Northwest Atlantic
Fisheries Organization

International Council for
the Exploration of the Sea

Conseil International pour
l'Exploration de la Mer

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NAFO/ICES *Pandalus* Assessment Group Meeting, 1-4 November 2021
By Webex

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NAFO/ICES *Pandalus* Assessment Group Meeting
NIPAG 1-4 November 2021

Contents

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

Chair : Mark Simpson **Rapporteur :** Tom Blasdale

I. Opening

The NAFO/ICES *Pandalus* Assessment Group (NIPAG) met by WebEx on 1-4 November 2021, to review stock assessments referred to it by the Scientific Council of NAFO and by the ICES Advisory Committee. Representatives attended from Canada, Denmark (in respect of Greenland), European Union, Norway, Russian Federation and the United States of America. The NAFO Scientific Council Coordinator and Scientific Information Administrator were also in attendance.

II. General Review

1. Review of Research Recommendations in 2019 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)

This stock was assessed during the 08-09 September 2021 meeting of the Scientific Council in conjunction with NIPAG (NAFO SCS Doc. 21/18. NIPAG reviewed the assessment during the present meeting. There were no further recommendations.

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

This stock was assessed during the 08-09 September 2021 meeting of the Scientific Council in conjunction with NIPAG (NAFO SCS Doc. 21/18). NIPAG reviewed the assessment during the present meeting. There were no further recommendations.

3. Northern shrimp (*Pandalus borealis*) off West Greenland (NAFO SA 0 and SA 1)

(SCR Docs. 04/075, 04/076, 08/006, 11/053, 11/058, 12/044, 13/054, 20/053, 20/054, 20/057, 20/058, 21/040, 21/041, 21/042)

Environmental overview (STACFEN report in SCS Doc. 21-17)

Recent Conditions in Ocean Climate and Lower Trophic Levels in NAFO OB

- *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.*

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 counter balanced by warmer waters are carried northward by the offshore branch of the West Greenland Current (WGC). The water masses constituting the WGC originate from the western Irminger Basin where the East

Greenland Currents (EGC) meets the Irminger Current (IC). While the EGC transports ice and cold low-salinity Surface Polar Water to the south along the eastern coast of Greenland, the IC is a branch of the North Atlantic current and transports warm and salty Atlantic Waters northwards along the Reykjanes Ridge. After the currents converge, they turn around the southern tip of Greenland, forming a single jet (the WGC) that propagates northward along the western coast of Greenland. The WGC is important for Labrador Sea Water formation, which is an essential element of the Atlantic Meridional Overturning Circulation. At the northern edge of the Labrador Sea, after receiving freshwater input from Greenland and Davis Strait, part of the WGC bifurcates southward along the Canadian shelf edge as the Labrador Current.

Ocean Climate and Ecosystem Indicators

The ocean climate index in Subarea 0-1 has been predominantly above or near normal since the early 2000s, except for 2015 and 2018 that were below normal (Figure. 3.1.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 have been recorded during the late 2010s (Figure. 3.1.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 with the exception of a few highly productive bloom in 2006, 2015 and 2018 (Figure. 3.1.C). The late bloom onset observed in 2019 and 2020 are associated below or near normal total production for the corresponding years (Figure. 3.1.B-C).

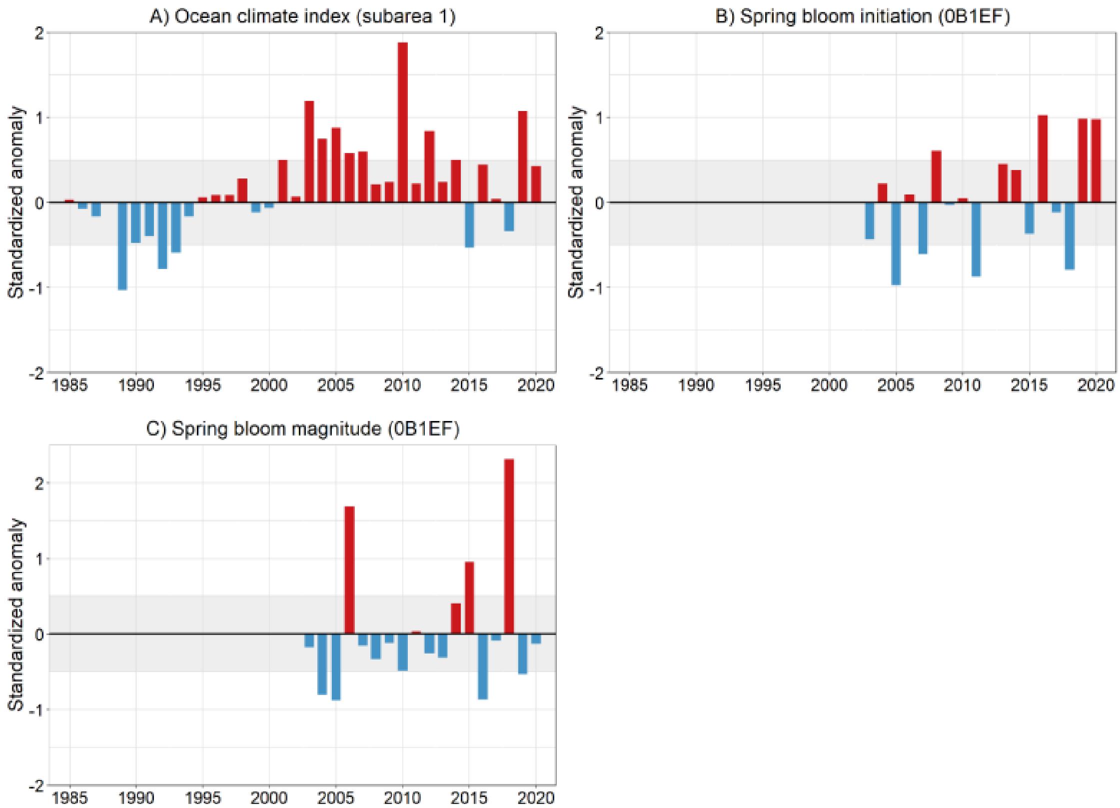

Figure 3.1. Environmental indices for NAFO Subarea 0 and 1. The climate index (A) for Subarea 0 and 1 is the average of 10 individual time series. These includes standardized anomalies of 4 SSTs time series, 4 temperature time series at 3 hydrographic stations and 2 air temperatures time series (see 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 Divisions 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

The shrimp stock off West Greenland is distributed mainly in NAFO Subarea 1 (Greenland EEZ), but a small part of the habitat, and of the stock, intrudes into the eastern edge of Div. 0A (Canadian EEZ). Canada has defined 'Shrimp Fishing Area 1' (Canadian SFA1), to be the part of Div. 0A lying east of 60°30'W, i.e., east of the deepest water in this part of Davis Strait.

The stock is assessed as a single population. The Greenland fishery exploits the stock in Subarea 1 (Div. 1A– 1F). The Canadian fishery has been limited to Div. 0A.

Four fleets, one from Canada and three from Greenland (Kongelige Grønlandske Handel (KGH) fleet fishing from 1976 to 1990, the offshore fleet and coastal fleet) have participated in the fishery since the late 1970s. The Canadian fleet and the Greenland offshore fleets have been restricted by areas and quotas since 1977. The Greenland coastal fleet has privileged access to inshore areas (primarily Disko Bay and Vaigat in the north, and Julianehåb Bay in the south). Coastal licenses were originally given only to vessels under 80 tons, but in recent years larger vessels have entered the coastal fishery. Greenland allocates a quota to EU vessels in Subarea 1; this quota is usually fished by a single vessel which, for analyses, is treated as part of the Greenland offshore fleet. Mesh size is at least 40 mm in both Greenland, and Canada. Most trawlers in Greenland use mesh size at 44 mm and sorting grids, to reduce bycatch of fish are required in both of the Greenland fleets and in the Canadian fleet. Discarding of shrimps is prohibited.

The enacted TAC for Greenland Waters in 2021 was set at 115 000 t and for Canadian Waters, 15 937 t.

Greenland requires that logbooks catch is recorded as live weight. For shrimps sold to on-shore processing plants, a former allowance for crushed and broken shrimps in adjusting quota draw-downs was abolished in 2011 to bring the total catch live weight into closer agreement with the enacted TAC. Since 2012, *Pandalus montagui* has been included among the species protected by a 'moving rule' to limit bycatch and there are no licenses issued for directed fishing on it (SCR Doc. 20/054). Instructions for reporting *P. montagui* in logbooks were changed in 2011, to improve the reporting of these catches.

The table of recent catches was updated (SCR Doc. 21/040, 21/041). Total catch increased from about 10 000 t in the early 1970s to more than 105 000 t in 1992 (Figure 3.2). Actions by the Greenlandic authorities to reduce effort, as well as fishing opportunities elsewhere for the Canadian fleet, caused catches to decrease to about 80 000 t by 1998. Total catches increased to an average over 150 000 t in 2005 to 2008 but have since decreased to 72 256 t in 2015. Since 2016, the catches have been increasing in conjunction with increasing TACs and was in 2020, 113 117 t. The projected catch for 2021 is 108 000 t. The projected catch for Canada from Div. 0A in 2021 is expected to be in the region of 100 t.

Recent catches, projected catch for 2021 and recommended and enacted TACs (t) for northern shrimp in Sub-area 1 and Div. 0A (east of 60°30'W) are as follows:

	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
TAC										
Advised	90 000	80 000	80 000	60 000	90 000	90 000	105 000	105 000	110 000	115 000
Enacted[1]	114 425	100 596	97 649	82 561	96 426	101 706	114 873	119 875	125 229	130 937
Catches (NIPAG)										
SA 1	115 965	95 379	88 765	72 254	84 356	89 369	93 189	101 997	113 117	107 900[2]
Div. 0A	12	2	0	2	1 171	3 215	1 689	2 463	751	100[2]
TOTAL	115 977	95 381	88 765	72 256	85 527	92 584	94 878	104 440	113 868	108 000[2]
STATLANT 21										
SA 1	114 958	91 800	88 834	71 777	82 922	88 947	90 457	98 219	110 095	
Div. 0A	12	2	0	2	1 381	2 778	1 412	1328	204	

1Canada and Greenland set independent and autonomous TACs

2 Projected total catches for the year.

Until 1988 the fishing grounds in Div. 1B were the most important. The offshore fishery subsequently expanded southward, and after 1990 catches in Div. 1C–D, taken together, began to exceed those in Div. 1B. However, since 1998 catch and effort in southern West Greenland have continually decreased, and since 2008 effort in Div. 1F has been virtually nil (SCR Doc. 21/040). The fishery has moved north and, since 2009, about 80% of the total catch was taken in Div. 1A and 1B.

In 2002–2005 the Canadian catch was stable at 6000 to 7000 t - about 4–5% of the total - but since 2007 fishing effort has been sporadic and catches variable, averaging about 1750 t in 2007–11 and from 2012 to 2015 catches in Div. 0A did not exceed 5 t (SCR Doc. 21/040). In 2016 fishing increased in the Canadian EEZ and from 2016 to 2020, Canadian catches averaged about 1800 t.

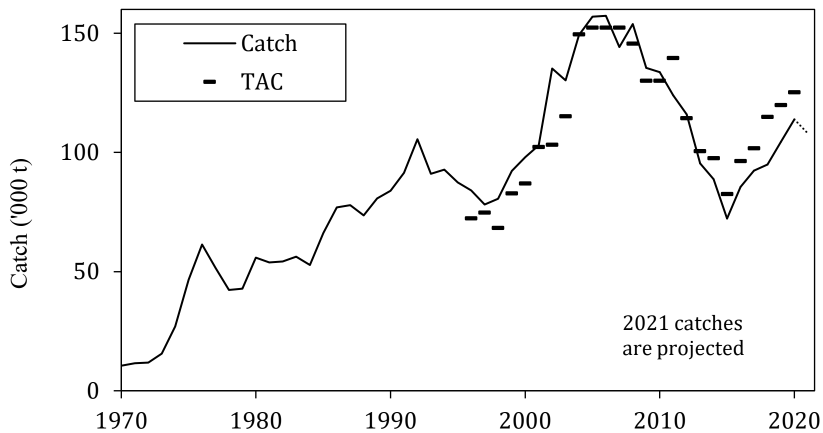

Figure 3.2. Northern shrimp in Subarea 1 and Div. 0A: Enacted TACs and total catches (2021 expected for the year).

b) Input data

i) Fisheries Data

Fishing effort and CPUE. Catch and effort data from the fishery were available from Greenland logbooks for Subarea 1 (SCR Doc. 21/040). In recent years both the distribution of the Greenland fishery and fishing power have changed significantly: for example, larger vessels have been allowed in a limited part of coastal areas; the coastal fleet has fished outside Disko Bay; the offshore fleet now commonly uses double trawls. Furthermore, quota transfers between the two fleets are now allowed. Catch data before 2004 were under-reported, which was corrected in 2008.

CPUEs were standardized by linearized multiplicative models including terms for vessel, month, gear type, year, and statistical area. Standardized CPUE series were done separately for three different fleets (Figure 3.3); the early offshore fleet fishing in Div. 1A and part of 1B (KGH-index, 1976-1990), the present offshore fleet fishing in Subarea 1 (1987-2021) and the coastal fleet fishing in coastal and inshore areas (1989-2021). CPUE for the Canadian fleet fishing in Div. 0A has not been updated because it is not possible to receive new logbook information from Canada. In the recent four years the CPUE of the coastal fleet has slightly decreased while the CPUE of the offshore fleet increased from 2016 to 2017 and dropped little from 2018 to 2020. The declining trend has stopped and half year data from 2021 indicating an increase in CPUE for both fleet components.

The three CPUE series are combined by assuming they all reflect the overall biomass series scaled by a constant fleet factor, and that the errors had mean zero and variances inversely proportional to the fishing ground of the fleet. The estimation was done in a Bayesian framework.

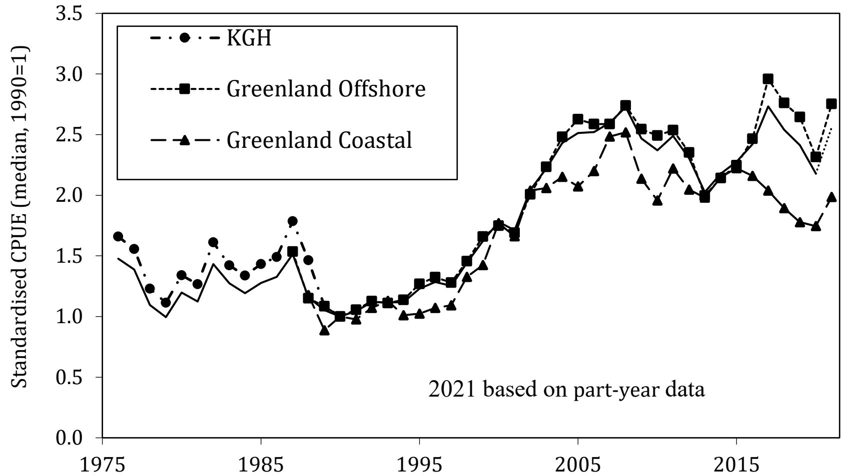

Figure 3.3. Northern shrimp in Subarea 1 and Div 0A: Standardized CPUE index series 1976–2021.

The distribution of catch and effort among statistical areas was summarized using Simpson's diversity index to calculate an 'effective' number of statistical areas being fished as an index of how widely the fishery is distributed (Figure 3.4). The 'effective' number of statistical areas being fished in Subarea 1 reached a plateau in 1992–2003. The range of the fishery has since contracted northwards, and the 'effective' number of statistical areas being fished has decreased.

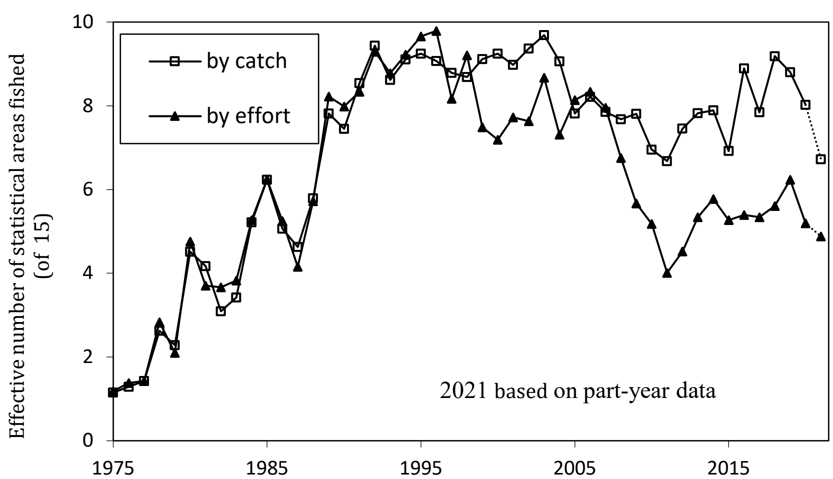

Figure 3.4. Northern shrimp in Subarea 1 and Div. 0A: Indices for the distribution of the Greenland fishery between statistical areas in 1975–2021.

Catch composition. There is no biological sampling program from the fishery that is adequate to provide catch composition data to the assessment.

ii) Research survey data

No new survey data is available for 2021, due to the delay of delivery of the new Greenlandic research ship *r/v Tarajoq*.

Greenland trawl survey. Stratified semi-systematic trawl surveys designed primarily to estimate shrimp stock biomass have been conducted since 1988 in offshore areas and since 1991 also inshore in Subarea 1 (SCR Doc. 20/053). From 1993, the survey was extended southwards into Div. 1E and 1F. A cod-end liner of 22 mm stretched mesh has been used since 1993. From its inception until 1998 the survey used 60-min. tows, but since 2005 all tows have lasted 15 min. In 1988 to 2005 the *Skjervøy 3000* survey trawl used was replaced by a *Cosmos 2000* with rock-hopper ground gear, calibration trials were conducted, and the earlier data were adjusted.

In 2018 and 2019-2020, the annual trawl survey was conducted with two different chartered vessels during the same time period as the usual survey. All the standard gear from the research vessel Paamiut (such as cosmos trawl, doors, all equipment such as bridles etc., Marport sensors on doors and headlines) were used and all the standard research protocols were followed in an attempt to make the surveys as comparable as possible to earlier surveys. At least two crew members from Paamiut participated in each of the surveys. NIPAG therefore assumed that the 2018 and 2019-2020 results were directly comparable with the previous surveys, however without comparative fishing there remains some uncertainty. A more detailed description is available in SCR Docs. 20/053.

The survey average bottom temperature increased from about 1.7°C in 1990–93 to about 3.1°C in 1997–2014 but has since declined to 2.5° in 2019 and remained stable in 2020 (SCR Doc. 20/053). About 80% of the survey biomass estimate is in water 200–400 m deep throughout the time series. Since 2001 most of the biomass has been in water 200–300 m deep (SCR Doc. 20/053). The proportion of survey biomass in Div. 1E–F has been low in recent years and the distribution of survey biomass, like that of the fishery, has become more northerly.

Biomass. The survey index of total biomass remained fairly stable from 1988 to 1997. It then increased until 2003. Subsequent values were consecutively lower, with the second lowest level in the last 20 years occurring in 2014 (Figure 3.5) (SCR Doc. 20/053). Over the past 5 years biomass has increased. Offshore regions comprise 82% of the total survey biomass, and 18% is inshore in Disko Bay and Vaigat. The inshore regions have far higher densities and is almost three times as high as offshore (Figure 3.5) (SCR Doc. 20/053).

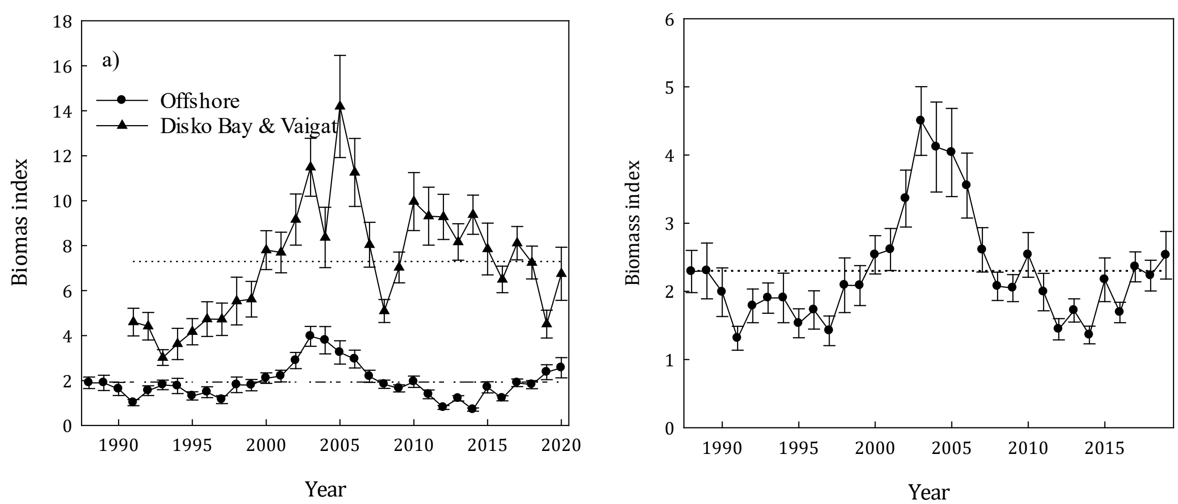

Figure 3.5. Northern shrimp in Subarea 1 and Div. 0A: Biomass index (survey mean catch rates) inshore and offshore (left panel) and overall (right panel) 1988–2020 (error bars 1 SE). Horizontal lines are the series average.

Length and sex composition (SCR Doc. 20/053). In 2020, in Disko Bay regions the proportion of fishable males of survey increased, to a level close to its 15-year median. In offshore regions the proportion declined little to a value above its 15-year lower quartile. Like in most recent years, females compose a high proportion of survey and fishable biomass index in both regions, however close to their 15-year lower quartile offshore, but above and at their 15-year upper quartile in Disko Bay (SCR Doc. 20/056).

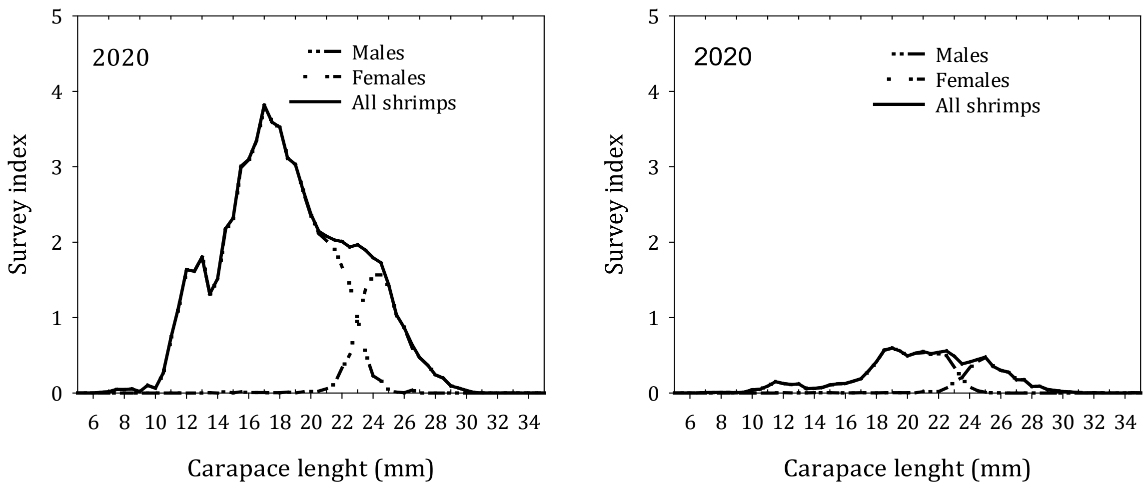

Figure 3.6. Northern Shrimp in Subarea 1 and Div. 0A: Survey mean catch rates at length in offshore regions (left) and Disko Bay & Vaigat (right) at the West Greenland trawl survey in 2020.

Recruitment. The number at age-2 (10.5 to 13.5 mm) reached a peak in 2000 and 2001 and has since declined to a much lower level, with three high values in 2015, 2019 and 2020. The pre-recruit index (14–16.5 mm, expected to recruit to next year's fishable biomass) had high values in 2002 -2005 (except in 2004) and has since fluctuated at a lower level, with relatively high values in 1999-2000 and again in 2015, 2017 and 2020 (SCR Doc. 20/053, 20/056) (Figure 3.7). Numbers of age-2 and pre-recruits in 2020 are above the 1993 to 2020 average, respectively.

Linear regression has shown a significant relationship between the number of age-2 shrimp, pre-recruits and the fishable biomass with a lag of 2, 3 or 4 years. The correlation was strongest ($R^2 = 0.64$) between number of age-2 shrimp and the fishable biomass 4 years later (SCR Doc. 20/053), whereas the correlation was strongest ($R^2 = 0.68$) between pre-recruits and fishable biomass 1 year later (SCR Doc. 20/057). Furthermore, there was also a significant relationship between number of age-2 shrimp and the number of pre-recruits 2-years later ($R^2 = 0.52$) (SCR Doc. 20/057).

The stock composition in Disko Bay has historically been characterized by a higher proportion of young shrimps than that offshore, exceptions were in 2017, 2019 and 2020, where younger shrimps offshore were much higher in numbers and relative to survey biomass. Both in 2019 and 2020, numbers of age 2-shrimps relative to survey biomass are much higher among offshore regions than inshore, where numbers of age-2 shrimps were record low (SCR Doc. 20/053, 20/056). Numbers of pre-recruits relative to survey biomass were considerably lower inshore than offshore regions (SCR Doc. 20/053, 20/056).

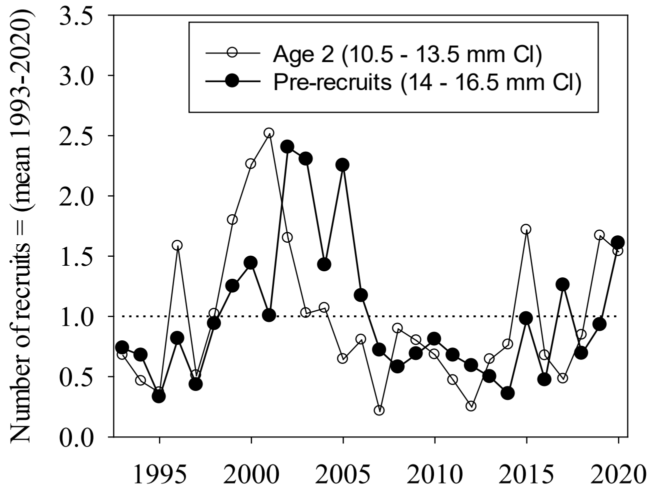

Figure 3.7. Northern shrimp in Subarea 1 and Div. 0A: Survey index of numbers at age 2 (10.5 - 13.5 mm) and index of number of pre-recruits (14-16.5 mm), 1993-2020. Indices are standardized to the series mean.

Predation index. Four distinct stocks of Atlantic cod, spawning variously in inshore and offshore West Greenland, East Greenland, and Iceland, mix at different life stages on the West Greenland banks. They are subject to different influences, oceanographic and others, including drift of pelagic larval stages from east to west.

The overall cod-stock biomass index, used within the shrimp assessment model, was from 2020 modelled in a state-space assessment model (SAM) (SCR Doc. 20/058) and based on catch at age in the commercial fishery and the Greenland trawl survey (Skjærvøj and Cosmos trawl).

Indices of cod biomass are adjusted by a measure of the overlap between the stocks of cod and shrimps to obtain an index of ‘effective’ cod biomass, which is entered in the assessment model (SCR Doc. 14/062). Currently the cod stock at West Greenland is at a low level compared to the period before the collapse in the beginning of 1990s, but has since 2010 shown a slow, but progressive increases and has remained almost stable since 2015. The index of its overlap with the shrimp stock decline to an average below the serial value. This resulted in a 2020 ‘effective cod biomass’ index of 7 kt in 2020 (Figure 3.8) (SCR Doc. 16/042, 16/047, SCR Doc. 20/056, SCR Doc. 20/058). Because of missing survey in 2021 and the need of input variables for the cod biomass and overlap factor for model performance, an average of the most recent three years was used as input data for those variables (21/042). This resulted in an estimated 2021 ‘effective cod biomass’ index of 6 kt and in line with the most recent years.

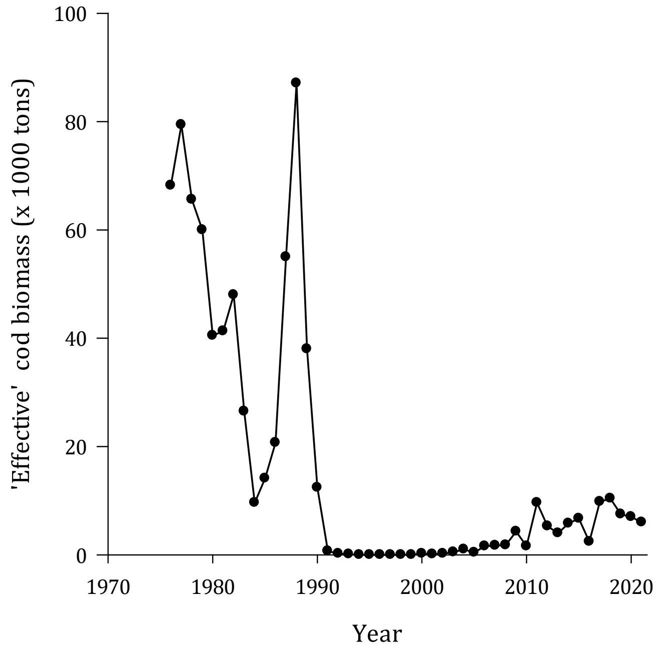

Figure 3.8. Indices of the 'effective' cod biomass in Subarea 1 and Div. 0A 1976 - 2021 (measure of the potential predation pressure by cod on shrimps).

c) Assessment

A Schaefer surplus-production model of population dynamics was fitted to series of CPUE, catch, and survey biomass indices (SCR Doc. 21/042). The model includes a term for predation by Atlantic cod. Total shrimp catches for 2021 are expected to be 108 000 t.

In 2017 NIPAG noted concern about the degree of instability in MSY estimates in successive assessments. To solve this problem, two changes were made. Firstly, the time window was changed from 30- year to the entire time series from 1976 to 2018. Secondly, the time invariant catchability in the CPUE time series was changed to a time variant by including two periods with different catchability.

A more comprehensive description of the evaluation and changes of the model are available in SCR Doc. 18/060. These changes have been included in the assessment since 2018 and have resulted in increased stability of the model parameters and a much-improved retrospective pattern (Figure 3.10).

Estimates of stock-dynamic parameters from fitting a Schaefer stock-production model to 46 years' data are given in Table 3.1. Median values from the 2020 assessment are provided for comparison. The modelled biomass (Figure 3.9a) was relatively low and stable until the late 1990s, when it started a rapid increase, doubling by 2004. Modelled biomass steadily declined from 2004 to 2013 but has since slightly increased and have been stable over the most recent years. The median biomass has been above B_{msy} since the late 1990s except from 2013 to 2014. Mortality has generally been close to or below Z_{msy} during the modelled period (Figure 3.9b). Estimates of total mortality have increased in the most recent years. Assuming catches of 108 000 t, total mortality in 2021 is estimated to be below Z_{msy} with probability of $Z_{2021} > Z_{msy}$ = 33%. Biomass at the end of 2021 is projected to be close to the 2020 value and above B_{msy}. The probability of the biomass at the end of 2021 being below B_{msy} is 24% and the probability of being below B_{lim} is very low (<1%).

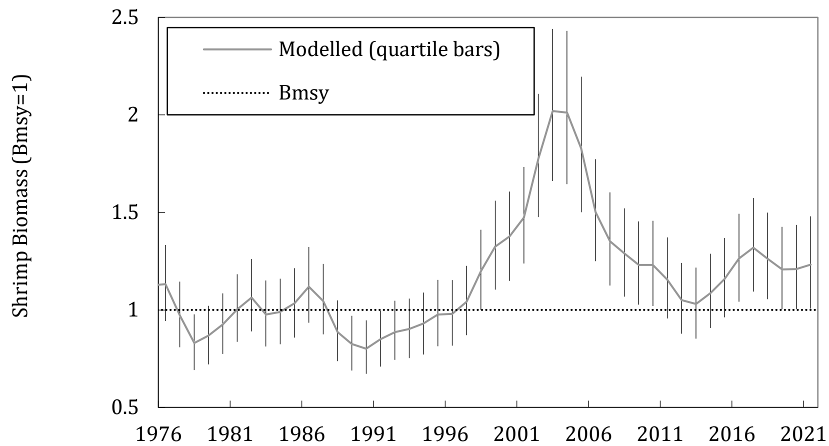

Figure 3.9a. Northern shrimp in SA 1 and Div. 0A: Relative stock biomass with quartile error bars 1976–2021. Dotted line corresponds to $B = B_{msy}$.

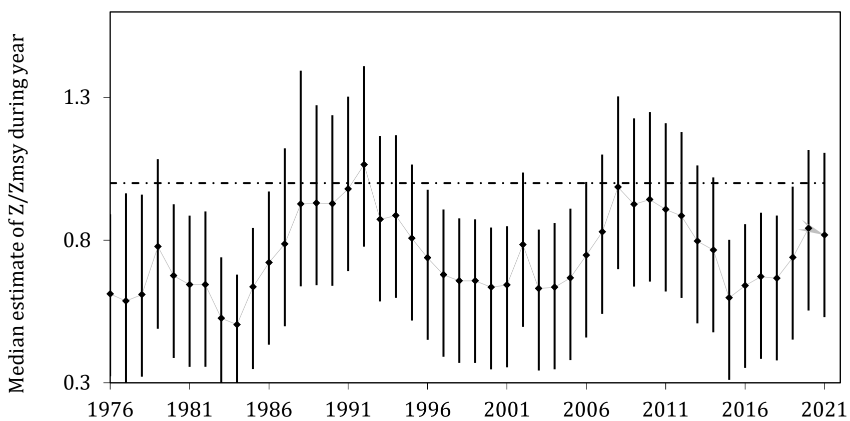

Figure3.9b. Northern shrimp in SA 1 and Div. 0A: Trajectory of the median modelled estimate of mortality relative to Z_{msy} during the year, 1976–2021 with quartile error bars.

Table 3.1. Estimates of stock-dynamic and parameters from fitting a Schaefer stock-production model to 46 years' data on the West Greenland stock of the northern shrimp in 2021. The median (2020) column shows results from last year's assessment.

	Mean	S.D.	25%	Median	75%	Est. mode	Median (2020)
Max.sustainable yield	137.3	62.9	102.1	123.4	154.6	95.6	123.0
B/Bmsy, end current year (proj.)(%)	126.2	35.3	100.7	123.2	148.0	117.2	122.5
Biomass risk, end current year(%)	24.4	43.0	–	–	–	–	–
Z/Zmsy, current year (proj.)(%)	–	–	55.6	81.8	110.6	–	89.3
Carrying capacity	3559	1972	2040	3048	4544	2026	2896
Max. sustainable yield ratio (%)	9.4	4.7	5.9	8.8	12.4	7.5	9.0
Survey catchability (%)	17.3	11.1	9.1	14.5	22.7	8.9	15.4
CPUE(1) catchability	1.0	0.6	0.5	0.8	1.3	0.5	0.9
CPUE(2) catchability	1.6	1.0	0.8	1.3	2.1	0.8	1.4
Effective cod biomass 2021 (Kt)	10.5	49.1	-2.2	6.0	17.7	-3.0	7.0
$P_{50\%}$ (prey biomass index with consumption 50% of max.)	4.5	11.3	0.2	1.3	4.7	-5.2	1.3
V_{max} (maximum consumption per cod)	1.9	2.2	0.4	0.9	2.5	-1.0	0.9
CV of process (%)	12.8	2.8	10.9	12.6	14.6	12.2	13.0
CV of survey fit (%)	18.0	3.2	15.7	17.7	19.8	17.1	17.2
CV of CPUE (1) fit (%)	7.0	1.5	5.9	6.7	7.8	6.1	6.7
CV of CPUE (2) fit (%)	7.6	2.3	5.9	6.9	8.5	5.7	7.0

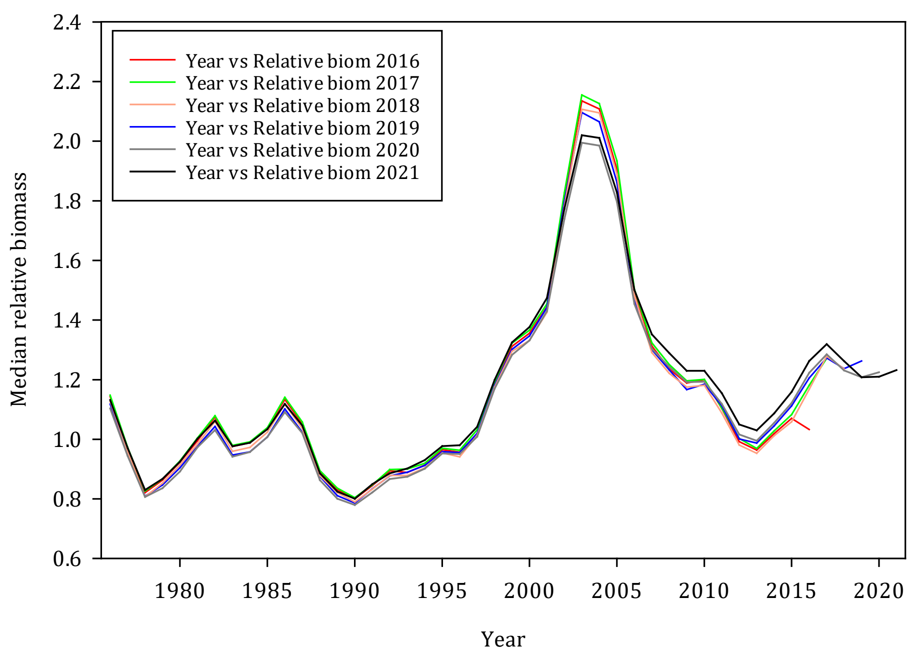

Figure 3.10. Retrospective plots of the relative biomass B/B_{msy} 2016 to 2021. Mohn's rho is estimated to –0.034.

A six-year retrospective analysis was performed (Figure 3.10) and results were found to be quite stable.

d) Reference points

B_{lim} has been established as 30% B_{msy}, and Z_{msy} (fishery and cod predation) has been set as the mortality reference point. B_{msy} and Z_{msy} are estimated directly from the assessment model (SCR Doc. 021/042).

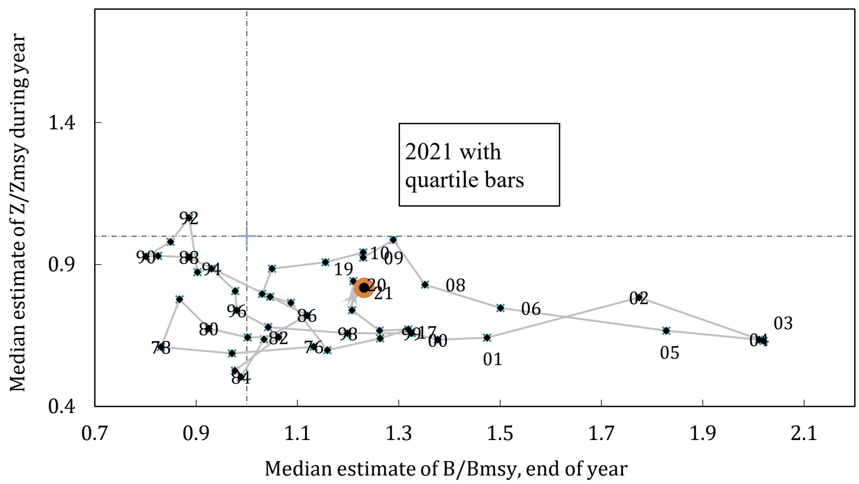

Figure 3.11. Northern shrimp in Subarea 1 and Div. 0A: Trajectory of relative biomass and relative mortality, 1976–2021.

e) State of the stock

Biomass. Biomass at the end of 2021 is above B_{msy} and the probability of being below B_{lim} is very low (<1%).

Mortality. Assuming catches of 108 000 t and an effective cod biomass of 6 kt, the probability of being above Z_{msy} is 33%.

Recruitment. Both numbers of age-2 and numbers of pre-recruits in 2020 were above the average of 1993 to 2020.

State of the Stock. Biomass at the end of 2021 is above B_{msy} and the probability of being below B_{lim} is very low (<1%). The probability of mortality in 2021 being above Z_{msy} is 33%. Recruitment (number of age-2 shrimp) in 2020 was above average.

f) Projections

Three years projections for years 2022–2024 under eight catch options and subject to predation by the cod stock with an 'effective' biomass of 6 kt (the estimated value for 2021 was 6 kt) were evaluated. Additional projections assuming 'effective' cod biomasses of 5 kt, and 7 kt were conducted but results indicated small differences in risk probabilities (SCR Doc 21/042).

6 000 t cod	Catch option ('000 tons)							
Risk of:	95	100	105	110	115	120	125	130
$B_{msy} < B_{2022}$ (%)	26	26	26	26	28	27	27	27
$B_{msy} < B_{2023}$ (%)	26	27	27	27	29	30	30	30
$B_{msy} < B_{2024}$ (%)	26	28	28	29	30	32	32	34
$B_{lim} < B_{2022}$ (%)	0	0	0	0	0	0	0	0
$B_{lim} < B_{2023}$ (%)	0	0	0	0	0	0	0	0
$B_{lim} < B_{2024}$ (%)	0	0	0	0	0	0	0	0
exceeding Z_{msy} in 2022 (%)	20	23	26	30	33	37	40	43
exceeding Z_{msy} in 2023 (%)	21	24	27	31	35	38	41	44
exceeding Z_{msy} in 2024 (%)	21	25	28	31	35	38	42	45
$B < B_{msy}$ 80% 2022 (%)	9	10	10	10	10	11	10	11
$B < B_{msy}$ 80% 2023 (%)	10	11	11	11	13	13	13	14
$B < B_{msy}$ 80% 2024 (%)	11	12	12	13	14	16	16	16

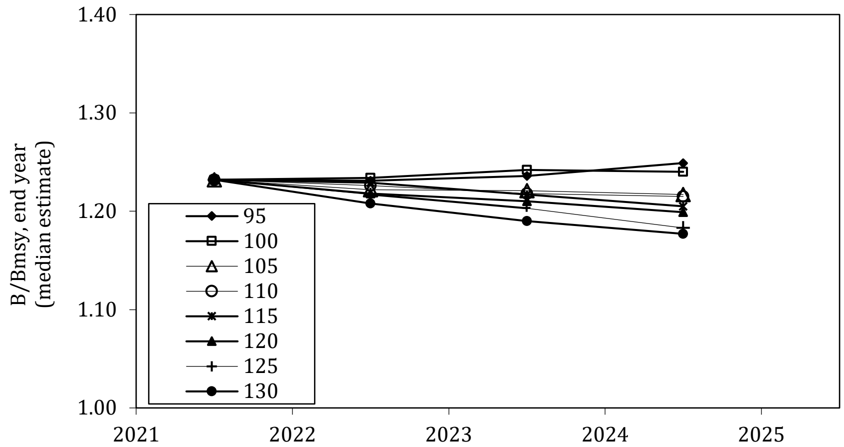

Figure 3.12. Northern shrimp in Subarea 1 and Div. 0A: Median estimates of year-end biomass trajectory for 2022–2024 with annual catches at 95 –130 kt. and an 'effective' cod stock assumed at 6 kt.

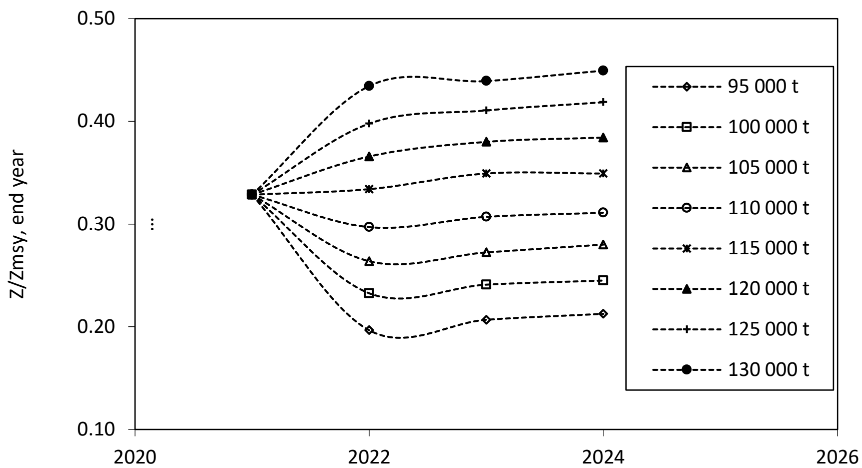

Figure 3.13. Northern shrimp in Subarea 1 and Div. 0A: Risks of transgressing mortality and biomass precautionary limits with annual catches at 95–130 kt projected for 2022–24 with an 'effective' cod stock assumed at 6 kt.

g) Research recommendations

- *NIPAG* ***recommended*** *in 2018 that random sampling of the catches be conducted to provide catch composition data to the assessment.*

Status: Done (SCR Doc. 21-041).

- *NIPAG recommends increasing sampling to cover the whole fleet.*
- *NIPAG* ***recommends*** *that diagnostics of the model should be further explored.*

Status: information is presented in SCR Doc. 21/042 **Completed.**

4. Northern shrimp (*Pandalus borealis*) in the Denmark Strait and off East Greenland (ICES Div. 14b and 5a)

(SCR Docs. 04/012, 20/060, 21/040, 21/043)

Environmental Overview

Oceanography

In the region of East Greenland, South of Denmark Strait the polar waters are constrained to a narrow coastal region on the shelf, which means that warmer and more saline Atlantic waters, originating from the Subtropical Gyre and transported by the Irminger Current, are more prevalent. The region is dominated by an inflow of multi-year ice from the Central Arctic Ocean, with maximum coverage in March and minimum in September. In the region drift ice is seasonal (early spring), transported from the region further north. Much of the waters in the region are stratified shelf waters, with cold and fresher polar waters overlaying warmer and more saline Atlantic waters (ICES, 2020).

Ecosystem changes

Sea ice coverage in the area North of the region has been diminishing in the several past decades, including a decrease in winter maximum sea ice extent since the start of satellite records in 1979, and a weak decline in summer minimum ice coverage since 2006 (ICES, 2020).

Surface waters on the narrow south-eastern Greenland shelf and in the area north of Denmark Strait are 1–2°C warmer than the mean conditions for 1981–2010 for much of the year. In contrast, surface waters in the south-eastern reaches of the region have cooled by up to 2°C. Surface salinity has increased in the open waters of the ecoregion but decreased in the East Greenland shelf waters and Irminger Sea surface waters (ICES, 2020).

a) Introduction

Northern shrimp off East Greenland in ICES Div. 14b and 5a is assessed as a single population.

A multinational fleet exploits the stock. During the recent ten years, vessels from Greenland, EU, the Faroe Islands and Norway have fished in the Greenland EEZ. Only Icelandic vessels are allowed to fish in the Icelandic EEZ. At any time of the year access to these fishing grounds depends strongly on ice conditions.

In the Greenland EEZ, the minimum permitted mesh size in the cod-end is 40 mm but most trawlers used 44 mm in the cod-end. The fishery is managed by catch quotas allocated to national fleets. In the Icelandic EEZ, the mesh size is 40 mm and there are no catch limits, however, there have been no catches by Iceland since 2005. In both EEZs, sorting grids with 22-mm bar spacing to reduce by-catch of fish are mandatory. Discarding of shrimp is prohibited in both areas.

The fishery started in 1978 and during the period 1985 to 2003 the total catches fluctuated between 9000 t and 15 000 t. Between 2004 and 2016 the total catch decreased to 49 t in 2016. Catches have since then increased to 3172 t in 2020 (Figure 4.1). Since 2012, no or very little fishery has taken place in the southern area.

Catches in the first half year of 2021 were 2370 based on logbooks. Since 2014, the fishing effort have been historical low and concentrated in a relatively small area.

Recent catches and TACs (t) for shrimp in in the Denmark Strait and off East Greenland (ICES Div. 14b and 5a) are as follows:

	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021[1]
Recommended TAC, total area	12 400	12 400	2 000	2 000	2 000	2 000	2 000	2 000	2 000	2 000
Actual TAC, Greenland	12 400	12 400	8 300	6 100	5 300	5 300	4 300	3 384	4 750	7 000
North of 65°N, Greenland EEZ	1 893	1 714	622	576	49	561	547	1 574	3 172	2 369
North of 65°N, Iceland EEZ	0	0	0	0	0	0	0	0	0	0
North of 65°N, total	1 893	1 714	622	576	49	561	547	1 574	3 172	2 369
South of 65°N, Greenland EEZ	215	3	0	0	0	0	0	2	0	0
TOTAL NIPAG	2 109	1 717	622	576	49	561	547	1 576	3 172	2 370

[1] Catches until June 30 2021

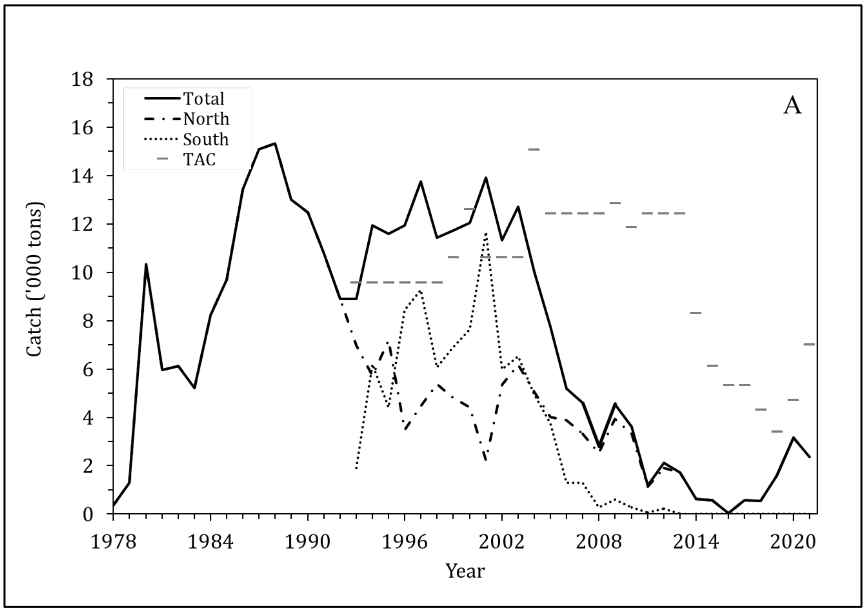

Figure 4.1. Shrimp in Denmark Strait and off East Greenland: Catch and TAC (2021 catches until June 30th).

b) Input data

Commercial fishery data

Fishing effort and CPUE. Data on catch and effort (hours fished) on a haul-by-haul basis from logbooks from Greenland, Iceland, Faroe Islands and EU since 1980 and from Norway since 2000 are used. Since 2004, more than 60% of all hauls were performed with double trawl, and both single and double trawl are included in the standardized catch rate calculations.

Catches and corresponding effort are compiled by year for the two areas, north and south of 65°N. Standardised Catch-Per-Unit-Effort (CPUE) was calculated and applied to the total catch of the year to estimate the total annual standardised effort (SCR Doc. 21/043).

The overall CPUE index increased from 1993 to 2009, followed by a continuous decline to a low value in 2014 and has been increasing since (Figure 4.2), reaching a record high level in 2020, which may indicate an improvement of the stock state. In 2021 the CPUE index value is the third highest in the time series, but below the 2019 and 2020 values. The estimates for recent years are based on relatively low fishing effort (from 300 fishing hours in 2016 to 3737 fishing hours in 2020) which is concentrated in a relatively small area north of 65^{0}N and west of 30^{0}W. As most of the fishing has been conducted in the northern area the overall CPUE index is dominated by the CPUE index for this area (Figure 4.2 and Figure 4.3). In the southern area a standardized catch rate series increased until 1998, and then fluctuated without a trend until 2012 (Figure 4.4). No index for the southern area has been calculated since 2012 due to a low number of hauls. In 2021 EU fleet started fishing in April which is later than previous year, where a larger portion of the catch is taken in February/March.

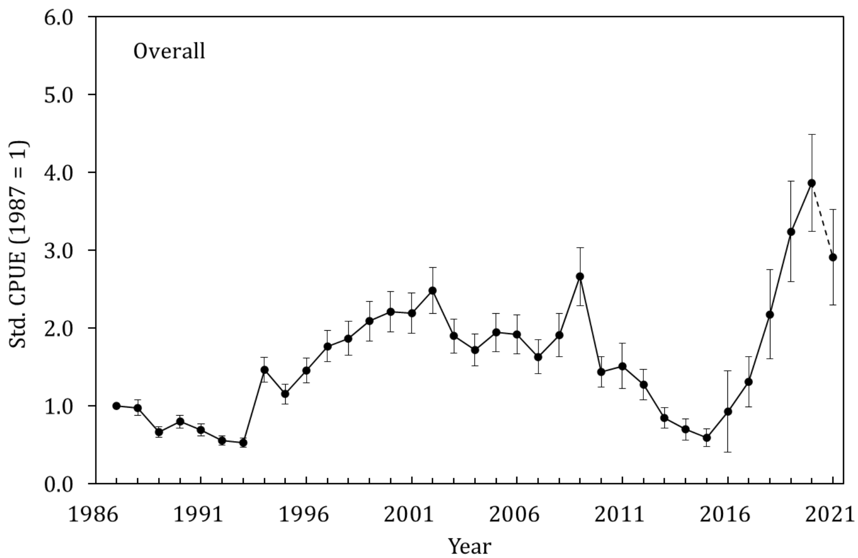

Figure 4.2. Shrimp in Denmark Strait and off East Greenland: Annual standardized CPUE index (1987 = 1) with ± 1 SE combined for the total area. 2021 data until June 30th (dotted line).

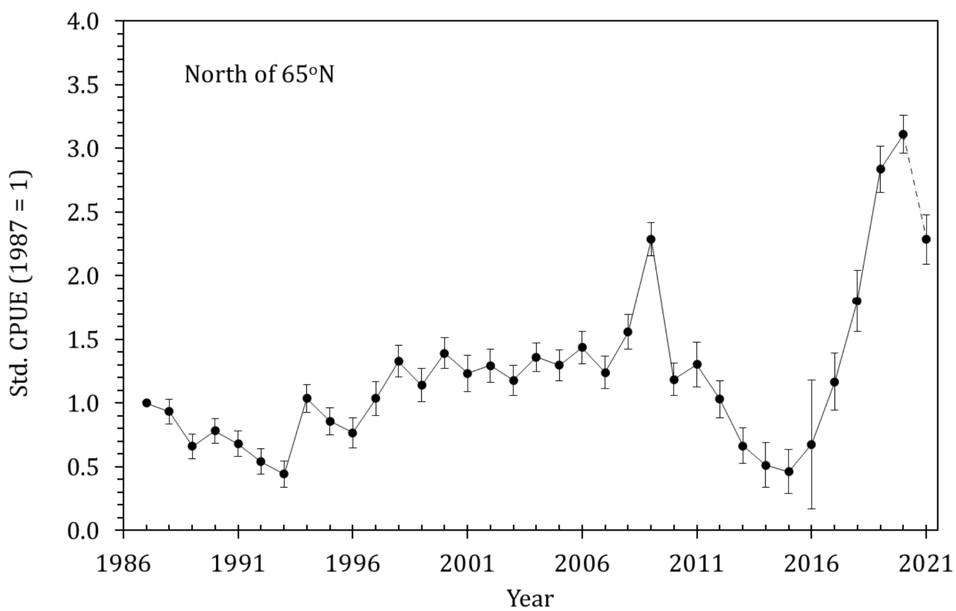

Figure 4.3. Shrimp in Denmark Strait and off East Greenland: Annual standardized CPUE (1987 = 1) with ±1 SE fishing north of 65°N. 2021 data until June 30th (dotted line).

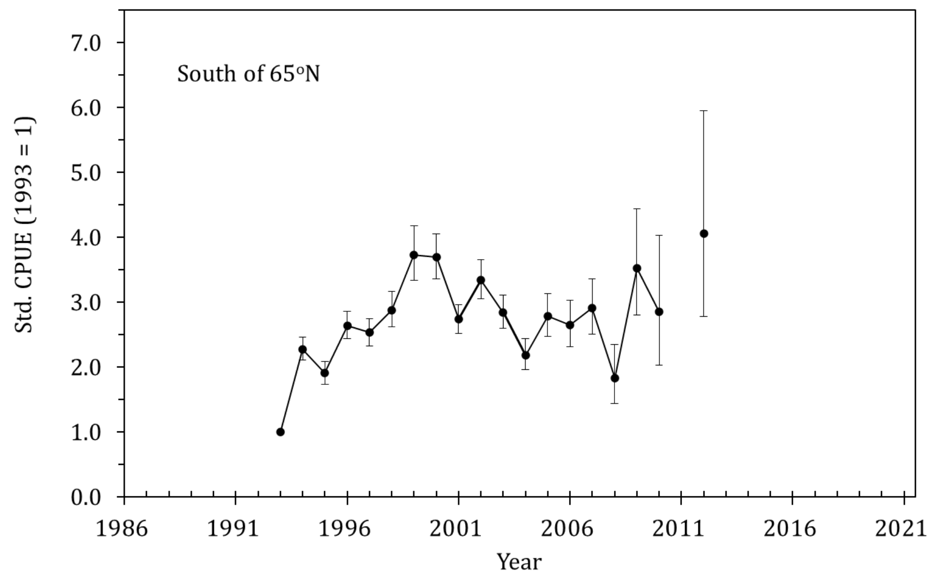

Figure 4.4. Shrimp in Denmark Strait and off East Greenland: Annual standardized CPUE (1993 = 1) with ±1 SE fishing south of 65°N (no data for the area since 2010/2012).

Standardized effort index time series (catch divided by standardized CPUE) as a proxy for exploitation rate for the total area shows a decreasing trend since 1993. Recent levels are the lowest of the time series (Figure 4.5). The 2016 to 2021 levels of exploitation rate may be biased given the issues on CPUE described above.

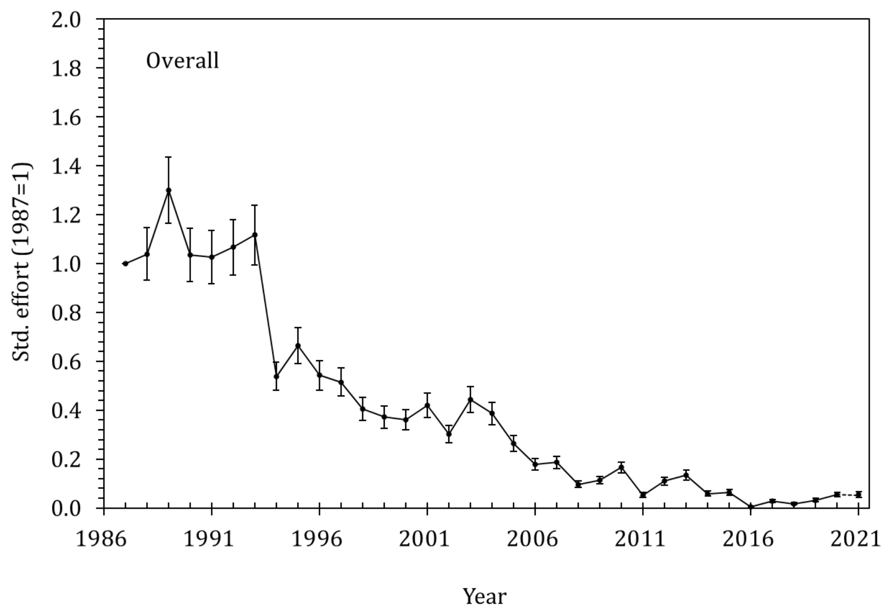

Figure 4.5. Shrimp in Denmark Strait and off East Greenland: Annual standardized effort indices, as a proxy for exploitation rate (± 1 SE; 1987 = 1), combined for the total area (2021 effort until June 30th).

iii) Research survey data

Trawl surveys have been conducted to assess the stock status of northern shrimp in the East Greenland area since 2008 (SCR Doc. 20/060). Due to lack of research vessel, no survey was conducted in the period 2017 to 2019. In 2020 the survey was conducted with the chartered fishing vessel *Helga Maria* using the same gear configuration (SCR Doc. 20-53 and 20-060). Lack of comparative fishing with the survey vessel used in 2020 leads to uncertainty in the survey estimates. Smaller geographical areas were also surveyed in 1985-1988 (Norwegian survey) and in 1989-1996 (Greenlandic survey). The historical surveys are not directly comparable with the recent survey due to different areas covered, survey technique and trawling gear.

Biomass. The survey biomass index decreased from 2009 to 2012 and then remained at a low level until 2016, there are no estimates for the years 2017-2019. The 2020 estimate is the highest in the timeseries (Figure 4.6). There was no survey in 2021.

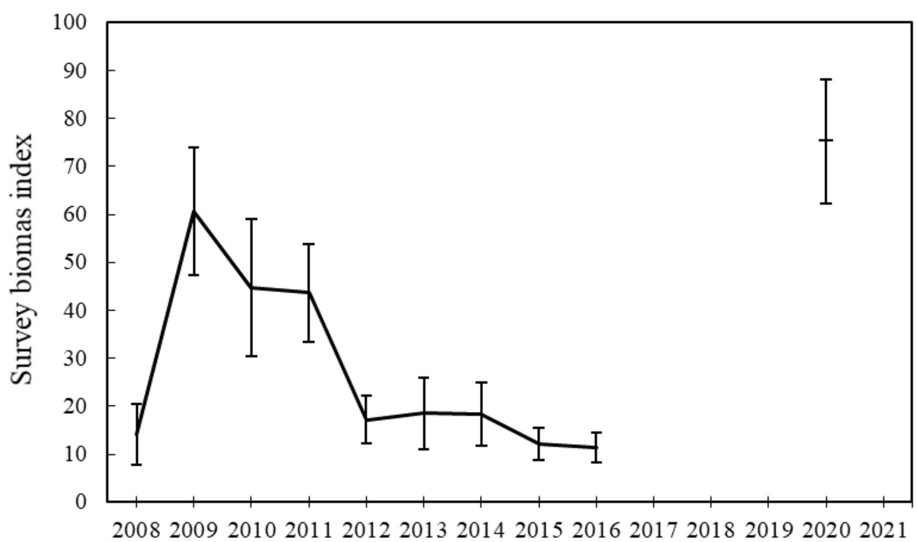

Figure 4.6. Shrimp in Denmark Strait and off East Greenland: Survey biomass index from 2008- 2016 and 2020 (± 1 SE). No survey was carried out in the period 2017 to 2019 and in 2021.

The surveys conducted since 2008 indicate that the shrimp stock is concentrated in the area north of 65°N (Figure 4.7).

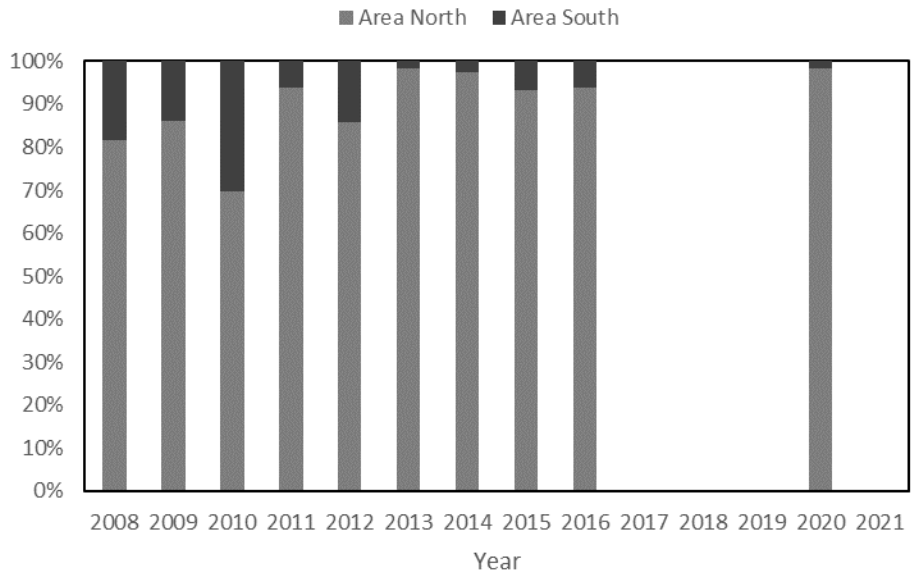

Figure 4.7. Shrimp in Denmark Strait and off East Greenland: Distribution of survey biomass north and south of 65°N (in %) from 2008-2016 and 2020. No survey was carried out in the period 2017 to 2019 and in 2021.

Stock composition. The demography in East Greenland consists of roughly equal proportions of males and females in most years. The proportion of females fluctuates between 40-60% all years except 2009 and 2020. In 2020 36.9 % of the biomass was female, the second lowest in the time series (SCR Doc. 20/060). In 2020 there may have been some issues regarding the classification of primiparous and multiparous females. The analysis was carried out on the combined female biomass.

Very few males smaller than 20 mm CL are caught in the survey (Figure 4.8). Scarcity of smaller shrimp in the survey area stresses that the total area of distribution and recruitment patterns of the stock are still unknown.

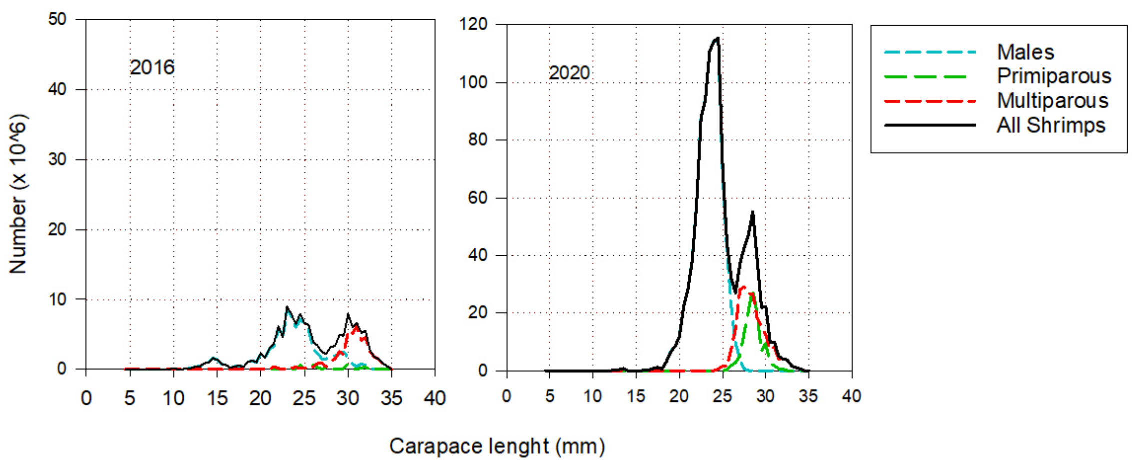

Figure 4.8. Shrimp in Denmark Strait and off East Greenland: Numbers of shrimp by length group (CL) in the total survey area in 2016 and 2020. No survey was carried out in the period 2017 to 2019 and in 2021.

c) Assessment results

Evaluation of the stock status is based upon interpretation of commercial fishery and survey data. The standardized CPUE have increase since 2015 and peaked in 2020 at a historical high level. In 2021 (until June 30th) the CPUE index value is the third highest in the time series but below the 2019 and 2020 values. The fishery in recent years is concentrated in a relatively small area north of 65^{0}N and west of 30^{0}W. Since 2016 only one survey in 2020 has been performed showing a record high survey biomass. The increase in CPUE since 2016 and the high survey biomass found in 2020, may indicate an improvement of shrimp density in the northern area. There was a decrease in CPUE in the first half of 2021, however, the fishery started late in 2021 and this may have impacted the fishing patterns.

During the 2021 NIPAG meeting a comprehensive sensitivity analysis of the surplus production model (SPiCT) was presented (SCR Doc. 21/044), following the recommendation of 2020 NIPAG. However, the SPiCT model was not applicable as a preliminary assessment tool this year, mainly because of the lack of survey biomass index in 2021 (and 2017 to 2019). However, it should be noted that nearly all model settings analyzed indicated B/Bmsy > 1 and F/Fmsy < 1.

d) Reference points

Scientific Council considers that 15% of the maximum survey female biomass provides a proxy for B_{lim} (SCS Doc. 17-017). In 2020 B_{lim} was recalculated based on new high survey female biomass from the 2020 survey (Figure 4.2). No fishing mortality reference point is defined.

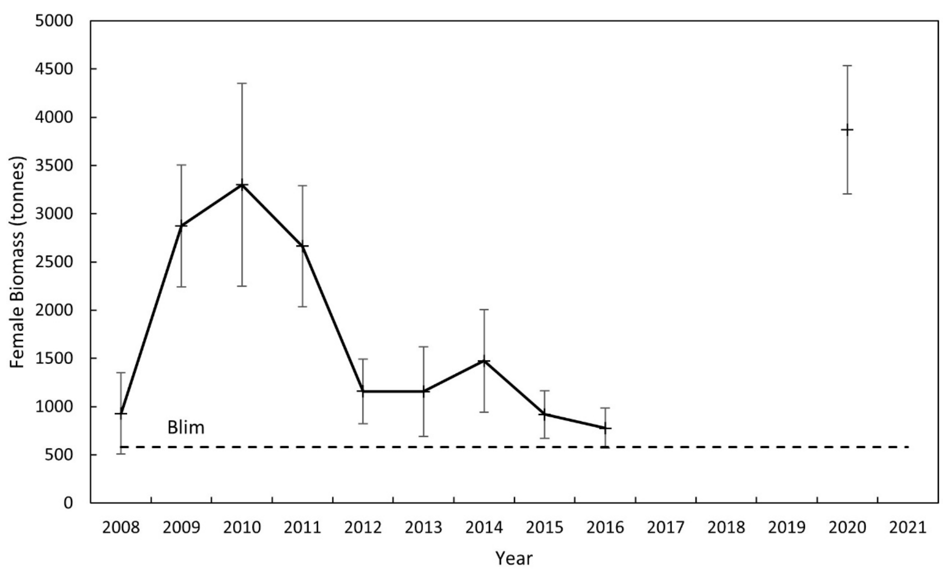

Figure 4.9. Shrimp in Denmark Strait and off East Greenland: Spawning stock biomass index (SSB) ±SE from 2008-2016 and 2020, and B_{lim} estimated as 15% of maximum survey female biomass. No survey was carried out in the period 2017 to 2019 and in 2021.

e) State of the stock

CPUE: The CPUE index declined continuously from its highest point in 2009 to a low value in 2014 and has been increasing until 2020, in 2021 there was a drop in CPUE, but the value remains at a high level. Estimates for the period 2016 to 2021 is based on fishing in a relatively small area and may not reflect the state of the total stock.

Recruitment. No recruitment estimates were available.

Biomass. The survey biomass index decreased by around 80% from 2010 to 2016. No survey was conducted in the period 2017 to 2019. The survey biomass in 2020 is the highest observed. There was no survey in 2021.

Exploitation rate. Since the mid-1990s the exploitation rate index based on standardized commercial effort has decreased, currently reaching the lowest levels seen in the time series. The 2016 to 2021 levels of exploitation rate may be biased given the issues on CPUE described above.

State of the stock. The survey biomass in 2020 is the highest observed since the beginning of the survey, in 2008. The commercial CPUE in 2021 has dropped slightly since 2020 which was the highest since the beginning of the time series, in 1986. There is no recruitment index available for this stock, few juvenile shrimps are caught in the survey area.

f) Research recommendations

- *NIPAG* ***recommends*** *in 2020 that: further model exploration should be carried out, including adding risk levels for different catch projection scenarios.*

Status: Has been completed; this recommendation should be progressed when new survey biomass and CPUE data become available

References

ICES, 2020, ICES Ecosystem Overviews Greenland Sea ecoregion. Published 10 December 2020 ICES Advice 2020 – https://doi.org/10.17895/ices.advice.763

5. Northern shrimp (*Pandalus borealis*) in the Skagerrak and Norwegian Deep (ICES Subdivision 27.3a.20 and the eastern part of Division 27.4a)

This stock was assessed during the 25–27 February 2019 NIPAG meeting. NIPAG reviewed the assessment during the present meeting. There were no further recommendations.

6. Northern shrimp (*Pandalus borealis*) in the Barents Sea (ICES Subareas 1 and 2)

Background documentation (equivalent to stock annex) is found in SCR Docs. 20/65, 66, 67, 70; 08/56, 07/75, 86; 06/64.

Ecosystem overview

Since the 1980s, the Barents Sea has gone from a situation with high fishing pressure, cold conditions and low demersal fish stock levels, to the current situation with high levels of demersal fish stocks, reduced fishing pressure and warm conditions.

The capelin stock has increased again after a steep decline between 2017 and 2019 and has been estimated to be above B_{lim}. Cod biomass has decreased in recent years following a peak around 2013 but is still at a relatively high level. Despite the recent increase in capelin, cod abundance remaining on historically high levels may put relatively high predation pressure on shrimp. The levels of environmental and organic pollution in the Barents Sea are generally low and do not exceed threshold limits or global background levels. More detailed information can be found in ICES (2018b).

a) Introduction

Northern shrimp (*Pandalus borealis*) in the Barents Sea and in the Svalbard fishery protection zone (ICES Subareas 1 and 2) is considered one stock (Figure 6.1). Norwegian and Russian vessels exploit the stock in the entire area, while vessels from other nations are restricted to the Svalbard fishery zone and the "Loophole" (Figure 6.1).

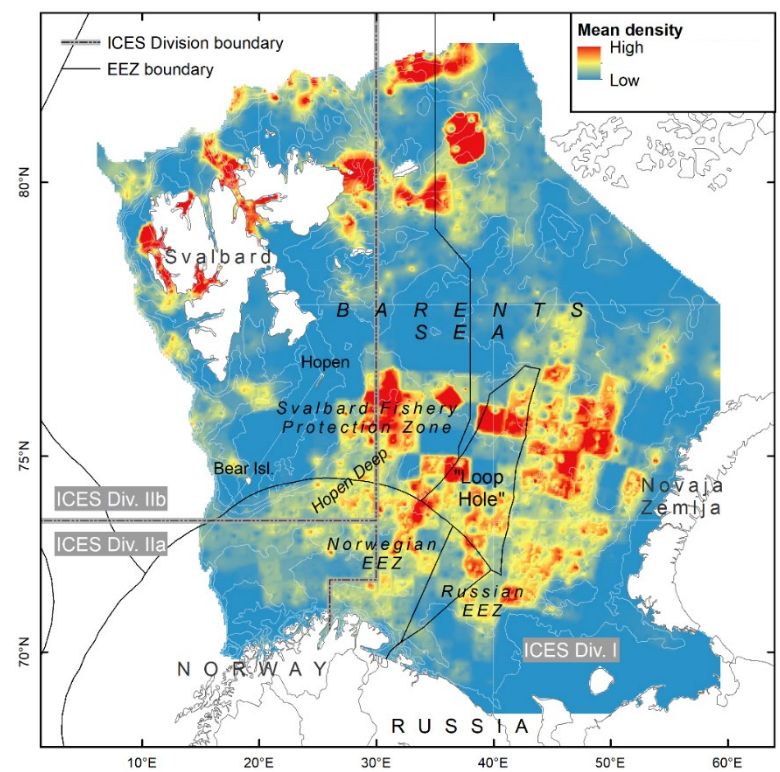

Figure 6.1. Shrimp in ICES SA 1 and 2: Stock distribution (Mean survey density index (kg/km2) from the joint Norwegian-Russian survey).

Norwegian vessels initiated the fishery in 1970. As the fishery developed, vessels from several nations joined and catches increased rapidly (Figure 6.2). Vessels from Norway, Russia, Iceland, Greenland, Faroes and the EU participate in this fishery on a regular basis.

There is no overall TAC established for this stock. The fishery is partly regulated by effort control (Norwegian and Svalbard zone), and a TAC in the Russian zone only. Licenses are required for the Russian and Norwegian vessels. In the Norwegian and Svalbard zones, the fishing activity of these license holders is constrained only by bycatch regulations whereas the activity of third country fleets operating in the Svalbard zone is also restricted by the number of effective fishing days and the number of vessels by country. The minimum stretched mesh size is 35 mm. Bycatch is limited by mandatory sorting grids and by the temporary closing of areas where excessive bycatch of juvenile cod, haddock, Greenland halibut, redfish or shrimp <15 mm CL is registered.

Landings. Landings have increased from 20 000 t in 2013 to more than 60 000 t in the most recent years and are predicted to reach 57 000 tons by the end of 2021.

Table 6.1. Shrimp in ICES SA 1 and 2: Recent landings in tonnes, as used by NIPAG for the assessment.

	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021[1]
Recommended TAC	60 000	60 000	60 000	70 000	70 000	70 000	70 000	70 000	150 000	140 000
Norway	14 158	8 846	10 234	16 618	10 896	7 010	23 126	23 925	19 118	21 000
Russia	0	1 067	741	1 151	2 491	3 849	12 561	28 081	21 265	14 000
Others	10 598	9 336	9 989	16 253	17 359	19 582	200 254	21 576	21 494	22 000
Total	24 756	19 249	20 964	34 022	30 748	30 441	55 941	73 582	61 877	57 000

[1] Catches projected to the end of the year.

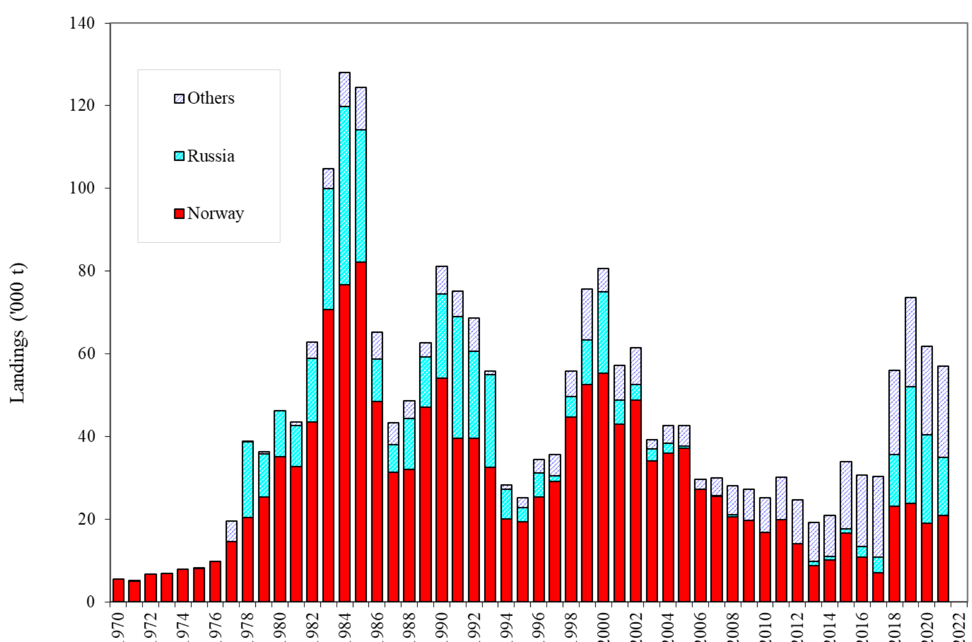

Figure 6.2. Shrimp in ICES SA 1 and 2: Total annual landings (2021 projected to the end of the year).

Discards and bycatch and ecosystem effects*.* Discards of shrimp cannot be quantified but are believed to be small as the fishery is not limited by quotas. Bycatch rates of other species are estimated from at-sea inspections and research surveys and are corrected for differences in gear selection pattern (ICES 2018a). Area-specific bycatch rates are then multiplied by the corresponding shrimp catches from logbooks to give an overall bycatch estimate. Revised and updated discard estimates (1983–2017) of cod, haddock and redfish juveniles in the Norwegian commercial shrimp fishery in the Barents Sea were available in 2018 (Figure 6.3). Since the introduction of the Nordmøre sorting grid in 1992, only small individuals of cod, haddock, Greenland halibut, and redfish, in the 5–25 cm size range, are caught as bycatch. Updated analyses of bycatch were presented at this year's ICES AFWG, but the report has not yet been published.

In 2017, specific information on bycatch from EU-Estonia based on onboard scientific observers was presented. They indicated 2.9% by weight of fish discards and 0.6% discards of shrimp.

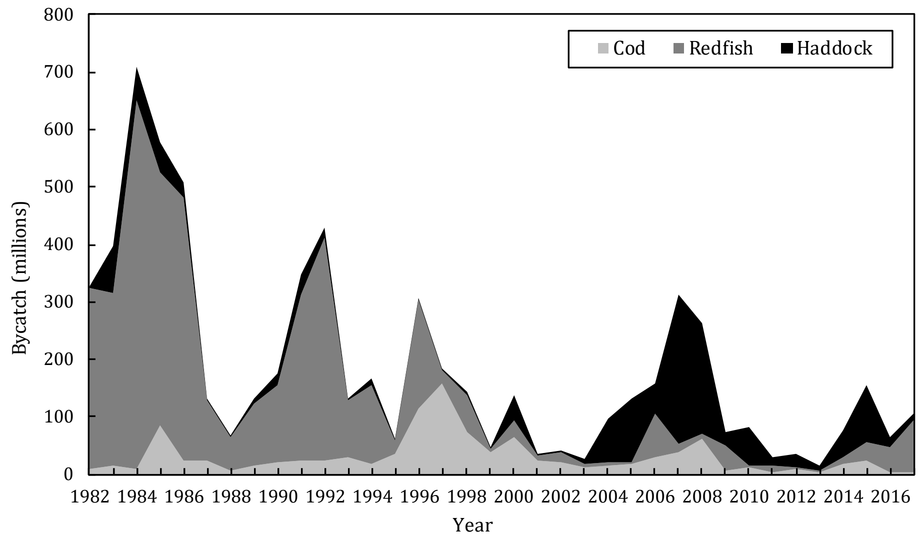

Figure 6.3. Shrimp in ICES SA 1 and 2: Estimated bycatch of cod, haddock and redfish in the Norwegian shrimp fishery (million individuals). The sorting grid was introduced in 1992 and has been mandatory since and following that, the vast majority of bycatch is assumed to have been juveniles.

b) Input data

i) Commercial fishery data

Logbook data are normally available only from the Norwegian fleet, but 2017 data was also available from the EU-Estonia fleet. In 2020 and 2021 summary catch and effort data was received from Poland, Latvia and Estonia. In addition, information was provided by Russia in SCR Doc. 21/052, including information on catch distribution and standardized catch rates.

A major restructuring of the Norwegian shrimp fishing fleet towards fewer and larger vessels took place during the late-1990s through the early 2000s (Figure 6.4). Until 1996, the fishery was conducted using single trawls only. Double and triple trawls were then introduced. An individual vessel may alternate between single and multiple trawling depending on what is appropriate on given fishing grounds.

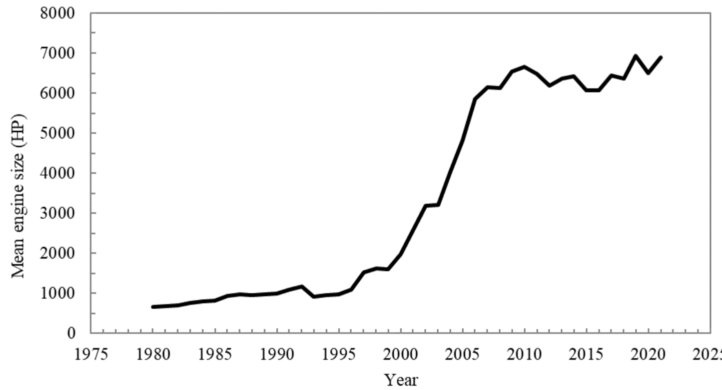

Figure 6.4. Shrimp in ICES SA 1 and 2: Mean engine power (HP) weighted by trawl-time (Norwegian vessels).

The fishery takes place throughout the year but may in some years be seasonally restricted by ice conditions. The lowest effort is generally in October through March, the highest in May to August.

The fishery was originally conducted mainly in the central Barents Sea and on the Svalbard Shelf along with the Goose Bank (southeast Barents Sea). Norwegian logbook data since 2009 show decreased activity in the Hopen Deep and around Svalbard, coupled with increased effort further east in international waters (the "Loophole") (Figure 6.5). Information from the Norwegian industry points to decreasing catch rates and more frequent area closures due to bycatch of juvenile fish on the traditional shrimp fishing grounds as the main reasons for the observed change in fishing pattern.

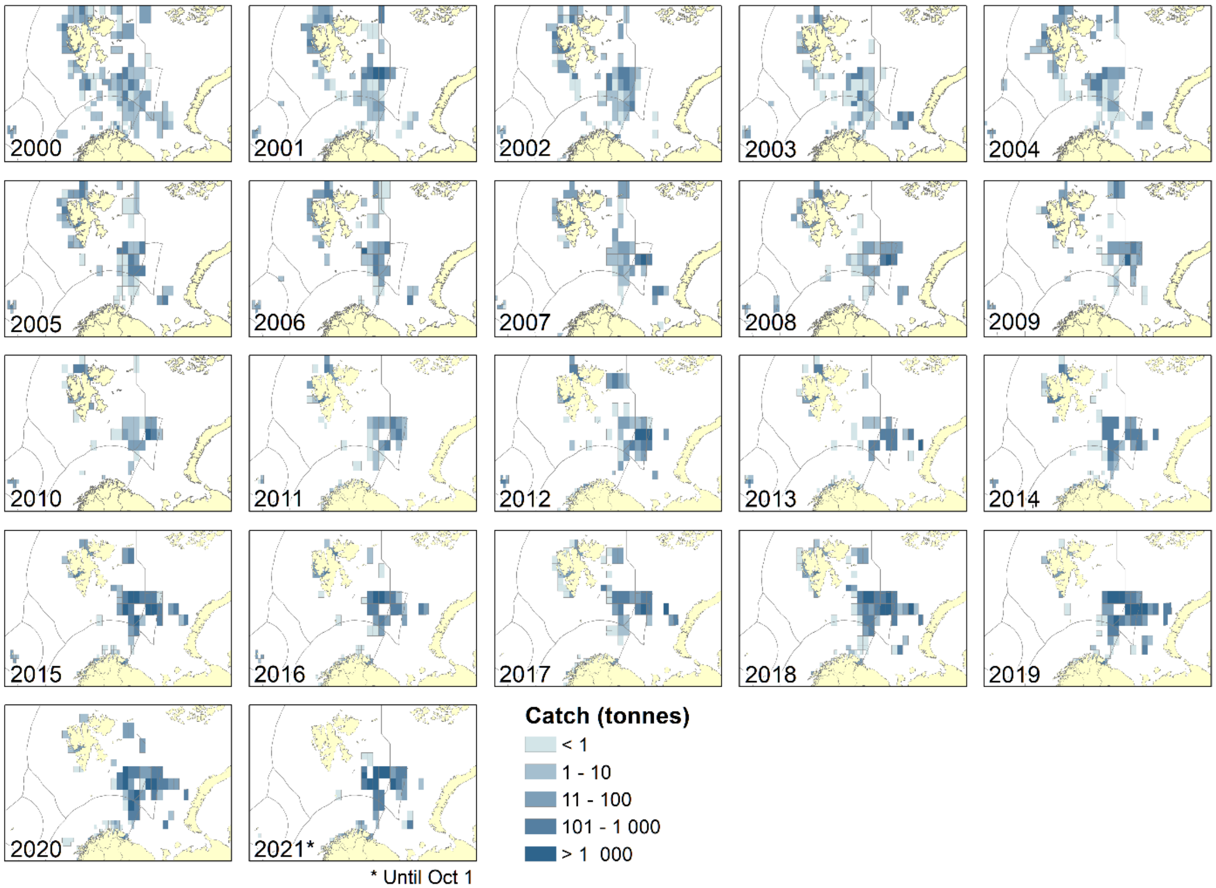

Figure 6.5. Shrimp in ICES SA 1 and 2: Distribution of catches by Norwegian vessels since 2000 based on logbook information. *2021 includes only data until October 1st.

The Soviet/Russian fishery for the northern shrimp in the Barents Sea started in 1978. Catches peaked in 1983-1985 and varied in subsequent years (Fig. 6.2) In 2009-2012, the Russian fishery for shrimp came to a full stop. Following a restructuring of the fleet catches have again increased in excess of 20 000 t in 2020.

In the early 2000s, the Russian fishery was mainly conducted in the open part of the Barents Sea and the Svalbard area (Fig. 6.6). With the resumption of fishery in 2013, the main fishing grounds were shifted eastward. Currently fishing occurs in the Russian EEZ in the areas of the Novaya Zemlya Bank, the Perseus Upland, Cape Zhelaniya and Cape Sukhoi Nos. The main fishing period is March to September; however, some vessels fish all year round.

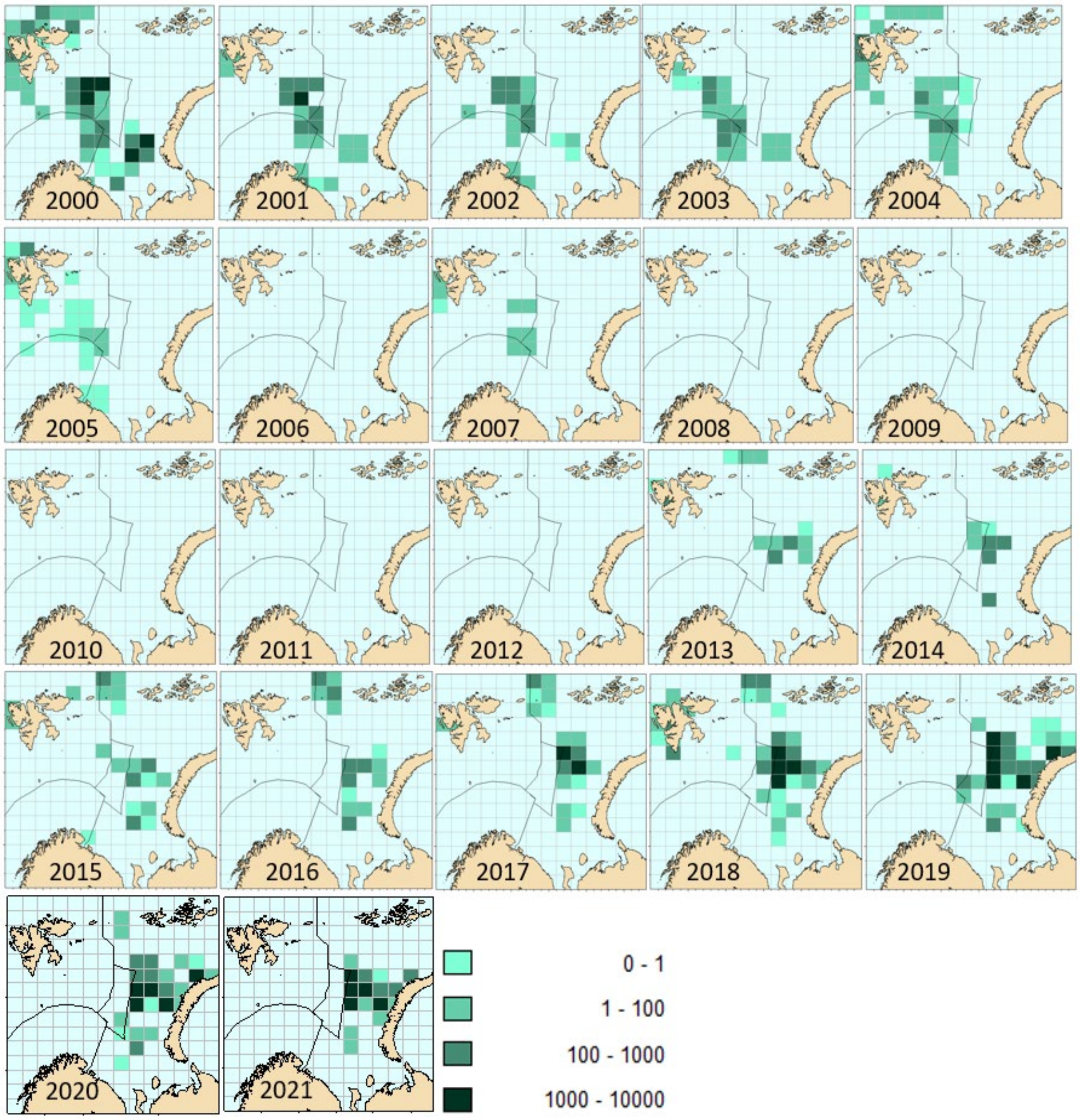

Figure 6.6. Distribution of catches by Russian vessels since 2000 based on logbook information. (2021 only data until September)

A standardized CPUE index based on a generalized linear model (GLM) that took area, depth, gear, and month into account, has been relatively stable since 2016 (Fig. 6.7). This standardized CPUE, being new and not fully evaluated by NIPAG was at this point not used as input to the assessment model. The inclusion of this index will be further considered at the up-coming benchmark in 2022.

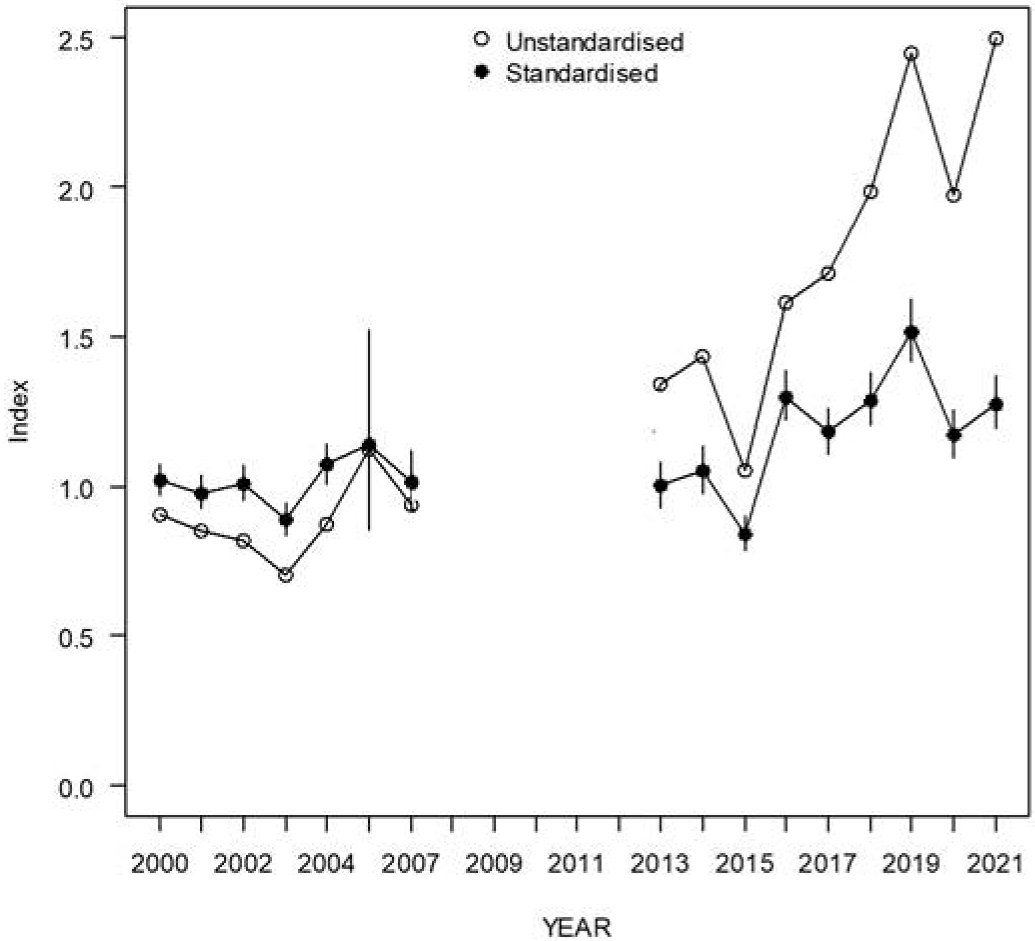

Figure 6.7. Unstandardized (geometric mean of annual observations) and standardized (year coefficients from GLM) CPUE indices for Russian shrimp fishery. Error bars indicate +2 s.e. Each series has been normalized to a geometric mean of 1. There was no Russian fishery between 2009 and 2012.

Norwegian logbook data were used in a GLM to calculate standardized annual catch rate indices (SCR Doc. 19/056). The GLM used to derive the CPUE indices included the following variables: (1) vessel, (2) season (month), (3) area (five survey strata), and (4) gear type (single, double or triple trawl). The resulting series provides an index of the fishable biomass of shrimp ≥17 mm CL, *i.e*. females and older males (Figure 6.8). The minimum commercial size in this fishery is 15mm.

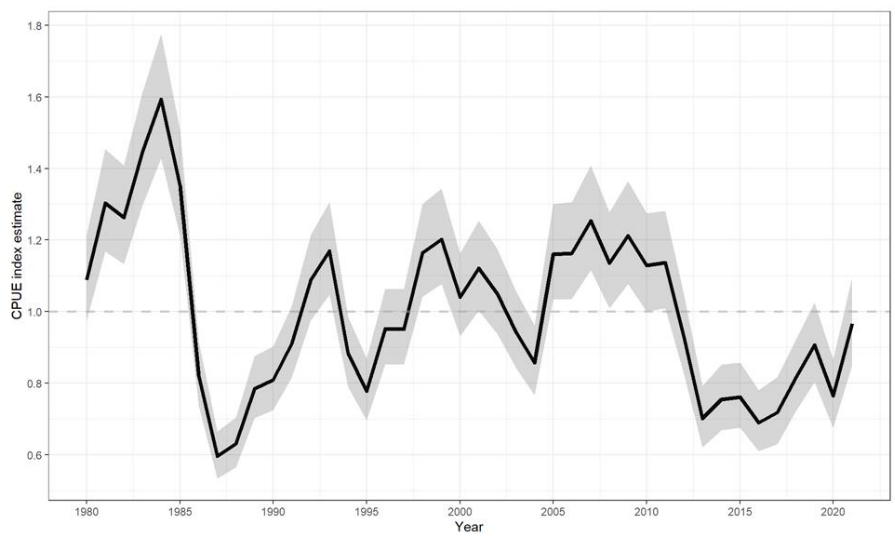

Figure 6.8. Shrimp in ICES SA 1 and 2: Standardized CPUE index based on Norwegian data. Index values are centered around the mean of the series. The shaded area marks the 95% confidence intervals.

The Norwegian logbook data on which the CPUE index is based represents fishing activity from most of the stock distribution area. However, in recent years the portion of total catches taken by Norway has been halved and now only represents about one third of the total catches.

The addition of the updated data set for 2020 and provisional 2021 data has slightly changed the trajectory of the standardized CPUE series for the most recent years as compared to the estimation presented at the 2020 assessment, however, the overall trend remains the same. Following the work towards the 2022 benchmark, a correction was made to the way the uncertainty was calculated which have resulted in larger (and likely more realistic) uncertainty estimates than seen in previous assessments.

ii) Research survey data

Russian and Norwegian surveys were conducted in their respective EEZs of the Barents Sea from 1982 to 2005 to assess the status of the northern shrimp stock (SCR Docs. 06/70, 07/75, 14/51, 15/52). In 2004, these surveys were replaced by a joint Norwegian-Russian "Ecosystem survey" in August/September, which monitors shrimp along with a multitude of other ecosystem variables in the Barents Sea and around Svalbard (SCR Docs.14/55, 7/68).

Biomass. The biomass indices of survey 1 and 2 have fluctuated without trend over their respective time periods covered (Figure 6.10). The most recent survey series (survey 3) has increased substantially since a low in 2016 to reach its highest value in 2019. However, the 2020 value is down again close to the 2016 value. In general, the entire survey area of the Ecosystem survey (survey 3 in Figure 6.10) is covered in all years, however, due to heavy ice conditions in 2014 the northern part of the area (stratum 3, see SCR Doc. 17/68) was not covered. For the 2004-2013 survey period this area accounts for on average 13% of the biomass (range: 8-27%). The 2014 biomass for stratum 3 was estimated by calculating the average ratio of biomass density in stratum 3 to biomass density in the remaining survey area for the 2009-2013 period and applying this average to the density of the 2014 surveyed area. Estimates of variance for stratum 3 was taken as the variance of the 2009-2013 estimates for stratum 3. A similar method incorporating 2015 to 2017 data was used to compensate for missing coverage due to vessel malfunction of stratum 5 and stratum 4 in 2018 and 2019 respectively.

In the 2020 the Russian part of the survey area (about 50%) was not finalized before the start of the 2020 assessment due to technical issues. These data have now been added (Figure 6.9) and the updated 2020 index value is similar (<1% difference) to the one estimated based on partial data last year. For this year the Russian

2021 survey data had not yet been entered in the Norwegian database and therefore not available for this assessment (Figure 6.9). The same approach as agreed on by NIPAG in 2020 (see full description in 2020 report) was applied to correct for the missing coverage, using the long-term mean biomass proportion of the strata without data compared to the total biomass to raise the total biomass. The mean proportion of the missing strata was 67.8% and total biomass, thus, increased by 32.2%.

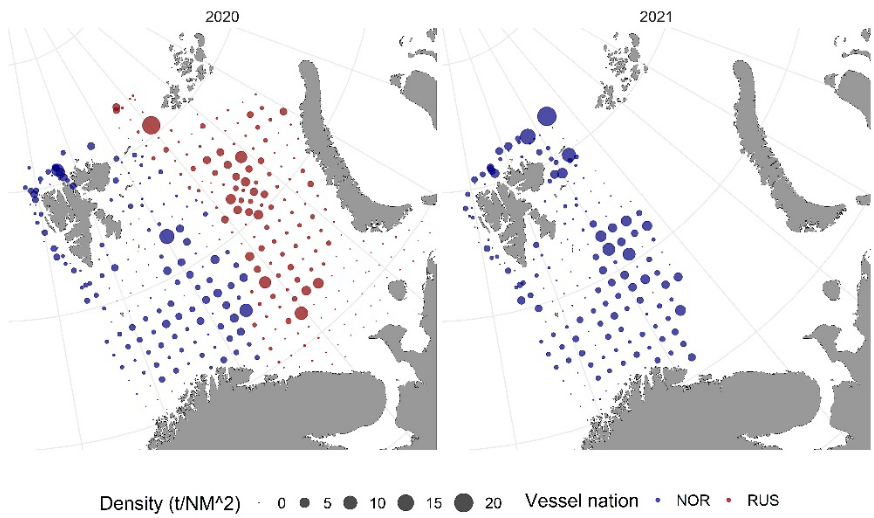

Figure 6.9. Survey data availability 2020 and 2021 of the joint Norwegian-Russian survey at the time of the 2021 NIPAG meeting. Dots are scaled to the registered catches of shrimp, colors indicate different survey vessels.

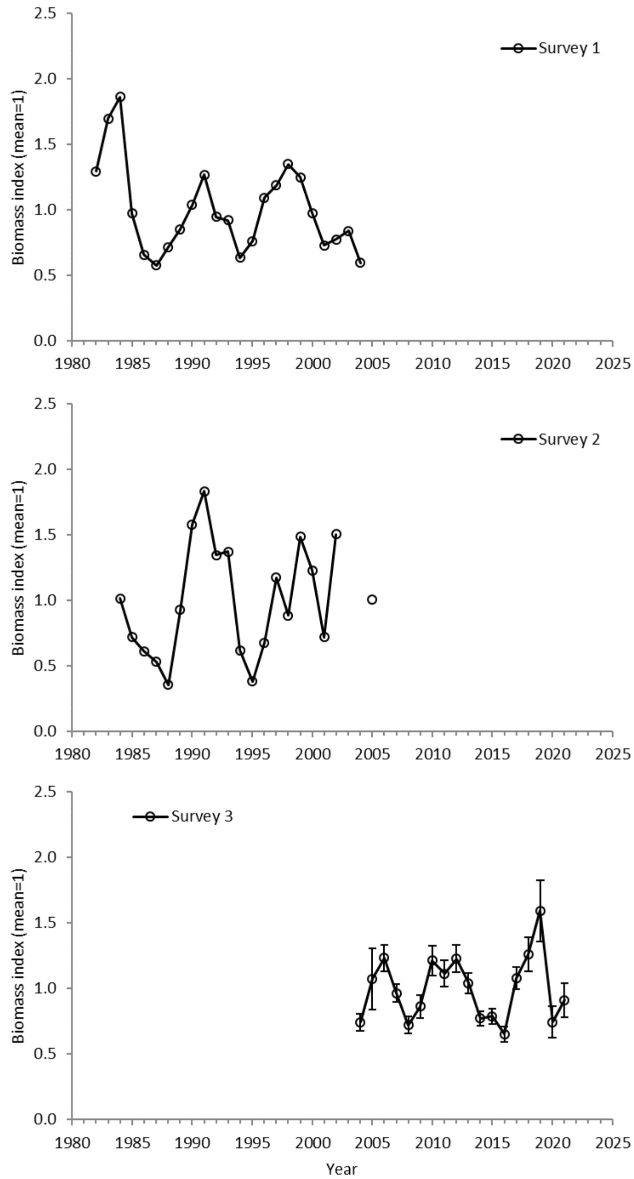

Figure 6.10. Shrimp in ICES SA 1 and 2: Indices of total stock biomass from the (1) 1982-2004 Norwegian shrimp survey, (2) the 1984-2005 Russian survey, and (3) the joint Russian-Norwegian ecosystem survey since 2004. Error bars represent 1 SE.

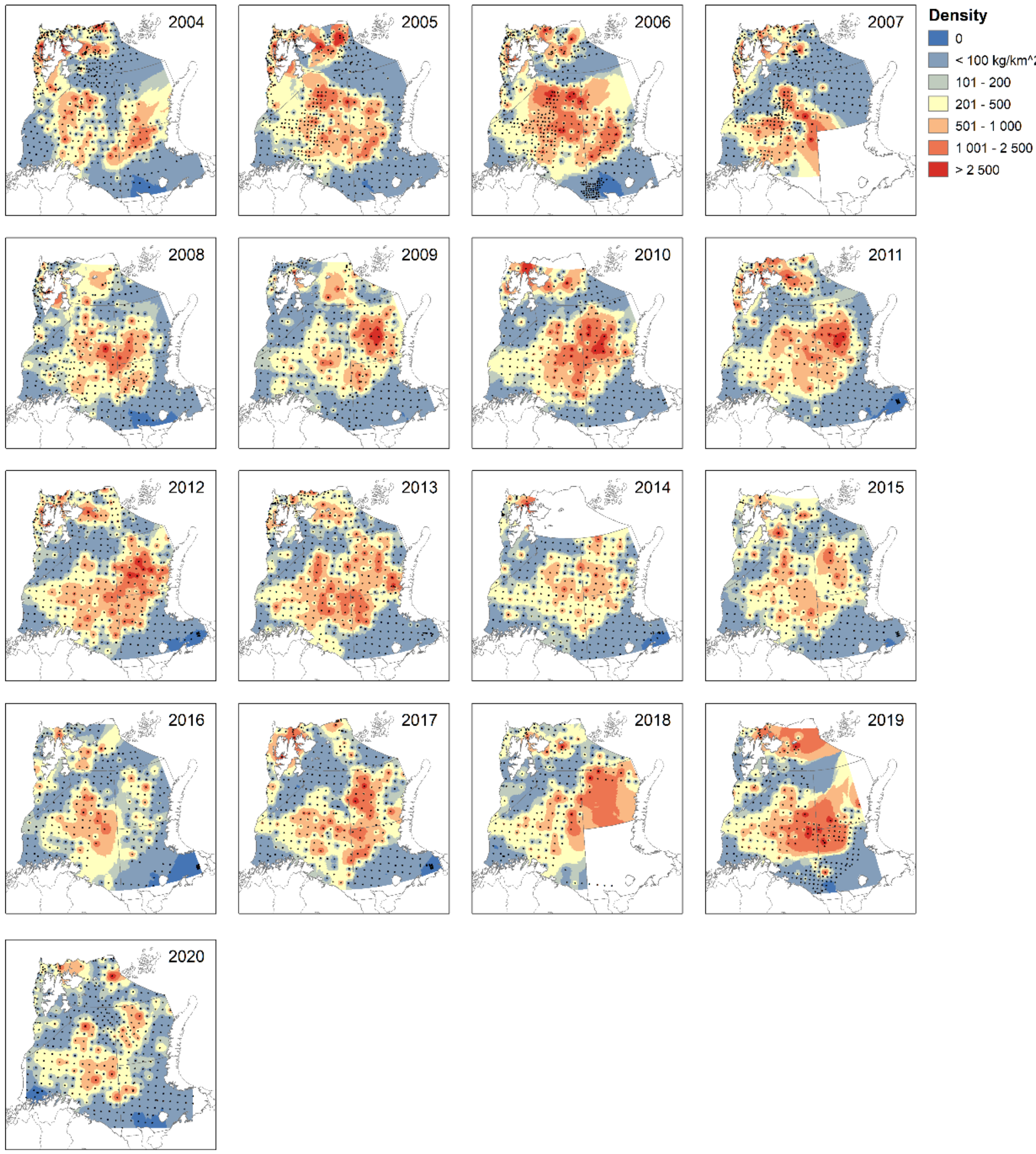

Figure 6.11. Shrimp in ICES SA 1 and 2: shrimp density (kg/km2) as calculated from the Ecosystem survey data since 2004 (no data for stratum 3 in 2014 due to ice conditions; no data for stratum 5 in 2018 and 4 in 2019 due to vessel malfunction; for survey 2021 see text.

Recruitment indices. No information is included as data are not available since 2013. Length distribution data from the Estonian fishery and survey data from the Norwegian EEZ were investigated during the meeting and these gave some indication of good recruitment in 2015 and 2019, however, NIPAG deferred further analysis to the upcoming benchmark in 2022.

c) Assessment

The modelling framework introduced in 2006 (SCR Doc. 06/064) was used for the assessment. Model settings were the same as those used in previous years. However, the observation error for the 2021 survey data point was assumed to be twice that of the remaining series, considering that the survey data did not cover the entire shrimp distribution area.

Within this model, parameters relevant for the assessment and management of the stock are estimated, based on a stochastic version of a surplus-production model. The model is formulated in a state-space framework and Bayesian methods are used to derive "posterior" probability density distributions of the parameters (SCR Doc. 20/066).

The model synthesized information from input priors, four independent series of shrimp biomass indices and one series of shrimp catch. The biomass indices were: a standardized series of annual fishery catch rates for 1980–2020 (Figure 6.6, SCR Doc. 20/067); and trawl-survey biomass indices for 1982–2004, 1984–2005 and for 2004–2020 (Figure 6.7, SCR Doc. 20/065). These indices were scaled to true biomass by individual catchability parameters, q_j, and lognormal observation errors were applied. Total reported catch in ICES Div. 1 and 2 since 1970 was used as yield data (Figure 6.2, SCR Doc. 20/067). The fishery being without major discarding problems or variable misreporting, reported catches were entered into the model as error-free.

Biomass, *B,* was thus measured relative to the biomass that would yield Maximum Sustainable Yield, B_{msy}. The estimated fishing mortality, *F*, refers to the removal of biomass by fishing and is scaled to the fishing mortality at MSY, F_{msy}. The state equation describing stock dynamics took the form:

$$P_{t+1} = \left(P_t - \frac{C_t}{B_{MSY}} + \frac{2\,MSY\,P_t}{B_{MSY}}\left(1 - \frac{P_t}{2}\right)\right) \cdot \exp(\nu_t)$$

where P_t is the stock biomass relative to biomass at *MSY* ($P_t = B_t/B_{msy}$) in year *t*. This frames the range of stock biomass on a relative scale where $B_{msy} = 1$ and the carrying capacity (*K*) equals 2. The ‘process errors’, *v*, are normally, independently and identically distributed with mean 0 and variance σ_P^2.

The observation equations had lognormal errors, ω, κ, η and ε, for the series of standardised CPUE ($CPUE_t$), Norwegian shrimp survey ($survR_t$), The Russian shrimp survey ($survRu_t$) and joint ecosystem survey ($survE_t$) respectively giving:

$$CPUE_t = q_C B_{MSY} P_t \exp(\omega_t)\,,\; survR_t = q_R B_{MSY} P_t \exp(\kappa_t)\,,\; survRu_t = q_{Ru} B_{MSY} P_t \exp(\eta_t)\,,\; survE_t = q_E B_{MSY} P_t \exp(\varepsilon_t)$$

The observation error terms, ω, κ, η and ε are treated as normally, independently and identically distributed with mean 0 and variances σ_C^2, σ_R^2, σ_{Ru}^2 and σ_E^2 respectively.

Summaries of the estimated posterior probability distributions of selected parameters are shown in Table 6.2. Values are similar to the ones estimated in previous assessments. *K* could not be well estimated from the data alone and its posterior will depend somewhat on the chosen prior. For the estimates of relative stock size relaxing the *K*-prior did not have much effect (SCR Doc. 07/076) except for a slight increase in uncertainty. However, the posterior for *MSY* is sensitive as *K* is correlated with *MSY*: in particular, the right-hand side of the posterior distribution is widened while the left-hand side seems pretty well determined by the data. The mode of the distribution of *MSY* is around 110 kt and would likely be a best point estimate of this parameter.

Table 6.2. Shrimp in ICES SA 1 and 2: Summary of parameter estimates: mean, standard deviation (sd) and quartiles of the posterior distributions of selected parameters estimated in the 2021 assessment and the median values from the 2020 assessment.

	Mean	sd	25 %	Median	75 %	Median (2020)
MSY (ktons), maximum sustainable yield	211	117	118	191	291	204
K (ktons), carying capacity	2997	1529	1868	2699	3787	2686
r, intrinsic growth rate	0.30	0.14	0.21	0.30	0.40	0.32
q_R, catchability of survey 2	0.13	0.08	0.07	0.11	0.16	0.11
q_{Ru}, catchability of survey 1	0.32	0.21	0.18	0.26	0.40	0.27
q_E, catchability of survey 3	0.20	0.13	0.11	0.17	0.25	0.17
q_C, catchability of CPUE index	4.7E-04	3.0E-04	2.6E-04	3.8E-04	5.8E-04	3.8E-04
P_0, initial relative biomass (1969)	1.51	0.26	1.33	1.51	1.68	1.51
P_{2021}, relative biomass in 2021	1.69	0.31	1.53	1.70	1.87	1.86
σ_R, coefficient of variation for survey 2	0.18	0.03	0.16	0.18	0.20	0.17
σ_{Ru}, coefficient of variation for survey 1	0.34	0.05	0.31	0.34	0.37	0.34
σ_E, coefficient of variation for survey 3	0.18	0.03	0.16	0.18	0.20	0.19
σ_C, coefficient of variation for CPUE index	0.12	0.02	0.11	0.12	0.13	0.13
σ_P, coefficient of variation for process	0.18	0.02	0.16	0.17	0.19	0.18

Reference points. Four reference points are considered (buffer reference points are obsolete as probability of transgressing the PA limit reference points can be calculated directly):

	Type	Value	Technical basis
MSY approach	$B_{trigger}$	$0.5B_{MSY}$	Approximately corresponding to 10th percentile of the B_{msy} estimate (NIPAG 2010)
	F_{MSY}		Resulting from the assessment model.
Precautionary approach	B_{lim}	$0.3B_{MSY}$	The *B* where production is reduced to 50% *MSY* (NIPAG 2006)
	F_{lim}	$1.7F_{MSY}$	The *F* that drives the stock to B_{lim}

The results of this year's assessment are at large consistent with those of previous years (model introduced in 2006). The conclusions on stock status drawn from the model have been found on investigation to largely be insensitive to the setting of the priors for initial stock biomass and carrying capacity (SCR Docs. 06/064 and 07/076).

Stock size and fishing mortality. A steep decline in stock biomass in the mid-1980s was noted following some years with high catches and the median relative biomass almost dropped to the *Bmsy*-level (Figure 6.12, upper). Since the late 1980s, however, the stock has varied with a slightly increasing trend. The estimated probability of stock biomass being below $B_{trigger}$ by the end of 2021 is less than 1% (Table 6.3). The median estimate of fishing mortality has remained below F_{msy} throughout the history of the fishery (Figure 6.12 lower). In 2021, there is a less than 5% probability of the *F* being above F_{msy} (Table 6.3).

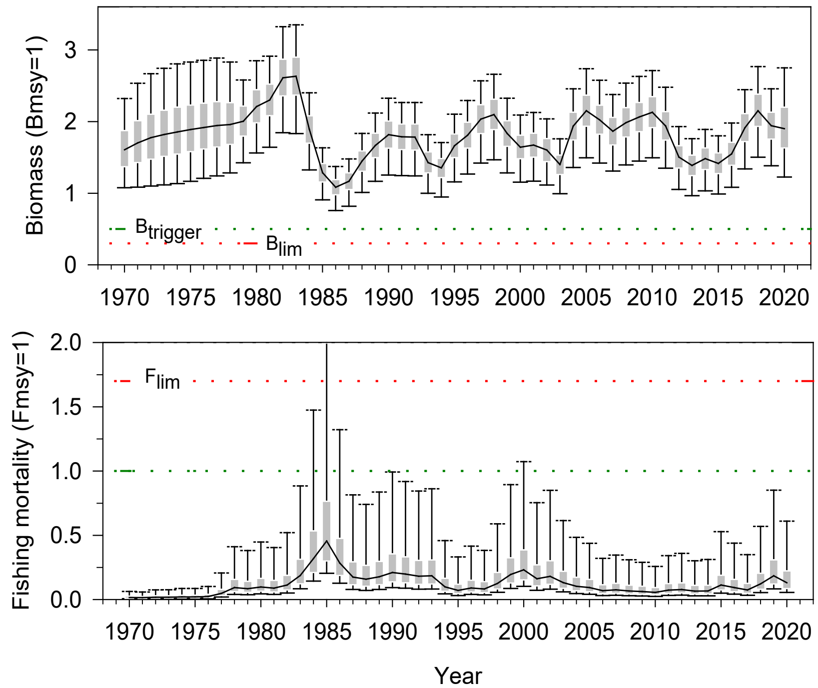

Figure 6.12. Shrimp in ICES SA 1 and 2: Estimated relative biomass (B/B_{msy}) and fishing mortality (F/F_{msy}) since 1970. Boxes represent inter-quartile ranges and the solid black line in the middle of each box is the median; the arms of each box cover the central 90% of the distribution. The broken lines indicate *MSY* and precautionary approach reference points.

Table 6.3. Shrimp in ICES SA 1 and 2: Stock status for 2020 and projected to the end of 2021 with a predicted total catch of 57000 t.

Status	2020	2021
Risk of falling below B_{lim}	0.1 %	0.1 %
Risk of falling below $B_{trigger}$	0.3 %	0.3 %
Risk of exceeding F_{MSY}	4.0 %	4.1 %
Risk of exceeding F_{lim}	1.8 %	1.8 %
Stock size (B/Bmsy), median	1.70	1.71
Fishing mortality (F/Fmsy)	0.19	0.18

Projections. Catch advice at the median of F_{msy} (ICES MSY approach) would imply no more than 289 ktons, which is outside the catch history of the fishery. Given that the right-hand side of the probability distributions of the yield at the F_{msy} is less well estimated, NIPAG considers it more appropriate to apply the mode as a point estimate of yield at F_{msy}. This mode is at 140 kt. Assuming a catch of 57 ktons for 2021, catch options up to 140 ktons for 2021 have low risks of exceeding F_{msy} (<18%), F_{lim} (<6%), and of going below $B_{trigger}$ (<1%) by the end of 2022 (Table 6.4) and all these options are likely to maintain the stock above B_{msy}.

Table 6.4. Shrimp in ICES SA 1 and 2: Predictions of risk and stock status associated with optional catch levels for 2022.

	Catch option 2022 (ktons)						Yield at Fmsy (mode)	Yield at Fmsy (median)
	60	70	80	90	100	110	140	289
Risk of falling below B_{lim}	0.1 %	0.1 %	0.1 %	0.1 %	0.1 %	0.1 %	0.3 %	1.2 %
Risk of falling below $B_{trigger}$	0.4 %	0.4 %	0.4 %	0.4 %	0.4 %	0.4 %	0.7 %	2.9 %
Risk of exceeding F_{MSY}	4.3 %	5.6 %	7.1 %	8.6 %	10.3 %	12.2 %	17.6 %	50 %
Risk of exceeding F_{lim}	2.0 %	2.5 %	3.0 %	3.8 %	4.5 %	5.3 %	7.6 %	24 %
Stock size (B/Bmsy), median	1.72	1.71	1.72	1.69	1.69	1.68	1.64	1.57
Fishing mortality (F/Fmsy),	0.18	0.21	0.24	0.27	0.31	0.34	0.45	1.00

d) Environmental and other considerations

Temperature. In the ecosystem survey, shrimps were only caught in areas where bottom temperatures were above 0°C. Highest shrimp densities were observed between zero and 4°C, while the limit of their upper temperature preference appears to lie at about 6-8°C. The warming of the western Barents Sea coincides with the shift in shrimp distribution eastwards (Figure 6.8), thus temperature might be a factor in explaining the observed changes in spatial distribution.

Predation. Both stock development and the rate at which changes might take place can be affected by changes in predation, in particular by cod, which has been documented as capable of consuming large amounts of shrimp. Continuing investigations to include cod predation as an explicit effect in the assessment model have so far not been successful; it has not been possible to establish a relationship between the density of cod and the stock dynamics of shrimp. The cod stock in the Barents Sea has decreased but remained at a relatively high level during the recent ten years. If predation on shrimp was to increase rapidly beyond the range previously experienced, the shrimp stock might decrease in size more than the model results have indicated as likely.

Recruitment, and reaction time of the assessment model. The model used is best at projecting trends in stock development but estimates and uses long-term averages of stock dynamic parameters. Large and/or sudden changes in recruitment or mortality may therefore be underestimated in model predictions which seems to be exemplified by the 2018-19 abrupt increase in stock biomass.

Model performance. The model was able to produce good simulations of the observed data (Figure 6.13). The differences between observed values of biomass indices and the corresponding values predicted by the model were checked numerically (SCR Doc 20/066). They were found generally not to include excessively large deviations.

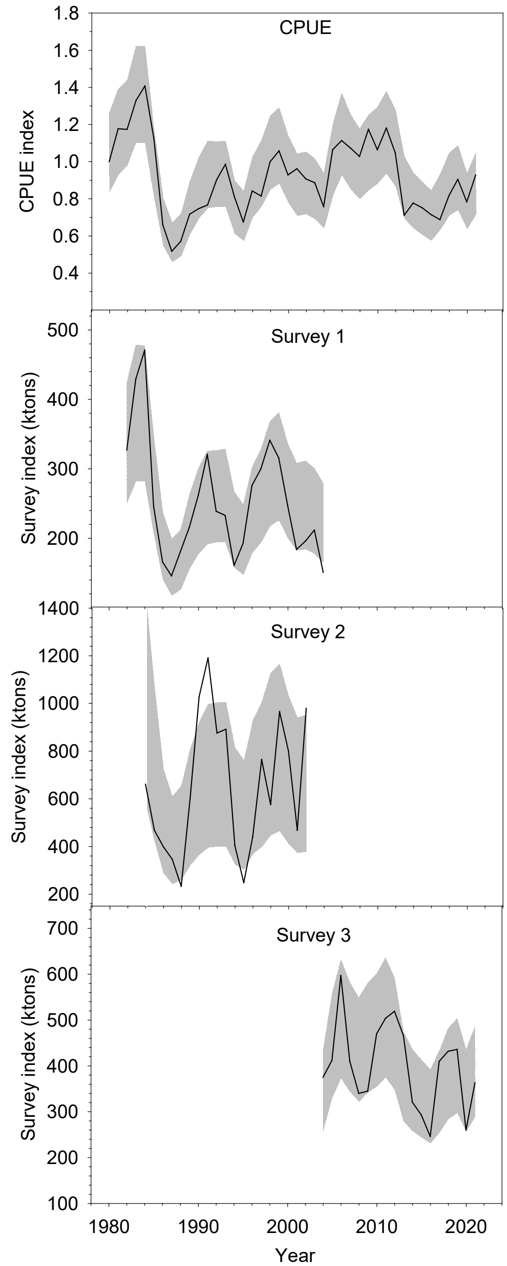

Figure 6.13. Shrimp in ICES SA 1 and 2: Observed (solid line) and estimated (shaded) series of the included biomass indices: the standardized catch-per-unit-effort (CPUE), the 1982–2004 Norwegian shrimp survey (survey 1), the 1984 to 2005 Russian survey (Survey 2) and the Joint Norwegian-Russian Ecosystem Survey (survey 3) since 2004. Grey shaded areas cover the 80% probability interval of their posteriors.

The model did tend to be pessimistic regarding the final years during the stock increase since 2015 (Figure 6.14), but all of these were well inside the updated estimated probability distributions the following year. The model only slightly underestimated the decline from 2019 to 2020. A simple calculation of Mohn's rho based on the point estimates (medians) for five years is -0.07.

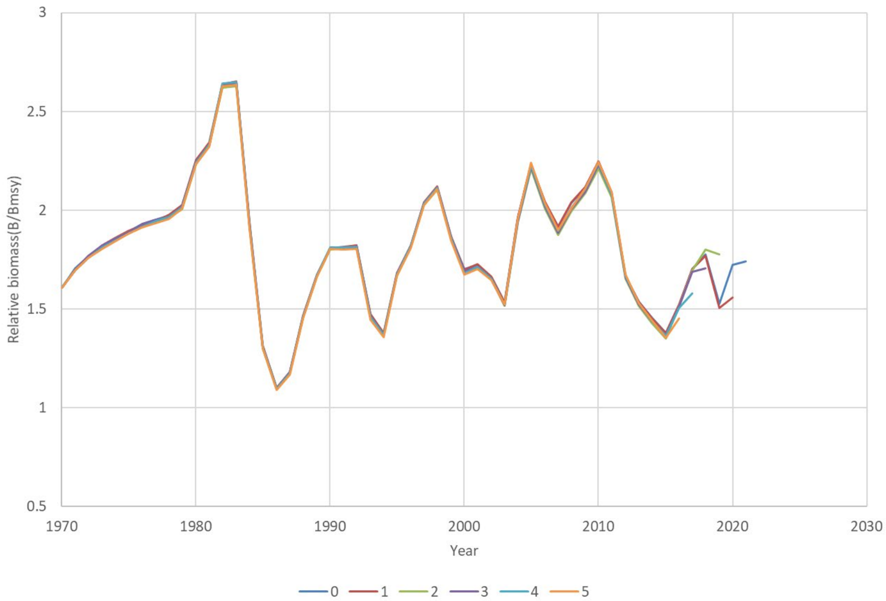

Figure 6.14. Shrimp in ICES SA 1 and 2: Retrospective plot of median relative biomass (B/B_{msy}). Relative biomass series are estimated by consecutively leaving out from 0 to 5 years of data.

e) State of the stock

Biomass. Stock biomass has been above $B_{trigger}$ throughout the history of the fishery. The probability that the biomass at the end of 2021 is below $B_{trigger}$ is less than 1%.

Mortality. Fishing mortality is likely to have remained below F_{msy} throughout the history of the fishery. In 2021 there is 2% risk of fishing mortality exceeding F_{lim}.

Recruitment. No explicit information was available but there were some indications of good recent recruitment from preliminary investigation of observer and survey data.

State of the Stock. The Stock is estimated to be well above B_{msy} and exploited sustainably.

f) Research recommendations

- *The fishery has expanded since 2014 and catches by countries other than Norway have increased to account for about 65% of the total. In 2016, NIPAG therefore* ***recommended*** *that available data (logbook data and catch samples) from the participating nations be made available to NIPAG.*

Status: An official data call has been made and some parties have now provided aggregated data on total catch and effort. This is of limited use for the work of NIPAG and this recommendation is therefore reiterated.

- *In 2017, NIPAG* ***recommended*** *that the information regarding catch effort and bycatch from the Estonian commercial fishery should be further analysed e.g. CPUE data explored as a potential index of biomass.*

Status: no progress. This recommendation is not reiterated.

References

ICES. 2018a. Report of the Arctic Fisheries Working Group (AFWG), 18–24 April 2018, Ispra, Italy. ICES CM 2018/ACOM:06. 859 pp

ICES. 2018b. Interim Report of the Working Group on the Integrated Assessments of the Barents Sea (WGIBAR). ICES WGIBAR REPORT 9-12 March 2018. Tromsø, Norway. ICES CM 2018/IEASG:04. 210 pp.

7. Northern shrimp (*Pandalus borealis*) in the Fladen Ground (western part of ICES Division 27.4a)

Background documentation is found in SCR Doc. 21/046.

a) Introduction

From the 1960s up to around 2000, a significant shrimp fishery exploited the shrimp stock on the Fladen Ground in the northern North Sea. Landings from the Fladen Ground have been recorded since 1970, and total landings have fluctuated between zero and a maximum of around 9 000 t in 1987 (Fig. 7.1, Table 7.1). Historically, the Danish fleet accounted for the greatest share of these landings, while the Scottish fleet landed a smaller portion. Norway landed minor catches in some years. The fishery took place mainly during the first half of the year, with the highest activity in the second quarter. Since 1998, landings decreased steadily and since 2004, the Fladen Ground shrimp fishery has been virtually non-existent. Interview information from the fishing industry obtained in 2004 gave the explanation that the decline was caused by high fuel prices, low shrimp abundance and low prices on the small shrimp which are characteristic of the Fladen Ground. Since 2011, there have been minor Danish and Norwegian landings of shrimp from Fladen Ground, mainly taken as bycatch in the Norway pout fishery.

The Fladen Ground shrimp stock was surveyed as part of the annual Norwegian shrimp survey in the Skagerrak and Norwegian Deep in the late 1980s and early 1990s. The stock was surveyed again in January 2021. For many years, due to lack of both fishery and survey data, it was not known if the decline in the fishery reflected a decline in the stock. The last ICES advice given in 2019 advised no targeted fishery (ICES 2019). In 2021, there is an agreed quota of 660 tons which applies to the United Kingdom and European Union waters of Area 4, and the United Kingdom waters of Division 2.a.

Table 7.1. Shrimp in ICES Division 4.a West: Recent landings in metric tonnes, as used by NIPAG for the assessment.

	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021[1]
Recommended TAC	*	*	*	*	*	*	*	0	0	0
Actual TAC	3 058	3 058	2 446	2 446	2 446	2 446	1 957	1 566	1 200	660
Denmark	0	0	1	19	0	1	0	2	153	277
UK (Scotland)	0	0	0	1.1	0	3.7	0	0	0	0
Sweden	0	0	0	0	0	0	0	0	0	0
Norway	0.5	0	0	0	10	6	0	6	66	0
Total	0	0	1	20.1	10	10.7	0	8	219	277

[1] Landings until October 2021.
* ICES catch advice for 2012-2018 was “no increase in catch”.

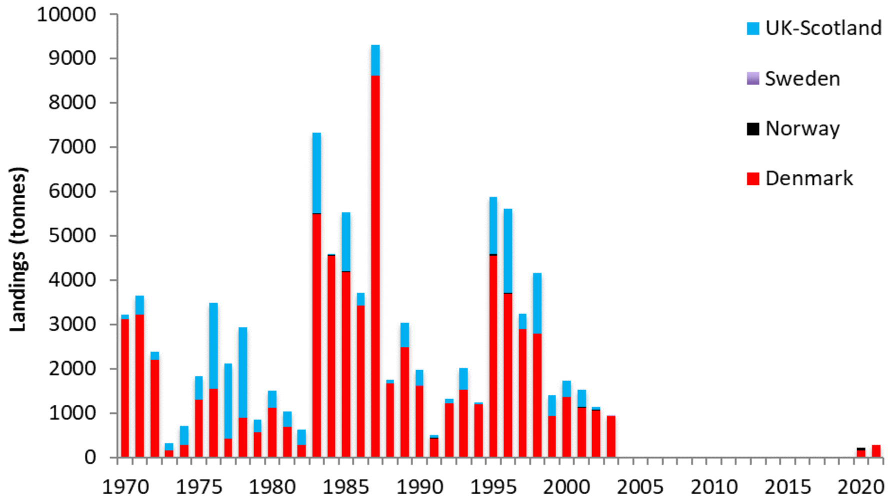

Figure 7.1. Shrimp in ICES Division 4.a West: Official landings by country, 1970-2021. The 2021-numbers are until October.

b) Input data

i) Commercial fishery data

The Danish shrimp fishery on Fladen Ground took place mainly from 1987 to 2003. Since 2004, only sporadic targeted fishery has taken place, 1 ton in 2014, 13 tons in 2015 and 24 tons in 2021. In recent years, the largest volumes of shrimp are by-caught in other small-meshed trawl fisheries such as the fishery for Norway pout. Especially in 2020 and 2021, total Danish shrimp bycatches were substantial, resembling the values experienced during the primary period of the targeted shrimp fishery in the 1990s. For the targeted Danish shrimp fishery on Fladen Ground (codend mesh size 32-69 mm) a landings-per-unit-effort (LPUE) time series has been calculated by dividing the total annual landings with the total annual kilowatt days in the fishery (Fig. 7.2). This index of stock size shows that in the three years with a significant targeted fishery since the minimum of the time series (and the stop of the fishery) in 2004, the LPUE values have been increasing, and in 2021, the value approaches the overall mean of the time series.

The Danish Norway pout landings from Fladen Ground have been sampled in harbour by the Danish Control Agency since 1989 to estimate total species composition in weight. The data cover the period from 1989 to April 2020, except for 2005 and 2007 when there was no quota and therefore no fishery. In April 2020, a change in the bycatch monitoring of the Norway pout fishery was implemented, increasing the sampling coverage. Based on the two harbour sampling schemes for the Norway pout fishery, two shrimp bycatch indices have been defined. Index #1 covers the period from 1989 to 30th of April 2020, and Index #2 covers the later period until October 2021. Index #1 is based on all industrial samples from the Norway pout fishery from the approximately 20 ICES squares which make up the distributional area of the Fladen Ground shrimp stock, whereas Index #2 is based on data from the same fishery, but for the full (slightly larger) area of the Fladen Ground Norway pout fishing grounds. The by-catch percentage was calculated as an average over all samples from a given year and plotted in the same figure (Fig. 7.2), demonstrating that the two 2020 values were almost identical (adding confidence to the comparability of the two-time series) and that the bycatch percentage increased substantially in 2020 and 2021, approaching the highest levels of the time series (values from the mid-1990s). The trend in the bycatch time series aligns with the trend in the LPUE index from the targeted shrimp fishery and supports the perception of the shrimp stock biomass having increased in recent years.

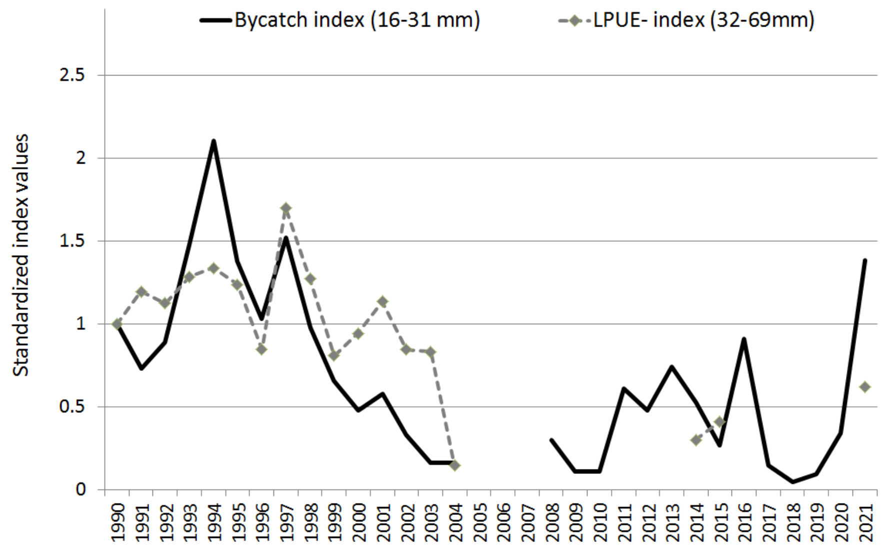

Figure 7.2. Shrimp in ICES Division 4.a West: time series of two stock size indices; one based on harbour sampling of bycatch in the Danish small meshed trawl fishery for Norway pout (codend mesh size 16-31 mm) and one based on landings and effort (LPUE) in the targeted Danish shrimp fishery. Index values are standardized to the first year of the time series (1990). The time series spans a change in the harbour sampling scheme in 2020, which is not assessed to have biased the subsequent estimates of the bycatch index (SCR Doc. 21/046).

ii) Research survey data

Abundance and density. A trawl survey for shrimp in Skagerrak and the Norwegian Deep (ICES Divisions 3.a and 4.a East) has since 1984 been conducted annually by the Norwegian Institute of Marine Research (IMR) with the objective of assessing the distribution, biomass, abundance and length distribution of the shrimp stock (Søvik and Thangstad 2021). In the late 1980s and early 1990s, IMR surveyed also the shrimp stock on the Fladen Ground. A total of seven cruises were conducted in October/November, as part of the first time series from 1984-2002 using R/V Michael Sars and the Campelen-trawl. No scientific survey has covered the shrimp stock on Fladen Ground since the mid-1990s. However, as recent bycatches of shrimp in the Danish and Norwegian Norway pout fisheries have indicated increasing densities of shrimp on the Fladen Ground, a cruise was again conducted by IMR, in January 2021. The timing of the annual shrimp survey shifted to the 1st quarter in 2006 (Søvik and Thangstad 2021). There have also been changes in the vessel used, but the gear is still the standard Campelen-trawl.

The high abundance of shrimp on the Fladen Ground perceived from the fisheries data was confirmed by the 2021-survey. In fact, the two highest trawl catches of shrimp (157 and 342 kg, in 30 minutes tows) in the whole 2021 survey were taken on Fladen Ground (Fig. 7.3). Mean abundance in 2021 was considerably higher compared with the time series 1986-1994, mainly due to the two high trawl catches, while the median was on the same level as the earlier years (Fig. 7.4). The same pattern is seen for the density of shrimp (kg per trawled nautical mile).

Recruitment. The Fladen Ground stock in the first quarter consists mainly of three year-classes (Fig. 7.5) (2021-plot). The size of the 1-group in 2021 was relatively large, indicating good recruitment to the stock in the near future. This age group has already recruited to the fishable biomass (second half of 2021). Length frequency distributions from the 1980s and 1990s indicate that the shrimp stock in the fourth quarter consists mainly of two age groups, the 1- and 2-year old shrimp. The 0-group is visible in some of the plots. The exception is the length distribution from 1986, showing 4-5 age groups with shrimp up to 30 mm carapace length.

Due to fast growth, the Fladen Ground shrimp stock is dependent on frequently good year classes to sustain high densities. It should be noted that recruitment to the neighboring stock Skagerrak and the Norwegian Deep has been low for many years (NAFO/ICES 2020). However, stock dynamics might be different on the Fladen Ground compared with in the Norwegian Deep and Skagerrak (SCR Doc. 21/046). Results from genetic investigations suggest two separate populations (Knutsen et al. 2015).

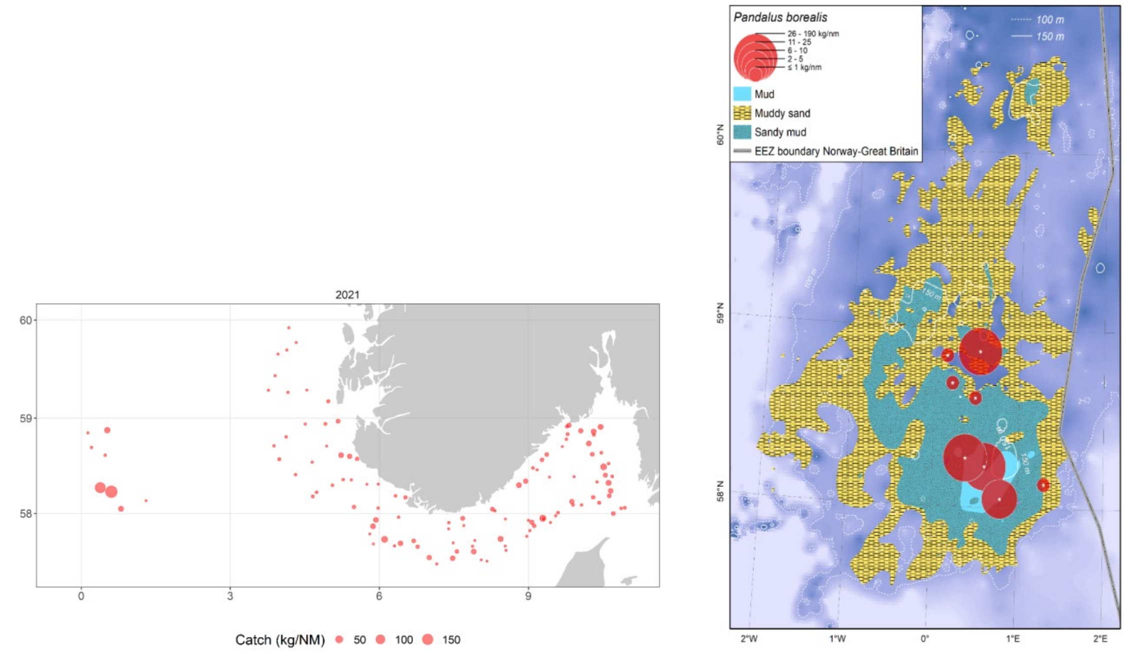

Figure 7.3. Shrimp in ICES Division 4.a west: i) the left-hand panel shows the distribution and size of trawl catches on the full IMR annual shrimp survey (both the Fladen and the Skagerrak and Norwegian Deep stocks) in January 2021, and ii) the right-hand figure shows the distribution of trawl catches on Fladen grad overlaid with sediment information, where the muddy areas give an indication of the extent of the shrimp stock.

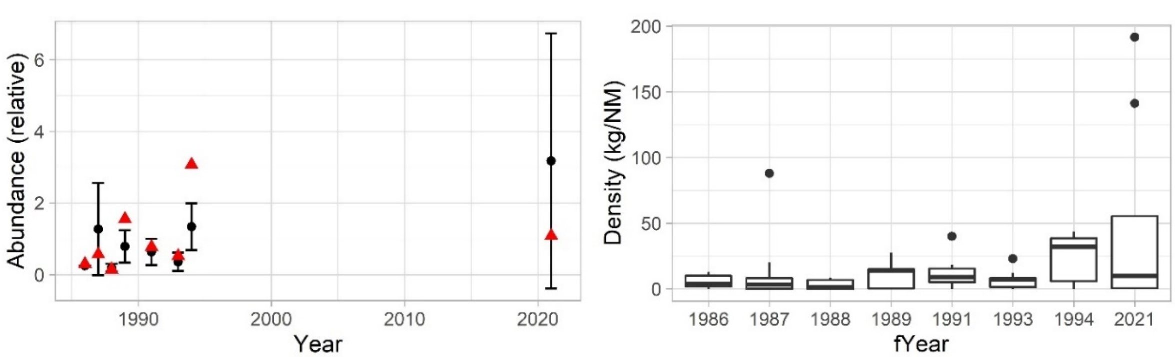

Figure 7.4. Shrimp in ICES Division 4.a West: Survey time series, 1986-1994 and 2021, abundance (relative index), mean ± 95 % confidence interval (black dots) and median (red triangles) (left), and density (kg/nm) (right), boxplot showing median (bold line), first and third quartiles (hinges, the 25th and 75th percentiles), and whiskers spanning 1.5 times the inter-quantile range above and below the hinges. Dots indicate outliers outside of the inter-quantile range.

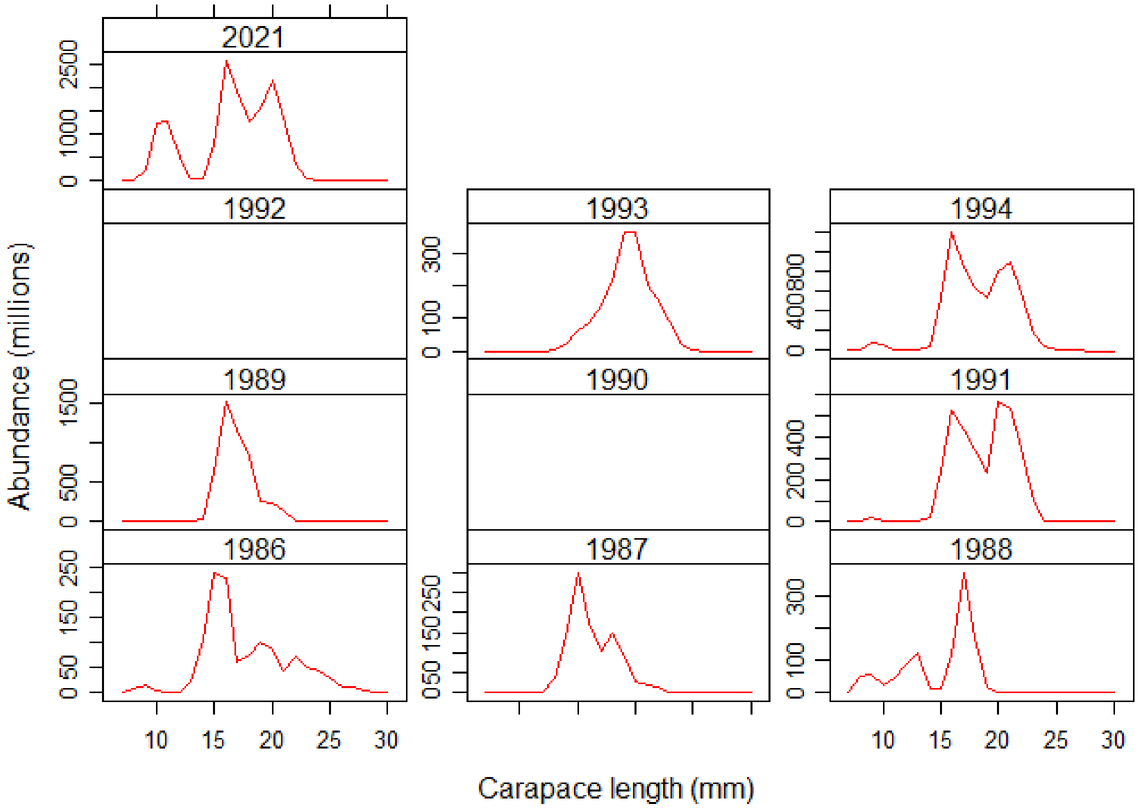

Figure 7.5. Shrimp in ICES Division 4.a West: Length frequency distributions from the annual IMR surveys in October/November 1986-1994 (no surveys in 1990 and 1992), and in January 2021. Note different y-axes.

c) Assessment

New information and analyses of historical data have substantially improved the knowledge basis for assessing the stock status of the Fladen Ground shrimp stock. Overall, the different sources of new information; Norwegian survey data, a new Danish LPUE-index and a new Danish bycatch-based stock index, all indicate that the shrimp stock on Fladen Ground has increased since 2018 and likely is at a relatively high level.

A Danish observer and self-sampling program for the targeted shrimp fishery was initiated in 2021, which provided biological data of the stock (weight, length, and sex). If a commercial shrimp fishery is continued on Fladen Ground, these 2021 data may form the start of a new commercially-based time series that together with biological data from the Norwegian survey may enable a full analytical assessment of the stock. Due to likely irregular visits to Fladen Ground by the annual IMR shrimp survey an analytical assessment will have to be based mainly on fishery data.

Reference points. There are no reference points defined for this stock.

Stock size and fishing mortality. Stock size is likely at a relative high level and fishing mortality at a relatively low level.

Projections. There are no projections for this stock.

d) Additional considerations

Environmental conditions*.* The Fladen Ground is a rather shallow area with depths between 100 and 150 m. The area of suitable muddy shrimp habitat is limited and surrounded by sandy bottom.

Temperature. Measurements of bottom temperature in January 2021 at the annual Norwegian shrimp survey gave values between 7.9 and 8.2 ^{0}C, indicating warm bottom water.

e) State of the stock

State of the Stock. The state of the stock relative to reference points is unknown. However, new information from the fisheries and the Norwegian shrimp survey indicate that the stock size has increased since 2018 and presently is at a relatively high level.

f) Research recommendations

NIPAG **recommends** that a trial fishery including compulsory sampling of catches is initiated on the Fladen Ground.

References

Eigaard, O.R. and Søvik, G. 2021. New data and information on the northern shrimp (Pandalus borealis) stock in Division 4.a west. NAFO SCR Doc. 21/046, Serial No. N7245. 11pp. https://www.nafo.int/Portals/0/PDFs/sc/2021/scr21-046.pdf

(Northern North Sea, Fladen Ground)

ICES. 2019. ICES Advice 2019 – pra.27.4a – https://doi.org/10.17895/ices.advice.5704

Knutsen, H., Jorde, P. E., Gonzalez, E. B., Eigaard, O. R., Pereyra, R. T., Sannæs, H., Dahl, M., Andre, C., & Søvik, G. 2015. Does population genetic structure support present management regulations of the northern shrimp (Pandalus borealis) in Skagerrak and the North Sea? ICES Journal of Marine Science, 72(3), 863-871. https://doi.org/10.1093/icesjms/fsu204

NAFO/ICES. 2020. Report of the NAFO/ICES Pandalus Assessment Group Meeting, 26 - 30 October 2020, WebEx. NAFO SCS Doc. 20/21.

Søvik, G. and Thangstad, T. 2021. Results of the Norwegian Bottom Trawl Survey for Northern Shrimp (Pandalus borealis) in Skagerrak and the Norwegian Deep (ICES Divisions 3.a and 4.a east) in 2021. NAFO SCR Doc. 21/001, Serial No. N7157. 38 pp. https://www.nafo.int/Portals/0/PDFs/sc/2021/scr21-001.pdf

IV. Other matters

a) Date and place for the next NIPAG meeting

As agreed at the 2018 meeting, NIPAG reassessed the timing of meetings in view of differing requirements for timing of advice and availability of survey data. The main considerations were as follows:

- *In future years, advice for the Barents Sea stock will be required by late summer to accommodate the Norway/Russia Fisheries Commission meeting which takes place in October. It would be preferable to have the meeting in late November to allow inclusion of autumn survey data but, if the meeting is held earlier, it would be possible to do an update before Norway/Russia Commission meeting.*
- *The timing of the East Greenland survey in future years is uncertain but could most likely be in the summer. The West Greenland survey will be June/July, as usual.*
- *The Skagerrak stock will continue to be assessed during February/March. This will be considered as a full NIPAG meeting, and meeting times will be arranged to allow full participation in North American time zones.*
- *As in the last two years, the NAFO Commission will require advice for the NAFO 3M stock to be available for their Annual Meeting in September. The EU Flemish Cap survey will be completed in late July but, due to the time taken for the vessel to return to Spain and the summer holiday season, it is not expected that the data would be available before the end of August.*

In view of the experience gained in holding meetings by WebEx during the current pandemic, the group considered the possibility of conducting the majority of future meetings by WebEx, which would allow the possibility that multiple meetings could be held at different times of year. Under this option, full face to face would only occur every two or three years. Most NIPAG members considered it preferable to maintain the current arrangement of holding annual face to face meeting with additional meetings for stock that cannot be accommodated within the normal schedule. This allows for more thorough peer review than could be achieved through WebEx meetings.

It was agreed that the main 2022 NIPAG meeting will be held 12-17 September in Copenhagen. It will be necessary to assess the 3M stock early in the meeting to allow the advice to be ready well in advance of the NAFO Annual Meeting.

There will be an additional NIPAG meeting by Webex in November, if required, to assess stocks not covered in the September meeting.

Table IV.1 Timing of key events relevant to the timing of *Pandalus* assessments currently done under NIPAG.

Management Unit	Management Cycle	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	*Potential* Assessment Window
3LNO	Jan 1 - Dec 31													Mar-Sep
3M	Jan 1 - Dec 31													Aug-Sep
West Greenland (Div 0A + SA1)	Jan 1 - Dec 31													Sep-Oct
East Greenland + Denmark St	Jan 1 - Dec 31													Sep-Oct
Barents Sea	Jan 1 - Dec 31													Aug-Oct
Skaggerak & Norwegian Deep	Jan 1 - Dec 31													Feb-Mar
Fladen Ground	Jan 1 - Dec 31													Aug-Oct

Legend

- Survey Data Available
- Logbook Data Available
- Assessment Preparation Complete
- Advice is required
- TAC Decision

Table IV.2. Advice Schedule for NIPAG shrimp stocks

	November 2021	March 2022	September 2022	November 2022	March 2023	September 2023 WebEx	November 2023
3M	Produce Advice for 2022-23		Interim monitoring Report			Produce Advice for 2024-25	provisional advice 2025
3LNO	interim monitoring report		produce advice for 2020 and 2021	interim monitoring report		update if required	provisional advice 2022 and 2023
Skagerrak and Norwegian Deep	provisional advice for 1st half 2019	full advice for 2019, provisional advice 1st half 2020		review	full advice for 2020, provisio nal advice 1st half 2021		review
Fladen Ground	Full Advice			Full Advice			Full Advice
West Greenland	Full Advice (subject to requests from Greenland and Canada)			Full Advice (subject to requests from Greenland and Canada)			Full Advice (subject to requests from Greenland and Canada)
Denmark strait and East Greenland	Full Advice (subject to requests from Greenland)			Full Advice (subject to requests from Greenland)			Full Advice (subject to requests from Greenland)
Barents Sea	Full Advice			Full Advice			Full Advice

V. Adjournment

The NIPAG meeting was adjourned at 1300 hours on 4 November 2021. The Chair thanked all participants, especially the designated experts and stock coordinators, for their hard work. The Chair thanked the NAFO and ICES Secretariats for all of their logistical support. The report was adopted at the close of the meeting, subject to editorial changes.

APPENDIX I. AGENDA NAFO/ICES *PANDALUS* ASSESSMENT GROUP

By WebEx

1 to 4 November 2021

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

I. Opening (chairs Mark Simpson)

1. Appointment of Rapporteur
2. Adoption of Agenda
3. Plan of Work

II. General Review

1. Review of Recommendations in 2020
2. Review of Catches

III. Stock Assessments

- *Northern shrimp (NAFO Division 3M) (review of assessment September 2021)*
- *Northern Shrimp (NAFO Divisions 3LNO) (review of assessment September 2021)*
- *Northern shrimp (NAFO Subareas 0 and 1) (full assessment)*
- *Northern shrimp (in Denmark Strait and off East Greenland) (full assessment)*
- *Northern shrimp in the Skagerrak and Norwegian Deep (ICES Subdivision 27.3a.20 and the eastern part of Division 27.4a) (review of assessment February 2021)*
- *Northern Shrimp in Barents Sea and Svalbard area (ICES Sub-areas I & II) (full assessment)*
- *Northern shrimp in Fladen Ground (ICES Division IVa) (full assessment)*

IV. Other Business

1. FIRMS Classification for NAFO Shrimp Stocks
2. Benchmark planning
3. Scheduling of future meetings

V. Adjournment

ANNEX 1. COMMISSION'S REQUEST FOR SCIENTIFIC ADVICE ON MANAGEMENT IN 2022 AND BEYOND OF CERTAIN STOCKS IN SUBAREAS 2, 3 AND 4 AND OTHER MATTERS

(COM Doc. 20-16)

Following a request from the Scientific Council, the Commission agreed that items 1, 2, 8 and 11 should be the priority for the June 2021 Scientific Council meeting subject to resources and COVID-related restrictions.

1. The Commission requests that the Scientific Council provide advice for the management of the fish stocks below according to the assessment frequency presented below. In keeping with the NAFO Precautionary Approach Framework (FC Doc. 04-18), the advice should be provided as a range of management options and a risk analysis for each option without a single TAC recommendation. The Commission will decide upon the acceptable risk level in the context of the entirety of the SC advice for each stock guided and as foreseen by the Precautionary Approach.

Yearly basis	Two-year basis	Three-year basis
Cod in Div. 3M Northern shrimp in Div. 3M	Redfish in Div. 3M Northern shrimp in Div. 3LNO Thorny skate in Div. 3LNO Witch flounder in Div. 3NO Redfish in Div. 3LN White hake in Div. 3NO	American Plaice in Div. 3LNO American Plaice in Div. 3M Capelin in Div. 3NO Northern shortfin squid in SA 3+4 Redfish in Div. 3O Yellowtail flounder in Div. 3LNO Cod in Div. 3NO

To implement this schedule of assessments, the Scientific Council is requested to conduct a full assessment of these stocks as follows:

In 2021, advice should be provided for 2022 for Cod in Div. 3M and Northern shrimp in Div. 3M. With respect to Northern shrimp in Div. 3M, SC is requested to provide its advice to the Commission prior to the 2021 Annual Meeting based on the survey data up to and including 2021.

In 2021, advice should be provided for 2022 and 2023 for: Redfish in Div. 3M, Northern shrimp in Div. 3LNO, and White hake in Div. 3NO

In 2021, advice should be provided for 2022, 2023 and 2024 for: American plaice in Div. 3LNO, Capelin in Div. 3NO, Cod in Div. 3NO, Yellowtail flounder in Div. 3LNO

Advice should be provided using the guidance provided in **Annexes A or B as appropriate** or using the predetermined Harvest Control Rules in the cases where they exist (currently Greenland halibut 2+3KLMNO).

The Commission also requests the Scientific Council to continue to monitor the status of all other stocks annually and, should a significant change be observed in stock status (e.g. from surveys) or in bycatch in other fisheries, provide updated advice as appropriate.

2. The Commission requests the Scientific Council to monitor the status of Greenland halibut in Subarea 2+Div. 3KLMNO annually to compute the TAC using the agreed HCR and determine whether exceptional circumstances are occurring. If exceptional circumstances are occurring, the exceptional circumstances protocol will provide guidance on what steps should be taken.

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

4. The Commission requests the Scientific Council to implement the steps of the Action plan relevant to the Scientific Council and in particular the tasks identified under section 2.2 of the Action Plan, for progression in the management and minimization of Bycatch and discards (COM Doc. 17-26).

   - Tasks outlined in Tasks 3.1 and 3.2 of the NAFO Action Plan in the Management and Minimization of Bycatch and Discards (COM Doc. 17-26).

5. The Commission requests that Scientific Council continue to refine work on the Ecosystem Road Map:

   - Continue to test the reliability of the ecosystem production potential model and other related models

   - Report on these results to WG-EAFFM and WG-RBMS to further develop how it may apply to management decisions

   - Develop options of how ecosystem advice could inform management decisions, an issue which is directly linked to the results of the foreseen EAFM roadmap workshop.

   - Continue its work to develop models that support implementation of Tier 2 of the EAFM Roadmap."

6. The Commission requests that the Scientific Council, in preparation of the re-assessment of NAFO bottom fisheries in 2021 and discussion on VME fishery closures:

   - Assess the overlap of NAFO fisheries with VME to evaluate fishery specific impacts in addition to the cumulative impacts for NRA fisheries;

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

   - Maintain efforts to assess all of the six FAO criteria including the three FAO functional SAI criteria which could not be evaluated in the current assessment.

   - Provide input and analysis of potential management options, with the goal of supporting meaningful and effective discussions between scientists and managers at the 2021 WG-EAFFM meeting;

   - Continue to work on the VME indicator species as listed in Annex IE, Section VI to prepare for the next assessment.

7. The Commission requests that the Scientific Council review the proposed revisions to Annex I.E, Part VI as reflected in COM-SC EAFFM-WP 18-01, for consistency with the taxa list annexed to the VME guide and recommend updates as necessary.

8. The Commission requests the Scientific Council to continue progression on the review of the NAFO PA Framework in accordance to the PAF review work plan approved in 2020 (NAFO COM-SC Doc. 20-04)

9. The Commission requests that the Scientific Council Work with WG- BDS to identify areas and times where bycatch and discards of Greenland sharks have a higher rate of occurrence in time for consideration by the Commission in 2021 to inform the development of measures to reduce bycatch in the NRA.

10. The Commission requests the Scientific Council to continue to develop a 3-5 year work plan, which reflects requests arising from the 2020 Annual Meeting, other multi-year stock assessments and other scientific inquiries already planned for the near future. The work plan should identify what resources are necessary to successfully address these issues, gaps in current resources to meet those needs and proposed prioritization by the Scientific Council of upcoming work based on those gaps.

11. The Commission requests that the Scientific Council, carry out a scoping exercise to provide guidance to the WG-RBMS on the process of conducting of a full review/evaluation of the management strategy of Div. 3LN redfish.

12. The Commission requests the Scientific Council review submitted protocols for a survey methodology to inform the assessment of Splendid Alfonsino. The Scientific Council to report on the outcome of this work at next Commission annual meeting.

13. The Commission requests that results from stock assessments and the scientific advice of Cod 2J3KL (Canada), Witch 2J3KL (Canada) and Pelagic Sebastes mentella (ICES Divisions V, XII and XIV; NAFO 1) to be presented to the Scientific Council (SC), and request the SC to prepare a summary of these assessments to be included in its annual report.

14. The Commission requests the Scientific Council, jointly with the Secretariat, to conduct ongoing analysis of the Flemish Cap cod fishery data by 2022 in order to:

    (1) monitor the consequences of the management decisions (including the analysis of the redistribution of the fishing effort along the year and its potential effects on ecosystems, the variation of the cod catch composition in lengths/ages, and the bycatch levels of other fish species, benthos in general, and VME taxa in particular), and
    (2) carry out any additional monitoring that would be required, including Div. 3M cod caught as bycatch in other fisheries during the closed period.

15. The Commission requests the Scientific Council, in its future work, to consider whether other measures, such as depth restrictions, spatial and mesh changes, could reduce the catch of juvenile and immature cod across all fisheries in 3M.

16. The Commission requests the Scientific Council to continue to monitor and provide updates resulting from relevant research related to the potential impact of activities other than fishing in the Convention Area. Further, that the Secretariat and the Scientific Council work with other international organizations, such as the FAO and ICES, to bring in additional expertise to inform the Scientific Council's work.

17. The Commission requests the Scientific Council to provide information to the Commission at its next annual meeting on sea turtles, sea birds, and marine mammals that are present in NAFO Regulatory Area based on available data.

18. The Commission requests that the Scientific Council proceed with developing the ecosystem summary sheets for 3M and 3LNO move toward undertaking a joint Workshop with ICES (International Council for the Exploration of the Sea) as part of a peer review of North Atlantic ecosystems.

ANNEX A: Guidance for providing advice on Stocks Assessed with an Analytical Model

The Commission requests 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}, 90% F_{msy},95% F_{msy}, F_{msy} 0.75 X $F_{status\ quo}$, $F_{status\ qu}$,1.25 X Status quo, F=0; TAC Status quo, 85% TAC Status quo, 90% TAC Status quo, 95% TAC Status quo
- For stocks under a moratorium to direct fishing: $F_{status\ quo}$, 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(B2024 > B2020)
F in 2022 and following years*	Yield 2022 (50%)	Yield 2023 (50%)	Yield 2024 (50%)	2022	2023	2024	2022	2023	2024		2022	2023	2024	2022	2023	2024		
2/3 Fmsy	t	t	t	%	%	%	%	%	%		%	%	%	%	%	%		%
3/4 Fmsy	t	t	t	%	%	%	%	%	%		%	%	%	%	%	%		%
85% Fmsy	t	t	t	%	%	%	%	%	%		%	%	%	%	%	%		%
90% Fmsy																		
95% Fmsy																		
Fmsy	t	t	t	%	%	%	%	%	%		%	%	%	%	%	%		%
0.75 X Fstatus quo	t	t	t	%	%	%	%	%	%		%	%	%	%	%	%		%
Fstatus quo	t	t	t	%	%	%	%	%	%		%	%	%	%	%	%		%
1.25 X Status quo	t	t	t	%	%	%	%	%	%		%	%	%	%	%	%		%
F=0	t	t	t	%	%	%	%	%	%		%	%	%	%	%	%		%
TAC Status quo																		
85% TAC Status quo																		
90% TAC Status quo																		
95% TAC Status quo																		

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% $F_{status\ quo}$, $F_{status\ quo}$, 125% $F_{status\ quo}$,
- For stocks under a moratorium to direct fishing: $F_{status\ quo}$, F = 0.

The first year of the projection should assume a catch equal to the agreed TAC for that year. Results from stochastic short-term projection should include:

- The 10%, 50% and 90% percentiles of the yield, total biomass, spawning stock biomass and exploitable biomass for each year of the projections
- The risks of stock population parameters increasing above or falling below available biomass and fishing mortality reference points. The table indicated below should guide the Scientific Council in presenting the short-term projections.

				Limit reference points														
				P(F.>F_{lim})			P(B<B_{lim})				P(F>F0.1)			P(F>F_{max})				P(B2024 > B2020)
F in 2022 and following years*	Yield 2022	Yield 2023	Yield 2024	2022	2023	2024	2022	2023	2024		2022	2023	2024	2022	2023	2024		
F0.1	t	t	t	%	%	%	%	%	%		%	%	%	%	%	%		%
F_{max}	t	t	t	%	%	%	%	%	%		%	%	%	%	%	%		%
66% F_{max}	t	t	t	%	%	%	%	%	%		%	%	%	%	%	%		%
75% F_{max}	t	t	t	%	%	%	%	%	%		%	%	%	%	%	%		%
85% F_{max}	t	t	t	%	%	%	%	%	%		%	%	%	%	%	%		%
0.75 X F_{2018}	t	t	t	%	%	%	%	%	%		%	%	%	%	%	%		%
F_{2018}	t	t	t	%	%	%	%	%	%		%	%	%	%	%	%		%
1.25 X F_{2018}	t	t	t	%	%	%	%	%	%		%	%	%	%	%	%		%

ANNEX B. Guidance for providing advice on Stocks Assessed without a Population Model

For those resources for which only general biological and/or catch data are available, few standard criteria exist on which to base advice. The stock status should be evaluated in the context of management requirements for long-term sustainability and the advice provided should be consistent with the precautionary approach.

The following graphs should be presented, for one or several surveys, for the longest time-period possible:

a. *time trends of survey abundance estimates*
b. *an age or size range chosen to represent the spawning population*
c. *an age or size-range chosen to represent the exploited population*
d. *recruitment proxy or index for an age or size-range chosen to represent the recruiting population.*
e. *fishing mortality proxy, such as the ratio of reported commercial catches to a measure of the exploited population.*
f. *Stock trajectory against reference points*

And any information the Scientific Council deems appropriate.

ANNEX 2. DENMARK (ON BEHALF OF GREENLAND) REQUESTS FOR SCIENTIFIC ADVICE ON MANAGEMENT IN 2022 AND BEYOND OF CERTAIN STOCKS IN SUBAREA 0 AND 1.

Denmark (on behalf of Greenland) requests scientific advice on management in 2020 of Certain Stocks in NAFO Subarea 0 and 1. Denmark (on behalf of Greenland) requests the Scientific Council for advice on the following species:

1. **Golden Redfish, Demersal Deep-Sea Redfish, Atlantic Wolffish and Spotted Wolffish**
   Advice on Golden Redfish (*Sebastes marinus*), Demersal Deep-Sea Redfish (*Sebastes mentella*), Atlantic Wolffish (*Anarhichas lupus*) and Spotted Wolffish (*Anarhichas minor*) in Subarea 1 was in June 2020 given for 2021-2023. Consequently, the Scientific Council is requested to continue its monitoring of the above stocks and provide updated advice as appropriate in the event of significant changes in stock levels.

2. **Greenland Halibut, Offshore**
   Advice on Greenland Halibut, Offshore in Subareas 0 and 1 was in 2020 given for 2021 and 2022. Consequently, the Scientific Council is requested to continue its monitoring of the above stocks and provide updated advice as appropriate in the event of significant changes in stock levels. The Scientific Council is also asked to advice on any other management measures it deems appropriate to ensure the sustainability of these resources.

3. **Greenland Halibut, Inshore, West Greenland**
   Advice on Greenland Halibut in Division 1A inshore, Division 1BC inshore, Division 1D inshore and Division 1EF inshore was in 2020 given for 2021-2022. Consequently, the Scientific Council is requested to continue its monitoring of the above stocks and provide updated advice as appropriate in the event of significant changes in stock levels. The Scientific Council is also asked to advice on any other management measures it deems appropriate to ensure the sustainability of these resources.

4. **Northern Shrimp, West Greenland**
   Subject to the concurrence of Canada as regards to Subareas 0 and 1, Denmark (on behalf of Greenland) requests the Scientific Council before December 2021 to provide advice on the scientific basis for management of Northern Shrimp (*Pandalus borealis*) in Subareas 0 and 1 in 2022 in line with Greenland's stated management objective of maintaining a mortality risk of no more than 35% in the first year prediction and to provide a catch option table ranging with 5,000 t increments. Future catch options should be provided for as many years as data allows for. Furthermore, Scientific Council is requested to provide a catch level corresponding to a mortality risk of exact 35% in the first year of prediction.

5. **Northern Shrimp, East Greenland**
   Furthermore, the Scientific Council is in cooperation with ICES requested to provide advice on the scientific basis for management of Northern Shrimp (*Pandalus borealis*) in Denmark Strait and adjacent waters east of southern Greenland in 2022 and for as many years ahead as data allows for.

ANNEX 3. REQUESTS FROM CANADA FOR ADVICE ON NAMAGEMENT IN 2022 AND BEYOND

1. *Greenland halibut (Subarea 0 + 1 (offshore)*[1]

Advice on Greenland Halibut in Subareas 0 and 1 was provided in 2020 for 2021 and 2022. Canada requests that the Scientific Council monitor the status of this stock in 2021, and, should a significant change be observed in stock status (e.g. from surveys or in bycatches in other fisheries), provide updated advice as appropriate.

2. *Shrimp (Subarea 1 and Division 0A)*

Canada requests the Scientific Council to consider the following options in assessing and projecting future stock levels for Shrimp in Subarea 1 and Division 0A:

The status of the stock should be determined and risk-based advice provided for catch options corresponding to Z_{msy}, in 5,000-10,000t increments (subject to the discretion of Scientific Council), with forecasts for 2022 to 2024. These options should be evaluated in relation to Canada's Harvest Strategy (attached) and NAFO's Precautionary Approach Framework, and presented in the form of risk analyses related to B_{msy}, 80% B_{msy}, B_{lim} (30% B_{msy}) and Z_{msy}.

Presentation of the results should include graphs and/or tables related to the following:

- *Historical and current yield, biomass relative to B_{msy}, total mortality relative to Z_{msy}, and recruitment (or proxy) levels for the longest time period possible;*
- *Total mortality (Z) and fishable biomass for a range of projected catch options (as noted above) for the years 2022 to 2024. Projections should include both catch options and a range of effective cod predation biomass levels considered appropriate by the Scientific Council. Results should include risk analyses of falling below: B_{MSY}, 80% B_{msy} and B_{lim} (30% B_{msy}), and of being above Z_{msy} based on the 3-year projections, consistent with the Harvest Decision Rules in Canada's Harvest Strategy; and*
- *Total area fished for the longest time period possible.*

Please provide the advice relative to Canada's Harvest Strategy as part of the formal advice (i.e., grey box in the advice summary sheet).

[1] The Scientific Council has noted previously that there is no biological basis for conducting separate assessments for Greenland halibut throughout Subareas 0-3, but has advised that separate TACs be maintained for different areas of the distribution of Greenland halibut.

ANNEX IV. ICES TERMS OF REFERENCE FOR NIPAG

A. Generic ToRs for Regional and Species Working Groups

This resolution was approved 2 September 2021
Generic ToRs for Regional and Species Working Groups

2020/2/FRSG01 The following ToRs apply to: AFWG, HAWG, NWWG, NIPAG, WGWIDE, WGBAST, WGBFAS, WGNSSK, WGCSE, WGDEEP, WGBIE, WGEEL, WGEF, WGHANSA and WGNAS.

The working group should focus on:

a) Consider and comment on Ecosystem and Fisheries overviews where available;

b) For the aim of providing input for the Fisheries Overviews, consider and comment on the following for the fisheries relevant to the working group:

i. *descriptions of ecosystem impacts on fisheries*
ii. *descriptions of developments and recent changes to the fisheries*
iii. *mixed fisheries considerations, and*
iv. *emerging issues of relevance for management of the fisheries;*

c) Conduct an assessment on the stock(s) to be addressed in 2021 using the method (assessment, forecast or trends indicators) as described in the stock annex and produce a **brief** report of the work carried out regarding the stock, providing summaries of the following where relevant:

i. *Input data and examination of data quality; in the event of missing or inconsistent survey or catch information refer to the ACOM document for dealing with COVID-19 pandemic disruption and the linked template that formulates how deviations from the stock annex are to be reported.*
ii. *Where misreporting of catches is significant, provide qualitative and where possible quantitative information and describe the methods used to obtain the information;*
iii. *For relevant stocks (i.e., all stocks with catches in the NEAFC Regulatory Area), estimate the percentage of the total catch that has been taken in the NEAFC Regulatory Area in 2020.*
iv. *Estimate MSY reference points or proxies for the category 3 and 4 stocks*
v. *Evaluate spawning stock biomass, total stock biomass, fishing mortality, catches (projected landings and discards) using the method described in the stock annex;*
    1) *for category 1 and 2 stocks, in addition to the other relevant model diagnostics, the recommendations and decision tree formulated by WKFORBIAS (see Annex 2 of https://www.ices.dk/sites/pub/Publication%20Reports/Expert%20Group%20Report/Fisheries%20Resources%20Steering%20Group/2020/WKFORBIAS_2019.pdf) should be considered as guidance to determine whether an assessment remains sufficiently robust for providing advice.*
    2) *b. If the assessment is deemed no longer suitable as basis for advice, consider whether it is possible and feasible to resolve the issue through an interbenchmark. If this is not possible, consider providing advice using an appropriate Category 2 to 5 approach.;*

vi) The state of the stocks against relevant reference points;

Consistent with ACOM's 2020 decision, the basis for Fpa should be Fp.05.

1) *Where Fp.05 for the current set of reference points is reported in the relevant benchmark report, replace the value and basis of Fpa with the information relevant for Fp.05*
2) *Where Fp.05 for the current set of reference points is not reported in the relevant benchmark report, compute the Fp.05 that is consistent with the current set of reference points and use as Fpa. A review/audit of the computations will be organized.*
3) *Where Fp.05 for the current set of reference points is not reported and cannot be computed, retain the existing basis for Fpa.*

vii) Catch scenarios for the year(s) beyond the terminal year of the data for the stocks for which ICES has been requested to provide advice on fishing opportunities;

viii) Historical and analytical performance of the assessment and catch options with a succinct description of associated quality issues. For the analytical performance of category 1 and 2 age-structured assessments, report the mean Mohn's rho (assessment retrospective bias analysis) values for time series of recruitment, spawning stock biomass, and fishing mortality rate. The WG report should include a plot of this retrospective analysis. The values should be calculated in accordance with the "Guidance for completing ToR viii) of the Generic ToRs for Regional and Species Working Groups - Retrospective bias in assessment" and reported using the ICES application for this purpose.

d) Produce a first draft of the advice on the stocks under considerations according to ACOM guidelines.

i. In the section 'Basis for the assessment' under input data match the survey names with the relevant "SurveyCode" listed ICES survey naming convention (restricted access) and add the "SurveyCode" to the advice sheet.

e) Review progress on benchmark issues and processes of relevance to the Expert Group.

i. update the benchmark issues lists for the individual stocks;
ii. review progress on benchmark issues and identify potential benchmarks to be initiated in 2022 for conclusion in 2023;
iii. determine the prioritization score for benchmarks proposed for 2022–2023;
iv. as necessary, document generic issues to be addressed by the Benchmark Oversight Group (BOG)

f) Prepare the data calls for the next year's update assessment and for planned data evaluation workshops;

g) Identify research needs of relevance to the work of the Expert Group.

h) Review and update information regarding operational issues and research priorities on the Fisheries Resources Steering Group SharePoint site.

i) If not completed in 2020, complete the audit spread sheet 'Monitor and alert for changes in ecosystem/fisheries productivity' for the new assessments and data used for the stocks. Also note in the benchmark report how productivity, species interactions, habitat and distributional changes, including those related to climate-change, could be considered in the advice.

B. NIPAG – Joint NAFO/ICES *Pandalus* Assessment Working Group 2020

NIPAG – Joint NAFO/ICES Pandalus Assessment Working Group

This resolution was approved 3 November 2020

2020/2/FRSG04 The Joint NAFO/ICES Pandalus Assessment Working Group (NIPAG), chaired by Ole Ritzau Eigaard, Denmark (ICES) and Brian Healey, Canada (NAFO), will meet by correspondence, 25–26 February 2021, to:

a) Address generic ToRs for Regional and Species Working Groups for Northern shrimp in divisions 3.a and 4.a East stock.

NIPAG will report by 5 March 2021 for the attention of ACOM.

APPENDIX IV. RELEVANT RECOMMENDATIONS FROM 2019 AND 2020

- *Northern Shrimp in Division 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. This recommendation is **reiterated**.*
- *NIPAG **recommends** 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.*
- *NIPAG **recommends** 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.*
- *Northern Shrimp in Divisions 3NLO*
- *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. This recommendationis **reiterated**.*
- *NIPAG **recommended** in 2018 that further work on the development of a recruitment index for Div. 3LNO be completed. This recommendation is **reiterated**.*
- *NIPAG **recommends in 2018** that further work on the development of a recruitment index for Div. 3LNO be completed. This recommendation is **reiterated**.*
- *Northern shrimp (Pandalus borealis) off West Greenland (NAFO Subarea 0 And Subarea 1)*
- *NIPAG recommended in 2018 that random sampling of the catches be conducted to provide catch composition data to the assessment. This recommendation is reiterated.*
- *NIPAG recommends that diagnostics of the model should be further explored.*
- *Northern shrimp (Pandalus borealis) In the Denmark Strait and off East Greenland (ICES Divisions XIVb and Va)*
- *NIPAG **recommends** in 2020 that: further model exploration should be carried out, including adding risk levels for different catch projection scenarios.*
- *Northern shrimp (Pandalus borealis) in the Skagerrak and Norwegian Deep (ICES Divisions IIIa and IVa East)*
- *NIPAG **recommended** in 2010-2014 that: differences in recruitment and stock abundance between Skagerrak and the Norwegian Deep should be explored. This recommendation is **reiterated.** This issue will be addressed at the 2022 benchmark.*
- *NIPAG **recommended** in 2016 that: a full benchmark for this stock, including a data compilation workshop, be conducted in the near future and no later than 2020. This recommendation is **reiterated**. Benchmark is planned for 2021/2022.*
- *Northern shrimp (Pandalus borealis) in the Barents Sea (ICES Subareas I and II)*
- *The assessment procedure used has been in place since 2006 and in 2016 NIPAG **recommended** that it be considered for a benchmark workshop in near future, no later than 2019. This recommendation is **reiterated***
- *The fishery has expanded since 2014 and catches by countries other than Norway have increased to account for about 65% of the total. In 2016, NIPAG therefore **recommended** that available data (logbook data and catch samples) from the participating nations be made available to NIPAG. This recommendation is **reiterated**.*
- *In 2017, NIPAG **recommended** that a recruitment index should be developed for this stock. This recommendation is **reiterated**.*
- *In 2017, NIPAG **recommended** that the information regarding catch effort and bycatch from the Estonian commercial fishery should be further analysed e.g. CPUE data explored as a potential index of biomass. This recommendation is **reiterated**.*

APPENDIX V. DESIGNATED EXPERTS FOR PRELIMINARY ASSESSMENT OF CERTAIN NAFO STOCKS

The following is the list of Designated Experts for 2020 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.skanes@dfo-mpo.gc.ca

From the Instituto Español de Oceanografia, Aptdo 1552, E-36200 Vigo (Pontevedra), Spain

Shrimp in Division 3M	Jose Miguel Casas Sanchez	Tel: +34 986 49 2111	mikel.casas@ieo.es

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 21/001	N7157	G. Søvik and T. H. Thangstad	Results of the Norwegian Bottom Trawl Survey for Northern Shrimp (*Pandalus borealis*) in Skagerrak and the Norwegian Deep (ICES Divisions 3.a and 4.a East) in 2021
SCR 21/040	N7238	Burmeister and Rigét	The Fishery for Northern Shrimp (Pandalus borealis) off West Greenland, 1970–2020
SCR 21/041	N7239	Burmeister	Catch Table Update for the West Greenland Shrimp Fishery
SCR 21/042	N7240	Burmeister and Rigét	A provisional Assessment of the shrimp stock off West Greenland in 2020
SCR 21/043	N7241	Buch, Burmeister and Rigét	The Fishery for Northern Shrimp (Pandalus borealis) in Denmark Strait / off East Greenland 1978 – 2020
SCR 21/044	N7242	Rigét, Burmeister and Buch	Applying a stochastic surplus production model (SPiCT) to the East Greenland Stock of Northern Shrimp
SCR 21/046	N7245	Ole Ritzau Eigaard and Guldborg Søvik	New data and information on the northern shrimp (Pandalus borealis) stock in Division 4.a West (Northern North Sea, Fladen Ground)
SCR 21/052	N7255	S. Bakanev	Russian fishery for the northern shrimp (Pandalus borealis) in the Barents Sea in 2000-2021

SCS Document			
Doc No.	**Serial No**	**Author**	**Title**
SCS 21-17	N7249	NAFO	Report of the Scientific Council Meeting 20–24 September 2021
SCS 21-18	N7237	NAFO	Report of the NAFO/ICES Pandalus Assessment Meeting 08–09 September 2021
SCS 21-19	N7250	NAFO	Report of the NAFO/ICES Pandalus Assessment Group Meeting 01-04 November 2021
SCS 21-20	N7251	NAFO	Report of the Scientific Council (in conjunction with NIPAG) Meeting 01-04 November 2021

APPENDIX II. LIST OF PARTICIPANTS, 1 - 4 NOVEMBER 2021

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