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, 17 to 22 October 2018

NAFO Secretariat, Dartmouth, Canada

THIS REPORT IS NOT TO BE CITED WITHOUT PRIOR REFERENCE

TO THE NAFO OR ICES SECRETARIATS

NAFO/ICES *Pandalus* Assessment Group Meeting
NIPAG 17-22 October 2018

Contents

NIPAG Participants 2018

Back Row: Tom Blasdale, Antoine Balazuc, Kalvi Hubel, Carsten Hvingel, Frank Rigét

Front Row: Guldborg Søvik, AnnDorte Burmeister, Susan Thompson, Brian Healey, Dayna Bell MacCallum

Report of the NIPAG Meeting

17-22 October 2018

Co-Chairs: Brian Healey, Guldborg Søvik. Rapporteur: Tom Blasdale

I. OPENING

The NAFO/ICES *Pandalus* Assessment Group (NIPAG) met at the NAFO Secretariat, Dartmouth, Canada from 17 to 22 October 2018 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 (Estonia), and Norway. The NAFO Scientific Council Coordinator and Scientific Information Administrator were also in attendance.

II. GENERAL REVIEW

1. Review of Research Recommendations in 2017

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

2. Review of Catches

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

III. STOCK ASSESSMENTS

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

(SCR Docs. 18-062, 18-064)

Environmental Overview

Recent Conditions in Ocean Climate and Lower Trophic Levels

- Ocean climate composite index in SA3 – Flemish Cap continue to remain below normal since 2014. The large negative anomalies observed in 2014-2016 are comparable with the previous cold period during the early-mid 1990's. Conditions moderated significantly in 2017.
- Total production of the spring bloom (magnitude) on the Flemish Cap has remained below normal in 2017 for a third consecutive year. The timing of the spring bloom was delayed in 2017 transitioning from predominately early onset since 2012 compared to the reference period.
- The zooplankton abundance index has remained above normal since 2010 but biomass was below normal for a third consecutive year since a record-low observed in 2015.

a) Introduction

The shrimp fishery in Div. 3M is now under moratorium. This fishery began in 1993. Initial catch rates were favorable and, shortly thereafter, vessels from several nations joined. Catches peaked at over 60 000 t in 2003 and declined thereafter (Fig 1.1).

Fishery and catches: A moratorium was imposed in 2011. Catches are expected to be close to zero in 2018. Recent catches (tonnes) were as follows (ndf=no directed fishery):

	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
NIPAG	5000	2000	0	0	0	0	0	0	0	0[1]
STATLANT 21	5374	1976	0	0	0	0	0	0	0	
SC Recommended Catches	18000–27000	ndf	ndf	ndf	ndf	ndf	ndf	ndf	ndf	ndf
Effort[2] (Agreed Days)	10555	5227	0	0	0	0	0	0	0	07

1 To September 2018
2 Effort regulated

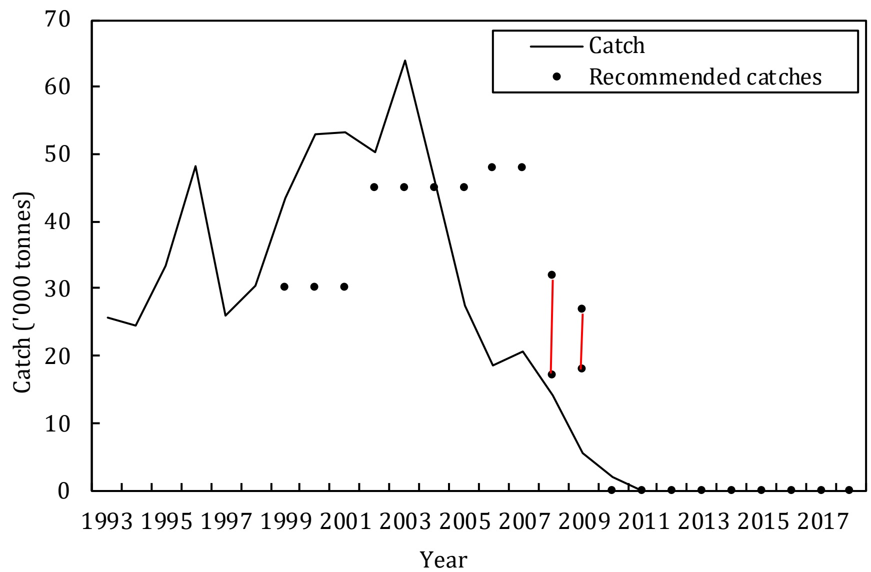


Fig. 1.1. Shrimp in Div. 3M: Catches (t) of shrimp on Flemish Cap and catches recommended in the period 1993-2018. In 2008 and 2009, a range of catches was advised rather than a single TAC value.

b) Input Data

i) Commercial fishery data

Time series of size and sex composition data were available mainly from Iceland and Faroes between 1993 and 2005. Because of the moratorium, catch and effort data have not been available since 2010, and therefore the standardized CPUE series has not been extended.

ii) Research Survey Data

Stratified-random trawl surveys have been conducted on Flemish Cap by the EU in July from 1988 to 2018. A new vessel was introduced in 2003 which continued to use the same trawl employed since 1988. In addition, there were differences in cod-end mesh sizes utilized in the 1994 and 1998 surveys that have likely resulted in biased estimates of total survey biomass. Nevertheless, for this assessment, the series prior to 2003 were converted into comparable units with the new vessel using the methods accepted by STACFIS in 2004 (NAFO 2004 SC Rep., SCR Doc. 04/77).

c) Assessment

No analytical assessment is available. Evaluation of stock status is based upon interpretation of commercial fishery data up to 2010, and research survey data.

d) Reference Points

Scientific Council considers that a female survey biomass index of 15% of its maximum observed level provides a proxy for B_{lim}. A limit reference point for fishing mortality has not been defined.

e) State of the stock

Recruitment: All year-classes after the 2002 cohort (i.e. age 2 in 2004) have been weak (Fig 1.2).

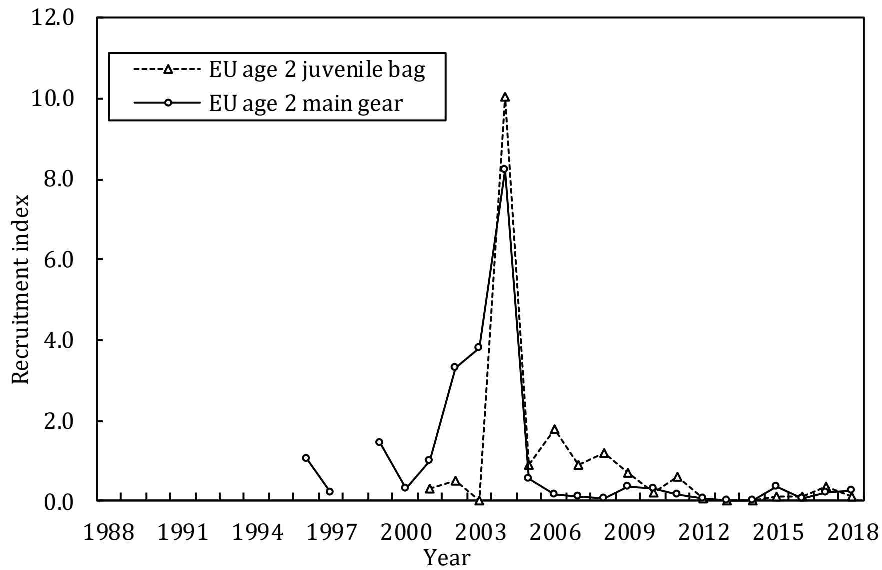


Fig. 1.2. Shrimp in Div. 3M: Abundance indices at age 2 from the EU survey. Each series was standardized to its mean.

Biomass: The survey female biomass index was stable at a high level from 1998 to 2007, it declined since then until 2014 (Fig 1.3). Since 2015 the biomass index has been increasing successively. In 2018 the female biomass increased compared to 2017 and the estimated biomass is now above B_{lim}. The probability that B_{2018} is below B_{lim} is low.

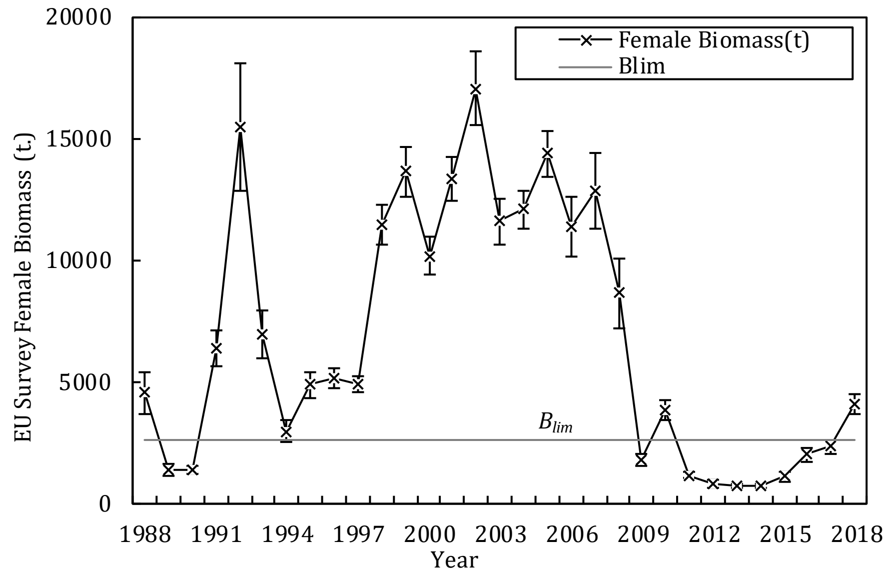


Fig. 1.3. Shrimp in Div. 3M: Female biomass index from EU trawl surveys, 1988-2018. Error bars are 1 std. err.

Exploitation rate: Because of low catches following the moratorium, the exploitation rate index (nominal catch divided by the EU survey biomass index of the same year, Fig. 1.4) declined to zero and has remained at that level since 2011.

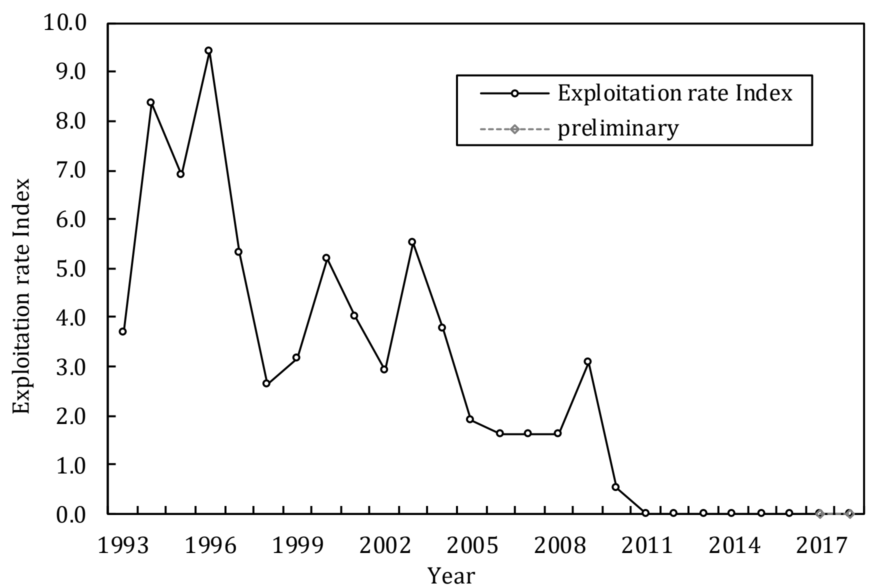


Fig. 1.4. Shrimp in Div. 3M: Exploitation rate index as derived by catch divided by the EU survey biomass index of the same year.

State of the Stock: Although the stock has shown signs of improvement since 2014 and the 2018 index indicates that the stock has a low probability of being below B_{lim}, the stock remains in a state of impaired recruitment and there are concerns that the stock will remain at low levels.

f) Ecosystem considerations

The drastic decline of shrimp biomass correlates with an increase of both cod and redfish in Div. 3M (Fig 1.6). It is uncertain whether this represents a causal relationship and/or covariance as the result of an environmental factor.

Multispecies models (Pérez-Rodríguez et al. 2016, Pérez-Rodriguez and D. González-Troncoso 2018) suggest that predation by cod and redfish, together with fishing have been the main factors driving the shrimp stock to the collapse.

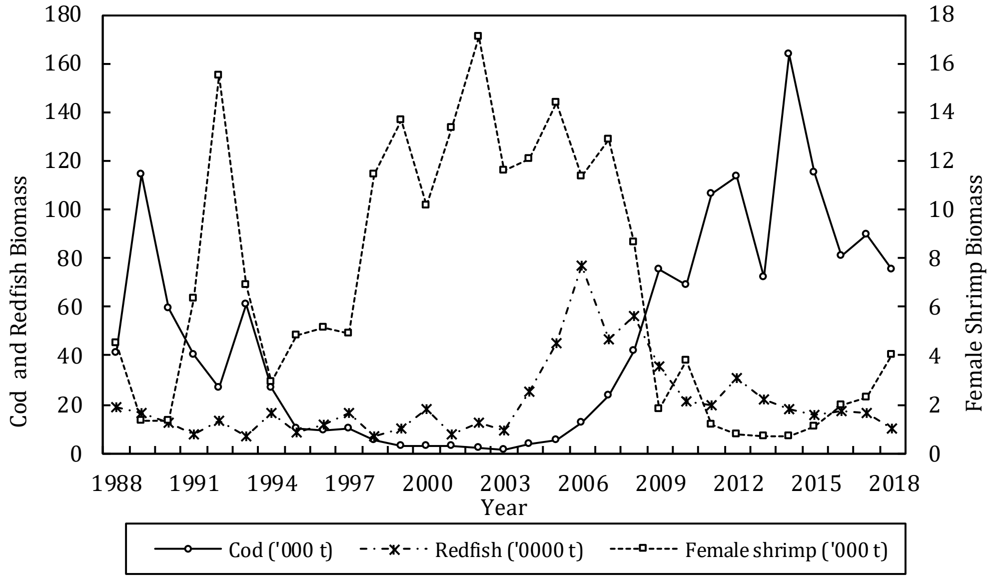


Fig. 1.5. Shrimp in Div. 3M: Cod, Redfish and Female shrimp biomass indices from EU trawl surveys, 1988-2018.

g) Research Recommendations

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

STATUS: Recent progresses have been made from the article presented by (Pérez-Rodriguez and D. González-Troncoso 2018).

References

Pérez-Rodríguez, A, D. Howell, M. Casas, F. Saborido-Rey, A. Ávila-de Melo, F. González-Costas, D. González-Troncoso. 2016. GadCap: A GADGET multispecies model for the Flemish Cap cod, redfish and shrimp. NAFO SCR Doc. 16/035, Serial No. N6578.

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

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

(SCR Doc. 18-63)

Environmental Overview

Recent Conditions in Ocean Climate and Lower Trophic Levels

- After a decade of above average ocean climate conditions in SA3 - Grand Bank, the trend in recent years shows signs of returning to colder conditions similar to the mid-1990's with below normal conditions in 2017, similar to 2015.
- The total production (magnitude) of the spring bloom remained well below normal in 2017 for a third consecutive year. The past three years have yielded the lowest anomalies of the time series including a record-low in 2016.
- Spring bloom peak timing was later than normal for the reference period for the fifth consecutive year.
- The composite zooplankton abundance index has remained above normal since 2009, with a record-high in 2016. During the same period, the zooplankton biomass index has remained near or below normal.

a) Introduction

This shrimp stock is distributed around the edge of the Grand Bank, mainly in Div. 3L. The fishery began in 1993 and came under TAC control in 2000 with a 6 000 t TAC. Annual TACs were raised several times between 2000 and 2009 reaching a level of 30 000 t for 2009 and 2010. The TAC was then reduced annually until no directed fishing (ndf) was implemented in 2015 to 2018 (Fig. 2.1). The TAC entries in the table below include autonomous TACs from Denmark. Catches are taken from STATLANT 21 data.

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

	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
TAC[1]	32767	32767	20971	13108	9393	4697	ndf	ndf	ndf	ndf
STATLANT 21	27236	19745	13013	10099	7919	2282	0	0	0	
NIPAG[2]	25900	20536	12900	10108	8647	2289	0	0	0	

[1] Includes autonomous TACs as set by Denmark.
[2] NIPAG catch estimates have been updated using various data sources (see p. 13, SCR. 14/048).

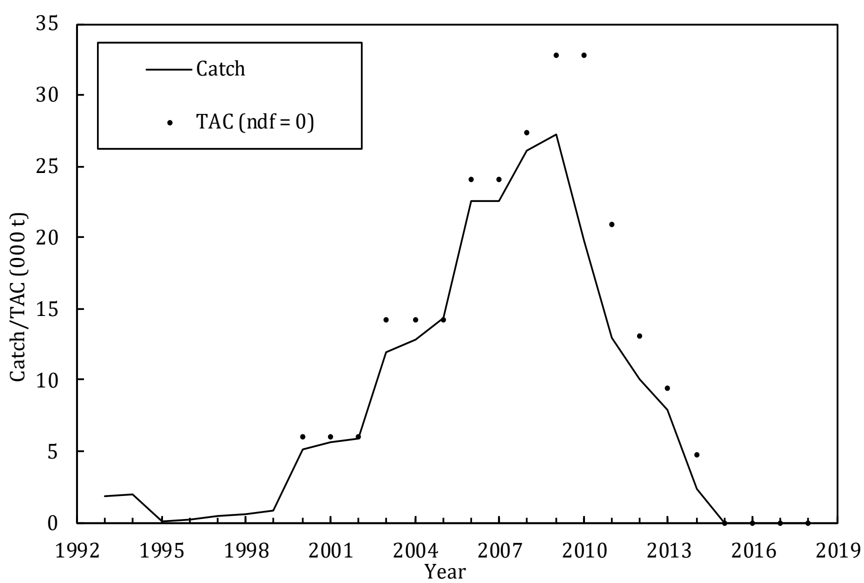


Fig. 2.1. Shrimp in Div. 3LNO: Catches and TAC. The TAC illustrated includes the autonomous quotas, set by Denmark, with respect to Faroes and Greenland. No directed fishing is plotted as zero TAC.

b) Input data

i) *Commercial fishery data*

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

ii) *Research survey data*

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

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

c) Assessment

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

Biomass indices. In Canadian surveys, about 95% of the biomass was found in Div. 3L, distributed mainly along the northeast slope in depths from 185 to 550 m. Total, fishable (shrimp with carapace length > 17mm) and female (SSB) biomass and abundance indices follow the same trend throughout the survey time series. There was an overall increase in both the spring and autumn indices to 2007 after which they decreased by over 95% to the lowest levels in the time-series in 2016 and 2017, respectively (Fig. 2.2).

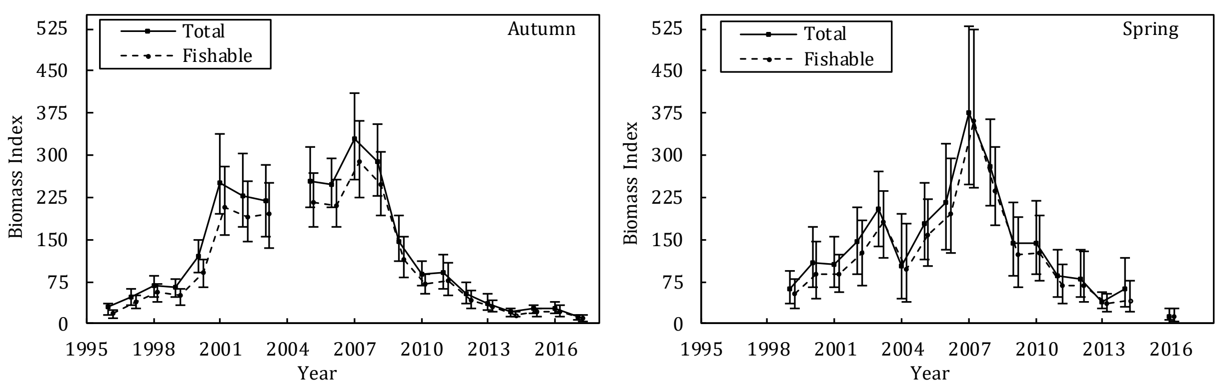


Fig. 2.2. Shrimp in Div. 3LNO: Total and fishable biomass index estimates from Canadian autumn and spring multi-species surveys (with 95% confidence intervals). The 2014 autumn index is for Div. 3L only. There are no available biomass index estimates for spring 2015, 2017 or 2018.

EU-Spain survey biomass indices for Div. 3LNO, within the NRA only, increased from 2003 to 2008 followed by a 93% decrease by 2012 remaining near that level through 2018 (Fig. 2.3).

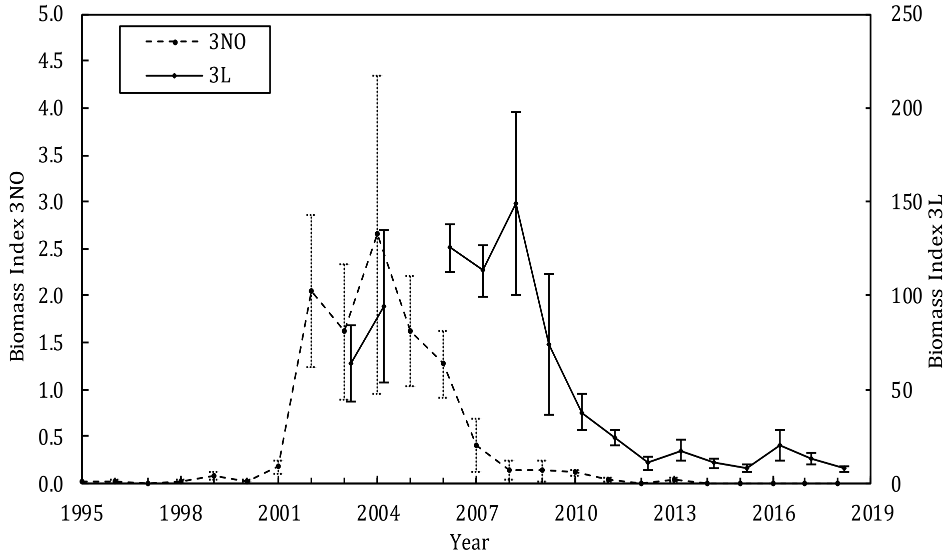


Fig. 2.3. Shrimp in Div. 3LNO: Total biomass index estimates from EU - Spain multi-species surveys (± 1 SE) in the NAFO Regulatory Area (NRA) of Div. 3LNO.

Stock Composition. Both males and females showed a broad distribution of lengths in recent surveys indicating the presence of more than one year class (Fig. 2.4).

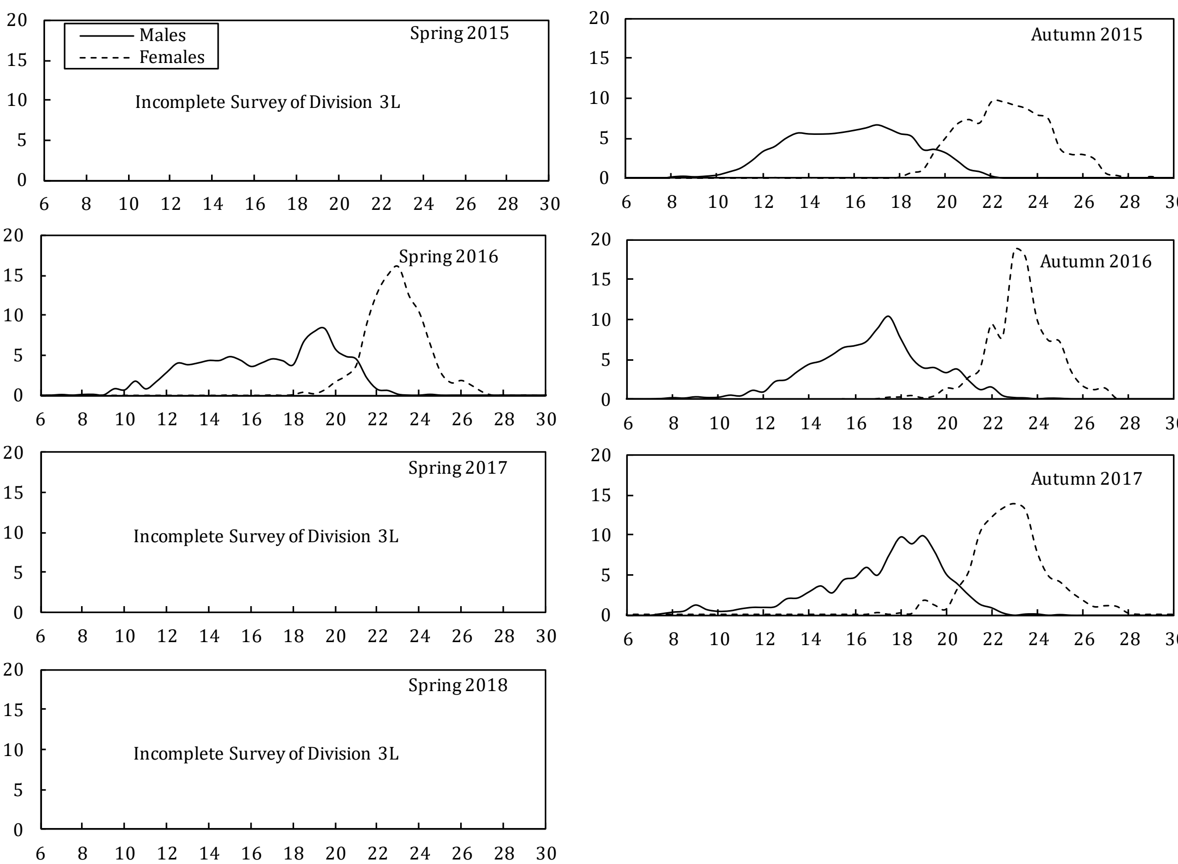


Fig. 2.4. Shrimp in Div. 3LNO: Composition of survey catches (percentage at length) from Canadian spring and autumn multi-species survey data. No data for spring 2015, 2017 or 2018.

Recruitment indices. Recruitment indices were based upon abundance indices of shrimp with carapace lengths of 11.5 – 17 mm from Canadian multi-species survey data. The 2006 – 2008 indices were among the highest in both spring and autumn time-series but have since declined to the lowest levels in the survey time series (Fig. 2.5).

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

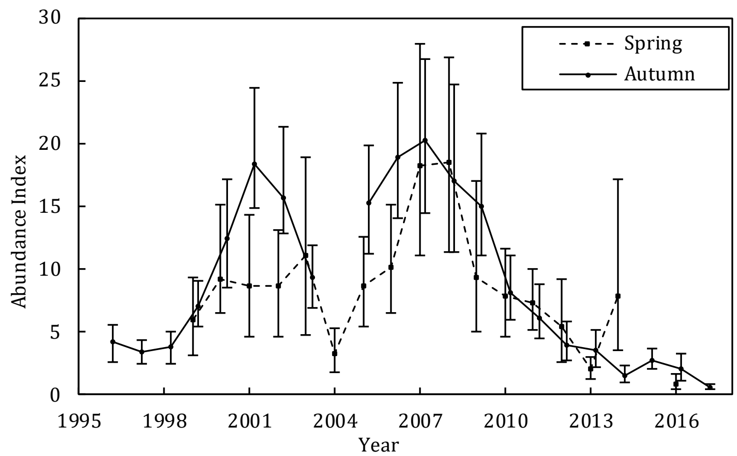


Fig. 2.5. Shrimp in Div. 3LNO: Indices of recruitment-sized shrimp based on abundance of shrimp with 11.5 – 17 mm carapace lengths from Canadian spring and autumn multi-species surveys. Error bars represent 95% confidence intervals. The autumn index for 2014 is for Div. 3L only.

Exploitation index. An index of exploitation was derived by dividing the catch in a given year by the fishable biomass index from the previous autumn survey. The exploitation index generally increased throughout the course of the fishery until dropping sharply in 2014 (Fig. 2.6). Since there was no directed fishing in 2015-2018, the exploitation index is zero.

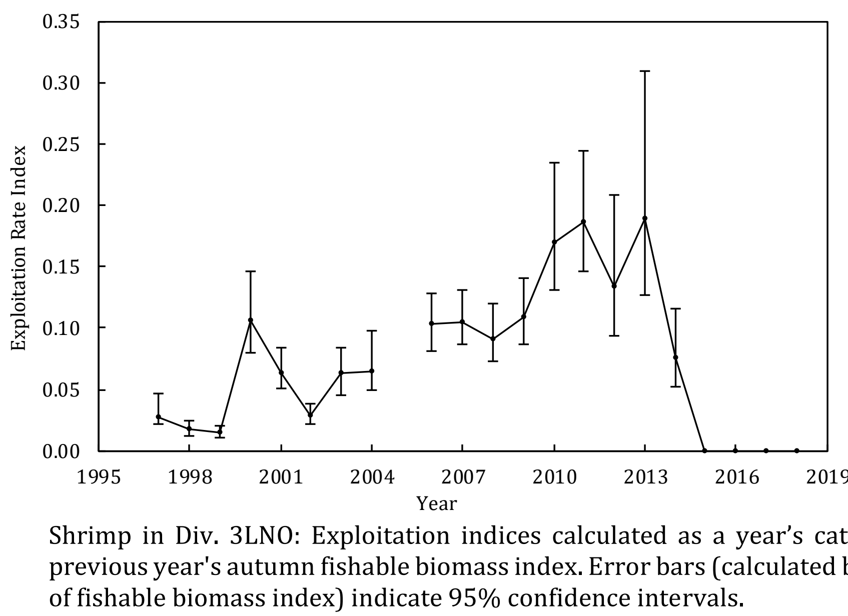


Fig. 2.6. Shrimp in Div. 3LNO: Exploitation indices calculated as a year's catch divided by the previous year's autumn fishable biomass index. Error bars (calculated based on estimates of fishable biomass index) indicate 95% confidence intervals.

d) Reference points

The point at which a valid index of female spawning stock size has declined to 15% of its highest observed value is considered to be B_{lim} (SCS Doc. 04/12). In 2017 the risk of being below B_{lim} was greater than 95% (Fig. 2.7). A limit reference point for fishing mortality has not been defined.

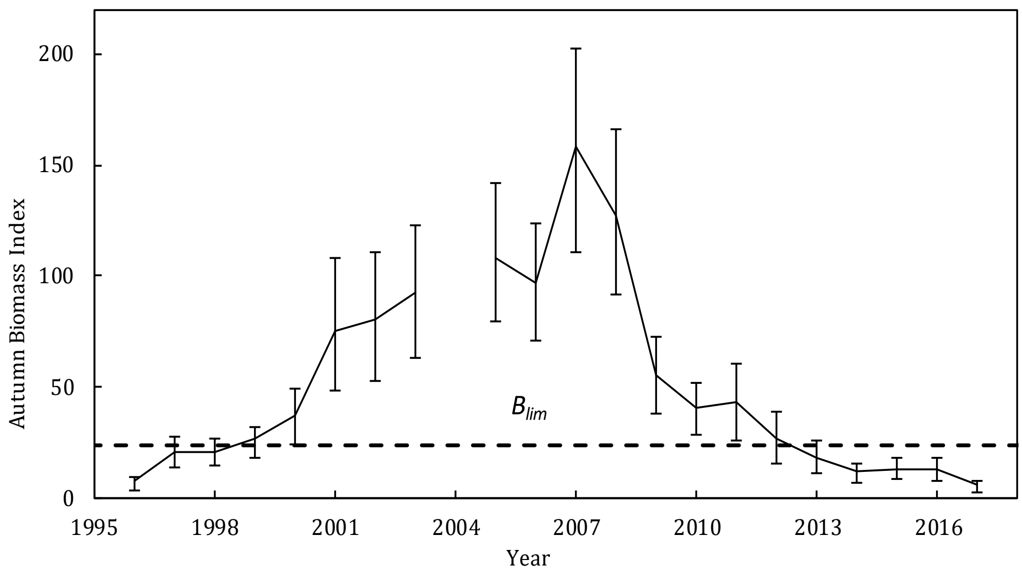


Fig. 2.7. Shrimp in Div. 3LNO: Autumn female spawning stock biomass index (SSB) and B_{lim}. B_{lim} is defined as 15% of the maximum autumn female biomass over the time-series. Error bars indicate 95% confidence intervals. The autumn index for 2014 is for Div. 3L only.

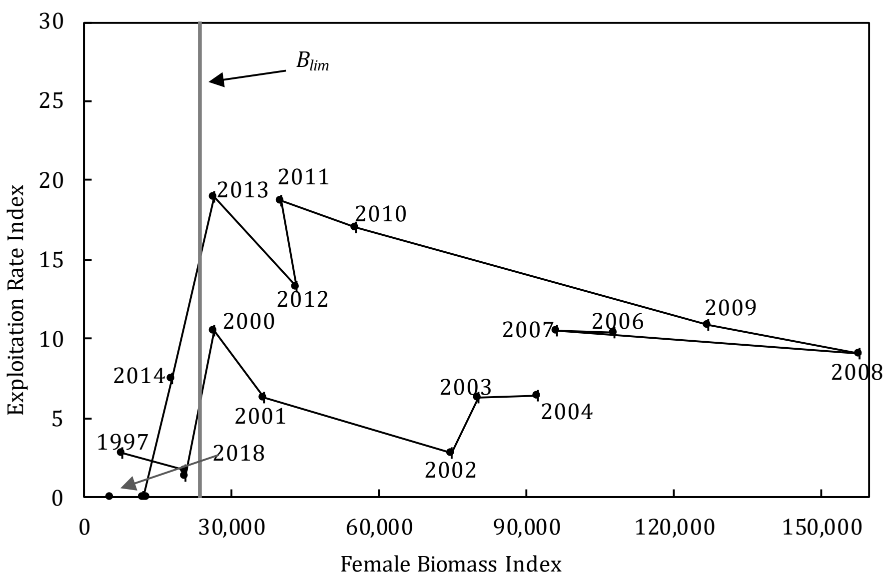


Fig. 2.8. Shrimp in Div. 3LNO: Exploitation rate vs female SSB index from Canadian autumn survey. Vertical line denotes B_{lim}.

e) State of the stock

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

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

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

State of the Stock. In 2017 the risk of the stock being below B_{lim} was greater than 95%. There is no indication of improved recruitment.

f) Ecosystem considerations

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

g) Research recommendations

NIPAG **recommended** in 2015 that *ecosystem information related to the role of shrimp as prey in the Grand Bank (i.e. 3LNO) Ecosystem be presented to the 2016 NIPAG meeting*.

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

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

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

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, 18/055, 18/056, 18/057, 18/058, 18/060)

Environmental overview

Recent Conditions in Ocean Climate and Lower Trophic Levels

- The composite climate index in Subarea 0-1 has remained mostly above normal since the early 2000s, it reached a peak in 2010 but has been in decline since then, reaching a below normal state in 2015 before returning to near normal climatological conditions in 2016 and 2017.
- Total production of the spring bloom (magnitude) remained above normal in 2017 but declined from the record-high observed in 2015.

Spring bloom peak timing was delayed in 2016 and 2017 compared to the reference period.

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. 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 2018 was set at 101 250 t and for Canadian Waters, 14 875 t.

Greenland requires that logbooks should record catch live weight. For shrimps sold to on-shore processing plants, a former allowance for crushed and broken shrimps in reckoning 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. 18/058). 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. 18/057). Total catch increased from about 10 000 t in the early 1970s to more than 105 000 t in 1992 (Fig. 3.1). Moves 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. The catch in 2016 was 85 527 t and 92 584 t in 2017. The projected catch for 2018 is 101 250 t, i.e. the TAC enacted by Greenland.

Recent catches, projected catch for 2018 and recommended and enacted TACs (t) for northern shrimp in Sub-area 1 and Div. 0A (east of 60°30'W) are as follows:

	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
TAC										
Advised	110 000	110 000	120 000	90 000	80 000	80 000	60 000	90 000	90 000	105 000
Enacted[1]	130 153	130 153	139 583	114 425	100 596	97 649	82 561	96 426	101 706	114 873,[1]
Catches (NIPAG)										
SA 1	135 029	128 109	122 659	115 965	95 379	88 765	72 254	84 356	89 369	99 998[2]
Div. 0A	429	5 882	1 330	12	2	0	2	1 171	3 215	1,252[2]
TOTAL	135 458	133 991	123989	115 977	95 381	88 765	72 256	85 527	92 584	101,250[2]
STATLANT 21										
SA 1	133 561	123 973	122 061	114 958	91 800	88 834	71 777	82 922	89 069	
Div. 0A	429	5206	1134	12	2	0	2	1 381	2 656	

1Canada and Greenland set independent and autonomous TACs

2 Provisional total catches for the year as expected by industry observers.

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. 18/057). The fishery has moved north and, since 2009, at least 35% of the total catch was taken in Div. 1A.

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 no fishing was conducted in Div. 0A (SCR Doc. 18/057). In 2016 Canadian catch was 1171 t and 3215 t in 2017.

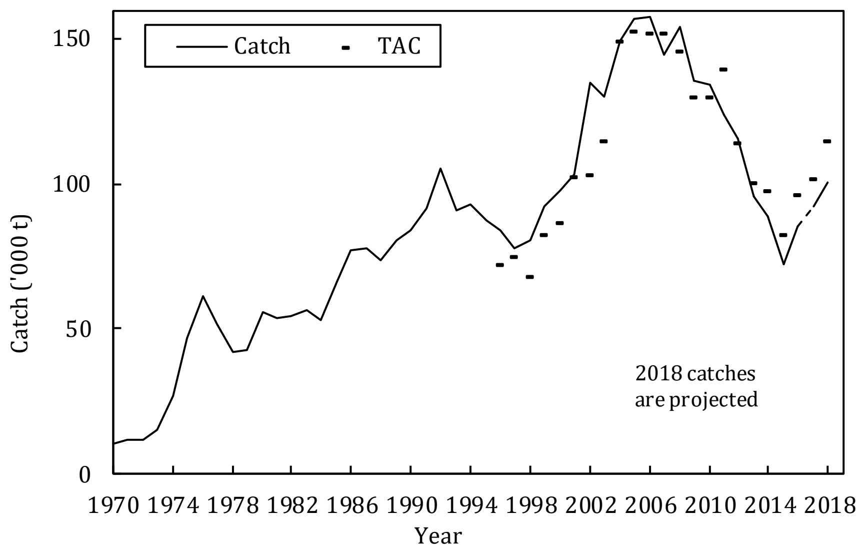


Fig. 3.1. Northern shrimp in Subarea 1 and Div. 0A: Enacted TACs and total catches (2018 expected for the year).

b) Input data

i) Fishery data

Fishing effort and CPUE. Catch and effort data from the fishery were available from Greenland logbooks for Subarea 1 (SCR Doc. 18/057). In recent years both the distribution of the Greenland fishery and fishing power have changed significantly: for example, larger vessels have been allowed in 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, year, and statistical area. Standardized CPUE series were done separately for three different fleets (Fig. 3.2); the early offshore fleet fishing in Div. 1A and part of 1B (KGH-index, 1976-1990), the present offshore fleet fishing in Subarea 1 (1987-2018) and the coastal fleet fishing in coastal and inshore areas (1989-2018). 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 two years the CPUE of the coastal fleet has slightly decreased while the CPUE of the offshore fleet increased from 2016 to 2017.

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.

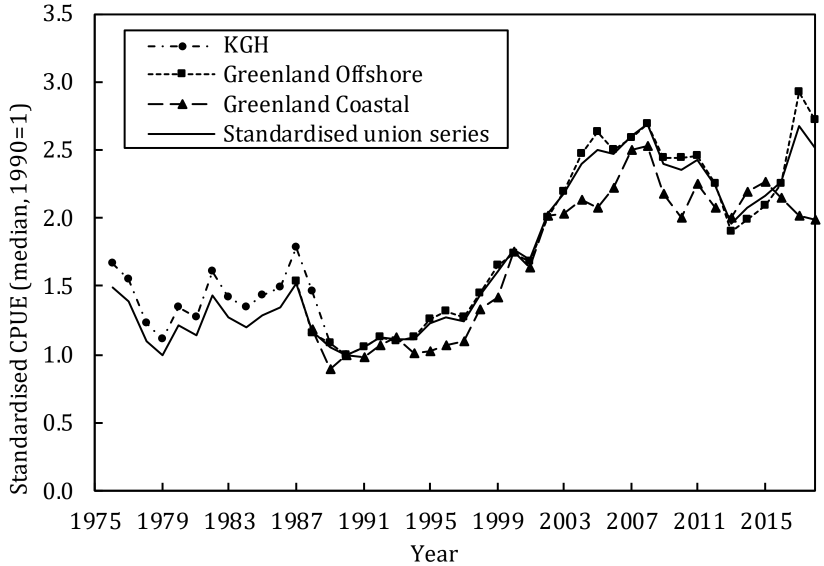


Fig. 3.2. Northern shrimp in Subarea 1 and Div 0A: Standardized CPUE index series 1976–2018.

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 (Fig. 3.3). 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.

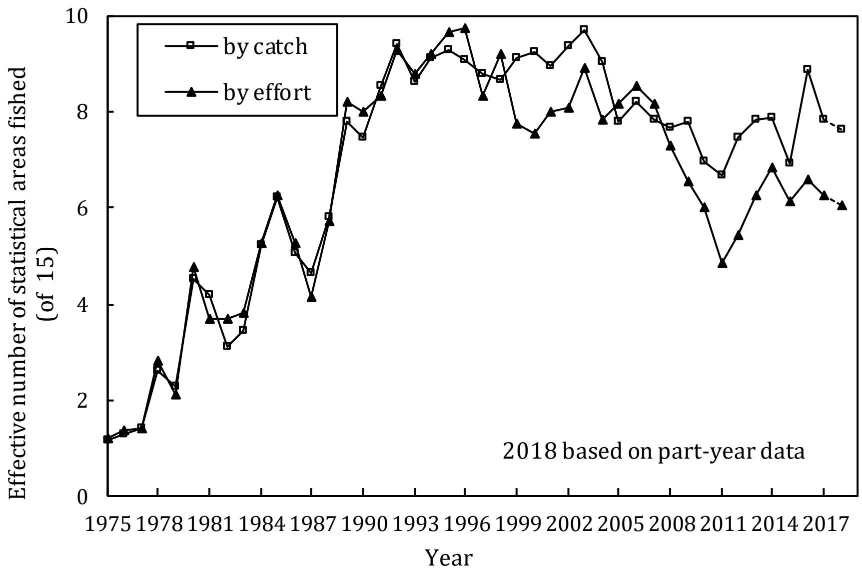


Fig. 3.3. Northern shrimp in Subarea 1 and Div. 0A: Indices for the distribution of the Greenland fishery between statistical areas in 1975–2018.

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

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. 18/055). 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, the annual trawl survey was conducted with a chartered vessel, the Faroese trawler Sjurdarberg 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 2018 survey as identical as possible with the previous years survey. All officers and two crew members from Paamiut participated in the survey. It was therefore assumed that the 2018 results were directly comparable with the previous surveys. A more detailed description is available in SCR Docs. 18/055.

The survey average bottom temperature increased from about 1.7°C in 1990–93 to about 3.1°C in 1997–2014, but have since declined to 2.1°C in 2018 (SCR Doc. 18/055). 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. 18/055). 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 (cv. 18%, downward trend 4%/yr). It then increased by, on average, 19%/yr until 2003, when it reached 316% of the 1997 value. Subsequent values were consecutively lower, with the second lowest level in the last 20 years occurring in 2014 (Fig. 3.4) (SCR Doc. 18/055). Over the past 4 years biomass has increased and was in 2018 163% of the low 2014 level. Offshore regions comprise 75% of the total survey biomass, and 25% is inshore in Disko Bay and Vaigat. The inshore regions have far higher densities than other areas, almost three times as high as offshore (Fig. 3.4) (SCR Doc. 18/055).

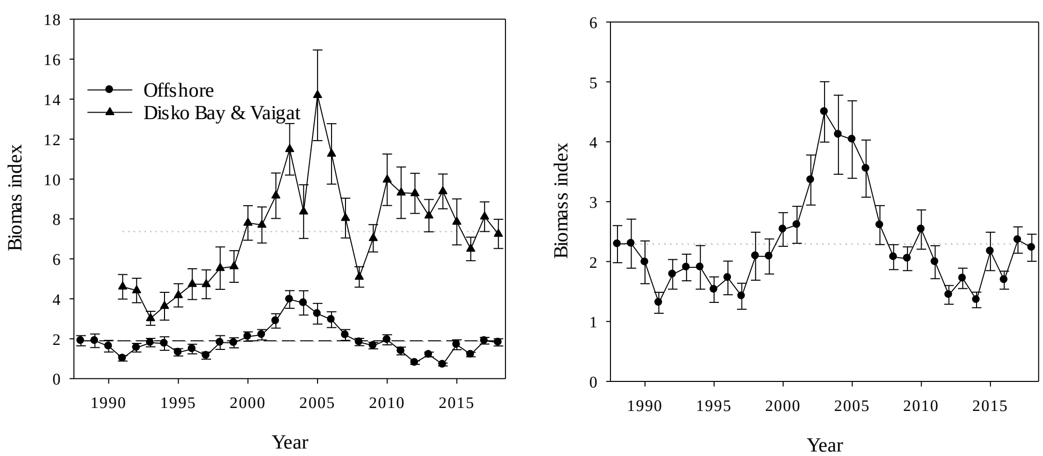


Fig. 3.4. Northern shrimp in Subarea 1 and Div. 0A: Biomass index (survey mean catch rates) inshore and offshore (upper panel) and overall (lower panel) 1988–2018 (error bars 1 SE).

Length and sex composition (SCR 18/055). In 2018, in Disko Bay regions fishable biomass of males remained at a level comparable to the 2017 value, but increased offshore to a value well above its 13-year median. Nevertheless, the proportion of males in Disko Bay regions is below its 13-year lower quartile and in offshore regions at their 13-year upper quartile of the total survey and fishable biomass indices. Like in most recent years, females compose a high proportion of survey and fishable biomass index in both regions, however below their 13-year median offshore, but well above their 13-year upper quartile in Disko Bay (SCR Doc. 18/056).

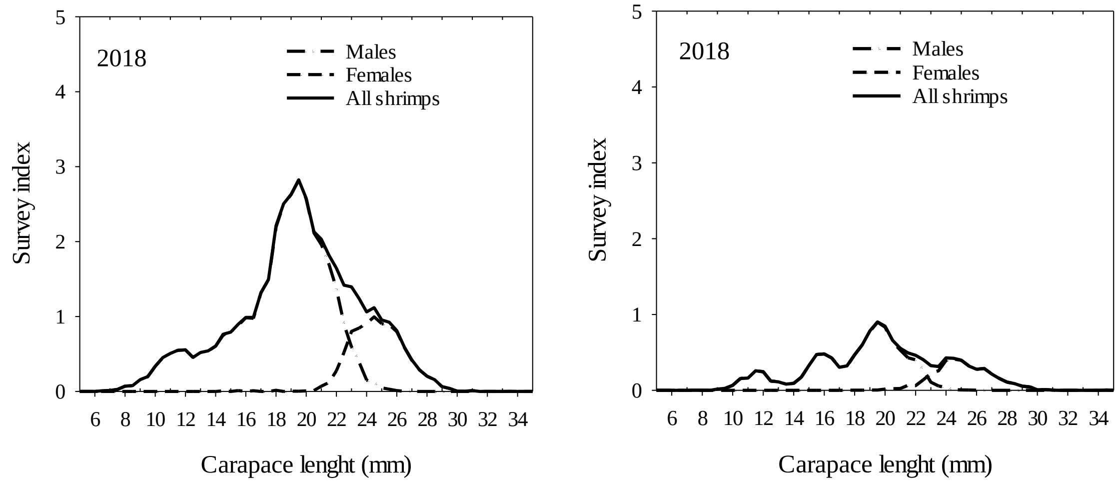


Fig. 3.5. Northern Shrimp in Subarea 1 and Div. 0A: Survey mean catch rates at length in offshore regions (above) and Disko Bay & Vaigat (below) at the West Greenland trawl survey in 2018.

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 a high value only in 2015. The pre-recruit index (14–16.5 mm, expected to recruit to next year's fishable biomass) had a high value in 2005 and has since fluctuated at a lower level, with relatively high values in 2015 and 2017 (SCR Doc. 18/055, 18/056) (Fig. 3.6). Numbers of age-2 and pre-recruits in 2018 are close to the 2005 to 2018 average.

Linear regression has shown a significant relationship between the number of age-2 shrimp and the fishable biomass with a lag of 2, 3 or 4 years later. The correlation was strongest ($R^2 = 0.68$) between number of age-2 shrimp and the fishable biomass 4 years later (SCR doc 18/055).

The stock composition in Disko Bay has historically been characterized by a higher proportion of young shrimps than that offshore, exception was in 2017, where younger shrimps offshore were much higher in numbers and relative to survey biomass. In 2018, numbers of age 2-shrimps and pre-recruits relative to survey biomass are comparable among Disko Bay regions and those offshore (SCR Doc. 18/055, 18/056).

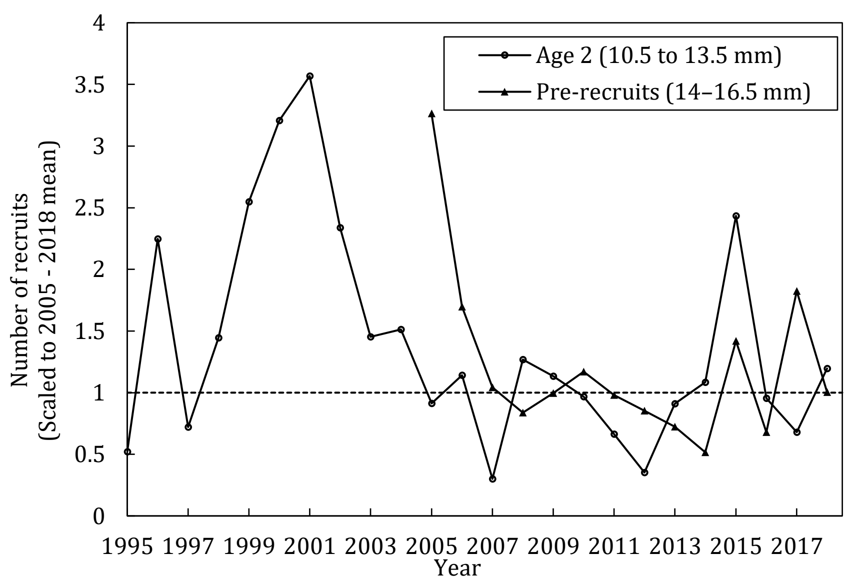


Fig. 3.6. Northern shrimp in Subarea 1 and Div. 0A: Survey index of numbers at age 2 (10.5 - 13.5 mm) and index of number of pre-recruits (14-16.5 mm), 1995-2018.

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 resulting dynamics are unpredictable both for the individual stocks and for their combination.

Series of estimates of cod biomass in West Greenland waters are available for different periods from VPA, from the German groundfish survey at West Greenland and from the Greenland trawl survey for shrimps. The results from the German survey for the current year are not available in time for the assessment. The overall cod-stock biomass index was based on four indices (VPA, Greenland trawl survey (Skjærvøj and Cosmos trawl) and the German survey) within the assessment model.

Indices of cod biomass are adjusted by a measure of the overlap between the stocks of cod and shrimps in order to obtain an index of 'effective' cod biomass, which is entered in the assessment model (SCR-Doc. 14-062). In 2018 the cod biomass density estimated by research trawl survey in West Greenland decreased over 2017 but the index of its overlap with the shrimp stock more than doubled to a record high value. This resulted in an 'effective cod biomass' index of 33.9 kt, compared with 21.9 kt in 2017 (Fig. 3.7) (SCR Doc. 16/042, 16/047, SCR Doc. 18/056).

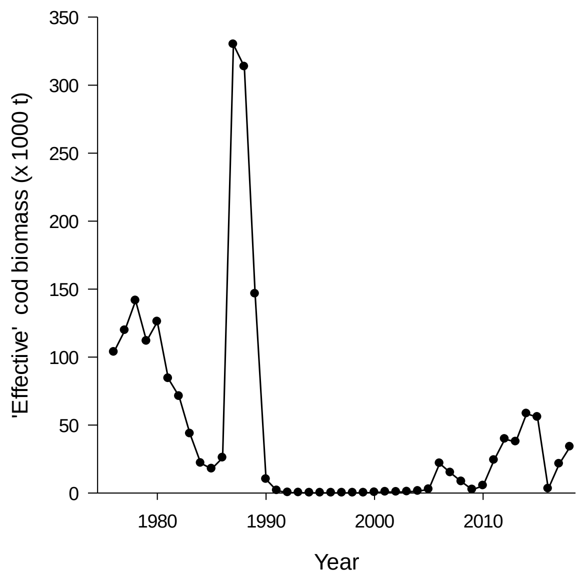


Fig. 3.7. Indices of the 'effective' cod biomass in Subarea 1 and Div. 0A 1976 - 2018 (measure of the potential predation pressure by cod on shrimps).

c) Assessment

A Schaefer surplus-production model of population dynamics was fitted to series of CPUE, catch, and survey biomass indices (SCR Doc. 18/056). The model includes a term for predation by Atlantic cod. Total shrimp catches for 2018 are expected to be 101 250 t.

From 2011 to 2017, the model has been run with data series shortened to 30 years to speed up the running; the effect of shortening the data series was checked in 2011 and found not significant (SCR Doc. 11/58).

In 2017 NIPAG noted concern about the degree of instability in MSY estimates in successive assessments. There were also problems with changes in perception of stock trajectory in recent years based on a 5-year retrospective analysis. In an attempt to solve this problem, the following changes were made:

- Change of the time window from 30- year to the entire time series from 1976 to 2018 (i.e. current assessment year).
- This ensured that all available data are included in the assessment especially data important for the estimation of the cod predation on shrimp.
- Change from a time invariant catchability for the commercial fleet to a time variant catchability. Based on the relationship between the survey and the CPUE indices, three periods were recognised. In the period from 1976 to 2002 the two indices were positively correlated. It was followed by a period (2003 to 2006) where the relationship broke down and was even negative. That period was considered as a "transition" period. A new positive relationship was established in the period 2007 to 2018. The "transition" period was characterised by several changes such as: a significant replacement of trawlers occurred, the shrimp biomass and the fishery moved into more shallow waters and to the north, and the water temperature increased considerably indicating a significant change in the environment. The CPUE in the "transition" period was removed from the assessment input. The remaining two periods (1976-2002 and 2007 - 2018) were modeled with independent catchability parameters.

A more comprehensive description of the evaluation and changes of the model are available in SCR Doc. 18/060. These changes were included in the current assessment and this resulted in increased stability of the model parameters and a much improved retrospective pattern (Fig. 3.9).

Estimates of stock-dynamic parameters from fitting a Schaefer stock-production model to 43 years' data are given in Table 3.1. Median values from the new model applied to the 2017 data are provided for comparison. The modelled biomass (Fig. 3.8a) was low and stable until the late 1990s, when it started a rapid increase and doubled by about 2004. Modelled biomass steadily declined from 2004 to 2013 but has since slightly increased. The median biomass has been above B_{msy} since the late 1990s except from 2012 to 2015. Mortality has generally been close to or below Z_{msy} during the modelled period (Fig. 3.8b). Estimates of total mortality have decreased in the most recent years. Assuming catches of 101 250 t, total mortality in 2018 is estimated to be below Z_{msy} with probability of $Z_{2018} > Z_{msy}$ = 36%. Biomass at the end of 2018 is projected to be close to the 2017 value and above B_{msy}. The probability of the biomass at the end of 2018 being below B_{msy} is 30% and the probability of being below B_{lim} is very low (<1%).

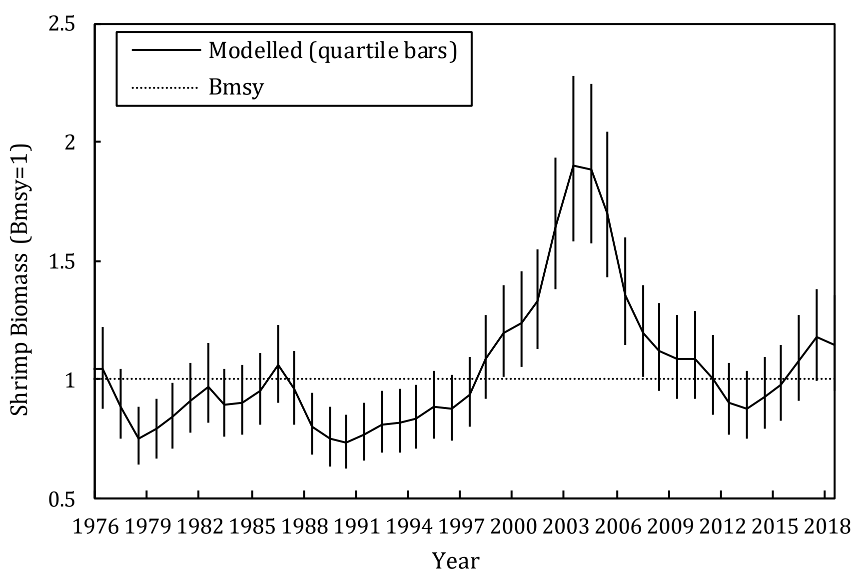


Fig. 3.8a. Northern shrimp in SA 1 and Div. 0A: Relative stock biomass with quartile error bars 1976–2018. Dotted line corresponds to $B = B_{msy}$.

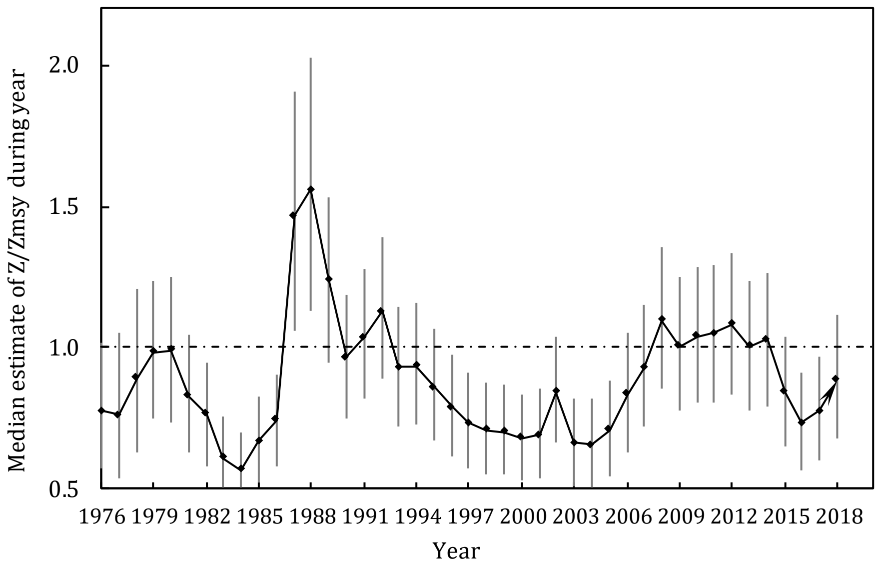


Fig 3.8b. Northern shrimp in SA 1 and Div. 0A: Trajectory of the median modelled estimate of mortality relative to Z_{msy} during the year, 1976–2018.

The perception of the stock in relation to its reference points has changed significantly as a result of applying the new revised assessment model setup, compared to the setup applied in last year assessment, especially for the period after 2006 where the catchability for the second period is estimated. The relative biomass (B/B_{msy}) after 2006 is considerably lower with the new model setup and the relative mortality (Z/Z_{msy}) is considerably higher in the current assessment compared to the 2017 assessment.

Table 3.1. Estimates of stock-dynamic and parameters from fitting a Schaefer stock-production model to 43 years' data on the West Greenland stock of the northern shrimp in 2018.

	Mean	S.D.	25%	Median	75%	Est. mode	Median (2017)
Max.sustainable yield	134.2	46.3	109.6	126.1	147.3	109.9	124.5
B/Bmsy, end of current year (proj.)(%)	117.5	30.5	95.7	114.2	136.0	107.6	113.7
Prob. B<Bmsy, end of current year(%)	30.4	46.0	–	–	–	–	–
Z/Zmsy, current year (proj.)(%)	–	–	67.4	88.4	111.7	–	82.4
Prob. Z>Zmsy end of current year(%)	36.2	48.1	–	–	–	–	–
Carrying capacity	2734	1630	1607	2237	3311	1243	2186
Max. sustainable yield ratio (%)	12.2	5.4	8.1	11.7	15.8	10.9	11.7
Survey catchability (%)	23.9	13.0	13.8	21.7	32.0	17.3	22.3
CPUE(1) catchability	1.4	0.7	0.8	1.2	1.8	1.0	1.3
CPUE(2) catchability	2.2	1.2	1.3	2.0	2.9	1.6	2.1
Effective cod biomass 2018 (Kt)	41.6	43.7	24.5	33.9	47.2	18.5	21.6
P50% (prey biomass index with consumption 50% of max.)	4.4	6.3	0.4	1.9	5.7	-2.9	1.8
Vmax (maximum consumption per cod)	2.3	2.4	0.5	1.3	3.3	-0.7	1.2
CV of process (%)	13.4	3.0	11.3	13.2	15.2	12.7	13.3
CV of survey fit (%)	16.3	3.1	14.1	15.9	18.0	15.1	16.5
CV of CPUE (1) fit (%)	6.8	1.4	5.7	6.5	7.5	5.9	6.6
CV of CPUE (2) fit (%)	7.5	2.4	5.8	6.9	8.5	5.6	0.1

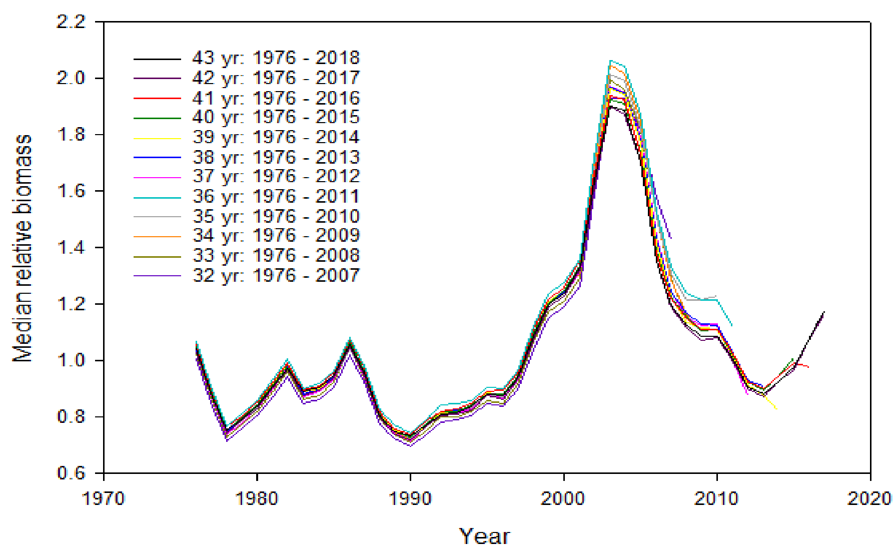


Fig. 3.9. Retrospective plots of the relative biomass B/B_{msy} 2007 to 2018.

A twelve year retrospective analysis was performed (Fig. 3.9) 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.

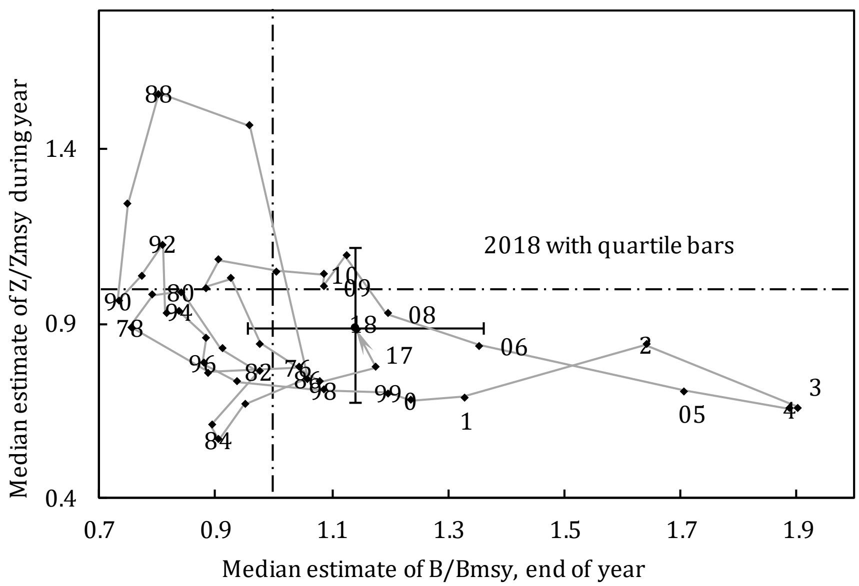


Fig. 3.10. Northern shrimp in Subarea 1 and Div. 0A: Trajectory of relative biomass and relative mortality, 1976–2018.

e) State of the stock

Biomass. Biomass at the end of 2018 is close to B_{msy} and the probability of being below B_{lim} is very low (<1%).

Mortality. Assuming catches of 101 250 t, total mortality in 2018 is estimated to be below Z_{msy} and the probability of being above Z_{msy} is 36%.

Recruitment. Numbers of age-2 and pre-recruits in 2018 are close to the 2005 to 2018 average.

State of the Stock. Biomass at the end of 2018 is close to B_{msy} and the probability of being below B_{lim} is very low (<1%). The probability of mortality in 2018 being above Z_{msy} is 36%. Recruitment is close to average.

f) Projections

Three years projections for years 2019–2021 under eight catch options and subject to predation by the cod stock with an 'effective' biomass of 34 kt (the estimated value for 2018) were evaluated. Additional projections assuming 'effective' cod biomasses of 29 kt, and 39 kt were conducted but results indicated small differences in risk probabilities (SCR Doc 18/056).

34 000 t cod	Catch option ('000 tons)							
Risk of:	80	85	90	95	100	105	110	115
falling below Bmsy end 2019 (%)	30	30	31	32	33	33	33	34
falling below Bmsy end 2020 (%)	30	30	30	33	34	35	35	37
falling below Bmsy end 2021 (%)	29	29	31	34	34	36	37	38
falling below Blim end 2019 (%)	0	0	0	0	0	0	0	0
falling below Blim end 2020 (%)	0	0	0	0	0	0	0	0
falling below Blim end 2021 (%)	0	0	0	0	0	0	0	0
exceeding Zmsy in 2019 (%)	13	17	21	26	30	35	40	44
exceeding Zmsy in 2020 (%)	13	17	22	26	31	36	41	46
exceeding Zmsy in 2021 (%)	14	17	23	27	32	38	42	47

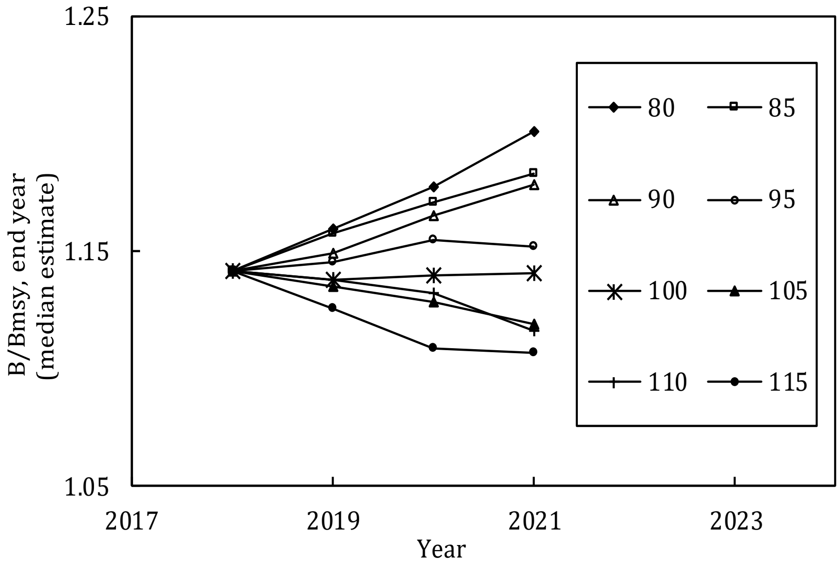


Fig. 3.11. Northern shrimp in Subarea 1 and Div. 0A: Median estimates of year-end biomass trajectory for 2019–2021 with annual catches at 80 –115 kt and an 'effective' cod stock assumed at 34 kt.

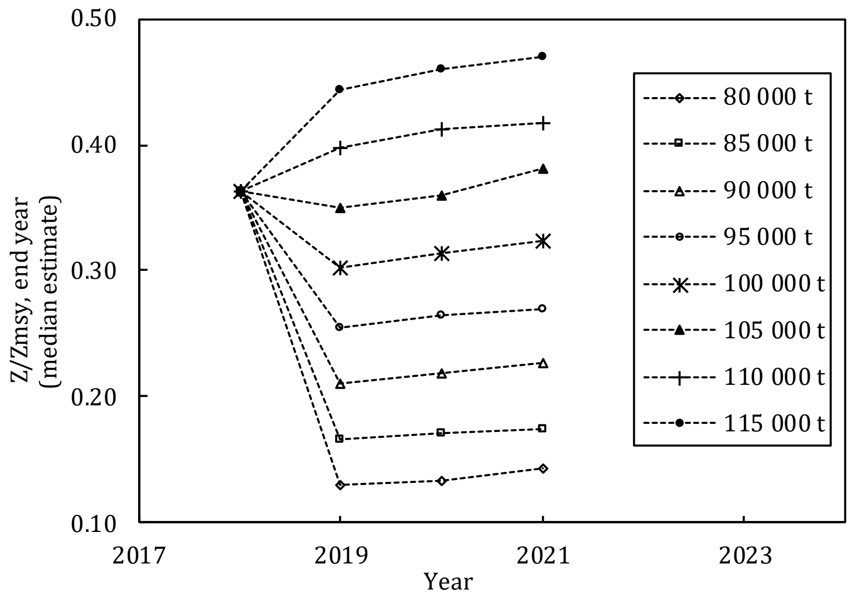


Fig. 3.12. Northern shrimp in Subarea 1 and Div. 0A: Risks of transgressing mortality and biomass precautionary limits with annual catches at 80–115 kt projected for 2019–21 with an 'effective' cod stock assumed at 34 kt.

g) Research recommendations

Survey trends inshore and offshore are divergent and NIPAG **recommended** in 2015 that *the nature and implications of this divergence is explored*.

Status: this has been and will continue to be monitored in the assessment of the stock.

NIPAG **recommended** in 2016 that *genetic stock structure in West and East Greenland should be further explored.*

Status: In progress; this recommendation is reiterated.

NIPAG **recommended** in 2017: *as information from the fishery indicates that catch sensors have been used for some time, the use of new technology which may influence the CPUE should be investigated and documented.*

Status: Completed (SCR Doc. 18/060). A review of the CPUE data was undertaken not focusing on changes in fishing technology but taking a broader perspective. The relationship between survey biomass index and the combined CPUE index of the commercial fleets indicates a shift in the beginning of the 2000s. At the same period significant replacement in the trawler fleet, the bottom temperature increased and the shrimp biomass and the fishery moved northward. After a "transition" period a new relationship between survey and CPUE index was established, where the CPUE catchability was improved compared to before the "transition" period.

NIPAG **recommended** in 2017 that *the relationship between the pre-recruit index and the subsequent years' fishable biomass should be investigated further.*

Status: In progress; this recommendation is reiterated.

NIPAG **recommended** in 2017 that *the instability of the model should be explored*.

Status: Completed: see section c) and additional detail in SCR Doc. 18-060.

NIPAG **recommended** in 2017 that *the P. montagui fishery should be explored further.*

Status: Completed (SCR Doc. 18/056). The standardized CPUE series based on logbooks was updated. In addition, a standardized LPUE series based on sale notes was initiated. Both series are relative short; 2001-2018 and 2008-2018, and because of likely fluctuating and changing reporting rates during the period, the CPUE series may not be reliable indicators of the *montagui* stock biomass. The survey time series is not considered to be a reliable indicator of stock abundance as the survey is not designed for this species. Data collection and analysis are expected to continue.

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

4. Northern shrimp (*Pandalus borealis*) in the Denmark Strait and off East Greenland (ICES Div. XIVb and Va)

(SCR Docs. 04/012, 16/045, 18/059)

a) Introduction

Northern shrimp off East Greenland in ICES Div. XIVb and Va 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 access to these fishing grounds depends strongly on ice conditions.

In the Greenland EEZ, the minimum permitted mesh size in the cod-end is 44 mm, and 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 after 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 9 000 t and 15 000 t. Since 2004 the total catch has decreased and in 2017 only 561 t were caught (Fig. 4.1). Since 2012, no or very little fishery has taken place in the southern area.

Catches in the first half year of 2018 were 545 t. Since 2015, this has mainly been an opportunistic fishery with vessels stopping off on route between other fishing grounds.

Recent catches and TACs (t) for shrimp in in the Denmark Strait and off East Greenland (ICES Div. XIVb and Va) are as follows:

	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018[1]
Recommended TAC, total area	12400	12400	12400	12400	12400	2000	2000	2000	2000	2000
Actual TAC, Greenland	12835	11835	12400	12400	12400	8300	6100	5300	5300	4300
North of 65°N, Greenland EEZ	3945	3323	1145	1893	1714	622	576	49	561	545
North of 65°N, Iceland EEZ	0	0	0	0	0	0	0	0	0	0
North of 65°N, total	3945	3323	1145	1893	1714	622	576	49	561	545
South of 65°N, Greenland EEZ	610	280	53	215	3	0	0	0	0	0
TOTAL NIPAG	4555	3602	1199	2109	1717	622	576	49	561	545

[1] Catches until July 2018

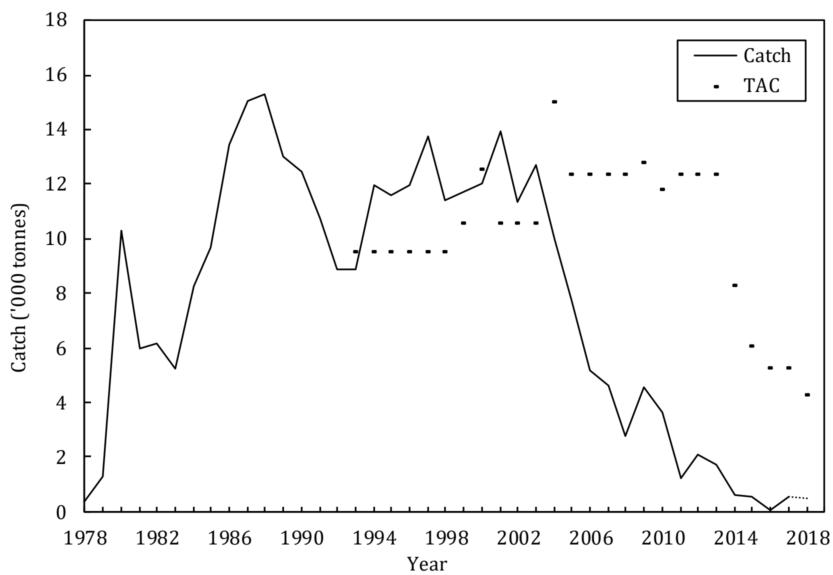


Fig. 4.1. Shrimp in Denmark Strait and off East Greenland: Catch and TAC (2018 catches until July).

b) Input data

i) 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.

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 2014 (Fig. 4.2). From 2016 the overall CPUE index increased, but the estimates for these years are based on a low number of hauls (50, 271 and 229, respectively) and are therefore subject to large uncertainty. Due to changing fishing patterns, the recent values may not reflect the state of the stock. 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 (Fig. 4.2 and Fig. 4.3). In the southern area a standardized catch rate series increased until 1998, and has since then fluctuated without a trend (Fig. 4.4). No index for the southern area has been calculated since 2012 due to a low number of hauls.

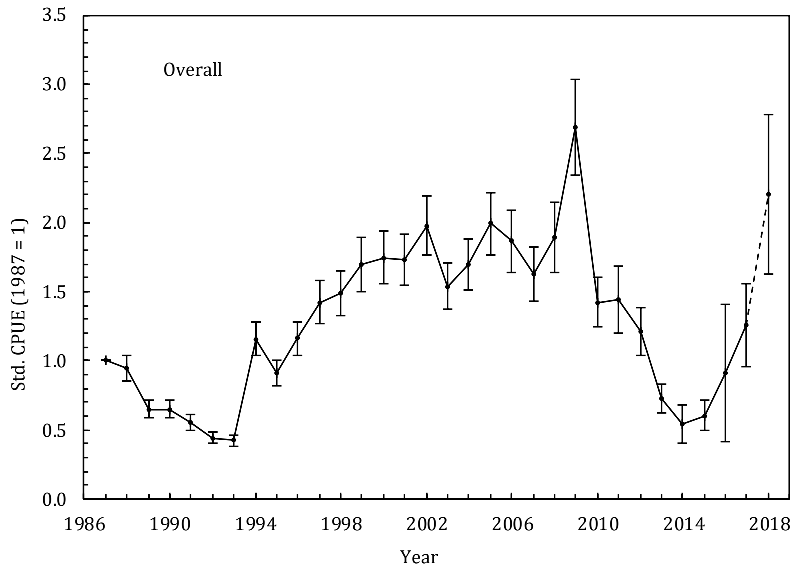


Fig. 4.2. Shrimp in Denmark Strait and off East Greenland: Annual standardized CPUE index (1987 = 1) with ± 1 SE combined for the total area. 2018 data until July (grey dotted line).

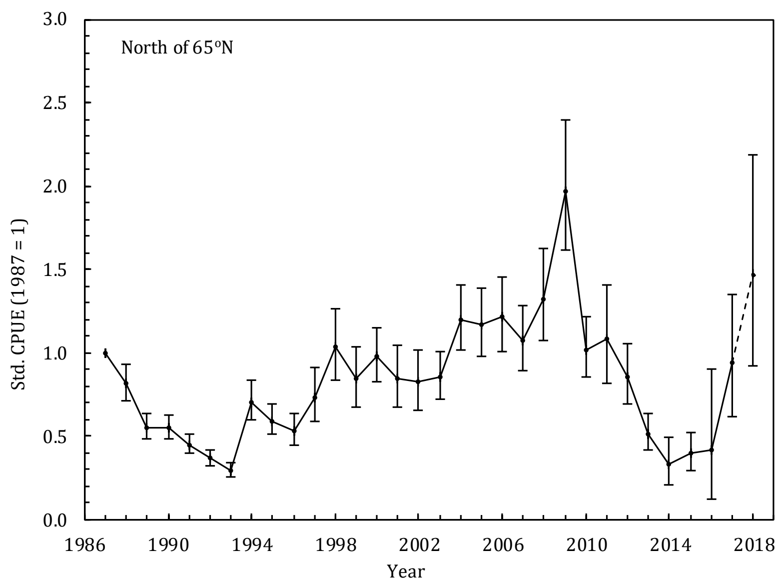


Fig. 4.3. Shrimp in Denmark Strait and off East Greenland: Annual standardized CPUE (1987 = 1) with ±1 SE fishing north of 65°N. 2018 data until July (grey dotted line).

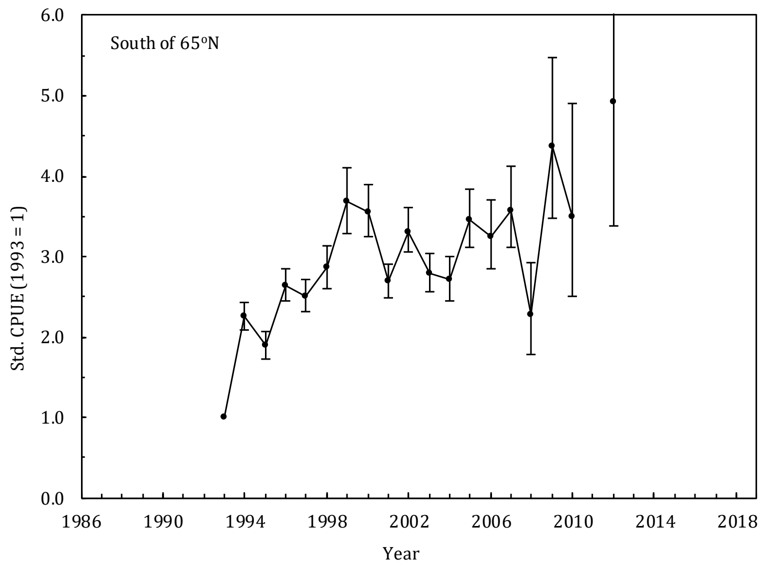


Fig. 4.4. Shrimp in Denmark Strait and off East Greenland: Annual standardized CPUE (1993 = 1) with ±1 SE fishing south of 65°N (no data for the area since 2010).

Standardized effort indices (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 (Fig. 4.5). The 2016 to 2018 levels of exploitation rate may be biased given the issues on CPUE described above.

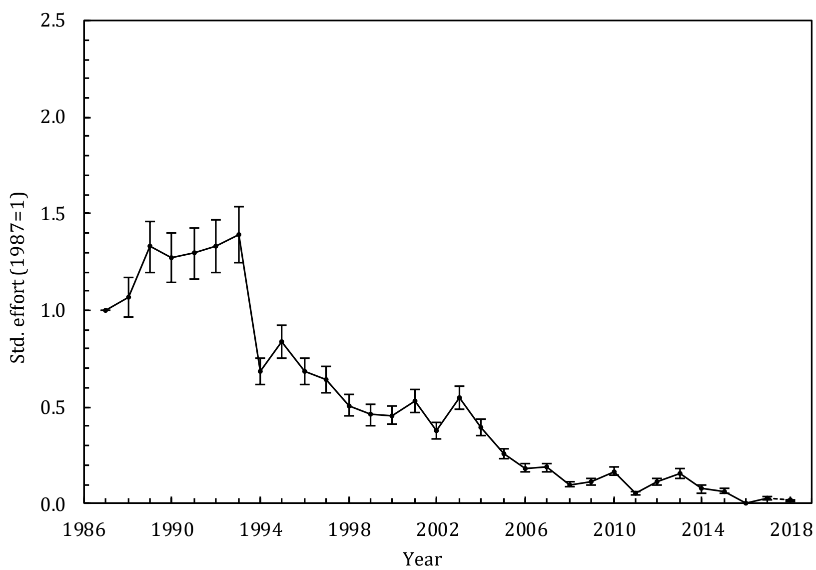


Fig. 4.5. Shrimp in Denmark Strait and off East Greenland: Annual standardized effort indices, as a proxy for exploitation rate (± 1 SE; 1987 = 1), combined for the total area (2018 effort until July).

ii) Research survey data

Trawl surveys have been conducted to assess the stock status of northern shrimp in the East Greenland area since 2008. Due to technical problems, no survey was conducted in 2017 and 2018. The main objectives of the survey are to obtain indices for stock biomass, abundance, recruitment and demographic composition. 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 has since then remained at a low level (Fig. 4.6).

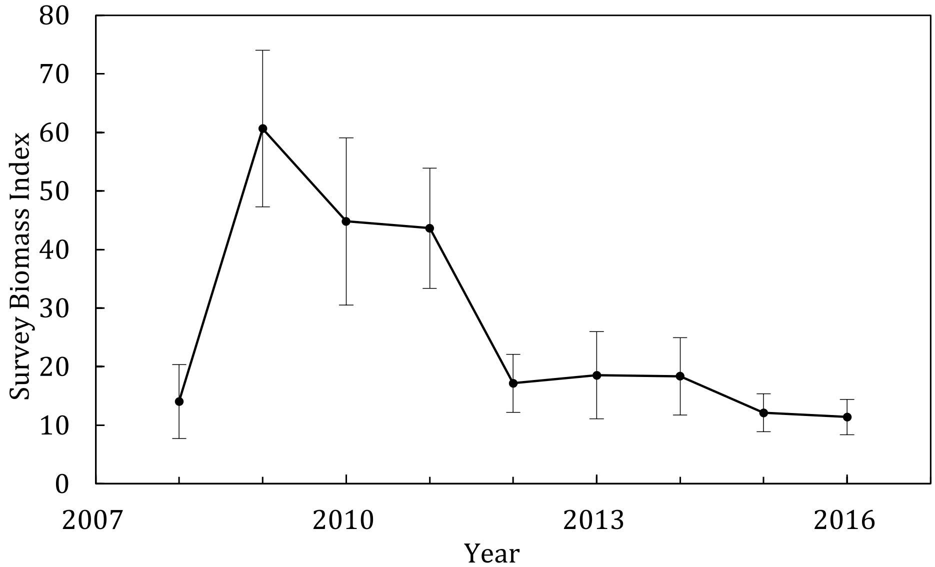


Fig. 4.6. Shrimp in Denmark Strait and off East Greenland: Survey biomass index from 2008- 2016 (± 1 SE). No survey was carried out in 2017 and 2018.

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

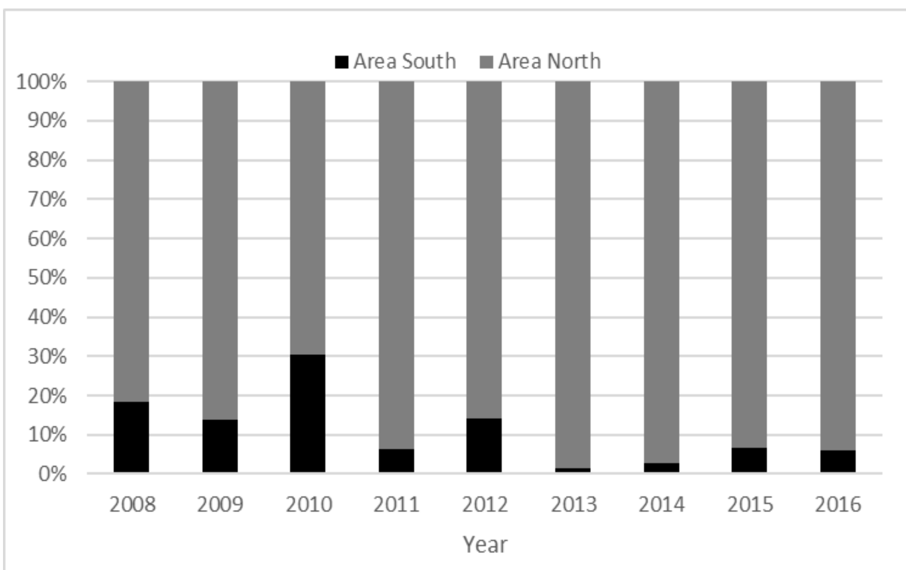


Fig. 4.7. Shrimp in Denmark Strait and off East Greenland: Distribution of survey biomass north and south of 65°N (in %) from 2008-2016. No survey was carried out in 2017 and 2018.

Stock composition. The demography in East Greenland is dominated by a large proportion of females and shows a paucity of males smaller than 20 mm CL (Fig. 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.

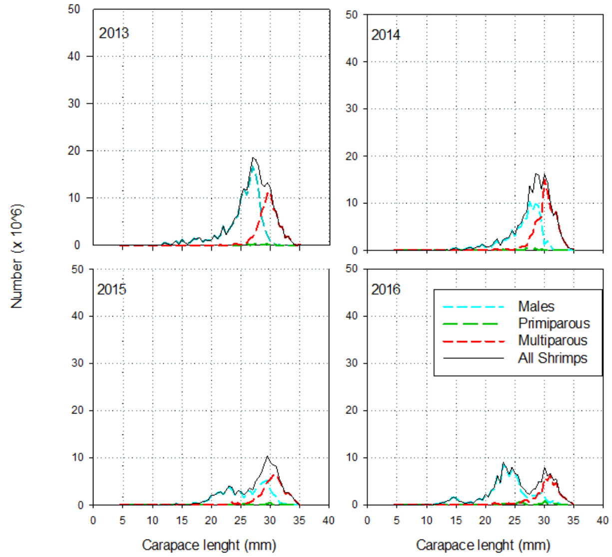


Fig. 4.8. Shrimp in Denmark Strait and off East Greenland: Numbers of shrimp by length group (CL) in the total survey area in 2013–2016. No survey was carried out in 2017 or 2018.

c) Assessment results

Evaluation of stock status is based upon interpretation of commercial fishery and research survey data. The trends in the survey and the standardized CPUE have been similar since the start of the survey, however they diverged in 2016. Since 2015, this has been an opportunistic fishery with vessels stopping off on route between other fishing grounds. This may indicate that recent CPUE values may not reflect stock status. No research survey was carried out in 2017 and 2018.

d) Reference points

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

Fig. 4.9. Shrimp in Denmark Strait and off East Greenland: Spawning stock biomass index (SSB) from 2008-2016 and precautionary approach B_{lim}. B_{lim} is defined as 15% of the maximum female biomass over the time series. No survey was carried out in 2017 and 2018.

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 since then (Fig. 4.2). Estimates for the period 2016 to 2018 are associated with higher uncertainty and, due to changes in the fishing pattern, may not reflect the state of the 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 2017 and 2018.

Exploitation rate. Since the mid-1990s the exploitation rate index has decreased, currently reaching the lowest levels seen in the time series. The 2016 to 2018 levels of exploitation rate may be biased given the issues on CPUE described above.

State of the stock. The stock size remained at a very low level in 2016 (relatively close to B_{lim}) despite several years of very low exploitation rates. There is no new information to indicate a change in stock status.

f) Research recommendations

NIPAG **recommended** in 2016 that *genetic stock structure of Pandalus borealis in West and East Greenland should be further explored.*

Status: in progress. This recommendation is reiterated.

NIPAG **recommended** in 2017 that *error bars should be added to the SSB so that risk can be assessed in relation to B_{lim}.*

Status: in progress. This recommendation is reiterated.

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

Background documentation is found in SCR Docs. 08/75; 13/68, 74; 14/66 and in the ICES Stock Annex .

a) Introduction

The shrimp in ICES Division 27.3.a (Skagerrak and Kattegat) and the eastern part of Division 27.4.a (Norwegian Deep) is assessed as one stock and is exploited by Norway, Denmark and Sweden. Shrimp fisheries expanded significantly in the early 1960s. By 1970, the landings had reached 5000 t and in 1981 they exceeded 10 000 t.

Since 1992, the shrimp fishery has been regulated by a TAC (Figure 5.1, Table 5.1). The overall TAC is shared according to historical landings, giving Norway 59%, Denmark 27%, and Sweden 14% between 2011 and 2017. The recommended TACs were until 2002 based on catch predictions. In 2003, the cohort-based assessment was abandoned and no catch predictions were available. The recommended TACs were therefore based on perceived stock development in relation to recent landings until 2013, when an assessment based on a stock production model was introduced for this stock. Thereafter, a new length-based assessment model was agreed on in a benchmark in January 2016. (ICES, 2016a).

The shrimp fishery is also regulated by a minimum mesh size (35 mm stretched), and by restrictions in the amount of landed bycatch. Sorting grids are mandatory in the whole area (see below). In 2009, an EU ban on highgrading was implemented and since 2016, the EU landing obligation applies for *Pandalus* in 27.3.a and 27.4.a. Norway has had a discard ban for many years.

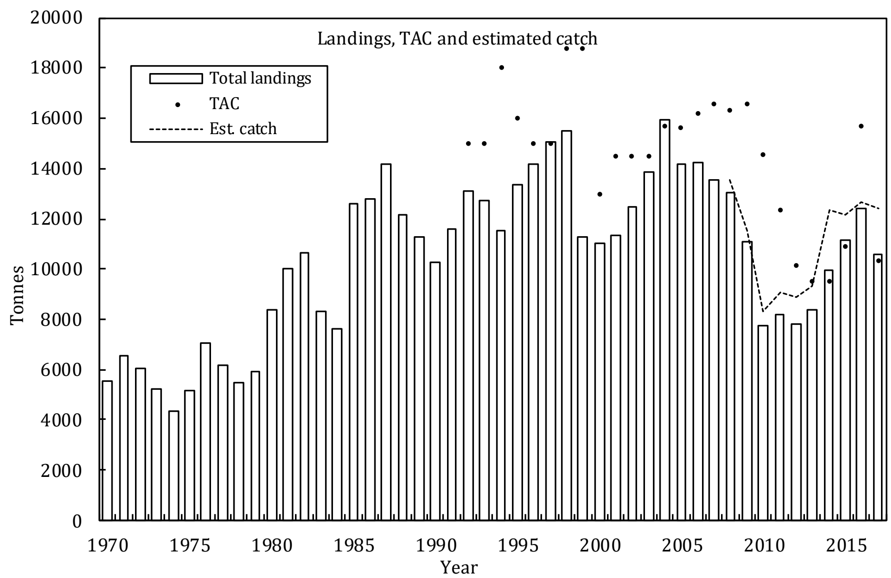


Fig. 5.1. Northern shrimp in Skagerrak and Norwegian Deep: TAC, total landings by all fleets, and total estimated catch including estimated Swedish discards for 2008–2017, and Norwegian and Danish discards for 2009–2017.

Table 5.1. Northern shrimp in Skagerrak and Norwegian deep: TACs, landings, and estimated discards and catches (t).

Year	2008	2009	2010	2011	2012	2013	2014	2015	2016[1]	2017
Advised TAC[2]	15000	15000	13000	8800	*	5800	6000	10900	13721	10316
Agreed TAC	16300	16600	14558	12380	10115	9500	9500	10900	15696	10316
Denmark landings	2274	2224	1301	1601	1454	2026	2432	2709	1997	2173
Norway landings	8261	6362	4673	4800	4852	5179	6123	6808	8305	6778
Sweden landings	2479	2483	1781	1768	1521	1191	1397	1644	2095	1634
Total landings	13014	11069	7755	8169	7827	8396	9952	11161	12397	10585
Est. Swedish discards	540	337	386	504	671	265	572	325	87	99
Est. Norw. Discards		94	133	247	292	459	1289	476	162	1549
Est. Danish discards		36	53	123	88	185	526	204	35	206
Total catch	13554	11536	8327	9043	8878	9305	12339	12166	12681	12439

[1]Advised and agreed TACs from October 2015 were changed in March 2016 following the benchmark assessment.
[2]From 2014 TAC advice has been given for catches

The Danish and Norwegian fleets have undergone major restructuring during the last 25 years. In Denmark, the number of vessels targeting shrimp has decreased from 138 in 1987 to only seven in 2017. The efficiency of the fleet has increased due to the introduction of twin trawls and increased trawl size.

In Norway, the number of vessels participating in the shrimp fishery has decreased from 423 in 1995 to 214 in 2017. Twin trawls were introduced around 2002, and in 2011–2017 were used by more than half of the Norwegian trawlers longer than 15 meters.

The Swedish specialized shrimp fleet (landings of shrimp larger than 10 t per year) has decreased from more than 60 vessels in 1995–1997 to below 40 in 2011–2017. There has not been any major change in single trawl size or design, but during the last ten years the landings of the twin trawlers have increased from 7 to over 50% (recent seven years) of the total Swedish *Pandalus* landings.

Landings and discards. Total landings have varied between 7500 and 16 000 t during the last 30 years. In the Swedish and Norwegian fisheries, approximately 50% of catches (large shrimp) are boiled at sea, and almost all catches are landed in home ports. Since 2002, an increasing number of the Danish vessels are boiling the shrimp on board and landing the product in Sweden to obtain a better price. The rest is landed fresh in home ports. In the total catch estimates the boiled fraction of the landings has been raised by a factor of 1.13 to correct for weight loss caused by boiling. Total catches, estimated as the sum of landings and discards, decreased from 2008 to 2012, to 8800 t, but has since increased to more than 12 400 t in 2017 (Table 5.1 and Figure 5.1).

Shrimps may be discarded to replace small and medium-sized, lower-value shrimps with larger and more profitable ones ("highgrading"). Since 2016, shrimp <15 mm CL are marketable, but fetch a lower price than medium-sized shrimp. The Swedish fishery has often been constrained by the national quota, which may have resulted in highgrading. Based on on-board sampling by observers, discards in the Swedish fisheries were estimated to be between 12 and 31% of total catch for 2008–2015, and Danish discards were estimated to be between 2 and 18% for 2009–2015. In 2016, due to the landing obligation, discarding decreased to 4 and 2% in Sweden and Denmark respectively. In 2017, the discard percentages were 6 and 9%, respectively. In 2017, approximately 80% of the Swedish landings were caught with mesh sizes of at least 45 mm. From 2009 onwards, Norwegian discards in Skagerrak were estimated applying the Danish discards-to-landings ratio to the Norwegian landings. In 2017, Norwegian discards were estimated by comparing length–frequency distributions of on-board samples of unsorted catches with samples from landings.

Bycatch and ecosystem effects. Shrimp fisheries in the Norwegian Deep and Skagerrak have bycatches of 10–23% (by weight) of commercially valuable species, which are legal to land if quotas allow (Table 5.2). Since 1997, trawls used in Swedish national waters must be equipped with a Nordmøre grid (no fish retention device), with a bar spacing of 19 mm, which excludes fish > approximately 20 cm length from the catch. Landings delivered by vessels using grids comprise 95–99% of shrimp (Table 5.2). Following an agreement between EU and Norway, the Nordmøre grid has been mandatory since 1st February 2013 in all shrimp fisheries in Skagerrak (except Norwegian national waters within the 4 nm limit). From 1st of January 2015, the grid has also been mandatory in shrimp fisheries in the North Sea south of 62°N. If the fish quotas allow, it is legal to use a fish retention device of 120 mm square mesh tunnel at the grid's fish outlet.

Table 5.2. Northern shrimp in Skagerrak and Norwegian Deep: Bycatch landings by the *Pandalus* fishery in 2017. Combined data from Danish and Swedish logbooks and Norwegian sale slips (t).

	SD IIIa, grid		SD IIIa, grid+fish tunnel		SD IVa East, grid+fish tunnel	
Species:	Landings (t)	% of total landings	Landings (t)	% of total landings	Landings (t)	% of total landings
Pandalus	639.5	97.0	7130.1	79.8	1857.9	77.4
Norway lobster	5.0	0.8	27.9	0.3	5.2	0.2
Anglerfish	0.2	0.0	105.0	1.2	63.2	2.6
Whiting	0.0	0.0	6.2	0.1	0.7	0.0
Haddock	0.1	0.0	44.3	0.5	11.5	0.5
Hake	0.1	0.0	25.5	0.3	48.3	2.0
Ling	0.1	0.0	55.8	0.6	38.0	1.6
Saithe	1.0	0.2	650.9	7.3	181.5	7.6
Witch flounder	0.1	0.0	78.1	0.9	2.8	0.1
Norway pout	11.0	1.7	63.6	0.7	33.5	1.4
Cod	1.5	0.2	569.6	6.4	105.2	4.4
Other marketable fish	0.9	0.1	178.1	2.0	51.0	2.1

The use of a fish retention device also prevents the escape of larger individuals of non-commercial species. Deep-sea species such as roundnose grenadier, rabbitfish, and sharks are frequently caught in shrimp trawls in the deeper parts of Skagerrak and the Norwegian Deep. No quantitative data on this mainly discarded catch are available and the impact on stocks is difficult to assess.

Catches of demersal fish species in the Campelen-trawl of the Norwegian annual shrimp survey covering Skagerrak and the Norwegian Deep (see below) give an indication of the level of potential bycatch of non-commercial species in shrimp trawls (Table 5.3 and Figure 5.2).

The catches of demersal fish in the Campelen-trawl are also used to calculate an index of potential shrimp predators. The large interannual variation in this predator biomass index is mainly due to variations in the indices of saithe and roundnose grenadier, which in some years are important components. The catch of these species depends to some extent on which survey stations are trawled, as the largest densities of saithe are found in shallow water and roundnose grenadier is found in deep water. The peak in 2013 was due to a high abundance of blue whiting. An index of potential shrimp predators without these three species varied without a trend from 2007 to 2015, but has been at a higher level since 2017, indicating higher biomass of potential predators in the last two years (Figure 5.2; the 2016 survey data were omitted, see below). This is in agreement with increasing trends in stock size observed in recent stock assessments of demersal fish species in the North Sea and Skagerrak (ICES, 2016b; ICES, 2016c).

Table 5.3. Northern shrimp in Skagerrak and Norwegian Deep: Estimated indices of predator biomass (catch in t per square nautical mile) from the Norwegian shrimp survey in 2007–2018. The 2016 survey data have been omitted (see text for details).

Species English	Latin	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2017**	**2018**
Blue whiting	*Micromesistius poutassou*	0.13	0.12	1.21	0.27	0.62	3.30	29.03	1.88	5.25	31.18	6.38
Saithe	*Pollachius virens*	39.75	208.32	53.89	18.53	7.52	5.66	112.80	14.13	8.56	9.71	12.87
Cod	*Gadus morhua*	1.28	0.78	2.01	1.79	1.66	1.26	1.69	2.92	2.37	2.00	2.05
Roundnosed grenadier	*Coryphaenoides rupestris*	6.85	19.02	19.03	10.05	4.99	4.43	1.97	2.90	1.46	1.41	2.17
Rabbit fish	*Chimaera monstrosa*	2.15	3.41	3.26	3.51	2.73	2.22	3.05	3.90	2.19	5.99	5.03
Haddock	*Melanogrammus aeglefinus*	4.21	1.85	3.18	3.46	5.82	5.75	5.18	2.15	2.60	1.86	1.51
Redfish	Scorpaenidae	0.40	0.26	0.43	0.80	1.02	0.37	0.47	0.48	0.20	0.53	0.97
Velvet belly	*Etmopterus spinax*	2.58	1.95	2.42	2.52	1.47	1.59	2.67	1.91	2.51	4.19	3.85
Skates, rays	Rajidae	0.95	0.64	0.17	0.60	0.88	0.98	1.00	2.25	1.69	1.64	1.20
Long rough dab	*Hippoglossoides platessoides*	0.64	0.42	0.28	0.47	0.51	0.56	0.56	1.17	1.45	0.94	0.81
Hake	*Merluccius merluccius*	0.78	0.64	2.56	1.60	0.56	0.52	1.06	0.69	0.59	1.24	1.66
Angler	*Lophius piscatorius*	0.91	0.87	1.25	1.70	0.92	0.17	0.65	0.75	0.58	1.13	0.57
Witch	*Glyptocephalus cynoglossus*	0.74	0.54	0.16	0.13	0.24	0.29	0.27	0.35	1.38	0.47	0.17
Dogfish	*Squalus acanthias*	0.19	0.28	0.14	0.11	0.21	0.60	1.02	1.00	0.36	0.42	0.45
Black-mouthed dogfish	*Galeus melastomus*	0.05	0.05	0.15	0.09	0.09	0.09	0.12	0.11	0.35	0.26	0.24
Whiting	*Merlangius merlangus*	1.01	1.35	3.02	2.42	3.07	1.64	2.02	3.38	1.59	2.60	4.56
Blue Ling	*Molva dypterygia*	0	0	0	0	0	0	0.01	0.01	0.03	0.01	0.03
Ling	*Molva molva*	0.11	0.34	0.79	0.64	0.24	0.17	0.22	0.32	0.63	0.90	0.99
Four-bearded rockling	*Rhinonemus cimbrius*	0.14	0.04	0.03	0.05	0.03	0.09	0.04	0.06	0.12	0.04	0.05
Cusk	*Brosme brosme*	0	0.02	0.05	0.13	0.29	0.04	0.10	0.05	0.19	0	0.14
Halibut	*Hippoglossus hippoglossus*	0.07	3.88	0.09	0.20	0.05	0.19	0	0	0.10	0.16	0.09
Pollack	*Pollachius pollachius*	0.25	0.03	0.13	0.12	0.15	0.07	0.24	0.65	0.23	0.10	0.15
Greater forkbeard	*Phycis blennoides*	0	0	0.01	0.04	0.02	0.05	0.06	0.12	0.05	0.18	0.22
Total		63.19	244.81	94.26	49.23	33.09	30.04	164.23	41.18	34.48	66.96	46.16
Total (except saithe and roundnosed grenadier)		16.59	17.47	21.34	20.65	20.58	19.95	49.46	24.15	24.46	55.84	31.12

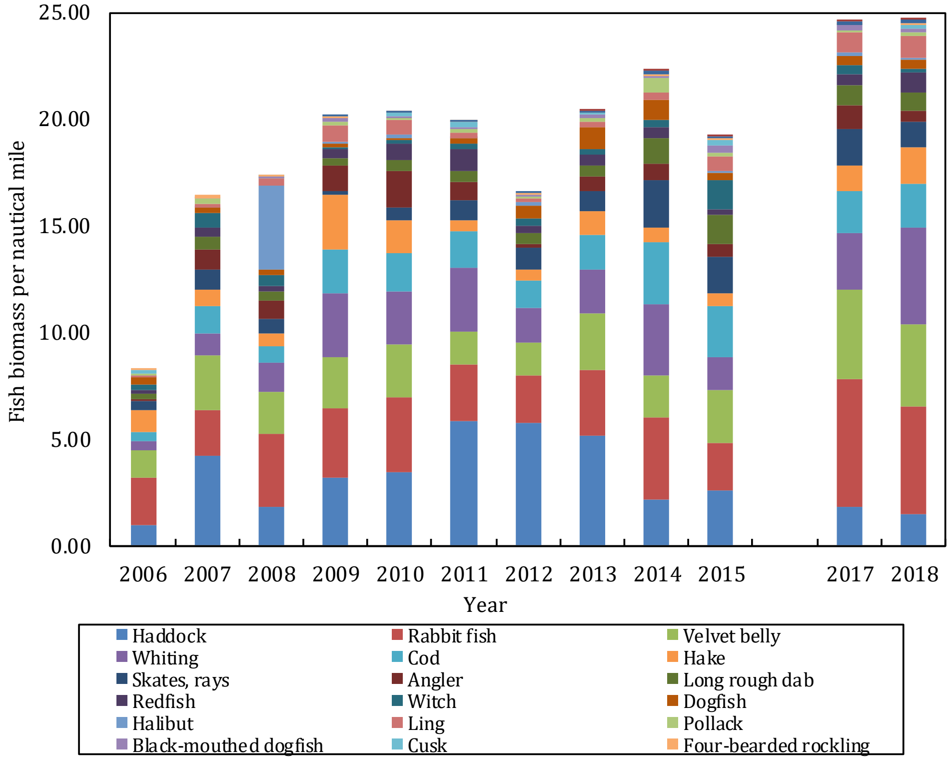


Fig. 5.2. Northern shrimp in Skagerrak and Norwegian Deep: Estimated indices of predator biomass (catch in t per square nautical mile) from the Norwegian shrimp survey in 2006–2018 excluding saithe, roundnose grenadier and blue whiting. The 2016 survey data have been omitted (see text for details).

b) Input data

i) Fishery data

Danish, Swedish and Norwegian catch and effort data from logbooks have been analysed and standardized (SCR Doc. 08/75). There was an increasing trend in the standardized lpue for all three series from 2000 to 2007 followed by a decreasing trend until 2012. All three series have generally increased since 2012, but the estimates for 2016 and 2017 are slightly lower than for 2015 (Fig. 5.3).

Time-series of standardized effort indices from Norway and Denmark have been fluctuating without any clear trend since the late 1990s while the Swedish standardized effort has decreased (Fig. 5.4).

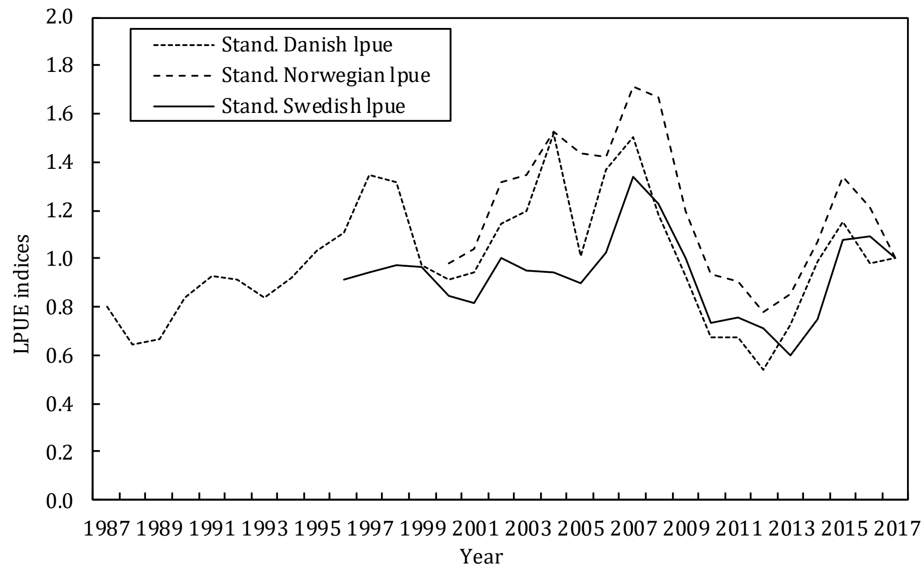


Fig. 5.3. Northern shrimp in Skagerrak and Norwegian Deep: Danish, Norwegian and Swedish standardized landings per unit effort (lpue) until 2017. Each series is standardized to its final year.

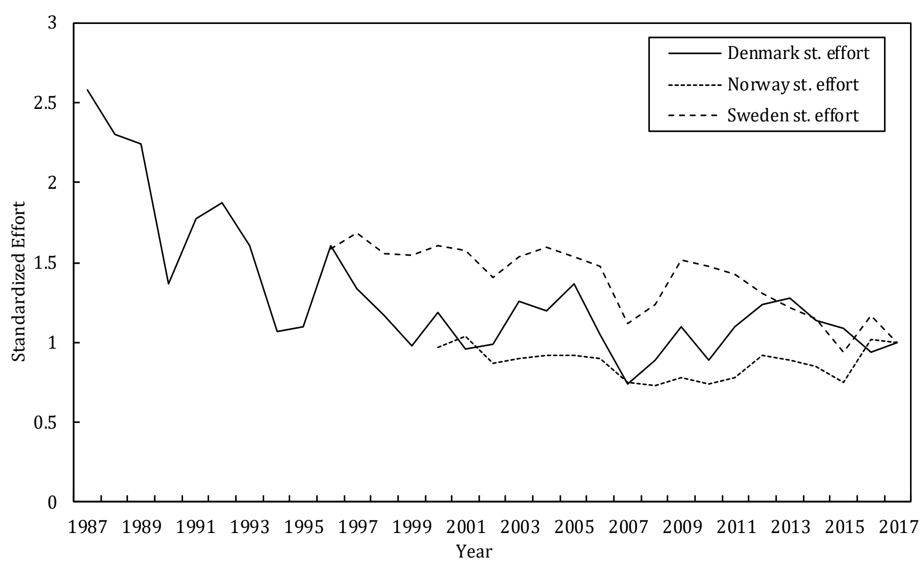


Fig. 5.4. Northern shrimp in Skagerrak and Norwegian Deep: Estimated standardized effort. Each series is standardized to its final year.

ii) Sampling of catches

Length frequencies of the commercial catches from 1985 to 2017 have been obtained by sampling. The samples also provide information on sex distribution and maturity. Numbers-at-length are input data to the length-based assessment model for this stock (see below).

iii) Survey data

The Norwegian shrimp survey went through large changes in vessel, gear and timing in 2003–2006, resulting in four indices: Survey 1: October/November 1984–2002 with Campelen trawl; Survey 2: October/November 2003 with shrimp trawl 1420; Survey 3: May/June 2004–2005 with Campelen trawl; and Survey 4: January/February 2006–present with Campelen trawl.

Due to time and weather restrictions not all survey strata were covered in all years. The following years have missing strata: 1984, 1986, 2002, 2006, 2012, 2014, and 2015 (Fig. 5.5). The index of total biomass for these years has been standardized by applying the missing strata's mean portion of the total biomass (averaged over all years with complete coverage) to the total biomass of the year. However, total numbers-at-length have not yet been standardized, which means that the length-based model (see below) uses unstandardized survey data.

In 2016, there were technical problems with the survey trawl (unequal wire lengths of the trawl gear) and this year's data have therefore been omitted from the time-series.

The biomass peaked in 2007, then declined until 2012. The index thereafter increased until 2015 but decreased again in 2017 and 2018 to the 2014 level (Fig. 5.5). The survey time-series has not been standardized for variability of factors such as swept volume, spatial coverage and trawling speed, which might add uncertainty to the stock estimates. A recruitment index has been calculated for the fourth survey time-series as the abundance of age 1 shrimp. The recruitment index declined from 2007 to 2010, and has since fluctuated at a lower level except for a peak in 2014 (Fig. 5.6). The 2017 year class is estimated to be around the average of the last ten years.

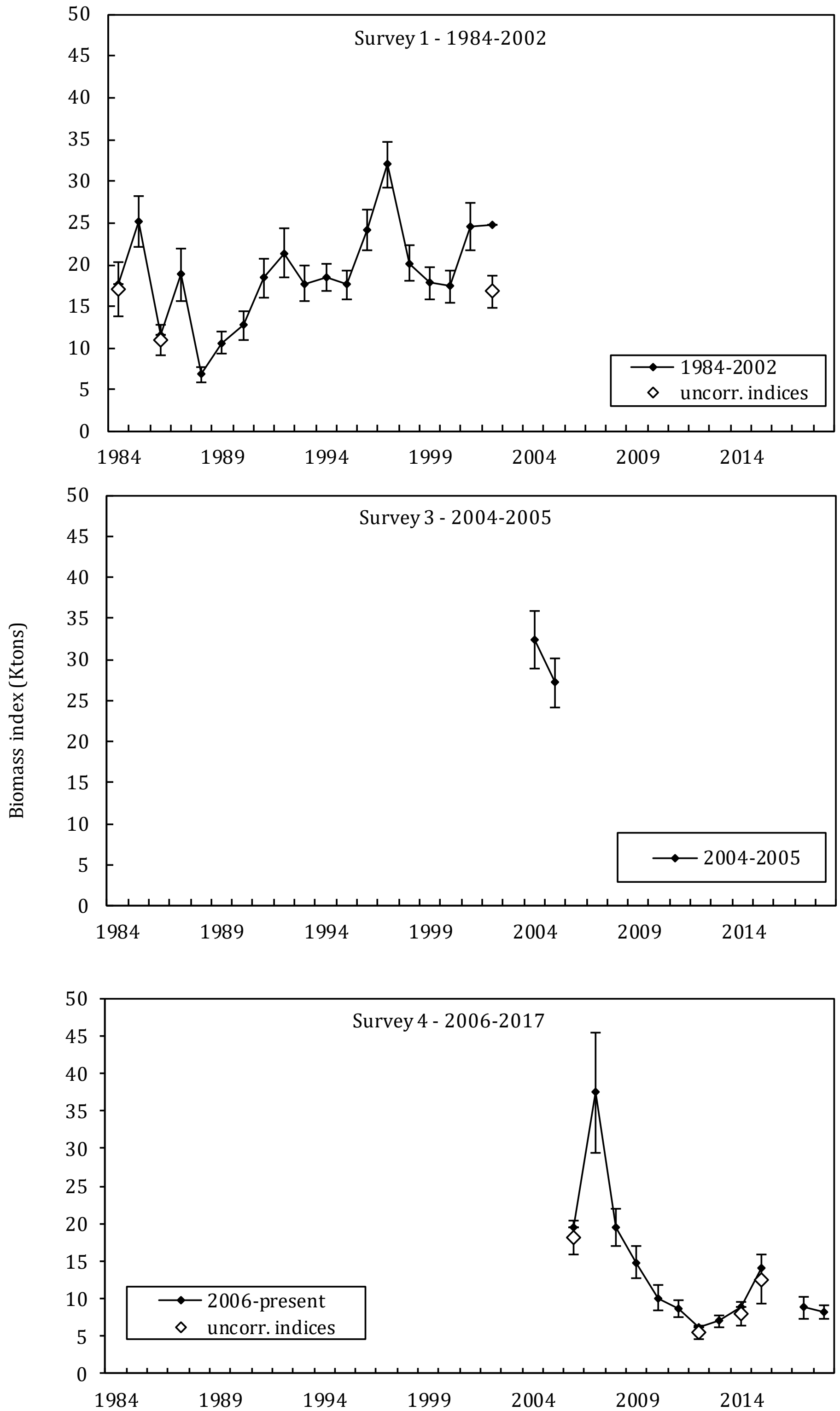


Fig. 5.5. Northern shrimp in Skagerrak and Norwegian Deep: Estimated survey biomass index in 1984–2018. The point estimate of 2003 is not shown. The 2016 survey data have been omitted (see text for details).

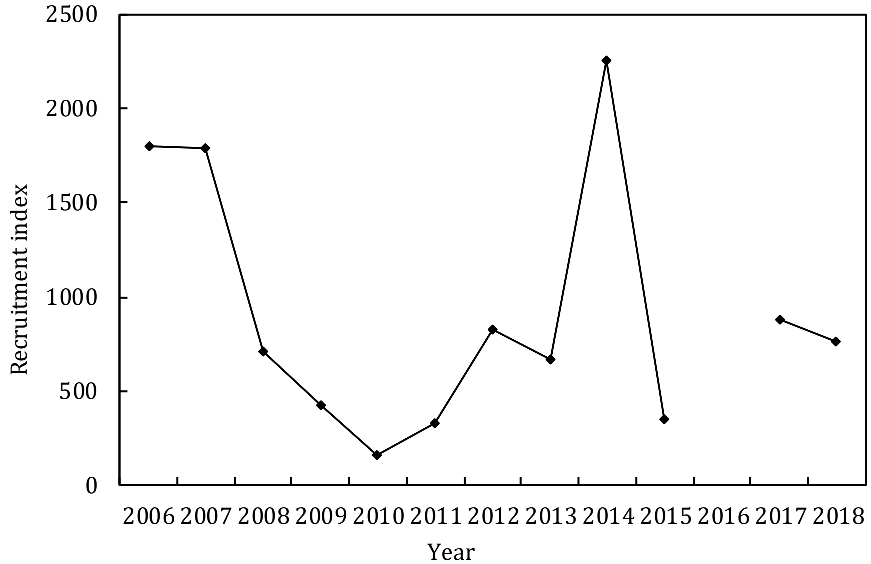


Fig. 5.6. Northern shrimp in Skagerrak and Norwegian Deep: Estimated recruitment index, 2006–2018. The 2016 survey data have been omitted (see text for details).

c) Assessment

i) Model

The stock assessment was benchmarked in January 2016 (ICES, 2016a). At the benchmark it was decided that a length-based Stock Synthesis (SS3) statistical framework (ICES, 2016a, and references therein) should replace the surplus production model (SCR Doc. 15/059) used since 2013, to assess status of the stock and form a basis for advice. New reference points were also defined at the 2016 benchmark (ICES, 2016a).

ii) Assessment results

SS3 model diagnostics of this year's run do not indicate any issues with the model fit.

iii) Sensitivity analysis

The benchmark in 2016 (ICES, 2016a) recognized the uncertainty in the current assumption of M = 0.75 to the assessment, which is based on estimates from the Barents Sea in the 1990s (Barenboim *et al*., 1991), and recommended that the sensitivity of model outputs and catch advice to the specifications of M should be explored. Preliminary sensitivity analyses of the assessment model regarding different levels of M carried out at the 2016 NIPAG meeting, showed that M = 0.90 did not change the perception of the current level of F and SSB relative to the reference points of F_{MSY} and $MSY\ B_{trigger}$ compared with M = 0.75 (base model) (Fig. 5.7). However, shrimp in the Norwegian Deep/Skagerrak are considered to have a lifespan of only about half of that of shrimp in the Barents Sea and it is therefore likely that M could be substantially higher and outside the 0.75–0.90 range explored. Previous analyses of different M assumptions for this stock (SCR 14/66) provide support for this hypothesis. NIPAG was not in a position at the meeting to fully explore the sensitivity to the M assumption used and stresses the importance of further investigations to be conducted well in advance of the next proposed benchmark in 2019–2020.

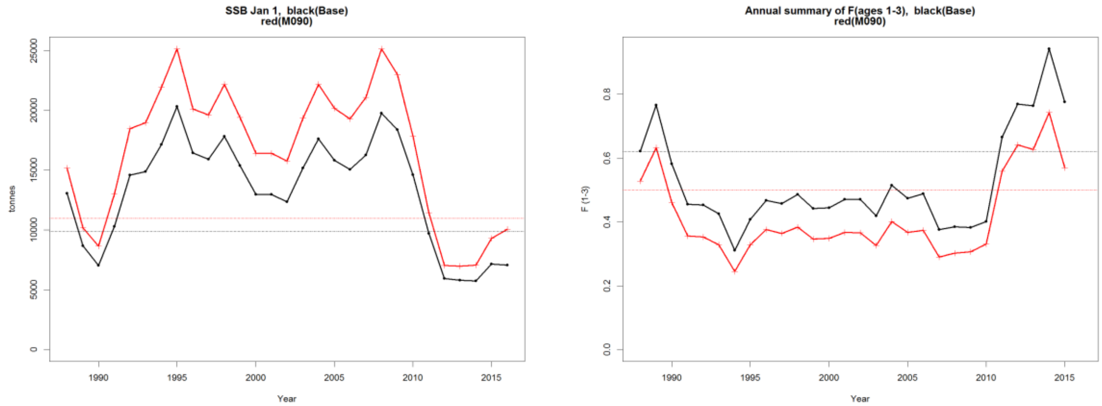


Fig. 5.7. Northern shrimp in Skagerrak and Norwegian Deep: *F* and SSB assessment results for natural mortality *M* = 0.75 (base model, black) and *M* = 0.90 (red). The horizontal lines indicate *MSY* $B_{trigger}$ (left panel) and F_{MSY} (right panel) values for each of the two *M*-levels.

iv) Historical stock trends and recruitment

Historical stock trends are shown in Figure 5.8.

Since 2008, when SSB was 22 443 t, which is the highest SSB estimate of the time-series, the SSB decreased to the time-series low of 6193 t in 2012. The SSB then increased up to 2016, but decreased again to 7835 t in 2018.

SS3 models recruitment as the abundance of the 0-group. A series of lower recruitment years between 2008 and 2017, with the exception of year 2013, should be noted. During this period of lower recruitment, the estimates of SSB were also for some years historically low and below B_{lim}. The uncertainty around the estimate of recruitment in 2017 is relatively large. The reason for this is that the model has not yet fully seen the recruits in the fishery data (catch data are until mid-2018) but only in the survey data (collected in January 2018).

Fishing mortality (*F*) for ages 1 to 3 remained relatively stable from the beginning of the 1990s to about 2010. After 2010, *F* increased steeply to 0.74 in 2014. *F* then decreased slightly in 2015, to increase again to 0.74 in 2017, which is the highest value of the time-series. Since 2011, the stock has been exploited at a level greater than the F_{MSY} of 0.62, except in 2015 and 2016.

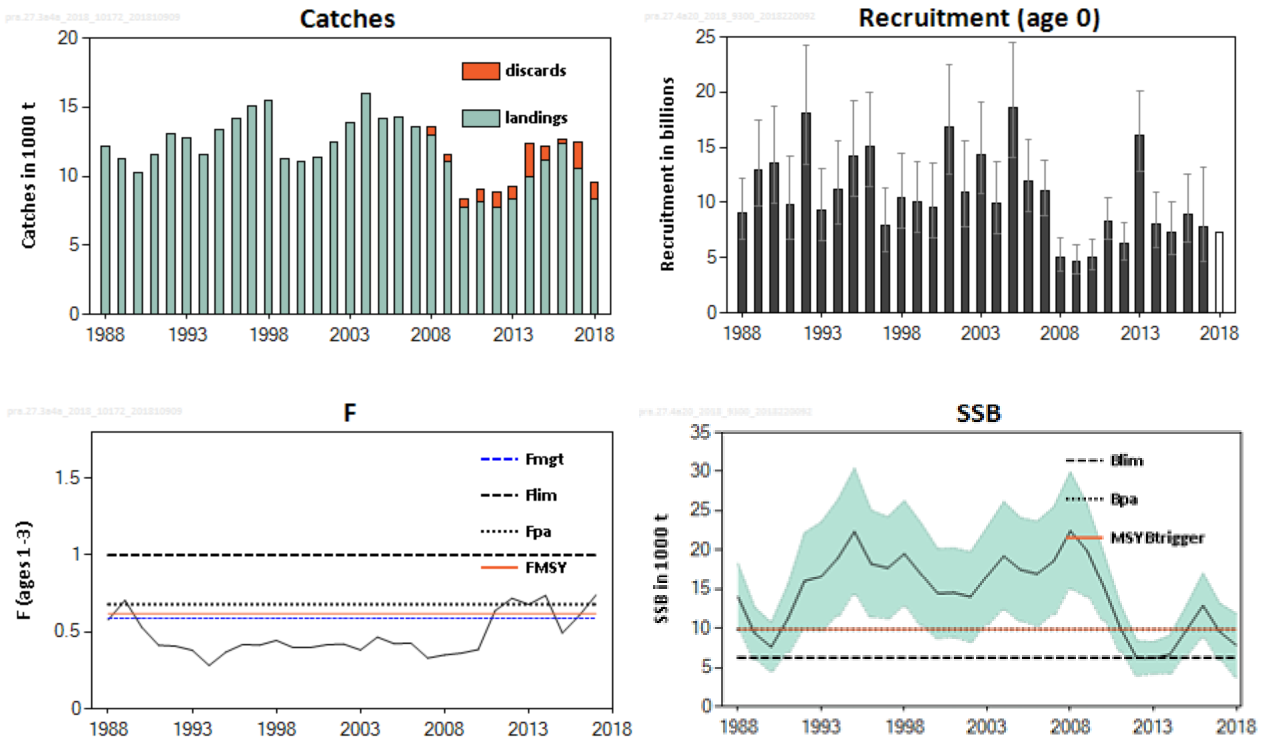
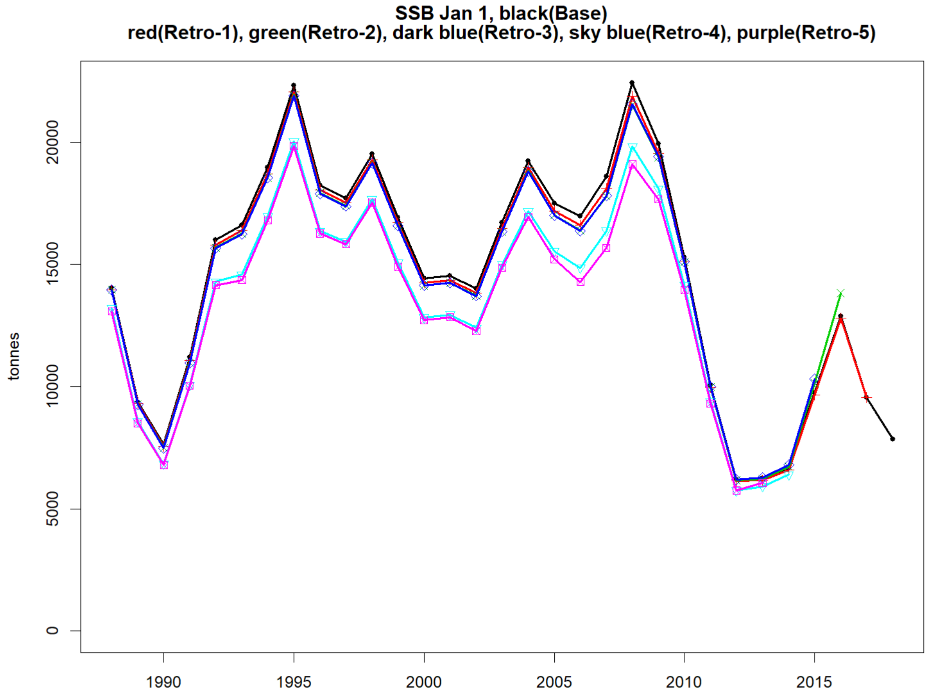
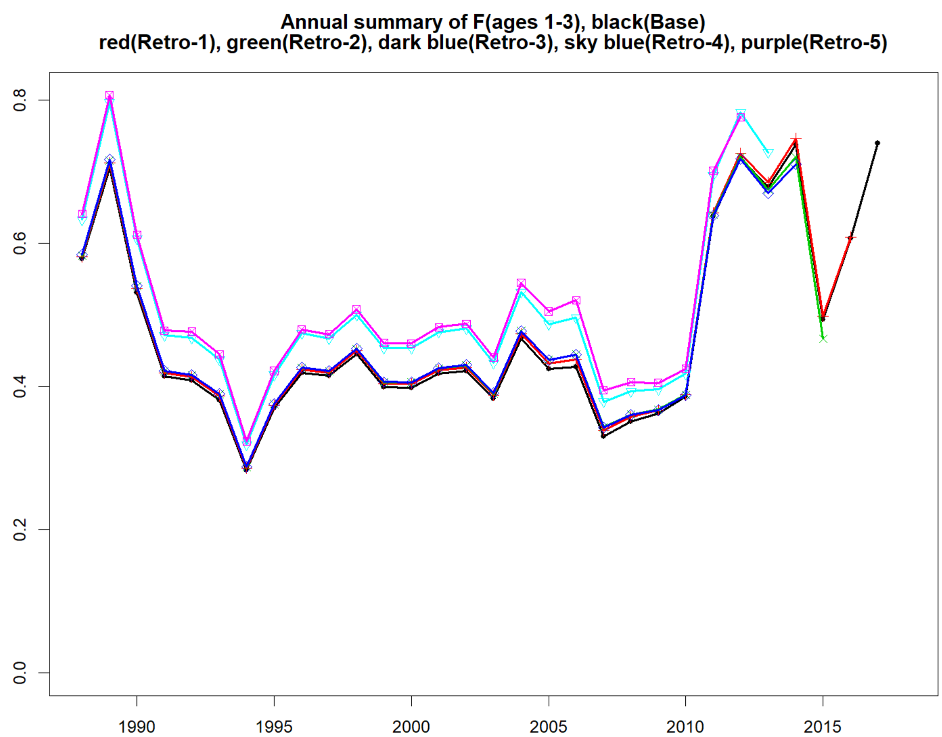


Fig. 5.8. Northern shrimp in Skagerrak and Norwegian Deep: Summary assessment output. Total catch, including estimated discards since 2008 (tonnes) and *F*, SSB and *R* assessment results. Catch in 2018 is equal to the TAC. SSB and *R* are depicted with 90% confidence intervals. The assumed recruitment value (geometric mean of the last ten years) for 2018 is unshaded.

v) Model retrospective





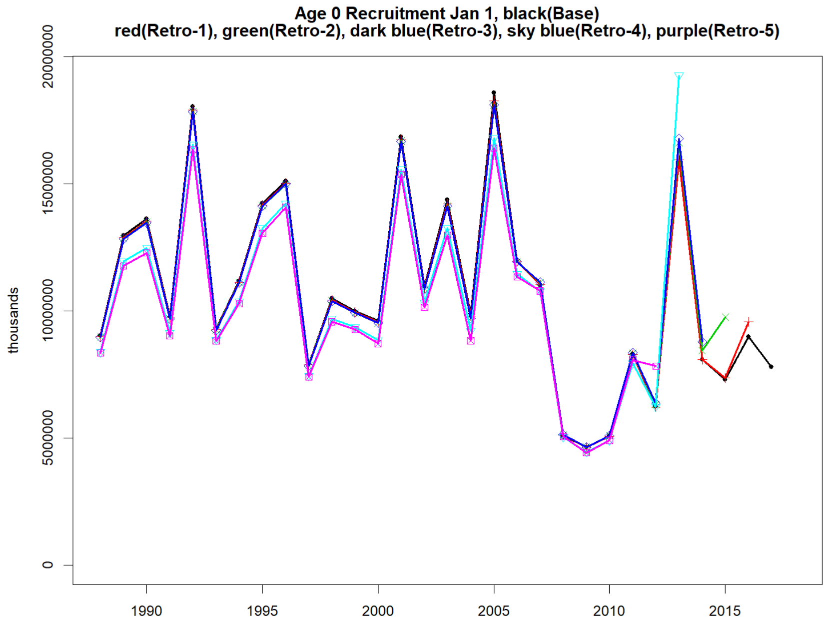


Fig. 5.9. Northern shrimp in Skagerrak and Norwegian Deep: Model retrospective of SSB, F(ages 1–3) and R.

Model retrospective for the assessment made in March 2018 is shown in Fig. 5.9 and are expected to be very similar to the assessment in October 2018. There is a moderate retrospective pattern for the historical part of the time-series of SSB and *F*, but the retrospective pattern is small after 2009 for SSB and after 2013 for *F*. Recruitment does not show any particular retrospective pattern for any part of the time-series. New retrospective runs will be made during the assessment in March 2019.

vi) New long term management strategy

In April 2018 following an MSE (ICES, 2017a), a long-term management strategy (Anon., 2018) was agreed between EU and Norway: values for B_{MGT} ($B_{TRIGGER}$) and F_{TARGET} are fixed at levels of 9 900 t and 0.59, respectively. The TAC will be established for each calendar year (from January 1st to December 31st).

- By end of the year N-1, a preliminary TAC will be adopted by the Parties based on ICES catch forecast for the six first months of the year N, released in March of year N-1.
- The Parties will establish the final TAC for the entire year N in light of the ICES catch advice released in March of year N.

When establishing the preliminary and the final TACs the following rules shall apply:

a. When the SSB at the start of the year is estimated at or above B_{MGT} the Parties will fix a TAC consistent with a fishing mortality rate of F_{TARGET}.
b. When the SSB at the start of the year is estimated below B_{MGT}, the Parties will fix a TAC consistent with a fishing mortality rate of F_{TARGET} x (SSB/B_{MGT}).

The TAC will include all removals made from the stock.

When SSB is estimated to be at or above B_{MGT}, the TAC derived from paragraph (a) can be deviated with up to 10% according to the agreed "banking and borrowing" scheme described in Annex III of the agreed record (Anon., 2018).

The LTMS will be applicable from 1st of January 2019 onwards.

The management strategy shall be revised by the end of 2021 or following the next ICES benchmark of the stock.

The advised TAC for the first two quarters of year *N* is based on multiplying the full TAC from the short term forecast for year *N* with the average proportion of quarterly catches ([Q1+Q2]/[Q1+Q2+Q3+Q4]) from the previous 5 years.

When the EU and Norway LTMS is fully implemented in 2019 it will rely on annual ICES advice issued in March. In the current transition phase the clients have requested ICES to issue an advice for the first two quarters of 2019, based on the LTMS, in October 2018.

d) Reference points

The reference points were computed at the benchmark in January 2016 based on the definition of the *Pandalus* stock as being a medium-lived species (ICES, 2016a; Table 5.4).

In 2009, ICES adopted a "Maximal Sustainable Yield (MSY) framework" (ACOM. ICES Advice, 2016. Book 1. Section 1.2) for deriving advice. It considers two reference points: F_{MSY} and $MSY\ B_{trigger.}$ (Table 5.4). Under the ICES PA two reference points are also required; B_{lim} and B_{pa} (Table 5.4). B_{lim} was set to $B_{loss,}$ which is the lowest observed value of the time-series estimated at the benchmark in 2016.

Two new reference points were computed as part of the MSE, F_{MGT} (F_{target}) and B_{MGT} ($B_{trigger}$) (ICES, 2017a). As part of the MSE, ICES also reviewed the MSY reference points for this stock, applying the stock-specific assessment/advice error settings developed for this *Pandalus* stock as part of the management strategy evaluation work. Applying the ICES guidelines (ICES, 2017b) for the calculation of reference points, the analysis resulted in an update of the F_{MSY} value to F_{MSY} = 0.60 (previously 0.62), whereas $MSY\ B_{trigger}$ = 9900 t remained unchanged. The lower F_{target} for the HCR compared to the F_{MSY} is due primarily to the more stringent risk criterion of the HCR.

Table 5.4. Northern shrimp in Skagerrak and Norwegian Deep: Reference points, values, and their technical basis.

Framework	Reference point	Value	Technical basis
MSY approach	MSY $B_{trigger}$	9900 t	The 5th percentile of the equilibrium distribution of SSB when fishing at F_{MSY}, constrained to be no less than B_{pa}
	F_{MSY}	0.60	The *F* that maximizes median equilibrium yield (defining yield as the total catch)
Precautionary approach	B_{lim}	6300 t	B_{loss} (lowest observed SSB in the benchmark assessment 2016)
	B_{pa}	9900 t	$B_{lim} \times \exp(1.645 \times \sigma)$, where $\sigma = 0.27$
	F_{lim}	1.00	The *F* that leads to 50% probability of SSB < B_{lim}
	F_{pa}	0.68	$F_{lim} \times \exp(-1.645 \times \sigma)$, where $\sigma = 0.23$
Management plan	B_{MGT}	9900 t	The 5th percentile of the equilibrium distribution of SSB when fishing at F_{MGT}, constrained to be no less than B_{pa}
	F_{MGT}	0.59	The *F* that maximizes median equilibrium yield (defining yield as the total catch)

Catch scenarios

Table 5.5. Northern shrimp in Skagerrak and Norwegian Deep: The basis for the catch options.

Variable	Value	Notes
F_{2018}	0.56	Corresponds to the estimated catches in 2018 = TAC.
SSB_{2019}	8685 t	
R_{2018}	7186405	GM 2008–2017
Catch (2018)	9512 t	Based on a TAC constraint of 9512 (8900 + 612 banked from 2017) tonnes for 2018.

Given an estimated catch of 9512 t in 2018 (TAC of 8900 t + 612 t banked from 2017), catch scenarios were evaluated for 2019 (Table 5.6). The advised TAC for the first two quarters of 2019 is based on multiplying the full TAC from the short term forecast for 2019 with the average proportion of quarterly catches from the previous 5 years, which gives a factor of 0.51 (SD=0.04). When applied to the full 2019 advised TAC of 9036 t this results in an advised TAC for the first two quarters of 2019 of 4608 t.

Table 5.6. Northern shrimp in Skagerrak and Norwegian Deep: The catch scenarios for the full year 2019.

Basis	Total catch (2019)	Q1 and Q2 catch ^	F_{total} (2019)	SSB (2020)	% SSB change *	% Annual TAC change **	% Annual advice change ***
ICES advice basis							
Long-term management strategy: $F_{MGT} = 0.59 \times (SSB_{2019}/9900)$	9036	4608	0.52	8851	1.9	1.5	5.4
Other scenarios							
F = 0	0	0	0	14929	71.9	−100.0	−100.0
F_{pa}	10993	5606	0.68	7627	−12.2	23.5	28.3
F_{MSY}	10048	5124	0.60	8212	−5.4	12.9	17.2
$F = F_{2018}$	9552	4872	0.56	8524	−1.9	7.3	11.4
SSB (2020) = $B_{PA} = B_{trigger}$	7407	3778	0.40	9900	14.0	−16.8	−13.6
SSB (2020) = B_{lim}	13205	6735	0.90	6300	−27.5	48.4	54.1
F_{lim}	14123	7203	1.00	5770	−33.6	58.7	64.8
MSY approach: $F = F_{MSY} \times (SSB_{2019}/MSY\ B_{trigger})$	9165	4674	0.53	8769	1.0	3.0	6.9

* SSB 2020 relative to SSB 2019.
** Catch in 2019 relative to final TACs in 2018 (8900 t).
*** Advice value for 2019 relative to the final advice value for 2018 (8571 t).
^ Total catch 2019 × average proportion of catch taken in the first two quarters of the last 5 years (0.51).

e) State of the stock

Mortality. Fishing mortality has been above F_{MSY} since 2011 except in 2015 and 2016.

Biomass. Stock biomass has been below $B_{trigger}$ since 2012 except in 2016, and was below B_{lim} in 2012 and 2013.

Recruitment. Recruitment has been below average since 2008, except for the 2013 year class.

State of the Stock. In the beginning of 2018, the stock is estimated to be below $B_{trigger}$ and above . Recruitment has been low in recent years. Fishing mortality was above F_{MGT}, F_{MSY} and F_{PA} in 2017.

Yield. According to the new long term management strategy, catches in the two first quarters of 2019 should be no more than 4608 t.

f) Research recommendations

NIPAG **recommended** in 2010-2014 that *differences in recruitment and stock abundance between Skagerrak and the Norwegian Deep should be explored.*

Status: No progress has been made. NIPAG reiterates this recommendation.

- NIPAG **recommended** in 2016 that *seasonal patterns of spatial distribution resulting from the migration of different age and sex classes should be investigated, as well as seasonal patterns of lpue in the three fisheries, particularly the reason why lpue for a given year increases when we have the full year's data compared to the lpue from only the first 5–6 months.*

Status: Spatial patterns in *Pandalus* distribution of the different age and sex classes has not been addressed and with the current sampling regime it is unlikely this can be addressed in the near future. However, spatial distribution of lpue will be addressed at the proposed benchmark for 2018.

- NIPAG **recommended** in 2016 that *age determination and validation using sections of eye-stalks should continue and results used to refine the life-history knowledge of the stock including age–length relationship and natural mortality assumption.*

Status: This work is ongoing.

- 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.*

Status: This recommendation is reiterated.

References

Anon. 2018. Agreed Record of Fisheries Consultations between the European Union and Norway for 2018. 25. April 2018.

Berenboim, B.I., Korzhev, V.A., Tretjak, V.L. and Sheveleva, G.K. 1991. On methods of stock assessment and evaluation of TAC for shrimp *Pandalus borealis* in the Barents Sea. ICES C.M. 1991/K:15. 22 pp.

ICES. 2016a. Report of the Benchmark Workshop on *Pandalus borealis* in Skagerrak and Norwegian Deep Sea (WKPAND), 20–22 January 2016, Bergen, Norway. ICES CM 2016/ACOM:39. 72 pp.

ICES. 2016b. Report of the Working Group on the Assessment of Demersal Stocks in the North Sea and Skagerrak (WGNSSK) 26 April–5 May 2016, Hamburg, Germany. ICES CM 2016/ACOM: 14. 1023 pp.

ICES. 2016c. Report of the Working Group for the Bay of Biscay and the Iberian waters Ecoregion (WGBIE) 13–19 May 2016, ICES HQ, Copenhagen, Denmark. ICES CM 2016/ACOM: 12. 485 pp.

ICES. 2017a. Report on the Long-term Management Strategy Evaluation for Northern Shrimp (*Pandalus borealis*) in Division 4.a East and Subdivision 20 (PandLTMS). October-November 2017, ICES CM 2017/ACOM:52. 182 pp.

ICES. 2017b. ICES fisheries management reference points for category 1 and 2 stocks. *In* Report of the ICES Advisory Committee, 2017. ICES Advice 2017 Technical Guidelines, Book 12, 12.4.3.1, DOI: 10.17895/ices.pub.3036

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. 18/65, 66, 67; 06/64, 08/56, 07/86, 07/75, 06/70.

a) Introduction

Northern shrimp (*Pandalus borealis*) in the Barents Sea and in the Svalbard fishery protection zone (ICES Subareas 1 and 2) is considered as one stock (Fig. 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 "Loop Hole" (Fig. 6.1).

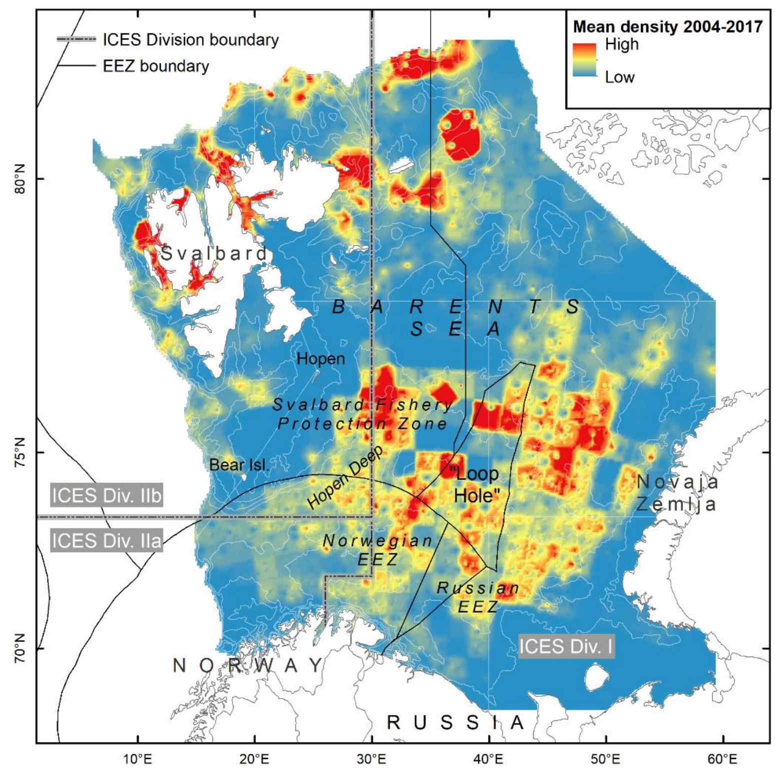


Fig. 6.1. Shrimp in ICES SA 1 and 2: Stock distribution. Survey density index (kg/km2).

Norwegian vessels initiated the fishery in 1970. As the fishery developed, vessels from several nations joined and the annual catch reached 128 000 t in 1984 (Fig. 6.2). In the recent 10-year period catches have varied between 20 000 and 45 000 t/yr, 25–75% taken by Norwegian vessels and the rest by vessels from Russia, Iceland, Greenland, Faeroes and the EU (Table 6.1).

There is no 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.

Catch. Catches have ranged from 5 000 to 128 000 t/yr (Fig. 6.2) since 1970. The most recent peak was seen in 2000 at approximately 83 000 t. Catches are predicted at 45 000 t in 2018.

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

	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018[1]
Recommended TAC	50 000	50 000	60 000	60 000	60 000	60 000	70 000	70 000	70 000	70 000
Norway	19784	16779	19928	14158	8846	10234	16618	10896	7010	16000
Russia	0	0	0	0	1067	741	1151	2460	3849	10000
Others	7488	8419	10298	10598	9336	9989	16252	16223	18894	19000
Total	27272	25198	30226	24756	19249	20964	34022	29609	29753	45000

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

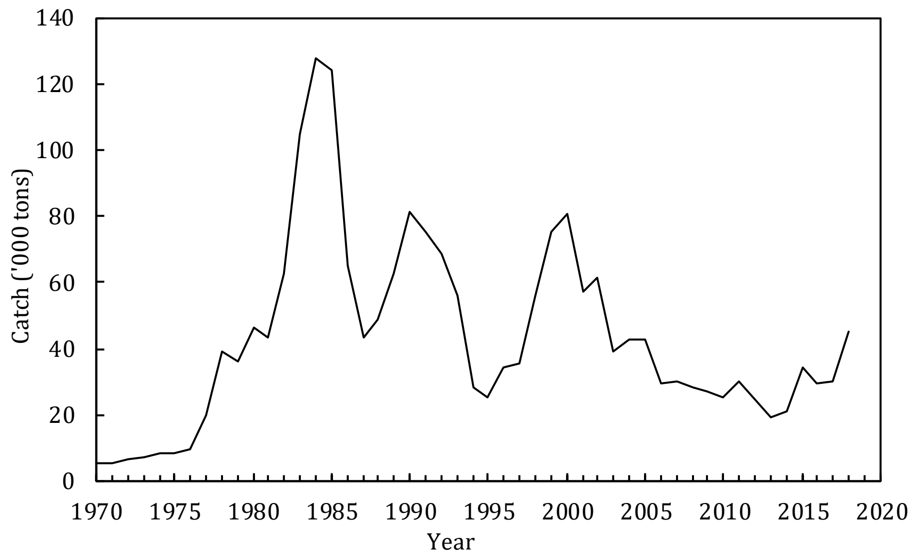


Fig. 6.2. Shrimp in ICES SA 1 and 2: Total catches since 1970 (2018 projected to the end of the year).

Discards and bycatch. Discard of shrimp cannot be quantified but is 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 discards estimates (1983–2017) of cod, haddock and redfish juveniles in the Norwegian commercial shrimp fishery in the Barents Sea were available in 2018 (Fig. 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.

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. Work will continue to explore these data further. No new data were available in 2018.

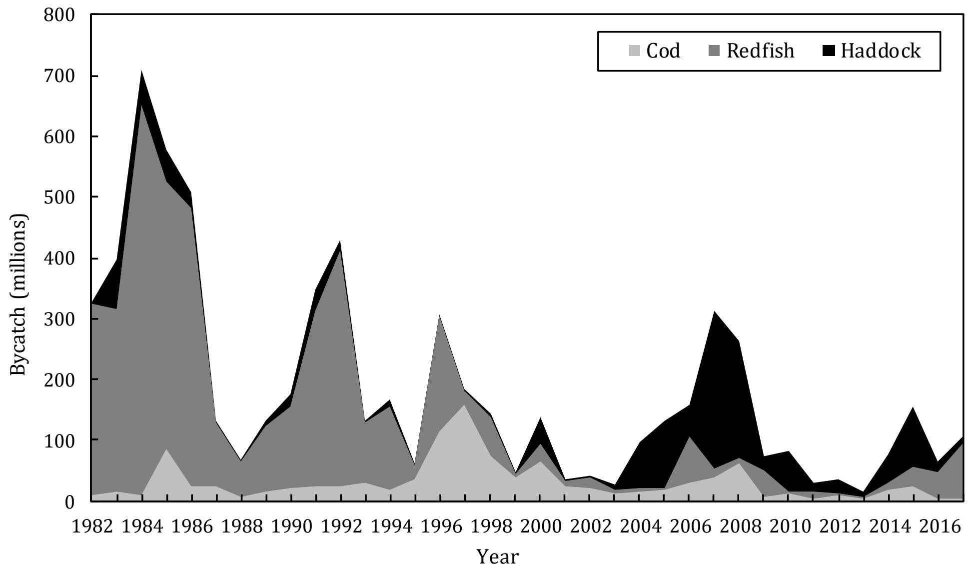


Fig. 6.3. Shrimp in ICES SA 1 and 2: Estimated bycatch of cod, haddock and redfish in the Norwegian shrimp fishery (million individuals). The sorting grid was introduced in 1992 and has been mandatory since.

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 . A major restructuring of the Norwegian shrimp fishing fleet towards fewer and larger vessels took place during the late-1990s through the early 2000s (Fig. 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.

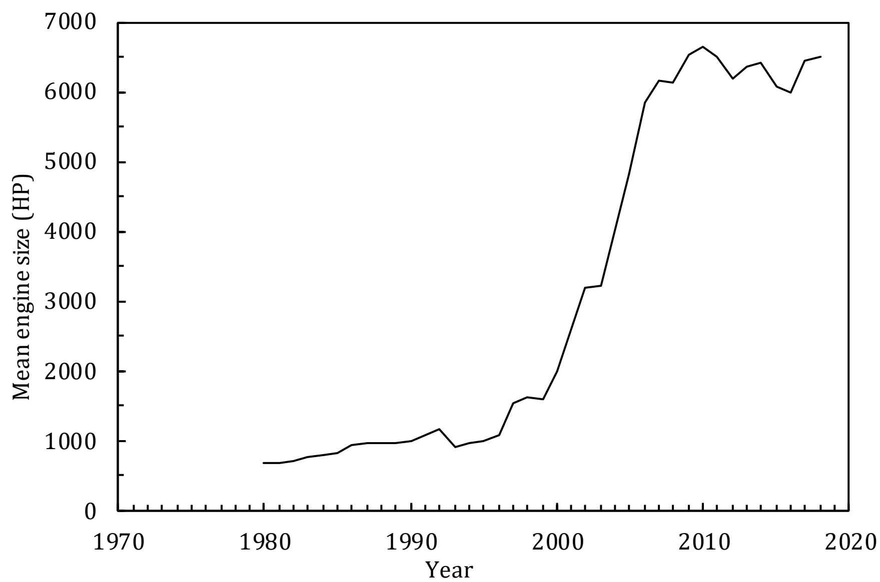


Fig. 6.4. Shrimp in ICES SA 1 and 2: Mean engine power (HP) weighted by trawl-time (Norwegian vessels).

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 is conducted mainly in the central Barents Sea (Hopen Deep) 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 "Loop Hole") (Fig. 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.

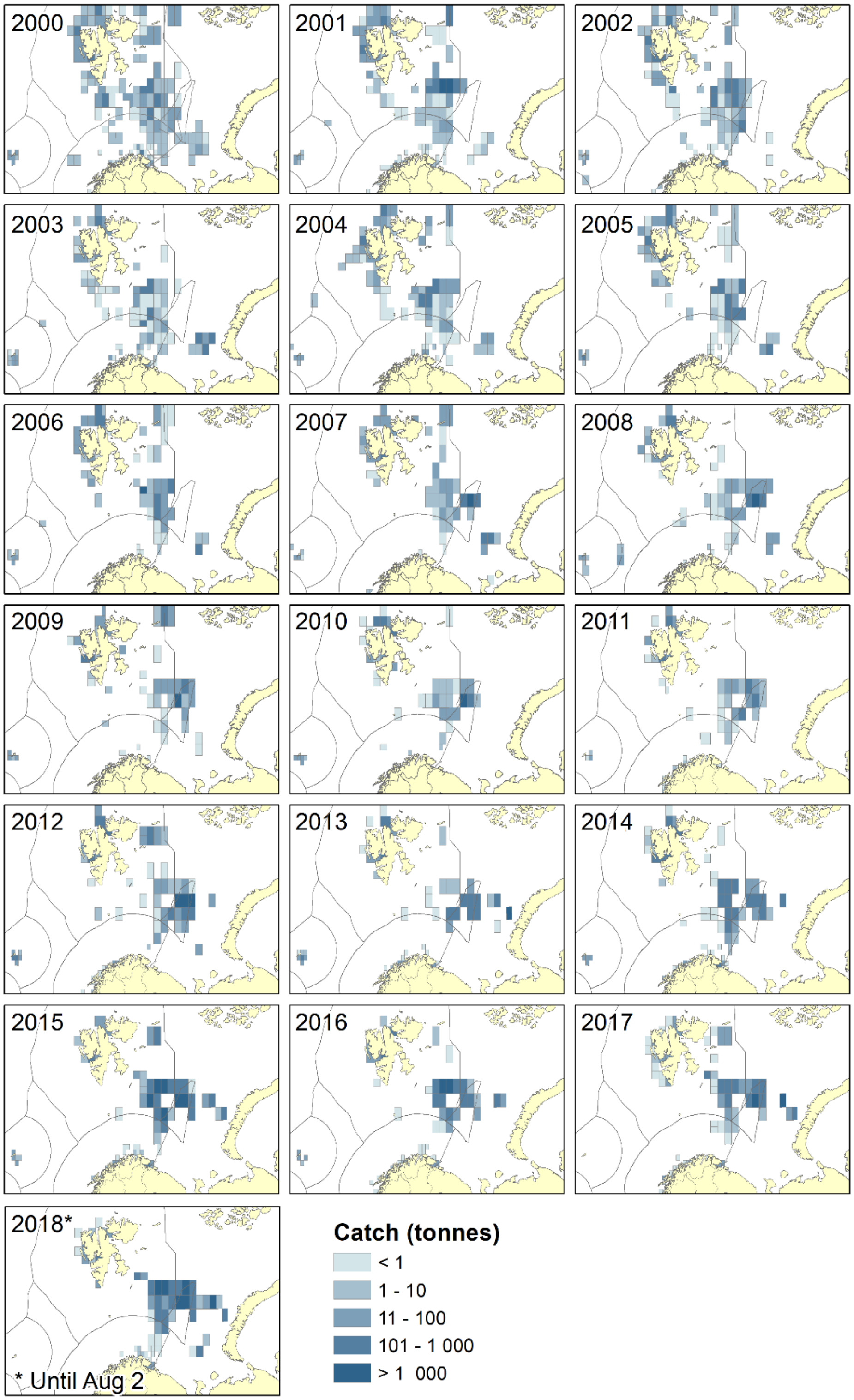


Fig. 6.5. Shrimp in ICES SA 1 and 2: Distribution of catches by Norwegian vessels since 2000 based on logbook information.

Norwegian logbook data were used in a multiplicative model (GLM) to calculate standardized annual catch rate indices (SCR Doc. 18/65). A new index series based on individual vessels rather than vessel groups was introduced in 2008 (SCR Doc. 08/56) in order to take into account the changes observed in the fleet. The GLM model used to derive the CPUE indices included the following variables: (1) vessel, (2) season (month), (3) area, 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 (Fig. 6.6).

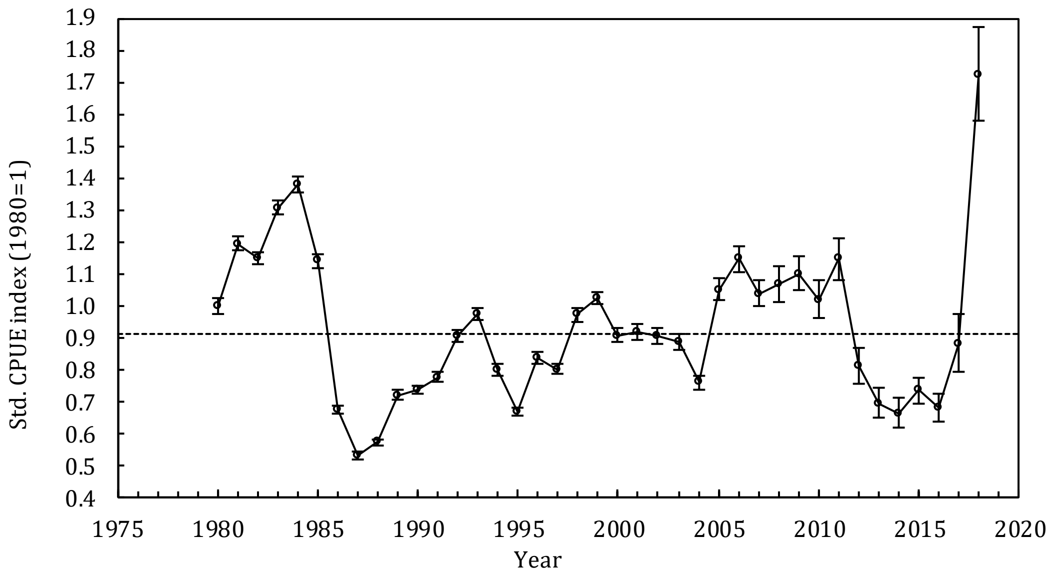


Fig. 6.6. Shrimp in ICES SA 1 and 2: Standardized CPUE based on Norwegian data. Error bars represent 1 SE; dotted line is the mean of the series.

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 2018 standardized CPUE value based on only partial data for the year (until July) is record high. Ancillary information from the industry reports of abnormally high catch rates in the beginning of the season in the Russian zone and later in Hopen Deep. However, after July, i.e. from the period of 2018 that is not yet included in the GLM analysis, catch rates are down to 1/3 of what they were earlier in the season. A comparison of recent years unstandardized CPUEs to the standardized, which typically are reasonably well correlated, points to the 2018 value being an outlier (SCR Doc. 18/65). Due to the uncertainty of whether the preliminary 2018 standardized CPUE index value is a good reflection of stock biomass a sensitivity analysis was conducted (see section c.).

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). The main objectives have been to obtain indices for stock biomass, numbers, recruitment and demographic composition. 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 all surveys have fluctuated without trend over their respective time periods covered (Fig. 6.7). In general, the entire survey area of the Ecosystem survey (survey 3 in Fig. 6.7) 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.

The geographical distribution of the stock in 2009-2017 was more easterly compared to that of the previous years (Fig. 6.8).

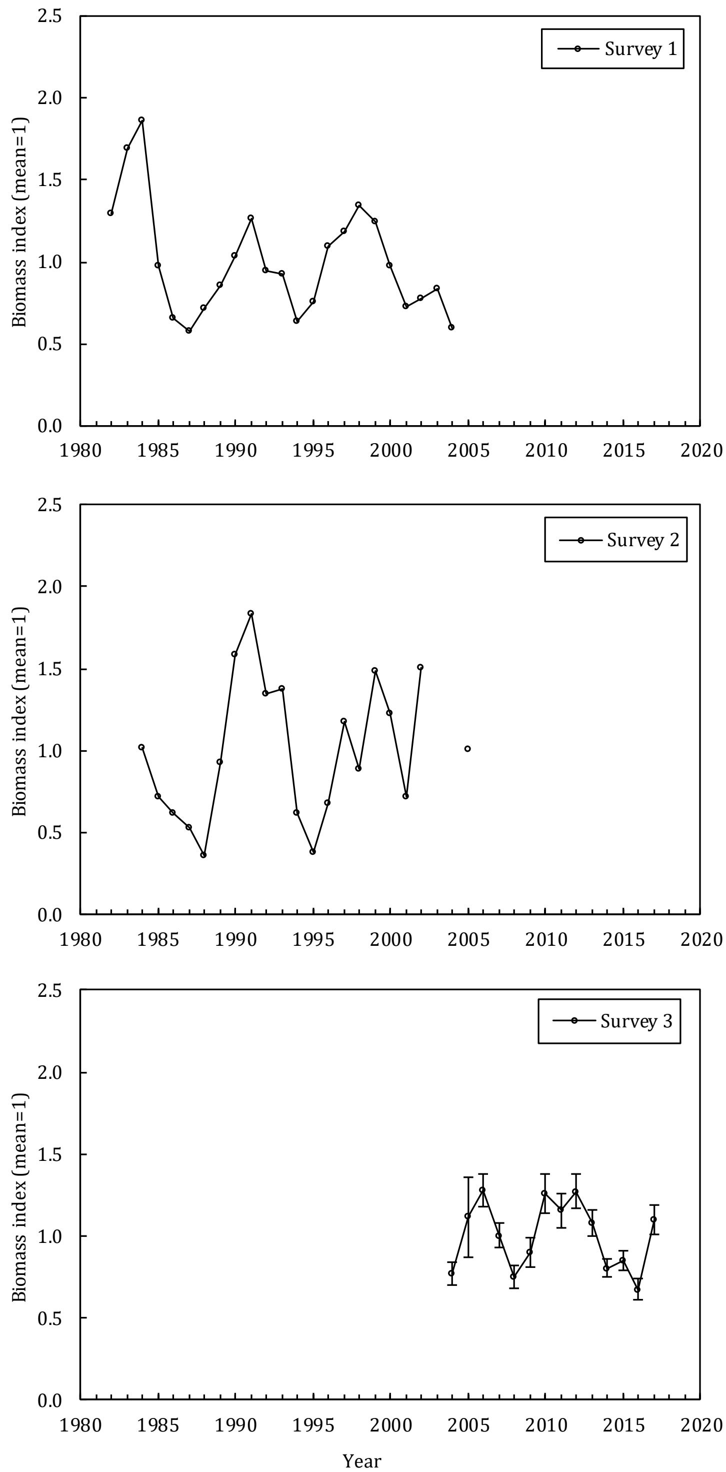


Fig. 6.7. Shrimp in ICES SA 1 and 2: Indices of total stock biomass from the (1) 1982-2004 Norwegian shrimp survey, (2) the 1984-2005 Russian survey, and (3) the joint Russian-Norwegian ecosystem survey since 2004 (the 2018 survey data were not available at the time of the NIPAG meeting). Error bars represent 1 SE.

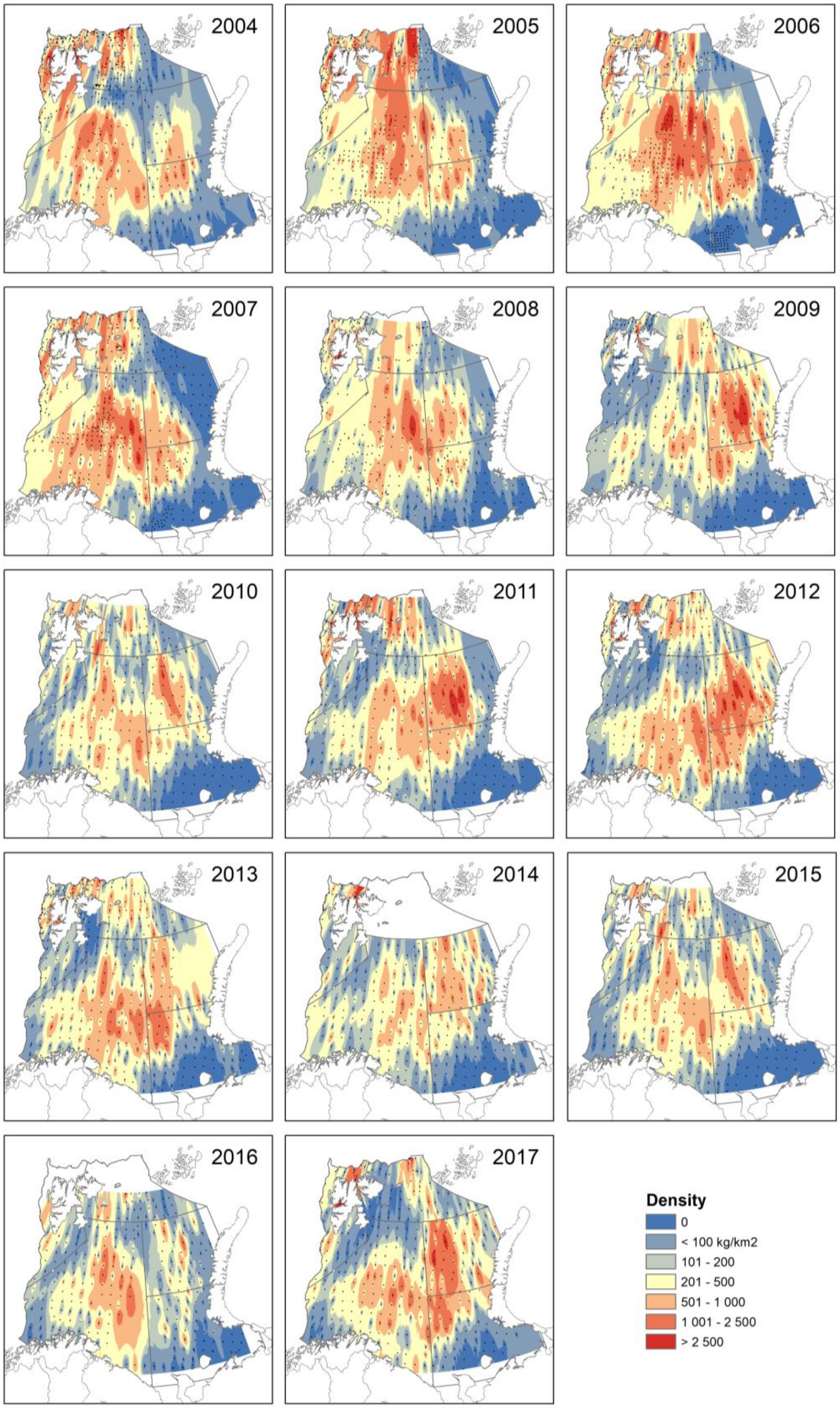


Fig. 6.8. Shrimp in ICES SA 1 and 2: shrimp density (kg/km2) as calculated from the Ecosystem survey data since 2004 (no data for stratum 3 in 2014 due to ice conditions).

Recruitment indices. No information is included as data are not available since 2013.

c) Assessment

The modelling framework introduced in 2006 (SCR Doc. 06/64) was used for the assessment. Model settings were the same as those used in previous years.

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. 18/67).

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 1980–2017 (Fig. 6.6, SCR Doc. 18/65); and trawl-survey biomass indices for 1982–2004, 1984–2005 and for 2004–2017 (Fig. 6.7, SCR Doc. 18/66). 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 (Fig. 6.2, SCR Doc. 18/65). The fishery being without major discarding problems or variable misreporting, reported catches were entered into the model as error-free.

Absolute biomass estimates had relatively high variances. For management purposes, it was therefore desirable to work with biomass on a relative scale in order to cancel out the uncertainty of the "catchability" parameters (the parameters that scale absolute stock size). 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_ε^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. 07/76) 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 100 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 (symbols are as in the text; r = intrinsic growth rate, P_0 = the 'initial" stock biomass in 1969).

	Mean	sd	25 %	Median	75 %
MSY (ktons), maximum sustainable yield	219	121	120	202	306
K (ktons), carying capacity	3068	1545	1932	2775	3859
r, intrinsic growth rate	0.31	0.15	0.20	0.30	0.40
q_R, catchability of survey 2	0.13	0.08	0.07	0.10	0.15
q_{Ru}, catchability of survey 1	0.31	0.20	0.18	0.26	0.39
q_E, catchability of survey 3	0.19	0.12	0.11	0.16	0.24
q_C, catchability of CPUE index	4.5E-04	2.9E-04	2.6E-04	3.7E-04	5.6E-04
P_0, initial relative biomass (1969)	1.51	0.26	1.33	1.51	1.68
P_{2018}, relative biomass in 2018	1.82	0.52	1.48	1.78	2.10
σ_R, coefficient of variation for survey 2	0.18	0.03	0.16	0.17	0.19
σ_{Ru}, coefficient of variation for survey 1	0.34	0.05	0.30	0.34	0.37
σ_E, coefficient of variation for survey 3	0.17	0.03	0.15	0.17	0.19
σ_C, coefficient of variation for CPUE index	0.13	0.02	0.11	0.13	0.14
σ_P, coefficient of variation for process	0.19	0.03	0.17	0.18	0.20

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 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. 06/64 and 07/76).

The 2018 CPUE data point was thought not to reflect the biomass and therefore, as a sensitivity analysis, we made a comparison of results from model runs with and without the 2018 standardized CPUE data point: including the 2018 data point created a large retro in the estimated biomass for 2017. Otherwise, parameter estimates were similar between the two runs. Therefore, considering: i) the anomalous increase in CPUE from 2017 to 2018, ii) the fact that industry has indicated that more recent 2018 CPUE (beyond the partial-year information available for standardization) has declined substantially, and, iii) the aforementioned retrospective problem, the 2018 data point of the CPUE series was not used in the assessment.

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 (Fig. 6.9, upper). Since the late 1980s, however, the stock has varied with a slightly increasing trend. The median 2016-18 values are above B_{msy}. The estimated risk of stock biomass being below $B_{trigger}$ in 2018 is less than 1% (Table 6.3). The median estimate of fishing mortality has remained below F_{msy} throughout the history of the fishery (Fig. 6.9 lower). In 2018, there is a less than 5% risk of the F being above F_{msy} (Table 6.3).

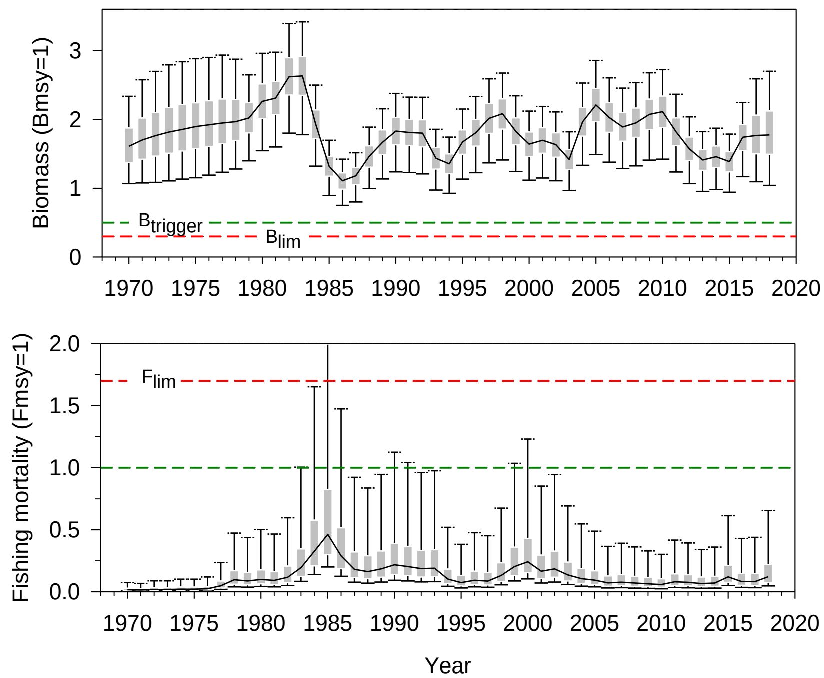


Fig. 6.9. Shrimp in ICES SA 1 and 2: Estimated relative biomass (B/B_{msy}) and fishing mortality (F/F_{msy}) since 1970. Boxes represent inter-quartile ranges and the solid black line in the middle of each box is the median; the arms of each box cover the central 90% of the distribution. The broken lines indicate *MSY* and precautionary approach reference points.

Table 6.3. Shrimp in ICES SA 1 and 2: Stock status for 2017 and predicted to the end of 2018.

Status	2017	2018*
Risk of falling below B_{lim}	0.0 %	0.0 %
Risk of falling below $B_{trigger}$	0.2 %	0.2 %
Risk of exceeding F_{MSY}	1.3 %	2.6 %
Risk of exceeding F_{lim}	0.6 %	1.2 %
Stock size (B/B_{msy}), median	1.77	1.78
Fishing mortality (F/F_{MSY}),	0.08	0.12
Productivity (% of MSY)	41 %	40 %

*Assumed 2018 catch = 45 ktons

Projections. Catch advice at the median of F_{msy} (ICES MSY approach) would imply no more than 338 kt – way 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, it is considered more appropriate to apply the mode as a point estimate of yield at F_{msy}. This mode is at 120 kt. Assuming a catch of 45 kt for 2018, catch options up to 120 kt for 2019 have low risks of exceeding F_{msy} (21%), F_{lim} (10%), and of going below $B_{trigger}$ (4%) by the end of 2019 (Table 6.4) and all these options are likely to maintain the stock at its current high level.

Table 6.4. Shrimp in ICES SA 1 and 2: Predictions of risk and stock status associated with optional catch levels for 2019.

	Catch option 2019 (ktons)						Yield at Fmsy (mode)	Yield at Fmsy (median)
	50	60	70	80	90	100	120	338
Risk of falling below B_{lim}	0.0 %	0.0 %	0.0 %	0.0 %	0.0 %	0.0 %	1.0 %	2.6 %
Risk of falling below $B_{trigger}$	0.3 %	0.3 %	0.4 %	0.4 %	0.4 %	0.4 %	3.6 %	8.7 %
Risk of exceeding F_{MSY}	3.3 %	4.5 %	5.8 %	7.1 %	8.6 %	10.1 %	21.2 %	50.0 %
Risk of exceeding F_{lim}	1.5 %	2.0 %	2.5 %	3.2 %	3.8 %	4.6 %	9.6 %	35.3 %
Stock size (B/Bmsy), median	1.78	1.76	1.75	1.75	1.74	1.73	1.71	1.57
Fishing mortality (F/Fmsy),	0.14	0.17	0.20	0.23	0.26	0.29	0.37	1.00
Productivity (% of MSY)	40 %	42 %	43 %	44 %	46 %	47 %	50 %	68 %

d) Additional considerations

Environmental conditions.

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. In 2017 water temperatures remained higher than average and typical of warm years, yet lower than temperature in 2016. Net primary production has increased over the years. An increase in ice-free areas, and length of the growing season, provide improved habitat for phytoplankton growth. Zooplankton biomasses in the Central Bank and Great Bank subareas have shown declining trends since the peak in 1995.

The capelin stock has recovered after a mini-collapse in 2015–2016. Cod biomass have decreased in recent years following a peak around 2013. With the increase in capelin and a reduction in cod abundance, predation pressure on shrimp may be less intense. 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).

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 (Fig. 6.8), thus temperature is probably a factor in explaining the observed change 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 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.

Model performance. The model was able to produce good simulations of the observed data (Fig. 6.10). The differences between observed values of biomass indices and the corresponding values predicted by the model were checked numerically (SCR Doc 18/67). They were found not to include excessively large deviation.

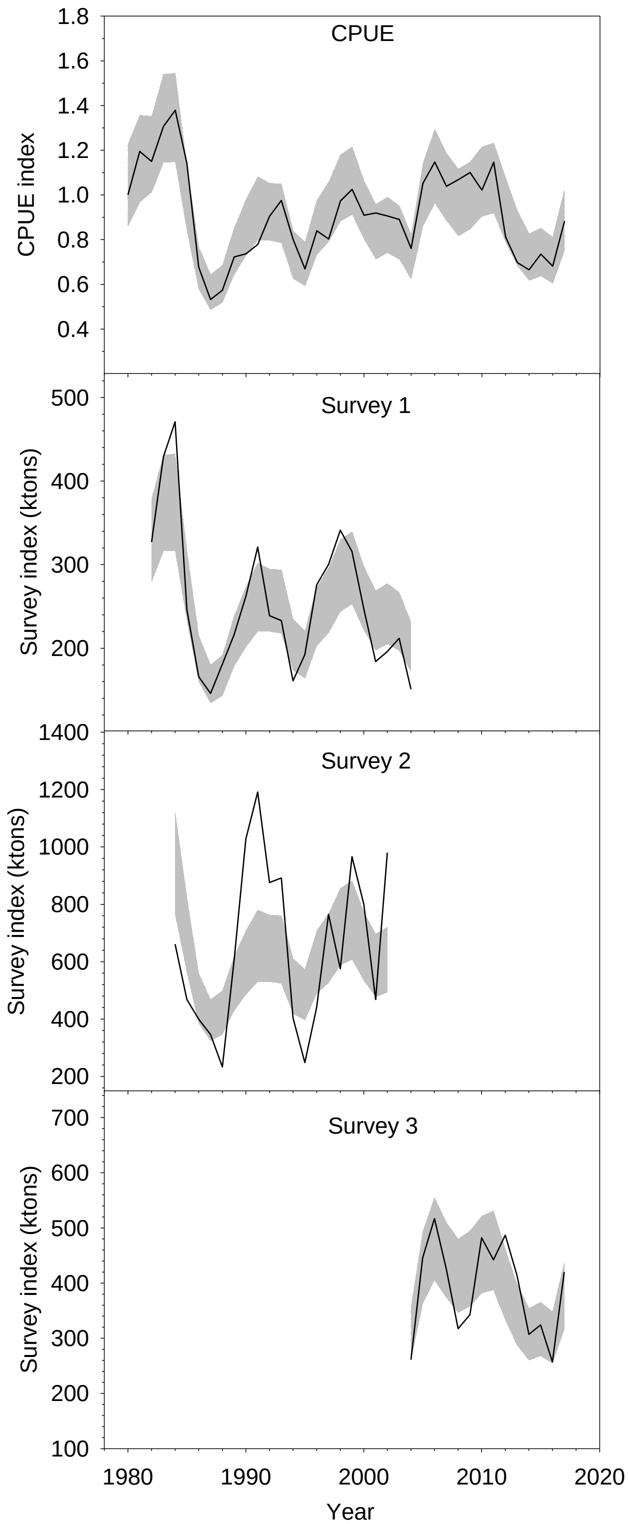
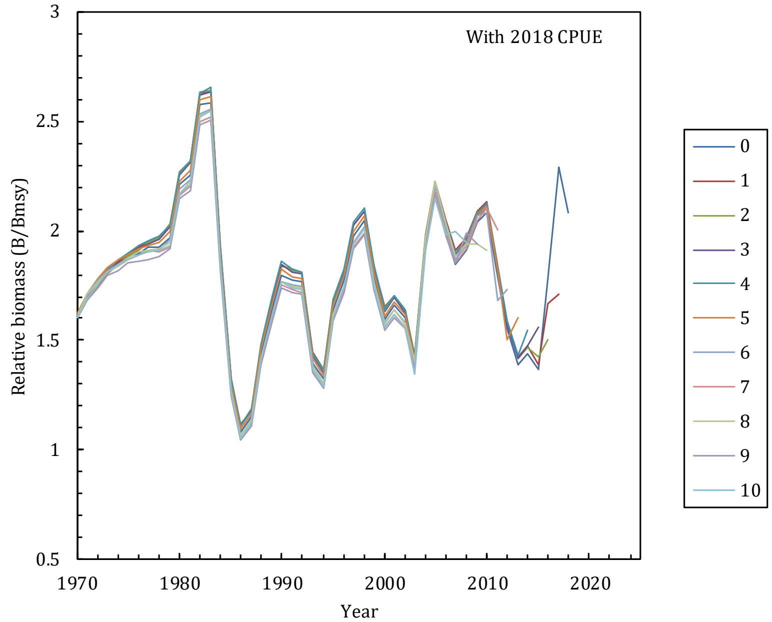


Fig. 6.10. Shrimp in ICES SA 1 and 2: Observed (solid line) and estimated (shaded) series of the included biomass indices: the standardized catch-per-unit-effort (CPUE), the 1982–2004 Norwegian shrimp survey (survey 1), the 1984 to 2005 Russian survey (Survey 2) and the Joint Norwegian-Russian Ecosystem Survey (survey 3) since 2004. Grey shaded areas cover the 90% probability interval of their posteriors.

When leaving out the estimate of the 2018 standardized CPUE in the input data for the assessment model, the retrospective pattern of the estimated series of median relative biomass did not reveal any major problems with sensitivity of the model to particular years (Fig. 6.11). The model did have a tendency to be too optimistic regarding the final years during the stock decline 2010 to 2014, but all of these were well inside the updated estimated probability distributions the following year. Including the 2018 CPUE index value however, created a retrospective for 2017 that was considered unacceptably large.



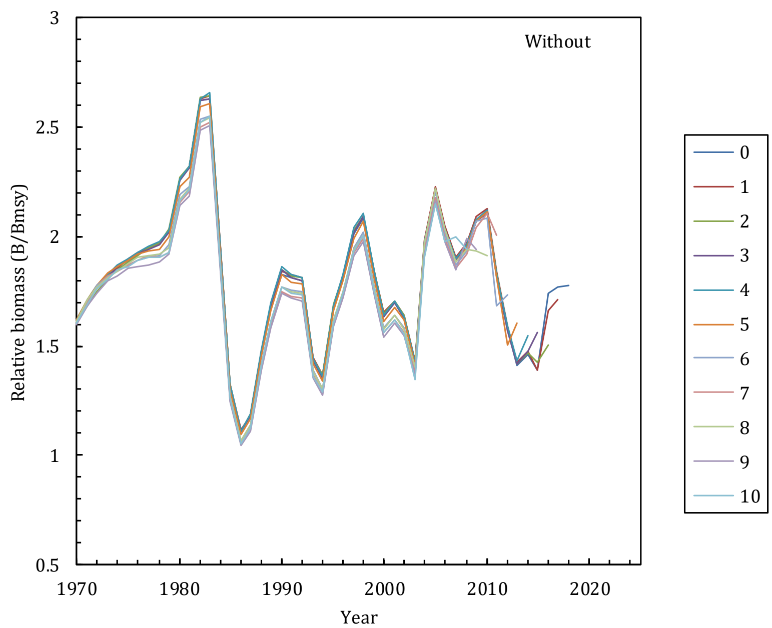


Fig. 6.11. Shrimp in ICES SA 1 and 2: Retrospective plot of median relative biomass (B/B_{msy}) for model runs including the 2018 standardized CPUE data point and without (the option chosen for the assessment). Relative biomass series are estimated by consecutively leaving out from 0 to 10 years of data.

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 2018 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 2018 there is a less than 5% risk of fishing mortality exceeding F_{lim}.

Recruitment. No explicit information has been available since 2013.

State of the Stock. The Stock is estimated to be in a healthy state and exploited sustainably.

f) Research recommendations

- 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*.

Status: In progress. Planned to be conducted in conjunction with the benchmark of the Skagerrak stock. This recommendation is reiterated noting that the benchmark is scheduled for 2020.

- The fishery has expanded since 2014 and catches by countries other than Norway have increased to account for about 50% 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: In progress. Information from EU-Estonia was presented at the 2017 NIPAG. An official data call has been made. This recommendation is reiterated.

- In 2017, NIPAG **recommended** that *a recruitment index should be developed for this stock.*

Status: planned as part of upcoming benchmark. 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.*

Status: In progress. This recommendation is reiterated.

Reference list

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 theBarents 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 (ICES division IVa)

From the 1960s up to around 2000 a significant shrimp fishery exploited the shrimp stock on the Fladen Ground in the northern North Sea. A short description of the fishery is given, as a shrimp fishery could be resumed in this area in the future. The landings from the Fladen Ground have been recorded since 1970. Total reported landings have fluctuated between zero and 9 000 t (Fig. 7.1, Table 7.1). The Danish fleet has accounted for the majority of these landings, while the Scottish fleet has landed a smaller portion. 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 fishery has been virtually non-existent. Interview information from the fishing industry obtained in 2004 gave the explanation that this decline was caused by low shrimp abundance, low prices on the small shrimp which are characteristic of the Fladen Ground, and high fuel prices. The stock has not been surveyed for many years, and the decline in this fishery may reflect a decline in the stock.

There have been minor Danish, Scottish and Norwegian landings of Northern shrimp from the Fladen Ground stock since 2011, mainly taken as bycatch in the Norway pout fishery. Denmark landed 17 tons from shrimp trawls in 2015.

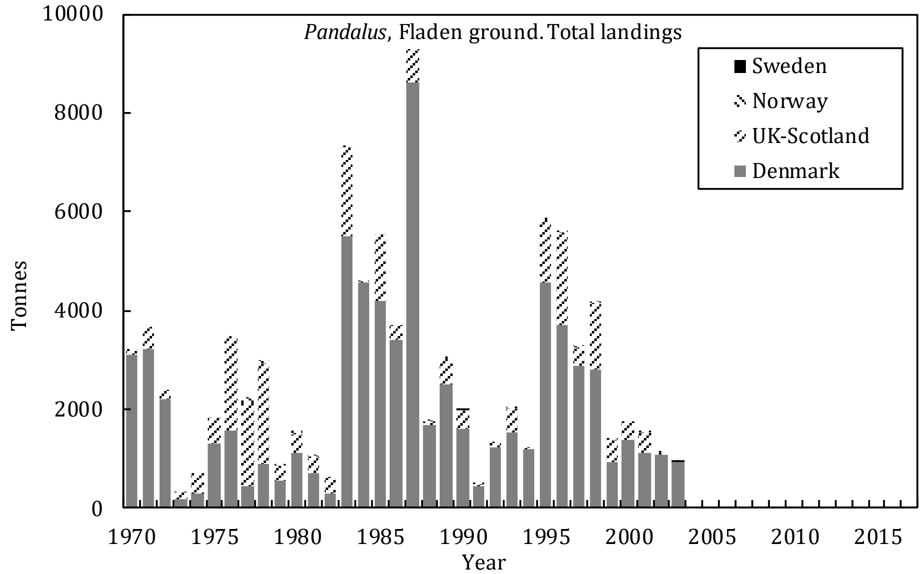


Fig. 7.1. Northern shrimp in Fladen Ground: Landings by country and total.

Table 7.1. Northern shrimp in Fladen Ground: Landings by country and total.

Year	Denmark	Norway	Sweden	UK-Scotland	Total
1970	3115			104	3219
1971	3216			436	3652
1972	2204			187	2391
1973	157			163	320
1974	282			434	716
1975	1308			525	1833
1976	1552			1937	3489
1977	425	112		1692	2229
1978	890	81		2027	2998
1979	565	44		268	877
1980	1122	76		377	1575
1981	685	1		347	1033
1982	283			352	635
1983	5492	8		1827	7327
1984	4553	13		25	4591
1985	4188			1341	5529
1986	3416			301	3717
1987	8620			686	9306
1988	1662	2		84	1748
1989	2495	25		547	3067
1990	1616	3	4	365	1988
1991	421	31		53	505
1992	1212			116	1328
1993	1516	38		509	2063
1994	1202	0		35	1237
1995	4552	15		1298	5865
1996	3689	32		1893	5614
1997	2886	9		365	3260
1998	2801	3		1365	4169
1999	934	9		456	1399
2000	1358			378	1736
2001	1117	18		397	1532
2002	1061	9		70	1140
2003	935	8	1		944
2004	21				21
2005	10				10
2006					0
2007					0
2008					0
2009					0
2010					0
2011					0
2012		1			1
2013					0
2014	1				1
2015	19			1	20
2016		10			10
2017	1	6		4	11

IV. OTHER BUSINESS

a) FIRMS classification for NAFO shrimp stocks

The table as agreed during the September SC meeting was updated with the agreed classifications for the northern shrimp stocks assessed this year.

The Stock Classification system is not intended as a means to convey the scientific advice to the Commission, and should not be used as such. Its purpose is to respond to a request by FIRMS to provide such a classification for their purposes. The category choices do not fully describe the status of some stocks. Scientific advice to the Commission is to be found in the Scientific Council report in the summary sheet for each stock.

Stock Size (incl. structure)	Fishing Mortality			
	None–Low	Moderate	High	Unknown
Virgin–Large	3LNO Yellowtail Flounder 3LN Redfish			
Intermediate	3M Redfish[2] 3M Cod	SA0+1 Northern shrimp 0&1A Offshore. & 1B–1F Greenland halibut		Greenland halibut in Disko Bay[1] SA1 Spotted Wolffish SA2+3KLMNO Greenland halibut
Small	SA3+4 Northern shortfin squid 3NOPs White hake 3NO Witch flounder 3LNOPs Thorny skate East Greenland Northern shrimp			Greenland halibut in Uummannaq[1] Greenland halibut in Upernavik[1]
Depleted	3M American plaice 3LNO American plaice 2J3KL Witch flounder 3NO Cod 3M Northern shrimp[2] 3LNO Northern shrimp			SA1 Redfish SA1 Atlantic Wolffish
Unknown	SA2+3 Roughhead grenadier 3NO Capelin 3O Redfish			6G Alfonsino

[1] Assessed as Greenland halibut in Div. 1A inshore

[2] Fishing mortality may not be the main driver of biomass for Div. 3M Shrimp and Redfish

b) Future of NIPAG and timing of future meetings

NIPAG discussed the future of the working group and timing of future meetings. Due to differences in the timing of advice requirements and in the availability of survey and/or logbook data, there is no ideal date which is suitable for all stocks. ICES have requested that advice for the Norwegian Deep/Skagerrak stock in March to include the latest survey data, whereas NAFO Commission have requested advice for the 3M stock prior to the September meeting to include data from the July survey. A September meeting would not be suitable for either Greenland or Barents Sea stocks due to survey data availability: for these stocks, the ideal timing would be later in the year.

Consequently it has been decided that:

- the assessment for the Norwegian Deep/Skagerrak stock will take place outside the main NIPAG meeting in a separate meeting in March.
- the next NIPAG meeting will take place in November 2019
- ICES scientists will continue to participate in the NIPAG meeting as much as possible although no advice will be produced for the Norwegian Deep/Skagerrak stock. NIPAG was informed that the incoming ICES Co-chair for NIPAG would be Ole Ritzau (EU-Denmark).
- an additional NIPAG/NAFO SC WebEx meeting will be held in September to produce advice on 3M and 3LNO stocks.

The main assessment of the Norwegian Deep/Skagerrak shrimp stock will take place in March. For this year only, provisional advice will be given in the current NIPAG meeting for the first half of 2019, which will be replaced by a full year advice for 2019 during the March meeting in 2019. For subsequent years, the March meeting will give provisional advice for first half of the following year which will be replaced by full advice for the whole of the advice year during the March meeting.

There was some discussion on whether the Norwegian Deep/Skagerrak assessment meeting would be considered as an ICES or NIPAG meeting. Several options were considered including naming the meeting as a new ICES WG and issuing the report as an ICES report, or holding the meeting as a full NIPAG meeting with NAFO participation by WebEx. It was decided that this will be an ICES meeting with the report issued by ICES but following the NAFO report format. The report will be included as an appendix to the NIPAG report following review by the November NIPAG meeting. The chair of this group will be Ole Ritzau (EU-Denmark).

The main NIPAG meeting will be in November. This meeting will continue to produce advice for the two Greenland stocks and the Barents sea stock and provisional advice for 3M and 3LNO according to the NAFO advice schedule. The 2019 NIPAG meeting will be held in Tromsø 8 to 13 November.

If required, NAFO will hold an additional meeting by WebEx immediately before the NAFO annual meeting in September. The report will be included as an appendix to the NIPAG report following review by the November NIPAG meeting.

This scheduling will be re-evaluated in the NIPAG meeting in 2020.

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													Jan-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 2018	March 2019	September 2019 WebEx	November 2019	March 2020	September 2020 WebEx	November 2020
3M	interim monitoring report		Produce Advice for 2020	provisional advice 2021		Update Advice 2021	provisional advice 2022
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, provisional 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 1500 hours on 21 October 2018, 1 day ahead of the scheduled finish. The Co-Chairs thanked all participants, especially the designated experts and stock coordinators, for their hard work. The Co-Chairs thanked the NAFO and ICES Secretariats for all of their logistical support. The report was adopted at the close of the meeting, subject to a two week period for editorial changes.

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

I. Opening (Co-chairs Brian Healey and Guldborg Søvik)

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

II. General Review

1. Review of Recommendations in 2016 and in 2017
2. Review of Catches

III. Stock Assessments

- Northern shrimp (Division 3M) (full assessment)
- Northern Shrimp (Divisions 3LNO) (interim monitoring report)
- Northern shrimp (Subareas 0 and 1) (full assessment)
- Northern shrimp (in Denmark Strait and off East Greenland) (full assessment)
- Northern shrimp in Skagerrak and Norwegian Deep (ICES Divisions IIIa and IVa East) (full assessment)
- 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. The Future of NIPAG

V. Adjournment

APPENDIX II. ICES TERMS OF REFERENCE FOR NIPAG

A. Generic ToRs for Regional and Species Working Groups 2017/2/ACOM05

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 for the fisheries relevant to the working group on:

   i) descriptions of ecosystem impacts of fisheries

   ii) descriptions of developments and recent changes to the fisheries

   iii) mixed fisheries considerations, and

   iv) emerging issues of relevance for the management of the fisheries;

c) Conduct an assessment on the stock(s) to be addressed in 2018 using the method (analytical, forecast or trends indicators) as described in the stock annex and produce a brief report of the work carried out regarding the stock, summarizing where the item is relevant:

   i) Input data and examination of data quality;

   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 area) estimate the percentage of the total catch that has been taken in the NEAFC Regulatory Area in 2017.

   iv) The developments in spawning stock biomass, total stock biomass, fishing mortality, catches (wanted and unwanted landings and discards) using the method described in the stock annex;

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

   vi) Catch options for next year(s) for the stocks for which ICES has been requested to provide advice on fishing opportunities;

   vii) Historical and analytical performance of the assessment and catch options and brief description of quality issues with these;

   viii) For the purpose of conducting further analyses relative to the issue of catch forecasts from biased assessment for category 1 and 2 age-structured assessment, report the mean Mohn's rho (assessment retrospective analysis) values for R, SSB and F. 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 fish stocks and fisheries under considerations according to ACOM guidelines.

e) Review progress on benchmark processes of relevance to the expert group;

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

g) Identify research needs of relevance for the expert group.

Information of the stocks to be considered by each Expert Group is available here.

B. NIPAG – Joint NAFO/ICES *Pandalus* Assessment Working Group 2017/2/ACOM08

The **Joint NAFO/ICES *Pandalus* Assessment Working Group** (NIPAG), chaired by Guldborg Søvik*, Norway (ICES) and Brian Healey, Canada (NAFO), will meet at NAFO in Halifax, Nova Scotia, Canada 17–23 October, 2018, to:

a) Address generic ToRs for Regional and Species Working Groups.

The assessments will be carried out on the basis of the stock annex. The assessments must be available for audit on the first day of the meeting.

Material and data relevant for the meeting must be available to the group on the dates specified in the 2018 ICES data call.

NIPAG will report by **30 October 2018** on the ICES shrimp stocks for the attention of ACOM.

APPENDIX III. RELEVANT RECOMMENDATIONS FROM 2016 AND 2017

NIPAG – 2016

1. Northern Shrimp in Div. 3M

NIPAG **recommends** 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.*

2. Northern Shrimp in Div. 3LNO

NIPAG **recommended** that *ecosystem information related to the role of shrimp as prey in the Grand Bank (i.e. 3LNO) Ecosystem be presented to the 2016 NIPAG meeting*. (reiterated)

3. Northern Shrimp in SA 0+1

NIPAG **recommends** that:

- *for Northern shrimp off West Greenland (NAFO Subareas 0 and 1): given that the CPUE series for the Greenland sea-going and coastal fleets continue to agree while neither agrees with changes in the survey estimates of biomass since 2002, possible causes for change in the relationship between fishing efficiency and biomass should be investigated;*
- *the relationship between estimated numbers of small shrimps and later estimates of fishable biomass should be investigated anew.*
- *further refinements to the "partial MIXing" method of estimating numbers at age should be explored.*
- *Survey trends inshore and offshore are divergent and NIPAG* ***recommends*** *exploration of the nature and implications of this divergence.*
- *methods for prediction of future cod biomass should be explored.*
- *genetic stock structure in West and East Greenland should be further explored.*

4. Northern shrimp in the Denmark Strait and off East Greenland (Ices Div. XIVb and Va)

NIPAG **recommends** that:

- *the potential for developing a B_{LIM} reference point for the stock be explored.*
- *genetic stock structure of Pandalus borealis in West and East Greenland should be further explored.*

5. Northern Shrimp in the Skagerrak and Norwegian Deeps

NIPAG **recommends** that:

- *Differences in recruitment and stock abundance between Skagerrak and the Norwegian Deep should be explored.*
- *NIPAG recommends an interim benchmark in conjunction with an in-year assessment in early 2017 to investigate the sensitivity of the assessment, reference points and the catch options to the setting of M and Blim. Also to investigate possibilities for producing a new standardized survey index.*
- *NIPAG* ***recommends*** *a full benchmark for this stock including a data compilation workshop in the near future and no later than 2019*
- *in the length-based model, explore the replacement of 'weight at age' with 'weight at length' data from the fishery*
- *the Norwegian shrimp survey should be extended east to cover important shrimp grounds in Swedish waters.*
- *comparing the results of the current assessment with those of an updated run including survey data collected early in the following year.*

6. Northern shrimp (Pandalus borealis) in the Barents Sea (ICES Sub-Areas I and II)

NIPAG **recommends** that:

- *The assessment procedure used has been in place since 2006 and is recommended to be considered for a benchmark workshop in near future, no later than 2019*
- *The fishery has expanded since 2014 and catches by countries other than Norway have increased to account for about 50% of the total. NIPAG therefore **recommends** that available data (logbook data and catch samples) from the participating nations be made available to NIPAG.*

NIPAG – 2017

1. Northern Shrimp in Div. 3M

NIPAG **recommends** that *further exploration of the relationship between shrimp, cod and the environment be continued in WG-ESA and NIPAG encourages the shrimp experts to be involved in this work.*

Northern Shrimp in 3NLO

NIPAG **recommends** that *ecosystem information related to the role of shrimp as prey in the Grand Bank (i.e. 3LNO) Ecosystem be presented to the 2016 NIPAG meeting*. (reiterated)

3. Northern shrimp (*Pandalus borealis*) off West Greenland (NAFO SA 0 And SA1)

NIPAG **recommends** that:

- *further refinements to the "partial MIXing" method of estimating numbers at age should be explored.*
- *Survey trends inshore and offshore are divergent and the nature and implications of this divergence should be explored.*
- *genetic stock structure in West and East Greenland should be further explored.*
- *as information from the fishery indicates that catch sensors have been used for some time, the use of new technology which may influence the CPUE should be investigated and documented.*
- *the relationship between the pre-recruit index and the subsequent years' fishable biomass should be investigated further.*
- *the instability of the model should be explored.*
- *the P. montagui fishery should be explored further.*

4. Northern shrimp (*Pandalus borealis*) In the Denmark Strait and off East Greenland (Ices Div. XIVb and Va)

NIPAG **recommends** that:

- *genetic stock structure of Pandalus borealis in West and East Greenland should be further explored.*
- *error bars should be added to the SSB so that risk can be assessed in relation to B_{lim}.*

5. Northern shrimp (*Pandalus borealis*) in the Skagerrak and Norwegian Deep (ICES Divs. IIIa and IVa east)

NIPAG **recommends** that:

- *seasonal patterns of spatial distribution resulting from the migration of different age and sex classes should be investigated, as well as seasonal patterns of LPUE in the three fisheries, particularly the* *reason why LPUE for a given year increases when we have the full year's data compared to the lpue from only the first 5–6 months.*

- *age determination and validation using sections of eye-stalks should continue and results used to refine the life-history knowledge of the stock including age–length relationship and natural mortality assumption.*
- *Differences in recruitment and stock abundance between Skagerrak and the Norwegian Deep should be explored.*
- *the results of the current assessment should be compared with those of an updated run including survey data collected early in the following year.*
- *a full benchmark for this stock including a data compilation workshop in the near future and no later than 2020 (Annex V).*

6. Northern shrimp (*Pandalus borealis*) in the Barents Sea (ICES Sub-Areas I and II)

NIPAG **recommends** that:

- *a recruitment index should be developed for this stock.*
- *the information regarding catch effort and bycatch from the Estonian commercial fishery should be further analysed eg. CPUE data explored as a potential index of biomass.*
- *information from all fleets fishing on this stock should be made available to NIPAG.*

APPENDIX IV. DESIGNATED EXPERTS FOR ASSESSMENT OF CERTAIN NAFO STOCKS

The following is the list of Designated Experts for 2018 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 Div. 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 Div. 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

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Northern shrimp in Denmark Strait	Frank Rigét	Tel: +299 36 1200	frri@natur.gl

APPENDIX V. LIST OF RESEARCH (SCR) AND SUMMARY (SCS) DOCUMENTS

RESEARCH DOCUMENTS (SCR)

SCR No.	Serial No.	Author(s)	Title
SCR Doc. 18- 054	N6855	J.M. Casas Sánchez	Division 3M Northern shrimp (Pandalus borealis) – Interim Monitoring Update
SCR Doc. 18- 055	N6869	Burmeister and Riget	The West Greenland trawl survey for Pandalus borealis, 2018, with reference to earlier results
SCR Doc. 18- 056	N6870	Burmeister and Riget	A provisional Assessment of the shrimp stock off West Greenland in 2018
SCR Doc. 18- 057	N6871	Burmeister and Riget	The Fishery for Northern Shrimp (Pandalus borealis) off West Greenland, 1970–2018
SCR Doc. 18- 058	N6872	Burmeister and Riget	Catch Table Update for the West Greenland Shrimp Fishery
SCR Doc. 18- 059	N6873	Riget and Burmeister	The Fishery for Northern Shrimp (Pandalus borealis) in Denmark Strait / off East Greenland 1978 – 2018.
SCR Doc. 18- 060	N6874	Riget, Burmeister and Hvingel	Improvements of the Greenlandic shrimp model
SCR Doc. 18- 061	N6875	Burmeister	Reply to the Canadian request for advice of shrimps in Subarea 0 and 1
SCR Doc. 18- 062	N6879	J.M. Casas Sánchez	Northern Shrimp (Pandalus borealis) on Flemish Cap Surveys 2018
SCR Doc. 18- 063	N6880	Casas, J.M., E. Román and M. Álvarez	Northern Shrimp (Pandalus borealis, Krøyer) from EU-Spain Bottom Trawl Survey 2018 in NAFO Div. 3LNO
SCR Doc. 18- 064	N6881	J.M. Casas Sánchez	Assessment of the International Fishery for Shrimp (Pandalus borealis) in Division 3M (Flemish Cap), 1993-2018
SCR Doc. 18- 065	N6882	Carsten Hvingel and Trude H. Thangstad	The Norwegian fishery for northern shrimp (Pandalus borealis) in the Barents Sea and round Svalbard 1970-2018
SCR Doc. 18- 066	N6883	Carsten Hvingel and Trude H. Thangstad	Research survey results pertaining to northern shrimp (Pandalus borealis) in the Barents Sea and Svalbard area 2004-2017
SCR Doc. 18- 067	N6884	Carsten Hvingel	Shrimp (Pandalus borealis) in the Barents Sea – Stock assessment 2018
SCR Doc. 18- 068	N6897	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 2018

SUMMARY DOCUMENTS (SCS)

SCS No.	Serial No.	Author(s)	Title
SCS Doc. 18-21	N6898	NAFO/ICES	NIPAG Report 2018
SCS Doc. 18-22	N6899	NAFO	Report of the Scientific Council- shrimp meeting 2018

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