PARTC: SCIENTIFIC COUNCIL MEETING, 21–29 OCTOBER 2009

Contents

PARTICIPANTS

Sten Munch-Petersen, Anthony Thompson, Ricardo Alpoim (Chair Scientific Council), Barb Marshall, Don Stansbury, George Campanis, Carsten Hvingel (Co-Chair NIPAG), Mats Ulmestrand, Helle Siegstad, Michael C.S. Kingsley, José Miguel Casas Sanchez, Joanne Morgan (Co-Chair NIPAG), Guldborg Søvik, Nanette Hammeken Arboe, Trond Thangstad, David Orr, Bill Brodie, Silver Sirp, Nikoline Ziemer

Report of Scientific Council Meeting

21-29 October 2009

Chair: Ricardo Alpoim Rapporteur: Anthony Thompson

I. PLENARY SESSIONS

The Scientific Council (SC) met at the NAFO Secretariat, Dartmouth, Canada during 21–29 October 2009, to consider the various matters in its Agenda. Representatives attended from Canada, Denmark (Greenland), European Union (Denmark, Estonia, Sweden, Portugal and Spain) and Norway. The Scientific Council Coordinator, Anthony Thompson, was in attendance.

The Executive Committee met prior to the opening session of the Council to discuss the provisional agenda and plan of work.

The opening session of the Council was called to order at 1025 hours on 21 October 2009.

The Chair welcomed representatives, advisers and experts to the opening session of Scientific Council. The Chair noted that the primary reason for this meeting was to provide advice on shrimp stocks based on the assessments provided by the joint NAFO/ICES *Pandalus* Assessment Group (NIPAG). ICES members of NIPAG were granted observer status at the Scientific Council meeting, and the Chair wished all NIPAG members a productive and successful meeting.

The Scientific Council Coordinator, Anthony Thompson, was appointed Rapporteur.

The Council was informed that authorization had been received by the Interim Executive Secretary for proxy votes from France (in respect of Saint Pierre et Miquelon), Iceland, Russian Federation and USA, to record their abstentions during voting procedures.

The Chair explained that under Rules of Procedure 4.3 a vote is required to add a Fisheries Commission Request from September 2009 to the agenda due to the required 60-day advance notice. Affirmative votes were received from Canada, Denmark, European Union, and Norway and, with the addition to the four votes of abstention noted above, the required quorum was met. The Provisional Agenda was adopted with the inclusion of the Fisheries Commission request under Item IV.1.c and IV.1.d. The Chair noted that any additional items that arose during the course of the meeting may be discussed and recorded in the minutes as appropriate.

This opening session was adjourned at 1050 hours. Several sessions were held throughout the course of the meeting to deal with specific items on the agenda.

The concluding session was convened at 1000 hours on 29 October 2009. The Council then considered and adopted Sections III.1–4 of the "Report of the NAFO/ICES *Pandalus* Assessment Group" (NAFO SCS Doc. 09/27, ICES CM 2009/ACOM:11). The Council, having considered the results of the assessments of the NAFO stocks, provided advice and recommendations and noted the requests of the Fisheries Commission and Coastal States had been addressed. The Council then considered and adopted its own report of the 21–29 October 2009 meeting.

The meeting adjourned at 1300 hours on 29 October 2009.

The revised Agenda, List of Research (SCR) and Summary (SCS) Documents, and the List of Representatives, Advisers and Experts, are given in Part D.

II. REVIEW OF RECOMMENDATIONS IN 2006–2009

From the Scientific Council Meeting 1–15 June 2006

XII. Other Matters 5. NAFO Reform

Scientific Council recommended that *boundaries of Divisions 3M and 3L be re-defined so that 3M includes that small rectangle currently in 3L.*

STATUS: This was discussed by General Council at this Annual Meeting and the proposal on the modification of the boundaries was not accepted. Further discussions on this are recorded under Agenda Item V.7.a.

From the Scientific Council Meeting 21-25 June 2009

VII.d.xi. Work arising via the NAFO Conservation and Enforcement Measures (CEM)

The Council noted that paragraph 9 of the recent "Report of the Standing Committee on International Control (STACTIC), 5-7 May 2009 Saint Pierre, St. Pierre et Miquelon (FC Doc. 09/3) raises concerns regarding the clarity of the CEM and has proposed the establishment of a drafting committee to work with the Secretariat on a review of the wording of CEM. It is hoped that the above concerns will be addressed by this drafting group.

The Council further noted that Chapter 1bis of CEM contains many instances of requests of the Scientific Council. The Scientific Council notes that the normal process within NAFO is for Fisheries Commission to refer requests via the Fisheries Commission Document "Requests for advice" developed at the September Annual NAFO meeting. Scientific Council supports and endorses the mechanism as being the proper means to convey requests and recommended that *Fisheries Commission provides both the request and guidance on how these requests should be addressed by Scientific Council through the "Requests for Advice"*.

STATUS: The Scientific Council Chair presented the concerns of Scientific Council regarding the format in which it receives requests for advice from Fisheries Commission during his presentation to Fisheries Commission at the 2009 Annual Meeting. The Chair confirmed that the formal "Requests for Advice" document was the preferred route, and that requests embedded within the CEM were difficult to identify and invariably lacked the necessary guidance and background necessary to address the request. The concerns of Scientific Council were forwarded to the CEM drafting group by the Scientific Council Coordinator on 9 October 2009.

III. NAFO/ICES *PANDALUS* ASSESSMENT GROUP

NIPAG has assessed four stocks of relevance to NAFO: 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. The Scientific Council summary sheets and conclusions for these stocks are presented in Section IV of this report. The recommendations to Fisheries Commission, with respect to stock advice, appear in the summary sheets. The full NIPAG report is available in NAFO SCS Doc. 09/27 and ICES CM 2009/ACOM:11.

IV. FORMULATION OF ADVICE (SEE ANNEXES 1, 2 AND 3)

1 Request from Fisheries Commission

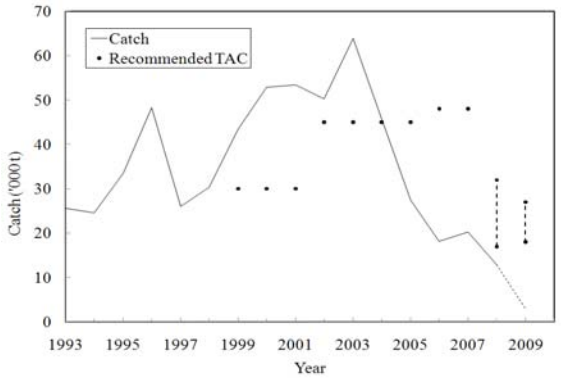
a) Northern shrimp in Div. 3M

Background: The shrimp fishery in Div. 3M began in 1993. Initial catch rates were favorable and, shortly thereafter, vessels from several nations joined. The number of vessels participating in the fishery has decreased by more than 60% since 2004 to 13 vessels.

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

	Catch ('000 t)		TAC ('000 t)	
Year	NIPAG	21A	Recommended	Agreed
2006	18	15[1]	48	er
2007	21	18[1]	48	er
2008	13	12[1]	(17-32)[3]	er
2009	3[2]	3[1,2]	(18-27)[4]	er

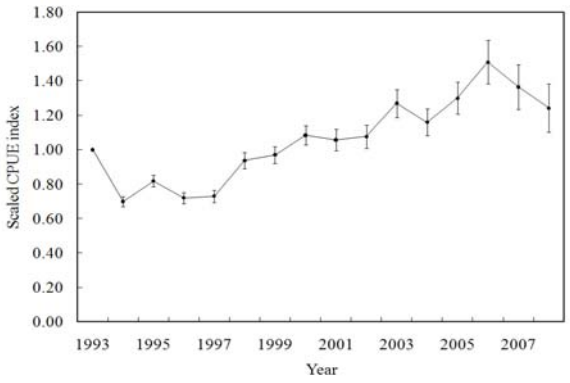
[1] Provisional.
[2] Preliminary to 10 October, 2009
[3] SC recommended in October meeting 2007 that exploitation level for 2008 and 2009 should not exceed the 2005 and 2006 levels (17 000 to 32 000 t).
[4] SC recommended in October meeting 2008 that exploitation level for 2009 and 2010 should not exceed the exploitation levels have occurred since 2005 (18 000 to 27 000 t.)
er Effort regulated



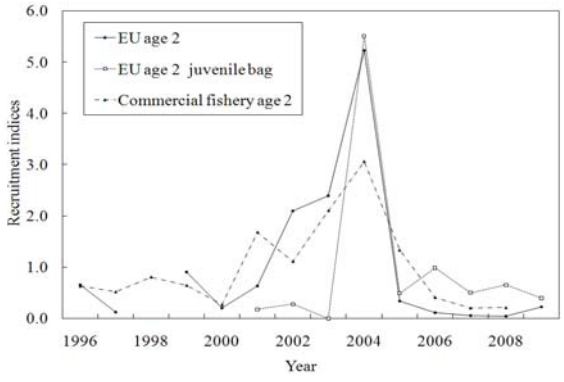
Data: Catch, effort and biological data were available from several Contracting Parties. Time series of size and sex composition data were available mainly from two countries between 1993 and 2005 and survey indices were available from EU research surveys (1988-2009). For lack of samples from the commercial fishery since 2006, length distributions from the EU-survey have been used instead. Reliable catch data were not available for 2009 and therefore the standardized CPUE series was only updated to 2008. This CPUE series accounted for changes in gear (single, double and triple trawl), fishing power and seasonality.

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.

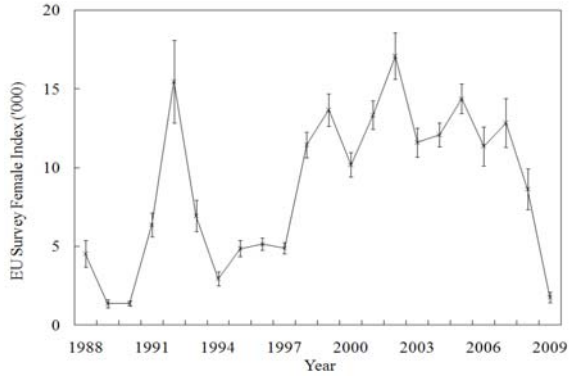
CPUE: Indices for both biomass (figure below) and female biomass from the commercial fishery showed increasing trends from 1996 to 2006. Although still high, both indices have decreased from 2006 to 2008.



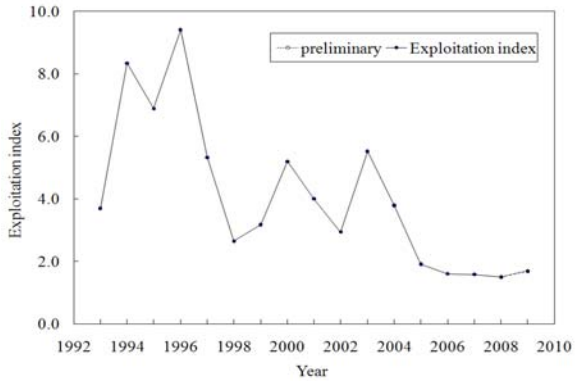
Recruitment: All year-classes since 2002 (i.e. age 2 in 2004) have been weak.



SSB: The survey index of female biomass increased from 1997 to 1998 and fluctuated without trend between 1998 and 2007. Since 2007 the survey index decreased and in 2009 it was the lowest since 1990.

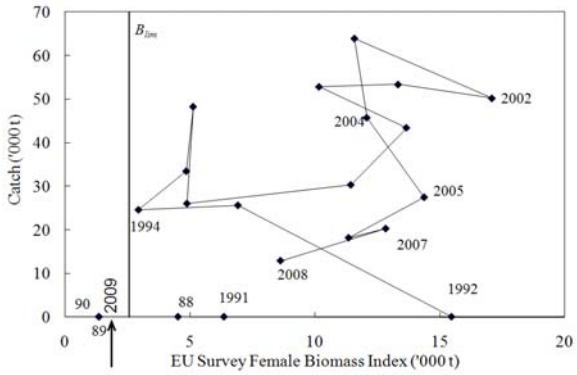


Exploitation rate: From 2005 to 2008 exploitation indices remained stable at relatively low values. The preliminary exploitation rate to 10 October 2009 remains low, but this is not based on projected catches and will increase when the total catch for the year is known.



State of the Stock: The indices of biomass in the July 2009 survey showed a sharp decline, confirming recent downward trends, even though the levels of exploitation have been low since 2005. The most recent estimate of stock size is below B_{lim}. Due to the continued poor recruitment, there are serious concerns that the stock will remain at low levels.

Reference Points: Scientific Council considers that the point at which a valid index of stock size has declined by 85% from the maximum observed index level provides a proxy for B_{lim}, for Div. 3M shrimp, 2 600 t of female survey biomass. The 2009 female biomass index is below this standard value for B_{lim}. It is not possible to calculate a limit reference point for fishing mortality.



Recommendations: The stock is now below B_{lim} *i.e.*, has now entered the collapse zone defined by the NAFO PA framework, and recruitment prospects remain poor. To be consistent with the precautionary approach, fishing mortality should be kept as close to zero as possible when a stock is in the collapse zone. Therefore, Scientific Council reiterates its September 2009 recommendation for 2010 that the fishing mortality be set as close to zero as possible. Scientific Council recommended that fishing mortality in 2011 be set as close to zero as possible.

Special Comments: This advice will be reviewed based on updated information in September 2010 when results from the summer survey are available.

The drastic decline of the shrimp biomass may not be related only to fishing mortality.

Sources of Information: SCR Doc. 04/64, 09/54, 56; SCS Doc 04/12

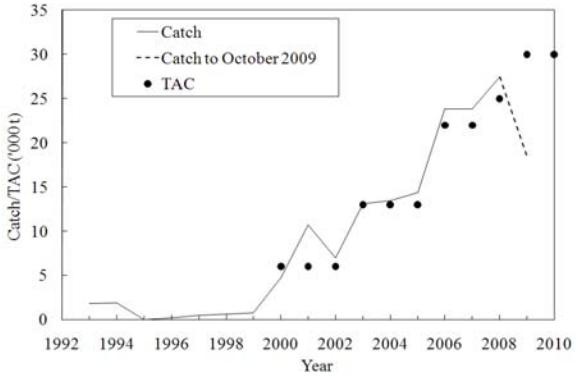
b) Northern shrimp in Div. 3LNO

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 has been restricted to Div. 3L.

Fishery and catches: Several countries participated in the fishery in 2009. The use of a sorting grid to reduce bycatches of fish is mandatory for all fleets in the fishery. Recent catches from the stock are as follows:

	Catch (´000 t)		TAC ('000 t)	
Year	NIPAG	21A	Recommended	Agreed
2006	26	23	22	22[3]
2007	24[2]	21[1]	22	22[3]
2008	27[2]	24[1]	25	25[3]
2009	19[2]	16[1]	25	30[3]
2010			See footnote [4]	30

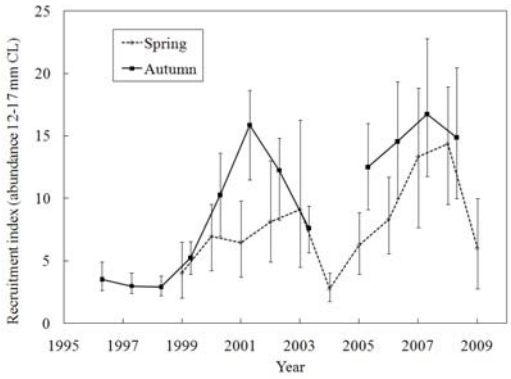
[1] Provisional,
[2] Preliminary to 10 October 2009,
[3] Denmark in respect of the Faroe Islands and Greenland did not agree to their quotas of 245 t (2006–2007), 278 t (2008), or 334 t (2009) and therefore set their own TAC of 2 274 t (2006–2008) and 3 101 t (2009). The increase is not included here.
[4] The recent exploitation rates of about 14% may be too high. Scientific Council therefore urges caution in the exploitation of the stock and considers that exploitation rates should not be raised, but kept below recent levels.



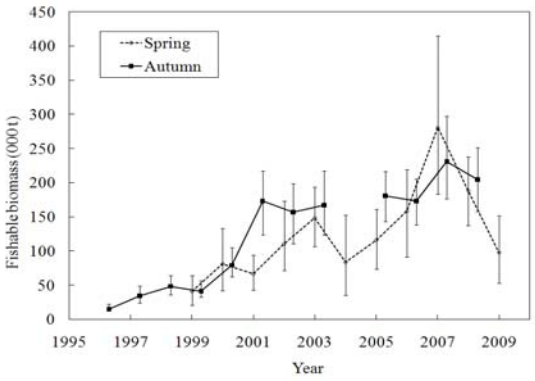
Data: Catch, effort and biological data were available from the commercial fishery. Biomass and recruitment indices as well as size and sex composition data were available from research surveys conducted in Div. 3LNO during spring (1999 to 2009) and autumn (1996 to 2008). The Canadian survey in autumn 2004 was incomplete.

Assessment: Analytical assessment methods have not been established for this stock. Evaluation of the status of the stock is based upon interpretation of commercial fishery and research survey data.

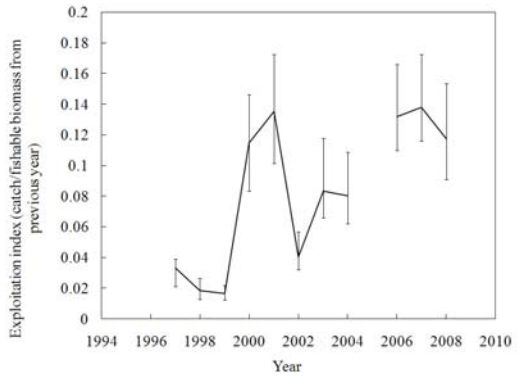
Recruitment: Recruitment indices from 2006 – 2008 were among the highest in the spring and autumn time series. Spring recruitment indices decreased to mean levels in 2009.



Biomass: Spring and autumn biomass indices generally increased, to record levels by 2007, but both decreased in 2008. Spring biomass indices decreased substantially in 2009.

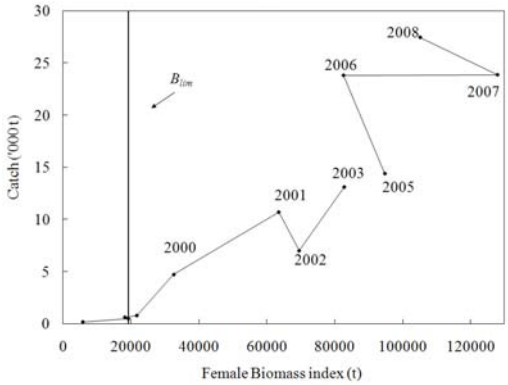


Fishing mortality: The index of exploitation has remained relatively stable since 2006, at a level less than 14%.



State of the Stock: Biomass levels peaked in 2007, decreased since, but remain at or above mean levels. The stock appears to be well represented by a broad range of size groups and recruitment prospects remain at or above mean levels. However, the decreased levels of biomass in the most recent spring surveys could indicate the start of a decreasing trend in the stock.

Precautionary Approach Reference Points: Scientific Council considers that the point at which a valid index of stock size has declined by 85% from the maximum observed index level provides a proxy for B_{lim} (approximately 19 000 t) for northern shrimp in Div. 3LNO. Currently, the female biomass is estimated to be well above B_{lim}. It is not possible to calculate a limit reference point for fishing mortality. A safe zone has not been determined in the precautionary approach framework for this stock.



Recommendation: For 2010: Scientific Council reiterates its recommendation from September 2009 for Div. 3LNO shrimp in 2010.

For 2011: Decreased levels of biomass in the most recent spring surveys could indicate the start of a decreasing trend in the stock. Given the uncertainties about the recent status of this stock and limited predictive capability of the assessment Scientific Council is at this point not in a position to provide advice for 2011.

Preliminary results from the autumn 2009 and spring 2010 surveys will be complete prior to the Annual meeting in September 2010 and may enable Scientific Council to determine whether the recent downward trends are continuing.

Sources of Information: SCR Doc. 09/055, 059

c) PA Reference points for shrimp in Div. 3LNO

At the 2009 Annual meeting, the Fisheries Commission requested: *With respect to Northern shrimp (Pandalus borealis) in Div. 3LNO, noting the NAFO Framework for Precautionary Approach and recognizing the desire to demonstrate NAFO's commitment to applying the precautionary approach, Fisheries Commission requests the Scientific Council to :*

a) identify F_{msy}
b) identify B_{msy}
c) provide advice on the appropriate selection of an upper reference point for biomass (e.g. B_{buf})

Fisheries Commission also requests the Scientific Council to provide information on the effect of the following catch levels in 2011 of 24,000t, 27,000t and 30,000t on the projected SSB and provide risk analyses where possible. (Item 10)

Scientific Council discussed this issue but concluded that it is unable to address this request at this time.

Work to determine F_{msy}, B_{msy} ,and the appropriate selection of an upper reference point for biomass (*e.g.* B_{buf}), will be undertaken and reviewed at future meetings of Scientific Council.

d) Seasonal biomass and catch of shrimp in Div. 3M

At the 2009 Annual meeting, the Fisheries Commission requested: *In considering the possible contribution of fishery catches to changes in stock size of 3M shrimp, it is noted that catches are summed by calendar year, but the surveys are executed in the summer. Is the temporal distribution of shrimp catches through the year well enough known to allow partial contribution of year's catches to stock-size changes to be calculated?* (Item 11)

In order to assess a possible relation between the fishery catches in the months prior to the survey (January to May) and the stock size estimated in that year survey, a linear regression was carried out with the catch data by month available from the NAFO STATLANT 21B. The results of the analysis are shown in the Fig. 1. Regression analysis showed that there was no relationship between the amount of catch taken prior to the survey in a year and the biomass index in the EU survey in that same year (SCR Doc 09/56).

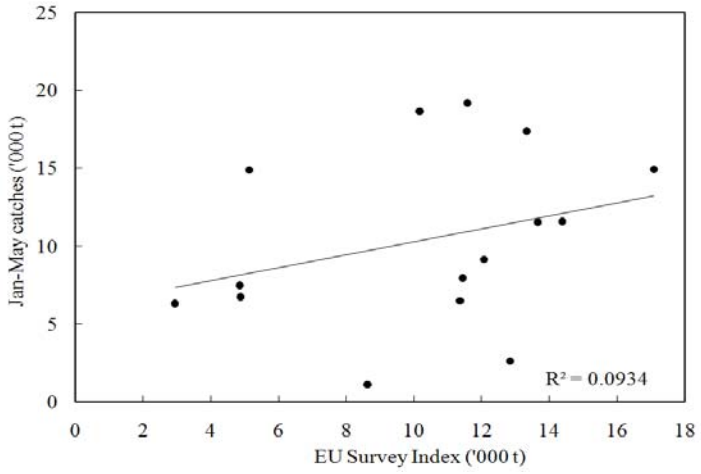


Fig. 1. Shrimp in Div. 3M: Relationship from commercial catches taken between January and May and the EU survey series indexes from 1993 to 2008 years.

On average, what fraction of the year's catches is taken before the execution of the survey?

The fraction of the annual catch taken during January to May of each year (the period prior to the EU survey) was calculated. On average 32% of the year's catch is taken prior to the execution of the EU survey (SCR Doc 09/56).

Year	Shrimp female biomass (t)	Commercial catches (t)		
	EU Survey Index	Annual	Jan-May	%
1994	2945	21537	6318	29%
1995	4857	33071	7481	23%
1996	5132	44615	14881	33%
1997	4885	23221	6732	29%
1998	11444	30035	7956	26%
1999	13669	43144	11548	27%
2000	10172	48734	18673	38%
2001	13336	50755	17377	34%
2002	17091	42965	14912	35%
2003	11589	57530	19198	33%
2004	12081	36509	9133	25%
2005	14381	26688	11592	43%
2006	11359	14065	6467	46%
2007	12843	15131	2610	17%
2008	8630	2832	1098	39%
Average				32%

2. Requests from Coastal States

a) Northern shrimp in Subareas 0 and 1

Background: The shrimp stock off West Greenland is distributed in Subarea 1 and Div. 0A east of 60°30'W. A small-scale inshore fishery began in SA 1 in the 1930s. Since 1969 an offshore fishery has developed.

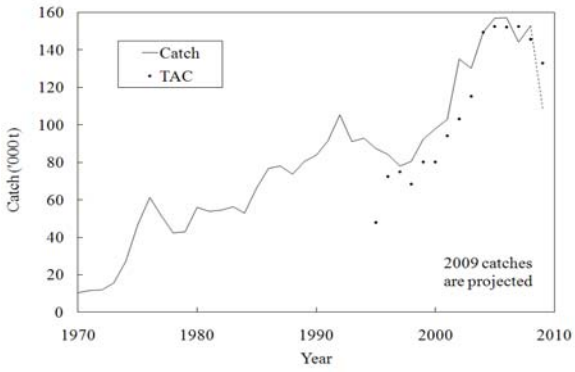
Fishery and Catches: The fishery is prosecuted mostly by Greenland and Canada; since 2004 the EU has had a 4000-t quota in SA 1. Canada did not fish in 2008 and has not fished in 2009. Recent catches from the stock are as follows:

	Catch ('000 t)		TAC ('000 t)	
Year	NIPAG	21A[1]	Advised	Actual[2]
2006	157.3	157.3	130	152.4
2007	144.2	144.1	130	152.4
2008	152.7	3.8	110	145.7
2009	108.8[3]	-	110	133.0

[1] Provisional.

[2] Total of TACs set by Greenland and Canada.

[3] Projected to year-end from data through June.

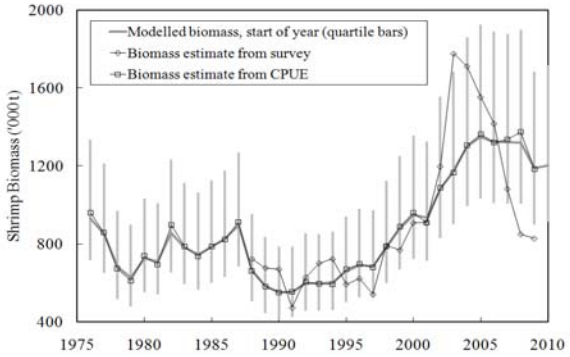


Data: Catch, effort, and position data were available from all vessels. Series of biomass and recruitment indices and size- and sex-composition data were available from research surveys. Series of cod biomass and cod consumption were also available.

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

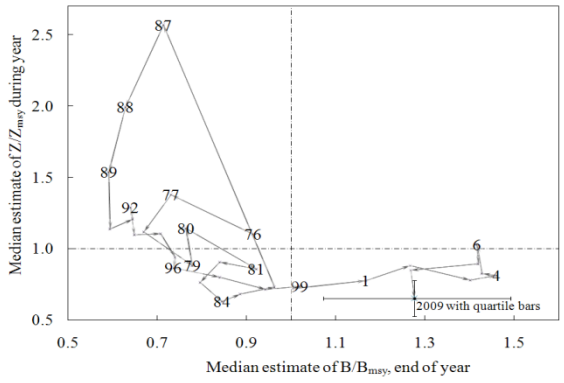
The model used was a stochastic version of a surplus-production model including an explicit term for predation by Atlantic cod, stated in a state-space framework and fitted by Bayesian methods. *MSY* (Maximum Sustainable Yield) defines maximum production, and B_{msy} is the biomass level giving *MSY*. A precautionary limit reference point for stock biomass (B_{lim}) is 30% of B_{msy} and the limit reference point for mortality (Z_{lim}) is Z_{msy}. The model fitted the data fairly well. Median estimate of *MSY* was 148 000 t/yr.

Indices of how widely the stock and the fishery were distributed were calculated from catch positions in the fishery and the survey.

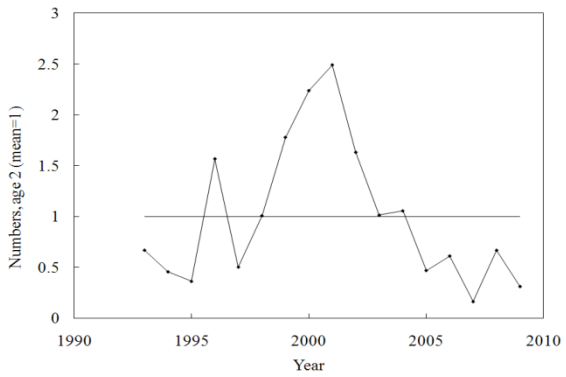


Biomass. A stock-dynamic model showed a maximum biomass in 2005 with a steepening decline since; the probability that biomass will be below B_{MSY} at end 2009 with projected catches at 109 000 t was estimated at 18% and of its being below B_{lim} at less than 1%.

Mortality. The mortality caused by fishing and cod predation (Z) has been stable below the upper limit reference (Z_{msy}) since 1995. With catches in 2009 projected at 109 000 t the risk that total mortality in 2009 would exceed Z_{msy} was estimated at about 3.5%.



Recruitment. Prospects for recruitment to the fishable stock in the next few years remain poor.



State of the Stock. Modelled biomass is estimated to have been declining since 2005. However, at the end of 2009 biomass is projected to be still above B_{msy} and total mortality below Z_{msy}. Annual estimates of numbers of small shrimps have stayed below average in 2005–2009, and concerns about future recruitment remain grave.

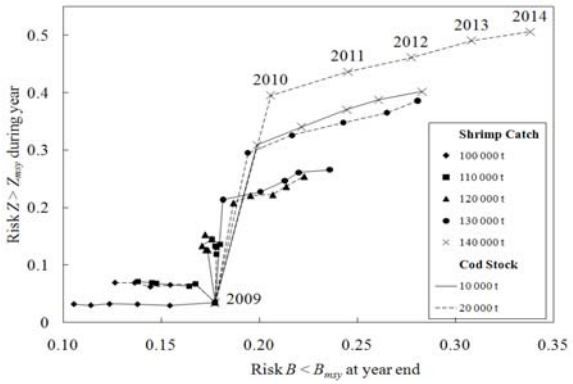
Short-term predictions: Estimated risks associated with each of five catch levels for 2010 with a 10 000 t cod stock are:

Risk of:	Catch option ('000 t)				
	100	110	120	130	140
falling below B_{msy} end 2010 (%)	15	17	17	18	20
falling below B_{lim} end 2010 (%)	<1	<1	<1	<1	<1
exceeding Z_{msy} during 2010 (%)	3	7	13	21	31

Medium-term Predictions: Medium-term predictions over five years are based on outputs from the assessment model, which does not take into account either the below-average recent year classes or the contracting area being fished. Risks of transgressing precautionary limits after five years for each of five catch levels at two possible cod stock biomass levels of 10 000 and 20 000 t were estimated at:

Catch (Kt/yr)	Prob. $B < B_{MSY}$ (%)		Prob. $B < B_{lim}$ (%)		Prob. $Z > Z_{msy}$ (%)	
	10 Kt	20 Kt	10 Kt	20 Kt	10 Kt	20 Kt
100	11	13	<1	<1	3	7
110	14	18	<1	<1	7	15
120	17	22	<1	<1	15	26
130	24	28	<1	<1	27	39
140	28	34	<1	<1	40	51

and the joint evolution of precautionary-approach risks over five years 2010–2014, with an 'effective' cod stock at 10 000 or 20 000 t, was predicted to be:



Recommendations: Scientific Council recognizes that there are significant stock-dynamic considerations that are not incorporated in the assessment model, and that recent values of recruitment indices, and contraction of the stock distribution area, mean that the model predictions may now be both optimistic and more uncertain. Taking these considerations into account, Scientific Council considers that catches should be set at a level bearing a low risk of exceeding Z_{msy}. Scientific Council therefore advises that catches in 2010 should not exceed 110 000 t.

Special Comments: The Scientific Council advice is for catch weight, correctly reported, without overpacking or allowances.

Sources of Information: SCR Doc. 02/158, 03/74, 04/75, 76, 09/53, 60, 65, 66, 67; SCS Doc. 04/12.

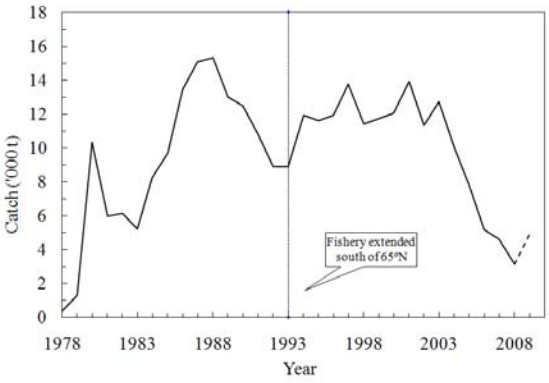
b) Northern shrimp in Denmark Strait and off East Greenland

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. Until 2005 catches in the area south of 65°N accounted for 50-60% of the total catch but since 2006 catches in the southern area accounted for 25% or less of the total catch.

Fishery and Catches: Five nations participated in the fishery in 2009. Catches in the Iceland EEZ decreased from 2002-2005 and since 2006 no catches has been taken. Recent catches and recommended TACs are as follows:

	Catch ('000 t)	TAC ('000 t)		
Year	NIPAG	Recommended	Greenland EEZ	Iceland EEZ[1]
2005	7.7	12.4	12.4	
2006	5.2	12.4	12.4	
2007	4.6	12.4	12.4	
2008	3.1	12.4	12.4	
2009	4.9[2]	12.4	12.8	

[1] Fishery unregulated in Icelandic EEZ.
[2] Catch until October 2009.

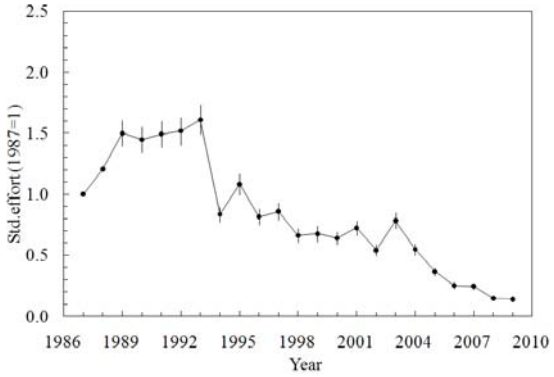


Data: Catch and effort data were available from trawlers of several nations. Surveys were not conducted between 1996 and 2008. The 2009 survey results are not yet available.

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

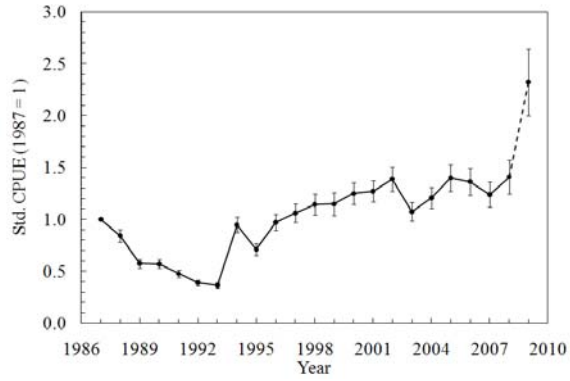
Recruitment: No recruitment estimates were available.

Exploitation rate: Since the mid-1990s, the exploitation rate index (standardized effort) has decreased to its lowest level in the series.



Biomass: No direct biomass estimates were available.

CPUE: Combined standardized catch-rate index for the total area decreased steadily from 1987 to 1993, showed an increase to a relatively high level at the beginning of the 2000s, and has fluctuated around this level until 2008. In 2009 (preliminary data) the standardized catch rate rose to the highest level ever seen, but probably does not reflect a corresponding increase in biomass.



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

Recommendation: Scientific Council finds no basis to change its previous advice and recommended that catches should remain below 12 400 t in 2010.

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

Sources of Information: SCR Doc. 03/74, 09/70

V. OTHER MATTERS

1. Catch and Effort Analysis using VMS Data

As requested by Scientific Council, the Secretariat presented an analysis of the full time series of VMS data to investigate changes in the distribution of fishing effort on shrimp stocks within the NRA. The presentation was in two sections. Firstly, an explanation of the various transmission strings providing catch and posititional information along with discussions on how these may be used in a spatial analysis of shrimp catch and effort. It was emphasized that any full analysis would require detailed "visual" inspection of individual cruise tracks, as summary information is difficult or impossible to extract through automated programming means. Secondly, maps of the distribution of shrimp around the Flemish cap (Div. 3M stock) and in the Sackville Spur area of the Grand Bank (part of Div. 3L stock).

Scientific Council was interested in many aspects of the work undertaken by the Secretariat and noted that the information could be of use in supporting catch and effort data from other sources. Scientific Council urged the Secretariat to continue its work on the potential use of VMS data in the shellfish and finfish assessments.

2. Stock Classifications

Scientific Council reviewed the status of the four assessed shrimp stocks assessed. The status of shrimp in Div. 3LNO, SA0+1, and Denmark Strait, remained unchanged at "moderate" fishing mortality and an "intermediate" stock size. The status of shrimp in Div. 3M was changed from "moderate" fishing mortality and an "intermediate" stock size to "none-low" fishing mortality and a "small" stock size.

3. Coordination with ICES Working Groups on Shrimp Stock Assessments

This year's report of NIPAG (the NAFO/ICES *Pandalus* Assessment Group) contains the assessments for NAFO Scientific Council and ICES ACOM. It was noted that the enhanced peer review was beneficial to both NAFO and ICES and should continue under the umbrella of the joint NIPAG group and the Co-Chairing arrangement.

4. Meeting of Oct 2010

The Scientific Council agreed that the dates and venue of the next Scientific Council / NIPAG meeting will be held from 20–27 October 2010 at the ICES Headquarters, Copenhagen, Denmark. The meeting dates have been shortened by one day.

5. Meeting of Oct 2011

The dates and venue of the Scientific Council/NIPAG meeting will be decided at the 2010 meeting. Provisional dates and venue are 19–26 October 2011. The meeting dates have been shortened by one day. Invitations from Greenland and Norway are being considered as a venue for this meeting.

6. Topics for Future Special Sessions

Scientific Council discussed "Bayesian methods" as a potential topic for the workshop in 2010. The Scientific Council Chair will contact possible Chairs/organisers/leaders and report on progress at the June 2010 meeting.

A NAFO co-organizer for the joint ICES/NAFO symposium on "Hydrobiological and ecosystem variability in the ICES area during the first decade of the XXI century" that is due to be held on 10-12 May 2011 has not yet been identified. Scientific Council requests that the STACFEN Chair makes further enquiries regarding possible co-convenors.

7. Other Business

a) Statistical boundary for Flemish Cap

Scientific Council, reiterates its concerns that the current boundary definitions of Div. 3L and Div. 3M can lead to the assignment of catch and effort to the wrong stock. Scientific Council recognizes that General Council, subject to the concurrence of Canada as a Coastal State exercising fisheries jurisdiction in part of Div. 3L in this case, is the body responsible for modifying the boundaries of statistical areas (see Article XX, paragraph 2, of the Convention), for scientific or statistical purposes. Further, Scientific Council respects the decision of General Council, and of the role of the coastal State in this decision, in keeping the original boundary definitions. However, Scientific Council maintains its opinion that the current boundary definitions for Div. 3L and Div. 3M does not, in all cases, result in the best reporting of catch and effort for target and bycatch species, and that this may lower the quality of the scientific advice.

Scientific Council notes that the southeastern portion of Div. 3L encroaches upon the Flemish Cap and the northwestern portion of Div. 3M encroaches upon the Grand Bank Sackville Spur. In both cases, catches could be assigned to the wrong stocks. The significance of this "mis-allocation" across the range of assessed stocks will be presented at the June 2010 meeting of Scientific Council.

b) Guidance for upcoming CWP and FIRMS meetings

The Chair noted that the next meetings of CWP and FIRMS will be in February 2010 in Hobart, Australia. Scientific Council will be represented by a member of the NAFO Secretariat, who will coordinate with the STACREC Chair. The Chair asked participants for any issues that should be raised at the upcoming CWP and FIRMS meetings.

Scientific Council discussed the reporting of invertebrate species, particularly corals and sponges, from commercial and research fishing vessels. It was noted that codes and standards have been established for shellfish and finfish species, but believes that no equivalent system exits for the structure-forming benthic organisms. Scientific Council requests that this issue be raised at the upcoming CWP meeting as an item for them to consider and to provide guidance to RFMOs on the recording of such information.

c) Timing of the Shrimp Advice

Scientific Council has consistently had difficulties in providing timely advice for Div. 3LNO shrimp and Div. 3M shrimp for the September Annual meeting. Currently, the advice is given 14 months before it will be applied to the fishery as a management measure, *i.e.* the October 2009 advice is for the 2011 management measures. This advice is updated by an interim monitoring report in September, and in some years has been subject to significant change, for example as happened in September 2009. Further, shrimp populations can decline quickly and somewhat unpredictably (as happened this year for Div. 3M shrimp), and this can result in great difficulty when providing advice 14 months in to the future (as seen this year for Div. 3LNO shrimp).

Surveys are important for the assessment of shrimp, and it would be best if the October advice could be applied to the fishery in the following year, *i.e.*, the October 2009 advice would be for the 2010 management measures. Clearly, this is only possible if there is an intersessional meeting of Fisheries Commission very soon after the October Scientific Council meeting, as is happening this year for Div. 3M shrimp.

The Scientific Council Chair will discuss this matter further with the Fisheries Commission Chair.

VI. ADOPTION OF SCIENTIFIC COUNCIL AND NIPAG REPORTS

The Council at its session on 29 October 2009 considered and adopted Sections III.1–4 of the “Report of the NAFO/ICES *Pandalus* Assessment Group” (SCS Doc. 09/27, ICES CM 2009/ACOM:11). The Council then considered and adopted its own report of the 21–29 October 2009 meeting.

VII. ADJOURNMENT

The Chair thanked the participants for their hard work and contribution to the success of this meeting, and welcomed the peer review and constructive comments received in formulating the scientific advice. The Chair thanked the Scientific Council Coordinator, Anthony Thompson for his excellent support during the meeting. The Chair then thanked the NAFO Secretariat for supporting and hosting this Scientific Council meeting and the NIPAG meeting, in particular, Barbara Marshall and Lisa Pelzmann. All participants were then wished a safe journey home and the meeting was adjourned at 1300 hours.

APPENDIX 1 – STOCKS ASSESSED BY NIPAG

Co-Chairs: Joanne Morgan (NAFO Stocks) and Carsten Hvingel (ICES Stocks) Rapporteurs: Various

1. Northern Shrimp on Flemish Cap (NAFO Div. 3M) – NAFO Stock

(SCR Doc. 04/64, 04/77, 09/56, 09/57, 09/54)

a) Introduction

The shrimp fishery in Div. 3M began in 1993. Initial catch rates were favorable and, shortly thereafter, vessels from several nations joined. The number of vessels participating in the fishery has decreased by more than 60% since 2004 to 13 vessels.

Catches peaked at 64 000 t in 2003 (Fig. 1.1). Since then catches have been lower, declining to 13 000 t in 2008. Provisional information to 10 October 2009 indicates removals of about 3 000 t, much lower than those recorded last year up to this date. Information from the fishing industry suggests that catch rates, fuel prices, and low market prices for shrimp may be affecting participation in this fishery.

NIPAG is concerned about suspected misreporting of catches since 2005, where catches from Div. 3L were reported as from Div. 3M.

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

	2001	2002	2003	2004	2005	2006	2007	2008	2009
Recommended TAC	30 000	45 000	45 000	45 000	45 000	48 000	48 000	17 000-32 000[3]	18 000-27 000[4]
STATLANT 21A	54 830	48 836	62 761	45 842	27 651	15 191[1]	17 642[1]	11 671[1]	2 958[1,2]
NIPAG	53 389	50 214	63 970	45 757	27 479	18 162	20 741	12 889	2 958[2]

[1] Provisional
[2] Preliminary to 10 October 2009.
[3] SC recommended in October meeting 2007 that exploitation level for 2008 and 2009 should not exceed the 2005 and 2006 levels (17 000 to 32 000 t).
[4] SC recommended in October meeting 2008 that exploitation level for 2009 and 2010 should not exceed the exploitation levels have occurred since 2005 (18 000 to 27 000 t).

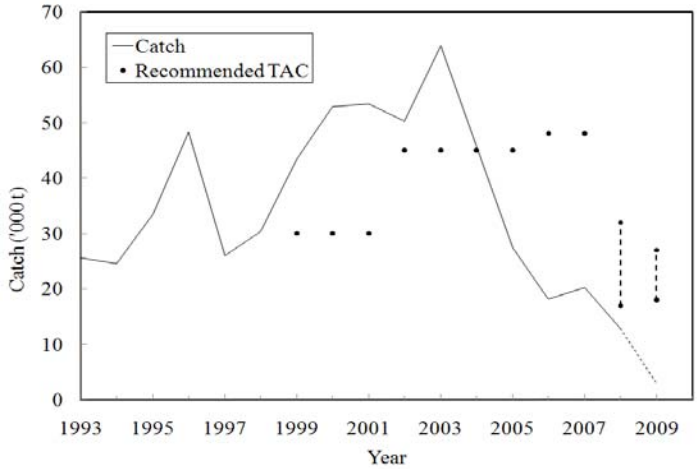


Fig. 1.1. Shrimp in Div. 3M: catches (2009 preliminary partial year's catch to 10 October). Preliminary information is shown by the dashed line.

b) Input Data

i) Commercial fishery data

Effort and CPUE. Logbook and/or observer data were available from Canadian, Greenlandic, Icelandic, Faroese, Norwegian, Russian, Estonian and Spanish vessels. From this information one international CPUE database for Div. 3M was constructed. There has been concerns that, since 2005, reporting of some Div. 3L catches as coming from Div. 3M was affecting the CPUE data for some fleets. In order to avoid the uncertainty around the catch rate standardization model used for Div. 3M, all trips from 2005 to 2008 where fishing occurred in both Div. 3M and Div. 3L were eliminated. When this criterion was applied to the 2009 data, there were no remaining data as all trips reported catches in both Divisions. Therefore, a standardized CPUE series was produced only for 1993 to 2008. CPUE gradually increased from the mid-1990s to 2006. In 2007 and 2008 the standardized CPUE declined. Effort levels have recently been low and NIPAG was concerned that the CPUE may not reflect the stock status in the same way as at higher levels of effort.

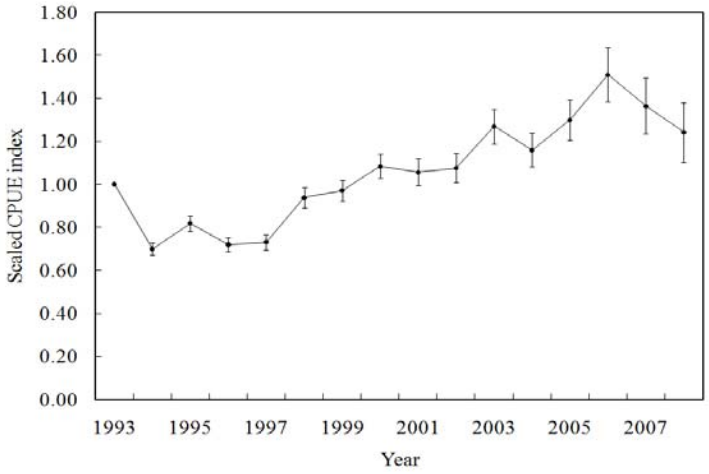


Fig. 1.2. Shrimp in Div. 3M: Standardized CPUE of shrimp on Flemish Cap, 1993-2008.

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

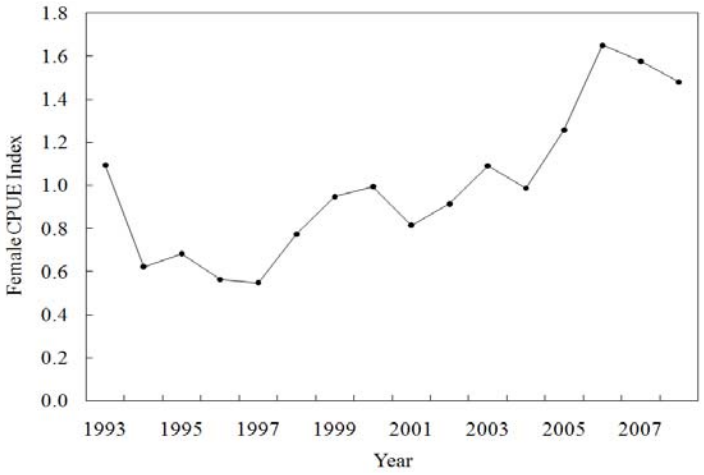


Fig. 1.3. Shrimp in Div. 3M: Standardized Female CPUE of shrimp on Flemish Cap, 1993-2008. The series was standardized its mean.

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

Ages 3, 4 and 5 generally dominate the commercial catch in numbers. By weight the 6 year-olds are also considered important in the fishery although generally fewer. The 2002 year-class appeared prominent as 3 year-olds in the 2005 fishery and as 4 and 5 year-olds in 2006 and 2007. In 2008 the abundance of this year-class declined drastically. Since 2004 recruitment (number of 2 year olds) has been decreasing.

Numbers/hour at age caught in the commercial fishery:

Age	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	Mean
1	9	0	6	0	0	23	667	0	0	0	0	0	54
2	2144	3331	2660	1108	6911	4569	8642	12559	5477	1689	849	876	4109
3	17024	19489	15836	23190	9257	38542	9539	29504	35615	8721	10904	25668	20810
4	17665	22800	18316	26971	29627	13117	38126	10559	31076	56559	34553	34236	26300
5	3470	7273	14736	15948	15637	15896	14871	22325	14798	34979	36314	23005	17050
6	703	2705	5305	3346	4426	3247	5855	4347	2905	15162	16722	1614	5199
7	61	303	61	162	598	128	87	24	478	1881	3653	0	620
Total	41068	55901	56914	70725	66456	75498	77119	79318	90350	118991	102995	85399	74089

ii) Research survey data

Stratified-random surveys have been conducted on Flemish Cap by the EU, in July from 1988 to 2009. A new vessel was introduced in 2003 which continued to use the same trawl employed since 1988. In addition, there were differences in cod-end mesh sizes utilized in the 1994 and 1998 surveys that have likely resulted in biased estimates of total survey biomass. Nevertheless, for this assessment, the series prior to 2003 were converted into comparable units with the new vessel based on the methodology accepted by STACFIS in 2004 (NAFO 2004 SC Rep., SCR Doc. 04/77). The index was stable at a high level from 1998 to 2007. In 2008 and 2009 the index showed a drastic decline to levels which are among the lowest observed in the time series (Fig. 1.4). This drastic decline of shrimp biomass may be associated with the increase of the cod stock in recent years (SCR Doc. 09/56) (Figure 1.5).

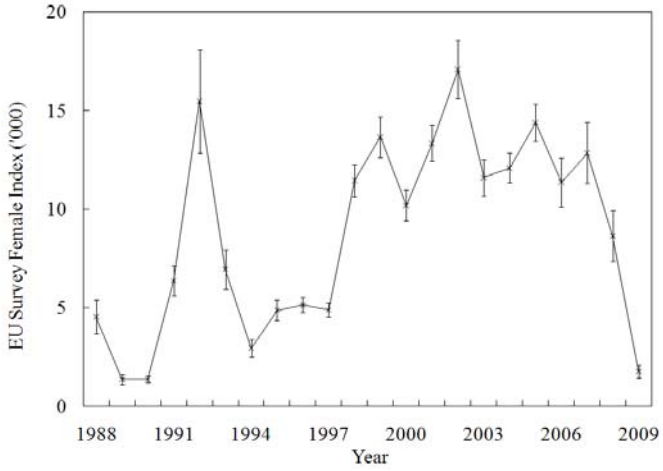


Fig. 1.4. Shrimp in Div. 3M: female biomass index from EU trawl surveys, 1988-2009.

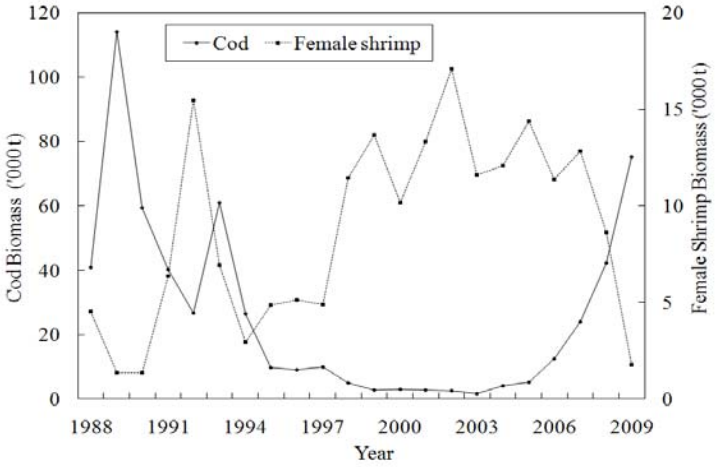


Fig. 1.5. Shrimp in Div. 3M: Cod and female shrimp biomass from EU trawl surveys, 1988-2009.

iii) Recruitment indices

Commercial fishery. Although the commercial fishery is conducted with larger mesh size than the survey indices, two year olds are frequently detected in the fishery. An index of two year old shrimp from 1996 to 2008, based on standardized number per hour correlated well (R^2= 0.59, Fig. 1.6) with a similar index derived for 3+ year olds (a proxy for the fishable biomass) from the fishery two years later. The number per hour of 2 year-olds in the commercial fishery has been declining since 2004 (see table above).

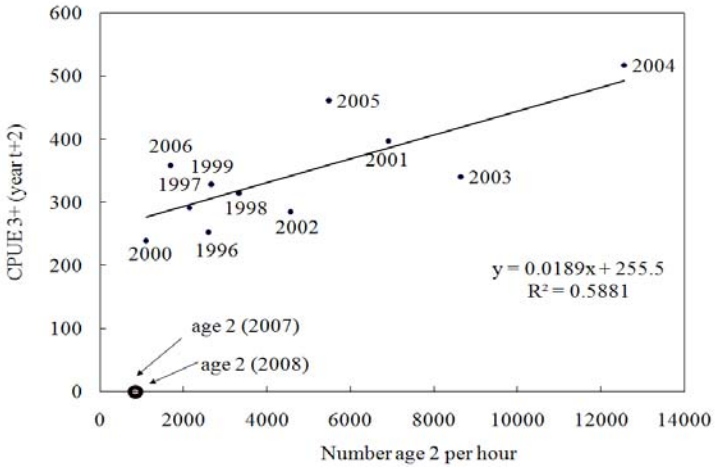


Fig. 1.6. Shrimp in Div. 3M: regression between number per hour of age 2 (year t) shrimp in the commercial fishery and standardized CPUE of age 3+ 2 years later.

EU bottom trawl surveys. From 1988 to 1995 shrimp age 2 and younger were not captured by the survey. Beginning in 1996 the presence of this component increased in the surveys and it is believed that the introduction of the new vessel in 2003 greatly improved the catchability of age 2 shrimp due to technological advances in maintaining consistent performance of the fishing gear. In addition, since 2001, a small mesh juvenile bag was also attached to the net which was designed to provide an index of juvenile shrimp smaller than that typically retained by the survey cod-end. The recruitment indices since 2005 are low in the main gear as well as in the juvenile bag (Fig. 1.7). The EU-survey agrees with the commercial fishery recruitment indices in showing an exceptionally large 2002 year-class and very weak 2003-2006 year-classes.

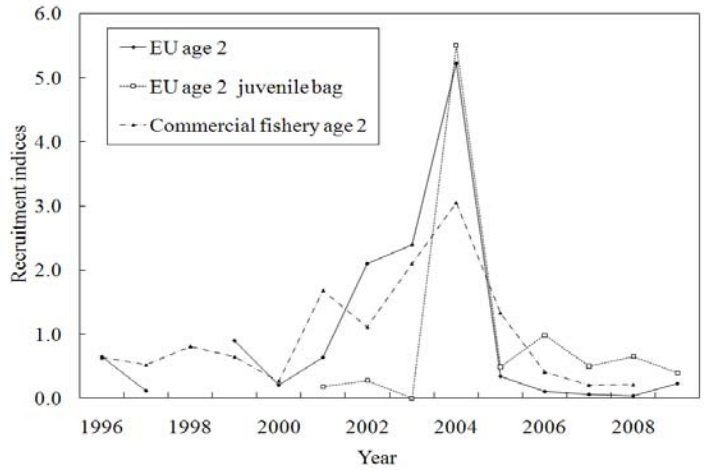


Fig. 1.7. Shrimp in Div. 3M: abundance indices at age 2 from the EU survey and commercial fishery. Each series was standardized to its mean.

iv) Exploitation rate

An index of exploitation was derived by dividing the nominal catch in a given year by the biomass index from the EU survey in the same year (Fig. 1.8). This was high in the years 1994-1997 when biomass was generally lower. From 2005 to 2008 exploitation indices remained stable at relatively low values (between 1.9-1.5). The preliminary exploitation rate to 10 October 2009 remains low at 1.7, but this is not based on projected catches and will increase when the total catch for the year is known.

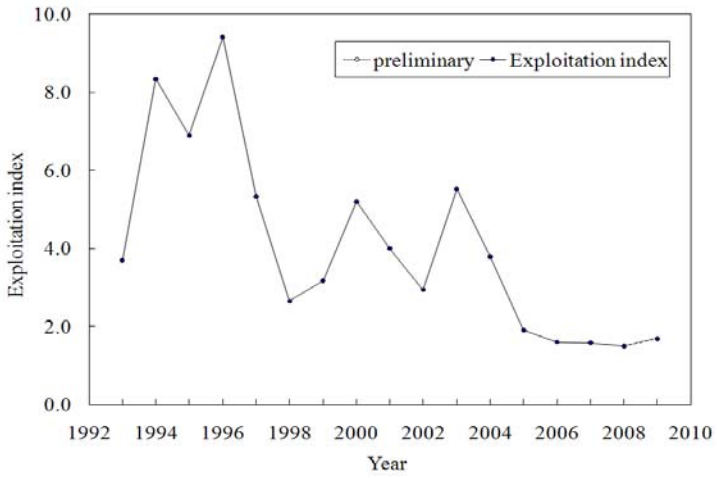


Fig. 1.8. Shrimp in Div. 3M: exploitation rates as derived by catch divided by the EU survey biomass index of the same year

v) Other studies

The fraction of the annual catch taken during January to May of each year (the period prior to the EU survey) was calculated. On average 32% of the year's catch is taken prior to the execution of the EU survey. Regression analysis showed that there was no relationship between the amount of catch taken prior to the survey in a year and the biomass index in the EU survey in that same year (SCR Doc 09/56) (Fig. 1.9)

Year	Shrimp female biomass (t)	Commercial catches (t)		
	EU Survey Index	Annual	Jan-May	%
1994	2945	21537	6318	29%
1995	4857	33071	7481	23%
1996	5132	44615	14881	33%
1997	4885	23221	6732	29%
1998	11444	30035	7956	26%
1999	13669	43144	11548	27%
2000	10172	48734	18673	38%
2001	13336	50755	17377	34%
2002	17091	42965	14912	35%
2003	11589	57530	19198	33%
2004	12081	36509	9133	25%
2005	14381	26688	11592	43%
2006	11359	14065	6467	46%
2007	12843	15131	2610	17%
2008	8630	2832	1098	39%
			Average	32%

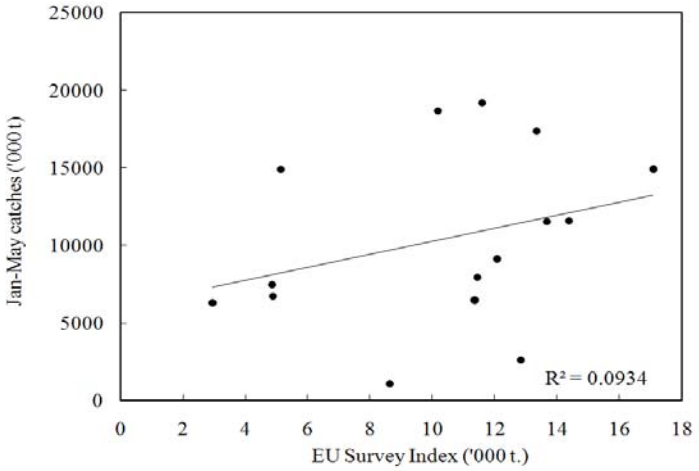


Fig. 1.9. Shrimp in Div. 3M: Relationship from commercial catches taken between January and May and the EU survey series indexes from 1994 to 2008 years.

c) Assessment Results

Suspicions of misreporting during recent years, and its effect on various indices derived from the commercial fishery, continued in 2009. In order to avoid the uncertainty around the catch rate standardization model, all trips for which there was fishing in both 3M and 3L were eliminated. When this criterion was applied to the 2009 data, there were no remaining data as all trips reported catches in both Divisions. Thus several indices derived from the CPUE for 2009 could not be used in the assessment this year.

Commercial CPUE indices. Indices for both biomass and female biomass from the commercial fishery showed increasing trends from 1996 to 2006. Although still high, both indices have decreased from 2006 to 2008.

Biomass. The survey index of female biomass increased from 1997 to 1998 and fluctuated without trend between 1998 and 2007. In 2008 and 2009 the biomass decreased reaching in 2009 the lowest level since 1990.

Recruitment. All year-classes since 2002 have been weak.

Exploitation rate. From 2005 to 2008 exploitation indices remained stable at relatively low values. The preliminary exploitation rate to 10 October 2009 remains low, but this is not based on projected catches and will increase when the total catch for the year is known.

State of the Stock. The indices of biomass in the July 2009 survey showed a sharp decline, confirming recent downward trends, even though the levels of exploitation have been low since 2005. The most recent estimate of stock size is below B_{lim}. Due to the continued poor recruitment, there are serious concerns that the stock will remain at low levels.

d) Precautionary Approach

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

The limit reference point for the Flemish Cap shrimp stock is taken from the EU survey where the biomass index of female shrimp is used. The EU survey of Div. 3M provides an index of female shrimp biomass from 1988 to 2009 with a maximum value of 17 100 t in 2002, (and a similar value of 15 500 t. in 1992). An 85% decline in this value would give a B_{lim} = 2 600 t. The female biomass index was below this value in 1989 and 1990, before the fishery. In

2007 and 2008 it was about 25% and 51%, respectively, below the maximum. The 2009 female biomass index is below this standard value for B_{lim} (Fig. 1.9).

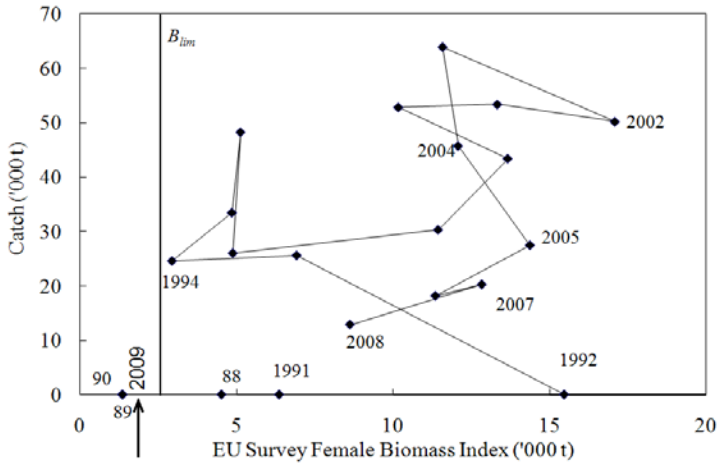


Fig. 1.10. Shrimp in Div. 3M: catch plotted against female biomass index from EU survey. Line denoting B_{lim} is drawn where biomass is 85% lower than the maximum point in 2002. The estimated female biomass index for 2009 (1764 t) is shown by the arrow on the x-axis, catch for 2009 is incomplete and is not shown in the figure.

e) Research Recommendations

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

- *biological and CPUE data from all fleets fishing for shrimp in the area, be submitted to Designated Experts by 1 September 2010.*
- *the catch and effort data from other sources, for example VMS and/or Observer data, continue to be investigated to validate commercial data obtained from summarized logbooks or STATLANT data.*
- *the relationship between the recruitment indices and fishable biomass be investigated further.*
- *Collaborative efforts should be made to standardize a means of predicting recruitment to the fishable stock.*

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

(SCR Doc. 09/55, 59)

a) Introduction

This shrimp stock is distributed around the edge of the Grand Bank mainly in Div. 3L. The fishery began in 1993 and came under TAC control in 2000 with a 6000 t TAC and fishing restricted to Div. 3L. Annual TACs were raised several times between 2000 and 2009 reaching a level of 30 000 t for 2009 and 2010. A total catch of 18 567 t was taken up to October 2009 (Fig. 2.1).

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

	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
TAC as set by FC	6 000	6 000	13 000[1]	13 000[1]	13 000[1]	22 000[1]	22 000[1]	25 000[1]	30 000[1]	30 000[1]
STATLANT 21A	5 647	5 894	11 979	12 767	14 281	23 144	21 062[2]	23 912[2]	15 676[2]	
NIPAG	10 697[3]	6 994[3]	13 099[3]	13 461[3]	14 384[3]	25 801[3]	23 855[3]	27 435[3]	18 567[3]	

[1] Denmark with respect to Faroes and Greenland did not agree to the quotas of 144 t (2003–2005), 245 t (2006–2007), 278 t (2008), or 334 t (2009) and set their own TACs of 1 344 t (2003–2005), 2 274 t (2006–2008) and 3 101 t (2009). The increase is not included in the table.

[2] Provisional catches.

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

Since this stock came under TAC regulation, Canada has been allocated 83% of the TAC. This allocation is split between a small-vessel (less than 500 GT and less than 65 ft) and a large-vessel fleet. By October 2009, the small- and large-vessel fleets had taken 12 995 t and 2 307 t of shrimp respectively in Div. 3L. In all years, most of the Canadian catch occurred along the northeast slope in Div. 3L.

The annual quota within the NAFO Regulatory Area (NRA) is 17% of the total TAC. Denmark (in respect of the Faroe Islands and Greenland) did not agree to the quotas from 2003 onwards and have set their own TACs.

The use of a sorting grid to reduce bycatches of fish is mandatory for all fleets in the fishery. The sorting grid cannot have a bar spacing greater than 22 mm.

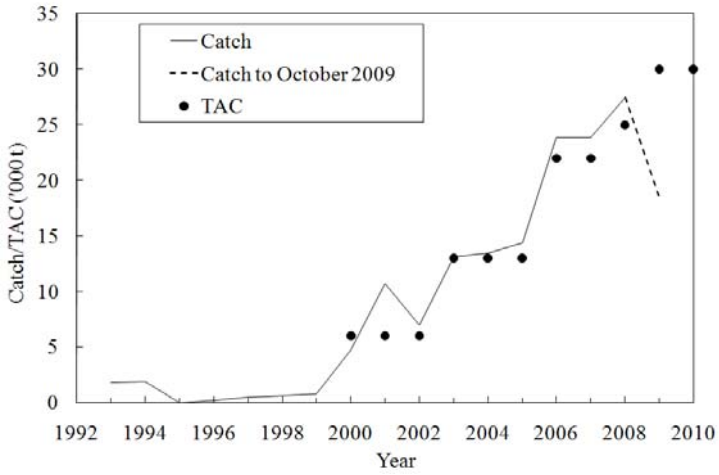


Fig. 2.1. Shrimp in Div. 3LNO: catches (to October 2009) and TAC as set by Fisheries Commission.

b) Input Data

i) Commercial fishery data

Effort and CPUE. Catch and effort data have been available from vessel logbooks and observer records since 2000. Standardized catch rates for large Canadian vessels (>500 t) have been stable since 2004 near the long term mean. There was insufficient data to estimate a standardized CPUE index for the 2009 Canadian small-vessel (≤500 t) fleet. The small-vessel CPUE increased from 2000 to 2005 after which it decreased to near the mean (Fig. 2.2).

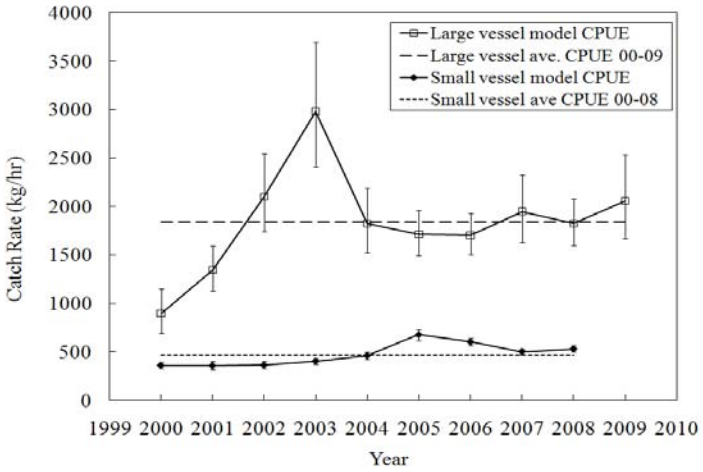


Fig. 2.2. Shrimp in Div. 3LNO: Standardized CPUE for the Canadian large-vessel (>500 t) and small-vessel (≤500 t; LOA<65') fleets fishing shrimp in Div. 3L within the Canadian EEZ.

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

Catch composition. In 2009, length compositions were derived from Canadian and Estonian observer datasets. As in previous years, the catch appears well represented by a broad range of size groups of both males and females.

ii) Research survey data

Canadian multi-species trawl survey. Canada has conducted stratified-random surveys in Div. 3LNO, using a Campelen 1800 shrimp trawl, from which shrimp data is available for spring (1999–2009) and autumn (1996–2008). All estimates were updated, where necessary, to correct for differences in research survey tow durations. The autumn survey in 2004 was incomplete and therefore of limited use for the assessment.

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

Biomass and Abundance. In Canadian surveys, over 90% of the biomass was found in Div. 3L, distributed mainly along the northeast slope in depths from 185 to 550 m. There was a significant increase in autumn shrimp biomass indices between 1996 and 2001 and this index has since remained at a high level. The autumn 2008 3LNO biomass index was estimated to be 249 300 t, the second highest in the autumn time series, down from 275 700 t in 2007. The spring biomass index increased from 93 500 t in 2004 to 288 600 t in 2007, but has since decreased to 112 500 t in 2009, a decrease of 61% over two years (Fig. 2.3). Confidence intervals from the spring surveys are usually broader than from the autumn surveys.

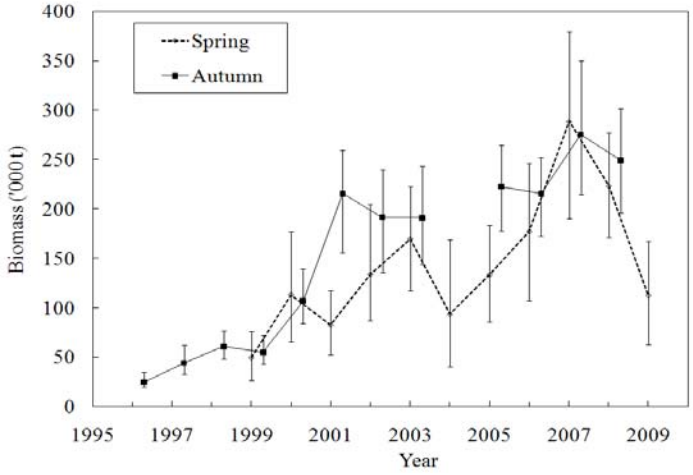


Fig. 2.3. Shrimp in Div. 3LNO: biomass index estimates from Canadian spring and autumn multi-species surveys (with 95% confidence intervals).

Spanish survey biomass indices for Div. 3L, within the NRA, increased between 2003 (64 000 t) and 2006 (126 000 t), remaining at a high level in 2007 and 2008 (149 000 t) followed by a 50% decrease in biomass in 2009 (74 000 t) (Fig. 2.4). Canadian spring and autumn survey biomass indices in Div. 3L both inside and outside the NRA increased to their highest levels in 2007 but have subsequently decreased.

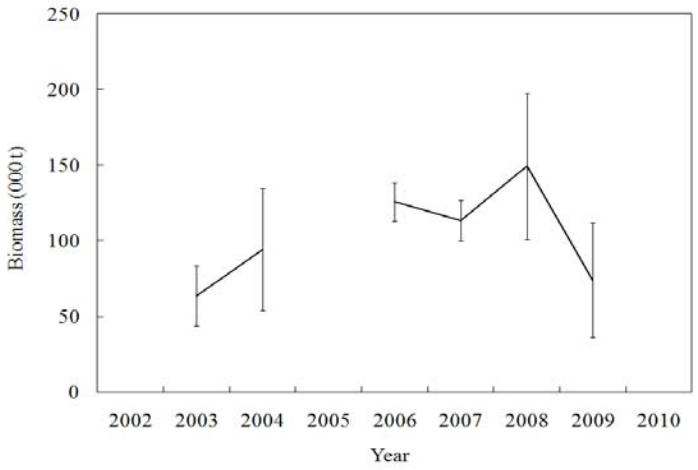


Fig. 2.4. Shrimp in Div. 3LNO: biomass index estimates from Spanish multi-species surveys (with 95% confidence intervals) in the Div. 3L NRA.

Spanish survey biomass indices for Div. 3NO in the NRA, have shown a decline from 3000 t in 2004 to 100 t in 2009. Canadian spring and autumn survey biomass indices in Div. 3NO both inside and outside the NRA fluctuated without trend over the same period.

Stock composition. The autumn surveys showed an increasing trend in the abundance of female (transitionals + females) shrimp up to 2007 and remained high in 2008. Spring female abundances showed an increasing trend until 2007 after which female abundances decreased by 63% from 23 billion females in 2007 to 8 billion females in 2009. Autumn male abundance indices increased until 2001 and have since remained stable at a high level, while spring male abundance indices followed similar trends as the females (Fig. 2.5).

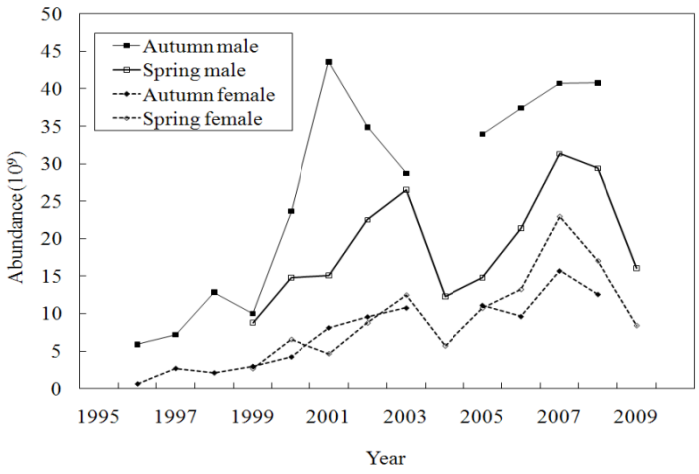


Fig. 2.5. Shrimp in Div. 3LNO: Abundance indices of male and female shrimp within Div. 3LNO as estimated from Canadian multi-species survey data.

Uncertainties in modal analyses prevented the assignment of year classes in the spring 2009 survey. However, both males and females showed a broad distribution of lengths in recent surveys indicating the presence of more than one year class. It is worth noting that very few shrimp with carapace lengths smaller than 10 mm were found in the spring 2009 survey (Fig. 2.6).

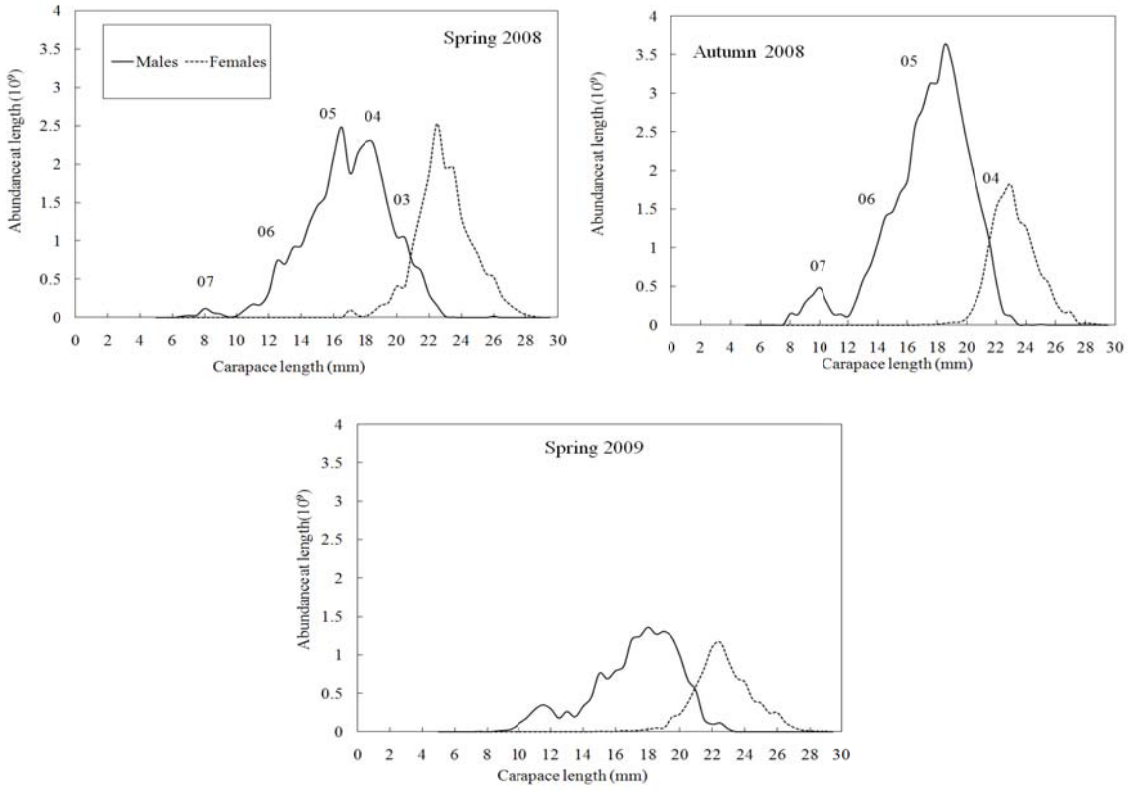


Fig. 2.6. Shrimp in Div. 3LNO: abundance at length for northern shrimp estimated from Canadian multi-species survey data. Numbers within charts denote year-classes.

Female Biomass (SSB). The autumn 3LNO female biomass index showed an increasing trend to 2007, it declined in 2008 to 105 200 t, the second highest in the autumn time series. The spring female biomass index increased from 20 000 t in 2004 to 176 700 t in 2007, but has since decreased to 59 000 t in 2009, a decrease of 67% over two years (Fig. 2.7).

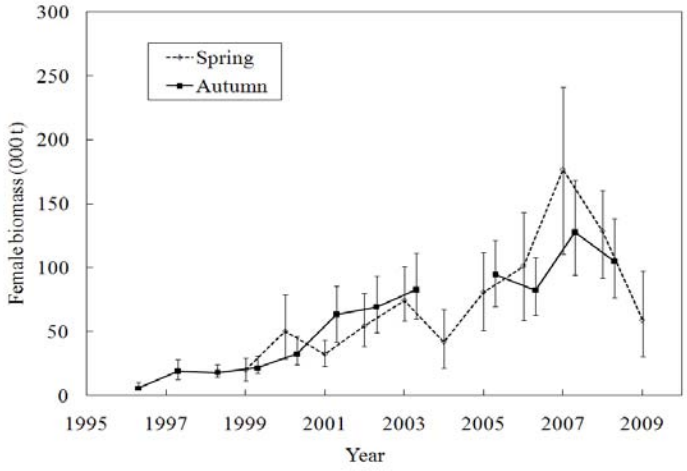


Fig. 2.7.Shrimp in Div. 3LNO: Female biomass estimates from Canadian spring and autumn multi-species surveys (with 95% confidence intervals).

Recruitment index. The recruitment indices were based upon abundances of male shrimp with carapace lengths of 12 – 17 mm from Canadian survey data. The 2006 – 2008 recruitment indices were among the highest in both spring and autumn time series. The spring index decreased to near the mean (Fig. 2.8) in 2009.

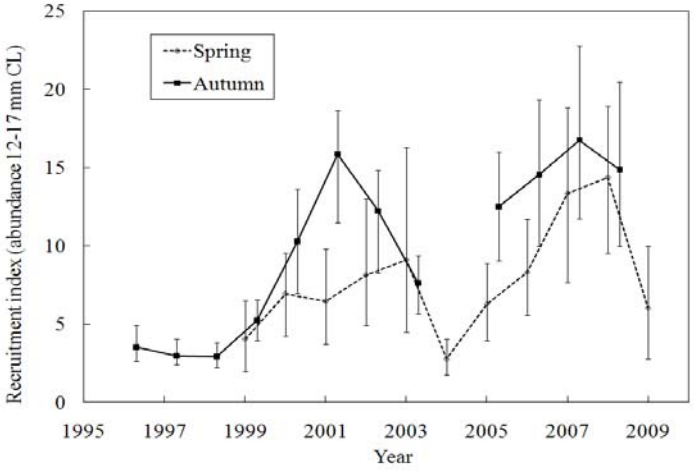


Fig. 2.8. Shrimp in Div. 3LNO: Recruitment indices derived from abundances of male shrimp with 12 – 17 mm carapace lengths from Canadian spring and autumn bottom trawl survey (1996–2009) data.

Fishable biomass and exploitation. There has been an increasing trend in Canadian spring and autumn survey fishable biomass indices (shrimp >17 mm carapace length) until 2007. The autumn index remained high in 2008 while the spring index decreased by 65% from 2007 to 2009 (Fig. 2.9).

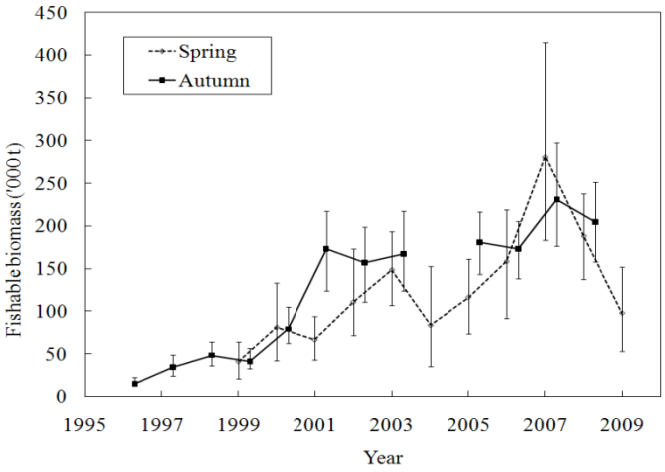


Fig. 2.9. Shrimp in Div. 3LNO: fishable biomass index. Bars indicate 95% confidence limits.

An index of exploitation was derived by dividing the catch in a given year by the fishable biomass index from the previous autumn survey. The exploitation index was less than 4% during 1996 - 1999, but increased to 11–13.5% in 2000–2001, the first two years of TAC regulation. Exploitation increased since 2002, but remained below 14% (Fig. 2.10).

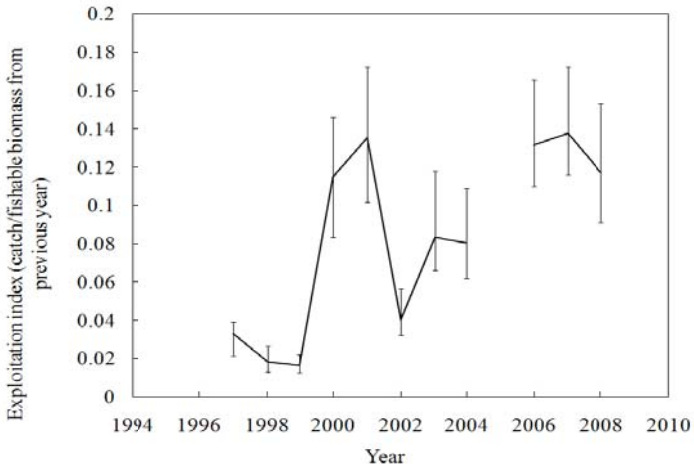


Fig. 2.10. Shrimp in Div. 3LNO: exploitation rates calculated as year's catch divided by the previous year's autumn fishable biomass index. Bars indicate 95% confidence limits.

c) Assessment Results

Recruitment. Recruitment indices from 2006 – 2008 were among the highest in the spring and autumn time series. Spring recruitment indices decreased to mean levels in 2009.

Biomass. Spring and autumn biomass indices generally increased, to record levels by 2007, but both decreased in 2008. Spring biomass indices decreased substantially in 2009.

Exploitation. The index of exploitation has remained relatively stable since 2006, at a level less than 14%.

State of the Stock. Biomass levels peaked in 2007, decreased since, but remain at or above mean levels. The stock appears to be well represented by a broad range of size groups and recruitment prospects remain at or above mean

levels. However, the decreased levels of biomass in the most recent spring surveys could indicate the start of a decreasing trend in the stock.

d) Precautionary Approach Reference Points

Scientific Council considers that the point at which a valid index of stock size has declined by 85% from the maximum observed index level provides a proxy for B_{lim} (approximately 19 000 t) for northern shrimp in Div. 3LNO (SCS Doc. 04/12). Currently, the female biomass is estimated to be well above B_{lim} (Fig. 2.10). It is not possible to calculate a limit reference point for fishing mortality. A safe zone has not been determined in the precautionary approach framework for this stock.

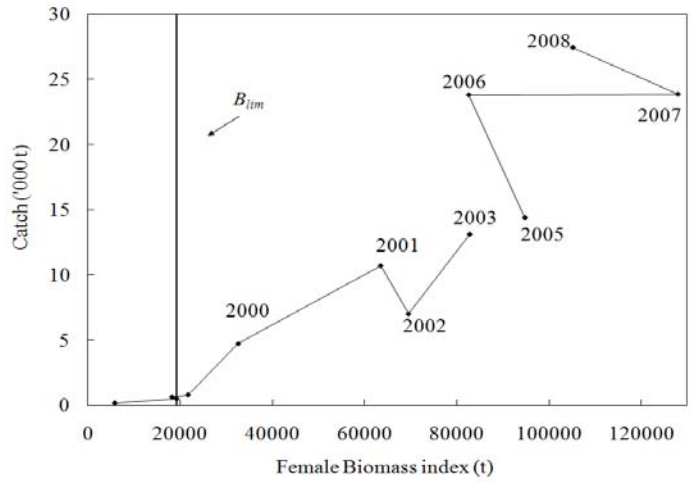


Fig. 2.11. Shrimp in Div. 3LNO: Catch against female biomass index from Canadian autumn survey. Line denoting B_{lim} (approximately 19 000 t) is drawn where female biomass is 85% lower than the maximum point in 2007.

e) Research Recommendations

NIPAG recommended that for Northern shrimp in Div. 3LNO:

- *biological and CPUE data from all fleets fishing for shrimp in the area be submitted to the Designated Expert, in the standard format, by 1 September 2010.*
- *Further exploration of the use of catch rate data as an index of biomass.*
- *Investigation of a production model for this stock. This would provide estimations of B_{msy} and F_{msy}.*
- *Collaborative efforts should be made to standardize a means of predicting recruitment to the fishable stock.*

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

(SCR Docs 04/75, 04/76, 08/62, 09/53, 09/60, 09/62, 09/64, 09/65, 09/67; SCS Doc. 04/12)

a) Introduction

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

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

Three fleets, one from Canada and two from Greenland (vessels above and below 80 GRT) have participated in the fishery since the late 1970s. The Canadian fleet and the Greenland offshore (large-vessel) fleet have been restricted by areas and quotas since 1977. The Greenland coastal (small-vessel) fleet has privileged access to inshore areas (primarily Disko Bay and Vaigat in the north, and Julianehåb Bay in the south); its fishing was unrestricted until January 1997, when quota regulation was imposed. Greenland allocates a quota to EU vessels in Subarea 1. Mesh size is at least 44 mm in Greenland, 40 mm in Canada. Sorting grids to reduce bycatch of fish are required in both of the Greenland fleets and in the Canadian fleet. Discarding of shrimps is prohibited.

The TAC advised for the entire stock for 2004, 2005, 2006 and 2007 was 130 000 t, reduced for 2008 and 2009 to 110 000t. Greenland set a TAC for Subarea 1 for 2007 of 134 000 t, of which 74 100 t was allocated to the offshore fleet, 55 900 t to the coastal and 4000 t to EU vessels; these allocations were reduced for 2008 to 70 281, 53 019 and 4000 t (total 127 300 t) and for 2009 further to 59 025, 51 545 and 4000 t (total 114 570 t). Canada set TACs for SFA1 of 18 417 t for 2007, 2008 and 2009.

Greenland requires that logbooks should record catch live weight, but for shrimps sold to on-shore processing plants—almost all the catch of the coastal fleet, and a required 25% of that of the offshore fleet—an allowance is made for crushed and broken shrimps in reckoning quota draw-downs, which are based on weight sold, not on weight caught. Total catch—both live weight and logbook reports—can therefore legally exceed the enacted TAC.

The table of recent catches was updated (SCR Doc. 09/64), mainly with improved STATLANT data for Greenland for 2006–07. Total catch increased from about 10 000 t in the early 1970s to more than 105 000 t in 1992 (Fig. 3.1). Moves by the Greenlandic authorities to reduce effort, as well as fishing opportunities elsewhere for the Canadian fleet, caused catches to decrease to about 80 000 t by 1998. Since then total catches increased to over 155 000 t in 2005 and 2006. Total catch for 2008 at 152 749 t was more than 20 000 t higher than the projection, based on the first six months' data, used in the 2008 assessment. This year's projected catch might therefore also be too low.

Recent catches, projected catches for 2009 and recommended and enacted TACs (t) for Northern Shrimp in Div. 0A east of 60°30'W and Subarea 1 are as follows:

	2000[1]	2001[1]	2002[1]	2003[1]	2004	2005	2006	2007	2008	2009[2]
TAC										
Recommended	65 000	85 000	85 000	100 000	130 000	130 000	130 000	130 000	110 000	110 000
Enacted	87 025	102 300	103 190	115 167	149 519	152 452	152 380	152 417	145 717	132 987
Catches (NIPAG)										
SA 1	96 378	99 301	128 925	123 036	142 326	149 978	153 188	142 245	152 749	*108 812*
SA 0A	1590	3625	6247	7137	7021	6921	4127	1945	0	*0*
TOTAL SA1–Div.0A	97 968	102 926	135 172	130 173	149 347	156 899	157 315	144 190	152 749	*108 812*
STATLANT 21A										
SA 1	79 120	81 517	103 645	78 436	142 326	149 978	153 188	142245[3]	3805[3]	
Div. 0A	659	2958	6053	2 170	6861	6410	3788	1878[3]	0	

[1] Catches before 2004 corrected for underreporting

[2] Catches projected to year-end—SA1 based on catches on the first 6 months; 0A at zero, because there is no fishing.

[3] Provisional

Until 1988 the fishing grounds in Div. 1B were the most important. The offshore fishery subsequently expanded southward, and after 1990 catches in Divs 1C–D, taken together, began to exceed those in Div. 1B. However, since about 1996 catch and effort in southern West Greenland have continually decreased, and in 2008 and the first six months of 2009 effort in Div. 1F was virtually nil. The Canadian catch in SFA1 was stable at 6 000 to 7 000 t in 2002–2005, about 4–5% of the total catch, but in 2006 was only 4 100 tons and in 2007 less than 2 000 t; in 2008 and 2009 (to date) there has been no fishing. SFA1 is expensive for the Canadian fleet to reach and not attractive unless catch rates and prices are high.

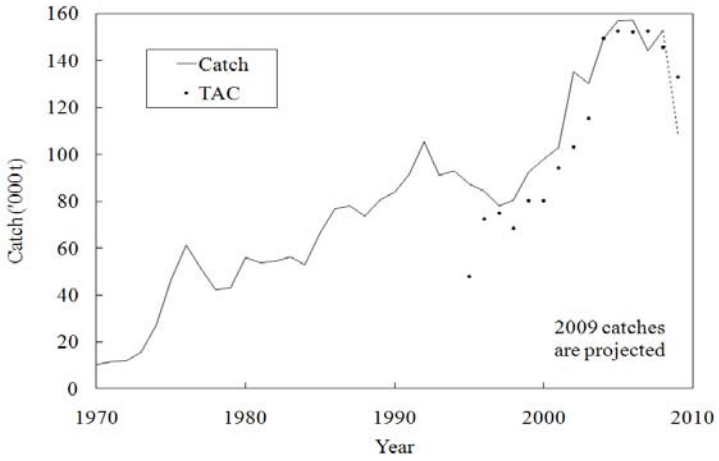


Fig. 3.1. Shrimp in Subarea 1 and Canadian SFA1: enacted TACs and total catches (2009 projected to the end of the year).

b) Input Data

i) Fishery data

Fishing effort and CPUE. Catch and effort data from the fishery were available from logbooks from Canadian vessels fishing in Canadian SFA 1 and from Greenland logbooks for Subarea 1 (SCR Doc. 09/66, 64). In recent years both the distribution of the Greenland fishery and fishing power have changed significantly: for example, larger vessels have been allowed in coastal areas; the coastal fleet has been fishing intensively in areas outside Disko Bay; the offshore fleet now commonly uses double trawls; and the previously rigid division between the offshore and coastal quotas has been relaxed and quota transfers are now allowed. A change in legislation effective since 2004 requiring logbooks to record catch live weight in place of a previous practice of under-reporting would, by increasing the recorded catch weights, have increased apparent CPUEs since 2004; this discontinuity in the CPUE data was corrected in 2008. CPUE series generated by including different sets of statistical areas and different sets of vessels in the analysis for each fleet, and different treatments of double- and single-trawl data, were compared in order to judge the effects of these choices (SCR Doc. 08/62).

CPUEs were standardised by linearised multiplicative models including terms for vessel effect, month, year, and statistical area; the fitted year effects were considered to be series of annual indices of total stock biomass. Series for the Greenland fishery after the end of the 1980s were divided into 2 fleets, a coastal and an offshore; for those ships of the present offshore fleet that use double trawls, only double-trawl data was used. A series for 1976–1990 was constructed for the KGH fleet of sister trawlers and a series for 1987–2007 for the Canadian fleet fishing in SFA1. The CPUE indices from the Greenland coastal and the Greenland offshore fleets remained closely in step from 1988 to 2004 (Fig. 3.2), but have diverged from each other more in the most recent years. CPUE in the Canadian fishery in SFA1 has always varied more from year to year and has never stayed closely in step with the Greenland fleets, although over time its overall trend has been similar and it has also increased between the 1990s and the most recent values.

The four CPUE series were unified in a separate step to produce a single series that was input to the assessment model. This all-fleet standardised CPUE was variable, but on average moderately high, from 1976 through 1987, but then fell to lower levels until about 1997, after which it increased markedly to plateau in 2004–07 at about twice its 1997 value (Fig. 3.2). A lower value for 2008 based, in that year, on part-year's data was not confirmed when the full year's data was analysed in 2009, so the currently available part-year value for 2009, which is also lower than the previous year's value, is not convincing.

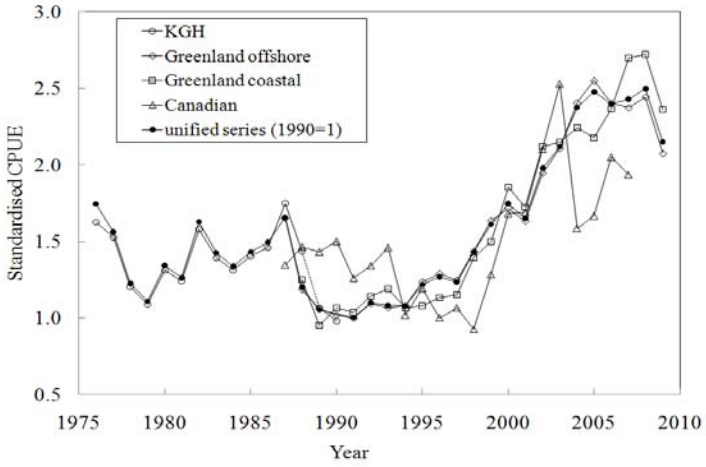


Fig. 3.2. Shrimp in Subarea 1 and Canadian SFA 1: standardised CPUE index series 1976–2009.

The distribution of catch and effort among NAFO Divisions was summarised using Simpson's diversity index to calculate an 'effective' number of Divisions being fished as an index of how widely the fishery is distributed (Fig 3.3). (In interpreting the index, it should be remembered that NAFO Divisions in Subarea 1, designed for the management of groundfish fisheries, are of unequal size with respect to shrimp grounds, and those recently abandoned by the fishery are the smaller ones.) The fishery area has recently contracted and NIPAG is concerned for effects of this contraction on the relationship between CPUE and stock biomass, and in particular that relative to earlier years biomass might be overestimated by recent CPUE values.

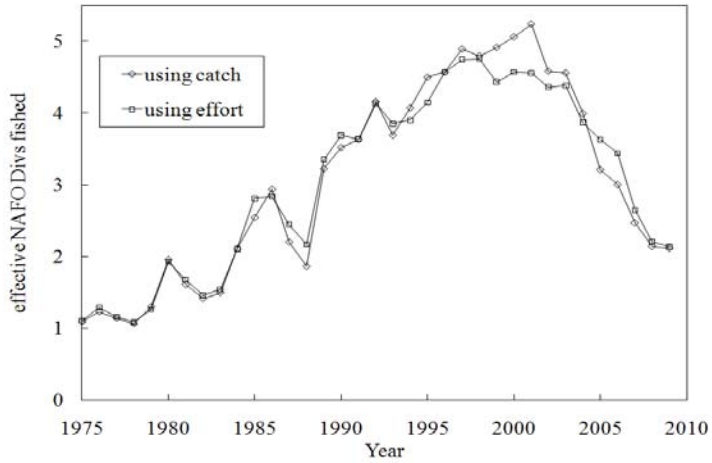


Fig. 3.3. Shrimp in Subarea 1 and Canadian SFA1: indices for the distribution of the Greenland fishery among NAFO Divisions in 1975–2009. (NB: 2009 point is calculated from Jan.–June data only.)

From the end of the 1980s there was a significant expansion of the fishery southwards and by 1996–97 areas south of Holsteinsborg Deep (66°00'N) accounted for 65% of the catch. At that time the effective number of Divisions being fished peaked at about 4.5–5. Since then, as the range of the fishery has contracted northwards and the effective number of Divisions being fished has decreased, the areas south of Holsteinsborg Deep now yield only 10–15% of the catches, and Julianehåb Bay no longer supports a fishery.

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

ii) Research survey data

Greenland trawl survey. Stratified semi-systematic trawl surveys designed primarily to estimate shrimp stock biomass have been conducted since 1988 in offshore areas and since 1991 also inshore in Subarea 1 (SCR Doc. 09/67). From 1993, the survey was extended southwards into Divs 1E and 1F. A cod-end liner of 22 mm stretched mesh has been used since 1993. From its inception until 1998 the survey only used 60-min. tows, but since 2005 all tows have lasted 15 min. In 2005 the *Skjervøy 3000* survey trawl used since 1988 was replaced by a *Cosmos 2000* with rock-hopper ground gear, calibration trials were conducted, and the earlier data was adjusted.

The survey average bottom temperature increased from about 1.7°C in 1990–93 to about 3.1°C in 1994–2009 (SCR Doc. 09/67). About 80% of the survey biomass estimate is in water 200–400 m deep. In the early 1990s, about ¾ of this was deeper than 300 m, but after about 1995 this proportion decreased and since about 2001 has been about ¼, and most of the biomass has been in water 200–300 m deep (SCR Doc. 09/67). The proportion of survey biomass in Div. 1E–F has decreased in recent years and the distribution of survey biomass, like that of the fishery, has become more concentrated and more northerly (SCR Doc. 09/67, 09/53).

Biomass. The survey index of total biomass remained fairly stable from 1988 to 1997 (c.v. 18%, downward trend 4%/yr). It then increased by, on average, 19%/yr until 2003, when it reached 316% of the 1997 value. Subsequent values have been consecutively lower, by 2008 less than half the 2003 maximum (Fig. 3.4) and 9% below the series mean; the 2009 value was nearly the same as that for 2008.

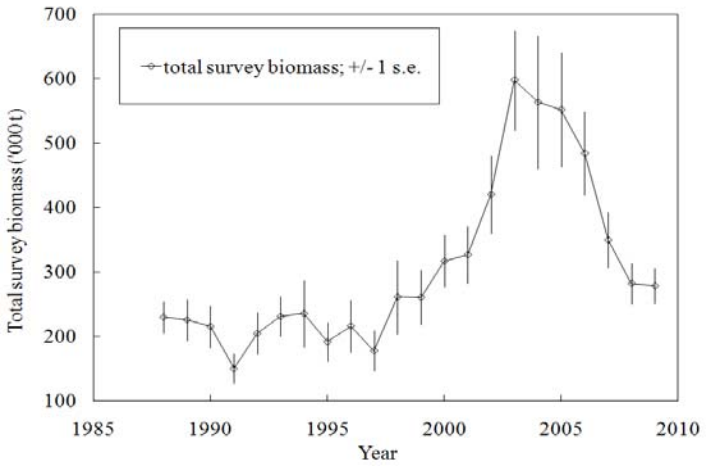


Fig. 3.4. Shrimp in Subarea 1 and Canadian SFA 1: survey indices of total stock biomass 1988–2009 (SCR Doc. 09/67).

Length and sex composition (SCR 09/67). In 2008 modes at 12 mm and 15 mm CL could be observed suggesting two- and three-year-olds; the two-year-old class in particular appeared stronger than in 2007. Male and female numbers in 2008 were 42.5 and 11.5 x 10^9 individuals respectively, both values below their series averages (50 and 12 x 10^9). The 2009 distribution of lengths appears very similar to that for 2008 (Fig. 3.5); cohorts can be distinguished at 11–13 mm and at 15.5–18 mm. Estimated numbers of both males and females — 41.5 and 12.2 × 10^9 — are very close to those for 2008, still below their series means.

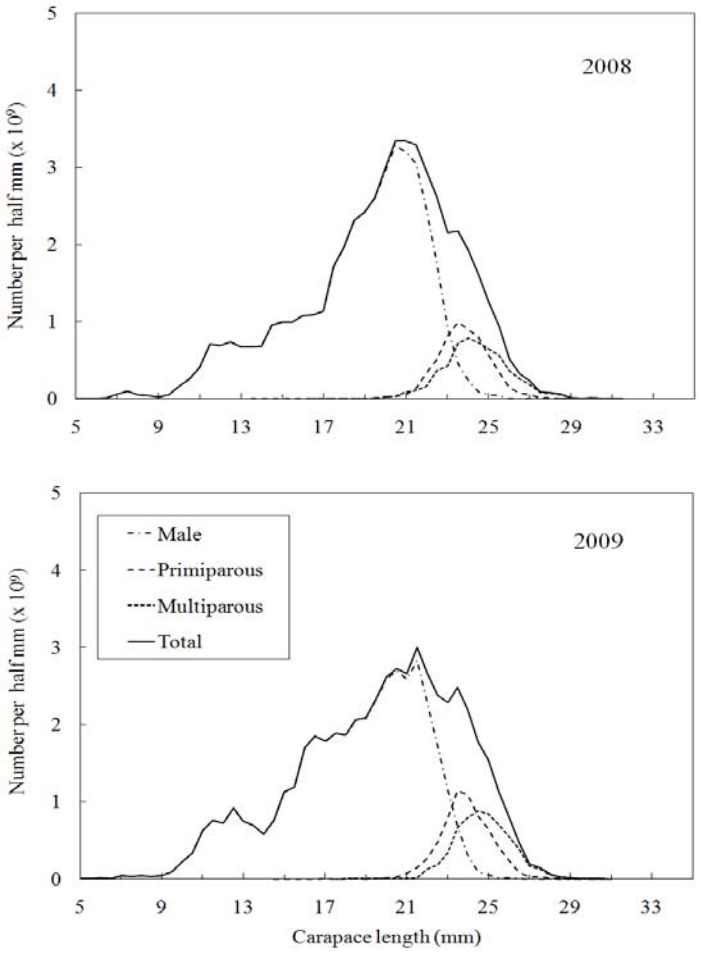


Fig. 3.5. Shrimp in Subarea 1 and Canadian SFA 1: length frequencies in the West Greenland trawl survey in 2008–2009.

Recruitment Index. The number at age 2 is a predictor of fishable biomass 2 – 4 years later (SCR Doc. 03/76). This recruitment index was high in 2001, decreased in 2002, was near average in 2003 and 2004, reached even lower values in 2005 and 2006, and decreased again in 2007 to the lowest recorded value (Fig.3.6). In 2008 the index was higher, at about 2/3 of the series mean. An estimated drop in 2009 to the second-lowest recorded value seems inconsistent with the length distribution of survey catches (Fig. 3.5).

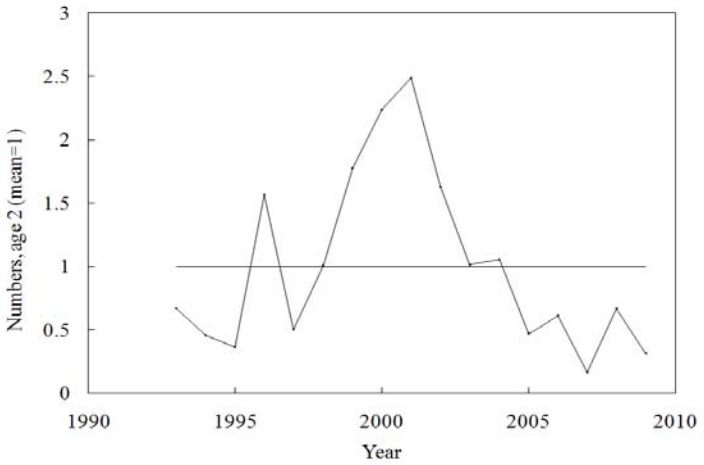


Fig. 3.6. Shrimp in Subarea 1 and Canadian SFA 1: index of numbers at age 2, estimated from West Greenland trawl survey.

The 2009 survey estimate of biomass at carapace lengths less than 17.5 mm, which may constitute an index of short-term recruitment, was well below average both as an absolute value and as a fraction of the total survey biomass.

iii) Other biological studies

Estimates of cod biomass from the German groundfish survey at West Greenland are used in the assessment of shrimp in SA 1 and in Div. 0A east of 60°30′W, but the results from the German survey for the current year are not available in time for the assessment. Although the West Greenland trawl survey is not primarily directed towards groundfish, the cod biomass indices it produces for West Greenland offshore waters are well correlated with those from the German groundfish survey ($r^2 = 0.86$). The index of cod biomass obtained from the 2009 Greenland survey would correspond to about 4069 t for the 2009 estimate from the German survey (SCR Doc. 09/65) — a drastic decrease from 2008, which itself was less than the 2007 value. The modest increase in the cod stock seen in recent years seems to have been completely reversed. Although in recent years almost all of the cod found by the survey have been in southern West Greenland, in 2009, while sparser, they were more widely spread and an index of overlap with the shrimp stock rose from 0.156 in 2008 to 0.602 in 2009. All the same, the 'effective' cod stock, i.e. that which could prey on the shrimp stock, is estimated at only 2 400 t (SCR Doc. 09/65).

c) Results of the Assessment

i) Estimation of Parameters

A Schaefer surplus-production model of population dynamics was fitted to series of CPUE, catch, and survey biomass indices. The model included a term for predation by Atlantic cod and a cod biomass series was included in the input data. CPUE data extended back as far as 1976, but survey data only started in 1988.

The model used in 2009 was very similar to that used in 2008. The model fitted reasonably well to the data, although uncertainties of parameter estimates were noticeably larger than in 2008. The estimated biomass trajectory closely followed the CPUE series, the error CV of biomass prediction from CPUE being only 3.6%; it was much less influenced by the survey series, the prediction error CV of which was about 21% (Fig. 3.7). The median estimate of MSY was 148 000 t, a slight increase over the 2008 estimate, catch rates having stayed high in spite of a now five-year series of annual catches averaging 152 000 t.

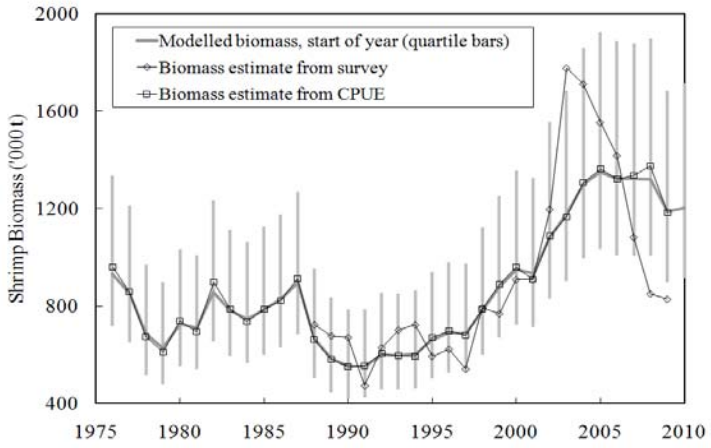


Figure 3.7: Shrimp in SA 1 and Canadian SFA1: trajectory of the median estimate of stock biomass at start of year, with the year's median CPUE and survey indices.

Estimates of stock-dynamic and fit parameters from fitting a Schaefer stock-production model to data on the West Greenland stock of the northern shrimp in 2009:

	2009						2008
	Mean	S.D.	25%	Median	75%	Est. Mode	Median
Max.sustainable yield	159	54	133	148	168	126	144
Carrying capacity	2584	2764.5	1526	1922	2642	598	1780
Max. sustainable yield ratio (%)	15.3	4.7	12.2	15.5	18.5	15.8	16.3
Survey catchability (%)	31.6	14.0	21.7	30.9	40.4	29.3	32.5
CV of process (%)	9.3	2.3	7.8	9.4	10.8	9.5	9.6
CV of survey fit (%)	21.6	3.6	19.1	21.2	23.6	20.4	18.3
CV of CPUE fit (%)	3.8	1.6	2.6	3.6	4.7	3.0	3.5

ii) Assessment Summary

Recruitment. Prospects for recruitment to the fishable stock in the next few years remain poor.

Biomass. A stock-dynamic model showed a maximum biomass in 2005 with a steepening decline since; the probability that biomass will be below B_{msy} at end 2009 with projected catches at 109 000 t was estimated at 18% and of its being below B_{lim} at less than 1%.

Mortality. The mortality caused by fishing and cod predation (Z) has been stable below the upper limit reference (Z_{msy}) since 1995. With catches in 2009 projected at 109 000 t the risk that total mortality in 2009 would exceed Z_{msy} was estimated at about 3.5%.

State of the Stock. Modelled biomass is estimated to have been declining since 2005. However, at the end of 2009 biomass is projected to be still above B_{msy} and total mortality below Z_{msy}. Annual estimates of numbers of small shrimps have stayed below average in 2005–2009, and concerns about future recruitment remain grave.

d) Precautionary Approach

The fitted trajectory of stock biomass showed that the stock had been below its MSY level from the late 1970s to the late 1990s, with mortalities mostly near the MSY mortality level except for an episode of high predation mortality associated with a short-lived resurgence of cod in the late 1980s. In the late 1990s, with cod stocks at low levels, biomass started to increase at low mortalities to reach about 1.5 times the MSY level in 2003–06. Recent increases in the cod stock coupled with high catches have been associated with slight declines in the modelled biomass, although mortality remains below the MSY level and the biomass still above B_{msy}.

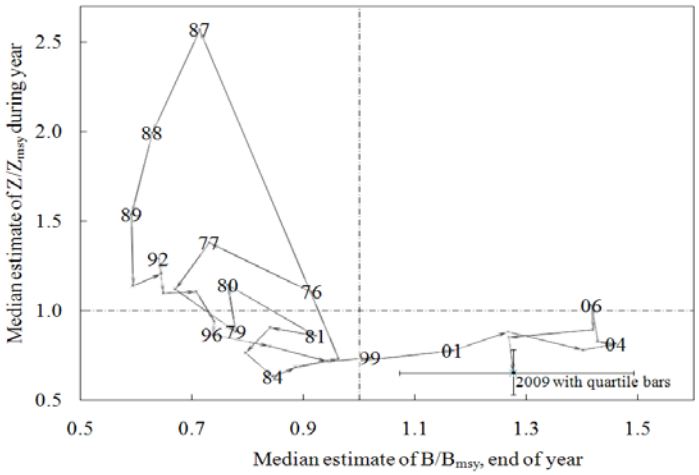


Fig. 3.8: Shrimp in SA 1 and Canadian SFA1: trajectory of past relative biomass and mortality.

Stock-dynamic modelling estimates the present stock status to be in the precautionary safe zone with biomass above the target level and mortality below Z_{msy}. With an 'effective' cod stock assumed at 10 000 t in 2010, catches up to 110 000 t would be associated with risks below 20% of transgressing either precautionary reference point. Higher catches in 2010 would be associated with rapidly increasing risks of exceeding Z_{msy}.

Predicted probabilities of transgressing precautionary limits in 2010 (risk table) under five catch options and predation by a cod stock with a biomass of 10 000 t:

	Catch option ('000 t)				
Risk of:	100	110	120	130	140
falling below B_{msy} end 2010 (%)	15.4	16.8	17.4	18.1	19.9
falling below B_{lim} end 2010 (%)	0.3	0.3	0.2	0.2	0.2
exceeding Z_{msy} during 2010 (%)	3.0	6.7	12.6	21.4	30.9

In the medium term, with a 10 000 t cod stock, model results estimate catches of 120 000 t/yr to be associated with a very slowly deteriorating stock, above MSY level, with mortality below Z_{msy}. Catches of 130 000 t would be associated with a stock that still after 5 years would probably be within the safe zone. Higher catches would cause rapid deterioration of the state of the stock. With a 20 000 t cod stock, annual catches as low as 120 000 t are predicted to cause the stock status to deteriorate slowly.

Predicted probabilities of transgressing precautionary limits after 5 years in the fishery for northern shrimp on the West Greenland shelf with 'effective' cod stocks assumed at 10 000 t and 20 000 t.

Catch (Kt/yr)	Prob. $B < B_{msy}$ (%)		Prob. $B < B_{lim}$ (%)		Prob. $Z > Z_{msy}$ (%)	
	10 Kt	20 Kt	10 Kt	20 Kt	10 Kt	20 Kt
100	10.5	12.6	0.2	0.2	3.2	6.9
110	13.8	17.6	0.2	0.2	7.1	14.5
120	17.2	22.3	0.2	0.3	15.3	25.5
130	23.6	28.1	0.2	0.2	26.6	38.6
140	28.3	33.8	0.3	0.2	40.2	50.6

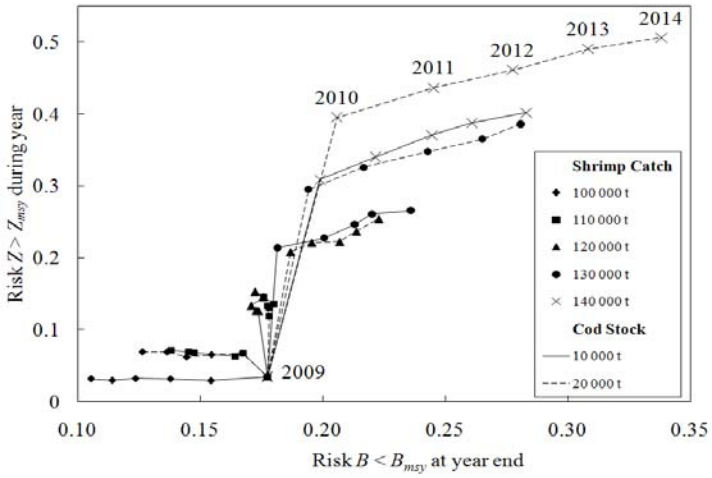


Fig. 3.9. Shrimp in SA 1 and Canadian SFA1: Risks of transgressing mortality and biomass precautionary limits for catches at 100 000 – 140 000 t projected over five years with 'effective' cod stock assumed at 10 000 or 20 000 t.

Medium term predictions were summarised by plotting the risk of exceeding Z_{msy} against the risk of falling below B_{msy} over 5 years for 5 catch levels, considering also two possible levels for the 'effective' cod stock (Fig. 3.9). The biomass risk changes with time, upwards or downwards depending on catch level and cod-stock level; the mortality risk depends immediately upon the assumed future catch and cod-stock levels, but changes less quickly with time. A 10 000 t change in the cod stock is practically equivalent to a 10 000 t change in catch. For catches of 100 000 t or 110 000 t the mortality risk is low and nearly constant over the projection period, while the biomass risk decreases as the stock is projected to grow. At a catch level of 120 000 t the stock is nearly stationary above B_{msy} if the effective cod stock is assumed near 10 000 t. With a cod stock at 20 000 t and a 120 000 t catch the risk of falling below B_{msy}, although it starts at about 20%, increases steadily with time as the stock is fished down. Catches of 130 000 t or 140 000 t are associated with higher and increasing risks of transgressing both precautionary limits whether the cod stock is assumed at 10 000 t or 20 000 t.

e) Research Recommendations

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

- *collaborative efforts should be made to standardise a means of predicting recruitment to the fishable stock;*
- *the adjustment of CPUE index series to take account of changes in the area of distribution of the fishery should be investigated;*
- *methods of 'modal analysis' for estimating age-class numbers should be further developed;*
- *improvements in the estimation of weight-length relationships, and their use in estimating sex-specific biomasses, should be investigated;*
- *downweighting of older data in the assessment model should be investigated.*

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

(SCR Doc. 03/74, 09/70)

a) Introduction

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

In 1993 a new fishery began in areas south of 65°N down to Cape Farewell. From 1996 to 2005 catches in this area accounted for 50 - 60% of the total catch. In 2006 and 2007 catches in the southern area only accounted for 25% of the total catch falling to less than 10% in 2008. For catch data until October 2009 the southern area accounted for 25% of the total catch again.

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

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.

As the fishery developed, catches increased rapidly to more than 15 000 tons in 1987-88, but declined thereafter to about 9000 tons in 1992-93. Following the extension of the fishery south of 65°N catches increased again reaching 11 900 tons in 1994. From 1994 to 2003 catches fluctuated between 11 500 and 14 000 tons (Fig. 4.1). In 2004 the catches started dropping from 10 000 tons to a low of 3100 tons in 2008. 5 000 tons has been caught during the first 9 months of 2009. Catches in the Iceland EEZ decreased from 2002-2005 and since 2006 no catches has been taken.

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

	2000[1]	2001[1]	2002[1]	2003[1]	2004	2005	2006	2007	2008	2009[2]
Recommended TAC, total area	9 600	9 600	9 600	9 600	12 400	12 400	12 400	12 400	12 400	12 400
Actual TAC, Greenland EEZ	12 600	10 600	10 600	10 600	15 043	12 400	12 400	12 400	12 400	12 835
North of 65° N, Greenland EEZ	4 288	2 227	4 113	5 480	4 654	3 987	3 887	3 314	2 853	3 563
North of 65° N, Iceland EEZ	132	10	1 231	703	411	29	0	0	0	0
North of 65° N, total	4 420	2 237	5 344	6 183	5 065	4 016	3 887	3 314	2 853	3 563
South of 65° N, Greenland EEZ	7 632	11 674	5 985	6 522	4 951	3 737	1 302	1 286	265	1 327
TOTAL NIPAG	12 053	13 911	11 329	12 705	10 016	7 753	5 189	4 600	3 118	4 890

[1] Estimates 1998-2003 corrected for "overpacking".
[2] Catches until October 2009

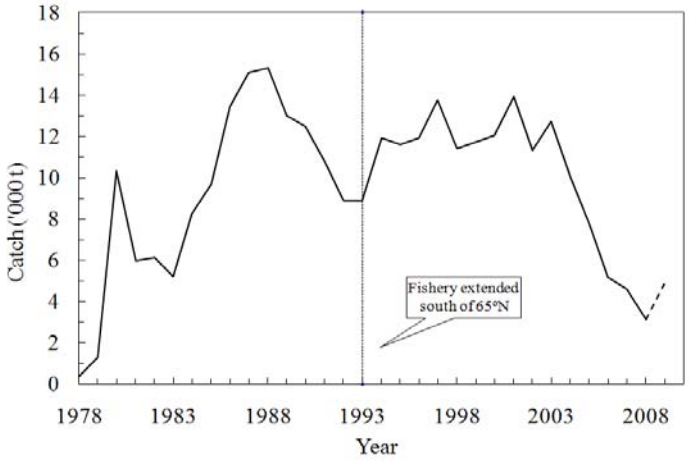


Fig. 4.1. Shrimp in Denmark Strait and off East Greenland: Total catches (2009 catches until October).

b) Input Data

i) Commercial fishery data

Fishing effort and CPUE. Data on catch and effort (hours fished) on a haul by haul basis from logbooks from Greenland, Iceland, Faroe Islands and EU-Denmark since 1980, from Norway since 2000 and from EU-France for the years 1980 to 1991 are used . Until 2005, the Norwegian fishery data was not reported in a compatible format and were not included in the standardized catch rates calculations. In 2006 an evaluation of the Norwegian logbook data from the period 2000 to 2006 was made and since then these data have been included in the standardized catch rate calculations. Since 1998 approximately 40% of all hauls were performed with double trawl and the 2009 assessment included both single and double trawl in the standardized catch rate calculations.

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

The Greenlandic fishing fleet, catching 40% of the total catch from 1998 to 2005 and between 10% and 30% from 2006, has decreased its effort in recent years, and this creates some uncertainty as to whether recent values of the indices accurately reflect the stock biomass. There could be several reasons for decreasing effort, some possibly related to the economics of the fishery. The fishing opportunities off West Greenland seem to have been adequate in recent years and the fishing grounds off East Greenland are for several reasons a less desirable fishing area. Even though both effort and catches in East Greenland have declined, the catch rates (CPUE's) are still high; however, this could be partly because the fleet can concentrate effort in areas of high densities of sought-after size classes of shrimp.

North of 65°N standardized catch rates based on logbook data from Danish, Faroese, Greenlandic, Norwegian and Icelandic vessels declined continuously from 1987 to 1993 but showed a significant increase between 1993 and 1994. Since then rates have varied but shown a slightly increasing trend until 2008. From 2008 to 2009 the catch rate nearly doubled (provisional data for 2009) (Fig. 4.2).

In the southern area a standardized catch rate series from the same fleets, except the Icelandic, increased until 1999, and varied around this level until 2008. In 2009 the catch rate nearly doubled (provisional data) compared with 2008 (Fig. 4.3).

The combined standardized catch rate index for the total area decreased steadily from 1987 to 1993, and then showed an increasing trend until the beginning of the 2000s. The index stayed at or around this level until 2008, but nearly doubled in 2009 (until October) (Fig. 4.4).

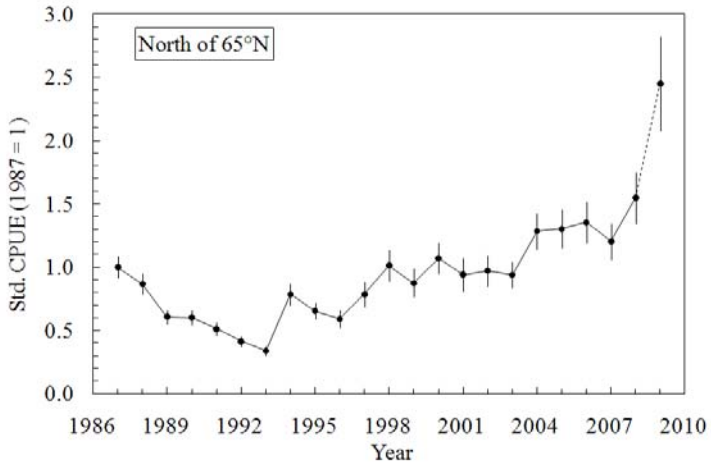


Fig. 4.2. Shrimp in Denmark Strait and off East Greenland: annual standardized CPUE (1987 = 1) with ±1 SE calculated from logbook data from Danish, Faeroese, Greenland, Icelandic and Norwegian vessels fishing north of 65°N.

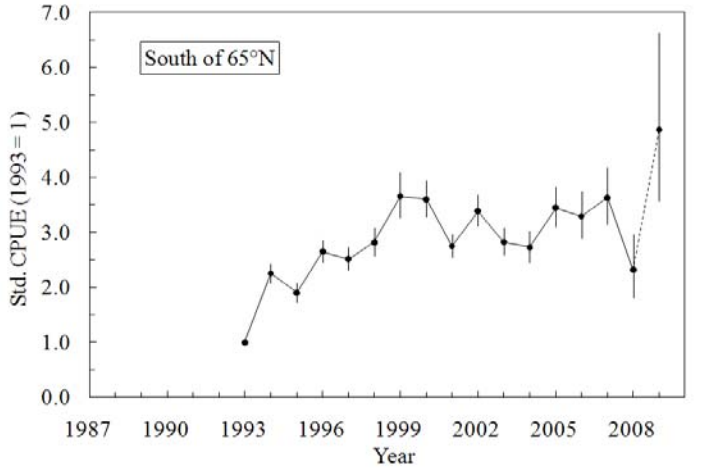


Fig. 4.3. Shrimp in Denmark Strait and off East Greenland: annual standardized CPUE (1993 = 1) with ±1 SE calculated from logbook data from Danish, Faeroese, Greenland and Norwegian vessels fishing south of 65°N.

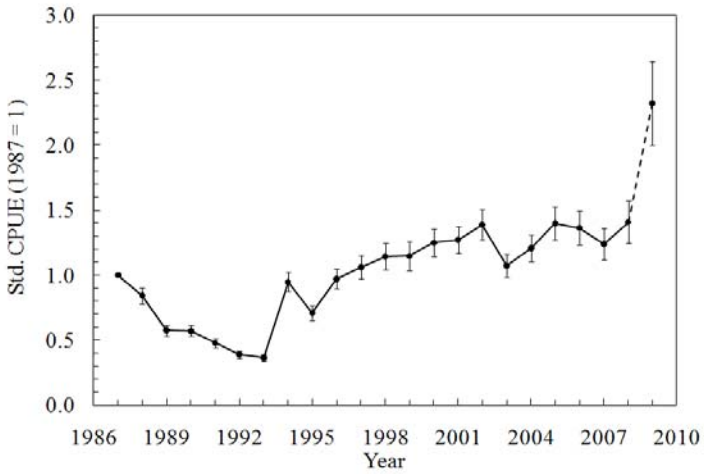


Fig. 4.4. Shrimp in Denmark Strait and off East Greenland: annual standardized CPUE-indices (1987 = 1) with ± 1 SE combined for the total area.

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

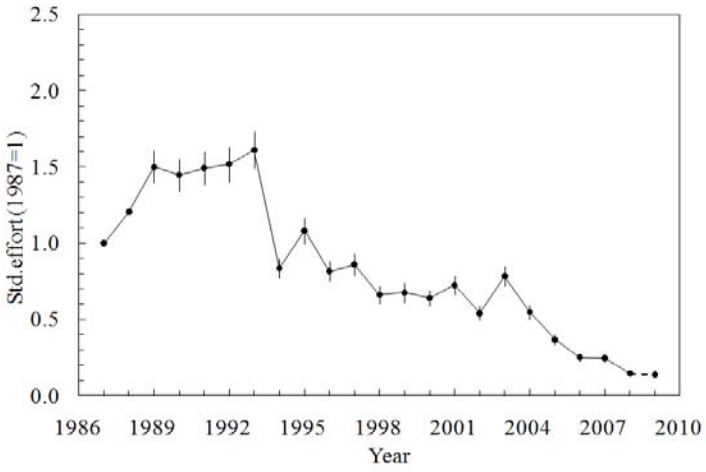


Fig. 4.5. Shrimp in Denmark Strait and off East Greenland: annual standardized effort indices, as a proxy for exploitation rate (± 1 SE; 1987 = 1), combined for the total area.

Biological data

There are no biological data available.

Research survey data

A survey has been conducted in August/September 2009 and is the onset of a survey series.

Length distributions were obtained during the survey. The results were not available for this meeting.

Other studies

None

c) Assessment Results

CPUE. Combined standardized catch-rate index for the total area decreased steadily from 1987 to 1993, showed an increase to a relatively high level at the beginning of the 2000s, and has fluctuated around this level until 2008. In 2009 (preliminary data) the standardized catch rate rose to the highest level ever seen, but probably does not reflect a corresponding increase in biomass.

Recruitment. No recruitment estimates were available.

Biomass. No direct biomass estimates were available.

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

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

d) Research Recommendations

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

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

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

(SCR Doc. 09/58, 09/68, 69)

a) Introduction

The shrimp in the northern part of ICES Div. IIIa (Skagerrak) and the eastern part of the Div. IVa (Norwegian Deep) is assessed as one stock and is exploited by Norway, Denmark and Sweden. The Norwegian and Swedish fisheries began at the end of the 19th century, while the Danish fishery started in the 1930s. All fisheries expanded significantly in the early 1960s. By 1970 the catches had reached 5 000 t and in 1981 they exceeded 10 000 t. Since 1992 the shrimp fishery has been regulated by a TAC, which has been around 16 000 t the last five years (Fig. 5.1, Table 5.1). In recent years an increasing number of the Danish vessels have started boiling the shrimp on board and landing the product in Sweden to obtain a better price. Most of the Danish catches are, however, still landed in home ports. In the Swedish and Norwegian fisheries approximately 50% of catches are boiled at sea (Quality A), and almost all catches are landed in home ports.

The TAC is shared according to historical landings, giving Norway the highest quota (55%), and Sweden the lowest (18%). In recent years the Swedish fishery has been constrained by the national quota, which may have resulted in 'high-grading' of the catch by the Swedish fleet. The recommended/suggested TACs until 2002 were based on catch predictions. However since 2003, no catch predictions have been available, and the recommended TACs have been based on recent landings. The shrimp fishery is also regulated by mesh size (35 mm stretched), and by restrictions in the amount of landed bycatch. The use of Nordmøre selective grids with un-blocked fish openings reduces bycatch significantly (SCR Doc. 09/069) and is used by an increasing number of vessels in all fleets. However, at present it is mandatory only in Swedish national waters.

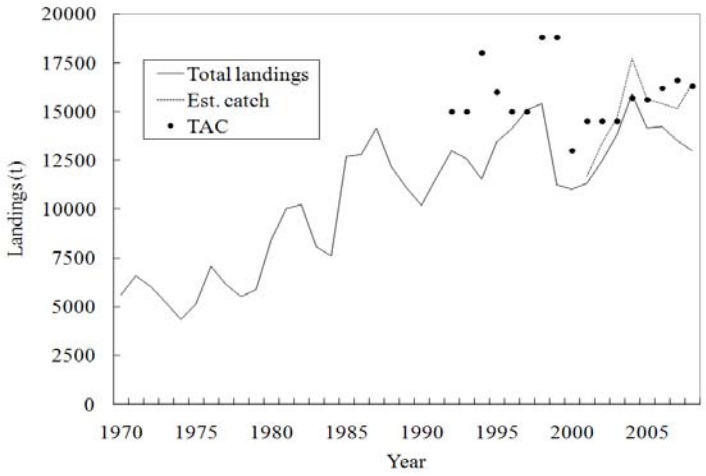


Fig. 5.1. Northern shrimp in Skagerrak and Norwegian Deep: TAC, total landings by all fleets, and total catch including estimated Swedish high-grading discards for 2001-2008 and Norwegian discards for 2007-2008.

Total catch has varied between 10 000 t and 18 000 t during the last 20 years. The catches in 2005 to 2008 have been around 15 000 to 16 000 t. The increase in total catches in 2008 compared with 2007 is due to the estimates of Norwegian and Swedish discards. Danish and Norwegian landings have decreased in 2008 compared with 2007 (Table 5.1 and Fig. 5.1). There are large uncertainties in both the Swedish and Norwegian estimated discards. Notice, that the Norwegian and Swedish landings have been corrected for weight loss caused by boiling.

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

	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
Recommended TAC	19 000	19 000	11 500	13 400	12 600	14 700	15 300	13 000	14 000	14 000	15 000
Agreed TAC	18 800	18 800	13 000	14 500	14 500	14 500	15 690	15 600	16 200	16 600	16 300
Denmark	3 330	2 072	2 371	1 953	2 466	3 244	3 905	2 952	3 061	2 380	2 259
Norway	9 606	6 739	6 444	7 266	7 703	8 178	9 544	8 959	8 669	8 686	8 260
Sweden	2 469	2 445	2 225	2 108	2 301	2 389	2 464	2 257	2 488	2 445	2 479
Total landings	15 405	11 256	11 040	11 327	12 470	13 811	15 913	14 168	14 218	13 511	12 998
Est. Swedish high-grading				375	908	868	1 797	1 483	1 186	1 124	2 003
Est. Norwegian discards*										526	1 408
Total catch				11 702	13 378	14 679	17 710	15 651	15 404	15 161	16 409

* Collection of discard data inititated in 2007

The Danish and Norwegian fleets have undergone major restructuring in recent years. In Denmark, the number of vessels targeting shrimp has decreased from 191 in 1987 to 24 in 2006 and only 11 in 2008. It is mostly the small trawlers (<24 m LOA) which have left the fishery and in 2008 the average length of the vessels was around 26 m (SCR Doc. 09/69). The efficiency of the gear has also increased due to twin trawl technology and increasing trawl sizes. In Norway there has been an increase in the number of smaller vessels (10-10.99 m LOA), and this length group is now the numerically dominant one, owing to the fact that vessels <11 m do not need a licence to fish. Vessels ≥21 m LOA constitute about 11% of the fleet. Some Norwegian fishers started using twin trawl around 2002, and the use is increasing. According to the Norwegian fisheries organization "Fiskarlaget", twin trawls are at present in use by 40-50 Norwegian trawlers. Quantitative information on these changes in gear is, however, not available from the logbooks. In the Norwegian logbooks only 9 vessels have systematically recorded their use of twin trawl over the last seven years. Corrections have been made (see assessment data). The Swedish specialized shrimp fleet (≥ 10 t/yr) has been around 40-50 vessels for a long time according to logbooks and there has not been

any major change in trawl size or trawl design according to the Swedish net manufacturer. In Sweden the use of twin trawls in the *Pandalus* fishery is not yet common (SCR Doc. 09/69).

Catch and discards. Discarding of shrimp may take place in two ways: 1) discards of shrimp <15 mm CL which are not marketable, even by the canning industry, and 2) high-grading discards of medium-sized and lower-value shrimp. The latter takes place primarily in the Swedish fleet, because of quota limits on total landed weight. The amount of high-grading discards in the Swedish fisheries was estimated to around 2 000 t in 2008 based on comparison of length distributions in Swedish and Danish landings (Fig. 5 in SCR Doc 09/69). The Danish length distribution for each year is scaled to fit the Swedish length distribution for the same year for the larger shrimp (≥21 mm CL). This correction assumes that there is no discarding of the most valuable larger shrimp and that Swedish and Danish fisheries are conducted on the same grounds. The higher numbers in the Danish size groups <21 mm CL are compared to the Swedish numbers, and the differences are then multiplied with the mean weights of each size group. The sum of mean weights by size group is considered as the weight of the Swedish discarding due to high-grading.

The uncertainties in this estimation have increased due to changes in the Swedish fishing pattern. Swedish shrimp trawlers have been avoiding grounds with small size composition in the catch. There is also an increasing part that voluntarily use 45 mm mesh size instead of legislated 35 mm.

In 2007 Norwegian discards were estimated by comparing length distributions of unprocessed commercial catches (sampling initiated in 2005) with those of landings (sampling initiated in 2007). Comparison of corresponding samples in 2008 gave negative discards, therefore the Norwegian landings were compared with the Danish landings as described for Swedish landings above.

Bycatch and ecosystem effects. In recent years, ICES has paid increasing attention to mixed fisheries in the North Sea area, especially those affecting stocks subject to recovery plans. In the shrimp fisheries in the North Sea and Skagerrak, there is bycatch of 10-20% of commercially valuable species, although regulations restrict the weights that may be landed. Since 1997, trawls used in Swedish national waters must be equipped with a Nordmøre grid, with bar spacing 19 mm, which excludes fish >20 cm from the catch. Based on log-book information, landings delivered by vessels using this grid consist of 99% shrimp compared to only 80-90% in landings from trawls without grid (Table 5.2). In the area outside of Swedish national waters the grids are not mandatory, however, there has been an increase in their use, which constituted 33% of Swedish shrimp effort in 2008.

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

Table 5.2. Northern shrimp in Skagerrak and Norwegian Deep: Landings in the *Pandalus* fishery in 2008. Combined data from Danish and Swedish logbooks and Norwegian sale slips (t).

	Sub-Div. IIIa, no grid		Sub-Div. IIIa, grid		Sub-Div. IVa East, no grid	
Species:	Total (t)	% of total catch	Total (t)	% of total catch	Total (t)	% of total catch
Pandalus	9606	86.9	634	99.3	2126	77.0
Norway lobster	52	0.5	3	0.5	76	2.8
Angler fish	52	0.5	0	0.0	74	2.7
Whiting	9	0.1	0	0.0	5	0.2
Haddock	78	0.7	0	0.0	24	0.9
Hake	45	0.4	0	0.0	41	1.5
Ling	45	0.4	0	0.0	31	1.1
Saithe	510	4.6	0	0.0	233	8.4
Witch flounder	95	0.9	0	0.0	4	0.1
Norway pout	0	0.0	0	0.0	0	0.0
Cod	399	3.6	0	0.0	101	3.7
Other market fish	164	1.5	0	0.0	46	1.7

b) Assessment Data

i) Commercial fishery data:

LPUE The Danish catch and effort data from logbooks have been analysed and standardised (SCR Doc. 08/75, 09/69). A GLM standardisation of the LPUE series was performed on around 20 500 shrimp fishing trips conducted in the period 1987-2008:

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

where 'vessel' denotes the horse power of the individual vessels, 'year' covers the period 1987-2008, 'area' covers Norwegian Deep and Skagerrak, 'season', in this case quarter, covers possible seasonal variation, and the variance of the error term is assumed to be normally distributed.

In the standardisation of the Norwegian LPUE (2000-2009) (SCR Doc. 09/68) a similar model was applied, but gear type (single and twin trawl) was also included as a variable:

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

Here the variable 'season' denotes month and 'gear' covers single and twin trawl. Based on interviews with ship owners incorrect records of gear type were corrected. If reliable information on gear type was not received, the vessel was deleted from the data (8.6% of all recordings). In 2008, catches recorded in logbooks only included 20.5% and 26.4% of the respective landings in Divs. IIIa and IVa east. This is partly due to vessels <11 m not being required to fill in log-books. Unfortunately data are lacking also for larger vessels.

NIPAG decided to use both the Danish and Norwegian standardised LPUEs as the best available indicators for stock biomass (Fig. 5.2). The two time series show similar trends, increasing from 2000 to 2004, decreasing in 2005 and then increasing again until 2007. In 2008 both LPUE indices decreased and the Norwegian index decreased further in 2009 (preliminary data). However, since the mid-1990s the Danish standardised LPUE seems to fluctuate without any clear trend. NIPAG interprets this as a sign of stability of the stock.

The Swedish LPUE data were not used in the assessment (SCR Doc 09/69) because of uncertainties caused by discarding due to high-grading and lack of information necessary for standardization.

In previous assessments, estimates of harvest rates (H.R.) were estimated from landings and corresponding biomass indices from the Norwegian survey. Since the new survey only covers 4 years, a time series of standardised effort indices (total landings/Danish LPUE indices) has been estimated in addition to H.R. estimates for 2006-2008 (Fig. 5.3) Standardised effort seems to fluctuate without any clear trend indicating stability in the exploitation of the stock.

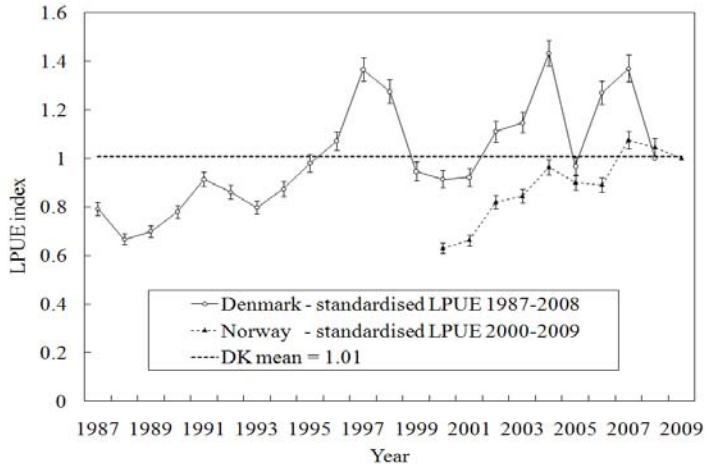


Fig. 5.2. Northern shrimp in Skagerrak and Norwegian Deep: Danish standardised LPUE until 2008 and Norwegian standardised LPUE until August 2009. Danish 2009 data were not available.

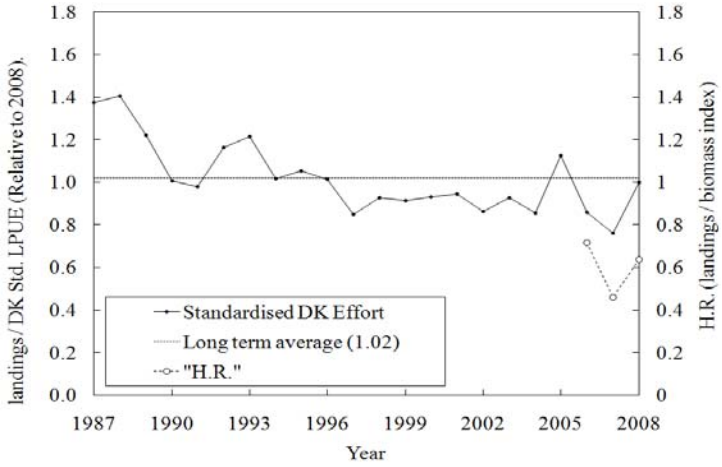


Fig. 5.3. Northern shrimp in Skagerrak and Norwegian Deep: Harvest rate (total landings/survey indices of biomass) and estimated standardised effort based on total landings and Danish standardised LPUE (1987-2008). Long term mean = 1.02

ii) Sampling of landings.

For cohort analysis purposes information on the size and subsequently age distribution of the landings are obtained by sampling the landings. The samples also provide information on sex distribution and maturity (SCR Doc. 09/69).

iii) Survey data

The Norwegian shrimp survey has gone through large changes in recent years (SCR Doc. 09/58) resulting in a series of four different surveys, lasting from one to nineteen years. NIPAG (2004) strongly recommended the survey to be

conducted in the 1st quarter as it gives good estimates of the 1-group (recruitment) and female biomass (SSB). Thus, a new time series at the most optimal time of year was established in 2006.

There was no trend in the annual survey biomass estimates from the mid 1990s to 2002, when the first series was discontinued. The 2004 and 2005 mean values of a new biomass index series were not statistically different (Fig. 5.4). In 2008 the index declined back to the 2006 level, and in 2009 the index has shown a further decline.

The abundance of age 1 shrimp in 2006 was equal to the abundance of age 1 shrimp in 2007. However the recruitment in 2008 and 2009 (age 1) is only 1/3-1/4 of the recruitment in the two previous years (Fig 5.5). NIPAG has, however, noticed that a decline in recruitment in a particular year has rarely caused serious decreases in adult biomass in subsequent years, and this stock has been fluctuating around a stable level for many years.

SSB (female biomass) has been calculated for the years 2006-2009 (Fig. 5.6).The index follows the overall biomass index, increasing from 2006 to 2007, then declining back to the 2006-level in 2008 and further declining in .2009

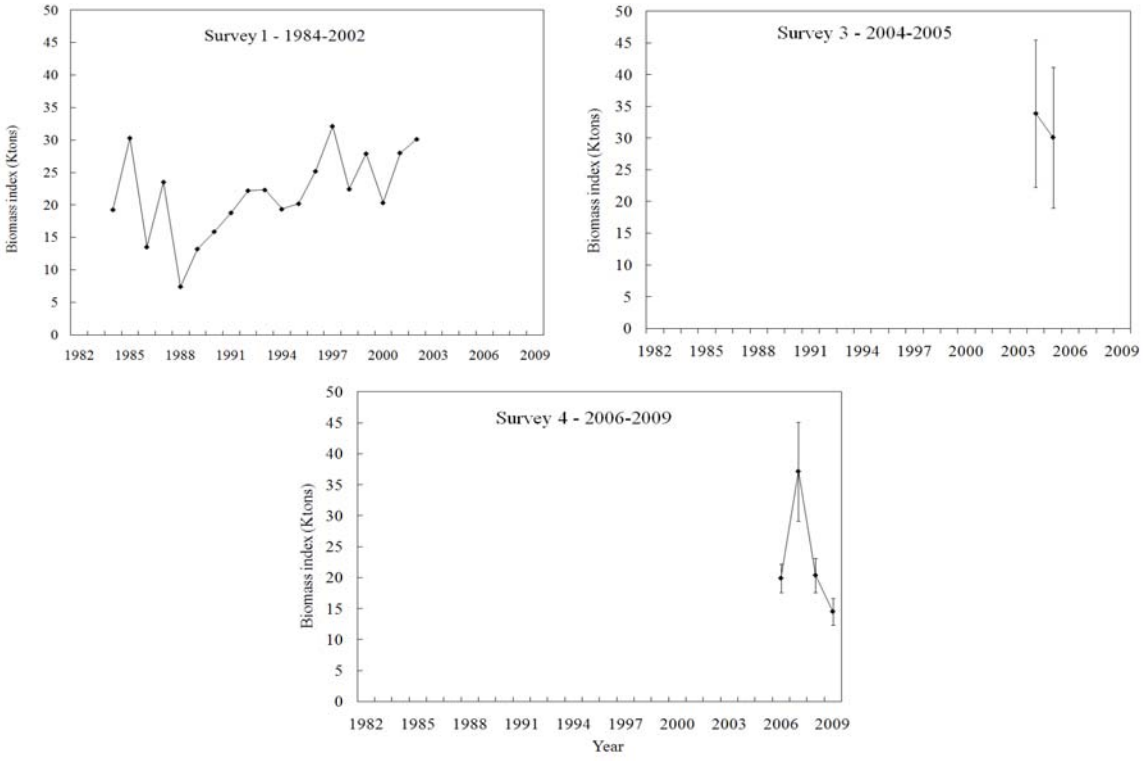


Fig. 5.4. Northern shrimp in Skagerrak and Norwegian Deep: Estimated survey biomass indices in 1984 to 2009. The four surveys are not calibrated to a common scale. Standard errors (error bars) have been calculated for the 2004-2009 surveys. Survey 1: October/November 1984-2002 with Campelen-trawl; Survey 2: October/November 2003 with shrimp trawl 1420 (not shown); Survey 3: May/June 2004-2005 with Campelen trawl; Survey 4: January/February 2006-2009 with Campelen trawl.

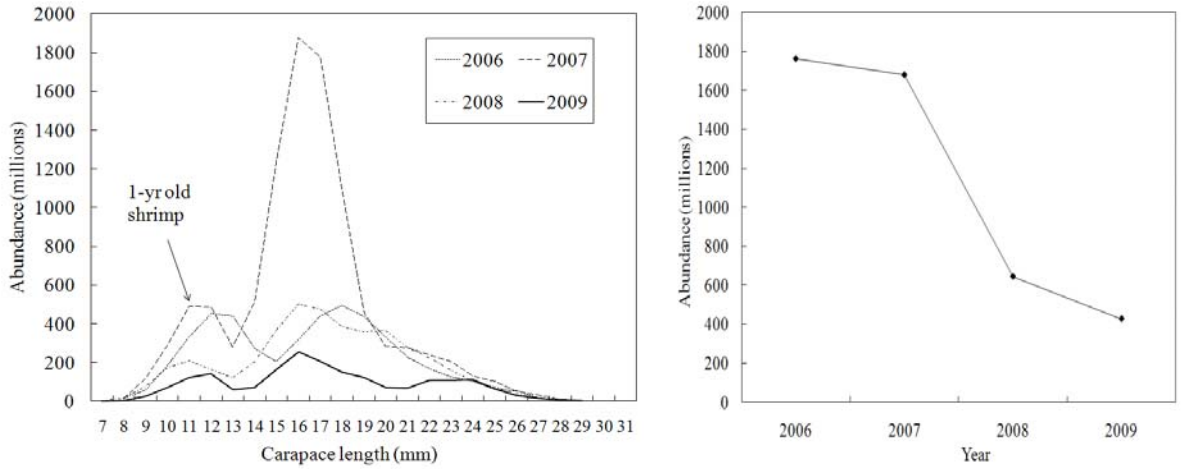


Fig. 5.5. Northern shrimp in Skagerrak and Norwegian Deep: Estimated length frequency distribution from the Norwegian shrimp surveys in 2006-2009, and recruitment indices from the same years. The recruitment index is calculated as the abundance of age 1 shrimp (the first mode in the length frequency distribution).

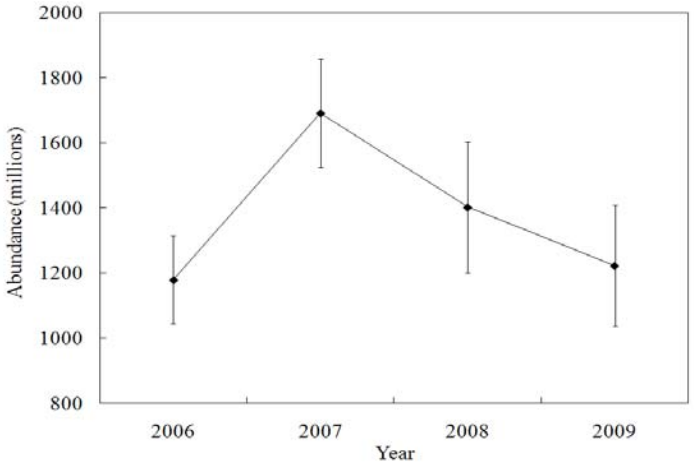


Fig. 5.6. Northern shrimp in Skagerrak and Norwegian Deep: SSB abundance from the Norwegian shrimp surveys in 2006-2009. The abundance index of the spawning stock is calculated as the abundance of females (except females in a resting stage). Error bars are SE.

The total index of shrimp predator biomass was estimated to 94.1 kg/nm in 2009, which is a decrease compared with 244.7 kg/nm in 2008 (SCR Doc. 09/58, Table 5.3). Variation in the predator biomass index is heavily influenced by variations in the saithe index, which in turn is influenced by which stations are trawled.

Table 5.3**.** Northern shrimp in Skagerrak and Norwegian Deep: Estimated indices of predator biomas (catch in kg per towed nautical miles) from the Norwegian shrimp survey in 2006-2009.

	biomass index			
Species	2006	2007	2008	2009
Blue whiting	0.13	0.13	0.12	1.21
Saithe	7.33	39.75	208.32	53.89
Cod	0.51	1.28	0.78	2.01
Roundnosed Grenadier	3.22	6.85	19.02	19.03
Rabbit fish	2.24	2.15	3.41	3.26
Haddock	0.97	4.21	1.85	3.18
Redfishes	0.18	0.40	0.26	0.43
Velvet Belly	1.31	2.58	1.95	2.42
Skates, Rays	0.41	0.95	0.64	0.17
Long Rough Dab	0.22	0.64	0.42	0.28
Hake	0.98	0.78	0.64	2.56
Angler	0.15	0.91	0.87	1.25
Witch	0.24	0.74	0.54	0.16
Dogfish	0.31	0.19	0.28	0.14
Whiting	0.35	1.01	1.35	3.02
Blue Ling	0	0	0	0
Ling	0.04	0.11	0.34	0.79
Fourbearded Rockling	0.06	0.14	0.04	0.03
Cusk	0.20	0	0.02	0.05
Halibut	0.08	0.07	3.88	0.09
Pollack	0.06	0.25	0.03	0.13
Greater Fork-beard	0	0	0	0.01
Total	18.99	63.14	244.76	94.11

c) Assessment Results

The 2007 assessment was based solely on Danish LPUE data, while the 2008 assessment was based on evaluation of both Danish and Norwegian standardised LPUEs, standardised effort from the fishery in 1987-2007, and the survey indices of recruitment and biomass. The 2009 assessment is based on the same indices as the 2008 assessment.

LPUE. The standardised Danish and Norwegian LPUEs show similar fluctuations since 2000 (Fig. 5.2). Since the mid-1990s the Danish standardised LPUE seems to fluctuate without any clear trend. NIPAG interprets this as a sign of stability of the stock. However, in 2008 both LPUE indices decreased and the Norwegian index decreased further in 2009 (preliminary data).

Recruitment. The recruitment in 2009 (age 1) has decreased slightly from last year and seems to be only 1/4 of the recruitment in 2006-2007 (Fig 5.5).

Survey biomass. The biomass index has decreased since 2007.

State of the stock. The LPUE indices indicate that the stock has been fluctuating without any clear trends since the mid-1990s. The 2008 stock indices are at lower levels than in 2007, and the survey indices for 2009 continue this drecrease. This could indicate a decrease in stock biomass from 2007 to 2009. The recruitment in both 2008 and 2009 is lower than in 2006-2007 and may imply a further decline in stock biomass in 2010.

d) Biological Reference Points

No reference points were provided in this assessment.

e) Management Recommendations

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

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

f) Research Recommendations

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

- *collaborate efforts should be made to standardize a means of predicting recruitment to the fishable stock*
- *the Norwegian shrimp survey should be continued on an annual basis*
- *differences in recruitment and stock abundance between Skagerrak and the Norwegian Deep should be explored.*

6. Northern Shrimp in Barents Sea and Svalbard area (ICES SA I and II) – ICES Stock

(SCR Doc. 04/12, 06/64, 70; 07/86; 08/56; 09/61, 62, 63)

a) Introduction

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

Norwegian vessels initiated the fishery in 1970. As the fishery developed, vessels from several nations joined and the annual catch reached 128 000 t in 1984 (Fig. 6.1). During the recent decade catches have varied between 26 000 and 83 000 t/yr, 70–90% of these were taken by Norwegian vessels and the rest by vessels from Russia, Iceland, Greenland and the EU (Table 6.1).

There is no TAC established for this stock. The fishery is partly regulated by effort control. Licenses are required for the Russian and Norwegian vessels. The fishing activity of these license holders are constrained only by bycatch regulations (see below) whereas the activity of third country fleets operating in the Svalbard zone is also restricted by the number of effective fishing days and the number of vessels by country. The minimum stretched mesh size is 35 mm. Other species are protected by mandatory sorting grids and by the temporary closing of areas where excessive bycatch of juvenile cod, haddock, Greenland halibut, redfish or shrimp <15 mm CL is registered.

The fishery is conducted mainly in the Hopen area (central Barents Sea) and on the Svalbard Shelf. The fishery takes place in all months but may in certain years be restricted by ice conditions. The lowest effort is generally seen in October through March, the highest in May to August.

Catch. Overall catches have ranged from 5 000 to 128 000 t/yr (Fig. 6.1). The most recent peak was seen in 2000 at approximately 83 000 t. Catches thereafter declined to about 26 000 t in 2008 due to reduced profitability of the fishery (reduced shrimp prices and increased fuel prices). Based on information from the industry, catch statistics until August and the seasonal fishing pattern of the most recent years the 2009 catches are estimated at 23 000 t.

Table 6.1. Shrimp in ICES SA I and II : Catches (1999 – 2008) and projected catches (2009) in metric tons, as used by NIPAG for the assessment.

	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009[1]
Recommended TAC	-	-	-	-	-	-	41 299[2]	40 000	50 000	50 000	50 000
Norway	52 612	55 333	43 031	48 799	34 172	35 918	36 966	27 352	25 403	20 638	19 000
Russia	10 765	19 596	5 846	3 790	2 186	1 170	933	0	9	370	0
Others	12 292	8 241	8 659	8 899	1 599	4 211	3 519	2 282	3 765	5 129	4 000
Total	75 669	83 170	57 536	61 488	37 957	41 299	41 418	29 634	29 177	26 137	23 000

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

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

Since the introduction of the Nordmøre sorting grid in 1992, only small cod, haddock, Greenland halibut, and redfish in the 5–25 cm size range are caught as bycatch. The bycatch of small cod ranged between 2–67 million individuals/yr and redfish between 2–25 million individuals/yr since 1992, while 1–9 million haddock/yr and 0.5–14 million Greenland halibut/yr were registered in the period 2000–2004 (Fig. 6.2). In recent years there has been a decline in bycatch following a reduced effort in the shrimp fishery. Details of bycatch is reported in AFWG.

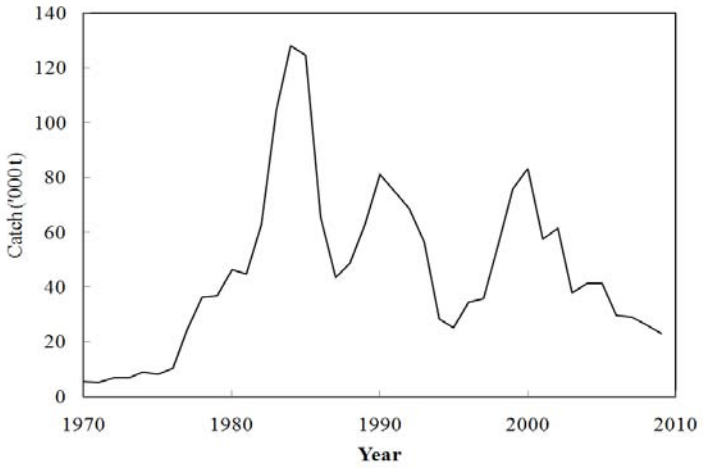


Fig. 6.1. Shrimp in ICES SA I and II: total catches 1970–2009 (2009 projected to the end of the year).

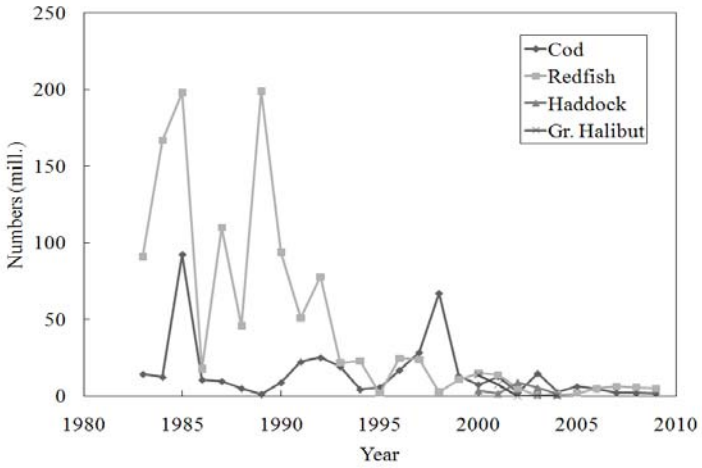


Fig. 6.2. Shrimp in ICES SA I and II: Estimated bycatch of cod, haddock, Greenland halibut and redfish in the Norwegian shrimp fishery (million individuals).

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

In late winter 2009 the bottom temperatures in the northern Hopen Trench were below the long-term mean and 0.5-1°C colder than in the winter of 2008. In late summer 2009 most of the Barents Sea had bottom temperatures above the long-term mean (in particular the areas east of 40°E). The recent shift eastwards in shrimp distribution as observed in the survey (Fig. 6.3) may be explained by the changes in ocean climate, with shrimp found mainly in 0-4°C water.

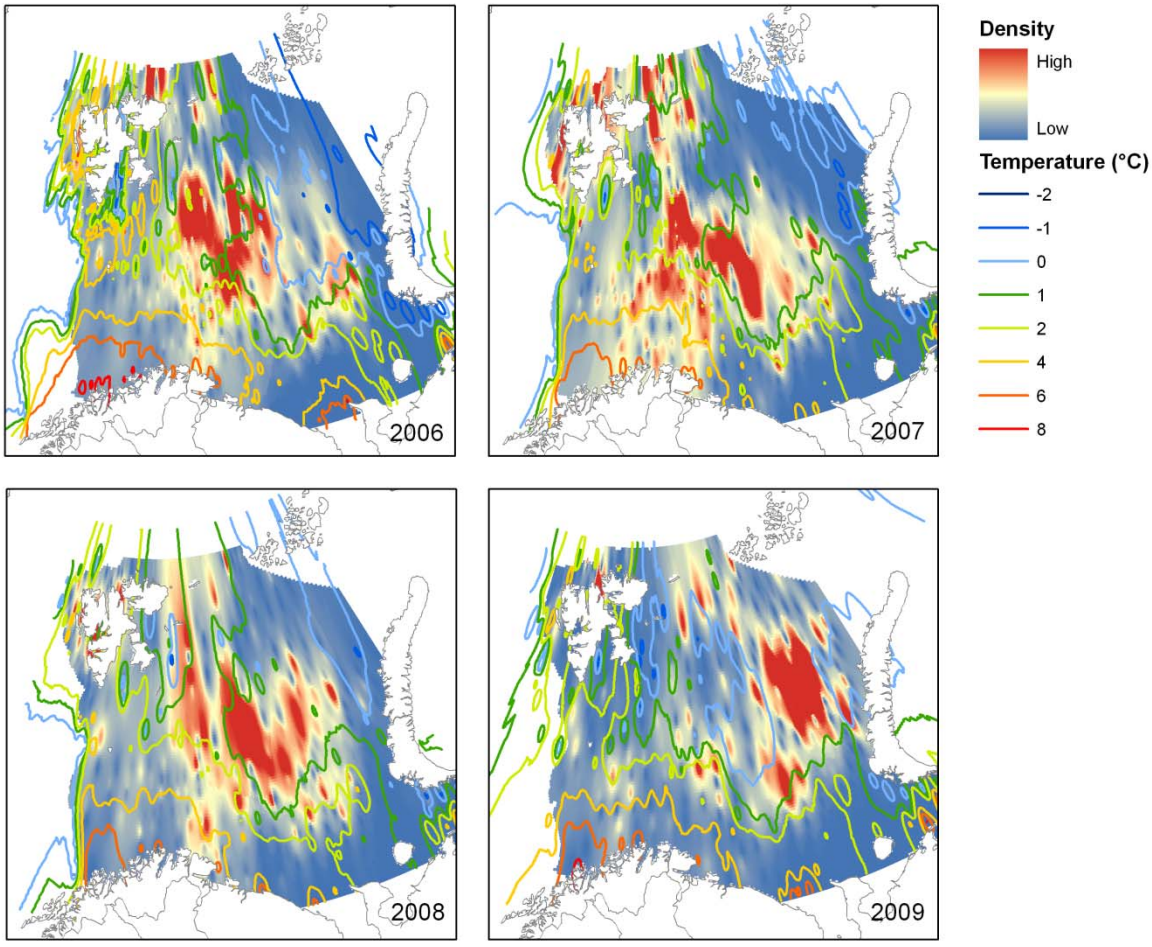


Fig. 6.3. Shrimp in ICES SA I and II: Bottom temperature contour overlays from the 2006 to 2009 ecosystem surveys on shrimp density distributions.

b) Input Data

i) Commercial fishery data

A major restructuring of the shrimp fishing fleet towards fewer and larger vessels has taken place since the mid-1990s. At that time an average vessel had around 1 000 horse powers (HP); 10 years later this value had increased to more than 6 000 HP (Fig. 6.4). Until 1996 the fishery was conducted by using single trawls only. Double trawls were then introduced, and in 2002 approximately ⅔ of the total effort spent was by using two trawls simultaneously. In 2000 a few vessels started to experiment with triple trawls: 50% of the effort in 2009 is accounted for by this fishing method (Fig. 6.5). An individual vessel may alternate between single and multiple trawling depending on what is appropriate on given fishing grounds.

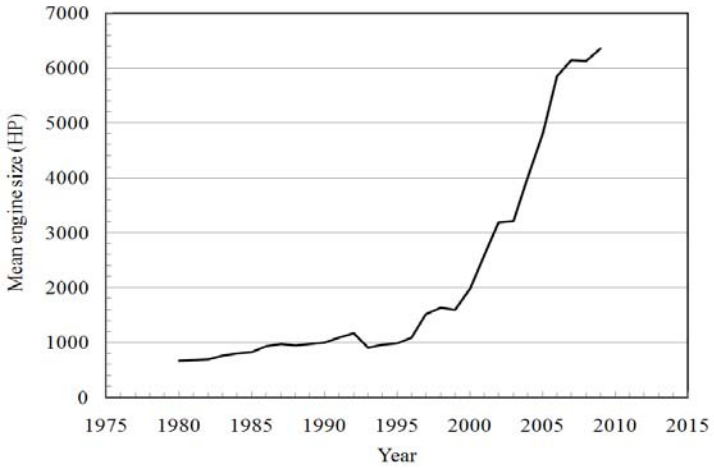


Fig. 6.4. Shrimp in ICES SA I and II: Mean engine size (horse power) of trawling in the years 1980–2009.

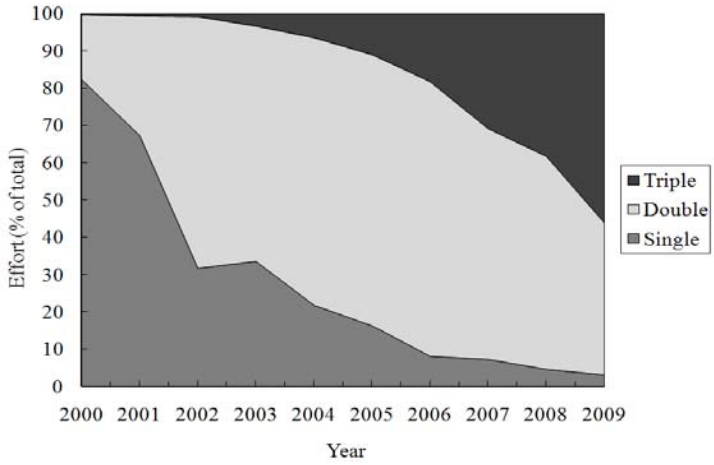


Fig. 6.5. Shrimp in ICES SA I and II: Percentage of total fishing effort spent by using single, double or triple trawls 2000–2009. Norwegian data.

Norwegian logbook data were used in a multiplicative model (GLM) to calculate standardized annual catch rate indices (SCR Doc. 09/62). The new index series based on individual vessels rather than vessel groups was introduced in 2008 (SCR Doc. 08/56) in order to take into account the changes observed in the fleet. The GLM model to derive the CPUE indices included the following variables: (1) vessel, (2) season (month), (3) area and (4) gear type (single, double or triple trawl). The resulting series is assumed to be indicative of the biomass of shrimp ≥17 mm CL, *i.e.* females and older males.

The standardized CPUE declined by 60% from a maximum in 1984 to the lowest value of the time series in 1987 (Fig. 6.6). Since then it has showed an overall increasing trend. A new peak was reached in 2006. The 2007 to 2009 mean values are all about 10% lower than the 2006-value, but is still above the average of the series. The standardized effort (Fig. 6.7) has shown a decreasing trend since 2000.

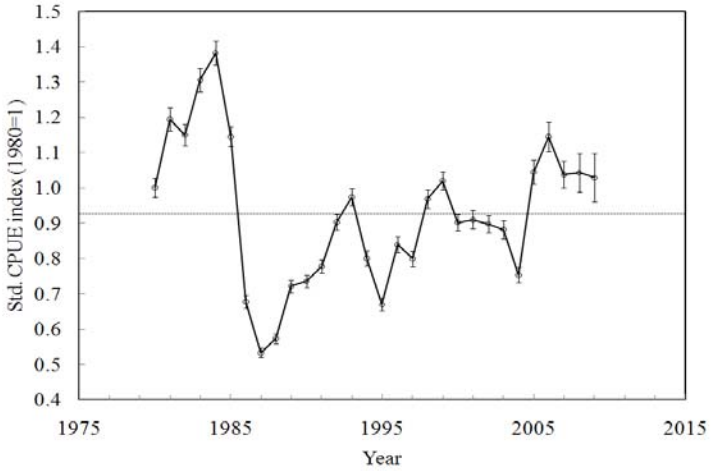


Fig. 6.6. Shrimp in ICES SA I and II: standardized CPUE based on Norwegian data. Error bars represent one standard error; dotted line is the overall mean of the new series.

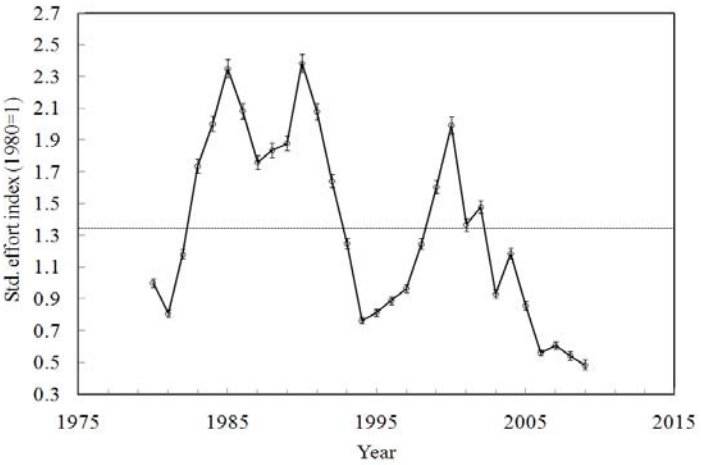


Fig. 6.7. Shrimp in ICES SA I and II: Standardized effort (Catch divided with standardized CPUE). Error bars represent one standard error; dotted line is the overall mean of the series.

ii) Research survey data

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

The Norwegian shrimp survey 1982–2004, representing the most important shrimp grounds for that period, and the Joint Russian Norwegian Ecosystem survey 2004-present representing the entire area was used as input for the assessment model.

Biomass. The Biomass indices of the Norwegian shrimp survey have varied in a cyclic manner with periods of approximately 7 years since the start of the series in 1982 (Fig. 6.8).

The Ecosystem survey has not been calibrated to the ones discontinued in 2004. The estimate of mean biomass increased by about 66% from 2004 to 2006 and then decreased again to the 2004-level in 2008 (Fig. 6.8). The 2009 value is 20% up compared to 2008.

The geographical distribution of the stock in 2009 is more easterly compared to that of the previous years (Fig. 6.9).

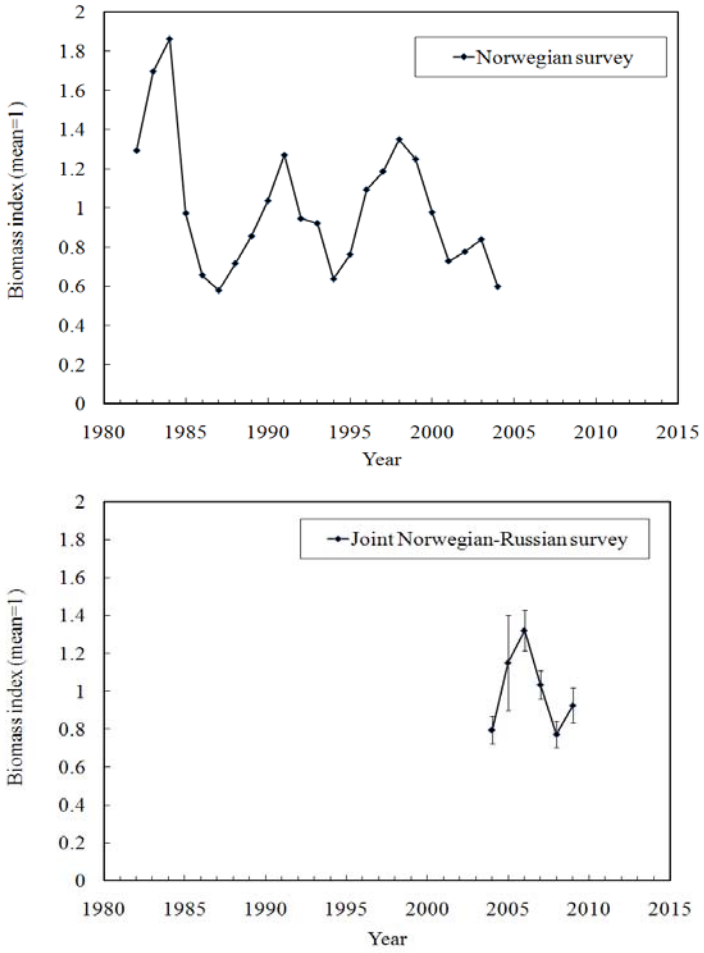


Fig. 6.8. Shrimp in ICES SA I and II: Indices of total stock biomass from the 1982-2004 Norwegian shrimp survey (*upper panel*) and the joint Russian-Norwegian ecosystem survey (*lower panel*). Error bars represent one standard error.

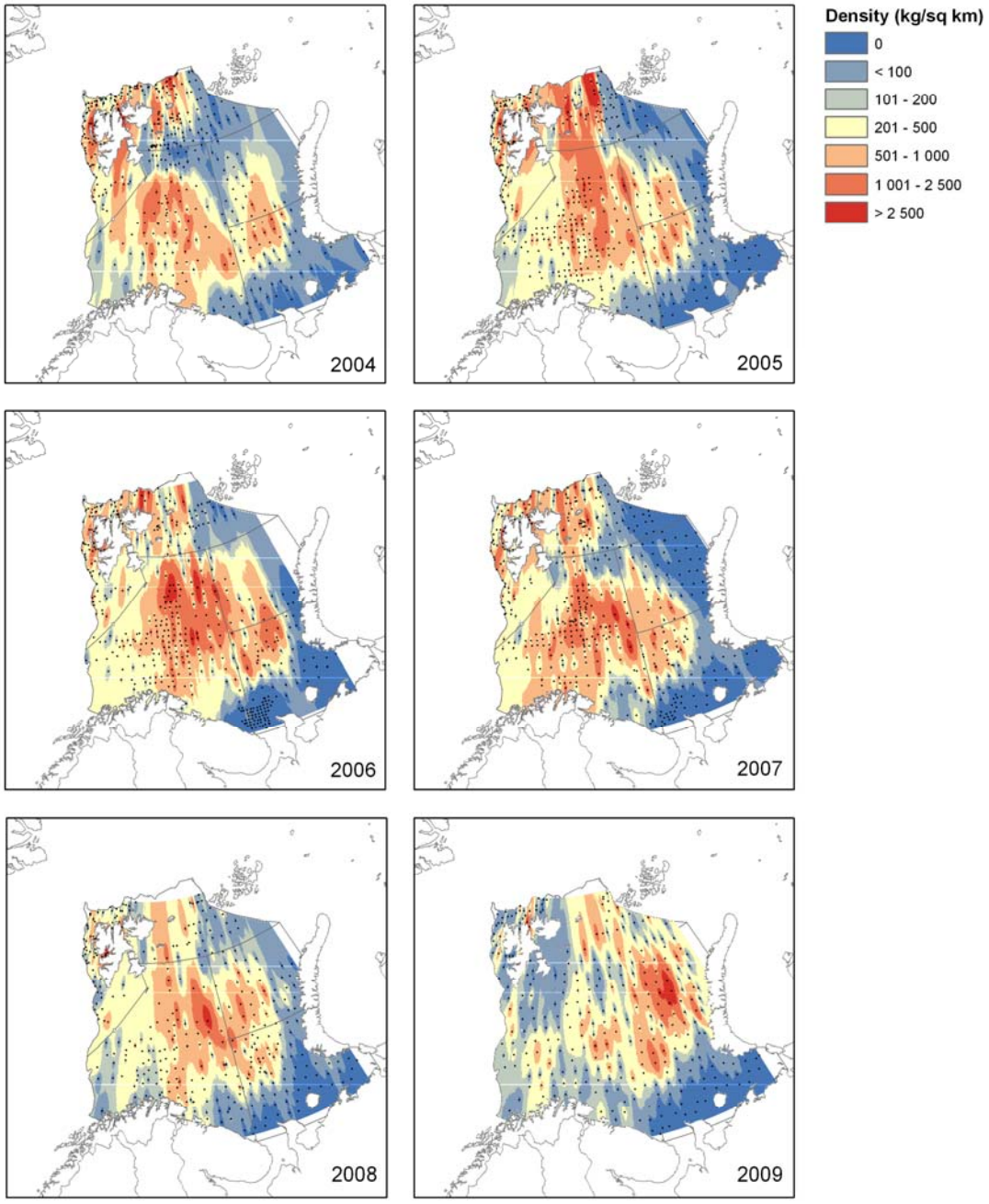


Fig. 6.9. Shrimp in ICES SA I and II: Shrimp density (kg/km^2) as calculated from the Ecosystem survey data 2004–2009).

Length composition. Overall size distributions (Fig. 6.10) indicate a relatively large amount of smaller shrimp in 2004 which resulted in the increase in stock biomass until 2006 (Fig. 6.8). The recruitment index – estimated abundance of shrimp at 13–17mm CL supposed to enter the fishery in the following 1–2 years) decreased from 2004 to 2008 (Fig. 6.11). Demographic information was not available for 2009.

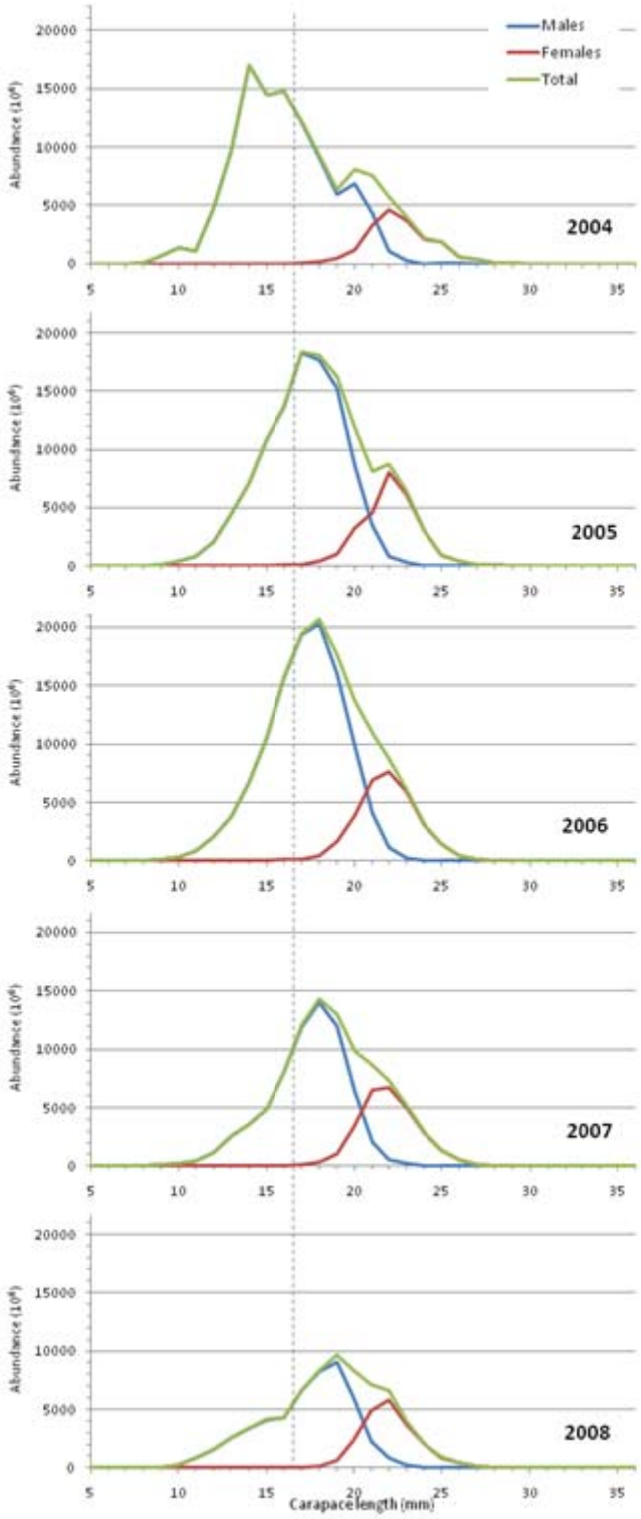


Fig. 6.10. Shrimp in ICES SA I and II: size distribution of males, females and total 2004–2008 (no data available for 2009).

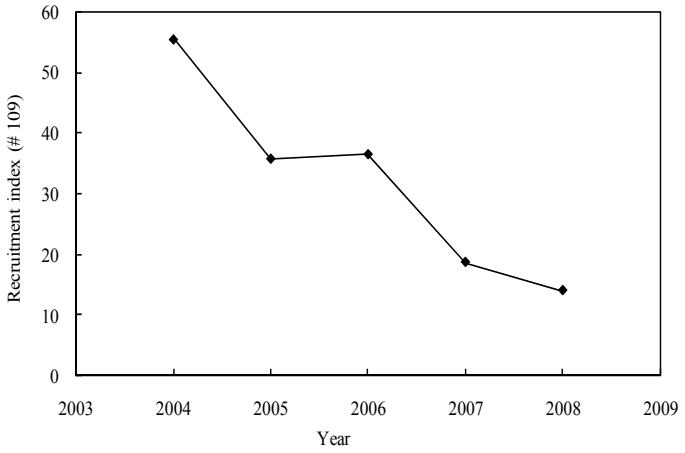


Fig. 6.11. Shrimp in ICES SA I and II: Index of recruitment: abundance of shrimp at size 13–17 mm CL (no data available for 2009).

c) Estimation of Parameters

The modelling framework introduced in 2006 (Hvingel, 2006) was used for the assessment. All model settings were kept similar to the ones used in previous years and input data was similar to last year's except for the addition of an extra year of data.

Within this model parameters relevant for the assessment and management of the stock is estimated, based on a stochastic version of a surplus-production model. The model is formulated in a state-space framework and Bayesian methods are used to construct "posterior" likelihood distributions of the parameters (SCR Doc. 09/63).

The model synthesized information from input priors, three independent series of shrimp biomass and one series of shrimp catch. The three series of shrimp biomass indices were: a standardized series of annual commercial-vessel catch rates for 1980–2009 (SCR Doc. 09/62); and two trawl-survey biomass index for 1982–2004 and 2004–2009 (SCR Doc. 07/75, 09/61). These indices were scaled to true biomass by catchability parameters and lognormal observation errors were applied. Total reported catch in ICES Div. I and II 1970–2009 was used as yield data (Fig. 6.1, SCR Doc. 09/62). The fishery being without major discarding problems or variable misreporting, reported catches were entered into the model as error-free.

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

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

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

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

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

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

Estimates of selected parameters are shown in Table 6.2.

Table 6.2. Shrimp in ICES SA I and II : Summary of parameter estimates: mean, standard deviation (sd) and 25, 50, and 75 percentiles of the posterior distribution of selected parameters (symbols are as in the text). MSY = Maximum Sustainable Yield (kt), K = carrying capacity, r = intrinsic growth rate, qC, qR and qE are catchability parameters, P_{1970} = the 'initial" stock biomass in 1970, σ = CV of CPUE and surveys, and σ_p = the process error.

	Mean	Sd	25 %	Median	75 %
MSY (ktons)	254	190	114	201	343
K (ktons)	3289	1850	1872	2864	4288
R	0.32	0.16	0.20	0.31	0.43
q_R	0.14	0.10	0.07	0.10	0.17
q_E	0.19	0.14	0.09	0.14	0.24
q_C	4.87E-04	3.71E-04	2.38E-04	3.75E-04	6.18E-04
P_{1970}	1.50	0.26	1.33	1.51	1.68
P_{2009}	1.85	0.42	1.63	1.86	2.08
σ_R	0.18	0.03	0.16	0.18	0.20
σ_E	0.17	0.04	0.14	0.16	0.19
σ_C	0.13	0.02	0.11	0.12	0.14
σ_P	0.19	0.03	0.17	0.19	0.21

d) Assessment Results

The results of this year's model run are similar to those of the three previous years.

Stock size and fishing mortality. Since the 1970s, the estimated median biomass-ratio has been above its MSY-level (Fig. 6.12) and the probability that it had been below the optimum level (B_{msy}) was small for most years, *i.e.* it seemed likely that the stock had been at or above its MSY level since the start of the fishery (SCR Doc. 09/63).

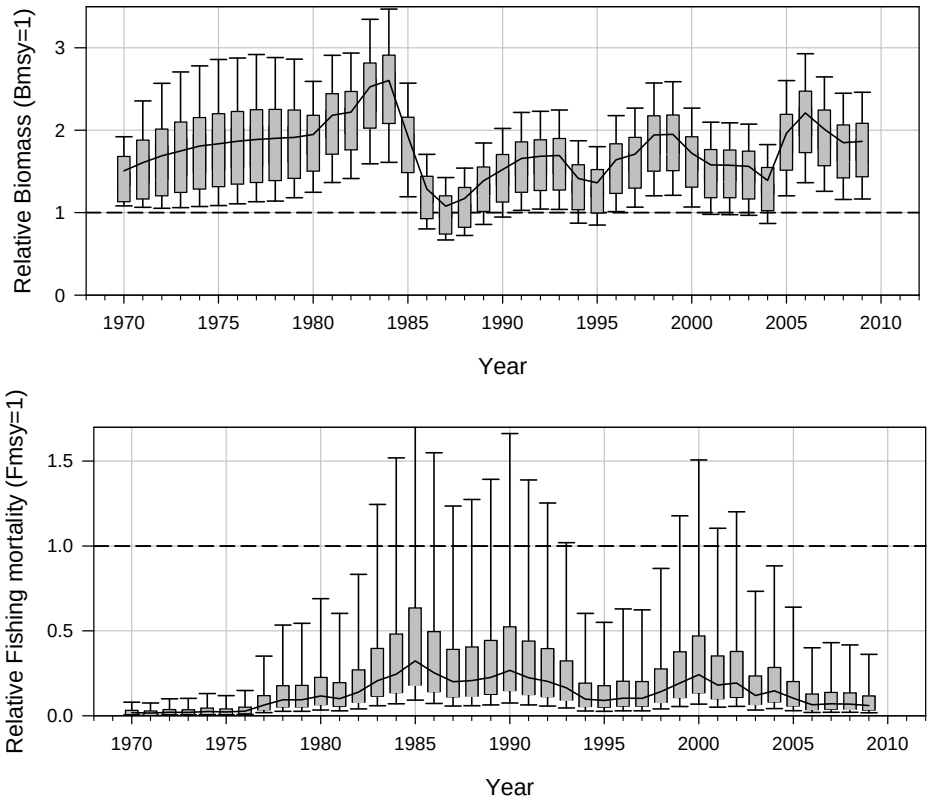


Fig. 6.12. Shrimp in ICES SA I and II: estimated relative biomass (B_t/B_{msy}) and fishing mortality (F_t/F_{msy}) 1970–2009. Boxes represent inter-quartile ranges and the solid black line at the (approximate) centre of each box is the median; the arms of each box extend to cover the central 95% of the distribution.

A steep decline in stock biomass was noted in the mid 1980s following some years with high catches and the median estimate of biomass-ratio went close to the optimum (Fig. 6.12). Since the late 1990s the stock has varied with an overall increasing trend and reached a level in 2009 estimated to be close to 80% *K*. The estimated risk of stock biomass being below B_{msy} in 2009 was 3% (Table 6.3). The median fishing mortality ratio (*F*-ratio) has been well below 1 throughout the series (Fig. 6.12). In 2009 there is 1% risk of the *F*-ratio being above F_{msy} (Table 6.3).

Table 6.3. Shrimp in ICES SA I and II: stock status for 2008 and predicted to the end of 2009. (F_{msy}=F_{lim}; 1.7F_{msy}=fishing mortality that corresponds to a B_{lim} at 0.3B_{msy}).

Status	2008	2009*
Risk of falling below B_{lim} (0.3B_{MSY})	0.0 %	0.0 %
Risk of falling below B_{MSY}	3.0 %	2.9 %
Risk of exceeding F_{MSY}	1.2 %	1.0 %
Risk of exceeding 1.7F_{MSY}	0.6 %	0.5 %
Stock size (B/Bmsy), median	1.84	1.84
Fishing mortality (F/Fmsy),	0.14	0.14
Productivity (% of MSY)	30 %	30 %

*Predicted catch = 23ktons

For stocks assessed with production models, the NAFO Scientific Council has developed limit reference points for stock size (B_{lim} at 30% of B_{msy}) and for fishing mortality (F_{lim} at 100% of F_{msy}) (SCS Doc. 04/12) (the reference point 1.7 F_{msy} is discussed in the 'Other studies'-section).

Estimated median biomass has been above B_{lim}. Fishing mortality ratio has been below F_{lim} throughout the time series (Fig. 6.13). At the end of 2009 there is less than 1% risk that the stock would be below B_{lim}, while the risk that F_{lim} was exceeded is 1% (Table 6.3).

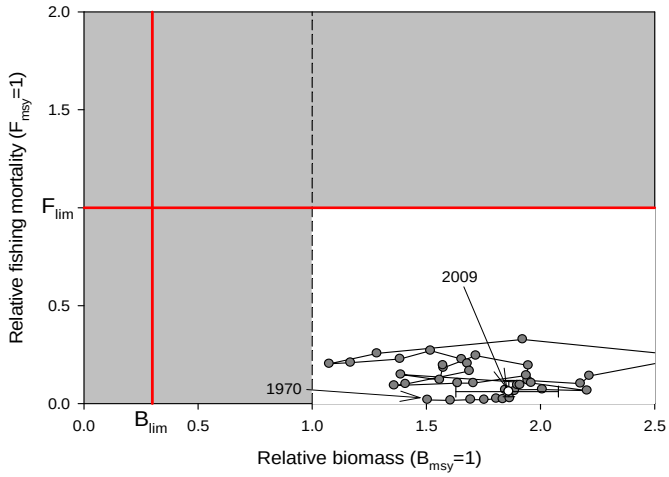


Fig. 6.13. Shrimp in ICES SA I and II: Estimated annual median biomass-ratio (B/B_{msy}) and fishing mortality-ratio (F/F_{msy}) 1970–2009. The reference points for stock biomass, B_{lim}, and fishing mortality, F_{lim}, are indicated by the red (bold) lines. Error bars on the 2009 value are inter-quartile range.

Predictions. Given the high probabilities of the stock being considerably above B_{msy}, risk of stock biomass falling below this optimum level within a one-year perspective is low. Risk associated with six optional catch levels for 2010 are as follows:

Catch option 2010 (ktons)	30	40	50	60	70	90
Risk of falling below B_{lim} ($0.3B_{MSY}$)	0.0 %	0.0 %	0.0 %	0.0 %	0.0 %	0.0 %
Risk of falling below B_{MSY}	3.9 %	4.1 %	4.2 %	4.4 %	4.3 %	4.6 %
Risk of exceeding F_{MSY}	1.7 %	2.6 %	3.8 %	5.1 %	6.5 %	9.8 %
Risk of exceeding $1.7F_{MSY}$	0.7 %	1.2 %	1.7 %	2.3 %	2.9 %	4.4 %
Stock size (B/Bmsy), median	1.85	1.83	1.83	1.82	1.82	1.79
Fishing mortality (F/Fmsy),	0.08	0.11	0.14	0.16	0.19	0.25
Productivity (% of MSY)	28 %	31 %	31 %	33 %	34 %	37 %

The risk associated with ten-year projections of stock development assuming annual catch of 30 000 to 90 000 t were investigated (Fig. 6.14). For all options the risk of the stock falling below B_{msy} in the short to medium term (1-5 years) is low, (<11%). The stock has a less than 1% risk of being below B_{lim} in 2009 and none of these catch options are likely to increase that risk above 5% over a 10 year period (Fig. 6.14). Catch options up to 50 000 t, have a low risk (<5%) of exceeding F_{lim} and are likely to maintain the stock at its current high level.

Taking 70 000 t/yr will increase risk of going below B_{msy} to about 11% during the ten years of projection (Fig. 6.14). The risk that catches of this magnitude will not be sustainable (*prob* ($F > F_{MSY}$), in the longer term doubles as compared to the 50 000 t option but is still below or at 10% after five years.

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

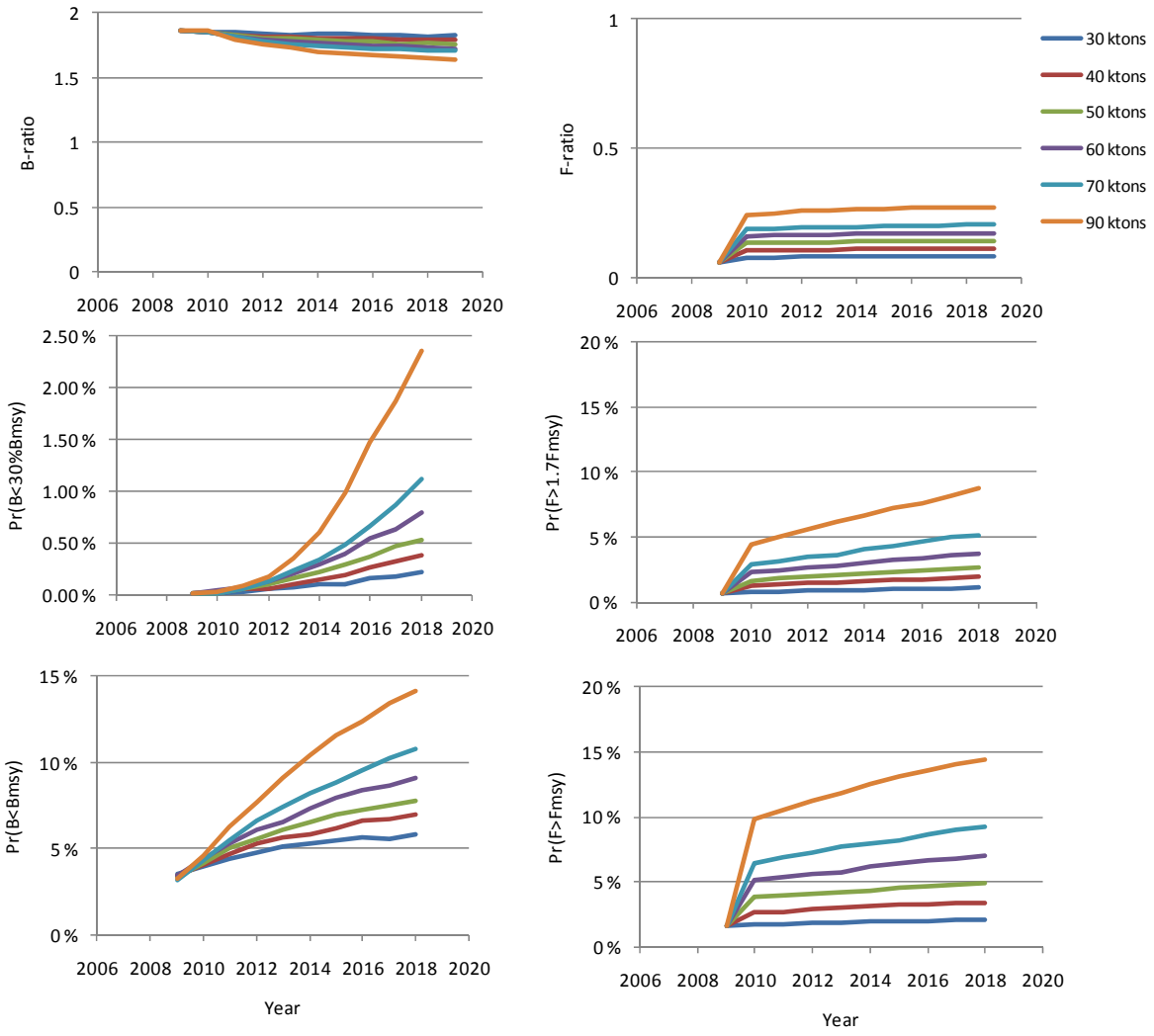


Fig. 6.14. Shrimp in ICES SA I and II: Projections (*top*): Medians of estimated posterior biomass and fishing mortality ratios; estimated risk (*right* and *below*) of going below B_{msy} and B_{lim}, and of exceeding F_{lim} anf 1.7 F_{MSY} given different catch options (see legend).

Additional considerations

Model performance. The model was able to produce reasonably good simulations of the observed data (Fig. 6.15) and the observations did not lie in the extreme tails of their posterior distributions (SCR Doc. 09/63) The retrospective pattern of relative biomass series estimated by consecutively leaving out from 0 to 10 years of data did not reveal any problems with sensitivity of the model to particular years (Fig. 6.16).

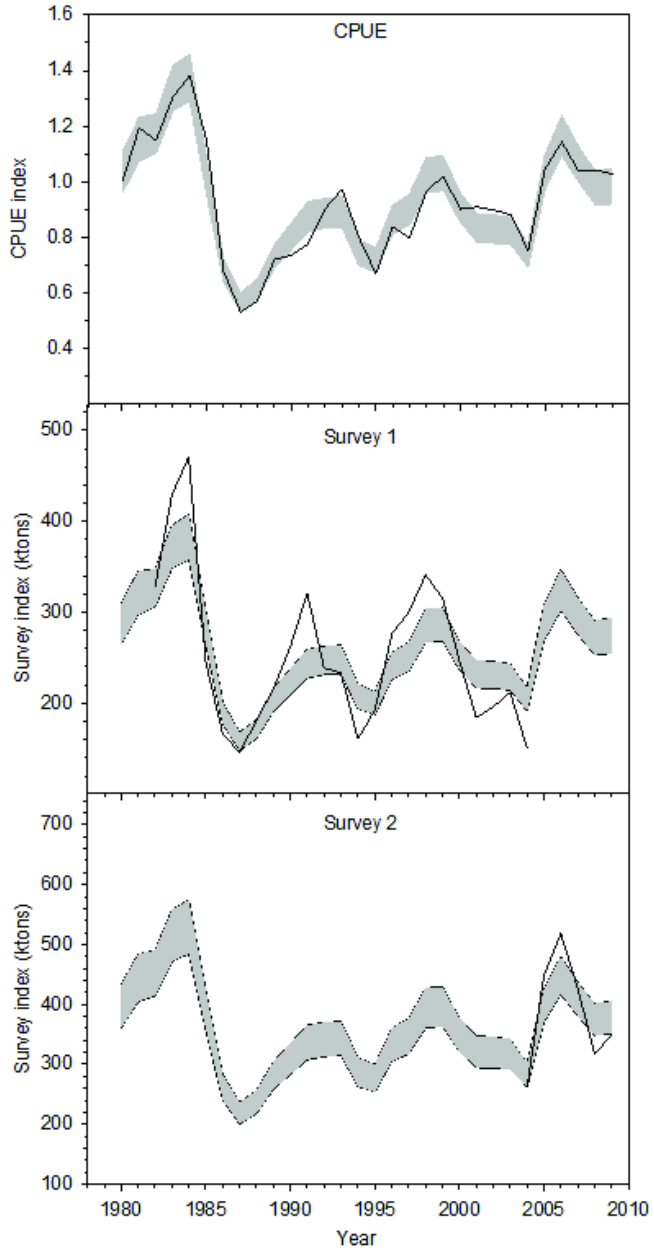


Fig. 6.15. Shrimp in ICES SA I and II: Observed (solid line) and estimated (shaded) series of the included biomass indices: the standardized catch-per-unit-effort (CPUE), the 1982–2004 shrimp survey (survey 1) and the joint Norwegian-Russian Ecosystem survey (survey 2). Grey shaded areas are the inter-quartile range of the posteriors.

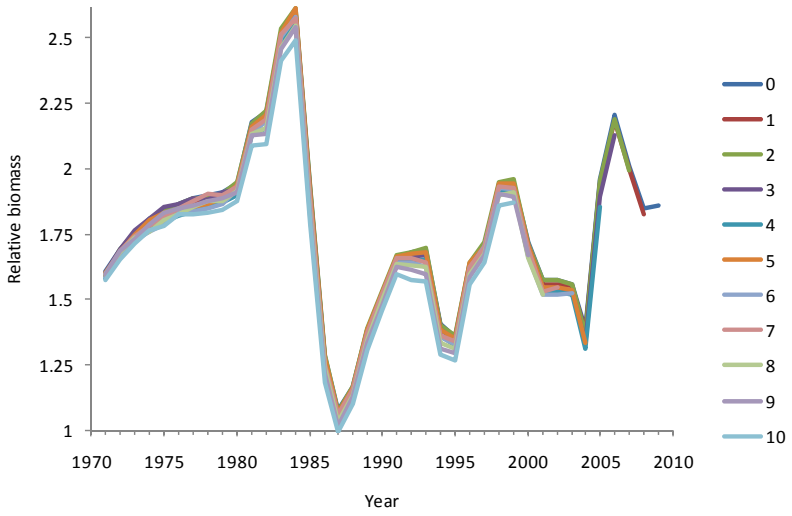


Fig. 6.16. Shrimp in ICES SA I and II: Retrospective plot of median relative biomass (B/B_{msy}). Relative biomass series are estimated by consecutively leaving out from 0 to 10 years of data.

Predation. Both stock development and the rate at which changes might take place can be affected by changes in predation, in particular by cod, which has been estimated to consume on average 4–5 times the catches. If predation on shrimp were to increase rapidly outside the range previously experienced by the shrimp stock within the modelled period (1970–2009), the shrimp stock might decrease in size more than the model results have indicated as likely. The cod stock has recently increased (AFWG, ICES). However, as the total predation depends on the abundance of cod, shrimp and also of other prey species (e.g.capelin) the likelihood of such large reductions is at present hard to quantify.

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

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

Other studies (SCR Doc. 09/63)

In the NAFO approach F_{lim}=F_{msy} and $B_{lim.}$=0.3B_{msy}, i.e. F_{lim} would not be the fishing mortality that drives the stock to $B_{lim.}$. Instead F_{lim} would get the stock to B_{msy} – the stock size that gives maximum yield. This might be considered somewhat confusing and lead to inconsistencies in the definitions of 'limit reference points'.

$B_{lim.}$ The Schaefer production curve fitted by the assessment model corresponds to the estimated stock-recruitment relation. The slope of this curve is decreasing linearly (Fig. 6.17) i.e. there is not a distinct "change-point" where recruitment starts to decline rapidly as the stock is reduced, which could provide a candidate for a $B_{lim.}$ reference. A B_{lim} equal to 30% B_{msy} has been used in previous assessments. At 30% B_{msy} production is reduced to 50% of its maximum (Fig. 6.17). This is equivalent to the SSB-level (spawning stock biomass) at 50% R_{max} (maximum recruitment). The $B_{lim.}$ value of 30% B_{msy} is arbitrarily chosen and is not necessarily appropriate for all stocks. As an alternative $B_{lim.}$ could be based on the time it takes for the stock to recover from this point (cf. Cadrin 1999).

F_{lim}. An F-ratio (F/F_{msy}) corresponding to a yield of 50% MSY (50% R_{max}) at a stock biomass of 30% B_{msy} ($=B_{lim}$) may be derived from the equations of the assessment model (see section 'estimation of parameters') as follows:

$$\frac{production}{B_{MSY}} = \frac{2\,MSY\,P_t}{B_{MSY}}\left(1-\frac{P_t}{2}\right),$$

at equilibrium: $C = production$ and

$$F = \frac{C}{B} = \frac{C}{B_{MSY}}\frac{B_{MSY}}{B} \Rightarrow$$

$$F = \frac{2\,MSY\,P_t}{B_{MSY}}\left(1-\frac{P_t}{2}\right)\frac{1}{P}, \quad \text{as } F_{MSY} = \frac{MSY}{B_{MSY}} \Rightarrow$$

$$\frac{F}{F_{MSY}} = Fratio = 2-P$$

Thus, if B_{lim} is 30% B_{msy} (P=0.3) then the corresponding F-ratio is 1.7 (Fig.6.17).

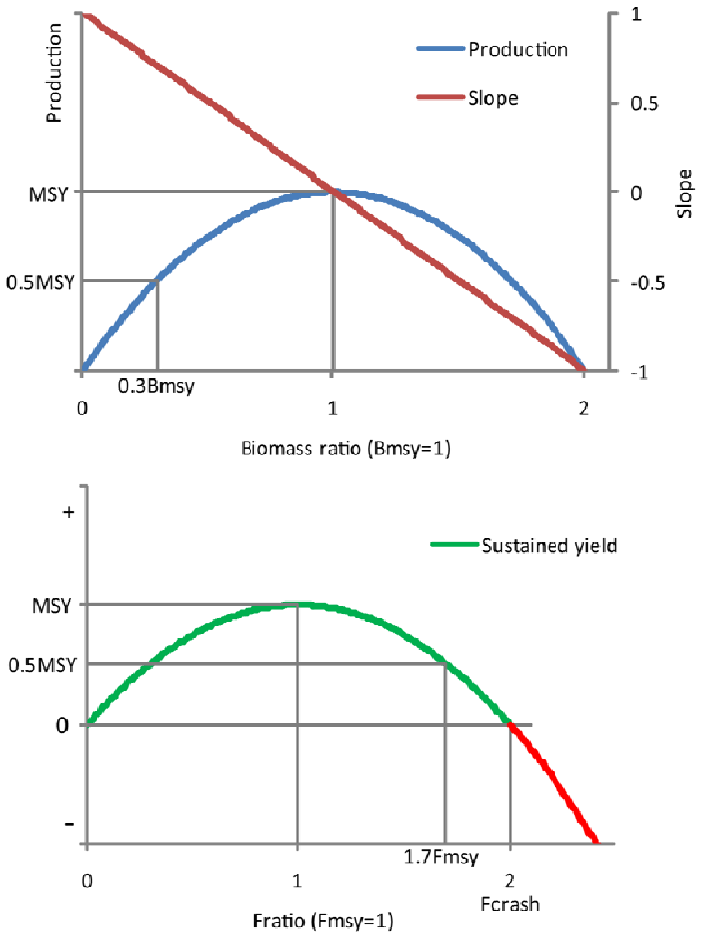


Fig. 6.17. Shrimp in ICES SA I and II: The logistic production curve in relation to stock biomass (B/B_{msy}) (*upper*) and fishing mortality (F/F_{msy}) (*lower*). *Upper*: points of maximum sustainable yield (MSY) and corresponding stock size are shown as well as the slope (red line) of the production curve (blue line); *lower*: points of MSY and corresponding fishing mortality and F_{crash} ($F \geq F_{crash}$ do not have stable equilibriums and will drive the stock to zero).

e) Summary

Mortality. The fishing mortality has been below the upper limit reference (F_{lim}=F_{msy}) throughout the exploitation history of the stock. The risk that F exceeded F_{lim} is estimated at about 1% for 2009, given a projected 2009 catch of 23 000 t.

Biomass. Stock size decreased slightly from 2006 to 2009, but is still estimated to be at a relatively high level. The estimated risk of stock biomass being below B_{msy} at end 2009 was 3%, and less than 1% of being below B_{lim}.

Recruitment. The recruitment index has decreased by 75% from 2004 to 2008.

State of the Stock. The stock biomass estimates have varied above its MSY level throughout the history of the fishery. Biomass at the end of 2009 is estimated to be well above B_{msy} and fishing mortality well below F_{msy}. However, estimated numbers of small shrimp decreased from 2004 to 2008 which may result in reduced recruitment to the fishery in the near future.

f) Research Recommendations for 2010

NIPAG **recommended** that, for the shrimp stock in in Barents Sea and Svalbard (ICES Div. I and II):

- Demographic information continue to be collected
- Collaborative efforts should be made to standarsize a means of predicting recruitment to the fishable stock.
- Work to include explicit information on recruitment in the assessment model should be continued.

g) Management Recommendations

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

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

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

From the 1960s up to around 2000 a significant shrimp fishery exploited the shrimp stock on the Fladen Ground in the northern North Sea. A short description of the fishery is given, as a shrimp fishery could be resumed in this area in the future. The landings from the Fladen Ground have been recorded from 1972 (SCR Doc. 09/69, Table 9). Total reported landings since 1997 have fluctuated between zero in 2006 to above 4000 t (Table 6.1). The Danish fleet accounts for the majority of these landings, with the Scottish fleet landing a minor portion. The fishery took place mainly during the first half of the year, with the highest activity in the second quarter. Since 2006 no landings have been recorded from this stock.

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

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

Country/Fleet	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
Denmark	3 022	2 900	1 005	1 482	1 263	1 147	999	23	10	0	0	0
Norway	9	3	9		18	9	8	0	0	0	0	0
Sweden							1	0	0	0	0	0
UK (Scotland)	365	1 365	456	378	397	70		0	0	0	0	0
Total	3 396	4 268	1 470	1 860	1 678	1 226	1 008	23	10	0	0	0

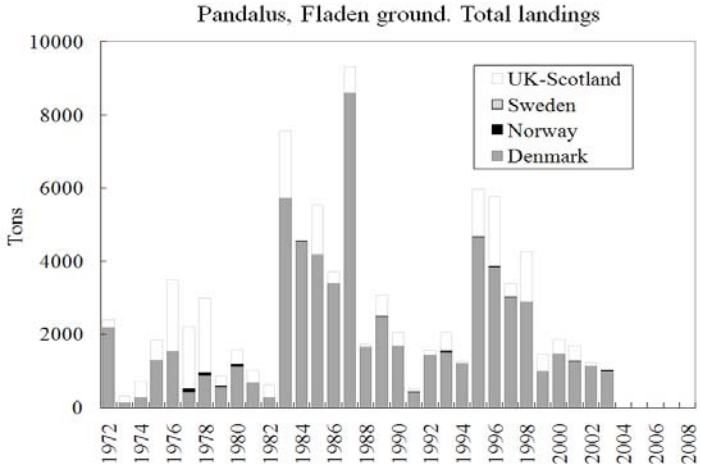


Fig. 7.1. Northern shrimp in Fladen Ground: Catches