PART C

Scientific Council Meeting, 27 October-4 November 2004

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Participants, Scientific Council Meeting, 27 Octdober-4 November 2004 at ICES Headquarters, Copenhagen, Denmark.

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Chairs and Designated Experts

Left to Right: Dave Orr (Shrimp Div. 3LNO), Hilario Murua (STACFIS Chair), Carsten Hvingel (Shrimp SA 0+1 and Denmark Strait), Unnur Skuladottir (Shrimp 3M) Joanne Morgan (SC Chair) and Munch Pederson (Chair of WPPAND).

Scientific Council Meeting, 27 October-4 November 2004: In Session.

REPORT OF SCIENTIFIC COUNCIL MEETING

27 October-4 November 2004

Chair: M. Joanne Morgan Rapporteur: Various

I. PLENARY SESSIONS

The Scientific Council met at ICES Headquarters, Copenhagen, Denmark, during 27 October-4 November 2004, in conjunction with the Pandalus Working Group of ICES (WGPAND) in accordance with the Scientific Council Meeting decisions of November 2003 and June 2004. Representatives attended from Canada, Denmark (in respect of Faroe Islands and Greenland), Estonia, European Union (Denmark, Spain, Sweden), Iceland, Norway and Russian Federation.

The Executive Committee, the Designated Experts and Chair of WGPAND met briefly before the opening to discuss the plan of work.

The opening session was called to order at 0945 hours on 27 October 2004.

The Council noted that STACFIS would undertake the assessments of the stocks (see Appendix I), while the prognoses and advice would be undertaken by the Council. Some joint sessions would also be held in conjunction with WGPAND

The Provisional Agenda was considered and **adopted** with editorial changes (see Part D, this volume).

The session was adjourned at 1030 hours.

The Council welcomed STACFIS to conduct its business through 27 October-2 November 2004, noting most of the Council's work would be addressed through 3-4 November 2004.

The concluding session was convened at 0930 hours on 4 November 2004. The Council addressed the requests of the Fisheries Commission and the Coastal States and considering the results of the assessments, provided advice and recommendations.

The Council then considered and **adopted** the STACFIS Report, and considered its own report and **adopted** the report of this meeting of 27 October- 4 November 2004.

The meeting was adjourned at 1230 hours on 4 November 2004.

The Report of Standing Committee on Fisheries Science (STACFIS) as **adopted** by the Council is given at Appendix I.

The Agenda, List of Research (SCR) and Summary (SCS) Documents, and List of Representatives and Advisers/Experts of this meeting are in Part D, this volume.

The Council's considerations on the Standing Committee Report, and other matters addressed by the Council follow in Sections II-IV.

II. FISHERIES SCIENCE

The Council **adopted** the Report of Standing Committee on Fisheries Science (STACFIS) as presented by the Chair, Hilario Murua. The full report is given at Appendix I.

The Council's summary sheets and conclusions on Northern shrimp in Div. 3M, Northern shrimp in Div. 3LNO, Northern shrimp in Subareas 0 and 1 and Northern shrimp in Denmark Strait and off East Greenland are presented in Section III of this report. The recommendations with respect to stock advice appear therein.

The research **recommendations** from this meeting as **endorsed** by the Council are as follows:

1. **For Northern Shrimp in Division 3M**

   - *biological and CPUE data from all fleets fishing for shrimp in the area, be submitted to Designated Experts by 1 September 2005.*

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

2. **For Northern Shrimp in Divisions 3LNO**

   - *sensitivity analyses be conducted to determine whether Ogmap is an appropriate method to determine Div. 3LNO shrimp biomass/abundance indices and population adjusted length frequencies from stratified random surveys.*

   - *biological and CPUE data from all fleets fishing for shrimp in the area, be submitted to the designated expert, in the standardized format, by 1 September 2005.*

3. **For Northern Shrimp in Subareas 0 and 1**

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

   - *the time series of cod biomass used as input in the shrimp assessment model be re-evaluated.*

   - *time series of recruitment (index of age 2 abundance) and its link to the fishable biomass in a later year be considered for inclusion in the shrimp assessment model*

4. **For Northern Shrimp in Denmark Strait and off East Greenland**

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

III. MANAGEMENT ADVICE AND RESPONSES TO SPECIAL REQUESTS

1. **Responses to Fisheries Commission**

   a) **Advice on TAC and Other Management Measures**

   The Scientific Council reviewed the STACFIS assessments of Northern shrimp in Div. 3M and Div. 3LNO, and the agreed summaries are as follows:

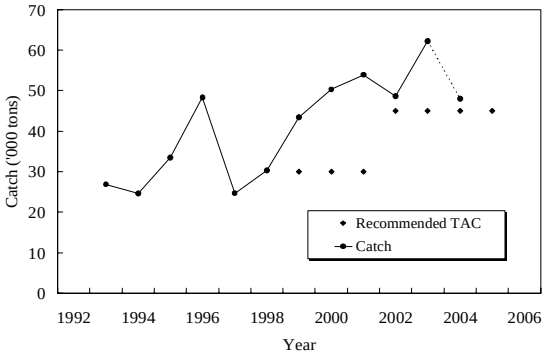
Northern Shrimp (Pandalus borealis) in Division 3M

Background: The shrimp fishery in Div. 3M began in late-April 1993. Initial catch rates were favourable and, shortly thereafter, vessels from several nations joined. Since 1993 the number of vessels ranged from 40-110. In 2004 there were approximately 50 vessels fishing shrimp in Div. 3M.

Fishery and catches: This stock is under effort regulation. Recent catches were as follows.

	Catch ('000 tons)		TAC ('000 tons)	
Year	STACFIS	21A	Recommended	Agreed
2001	54	51[1]	30	er
2002	49	48[1]	45	er
2003	62	62[1]	45	er
2004	48[2]		45	er
2005			45	er

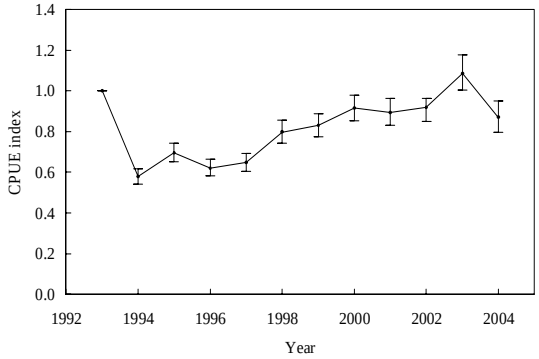
[1] Provisional.
[2] Projected to the end of 2004.
er Effort regulations.



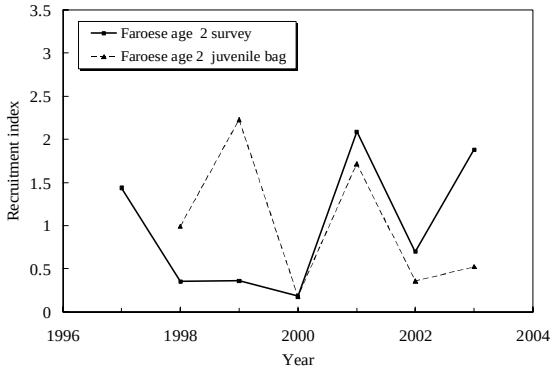
Data: Catch, effort and biological data were available from several Contracting Parties. A standardized CPUE index was developed to account for changes in gear (single, double and triple trawl), fishing power and seasonality. Time series of size and sex composition data were available from three countries and survey indices were available from Faroese (1997-2003) and EU research surveys (1988-2004). A new research vessel was introduced in the EU survey in 2003. The biomass indices have been converted for years 2003 and 2004.

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

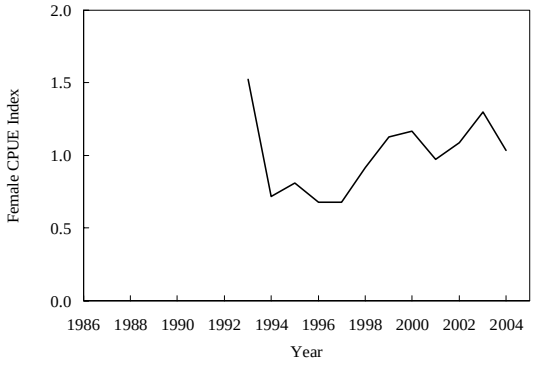
CPUE: Standardized catch rates declined between 1993 and 1994, varied without a trend to 1997, increased to 2003, and declined in 2004.

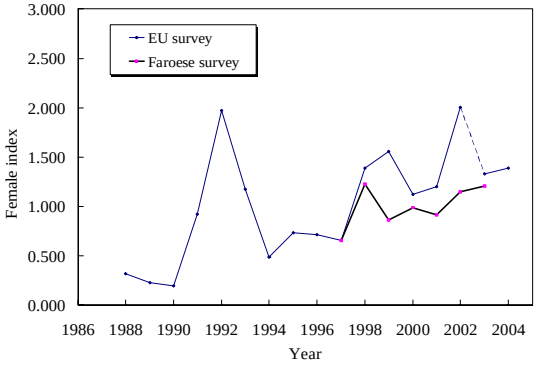


Recruitment: The 2000 year-class appears weak. Based both on survey and commercial fishery data the 2001and 2002 year-classes appear to be above average.



SSB: All indices of female biomass increased from 1997 or 1998 and have fluctuated without a trend since then.

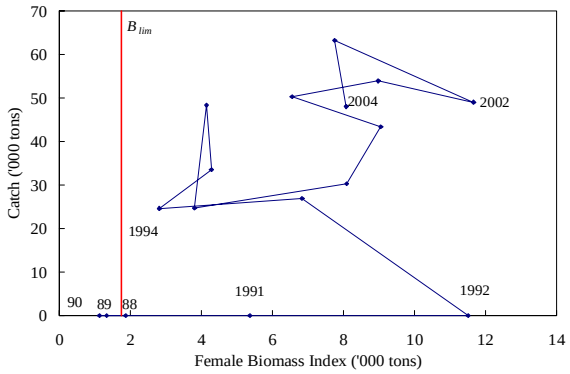




State of the Stock: Stock size indicators have been stable since 1998. The 2001and 2002 year-classes are both above the average and are likely to contribute to the fishery in 2005 and 2006.

Recommendations: The stock appears to have sustained an average annual catch of about 48 000 tons since 1998 with no detectable effect on stock biomass. Of the year-classes that will be the main contributors to the fishery over the next few years, the 2000 year-class seems weak and the 2001 and 2002 year-classes appear above average. The Scientific Council advises a catch of 48 000 tons for 2006.

Reference Points: Scientific Council considers that 15% of the maximum survey female biomass index is a limit reference point for biomass (B_{lim}) for northern shrimp in Div. 3M. It is not possible to calculate a limit reference point for fishing mortality. Currently, the biomass is estimated to be well above B_{lim}.



Special comments: This advice will be reviewed based on updated information in September 2005.

Sources of Information: SCR Doc. 04/77, 78, 82, 84, 89, SCS 04/12.

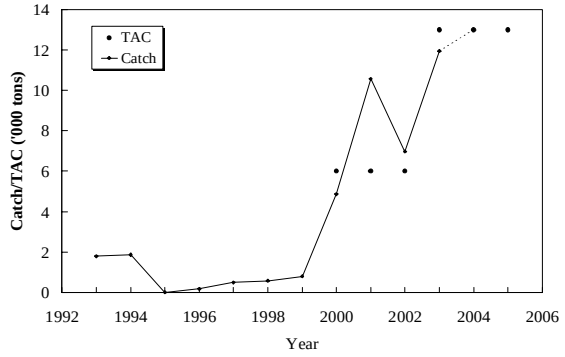
Northern Shrimp (Pandalus borealis) in Divisions 3L, 3N and 3O

Background: Most of this stock is located in Div. 3L and exploratory fishing began there in 1993. The stock came under TAC regulation in 2000, and fishing was restricted to Div. 3L.

Fishery and catches: Twelve nations participated in the fishery in 2004. The use of a sorting grid to reduce by-catches of fish is mandatory for all fleets in the fishery. Recent catches from the stock are as follows:

	Catch ('000 tons)		TAC ('000 tons)	
Year	STACFIS	21A	Recommended	Agreed
2001	11	5[1]	6	6
2002	7	6[1]	6	6
2003	12	11[1]	13	13[3]
2004	13[2]		13	13[3]
2005			13	13

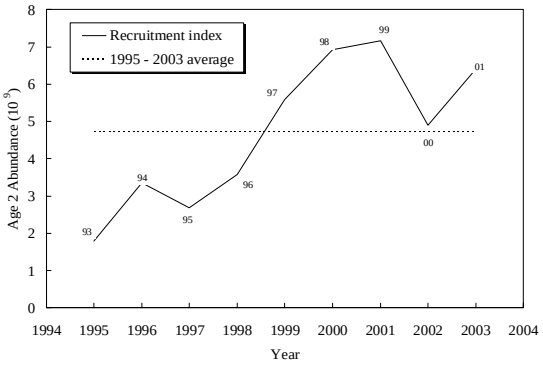
[1] Provisional.
[2] Projected to the end of 2004.
[3] Denmark (in respect of Faroe Islands and Greenland) set an autonomous TAC of 1 344 tons for 2003 and 2004.



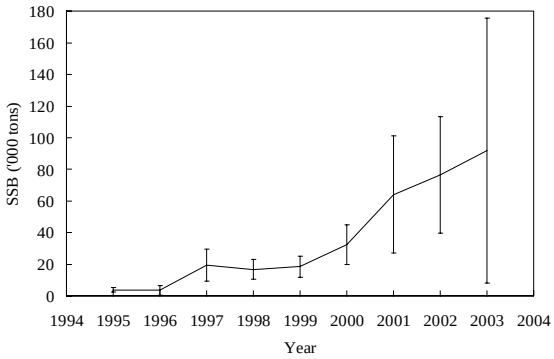
Data: Catch, effort and biological data were available from the commercial fishery. Biomass and recruitment indices and size and sex composition data were available from research surveys conducted in Div. 3LNO during spring (1999 to 2004) and autumn (1995 to 2003).

Assessment: No analytical assessment is available. Evaluation of the status of the stock is based upon interpretation of commercial fishery and research survey data.

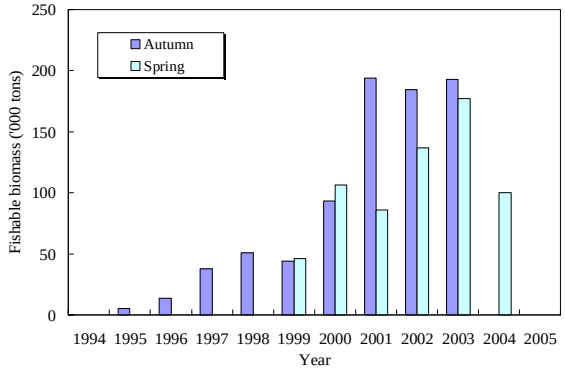
Recruitment: The 1998 and 1999 year-classes are the two strongest year-classes in the short time series. They are followed by the 2000 year-class which was slightly above average and the 2001 year-class which was the third strongest in the time series.

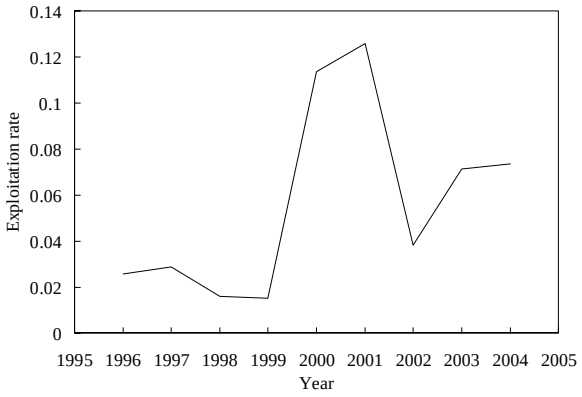


Biomass: There was a significant increase in SSB and total biomass between 1995 and 1997 followed by a period of stability between 1997 and 1999. Autumn SSB and total biomass indices have been at a higher level since 2000.



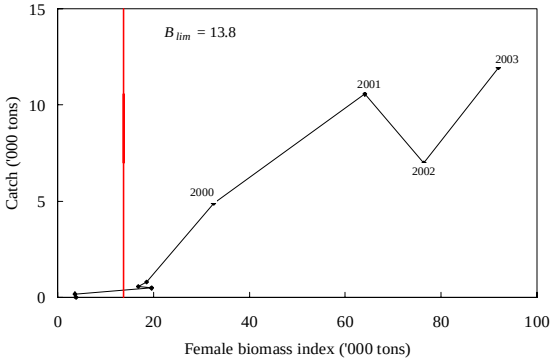
Fishable biomass and exploitation: In general, the fishable biomass has been increasing over time. The exploitation index (catch/autumn fishable biomass) increased during 2000-2001, at the beginning of the fishery, and has decreased since then.





State of the Stock. There has been an increasing trend in SSB and recruitment since 1999. The stock appears to be well represented by a broad range of size groups, and the exploitation index is low.

Precautionary Approach Reference Points: Scientific Council considers that 15% of the maximum female biomass index of the Canadian autumn survey is a limit reference point for biomass (B_{lim}) for northern shrimp in Div. 3LNO. It is not possible to calculate a limit reference point for fishing mortality. Currently, the biomass is estimated to be well above B_{lim}.



Recommendation*:* The TAC, within an adjacent Canadian shrimp stock, has been about 12% of the fishable biomass since 1997. Applying this percentage to the inverse variance weighted average fishable biomass from the four most recent surveys results in a TAC of 22 000 tons. Therefore, Scientific Council recommends that the 2006 TAC should not exceed 22 000 tons and that this TAC should not be raised for a number of years to allow time to monitor the impact of the fishery upon the Div. 3LNO shrimp stock.

Survey	Fishable biomass ('000 tons)	Variance weighting factor
Autumn 2002	184	0.34136
Spring 2003	177	0.36223
Autumn 2003	193	0.27078
Spring 2004	99.8	0.02562

Scientific Council reiterated its recommendations that the fishery be restricted to Div. 3L and that the use of a sorting grate with a maximum bar spacing of 22 mm be mandatory for all vessels in the fishery.

Special Comments: Advice for the 2006 fishery will be reviewed at the September 2005 Scientific Council meeting, when results from the 2004 autumn and spring 2005 surveys will be available.

Sources of Information: SCR Doc. 04/78, 79, 80, 82, 85, 86, SCS Doc. 04/12.

b) **Responses to Special Requests from the Fisheries Commission**

Request on Shrimp in Divisions 3LNO

The Fisheries Commission with the concurrence of the Coastal States as regards shrimp in Div. 3LNO requested Scientific Council: *at its meeting of November, 2004 in review of the most recent data to provide advice concerning the scope for an adjustment to the TAC for 2005 from the currently advised level of 13 000 tons.*

At the current meeting, the Scientific Council advised that the TAC for 2006 for Div. 3LNO shrimp should not exceed 22 000 tons. This advice was based on a change in methodology, necessitated in part by the spring survey estimate in 2004 which has very high variability. Had this new method been used in 2003, it is likely that the catch figure calculated for 2005 would have been around 22 000 tons instead of the 13 000 tons actually advised. However, SC noted that the TAC recommendation for this stock has always included the advice that *"the development of any fishery in the Div. 3L area take place in a gradual manner with conservative catch limits imposed and maintained for a number of years in order to monitor stock response".* The initial TAC of 6 000 tons was in place for 3 years, but the current TAC of 13 000 tons has been in place only since the beginning of 2003. This period of less than 2 years has not been sufficient to determine the impact of the 13 000 ton catch level on the stock. If monitoring the stock response to a given level of TAC for a number of years continues to be an important consideration for Fisheries Commission, then the current TAC of 13 000 tons should be maintained in 2005. The Scientific Council advice for the 2006 TAC will be reviewed in September 2005 when results of the autumn 2004 and spring 2005 survey will be available.

2. **Responses to the Coastal States**

The Scientific Council reviewed the STACFIS assessments for Northern shrimp in Subareas 0 and 1 and in Denmark Strait and off East Greenland, and the agreed summaries are as follows:

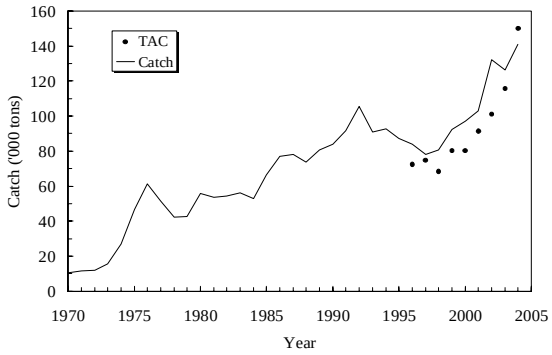
Northern Shrimp (Pandalus borealis) in Subareas 0 and 1

Background: A small-scale inshore fishery began in SA 1 during the 1930s. Since 1969 an offshore fishery has developed. The shrimp stock off West Greenland is distributed in Subarea 1 and Div. 0A east of 60°W.

Fishery and catches: The fishery is conducted by Greenland and Canada. Catch figures until 2003 of SA 1 were corrected for overpacking and product to live weight differences by applying a factor of about 1.23 (average). Recent catches from the stock are as follows:

	Catch ('000 tons)		TAC ('000 tons)	
Year	STACFIS	21A[1]	Recommended	Actual[2]
2001	102.8[3]	85.1	85.0	91.4
2002	132.2[3]	105.9	85.0	101.0
2003	126.5[3]	138.1	100.0	115.7
2004	141.0[4]		130.0	150.0

[1] Provisional.
[2] Total of TACs set by Greenland and Canada.
[3] Corrected for overpack.
[4] Projected to the end of 2004.



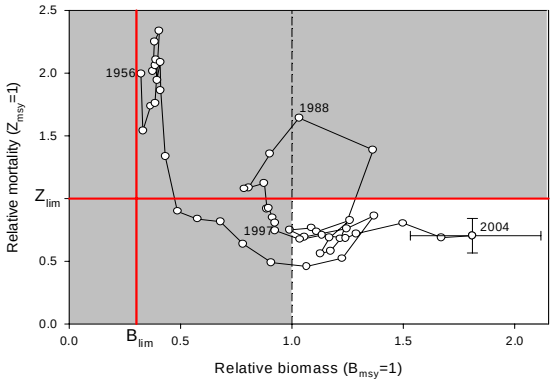
Data: Catch and effort data were available from all vessels. Time series of biomass and recruitment indices, size and sex composition data were available from research surveys. Series of cod biomass and cod consumption were available.

Assessment: An analytical assessment framework was used to describe stock dynamics in terms of biomass (*B*) and mortality (*Z*) relative to biological reference points.

The applied model was a stochastic version of a surplus-production model including an explicit term for predation by cod (*Gadus morhua*) and stated in a Bayesian framework.

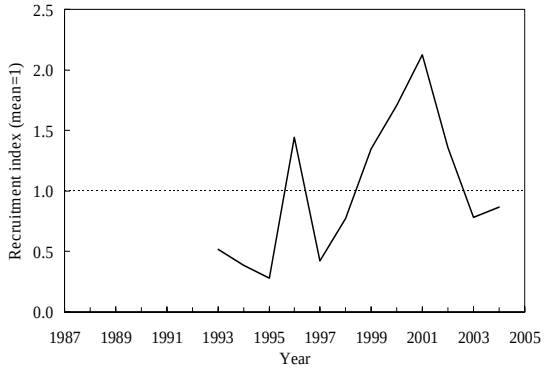
The reference points were: *MSY* (Maximum Sustainable Yield) which defines maximum production; B_{msy} which is the biomass level giving *MSY*; a precautionary limit reference point for stock biomass (B_{lim}) which is 30% B_{msy} and Z_{msy} which is the limit reference point for mortality (Z_{lim}).

Mortality: The mortality caused by fishing and cod predation (*Z*) has been stable well below the upper limit reference (Z_{msy}) since 1997. The estimated risk of current mortality exceeding Z_{msy} was less than 10%.



Biomass: Since the late-1990s the stock has increased and reached its highest level in 2004. The estimated risk of current stock biomass being below B_{msy} was less than 5% and less than 1% of being below B_{lim}.

Recruitment: A recruitment index (shrimp at age 2) decreased in 2002 and was below average in 2003 as well as in 2004, which may suggest a decline in fishable biomass after 2005.



State of the stock: The stock biomass has increased substantially since the late-1990s and reached its highest level in 2004. Biomass is well above B_{msy} and mortality by fishery and cod predation is well below Z_{msy}.

The abundance of males between 17 and 22 mm CL in 2004 is estimated to be high and should sustain good catch rates of larger shrimp in 2005. However, both model simulations of stock development and indices of

recruitment indicate that fishable biomass can be expected to follow a decreasing trend after 2005.

Recommendations: If catches exceed 130 000 tons in 2005 the risk of exceeding a mortality that is considered to be a limit reference point is greater than 17%. However, given that stock biomass is estimated to be considerably above B_{msy}, risk of stock biomass falling below this optimum level within a one-year perspective is low. Scientific Council therefore concludes that a total catch of around 130 000 tons in Div. 0A and SA 1 in 2005 will have a high probability of maintaining the stock within the safe zone.

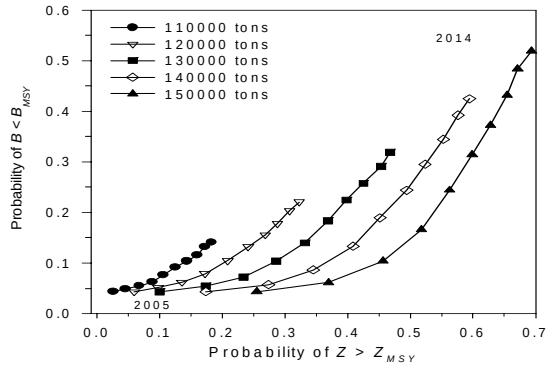
Risk associated with five optional catch levels for 2005 are as follows:

Catch option ('000 tons)	100	120	130	140	150
Risk of falling below B_{msy}	4%	5%	5%	6%	6%
Risk of falling below B_{lim}	<1%	<1%	<1%	<1%	<1%
Risk of exceeding Z_{msy}	5%	9%	17%	27%	37%

Medium-term Considerations: Ten-year projections of stock development were made using the assumption that the cod stock will remain at its low 2004 abundance. Five levels of annual catch: 110, 120, 130, 140 and 150 thousand tons were investigated.

With a catch of 130 000 tons/yr there is less than 10% risk of stock biomass falling below B_{msy} and less than 1% of falling below B_{lim} in the first three years. However, this level of exploitation might not be sustainable in the medium to longer term, as the estimated risk of falling below optimum biomass continues to increase through time.

Catches greater than 130 000 tons/yr are not likely to be sustainable in the medium to longer term.



Special Comments: The Scientific Council advice is based on catches in 2005 being reported correctly, accounting for overpack.

Both stock development and the rate at which changes might take place depend heavily on the abundance of predators (in particular cod) present within the shrimp habitat. In the most recent years slight increases in cod abundance have been registered. However, these estimates are well below those in the late-1980s and certainly in the 1950s and 1960s.

If the cod stock were to increase rapidly above the current level, as seen in the late-1980s, consumption could reach the same level as the current catches within a 3-4 year period. Such an event should, however, be detected by routine survey programs and management options can then be evaluated.

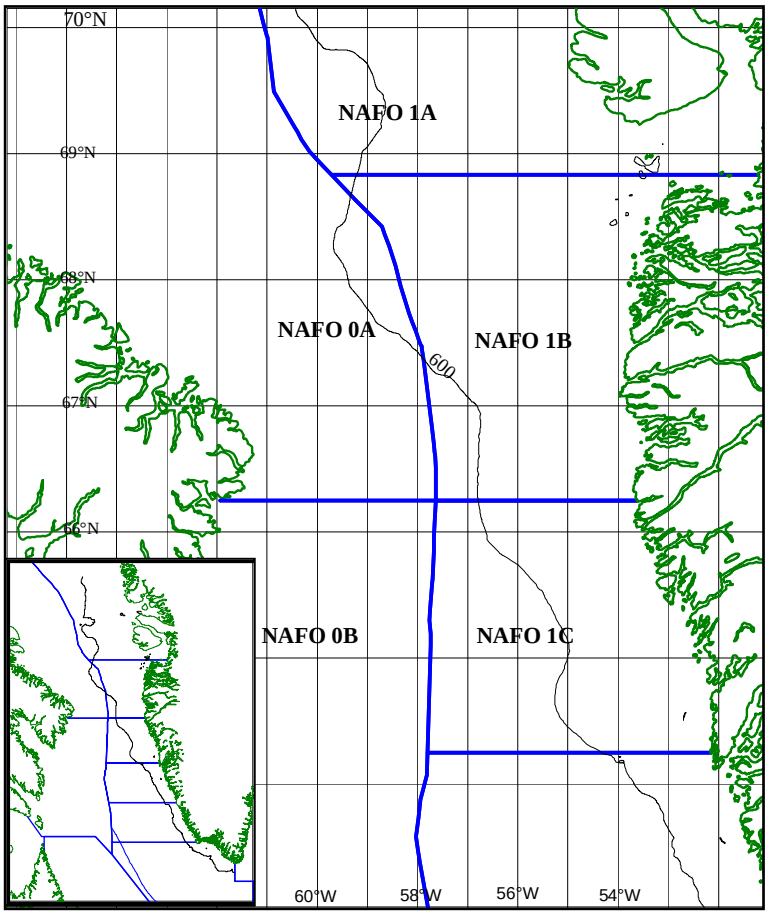
Sources of Information: SCR Doc. 02/158, 03/74, 04/70, 71, 72, 73, 74, 75, 76, SCS Doc. 04/12.

a) **Response to Special Request from the Coastal States**

Denmark (in respect to Faroe Islands and Greenland) had asked the Scientific Council: *to update on the distribution of Northern shrimp and provide advice on allocation of TACs to Subarea 0 and Subarea 1.*

The Scientific Council with respect to allocation of TACs to Subareas 0 and 1 responded (SCR Doc. 04/76):

The distribution area of the Northern shrimp stock off West Greenland includes Subarea 1, from Cape Farewell to 72°30 N and an adjacent small part of Div. 0A between 67°and 69°N, east of 60°W and shallower than 600 m (see map).



Surveys conducted by Greenland covered the distribution of Northern shrimp in Subarea 1 and Div. 0A, east of 60°W. The surveys carried out between 1994 and 2004 (with the exception of 2003) have consistent coverage, allowing estimations and comparisons of biomass distribution in the two areas. Annual estimates of biomass have inherent uncertainties and high variance. To minimize effects of these uncertainties the average and range for this period are calculated and used in the analysis. The average percentage of the biomass in Div. 0A was 1.6%, ranging from 0.1% to 4.1%. If TAC for shrimp in Subarea 1 and Div. 0A is split according to the average biomass distribution, the split would be 98.4% in Subarea 1 and 1.6% in Div. 0A. There is no information on the abundance of shrimp in Div. 0A outside of the survey area. Advice on allocation of TAC can be revised, if information on the distribution of shrimp changes.

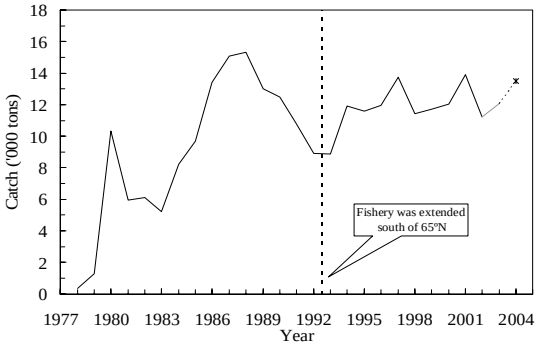
Northern shrimp (Pandalus borealis) in Denmark Strait and off East Greenland

Background: The fishery began in 1978 in areas north of 65°N in Denmark Strait, where it occurs on both sides of the midline between Greenland and Iceland. Areas south of 65°N in Greenlandic waters have been exploited since 1993.

Fishery and Catches: Five nations participated in the fishery in 2004. For this year's assessment catch figures until 2003 from the Greenland EEZ were corrected for overpack and product to live weight differences by applying a factor of about 1.24 (average). Recent catches and recommended TACs are as follows:

	Catch ('000 tons)		TAC ('000 tons)		
Year	STACFIS	21A[1]	Recom.	GR EEZ	ICE EEZ[2]
2001	13.9[3]	11.1	9.6	10.6	
2002	11.2[3]	9.2	9.6	10.6	
2003	12.1[3]	9.8	9.6	10.6	
2004	13.5[4]		12.4	15.6	

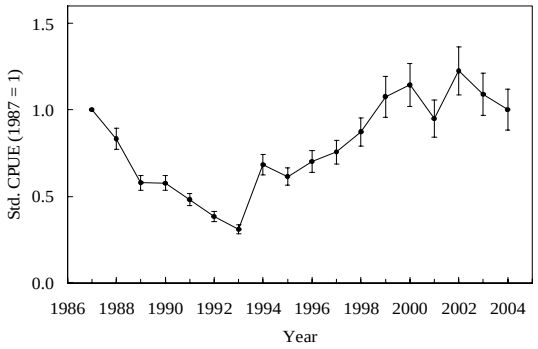
[1] Provisional catches.
[2] Fishery unregulated in Icelandic EEZ.
[3] Corrected for overpack.
[4] Projected to the end of 2004.



Data: Catch and effort data were available from trawlers of several nations. Surveys have not been conducted since 1996.

Assessment: No analytical assessment is available. Evaluation of the status of the stock is based on interpretation of commercial fishery data.

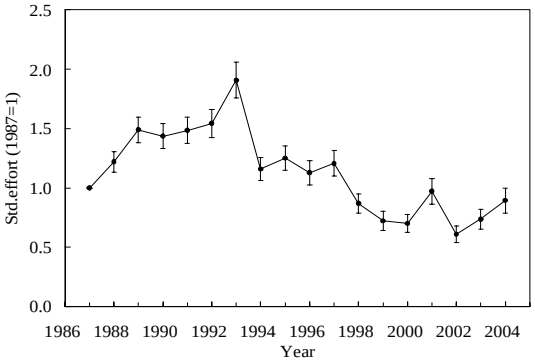
CPUE: Combined standardized CPUE indices for the total area declined from 1987 to 1993 and increased thereafter to approximately the same level in 2000-2004 as at the start of the time series in 1987.



Recruitment: No recruitment estimates were available.

Biomass: No direct biomass estimates were available.

Exploitation rate: From 1998 through 2004 an exploitation rate index (catch/CPUE) has been at its lowest levels in the 18-year series.



State of the Stock: Standardized CPUE data for all the areas combined indicate an increasing trend in fishable biomass from 1993 to 2000. The 2000 to 2004 values equal the relatively high values at which the series started in 1987.

Recommendation: Since 1994, annual catches have remained near the recently recommended TAC of 12 400 tons, while stock biomass indices have increased. This increase may not, however, have continued after 1999. Scientific Council therefore advises that catches of shrimp in Denmark Strait and off East Greenland should not exceed 12 400 tons in 2005.

Special Comments: The apparent increase in the advised TACs since 2004 is based on a revision of catch estimates to account for overpack and not on a comparable increase in stock production. The advice for 2004 and 2005 may therefore not be interpreted as if actual removals by the fishery should be increased

comparatively. The Scientific Council advice is based on catches in 2005 being reported correctly, accounting for overpack.

Sources of Information: SCR Doc. 03/74, 04/81, 83.

IV. OTHER MATTERS

1. **Scientific Council Meeting, October/November 2005**

The Scientific Council agreed to the dates 26 October to 3 November 2005 for this meeting to be held jointly with the ICES Pandalus Assessment Working Group (WGPAND) at the NAFO Headquarters, Dartmouth, Nova Scotia, Canada.

2. **Scientific Council Meeting, October/November 2006**

The Scientific Council agreed to that this meeting would be held jointly with the ICES Pandalus Assessment Working Group (WGPAND), at ICES Headquarters in Copenhagen, Denmark.

3. **Coordination with ICES Working Groups on Shrimp Stock Assessments**

This year's Scientific Council meeting was held jointly with the ICES Pandalus Working Group (WGPAND). Both groups felt that joint meetings would be of great benefit to the work of the groups. The purpose of such joint meetings is to provide greater peer review of the assessment of Pandalus stocks. In addition such meetings will allow the exchange of information on assessment methods and on shrimp population dynamics. Unfortunately this first attempt at a joint meeting was less than successful, with the number of joint sessions being far less than had been planned. Part of this problem was lack of crucial assessment data as well as poor information to the WGPAND members on these data problems prior to the meeting. As a result the meeting developed into parallel sessions with only few joint scientific sessions and this is not the optimal way for joint meetings to be held. However it was felt by both groups that this problem could be overcome in the future and that the success of future meetings would be enhanced by having preliminary assessments ready for all stocks at the beginning of the meeting.

It was agreed that a joint NAFO-ICES WGPAND should meet in October 2005. In order to facilitate future meetings the Chairs of Scientific Council, STACFIS and WGPAND will work together to prepare a proposal for a plan for future meetings. This proposal will first be reviewed by members of the two groups, intersessionally and then presented to Scientific Council at its June 2005 Meeting. In devising such a plan the Chairs will consider the merits of running the STACFIS/WGPAND section of the meeting under a single Chairmanship and they will also consider the possibility of incorporating review of methodological developments in future meetings.

4. **Other Business**

Assessment methodologies

At its November 2003 Meeting STACFIS noted the need for the development and review of the methodologies for stock assessment and proposed that the Chair of Scientific Council should initiate discussion on this matter. Council was informed that this matter was discussed during the September 2004 Meeting of Scientific Council where Council noted that there is often limited time for members of Council to become familiar with and thoroughly evaluate changes to assessment models or new methods during the normal course of the assessment meetings. One possible approach that was considered during the September 2004 Meeting was to hold a Special Session of Scientific Council on this matter in conjunction with the annual meeting on a regular basis, perhaps every second year. These sessions would provide an opportunity for 'benchmark' or 'comprehensive' assessments on selected stocks as well as the evaluation of the impact of changes to assessment methods or assumptions. However, such an approach would separate important considerations related to the assessments from the assessment process. As such Council decided that an attempt must be made to address these issues during the annual assessments during the June Meetings and the October/November Shrimp Meetings of Scientific Council.

V. ADOPTION OF REPORTS

The Council at its session on 4 November 2004 considered and **adopted** the Report of STACFIS (see Appendix I). The recommendations made by STACFIS and endorsed by the Scientific Council are given therein in Sections II and III above. The Council then considered and **adopted** its own Report of this 27 October-4 November 2004 Meeting.

VI. ADJOURNMENT

The Chair thanked the members of the Scientific Council for their contributions during this meeting, noting especially the work of the Designated Experts and the Chair of STACFIS. The Chair also thanked the NAFO Secretariat for their support during the meeting, both Barb Marshall for providing onsite support and Secretariat Staff providing support from Headquarters. Appreciation was extended to the ICES Secretariat for their support during the meeting. There being no other business, the meeting was adjourned at 1230 hours on 4 November 2004.

APPENDIX I. REPORT OF THE STANDING COMMITTEE ON FISHERIES SCIENCE (STACFIS)

Chair: Hilario Murua Rapporteur: Various

I. OPENING

The Committee met at ICES Headquarters, Copenhagen, Denmark, during 27 October-4 November 2004, in conjunction with the WGPAND of ICES in accordance with the Scientific Council Meeting decisions of November 2003 and June 2004, to consider and report on matters referred to it by the Scientific Council, particularly those pertaining to the provision of scientific advice on certain Northern shrimp stocks. Representatives attended from Canada, Denmark (in respect of Faroe Islands and Greenland), Estonia, European Union (Denmark, Spain and Sweden), Iceland, Norway and Russian Federation.

The Chair, Hilario Murua (EU/Spain), opened the meeting on 27 October 2004 welcoming the participants. The Agenda was reviewed and a plan of work developed for the meeting. The Provisional Agenda was adopted (see Appendix I).

II. GENERAL REVIEW

1. **Review of Recommendations in 2003 and 2004**

Recommendations in November 2003

Northern Shrimp (*Pandalus borealis*) in Division 3L, 3N and 3O

STACFIS had recommended *that biological and CPUE data from all fleets fishing for shrimp in the area, be submitted to Designated Experts by 1 October 2004.*

STATUS**:** Implemented, however, the data were not submitted in the standardized format.

Northern Shrimp (*Pandalus borealis*) in Division 3M

STACFIS had recommended *that biological and CPUE data from all fleets fishing for shrimp in the area, be submitted to Designated Experts by 1 October 2004*

STATUS**:** CPUE data were submitted only for 2 countries and the biological data in the standardized format by only one country.

STACFIS had recommended *that a more detailed conversion document including information on the geometry and behaviour of the trawls and detailed calculations of the conversion for shrimp be presented at the September 2004 meeting.*

STATUS**:** Implemented.

STACFIS had recommended *that indices of stock size be presented with error bars where possible.*

STATUS**:** No progress has been made.

Northern Shrimp (*Pandalus borealis*) in Subareas 0 and 1

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

STATUS**:** STACFIS again noted it has not been possible to get any information on which to base reliable assessments of age-, size- and sex composition and assessments of fecundity and frequency of spawning of the stock in Subarea 1.

Northern Shrimp (*Pandalus borealis*) in Denmark Strait and off East Greenland

STACFIS had recommended *that a survey series be established, to provide fishery independent data of the stock throughout its range.*

STATUS**:** No progress has been made.

STACFIS had recommended *that sampling of catches by observers – essential for assessing age, size, sex composition, fecundity and frequency of spawning of the stock – be re-established in the Greenland EEZ and improve in the Icelandic EEZ.*

STATUS**:** STACFIS again noted it has not been possible to get any information on which to base reliable assessments of age-, size- and sex composition and assessments of fecundity and frequency of spawning of the stock in both Greenland and Icelandic EEZ.

2. **Review of Catches of Shrimp**

STACFIS reviewed and agreed on the catch figures available for all stocks being assessed at this meeting during consideration of each relevant stock.

3. **Environmental Review**

Subarea 3

Stocks on the Flemish Cap, Division 3M: The water mass characteristics of the Flemish Cap area are formed from a mixture of Labrador Current Slope Water and North Atlantic Current Water. These water masses are warmer and saltier than the sub-polar waters of the Newfoundland shelf with temperature >3.5°C and salinities in the range of 34 to 34.8 parts per thousand. The general circulation in the vicinity of the Flemish Cap consists of the offshore branch of the Labrador Current which flows through the Flemish Pass on the Grand Bank side and a jet that flows to the east, north of the Cap, which then flows southward. To the south, the Gulf Stream flows to the northeast merging with the Labrador Current to form the North Atlantic Current which influences waters around the southern areas of the Cap. In the absence of strong wind forcing the circulation over the central Flemish Cap is dominated by a topographically induced anticyclonic gyre. The stability of this circulation pattern may influence the retention of ichthyoplankton on the bank and is probably a factor in determining the year-class strength of shrimp on the Cap. The circulation pattern during the summer of 2004 was dominated by the southward flowing Labrador Current to the east of the Cap indicating a reduced gyre circulation. Recent trends in temperature on the Flemish Cap indicate cold periods during the 1970s, mid-1980s and the late-1980s to the mid-1990s and generally warm conditions during the latter half of the 1990s. During the summer of 2003 temperatures directly over the Cap were highly variable while adjacent areas showed significant positive anomalies and during 2004 temperatures continued to increase to above normal values. Near bottom temperatures over the Cap during 2004 were >4°C, which was above normal, particularly over the shallow areas of the Cap. The trend in salinity during the latter half of the 1990s ranged from slightly above normal at the surface to near-normal at deeper depths. Annual salinity anomalies in 2003 and 2004 continued the increase over all depths reaching >0.5 above normal in the near-surface waters.

Stocks on the Grand Bank, Divisions 3LNO: The water mass characteristics on the Grand Bank are typical cold-intermediate-layer (CIL) waters which extend to the bottom in northern areas (Div. 3L) with average bottom temperatures generally <0°C during spring through to autumn. The winter formed CIL water mass is a reliable index of ocean climate conditions in this area. Bottom temperatures in the southern areas of the Grand Bank (Div. 3NO) are warmer than those in 3L generally in the range of 1° to 4°C. Bottom temperature along the slopes of the Grand Bank below 200 m depth are generally >3°C. The general circulation in this region consists of the relatively strong offshore Labrador Current at the shelf break and a weaker branch near the coast in the Avalon Channel.

Currents over the banks are very weak and the variability often exceeds the mean flow. In most areas of the Grand Bank 2003 was a year of extremes, with very cold spring conditions that moderated by mid-summer and warmed to above normal conditions throughout the remainder of the year. During the spring of 2003 for example, the spatially averaged spring bottom temperature on the Grand Bank was about 1°C, the 11th coldest in the 28 year record. In contrast, fall bottom temperatures, while having decreased by about 1°C over the warm values in 1999, have remained relatively constant, slightly warmer-than-normal during the past 3-years. Mid-summer CIL temperature values were below-normal (implying warm conditions) across the Grand Bank during 2004 for the 7th consecutive year. Analysis of historical data indicates that on average the thermal bottom habitat of the Div. 3LNO region during both spring and autumn is very similar except for the upper water column and shallow areas of the southeast Grand Bank. In these areas solar heating throughout the summer months increases water temperatures significantly over spring values. There are exceptions however, the most noteworthy being the spring of 2004 when most of the area had warmed significantly compared to the autumn of 2003. In 2004 the average spring bottom temperature increased over 2003 to >2°C, the highest since the early-1980s with very little bottom water with temperatures <0°C.

Subarea 1

Bottom temperatures in Subarea 1 and Div. 0A east of 60ºW recorded at depths between 150 and 600 m during the West Greenland bottom trawl survey in summer 2004 were examined and compared to previous results in the survey series (SCR Doc. 04/72). In 2004, bottom temperatures ranged from 0.9°C in the shallow (<200 m) parts of the Disko Bay to about 6°C in the southern offshore areas. Values above 4°C were found in large parts of offshore area south of 63°45'N whereas bottom temperatures between 2 and 3°C prevailed in the remaining parts of the surveyed area. The overall area weighted mean bottom temperature amounted to 2.8°C, which is close the average observed since 1997 indicating that the recent relative warm period has continued.

III. STOCK ASSESSMENTS

This STACFIS meeting was held in conjunction with the ICES WGPAND. The Chair noted the substantial effort made by the participants who prepared all the basic information related to the assessments, as well as preparing the assessment papers for all STACFIS stocks in advance of the meeting. This greatly facilitated the work of STACFIS during this meeting.

Submission of data for assessment

In relation to submission of the data requested, STACFIS found it necessary to emphasize and spell out details pertaining to data submissions due to the lack of compliance in the past.

Protocol and format for shrimp data submission are the following:

Catch Rate Data

The standard dataset should be in column format aggregated by nation, NAFO Division, year, month, vessel as suggested in the example below:

Nation	NAFO Div.	Year	Month	Vessel id.	Gear Type	Vessel Size (GRT)	Engine Power (HP / kilowatts)	Shrimp catch (kg)	Effort (hrs)
	3L	1999	January = 01		Single trawl = 1			Total catch aggregated by nation, area, year, month and vessel. This should include discards	Total effort aggregated by nation, area, year, month, and vessel.

Catch rate and biological data should be provided for the following areas:

NAFO Area	ICES Area:
0A SA 1A, B, C, D, E, F 3L, N, O 3M	Divisions XIVa, XIVb and Va Denmark Strait north of 65° N Denmark Strait south of 65° N

Length Frequency Data

The length frequency data should be categorized by year, NAFO Division, month, maturity and sex stage: 1) males; 2) transitionals and primiparous; 3) multiparous females and 4) ovigerous. The length frequencies measured as accurately as possible and pooled in 0.5 mm categories (Frechette and Parsons, 1983[1]). In calculations, the midpoint of these categories should be used since possible measurement errors can be expected to be normally distributed. Each length frequency should be accompanied by data on total catch and effort by month. The data should be in the following format:

Nation	NAFO Div.	Year	Month	Catch (kg)	Effort (hrs.)	Raw length frequency by maturity and sex stage categorized to the nearest 0.5 mm
	3L	1999 = 99;	January = 01	Total catch aggregated by nation, month, area and year	Total effort aggregated by nation, month, area and year.	Males

By-catch

Total by-catch by species and the corresponding shrimp catch (kg) reported by year, nation, month and NAFO Division.

1. **Northern Shrimp (*Pandalus borealis*) in Division 3M** (SCR Doc. 04/77, 78, 82, 84, 89, SCS 04/12)

a) **Introduction**

The shrimp fishery in Div. 3M began in late April 1993. Initial catch rates were favourable and, shortly thereafter, vessels from several nations joined. Since 1993 the number of vessels ranged from 40-110, and in 2004 there were approximately 50 vessels fishing shrimp in Div. 3M.

Total catches were approximately 27 000 tons in 1993, increased to 48 000 tons in 1996, declined in 1997, increased steadily to 54 000 in 2001, declined to about 49 000 tons in 2002 and increased to 62 000 tons in 2003 (Fig. 1.1). Catch statistics to 1 October 2004 indicate removals of about 31 000 tons. This would likely result in a total catch of about 48 000 tons by the end of the year.

Recent catches and TACs (tons) are as follows:

	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
Recommended TAC	-	-	-	30 000	30 000	30 000	45 000	45 000	45 000	45 000
STATLANT 21A	39 042	23 916	30 035	42 041	49 184[1]	51 426[1]	47 907[1]	62 005[1]		
STACFIS	48 300	24 675	30 308	43 438	50 311	53 922	48 979	62 165		

[1] Provisional.
[2] Projected to the end of the year.

[1] FRECHETTE, J., and D. G. PARSONS. 1983. Report of shrimp ageing workshop held at St. Foy, Quebec, in May and at Dartmouth, Nova Scotia, in November 1981. *NAFO Sci. Coun. Studies*, **6**: 79-100.

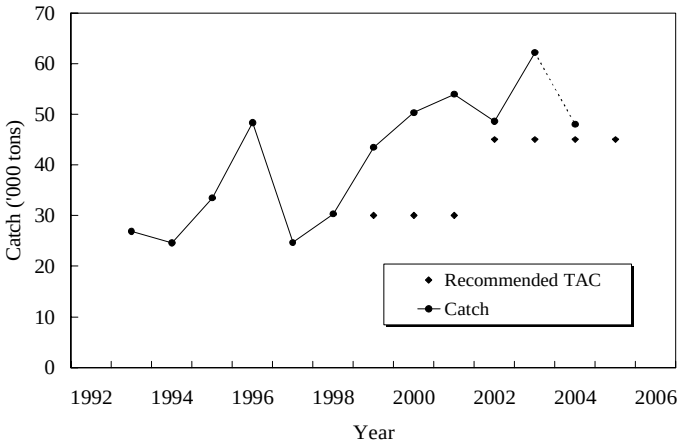


Fig. 1.1. Shrimp in Div. 3M: catches (2004 projected to end of the year).

b) **Input Data**

i) **Commercial fishery data** (SCR Doc. 04/78, 82, 84, 89)

Effort and CPUE. Data from logbooks of Canadian, Greenlandic, Icelandic, Faroese, Norwegian and Russian vessels were available. A Standardized CPUE series was produced to address differences due to seasonality, fishing power and gear (single, double and triple trawl). CPUE decreased from 1993 to 1994, varied without a trend to 1997 and increased until 2003 (Fig. 1.2). In 2004 it declined to the level observed in the years 2000-2002.

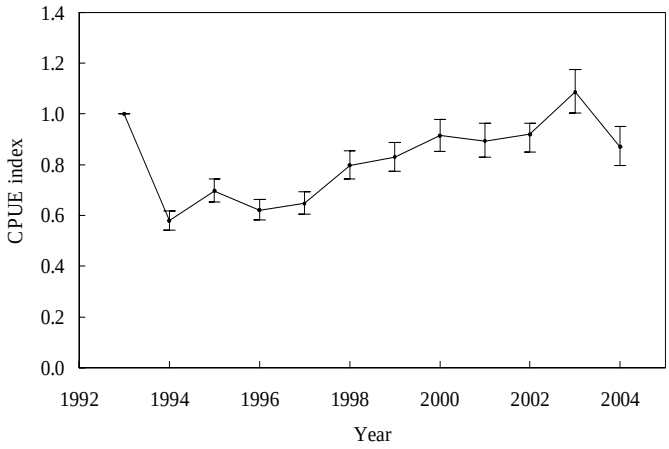


Fig. 1.2. Shrimp Div. 3M: the standardized CPUE of shrimp on Flemish Cap, 1993-2004.

Standardized CPUE female SSB. A spawning stock index was calculated from the standardized CPUE as kg/hr of all females (transitionals and females). The spawning stock declined from 1993 to 1997, and has shown an increasing trend to 1998 and has been stable since then (Fig. 1.3).

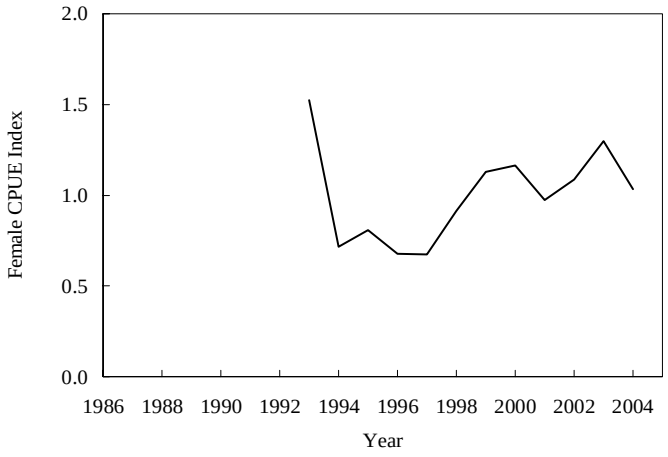


Fig. 1.3. Shrimp Div. 3M: standardized female CPUE index, 1993-2004. The series was standardized to the mean of the series.

Biological data. Age composition was assessed from commercial samples obtained from Iceland in 2003 and 2004 and from Canada, Greenland, Russia and Estonia in previous years. Number/hour was calculated for each year-class by applying a weight/age relationship and the total number as calculated from the nominal catch and the standardized CPUE data.

The results in the Table below indicate that age 3 and 4 generally dominate the commercial catch in numbers. In both 2001 and 2002 the 1997 year-class appears to be above average according to its contribution to the commercial catch rates. The 1998 year-class on the other hand, appears to be below average. The 1999 year-class, at ages 3 and 4, was even more numerous than the 1997 year-class was at those ages. The 2000 year-class appeared weak as 3 year olds. Both the 2001 and 2002 year-classes seem to be above average.

Numbers per hours at age in the commercial fishery.

Age	1996	1997	1998	1999	2000	2001	2002	2003	2004	Mean
1			5				21	618		71
2	2 425	2 058	3 072	2 462	851	6 422	4 228	4 580	8 823	4 251
3	25 396	16 338	17 974	14 658	21 246	8 601	35 672	8 185	23 424	19 127
4	7 736	16 953	21 028	16 954	23 980	27 529	12 140	37 082	9 386	19 003
5	2 238	3 330	6 707	13 640	14 311	13 943	14 712	15 669	17 083	11 082
6	1 169	675	2 494	4 911	3 583	4 112	3 005	4 594	3 788	3 240
7		58	280	57	177	556	119	2	1 478	312
	38 964	39 412	51 555	52 687	64 148	61 163	69 697	72 063	63 982	57 096

ii) **Research survey data** (SCR Doc. 03/66, 87; 04/77)

EU surveys. EU-groundfish surveys have been conducted on Flemish Cap in July from 1988 to 2004. The 1994 and 1998 total biomass indices are likely biased due to changes in sizes of codend mesh. However STACFIS does not consider the female biomass to be affected by the change of codend mesh size. The female shrimp biomass declined to relatively low values in 1994 to 1997, increased to a higher level in 1998-2002 and declined again in 2003 and 2004 (Fig. 1.4). A new research vessel was introduced in 2003. The biomass indices have been converted for the years 2003 and 2004 adjusting for the more efficient research vessel (SCR Doc. 04/77).

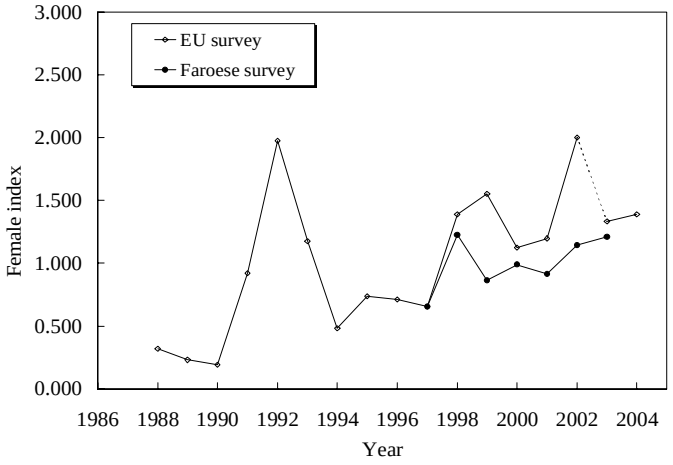


Fig. 1.4. Shrimp in Div. 3M: female biomass index from EU trawl surveys, 1988-2004 and Faroese survey, 1997-2003. Each series was standardized to the mean of that series.

Faroese survey. A stratified-random surveys were conducted in June-July 1997-2003 by a Faroese shrimp trawler. The total biomass index fluctuated between 16 000 and 22 000 tons in the years 1997 to 2001 increasing to about 27 000 in 2002 and 2003 (Fig. 1.5). Surveys utilized a juvenile bag attached to the cod end since 1998. Results indicate that the 1997 and 1999 year-classes were above average, the 1998 and 2000 year-classes appear weak and the 2001 was average (Fig. 1.5).

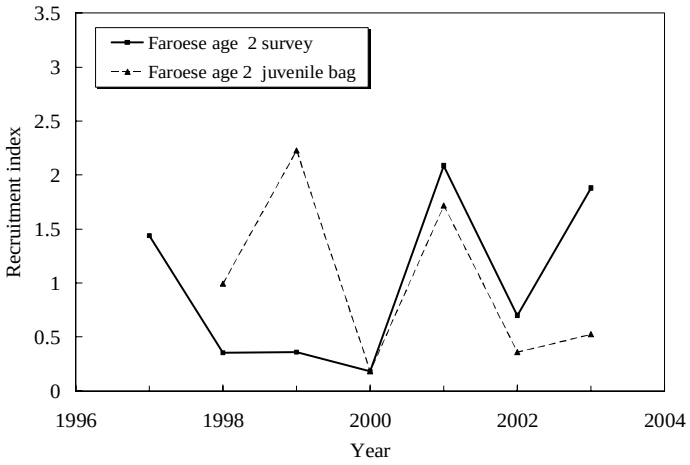


Fig. 1.5. Shrimp in Div. 3M: abundance indices at age 2 from the Faroese survey. Each series was standardized to its mean.

c) **Assessment Results**

Commercial CPUE. Standardized catch rates declined between 1993 and 1994, varied without a trend to 1997, increased to 2003 and declined in 2004.

Recruitment. The 2000 year-class appears weak. Both the 2001 and 2002 year-classes appear to be above average.

Spawning Stock Biomass. All indices of female biomass increased from 1997 or 1998 and have fluctuated without a trend since then.

State of the Stock. Stock indicators have been stable since 1998. The 2001 and 2002 year-classes are both above average and are likely to contribute to the fishery in 2005 and 2006.

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

d) **Precautionary Approach – Division 3M Shrimp** (SCS Doc. 04/12)

To determine if reference points under the precautionary approach framework could be derived for shrimp in Div. 3M, STACFIS examined yield per recruit analyses. Inputs to the model included von Bertalanffy growth parameters, a length-weight relationship, a maturity ogive, and a fishing selectivity pattern derived from an Extended Survivor Analysis (XSA) done in 2001. The yield-per-recruit model was run at three different levels of natural mortality (*M*): 0.3, 0.5, and 0.7. Fishing mortality reference points $F_{0.1}$ and F_{max} were calculated, but were very dependent on the choice of *M*. Another reference point calculation, equivalent to $F_{30\%SPR}$ (the fishing mortality producing 30% of the spawner-per-recruit value at $F = 0$), was not sensitive to the choice of *M*. Due to the uncertainties in choosing a value for M and also because the input selectivity pattern was derived from a previous assessment model that had not been accepted by STACFIS, it was concluded the results of the yield per recruit analyses could not be used to define reference points.

STACFIS noted that the Scientific Council Study Group on Limit Reference Points, which met in Lorient in April 2004, recommended that survey biomass indices could be used to indicate a limit reference point for biomass, in situations where other methods were not available (SCS Doc. 04/12). In such cases, "the point at which a valid index of stock size has declined by 85% from the maximum observed index level provides a proxy for B_{lim}". B_{lim} is defined as a biomass level, below which stock productivity is likely to be seriously impaired, that should have a very low probability of being violated.

The EU survey of Div. 3M provides an index of female shrimp biomass from 1988 to 2004, with a maximum value of 11.7 in 2002, (and a similar value of 11.5 in 1992). An 85% decline in this value would give a B_{lim} = 1.7. The biomass index was below this value in only 1989 and 1990, before the fishery, and in 2003-04 was about 30-35% 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. 1.6).

Noting the progress made in this meeting on the precautionary approach for shrimp in Div. 3M, STACFIS encouraged further work in this area, particularly on the definition of limit reference points.

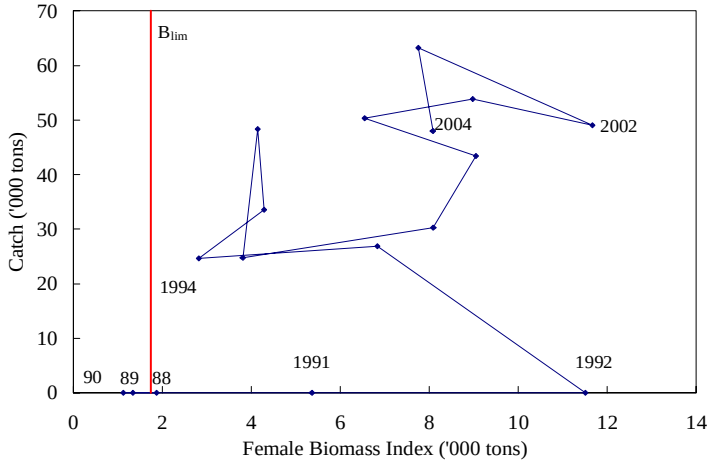


Fig. 1.6. Shrimp in Div. 3M. Catch plotted against female biomass index from EU survey. Line denoting B_{lim} is drawn where biomass is 85% lower than the maximum point in 2002.

e) **Research Recommendations**

STACFIS **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 2005.*

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

2. **Northern Shrimp (*Pandalus borealis*) in Divisions 3L, 3N and 3O** (SCR Doc. 04/78, 79, 80, 82, 85, 86. SCS Doc. 04/12)

a) **Introduction**

This shrimp stock is distributed around the edge of the Grand Banks mainly in Div. 3L. The fishery began in 1993 with catches around 1 800 tons. Exploratory fishing from 1996-99 resulted in catches ranging from 179 to 795 tons. In 2000, Fisheries Commission implemented a TAC of 6 000 tons, and fishing was restricted to Div. 3L. In 2003, Fisheries Commission increased the TAC to 13 000 tons because biomass had increased significantly since 1999.

Catches from 1993 to 2000 are as reported in the STATLANT 21A database. Reliable catch reports were not available for all countries in 2001 and 2002. Estimates from other sources (Canadian surveillance, observer datasets, STACFIS estimation, etc.) were used in these cases. For 2003 and 2004, estimates of catch were available for all countries, so STACFIS was able to project total catches to the end of 2004. The total catch to date in 2004 is estimated to be about 12 100 tons, and is projected to 13 000 tons for the full year (Fig. 2.1).

In 2000, small vessels (less than 500 tons) caught about three-quarters of the Canadian catch. In 2001 and 2002, the Canadian quota was divided equally between the large and small vessel fleets. As a result, the proportion of catch taken by large vessels increased and most of their catch came from single trawls. In 2003 and 2004, about 60% of the Canadian TAC was assigned to the small vessel fleet. By October 2004, the small and large vessel fleets had taken 6 593 and 3 584 tons of shrimp respectively in Div. 3L. In all years, most of the Canadian catch occurred along the northeast slope in Div. 3L. The use of a sorting grid to reduce by-catches 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 (tons) for shrimp in Div. 3LNO (total) are as follows:

	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
TAC	-	-	-	-	6 000	6 000	6 000	13 000[1]	13 000[1]	13 000
STATLANT 21A	179	485	567	795	4 930[2]	5 323[2]	5 697[2]	11 016[2]	11 660[2]	
STACFIS	179	485	567	795	4 896	10 566	6 977	11 947	13 000[3]	

[1] Denmark (in respect of Faroe Islands and Greenland) set an autonomous TAC of 1 344 tons for 2003 and 2004.

[2] Provisional catches.

[3] Projected catches for 2004.

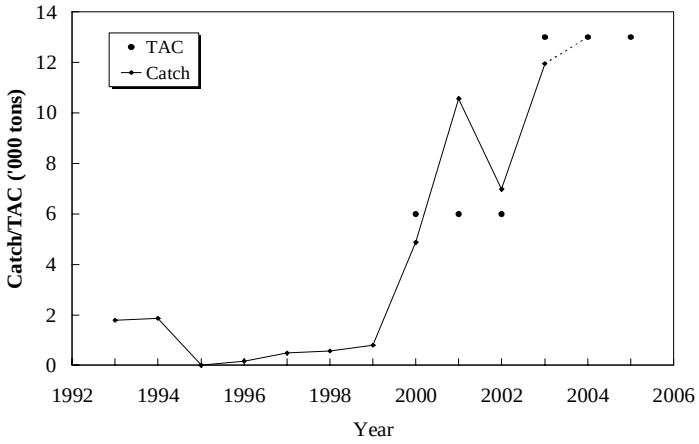


Fig. 2.1. Shrimp in Div. 3LNO: catches and TAC (2004 projected to end of the year).

b) **Input Data**

i) **Commercial fishery data** (SCR Doc. 04/78, 82, 86)

Fishing effort and CPUE. Catch and effort data have been available from Canadian fishing vessel logbooks and observer records since 2000. Standardized catch rates for large vessels remained at approximately 1 400 kg/hr over the history of the fishery. Whereas, Canadian small vessel CPUE increased to approximately 490 kg/hr in 2004. Unstandardized international CPUE data showed increasing trends over time. The 2000-2003 average Iceland, Spanish and Russian single trawl catch rate was 370 kg/hr while the average Iceland and Russian double trawl catch rate was 640 kg/hr. These are much lower than the respective average Greenlandic and Norwegian catch rates (single trawl = 1 800 kg/hr.; double trawl = 2 200 kg/hr.).

Catch composition. Observers sampled and measured Canadian catches (approximately 2-5% of the small vessel catches and over 90% of the large vessel catches were observed) in Div. 3L. Length frequency distributions were presented from catches taken by large vessels during 2000-2003. At least seven year-classes were evident in all four length frequency distributions. The relatively strong 1997-99 year-classes could easily be tracked over the short time series. The 1997-99 year-classes appear very strong compared to the weak 1995 and 1996 year-classes. In 2003, the 2000 and 2001 year-classes appeared as strong as the 1997-99 year-classes at comparable ages. The female distributions are broad throughout the short time series indicating that they are composed of more than one year-class.

The 2000-2004 small vessel and 2004 large vessel catch composition data were not available for this assessment.

ii) **Research survey data** (SCR Doc. 04/80, 86)

Canadian multi-species trawl survey. Canada has conducted stratified-random surveys in Div. 3LNO, using a Campelen 1800 shrimp trawl, during spring and autumn since late-1995. Data for shrimp were available from the autumn surveys in 1995-2003, and from spring surveys in 1999-2004.

Biomass and Abundance. Biomass and abundance indices were derived using stratified areal expansion calculations. In all surveys, over 90% of the biomass was found in Div. 3L, distributed mainly along the northeast slope in depths from 185-550 m. Based upon comparisons of confidence intervals, there was a significant increase in autumn shrimp biomass/abundance indices between 1995 and 1997 followed by stability from 1997 until 1999. Both biomass and abundance indices remained at a higher level since 2000 (Fig. 2.2). Similarly spring 2002 and 2003 indices are significantly higher

than spring 1999 indices (Fig. 2.3). The spring 2004 index decreased to the 2001 level; however the spring 2004 index is thought to be imprecise because the confidence intervals are broad.

Canadian multi-species survey autumn and spring biomass indices ('000 tons) are indicated below:

Year	Lower 95% C. I.	Autumn Estimate	Upper 95% C.I.	Lower 95% C.I.	Spring Estimate	Upper 95%C.I.
1995	3.6	5.9	8.2			
1996	10.2	20.1	29.9			
1997	25.5	46.2	66.9			
1998	40.0	59.9	79.8			
1999	36.2	53.1	70.1	12.6	55.3	98.1
2000	93.1	118.2	143.2	-15.9	122.8	259.5
2001	77.6	224.0	370.4	62.4	102.6	142.8
2002	126.2	215.0	303.8	121.1	159.5	197.9
2003	106.3	223.6	340.8	112.3	193.8	275.2
2004				-529.8	110.8	751.4

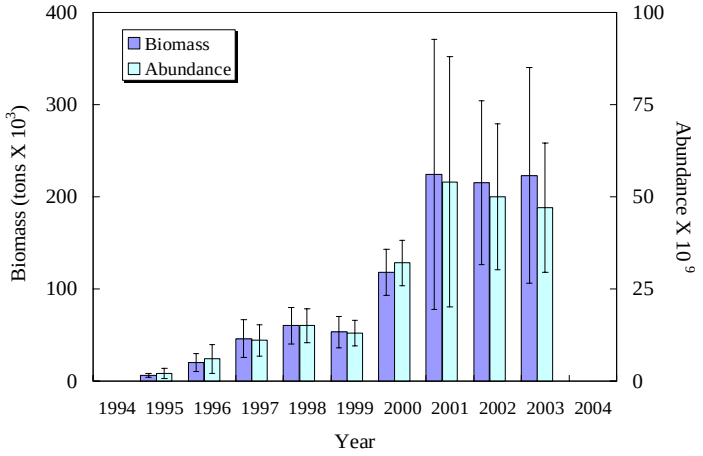


Fig. 2.2. Shrimp in Div. 3LNO: biomass and abundance estimates from Canadian autumn multi-species surveys (±95% confidence intervals).

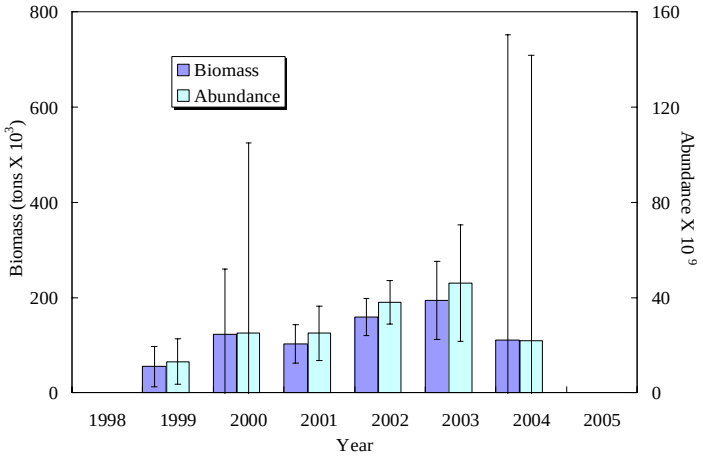


Fig. 2.3. Shrimp in Div. 3LNO: biomass and abundance estimates from Canadian spring multi-species surveys (±95% confidence intervals).

Sex and age composition. Estimated total number (10^9) of shrimp in Div. 3LNO from autumn 1995 to spring 2004 surveys are as follows:

Survey	Males	Females	Total	Males %	Female %
Autumn 1995	3.1	1.3	4.4	70.5	29.5
Autumn 1996	6.9	0.8	7.7	89.6	10.4
Autumn 1997	7.5	2.8	10.3	72.8	27.2
Autumn 1998	14.1	2.3	16.4	86.0	14.0
Spring 1999	11.0	3.4	14.4	76.4	23.6
Autumn 1999	10.5	3.2	13.7	76.6	23.4
Spring 2000	19.5	8.3	27.8	70.1	29.9
Autumn 2000	24.8	4.5	29.3	84.6	15.4
Spring 2001	16.8	5.4	22.2	75.7	24.3
Autumn 2001	44.8	8.4	53.2	84.2	15.8
Spring 2002	27.8	10.8	38.6	72.0	28.0
Autumn 2002	36.9	10.2	47.1	78.3	21.7
Spring 2003	29.8	14.1	43.9	67.9	32.1
Autumn 2003	30.3	11.7	42.0	72.1	27.9
Spring 2004	16.3	7.5	23.8	68.5	31.5

The sexed length frequencies were derived using OGive MAPping (Ogmap) calculations as opposed to stratified areal expansion as was done in the past. A paper presented (SCR Doc. 04/80) compares biomass/ abundance indices and length frequencies calculated by the two methods. The length frequencies produced by the two methods have been very similar.

Abundance estimates from the autumn 2003 survey were dominated by males with a modal length of 18.8 mm CL (2000 year-class). This year-class was preceded by 1997-99 year-classes which were also strong relative to all previous year-classes. The relatively broad female size distribution suggests that it consisted of more than one year-class (Fig. 2.4). The percent numbers of females in the last three surveys have all been above the average, 23.6%.

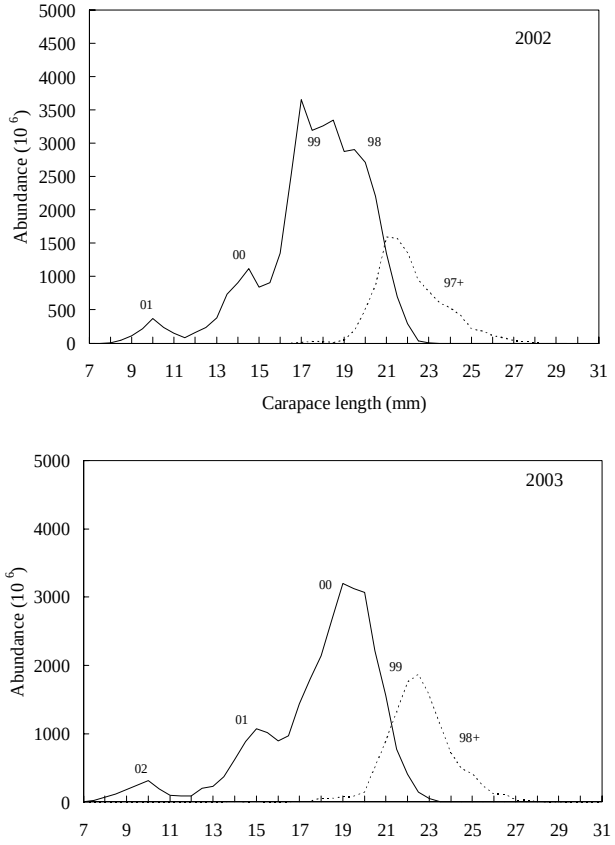


Fig. 2.4. Shrimp in Div. 3LNO: abundance at length for northern shrimp estimated from Canadian multi-species survey data using Ogmap calculations.

Spawning Stock Biomass (SSB). In general, the SSB (transitionals and all females) index from the autumn surveys has been increasing over the time series (Fig. 2.5). The confidence intervals on the SSB index in 2003 were wider relative to those from the total biomass from the same survey. This is due to differences in density and distribution of male and female shrimp in the surveys.

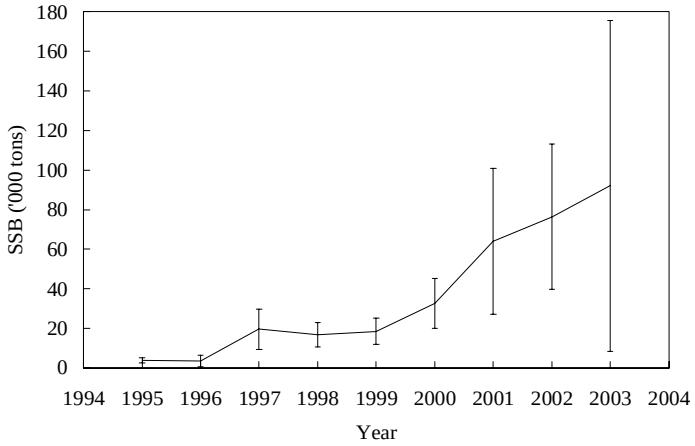


Fig. 2.5. Shrimp in Div. 3LNO: Spawning stock biomass (SSB) estimates from Canadian autumn multi-species surveys (±95% confidence intervals).

Recruitment index. A recruitment index (shrimp considered to be age 2) was constructed from the autumn surveys of 1995-2003. The recruitment index was based upon modal analysis of ogmapped length frequencies as described above. Recruitment increased from 1997 to 2001, decreased in 2002, and increased in 2003. The index indicates that all years from 1997 to 2001 are above average (Fig. 2.6).

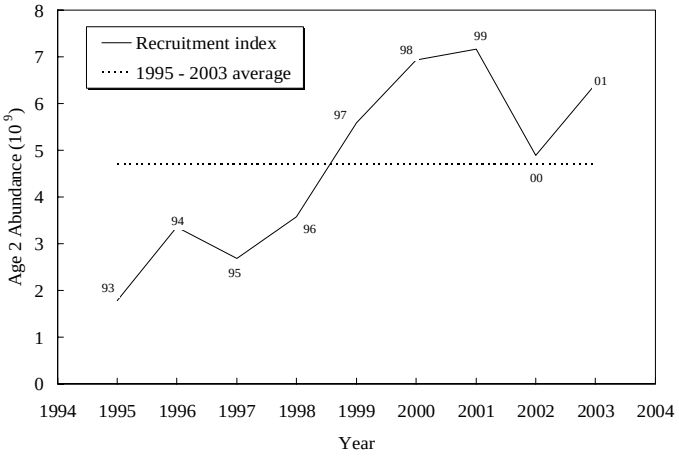


Fig 2.6. Shrimp in Div. 3LNO: age 2 recruitment indexes as determined from Canadian autumn multi-species surveys (numbers indicate year-classes).

Fishable biomass and exploitation In general, the fishable biomass has been increasing over the time series (Fig. 2.7). An index of exploitation was derived by dividing the catch in a given year by the fishable biomass index (shrimp biomass for all animals with carapace lengths greater than or equal to 17 mm) from the previous autumn survey. The exploitation index was less than 3% during 1996-99, but increased to 11-12% in 2000-2001; the first two years of TAC regulation. Even though catches increased to 12 000 tons in 2003 and are projected to be 13 000 tons in 2004, the exploitation index is estimated to be less than 8% due to the increase in fishable biomass (Fig. 2.8).

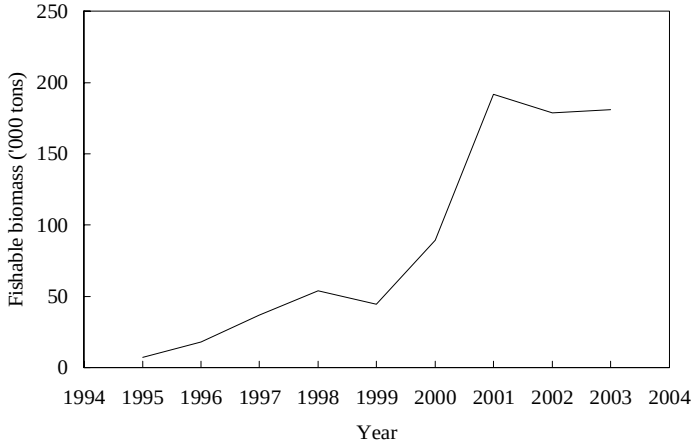


Fig. 2.7. Shrimp in Div. 3LNO: fishable biomass index. Indices were estimated using Ogmap calculations.

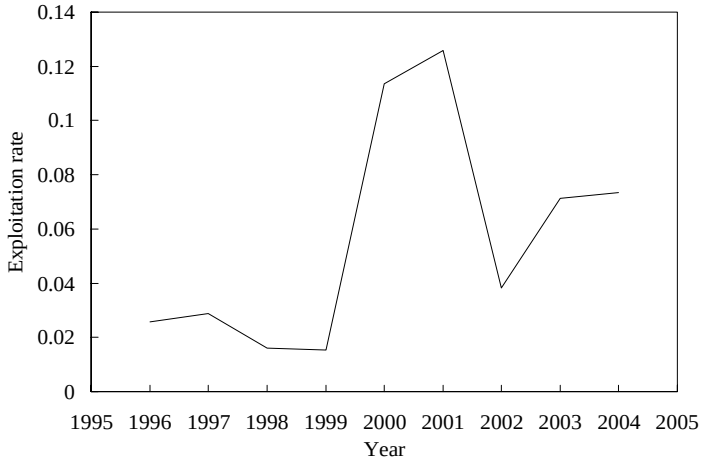


Fig 2.8. Shrimp in Div. 3LNO: exploitation rates as derived by catch/the previous year's autumn fishable biomass index.

iii) **Other biological studies** (SCR Doc. 04/80, 85, 86)

OGive MAPping (Ogmap) was presented as a method to determine abundance/ biomass indices and population adjusted length frequencies. Comparisons between Ogmap and stratified areal expansion methods demonstrated that index point estimates and population adjusted length frequencies were similar. However, STACFIS noted that sensitivity analyses had to be conducted before it would be possible to determine whether Ogmap is an appropriate method to determine Div. 3LNO shrimp biomass/abundance indices and population adjusted length frequencies from stratified random surveys. (SCR Doc. 04/80).

Spatial distributions and abundances of northern shrimp were presented in relation to the water temperatures for Div. 3LNO as determined from Canadian spring (1998-2004) and autumn (1995-2003) multi-species bottom trawl surveys (SCR Doc. 04/85). During spring surveys, the highest numbers of shrimp were caught in the 2°-4°C temperature range; however, the highest autumn catches were in the 1°-3°C temperature range. In general, most large spring catches were found in the warmer water along the slopes of Div. 3LN. During autumn there was an apparent shift in distribution toward colder temperatures upon the Grand Banks and toward inshore regions resulting in a greater proportion of the catches being taken in the 0°-1°C temperature range. During the spring of 2004 most of the shrimp were found in the 3°-4°C temperature range with a significant decrease in the overall catches over the previous 2 year. It is not known if the decrease in abundance during the spring is related to the warming environment on the Grand Banks during the spring of 2004. Furthermore, it is not clear if the observed changes in the distribution from spring to fall are environmentally driven, or due to other factors, such as changes in trawl catchability due to vertical migration, feeding behaviour or other unknown environmental variables.

A study was conducted to examine correlations between abundance at age 2 and indices of fishable biomass two, three and four years later (SCR Doc. 04/86). All comparisons showed significant correlations. This indicates that the age 2 abundance index may be used as a predictor of future fishable biomass, but such correlations may be expected since the entire stock is increasing.

c) **Assessment Results**

Recruitment. The 1998 and 1999 year-classes are the two strongest year-classes in the short time series. They are followed by the 2000 year-class which was slightly above average and the 2001 year-class which was the third strongest in the time series.

Biomass. There was a significant increase in SSB and total biomass between 1995 and 1997 followed by a period of stability between 1997 and 1999. Autumn SSB and total biomass have been at a higher level since 2000.

Exploitation: The exploitation index (catch/fishable biomass) increased during 2000-2001, at the beginning of the fishery, and has decreased since then.

State of the Stock. There has been an increasing trend in SSB and recruitment since 1999. The stock appears to be well represented by a broad range of size groups, and the exploitation index is low.

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

Scientific Council considers that 15% of the maximum female biomass index of the Canadian autumn survey is a limit reference point for biomass (B_{lim}) for northern shrimp in Div. 3LNO. It is not possible to calculate a limit reference point for fishing mortality. Currently, the biomass is estimated to be well above B_{lim}.

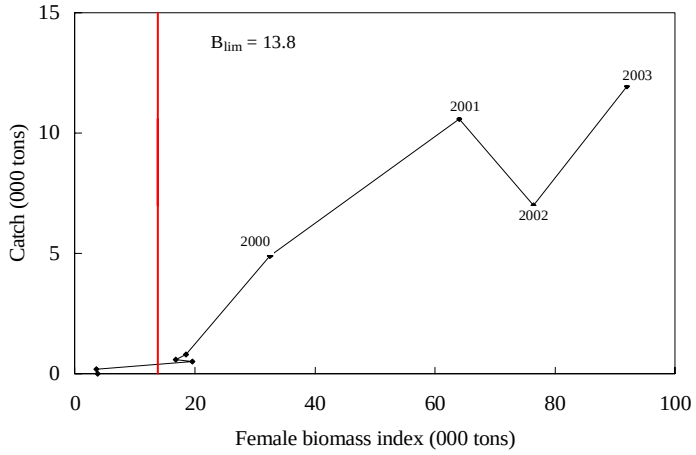


Fig 2.9. Shrimp in Div. 3LNO: Catch plotted against female biomass index from Canadian autumn survey. Line denoting B_{lim} is drawn where biomass is 85% lower than the maximum point in 2003.

e) **Research Recommendations**

STACFIS **recommended** that, for shrimp in Div. 3LNO:

- *sensitivity analyses be conducted to determine whether Ogmap is an appropriate method to determine Div. 3LNO shrimp biomass/abundance indices and population adjusted length frequencies from stratified random surveys.*

- *biological and CPUE data from all fleets fishing for shrimp in the area, be submitted to the Designated Expert, in the standardized format, by 1 September 2005.*

3. **Northern Shrimp (*Pandalus borealis*) in Subareas 0 and 1** (SCR Doc. 02/158, 03/74, 04/70, 71, 72, 73, 74, 75, 76, SCS Doc. 04/12)

a) **Introduction**

The shrimp stock off West Greenland is distributed in Subarea 1 and Div. 0A east of 60°W. Shrimp within this area is assessed as a single population. The Greenland fishery exploits the stock in Subarea 1 (Div. 1A to 1F) in offshore and inshore areas (primarily Disko Bay). Since 1981 the Canadian fishery has been limited to Div. 0A.

Three fleet components, one from Canada and two from Greenland (vessels above and below 80 GRT) 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 fishery by the Greenland small-vessel fleet was unrestricted until January 1997, when quota regulation was imposed. In 2004, the advised TAC for the entire stock was 130 000 tons. In 2004 the Greenland authorities set a TAC for Subarea 1 of 135 000 tons, and a TAC for Div. 0A east of 60°30'W of 14 667 tons was set by the Canadian authorities for the same year. The use of a sorting grid to reduce by-catches of fish is mandatory for both the Greenland large-vessel fleet and the Canadian fleet (max. 22 mm bar distance in Greenland zone; max. 28 mm bar distance in the Canadian zone). Discarding of shrimp is prohibited.

Until 2003 catches of shrimp taken in SA 1 have been reported without accounting for "overpacking" – the amount of surplus weight in packaging – or the difference between the product weight and live weight. On 1 January 2004 new legislation was enforced to ensure that total removals by fishing are reported in units of live weight. To allow management advice derived from the stock assessment to be stated in the same units as used within this reporting practice a correction of the input catch data series 1978-2003 was performed (SCR Doc.03/74) and tabulated here:

Year	Reported catch SA 1 (tons)	Correction factor SA 1	Corrected catch SA 1 (tons)	Catch Div. 0A (tons)	Total STACFIS estimate
1970	8 559	1.2285	10 515	0	10 515
1971	8 437	1.2285	11 593	0	11 593
1972	9 656	1.2285	11 862	0	11 862
1973	12 642	1.2285	15 530	0	15530
1974	22 009	1.2285	27 038	0	27 038
1975	27 890	1.2285	46 547	0	46 547
1976	49 674	1.2285	61 023	392	61 415
1977	41 643	1.2285	51 158	457	51 615
1978	34 347	1.2285	42 195	122	42 317
1979	33 458	1.2285	41 102	1 732	42 834
1980	43 278	1.2285	53 166	2 726	55 892
1981	39 516	1.2285	48 545	5 284	53 829
1982	42 515	1.2285	52 229	2 064	54 293
1983	41 354	1.2285	50 803	5 413	56 216
1984	41 241	1.2285	50 664	2 142	52 806
1985	51 396	1.2285	63 139	3 069	66 208
1986	60 134	1.2285	73 873	2 995	76 868
1987	57 641	1.2463	71 836	6 095	77 931
1988	54 392	1.2453	67 735	5 881	73 616
1989	58 422	1.2570	73 436	7 235	80 671
1990	63 184	1.2312	77 793	6 177	83 970
1991	69 092	1.2259	84 701	6 788	91 489
1992	79 258	1.2364	97 994	7 493	105 487
1993	70 123	1.2196	85 522	5 491	91 013
1994	71 811	1.2260	88 039	4 766	92 805
1995	68 329	1.2444	85 027	2 361	87 388
1996	66 610	1.2230	81 463	2 632	84 095
1997	64 000	1.2127	77 611	517	78 128
1998	65 170	1.2208	79 562	933	80 495
1999	73 985	1.2184	90 145	2 046	92 191
2000	78 337	1.2181	95 424	1 782	97 206
2001	81 398	1.2182	99 156	3 625	102 781
2002	105 465	1.2223	128 906	3 300	132 206
2003	101 627	1.2186	123 845	2 617	126 462
2004*	135 000	1.0000	135 000	6 000	141 000

* Projected from October to end of the year.

Overall annual catch has increased from about 10 000 tons in the early-1970s to more than 105 000 tons in 1992 (Fig. 3.1). Restrictions by the Greenlandic authorities to reduce effort, and fishing opportunities elsewhere for the Canadian fleet resulted in catches decreasing to about 80 000 tons in 1998. Since then overall catches have increased. The projected catch of 2004 is expected to be around 141 000 tons (Fig. 3.1) based on data through October 2004.

Recent nominal catches, projected figures for 2004 and recommended TACs (tons) for shrimp in Div. 0A east of 60°W and Subarea 1 are as follows:

	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
Recommended TAC[1]	60 000	60 000	60 000	55 000	65 000	65 000	85 000	85 000	100 000	130 000
Actual TAC		72 422	74 800	68 379	80 350	80 350	91 350	101 000	115 667	150 019
SA 1	75 450	66 736	60 325	65 080	73 961	79 738	82 126	102 572	135 465	135 000
Div. 0A	2 358	2 617	517	914	2 093	841	2 958	3 300	2 617	6 000
Total STATLANT 21A	77 808[2]	69 353[2]	60 842[2]	65 994[2]	76 054[2]	80 579[3]	85 084[3]	105 872[3]	138 082[3]	
Total STACFIS[4]	87 388	84 095	78 128	80 495	92 191	97 206	102 781	132 206	126 462	141 000[5]

[1] Until 2003 recommended TAC were given in the units of the STATLANT reporting.

[2] Data updated to be consistent with STATLANT 21A

[3] Provisional catches.

[4] Estimates 1995-2003 corrected for overpack.

[5] Catches projected to end of 2004.

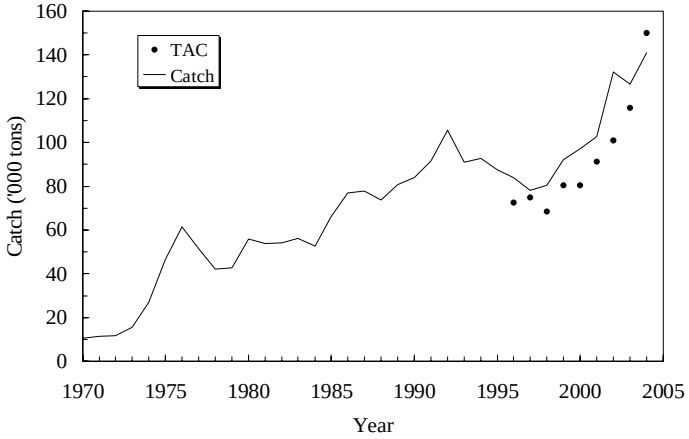


Fig. 3.1. Shrimp in Subareas 0 and 1: total catches (2004 projected to the end of the year) and actual TACs (1996-2003 values are scaled to account for "overpack").

Until 1988, the fishing grounds in Div. 1B have been the most important. Since then, a southward expansion in the offshore fishery has taken place, and from 1990 catches in Div. 1C and 1D have exceeded those from Div. 1B. At the end of the 1980s, exploitation began in Div. 1E and 1F, and catches from these areas now account for about 20% of the total catch. The Canadian fishery in Div 0A east of 60°W has taken from 1.8 to 4.3% of total annual catches in the recent five years. The distribution of the fishery has not changed since 1996.

b) **Input Data**

i) **Commercial fishery data**

Fishing effort and CPUE. Catch and effort data from the shrimp fishery were available from fishing records from Canadian vessels in Div. 0A east of 60°W and from Greenland logbooks for Subarea 1 (SCR Doc. 04/75).

Multiplicative models were used to calculate fleet specific annual catch rate indices. From these individual indices one unified time series covering 1976-2004 was derived. All fleets included in the analysis mainly exploit shrimp ≥17 mm carapace length (CL). The CPUE indices are therefore indicative of the combined biomass of older males and the females.

The standardized CPUE series showed an increasing trend since 1990 (Fig. 3.2). The 2004 mean value is the highest in the time series.

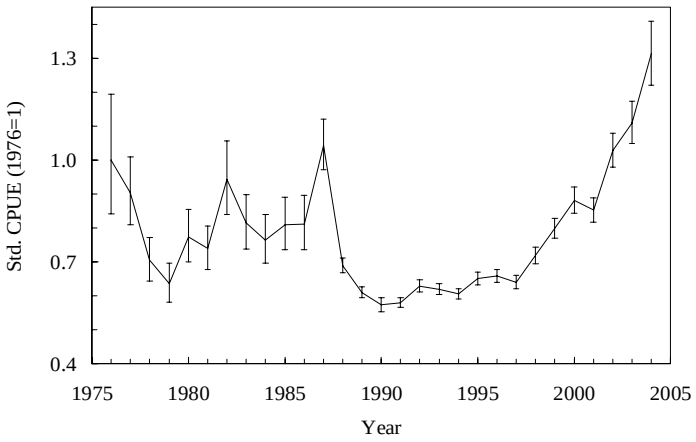


Fig. 3.2 Shrimp in Subareas 0 and 1: standardized CPUE index. Error bars are upper and lower quartiles.

Catch composition. Catch composition was assessed from samples obtained by observers in the commercial fishery in Div. 0A from 1981 to 2001, and in Subarea 1 from 1991 to 2001 (SCR Doc. 04/75). The mean size of shrimp caught has declined since 1991. In spite of these changes, the proportions of female to male shrimp in the catches seemed relatively stable until the late-1990s. In 2002 and 2003 STACFIS recommended that "sampling of catches by observers – essential for assessing stock age, size and sex composition – be re-established". However, the sampling program remained inadequate and sparse sampling prohibited an analysis of catch composition for the years 2002-2004.

ii) **Research survey data**

Greenland trawl survey. Stratified-random trawl surveys have been conducted since 1988 in offshore areas (Subarea 1 and Div. 0A east of 60°W) and since 1991 also inshore in Subarea 1 (SCR Doc. 04/72). From 1993, the survey extended further south into Div. 1E and 1F.

Biomass. The survey biomass indices indicated a fairly stable stock size from 1988 to 1997. Since then a significant increasing trend was observed. The 2003 and 2004 - values are the highest of the time series (Fig. 3.3).

Within the survey area, large year-to-year variations in the distribution of biomass were observed geographically as well as over depth zones. Some areas account for a large proportion of the variances of the estimated biomasses. During the recent period of increasing biomass indices, an increased proportion of the biomass was seen both in depths between 200 and 300 m and in the northern most areas.

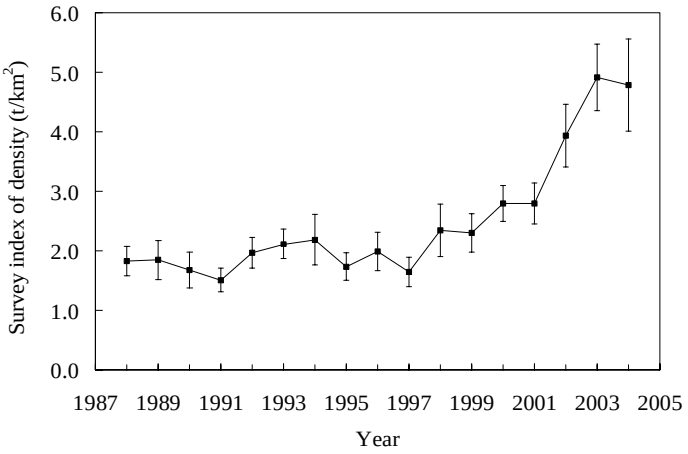


Fig. 3.3. Shrimp in Subareas 0 and 1: Survey indices of stock biomass density, ±1 standard error.

Abundance. Indices of total abundance ($\times 10^9$) of shrimp in Subarea 1 and Div. 0A east of 60°W from 1988 to 2004 are as follows (SCR Doc. 04/72):

Year	Males	Females	Total	Males (%)	Females (%)
1988[1]	24.3	9.9	34.2	71.0	29.0
1989[1]	35.0	7.6	42.5	82.2	17.8
1990[1]	28.5	10.0	38.5	74.1	25.9
1991	17.4	6.2	23.6	73.8	26.2
1992	29.7	7.3	36.9	80.3	19.7
1993	35.5	9.7	45.2	78.5	21.7
1994	33.9	10.9	44.8	75.7	24.3
1995	29.2	7.9	37.1	78.7	21.3
1996	41.4	8.1	49.5	83.7	16.3
1997	29.5	7.6	37.0	79.6	20.4
1998	42.9	11.5	54.5	78.8	21.2
1999	44.8	11.3	56.2	79.9	20.1
2000	66.7	12.7	79.4	84.0	16.0
2001	61.1	13.7	74.8	81.7	18.3
2002	90.6	16.7	107.2	84.5	15.5
2003	103.2	27.9	131.1	78.7	21.3
2004	77.2	27.2	104.4	73.9	26.1

[1] No inshore survey in 1988-90. The numbers in 1988 to 1990 represent an average of the estimated numbers of shrimp inshore from 1991-97 added to the actual estimates from the offshore area.

The index of total abundance of shrimp in 2004 is down by 20% compared to the previous year, but still one of the highest values of the series. The proportion of females in 2004 was above the average of the values recorded.

Length composition. A progression of the 1999 year-class from about 13.5 mm CL in 2001, to 17.5 mm CL in 2002 and to 20 mm CL in 2003 is clearly visible in the length frequency distributions, and parts of this year-class has probably passed into the female group in 2004 (SCR.Doc. 04/72). The subsequent year-classes were weaker and more difficult to trace.

The high abundance of males between 17 and 22 mm CL in 2004 (Fig. 3.4) is promising in terms of progression to the female group in the next year.

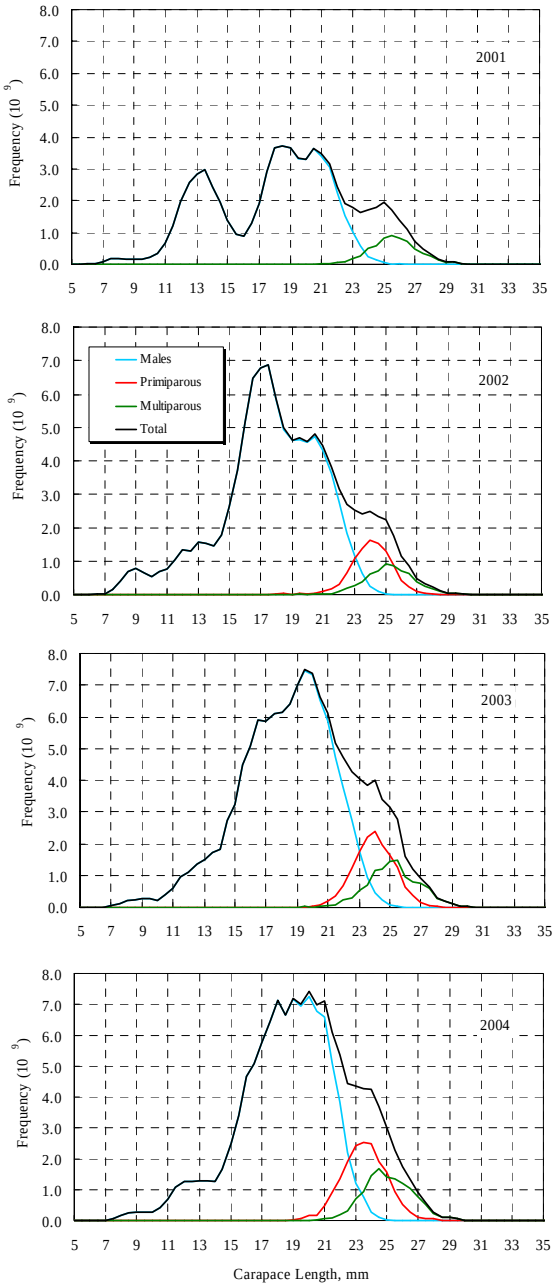


Fig. 3.4. Shrimp in Subareas 0 and 1: Numbers of shrimp by 0.5 mm CL length group in the total area during 2001-2004 (mesh size in the cod-end 20 mm stretched).

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Index of recruitment. Abundance at age 2 correlates with indices of fishable biomass two and three years later and may therefore be regarded as predictors of short-term changes in the recruitment to the fishery (SCR Doc. 04/73). The index of recruitment decreased in 2002 and was below average in 2003 as well as in 2004, which may suggests a decline in fishable biomass in the coming years (Fig. 3.5)

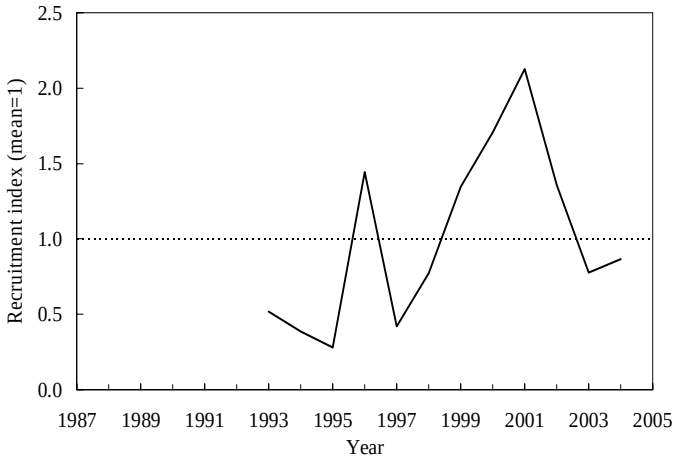

Fig. 3.5. Shrimp in Subareas 0 and 1: recruitment index (age 2 survey abundance index scaled to the mean of the series).

Index of spawning stock biomass. The index of female biomass (SCR Doc. 04/72) showed an increasing trend since 1997 and the value in 2004 is the highest observed in the series (Fig. 3.6).

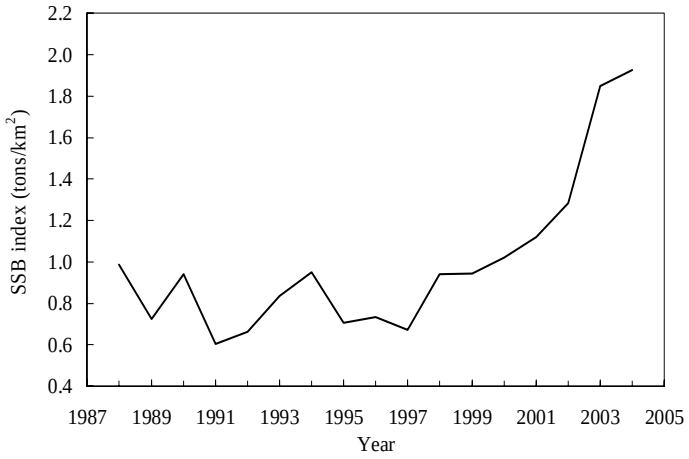

Fig. 3.6. Shrimp in Subareas 0 and 1: female spawning stock biomass index.

iii) **Other studies**

Length frequency distributions of Northern shrimp (*Pandalus borealis*) from the West Greenland Bottom Trawl Survey in the years 1993 to 2004 were examined in order to extract mean lengths and abundance indices for ages 1 to 4 by modal analysis (SCR. Doc. 04/73). The original survey data were aggregated into five major regions defined by latitudinal differences in bottom temperature. Mean size at age differed considerably between regions and years. The changes in mean size at age were positively correlated with bottom temperature for all of the four age groups. A tendency towards smaller size at age and growth rate was observed for the most recent years in which stock density has increased substantially in large parts of the survey area. Abundance at age 2 correlated significantly with the fishable biomass lagged by two and three years. Thus the survey estimates of abundance of age 2 can be regarded as suitable predictors of short-term changes in recruitment to the fishery.

Standard and modified Ricker stock-recruitment functions incorporating environmental variables were compared in order to examine the effect of stock size, mean female size, predator biomass and temperature on recruitment of Northern shrimp off West Greenland (SCR Doc 04/74). The standard Ricker equations did not model the observed recruitment very well. Better fits were obtained when environmental variables were incorporated as co-variables. In addition to parental stock size, significant variables were mean female length, bottom temperature in the year the larvae settled and biomass of Greenland halibut (a proxy for the predation effect on the 1-group). Projections of recruitment from these models suggest that recruitment will be at or even below average in the coming three years despite a high level of female biomass. This interpretation should, however, been taken with some caution as the analysis was based on a relative short time series.

Estimates of cod biomass from the German ground fish survey at West Greenland are used in the assessment of the shrimp stock in SA 1 and Div 0A east of 60°W to estimate consumption of shrimp. A comparative study of cod catches at West Greenland from the German ground fish survey and the Greenland survey for fish and shrimp was carried out (SCR Doc. 04/70). The analysis was restricted to years with sufficient area coverage and regions included in both surveys. A close correlation between the cod biomass estimates obtained in the two surveys was found (r^2 = 0.75, P <0.001). Hence, this relation may be used to convert from the Greenland survey estimates, which is available at the time of the assessment, to the German survey estimates, which is not. This conversion was used in the current assessment.

Three series of Atlantic cod biomass at West Greenland were evaluated for potential use in the assessment of the shrimp stock off West Greenland (SCR Doc. 04/71). Conclusions from this study indicate that a series based on Buch *et al.* (1994)[2] is less biased – at least compared to available survey indices. However, this data series is affected by the inclusion of inshore areas, in which the major fraction of catches were taken in the mid-1920s as well as from the late-1970s to the late-1980s, and alternative approaches might be explored.

c) **Estimation of Parameters**

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

The model synthesized information from input priors and the following data: a 17-year series of a survey biomass indices of shrimp ≥17 mm CL; a 29-year series of combined CPUE indices; a 50-year series of catches by the fishery; a 50-year series of a cod biomass estimates; and a short series (4 years) of estimates of the shrimp biomass consumed by cod (SCR Doc. 04/76).

Absolute biomass estimates had relatively high variances. For management purposes therefore it is 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, is thus measured relative to the biomass that yields Maximum Sustainable Yield, B_{msy}. The estimated mortality, Z, refers to the removal of biomass by fishing and cod predation and is scaled to Z_{msy} - the mortality at *MSY*.

d) **Assessment Results**

The model estimated the median annual consumption by cod 1956-2004 in the range of 200 tons to about 120 000 tons. The estimated consumption declined since 1960 as a result of a decline in cod abundance at West Greenland (Fig. 3.7). A short-lived resurgence of the cod stock in the late-1980s caused consumption to increase. The cod disappeared in the beginning of the 1990s and estimates of consumption went to zero.

[2] BUCH, E., S. A. HORSTED, and H. HOVGAARD. 1994. Fluctuations in the occurrence of cod in Greenland waters and their possible causes. *ICES Mar. Sci. Symp.*, **198**: 158-174.

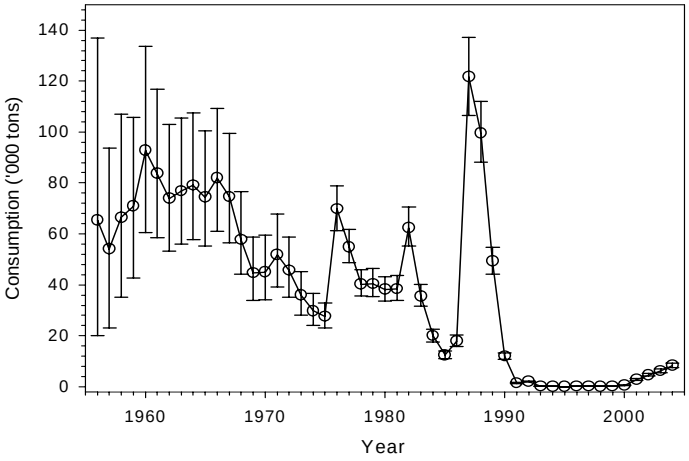

Fig. 3.7. Shrimp in Subareas 0 and 1: estimated consumption of shrimp by cod (error bars are 25th and 75th percentiles).

The trajectory of the median estimate of 'biomass-ratio' (B_t/B_{msy}) plotted against 'mortality-ratio' (Z_t/Z_{msy}) (Fig. 3.8) starts in 1956 at about half the optimum biomass ratio and at a mortality-ratio well above 1. The stock maintained itself in this region during the years when cod were abundant. When the cod stock declined in the late-1960s (Fig. 3.7), and predation pressure was lifted, shrimp stock biomass increased and eventually began cycling in the left upper corner of the graph (Fig. 3.8) during the current regime of low cod abundance (SCR. Doc. 04/76).

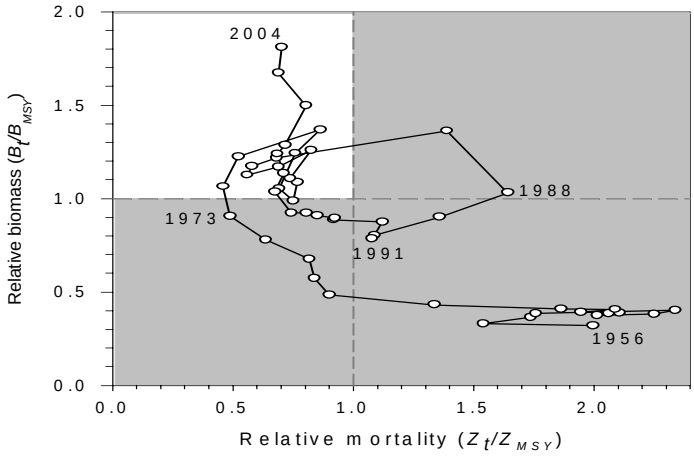

Fig. 3.8. Shrimp in Subareas 0 and 1: estimated annual median biomass-ratio (B/B_{msy}) and mortality-ratio (Z/Z_{msy}) 1956-2004.

Since the early-1970s when the fishery started expanding to offshore areas, the estimated median biomass-ratio ranged between about 0.8 and 1.81 (Fig. 3.8). The probability that it had been below the optimum level was small for most years (Fig. 3.9). However, stock biomass was likely driven below B_{msy} in the late-1980s to mid-1990s following a short-lived resurgence of the cod stock. The shrimp stock has increased since then and reached its highest level ever in 2004 with a median estimate of biomass-ratio of 1.81, corresponding to about 78% of estimated median carrying capacity. The estimated risk of stock biomass being below B_{msy} in 2004 was 0.04 (Fig. 3.9).

The mortality ratio (*Z*-ratio, which includes mortality by fishing and predation by cod) has been below 1 for most of the time since 1974, except for the period of high cod predation in the late-1980s to early-1990s (Fig. 3.8). Since 1997, annual median *Z*-ratio has been stable at approximately 0.7, i.e. well below the value that maximizes yield. The median of estimate for 2004 is 0.7 with a risk of only 0.09 of being above 1 (Fig. 3.9).

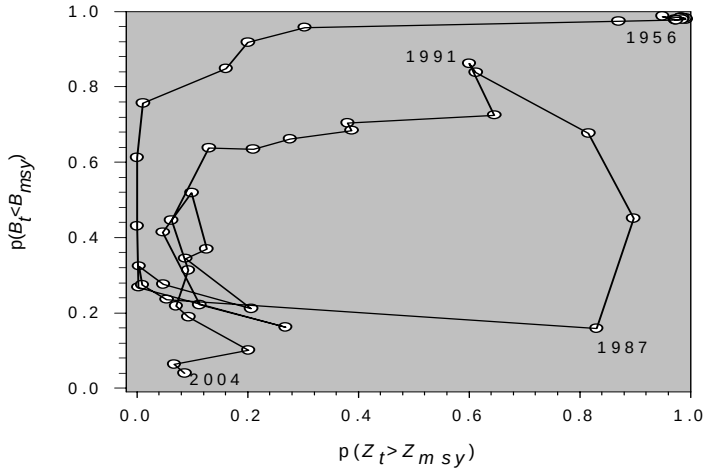

Fig 3.9. Shrimp in Subareas 0 and 1: risk of annual biomass being below B_{msy} and of mortality caused by fishing and cod predation being above Z_{msy} 1956-2004.

The median estimate of the maximum annual production surplus, available to the fishery and the cod (*MSY*) was estimated to 128 000 tons (Fig. 3.10). The risk function relating the probability of exceeding *MSY* to the combined removal by fishery and cod predation is given as the integral of this distribution (Fig. 3.10).

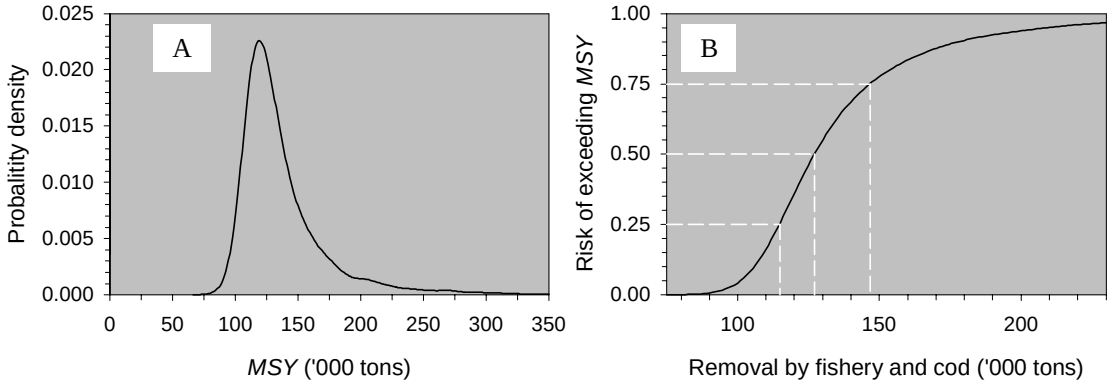

Fig. 3.10. Shrimp in Subareas 0 and 1: Posterior probability distribution of the maximum annual production surplus, available to the fishery and cod (*MSY*) (left) and the cumulative probability of exceeding *MSY* (right).

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 five optional catch levels for 2005 are as follows:

Catch option ('000 tons)	110	120	130	140	150
Risk of falling below B_{msy}	4%	5%	5%	6%	6%
Risk of exceeding Z_{msy}	5%	9%	17%	27%	37%

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

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

Although there are indications of an increasing cod stock, absolute estimates are still way below those in the late-1980s and certainly in the 1950s and 1960s. If and when the development of the cod stock warrants, management options given this scenario can be evaluated by STACFIS.

Ten-year projections of stock development were therefore made under the assumption that the cod stock will remain at its current low abundance. Five levels of annual catch: 110 000, 120 000, 130 000, 140 000 and 150 000 tons were investigated (Fig. 3.11).

At the investigated catch options of 110 000 ton/yr the stock is likely to remain above B_{msy} during the ten years of projection (Fig. 3.11). The combined relative fishing and cod predation mortality, Z_t/Z_{msy}, has a high probability of being below 1 within this period (Fig. 3.12).

Annual catches of 120 000 tons/yr is not likely to drive the stock below B_{msy} in the short to medium term (Fig. 3.11), i.e. the risk is less than 10% within the first three years and less than 25% after 10 years (Fig. 3.12). However, this level of exploitation might not be sustainable in the longer term (>10 years), as risk of exceeding B_{msy} continues to increase through time. The risk of exceeding to Z_{msy} increases through time and is about 30% after 10 years.

A catch option of 130 000 tons/yr is near the estimated median *MSY* but is not likely to drive the stock below B_{msy} in the shorter term (Fig. 3.11), i.e. the risk is less than 10% within the first three years and just above 25% after year 10 (Fig. 3.12). However, this level of exploitation might not be sustainable in the medium to longer term. After 10 years the risk of the stock dropping below optimum size is 32%. The risk of exceeding Z_{msy} increases from about 9% to 45% during the 10-year projection.

Fishing 140 000 or 150 000 tons/yr bears a 69% and 78% risk, respectively, of being above *MSY* (Fig. 3.11), thus these catch levels are not likely to be sustainable in the medium to long term. Owing to the current high stock level the risk of exceeding B_{msy} is no more than 16% after three years at 150 000 tons/yr, although after 10 years it is close to 50% with a concurrent risk of 70% of exceeding Z_{msy} (Fig. 3.12).

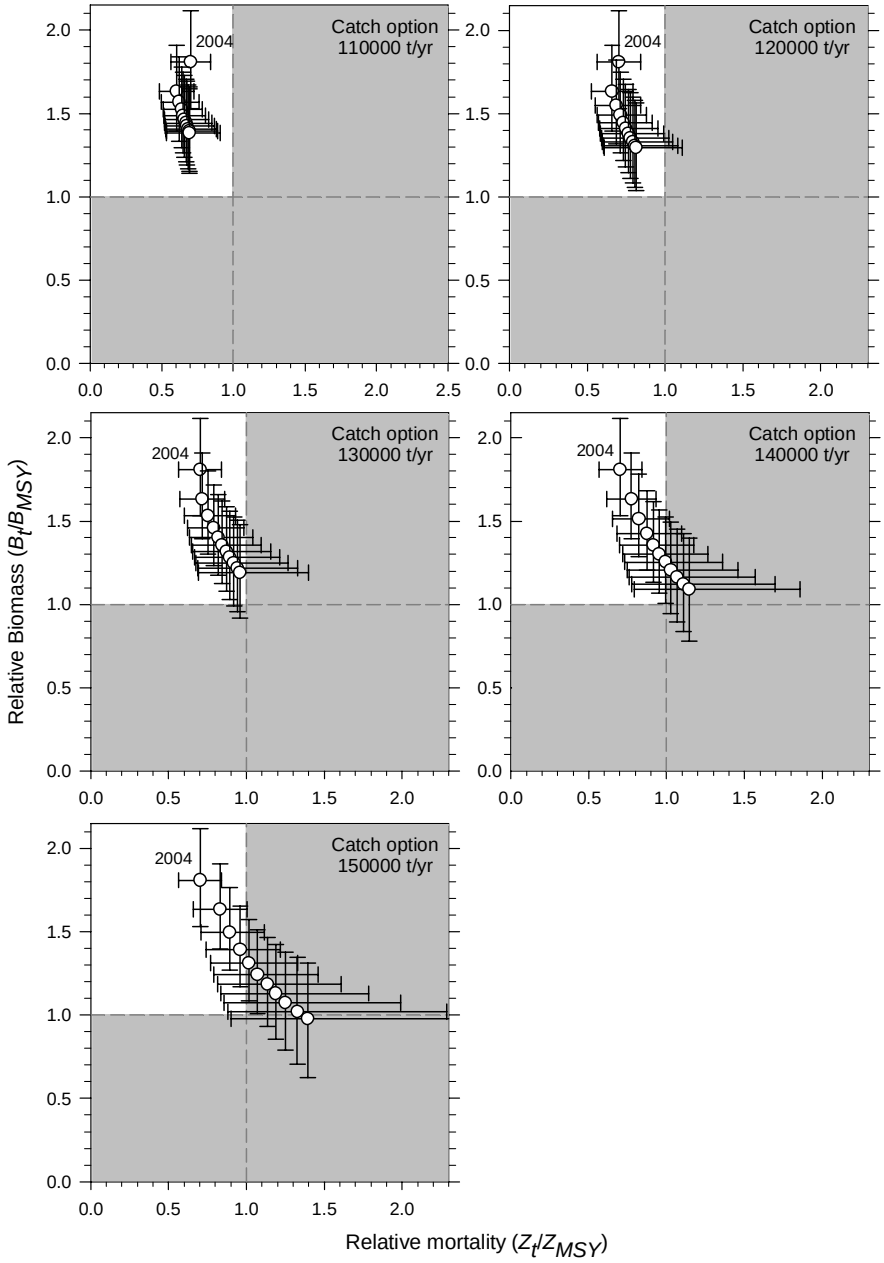

Fig. 3.11. Shrimp in Subareas 0 and 1: estimates of stock development for the period 2004-2014 quantified in a biomass (B/B_{msy})-mortality (Z/Z_{msy}) continuum. Dynamics at 110, 120, 130, 140 and 150 thousand tons of fixed annual catch levels are shown as medians with error-bars at the 25th and 75th percentiles. Dashed lines indicate level of biomass and mortality at *MSY*.

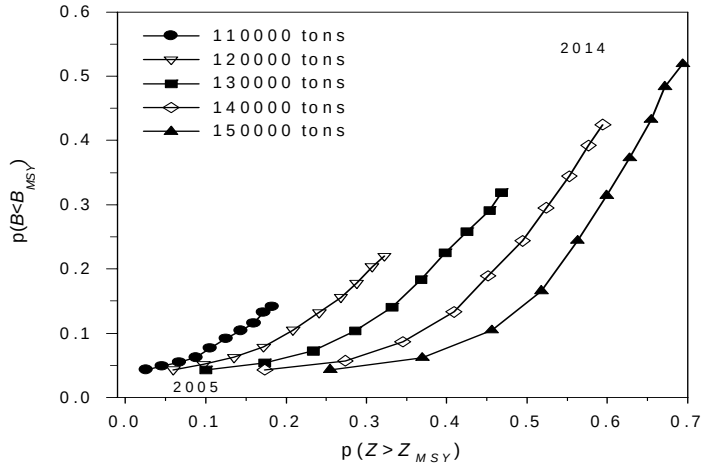

Fig.3.12. Shrimp in Subareas 0 and 1: risk of exceeding Z_{msy} and of driving the stock below B_{msy} by maintaining optional annual catch levels of 110-150 000 tons/yr during the period 2005-2014.

If on the other hand there is an abrupt increase in cod biomass resulting from immigration from other areas changes of shrimp stock condition may be much more rapid. Investigations of the event of an immigration of two large year-classes of cod were made by simulating a repetition of the short-lived resurgence of the cod stock seen in the late-1980s. The simulation showed that predation could within a 3-4 year period go from negligible to between 88 000 and 163 000 tons (SCR Doc. 04/76).

Mortality: The mortality caused by fishing and cod predation (Z) has been stable well below the upper limit reference (Z_{msy}) since 1997. The estimated risk of current mortality exceeding Z_{msy} was less than 10%.

Biomass: Since the late-1990s the stock has increased and reached its highest level in 2004. The estimated risk of current stock biomass being below B_{msy} was less than 5% and less than 1% of being below B_{lim}.

Recruitment: A recruitment index (shrimp at age 2) decreased in 2002 and was below average in 2003 as well as in 2004, which may suggest a decline in fishable biomass after 2005.

State of the Stock. The stock biomass has increased substantially since the late-1990s and reached its highest level in 2004. Biomass is well above B_{msy} and mortality by fishery and cod predation is well below Z_{msy}.

The abundance of males between 17 and 22 mm CL in 2004 is estimated to be high and should sustain good catch rates of larger shrimp in 2005. However, both model simulations of stock development and indices of recruitment indicate that fishable biomass can be expected to follow a decreasing trend after 2005.

Both stock development and the rate at which changes might take place depend heavily on the abundance of predators (in particular cod) present within the shrimp habitat. In the most recent years slight increases in cod abundance have been registered. However, these estimates are well below those in the late-1980s and certainly in the 1950s and 1960s.

c) **Precautionary Approach**

The results of this year's assessment could be stated within in the precautionary framework developed by Scientific Council and the recommendations made in SCS Doc. 04/12. The limit reference point for stock size (B_{lim}) is 30% B_{msy} while Z_{msy} is the limit reference point for mortality (Z_{lim}).

Estimated median biomass has been above B_{lim} throughout the time series (Fig. 3.13). The mortality ratio (relative *Z*, which is the total mortality caused by fishing and predation by cod) has been below 1 for most of the time since the early-1970s when the modern fishery developed, except for the period of high cod predation in the late-1980s to early-1990s. In 2004 there is less than 1% risk of the stock being below B_{lim} and the risk of Z_{lim} being exceeded is 9%. Therefore there is only a small risk of the stock being outside the safe zone.

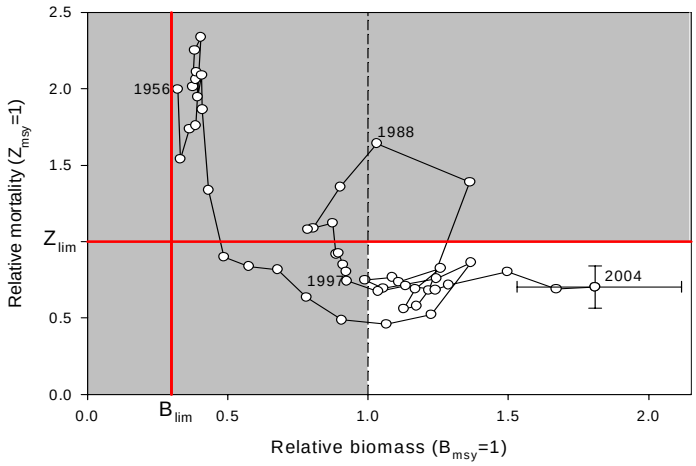

Fig.3.13. Shrimp in Subareas 0 and 1: Stock dynamics 1956 to 2004 in a mortality/biomass continuum. Points are the median values of estimated biomass and mortality ratio. Red lines are limit reference points. Error bars for the 2004-value are upper and lower quartiles.

f) **Research Recommendations**

For the shrimp stock in Subarea 1 and Div. 0A east of 60°W, STACFIS **recommended** that:

- *sampling of catches by observers – essential for assessing age, size, sex composition, fecundity and frequency of spawning of the stock – be re-established in Subarea 1.*
- *the time series of cod biomass used as input in the shrimp assessment model be re-evaluated.*
- *time series of recruitment (index of age 2 abundance) and its link to the fishable biomass in a later year be considered for inclusion in the shrimp assessment model*

4. **Northern shrimp (*Pandalus borealis*) in Denmark Strait and off East Greenland** (SCR Doc. 03/74, 04/81, 83)

a) **Introduction**

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

In 1993 a new fishery began in areas south of 65°N down to Cape Farewell. Access to all these fishing grounds depends heavily on ice conditions.

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

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

Catches of shrimp taken in the Greenland EEZ until 2003 have been reported without accounting for "overpacking" – the amount of surplus weight in packaging – or the difference between the product weight and live weight. New information states that this is not the case in the Iceland EEZ. Therefore in this assessment, only catches in the Greenland EEZ have been adjusted for overpacking (SCR Doc. 03/74) as follows:

	Greenland EEZ			Iceland EEZ	Total area
Year	Reported catch (tons)	Correction factor	Corrected catch (tons)	Reported catch (tons)	STACFIS estimate catch (tons)
1978				363	363
1979	800	1.2511	1001	485	1 486
1980	7 646	1.2511	9 566	759	10 325
1981	4 667	1.2511	5 839	125	5 964
1982	4 902	1.2511	6 133	0	6 133
1983	4 132	1.2511	5 169	43	5 212
1984	5 989	1.2511	7 493	742	8 235
1985	6 316	1.2511	7 902	1 794	9 696
1986	9 814	1.2511	12 278	1 150	13 428
1987	10 848	1.2669	13 743	1 330	15 073
1988	11 125	1.2479	13 882	1 431	15 313
1989	9 416	1.2397	11 673	1 326	12 999
1990	9 994	1.2207	12 199	281	12 480
1991	8 192	1.2564	10 292	465	10 757
1992	5 764	1.2406	7 151	1 750	8 901
1993	5 095	1.2430	6 333	2 553	8 886
1994	8 298	1.2555	10 418	1 514	11 932
1995	8 355	1.2491	10 437	1 151	11 588
1996	9 147	1.2439	11 378	566	11 944
1997	8 733	1.2479	10 898	2 856	13 754
1998	7 900	1.2659	10 001	1 421	11 422
1999	8 698	1.2589	10 950	769	11 719
2000	9 462	1.2598	11 921	132	12 053
2001	11 043	1.2588	13 901	9	13 909
2002	8 025	1.2583	10 098	1 231	11 329
2003	9 128	1.2550	11 456	703	12 159
2004*	8 978	1.0000	8 978	410	9 388

* Up to 30 September

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 in recent years have been between 11-14 000 tons (Fig. 4.1).

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

	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
Recommended TAC	5 000	5 000	5 000	5 000	9 600	9 600	9 600	9 600	9 600	12 400
North of 65°N, Greenland EEZ	4 823	2 351	1 300	3 115	3 223	3 404	1 769	861	1 763	8 700
North of 65°N, Iceland EEZ	1 151	566	2 856	1 421	769	132	9	1 231	703	460
North of 65°N, total	5 974	2 917	4 156	4 536	3 992	3 536	1 778	2 092	2 466	9 160
South of 65°N, Greenland EEZ	3 532	6 796	7 433	4 785	5 475	6 058	9 274	7 164	7 365	4 340
Total STATLANT 21A	9 506	9 713	11 589	9 321	9 467	9 594[1]	11 052[1]	9 196[1]	9 763[1]	
Total STACFIS[2]	11 558	11 944	13 754	11 442	11 719	12 053	13 909	11 242	12 091	13 500[3]

[1] Provisional.
[2] Estimates 1995-2003 corrected for overpack.
[3] Catches projected to end of 2004.

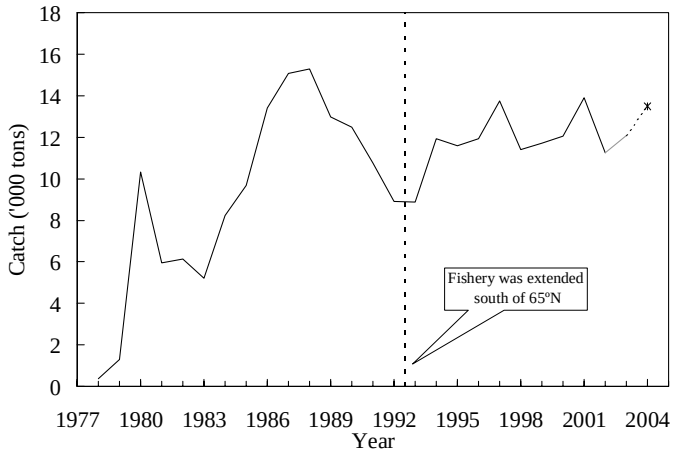

Fig. 4.1. Shrimp in Denmark Strait and off East Greenland: total catches (2004 projected to the end of the year based on January to 1 October data).

b) Input Data

i) Commercial fishery data

Fishing effort and CPUE. Catch and effort (hours fished) from logbooks were available from Greenland, Norway, Iceland, Faroe Islands and EU-Denmark since 1980 and from EU-France for 1980 to 1991.

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

A combined standardized catch-rate index for the total area decreased steadily from 1987 to 1993, showed an increasing trend until the late-1990s, and fluctuated thereafter. The 2000 to 2004 values equal that at the start of the time series in 1987 (Fig. 4.4).

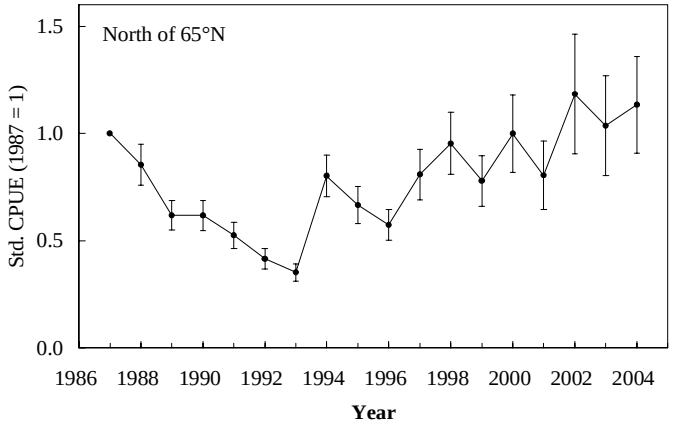

Fig. 4.2. Shrimp in Denmark Strait and off East Greenland: annual standardized CPUE (1987 = 1) with ±1 SE calculated from logbook data from Danish, Faroese, Greenlandic and Icelandic vessels fishing north of 65°N.

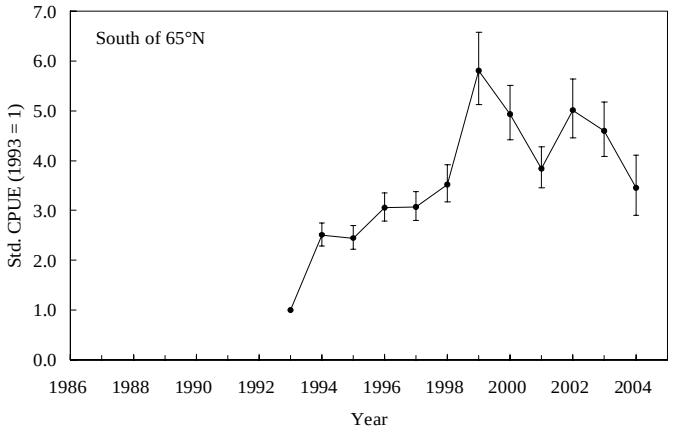

Fig. 4.3. Shrimp in Denmark Strait and off East Greenland: annual standardized CPUE (1993 = 1) with ±1 SE calculated from logbook data from Danish, Faroese and Greenlandic vessels fishing south of 65°N.

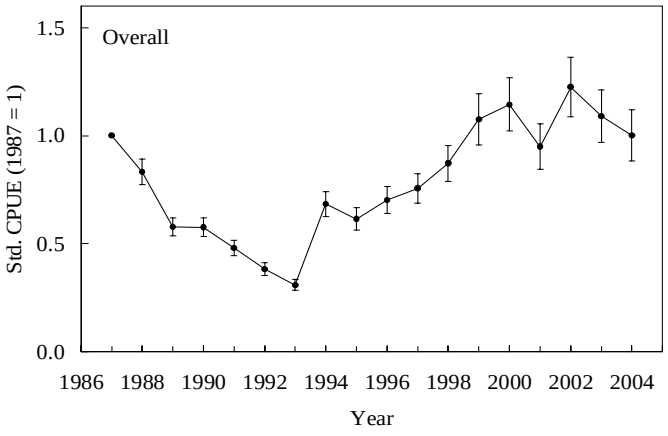

Fig. 4.4. Shrimp in Denmark Strait and off East Greenland: annual standardized CPUE-indices (1987 = 1) with ± 1 SE combined for the total area.

An index of exploitation rate (catch divided by standardized CPUE) for the total area showed a decreasing trend since 1993. Recent levels are the lowest of the time series (Fig. 4.5).

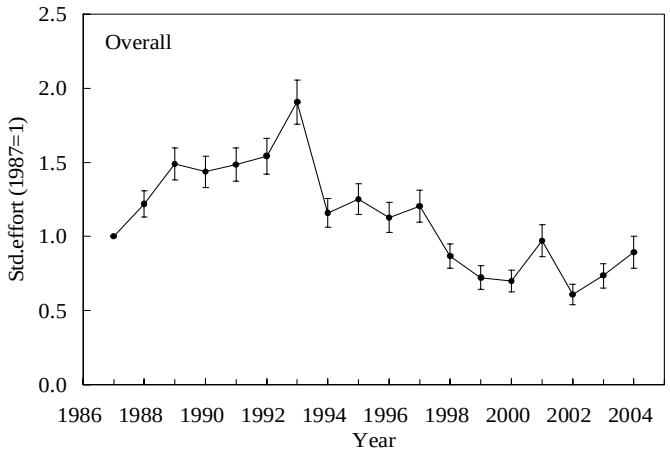

Fig. 4.5. Shrimp in Denmark Strait and off East Greenland: annual standardized exploitation-rate indices (± 1 SE; 1987 = 1), combined for the total area.

Biological data. In 2002 and 2003 STACFIS recommended that "sampling of catches by observers – essential for assessing stock age, size and sex composition – 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**

Commercial CPUE. Combined standardized CPUE indices for the total area declined from 1987 to 1993 and increased thereafter to approximately the same level in 2000–2004 as at the start of the time series in 1987.

Recruitment. No recruitment estimates were available.

Biomass. No direct biomass estimates were available.

Exploitation rate. From 1998 through 2004 the exploitation rate index (catch/CPUE) has been at its lowest levels in the 18-year series.

State of the stock. Standardized CPUE data for all the areas combined indicate an increasing trend in fishable biomass from 1993 to 2000. The 2000 to 2004 values equal the relatively high values at which the series started in 1987.

d) **Research Recommendations**

STACFIS **recommended** that, for shrimp in Denmark Strait and off East Greenland:

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

IV. OTHER BUSINESS

1. **Adjournment**

There being no other business, the Chair expressed his gratitude to the members of the Committee for their valuable contributions, especially from the Designated Experts. The Chair also thanked the NAFO Secretariat for their support during the meeting, both Barb Marshall for providing on-site support and Secretariat Staff providing support from Headquarters. Appreciation was extended to the ICES Secretariat for their support during the meeting, and adjourned the meeting