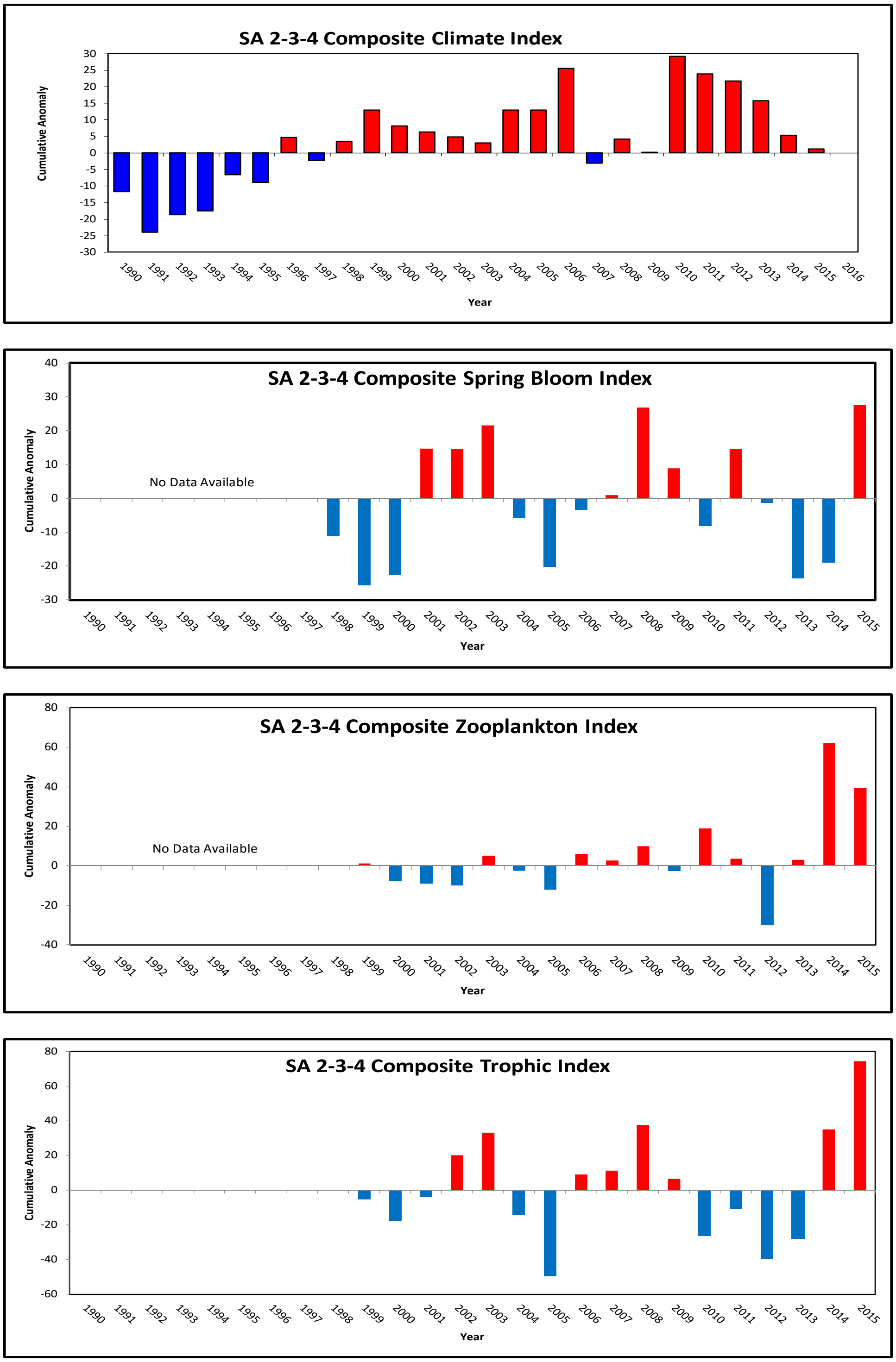


Figure III 4. Composite ocean climate index for NAFO Subarea 2-3-4 (widely distributed stocks) derived by summing the standardized anomalies (top panel) during 1990-2015, composite spring bloom (cumulative anomalies for magnitude and timing metrics of the spring bloom) index during 1998-2015, and composite trophic (summed nutrient and standing stocks of phyto- and zooplankton indices) index (bottom panel) during 1999-2015. Red bars are positive anomalies indicating above average levels while blue bars are negative anomalies indicating below average values.

Environmental Overview

The water mass characteristics of Newfoundland and Labrador Shelf are typical of sub-polar waters with a sub-surface temperature range of -1-2ºC and salinities of 32-33.5. Labrador Slope Water flows southward along the shelf edge and into the Flemish Pass region, this water mass is generally warmer and saltier than the sub-polar shelf waters with a temperature range of 3°-4°C and salinities in the range of 34-34.75. On average bottom temperatures remain <0°C over most of the northern Grand Banks but increase to 1-4°C in southern regions and along the slopes of the banks below 200 m. North of the Grand Bank, in Div. 3K, bottom temperatures are generally warmer (1-3°C) except for the shallow inshore regions where they are mainly <0°C. In the deeper waters of the Flemish Pass and across the Flemish Cap bottom temperatures generally range from 3-4°C. Throughout most of the year the cold, relatively fresh water overlying the shelf is separated from the warmer higher-density water of the continental slope region by a strong temperature and density front. This winter-formed water mass is generally referred to as the Cold Intermediate Layer (CIL) and is considered a robust index of ocean climate conditions. In general, shelf water masses undergo seasonal modification in their properties due to the seasonal cycles of air-sea heat flux, wind-forced mixing and ice formation and melt, leading to intense vertical and horizontal gradients particularly along the frontal boundaries separating the shelf and slope water masses. Temperature and salinity conditions in the Scotian Shelf, Bay of Fundy and Gulf of Maine regions are determined by many processes: heat transfer between the ocean and atmosphere, inflow from the Gulf of St. Lawrence supplemented by flow from the Newfoundland Shelf, exchange with offshore slope waters, local mixing, freshwater runoff, direct precipitation and melting of sea-ice. The Nova Scotia Current is the dominant inflow, originating in the Gulf of St. Lawrence and entering the region through Cabot Strait. The Current, whose path is strongly affected by topography, has a general southwestward drift over the Scotian Shelf and continues into the Gulf of Maine where it contributes to the counter-clockwise mean circulation. The properties of shelf waters are modified by mixing with offshore waters from the continental slope. These offshore waters are generally of two types, Warm Slope Water, with temperatures in the range of 8-13°C and salinities from 34.7-35.6, and Labrador Slope Water, with temperatures from 3.5°C to 8°C and salinities from 34.3 to 35. Shelf water properties have large seasonal cycles, east-west and inshore-offshore gradients, and vary with depth.

Ocean Climate and Ecosystem Indicators

The composite climate index across the widely distributed stocks in Subareas 2 to 4 has remained above normal in 2013 and in recent years peaking in 2010 (Figure III.4). The composite spring bloom index has declined in 2013-2014 compared to positive anomalies observed back to 2006 (Figure III.4). The composite zooplankton index has returned to a record-high in 2014 due to remarkable positive anomalies for invertebrate taxa observed in the Gulf of St. Lawrence (Figure III.4). The composite trophic index also peaked in 2014 due to the substantial increase observed in the Gulf (Figure III.4).

Sea surface temperature (SST) in the Labrador Sea indicated above normal conditions showing an anomaly ranging from 1 to 6°C in the winter and about 0.5°C in the summer. The Labrador Shelf ice concentration was below normal in January and March of 2013 (reference period: 1979-2000), while in February 2013, the ice concentration was higher than normal for the northwestern part of Labrador Shelf. Winter time convection in 2013 reached to 1000 m, which is significantly shallower than the 1400 m seen in the previous year, although still deeper than in the years of reduced convective activity (e.g., 2007 and 2011). The 1000-1500 m layer of the central Labrador Sea has been gradually warming since 2012. Under the warming trend, the winter ice extent has also decreased on the Labrador shelf. The increasing decadal trend of the total inorganic carbon and decreasing trend of pH continue into 2013. For the year of 2013 as a whole, chlorophyll a estimated from remote sensing imagery showed the three regions together being close to normal, with the Labrador shelf just above normal, the central basin slightly below and the Greenland shelf almost even. In 2013 *Calanus finmarchicus* abundances were similar to those seen in other years when sampling was in spring.

Above normal conditions prevailed in NAFO area 4 in 2013. The climate index, a composite of 18 selected, normalized time series, averaged +0.9 standard deviations (SD) making 2013 the eight warmest year in the last 45 years. The anomalies did not show a strong spatial variation. Bottom temperatures were above normal with anomalies for NAFO areas 4Vn, 4Vs, 4W, 4X of +0.2°C (+0.5 SD), +0.8°C (+1.1 SD), +0.6°C (+0.8 SD), and +1.0°C (+1.5 SD) respectively. Compared to 2012, bottom temperatures decreased in areas 4Vn, 4Vs, 4W and 4X by 0.3, 0.5, 1.2 and 1.1°C.

18. Roughhead Grenadier (*Macrourus berglax*) in SAs 2 and 3

(SCR Doc. 16/12, 16, 22, 24, 26 and 28; SCS Doc. 16/05, 06, 08, 09 and 10)

a) Introduction

The stock structure of this species in the North Atlantic remains unclear because there is little information on the number of different populations that may exist and their relationship. Roughhead grenadier is distributed throughout NAFO Subareas 0 to 3 in depths between 300 and 2 000 m. However, for assessment purposes, NAFO Scientific Council considers the population of Subareas 2 and 3 as a single stock.

b) *Description of the fisheries and catches*

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

A substantial part of the grenadier catches in Subarea 3 previously reported as roundnose grenadier has been roughhead grenadier. To correct the catch statistics STACFIS revised and approved roughhead grenadier catch statistics since 1987. Catches of roughhead grenadier increased sharply from 1989 (333 tons) to 1992 (6725 tons); since then until 1997 total catches have been about 4000 t. In 1998 and 1999 catches increased and were near the level of 7000 tons. Since then, catches decreased to 3000–4000 tons in the period 2001–2004 and to 1000 tons in 2007. In the period 2007-2012, annual catches have been around 1000 tonnes and in the last three years about or less than 500 tonnes (Fig. 18.1) Most of the catches were taken in Div. 3LMN by Spain, Portugal and Russia fleets. In the catch series available, less than 2% of the yearly catch has been taken in Subarea 2.

Recent catches ('000 tons) are as follow:

	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
STATLANT 21	0.6	0.5	0.4	0.7	0.8	1	1.3	0.4	0.6	0.2
STACFIS	1.4	0.7	0.8	0.6	0.9	1	1.3	0.4	0.6	0.2

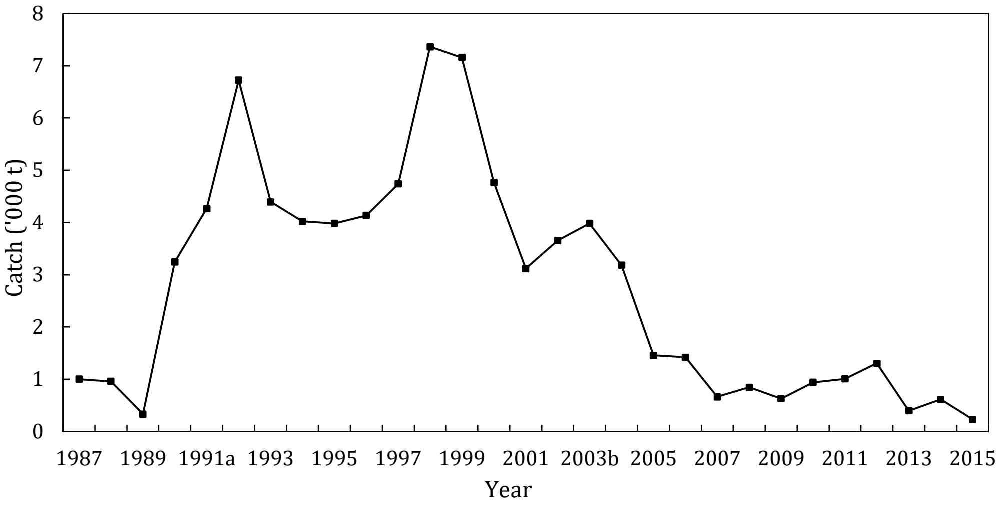


Fig. 18.1. Roughhead grenadier in Subareas 2+3: total catches.

i) Input Data

b) *Commercial fishery data*

Length frequencies from the Spanish, Russian and Portuguese trawl catches in Divs 3LMNO are available since 1992, 1992 and 1996 respectively. Due to the growth differences between sexes, length and age data have been analyzed by sex. The Spanish and Portuguese lengths frequencies were presented as pre anal fin length (AFL), while the Russian ones as total lengths. The roughhead length compositions from the Russian catches have been converted to AFL. Catch-at-age data from the total catches in Divs. 3LMNO were obtained since 1992 applying an annual Spanish commercial ALK. Since 2006 it can be observed a decreased in the mode of the catch at age, in the last three years the mode was around 6 cm AFL.

ii) Research survey data

Biomass indices for the roughhead grenadier Subareas 2 and 3 stock are available from various research surveys, with different depth and area coverage. None of them cover the total area and depth distribution of this stock.

Canadian autumn surveys. The estimates from 1995 onwards are not directly comparable with the previous time series because of the change in the survey gear. Taking into account the incomplete coverage of some strata in divisions 2GH and 3LMNO only the index of divisions 2J and 3K from both series (Engel and Campelen) are considered. The Engel series (1978-1994) present a clear decreasing trend since 1978 till 1994. The Campelen series shows an opposite trend, the index increase from 1995 till 2014 with a slight decline in 2015 (Figure 18.2).

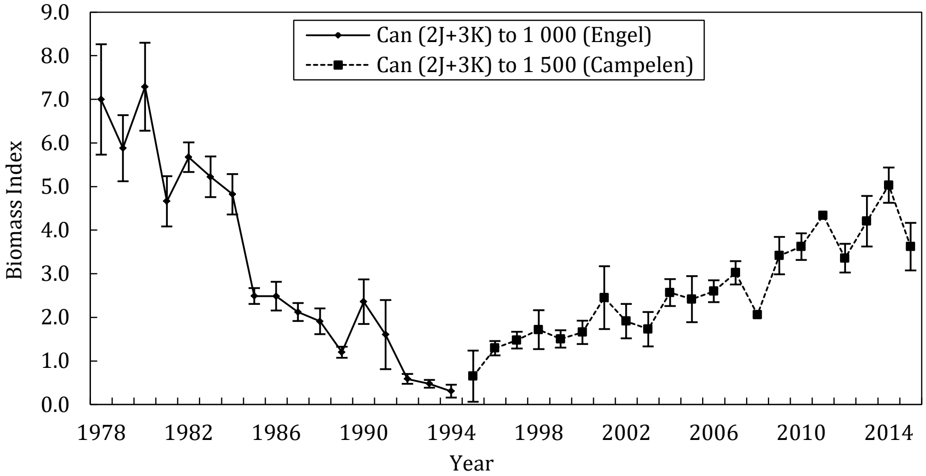


Fig. 18.2. Roughhead grenadier in Subareas 2+3: biomass indices ($^{+}/_{-}$ SE) from the Canadian autumn (Div. 2J3K) survey.

Canadian spring surveys. Figure 18.3 shows the biomass estimate from this survey from 1996 until 2014. Operational difficulties in 2006 and 2015 resulted in incomplete coverage of the survey and the estimates for these years are not directly comparable. From 1996 to 2004, the biomass level does not present a clear trend. In 2005 and 2007, the biomass index had a big increase. After 2007 it is more or less stable at similar level than the period 1996-2004. Biomass estimates from the spring survey series are considerably lower than the ones obtained in the autumn series, as the spring surveys cover only the southern divisions and the shallower depths, where according to the Canadian deep-water survey information this species is less abundant.

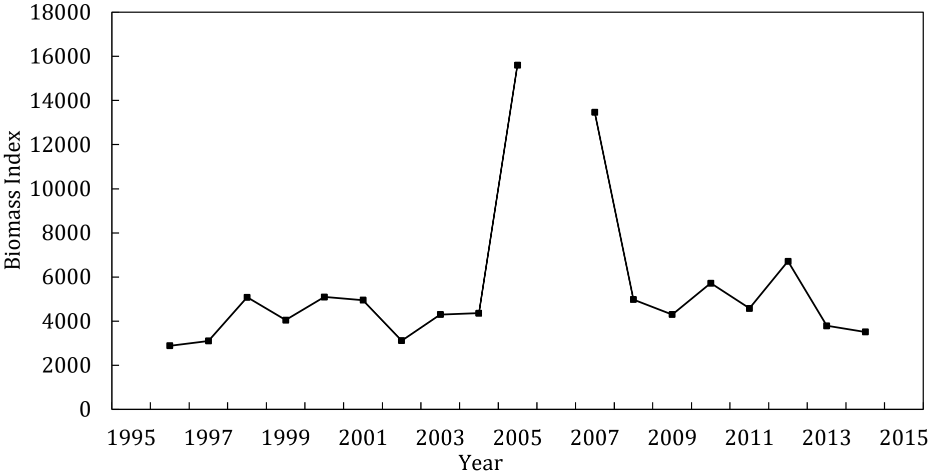


Fig. 18.3 Roughhead grenadier in Subareas 2+3: biomass indices from the Canadian spring surveys.

Canadian deep-water survey: Canada conducted deep-water bottom trawl surveys (750 – 1500 m.) in 1991, 1994 and in 1995 in Divisions 3 KLMN. Most part of the biomass was taken in Div. 3L and 3M at depth more than 700 m, which confirms that the stock in those Divisions is distributed beyond the depths covered by the spring surveys in those Divisions.

EU (Spain and Portugal) Flemish Cap survey. Indices of biomass are presented for the full depth range over 2004 to 2015 and 0-730 m from 1991-2015 (Fig 18.4). The roughhead grenadier age composition from this survey series was presented. The 730 m. biomass index presents a peak in 1993. From then until 2002, the biomass index was more or less stable. From 2002 onwards, the biomass index shows an increasing trend, reaching a historical maximum in 2006. Since 2007 the indices have been variable with a general decreased trend, reaching their historical minimum in 2014. The index covering deeper water shows a clear decreasing trend since the beginning of the series with its minimum in 2015.

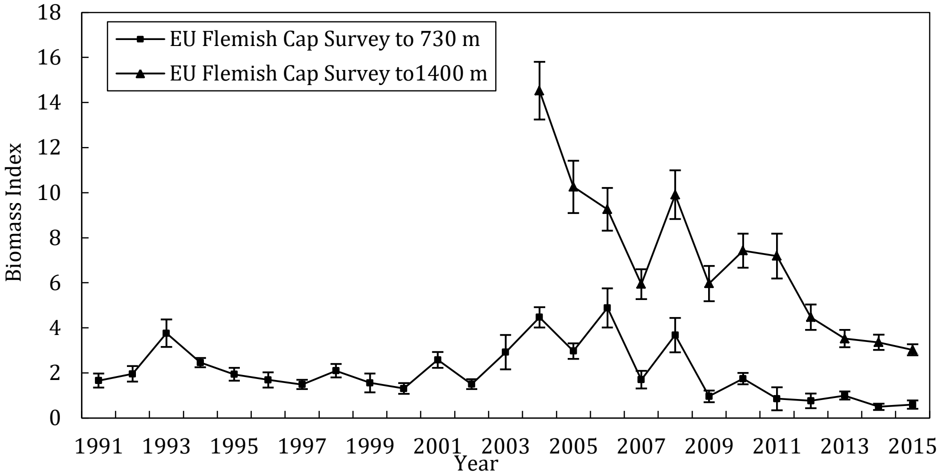


Fig. 18.4. Roughhead grenadier in Subareas 2+3: biomass indices (+/- SE) from the EU Flemish Cap (Div. 3M) survey.

EU (Spain) Div. 3NO survey. From 1997 to 2002 the biomass index of this survey did not show a clear trend. However, since then it has increased and in the period 2004-2006 reached the maximum level. In 2007 decreased to the 2003 level and since then till 2012 was more or less stable. In the last three years show a decreasing trend (Figure 18.5).

EU-Spanish 3L Survey (Flemish pass). The Roughhead grenadier biomass index from 2006 to 2008 was stable and since then presents a clear decreasing trend, reaching the time series minimum in 2012. In the period 2012-2015 the index has increased to levels similar to its maximum (Figure 18.5).

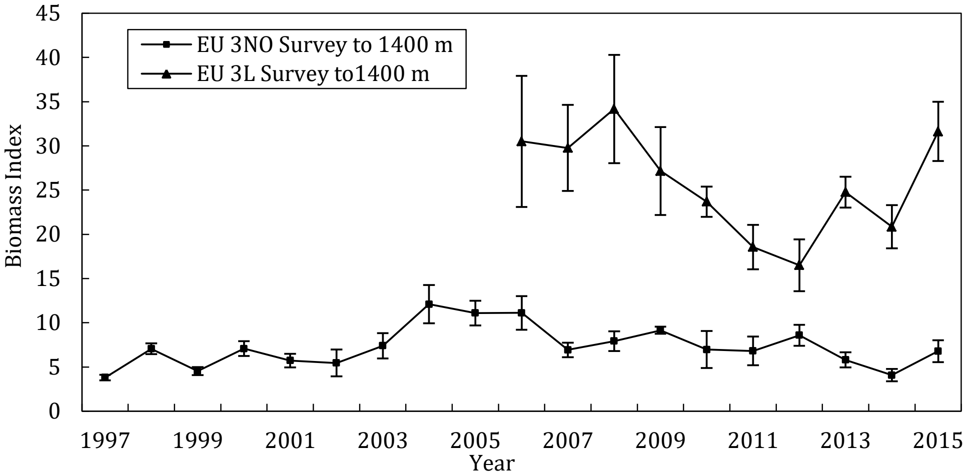


Fig. 18.5. Roughhead grenadier in Subareas 2+3: biomass indices ($^{+}/_{-}$ SE) from the EU-Spanish Div. 3NO and 3L surveys.

Summary of research surveys data trends. There are not available surveys indices covering the total distribution, in depth and area, of this stock. According to other information this species is predominant at depths ranging from 800 to 1500 m, therefore the best survey indicators of stock biomass should be the series extending 1500 meters depth as they cover the depth distribution of Roughhead grenadier fairly well. Figure 18.6 presents the biomass indices for the following series: Canadian fall 2J+3K Engel (1978-1994) and Campelen (1995-2015), EU 3NO (1997-2015), EU 3L (2006-2015) and EU Flemish Cap till 1400 m (2004-2015). An increase is shown since 1995 until 2004-2008 for all available indices. In the period 2008-2012 all the indices show a decreasing trend, except the Canadian fall 2J+3K index. In the most recent period (2013-2015) the information of the different indices is contradictory, the Canadian 2J3K and the EU 3L show an increase while EU-FC and EU 3NO continue to decline.

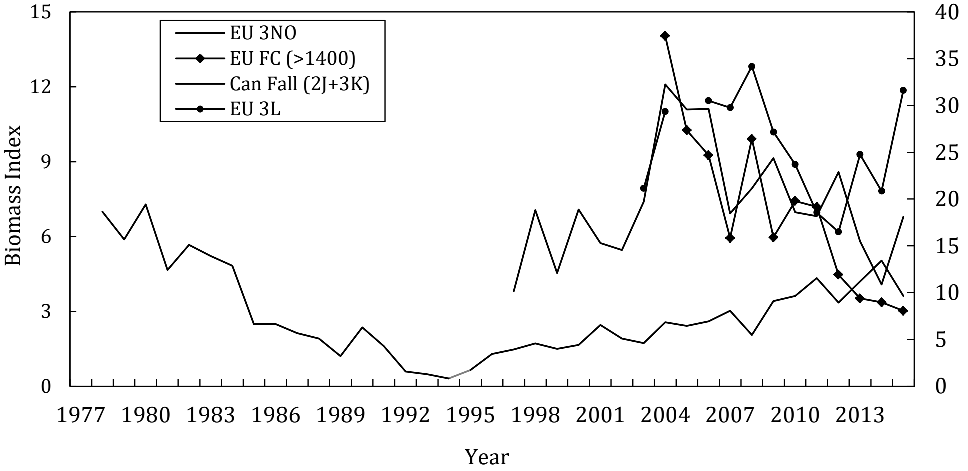


Fig. 18.6. Roughhead grenadier in Subareas 2+3: Biomass indices for the Canadian fall 2J+3K Engel (1978-1994) and Campelen (1995-2015), EU 3NO (1997-2015), EU 3L (2006-2015) and EU Flemish Cap till 1400 m (2004-2015).

iii) Recruitment.

Figure 18.7 presents the abundance index series for age 3 for different surveys indices. In the age 3 Figure, it can be observed at least three good cohorts: 1993, 2001 and 2012 year classes. Normally the EU signals are observed one year later. This could be due to the survey season, at the end of the year in the Canadian autumn survey and in the middle of the year for EU surveys. Since 2004 the level of the recruitment was more or less constant in all series at low level, with the exception of an increase since 2012 in the Canadian fall (2J+3K) and the EU Div. 3NO survey. To confirm the strength of the last good year classes it would need to have more information about them.

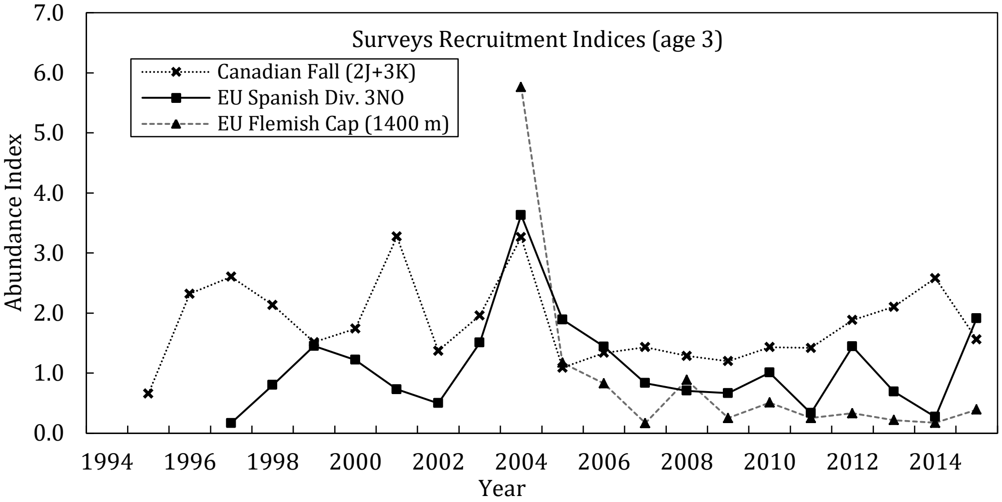


Fig. 18.7. Roughhead grenadier in Subareas 2+3: Canadian fall (2J+3K), the EU Div. 3NO and the EU Flemish Cap till 1400 m surveys abundance at ages 3.

iv) Biological studies

Age and length structure information for commercial catches and surveys indices were provided. Age and length compositions of the catches show clear differences between sexes. The proportion of males in the catches decreased progressively as length or age increases.

A study about the NAFO 3LMN roughhead grenadier reproductive biology including the evaluation of maturity ogive estimates was presented. Spawning capable females are homogeneously distributed nearly year-round, but in scarce numbers what prevent to define a spawning season. This fact, associated with the high levels of atresia, could indicate a reproductive migration. It was observed a clear decrease in length at first maturity (L50) of females from 27.8 cm in the period 2005-2011 to 25.6 cm in the last four years. The age at first maturity, A50, varied between 13.1 and 15 years, and there is not an evident trend of change over the years. Special attention has been paid to atresia because of its potential impact on stock productivity. These results will be used in future assessments.

c) Assessment Results

Three different assessments were presented: Extended Survivors Analysis (XSA), a Stock-Production Model Incorporating Covariates (ASPIC) and a qualitative assessment based on survey and fishery information. The fit of the data to the XSA and ASPIC has been very poor mainly due to lack of contrast and conflicting information from the available data. Therefore the results are not considered representative of the status of the stock. Biomass indices from the surveys with depth coverage to 1400 meters are considered as the best survey information to monitor trends in resource status because they cover the depth distribution of roughhead grenadier fairly well.

Biomass: Surveys biomass indices present a general increasing trend in the period 1995-2004. In the period 2005-2012 all available indices show a clear downward trend except the Canadian Fall (2J+3K) index. In the most recent period (2013-2015) the information of the different indices is contradictory, the Canadian 2J3K and the EU 3L show an increase while EU-FC and EU 3NO continue to decline.

Fishing Mortality: The catch / biomass (C/B) ratios obtained using different biomass indices show a clear decreasing trend from 1998 to 2006 and since then is more or less stable at very low level. (Fig. 18.8).

Recruitment: Despite the difficulty in following cohorts strength, the recruitment indices analysed show at least three good cohorts: 1993, 2001 and 2012 year classes. Normally the EU signals are observed one year later. To confirm the strength of the last good year class (2012) it would need to have more information about it.

State of the Stock: In the most recent period (2013-2015) the information of the different indices is contradictory, the Canadian 2J3K and the EU 3L show an increase while EU-FC and EU 3NO continue to decline. Fishing mortality indices have remained at low levels since 2005. The recruitment indices show at least three good cohorts: 1993, 2001 and 2012 year classes.

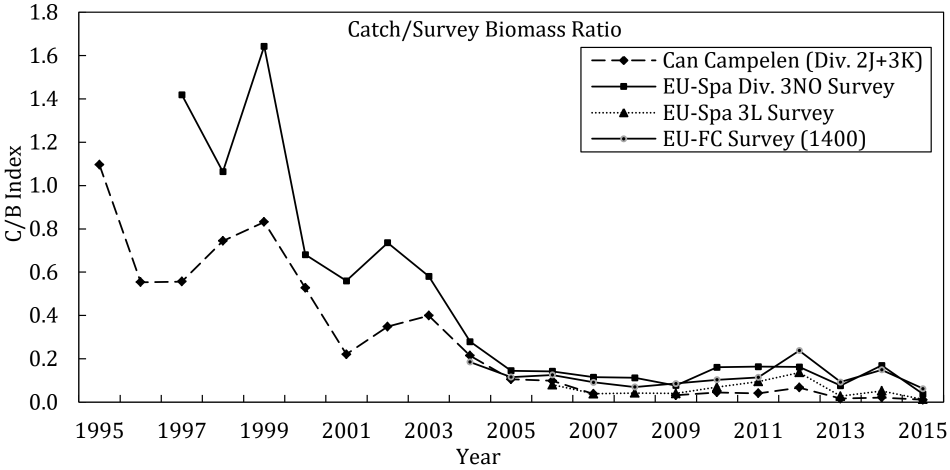


Fig. 18.8. Roughhead grenadier in Subareas 2+3: catch/biomass survey indices based upon Canadian Autumn (Campelen series), EU-Spanish Div. 3NO, EU-Spanish 3L and EU-Flemish Cap till 1400 m.

d) Reference Points

STACFIS is not in a position to provide reference points at this time.

Next full assessment will be in 2019.

19. Witch Flounder (*Glyptocephalus cynoglossus*) in Divs. 2J+3KL

(SCR Doc. 16/ 15, 16/20; SCS Doc. 16/5, 8, 9, 10)

a) Introduction

The fishery for witch flounder began in the 1960s and has been regulated by TAC since 1974 (first introduced by ICNAF). 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 2005-2015, catches averaged less than 200 tons.

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

	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Recommended TAC	ndf	ndf	ndf	ndf	ndf	ndf	ndf	ndf	ndf	ndf
STATLANT 21	0.1	0.1	0.1	0.2	0.2	0.2	0.2	0.2	0.2	
STACFIS	0.1	0.1	0.1	0.2	0.2	0.2	0.2	0.2	0.2	

ndf= no directed fishing.

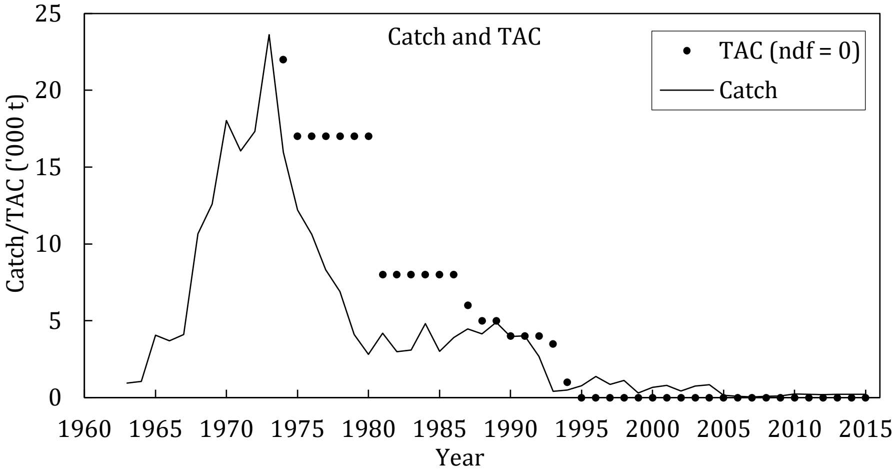


Fig. 19.1. Witch flounder in **Divs. 2J+3KL**: catches and TAC.

i) Input Data

Abundance and biomass data, as well as mean numbers and weights (kg) per tow from Canadian autumn surveys during 1977-2015 were available. Age based data have not been available since 1993 and none are anticipated in the near future.

b) *Research survey data*

Canadian stratified–random autumn surveys. Canadian surveys were conducted in Div. 2J+3KL during autumn from 1977-2015 (Fig 19.2). Generally, the survey biomass estimates showed an increasing trend from 2003 to 2015, and remains below B_{lim} although estimates are imprecise. During the recent period (2013 to 2015), increases in biomass index values were due to increases in both Divs. 2J and 3K (Fig 19.2). Survey coverage in Div. 3L began in 1984, but was incomplete in 2004 and 2005, and in 2008 there were substantial survey coverage deficiencies in Div. 2J, 3K and 3L (SCR Doc. 09/012). Results in these years may, therefore, not be comparable to other years.

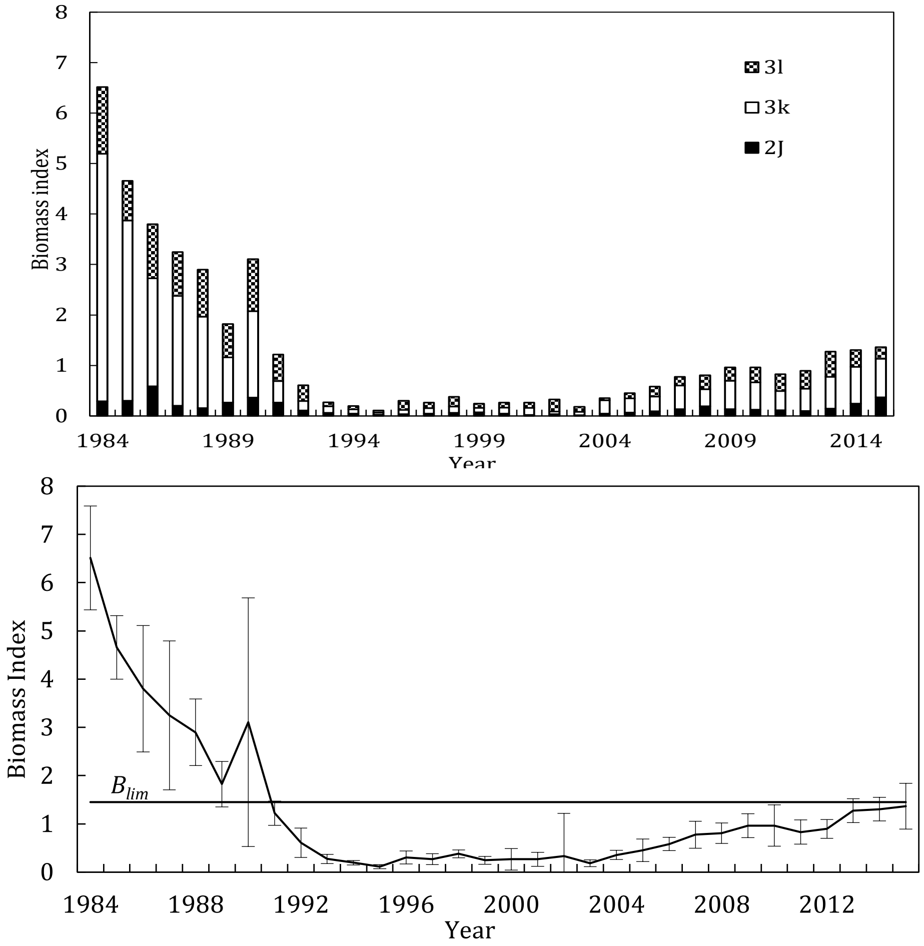


Fig. 19.2. Witch flounder in **Divs. 2J+3KL**: Index of biomass from Canadian autumn surveys by Division (top panel) and overall (bottom panel with 95 % confidence limits). Values are Campelen units or, prior to 1995, Campelen equivalent units.

Stock Distribution. Survey distribution data from the late 1970s and early 1980s indicated that witch flounder were widely distributed throughout the shelf area in deeper channels around the fishing banks primarily in Div. 3K. By the mid-1980s, however, they were rapidly disappearing and by the early 1990s had virtually disappeared from the area entirely except for some very small catches along the slope and more to the southern area. They now appear to be located along the deep continental slope area, both inside and outside the Canadian 200-mile fishery zone and in some deeper channels offshore (Fig. 19.3).

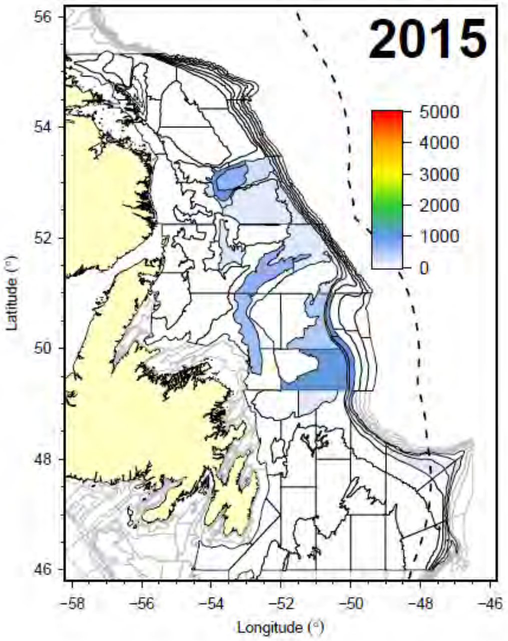


Fig. 19.3. Witch flounder in **Divs. 2J+3KL**: spatial distribution of biomass index from the Canadian survey during autumn 2015.

c) Assessment Results

No analytical assessment was possible.

Biomass: Survey biomass index showed a rapid downward trend since the mid-1980s and since 1995 has remained at an extremely low level. However, a slightly increasing trend in the total stock survey biomass index was observed from 2003 to 2015 with $P(B_{2015} < B_{lim}) = 0.66$.

Recruitment: Population numbers of juvenile witch flounder (<23 cm) from Canadian autumn surveys from 1996-2015 are given in Fig. 19.4. Five of the most recent seven surveys have been above the long term average.

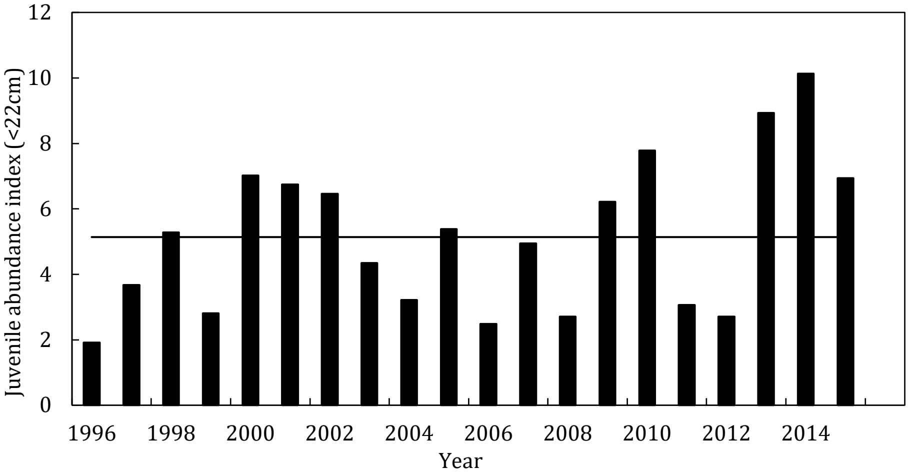


Fig. 19.4. Witch flounder in **Divs. 2J+3KL:** Index of juvenile (<23 cm) abundance from Canadian autumn surveys 1996-2015. Horizontal line is the time series average.

Fishing mortality: A proxy for fishing mortality, the ratio of catch to Canadian autumn survey biomass index, is given in Figure 19.5. Fishing mortality has been very low since 2005.

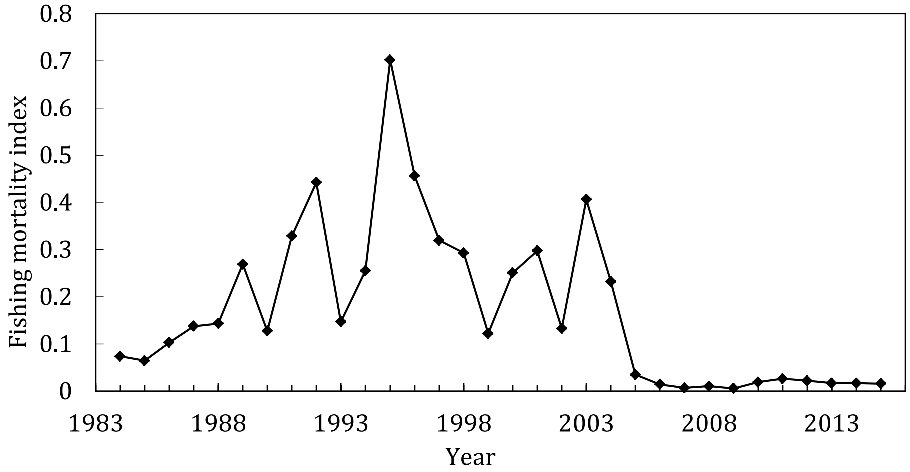


Fig. 19.5. Witch flounder in Divs. 2J+3KL: Fishing mortality index.

d) State of the stock

There was a general increase in the survey biomass index from 2003 to 2015, nevertheless, the overall stock remains below *B_{lim}* (P($B_{2015} < B_{lim}$) = 0.66). In five of the most recent seven surveys, the recruitment (juvenile abundance index) has been above the long term average. Current fishing mortality is very low.

e) Reference Points

A proxy for B_{lim} for this stock was previously calculated as 15% of the highest observed survey biomass index adjusted for less extensive depth coverage in the early part of the survey time series (B_{lim} = 1.45). The biomass index has been below this reference point (Fig. 19.2, 19.6) since 1991, and in 2015 was 94% of B_{lim} with P($B_{2015} < B_{lim}$) = 0.66.

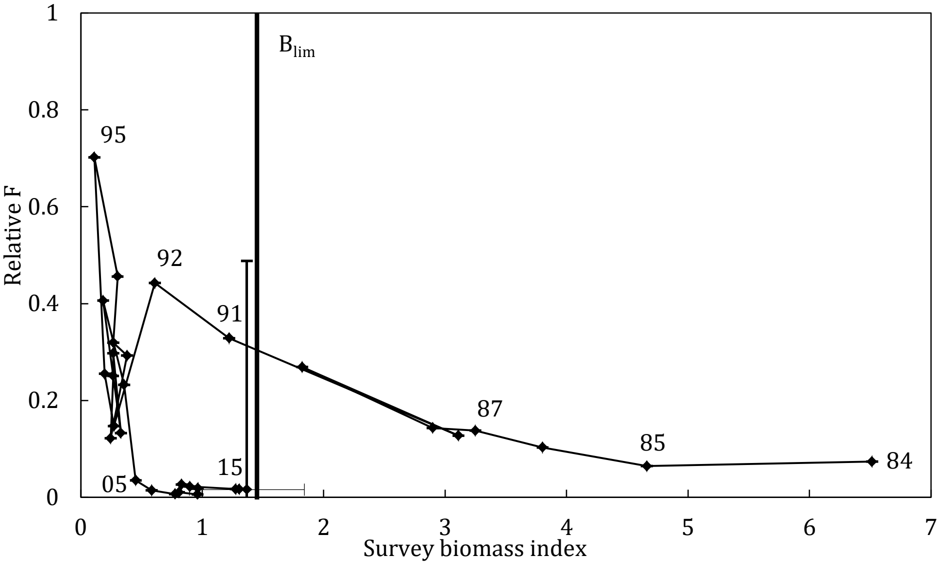


Fig 19.6. Witch flounder in Divs. 2J+3KL: Stock trajectory (1984-2015) within the NAFO PA framework.

f) Research Recommendations:

STACFIS **recommends** that *for 2+3KL witch flounder an evaluation be conducted of the influence of deep water strata (>732 m) in Div. 3L on the stock biomass index.*

The next full assessment of this stock is scheduled for 2019.

20. Greenland Halibut (*Reinhardtius hippoglossoides*) in SA 2 + Divs. 3KLMNO

(SCR Doc. 16/09, 10, 15, 20, 24, 38, 39, 12/19; SCS Doc. 16/05, 06, 08, 09, 10, 12; FC Doc. 03/13, 10/12, 13/23)

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 since 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). STACFIS could not estimate total catches for 2011-2015. See general review of catches and fishing activity for an explanation on the planned way forward for catch estimation from 2011-2015. .

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

	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
TAC	16	16	16	16	17.2[1]	16.3[1]	15.5[1]	15.4[1]	15.6[1]	14.8[1]
STATLANT 21	15.3	15.0	14.7	15.7	15.7	15.2	15.6	15.6	14.9	
STACFIS	22.7	21.2	23.2	26.2	na	na	na	na	na	

na – not available

[1] – TAC generated from HCR

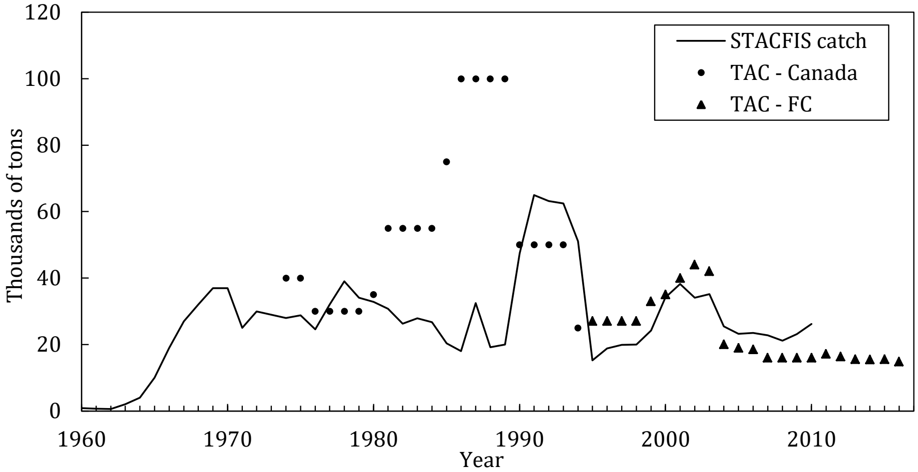


Fig. 20.1. Greenland halibut in Subarea 2 + Div. 3KLMNO: TACs and STACFIS catches.

i) 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 (1978-2015), EU in Div. 3M (1988-2015), EU-Spain in Div. 3NO (1995-2015) and EU-Spain in Div. 3L (2003-2015). Different years are examined to represent population trends from the different surveys. For the Canadian fall survey in Divs. 2J3K the years are 1978-2015 (excluding 2008); from the Canadian spring survey in Divs. 3LNO 1996-2014 (excluding 2006); for the survey in Div. 3M to 700 m 1988-2015, and to 1400 m 2004-2015; for the survey by EU-Spain in Div. 3L 2006-2005; and for the survey by EU-Spain in Divs. 3NO 1997-2015. Commercial catch-at-age data were available from 1975-2010 but were not compiled for 2011-2015 because STACFIS could not estimate total catch.

b) *Commercial fishery data*

Catch and effort.

Analyses of otter trawl catch rates from Canadian vessels operating inside of the Canadian 200 mile limit indicated a general decline from the mid-1980s to the mid-1990s. The 2010 – 2012 estimates of standardized CPUE for Canadian otter-trawlers decreased substantially. It increased since 2012 but remains below the very high 2007-2008 levels.

Analyses of catch-rates of Portuguese otter trawlers fishing in the NRA of Div. 3LMNO over 1988-2015 show that the CPUE has been variable but at a high level since 2006.

Analyses of data from the Spanish fishery show that the CPUE has been variable at a high level since 2006.

In general, for the Russian fishery, the catch rate per fishing vessel day in the area ranged from 1.9 t to 23.9 t and averaged 14.7 t per fishing vessel day and 0.88 t per hour of hauling.

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 2007-2015 than in the period of the 1990s to the mid 2000s.

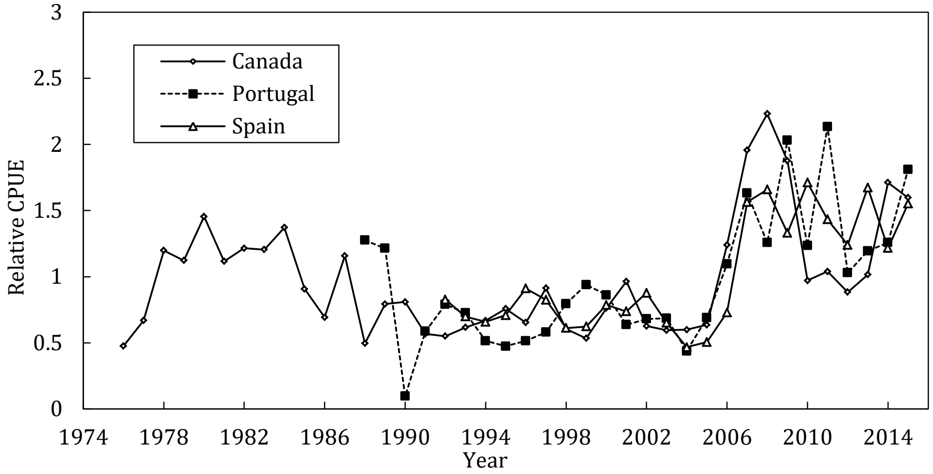


Fig. 20.2 Greenland halibut in Subarea 2 + Div. 3KLMNO: standardized CPUE from Canadian, Portuguese and Spanish trawlers. (Each standardized CPUE series is scaled to its 1992-2015 average)

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 2015 fishery were provided by EU-Spain, EU-Portugal, EU-Estonia, and Russia. Aging information was available for the Spanish fishery, but was incomplete for 2011-2015 from the Canadian fisheries. STACFIS could not estimate total catch for 2011-2015, therefore the catch-at-age was not calculated.

ii) Research survey data

STACFIS reiterated that most research vessel survey series providing information on the abundance of Greenland halibut are deficient in various ways and to varying degrees. Variation in divisional and depth coverage creates problems in comparing results of different years (SCR Doc. 12/19). A single survey series which covers the entire stock area is not available. A subset of standardized (depth and area) stratified random survey indices have been used to monitor trends in resource status, and are described below.

Canadian stratified-random autumn surveys in Div. 2J and 3K. The Canadian autumn Div. 2J3K survey index provides the longest time-series of abundance and biomass indices (Fig. 20.3) for this resource. Biomass declined from relatively high estimates of the early 1980s to reach an all-time low in 1992. The index increased substantially due to the abundant 1993-1995 year-classes, but this increase was not sustained, with declines over 1999-2002. The index has increased substantially from 2010-2014 to levels near those of the early part of the time series. However, the index declined substantially in 2015. 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 2015 indices are considerably lower. The number of age 1-4 is below the series average in 2012-2015.

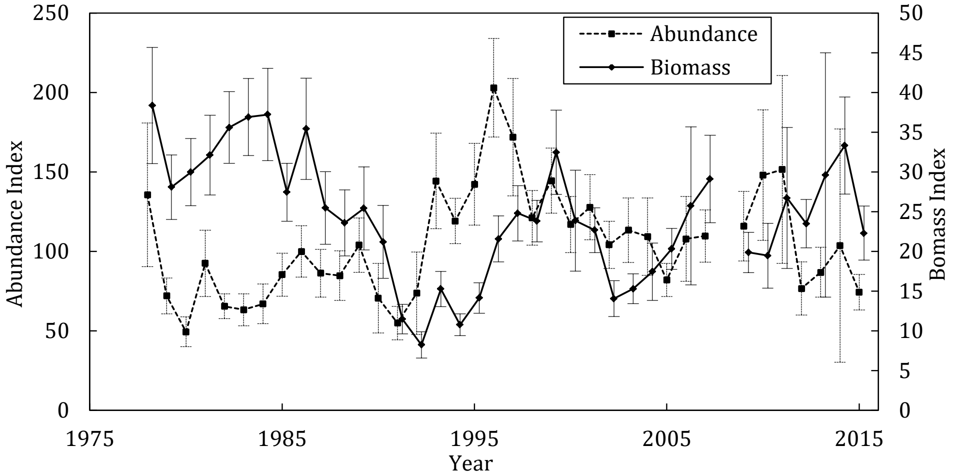


Fig. 20.3. Greenland halibut in Subarea 2 + Div. 3KLMNO: biomass and abundance indices (with 95% CI) from Canadian autumn surveys in Div. 2J and 3K. The 2008 survey was not completed.

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 and 2014, both abundance and biomass were below the time-series average. The abundance of recruits (ages 1-4) in 2013 and 2014 is below the time series average. The 2015 survey was incomplete and is not considered representative of the population.

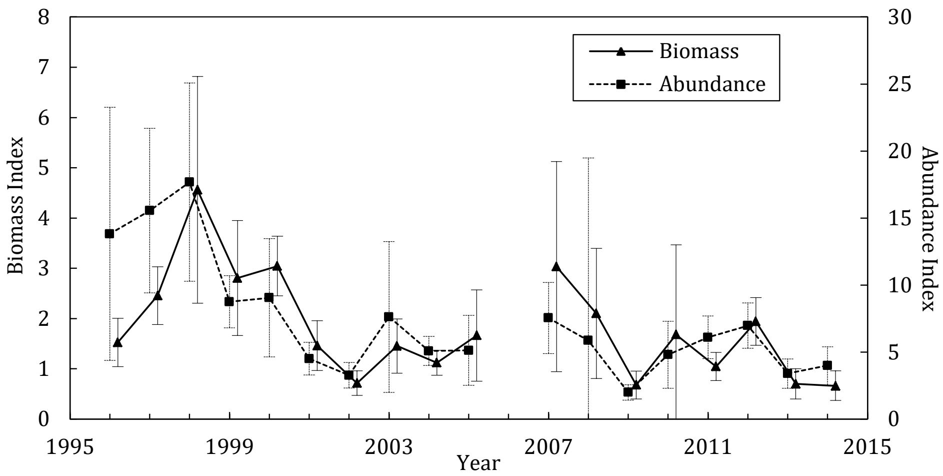


Fig. 20.4. Greenland halibut in Subarea 2 + Div. 3KLMNO: biomass and abundance indices (with 95% CI) from Canadian spring surveys in Div. 3LNO.

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. The index increased in 2014 and 2015 but 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 declined thereafter. The 2012 and 2013 estimates are below the time-series average, while the 2014 estimate increased to around the series average. There was a large increase in the biomass index from 2014 to 2015and this should be regarded with caution. From 2007-2015, recruitment indices (ages 1-4) from this survey (both over the shallower 0-730 m portion and the total 0-1460 m) are below average.

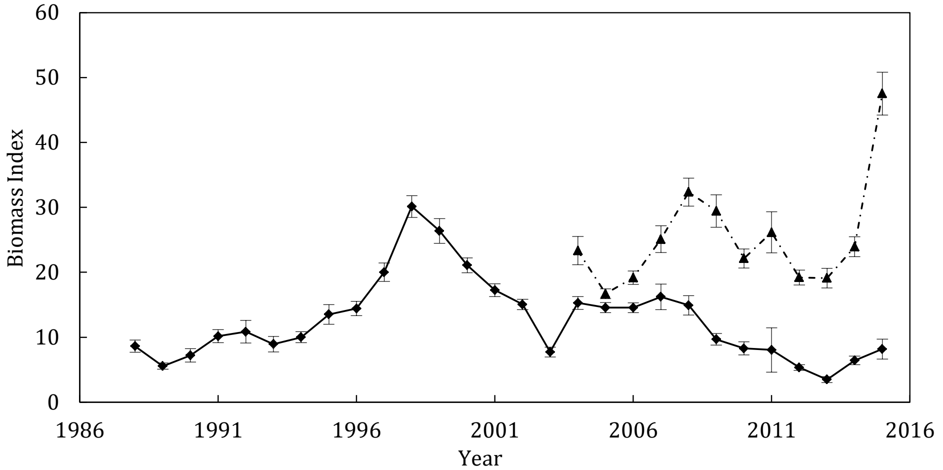


Fig. 20.5. Greenland halibut in Subarea 2 + Div. 3KLMNO: Biomass index (± 1 S.E.) from EU Flemish Cap surveys in Div. 3M. Solid line: biomass index for depths <730 m. Dashed line: biomass index for all depths <1460 m.

EU-Spain stratified-random surveys in NAFO Regulatory Area of Div. 3LNO. The biomass index for survey of the NRA in Div. 3NO generally declined over 1999 to 2006 (Fig. 20.6) but increased four-fold over 2006-2009. The survey index from 2013-2014 was below average but increased to above average in 2015. 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 since and 2014 and 2015 are among the highest in the series.

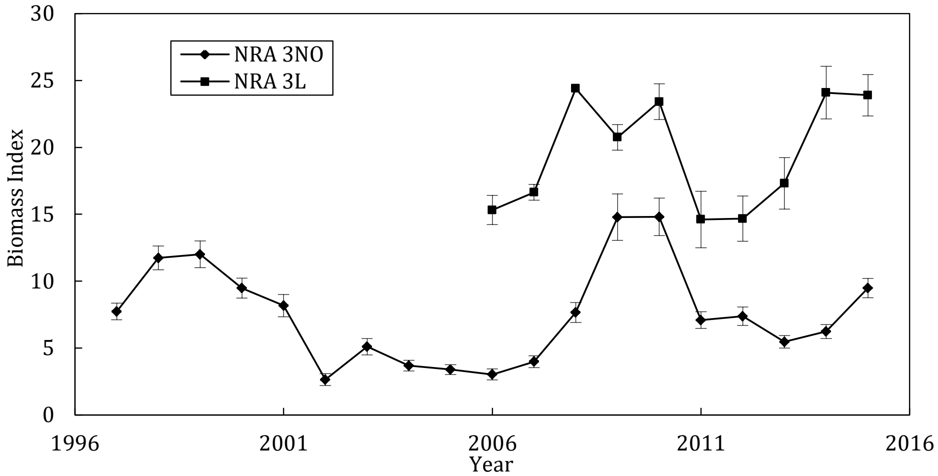


Fig. 20.6. Greenland halibut in Subarea 2 + Div. 3KLMNO: biomass index (±1 SE) from EU-Spain spring surveys in the NRA of Div. 3NO and Div. 3L.

Summary of research survey data trends. These surveys provide coverage of the majority of the spatial distribution of the stock and the area from which the majority of catches are taken. Over 1995-2007, indices from the majority of the surveys generally provided a consistent signal in stock biomass (Fig. 20.7). Results since 2007 show greater divergence which complicates interpretation of overall status. The overall trend since 2007 is unclear.

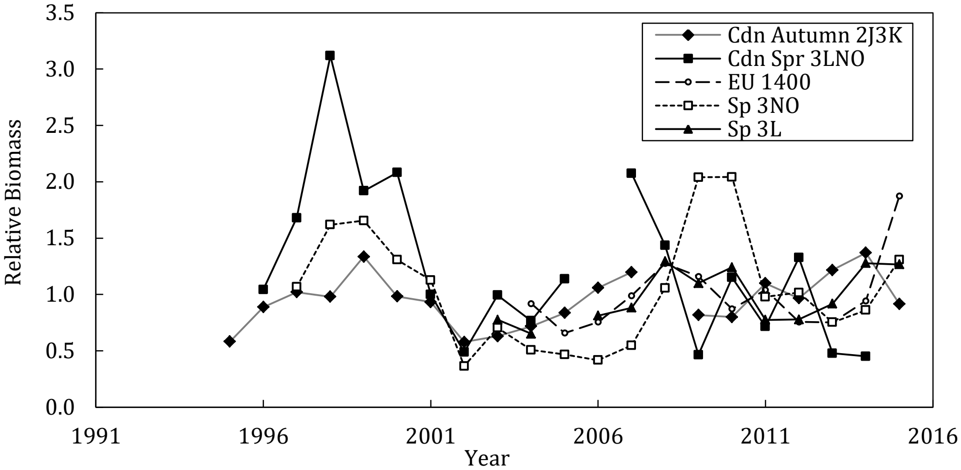


Fig. 20.7. Greenland halibut in Subarea 2 + Div. 3KLMNO: Relative biomass indices from Canadian autumn surveys in Div. 2J3K, Canadian spring surveys in Div. 3LNO, EU survey of Flemish Cap, and EU-Spain surveys of the NRA of Div. 3NO. Each series is scaled to its 2004-2015 average.

Recruitment from surveys

Abundance indices at age 4 from 3 surveys (Canadian spring Divs. 3LNO, Canadian fall Divs. 2J3K and EU Div. 3M to 1400m) were examined as a measure of recruitment. Abundance at age 4 has been below average since 2004 in the Canadian spring Divs. 3LNO survey and since the 2012 year class in the Canadian fall Divs. 2J3K survey. After 3 very large year classes in the EU survey of Div. 3M from 2004-2007, abundance at age 4 has been below average.

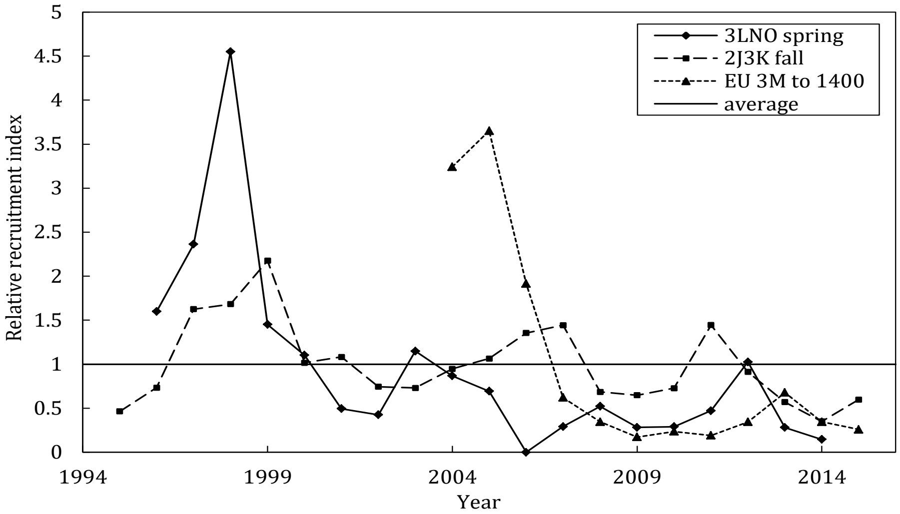


Fig. 20.8. Greenland halibut in Subarea 2 + Div. 3KLMNO: Relative recruitment indices from Canadian autumn surveys in Div. 2J3K, Canadian spring surveys in Div. 3LNO, and EU survey of Flemish Cap. Each series is scaled to its average and the average line is shown.

c) Assessment results

Biomass: Survey data from 2011-2015 are variable which complicates the interpretation of overall status. The three surveys that are used in the HCR show differing trends over this period. The remaining surveys do not clarify the overall trend in stock biomass.

Recruitment: Results of Canadian surveys and the EU Flemish Cap survey indicate that recruitment has been below average in the four most recent years.

Fishing Mortality: Unknown, as estimates of total catch were unavailable.

State of the stock: Survey results in recent years show greater divergence which complicates interpretation of overall status. The slope for one of the three indices used in the HCR was negative one was positive and one essentially had a slope of zero, and when averaged result in an overall decline over the last 5 years.

d) Other Studies

Recent tagging studies are described in the STACREC report.

e) Reference Points

i) Precautionary approach reference points

Precautionary approach reference points have not been determined for this stock at this time.

f) Research recommendations

STACFIS **recommended** that *methods for estimating catch for 2011-2014 be explored for Greenland Halibut in SA 2 + Div. 3KLMNO, including where ever possible the utility of using effort in conjunction with estimates of catch per unit effort.*

A method to relate CPUE in the surveys by EU-Spain to available estimates of CPUE from scientific observers was explored (SCR 16/09). However, STACFIS concluded that this method was not appropriate for estimating catch from 2011-2014.

STACFIS agreed a method to estimate catch in 2011 to 2014 that will be applied intersessionally to try to resolve this before the September 2016 meeting. The basis of this method is that VMS effort was considered the most reliable information available. The estimates of catches over a time period covering 2011-2014, will therefore depend on the estimation of appropriate commercial CPUEs. Scientific observer CPUEs were considered to be the best estimate of CPUE, but these are not available for all countries, for all considered years. For those countries that cannot produce an estimate of CPUE from scientific observer data for each year from 2011 to 2014, average CPUE from an earlier period will be used to fill any gaps. The period of averaging will be determined intersessionally giving consideration to trends in available CPUE values. For countries for which no scientific observer CPUE data is available, weighted average values for the relevant year from other flag states will be used.

For the Canadian gillnet fleet, STATLANT data will be used as the CPUE method was not considered reliable due to changes in fishing pattern (eg mesh size and baiting of nets) that cannot be accounted for in standardisation. For Canada, otter trawl estimates of CPUE based on scientific observer data, and the resulting catch values, will be used.

For 2015, it was proposed to use the method that will be recommended by CDAG.

This stock will next be assessed in June 2017.

21. Northern Shortfin Squid (*Illex illecebrosus*) in SAs 3+4

(SCR Doc. 98/59, 75, 06/45, 16/21REV, 16/34REV)

a) Introduction

Northern shortfin squid (*Illex illecebrosus*) is assumed to constitute a single stock throughout its range from Newfoundland to Florida, in NAFO Subareas 3-6, but is managed as northern (Subareas 3+4) and southern stock components (Subareas 5+6) by NAFO and the USA, respectively (SCR Doc. 98/59). Thus, fishery removals in relation to the biomass levels of each stock component affect one another so fishery and research survey data for the southern stock component in Subareas 5+6 are also presented. The two stock components have separate annual catch quotas.

I. illecebrosus is a semelparous species (spawns once during its lifespan then dies) which has a lifespan of less than one year (SCR Doc. 98/59). Age data indicate that spawning occurs throughout the year. The only documented spawning area is located on the USA shelf in the Mid-Atlantic Bight, where and spawners found this area, which have been found during spring through summer, and likely provide the primary source of recruitment to northern fishing grounds on the Scotian Shelf and off Newfoundland (SCR Doc. 16/34). *I. illecebrosus* is an oceanic squid species which undergoes annual migrations on and off the continental shelf between Cape Hatteras, North Carolina and the Grand Bank off Newfoundland during spring/early summer and late fall, respectively. The migrations progress from south to north in the spring and north to south in the fall. Distribution, growth rates and recruitment of this highly migratory species are primarily influenced by oceanographic conditions which, when favorable, may lead to high productivity periods. Indices of relative biomass and mean body size, computed using data from the Div. 4VWX bottom trawl surveys conducted during July by Canada, were used to assess whether the Subareas 3+4 stock component was at a low or high productivity level during the previous year.

i) Description of Fisheries and Catches

The onset and duration of the fisheries in each Subarea generally reflect the timing of squid migrations through each fishing area. Fisheries in the south start and end earlier than those in the north; in Subareas 5+6 and Subarea 4 (June-September/October) and in Subarea 3 (July-November, SCR Doc. 16/34). Fisheries for Northern shortfin squid consist of a Canadian inshore jig fishery in Subarea 3, and prior to 1999, an international bottom trawl fishery for silver hake, shortfin squid and argentine operated in Subarea 4. Since 1999, there has been no directed squid fishery in Subarea 4 and catches have mainly been from bycatch in Canadian small-mesh bottom trawl fisheries (e.g., silver hake). Total catches from Subareas 3-6 were primarily from Subareas 3+4 during 1976-1981 and have been primarily from the USA offshore bottom trawl fishery in Subareas 5+6 since then. Prior to the mid-1980s, international bottom trawl and midwater trawl fleets participated in directed squid fisheries in Subareas 3, 4 and 5+6.

In Subareas 3+4, a TAC of 150 000 tons was in place during 1980-1998. The TAC was 75 000 tons in 1999 and has been 34 000 tons since then. Occasionally, very low catches occur in Subarea 2 and these catches have been included with Subarea 3 for convenience. Subareas 3+4 catches were highest during 1976-1981, with a peak of 162 100 tons in 1979, but then declined sharply to 400 tons in 1983 and were less than 1 000 t through 1988 (SCR Doc. 16/34). During 1989-1998, catches in Subareas 3+4 ranged between 1 100 t in 1995 and 15 600 t in 1997; the latter being the highest catch since 1981. Since 1999, catches from Subareas 3+4 have been much lower, and with no directed fishery in Subarea 4, were primarily from the Subarea 3 inshore jig fishery during 2000-2011. During 1999-2006, catches in Subareas 3+4 ranged between 57 tons in 2001 and 7 000 tons in 2006. Thereafter, Subareas 3+4 catches ranged from 700 tons in 2009 to 14 tons in 2015; the lowest level since 1953.

Since this species is considered to constitute a single stock throughout Subareas 2 to 6 (SCR Doc. 98/59), catch trends in Subareas 3+4 must be considered in relation to those in Subareas 5+6.

During 1972-1982, the period of highest catches by the international squid fishing fleets, catches in Subareas 5+6 ranged from 15 600 tons in 1981 to 24 900 tons in 1977. After 1982, the international fleets were phased out and an offshore, domestic bottom trawl fishery for Northern shortfin squid was developed. Catches in Subareas 5+6 averaged 12 000 tons during 1983-2014 and reached the highest catch on record in 2004 (26 100 tons). The Subareas 5+6 catch declined in recent years from 15 800 t in 2011 to 2 400 t in 2015 (Fig. 21.1).

Recent nominal catches and TACs ('000 tons) are as follows:

	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
TAC SA 3+4	34	34	34	34	34	34	34	34	34	34
STATLANT21 SA 3+4	0.2	0.5	0.7	0.1	0.2	<0.1	0.1	nd[1]	0.1	
STATLANT21 SA 5+6	9.0	15.9	18.4	15.3	18.4	11.7	3.8	8.8	nd[2]	
STACFIS SA 3+4	0.2[3]	0.5	0.7	0.1[3]	0.1[3]	<0.1[3]	<0.1[3]	<0.1[3]	<0.1[3]	
STACFIS SA 5+6	9.0	15.9	18.4	15.8	18.8	11.7	3.8	8.8	2.4	
STACFIS Total SA 3-6	9.2	16.4	19.1	15.9	18.9	11.7	3.8	8.8	2.4	

nd = no data; Illex catches were not reported by the CA-Maritimes Regions, but CA-Newfoundland catch was zero.

Catches from SA 5+6 were included because there is no basis for considering separate stocks in SA 3+4 and SA 5+6. nd = no data; Illex catches were not reported by the USA.

Includes amounts, ranging from 0.001-18 t, reported as Unspecified Squid from Subarea 4.

Fig. 21.1. Northern shortfin squid in Subareas 3+4: nominal catches and TACs in relation to catches from Subareas 5+6 and the total stock.

i) Input Data

b) *Commercial fishery data*

Nominal catches were available for Subareas 3+4, during 1953-2015, and for Subareas 5+6 during 1963-2015. Catches from Subareas 5+6, prior to 1976, may not be accurate because distant-water fleets did not report all squid catch by species so the shortfin squid catches were prorated. The accuracy of the Subareas 3+4 catches prior to the mid-1970s is unknown. Subarea 4 catches include catches obtained by the Canadian Observer Program Database, during 1987-1998, a period of 100% fishery coverage plus catches from the Canadian MARFIS Database (SCR Doc. 16/34).

ii) Research survey data

Biomass indices were available from various research bottom trawl surveys, with different depth and area coverage. There is no single synoptic survey that covers the entire distribution of the stock. However, trends in biomass indices were positively correlated for the Div. 4VWX July survey and the Subareas 5+6 and 4T fall surveys (SCR Doc. 98/59). Therefore, biomass indices for these other surveys, including the Div. 3M July survey, were included in the assessment. Relative biomass indices were derived for the northern stock component using data from stratified, random multi-species bottom trawl surveys conducted in Subarea 3 and Subarea 4. Relative abundance and biomass indices were also derived for the southern stock component using data from research bottom trawl surveys conducted by the Northeast Fisheries Science Center (USA). All of the surveys incorporated stratified-random sampling designs with stratification based on depth. Sampling during all surveys was conducted around-the-clock with the exception of the Div. 3M surveys and the 1971-1984 Div. 4T surveys which were conducted solely during the daytime (SCR Doc. 16/34).

The spring and fall surveys in Div. 3LNO occur when the species is migrating on and off the Grand Bank, respectively (SCR Doc. 06/45), and the biomass indices from these surveys were very low, averaging 0.036 kg per tow and 0.046 kg per tow, respectively, during 1996-2013 (SCR Doc. 16/31). As a result, the Div. 3LNO biomass indices were not included in the assessment.

Summer surveys

Biomass indices were derived for Canadian research bottom trawl surveys conducted during July on the Scotian Shelf and Bay of Fundy (Div. 4VWX, 1970-2015) for the EU-Spain/Portugal research bottom trawl surveys conducted primarily during July (Div. 3M, 1988-2015; Fig. 21.2). Both surveys occur before or near the start of the shortfin squid fisheries in all Subareas, so the indices are assumed to represent pre-fishery measures of relative biomass.

Biomass indices for the Div. 4VWX surveys were derived using data from strata 440-495. Different vessels were used to conduct the Div. 4VWX surveys during the periods of: 1970-1981 (RV *A. T. Cameron*); 1982 (RV *Lady Hammond*); 2004 (CCGS *Teleost*); and 1983-2003 and 2005-2015 (CCGS *Alfred Needler*). A survey gear change occurred in 1982, but there are no gear or vessel conversion coefficients available with which to standardize the shortfin squid biomass indices prior to 2004. However, a comparative fishing experiment, conducted during July of 2005, found no significant vessel effect between the CCGS *Teleost* and CCGS *Needler*.

Minimum biomass estimates (swept-area biomass) for the Div. 3M surveys were derived using data from strata 1-19 (SCR Doc. 16/21; SCR Doc. 16/34). The biomass time series was standardized for the vessel change that occurred in 2003. Analyses that utilized data from comparative fishing experiments indicated that the vessel currently used to conduct the Div. 3M surveys is 28% more efficient at catching Northern shortfin squid, in terms of biomass, than the previous survey vessel that conducted most of the surveys during 1988 and 1991-2002 (biomass conversion factor = 1.279,SCR Doc. 16/21).

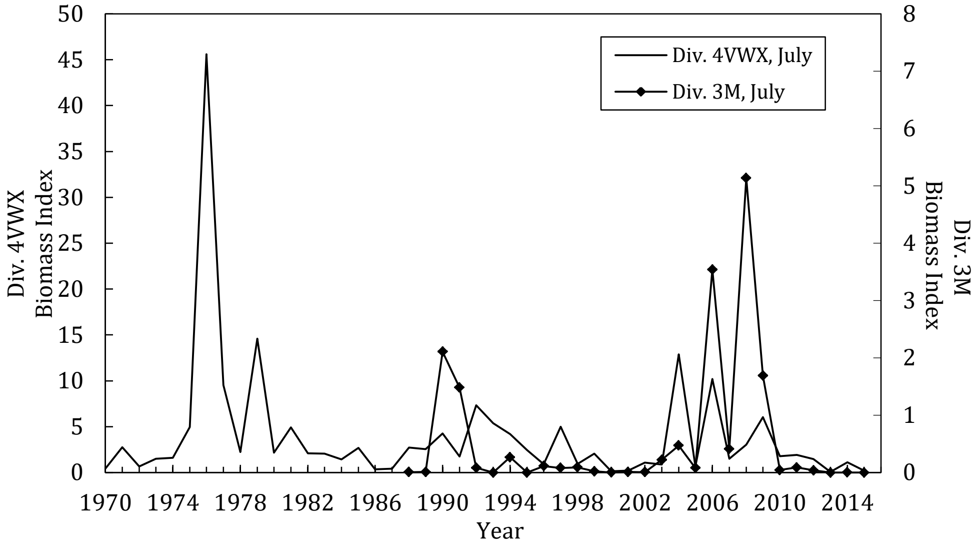


Fig. 21.2. Northern shortfin squid in Subareas 3+4: summer biomass indices for Div. 4VWX and Div. 3M.

Fall surveys

Biomass indices were derived for Canadian research bottom trawl surveys conducted during September in the southern Gulf of St. Lawrence (Div. 4T, 1971-2015) and USA research bottom trawl surveys conducted during September-October on the USA continental shelf between Cape Hatteras, North Carolina and the Gulf of Maine (Subareas 5+6, 1967-2015; Fig. 21.3).

Biomass indices for the Subareas 5+6 and Div. 4T surveys were standardized for all vessel and gear changes. The Div. 4T survey indices were also standardized for diel changes in catchability. Both surveys occur at or near the end of the shortfin squid fisheries and are assumed to represent post-fishery measures of relative biomass.

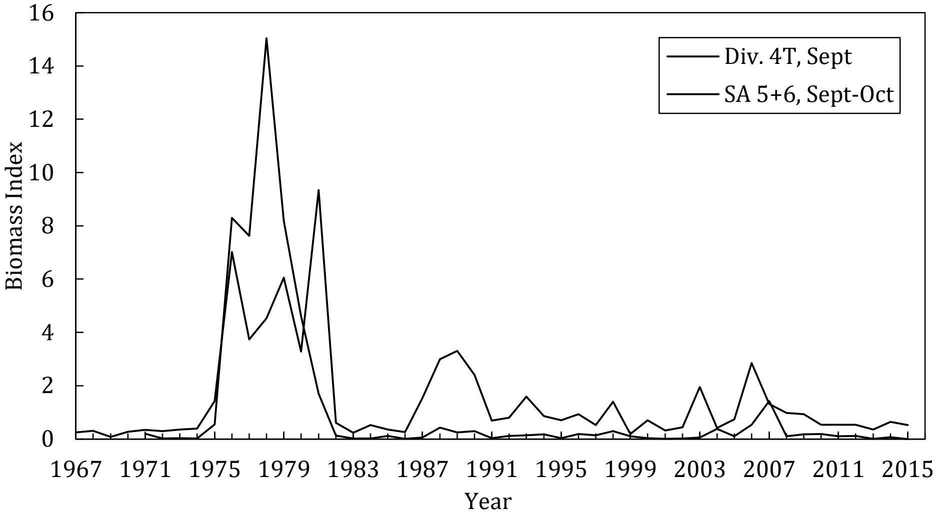


Fig. 21.3. Northern shortfin squid in Subareas 3+4 in relation to Subareas 5+6: fall survey biomass indices in Div. 4T and Subareas 5+6.

Summary of research surveys data trends. The Div. 4VWX survey indices are the best indicator of biomass for the northern stock component because the survey covers a large area of shortfin squid habitat and occurs during July, a time when the species has migrated onto the continental shelf and is most available to the survey, and because the survey is a measure pre-fishery biomass (SCR Doc. 16/34). The Div. 4VWX biomass indices showed a high degree of interannual variability. However, a period of high productivity occurred during 1976-1981, averaging 13.2 kg/tow, followed by low productivity periods during 1970-1975 and 1982-2014, averaging 2.0 kg/tow and 2.8 kg/tow, respectively. During the 1982-2014 low productivity period, the biomass index was highest in 2004 (12.9 kg/tow) and the second highest in 2006 (10.2 kg/tow), but both indices were followed by very low indices in subsequent years. Biomass indices generally declined after 2004 and were below the 1982-2014 low productivity period average during 2010-2014. Relative biomass indices generally declined after 2004 and were below the 1982-2014 low productivity period average during 2010-2014. During 2015, the biomass index was the third lowest value in the time series (0.2 kg per tow).

The Div. 3M biomass indices during 1988-2014 were low (< 100 t) during most years and averaged 593 t (range of 0-5,137 t). There were no catches of Northern shortfin squid in 2013 and 2015 and only 3 t in 2014. Trends in the Div. 3M biomass indices were similar to the trends in the Div. 4VWX biomass indices only during periods of high biomass in Div. 3M (SCR Doc. 16/34). This suggests that the Flemish Cap represents marginal *Illex* habitat in July during most years, but that the survey indices are useful biomass indicators for Subareas 3+4 when squid biomass is high on the Flemish Cap.

Similar to the Div. 4VWX survey biomass indices, biomass indices for both the Div. 4T and Subareas 5+6 fall surveys were much higher during 1976-1981 than thereafter. Trends in the biomass indices for the both surveys were correlated, despite the fact that the 4T survey area covers only a portion of shortfin squid habitat in Subarea 4. There were no *Illex* catches in the Div. 4T survey during 2015 and biomass indices during 2013 and 2014 were very low, similar to the 2013-2015 biomass indices for Div. 4VWX.

Overall, biomass indices for the Div. 4VWX surveys, as well as the Div. 4T, Div. 3M and SA 5+6 surveys were at or near the lowest values for each time series during 2013-2015.

iii) Biological studies

Trends in mean body size reflect the combined effects of emigration/immigration, recruitment, growth and mortality of the overlapping microcohorts which occur as a result of continuous recruitment throughout the year for this semelparous species. For *I. illecebrosus*, these factors are primarily influenced by environmental conditions (SCR Doc. 16/34). Mean body weights of shortfin squid caught in the July Div. 4VWX surveys were highest during 1976-1981, averaging 150 g, and much lower, averaging 80 g, during 1982-2014 (Fig. 21.4). Likewise, mean body weights were much larger in the Subareas 5+6 fall surveys during 1976-1981, averaging 284 g, and much lower, averaging 101 g, during 1982-2014. There is a fairly strong, positive correlation between the mean body weights of squid from both surveys (SCR Doc. 16/34). Since 1982, the mean body weight of squid caught in the Div. 4VWX surveys has fluctuated widely around the 1982-2014 low productivity period average, but was generally at or above the average during 2002-2015. After reaching a low productivity period peak of 137 g in 2006, mean body weight declined to the fourth lowest value in the time series during 2013, but then increased and was 96 g in 2015.

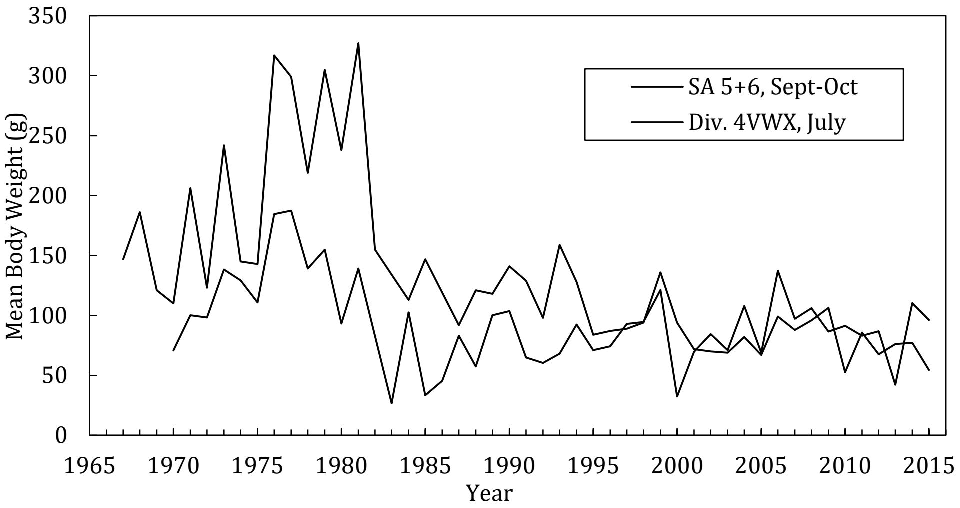


Fig. 21.4. Northern shortfin squid in Subareas 3+4: mean body weight of squid in the Div. 4VWX surveys during July and in the Subareas 5+6 surveys during September-October.

iv) Relative fishing mortality indices

Relative fishing mortality indices for Subareas 3+4 were computed as the Subareas 3+4 nominal catch divided by the Div. 4VWX July survey biomass index (SCR Doc. 98/75). The indices were highest during 1977-1982, reaching a peak of 4.20 in 1978 and averaging 1.69 (Fig. 21.4). During 1982-2014, relative fishing mortality indices were much lower, averaging 0.12, with a peak of 0.96 in 1996. Relative fishing mortality indices have consistently been below 0.12 since 2004, and during 2009-2015, were the lowest values in the time series.

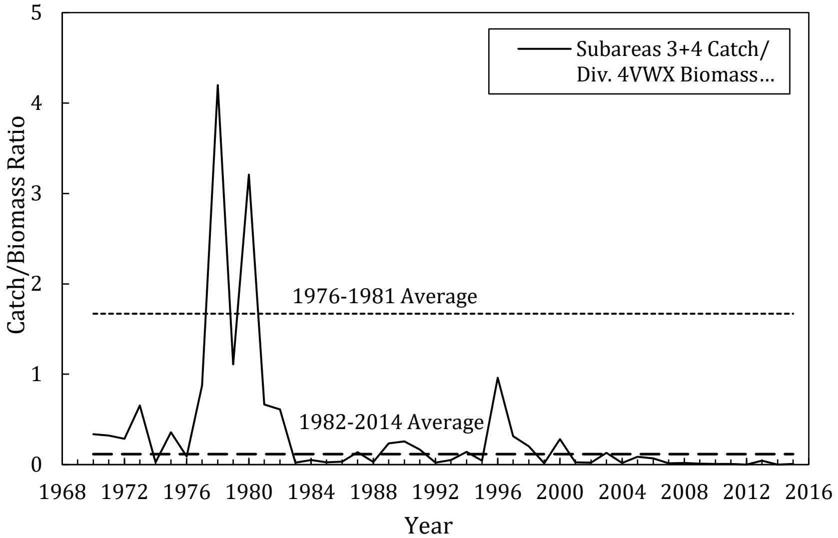


Fig. 21.4. Northern shortfin squid in Subareas 3+4: relative fishing mortality indices.

c) Assessment Results

Trends in fishery and research vessel survey data indicate that a period of high productivity (1976-1981) occurred in Subareas 3+4 between two low productivity periods (1970-1975 and 1982-2014).

Biomass and Mean Body Size: During 2010-2012, relative biomass indices from the Division 4VWX surveys remained at levels ranging from 1.5-1.9 kg per tow, which were well below the average for the 1982-2014 low productivity period (2.8 kg per tow). During 2013 and 2014 the Div. 4VWX biomass indices declined further, and in 2015, the biomass index was the third lowest value in the time series (0.2 kg per tow).

The high productivity period was associated with a larger mean body size (averaging 150 g) than the 1982-2014 low productivity period (averaging 80 g). Mean body weight decreased from a low productivity period high of 137 g in 2006 to 42 g in 2013 but was above average during 2006-2014, with the exception of 2013. During 2015, mean body weight (96 g) was slightly above the low productivity period mean.

Fishing Mortality: Relative fishing mortality indices for Subareas 3+4 were highest during 1977-1982 and have been much lower since 1982. There were no catches of *Illex* in Subarea 3 during 2013-2015 and there has not been a directed fishery in Subarea 4 since 1999. During 2009-2015, relative fishing mortality indices were at the lowest levels on record.

Recruitment: Recruitment occurs throughout the year and is strongly influenced by environmental conditions, resulting in low and high productivity states and the lack of a stock-recruitment relationship (SCR Doc. 98/75).

State of the Stock: During 2015, indices of relative biomass and mean body weight, in the Div. 4VWX surveys, and relative fishing mortality indices, were very low in relation to their 1982-2014 low productivity period averages. As a result, the Subareas 3+4 stock component of Northern shortfin squid remained in a state of low productivity during 2015.

d) Reference Points

Conventional reference points are inappropriate for squid stocks because of their unique life history. Two reference states, "high productivity" or "low productivity" states, are defined by trends in stock biomass and mean body weight in the July Div. 4VWX bottom trawl surveys. Two proxies for F_{lim}, the potential yield which the northern stock component may be able to sustain under the current low productivity regime, are 19 000 tons and 34 000 tons (SCR Doc. 98/75). The potential yield during a high productivity state has not been determined.

Limit reference points may not be appropriate for the northern stock component given the life history of this short-lived species. The current management advice for this stock component is based on the potential yield depending on whether the stock is in a low or high productivity state. The method used to compute potential yield only applies to the low productivity period, does not account for effects of environmental conditions on squid yield, and assumes that the high relative fishing mortality indices which occurred during 1976-1981 (which were followed by a rapid decline in the Div. 4VWX biomass indices) are appropriate for the current time period.

e) Research Recommendations

STACFIS **recommends** 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. STACFIS reiterates this research recommendation.

IV. STOCKS UNDER A MANAGEMENT STRATEGY EVALUATION

1. Greenland halibut in SA2 and Divs. 3KLMNO

This stock is taken under D. Widely Distributed Stocks: SA 2, SA 3 and SA 4.

V. OTHER MATTERS

1. FIRMS Classification for NAFO Stocks

STACFIS reviewed the assessments of stocks managed by NAFO in June 2016. STACFIS reiterates that the Stock Classification system is not intended as a means to convey the scientific advice to Fisheries Commission, and should not be used as such. Its purpose is to respond to a request by FIRMS to provide such a classification for their purposes. The category choices do not fully describe the status of some stocks. Scientific advice to the Fisheries Commission is to be found in the Scientific Council report in the summary sheet for each stock.

Stock Size (incl. structure)	Fishing Mortality			
	None–Low	Moderate	High	Unknown
Virgin–Large	3LNO Yellowtail Flounder 3LN Redfish			
Intermediate	3M Redfish[3] 3NO Witch flounder	SA0+1 Northern shrimp[1] DS Northern shrimp[1] 0&1A Offsh. & 1B–1F Greenland halibut	3M Cod	Greenland halibut in Uummannaq[2] Greenland halibut in Upernavik[2] Greenland halibut in Disko Bay[2] SA1 American Plaice SA1 Spotted Wolffish
Small	SA3+4 Northern shortfin squid 3NOPs White hake			3LNOPs Thorny skate SA2+3KLMNO Greenland halibut
Depleted	3M American plaice 3LNO American plaice 2J3KL Witch flounder 3NO Cod 3M Northern shrimp[1,3] 3LNO Northern shrimp[1]			SA1 Redfish SA0+1 Roundnose grenadier SA1 Atlantic Wolffish
Unknown	SA2+3 Roughhead grenadier 3NO Capelin 3O Redfish			SA2+3 Roundnose grenadier

[1] Shrimp will be re-assessed in September 2016

[2] Assessed as Greenland halibut in Div. 1A inshore

[3] Fishing mortality may not be the main driver of biomass for Div. 3M Shrimp and Redfish

2. Other Business

No additional items were discussed.

VI. ADJOURNMENT

STACFIS Chair thanked the Designated Experts for their competence and very hard work and the Secretariat for its great support. The Chair also noted the contributions of Designated Reviewers in providing detailed reviews of interim monitoring reports. The STACFIS Chair also thanked the Chair of Scientific Council, and the Scientific Council Coordinator for their support and help. The meeting was adjourned at 1400 on 16 June 2016.

APPENDIX V. AGENDA, SCIENTIFIC COUNCIL 03 – 16 JUNE 2016

I. Opening (Scientific Council Chair: Kathy Sosebee)
  1. Appointment of Rapporteur
  2 Presentation and Report of Proxy Votes
  3. Adoption of Agenda
  4. Attendance of Observers
  5. Appointment of Designated Experts
  6. Plan of Work
  7. Housekeeping issues

II. Review of Scientific Council Recommendations in 2015

III. Fisheries Environment (STACFEN Chair: Andrew Cogswell)

  1. Opening
  2. Appointment of Rapporteur
  3. Adoption of Agenda
  4. Review of Recommendations in 2015
  5. Invited speaker
  6. Integrated Science Data Management (ISDM) Report for 2015
  7. Review of the physical, biological and chemical environment in the NAFO Convention Area during 2015
  8. Interdisciplinary studies
  9. Formulation of recommendations based on environmental conditions during 2015
  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 2015
  5. Review of Publications
    a) Annual Summary
      i) Journal of Northwest Atlantic Fishery Science (JNAFS)
      ii) Scientific Council Studies
      iii) Scientific Council Reports
  6. Other Matters
  7. Adjournment

V. Research Coordination (STACREC Chair: Brian Healey)
  1. Opening
  2. Appointment of Rapporteur
  3. Review of Recommendations in 2015
  4. Fishery Statistics
    a) Progress report on Secretariat activities in 2015/2016

        - i) STATLANT 21A and 21B
        - ii) Availability of STACFIS catch estimates

5. Research Activities
    - a) Biological sampling
        - i) Report on activities in 2015/2016
        - 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 2015 (by National Representatives and Designated Experts)
        - ii) Surveys planned for 2016 and early 2017
    - c) Tagging activities
        - i) Notification to Fishing and Research Survey vessels.
        - ii) Greenland Halibut Tagging in Divs. 3KL
    - d) Other research activities
6. Review of SCR and SCS Documents
7. Other Matters
    - a) Summary of progress on previous recommendations
    - b) Stock Assessment Spreadsheets
    - c) Presentation on EIUI Project Results
8. Adjournment

VI. Fisheries Science (STACFIS Chair: Joël Vigneau)

1. Opening
2. General Review of Catches and Fishing Activity
3. Invited speaker
4. Stock Assessments
    - 1. Greenland Halibut (*Reinhardtius hippoglossoides*) in SA 0, Div. 1A offshore and Div. 1B-F (fully assessed)
    - 2. Greenland Halibut (*Reinhardtius hippoglossoides*) Div. 1A inshore (fully assessed)
    - 3. Roundnose Grenadier (*Coryphaenoides rupestris*) in Subareas 0 and 1 (monitor)
    - 4. Demersal Redfish (*Sebastes* spp.) in SA 1 (monitor)
    - 5a. Wolffish in Subarea 1 (monitor)
    - 5b. American plaice (*Hippoglossoides platessoides*) in Subarea 1 (monitor)
    - 6. Cod (*Gadus morhua*) in Div. 3M (monitor)
    - 7. Redfish (*Sebastes mentella* and *Sebastes fasciatus*) in Div. 3M (monitor)
    - 8. American Plaice (*Hippoglossoides platessoides*) in Div. 3M (monitor)
    - 9. Cod (*Gadus morhua*) in NAFO Div. 3NO (monitor)
    - 10. Redfish (*Sebastes mentella* and *Sebastes fasciatus*) in Divisions 3L and 3N (fully assessed – special request)
    - 11. American Plaice (*Hippoglossoides platessoides*) in Div. 3LNO (fully assessed)
    - 12. Yellowtail flounder (*Limanda ferruginea*) in Div. 3LNO (monitor)
    - 13. Witch Flounder (*Glyptocephalus cynoglossus*) in Div. 3NO (monitor)
    - 14. Capelin (*Mallotus villosus*) in Div. 3NO (monitor)
    - 15. Redfish (*Sebastes mentella* and *Sebastes fasciatus*) in Div. 3O (fully assessed)
    - 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 (fully assess)

        19. Witch Flounder (*Glyptocephalus cynoglossus*) in Div. 2J+3KL (fully assess)
        20. Greenland Halibut (*Reinhardtius hippoglossoides*) in SA 2 + Div. 3KLMNO (management strategy)
        21. Northern Shortfin Squid (*Illex illecebrosus*) in Subareas 3+4 (fully assess)

5. Stocks under a Management Strategy Evaluation (FC Item 3a)
    a) Greenland halibut in SA 2 and Div. 3KLMNO
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))
        a) <u>For 2017 and 2018</u>
        - American plaice in Div. 3LNO
        - Thorny skate in Div. 3LNO
        b) <u>For 2017, 2018 and 2019</u>
        - Redfish in Div. 3O
        - Witch flounder in Div. 2J+ 3KL
        - Northern short-finned squid in SA3+4
    b) Monitoring of Stocks for which Multi-year Advice was provided in 2013 or 2014 (Item 1)
        - Cod in Div. 3M
        - Redfish in Div. M
        - American plaice in Div. 3M
        - Yellowtail flounder in Div. 3LNO
        - Witch flounder in Div. 3NO
        - Capelin in Div. 3NO
        - White hake in Div. 3NO
    c) Special Requests for Management Advice
        i) TAC calculation for Greenland halibut in SA2 + Divs. 3KLMNO (Item 2a)
        ii) Exceptional circumstances in Greenland halibut MSE (Item 2b)
        iii) Assessment of redfish in Div. 3LN (Item 3)
        iv) Risk assessment for SAI on VME elements and species (Item 4)
        v) Seamount VME Species Guides (Item 5)
        vi) Risk assessments for impacts of trawl surveys on VME in closed areas (Item 6)
        vii) Bycatch of cod, redfish and moratoria species from haul-by-haul data (Item 7)
        viii) Review of F_{lim} value for Div. 3M Cod (Item 8)
        ix) Assessment of individual species components of Div. 3M Redfish (Item 9)
        x) Appropriateness of survey coverage for Greenland halibut (Item 10)
        xi) Workplan for assessment of impacts other than fishing in the NAFO Regulatory Area (Item 11)
        xii) A full assessment of Greenland halibut in SA2 and Div. 3KLMNO using both XSA and SCAA (Item 12)
        xiii) How many SSB points above 30,000t are considered sufficient to conduct a review of B_{lim} of cod in 3NO? (Item 13)
        xiv) Survey biomass trends for Witch flounder in Div. 3M (Item 14)

        - xv) Review results of 2015 Canadian photographic surveys for non-coral and sponge VME indicator species
        - xvi) Plan for of work for the benchmark process for Cod in Div. 3M (Item 16)

2. Coastal States
    - a) Request by Denmark (Greenland) for Advice on Management in 2016 (Annex 2)
        - i) Roundnose grenadier in SA 0+1 (Item 1)
        - ii) Redfish, Atlantic wolfish, Spotted wolfish and American plaice in SA 1 (Item 2)
        - iii) Greenland halibut in inshore areas of Div. 1A (Item 4)
        - iv) *Pandalus borealis* east of Greenland and in the Denmark Strait (in conjunction with ICES). (Item 6)

    - b) Request by Canada and Greenland for Advice on Management in 2016 (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) Greenland halibut in Div. 0B + Div. 1C-1F (Annex 2, Item 3, Annex 3, Item 1)
        - iii) *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), 8 – 15 Sep 2016
2. Scientific Council, 20 – 24 Sep 2016
3. Scientific Council, Jun 2017
4. Scientific Council (in conjunction with NIPAG), Sep 2017
5. Scientific Council, Sep 2017
6. NAFO/ICES Joint Groups
    - a) NIPAG, 8 – 15 Sep 2016
    - b) NIPAG, 2017
7. WGESA
8. WGDEC
9. WGHARP

IX. Arrangements for Special Sessions

1. Topics for future Special Sessions

X. Meeting Reports

1. Working Group on Ecosystem Science and Assessment (WG-ESA), Nov 2015
2. Report from ICES-NAFO Working Group on Deep-water Ecology (WGDEC), Mar 2016
3. Report from Joint FC-SC Working Group on Risk Based Management Strategies (WG-RBMS), Apr 2016
4. Report from *ad hoc* Joint Working Group on Catch Reporting (WG-CDAG), Feb 2016
5. Working Group on the Precautionary Approach, Mar 2016
6. Meetings attended by the Secretariat:
    - a) FIRMS

XI. Review of Scientific Council Working Procedures/Protocol

1. General Plan of Work for September 2016 Annual Meeting

2. Other Matters
    a. External Review of Assessments

XII. Other Matters

1. Designated Experts
2. Stock Assessment spreadsheets
3. Scientific Merit Awards
4. Budget items
5. Other Business

XIII. Adoption of Committee Reports

1. STACFEN
2. STACREC
3. STACPUB
4. STACFIS

XIV. Scientific Council Recommendations to General Council and Fisheries Commission

XV. Adoption of Scientific Council Report

XVI. Adjournment

ANNEX 1. FISHERIES COMMISSION'S REQUEST FOR SCIENTIFIC ADVICE ON MANAGEMENT IN 2017 AND BEYOND OF CERTAIN STOCKS IN SUBAREAS 2, 3 AND 4 AND OTHER MATTERS

1. Fisheries Commission requests that the Scientific Council provide advice for the management of the fish stocks below according to the assessment frequency presented below. The advice should be provided as a range of management options and a risk analysis for each option (rather than a single TAC recommendation).

Yearly basis	Two year basis	Three year basis
Northern shrimp in Div. 3LNO	American plaice in Div. 3LNO Cod in Div. 3M Redfish in Div. 3M Northern shrimp in Div. 3M Thorny skate in Div. 3LNO White hake in Div. 3NO Witch flounder in Div. 3NO	American plaice in Div. 3M Capelin in Div. 3NO Cod in Div. 3NO Northern shortfin squid in SA 3+4 Redfish in Div. 3O Witch flounder in Div. 2J+3KL Yellowtail flounder in Div. 3LNO

To implement this schedule of assessments, the Scientific Council is requested to conduct the assessment of these stocks as follows:

In 2016, advice should be provided for 2017 for Northern shrimp in NAFO Div. 3LNO

In 2016, advice should be provided for 2017 and 2018 for American plaice in Div. 3LNO and for Thorny skate in Div. 3LNO.

In 2016, advice should be provided for 2017, 2018 and 2019 for Redfish in Div.3O, Witch flounder in Div. 2J+3KL and Northern shortfin squid in SA 3+4.

Advice should be provided using the guidance provided in **Annexes A or B as appropriate**, or using the predetermined Harvest Control Rules in the cases where they exist.

The Fisheries Commission also requests the Scientific Council to continue to monitor the status of all these stocks annually and, should a significant change be observed in stock status (e.g. from surveys) or in bycatch in other fisheries, provide updated advice as appropriate.

2. The Fisheries Commission adopted in 2010 an MSE approach for Greenland halibut stock in Subarea 2 + Division 3KLMNO (FC Doc. 10/12) and agreed to use it until 2017 (FC Doc.13/23). This approach considers a survey based harvest control rule (HCR) to set a TAC for this stock on an annual basis. The Fisheries Commission requests the Scientific Council to:

   a) Monitor and update the survey slope and to compute the TAC according to HCR adopted by the Fisheries Commission according to Annex 1 of FC Doc. 10/12.
   b) Advise on whether or not an exceptional circumstance is occurring.

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 biannual catch increase, with the same amount of increase every two years The Fisheries Commission request Scientific Council conduct a full assessment in 2016 to evaluate the effect of removals in 2014 and 2015 on stock status.

4. The Fisheries Commission requests the Scientific Council to continue to develop work on Significant Adverse Impacts in support of the reassessment of NAFO bottom fishing activities required in 2016,

specifically an assessment of the risk associated with bottom fishing activities on known and predicted VME species and elements in the NRA.

FC further requests that:

a) that Scientific Council should take into account the protection afforded to VME areas outside the NAFO fisheries footprint in the calculation of the VME area and biomass at risk of bottom fishing impact;
b) that Scientific Council refine VME kernel density analysis polygon boundaries, taking into account current understanding of distribution patterns in relation to environmental variables.

5. FC requests the Scientific Council consider widening the scope of the NAFO coral and sponge identification guides to include other relevant species on seamounts.

6. FC requests that Scientific Council consider options to expedite a risk assessment of scientific trawl surveys impact on VME in closed areas, and the effect of excluding surveys from these areas on stock assessments.

7. FC requests the Scientific Council consider, based on analysis of logbook data and patterns of fishing activity, to be conducted by the Secretariat, to examine relative levels of bycatch and discards of 3M cod/redfish, and stocks under moratoria in the different circumstances (e.g. fisheries, area, season, fleets, depth, timing)

8. It is difficult to match the current F_{lim} proxy with the 3M cod assessment results given by the 2015 Bayesian XSA assessment. These results were presented to SC in June and used for short term (2016-2017) projections under several F options (NAFO SCR 15/33 González-Troncoso, 2015); NAFO SC June 2015 Report). Focusing on the last assessment and projections, assuming at the same time a candidate F_{lim}= $F_{30\%}$SPR=0.131, they would imply that:

   - During the past five years (2010-2014) 3M cod has been exploited at an average F_{bar} level over two fold F_{lim}.
   - While SSB was sustained at a high average level representing 87% of the highest estimated SSB of the 1972-2014 interval (36 7041 on 1972).
   - The two highest year classes since 1992 occurred in 2011-2012.

   Under these circumstances the Scientific Council is requested to analyze whether the current F_{lim} value for 3M cod is currently underestimated and to revise if required the relevant fishing mortality and biomass reference points appropriately.

9. The stock of redfish 3M covers catches of three Sebastes species and the scientific advice is based on data of only two species (*S. mentella* and *S. fasciatus*). Golden redfish, *Sebastes marinus* (aka norvegicus), represents part of the catch but has not yet been subject to a full assessment in NAFO. The Scientific Council is requested to explore the possibility and options of an individual assessment of the golden redfish (*S. marinus*, aka norvegicus) and of including this species in the scientific advice for 2018-2019. The Scientific Council is also requested to advice on the implications for the three species in terms of catch reporting and stock management.

10. As part of the Greenland halibut's MSE review scheduled for 2016-2017, the SC is asked to specifically monitor and evaluate Contracting Parties surveys with the aim of optimizing resources in order to avoid duplication of data, identify data gaps and streamline survey methodologies, so that all data is used in the assessment.

11. Article 23 NCEM foresees a reassessment of bottom fishing activities in 2016. The NAFO Roadmap for Developing an Ecosystem Approach to Fisheries extends the work of the Scientific Council to include the assessment of potential impacts of activities other than fishing. Also, impacts of human activities in ecosystems should not be analyzed in isolation since cumulative effects might occur representing more than the sum of the individual factors. The Scientific Council is therefore requested to develop a workplan

at its meeting in 2016 that will allow to address and analyze the potential impact of activities other than fishing (eg. oil and gas exploration, marine cables, ocean dumping, marine transportation) on NAFO VMEs, in particular VME closed areas.

12. The Fisheries Commission requests the Scientific Council to conduct a full assessment of Greenland halibut in Subarea 2 + Division 3KLMNO (using both XSA and SCAA[1]) and to consider the weighting of each survey as a first step to inform the 2017 MSE review.

13. The Fisheries Commission requests the Scientific Council to advise on how many SSB points above 30,000t are considered sufficient to conduct a review of B_{lim} of cod in 3NO.

14. The Fisheries Commission requests the Scientific Council to provide survey biomass trend(s) of witch flounder in Div. 3M for as long as data is available.

15. The Fisheries Commission requests the Scientific Council to review the results of the 2015 Canadian in situ photographic surveys for non-coral and sponge VME indicator species on Grand Bank (tail of Grand Bank) in relation to previous analyses presented in 2014 (that modelled their distribution using research vessel survey trawl bycatch data), and to identify areas of significant concentrations of non-coral and sponge VME indicator species using all available information.

16. Recognizing the importance of the 3M cod fishery to NAFO.

Mindful that even though the current SSB is well above B_{lim}, the recruitment of the two most recent years is low.

Noting that according to the Scientific Council stock assessment we are currently fishing only on two year-classes – once they are depleted in about two years time prospects for a continued fishery at the current level is not likely to be possible.

Further noting that recent assessment of the stock has shown some year-to-year instability and that estimation of risk levels associated with given fishing mortalities cannot be calculated at this time, which further adds to our concern for the future of this fishery and its management.

It is proposed that Scientific Council organize a full benchmark review of the 3M cod assessment in two stages: For 2016 Scientific Council will agree on a standardized approach and prepare a plan for the benchmark process at NAFO including required resources. For 2017 SC will review the benchmark assessment methodology for 3M cod.

[1.] SCAA will not be possible unless a contractor can be hired.

ANNEX A: Guidance for providing advice on Stocks Assessed with an Analytical Model

The Fisheries Commission request the Scientific Council to consider the following in assessing and projecting future stock levels for those stocks listed above. These evaluations should provide the information necessary for the Fisheries Commission to consider the balance between risks and yield levels, in determining its management of these stocks:

1. For stocks assessed with a production model, the advice should include updated time series of:

- Catch and TAC of recent years
- Catch to relative biomass
- Relative Biomass
- Relative Fishing mortality
- Stock trajectory against reference points
- And any information the Scientific Council deems appropriate.

Stochastic short-term projections (3 years) should be performed with the following constant fishing mortality levels as appropriate:

  - For stocks opened to direct fishing: 2/3 F_{msy}, 3/4 F_{msy} 85% F_{msy}, 75% F_{2015}, F_{2015}, 125% F_{2015},
- For stocks under a moratorium to direct fishing: F_{2015}, F = 0.

The first year of the projection should assume a catch equal to the agreed TAC for that year.

Results from stochastic short term projection should include:

- The 10%, 50% and 90% percentiles of the yield, total biomass, spawning stock biomass and exploitable biomass for each year of the projections
- The risks of stock population parameters increasing above or falling below available biomass and fishing mortality reference points. The table indicated below should guide the Scientific Council in presenting the short term projections.

				Limit reference points														
				P($F>F_{lim}$)			P(B< B_{lim})				P($F>F_{msy}$)			P($B<B_{msy}$)				P(B_{2019} > B_{2016})
F in 2016 and following years*	Yield 2017 (50%)	Yield 2018 (50%)	Yield 2019 (50%)	2016	2017	2018	2016	2017	2018		2016	2017	2018	2016	2017	2018		
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_{2015}	t	t	t	%	%	%	%	%	%		%	%	%	%	%	%		%
F_{2015}	t	t	t	%	%	%	%	%	%		%	%	%	%	%	%		%
1.25 X F_{2015}	t	t	t	%	%	%	%	%	%		%	%	%	%	%	%		%
F=0	t	t	t	%	%	%	%	%	%		%	%	%	%	%	%		%

2. For stock assessed with an age-structured model, information should be provided on stock size, spawning stock sizes, recruitment prospects, historical fishing mortality. Graphs and/or tables should be provided for all of the following for the longest time-period possible:

- historical yield and fishing mortality;
- spawning stock biomass and recruitment levels;
- Stock trajectory against reference points

And any information the Scientific Council deems appropriate

Stochastic short-term projections (3 years) should be performed with the following constant fishing mortality levels as appropriate:

- For stocks opened to direct fishing: $F_{0.1}$, F_{max}, 2/3 F_{max}, 3/4 F_{max}, 85% F_{max}, 75% F_{2015}, F_{2015}, 125% F_{2015},
- For stocks under a moratorium to direct fishing: F_{2015}, F = 0.
  The first year of the projection should assume a catch equal to the agreed TAC for that year.

Results from stochastic short term projection should include:

- The 10%, 50% and 90% percentiles of the yield, total biomass, spawning stock biomass and exploitable biomass for each year of the projections
- The risks of stock population parameters increasing above or falling below available biomass and fishing mortality reference points. The table indicated below should guide the Scientific Council in presenting the short term projections.

				Limit reference points														
				P($F.>F_{lim}$)			P($B<B_{lim}$)				P($F>F_{0.1}$)			P($F>F_{max}$)				P(B_{2019} > B_{2016})
F in 2016 and following years*	Yield 2017	Yield 2018	Yield 2019	2016	2017	2018	2016	2017	2018		2016	2017	2018	2016	2017	2018		
$F_{0.1}$	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_{2015}	t	t	t	%	%	%	%	%	%		%	%	%	%	%	%		%
F_{2015}	t	t	t	%	%	%	%	%	%		%	%	%	%	%	%		%
1.25 X F_{2015}	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 2016 OF CERTAIN STOCKS IN SUBAREAS 0 AND 1

1. **Roundnose Grenadier:** For Roundnose Grenadier in Subarea 0 + 1 advice was in 2014 given for 2015-2017. Denmark (on behalf of Greenland) requests the Scientific Council to continue to monitor the status of Roundnose Grenadier in Subareas 0 and 1 annually, and should significant changes in the stock status be observed (e.g. from surveys) the Scientific Council is requested to provide updated advice as appropriate.

2. **Golden Redfish, Demersal Redfish, American Plaice, Atlantic Wolffish and Spotted Wolfish:** Advice on Golden Redfish (*Sebastes marinus*), Demersal Deep-sea Redfish (*Sebastes mentella*) American Plaice (*Hippoglossoides platessoides*), Atlantic Wolffish (*Anarhichas lupus*) and Spotted Wolffish (*Anarhichas minor*) in Subarea 1 was in 2014 given for 2015-2017. Denmark (on behalf of Greenland) requests the Scientific Council to continue to monitor the status of these species annually, and should significant changes in stock status be observed the Scientific Council is requested to provide updated advice as appropriate.

3. **Greenland Halibut, offshore:** Subject to the concurrence of Canada as regards Subareas 0 and 1, the Scientific Council is requested to provide advice on appropriate TAC levels for 2017 and as long time ahead as considered appropriate separately for Greenland Halibut 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 advice on any other management measures it deems appropriate to ensure the sustainability of these resources.

4. **Greenland Halibut, inshore:** Advice on Greenland Halibut in Division 1A inshore was in 2014 given for 2015-2016. Denmark (on behalf of Greenland) requests the Scientific Council for advice on Greenland Halibut in Division 1A inshore for 2017-2018.

5. **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 2016 to provide advice on the scientific basis for management of Northern Shrimp (*Pandalus borealis*) in Subarea 0 and 1 in 2017 and for as many years ahead as data allows for.

   The Scientific Council is asked to consider, if the advice for Subarea 0 and 1 could be limited in north to 73 °30’N owing to the fact, that stock assessment is based on data from scientific survey and logbooks within the area 60°N to 73°30’N.

6. **Northern Shrimp, East Greenland:** Furthermore, the Scientific Council is in cooperation with ICES requested to provide advice on the scientific basis for management of Northern Shrimp (*Pandalus borealis*) in Denmark Strait and adjacent waters east of southern Greenland in 2017 and for as many years ahead as data allows for.

ANNEX 3. REQUESTS FOR ADVICE FROM CANADA

1. Greenland halibut (Subareas 0 and 1)

The Scientific Council is requested, subject to the concurrence of Denmark (on behalf of Greenland) as regards Subarea 1, 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 2017, separately, for Greenland halibut in Divisions 0A+1A (offshore) and 1B, and Divisions 0B+1C-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 TACs.[2]

The following graphs should be presented, for one or several surveys, for the longest time-period possible:

- historical catches;
- abundance and biomass indices;
- an age or size range chosen to represent the spawning population;
- an 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;
- stock trajectory against reference points

Any other information the Scientific Council feels is relevant should also be provided.

2. Shrimp (Divisions 0A and Subarea 1)

Canada requests the Scientific Council to consider the following options in assessing and projecting future stock levels for Shrimp in Subareas 0 and 1:

a) The status of the stock should be reviewed and management options evaluated in terms of their implications for fishable stock size, spawning stock size, recruitment prospect, catch rate and catch over the next 5 years. The implications of catch options ranging from 30,000 t to the catch corresponding to Z MSY, in 5,000 t increments, should be forecast for 2017 through 2021 if possible, and evaluated in relation to precautionary reference points of both mortality and fishable stock biomass. Results should include a partitioning of the future estimable removals between catches and estimable predation for the various catch options requested. The present stock size and fishable stock size should be described in relation to those observed historically and those to be expected in the next 5 years under the various catch options requested, and any other options Scientific Council feels worthy of consideration.

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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 10, 15 or 25%), noting that data conditions do not allow for such advice at this time.

b) Management options should be provided within the Northwest Atlantic Fisheries Organization Precautionary Approach Framework. Uncertainties in the assessment should be evaluated and presented in the form of risk analyses related to the limit reference points of B_{lim} and Z_{MSY}.

c) Presentation of the results should include the following:

- a graph and table of historical yield and fishing mortality for the longest time period possible;
- a graph of biomass relative to B_{MSY}, and recruitment levels for the longest time period possible.
- a graph of the stock trajectory compared to B_{lim} and/or B_{MSY} and Z_{MSY}.;
- graphs and tables of total mortality (Z) and fishable biomass for a range of projected catch options (as noted in 2 a) for the years 2017 to 2021 if possible. Projections should include both catch options and a range of cod biomass levels considered appropriate by SC. Results should include risk analyses of falling below B_{MSY} and B_{lim}, and of exceeding Z_{MSY}.;
- a graph of the total area fished for the longest time period possible; and
- any other graph or table the Scientific Council feels is relevant.

APPENDIX VI. LIST OF SCR AND SCS DOCUMENTS, 03 – 16 JUNE 2016

SCR Documents			
Doc No.	**Serial No**	**Author(s)**	**Title**
SCR Doc. 16-001	N6534	B. Cisewski	Hydrographic conditions off West Greenland in 2015
SCR Doc. 16-002	N6535	J. Mortensen	Report on hydrographic conditions off Southwest Greenland June 2015
SCR Doc. 16-003	N6537	P. Fratantoni	Hydrographic Conditions on the Northeast United States Continental Shelf in 2015 – NAFO Subareas 5 and 6
SCR Doc. 16-004	N6540	O.A. Jørgensen	Survey for Greenland Halibut in NAFO Divisions 1C-1D, 2015
SCR Doc. 16-005	N6541	O.A. Jørgensen	Estimation of By Catch in the Commercial Fishery for Greenland halibut at West Greenland based on Survey Data
SCR Doc. 16-006	N6542	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 2015
SCR Doc. 16-007	N6543	E. Colbourne, J. Holden, D. Senciall, W. Bailey and S. Snook	Physical Oceanographic Environment on the Newfoundland and Labrador Shelf in NAFO Subareas 2 and 3 during 2015
SCR Doc. 16-008	N6544	G. Maillet, P. Pepin, B. Casault, C. Johnson, S. Plourde, P.S. Galbraith, L. Devine, M. Starr, M. Scarratt, E. Head, C. Caverhill, H. Maass, J. Spry, A. Cogswell, J.F. St-Pierre, L. St-Amand, P. Joly, S. Fraser, G. Doyle, A. Robar, C. Porter, G. Redmond, T. Shears	Biological Oceanographic Conditions in the Northwest Atlantic During 2015
SCR Doc. 16-009	N6545	F. González-Costas	A method to estimate the NAFO Subarea 2+3KLMNO GHL catches based on survey information
SCR Doc. 16-010	N6546	D. González-Troncoso, A. Gago, A. Nogueira and E. Román	Results for Greenland halibut, American plaice and Atlantic cod of the Spanish survey in NAFO Div. 3NO for the period 1997-2015
SCR Doc. 16-011	N6547	D. González-Troncoso, A. Nogueira and A. Gago	Yellowtail flounder, redfish (*Sebastes spp.*) and witch flounder indices from the Spanish Survey conducted in Divisions 3NO of the NAFO Regulatory Area
SCR Doc. 16-012	N6548	D. González-Troncoso, A. Gago and A. Nogueira	Biomass and length distribution for roughhead grenadier, thorny skate and white hake from the surveys conducted by Spain in NAFO 3NO
SCR Doc. 16-013	N6550	A. Nogueira and D. González Troncoso	Results for capelin from the surveys conducted by Spain in the NAFO Regulatory Area of Div. 3NO, 1995-2015

SCR Doc. 16-014	N6551	R. Nygaard and O. A. Jørgensen	Biomass and Abundance of Demersal Fish Stocks off West and East Greenland estimated from the Greenland Institute of Natural resources Shrimp and Fish Survey, 1988-2015.
SCR Doc. 16-015	N6556	E. Román, C. González-Iglesias, D. González-Troncoso and M. Álvarez	Results for the Spanish Survey in the NAFO Regulatory Area of Division 3L for the period 2003-2015
SCR Doc. 16-016	N6557	E. Román, Á. Armesto, D. González-Troncoso and C. González-Iglesias	Results for the Atlantic cod, roughhead grenadier, redfish, thorny skate and black dogfish of the Spanish Survey in the NAFO Div. 3L for the period 2003-2015
SCR Doc. 16-017	N6558	M. Ouellet	Oceanography and Scientific Data NAFO Report 2015
SCR Doc. 16-018	N6559	M. Ringuette	Environmental conditions in the Labrador Sea During 2015
SCR Doc. 16-019	N6560	E. Colbourne, A. Perez-Rodriguez, A. Cabrero and G. Gonzalez-Nuevo	Physical Oceanographic Conditions on the Flemish Cap in NAFO Subdivision 3M during 2015.
SCR Doc. 16-020	N6563	R. Rideout	Spatial distribution patterns of NAFO demersal fish stocks based on data from the Canadian multi-species surveys of Divisions 2HJ3KLNO
SCR Doc. 16-021	N6564	D. González Troncoso	Calculation of the calibration factors for witch flounder and squid from the comparative experience between the R/V Cornide de Saavedra and the R/V Vizconde de Eza in Flemish Cap in 2003 and 2004
SCR Doc. 16-022	N6565	D. Garabana; P. Sampedro, R. Dominguez-Petit, C. Gonzalez-Iglesias, A. Villaverde, M. Álvarez, C. González-Tarrío, and M. Hermida	A review of NAFO 3LMN roughhead grenadier (Macrourus berglax Lacepède, 1801) reproductive biology including the evaluation of maturity ogive estimates
SCR Doc. 16-023	N6566	F. González-Costas, D. González-Troncoso and M. Mandado	Full benchmark review of the 3M cod assessment
SCR Doc. 16-024	N6567	R. Alpoim and D. González Troncoso	Results from Bottom Trawl Survey on Flemish Cap of June-July 2015
SCR Doc. 16-025	N6568	M.A. Treble	Report on Greenland halibut caught during the 2015 trawl survey in Divisions 0A and 0B
SCR Doc. 16-026	N6569	F. González-Costas	An assessment of NAFO roughhead grenadier Subarea 2 and 3 stock.
SCR Doc. 16-027	N6570	R. Nygaard	Trawl, gillnet and longline survey results from surveys conducted by the Greenland Institute og Natural Resources in NAFO Division 1A Inshore
SCR Doc. 16-028	N6571	D. Power, D.W. Ings, R.M. Rideout , and B.P. Healey	Performance and description of Canadian multi-species bottom trawl surveys in NAFO subarea 2 + Divisions 3KLMNO, with emphasis on 2014-2015
SCR Doc. 16-029	N6572	O.A. Jørgensen and M.A. Treble	Assessment of the Greenland Halibut Stock Component in NAFO Subarea 0 +Division 1A Offshore + Divisions 1B-1F

SCR Doc. 16-030	N6573	K. Dwyer, R. Rideout, D. Ings, D. Power, J. Morgan, B. Brodie, and B.P. Healey	Assessment of American Plaice in Div. 3LNO
SCR Doc. 16-031	N6574	D. W. Ings, D. Power and R.M. Rideout	An Assessment of the Status of Redfish in NAFO Division 3O
SCR Doc. 16-032	N6575	M.R. Simpson, C.M. Miri, and R.K. Collins	Assessment of Thorny Skate (Amblyraja radiata Donovan, 1808) in NAFO Divisions 3LNO and Subdivision 3Ps
SCR Doc. 16-033	N6576	A. M. Ávila de Melo, Nuno Brites, R. Alpoim, D. González Troncoso, F. González and K. Fomin	A Revised Update of the 2014 ASPIC Assessment of Redfish (*S. mentella and S. fasciatus*) in Divisions 3LN (*how the the stock is coping with the actual Management Strategy and its likely impact on the next coming years*)
SCR Doc. 16-034	N6577	L. C. Hendrickson and M. A. Showell	Assessment of Northern Shortfin Squid (Illex illecebrosus) in Subareas 3+4 for 2015
SCR Doc. 16-035	N6578	A. Pérez-Rodríguez, D. Howell, M. Casas, F. Saborido-Rey, Antonio Ávila-de Melo, F. González-Costas, D. González-Troncoso	GadCap: A GADGET multispecies model for the Flemish Cap cod, redfish and shrimp.
SCR Doc. 16-036	N6579	V. Korzhev and M. Pochtar	Optimization of redfish fishery on the Flemish Cap Bank using biological target reference points
SCR Doc. 16-037	N6582	R. Nygaard	An assessment of Greenland Halibut Stock Component in NAFO Division 1A Inshore.
SCR Doc. 16-038	N6583	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. 16-039	N6585	D. Power	Standardized Catch Rate Indices for Greenland Halibut in SA2+3KLMNO
SCR Doc. 16-040	N6586	D. González Troncoso, A. Nogueira and R. Alpoim	Effect in mean catch and biomass index of removing stations in the closed Coral, Sponge and Seapen Protection Areas in the design of the EU Flemish Cap survey

SCS Documents			
Doc No.	**Serial No**	**Author**	**Title**
SCS Doc. 16-01	N6528	NAFO	Fisheries Commission's Request for Scientific Advice on Management in 2017 and Beyond of Certain Stocks in Subareas 2, 3 and 4 and Other Matters
SCS Doc. 16-02	N6529	NAFO	Scientific Council Subgroup on the Implications of Removing Fishery Surveys from VME Closed AreasNAFO
SCS Doc. 16-03	N6530	NAFO	Greenland Request
SCS Doc. 16-04	N6533	NAFO	Canada Request
SCS Doc. 16-05	N6539	F. González-Costas, G. Ramilo, E. Román, A. Gago, M. Casas1, M. Sacau1, E. Guijarro D. González-Troncoso and. J. Lorenzo	Spanish Research Report for 2015
SCS Doc. 16-06	N6552	K.A. Sosebee	US Research Report
SCS Doc. 16-07	N6553	Greenland Institute of Natural Resources	Denmark/Greenland Research Report for 2015
SCS Doc. 16-08	N6554	T.Tõrra, S.Sirp and K.Hubel	Estonian Research Report for 2015
SCS Doc. 16-09	N6555	J. Vargas, R. Alpoim, E. Santos and A. M. Ávila de Melo	Portuguese Research Report for 2015
SCS Doc. 16-10	N6562	K. Fomin and M.Pochtar	Russian Research Report
SCS Doc. 16-11	N6580	NAFO	Reported Tagging in the NW Atlantic 2015
SCS Doc. 16-12	N6581	E. Parrill	Canadian Research Report for 2015 Newfoundland and Labrador Region
SCS Doc. 16-13	N6584		Inventory of Biological Surveys for 2015

APPENDIX VII. LIST OF PARTICPANTS, 03 – 16 JUNE 2016

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ANNEX VIII.- FULL SAI ASSESSMENT

ToR 4. Update on recent and relevant research related to the application of ecosystem knowledge for fisheries management in the NAFO area.

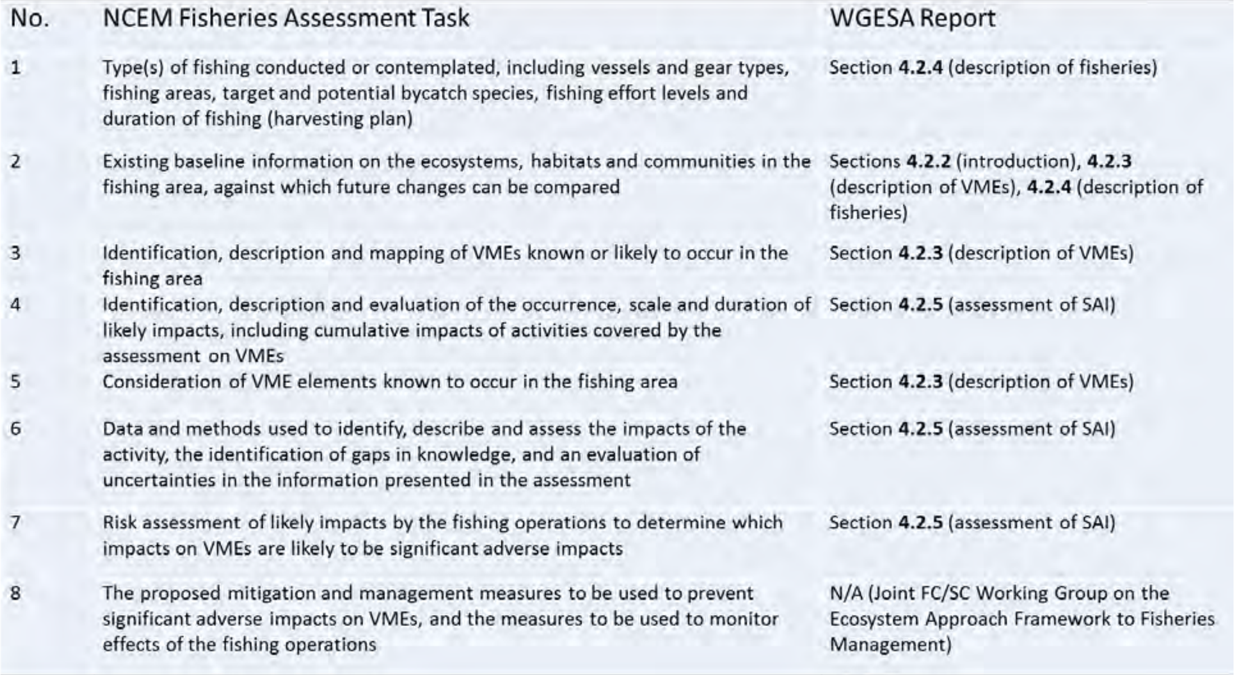
ToR 4.2. [FC Request #4]. Continue to develop work on Significant Adverse Impacts in support of the reassessment of NAFO bottom fishing activities required in 2016, specifically an assessment of the risk associated with bottom fishing activities on known and predicted VME species and elements in the NRA.

4.2.1. Background to the assessment

In 2012 WGESA was tasked with drafting a work plan for the reassessment of NAFO fisheries in 2016. Specifically, WGESA was requested by NAFO Fisheries Commission to provide guidance on how achieve the reassessment of all NAFO fisheries by September 2016 and every 5 years thereafter, identifying the necessary steps to be taken, as well as the information and resources to do so.

The requirement for the assessment of bottom fishing activities in the NAFO regulatory area (NRA) was broadly defined in the NAFO Conservation and Enforcement Measures (NCEM; NAFO/FC Doc 13/1), which sets out a number of issues to be addressed by the assessment, these in turn have been addressed in the present report as requested by Fisheries Commission in 2015 (see Table 4.2.1.1).

Table 4.2.1.1. NCEM bottom fisheries assessment issues and relevant sections of the present report in which they are addressed.



No.	NCEM Fisheries Assessment Task	WGESA Report
1	Type(s) of fishing conducted or contemplated, including vessels and gear types, fishing areas, target and potential bycatch species, fishing effort levels and duration of fishing (harvesting plan)	Section **4.2.4** (description of fisheries)
2	Existing baseline information on the ecosystems, habitats and communities in the fishing area, against which future changes can be compared	Sections **4.2.2** (introduction), **4.2.3** (description of VMEs), **4.2.4** (description of fisheries)
3	Identification, description and mapping of VMEs known or likely to occur in the fishing area	Section **4.2.3** (description of VMEs)
4	Identification, description and evaluation of the occurrence, scale and duration of likely impacts, including cumulative impacts of activities covered by the assessment on VMEs	Section **4.2.5** (assessment of SAI)
5	Consideration of VME elements known to occur in the fishing area	Section **4.2.3** (description of VMEs)
6	Data and methods used to identify, describe and assess the impacts of the activity, the identification of gaps in knowledge, and an evaluation of uncertainties in the information presented in the assessment	Section **4.2.5** (assessment of SAI)
7	Risk assessment of likely impacts by the fishing operations to determine which impacts on VMEs are likely to be significant adverse impacts	Section **4.2.5** (assessment of SAI)
8	The proposed mitigation and management measures to be used to prevent significant adverse impacts on VMEs, and the measures to be used to monitor effects of the fishing operations	N/A (Joint FC/SC Working Group on the Ecosystem Approach Framework to Fisheries Management)

The focus of the assessment is therefore on evaluating the risks of Significant Adverse Impacts (SAI) on Vulnerable Marine Ecosystems (VMEs) by bottom fishing activities. As such, the review of VME fishery closures conducted for NAFO in 2014 (SC Ref), combined with the latest data and information on bottom fisheries activities provides the basis for this assessment.

The content of the report is set out in four sections; dealing with: **4.2.2** introduction (summary of environment and general ecosystem background information), **4.2.3** description of VMEs to be assessed, **4.2.4** description of the fisheries, and finally, **4.2.5** A provisional assessment of SAI.

4.2.2. Introduction

4.2.2.1 Oceanographic conditions in the NRA

The NRA is influenced principally by two major ocean currents: the southward flowing Labrador Current to the east of the Newfoundland Shelf and Grand Banks and north of the Flemish Cap, and the North Atlantic Current which represents the bulk continuation of the warm Gulf Stream, flowing in an east-north easterly direction to the south and east of the Flemish Cap (Stein 2007).

The Labrador Current is a continuation of the Baffin Bay current, which carries cold and relatively low salinity waters of Arctic origin, with two main branches. The small inshore branch carries approximately 15% of the water transport and hugs the coast of Newfoundland and is unlikely to influence the Cap, whereas the offshore branch follows along the shelf-break. The offshore branch of the Labrador Current splits north of the Flemish Cap, with the main branch flowing through Flemish Pass, east of the Cap and along the eastern side of the Grand Banks, where it is reduced to a width of 50 km and a flow of 30 cm s^{-1} while the weaker side-branch flows in clockwise around the northern and western side of the Cap (Petrie and Anderson, 1983; Stein, 2007). Geostrophic calculations reveal that the body of the Labrador Current reaches a depth of 250-300 m in the Flemish Pass and that the side-branch reaches a depth of ~200 m (Maillet and Colbourne, 2007). According to Stein (2007), the lower end of temperature-salinity profiles of the Labrador Current in the Flemish Pass is achieved at a temperature of 3.3°C and a salinity of 34.8 at a depth of 800 m, while in the side-branch this is achieved a temperature of 3.5°C and a salinity of 34.8 at a depth of 610 m.

The North Atlantic Current is comprised of a combination of cold Slope Water Current and Warm Gulf Stream waters (Mann, 1967). Krauss et al. (1976) found that the North Atlantic Current generally looped around the northwest corner of the Flemish Cap after which it turns in an easterly direction, but in some circumstances meanders from the Current can result in significant easterly flow before it reaches the Flemish Cap. The lower end of the temperature-salinity profile is achieved at 1.69°C and salinity of 34.92 at a depth of 4025 m (Stein, 2007).

Temperature profiles reveal that waters in areas west and north of the Flemish Cap are similar to conditions found in the Labrador Current and Labrador Sea, with relatively weak horizontal gradients. In contrast, conditions Flemish Pass and along the southern edge of the Grand Banks show strong horizontal gradients in temperature profiles, indicative of the contrast between the side-branch of the Labrador Current the North Atlantic Current. The mean position of the frontal zone is relatively stable throughout the year (Stein, 2007). At the surface, the contrast between Labrador Current and North Atlantic Current waters may be of the order of ~10°C based on Stein's (2007) analyses, while at depth waters surrounding the Cap on all sides are near 4°C. Waters associated with the Labrador Current have slightly higher concentrations of nitrate, silicate and oxygen than those associated with the North Atlantic Current (Maillet et al., 2005).

4.2.2.2. Ecosystems

The Flemish Cap ecosystem is highly isolated in relation to the near Grand Bank and Newfoundland shelf systems. The Flemish Pass, a channel with depth of c. 1100 m, hinders the migration of the shallower benthic and demersal fish populations (but not deep water dwelling species) between the cap and the banks, while the quasi-permanent oceanic anti-cyclonic gyre (Colbourne and Foote, 2000) retains eggs and larvae over the cap that will eventually recruit to the Flemish Cap populations.

Primary production is high over the Flemish Cap (Berger et al., 1989), which is related with the existence of a consistently elevated concentration of nutrients on the Flemish Cap, very likely due to the entrance of water from the North Atlantic current and advective and mixing processes (Maillet, 2005). This high production supports a high secondary production, with copepods as the main zooplankton group (*Calanus finmarchicus* is the most important Copepod species in terms of biomass, while in terms of numbers, cyclopoid copepods like those of genus *Oithona* are of higher importance). Other important groups in the zooplankton community are euphausiids, hyperiid amphipods, chaetognaths or ctenophors (Anderson, 1990).

4.2.2.3. Habitats

The most notable of benthic habitats found on the seabed within the NRA are those that are biogenic in origin, such as sponge and coral grounds, and aggregations of emergent fauna such as sea pens, which collectively can alter local conditions and provide refuge, food or a settling surface for other organisms. Collectively, such habitats are considered to be VMEs, especially when they are likely to interact with fishing activities.

As part of the Canadian contribution to the international NEREIDA research programme to characterize VMEs in the NRA, in 2009 the Department of Fisheries and Oceans Canada (DFO) collected in situ benthic imagery transects on the western Flemish Cap slope and Flemish Pass, and on Sackville Spur. These image transects were analysed for the diversity and abundance of epibenthic megafauna, i.e. epifauna that are ≥1 cm. The acquired data were subsequently analysed to determine the influence of structure-forming sponge VME on the abundance, composition, and diversity of the epibenthic megafaunal community in both the Flemish Pass/western Flemish Cap slope and on Sackville Spur. The relative importance of structure-forming sponge VME in influencing the associated epibenthic community was assessed against several environmental variables within each area. The results of these analyses have been published in the primary literature (Beazley et al., 2013 and 2015). These studies revealed diverse epibenthic communities in both areas dominated by large numbers of sponges and ophiuroid brittle stars. Beazley et al. (2013) found that in the Flemish Pass/western Flemish Cap slope, the presence of structure-forming sponge VME was associated with a higher abundance, diversity, and different composition of megafauna compared to areas lacking these sponges. Similarly, Beazley et al. (2015) found that of 49 physical drivers, the abundance of structure-forming sponges was the most important determinant of megafaunal composition on the Sackville Spur. The authors suggest that the sponge grounds of the Sackville Spur are associated with a warm, salty water mass that lies over the seabed between c. 1300 and 1800 m depth.

4.2.2.4. Communities

Fish

During the European Union fisheries surveys conducted yearly between 1988 and 2014, 129 fish species were identified, 65 of them considered demersal based in FishBase information (www.fishbase.org). As an average value, since 1960, 99% of the declared annual catches corresponded to demersal fish species. This fact points to the demersal dominance of the Flemish Cap fish assemblage. Unlike on the Newfoundland Shelf, pelagic species, such as capelin, herring and sandlance only occasionally appear in the Flemish Cap. Owing to the relatively high mean depth of the bank, the most important pelagic fishes found there belong to the order Myctophidae, especially *Myctophum punctatum*, *Ceratoscopelus maderensis* and *Benthosema glaciale* (Poletayev, 1980). In conctrast, as shown by Alpoim et al. (2002), the most diverse fish orders in the Flemish Cap were the Rajiformes, Stomiiformes, Gadiformes, Osmeriformes, Perciformes and Scorpaeniformes, although from a fisheries point of view the most important species were Pleuronectiformes (American plaice and Greenland halibut), Gadiformes (cod and roughead grenadier) and Scorpaeniformes (redfish species).

Across the same 1988-2014 period, the most abundant demersal species were cod, redfish, Northern shrimp and Greenland halibut, all accounting, as an average, for 83.5% of total index of biomass every year. After the collapse of cod population in the early 1990s, the demersal community experienced very important variations (Pérez-Rodríguez et al., 2011). Among the most important variations: (1) shrimp experienced a marked increase since 1993 and reached the highest levels ever observed in the late 1990s; (2) after 2003 the redfish stocks showed a rise in their biomass, which was followed by the decline of shrimp population; and (3) the decline of shrimp as well as redfish stocks became even more pronounced with the recovery of cod population, which, after various successful recruitment events since 2006, reached to the levels of biomass observed in the late 1980s. Water temperature, along with predation and fishing mortality were significant drivers for these changes (Pérez-Rodríguez et al. 2011). The abundance of low abundance demersal species was related with water temperature, with a transition in the species composition between cold and warm periods.

Epibenthos

The structure, composition and distribution of epibenthic invertebrate megafaunal assemblages in the international waters on the NRA have been investigated based on the analysis of trawl samples collected between 45 and 1400 m and 135 and 1500 m water depth respectively, and the key factors that shape their spatial distribution were identified.

In total, 287 depth-stratified random trawls were processed and all epibenthic invertebrate fauna retained by the nets were identified to the lowest possible taxonomic level, counted when possible and weighed. Faunal groups were identified using clustering algorithms based on species presence/absence and de-trended correspondence analysis was used to ordinate the species data and correlate it with the abiotic variables. The role of regional variables, such as depth, substrate type, water temperature and salinity, in shaping benthic community composition was also examined. Lastly, the relationship between recent (2001-2009) fishing intensity and benthic community structure was quantified.

Benthic biomass was dominated by Echinodermata and Porifera, owing to the presence of large-bodied species in each of these groups. In all, 439 benthic invertebrates were identified, 321 from the Tail of the Grand Bank and 288 from the Flemish Cap. The maximum number of species was found along the continental slope in both areas. A clear separation between three large groups of benthic fauna based on bathymetry and spatial distribution was found at major partitions: (1) the continental shelf of the Tail of the Grand Bank, typified by the echinoderms *Cucumaria frondosa*, and *Echinarachnius parma*; (2) the upper slope of the Grand Bank and top of Flemish Cap, typified by the sponges *Radiella hemisphaerica*, and *Iophon piceum* and by the sea star *Ceramaster granularis*; and (3) the lower slope of the Grand Bank and Flemish Cap, typified by the sea urchin *Phormosoma placenta* and the sea pens *Anthoptilum grandiflorum* and *Funiculina quadrangularis*. At minor partitions, depth and sediment type related to the oceanographic conditions were important determinants. The assemblages found showed a similar pattern to the fish assemblages described in this area where the major clusters were "associated" with bottom depth and oceanographic features. High fishing was associated with the clusters with the least spatial cohesion which may reflect the different pressures exerted on this anthropogenic driver from those of the environmental factors which shape the majority of the assemblages. These findings fill an important gap in knowledge of benthic communities in this area of the northwest Atlantic Ocean; they are covered in greater detail by Murillo et al. (submitted).

Infauna

The infaunal community within the NRA has been investigated by analysing box-core samples collected during the NEREIDA sampling programme in 2009-10, aboard the Spanish research vessel *Miguel Oliver*. Findings from these analyses conducted at a coarse level of taxonomic resolution have been published in Barrio Froján et al. (2015), whilst work identifying organisms at a finer taxonomic scale is still ongoing for selected taxonomic groups.

4.2.2.5. Description of ecosystem production units

Ecosystems are not homogenous; they are organized in a hierarchical way, where different physical and biological processes operate at different spatial scales. It is the integration of these processes in space and time what defines a functional system, where trophic interactions are main mechanism for transfer of energy among the different biological populations. From this functional perspective, three spatial scales have been identified as relevant for the development of ecosystem summaries and ecosystem-level management plans: Bioregion, Ecosystem Production Units (EPUs), and Ecoregion (DFO 2014, 2015). The EPU is the spatial scale considered more appropriate for integrated fisheries management plans because it defines a major geographical subunit within a Bioregion characterized by distinct productivity and a reasonably well defined major marine community/food web system.

Current analyses in the NAFO Convention area have been focused on continental shelves ecosystems from the northern Labrador to the Mid-Atlantic Bight, and have allowed identifying four major Bioregions (Newfoundland and Labrador Shelves, Flemish Cap, Scotian Shelf and Northeast US Continental Shelf) (NAFO 2014, 2015, Pepin et al. 2014). From these bioregions, only two extend into the NRA. The Flemish Cap Bioregion is entirely within the NRA, and the Newfoundland and Labrador Shelves Bioregion extend beyond Canada's EEZ into the NRA in the areas known as the Nose and Tail of the Grand Bank.

In terms of EPUs, the Flemish Cap Bioregion contains a single EPU (i.e. bioregion and EPU are the same, the shelf area within NAFO Div. 3M), while three EPUs have been properly identified in the Newfoundland and Labrador Shelves Bioregion: the Labrador Shelf EPU (shelf area within NAFO Divs 2GH), the Newfoundland Shelf EPU (shelf area within NAFO Divs 2J3K), and the Grand Bank EPU (shelf area within NAFO Divs 3LNO) (NAFO 2014, 2015, Pepin et al. 2014). Based on preliminary analyses, a fourth EPU in this bioregion can be associated with the shelf area in NAFO Subdiv. 3Ps. On this basis, only two continental shelf EPUs are in the NRA, the Flemish Cap and the Grand Bank. The first one is entirely within the NAFO fishing footprint, while only the Nose and Tail from the Grand Bank EPU are part of the NAFO footprint.

Comparative analysis of the productivity of these two EPUs and overall fishing levels indicate that these ecosystem units have been overfished in the past, with more severe overfishing levels in the Grand Bank EPU (Koen-Alonso et al. 2013, NAFO 2014). These EPUs experienced major changes in their fish communities during the last decades (NAFO 2010, Koen-Alonso et al. 2010, Pérez-Rodriguez 2012). In the case of the Grand Bank EPU, these changes are associated to a regime shift that has been formally recognized for the Newfoundland and Labrador Shelves Bioregion during the 1990s (Buren et al. 2014). As a consequence of these changes, it is believed that the fisheries productivity of the Grand Bank EPU remains impaired until this day (NAFO 2014, 2015).

Taking into account current catches and productivity level, both EPUs can be considered fully exploited at the present time. The Flemish Cap productivity does not appear impaired, so this EPU is being exploited at its maximum potential. The current Grand Bank EPU fisheries productivity is estimated to be around 50% of its maximum potential, suggesting that rebuilding the functionality of this EPU could allow doubling current catch levels (NAFO 2014, 2015).

4.2.3. Description of vulnerable marine ecosystems

The description of VMEs in this section is in relation to the assessment of potential significant adverse impacts (SAI) on VMEs within the NAFO footprint of bottom fisheries (see Section 4). A full description of all VMEs and VME elements in the NRA can be found in NAFO SCS Doc. 13/024 (NAFO, 2013), including those VME elements not included in the present assessment on account of there being no bottom fishing activities operating in those areas (e.g., seamounts).

4.2.3.1. Defining, recognising and mapping VME

NAFO has identified 8 categories of VME, namely sponge grounds, large gorgonian corals, small gorgonian corals, sea pens, erect bryozoans, large sea squirts, cerianthid anemones, and crinoids (NAFO, 2014). These taxa were selected after a review of all invertebrate by-catch species taken in research vessel surveys, following the FAO International Guidelines for the Management of Deep-sea Fisheries in the High Seas (FAO, 2009), which provide general tools and considerations for the identification of VMEs. These VME categories are characterized by populations or assemblages of species with one or more of the following characteristics: slow growth rates, late age of maturity, low or unpredictable recruitment, or long-lived. In addition, they all create structural complexity through the provision of habitat for other species, and are characterized by complex physical structures. In these ecosystems, ecological processes can be highly dependent on these structured systems. Further, such ecosystems often have high diversity, which is dependent on the structuring organisms. This has been established for the sponge grounds in the NRA which have been shown to support increased biodiversity compared with non-sponge ground habitat (Beazley et al., 2013; Beazley et al. 2015).

NAFO Scientific Council has adopted formal definitions for many of the terms used in the FAO Guidelines (NAFO, 2014). There, VME are defined as “Under the structure-forming criterion, a VME is a regional habitat that contains VME indicator species at or above significant concentration levels. These habitats are structurally complex, characterized by higher diversities and/or different benthic communities, and provide a platform for ecosystem functions/processes closely linked to these characteristics.” (NAFO, 2013).

NAFO Scientific Council has used quantitative methods to determine the distribution of VME indicator species and define the extent of the VME. The spatial scale of these habitats is often larger than the footprint of a higher concentration observation. The primary tool used to quantitatively determine VMEs is kernel density analysis (KDE; Kenchington et al., 2014). This analysis identifies “hotspots” in the biomass distribution derived from research vessel trawl survey data, by looking at natural breaks in the spatial distribution associated with changes in local density (Figure 4.2.3.1.1). These natural breaks allow defining of significant area polygons. There is minimal interpolation to unsampled areas in this type of analysis (as opposed to species distribution modelling). However, it is recognized that the boundaries of the polygons can be influenced by the search radius used as well as the spatial distribution of the data (Kenchington et al., 2014) and that ecological knowledge (environmental niches) can further refine the polygon boundaries. Consequently, ground-truthing of candidate areas for protection has been recommended (Kenchington et al., 2014).

Experience in WGESA has shown that the KDE as applied to the data available in the NRA, is a robust method for identifying coral and sponge VME. New survey data acquired in subsequent years typically falls within the existing kernel boundaries. Further ground-truthing with benthic camera systems has consistently identified coral and sponge habitats within the KDE polygon boundaries. However, the patch size of erect bryozoans and large sea squirts is smaller than that of the tow length where they are found on the tail of Grand Bank. These taxa are known to attach to hard substrate and likely form aggregations (significant catches) in areas where suitable habitat is found. For these, the KDE polygons are much larger than the VME and the WGESA has recommended that conservation of these VMEs be achieved through protection of the individual tows, rather than the more expansive KDE polygon.

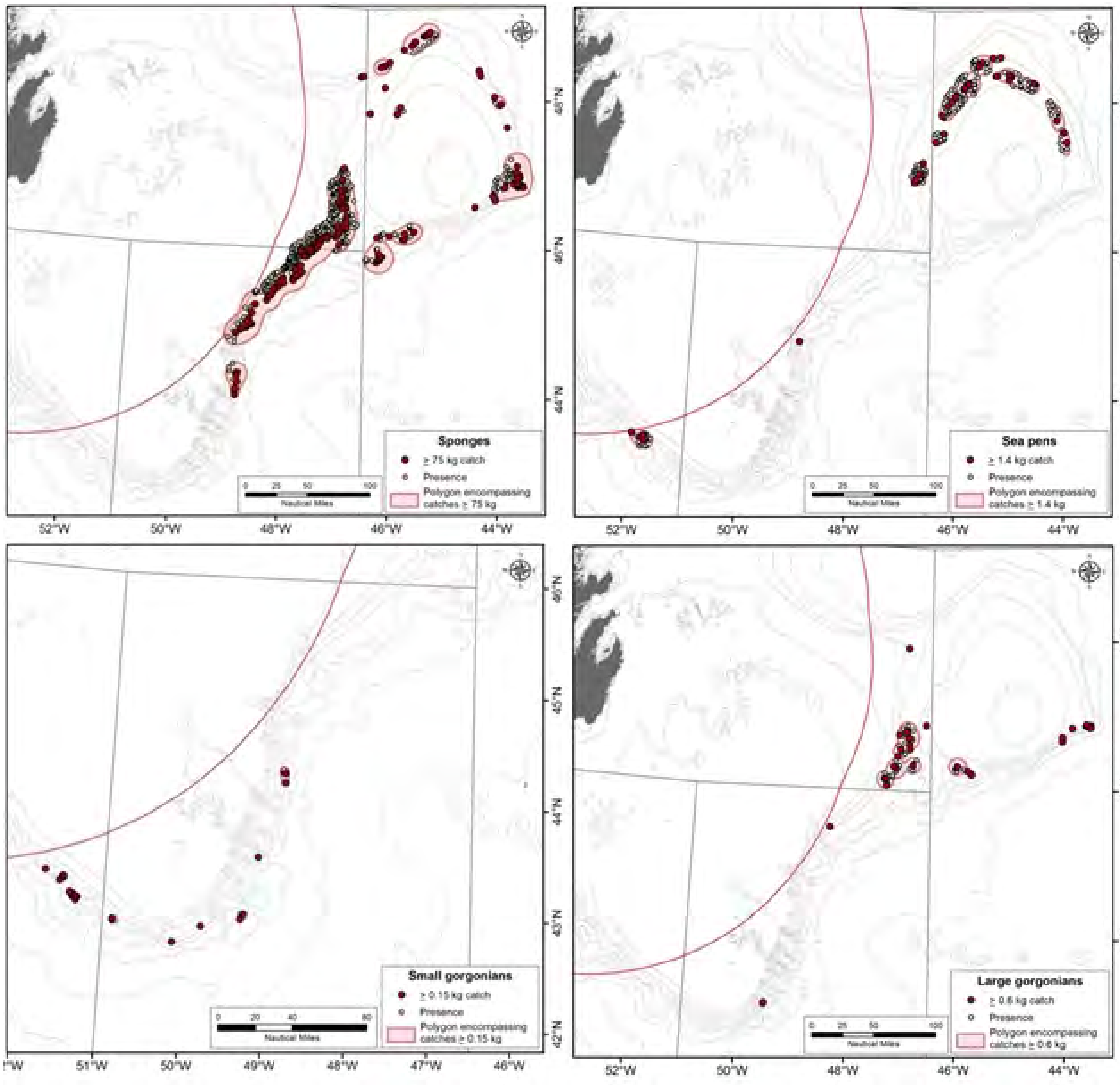


Fig. 4.2.3.1.1. Location of kernel density-derived polygons for sponges, sea pens, small and large gorgonian corals used for the assessment of SAI.

The starting point for the assessment of SAI by members of the WGESA was the KDE polygons produced for the review of the closed areas in 2014 (NAFO, 2013); this approach was endorsed by the SC at its June meeting (NAFO, 2014). The Cerianthid anemones, erect bryozoans and large sea squirts must be assessed for SAI based on the location of individual RV trawls where large catches were taken. For the former there is no quantitative criterion for defining "large catches" but for the others, the KDE can be used to identify significant concentrations (NAFO, 2013).

4.2.3.2. Modified VME polygon boundaries

The KDE method of mapping VME extent (described above) does not explicitly take into account the known data on habitat characteristics associated with the VMEs. As such it was recommended by NAFO Scientific Council in June 2015 that environmental data should be included in the species distribution modelling. Random forest-generated presence/absence species distribution models have been produced for some of the VME indicators; namely: sponge grounds (Knudby et al., 2013a), large gorgonian corals, sea pens and the black corals (Knudby et al., 2013b), in the NAFO regulatory area using a suite of 10 (sponges) and 23 environmental variables (NAFO, 2014). All models performed well, producing cross-validated AUC values of 0.982, 0.937, 0.885 and 0.888 respectively. Prediction surfaces for the three species groups produced clearly-defined areas of high occurrence probability. Those models used a suite of model-based environmental variables describing seasonal chlorophyll-a, surface and bottom sea temperature and salinity, currents, and bottom shear, as well as depth and slope. The interpolated variables and the distribution models were evaluated with independent data (CTD, NEREIDA box core data, seafloor imagery) to the extent possible.

Downie (2015) presented new random forest models of biomass which focused on benthic variables derived from the NEREIDA surveys. She used multibeam echosounder bathymetry gridded to 75 m cell size to derive a number of derivative spatial data layers describing topographic attributes from the bathymetry. These included bathymetric roughness and standard deviation (calculated within a 3-cell neighbourhood) and rugosity (calculated within a 5-cell neighbourhood). Eastness and northness described the main direction (aspect) of the slope, whilst the Bathymetric Position Index (BPI), described the elevation of each cell in relation to the average in the specified neighbourhood (Downie, 2015). Layers describing sediment composition, namely the percentage values of sand, clay, silt and organic carbon, were produced from 314 box core Particle Size Analysis (PSA) samples (Downie, 2015), although the WG recalled the issues of interpolating such data given the need to consider surficial features such as slumping etc. that occur between data points. Therefore, these variables used a different set of predictor variables from those used previously. Models for sea pens and sponges achieved R^2 values of 0.38, the model for large gorgonians, however, only had an R^2 value of 0.04, indicating very low correlation between predicted and observed values and hence resulted in a poor model that was not used further. That of sea pens was consistent with the KDE and SDM models used previously, but due to the reliance on the multibeam data did not model the full extent of sea pen distribution. That of the sponges was very consistent with previous work (Downie, 2015).

The WGESA used the previously published species distribution model (SDM) outputs to refine the KDE polygons, although it considered the new results of Downie (2015) for each taxon where appropriate. Quantitative methods were used to determine the probability cut offs. For unbalanced species distribution models with unequal numbers of presence and absence, species frequency is termed prevalence, and prevalence in samples should be similar to natural species prevalence, for unbiased samples. Predicted probabilities vary with prevalence or species frequency (Hanberry & He, 2013), which has been recognized under the name of the "unbalanced sample effect" (Hosmer & Lemeshow, 1989). In order to avoid this effect in species distribution modelling, some authors have recommended balancing the modelling prevalence (McPherson et al., 2004; Liu et al., 2005). However, in the case of reliable training data such as that used here from the research vessel surveys, which are neither spatially nor environmentally biased, resampling should be avoided because it would yield a loss of information, especially for rare species with scarce reliable data (Jiménez-Valverde & Lobo, 2006). In addition, Hanberrry & He (2013) found that the use of sampling prevalence produced similar models compared to use of adjusted modelling prevalences. Therefore, they do not recommend balancing the modelling prevalence and propose instead to retain a threshold or cut-off value that is similar to prevalence to maintain fairly constant the error rates (similar to reported by Liu et al. (2005) and Jiménez-Valverde & Lobo (2006)). That is the approach adopted here, and the prevalence values for the sponge grounds, sea pens and large gorgonians used in the species distribution models are provided in 4.2.3.2.1.

Table 4.2.3.2.1. Prevalence values for use as cut-offs in probabilities from Species Distribution Models.

	Presence	Absence	Prevalence
Sponge grounds	150	3455	0.042
Sea pens	1327	2183	0.378
Large gorgonians	214	3192	0.063

The approach adopted by WGESA to modify the KDE boundaries used a combination of SDM models, which incorporate environmental data to predict species distributions, as shown in Table 4.2.3.2.2.

For example, the two corresponding sponge habitat-based SDM model outputs (Knudby et al 2013a and Downie 2015) were overlaid onto the KDE sponge VME polygon (Kenchington et al 2014) and a revised KDE polygon boundary was redrawn around the extent of the SDM models combined (Figure 4.2.3.2.1).

Research vessel tows from within the sponge polygons show that there were very small catches of sponges in the zone predicted to have no sponge (Downie, 2015) or sponge grounds (Knudby et al., 2013a). This was done for all of the KDE polygons for sponge grounds and large gorgonian corals (Knudby et al., 2013b). The sea pens were all in high prevalence areas, and the Downie (2015) models showed that these areas, in so much as they had the same spatial extent, support high biomass. Therefore, the existing KDE polygons were used for the sea pens VMEs without any changes to their boundaries. The revised polygon boundaries for sponge and sea pen VME are shown in Figure 4.2.3.2.2.

Table 4.2.3.2.2. Models used to revise the KDE VME polygon boundaries.

VMEs	Models used for the modification of VME polygon boundaries
Sponge	Biomass SDM (Downie, 2015), Presence/absence SDM (Knudby et al 2013a), KDE (Kenchington et al, 2014)
Sea pen	Biomass SDM (Downie, 2015), Presence/absence SDM (Knudby et al 2013a), KDE (Kenchington et al, 2014)
Large gorgonian	Presence/absence SDM (Knudby et al 2013a), KDE (Kenchington et al, 2014)

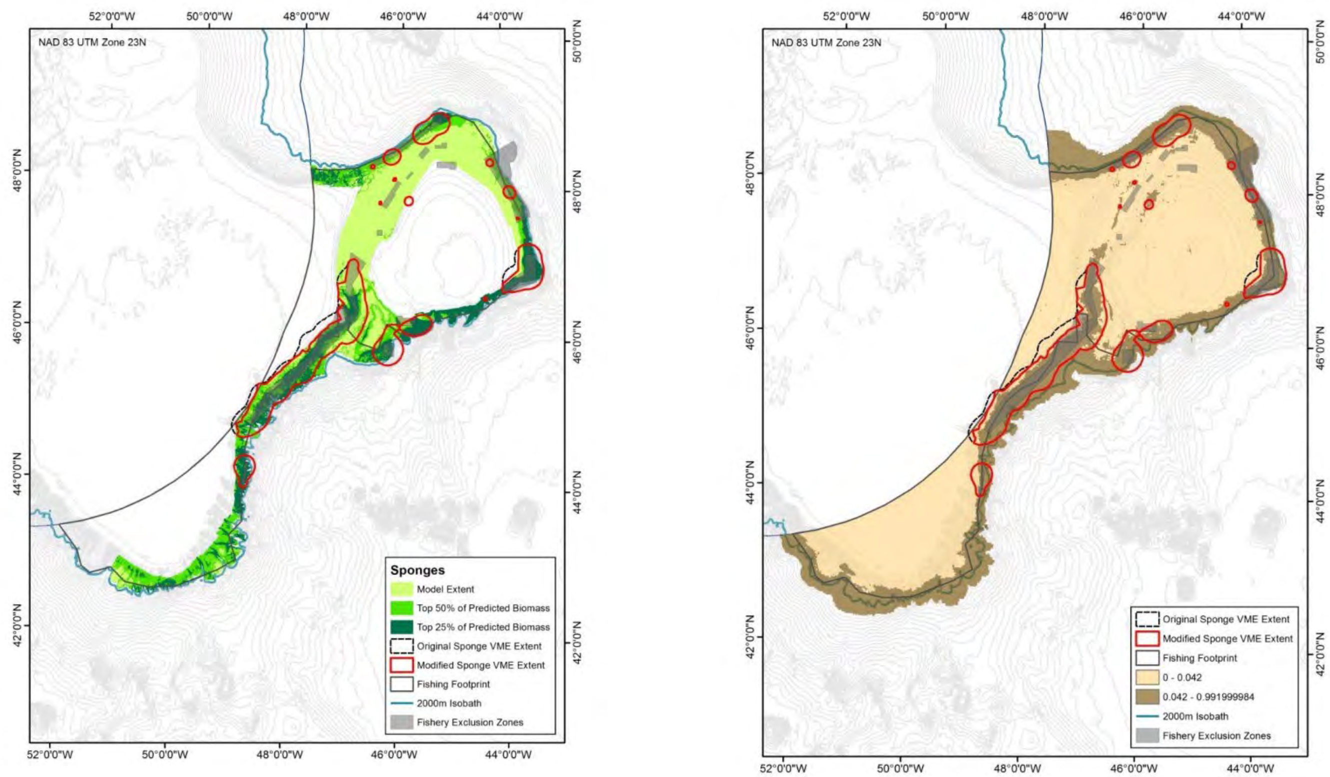


Fig. 4.2.3.2.1. (left panel). Sponge predicted biomass using all sponge data from survey trawls sampled in areas not subject to fishing activity (Downie, 2015). (right panel). Sponge predicted model using presence/absence of significant sponge concentration data from surveys trawls (Knudby et al., 2013a).

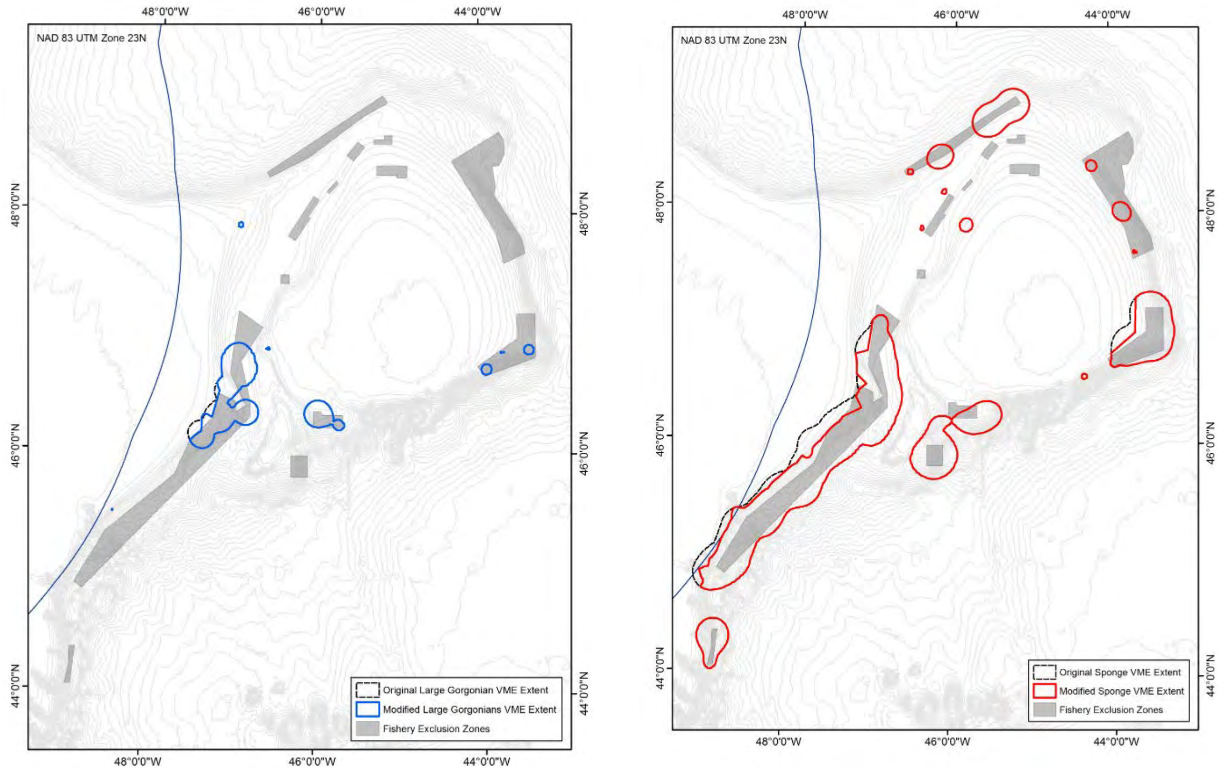


Fig.4.2.3.2.2. Modified Kernel density-derived polygons for sponge ground and large gorgonian VMEs (sea pens did not change from the KDE analysis). Grey areas indicate coral and sponge closed areas as of January 1, 2016.

4.2.4 Classification of fisheries and distribution of effort in the NRA

4.2.4.1. Description of the fisheries in the NRA

Within the NRA there are three main classes of fisheries: groundfish (GRO - primarily in Div. 3KLMNO), shrimp (PRA - primarily in Div. 3LM) and pelagic redfish (REB - primarily in Div. 1F and 2J). In 2014, WGESA used the Daily Catch Records (DCR) and Vessel Monitoring System (VMS) as the data sources and used the adopted NCEM definition of a directed fishery (NCEM Art. 5.2) to provide a basis to classify various fisheries.

It is recognized that different directed fisheries should exert different levels of effort as well as proximity to known and predicted VME species and elements in the NRA. In many cases, one-to-one matching of the data sources is not possible because DCR are reported per day and VMS per hour. The difficulty is that several hauls can be conducted in one day that could span different directed fisheries. Therefore, it was decided to classify the fishing activities into groups of directed fisheries that are conducted in a similar spatial areas and depth zones.

The use of the VMS data required some assumptions to be made for determining a 'trawling' event from all other possibilities that could exist when the VMS data is transmitted (e.g., vessel was steaming, weather bound). In this regard, the data were aggregated by a grid bounded by 0.05 degree of latitude and 0.05 degree of longitude where the reported speed was between 0.5 kts to 5.0 kts.

Considering their target species/stock, main area of operation and gear, a total of 11 operational fisheries have been initially identified for consideration in the analyses towards the Reassessment of Bottom Fishing Activities (Table 4.2.4.3.1).

The maps of fishing effort produced to date by WGESA were updated to include the 2014 VMS data. Information on bycatch was extracted and summarized for 2015 based on the provisional logbook information from January to September from those fleets that have sent the data to the NAFO Secretariat. It was noted that the reporting procedure for logbooks in 2015 only required data recording of the top three species which may complicate the interpretation of bycatch percentages in directed fisheries. There was insufficient time at this meeting to map fishing effort based on the recorded start and end positions of tows due to formatting issues amongst the data submissions.

Bottom fisheries not managed under the NAFO convention (eg. snow crab, surf clam), and small-scale fisheries for which NAFO does not set a TAC (e.g. longlining for Atlantic halibut), were not included in the SAI analyses(see Section 4), WGESA did review the spatial information available on their fishing footprint and such fisheries were not considered an important source of SAI as they did not overlap with VMEs. In addition, the redfish fisheries in Div 1F, 2J and 3K, and the *Alfonsino* fisheries on seamounts in Div. 6G were not described herein as they use midwater trawls and not the bottom-contact fishing gears for which the UNGA resolutions call for assessments.

Table 4.2.4.3.1. Operational fisheries identified in the NRA for consideration in the process of developing the Reassessment of Bottom Fishing Activities.

Fishery	Target Species	Main Area of Operation	Gear
Greenland Halibut Fishery	Greenland halibut	NAFO Divs 3LMNO	Bottom otter trawl
3M Redfish Fishery	Redfish	NAFO Div. 3M	Bottom otter trawl
3M Shrimp Fishery (under moratorium)	Shrimp	NAFO Div. 3M	Bottom otter trawl
3M Trawl Cod Fishery	Atlantic Cod	NAFO Div. 3M	Bottom otter trawl and paired bottom trawls
3M Longline Cod Fishery	Atlantic Cod	NAFO Div. 3M	Longline
Skate Fishery	Skate	NAFO Divs 3NO	Bottom otter trawl
Yellowtail flounder Fishery	Yellowtail flounder	NAFO Div. 3N	Bottom otter trawl
Witch flounder Fishery (re-opened in 2015)	Witch flounder	NAFO Divs 3NO (expected area)	Bottom otter trawl
3LNO Redfish Fishery	Redfish	NAFO Divs 3LNO	Bottom otter trawl
3LNO Shrimp Fishery (under no directed fishery in 2015)	Shrimp	NAFO Div. 3L	Bottom otter trawl
White Hake Fishery	White hake	NAFO Divs 3NO	Bottom otter trawl

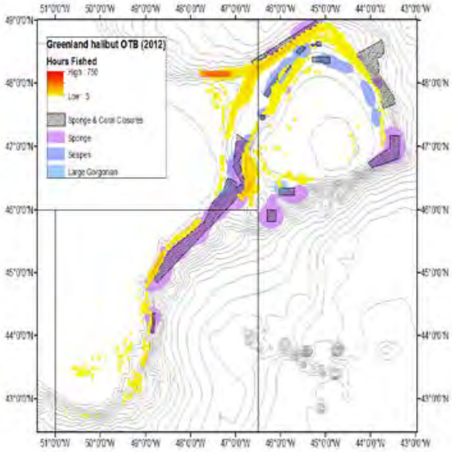
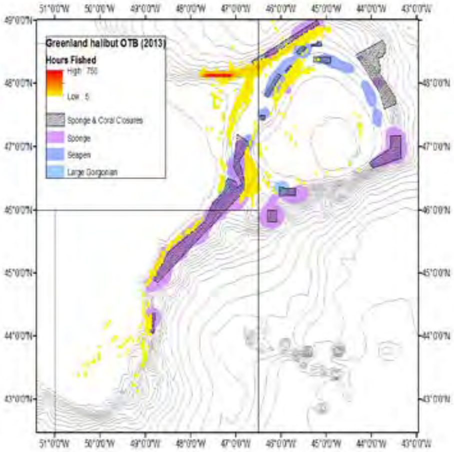
4.2.4.2 Demersal fisheries

The groundfish fisheries were separated into different components depending on the target species, area, depth and gear (mesh size). Based on these aspects, and assuming Spanish observer data from 2005-2011 and preliminary 2015 logbook data are representative of most fleets' general activity, the demersal fisheries in the NRA were initially classified as follows:

Divisions 3LMNO at >800 m: Greenland halibut fishery

The principal fishery is conducted from 800-1400 m with 130 mm mesh size bottom trawls and although widespread throughout the divisions, there were four primary areas. These included, in decreasing area of importance: (1) the northeast of Div. 3L, (2) the northwest of Div. 3M, (3) the southeast of Div.3L along the Div.3LM boundary, and (4) the northeast of Div. 3N (Figure 3). The maps of fishing effort (Figure 4.2.4.2.1) demonstrate the difficulty in matching VMS with the DCR as Greenland halibut is a deep-water species and there is effort attributed as 'directed' in shallow water on the southern Grand Bank area. Greenland halibut comprised 95% of the catch based on 2015 logbook data and main by-catch are grenadiers, witch, skates and plaice (each species <1%).

Division	Gear	Depth Range	Mean Vessel Length (m, ± range)	Logbook Catch Composition	
3LMNO	OTB	800-1400 m			
Target Species	Mesh Size	Mean Vessel Power (KW, ± range)		Species	Percentage of catch (2015)
Greenland halibut	130mm	1746 (588-4080)	65 (50-85)	Greenland halibut	95%
				Roundnose grenadier	1%
				Roughhead grenadier	1%
				Witch	1%
				Skate	1%
				Plaice	1%
				Others	1%

Spatial Distribution (2012)	Spatial Distribution (2013)
	
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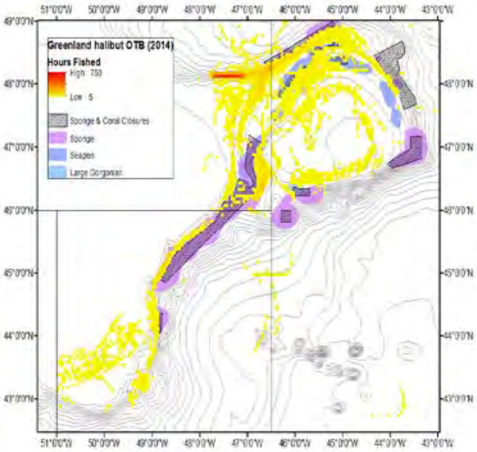	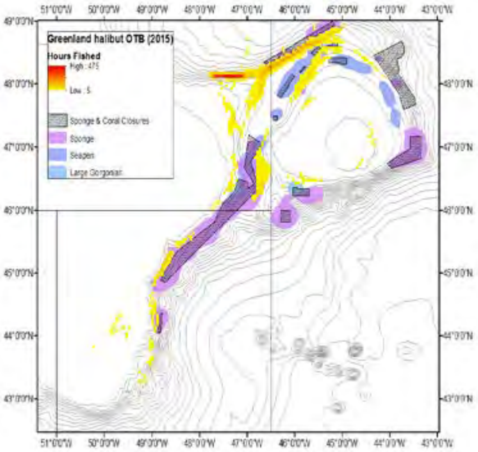

Fig. 4.2.4.2.1. Characteristics of the Greenland halibut fisheries in Div. 3LMNO (OTB = bottom otter trawl).

Division 3M at 150-600 m: redfish, cod and shrimp fisheries

The shrimp fishery was under moratorium since 2012 but previous fisheries were conducted with 40 mm mesh size bottom trawls primarily in depths between 300 and 500 m. Shrimp comprised 98% of the catches with redfish as main by-catch (2%).

The redfish fishery is conducted with 130 mm mesh size bottom trawl gear primarily within the 200m-600 m depth zone in Div 3M along the southern and north-western slope of the bank (Fig. 4.2.4.2.2). Redfish comprise 80% of the catch and the main by-catch species were Greenland halibut (4%) and cod (3%).

The cod fishery in Div 3M is conducted with 130 mm mesh size bottom trawl gear at depths between 150-550 m, with the highest concentrations of effort in the south western and south-eastern areas of the slope of the bank (Fig. 4.2.4.2.3). Most of the hauls were carried out at depth between 300-400 m. Cod comprised 92% of the catches and the most important species in the by catch was redfish (7%).

Although the maps of OTB fishing effort for redfish and cod are split based on the NCEM definition of directed species, these generally tend to be mixed fisheries.

A long-line fishery is also conducted for cod between 200 and 400 m in the north west portion along the slope of the bank (Fig. 4.2.4.2.4), and the principal by-catch is skate and Greenland shark.

Division	Target Species	Gear	Mesh Size	Depth Range	Mean Vessel Power (KW, ± range)	Mean Vessel Length (m, ± range)	Commercial Bycatch Species
3M	Redfish	OTB	130 mm	200-600 m	1716 (700-3300)	68 (50-85)	Cod Greenland halibut

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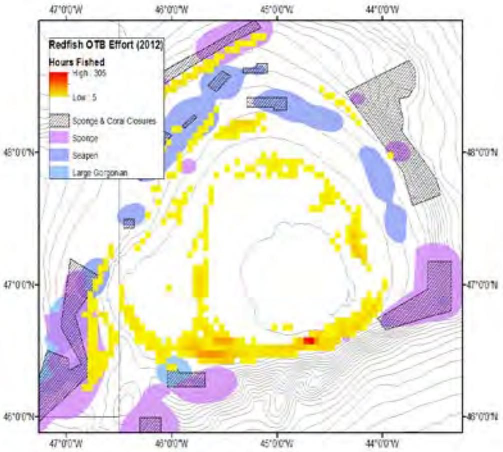

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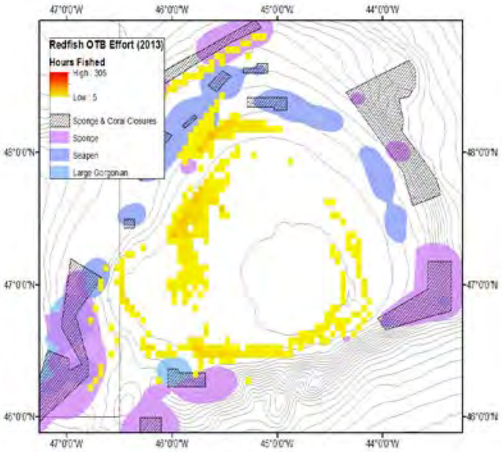

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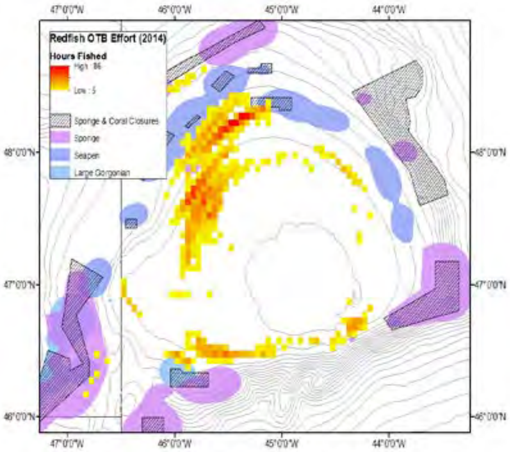

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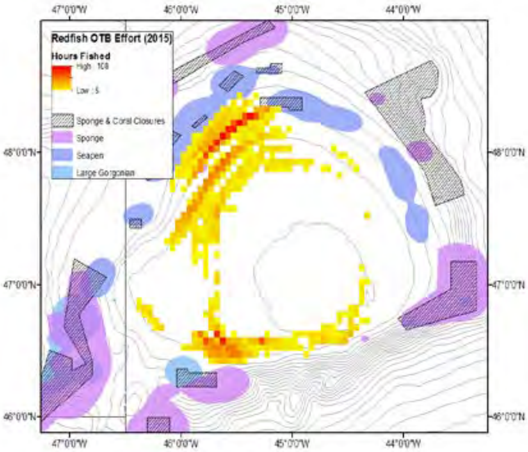
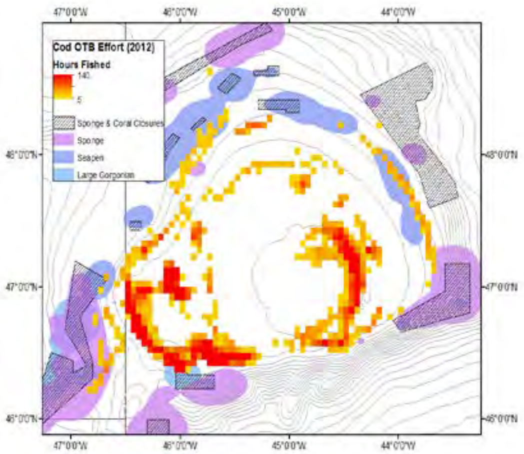


Fig. 4.2.4.2.2. Characteristics of the 3M redfish fisheries (OTB = bottom otter trawl).

Division	Target Species	Gear	Mesh Size	Depth Range	Mean Vessel Power (KW, ± range)	Mean Vessel Length (m, ± range)	Logbook Catch Composition	
							Species	**Percentage of catch (2015)**
3M	Cod	OTB (some use of PTB)	130mm (some use of 140 mm)	200-600 m	1716 (700-3300)	68 (50-85)	Cod	97%
							Redfish	1%
							Plaice	1%
							Others	1%

Spatial Distribution (2012)



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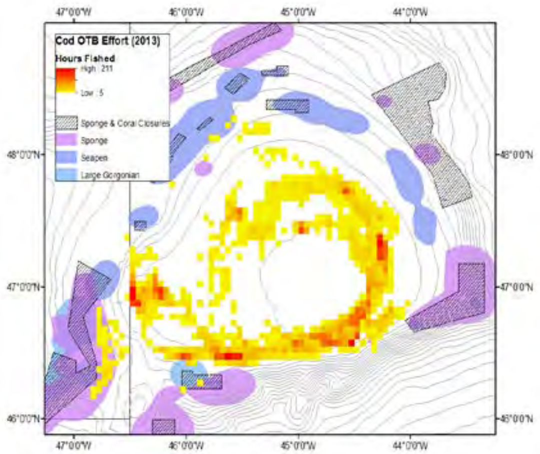

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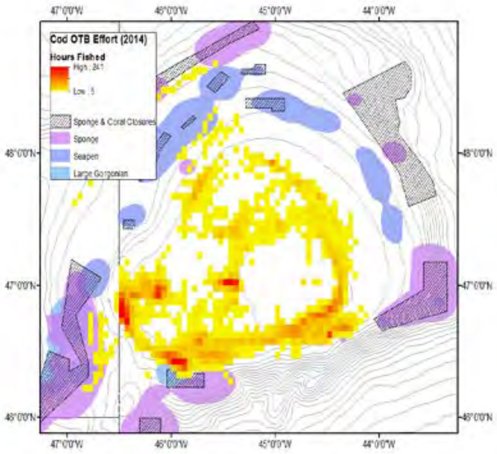

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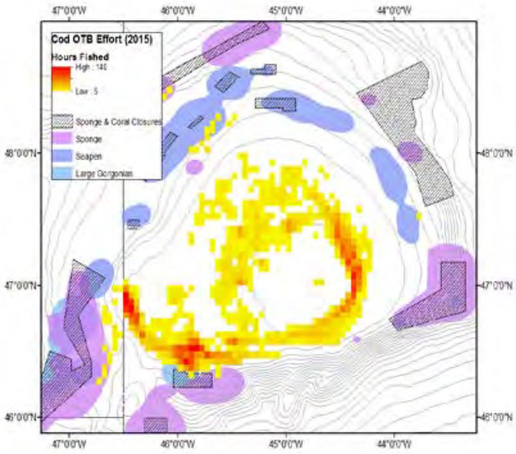

Fig. 4.2.4.2.3. Characteristics of the 3M OTB Cod Fishery.

Division	**Target Species**	**Gear**	**Mesh Size**	**Depth Range**	**Mean Vessel Power (KW, ± range)**	**Mean Vessel Length (m, ± range)**	**Commercial Bycatch Species**
3M	Cod	LL	NA	200-400 m	NA	NA	Skate Greenland shark

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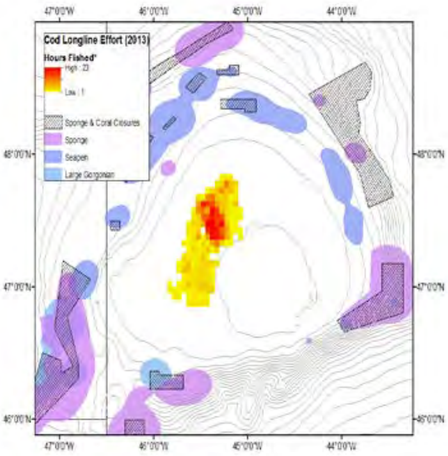
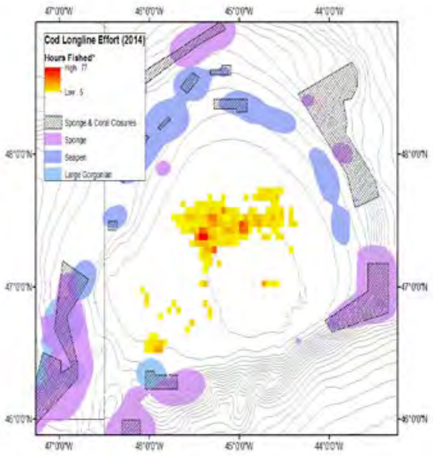
<tr><td>
</td><td>
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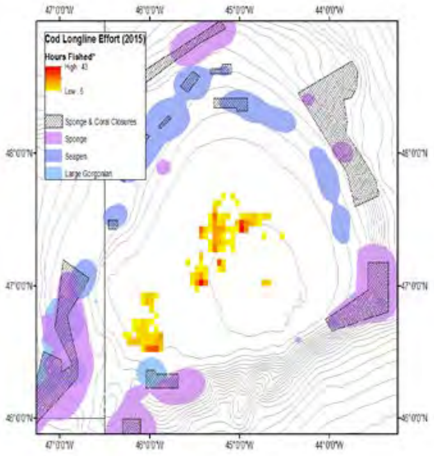
<tr><td>
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Fig. 4.2.4.2.4. Characteristics of the 3M Longline Cod Fishery. (LL = long-line, NA = not available, * hours fished from VMS data is considered a poor metric of effort in long-line fisheries).

Divisions 3LNO at <500 m: skate and yellowtail fisheries

The skate fishery is conducted with 280 mm mesh size bottom trawls primarily in depths from 100 to 500 m (Fig. 4.2.4.2.5) in Divisions 3NO. Skates comprised 97% of the catch with redfish as the primary by-catch species based on 2015 logbook data.

The yellowtail fishery is conducted with 130 mm mesh size bottom trawls in Divisions 3LNO primarily in depths <50 m on the southeast shoal in Div. 3N (Fig. 4.2.4.2.6). The primary by-catch species are skate, American plaice and cod.

Division	Target Species	Gear	Mesh Size	Depth Range	Mean Vessel Power (KW, ± range)	Mean Vessel Length (m, ± range)	Logbook Catch Composition	
							Species	Percentage of catch (%)
3LNO	Skate	OTB	280 mm	100-500 m	1352 (588-2648)	64 (50-84)	Skate	97%
							Redfish	2%
							Haddock	1%
							Others	1%

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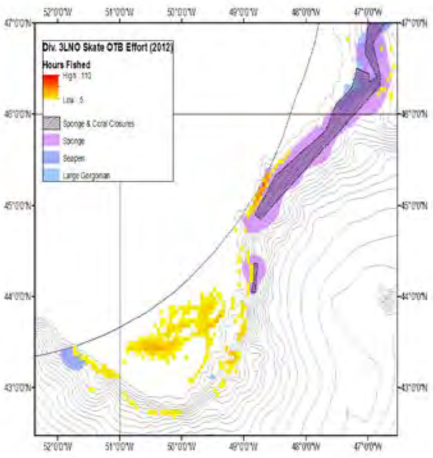	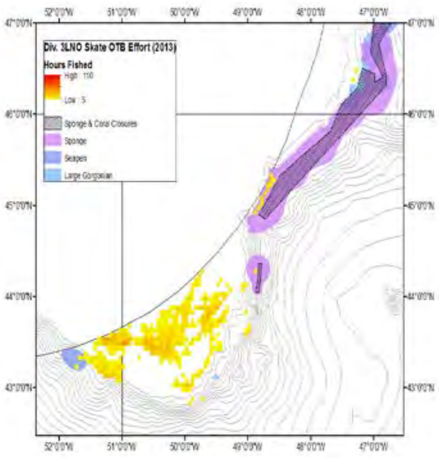
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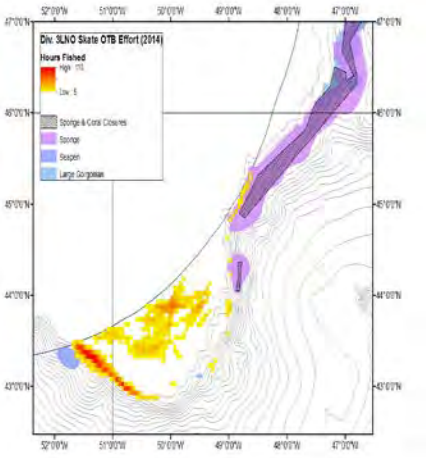
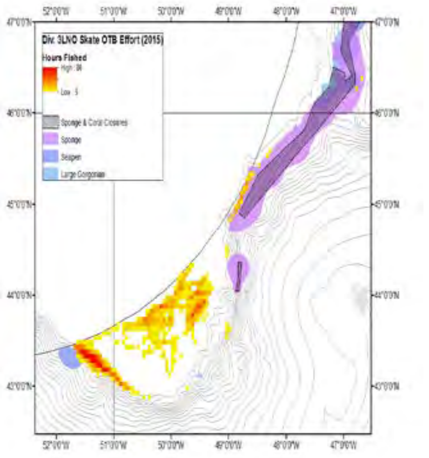
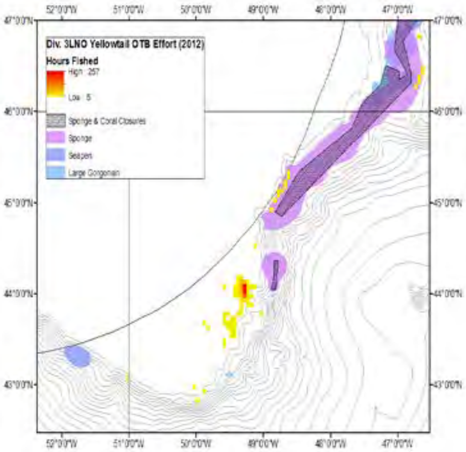
	

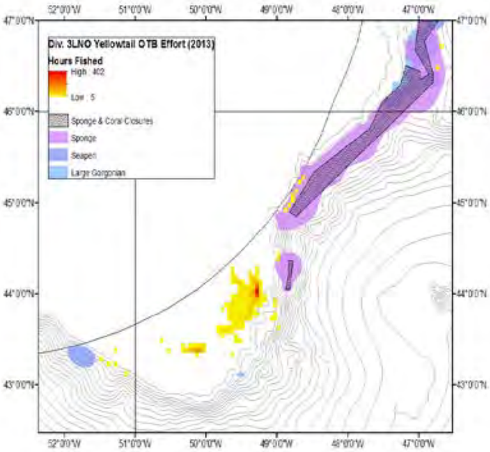
Fig. 4.2.4.2.5. Characteristics of the 3LNO skate fishery (OTB = bottom otter trawl).

Division	Target Species	Gear	Mesh Size	Depth Range	Mean Vessel Power(KW, ± range)	Mean Vessel Length (m, ± range)	Logbook Catch Composition	
							Species	Percentage of catch (2015)
3LNO	Yellowtail flounder	OTB	130 mm	<200 m	1565 (50-84)	61 (50-84)	Yellowtail	83%
							Plaice	10%
							Skate	3%
							Cod	2%
							Witch	1%
							Silver Hake	1%
							Others	1%

Spatial Distribution (2012)



Spatial Distribution (2013)



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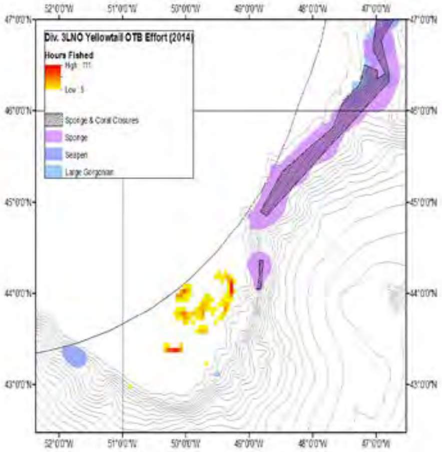


Spatial Distribution (2015)

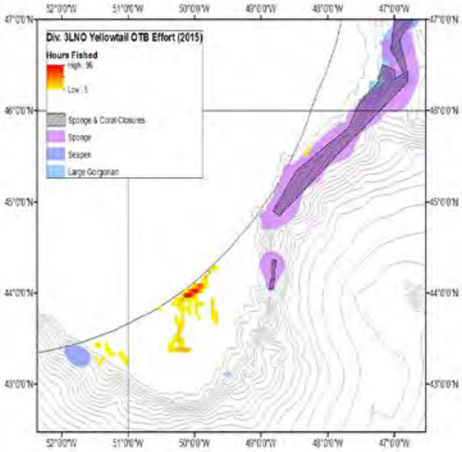


Fig. 4.2.4.2.6. Characteristics of the 3LNO yellowtail flounder fishery (OTB = bottom otter trawl).

Divisions 3LNO at 200-1000 m: redfish and shrimp fisheries

The redfish fishery is conducted with 130 mm mesh size trawl bottom trawls with the primary areas being the slope area of Div. 3O, the east-central area of Div. 3N and the southeast area of Div. 3L near the border with Div. 3N in depths <600m (Fig. 4.2.4.2.7). Redfish comprise 90% of the catch and the main by-catch species were American plaice (2%), cod (2%), silver hake (2%) and Atlantic halibut (2%) based on 2015 logbook information. Although mid-water trawling has comprised a significant percentage of redfish fisheries for principal Russian fleet in the past, its use has diminished in recent years and only bottom trawls were deployed in 2013-14.

The shrimp fishery is conducted with 40 mm mesh size bottom trawls in Div. 3L, primarily concentrated in an area along the central eastern slope in depths between 300 and 500 m (Fig. 4.2.4.2.8), with shrimp comprising with 99% of the catches. This fishery was closed to directed fishing in 2015.

Division	Target Species	Gear	Mesh Size	Depth Range	Mean Vessel Power (KW, ± range)	Mean Vessel Length (m, ± range)	Catch and Bycatch	
							Species	**Percentage of catch (2015)**
3LNO	Redfish	OTB	130 mm	200-600 m	1900 (600-6400)	63 (15-85)	Redfish	89%
							Cod	2%
							Silver hake	2%
							Atlantic halibut	2%
							American plaice	2%
							Skates	1%
							Others	2%

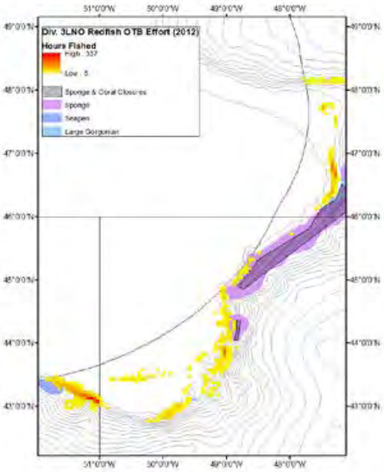
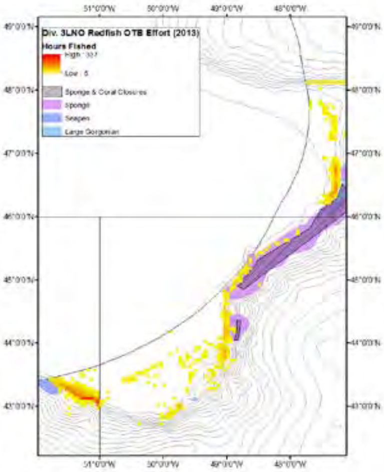
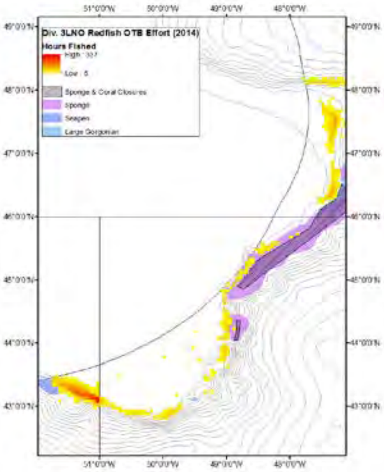
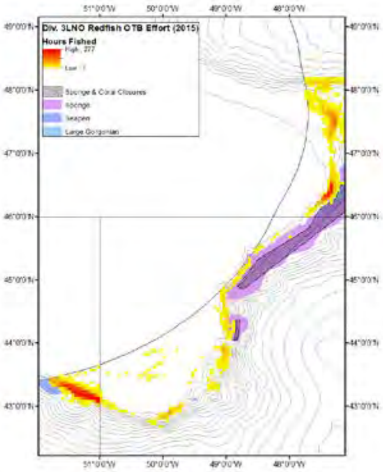
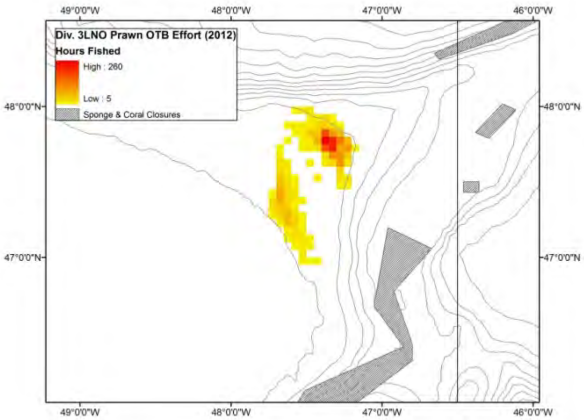
Spatial Distribution (2012)	**Spatial Distribution (2013)**
	
Spatial Distribution (2014)	**Spatial Distribution (2015)**
	

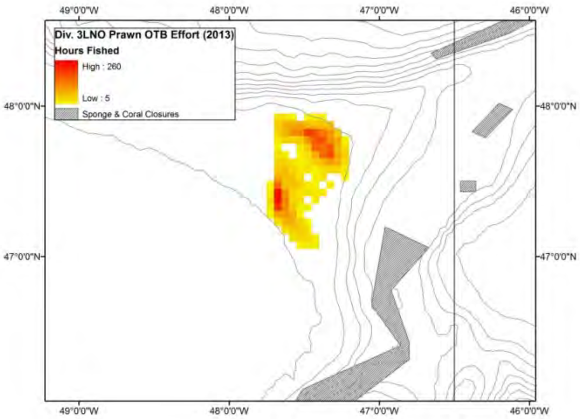
Fig. 4.2.4.2.7. Characteristics of the 3LNO redfish fishery (OTB = bottom otter trawl).

Division	Target Species	Gear	Mesh Size	Depth Range	Mean Vessel Power (KW, ± range)	Mean Vessel Length (m, ± range)	Commercial Bycatch Species
3LNO	Northern prawn	OTB	40 mm	200-400 m	2400 (1100-3000)	60 (55-65)	No targeted fishery in 2015

Spatial Distribution (2012)



Spatial Distribution (2013)



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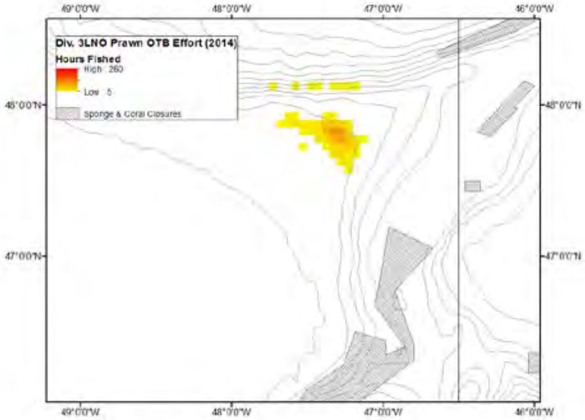


Fig. 4.2.4.2.8. Characteristics of the 3LNO shrimp fishery (OTB = bottom otter trawl).

Divisions 3NO at <800 m: witch flounder fisheries

A directed fishery for witch flounder was re-opened in 2015 for the first time since it was placed under a moratorium in 1995. This fishery will be conducted with 130 mm mesh size and is likely to occur at various depths to 800 m. Information on by-catch is not yet available.

Divisions 3LNO at >30 m: white hake

The white hake fishery operates mostly along the shelf edge of the southern part of NAFO Div. 3NO, and tends to be an opportunistic fishery and therefore can be quite irregular. The fishery uses 130 mm mesh size bottom trawl gear. A directed fishery for white hake has not taken place in the years 2012-2015 for which VMS and daily catch data are available.

4.2.5. Assessment of SAI on VME

4.2.5.1. Background to SAI and its definition

RFMOs have made a commitment to investigate the potential for SAI as part of their reaction to the UNGA resolution 61/105 on sustainable fisheries (UNGA, 2006b). The resolution calls upon States and RFMOs to identify VME in the high seas and to consider whether fishing activities would have SAI on these ecosystems. One of the difficulties in assessing SAI in the NRA in the past has been the inaccessibility or lack of data of sufficient quality and resolution, both temporally and spatially, on the extent of fishing activities and of the identity and distribution of VME. Only recently have suitable datasets become available. Capitalising on the availability of such datasets, scientists in the NAFO WGESA have developed an approach for analysing and evaluating SAI, thus contributing to a qualitative risk assessment and management framework to avoid SAI on VME from bottom fishing activities in the NRA.

The FAO guidelines (FAO, 2009) define SAI as: "those that compromise ecosystem integrity (i.e., ecosystem structure or function) in a manner that: (i) impairs the ability of affected populations to replace themselves, (ii) degrades the long-term natural productivity of habitats, and (iii) causes, on more than a temporary basis, significant loss of species richness, habitat or community types".

Very little is known about the life histories of the VME indicator species identified by NAFO (Fuller et al., 2008; Kenchington et al., 2011; Murillo et al., 2011). The reproductive biology of few of the indicator species has been studied to date and recruitment is unknown. Some studies have aged deep-sea corals and shown them to be slow growing, long-lived, with growth rates that will require decades to centuries to recover, and this was considered at the time they were identified as VME indicators (Fuller et al., 2008). Recent evidence has confirmed this. For example, a dense forest of bamboo coral in Baffin Bay (Div. 0A) was impacted by a scientific research trawl in 1999 and re-surveyed in 2013 utilizing a Remotely Operated Vehicle (ROV). Living colonies were observed as dense patches (55 m patch length x 1 m colony height) but the trawl track showed no evidence of recovery (Neves et al., 2014). Sponges are attached to the sea floor and reproduce by broadcasting sperm into the water column which fertilize eggs held in the bodies of neighbouring sponges. If sponges are too far apart then fertilization success may be compromised. An extinction vortex is the term used to describe the process that declining populations undergo when a mutual reinforcement occurs among biotic and abiotic processes that drives population size downward to extinction. Sponges, corals and sea pens, which also have broadcast spawning, may be vulnerable to extinction vortices. The sponges also may have very limited dispersal ability. The fertilized egg usually develops in the sponge and on hatching, larvae are released into the water column where they are only viable for a few days, and in some species, only hours. They then settle and attach. This could mean that the sponges are highly inbred and have very limited dispersal range. If this is the case greater importance is placed on each self-recruiting population. Alternative models include source-sink dynamics, where one or more populations provide the recruitment for other populations and clinal variation, where genetic variation follows the distribution gradient. Each model has different implications for management and very little is known about the population genetics and connectivity of these species.

The FAO guidelines (FAO, 2009) provide further insight into the issue of defining a SAI by stating that "When determining the scale and significance of an impact, the following six criteria should be considered:

1 The intensity or severity of the impact at the specific site being affected.

2 The spatial extent of the impact relative to the availability of the habitat type affected.

3 The sensitivity/vulnerability of the ecosystem to the impact.

4 The ability of an ecosystem to recover from harm, and the rate of such recovery.

5 The extent to which ecosystem functions may be altered by the impact.

6 The timing and duration of the impact relative to the period in which a species needs the habitat during one or more of its life-history stages."

So far, given the data available from within the NRA and in particular the NAFO footprint, the assessment has been possible with regard to the first two criteria (i and ii). Criterion i, the sensitivity or severity of the impact has been shown, through literature review, to be very high on the first pass through all VMEs identified by NAFO. Indeed, it is part of the determination that a taxon is a VME and was reviewed for each VME indicator previously (Fuller et al., 2008; Kenchington et al., 2011; Murillo et al., 2011). Structural sponge habitat is extremely vulnerable to commercial and research trawling, suffering immediate declines through direct removal of sponges and further reductions in population densities of sponges due to delayed mortality (Kenchington et al., 2011). Similarly, gorgonian corals are very fragile and highly susceptible to trawling impacts (Fuller et al., 2008). Sea pens can also be severely impacted on the first pass, however unlike the corals and sponges, they have flexible axial rods and some species are able to re-anchor in the sediment if they are dislodged (Kenchington et al., 2011). Consequently, they may be able to withstand greater disturbance than the other VME indicators, as they are less susceptible to direct mortality. The cut-off values identified in this analysis for these three VME groups are in agreement with these observations, where fishing effort cut-offs were the smallest for gorgonians, and the largest for sea pens.

Criterion ii, has been accomplished in this report. Here, the location of the VME is mapped and the proportion of the area that is currently impacted by fishing is identified, as well as the proportion that is protected by the closed areas, and the proportion that is at risk of being impacted.

Ecosystem function can be defined as the biological, geochemical and physical processes and components that take place or occur within an ecosystem. It can be divided into three categories; regulating, supporting and provisional functions. Regulating functions include processes such as biochemical and water cycling. Biochemical cycling includes processes such as benthic-pelagic coupling and bioturbation. Both contribute significantly to biochemical cycles by turning over nutrients, living or decomposed constituents, in an otherwise nutrient poor environment. Supporting functions include habitat for associated species, nurseries, refuge from predators, and supporting connectivity between populations (e.g. patchiness). The final category is the provisional function including ecosystem basics such as food (e.g., foraging area) and shelter. For a review of ecosystem function see ToR 3.4 (WGESA Report 2013).

Criteria iii-v require knowledge of the ecosystem processes and function of the VME that is not known in sufficient detail to determine the effects of, and recovery from, impacts at an ecosystem level. For example, sponge grounds provide a number of ecosystem services which directly support fisheries in the NRA. As they stand proud of the sea floor, they modify bottom currents and create habitats for other species, while as they die they leave behind spicules which create habitat of their own. Fish use sponge grounds for feeding, reproduction and resting, while sponges filter vast amounts of water on a daily basis (one sponge can filter 25 000 litres per day) and serve broader roles in energy flow linking pelagic and benthic systems and locally increasing biodiversity. At some unknown size and spatial configuration, these ecosystem services will be compromised and each function may have a different ecological tipping point. Further, recovery of these disrupted ecosystem functions and services not only requires knowledge of the life-history of the key species, it requires a thorough understanding of the entire benthic community and the successional processes that occur. Ecosystems have a degree of functional redundancy in them and it could be that some functions are maintained by non-VME indicator species. Knowledge of the degree to which fishing can proceed without compromising ecosystem services is an extremely important question that will require a targeted research program over a number of years to address. Lastly, criterion vi introduces a temporal component to the impacts of criteria iii-v.

WGESA initiated the discussion of how to assess SAI at two basic levels:

1 Assume that any present or past fishing activity impacting VME is significant based on the Precautionary Approach; or

2 Assume that the present or past fishing activity impacting VME may not be significant as both VME and fishing have co-existed for several decades.

The first scenario was thought, by some, to be applicable to the sponges and large gorgonian corals, but not to the sea pens. The argument for not including sea pens under this scenario was based on their relative resilience at the species level to trawling, as noted above. However, in situ photographs of the sea floor within a heavily fished portion of a sea pen VME polygon showed no megafauna, despite the presence of sea pens in the nearby closed area, indicating that sea pens cannot withstand concentrated and repeated fishing effort. Furthermore, WGESA previously noted that redfish larvae attach to the sea pen stalks and these habitats may be important nursery areas for *Sebastes* spp. (see ToR 3.1.2 of NAFO 2014), thereby increasing the risk to NAFO fisheries should too much sea pen habitat be destroyed. WGESA at its 2013 meeting assessed the protection of sea pens on Northern and North-western Flemish Cap to be "Inadequate collectively" based on the fact that the closures are covering a system of sea pen VME, identified in the SDM and verified with trawl survey data, that is not adequately protected. In particular, the lack of protection for the entire eastern part of their distribution was of concern for the long term sustainability of these VME given the lack of knowledge of recruitment processes and connectivity. Therefore, although they may be more resilient to a first pass of the trawl gear than other types of coral or sponge, sea pens have more of their core VME area unprotected.

This discussion also raised the point of the need to take into account the impact to individual VME polygons as some VME areas may be severely impacted by fishing, while others are not impacted at all. This could lead to the loss of individual patches of VME which could have consequences for other areas of the same VME type depending on source/sink relationships.

The second scenario has some logic to it. Fishing has persisted in these areas for many years and previously WGESA has shown that the areas fished have been remarkably consistent (NAFO 2015). The directed Greenland halibut fishery, that is the main fishery carried out in waters below 700 m depth (Gonzalez-Costas et al., 2011), where the sponge VME occur, began in the early-1960s in this area (Bowering and Brodie, 1995), indicating that impacts of fishing on the sponge VME may have been accumulating for at least 50 years. Therefore, if the current extent and impact of fishing had caused SAI then we would expect to see consequences either to the fisheries or to the VME indicators. A review of existing in situ imagery to assess size distribution and recruitment of VME indicators could give some insight into this issue, and/or targeted in situ monitoring could be conducted. Until research vessel surveys cease to fish in the closed areas, they could be tasked with recording the length frequencies of all VME indicator taxa within the VME polygons.

However, an important consideration for assessing SAI and highlighted in the FAO guidelines, is the need to determine the area of VME impacted as a proportion of the area of VME unimpacted. Studies in other marine ecosystems, in the context of the EU Habitat Directive, had considered that impacts of 25% or more of the total habitat area as the criteria for deeming those habitats to be in unfavourable conditions (Korpinen and Laamanen, 2013). However, this value has no direct scientific derivation, and the ecosystem considered in the study is very different from the ones in the NRA. Although its application in the NRA would provide consistency with other jurisdictions, it would only represent the level of risk that management might deem acceptable. As stated above, it is not possible at the present time to provide a clear cut quantitative assessment of Significant Adverse Impacts.

WGESA therefore concluded that not all impacts on VME should be presumed to be SAI, and an assessment of the relative areas of VME which have been impacted with areas of VME of the same type at risk of impact according to the FAO guidelines (FAO, 2009) is an important step in assessing SAI.

4.2.5.2 Analytical approach for assessing VME impacted and at risk of VME impact

A number of assumptions are made to frame the proposed assessment of impacts. First, the risk of impact to VME from fishing inside either closed areas or in areas outside the fishing footprint is deemed to be very low (at least in terms of direct impact from bottom fishing activities; although there is a recognised secondary risk from re-suspended fine sediment from adjacent fished areas (Boutillier et al., 2013), this has not been assessed). Second, VME which occur outside closed areas, but within the fishing footprint, are potentially at risk of impact from bottom fishing activities. However, not all VME which occurs outside the closed areas will be at the same immediate risk of impact from bottom fishing activities; e.g., the degree of risk of impact will depend upon a combination of present-day and historic fishing intensity, and predicted and/or known VME biomass distributions. Given such assumptions, and the innate properties (FAO, 2009) of the species which comprise the VME habitats, the following assertion can be made:

"frequently fished areas of VME will tend to support lower biomass of VME indicator taxa compared to areas of the same VME that have been fished less frequently."

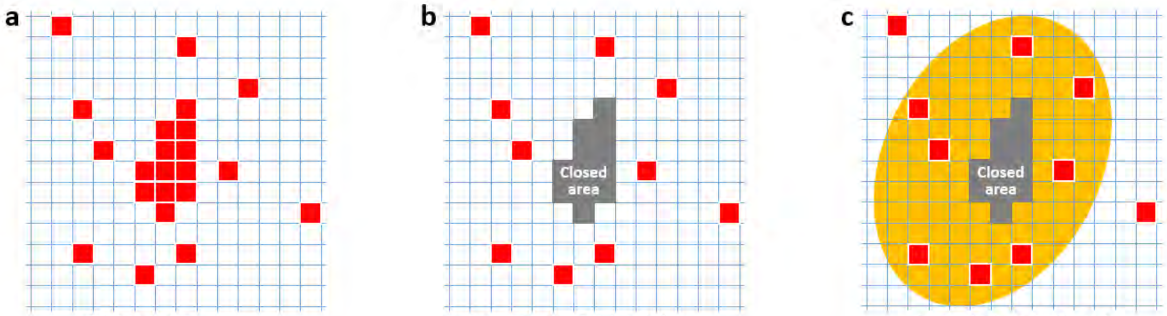
Therefore, areas of VME within the NAFO fishing footprint fall into three impact-risk categories (i) protected areas with low risk of impact, although there is a recognised secondary risk from re-suspended fine sediment from adjacent fished areas (Boutillier et al., 2013); (ii) areas of VME at 'high risk' of impact (and therefore subject to potential SAI) which are subject to relatively low fishing pressure or have not been fished since 2008, and (iii) areas of VME which are impacted and coincide with areas of high fishing effort, and have been fished for many years, and where VME indicator taxa are found in much reduced densities or biomass but according to the species distribution models have potential for recovery.

The present study has quantified the limits in fishing effort which correspond to large changes in VME species biomass. The identified limits (or cut-off values) when applied to the fishing effort data allow areas of impact and areas at risk of impact to be determined. The method uses the cumulative distribution of biomass catch in conjunction with fishing effort (VMS) data to determine cut-offs in VME species biomass in a similar manner to the original identification of significant concentrations of VME (NAFO, 20013). Figure 4.2.5.2.1a-f, illustrates the methodological approach taken to determine the impact 'cut-off' limits.

Within the fishing footprint it is possible to observe a gradient in fishing intensity, by quantifying how often fishing takes place within a given area (attained from satellite-derived VMS records over several years). The smaller the unit area in which fishing is quantified, the greater the spatial resolution in the variability of fishing intensity can be assessed. However, the chosen size of the unit area must also be sufficiently large to contain enough records of fishing activity to achieve an accurate estimation of fishing intensity over time. Ideally, the same unit area is chosen to quantify the biomass of VME indicator taxa within the fishing footprint, and similarly, it is constrained by the density of available VME species biomass records. If the records are too few and the chosen unit area is too large, the spatial resolution will be too low so as to be of little practical use for the management of fishing practices to prevent SAI to VME. A hypothetical grid within a fishing footprint showing occurrences of VME indicator taxa is depicted in Fig.4.2.5.2.1a (note that no indication of fishing intensity across the grid is shown).

It may be that certain areas of observed aggregations of high VME indicator taxa biomass have already been closed to fishing activities to protect the VME (Fig. 4.2.5.2.1b), in which case it can be assumed that the risk of impact to VME within these areas is very low. For the purpose of assessing the risk of impact to VME from fishing, such closed areas can be excluded from the assessment, as they are already under some form of protection. Instead, the areas of concern are those areas of VME which fall outside of the closed areas. To ascertain the biogeographical limits of the VME falling outside current closures, NAFO has used threshold-defining approaches based on area derived from kernel density estimation analyses (NAFO, 2013, 2014; Fig.4.2.5.2.1c) which uses RV survey biomass data with minimal interpolation (<20 km from the point source). In the present analysis the boundaries of the VME polygons were refined using species distribution models, although those involve interpolation and extrapolation methodology (see section 4.2.3.2). Once the predicted extent of the VME has been determined, the precise area of VME at risk of impact and area of VME potentially impacted can be defined (Fig. 4.2.5.2.1d).

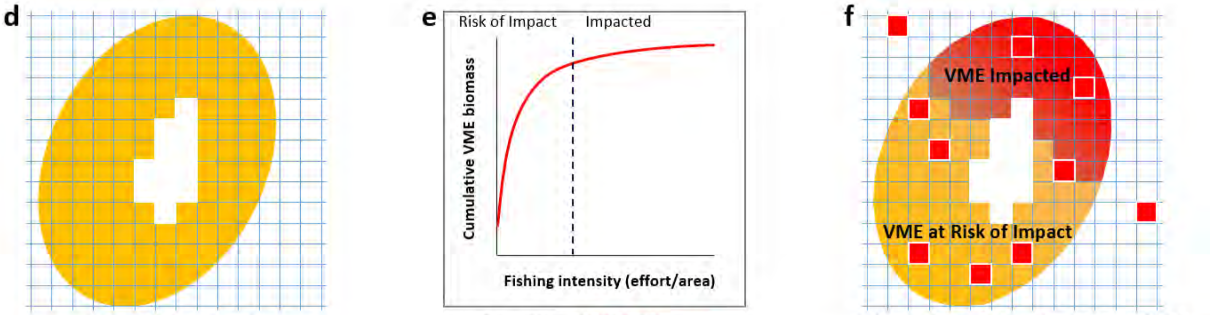
The interaction between observed fishing intensity (total hrs of trawling) and VME biomass (average kg wet weight) is performed at the scale of individual grid cells (1 NM). By ranking every grid cell within the area at risk of impact (VME excluding closed area) on a gradient of increasing fishing intensity and plotting the observed VME biomass along that gradient, a cumulative rate of increase in VME biomass with increasing fishing intensity can be produced (Fig. 4.2.5.2.1e). The plot shows that the grid cells with the least fishing pressure (which tend to support higher biomass of VME indicator species) accumulates biomass more rapidly than cells which are exposed to high fishing pressure (which are more likely to support much reduced amounts of VME indicator species biomass). The point at which the addition of grid cells with higher fishing intensity no longer corresponds with a significant increase of VME biomass denotes a 'cut-off' in fishing intensity above which there is no increase in VME biomass observed; grid cells falling above this cut-off therefore represent an area of potential impact. Grid cells falling below the cut-off, which continue to support high biomass of VME indicator species at very low levels of fishing effort can be considered at risk of impact (Fig.4.2.5.2.1f). The precise location of this cut-off along the incremental fishing intensity gradient cannot be pre-defined, but will be predicated by the sensitivity and recoverability of particular VME indicator taxa (among other site specific factors). The cut-off can be determined by identifying the point of inflexion on the cumulative plot of VME biomass ranked against increasing fishing intensity for each of the taxon-specific VMEs, or by identifying a cumulative biomass limit. For consistency the cut-off for each VME taxon was determined to be at the point where 95% of the biomass had been accumulated, which closely corresponds to the inflexion point in all cases.



Gridded observations of **VME biomass** within fishing footprint

Assignation of fishery closures around significant aggregations of VME biomass

Modelled prediction of **VME extent**



Area at Risk of Impact = VME extent – Closed Area

Evaluation of **VME biomass** observations inside area at Risk of Impact

- Areas of low fishing intensity and high VME biomass = **Risk of Impact**
- Areas of high fishing intensity and low VME biomass = **Impacted**

Fig. 4.2.5.2.1. Schematic representation of a method for delineating areas of VME at risk of impact and VME impacted from bottom fishing activities. See main text for explanation.

4.2.5.3. Application of the impact assessment method

The fishing footprint

NAFO delineated a fishing footprint within its regulatory area based on bottom fishing activity data covering a 20-year period (1987-2007) submitted by fishing vessel flag States (NAFO, 2009c). The western extent of the fishing footprint intersects the Canadian EEZ, whilst in other directions fishing is mostly restricted to above the 1600 m depth contour, which would approximate to the maximum depth at which a trawl normally operates. However, this footprint was a perimeter and did not acknowledge the many unfished areas in the NRA. Consequently, a new fishing footprint was created for this assessment.

Fishing effort calculation

Vessels fishing in the NRA are equipped with a satellite monitoring device (i.e., VMS) that transmits the vessels' position, heading and speed every hour; each transmission is termed a 'ping'. VMS data collected from 2008 to 2014 were filtered to exclude records of vessel speed greater than 5 knots; the assumption being that vessels in the NRA operating below 5 knots were likely to be fishing. Using ArcGIS (ESRI Canada), the area covered by the fishing footprint within the NRA was gridded at a resolution of 1 nm x 1 nm cells. For each cell, the number of pings recorded within it each year was counted. This produced a value for annual number of pings per cell, which can also be expressed as the yearly number of hours of fishing within a cell, i.e., the fishing effort. The annual fishing effort per cell value was divided by the total area of the cell, producing a measure of annual fishing intensity (in hrs km^{-2}) for each cell. It is worth noting that where the boundary of a closed area bisected a cell, each portion of the cell falling inside or outside the closed area was treated separately. Lastly, each cell was classified and colour-coded along a gradient of fishing intensity to produce a data layer of fishing intensity (Fig. 4.2.5.3.1). Note that the green colour in Fig. 4.2.5.3.1 represents areas that have not been fished between 2008-2014, demonstrating the general spatial mismatch between fishing effort and VME location, particularly in the deeper waters.

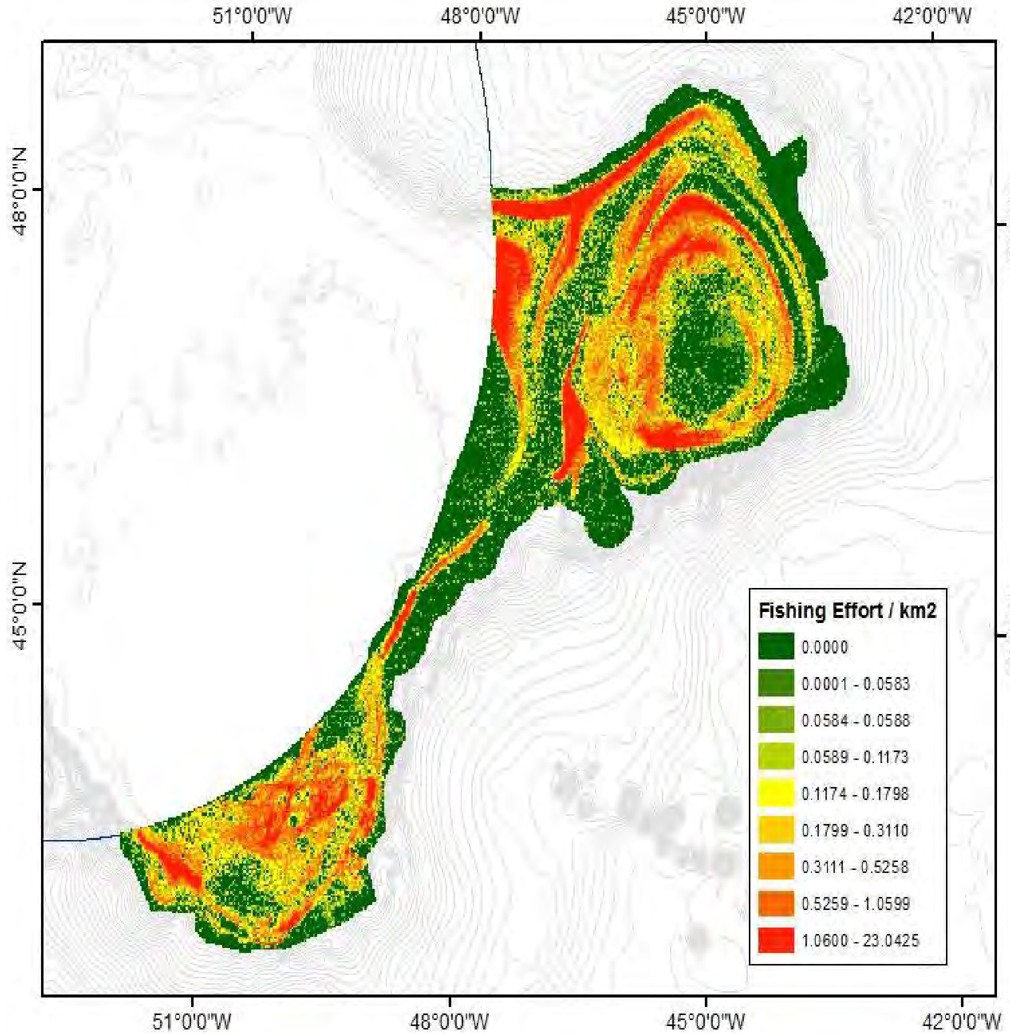


Fig. 4.2.5.3.1. Representation of fishing intensity in the fishing footprint of the NRA based on 2008-2014 VMS data.

VME biomass observations

Since 1988, Canada and the European Union (Spain) have conducted annual fishery surveys within the NRA to acquire basic fish stock data and information for scientific research and fisheries management. Georeferenced biomass data of sponges (Porifera), large gorgonian corals (Octocorallia) and sea pens (Pennatulacea) collected by these surveys (between 2005 & 2014, 2007 & 2015, and 2000 & 2015, respectively) have been used to create a gridded layer of average VME biomass (in kg km^{-2}) at the same spatial resolution as the fishing effort (i.e., 1 x 1 NM grid cell). This allows for direct spatial comparison and integration with the fishing effort layer.

Delineation of VME

As described in Section 4.2.3 of this report, Kenchington et al. (2014) performed kernel density estimation analyses (KDE) on fishery survey trawl data from inside the fishing footprint of the NRA to create biomass density surfaces for a selection of VME indicator taxa. In doing so, they were able to define polygons for each of the VMEs which have been accepted by NAFO Scientific Council and NAFO Fisheries Commission as the best available approach to define the overall extent of VME within the NRA. A refinement of the VME polygon boundaries was requested by NAFO SC in 2015, specifically to incorporate environmental data into the analysis, to better define the extent of VME habitat. The integration of the KDE polygons with the outcome of the developed SDMs (see Section 4.2.3) provided the basis for refining the VME boundaries as shown in Fig. 4.2.5.3.2. For sea pens, no modification of the VME boundaries were made as the SDMs predicted high presence and/or biomass throughout the entire sea pen polygons. For sponges, the polygons on the Flemish Pass were modified at their shallow boundary using SDM, as both the presence/absence and biomass models were in agreement. Similar modification of the sponge polygons in the Sackville Spur area were not made as the two model types were not in agreement and more investigation of the biomass models is required. The large gorgonian coral VME polygons were modified using the presence/absence SDM (Knudby et al. 2013b). The deepwater closed area on the NE Flemish Cap was put in place based on underwater camera observations and in part lies outside the NAFO Fishing footprint. Otherwise there is general agreement between the closed areas and the VMEs, with the notable exception of the sea pen VMEs on eastern Flemish Cap and the 3O Notch.

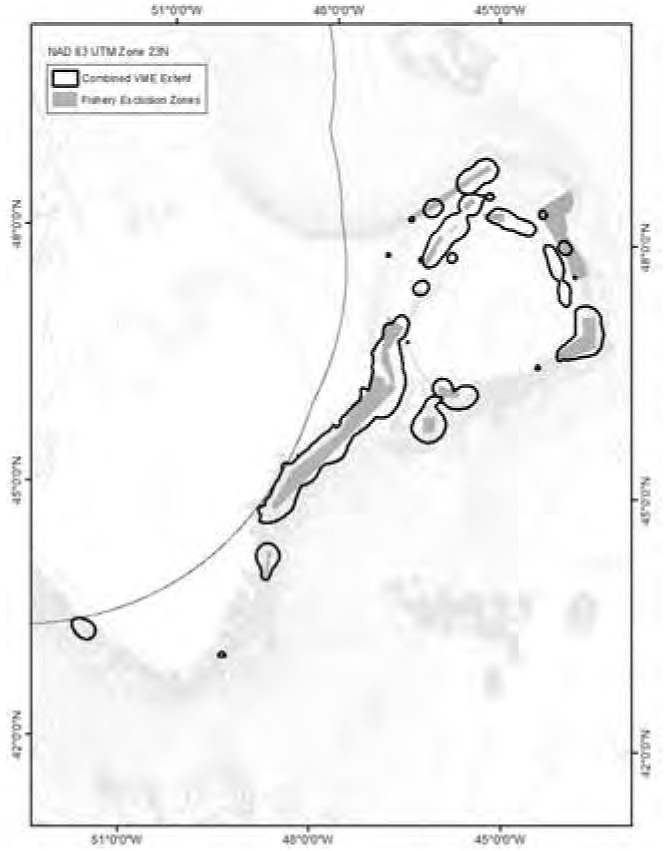


Fig. 4.2.5.3.2. Combined extent of the modified sponge VME, sea pen VME and large gorgonian coral VME in the NRA, as defined in Section 4.2.3.

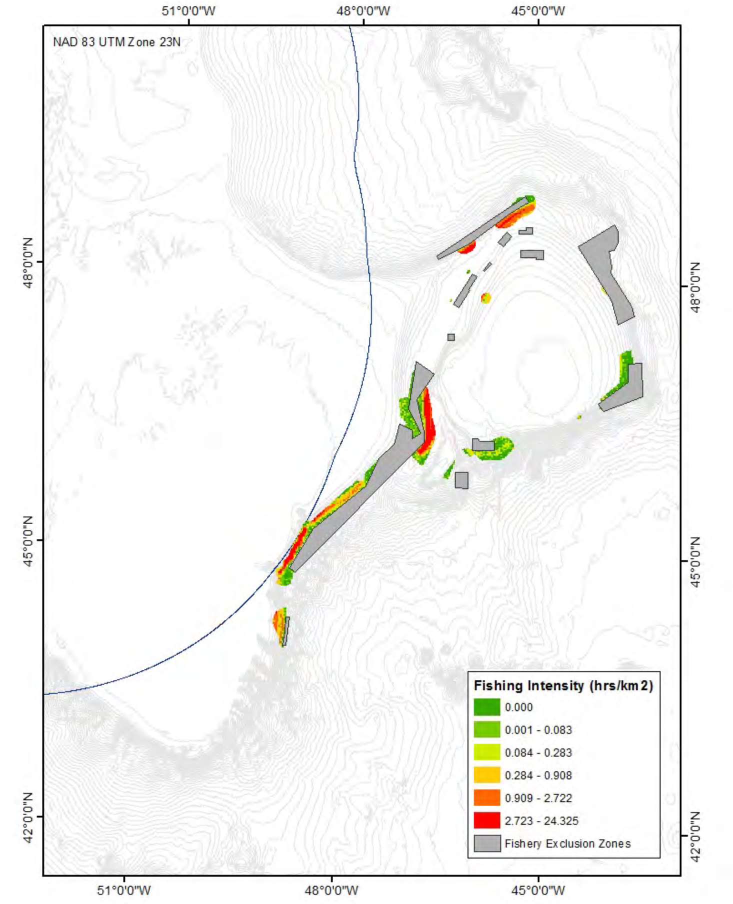
Assessment of VME impact

The fishing intensity (Fig. 4.2.5.3.1) and the VME biomass gridded layers were clipped to within the boundaries of the re-defined VME extent (Fig. 4.2.5.3.2). Given the assumption that selected VME indicator taxa are **unlikely** to occur in significant concentrations outside of the VME extent boundary, it was considered that the seabed within the fishing footprint, but falling outside of the re-defined VME boundary, would be at low risk of impact from bottom fishing (noting that the VME extent presented here is only for selected VME indicator taxa).

Figures 4.2.5.3.3 to 4.2.5.3.5, present the extent of VME species specific biomass observations and fishing intensity within the re-defined VME polygon boundaries. It can be seen that within the extent of some VME (outside of current closed areas) relatively high intensity fishing effort has occurred. Closer inspection reveals that areas of higher fishing intensity tend to occur on the shallower flanks and slopes of the Flemish

Cap and the Grand Banks of Newfoundland. It can also be seen that the observed VME biomass records are scattered throughout the VME extent, although some areas have more observation points than others. Areas devoid of VME biomass observations (due to lack of survey samples) lie beyond the scientific fishery survey area which tends to be at water depths greater than 1,600 m.

For each taxon-specific VME, the average VME biomass value (in kg km^{-2}) of every cell in which a VME biomass observation has been made was added cumulatively against a gradient of increasing fishing intensity per cell (in hrs km^{-2}) using average fishing effort (e.g., 2008-2014) and excluding any cells/observations within the closed areas. Plots of cumulative VME indicator species biomass against ranked fishing intensity were performed for sponge, sea pen and large gorgonians (Fig. 4.2.5.3.6). In all cases there is a clear point where VME biomass no longer increases at a given level of fishing intensity. Each of these inflection points is taken to represent a limit of fishing effort which separates areas of VME which have been impacted (e.g., defined by the cells above the cut-off value), and areas of VME which are at potential risk of impact (e.g., cells below the cut-off value). A test of significance was also applied to the cumulative plots in the form of a randomised permutation test, e.g., the order of the biomass was randomised against the fishing effort to generate 1000 sets of data against which the observed cumulative plot of biomass against fishing effort was compared, the level of significance (p value) is given in the figure caption.


51°0'0"W
48°0'0"W
45°0'0"W
NAD 83 UTM Zone 23N
48°0'0"N
45°0'0"N
42°0'0"N
Fishing Intensity (hrs/km2)
0.000
0.001 - 0.083
0.084 - 0.283
0.284 - 0.908
0.909 - 2.722
2.723 - 24.325
Fishery Exclusion Zones

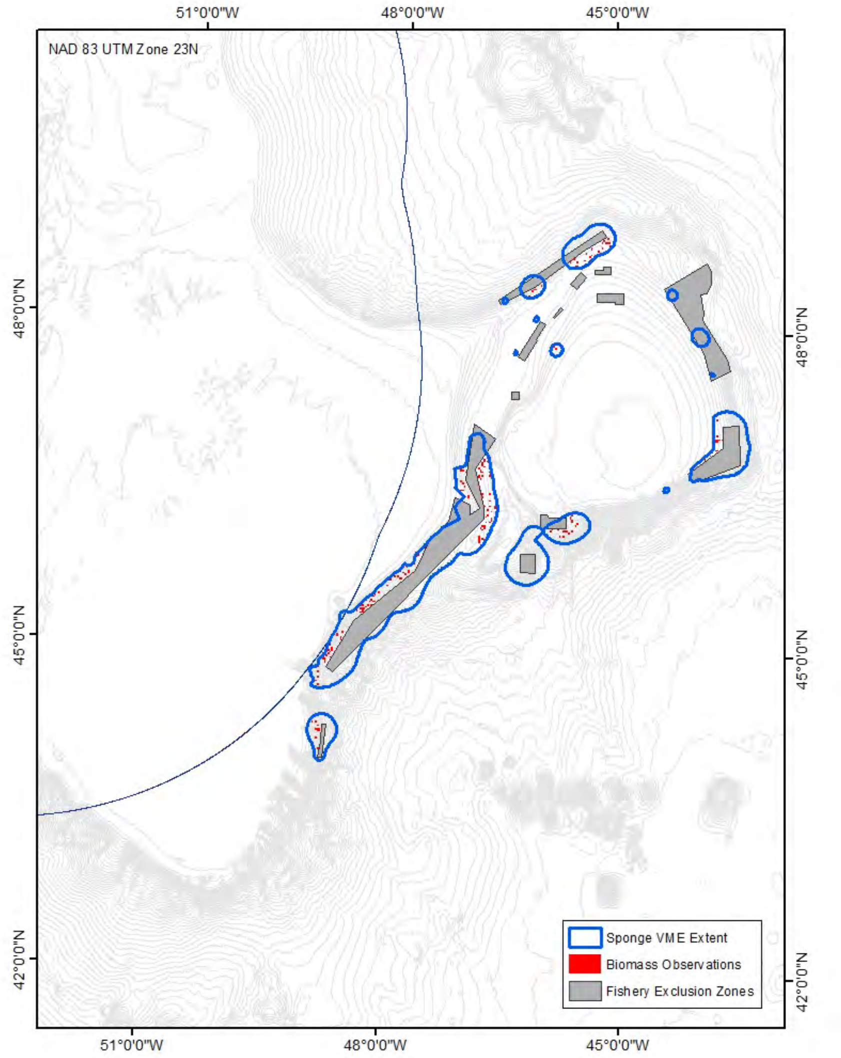
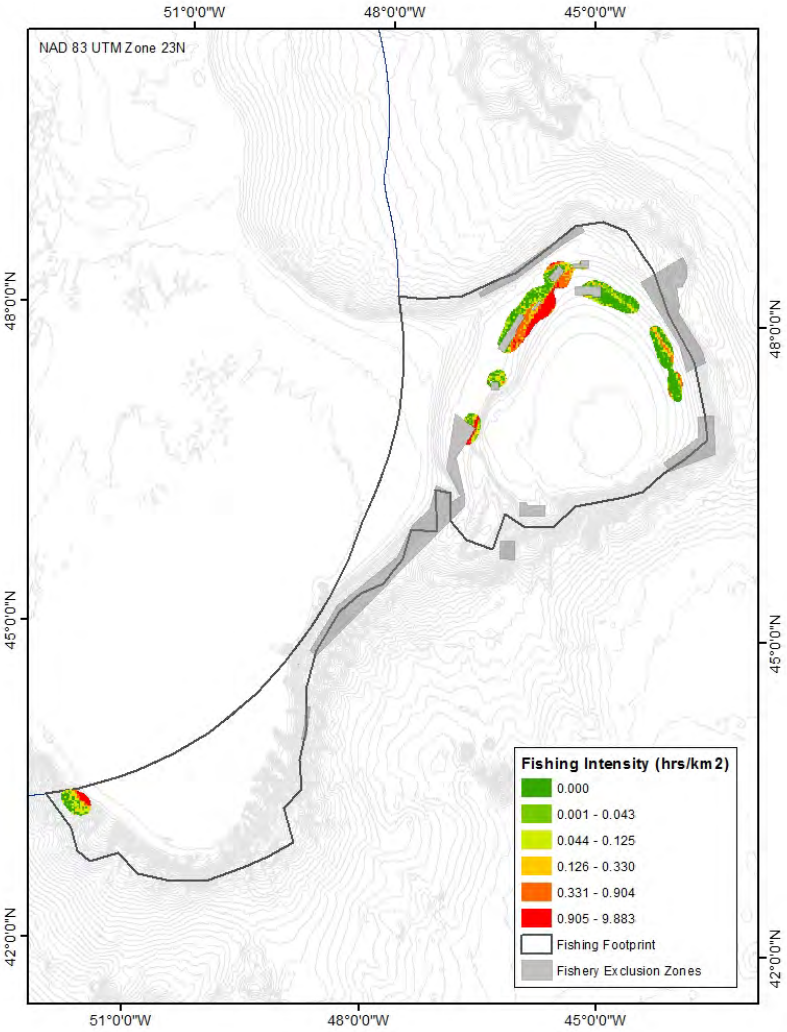


Fig.4.2.5.3.3. Distribution of fishing effort using VMS data between 2008 and 2014and biomass observations within the extent of sponge VME.


NAD 83 UTM Zone 23N
51°0'0"W
48°0'0"W
45°0'0"W
48°0'0"N
45°0'0"N
42°0'0"N
Fishing Intensity (hrs/km2)
0.000
0.001 - 0.043
0.044 - 0.125
0.126 - 0.330
0.331 - 0.904
0.905 - 9.883
Fishing Footprint
Fishery Exclusion Zones

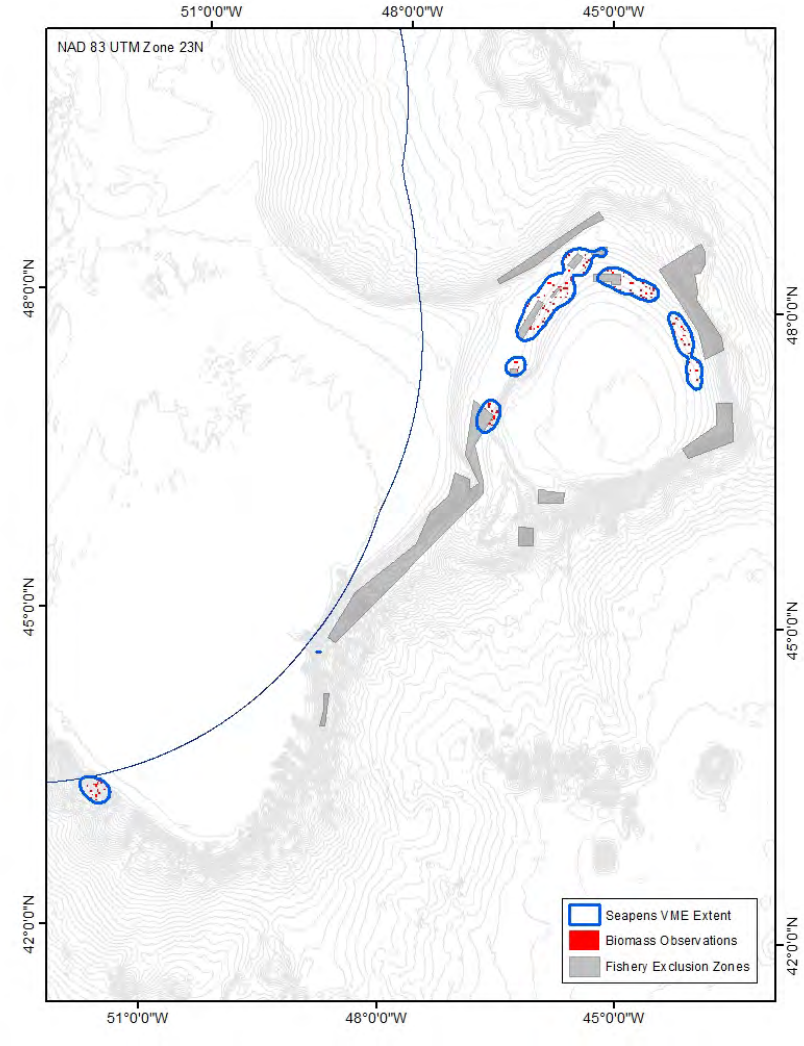
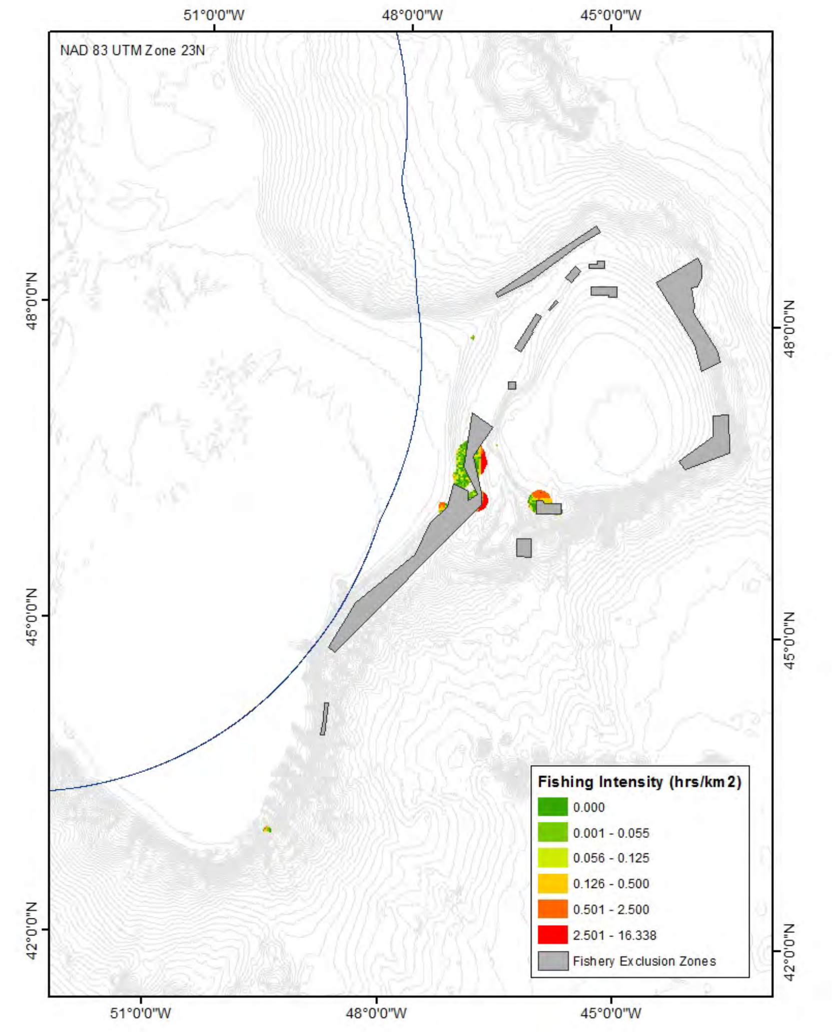


Fig. 4.2.5.3.4. Distribution of fishing effort (2008-2014) and biomass observations within the extent of sea pen VME.


NAD 83 UTM Zone 23N
51°0'0"W
48°0'0"W
45°0'0"W
48°0'0"N
45°0'0"N
42°0'0"N
Fishing Intensity (hrs/km2)
0.000
0.001 - 0.055
0.056 - 0.125
0.126 - 0.500
0.501 - 2.500
2.501 - 16.338
Fishery Exclusion Zones

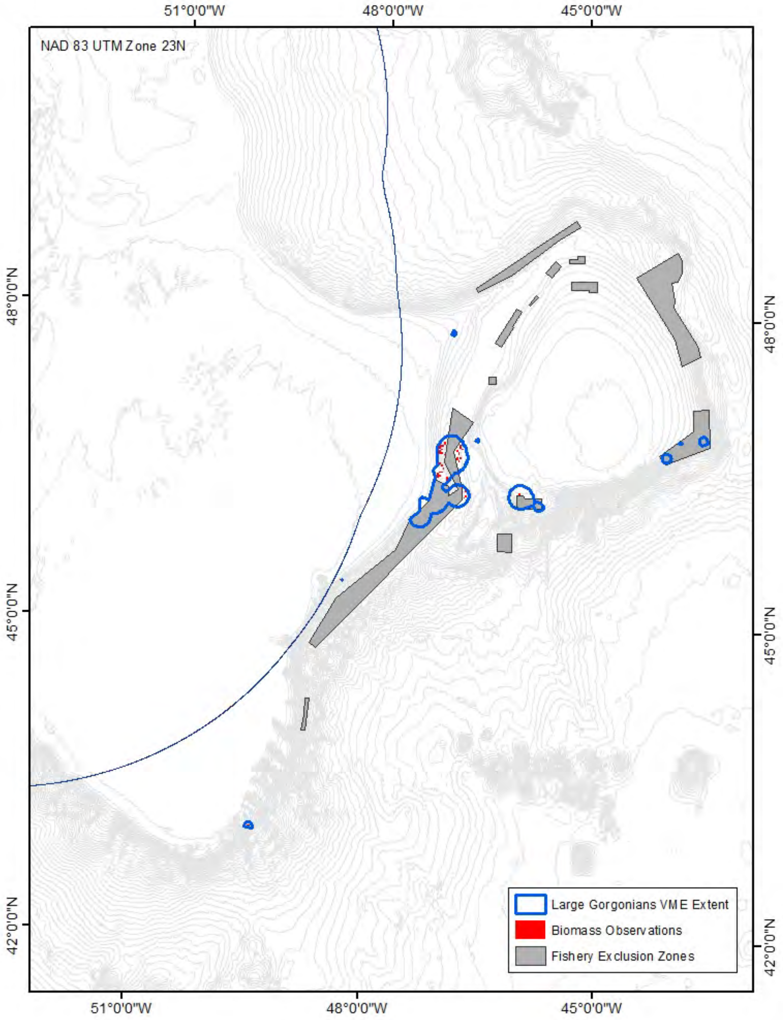


Fig. 4.2.5.3.5. Distribution of fishing effort (2008-2014) and biomass observations within the extent of large gorgonian VME.

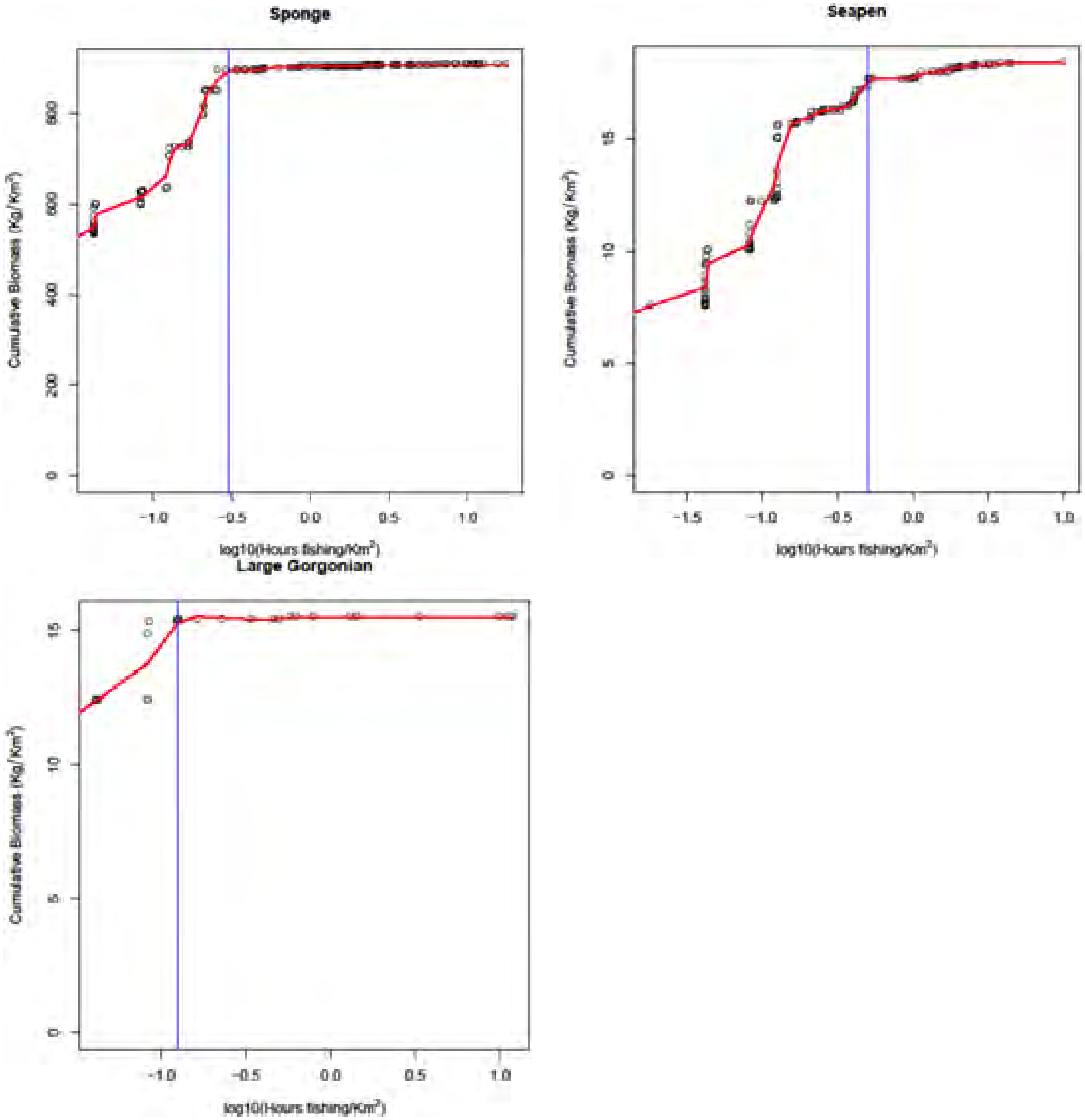


Fig. 4.2.5.3.6. Left: Cumulative plot of sponge VME biomass against fishing effort, inflexion a cut-off value of 0.3 hrs km^{-2}, p = <0.05. Centre: cumulative plot of sea pen VME biomass against fishing effort, inflexion cut-off value of 0.5 hrs km^{-2}, p = >0.05 <0.1. Right: cumulative plot of large gorgonian VME biomass against fishing effort, inflexion cut-off value of 0.1 hrs km^{-2}, p = >0.1<0.25.

Defining the spatial extent of VME impact relative to the area of VME

Each of the defined VME specific cut-off values was applied to the fishing effort corresponding to the respective VME polygons, to calculate the proportion of the VME area at high risk, low risk and impacted. This analysis addresses the second criteria of the FAO guidance, i.e., to assess the "spatial extent of the impact relative to the availability of the habitat type affected". Figure 4.2.5.3.7, shows the area of sponge VME at high risk of impact represents 14% of the total sponge VME area, whereas 21% of the sponge VME has been assessed to have been impacted. Accordingly, a total of 65% of sponge VME falls within the low risk category, either because it is protected by a fishery closure or it is in an area outside of the historical fishing footprint. Fig. 4.2.5.3.8, shows the area of sea pen VME at relatively high risk of impact represents 46% of the total sea pen VME area, whereas 38% of the sea pen VME has been assessed to have been impacted. However, only 16% of sea pen has been assessed to be at low risk of impact, either because it is protected by fishery closures or it is in an area outside of the historical fishing footprint. Figure 4.2.5.3.9, shows the area of large gorgonian VME at relatively high risk of impact represents 12% of the total large gorgonian VME area, whereas 31% of the large gorgonian VME has been assessed to have been impacted. Nevertheless, a total of 56% of large gorgonian VME is assessed to be at low risk of impact due to either protection by fishery closures or it is found in an area outside of the historical fishing footprint.

Similar calculations were performed using gridded biomass data for the same defined areas of impact, low and high risk categories. It should be noted that the gridded biomass layer is a modelled biomass layer derived from the KDE analysis (Kenchington et al., 2014) which predicts biomass in areas which have been impacted. The biomass values associated with each of the impact/risk categories are therefore modelled and not actual biomass values.

The total area and biomass of low risk, high risk and impacted categories for each VME assessed is summarised in Tables 4.2.5.3.1 and 4.2.5.3.2, respectively.

Table 4.2.5.3.1. Area (km^2) of VME at low risk, impacted and at high risk.

	Sponges			**Sea pens**			**Large gorgonians**	
	km^2	**(%)**		**km^2**	**(%)**		**km^2**	**(%)**
VME at Low risk	12,874	(65)		1,094	(16)		1,980	(56)
Closure inside footprint	4,227	(21)		1,094	(16)		1,485	(42)
Closure outside footprint	3,679	(19)					495	(14)
Outside fishing footprint	4,888	(25)						
VME Impacted	4,259	(21)		2,662	(38)		1,091	(31)
VME at High risk	2,771	(14)		3,226	(46)		434	(12)
Total area of VME	19,824	(100)		6,983	(100)		3,505	(100)

Table 4.2.5.3.2. Biomass (kg) of VME at low risk, impacted and at high risk.

	Sponges			Sea pens			Large gorgonians	
	kg	(%)		kg	(%)		kg	(%)
VME at Low risk	113,157	(73)		20	(19)		132	(63)
Closure inside footprint	49,541	(32)		20	(19)		115	(55)
Closure outside footprint	45,806	(30)					17	(8)
Outside fishing footprint	17,810	(11)						
VME Impacted	25,621	(17)		45	(42)		48	(23)
VME at High risk	16,149	(10)		41	(39)		28	(14)
Total biomass of VME	15,4926	(100)		106	(100)		208	(100)

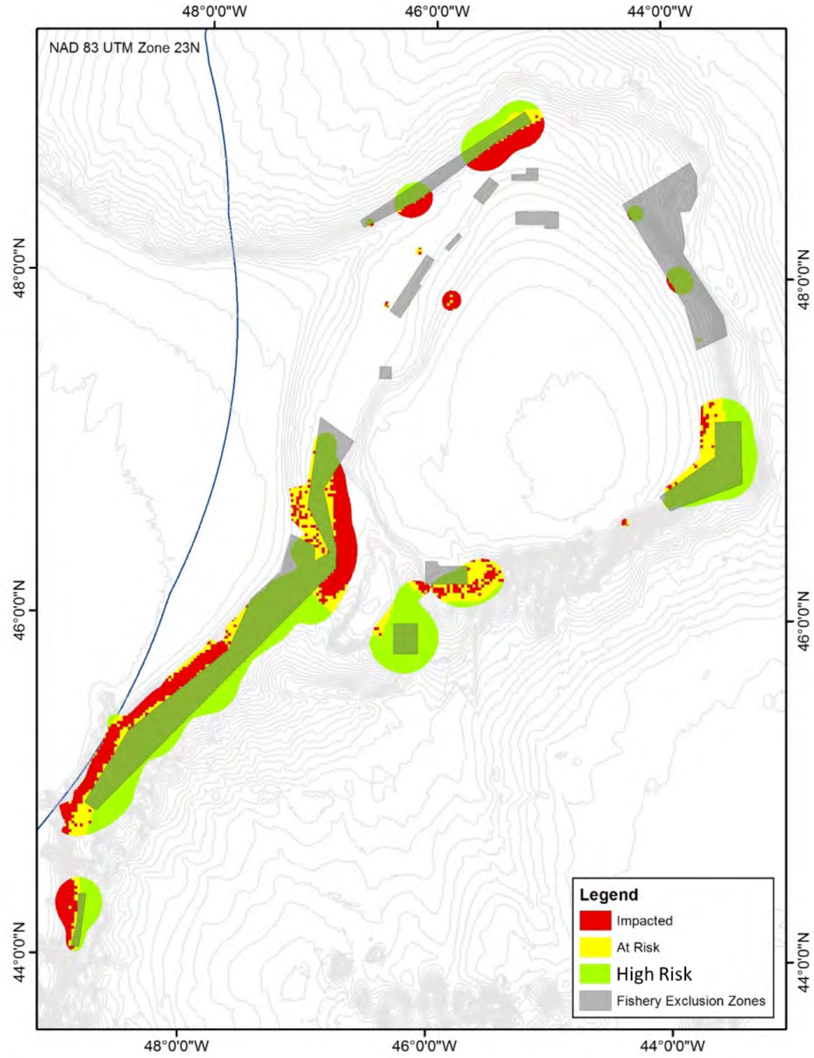


Fig.4.2.5.3.7. Areas of sponge VME at high risk of impact (yellow), impacted (red) and low risk of impact (green), according to calculated fishing intensity cut-off value.

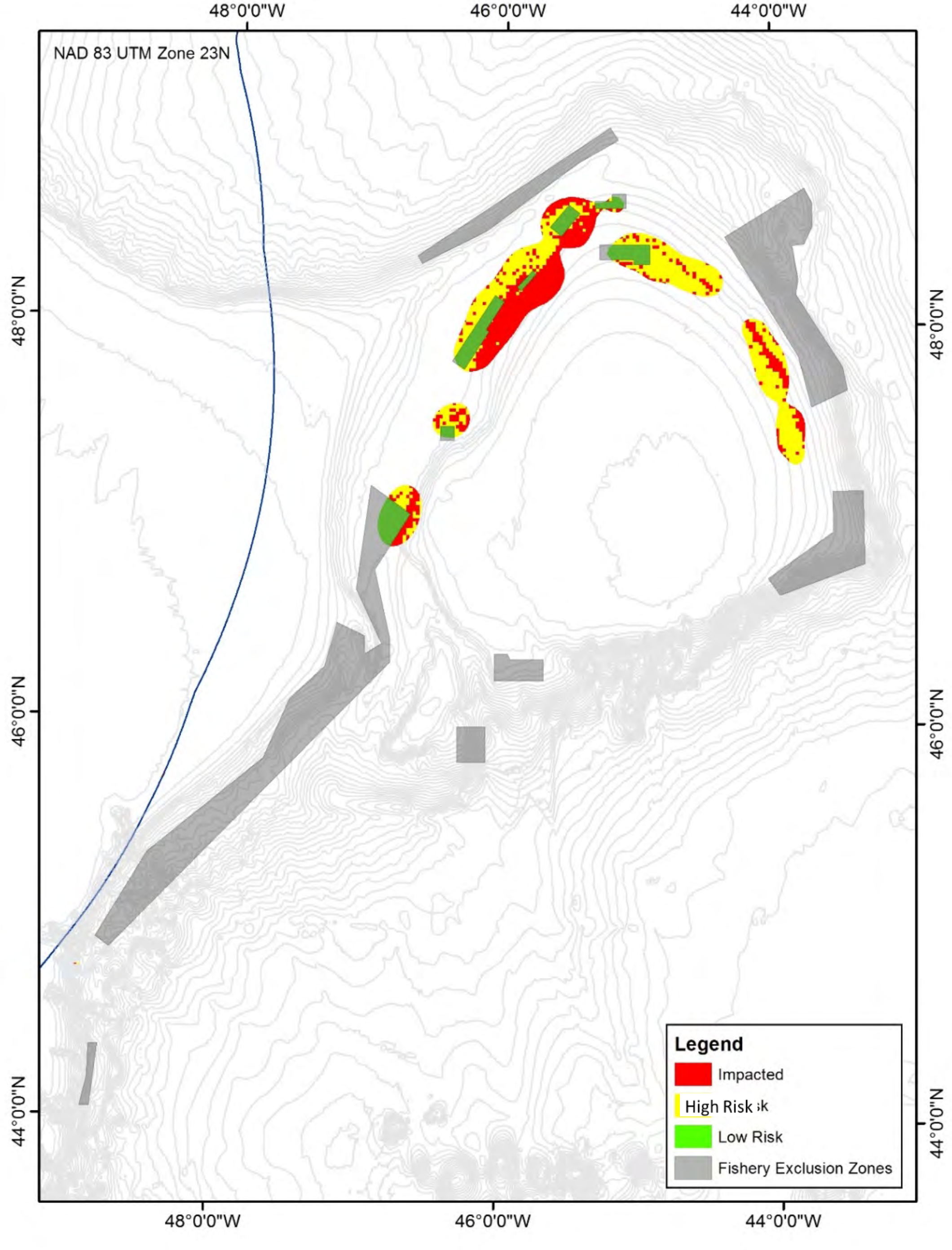


Fig. 4.2.5.3.8. Areas of sea pen VME at high risk of impact (yellow), impacted (red) and low risk (green), according to calculated fishing intensity cut-off value.

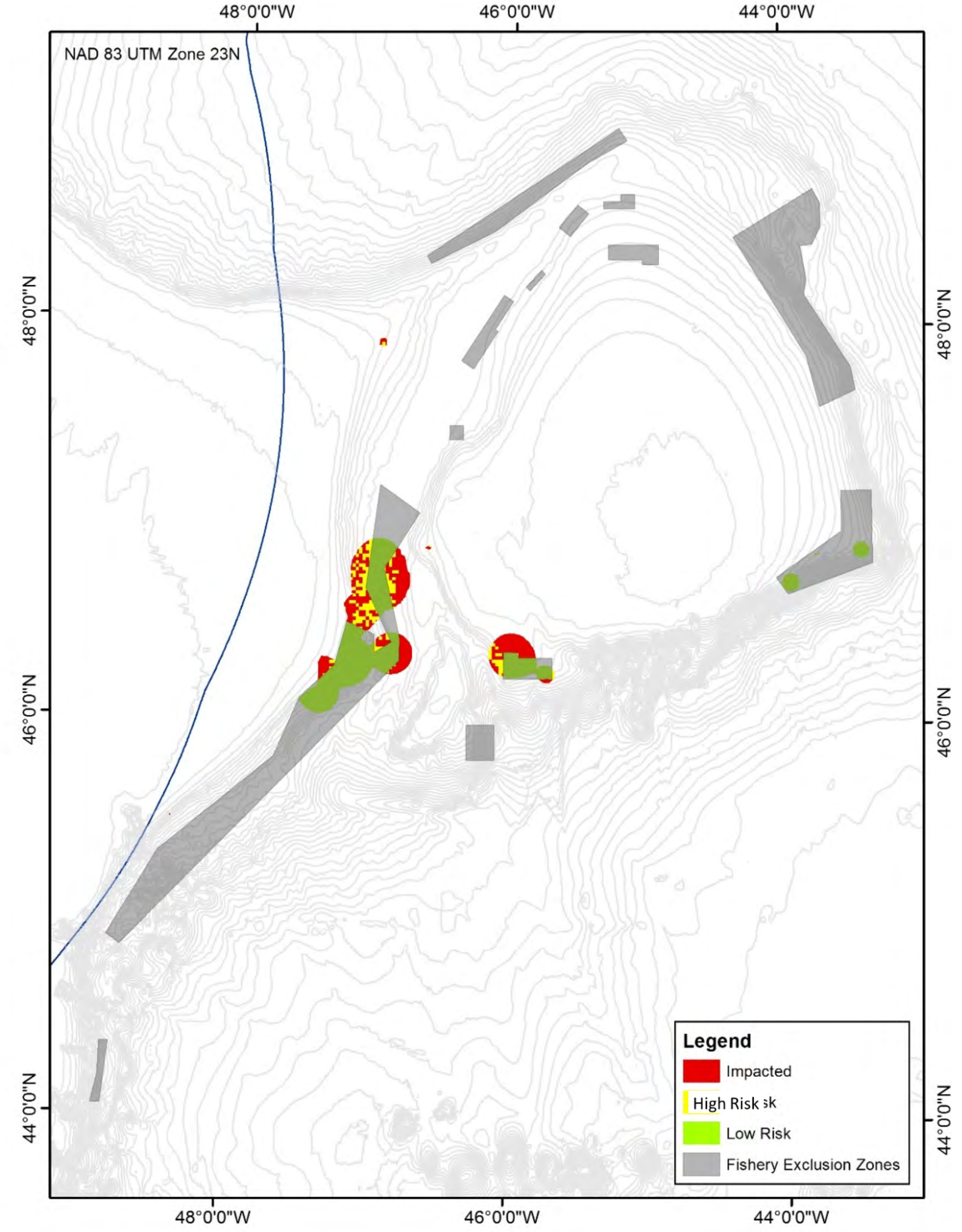


Fig. 4.2.5.3.9. Areas of large gorgonian coral VME at high risk of impact (yellow), impacted (red) and low risk (green) according to calculated fishing intensity cut-off value.

Overall assessment of SAI

Ideally, we would wish to take the output of FAO criterion ii, "the spatial extent of the impact relative to the availability of the habitat type affected", and through consideration of FAO criteria iii through vi, state whether or not the calculated impact on VME is significant. However, as quantitative data are not available for all of the FAO criteria, an evaluation of SAI against such criteria is not possible at this stage. Nevertheless, there are several other attributes of VMEs which can be assessed for which there are data available. For example, i. the proportion of area or biomass of VME which is assessed to be at low risk compared to high risk and impacted, ii. the number and area of overlapping VMEs, iii. the relative sensitivity of VMEs, iv. fishing area stability, and v. the level of VME fragmentation. Each of these criteria, which are defined in Table 4.2.5.3.3, can be quantitatively evaluated and assessed in relation to their relative risk of causing SAI. The results of this are given in Table 4.2.5.3.4. The cumulative impacts have been assessed by applying the calculated fishing pressure cut-off values to each year of VMS data. The cells which exceed the cut-off were then cumulated in order to generate a cumulative map of fishing pressure which exceeds the cut-off value.

Table 4.2.5.3.3. Definition of criteria used to assess SAI in the current study.

SAI criteria	**Definition**
Area/Biomass at low risk	This refers to the proportion of the area or biomass of VME which is currently at low risk either because it falls within a fishery closure area and/or is in an area outside of the fishing footprint
Area/Biomass impacted	Proportion of the area or biomass of VME which has been exposed to a level of fishing effort above the defined cut-off point within any one year
Area/Biomass at high risk	Proportion of the area or biomass of VME which falls below the defined cut-off point of fishing effort within any one year.
Number of overlapping VMEs	Proportion of area overlapping with other VMEs
Fishing effort/biomass cut-off value (Index of VME sensitivity)	The impact cut-off values for each of the VMEs are used as a proxy of sensitivity (a high cut-off value indicates a low sensitivity) as it indicates the point at which trawl duration/length exceeds VME indicator patch size within the habitat
Index of fishing stability	Number of cells consistently fished above the impact cut-off value over time as a proportion of the total cells impacted
Index of Risk of VME fragmentation	Proportion of discrete VME without protection

Table 4.2.5.3.4. Quantitative evaluation of SAI criteria used in the present overall assessment of SAI for sponge, sea pen and large gorgonian VME in the NRA.

	Sponge		**Sea pen**		**Large gorgonian**	
SAI criteria	**Area**	**Biomass**	**Area**	**Biomass**	**Area**	**Biomass**
Low risk	65%	73%	16%	19%	56%	63%
High risk	14%	10%	46%	39%	12%	14%
Impacted	21%	17%	38%	42%	31%	23%
VMEs overlapping	11%		2%		74%	
Fishing effort/biomass cut-off value (index of sensitivity)	0.3		0.5		0.1	
Fragmentation	1%		26%		2%	
Fishing area stability	32%		14%		21%	

An expert comparative evaluation of these results (above) was undertaken such each result was assigned a relative risk score of SAI being realised (e.g., low, moderate and high risk). For example, if a VME has a large proportion of its area and/or biomass evaluated at low risk of impact then it would be assessed as having a relatively low risk score for SAI. By contrast, if a VME had a relatively high level of sensitivity (low fishing effort/biomass cut-off value) it would be assessed as having a high risk score of SAI. The overall results of the expert assessment of SAI is given in Table 4.2.5.3.5.

Table 4.2.5.3.5. Overall SAI risk scores for sponge, sea pen and large gorgonian VME in the NRA. The risk scores are relative (e.g, low, medium and high) and determined by expert evaluation of the data presented in Table 4.2.5.3.4 .

	Sponge		**Sea pen**		**Large gorgonian**	
SAI criteria	**Area**	**Biomass**	**Area**	**Biomass**	**Area**	**Biomass**
Low risk	Low	Low	High	Mod	Mod	Low
High risk	Low	Low	High	High	Low	Low
Impacted	Mod	Mod	High	High	High	Mod
VMEs overlapping	Mod		High		Low	
Index of Sensitivity	High		Mod		High	
Fragmentation	Low		High		Low	
Fishing area stability	Low		High		Low	
Overall risk of SAI	**Low**		**High**		**Low**	

Sea pens

Photographs of the sea floor within a heavily fished portion of a sea pen VME polygon showed no megafauna, despite the presence of sea pens in the nearby closed area, indicating that sea pens cannot withstand concentrated and repeated fishing effort. In addition, WGESA previously noted that redfish larvae attach to the sea pen stalks and these habitats may be important nursery areas for *Sebastes* spp. (see ToR 3.1.2 of NAFO, 2014), thereby increasing the risk to the long term sustainability of NAFO fisheries should too much sea pen habitat be destroyed. WGESA at its 2013 meeting noted the lack of protection for the entire eastern Flemish Cap part of the sea pen system was of concern for the long term sustainability of these VME given the lack of knowledge of recruitment processes and connectivity. Therefore, although they may be more resilient to a first pass of the trawl gear than other types of coral or sponge, sea pens have more of their core VME area unprotected.

Furthermore, with the current high level of fragmented sea pen closures and exposure to a relatively low level of fishing stability, WGESA consider that there is ongoing high risk of further sea pen SAI (see Fig. 4.2.5.3.7). This could lead to the loss of individual VME polygons which could have consequences for other areas depending on source/sink relationships. In conclusion sea pens are assessed as having experienced SAI (Table 4.2.5.3.5) and also being at high risk of further SAI.

Sponge and large gorgonian corals

Fishing in the vicinity of sponge VME has persisted in the same areas for many years with little change in the impact footprint as evidenced by the relatively high value of fishing stability exposure calculated for these VMEs (Table 4.2.5.3.4). The directed Greenland halibut fishery, that is the main fishery carried out in waters below 700 m depth (Gonzalez-Costas et al., 2011), where the sponge and large gorgonian VME occur, began in the early-1960s in this area (Bowering and Brodie, 1995), indicating that impacts of fishing on the sponge and large gorgonian VME may have been accumulating for at least 50 years. However, based upon the current analysis and assessment of SAI which utilizes the last 7 years of VME effort data, little change is observed in the identified core fishing areas associated with these VMEs. This, combined with an overall greater proportion of sponge and large gorgonian VME protected by fishery closures, results in an overall evaluation of a low likelihood of SAI for these VMEs.

Impacts on non-coral and sponge VME

The WGESA completed the assessment of SAI on the sponges, large gorgonian corals and sea pens. The remaining VME indicators, that is the erect bryozoans, large size sea squirts, crinoids, cerianthid anenomes and small gorgonian corals were not assessed. Previously, WGESA had undertaken kernel density analyses of the small gorgonian corals, erect bryozoans and large size sea squirts, however in situ surveys conducted in 2015, demonstrated that the significant concentration polygons for erect bryozoans and large size sea squirts were not indicative of VME for these species, and WGESA recommended that the location of tows with catches over the threshold be considered the VME. To date, species distribution models have not been conducted on these indicator species, so there is potential for those analyses to assist in the delineation of the VME. In this section we examined the relationship between the tows with significant catches of erect bryozoans and large size sea squirts to determine whether the approach we have used for the sponges, large gorgonian corals and sea pens will be applicable to these taxa. This will allow an evaluation of the cut off levels for the impact but not its spatial extent or significance (until more modelling is completed at the next meeting).

Erect bryozoans

The largest of the significant catches of bryozoans was of 7.843 kg (Fig. 4.2.5.3.10). The distribution of the significant catches of bryozoans was localized to the Tail of the Grand Bank (Fig. 4.2.5.3.11) in areas where there has been little fishing effort over the last years (2007 to 2014) (Fig. 4.2.5.3.12). The relationship between the cumulative biomass and average fishing effort reflects this, with the cut-off for fishing being very clear at 2.3 hours (Fig.4.2.5.3.13).

Fig. 4.2.5.3.10. The largest catch of erect bryozoans from the research vessel surveys. This 2008 catch of ~7.8 kg was from the Tail of Grand Bank.

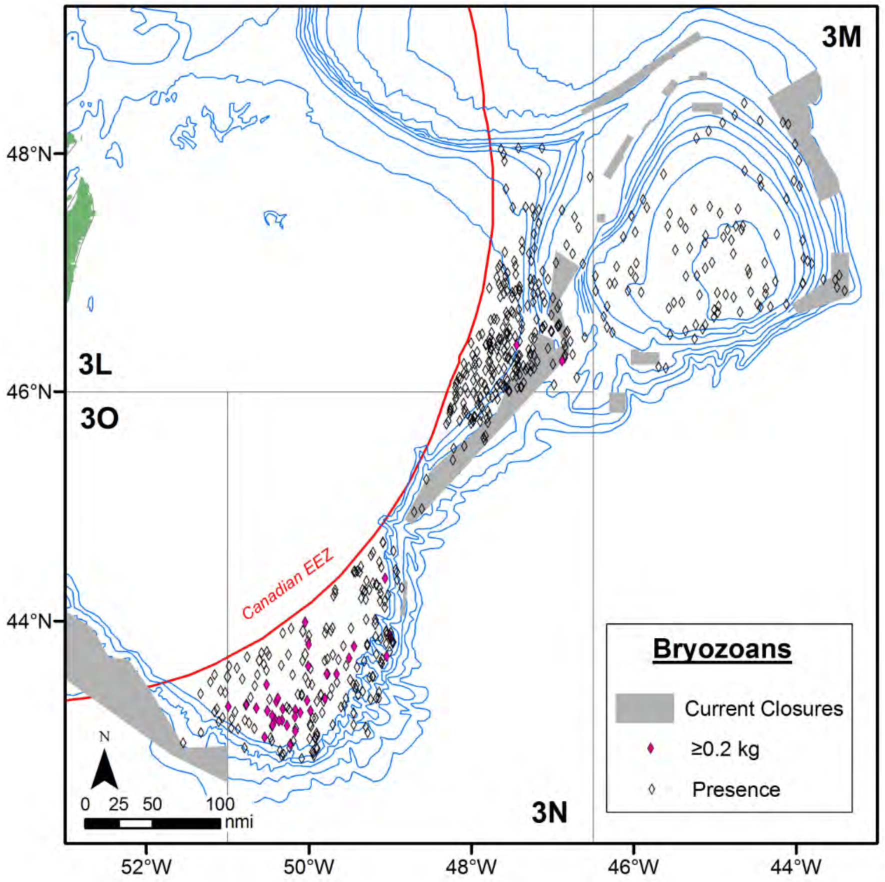


Fig.4.2.5.3.11. Location of research vessel survey catches of VME indicator erect bryozoans. Significant catches were determined by kernel density analysis and assessment (NAFO, 2013).

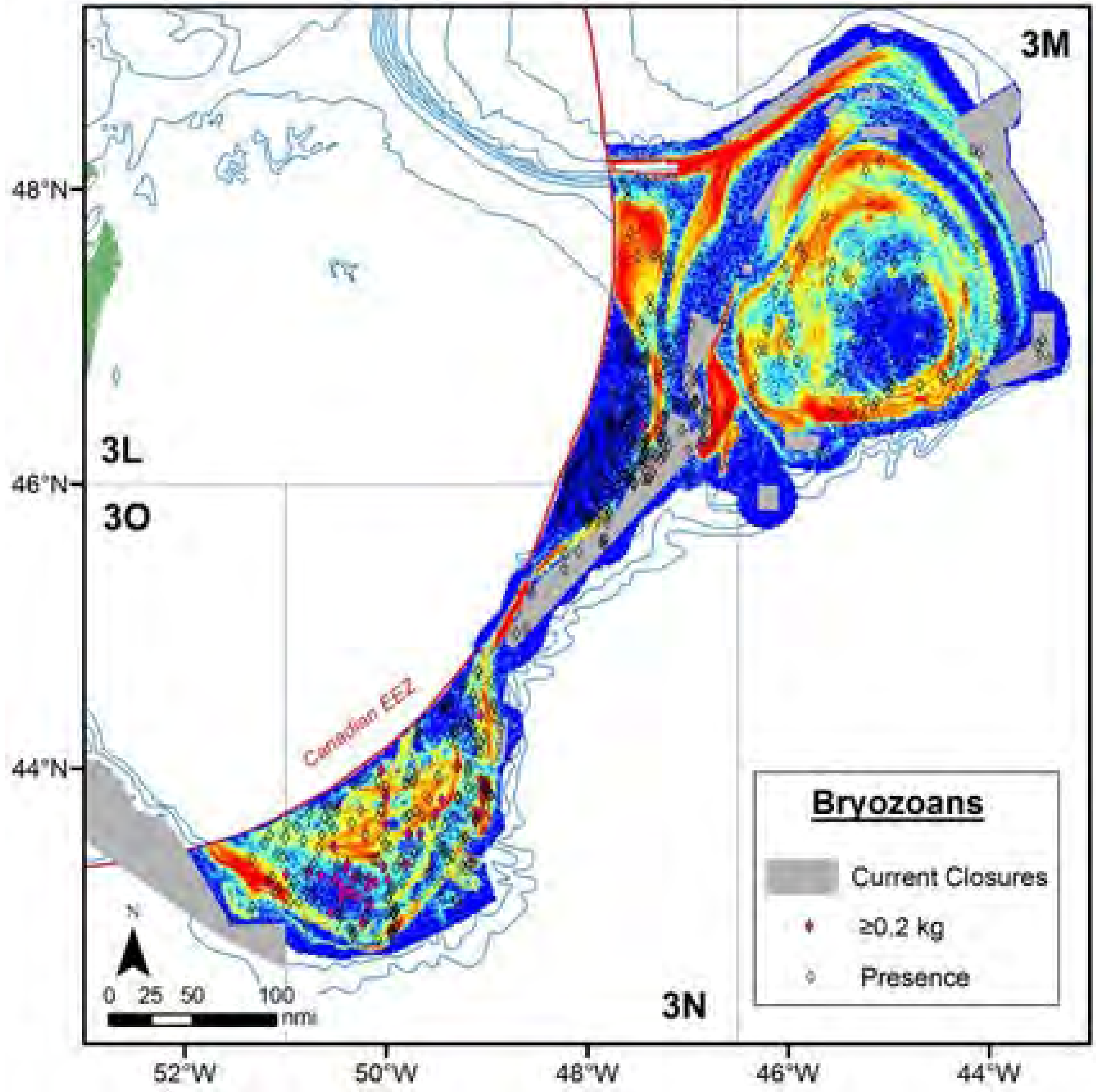


Fig. 4.2.5.3.12. Location of research vessel survey catches of VME indicator erect bryozoans in relation to the average fishing effort from 2008- 2014. Significant catches were determined by kernel density analysis and assessment (NAFO, 2013).

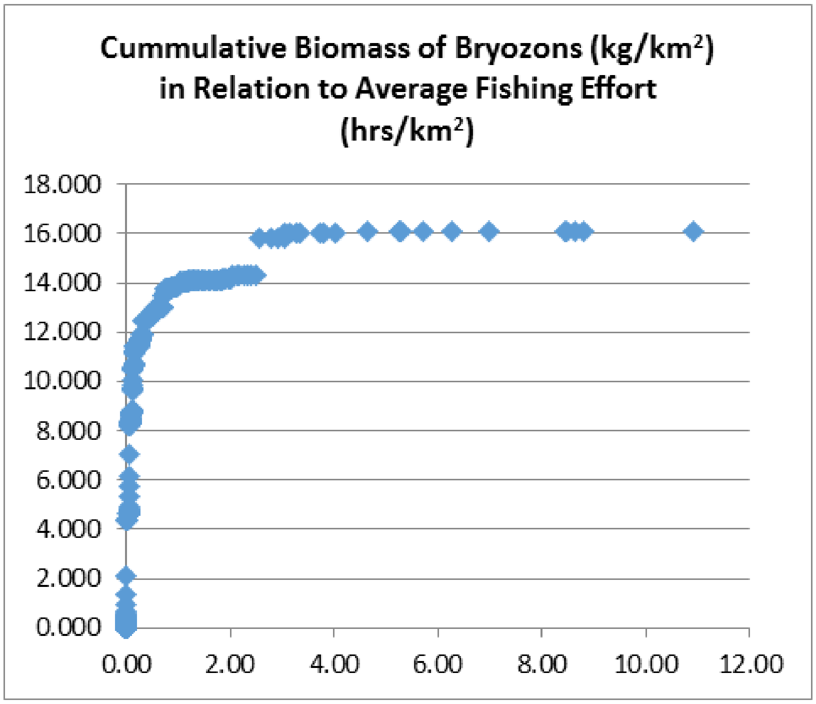


Fig. 4.2.5.3.13. Cumulative distribution of the biomass of erect bryozoans (Y axis) with increase in average fishing effort (X axis).

Large sea squirts

The distribution of the significant catches of large sea squirts, mostly the sea potato or sea onion *Boltenia ovifera*, was localized to the Tail of the Grand Bank (Fig. 4.2.5.3.14) in areas adjacent to heavy fishing effort over the last years (2007 to 2014) (Fig. 4.2.5.3.15). The relationship between the cumulative biomass and average fishing effort was not as clear as for the erect bryozoans, however the inflection of the curve appears to be between 0.4 and 0.5 hours (Fig. 4.2.5.3.16).

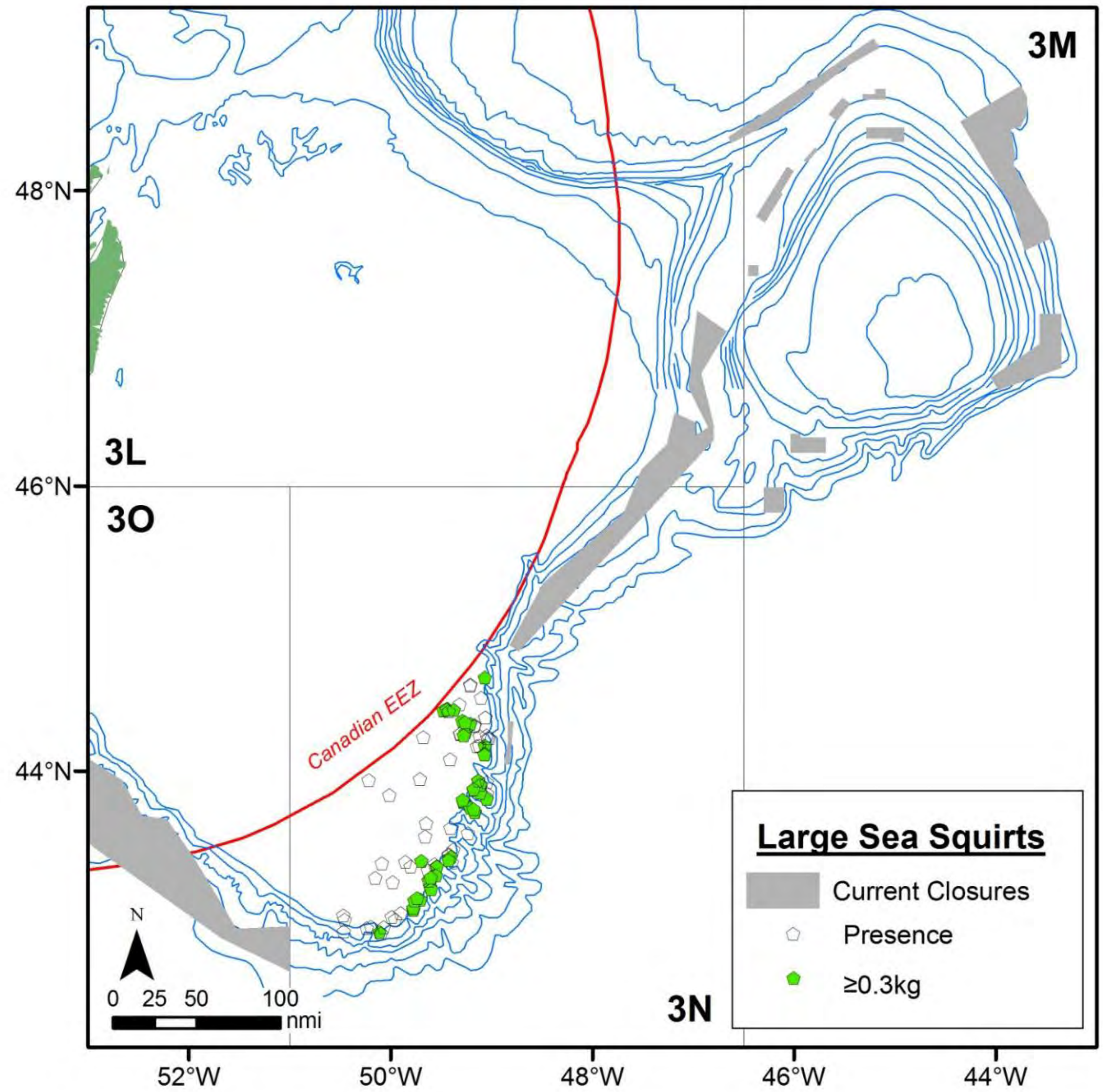


Fig. 4.2.5.3.14. Location of research vessel survey catches of VME indicator large sea squirts. Significant catches (≥0.3 kg) were determined by kernel density analysis and assessment (NAFO, 2013).

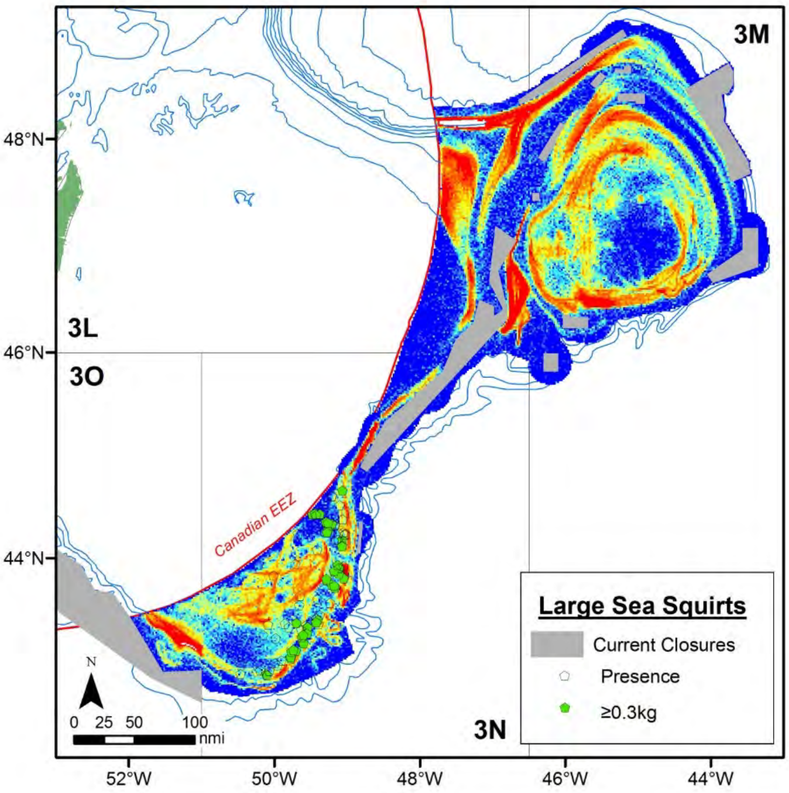


Fig. 4.2.5.3.15. Location of research vessel survey catches of VME indicator large sea squirts in relation to the average fishing effort from 2008-2014. Significant catches were determined by kernel density analysis and assessment (NAFO, 2013).

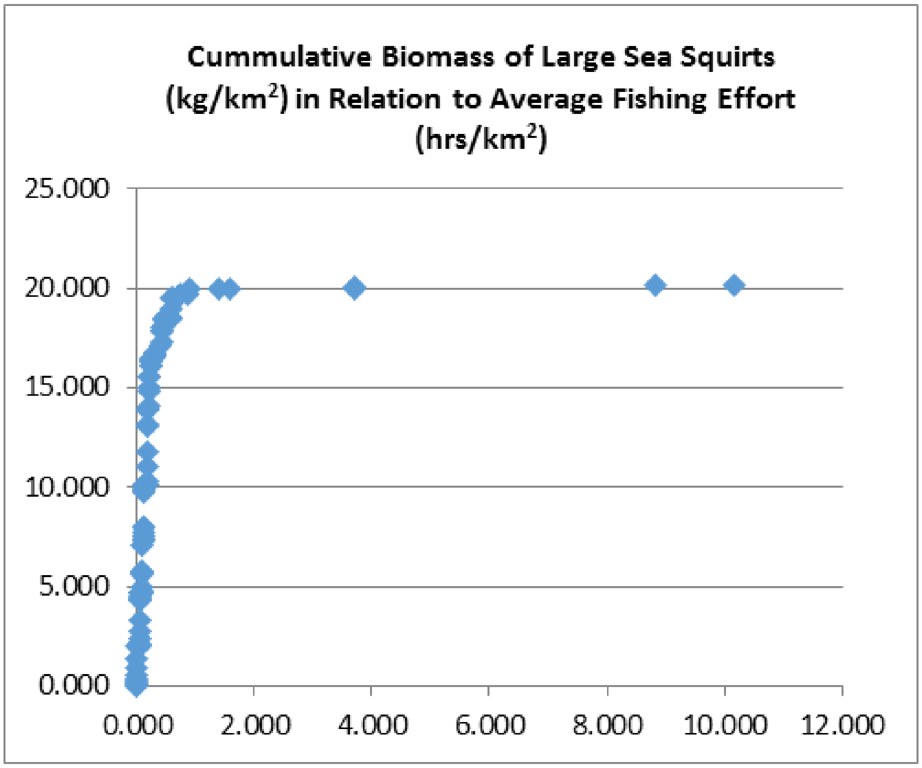


Fig. 4.2.5.3.16. Cumulative distribution of the biomass of large sea squirts (Y axis) with increase in average fishing effort (X axis).

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