PART E: NAFO/ICES *PANDALUS* ASSESSMENT GROUP MEETING, 17–24 OCTOBER 2012

CONTENTS

REPORT OF NIPAG MEETING

17–24 October 2012

Co-Chairs: Jean-Claude Mahé and Peter Shelton Rapporteurs: Various

I. OPENING

The NAFO/ICES *Pandalus* Assessment Group (NIPAG) met at the Institute of Marine Research, Tromsø, Norway during 17-24 October 2014 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 Faroe Islands and Greenland), European Union (Denmark, Estonia, France, Spain and Sweden), Norway, Russian Federation. The NAFO Scientific Council Coordinator was also in attendance.

II. GENERAL REVIEW

1. Review of Research Recommendations in 2011

These 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 on Flemish Cap (NAFO Div. 3M)

Environmental Overview

The water masses characteristic of the Flemish Cap area are a mixture of Labrador Current Slope Water and North Atlantic Current Water and are generally warmer and saltier than the sub-polar shelf waters with a temperature range of 3-4^{o}C and salinities in the range of 34-34.75. The general circulation in the vicinity of the Flemish Cap consists of the offshore branch of the Labrador Current which flows through the Flemish Pass on the Grand Bank side and a component that flows eastward north of the Cap and then southward east of the Cap. To the south, the Gulf Stream flows to the northeast to form the North Atlantic Current and influences waters around the southern areas of the Cap. In the absence of strong wind forcing the circulation over the central Flemish Cap is dominated by a topographically induced anticyclonic gyre. During April of 2012 near bottom temperatures around the Cap were about 4°C which ranged from 0.5°-1°C above the long term average. Upper layer temperatures during April ranged from 4°-5°C, also above normal by up to 1°-2°C. Satellite SST during spring and summer months were above normal by 1.5°C and 2.5°C, respectively. The summer SST on the Flemish Cap was the highest observed in the time series going back to 1985.

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.

Fishery and catches: The effort allocations were reduced by 50% in 2010 and a moratorium was imposed in 2011. Catches are expected to be close to zero in 2012.

Recent catches were as follows:

	2006	2007	2008	2009	2010	2011	2012
NIPAG	18 000	21 000	13 000	5 000	2 000	0	0
STATLANT 21	15191	17642	13431	5374	1976	0	0[1]
Recommended TAC	48 000	48 000	17 000 – 32 000	18 000 – 27 000	ndf	ndf	ndf
Effort[2] (Agreed Days)	10555	10555	10555	10555	5227	0	0

[1] To October 2012
[2] Effort regulated

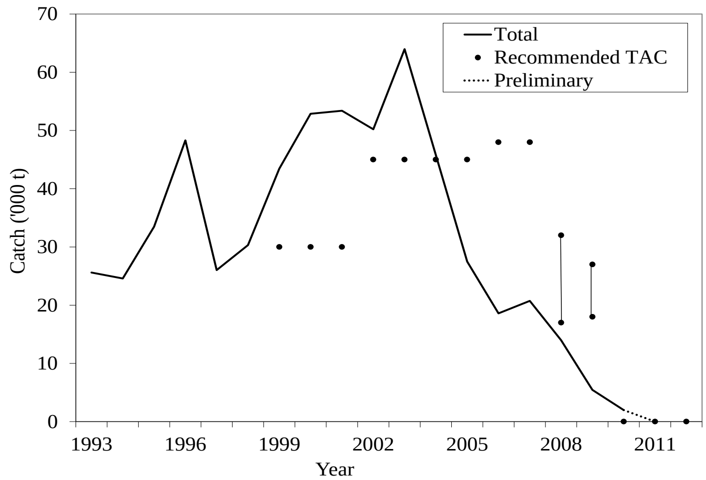


Fig. 1.1. Shrimp in Div. 3M: Catches (t) of shrimp on Flemish Cap and TACs recommended in the period 1993-2012. Due to a moratorium, the shrimp catch is expected to be zero in 2012.

b) Input Data

i) Commercial fishery data

Catch, effort and biological data were available from several Contracting Parties. Time series of size and sex composition data were available mainly from two countries between 1993 and 2005 and survey indices were available from EU research surveys (1988-2011). Catch data were updated for 2012. Because of the moratorium catch and effort data were not available for 2011 and 2012. Therefore the standardized CPUE series was not updated from 2012.

ii) Research survey data

Stratified-random surveys have been conducted on Flemish Cap by the EU in July from 1988 to 2012, using a Lofoten trawl. 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 based on the methodology accepted by STACFIS in 2004 (NAFO 2004 SC Rep., SCR Doc. 04/77). The index was stable at a high level from 1998 to 2007. After 2007 the survey biomass index declined and in 2012 was the lowest in the survey series, well below B_{lim}.

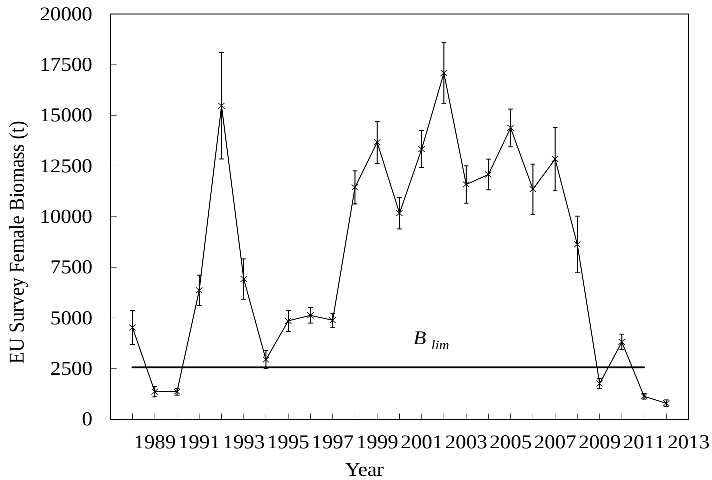


Fig. 1.2. Shrimp in Div. 3M: Female biomass index from EU trawl surveys, 1988-2012. Error bars are 1 std. err.

c) Assessment

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

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

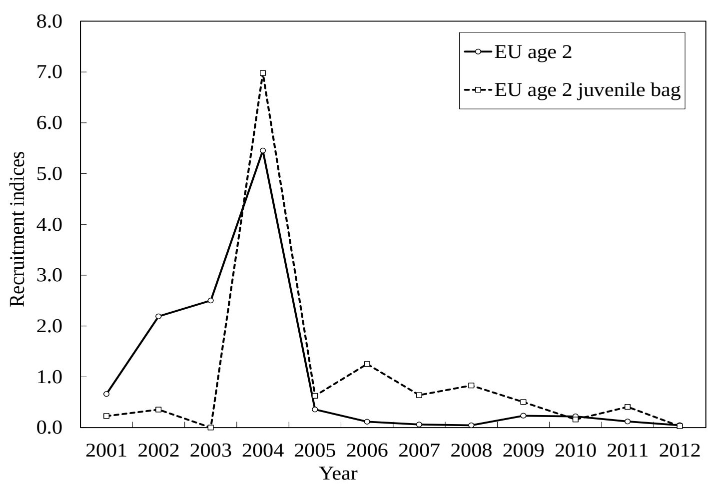


Fig. 1.3. Shrimp in Div. 3M: Abundance indices at age 2 from the EU survey. Each series was standardized to its mean.

SSB: The survey female biomass index was at a high level from 1998 to 2007, and has declined to its lowest level in 2012, well below B_{lim}.

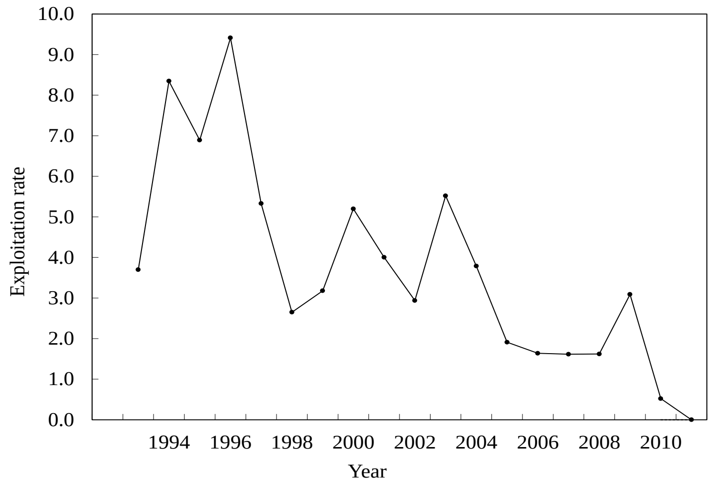


Fig. 1.4. Shrimp in Div. 3M: exploitation rate as derived by catch divided by the EU survey biomass index of the same year.

Exploitation rate: From 2005 to 2008 exploitation rates (nominal catch divided by the EU survey biomass index of the same year) remained stable at relatively low values and increased in 2009. Because catches in 2010 were low, while the female biomass estimate increased slightly, the exploitation rate declined to its lowest observed level. From 2011 no catches were recorded due to the moratorium and the exploitation rate is 0 or very close to 0.

d) State of the Stock

The low values of the total and female biomass indexes in 2009 continued in 2010 and are well below the B_{lim} proxy in 2011 and 2012, confirming the strong decrease of this stock caused by the weak recruitments in the last eight years and the increase of cod stock, one of their most important predators. NIPAG concluded that there was no change in the status of the stock.

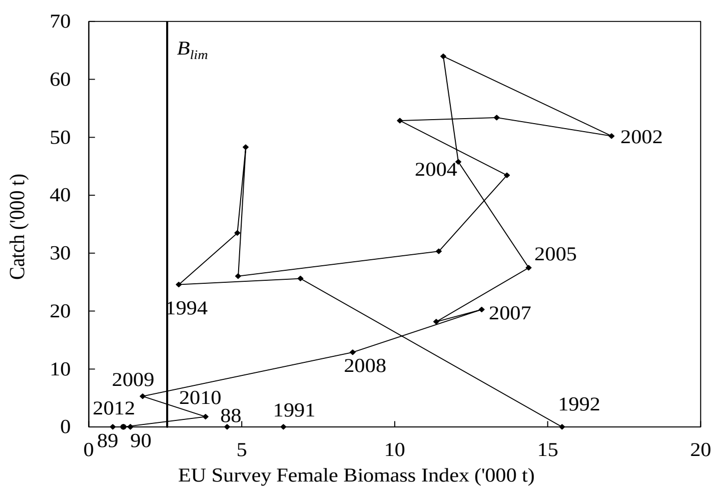


Fig. 1.5. Shrimp in Div. 3M: Catch plotted against female biomass index from EU survey. Line denoting B_{lim} is drawn where biomass is 85% lower than the maximum point in 2002. Due to the moratorium on shrimp fishing the expected catch in 2012 is 0 t.

e) Reference Points

Scientific Council considers that the point at which a valid index of stock size has declined by 85% from its maximum observed level provides a proxy for B_{lim}. This is 2 564 t for northern shrimp in Div. 3M. The index in 2011 and 2012 is below B_{lim}. It is not possible to calculate a limit reference point for fishing mortality.

f) Ecosystem considerations

The drastic decline of shrimp biomass since 2008 coincided with the increase of the cod stock in recent years.

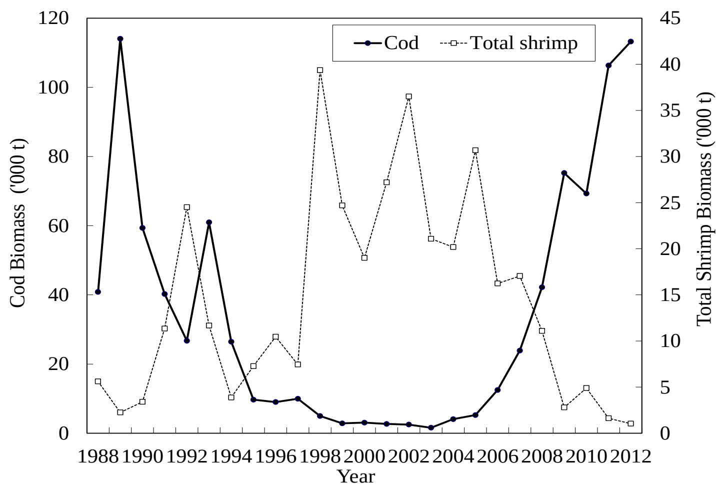


Fig. 1.6. Shrimp in Div. 3M: Cod and total shrimp biomass from EU trawl surveys, 1988-2012.

The consumption rate of shrimp by cod increased after the increase of shrimp biomass, showing a high consumption rate in the period 1999-2006. After that, despite the consumption rate decreasing, the shrimp biomass declined in conjunction with the increase of the cod biomass.

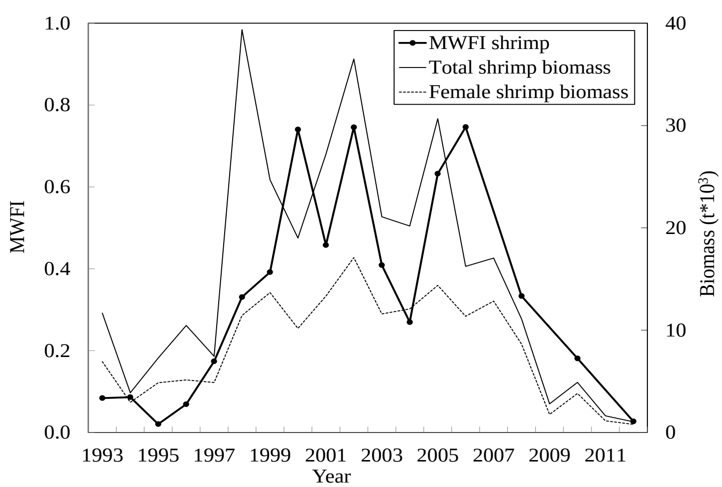


Fig. 1.7. Shrimp in Div. 3M: Shrimp consumption rate by cod along the years; Mean Weight Fullness Index (MWFI), and Total and Female biomass.

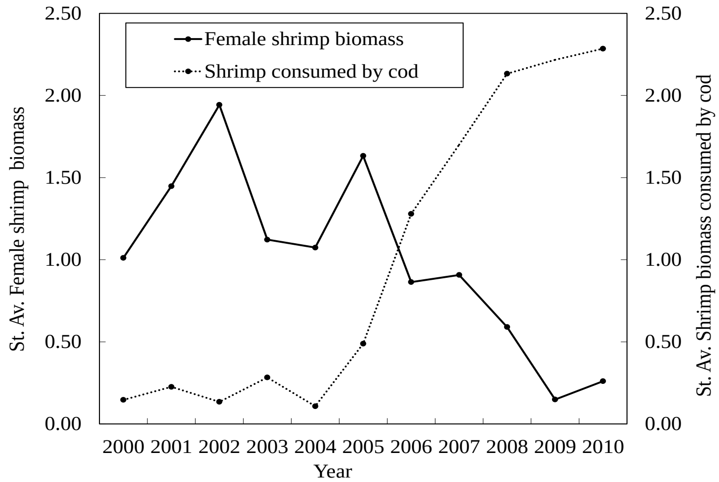


Fig. 1.8. Shrimp in Div. 3M: Standardized female shrimp biomass and shrimp biomass consumed by cod between 2000 and 2010 (values for shrimp predated in 2007, 2009 and 2011 were not available because the food sampling was not carried out in those years).

g) Conclusions

The low values of the total and female biomass indexes in 2009 continued in 2010 and were well below the B_{lim} proxy in 2011 and 2012, confirming the strong decrease of this stock caused by the weak recruitments in the last eight years and the increase of cod stock, one of their most important predators. STACFIS concludes that there was no change in the status of the stock.

2. Northern Shrimp in Divisions 3LNO

(SCR Doc. 12/047, 054, 056 and 058)

Environmental Overview

The water masses characteristic of the Grand Banks are typical Cold-Intermediate-Layer (CIL) sub-polar waters which extend to the bottom in northern areas with average bottom temperatures generally <0°C during spring and through to autumn. The general circulation in this region consists of the relatively strong offshore Labrador Current at the shelf break and a considerably weaker branch near the coast in the Avalon Channel. Currents over the banks are very weak and the variability often exceeds the mean flow. The proportion of bottom habitat on the Grand Banks covered by <0°C water has decreased from near 50% during the first half of the 1990s to <15% during recent years. The cross-sectional area of cold intermediate water (CIL) along the 47°N section across the Grand Bank is a reliable index of ocean climate conditions in this area. During the spring of 2012 the CIL area increased over the record low value of 2011 but remained below normal for the 3rd consecutive year. Bottom temperatures on the northern Grand Bank during the spring of 2012 generally ranged from 0°-3°C about 0.5°-1°C (1-2 standard deviations) above normal over most areas of Div. 3L. However, these represent a decreased of up to 1.5°C from the warm spring conditions of 2011. The January to June average surface temperature at Station 27 off eastern Newfoundland remained above the long-term mean by 1.2 standard deviations, while bottom temperatures were above normal by 1.8 standard deviations.

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 and fishing restricted to Div. 3L. Annual TACs were raised several times between 2000 and 2009 reaching a level of 30 000 t for 2009 and 2010 before decreasing to 12 000 t in 2012 and 8 600 t in 2013. A total catch of 8 947 t was taken up to September 30, 2012 (Fig. 2.1).

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

	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
TAC as set by FC	13 000[1]	13 000[1]	22 000[1]	22 000[1]	25 000[1]	30 000[1]	30 000[1]	19 200[1]	12 000[1]	8 600
STATLANT 21	11 937	13 533	21 426	21 543[1]	21 121[1]	24 142[1]	16 310[1]	12 836[2]	8 561[3]	
NIPAG[4]	13 204	14 775	25 699	23 570	26 649	27 527	20 536	12 286		

[1] Denmark with respect to Faroes and Greenland did not agree to the quotas of 144 t (2003–2005), 245 t (2006–2007), 278 t (2008), or 334 t (2009) and set their own TACs of 1 344 t (2003–2005), 2 274 t (2006–2008), 3 106 t (2009), 532 t (2010), 1 985 t (2011) and 1 241 t (2012). The increase is not included in the table.

[2] Provisional catches.

[3] Estimated catches to September 2012.

[4] NIPAG catch estimates have been updated using various data sources (see p. 15, SCR Doc. 12/47).

Since this stock came under TAC regulation, Canada has been allocated 83% of the TAC. This allocation is split between a small-vessel (less than 500 GT and less than 65 ft.) and a large-vessel fleet. By September 30, 2012, the small- and large-vessel fleets had taken 6 183 t and 1 684 t of shrimp respectively in Div. 3L. In all years, most of the Canadian catch occurred along the northeast slope in Div. 3L. The annual quota within the NAFO Regulatory Area (NRA) is 17% of the total TAC.

The use of a sorting grid to reduce bycatches of fish is mandatory for all fleets in the fishery. The sorting grid cannot have a bar spacing greater than 22 mm.

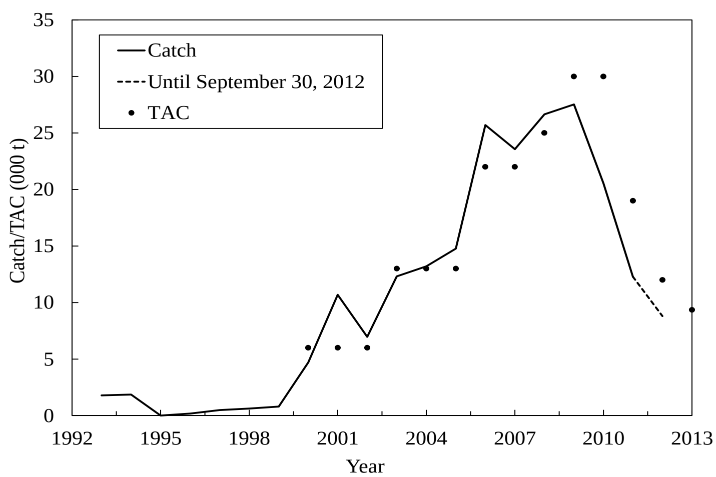


Fig. 2.1. Shrimp in Div. 3LNO: catches (to September 2012) and TAC as set by Fisheries Commission.

b) Input Data

i) Commercial fishery data

Effort and CPUE.

Catch and effort data have been available from vessel logbooks and observer records since 2000. Data for the time series have been updated for these analyses. CPUE models were standardized to 2001 values rather than the last year of the fishery. The 2012 index for small vessel CPUEs were significantly lower than the long term mean and were similar to the 2001 values while the large vessel CPUEs were the lowest in the time series (Fig. 2.2).

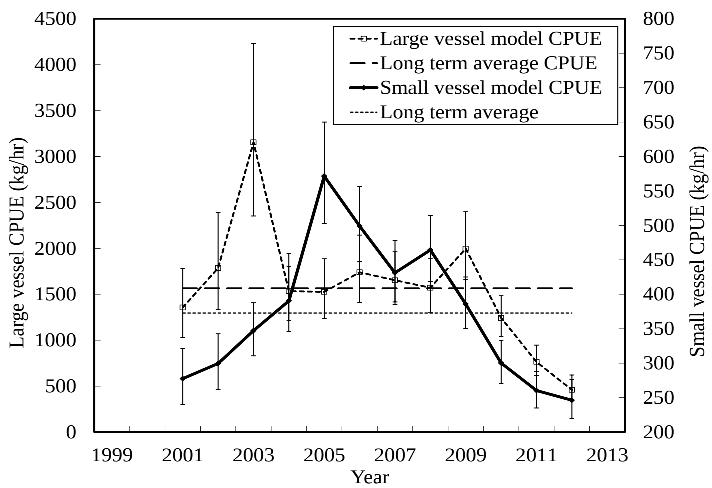


Fig. 2.2. Shrimp in Div. 3LNO: Standardized CPUE for the Canadian large-vessel (>500 t) and small-vessel (≤500 t; LOA<65’) fleets fishing shrimp in Div. 3L within the Canadian EEZ.

Logbook data were available for the shrimp fishery within the NRA, in 2012, but this came from only Estonia. The data was insufficient to produce a standardized CPUE model.

Catch composition. Length compositions were derived from Canadian, Spanish and Estonian observer datasets from 2003 to 2012, 2011 and 2010 – 2012 respectively. Catches appeared to be represented by a broad range of size groups of both males and females.

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 is available for spring (1999–2012) and autumn (1996–2011). The autumn survey in 2004 was incomplete and therefore of limited use for the assessment.

Spanish multi-species trawl survey. EU-Spain has been conducting a spring stratified-random survey in Div. 3NO within the NRA since 1995; the survey has been extended to include the NRA in Div. 3L since 2003. From 2001 onwards data were collected with a Campelen 1800 trawl. There was no Spanish survey in 2005 in Div. 3L.

Biomass. In Canadian surveys, over 90% of the biomass was found in Div. 3L, distributed mainly along the northeast slope in depths from 185 to 550 m. There was an overall increase in the both spring and autumn indices to 2007 after which they decreased by about 75% to 2012 (Fig. 2.3). Confidence intervals from the spring surveys are usually broader than from the autumn surveys.

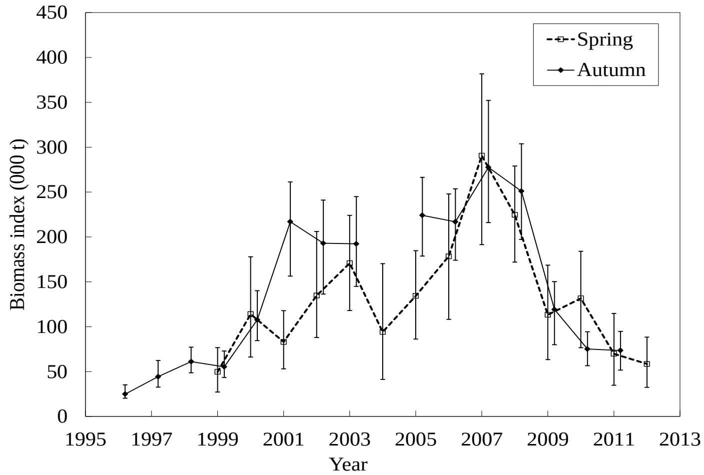


Fig. 2.3. Shrimp in Div. 3LNO: biomass index estimates from Canadian spring and autumn multi-species surveys (with 95% confidence intervals).

Spanish survey biomass indices for Div. 3L, within the NRA, increased from 2003 to 2008 followed by a 93% decrease by 2012 (Fig. 2.4).

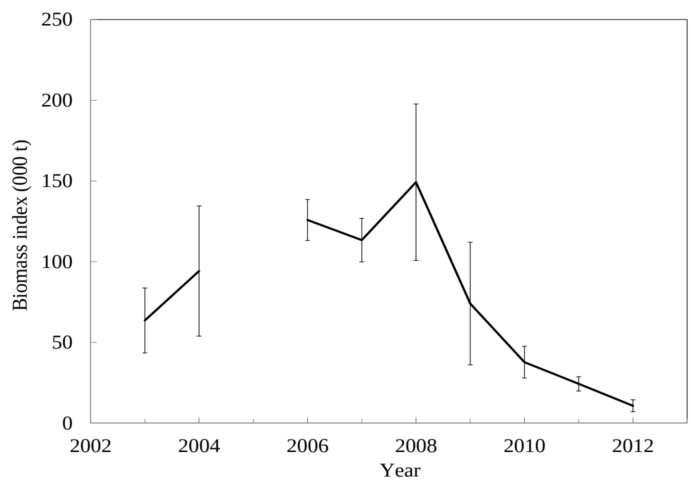


Fig. 2.4. Shrimp in Div. 3LNO: biomass index estimates from EU - Spanish multi-species surveys (± 1 s.e.) in the 3L NRA.

Female Biomass (SSB) indices. The autumn 3LNO female biomass index showed an increasing trend to 2007 but decreased 72% by 2012. The spring SSB index decreased by 84% between 2007 and 2012 (Fig. 2.5).

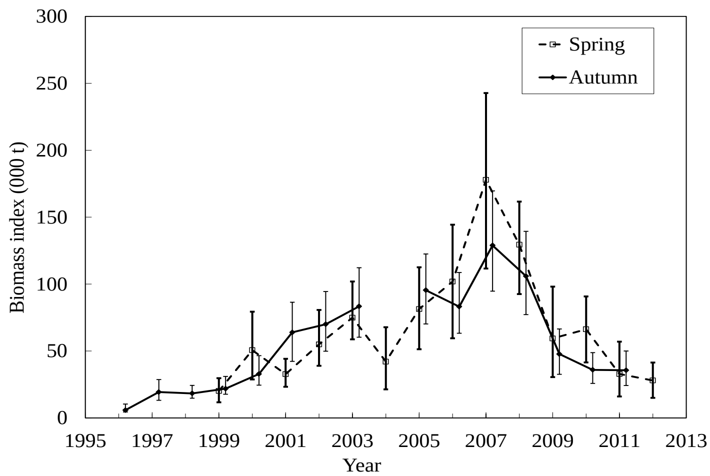


Fig. 2.5. Shrimp in Div. 3LNO: Female biomass indices from Canadian spring and autumn multi-species surveys (with 95% confidence intervals).

Stock composition. The autumn surveys showed an increasing trend in the abundance of female (transitional + females) shrimp up to 2007 and remained high in 2008 then decreased by 72% through to 2011. Similarly, spring female abundance series increased until 2007, remained high in 2008 then decreased by 84% through to 2012. Male autumn abundance index peaked in 2001 and remained high until 2008 before decreasing by 74% by 2011. The spring male abundance index followed trends similar to their respective female index (Fig. 2.6).

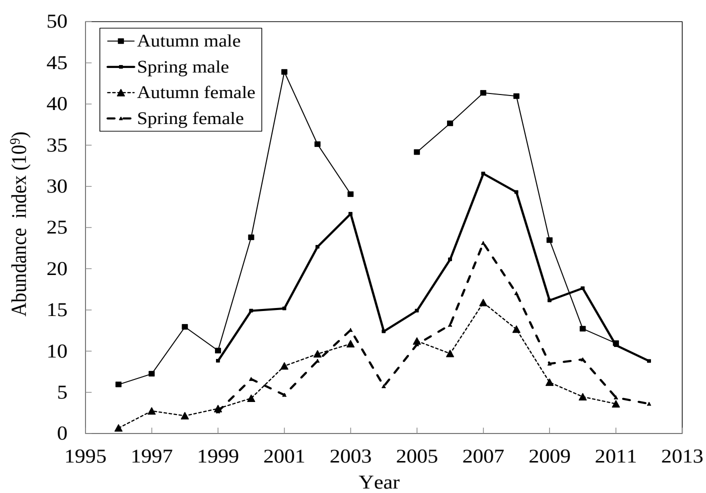


Fig. 2.6. Shrimp in Div. 3LNO: Abundance indices of male and female shrimp within Div. 3LNO as estimated from Canadian multi-species survey data.

Both males and females showed a broad distribution of lengths in recent surveys indicating the presence of more than one year class. It is worth reiterating that since 2008 the abundances at all length classes were greatly reduced from those found in previous Canadian surveys (Fig. 2.7).

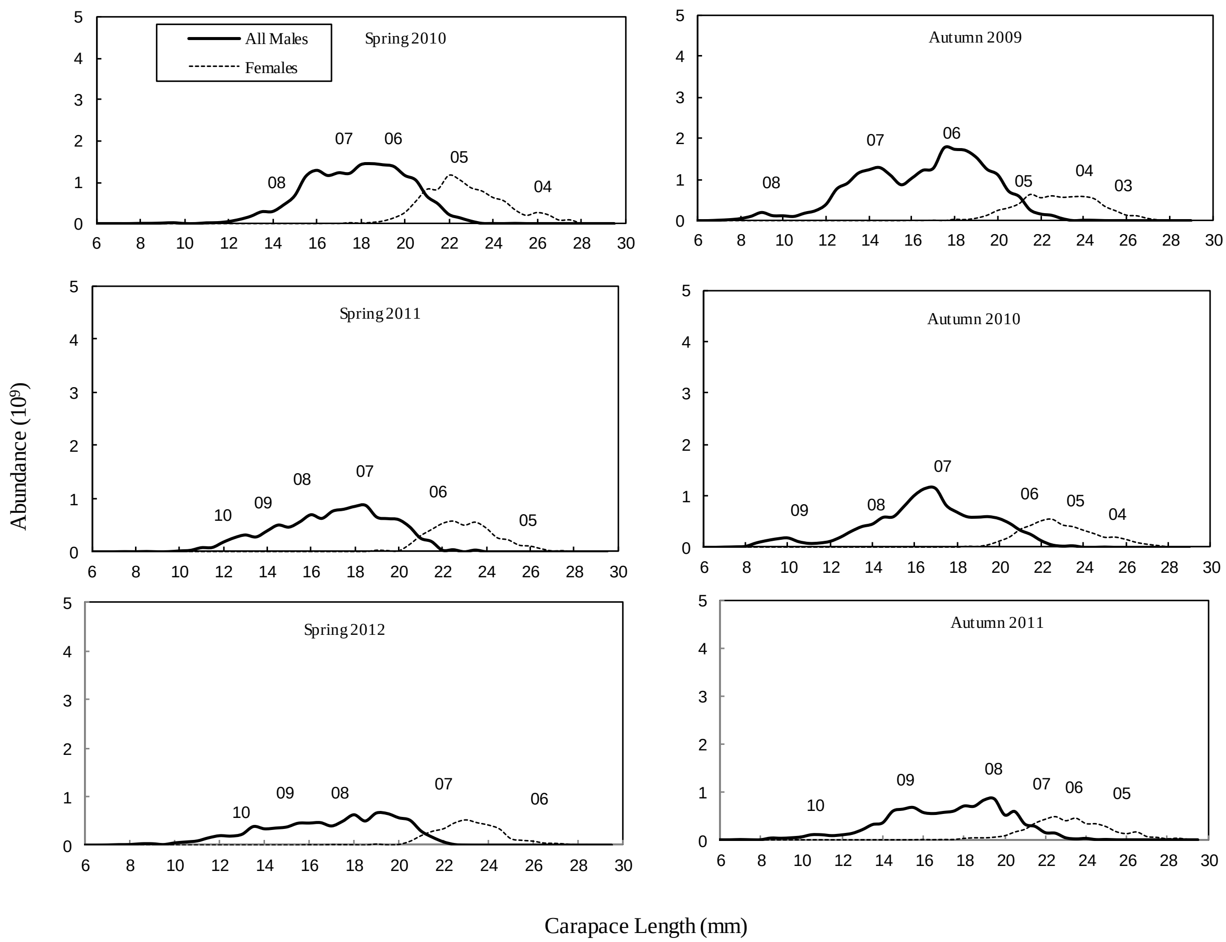


Fig. 2.7. Shrimp in Div. 3LNO: abundance at length (smoothed) for northern shrimp estimated from Canadian multi-species survey data. Numbers within charts denote year-classes.

Recruitment indices. The recruitment indices were based upon abundances of all shrimp with carapace lengths of 11.5 – 17 mm from Canadian survey data. The 2006 – 2008 recruitment indices were among the highest in both spring and autumn time series. Both indices decreased through to spring 2012 (Fig. 2.8).

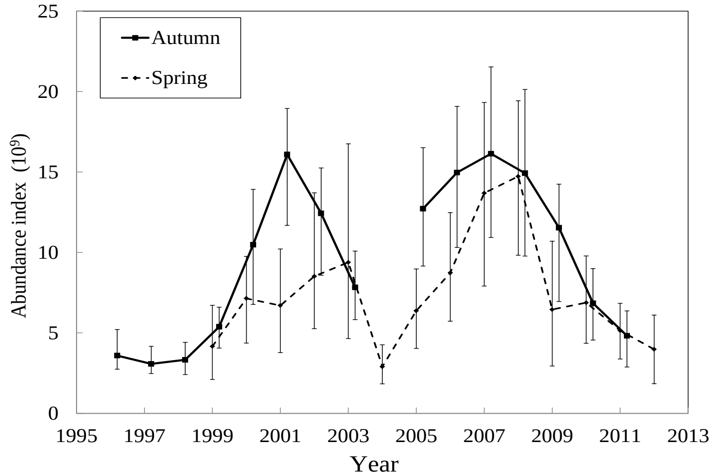


Fig. 2.8. Shrimp in Div. 3LNO: Recruitment indices derived from abundances of all shrimp with 11.5 – 17 mm carapace lengths from Canadian spring and autumn bottom trawl survey (1996–2012) data.

Fishable biomass and exploitation indices. There had been an increasing trend in Canadian spring and autumn survey fishable biomass indices (shrimp >17 mm carapace length) until 2007. The autumn fishable biomass showed an increasing trend until 2007 then decreased by 76% through to 2010 and remaining near that level in 2011. Similarly, the spring fishable biomass index increased to 2007 but has since decreased by 82% through to 2012 (Fig. 2.9).

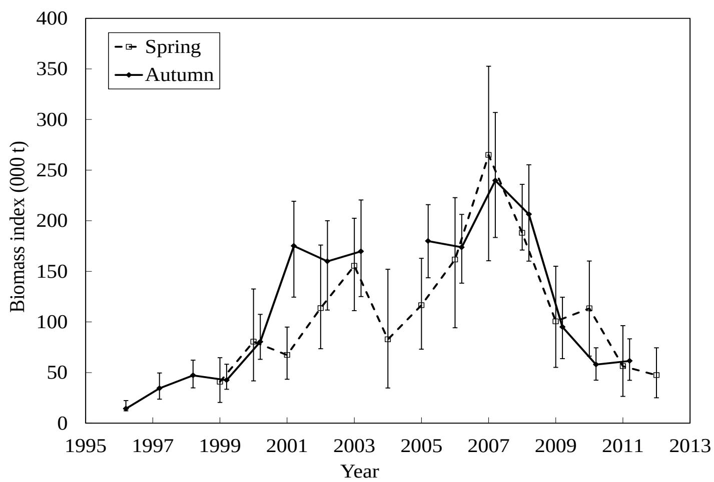


Fig. 2.9. Shrimp in Div. 3LNO: fishable biomass index. Bars indicate 95% confidence limits.

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 catch series was updated in the September 2012. The exploitation index has been below 0.15 until 2010 when it increased to 0.21. By September 30, 2012, the 2012 exploitation rate index was 0.14. Based upon the autumn 2011 fishable biomass of 61 500 t, if the entire 12 000 t quota was to be taken, the exploitation rate index would increase to 0.20 (Fig. 2.10).

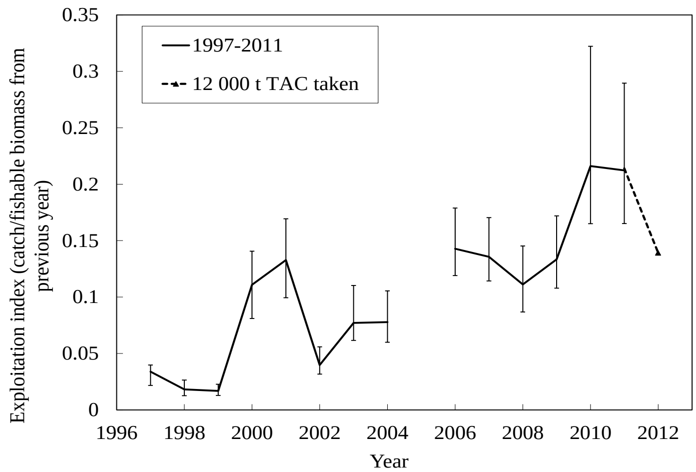


Fig. 2.10. Shrimp in Div. 3LNO: exploitation rates calculated as year's catch divided by the previous year's autumn fishable biomass index. The 2012 exploitation rate index is based upon incomplete catch data. Bars indicate 95% confidence limits.

c) Assessment Results

Recruitment. Recruitment indices from 2006 – 2008 were among the highest in the spring and autumn time series but have decreased since and are now close to the lowest observed values.

Biomass. Spring and autumn biomass indices generally increased, to record levels by 2007, but decreased substantially by 2010 and remained near that level in 2011. The spring biomass indices remained at a low level in 2012.

Exploitation. The index of exploitation has remained below 0.15 until 2010 but has since increased.

State of the Stock. The predicted decline in the 2011 autumn survey biomass did not occur. However, the decreased levels of biomass in the Canadian survey series since 2007 are a reason for concern. The biomass is likely to be above B_{lim}.

d) Precautionary Reference Points

Scientific Council considers that the point at which a valid index of stock size has declined by 85% from the maximum observed index level provides a proxy for B_{lim} (approximately 19 000 t) for northern shrimp in Div. 3LNO (SCS Doc. 04/12). Currently, the female biomass index is estimated to be above B_{lim} (Fig. 2.11). It is not possible to calculate a limit reference point for fishing mortality. A safe zone has not been determined in the precautionary approach for this stock.

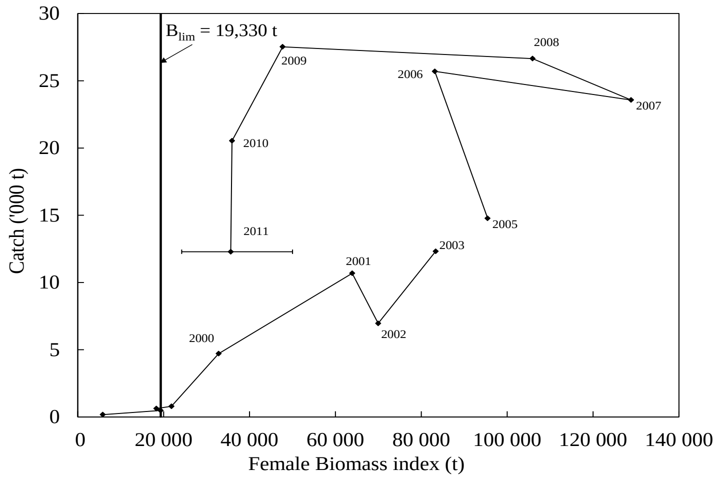


Fig. 2.11. Shrimp in Div. 3LNO: Catch against female biomass index from Canadian autumn survey. Line denoting B_{lim} (approximately 19 000 t) is drawn where female biomass is 85% lower than the maximum point in 2007.

e) Conclusion

The predicted decline in the 2011 autumn survey biomass did not occur. However, the decreased levels of biomass in the Canadian survey series since 2007 are a reason for concern. The biomass is likely to be above B_{lim}. NIPAG concluded that there was no change in the status of the stock.

f) Other Studies

Yield per Recruit model. A yield per recruit model for NAFO Div. 3LNO Northern Shrimp was presented at this assessment meeting. The main inputs for the model are those data presented in (SCR Doc. 12/47) and the software used is from the Woods Hole NFT Toolbox (VBYPRLen version 2.1 http://nft.nefsc.noaa.gov/Download.html). The model was able to produce $F_{0.1}$ and F_{max} reference points, however, NIPAG agreed that in the absence of an age or length based analytical assessment, Yield per Recruit reference points are of no use in providing advice to managers.

g) Review of Recommendations from 2011

NIPAG **recommended** that *research continue into fitting production models to data for northern shrimp in Div. 3LNO including studies of stock structure and continued investigation of stock assessment models for Pandalus borealis in NAFO Div. 3LNO. This may help provide estimations of* B_{MSY} *and* F_{MSY}.

STATUS: Sensitivity analysis was presented for a Bayesian surplus production model but led to no conclusion for selection of a final model to determine stock status for 2012. Preliminary analysis of genetic studies by Norway showed promise in determining stock structure (see Scientific Council Report Section V.4)

It was concluded to continue with the work using a Bayesian surplus production model, to help provide estimates of B_{MSY} and F_{MSY} for the meeting in September 2013. Specifically:

1. Determine appropriate priors
2. Investigate the efficacy of an alternate parameterization of the model in terms of intrinsic rate of growth (r).
3. Incorporate both Canadian spring and autumn survey series.

3. Northern shrimp (Subareas 0 and 1)

(SCR Doc. 04/75, 04/76, 08/62, 12/44, 12/45, 12/46, 12/48, 12/57; SCS Doc. 04/12)

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). Since 1981 the Canadian fishery has been limited to Div. 0A.

Three fleets, one from Canada and two from Greenland (offshore and coastal) have participated in the fishery since the late 1970s. The Canadian fleet and the Greenland offshore fleet 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 t, but in recent years much 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 44 mm in Greenland, 40 mm in 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 TAC advised for the entire stock for 2004–2007 was 130 000 t, reduced for 2008–2010 to 110 000 t and increased again for 2011 to 120 000 t. The quantitative model used in the assessment was modified in 2011 (SCR Doc. 11/58) and as a result the TAC advised for 2012 was reduced to 90 000 t. For 2012, Greenland enacted a TAC of 101 675 t for Subarea 1. Of this, 4000 t was allocated (by contract) to the EU, 55 675 t to the Greenland sea-going fleet and 42 000 t to the coastal fleet. Canada enacted a TAC of 16 921 t for SFA 1.

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. However, the coastal fleet catching bulk shrimps does not log catch weights of *P. montagui* separately from *P. borealis;* weights are estimated by catch sampling at the point of sale and the price adjusted accordingly, but the weight of *P. montagui* is not deducted from the quota (SCR Doc. 11/53). Logbook-recorded catches can therefore still legally exceed quotas. Instructions for reporting *P. montagui* in logbooks have been changed in 2012, with a view to improve the reporting.

The table of recent catches was updated (SCR Doc. 12/45). 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 average over 150 000 t in 2005–08, but have since decreased, to 110 000 t (projected) in 2012.

Recent catches, projected catches for 2012 and recommended and enacted TACs (t) for Northern Shrimp in Div. 0A east of 60°30'W and in Subarea 1 are as follows:

	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
TAC										
Advised	100 000	130 000	130 000	130 000	130 000	110 000	110 000	110 000	120 000	90 000
Enacted[4]	115 167	149 519	152 452	152 380	152 417	145 717	132 987	132 987	142 597	118 596
Catches (NIPAG)										
SA 1	123 036[1]	142 311	149 978	153 188	142 245	153 889	135 029	128 108	122 655	*110 000*[2]
Div. 0A (SFA 1)	7137	7021	6921	4127	1945	0	429	5882	1 330	*0*
TOTAL SA1–Div.0A	130 173	149 332	156 899	157 315	144 190	152 749	135 458	133 990	123 985	*110 000*[2]
STATLANT 21										
SA 1	78 436	142 311	149 978	153 188	142 245	148 550	133 561	123 973[3]	121 207[3]	
Div. 0A	2170	6861	6410	3788	1878	0	429	5206[3]	859[3]	

[1] Catches before 2004 corrected for underreporting
[2] Total catches for the year as predicted by industry observers.
[3] Provisional
[4] Canada and Greenland set independent autonomous TACs.

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 about 1996 catch and effort in southern West Greenland have continually decreased, and since 2008 effort in Div. 1F has been virtually nil (SCR Doc. 12/48).

The Canadian catch in SFA1 was stable at 6 000 to 7 000 t in 2002–2005, about 4–5% of the total catch, but since 2007 fishing effort has been sporadic and catches variable, averaging about 1 600 t in 2007–12.

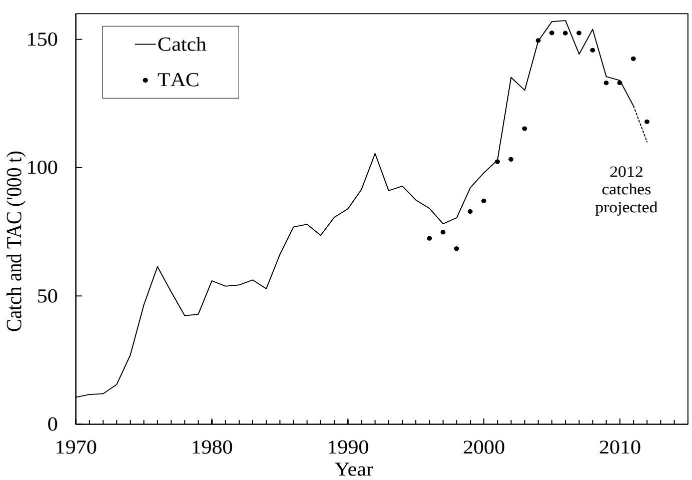


Fig. 3.1. Northern shrimp in Subarea 1 and Canadian SFA1: enacted TACs and total catches (2012 predicted for the year).

b) Input Data

i) Fishery data

Fishing effort and CPUE. Catch and effort data from the fishery were available from logbooks from Canadian vessels fishing in Canadian SFA 1 and from Greenland logbooks for Subarea 1 (SCR Doc. 12/48). 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; and the previously rigid division between the offshore and coastal quotas has been relaxed and quota transfers are now allowed. A change in legislation effective since 2004 requiring logbooks to record catch live weight in place of a previous practice of under-reporting would, by increasing the recorded catch weights, have increased apparent CPUEs since 2004; this discontinuity in the CPUE data was corrected in 2008.

CPUEs were standardised by linearised multiplicative models including terms for vessel effect, month, year, and statistical area; the fitted year effects were considered to be series of annual indices of total stock biomass. Series for the Greenland fishery after the end of the 1980s were divided into 2 fleets, a coastal and an offshore; for those ships of the present offshore fleet that use double trawls, only double-trawl data was used. A series for 1976–1990 was constructed for the KGH (Kongelige Grønlandske Handel) fleet of sister trawlers and a series for 1987–2007 and 2010 for the Canadian fleet fishing in SFA1. The CPUE indices from the Greenland coastal and the Greenland offshore fleets remained closely in step from 1988 to 2004 (Fig. 3.2), then diverged more from each other in 2005 and 2007, but in 2008–2012 their trajectories have again agreed. CPUE in the Canadian fishery in SFA1 has always varied more from year to year and has never stayed closely in step with the Greenland fleets, although over time its overall trend has been similar and it has also increased between the 1990s and the most recent values.

The four CPUE series were unified in a separate step to produce a single series that was input to the assessment model. This all-fleet standardised CPUE was variable, but on average moderately high, from 1976 through 1987, but then fell to lower levels until about 1997, after which it increased markedly to plateau in 2004–08 at about twice its 1997 value (Fig. 3.2). Values for 2009 to 2011 have been lower (SCR Doc. 12/48).

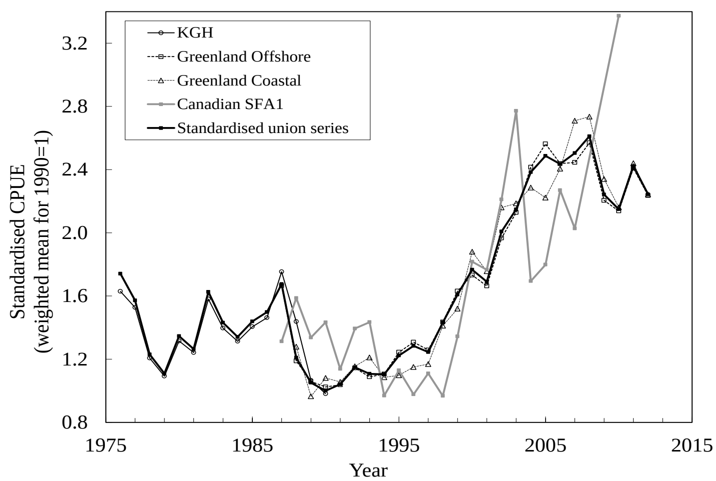


Fig. 3.2. Northern shrimp in Subarea 1 and Canadian SFA1: standardised CPUE index series 1976–2012.

The distribution of catch and effort among NAFO Divisions was summarised using Simpson's diversity index to calculate an 'effective' number of Divisions being fished as an index of how widely the fishery is distributed (Fig 3.3). (In interpreting the index, it should be remembered that NAFO Divisions in Subarea 1, designed for the management of groundfish fisheries, are of unequal size with respect to shrimp grounds, and those recently abandoned by the fishery are the smaller ones.) The fishery area has contracted and continues to do so; NIPAG has for some years been concerned for effects of this contraction on the relationship between CPUE and stock biomass, and in particular that relative to earlier year's biomass might be overestimated by recent CPUE values.

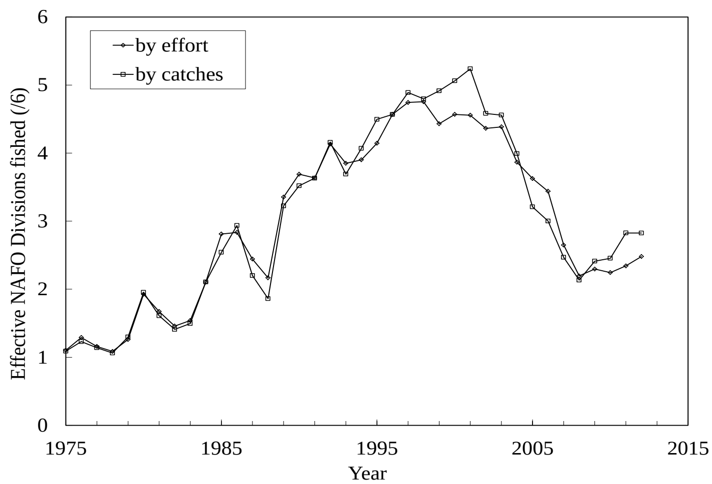


Fig. 3.3. Northern shrimp in Subarea 1 and Canadian SFA1: indices for the distribution of the Greenland fishery among NAFO Divisions in 1975–2012.

From the end of the 1980s there was a significant expansion of the fishery southwards and in 1996–98 areas south of Holsteinsborg Deep (66°00'N) accounted for 65% of the Greenland catch. The effective number of Divisions of SA 1 being fished peaked at about 4.5–5 in 1995–2003. Since then the range of the fishery has contracted northwards and the effective number of Divisions being fished has decreased. Since 2007 the areas south of Holsteinsborg Deep have yielded only about 10% of the catch, and Julianehåb Bay no longer supports a fishery.

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. 12/44). 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 only used 60-min. tows, but since 2005 all tows have lasted 15 min. In 2005 the *Skjervøy 3000* survey trawl used since 1988 was replaced by a *Cosmos 2000* with rock-hopper ground gear, calibration trials were conducted, and the earlier data was adjusted.

The survey average bottom temperature increased from about 1.7°C in 1990–93 to about 3.1°C in 1997–20011 (SCR Doc. 12/44). About 80% of the survey biomass estimate is in water 200–400 m deep. In the early 1990s, about ¾ of this was deeper than 300 m, but after about 1995 this proportion decreased and since about 2001 has been about ¼, and most of the biomass has been in water 200–300 m deep (SCR Doc. 12/44). The proportion of survey biomass in Div. 1E–F has decreased in recent years and the distribution of survey biomass, like that of the fishery, has become more concentrated and more northerly.

Biomass. The survey index of total biomass remained fairly stable from 1988 to 1997 (c.v. 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, by 2008–2009 less than half the 2003 maximum (Fig. 3.4) and 9% below the series mean. In 2010 the survey biomass index increased by nearly 24%, but in 2011 it returned to below the 2009 level and in 2012 decreased by a further 23% (SCR Doc. 12/44). Of the survey biomass, 48%, an exceptionally high proportion, was in Disko Bay and Vaigat, about 7% of the survey area.

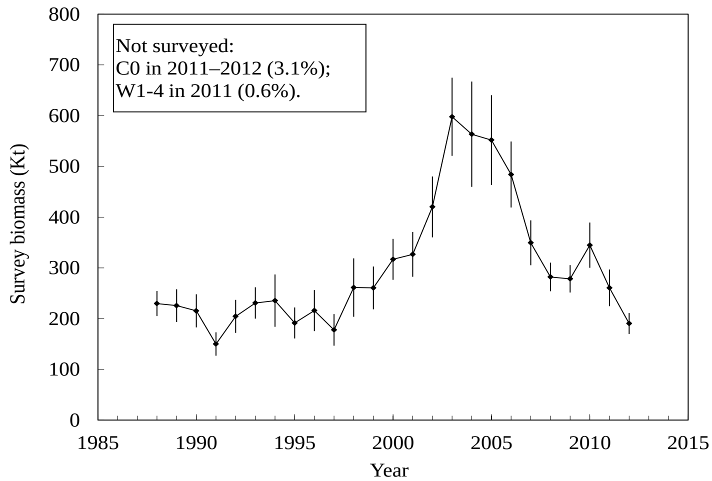
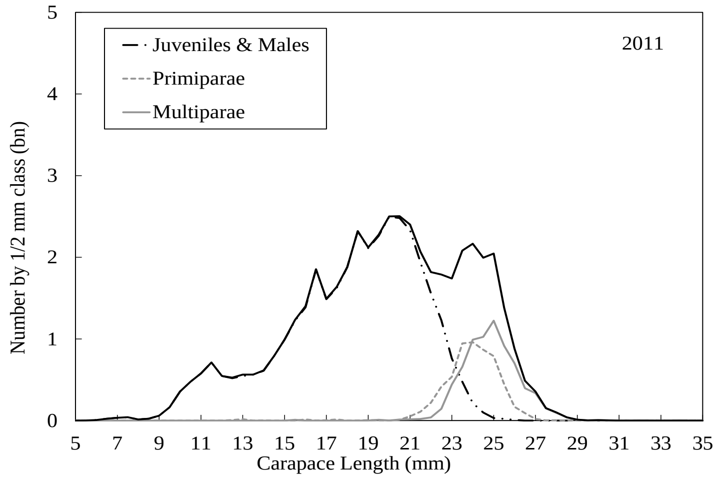


Fig. 3.4. Northern Shrimp in Subarea 1 and Canadian SFA 1: survey indices of stock biomass 1988–2012 (SCR Doc. 12/44) (error bars 1 s.e.)

Length and sex composition (SCR Doc. 12/44). In 2008 modes at 12 mm and 15 mm CL could be observed suggesting two- and three-year-olds; the two-year-old class in particular appeared stronger than in 2007. The 2009 distribution of lengths appeared very similar to that for 2008; cohorts could be distinguished at 11–13 mm and at 15.5–18 mm. The supposed 2-year-old class appears to have numbered about the same in 2009 and 2010 as in 2008, but in 2011 numbered 68% of the 2008–10 mean and 55% of the series mean (Fig. 3.5). Numbers at age 2 are well below the 20-year lower quartile in 2012; given that survey biomass is about as low as has ever been observed; absolute numbers at age 2 are therefore very low.

Estimated numbers of males and females in 2009 - 41.5 and 12.2 bn - were close to those for 2008 and still below their series means. In 2010 the number of males was about 40% higher at 56.2 bn while the number of females increased by only about 16% to 14.4 bn; in 2011 total numbers at 49.8 bn are 30% less than in 2010, but almost all the decrease is in numbers of males, while females remain at 96% of the 2010 number. In 2011 the stock was estimated to have its highest-ever proportion of females both by number (26%) and by weight (43%), but to be short of shrimps at 15 - 22 mm CPL. The fishable proportion was estimated at 91.4%, close to its average level.

In 2012 overall the fishable biomass at 91.1% of total was a little below its 20-year median, but comprised an exceptionally high proportion of females. Pre-recruits (14 - 16.5 mm) have been few since 2008 in absolute numbers.



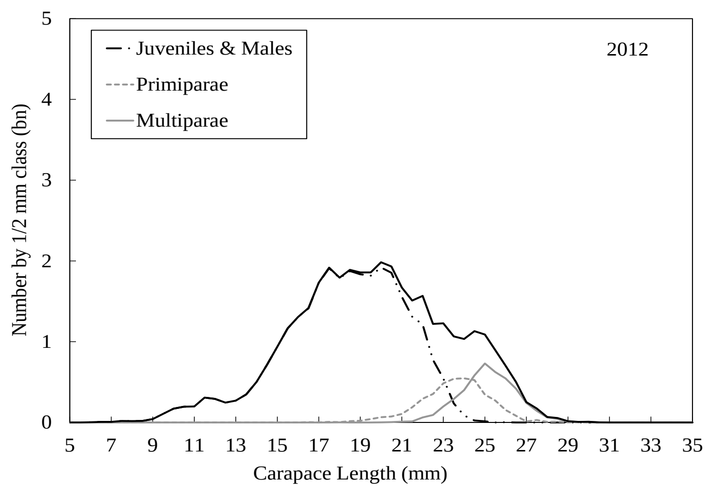


Fig. 3.5. Northern Shrimp in Subarea 1 and Canadian SFA 1: length frequencies in the West Greenland trawl survey in 2011–2012.

Recruitment Index. The number at age 2 is a possible predictor of fishable biomass 2–4 years later (SCR Doc. 03/76). This recruitment index was high in 2001, but decreased continually to 2007. From 2008 to 2010 estimated numbers at age 2 were higher than in 2007 and about stable near 78% of the series mean, but in 2011 decreased to 55% of the mean and in 2012 to the lowest level ever. A relative lack of fishable males in 2012 presages poor immediate recruitment to the spawning stock.

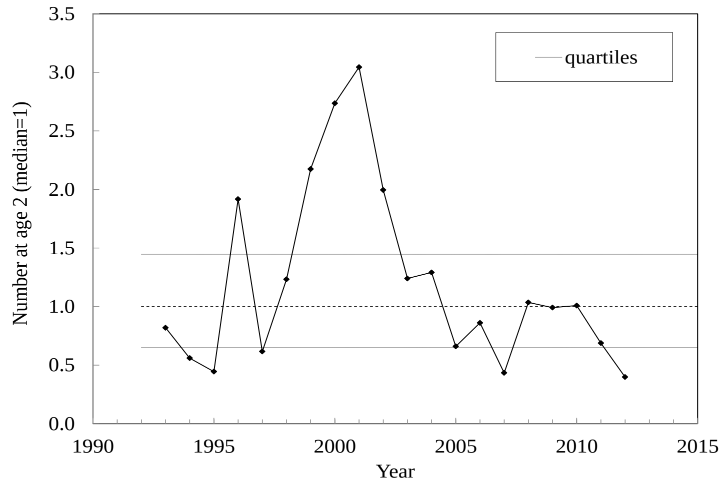


Fig. 3.6. Northern Shrimp in Subarea 1 and Canadian SFA 1: survey index of numbers at age 2, 1993–2012.

iii) Predation index

Estimates of cod biomass from the German groundfish survey at West Greenland are used in the assessment of shrimp in SA 1 and in Div. 0A east of 60°30′W, but the results from the German survey for the current year are not available in time for the assessment. Although the West Greenland trawl survey is not primarily directed towards groundfish, the cod biomass index it produces for West Greenland offshore waters is well correlated with that from the German groundfish survey (r^2 = 0.86). The index of cod biomass is adjusted by a measure of the overlap between the stocks of cod and shrimp in order to arrive at an index of 'effective' cod biomass, which is entered in the assessment model. In recent years cod stocks have fluctuated, and a great increase in biomass in 2006–07 was short-lived (Fig. 3.7). In 2011 cod was widely distributed along the West Greenland shelf and the index of overlap between the distributions of cod and shrimp increased to 88.8%, giving an effective biomass of 21.8 Kt. In 2012 the overlap decreased as the biomass increased and the effective biomass was 22.7 Kt.

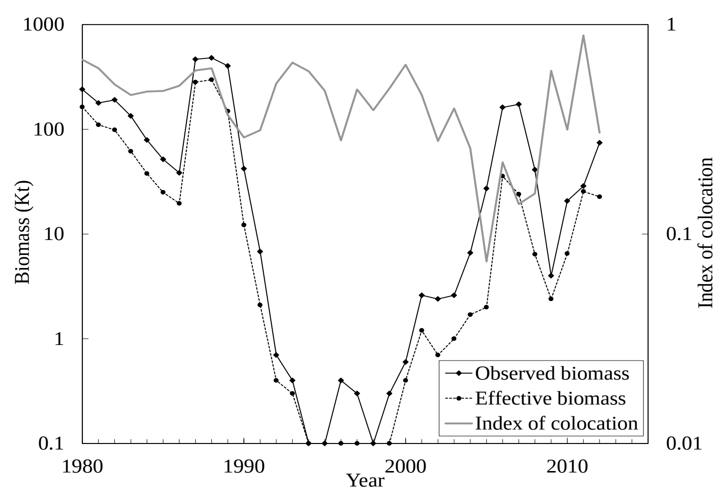


Fig. 3.7. Northern shrimp in Subarea 1 and Canadian SFA1: Indices of the biomass of Atlantic cod, including its index of colocation with the stock of Northern shrimp, 1980–2012

c) Results of the Assessment

i) Estimation of Parameters

A Schaefer surplus-production model of population dynamics was fitted to series of CPUE, catch, and survey biomass indices (SCR Doc. 12/46). The model included a term for predation by Atlantic cod and the series of 'effective' cod biomass values was included in the input data. Total catches for 2012 were assumed to be 110 000 t. The assessment model was slightly modified in 2012 to include the uncertainty of projecting the current year's catches.

In 2011 the previously accepted assessment model had been constrained to fit the biomass trajectory at least as closely to the survey index as to the CPUE index: i.e. the survey CV should be no greater than the CPUE CV. The model was run with data series shortened to 30 years to speed up the running; the effect of shortening the data series was checked and found not significant. The result was a biomass trajectory that tracked between the survey index and the CPUE index instead of closely following the CPUE index; the survey CV was estimated at 13% and that of the CPUE at 15%. The process error and the error associated with the predation term both increased considerably, so predictions became more uncertain. The biomass was then considered to have decreased, as the survey index did, between 2003 and 2011 under the influence of the high catches of 2004–2008, instead of staying high like the CPUE index. In consequence, the model estimated the MSY lower in 2011 than in previous assessments, at 135 Kt/yr.

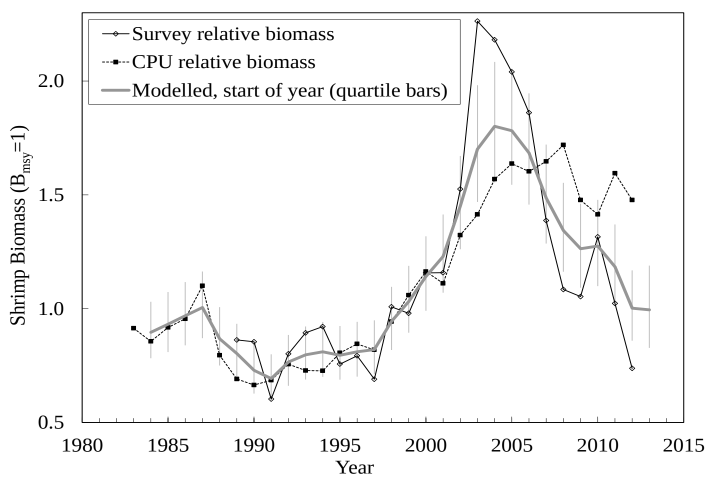


Fig. 3.8: Northern Shrimp in SA 1 and Canadian SFA1: trajectory of the median estimate of relative stock biomass at start of year 1983–2013, with median CPUE and survey indices; 30 years' data with constrained CVs.

Table 3.1 Estimates of stock-dynamic and fit parameters from fitting a Schaefer stock-production model, with constrained CVs, to 30 years' data on the West Greenland stock of the northern shrimp in 2012, with median values from 2011 assessment:

	2012 assessment						2011 assessment
	Mean	S.D.	25%	Median	75%	Est. Mode	Median
Max.sustainable yield	139	67	108	132	160	118	136
B/Bmsy, end current year (proj.)	1.02	0.29	0.83	1.00	1.19	0.95	1.08
Biom. risk, end current yr (%)	51	50					
Z/Zmsy, current year (proj.)	2.86	26.82	0.77	1.08	1.51	—	1.09
Carrying capacity	3776	3418	1861	2767	4427	749	2661
Max. sustainable yield ratio (%)	10.7	6.3	6.0	10.1	8.9	8.9	10.7
Survey catchability (%)	20.5	13.7	10.3	17.4	11.2	11.2	20.3
CV of process (%)	12.2	2.9	10.2	11.9	14.0	11.3	11.0
CV of survey fit (%)	14.5	2.0	13.2	14.5	15.8	14.4	13.1
CV of CPUE fit (%)	17.2	2.5	15.5	16.9	18.6	16.3	14.9

ii) Assessment Summary

Recruitment. The stock structure in 2012 is deficient in fishable males, presaging poor short-term recruitment to the spawning stock. Pre-recruits (CL 14–16.5 mm), expected to enter the fishery in 2013, have been few since 2008 in absolute terms. Numbers at age 2 in 2012 have declined to their lowest-ever level, so medium-term recruitment is also expected to be poor.

Biomass. A stock-dynamic model showed a maximum biomass in 2003 with a continuing decline since; the probability that biomass will be below B_{msy} in 2012 with projected catches at 110 000 t was estimated at 51%; of its being below B_{lim} at 1–2%.

Mortality. The mortality caused by fishing and cod predation (Z) is estimated to have stayed below the upper limit reference (Z_{msy}) from 1996 to 2005, but is estimated to have averaged 2.6% over the limit value since 2006. With catches projected at 110 000 t the risk that total mortality in 2012 would exceed Z_{msy} was estimated at about 56%. Atlantic cod is, in 2012, more concentrated in southerly areas where shrimps are now scarce, and predation is expected to be moderate or low.

State of the Stock. Modelled biomass is estimated to have been declining since 2004. At the end of 2012 biomass is projected to be close to B_{msy}. Total mortality is projected to exceed Z_{msy}. Recruitment to the fishable and spawning stock in the short- and medium-term is expected to remain low.

d) Precautionary Approach

The fitted trajectory of stock biomass showed that the stock had been below its MSY level until the late 1990s, with mortalities mostly near the MSY mortality level except for an episode of high mortality associated with a short-lived resurgence of cod in the late 1980s. In the mid-1990s, with cod stocks at low levels, biomass started to increase at low mortalities to reach about 1.6 times B_{msy} in 2003–05. Recent increases in the cod stock coupled with high catches have been associated with higher mortalities and continuing decline in the modelled biomass, although the biomass is still estimated at near B_{msy}.

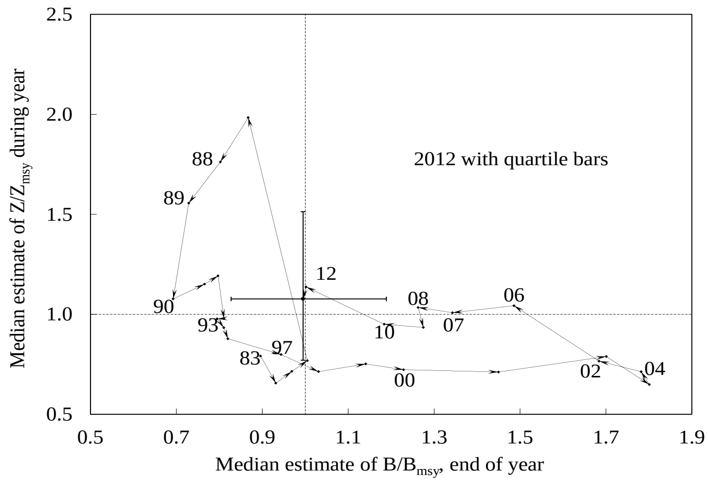


Fig. 3.9: Northern shrimp in Subarea 1 and Canadian SFA1: trajectory of relative biomass and relative mortality, 1983–2012.

e) Projections

Predicted probabilities of transgressing precautionary reference points in 2013 and 2014 (risk table) under seven catch options and subject to predation by a cod stock with an effective biomass of 25 000 t:

25 000 t cod	Catch option ('000 t)						
Risk of:	70	75	80	85	90	95	100
falling below B_{msy} end 2013 (%)	46.8	47.6	47.8	48.7	48.9	49.8	50.9
falling below B_{lim} end 2013 (%)	1.4	1.4	1.4	1.4	1.4	1.5	1.6
exceeding Z_{msy} during 2013 (%)	27.1	30.9	34.1	38.4	43.0	47.2	50.7
exceeding Z_{msy} during 2014 (%)	27.2	30.8	34.4	38.2	42.5	46.7	50.9

In the medium term, with a 25 000 t effective biomass of cod, model results estimate catches of 95 000 t/yr to be associated with a stationary stock close to B_{msy}.

Predicted probabilities of transgressing precautionary reference points after 3 years in the fishery for Northern Shrimp on the West Greenland shelf with 'effective' cod stocks assumed at 20 000 t and 25 000 t.

Catch (Kt/yr.)	Prob. biomass < B_{msy} (%)		Prob. biomass< B_{lim} (%)		Prob. mort > Z_{msy} (%)	
	20 Kt	25 Kt	20 Kt	25 Kt	20 Kt	25 Kt
70	40.2	41.2	2.3	2.6	24.8	27.4
75	41.4	42.8	2.5	2.6	28.0	30.8
80	42.9	43.7	2.3	2.7	31.9	34.3
85	44.5	45.5	2.6	2.8	35.6	38.0
90	46.0	46.5	2.8	2.8	39.9	42.6
95	47.3	48.5	2.6	3.2	43.9	46.5
100	48.3	49.8	3.0	3.3	48.0	50.8

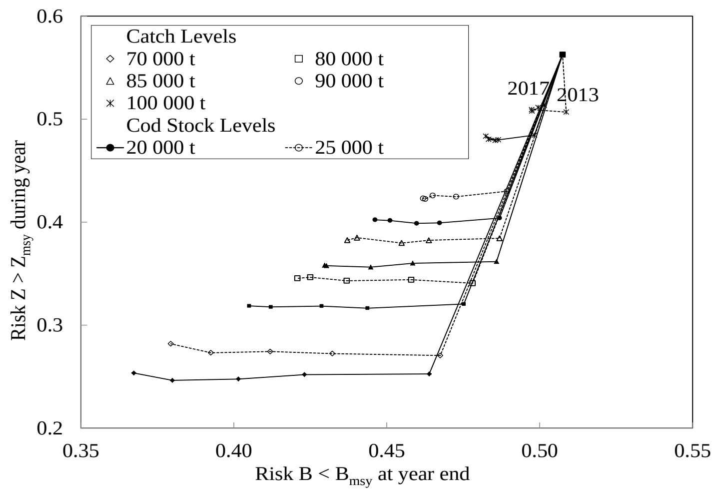


Fig. 3.10. Northern shrimp in Subarea 1 and Canadian SFA1: Risks of transgressing mortality and biomass precautionary limits for catches at 70 000–100 000 t projected over five years with an ‘effective’ cod stock assumed at 20 000 or 25 000 t.

Medium-term projections were summarised by plotting the risk of exceeding Z_{msy} against the risk of falling below B_{msy} over 5 years for 5 catch levels, considering also two possible levels for the ‘effective’ cod stock (Fig. 3.9). The immediate biomass risk is relatively insensitive to catch level but changes with time, upwards or downwards depending on catch level and cod-stock level; the mortality risk depends immediately upon the assumed future catch and cod-stock levels, but changes little with time. For catches of 70 000 t to 90 000 t the mortality risk is 25–40% and nearly constant over the projection period, while the biomass risk decreases as the model projects the stock to grow. At a catch level of 100 000 t the stock is nearly stationary above B_{msy} if the effective cod stock is assumed near 20 000 t, but if the cod stock increases to an effective biomass of 25 000 t catches of 100 000 t/yr. are predicted to be associated with a decreasing biomass.

f) Review of Research Recommendations

NIPAG **recommended** in 2010 that, for shrimp off West Greenland (NAFO Subareas 0 and 1):

- *the estimate of the biomass of Atlantic cod from the W. Greenland trawl survey should be explicitly included in the stock-production model used for the assessment.*

STATUS: no progress has been made on this recommendation.

g) Research Recommendations

For shrimp off West Greenland (NAFO Subareas 0 and 1), NIPAG **recommended** that:

- *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.*

- *More robust methods of including biomass index series in the quantitative assessment model should be investigated.*

4. Northern shrimp (in Denmark Strait and off East Greenland) – NAFO Stock

(SCR Doc. 03/74, 12/62, 12/63)

a) Introduction

Northern shrimp off East Greenland in ICES Div. XIVb and Va is assessed as a single population. The fishery started in 1978 and, until 1993, occurred primarily in the area of Stredebank and Dohrnbank as well as on the slopes of Storfjord Deep, from approximately 65°N to 68°N and between 26°W and 34°W.

In 1993 a new fishery began in areas south of 65°N down to Cape Farewell. From 1996 to 2005 catches in this area accounted for 50 - 60% of the total catch. In 2006 and 2007 catches in the southern area only accounted for 25% of the total catch. Since 2008 about 10% of the total catch has been taken in the southern area.

A multinational fleet exploits the stock. During the recent ten years, vessels from Greenland, EU-Denmark, 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. In both EEZs, sorting grids with 22-mm bar spacing to reduce bycatch of fish are mandatory. Discarding of shrimp is prohibited in both areas.

As the fishery developed, catches increased rapidly to more than 15 000 tons in 1987-88, but declined thereafter to about 9000 t in 1992-93. Following the extension of the fishery south of 65°N catches increased again reaching 11 900 t in 1994. From 1994 to 2003 catches fluctuated between 11 500 and 14 000 t (Fig. 4.1). Since 2004 the catches decreased continually from 10 000 t down to 1 235 t in 2011. Catches in the Iceland EEZ decreased from 2002-2005 and since 2006 no catches have been taken.

Recent recommended and actual TACs (t) and nominal catches are as follows:

	2003[1]	2004	2005	2006	2007	2008	2009	2010	2011	2012[2]
Recommended TAC, total are	9600	12400	12400	12400	12400	12400	12400	12400	12400	12400
Actual TAC, Greenland	10600	15043	12400	12400	12400	12400	12835	12400	12400	12400
North of 65°N, Greenland EE	5480	4654	3987	3887	3314	2529	3945	3321	1146	1911
North of 65°N, Iceland EEZ	703	411	29	0	0	0	0	0	0	0
North of 65°N, total	6183	5065	4016	3887	3314	2529	3945	3321	1146	1911
South of 65°N, Greenland EE	6522	4951	3737	1302	1286	266	610	413	89	221
TOTAL NIPAG	12705	10016	7753	5189	4600	2794	4555	3735	1235	2132

[1] Estimates corrected for "overpacking".
[2] Catches until September 2012

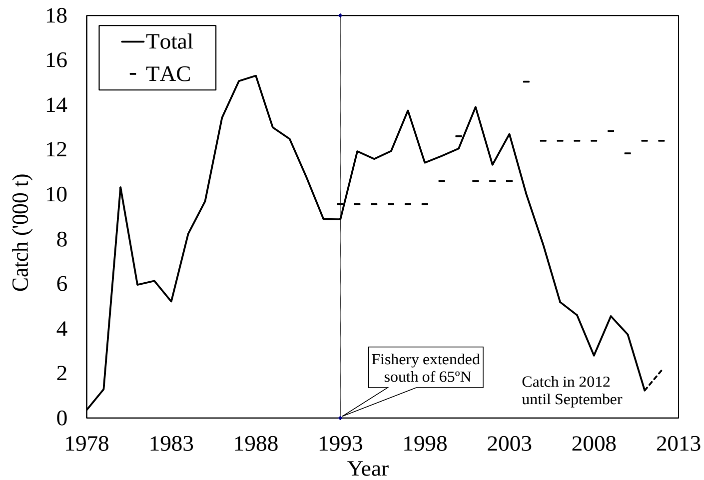


Fig. 4.1. Shrimp in Denmark Strait and off East Greenland: Total catches (2012 catches until September).

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-Denmark since 1980, from Norway since 2000 and from EU-France for the years 1980 to 1991 are used . Until 2005, the Norwegian fishery data was not reported in a compatible format and were not included in the standardized catch rates calculations. In 2006 an evaluation of the Norwegian logbook data from the period 2000 to 2006 was made and since then these data have been included in the standardized catch rate calculations. Since 2004 more than 60% of all hauls were performed with double trawl and the 2012 assessment included both single and double trawl in the standardized catch rate calculations.

Catches and corresponding effort are compiled by year for two areas, one area north of 65°N and one south thereof. Standardised Catch-Per-Unit-Effort (CPUE) was calculated and applied to the total catch of the year to estimate the total annual standardised effort. Catches in the Greenland EEZ are corrected for “overpacking” (SCR Doc. 03/74).

The Greenlandic fishing fleet, catching 40% of the total catch from 1998 to 2005 and between 0% and 30% from 2006, has decreased its effort in recent years, and this creates some uncertainty as to whether recent values of the indices accurately reflect the stock biomass. There could be several reasons for decreasing effort, some possibly related to the economics of the fishery. The fishing opportunities off West Greenland seem to have been adequate in recent years and the fishing grounds off East Greenland are a less desirable fishing area because of lower prices for large shrimps, which were the target of the fishery, and higher prices for fuel. Even though both effort and catches in East Greenland have declined, the catch rates (CPUE’s) are still high; however, this could be partly because the fleet can concentrate effort in areas of high densities of sought-after size classes of shrimp.

North of 65°N standardized catch rates based on logbook data from Danish, Faroese, Greenlandic, Norwegian and Icelandic vessels declined continuously from 1987 to 1993 but showed a significant increase between 1993 and 1994. Since then rates have varied but shown a slightly increasing trend until 2008. From 2008 to 2009 the catch rate increased by 50%. Since then the index has been going down reaching the values seen in the late nineties and early 2000s (Fig. 4.2).

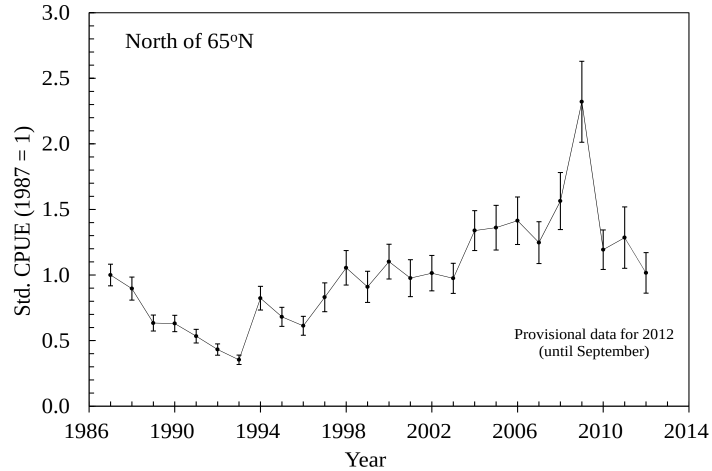


Fig. 4.2. Shrimp in Denmark Strait and off East Greenland: annual standardized CPUE (1987 = 1) with ±1 SE calculated from logbook data from Danish, Faeroese, Greenland, Icelandic and Norwegian vessels fishing north of 65°N.

In the southern area a standardized catch rate series from the same fleets, except the Icelandic, increased until 1999, and has since then fluctuated without a trend (Fig. 4.3). No index for the southern area was calculated in 2011 and 2012, due to a low number of hauls (7 in 2011 and 47 in 2012).

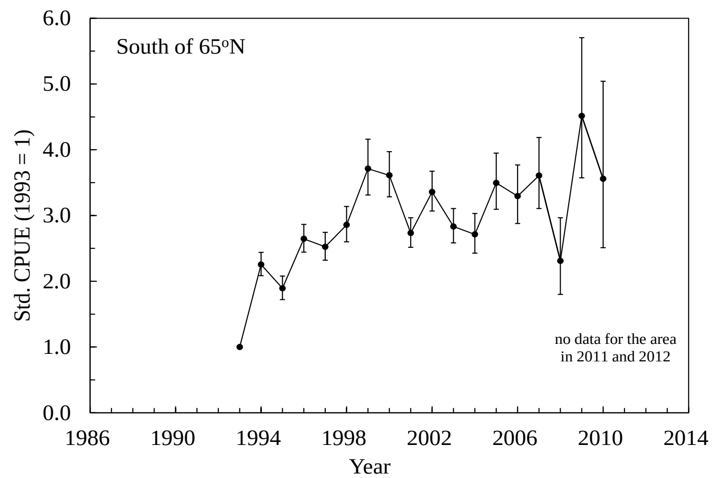


Fig. 4.3. Shrimp in Denmark Strait and off East Greenland: annual standardized CPUE (1993 = 1) with ±1 SE calculated from logbook data from Danish, Faeroese, Greenland and Norwegian vessels fishing south of 65°N.

The combined standardized catch rate index for the total area decreased steadily from 1987 to 1993, and then showed an increasing trend until the beginning of the 2000s. The index stayed at or around this level until 2008, but nearly doubled in 2009. Since then the combined index has been declining and is now lower than during the 2000s. (Fig. 4.4).

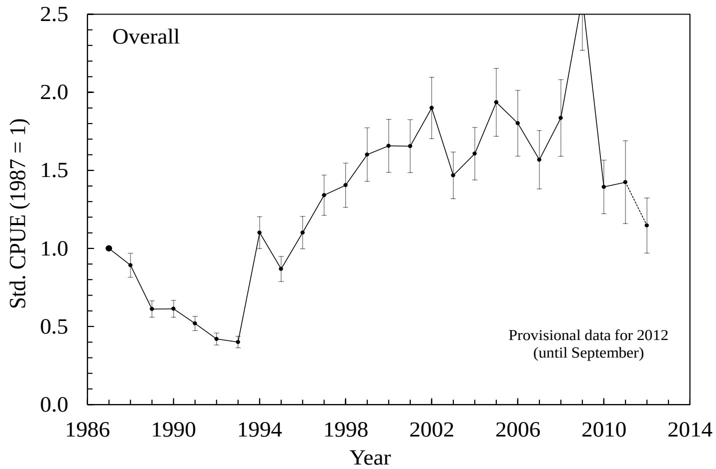


Fig. 4.4. Shrimp in Denmark Strait and off East Greenland: annual standardized CPUE-indices (1987 = 1) with ± 1 SE combined for the total area.

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).

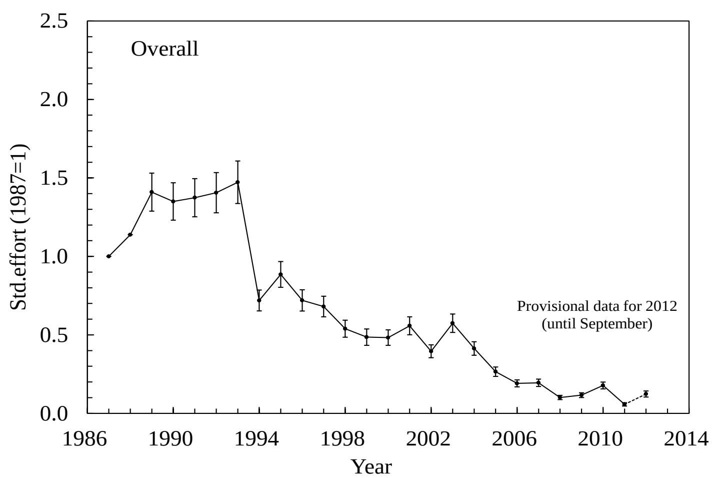


Fig. 4.5. Shrimp in Denmark Strait and off East Greenland: annual standardized effort indices, as a proxy for exploitation rate (± 1 SE; 1987 = 1), combined for the total area.

Biological data. There are no biological data available from the commercial fishery.

ii) Research survey data

Stratified-random trawl surveys have been conducted to assess the stock status of northern shrimp in the East Greenland area since 2008 (SCR Doc. 12/62). The main objectives were to obtain indices for stock biomass, abundance, recruitment and demographic composition. The area was also surveyed in 1985-1988 (Norwegian survey) and in 1989-1996 (Greenlandic survey). The historic survey is not directly comparably with the recent survey due to different areas covered, survey technique and trawling gear. However, the 1989-1996 survey estimated biomass and abundance at the same level as the 2008-2012 survey. The two Greenlandic surveys also showed similar overall size distributions. Absence of the smaller shrimp in the survey area stresses that the total area of distribution and recruitment patterns of the stock are still unknown.

Biomass estimate. The biomass estimates (t) for the entire survey area are given in Fig. 4.6.

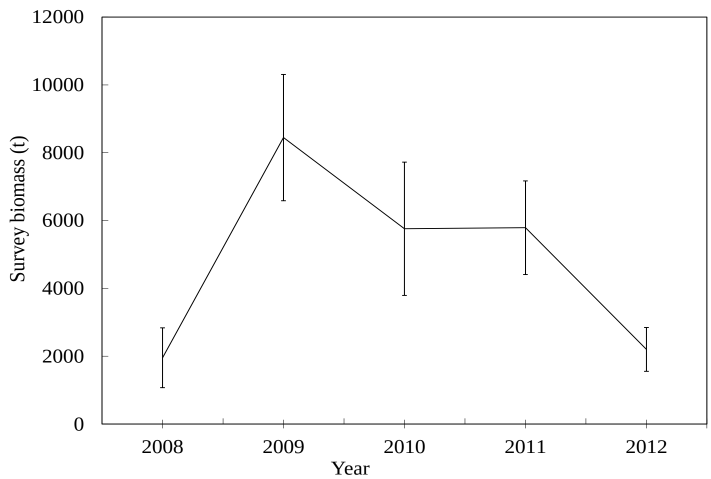


Fig. 4.6. Shrimp in Denmark Strait and off East Greenland: Survey biomass (t) from 2008- 2012(± 1 SE).

The surveys conducted since 2008 shows that the shrimp stock is concentrated in the area North of 65°N.

Stock composition. Total number of shrimp in 2012 was estimated to be 194 million and the lowest in the five year time series which have an average of almost 500 million. Female abundance in 2012 was record low at 77 million compared to roughly 200 million between 2009 and 2011. The abundance of males declined from 700 million in 2009 to 300 million in 2010 and 2011 but declined drastically in 2012 to 100 million (Fig 4.7).

There were very few male shrimp smaller than 20mm CL in the East Greenland survey length distribution (Fig. 4.8), which means that no recruitment index is available.

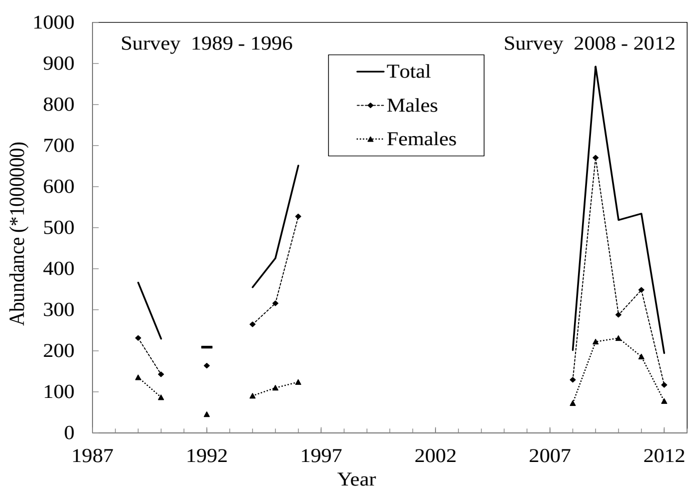


Fig. 4.7. Shrimp in Denmark Strait and off East Greenland. Abundance of males and females in two different surveys series from 1989-1995 and 2008-2012 for the areas North of 65°N. The two survey series are not directly comparable due to gear differences

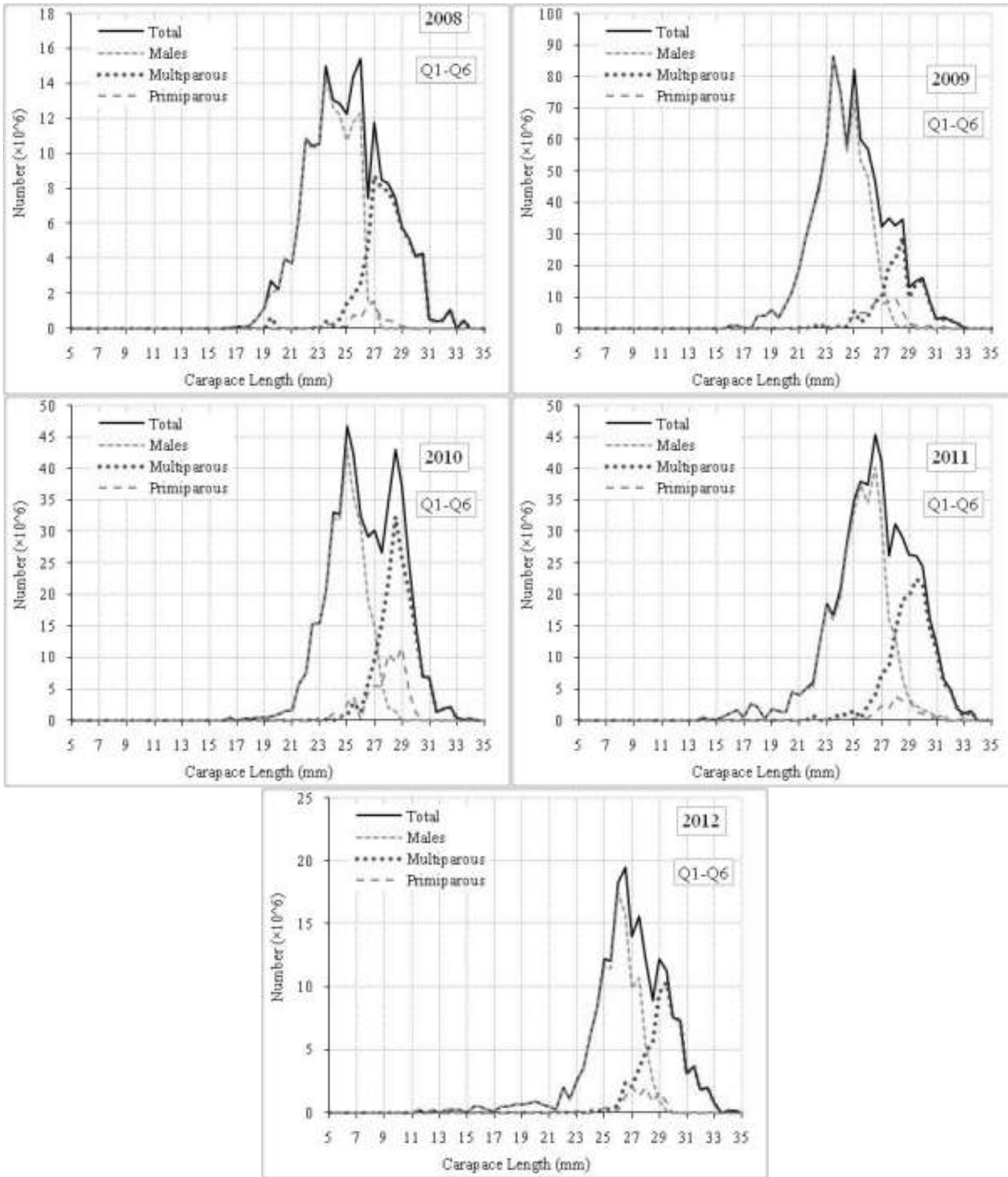


Fig.4.8. Shrimp in Denmark Strait and off East Greenland. Numbers of shrimp by length group (CL) in the total survey area in 2008 - 2012 based on pooling of samples weighted by catch and stratum area.

c) Assessment Results

CPUE: The combined standardized catch rate index for the total area remained at a high level from 2000 to 2009. Since then the combined index has been declining and is now lower than seen during the 2000's

Recruitment. No recruitment estimates were available.

Biomass. The survey biomass index has decreased since 2009 and is now at the level seen at the beginning of the short time series in 2008.

Exploitation rate. Since the mid-1990s exploitation rate index (standardized effort) has decreased, reaching the lowest levels seen in the time series from 2008 - 2012.

State of the stock. Indices of stock biomass indicate a decline during the last 3 years. The biomass is now believed to be slightly lower than the relatively high level seen during most of the 2000s.

5. Northern shrimp in Skagerrak and Norwegian Deep (ICES Div. IIIa and IVa East) – ICES Stock

Background documentation (equivalent to stock annex) is found in SCR Doc. 12/59, 61, 64, 65, 66; 11/069; 08/75; 10/70.

a) Introduction

The shrimp in the northern part of ICES Div. IIIa (Skagerrak) and the eastern part of Div. IVa (Norwegian Deep) is assessed as one stock and is exploited by Norway, Denmark and Sweden. The Norwegian and Swedish fisheries began at the end of the 19th century, while the Danish fishery started in the 1930s. All fisheries expanded significantly in the early 1960s. By 1970 the landings had reached 5 000 t and in 1981 they exceeded 10 000 t. Since 1992 the shrimp fishery has been regulated by a TAC, which was around 16 500 t in 2006-2009, but decreased to 12 380 t in 2011 and further to 10 115 t in 2012 (Fig. 5.1, Table 5.1). In the Swedish and Norwegian fisheries approximately 50% of catches are boiled at sea, and almost all catches are landed in home ports. Since 2002 an increasing number of the Danish vessels have started boiling the shrimp on board and landing the product in Sweden to obtain a better price. In 2011 around 35% of Danish landings were boiled. Most of the Danish catches are, however, still landed fresh in home ports. The overall TAC is shared according to historical landings, giving Norway 60%, Denmark 26%, and Sweden 14% in 2011 and 2012. The recommended TACs until 2002 were based on catch predictions. However, since 2003 when the cohort based analytical assessment was abandoned no catch predictions have been available, and the recommended TACs have been based on perceived stock development in relation to recent landings. The shrimp fishery is also regulated by mesh size (35 mm stretched), and by restrictions in the amount of landed bycatch. The Nordmøre selective grid with un-blocked fish openings can reduce bycatch significantly (SCR Doc. 12/65), and is used voluntarily by an increasing number of vessels in the Norwegian and Danish fleet. However, at present it is mandatory only in Swedish national waters. Of the total Swedish landings, the percentage taken with grid trawls increased from 9% in 2002 to 32% in 2009 and has thereafter dropped to 20% in 2011. Currently it is under discussion between EU and Norway whether a grid should be mandatory in all shrimp fisheries in Skagerrak and the North Sea (see section on Bycatch and ecosystem effects below).

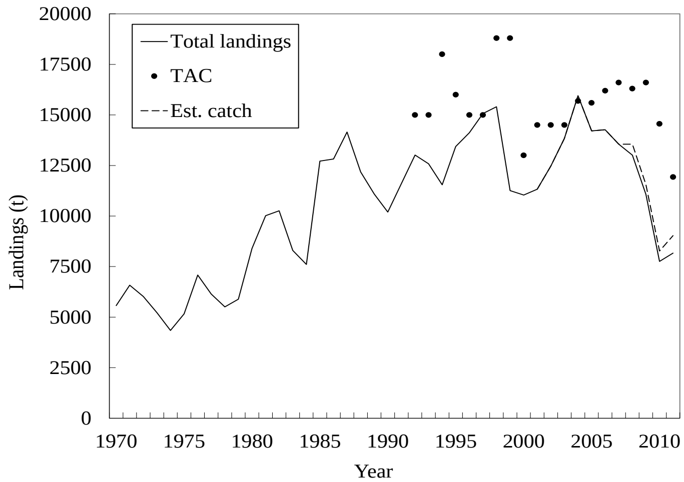


Fig. 5.1. Northern shrimp in Skagerrak and Norwegian Deep: TAC, total landings by all fleets, and total estimated catch including estimated Swedish discards for 2008-2011, Norwegian discards for 2007-2011 and Danish discards for 2009-2011.

Total landings have varied between 7 500 and 16 000 t during the last 30 years. 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 are estimated as the sum of landings and discards and have varied between 11 000 and 18 000 t in 2001-2009, but decreased to around 8 500 t in 2010-2011. (Table 5.1 and Fig. 5.1).

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

	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Recommended TAC	19000	11500	13400	12600	14700	15300	13000	14000	14000	15000	15000	13000	6500
Agreed TAC	18 800	13 000	14 500	14 500	14 500	15 690	15 600	16 200	16 600	16 300	16 600	14 558	11 928
Denmark	2 072	2 371	1 953	2 466	3 244	3 905	2 952	3 061	2 380	2 259	2 155	1 229	1 600
Norway	6 739	6 444	7 266	7 703	8 178	9 544	8 959	8 669	8 686	8 260	6 364	4 673	4 800
Sweden	2 445	2 225	2 108	2 301	2 389	2 464	2 257	2 488	2 445	2 479	2 483	1 781	1 768
Total landings	11 256	11 040	11 328	12 474	13 837	15 952	14 208	14 268	13 553	13 013	11 071	7 755	8 168
Est. Danish discards											36	53	123
Est. Swedish high-grading										540	337	386	504
Est. Norwegian discards											115	75	235
Total catch			11 328	12 474	13 837	15 952	14 208	14 268	13 553	13 553	11 560	8 269	9 030

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 24 in 2006 and only 13 in 2011. It is mostly the small (< 24 m LOA) trawlers which have left the fishery and in 2011 the Danish fleet consisted of vessels with an average length of 26 m and average engine power of 700 hp (SCR Doc. 11/69). The efficiency of the fleet has also increased due to the introduction of twin trawl technology and increased trawl size.

In Norway the number of vessels participating in the shrimp fishery has decreased from 423 in 1995 to 217 in 2011. The number of smaller vessels (10-10.99 m LOA) has increased from the mid-1990s until present, while the number of larger vessels (11-20.99 m LOA) has decreased. The length group 10-10.99 m LOA has been the numerically dominant one since 2005 (37% of all vessels in 2011), owing to the fact that vessels < 11 m do not need a license to fish. Vessels ≥ 21 m LOA constitute only 13% of the fleet, which illustrates the difference between the Norwegian and Danish fleets. Twin trawl was introduced around 2002, and the use is increasing. In 2011 twin trawls are estimated to be in use by half of the Norwegian trawlers larger than 15 meters, whereas the smaller vessels most likely are using single trawls

The Swedish specialized shrimp fleet (catch of shrimp ≥ 10 t/yr.) has been at around 40-50 vessels for the last decade and there has not been any major change in single trawl size or design according to the Swedish net manufacturer, but during the last six years the number of twin trawlers has increased from 5 to 23. These twin trawlers have 40- 80% higher catch rates compared to the vessels using single rigged trawls (SCR Doc. 12/65).

Catch and discards. Discarding of shrimp may take place in two ways: 1) discards of shrimp <15 mm CL which are not marketable, and 2) high-grading discards of medium-sized and lower-value shrimp. The Swedish fishery has regularly been constrained by the national quota, which may have resulted in 'high-grading' of the catch. Based on on-board sampling high-grading and discards in the Swedish fisheries was estimated to be between 12 and 22% of total catch for the years 2008 -2011, and Danish discards were estimated to be between 2 and 7% for the years 2009-2012 (SCR Doc. 12/65). Previous estimates of Swedish high-grading based on comparison of length distributions of Swedish landings with Danish landings (assuming no discards in the Danish fishery) have been omitted in this year's report as these estimates are considered less accurate than the ones resulting from on-board sampling. As there are no observer data for Norwegian discards, these have been estimated indirectly by comparing the length distributions of Norwegian unprocessed commercial catches with those of Norwegian sorted landings (SCR Doc. 12/65). The 2010 and 2011 discards from Skagerrak were also estimated applying the Danish discards-to-landings ratio to the Norwegian landings, yielding discards of 63 t and 229 t, respectively. These figures are considered the most reliable. There is no Danish on-board sampling in the Norwegian Deep. Assuming that Norwegian discards are mainly made up of non-marketable shrimp < 15 mm CL, comparison of length distributions yielded discards of respectively 12 and 6 t from the Norwegian Deep in 2010 and 2011.

Bycatch and ecosystem effects. Shrimp fisheries in the North Sea and Skagerrak have bycatches of 10-22% (by weight) of commercially valuable species (Table 5.2). Since 1997, trawls used in Swedish national waters must be equipped with a Nordmøre grid, with a bar spacing of 19 mm, which excludes fish > approx. 20 cm from the catch. Logbook information shows that landings delivered by vessels using this grid consist of 98-99% shrimp compared to only 78-84% in landings from trawls without grid (Table 5.2). In the area outside of Swedish national waters the grids are not mandatory, however, the grid is to some extent used voluntarily by fishers from all three countries in order to sort the landable part of the bycatch (SCR Doc. 12/65).

The effects of shrimp fisheries on the North Sea ecosystem have not been the subject of special investigation. It is known that deep-sea species such as argentines, 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 component is available and the impact on stocks is difficult to assess, but it is currently under discussion between EU and Norway whether a grid should be mandatory in all shrimp fisheries in Skagerrak and the North Sea – such a grid would be expected to substantially reduce by catch of the above mentioned species. It has also been decided to introduce a discard ban in Skagerrak during 2014. Norwegian vessels are already subject to a discard ban. The details are still not decided (e.g. exceptions for certain gears and species) and it is difficult to predict what consequences a Skagerrak discard ban will have for the *Pandalus* fishery.

Table 5.2. Northern shrimp in Skagerrak and Norwegian Deep: Landings by the Pandalus fishery in 2011. Combined data from Danish and Swedish logbooks and Norwegian sale slips (t).

	Sub-Div. IIIa, no grid		Sub-Div. IIIa, grid		Sub-Div. IVa East, no grid	
Species:	Total (t)	% of total catch	Total (t)	% of total catch	Total (t)	% of total catch
Pandalus	5249	78.4	326	98.5	2028	84.3
Norway lobster	31	0.5	2	0.6	9	0.4
Angler fish	44	0.7	0	0.0	60	2.5
Whiting	12	0.2	0	0.0	3	0.1
Haddock	56	0.8	0	0.0	8	0.3
Hake	24	0.4	0	0.0	27	1.1
Ling	47	0.7	0	0.0	39	1.6
Saithe	623	9.3	1	0.2	93	3.9
Witch flounder	67	1.0	0	0.0	2	0.1
Norway pout	1	0.0	0	0.0	0	0.0
Cod	358	5.4	0	0.1	65	2.7
Other market fish	180	2.7	2	0.5	72	3.0

Environmental considerations. The effect of temperature changes in recent years on Northern shrimp in the North sea area is not known. The cold winter in 2009 to 2010 caused a cooling of the surface water which sank into the deeper part of the Norwegian Deep. Bottom water temperatures were still unusually cold in January 2011, with the mean bottom temperature in the Skagerrak 1.5–2°C below the mean during 2006-2010. A similar situation with unusual cold bottom water occurred in mid-1960s and coincided with a sharp decline in the *Pandalus* stock (see SCR Doc 12/65 and 12/59).

b) Assessment Data

i) Commercial fishery data:

The Danish catch and effort data from logbooks have been analyzed and standardized (SCR Doc. 08/75, 12/65) to provide indices of stock biomass. A GLM standardization of the LPUE series was performed on all shrimp fishing trips (value of shrimp landings at least 50% of total trip landing value) conducted in the period 1987-2012:

$$ln(LPUE) = ln(LPUEmean) + ln(a*Hp) + ln(area) + ln(year) + ln(season) + error$$

where a is the linear coefficient of the relationship between LPUE and the vessel engine power (horsepower), the ‘year’ factor covers the period 1987-2012, ‘area’ covers Norwegian Deep and Skagerrak, ‘season’, in this case month, covers possible seasonal variation, and the variance of the error term is assumed to be normally distributed.

In the standardization of the Norwegian LPUE (2000-2012) (SCR Doc. 12/64) a similar model was applied, but gear type (single and twin trawl) was also included as a variable:

$$ln(LPUE) = ln(LPUEmean) + ln(vessel) + ln(area) + ln(year) + ln(month) + ln(gear) + error$$

Information on gear use recorded in Norwegian logbooks (single or twin trawl) was prior to 2011 corrected by interviews with fishers. However, in the electronic logbooks compulsory for all vessels ≥15 m introduced in 2011, information on the use of single and twin trawl is included. Data from vessels <15 m are still missing in the logbooks.

A similar standardization of Swedish lpue - with a slightly different combination of explanatory variables - was carried out for data from 1997 to 2011:

$$ln(LPUE) = ln(LPUEmean) + ln(year*month) + ln\ (gear\ code) + ln\ (number\ of\ gears) + ln(a*kW) + error$$

where a is the linear coefficient of the relationship between LPUE and kW. Gear code is trawl 1) without grid, 2) with grid (unblocked fish opening) or 3) with grid and large square mesh fish tunnel in order to retain marketable fish. Number of gears is either single or twin trawl (SCR Doc. 12/65). Additional work is underway to model the Swedish LPUE series from 1963 onwards, but is not yet completed.

Since the mid-1990s the Danish standardised LPUE has fluctuated without long term trends (Fig. 5.2). For the last decade the three time series show similar fluctuations, increasing from 2000 to 2004, decreasing in 2005 and then increasing again until 2007. All three LPUE indices have decreased since 2008.

In previous assessments harvest rates (H.R.) were estimated from landings and corresponding biomass indices from the Norwegian survey. Since the new survey only covers six years, time series of standardised effort indices (total landings/Danish, Swedish and Norwegian standardised LPUE indices) have been estimated in addition to H.R. estimates for 2006-2011 (Fig. 5.3) Standardised effort seems to have been fluctuating without any clear trend since the mid-1990s indicating stability in the exploitation of the stock. It should be noted that CPUE series are standardised to the first year for which data are available.

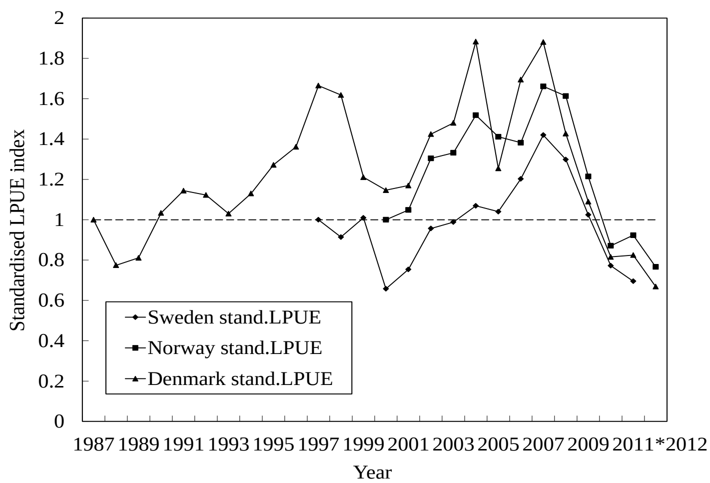


Fig. 5.2. Northern shrimp in Skagerrak and Norwegian Deep: Danish, Norwegian and Swedish standardised LPUE until 2012. *2012 is not complete

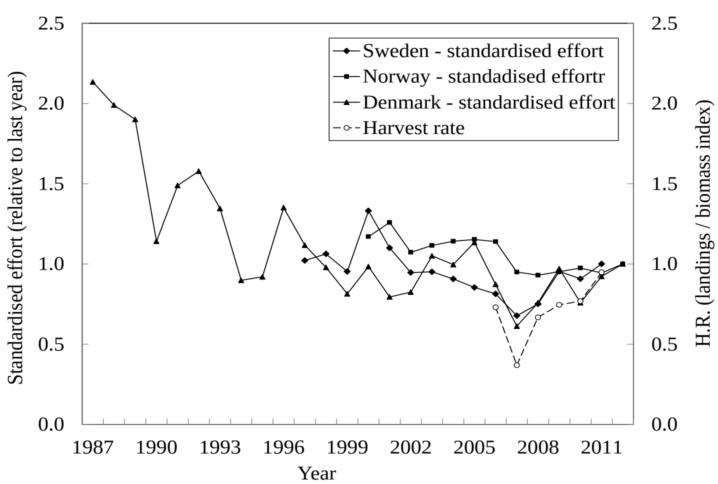


Fig. 5.3. Northern shrimp in Skagerrak and Norwegian Deep: Harvest rate (total landings/survey indices of biomass) and estimated standardised effort based on total landings and Danish, Norwegian and Swedish standardised LPUE.

ii) Sampling of landings.

Numbers and weight at age from 1985 – 2011 are shown in Table 5.3 and the length frequencies of the catch are shown in Fig. 4 of SCR Doc 12/61. Information on size and subsequently age distribution of the landings are obtained by sampling. The samples also provide information on sex distribution and maturity (SCR Doc. 12/65). This substantial amount of information has not been used in the current assessment, but is used in the ongoing benchmark assessment of the Skagerrak and Norwegian Deep shrimp stock (end date 1st March 2013) intended to provide NIPAG with a full analytical assessment model for the 2013 meeting.

Table 5.3. Numbers (in millions) at age in total landings, 1985-2011.

Age	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998
0	17.7	7.4	2.7	14.1	31.3	0.0	3.9	25.5	27.2	0.7	2.7	61.1	19.7	12.7
1	1200.8	1146.4	1260.5	1086.6	2083.6	2250.1	1231.8	1071.4	1889.6	671.9	646.0	1211.6	2175.6	903.4
2	1305.4	1029.7	1205.6	923.9	385.5	910.8	1035.8	1289.2	803.8	1380.4	970.5	991.4	1181.9	1597.9
3	187.9	482.7	390.2	300.2	173.8	121.1	326.7	569.1	262.7	143.0	851.5	454.6	295.6	468.1
+gp	52.3	25.1	203.2	146.7	13.6	31.3	25.6	57.5	15.5	30.5	42.0	69.5	29.8	48.2
Total	2764.1	2691.3	3062.1	2471.5	2687.9	3313.3	2623.8	3012.7	2998.7	2226.4	2512.5	2788.2	3702.6	3030.2

Age	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
0	4.6	88.1	0.1	3.9	2.4	5.7	13.7	4.8	0.1	1.2	0.1	4.9	0.1
1	1436.1	1270.7	904.7	922.3	668.7	1062.9	749.4	1021.4	433.1	701.9	555.1	297.9	304.4
2	720.1	836.3	824.5	858.4	1466.5	1251.4	1172.7	1149.2	1349.9	915.0	853.2	787.6	1136.5
3	318.3	199.3	390.0	581.8	283.8	477.6	410.1	379.0	220.1	673.7	592.9	238.2	221.3
+gp	43.3	39.2	68.3	101.8	0.0	50.4	0.0	28.5	0.0	0.0	16.5	0.0	0.0
Total	2522.4	2433.5	2187.6	2468.3	2421.4	2847.9	2345.9	2582.8	2003.1	2291.9	2017.8	1328.6	1662.3

iii) Survey data

The Norwegian shrimp survey went through large changes in the years 2003-06 with changes in vessel and timing (SCR Doc. 12/59) resulting in four different survey series, lasting from one to nineteen years. ICES (2004) strongly recommended the survey to be conducted in the 1st quarter as it gives good estimates of the 1-group (recruitment) and female biomass (SSB). Thus, a new time series at the most optimal time of year was started in 2006. It was noted that the first, third and fourth survey series tracked the standardised Danish LPUE series.

Biomass indices from the first time series were recalculated in 2012 in order to provide SE's. The recalculated indices corresponded well with the old ones. The biomass index increased from 1988 to this time series' maximum in 1997. A decrease in 1998-2000 was followed by an increase in 2001-2002, when this series was discontinued (Fig. 5.4). In 2003 the survey was carried out with a different trawl in use only that year. The 2004 and 2005 mean values of a new biomass index series were not statistically different. The new biomass index series peaked in 2007. Since 2008 the index has shown a steady decline, to the time series' minimum in 2012.

The abundance of age 1 shrimp in 2006 was equal to the abundance of age 1 shrimp in 2007. From 2007 to 2010 recruitment (age 1) showed a steady decline to a low level of only 1/10 of the 2006 and 2007 indices (Fig 5.5). Recruitment increased in both 2011 and 2012.

SSB (female biomass) has been calculated for the years 2006-2012 (Fig. 5.6). The index follows the overall biomass index, increasing from 2006 to 2007, then declining back to the 2006-level in 2008 and further declining in 2009-2012.

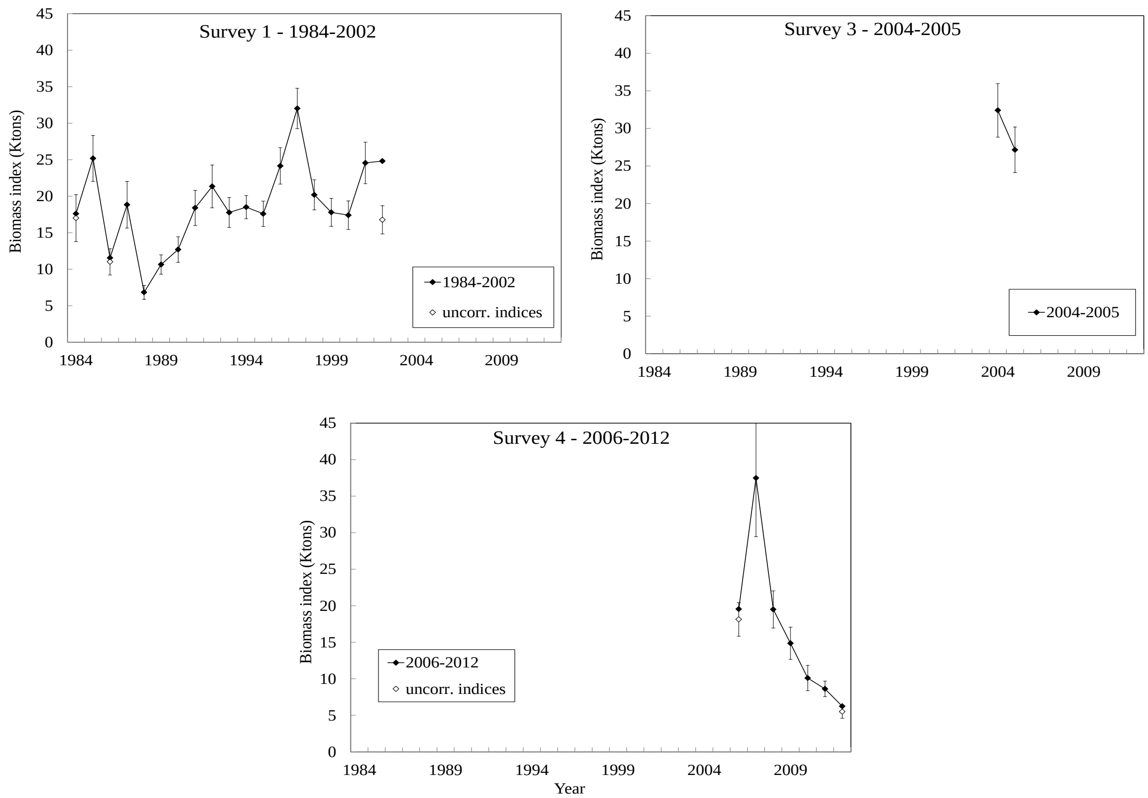


Fig. 5.4. Northern shrimp in Skagerrak and Norwegian Deep: Estimated survey biomass indices in 1984 to 2012. The 1984 – 2005 indices were re-calculated in 2012, providing SEs for the whole time series. Survey 1: October/November 1984-2002 with Campelen trawl; Survey 2: October/November 2003 with shrimp trawl 1420 (not shown); Survey 3: May/June 2004-2005 with Campelen trawl; Survey 4: January/February 2006-2012 with Campelen trawl.

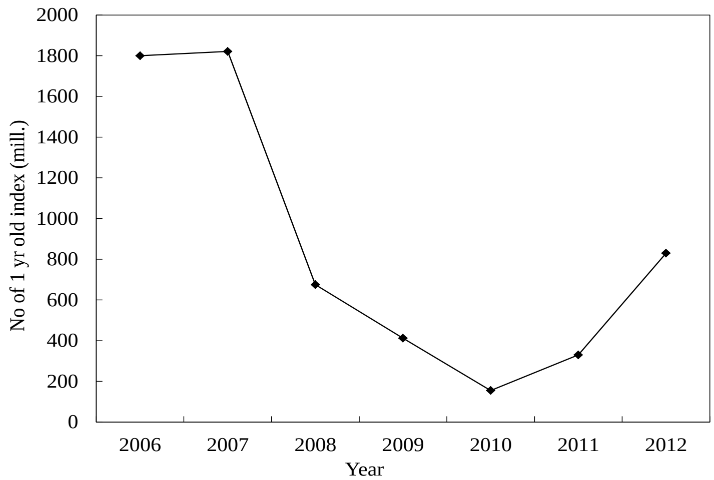


Fig. 5.5. Northern shrimp in Skagerrak and Norwegian Deep: Estimated recruitment indices from 2006-2012. The recruitment index is calculated as the abundance of age 1 shrimp (the first mode, approx. 9-13mm, in the length frequency distribution).

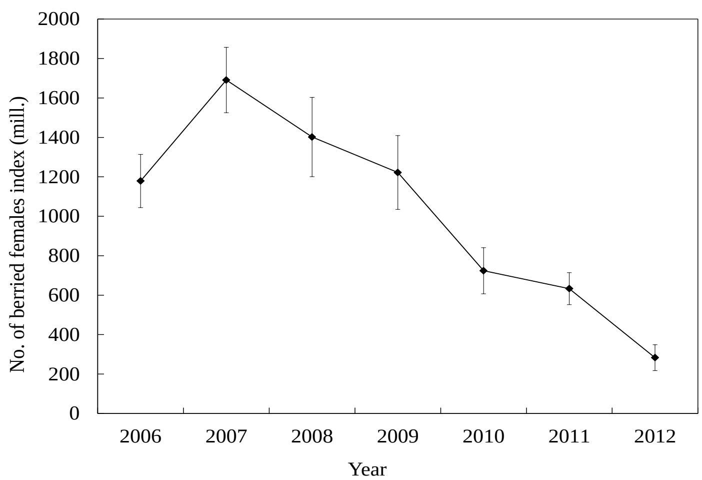


Fig. 5.6. Northern shrimp in Skagerrak and Norwegian Deep: SSB abundance from the Norwegian shrimp surveys in 2006-2012. The abundance index of the spawning stock is calculated as the abundance of berried females. Error bars are SE.

The large inter-annual variation in the predator biomass index is mainly due to variations in the saithe and roundnose grenadier indices. The sizes of these indices are heavily influenced by which stations are trawled as saithe is found on the shallowest stations and roundnose grenadier on the deepest ones. An index without these species is shown at the bottom of Table 5.4. The total index of shrimp predator biomass excluding saithe and roundnose grenadier has been at the same level during the 5 last years (Table 5.4).

Table 5.4. Northern shrimp in Skagerrak and Norwegian Deep: Estimated indices of predator biomass (catch in kg per towed nautical miles) from the Norwegian shrimp survey in 2006-2012.

Species	biomass index							
English	2006	2007	2008	2009	2010	2011	2012	mean
Blue whiting	0.13	0.13	0.12	1.21	0.27	0.62	3.30	
Saithe	7.33	39.75	208.32	53.89	18.53	7.52	5.66	
Cod	0.51	1.28	0.78	2.01	1.79	1.66	1.26	
Roundnose Grenadier	3.22	6.85	19.02	19.03	10.05	4.99	4.43	
Rabbit fish	2.24	2.15	3.41	3.26	3.51	2.73	2.22	
Haddock	0.97	4.21	1.85	3.18	3.46	5.82	5.75	
Redfish	0.18	0.40	0.26	0.43	0.80	1.02	0.37	
Velvet Belly	1.31	2.58	1.95	2.42	2.52	1.47	1.59	
Skates, Rays	0.41	0.95	0.64	0.17	0.60	0.88	0.98	
Long Rough Dab	0.22	0.64	0.42	0.28	0.47	0.51	0.56	
Hake	0.98	0.78	0.64	2.56	1.60	0.56	0.52	
Angler	0.15	0.91	0.87	1.25	1.70	0.92	0.17	
Witch	0.24	0.74	0.54	0.16	0.13	0.24	0.29	
Dogfish	0.31	0.19	0.28	0.14	0.11	0.21	0.60	
Black-mouthed dogfish	0.00	0.05	0.05	0.15	0.09	0.09	0.09	
Whiting	0.35	1.01	1.35	3.02	2.42	3.07	1.64	
Blue Ling	0	0	0	0	0	0	0	
Ling	0.04	0.11	0.34	0.79	0.64	0.24	0.17	
Four-bearded Rockling	0.06	0.14	0.04	0.03	0.05	0.03	0.09	
Cusk	0.20	0	0.02	0.05	0.13	0.29	0.04	
Halibut	0.08	0.07	3.88	0.09	0.20	0.05	0.19	
Pollack	0.06	0.25	0.03	0.13	0.12	0.15	0.07	
Greater Forkbeard	0	0	0	0.01	0.04	0.02	0.05	
Total	18.99	63.19	244.81	94.26	49.23	33.09	30.04	76.23
Total (except saithe and roundnose grenadier)	8.44	16.59	17.47	21.34	20.65	20.58	19.95	17.86

Exploratory model work

Two assessment models developed in the ongoing ICES inter benchmark assessment (end date 1st March 2013) were presented to the NIPAG expert group; a stochastic length-based assessment model (SCR Doc. 12/61) and a Bayesian surplus production model (SCR 12/66). Biological reference points and short term forecasts from the two models were produced, presented and discussed during the NIPAG meeting and both models were evaluated as capable of delivering a full analytical assessment. The two models also demonstrated some agreement in the long term trends of SSB and *F* estimates, although discrepancies of individual years were somewhat pronounced (Fig. 5.7). It was, however, decided by the expert group to await completion of the entire benchmark process before implementing any new model. This decision was to some degree based on the model discrepancies and the need to update the length distribution time series from the Norwegian shrimp survey, which informs one of the models. This update to length distribution was performed during the NIPAG meeting, but not in time to redo and re-evaluate full analytical assessments from the two benchmark models.

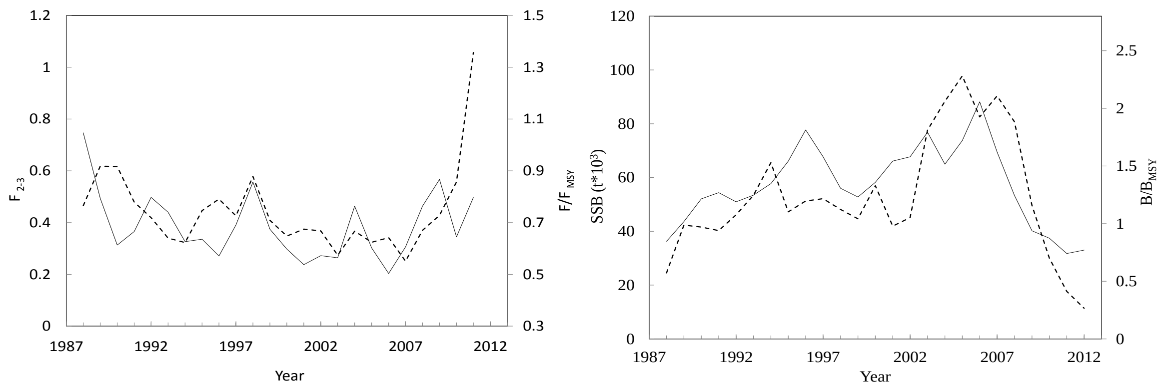


Fig. 5.7 Overlayed outputs of $F_{2\text{-}3}$ and SSB from the length-based model (dashed line), and F/F_{msy} and B/B_{msy} from the Bayesian model (solid line).

c) Assessment Results

This year's assessment was based on evaluation of Danish, Norwegian and Swedish standardised LPUEs, standardised effort from the fishery in 1987–2011, and the survey indices of recruitment and biomass in 2006-2012.

LPUE: All three standardised LPUEs have shown similar fluctuations since 2000 (Fig. 5.2). The indices have decreased since 2007, and are now below their respective long term means.

Recruitment: The recruitment index (age 1) has declined to 1/10 from 2007 to 2010, but has increased by 112% in 2011 and 152% in 2012.

Survey biomass: The biomass index has decreased with 87% from 2007 to 2012.

State of the stock: Indices of stock biomass indicate a decline from 2007 to 2012.The recruitment index has shown an increasing trend since 2010 and recruitment to the fishable stock may lead to an increase in 2013.

According to ICES' implementation of RGLIFE advice on Data Limited Stocks (DLS) *Pandalus* in Skagerrak and Norwegian Deep is to be considered as a Category 3 stock. Following the 3.2.0 guidelines the catch advice is derived as follows:

Catch advice for Data Limited Stocks

Category 3 - Stocks for which survey-based assessments indicate trends

Method 3.2.05. If there are survey data on abundance (e.g. CPUE over time), but there is no survey-based proxy for MSY $B_{trigger}$ and F values or proxies are not known,

1. Determine catch advice from the survey-adjusted status-quo catch:

Average landings 2009-2011	8 998 t
Average Survey Biomass 2011 – 2012	7 435 t
Average Survey Biomass 2008 – 2010	14 830 t
Ratio	0.5
Catch Advice	0.5 * 8 998 = 4 499 t

This change is greater than the 20% constraint rule, therefore the uncertainty cap and precautionary buffer were applied.

2. Apply the 20% Uncertainty Cap to the catch advice (see above Methods -- Definition of common terms and methods).

Uncertainty Cap:

Average landings 2009-2011		8 998 t
Catch Advice	-20%	7 199t

3. Then apply the Precautionary Buffer to the catch advice (see above Methods -- Definition of common terms and methods).

Precautionary Buffer:

Catch Advice	-20%	5 759 t

The justifications for these calculations are not fully understood by NIPAG.

d) Biological Reference Points

No reference points were provided in this assessment.

e) Management Recommendations

NIPAG **recommended** that, for shrimp in Skagerrak and Norwegian Deep:

- *sorting grids or other means of facilitating the escape of fish should be implemented in this fishery.*
- *all Norwegian vessels should be required to complete and provide log books.*

f) Research Recommendations

NIPAG **recommended** that for shrimp in Skagerrak and Norwegian Deep:

- *that a stock annex be written for this stock.*

g) Research Recommendations from the 2009-2011 meetings

- *The Norwegian survey time series indices from 1984 - 2003 should be recalculated in order to provide confidence intervals and length frequency distributions.*

STATUS: Completed.

- *the Swedish effort data should be standardised*

STATUS: The Swedish effort data have been standardised and included in the basis for assessing stock status

- *the Stochastic assessment model as described in SCR Doc.10/70 should be implemented and MSY reference points should be established.*

STATUS: The length based modelling framework, along with a Bayesian surplus production model, were further explored at the NIPAG 2012 meeting Conclusions on an appropriate analytical assessment will be drawn by the benchmark meeting.

- *A benchmark assessment is carried out before next NIPAG meeting as suggested by the 2009 Review Group.*

STATUS: Benchmark assessment is ongoing (end date 1st of March 2013)

- *collaborative efforts should be made to standardise a means of predicting recruitment to the fishable stock.*

STATUS: No progress

- *the Norwegian shrimp survey should be continued on an annual basis*

STATUS: The survey will most likely be conducted annually.

- *Differences in recruitment and stock abundance between Skagerrak and the Norwegian Deep should be explored.*

STATUS: This forms part of the research projects described below

- *the ongoing genetic investigations to explore the relation/connection/mixing between the shrimp (stock units) in Skagerrak and the Norwegian Deep on the one hand and the Fladen Ground shrimp on the other hand should be continued until these relationships have been clarified.*

STATUS: Results from the two research projects focusing on the genetic stock structure of northern shrimp in respectively the whole North Atlantic (POPBOREALIS) and the Skagerrak/North Sea area (Sustainable shrimp fishing in Skagerrak), were presented to the working group. As the data set from the North Sea/Skagerrak is not yet finalized, and since the statistical analyses are still ongoing, the results are still preliminary. However, the results indicate that shrimp in some areas, especially around Iceland, Jan Mayen and in Gulf of Maine, and possibly also on Flemish Cap, constitute isolated populations, while shrimp in other areas, such as the Barents Sea and the eastern coast of Canada constitute distinct, but large, interbreeding populations. The genetic differences between samples within Skagerrak and the North Sea are small compared with the differences across the North Atlantic as a whole. A finalized data set is expected before the end of 2012 such that conclusions on the stock structure in Skagerrak and the North Sea can be drawn as part of the ICES process for benchmarking stock assessments. Samples from the Gulf of St. Lawrence and east of Greenland would provide a more complete picture of global stock identity.

6. Northern Shrimp in Barents Sea and Svalbard area (ICES SA I and II) – ICES Stock

Background documentation (equivalent to stock annex) is found in SCR Doc 12/49, 50, 51, 60; 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 Sub-areas I and II) 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 in the “Loop Hole” (Fig. 6.1).

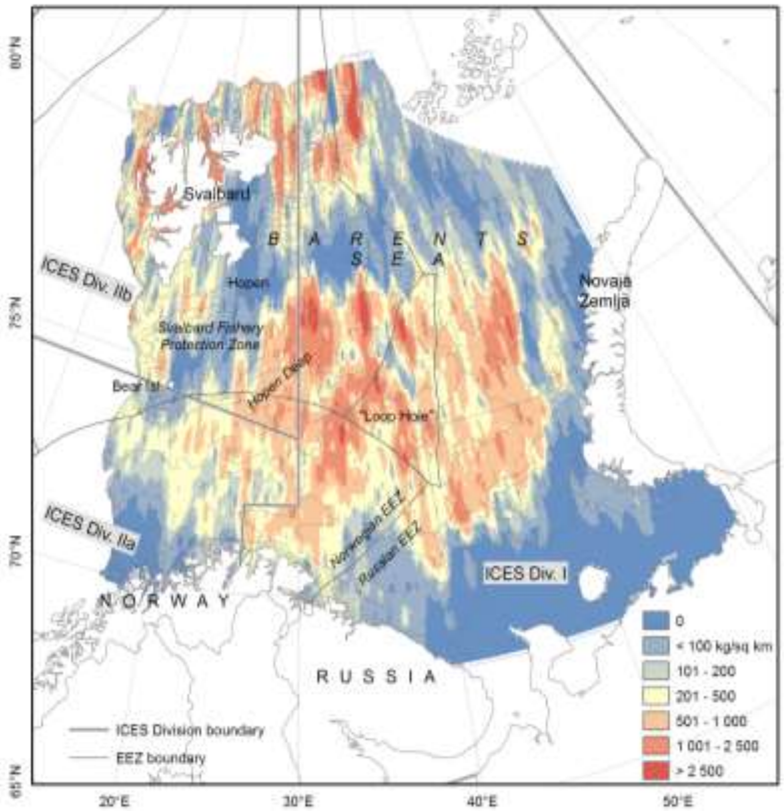


Fig. 6.1. Shrimp in the Barents Sea: stock distribution, mean density index (kg/km^2), based on survey data 2000-2010.

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 60 000 t/yr, about 67–92% of these were taken by Norwegian vessels and the rest by vessels from Russia, Iceland, Greenland and the EU (Table 6.1).

There is no TAC established for this stock. The fishery is partly regulated by effort control, and a partial TAC (Russian zone only). Licenses are required for the Russian and Norwegian vessels. The fishing activity of these license holders are 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. Overall 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 thereafter declined to about 30 000 t in 2011 partly due to reduced profitability of the fishery. Based on information from the industry and catch statistics until August the 2012 catches are predicted to reach 20 000 t.

Table 6.1. Shrimp in ICES SA I and II: Recent catches (2001–2012) in metric tons, as used by NIPAG for the assessment (minor revisions made in 2012).

	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012[1]
Recommended TAC	-	-	-	41 299[2]	40 000	50 000	50 000	50 000	50 000	60 000	60 000
Norway	48799	34172	35918	37253	27352	25558	20662	19784	16779	19923	13000
Russia	3790	2776	2410	435	4	192	417	0	0	0	0
Others	8899	2277	4406	4930	2271	4181	7109	7488	8419	9867	7000
Total	61488	39225	42734	42618	29627	29931	28188	27272	25198	29790	20000

[1] Catches projected to the end of the year;
[2] Should not exceed the 2004 catch level (ACFM, 2004).

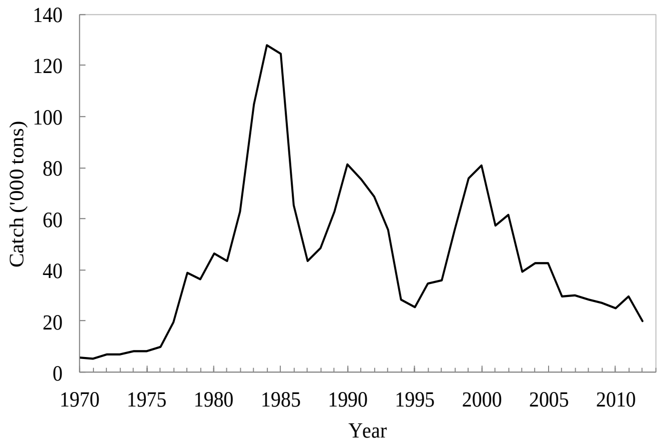


Fig. 6.2. Shrimp in ICES SA I and II: total catches 1970–2012 (2012 projected to the end of the year).

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 surveillance and research surveys and are corrected for differences in gear selection pattern (SCR Doc. 07/86). The bycatch rates in specific areas are then multiplied by the corresponding shrimp catch from logbooks to give the overall bycatch.

Since the introduction of the Nordmøre sorting grid in 1992, only small cod, haddock, Greenland halibut, and redfish in the 5–25 cm size range are caught as bycatch. The bycatch of small cod ranged between 2–67 million individuals/yr. and redfish between 2–25 million individuals/yr. since 1992, while 1–9 million haddock/yr. and 0.5–14 million Greenland halibut/yr. were registered in the period 2000–2004 (Fig. 6.3). In recent years there has been a decline in bycatch following a reduced effort in the shrimp fishery. Details of bycatch is no longer reported by the ICES Arctic Fisheries Working Group. NIPAG will from now on take over this task and update bycatch information starting at its 2013 meeting.

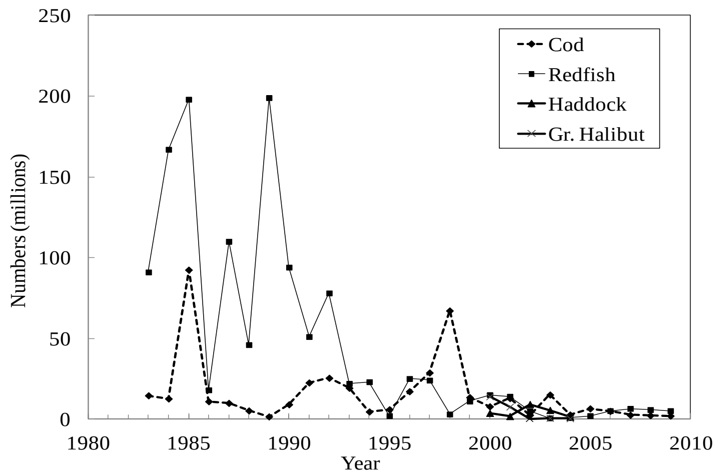


Fig. 6.3. Shrimp in ICES SA I and II: Estimated bycatch of cod, haddock, Greenland halibut and redfish in the Norwegian shrimp fishery (million individuals). No data available for 2010-12.

b) Input Data

i) Commercial fishery data

A major restructuring of the shrimp fishing fleet towards fewer and larger vessels has taken place since the mid-1990s. At that time an average vessel had around 1 000 HP; 10 years later this value had increased to more than 6 000 HP (Fig. 6.4). Until 1996 the fishery was conducted by using single trawls only. Double trawls were then introduced, and in 2002 approximately ⅔ of the total effort (trawl-time) spent was by using two trawls simultaneously. In 2000 a few vessels started to experiment with triple trawls: 58% of the effort in 2010 is accounted for by this fishing method (Fig. 6.5). An individual vessel may alternate between single and multiple trawling depending on what is appropriate on given fishing grounds.

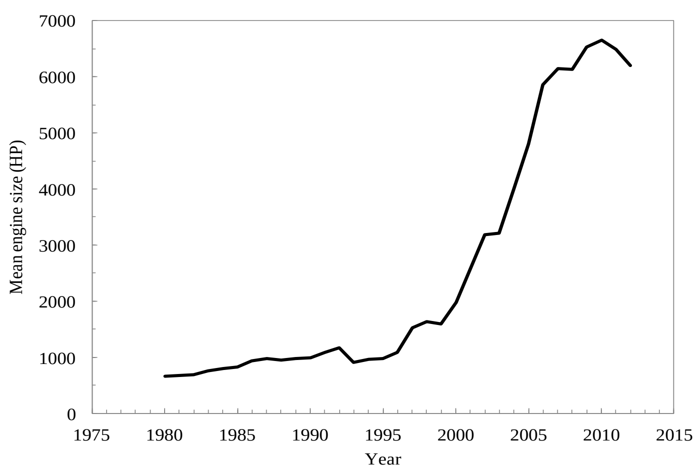


Fig. 6.4. Shrimp in ICES SA I and II: Mean engine power (HP) weighted by trawl-time, in the years 1980–2012.

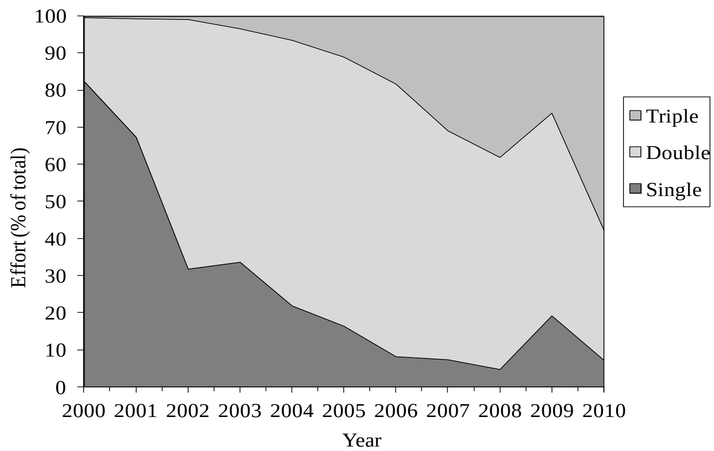


Fig. 6.5. Shrimp in ICES SA I and II: Percentage of total fishing effort spent by using single, double or triple trawls 2000–2010 (Norwegian data).

The fishery is conducted mainly in the central Barents Sea and on the Svalbard Shelf (Fig. 6.6). The fishery takes place throughout the year but may in some years be restricted by ice conditions. The lowest effort is generally seen in October through March, the highest in May to August.

Logbook data from 2009 to 2012 show decreased activity in the Hopen Deep, coupled with increased effort further east in international waters in the so-called “Loop Hole” (Fig 6.6). Information from the industry points to decreasing catch rates and 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.

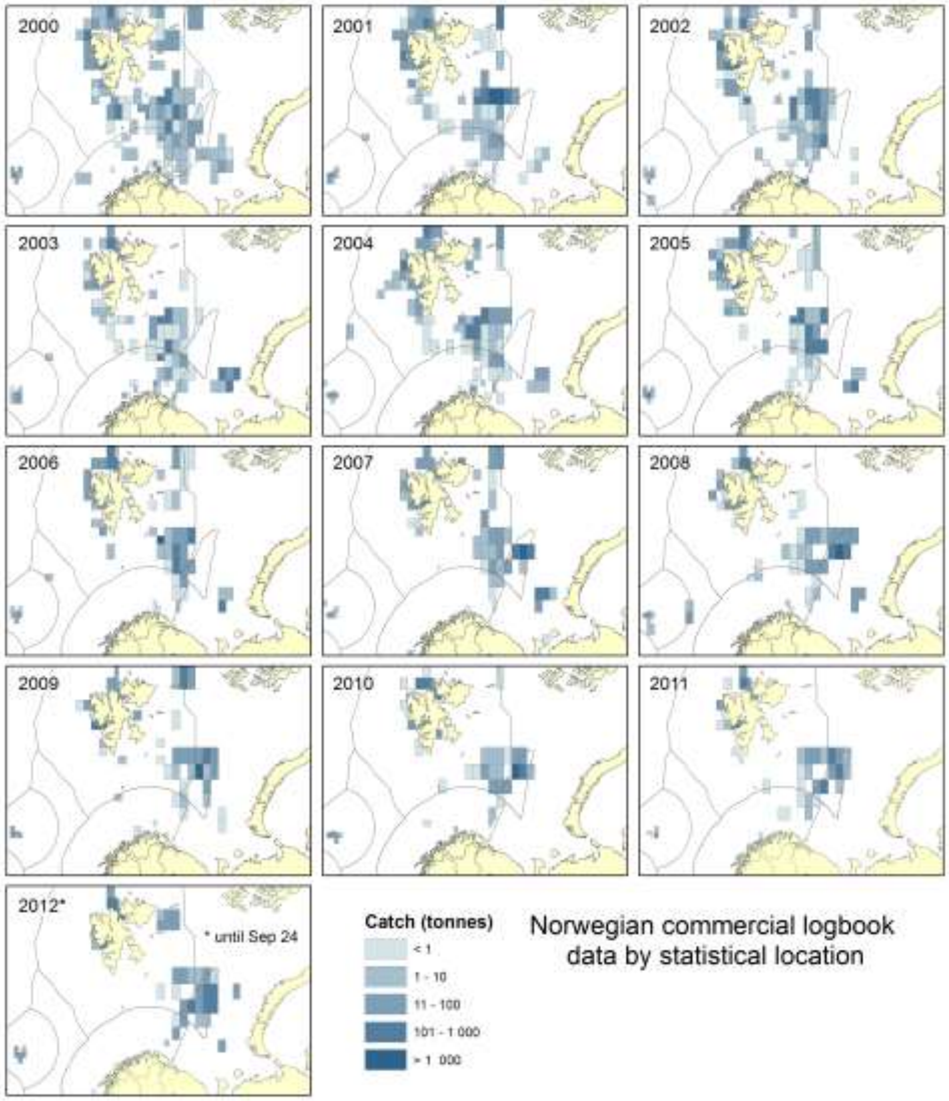


Fig. 6.6. Distribution of catches by Norwegian vessels 2000-2012 based on logbook information.

Norwegian logbook data were used in a multiplicative model (GLM) to calculate standardized annual catch rate indices (SCR Doc. 12/51). 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 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 is assumed to be indicative of the biomass of shrimp ≥17 mm CL, *i.e*. females and older males.

The standardized CPUE declined by 60% from a maximum in 1984 to the lowest value of the time series in 1987 (Fig. 6.7). Since then it has showed an overall increasing trend. A new peak was reached in 2006 and the 2007 to 2011 mean values have fluctuated above the average of the series thereafter. In 2012 the index decreased significantly to just below average. The standardized effort (Fig. 6.8) has shown a decreasing trend since 2000.

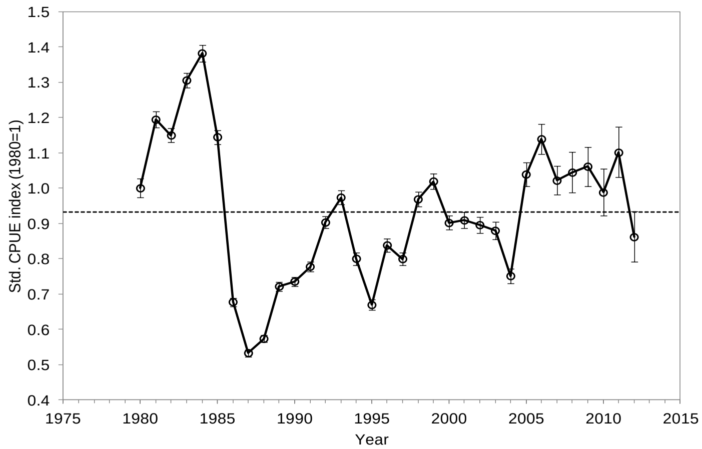


Fig. 6.7. Shrimp in ICES SA I and II: standardized CPUE based on Norwegian data. Error bars represent one standard error; dotted line is the overall mean of the series.

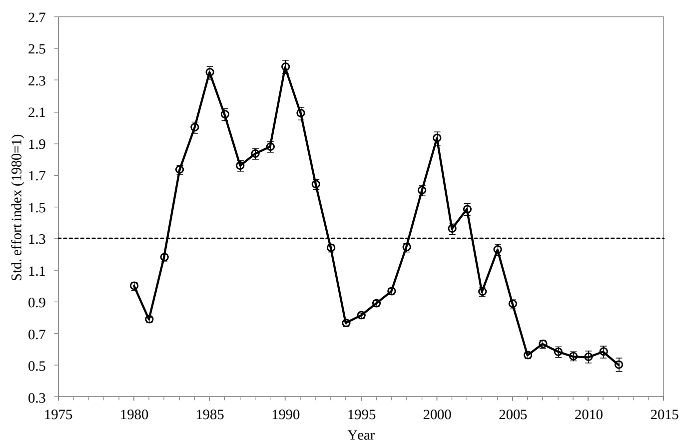


Fig. 6.8. Shrimp in ICES SA I and II: Standardized effort (Catch divided with standardized CPUE). Error bars represent one standard error; dotted line is the overall mean of the series.

ii) Research survey data

Russian and Norwegian shrimp surveys have been conducted in their respective EEZs of the Barents Sea since 1982 to assess the status of the northern shrimp stock (SCR Doc. 06/70, 07/75, 12/50). The main objectives were to obtain indices for stock biomass, abundance, recruitment and demographic composition. In 2004, these surveys were replaced by the joint Norwegian-Russian "Ecosystem survey" which monitors shrimp along with a multitude of other ecosystem variables in the entire area. Details of the survey design are contained in SCR Doc. 12/50.

Biomass. The Biomass indices of the Norwegian and Russian shrimp surveys (survey 1 and 2) varied without trend between 1982 and 2005 (Fig. 6.9). The Joint Russian-Norwegian Ecosystem survey (survey 3) increased by about 66% from 2004 to 2006 and then decreased back to the 2004-value in 2008 (Fig. 6.9). The 2010 to 2012 values is back up close to that of 2006.

The geographical distribution of the stock in 2009-2012 is more easterly compared to that of the previous years (Fig. 6.10).

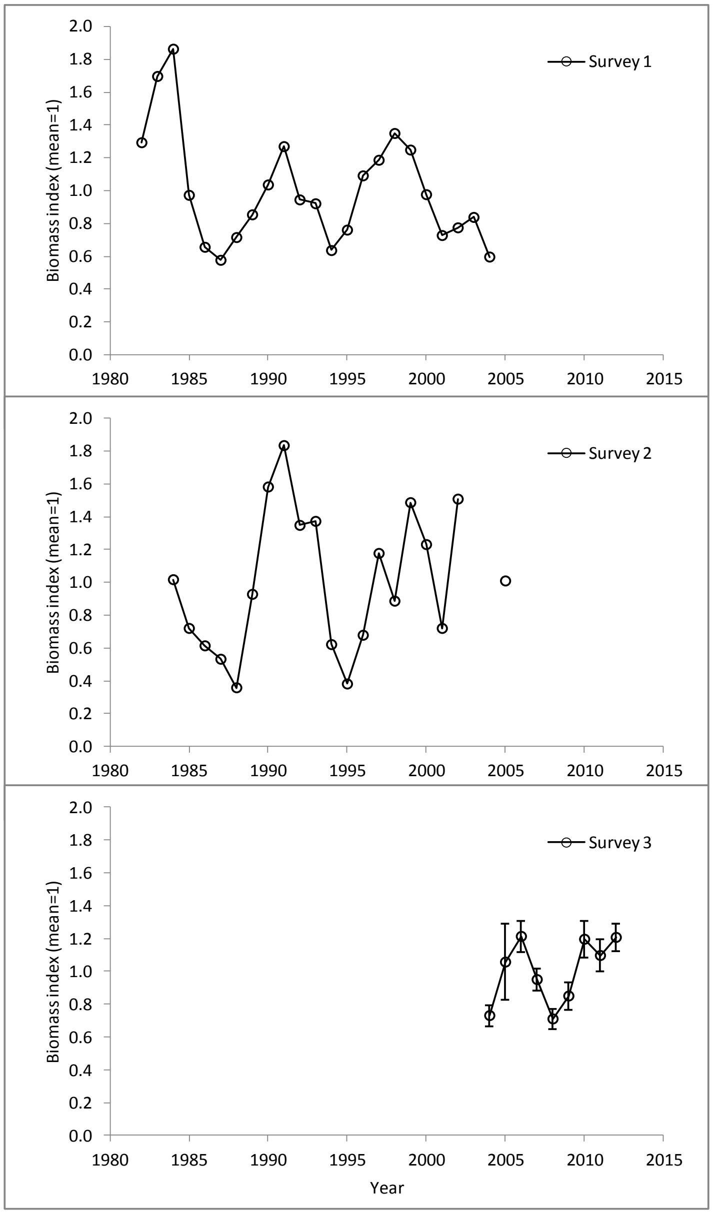


Fig. 6.9. Shrimp in ICES SA I and II: Indices of total stock biomass from the (1) 1982-2004 Norwegian shrimp survey, (2) the 1984-2005 Russian survey, and (3) the joint Russian-Norwegian ecosystem survey. Error bars represent one standard error.

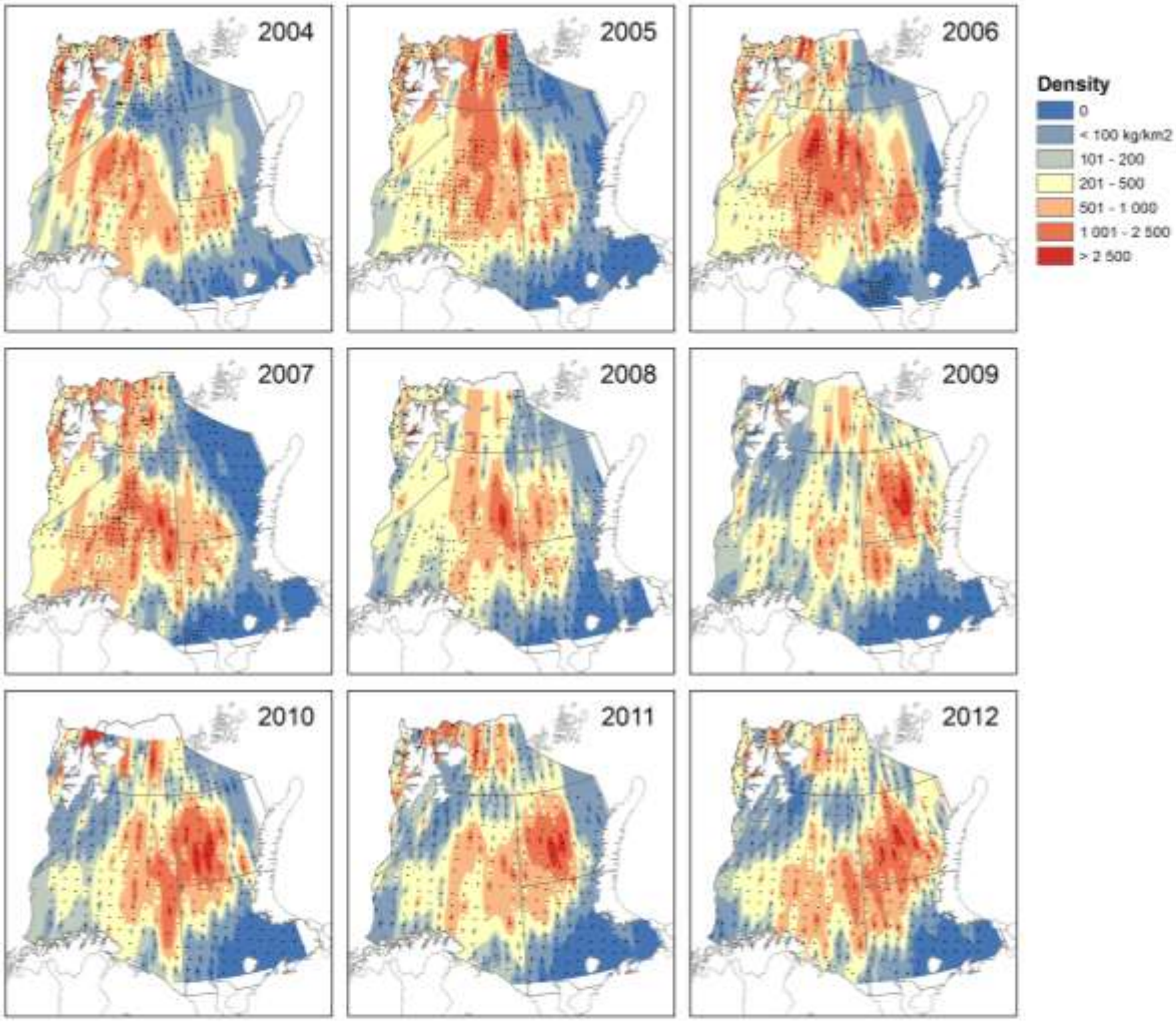


Fig. 6.10. Shrimp in ICES SA I and II: Shrimp density (kg/km^2) as calculated from the Ecosystem survey data 2004–2012).

Recruitment indices. Two recruitment indices were derived from the overall size distributions based on Russian and Norwegian samples (SCR Doc. 12/60 and 12/50 respectively) as estimated abundance of shrimp at 13 to 16 mm CL. Shrimp at this size will probably enter the fishery in the following one to two years. Recruitment indices showed no major changes in the period 2004 – 2012 (Fig. 6.11).

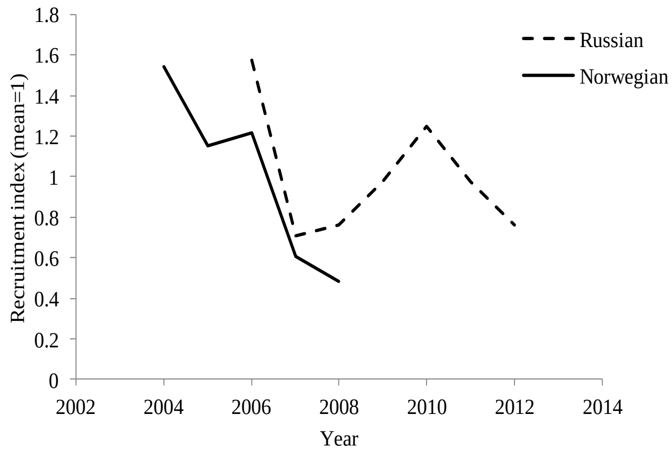


Fig. 6.11. Shrimp in ICES SA I and II: Indices of recruitment: abundance of shrimp at size 13–16 mm CL based on Norwegian survey samples 2004-2008 and Russian survey samples 2006-2012.

Environmental considerations. Temperatures in the Barents Sea have been high since 2004, largely due to increased inflow of warm water masses from the Norwegian Sea. An increase from 2011 to 2012 was observed in near-bottom temperatures primarily in the north and northwestern parts of the Barents Sea, but also in the southwest where temperatures at the bottom were the highest on record since 1951 (pers. comm. R. Ingvaldsen/A. Trofimov). In 2012 temperatures in the rest of the water column were largely unchanged, while temperatures near the surface were substantially lower than in 2011, probably due to a marked shift in the large wind and pressure field in the northernmost parts of the Barents Sea/Arctic Ocean (SCR Doc. 12/49).

Shrimps were only caught in areas where bottom temperatures were above 0°C (Fig. 6.4). 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 changes in shrimp distribution eastwards may be associated with the temperature changes observed (Fig. 6.12).

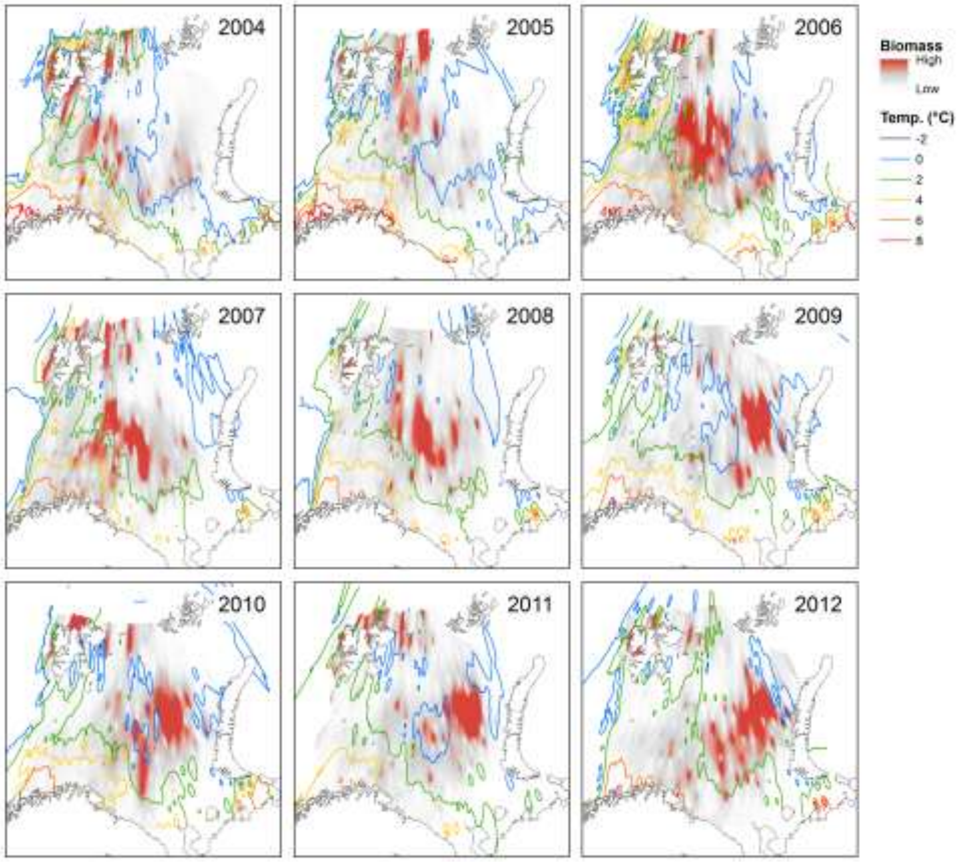


Fig. 6.12. Shrimp in ICES SA I and II: Bottom temperature contour overlays from the 2004 to 2012 ecosystem surveys on shrimp density distributions (SCR Doc. 12/50).

c) Estimation of Parameters

The modelling framework introduced in 2006 (SCR Doc. 06/64) was used for the assessment. Model settings were the same as ones used in previous years except that the historic Russian 1984-2005 survey biomass series is now included as input data (Fig 6.9, survey 2).

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" likelihood distributions of the parameters (SCR Doc. 12/49).

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 commercial vessel catch rates for 1980–2012 (Fig. 6.7, SCR Doc. 12/51); and trawl-survey biomass indices for 1982–2004, 1984–2005 and for 2004–present (Fig, 6.9, SCR Doc. 12/50). These indices were scaled to true biomass by catchability parameters, q, and lognormal observation errors were applied. Total reported catch in ICES Div. I and II since 1970 was used as yield data (Fig. 6.2, SCR Doc. 12/51). 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 normally, independently and identically distributed with mean 0 and variance (observation error) σ_C^2, σ_R^2, σ_{Ru}^2 and σ_E^2 respectively. Summaries of the estimated posterior probability distributions of selected parameters are shown in Table 6.2. Values are similar to the ones estimated in the 2011 assessment.

Table 6.2. Shrimp in ICES SA I and II : Summary of parameter estimates: mean, standard deviation (sd) and 25, 50, and 75 percentiles of the posterior distribution of selected parameters (symbols are as in the text; r = intrinsic growth rate, P0 = the 'initial" stock biomass in 1969).

	Mean	sd	25 %	Median	75 %
MSY (ktons)	267	192	125	214	358
K (ktons)	3269	1829	1883	2851	4217
r	0.34	0.17	0.22	0.33	0.45
q_R	0.13	0.09	0.07	0.10	0.17
q_{Ru}	0.33	0.23	0.16	0.26	0.42
q_E	0.20	0.14	0.10	0.16	0.25
q_C	4.8E-04	3.3E-04	2.4E-04	3.8E-04	6.0E-04
P_0	1.50	0.26	1.33	1.50	1.68
P_{2012}	1.90	0.51	1.58	1.87	2.18
σ_R	0.17	0.03	0.15	0.17	0.19
σ_{Ru}	0.34	0.05	0.30	0.34	0.37
σ_E	0.17	0.04	0.15	0.17	0.19
σ_C	0.13	0.02	0.12	0.13	0.14
σ_P	0.19	0.03	0.17	0.19	0.21

Reference points. In 2009 ICES adopted a "Maximal Sustainable Yield (MSY) framework" (ACOM. ICES Advice, 2010. Book 1. Section 1.2) for deriving advice. There are three reference points to be considered: F_{msy}, $B_{trigger}$ and B_{lim}. In the MSY management approach the F_{lim} is somewhat redundant, however, recent discussions on the setting of an F_{lim} reference can be found in the 2009 NIPAG report. F_{msy} and the probability of exceeding it can be estimated, as well as the risk of exceeding B_{lim} which is set at 30% B_{msy} (NIPAG, 2006), F_{lim} suggested to be 170% of F_{msy} (NIPAG, 2009) and $B_{trigger}$ set at 50% B_{msy} (p.56, NIPAG, 2010).

d) Assessment Results

The results of this year's model run are similar to those of the previous years (model introduced in 2006). The sensitivity of model results to the setting of the priors for initial stock biomass and carrying capacity has previously been investigated (SCR Doc. 06/64 and 07/76) and found to have little effect on the conclusions drawn from the model.

Stock size and fishing mortality. Since the 1970s, the estimated median relative biomass (B/B_{msy}) has been above 1 (Fig. 6.13, upper panel) and the probability that it had ever been below $B_{trigger}$ was small.

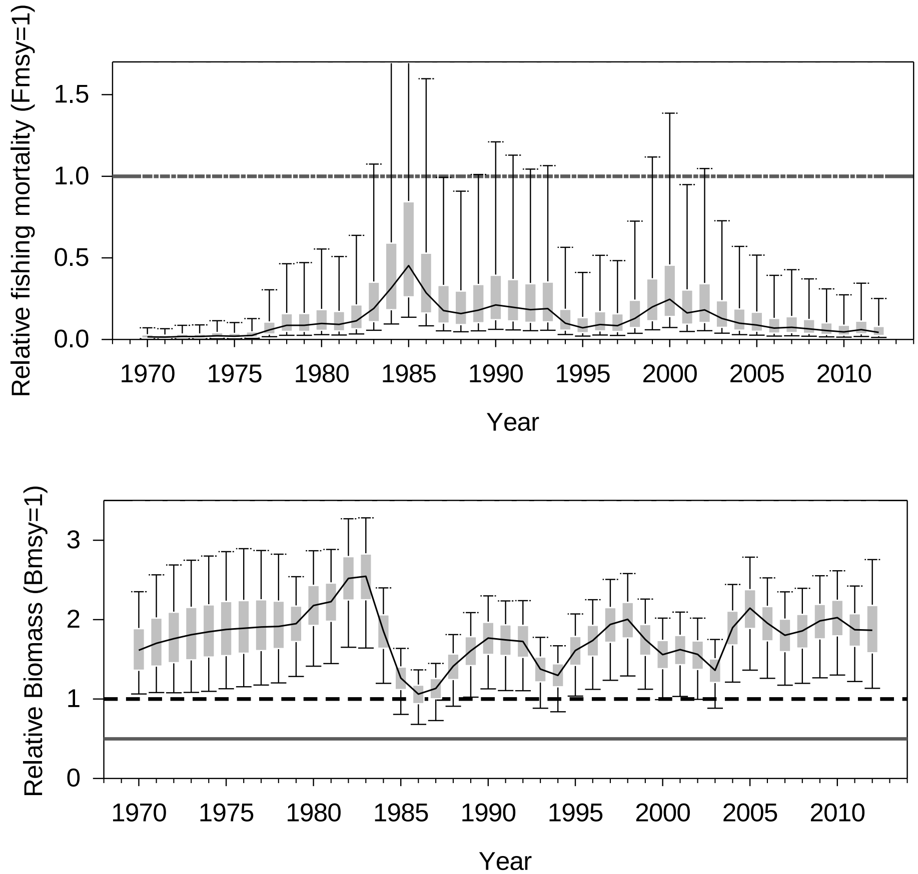


Fig. 6.13. Shrimp in ICES SA I and II: estimated relative biomass (B_t/B_{msy}) and fishing mortality (F_t/F_{msy}) for the years (t) 1970–2012. Boxes represent inter-quartile ranges and the solid black line at the (approximate) centre of each box is the median; the arms of each box extend to cover the central 90% of the distribution. The Green lines are the $B_{trigger}$ and F_{msy} references respectively

A steep decline in stock biomass was noted in the mid-1980s following some years with high catches and the median relative biomass went close to 1 (Fig. 6.13, upper). Since the late 1990s the stock has varied with an overall increasing trend and reached a level estimated to be close to K in 2005. The estimated risk of stock biomass being below B_{MSY} in 2011 and 2012 was 3% (Table 6.3). The median relative fishing mortality (F/F_{MSY}) has been well below 1 throughout the series (Fig. 6.13 lower). In 2012 there is a low 1% risk of exceeding F_{MSY} (Table 6.3).

Table 6.3. Shrimp in ICES SA I and II: stock status for 2011 and predicted to the end of 2012 assuming a total catch of 18 ktons. (170% F_{MSY} = fishing mortality that corresponds to a B_{lim} at $0.3B_{MSY}$).

Status	2011	2012*
Risk of falling below Blim (0.3Bmsy)	<1 %	<1 %
Risk of falling below Btrig (0.5Bmsy)	<1 %	<1 %
Risk of falling below Bmsy	3 %	3 %
Risk of exceeding Fmsy	1 %	1 %
Risk of exceeding 1.7Fmsy	<1 %	<1 %
Stock size (B/Bmsy), median	1.87	1.87
Fishing mortality (F/Fmsy), median	0.06	0.04
Productivity (% of MSY)	24 %	25 %

Estimated median biomass has been above $B_{trigger}$ and fishing mortality ratio has been below F_{msy} throughout the time series (Fig. 6.14). At the end of 2011 there is less than 1% risk that the stock would be below $B_{trigger}$, and that F_{msy} will be exceeded (Table 6.3).

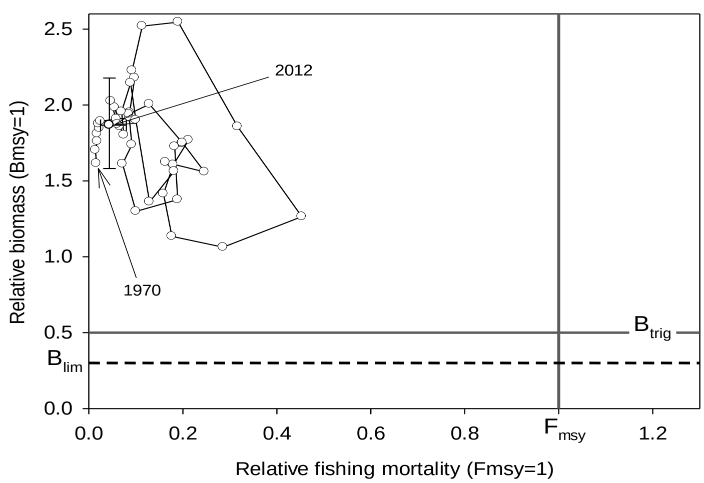


Fig. 6.14. Shrimp in ICES SA I and II: Estimated annual median biomass-ratio (B/B_{MSY}) and fishing mortality-ratio (F/F_{MSY}) 1970–2012. The MSY reference points for stock biomass, $B_{trigger}$, and fishing mortality, F_{msy}, are indicated by green lines. The PA reference B_{lim} is the broken line. Error bars on the 2012 value are inter-quartile range.

Predictions. Assuming a catch of 18 kt for 2012, catch options up to 60 kt for 2013 have a low risk (<5%) of exceeding F_{MSY} (Table 6.4) and is likely to maintain the stock at its current high level.

Table 6.4. Shrimp in ICES SA I and II: Predictions of risk and stock status associated with six optional catch levels for 2013. (170% F_{MSY} = fishing mortality that corresponds to a B_{lim} at $0.3B_{MSY}$).

Catch option 2013 (ktons)	30	40	50	60	70	90
Risk of falling below Blim (0.3Bmsy)	<1 %	<1 %	<1 %	<1 %	<1 %	<1 %
Risk of falling below Btrig (0.5Bmsy)	<1 %	<1 %	<1 %	<1 %	<1 %	<1 %
Risk of exceeding Fmsy	1 %	2 %	3 %	4 %	6 %	8 %
Risk of exceeding 1.7Fmsy	1 %	1 %	1 %	2 %	3 %	4 %
Stock size (B/Bmsy), median	1.86	1.85	1.84	1.83	1.83	1.80
Fishing mortality (F/Fmsy),	0.08	0.10	0.13	0.15	0.18	0.23
Productivity (% of MSY)	27 %	28 %	30 %	30 %	32 %	36 %

The risks associated with ten-year projections of stock development assuming annual catch of 30 000 to 90 000 t were investigated (Fig. 6.15). For all options the risk of the stock falling below $B_{trigger}$ in the medium term (10 years) is less than 5% (Fig. 6.13). Catch options up to 60 000 t, have a low risk (<5%) of exceeding F_{MSY} in the short term (Fig. 6.14).

Taking 90 000 t/yr will increase the risk of going above F_{msy} to more than 10% during the ten years of projection (Fig. 6.15). However, the risk of going below $B_{trigger}$ remains under 5%.

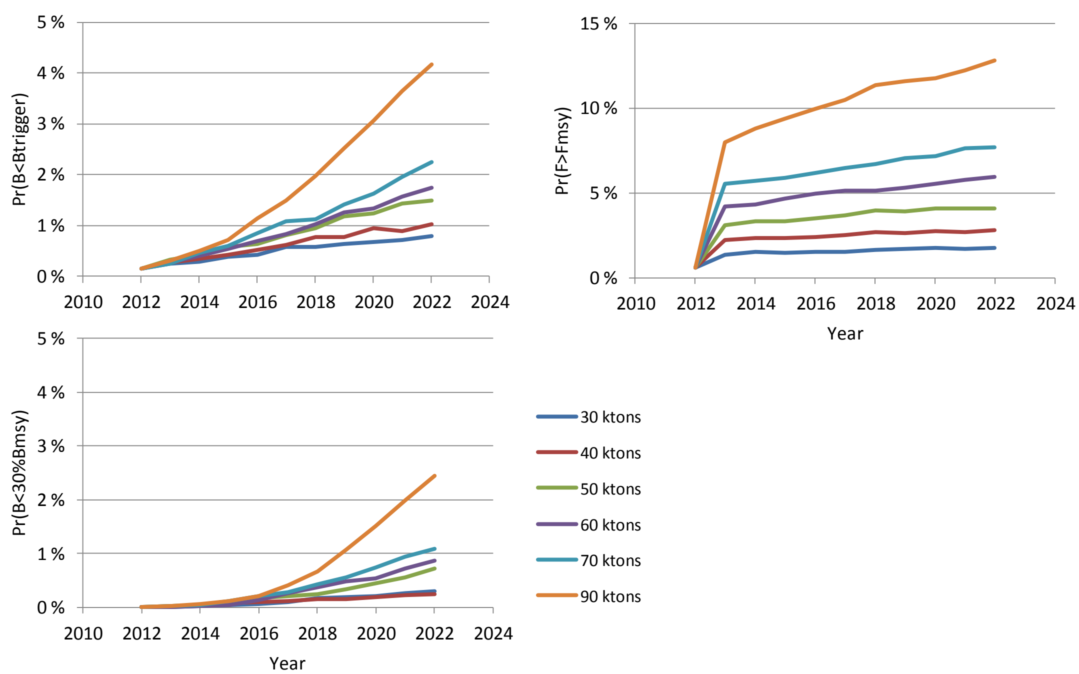


Fig. 6.15. Shrimp in ICES SA I and II: Projections of estimated risk of going below $B_{trigger}$ and of exceeding F_{msy} (top) and going below B_{lim} (bottom) given different catch options (see legend).

Yield predictions can be made for various levels of fishing mortalities (e.g. at target fishing mortality=F_{MSY}) but such estimates have high uncertainties as absolute biomass can only be estimated with relatively high variances (see section on “estimation of parameters”) and therefore such point estimates should be interpreted with caution. Instead we estimate yield at risk level of exceeding the target of F_{MSY} (Table 6.5) and managers may pick their preferred risk level from this.

Table 6.5. Shrimp in ICES SA I and II: Yield predictions (kt) at five risk levels of exceeding F_{msy}.

	Risk of exceeding F_{msy}				
Year	2.5 %	5 %	10 %	25 %	50 %
2013	45	70	107	190	338
2014	45	71	106	189	336
2015	45	66	100	172	305
2016	41	64	94	162	281
2017	42	62	89	153	267
2018	40	60	85	146	255
2019	41	57	82	141	246
2020	38	56	81	137	238
2021	37	54	78	133	230
2022	35	53	77	132	228

Additional considerations

Model performance. The model was able to produce good simulations of the observed data (Fig. 6.16). The observations did not lie in the extreme tails of their posterior distributions (Table 6.6.). There is little retrospective pattern in the model (NIPAG, 2011).

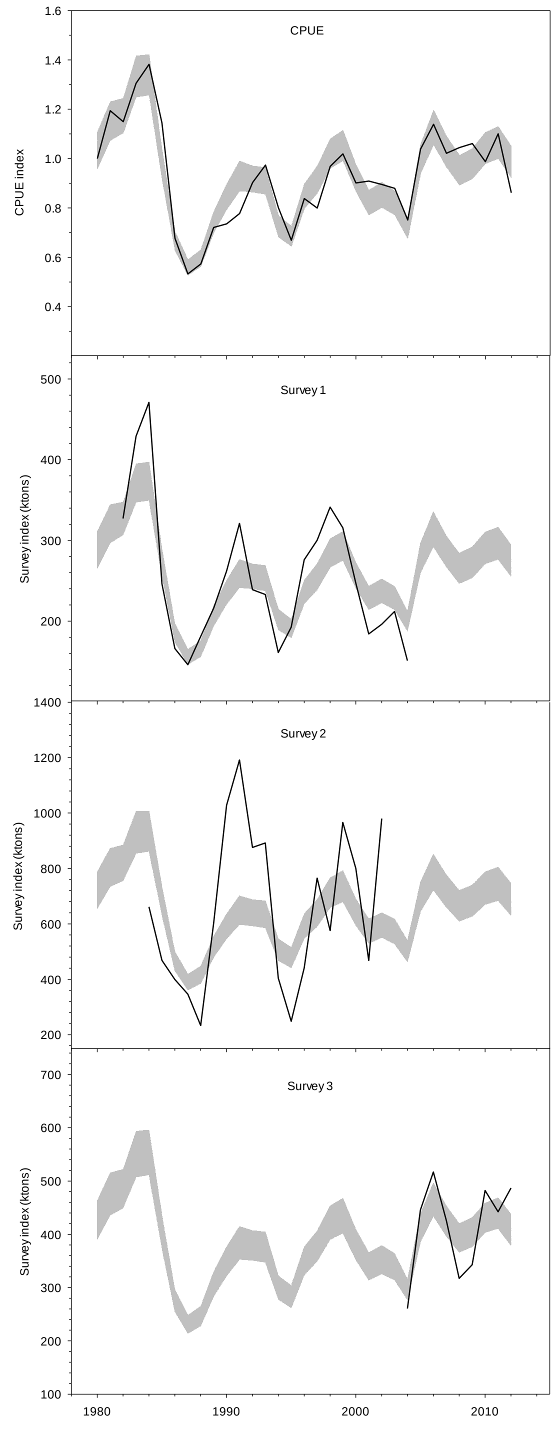


Fig. 6.16. Shrimp in ICES SA I and II: Observed (solid line) and estimated (shaded) series of the included biomass indices: the standardized catch-per-unit-effort (CPUE), the 1982–2004 shrimp survey (survey 1), a Russian survey index discontinued in 2005 (Survey 2) and the joint Norwegian-Russian Ecosystem survey (survey 3). Grey shaded areas are the inter-quartile range of their posteriors.

Table 6.6 Model diagnostics: residuals (% of observed value) and probability of getting a more extreme observation (pr; pr=0.5 means the observations is in the center of its predicted distribution while values close to 1 or 0 means that it is in the tail).

	CPUE		Survey 1		Survey 2		Survey 3	
Year	resid (%)	Pr	resid (%)	Pr	resid (%)	Pr	resid (%)	Pr
1980	3.64	0.43	-	-	-	-	-	-
1981	-3.31	0.59	-	-	-	-	-	-
1982	2.37	0.46	0.25	0.50	-	-	-	-
1983	2.29	0.45	-13.30	0.77	-	-	-	-
1984	-2.83	0.58	-20.61	0.88	41.94	17.08	-	-
1985	-14.44	0.84	10.88	0.31	46.22	15.21	-	-
1986	-1.41	0.55	11.95	0.29	16.87	33.16	-	-
1987	5.00	0.38	6.74	0.38	13.00	36.62	-	-
1988	4.25	0.40	-8.11	0.68	79.11	5.53	-	-
1989	2.99	0.44	-4.15	0.59	-13.85	67.59	-	-
1990	15.26	0.20	-9.86	0.71	-42.36	93.67	-	-
1991	19.85	0.14	-19.13	0.86	-45.36	95.24	-	-
1992	1.80	0.47	7.09	0.37	-26.69	81.62	-	-
1993	-6.41	0.67	8.93	0.34	-28.60	83.57	-	-
1994	-9.19	0.74	25.64	0.13	25.63	26.84	-	-
1995	2.63	0.44	-0.95	0.52	93.42	3.83	-	-
1996	1.33	0.48	-14.34	0.79	34.49	20.63	-	-
1997	14.87	0.20	-14.82	0.80	-16.20	69.89	-	-
1998	5.59	0.38	-16.45	0.83	24.10	28.10	-	-
1999	3.54	0.42	-7.03	0.66	-23.70	78.29	-	-
2000	2.35	0.45	4.07	0.43	-19.39	73.50	-	-
2001	-9.42	0.74	24.59	0.14	22.90	29.55	-	-
2002	-4.58	0.63	21.46	0.17	-39.05	92.37	-	-
2003	-6.66	0.67	7.89	0.35	-	-	-	-
2004	-4.35	0.62	32.48	0.08	-	-	13.73	0.27
2005	-3.61	0.60	-	-	6.68	43.55	-7.25	0.65
2006	-0.80	0.53	-	-	-	-	-9.74	0.70
2007	0.88	0.48	-	-	-	-	-0.04	0.52
2008	-8.52	0.72	-	-	-	-	24.42	0.15
2009	-7.54	0.69	-	-	-	-	18.13	0.21
2010	5.78	0.36	-	-	-	-	-10.45	0.72
2011	-2.97	0.59	-	-	-	-	-0.18	0.51
2012	15.00	0.21	-	-	-	-	-16.01	0.81

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 estimated to consume large amounts of shrimp. If predation on shrimp were to increase rapidly outside the range previously experienced by the shrimp stock within the modelled period (1970–2011), the shrimp stock might decrease in size more than the model results have indicated as likely. The cod stock has recently increased (ICES AFWG, 2012). Continuing investigations to include cod predation as an explicit effect in the assessment model has not so far been successful as it has not been possible to establish a relationship between shrimp/cod densities.

Recruitment/reaction time of the assessment model. The model used is best at describing trends in stock development but shows some inertia in its response to year-to-year changes. Large and sudden changes in recruitment may therefore not be fully captured in model predictions however such changes have not been observed in the recent period.

Rebuilding potential. Although the stock is in a healthy state it should be noted that at 30% B_{msy} (B_{lim}) production is reduced to 50% of its maximum The estimate of the *r* (intrinsic rate of increase) had 80% confidence interval ranging from 0.13 to 0.56. Thus without a fishery it would take 4-14 years to rebuild the stock from B_{lim} to B_{msy}.

e) Summary

Mortality. The fishing mortality has been below F_{MSY} throughout the exploitation history of the stock. The risk that F will exceed F_{MSY} in 2012 is estimated to be less than 1%.

Biomass. The stock biomass estimates have been above B_{MSY} throughout the history of the fishery. Biomass at the end of 2012 is estimated to be well above $B_{trigger}$.

Recruitment. Recruitment indices showed no major changes in the period 2004 – 2012

State of the Stock. The Stock is estimated to be close to the carrying capacity. The risk of stock biomass being below $B_{trigger}$ and fishing mortality above F_{MSY} at end 2012 is less than 1%.

Yield. Catch options up to 60 000 t/yr, have a low risk (<5%) of exceeding F_{MSY} in the coming 3 years. At a higher risk tolerance larger yield may be achieved.

f) Review of Recommendations from 2011

There were no recommendations.

g) Research Recommendations

For the shrimp stock in Barents Sea and Svalbard (ICES Div. I and II), NIPAG **recommended** that *the technical basis for the assessment in various SCR Docs. be collated into a single technical stock annex*.

NIPAG reiterated its **recommendations** from 2010 that, *for the shrimp stock in Barents Sea and Svalbard (ICES Div. I and II):*

- *Demographic information (length, sex and stage etc.) be collected also from the Norwegian part of* ***the Barents Sea ecosystem survey.***
- *Collaborative efforts should be made to standardize a means of predicting recruitment to the fishable stock.*
- *Work to include explicit information on recruitment in the assessment model should be continued.*

7. Northern shrimp in 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 from 1972 (SCR Doc. 09/69, Table 9). Total reported landings since 1997 have fluctuated between zero in 2006 to above 4000 t (Table 6.1). The Danish fleet accounts for the majority of these landings, with the Scottish fleet landing a minor portion. The fishery took place mainly during the first half of the year, with the highest activity in the second quarter. Since 2006 no landings have been recorded from this stock.

Since 1998 landings have decreased steadily and since 2004 the Fladen Ground fishery has been virtually non-existent with total recorded landings being less than 25 t. Interview information from the fishing industry obtained in 2004 gives the explanation that this decline is caused by low shrimp abundance, low prices on the small shrimp which are characteristic of the Fladen Ground, and high fuel prices. This stock has not been surveyed for several years, and the decline in this fishery may reflect a decline in the stock.

Table 7.1. Northern shrimp in Fladen Ground: Landings of *Pandalus borealis* (t) from the Fladen Ground (ICES Div. IVa) estimated by NIPAG.

Country/Fleet	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Denmark	2 900	1 005	1 482	1 263	1 147	999	23	10	0	0	0	0	0	0
Norway	3	9		18	9	8	0	0	0	0	0	0	0	0
Sweden						1	0	0	0	0	0	0	0	0
UK (Scotland)	1 365	456	378	397	70		0	0	0	0	0	0	0	0
Total	4 268	1 470	1 860	1 678	1 226	1 008	23	10	0	0	0	0	0	0

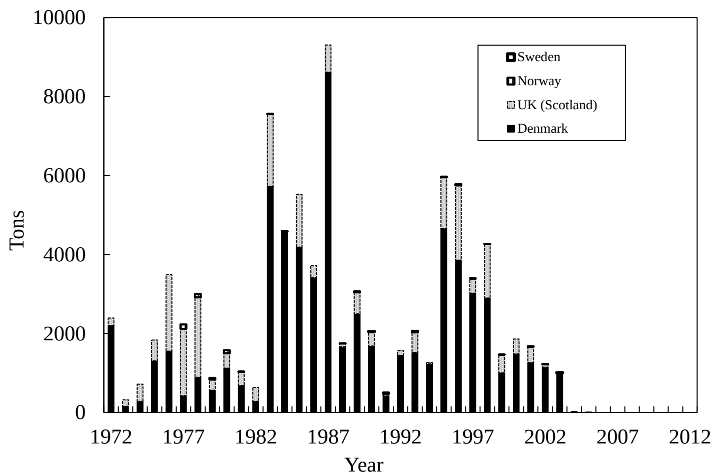


Fig. 7.1. Northern shrimp in Fladen Ground: Catches

IV. OTHER BUSINESS

Future Meetings

An invitation was made to the group from Greenland to host the September 2014 SC / NIPAG meeting in Nuuk. This suggestion was warmly received by NIPAG.

V. ADJOURNMENT

The NIPAG meeting was adjourned at 1630 hours on 23 October 2012. 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. Thanks were also given to the Norwegian host for the excellent facilities supplied for the meeting.