Northwest Atlantic Fisheries Organization

International Council for the Exploration of the Sea

Conseil International pour l'Exploration de la Mer

NAFO SCS Doc. 08/25
Serial No. N5593

ICES CM 2008/ACOM:11

NAFO/ICES *Pandalus* Assessment Group Meeting, 22–30 October 2008

ICES Headquarters,

Copenhagen,

Denmark

NAFO/ICES *Pandalus* Assessment Group Meeting, 22–30 October 2008

Contents

Report of NIPAG Meeting

22–30 October 2008

Co-Chairs: Michael Kingsley (NAFO Stocks) and Michaela Aschan (ICES Stocks) Rapporteurs: Various

I. OPENING

The NAFO/ICES *Pandalus* Assessment Group (NIPAG) met at the ICES Headquarters, Copenhagen, Denmark, from 22 to 30 October 2008 to review stock assessments referred to it by the Scientific Council of NAFO and by the ICES Advisory Committee on Management. Representatives attended from Canada, Denmark, Denmark (in respect of Faroe Islands and Greenland), European Union (Spain), Norway, the Russian Federation, and Sweden.

II. GENERAL REVIEW

1. Review of Research Recommendations in 2007

a) NIPAG Research Recommendations in 2007

For shrimp on Flemish Cap (NAFO Div. 3M)

1. Biological and CPUE data from all fleets fishing for shrimp in the area be submitted to Designated Experts by 1 September in the assessment year.

STATUS: this recommendation was reiterated.

2. 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.

STATUS: this investigation was reported as now in progress, but results are difficult to obtain and progress is slow.

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

STATUS: this investigation was reported as now in progress; addition of more years' data will improve the investigation.

For Shrimp on the Grand Banks (NAFO Div. 3L, 3N and 3O)

4. Biological and CPUE data from all fleets fishing for shrimp in the area be submitted to the Designated Expert, in the standard format, by 1 September of the assessment year.

STATUS: NIPAG drew attention to the late and inadequate submission of this information by a number of Contracting Parties, and reiterated its recommendations for improvements.

5. There be exploration of methods to incorporate areal expansion/contraction, of the commercial fishery, into future CPUE models; this will require that positional data on catch and effort be available to the investigation.

STATUS: analyses of haul location data, from both commercial fishery and survey, were presented that showed progressive changes in the area occupied by the stock and in that over which the fishery is distributed. Incorporation of this information to CPUE indices is proceeding.

For shrimp off West Greenland (NAFO Subareas 0 and 1)

6. Onboard 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.

STATUS: no progress; this recommendation was reiterated.

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

STATUS: there was no progress on this recommendation, which was reiterated.

8. Recruitment indices and their relationship to subsequent fishable biomass should be considered for inclusion in the shrimp assessment model.

STATUS: initial explorations of this problem were reported as having been carried out, but with little success so far in including the recruitment index in the model and then getting it to run.

9. Methods of incorporating weighted CPUE indices into the assessment model should be explored.

STATUS: if different CPUE series are combined in a separate step from the main stock-dynamic modelling to give a single series, it seems easy to vary their relative weights and also to include the survey index, with its own optional weight, in the same step. But so far, there has been some difficulty in running the model with individual CPUE series included separately and there has been little progress in investigating ways of deliberately varying their respective weights.

10. Update the model accepted in the 2006 assessment with the data available in the 2008 assessment and investigate the impact of the alternative treatment of the various input series.

STATUS: the model accepted in the 2006 assessment was updated with 2008 data, which it fitted well. The effect of different catch:effort data sets and alternative treatments of catch:effort data were investigated in a series of comparisons of CPUE standardizations, and appropriate selections of statistical areas and fleet composition were identified from these results (SCR Doc. 08/62). A suitable method of correcting pre-2004 catch data for under-reporting, at the level of the individual haul, was arrived at by consulting industry experts and applied to historical data.

For shrimp in Denmark Strait and off East Greenland

11. A survey be conducted to provide fishery-independent data on the stock.

STATUS: a survey in east Greenland is under development, but has so far emphasized Greenland halibut and Atlantic cod. This recommendation was reiterated to encourage Greenland to increase the emphasis on northern shrimp in this area.

12. 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.

STATUS: no progress; observers are not sailing on Greenland vessels fishing in East Greenland.

13. The availability and usefulness of size data from commercial landings be investigated as a source of information on stock structure.

STATUS: some data on product classes may be available in logbook entries for some fleets, but how informative it is on the size structure of the stock has not yet been investigated.

14. The existence and availability of survey data from Norwegian sources be investigated.

STATUS: a review of Norwegian survey data from the mid-1980s from East Greenland waters was presented as SCR Doc. 08/63. It included information on the distribution of survey catches, size distributions, and a possible route of drift and migration of different size classes.

For shrimp in Barents Sea and Svalbard area

15. NIPAG recommends that further studies be done to fully investigate the effects of the changes in the fleet on the standardized CPUE.

STATUS: a new analysis allowed the use of individual vessels in the GLM model. The history of these vessels units were tracked through time and were given new IDs if changes were registered in engine size, GRT and/or length. The concern that the recent changes in the fleet would increase the fishing power of the vessel-groupings used as the level of fishing power in the GLM model and therefore induce bias in the index series is no longer present.

16. A recruitment index and its link to subsequent fishable biomass should be considered for inclusion in the assessment model.

STATUS: ongoing work.

17. Integrated analyses of all ‘ecosystem survey’ data (Russian and Norwegian) and investigation of available information to aid calibration of the old and the new surveys be conducted.

STATUS: all data (Russian and Norwegian) are now analyzed together and indices of stock dynamics for the entire ecosystem survey area was presented. Investigations regarding available information to aid calibration of old and new surveys are not yet completed.

For shrimp in Skagerrak and Norwegian Deep

18. NIPAG recommended 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 need to be clarified by using genetic separation technologies.

STATUS: work in progress.

19. Further development of the Bayesian stock production model presented in 2005, and comparisons and evaluations of the assessment models available for this shrimp stock is recommended.

STATUS: work in progress.

20. Standardized Danish LPUE is provided for the current year.

STATUS: not accomplished in 2008 due to technical problems.

21. Develop new commercial shrimp trawls that will reduce impacts upon the bottom.

STATUS: not accomplished.

22. Develop limit reference points.

STATUS: not accomplished.

b) ICES RG Research Recommendations in 2007

Recommendations for shrimp in Skagerrak and Norwegian Deep

1. The Norwegian LPUE series should be included in the assessment.

STATUS: accomplished.

2. The definition of a *Pandalus* trip in the Danish LPUE data should be explored.

STATUS: accomplished.

For shrimp in Barents Sea and Svalbard area

3. The RG advises the WG to explore the reference points in the light to the ICES approach to PA reference points.

STATUS: ongoing work.

4. To explore a calibration of the old and new surveys using overlap in areas so that both can be used in the future.

STATUS: ongoing work.

2. Review of Catches

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

III. STOCK ASSESSMENTS

1. Northern Shrimp (*Pandalus borealis*) on Flemish Cap (NAFO Div. 3M) – NAFO Assessed

(SCR Doc. 04/64, 74, 08/65, 67, 68, 77; SCS Doc. 04/12)

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 to 110, and in 2006 there were approximately 20 vessels fishing shrimp in Div. 3M compared with 50 in 2004. No information is available on the number of vessels taking part in the shrimp fishery in 2008.

Catches increased from about 26 000 t in 1993 to 48 000 t in 1996, declined to 26 000 t in 1997 then increased gradually to a peak of 64 000 t in 2003 (Fig. 1.1). The catch declined in 2005 and 2006 to 27 000 t and 18 000 t respectively. The catches increase to 20 000 t. in 2007 and provisional information to 1 October 2008 indicates removals of about 7 805 t, similar to those recorded last year up to this date. Supplementary information from the fishery suggests that economic considerations (price of fuel and market prices for shrimp) may be affecting participation.

b) Input Data

NIPAG expressed its concern about suspected misreporting of catches in 2005, 2006 and 2007, where catches from Div. 3L were reported as from Div. 3M.

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

	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Recommended TAC	30 000	30 000	45 000	45 000	45 000	45 000	48 000	48 000	(3)	(4)
STATLANT 21A	50 471	54 830	48 836	62 671	45 842	27 651[1]	14 422[1]	17 600[1]		
NIPAG	52 867	53 389	50 214	63 970	45 757	27 479	18 162	20 267	7 805[2]	

[1] Provisional.
[2] Preliminary to 1 October 2008.
(3) SC recommended that exploitation level for 2008 and 2009 should not exceed 2005 and 2006 levels.
(4) SC recommended that a TAC for 2009 should not exceed the 2005 and 2006 exploitation levels.

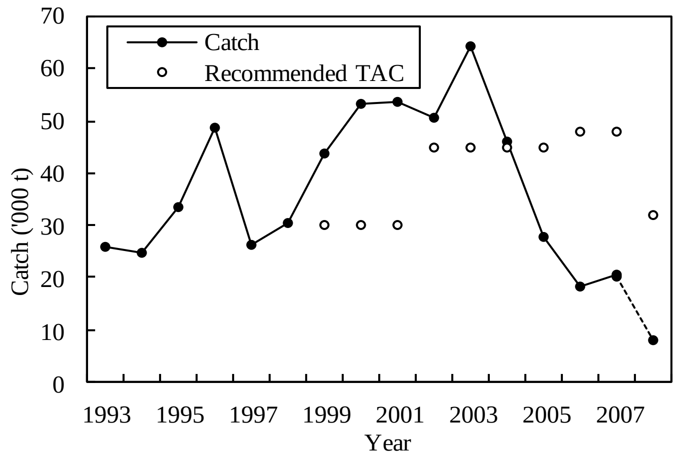


Fig. 1.1. Shrimp in Div. 3M: catches (2008 preliminary partial year's catch). Preliminary information is shown by the dashed line.

i) Commercial fishery data

Effort and CPUE. Logbook and/or observer data were available from Canadian, Greenlandic, Icelandic, Faroese, Norwegian, Russian, Estonian and Spanish vessels. From this information one international CPUE database for Div. 3M was constructed. In recent years there have been concerns that suspected misreporting of some catches from 2005 to the present (Div. 3L catches being reported as Div. 3M catches), was affecting the CPUE data for some shrimp fleets fishing in these areas. In order to avoid the uncertainty around the catch rate standardization model used for Div. 3M, all trips from 2005 to 2008 where the catches were mixed up between Div. 3M and 3L were eliminated from the database. This way the CPUE was corrected and a standardized CPUE series was produced. CPUE decreased from 1993 to 1994, and was at low levels through 1997. From 1998 it gradually increased through 2006. In 2007 and 2008 the standardized CPUE declined, but owing to the scanty observations in 2008 (only Estonian data were available) there is considerable uncertainty regarding the 2008 point (Fig. 1.2). Effort levels have recently been low and NIPAG was concerned that the CPUE may not reflect the stock status in the same way as at higher exploitation rates.

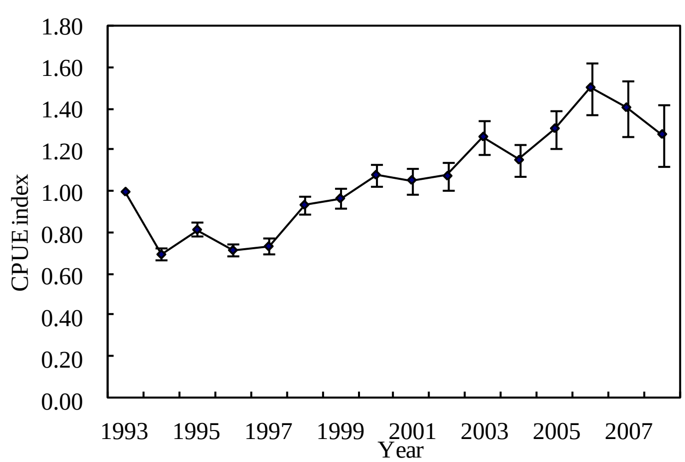


Fig. 1.2. Shrimp Div. 3M: Standardized CPUE of shrimp on Flemish Cap, 1993–2008.

Standardized CPUE female SSB. It has been shown for this stock that transitionals will be functional females at spawning time in the same year (SCR Doc. 04/64). Accordingly a spawning stock index was calculated from the standardized CPUE as kg/hr of all females (transitionals and full females). The spawning stock declined from 1993 to 1997, and had shown an increasing trend with fluctuations to 2006 (Fig. 1.3). In 2007 this increasing trend is interrupted and the lower value estimated in 2008 appears to confirm the decline of the spawning stock.

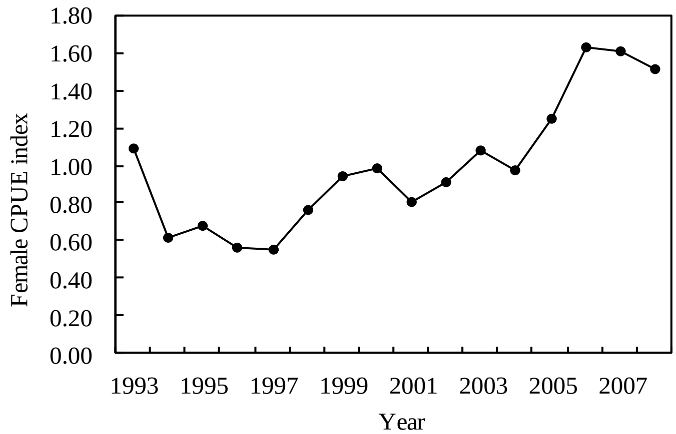


Fig. 1.3. Shrimp Div. 3M: Standardized Female CPUE of shrimp on Flemish Cap, 1993–2008. The series was standardized to the mean of the series.

This change of the trend may however be questionable. For want of samples from the commercial fishery since 2006, length distributions from the EU survey have been used instead. Given differences in gear, fishing methods and targeting, NIPAG was concerned that survey samples might not be a satisfactory substitute for fishery samples for this purpose, and recommended that the length distributions of the two kinds of sample should be compared for years when both were obtained. Also, as was noted for the standardized CPUE above, the scanty observations can affect the values estimated in 2008.

Biological data. The age composition was assessed from commercial samples obtained from Iceland from 2003 to 2005 and from Canada, Greenland, Russia and Estonia in previous years. In recent years the few samples obtained from Spain for 2005 and 2006 and Ukraine in 2006 have been insufficient to assess the age distribution so the length distribution from the EU survey was used. Number caught per hour for each age-class was calculated for each year by applying a weight/age relationship and age proportions in the catches on the annual standardized CPUE data.

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 fewer. The 2002 year-class seems to be very prominent as 3 year-olds in the 2005 fishery and as 4- and 5-year-olds in 2006 and 2007 respectively. In 2008 the abundance of this year-class declined drastically. The number of 2-year-olds is about average in 2005, below average in 2006 and very low in 2007 and 2008 pointing to recruitment being very low since 2004. The 2002 year-class appears to be growing very slowly as seen when the mean lengths at age are studied in the years 2005-2007. This may be caused by the exceptionally high numbers of that year-class in those years. Again the uncertainty about the full usefulness of the length distributions estimated from EU surveys as substitute for fishery samples means that these results ought to be interpreted with caution. NIPAG recommended the comparison of the age compositions from the two kinds of sample for the years when both were available.

Numbers caught per hour at age in the commercial fishery:

Age group	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	Mean
1	0		6			23	665						53
2	2167	3330	2655	1106	6906	4571	8610	12495	5499	1680	874	901	4107
3	17205	19480	15803	23135	9251	38565	9503	29354	35757	8677	11229	26381	20891
4	17853	22790	18278	26907	29607	13125	37983	10506	31200	56273	35582	35186	26430
5	3507	7269	14705	15910	15626	15905	14816	22211	14857	34802	37395	23644	17157
6	710	2703	5294	3338	4423	3249	5833	4325	2917	15085	17220	1658	5231
7	61	303	61	162	598	128	86	24	480	1872	3761	0	580
Total	**41504**	**55876**	**56802**	**70556**	**66410**	**75566**	**77495**	**78915**	**90711**	**118390**	**106062**	**87770**	**74450**

ii) Research survey data

EU bottom trawl surveys. Stratified random surveys have been conducted on Flemish Cap in July from 1988 to 2008. A new vessel was introduced in 2003, although it continued to use the trawl employed since 1988. In addition, there were differences in cod-end mesh sizes utilized in the 1994 and 1998 surveys that have likely affected the estimates of total survey biomass. Nevertheless, for this assessment, the series prior to 2003 were converted to be comparable with data obtained with the new vessel, using the methods accepted by STACFIS in 2004 (NAFO SC 2004 Rep., SCR Doc. 04/77). The revised index of female shrimp biomass shows 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 2007 without trend (Fig. 1.4). However the assessment group observed that the continued decline in L_{50} (sex change) that has been observed would cause females to be a steadily increasing proportion of the total biomass and would thus prop up the female biomass index. Furthermore, the 2008 survey index was the lowest since 1998.

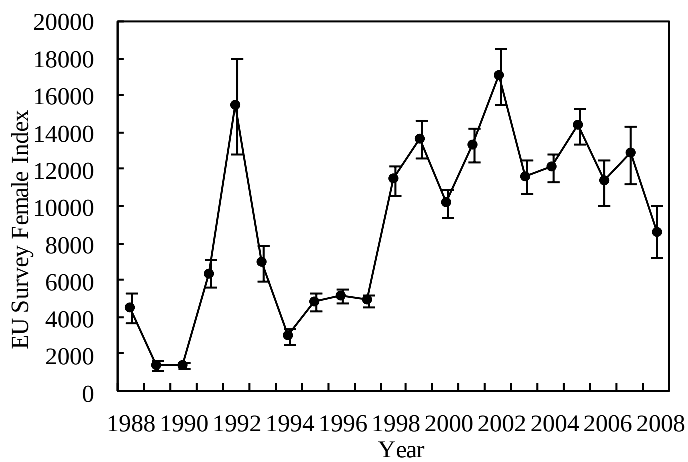


Fig. 1.4. Shrimp in Div. 3M: female biomass index from EU trawl surveys, 1988-2008.

iii) Recruitment indices

Commercial fishery. Although the commercial fishery is conducted with larger mesh size than the survey, two-year-olds are frequently detected in the fishery. An index of two-year-old shrimp from 1996 to 2008, based on standardized number per hour correlated well (R^2= 0.55, Fig. 1.5) with a similar index derived for 3+-year-olds (a proxy for the fishable biomass) from the fishery two years later. The number per hour of 2-year-olds in the commercial fishery has been declining since 2004 (see table above).

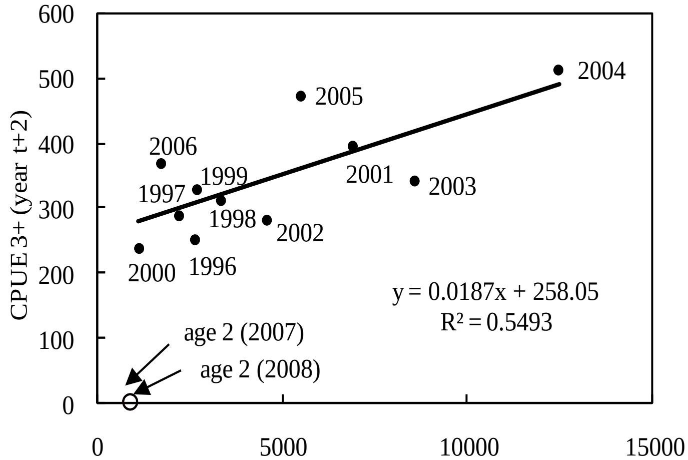


Fig. 1.5. Shrimp in Div. 3M: regression between CPUE of age 2 (year t) shrimp from samples from the commercial fisheries and CPUE of age 3+ (year t+2), 2 years later.

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 owing 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, intended to provide an index of shrimp smaller than those typically retained by the survey cod-end. Although the relationship between the number of age 2 from the juvenile bag and the abundance of age 3+ one year later seems to show a good relationship (R^2 = 0.57), this relationship disappears if we do not consider the extreme data corresponding to age 2 in year 2004, showing the lack of robustness in the relationship. Furthermore neither index shows a good and robust relationship with the 3+ survey index either 1, 2 or 3 years later. This may be because there are only limited data points for a valid comparison and the probable low catchability of the juvenile bag in the first years of the series (2001–2003), due to technical problems. The recruitment indices for both 2005 and 2006 are low in the main gear as well as in the juvenile bag (Fig. 1.6). The EU survey agrees with the commercial fishery recruitment indices in showing an exceptionally large 2002 year-class and very weak 2003–2006 year-classes.

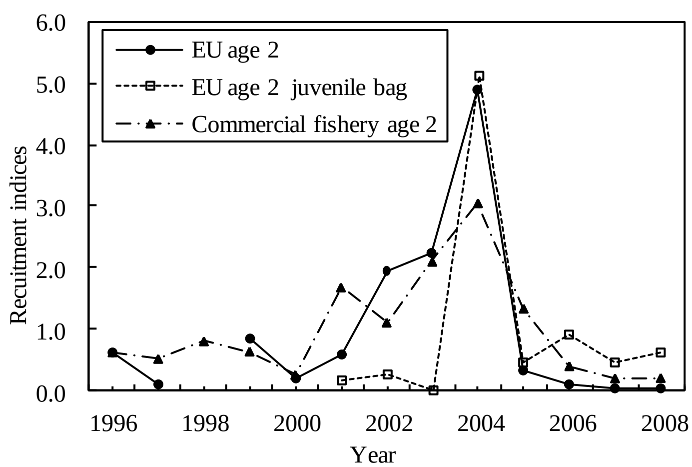


Fig. 1.6. Shrimp in Div. 3M: abundance indices at age 2 from the EU survey. Each series was standardized to its mean.

iv) Exploitation rate

An index of exploitation was derived by dividing the nominal catch in a given year by the biomass index from the EU survey in the same year. The exploitation index was high in 1994–1997 when biomass was generally lower. In 1998–2006 the catch rate has been rather stable at a lower level. However the provisional exploitation rate estimated in 2008 was the lowest in the historical series continuing a probable decreasing trend initiated in 2004. This trend appears to be mostly due to decreasing catches.

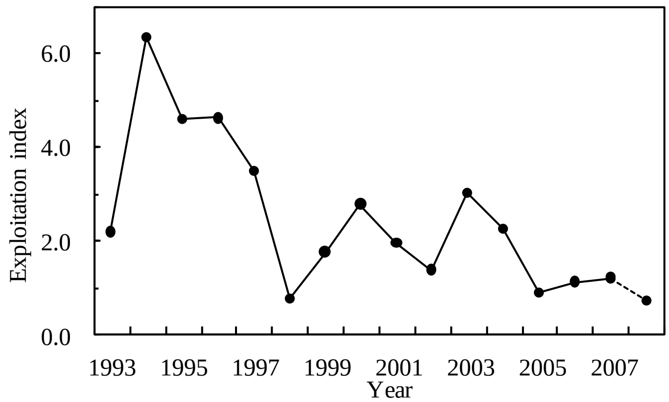


Fig. 1.7. Shrimp in Div. 3M: exploitation rates as derived by catch divided by the EU survey biomass index of the same year.

v) Other studies

An analysis of catch rate of Estonian shrimp vessels in Div. 3M and Div. 3L in 2007 and 2008 was presented (SCR Doc. 08/77). The author defined and compared four CPUE groups. Observed catch rates in Div. 3M appeared to be higher two days before and after fishing in Div. 3L (group 3) than on other days of fishing in Div. 3M (groups 1 and 2). Two possible reasons were investigated: seasonality effect and use of single and double trawls. The fourth group, hauls in Div. 3L, was not compared with any other group.

c) Assessment Results

The problems in recent years about suspected misreporting and its effect on various indices derived from the commercial fishery continued this year and were solved with the same criterion as in recent years. Thus several indices derived from the number per hour could be used in the assessment of this year.

Commercial CPUE indices. Indices for both biomass and female biomass from the commercial fishery showed increased trends from 1996 to 2006. Although still high, both indexes have decreased since 2006.

Biomass. The survey index of female biomass increased from 1997 to 1998 and fluctuated without trend between 1998 and 2007, but the 2008 survey index was the lowest since 1998.

Recruitment. The 2002 year-class was strong, but all later year-classes have been much weaker.

Exploitation rate. The exploitation rate projected for 2008 was the lowest in the historical series continuing a decreasing trend initiated in 2004. This trend appears to be mostly due to decreasing catches.

State of the Stock. The indices of biomass are at a relatively high level but showing signs of decline, even at present low catch levels. There are expectations of continued poor recruitment to the fishable stock, which may affect the 2009 fishery.

d) Precautionary Approach

NIPAG noted that the Scientific Council Study Group on Limit Reference Points has 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}".

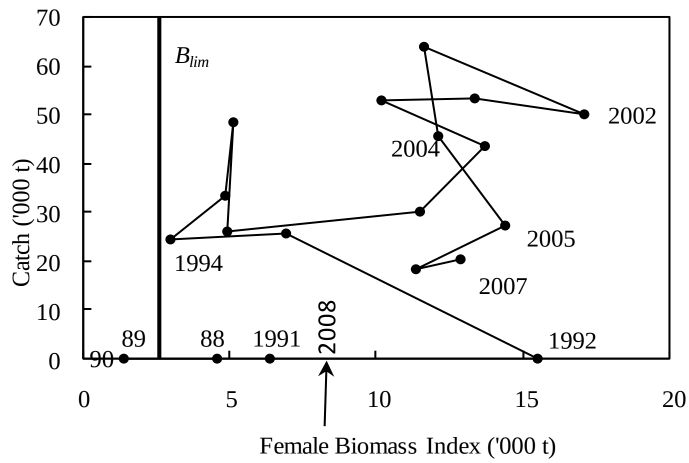


Fig. 1.8. Shrimp in Div. 3M: catch plotted against female biomass index from EU survey. Line denoting B_{lim} is drawn where biomass is 85% lower than the maximum point in 2002. The preliminary female biomass index for 2008 is estimated at 7 805 t to 1 October 2008 and is shown by the arrow on the x-axis.

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 in Div. 3M provides an index of female shrimp biomass from 1988 to 2008 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} = 2600 t. The female biomass index was below this value in only 1989 and 1990, before the fishery. In 2007 and 2008 it was about 25% and 51% 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. 1.8).

e) 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 2008.*
- *the catch and effort data from other sources, for example VMS and/or Observer data, continue to be investigated to validate commercial data obtained from summarized logbooks or STATLANT data.*
- *the relationship between the recruitment indices and fishable biomass be investigated further.*
- *age composition by sex in the fishery calculated from length distributions in the EU survey and from commercial samples should be compared for years when both were obtained.*

2. Northern Shrimp (Div. 3LNO) – NAFO Assessed

(SCR Doc. 08/58, 65, 77)

a) Introduction

This shrimp stock is distributed around the edge of the Grand Banks mainly in Div. 3L. The fishery began in 1993 and came under TAC control in 2000 with a 6000 t TAC and fishing restricted to Div. 3L. Annual TACs were raised to 13 000 t for 2003–2005, to 22 000 t for 2006–2007 fisheries and then to 25 000 t for 2008 resulting in a total catch of 22 932 t up to October 2008 (Fig. 2.1). For 2009 the TAC has been increased to 30 000 t.

Since this stock came under TAC regulation, Canada has been allocated 83% of the TAC. This allocation is split between a small-vessel (less than 500 GT and less than 65 ft) and a large-vessel fleet. By October 2008, the small- and large-vessel fleets had taken 14 632 t and 5135 t 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 in 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, from 2003 to 2005 Denmark (in respect of the Faroe Islands and Greenland) set an autonomous annual TAC of 1344 t. This autonomous TAC was raised to 2274 t in 2006 and was maintained at this level through to 2008.

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:

	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
TAC as set by FC	6 000	6 000	6 000	13 000[1]	13 000[1]	13 000[1]	22 000[1]	22 000[1]	25 000[1]	30 000
STATLANT 21A	5 040	5 647	5 894	11 979	12 767	14 281	22 166[2]	20 668[2]	22 932[2]	
NIPAG	4 711	10 697[3]	6 994[3]	13 200	13 461	14 387	23 832[3]	23 856[3]	22 932	

[1] DFG did not agree to the quotas of 144 t (2003–2005), 245 t (2006–2007) or 278 t (2008), and set their own quota of 1 344 t (2003–2005) and 2 274 t (2006–2008). The increase is not included here.
[2] Provisional catches.
[3] Reliable catch reports were not available for all countries, and therefore estimates were made using other sources (Canadian surveillance, observer datasets, STACFIS estimation *etc.*).

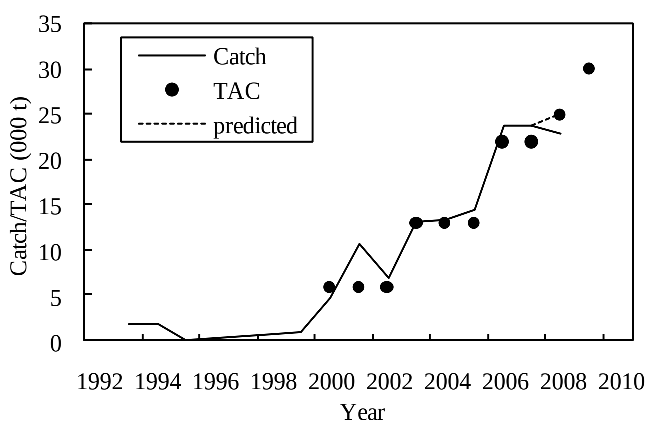


Fig. 2.1. Shrimp in Div. 3LNO: catches (to October 2008) and TAC as set by FC.

b) Input Data

i) Commercial fishery data

Effort and CPUE. Catch and effort data have been available from vessel logbooks and observer records since 2000. Standardized catch rates for large Canadian vessels (>500 t) have been stable since 2004 near the long term mean (Fig. 2.2). There was insufficient data to estimate a standardized CPUE index for the 2008 Canadian small-vessel (≤500 t) fleet.

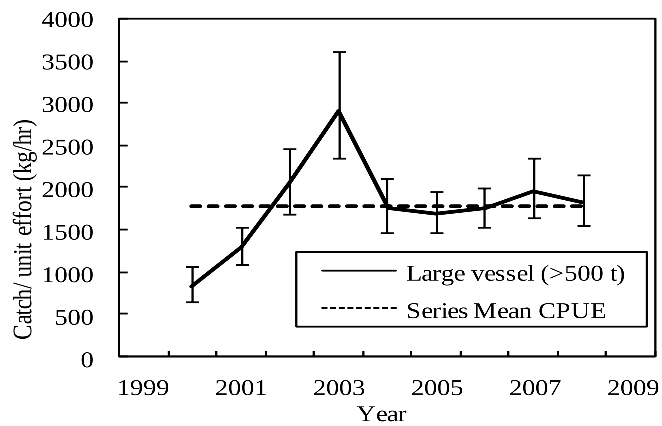


Fig. 2.2. Shrimp in Div. 3LNO: Standardized CPUE for the Canadian large-vessel (>500 t) fleet fishing shrimp in Div. 3L within the Canadian EEZ.

Data were available from other nations fishing in the NRA (Estonia, Greenland, Spain and Norway) but were insufficient to produce a standardized CPUE model.

Sex and age composition. Stock composition data from previous years has shown that the fishery has exploited a wide range of year classes. Catch compositions were derived from Canadian and Spanish observer datasets. In 2007, the male portion of the fishery was dominated by the 2003 and 2004 year classes. The female portion was still well represented. Length frequency data for 2008 were available from Canadian catches only. The 2008 Canadian fishery exploited a wide range of year classes with the male portion of the fishery dominated by 2004 and 2005 year classes. The female portion was well represented in the 2008 fishery.

ii) Research survey data

Canadian multi-species trawl survey. Canada has conducted stratified-random surveys in Div. 3LNO, using a Campelen 1800 shrimp trawl, from which shrimp data is available for spring (1999–2008) and autumn (1996–2007). The autumn survey in 2004 was incomplete and therefore of limited use for the assessment.

In the past, Canadian stock size parameters were determined without corrections for research survey tow durations, which were all assumed equal. In 2008, correct durations were used to revise all index estimates throughout the survey series. For this reason, present indices may not be the same as past values.

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

Biomass and Abundance. In Canadian surveys, over 90% of the biomass was found in Div. 3L, distributed mainly along the northeast slope in depths from 185 to 550 m. There was a significant increase in autumn shrimp biomass indices between 1996 and 2001 and this index has since remained at a high level. The autumn 2007 index was

275 000 t, the highest in the autumn time series. The spring biomass indices increased from 1999 to 2003, decreased in 2004 and then increased to 2007 with a decrease in 2008. The spring 2008 biomass index was 232 000 t, the second highest in the spring series (Fig. 2.3). Confidence intervals from the spring surveys are usually broader than from the autumn surveys.

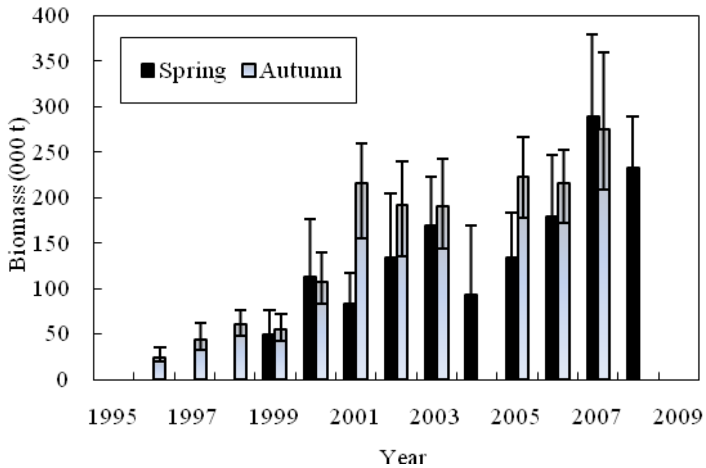


Fig. 2.3. Shrimp in Div. 3LNO: biomass index estimates from Canadian spring and autumn multi-species surveys (with 95% confidence intervals).

Spanish survey biomass estimates for Div. 3L, within the NRA, increased between 2003 (64 000 t) and 2006 (126 000 t), remaining at a high level in 2007 and 2008 (149 000 t); Canadian survey biomass estimates in Div. 3L both inside and outside the NRA increased between 1996 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 unknown. Spanish survey biomass estimates for Div. 3NO in the NRA, have shown a gradual decline from 3000 t in 2004 to 100 t in 2008; Canadian survey biomass estimates in Div. 3NO both inside and outside the NRA fluctuated between 700 and 3000 t over this period.

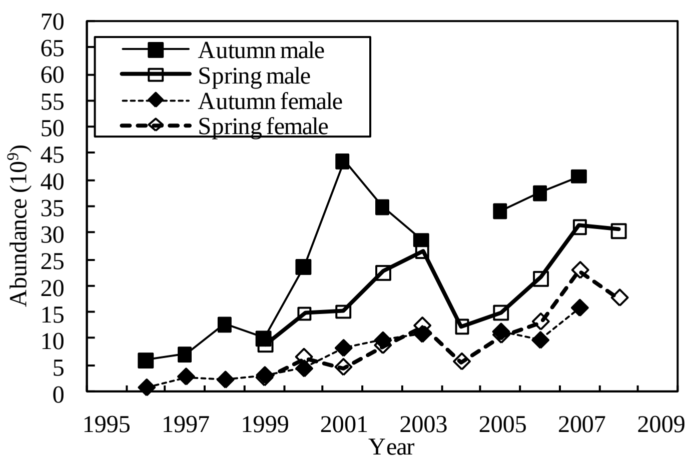


Figure 2.4. Abundance indices of male and female shrimp within Div. 3LNO as estimated from Canadian multi-species survey data.

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. 2.4).

Shrimp aged 3, 4 and 5 (2004, 2003 and 2002 year-classes) were well represented in the male component of the spring 2007 survey length frequencies with carapace-length modes at 15.66, 17.96 and 20.29 mm respectively. The male component of the autumn 2007 survey length frequencies was dominated by shrimp aged 2, 3 and 4 (2005, 2004 and 2003 year-classes) with modes at 14.64, 17.33 and 20.15 mm, respectively. Shrimp aged 3 and 4 (2005 and 2004 year-classes) dominated the spring 2008 survey with modes at 15.66 and 17.96 mm respectively (Fig. 2.5). A broad mode of females was present in all surveys indicating the presence of more than one year class.

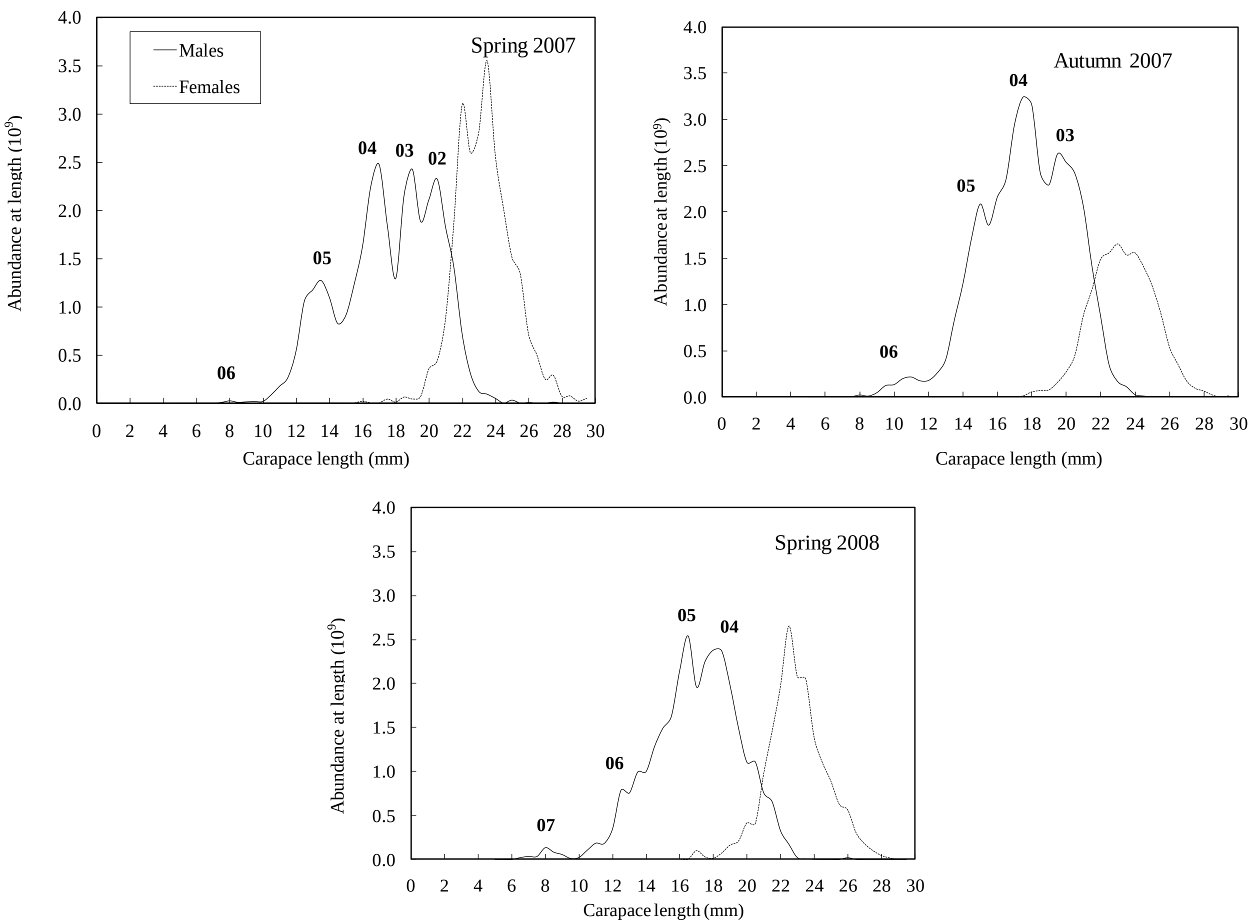


Fig. 2.5. Shrimp in Div. 3LNO: abundance at length for northern shrimp estimated from Canadian multi-species survey data. Numbers within charts denote year-classes.

Female Biomass (SSB). The autumn female (transitionals + females) biomass index increased after 1999 to reach its highest level in 2007. The spring survey biomass index increased from 1999 to its highest level in 2007 and then decreased to the second highest level in 2008 (Fig. 2.6).

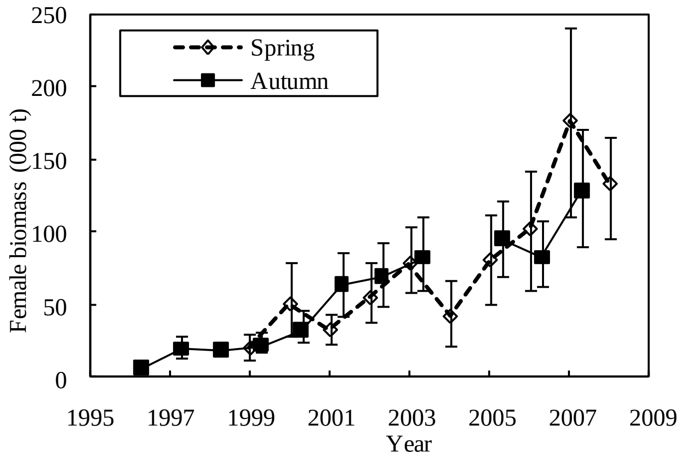
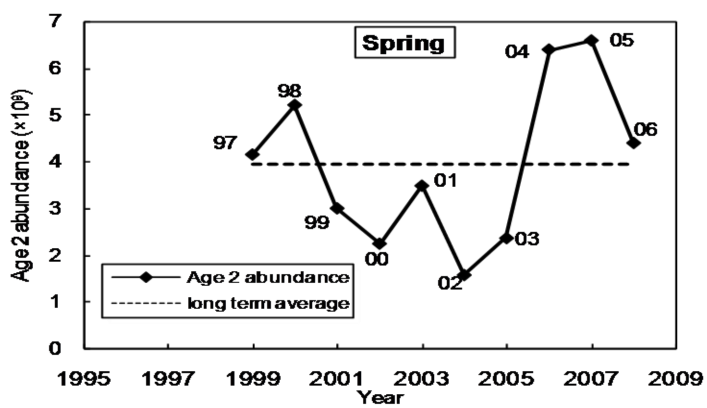


Fig. 2.6. Shrimp in Div. 3LNO: Female biomass estimates from Canadian spring and autumn multi-species surveys (with 95% confidence intervals).

Recruitment index. The recruitment indices were based upon modal analysis of length frequency data from Canadian spring 1999–2008 and autumn 1996–2007 survey data. Recruitment indices, both from spring and autumn surveys, have been fluctuating in the recent past but the 2004 and 2005 year classes have been particularly strong. The 2006 year class was near average, based upon the spring 2008 survey (Fig. 2.7).



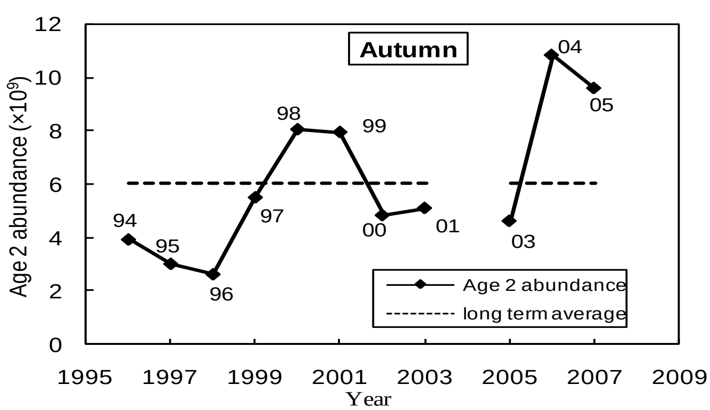


Fig 2.7. Shrimp in Div. 3LNO: Recruitment indices (age 2 abundance) derived using modal analysis of Canadian spring and autumn bottom trawl survey (1996–2008) data.

Fishable biomass and exploitation. General trends from the Canadian spring and autumn survey fishable biomass indices (shrimp >17 mm carapace length) are similar to trends in the female spawning stock biomass from the same surveys (Fig. 2.8). 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 - 1999, but increased to 11–13.5% in 2000–2001, the first two years of TAC regulation. Even though catches increased to 24 000 t by 2006 and are projected to be 25 000 t in 2008, the exploitation index remained less than 14% (Fig. 2.9).

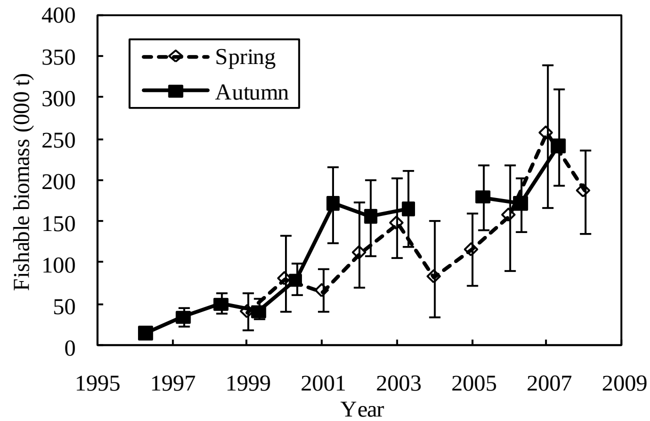


Fig. 2.8. Shrimp in Div. 3LNO: fishable biomass index. Bars indicate 95% confidence limits.

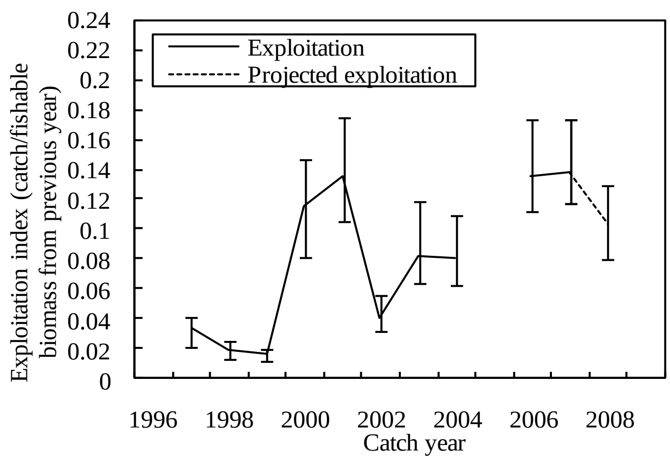


Fig. 2.9. Shrimp in Div. 3LNO: exploitation rates calculated as year's catch divided by the previous year's autumn fishable biomass index. Bars indicate 95% confidence limits.

c) Assessment Results

Recruitment. The 2005 year-class was particularly strong at age 2 in both the spring and autumn surveys. The 2006 year-class was slightly above average in the 2008 spring survey.

Biomass. Indices of biomass have been increasing since 1999 and are at or near the highest observed levels.

Exploitation. The index of exploitation has remained below 14%.

State of the Stock. Biomass indices have been increasing since 1999 and are at or near the highest observed levels. The stock appears to be well represented by a broad range of size groups and recruitment prospects continue to be above average.

d) Precautionary Approach Reference Points

Scientific Council considers that the point at which a valid index of stock size has declined by 85% from the maximum observed index level provides a proxy for B_{lim} for northern shrimp in Div. 3LNO (SCS Doc. 04/12). It is not possible to calculate a limit reference point for fishing mortality. Currently, the female biomass is estimated to be well above B_{lim} (Fig. 2.10).

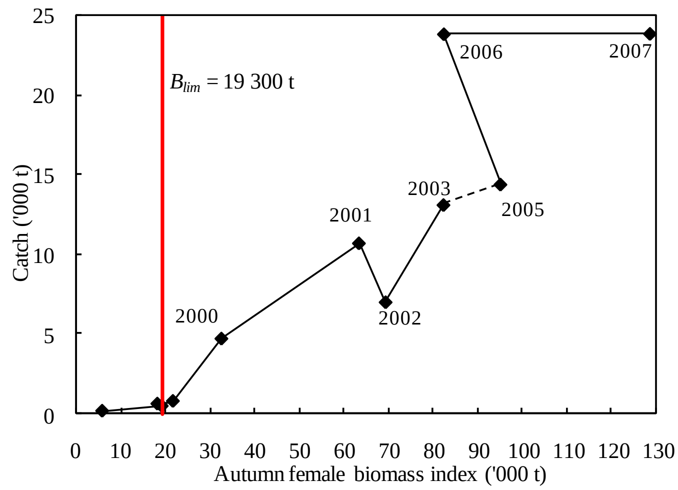


Fig. 2.10. Shrimp in Div. 3LNO: Catch against female biomass index from Canadian autumn survey. Line denoting B_{lim} is drawn where female biomass is 85% lower than the maximum point in 2007.

e) Other Studies

The abundance of 12–17 mm carapace length males was explored as a potential index of recruitment. Recruitment had previously been recorded as the abundance of age-2 males from modal analysis. However, a new method was proposed because shrimp recruit to the fishery by size and not by age. The recruiting animals probably consist of age 2 and 3 males. When autumn fishable biomass was lagged by one year and regressed against the new index, the predictive power increased for a one year forecast.

This work resulted in a recommendation that shrimp assessment biologists work together to standardize length-based methods of predicting recruitment to the fishable stock.

An analysis of catch rate data from Estonian shrimp vessels in Div. 3M and Div. 3L in 2007 and 2008 was presented (SCR Doc. 08/77). The author defines and compares four CPUE groups. In order to analyze the observed catch rates of Div. 3M being higher two days before and after fishing in Div. 3L (group 3) compared with other days when fishing in 3M (groups 1 and 2) two reasons are investigated: seasonality effect and use of single and double trawls. There appeared to be preliminary indications that reported catch rates were higher among the group 3 hauls than among group 2. The fourth group, hauls in Div. 3L, were not compared.

e) Research Recommendations

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

- *biological and CPUE data from all fleets fishing for shrimp in the area be submitted to the Designated Expert, in the standard format, by 1 September 2009.*

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

3. Northern shrimp (Subareas 0 and 1) – NAFO Assessed

(SCR Doc. 02/158, 03/74, 04/75, 76, 08/57, 61, 62, 64, 69, 71, 78; 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 'Shrimp Fishing Area 1' (Canadian SFA1), to be the part of Div. 0A lying east of 60° 30' W, *i.e*. east of the deepest water in this part of Davis Strait.

The stock is assessed as a single population. The Greenland fishery exploits the stock in Subarea 1 (Div. 1A–1F). Since 1981 the Canadian fishery has been limited to Div. 0A.

Three fleets, one from Canada and two from Greenland (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 in Greenland, and 40 mm in Canada. Sorting grids to reduce bycatch of fish are required in both of the Greenland fleets and in the Canadian fleet. Discarding of shrimp is prohibited.

The annual TAC advised for the entire stock for 2004–2007 was 130 000 t, reduced for 2008 to 110 000 t. Greenland set a TAC for Subarea 1 for 2007 of 134 000 t, of which 74 100 t was allocated to the offshore fleet, 55 900 t to the inshore and 4000 t to EU vessels; these allocations were reduced for 2008 to 70 281, 53 019 and 4 000 t. Canada set TACs for SFA1 of 18 417 t for both 2007 and 2008.

The comprehensive table of recent catches that had been presented in 2007 was updated (SCR Doc. 08/61), significantly with improved STATLANT data for Greenland for 2004 and 2005.

Total catch increased from about 10 000 t in the early 1970s to more than 105 000 t in 1992 (Fig. 3.1). Moves by the Greenlandic authorities to reduce effort, as well as fishing opportunities elsewhere for the Canadian fleet, caused catches to decrease to about 80 000 t by 1998. Since then total catches increased to near 155 000 t in 2005 and 2006. Total catch for 2007 was given by Greenland logbooks and DFO CAQR combined as 141 600 t; the total TAC was not taken largely because TAC in the Canadian zone exceeded the catch by over 16 000 t. Projected catch for 2008 was 131 700 t.

Table 3.1. Recent catches, projected catches for 2008 and recommended and enacted TACs (t) for northern shrimp in Div. 0A east of 60° 30' W and Subarea 1 are as follows:

	1999[1]	2000[1]	2001[1]	2002[1]	2003[1]	2004	2005	2006	2007	2008[2]
Recommended TAC	65 000	65 000	85 000	85 000	100 000	130 000	130 000	130 000	130 000	110 000
Actual TAC	82 850	87 025	102 300	103 190	115 167	149 519	152 452	152 380	152 417	145 717
SA 1 (NIPAG)	90 152	96 378	99 301	128 925	123 036	142 326	149 978	150 533	139 631	*126 221*
SA 0A (NIPAG)	2 046	1 590	3 625	6 247	7 137	7 021	6 921	4 127	1 945	*5 430*
STATLANT (SA 1)	73 990	79 120	81 517	103 645	78 436	142 326	149 978	3 668[3]	3 394[3]	
STATLANT (Div. 0A)	2 093	659	2 958	6 053	2 170	6 861	6 410	3 788[3]	1 878[3]	
TOTAL SA1-Div.0A (NIPAG)	92 198	97 968	102 926	135 172	130 173	149 347	156 899	154 660	141 576	*131 651*

[1] Catches before 2004 corrected for under-reporting.
[2] Catches projected to year-end—SA1 based on catches on the first 6 months and Div. 0A at mean of reports for previous 5 yr.
[3] Provisional.

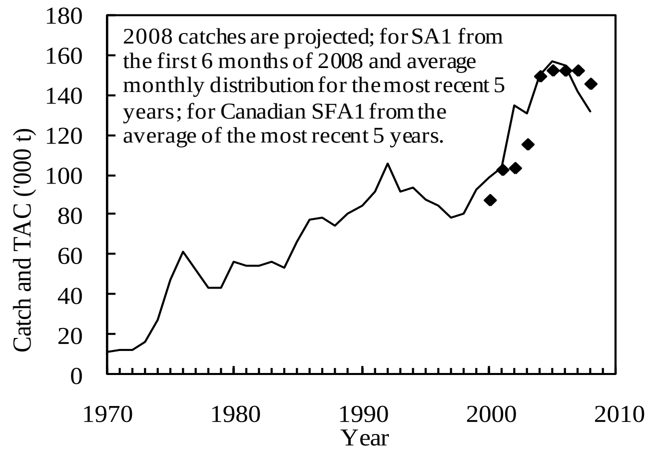


Fig. 3.1. Shrimp in Subareas 0 and 1: actual TACs and total catches (2008 projected to the end of the year; all values represent live (catch) weight). TACs only illustrated since 2000.

Until 1988 the fishing grounds in Div. 1B were the most important. The offshore fishery subsequently expanded southward, and after 1990 catches in Div. 1CD, taken together, began to exceed those in Div. 1B. Catch and effort in Div. 1E–F have recently decreased, and in the first six months of 2008 effort in Div. 1F is virtually zero. The Canadian catch in SFA1 was stable at 6 000–7 000 t in 2002–2005, about 4–5% of the total catch, but in 2006 the catch in SFA1 was only 4 100 tons and in 2007 less than 2 000 t.

b) 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. 08/57, 62). In recent years large changes in fishery performance have occurred in relation both to the distribution of the fishery and to changes in fishing power (*e.g.* larger vessels have been allowed in coastal areas; the coastal fleet has been fishing intensively in areas outside Disko Bay; the offshore fleet now commonly uses double trawls.) Furthermore, a change in legislation effective since 2004 and requiring logbooks to record catch live weight in place of a previous practice of under-reporting would, by increasing the catch weights recorded, have increased apparent CPUEs since 2004; this aberration in the CPUE data needed to be corrected. CPUE series generated by including different sets of statistical areas and different sets of vessels in the analysis for each fleet, and different treatments of double- and single-trawl data, were compared in order to judge the effects of these choices (SCR Doc. 08/62). A standardized CPUE series (Fig 3.2) and an index of how widely the fishery is distributed (Fig. 3.3) were generated.

The all-fleet standardized CPUE was variable, but on average moderately high, from 1976 through 1987, then fell to uniform lower levels until about 1997. It has since increased markedly to plateau in 2004–2007 at about twice its 1997 value (Fig. 3.2). In 2008 the CPUE has decreased from this level.

The CPUE indices from the Greenland coastal and the Greenland offshore fleets have remained closely in step from 1988 to 2004 (Fig. 3.2), diverging from each other slightly more in the most recent years. CPUE in the Canadian fishery in SFA1 has always varied more from year to year and has never stayed closely in step with the Greenland fleets, although over time its overall trend has been similar and it has also increased between the 1990s and the present.

The fishery area for this stock has been contracting in recent years, and NIPAG was therefore concerned that any relationship between CPUE and stock biomass would be affected, and in particular that relative to earlier years biomass might be overestimated.

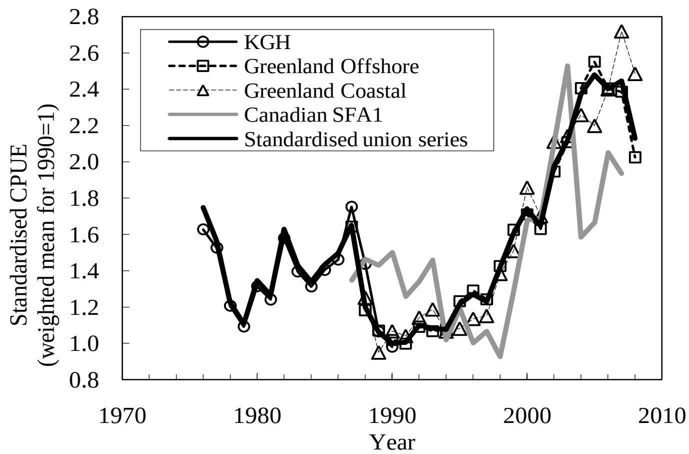


Fig. 3.2. Shrimp in Subarea 1 and Canadian SFA 1: standardized CPUE index series.

The distribution of catch and effort among NAFO Divisions was summarized using Simpson's diversity index to calculate an 'effective' number of Divisions being fished (Fig. 3.3). This index shows how widely the fishery is distributed over the possible grounds.

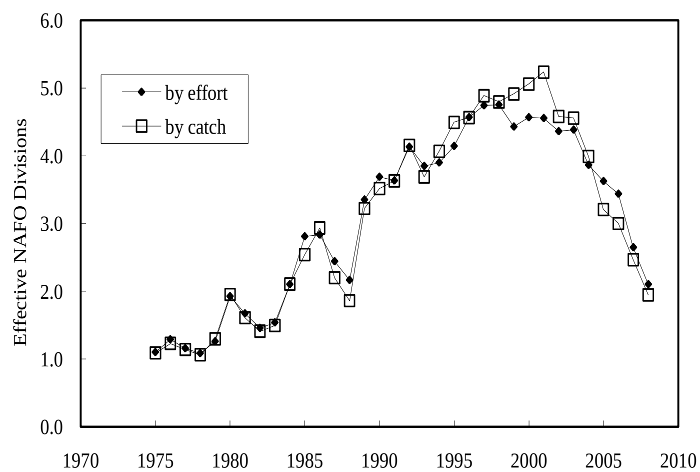


Fig. 3.3. Diversity indices for the distribution of logbook records of the West Greenland fishery among NAFO Divisions in 1975–2008. (NB: 2008 point is calculated from January–June data only.)

From the end of the 1980s there was a significant expansion of the fishery southwards and by 1996–1997 areas south of Holsteinsborg Deep (66° 00' N) accounted for 65% of the catch. At that time the effective number of Divisions being fished peaked at about 4.5–5. Since then, the range of the fishery has contracted northwards and the effective number of Divisions being fished has decreased as effort, and catches, have become more concentrated. The areas south of Holsteinsborg Deep now yield only 10% of the catches, and Julianehåb Bay supports no fishery.

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

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. 08/71). From

1993, the survey was extended southwards into Div. 1E-F. A cod-end liner of 22 mm stretched mesh has been used since 1993. From its inception until 1998 the survey only used 60-min. tows, but shorter tows have been shown to give as accurate results, and since 2005 all tows have lasted 15 min. In 2005 the *Skjervøj 3000* survey trawl used since 1988 was replaced by a *Cosmos 2000* with rock-hopper ground gear, calibration trials were conducted, and the earlier data was adjusted.

The proportion of survey biomass estimated to be in water less than 300 m deep increased from about 30% in the early 1990s (up to 1995) to about 70% in 2001, and has stayed at that level; the average bottom temperature in the survey area increased by 1.4°C between 1996 and 1998 and has stayed at the higher level (SCR Doc. 08/71). The proportion of survey biomass in Div. 1E-F has decreased in recent years and the distribution of the stock, like that of the fishery, has become more concentrated and more northerly (SCR Doc. 08/71, 78).

Biomass. The survey index of total biomass remained fairly stable from 1988 to 1997 (c.v. 18%, downward trend 4%/yr). It then increased by, on average, 19%/yr until 2003, when it reached 316% of the 1997 value. Subsequent values have been consecutively lower, by 2008 less than half the 2003 maximum (Fig. 3.4) and 9% below the series mean.

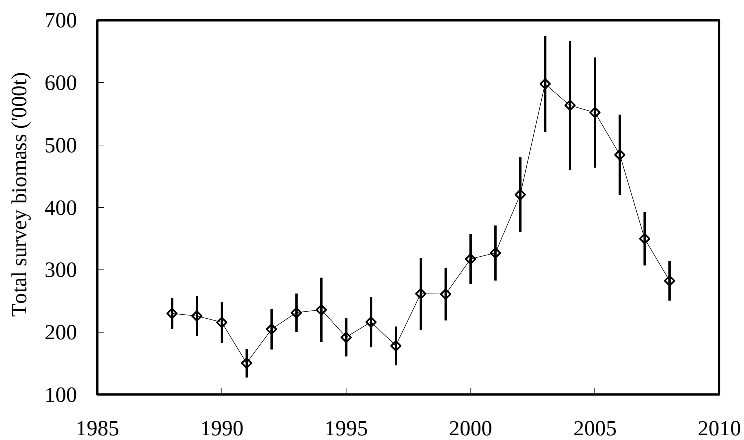


Fig. 3.4. Shrimp in Subareas 0 and 1: survey indices of total stock biomass with ± 1 s.e. error bars for 1988–2008 (SCR Doc. 08/71).

Length and sex composition. The stock in 2007 was dominated (≈95 % by number) by one year-class (3-year-old shrimp). This year-class was composed mostly of males (modal length ≈20 mm CL) but it also contained primiparous females (modal length ≈23 mm CL). Younger/smaller shrimp were rare in the stock and so were older/larger shrimp.

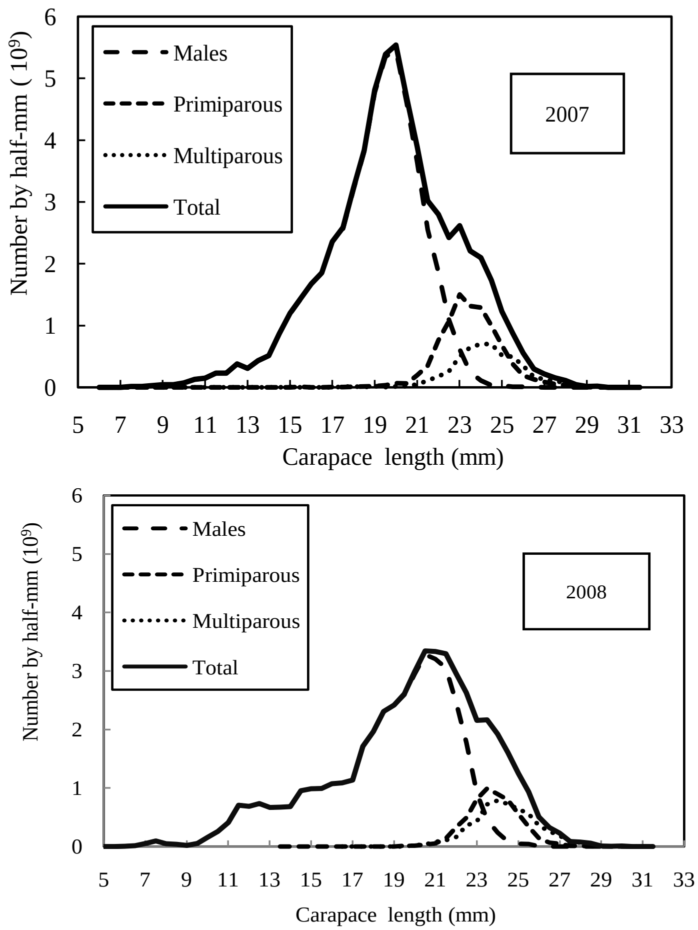


Fig. 3.5. Shrimp in Subarea 1 and Canadian SFA 1: length frequencies of northern shrimp in the total survey area (offshore and Disko Bay/Vaigat combined) in 2007–08.

This year-class is seen in 2008 as a mode of males at 21 mm CL, but lower and less distinct, and primiparous females (mode at 23.5 mm) were also fewer. In 2008 modes at 12 mm and 15 mm CL could be observed suggesting year-classes of two- and three-year-olds; the two-year-old class in particular appeared stronger than in 2007. Male and female numbers in 2008 were 42 and 11 × 10^9 individuals, respectively, both values below their long-term averages of 50 and 12 × 10^9, respectively.

Recruitment Index. The number at age 2 is a predictor of fishable biomass 2–4 years later (SCR Doc. 03/76). This recruitment index was high in 2001, decreased in 2002, was near average in 2003 and 2004, reached even lower values in 2005 and 2006, and decreased again in 2007 to the lowest recorded value (Fig. 3.6). In 2008 the index was higher, at about ⅔ of the series mean.

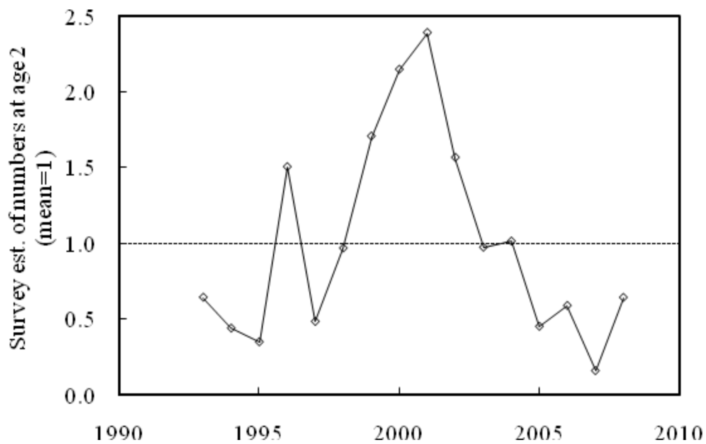


Fig. 3.6. Shrimp in Subarea 1 and Canadian SFA 1: index of numbers at age 2 from survey (series mean = 1).

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 German survey is conducted in October–November and the results for the current year are 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; the two survey estimates of cod biomass were closely correlated (r^2 = 0.91, P <0.001). Regression analysis of 15 years' data estimated that the index of cod biomass from the 2008 Greenland survey would correspond to about 84 700 t in the German survey (SCR Doc. 08/69). The biomass of Atlantic cod is still low compared with the 1980s, despite its moderate increase in the most recent years. The distribution is pronouncedly southern: 90% of the biomass is found in NAFO Div. 1F. The spatial overlap between Atlantic cod and Northern shrimp in West Greenland appears currently to be small and the 'effective' cod stock, *i.e*. that which could prey on the shrimp stock, is estimated at 13 200 t (SCR Doc. 08/69).

c) Results of the Assessment

i) Estimation of Parameters

A Schaefer surplus-production model of population dynamics was fitted to series of CPUE, catch, and survey biomass indices. The model included a term for predation by Atlantic cod and a cod biomass series was included in the input data. CPUE data extended back as far as 1976, but survey data only started in 1988. CPUEs were standardized by linearized multiplicative models including terms for vessel effect, month, year, and statistical area; the fitted year effects were considered to be series of annual indices of total stock biomass. Series for the Greenland fishery after the end of the 1980s were divided into 2 fleets, a coastal and an offshore; a series for 1976–1990 was constructed for the KGH fleet of sister trawlers and a series for 1987–2006 for the Canadian fleet fishing in SFA1. For those ships of the present offshore fleet that use double trawls, only double-trawl data was used. The four CPUE series were unified in a separate step to a single series that was input to the assessment model.

The model used in 2008 was the same as that used in 2006, except that it used an index of an 'effective' cod stock instead of simply using the total cod biomass. The effect of this is to reduce the predation pressure from cod stocks in the most recent 10 years or so compared with the earlier years of the series.

The model fitted well to the data with relatively small uncertainties to the parameter estimates. The estimated biomass trajectory closely followed the CPUE series, the error CV of biomass prediction from CPUE being only 3.5%; it was much less influenced by the survey series, the prediction error CV of which was about 18%. The median estimate of MSY was 144 000 t, in the same region as the estimates obtained in 2007 when the CPUE series were stopped in 2003 (where the catch correction became effective) or when only survey data was used.

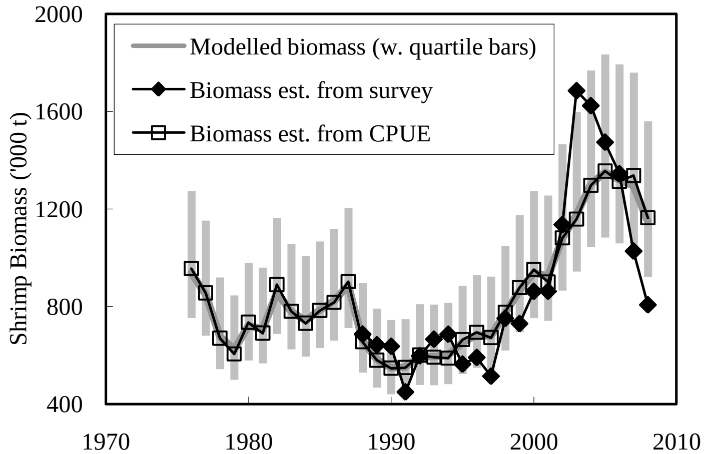


Fig. 3.7: Shrimp in SA 1 and Canadian SFA1: trajectory of the median estimate of stock biomass, with CPUE and survey indices.

The modelled trajectory of the stock biomass followed the CPUE index closely, with a CV of only 3.5%. The model paid less attention to the survey data, and the error CV of prediction from the survey was 18%. The stock-dynamic process error was also quite small at 10%.

Table 3.2. Estimates of stock-dynamics and fit parameters from fitting a Schaefer stock-production model to data on the West Greenland stock of the northern shrimp in 2008.

	Mean	S.D.	25%	Median	75%	Est. mode	Median (2007)[1]
Max. sustainable yield	153	46	130	144	163	139	137
Carrying capacity	2355	2360	1427	1780	2417	1493	1819
Max. sustainable yield ratio (%)	16.0	4.9	12.9	16.3	19.2	16.5	15.1
Survey catchability (%)	33.3	14.7	22.9	32.5	43.0	32.1	33.6
CV of process (%)	9.7	2.1	8.3	9.6	11.0	9.6	8.6
CV of survey fit (%)	18.7	3.2	16.4	18.3	20.6	18.1	
CV of CPUE fit (%)	3.8	1.4	2.8	3.5	4.5	3.4	[2]

[1] stock-dynamic parameter values were estimated in 2007 for different treatments of input data. Those cited here were generated when CPUE series were truncated at 2003, later values omitted. CPUE indices for 2004 and after were affected by catch corrections, which were applied differently in 2008 (SCR Doc. 08/62).
[2] CPUE series were entered independently in 2007; CVs of fits were 5–9% for the Greenland fleets, 16% for the Canadian.

ii) Assessment Summary

CPUE: CPUE was at historically high levels in 2004–2007; a slight decline in 2005–2007 has steepened in 2007–2008. The fished area has contracted markedly since 2001 and CPUE may therefore be unreliable as an indicator of fishable biomass.

Recruitment: In 2007 numbers at age 2 reached a record low, at about 7% of a 2001 peak. Numbers at age 2 have increased slightly in 2008, but are still below the series mean. Prospects for recruitment to the fishable stock remain poor.

Biomass: Survey biomass increased to an all-time high in 2003 and has since steadily declined, in 2008 to below the series mean. A stock-dynamic model showed a maximum biomass in 2005 with a steepening decline since; the probability that biomass will be below B_{msy} at end 2008 with projected catches at 132 000 t was estimated at 19% and of being below B_{lim} at 0.2%.

Mortality: The mortality caused by fishing and cod predation is modelled as having been below the reference level, Z_{msy}, since 1995. With catches in 2008 projected at 132 000 t the risk that total mortality would exceed Z_{msy} was estimated to be about 30%.

State of the stock: CPUEs are high, but are starting to decline. The stock is being fished in a shrinking area. Survey biomass has decreased every year since 2003. Estimated numbers of small shrimp decreased for 6 years to 2007, and although this index has increased in 2008 concerns about future recruitment remain serious. They are reinforced by the repeated indications of decreasing stock biomass.

d) Precautionary Approach

The fitted trajectory of stock biomass showed that the stock had been below its MSY level from the late 1970s to the late 1990s, with mortalities mostly near the MSY mortality level except for an episode of high predation mortality associated with a short-lived resurgence of cod in the late 1980s. In the late 1990s, with cod stocks at low levels, biomass started to increase at low mortalities to reach about 1.5 times the MSY level in 2003–2006. Recent increases in the cod stock coupled with high catches have been associated with slight declines in the modelled biomass, although mortality remains slightly below the MSY level and the biomass still well above B_{msy}.

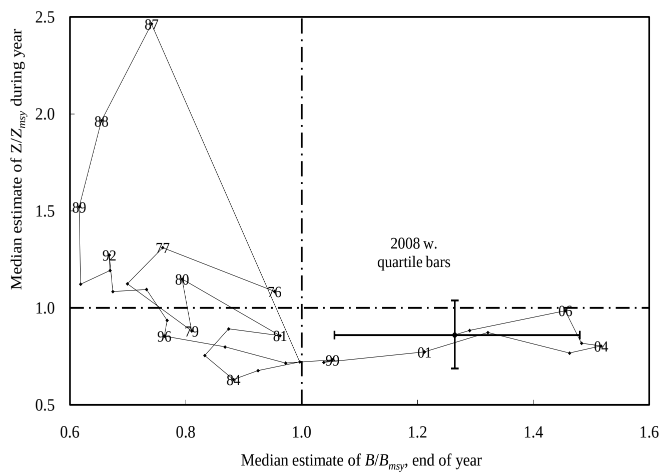


Figure 3.8: Trajectory of relative biomass and mortality for northern shrimp in SA0&1

Stock-dynamic modelling estimates the present stock status to be in the precautionary safe zone with biomass above the target level and mortality below F_{lim}. With an effective cod stock assumed at 22 000 t (mean of the last 3 years) in 2009, catches up to 110 000 t would be associated with risks below 20% of transgressing either precautionary reference point. Higher catches in 2009 would be associated with rapidly increasing risks of exceeding F_{lim} (Table 3.3).

In the medium term, with a 22 000 t cod stock, model results estimate catches up to 110 000 t/yr to be associated with a stable stock above MSY level with mortality well below Z_{msy}, and catches of 120 000 t/yr with a stock slowly declining toward the MSY level but, after 5 years, still probably within the safe zone. Higher catches cause rapid deterioration of the state of the stock. With a 40 000 t cod stock, catches as low as 110 000 t/yr cause the stock status to deteriorate slowly.

Table 3.3. Predicted probabilities (percent) of transgressing precautionary limits in 2009 under six catch options and assuming a cod stock size of 22 000 t.

	Catch option ('000 t)					
Risk of	90	100	110	120	130	140
falling below B_{MSY} end 2009	16.8	18.1	19.3	20.9	22.0	23.0
falling below B_{lim} end 2009	<1	<1	<1	<1	<1	<1
exceeding Z_{MSY} during 2009	5.5	10.7	18.2	28.4	38.2	47.5

Table 3.4. Predicted probabilities (percent) of transgressing precautionary limits after 5 years in the fishery for northern shrimp on the West Greenland shelf with 'effective' cod stocks assumed at 22 000 t and 40 000 t.

Catch (Kt/yr)	Prob. biomass <B_{MSY}		Prob. biomass <B_{lim}		Prob. mort >Z_{msy}	
	22 Kt	40 Kt	22 Kt	40 Kt	22 Kt	40 Kt
90	12.5	18.6	<1	<1	5.3	15.2
100	15.9	22.8	<1	<1	10.8	25.5
110	20.7	28.5	<1	<1	20.6	38.4
120	25.6	35.6	<1	<1	32.5	50.4
130	32.7	41.3	<1	<1	47.2	61.2
140	38.1	47.7	<1	<1	58.0	69.9

* limit biomass is 30% of B_{msy}

Medium term predictions were summarized by plotting the risk of exceeding Z_{msy} against the risk of falling below B_{msy} over 6 years for 6 catch levels (Fig. 3.8). For catches of 90 000 t or 100 000 t the mortality risk was low and nearly constant over the projection period, while the biomass risk slowly decreased as the stock was projected slowly to grow. At 110 000 t both risks were projected slowly to increase. Catches of 120 000–140 000 t were associated with higher and more rapidly increasing risks of transgressing both precautionary limits.

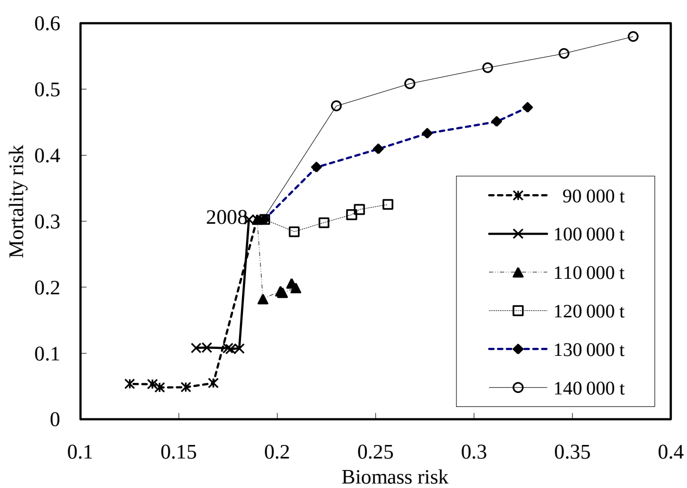


Fig. 3.9. Risks of transgressing mortality (Z_{msy}) and biomass (B_{msy}) precautionary limits for catch levels at 90 000–140 000 t projected over 6 years with an 'effective' cod stock assumed at 22 000 t.

e) Research Recommendations

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

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

- *methods of incorporating weighted CPUE indices into the assessment model, and of adjusting the weighting of the survey series, 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.*

- *methods of analyzing survey data should be explored that would allow expressing, in one or two indices, measures of how the stock biomass is distributed.*

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

(SCR Doc. 03/74, SCR08/63, 72)

a) Introduction

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

In 1993 a new fishery began in areas south of 65° N down to Cape Farewell. Access to these fishing grounds depends strongly on ice conditions. From 1996 to 2005 catches in the area south of 65°N accounted for 50–60% of the total catch but in 2006 and 2007 only for 25%.

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

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 and discarding of shrimp is prohibited.

Total catches increased rapidly to around 15 000 t in 1987 and 1988, but declined thereafter to about 9000 t in 1992 and 1993. Following the extension of the fishery south of 65°N catches increased to 13 800 t in 1997. Catches from 1998 to 2003 have been around 12 000 t (Fig. 4.1) and have decreased thereafter, reaching a low of 4600 t in 2007. Catches in 2008 are projected to stay at this level. Catches in the Iceland EEZ decreased from 2002 to 2005 and since 2006 no catches have been taken.

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

	1998[1]	1999[1]	2000[1]	2001[1]	2002[1]	2003[1]	2004	2005	2006	2007	2008[2]
Recommended TAC	5000	9600	9600	9600	9600	9600	12400	12400	12400	12400	12400
Actual TAC[3]	9563	10600	12600	10600	10600	10600	15043	12400	12400	12400	12400
North of 65° N, Greenland EEZ	3943	4058	4288	2227	4041	5404	4611	3952	3889	3326	2678
North of 65° N, Iceland EEZ	1421	769	132	10	1231	703	411	29	0	0	0
North of 65° N, total	5364	4827	4420	2237	5272	6107	5022	3981	3889	3326	2678
South of 65° N, Greenland EEZ	6057	6893	7632	11674	6056	6598	4994	3690	1304	1286	265
Total STATLANT 21A	9321	9467	9594	11052	9169	9763	10016	7671	5193	4612	2943
TOTAL STACFIS	11422	11719	12053	13911	11329	12705	10016	7671	5193	4612	2943

1 Estimates 1998-2003 corrected for "overpacking".
2 Catches till October 2008
3 For Greenland zone only; no restrictions in Iceland zone

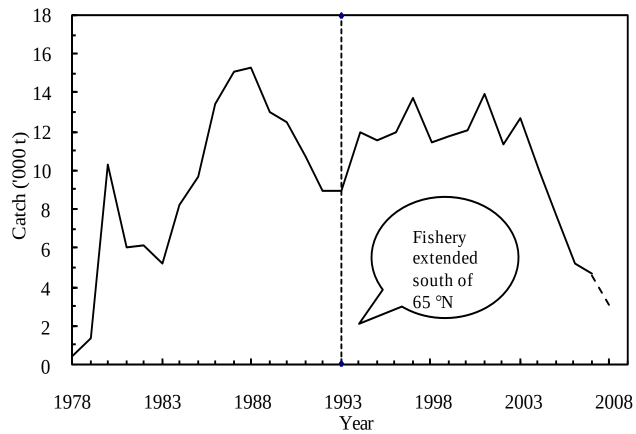


Fig. 4.1. Shrimp in Denmark Strait and off East Greenland: Total catches (2008 catches until October 2008).

b) Input Data

i) Commercial fishery data

Fishing effort and CPUE. Data on catch and effort (hours fished) on a haul by haul basis from logbooks from Greenland, Iceland, Faroe Islands and EU-Denmark since 1980, from Norway since 2000 and from EU-France for the years 1980 to 1991 are used . Until 2005, the Norwegian fishery data was not reported in a compatible format and were not included in the standardized catch rates calculations. In 2006 an evaluation of the Norwegian logbook data from the period 2000 to 2006 was made and since then these data have been included in the standardized catch rates calculations. Since 2004 more than 60% of all hauls were performed with double trawls and the 2007 assessment includes both single and double trawls in the standardized catch rate calculation.

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

The Greenlandic fishing fleet, (catching 40% of the total catch), has decreased its effort in recent years, and this creates some uncertainty as to whether recent values of the indices accurately reflect the stock biomass. There could be several reasons for decreasing effort, some possibly related to the economics of the fishery. The fishing opportunities off West Greenland seem to have been adequate in recent years and the fishing grounds off East Greenland are for several reasons a less desirable fishing area. Even though both effort and catches in East

Greenland have declined, the catch rates (CPUEs) are still high; however, this could be partly because the fleet can concentrate effort in areas of high densities of sought-after size classes of shrimp.

North of 65° N standardized catch rates based on logbook data from Danish, Faroese, Greenlandic, Norwegian and Icelandic vessels declined continuously from 1987 to 1993 but showed a significant increase between 1993 and 1994. Since then rates have varied but shown a slightly increasing trend (Fig. 4.2). In the southern area a standardized catch-rate series from the same fleets, except the Icelandic, increased until 1999, and varied around this level until 2007 (Fig. 4.3).

The combined standardized catch-rate index for the total area decreased steadily from 1987 to 1993, and then showed an increasing trend until the beginning of the 2000s. This index has since then stayed at or around this level (Fig. 4.4).

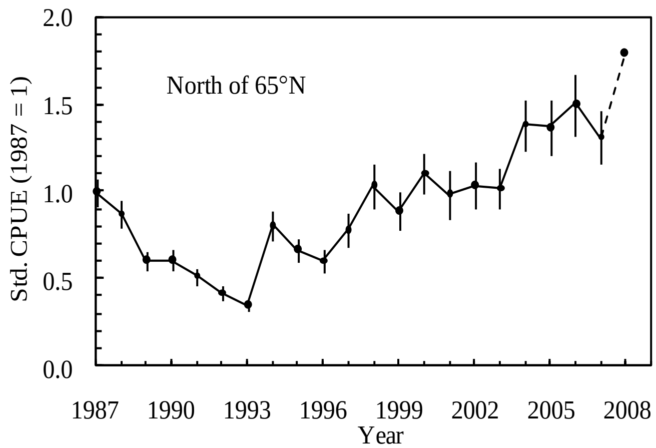


Fig. 4.2. Shrimp in Denmark Strait and off East Greenland: annual standardized CPUE (1987 = 1) with ±1 SE calculated from logbook data from Danish, Faeroese, Greenland, Icelandic and Norwegian vessels fishing north of 65° N.

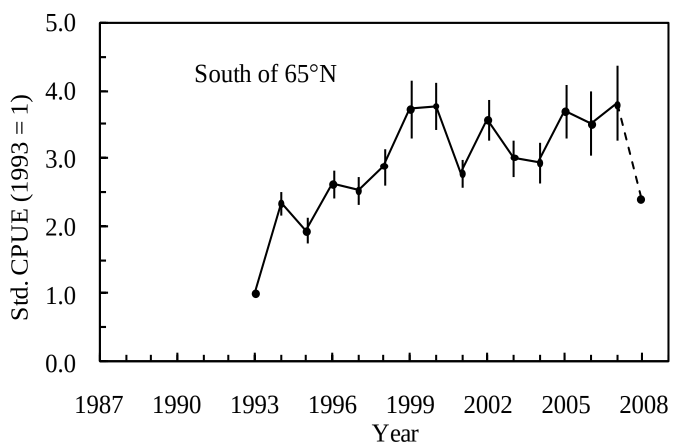


Fig. 4.3. Shrimp in Denmark Strait and off East Greenland: annual standardized CPUE (1993 = 1) with ±1 SE calculated from logbook data from Danish, Faeroese, Greenland and Norwegian vessels fishing south of 65° N.

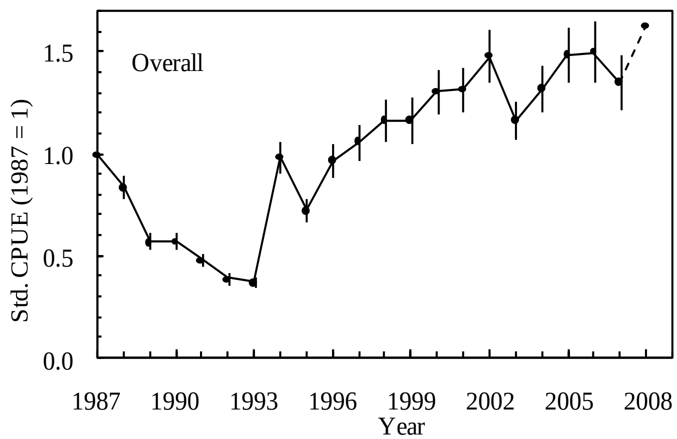


Fig. 4.4. Shrimp in Denmark Strait and off East Greenland: annual standardized CPUE-indices (1987 = 1) with ±1 SE combined for the total area.

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

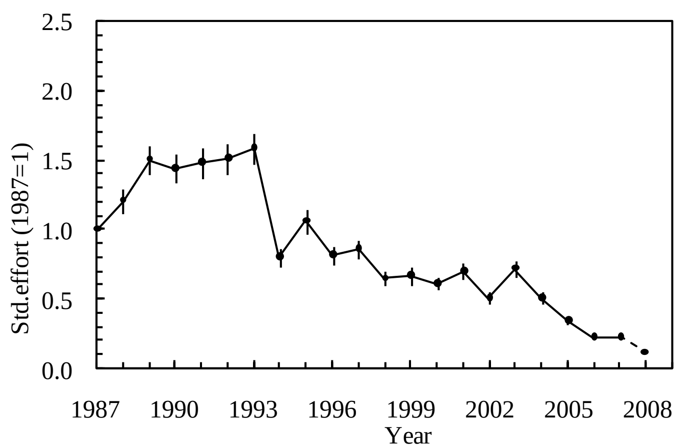


Fig. 4.5. Shrimp in Denmark Strait and off East Greenland: annual standardized effort indices, as a proxy for exploitation rate (±1 SE; 1987 = 1), combined for the total area.

iii) Biological data

There is no biological data available.

iv) Research survey data

No surveys have been conducted since 1996.

v) Other studies

The existence and availability of survey data from Norwegian sources has been investigated. These data came from three sources: scientific cruises, observers on board commercial shrimp vessels, and Norwegian landings statistics and logbook data from this fishery. Norwegian cruises were, according to our information, carried out in 1983-1986.

Observations on board shrimp vessels took place the same years. Logbook and landings data are presented for the years 1982-1986 (SCR Doc. 08/63).

The CPUE for 1982–1986 only exist for April and May. The data are too scarce to draw any conclusions about the state of the stock.

c) Assessment Results

CPUE. Combined standardized catch-rate index for the total area decreased steadily from 1987–1993, showed an increase to a relatively high level at the beginning of the 2000s, and has 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 decreased to its lowest levels in the 22-year series.

State of the stock. The stock is believed to be at a relatively high level, and to have been there 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*
- *ways of getting samples from the fishery that could inform about stock structure and contribute to the assessment should be explored.*
- *the availability and usefulness of size data from commercial landings should be investigated as a source of information on stock structure.*

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

(SCR Doc. 08/73, 74, 75, 76)

a) Introduction

The shrimp in the northern part of ICES Div. IIIa (Skagerrak) and the eastern part of Div. IVa (Norwegian Deep) is considered one stock (a single assessment unit) and is exploited by Norway, Denmark and 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 TAC, which has been around 16 000 t in recent years (Fig. 5.1, Table 5.1). In recent years an increasing number of the Danish vessels have started boiling the shrimp on board and landing the product in Sweden to obtain a better price. Most of the Danish catches are, however, still landed in home ports. In the Swedish and Norwegian fisheries approximately 50% of the catches are boiled at sea (Quality A), and almost all catches are landed in home ports.

The TAC is shared according to historical landings, giving Norway the highest quota (55%), and Sweden the lowest (18%). In recent years the Swedish fishery has been constrained by the national quota, which has resulted in ‘high-grading’ of the catch by the Swedish fleet. The recommended TACs until 2002 were based on catch predictions. However, since 2003 no catch predictions have been available, and the recommended TACs have been based on recent landings. The shrimp fishery is also regulated by mesh size (35 mm stretched), and by restrictions in the amount of landed bycatch. The use of selective grids reduces bycatch significantly (SCR Doc. 08/76) and is used by an increasing number of vessels in all fleets. However, at present it is mandatory only in Swedish national waters.

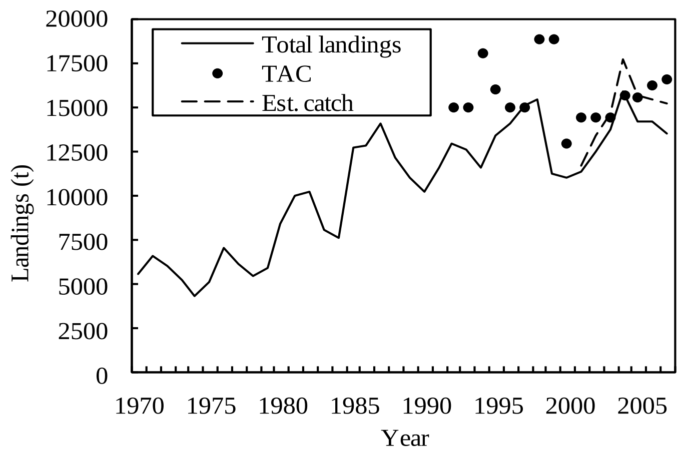


Fig. 5.1. Northern shrimp in Skagerrak and Norwegian Deep: TAC, total landings by all fleets, and total catch including estimated Swedish high-grading discards for 2001–2007 and Norwegian discards for 2007.

Total catch has varied between 10 000–18 000 t during the last 20 years. Since 2004 catches have declined (Table 5.1, Fig. 5.1), and were around 15 100 t in 2007. The landings and estimated Swedish high-grading derived by NIPAG for this assessment unit are given in Table 5.1. In 2007 Norwegian discards have been estimated for Skagerrak (IIIa). Notice, that the Norwegian and Swedish landings have been corrected for weight loss caused by boiling.

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

	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
Recommended TAC	19 000	19 000	11 500	13 400	12 600	14 700	15 300	13 000	14 000	14 000-16 000
Actual TAC	18 800	18 800	13 000	14 500	14 500	14 500	15 690	15 600	16 200	16 600
Denmark	3 330	2 072	2 371	1 953	2 466	3 244	3 905	2 952	3 061	2 380
Norway	9 606	6 739	6 444	7 266	7 703	8 178	9 544	8 959	8 669	8 686
Sweden	2 469	2 445	2 225	2 108	2 301	2 389	2 464	2 257	2 488	2 445
Total landings	15 405	11 256	11 040	11 327	12 470	13 811	15 913	14 168	14 218	13 511
SW high-grading discards				375	908	868	1 797	1 483	1 186	1 124
No discards[1]										526
Total catch				**11 702**	**13 378**	**14 679**	**17 710**	**15 651**	**15 404**	**15 161**

[1] shrimp <15 mm CL. Collection of discard data initiated in 2007.

The Danish and Norwegian fleets have undergone major restructuring in recent years. In Denmark, the number of vessels targeting shrimp has decreased from 191 in 1987 to 24 in 2006 and only 12 in 2007. It is mostly the small trawlers (<24 m LOA) which have left the fishery, and in 2007 the average length of the vessels was around 26 m (SCR Doc. 08/75). The efficiency of the gear has also increased due to twin trawl technology and increasing trawl sizes. In Norway there has been an increase in the number of smaller vessels (10–10.99 m LOA), and this length group is now the numerically dominant one, owing to the fact that vessels <11 m do not need a license to fish. Vessels ≥21 m LOA constitute about 11% of the fleet. According to the Norwegian fisheries organization "Fiskarlaget", twin trawls have been in use by 20–30 Norwegian trawlers the last six years. Quantitative information on these changes in gear is, however, not available from the logbooks. In the Norwegian logbooks only seven vessels have systematically recorded their use of twin trawl over the last six years. Lack of recording may be due to the wording of the logbooks, and it seems likely that many fishers will note "shrimp trawl" for any type of shrimp trawl used, be it single, twin or triple. Corrections have been made (see assessment data).

Discards. Discarding of shrimp may take place in two ways: 1) discards of shrimp <15 mm CL which are not marketable, even by the canning industry, and 2) high-grading discards of medium-sized and lower-value shrimp. The latter takes place primarily in the Swedish fleet, because of quota limits on total landed weight. The amount of high-grading discards in the Swedish fishery was estimated to around 1 100 t in 2007, based on comparison of length distributions in Swedish and Danish landings (Fig. 4 in SCR Doc. 08/76). The Danish length distribution for each year is scaled to fit the Swedish length distribution for the same year for the larger shrimp (≥21 mm CL). This correction assumes that there is no discarding of the most valuable larger shrimp, and that Swedish and Danish fisheries are conducted on the same grounds. The higher numbers in the Danish size groups <21 mm CL are compared to the Swedish numbers, and the differences are then multiplied with the mean weight of each size group. The sum of mean weights by size group is considered as the weight of the Swedish discarding due to high-grading.

In 2007 Norwegian discards were estimated for Skagerrak by comparing length distributions of unprocessed commercial catches (sampling initiated in 2005) with those of landings (sampling initiated in 2007). Most of the discarded Norwegian shrimp were specimens of length <15 mm CL.

Bycatch and ecosystem 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. The shrimp fisheries in the North Sea and Skagerrak have a 10–20% bycatch of commercially valuable species, 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. According to logbook data, landings delivered by vessels using this grid consist of 99% shrimp compared to only 80–90% in landings from trawls without grid (Table 5.2). Off Swedish national waters the grids are not mandatory, however, there has been an increase in their use, which constituted 33% of Swedish shrimp effort in 2007.

The effects of shrimp fisheries on the North Sea ecosystem have not been the subject of special investigation. It is known that deep-sea species such as Argentines, roundnose grenadier, rabbitfish, and sharks are frequently caught in shrimp trawls in the deeper parts of Skagerrak and the Norwegian Deep. However, no quantitative data on this mainly discarded catch component is available. The general aspects of byctach regulations are discussed under Agenda item IV.1

Table 5.2. Northern shrimp in Skagerrak and Norwegian Deep: Bycatch in the shrimp fishery in 2007. Combined data from Danish and Swedish logbooks and Norwegian landings (t).

	Sub-Div. IIIa, no grid		Sub-Div. IIIa, grid		Sub-Div. IVa East, no grid	
Species:	Total (t)	% of total catch	Total (t)	% of total catch	Total (t)	% of total catch
Pandalus	10 044	88.5	611	99.1	2 272	80.9
Norway lobster	56	0.5	3	0.5	39	1.4
Angler fish	48	0.4	0	0.0	77	2.7
Whiting	10	0.1	0	0.0	3	0.1
Haddock	60	0.5	0	0.0	28	1.0
Hake	21	0.2	0	0.0	19	0.7
Ling	34	0.3	0	0.0	30	1.1
Saithe	405	3.6	0	0.0	185	6.6
Witch flounder	102	0.9	0	0.0	3	0.1
Norway pout	35	0.3	0	0.0	0	0.0
Cod	313	2.8	2	0.3	99	3.5
Other market fish	228	2.0	0	0.0	55	2.0

b) Assessment Data

Until 2002 cohort analysis (the XSA used in ICES) was applied to assess this stock. However, this methodology was abandoned because of the assumed very high predation mortality compared to the fishing mortality. A Bayesian stock production model was applied in 2005 (WGPAND, 2005), but the assessment from this model was not accepted by ICES in 2005. Further development of the model was recommended, but no progress in this work has been accomplished.

i) Commercial fishery data: LPUE

The 2007 assessment was based on Danish LPUE data. This year Danish and Norwegian standardized LPUEs were used as the best available indicators for stock biomass (Fig. 5.2). The two time series show similar trends, increasing from 2000 to 2004, decreasing in 2005 and then increasing again until 2007. Standardized LPUE seems to fluctuate without any clear trend. NIPAG interprets this as a sign of stability of the stock.

The Danish catch and effort data from logbooks have been analyzed and standardized (SCR Doc. 08/75). In 2008 season was introduced as a variable. The definition of a *Pandalus* trip (50% of the landed value) was explored and kept. Trip definitions with thresholds of 10% and 30% of total landing value, and with kilo instead of catch value, were also tried. These showed only small deviations from the 50% catch value definition in resulting number of trips for the 22 year period (10% definition=21 447 *Pandalus* trips, 30% definition=21 283 trips, and 50% definition = 20 539 trips). The choice of the 50% threshold is made to ensure of exclusion of trips, where *Pandalus* landings can be considered as bycatch rather than target species. A GLM standardization of the LPUE series was performed on around 20 500 shrimp fishing trips conducted in the period 1987–2007:

$$\ln(LPUE) = \ln(LPUEmean) + \ln(vessel) + \ln(area) + \ln(year) + \ln(season) + error$$

where ‘vessel’ denotes the vessel effect in horse power of the individual vessels, ‘year’ is the year effect 1987–2007, ‘area’ is the spacial effect with two levels Norwegian Deep and Skagerrak, ‘season’, in this case quarter of the year, covers possible seasonal variation, and the variance of the error term is assumed to be normally distributed.

In the standardization of the Norwegian LPUE (2000–2008) (SCR Doc. 08/73) a similar model was applied, but gear type (single and twin trawl) was also included as a variable:

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

Here the variable ‘season’ is the effect of month, and ‘gear’ is the effect of single and twin trawl. Before standardization, the Norwegian logbooks were corrected according to gear type, based on interviews with ship owners. If reliable information on gear type was not received, the vessel was deleted from the data (18% of all recordings). In 2007, catches recorded in Norwegian logbooks only included 25% and 33% of the respective landings in Div. IIIa and IVa east. This is partly due to vessels <11 m not being required to fill in logbooks. Unfortunately data are lacking also for larger vessels.

The Swedish LPUE data were not used in the assessment (SCR Doc. 08/76) because of uncertainties caused by discarding due to high-grading and lack of information necessary for standardization.

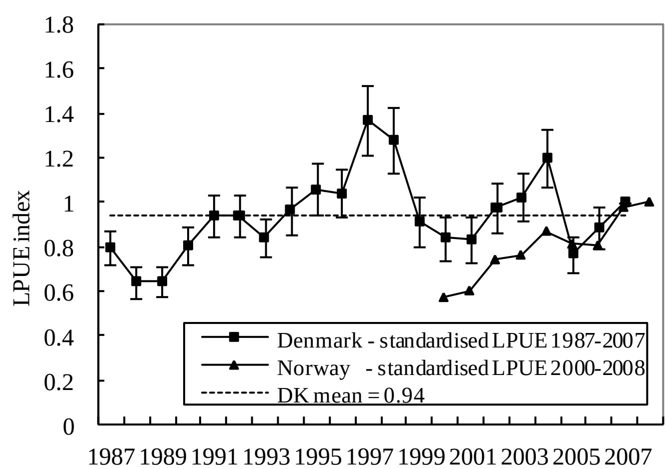


Fig. 5.2. Northern shrimp in Skagerrak and Norwegian Deep: Danish and Norwegian standardized LPUEs. Error bars are standard errors. Danish 2008 data are not included due to problems with data extraction. Dashed line is the long term mean = 0.94.

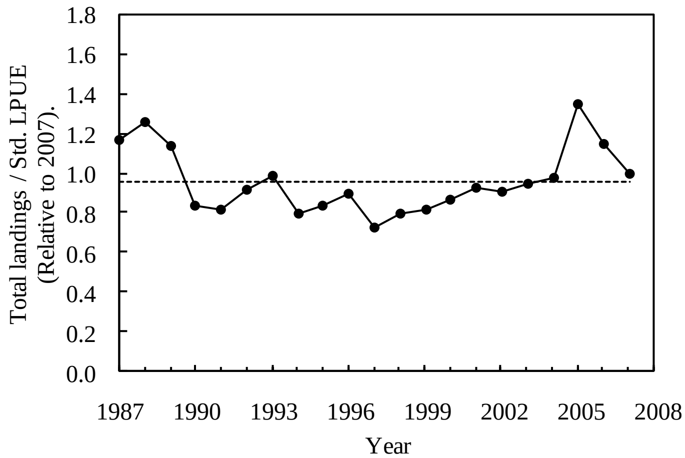


Fig. 5.3. Northern shrimp in Skagerrak and Norwegian Deep: Estimated standardized effort based on total landings and Danish standardized LPUE (1987-2007). Dotted line is the long term mean = 0.96.

In previous assessments harvest rate (HR) was estimated from landings and the corresponding biomass index from the Norwegian survey. Since the new survey only covers three years, a time series of standardized effort has been estimated instead of HR (Fig. 5.3). The standardized effort seems to fluctuate without any clear trend indicating stability in the exploitation of the stock.

Sampling of landings. Information on the size and subsequently age distribution of the landings are obtained by sampling the landings. The samples also provide information on sex distribution and maturity (SCR Doc. 08/76).

ii) Survey data

The Norwegian shrimp survey has gone through large changes in recent years (SCR Doc. 08/74) resulting in a series of four different surveys, lasting from one to nineteen years. NIPAG (2004) strongly recommended the survey to be conducted in the 1st quarter as it gives good estimates of the 1-group (recruitment) and female biomass (SSB). Thus, a new time series at the most optimal time of year was established in 2006.

There was no trend in the annual survey biomass estimates from the mid 1990s to 2002, when the first series was discontinued. The second “series” consists of a single point for 2003 as a different trawl was used. The 2004 and 2005 mean values of a new biomass index series were not statistically different (Fig. 5.4). The 2007 index, heavily influenced by the very high biomass of one particular trawl station, was very high compared to the 2006 value. In 2008 the index declined back to the 2006 level.

The abundance of age 1 shrimp in 2006 was equal to the abundance of age 1 shrimp in 2007. However, the recruitment in 2008 (age 1) is only ⅓ of the recruitment in the two previous years (Fig. 5.5). NIPAG has noticed that a decline in recruitment in a particular year has rarely caused serious decrease in adult biomass in subsequent years, and this stock has been fluctuating around a stable level for many years.

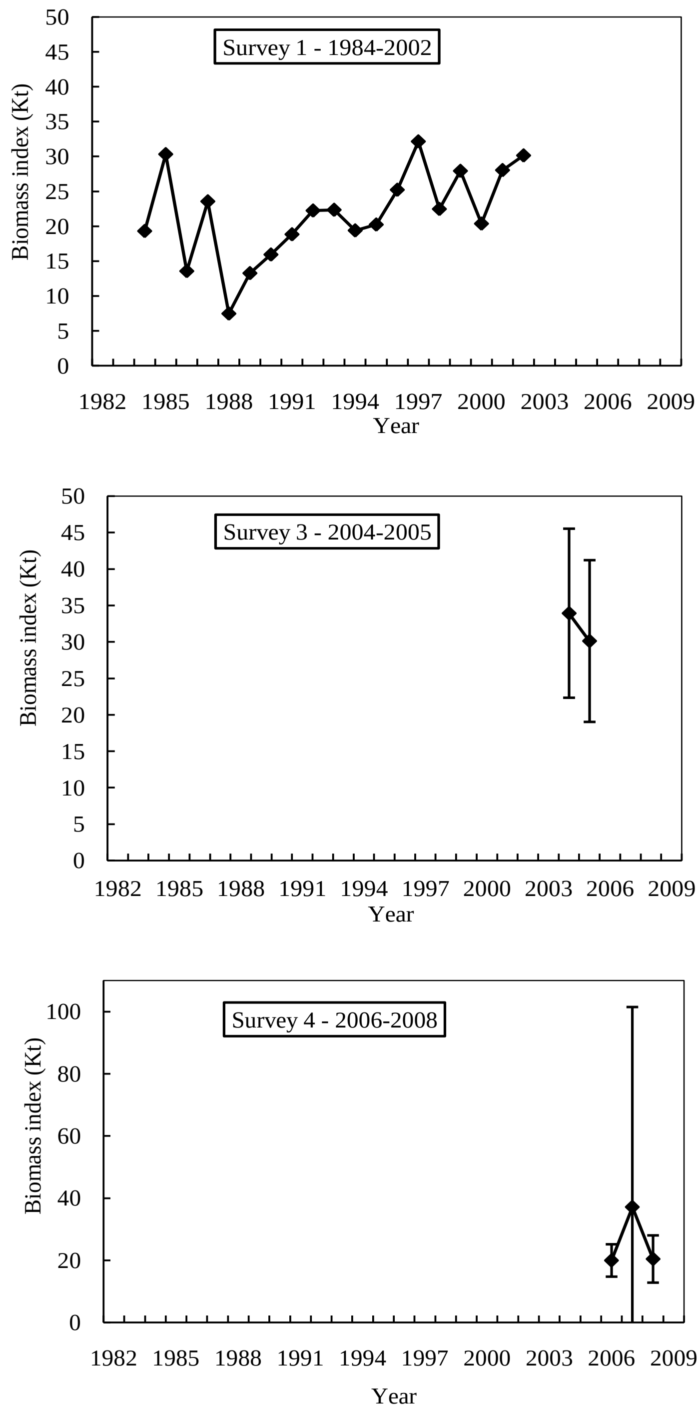


Fig. 5.4. Northern shrimp in Skagerrak and Norwegian Deep: Estimated survey biomass indices in 1984 to 2008. The four surveys are not calibrated to a common scale. Standard errors (error bars) have been calculated for the 2004 -2008 surveys. Survey 1: October/November 1984–2002 with Campelen-trawl; Survey 2: October/November 2003 with shrimp trawl 1420 (not shown); Survey 3: May/June 2004–2005 with Campelen trawl; Survey 4: February 2006–2008 with Campelen trawl.

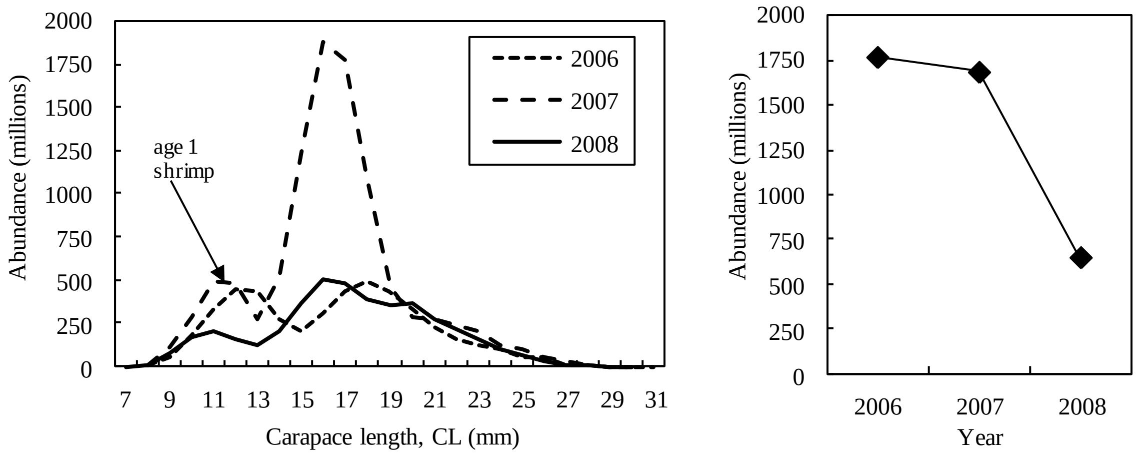


Fig. 5.5. Northern shrimp in Skagerrak and Norwegian Deep: Estimated length frequency distribution from the Norwegian shrimp surveys in 2006 to 2008, and recruitment indices (number of shrimp in the first mode) from the same years. The recruitment index is calculated distribution. One large catch station in 2007 doubles the amplitude of the 2 year mode.

The total index of shrimp predator biomass was estimated to 244.8 kg/nm in 2008, which is a large increase compared with only 60.8 kg/nm in 2007 and only 18.7 kg/nm in 2006 (SCR Doc. 08/74, Table 5.3). The increase is mainly due to an increase in the saithe biomass index.

Table 5.3. Northern shrimp in Skagerrak and Norwegian Deep: Estimated indices of predator biomass (kg/nm) from the Norwegian shrimp survey in 2006–2008.

	biomass index		
Species	2006	2007	2008
Blue whiting	0.13	0.13	0.12
Saithe	7.33	39.75	208.32
Cod	0.51	1.28	0.78
Roundnosed Grenadier	3.22	6.85	19.02
Rabbit fish	2.24	2.15	3.41
Haddock	0.97	4.21	1.85
Redfishes	0.18	0.40	0.26
Velvet Belly	1.31	2.58	1.95
Skates, Rays	0.41	0.95	0.64
Long Rough Dab	0.22	0.64	0.42
Hake	0.98	0.78	0.64
Angler	0.15	0.91	0.87
Witch	0.24	0.74	0.54
Dogfish	0.31	0.19	0.28
Whiting	0.35	1.01	1.35
Blue Ling	0	0	0
Ling	0.04	0.11	0.34
Fourbearded Rockling	0.06	0.14	0.04
Cusk	0.20	0	0.02
Halibut	0.08	0.07	3.88
Pollack	0.06	0.25	0.03
Greater Fork-beard	0	0	0
Total	18.99	63.14	244.76

c) Assessment Results

The 2007 assessment was based on Danish LPUE data. The 2008 assessment is based on evaluation of both Danish and Norwegian standardized LPUEs, standardized effort from the fishery in 1987–2007, and the survey indices of recruitment and biomass.

LPUE. Since 1987 the standardized Danish LPUE has fluctuated without any trend. The level in 2007 appears to be around average (Fig. 5.2), and the Norwegian and Danish LPUEs indicate no signs of decline in stock size.

Recruitment. The recruitment in 2008 (age 1) seems to be only 1/3 of the recruitment in the two previous years (Fig. 5.5).

Survey biomass. The biomass index for 2008 is lower than the 2007 index and similar to the 2006 index. It is, however, noticed that the high value of the 2007 index is associated with a high uncertainty.

State of the stock. LPUEs and survey indices do not show any significant change in stock biomass from 2006–2008. The recruitment in 2008 seems to be lower than in the two preceding years and may imply a decline in stock biomass in 2009.

d) Biological Reference Points

No reference points were provided in this assessment (SCR Doc. 08/76).

e) Management Recommendations

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

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

f) Research Recommendations

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

- *a standardized LPUE index utilizing combined Danish, Norwegian and Swedish data be investigated.*
- *the ongoing genetic investigations to explore the relation/connection/mixing between the shrimp (stock units) in Skagerrak and the Norwegian Deep on the one hand and the Fladen Ground shrimp on the other hand should be continued until these relationships have been clarified.*
- *1) a further development of the Bayesian stock production model presented in 2005, and 2) comparisons with and exploration of other assessment models, e.g. new cohort based models are conducted for this shrimp stock.*
- *an index for female biomass (SSB) should be calculated from the Norwegian survey data to make* B_{lim} *estimates possible.*
- *identification of best recruitment index.*

6. Northern Shrimp in Barents Sea and Svalbard area (ICES SAI and II) – ICES Assessed

(SCS Doc. 04/12, 06/64, 70, 07/74, 75, 76, 85, 86, 87; 08/56, 59, 60, 70; ICES C.M. 2007/ACFM:32)

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 26 000 and 83 000 t/yr with 70–90% of these were taken by Norwegian vessels and the rest by vessels from Russia, Iceland, Greenland and the EU.

There is no TAC established for this stock. The fishery is partly regulated by effort control. Licenses are required for the Russian and Norwegian vessels. The fishing activity of these license holders are constrained only by bycatch regulations (see below) whereas the activity of third country fleets operating in the Svalbard zone is also restricted by the number of effective fishing days and the number of vessels by country. The minimum stretched mesh size is 35 mm. 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 or shrimp <15 mm CL is registered.

The fishery is conducted mainly in the Hopen area (central Barents Sea) and the Svaldbard Shelf. 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.

Catch. Overall catches have ranged from 5 000 to 128 000 t/yr (Fig. 6.1). The most recent peak was seen in 2000 at approximately 83 000 t. Catches thereafter declined to 30 000 t in 2007 due to reduced profitability of the fishery (reduced shrimp prices and increased fuel prices). Based on information from the industry, catch statistics until October and the seasonal fishing pattern of the most recent years the 2008 catches are estimated at 26 000 t.

Table 6.1. Catches (1998–2007) and projected catches (2008) in metric tons, as used by NIPAG for the assessment of shrimp in ICES Div. I and II.

	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008[1]
Recommended TAC	-	-	-	-	-	-	-	41 299[2]	40 000	50 000	50 000
Norway	44 792	52 612	55 333	43 031	48 799	34 172	35 918	36 966	27 352	26 154	23 000
Russia	4 895	10 765	19 596	5 846	3 790	2 186	1 170	933	0	9	500
Others	6 103	12 292	8 241	8 659	8 899	1 599	4 211	3 519	2 282	4 252	2 500
Total	55 790	75 669	83 170	57 536	61 488	37 957	41 299	41 418	29 634	30 415	26 000

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

Discards and bycatch. Discard of shrimp cannot be quantified but is believed to be small as the fishery is not limited by quotas. Bycatch rates of other species are estimated from surveillance- and research surveys and corrected for differences in gear selection pattern (SCR Doc. 07/86). The bycatch rates in specific areas are then multiplied by the corresponding shrimp catch from logbooks to give the overall bycatch. General aspects of byctach regulation are discussed under agenda item IV.1.

Since the introduction of the Nordmøre sorting grid in 1992, only small cod, haddock, Greenland halibut, and redfish in the 5–25 cm size range are caught as bycatch. The bycatch of small cod ranged between 2–67 million individuals/yr and redfish between 2–25 million individuals since 1992, while 1–9 million haddock/yr and 0.5–14 million Greenland halibut/yr and was registered in the period 2000–2004 (SCR Doc. 07/85, 87). In recent years there has been a decline in bycatch following a reduced effort in the shrimp fishery.

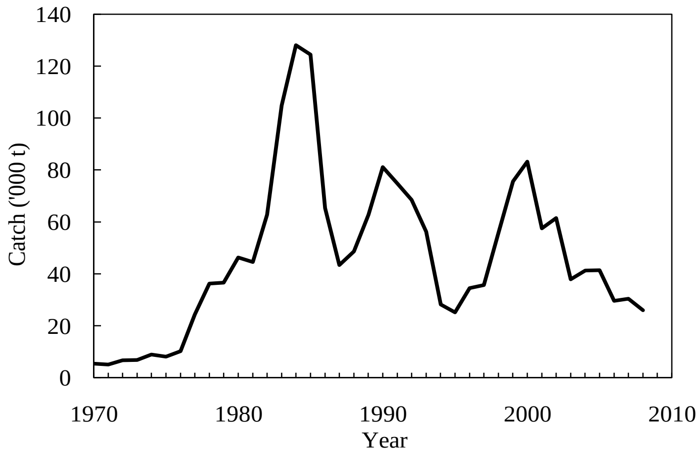


Fig. 6.1. Shrimp in the Barents Sea: total catches 1970–2008 (2008 projected to the end of the year).

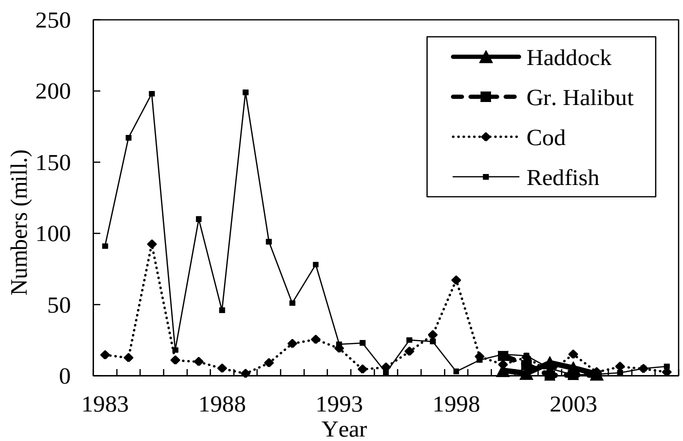


Fig. 6.2. Estimated bycatch of cod, haddock, Greenland halibut and redfish in the Norwegian shrimp fishery (million individuals).

Environmental considerations. The trend in the period 1996–2006 has been of warming and increased salinity in the upper ocean. The summer temperatures decreased in 2007 and 2008, but the temperatures in late winter 2008 (March) were record-high in the western Barents Sea. However, as the Atlantic inflow in late March and April was well below average, the typical temperature increase in spring did not occur this year. In summary the climatic situation in the Barents Sea has been somewhat extraordinary in 2008. The low temperatures in spring may increase the mortality of young shrimp.

b) Input Data

i) Commercial fishery data

A major restructuring of the shrimp fishing fleet towards fewer and larger vessels has taken place since the mid-1990s. At that time an average vessel had around 1000 horse powers (HP); 10 years later this value had increased to more than 4 000 HP (Fig. 6.2). Until 1996 the fishery was conducted by using single trawls only. Double trawls were then introduced and in 2002 approximately ⅔ the total effort spent was by using two trawls simultaneously. In 2000 a few vessels started to experiment with triple trawls: 30% of the effort in 2007 and 2008 is accounted for by this fishing method (Fig. 6.3). An individual vessel may alternate between single and multiple trawling depending on what is appropriate on given fishing grounds.

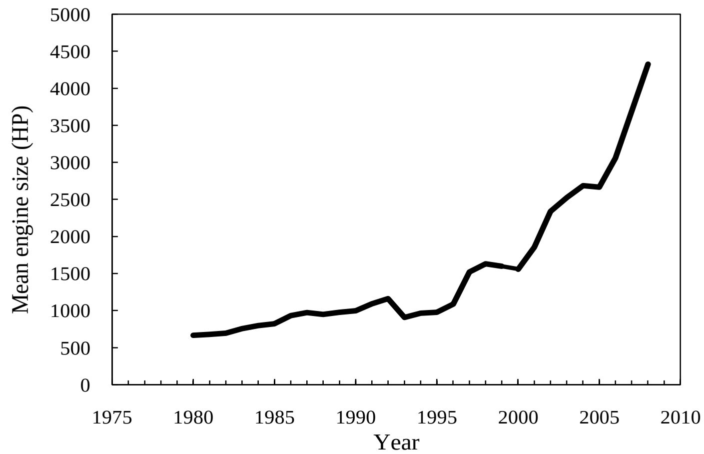


Fig. 6.2. Shrimp in the Barents Sea: Mean engine size (horse power) of trawling in the years 1980–2008.

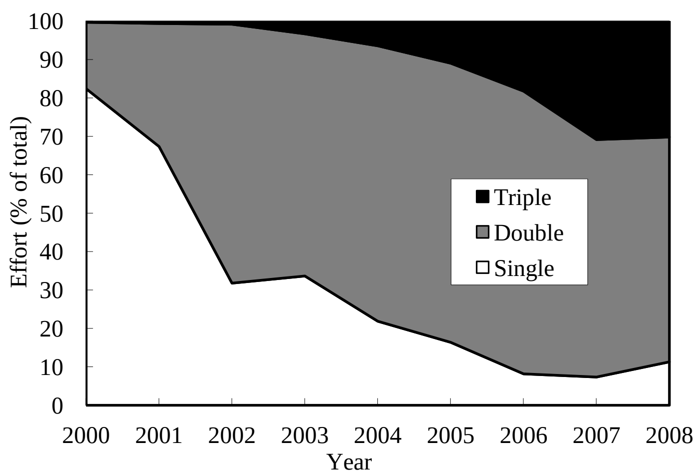


Fig. 6.3. Shrimp in the Barents Sea: Percentage of total fishing effort spent by using single, double or triple trawls 2000–2008. Norwegian data.

Norwegian logbook data were used in a multiplicative model (GLM) to calculate standardized annual catch rate indices (SCR Doc. 08/56).

A unique vessel identifier (*e.g*. registration id, call sign) was not readily available in logbooks until year 2000. Therefore fishing power has in previous assessments been treated on the level of vessel groups, sorted by intervals of engine size (HP) rather than on an individual vessel level. In the recent years many vessels have left the fishery, presumably the least effective ones, which could lead to changes (improvements) of the fishing efficiency of the vessel groups and thus bias the standardized CPUE as a stock biomass indicator (SCR Doc. 07/74). A new analysis of the available logbook data, tracking vessels variables such as GRT, HP, length and local area registration numbers, allowed the construction of a new and unique vessel ID for use in the standardization procedure.

The GLM model to derive the CPUE indices included the following variables: (1) vessel, (2) season (month), (3) area (SCR Doc. 08/56) and (4) gear type (single, double or triple trawl). This resulting series is assumed to be indicative of the biomass of shrimp >16 mm CL, *i.e*. older males and females.

The new index series based on individual vessels the level of fishing power was not radically different from the old one using vessel groups (Fig. 6.4). However, the overall increase from 1986–2007 is lower as well as the recent increase from 2004–2006, and the difference between the peaks in 1999 and 2006 were smaller. This indicated that the ‘old’ series based on vessel groups may have slightly overestimated the recent improvement in stock density.

The standardized CPUE declined by 60% from a maximum in 1984 to the lowest value of the time series in 1987 (Fig. 6.4). Since then it has showed an overall increasing trend. The 2008 mean value is about 14% lower than the 2006-value, but is still above the average of the series. The standardized effort (Fig. 6.5) has shown a decreasing trend since 2000.

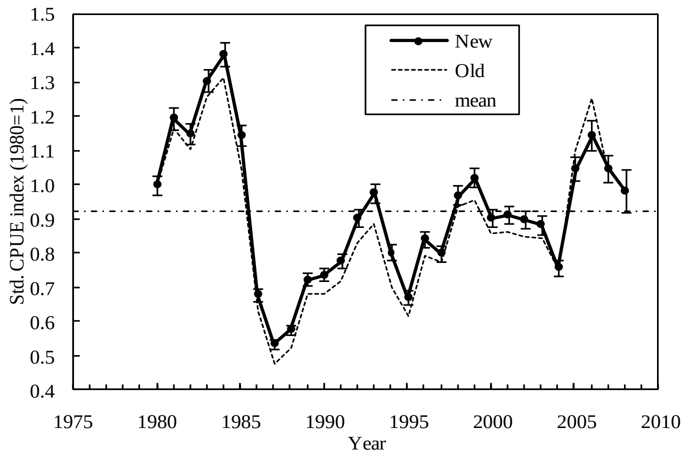


Fig. 6.4. Shrimp in the Barents Sea: standardized CPUE based on Norwegian data. Old: calculated as in previous assessment *i.e*. the fishing power term is groupings of vessels by engine size (see text); New: the index used in this assessment where the fishing power term is individual vessels (see text). Error bars are standard error (thousands of observations gives low SE); dotted line is the overall mean of the new series.

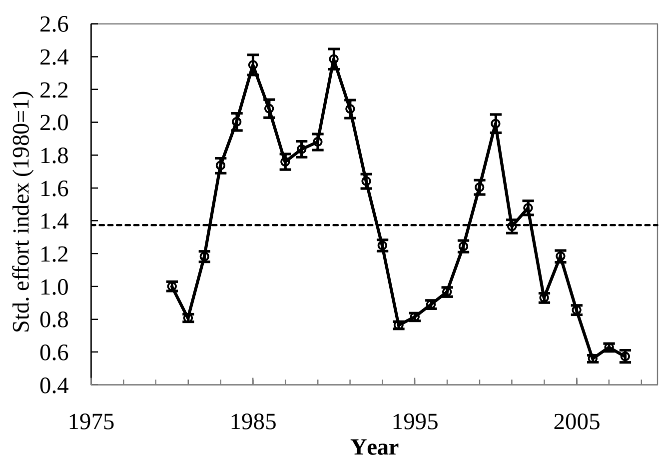


Fig. 6.5. Shrimp in the Barents Sea: Standardized effort (Catch divided with standardized CPUE). Error bars are standard error; dotted line is the overall mean of the series.

ii) Research survey data

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

The Norwegian shrimp survey 1982–2004 representing the most important shrimp grounds for that period and the Joint Russian Norwegian Ecosystem survey 2004-present representing the entire area was used for the assessment. In previous assessments only Norwegian data from the Ecosystem surveys went into the analyses due to technical problems of data exchange. These problems have been solved and the analysis now contains the entire data set. The data was stratified by depth and area (Fig. 6.6) which is different to the stratification scheme used previously in order to include the additional data from the Russian EEZ.

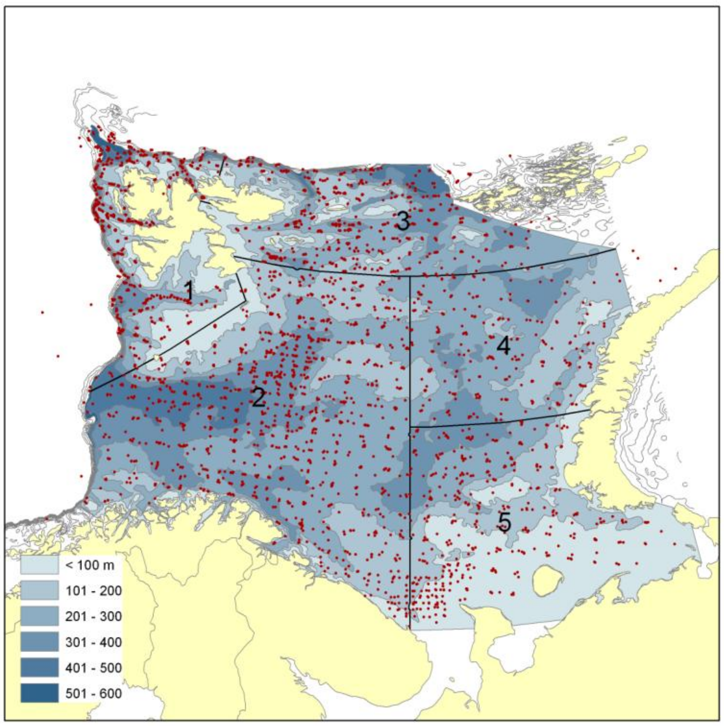


Fig. 6.6. Shrimp in the Barents Sea: The Ecosystem Survey area stratification. The main areas 1-5 is further divided in 6 depth strata of 100 m intervals. Red dots mark the location of trawl hauls used in the 2004–2008 analyses.

Biomass. The Biomass indices of the Norwegian shrimp survey have varied in a cyclic manner with periods of approximately 7 years since the start of the series in 1982 (Fig. 6.7).

The Ecosystem survey has not been calibrated to the ones discontinued in 2004. The estimate of mean biomass from this survey increased by about 40% from 2004 to 2006 and then decreased again to slightly below the 2004 value (Fig. 6.7). The trend of this new stock biomass series is similar to the one used in previous assessments (Fig. 6.8).

The geographical distribution of the stock in 2008 is similar to that of the previous years (Fig. 6.9).

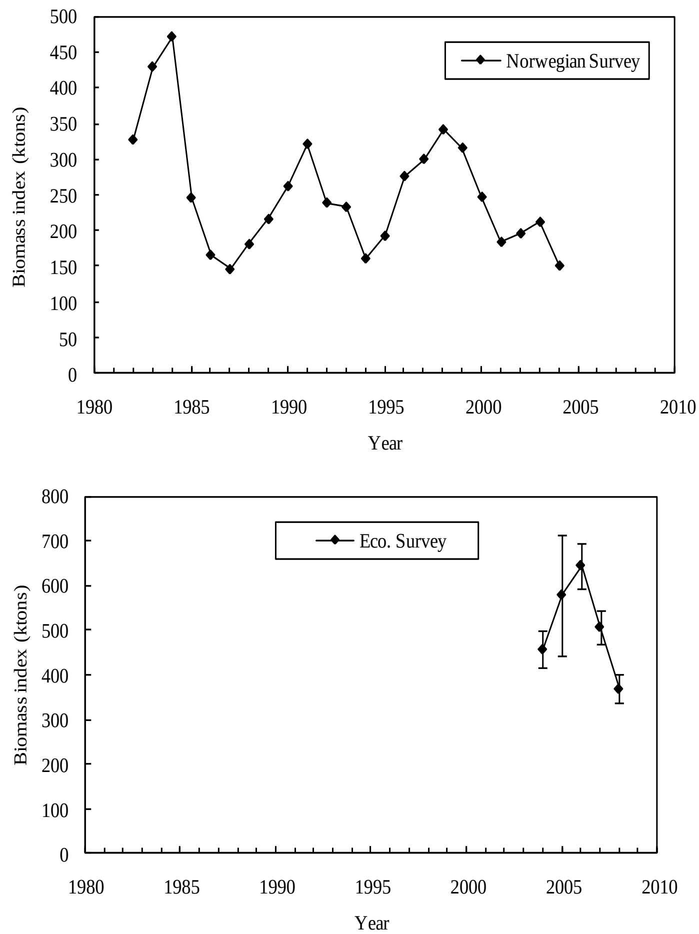


Fig. 6.7. Shrimp in the Barents Sea: Indices of total stock biomass from the 1982-2004 Norwegian shrimp survey (*upper panel*) and the joint Russian-Norwegian ecosystem survey (*lower panel*). Note that the two series represent different areas and therefore their absolute annual values cannot be directly compared. Error bars are standard error.

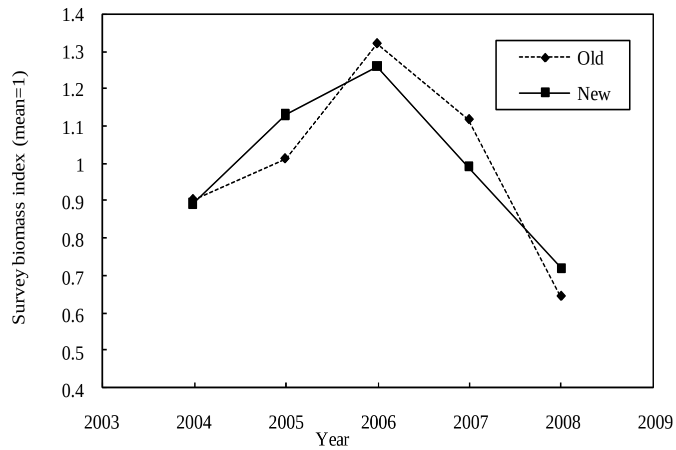


Fig. 6.8. Shrimp in the Barents Sea: Estimated mean biomass as calculated by using the ‘old’ stratification and Norwegian data only (SCR Doc. 07/75) and by using both Norwegian and Russian data in a ‘new’ stratification scheme.

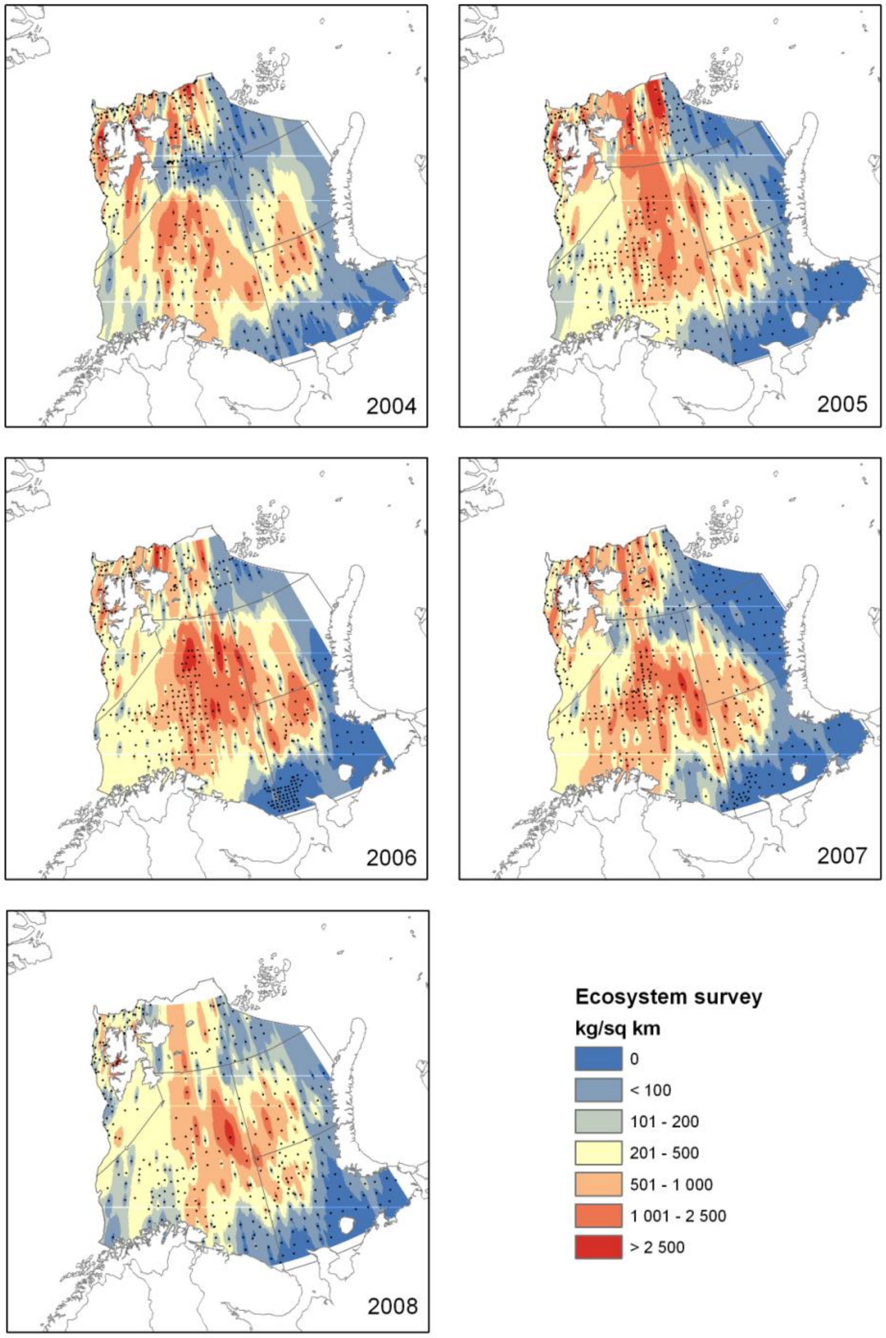


Fig. 6.9. Shrimp in the Barents Sea: Shrimp density (kg/km^2) as calculated from the Ecosystem survey data 2004–2008).

Length composition. Overall size distributions (Fig. 6.10) indicate a relatively large amount of smaller shrimp in 2004 which resulted in the increase in stock biomass until 2006 (Fig. 6.7). The recruitment index – estimated abundance of shrimp at 13–16mm CL supposed to enter the fishery in the following 1–2 years) decreased since 2004 (Fig. 6.11).

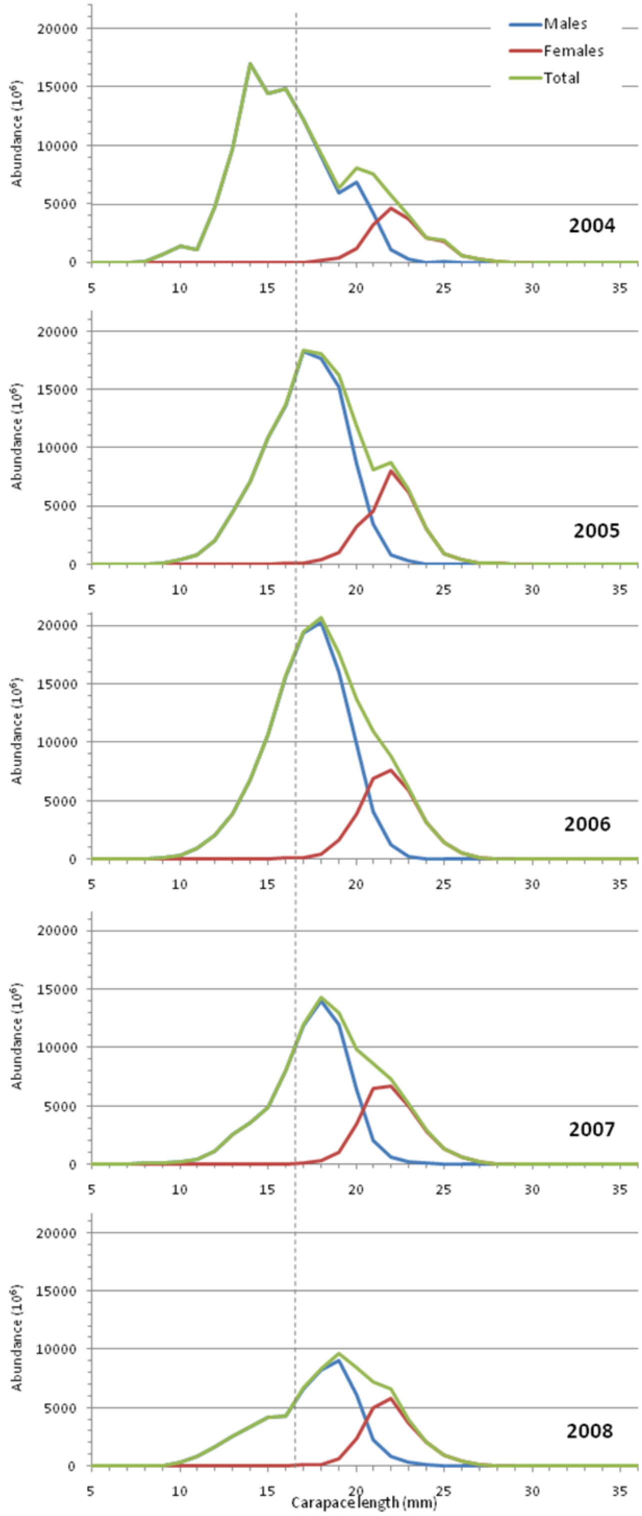


Fig. 6.10. Shrimp in the Barents Sea: size distribution of males, females and total 2004–2008.

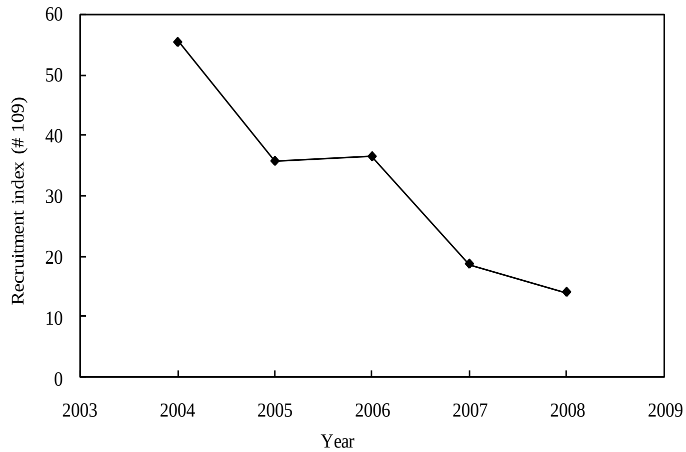


Fig. 6.11. Shrimp in the Barents Sea: Index of recruitment: abundance of shrimp at size 13–16 mm CL.

c) Estimation of Parameters

The new modelling framework introduced in 2006 (Hvingel, 2006) was used again for this year's assessment with all settings being similar to the ones used in 2006 and 2007.

Within this model parameters relevant for the assessment and management of the stock is estimated, based on a stochastic version of a surplus-production model. The model is formulated in a state-space framework and Bayesian methods are used to construct "posterior" likelihood distributions of the parameters (SCR Doc. 08/59).

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 1980–2008 (SCR Doc. 08/56); and two trawl-survey biomass index for 1982–2004 and 2004–2008 (SCR Doc. 07/75, 08/60). 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 1970–2008 was used as yield data (Fig. 6.1, SCR Doc. 08/56). The fishery being without major discarding problems or variable misreporting, reported catches were entered into the model as error-free.

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

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

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

The observation equations had lognormal errors, ω, κ and ε , giving:

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

The observation error terms, ω, κ and ε are normally, independently and identically distributed with mean 0 and variance σ_ω^2, σ_κ^2 and σ_ε^2.

The estimated survey catchabilities, q_R and q_E, indicated that the new "Ecosystem survey" has a 50% higher catchability than the old "Shrimp survey" (Table 6.1). The estimated CVs of the two surveys series had a median at about 17% and for the CPUE series at 13%. The process error, σ_p, had a median of 19%.

Table 6.1. Summary of parameter estimates: mean, standard deviation (sd) and 25, 50, and 75 percentiles of the posterior distribution of selected parameters (symbols are as in the text). MSY = Maximum Sustainable Yield (kt), K = carrying capacity, r = intrinsic growth rate, qC, qR and qE are catchability parameters, P1 = the 'initial" stock biomass in 1970, σ = CV of CPUE and surveys, and σ_p = the process error.

	Mean	sd	25 %	Median	75 %
MSY	257	192	114	203	349
K	3 387	1 858	1 977	2 986	4 398
r	0.32	0.16	0.20	0.31	0.42
q_R	0.13	0.10	0.06	0.10	0.16
q_E	0.21	0.16	0.10	0.16	0.25
q_C	4.69E-04	3.61E-04	2.32E-04	3.59E-04	5.83E-04
P_1	1.50	0.26	1.33	1.50	1.68
σ_R	0.18	0.03	0.16	0.18	0.20
σ_E	0.17	0.04	0.14	0.16	0.19
σ_C	0.13	0.02	0.11	0.13	0.14
σ_P	0.20	0.03	0.17	0.19	0.22

d) Assessment Results

The results of this year's model run are similar to those of 2006 and 2007.

Stock size and fishing mortality. Since the 1970s, the estimated median biomass-ratio has been above its MSY-level (Fig. 6.12) and the probability that it had been below the optimum level was small for most years, *i.e.* it seemed likely that the stock had been at or above its MSY level since the start of the fishery (SCR Doc. 08/59).

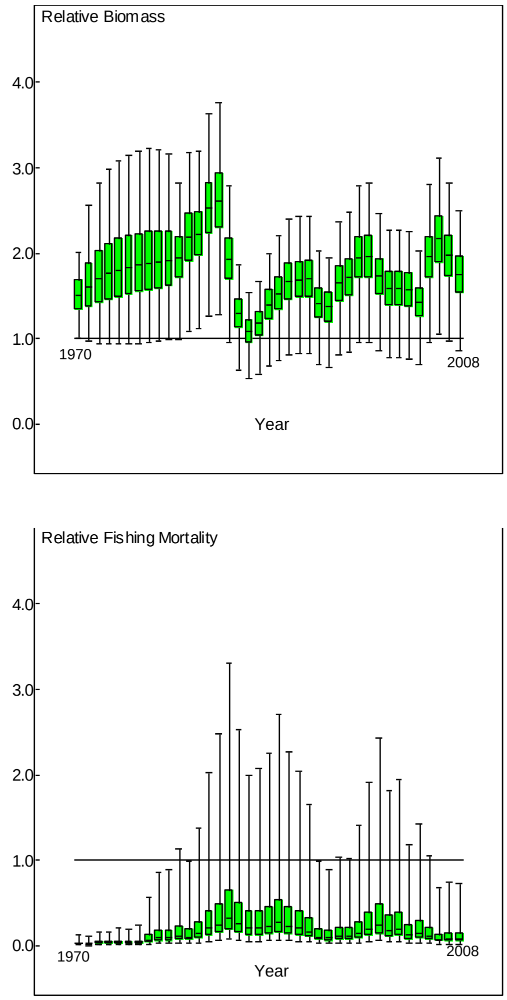


Fig. 6.12. Shrimp in the Barents Sea: estimated relative biomass (B_t/B_{msy}) and fishing mortality (F_t/F_{msy}) 1970–2008. Boxes represent inter-quartile ranges and the solid black line at the (approximate) centre of each box is the median; the arms of each box extend to cover the central 95% of the 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 close to the optimum (Fig. 6.12). Since the late 1990s the stock has varied with an overall increasing trend and reached a level in 2008 estimated to be close to 80% *K*. The estimated risk of stock biomass being below B_{msy} in 2008 was 4%. The median fishing mortality ratio (*F*-ratio) has been well below 1 throughout the series (Fig. 6.12). In 2008 there is 1% risk of the *F*-ratio being above 1.

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).

Estimated median biomass has been above B_{lim}. Fishing mortality ratio has been below F_{lim} throughout the time series (Fig. 6.13). At the end of 2008 there is less than 1% risk that the stock would be below B_{lim}, while the risk that F_{lim} was exceeded is 1%.

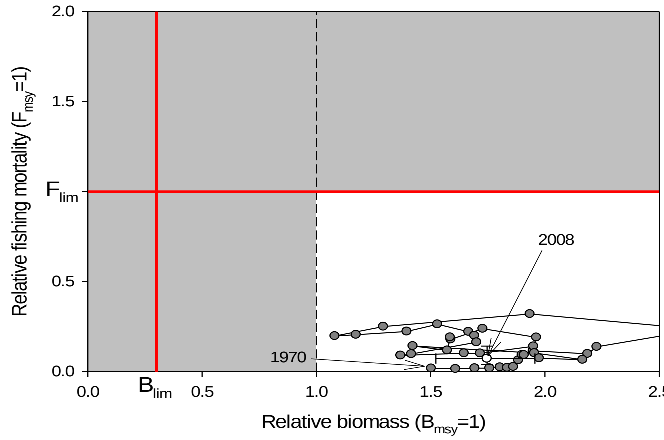


Fig. 6.13. Shrimp in the Barents Sea: Estimated annual median biomass-ratio (*B/B_{msy}*) and fishing mortality-ratio (*F/F_{msy}*) 1970–2008. The reference points for stock biomass, B_{lim}, and fishing mortality, F_{lim}, are indicated by the red (bold) lines. Error bars on the 2008 value are inter-quartile range.

Predictions. 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 2009 are as follows:

Catch option (kt)	30	40	50	60	70	90
Probability of falling below B_{lim}	<1%	<1%	<1%	<1%	<1%	<1%
Probability of falling below B_{msy}	5.4 %	5.5 %	5.8 %	5.9 %	6.0 %	6.6 %
Probability of exceeding F_{lim}	2.1 %	3.1 %	4.5 %	5.9 %	7.4 %	11.1 %

The risk associated with ten-year projections of stock development assuming annual catch of 30 000 to 90 000 t were investigated (Fig. 6.14). For all options the risk of the stock falling below Bmsy in the short to medium term (1-5 years) is low, (<11%). 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. 6.14). Catch options up to 50 000 t, 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. 6.14). The risk that catches of this magnitude will not be sustainable (*prob* (*F*> F_{lim}), 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.

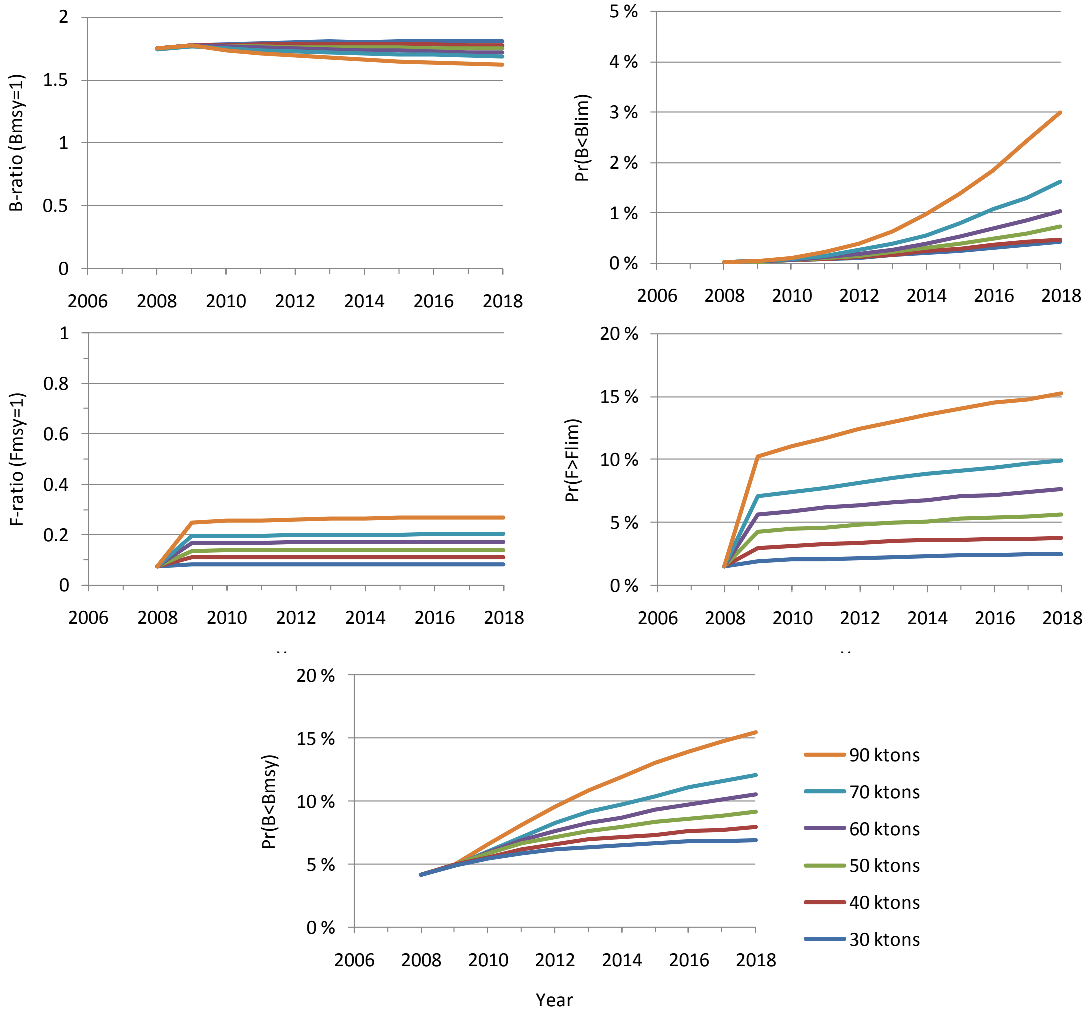


Fig. 6.14. Northern shrimp in the Barents Sea: Projections (*left*): Medians of estimated posterior biomass and fishing mortality ratios; estimated risk (*right* and *below*) of going below B_{msy} and/or B_{lim} and of exceeding F_{lim} given different catch options.

Additional considerations

Model performance. The model was able to produce reasonably good simulations of the observed data (Fig. 6.12) and the observations did not lie in the extreme tails of their posterior distributions (SCR Doc. 08/59) The retrospective pattern of relative biomass series estimated by consecutively leaving out from 0 to 10 years of data did not reveal any problems with sensitivity of the model to particular years.

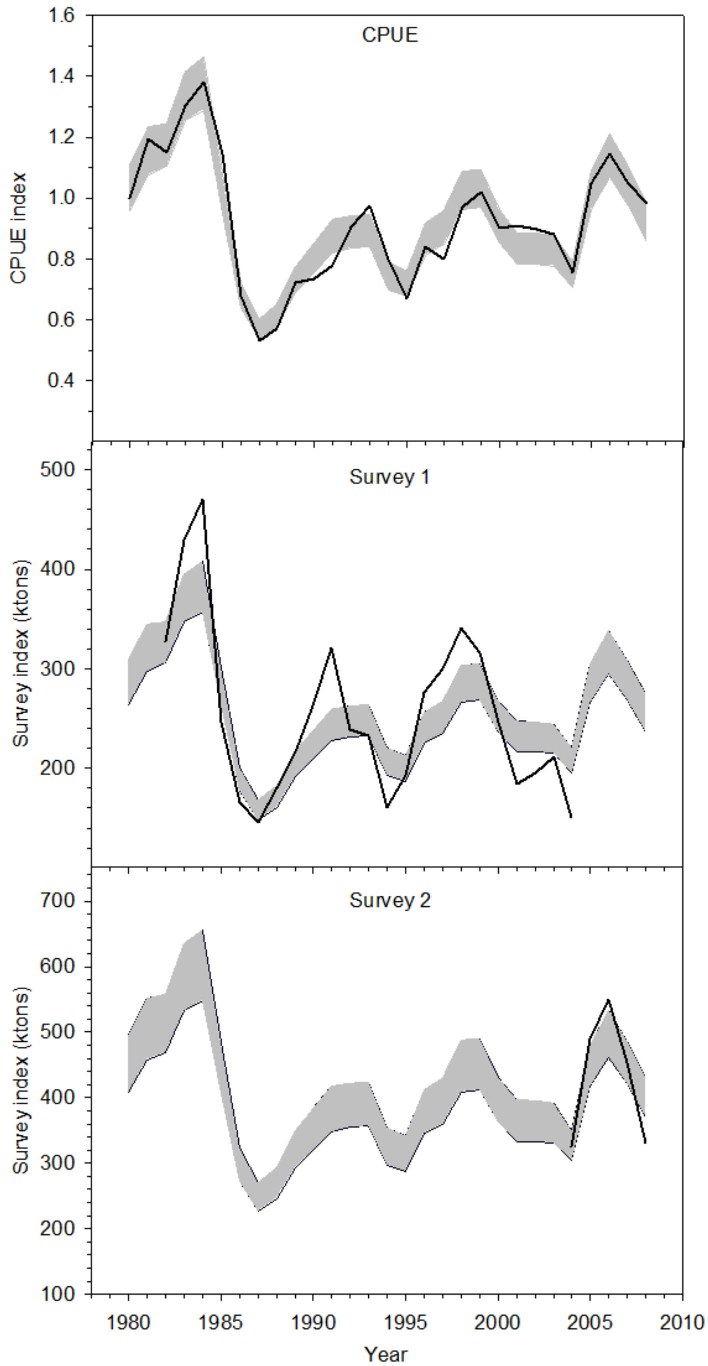


Fig. 6.16. Shrimp in the Barents Sea: Observed (solid line) and estimated (shaded) series of the included biomass indices: the standardized catch-per-unit-effort (CPUE), the 1982–2004 shrimp survey (survey 1) and the Ecosystem survey (survey 2). Grey shaded areas are the inter-quartile range of the posteriors.

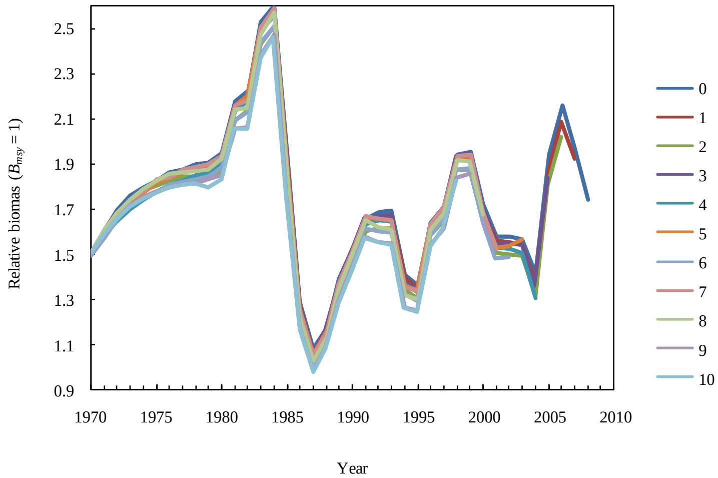


Fig. 6.17. Shrimp in the Barents Sea: Retrospective plot of median relative biomass (*B/B_{msy}*). Relative biomass series are estimated by consecutively leaving out from 0 to 10 years of data.

Predation. Both stock development and the rate at which changes might take place can be affected by changes in predation, in particular by cod, which has been estimated to consume on average 4–5 times the catches. If predation on shrimp were to increase rapidly outside the range previously experienced by the shrimp stock within the modelled period (1970–2008), the shrimp stock might decrease in size more than the model results have indicated as likely. The cod stock has shown signs of increase recently (AFWG, ICES). However, as the total predation depends on the abundance of cod, shrimp and also of other prey species the likelihood of such large reductions is at present hard to quantify.

Continuing investigations to include cod predation as an explicit effect in the assessment model has not so far been successful as it has not been possible to establish a relationship between shrimp/cod densities.

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

Other studies

A study (SCR Doc. 08/70) was presented examining the sensitivity of the conclusions drawn from the assessment model to the priors for the initial biomass, P_1, and for K, the carrying capacity. The overall conclusions are in line with those previously presented in SCR Doc. 06/64 and 07/76, *i.e.* that the model results show little sensitivity to the prior for P_1, but more so to the prior for K.

e) Summary

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 1% for 2008, given a projected 2008 catch of 26 000 t.

Biomass. Indices of stock size have increased from 2004 to 2006, but decreased again from 2006 to 2008. The estimated risk of stock biomass being below B_{msy} at end 2008 was 4%, but less than 1% of being below B_{lim}.

Recruitment. The recruitment index has decreased by 75% since the beginning of the time series in 2004.

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 2008 is estimated to be well above B_{msy} and fishing mortality well below F_{msy}. However, estimated numbers of small shrimp decreased since 2004 which may result in reduced recruitment to the fishery in 2009.

g) Research Recommendations for 2009

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

- *To explore the reference points in the light of the ICES approach to PA reference points.*
- *Evaluate methods for constructing a recruitment index.*
- *Work to include explicit information on recruitment in the assessment model should be continued.*
- *Bycatch information be provided well in advance of the NIPAG meeting*
- *Investigate the means of constructing an informative prior to aid models ability to scale the old and the new surveys.*
- *identification of best recruitment index.*

h) Management Recommendations

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

- *nations active in the fishery must be required to provide information on the shrimp length and sex distributions in the catches in advance of the assessment (1 September).*

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

This stock was not included in the terms of reference received by NIPAG from ACOM. However, a short description of the fishery is given, as a shrimp fishery could be resumed in this area in the future. The landings from the Fladen Ground have been recorded from 1972 (SCR Doc. 08/76, Table 9). Total reported landings since 1997 have fluctuated between zero in 2006 to above 4000 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.

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

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

Country/Fleet	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
Denmark	3 022	2 900	1 005	1 482	1 263	1 147	999	23	10	0	0
Norway	9	3	9		18	9	8	0	0	0	0
Sweden							1	0	0	0	0
UK (Scotland)	365	1 365	456	378	397	70		0	0	0	0
Total	3 396	4 268	1 470	1 860	1 678	1 226	1 008	23	10	0	0

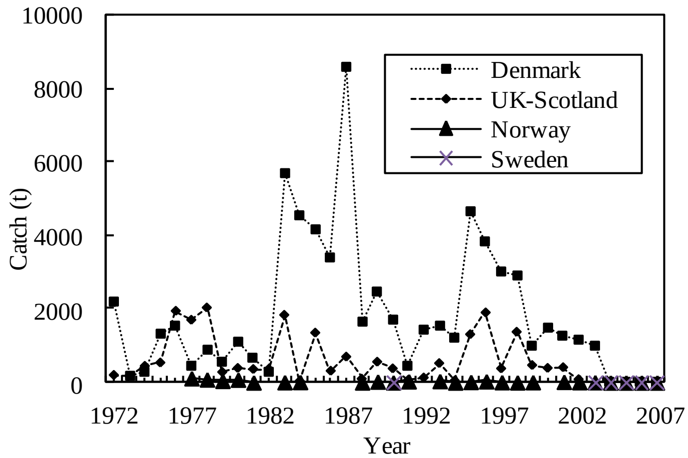


Fig. 7.1. Northern shrimp in Fladen Ground: Catches

8. Northern shrimp in Farns Deep – 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 100 t were reported. In the past 10 years the *Pandalus* fishery in Farn Deeps has been negligible (SCR Doc. 08/76).

IV. OTHER MATTERS

1. Bycatches in the shrimp fishery

The Northern Shrimp fisheries in the North Atlantic have introduced sorting grids (Nordmoere grid) in the 1990s, which excludes bycatch of most fish larger than 25 cm. The grate spacing varies between 19 (Barents Sea) and 22 mm (Greenland, Div. 3LNO, Div. 3M) and has influence on the selectivity. The bycatch species occurring in the shrimp catch in the Barents Sea, Greenland and Flemish Cap are capelin, juvenile cod, haddock, redfish and Greenland halibut (SCR Doc. 08/31(Rev), 56).

In the Barents Sea area closures are introduced in periods when bycatch of juvenile commercial fish exceeds a certain number (3–10) per kg of shrimp. In the SA1, Div. 3M and Div. 3LNO vessels are required to move at least 5 nautical miles if bycatch of all regulated ground fish exceeds the specified percentage by weight of the shrimp catch. The only fishery where grids are not obligatory is the shrimp fishery is in the Norwegian Deep and Skagerrak area. The landed bycatch from the shrimp fleet not using grates is 10–20% of the total landings. The main landed bycatch species are saithe, cod, witch flounder and anglerfish (SCR Doc. 08/76).

The annual average bycatch in the Barents Sea shrimp fishery is estimated at approximately 14, 10, 4 and 5 million individuals for cod, redfish, haddock and Greenland halibut, respectively. Bycatch in the NRA shrimp fisheries was identified as being mainly capelin, American plaice, Greenland halibut, redfish, lanternfish, and Arctic eelpout.

2. CPUE and its relationship to stock biomass

Catch per unit of fishing effort is commonly used as an indicator of fishable stock biomass. It is generally accepted that there is a monotonic relationship: *i.e*. that, other factors being constant, high CPUE shows greater biomass and low CPUE shows less biomass. Furthermore, in some assessment models, including some standard models, it is assumed that there is an interval relationship, usually a proportional one. However, reservations about these assumptions are often voiced: firstly, that other factors are not always constant, and it may not be obvious how unequal they are; and secondly, that even if other factors are constant, the assumed proportional relationship may not hold for various reasons.

NIPAG discussed this question in connection with the universal use of CPUE as an indicator of stock biomass for North Atlantic shrimp stocks, noting that when there is no survey data CPUE may be the only indicator of stock size available, but that when there is survey data that would be the preferred index. However, a number of caveats or cautions were suggested, among them:

- if fleets are trying to maximize economic return, fishing patterns vary depending on e.g. markets and market prices, fuel prices and the steaming distances to preferred grounds, so that simple catch weight is not always what fishermen are trying to maximize; (other factors not constant),

- catch rates measure density in fished areas, and if a stock distribution is shrinking its biomass could go down very much while catch rates stay high; this is a recognized hazard associated with relying on CPUEs when assessing gregarious schooling species such as anchovy; (other factors may be constant, but the proportional relationship CPUE-biomass doesn't hold),

- fishermen can exercise some control over CPUE and may be particularly good at maintaining catch rates in the early days of a stock decline; if a fishery is in decline, the least effective vessels or crews may retire first; (other factors not constant),

- CPUE also depends on species biology,

- CPUE may depend on exploitation rate: with a small fleet and little fishing effort applied, vessels may have more freedom to select rewarding fishing areas than when effort is high and there are more ships seeking fishing areas; although it was also observed that higher effort levels could mean more ships searching the grounds and therefore a higher chance that the most rewarding spots would be found. (other factors may be constant, but the proportional relationship doesn't hold),

- 'Technological creep' of various kinds might defeat the usual standardization methods, which assume that a ship has constant fishing power; unquantifiable advances in gear rigging or instrumentation, wire control, navigation, *etc*., might change the relationship between stock density or biomass and catch rate without being well enough documented to be taken into account in any analysis. (other factors not constant).

NIPAG came to no definite conclusions as a result of its brief discussion of this issue, except to observe that caution is appropriate in interpreting CPUE as an index of stock biomass, especially when the circumstances of the fishery are changing.

V. OTHER BUSINESS

1. Progress on the Northern Shrimp Working Group

NIPAG reviewed the general topic of the Northern Shrimp Working Group and concluded that *ad hoc* groups could be set up as needed and that there was currently no need for a specific working group.

2. Stock classification

The classification of the NAFO Shrimp stocks for FIRMS descriptors were discussed by the NAFO Scientific Council in June 2008 (SCS Doc. 08/19). NIPAG discussed the current classifications and forwarded their conclusions to the NAFO Secretariat for forwarding to FIRMS.

3. Date of next meeting

The date of the next NIPAG meeting is 21–29 October 2009 at the NAFO Secretariat, Dartmouth, NS, Canada.

VI. ADJOURNMENT

The NIPAG meeting was adjourned at 1030 hours on 30 October 2008.

AGENDA NIPAG MEETING, 22 - 30 OCTOBER 2008

I. Opening (Co-chairs: Michael Kingsley and Michaela Aschan)

1. Appointment of Rapporteur

2. Adoption of Agenda

3. Plan of Work

II. General Review

1. Review of Recommendations in 2007 and in 2008

2. Review of Catches

III. Stock Assessments

1) Northern shrimp (Division 3M) – NAFO Assessed

2) Northern Shrimp (Divisions 3LNO) – NAFO Assessed

3) Northern shrimp (Subareas 0 and 1) – NAFO Assessed

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

5) Northern Shrimp in North Sea, Skagerrak and Kattegat – ICES Assessed

6) Northern shrimp in Barents Sea – ICES Assessed

7) Northern shrimp in Fladen Ground – ICES Assessed

8) Northern shrimp in Farns Deep – ICES Assessed

IV. Other Matters

1) Byctaches in the shrimp fishery

2) CPUE and its relationship to stock biomass

V. Other Business

1) Progress on the Northern Shrimp Working Group

2) Stock classification

3) Date of next meeting

VI. Adjournment

ANNEX 1a. Fisheries Commission's Request for Scientific Advice on Management in 2009 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 2008 Annual Meeting, provide advice on the scientific basis for the management of the following fish and invertebrate stocks or groups of stocks in 2009:

Northern shrimp in Div. 3M, 3LNO

Greenland halibut in SA 2 and Div. 3KLMNO

Noting that SC will meet in Oct-Nov of 2007, FC requests SC to update its advice for 2008, as well as to provide advice for 2009, for both shrimp stocks referenced above.

2. 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 2008 Annual Meeting, provide advice on the scientific basis for the management of the following fish stocks according to the following assessment frequency:

Two year basis	Three year basis
American plaice in Div. 3LNO	American plaice in Div. 3M
Capelin in Div. 3NO	Cod in Div. 3NO
Redfish in Div. 3M	Cod in Div. 3M
Thorny skate in Div. 3LNOPs	Northern shortfin squid in SA 3+4
White hake in Div. 3NOPs	Redfish in Div 3LN
Yellowtail flounder in Div. 3LNO	Redfish in Div. 3O
	Witch flounder in Div. 2J+3KL
	Witch flounder in Div. 3NO

- In 2007, advice was provided for 2008 and 2009 for American plaice in Div. 3LNO, redfish in Div. 3M, white hake in Div. 3NO and capelin in Div. 3NO. These stocks will be next assessed in 2009.
- In 2007, advice was provided for 2008, 2009 and 2010 for redfish in Div. 3LN, redfish in Div. 3O, cod in Div. 3NO and witch flounder in Div. 2J+3KL. These stocks will be next assessed in 2010.

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

- In 2008, advice will be provided for 2009 and 2010 for yellowtail flounder in Div. 3LNO, and thorny skate in Div. 3LNOPs. These stocks will be next assessed in 2010.
- In 2008, advice will be provided for 2009, 2010 and 2011 for cod in Div. 3M, American plaice in Div. 3M, witch flounder in Div. 3NO, redfish in Div. 3LN and northern shortfin squid in SA 3+4. These stocks will be next assessed in 2011.
- Despite the advice on redfish in Div. 3LN in 2007, the Fisheries Commission requests a full assessment and advice in 2008 for this stock.

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

3. The Commission and the Coastal State request the Scientific Council to consider the following in assessing and projecting future stock levels for those stocks listed above:

a) The preferred tool for the presentation of a synthetic view of the past dynamics of an exploited stock and its future development is a stock assessment model, whether age-based or age-aggregated.

b) For those stocks subject to analytical-type assessments, the status of the stocks should be reviewed and management options evaluated in terms of their implications for fishable stock size in both the short and long term. As general reference points, the implications of fishing at $F_{0.1}$ and F_{2007} in 2009 and subsequent years should be evaluated. The present stock size and spawning stock size should be described in relation to those observed historically and those expected in the longer term under this range of options.

c) 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. In this case, the level of fishing effort or fishing mortality (F) required to take two-thirds MSY catch in the long term should be calculated.

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

e) Spawning stock biomass levels considered necessary for maintenance of sustained recruitment should be recommended for each stock. In those cases where present spawning stock size is a matter of scientific concern in relation to the continuing reproductive potential of the stock, management options should be offered that specifically respond to such concerns.

f) Information should be provided on stock size, spawning stock sizes, recruitment prospects, fishing mortality, catch rates and TACs implied by these management strategies for the short and the long term in the following format:

I. For stocks for which analytical-type assessments are possible, graphs should be provided of all of the following for the longest time-period possible:

- historical yield and fishing mortality;
- spawning stock biomass and recruitment levels;
- catch options for the year 2009 and subsequent years over a range of fishing mortality rates
- (F) at least from $F_{0.1}$ to F_{max};
- spawning stock biomass corresponding to each catch option;
- 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 as a function of fishing mortality rate or fishing effort should be provided. Age aggregated assessments should also provide graphs of all of the following for the longest time period possible:

- exploitable biomass (both absolute and relative to B_{MSY})
- yield/biomass ratio as a proxy for fishing mortality (both absolute and relative to F_{MSY})
- estimates of recruitment from surveys, if available.

III. Where analytical methods are not attempted, the following graphs should be presented, for one or several surveys, for the longest time-period possible:

- time trends of survey abundance estimates, over:
- an age or size range chosen to represent the spawning population
- an age or size-range chosen to represent the exploited population
- recruitment proxy or index for an age or size-range chosen to represent the recruiting population.

- fishing mortality proxy, such as the ratio of reported commercial catches to a measure of the exploited population.

For age-structured assessments, yield-per-recruit graphs and associated estimates of yield-per-recruit based reference points should be provided. In particular, the three reference points, actual F, $F_{0.1}$ and F_{max} should be shown.

4. Noting the Precautionary Approach Framework as endorsed by Fisheries Commission, the Fisheries Commission requests that the Scientific Council provide the following information for the 2008 Annual Meeting of the Fisheries Commission for all stocks under its responsibility requiring advice for 2009:

a) the limit and precautionary reference points as described in Annex II of the UN Fisheries Agreement indicating areas of uncertainty (for those stocks for which precautionary reference points cannot be determined directly, proxies should be provided);

b) the stock biomass and fishing mortality trajectory over time overlaid on a plot of the PA Framework (for those stocks where biomass and/or fishing mortality cannot be determined directly, proxies should be used);

c) information regarding the current Zone the stock is within as well as proposals regarding possible harvest strategies to move the resource to (or maintain it in) the Safe Zone including medium term considerations and associated risk or probabilities which will assist the Commission in developing the management strategies described in paragraphs 4 and 5 of Annex II in the Agreement.

5. The following elements should be taken into account by the Scientific Council when considering the Precautionary Approach Framework:

a) References to “risk” and to “risk analyses” should refer to estimated probabilities of stock population parameters falling outside biological reference points.

b) Where reference points are proposed by the Scientific Council as indicators of biological risk, they should be accompanied by a description of the nature of the risk associated with crossing the reference point such as recruitment overfishing, impaired recruitment, etc.

c) When a buffer reference point is proposed in the absence of a risk evaluation in order to maintain a low probability that a stock, measured to be at the buffer reference point, may actually be at or beyond the limit reference point, the Scientific Council should explain the assumptions made about the uncertainty with which the stock is measured.

d) Wherever possible, short and medium term consequences should be identified for various exploitation rates (including no fishing) in terms of yield, stability in yield from year to year, and the risk or probability of maintaining the stock within, or moving it to, the Safe Zone. Whenever possible, this information should be cast in terms of risk assessments relating fishing mortality rates to the trends in biomass (or spawning biomass), the risks of stock collapse and recruitment overfishing, as well as the risks of growth overfishing, and the consequences in terms of both short and long term yields.

e) When providing risk estimates, it is very important that the time horizon be clearly spelled out. By way of consequence, risks should be expressed in timeframes of 5, 10 and 15 years (or more), or in terms of other appropriate year ranges depending on stock specific dynamics. Furthermore, in order to provide the Fisheries Commission with the information necessary to consider the balance between risks and yield levels, each harvesting strategy or risk scenario should include, for the selected year ranges, the risks and yields associated with various harvesting options in relation to B_{lim}, and F_{lim} and target F reference points selected by managers.

6. Many of the stocks in the NAFO Regulatory Area are well below any reasonable level of B_{lim} or B_{buf}. For these stocks, the most important task for the Scientific Council is to inform on how to rebuild the stocks. In this context and building on previous work of the Scientific Council in this area, the Scientific Council is requested to evaluate various scenarios corresponding to recovery plans with timeframes of 5 to 10 years, or longer as appropriate. This evaluation should provide the information necessary for the Fisheries Commission to consider the balance between risks and yield levels, including information on the consequences and risks of no action at all.

a) information on the research and monitoring required to more fully evaluate and refine the reference points described in paragraphs 1 and 3 of Annex II of the Agreement; these research requirements should be set out in the order of priority considered appropriate by the Scientific Council;

b) any other aspect of Article 6 and Annex II of the Agreement which the Scientific Council considers useful for implementation of the Agreement's provisions regarding the precautionary approach to capture fisheries; and

c) propose criteria and harvest strategies for new and developing fisheries so as to ensure they are maintained within the Safe Zone.

7. Regarding pelagic *S. mentella* redfish in NAFO Subareas 1-3, the Scientific Council is requested to review the most recent information available on the distribution and abundance of this resource, as well as any new information on the affinity of this stock to the pelagic redfish resource found in the ICES Sub-area XII, parts of SA Va and XIV and to the shelf stocks of redfish found in ICES Sub-areas V, VI and XIV, and NAFO Subareas 1-3.

8. With respect to porbeagle shark (*Lamna nasus*) in the NAFO Convention Area, the Fisheries Commission with the concurrence of the Coastal State requests Scientific Council, at a meeting in advance of the 2008 Annual Meeting, to provide the following:

a) Information on historical and current catches and bycatches of the species in the NAFO Convention Area and NRA, summarized by NAFO Subarea and fishery;

b) Information on the abundance and distribution of the species in the Convention Area and the NRA;

c) Identification and delineation of any fishery areas or exclusion zones which might reduce the incidental bycatch of this species in NAFO regulated fisheries.

9. Noting the FC Rebuilding Plan for 3NO cod adopted in September 2007, Fisheries Commission requests Scientific Council to advise, before September 2010, on a range of possible management measures to ensure bycatch of cod is kept at the lowest possible level.

10. Recognizing the initiatives on vulnerable marine ecosystems (VME) Fisheries Commission requests the Scientific Council to:

a) Develop initial methodologies for the identification of VME and assessment of individual fishing activities, drawing on relevant international information and objective standards and guidelines as may have been developed, as deemed appropriate for this work;

b) Assess, at least on a preliminary basis, using the best available scientific information and assessment methodology, whether individual bottom fishing activities would have significant adverse impacts on identified vulnerable marine ecosystems, with a view to reporting these findings to the Fisheries Commission and ensuring that additional conservation and management measures, where required, are recommended, through a Working Group of Fishery Managers and Scientists on Ecosystems Management, to the Fisheries Commission at its September 2008 meeting.

c) Develop appropriate scientific methods for the longer term monitoring of the health of VME.

ANNEX 1b. Fisheries Commission's Request for Scientific Advice on Management in 2010 and Beyond of Certain Stocks in Subareas 2, 3 and 4 and Other Matters

(Item 1 of the request is the only request relevant to this meeting)

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 2009 Annual Meeting, provide advice on the scientific basis for the management of the following fish and invertebrate stocks or groups of stocks in 2010:

Northern shrimp in Div. 3M, 3LNO

Greenland halibut in SA 2 and Div. 3KLMNO

Noting that SC will meet in October of 2008, FC requests SC to update its advice for 2009, as well as to provide advice for 2010, for both shrimp stocks referenced above.

ANNEX 2. Canadian Request for Scientific Advice on Management in 2008 of Certain Stocks in Subareas 0 to 4

1. Canada requests that the Scientific Council, at its meeting in advance of the 2008 Annual Meeting of NAFO, subject to the concurrence of Denmark (on behalf of Greenland), provide advice on the scientific basis for management in 2009 of the following stocks:

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 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 area throughout its range and comment on its management in Subareas 0+1 for 2009, and to specifically:

a) advise on appropriate TAC levels for 2009, separately, for Greenland halibut in the offshore area of Divisions 0A+1AB and Divisions 0B+1C-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_{2007} in 2009 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 NAFO 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 and/or catch data are available, few standard criteria exist on which to base advice. The stock status should be evaluated in the context of the 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:

a. 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 2009 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.

b. 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).

3. Regarding Greenland halibut in Subarea 2 + Divisions 3KLMNO, Canada requests the Scientific Council:

1) to advise on appropriate TAC levels for 2009, based on biomass distribution, for Greenland halibut in these areas separately: SA 2+Division 3K and Divisions 3LMNO.

2) to provide information on the status of Greenland halibut in SA 2+Divisions 3KLMNO in relation to the Greenland Halibut Rebuilding Plan and Strategy, including commentary on progress in relation to the targets described in the Strategy.

Yours sincerely,
David Bevan
Assistant Deputy Minister
Fisheries and Aquaculture Management
DFO
Ottawa, Canada

ANNEX 3. Denmark's (Greenland) request for Scientific Advice on Management in 2008 of Certain Stocks in Subarea 0 and 1

1. In the Scientific Council report of 2005, scientific advice on management of Roundnose grenadier in Subarea 0+1 was given as a 3-year advice (for 2006, 2007 and 2008). Denmark, on behalf of Greenland, requests the Scientific Council to provide advice on the scientific basis for the management of Roundnose grenadier in Subarea 0+1 for 2009-2011.

2. Advice for redfish (*Sebastes spp*.) and other finfish (American plaice (*Hippoglossoides platessoides*), Atlantic wolffish (*Anarhichas lupus*), spotted wolffish (*A. minor*) and thorny skate (*Raja radiata*)) in Subarea 1 was in 2005 for 2006-2007 (also 2006 for 2006-2008). Denmark, on behalf of Greenland, requests the Scientific Council to provide advice on the scientific basis for the management of Redfish (*Sebastes spp*.) and other finfish in Subarea 0+1 for 2009-2011.

3. Subject to the concurrence of Canada as regards Subarea 0, the Scientific Council is requested to provide advice on the scientific basis for the management of Greenland halibut in the offshore area in Subarea 0 +Division 1A Offshore and Division 1B-1F in 2009, and as many years forward as data allow.

4. Advice for Greenland halibut in Subarea 1A inshore was in 2006 given for 2007-2008. Denmark, on behalf of Greenland, requests the Scientific Council to provide advice on the scientific basis for the management of Greenland halibut in Subarea 1A inshore for 2009-2010.

5. Subject to the concurrence of Canada as regards Subarea 0, Denmark, on behalf of Greenland, further requests the Scientific Council of NAFO before December 2008 to provide advice on the scientific basis for management of Northern shrimp (*Pandalus borealis*) in Subarea 0 and 1 in 2009, and as many years forward as data allow.

6. Further, the Council is requested to provide advice, in co-operation with ICES, on the scientific basis for management of Northern shrimp (*Pandalus borealis*) in Denmark Strait and adjacent areas east of southern Greenland in 2009, and as many years forward as data allow.

On behalf of

The Department of Fisheries, Hunting and Agriculture
Sincerely
Amalie Jessen
Deputy Minister (acting)

ANNEX 4. Terms of Reference for ICES Stocks

2007/2/ACOM11

(http://www.ices.dk/iceswork/recs/2007%20Resolutions/ACOM/ACOM%20resolutions%202007.pdf)

The Working Group on *Pandalus* [WGPAND] will be dissolved and will be re-established as the Joint NAFO/ICES *Pandalus* Assessment Working Group [NIPAG] (Chair: M. Aschan, Norway) and will meet at ICES Headquarters, 22–30 October 2008 to:

a) compile, update, analyse and document time-series of relevant fisheries, environmental data and regulatory changes (see generic ToRs). Including:

i) Specification of bycatches in the shrimp fishery

b) Summarise the findings for the following stocks (see generic ToR 4):

i) *Pandalus borealis* in the Barents Sea

ii) *Pandalus borealis* the North Sea, Skagerrak, and Kattegat

c) Consider shrimp stocks as decided by NAFO Sc. C.

NIPAG will report on the ICES shrimp stocks, see b) for the attention of ACOM 31 October 2008.

APPENDIX II. TECHNICAL MINUTES FROM THE ICES ACOM REVIEW GROUP FOR THE 2008 NIPAG REPORT (ICES STOCKS)

31 October 2008

Reviewers:	Martin Pastoors (chair)
	Yuri Kovalev (Russia)
	Unnur Skuladottir (Iceland)
	Colm Lordan (Ireland)
Chair WG:	Michaela Aschan (Norway)
Secretariat:	Barbara Schoute

General

The Working Group is complimented for a clearly structured and understandable report. As in the previous year, the report refers primarily the working documents. The WG uploaded the report and the working documents at an early stage to the sharepoint folder which has been welcomed by the reviewgroup.

The report contains a general section about sorting grids and other technical gear devices. This section has not been reviewed by the RG because it was not included in the report extract that deals with the ICES stocks. It would be helpful if the WG would make references to that general section in the sections dealing with the different stocks.

The review group would like to get a better underpinning of the advice by the WG. This could be done by providing a section on past management advice and what it was based on;

Northern Shrimp (*Pandalus borealis*) in Subareas I and II (Barents Sea)

Assessment type	Update, with minor tweaks
Assessment:	accepted
Forecast:	stochastic forecast (10 years)
Assessment model:	Bayesian State-Space production model
Consistency:	very consistent with last year
Stock status:	B > Blim, F < Flim, R probably low in last year
Man. Plan.:	none

A Bayesian production model has been applied using 2 surveys in different periods and a standardized CPUE series which has been adjusted compared to last year because single vessel identification is now available instead of just vessel size. A production model was used because cohort modes are difficult to distinguish in cold areas. Predation is not included because there is no relationship between shrimp and cod densities. Recruitment is not included but recruitment estimation is being worked on and there is a need for a common approach for other *Pandalus* stocks.

A concern with the model is that it is not responding to survey change as much as it does to CPUE signal; the CPUE signal shows less change and gets higher weight.

The problem with access to survey data has been resolved and there is a common survey dataset for the joint Norway and Russia survey (since 2004).

Regarding exclusion grids, the report states (just above Fig. 6.2): *“In recent years there has been a decline in bycatch following a reduced effort in the shrimp fishery.”* Was the bar spacing in the sorting grid larger in the beginning? That could explain the sudden drop in by-catch in the Barents Sea not just in 1993 (when mandatory) but again in 1999. SCR documents 07/85, 07/86 and 07/87 on redfish-, cod-, haddock- and Greenland halibut-bycatch do not mention the bar spacing. Iceland has used 21-22 mm bar spacing in the offshore shrimp fishery since 1996, but at Flemish Cap they used 28 mm before 1996 and 22 mm since then. The basis of the bar spacing should be better elaborated in the WG report and supporting documents.

Predation is not included in the model because there is no relationship between shrimp and cod densities. This is a worrisome issue. The RG does not see any analysis on that and no references. The RG proposes for next year to include information on cod consumption in the report (could be taken from AFWG table 1.4). The investigation of this relationship should be described in report or referred. The work on inclusion at least cod consumption in the model should continue.

An important issue is the definition of reference points for this stock. Reference points are set using NAFO standards: 30% Bmsy = Blim and Flim=Fmsy. This is somewhat different from the standard ICES approach. In this case there is no direct link between Blim and Flim as would be normal in the ICES PA framework. Nevertheless, it is somewhat close to the approach for other production model estimates (e.g. anglerfish). The group used the 5% risk level for ICES stocks and 20% for the Greenland stock. The RG noted that there has been a sharp decline in biomass in the mid 1980s possibly as a response to high catches in early 1980s. However it is unclear what came first: the decline in SSB which lead to lower catches or the high catches which lead to a lower SSB. The group should investigate the relationship between catches and stock dynamics.

However, during the period of high catches, fishing mortality was still well below Flim which raised the question of the appropriateness of the current Flim. On the other hand, the report states at several occasions that the predation mortality is probably at least 4 times higher than the fishing mortality although it has not been possible to include these predation estimates (because of lack of signal). This could be interpreted as an indication that fishing mortality limits may not be appropriate for this stock (c.f. Norway pout, sandeel, etc.).

The RG recommends to include the definition of reference points for Barents Sea *Pandalus* in an overall review of reference points within ICES and more specifically for those stocks that are short-lived and use Bayesian methods for stock estimation.

The recruitment plot that is presented by the WG (figure 6.11) gives a worrisome signal, but it is very short. It would be informative to explore and present the recruitment proxy information from the old survey to get a better understanding of the likely variability in recruitment.

The Review group suggests that the prediction probabilities in the text table should be without digits.

Conclusions

Assessment accepted as a basis for the advice. A revision of reference points with reference to other short lived, highly predation mortality species is required.

Northern shrimp (*Pandalus borealis*) in Division IIIa West and Division IVa East (Skagerrak and Norwegian Deeps)

Assessment type	Trends in 2 CPUE series and 1 Survey
Assessment:	no agreed assessment
Forecast:	not conducted
Assessment model:	Standardized CPUE (GLM)
Consistency:	same as last year

Stock status: no reference points defined

Man. Plan.: none

Generally stable perception based on LPUE trends. Changes based on recommendations from last year have been implemented. No analytical assessment.

Last year: only Danish LPUE series as basis for advice. Now recalculated and includes season in the GLM. No data available for 2008 yet. Norwegian LPUE now also included (2000-2008) despite discussion about reliability (small part of catch). The scaling of the two LPUE series in figure 5.2 is unclear and not explained in the legend or text.

Swedish LPUE not included because of substantial discarding and high-grading which is difficult to correct for.

RGPAND 2007 raised the issue: what is a shrimp trip? WG 2007 had used 50% value of shrimp in trip. This year the WG explored alternative percentages in a WD but decided to stick to 50%. However, the RG would like to see the results of the sensitivity analysis presented in the report. The report only states that it has been explored and kept, but the basis of that decision is not revealed.

The title for Table 5.2 and the text is not particularly clear on the apparent difference between Danish & Swedish "Logbooks" and Norwegian "landings"? The RG suggests to add: "Danish and Swedish logbooks (including discards estimates)".

Section dealing with by-catch and ecosystem effects is based on landings are there any other species discarded? Table 5.3 gives estimates of predator biomass based on surveys which gives an idea about species that may be caught. The WG should make links with this information in the section dealing with ecosystem effects. On the other hand, the RG wonders whether the use of the shrimp survey to quantify predator abundance in Table 5.3 is appropriate? Has this been tested? And has the WG considered other indicator of predator abundance in the area (e.g. IBTS surveys).

Figure 5.3 (Danish fleet only) shows that the "effort" is stable. However, the number of vessels has decreased 20-fold and apparently small boats have been replaced by fewer but larger vessels. This should have been included in the WG report.

The presentation of discard data to the assessment for Norway is OK for information purposes. However, there is no information on the sampling precision or accuracy. The raising procedure used is probably reasonable but it should be examined/discussed in more detail. It is not consistent to introduce discards in 2007 to the assessment if discards have been taking place in previous years but are not included. The RG **recommends** that discard estimates for previous years (SCR 08-73 Table 2) are included in next year assessment and accuracy of these data be presented.

It is difficult to draw real conclusions from the survey data because they are chopped up in 4 separate time series (due to gear and season changes). The RG reiterates the **recommendation** for integration of the data sets. The WG could explore methods generated by the Study Group on Survey Trawl Standardization (SGSTS 2008) or swept area methods (e.g. WKNEPHTV 2007).

The high survey biomass and high uncertainty in 2007 derives from a single station effect. The WG should explore the impacts of this single haul. Excluding that haul would reduce the mode to half it size (pers. comm. WG chair). There is a growing literature on how to handle exceptional hauls in a survey and the WG should make use of this body of knowledge. If the WG presents uncertainty on the overall abundance (like in figure 5.4), it should to the same with the numbers at length and recruitment (figure 5.5). That should show the uncertainty in the numbers at length of the 2007 survey.

The WG is inconsistent in it's presentation of recruitment. The conclusion: *"NIPAG has noticed that a decline in recruitment in a particular year has rarely caused serious decrease in adult biomass in subsequent years, and this stock has been fluctuating around a stable level for many years."* may well be correct but it is not supported by any evidence in the report. Furthermore the rational for changing the survey is linked in the text to providing better recruit estimates which are now considered not important. This apparent conclusion is overturned in state of the stock where *"the lower recruitment may imply a decline in biomass in 2009"*.

In the summary of results on LPUE, there is no reference to the Norwegian LPUE data although it is said to be also the basis for the advice.

There is no mentioning of high-grading in the management recommendations. The RG suggests to include a section in the WG report on management considerations.

For the future direction of the assessment, the WG could present and evaluate the available length and/or age structured time series. Simple recruitment proxies such as landings or survey catches below some threshold length could be informative. The WG could explore the possibility to generate exploitation proxies or stock status proxies from these types of data e.g. proportion of landings above some size, slope of the right hand limb of the length frequency distributions (or Z estimates if the age information is credible).

Conclusions

The RG accepts the overall conclusions of the WG based on the Danish and Norwegian CPUE series. The interpretation of recent recruitment based on the survey is somewhat problematic because of the very short time series and the high uncertainty in the 2007 survey.

Northern shrimp (*Pandalus borealis*) in Division IVa (Fladen Ground)

Assessment type no assessment

No comments by the RG. There is no basis for an advice for this stock.

APPENDIX III. LIST OF RESEARCH AND SUMMARY DOCUMENTS, 22-30 OCTOBER 2008

RESEARCH DOCUMENTS (SCR)

SCR No.	Ser. No.	Author(s)	Title
SCR 08/31 (Rev)	N5532	Orr, Veitch, Firth and Peters	Groundfish by-catch within the northern shrimp fishery off the eastern coasts of Newfoundland and Labrador over the years 2004–2008
SCR 08/56	N5585	Hvingel & Thangstad	The Norwegian fishery for northern shrimp (*Pandalus borealis*) in the Barents Sea and round Svalbard
SCR 08/57	N5586	Kingsley	The Fishery for Northern Shrimp (*Pandalus borealis*) off West Greenland, 1970-2008
SCR 08/58	N5587	Orr et al	An update of information pertaining to Northern Shrimp (*Pandalus borealis*, Kroyer) in NAFO Divisons 3LNO
SCR 08/59	N5588	Hvingel	An assessment of the shrimp (*Pandalus borealis*) stock in the Barents Sea 2008
SCR 08/60	N5589	Hvingel et al	Research survey information regarding northern shrimp (*Pandalus borealis*) in the Barents Sea and Svalbard area
SCR 08/61	N5590	Kingsley	Catch Table Update for the West Greenland Shrimp Fishery
SCR 08/62	N5591	Kingsley	CPU Series for the West Greenland Shrimp Fishery
SCR 08/63	N5595	Krogness & Søvik	An overview of Norwegian investigations of the shrimp stock off East Greenland in 1982-1986
SCR 08/64	N5596	Kingsley	A Provisional Assessment of the Shrimp Stock off West Greenland in 2008
SCR 08/65	N5597	Casas	The Spanish Shrimp Fishery on Flemish Cap (Division 3M) and Division 3L in 2007
SCR 08/66	N5598	Casas, Román & Teruel	Northern Shrimp (*Pandalus borealis*, Krøyer) from Spanish Bottom Trawl Survey 2008 in NAFO Div. 3LNO
SCR 08/67	N5599	Casas	Assessment of the International Fishery for Shrimp (*Pandalus borealis*) in Division 3M (Flemish Cap), 1993-2008
SCR 08/68	N5600	Casas	Northern Shrimp (*Pandalus borealis*) on Flemish Cap Surveys 2008
SCR 08/69	N5601	Sünksen	A preliminary estimate of Atlantic cod (*Gadus morhua*) biomass in West Greenland offshore waters (NAFO Subarea 1) for 2008 and recent changes in the spatial overlap with Northern shrimp (*Pandalus borealis*)
SCR 08/70	N5602	Bakanev	On the Assessment of the Northern Shrimp Stock in the Barents Sea

SCR 08/71	N5603	Ziemer & Siegstad	Results of the Greenland Bottom Trawl Survey for Northern shrimp (*Pandalus borealis*) Off West Greenland (NAFO Sub area 1 and Division 0A), 1988-2008
SCR 08/72	N5604	Hammeken Arboe & Siegstad	An assessment of the shrimp stock in Denmark Strait / off East Greenland – 2008
SCR 08/73	N5605	Thangstad & Søvik	The Norwegian Fishery for Northern Shrimp (*Pandalus borealis*) in Skagerrak and the Norwegian Deep (ICES Divisions IIIa and IVa east), 1970-2008
SCR 08/74	N5606	Søvik & Thangstad	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 2008
SCR 08/75	N5607	Eigaard & Munch-Petersen	LPUE standardisation of The Danish *Pandalus* fishery in Skagerrak and the Norwegian Deep
SCR 08/76	N5608	Munch-Petersen, Eigaard, Søvik & Ulmestrand	The Northern shrimp (*Pandalus borealis*) Stock in Skagerrak and the Norwegian Deep (ICES Divisions IIIa and IVa East)
SCR 08/77	N5609	Sirp	Analysis of catch rate of Estonian shrimp vessels in Div. 3M and Div. 3L in 2007 and 2008
SCR 08/78	N5610	Kingsley	Indices of distribution and location of shrimp biomass for the West Greenland research trawl survey

SUMMARY DOCUMENTS (SCS)

SCR No.	**Ser. No.**	**Author(s)**	**Title**
SCS 08/25	N5593		NIPAG Report
SCS 08/26	N5594		NAFO Scientific Council Report

APPENDIX IV. LIST OF PARTICIPANTS

NAFO Participants

CANADA

W. (Bill) B. Brodie	Fisheries and Oceans Canada Northwest Atlantic Fisheries Center, P.O. Box 5667, St John's NF A1C 5X1, Canada	Phone +709 772 3288 Email: bill.brodie@dfo-mpo.gc.ca
Ellen L. Kenchington	Fisheries and Oceans Canada Bedford Institute of Oceanography, P.O. Box 1006, Dartmouth NS B2Y 4A2, Canada	Phone + 902 426 2030 Email: kenchingtone@mar.dfo-mpo.gc.ca
David Orr	Fisheries and Oceans Canada Northwest Atlantic Fisheries Center, P.O. Box 5667, St John's NF A1C 5X1, Canada	Phone +709 772 7347 Email: david.orr@dfo-mpo.gc.ca
Don Power	Fisheries and Oceans Canada Northwest Atlantic Fisheries Center, P.O. Box 5667, St John's NF A1C 5X1, Canada	Phone +709 772 4932 Email: don.power@dfo-mpo.gc.ca
Don Stansbury	Fisheries and Oceans Canada, PO Box 566, St. John's NL A1C 5X1, Canada	Phone + 709 772 0559 Email: don.stansbury@dfo-mpo.gc.ca

DENMARK (in respect of Faroe Islands and Greenland)

Michael C.S. Kingsley, Chair - NAFO	Greenland Institute for Natural Resources, P.O. Box 570, GL-3900 Nuuk, Greenland	Phone +299 36 1200 Email: mcsk@natur.gl
Nanette Hammeken Arboe	Greenland Institute for Natural Resources, P.O. Box 570, GL-3900 Nuuk, Greenland	Phone +299 361200 Email: NaHa@natur.gl
Helle Siegstad	Greenland Institute for Natural Resources, P.O. Box 570, GL-3900 Nuuk, Greenland	Phone +299 36 1200 Email: HeSi@natur.gl
Nikoline Ziemer	Greenland Institute for Natural Resources, P.O. Box 570, GL-3900 Nuuk, Greenland	Phone +299 361200 Email: nizi@natur.gl

EUROPEAN UNION (EU)

José Miguel Casas Sanchez	Instituto Español de Oceanografía Centro Oceanográfico de Vigo, P.O. Box 1552, E-36200 Vigo (Pontevedra), Spain	Phone +34 986 492 111 Email: mikel.casas@vi.ieo.es
Silver Sirp	Estonian Marine Institute, 10a Mäealuse Street, EE-126 18 Tallinn, Estonia	Phone +372 5295396 Email: silver.sirp@ut.ee

ICES Participants

Michaela Aschan Chair - ICES	University of Tromsø, The Norwegian College of Fishery Science, N-9037 Tromsø, Norway	Phone +47 99261 458 Email: michaela.aschan@nfh.uit.no
Sergei Bakanev	Knipovich Polar Research Institute of Marine Fisheries and Oceanography, 6 Knipovitch Street, RU-183763 Murmansk, Russian Federation	Phone +47 78910518 Email: bakanev@pinro.ru
Ole Eigaard	The National Institute of Aquatic Resources, Department of Sea Fisheries, Charlottenlund Slot, Jægersborg Alle 1, DK-2920 Charlottenlund, Denmark	Phone +45 33963388 Email: ore@aqua.dtu.dk
Carsten Hvingel	Institute of Marine Research, P.O. Box 1870, N-5817 Bergen, Norway	Phone +47 77609750 Email: carsten.hvingel@imr.no
Sten Munch-Petersen	The National Institute of Aquatic Resources, Department of Sea Fisheries, Charlottenlund Slot, Jægersborg Alle 1, DK-2920 Charlottenlund, Denmark	Phone 45 33063390 Email: smp@aqua.dtu.dk
Guldborg Søvik	Institute of Marine Research, P.O. Box 1870, N-5817 Bergen, Norway	Phone +47 5523 8500 Email: guldborg.soevik@imr.no
Trond Thangstad	Institute of Marine Research, P.O. Box 1870, N-5817 Bergen, Norway	Phone +47 77609741 Email: trond@imr.no
Mats Ulmestrand	Swedish Board of Fisheries, Institute of Marine Research, Lysekil, P.O. Box 4, SE-453 21 Lysekil, Sweden	Phone +46 52318700 Email: mats.ulmestrand@fiskeriverket.se

NAFO Secretariat

Anthony Thompson	Scientific Council Coordinator, Northwest Atlantic Fisheries Organization, P.O. Box 638 Dartmouth NS B2Y 3Y9 Canada	Phone +1 902 468 7542 Email: athompson@nafo.int
Barbara Marshall	Information Manager, Northwest Atlantic Fisheries Organization, P.O. Box 638 Dartmouth NS B2Y 3Y9 Canada	Phone +1 902 468 8598 Email: bmarshall@nafo.int