Northwest Atlantic Fisheries Organization

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

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NAFO/ICES *PANDALUS* ASSESSMENT MEETING, 24 OCTOBER – 1 NOVEMBER 2007

CONTENTS

REPORT OF NIPAG MEETING

25 OCTOBER -1 NOVEMBER 2007

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

I. OPENING

The NAFO/ICES *Pandalus* Assessment Group (NIPAG) met at the NAFO Secretariat, Dartmouth, NS, Canada, from 24 October to 1 November 2007 to consider the various matters in its Agenda. Representatives attended from Canada, Denmark, Denmark (in respect of Faroe Islands and Greenland), European Union (Estonia and Spain), Norway and Sweden.

II. GENERAL REVIEW

1. Review of Recommendations in 2006 and in 2007

a) For NAFO Assessed Stocks

i) NIPAG recommended that, for shrimp on Flemish Cap (NAFO Division 3M) (NAFO SC Rep. 2006:231)

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

STATUS: this recommendation was reiterated.

- *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.

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

STATUS: this investigation was reported as now in progress.

ii) NIPAG recommended that, for Shrimp on the Grand Banks (NAFO Divisions 3L, 3N and 3O) (NAFO SC Rep. 2006:240)

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

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.

iii) NIPAG recommended that, for shrimp off West Greenland (NAFO Subareas 0 and 1) (NAFO SC Rep. 2006:251)

- *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: this recommendation was reiterated.

- *ways to include a flexible and comprehensive exploration of the effects of future trajectories of the cod stock on assessment predictions should be investigated and presented in 2007.*

STATUS: the stock-production model was reported as now capable of considering any number of future trajectories for the cod stock simultaneously; the model can also consider uncertain predictions of cod-stock trajectory.

- *methods of incorporating the spatial relationship between shrimp and cod, and its effect on predation rate, into the assessment model should be explored.*

STATUS: initial explorations of this problem have been carried out; it was reported that an 'effective' cod stock is now included in the model.

- *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.

- *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.

iv) NIPAG recommended that, for shrimp in Denmark Strait and off East Greenland (NAFO SC Rep. 2006:255)

- *a survey be conducted to provide fishery independent data of the stock*

STATUS: no progress; this recommendation was reiterated.

- *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; this recommendation was reiterated.

b) For ICES Assessed Stocks

i) NIPAG recommended that, for shrimp in Skagerrak and Norwegian Deep (*NAFO SC Rep.* 2006:260)

Research Recommendations

- *the relation/connection/mixing between the shrimp (stock units) in Skagerrak and the Norwegian Deep on the one side and the Fladen Ground shrimp on the other needs to be clarified by using genetic separation technologies.*

STATUS: Work in progress.

- *a further development of the Bayesian stock production model presented in 2005 and comparisons and evaluation of the assessment models available for this Pandalus stock is recommended.*

STATUS: Work in progress.

ii) NIPAG recommended that, for the shrimp stock in Barents Sea and Svalbard area (*NAFO SC Rep.* 2006:268)

Research Recommendations

- *the existing ecosystem survey should be calibrated to the discontinued shrimp surveys*

STATUS: An explicit calibration study will not take place. The assessment model is supposed to scale the two series. Further, a new study using already existing data will take place in advance of the 2008 assessment. This study may provide a basis for building an informative prior for the relative catchability and thus aid the model in bridging the two time series.

- *improve estimates of shrimp consumption, by cod and other predators, for inclusion in the model*

STATUS: A study was presented (SCR Doc. 07/80) to investigate whether spatial patterns not accounted for in previous studies would improve the correlation between predation and shrimp stock dynamics.

- *a recruitment index and its link to subsequent fishable biomass should be considered for inclusion in the assessment model*

STATUS: Ongoing work.

- *work on developing and evaluating assessment methods should be continued*

STATUS: Ongoing work.

- *work be conducted on classifying, and on defining the fishing power of the different shrimp fishing gears.*

STATUS: A study was presented (SCR. Doc. 07/84) showing that GLM terms for 'fishing gear' (size of trawl) and 'vessel horse power' are correlated.

2. Review of Catches

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

III. STOCK ASSESSMENTS

1) Northern shrimp (Division 3M) – NAFO Assessed (SCR Doc. 07/72, 77, 78, 89)

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 2007.

Catches increased from about 27 000 t in 1993 to 48 000 t in 1996, declined to 25 000 t in 1997 then increased gradually to a peak of 63 000 t in 2003 (Fig. 1.1). The catch declined in 2005 to 32 000 t and again in 2006 declined to 16 500 t. Provisional information to 1 September 2007 indicates removals of about 5 800 t; lower than usually reported for the same period. Supplementary information from the fishery suggests that economic considerations (price of fuel and market prices for shrimp) may be affecting participation in the fishery.

b) Input Data

NIPAG expresses concern about suspected misreporting 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:

	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
Recommended TAC	30 000	30 000	30 000	45 000	45 000	45 000	45 000	48 000	48 000	(3)
STATLANT 21A	42 041	50 471	53 793	47 299[1]	61 671[1]	44 873[1]	25 392[1]	9 237[1]		
NIPAG	43 438	52 664	52 671	48 704	63 226	45 543	31 862	16 510	5 861[2]	

[1] Provisional;
[2] Preliminary to 1 September 2007.
(3) SC advised no change in exploitation rate

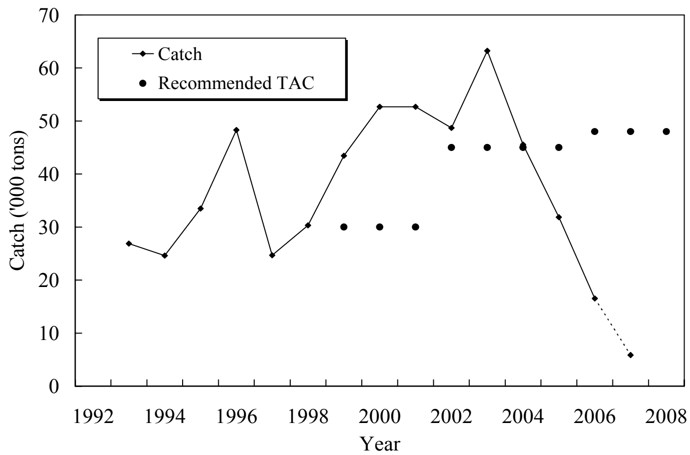


Fig. 1.1. Shrimp in Div. 3M: catches (2007 preliminary).

i) Commercial fishery data (SCR Doc. 07/77, 89)

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 3M was constructed. Last year there were concerns that suspected misreporting of some catches in 2005 and 2006 (Div. 3L catches being reported as Div. 3M catches), were 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 for 2005, 2006 and 2007 where the catches were mixed up between 3M and 3L were eliminated from the database. This way we can get the corrected CPUE and a standardized CPUE series was produced. CPUE decreased from 1993 to 1994, was at low levels to 1997. From 1998 it gradually increased to 2006. In 2007 the standardized CPUE declined, however due to the scanty observations there is considerable uncertainty regarding the 2006 and 2007 points (Fig. 1.2).

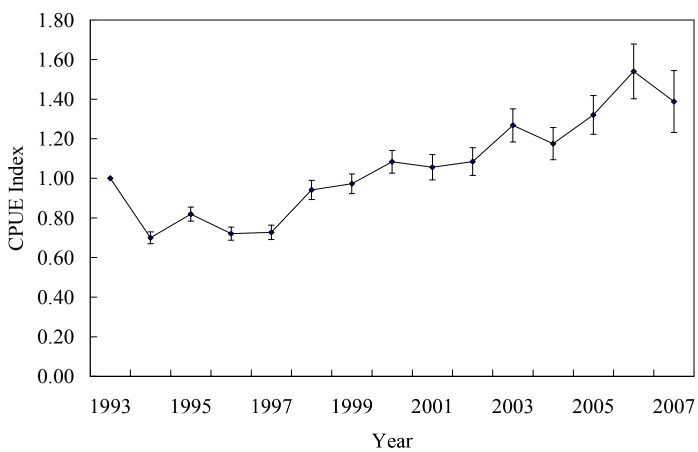


Fig. 1.2. Shrimp Div. 3M: Standardized CPUE of shrimp on Flemish Cap, 1993-2007.

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 2007 (Fig. 1.3). The marked increase in 2007 may however be questionable, as noted for the standardized CPUE above.

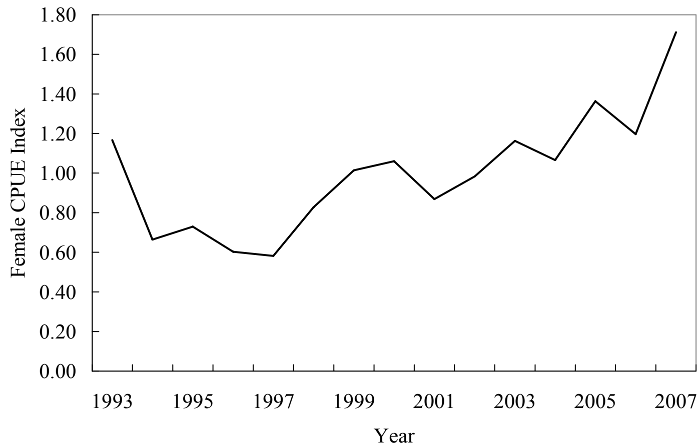


Fig. 1.3. Shrimp Div. 3M: Standardized Female CPUE of shrimp on Flemish Cap, 1993-2007. The series was standardized to the mean of the series.

Biological data. The age composition was assessed from commercial samples obtained from Iceland from 2003 to 2006 and from Canada, Greenland, Russia and Estonia in previous years. A few samples were obtained from Spain for 2005 and 2006 and Ukraine in 2006. Only those samples thought to be correctly attributed to Div. 3M were utilized. For 2007 there were not yet available any commercial samples and the age composition from preliminary catches was assessed from EU survey samples. Number/hour caught per age-class was calculated for each year by applying a weight/age relationship and age proportions in the catches to 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 important in the fishery although generally smaller in numbers. The 2002 year-class seems to be very prominent as 3 year-olds in the 2005 fishery and as 4 and 5 year-olds in 2006 and 2007 respectively. Although in 2008 the abundance of this year-class will be reduced, its importance in weight will probably stay high. The number of 2 year-olds is about average in 2005, not visible in catches in 2006 and very low in 2007 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.

Numbers/hour at age caught in the commercial fishery:

Age group	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	Mean
1	0	0	0	6	0	0	23	666	0	0	0	0	63
2	2604	2134	3345	2666	1108	6908	4606	8630	12732	5568	0	864	4264
3	27268	16945	19568	15872	23187	9253	38858	9526	29912	36208	7933	11096	20469
4	8307	17583	22892	18358	26968	29615	13224	38074	10705	31593	68409	35161	26741
5	2403	3454	7302	14770	15946	14999	16026	14851	22633	15044	12833	36953	14768
6	1255	700	2716	5317	3345	4424	3274	5847	4408	2954	5749	17016	4750
7	0	61	304	62	162	598	129	87	24	486	420	3717	504
Total	41836	40877	56127	57052	70717	65798	76139	77681	80415	91854	95344	104806	71554

ii) ***Research survey data*** (SCR Doc. 07/78)

EU bottom trawl surveys. Stratified-random surveys have been conducted on the Flemish Cap in July from 1988 to 2007. A new vessel was introduced in 2003, which, however, continued to use the same trawl as that employed since 1988. In addition, there were differences in cod-end mesh sizes utilized in the 1994 and 1998 surveys that have likely resulted in biased estimates of total survey biomass. Nevertheless, for this assessment, the series prior to 2003 were converted into comparable units with the new vessel based on the methodology accepted by STACFIS in 2004 (*NAFO 2004 SC Rep.*, SCR Doc. 04/77). The revised index of female shrimp biomass reveals a rapid increase from the lowest observed level in 1990 to a 10-fold increase in 1992 followed by an equally dramatic decline to 1994. The index was stable at a relatively low level between 1994 and 1997; then increased to a higher level with fluctuation between 1998 and 2007 (Fig. 1.4).

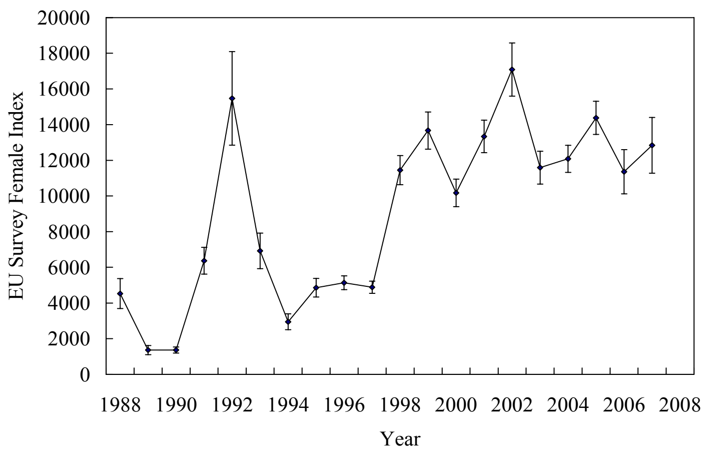


Fig. 1.4. Shrimp in Div. 3M: female biomass index from EU trawl surveys, 1988-2007.

iii) Recruitment indices

Commercial fishery. Although the commercial fishery is conducted with larger mesh size than the survey, 2 year-olds are frequently detected in the fishery. An index of 2 year-old shrimp from 1996 to 2007, based on standardized number per hour correlated well (R^2 = 0.81, 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 (table above).

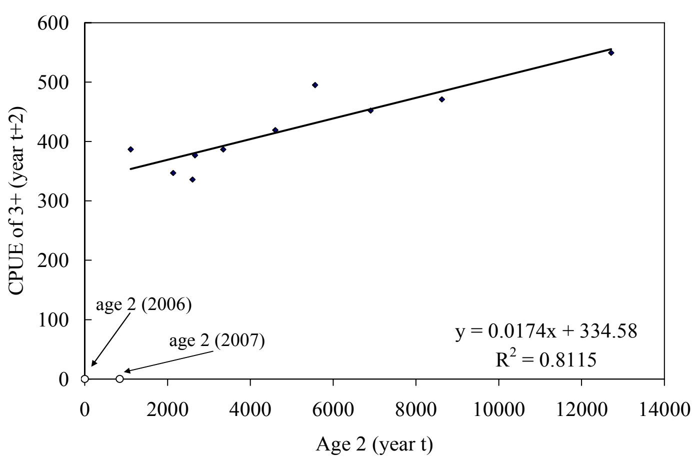


Fig. 1.5. Relationship between Div. 3M shrimp CPUE in year *t*+2 and year *t* from samples from the commercial fisheries.

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 attached to the net which was designed to provide an index of juvenile shrimp smaller than those typically retained by the survey cod-end. Neither index shows a good relationship with the 3+ survey index either 2 or 3 years later. This may be because there are only limited data points for a valid comparison. The recruitment indices for both 2005 and 2006 are low in the main gear as well as in the juvenile bag (Fig. 1.6). Finally the EU surveys agree with the commercial fishery recruitment indices in showing an exceptionally large 2002 year-class and very weak 2003–2005 year-classes.

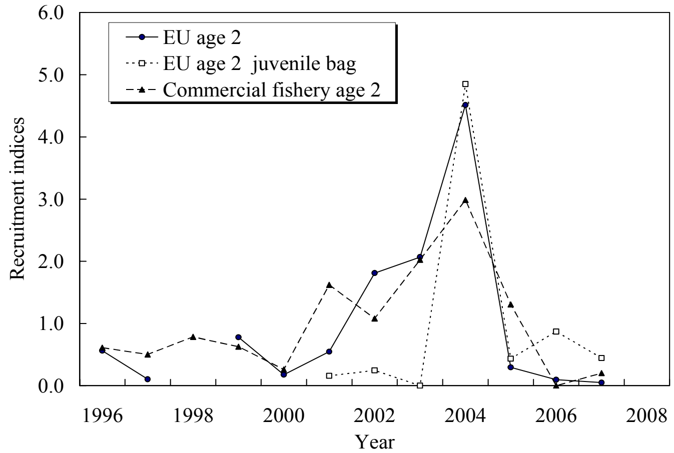


Fig. 1.6. Shrimp in Div. 3M: abundance indices at age 2 from the EU survey. Each series was standardized to its mean.

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. This was high in the years 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 2007 was the lowest in the historical series showing a probable decreasing trend initiated in 2004. This trend appears to be mostly due to decreasing catches.

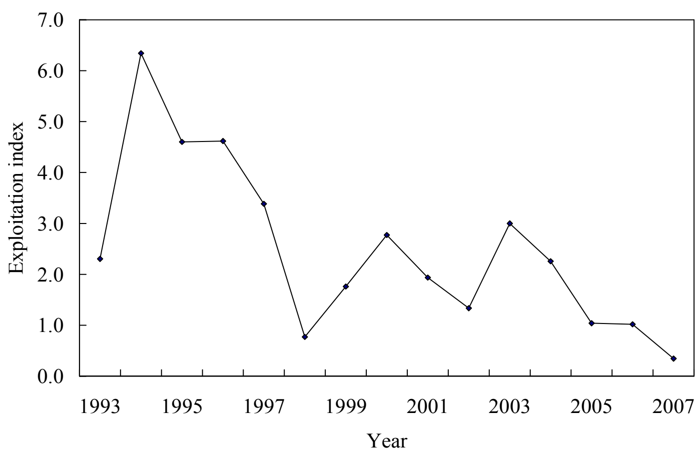


Fig. 1.7. Shrimp in Div. 3M: exploitation rates calculated as catch divided by EU survey biomass index in the same year.

v) Other studies.

A study on how trawl size might affect the Icelandic CPUE series was presented (SCR Doc. 07/72). In most years from 1993 to 2003 average size of trawl in the Icelandic fleet was 3 000 meshes. However between 2004 and 2006 the average size of trawl has increased to 4 460 meshes. The author therefore suggested that CPUE should be standardized on the average size of trawl and an adjusted CPUE series was presented for the Icelandic fleet.

c) Assessment Results

The concerns expressed last year about suspected misreporting and its effect on various indices derived from the fishery have been resolved in the intervening year and several indices derived from the number per hour could be used in this year's assessment.

Commercial CPUE indices. Indices for both biomass and female biomass from the commercial fishery showed increasing trends from 1996 to 2007.

Biomass. The survey index of female biomass increased from 1997 to 1998 and has fluctuated without trend since then.

Recruitment. The 2002 year-class appears to be large, but the 2003–2005 year-classes appear weak.

Exploitation rate. The provisional exploitation rate estimated in 2007 was the lowest in the historical series showing a probable 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 there are indications of a decline in recruitment, which may affect the 2008 fishery.

d) Precautionary Approach

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

The limit reference point for the Flemish Cap shrimp stock is taken from the EU survey where the biomass index of female shrimp is used. The EU survey of Div. 3M provides an index of female shrimp biomass from 1988 to 2006 with a maximum value of 17 100 t in 2002 and a similar value of 15 500 in 1992. An 85% decline in this value would give a B_{lim} = 2 600 t. The female biomass index was below this value only in 1989 and 1990, before the fishery. In 2006 and 2007 it was about 33% and 25% 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).

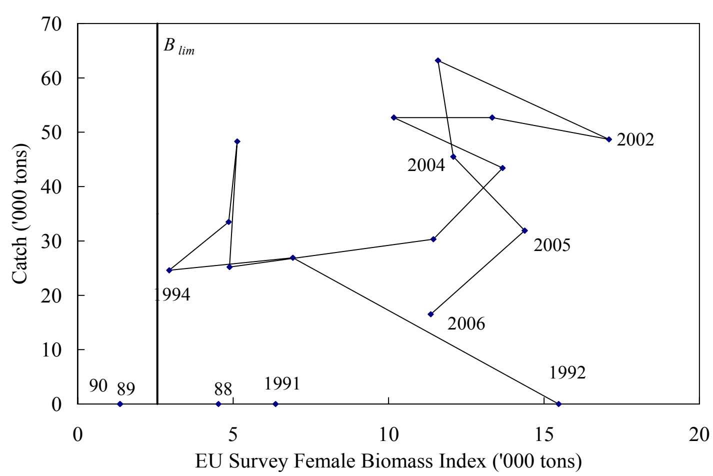


Fig. 1.8. Shrimp in Div. 3M: catch plotted against female biomass index from EU survey. Line denoting B_{lim} is drawn where biomass is 85% lower than the maximum point in 2002. Not updated for 2007 owing to incomplete catch.

e) Research Recommendations

NIPAG **recommended** 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.*

2) Northern Shrimp (Divisions 3LNO) – NAFO Assessed (SCR Doc. 07/77, 78, 79, 89, 91)

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 6 000 t TAC and fishing restricted to Div. 3L. Annual TACs were raised to 13 000 t for the 2003–2005 fisheries and raised again to 22 000 t for the 2006 fishery resulting in a total catch of 24 015 t during that year and 17 008 t up to October 2007 (Fig. 2.1).

Since this stock came under TAC regulation, Canada has been allocated 83% of the TAC. The Canadian allocation is split between a small vessel (less than 500 t and less than 65 ft) and a large vessel fleet. By October 2007, the small and large vessel fleets had taken 12 297 and 2 241 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 Island and Greenland) set an autonomous annual TAC of 1 344 t. This autonomous TAC was raised to 2 274 t in 2006 and maintained at this level for 2007.

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:

	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
TAC	-	6 000	6 000	6 000	13 000	13 000	13 000[1]	22 000[1]	22 000[1]	25 000[4]
STATLANT 21A	795	4 930	5 323	5 697	11 016[2]	11 660[2]	13 943[2]	23,144[2]	16,755[2]	
NIPAG	795	4 896	10 566[3]	6 977[3]	11 947	12 620	14 137	24 015[3]	17 008[3]	

[1] Denmark (in respect of Faroe Islands and Greenland) set an autonomous TAC of 1 344 t for 2003 - 2005 and raised it to 2 274 t for 2006 and 2007; this autonomous TAC replaces the DFG quota of the TAC tabulated above.
[2] Provisional catches.
[3] Reliable catch reports were not available for all countries therefore estimates were made using other sources (Canadian surveillance, observer datasets, STACFIS estimation etc.).
[4] Provisional TAC advice.

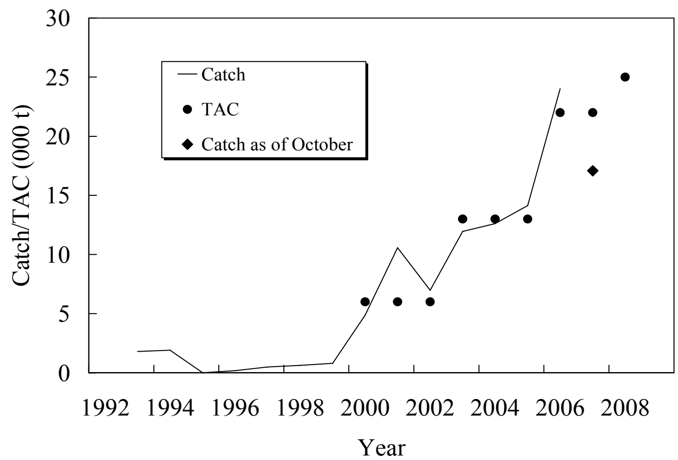


Fig. 2.1. Shrimp in Div. 3LNO: catches (to October 2007) and TAC.

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 fluctuating around the long term mean since 2000 with the 2007 catch rate index above average and similar to the 2002 – 2004 and 2006 catch rates (Fig. 2.2). There was insufficient data to estimate a standardized CPUE index for the 2007 Canadian small vessel (≤ 500 t) fleet.

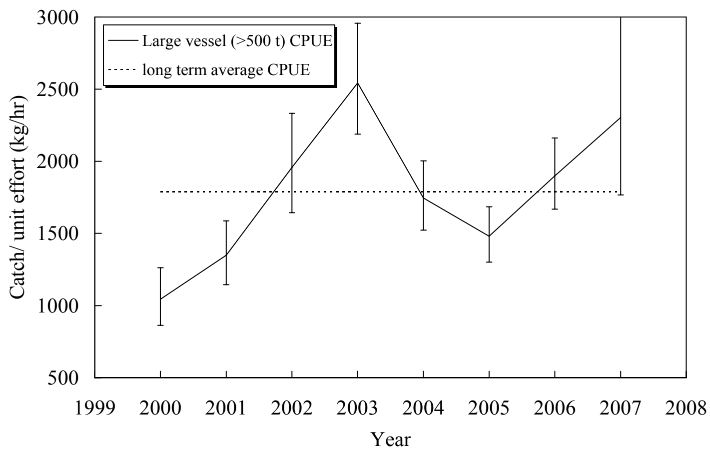


Fig. 2.2 Shrimp in Div. 3LNO: Standardized CPUE for the Canadian large vessel (>500 t) fleet fishing shrimp in Div. 3L within the Canadian EEZ.

Data were available from other nations fishing in the NRA (Estonia, Greenland, Spain and Norway) although the data 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, Icelandic and Ukrainian observer datasets. In 2006, the male portion of the fishery was dominated by the 2002 and 2003 year-classes. The female portion was still well represented. Neither sex nor age composition data from the 2007 fishery were available in time for the 2007 assessment.

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 (1999-2007) and autumn (1995-2006). The autumn survey in 2004 was incomplete and therefore was of limited use for the assessment.

In past years, areal expansion calculations were used to estimate indices from Canadian survey data. However, it was decided during the 2006 NIPAG assessment meeting that Ogive Mapping (Evans *et al.*, 2000. *JNAFS*, 27: 133-138) could be used to calculate index estimates. Therefore indices based upon Canadian survey data differ slightly from past presentations. This applies to all estimates, in this assessment, of biomass and numbers of different size classes and sexes from the Canadian surveys.

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 185–550 m. There was a significant increase in autumn shrimp biomass indices between 1995 and 2001 and this index has since remained at a high level (Fig. 2.3). The autumn 2006 index was 215 000 t (47 billion individuals), the second highest in the autumn time series.

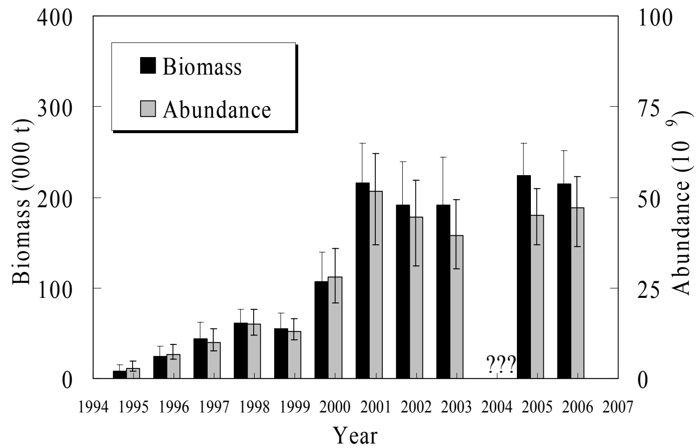


Fig. 2.3. Shrimp in Div. 3LNO: biomass and abundance index estimates from Canadian autumn multi-species surveys (with 95% confidence intervals).

The spring 2007 biomass index was 289 000 t (54 billion individuals), the highest in the time series (Fig. 2.4). Owing to broad confidence limits around these estimates, spring survey indices are not thought to be as reliable as autumn survey indices.

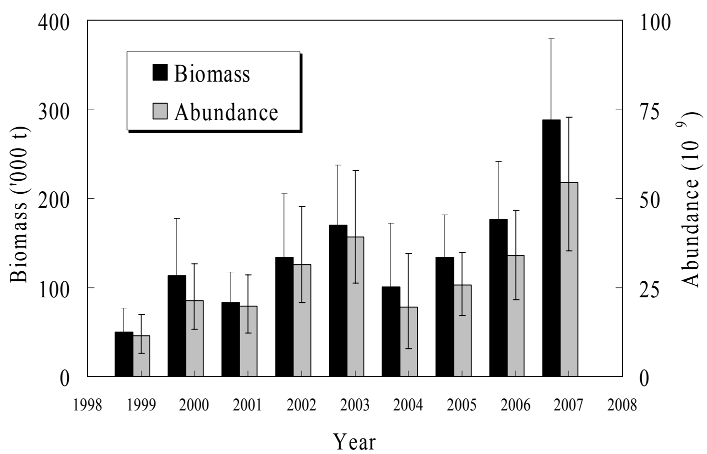


Fig. 2.4. Shrimp in Div. 3LNO: biomass estimates from Canadian spring multi-species surveys (with 95% confidence intervals).

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 (113 000 t); Canadian survey biomass estimates increased between 1995 and 2001 and have since fluctuated at a high level. The reason for differences between the Spanish and Canadian Div. 3L survey biomass and abundance indices remains unknown. Spanish and Canadian survey biomass estimates for Div. 3NO in the NRA, have fluctuated between 100 and 4 500 t in 2002–2007.

Sex and age composition. The spring and autumn surveys showed an increase in the abundance of female (transitionals + females) shrimp over the full time series. Autumn male abundance indices increased until 2001 and have since remained stable at a high level while spring male abundance indices have varied over time (Fig. 2.5).

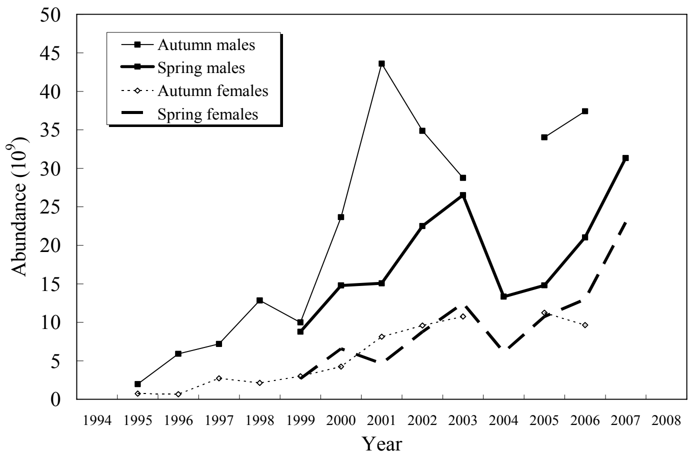


Figure 2.5. Abundance indices of male and female shrimp within Div. 3LNO as estimated from Canadian multi-species survey data.

Shrimp aged 2 and 4 were well represented in the male component of the spring 2006 survey length frequencies (2004 and 2002 year-classes) with carapace-length modes at 13.24 and 19.44 mm respectively. The male component of the autumn 2006 survey length frequencies was dominated by shrimp aged 2, 3 and 4 (2004, 2003 and 2002 year-classes) with modes at 14.50, 17.99 and 20.11 mm respectively. Similarly, shrimp aged 2, 3 and 4 were well represented in the spring 2007 survey (2005, 2004 and 2003 year-classes) with modes at 13.06, 16.66 and 19.89 mm respectively (Fig. 2.6). A broad mode of females was present in all surveys indicating the presence of more than one year-class.

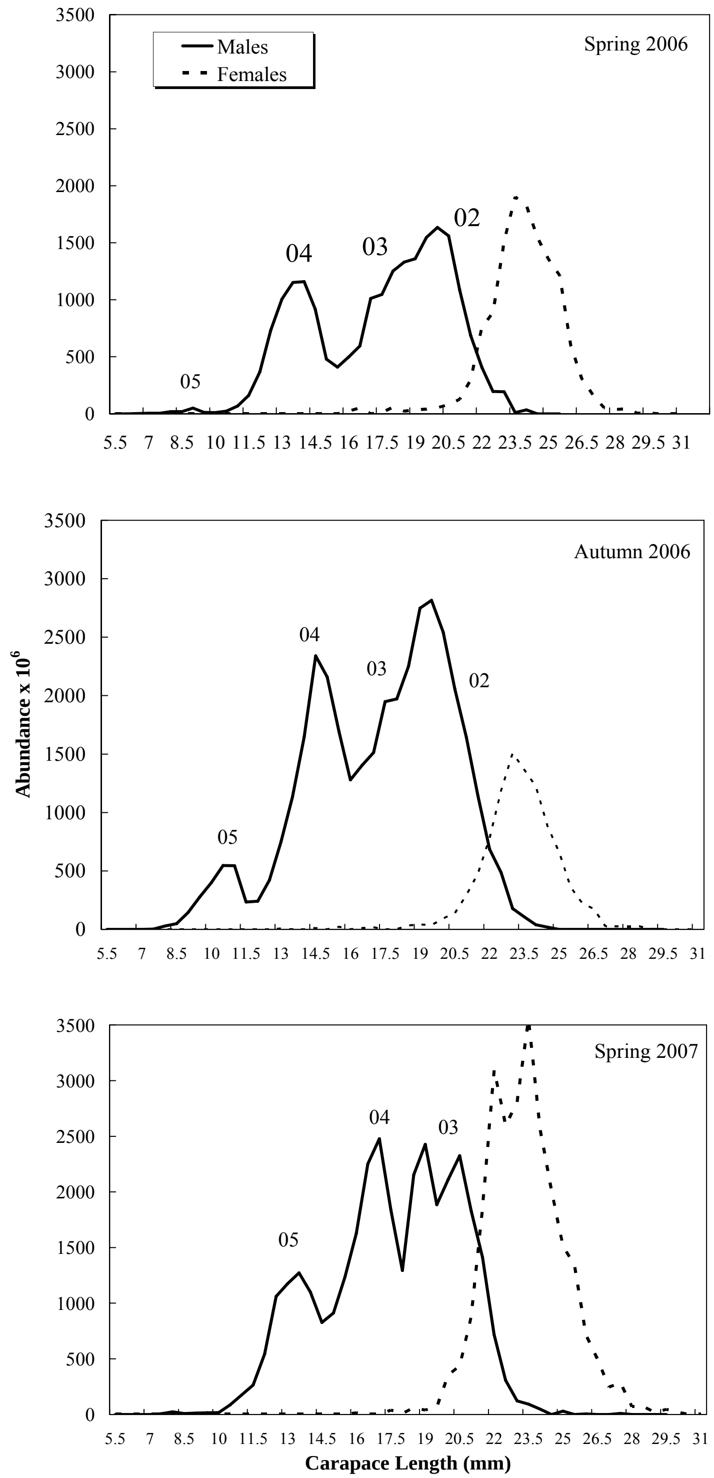


Fig. 2.6. Shrimp in Div. 3LNO: abundance at length for northern shrimp estimated from Canadian multi-species survey data.

Female Biomass (SSB). The autumn female (transitionals and full females) biomass index increased between 1999 and 2003; there was an incomplete survey in autumn 2004, after which the index increased to the highest level, in

2005. It then decreased slightly in 2006. (Fig. 2.7). The spring survey index increased from 1999–2003 and decreased slightly in 2004, after which the female biomass has been increasing (Fig. 2.8).

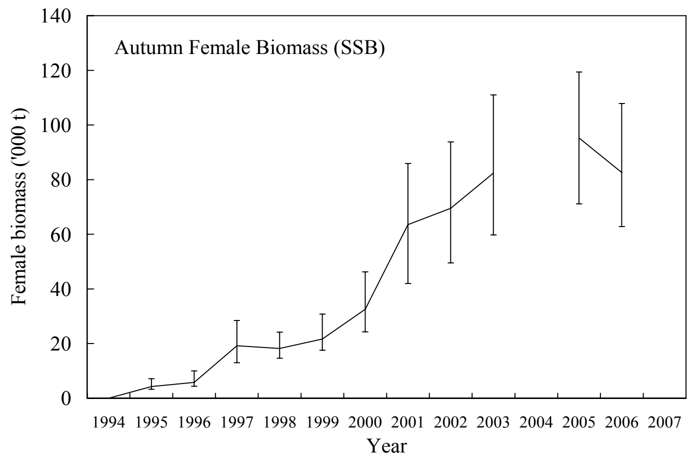


Fig. 2.7. Shrimp in Div. 3LNO: Female biomass (SSB) estimates from Canadian autumn multi-species surveys (with 95% confidence intervals).

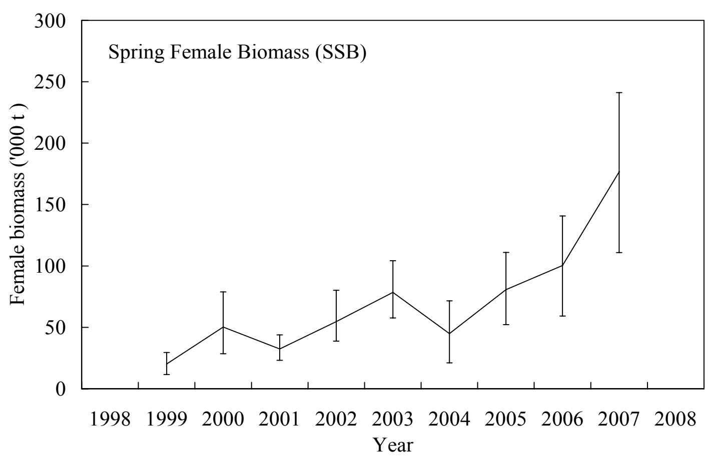


Fig. 2.8. Shrimp in Div. 3LNO: Female biomass (SSB) estimates from Canadian spring multi-species surveys (with 95% confidence intervals).

Recruitment index. The recruitment index for this assessment was estimated through modal analysis, whereas last year the recruitment index was derived through a multiplicative model using values estimated from modal analysis. As with last year's analysis, all recruitment indices from year-classes prior to 1997 were weak. The indices from autumn 1997, 2000, 2001 and 2003 year-classes were average while those from the 1998, 1999 and 2004 year-classes appeared relatively strong (Fig. 2.9). The spring recruitment indices from the 2000, 2002 and 2003 year-classes were weak, those from the 1997, 1999, and 2001 year-classes were average while the recruitment indices from the 1998, 2004 and 2005 year-classes were strong relatively (Fig. 2.10).

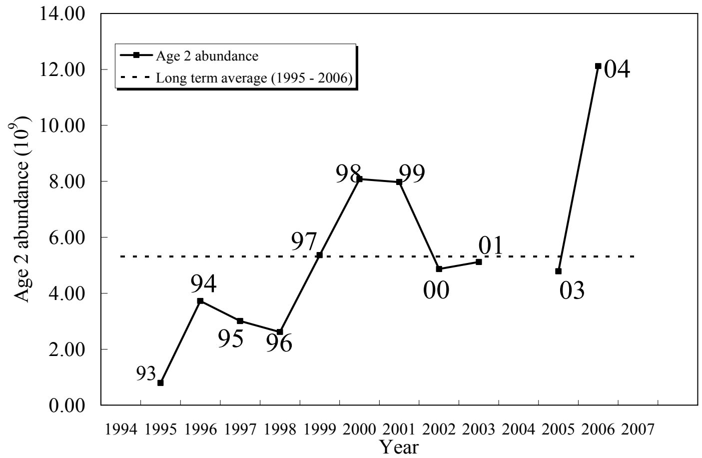


Fig 2.9.Shrimp in Div. 3LNO: Autumn recruitment index (age 2 abundance) derived using modal analysis of Canadian bottom trawl survey (1995–2006) data.

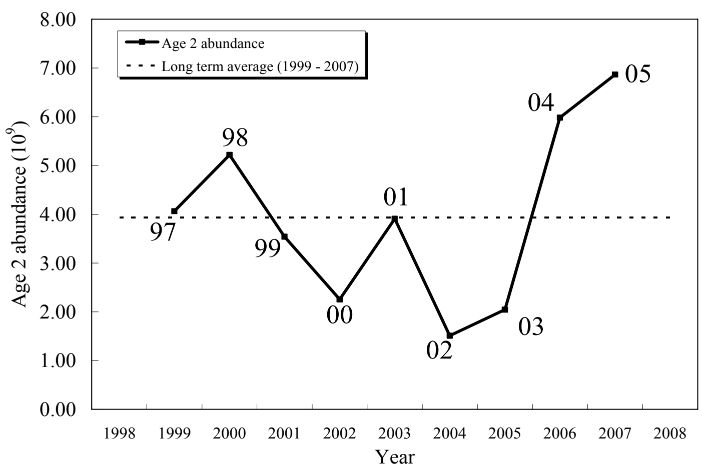


Fig 2.10.Shrimp in Div. 3LNO: Spring recruitment index (age 2 abundance) derived using modal analysis of Canadian bottom trawl survey (1999–2007) data.

Fishable biomass and exploitation. The fishable biomass index (shrimp >17 mm carapace length) from the Canadian autumn survey (1995-2006) increased from 1999 to 2001, varying slightly at a high level since, while the spring survey index increased from 1999–2003, decreased during 2004, and but has steadily increased since (Fig. 2.11). An index of exploitation was derived by dividing the catch in a given year by the fishable biomass index from the previous autumn survey. The exploitation index was less than 4% during 1996-99, but increased to 11-12% in 2000-2001, the first two years of TAC regulation. Even though catches increased to 24 000 t in 2006, the exploitation index remained less than 14% owing to the increase in fishable biomass (Fig. 2.12).

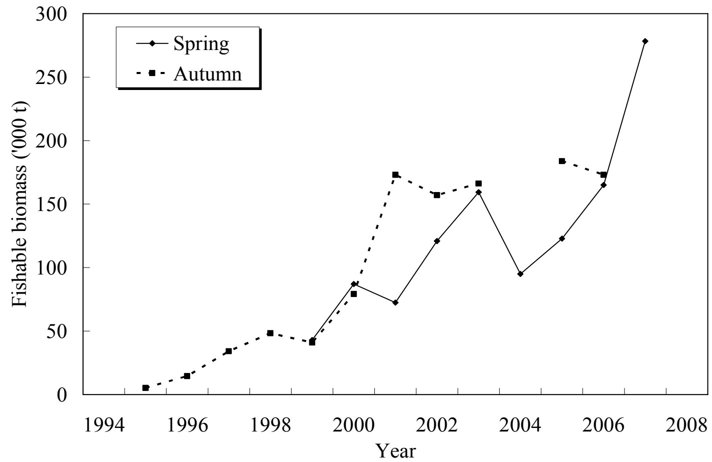


Fig. 2.11.Shrimp in Div. 3LNO: fishable biomass index.

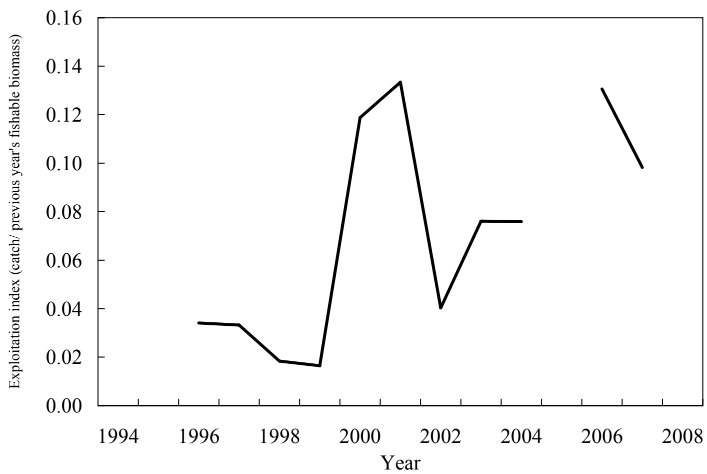


Fig 2.12.Shrimp in Div. 3LNO: exploitation rates as derived by catch divided by the previous year's autumn fishable biomass index.

c) Assessment Results

Recruitment. Recruitment indices from autumn survey data indicated that the 2003 year-class was average while recruitment from the 2004 year-class was the highest in that time series. The spring recruitment indices for the 2002 and 2003 year-classes were below average while those from the 2004 and 2005 year-classes were the highest in the spring series.

Biomass. There has been a significant increase in the index of total biomass between 1995 and 2001 followed by stability at a high level. Both spring and autumn indices of female biomass (SSB) have been increasing since 1999.

Exploitation: The index of exploitation (catch / autumn survey fishable biomass from previous year) has remained below 14%.

State of the Stock. Total biomass indices have been stable at a high level since 2001. The female biomass (SSB) indices have been increasing since 1999. The stock appears to be well represented by a broad range of size groups; the stock biomass index has not declined at the observed levels of exploitation. The above average recruitment in 2004 is expected to be present in the fishery during 2007 and that from 2005 is expected to enter the fishery in 2008.

d) Precautionary Approach Reference Points (SCS Doc. 04/12)

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. 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. 2.13).

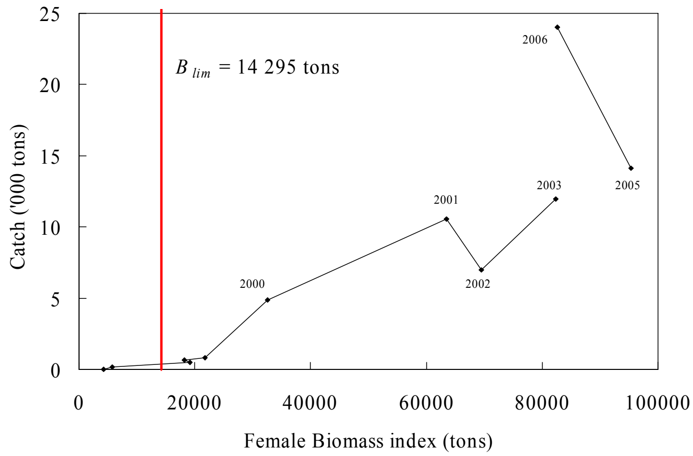


Fig 2.13. Shrimp in Div. 3LNO: Catch plotted against female biomass index from Canadian autumn survey. Line denoting B_{lim} is drawn where female biomass is 85% lower than the maximum point in 2005. (The B_{lim} is below the value presented last year because survey indices were derived using areal expansion calculations in past years while they were derived using Ogive Mapping calculations this year).

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 2008.*

- *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.*

3) Northern shrimp (Subareas 0 and 1) – NAFO Assessed (SCR Doc. 02/158, 03/74, 04/75, 04/76, 07/66, 67, 69, 73, 88; SCS Doc. 04/12)

a) Introduction

The shrimp stock off West Greenland is distributed mainly in NAFO Subarea 1 (Greenland EEZ), but a small part of the habitat, and of the stock, intrudes into the eastern edge of Div. 0A (Canadian EEZ). To facilitate management of the fishery, Canada has defined a management unit, Shrimp Fishing Area 1 (Canadian SFA1), to be the part of Div. 0A lying east of 60°30'W, i.e. east of the deepest water in this part of Davis Strait.

The stock is assessed as a single population within its whole area of distribution. The Greenland fishery exploits the stock in Subarea 1 (Div. 1A-F). Since 1981 the Canadian fishery has been limited to Div. 0A.

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

The advised TAC for the entire stock for 2007 was 130 000 t; the Greenland authorities set a TAC for Subarea 1 of 134 000 t, of which 74 100 t was allocated to the offshore fleet, 55 900 t to the inshore and 4 000 t to EU vessels; Canada set a TAC for SFA1 for 2007 of 18 417 t.

Catch data since 1999 was reviewed in order to clarify uncertainties and to resolve conflicts between different sources (SCR Doc. 07/66). Because logbook reports were used in 2007, instead of quota drawdowns as in 2006, catch figures for 2003 to 2005 were 8-12% higher than those used in 2006. Earlier catches changed slightly. Reported catches from 1978 through 2003 had been corrected upwards, by 22.8-25.7%, in 2003 (SCR Doc. 03/74).

Overall annual catch increased from about 10 000 t in the early 1970s to more than 105 000 t in 1992 (Fig. 3.1). Moves by the Greenlandic authorities to reduce effort, as well as fishing opportunities elsewhere for the Canadian fleet, caused catches to decrease to about 80 000 t by 1998. Since then total catches increased to 154 600 tons in 2005 and 2006. Total catch for 2007 has been projected to be lower at about 135 000 tons.

Recent catches, projected figures for 2007 and recommended TACs (t) for northern shrimp in Div. 0A east of 60°30'W and Subarea 1 are as follows:

	1998[2]	1999[2]	2000[2]	2001[2]	2002[2]	2003[2]	2004	2005	2006	2007[1,3]
Recommended TAC	55 000	65 000	65 000	85 000	85 000	100 000	130 000	130 000	130 000	130 000
Actual TAC	68 379	82 850	87 025	102 300	103 190	115 167	149 519	152 452	152 380	152 417
SA 1 (NIPAG)	79 562	90 152	96 378	99 301	128 925	123 036	135 212	147 695	150 536	128 879
SA 0A (NIPAG)	933	2 046	1 590	3 625	6 247	7 137	7 021	6 921	4 127	6 291
STATLANT (SA 1)	60 406	73 990	79 120	81 517	103 645	78 433	134037	3 699	3 629[1]	
STATLANT (Div. 0A)	517	2 093	659	2 958	6053	2 170	6 861	6 410	0	
TOTAL SA1-Div.0A (NIPAG)	80 495	92 198	97 968	102 926	135 172	130 173	142 233	154 616	154 663	135 169

1 Provisional catches;
2 Estimates 1998-2003 corrected for over packing;
3 Catches projected to year-end — SA1 based on catches on the first 6 months and 0A at mean of reports for previous 5 yr.

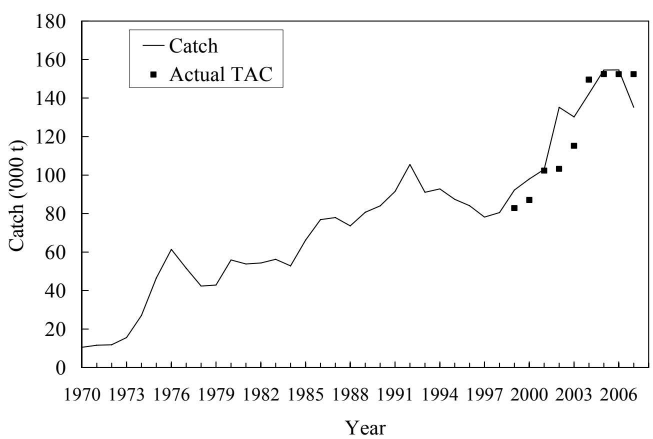


Fig. 3.1. Shrimp in Subareas 0 and 1: actual TACs and total catches (2007 projected to the end of the year; 1999–2007 values have been corrected to live (catch) weight).

Until 1988 the fishing grounds in Div. 1B were the most important. The offshore fishery subsequently expanded southward, and after 1990 catches in Div. 1C-D, taken together, began to exceed those in Div. 1B. By 1996–97 the southern areas Div. 1D-F accounted for almost 60% of the catch. Catch and effort in Div. 1E-F now appear to be decreasing. The Canadian catch in SFA1 has stabilized at 6 000 to 7 000 t in 2002-2005, about 4-5% of the total catch. In 2006 catches in SFA1 were only 4 100 tons.

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. 07/69). In recent years large changes in fishery performance has occurred both in relation the distribution of the fishery and to changes in fishing power (e.g. larger vessels have been allowed in coastal areas). Logbook data and information on vessel characteristics and fishing patterns was examined, resulting in a new standardized CPUE series (Fig 3.2) as well as an index of how widely the fishery is distributed (Fig 3.3).

The logbook data was analysed with standard linear models to create fleet-specific series of annual CPUE indices, standardized for changes in fleet composition and fishing power and for variation in the distribution of the fishery. These were combined to give a single standard CPUE series as an index of the biomass densities available to the fishery.

The overall 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 reach a maximum in 2007 of about twice its 1997 value (Fig. 3.2).

The CPUE indices from the Greenland coastal and the Greenland offshore fleets have remained closely in step from 1988 to 2003 (Fig. 3.2). However, since 2004 they have diverged more than in previous years, the offshore fleet managing a continued increase in catch rates while the coastal fleet, although its catch rates have remained high in historical terms, has seen greater fluctuation in CPUE from year to year. 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 also has increased between the 1990s and the present.

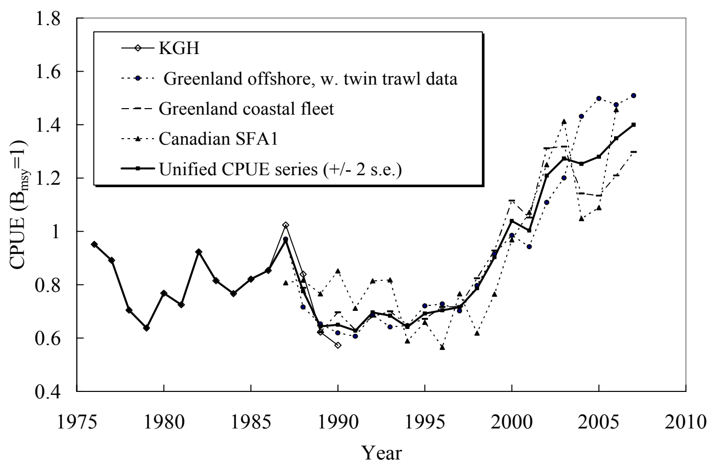


Fig. 3.2. Shrimp in Subareas 0 and 1: standardized CPUE index.

The distribution of the fishery and its change with time were also examined (Fig 3.3). Catch and effort were allocated to NAFO Divisions, and the allocation was summarised using Simpson's diversity index to calculate an 'effective' number of Divisions being fished.

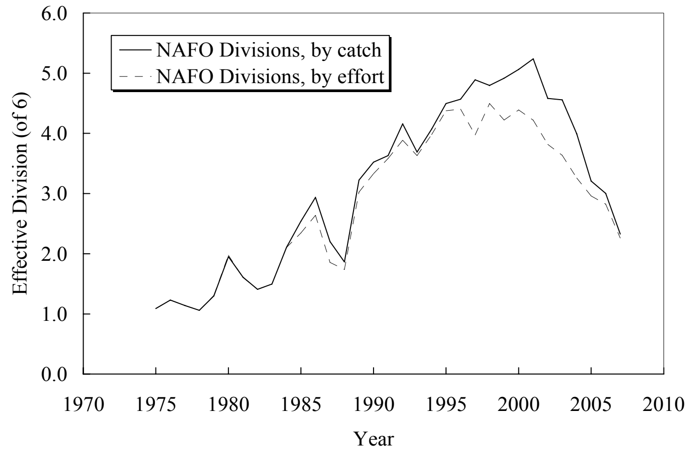


Fig. 3.3. Shrimp in Subareas 0 and 1: Diversity indices for the distribution of logbook records of the West Greenland fishery between NAFO Divisions for 1975–2007.

From the end of the 1980s there was a significant expansion of the fishery southwards and by 1996–97 the southern areas accounted for almost 60% 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 and the effective number of Divisions being fished has decreased as effort, and catches, have become more concentrated.

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. 07/71). From 1993, the survey was extended southwards into Div. 1E and 1F. A 22 mm stretched mesh cod-end liner has been used since 1993. From its inception until 1998 the survey only used 60 min. tows, but shorter tows have been shown to give as accurate results, and since 2005 all tows have lasted 15 min.

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

Biomass. The survey index of mean stock density remained fairly stable from 1988 to 1997 (c.v. 18%, downward trend 4%/yr). It then began a period of continued increase lasting until 2003, when it reached 316% of the 1997 value. Subsequent values have been consecutively lower, by 2007 58% below the maximum (Fig. 3.3) but still 13% above the series mean.

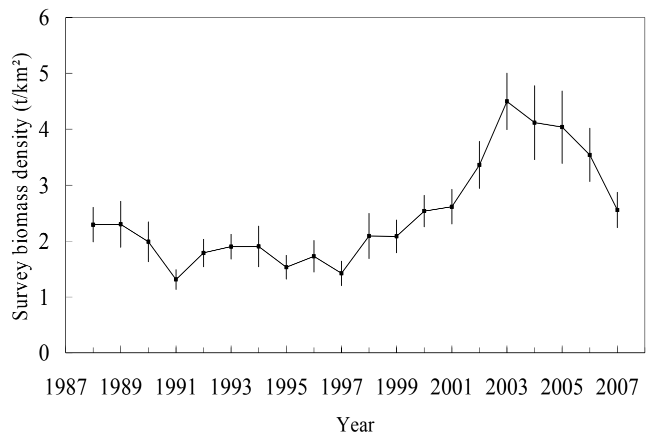


Fig. 3.4. Shrimp in Subareas 0 and 1: survey indices of stock biomass density (SCR Doc. 07/71).

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 very rare in the stock and so were older/larger shrimp (multiparous females, older than 4 years (Fig. 3.4)). In 2007, the abundance of males and females amounted to 51 × 10^9 and 15 × 10^9 individuals, respectively. These values are close to the long-term averages (50× 10^9 and 12× 10^9 individuals). The abundance of males and females in 2007 has declined by 48 % and 40 % respectively from the peak values of 2003 (SCR Doc. 07/71).

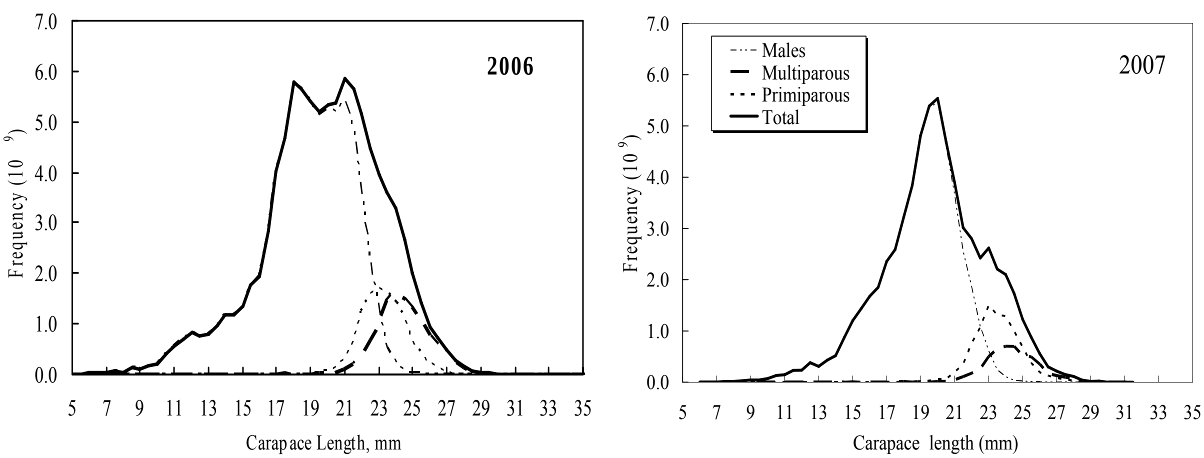


Fig. 3.5. Shrimp in Subareas 0 and 1: length frequencies of northern shrimp in the total survey area (offshore and Disko Bay/Vaigat combined) in 2006 and 2007.

Recruitment Index. The number at age 2 is a short-term predictor of fishable biomass 2 to 4 years later (SCR Doc. 07/71). This recruitment index was high in 2001, decreased in 2002, was below average in 2003 and 2004, reached even lower values in 2005 and 2006, and decreased in 2007 to the lowest recorded value (Fig. 3.5).

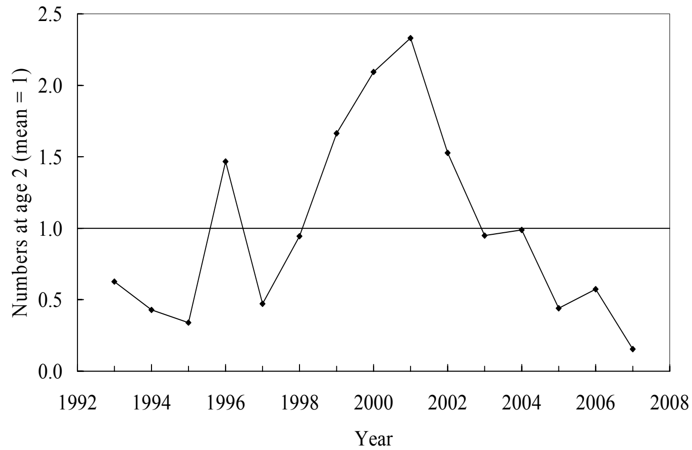


Fig. 3.6. Shrimp in Subareas 0 and 1: index of numbers at age 2 from survey (scaled to the mean of the series).

iii) Other biological studies

The quantitative model in use for the assessments of the shrimp stock includes a term for predation by Atlantic cod. The model was found to be sensitive to the cod biomass series, producing aberrant results when the series was changed. Systematic investigation traced the problem to an adjustment made to a set of predation data so that it would fit the cod biomass series originally used (SCR Doc. 07/67). The treatment of the predation term in the model was slightly modified so that the adjustment of the predation data was unnecessary, and the predation estimates were coupled with the cod biomass estimates on which they had originally been based. The estimates of the basic shrimp stock-dynamic parameters, such as MSY, from the revised model were found to be much less sensitive to changes in the cod-stock series, which, however, by altering the parameters of the cod-shrimp predation relationship, did have an effect on predictions of the shrimp stock trajectory under different scenarios for the development of the cod stock.

Estimates of cod biomass from the German groundfish survey at West Greenland are used in the assessment of shrimp in SA 1 and in Div. 0A east of 60°30′W. The survey is conducted in October-November and the results for the current year 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 of data estimated that the index of cod biomass from the 2007 Greenland survey would correspond to about 36 692 t in the German survey (SCR Doc. 07/73). 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.

A study on the discard levels of fish in the shrimp fishery in 2006 and 2007 were presented (SCR Doc. 07/88). A scientific technician from the Greenland Institute of Natural Resources (GINR) sailed aboard different fishing vessels to weighand identify to species level the fish caught as bycatch, and to compare these values with estimates from the captain and the observer from Greenland Fishery License Control (GFLK). Data on the discard levels of fish has been collected from 332 hauls in 12 trips on 9 different vessels in NAFO Div. 1B-1E and in ICES XIVB. This study showed an average discard percentage of 2.2% of the shrimp catch weight, which is somewhat higher than logbook records in recent years, where the discard level on average has remained well below 1% (Kingsley 2007). The dominant species were Redfish (*Sebastes* sp.), Capelin (*Mallotus villosus*), Goiter blacksmelt (*Bathylagus euryops*), American plaice (*Hippoglossus platessoides*), Eelpouts (*Lycodes* sp.), Greenland halibut (*Reinhardtius hippoglossoides*) and Cod (*Gadus morhua*). The use of grid separators in front of the codend restricts bycatch to relatively small fish, and very few fish longer than 25 cm were recorded.

c) 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 standardised by linearised multiplicative models including terms for vessel effect, month, year, and statistical area; the fitted year effects were considered to be series of annual indices of total stock biomass. Series for the Greenland fishery after the end of the 1980s were divided into 2 fleets, a coastal and an offshore; 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. Twin-trawl data was included for the recent offshore fleets, a twin-trawl effect being included in the models. The four CPUE series were included separately in the surplus-production model.

While the model used in 2007 (see Table 3.1, model 1) was broadly similar to that used in 2006, there were differences of detail that impede direct comparison of results. Among them are the use of four CPUE series separately in the model, where in 2006 a unified series was constructed in a separate preliminary step, revised coding for the inclusion of the direct estimates of cod predation (SCR Doc. 07/66), and a substantial correction to catch figures for 2003–2005 (SCR Doc. 07/69). An ‘effective’ cod biomass series was used, that allows for low spatial overlap between shrimp and cod (SCR Doc. 04/71, SCR Doc. 06/57, SCR 07/73), where in 2006 a ‘total’ cod-stock series had to be used.

Table 3.1. Summary statistics of stock dynamics, present stock status, and short-term predictions for different catch levels, estimated from different data inputs, and compared with estimates made in 2006.

	1. Full CPUE & Survey		**2.** Short CPUE & Survey		**3.** Survey only		**4.** 2006 Assessment	
	Median	IQR/Med. [1]	Median	IQR/Med.	Median	IQR/Med.	Median	IQR/Med.
MSY	161.2	42	136.5	26	148.7	54	161.4	40
K	3158	110	1819	60	3245	104	3036	88
Z_{msy}(%)	10.63	66	15.05	42	9.67	76	11.66	58
B/B_{msy}(2007)	1.25	49	1.15	40	1.40	49	1.49	37
$P(Z>Z_{msy}$, 2008) (%)								
90 Kt	10		12		13			
110 Kt	18		34		24		2.6	
120 Kt	26				27			
130 Kt	33		62		34		12	

[1] I.Q.R./Med.: ratio (%) of inter-quartile range to median estimate.

Results obtained from model 1. were similar to those obtained in the 2006 assessment (Table 3.1, model 4) as regards stock-dynamic parameters, but more pessimistic as regards the present state of the stock—although still estimating it to be above B_{msy}—and as regards short-term predictions.

An increasing concentration of the stock and the fishery, noted earlier, would be consistent with the observed decreasing biomass index from the research trawl survey while catch rates in the fishery remained high. Using the CPUE data as above could therefore be regarded as giving too much credence to recent CPUE values that apply to a period when the fishery, and the stock, appear to be concentrated and CPUEs therefore apt to overestimate biomass relative to periods when the fishery was more widely distributed. A model (Table 3.1, model 2) was therefore also run with the three recent CPUE series truncated at 2003 before the stock contraction became so evident. The truncation was applied to the same GLM outputs as were used in the full series; the GLMs were not re-run and there were no other changes to model or data.

When the CPUE series were truncated (model 2), the years omitted were years for which the series disagreed with each other and with the survey series. The model estimated a lower MSY at 136 000 t; estimates of the present state of the stock were lower than those based on all the CPUE data (model 1). However, this selection can be regarded as setting a bound, on the pessimistic side, of the use of the available data and therefore of the state of the stock.

This selecting of CPUE data also raised some concerns, so a model (Table 3.1, model 3) was also run with the survey series alone as the only biomass index series. Recent biomass levels, relative to B_{msy}, were estimated higher than when CPUEs were included, and the MSY was between the value estimated with full CPUE series and that from shortened CPUE series. Risk levels for short-term predictions were similar to those obtained when the full CPUE series were used, therefore more optimistic than when the CPUEs were truncated.

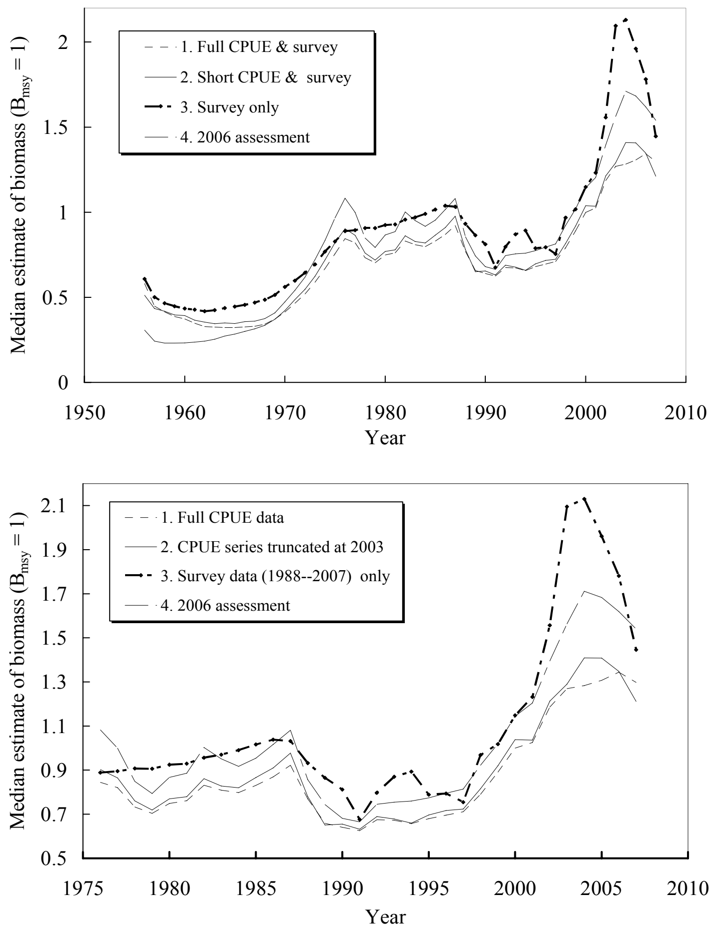


Fig. 3.7. Shrimp in Subareas 0 and 1: trajectories of the median estimate of stock biomass, relative to biomass at maximum sustainable yield, from running a Schaefer surplus production model with different selections of input data.

MSY estimated in 2006 (Table 3.1, model 4) was close to the 161 000 t estimated in 2007, but the 2006 assessment was more optimistic about the current state of the stock. The future predictions were therefore also more optimistic; more so about future biomass than about future mortality. Mortality predictions must be considered in the light of the 2006 predictions' having been made with a cod stock assumed constant at 22 700 t where 33 200 t was assumed in 2007.

Using CPUE as calculated (Table 3.1, model 1), catches of 120 000 t are associated with probabilities of exceeding Z_{msy} in the short term that are near 30%, and catches of 130 Kt with probabilities over 30%. Catches of 110 000 t give probabilities near 20%. This might be a selection of data that gives an optimistic view, but use of survey data alone gives similar estimates. Model 2, which includes truncated CPUE series, predicts a 30% chance of exceeding Z_{msy} in the short term with catches of 110 000 t. As the stock is considered to be above B_{msy} it can be expected that even removals below the MSY could be associated with decreases in stock biomass.

Recent estimates of consumption by cod in model 2 were about ¾ tons of shrimp per ton of cod, so a cod-stock prediction of 30 000 t would indicate that an allowance of order 20 000 t from the estimated MSY would be needed for sustainability.

d) State of the Stock

CPUE. In aggregate, standardised catch-rate indices, roughly stable from 1976 to 1987, decreased sharply to the early 1990s and stayed low for a few years, but then increased steadily to high levels in the early 2000s. An apparent recent contraction of the fished area casts doubt on how well recent CPUEs reflect trends in biomass.

Recruitment. Numbers at age 2 from the research trawl survey peaked in 2001 but have since continually decreased, have been below average since 2003, and in 2007 have reached a record low, at about 7% of the 2001 peak and 15% of the series mean. Prospects for recruitment to the fishable stock are bleak.

Biomass. Survey biomass, relatively low from 1988–1998, increased to a all-time high in 2003, but has since steadily declined, in 2007 to 58% of its 2003 value; however, it is still 13 % above the series mean. Stock-dynamic modelling estimates that current biomass level is above B_{msy}, with a small probability of being below B_{lim}. However, it also confirms a decrease in biomass in the most recent years.

Mortality: The mortality caused by fishing and cod predation (Z) is modelled as having been below the reference level of (Z_{msy}) since 1993. With catches in 2007 projected at 134 000 t the risk that total mortality would exceed Z_{msy} was estimated to be in the range of 26 to 44 %.

State of the stock. CPUEs are high in historic terms, but the stock is being intensively fished in a shrinking area. Survey biomass, still moderately high, has nevertheless decreased markedly and uninterruptedly since 2003. Estimated numbers of small shrimp have decreased for 6 years, reaching now very low levels. Concerns about future recruitment expressed in previous years are in 2007 aggravated, and reinforced by indications of decreasing stock biomass and a narrow size spectrum.

e) Research Recommendations

NIPAG recommended 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 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.*
- *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.*

4) Northern shrimp (in Denmark Strait and off East Greenland) – NAFO Assessed (SCR Doc. 03/74, 07/68)

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 2003 catches in the area south of 65°N accounted for more than 60% of the total catch. Catches and effort in the area south of 65°N in 2004 and 2005 only accounted for 29% and 47% respectively and decreased further in 2006.

A multinational fleet exploits the stock. During the recent ten years, vessels from Greenland, Denmark, the Faroe Islands and Norway have fished in the Greenland EEZ. Only Icelandic vessels 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. Discarding of shrimp is prohibited in both areas.

Total catches increased rapidly to about 15 500 tons in 1987 and 1988, but declined thereafter to about 9 000 tons in 1992 and 1993. Following the extension of the fishery south of 65°N catches increased again to about 13 800 tons in 1997. Catches from 1998 to 2003 have been around 12 000 tons (Fig. 4.1), but have since decreased. Catches decreased in 2005 to 8 000 tons and in 2006 further to about 5 100 tons. Catches in 2007 are projected to stay at this level. Catches in the Iceland EEZ had decreased from 2002 to 2005, and no catches were taken in 2006 or, so far, in 2007.

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

	1998[3]	1999[3]	2000[3]	2001[3]	2002[3]	2003[3]	2004	2005	2006	2007[1]
Recommended TAC	5 000	9 600	9 600	9 600	9 600	9 600	12 400	12 400	12 400	12 400
Greenland EEZ, North of 65°N	3 943	4 058	4 288	2 227	4 042	5 405	4 612	3 952	3 854	3 480
Iceland EEZ, North of 65°N	1 421	769	132	10	1 231	703	411	29	0	0
Total, North of 65°N	5 364	4 827	4 420	2 237	5 273	6 108	5 023	3 981	3 854	3 480
Greenland EEZ, South of 65°N	6 057	6 893	7 632	11 674	6 055	6 597	4 993	3 690	1 253	919
Total STATLANT 21A	9 321	9 467	9 594	11 052	9 169	9 763	10 016	7 671	5 107	4 399
Total NIPAG[3]	11 422	11 719	12 053	13 911	11 329	12 705	10 016	7 671	5 107	4 399

[1] Catches till October 2007
[2] Provisional.
[3] Estimates 1998-2003 corrected for "overpacking".

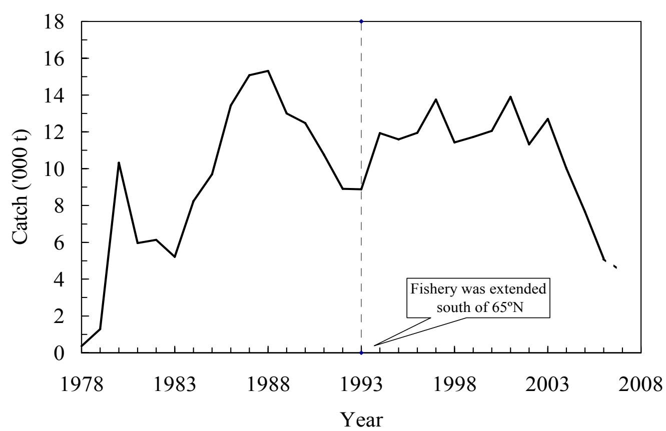


Fig. 4.1.Shrimp in Denmark Strait and off East Greenland: total catches (2007 catches until October 2007).

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 were used . Until 2005 the Norwegian fishery data was not reported in a compatible format and was not included in the standardized catch rate calculations. In 2006, however, the Norwegian logbook data from 2000 to 2006 was evaluated, resulting in its inclusion in the 2006 calculations of standardized catch rates. Since 2004 more than 60% of all hauls were performed with double trawls and the 2007 calculation of standardized catch rates is based on both single- and double-trawl data.

Catches and corresponding effort are compiled by year for two areas, one area north of 65°N and one south. Standardised Catch-Per-Unit-Effort (CPUE) was calculated and applied to the total catch of the year to estimate the total annual standardised effort. The geographic distribution of the fishery is shown by plotting the unstandardised CPUE by statistical units (7.5' latitude × 15' longitude). Catches in the Greenland EEZ have been corrected for "overpacking" (Hvingel, 2003).

The Greenland 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 stock biomass. The decrease may be related to the economics of the fishery.

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 2001 (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).

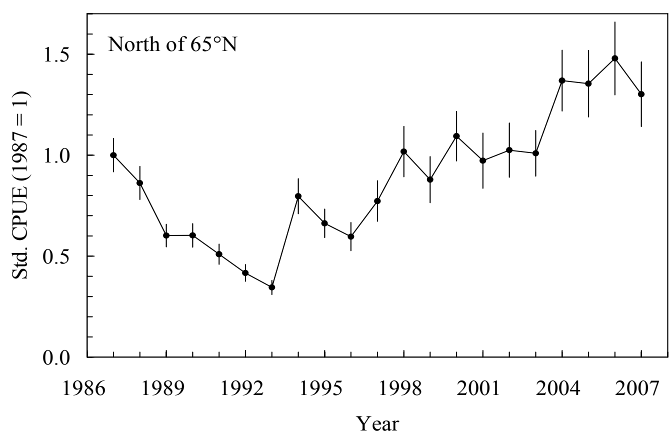


Fig. 4.2. Shrimp in Denmark Strait and off East Greenland: annual standardized CPUE, relative to 1987, with ±1 SE calculated from logbook data from Danish, Faeroese, Greenland, Icelandic and Norwegian vessels fishing north of 65ºN.

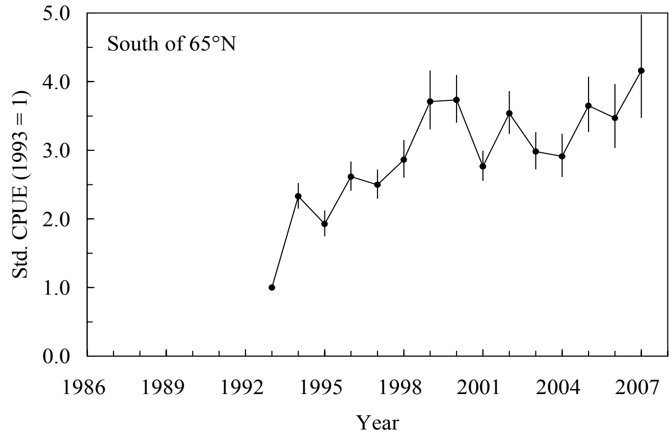


Fig. 4.3. Shrimp in Denmark Strait and off East Greenland: annual standardized CPUE, relative to 1993, with ±1 SE calculated from logbook data from Danish, Faeroese, Greenland and Norwegian vessels fishing south of 65ºN.

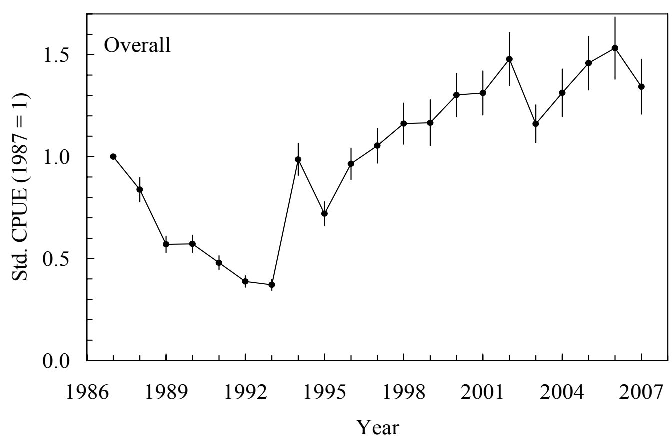


Fig. 4.4. Shrimp in Denmark Strait and off East Greenland: annual standardized CPUE indices, relative to 1987, combined for the total area. Error bars are ± 1 SE.

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).

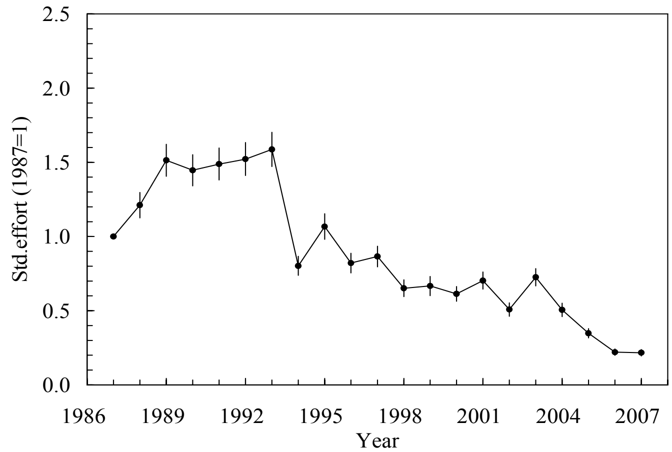


Fig. 4.5. Shrimp in Denmark Strait and off East Greenland: annual standardized effort indices, as a proxy for exploitation rate and relative to 1987, combined for the total area. Error bars are ± 1 SE.

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

ii) Research survey data

No surveys have been conducted since 1996.

c) Assessment Results

CPUE. Combined standardized catch-rate index for the total area decreased steadily from 1987 to 1993, showed an increase to a relatively high level at the beginning of the 2000s, and 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 21 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 **recommended** that, for shrimp in Denmark Strait and off East Greenland:

- *a survey be conducted to provide fishery independent data of the stock.*
- *the sampling of catches by observers be re-established. This is essential for assessing age, size, sex composition, fecundity and frequency of spawning of the stock.*
- *the availability and usefulness of size data from commercial landings be investigated as a source of information on stock structure.*
- *the existence and availability of survey data from Norwegian sources be investigated.*

5) Northern shrimp in Skagerrak and Norwegian Deep (ICES Divisions IIIa and IVa East) – ICES Assessed (SCR Doc. 07/81, 82, 83 and 84)

a) Introduction

The shrimp in the northern part of ICES Div. IIIa (Skagerrak) and the eastern part of the Div. IVa (Norwegian Deep) is considered as 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 and Norwegian vessels have started boiling the shrimp aboard and landing the product in Sweden to obtain a better price. Most of the Danish and Norwegian catches are, however, still landed in home ports. The Swedish fishery is smaller and approximately 50% of catches are boiled at sea, and almost all Swedish catches are landed in Sweden.

The TAC is shared according to historical landings, giving Norway the highest quota, and Sweden the lowest (18% of the TAC). 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 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. 07/81) and is used by an increasing number of vessels in all fleets. However, at present it is mandatory only in Swedish national waters.

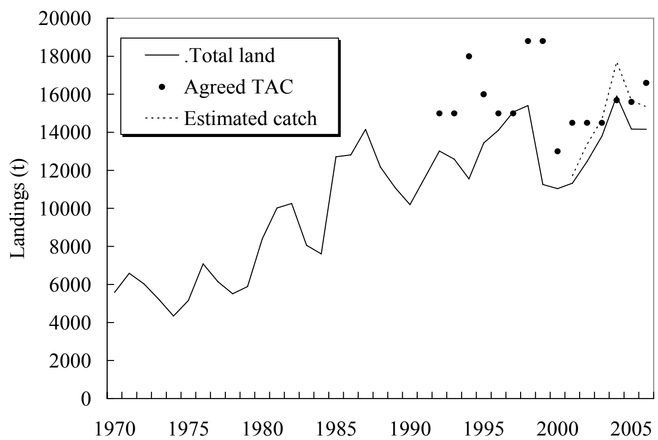


Fig. 5.1. Shrimp in ICES Divs. IIIa and Iva East: Agreed TAC total landings by all fleets and total catch including estimated Swedish high-grading for 2001-2005.

Total catch have varied between 12 000 t and 18 000 t during the 1990s. The catches in 2005 and 2006 were around 15 500 t, a decrease of around 2 000 t compared with landings in 2004 (Table 5.1 and Fig. 5.1). The landings and estimated Swedish high-grading derived by NIPAG for this assessment unit are given in the following table.

Table 5.1. Shrimp in ICES Divs. IIIa and Iva East: Agreed TAC, recent landings and estimated catches.

	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
Agreed TAC	15 000	18 800	18 800	13 000	14 500	14 500	14 500	15 690	15 600	16 200	16 600
Denmark	3 909	3 330	2 072	2 371	1 953	2 466	3 244	3 905	2 952	3 061	
Norway	8 565	9 606	6 739	6 118	6 895	7 318	7 715	8 998	8 507	8 613	
Sweden[1]	2 597	2 469	2 445	2 225	2 108	2 301	2 389	2 464	2 257	2 488	
Total landings	15 071	15 406	11 256	11 040	11 327	12 470	13 811	15 913	14 168	14 162	
Estimated Swedish high-grading					375	908	868	1 797	1 483	1186	
Total catch					11 702	13 378	14 679	17 710	15 651	15 348	

[1] Swedish and Norwegian (2000-2006) landings have been corrected for loss in weight due to boiling.

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 only 24 in 2006 (Fig. 5.2). It is mostly the small trawlers (<24 m LOA) which have left the fishery and in 2006 the average length of the vessels was around 26 m (SCR Doc. 07/84). 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 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 licence to fish. Vessels ≥21 m LOA constitute about 12% of the fleet. According to the Norwegian fisheries organization "Fiskarlaget", twin trawls have been in use by 20-30 Norwegian trawlers the last five years. Quantitative information on these changes in gear is, however, not available from the logbooks. In the Norwegian logbooks only 1-3 vessels have recorded the use of twin trawl on a regular basis 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).

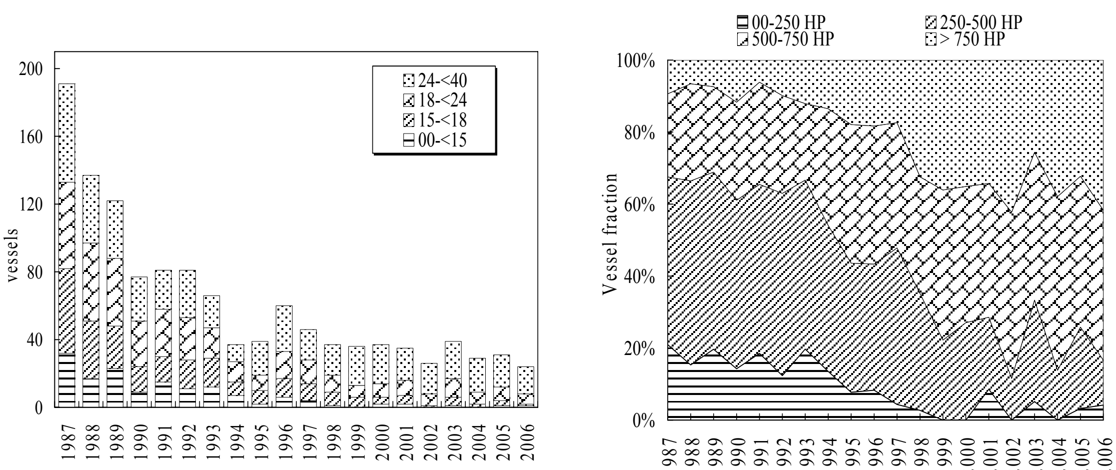


Fig. 5.2. Shrimp in ICES Divs. IIIa and Iva East: Trend in numbers (left) and engine power (right) by size groups of Danish shrimp trawlers from 1987 to 2006.

Catch and 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, 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 fisheries was estimated to around 1200 t in 2006 based on comparison of length distributions in Swedish and Danish landings (Fig 4 in SCR Doc 07/81). The annual Danish length distribution is scaled to fit the yearly Swedish length distribution for the larger shrimp, based on the assumption that there is no discarding of the most valuable larger shrimp (≥21 mm CL), and that Swedish and Danish fisheries are conducted on the same shrimp 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 weights 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.

From 2007 and onwards Norwegian discards will be estimated by comparing length distributions in unprocessed commercial catches (sampling initiated in 2005) and sorted landings (sampling initiated in 2007).

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. However, the shrimp fishery is not regarded as a mixed fishery, as it only targets shrimp. Nonetheless, there is some bycatch of commercially valuable species — amounting, for example, to estimated landings of around 500 t in the case of cod — although regulations restrict the weights that may be landed. Since 1997, trawls used in Swedish national waters must be equipped with a Nordmøre grid, with bar spacing 19 mm, which excludes fish >20 cm from the catch. Based on log-book information, landings delivered by vessels using this grid consist of 99% shrimp compared to only 80% in landings from trawls without grid (Table 5.2). In the area outside of Swedish national waters the grids are not mandatory, however, there has been an increase in their use, which constituted 28% of Swedish shrimp effort in 2006.

The effects of small-mesh 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 Norwegian Deep. However, no quantitative data on this catch component is available.

Table 5.2. Shrimp in ICES Divs. IIIa and Iva East: Logbook recorded bycatch in the shrimp fishery, 2006. (Combined Danish and Swedish logbook records, and records from Norwegian landings statistics).

	Sub-Div. IIIa, no grid		Sub-Div. IIIa, grid		Sub-Div. IVa East, no grid	
Species:	Total	% of total catch	Total	% of total catch	Total	% of total catch
Pandalus borealis	9269.3	84.6	552.7	98.8	3276.4	79.3
Norway lobster	36.6	0.3	2.6	0.5	19.9	0.5
Angler fish	31.6	0.3	0.1	0.0	120.5	2.9
Whiting	16.2	0.1	0.0	0.0	6.4	0.2
Haddock	82.5	0.8	0.2	0.0	29.4	0.7
Hake	21.1	0.2	0.0	0.0	29.4	0.7
Ling	34.2	0.3	0.0	0.0	42.5	1.0
Saithe	739.8	6.8	1.5	0.3	381.1	9.2
Witch flounder	78.9	0.7	0.2	0.0	5.7	0.1
Norway pout	0.0	0.0	0.0	0.0	0.2	0.0
Cod	436.8	4.0	2.0	0.3	149.8	3.6
Other market fish	205.1	1.9	0.4	0.1	69.6	1.7

b) Assessment Data

i) Commercial fishery data

LPUE. The Swedish LPUE data were not used in the assessment (SCR Doc. 07/81) due to uncertainties caused by high-grading and lack of information necessary for standardization.

In order to include gear type (single and twin trawl) as a variable in the standardisation of the Norwegian LPUE, the incorrect recordings of gear type in the logbooks were corrected based on interviews with ship owners (SCR Doc. 07/82). If reliable information on gear type was not received, the vessel was deleted from the data (18% of all recordings). The corrected data were used in a multiplicative model to calculate standardised LPUE indices (2000-2007):

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

The standardised LPUEs in last year's report were based on single trawl data only. Thus, figures for the years 2000-2006 have been updated in this year's report (Fig. 5.3).

In 2006, catches recorded in logbooks only included 19% and 29% of the respective landings in Divs. IIIa and IVa east. This is partly due to vessels <11 m not being required to fill in log-books. Because of the low coverage of the Norwegian log book data, NIPAG decided not to use them in this year's final assessment.

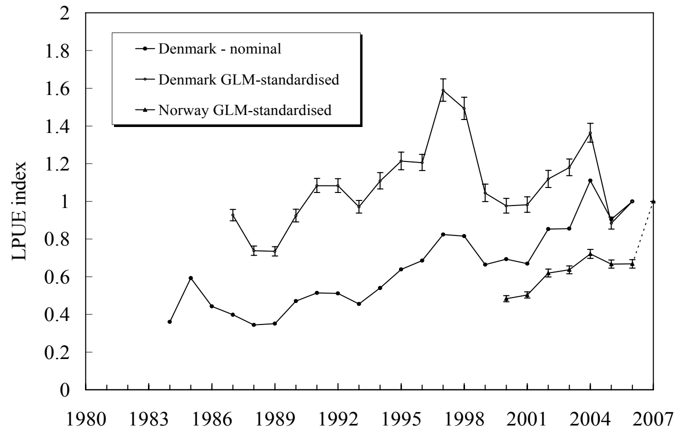


Fig. 5.3. Shrimp in ICES Divs. IIIa and Iva East: Danish standardised LPUE compared with nominal LPUE, and Norwegian standardised LPUE. Error bars are standard errors.

The Danish catch and effort data from logbooks have been analysed and standardised (SCR Doc. 07/84). A GLM standardisation of the LPUE series was performed on around 20 000 shrimp fishing trips conducted in the period 1987-2006:

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

where "vessel_hp" depicts the horse power of the individual vessels. The index "year" covers the period 1987-2006. The index "area" covers Norwegian Deep and Skagerrak, and the variance of the error term is assumed to be normally distributed. As HP is used as a proxy for trawl size (SCR Doc. 07/84) the comparison between standardised Danish LPUE and the nominal LPUE clearly demonstrates the influence of technological creep. NIPAG decided to use these standardised Danish LPUEs as the best available indicator for stock biomass. The standardised Norwegian LPUE supports the trend in the Danish standardised LPUE (Fig. 5.3).

Harvest Rate. In previous assessments estimates of harvest rates (HR) were estimated from landings and corresponding biomass indices from the Norwegian survey. Since the new survey only covers 2 years, indices of harvest rates have been estimated using the Danish LPUE as biomass index (Fig. 5.4). Both graphs seem to fluctuate without any clear trend. NIPAG interprets this as a sign of stability of the stock and in the exploitation of the stock.

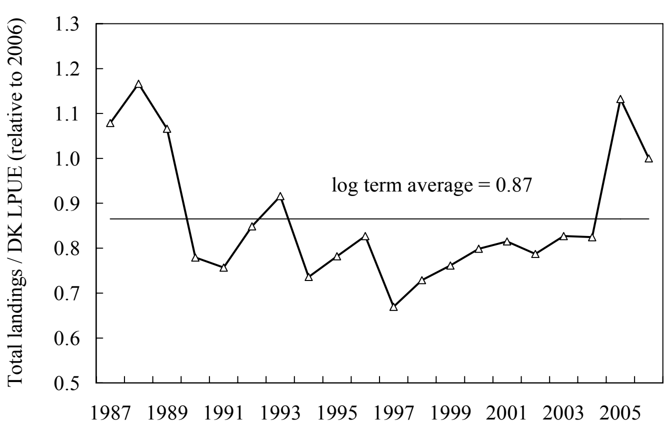


Fig. 5.4. Shrimp in ICES Divs. IIIa and Iva East: Estimated relative harvest rate (HR) based on total landings and standardised LPUE for Denmark (1987-2006) Notice, that the harvest rate may also be interpreted as effort indicator.

Biological sampling of landings. Information on the size and subsequently age distribution of the landings are obtained by sampling the landings. The biological samples also provide information on sex distribution and maturity (SCR Doc. 07/81).

ii) Research survey data

The Norwegian shrimp survey has gone through large changes in recent years (SCR Doc. 07/83). The result is 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 during 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 2004 and 2005 mean values of a new biomass index series were not statistically different (Fig. 5.5). The 2007 index is very high compared to the 2006 value, and is heavily influenced by the very high biomass of one particular stratum.

The size distribution of the February 2006 survey shows a large mode (12.3 mm CL) of 1-year old shrimp (Fig. 5.6), which appears as a very large mode of 2-year old shrimp (16.5 mm CL), dominating the catches in the 2007 survey. The 1-group in 2007 is of equal size as the 1-group in 2006, suggesting good catches of both 2- and 3-year old shrimp in 2008.

The total index of shrimp predator biomass was estimated to 60.8 kg/nm in 2007, compared with only 18.7 kg/nm in 2006 (SCR Doc. 07/83, Table 4). The increase is mainly due to an increase in the saithe index. Results from the first survey series (1984-2002) range from 28.6 to 63.1 kg/nm, while in 2004-2005 the indices were respectively 58.1 and 115.4 kg/nm. This indicates that last year’s index was very low, however, the results from the different surveys are not comparable.

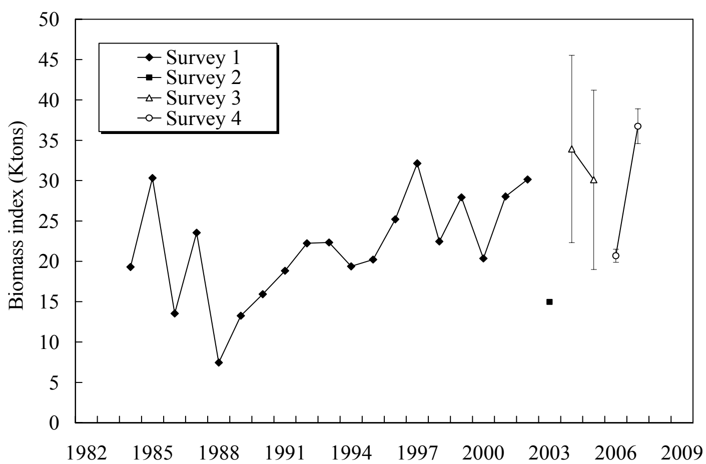


Fig. 5.5. Shrimp in ICES Divs. IIIa and Iva East: Biomass indices of shrimp from the Norwegian survey. The four surveys are not calibrated to a common scale. Standard errors (error bars) have been calculated for the 2004-2007 surveys. Survey 1: October/November 1984-2002 with Campelen-trawl; Survey 2: October/November 2003 with shrimp trawl 1420; Survey 3: May/June 2004-2005 with Campelen trawl; Survey 4: February 2006-2007 with Campelen trawl.

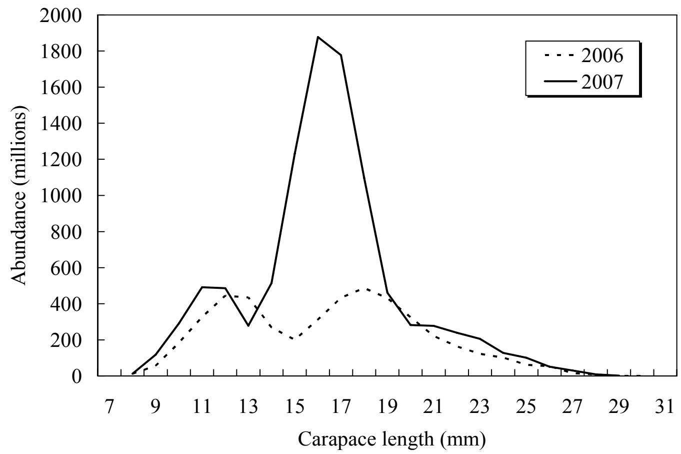


Fig. 5.6. Shrimp in ICES Divs. IIIa and Iva East: Estimated length frequency distribution of shrimp in Skagerrak and the Norwegian Deep from the Norwegian shrimp surveys in 2006 and 2007.

c) Assessment Results

Cohort analyses (XSA) were applied until 2002, but were then abandoned because of the assumed high predation mortality compared to the fishing mortality. A Bayesian stock production model was introduced in 2005 (WGPAND, 2005). However, the assessment from this model was not accepted by ICES in 2005. Further development of the model was recommended, but even if model development has progressed, lack of consistent fishery independent data has prevented its use for assessment of this stock. This year's assessment/evaluation of the current state of the stock is based on evaluation of the Danish standardised LPUE and harvest rate (standardised effort) from the fishery 1987-2006, and the available survey based indices of recruitment and biomass.

LPUE. As mentioned in b) NIPAG considers the standardised Danish LPUE as the best available stock indicator at present. Since 1987 the standardised LPUE has fluctuated somewhat, however the level in 2006 appears to be around average (Fig. 5.3). There are no signs of any decline in stock abundance.

Recruitment. Abundance of 1 year old shrimp in 2006 and 2007 will probably result in good catches of both 2- and 3-year old shrimp in 2008 (Fig 5.6).

Survey biomass. The biomass index for 2007 is only comparable with the 2006 index. The 2007 index is 77% higher than the 2006 index.

Harvest rate. The estimated HR (standardised effort) indices oscillate around the long time mean (Fig. 5.4).

State of the stock. The LPUE based perception of stock fluctuation indicates a high level in 2004 followed by a decrease in 2005. However, in 2006 the index suggests a slight increase in stock level. The survey based biomass index suggests an increase from 2006 to 2007, and the recruitment to the fishery seems good.

d) Biological Reference Points

No reference points were provided in this assessment (SCR Doc. 07/81).

e) Management Recommendations

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

- *the total landings from IIIa and IVa East in 2008 are not increased above the recent averages (2003-2006) of 14 000-16 000 t, which is a continuation of the recent TAC level of around 16 000 t.*

- *sorting grids facilitating the escape of fish should be implemented in this fishery, as it is in all other Pandalus borealis fisheries in the North Atlantic.*

- *all Norwegian vessels should be required to fill in and deliver logbooks.*

f) Research Recommendations

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

- *the current (2007) investigation of the relation/connection/mixing between the shrimp (stock units) in Skagerrak and Norwegian Deep on one hand and the Fladen Ground on the other hand by using genetic separation technologies, is continued until these relationships have been clarified.*

- *1) the Bayesian stock production model presented in 2005 is fully developed, and 2) other assessment models, e.g. new cohort based models, are explored and compared with the Bayesian models.*

- *standardised Danish LPUE is provided for the current year.*

- *an index for female biomass (SSB) should be calculated from the Norwegian survey data to make B_{lim} estimates possible.*

- *develop new commercial shrimp trawls that will reduce impacts upon the bottom.*

- *develop limit reference points.*

g) Research Recommendations from the 2006 meeting

- *the relation/connection/mixing between the shrimp (stock units) in Skagerrak and the Norwegian Deep on the one side and the Fladen Ground shrimp neesd to be clarified by using genetic separation technologies.*

STATUS: Work in progress

- *further development of the Bayesian stock production model presented in 2005, and comparisons and evaluations of the assessment models available for this shrimp stock are recommended.*

STATUS: Work in progress.

6) Northern Shrimp in Barents Sea and Svalbard area (ICES SAI and II) – ICES Assessed (SCS Doc. 04/12, SCR Doc. 06/70; 07/74, 75, 76, 80, 85, 86, 87; ICES C.M. 2007/ACFM:37)

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 28 000 and 83 000 t/yr – 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 and the fishery is partly regulated by effort control. Licenses are required for the Russian and Norwegian vessels and provide an upper ceiling on the effort. 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.

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

Catch

Since the early 1980s, landings have varied in a cyclic manner with local minima and maxima separated by periods of 4-5 years (Fig. 6.1). Overall catches have ranged from 5 000 to 128 000 t/yr . The most recent peak was seen in 2000 at approximately 83 000 t. Catches thereafter declined to 30 000 t in 2006. Based on information from the industry the 2007 catches are estimated to be of similar magnitude.

Catches (1997-2006) and projected catches (2007) in metric tons, as used by NIPAG for the assessment of shrimp in ICES Div. I and II are as follows:

	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007[1]
Recommended TAC	-	-	-	-	-	-	-	-	43 591[2]	40 000	50 000
Norway	29 079	44 792	52 612	55 333	43 031	48 799	34 172	35918	37253	27.413	26 000
Russia	1 493	4 895	10 765	19 596	5 846	3 790	2 776	2 410	0 435	0.004	0.004
Others	5 164	6 103	12 292	8 241	8 659	8 899	2 277	2 373	3 010	2 271	2 000
Total	35 736	55 790	75 669	83 170	57 536	61488	39 225	40701	40 698	29 688	28 004

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

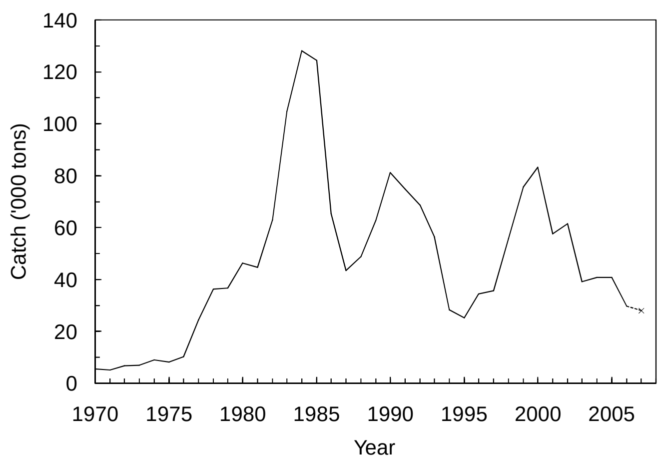


Fig. 6.1. Shrimp in the Barents Sea: total catches 1970-2007 (2007 projected to the end of the year).

Discards and bycatch

Discard of shrimp cannot be quantified but is believed to be small. Bycatch rates of other species are estimated from research surveys and surveillance surveys 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 as summarised from logbooks to give the overall bycatch.

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

Estimated bycatch of cod, haddock, Greenland halibut and redfish (million individuals) are as follows:

Year	Cod	Redfish	Haddock	Gr. halibut
1983	14.6	91.0		
1984	12.6	167.0		
1985	92.4	198.0		
1986	10.9	18.0		
1987	9.9	110.0		
1988	5.2	46.0		
1989	1.5	199.0		
1990	9.0	94.0		
1991	22.5	51.0		
1992	25.4	78.0		
1993	19.2	22.0		
1994	4.6	23.0		
1995	5.9	2.0		
1996	17.1	25.0		
1997	28.7	24.0		
1998	67.1	3.0		
1999	13.4	11.0		
2000	7.8	15.0	3.7	13.9
2001	12.9	14.0	1.8	7.6
2002	2.5	5.0	9.2	0.2
2003	15.0	0.6	5.5	0.6
2004	2.7	1.1	1.2	0.3
2005	6.5	2.0		
2006	4.9	5.1		

Environmental considerations

Changes in temperature, salinity, and large-scale water movements have been observed in the North Atlantic over the past few years. The trend in the last decade (1995-2005) has been of warming and increasing salinity in the upper ocean. In the Barents Sea, the period 2001-2005 is the warmest five-year period observed since 1900. 2006 was even warmer than the previous five years. In 2007 the temperatures are still high, but lower than in 2006 especially in the western Barents Sea. Large areas had bottom temperatures of 1-1.5°C above average, and some smaller areas even around 2°C above average.

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

b) Input Data

i) Commercial fishery data

Norwegian logbook data were used in a multiplicative model (GLM) to calculate standardized annual catch rate indices (SCR Doc. 07/74). The CPUE indices included the following variables: (1) vessels grouped by engine size, (2) season (month), (3) area (areas as in survey stratification) 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 standardized CPUE declined by 60% from a maximum in 1984 to the lowest value of the time series in 1987, showed an increasing trend until 2000, and then remained stable close to the mean of the series until 2003 (Fig. 6.2). Following a decline from 2003 to 2004 the std. CPUE increased significantly reaching values comparable to the 1984-maximum in 2006. The 2007 value is 18% lower than that of 2006, but is still well above the average of the series. The standardised effort (Fig. 6.3) has shown a decreasing trend since 2000.

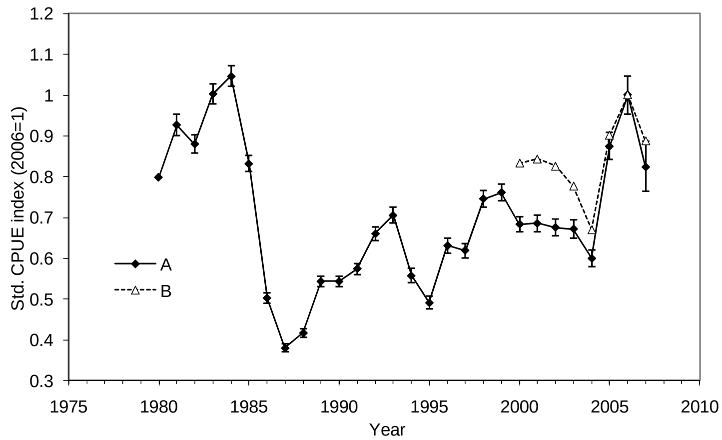


Fig. 6.2. Shrimp in the Barents Sea: standardized CPUE based on Norwegian data A. fishing power term is groupings of vessels by engine size (see text); B. fishing power term as individual vessels (see text). Error bars are standard error.

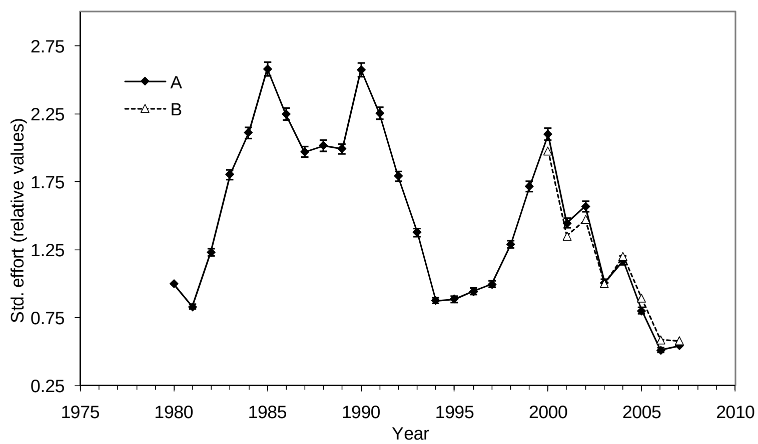


Fig 6.3. Shrimp in the Barents Sea: Standardised effort. A. fishing power term is groupings of vessels by engine size (see text); B. fishing power term as individual vessels (see text). Error bars are standard error.

A major restructuring of the fleet towards fewer and larger vessels has taken place since the mid 1990s. In 1994 6% of the catches reported in logbooks were taken by large factory trawlers (2 000-4 000 HP) whereas this fleet component accounted for more than 95% in 2007 (Fig. 6.4). Until 1996 the fishery was conducted by using single trawls only. Double trawls were introduced in 1996 and in 2002 approximately 50% of the total effort spent was by using two trawls simultaneously. In 2000 a few vessels started to experiment with triple trawls: 22% of the effort in 2007 is accounted for by this fishing method.

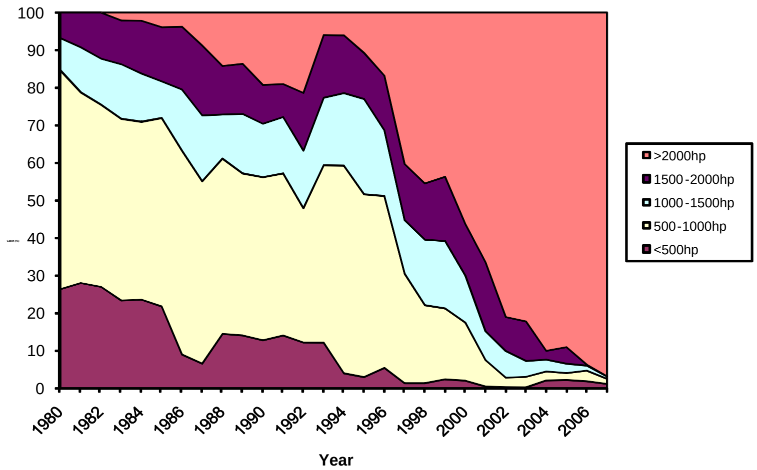


Fig. 6.4. Shrimp in the Barents Sea: Percentage of total catch taken by five fleet components separated by engine size 1980-2007 (hp=horse-power).

Whereas the recent changes in gear use seem reasonably well accounted for by the standardization procedure some concern was raised whether the increase in standardized CPUE in recent years fully represents the development of stock biomass (SCR Doc. 07/74). Major changes of fleet structure have taken place following reduced economic profitability in northern shrimp fisheries. Many vessels have left the fishery and it is likely that only the most efficient vessels have remained which would cause an increase in efficiency that is not accounted for in the standardization procedure based on vessel groupings by engine size. In particular the increase from early to mid 2000s (Fig. 6.2) might be overestimated.

An exploratory GLM model similar to the one described above but based on individual vessels as the unit of fishing power instead of vessel groupings was constructed using available data since 2000. This series also showed an increase since 2004 however somewhat smaller than that seen in the other series (Fig. 6.2). Further the increase from the early 2000 values to the most recent values was smaller compared to the original series indicating that the vessel group efficiency had improved and that the series based on vessel groups may overestimate the recent improvement in stock density. However, in general, the std. CPUE and the survey series have been well correlated ($r_{shrimp\ survey} = 0.8$; $r_{ecosystem\ survey} = 0.88$, Fig. 6.5).

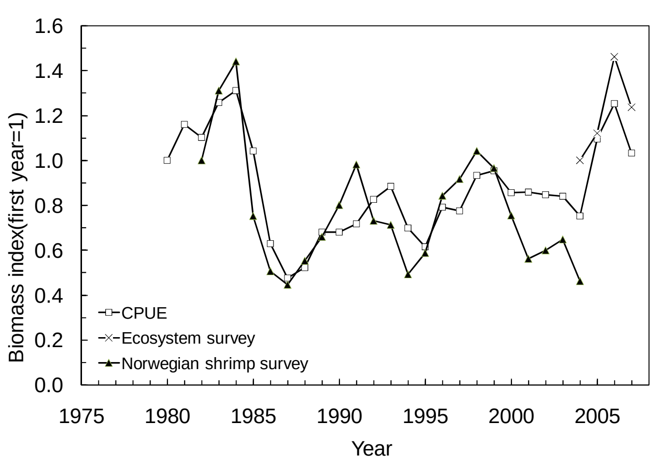


Fig 6.5. Shrimp in the Barents Sea: Norwegian standardised CPUE and survey index series standardised to their first year.

ii) Research survey data

Russian and Norwegian shrimp surveys have been conducted to assess the stock status of northern shrimp in 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, the joint Norwegian-Russian "Ecosystem survey" was introduced as the platform for monitoring shrimp along with a multitude of other ecosystem variables. The Russian survey was not used in the assessment.

Biomass. 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. 6.6). The Ecosystem survey has not been calibrated to the one discontinued in 2004. The estimate of mean biomass based on the Norwegian part of the new Ecosystem survey increased by 45% from 2004 to 2006 and decreased by 18% from 2006 to 2007.

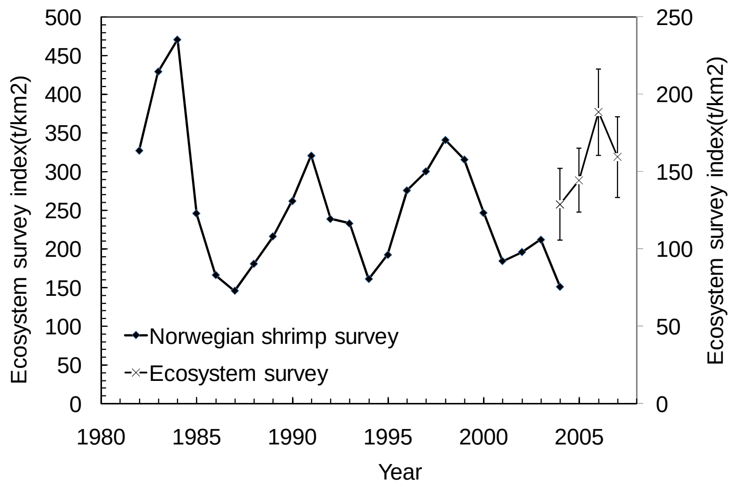


Fig. 6.6. Shrimp in the Barents Sea: Shrimp stock biomass indices of the Norwegian shrimp survey 1982-2004 and the joint Norwegian/Russian ecosystem survey estimates based on Norwegian data since 2004. (Note different scales on y-axis – the two series are not inter calibrated). Error bars are standard error.

Length composition. Overall shrimp size distributions (Fig. 6.7) indicate a larger amount of small shrimp (<16 mm CL) in 2004, which apparently has caused the stock increase in 2005 and 2006. Abundance estimates of shrimp at 13-16 mm CL supposed to start entering the fishery in 2008 decreased from 2004 to 2005 and remained stable thereafter (Fig. 6.7).

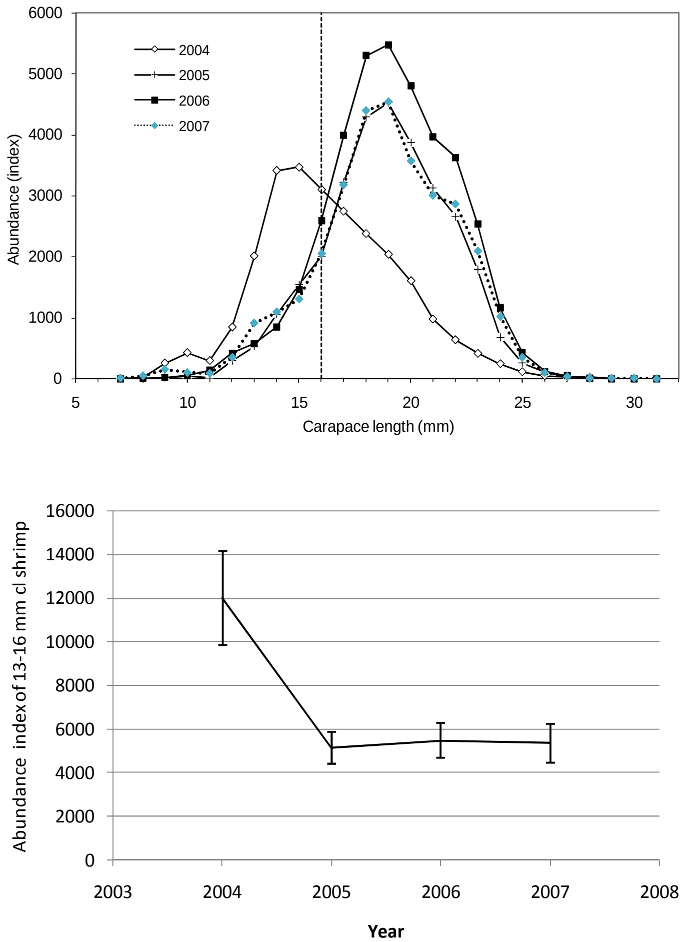


Fig. 6.7. Shrimp in the Barents Sea: Size distribution estimates of shrimp based on Survey 3 data 2004 to 2007 (upper panel) and estimated number of shrimp at size 13-16 mm CL (lower panel). Error bars are standard error.

c) Estimation of Parameters

A new assessment framework based on the work of Hvingel and Kingsley (2002, 2006) was introduced in 2006 (Hvingel, 2006) and later accepted as a basis for the advice. 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. 07/76).

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 1980-2007 (SCR Doc. 07/74); and two trawl-survey biomass index for 1982-2004 and 2004-2007 (SCR Doc. 07/75). 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 1970-2007 was used as yield data (Fig. 6.1, SCR Doc. 07/74). 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 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:

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

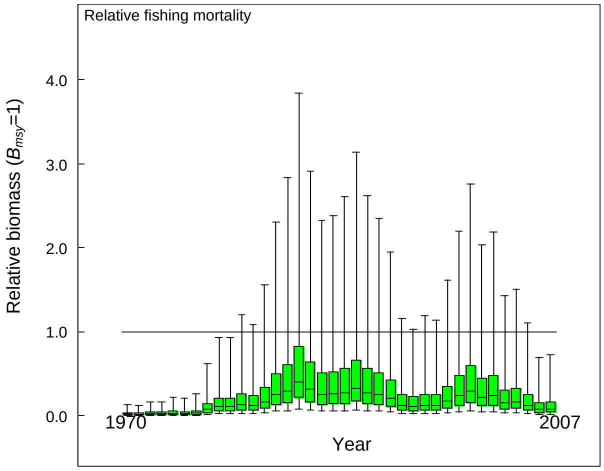
The observation error terms, ω, κ and ε are normally, independently and identically distributed with mean 0 and variance σ_ω^2 , σ_κ^2 and σ_ε^2 .

Cod is considered an important predator on shrimp (Hvingel and Kingsley, 2006 and references therein) and imperative to any shrimp assessment model for the Barents Sea stock (Anon., 2005a). However, Hvingel (2006) concluded that available consumption data and information on cod stock dynamics did not provide information on the dynamics of the shrimp stock in the Barents Sea and that the spatial resolution of the consumption data might be masking the correlation. A new study addressing some of these considerations came up with a consumption series that showed similar year-to-year dynamics as the consumption series previously used (SCR Doc. 07/80). Therefore we were still not in a position to include cod consumption in the assessment model. Seemingly the biological settings for cod-shrimp relation in the Barents Sea is more complex than what is seen e.g. in the West Greenland ecosystem. Investigations for including cod predation in the assessment model continue.

d) Assessment Results

Stock size and fishing mortality

Since the 1970s, the estimated median biomass-ratio has been above its MSY-level (Fig. 6.8) and the probability that it had been below the optimum level was small for most years, *i.e.* it seemed likely that the stock had been at or above its MSY level since the start of the fishery (SCR Doc. 07/76). This perception was not sensitive to changes in the priors for the Carrying Capacity (K) and initial biomass. The 2007 biomass value is among the highest of the series.



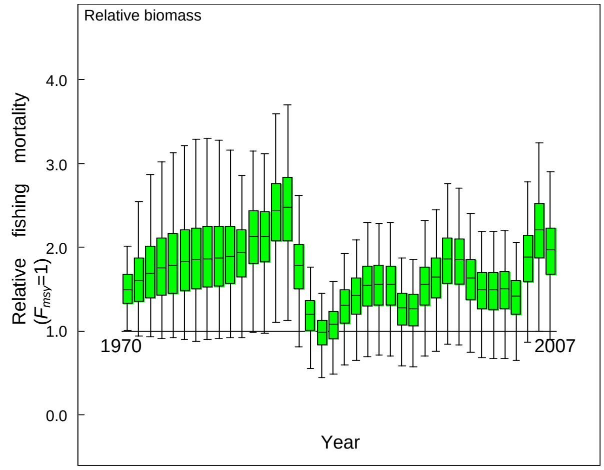


Fig. 6.8. Shrimp in the Barents Sea: estimated relative biomass (B_t/B_{msy}) and fishing mortality (F_t/F_{msy}) 1970-2007. Boxes represent inter-quartile ranges and the solid black line at the (approximate) centre of each box is the median; the arms of each box extend to cover the central 95 per cent of the distribution. [1]=1970, [38]=2007.

A steep decline in stock biomass was noted in the mid 1980s following some years with high catches and the median estimate of biomass-ratio went below the optimum (Fig. 6.8). Since the late 1990s the stock has varied with an overall increasing trend and reached a level in 2007 estimated to be close to *K*. The estimated risk of stock biomass being below B_{msy} in 2007 was 3%. The median fishing mortality ratio (*F*-ratio) has been well below 1 throughout the series (Fig. 6.8). In 2007 there is a low 2% 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. 6.9). At the end of 2007 there is less than 1% risk that the stock would be below B_{lim}, while the risk that F_{lim} was exceeded is 3%.

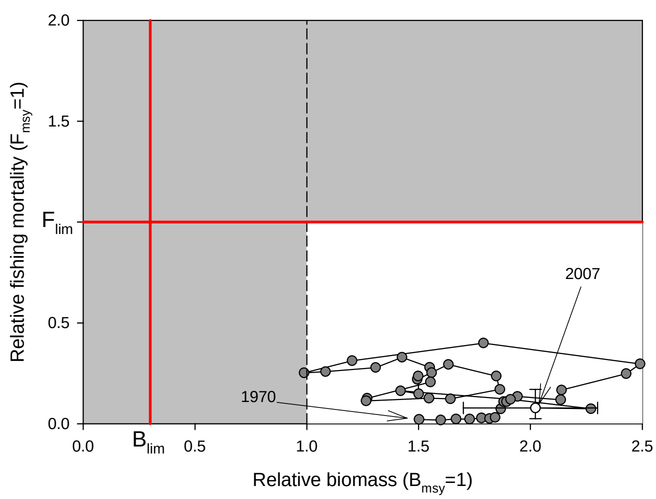


Fig. 6.9. Shrimp in the Barents Sea: Estimated annual median biomass-ratio (B/B_{msy}) and fishing mortality-ratio (F/F_{msy}) 1970-2007. The reference points for stock biomas, B_{lim}, and fishing mortality, F_{lim}, are indicated by the red (bold) lines. Error bars on the 2007 value are inter-quartile range.

Production

The posterior for MSY was positively skewed with a mode at 95 000 t (Fig. 6.10) and upper and lower quartiles at 100 000 t and 309 000 t. The right tail of the MSY-posterior showed some sensitivity to changes in the prior for *K*. However, no matter which prior used the model estimated a probability of at least 95% that MSY is higher than the recent advised TACs of 40 000 to 50 000 t.

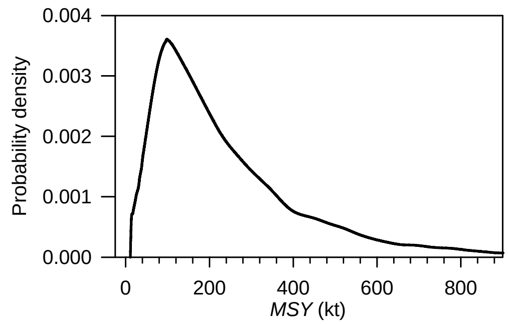


Fig. 6.10. Shrimp in the Barents Sea: Posterior probability density distribution for MSY.

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 2008 are as follows:

Catch option ('000 t)	30	40	50	60	70	90
Risk of falling below B_{lim}	<1%	<1%	<1%	<1%	<1%	<1%
Risk of falling below B_{MSY}	4%	4%	4%	4%	4%	5%
Risk of exceeding F_{MSY}	2%	3%	4%	6%	7%	11%

The risk associated with ten-year projections of stock development assuming annual catch of 30 000 to 90 000 t were investigated (Fig. 6.11). For all options the risk of the stock falling below Bmsy in the short to medium term (1-5 years) is low, (<11%). However, it is less certain that these catch levels can be sustained in the longer term (risk of exceeding F_{lim}). The stock has a less than 1% risk of being below B_{lim} and none of these catch options are likely to increase that risk above 5% over a 10 year period (Fig. 6.11). 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. 6.11). The risk that catches of this magnitude will not be sustainable (*prob* ($F > F_{lim}$), (Fig. 6.11) 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.

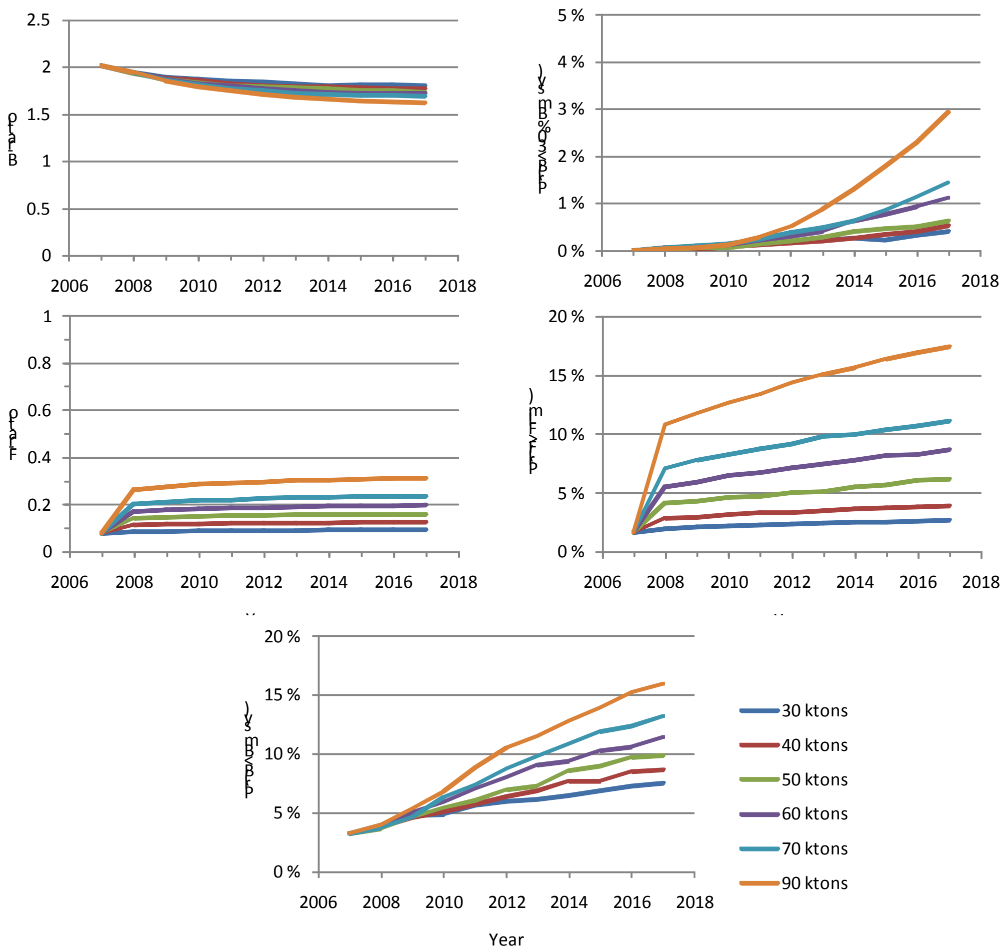


Fig. 6.11. Shrimp in the Barents Sea: Projections (left): Medians of estimated posterior biomass and fishing mortality ratios; estimated risk (right and below) of exceeding F_{msy} and F_{lim} (1.7 F_{msy}) or going below and B_{lim} given different catch options.

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. 07/76). The CPUE series was generally better estimated than the survey series. Otherwise no major problems in capturing the variability of the data were detected.

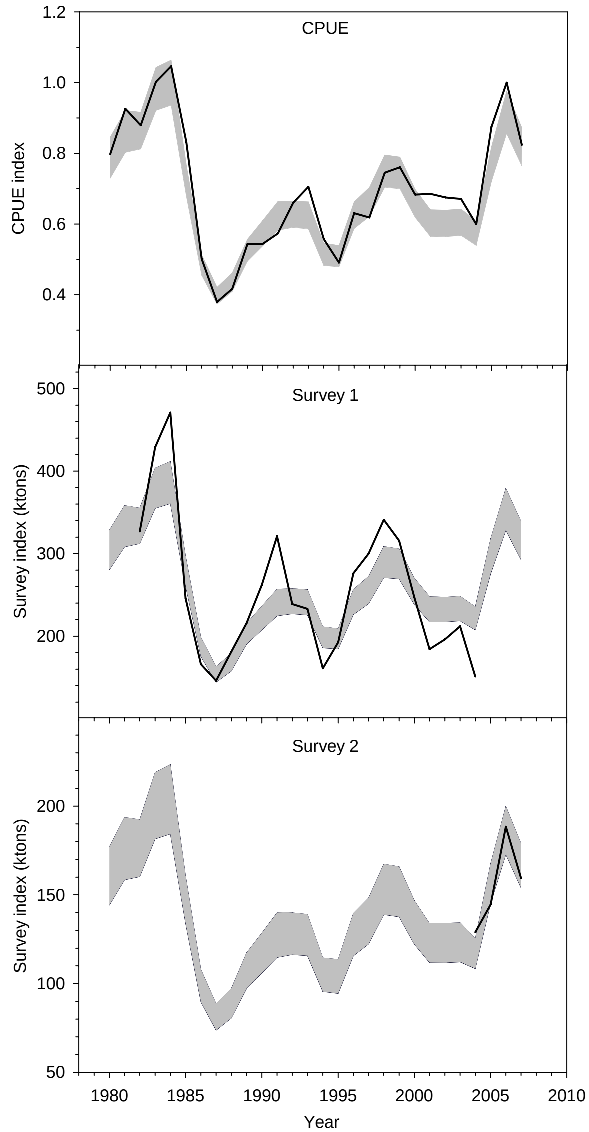


Fig. 6.12. Shrimp in the Barents Sea: Observed (solid line) and estimated (shaded) series of the included biomass indices: the standardised catch-per-unit-effort (CPUE), the 1982-2004 shrimp survey (survey 1) and the Ecosystem survey (survey 2). Gray shaded areas are the inter-quartile range of the posteriors.

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.

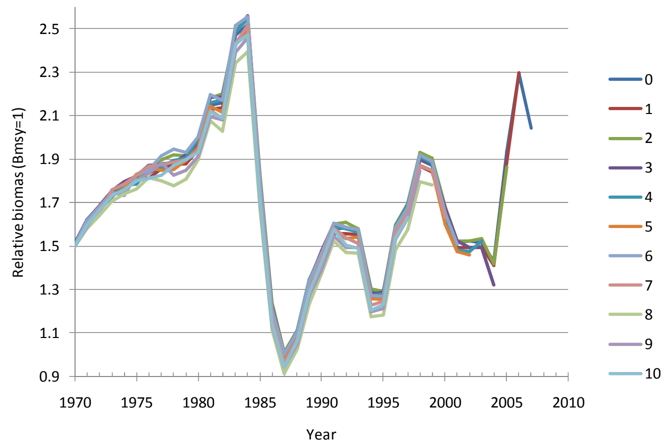


Fig. 6.13. Shrimp in the Barents Sea: Retrospective plot of median relative biomass (B/B_{msy}). Relative biomass series are estimated by consecutively leaving out from 0 to 10 years of data.

For the parameters *K* and *P1* the posterior distributions tended to approximate the input priors. The prior for the "initial" shrimp stock biomass (*P1*) was slightly informative giving credit to "virgin stock conditions" at the start of the series in 1970. Making this prior low-informative by giving *P1* a uniform prior between 0 and 2 had little or no effects on the posterior of other parameters in the model – except for the first 9-10 years of *P* (relative biomass). After this period the series converge (Fig. 6.14).

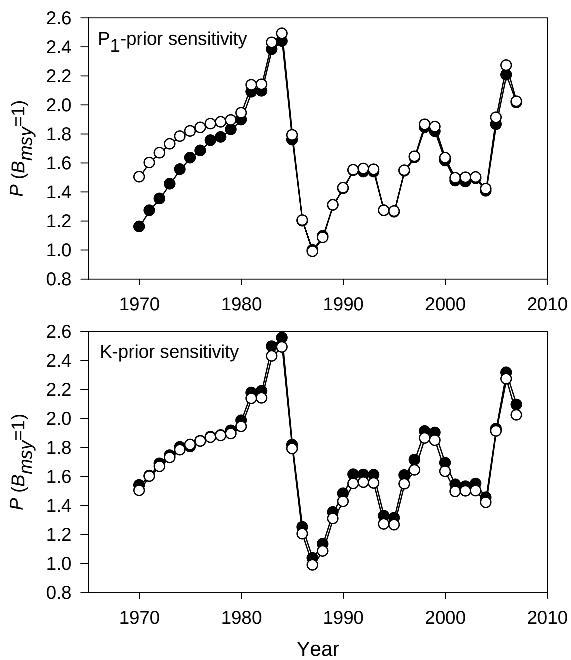


Fig. 6.14. Shrimp in the Barents Sea: Median relative biomass, *P*, 1970-2007. Open dotted series as estimated from the model used. Series with closed dots was given low informative priors: upper panel *P1*~dunif(0, 2), lower panel *K*~dunif(1, 10 000).

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 five times the catches. If predation on shrimp were to increase rapidly outside the range previously experienced by the shrimp stock within the modelled period (1970–2007), the shrimp stock might decrease in size more than the model results have indicated as likely. However, as the total predation depends on the abundance both of cod and also of other prey species the likelihood of such large reductions is at present hard to quantify.

Rebuilding potential

At 30% B_{msy} (B_{lim}) production is reduced to 50% of its maximum. The estimate of *r* (intrinsic rate of increase) had 95% confidence intervals ranging from 0.05 to 0.33 (Fig. 6 left). Thus without fishery it would take 3-10 years to rebuild the stock from B_{lim} to B_{msy} (Fig. 6 right).

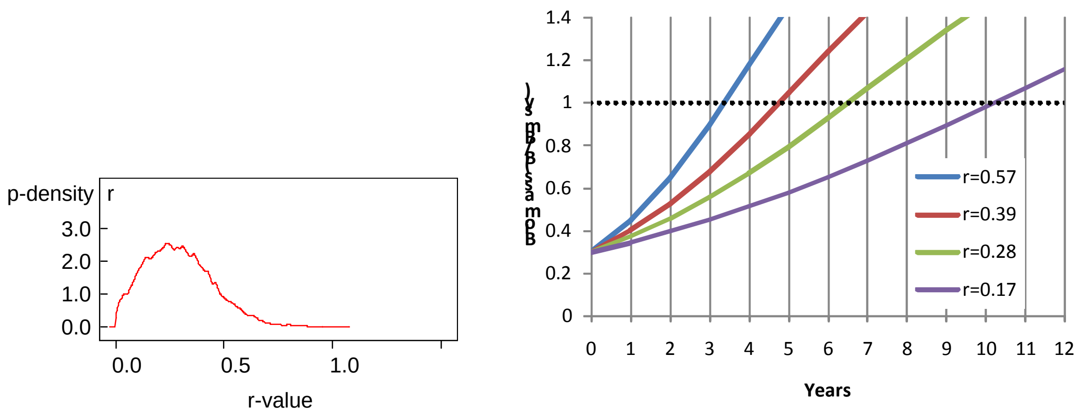


Fig. 6.15. Shrimp in the Barents Sea: *Left*: The posterior probability density distribution of r, the intrinsic rate of growth. *Right*: estimated recovery time from B_{lim} (0.3 B_{msy}) to B_{msy} (relative biomass = 1) given r values ranging within the 95% CL of the posterior (left figure) and no fishing mortality.

Potential bias in the input std. CPUE series

Investigative model runs replacing the original long 1970-2007 CPUE series based on vessel grouped by engine size with an alternative 2000-2007 series based on individual vessel fishing power were done. The results showed little change in estimates of stock production potential (MSY) *i.e.* the median values were the same but the uncertainty of the estimate increased by 20%. Some changes in the series of estimated median stock biomass were noted (Fig. 6.16). Using the alternative short series provided larger estimates for the 'peaks in early 1980s, early and late 1990s, but it was less optimistic regarding the development in the most recent years. However, the conclusions about stock status and exploitation i.e. that the stock is well above B_{msy} and fishing mortality well below F_{msy} still stands. Further, as similar estimates of production potential was obtained from the different runs the perceived future effects of different catch options as described above also remained largely unchanged.

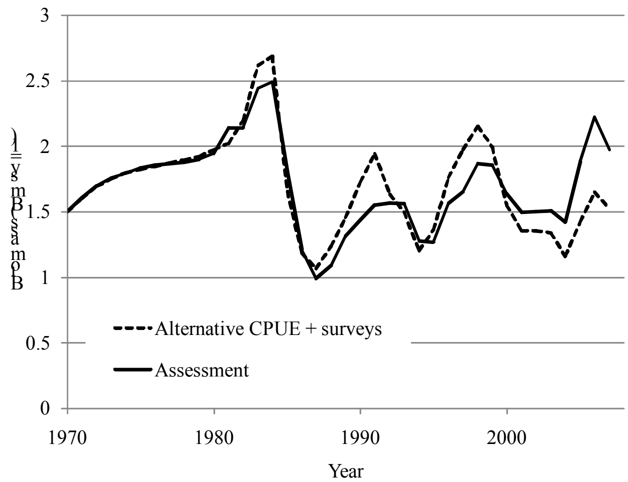


Fig. 6.16. Shrimp in the Barents Sea: Estimated median biomass trajectories 1970-2007 from 1) an exploratory run using an alternative short CPUE series (see text) and 2) the results from the original assessment run.

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 2% for 2007, given a projected 2007 catch of 28 000 t.

Biomass. Indices of stock size have increased from 2004 to 2006. A decrease of 18% was observed from 2006 to 2007. The estimated risk of stock biomass being below Bmsy at end 2007 was 3%, but less than 1% of being below B_{lim}.

Recruitment. Estimates of the abundance shrimp at 13-16 mm CL supposed to start entering the fishery in 2008 decreased from 2004 to 2005 and remained stable thereafter.

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 2007 is estimated to be well above B_{msy} and fishing mortality well below F_{msy}.

f) Research Recommendations 2008

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

- *NIPAG recommends that further studies be done to fully investigate the effects of the changes in the fleet on the standardised CPUE.*
- *a recruitment index and its link to subsequent fishable biomass should be considered for inclusion in the assessment model.,*
- *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.*

g) Research Recommendations from 2006 and comments

- *the existing ecosystem survey should be calibrated to the discontinued shrimp surveys.*

STATUS: An explicit calibration study will not take place. The assessment model is supposed to scale the two series. Further, a new study using already existing data will take place in advance of the 2008 assessment. This study may provide a basis for building an informative prior for the relative catchability and thus aid the model in bridging the two time series.

- *improve estimates of shrimp consumption, by cod and other predators, for inclusion in the model.*

STATUS: A study was presented (SCR Doc. 07/80) to investigate whether spatial patterns not accounted for in previous studies would improve the correlation between predation and shrimp stock dynamics.

- *a recruitment index and its link to subsequent fishable biomass should be considered for inclusion in the assessment model.*

STATUS: Ongoing work.

- *work on developing and evaluating assessment methods should be continued.*

STATUS: Ongoing work.

- *work be conducted on classifying, and on defining the fishing power of the different shrimp fishing gears.*

STATUS: A study was presented (SCR. Doc. 07/84) showing that GLM terms for 'fishing gear' (size of trawl) and 'vessel horse power' are correlated.

h) Management Recommendations

NIPAG **recommended** 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 (1st 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 ACFM. 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. 07/81, 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
Denmark	3 022	2 900	1 005	1 482	1 263	1 147	999	23	10	0
Norway	9	3	9		18	9	8	0	0	0
Sweden							1	0	0	0
UK (Scotland)	365	1 365	456	378	397	70		0	0	0
Total	3 396	4 268	1 470	1 860	1 678	1 226	1 008	23	10	0

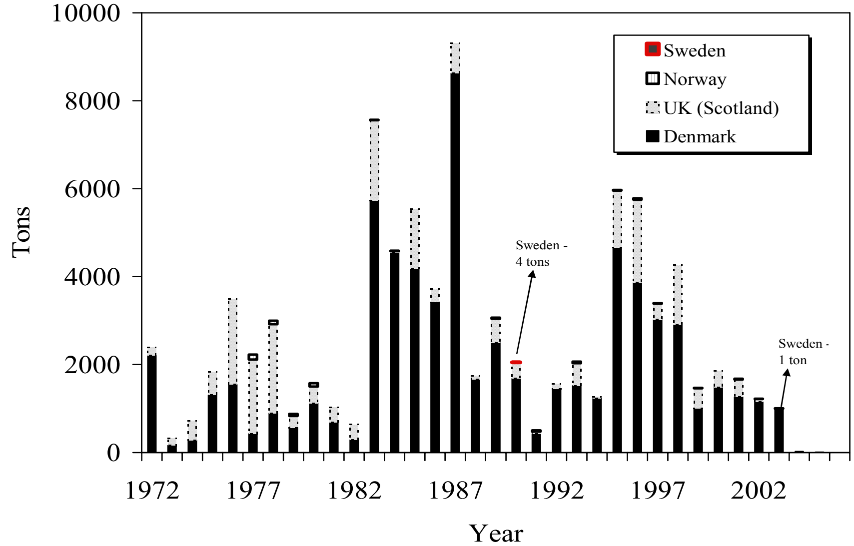


Fig. 7.1. Northern shrimp in Fladen Ground: Catches.

8) Northern Shrimp in the Farns Deeps (ICES Division 1Vb) – 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 (ICES CM Doc, No 2006/ACFM:10 Ref. G., 2005).

IV. OTHER BUSINESS

There was no other business

V. ADJOURNMENT

The NIPAG meeting was adjourned at 1350 hours on 1 November 2007.

APPENDIX I. AGENDA - NIPAG MEETING, 25 OCTOBER – 1 NOVEMBER 2007

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. Recommendations in 2006 and in 2007
2. Review of Catches

III. Stock Assessments

1. Northern shrimp on Flemish Cap (Div. 3M) – NAFO Assessed

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

3. Northern shrimp off West Greenland (SA 0 and 1) – NAFO Assessed

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

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

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

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

8. Northern shrimp in the Farns Deep (ICES Div. IVb) – ICES Assessed

IV. Other Business

V. Adjournment

ANNEX 1. Fisheries Commission's Request for Scientific Advice on Management in 2008 of Certain Stocks in Subareas 2, 3 and 4

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

   Northern shrimp in Div. 3M, 3LNO

   Greenland halibut in SA 2 and Div. 3KLMNO

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 2007 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 2006, advice was provided for 2007 and 2008 for cod in Div. 3M, American plaice in Div. 3M, yellowtail flounder in Div. 3LNO, witch flounder in Div. 3NO, thorny skate in Div. 3LNOPs and northern shortfin squid in SA 3+4.

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

- In 2007, advice will be 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 will be 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.
- 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, and northern shortfin squid in SA 3+4. These stocks will be next assessed in 2011.

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 by-catches 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_{2006} in 2008 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 2008 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 2007 Annual Meeting of the Fisheries Commission for all stocks under its responsibility requiring advice for 2008:

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. Noting the desire of NAFO to apply ecosystem considerations in the conservation and management of fish stocks in the NAFO area, the Scientific Council is requested to provide the Fisheries Commission at its next annual meeting in 2007 with an overview of present knowledge related to role of seals in the marine ecosystem of the Northwest Atlantic and their impact on fish stocks in the NAFO area, taking into account the work of other relevant organizations, including ICES and NAMMCO.

8. Whether the following measures on Redfish in Division 3O, if applied in the NAFO Regulatory Area, are effective, in particular, in regard to addressing bycatch of species such as American plaice and Cod as conservation and management measure:

- 90 mm mesh size
- Limiting the maximum permissible harvest of 15% (by number) of redfish 22cm or smaller, imposing 5% limit on the bycatch of any other groundfish species in the fishery
- Closure of fishing for a minimum of 10 days after reaching or exceeding of either the small fish or bycatch levels
- Re-opening of fishery through use of test fisheries

9. Regarding the precautionary closure to four seamount areas based on the ecosystem approach to fisheries (FC Doc. 06/5), using existing survey and commercial data from these seamount areas the Scientific Council is requested to provide the Fisheries Commission, at the 2007 Annual Meeting, recommendations on: 1) areas that could be fished on each seamount and, 2) a protocol for the collection of the data required to assess these seamounts, with a view to future recommendations on management measures for these areas.

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 2007 Annual Meeting of NAFO, subject to the concurrence of Denmark (on behalf of Greenland), provide advice on the scientific basis for management in 2008 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 asked therefore, subject to the concurrence of Denmark (on behalf of Greenland) as regards Subarea 1, to provide an overall assessment of status and trends in the total stock throughout its range and comment on its management in Subareas 0+1 for 2008, and to specifically:

   a) advise on appropriate TAC levels for 2008, separately, for Greenland halibut in the offshore area of Divisions OA+lAB and Divisions OB+lC-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_{2006} in 2008 and subsequent years should be evaluated in relation to precautionary reference points of both fishing mortality and spawning stock biomass. The present stock size and spawning stock size should be described in relation to those observed historically and those to be expected in the longer term under this range of fishing mortalities, and any other options Scientific Council feels worthy of consideration under the precautionary approach framework.

      Opinions of the Scientific Council should be expressed in regard to stock size, spawning stock sizes, recruitment prospects, catch rates and catches implied by these management strategies for the short and long term. Values of F corresponding to the reference points should be given. Uncertainties in the assessment should be evaluated and presented in the form of risk analyses related to B_{lim} (B_{buf}), and F_{lim} (F_{buf}), as per the NAFO Precautionary Approach Framework.

   b) For those stocks subject to general production-type assessments, the time series of data should be updated, the status of the stock should be reviewed and management options evaluated in the way described above to the extent possible. Management options should be within the NAFO Precautionary Approach Framework.

   c) For those resources for which only general biological advice 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 management options evaluated in the way described above to the extent possible. Management options should be within the NAFO Precautionary Approach Framework.

   d) Presentation of the results should include the following:

      I. For stocks for which analytical-type assessments are possible:

         - A graph of historical yield and fishing mortality for the longest time period possible;
         - A graph of spawning stock biomass and recruitment levels for the longest time period possible. The biomass graph should indicate the stock trajectory compared to B_{lim}
         - Graphs and tables of catch options for the year 2008 and subsequent years over a range of fishing mortality rates (F) at least from F=0 to $F_{0.1}$ including risk analyses;
         - Graphs and tables showing spawning stock biomass corresponding to each catch option including risk analyses;
         - Graphs showing the yield-per-recruit and spawning stock per recruit values for a range of fishing mortalities.

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

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

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

    1) to advise on appropriate TAC levels for 2008, 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+ Divs. 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 Subareas 0 and 1

1. In the Scientific Council report of 2006, 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 continue to monitor the status of Roundnose grenadier in Subarea 0+1 annually and, should significant change in stock status be observed (e.g. from surveys), the Scientific Council is requested to provide updated advice as appropriate.

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 2006 given for 2006-2008. Denmark, on behalf of Greenland, requests the Scientific Council to continue to monitor the status of Redfish (*Sebastes* spp.) and other finfish in Subarea 0+1 annually and, should significant change in stock status be observed (e.g. from surveys), the Scientific Council is requested to provide updated advice as appropriate.

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 2008, and as many years forward as data allow.

4. Advice for Greenland halibut in Subarea 1A inshore was in 2006 given for 2006-2008. Denmark, on behalf of Greenland, requests the Scientific Council to continue to monitor the status of Greenland halibut in Subarea 1A inshore annually and, should significant change in stock status be observed (e.g. from surveys), the Scientific Council is requested to provide updated advice as appropriate.

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 2007 to provide advice on the scientific basis for management of Northern shrimp (*Pandalus borealis*) in Subarea 0 and 1 in 2008, and as many years forward as data allow.

    Further, the Council is requested to advise, in co-operation with ICES, on the scientific basis for management of Northern shrimp (*Pandalus borealis*) in Denmark Strait and adjacent areas east of southern Greenland in 2008, 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. 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 by-catches 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 F0.1 and F2007 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 F0.1 to Fmax;
- 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 BMSY)
- yield/biomass ratio as a proxy for fishing mortality (both absolute and relative to FMSY)
- 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, F0.1 and Fmax 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 Blim, and Flim 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 Blim or Bbuf. 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 by-catch 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 5. ToRs for ICES Stocks

2006/2/ACFM10 The Pandalus Assessment Working Group [WGPAND])Chair: M. Aschean, Norway) will meet from 24 October – 1 November 2007 in Dartmouth, Canada, to:

a) Assess the status of and provide management options for 2008 for the stocks of *Pandalus borealis* in the Barents Sea, the North Sea, Skagerrak, and Kattegat and, taking prdation mortality on *Pandalus* stocks into account;

b) For the stocks mentioned in a) perform the tasks described in C.Res. 2ACFM01.

ToRs are to be reviewed after the meeting in 2007 back-to-back with NAFO Sc.C./STACFIS Pandalus meeting.

APPENDIX II. TECHNICAL MINUTES FROM THE ICES ACFM REVIEW GROUP FOR THE 2007 WGPAND REPORT

1–5 November 2007 (by correspondence)

Martin Pastoors	Chair
Michaela Aschan	Chair of WGPAND
Unnur Skuladottir	Member
Max Cardinale	Member

General

The structure of the report was changed last year, and the report refers much more to the working documents. The WG uploaded the working documents on an earlier stage than last year, which was helpful.

Trends in commercial CPUE (LPUE) are discussed for both stocks. Some questions were raised on the details on the method of standardisation (Barents Sea) or 'adjustment' (Danish IVa East & IIIa) ? The review group recommends to harmonize the terminology and the methodological approaches for effort standardization for the two stocks.

Like last year, trends in the surveys and CPUE are compared in one figure (e.g. Figure 6.5), although the surveys have not been calibrated to each other. The text gives some warning to this effect but the RG thinks it not a good idea to mix the graphs. Showing three different graphs would be preferable and this was implemented in the ACFM summaries

Effort standardization

The RG has problems with the standardization for the gear size effect when comparing CPUE/LPUE. This was done using a GLMZ while gear size effect should have been scaled out using gear size (i.e swept area) before the GLMZ analysis. Unfortunately, the lack of appropriate data prevents this.

The residual analysis of the CPUE standardization and the rationale for using a normal distribution are poor. The logn transformation as used now can be avoided using an appropriate distribution (gamma or exponential, see Martin et al, 2006 and Minami et al, 2007). RG would like to see the residual analysis of the CPUE standardizations.

In order to evaluate the consistency of available information, assessment and advice, it is important that comparisons are made with previous WG meetings. E.g. the inclusion of last year's assessment methodology and advice for each stock would be useful.

Pandalus in IVa East and IIIa

Argumentation for exclusion of Norwegian CPUE series (data series is too short) is not thought convincing. RG concludes that it can be included anyway because it does have good coverage and matches the DK conclusions.

RG is not convinced with the use of harvest rate (only 2 year data) as an effort indicator. Agrees with WG to rather present this survey in a couple of years when it has sufficient results. RG prefers the use of Standardised effort instead of nominal effort.

The WG defines Pandalus trips as any trip where the landing value of Pandalus catches was larger than or equal to 50% of the total landing value of the trip. The RG would prefer to make the time series less conservative or at least to compare this with a time series with a smaller threshold (30%) or based on weight instead of value. This to test the sensitivity of the time series analysis on made assumptions. Also, using 50% of the value will eliminate trips/hauls with low catches and this will likely to make the time series hyperstable.

WG recommended that month or season variability should be included in the GLM as this is usually an important predictor of LPUE. The RG agrees fully with this recommendation.

RG congratulates the WG with the fact that the survey is now finally done in the most useful period as the WG had suggested (doc 81/07).

A table on biomass indices for species (potential bycatch and predators) occurring in the shrimp survey 2006-2008 should be provided.

The statement on recruitment in the conclusions is difficult to interpret. The only information about this is in figure 5.6 (main doc), and the RG thinks this should be referred to in the conclusions.

The state of the stock does not follow from the assessment. The text seems to mix state of the stock and remarks on methodology. The RG suggests that this should read: The LPUE based perception of stock fluctuation indicates slight variations since 2004. The survey based biomass index suggests an increase in 2007, and the recruitment to the fishery seems good.

RG would like to know what happened to the 1984-1987 years of the DK data. These data are missing in this year's graphs. The chair of the WG replied that the standardised Danish LPUE starts in 1987 as data resolution does not allow for standardisation further back in time.

WG concludes that lack of fisheries independent data prevents the use of the (further developed) Bayesian stock production model. RG notes that the WG does not give any recommendations to collect more data to improve this situation? Already last year, the RG recommended that: The WG should outline the assessment approach for the near future.

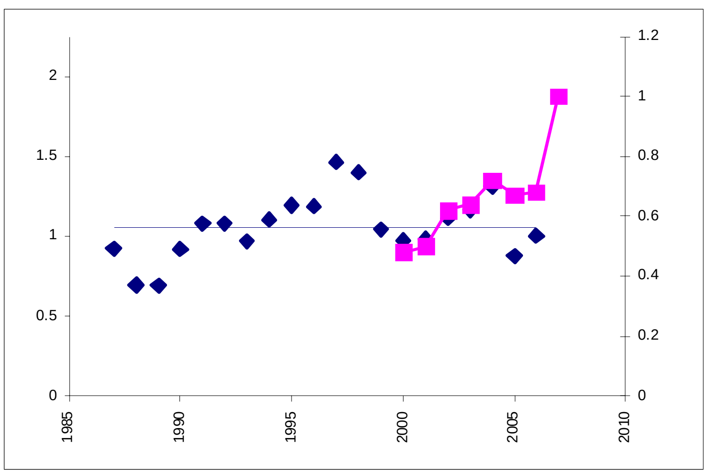


Figure: standardized trends in the Danish and Norwegian CPUE series. The Norwegian series is no longer used this year.

The figure above shows that the trends in the CPUE series is quite different if they are scaled on the same level for the first part of the 2000s. The RG acknowledges that the Norwegian CPUE series is no longer used as a reliable indicator in this years report. However, it was considered relevant last year. The WG is invited to better document the reason for the exclusion of the Norwegian CPUE and to comment on the apparent discrepancies between these two series.

***Pandalus* in the Barents Sea (Div I and II)**

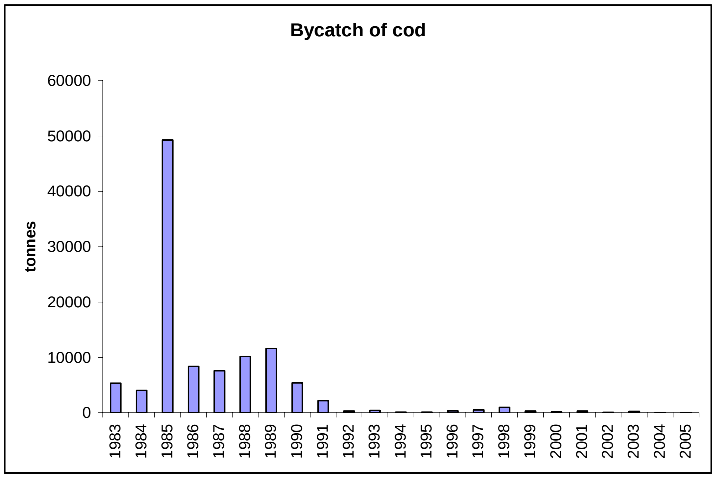
The approach presented by the WG is one based on a Bayesian surplus-production model. ..

Effort management: the WG concludes that the current management does not restrict effort. RG discusses if this can be called effort mgt. Maybe a 'no entry system' in the Svalbard economic zone would be more appropriate. Statistics on effort trends are needed anyhow.

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

The basis for the projected catch for 2007 is unclear. This is not a projection from the WG. The chair of the WG informed the RG that the fishing industry provided data up to the 30th of September and the catches of last three months were estimated using recent catch level and monthly catch previous years. This should be explained in next years report.

Presentation of bycatch information is much appreciated. RG suggests to insert a similar graph as for redfish next year



The Russian survey was not used in the assessment because this was discontinued in 2005 and it does not cover the whole area. However, it used to compare very well with the Norwegian survey.

The RG strongly recommends that the compiled data from the joined NO/RUS survey should be available for the WG from the beginning of September every year. Now the RUS data are lacking.

The phrasing of the periodicity of catches and surveys is too loose: Catch description: “Since the early 1980s, landings have varied in a cyclic manner with local minima and maxima separated by periods of 4-5 years”. Survey results: “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”.

There appears to be a major disagreement between the Norwegian survey and the CPUE data in 2004 when survey suggests decrease in stock and CPUE increase. Unfortunately the survey was discontinued/changed so that we do not know what would have happened afterwards. The new survey is very consistent with the CPUE information but the absolute scale of the stock is difficult to derive from the survey. Probably the signal in the stock is heavily driven by the CPUE information because that is the only one that covers the full time series.

Now the assessment uses the standardised CPUE, the Norwegian survey until 2004 and the new survey from 2004 onwards. The WG tried another run with shorter CPUE series (fig 6.16). The result shows great sensitiveness to the CPUE information and weighing. The RG misses the analysis of this sensitivity of the assessment to weighing factors.

The assumed natural mortality is not quantified. The fixed natural mortality is part of R, but mortality and its effect on growth rate cannot be readily extracted. It is estimated to be 2-4 times the catches, but no relationship in shrimp/cod densities can be proven. The RG would like this explanation to be part of the text.

The RG sees the use of the three different gear types as proxies for the estimate of the gear effect. However, using only trawl types increases the chance of overestimating CPUE. It would help to include wingspread or circumference (# meshes in belly of trawl) but since these data are not available, vessel size and hp’s may make a better proxy.

Conclusion

Table with the residuals from surveys was very helpful. Assessment consistent with last year. Useful diagnostics presented.

RG advises the WG to explore the reference points in the light of the ICES approach to pa reference points.

The WG is also invited to explore a calibration of the old and new surveys using overlap in areas so that both can be used in the future

***Pandalus* in the Fladen Grounds**

No comments

References

Martin, T.G. Wintle, A.B. Rhodes, J.R. Kuhnert, P.M. Field, S.A. Low-Choy, S.J. Tyre A.J. Possingham, H.P. 2006. Zero tolerance ecology: improving ecological inference by modelling the source of zero observations. Ecol. Lett. 8: 1235–1246.

Minami, M., Lennert-Cody, C.E., Gao, W. and Roman-Verdesoto, M. 2007. Modelling shark by-catch: the zero-inflated negative regression model with smoothing. Fish. Res. 84: 210–221.

APPENDIX III. LIST OF RESEARCH AND SUMMARY DOCUMENTS, 25 OCTOBER – 1 NOVEMBER 2007

Scientific Council Research Documents (SCR)

N5451	SCR 07/66	Michael C.S. Kingsley	Catches of Northern Shrimp (*Pandalus borealis*) off West Greenland, 1999–2006.
N5452	SCR 07/67	Michael C.S. Kingsley	Effect of Changing the Cod Series on a Bayesian Production Model for West Greenland Shrimp.
N5454	SCR 07/68	H. Siegstad	An assessment of the shrimp stock in Denmark Strait/off East Greenland – 2007
N5455	SCR 07/69	Michael C.S. Kingsley	The Fishery for Northern Shrimp (*Pandalus borealis*) off West Greenland, 1970-2007
N5456	SCR 07/70	Michael C.S. Kingsley	A Provisional Assessment of the Shrimp Stock off West Greenland in 2007
N5457	SCR 07/71	B. Bergstrom	Results of the Greenland Bottom Trawl Survey for Northern shrimp (*Pandalus borealis*) off West Greenland (NAFO Sub area 1 and Division 0A), 1988-2007
N5458	SCR 07/72	U. Skúladóttir	Revised CPUE in Icelandic Shrimp Fishery at Flemish Cap in 2004-2006
N5459	SCR 07/73	Kaj Sünksen	A preliminary estimate of Atlantic cod (*Gadus morhua*) biomass in West Greenland offshore waters (NAFO Subarea 1) for 2007 and recent changes in the spatial overlap with Northern shrimp (*Pandalus borealis*)
N5460	SCR 07/74	C. Hvingel and T. Thangstad	The Norwegian fishery for northern shrimp (*Pandalus borealis*) in the Barents Sea
N5461	SCR 07/75	C. Hvingel and T. Thangstad	Research survey information regarding northern shrimp (*Pandalus borealis*) in the Barents Sea
N5462	SCR 07/76	C. Hvingel.	An assessment of the shrimp (Pandalus borealis) stock in the Barents Sea
N5463	SCR 07/77	J. M. Casas	The Spanish Shrimp Fishery on Flemish Cap (Division 3M) and Division 3L in 2006
N5464	SCR 07/78	J. M. Casas	Northern Shrimp (*Pandalus borealis*) on Flemish Cap Surveys 2007
N5465	SCR 07/79	J. M. Casas	Northern Shrimp (*Pandalus borealis*, Krøyer) from Spanish Bottom Trawl Survey 2006 in NAFO Divisions 3LNO
N5466	SCR 07/80	Johannesen, E., Hvingel, C., Aschan, M. and B. Bogstad	Survey based estimation of consumption: spatial and seasonal aspects of cod predation on shrimp
N5467	SCR 07/81	Munsch-Petersen, Eigaard, Søvik and Ulmestrand	The *Pandalus* Stock in Skagerrak and the Norwegian Deep (Divisions IIIa and Iva East)
N5468	SCR 07/82	G. Søvik and T. Thangstad	The Norwegian Fishery for Northern Shrimp (*Pandalus borealis*) in Skagerrak and the Norwegian Deep (ICES Divisions IIIa and IVa east), 1970-2007
N5469	SCR 07/83	G. Søvik and T. 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 2006 and 2007
N5470	SCR 07/84	Ole Ritzau Eigaard and Sten Munch-Petersen	LPUE standardisation of The Danish Pandalus fishery in Skagerrak and the Norwegian Deep
N5471	SCR 07/85	Ajiad A., Aglen, A. and Nedreaas K.	Bycatch Estimates of Redfish (*Sebastes* spp.) in the Norwegian Barents Sea Shrimp Fisheries During 1983-2002
N5472	SCR 07/86	Ajiad , A., Aglen, A., Nedreaas K. and Kvamme, C	Cod bycatches in the Barents Sea shrimp fishery during 1983-2005

N5473	SCR 07/87	Kvamme, C., Ajiad, A., Aglen, A. and Nedreaas, K.	Estimated bycatch of haddock (*Melanogrammus aeglefinus*) and Greenland halibut (*Reinhardtius hippoglossoides*) in the Barents Sea shrimp fishery during 2000-2005
N5474	SCR 07/88	Kaj Sünksen	Discarded by-catch in shrimp fisheries in Greenlandic offshore waters 2006-2007
N5475	SCR 07/89	M. Casas	Assessment of the International Fishery for Shrimp (*Pandalus borealis*) in Division 3M (Flemish Cap), 1993-2007
N5481	SCR 07/90	Campanis, G. and A. B. Thompson	Analysis of Shrimp Fishing Effort Using VMS data.
N5482	SCR 07/91	D.C. Orr, P.J. Veitch and D.J. Sullivan.	Update of information pertaining to Northern Shrimp (*Pandalus borealis*, Kroyer) and Groundfish in NAFO Divisions 3LNO

Scientific Council Summary Documents (SCS)

SCS No.	Serial No.	Author(s) and Title
SCS 07/24	N5476	SC Report
SCS 07/25	N5477	NIPAG Report

APPENDIX IV. LIST OF REPRESENTATIVES, ADVISERS/EXPERTS AND OBSERVERS

NAFO Participants

CANADA

W. (Bill) B. Brodie.	DFO, Science Branch, P.O. Box 5667 St. John's, NL A1C 5X1 Canada	Tel +709-772-3288 brodieb@dfo-mpo.gc.ca
David C. Orr	DFO, Science Branch, P.O. Box 5667 St. John's, NL A1C 5X1 Canada	Tel +709-772-7347 orrd@dfo-mpo.gc.ca
Don Power	DFO, Science Branch, P.O. Box 5667 St. John's, NL A1C 5X1 Canada	Tel +709-772-4935 powerd@dfo-mpo.gc.ca
Katherine Skanes	DFO, Science Branch, P.O. Box 5667 St. John's, NL A1C 5X1 Canada	Tel +709 772-8437 skanesk@dfo-mpo.gc.ca
Don Stansbury	DFO, Science Branch, P.O. Box 5667 St. John's, NL A1C 5X1 Canada	Tel +709 772-0559 stansburyd@dfo-mpo.gc.ca

DENMARK (in respect of Faroe Islands and Greenland)
GREENLAND

Helle Siegstad	Greenland Institute of Natural Resources, P. O. Box 570, DK-3900 Nuuk, Greenland	Tel +299 36 1200 helle@natur.gl
Bo Bergström	Greenland Institute of Natural Resources P. O. Box 570, DK-3900 Nuuk Greenland	Tel +299 36 1203 bobe@natur.gl
Michael C.S. Kingsley	Greenland Institute of Natural Resources, P. O. Box 570, DK-3900 Nuuk Greenland	Tel +299 36 1200 mcsk@natur.gl
Nikoline Ziemer	Greenland Institute for Natural Resources P.O. Box 570, DK-3900 Nuuk Greenland	Tel +299 361200 nizi@natur.gl

EUROPEAN UNION (EU)

Jose Miguel Casas Sanchez	Instituto Español de Oceanografía, P.O. Box 1552, Vigo Spain	Tel: +34 986 49 2111 mikel.casas@vi.ieo.es
Silver Sirp	Estonian Marine Institute, University of Tartu, Maealuse 10A, 12618 Tallinn, Estonia	Tel +372 5295396 Silver.sirp@ut.ee

ICES Participants

Michaela Aschan	Norwegian College of Fisheries Science University of Tromsø, Dept of Aquatic Biosciences, Beivika, 9037 Tromsø Norway	Tel +47 99261 458 michaela.aschan@imr.no
Carsten Hvingel	Institute of Marine Research PO Box 6404, N-9294 Tromsø Norway	Tel +47 77609750 carstenh@imr.no
Sten Munch-Petersen	Danish Institute for Fishery Research (DIFRES), Charlottenlund Slot DK-2920 Charlottenlund Denmark	Tel +45 33063390 smp@difres.dk
Ole Ritzau Eigaard	Danish Institute for Fishery Research (DIFRES), Charlottenlund Slot DK-2920 Charlottenlund Denmark	Tel +45 33063390 ore@difres.dk
Guldborg Søvik	Havforskningsinstituttet Postboks 1870 Nordnes, 5817 Bergen Norway	Tel +47 55 23 85 00 guldborg.soevik@imr.no

Trond Thangstad	Institute of Marine Research PO Box 6404, N-9294 Tromsø Norway	Tel +47 77609741 trond@imr.no
Mats Ulmestrand	National Board of Fisheries Institute of Marine Research Box 4, SE-453 21 Lysekil Sweden	Tel +46 52318700 mats.ulmestrand@fiskeriverket.se

NAFO SECRETARIAT

Johanne Fischer	Executive Secretary	jfischer@nafo.int
Anthony Thompson	Scientific Council Coordinator	athompson@nafo.int
Barbara Marshall	Information Manager	bmarshall@nafo.int
Lisa Pelzmann	Office Manager	lpelzmann@nafo.int
George Campanis	IT Manager	gcampanis@nafo.int
Stan Goodick	Senior Finance Officer & Staff Administrator	sgoodick@nafo.int
Barry Crawford	Senior Publication Manager	bcrawford@nsfo.int
Ricardo Federizon	Fisheries Commission Coordinator	rfederizon@nafo.int
Bev McLoon	Personal Assistant	bmcloon@nafo.int
Cindy Kerr	Fisheries Information Manager	ckerr@nafo.int
Natalia Alonso	Data Entry	nalonso@nafo.int