

Northwest Atlantic Fisheries Organization



Report of the Scientific Council (in conjunction with NIPAG) Meeting

8-9 September 2021

By WebEx

NAFO
Halifax, Nova Scotia, Canada
2021



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**REPORT OF THE SCIENTIFIC COUNCIL (IN CONJUNCTION WITH NIPAG) MEETING
8 September 2021, via WebEx**

Chair: Carmen Fernández

Rapporteur: Tom Blasdale

I. PLENARY SESSIONS

Scientific Council, in conjunction with the NAFO/ICES *Pandalus* Assessment Group, met by WebEx on 8 September 2021, to formulate management advice for northern shrimp in NAFO Divisions 3M and 3LNO. Representatives attended from Canada, Denmark (in respect of the Faroe Islands and Greenland), the European Union, Norway and Ukraine. A full list of participants is included in Appendix V.

The Chair, Carmen Fernandez, opened the meeting 08:00 Halifax time (12:00 UTC) and welcomed participants. The provisional agenda was adopted as circulated. The Scientific Council Coordinator was appointed as rapporteur.

II. REVIEW OF SCIENTIFIC COUNCIL RECOMMENDATIONS IN 2020

Recommendations from 2020 are considered in the relevant sections of this report.

III. NAFO/ICES PANDALUS ASSESSMENT GROUP

In September 2021, NIPAG fully assessed two stocks of relevance to NAFO: northern shrimp in NAFO Division 3M and Northern shrimp in NAFO Divisions 3LNO. Northern shrimp in Subareas 0 and 1, and northern shrimp in Denmark Strait and off East Greenland will be assessed in the November 2021 NIPAG meeting, as will northern shrimp in the Barents Sea, northern shrimp in the Skagerrak and Norwegian Deep, and northern shrimp in the Fladen ground. The September 2021 NIPAG report is presented as Appendix I in this report.

IV. MANAGEMENT ADVICE

1. Request for Advice on TACs and Other Management Measures

Requests from the NAFO Commission for advice on Northern Shrimp in Division 3M and Northern Shrimp in Divisions 3LNO were addressed during this meeting. Requests from coastal states will be addressed in November 2021 (see section V.1, Scheduling of Future Meetings).

a) Northern Shrimp in Division 3M

Advice September 2021 for 2022

Recommendation

The stock is now below B_{lim} i.e. it has now entered the collapse zone defined by the NAFO PA framework. The indications of improved recruitment observed in 2020 did not translate into an increase in stock biomass. There are indications of worsening recruitment in the 2021 survey data.

To be consistent with the precautionary approach, Scientific Council advises that no directed fishery should occur in 2022.

Management objectives

No explicit management plan or management objectives defined by the Commission. Convention general principles are applied. Advice is based on qualitative evaluation of biomass indices in relation to historic levels, and provided in the context of the precautionary approach framework (FC Doc. 04/18).

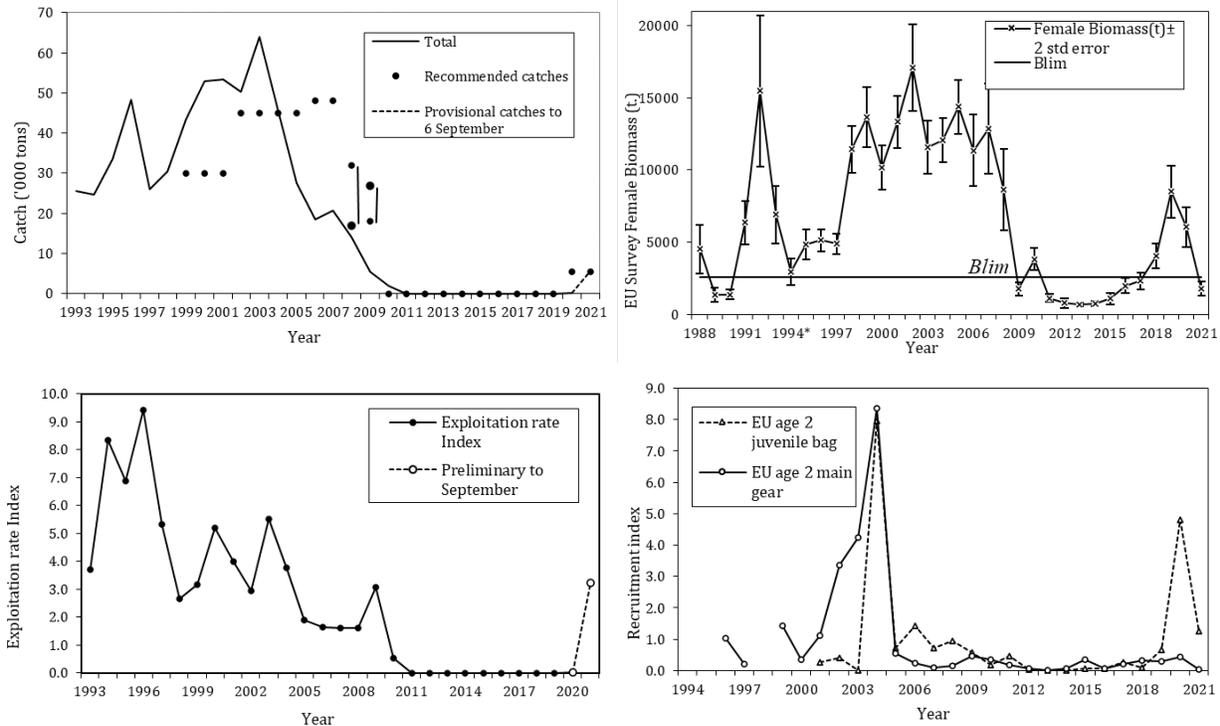
<i>Convention objectives</i>	<i>Status</i>	<i>Comment/consideration</i>	
Restore to or maintain at B_{msy}		Stock below B_{lim} . B_{msy} is unknown.	 OK
Eliminate overfishing		F_{lim} not defined.	 Intermediate
Apply Precautionary Approach		B_{lim} defined. No fishing mortality reference point defined	 Not accomplished
Minimise harmful impacts on living marine resources and ecosystems		VME closures in effect, sorting grids mandatory	 Unknown
Preserve marine biodiversity		Cannot be evaluated	

Management unit

The Northern Shrimp stock on Flemish Cap is considered to be a separate population.

Stock status

After an upward trend that started in 2014, the stock has decreased since 2019, and it is now below B_{lim} . The strong age 2 recruitment observed in 2020 did not translate into the expected high stock biomass in 2021 and recruitment decreased strongly in 2021. The exploitation rate index estimated from the preliminary catch data until the beginning of September 2021 increased markedly due to the resumed fishery and the decline of biomass index.



Reference points

Scientific Council considers that a female survey biomass index of 15% of its maximum observed level provides a proxy for B_{lim} (SCS Doc. 04/12).

Projections

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

Assessment

No analytical assessment is available. Evaluation of stock status is based upon fishery and research survey data.

Further exploration of data and assessment possibilities will occur during the next year with participation in a joint benchmark process with ICES in early 2022.

The next assessment will take place prior the NAFO Annual Meeting in September 2022.

Human impact

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

Biological and Environmental Interactions

Multispecies models (Pérez-Rodríguez et al. 2016, Pérez-Rodríguez and D. González-Troncoso 2018), suggest that, predation by cod and redfish, together with fishing were the main factors driving the shrimp stock to the collapse after 2007. In the most recent years, decreasing redfish and cod stocks have likely resulted in reduced predation mortality on shrimp.

Results of modelling suggest that, in unexploited conditions, cod and redfish would be expected to be a highly dominant component of the system, and high shrimp stock sizes like the ones observed in the 1998 – 2007 period would not be a stable feature in the Flemish Cap.

Fishery

This fishery is effort-regulated. The effort allocations were reduced by 50% in 2010 and a moratorium was imposed in 2011. The fishery was reopened in 2020. Fishing effort and catches were very low in 2020 but increased in 2021. Recent catches and agreed effort by the NAFO Commission were as follows:

	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
NIPAG	2000	0	0	0	0	0	0	0	0	0	79	5811 ¹
STATLANT 21	1976	0	0	0	0	0	0	0	0	0	0	0
Effort (Agreed Days)	5227	0	0	0	0	0	0	0	0	0	2640	2640
Effort days used	37										21	423 ¹
SC Recommended Catches (tonnes)	ndf	5448	5448									

¹ preliminary catch and effort to September 6th 2021

Effects of the fishery on the ecosystem

The fishery was closed to directed fishing from 2011 to 2019.

Special comments

In September 2019, the Commission asked the SC to advise on the possible sustainable management measures for northern shrimp in div 3M, including quota, fishing effort, periods or other technical measures. In its response, SC recommends that the management of 3M shrimp be converted from the existing “effort regulation” to “catch regulation” in line with all other stocks in the NAFO Regulatory Area. Full detail of the response is available in SCS Doc. 19/23

SC notes that only about 16% of the allocated effort has been used until September 2021, but catches have already exceeded the advised catch for 2021. If all fishing days were used, the catches advised by SC would be expected to be greatly exceeded.

Source of Information

SCR Doc. 21/038

b) Northern Shrimp in Divisions 3LNO

Advice September 2021 for 2022-2023

Recommendation

No directed fishery in 2022 and 2023 as the stock is below B_{lim} with no indication of short-term recovery.

Management objectives

No explicit management plan or management objectives have been defined by the Commission. Convention General Principles are applied. Advice is based on qualitative evaluation of biomass indices in relation to historic levels and provided in the context of the precautionary approach framework (FC Doc. 04/18).

<i>Convention General Principles</i>	<i>Status</i>	<i>Comment/consideration</i>
<i>Restore to or maintain at B_{msy}</i>	●	<i>Stock below B_{lim}</i>
<i>Eliminate overfishing</i>	●	<i>No directed fishery</i>
<i>Apply Precautionary Approach</i>	●	<i>B_{lim} is defined. No fishing mortality reference point defined</i>
<i>Minimise harmful impacts on living marine resources and ecosystems</i>	●	<i>No directed fishery</i>
<i>Preserve marine biodiversity</i>	○	<i>Cannot be evaluated</i>

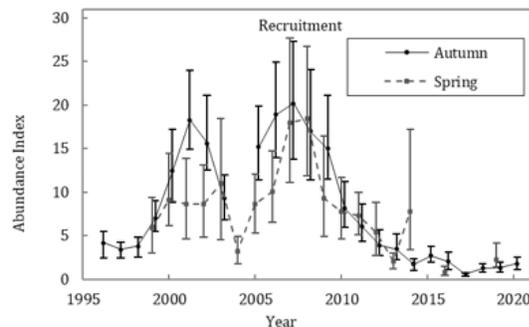
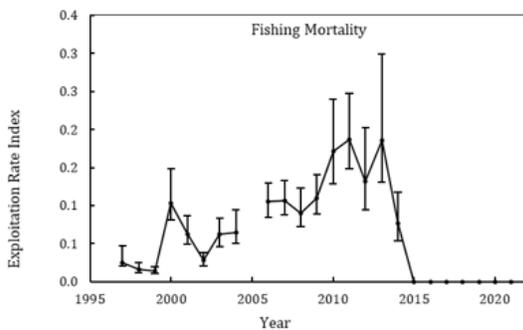
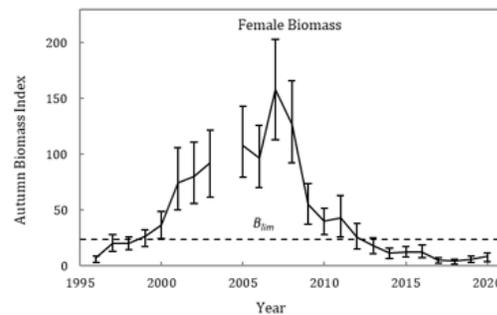
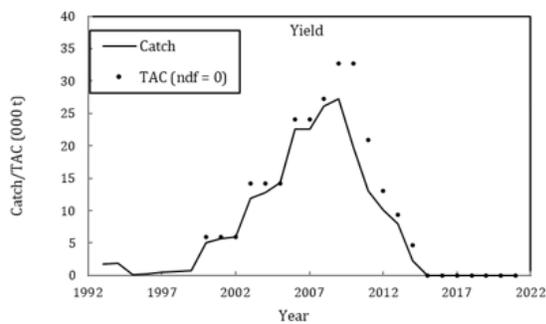
- OK
- Intermediate
- Not accomplished
- Unknown

Management Unit

The stock in Div. 3LNO is assessed and managed as a discrete population (see special comments).

Stock Status

Currently the risk of the stock being below B_{lim} is greater than 95%. There is no indication of improved recruitment.



Reference points

Scientific Council considers that a female survey biomass index of 15% of its maximum observed level provides a proxy for B_{lim} (SCS Doc. 04/12).

Projections:

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

Assessment

Based upon a qualitative evaluation of trends in stock biomass, fishing mortality proxy and recruitment. Input data are research survey indices and fishery catches.

Next full assessment is planned for 2023.

Human impact

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

Biological and Environmental Interactions

After reaching record-high conditions in 2010-2011 (warmest conditions since 1980), the bottom temperature in 3LNO had cooled down to near-normal conditions in 2014-2018 and a warming trend has been emerging since. Direct effects of temperature on shrimp distribution, recruitment, growth and survival are poorly understood.

Predation (by cod, Greenland halibut and redfish), low abundance of high energy prey (such as capelin) and environmental factors (including phytoplankton bloom dynamics) appear to be important drivers of the decline of Northern Shrimp in Divs. 2J3KL.

Fishery

The fishery, until 2014, was a directed bottom trawl fishery and there is little or no bycatch of shrimp in other trawl fisheries. The fishery in Div. 3LNO is regulated by quota.

	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
Enacted TAC ¹	13 108	9393	4697	ndf						
STATLANT 21	10 099	7919	2282	0	0	0	0	0	0	
NIPAG ²	10 108	8647	2289	0	0	0	0	0	0	

¹ Includes autonomous TAC as set by Denmark in respect of Faroes and Greenland.

² NIPAG catch estimates have been updated using various data sources (see p. 13, SCR. 14/048).

Effects of the fishery on the ecosystem

The fishery was closed to directed fishing beginning in 2015.

Special Comments

Shrimp in Div. 3LNO are genetically distinct from those in Div. 3M and the Gulf of Maine, but not from those further north. Work is ongoing to investigate the contribution of stocks north of Div. 3L to the production of Div. 3LNO shrimp.

Research on transport of larval shrimp indicates that most larvae that originate in Div. 3L are transported out of that division. Additionally, it was found that most recruitment in Div. 3L originates further north of the area. The results of this research have not yet been quantified in order to develop a more comprehensive recruitment index for Div. 3LNO.

Sources of information

<http://www.dfo-mpo.gc.ca/Library/352955.pdf>

V. OTHER MATTERS

1. Scheduling of Future Meetings

a) Scientific Council meetings

i) Scientific Council, September 2021

The Annual Meeting will be held by WebEx from 20 to 24 September 2021.

ii) Scientific Council, June 2022

Scientific Council June 2022 meeting will be held in Halifax, Nova Scotia, Canada, from 3 to 16 June 2022.

iii) Scientific Council, (in conjunction with NIPAG), September 2022

The Scientific Council shrimp advice meeting will be held in Copenhagen, Denmark, from 12 to 17 September 2022.

iv) Scientific Council, September 2022

The Annual meeting will be held in Lisbon, Portugal, from 19 to 23 September 2022.

b) NAFO/ICES Joint Groups

i) ICES – NAFO Working Group on Deep-water Ecosystem, 2022

Dates and location to be determined.

ii) ICES/NAFO/NAMMCO WG-HARP

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

iii) NIPAG, November 2022

The Scientific Council shrimp advice meeting will be held in Copenhagen, Denmark, from 12 to 17 September 2022.

2. Topics for Future Special Sessions

No special session was proposed.

3. Other Business

No other business was discussed.

VI. ADOPTION OF SCIENTIFIC COUNCIL AND NIPAG REPORTS

VII. ADJOURNMENT

APPENDIX I. REPORT OF THE NAFO/ICES *PANDALUS* ASSESSMENT GROUP (NIPAG)

Co-chairs: Katherine Sosebee and Ole Ritzau Eigaard

I. OPENING

The NAFO/ICES *Pandalus* Assessment Group (NIPAG) met by WebEx on 8 September 2021, to review stock assessments northern shrimp in NAFO Divisions 3M and 3LNO. Representatives attended from Canada, Denmark (in respect of the Faroe Islands and Greenland), the European Union, Norway, and Ukraine. The NAFO Scientific Council Coordinator and Scientific Information Administrator were also in attendance. A full list of participants is included in Appendix V.

The Co-chairs Katherine Sosebee and Ole Ritzau Eigaard opened the meeting 08:00 Halifax time (12:00 UTC) and welcomed participants. The provisional agenda was adopted as circulated. The Scientific Council Coordinator was appointed as rapporteur.

II. GENERAL REVIEW

1. Review of Research Recommendations in 2019 and 2020

Recommendations applicable to individual stocks are given under each stock in the “stock assessments” section of this report.

2. Review of Catches

Catches and catch histories were reviewed on a stock-by-stock basis in connection with each stock.

III. STOCK ASSESSMENTS

1. Northern shrimp (*Pandalus borealis*) on the Flemish Cap (NAFO Div. 3M)

(SCR Docs. 21/038, 21/047)

Environmental Overview

Recent Conditions in Ocean Climate and Lower Trophic Levels

- After being below normal between 2015 and 2017, the ocean climate index in 3M has been normal since 2018;
- Spring bloom initiation was near normal in 2020 for a second consecutive year;
- Spring bloom magnitude was below normal in 2020 after three consecutive years of above-normal production;
- The abundance of copepod and non-copepod zooplankton was near normal in 2020 after having remained mostly above normal from 2015 to 2018;
- Zooplankton biomass was near normal in 2020 and has remained mostly near or below normal since the 2016 record high.

Recent Conditions in Ocean Climate and Lower Trophic Levels

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 sub-surface temperature range of 3-4°C and salinities in the range of 34-34.75. The general circulation in the vicinity of the Flemish Cap consists of the offshore branch of the Labrador Current which flows through the Flemish Pass on the Grand Bank side and a jet that flows eastward north of the Cap and then southward east of the Cap. To the south, the Gulf Stream flows to the northeast to form the North Atlantic Current and influences waters around the southern areas of the Cap. In the absence of strong wind forcing the circulation over the central Flemish Cap is dominated by a topographically induced anti-cyclonic (clockwise) gyre. Variation in the

abiotic environment influences the distribution and biological production of Newfoundland and Labrador Shelf and Slope waters where arctic, boreal, and temperate species coexist. The elevated temperatures on the Flemish Cap result in relatively ice-free conditions that may allow longer phytoplankton growing seasons compared to the Grand Banks where cooler conditions prevail. The entrainment of nutrient-rich North Atlantic Current water around the Flemish Cap 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 Grand Bank which may influence year-class strength of various fish and invertebrate species.

Ocean Climate and Ecosystem Indicators

The ocean climate index in Division 3M (Figure 1.1.A) has remained mostly above normal between the late 1990s and 2013. After the record-high of 2011, the index gradually decreased reaching in 2015 its lowest value since 1993. After been below normal between 2015-2017, the index was normal between 2018 and 2020. Spring bloom initiation has been oscillating between early and late timing between 2003 and 2020 but has remained mostly near or later than normal since 2011 (Figure. 1.1.B). Spring bloom magnitude (total production) was below normal in 2020 after three consecutive years of above-normal production (Figure. 1.1.C). In general, late bloom onsets are associated with limited production (Figure. 1.1.B-C). The abundance of copepod and non-copepod zooplankton show general increasing trends throughout the 1999-2020 time series (Figure. 1.1.D-E). However, copepod abundance decreased to below or near-normal levels over the past two years after having remained above normal from 2016 to 2018 (Figure. 1.1.D). Similarly, the abundance of non-copepod zooplankton decreased to near-normal in 2019-2020 after four consecutive years of above-normal levels (Figure 1.1.E). Total zooplankton biomass on the Flemish Cap has remained mostly below to near normal since 2015 with the exception of the record-high biomass observed in 2016 (Figure 1.1.F).

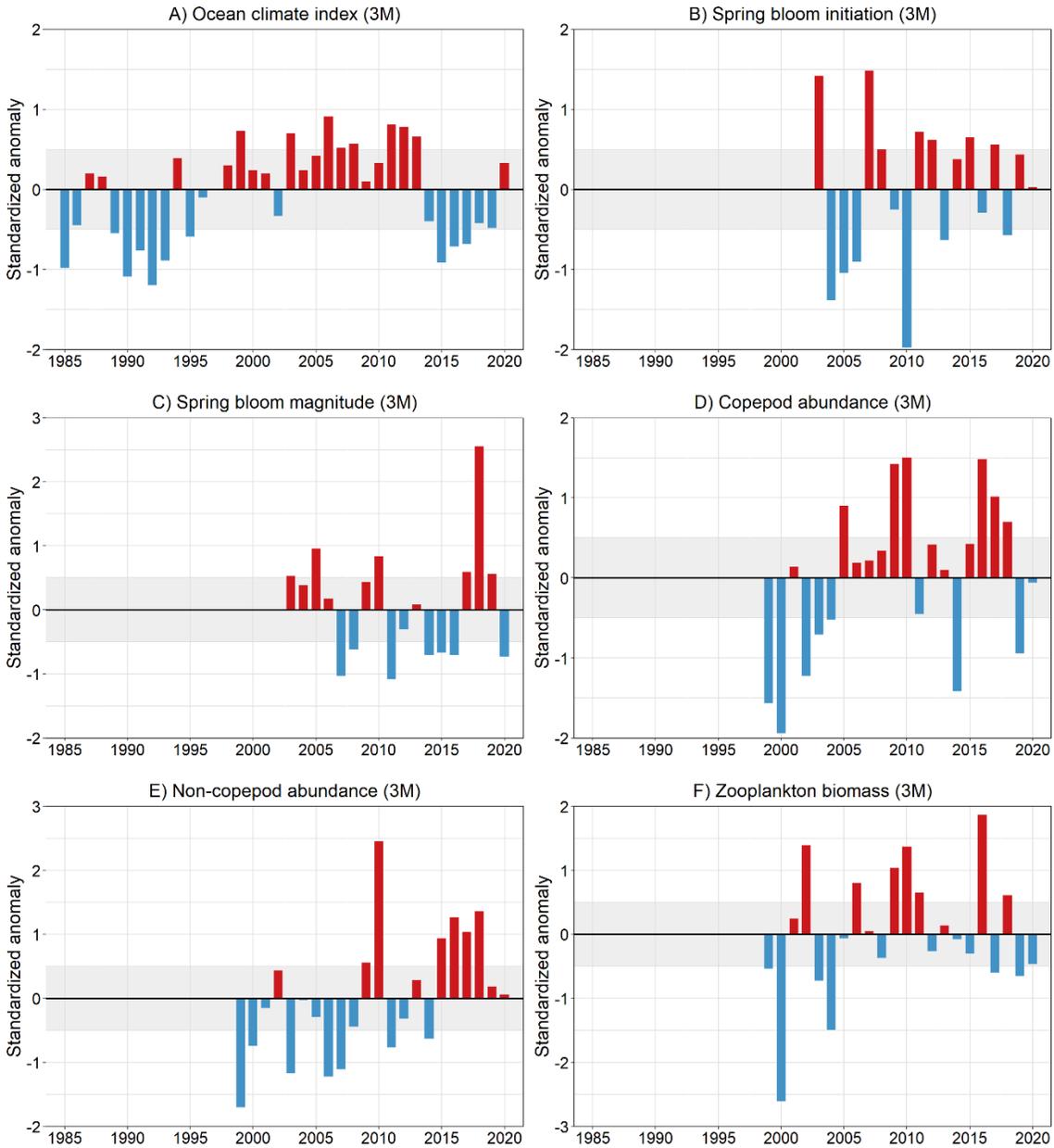


Figure 1.1. Environmental indices for the Flemish Cap (NAFO Div. 3M). The ocean climate index (A) for the Flemish Cap is the average of 3-time series of standardized ocean temperature anomalies of sea surface temperatures (SSTs), hydrographic section observations, and summer mean bottom temperature over the cap. Positive/negative anomalies indicate values above/below (or late/early timing) the long-term average for the reference period. Anomalies were calculated using the following reference periods: 1981-2010 for ocean climate index, 2003-2020 for spring bloom initiation and magnitude, and 1999-2020 for zooplankton abundance and biomass indices. Anomalies within ± 0.5 SD (grey rectangle) are considered near-normal conditions.

a) Introduction

The shrimp fishery in Div. 3M began in 1993. Catches peaked at over 60 000 t in 2003 and declined thereafter. A moratorium was imposed from 2011 to 2019. Since 2020 the fishery was resumed.

Fishery and catches: This stock is under effort regulations. The fishery was reopened in 2020 after nine years under moratorium with 2640 fishing days. The effort directed to the shrimp fishery and catches in 2020 were very low (19 days and 79 t) but increased in the first half of 2021.

Recent catches and effort agreed by the NAFO Commission were as follows (ndf=no directed fishery):

	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
NIPAG	2000	0	0	0	0	0	0	0	0	0	79	3691 ¹
STATLANT 21	1976	0	0	0	0	0	0	0	0	0	0	0
SC Recommended Catches	ndf	5448	5448									
Effort ² (Agreed Days)	5227	0	0	0	0	0	0	0	0	0	2640	2640

1 Preliminary in the first half of 2021

2 Effort regulated

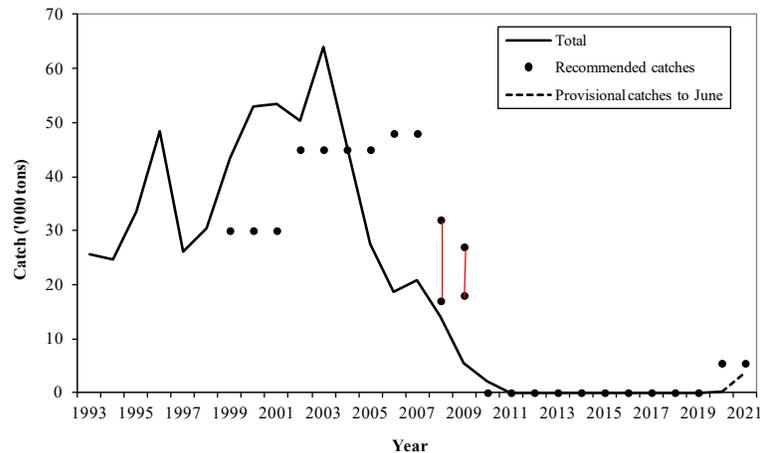


Figure 1.2. Shrimp in Div. 3M: Catches (t) of shrimp on Flemish Cap and catches recommended in the period 1993-2021.

b) Input Data

i) Commercial fishery data

Time series of size and sex composition data were available mainly from Iceland and Faroes between 1993 and 2005. Because of the moratorium catch and effort data have not been available from 2011 to 2019, and therefore the standardized CPUE series has not been extended.

In 2020 and 2021, although the shrimp fishery was resumed, the length and sex composition from commercial catches were not available.

ii) Research Survey Data

EU Bottom Trawl Research Survey. Stratified-random trawl surveys have been conducted on Flemish Cap by the EU in July from 1988 to 2021. A new vessel was introduced in 2003 which continued to use the same trawl employed since 1988. In addition, there were differences in cod-end mesh sizes utilized in the 1994 and 1998 surveys that have likely resulted in biased estimates of total survey biomass. Nevertheless, for this assessment, the series prior to 2003 were converted into comparable units with the new vessel using the methods accepted by STACFIS in 2004 (NAFO 2004 SC Rep., SCR Doc. 04/077).

c) Assessment

No analytical assessment is available. Evaluation of stock status is based upon interpretation of commercial fishery information and research survey data.

SSB: The survey female biomass index was stable at a high level from 1998 to 2007, and subsequently declined until 2014. Since 2015 the biomass index increased successively and in 2019 the estimated female biomass was well above B_{lim} . In 2020 the female biomass experienced some decrease but remained above B_{lim} . In 2021 the biomass decreased for the second consecutive year and it is now below B_{lim} .

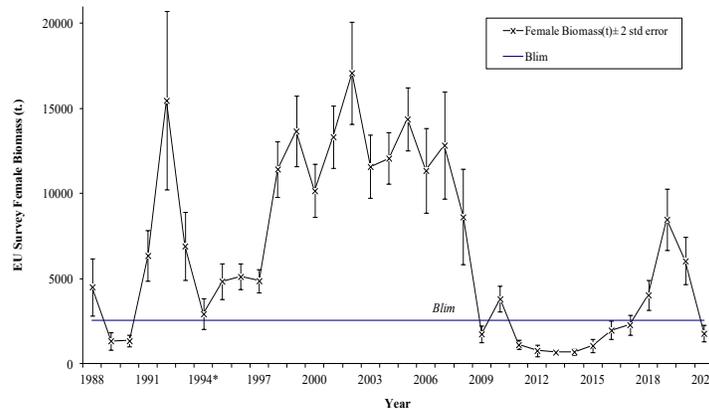


Figure. 1.3. Shrimp in Div. 3M: Female biomass index from EU trawl surveys, 1988-2021. Error bars are 2 std. err.

Recruitment: Age estimation was carried out using Rmix library from the preliminary shrimp length distribution and growth rates in the first three years allow the identification of cohorts. Considering the abundance at age 2 as indicator of recruitment, all year-classes from the 2002 cohort to 2017 have been weak from the main gear and from small mesh juvenile bag attached to the net (Figure 1.4). The recruitment index (age 2) in 2021 was the second lowest of the historical series and the 2018 year class (age 3) was not stronger than expected suggesting the worsening of future recruitments in the next years.

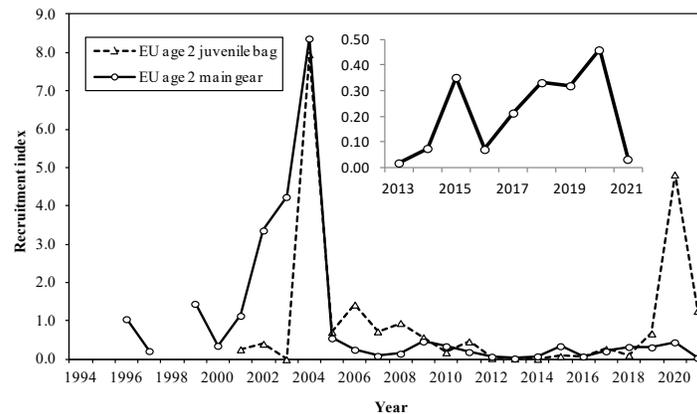


Figure. 1.4. Shrimp in Div. 3M: Abundance indices at age 2 from the EU survey. Each series was standardized to its mean.

Exploitation rate: Because of low catches, followed by the moratorium, the exploitation rate index declined to zero and has remained at that level since 2011 to 2020. In 2020, the fishery was resumed but the effort directed to shrimp fisheries and catches were residual resulting in a very low exploitation rate (0.01). In 2021 the exploitation rate increased notably (2.1) due to the increase in the catches (provisional catches until June of 3 691 t) and the decrease in the UE survey index.

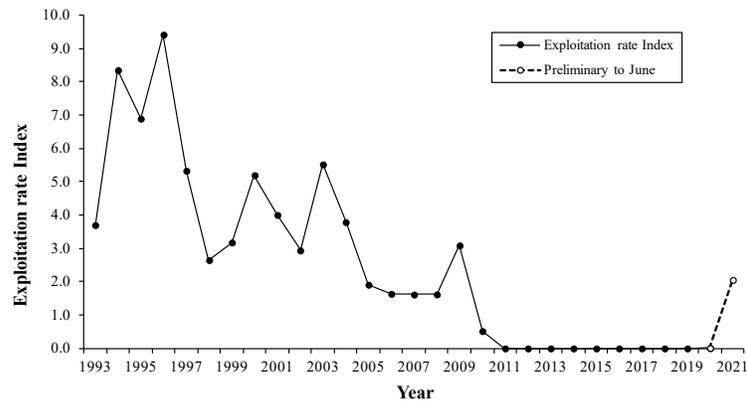


Figure 1.5. Shrimp in Div. 3M exploitation rate index as derived by catch divided by the EU survey biomass index of the same year.

d) State of the stock

After an upward trend started in 2014, the stock has decreased from 2020, and it is now below B_{lim} . Recruitment has declined sharply after a general upward trend in the last years and there are not indications of improved recruitment in 2022. Also the exploitation rate increased markedly due to the low level of biomass estimated in 2021 and the relative high catches carried out from the first half of the year. As a consequence of the decrease in biomass levels and the weak recruitments in the short term, there are serious concerns that the stock will remain at low levels.

e) Reference Points

A limit reference point for fishing mortality has not been defined. Scientific Council considers that a female survey biomass index of 15% of its maximum observed level provides a proxy for B_{lim} . This corresponds to an index value of 2 564 t (Figure 1.6).

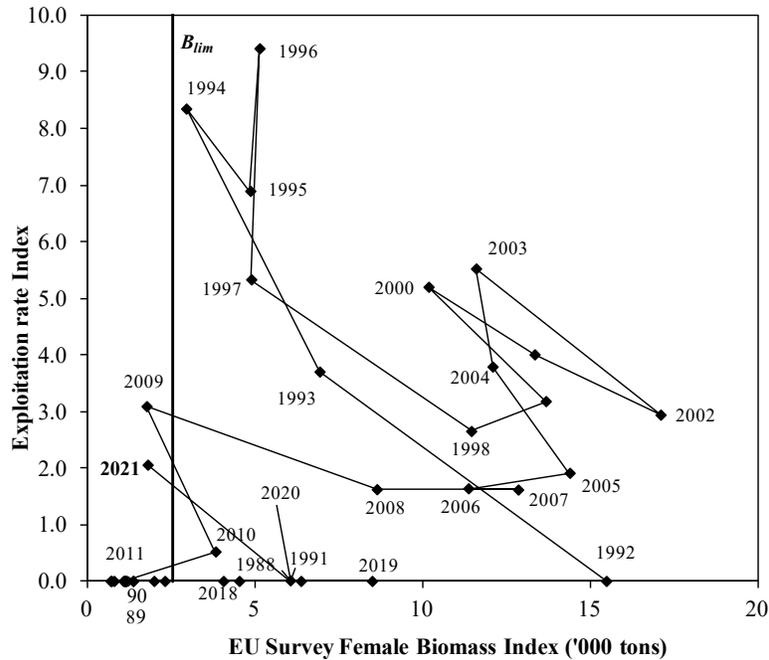


Figure 1.6. Exploitation rate index plotted against female biomass index from EU survey. Line denoting B_{lim} is drawn where biomass is 15% of the maximum point in 2002.

f) Ecosystem considerations

The drastic decline of shrimp biomass around 2008-2010 correlates with an increase of both cod and redfish in Div. 3M. It is uncertain whether this represents a causal relationship and/or covariance as a result of some environmental factor.

Multispecies models (Pérez-Rodríguez et al. 2016, Pérez-Rodríguez and D. González-Troncoso 2018), suggest that predation by cod and redfish, together with fishing, have been the main factors driving the shrimp stock to the collapse after 2007. In the most recent years, decreasing redfish and cod stocks have likely resulted in reduced predation mortality on shrimp, consistent with a period of increase in the shrimp stock.

Results of modelling suggest that, in unexploited conditions, cod and redfish would be expected to be a highly dominant component of the system, and high shrimp stock sizes like the ones observed in the 1998 – 2007 period would not be a stable feature in the Flemish Cap.

Preliminary data from EU summer survey show that in 2021 redfish and cod stocks decreased and therefore the decrease of shrimp biomass this year was not related with the recovery of redfish and cod stocks and it is probably due to the resumed exploitation of the shrimp fishery since 2020.

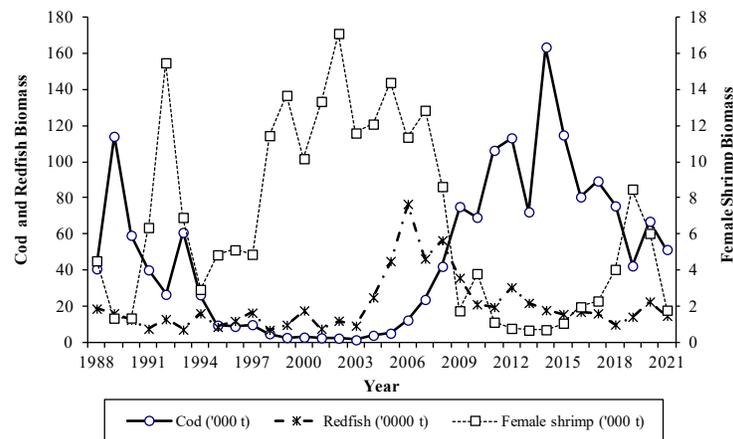


Figure 1.7. Shrimp in Div. 3M: Cod, Redfish and Female shrimp biomass from EU trawl surveys, 1988-2021. 2021 cod and redfish data are preliminary.

g) Research Recommendations

For Northern Shrimp in Div. 3M NIPAG recommended in 2016 that *further exploration of the relationship between shrimp, cod and the environment be continued in WGESA and NIPAG encourages the shrimp experts to be involved in this work.*

STATUS: No progress from last year.

In 2019, NIPAG **recommended** that in future years NIPAG should investigate the options to implement an analytical assessment for this stock. Models to explore could include SPiCT, Stock Synthesis (as applied for Northern shrimp in Skagerrak and Norwegian Deep), or other length based models.

STATUS: progress will be updated at NIPAG 2021

In 2019, NIPAG **recommended** that this stock be considered for a benchmark workshop in conjunction with the benchmark of the Skagerrak and Barents Sea stocks anticipated for 2020/21. The NIPAG 2020 meeting will be utilized for a workshop to clarify the data situation and potential assessment models.

STATUS: progress will be updated at NIPAG 2021

The next assessment will take place prior the NAFO Annual Meeting in September 2022.

References

Pérez-Rodríguez, A. and D. González-Troncoso. 2018. Update of the Flemish Cap multispecies model GadCap as part of the EU SC05 project: "Multispecies Fisheries Assessment for NAFO", NAFO SCR Doc.18/024, serial No.N6808

2. Northern shrimp (*Pandalus borealis*) on the Grand Bank (NAFO Divs. 3LNO)

(SCR Doc. 04/012)

Environmental Overview

Recent Conditions in Ocean Climate and Lower Trophic Levels

- The ocean climate index in Subarea 0-1 was normal in 2020;
- The initiation of the spring bloom was delayed for a second consecutive year in 2020;
- Total spring bloom production (magnitude) was near normal in 2020.

Recent Conditions in Ocean Climate and Lower Trophic Levels

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

Ocean Climate and Ecosystem Indicators

The ocean climate index in Subarea 0-1 has been predominantly above or near normal since the early 2000s, except for 2015 and 2018 that were below normal (Figure 2.1.A). After being in 2019 at its highest value since the record high of 2010, the index was normal in 2020. Before the warm period of the last decade, cold conditions persisted in the early to mid-1990s. Spring bloom initiation has been oscillating between early (negative anomalies) and late (positive anomalies) timing between 2003 and 2020 but several notable late bloom onsets were recorded during the late 2010s (Figure 2.1.B). In 2020, the initiation of the spring bloom was later than normal for a second consecutive year. Spring bloom magnitude (total production) remained mostly below to near-normal between 2003 and 2020 except for a few highly productive blooms in 2006, 2015 and 2018 (Figure 2.1.C). The late bloom onsets of 2019 and 2020 are associated to below-normal or near-normal total production for the corresponding years (Figure 2.1.B-C).

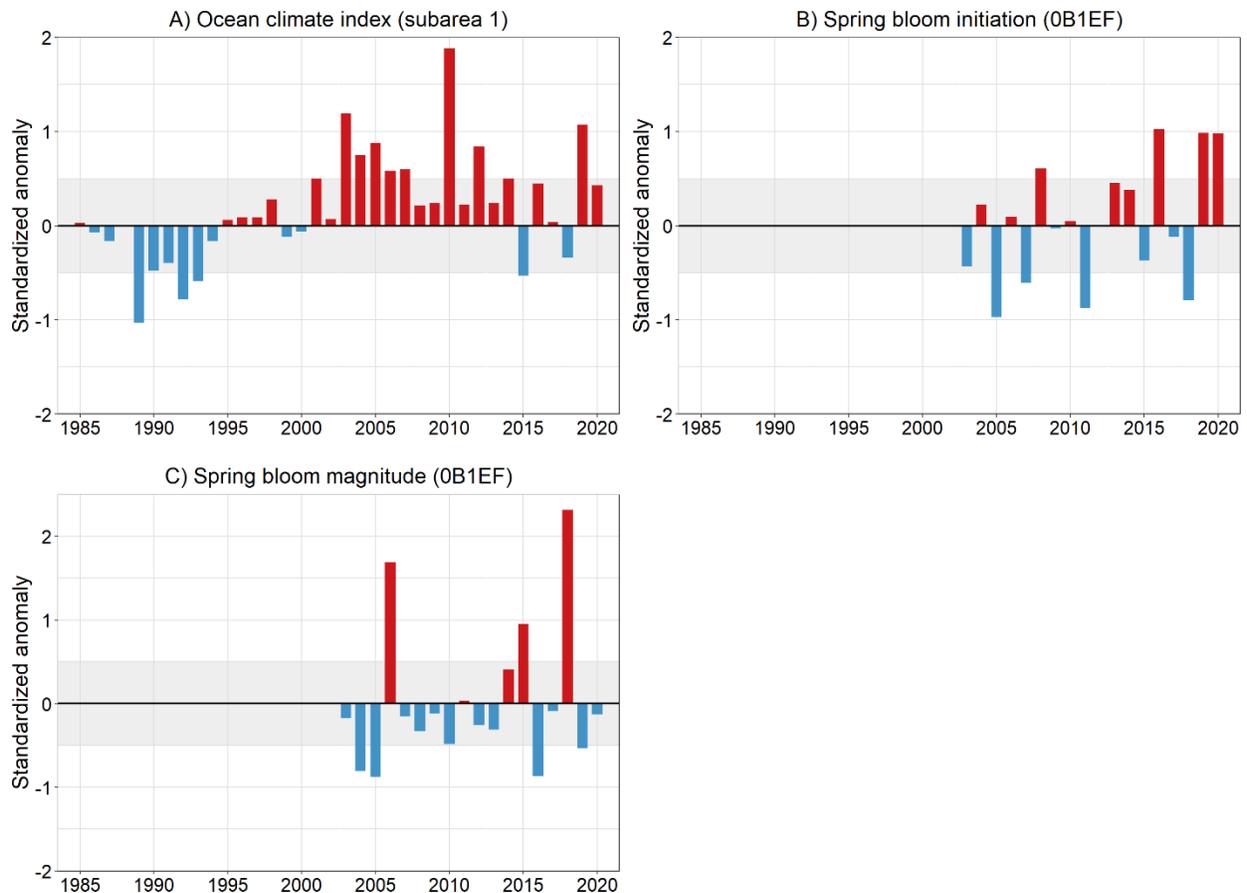


Figure 2.1. Environmental indices for NAFO Subarea 0 and 1. The climate index (A) for Subarea 0 and 1 is the average of 10 individual time series. These includes standardized anomalies of 4 SSTs time series, 4 temperature time series at 3 hydrographic stations and 2 air temperatures time series (see text for details). Phytoplankton spring bloom initiation (B) and magnitude (C) indices for the 2003-2020 period are derived from three satellite boxes covering NAFO Divs. 0B and 1EF (see text for details). Positive/negative anomalies indicate values above/below (or late/early timing) the long-term average for the reference period. Anomalies were calculated using the following reference periods: 1981-2010 for ocean climate index, 2003-2020 for spring bloom initiation and magnitude. Anomalies within ± 0.5 SD (grey rectangle) are considered near-normal conditions.

a) Introduction

This shrimp stock is distributed around the edge of the Grand Bank, mainly in Div. 3L. The fishery began in 1993 and came under TAC control in 2000 with a 6 000 t TAC. Annual TACs were raised several times between 2000 and 2009 reaching a level of 30 000 t for 2009 and 2010. The TAC was then reduced annually until no directed fishing (ndf) was implemented in 2015 to 2021 (Figure 2.2). The TAC entries in the table below include autonomous TACs from Denmark (in respect of the Faroe Islands and Greenland) and STATLANT 21 entries.

Recent catches and TACs (t) for shrimp in Div. 3LNO (total) are as follows:

	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
TAC ¹	13108	9393	4697	ndf						
STATLANT 21	10099	7919	2282	0	0	0	0	0	0	0
NIPAG ²	10108	8647	2289	0	0	0	0	0	0	0

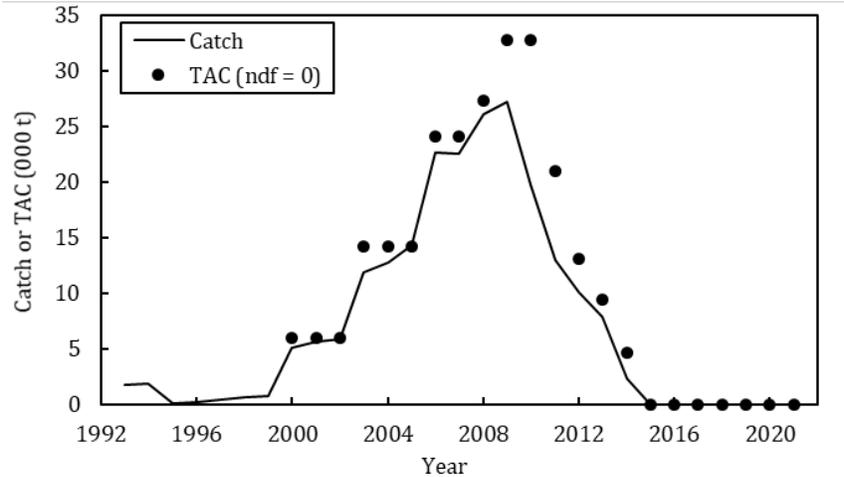


Figure 2.2. Shrimp in Div. 3LNO: Catches and TAC. The TAC illustrated includes the autonomous quotas set by Denmark (in respect of the Faroe Islands and Greenland). No directed fishing is plotted as zero TAC.

b) Input data

i) Commercial fishery data

Effort and CPUE. Catch and effort data have been available from Canadian vessel logbooks and observer records since 2000; however there was no fishery from 2015 to present.

ii) Research survey data

Canadian multi-species trawl survey. Canada has conducted stratified-random surveys in Div. 3LNO, using a Campelen 1800 shrimp trawl for spring (1999–2019) and autumn (1996–2020). The autumn survey in 2004, and the spring surveys in 2015, 2017–2018 and 2020–2021 were incomplete and therefore could not be used to produce biomass indices for Div. 3LNO. The autumn 2014 survey only surveyed Div. 3L, however since about 95% of the biomass in Div. 3LNO comes from Div. 3L annually, it was considered useful as a proxy for Div. 3LNO for 2014.

Spanish multi-species trawl survey. EU-Spain has been conducting a stratified-random survey in the NAFO Regulatory Area (NRA) part of Div. 3L since 2003 and in the NRA part of Div. 3NO since 1995. Data are collected with a Campelen 1800 trawl. There were no EU-Spain Div. 3L surveys in 2005 or 2021 and no Div. 3LNO survey in 2020.

c) Assessment results

No analytical assessment is available. Evaluation of stock status is currently based upon interpretation of research survey data.

Biomass indices. In Canadian surveys, about 95% of the biomass was found in Div. 3L, distributed mainly along the northeast slope in depths from 185 to 550 m. Total, fishable (shrimp with carapace length > 17mm) and female (SSB) biomass and abundance indices follow the same trend throughout the survey time series. There was an overall increase in both the autumn and spring indices to 2007 after which they decreased by

over 95% to the lowest levels in the autumn time-series in 2018 and the second lowest level in the spring time-series in 2019 (Figure 2.3). While autumn indices have increased slightly since 2018, they are still amongst the lowest levels in the autumn time-series.

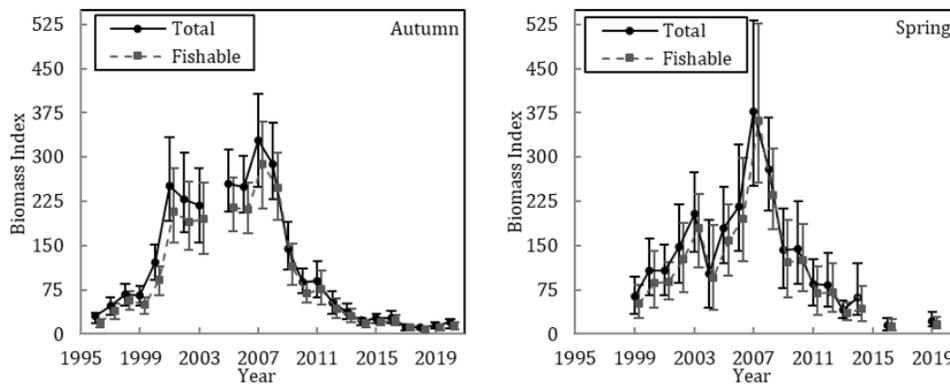


Figure 2.3. Shrimp in Div. 3LNO: Total and fishable biomass index estimates from Canadian autumn and spring multi-species surveys (with 95% confidence intervals). The 2014 autumn index is for Div. 3L only. There are no available biomass index estimates for spring 2015, 2017-2018 or 2020-2021.

EU-Spain survey biomass indices for Div. 3L and Divs. 3NO, within the NRA only, increased from 2003 to 2008 followed by a 93% decrease by 2012 remaining near that level through 2019 (Figure 2.4).

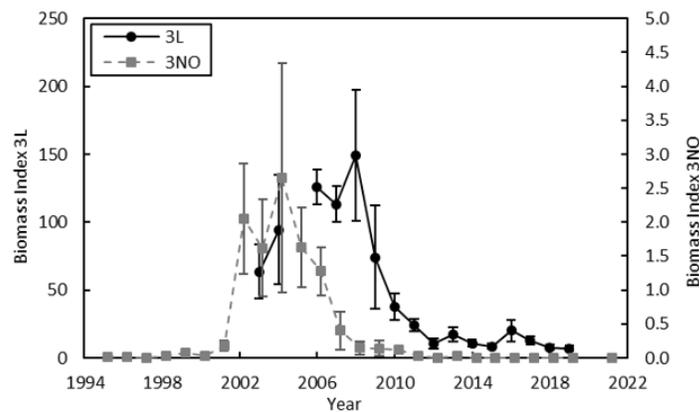


Figure 2.4. Shrimp in Div. 3LNO: Total biomass index estimates from EU - Spain multi-species surveys (± 1 SE) in the NAFO Regulatory Area (NRA) of Div. 3LNO. There are no available biomass index estimates for 2020 and only Div. 3NO was surveyed in 2005 and 2021.

Stock Composition. Both males and females showed a broad distribution of lengths in recent surveys indicating the presence of more than one year class (Figure 2.5).

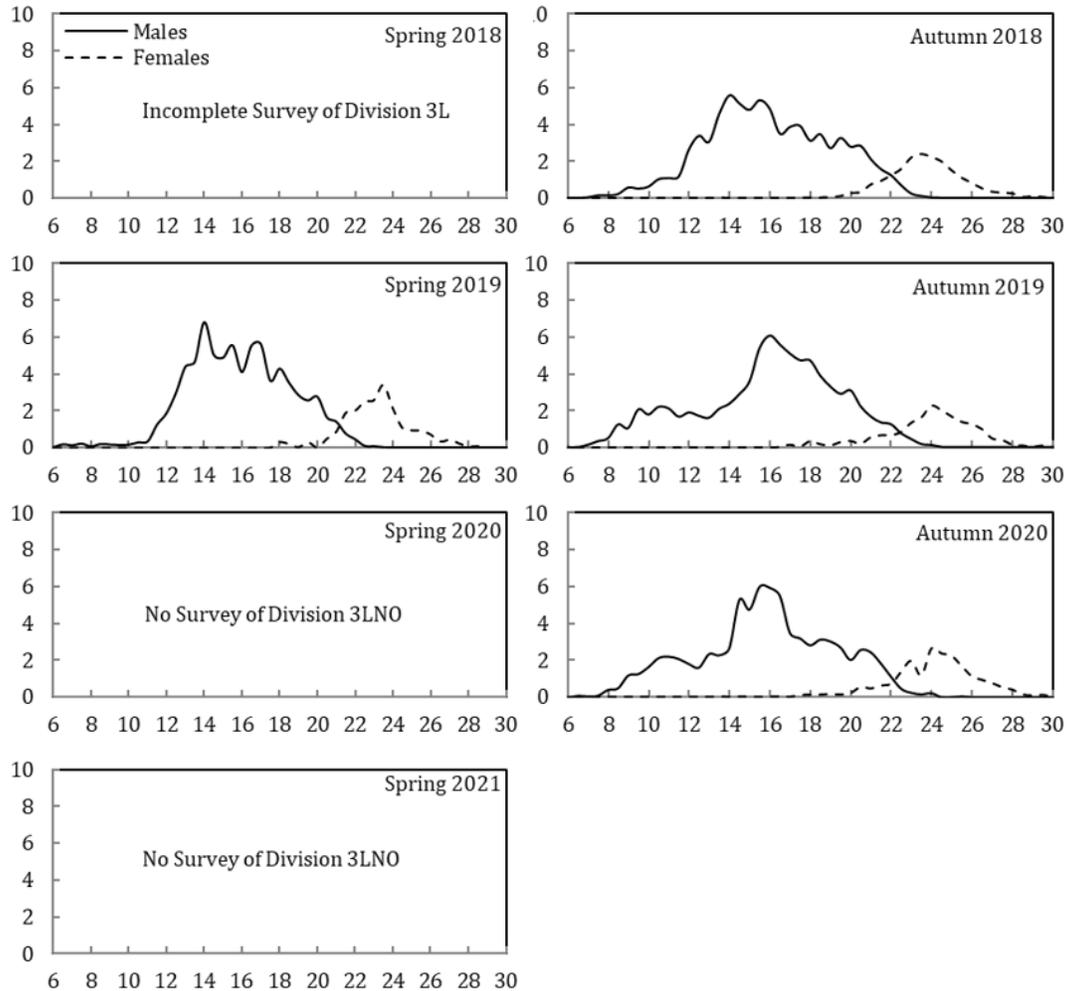


Figure 2.5. Shrimp in Div. 3LNO: Composition of survey catches (percentage at length) from Canadian spring and autumn multi-species survey data. No data for spring 2017-2018 or 2020-2021.

Recruitment indices. Recruitment indices were based upon abundance indices of shrimp with carapace lengths of 11.5 – 17 mm from Canadian multi-species survey data. The 2006 – 2008 indices were among the highest in both spring and autumn time-series but have since declined to the lowest levels in the survey time series (Figure 2.6).

Research on transport of larval shrimp (Le Corre et al.) indicates that most larvae that originate in Div. 3L are transported out of that division. Additionally, it was found that most recruitment in Div. 3L originates further north of the area. The results of this research have not yet been quantified in order to develop a more comprehensive recruitment index for Div. 3LNO.

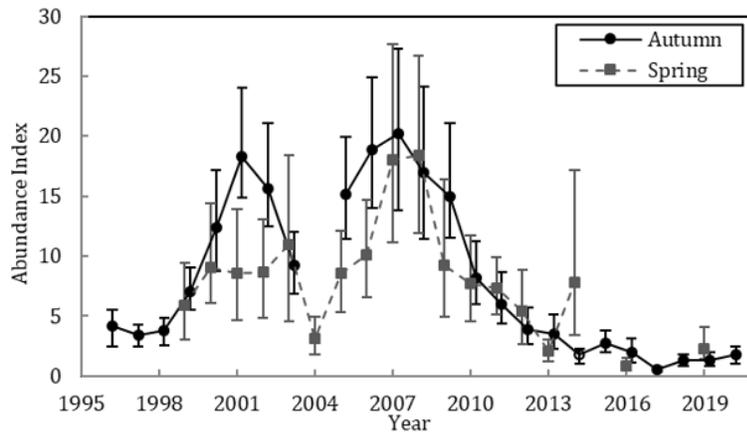


Figure 2.6. Shrimp in Div. 3LNO: Indices of recruitment-sized shrimp based on abundance of shrimp with 11.5 – 17 mm carapace lengths from Canadian spring and autumn multi-species surveys. Error bars represent 95% confidence intervals. The autumn index for 2014 is for Div. 3L only.

Exploitation index. An index of exploitation was derived by dividing the catch in a given year by the fishable biomass index from the previous autumn survey. The exploitation index generally increased throughout the course of the fishery until dropping sharply in 2014 (Figure 2.7). Since there was no directed fishing in 2015-2021, the exploitation index is zero for that period of time. Mortality due to bycatch during other fisheries is unknown.

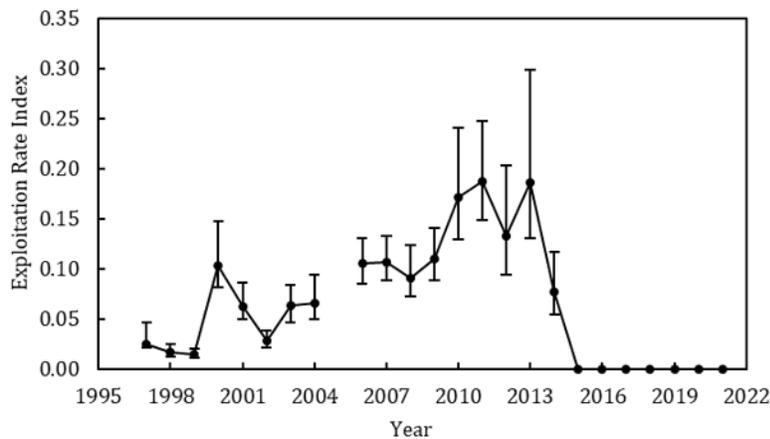


Figure 2.7. Shrimp in Div. 3LNO: Exploitation indices calculated as a year’s catch divided by the previous year’s autumn fishable biomass index. Error bars (calculated based on estimates of fishable biomass index) indicate 95% confidence intervals.

d) Reference points.

The point at which a valid index of female spawning stock size has declined to 15% of its highest observed value is considered to be B_{lim} (SCS Doc. 04/12). In 2021 the risk of being below B_{lim} was greater than 95% (Figure 2.8). A limit reference point for fishing mortality has not been defined.



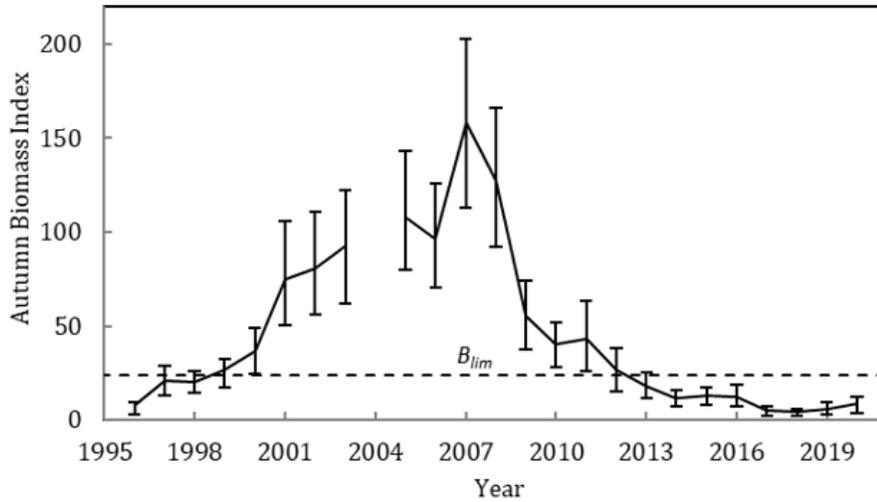


Figure 2.8. Shrimp in Div. 3LNO: Autumn female spawning stock biomass index (SSB) and B_{lim} . B_{lim} is defined as 15% of the maximum autumn female biomass over the time-series. Error bars indicate 95% confidence intervals. The autumn index for 2014 is for Div. 3L only.

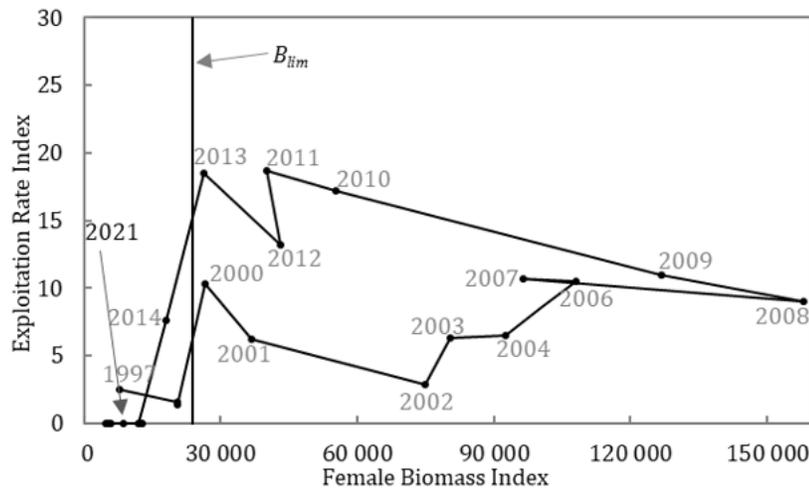


Figure 2.9. Shrimp in Div. 3LNO: Exploitation rate vs female SSB index from Canadian autumn survey. Vertical line denotes B_{lim} .

e) State of the stock

Biomass. Spring and autumn biomass indices have decreased considerably since 2007 and are among the lowest levels in the time series.

Recruitment. Recruitment indices have decreased since 2008 to the lowest levels in the time series.

Exploitation. The index of exploitation has been zero since 2015.

State of the Stock. Currently the risk of the stock being below B_{lim} is greater than 95%. There is no indication of improved recruitment.

f) Ecosystem considerations

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

g) Research recommendations

NIPAG **recommended in 2015** that *ecosystem information related to the role of shrimp as prey in the Grand Bank (i.e. 3LNO) Ecosystem be presented to NIPAG.*

Status: No new information was available to the current meeting and this recommendation is reiterated.

NIPAG **recommends in 2018** that *further work on the development of a recruitment index for Div. 3LNO be completed.*

Status: While it was anticipated that a length based model would improve knowledge of a recruitment index for Div. 3LNO, that work has not been successfully completed. Hence this recommendation is reiterated.

References

Le Corre N, Pepin P, Han G, Ma Z, Snelgrove PVR. Assessing connectivity patterns among management units of the Newfoundland and Labrador shrimp population. *Fish Oceanogr.* 2018;00:1–20. <https://doi.org/10.1111/fog.12401> (in press).

APPENDIX II. PROVISIONAL AGENDA

By WebEx
8-9 September 2021

Daily hours (Halifax time, Canada): 08:00 to 13:00 h

- I. Opening (Chair: Carmen Fernández)
 1. Appointment of Rapporteur
 2. Adoption of Agenda
 3. Attendance of Observers
 4. Plan of Work
- II. Review of Recommendations in 2020
- III. NAFO/ICES Pandalus Assessment Group (Co-chairs Katherine Sosebee and Ole Ritzau Eigaard)
- IV. Formulation of Advice (see Annexes 1–3)
 1. Request for Advice on TACs and Other Management Measures (Annex I)
 - a) Northern shrimp in Div. 3LNO
 - b) Northern shrimp in Div. 3M
- V. Other Matters
 1. Scheduling of Future Meetings
 2. Topics for Future Special Sessions
 3. 2022 benchmark preparation
 4. Other Business
- VI. Adoption of Scientific Council and NIPAG Reports
- VII. Adjournment

APPENDIX III. EXPERTS FOR ASSESSMENT OF CERTAIN STOCKS

The following is the list of Designated Experts for 2021 assessments:

From the Science Branch, Northwest Atlantic Fisheries Centre, Department of Fisheries and Oceans, P. O. Box 5667, St. John's, NL, Canada A1C 5X1, Canada

Northern shrimp in Divisions 3LNO	Katherine Skanes	Tel: +1 709-772-8437	Katherine.skane@dfo- mpo.gc.ca
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From the Instituto Español de Oceanografía, Aptdo 1552, E-36200 Vigo (Pontevedra), Spain

Shrimp in Division 3M	Jose Miguel Casas Sanchez	Tel: +34 986 49 2111	mikel.casas@ieo.es
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From the Greenland Institute of Natural Resources, P. O. Box 570, DK-3900 Nuuk, Greenland

Northern shrimp in Subarea 0+1	AnnDorte Burmeister	Tel: +299 36 1200	anndorte@natur.gl
Northern shrimp in Denmark Strait	Frank Riget		frri@natur.gl

APPENDIX IV. LIST OF SCR AND SCS DOCUMENTS

SCR Document			
Doc No.	Serial No	Author	Title
SCR Doc. 21/038	N7214	J.M. Casas Sánchez	Division 3M Northern shrimp (<i>Pandalus borealis</i>) – Interim Monitoring Update
SCR Doc. 21/047	N7246	J.M. Casas Sánchez	Northern Shrimp (<i>Pandalus borealis</i>) on Flemish Cap Surveys 2021

SCS Document			
Doc No.	Serial No	Author	Title
SCS Doc. 21/18	N7237	NAFO	Report of the NAFO/ICES Pandalus Assessment Meeting, 08–09 September 2021

APPENDIX V. LIST OF PARTICIPANTS, 8 SEPTEMBER 2021

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