Northwest Atlantic Fisheries Organization

International Council for the Exploration of the Sea
Conseil International pour l'Exploration de la Mer

NAFO SCS Doc. 06/27 **Serial No. N5336** **ICES CM 2006/ACFM:37**

REPORT OF THE NAFO/ICES *PANDALUS* ASSESSMENT GROUP
25 October-2 November 2006
(Prepared by NAFO and ICES[1])

Page

[1] NAFO. ICES. 2006. Report of the NAFO/ICES Pandalus Assessment Group. 25 October-2 November 2006. NAFO SCS Doc. 06/27. ICES CM 2006/ACFM:37. 64 pp.

REPORT OF THE NAFO/ICES *PANDALUS* ASSESSMENT GROUP

Co-Chairs: Don Power (NAFO Stocks) and Michaela Aschan (ICES Stocks) Rapporteur: Various

I. OPENING

The NAFO/ICES *Pandalus* Assessment Group (hereafter 'NIPAG') met at ICES Headquarters, Copenhagen, Denmark, during 25 October-2 November 2006 to consider and report on matters referred to it by the NAFO Scientific Council and ICES ACFM, in particular, to those pertaining to the provision of scientific advice on certain *Pandalus* stocks in the North Atlantic. Members of the NAFO Standing Committee on Fisheries Science (STACFIS) and the ICES Working Group on *Pandalus* Stocks (WGPAND) were in attendance with representation from Canada, Denmark (in respect of Greenland), European Union (Denmark, Estonia, Spain, Sweden), Iceland, Norway, and Russian Federation. The Co-Chairs, Don Power (Canada – STACFIS) and Michaela Aschan (Norway – WGPAND), opened the meeting on 25 October 2006 and welcomed the participants.

It was announced that it had been agreed by the Co-Chairs to produce a single report for this year rather than separate reports that had been produced since the joint meeting was initiated in November 2004. The Co-Chairs provided participants with details of the report format, which more closely follows the NAFO style and would be compiled by the NAFO Secretariat. The provisional STACFIS agenda was reviewed as the basis of an agenda for NIPAG. It was agreed to adopt this agenda and a plan of work was developed for the meeting. This meeting included the ICES *Pandalus* Assessment Working Group (WGPAND) and dealt with the Terms of Reference for WGPAND as agreed by the ICES Council (C. Res. 2005/2/ACFM16). It was also agreed between the chairs that NAFO stocks will be chaired by the STACFIS Chair and the ICES stocks will be chaired by the WGPAND Chair.

II. GENERAL REVIEW OF NAFO STOCKS

1. Review of Recommendations in 2005 and in 2006

The recommendations from last year were reviewed on a stock-by-stock basis.

a) STACFIS Recommendations in November 2005

i) For Northern Shrimp in Division 3M (NAFO SC Rep. 2005:235)

- *Biological and CPUE data from all fleets fishing for shrimp in the area, be submitted to Designated Experts by 1 September 2006.*

STATUS: There was an improvement for this assessment but there were still data arriving just before the meeting.

- *Indices of female stock size be presented with error bars where possible.*

STATUS: This was completed for the RV data.

- *The relationship between the recruitment index and fishable biomass be investigated further.*

STATUS: No progress.

ii) For Northern Shrimp in Divisions 3LNO (NAFO SC Rep. 2005:244)

- *Ogmap should be reviewed further to determine whether it is an appropriate method to determine Div. 3LNO shrimp biomass/abundance indices from stratified random surveys.*

STATUS: The Co-Chair (NAFO) pointed out that this method was published in the NAFO Journal (*JNAFS* (2000) 27:133-138) and as such, NIPAG accepted that this model-based approach was adequately reviewed as a method to derive abundance/biomass indices from stratified random surveys.

- *Biological and CPUE data from all fleets fishing for shrimp in the area, be submitted to the Designated Expert, in the standardized format, by 1 September 2006.*

STATUS: There was an improvement for this assessment but there were still data from arriving just before the meeting.

iii) **For Northern Shrimp in Subareas 0 and 1** (NAFO SC Rep. 2005:257)

- *Sampling of catches by observers - essential for assessing age, size, sex composition, fecundity and frequency of spawning of the stock – should be re-established in Subarea 1.*

STATUS: No progress.

- *Ways to include the exploration of the effects of future trajectories of the cod stock on assessment predictions should be investigated and presented in 2006.*

STATUS: No progress.

- *The impact of other predators on the stock should also be considered for inclusion in the assessment model.*

STATUS: No progress.

- *The age-2 abundance index and its link to subsequent fishable biomass should be considered for inclusion in the shrimp assessment model.*

STATUS: No progress.

iv) **For Northern Shrimp in Denmark Strait and off East Greenland** (NAFO SC Rep. 2005:261)

- *A survey be conducted, to provide fishery independent data of the stock throughout its range.*

STATUS: No progress.

- *As a minimum requirement: sampling of catches by observers is required - essential for assessing age, size, sex composition, fecundity and frequency of spawning of the stock – and be re-established in the Greenland EEZ and improved in the Icelandic EEZ.*

STATUS: No progress.

b) **WGPAND Recommendations in November 2005**

i) **For Northern shrimp in the Barents Sea**

- *It was strongly recommended that the Russian and Norwegian shrimp survey should be re-instituted; if the shrimp surveys can not be re-instituted, the existing ecosystem survey should be calibrated by conducting a directed survey for shrimp in spring in a limited area in two consecutive years.*

STATUS: No progress.

- *Scientists should further investigate procedures for estimating the shrimp consumed by cod and give reliable estimates of biomass consumed.*

STATUS: New estimates for the shrimp consumption by cod were presented (SCR Doc. 06/60, 71).

- *Licensing of vessels participating in the shrimp fishery should include an obligation for all nations active in the fishery to report length and sex distributions from commercial catches.*

STATUS: No progress.

- *Work on developing and evaluating assessment methods should be contained.*

STATUS: A Bayesian production model was applied on the Barents Sea stock in the assessment for 2006 (SCR Doc. 06/64).

c) **Recommendations in September 2006**

No recommendations on the NAFO Shrimp stocks were made in September 2006.

d) **Summary Discussion**

NIPAG noted the general recommendation for each stock of submitting data to the Designated Experts by 1 September 2006 for use in assessments was not completely fulfilled for all data. The committee agreed that such recommendations should continue to be stated as a procedural item, but in practical terms, it was suggested that the Designated Experts should send a detailed communication to representatives of Contracting Parties requesting the various information with sufficient notice to enable compliance by 1 September.

2. **Review of Catches**

NIPAG reviewed and agreed on the catch figures available for all stocks being assessed at this meeting during consideration of each relevant stock. It was also noted that there was suspected misreporting occurring between the fishery catches in Div. 3M and 3L and this had been taken into account into those assessments.

III. STOCK ASSESSMENTS

1. **Northern Shrimp (*Pandalus borealis*) in Flemish Cap (NAFO Division 3M) – NAFO Assessed (**SCR Doc. 06/59, 66, 67, 74, 75, 76, 77)

a) **Introduction**

The shrimp fishery in Div. 3M began in 1993. Initial catch rates were favorable and, shortly thereafter, vessels from several nations joined. Since 1993 the number of vessels ranged from 40-110, and in 2005 there were approximately 17 vessels fishing shrimp in Div. 3M compared to 50 in 2004. No information is available on the number of vessels taking part in the shrimp fishery in 2006.

Catches increased from about 27 000 t in 1993 to 48 000 t in 1996, declined to 25 000 t in 1997 then increased gradually to a peak of 63 000 t in 2003 (Fig. 1.1). In 2005, the catch declined to 32 000 t and provisional information to 1 September 2006 indicate removals of about 11 000 t. Supplementary information from the fishery suggests that economic considerations (price of fuel and market prices for shrimp) may be affecting participation in the fishery.

b) Oceanographic Overview

The water mass characteristics of the Flemish Cap are derived from a mixture of Labrador Current Water and North Atlantic Current Water, resulting in a water mass that is generally warmer (3°-4°C) and saltier (34-34.75‰) than the adjacent sub-polar shelf waters of the Grand Banks. The general circulation consist of the offshore branch of the Labrador Current which flows through the Flemish Pass on the Grand Bank side and a branch that flows to the east, north of the Flemish Cap, which then flows southward. To the south, the Gulf Stream flows to the northeast merging with the Labrador Current to form the North Atlantic Current which influences waters around the southern areas of the Flemish Cap. In the absence of strong wind forcing the circulation over the bank is dominated by a topographically induced clockwise (anti-cyclonic) gyre. The stability of this circulation pattern may influence the retention of ichthyoplankton on the bank and is probably a factor in determining the year-class strength of shrimp in the area. Estimates of currents from TS data indicate that the circulation pattern around the Cap was dominated by a clockwise gyre circulation with an increase in strength during the summer of 2006 compared to that of 2005. In general, the colder-than-normal temperatures experienced over the continental shelf and on the Flemish Cap from the late 1980s up to the mid-1990s moderated by the summer of 1996 and continued to warm until 1999, after which they decreased slightly until 2002. From 2003-2005 most areas of the water column again experienced an increase in both temperature and salinity with near bottom temperatures exceeding 4°C, which were above normal by 1°C. By the summer of 2006 near-bottom temperatures had decreased slightly over 2005 values, while surface temperatures increased to a near-record value of 3°C above the long-term average. Salinities over most of the water column during the summer of 2002-2005 were generally saltier-than-normal but decreased to near-normal values in 2006. During 2006 chlorophyll levels in the upper 100-m of the water column were higher compared to the adjacent Grand Bank indicating enhanced productivity potential over the Flemish Cap (SCR Doc. 06/75).

c) Input Data

Recent catches and TACs (metric tons) are as follows:

	1998	1999	2000	2001	2002	2003	2004	2005	2006[2]	2007
Recommended TAC	-	30 000	30 000	30 000	45 000	45 000	45 000	45 000	48 000	48 000
STATLANT 21A	30 035	42 041	50 471	53 793	47 299[1]	50 550[1]	43 953[1]	22 325[1]		
NIPAG	30 308	43 438	52 664	52 671	48 704	63 226	45 543	31 862	(10 800[2])	

[1] Provisional;
[2] Preliminary to 1 September 2006.

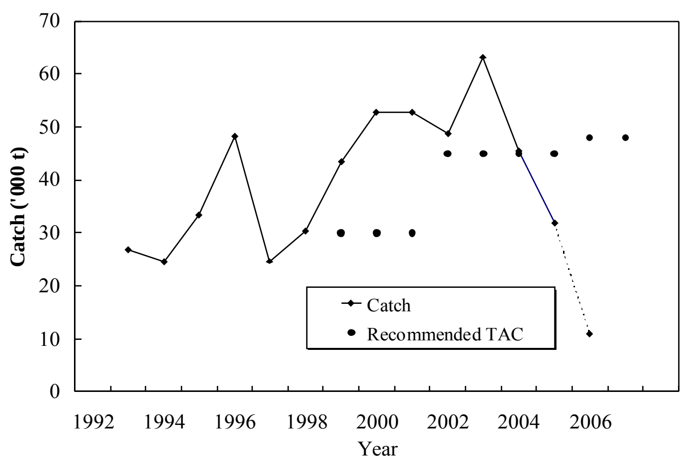


Fig. 1.1. Shrimp in Div. 3M: catches (2006 preliminary).

i) **Commercial fishery data** (SCR Doc. 06/59, 67, 74, 76, 77)

Effort and CPUE. Logbook and/or observer data were available from Canadian, Greenlandic, Icelandic, Faroese, Norwegian, Russian and Estonian vessels. There were concerns that suspected misreporting of some catches in 2006 and possibly in earlier years (Div. 3L catches being reported as Div. 3M catches), was affecting the CPUE data for some shrimp fleets fishing in these areas. In addition, there was also some uncertainty around the catch rate standardization model used for Div. 3M. As a result of these concerns, NIPAG decided that it was not possible to accept the standardized CPUE and effort data from the fisheries in Div. 3M as being indicative of stock dynamics.

Biological data. The age composition was assessed from commercial samples obtained from Iceland from 2003 to 2006 and from Canada, Greenland, Russia and Estonia in previous years. A few samples were obtained from Spain for 2005 and Ukraine in 2006. Only those samples thought to be correctly attributed to Div. 3M were utilized. Number caught per age-class was calculated for each year-class by applying a weight/age relationship and the total number as calculated from the nominal catch. A percentage at age frequency was then obtained for each year from 1996-2006.

The percent catch-at-age data showed a dominance of 1-4 year-olds (predominantly the male component) in the same length classes which indicate the presence of the 2002 year-class in the Icelandic samples (Table below). The results indicate that ages 3, 4 and 5 generally dominate the commercial catch in numbers. By weight the 6 year-olds are also considered important in the fishery although generally smaller in numbers. The 2002 year-class seems to be very prominent as 3 year-olds in the 2005 fishery and as 4 year-olds in 2006. It shall be important in the fishery in 2007 but less important in year 2008. The number of 2 year-olds is about average in 2005 and not visible in catches in 2006 pointing to recruitment being very low in that year. The 2002 year-class appears to be growing very slowly as seen when the monthly increments are studied in the years 2005 and 2006. This may be caused by the exceptionally high numbers of that year-class judging from the first quarter of the year 2006.

Due to problems associated with misreporting of catch and effort between Div. 3L and 3M, indices derived from the number per hour could not be used this year.

Numbers (%) at age caught in the commercial fishery:

Age Group	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	Mean
1	0.0	0.02	0.0	0.01	0.0	0.0	0.03	0.9	0.0	0.0	0.0	0.1
2	6.2	5.2	6.0	4.7	1.6	10.4	6.0	11.1	15.8	6.1	0.0	6.6
3	65.2	41.4	34.9	27.8	32.8	13.9	51.0	12.3	37.2	39.4	8.3	33.1
4	19.9	43.0	40.8	32.2	38.1	44.6	17.4	49.0	13.3	34.4	71.7	36.8
5	5.7	8.4	13.0	25.9	22.5	23.5	21.0	19.1	28.1	16.4	13.5	17.9
6	3.0	1.7	4.8	9.3	4.7	6.7	4.3	7.5	5.5	3.2	6.0	5.2
7	0.0	0.1	0.5	0.1	0.2	0.9	0.2	0.1	0.0	0.5	0.4	0.3
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

ii) **Research survey data** (SCR Doc. 06/66)

EU bottom trawl surveys. Stratified-random surveys have been conducted on Flemish Cap in July from 1988 to 2006. A new vessel was introduced in 2003 which continued to use the same trawl employed since 1988. In addition, there were differences in cod-end mesh sizes utilized in the 1994 and 1998 surveys that have likely resulted in biased estimates of total survey biomass. Nevertheless, for this assessment, the series prior to 2003 were converted into comparable units with the new vessel based on the methodology accepted by STACFIS in 2004 (NAFO 2004 SC Rep., SCR Doc. 04/77). The revised index of female shrimp biomass reveals a rapid increase from the lowest observed level in 1990 to a 10-fold increase in 1992 followed by an equally dramatic decline to 1994. The index was stable at a relatively low level between 1994 and 1997; then increased to a higher level with fluctuation between 1998 and 2006 (Fig. 1.2).

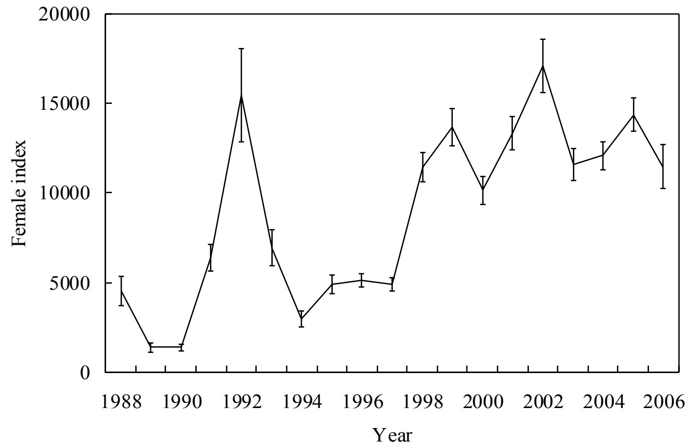


Fig. 1.2. Shrimp in Div. 3M: female biomass index from EU trawl surveys, 1988-2006.

iii) **Recruitment indices**

EU bottom trawl surveys. From 1988 to 1995 shrimp age 2 and younger were not captured by the survey. Beginning in 1996 the presence of this component increased in the surveys and it is believed that the introduction of the new vessel in 2003 greatly improved the catchability of age 2 shrimp due to technological advances in maintaining consistent performance of the fishing gear. In addition, since 2001, a small mesh juvenile bag was also attached to the net which was designed to provide an index of juvenile shrimp smaller than that typically retained by the survey cod-end. Both indices do not show a good relationship with the 3+ survey index either 2 or 3 years later. This may be because there are only limited data points for a valid comparison. The recruitment indices for both 2005 and 2006 are low in the main gear as well as in the juvenile bag (Fig. 1.3).

Commercial fishery. The percentage of 2 year-olds in the commercial fishery has been declining since 2004 (see table above). These results correspond with estimates from the EU surveys for the last couple of years.

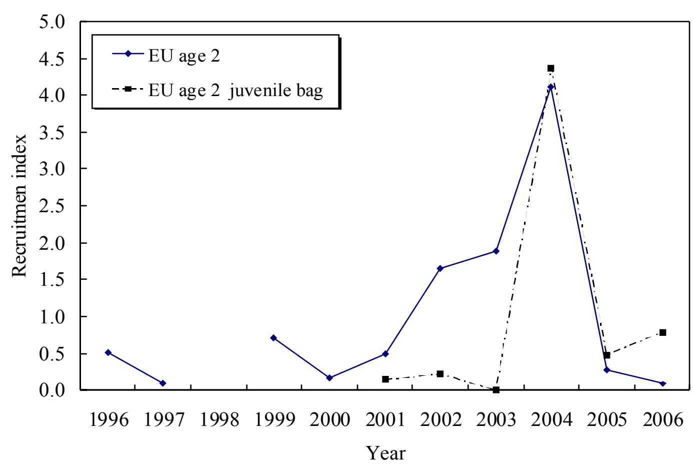


Fig. 1.3. Shrimp in Div. 3M: abundance indices at age 2 from the EU survey. Each series was standardized to its mean.

d) **Parameter Estimation**

The total mortality rate from the EU trawl survey was calculated by comparing the abundance of age 4-7 year-olds in year *t*+1 with the abundance of age 3-6 year-olds in the year *t*. Although there are noticeable year effects, for 1993 to 2006, total mortality rates averaged 0.66 (Fig. 1.4).

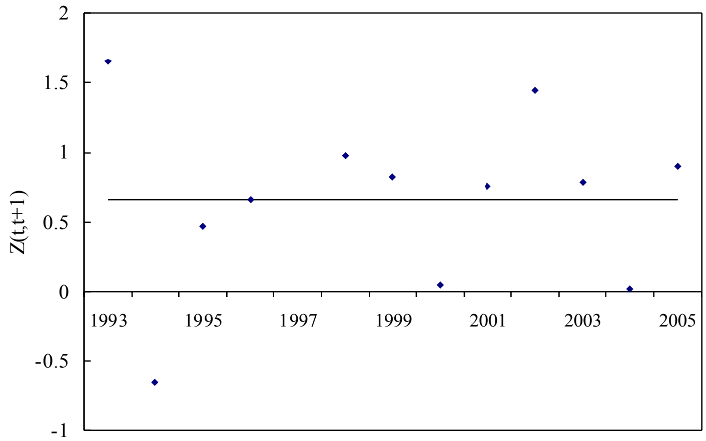


Fig. 1.4. Shrimp in Div. 3M: total annual mortality rates for 3-6 year-old shrimp in EU trawl surveys, 1993-2006.

In last years assessment, an index of 2 year-old shrimp from 1996-2005 based on standardized number per hour correlated well with a similar index derived for 3+ year-olds (a proxy for the fishable biomass) from the fishery two years later. Due to concerns about misreporting between Div. 3M and 3L, NIPAG did not accept the CPUE series on which these were based.

e) **Assessment Results**

NIPAG concluded that due to problems in suspected misreporting and its effect on various indices derived from the commercial fishery the basis for advice for the shrimp stock in Div. 3M is the EU survey, as well as general inferences about age composition of shrimp in the fishery.

Biomass. The female biomass increased from 1997 and has fluctuated without trend since then.

Recruitment. The 2002 year-class appears to be large, but the 2003 and 2004 year-classes appear weak.

State of the Stock. The indices of biomass are at a relatively high level but there are indications of a decline in recruitment, which may affect the 2008 fishery.

NIPAG considers it important to recognize that its ability to assess the resource will improve with the continuation of a series of research surveys directed for shrimp, especially if appropriate measures to sample juvenile shrimp are applied.

f) **Precautionary Approach**

NIPAG noted that the Scientific Council Study Group on Limit Reference Points, recommended that survey biomass indices could be used to indicate a limit reference point for biomass, in situations where other methods were not available (SCS Doc. 04/12). In such cases, "the point at which a valid index of stock size has declined by 85% from the maximum observed index level provides a proxy for B_{lim}". B_{lim} is defined as a biomass level, below which stock productivity is likely to be seriously impaired, that should have a very low probability of being violated.

The limit reference point for the Flemish Cap shrimp stock is taken from the EU survey where the biomass index of female shrimp is used. The EU survey of Div. 3M provides an index of female shrimp biomass from 1988 to 2006 with a maximum value of 17 100 t in 2002, (and a similar value of 15 500 in 1992). An 85% decline in this value would give a B_{lim} = 2 600 t. The female biomass index was below this value in only 1989 and 1990, before the fishery, and in 2004-2005 was about 30-32% below the maximum. If this method is accepted to define B_{lim}, then it appears unlikely that the stock is below B_{lim} at the present time (Fig. 1.5).

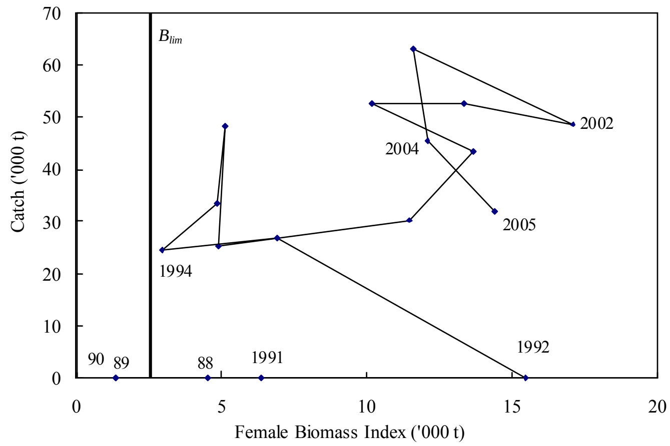


Fig. 1.5. Shrimp in Div. 3M: catch plotted against female biomass index from EU survey. Line denoting B_{lim} is drawn where biomass is 85% lower than the maximum point in 2002. Not updated for 2006 due to incomplete catch.

g) **Research Recommendations**

NIPAG **recommends** that, for shrimp in Div. 3M:

- *biological and CPUE data from all fleets fishing for shrimp in the area, be submitted to Designated Experts by 1 September 2007.*
- *the catch and effort data from other sources, for example VMS and/or Observer data, be fully investigated to validate existing CPUE data obtained from summarized logbooks or STATLANT data in order to provide a reliable standardized CPUE index.*
- *the relationship between the recruitment index and fishable biomass be investigated further.*

2. Northern Shrimp (*Pandalus borealis*) in Grand Banks (NAFO Divisions 3L, 3N and 3O) – NAFO Assessed (SCR Doc. 06/11, 59, 67, 69, 73, 77, 79, 80)

a) **Introduction**

This shrimp stock is distributed around the edge of the Grand Banks mainly in Div. 3L. The fishery began in 1993, and in 2000, the fishery came under TAC control with a 6 000 tons TAC and fishing restricted to Div. 3L. Annual TACs were raised to 13 000 t for the 2003-2005 fisheries and raised again to 22 000 t for the 2006 fishery resulting in a total catch of 23 886 t (Fig. 2.1).

Since this stock came under TAC regulation Canada has been allocated 83% of the TAC. The Canadian allocation is split between a small vessel (less than 500 t and less than 63 ft) and large vessel fleet. By October 2006, the small and large vessel fleets had taken 11 946 and 3 868 tons of shrimp respectively in Div. 3L. In all years, most of the Canadian catch occurred along the northeast slope in Div. 3L.

Sixteen contracting parties have reported catches the NRA since 2000. The annual quota within the NRA is 17% of the total TAC and is meant to be split evenly among these nations; however, over the period 2003-

2005, Denmark (in respect of the Faroe Island and Greenland) set autonomous annual TAC of 1 344 tons. This autonomous TAC was raised to 2 274 tons during 2006.

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.

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

	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
TAC	-	-	6 000	6 000	6 000	13 000	13 000[1]	13 000[1]	22 000[1]	22 000
STATLANT 21A	567	795	4 930	5 323	5 697[2]	11 016[2]	11 660[2]	13 943[2]		
STACFIS	567	795	4 896	10 566[3]	6 977[3]	11 947	12 620	14 137	23 886[3]	

[1] Denmark (in respect of Faroe Islands and Greenland) set an autonomous TAC of 1 344 tons for 2003-2005, that was raised to 2 274 tons during 2006;

[2] Provisional catches;

[3] Reliable catch reports were not available for all countries therefore estimates were made using other sources (Canadian surveillance, observer datasets, NIPAG estimation, etc.)

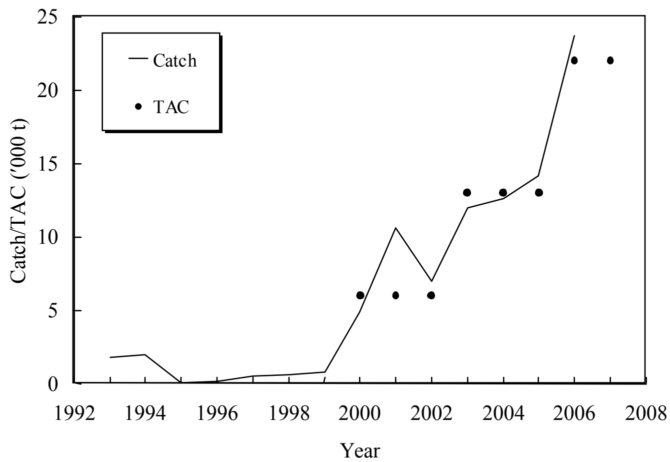


Fig. 2.1. Shrimp in Div. 3LNO: catches (to October 2006) and TAC.

b) **Oceanographic Overview** (SCR Doc. 06/11, 79)

The water mass characteristics on the Grand Banks are typical of sub-polar waters with a cold-intermediate-layer (CIL) that extends to the bottom in northern areas with average bottom temperatures generally <0°C during most of the year. Bottom temperatures increase to 2°-4°C in southern areas due to atmospheric warming in shallow waters and along the slopes of the banks below 200-m depth due to the presence of warmer Labrador Slope Water. On the southern slopes of the Grand Banks in Div. 3NO bottom temperatures may reach 4°-8°C due to the influence of Gulf Stream Water from the south. The general circulation in this region consists of the relatively strong Labrador Current at the shelf break and a weaker branch near the coast in the Avalon Channel. Currents over the banks are very weak and the variability from winds and tides often exceeds the mean flow. The winter formed CIL water mass which is a robust index of ocean climate conditions, was below-normal (implying warm conditions) across the Grand Bank for the 9th consecutive year in 2006, ranking the 5th lowest in the 56 year time series. The average bottom temperature for Div. 3LNO shows large inter-annual variations and a downward trend that started in 1984 and continued until the early 1990s. Recently, temperatures have increased over the sub-zero values of the early 1990s with the average bottom temperature during the spring of 2004 reaching near 2.5°C, the highest since 1983. The 2005 value was slightly <2°C and the available data for the spring of 2006 indicates a further increase in bottom temperatures in 3L. From 1984-1997 there was also a large increase in the area of the bottom covered by water with temperatures <0°C, up to 60% in some years. Since 1997 there was a significant decrease in the area of <0°C water and with the exception of 2003 this area has remained <30% up to the spring of 2006, which had the 3rd lowest (<10%) in 31 years.

c) **Input Data**

i) Commercial fishery data (SCR Doc. 06/77, 59, 67, 73)

Effort and CPUE. Catch and effort data have been available from vessel logbooks and observer records since 2000. Standardized catch rates for large Canadian vessels (>500 t) have been fluctuating around the long term mean since 2000 with the 2006 catch rate index above average and similar to the 2002-2004 catch rates (Fig. 2.2). There was insufficient data to estimate a standardized CPUE index for the 2006 Canadian small vessel (<= 500 t) fleet.

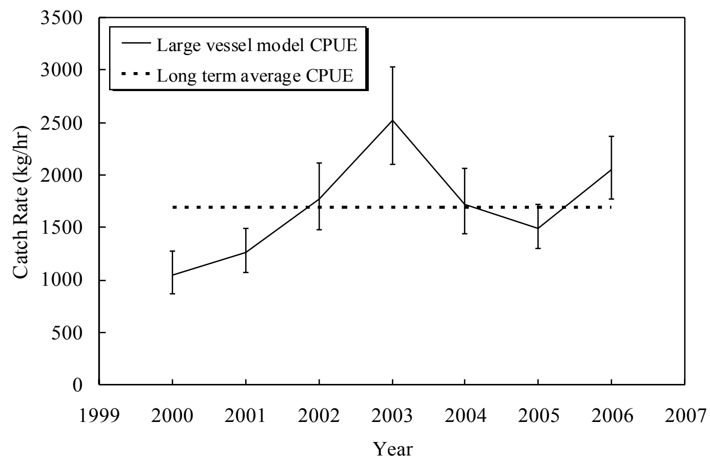


Fig. 2.2. Shrimp in Div. 3LNO: standardized CPUE for the Canadian large vessel fleet (>500 t) fishing shrimp within the Div. 3L EEZ.

Data were available from other nations fishing in the NRA (Estonia, Greenland, Iceland, Spain and the Ukraine), although the data were insufficient to produce a standardized CPUE model and there were concerns about suspected misreporting.

Sex and age composition. Catch compositions were derived from Canadian, Icelandic and Ukrainian observer datasets. In 2006, the male portion of the fishery was dominated by 2002-2003 year-class male shrimp. The female portion was still well represented.

ii) **Research survey data** (SCR Doc. 69, 73, 80)

Canadian multi-species trawl survey. Canada has conducted stratified-random surveys in Div. 3LNO, using a Campelen 1800 shrimp trawl, during spring (1999-2006) and autumn (1995-2005). The autumn survey in 2004 was incomplete and therefore had limited use in the assessment.

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

Biomass and Abundance. Based on Canadian surveys, over 90% of the biomass was found in Div. 3L, distributed mainly along the northeast slope in depths from 185-550 m. There was a significant increase in autumn shrimp biomass indices between 1995 and 2001 and this index has since remained at a high level (Fig. 2.3). The autumn 2005 index was 264 000 t (53 billion individuals), the highest in the autumn time series.

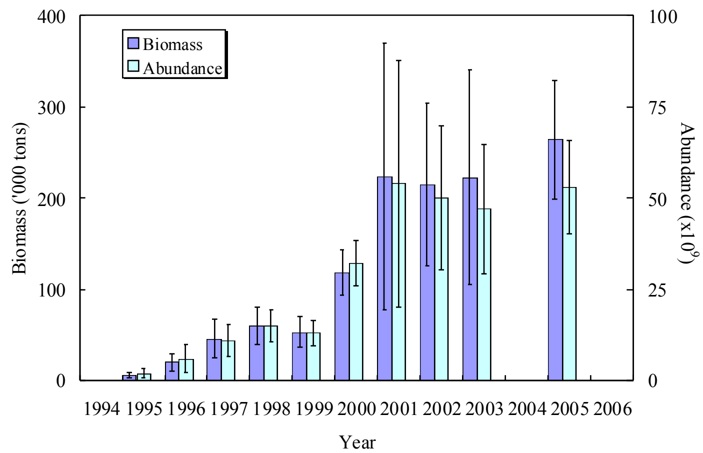


Fig. 2.3. Shrimp in Div. 3LNO: biomass and abundance index estimates from Canadian autumn multi-species surveys (±95% confidence intervals).

The spring 2006 biomass index was 180 000 t (35 billion individuals), the second highest in spring time series (Fig. 2.4). Due to broad confidence limits around these estimates, spring survey indices are not thought to be as reliable as the autumn survey indices.

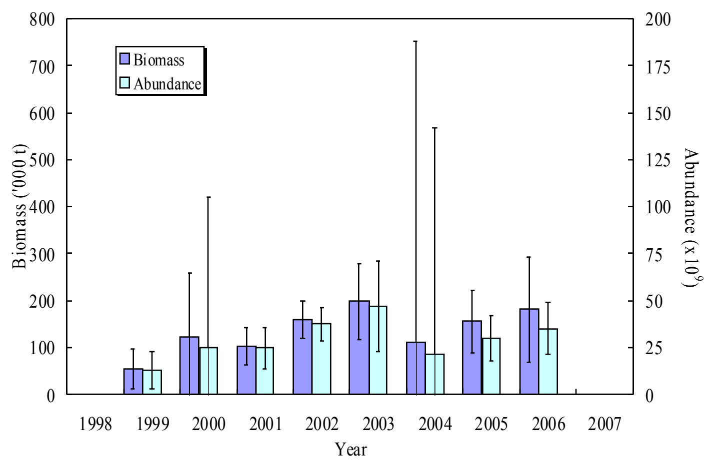


Fig. 2.4. Shrimp in Div. 3LNO: biomass estimates from Canadian spring multi-species surveys (±95% confidence intervals).

Spanish survey biomass estimates for the area within the Div. 3L NRA have been increasing since 2003 (72 000-161 000 t), while Canadian survey biomass estimates increased between 1995 and 2001 and have since fluctuated at a high level. The reason for differences between the Spanish and Canadian 3L survey biomass and abundance indices remains unresolved. Spanish and Canadian survey biomass estimates for Div. 3NO, in the NRA, have fluctuated between 400 and 3 300 t over the period 2002-2006.

Sex and age composition. The spring and autumn surveys showed an increase in the abundance of female (transitionals + females) shrimp over the full time series. Autumn male abundance indices increased until 2001 and have since remained stable at a high level while spring male abundance indices have varied over time (Fig. 2.5). This figure is different from that presented during the 2005 assessment because the 2005 abundance indices were estimated from length frequency files and a problem has been identified with the spring 2003 survey length frequency dataset. This year the abundance indices were estimated from the catch dataset.

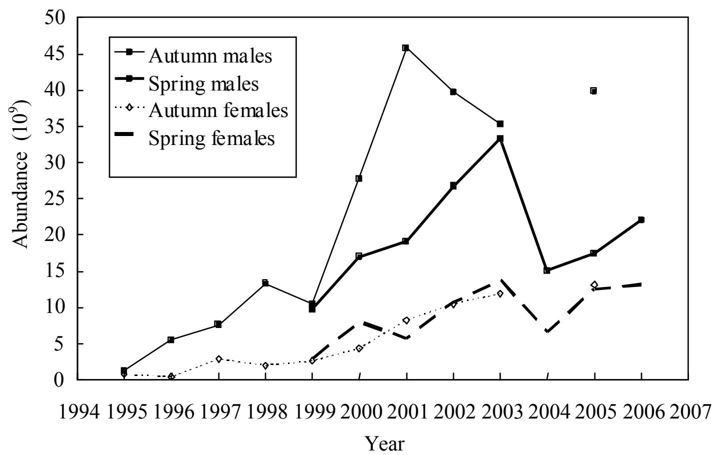


Fig. 2.5. Shrimp in Div. 3LNO: abundance indices of male and female shrimp within Div. 3LNO as estimated from Canadian multi-species survey data, using stratified areal expansion calculations.

Shrimp aged 3 and 4 dominated the male component of the length frequencies in spring 2005 (2002 and 2001 year-classes) survey with carapace length frequency modes at 16.94 and 19.55 mm respectively. Similarly, abundance estimates from the autumn 2005 survey were dominated by shrimp aged 3 and 4 (2002 and 2001 year-classes) with modes at 17.00 and 19.59 mm respectively while shrimp aged 2-4 were well represented in the spring 2006 survey (2002-2004 year-classes) (Fig. 2.6). A broad mode of females was present in all surveys indicating the presence of more than one year-class of females.

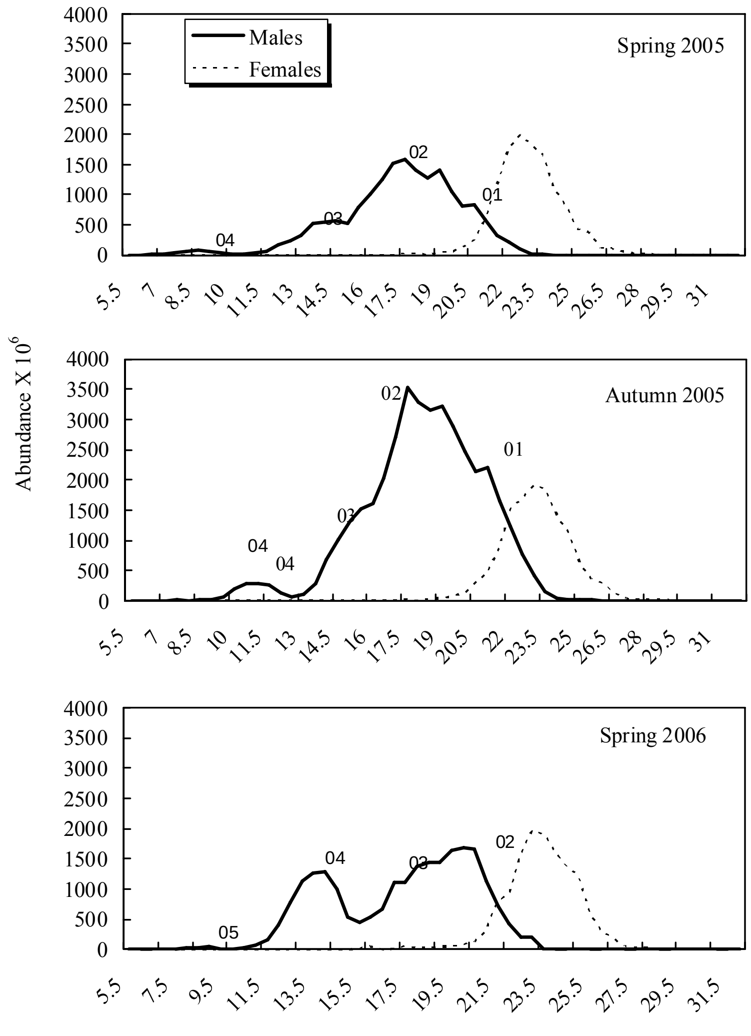


Fig. 2.6. Shrimp in Div. 3LNO: abundance at length for northern shrimp estimated from Canadian multi-species survey data using stratified areal expansion calculations.

Female Biomass Index. The autumn female biomass (transitionals and all females) index has been steadily increasing since 1999 (Fig. 2.7) while the spring survey index increased from 1999-2003 and has shown no significant change thereafter (Fig. 2.8).

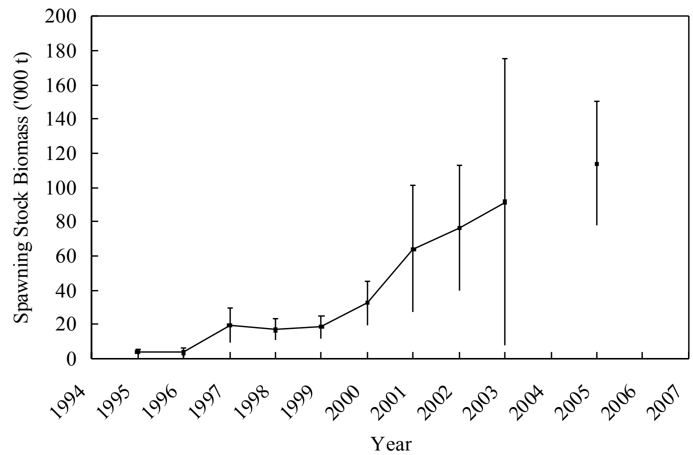


Fig. 2.7. Shrimp in Div. 3LNO: female biomass estimates from Canadian autumn multi-species surveys (±95% confidence intervals).

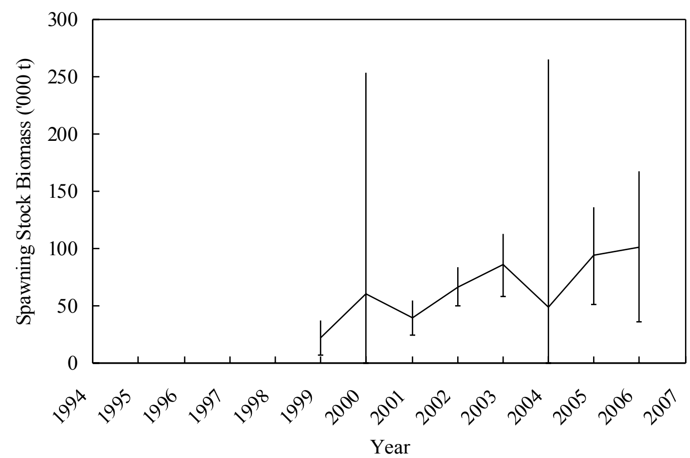


Fig. 2.8. Shrimp in Div. 3LNO: female biomass estimates from Canadian spring multi-species surveys (±95% confidence intervals).

Recruitment Index. A multiplicative model was used to estimate the relative year-class strength based upon two Canadian multi-species survey series (SCR Doc. 06/80). Recruitment indices were constructed from the autumn 1995-2005 and spring 1999-2006 surveys. Recruitment indices were based upon modal analysis of length frequencies.

For this assessment only ages 1 to 4 were used in the model. A model run using ages 1-3 had no significant difference in the year-class trend.

Model results show that year-classes prior to 1997 were weak. The 1997 to 2002 year-classes appear to be strong with the exception of the 2000 year-class which was below average. The 2003 year-class was also below the mean of the time series while the 2004 year-class was above average (Fig. 2.9).

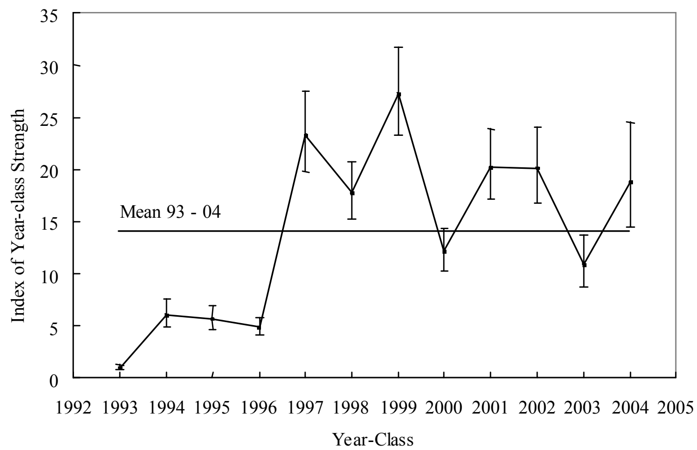


Fig 2.9. Shrimp in Div. 3LNO: index of year-class strengths as determined from Canadian autumn (1995-2005) and spring multi-species surveys (1999-2006).

Fishable biomass and exploitation. In general, the fishable biomass index (shrimp >17 mm cl) from the Canadian autumn survey (1995-2005) has been increasing since 1999 while the spring survey index increased from 1999-2003 and varied without trend thereafter (Fig. 2.10). 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 was less than 4% during 1996-99, but increased to 11-12% in 2000-2001; the first two years of TAC regulation. Even though catches increased to 23 886 t in 2006, the exploitation index remained near 11% due to the increase in fishable biomass (Fig. 2.11).

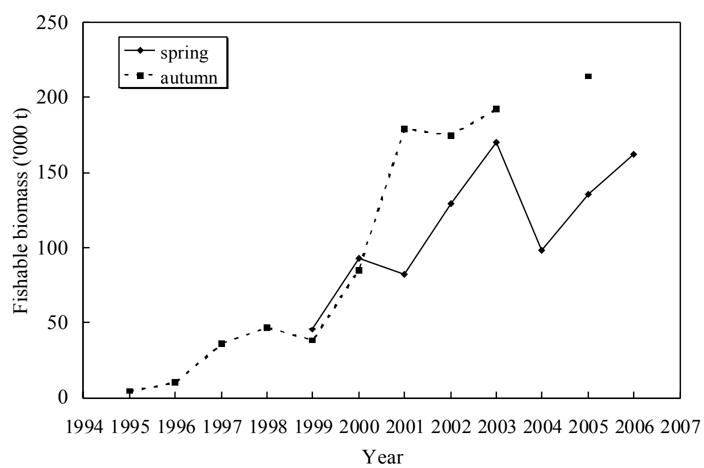


Fig. 2.10. Shrimp in Div. 3LNO: fishable biomass index. Indices were estimated using stratified areal expansion calculations.

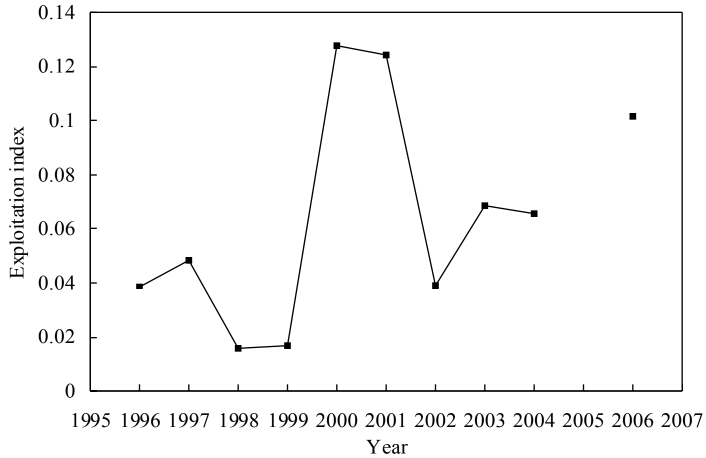


Fig 2.11. Shrimp in Div. 3LNO: exploitation rates as derived by catch divided by the previous year's autumn fishable biomass index.

iii) **Other biological studies** (SCR Doc. 06/79)

A study on the spatial distribution and abundance of northern shrimp in relation to their thermal habitat for NAFO Div. 3LNO from spring and fall multi-species surveys was conducted (SCR Doc. 06/79). Shrimp habitat preferences by temperature, season, maturity stage and age groups were investigated. The spatial distribution and abundance of northern shrimp indicate that the highest numbers of shrimp are generally found in the 2°-4°C temperature range during the spring with lower numbers in water <2°C and >4°C. During the fall most shrimp are found in a colder temperature range of 1^{o}-3^{o}C as a result of seasonal migration into the shallower colder water of the Grand Bank. The changes in distribution is not believed to be related to seasonal temperatures changes but may be related to reproductive cycles, other environmental factors, feeding behaviour or changes in trawl catchability. The average weight of individual shrimp indicates that larger shrimp (6-7 g) are associated with temperatures >3°C while smaller shrimp (4-5 g) are found in temperatures <2°C. Cumulative frequency distributions of available temperature and total catch indicate that about 90% of the shrimp were caught in the 2^{o}-4^{o}C temperature range during the spring, while only about 50% appeared in this temperature range during the fall. The distributions by age show that younger male shrimp are associated with the colder habitat in both spring and fall, although there is an overall shift into warmer waters in spring. The distributions by maturity stage show that ovigerous females are found in the deeper warmer waters along the slope of the Grand Banks compared to females that have either spawned or are developing eggs. The numbers of age-2 male shrimp from the fall surveys show a significant increase in 1999-2001 but then decreased to lower values in the most recent years. The 2-year lagged temperature measurements also show a similar pattern with spring bottom temperatures showing the strongest correlation. The numbers of fishable shrimp from the fall surveys and the Station 27 bottom temperatures at time lags of 4 and 5 years also show a significant positive correlation. The total fishable numbers of shrimp experienced a significant increase beginning in 2000 which coincided with the increase in bottom temperatures in 1996, a time lag approximately equal to the ages of commercial size shrimp. While these results indicate that the increase in temperature may have resulted in better shrimp survival in recent years, we note that the time series of survey data is too short to draw firm conclusions.

d) **Assessment Results**

Recruitment. The recruitment index derived from the year-class model estimated the 2002 and 2004 year-classes to be above average, and the 2003 year-class is below average.

Biomass. There has been a significant increase in the biomass index between 1995 and 2001 followed by stability at a high level. Autumn female biomass indices have been increasing since 1999, while spring female biomass indices increased from 1999-2003 and varied without trend thereafter.

Exploitation: The level of exploitation has not increased since TACs were set in 2000.

State of the Stock. The total biomass index and the female biomass index have been stable at a high level since 2001. The stock appears to be well represented by a broad range of size groups. The stock biomass has not declined at the observed exploitation rates. The above average recruitment in 2002 and 2004 is expected to enter the fishery in 2006 and 2008, respectively.

e) **Precautionary Approach** (SCS Doc. 04/12)

NIPAG considers that the point at which a valid index of stock size has declined by 85% from the maximum observed index level provides a proxy for B_{lim} for northern shrimp in Div. 3LNO. It is not possible to calculate a limit reference point for fishing mortality. The B_{lim} reference point is 17 100 t based on the female biomass index from the Canadian Autumn survey for shrimp in 3LNO. Currently, the female biomass index is estimated to be well above B_{lim} (Fig. 2.12).

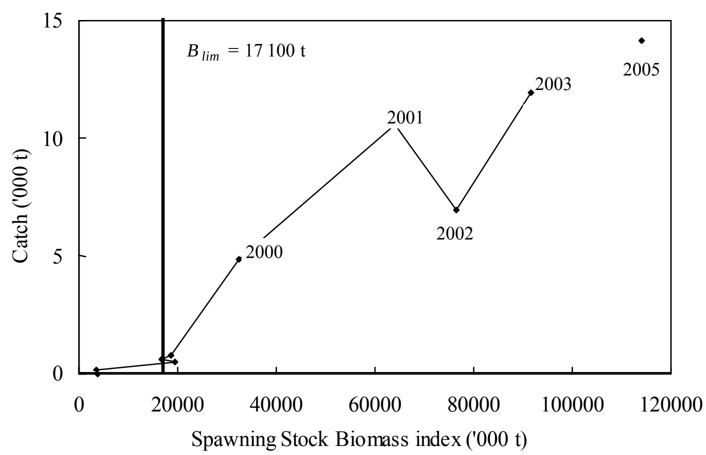


Fig 2.12. Shrimp in Div. 3LNO: Catch plotted against female biomass index from Canadian autumn survey. Solid line denoting B_{lim} is drawn where the female biomass index is 85% lower than the maximum point in 2005.

f) **Research Recommendations**

NIPAG **recommends** that, for Shrimp in Grand Banks (NAFO Divisions 3L, 3N and 3O):

- *Biological and CPUE data from all fleets fishing for shrimp in the area, be submitted to the Designated Expert, in the standardized format, by 1 September 2007.*

3. **Northern Shrimp (*Pandalus borealis*) off West Greenland (NAFO Subareas 0 and 1) – NAFO Assessed** (SCR Doc. 02/158, 04/75, 04/76, 06/57, 58, 60, 61, 68, 72; 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). To facilitate management of the fishery, Canada has defined a management unit, 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 within its whole area of distribution. The Greenland fishery exploits the stock in Subarea 1 (Div. 1A-F). Since 1981 the Canadian fishery has been limited to Div. 0A.

Three fleets, one from Canada and two from Greenland (vessels above and below 80 GRT) have participated in the fishery since the late 1970s. The Canadian fleet and the Greenland large-vessel fleet have been restricted by areas and quotas since 1977. The Greenland small-vessel fleet has privileged access to inshore areas (primarily Disko Bay); its fishing was unrestricted until January 1997, when quota regulation was imposed. Pursuant to a revised fishery agreement, Greenland now allocates a quota to EU vessels in Subarea 1. Mesh size is at least 44 mm. Sorting grids to reduce bycatch of fish are required in both the Greenland fleets (max. bar spacing 22 mm) and the Canadian fleet (28 mm). Discarding of shrimp is prohibited.

Until 2003 catches of shrimp taken in Subarea 1 were reported without accounting for either a prevalent practice of overpacking or the difference between product weight and live weight. On 1 January 2004 new legislation came into force requiring removals by fishing to be reported as live (catch) weight. To maintain consistency of management advice the annual catches from 1978 through 2003 were corrected upwards, by 22.8-25.7%; this was fully reported in the 2004 advisory document.

The advised TAC for the entire stock for 2006 was 130 000 t; the Greenland authorities set a TAC for Subarea 1 of 134 000 t, of which 74 100 t was allocated to the offshore fleet, 55 900 t to the inshore and 4 000 t to EU vessels; Canada set a TAC for SFA1 for 2006 of 18 381 t.

Overall annual 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. Since then total catches have increased. Logbook-reported catches in Greenland in the early part of 2006 were unusually high and the total for 2006 is expected to be near 140 200 t assuming that the Greenland catch equals the TAC and the Canadian catch is near the level of the last three years at about 6 500 t (Fig. 3.1).

Recent nominal catches, projected figures for 2006 and recommended TACs (t) for northern shrimp in Div. 0A east of 60°30'W and Subarea 1 are as follows:

	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
Recommended TAC	60 000	55 000	65 000	65 000	85 000	85 000	100 000	130 000	130 000	130 000
Actual TAC	74 800	68 379	80 350	80 350	94 040	109 340	115 167	149 519	148 167	152 381
STATLANT (SA 1)	60 406	65 191	73 990	79 120	81 517	103 645	78 433	134 037	3 699[2]	
STATLANT (Div. 0A)	517	914	2 093	659	2 958	6 053	2 170	5 240	4 283[2]	
Total STATLANT (SA1+Div. 0A)	60 923	66 105	76 083	79 779	84 475	109 698	80 603	139 277[2]	7 982[2]	
Total NIPAG[3]	78 128	80 495	92 191	97 966	102 926	136 2991	120 303	128 483	138 551	140 197[4]

[1] Data updated to be consistent with STATLANT 21A;
[2] Provisional catches;
[3] Estimates 1995-2003 corrected for overpacking;
[4] Catches projected to year end — SA1 at Actual TAC, Div. 0A at mean of reports for previous 5 yr.

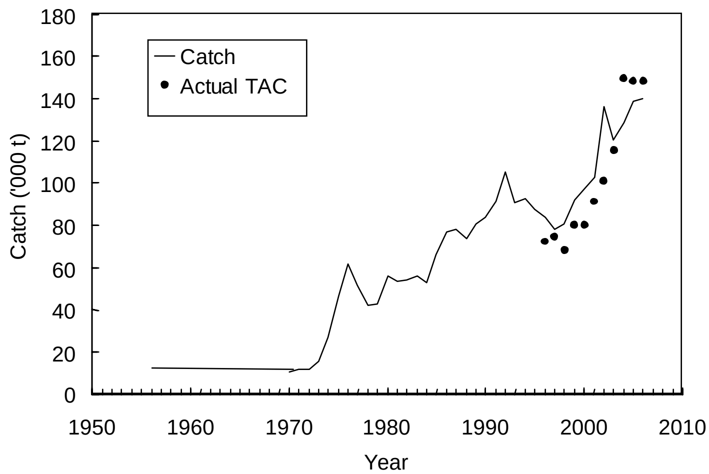


Fig. 3.1. Shrimp in Subareas 0 and 1: actual TACs and total catches (2006 projected to the end of the year; 1996–2003 values have been corrected to live (catch) weight).

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. At the end of the 1980s Div. 1E-F began to attract fishing effort, and catches from these areas accounted for 15% of the total catch by 1997 and 20% by the turn of the century. Catch and effort in Div. 1E-F now appear to be decreasing. From low levels in the late 1990s and at the turn of the century, the Canadian catch in SFA1 has stabilized at 6 000 to 7 000 t in 2002-2005, about 5% of the total.

b) **Oceanographic Overview** (SCR Doc. 06/01, 06/58)

The northward extension of pure Irminger Water as far north as Fylla Bank indicates high inflow of warm water of Atlantic origin to the West Greenland area in the recent years. The average temperature west of Fylla Bank, which is where the core of the Irminger Water is normally found, showed a record high value (3.8°C) in 2005. The 55-year time series of mid-June temperatures on top of Fylla Bank was about 1.5°C above average conditions, while the salinity was slightly higher than normal. In June 2006 the temperature of the surface layer (0-40 m) on top of Fylla Bank was about 2.7°C, which is considerably lower than in 2005 but is still about 0.9°C above the long-term average. The presence of lower salinity water and "Storis" (multi-year Arctic ice transported from east Greenland waters) off Southwest Greenland in early summer suggest that the amount of Polar Water on the West Greenland Shelf has increased in 2006. Bottom temperatures measured on the Greenland bottom trawl survey for shrimp and fish in the summer of 2006 ranged from 1.1°C in the shallow (<200 m) waters of Disko Bay to about 5.6°C in the deeper (>400 m) waters of the southernmost offshore areas. Values >4.5°C were frequently found at the offshore slope of the shelf in the area south of 60.5°N, but in contrast to 2005 lower values (<3.5°C) were dominant in the inner part of Julianehåb Bight (60° to 60.5°N) as well as in the coastal waters between 60° and 63.5°N. This resulted in a pronounced decrease of the mean temperature for the southern part of the survey area compared with the previous year. Such a change was not found in other parts of the survey area. A transition from a cold to a warm period has been recorded in the mid-1990s and was observed in all depth strata of the survey. The overall area-weighted mean bottom temperature was 3.0°C in 2006, close to the average value observed since 1997, and indicates that the recent warm period is continuing in West Greenland waters.

c) **Input Data**

i) **Commercial fishery data**

Fishing effort and CPUE. Catch and effort data from the shrimp fishery were available from logbooks from Canadian vessels fishing in Canadian SFA 1 and from Greenland logbooks for Subarea 1 (SCR Doc. 06/61).

Multiplicative models were used to calculate fleet-specific annual catch-rate indices. From these individual indices one unified series was derived for 1976-2006. All the fleets included in the analysis mainly exploit shrimp ≥17 mm cl. The CPUE indices are therefore indicative of the combined biomass of older males and females. The current-year point in the series is based on about eight months of data from the Greenland fishery and on very little data from Canada, and is therefore tentative.

The standardized CPUE series showed an increasing trend since 1990 (Fig. 3.2). The 2004 value was the highest in the series, 2005 and 2006 showing a slight decline.

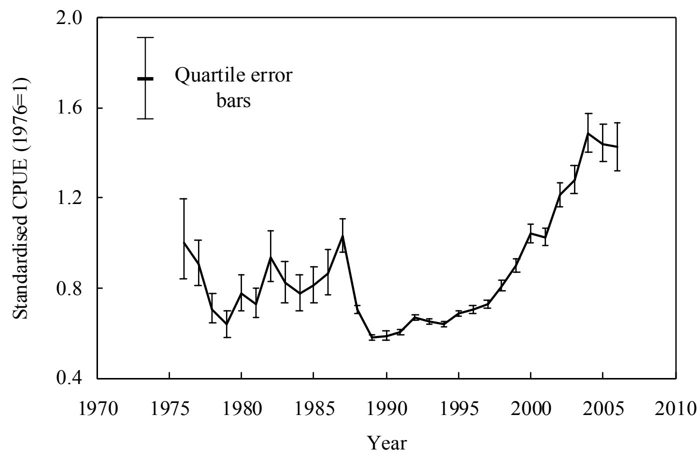


Fig. 3.2. Shrimp in Subarea 1 and Canadian SFA 1: standardized CPUE index.

Catch composition. Catch composition was assessed from samples obtained by observers in the commercial fishery in Canadian SFA1 from 1981 to 2001, and in Subarea 1 from 1991 to 2001 (SCR Doc. 04/75). The mean size of shrimp caught declined since 1991. In spite of these changes, the proportions of female to male shrimp in the catches seemed relatively stable until the late 1990s. In 2002 and 2003 WGPAND recommended that 'sampling of commercial catches by observers — essential for assessing age, size, sex composition, fecundity and frequency of spawning of the stock — should be re-established in Subarea 1'. However, the sampling program in the Greenland fishery has remained inadequate and sparse sampling prevented an analysis of catch composition for more recent years (SCR Doc. 05/83). An attempt to infer size composition of the standing stock from logbook weights of size-classified products was inconclusive (SCR Doc. 06/61).

ii) **Research survey data**

Greenland trawl survey. Stratified random 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. 06/58). From 1993, the survey was extended southwards into Div. 1E and 1F. A 22-mm stretched mesh cod-end liner has been used since 1993. From its inception until 1998 the survey only used 60-min. tows, but shorter tows have been shown to give as accurate results, and since 2005 all tows have lasted 15 min.

The *Skjervøy* trawl with steel-sphere bobbin ground gear used from 1988 through 2004 was replaced in 2005 by a Cosmos trawl with rubber-disk rock-hopper ground gear so that the survey can fish a wider range of bottoms. Calibration trawling was carried out in 2004 and 2005, and length-specific corrections have been applied to the earlier survey data. (SCR Doc. 05/75) In 2006 a further correction was applied to the survey series for the difference in swept area.

Within the survey area, large year-to-year variations in the distribution of biomass have been observed geographically as well as over depth zones. Some survey strata, but not always the same ones, account for a large proportion both of the estimated biomass and of its associated uncertainty. Since 2000 an increased proportion of the biomass has been seen in depths between 200 and 300 m and in more northerly areas, and the proportion of biomass in Div. 1E-F appears to have been decreasing.

Biomass. The survey index of mean stock density remained fairly stable from 1988 to 1997 (c.v. 18%, downward trend 4%/yr). It then began a period of continued increase lasting until 2003, when it reached 316% of the 1997 value. Subsequent values have been consecutively lower, by 2006 21% below the maximum (Fig. 3.3), but still 195% of the 1988-1997 average.

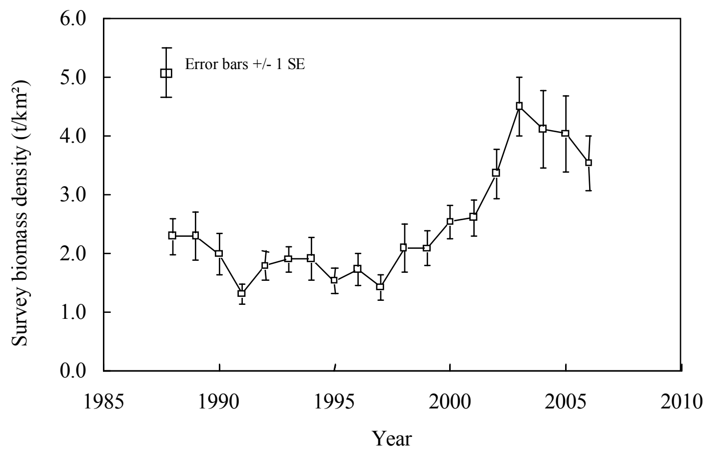


Fig. 3.3. Shrimp in Subareas 0 and 1: survey indices of stock biomass density (SCR Doc. 06/58).

Length and sex composition. The presence of a significant class of males between 17 and 23 mm cl, which likely comprises not more than two year-classes, suggests that progression to the female stock is secured for 2007 (Fig. 3.4). In 2006, male and females abundance amounted to 75 and 23 x 10^9 individuals, respectively. These values are well above the long-term average. The male abundance has declined by 24 % of the peak level recorded in 2003, whereas a much smaller decrease in the number of females has occurred so far, and the proportion of females in 2006 is amongst the highest in the series (SCR Doc. 06/58).

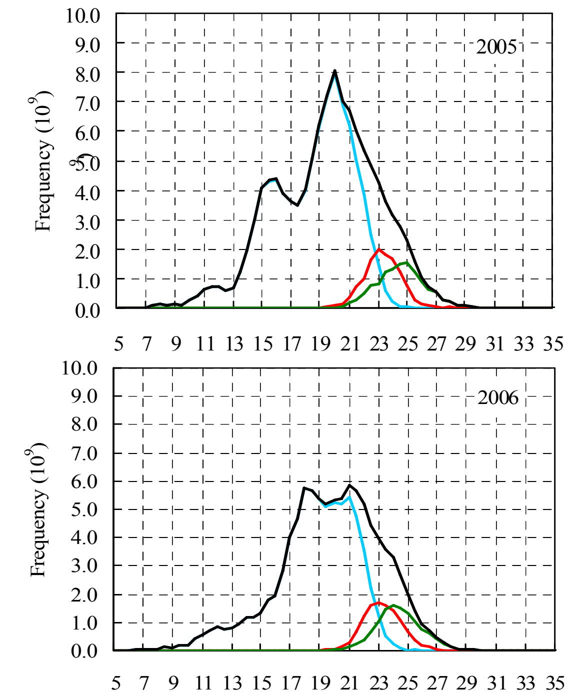


Fig. 3.4. Shrimp in Subarea 1 and Canadian SFA 1: length frequencies of northern shrimp in the total survey area (offshore and Disko Bay/Vaigat combined) in 2005-2006.

Recruitment Index. The number at age 2 is a short-term predictor of recruitment to the fishery in 2 to 3 years time[2] (SCR Doc. 06/58). This recruitment index was high in 2001, decreased in 2002, was below average in 2003 and 2004, decreased again in 2005 to a value near the lowest of the 13-year series, and remained very low in 2006 (Fig. 3.5).

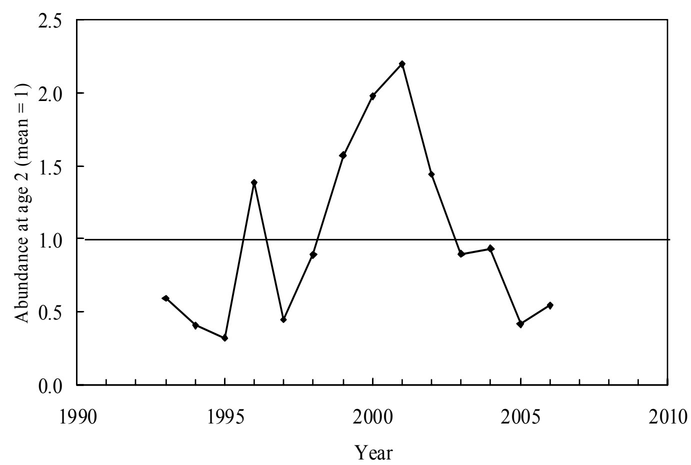


Fig. 3.5. Shrimp in Subarea 1 and Canadian SFA 1: index of numbers at age 2 from survey (scaled to the mean of the series).

2 In survey data, numbers at age 2 in 1993-2003 were positively correlated with fishable biomass 3 years later. The correlation coefficient was 0.656, with 95% CI 0.409-0.948.

iii) **Other biological studies**

Estimates of cod biomass from the German groundfish survey at West Greenland are used in the assessment of shrimp in SA 1 and in Div. 0A east of 60°30′W. The survey is conducted in October-November and the results for the current year area not available in time for the shrimp assessment. A comparison of cod biomass indices for West Greenland offshore waters from the German groundfish survey and from the Greenland survey for shrimp and fish was updated (SCR Doc. 06/57); it was restricted to years with sufficient coverage and to regions included in both surveys. The two survey estimates of cod biomass were closely correlated (r^2 = 0.91, P <0.001). Regression analysis of 14 years data estimated that the index of cod biomass from the 2006 Greenland survey would correspond to about 23 000 t in the German survey. This is still low compared with the 1980s, despite its moderate increase in the most recent years. Furthermore, the geographical distributions of cod in 2005 and 2006 have been extremely southern, and an index of co-location for cod and shrimp indicates a rather small overlap of the two species in the past years. The impact of cod predation on shrimp appears currently to be negligible on account the low biomass of cod and the limited overlap between the distributions of the two species. This interpretation is supported by the results of stomach content analysis (SCR Doc. 06/68) showing that the dry weight percentage of shrimp in cod diet declined from 86% in NAFO Div. 1B to 1% in NAFO Div. 1F where about 80% of total cod biomass was recorded in the German groundfish survey in 2005.

Knowledge of the timing of hatching is important in relation to estimates of operational spawning biomass. It was studied in 16 samples taken from commercial catches between 15 February and 19 May in 2006. The (decreasing) proportion of berried females and the (increasing) proportion of females in breeding dress were regressed against sampling date. The intersection of the straight regression lines was taken to indicate the mean date of hatching, and the intersection of the confidence bands about them a corresponding confidence interval. The estimated peak hatching time was between the last week in March and the first week in April, earlier than previously reported for W. Greenland — possibly owing to warmer water in Davis Strait in 2005 — and similar to estimates from Flemish Cap (SCR Doc. 04/64), Norwegian waters, the North Sea and the Gulf of Maine. It was noted, however, that this result is based on few samples from only one year (SCR Doc. 06/60).

d) **Estimation of Parameters**

Parameters relevant for the assessment and management of the stock were estimated, based on a stochastic version of a surplus-production model that included an explicit term for predation by cod, which was included in the model as a single term described by its total biomass. The model was formulated in a state-space framework and Bayesian methods were used to construct "posterior" likelihood distributions of the parameters (SCR Doc. 02/158).

The model synthesized information from input priors and the following data: a series of survey biomass indices of shrimp ≥17 mm cl from 1988 to 2006; a combined CPUE index series spanning 1976-2006; series of catches and of cod biomass estimates from 1955 to 2006; and a short series (4 years) of estimates of the shrimp biomass consumed by cod (SCR Doc. 06/72).

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 mortality, Z, refers to the removal of biomass by fishing and cod predation and is scaled to the mortality at MSY (Z_{msy}).

Assessment Results. The model estimated the annual median consumption of shrimp by cod in 1956-2006 to have ranged from 200 to *ca*. 120 000 t. The estimated consumption declined sharply after 1966 as a result of the near-disappearance of cod from West Greenland (Fig. 3.7). A short-lived resurgence of the cod stock in the late 1980s caused consumption to return briefly to mid-1960s levels. The cod disappeared again in the beginning of the 1990s and estimates of consumption went to near zero. Recent estimates of cod abundance have been larger and the estimated consumption for 2006 is about 20 020 t. The parameters of the predation function estimated by the model showed that cod predation could be a significant burden on the stock and further increases in the cod stock could have significant impacts on the amount of surplus production that would be available to the fishery. The question is, however, complicated by uncertainty as to the overlap between high-shrimp-density areas and the areas where cod are showing their most significant increase, and to the significance of limited overlap and the method — i.e. as a single unstructured term — by which the cod stock and its predation effect have hitherto been included in the assessment model.

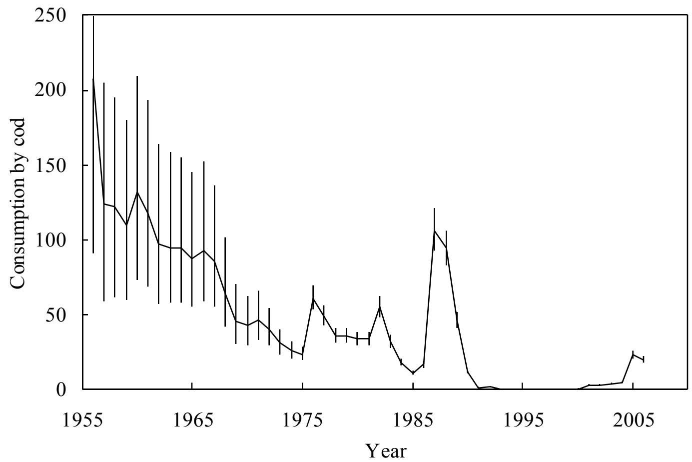


Fig. 3.7. Shrimp in Subareas 0 and 1: modeled estimates of consumption of shrimp by cod, 1956-2006, with quartile error bars.

The trajectory of the median estimate of 'biomass-ratio' (B_t/B_{msy}) plotted against 'mortality-ratio' (Z_t/Z_{msy}) (Fig. 3.8) started in 1957 at about half the optimum biomass ratio and at a mortality ratio well above 1. The stock maintained itself in this depressed state during the years when cod were abundant. When the cod stock declined drastically in the late 1960s (SCR Doc. 06/72) and predation pressure on shrimp was lifted, the shrimp stock mortality decreased. A short lived resurgence of cod stock in the late 1980s was associated with an excursion into higher mortalities and a reduction in biomass ratio. During the current regime of low cod abundance, the stock has moved from a region of high mortality and low biomass to a region of low mortality and high biomass. (Fig. 3.8) (SCR. Doc. 06/72).

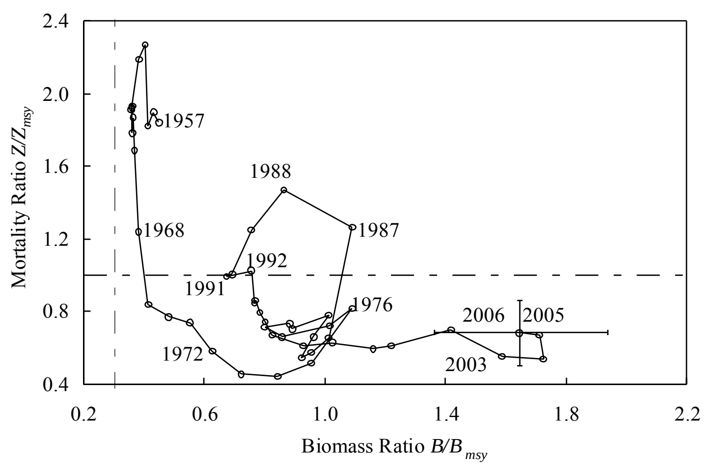


Fig. 3.8. Shrimp in Subareas 0 and 1: estimated annual median biomass-ratio (B/B_{msy}) and mortality-ratio (Z/Z_{msy}) 1957-2006.

Since the early 1970s when the fishery started expanding to offshore areas, the estimated median biomass ratio ranged between about 0.7 and about 1.4 (Fig. 3.8). The probability that it had been below the optimum level was small for most years (Fig. 3.9). However, stock biomass was probably driven below B_{msy} in the late 1980s to mid-1990s associated with a short-lived resurgence of the cod stock. The shrimp stock has increased since then, and reached its highest level in 2004 with a median estimate of biomass ratio of 1.72, corresponding to about 86% of estimated median carrying capacity. The estimated risk of stock biomass being below B_{msy} at the end of 2006 was about 7% (Fig. 3.9).

The mortality ratio (Z-ratio, which includes mortality by fishing and predation by cod) has been below 1 for most of the time since 1974, except for the period of high cod predation in the late 1980s to early 1990s (Fig. 3.8). Since 1997, annual median Z-ratio has been stable in the range 0.6-0.8, i.e. below the value that maximizes yield. The median estimate for 2006 (with catches assumed 140 200 t) is 0.68 with a 9% risk of being above 1 (Fig. 3.9).

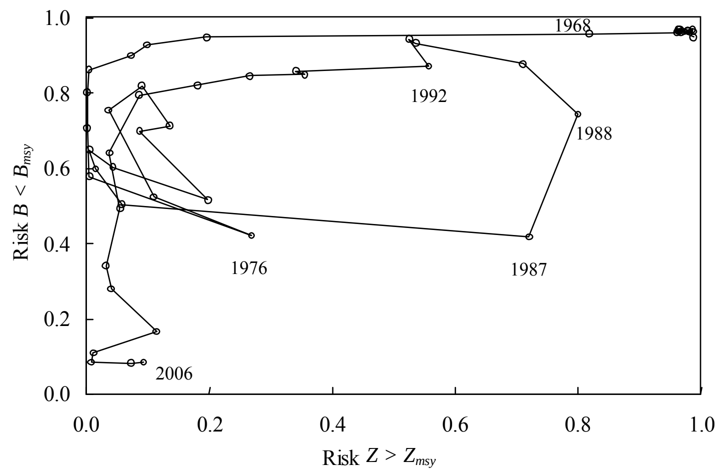


Fig. 3.9. Shrimp in Subareas 0 and 1: risk of annual biomass being below B_{msy} and of mortality caused by fishing and cod predation being above Z_{msy} 1956-2006.

The median estimate of the maximum annual production surplus available to the fishery and the cod (MSY) was 160 000 t (Fig. 3.10). The risk function relating the probability of exceeding MSY to the combined removal by fishery and cod predation is given in Fig. 3.10.

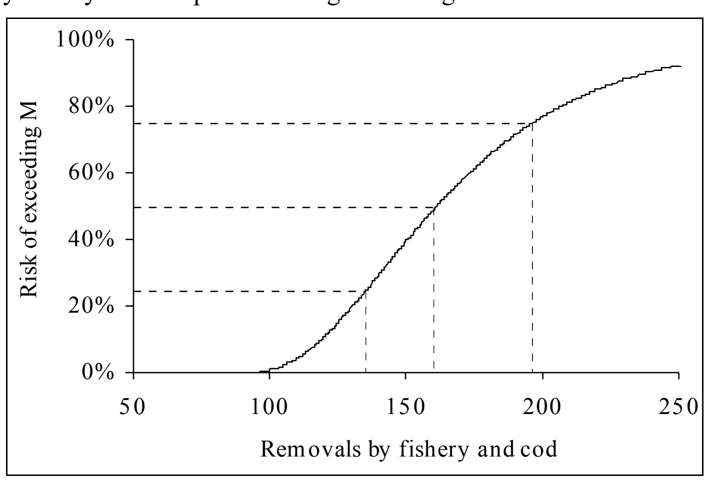


Fig. 3.10. Shrimp in Subareas 0 and 1: cumulative probability distribution of the maximum annual production surplus, available to the fishery and to cod (MSY). The median estimate (160 Kt/yr) and quartiles (135 and 196 Kt/yr) are shown.

Given the high probabilities that the stock is considerably above B_{msy}, risk of stock biomass falling below this optimum level within a one-year perspective is low. Risks associated with five optional catch levels for 2006 are as follows:

Catch option ('000 t) in 2007	110	120	130	140	150
Risk of exceeding Z_{msy} in 2007	2.3%	4.4%	8.4%	13.7%	21.0%
Risk of falling below B_{msy} by end 2007	9.3%	9.4%	9.4%	9.4%	9.5%

Predation by cod can be significant (Fig. 3.7) and have a major impact on shrimp stock size. In spite of recent increases, the cod stock at West Greenland is now still at a low level. A large cod stock that would significantly increase shrimp mortality could be established in two ways: either by a slow rebuilding process or by immigration of one or two large year-classes from areas around Iceland as seen in the late 1980s.

An increase in cod abundance through growth of the existing stock would, however, be noted in an early phase during routine monitoring programs and fisheries management would have at least two years to respond before the shrimp stock is driven below optimal levels, given the current good condition of the stock.

Although there are indications of an increasing cod stock, absolute estimates are still well below those of the late 1980s and certainly those of the 1950s and 1960s; furthermore, indications are that the greatest increase in the cod stock is occurring in areas where the density of shrimp is relatively low (SCR Doc. 06/57).

Ten-year projections of stock development were made from 2007 to 2016 under the assumption that the cod stock will remain at its present level. Annual catches of 110 000, 120 000, 130 000, 140 000 and 150 000 t were investigated (Fig. 3.11).

At the investigated catch option of 110 000 t/yr the stock is very likely to remain above B_{msy} during the ten years of projection (Fig. 3.11). The combined relative fishing and cod predation mortality, Z_t, has an 11% probability of exceeding Z_{msy} within this period (Fig. 3.12).

Annual catches of 120 000 t/yr are not likely to drive the stock below B_{msy} in the short to medium term (Fig. 3.11); after 10 years, the risk is estimated at 18% (Fig. 3.12). However, this level of exploitation might not be sustainable in the longer term (>10 years), as uncertainties compound over time and the risk of falling below B_{msy} continues to increase. The risk of exceeding Z_{msy} is about 18% after 10 years.

A catch option of 130 000 t/yr is below the estimated median MSY but when combined with predation may reduce the stock, although not below B_{msy} in the short term (Fig. 3.11). By end 2009 the risk is estimated at 11% and is about 22% after 10 years (Fig. 3.12). The risk of exceeding Z_{msy} increases to about 24% over a 10-year projection.

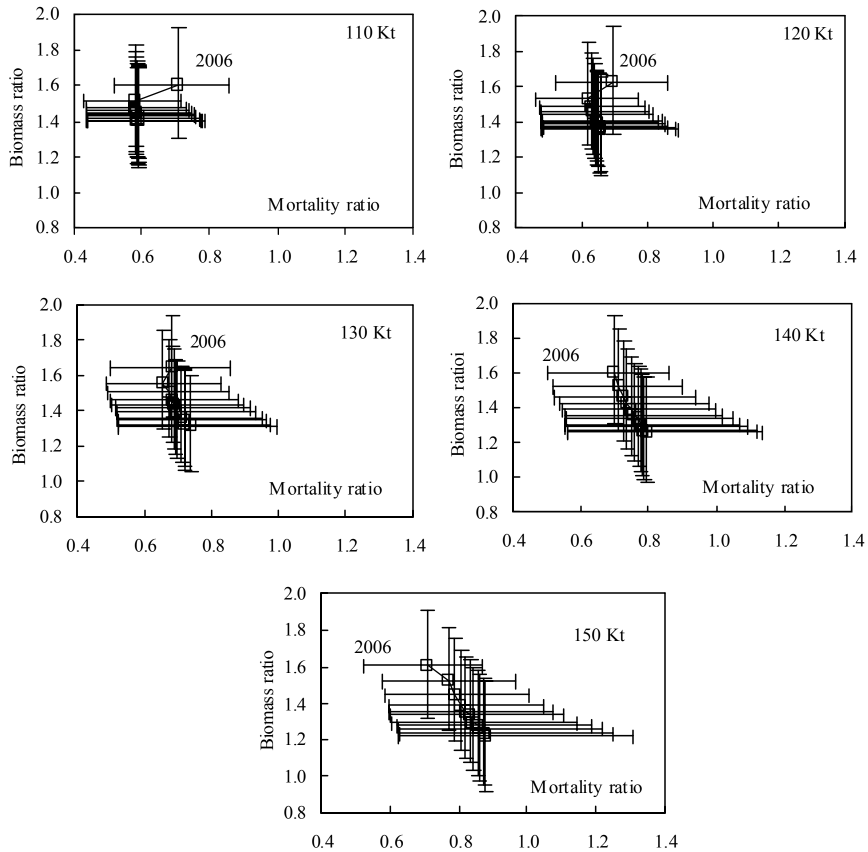


Fig. 3.11. Shrimp in Subareas 0 and 1: estimates of stock development for the period 2006-2016 quantified in a biomass (B/B_{msy})-mortality (Z/Z_{msy}) continuum. Dynamics at 110, 120, 130, 140 and 150 thousand tons of fixed annual catches are shown as medians with quartile error bars.

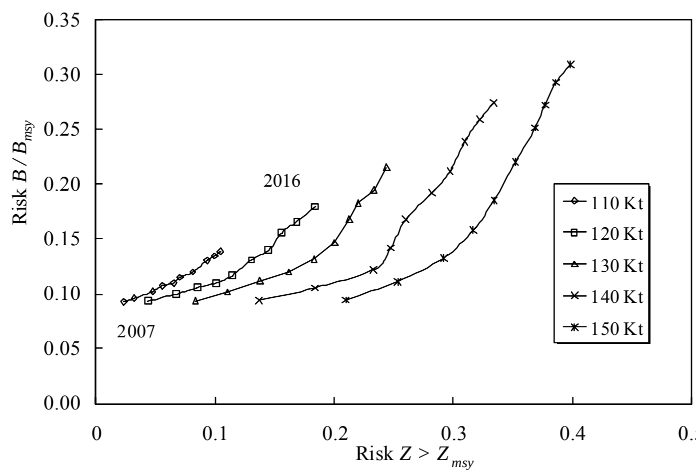


Fig. 3.12. Shrimp in Subareas 0 and 1: risk of exceeding Z_{msy} and of driving the stock below B_{msy} by maintaining catches at110 000-150 000 t/yr over a ten-year prediction period 2007-2016.

Fishing at 140 000 t/yr bears a 14%, and 150 000 t a 21% risk, of being immediately above MSY (Fig. 3.11). Owing to the current high stock level and the high MSY the risk of transgressing B_{msy} is no more than 13% by end 2009 at 150 000 t/yr; after 10 years it is 31% with a concomitant 40% risk of exceeding Z_{msy} (Fig. 3.12).

Runs of the assessment model with the most recent data, but the same prior probability distributions for key parameters, have produced slightly more optimistic estimates of stock-dynamic parameters than in the 2005 assessment. Estimated MSY has increased from 150 000 to 160 000 t. B_{msy} has increased from about 1 100 000 t to 1 500 000 t Combined with a near-halving of the present estimates and future forecasts for the cod stock, and therefore of predation on shrimp, these changes in estimates have significantly affected the risks associated with catch levels near to the available fishable surplus, relative to those estimated last year.

The projections assume not only that the parameters of shrimp stock dynamics will be stable, but also that the cod biomass will remain stable at its present level. However, sudden large changes in the sizes of cod stocks do occur, and if there is an abrupt increase in cod biomass in West Greenland — such as might result from immigration — the condition of the shrimp stock may change much more rapidly. The effect of an immigration of two large year-classes of cod was investigated in 2004 (SCR Doc. 04/76) and it was shown that predation could within a 3-4 year period go from negligible to between 88 000 and 163 000 t.

Mortality: The mortality caused by fishing and cod predation (Z) is modeled as having been below the reference level (Z_{msy}) since 1993. With catches in 2006 projected at 140 200 t, the risk that total mortality would exceed Z_{msy} was estimated at about 9%.

Biomass: Since the late 1990s the stock has increased and the survey index of fishable biomass reached high levels in 2003 and 2004. This index then decreased in 2005 and again in 2006, and standardized CPUE also declined. The modeled stock biomass reached its highest value in 2004; the estimated risk of stock biomass being below B_{msy} at end 2006 was 7%, and less than 1% of being below B_{lim}.

Recruitment: The estimated number of age-2 shrimp decreased in 2002, was below average in 2003 and 2004, decreased again in 2005 to near a 10-year low value and stayed very low in 2006.

State of the Stock: The fishable biomass increased substantially from the late 1990s to historically high levels in 2004, and has then shown a slight decrease to 2006. Biomass at the end of 2006 is estimated to be well above B_{msy} and mortality by fishery and cod predation well below Z_{msy}. Recruitment to the fishable stock is likely to decrease after 2006 and to remain low for the next several years.

e) **Precautionary Approach**

The NAFO Scientific Council has recommended limit reference points for stock size (B_{lim}) at 30% of B_{msy} and for mortality (Z_{lim}) at 100% of Z_{msy} (Fig. 3.8) (SCS Doc. 04/12). The following shows risks for various 2007 catch options:

	Catch option for 2007 ('000 t)				
By end 2007:	110	120	130	140	150
Risk of falling below B_{lim}	<<1%	<<1%	<<1%	<<1%	<<1%
Risk of exceeding Z_{lim}	2.3%	4.4%	8.4%	13.7%	21.0%

f) **Research Recommendations**

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

- *sampling of commercial catches by observers — essential for assessing age, size, sex composition, fecundity and frequency of spawning of the stock — should be re-established in Subarea 1.*

- *ways to include a flexible and comprehensive exploration of the effects of future trajectories of the cod stock on assessment predictions should be investigated and presented in 2007.*
- *methods of incorporating the spatial relationship between shrimp and cod, and its effect on predation rate, into the assessment model should be explored.*
- *the impact of other predators on the stock should also be considered for inclusion in the assessment model.*
- *recruitment indices and their relationship to subsequent fishable biomass should be considered for inclusion in the shrimp assessment model.*

4. **Northern Shrimp (*Pandalus borealis*) in Denmark Strait and off East Greenland (ICES Division XIVb and Va) – NAFO Assessed** (SCR Doc. 03/74, 06/78)

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, up to 1993, occurred primarily in the area of Stredebank and Dohrnbank as well as on the slopes of Storfjord Deep, from approximately 65°N to 68°N and between 26°W and 34°W.

In 1993 a new fishery began in areas south of 65°N down to Cape Farewell. Access to all these fishing grounds depends heavily on ice conditions. From 1996 to 2003 catches in the area south of 65°N accounted for more than 60% of the total catch. Catches and effort in the area south of 65°N in 2004 and 2005 only account for 29% and 47% respectively of the total catch.

A multinational fleet exploits the stock. During the recent ten years, vessels from Greenland, Denmark, the Faroe Islands and Norway have fished in the Greenland EEZ. Only Icelandic vessels fish in the Icelandic EEZ.

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

Catches of shrimp taken in the Greenland EEZ until 2003 have been reported without accounting for "overpacking" – the amount of surplus weight in packaging – or the difference between the product weight and live weight, all catches in the Greenland EEZ have therefore been adjusted for overpacking (SCR Doc. 03/74).

Total catches increased rapidly to about 15 500 t in 1987 and 1988, but declined thereafter to about 9 000 t in 1992 and 1993. Following the extension of the fishery south of 65°N catches increased again to about 13 800 t in 1997. Catches from 1998 to 2003 have been around 12 000 t (Fig. 4.1) and have decreased thereafter. In 2005 catches decreased to 8 000 t and catches in 2006 are projected to decrease further to 6 000 to 7 000 t (projected from October). Catches in the Iceland EEZ has decreased since 2002, and no catches have so far been taken in 2006.

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

	1997[3]	1998[3]	1999[3]	2000[3]	2001[3]	2002[3]	2003[3]	2004	2005	2006[1]
Recommended TAC	5 000	5 000	9 600	9 600	9 600	9 600	9 600	12 400	12 400	12 400
Greenland EEZ, North of 65°N	1 622	3 943	4 058	4 288	2 227	1 344	4 143	6 736	4 286	3 999
Iceland EEZ, North of 65°N	2 856	1 421	769	132	10	1 144	635	380	21	0
Total, North of 65°N	4 478	5 364	4 827	4 420	2 237	2 488	4 778	7 116	4 307	3 999
Greenland EEZ, South of 65°N	9 276	6 057	6 893	7 632	11 674	8 753	7 858	2 869	3 807	694
Total STATLANT 21A	11 589	9 321	9 467	9 594	11 052	9 196	9 763	9 985	8 114	-
Total STACFIS[3]	13 754	11 422	11 719	12 053	13 911	11 242	12 637	9 985	8 114	4 693

1 Catches till October 2006;
2 Provisional; 3 Estimates 1997-2003 corrected for overpack.

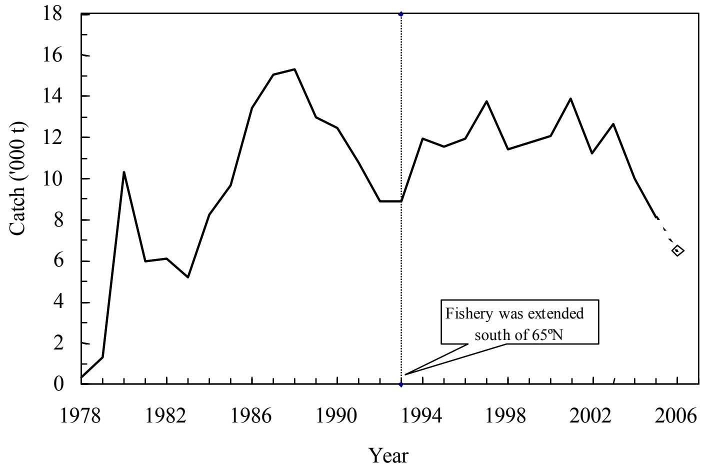


Fig. 4.1. Shrimp in Denmark Strait and off East Greenland: total catches (2006 projected to the end of the year based on data until October 2006).

b) **Input Data**

i) **Commercial fishery data**

Fishing effort and CPUE. 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 supplied data on catch and effort (hours fished) on a by haul basis. Up to 2005, the Norwegian fishery data was considered to have too little information on different area fished and data was therefore not include in the standardized catch rates calculations. In 2006 an evaluation on the Norwegian logbook data from 2000 to 2006 was conducted with positive result and data included in the 2006 standardized catch rates calculations. Since 2004 more than 60% of all hauls were preformed with double trawl and the 2006 assessment both included single and double trawl in the standardized catch rates calculations. Compared to earlier years the 2006 assessment include data from Norwegian logbooks and double trawl and indices changes slightly. However, the trends did not change and the overall perception of the stock is the same.

The Greenland fishing fleet, accounting for 40% of total catch has decreased their effort in recent years, which gives some uncertainty on whether recent index values are a true reflection of the stock biomass. This decrease may be related to the economics of the fishery.

Standardized catch rates based on logbook data from Danish, Faroese, Greenlandic, Norwegian and Icelandic vessels in the northern area declined continuously from 1987 to 1993, showed a significant increase between 1993 and 1994, and have fluctuated with a slightly increasing trend thereafter (Fig. 4.2). In the southern area a standardized catch-rate series for the same fleets (Iceland excluded) increased until 1999, and fluctuated at this level thereafter till 2005 (Fig. 4.3). The 2006 preliminary data indicate a decreasing trend.

A combined standardized catch-rate index for the total area decreased steadily from 1987 to 1993, and then showed an increasing trend until the beginning of the 2000s. The stock biomass index has since stayed at or around this level (Fig. 4.4). Standardized effort indices (catch divided by standardized CPUE) as a proxy for exploitation rate for the total area showed a decreasing trend since 1993. Recent levels are the lowest of the time series (Fig. 4.5).

Biological data. Since 2002, the NAFO Scientific Council has recommended that, "sampling of catches by observers – essential for assessing stock age, size and sex composition – should be re-established". However, sampling of the commercial fishery in recent years has been insufficient to obtain annual estimates of catch composition.

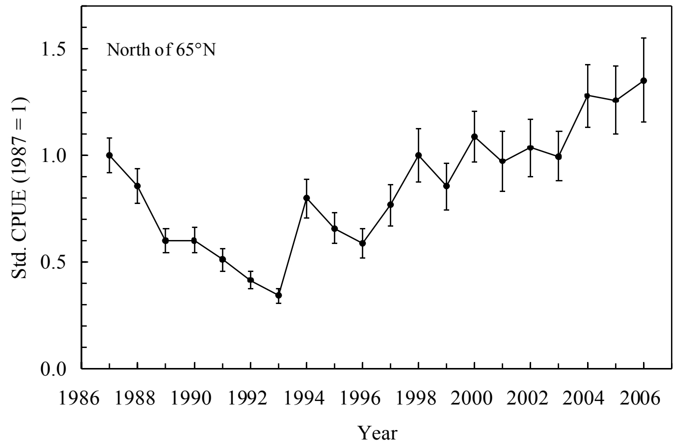


Fig. 4.2. Shrimp in Denmark Strait and off East Greenland: annual standardized CPUE (1987 = 1) with ±1 SE calculated from logbook data from Danish, Faeroese, Greenland, Icelandic and Norwegian vessels fishing north of 65°N.

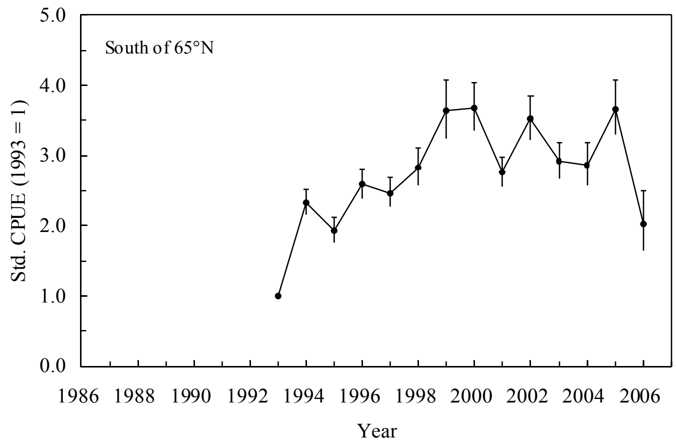


Fig. 4.3. Shrimp in Denmark Strait and off East Greenland: annual standardized CPUE (1993 = 1) with ±1 SE calculated from logbook data from Danish, Faeroese, Greenland and Norwegian vessels fishing south of 65°N.

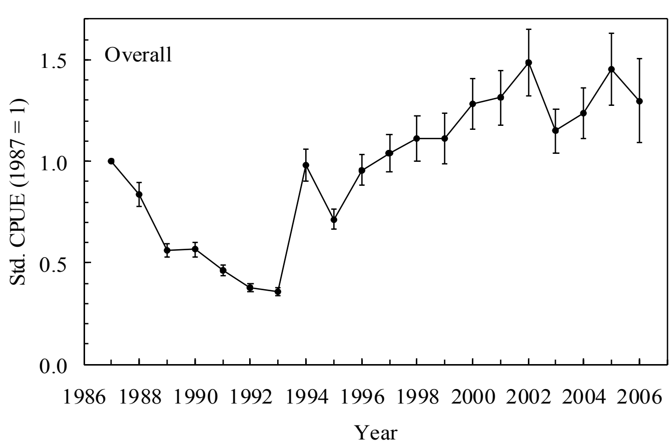


Fig. 4.4. Shrimp in Denmark Strait and off East Greenland: annual standardized CPUE-indices (1987 = 1) with ±1 SE combined for the total area.

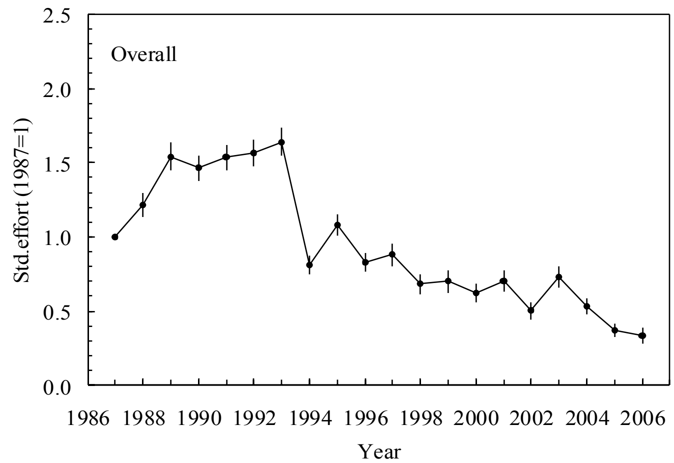


Fig. 4.5. Shrimp in Denmark Strait and off East Greenland: annual standardized effort indices, as a proxy for exploitation rate (±1 SE; 1987 = 1), combined for the total area.

ii) **Research survey data**

No surveys have been conducted since 1996.

c) **Assessment Results**

CPUE. Combined standardized catch-rate index for the total area decreased steadily from 1987 to 1993, showed an increase to a relatively high level at the beginning of the 2000s, and fluctuated around this level thereafter.

Recruitment. No recruitment estimates were available.

Biomass. No direct biomass estimates were available.

Exploitation rate. Since the mid 1990s exploitation rate index (standardized effort) has decrease to its lowest levels in the 20-year series.

State of the stock. The stock is believed to be at a relatively high level, and has been since the beginning of the 2000s.

d) **Research Recommendations**

NIPAG **recommends** that, for shrimp in Denmark Strait and off East Greenland:

- *a survey be conducted to provide fishery independent data of the stock*
- *the sampling of catches by observers be re-established. This is essential for assessing age, size, sex composition, fecundity and frequency of spawning of the stock.*

5. **Northern Shrimp (*Pandalus borealis*) in Skagerrak and Norwegian Deep (ICES Divisions IIIa and IVa East) – ICES Assessed** (SCR Doc. 06/62, 81, 82)

a) **Introduction**

The North Sea-Skagerrak shrimp stock, which occurs predominantly in ICES Div. IVa east and IIIa, is exploited by Norway, Denmark and Sweden. In recent years an increasing number of the Danish and

Norwegian vessels have started boiling the shrimp aboard and landing them in Sweden to obtain a better price. Most of their catches are, however, still landed in their home ports. The Swedish fishery is smaller and approximately 50% of catches are boiled at sea (quality A). Almost all Swedish catches are landed in Sweden.

The Norwegian and Swedish fisheries began already 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 catches had reached 5 000 t and in 1981 they exceeded 10 000 t. Since 1992 the shrimp fishery has been regulated by a quota, which has been approximately 15 000 t in recent years (see table below). The TAC is not fully fished by all countries. This quota has been divided between countries according to historical landings, so that Norway has the highest quota, and Sweden the lowest. This has resulted in high-grading by the Swedish fleet. The *Pandalus* fishery is also regulated by mesh size (35 mm), and by restrictions on the amount of landed bycatch. The use of selective grids, mandatory only in Swedish national waters, but used by some vessels in all fleets, reduces bycatch (SCR Doc. 06/81).

The Danish and Norwegian fleets have undergone major restructuring in recent years. In Denmark, trawlers <24 m formerly made up about half the fleet but during the last five years almost all of them have disappeared. In Norway there has been an increase in vessels 10-10.99 m, as vessels <11 m do not need a permit to fish. During the last ten years almost all Danish vessels have been equipped with twin trawls. According to Norwegian fisheries organizations, twin trawls have been in use by 20-30 Norwegian trawlers the last five years. Quantitative information on these changes in gear are, however, not available from the logbooks.

Catch and discards. Discard of shrimp may take place in two ways: 1) discard of shrimp <15 mm cl which is not marketable, even to the canning industry, and 2) high-grading discards of medium-sized, lower-value (quality B) shrimp, primarily by the Swedish fleet, because of quota limits on total landed weight. The Swedish practice of dividing annual quotas into weekly rations increases the incentive to high-grade.

Landings have varied between 10 000 t and 15 000 t during the last decade. The landings in 2005 were around 13 700 t, a decrease of around 1 600 t compared with landings in 2004 (Fig. 5.1). The landings and estimated Swedish high-grading derived by NIPAG for the assessment unit 'Skagerrak and the Norwegian Deep' i.e. Div. IIIa and the eastern part of Div. IVa are given in the following table:

	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
Agreed TAC	16 000	15 000	15 000	18 800	18 800	13 000	14 500	14 500	14 500	15 690	15 600
Denmark	2 460	3 868	3 909	3 330	2 072	2 371	1 953	2 466	3 244	3 905	2 952
Norway	8 095	7 878	8 565	9 606	6 739	6 118	6 895	7 318	7 715	8 998	8 507
Sweden[1]	2 882	2 371	2 597	2 469	2 445	2 225	2 108	2 301	2 389	2 464	2 257
Total landings	13 437	14 117	15 071	15 406	11 256	10 714	10 956	12 085	13 348	15 367	13 716
Estimated Swedish high-grading								908	868	1 797	1 483
Catch								12 993	14 216	16 151	15 085

[1] Swedish landings have been corrected for loss in weight due to boiling.

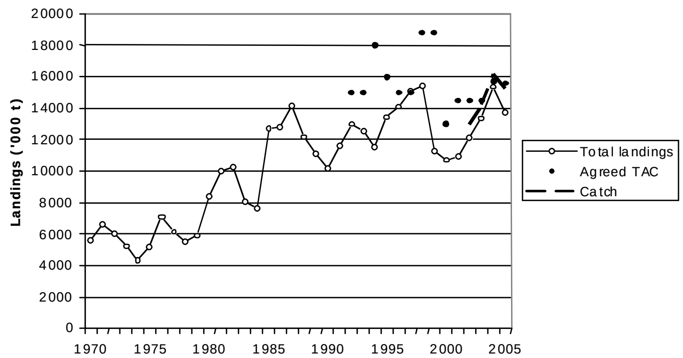


Fig. 5.1. Agreed TAC, total landings by all fleets, and total catch including estimated Swedish high-grading for 2002-2005.

Bycatch and environmental effects. In recent years, ICES has paid increasing attention to mixed fisheries in the North Sea area, especially those affecting stocks subject to recovery plans. However, the *Pandalus* fishery cannot be regarded as a mixed fishery, as it only targets shrimp. Nonetheless, there is some bycatch of commercially valuable species — amounting, for example, to landings of 500 t in the case of cod — although regulations restrict the weights that may be landed. Since 1997, trawls used in Swedish national waters must be equipped with a Nordmøre grid, with bar spacing 19 mm, which excludes fish >20 cm from the catch. Landings by ships so equipped have been 99% *Pandalus*. The use of grids has been increasing and, in 2005, constituted 24% of Swedish *Pandalus* effort.

The effects of these small-mesh fisheries on the North Sea ecosystem have not been the subject of special investigation. Quantitative data on bycatch recorded in logbooks are compiled by NIPAG (SCR Doc. 06/81). However, these data only include the landed component. It is known that deep-sea species such as Argentines, roundnose grenadier, rabbitfish, and sharks are frequently caught in shrimp trawls in the deeper parts of Skagerrak and the Norwegian Deep.

b) **Input Data**

i) **Commercial fishery data**

The Swedish shrimp vessels still mainly use single trawls. The Swedish LPUE is probably underestimated in past years, owing to the prevalence of high-grading (SCR Doc. 06/81). It was therefore not used in assessing stock status.

Technological 'creep' in the Danish *Pandalus* fishery has been taken into account by using information from fishermen when adjusting the Danish LPUE values for 1984-2005 (Fig. 5.2). However, at present the resolution of the Danish logbook data, as well as lack of data on technological development of gear, prevented GLM standardization. (Note: The term 'adjusted' refers to a specific value that has been corrected independently of other values in the series e.g. *via* an effort raising factor or to allow for improvements in gear technology. The term 'standardized' refers to specific values being corrected in relation to other values in the series e.g. by the use of a GLM or multiplicative model applied to all values in the series e.g. to correct for sampling in different areas or at different times).

Total Norwegian fishing effort has been estimated from landings and LPUE data based on logbook records. The quantitative information on the development of the Norwegian shrimp gear is incomplete and cannot be used for standardizing the Norwegian LPUE series. The Norwegian annual LPUE indices have, however, been standardized according to area, month and vessel for 2000-2006 (Fig. 5.2).

Combined Danish and Norwegian unadjusted fishing effort has decreased steadily since the late 1980s (Fig. 5.3).

The Danish and Norwegian LPUEs both increased from 2001 to a historical maximum in 2004. Both these indices then decreased in 2005 (Fig. 5.2), and the standardized Norwegian LPUE decreased again in 2006 to the level of the late 1990s. However, this value is only based on preliminary data from the first 4 months of the year.

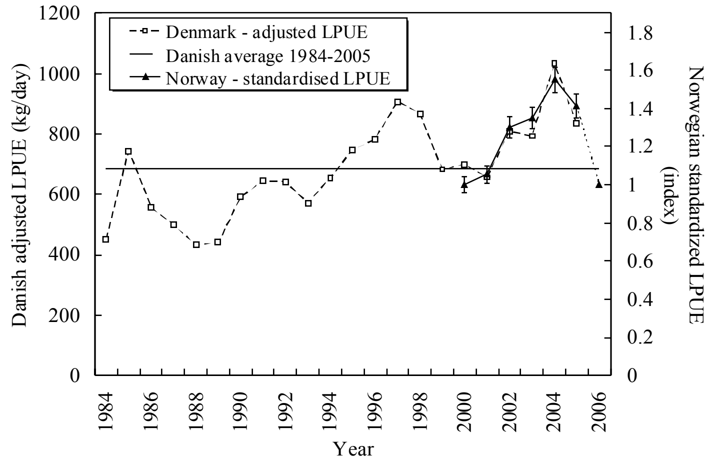


Fig. 5.2. Long-term adjusted LPUE for Denmark (whole period) and standardized LPUE for Norway (2000-2006) with SE.

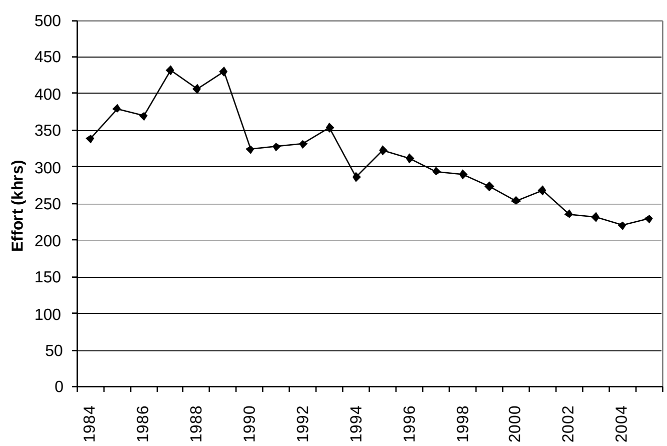


Fig. 5.3. Long-term trend in combined unadjusted Danish and Norwegian fishing effort.

Biological sampling of landings. Information on the size and subsequently age distribution of the landings are obtained by sampling the landings. The biological samples also provide information on sex distribution and maturity. These data are not included in the assessment but contribute to the estimation of corrected landing biomass.

ii) **Research survey data**

The Norwegian shrimp survey has gone through large changes in recent years. The result is a series of four different surveys, lasting from one to nineteen years. New series were initiated in both 2004 and 2006. There was no trend in the annual survey biomass estimates from the mid 1990s to 2002 when this series was discontinued. The 2004 and 2005 mean values of a new biomass index series were not statistically different (Fig. 5.4). The very low 2006 mean biomass index (first year of new survey at the most optimal time of year) is to some extent due to the poor geographical coverage of the 2006 survey (SCR Doc. 06/82).

The percent size distribution of the February 2006 survey was similar to the long term average from the 1988-2002 survey series which suggests that the proportion of the incoming one year-old size group is about equal to the proportion of all other age groups in the population. However, it is not possible to determine the relative strength of this recruitment as these survey series are not directly comparable.

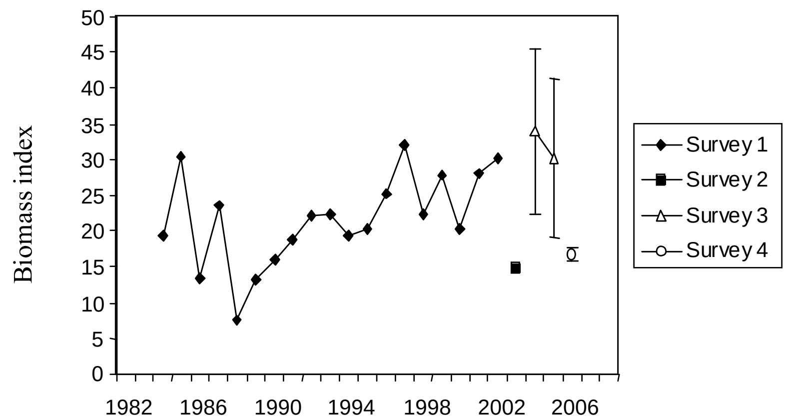


Fig. 5.4. Estimated survey biomass indices of northern shrimp in Skagerrak and the Norwegian Deep. The four surveys are not calibrated to a common scale. Standard errors (error bars) have been calculated for the 2004-2006 surveys. Survey 1: October/November 1984-2002 with Campelen-trawl; Survey 2: October/November 2003 with shrimp trawl 1420; Survey 3: May/June 2004-2005 with Campelen trawl; Survey 4: February 2006 with Campelen trawl.

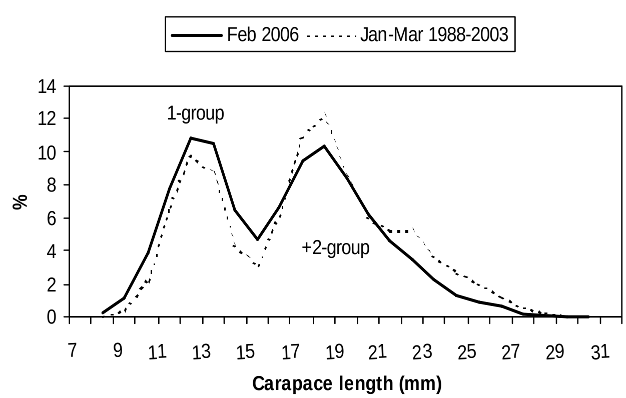


Fig. 5.5. Estimated length frequency distribution of shrimp in Skagerrak and the Norwegian Deep from the 2006 Norwegian shrimp survey, compared with research survey data from Quarter 1 from the same area (data from all years are pooled without weighting).

c) **Assessment Results**

Until 2002 standard cohort analyses (XSA) were applied, but were abandoned because of the assumed high predation mortality compared to the fishing mortality. Last years assessment included a Bayesian stock production model (WGPAND, 2005). The model work for 2006 was not completed due to a change in priorities. This year's assessment of the current state of the stock is based on evaluation of LPUEs from the fishery 1984-2006 and the surveys.

LPUE. The adjusted Danish and standardized Norwegian LPUEs both increased from 2001 to a historical maximum in 2004. Both these indices then decreased in 2005 and the standardized Norwegian LPUE decreased further in 2006 to the level of the late 1990s (Fig. 5.2 and 5.6). The standardized Norwegian LPUE for 2006 is based on partial data for the year and may therefore be subject to relatively larger uncertainty and possibly b ias.

Recruitment. The shrimp percentage at length-frequency distribution of the February 2006 survey appears similar to the percentage at length-frequency distributions from pooled survey data from the first Quarter in the period 1988 to 2003. Combined with the perception that the stock biomass estimates were at a historical maximum in 2004, this indicates that there may be average recruitment (Fig. 5.5).

Survey biomass. The biomass index for 2006 was not comparable with previous years. The survey indices from 2004 and 2005 contribute to the overall impression of a stable stock, but also indicate a slight decline.

Exploitation rate. No estimation on exploitation rate is available.

State of the stock. The stock has increased since 1988 to an all time high in 2004 and has since shown a declining trend, but is likely still at the level of the long term mean from 1984-2002 (Fig. 5.6).

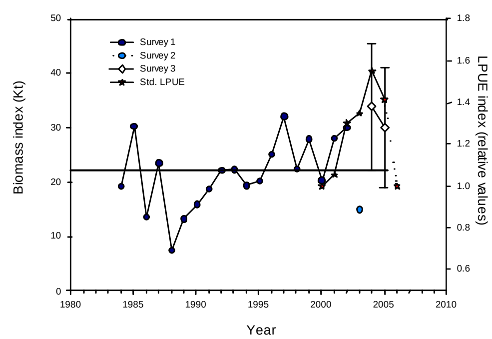


Fig. 5.6. Estimated survey biomass index of northern shrimp in Skagerrak and the Norwegian Deep and standardized Norwegian LPUE. Survey 1: October-November 1984- 2002 with Campelen-trawl; Survey 2: October-November 2003 with shrimp trawl 1420; Survey 3: May-June 2004-2005, Campelen trawl. The horizontal line is the long term mean for Survey 1.

d) **Biological Reference Points**

No reference points were provided in this assessment (SCR Doc. 06/81).

e) **Management Recommendations**

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

- *the total landings from IIIa and IVa East in the 2007 are not increased above the recent averages (2003-2006) of 14 000-15 000 t, which is a continuation of the recent TAC level of around 15 000 t.*
- *sorting grids or other means of facilitating the escape of fish should be implemented in this fishery.*

f) **Research Recommendations**

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

- *the relation/connection/mixing between the shrimp (stock units) in Skagerrak and the Norwegian Deep on the one side and the Fladen Ground shrimp on the other needs to be clarified by using genetic separation technologies.*
- *a further development of the Bayesian stock production model presented in 2005 and comparisons and evaluation of the assessment models available for this Pandalus stock is recommended.*

6. **Northern Shrimp (*Pandalus borealis*) in Barents Sea and Svalbard Area (ICES Sub-areas I and II) – ICES Assessed** (SCR Doc. 06/63, 64, 65, 70, 71; ICES C.M. 2006/ACFM:10 Ref. G)

a) **Introduction**

The resource of northern shrimp (*Pandalus borealis*) in the Barents Sea within the Norwegian EEZ and in the Svalbard zone (ICES Sub-areas I and II) is considered as one stock. Norwegian and Russian vessels exploit the stock in the entire area, while vessels from other nations are restricted to the Svaldbard fishery zone.

Norwegian vessels initiated the fishery in 1970. While the fishery developed, vessels from several nations joined and the annual catch reached 128 000 t in 1984 (Fig. 6.1). During the recent decade catches have varied between 35 000 and 85 000 t/yr – 70-90% of these were taken by Norwegian vessels and the rest by vessels from Russia, Iceland, Greenland and the EU.

The fishery is regulated by effort control. Licences are required for the Russian and Norwegian vessels, whereas the fleets operating in the Svalbard zone is regulated by the number of effective fishing days and the number of vessels by country. The minimum stretched mesh size is 35 mm. Other species are protected by mandatory sorting grids and by the temporary closing of areas where excessive bycatch of juvenile cod, haddock, Greenland halibut, redfish and shrimp <15 mm cl.

The fishery is conducted mainly in the Hopen Area (central Barents Sea) which, along with the Svaldbard Shelf, is considered the most important fishing ground. The fishery takes place in all months but may in certain years be restricted by ice conditions. The lowest intensity is generally seen in October through March, the highest in May to August.

A major restructuring of the fleet towards fewer and larger vessels has taken place since the mid-1990s. In 1995, 6% of the catches reported in logbooks were taken by large factory trawlers (>2000 HP) whereas this fleet component accounted for more than 95% in 2006.

Catch. Since the early 1980s, landings have varied in a cyclic manner with local minima and maxima separated by periods of 4-5 years (Fig. 6.1). Overall catches have ranged from 28 000 to 128 000 t. The most recent peak was seen in 2000 at approximately 83 000 t. Catches thereafter declined to 40 000 t in 2005. The 2006 catches are estimated to be at or a little below this level.

Catches (1996-2005) and projected catches (2006) in metric tons, as used by NIPAG for the assessment of shrimp in ICES Div. I and II are as follows:

	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006[1]
Recommended TAC	-	-	-	-	-	-	-	-	-	43 591[2]	40 000
Norway	25 445	29 079	44 792	52 612	55 333	43 021	48 799	34 652	36 188	36 456	35 000
Russia	5 747	1 493	4 895	10 765	19 596	5 875	3 802	2 776	2 400	0 287	0 003
Others	3 320	5 164	6 103	12 292	8 241	8 136	8 105	2 340	5 002	4 035	4 000
Total	34 512	35 736	55 790	75 669	83 170	57 032	60 706	39 768	43 590	40 778	39 003

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

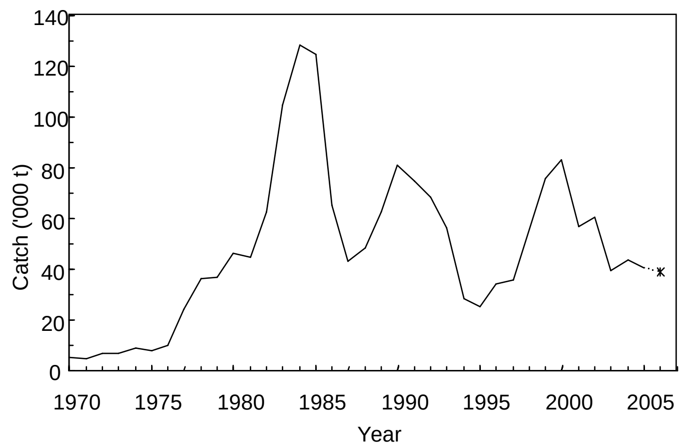


Fig. 6.1. Shrimp in the Barents Sea: total catches 1970-2006 (2006 projected to the end of the year).

Discards and bycatch. Discard of shrimp is believed to be small as the fishery is not catch regulated. Small cod, haddock, Greenland halibut and redfish in the size range of 5-25 cm are caught as bycatch. The bycatch of small cod ranged between 2 and 67 million individuals/yr since 1997, while 1-9 million haddock/yr and 0.5 to 14 million Greenland halibut/yr was registered since 2000. There are no estimates of bycatch of redfish. There has been a decline in recent years in bycatch for cod, haddock and Greenland halibut as a consequence of the reduced effort in the shrimp fishery. Details on bycatch are reported to AFWG (ICES).

Environmental considerations. Changes in temperature, salinity, and large-scale water movements have been observed in the North Atlantic over the past few years. The trend in the last decade (1995-2005) has been of warming and increasing salinity in the upper ocean. In the Barents Sea, the period 2001-2005 is the warmest five-year period observed since 1900.

The bottom temperatures were between approx. 0.3-1.3°C higher in autumn 2006 than in autumn 2005 in most of the Barents Sea except in the northern and eastern parts, where waters were colder than in 2005. The water temperature at depths of 100 and 200 m was in general higher in 2006 than in 2005 in most of the survey area.

Volume transport of warm Atlantic water into the Barents Sea increases primary production, which in turn might improve conditions for shrimp growth. On the other hand increased primary production could also lead to increase in the abundance of important shrimp predators, e.g. Atlantic cod.

b) Input Data

i) Commercial fishery data

Fishing effort and CPUE is summarized in SCR Doc. 06/65. Norwegian logbook data were used in a multiplicative model to calculate standardized annual catch rate indices. This series is indicative of the biomass of shrimp >16 mm cl, i.e. older males and females.

The standardized CPUE declined by 60% from a maximum in 1984 to the lowest value of the time series in 1987, showed an increasing trend until 2000, and then remained stable close to the mean of the series until 2003. Since 2004, the standard CPUE has increased and the 2006 value is similar to the 1984 value (Fig. 6.2).

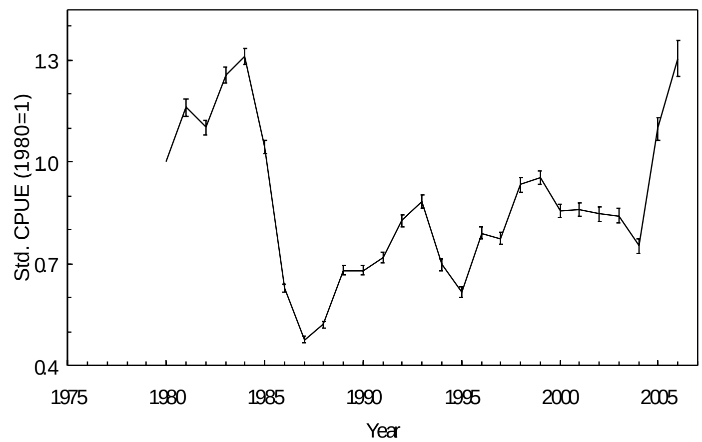


Fig. 6.2. Shrimp in the Barents Sea: standardized CPUE based on Norwegian data.

ii) Research survey data

Russian and Norwegian shrimp surveys have been conducted to assess the stock status of northern shrimp, *Pandalus borealis*, in the Barents Sea since 1982 (SCR Doc. 06/63). The main objectives were to obtain indices for stock biomass, abundance, recruitment and demographic composition. In 2004, the new joint Norwegian-Russian "Ecosystem survey" was introduced as the platform for monitoring shrimp along with a multitude of other ecosystem variables.

Three time series exist: (Survey 1) The Norwegian shrimp survey 1982-2004, (Survey 2) The Russian shrimp survey 1984-2002 and 2005, and (Survey 3). The joint Norwegian-Russian ecosystem survey 2004-2006.

Biomass. Biomass indices (Survey 1 and 2) have varied in a cyclic manner with periods of approximately 7 years since the start of the series in 1982 (Fig. 6.3). The new survey (Survey 3) has not been calibrated to the ones discontinued in 2004 (Survey 1) and 2005 (Survey 2). The estimate of mean biomass based on the Norwegian part of the new Ecosystem survey (Survey 3) increased by 45% from 2004 to 2006 (Preliminary estimates from the same survey including both Russian and Norwegian data showed a similar increase). The geographical distribution of the stock seemed stable since 2004.

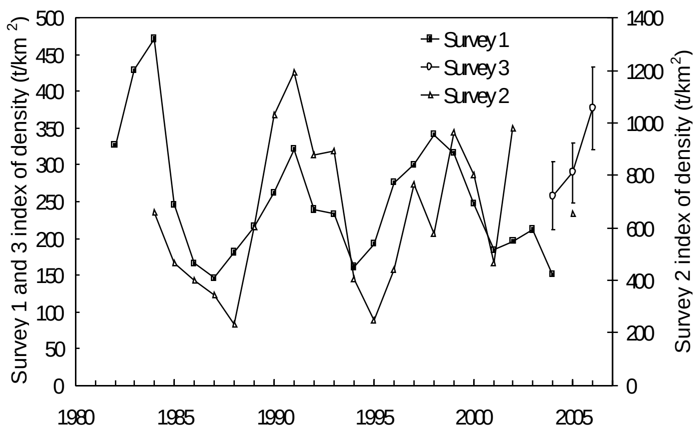


Fig. 6.3. Shrimp in the Barents Sea: Shrimp stock biomass indices of Survey 1 (the Norwegian shrimp survey; 1982-2004), Survey 2 (Russian shrimp survey; 1984-2002, 2005) and Survey 3 (the joint Norwegian/Russian ecosystem survey estimates based on Norwegian data; since 2004).

Length composition. Overall shrimp size distributions (Fig. 6.4) indicate a larger amount of small shrimp (<16 mm cl) in 2004, which apparently has caused the stock increase in 2005 and 2006. The size distributions of 2005 and 2006 are similar.

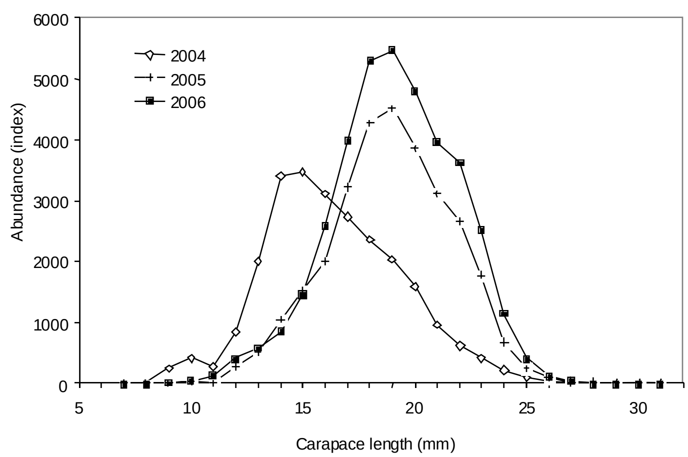


Fig. 6.4. Shrimp in the Barents Sea: Size distribution estimates of shrimp based on Survey 3 data 2004 to 2006.

c) Estimation of Parameters

Parameters relevant for the assessment and management of the stock were estimated, based on a stochastic version of a surplus-production model. The model was formulated in a state-space framework and Bayesian methods were used to construct "posterior" likelihood distributions of the parameters (SCR Doc. 06/64). The inclusion of an explicit predation effect by cod as recommended in previous assessments was considered, but even though estimates of shrimp consumption by cod was on average five times that of the catches this effect was weakly correlated with dynamics of the shrimp stock. It was noted that scaling and variation originating from the underlying spatial structure of the estimates of shrimp stock size and consumption by cod could be an explanation for this lack of correlation.

The model synthesized information from input priors, three independent series of shrimp biomasses and one series of shrimp catches. The three series of shrimp biomass indices were: a standardized series of annual commercial-vessel catch rates for 1980-2006 (SCR Doc. 06/65); and two trawl-survey biomass index for 1982-2004 and 2004-2006 (SCR Doc. 06/63). These indices were scaled to true biomass by catchability parameters and lognormal observation errors were applied. Total reported catch in ICES Div. I and II 1970-2006 was used as yield data (Fig. 6.1, SCR Doc. 06/65). The fishery being without major discarding problems or variable misreporting, reported catches were entered into the model as error-free.

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

Preliminary results of an alternative assessment model including an effect for cod predation was presented and gave promising results (SCR Doc. 06/70).

An alternative series of cod consumption estimates 1993-2005 was presented to correct for assumed bias in an earlier series (SCR. Doc. 06/71). These estimates were on average about 25% lower than previous estimates. However, the correlation of the consumptions series to changes in shrimp stock biomass was weak (SCR Doc. 06/64).

d) **Assessment Results**

Since the 1970s, the estimated median biomass-ratio has been above its MSY-level (Fig. 6.5) and the probability that it had been below the optimum level was small for most years (Fig. 6.6), i.e. it seemed likely that the stock had been at or above its MSY level since the start of the fishery (SCR Doc. 06/64). This perception was not sensitive to changes in the priors for the Carrying Capacity (K) and initial biomass. The 2006 biomass value is among the highest of the series.

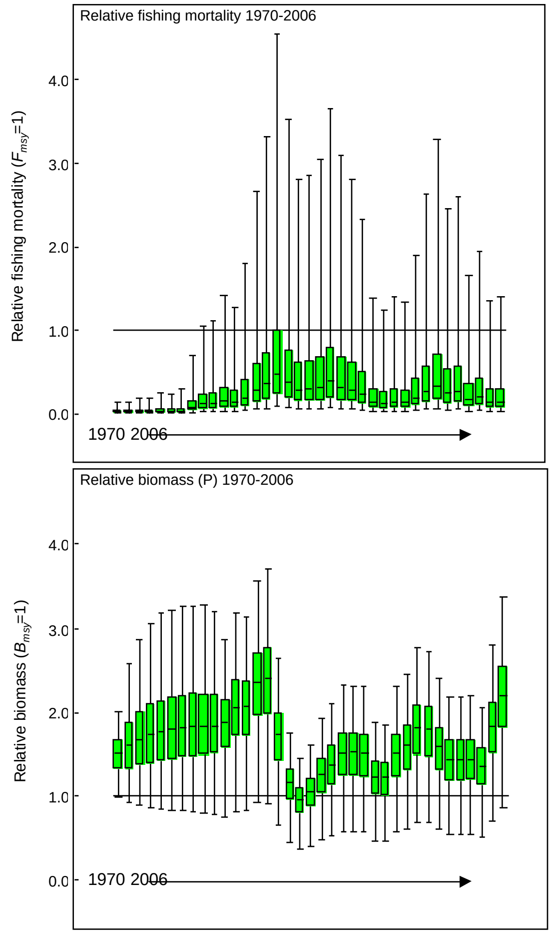


Fig. 6.5. Shrimp in the Barents Sea: estimated relative biomass (B_t/B_{msy}) and fishing mortality (F_t/F_{msy}) 1970-2006. Boxes represent inter-quartile ranges and the solid black line at the (approximate) centre of each box is the median; the arms of each box extend to cover the central 95 per cent of the distribution.

A steep decline in stock biomass was noted in the mid 1980s following some years with high catches and the median estimate of biomass-ratio went below the optimum (Fig. 6.5). Since the late 1990s the stock has varied with an overall increasing trend and reached a level in 2006 estimated to be close to *K*) The estimated risk of stock biomass being below B_{msy} in 2006 was 4% (Fig. 6.6).

The median fishing mortality ratio (*F*-ratio) has been well below 1 throughout the series (Fig. 6.5). However, as this parameter can only be estimated with relatively large uncertainty there is some probability that the stock was fished above F_{msy} (Fig. 6.6). Since 2003 there has been les than 8% risk of the *F*-ratio being above 1 (Fig. 6.6).

The posterior for MSY was positively skewed with a mode at 95 000 t (Fig. 6.7) and upper and lower quartiles at 91 000 t and 282 000 t. As mentioned above the right tail of the MSY-posterior showed some sensitivity to changes in the prior for *K*. However, no matter which prior used the model estimated a probability of at least 95% that MSY is higher than the 2005 advised TAC of 40 000 t.

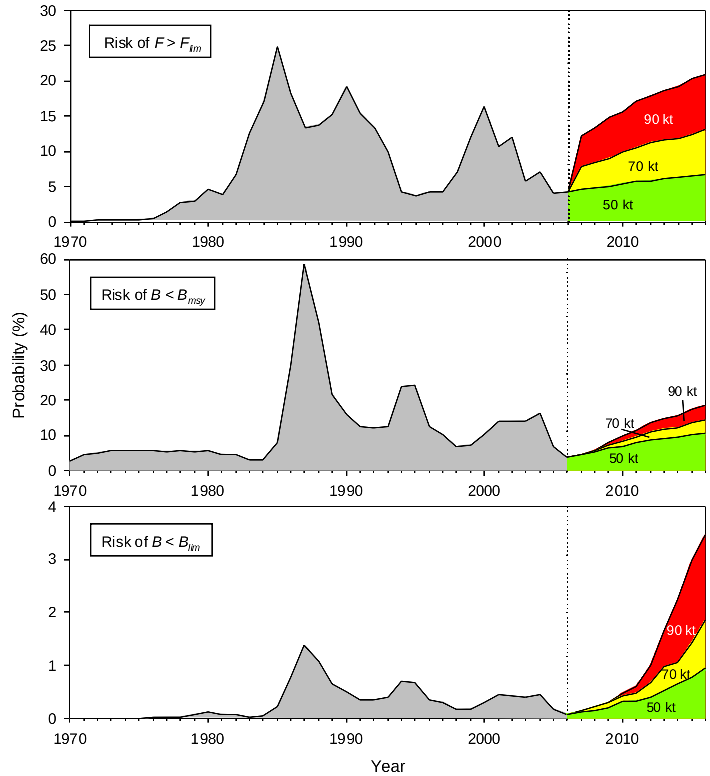


Fig. 6.6. Shrimp in the Barents Sea: estimated risk of exceeding F_{lim} (upper panel) or going below B_{msy} (middle panel) and B_{lim} (lower panel) for the period 1970-2006 (grey area) and future (colored, right area) until 2016. Projections are shown for 3 optional catches 50 (green, lower), 70 (yellow, middle) and 90 (red, upper) kt/yr. The dotted line is at 2006.

Given the high probabilities of the stock being considerably above B_{msy}, risk of stock biomass falling below this optimum level within a one-year perspective is low. Risk associated with six optional catch levels for 2007 are as follows:

Catch option (ktons)	30	50	70	90	110	130
Risk of falling below B_{lim}	<1%	<1%	<1%	<1%	<1%	1 %
Risk of falling below B_{MSY}	4 %	4 %	5 %	5 %	5 %	6 %
Risk of exceeding F_{MSY}	2 %	4 %	8 %	12 %	17 %	21 %

The risk profile associated with ten-year projections of stock development assuming annual catch of 50 000, 70 000 and 90 000 t were investigated (Fig. 6.7). For all options the risk of the stock falling below B_{msy} in the short to medium term (1-5 years) is low, (<11%) (Fig. 6.6). However, it is less certain that these catch levels can be sustained in the longer term (risk of exceeding F_{lim}). The stock has a less than 1% risk of being below B_{lim} and none of these catch options are likely to increase that risk above 5% over a 10 year period (Fig. 6.6).

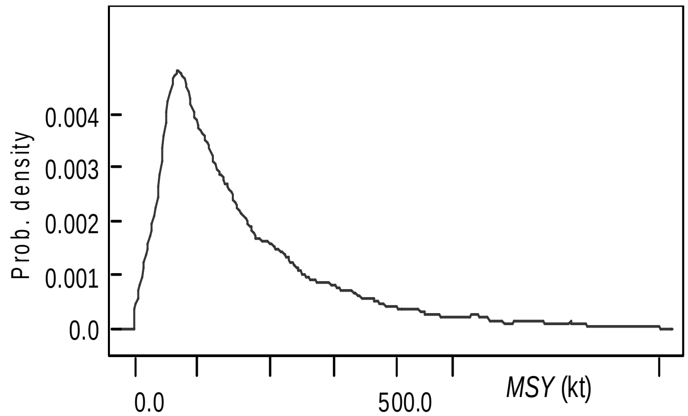


Fig. 6.7. Shrimp in the Barents Sea: Posterior probability density distribution for MSY.

A catch option of 50 000 t, 10 000 t above the advised maximum catch level for 2006 (ACFM, 2005), has a low risk of exceeding F_{lim} and is likely to maintain the stock at its current high level.

Taking 70 000 t/yr will increase risk of going below B_{msy} by about 5% during the ten years of projection. However, the risk will still be lower than 10% during the following 5 years (Fig. 6.6). The risk that catches of this magnitude will not be sustainable ($P(F>F_{lim})$, Fig. 6.6) in the longer term doubles as compared to the 50 000 t-option but is still below or at 10% after five years.

If the catches are increased to 90 000 t/yr, the stock is still not likely to go below B_{msy} in the short term, but whether this catch level will be sustainable in the longer term is uncertain.

Both stock development and the rate at which changes might take place can be affected by changes in predation — in particular by cod, which has been estimated to consume on average 5 times the catches. If predation on shrimp were to increase rapidly outside the range previously experienced by the shrimp stock within the modeled period (1970-2006), the shrimp stock might decrease in size more than the model results have indicated as likely. However, as the total predation depends on the abundance both of cod and also of alternative prey species the likelihood of such large reductions is at present hard to quantify.

Mortality. The fishing mortality has been below the upper limit reference (F_{lim}) throughout the exploitation history of the stock. The risk that F exceeded F_{lim} is estimated at about 3% for 2006, given a projected 2006 catch of 40 000 t.

Biomass. Since 2004 indices of stock size have increased. The modeled stock biomass for 2006 is close to the high values observed in 1984; the estimated risk of stock biomass being below B_{msy} at end 2006 was 4%, but less than 1% of being below B_{lim}.

Recruitment. No indices of recruitment were available.

State of the Stock. The stock biomass estimates has varied above its MSY level throughout the history of the fishery. Biomass at the end of 2006 is estimated to be well above B_{msy} and fishing mortality well below F_{msy}.

e) **Precautionary Approach**

For stocks assessed with production models, the NAFO Scientific Council has developed limit reference points for stock size (B_{lim} at 30% of B_{msy}) and for fishing mortality (F_{lim} at 100% of F_{msy}) (SCS Doc. 04/12). NIPAG proposes that these limit reference points also applies to the Barents Sea shrimp stocks.

Since 1970s, the estimated median biomass-ratio has been above its MSY-level (Fig. 6.8) and the probability that it had been below the optimum level was small for most years (Fig. 6.6), i.e. it seemed likely that the stock had been at or above its MSY level since the start of the fishery. The 2006 biomass value is among the highest of the series.

Estimated median biomass has been above B_{lim} Fishing mortality ratio has been below F_{lim} throughout the time series (Fig. 6.8). At the end of 2006 there is less than 1% risk that the stock would be below B_{lim}, while the risk that F_{lim} was exceeded is 3%.

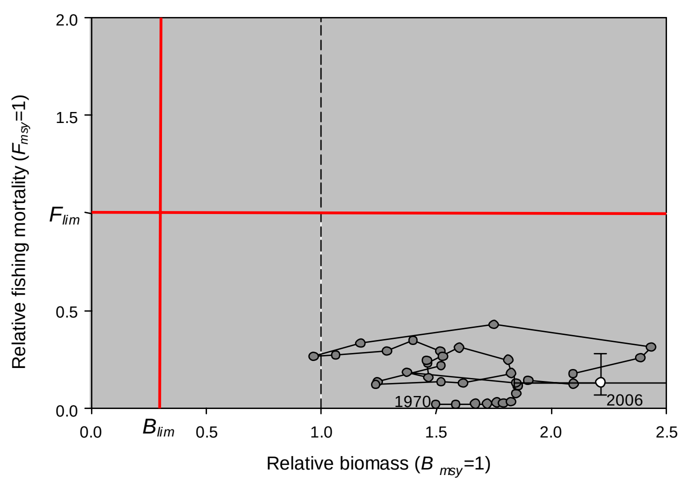


Fig. 6.8. Shrimp in the Barents Sea: estimated annual median biomass-ratio (B/B_{msy}) and fishing mortality-ratio (F/F_{msy}) 1970-2006. The reference points for stock biomas, B_{lim}, and fishing mortality, F_{lim}, are indicated by the red (bold) lines. Error bars on the 2006 value is inter-quartile range.

f) **Research Recommendations**

NIPAG recommends that, for the shrimp stock in ICES Div. I and II:

- the existing ecosystem survey should be calibrated to the discontinued shrimp surveys
- improve estimates of shrimp consumption, by cod and other predators, for inclusion in the model
- a recruitment index and its link to subsequent fishable biomass should be considered for inclusion in the assessment model
- work on developing and evaluating assessment methods should be continued
- work be conducted on classifying, and on defining the fishing power of the different shrimp fishing gears

g) **Management Recommendations**

- nations active in the fishery must be required to provide information on the shrimp length and sex distributions in the catches
- logbooks should include information on the size and type of trawl used

7. **Northern shrimp (*Pandalus borealis*) in Fladen Ground (ICES Division IVa) – ICES Assessed**

This stock was not included in the terms of reference received by NIPAG from ACFM. However, a short description of the fishery is given, as a shrimp fishery may be conducted in this area in the future. The landings from the Fladen Ground have been recorded from 1972. Total reported landings since 1991 have fluctuated between zero in 2006 to above 5 000 t (Table 7.1). The Danish fleet accounts for the majority of these landings, with the Scottish fleet landing a minor portion. The fishery takes place mainly during the first half of the year, with the highest activity in the second quarter.

Total Fladen landings have steadily declined since 1999, and since 2004 the Fladen Ground fishery was close to non-existent with total recorded landings being less than 25 t. Interview information from the fishing industry obtained in 2004 gives the explanation that this decline is caused by low shrimp abundance, low prices on the small shrimp which are characteristic of the Fladen Ground, and high fuel prices. This stock has not been surveyed for several years, and the decline in this fishery may reflect a decline in the stock.

Table 7.1. Estimate landings of *Pandalus borealis* (t) from the Fladen Ground (ICES Div. IVa) estimated by NIPAG.

Fleet	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
Denmark	4 659	3 858	3 022	2 900	1 005	1 482	1 263	1 147	999	23	10
Norway	15	32	9	3	9		18	9	8	0	0
Sweden									1	0	0
UK (Scotland)	1 298	1 893	365	1 365	456	378	397	70		0	0
Total	5 972	5 783	3 396	4 268	1 470	1 860	1 678	1 226	1 008	23	10

8. **Northern shrimp (*Pandalus borealis*) in the Farn Deeps (ICES Division IVb) – ICES Assessed**

NIPAG has not provided advice on this small stock because no catches have been recorded since 1998. Since 1991, only UK vessels have fished *Pandalus* in the Farn Deeps. Total landings fell from 500 t in 1988 to none in 1993. In 1995 and 1996 again about 100t were reported. In the past 10 years the *Pandalus* fishery in Farn Deeps has been negligible (ICES, 2005).

IV. OTHER BUSINESS

Efficiency of Shrimp Trawls

During deliberations of various shrimp stocks it was noted that twin trawls, and in some cases triple trawls, were being utilized for the improvement of catch quality rather than catch rate. It was pointed out that the physical attributes of some twin trawls (e.g. the number of meshes in the circumference) may not be too different from single trawls. NIPAG considered that further investigations should be conducted to address this as it is could be very informative in interpreting standardized catch rate indices. This would include investigations of the use of twin and triple trawls in other fisheries as well, for example Greenland halibut directed fisheries, where their deployment may be used to improve catch rate rather than catch quality. NIPAG recommended that this issue be taken up by the NAFO Standing Committee on Research Coordination (STACREC) and the ICES Fishing Technology Working Group

V. ADJOURNMENT

There being no other business, the Co-Chairs expressed their gratitude to the members of NIPAG for their valuable contributions. The Co-Chairs thanked the effort of the NAFO Designated Experts and the ICES Stock Coordinators for their roles in providing timely assessments and excellent peer-review during plenary discussions. The Co-Chairs considered this joint NAFO/ICES meeting a successful venture which should be continued in future. In consideration that a joint report had been achieved at this meeting, the Co-Chair (Don Power) acknowledged the particular efforts of the ICES Stock Coordinators in adopting to a format that was more in the NAFO style. The Co-Chairs were also grateful for the support received from the NAFO and ICES Secretariats during the meeting, in particular to Anthony Thompson (NAFO Scientific Council Coordinator) for his helpful suggestions and endurance in capturing editorials in plenary sessions.

The Co-Chair (Don Power) noted this meeting will be the last for Unnur Skuladottir, the designated expert for Shrimp in NAFO Div. 3M, and thanked her for her many years of hard work and dedication to shrimp assessments and research.

The report was adopted, noting that a final editorial check would be completed within two weeks of the meeting and the meeting was adjourned.

APPENDIX 1. AGENDA – NAFO/ICES PANDALUS ASSESSMENT GROUP
(held at ICES Headquarters, Copenhagen, Denmark on 25 October-2 November 2006)

I. Opening (Co-chairs: Don Power and Michaela Aschan)

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

II. General Review

1. Review of Recommendations in 2005 and in 2006
2. Review of Catches

III. Stock Assessments

- Northern shrimp (Division 3M)
- Northern Shrimp (Divisions 3LNO)
- Northern shrimp (Subareas 0 and 1)
- Northern shrimp (in Denmark Strait and off East Greenland)
- Northern shrimp in Skagerrak and Norwegian Deep (ICES Divisions IIIa and IVa East)
- Northern shrimp in Fladen Ground (ICES Division IVa)
- Northern Shrimp in Barents Sea and Svalbard area (ICES Sub-areas I & II)

IV. Other Business

V. Adjournment

APPENDIX 2. NAFO REQUESTS FOR ADVICE

The following requests on advice for shrimp have been made to the NAFO Scientific Council and forwarded to the Group:

ANNEX 1. FISHERIES COMMISSION'S REQUEST FOR SCIENTIFIC ADVICE ON MANAGEMENT IN 2007 OF CERTAIN STOCKS IN SUBAREAS 2, 3 AND 4

1. The Fisheries Commission with the concurrence of the Coastal State as regards the stocks below which occur within its jurisdiction, requests that the Scientific Council, at a meeting in advance of the 2006 Annual Meeting, provide advice on the scientific basis for the management of the following fish and invertebrate stocks or groups of stocks in 2007:

   Northern shrimp (Div. 3M, 3LNO)
   Greenland halibut (Subarea 2 and Div. 3KLMNO)

ANNEX 2. CANADIAN REQUEST FOR SCIENTIFIC ADVICE ON MANAGEMENT IN 2007 OF CERTAIN STOCKS IN SUBAREAS 0 TO 4

1. Canada requests that the Scientific Council, at its meeting in advance of the 2006 Annual Meeting of NAFO, subject to the concurrence of Denmark (on behalf of Greenland), provide advice on the scientific basis for management in 2007 of the following stocks:
2.

   Shrimp (Subareas 0 and 1)
   Greenland halibut (Subareas 0 and 1)

   The Scientific Council has noted previously that there is no biological basis for conducting separate assessments for Greenland halibut throughout Subareas 0-3, but has advised that separate TACs be maintained for different areas of the distribution of Greenland halibut. The Council is asked therefore, subject to the concurrence of Denmark (on behalf of Greenland) as regards Subarea 1, to provide an overall assessment of status and trends in the total stock throughout its range and comment on its management in Subareas 0+1 for 2007, and to specifically:

   a) advise on appropriate TAC levels for 2007, separately, for Greenland halibut in the offshore area of Divisions OA+l AB and Divisions OB+l C-F. The Scientific Council is also asked to advise on any other management measures it deems appropriate to ensure the sustainability of these resources.
   b) With respect to shrimp, it is recognized that the Council may, at its discretion, delay providing advice until later in the year, taking into account data availability, predictive capability, and the logistics of additional meetings.

2. Canada requests the Scientific Council to consider the following options in assessing and projecting future stock levels for Shrimp and Greenland halibut in Subareas 0 and 1:

   a) For those stocks subject to analytical-type assessments, the status of the stock should be reviewed and management options evaluated in terms of their implications for fishable stock size in both the short and long term. The implications of no fishing as well as fishing at $F_{0.1}$, and F_{2005} in 2007 and subsequent years should be evaluated in relation to precautionary reference points of both fishing mortality and spawning stock biomass. The present stock size and spawning stock size should be described in relation to those observed historically and those to be expected in the longer term under this range of fishing mortalities, and any other options Scientific Council feels worthy of consideration under the precautionary approach framework.
   Opinions of the Scientific Council should be expressed in regard to stock size, spawning stock sizes, recruitment prospects, catch rates and catches implied by these management strategies for the short and long term. Values of F corresponding to the reference points should be given. Uncertainties in the assessment should be evaluated and presented in the form of risk analyses related to B_{lim} (B_{buf}), and F_{lim} (F_{buf}), as per the NAFO Precautionary Approach Framework.
   b) For those stocks subject to general production-type assessments, the time series of data should be updated, the status of the stock should be reviewed and management options evaluated in the way described above to the extent possible. Management options should be within the NAFO Precautionary Approach Framework.
   c) For those resources for which only general biological advice andlor catch data are available, few standard criteria exist on which to base advice. The stock status should be evaluated in the context of management requirements for long-term sustainability and management options evaluated in the way described above to the extent possible. Management options should be within the NAFO Precautionary Approach Framework.

d) Presentation of the results should include the following:

I. For stocks for which analytical-type assessments are possible:
- A graph of historical yield and fishing mortality for the longest time period possible;
- A graph of spawning stock biomass and recruitment levels for the longest time period possible. The biomass graph should indicate the stock trajectory compared to B_{lim}
- Graphs and tables of catch options for the year 2007 and subsequent years over a range of fishing mortality rates (F) at least from F=0 to $F_{0.1}$ including risk analyses;
- Graphs and tables showing spawning stock biomass corresponding to each catch option including risk analyses;
- Graphs showing the yield-per-recruit and spawning stock per recruit values for a range of fishing mortalities.

II. For stocks for which advice is based on general production models, the relevant graph of production on fishing mortality rate or fishing effort.

In all cases, the reference points, F=0, actual F, and $F_{0.1}$ should be shown. As well, Scientific Council should provide the limit and precautionary reference points as described in the NAFO Precautionary Approach Framework, indicating areas of uncertainty (when reference points cannot be determined directly, proxies should be provided).

ANNEX 3. DENMARK'S (GREENLAND) REQUEST FOR SCIENTIFIC ADVICE ON MANAGEMENT IN 2007 OF CERTAIN STOCKS IN SUBAREA 0 AND 1

4. Subject to the concurrence of Canada as regards Subarea 0, Denmark, on behalf of Greenland, requests the Scientific Council of NAFO before December 2006 to provide advice on the scientific basis for management of Northern shrimp (*Pandalus borealis*) in Subarea 0 and 1 in 2007, and as many years ahead as data allow.

   Further, the Council is requested to advise, in co-operation with ICES, on the scientific basis for management of Northern shrimp (*Pandalus borealis*) in the Denmark Strait and adjacent areas east of southern Greenland in 2007, and as many years forward as data allow.

ANNEX 4. FISHERIES COMMISSION'S REQUEST FOR SCIENTIFIC ADVICE ON MANAGEMENT IN 2008 OF CERTAIN STOCKS IN SUBAREAS 2, 3 AND 4

1. The Fisheries Commission with the concurrence of the Coastal State as regards the stocks below which occur within its jurisdiction, requests that the Scientific Council, at a meeting in advance of the 2007 Annual Meeting, provide advice on the scientific basis for the management of the following fish and invertebrate stocks or groups of stocks in 2008:

   Northern shrimp in Div. 3M, 3LNO
   Greenland halibut in SA 2 and Div. 3KLMNO

APPENDIX 3. ICES TERMS OF REFERENCE

The Terms of Reference for "The *Pandalus* Assessment Working Group "(WGPAND) as agreed by the ICES Council are:

C. Res. 2005/2/ACFM01

D) Concerning advice for Pandalus stocks: the Pandalus Assessment Working Group will meet at ICES HQ in parallel with the NAFO Sc. C./STACFIS shrimp meeting. The report of WGPAND will be available for ACFM s consideration in early November 2006 with a view to release the report by 10 November 2006. TORs including dates and new Chair for WGPAND 2006 to be decided after the WGPAND meeting in November 2005;

C. Res. 2005/2/ACFM16

a) assess the status of and provide management options for 2007 for the stocks of *Pandalus borealis* in the Barents Sea, the North Sea, Skagerrak, and Kattegat and, taking predation mortality on *Pandalus* stocks into account; b) for the stocks mentioned in a) perform the tasks described in C. Res. 2ACFM01.

TORs to be reviewed after the meeting in November 2005 back to-back with NAFO Sc. C./STACFIS *Pandalus* meeting.

APPENDIX 4. TECHNICAL MINUTES FROM THE ICES ACFM REVIEW GROUP FOR THE 2006 WGPAND REPORT

1–7 November 2006 (by correspondence)

Martin Pastoors	Chair
Michaela Aschan	Chair of WGPAND
Helen Dobby	UK

GENERAL

Structure of the report has been changed. It is now referring quite heavily to working documents that are (will be) available on internet, which is a good approach. However, if the SCR documents should be used as a substitute for some report sections, they should be finalized by the end of the meeting (including legends to tables and figures). The division of what belongs to the working documents and what in the report is an issue of balancing. The reviewers needed to resort to the working documents to extract some pieces of key information that were needed to understand the outcome.

To make it easier for the readers/reviewers to find the relevant information, it would be useful to make specific linkages to the parts of the working documents that are referred to (e.g. which figure or section).

The numbering system that is used is confusing because subsections cannot be readily identified. Suggest to revert to standard numbering system.

Trends in commercial CPUE (LPUE) are discussed for both stocks. It would be useful if more details on the method of standardization (Barents Sea) or 'adjustment' (Danish IVa East and IIIa) were included in the main report rather than being in working documents.

There appears to be a general tendency to focus on the information and advice that is generated by this specific WG meeting. In order to evaluate the consistency of available information, assessment and advice, it is important that comparisons are made with previous WG meetings. E.g. the inclusion of last year's assessment methodology and advice for each stock would be useful.

PANDALUS IN IVA EAST AND IIIA

An assessment was presented last year based on a Bayesian stock production model. This year, the report states: "The model work for 2006 was not completed due to a change in priorities. This year's assessment of the current state of the stock is based on evaluation of LPUEs from the fishery 1984-2006 and the surveys." It is unclear whose priorities are meant here: the WG, the institutes? It also points to the fact that the methodology may be very dependent on the analyst, which means that the WG may not be in a position to really evaluate the results. The WG should outline the assessment approach for the near future.

There has been major restructuring of the two main fleets exploiting this fishery (Norwegian and Danish vessels) with likely increases in power and efficiency. Although some attempts have been made to account for technological creep in the Danish fishery (not clear how), logbook data are apparently insufficiently detailed to allow appropriate standardisation of LPUE indices. In the case of Norwegian LPUE calculations, the report states that 'Total Norwegian effort has been estimated from landings and LPUE data based on logbook records'. This sentence is confusing and does not explain clearly where Norwegian effort data comes from. It is therefore unclear as to whether the LPUE indices presented in the report can be considered as indices of stock biomass. In any case, the terminologies "adjustment" and "standardization" need a better explanation.

The fundamental issue with the interpretation of the survey time series is the question whether they can be plotted on the same scale. By plotting them on the same scale the WG invites the interpretation that we can compare the results between the series. The survey timing, vessel and gear has changed as follows:

- October-November 1984 to 2002 using R/V *Michael Sars* and the Campelen-trawl;
- October-November 2003 with R/V *Håkon Mosby* using the Shrimp trawl 1420
- May-June 2004 to 2005 with R/V *Håkon Mosby* using the standard Campelen trawl
- February 2006 with R/V *Håkon Mosby* using the Campelen trawl.

In addition, the number of strata and the number of hauls in the survey has changed over time. There needs to be a thorough analysis about the use of survey data as indicators of stock size with a focus on the likely effects of the changes in timing, strata and gears.

The survey estimates the abundance of predator species but the results are not presented in the report. In the SCR Document there is a reference to the predator abundance in 2006. It would be useful to give a time series of abundance of predators from the surveys rather than one single year.

Why is there no estimate of harvest rate available? Is that due to the absence of a full survey time series? It is not explained in the report and there was an estimate available last year.

Table 1: Estimates for Swedish high-grading are shown in the landings table, but there is no description of how these estimates are obtained. Furthermore, in 'Commercial fishery data' section the report states that Swedish LPUE is probably underestimated due to high-grading, implying that CPUE cannot be adjusted for the estimated high-grading. Additionally, in 2004 and 2005 the total catch is not the sum of landings plus estimates of Swedish high-grading. Landings are generally well below TAC. Is there an explanation for this?

Figure 3: (trends in effort) should be presented for the different fleets (in addition to the overall trend).

Figure 4: What are the error bars? 95% CIs? Why is the 2006 value so precise?

Figure 5: Why is the length distribution 'estimated'? What procedure is used to estimate it?

Biological Reference Points: The second paragraph of this section discusses the value of *M* compared to *F* estimated in 'previous assessments'. Why are these 'previous' assessment methods no longer used? If they were thought to be unreliable then why discuss estimated F values?

Conclusion: The review group accepts the overall conclusion that the indicators show a relatively high stock level in recent years and that this should be the basis for the advice. However, the use of the available data needs to be better explained, with a more critical attitude to what you can and cannot derive from the data. The fact that the survey design has changed so often in the recent years makes it almost impossible to use for assessment purposes.

PANDALUS IN THE BARENTS SEA (DIV. I AND II)

Clearly a good deal of work has gone into developing an appropriate assessment method for this stock. The approach presented by the WG is one based on a Bayesian surplus-production model. If this is a new approach, it would have been useful to include a fuller description of the model development and diagnostics within the main text (i.e. extract more from the working document).

The data used as input to the model appears to be of good quality: catch data (apparently few uncertainties due to discarding or misreporting), standardized commercial CPUE data and two survey indices, and performs relatively well with respect to fit to observed data. Additionally the results appear to be relatively insensitive to assumptions about some of the input priors.

One comment on the standardization of effort: the standardization appears to have taken place by vessel category. The relative efficiency of vessels within a category (more effective HP) and the change due to twin rigging have not been taken into account. The rate of change in the fleet is rather alarming (Figure 4) and it is unclear if the category

>2000 HP refers to vessels of around 2000 HP or whether there has been a further development to even larger engine powers. Apparently the technical creep has not been fully taken into account.

The model provides estimates of the state of the stock with respect to MSY based reference points. Results confirm the impression which is apparent from the trends observed in the raw indices.

Forward simulations based on the model indicate very low risk of F exceeding F_{lim} (around 5%) and B falling below B_{lim} (less than 2%) when catches remain at current levels (or are even increased somewhat).

The introduction to the section states that the fishery is managed by effort. From the rest of the text this is not very clear and all the simulations are presented in terms of catches. The chair of the WG informed the review group that the effort management was more of a ceiling on the maximum effort for Norway and Russia and that it did not constrain the fishing operations of those fleets. The main constraint was on fleets from third countries. This should be clearly explained in the report. Figure 10 in SCR Doc. 06/065 provides relevant input here in terms of time series of effort. The section on risks to the stock under different assumptions of catches is informative but it remains unclear how that relates to effort. When the fishery is managed in effective fishing days and there have been large changes in fleet composition: how is that taken into account in the management system. How is effective effort measured?

What is the data basis for the bycatch estimates of cod, haddock, Greenland halibut and redfish? It would be useful to report this in weight as well as numbers.

The WG has spent some time trying to understand the cod-capelin interaction. However, it is clearly complex and cannot easily be quantified. The inclusion/exclusion of cod predation is difficult to follow. In the section on estimation of parameters there are two confusing statements:

- "Preliminary results of an alternative assessment model including an effect for cod predation was presented (SCR Doc. 06/70).", and
- "An alternative series of cod consumption estimates 1993-2005 was presented to correct for assumed bias in an earlier series (SCR. Doc. 06/71). These estimates were on average about 25% lower than previous estimates. However, the correlation of the consumptions series to changes in shrimp stock biomass was weak (SCR Doc. 06/64)."

Further exploration of model runs including cod predation should be encouraged.

Trends in survey and CPUE are compared in one figure (e.g. Fig. 9). On the other hand the surveys have not been calibrated to each other. How are we to know that they can be plotted on the same scale?

Commercial fishery data: More detail on the GLM used for standardization would be useful, for example, details of the effects included in the model.

Figure 2: What are the error bars? 95% CIs?

Biomass: Where is the evidence for the statement 'the geographical distribution of the stock seemed stable since 2004'?

Figure 4: What are the units? Number per hour? Note there appear to be few small individuals in 2005 and 2006!

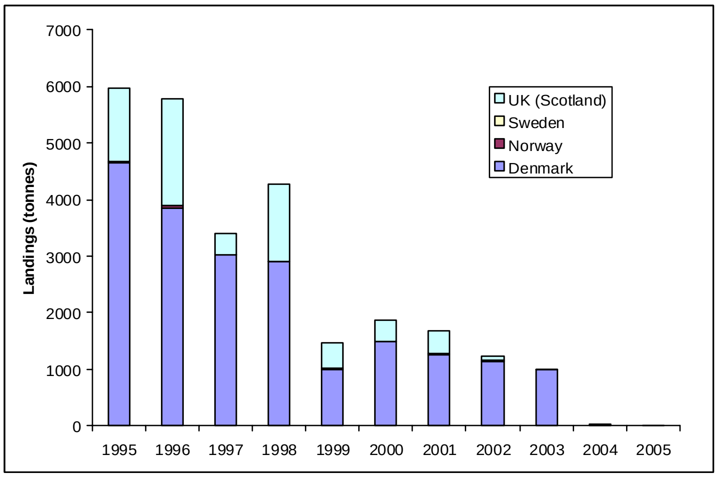
Assessment results: Would be nice to see some of the results of the sensitivity analysis.

Figure 6 and text in that section: Limit reference points discussed though not clear where they have been derived until the next section (e) Precautionary approach).

Conclusion: the review group accepts the overall conclusion of the assessment and that this should be the basis for the advice. The assessment approach seems a sensible one, given the available data. The issue of technical creep in the Norwegian fleet needs to be better addressed.

PANDALUS IN THE FLADEN GROUNDS

Time trends are always best shown in a graph. The time trend in landings from Fladen is very illustrative. Suggest to include this in the report in future.



SOME OTHER USEFUL FIGURES TO BE INCLUDED IN THE REPORT

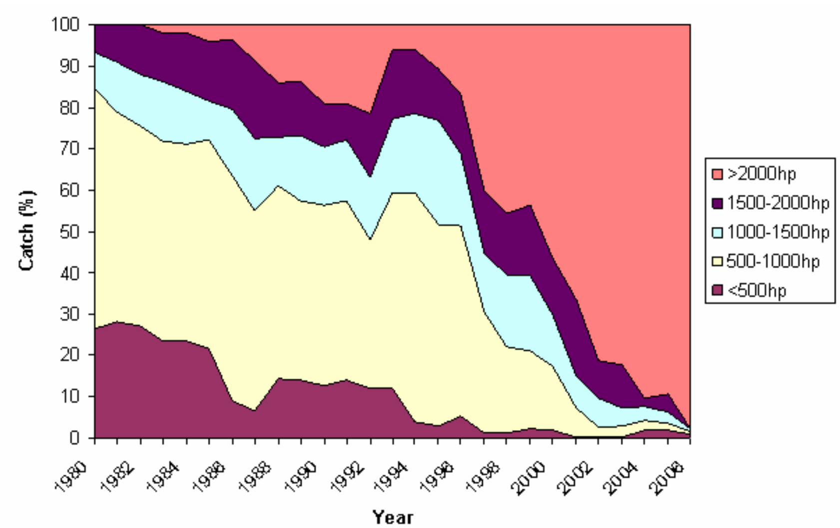


Fig. 4. Shrimp in the Barents Sea: Percentage of total catch taken by 5 fleet components separated by engine size (HP= horse-powers)1980-2006.

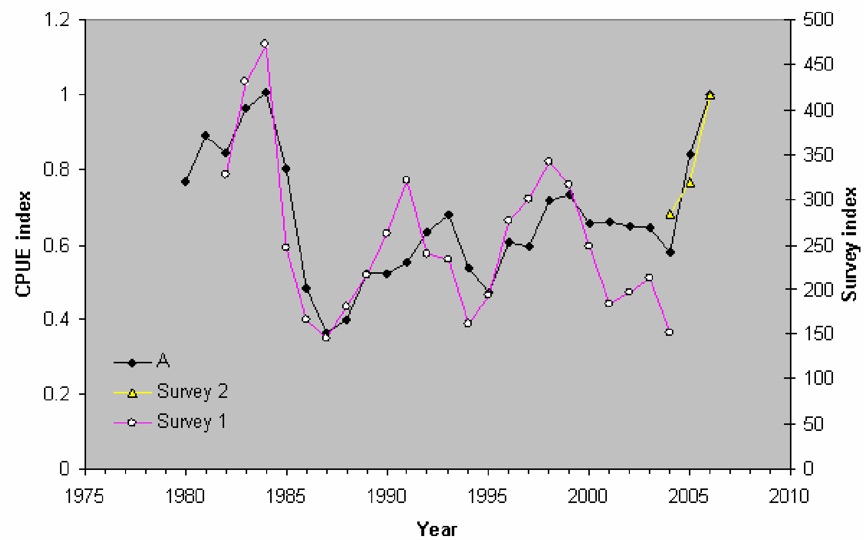


Fig 9. Shrimp in the Barents Sea: Standardised CPUE (A) and survey indices.

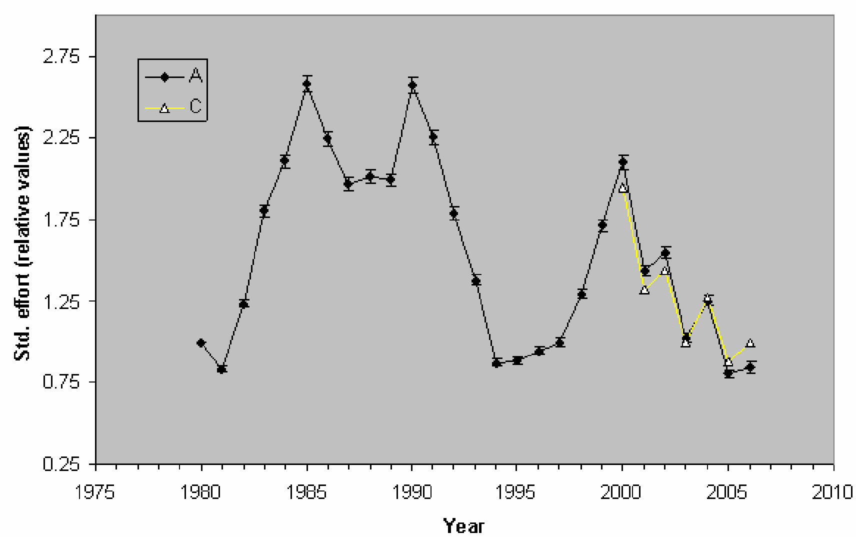


Fig 10. Shrimp in the Barents Sea: Standardised effort. (A) vessels grouped by engine size, (C) individual vessels as the unit of fishing power Norwegian data.

APPENDIX 5. LIST OF SCIENTIFIC COUNCIL RESEARCH DOCUMENTS (SCR)

SCR No.	Ser. No.	Author(s) and Title
06/57	N5305	WIELAND, K., and K. SÜNKSEN. A preliminary estimate of Atlantic cod (*Gadus morhua*) biomass in West Greenland offshore waters (NAFO Subarea 1) for 2006 and recent changes in the spatial overlap with Northern shrimp (*Pandalus borealis*). (11 pages)
06/58	N5306	WIELAND, K., and B. BERGSTRÖM. Results of the Greenland bottom trawl survey for northern shrimp (*Pandalus borealis*) off West Greenland (NAFO Subarea 1 and Division 0A), 1988-2006. (35 pages)
06/59	N5307	SIEGSTAD, H. The Greenland fishery for northern shrimp (*Pandalus borealis*) in NAFO Divisions 3M and 3L 2003-2006. (3 pages)
06/60	N5308	BERGSTRØM, B. I. A note on the timing of hatching of Northern Shrimp, (*Pandalus borealis* Krøyer, 1861) off West Greenland (NAFO Area 1D, 1C and 1B). (7 pages)
06/61	N5309	KINGSLEY, M. C. S. The fishery for northern shrimp (*Pandalus borealis*) off West Greenland, 1970-2006. (24 pages)
06/62	N5310	SØVIK, G., and C. HVINGEL. The Norwegian fishery for northern shrimp (*Pandalus borealis*) in the North Sea and Skagerrak (ICES Divisions IVa east and IIIa), 1970-2005. (12 pages)
06/63	N5313	HVINGEL, C. Research survey information regarding northern shrimp (*Pandalus borealis*) in the Barents Sea. (7 pages)
06/64	N5314	HVINGEL, C. Towards a quantitative assessment framework for the shrimp (*Pandalus borealis*) stock in the Barents Sea. (17 pages)
06/65	N5315	HVINGEL, C., and M. ASCHAN. The fishery for northern shrimp (*Pandalus borealis*) in the Barents Sea. (12 pages)
06/66	N5316	CASAS, J. M. Northern shrimp (*Pandalus borealis*) on Flemish Cap surveys 2006. (24 pages)
06/67	N5317	CASAS, J. M. The Spanish shrimp fishery on Flemish Cap (Division 3M) and Division 3L in 2005. (5 pages)
06/68	N5318	STORR-PAULSEN, M., J. CARL, and K. WIELAND. The importance of Atlantic cod (*Gadus morhua*) predation on northern shrimp (*Pandalus borealis*) in Greenland waters 2005. (16 pages)
06/69	N5319	CASAS, J. M., and J. TERUEL. Northern shrimp (*Pandalus borealis*, Krøyer) from Spanish bottom trawl survey 2006 in NAFO Divisions 3LNO. (10 pages)
06/70[c]	N5320	BAKANEV, S. V. On the possibility of using Bayesian Approach to assess the northern shrimp (*Pandalus borealis*) stock in the Barents Sea and Spitzbergen. (8 pages)
06/71[c]	N5321	ASCHAN, M., E. JOHANNESEN, B. BOGSTAD, and C. HVINGEL. Why does not the shrimp stock in the Barents Sea respond on predation by cod? (10 pages)
06/72[c]	N5322	KINGSLEY, M. C. S. A provisional assessment of the shrimp stock off West Greenland in 2006. (14 pages)

Scientific Council Research (SCR) (continued)

SCR No.	Ser. No.	Author(s) and Title
06/73	N5323	ORR, D. C., P. J. VEITCH, and D. J. SULLIVAN. An update of information pertaining to northern shrimp (*Pandalus borealis*, Krøyer) and groundfish in NAFO Divisions 3LNO. (56 pages)
06/74	N5324	SKÚLADÓTTIR, U. Icelandic Shrimp Fishery (*Pandalus borealis* Kr.) at Flemish Cap in 1993-2006. (22 pages)
06/75	N5325	COLBOURNE, E. B. Oceanographic conditions on the Flemish Cap in NAFO Division 3M during the summer of 2006. (14 pages)
06/76	N5326	SKÚLADÓTTIR, U., and G. PETURSSON. Assessment of the International Fishery for Shrimp (*Pandalus borealis*) in Division 3M (Flemish Cap), 1993-2006. (21 pages)
06/77	N5327	KORZUN, Y. V. The Ukrainian shrimp fishery on Flemish Cap (Division 3M) and Division 3L in 2006. (4 pages)
06/78	N5328	SIEGSTAD. H., and C. HVINGEL. An assessment of the shrimp stock in Denmark Strait/off East Greenland - 2006. (18 pages)
06/79	N5329	COLBOURNE, E. B., and D. C. ORR. The distribution and abundance of northern shrimp (*Pandalus borealis*) in relation to bottom temperatures in NAFO Divisions 3LNO based on multi-species surveys from 1995-2006. (17 pages)
06/80	N5330	D. STANSBURY. Northern Shrimp in 3LNO.
06/81	N5331	MUNCH-PETERSEN, S., G, SØVIK, and M. ULMESTRAND. The *Pandalus* stock in Skagerrak and the Norwegian Deep (Divisions IIIa and IVa east). (17 pages)
06/82	N5332	SØVIK, G., and C. HVINGEL. Results of the Norwegian bottom trawl survey for northern shrimp (*Pandalus borealis*) in Skagerrak and the Norwegian Deep (ICES Divisions IIIa and IVa east) in 2006. (8 pages)

APPENDIX 6. LIST OF PARTICIPANTS

NAFO Participants

Don Power (Co-chair)	DFO, Science Branch, P.O. Box 5667 St. John's, NL A1C 5X1 Canada	Tel +709-772-4935 Fax +709-772-4105 powerd@dfo-mpo.gc.ca
Bo Bergstrøm	Greenland Institute of Natural Resources P. O. Box 570, DK-3900 Nuuk Greenland	Tel +299 36 1203 Fax +299 36 1212 bobe@natur.gl
W.(Bill)B. Brodie.	DFO, Science Branch, P.O. Box 5667 St. John's, NL A1C 5X1 Canada	Tel +709-772-3288 Fax: +709-772-4105 brodieb@dfo-mpo.gc.ca
Jose Miguel Casas Sanchez	Instituto Español de Oceanografía, P.O. Box 1552, Vigo Spain	Tel: +34 986 49 2111 Fax: +34 986 49 2351 mikel.casas@vi.ieo.es
Eugene B. Colbourne,	DFO, Science Branch, P.O. Box 5667 St. John's, NL A1C 5X1 Canada	Tel +709-772-6106 Fax: +709-772-4105 colbourn@dfo-mpo.gc.ca
Michael C.S. Kingsley	Greenland Institute of Natural Resources, P. O. Box 570, DK-3900 Nuuk Greenland	Tel +299 36 1200 Fax +299 39 1212 mcsk@natur.gl
David C. Orr	DFO, Science Branch, P.O. Box 5667 St. John's, NL A1C 5X1 Canada	Tel +709-772-4935 Fax: +709-772-4105 orrd@dfo-mpo.gc.ca
Helle Siegstad	Greenland Institute of Natural Resources, P. O. Box 570, DK-3900 Nuuk, Greenland	Tel +299 36 1200 Fax +299 36 1212 helle@natur.gl
Silver Sirp	Estonian Marine Institute, University of Tartu, Maealuse 10A, 12618 Tallinn, Estonia	Tel +372 5295396 Fax +372 6718900 Silver.sirp@ut.ee
Unnur Skuladottir	Marine Research Institute P.O. Box 1390, Skúlagata 4, IS-l21 Reykjavík Iceland	Tel +354 5752000 unnur@hafro.is
Don Stansbury	DFO, Science Branch, P.O. Box 5667 St. John's, NL A1C 5X1 Canada	Tel +709 772-0559 Fax +709-772-4105 stansburyd@dfo-mpo.gc.ca
Antonio Vazquez	Instituto de Investigaciones Marinas Eduardo Cabello 6, 36208 Vigo Spain	Tel +34 9 86 23 Fax +34 9 86 29 2762 avazquez@iim.csic.es
Kai Wieland	Greenland Institute for Natural Resources P.O. Box 570, DK-3900 Nuuk Greenland	Tel +299 361200 Fax +299 361212 wieland@natur.gl

ICES Participants

Michaela Aschan (Co-chair)	Norwegian College of Fisheries Science University of Tromsø, Dept of Aquatic Biosciences, Beivika, 9037 Tromsø Norway	Tel +47 99261 458 Fax +47 77646 020 michaela.aschan@imr.no
Carsten Hvingel	Institute of Marine Research PO Box 6404, N-9294 Tromsø Norway	Tel +47 77609750 Fax +47 77609701 carstenh@imr.no
Sten Munch-Petersen	Danish Institute for Fishery Research (DIFRES), Charlottenlund Slot DK-2920 Charlottenlund Denmark	Tel +45 33063390 Fax +45 33963333 smp@difres.dk
Guldborg Søvik	Institute of Marine Research PO Box 6404, N-9294 Tromsø Norway	Tel +47 77609753 Fax +47 77609701 guldborg.soevik@imr.no
Trond Thangstad	Institute of Marine Research PO Box 6404, N-9294 Tromsø Norway	Tel +47 77609741 Fax +47 77609701 trond@IMR.no

Mats Ulmestrand	National Board of Fisheries Institute of Marine Research Box 4, SE-453 21 Lysekil Sweden	Tel +46 52318700 Fax +46 52313977 mats.ulmestrand@fiskeriverket. se
Sergei Bakanev	PINRO 6, Knipovitch Street, 183763 Murmansk Russia	Tel +47 78910518 Fax +78152472464 bakanev@pinro.ru

Support

Anthony Thompson	NAFO, P.O Box 638, Dartmouth, Nova Scotia B2Y 3Y9 Canada	Tel +1 902 468 7542 Fax +1 902 468 5538 tony.thompson@nafo.int
Michala Ovens	ICES, H.C. Andersens Boulevard 44-46, DK-1553 Copenhagen V Denamrk	Tel + 45 33 38 67 00 Fax + 33 93 42 15 michala@ices.dk