PART H: NAFO/ICES PANDALUS ASSESSMENT GROUP (NIPAG) MEETING, 10–17 SEPTEMBER 2014

Contents

Report of NIPAG Meeting

10–17 September 2014

Co-Chairs: Brian Healey and Michael Kingsley Rapporteurs: Various

I. OPENING

The NAFO/ICES *Pandalus* Assessment Group (NIPAG) met at the Greenland Institute of Natural Resources (Pinngortitaleriffik), Nuuk, Greenland during 10-17 September 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, Lithuania, Spain and Sweden), Norway and Russian Federation. The NAFO Scientific Council Coordinator and Information Officer were also in attendance.

II. GENERAL REVIEW

1. Review of Research Recommendations in 2013

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)

(SCR Doc. 14/049, 050)

Environmental Overview

Recent Conditions in Ocean Climate and Lower Trophic Levels

●Ocean climate composite index on SA3 – Flemish Cap has shifted downward in recent years although remains slightly above normal in 2013.

●The composite spring bloom index has shifted to negative values in 2013 after relatively high positive anomalies (highest in 2010) in recent years.

●The composite zooplankton index has remained above normal since 2009 and reached its highest level in 2013.

●The composite trophic index increased to its highest level in 2013.

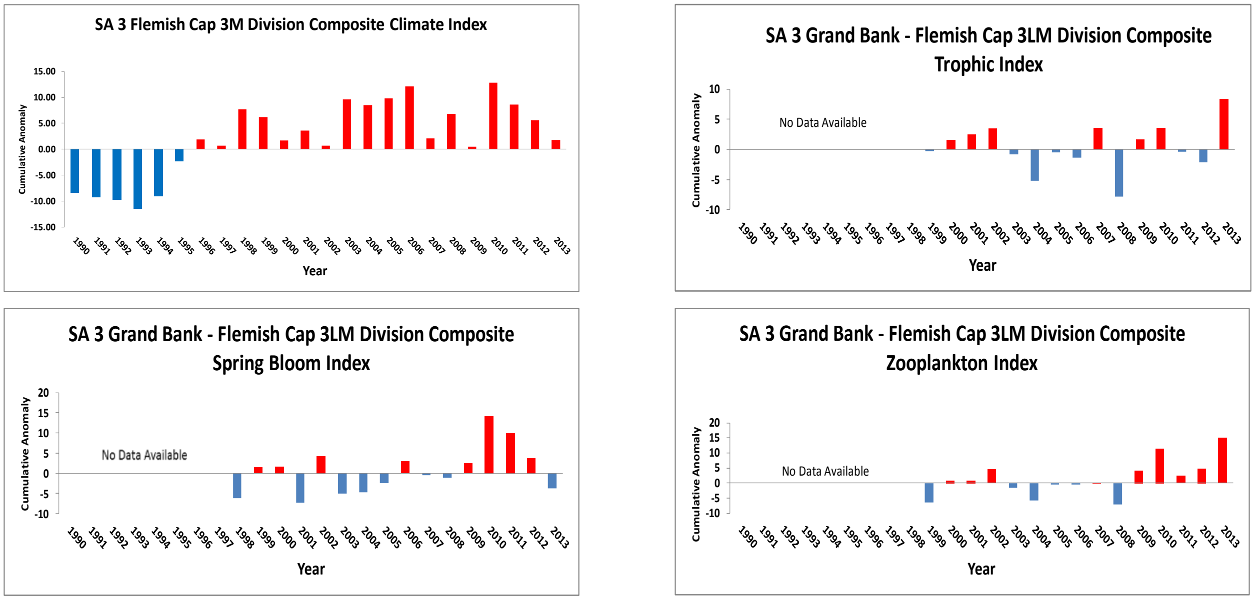


Fig. 1. Composite ocean climate index for NAFO Subarea 3 (Div. 3M) derived by summing the standardized anomalies during 1990-2013 (top left panel), composite spring bloom (summed background chlorophyll *a*, magnitude and amplitude indices) index (Div. 3LM) during 1998-2013 (lower left panel), composite zooplankton (cumulative anomalies of the four functional plankton taxa) index during 1999-2013 (top right panel), and composite trophic (summed anomalies of nutrient and standing stocks of phyto- and zooplankton indices) index (Div. 3LM) during 1999-2013 (bottom right panel). Red bars are positive anomalies indicating above average levels while blue bars are negative anomalies indicating below average values.

The water masses characteristic of the Flemish Cap area are a mixture of Labrador Current Slope Water and North Atlantic Current Water, generally warmer and saltier than the sub-polar Newfoundland Shelf waters with a temperature range of 3-4°C and salinities in the range of 34-34.75. The general circulation in the vicinity of the Flemish Cap consists of the offshore branch of the Labrador Current which flows through the Flemish Pass on the Grand Bank side and a jet that flows eastward north of the Cap and then southward east of the Cap. To the south, the Gulf Stream flows to the northeast to form the North Atlantic Current and influences waters around the southern areas of the Cap. In the absence of strong wind forcing the circulation over the central Flemish Cap is dominated by a topographically induced anti-cyclonic (clockwise) gyre. Variation in the abiotic environment is thought to influence the distribution and biological production of Newfoundland and Labrador Shelf and Slope waters, given the overlap between arctic, boreal, and temperate species. The elevated temperatures on the Cap as a result of relatively ice-free conditions, may allow longer growing seasons and permit higher rates of productivity of fish and invertebrates on a physiological basis compared to cooler conditions prevailing on the Grand Banks and along the western Slope waters. The entrainment of North Atlantic Current water around the Flemish Cap, rich in inorganic dissolved nutrients generally supports higher primary and secondary production compared with the adjacent shelf waters. The stability of this circulation pattern may also influence the retention of ichthyoplankton on the bank which may influence year-class strength of various fish and invertebrate species.

Ocean Climate and Ecosystem Indicators

The composite climate index in Subarea 3 (Div. 3M) has remained above normal since the mid-1990s although the index has been in decline since 2010 and now approaching near-normal conditions in 2013 (Fig. 1). The composite spring bloom index (Div. 3LM) peaked in 2010 and has declined sequentially shifting from a series of positive anomalies to below normal in 2013 (Fig. 1). The composite zooplankton index (mainly composed of copepod and invertebrate plankton) peaked in 2013 and has remained at above normal levels in recent years (Fig. 1). The composite tropic index which combines nutrient inventories and standing stocks of phytoplankton and zooplankton, increased to its highest level in 2013 (Fig. 1). Surface temperatures on the Flemish Cap were slightly above normal in

2013 with a standard deviation of 0.6. Bottom temperature anomalies across the Flemish Cap were similar to 2012 and ranged from 1-2 standard deviations above normal in 2013, and have remained high since 2008.

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: A moratorium was imposed in 2011. Catches are expected to be close to zero in 2014. Recent catches were as follows:

	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
STACFIS	27000	18000	21000	13000	5000	2000	0	0	0	0
STATLANT 21	27651	15191	17642	13431	5374	1976	0	0	0	0[1]
SC Recommended Catches	45000	48000	48000	17000–32000	18000–27000	ndf	ndf	ndf	ndf	ndf
Effort[2] (Agreed Days)	10555	10555	10555	10555	10555	5227	0	0	0	0

[1] To September 2014
[2] Effort regulated

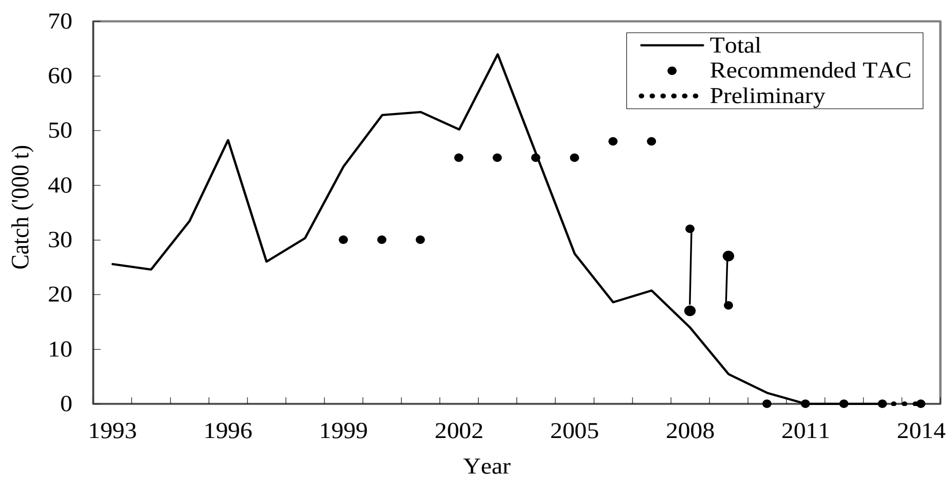


Fig. 1.1. Shrimp in Div. 3M: Catches (t) of shrimp on Flemish Cap and TACs recommended in the period 1993-2014. Due to a moratorium, the shrimp catch is expected to be zero in 2014.

b) Input Data

i) Commercial fishery data

Time series of size and sex composition data were available mainly from Iceland and Faroes between 1993 and 2005 and survey indices were available from EU research surveys (1988-2014). Because of the moratorium catch and effort data have not been available since 2010, and therefore the standardized CPUE series has not been extended.

ii) Research Survey Data

Stratified-random trawl surveys have been conducted on Flemish Cap by the EU in July from 1988 to 2014. A new vessel was introduced in 2003 which continued to use the same trawl employed since 1988. In addition, there were differences in cod-end mesh sizes utilized in the 1994 and 1998 surveys that have likely resulted in biased estimates of total survey biomass. Nevertheless, for this assessment, the series prior to 2003 were converted into comparable units with the new vessel using the methods accepted by STACFIS in 2004 (NAFO 2004 SC Rep., SCR Doc. 04/77). The female biomass index was stable at a high level from 1998 to 2007. After 2007 the survey biomass index declined and in 2014 although the shrimp biomass increased slightly (4%) over 2013, the estimated biomass (717 t.) remained among the lowest recorded in the historical series.

c) Assessment

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

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

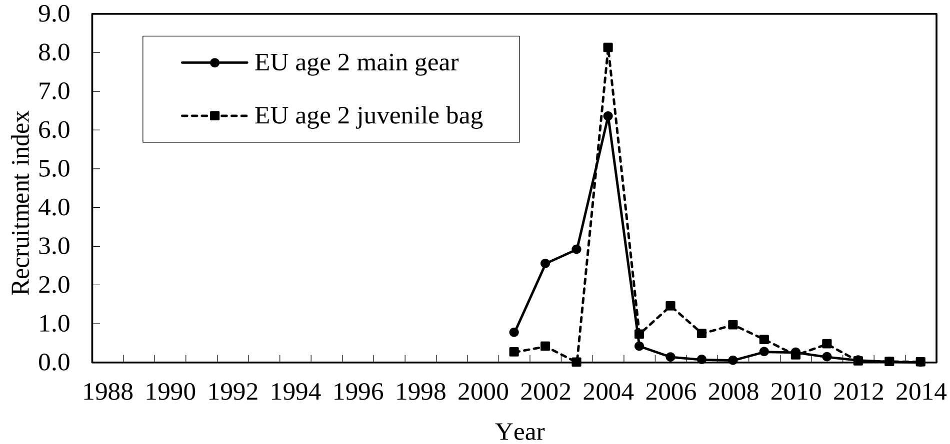


Fig. 1.2. Shrimp in Div. 3M: Abundance indices at age 2 from the EU survey. Each series was standardized to its mean.

SSB: The survey female biomass index was at a high level from 1998 to 2007, and has declined to second lowest level in 2014, well below B_{lim}.

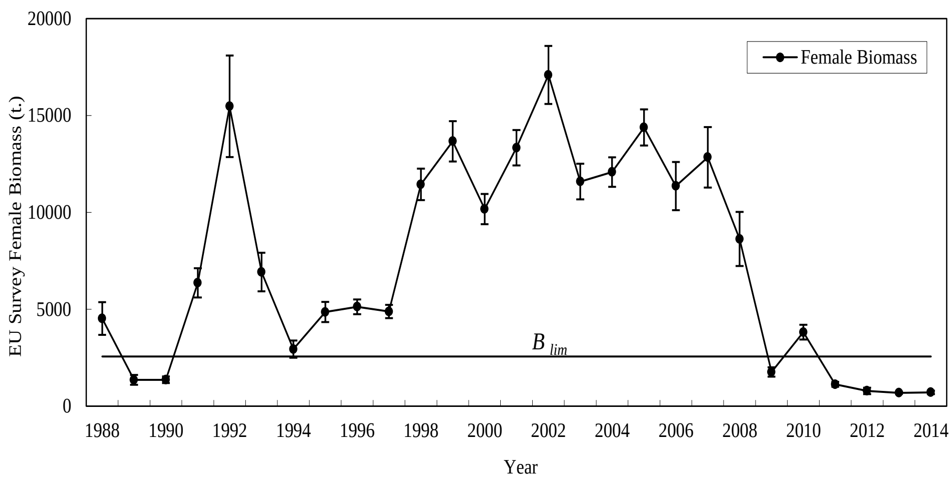


Fig. 1.3. Shrimp in Div. 3M: Female biomass index from EU trawl surveys, 1988-2014. Error bars are 1 std. err.

Exploitation rate: Because of low catches, followed by the moratorium, the exploitation rate index (nominal catch divided by the EU survey biomass index of the same year) has declined to near zero.

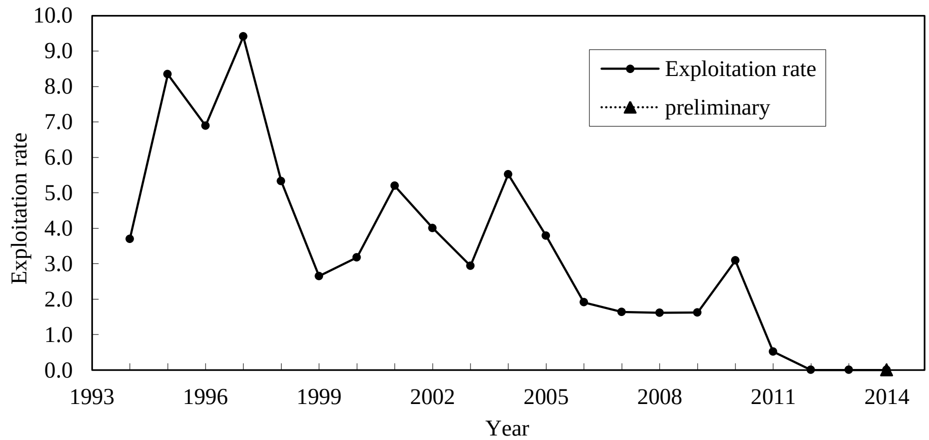


Fig. 1.4. Shrimp in Div. 3M exploitation rate index as derived by catch divided by the EU survey biomass index of the same year.

d) State of the Stock

Following several years of low recruitment, the spawning stock has declined, and has remained below B_{lim} since 2011. Due to continued poor recruitment there are concerns that the stock will remain at low levels.

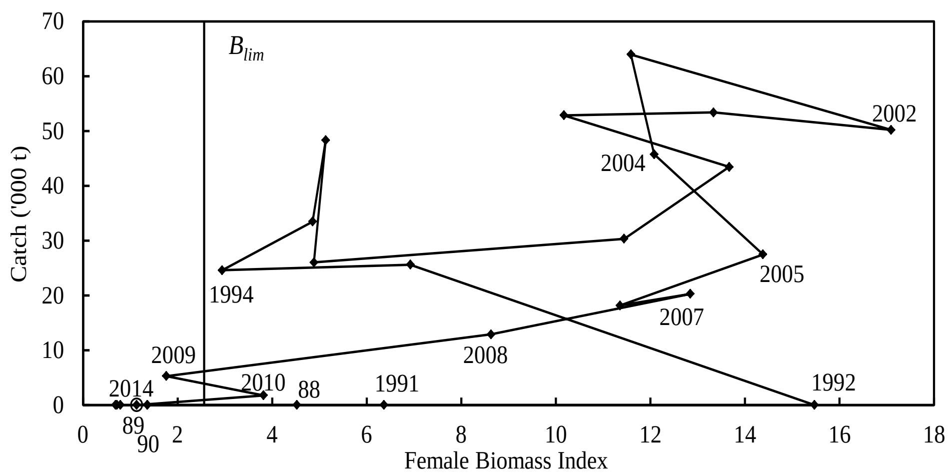


Fig. 1.5. Shrimp in Div. 3M: Catch plotted against female biomass index from EU survey. Line denoting B_{lim} is drawn where biomass is 15% of the maximum point in 2002. Due to the moratorium on shrimp fishing the expected catch in 2014 is 0 t.

e) Reference Points

Scientific Council considers that a female survey biomass index of 15% of its maximum observed level provides a proxy for B_{lim}. This corresponds to an index value of 2 564. The index has been below B_{lim} since 2010. A limit reference point for fishing mortality has not been defined.

f) Ecosystem considerations

The drastic decline of shrimp biomass since 2007 correlates with the increase of the cod stock in Div. 3M. It is uncertain whether this represents a causal relationship and/or covariance as the result of an environmental factor.

The environment, trophic interactions, and fisheries are important drivers of fish stock dynamics. Analyses of fish stomachs over 1990 to 2012 show an increasing proportion of shrimp in the diets of most fish species. Since the early 2000s, there has been an increase of redfish in the diet of large individuals of predatory species. These trends are observed throughout the Flemish Cap fish community.

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

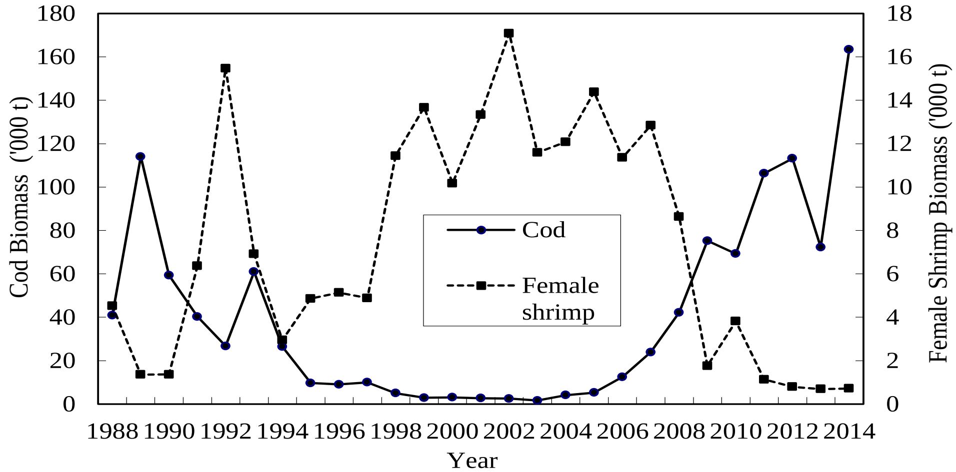


Fig. 1.6. Shrimp in Div. 3M: Cod and total shrimp biomass from EU trawl surveys, 1988-2014.

g) Research Recommendations

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

STATUS: No progress. This recommendation is reiterated.

2. Northern Shrimp (*Pandalus borealis*) in Div. 3LNO

(SCR Doc. 14/047, 048)

Environmental Overview

Recent Conditions in Ocean Climate and Lower Trophic Levels

●Ocean climate composite index on SA3 - Grand Bank continues to remain well above normal in 2013 and recent years.

●The composite spring bloom index declined in 2012-2013 after several years of relatively high positive anomalies.

●The composite zooplankton index has remained above normal since 2009 and reached a peak in 2013.

●The composite trophic index has remained near normal in recent years and increased to its highest level in the time series in 2013.

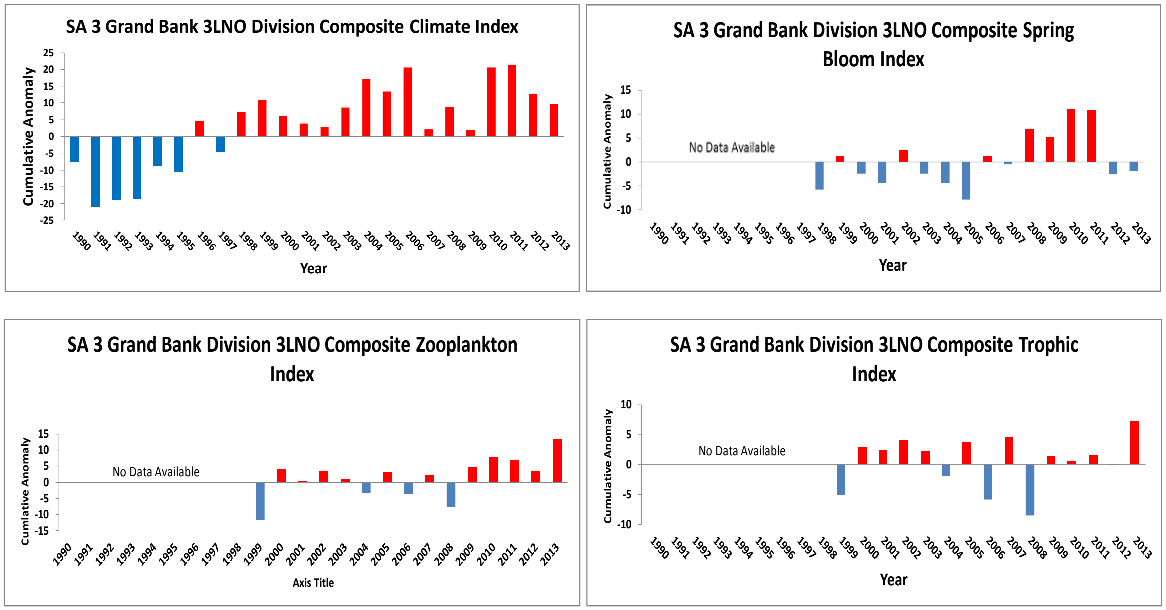


Fig. 2. Composite ocean climate index for NAFO Subarea 3 (SA3 Div. 3LNO) derived by summing the standardized anomalies (top left panel) during 1990-2013, composite spring bloom (summed background chlorophyll *a*, magnitude and amplitude indices) index (Div. 3LNO) during 1998-2013 (bottom left panel), composite zooplankton (cumulative anomalies of the four functional plankton taxa) index during 1999-2013 (top right panel), and composite trophic (summed anomalies of nutrient and standing stocks of phyto- and zooplankton indices) index (bottom right panel) during 1999-2013. Note the 2012 value for the composite trophic index is near zero and is not readily visible on the plot. Red bars are positive anomalies indicating above average levels while blue bars are negative anomalies indicating below average values.

The water mass characteristic of the Grand Bank are typical Cold-Intermediate-Layer (CIL) sub-polar waters which extend to the bottom in northern areas with average bottom temperatures generally <0°C during spring and through to autumn. The winter-formed CIL water mass is a reliable index of ocean climate conditions in this area. Bottom temperatures increase to 1-4°C in southern regions of Div. 3NO due to atmospheric forcing and along the slopes of the banks below 200 m depth due to the presence of Labrador Slope Water. On the southern slopes of the Grand Bank in Div. 3O bottom temperatures may reach 4-8°C due to the influence of warm slope water from the south. The general circulation in this region consists of the relatively strong offshore Labrador Current at the shelf break and a considerably weaker branch near the coast in the Avalon Channel. Currents over the banks are very weak and the variability often exceeds the mean flow.

Ocean Climate and Ecosystem Indicators

The composite climate index in Subarea 3 (Div. 3LNO) continues to remain above normal in 2013 but has declined in a pattern similar to Div. 3M in recent years (Fig. 2). Standing stocks of phytoplankton based on the composite spring bloom index has remained below average in 2013 consistent with levels observed in 2012 (Fig. 2). Standing stocks of zooplankton based on the composite zooplankton index peaked in 2013 and has remained well above normal in the past several years (Fig. 2). The composite trophic index also peaked in 2013 after several years of near-normal levels (Fig. 2).

The annual surface temperatures at Station 27 in Div. 3L continue to remain above normal (~1°C) in 2013. Bottom temperatures at Station 27 remained stable at levels observed in 2012. Vertically averaged temperatures were relatively stable at +1.1 SD from 2012. Surface salinities at Station 27 were near the long temp mean in 2013 while bottom salinities decreased below normal. The vertical thickness of the layer of cold <0°C water (commonly referred as the cold-intermediate-layer or CIL on the shelf) increased to the mean of the time series in 2013. Spring bottom temperatures in NAFO Div. 3LNO during 2013 were above normal and slightly less warm than the conditions of

2012. During the autumn, bottom temperatures in Div. 3LNO decreased and were near the long term mean of the time-series.

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 4 300 t in 2014 (Fig. 2.1).

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

	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
TAC[1]	14056	23784	23784	26718	32438	30396	20557	12975	9297	4300
STATLANT 21	13574	21284	21140	24855	25609	17575	12598	9994	8197	
NIPAG[2]	14775	25689	23570	25407	25900	20536	12900	10108	8647	1688[3]

[1] Includes autonomous TAC as set by Denmark.
[2] NIPAG catch estimates have been updated using various data sources (see p. 13, SCR. 14/048).
[3] Provisional catches up to August 25, 2014

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 August 25, 2014, the small- and large-vessel fleets had taken 1 594 t and 87 t of shrimp respectively in Div. 3L.. The annual quota within the NAFO Regulatory Area (NRA) is 17% of the total TAC. 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), 334 t (2009), 334 t (2010), 214 (2011), 133 (2012), 96 (2013), or 48 t (2014) and set their own TACs of 1 344 t (2003–2005), 2 274 t (2006–2008), 3 106 t (2009), 1064 t (2010), 1 985 t (2011), 1 241 t (2012) and 889 t (2013). The TAC includes the autonomous quotas set by Denmark with respect to Faroes and Greenland.

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.

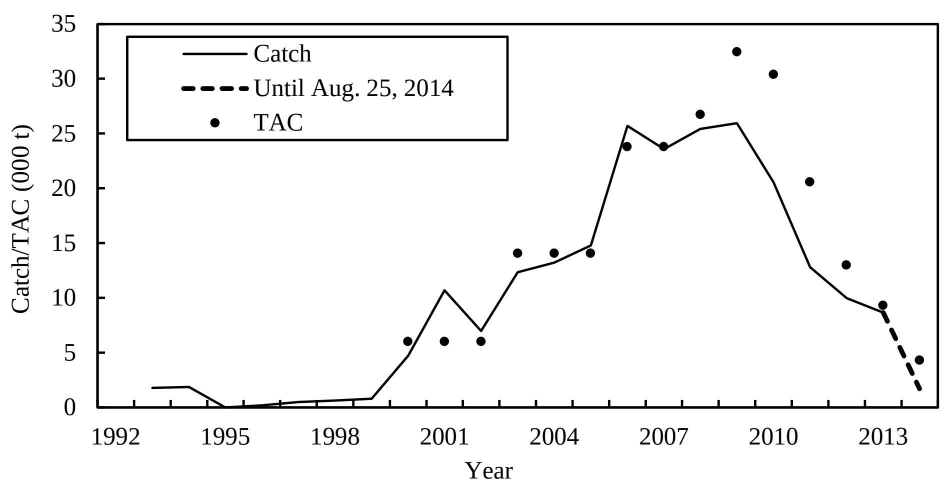


Fig. 2.1. Shrimp in Div. 3LNO: Catches (to August 25th 2014) and TAC. The TAC includes the autonomous quotas set by Denmark with respect to Faroes and Greenland.

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 has been updated for these analyses. CPUE models were standardized to 2001. The 2010 - 14 indices 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). CPUE, while reflecting fishery performance, is not effectively indicating the status of the resource. The trends of these CPUE indices show conflicting patterns with the survey biomass indices and were therefore not used as indicators of stock biomass.

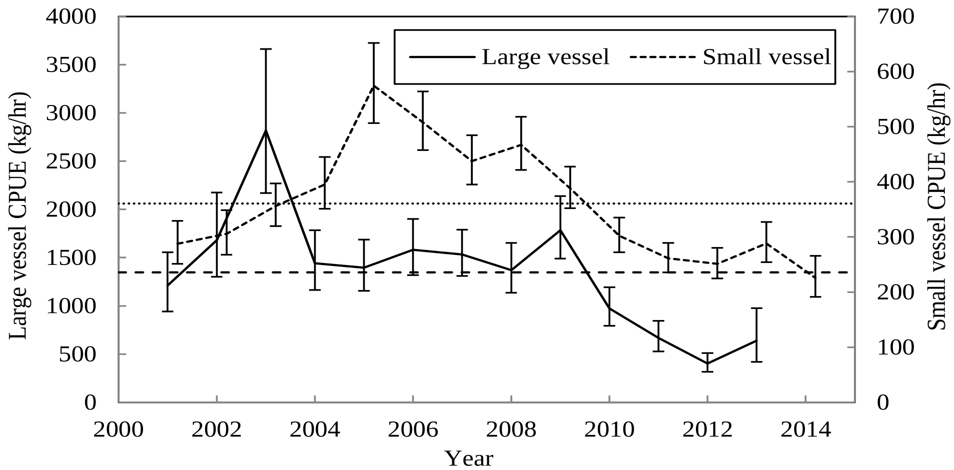


Fig. 2.2. Shrimp in Div. 3LNO: Standardized CPUE for the Canadian large-vessel (>500 t) and small-vessel (≤500 t; LOA<65') fleets fishing shrimp in Div. 3L within the Canadian EEZ.

Logbook data from Spain and Estonia, were available for the shrimp fishery within the NRA in 2014. The data was insufficient to produce a standardized CPUE model.

Catch composition. Length compositions were derived from Canadian (2003–2012) and Estonian (2010–2014) observer datasets. 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 (1999–2014) and autumn (1996–2013). 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 stratified-random survey in the NRA part of Div. 3L since 2003. Data is collected with a Campelen 1800 trawl. There was no Spanish survey in 2005.

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 both the spring and autumn indices to 2007 after which they decreased by over 90% to 2013. However, there was a slight increase during spring 2014 (Fig. 2.3). Confidence intervals from the spring surveys are usually broader than from the autumn surveys.

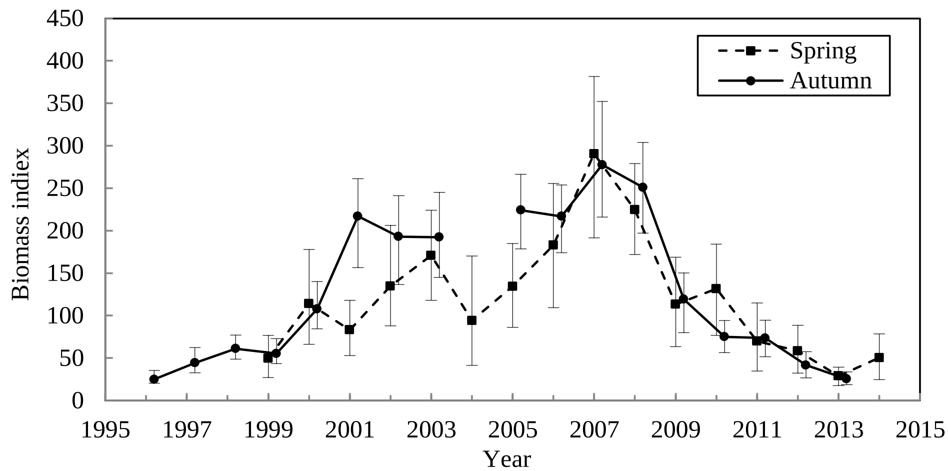


Fig. 2.3. Shrimp in Div. 3LNO: Total biomass index estimates from Canadian spring and autumn multi-species surveys (with 95% confidence intervals).

Spanish survey biomass indices for Div. 3LNO, within the NRA only, increased from 2003 to 2008 followed by a 93% decrease by 2012 remaining near that level in 2014 (Fig. 2.4).

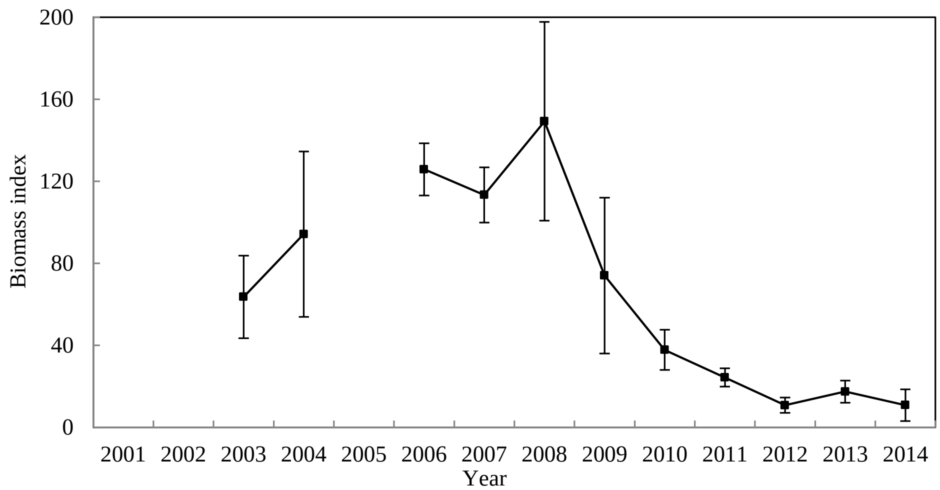


Fig. 2.4. Shrimp in Div. 3LNO: biomass index estimates from EU - Spanish multi-species surveys (± 1 s.e.) in the NRA of Div. 3LNO.

Female Biomass (SSB) indices. The autumn Div. 3LNO female SSB index showed an increasing trend to 2007 but decreased 91% by 2013. The spring SSB index decreased by 91% between 2007 and 2014 (Fig. 2.5).

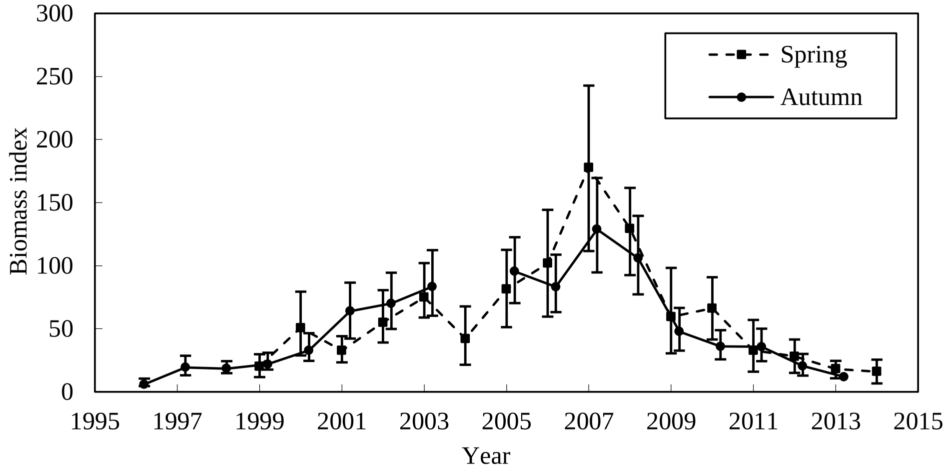


Fig. 2.5. Shrimp in Div. 3LNO: Female SSB indices from Canadian spring and autumn multi-species surveys (with 95% confidence intervals).

Stock Composition.

Both males and females showed a broad distribution of lengths in recent surveys indicating the presence of more than one year class (Fig. 2.6).

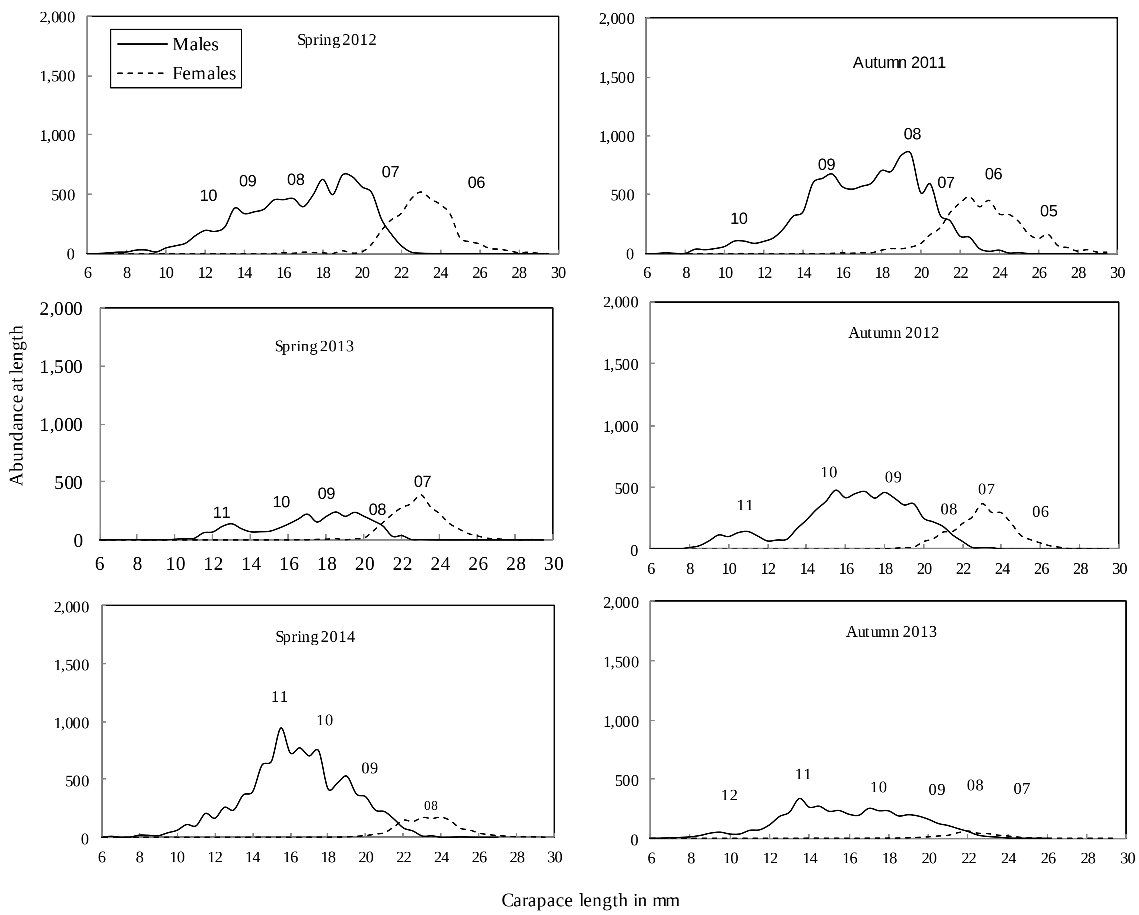


Fig. 2.6. Shrimp in Div. 3LNO: abundance at length estimated from Canadian multi-species survey data. Numbers within charts denote estimated modal length of each year-class.

Recruitment indices. The recruitment indices were based upon abundances of all shrimp with carapace lengths of 11.5 – 17 mm from Canadian survey data. These animals are thought to be one year away from the fishery. The 2006 – 2008 recruitment indices were among the highest in both spring and autumn time series. Both indices decreased through to autumn 2013. The index increased slightly in spring 2014, with a high degree of uncertainty (Fig. 2.7).

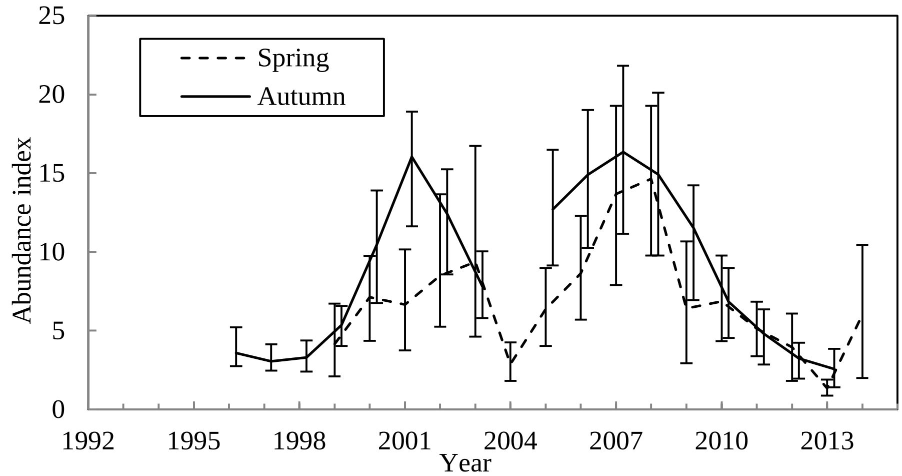


Fig. 2.7. Shrimp in Div. 3LNO: Recruitment indices derived from abundances of all shrimp with 11.5-17 mm carapace lengths from Canadian spring and autumn bottom trawl survey (1996-2014) data. Error bars represent 95% confidence intervals.

Fishable biomass and exploitation index. The autumn fishable biomass (shrimp >17mm CL) showed an increasing trend until 2007 then decreased by 92% through to 2013. Similarly, the spring fishable biomass index increased to 2007 but has since decreased by 91 % through to 2013 followed by a slight increase during 2014 (Fig. 2.8).

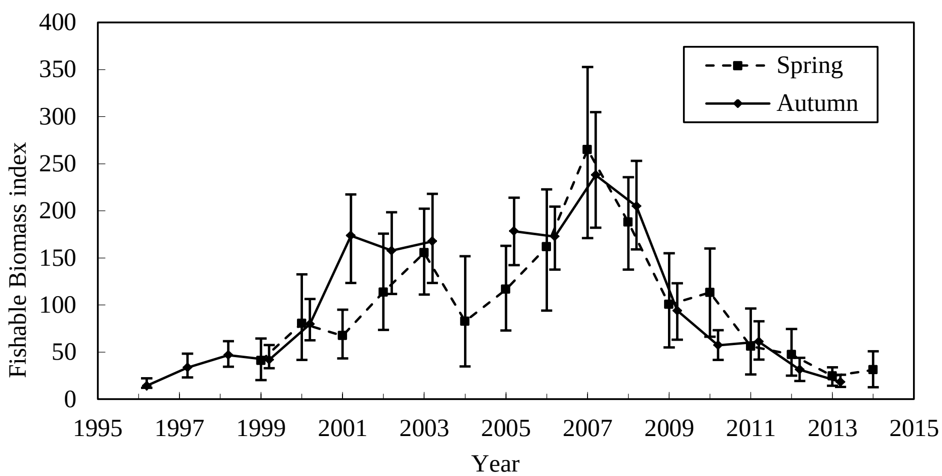


Fig. 2.8. Shrimp in Div. 3LNO: fishable (shrimp >17mm CL) biomass index. Bars indicate 95% confidence limits.

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 exploitation index has been generally increasing throughout the course of the fishery (Fig. 2.9). The exploitation rate for 2014 assumes the entire TAC is taken.

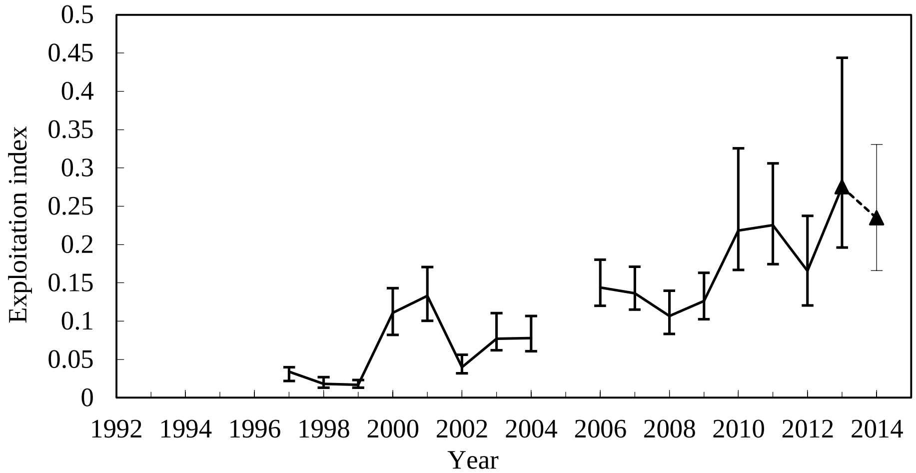


Fig. 2.9. Shrimp in Div. 3LNO: exploitation rates calculated as year's catch divided by the previous year's autumn fishable biomass index. Bars indicate 95% confidence limits.

c) Assessment Results

Recruitment. Recruitment indices have decreased since 2008 and are now among the lowest observed values.

Biomass. Spring and autumn biomass indices have decreased considerably since 2007.

Exploitation. The index of exploitation generally increased over the 1997 – 2014 period.

State of the Stock. The stock has declined since 2007, and in 2013 the risk of being below B_{lim} is greater than 95%.

Given expectations of poor recruitment and relatively high fishing mortality, the stock is not predicted to increase in the near future.

d) Precautionary Reference Points

The point at which a valid index of stock size has declined to 15% of its highest observed value is considered to be B_{lim} (SCS Doc. 04/12). The 2013 autumn female biomass index was 11 780 t, and in 2013 the risk of being below B_{lim} is greater than 95% (Fig 2.10). A limit reference point for fishing mortality has not been defined.

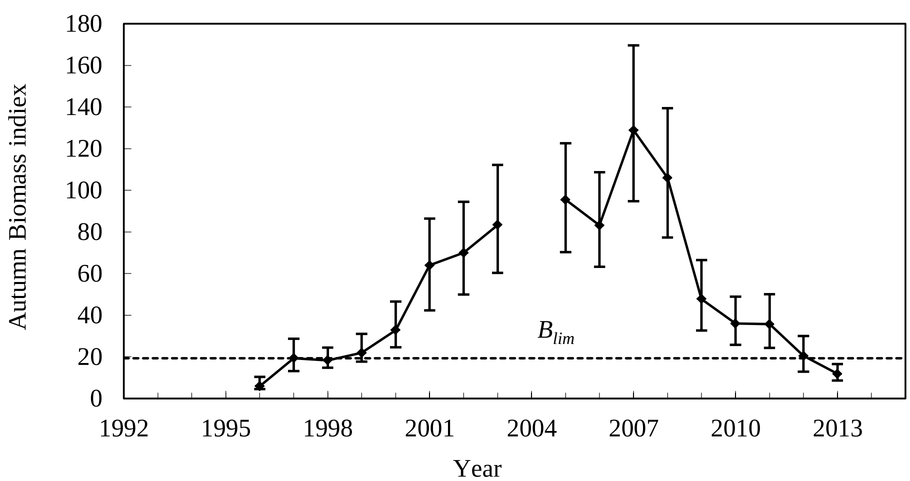


Fig. 2.10. Shrimp in Div. 3LNO: autumn female spawning stock biomass (SSB) and precautionary approach B_{lim}. B_{lim} is defined as 15% of the maximum autumn female biomass over the time series. Bars indicate 95% confidence limits.

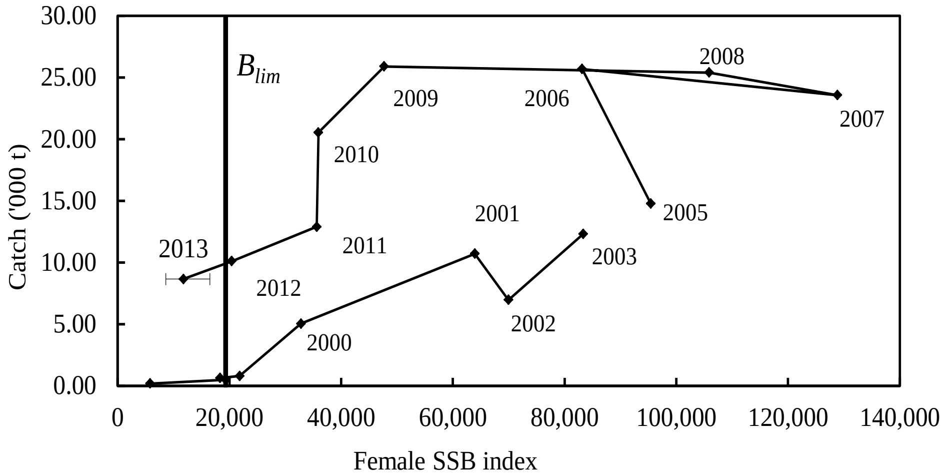


Fig. 2.11. Shrimp in Div. 3LNO: Catch against female SSB index from Canadian autumn survey. Line denoting B_{lim} (approximately 19 300) is drawn where female biomass index is 15% of the maximum estimate over the time series.

e) Other Studies

i) Female instantaneous mortality rate (Z).

SCR Doc. 14/048

The female mortality rate (*Z*) was determined from the spring survey dataset and compared with the ratio of catch to biomass (*F*). *F* increased after 2008, but *Z* appears to have remained stable (Fig 2.12). It is unknown at this point what the relative contributions of *F* and *M* are to *Z*, but there is no indication of increased natural mortality.

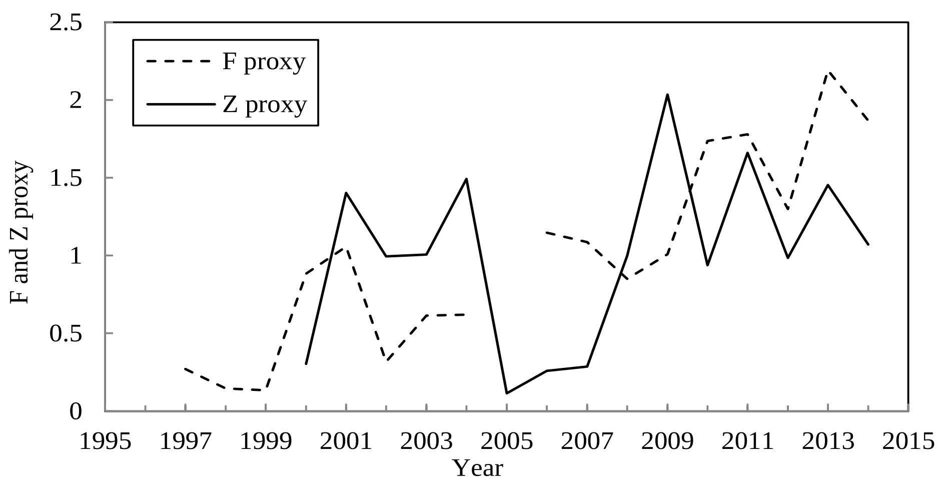


Fig. 2.12. Shrimp in Div. 3LNO: A comparison between exploitation rates (*F*) and the female instantaneous mortality rates (*Z*).

3. Northern shrimp (Subareas 0 and 1)

(SCR Docs 04/75, 76, 08/6, 11/53, 58, 12/44, 13/54, 14/52, 58, 59, 61, 62, 67; 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 licences were originally given only to vessels under 80 tons, but in recent years larger vessels have entered the coastal fishery. Greenland allocates a quota to EU vessels in Subarea 1; this quota is usually fished by a single vessel which, for analyses, is treated as part of the Greenland offshore fleet. Mesh size is at least 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 TAC advised for 2012 was 90 000t. For 2012, Greenland enacted a TAC of 101 675 t for Subarea 1; Canada enacted a TAC of 16 921 t for SFA 1. Further deterioration of the assessed status of the stock in 2012 induced yet lower advised TACs of 80 000 t for 2013 and 2014. In 2014 Greenland enacted a TAC of 82 807 t with quotas of 3400, 45 262 and 34 145 t, and Canada a TAC of 11 333 t.

Greenland requires that logbooks should record catch live weight. For shrimps sold to on-shore processing plants, a former allowance for crushed and broken shrimps in reckoning quota draw-downs was abolished in 2011 to bring the total catch live weight into closer agreement with the enacted TAC. However, in previous years, the coastal fleet catching bulk shrimps did not log catch weights of *P. montagui* separately from *borealis;* weights were estimated by catch sampling at the point of sale and the price adjusted accordingly, but the weight of *montagui* was not deducted from the quota (SCR Doc. 11/53). Logbook-recorded catches could therefore still legally exceed quotas. Since 2012 *P. montagui* has been included among the species protected by a 'moving rule' to limit bycatch and there are no licences issued for directed fishing on it (SCR Doc. 14/61). Instructions for reporting *montagui* in logbooks were changed in 2012, to improve the reporting of these catches.

The table of recent catches was updated (SCR Doc. 14/45). 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 95 380 t in 2013 and 90 000 t (projected) in 2014.

Recent catches, projected catches for 2014 and recommended and enacted TACs (t) for Northern Shrimp in Div. 0A east of 60°30'W and in Subarea 1 are as follows:

	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
TAC										
Advised	130 000	130 000	130 000	110 000	110 000	110 000	120 000	90 000	80 000	80 000
Enacted[3]	152 452	152 380	152 417	145 717	132 987	132 987	142 597	118 596	102 767	94 140
Catches (NIPAG)										
SA 1	149 978	153 188	142 245	153 889	135 029	128 108	122 655	115 963	95 379	*90 000*[1]
Div. 0A (SFA 1)	6921	4127	1945	0	429	5882	1 330	12	2	0
TOTAL SA 1–Div. 0A	156 899	157 315	144 190	153 889	135 458	133 990	123 985	115 975	95 380	*90 000*[1]
STATLANT 21										
SA 1	149 978	153 188	142 245	148 550	133 561	123 973	122 061	114 958	91 800[2]	
Div. 0A	6410	3788	1878	0	429	5206	1134	12	2[2]	

1 Total catches for the year as predicted by industry observers.
2 Provisional
3 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. 14/61).

In 2002–2005 the Canadian catch in SFA1 was stable at 6000 to 7000 t - about 4–5% of the total - but since 2007 fishing effort has been sporadic and catches variable, averaging about 1260 t in 2007–13 (SCR Doc. 14/46).

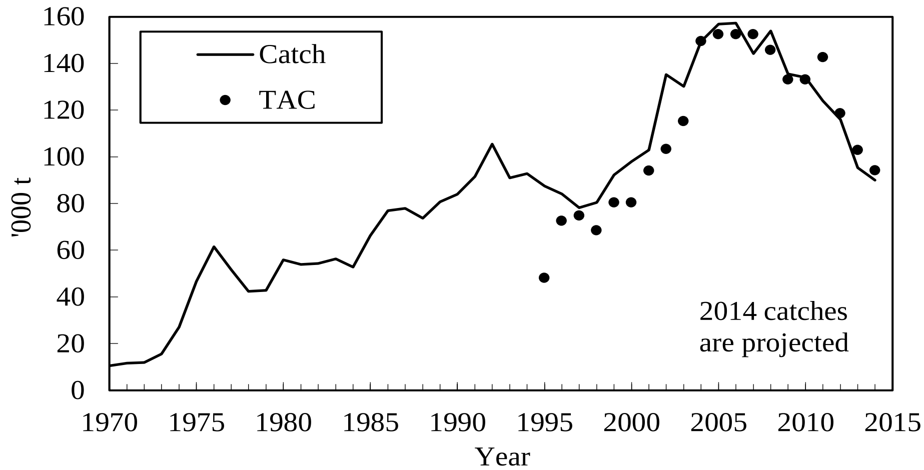


Fig. 3.1. Northern shrimp in Subarea 1 and Canadian SFA1: enacted TACs and total catches (2014 predicted for the year).

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. 14/45). 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 between the two fleets 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, 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. In 2013 for the first time catch and effort data for statistical area 0, which extends north to 74°N, comprises 82 300 sq. km. and in 2005–12 yielded 16% of the offshore catch, was included in the CPUE analyses. A series for 1976–1990 was constructed for the KGH (Kongelige Grønlandske Handel) fleet of sister trawlers and a series for 1989–96, 1998–2007 and 2010–11 for the Canadian fleet fishing in SFA1 (Fig. 3.2). The standardised CPUE estimate for the Canadian fleet in 2011 was anomalously low; close examination of the data confirmed that there had been low catch rates and little fishing. This value has little influence on the unified series.

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 peak in 2008 at over twice its 1997 value (Fig. 3.2). Values for 2009 to 2014 have been lower but remain relatively high (SCR Doc. 14/61).

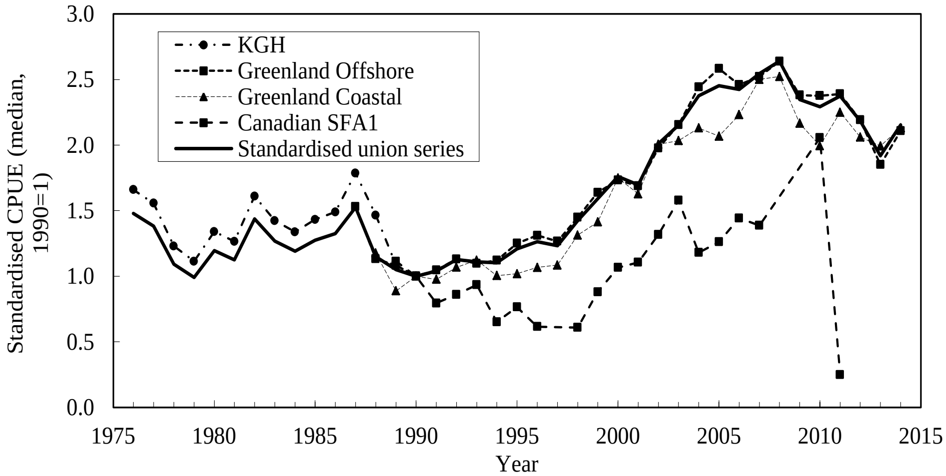


Fig. 3.2. Northern shrimp in Subarea 1 and Canadian SFA1: standardised CPUE index series 1976-2014.

The distribution of catch and effort among statistical areas was summarised using Simpson's diversity index to calculate an 'effective' number of statistical areas being fished as an index of how widely the fishery is distributed (Fig 3.3). The fishery area has contracted; 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 years biomass might be overestimated by recent CPUE values.

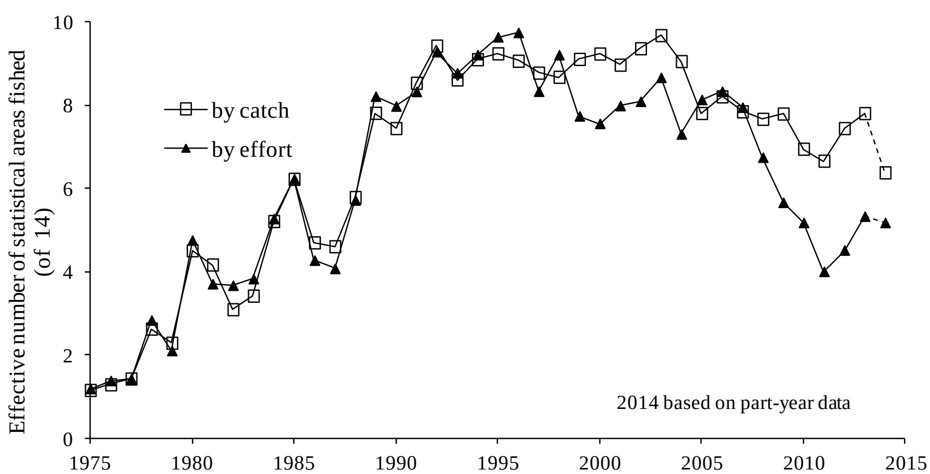


Fig. 3.3. Northern shrimp in Subarea 1 and Canadian SFA1: indices for the distribution of the Greenland fishery between statistical areas in 1975–2014.

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 statistical areas being fished in SA 1 reached a plateau in 1992–2003. The range of the fishery has since contracted northwards and the effective number of statistical areas being fished has decreased.

Catch composition. There is no biological sampling programme 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.

14/52). 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 1997–2014 (SCR Doc. 14/52). About 80% of the survey biomass estimate is in water 200–400 m deep. In the early 1990s, about ¾ of this 80% 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. 14/52). The proportion of survey biomass in Div. 1E–F has been low in recent years and the distribution of survey biomass, like that of the fishery, has become more northerly.

Biomass. The survey index of total biomass remained fairly stable from 1988 to 1997 (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); this decline has been continued in subsequent years, reaching in 2014 the second lowest level in the last 20 years (SCR Doc. 14/52). For the first time, the offshore survey biomass has gone below that in Disko Bay and Vaigat (Fig. 3.4). This inshore area composes only 7% of the survey area and so there is a large difference in mean density (Fig. 3.4).

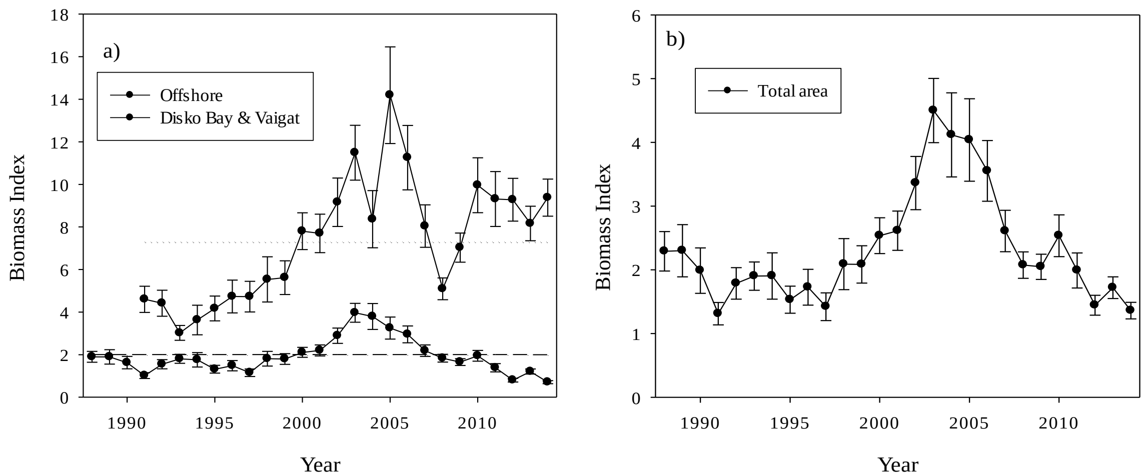


Fig. 3.4. Northern Shrimp in Subarea 1 and Canadian SFA 1: survey mean catch rates inshore and offshore (panel a) and overall (panel b) 1988–2014 (error bars 1 s.e.).

Length and sex composition (SCR Doc. 14/52).

In 2012 overall the fishable biomass at 91.1% of total was a little below its 20-year median, but included an exceptionally high proportion of females. Pre-recruits (14–16.5 mm) have been few since 2008 in absolute numbers. In 2013 the fishable biomass was estimated to have increased by one-third, but this seemed entirely due to increases in number and biomass of females, which composed an exceptionally high proportion of the stock (SCR Doc. 14/52). This size distribution continues in 2014: females still compose a high proportion of both the fishable and total biomass, while both fishable males and unrecruited males at 14–16.5 mm remain low in absolute numbers and as a proportion of the stock.

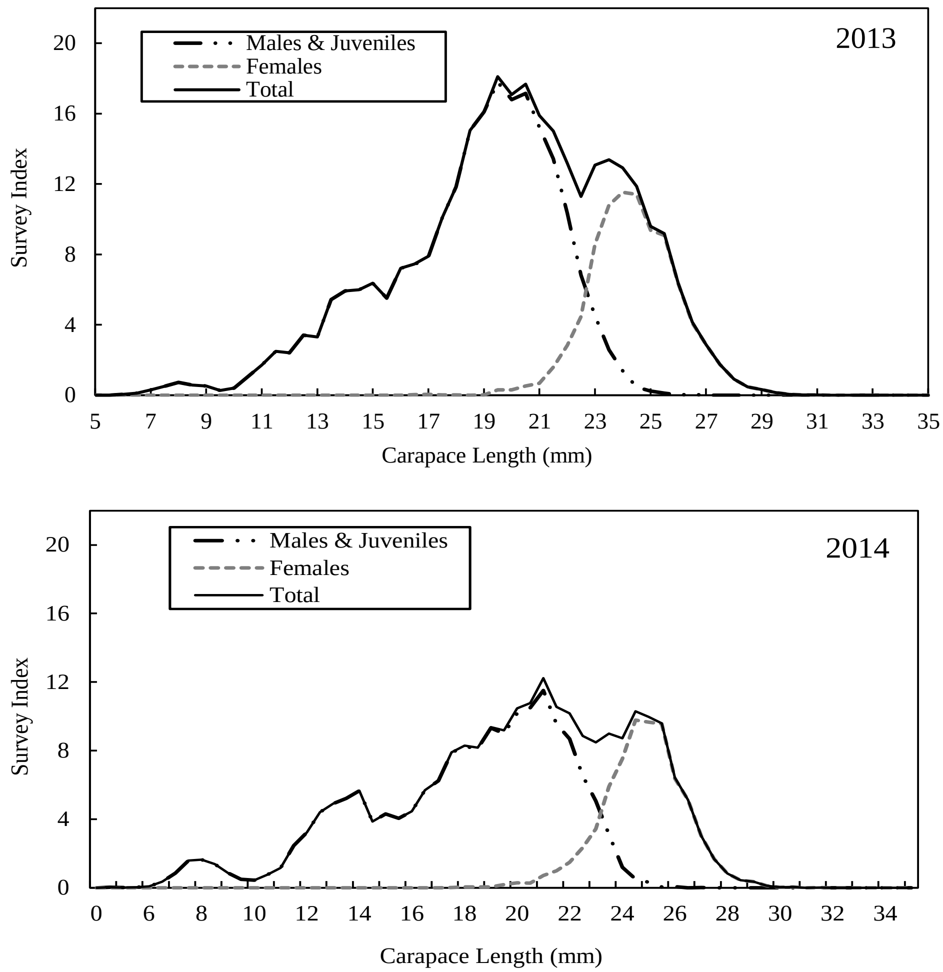


Fig. 3.5. Northern Shrimp in Subarea 1 and Canadian SFA 1: survey mean catch rates at length in the West Greenland trawl survey in 2013–2014.

Recruitment Index. In 2014 numbers at age 2 were estimated by fitting Normally distributed components to the length distribution, but only as far as 19 mm CPL. In other words, two components, considered age-1 and age-2, were fully fitted, and a third component was fitted only on its left-hand limb (SCR Doc. 14/58). Components were required to have equal CVs of CPL. This method was used to revise numbers at age 2 back to 2005.

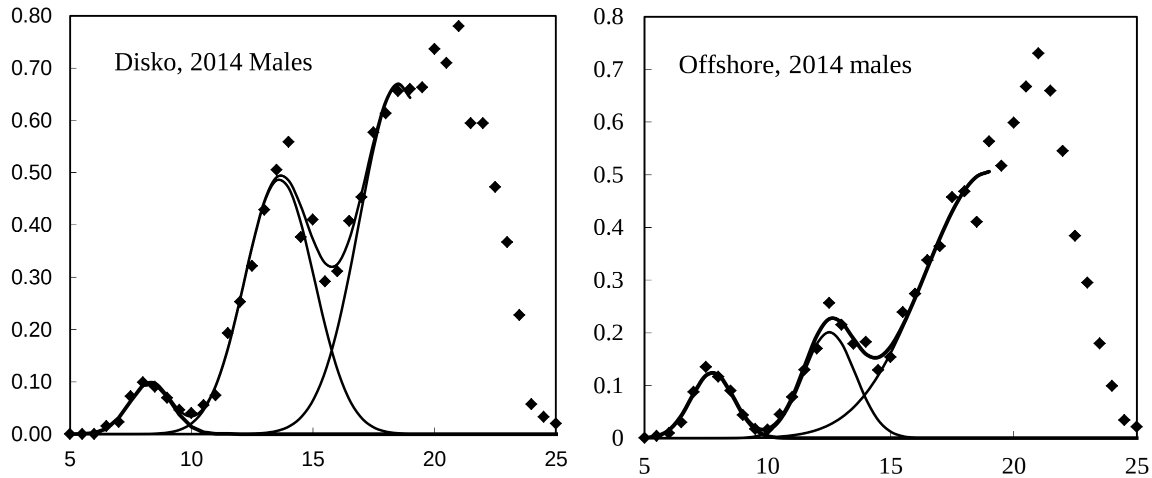


Figure 3.6: Examples of estimating numbers at age by fitting Normally distributed components, two full and one partial, with equal CVs, to the length distribution of males.

Numbers at age 2 have been low since 2010, but in 2013 and 2014 have been higher, although still below the 20-year median. The changes in 2013 and 2014 are mostly attributable to survey results in the inshore area.

Proportions, and numbers, of both unrecruited males and fishable males remain low, especially offshore, presaging poor recruitment to the fishable biomass and to the spawning stock next year.

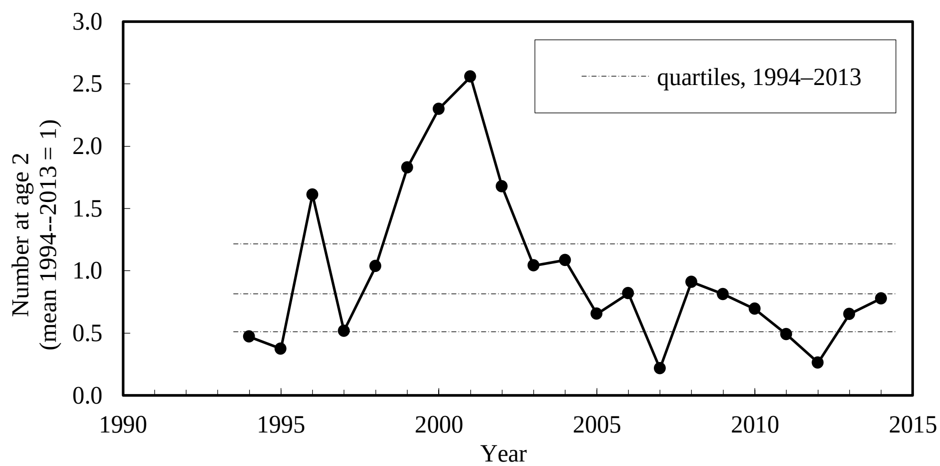


Fig. 3.7. Northern Shrimp in Subarea 1 and Canadian SFA 1: survey index of numbers at age 2, 1994-2014.

iii) Predation index

Series of estimates of cod biomass in West Greenland waters are available for different periods from VPA, from the German groundfish survey at West Greenland and from the Greenland trawl survey for shrimps. The results from the German survey for the current year are not available in time for the assessment. Heretofore the estimate from the German survey has been used as the main estimate, the Greenland trawl survey value, adjusted, being used only for the current year.

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. 14/59).

The model includes a term for predation by Atlantic cod. In 2014 the full Greenland trawl survey was combined with the German survey within the assessment model, the two always having been well correlated, to produce an overall cod-stock biomass estimate series. The estimate for the current year depends only on the (scaled) Greenland survey value, the German survey being late in the year. The methods used in the German survey have recently been reviewed and revised; past estimates were little changed. The index of cod biomass is adjusted by a measure of the overlap between the stocks of cod and shrimps in order to arrive at an index of ‘effective’ cod biomass, which is used in the assessment model to estimate predation.

Total catches for 2014 were projected at 90 000 t. The assessment model had been modified in 2012 to include the uncertainty of projecting the current year’s catches. 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 (SCR Doc. 11/58). Stability of the assessment was checked by looking at changes, due to the addition of subsequent years’ data, in year-end stock status estimates. Though slight changes occurred, they were commensurate with fluctuations in biomass indices and did not trend either up or down.

The modelled biomass was low and stable until the late 1990s, when it started a rapid increase. Biomass doubled by about 2004; the survey index increased much more than the fishery CPUE. Since 2004 the modelled biomass has steadily declined to reach in 2014 a level similar to that of the late 1990s, close to B_{msy}. The survey index has declined to 31% of its peak, but the fishery CPUE, although slowly decreasing since 2008, is still relatively high.

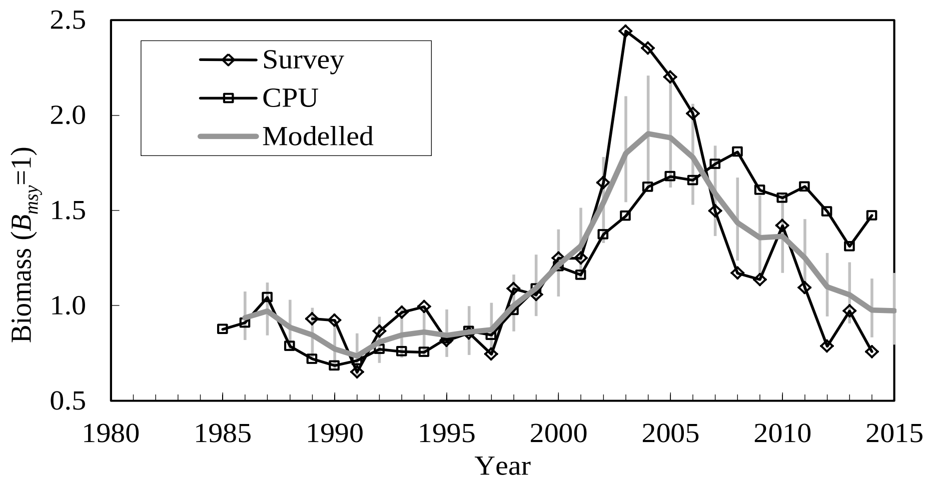


Fig. 3.8.a: Northern Shrimp in SA 1 and Canadian SFA1: trajectory of the median estimate of relative stock biomass at start of year 1986–2015, with median CPUE and survey indices; 30 years’ data with constrained CVs.

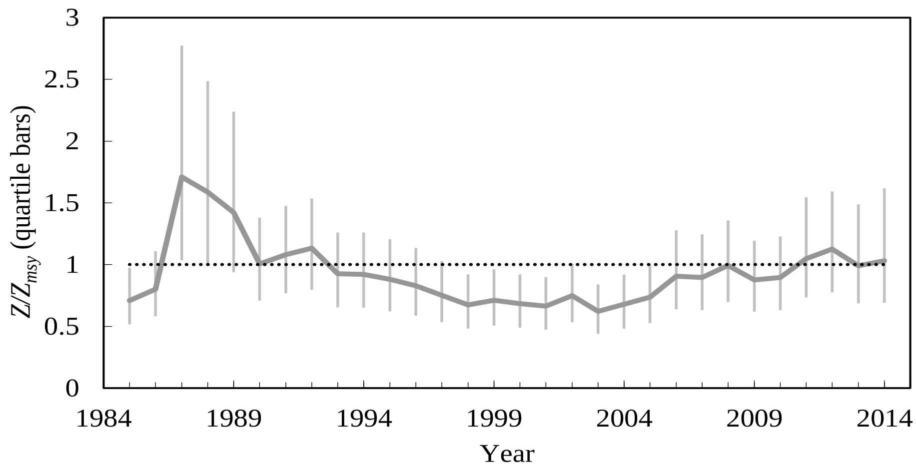


Fig 3.8.b: Northern Shrimp in SA 1 and Canadian SFA1: trajectory of the median modelled estimate of mortality relative to Z_{msy} during the year, 1985–2014, with quartile bars.

Mortality has generally been below Z_{msy} during the modelled period, although a short-lived episode of high cod biomass occasioned three years of high values in the late 1980s (Fig. 3.7). From 1998 to 2005 total mortality was noticeably low — in 1998–2001 because catches were still below 100 Kt while the stock had started to increase, in 2002–05 because the stock biomass increased, to high levels, much faster than catches. After 2005 increasing cod biomass, decreasing shrimp stock biomass, and persistent high catches have resulted in higher mortalities, exceeding Z_{msy} in recent years.

Estimates of stock-dynamic and fit parameters from fitting a Schaefer stock-production model, to 30 years' data on the West Greenland stock of the Northern shrimp in 2014. Median values from the 2013 assessment are provided for comparison. In 2014, biomass is predicted to be close to B_{msy}, and mortality to slightly exceed Z_{msy}.

	2014 assessment						2013 assessment
	Mean	S.D.	25%	Median	75%	Est. Mode	Median
Max.sustainable yield (kt)	140.5	76.5	102.9	131.3	165.0	112.9	138.0
B/Bmsy, end current year (proj.) (%)	98.9	30.6	79.5	97.3	117.2	94.0	109.0
Biom. risk, end current yr (%)	53.7	49.9	–	–	–	–	–
Z/Zmsy, current year (proj.)(%)	–	–	69.2	103.1	161.8	–	93.0
Carrying capacity (kt)	4216	3710	2042	3126	5057	946	3162
Max. sustainable yield ratio (%)	9.8	6.1	5.1	9.0	13.5	7.6	9.3
Survey catchability (%)	17.4	12.6	8.3	14.1	23.1	7.5	14.0
CV of process (%)	12.4	2.9	10.4	12.1	14.1	11.4	11.6
CV of survey fit (%)	15.8	2.1	14.4	15.9	17.3	16.1	15.0
CV of CPUE fit (%)	19.4	2.9	17.4	19.0	20.9	18.1	17.4
CV of predation fit (%)	131.0	87.5	59.5	115.4	185.3	84.2	112.4

ii) Assessment Summary

Recruitment. Pre-recruits at CL 14–16.5 mm are few and have been so since 2008 in absolute terms, so short-term recruitment is expected to be low. The number at age 2 in 2014 is near its 20-year median.

Biomass. A stock-dynamic model showed a maximum biomass in 2004 with a continuing decline since. At the end of 2014, the stock will be at B_{msy}, with a risk of being below B_{lim} (30% of B_{msy}) of 2%.

Mortality. With 2014 catches projected at 90 000 t the risk that total mortality will exceed Z_{msy} is estimated at about 53%. Atlantic cod is, in 2014, still concentrated in southerly areas where shrimps are now scarce, but its biomass is high and predation pressure is expected to be similar to the previous 3 years.

State of the Stock. Biomass is estimated to have been declining since 2004, and at the end of 2014 is projected to be near B_{msy} with a risk of being below B_{lim} (30% of B_{msy}) of 1.6%. The risk that total mortality in 2014 will exceed Z_{msy} is estimated at 53%.

d) Precautionary Approach

B_{lim} has been established as 30% B_{msy}, and Z_{msy} (fishery and cod predation) has been set as the mortality reference point.

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 high proportions of 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. At the end of 2014, the stock will be at B_{msy}, with a risk of being below B_{lim} (30% of B_{msy}) of 2%. The risk that total mortality in 2014 will exceed Z_{msy} is estimated at 53%.

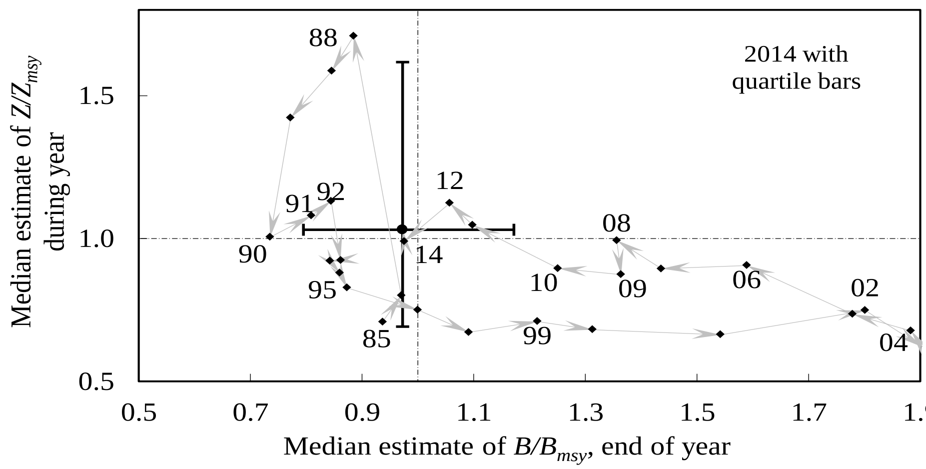


Fig. 3.9: Northern shrimp in Subarea 1 and Canadian SFA1: trajectory of relative biomass and relative mortality, 1985–2014.

e) Projections

Predicted probabilities of transgressing precautionary reference points in 2015 – 2017 under seven catch options and subject to predation by a cod stock with an effective biomass of 50 Kt (the value for 2014 being 44Kt.):

50 000 t cod		Catch option ('000 t)						
Risk (%) of transgressing:		50	55	60	65	70	80	90
B_{msy}, end	2015	50	51	51	52	52	53	54
	2016	47	47	48	49	49	52	53
	2017	45	46	47	48	49	52	54
B_{lim}, end	2015	3	3	3	3	3	3	3
	2016	3	4	4	4	4	4	4
	2017	5	5	5	5	5	5	6
Z_{msy} during	2015	27	30	32	36	39	47	53
	2016	28	30	33	37	40	47	54
	2017	28	31	34	37	41	47	55

In the medium term, model results estimate that catches up to 80 000 t/yr could be associated with a slowly increasing stock (Fig. 3.10). For larger catches estimates of biomass risk ($B<B_{msy}$) increase with projections into the future.

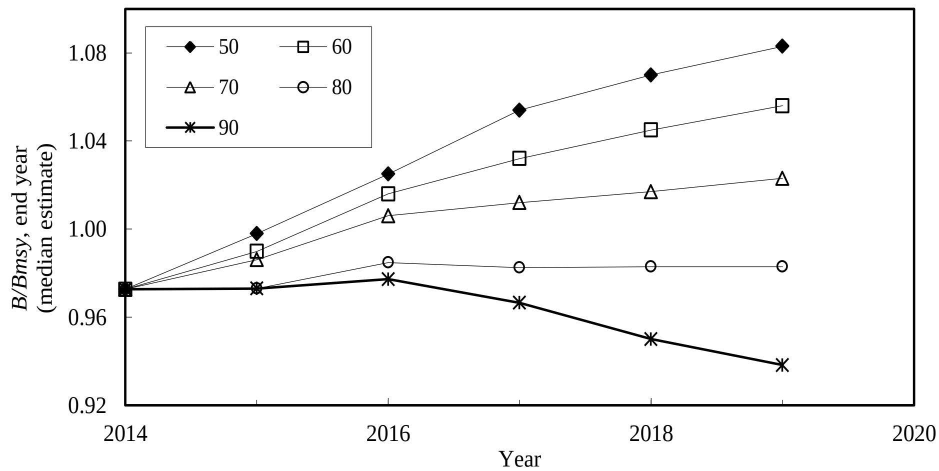


Fig. 3.10. Northern shrimp in Subarea 1 and Canadian SFA1: median estimates of biomass trajectory for 5 years with annual catches at 50–90 Kt and an 'effective' cod stock assumed at 50 Kt.

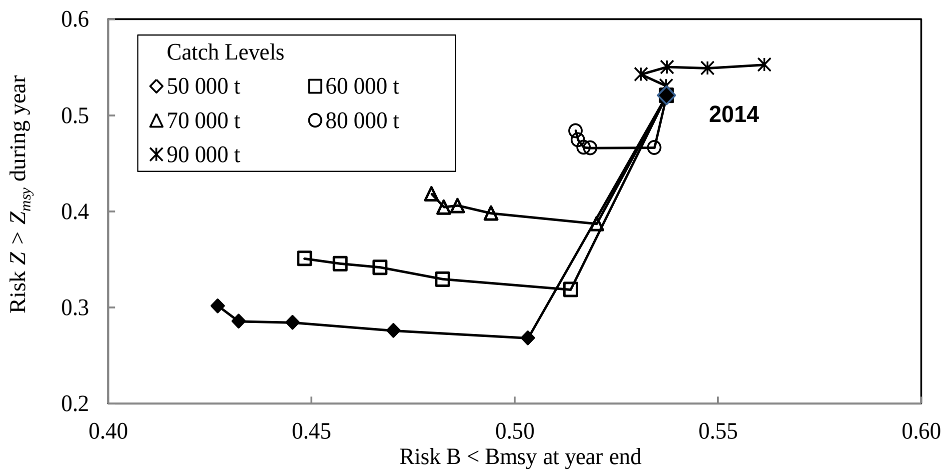


Fig. 3.11. Northern shrimp in Subarea 1 and Canadian SFA1: Risks of transgressing mortality and biomass precautionary limits with annual catches at 50–90 Kt projected for 2015–19 with an 'effective' cod stock assumed at 50 Kt.

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 an 'effective' cod stock close to the 2014 estimate (Fig. 3.11). The mortality risk depends immediately upon the assumed future catch and cod-stock levels, but changes little with time. For catches of 60 Kt to 70 Kt the mortality risk is 35–42% and nearly constant over the projection period. The immediate biomass risk is relatively insensitive to catch level but changes with time. At catch levels that permit rapid growth in biomass (70Kt or less), biomass risk decreases with time, but at catch levels that allow only slow growth, the compounding of uncertainties eventually causes estimated biomass risk to increase. This is aggravated by the high cod-stock biomass for which predictions are being made, the uncertainty associated with predation by cod being large in the present assessment.

f) Review of Research Recommendations

NIPAG **recommended** in 2010 that, for Northern 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: Completed

The assessment model was modified in 2014 so that cod biomass index series, including the W. Greenland trawl survey, were separately included among the data instead of being combined in advance and outside the model. The series of overlap indices used to scale down the estimated total cod biomass to an ‘effective’ biomass capable of preying on shrimps was also included among the input data in 2014 instead of being factored in outside the model. The 2013 assessment was re-run with this revision and its output found to agree closely with the original results; the principal difference was a larger uncertainty in the current-year predation and therefore also the total mortality.

NIPAG **further recommended** in 2012 that, for Northern shrimp off West Greenland (NAFO Subareas 0 and 1):

- *given that the CPUE series for the Greenland sea-going and coastal fleets continue to agree while neither agrees with changes in the survey estimates of biomass since 2002, possible causes for change in the relationship between fishing efficiency and biomass should be investigated;*

STATUS: In progress; this recommendation is reiterated.

- *the relationship between estimated numbers of small shrimps and later estimates of fishable biomass should be investigated anew.*

STATUS: In progress; this recommendation is reiterated.

g) Research Recommendations

NIPAG **recommends** that *the structure and coding in the assessment model of the relationship between cod biomass, shrimp biomass and estimated predation should be reviewed, including an analysis of the error variation*.

NIPAG **recommends** *that further refinements to the “partial MIXing” method of estimating numbers at age should be explored*.

Survey trends inshore and offshore are divergent and NIPAG **recommends** *exploration of the nature and implications of this divergence*.

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

(SCR Doc. 03/74, 14/57, 14/60)

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.

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

In 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, decreasing to about 10% from 2008 - 2012. No fishery has taken place in the Southern area in 2013 and 2014.

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

As the fishery developed, catches increased rapidly to more than 15 000 t in 1987-88, but declined thereafter to about 9 000 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 and have been about 2000 t since 2011. In the first half of 2014 catches of 609 t haves been obtained.

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

	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014[1]
Recommended TAC, total area	12 400	12 400	12 400	12 400	12 400	12 400	12 400	12 400	12 400	2 000
Actual TAC, Greenland	12 400	12 400	12 400	12 400	12 835	11 835	12 400	12 400	12 400	8 300
North of 65°N, Greenland EEZ	3 987	3 887	3 314	2 529	3 945	3 321	1 182	1 893	1 702	609
North of 65°N, Iceland EEZ	29	0	0	0	0	0	0	0	0	0
North of 65°N, total	4 016	3 887	3 314	2 529	3 945	3 321	1 182	1 893	1 702	609
South of 65°N, Greenland EEZ	3 737	1 302	1 286	266	610	279	53	215	3	0
TOTAL NIPAG	7 753	5 189	4 600	2 794	4 555	3 601	1 235	2 109	1 705	609

[1] Catches until July 2014

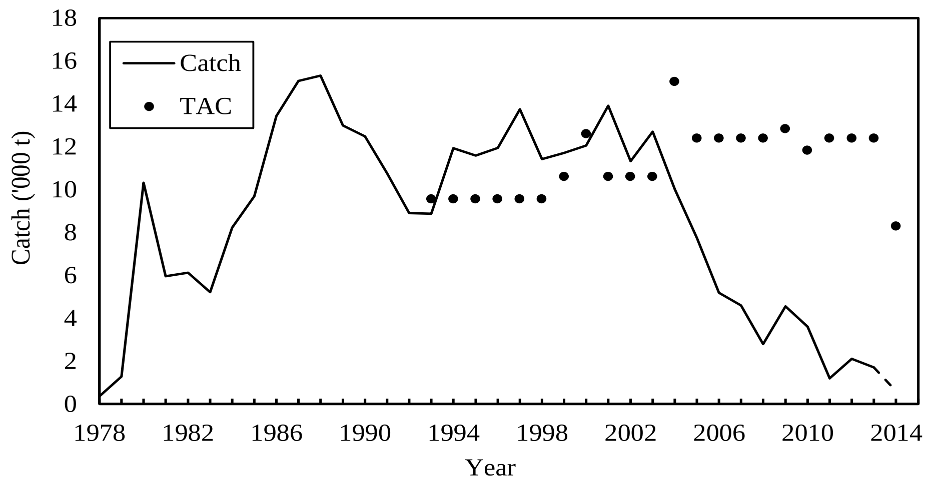


Fig. 4.1. Shrimp in Denmark Strait and off East Greenland. Catch and TAC (2014 catches until July).

b) Input Data

i) Commercial fishery data

Fishing effort and CPUE. Data on catch and effort (hours fished) on a haul by haul basis from logbooks from Greenland, Iceland, Faroe Islands and EU-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 both single and double trawl are included 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” up to 2004 (SCR Doc. 03/74).

The overall CPUE index remained at a high level from 2000-2008, nearly doubled in 2009, but has been declining since (Fig. 4.2).

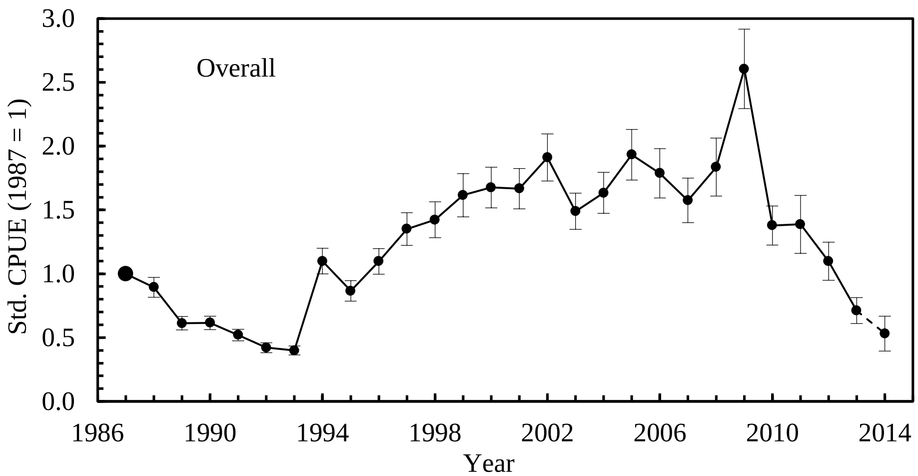


Fig. 4.2. Shrimp in Denmark Strait and off East Greenland: annual standardized CPUE-indices (1987 = 1) with ± 1 SE combined for the total area (2014 catches until July).

North of 65°N standardized catch rates declined continuously from 1987 to 1993. Since 1993 catch rates have increased until 2009 but have since decreased and in 2014 are close to the lowest level seen in the time series (Fig. 4.3).

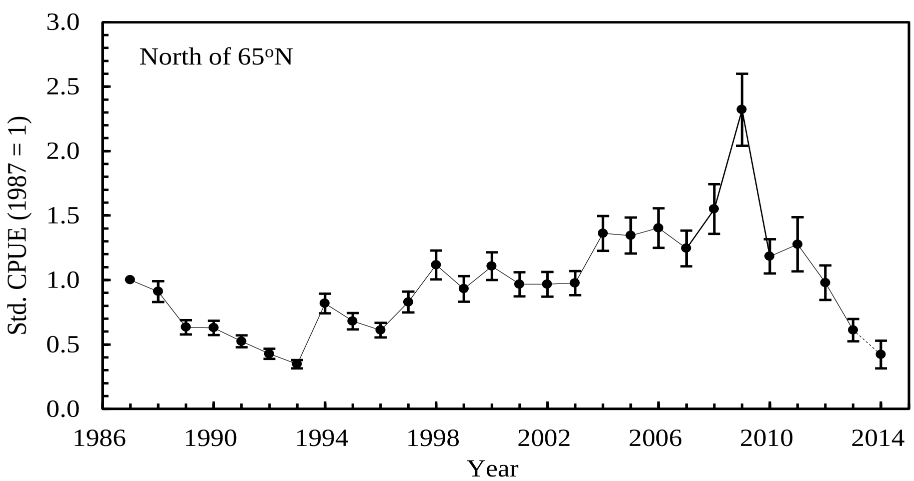


Fig. 4.3. Shrimp in Denmark Strait and off East Greenland: annual standardized CPUE (1987 = 1) with ±1 SE fishing north of 65°N (2014 catches until July).

In the southern area a standardized catch rate series increased until 1999, and has since then fluctuated without a trend (Fig. 4.4). No index for the southern area was calculated since 2010 due to a low number of hauls (less than 10 each year).

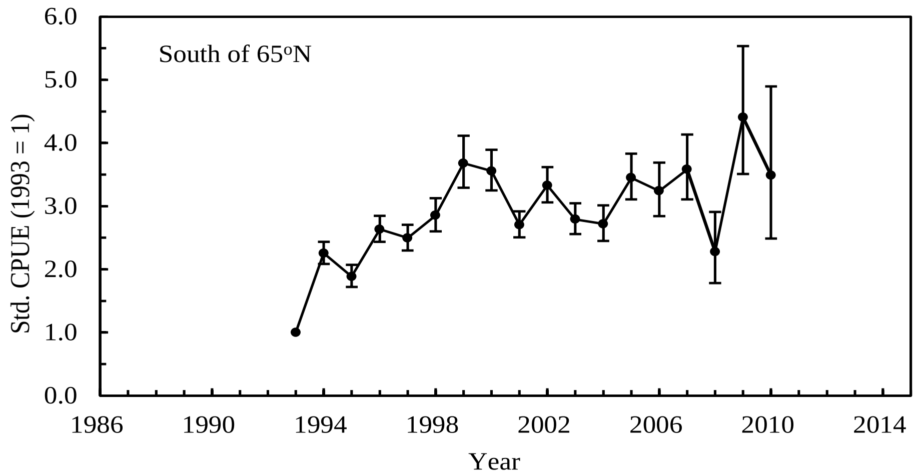


Fig. 4.4. Shrimp in Denmark Strait and off East Greenland: annual standardized CPUE (1993 = 1) with ±1 SE fishing south of 65°N (no data for the area since 2010).

Standardized effort indices (catch divided by standardized CPUE) as a proxy for exploitation rate for the total area shows a decreasing trend since 1993. Recent levels are the lowest of the time series (Fig. 4.5).

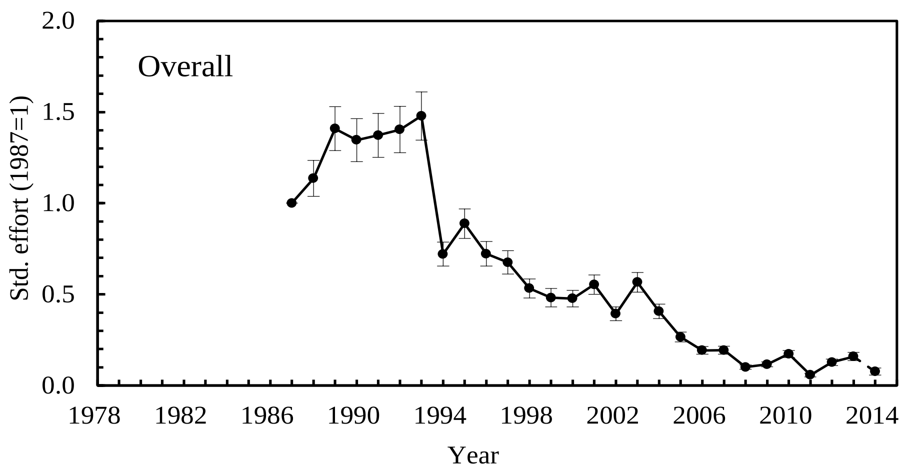


Fig. 4.5. Shrimp in Denmark Strait and off East Greenland: annual standardized effort indices, as a proxy for exploitation rate (± 1 SE; 1987 = 1), combined for the total area (2014 effort until July).

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. 14/057). 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 comparable with the recent survey due to different areas covered, survey technique and trawling gear.

Biomass. The survey biomass index decreased from 2009 to 2012 and have since then remained at a low level (Fig. 4.6).

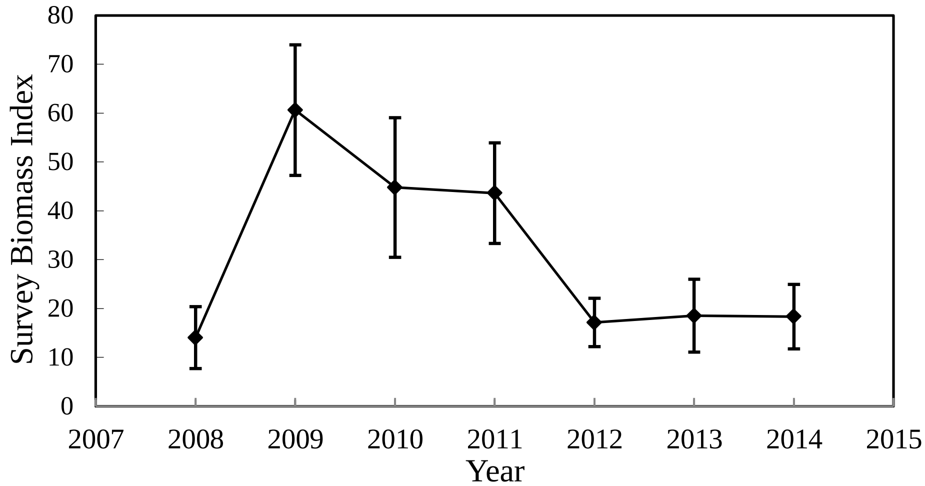


Fig. 4.6. Shrimp in Denmark Strait and off East Greenland: Survey biomass index from 2008- 2014 (± 1 SE).

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

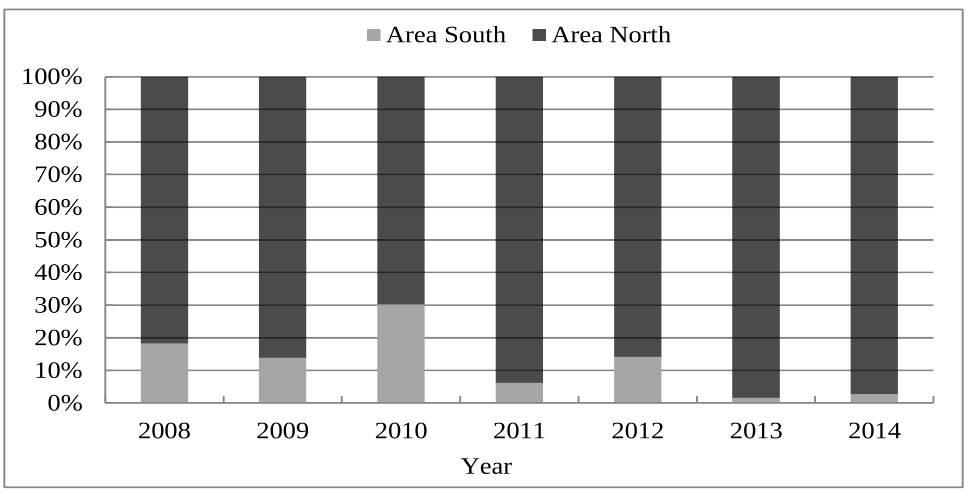


Fig. 4.7. Shrimp in Denmark Strait and off East Greenland: Distribution of Survey biomass North and South of 65°N (%) from 2008 - 2014.

Stock composition. The demography in East Greenland is dominated by a large proportion of females and shows a paucity of males smaller than 20 mm CL (Fig. 4.8).

Scarcity of smaller shrimp in the survey area stresses that the total area of distribution and recruitment patterns of the stock are still unknown.

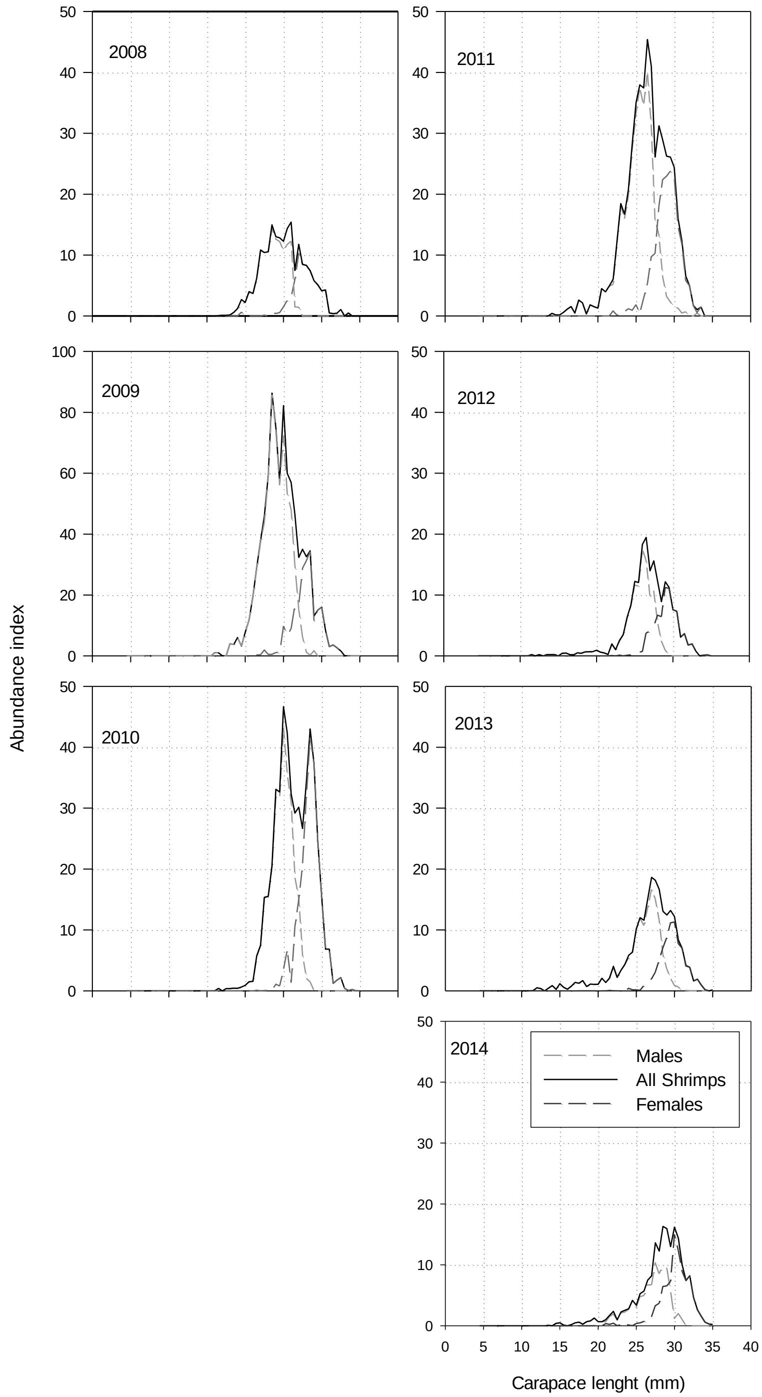


Fig.4.8. Shrimp in Denmark Strait and off East Greenland. Numbers of shrimp by length group (CL) in the total survey area in 2008 - 2014 (Please note that the scale in the figure for 2009 differs from other years).

c) Assessment Results

CPUE. The overall CPUE index remained at a high level from 2000-2008, nearly doubled in 2009, but has been declining since, and in 2014 is close to the lowest level seen in the time series.

Recruitment. No recruitment estimates were available.

Biomass. The survey biomass index has decreased by around 70% since 2009.

Exploitation rate. Since the mid-1990s the exploitation rate index has decreased, reaching the lowest levels seen in the time series.

State of the stock. The stock size remained at a very low level in 2014 despite several years of very low exploitation rates.

d) Reference points

NIPAG is unable to determine precautionary reference points at this time.

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. 08/75; 13/68, 74; 14/54, 56, 63, 65, 66.

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 has since declined steadily to only 9 500 t in 2013 and 2014 (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 are boiling the shrimp on board and landing the product in Sweden to obtain a better price; in 2013, 28%. The rest were landed fresh in home ports. The overall TAC is shared according to historical landings, giving Norway 60%, Denmark 26%, and Sweden 14% in 2011 to 2014. 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. Since February 1st 2013, it is mandatory to use grids in all *Pandalus* trawl fishery in Skagerrak. (see section on Bycatch and ecosystem effects below**)**.

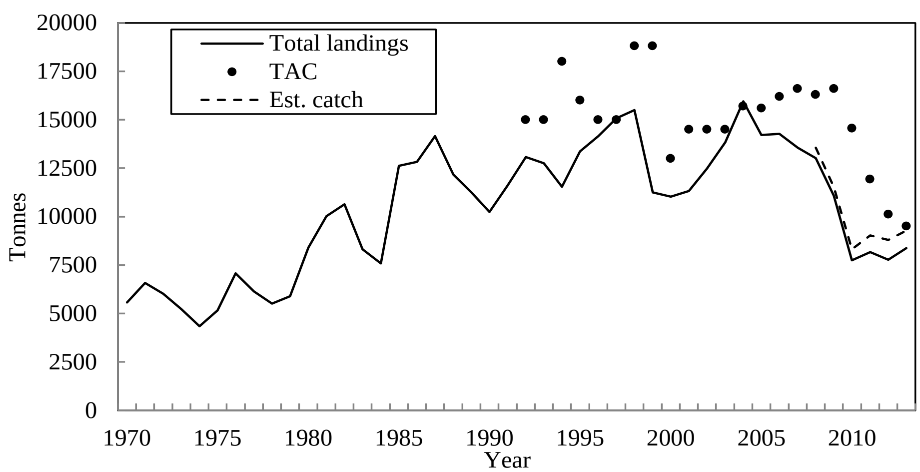


Fig. 5.1. Northern shrimp in Skagerrak and Norwegian Deep: TAC, total landings by all fleets, and total estimated catch including estimated Swedish discards for 2008-2013, Norwegian discards for 2009-2013 and Danish discards for 2009-2013.

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

Year	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Recommended TAC	19.000	11.500	13.400	12.600	14.700	15.300	13.000	14.000	14.000	15.000	15.000	13.000	8.800	*	6.500
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	10.115	9.500
Denmark	2.072	2.371	1.954	2.470	3.270	3.944	2.992	3.111	2.422	2.274	2.224	1.301	1.601	1.454	2.026
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	4.796	5.162
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	1.521	1.191
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	7.771	8.379
Est. Swedish discards										540	337	386	504	683	265
Est. Norw. discards											115	75	235	288	450
Est. Danish discards											36	53	123	92	185
Total catch			11.328	12.474	13.837	15.952	14.208	14.268	13.553	13.553	11.560	8.269	9.030	8.834	9.279

* Advice was to reduce catches

The Danish and Norwegian fleets have undergone major restructuring during the last 25 years. In Denmark, the number of vessels targeting shrimp has decreased from 138 in 1987 to only 10 in 2007-2014. The efficiency of the fleet has increased due to the introduction of twin trawls and increased trawl size (SCR Doc. 14/65).

In Norway the number of vessels participating in the shrimp fishery has decreased from 423 in 1995 to 188 in 2013. Twin trawls were introduced around 2002, and the use is increasing. In 2011-2013 twin trawls were used by more than half of the Norwegian trawlers larger than 15 meters (SCR Doc. 14/63).

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, but during the last seven years the twin trawlers have increased their landings from 7 to over 50% of total Swedish *Pandalus* landings (SCR Doc. 14/65).

Landings and discards. 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, estimated as the sum of landings and discards, were generally decreasing between 2008-2012, to 8 800 t, but increased to 9 300 t in 2013 (Table 5.1 and Fig. 5.1).

Shrimps can be discarded for one of two reasons: 1) shrimp <15 mm CL are not marketable (and in Norway, not legal to land), and 2) to replace medium-sized, lower-value shrimps with larger and more profitable ones (“high-grading”). The Swedish fishery has often been constrained by the national quota, which may have resulted in high-grading. Based on on-board sampling by observers, discards in the Swedish fisheries were estimated to be between 12 and 31% of total catch for 2008 -2013, and Danish discards were estimated to be between 2 and 8% for 2009-2013. Discarding is illegal in Norwegian waters, but there are no observer data. From 2009 onwards Norwegian discards in Skagerrak are estimated by applying the Danish discards-to-landings ratio to the Norwegian landings. Assuming, in the absence of observer data from the Norwegian Deep, that Norwegian and Danish discards there are mainly made up of shrimp < 15 mm CL, discards from this area are estimated as the weight of catches of shrimp < 15 mm CL, obtained from length distributions of catches and mean weight at length.

Bycatch and ecosystem effects. Shrimp fisheries in the Norwegian Deep and Skagerrak have bycatches of 10-22% (by weight) of commercially valuable species, which are legal to land if quotas allow (Table 5.2). Since 1997, trawls used in Swedish national waters must be equipped with a Nordmøre grid, with a bar spacing of 19 mm, which excludes fish > approx. 20 cm from the catch. Landings delivered by vessels using grids comprise 98-99% shrimp compared to only 78-84% in landings from trawls without grids (Table 5.2). Following an agreement between EU and Norway, the Nordmøre grid has been mandatory since 1st February 2013 in all shrimp fisheries in Skagerrak (except Norwegian national waters within the 4 nm limit). If the fish quotas allow, it is legal to use a fish retention device of 120 mm square mesh tunnel at the grid’s fish outlet (Table 5.2). A corresponding agreement for shrimp fisheries in the Norwegian Deep has not yet been concluded (SCR Doc. 14/63). A discard ban for a range of commercial species for all fleets fishing in Skagerrak is to be introduced

The use of a fish retention device also prevents the escape of non-commercial species: 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 is available and the impact on stocks is difficult to assess.

Table 5.2. Northern shrimp in Skagerrak and Norwegian Deep: Landings by the *Pandalus* fishery in 2013. Combined data from Danish and Swedish logbooks and Norwegian sale slips (t).

	SD IIIa, no grid		SD IIIa, grid		SD IIIa, grid+fish tunnel		SD IVa East, no grid	
Species:	Landings (t)	% of total landings	Landings (t)	% of total landings	Landings (t)	% of total landings	Landings (t)	% of total landings
Pandalus	21,8	56,5	540,9	98,3	6029,8	81,5	1170,8	81,3
Norway lobster	0,3	0,8	4,6	0,8	23,0	0,3	6,5	0,5
Angler fish	0,6	1,6	0,1	0,0	60,7	0,8	33,1	2,3
Whiting	0,1	0,2	0,0	0,0	3,2	0,0	1,1	0,1
Haddock	1,6	4,2	0,1	0,0	48,7	0,7	9,4	0,7
Hake	0,1	0,3	0,0	0,0	10,5	0,1	7,4	0,5
Ling	0,4	1,1	0,0	0,0	50,9	0,7	25,5	1,8
Saithe	8,2	21,3	1,2	0,2	526,3	7,1	83,8	5,8
Witch flounder	0,9	2,2	0,2	0,0	71,3	1,0	0,9	0,1
Norway pout	0,0	0,1	0,2	0,0	2,8	0,0	0,0	0,0
Cod	3,9	10,0	1,3	0,2	393,7	5,3	61,7	4,3
Other marketable fish	0,6	1,7	1,6	0,3	180,0	2,4	39,2	2,7

b) Assessment Data

i) Fishery data

Danish, Swedish and Norwegian catch and effort data from logbooks have been analyzed and standardized (SCR Doc. 08/75; 13/66, 72).

There was an upwards trend in the standardized LPUE for all three series from 2000 to 2007 followed by a decreasing trend until 2010; roughly stationary since then (Fig. 5.2).

Harvest rates (HR) were estimated from landings and corresponding biomass indices from the Norwegian survey. This year, the old survey time series was used to estimate the harvest rate back to 1984. The HR was high in the beginning of the time series but stabilized at a low level until 2009. Since then the HR increased until 2012 and shows thereafter a falling trend. Time series of standardized effort indices have also been estimated (Fig. 5.3). Standardized effort seems to have been fluctuating without any clear trend since the mid-1990s.

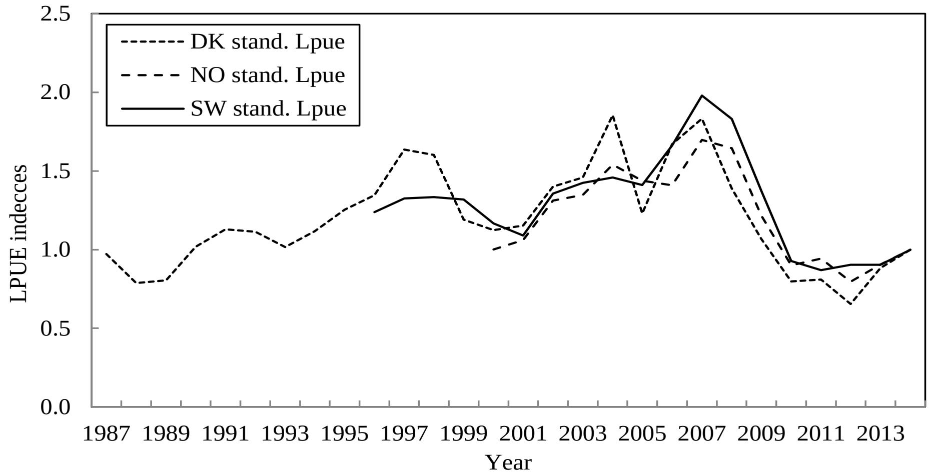


Fig. 5.2. Northern shrimp in Skagerrak and Norwegian Deep: Danish, Norwegian and Swedish standardized LPUE until 2014. 2014 data are preliminary. Each series is standardized to its last year.

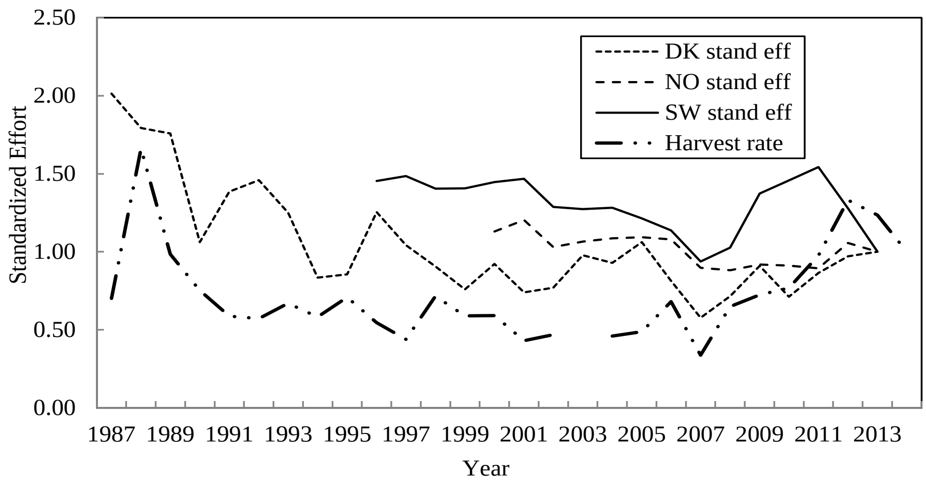


Fig. 5.3. Northern shrimp in Skagerrak and Norwegian Deep: Harvest rate (total catches/survey indices of biomass) and estimated standardized effort. Each series is standardized to its final year. The harvest rate in 2014 is the TAC/survey biomass index.

ii) Sampling of catches

Length frequencies of the catches from 1985 to 2013 (SCR Doc. 13/66, 72) have been obtained by sampling. The samples also provide information on sex distribution and maturity. Numbers at length are input data to the newly developed length-based analytical assessment model for this stock.

iii) Survey data

The Norwegian shrimp survey went through large changes in vessel, gear and timing in 2003-06, resulting in three series (SCR Doc. 13/71).

Biomass values from the first series were recalculated in 2012 in order to provide updated biomass estimates with standard errors. The recalculated values corresponded well with the old ones. The biomass index increased from 1988 to this series's maximum in 1997. A decrease in 1998-2000 was followed by an increase in 2001-2002, when this series was discontinued (Fig. 5.4). "Series 2" comprised a single point in 2003. The 2004 and 2005 values from the third series were similar. The fourth series peaked in 2007 and after that showed a steady decline, to a minimum in 2012. It increased slightly in 2013 and 2014.

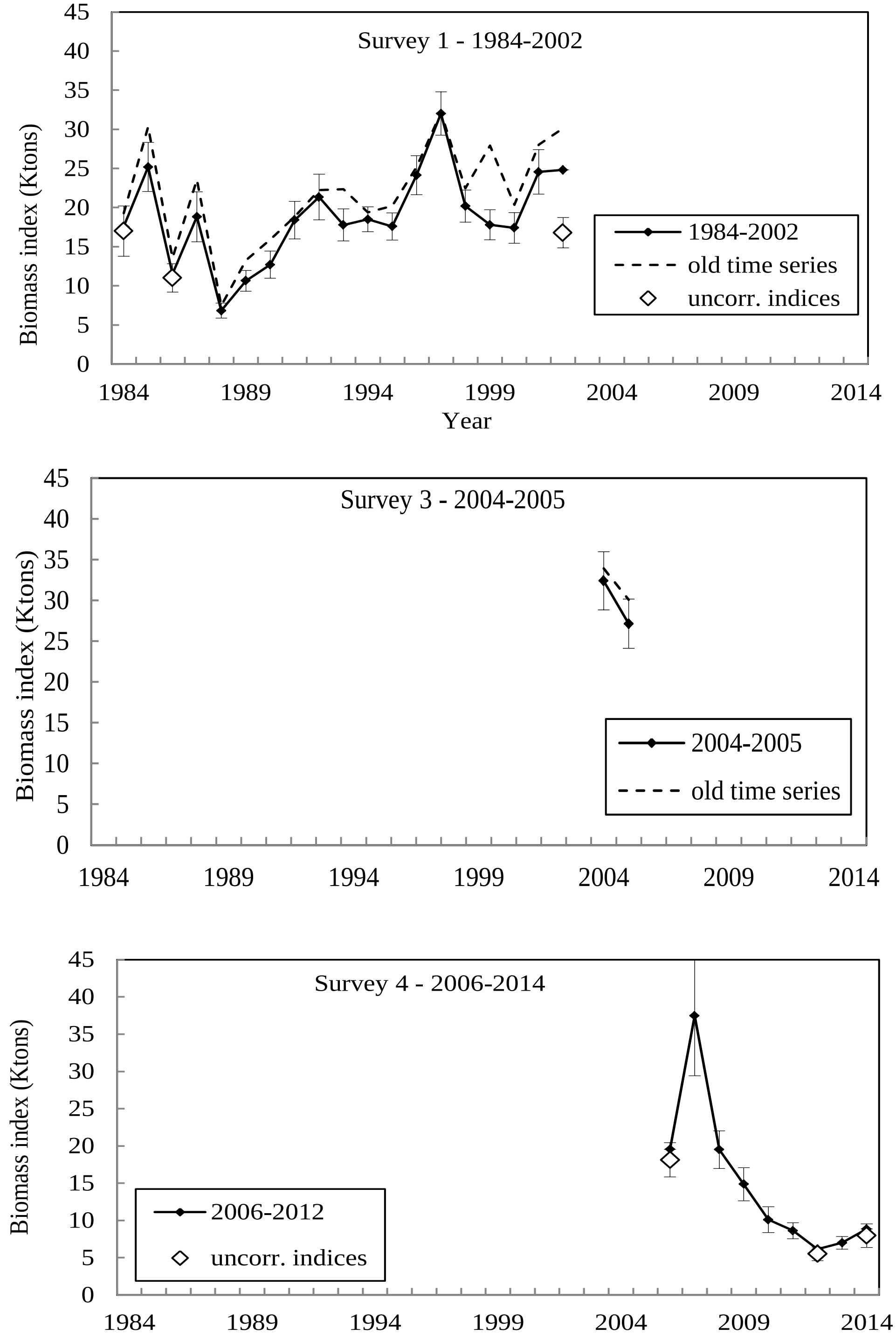


Fig. 5.4. Northern shrimp in Skagerrak and Norwegian Deep: Estimated survey biomass indices in 1984 to 2014. The 1984 – 2005 indices were re-calculated in 2012, providing SEs for the whole time series. Survey 1: October/November 1984-2002 with Campelen trawl; Survey 2: October/November 2003 with shrimp trawl 1420 (not shown); Survey 3: May/June 2004-2005 with Campelen trawl; Survey 4: January/February 2006-2014 with Campelen trawl.

The recruitment index value (abundance of age 1 shrimp) declined from 2007 to 2010 (Fig. 5.5). It increased in both 2011 and 2012, but decreased again in 2013. The 2014 value is the highest in the time series.

An SSB index, calculated as the number of berried females, follows the total biomass index (Fig. 5.6).

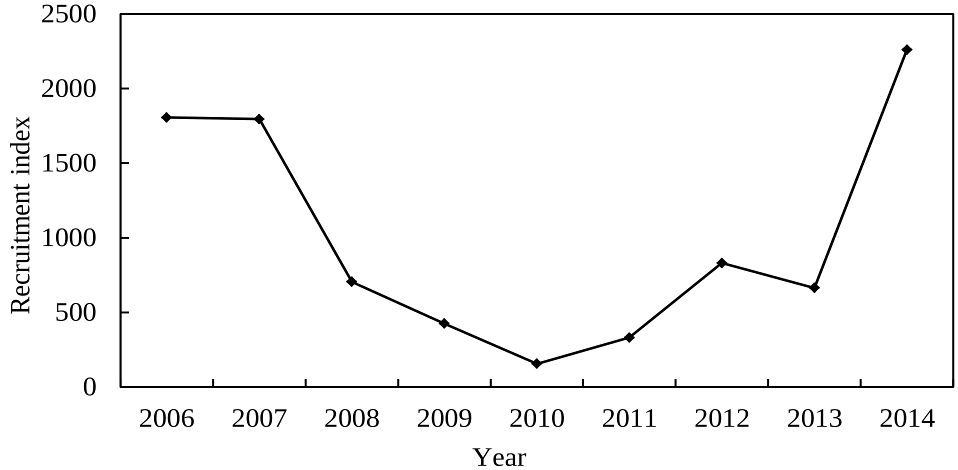


Fig. 5.5. Northern shrimp in Skagerrak and Norwegian Deep: Estimated recruitment index from 2006-2014.

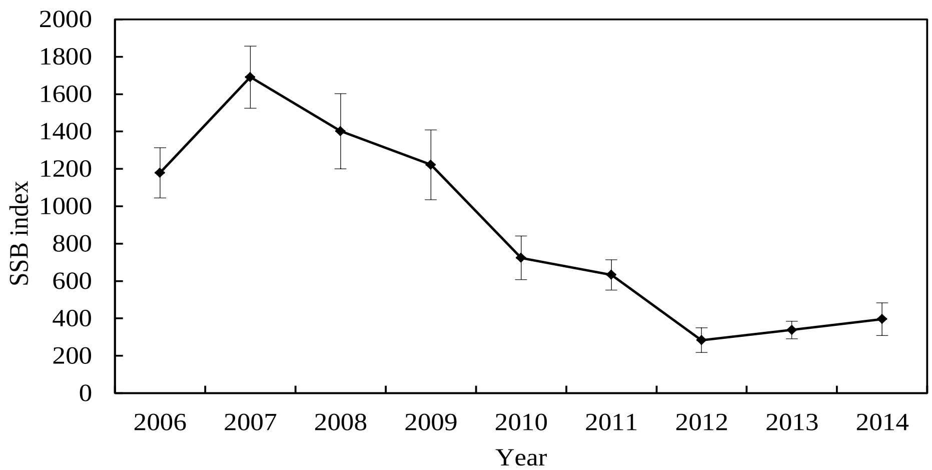


Fig. 5.6. Northern shrimp in Skagerrak and Norwegian Deep: SSB index from the Norwegian shrimp surveys in 2006-2014. Error bars are 1 SE.

iv) Predation index

The large inter-annual variation in the predator biomass index (Table 5.3) is mainly due to variations in the indices for saithe and roundnose grenadier, which in some years are important components. These contributions depend heavily upon 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 5.3. The total index of shrimp predator biomass excluding saithe and roundnose grenadier has been at the same level during the 9 last years. The predator index increased during 2013 due to an increased abundance of both saithe and blue whiting.

Table 5.3. 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 2006-2014.

Species		biomass index									
English	Latin	2006	2007	2008	2009	2010	2011	2012	2013	2014	mean
Blue whiting	*Micromesistius poutassou*	0,13	0,13	0,12	1,21	0,27	0,62	3,30	29,03	1,88	
Saithe	*Pollachius virens*	7,33	39,75	208,32	53,89	18,53	7,52	5,66	112,80	14,13	
Cod	*Gadus morhua*	0,51	1,28	0,78	2,01	1,79	1,66	1,26	1,69	2,92	
Roundnosed Grenadier	*Coryphaenoides rupestris*	3,22	6,85	19,02	19,03	10,05	4,99	4,43	1,97	2,90	
Rabbit fish	*Chimaera monstrosa*	2,24	2,15	3,41	3,26	3,51	2,73	2,22	3,05	3,90	
Haddock	*Melanogrammus aeglefinus*	0,97	4,21	1,85	3,18	3,46	5,82	5,75	5,18	2,15	
Redfish	Scorpaenidae	0,18	0,40	0,26	0,43	0,80	1,02	0,37	0,47	0,48	
Velvet Belly	*Etmopterus spinax*	1,31	2,58	1,95	2,42	2,52	1,47	1,59	2,67	1,91	
Skates, Rays	Rajidae	0,41	0,95	0,64	0,17	0,60	0,88	0,98	1,00	2,25	
Long Rough Dab	*Hippoglossoides platessoides*	0,22	0,64	0,42	0,28	0,47	0,51	0,56	0,56	1,17	
Hake	*Merluccius merluccius*	0,98	0,78	0,64	2,56	1,60	0,56	0,52	1,06	0,69	
Angler	*Lophius piscatorius*	0,15	0,91	0,87	1,25	1,70	0,92	0,17	0,65	0,75	
Witch	*Glyptocephalus cynoglossus*	0,24	0,74	0,54	0,16	0,13	0,24	0,29	0,27	0,35	
Dogfish	*Squalus acanthias*	0,31	0,19	0,28	0,14	0,11	0,21	0,60	1,02	1,00	
Black-mouthed dogfish	*Galeus melastomus*	0,00	0,05	0,05	0,15	0,09	0,09	0,09	0,12	0,11	
Whiting	*Merlangius merlangus*	0,35	1,01	1,35	3,02	2,42	3,07	1,64	2,02	3,38	
Blue Ling	*Molva dypterygia*	0	0	0	0	0	0	0	0,01	0,01	
Ling	*Molva molva*	0,04	0,11	0,34	0,79	0,64	0,24	0,17	0,22	0,32	
Four-bearded Rockling	*Rhinonemus cimbrius*	0,06	0,14	0,04	0,03	0,05	0,03	0,09	0,04	0,06	
Cusk	*Brosme brosme*	0,20	0	0,02	0,05	0,13	0,29	0,04	0,10	0,05	
Halibut	*Hippoglossus hippoglossus*	0,08	0,07	3,88	0,09	0,20	0,05	0,19	0	0	
Pollack	*Pollachius pollachius*	0,06	0,25	0,03	0,13	0,12	0,15	0,07	0,24	0,65	
Greater Forkbeard	*Phycis blennoides*	0	0	0	0,01	0,04	0,02	0,05	0,06	0,12	
Total		18,99	63,19	244,81	94,26	49,23	33,09	30,04	164,23	41,18	82,11
Total (except saithe and roundnosed grenadier)		8,44	16,59	17,47	21,34	20,65	20,58	19,95	49,46	24,15	22,07

v) Assessment models

Two assessment models were evaluated at the final benchmark session in 2013: a stochastic length-based assessment model (SCR Doc. 13/74) and a Bayesian surplus production model (SCR Doc. 13/070). The general performance of the two models, as well as the outputs (biological reference points and short term forecasts), were discussed during the benchmark session within the NIPAG meeting. 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 in individual years were somewhat pronounced. The analytical length-based model applies more detailed biological information in the assessment and therefore provides more immediate responses to change, and is the preferred model. However, the benchmark recommended the surplus production model continue to be applied each year for an initial period to verify performance of the length based model. The length-based model was in 2013 not fully operational to produce sufficient output for the ICES advice. This year, the model provided standard ICES output, but estimated catches were in disagreement with the observed landings. This could be due to errors in the estimated weight at age. Furthermore, concern was raised about model stability and it was recommended that retrospective analysis should be carried out. It was decided by the group that the suitability of $F_{0.1}$ as a proxy for F_{msy} should be confirmed. This year, as last year, it was therefore decided to provide advice based on the production model (SCR Doc. 13/070, 14/056), although estimates of stock status from both models were presented.

vi) Assessment Results

A. Length-based model (SCR Doc. 13/74).

The stock development as estimated by the length based model is shown in Fig. 5.7 (SSB, fishing mortality (F_{1-3}) and numbers in 0-group). Fishing mortality has increased steeply since 2007 and is now at the highest level estimated at 0.96. The recent steep increase in modelled fishing mortality is difficult to explain in terms of recent trends in estimates of fishing effort, but is in better agreement with recent changes in HR. SSB has declined since 2006 to the lowest level observed in the time series. The estimated number of the 0-group declined steeply between 2005 and 2008 and remained at low levels until 2012 where after it increased to a very high level in 2013.

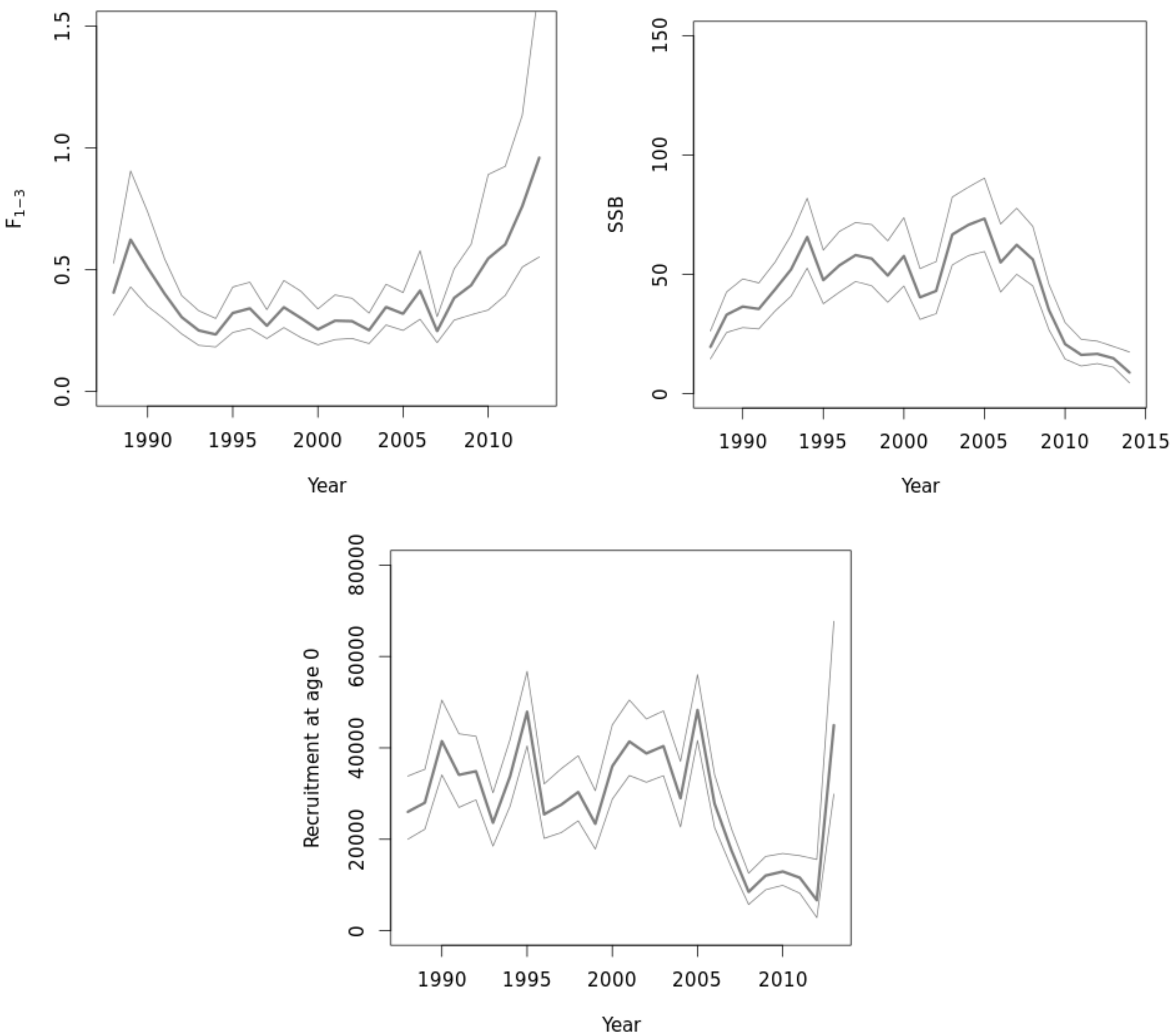


Fig. 5.7 Estimates of F_{1-3}, SSB (t) and recruits (millions) from the length-based model. Light grey lines represent 95% confidence intervals.

B. Stock production model fitted by Bayesian methods using fishery catch and effort data and data from the Norwegian trawl survey (SCR Doc. 13/070).

The input series of biomass indices span 1984-2014. Since the late 1980s the stock has varied with a slightly increasing trend until 2006 when it started to decline (Fig. 5.8). This is similar to the development of SSB according to the length-based model (Fig. 5.7). The median 2014 estimate is above B_{msy} (Table 5.4). The estimated risk of stock biomass being below $B_{trigger}$ in 2014 was 4% and of being below B_{lim}, 1% (Table 5.4).

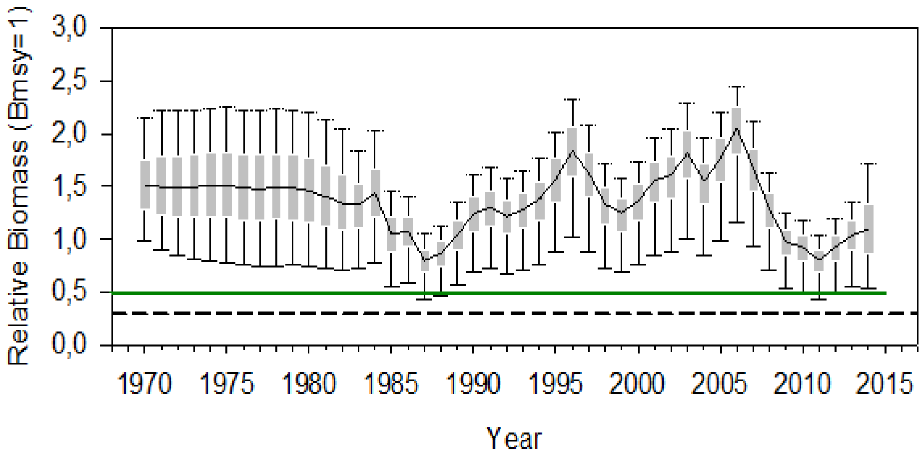


Fig. 5.8. Estimated time series of relative biomass (B_t/B_{msy}) 1970-2014. The solid black line is the median; boxes represent quartiles; the whiskers cover the central 90 % of the distribution. Dashed black line represents B_{lim}. Green line represents $B_{trigger}$.

Median estimate of fishing mortality has remained below F_{msy} since 1990 (Fig.5.9). There is a 17% risk of F_{2014} being above F_{msy} (Table 5.4).

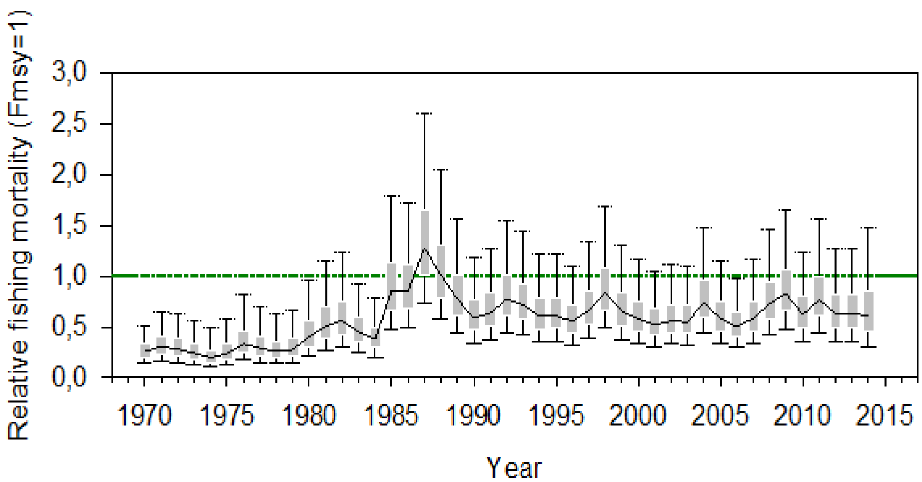


Fig. 5.9. Estimate of relative fishing mortality (F_t/F_{msy}) 1970-2014. The solid black line is the median; boxes represent quartiles; the whiskers cover the central 90 % of the distribution.

Table 5.4. Risk analysis 2013-2014

Status	2013	2014*
Risk of falling below B_{lim} (0.3B_{MSY})	1%	1%
Risk of falling below *Btrig* (0.5B_{MSY})	4%	4%
Risk of falling below B_{MSY}	42%	39%
Risk of exceeding F_{MSY}	13%	17%
Stock size (B/Bmsy), median	1.04	1.10
Fishing mortality (F/Fmsy), median	0.63	0.62
Productivity (% of MSY)	100%	99%

*Predicted catch = TAC

d) Stock development and biological reference points

Reference points. In 2009 ICES adopted a "Maximal Sustainable Yield (MSY) framework" (ACOM. ICES Advice, 2013. Book 1. Section 1.2) for deriving advice. It considers two reference points: F_{msy} and $B_{trigger.}$ In keeping with the reference points developed in 2006 and 2010 for the Barents Sea shrimp stock, 50% B_{msy} was adopted as $B_{trigger}$ (NIPAG, 2006). Under the ICES PA two reference points are required; B_{lim} and B_{pa}. Again in line with the Barents Sea shrimp stock, B_{lim} was set at 30% B_{msy} (NIPAG, 2006). B_{pa} is not considered relevant in the presence of a risk analysis.

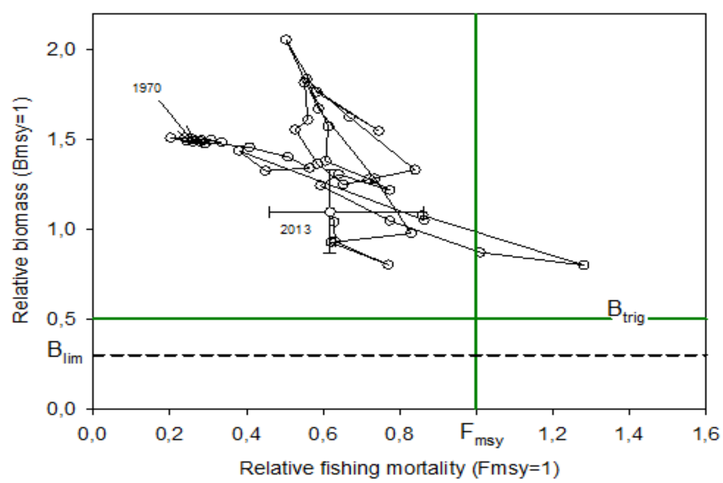


Fig. 5.10. Annual median estimates of biomass-ratio (B/B_{MSY}) and fishing mortality-ratio (F/F_{MSY}) 1970-2014. The reference points for stock biomass, $B_{trigger}$, and fishing mortality, F_{msy}, are indicated by green lines, B_{lim}, by a dotted line (quartile bars on the 2014 value)..

Projections. Given a catch of 9 279 t in 2013 and assuming a 2014 catch of 9 500 t (TAC), catch options from 6 000 t to 16 000 t were evaluated for 2015. Under all these catch options the risk of going below B_{lim} is 1%. Catches of up to 14 000 t have a <50% risk of exceeding F_{msy} and a 4% risk of falling below $B_{trigger}$ (Table 5.5).

Table 5.5. Catch option for 2015.

	Catch option 2015 (ktons)					
	6	8	10	12	14	16
Risk of falling below B_{lim} (0.3B_{msy})	1%	1%	1%	1%	1%	1%
Risk of falling below B_{trig} (0.5B_{msy})	4%	4%	4%	4%	4%	4%
Risk of falling below B_{msy}	32%	33%	35%	38%	40%	46%
Risk of exceeding F_{msy}	4%	9%	19%	30%	42%	58%
Risk of exceeding 1.7F_{msy}	1%	2%	4%	7%	12%	20%
Stock size (B/B_{msy}), median	1,19	1,17	1,14	1,12	1,10	1,04
Fishing mortality (F/F_{msy}),	0,36	0,49	0,62	0,76	0,91	1,10
Productivity (% of MSY)	96%	97%	98%	99%	99%	100%

Comparison of Assessment Models

Two models are used in the assessment of this stock. One is length/age based, uses data on numbers at length from catches and survey, and tracks the age cohorts into which those numbers are converted. The other is a surplus-production model which considers only the dynamics of the stock biomass using series of indicators of biomass.

1. The models agree that SSB has decreased fairly drastically since about 2006.
2. The length-based model measures a rapid recent increase in fishing mortality, not evident in the results of the surplus-production model. This agrees with the recent HR, but not with the recent trajectory of fishing effort.
3. The length-based model would be able to take into account, in its predictions, the recent observation of a large number of age-1 shrimps in the stock, which the surplus-production model is not constructed to be able to do.
4. The length-based model estimates current SSB at below B_{lim}, while the surplus production model estimates SSB above $B_{trigger}$ throughout the series.
5. The length-based method estimates short-term yield of 26 700 t at F_{msy}, while the surplus production model would yield 14 800 t.

Summary of Assessment

Mortality. Fishing mortality has remained below F_{msy} since 1990. There is a 17% risk of F_{2014} being above F_{msy}.

Biomass. Stock biomass has been above $B_{trigger}$ throughout the history of the fishery. The risk that the biomass at the end of 2014 is below $B_{trigger}$ is less than 5%.

Recruitment. The abundance of age-1 shrimp in the survey catches increased in both 2011 and 2012, but decreased again in 2013. The 2014 value is the highest in the series.

State of the Stock. The stock declined steeply from 2006 to 2011, followed by a moderate increase from 2011 to 2014. It is however, estimated to be still well above $B_{trigger}$.

Yield. Catch options up to 14 000 t/yr have a risk below 50% of exceeding F_{msy} in 2015.

e) Management Recommendations

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

- *Sorting grids should be implemented in the Norwegian Deep in addition to the Skagerrak.*
- *Norwegian vessels >=12m in the Norwegian Deep should be required to complete and provide log books.*

f) Research Recommendations

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

- *In the length-based model, explore the replacement of 'weight at age' with 'weight at length' data from the fishery*

g) Research Recommendations from the 2010-2013 meetings

- *the Norwegian shrimp survey should be extended east to cover important shrimp grounds in Swedish waters.*

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

- *compare the results of the current assessment with those of an updated run including survey data collected early in the following year.*

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

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

STATUS: The benchmark assessment which was finalized during the NIPAG meeting in September 2013 chose the length based model as a basis for advice for the shrimp stock in Skagerrak and the Norwegian Deep. However, it was also decided that the Bayesian surplus production model would be run alongside the coming years, as a quality check of the forecast produced by the length based model.

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

STATUS: A workshop is scheduled for April 2014.

- *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: Work in progress

- *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 project "*Sustainable shrimp fishing in Skagerrak*" has detected weak genetic structure in the Skagerrak/North Sea region, primarily associated with fjords in the Skagerrak region (Knutsen *et al.* in prep.). The shrimp in Skagerrak and the Norwegian Deep most likely comprise one single stock, which is in agreement with the oceanic current pattern in the area. The benchmark assessment in September 2013 thus concluded that we have one single shrimp stock in the Skagerrak and Norwegian Deep area. The conclusion on the relation between the shrimp (stock units) in Skagerrak and the Norwegian Deep on the one hand and the Fladen Ground shrimp on the other hand will await finalization of data analyses (Knutsen *et al.* in prep.).

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 14/51, 53, 55, 63; 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 the “Loop Hole” (Fig. 6.1).

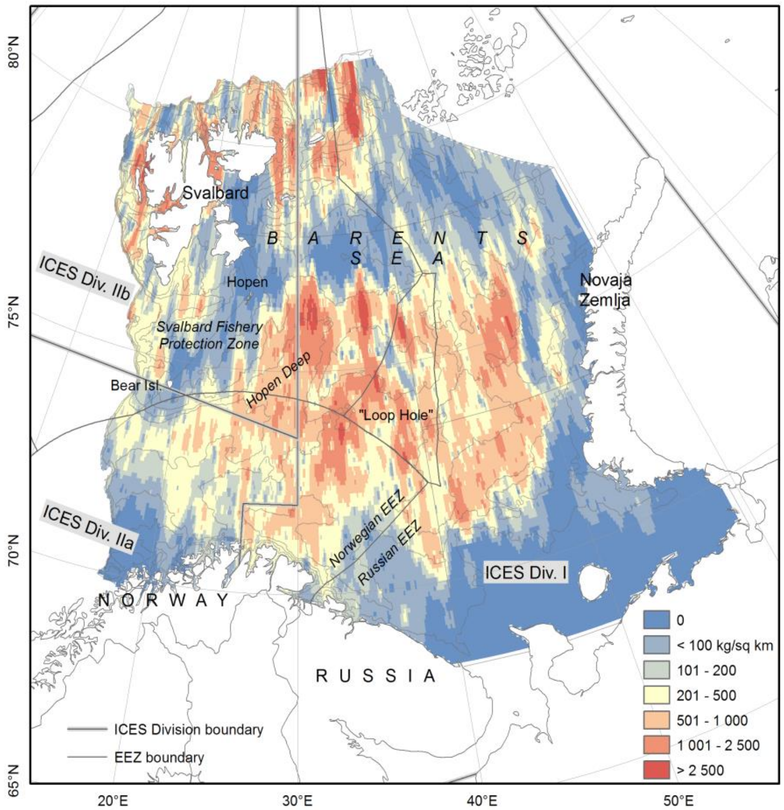


Fig. 6.1. Shrimp in the Barents Sea: stock distribution, mean density index (kg/km^2), based on survey data 2000-2010.

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 40 000 t/yr, 50–90% 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 is constrained only by bycatch regulations whereas the activity of third country fleets operating in the Svalbard zone is also restricted by the number of effective fishing days and the number of vessels by country. The minimum stretched mesh size is 35 mm. Bycatch is limited by mandatory sorting grids and by the temporary closing of areas where excessive bycatch of juvenile cod, haddock, Greenland halibut, redfish or shrimp <15 mm CL is registered.

Catch. Catches have ranged from 5 000 to 128 000 t/yr. (Fig. 6.2) since 1970. The most recent peak was seen in 2000 at approximately 83 000 t. Catches thereafter declined to about 20 000 t in 2013 and are predicted to remain at about that level in 2014.

Table 6.1. Shrimp in ICES SA I and II: Recent catches (2001–2014) in metric tons, as used by NIPAG for the assessment.

	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014[1]
Recommended TAC	-	41 299[2]	40 000	50 000	50 000	50 000	50 000	60 000	60 000	60 000	60 000
Norway	35918	37253	27352	25558	20662	19784	16779	19923	15208	8845	10000
Russia	2410	435	4	192	417	0	0	0	0	1067	2000
Others	4406	4930	2271	4181	7109	7488	8419	9867	10304	8773	9000
Total	42734	42618	29627	29931	28188	27272	25198	29790	25512	18686	21000

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

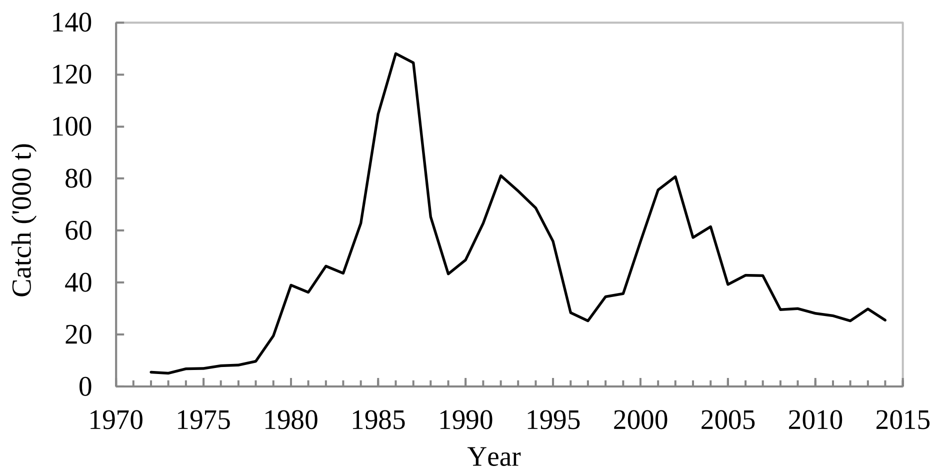


Fig. 6.2. Shrimp in ICES SA I and II: total catches 1970–2014 (2014 projected to the end of the year).

Discards and bycatch. Discard of shrimp cannot be quantified but is believed to be small as the fishery is not limited by quotas. Bycatch rates of other species are estimated from at-sea inspections and research surveys and are corrected for differences in gear selection pattern (SCR Doc. 07/86). Area-specific bycatch rates are then multiplied by the corresponding shrimp catches from logbooks to give an overall bycatch estimate.

Since the introduction of the Nordmøre sorting grid in 1992, only small individuals of cod, haddock, Greenland halibut, and redfish, in the 5–25 cm size range, are caught as bycatch. The bycatch of small cod ranged between 2 and 67 million individuals/yr and redfish between 2 and 25 million individuals/yr from about 1992 to 2010 while 1-9 million haddock/yr and 0.5–14 million Greenland halibut/yr were registered in 2000–2004 (Fig. 6.3). In recent years there has been a decline in bycatch owing to reduced effort in the shrimp fishery. Details of bycatch are no longer reported by the ICES Arctic Fisheries Working Group. NIPAG will update this bycatch information at its 2015 meeting.

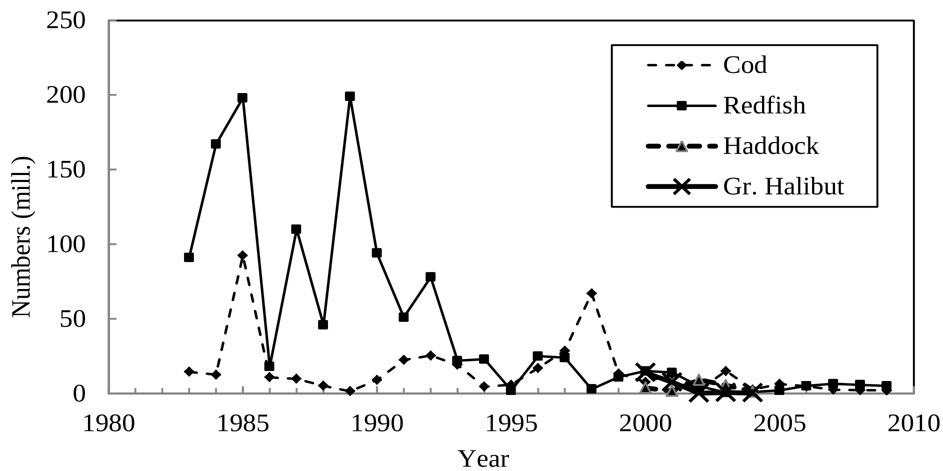


Fig. 6.3. Shrimp in ICES SA I and II: Estimated bycatch of cod, haddock, Greenland halibut and redfish in the Norwegian shrimp fishery (million individuals). No data available for 2010-14.

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 using single trawls only. Double- and triple trawls were then introduced. An individual vessel may alternate between single and multiple trawling depending on what is appropriate on given fishing grounds.

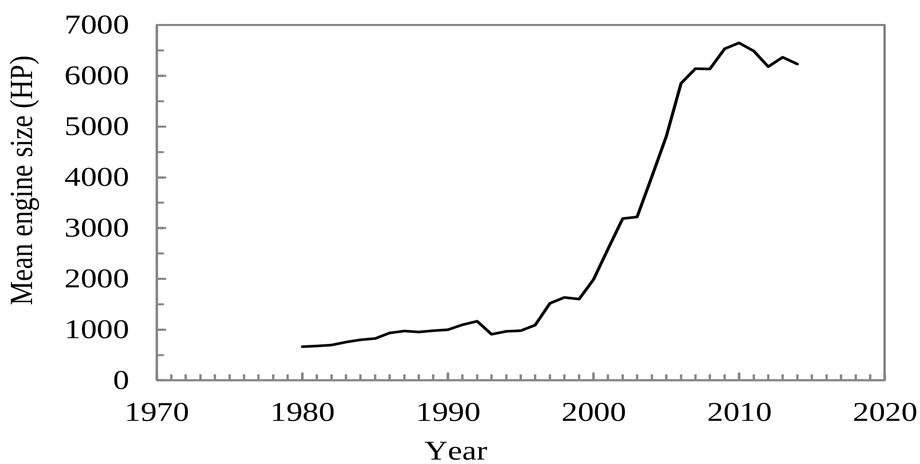


Fig. 6.4. Shrimp in ICES SA I and II: Mean engine power (HP) weighted by trawl-time, 1980–2014 (Norwegian data).

The fishery is conducted mainly in the central Barents Sea (Hopen Deep) and on the Svalbard Shelf along with the Goose Bank (south east Barents Sea) (Fig. 6.5). The fishery takes place throughout the year but may in some years be restricted by ice conditions. The lowest effort is generally in October through March, the highest in May to August.

Logbook data since 2009 show decreased activity in the Hopen Deep and around Svalbard, coupled with increased effort further east in international waters in the "Loop Hole" (Fig 6.5). Information from the industry points to decreasing catch rates and more frequent area closures due to bycatch of juvenile fish on the traditional shrimp fishing grounds as the main reasons for the observed change in fishing pattern.

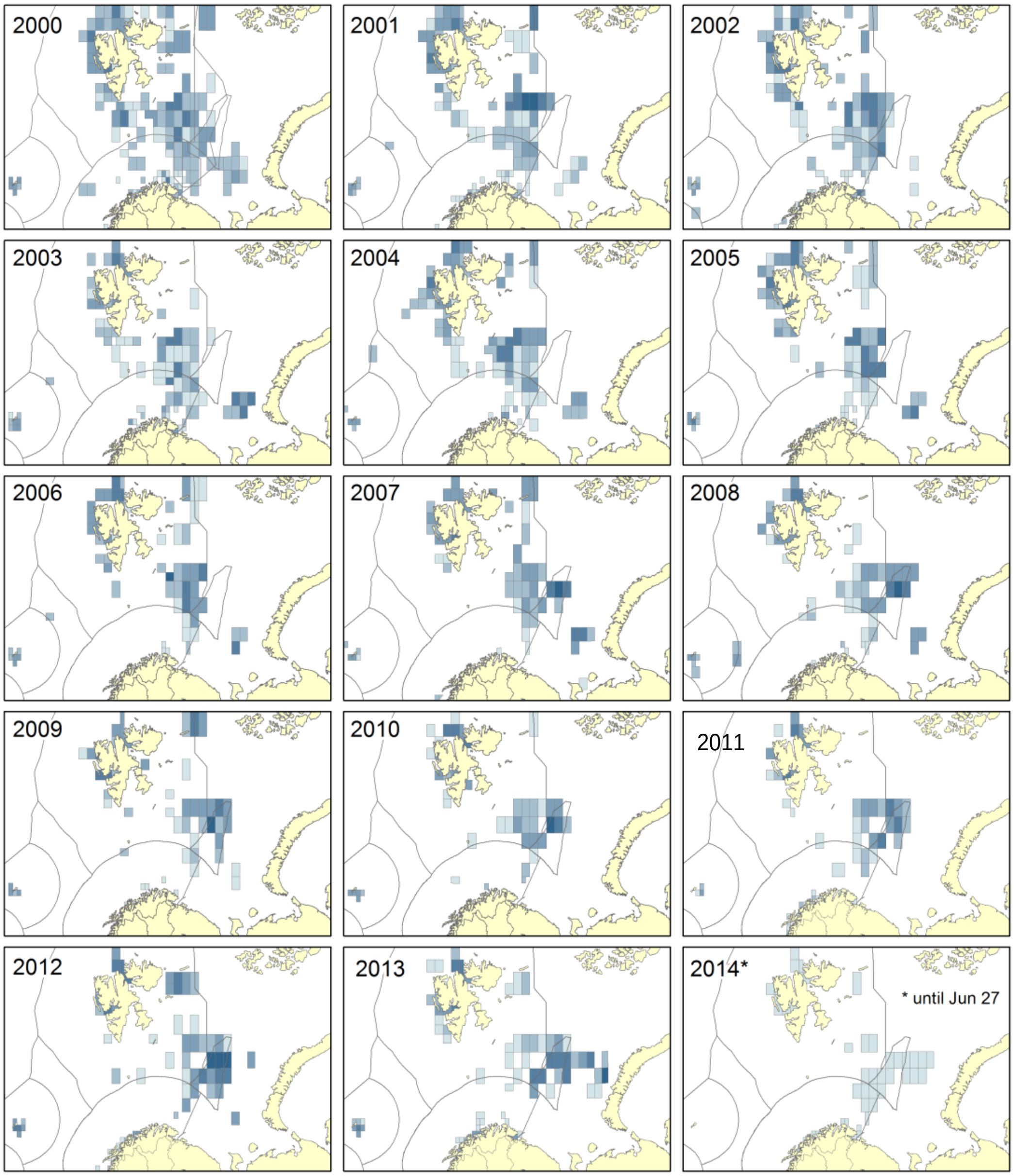


Fig. 6.5. Distribution of catches by Norwegian vessels 2000-2014 based on logbook information.

Norwegian logbook data were used in a multiplicative model (GLM) to calculate standardized annual catch rate indices (SCR Doc. 14/53). A new index series based on individual vessels rather than vessel groups was introduced in 2008 (SCR Doc. 08/56) in order to take into account the changes observed in the fleet. The GLM model used to derive the CPUE indices included the following variables: (1) vessel, (2) season (month), (3) area, and (4) gear type (single, double or triple trawl). The resulting series provides an index of the 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 series in 1987 (Fig. 6.6). From then until 2011 it showed an overall increasing trend. The 2012-14 are however down significantly to below-average values.

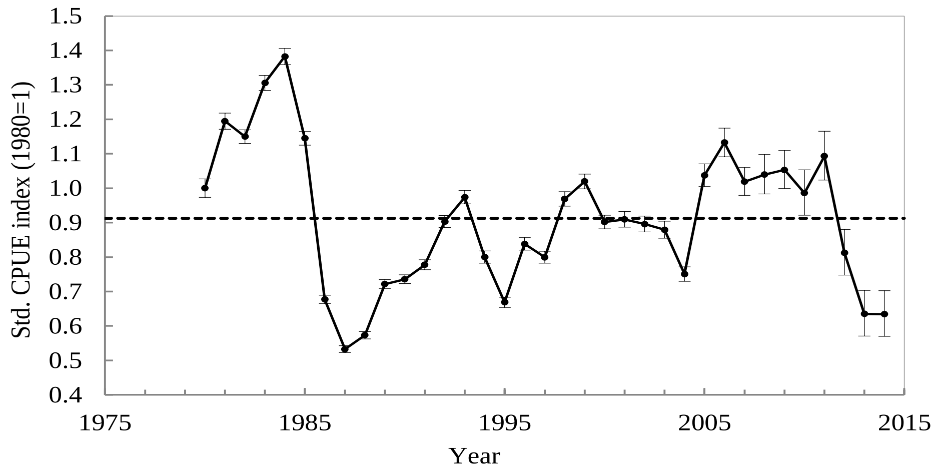


Fig. 6.6. Shrimp in ICES SA I and II: standardized CPUE based on Norwegian data. Error bars represent one standard error; dotted line is the mean of the series.

ii) Research survey data

Russian and Norwegian 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, 14/51). The main objectives have been to obtain indices for stock biomass, numbers, recruitment and demographic composition. In 2004, these surveys were replaced by a joint Norwegian-Russian "Ecosystem survey" which monitors shrimp along with a multitude of other ecosystem variables in the Barents Sea and around Svalbard (SCR Doc. 14/51, 14/55).

Biomass. The Biomass indices of the Norwegian and Russian shrimp surveys (survey 1 and 2) varied without trend between 1982 and 2005 (Fig. 6.7). 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. 6.7). The 2010 to 2013 values are back up close to that of 2006.

The geographical distribution of the stock in 2009-2012 was more easterly compared to that of the previous years (Fig. 6.8).

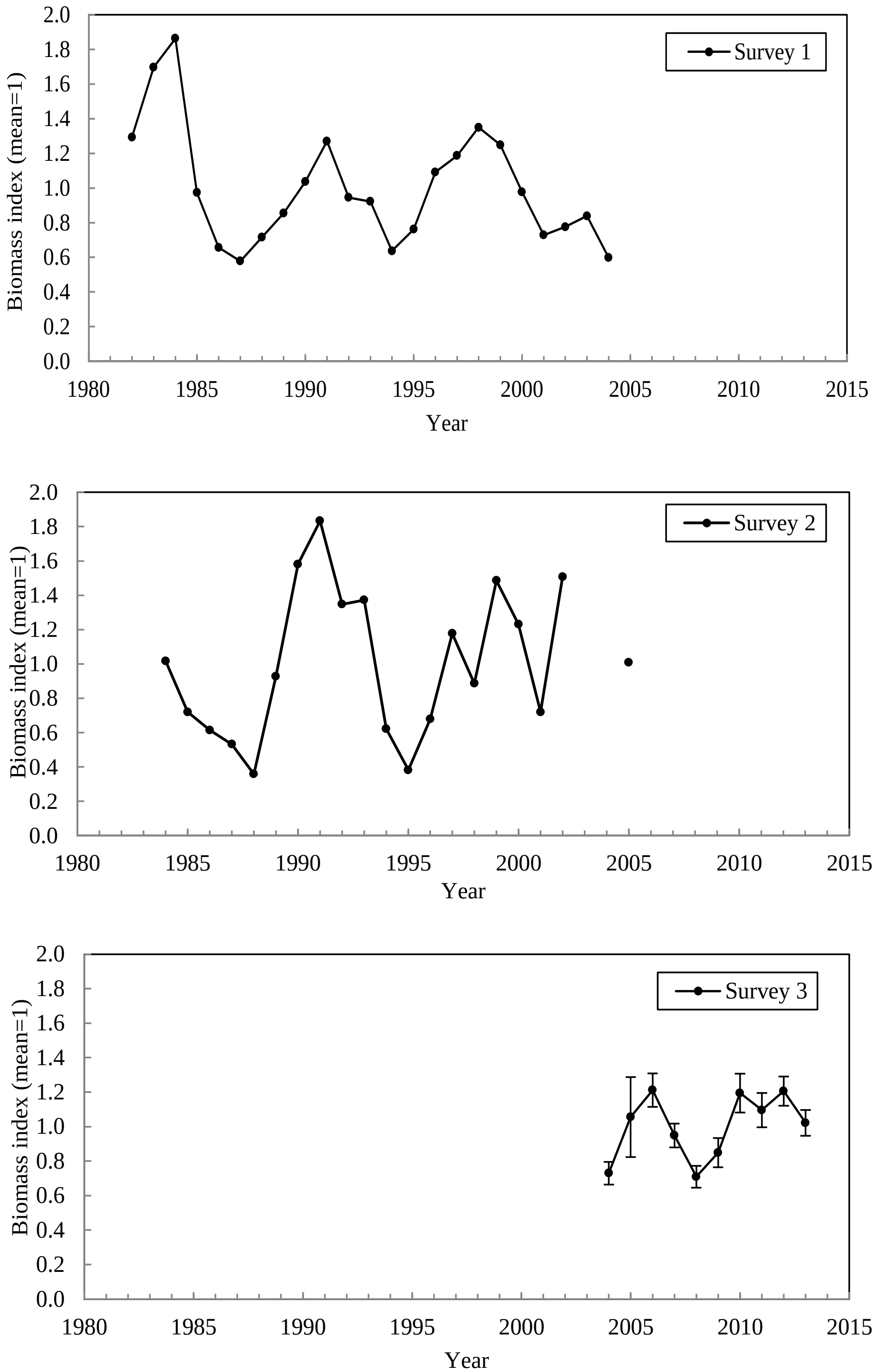


Fig. 6.7. Shrimp in ICES SA I and II: Indices of total stock biomass from the (1) 1982-2004 Norwegian shrimp survey, (2) the 1984-2005 Russian survey, and (3) the joint Russian-Norwegian ecosystem survey 2004-2013 (the 2014 survey data is not at the time of the NIPAG meeting). Error bars represent one standard error.

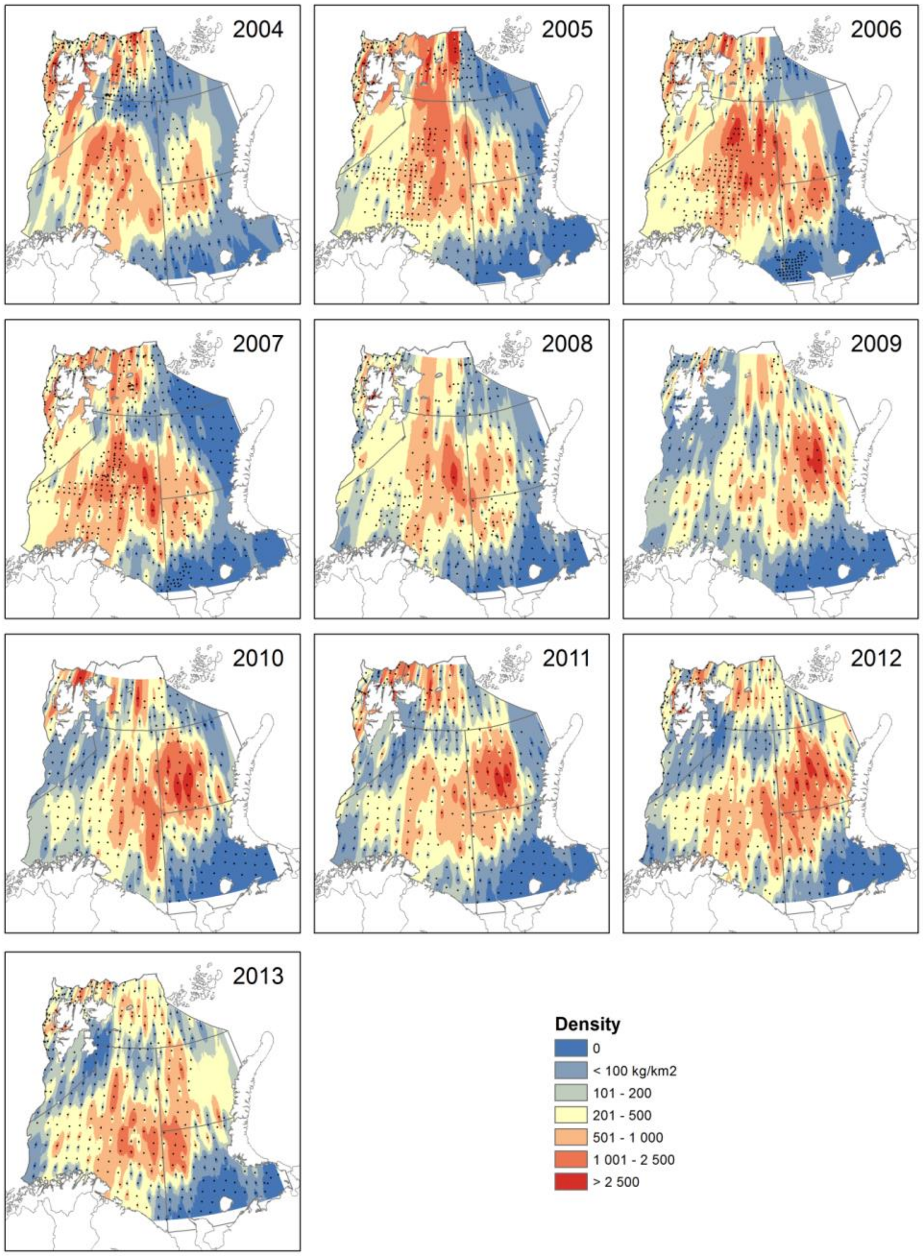


Fig. 6.8. Shrimp in ICES SA I and II: Shrimp density (kg/km2) as calculated from the Ecosystem survey data 2004–2013).

Recruitment indices. A recruitment index were derived from the overall size distributions based on Russian and Norwegian survey samples (SCR Doc. 14/55 and 14/51 respectively) as estimated abundances of shrimp at 13 to 16 mm CL. Shrimp at this size will probably enter the fishery in the following one to two years. This index has varied without trend since 2007 (Fig. 6.9).

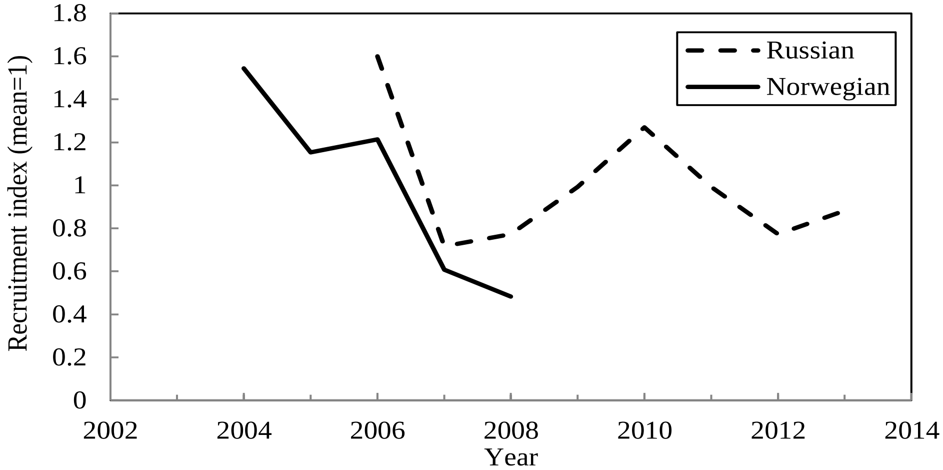


Fig. 6.9. Shrimp in ICES SA I and II: Index of recruitment: abundance of shrimp at size 13–16 mm CL based on Norwegian survey samples 2004-2008 and Russian survey samples 2006-2013.

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 are mainly caught in areas where bottom temperatures are above 0°C. Highest densities are observed between zero and 4°C, while the upper limit of their preferred temperature range appears to lie at about 6-8°C. The eastward shift in shrimp distribution in recent years may be associated with changes in temperature (SCR Doc. 12/49).

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.

Within this model, parameters relevant for the assessment and management of the stock are estimated, based on a stochastic version of a surplus-production model. The model is formulated in a state-space framework and Bayesian methods are used to derive "posterior" probability density distributions of the parameters (SCR Doc. 14/63).

The model synthesized information from input priors, four independent series of shrimp biomass indices and one series of shrimp catch. The biomass indices were: a standardized series of annual fishery catch rates for 1980–2014 (Fig. 6.6, SCR Doc. 14/53); and trawl-survey biomass indices for 1982–2004, 1984–2005 and for 2004–2013 (Fig, 6.7, SCR Doc. 14/51). These indices were scaled to true biomass by individual catchability parameters, q_j, and lognormal observation errors were applied. Total reported catch in ICES Div. I and II since 1970 was used as yield data (Fig. 6.2, SCR Doc. 14/53). The fishery being without major discarding problems or variable misreporting, reported catches were entered into the model as error-free.

Absolute biomass estimates had relatively high variances. For management purposes, it was therefore desirable to work with biomass on a relative scale in order to cancel out the uncertainty of the "catchability" parameters (the parameters that scale absolute stock size). Biomass, *B*, was thus measured relative to the biomass that would yield Maximum Sustainable Yield, B_{msy}. The estimated fishing mortality, *F*, refers to the removal of biomass by fishing and is scaled to the fishing mortality at MSY, F_{msy}. The state equation describing stock dynamics took the form:

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

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

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

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

The observation error terms, *ω*, *κ*, *η* and *ε* are treated as normally, independently and identically distributed with mean 0 and variances (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 previous assessments.

Table 6.2. Shrimp in ICES SA I and II : Summary of parameter estimates: mean, standard deviation (sd) and quartiles of the posterior distributions of selected parameters (symbols are as in the text; r = intrinsic growth rate, P_0 = the 'initial" stock biomass in 1969).

	Mean	**sd**	**25 %**	**Median**	**75 %**
MSY (ktons), maximum sustainable yield	269	193	122	220	369
K (ktons), carying capacity	3426	1809	2050	3031	4394
r, intrinsic growth rate	0.32	0.16	0.20	0.32	0.43
q_R, catchability of survey 2	0.11	0.08	0.06	0.09	0.14
q_{Ru}, catchability of survey 1	0.29	0.20	0.15	0.23	0.36
q_E, catchability of survey 3	0.18	0.12	0.09	0.14	0.23
q_C, catchability of CPUE index	4.1E-04	2.8E-04	2.2E-04	3.3E-04	5.2E-04
P_0, initial relative biomass (1969)	1.51	0.26	1.33	1.50	1.68
P_{2014}, relative biomass in 2014	1.53	0.42	1.25	1.50	1.76
σ_R, coefficient of variation for survey 2	0.17	0.03	0.15	0.17	0.19
σ_{Ru}, coefficient of variation for survey 1	0.34	0.05	0.30	0.33	0.37
σ_E, coefficient of variation for survey 3	0.19	0.04	0.16	0.18	0.21
σ_C, coefficient of variation for CPUE index	0.14	0.02	0.12	0.13	0.15
σ_P, coefficient of variation for process	0.19	0.03	0.17	0.19	0.21

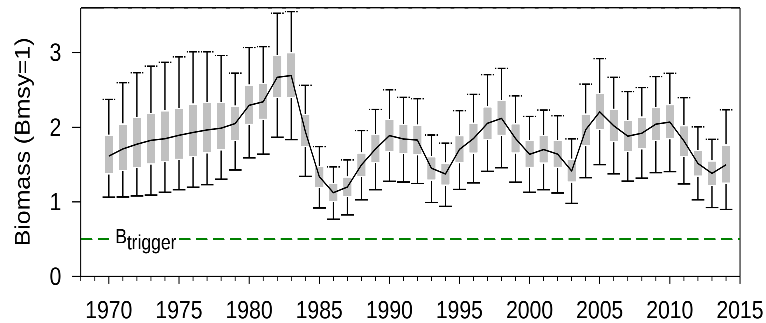
Reference points. Four reference points are considered: F_{msy}, $B_{trigger}$, F_{lim} and B_{lim}. In the present assessment, F_{msy} directly as is the probability of exceeding reference points. "buffer" reference points are obsolete due to the available risk analyses. B_{lim} is set at 30% B_{msy} (NIPAG, 2006), $B_{trigger}$ at 50% B_{msy} and F_{lim} at 1.7F_{msy} (NIPAG, 2010).:

	Type	Value	Technical basis
MSY approach	$B_{trigger}$	$0.5B_{MSY}$*	Approximately corresponding to10th percentile of the B_{MSY} estimate
	F_{MSY}	*	Resulting from the production model.
Precautionary approach	B_{lim}	$0.3B_{MSY}$	The B where production is reduced to 50% MSY
	F_{lim}	$1.7F_{MSY}$	the F that drives the stock to B_{lim}

d) Assessment Results

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

Stock size and fishing mortality. A steep decline in stock biomass in the mid-1980s was noted following some years with high catches and the median relative biomass dropped nearly to 1 (Fig. 6.10, upper). Since the late 1980s, however, the stock has varied with a slightly increasing trend. The median 2013-14 values are above Bmsy. The estimated risk of stock biomass being below $B_{trigger}$ in 2014 was less than 1% (Table 6.3). The median estimate of fishing mortality has remained below Fmsy throughout the history of the fishery (Fig. 6.10 lower). In 2014, there is a less than 5% risk of the F being above Fmsy (Table 6.3).



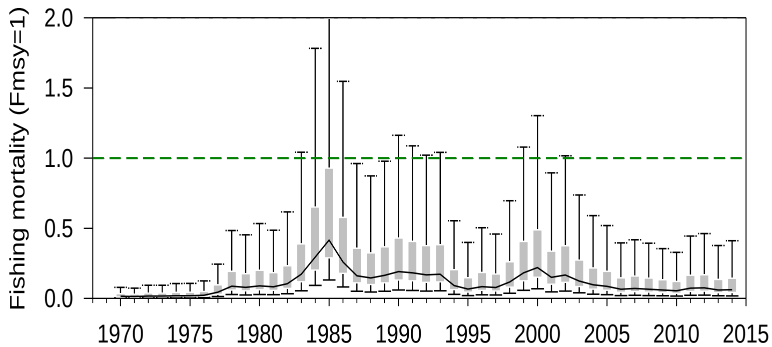


Fig. 6.10. Shrimp in ICES SA I and II: estimated relative biomass (B/B_{msy}) and fishing mortality (F/F_{msy}) for 1970–2014. Boxes represent inter-quartile ranges and the solid black line in the middle of each box is the median; the arms of each box cover the central 90% of the distribution. The broken lines are the $B_{trigger}$ and F_{msy} references respectively.

Table 6.3. Shrimp in ICES SA I and II: stock status for 2013 and predicted to the end of 2014.

Status	2013	2014*
Risk of falling below B_{lim}	0.0 %	0.0 %
Risk of falling below $B_{trigger}$	0.1 %	0.3 %
Risk of exceeding F_{MSY}	1.1 %	1.3 %
Risk of exceeding F_{lim}	0.6 %	0.7 %
Stock size (B/Bmsy), median	1.38	1.50
Fishing mortality (F/Fmsy),	0.06	0.06
Productivity (% of MSY)	85 %	75 %

*Predicted catch = 21 ktons

Predictions. Assuming a catch of 21 kt for 2014, catch options up to 70 kt for 2015 and 2016 have low risks of exceeding F_{msy} (<10%), F_{lim} (<5%), and of going below $B_{trigger}$ (<1%) in 2016 (Table 6.4) and all are likely to result in stock increase. At 90 kt the risk of exceeding F_{msy} is <15% and that of going below $B_{trigger}$ is <5% but that of tranfressing F_{lim} exceeds 5%.

Table 6.4. Shrimp in ICES SA I and II: Predictions of risk and stock status in 2016 associated with six optional catch levels for 2015—16.

	Catch option 2015-16 (ktons)					
	30	40	50	60	70	90
Risk of falling below B_{lim}	0.0 %	0.1 %	0.1 %	0.1 %	0.2 %	0.2 %
Risk of falling below $B_{trigger}$	0.6 %	0.7 %	0.8 %	0.9 %	0.9 %	1.1 %
Risk of exceeding F_{MSY}	2.5 %	3.6 %	5.2 %	6.4 %	8.3 %	12.0 %
Risk of exceeding F_{lim}	1.2 %	1.7 %	2.6 %	3.4 %	4.0 %	6.2 %
Stock size (B/Bmsy), median	1.65	1.63	1.62	1.61	1.59	1.56
Fishing mortality (F/Fmsy),	0.08	0.11	0.14	0.17	0.20	0.26
Productivity (% of MSY)	58 %	61 %	61 %	63 %	65 %	69 %

The risks associated with ten-year projections of stock development assuming annual catch of 30 000 to 90 000 t were investigated (Fig. 6.11). For all options the risk of the stock falling below $B_{trigger}$ in the longer term (10 years) is less than 10%. Catch options up to 60 000 t, have a low risk (<10%) of exceeding F_{MSY} after 10 years. Taking up to 90 000 t/yr will increase the risk of going above F_{msy} by the end of the ten-year projection to around 15%.

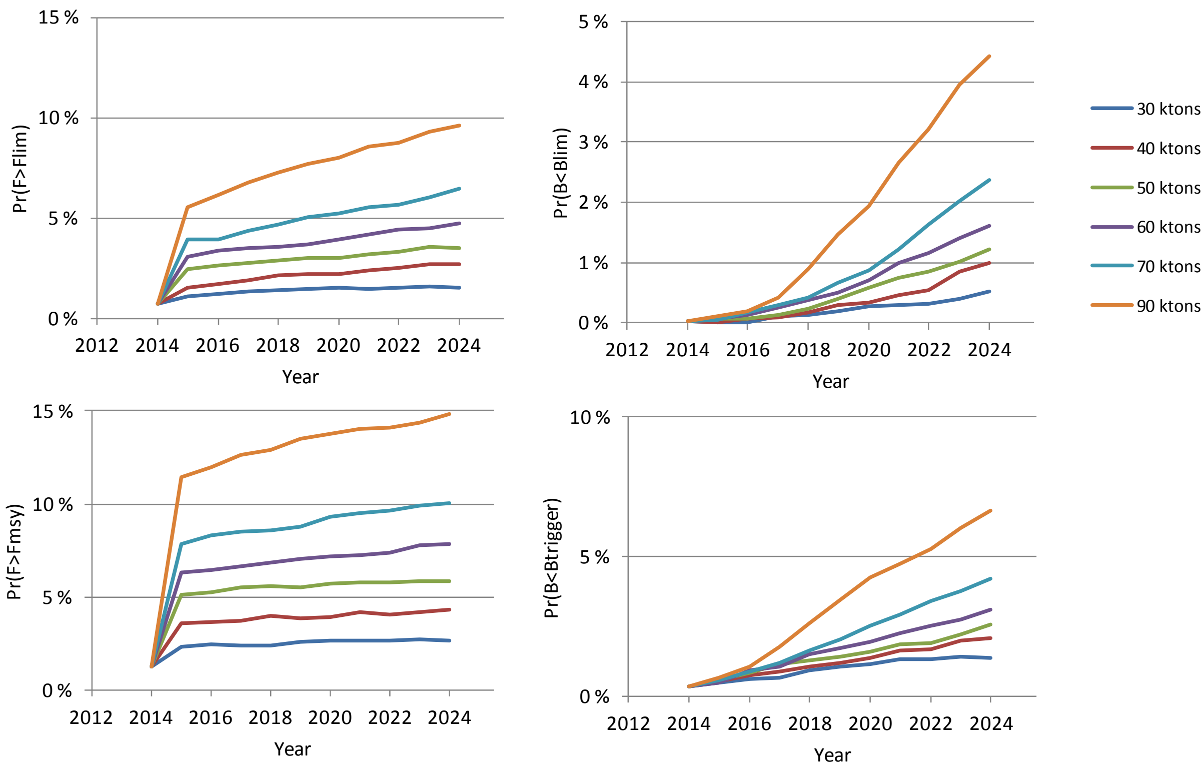


Fig. 6.11. Shrimp in ICES SA I and II: Projections of estimated risk of going below $B_{trigger}$ and B_{lim}, and of exceeding F_{msy} and F_{lim}, given different catch options.

Yield predictions could be made for various levels of fishing mortality (e.g. at target fishing mortality=F_{msy}) but such estimates would have high uncertainty. Instead we have estimated yields at different levels of risk of exceeding the target of F_{msy} (Table 6.5).

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	5 %	10 %	25 %	35 %	50 %
2015	45	73	151	221	290
2016	45	74	151	219	286
2017	44	73	144	205	266
2018	44	69	137	196	255
2019	42	69	133	189	245

Additional considerations

Model performance. The model was able to produce good simulations of the observed data (Fig. 6.12). The differences between observed values of biomassindices and the corresponding values predicted by the model were checked numerically. They were found not to include excessible large deviation.

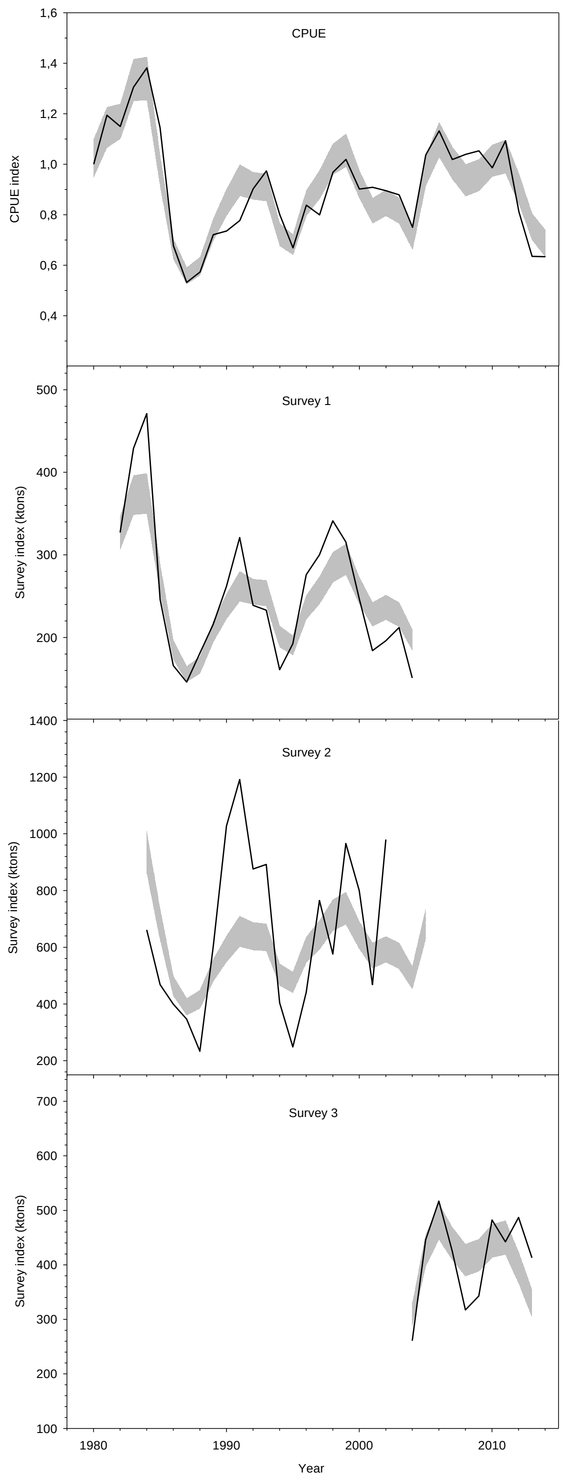


Fig. 6.12. Shrimp in ICES SA I and II: Observed (solid line) and estimated (shaded) series of the included biomass indices: the standardized catch-per-unit-effort (CPUE), the 1982–2004 shrimp survey (survey 1), a Russian survey index discontinued in 2005 (Survey 2) and the Joint Norwegian-Russian Ecosystem Survey (survey 3) until 2013. Grey shaded areas are the inter-quartile ranges of their posteriors.

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

Recruitment, and reaction time of the assessment model. The model used is best at describing trends in stock development but estimates, and uses, long-term averages of stock dynamic parameters. Large and/or sudden changes in recruitment or mortality may therefore be underestimated in model predictions. However such changes have not been observed in the recent period.

Rebuilding potential. At 30% B_{msy} (B_{lim}) production is reduced to 50% of its maximum. With an 80% confidence interval on *r* (the intrinsic rate of increase) ranging from 0.11 to 0.53 per year, it would take 4-14 years to rebuild the stock from B_{lim} to B_{msy} without a fishery.

e) Summary

Mortality. Fishing mortality has remained below F_{msy} throughout the history of the fishery. In 2014 there is a less than 5% risk of the *F* being above F_{msy}.

Biomass. Stock biomass has been above $B_{trigger}$ throughout the history of the fishery. The risk that the biomass at the end of 2014 is below $B_{trigger}$ is less than 1%

Recruitment. Recruitment indices have varied without trend in 2004 – 2013.

State of the Stock. The stock has declined since 2010, when it is estimated to have been close to the carrying capacity. Stock biomass is however estimated to be still well above $B_{trigger}$. The risks of stock biomass being below $B_{trigger}$ or of fishing mortality being above F_{msy} at the end of 2014 are both less than 5%.

Yield. Catch options up to 70 000 t/yr, have a risk below 10% of exceeding F_{msy} and below 5% of exceeding F_{lim} in the coming 2 years. At a higher risk larger yields may be achieved. E.g. catches of more than 200 kt can be taken without exceeding the median estimate of F_{msy}.

Special Comment. In recent years the distribution of the stock has changed, and some of the traditional fishing grounds are now less attractive to the fishery. Access to certain other fishing grounds is restricted by closures to prevent bycatch, and by regulations requiring vessels to sail long distances to specified entry and exit points of the Russian EEZ.

f) Review of Recommendations from 2012-13

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 Joint Norwegian – Russian Ecosystem Survey.***

STATUS: There has been no progress on this recommendation.

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

STATUS: There has been no progress on this recommendation.

- *Work to include explicit information on recruitment in the assessment model should be continued.*

STATUS: There has been no progress on this recommendation.

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 since 1972 (SCR Doc. 09/69). Total reported landings have fluctuated between zero since 2006 to above 8 000 t (Figure 7.1). 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.

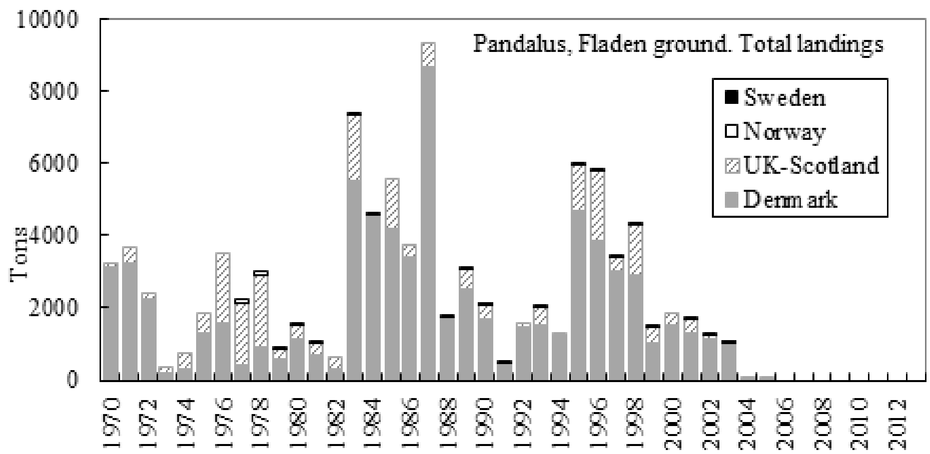


Fig. 7.1. Northern shrimp in Fladen Ground: Catches

IV. OTHER BUSINESS

1. FIRMS Classification for NAFO Shrimp Stocks

The table as agreed in June was updated with the agreed classifications for the Northern shrimp stocks assessed this year.

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

[1] Assessed as Greenland halibut in Div. 1A inshore
[2] Fishing mortality may not be the main driver of biomass for Div. 3M Shrimp

2. Future Meetings

An invitation was made to the group from Canada-Newfoundland and Labrador to host the September 2015 SC / NIPAG meeting in St. John’s, NL, Canada. This suggestion was warmly received by NIPAG.

3. Chairs of Future Meetings

NIPAG considered the succession of the chairmanship and decided to accept an offer from Peter Shelton to continue for one more year, and to reconsider the question in 2015.

4. Development of a management plan for Norwegian Deep and Skagerrak Shrimp Fishery

NIPAG was informed that Norway has taken the first steps toward developing a management plan for the shrimp stock in Skagerrak and the Norwegian Deep, with a view towards eventually also soliciting cooperation from EU (Denmark) and EU (Sweden). In discussions, it was observed that active participation of the fishery and its managers would be essential and should be immediately enlisted. Information was exchanged on sources of information for possible content and structuring of fishery management plans.

5. SC/NIPAG Intersessional Workshop on Recruitment Signals

Scientific Council will hold an intersessional meeting by correspondence to investigate the appropriate recruitment signal which can be used in prediction, taking into account environmental and trophic factors. This was proposed to be hosted by the NAFO Secretariat using Webex.

V. ADJOURNMENT

The NIPAG meeting was adjourned at 1500 hours on 17 September 2014. 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. Special thanks were given to the Greenland Institute of Natural Resources (Pinngortitaleriffik) for their hospitality during this meeting.