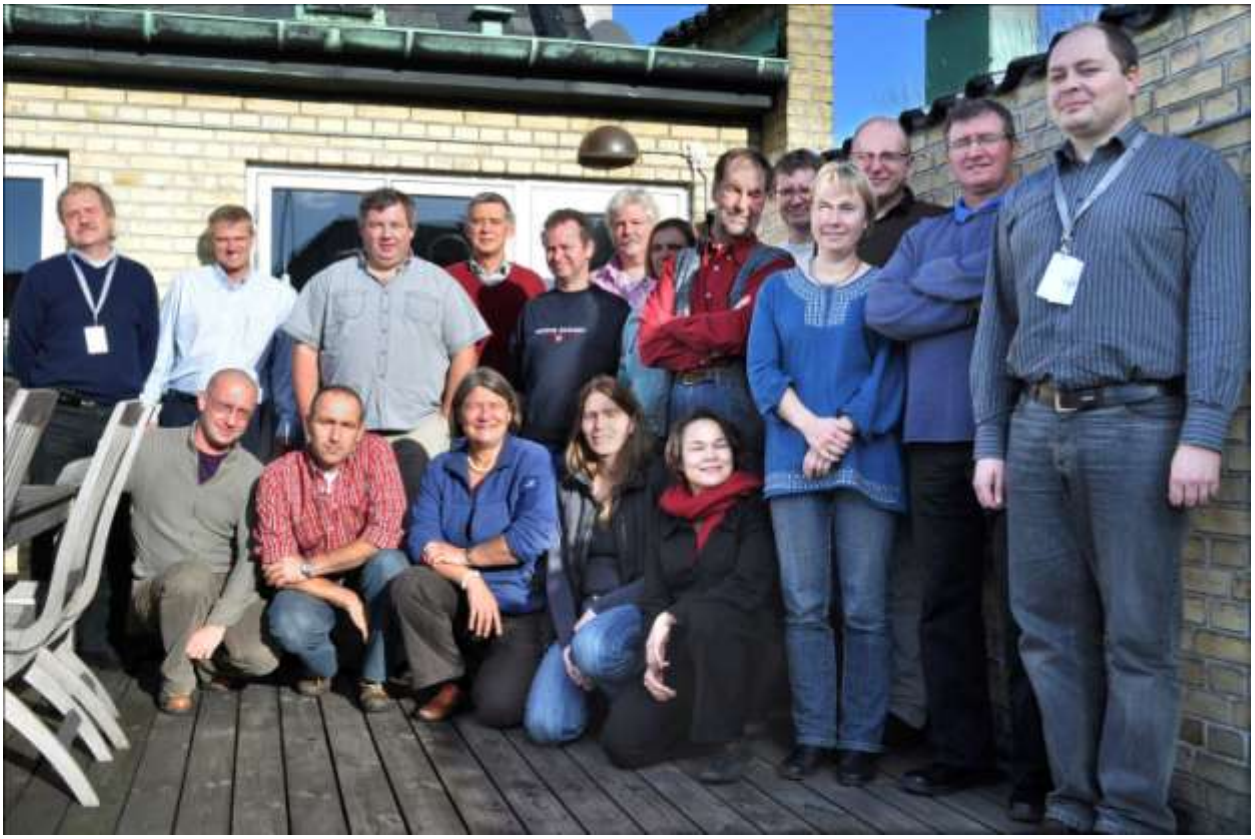
PART D: SCIENTIFIC COUNCIL MEETING, 20-27 OCTOBER 2010

Contents



Standing: Maris Plikss, Anthony Thompson (NAFO Secretariat), Ricardo Alpoim (Chair Scientific Council), Sten Munch-Petersen, David Orr, Mats Ulmestrand, Joanne Morgan (Co-Chair NIPAG), Michael C.S. Kingsley, Carsten Hvingel (Co-Chair NIPAG), Guldborg Søvik, Trond Thangstad, Don Stansbury, Silver Sirp.

Kneeling: Sergey Bakanev, José Miguel Casas Sanchez, Helle Siegstad, Nanette Hammeken Arboe, Nikoline Ziemer.

Report of Scientific Council Meeting

20-27 October 2010

Chair: Ricardo Alpoim Rapporteur: Anthony Thompson

I. PLENARY SESSIONS

The Scientific Council met at the ICES Headquarters, Copenhagen, Denmark, during 20-27 October 2010, to consider the various matters in its Agenda. Representatives attended from Canada, Denmark (Greenland), European Union (Denmark, Estonia, Latvia, Portugal and Spain), Norway and Russia. The Scientific Council Coordinator, Anthony Thompson, was in attendance.

The opening session of the Council was called to order at 0930 hours on 20 October 2010.

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.

This opening session was adjourned at 1000 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 1500 hours on 27 October 2010. The Council then considered and adopted Sections III.1–4 of the "Report of the NAFO/ICES *Pandalus* Assessment Group" (NAFO SCS Doc. 10/22, ICES CM 2010/ACOM:14). 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 20-27 October 2010 meeting.

The meeting adjourned at 1700 hours on 27 October 2010.

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

II. REVIEW OF RECOMMENDATIONS IN 2009

Scientific Council Meeting, 3-16 June 2010

X. Meeting Reports 4. Working Group on Reproductive Potential

Scientific Council was pleased that a workshop on "*Implementation of Stock Reproductive Potential into Assessment and Management Advice for Harvested Marine Species"* is planned for the spring of 2011. Council noted the importance of this workshop to the improvement of scientific advice and recommended that *Designated Experts attend the workshop.*

STATUS: Funding was approved during the Annual meeting held in September 2010 for two scientists to attend the workshop on Reproductive Potential.

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. 10/22 and ICES CM 2010/ACOM:14.

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

1. Request from Fisheries Commission

The Fisheries Commission Request for Advice from the September 2010 meeting (Annex 1d) for shrimp in Div. 3M and Div. 3LNO regarding stock assessment (Item 1) is given, respectively, under IV.1.a and IV.1.b below.

The Request for Advice on the identification of PA reference points (Item 3), on the distribution of shrimp (Item 4), and on an evaluation of stock recovery for shrimp in Div. 3M if the stock were subject to the 2009 catch level (Item 5) is given, respectively, under IV.1.c, IV.1.d and IV.1.e below.

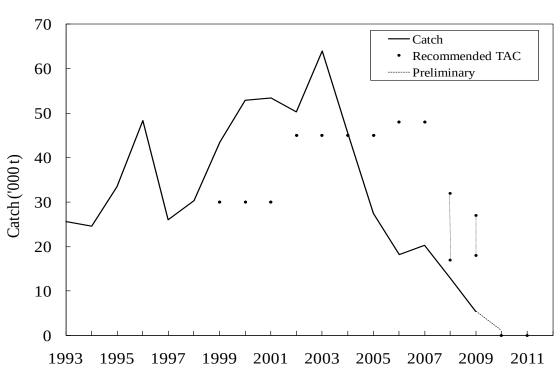
a) Northern shrimp in Div. 3M

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)	Effort[3] (days)
Year	NIPAG	21A	Recommended	Agreed
2006	18	15	48	10555
2007	21	18	48	10555
2008	13	12[1]	17-32	10555
2009	5	5[1]	18-27	10555
2010	1[2]		ndf	5277
2011			ndf	0

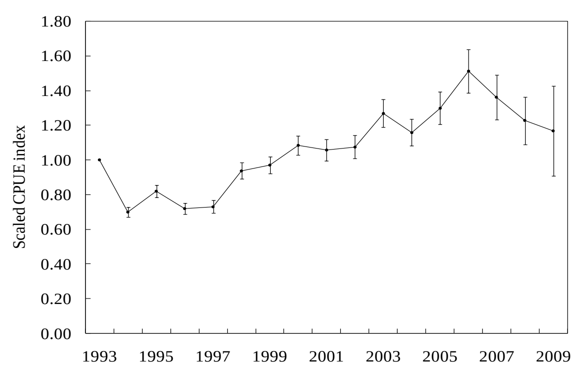
[1] Provisional.
[2] Preliminary to 10 October, 2010
[3] This stock is effort regulated
ndf- no directed fishery



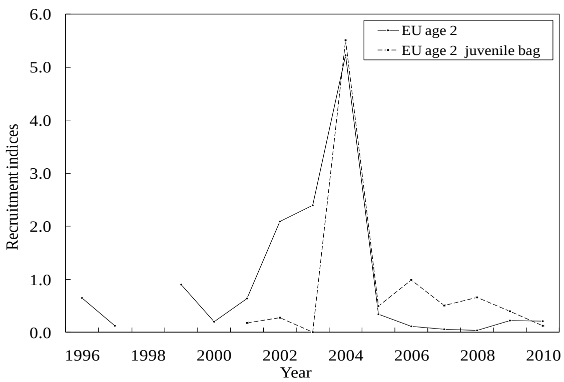
Data: Catch, effort and biological data were available from several Contracting Parties. Time series of size and sex composition data were available mainly from two countries between 1993 and 2005 and survey indices were available from EU research surveys (1988-2010). Only provisional catch data were available for 2010. Reliable catch and effort data were not available for 2010 and therefore the standardized CPUE series was only updated to 2009. 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.

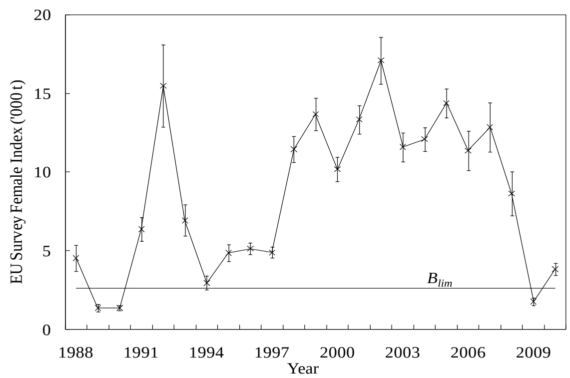
CPUE: Biomass index from the commercial fishery showed increasing trends from 1996 to 2006. This CPUE index has decreased from 2006 to 2009.



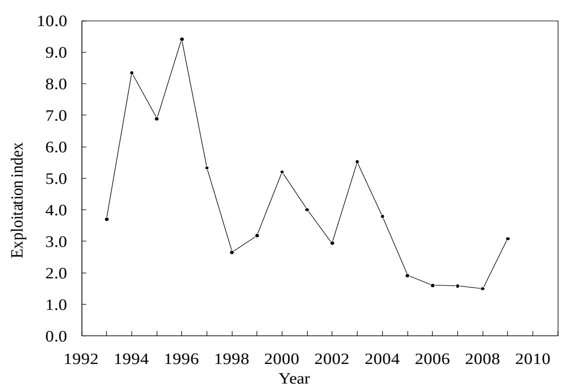
Recruitment: All year-classes since 2002 (i.e. age 2 in 2004) have been weak.



SSB: The female survey biomass index was at a high level from 1998 to 2007 then declined to very low levels in 2009 and 2010.

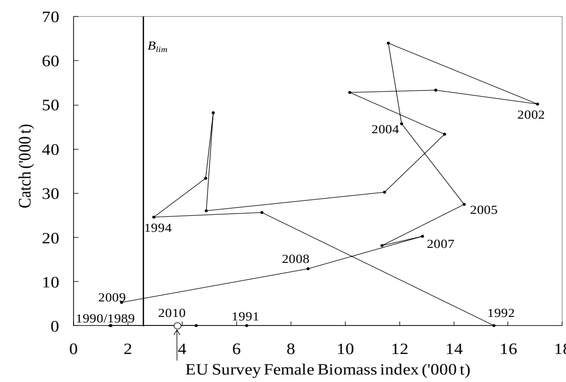


Exploitation rate: From 2005 to 2008 the exploitation index (catch/EU female biomass survey index of the same year) remained stable at relatively low values and increased in 2009.



State of the Stock: In 2009 the female biomass was below B_{lim}, but in 2010 it was slightly above 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 female biomass index was below B_{lim} in 2009, and it is slightly above it in 2010. It is not possible to calculate a limit reference point for fishing mortality.



Recommendation: The 2009-2010 survey biomass index indicates the stock is around the B_{lim} proxy and remains in a state of impaired recruitment. To favor future recruitment, Scientific Council recommended for 2012 that the fishing mortality be set as close to zero as possible.

Special Comments: This advice will be reviewed based on updated information in September 2011 when results from the summer survey are available.

Sources of Information: SCS Doc. 04/12, SCR Doc. 04/77, 10/64, 10/65, 10/66

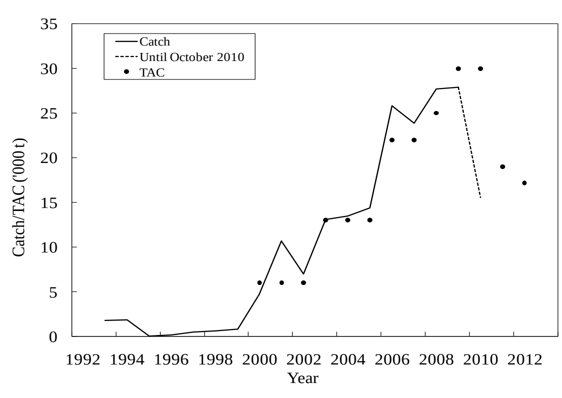
b) Northern shrimp in Div. 3LNO

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 2010. 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
2007	24	21	22	22[3]
2008	28	25[1]	25	25[3]
2009	28	26[1]	25	30[3]
2010	16[2]		See footnote [4]	30[3]
2011			<17[5]	19
2012				17

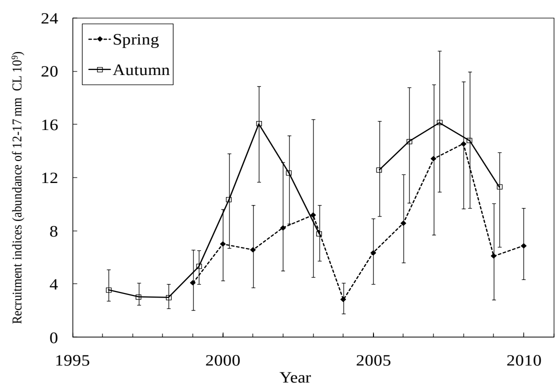
[1] Provisional
[2] Preliminary to October 2010
[3] Denmark with respect to Faroes and Greenland did not agree to the quotas of 144 t (2003–2005), 245 t (2006–2007), 278 t (2008), or 334 t (2009) and set their own TACs of 1 344 t (2003–2005), 2 274 t (2006–2008) and 3 106 t (2009). The 2010 autonomous TAC for Greenland was set at 532 t, while the Faroes did not set an autonomous TAC for 2010.
[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.
[5] In September 2010 SC considered that TAC options at 14% exploitation rate or higher to be associated with a relatively high risk of continued stock decline.



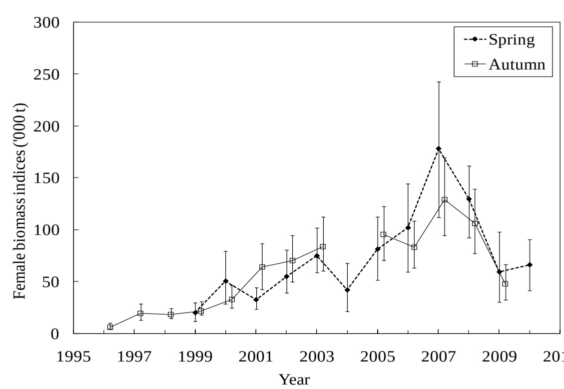
Data: Catch, effort and biological data were available from the commercial fishery. Biomass and recruitment indices as well as size and sex composition data were available from research surveys conducted in Div. 3LNO during spring (1999 to 2010) and autumn (1996 to 2009). The Canadian survey in autumn 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.

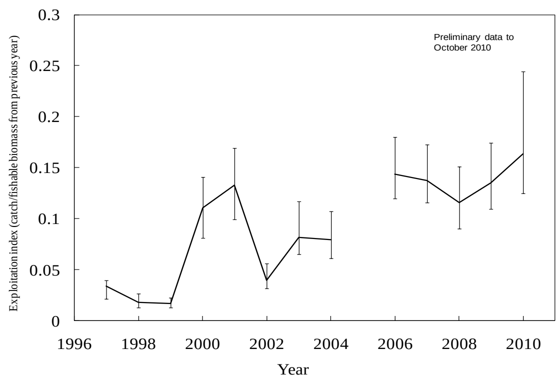
Recruitment: Recruitment indices from 2006–2008 were among the highest in the spring and autumn time series. The spring index decreased to near the mean in 2009 remaining near that level in 2010. The autumn recruitment index also declined in 2009.



Biomass: Spring and autumn biomass indices generally, increased, to record levels, but decreased substantially by 2009. The spring biomass indices remained at a low level in 2010.

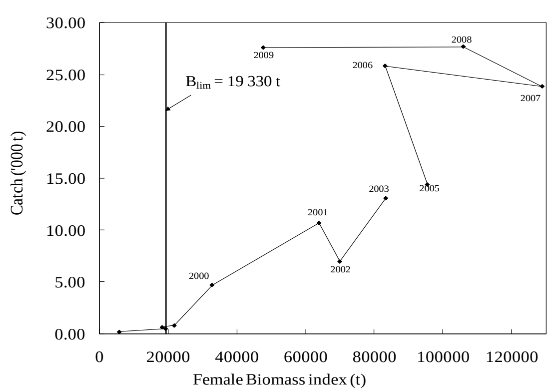


Fishing mortality: The index of exploitation has remained relatively stable since 2006.



State of the Stock**:** Biomass levels peaked in 2007 decreased substantially through to 2009 and remained at this lower level in 2010. The stock appears to be well represented by a broad range of size groups and recruitment prospects remain near mean levels. The female biomass index is estimated to be above B_{lim}. However, the decreased levels of biomass in the recent spring and autumn surveys are a reason for concern.

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 index is estimated to be above but nearing 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 for this stock.



Recommendation: Based on the average fishable biomass the following table shows catch levels at various exploitation rates in 2012:

10%	12%	14%	16%
12 018	14 422	17 000	19 200

Exploitation rates over the period 2006–2009 have been near 14% and were followed by stock decline. Scientific Council considers TAC options at 14% exploitation rate or higher to be associated with a relatively high risk of continued stock decline. TACs lower than that will tend to reduce this risk in proportion to the reduction in the exploitation rate. Scientific Council recommended that the TAC for 2012 be less than 17 000 t. Scientific Council is not able to quantify the absolute magnitude of the risk associated with alternative TAC options.

Sources of Information: SCR Doc. 10/50, 63, 65

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

Fisheries Commission requested, at their Annual Meeting in September 2010, that *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}*)*

Scientific Council responded:

This request was also address to Scientific Council in 2009 (*NAFO Sci. Cou. Rep*., 2009, p. 232). Scientific Council has been working to provide values for these reference points. Appropriate models have not yet been developed to a point where they have been accepted as a basis for the determination of reference points. Scientific Council is still unable to provide appropriate reference points to address this request. This request is therefore deferred to the June 2011 meeting of Scientific Council for further consideration.

d) Distribution of shrimp in Div. 3LNO

At the 2010 Annual Meeting, the Fisheries Commission requested: *The Scientific Council is requested to provide updated information on the proportion of the 3LNO shrimp stock that occurs in 3NO.*

Scientific Council responded:

Over the 1996-2010 spring and autumn time series of research surveys, over 90% of the Div. 3LNO shrimp stock has been found in Div. 3L.

Season	Year	Division	Biomass estimate (t)	% biomass within 3L
Autumn				
	1996	3L	22 900	93
	1997	3L	43 400	99
	1998	3L	56 000	92
	1999	3L	54 500	99
	2000	3L	105 800	99
	2001	3L	213 700	99
	2002	3L	187 800	98
	2003	3L	185 200	97
	2004	3L	???	
	2005	3L	221 200	99
	2006	3L	213 700	99
	2007	3L	271 500	98
	2008	3L	246 200	99
	2009	3L	116 800	99
Spring				
	1999	3L	47 500	96
	2000	3L	108 700	96
	2001	3L	82 700	100
	2002	3L	128 100	96
	2003	3L	165 400	98
	2004	3L	92 000	98
	2005	3L	133 200	100
	2006	3L	179 400	???
	2007	3L	282 100	98
	2008	3L	222 600	100
	2009	3L	110 200	98
	2010	3L	129 800	99

e) Effect of 5 000 t catch on shrimp abundance in Div. 3M

At the 2010 Annual Meeting, the Fisheries Commission requested: *With respect to 3M shrimp, the Scientific Council estimated in 2009 a proxy for B_{lim} as 85% decline from the maximum observed index levels, this is 2600 t of female biomass. In 2009 the Scientific Council estimated biomass to be below B_{lim} and recommended fishing mortality to be set as close to zero as possible.*

In 2009 estimated catches reached 5000 t. The Fisheries Commission decided on a 50% effort reduction in 2010 and provisional estimated catches up to September 2010 reached 1000 t. In its 2010 advice, the Scientific Council estimated biomass to be above B_{lim}, but reiterated its previous advice to set fishing mortality as close to zero as possible. The Fisheries Commission requests the Scientific Council to evaluate if the current level of catches is compatible with stock recovery, given that improvements in biomass levels were observed through current level of catches.

Scientific Council responded:

It's difficult to evaluate if the level of catches in 2009 (around 5 000 t.) is compatible with the recovery of the stock in Div. 3M. However Scientific Council notes that despite the increase of the biomass index in 2010 (79% compared to 2009), stock remains near the lowest recorded in the time series and near B_{lim}. All year-classes since 2002 (i.e. age 2 in 2004) have been weak. Catches in 2010 of around 5 000 t would produce exploitation rate index of around 1.3 that, under recent conditions (2005-2008) was associated with stock decline.

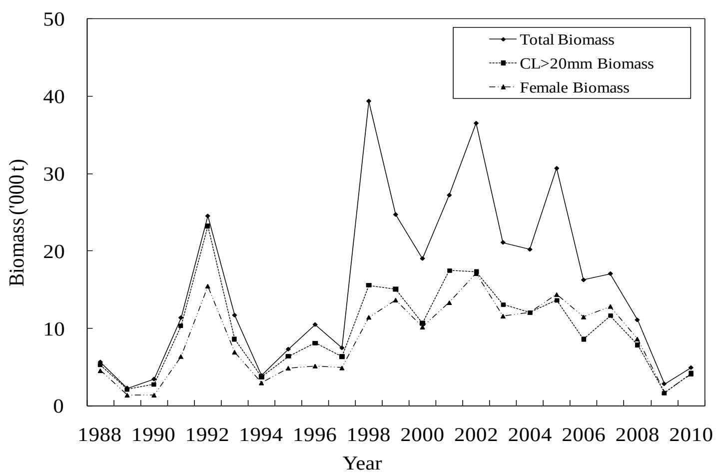


Fig. 1. Survey biomass index of shrimp in Div. 3M.

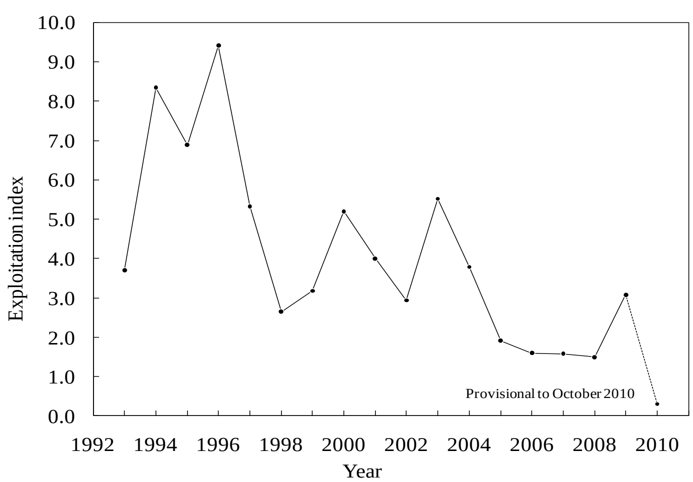


Fig. 2. Exploitation rates as nominal catch divided by the EU survey biomass index of the same year.

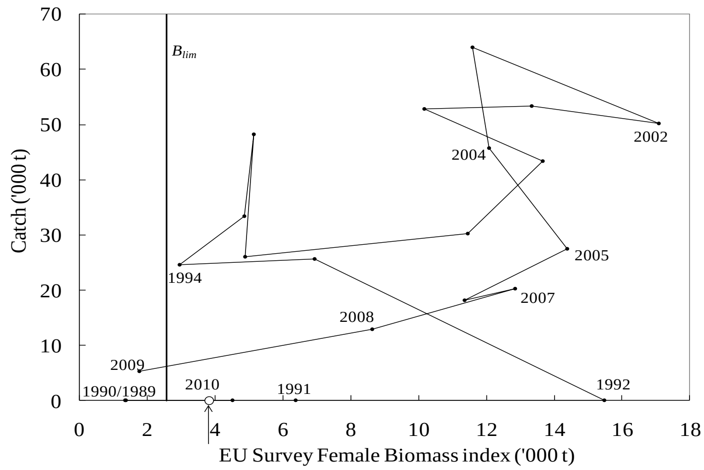


Fig. 3. Catch plotted against female biomass index from EU survey. Line denoting B_{lim} is drawn where biomass is 85% lower than the maximum point in 2002. Not updated for 2010 owing to incomplete catch.

2. Requests from Coastal States

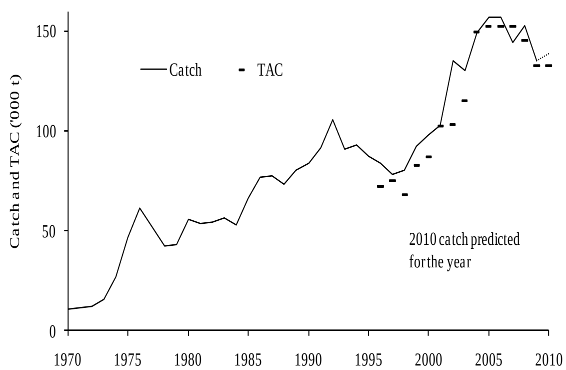
a) Northern shrimp in Subareas 0 and 1

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 in SA 1 and Canada in Div. 0A. Canada did not fish in 2008 and fished little in 2009, but has resumed fishing in 2010. Recent catches are:

	Catch ('000 t)		TAC ('000 t)	
Year	NIPAG	21A[1]	Advised	Actual[2]
2007	144.2	144.1	130	152.4
2008	152.7	148.6	110	145.7
2009	135.3	134.0	110	133.0
2010	138.5[3]	-	110	133.0

[1] Provisional.
[2] Total of TACs set by Greenland and Canada.
[3] Predicted to year-end by industry observers.

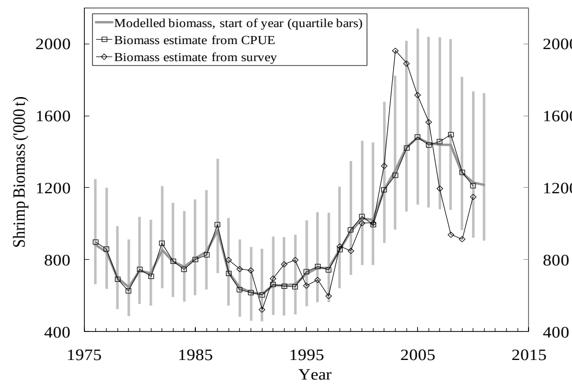


Data: Catch, effort, and position data were available from all vessels. Series of biomass and recruitment indices and size-composition and sex-composition data were available from research surveys. Series of cod biomass and cod consumption were also available.

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

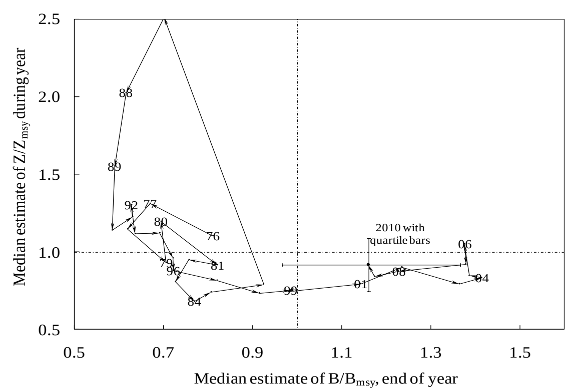
The model used was a stochastic version of a surplus-production model including an explicit term for predation by Atlantic cod, stated in a state-space framework and fitted by Bayesian methods. *MSY* (Maximum Sustainable Yield) defines maximum production, and B_{msy} is the biomass level giving *MSY*. 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 well. Median estimate of *MSY* was 147 000 t/yr.

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



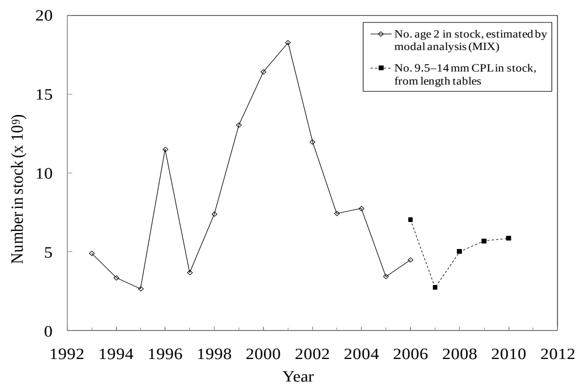
Biomass: A stock-dynamic model showed a biomass peaking in 2005 and declining since. The probability of biomass below B_{msy} at end 2010 with projected catches at 138 500 t was estimated at 28% and of its being below B_{lim} at less than 1%.

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 2010 projected at 138 500 t the risk of total mortality in 2010 exceeding Z_{msy} was estimated at about 37.5%.



Recruitment: A recruitment index based on survey numbers of small shrimps fell to low levels in 2005–2006. A second index remained near its 2006 level until 2010.

State of the Stock: Modelled biomass is estimated to have been declining since 2005. However, at the end of 2010 biomass is projected to be still above B_{msy} and total mortality below Z_{msy}. Recent estimates of recruitment indices have been low.



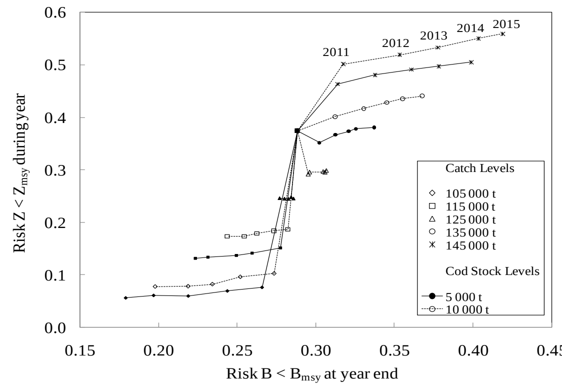
Short-term predictions: Estimated risks for 2011 with a 5 000 t cod stock are:

5 000 t cod	Catch option ('000 t)				
Risk (%), in 2011, of:	105	115	125	135	145
falling below B_{msy}	27	28	28	30	31
falling below B_{lim}	<1	<1	<1	<1	<1
exceeding Z_{msy}	8	15	25	35	46

Medium-term Predictions: Medium-term predictions over five years are based on the assessment model, which does not take into account either below-average recent year classes or changes in the area being fished. Percentage risks of transgressing precautionary limits after five years at cod stock biomass levels of 5 000 t (5 kt) and 10 000 t (10 kt) were estimated at:

Catch (kt/yr)	B_{MSY}		B_{lim}		Z_{msy}	
	5 kt	10 kt	5 kt	10 kt	5 kt	10 kt
105	18	20	<1	<1	6	8
115	22	24	<1	<1	13	17
125	28	30	<1	<1	25	30
135	34	37	<1	<1	38	44
145	40	42	1	1	51	56

and the joint evolution of precautionary-approach risks over five years 2011–2015, with an 'effective' cod stock at 5 000 or 10 000 t, was predicted to be:



Recommendation: The concerns of Scientific Council related to recruitment prospects and to contraction of the area of distribution of the resource are less grave than in 2009. None the less, 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 2011 should not exceed 120 000 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, 10/51, 53, 54, 56, 57; SCS Doc. 04/12.

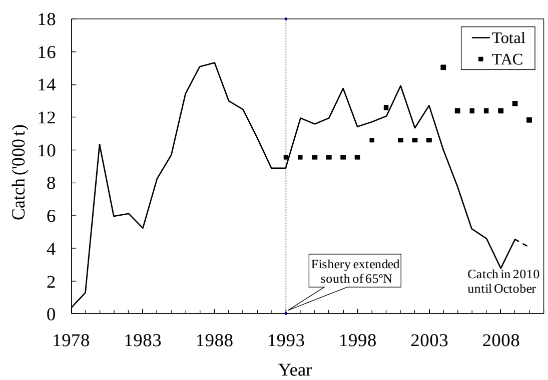
b) Northern shrimp in Denmark Strait and off East Greenland

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: Four nations participated in the fishery in 2010. 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	Recomm-ended	Greenland EEZ	Iceland EEZ[1]
2006	5.2	12.4	12.4	
2007	4.6	12.4	12.4	
2008	2.8	12.4	12.4	
2009	4.6	12.4	12.8	
2010	4.1[2]	12.4	11.8	

[1] Fishery unregulated in Icelandic EEZ;
[2] Catch till October 2010.

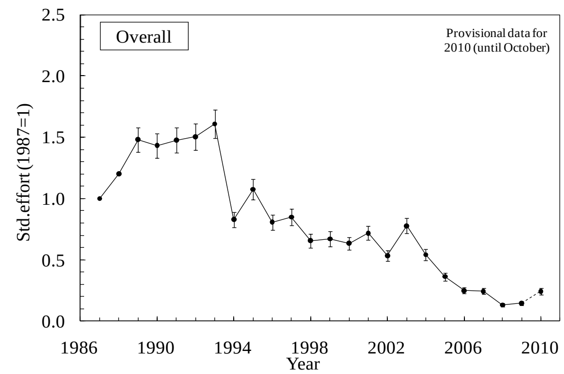


Data: Catch and effort data were available from trawlers of several nations. Annual surveys have been conducted since 2008.

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

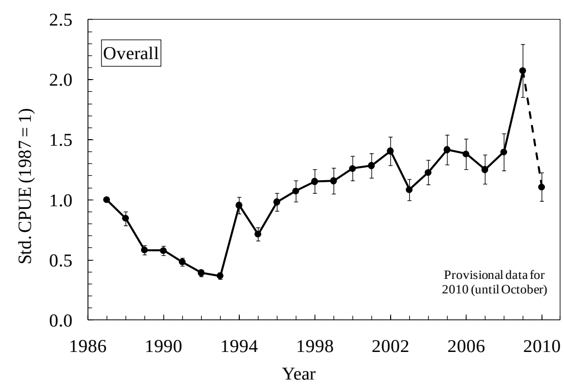
Recruitment: No recruitment estimates were available.

Exploitation rate: Since the mid 1990s, the exploitation index (standardized effort) has decreased, reaching the lowest levels seen in the time series from 2008 to 2010.



Biomass: The biomass index from 2008-2010 varied greatly with no clear trend.

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 the standardized catch rate rose to the highest level ever seen, but probably does not reflect a corresponding increase in biomass. In 2010 the standardized catch rate is back to the level seen from the beginning of the 2000s.



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.

Recommendation: Scientific Council finds no basis to change its previous advice and recommended that catches should remain below 12 400 t in 2011.

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, 10/59, 10/69.

V. OTHER MATTERS

1. Catch and Effort Analysis using VMS Data

In October 2009 and 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. Following from this, Scientific Council, supported the following recommendation made by NIPAG that, for shrimp in Div. 3M, that *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 Secretariat contacted the Designated Expert for shrimp in Div. 3M and started to analyze the VMS dataset to determine catch, effort and CPUE. New reporting requirements regarding the transmission of shrimp catch onboard when crossing the 3L boundary, detailed in Article 27 of the NAFO Control and Enforcement measures and referred to as CAT, were going to be used to determine catch. However, inspection of CAT reports from 2009 contained within the VMS transmissions indicated that it was not possible to know if the Div. 3L boundary used in the transmissions was as defined in Articles 5 and 6 of the CEM or as defined in Annex III of the Convention. It was therefore not possible to determine the catch of shrimp in Div. 3M from the CAT reports with any degree of certainty.

It was noted that shrimp in Div. 3M were now closed to directed fishing and hence the discussion was more general in nature. It was also noted that, though the positional information is precise, it is difficult to link this with actual fishing and particularly with gear, target species and catch. Scientific Council defers discussion on this item to the June 2011 Scientific Council (STACREC) meeting. Scientific Council requests that the Secretariat again review information transmitted by the VMS, focusing particularly on the identification of gear type and catch of the commercial species, and report to Scientific Council at its June 2011 meeting.

Scientific Council reiterates its previous recommendation in more general terms for consideration of all commercial fisheries, and **recommended** that *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*.

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

The 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 auspices of the joint NIPAG group and the Co-Chairing arrangement. The timing of this meeting was again discussed and it is realized that it is a compromise between Scientific Council wishing the meeting was a little later owing to the time required for working up the survey data and ICES wishing the meeting was a little earlier in order to meet its advisory schedule. Taking into account the availability of commercial catch and biological sampling data, and the timing of various research vessel surveys, Scientific Council again concluded that the primary assessment meeting could not occur before the latter half of October.

4. SC/NIPAG Meeting, October 2011

The Scientific Council agreed that the dates and venue of the next Scientific Council / NIPAG meeting will be 19-26 October 2011 at the NAFO Secretariat, Dartmouth, Canada.

5. Working Group on Reproductive Potential, April 2011

The working group on reproductive potential will co-convene a workshop to be held in Aberdeen, Scotland, during 12-14 April 2011. NAFO will support two scientists to attend this meeting. Outcomes from the workshop, and their importance to the stock assessment work of NAFO, will be presented at the June 2011 meeting of Scientific Council.

6. NAFO Special Session, May 2011

The NAFO 2011 special session will be the ICES/NAFO symposium on “The Variability of the North Atlantic and its Marine Ecosystems during 2000-2009” which will be held in Santander, Spain on 10-12 May 2011. NAFO is able to support the attendance of the NAFO Co-Chair, Steve Cadrin (School of Marine Science, University of Massachusetts, USA), Guest of Honour, Manfred Stein (the Johann Heinrich von Thünen Institute, Federal Research Institute for Rural Areas, Forestry and Fisheries, Institute of Sea Fisheries, Hamburg, Germany), and Andrew Kenny as keynote speaker (CEFAS, Lowestoft, England).

7. SC/NIPAG Meeting, October 2012

The dates and venue of the Scientific Council/NIPAG meeting will be decided at the 2011 meeting. Provisional dates and venue are 17-24 October 2012 at the Institute of Marine Research, Tromsø (IMR), Norway.

8. Future Special Sessions

There were no suggestions for future special sessions.

9. Other Business

a) Gear Codes

It was noted that FAO is looking at gear modifications and update the list of agreed gear codes. The Secretariat has contacted Designated Experts and asked that they provide input into the process as required. The Secretariat will circulate the minutes of the meeting held on 19-21 October 2010 in FAO, Rome, Italy.

b) Timing of the Shrimp Advice

Fisheries Commission requests that the Scientific Council provide advice in advance of the 2011 Annual Meeting for the management of Northern shrimp in Div. 3M, 3LNO in 2012. Fisheries Commission notes that Scientific Council meet in October 2010 to provide this advice for 2012, and requests the Scientific Council to update this advice in 2011 so that it is delivered in advance of the 2011 Annual Meeting.

Scientific Council discussed various options and noted that the conclusions drawn in similar discussions held in November 1992 are still valid (*NAFO Sci. Cou. Rep*, 1992, p. 245-246) and concluded NIPAG provides peer–review and conforms to the principles of "best scientific advice".

Scientific Council/STACFIS will, if necessary, meet before the Annual Meeting to update the shrimp advice at a date and venue to be decided by Scientific Council at their June 2011 meeting.

c) ICES Strategic Initiative on Stock Assessment Methods (SISAM)

ICES has invited NAFO to participate in its three year *Strategic Initiative on Stock Assessment Methods* (SISAM). Quoting from the invitation letter of 2 July 2010:

"There have been many recent advances in fish stock assessment methods and techniques. Many of these advances are conceptual and others are technological. ICES seeks to further advance and incorporate many of these developments into its advisory system in order to be among the world leaders in the development of stock assessment methods. This will allow better use of the available data resources, particularly in cases where the lack of standard catch-at-age and classic fisheries independent time series has in the past precluded analytical assessments, even when potentially useful information for these “data poor” stocks existed. As the client organizations of ICES require a broader portfolio of fisheries advice, as well as integrated regional advice, ICES need to ensure that the stock assessment methods it uses are able to provide the necessary basis for such advice.

The Initiative is a means by which ICES can reinvigorate the stock assessment methods it uses, and stimulate the development of new techniques and concepts. As this must be done without re-inventing the wheel, ICES requires a review of methods used around the world for fish stock assessment. It is hoped that this review will advance not just ICES knowledge but also the operation of its stock assessment experts and the advisory system as a whole. It is also STACREC 20-24 Sep 2010 hoped to make stock assessment software freely available to all fisheries scientists. Thus we invite you to join the initiative and hopefully we, as partners, can move stock assessment tools forward."

The first meeting was a workshop in Nantes, France (WKADSAM) from 27 September to 1 October 2010, and served to identify the key techniques and approaches and plan the review process. Brian Healey from the Northwest Atlantic Fisheries Centre, DFO, St. John's attended as the representative from Scientific Council and will report to Scientific Council in June 2011.

d) Ecosystem "Requests for Advice" from the 2010 Annual Meeting

The Fisheries Commission "Requests for Advice" numbers 13, 14 and 15 made at the September 2010 Annual Meeting (FC Doc 10/09 and Annex 1d) will be deferred to WGEAFM. Scientific Council requests WGEAFM to address these three "Requests for Advice" and provide a reply to Council before its meeting of 3-16 June 2011.

VI. ADOPTION OF SCIENTIFIC COUNCIL AND NIPAG REPORTS

The Council at its session on 27 October 2010 considered and adopted Sections III.1-4 of the "Report of the NAFO/ICES *Pandalus* Assessment Group" (SCS Doc. 10/22, ICES CM 2010/ACOM:14). The Council then considered and adopted its own report of the 20-27 October 2010 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 support during the meeting. The Chair then thanked the ICES and NAFO Secretariats for their support and ICES for hosting the Scientific Council and NIPAG meetings. All participants were then wished a safe journey home and the meeting was adjourned at 1700 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

Environmental Overview

The water masses characteristic of the Flemish Cap area are a mixture of Labrador Current Slope Water and North Atlantic Current Water, generally warmer and saltier than the sub-polar shelf waters with a temperature range of 3-4°C and salinities in the range of 34-34.75. The general circulation in the vicinity of the Flemish Cap consists of the offshore branch of the Labrador Current which flows through the Flemish Pass on the Grand Bank side and a component that flows eastward north of the Cap and then southward east of the Cap. To the south, the Gulf Stream flows to the northeast to form the North Atlantic Current and influences waters around the southern areas of the Cap. In the absence of strong wind forcing the circulation over the central Flemish Cap is dominated by a topographically induced anticyclonic gyre. The stability of this circulation pattern may influence the retention of ichthyoplankton on the bank and is probably a factor in determining the year-class strength of various fish and invertebrate species, such as cod, redfish and shrimp. During the spring of 2010 near bottom temperatures around the Cap were about 4°C which were up to 1°C above normal in some areas. Upper layer temperatures ranged from 4-6°C, also above normal by up to 1.5°C. During the summer (July) bottom temperatures remained about 4°C while surface temperatures had increased to >9°C. These were below normal at the surface but up to 1°C above normal near bottom. Salinities around the Cap were slightly above normal in the spring and about normal at 34-34.75 in the summer.

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 5 400 t in 2009. Provisional information to 10 October 2010 indicates removals of about 1 200 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:

	2003	2004	2005	2006	2007	2008	2009	2010	2011
Recommended TAC	45 000	45 000	45 000	48 000	48 000	17 000-32 000[3]	18 000-27 000[4]	0	0
STATLANT 21A	62 761	45 842	27 651	15 191	17 642	11 671[1]	5 429[1]		
NIPAG	63 970	45 757	27 479	18 162	20 741	12 889	5 429	1 233[2]	

[1] Provisional

[2] Preliminary to 10 October 2010.

[3] SC recommended that exploitation level for 2008 should not exceed the 2005 and 2006 levels (17 000 to 32 000 t).

[4] SC recommended that exploitation level for 2009 should not exceed the levels that have occurred since 2005 (18 000 to 27 000 t).

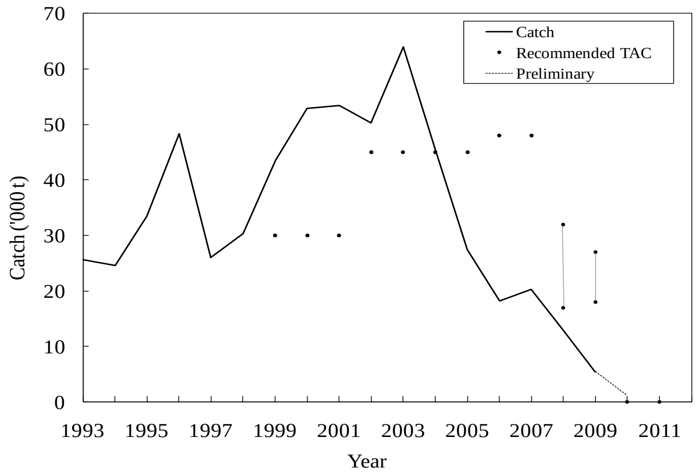


Fig. 1.1. Shrimp in Div. 3M: Catches of shrimp on Fleminsh Cap, 1993-2010. The 2010 value is the preliminary partial year's catch to 10 October and shown by a dashed line.

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 have been concerns that, since 2005, the reporting of some Div. 3L catches as coming from Div. 3M were 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 2010 where fishing occurred in both Div. 3M and Div. 3L were eliminated. When this criterion was applied to the 2010 data, there were no remaining data as all trips reported catches in both Div. 3M and Div. 3L. Therefore, a standardized CPUE series was produced only for 1993 to 2009. CPUE gradually increased from the mid-1990s to 2006. In 2007, 2008 and 2009 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.

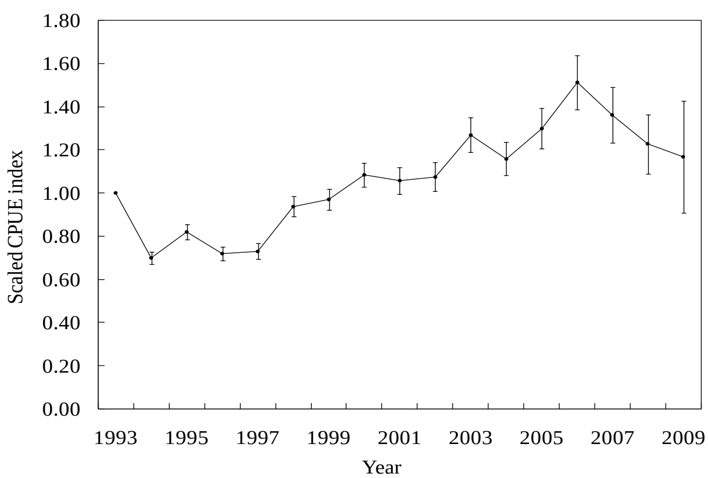


Fig. 1.2. Shrimp in Div. 3M: Standardized CPUE of shrimp on Flemish Cap, 1993-2009.

Biological data. The age and sex composition was assessed from commercial samples obtained from Iceland from 2003 to 2005 and from Canada, Greenland, Russia and Estonia in previous years. For these years 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. From 2006 the samples obtained from the fishery have been insufficient to assess the age of the catches and so was not possible to estimate the disaggregated CPUE (number/hour or kg/hour) by age and sex since 2006 to the present.

ii) Research survey data

Stratified-random surveys have been conducted on Flemish Cap by the EU in July from 1988 to 2010, using a Lofoten trawl. 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. The survey biomass indices declined to very low levels in 2009 and 2010 (Fig. 1.3).

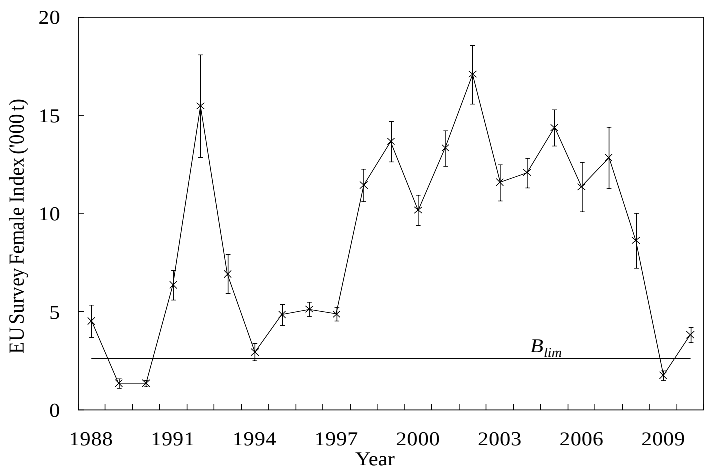


Fig. 1.3. Shrimp in Div. 3M: Female biomass index from EU trawl surveys, 1988-2010. Error bars are 1 std. err.

iii) Recruitment indices

EU bottom trawl surveys. From 1988 to 1995 shrimp at 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 codend. Both EU-survey indices show an exceptionally large 2002 year-class and very weak 2003-2008 year-classes (Fig. 1.4).

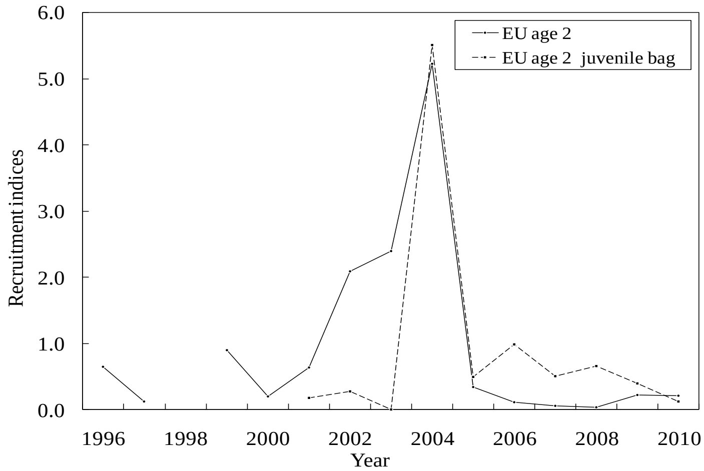


Fig. 1.4. Shrimp in Div. 3M: Abundance indices at age 2 from the EU survey. Each series was standardized to its mean.

iv) Exploitation index

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. 1.5). 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 and increased in 2009, as a consequence of decrease in the biomass estimated that year.

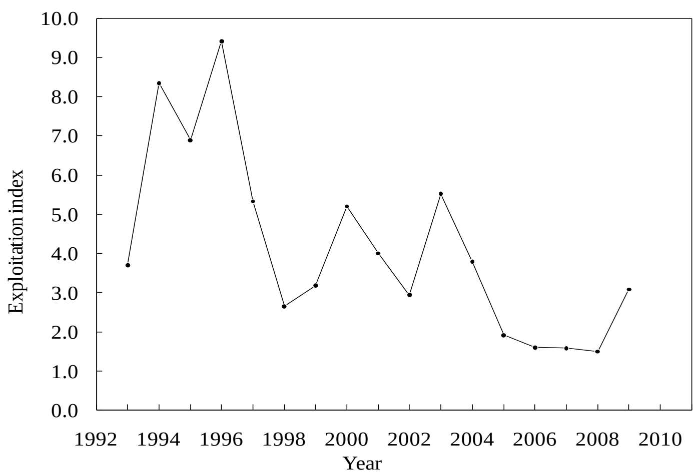


Fig. 1.5. Shrimp in Div. 3M: Exploitation indices as derived by catch divided by the EU survey biomass index of the same year.

v) Other studies

The shrimp CPUE from Estonian fishing trips in Div. 3M was compared between fishing trips when vessels were fishing only in Div. 3M and when vessels were fishing in both Div. 3M and Div. 3L. CPUE in Div. 3M was lower during trips when vessels were fishing only in Div. 3M. The CPUE in Div. 3L was higher when vessels fished only in that area compared to CPUE observed during fishing trips when fishing was done in both areas.

Results demonstrated that CPUE data from trips fishing in both divisions were unreliable for use in stock assessment.

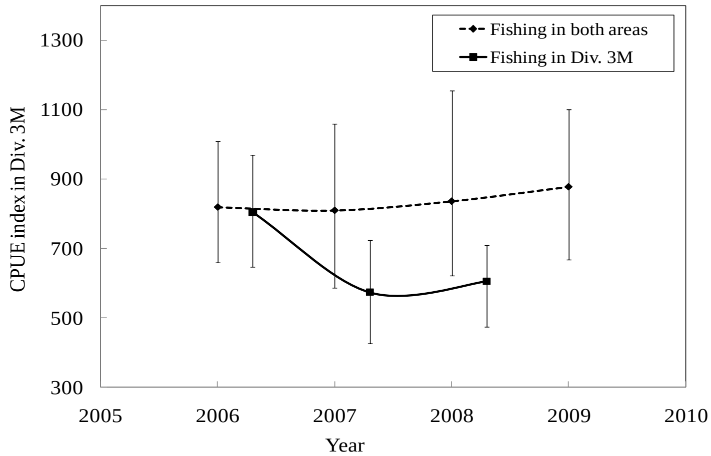


Figure 1.6. Shrimp CPUE from Estonian vessels in Div. 3M. Median and quartiles.

c) Assessment Results

Suspicions of misreporting during recent years, and its effect on various indices derived from the commercial fishery, continued in 2010. In order to avoid the uncertainty around the catch rate standardization model, all trips for which there was fishing in both Div. 3M and Div. 3L were eliminated. When this criterion was applied to the 2010 data, there were no remaining data as all trips reported catches in both Divisions. Thus several indices derived from the CPUE for 2010 could not be used in the assessment this year.

Commercial CPUE indices. Biomass index from the commercial fishery showed increasing trends from 1996 to 2006. This CPUE index has decreased from 2006 to 2009.

Biomass. The female survey biomass index was at a high level from 1998 to 2007 then declined to very low levels in 2009 and 2010.

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

Exploitation rate. From 2005 to 2008 the exploitation index (catch/EU female biomass survey index of the same year) remained stable at relatively low values and increased in 2009.

State of the Stock. In 2009 the female biomass was below B_{lim}, but in 2010 it was slightly above 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 2010 with a maximum value of 17 100 t in 2002. An 85% decline in this value would give a B_{lim} = 2 600 t. In 2007, 2008, 2009 and 2010 the female biomass index was, respectively, about 25%, 51%, 10% and 22% of the maximum (Fig. 1.7).

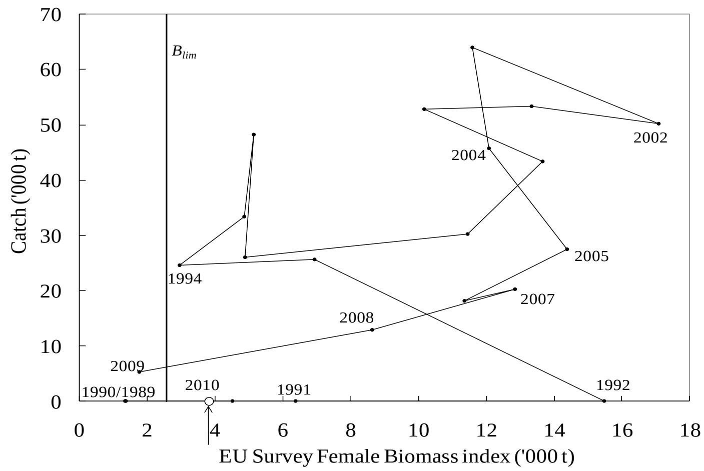


Fig. 1.7. Shrimp in Div. 3M: Catch plotted against female biomass index from EU survey. Line denoting B_{lim} is drawn where biomass is 85% lower than the maximum point in 2002. The estimated female biomass index for 2010 (3 819 t) is shown by the arrow on the *x*-axis, catch for 2010 is incomplete and is not shown in the figure.

e) Ecosystem considerations

The drastic decline of shrimp biomass in 2009 and 2010 years may be associated with the increase of the cod stock in recent years (SCR Doc. 10/66) (Fig. 1.4).

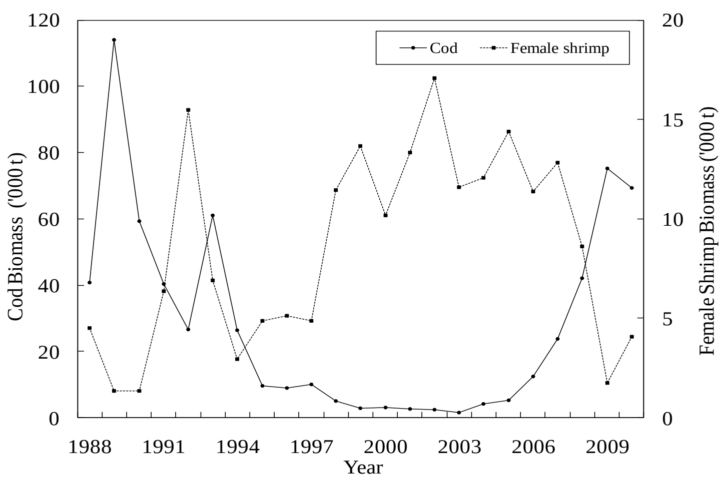


Fig. 1.8. Shrimp in Div. 3M: Cod and female shrimp biomass from EU trawl surveys, 1988-2010.

f) Review of Research Recommendations made in 2009

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.

STATUS: Data were submitted by this deadline.

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.

STATUS: An analysis of VMS data was presented but could not be used in the assessment (see SC report).

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

STATUS: No progress.

Collaborative efforts should be made to standardize a means of predicting recruitment to the fishable stock.

STATUS: No progress.

g) Research Recommendations

NIPAG **recommended** that *biological and CPUE data from all fleets fishing for shrimp in the area, be submitted to Designated Experts by 1 September 2011.*

NIPAG **recommended** that *for northern shrimp in Division 3M investigations be conducted into methods for demographic analyses of fishery CPUE.*

Sources of Information: SCS Doc 04/12 , SCR Doc. 04/77, 10/64, 10/65, 10/66.

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

Environmental Overview

The water masses characteristic of the Grand Banks are typical Cold-Intermediate-Layer (CIL) sub-polar waters which extend to the bottom in northern areas with average bottom temperatures generally <0°C during spring and through to autumn. The general circulation in this region consists of the relatively strong offshore Labrador Current at the shelf break and a considerably weaker branch near the coast in the Avalon Channel. Currents over the banks are very weak and the variability often exceeds the mean flow. The proportion of bottom habitat on the Grand Banks covered by <0°C water has decreased from near 50% during the first half of the 1990s to <15% during recent years. The cross-sectional area of this winter-formed water mass along the 47°N section is a reliable index of ocean climate conditions in this area. During the spring of 2010 the CIL area decreased over the above normal value of 2009 to the second lowest (warmest) in the 1970-2010 time series. During the summer of 2010 the CIL area remained below normal for the 13th year and was the 2nd lowest on record. Bottom temperatures on the northern Grand Bank during the spring of 2010 were generally >0°C, except in the deeper areas of the Avalon Channel. These values were up to 2°C above normal over most areas of Div. 3L. The spring surface temperature at Station 27 remained above the long-term by near 1 standard deviation, while spring bottom temperatures were the second highest on record, close to 1°C above normal.

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 before decreasing to 19 200 t in 2011 and 17 000 t in 2012. A total catch of 15 560 t was taken up to October 2010 (Fig. 2.1).

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

	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
TAC as set by FC	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]	19 200	17 000
STATLANT 21A	5 894	11 917	12 051	13 574	21 284	21 120	24 758[2]	25 621[2]			
NIPAG	6 997	13 069	13 452	14 389	25 831	23 859	27 691	27 928	15 560[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 3 106 t (2009). The 2010 autonomous TAC for Greenland was set at 532 t, while the Faroes did not set an autonomous TAC for 2010. The increase is not included in the table.

[2] Provisional catches.

[3] Estimated catches to October 2010.

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 2010, the small- and large-vessel fleets had taken 7 118 t and 4 863 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.

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.

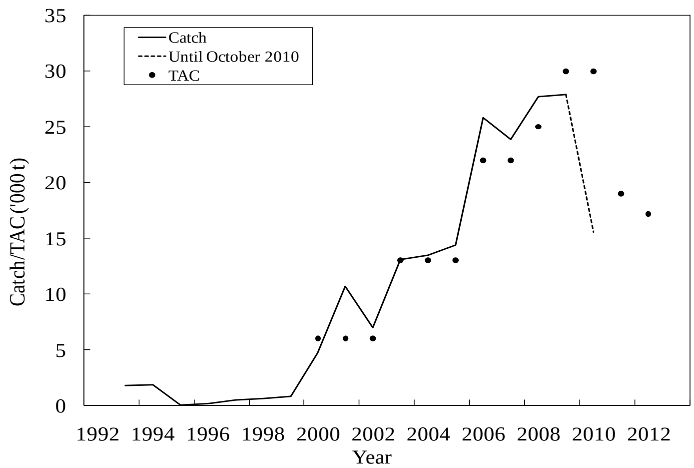


Fig. 2.1. Shrimp in Div. 3LNO: Catches from 1993 to 2010 and TAC as set by Fisheries Commission from 2000 to 2012. The 2010 value is the preliminary partial year's catch to 10 October and shown by a dashed line.

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. Data for the time series have been updated for these analyses. Standardized catch rates for large Canadian vessels (>500 t) have been stable since 2004 near the long term mean. The 2010 catch rate for large vessels is based upon data to October. There was insufficient data to estimate a standardized CPUE index for the 2010 Canadian small-vessel (≤500 t) fleet. The small-vessel CPUE increased from 2000 to 2005 after which it decreased to below the mean (Fig. 2.2).

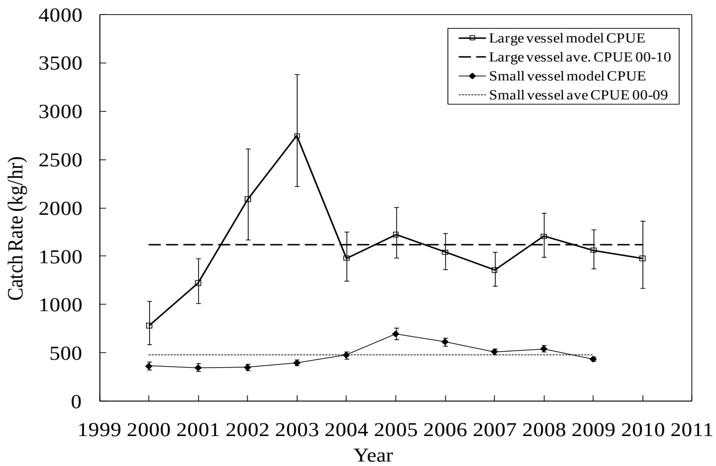


Fig. 2.2. Shrimp in Div. 3LNO: Standardized CPUE for the Canadian large-vessel (>500 t) and small-vessel (≤500 t; LOA <65 ft) fleets fishing shrimp in Div. 3L within the Canadian EEZ.

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

Catch composition. In 2010, 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 (1999–2010) and autumn (1996–2009). 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. 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 an overall increase in the both spring and autumn indices to 2007. They decreased by about 60% to 2009. The spring index has increased slightly by 16% to 2010 (Fig. 2.3). Confidence intervals from the spring surveys are usually broader than from the autumn surveys.

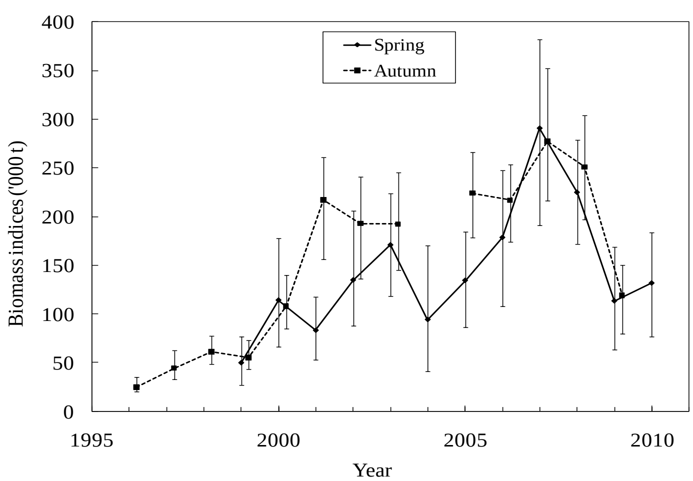


Fig. 2.3. Shrimp in Div. 3LNO: Biomass indices estimates from Canadian spring and autumn multi-species surveys (with 95% confidence intervals).

The Spanish survey biomass index for Div. 3L, within the NRA, increased from 2003 to 2008 followed by a 50% decrease annually during 2009 and 2010 (Fig. 2.4).

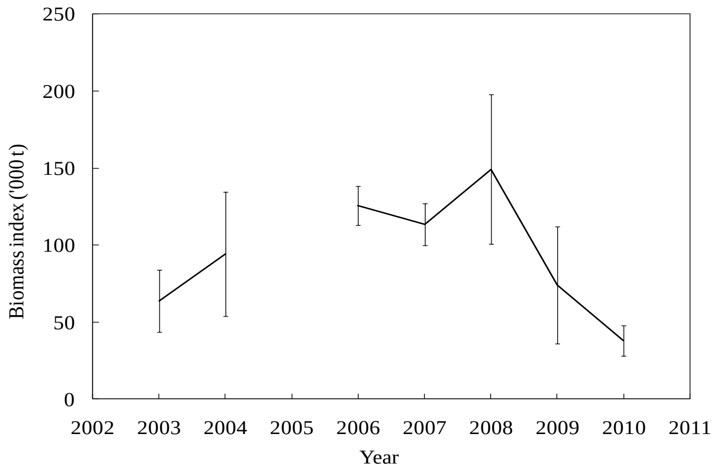


Fig. 2.4. Shrimp in Div. 3LNO: biomass index estimates from Spanish multi-species surveys (with 95% confidence intervals) in the Div. 3L NRA.

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 then decreased by 51% in 2009. Spring female abundance index increased until 2007 then decreased by 63% in 2009 remaining near that level in 2010. Male autumn abundance index peaked in 2001, decreased by 34% by 2003, increased by 42% to 41 by 2007, remained at that level in 2008 before decreasing by 43% in 2009. The spring male abundance index followed trends similar to their respective female index (Fig. 2.5).

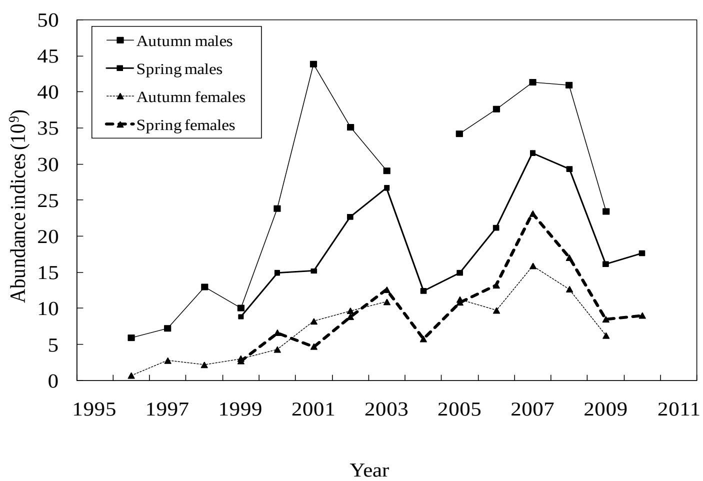


Fig. 2.5. Shrimp in Div. 3LNO: Abundance indices of male and female shrimp within Div. 3LNO as estimated from Canadian multi-species survey data.

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 since 2008 the abundances at all length classes were greatly reduced from those found in previous Canadian surveys (Fig. 2.6).

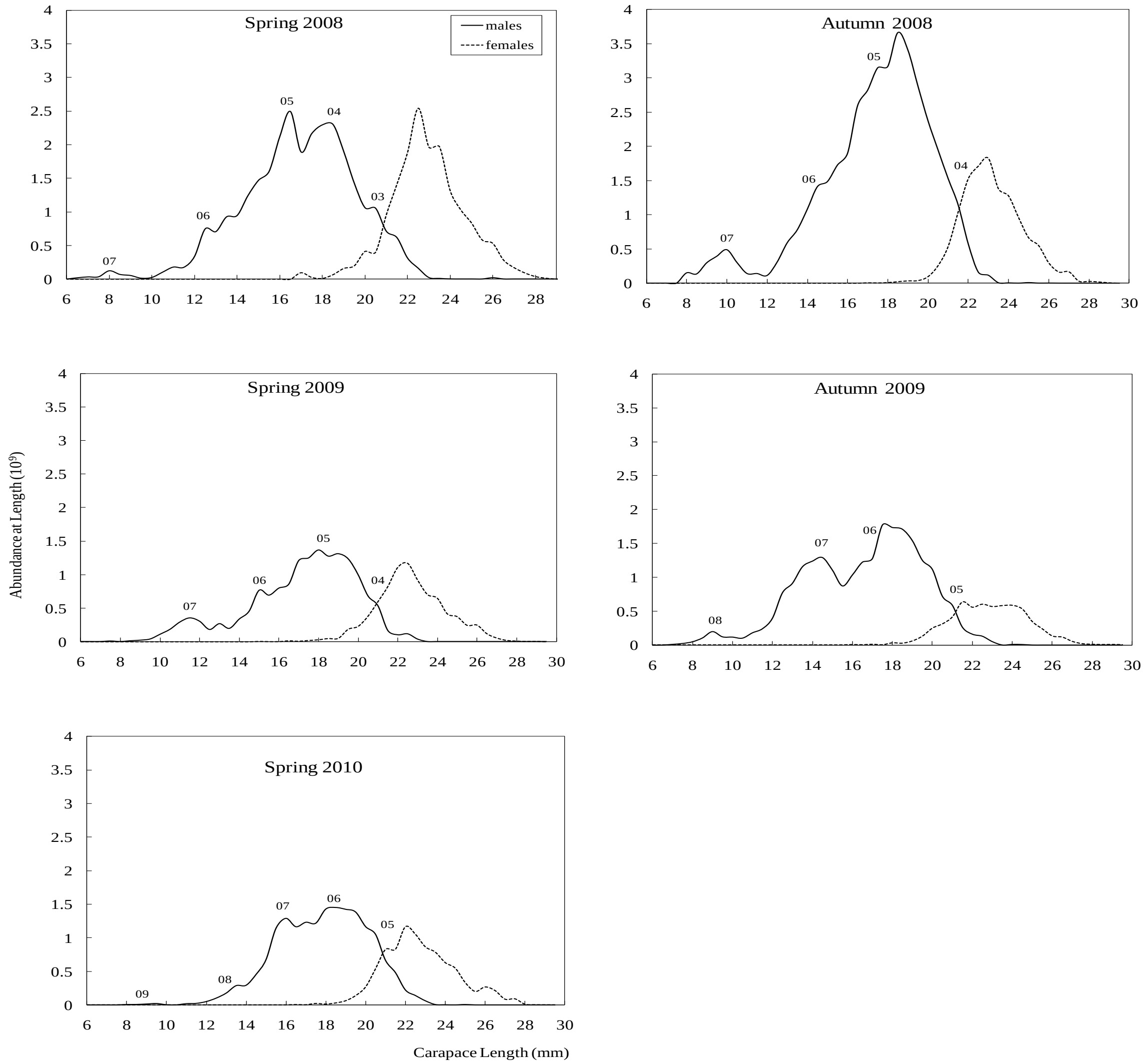


Fig. 2.6. Shrimp in Div. 3LNO: Abundance at length for northern shrimp estimated from Canadian multi-species survey data. Numbers within charts denote year-classes.

Female Biomass (SSB) indices. The autumn Div. 3LNO female biomass index showed an increasing trend to 2007 but decreased 63% by 2009. The spring SSB index decreased by 67% between 2007 and 2009, but has since increased by 12% in 2010 (Fig. 2.7).

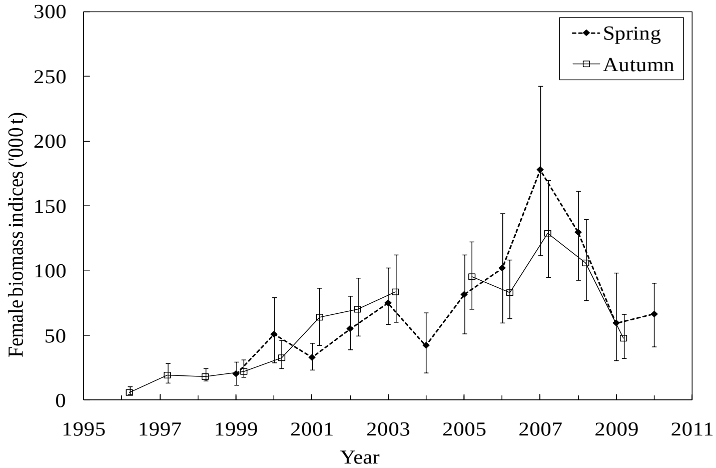


Fig. 2.7. Shrimp in Div. 3LNO: Female biomass indices from Canadian spring and autumn multi-species surveys (with 95% confidence intervals).

Recruitment indices. The recruitment indices were based upon abundances of all 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 in 2009 remaining near that level in 2010 (Fig. 2.8).

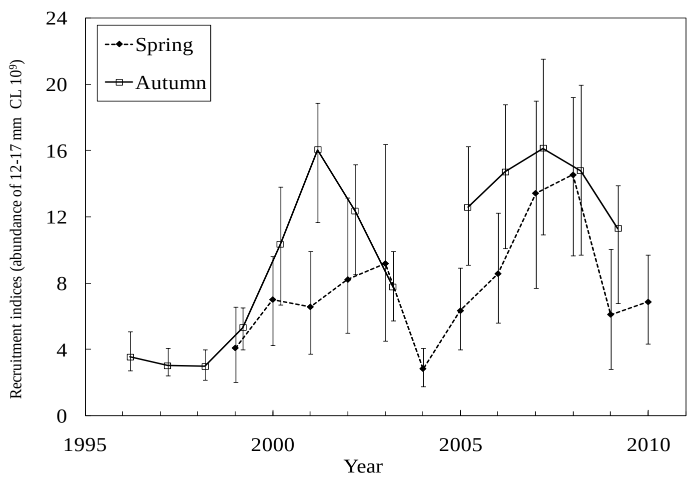


Fig. 2.8. Shrimp in Div. 3LNO: Recruitment indices derived from abundances of all shrimp with 12–17 mm carapace lengths from Canadian spring and autumn bottom trawl survey (1996–2010) data.

Fishable biomass and exploitation indices. There has been an increasing trend in Canadian spring and autumn survey fishable biomass indices (shrimp >17 mm carapace length) until 2007. The autumn fishable biomass showed an increasing trend until 2007 then decreased by 60% through to 2009. The spring fishable biomass index increased to 2003 then decreased 47% in the next year, before increasing by 220% to 2007 and finally decreasing by 62% through to 2009 and remaining near that level in 2010 (Fig. 2.9).

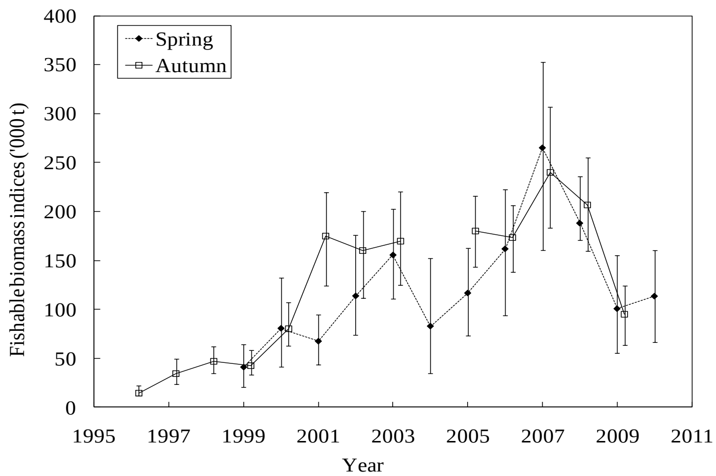


Fig. 2.9. Shrimp in Div. 3LNO: Fishable biomass indices. Bars indicate 95% confidence limits.

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 catch series was updated in the 2010 analysis. The exploitation index has been relatively stable since 2006. By October 2010, the 2009 exploitation rate index was 0.16. If the entire 30 000 t quota was to be taken, the exploitation rate index would increase to 0.32 (Fig. 2.10).

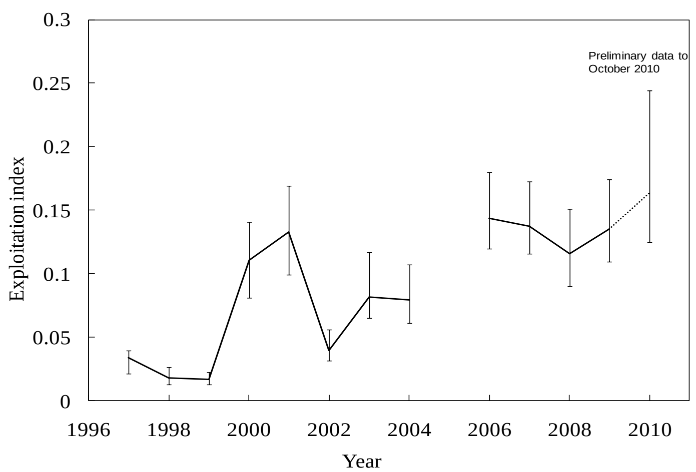


Fig. 2.10. Shrimp in Div. 3LNO: Exploitation rates calculated as year's catch divided by the previous year's autumn fishable biomass index. Bars indicate 95% confidence limits.

c) Assessment Results

Recruitment. Recruitment indices from 2006–2008 were among the highest in the spring and autumn time series. The spring index decreased to near the mean in 2009 remaining near that level in 2010. The autumn recruitment index also declined in 2009.

Biomass. Spring and autumn biomass indices generally increased, to record levels by 2007, but decreased substantially by 2009. The spring biomass indices remained at a low level in 2010.

Exploitation. The index of exploitation has remained relatively stable since 2006.

State of the Stock. Biomass levels peaked in 2007, decreased substantially through to 2009 and remained at this lower level in 2010. The stock appears to be well represented by a broad range of size groups and recruitment prospects remain near mean levels. The female biomass index is estimated to be above B_{lim}. However, the decreased levels of biomass in the recent spring and autumn surveys are a reason for concern.

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 index is estimated to be above but nearing B_{lim} (Fig. 2.11). It is not possible to calculate a limit reference point for fishing mortality. A safe zone has not been determined in the precautionary approach for this stock.

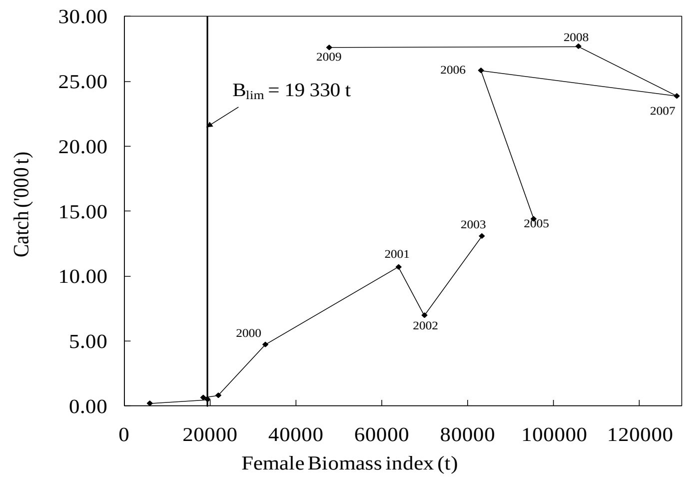


Fig. 2.11. Shrimp in Div. 3LNO: Catch against female biomass index from Canadian autumn survey. Line denoting B_{lim} (approximately 19 000 t) is drawn where female biomass is 85% lower than the maximum point in 2007.

e) Review of Research Recommendations from 2009

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.

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

Further exploration of the use of catch rate data as an index of biomass.

STATUS: This work is ongoing. Commercial catch data included geographic positional information making it possible to assign catch and effort data to the stratification scheme used in the Canadian multi-species research survey stratification maps. Individual tows were standardized as to wingspread, speed and effort; the mean catch per hour was determined for each stratum and then areal expansion methods were used to produce biomass estimates. Index strata were identified from the small vessel logbook dataset. Biomass estimates were made. These indices followed similar trends to the biomass indices developed using Canadian research survey data.

Investigation of a production model for this stock. This would provide estimations of B_{msy} and F_{msy}.

STATUS: This work is ongoing. NIPAG considered that the production modeling showed promise. It suggested that input series, including the length and weighting of some series be examined *a priori*. There were also suggestions to examine the use of various priors including different ranges and distributions, particularly for biomass in the first year, K and variance parameters. The determination of whether or not Div. 2J3KLNO is actually one population of northern shrimp is important and NIPAG looked forward to the results of genetic studies and suggested more examination of survey and fishery data on biology and distribution.

Collaborative efforts should be made to standardize a means of predicting recruitment to the fishable stock.

STATUS: No progress.

f) Research Recommendations

NIPAG **recommended** 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 2011.*

- *NIPAG recommended that research continue into fitting production models to data for northern shrimp in Div. 3LNO including studies of stock structure.*

- *Continued investigation of stock assessment models for Pandlus borealis in NAFO Divisions 3LNO. This may help provide estimations of B_{msy} and F_{msy}.*

g) Other Studies

MSE

Management strategies that are proposed as sustainable strategies should be evaluated through simulation trials to determine their robustness to uncertainty in meeting the required risk tolerances for performance measures such as those related to the PA. An example management strategy evaluation (MSE) was presented on simulated data generated from a maximum likelihood fit of a Schaefer production model in which process and observation error are estimated separately under the assumption that their variances are equal. Results suggest simple feedback harvest control rules perform better than those that respond to the state of the stock relative to Precautionary Approach reference points. The development of an accepted assessment model that partitions observation error and process error would be a big advantage to further MSE, whether or not this model is cast in a Bayesian or classical likelihood framework.

Length of survey series to determine stock status

Throughout the history of the NAFO Div. 3LNO northern shrimp fishery, TACs have been set using three methods. The first TAC was set in 1999 at 6 000 t TAC as 15% of the lower confidence limit of the autumn 1998 Div. 3L biomass index. This harvest level approximated those estimated for shrimp fishing areas along the coast of Labrador and off the east coast of Newfoundland. It was recommended that this harvest level be maintained for a number of years until the response of the resource to this catch level could be evaluated (NAFO Scientific Council Report, 2000, p. 241). During November 2002, Scientific Council noted that there had been a significant increase in biomass and recruitment in Div. 3LNO shrimp since 1999. Applying a 15% exploitation rate to the lower 95% confidence interval of biomass estimates, averaged over the autumn 2000-2001 and spring 2001-2002 surveys, resulted in a catch of approximately 13 000 t. In 2004, an analysis was completed to determine a TAC for the 2006 fishery. Due to the highly variable nature of the spring survey indices, Scientific Council felt it was necessary to change the methodology used in determining TACs. The TAC within an adjacent Canadian stock had been 12% of the fishable biomass since 1997. Applying this percentage to the inverse variance weighted average fishable biomass from the autumn 2002–spring 2004 surveys resulted in a TAC of 22 000 t. It was felt that by basing the TAC upon the inverse variance weighted average of the last two autumn and spring surveys the TAC would:

1. be based upon recent data,
2. smooth drastic changes in TAC trajectory due to year effects, and
3. down weight fishable biomass estimates with broad confidence intervals.

By selecting the most recent four rather than three survey fishable biomass index values the TAC determinations would not be biased toward one season since the determination would include information from two spring and two autumn surveys. Additionally the determination would be based upon only two years of data and therefore would be able to quickly react to changes in stock level without over reacting to year effects.

Sources of Information: SCR Doc. 10/50, 63, 65.

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

Environmental Overview

Hydrographic conditions in this region depend on a balance of atmospheric forcing, advection and ice melt. Winter heat loss to the atmosphere in the central Labrador Sea is offset by warm water carried northward by the offshore branch of the West Greenland Current. The excess salt accompanying the warm inflows is balanced by exchanges with cold, fresh polar waters carried south by the east Baffin Island Current. Within the 1 500 m depth range over much of the Labrador Sea temperatures have become steadily higher and salinity also higher over the past number of years compared with the early 1990s. The low temperature and salinity values in the inshore region of southwest Greenland reflect the inflow of Polar Water carried by the East Greenland Current. Water of Atlantic origin with temperatures >3°C and salinities >34.5 is normally found at the surface offshore off the shelf break in this area.

The general conditions in the West Greenland region have traditionally been presented with offset in the hydrography observed over the Fylla Bank. Oceanographic conditions during summer 2009 were characterised by lower amounts of cold-lower salinity Polar Water and above normal presence of warm-higher salinity Irminger Water. In general, the surface and subsurface temperatures and salinities were higher than normal suggesting reduced contributions of Polar Water and higher proportions of Irminger Water. In June, temperatures on Fylla Bank over the 0-40 m depth range were slightly less than 1°C above normal while salinities increased substantially to the second highest on record, reflecting the higher proportion of Irminger water. In the autumn temperature over the 0-200 m depth range were also about 1°C above normal and salinities continued higher than normal. No updates for 2010 were available.

The Labrador Sea experienced very warm winter surface air temperatures in 2009; temperatures ranged from approximately 8°C above normal in the northern region near Davis Strait to about 2-4°C above normal in the southern Labrador Sea. In 2009, convection was limited to the upper 800 m of the water column, a significant reduction compared to 2008 with convection penetrating to 1600 m. Maximum sea ice extent was near the long-term mean for this region, however, sea ice concentration was lower that normal in the region of the northern Labrador Sea. Monthly mean sea surface temperatures were slightly warmer than normal (approximately 1ºC) for all of 2009.

a) Introduction

The shrimp stock off West Greenland is distributed mainly in NAFO SA 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 SA 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 SA 1; this quota is usually fished by a single vessel which for analyses is treated as part of the Greenland offshore fleet. 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 2004–2007 was 130 000 t, reduced for 2008–2010 to 110 000 t. Greenland set a TAC for Subarea 1 for 2007 of 134 000 t, of which 74 100 t was allocated to the offshore fleet, 55 900 t to the 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 4 000 t (total 114 570 t). This total TAC was kept for 2010. Canada set TACs for SFA1 of 18 417 t for 2007–2010.

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—live weight and logbook reports—can therefore legally exceed the enacted TAC.

The table of recent catches was updated (SCR Doc. 10/54), mainly with improved STATLANT data for Greenland for 2008–2009. 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 was 152 749 t and for 2009 was 135 319 t.

The projections of total catch for the 2008 and 2009 assessment, based on data from the first half of the year, were underestimated by 20 000 and 26 000 t. Therefore, instead of the hitherto used projection formulas, the 2010 total catch has been based on estimates provided by industry observers.

Recent catches, projected catches for 2010 and recommended and enacted TACs (t) for Northern Shrimp in Div. 0A east of 60°30'W and SA 1 are as follows:

	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
TAC										
Recommended	85 000	85 000	100 000	130 000	130 000	130 000	130 000	110 000	110 000	110 000
Enacted	102 300	103 190	115 167	149 519	152 452	152 380	152 417	145 717	132 987	132 987
Catches (NIPAG)										
SA 1	99 301[1]	128 925[1]	123 036[1]	142 326	149 978	153 188	142 245	152 749	134 890	*134 000*[2]
Div. 0A	3625	6247	7137	7021	6921	4127	1945	0	429	*4500*[2]
TOTAL SA1–Div. 0A	102 926	135 172	130 173	149 347	156 899	157 315	144 190	152 749	135 319	*138 500*
STATLANT 21A										
SA 1	81 517	103 645	78 436	142 326	149 978	153 188	142 245	148 550[3]	133 561[3]	
Div. 0A	2958	6053	2 170	6861	6410	3788	1878	0	429	

[1] Catches before 2004 corrected for underreporting
[2] Total catches for the year as predicted by industry observers.
[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 Div. 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 2009 and the first six months of 2010 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 t and in 2007 less than 2 000 t; in 2008 there was no fishing and in 2009 very little, but in 2010 this fishery seems to have returned to normal levels of activity.

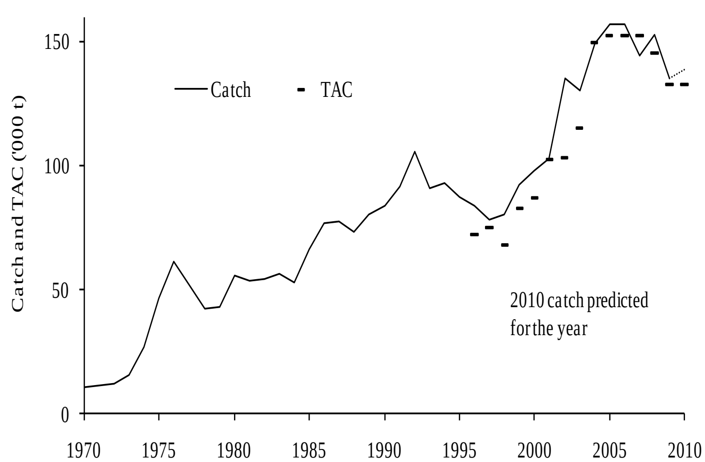


Fig. 3.1. Shrimp in SA 1 and Canadian SFA 1: Enacted TACs and total catches.

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 SA 1 (SCR Doc. 10/53, 64). In recent years both the distribution of the Greenland fishery and fishing power have changed: 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.

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 two 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 Kongelige Grønlandske Handel (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 more from each other 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 increased markedly after 1997 to plateau in 2004–2007 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, but the full-year value for 2009 and the part-year value for 2010 are both consecutively lower.

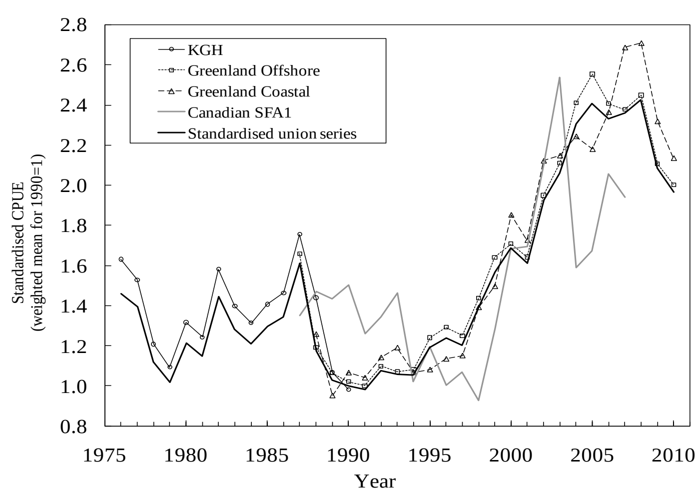


Fig. 3.2. Shrimp in SA 1 and Canadian SFA 1: Standardised CPUE index series 1976–2010.

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 SA 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.) This index has decreased in recent years, and NIPAG has been concerned for effects of this apparent 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. However, a distribution index based on much smaller, and more uniform-sized, areas, has not confirmed the degree of this contraction (SCR doc. 10/56) (Fig. 3.3). Instead, it appears as though the fishery might have compensated to some degree for the scarcity of shrimps in the (smaller) southerly Divisions by fishing more widely in the (larger) Div. 1A and Div. 1B.

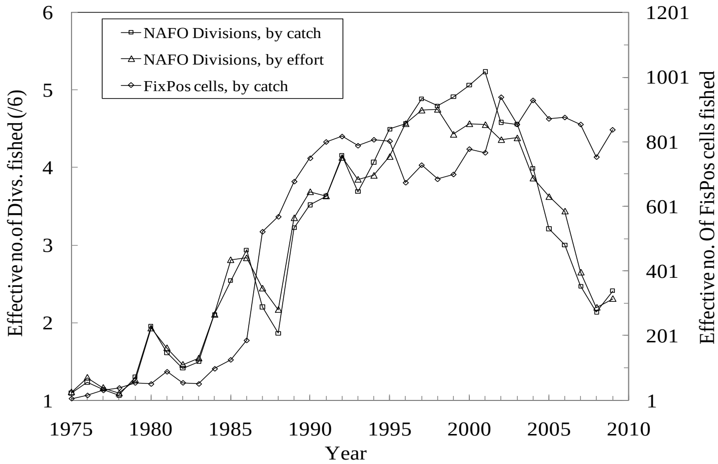


Fig. 3.3. Shrimp in SA 1 and Canadian SFA 1: Indices for the breadth of distribution of the Greenland fishery in 1975–2009.

From the end of the 1980s there was a significant expansion of the fishery southwards and by 1996–1997 areas south of Holsteinsborg Deep (66°00′ N) accounted for 65% of the catch. At that time the effective number of Divisions being fished peaked at about 4.5–5. Since then, 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 about 12% 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 SA 1 (SCR Doc. 10/57). From 1993, the survey was extended southwards into Div. 1E and Div. 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 on fishable biomass was adjusted.

The survey average bottom temperature increased from about 1.7°C in 1990–1993 to about 3.1°C in 1994–2010 (SCR Doc. 10/57). In 2010 about 90% of the survey biomass estimate is in water 200–400 m deep. In the early 1990s, about ¾ of the biomass between 200 and 400 m 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. 10/57). The proportion of survey biomass in Div. 1E–F has decreased in recent years and the distribution of survey biomass has become more concentrated and more northerly (SCR Doc. 10/57).

Biomass. The survey index of total biomass remained fairly stable from 1988 to 1997 (c.v. 18%, downward trend of 4%/yr). It then increased by, on average, 19%/yr until 2003, when it reached 316% of the 1997 value. Subsequent values were consecutively lower, by 2008–2009 less than half the 2003 maximum (Fig. 3.4) and 9% below the series mean. However, in 2010 the survey biomass index increased by 24% from the 2009 value.

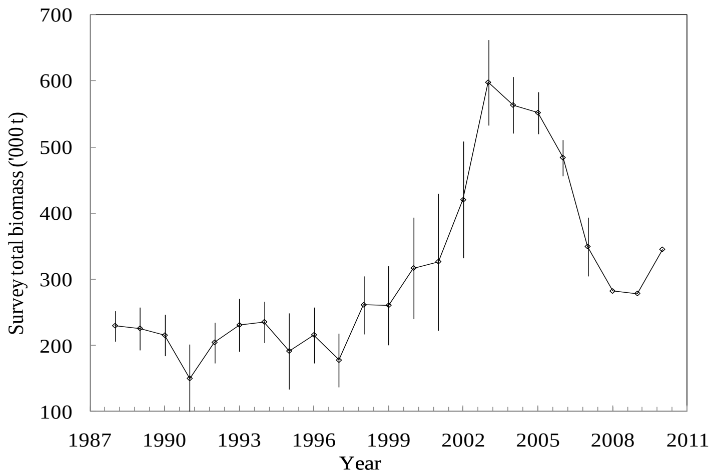


Fig. 3.4. Shrimp in SA 1 and Canadian SFA 1: Survey indices of total stock biomass 1988–2010 (SCR Doc. 10/57). Error bars ±1 s.e.

Length and sex composition (SCR doc.10/57). In 2008 peaks could be observed at 12 mm and 15 mm CL suggesting two- and three-year-olds; the two-year-old class in particular appeared stronger than in 2007. The 2009 distribution of lengths appeared very similar to that for 2008 (Fig. 3.5); cohorts could be distinguished at 11–13 mm and at 15.5–18 mm. There were many more males in 2010, and while modes can be picked out at 11.5–12.5 and at 16.5 mm, they are less evident in the generally higher profile of the length distribution (Fig. 3.5).

Male and female numbers in 2008 were 42.5 and 11.5×10^9 individuals respectively, both values below their series averages (50 and 12×10^9). Estimated numbers of males and females in 2009, 41.5×10^9 and 12.2×10^9 respectively, were close to those for 2008 and still below their series means, but in 2010 the number of males appears about 40% higher at 56.2×10^9 while the number of females has increased by only about 16% to 14.4×10^9.

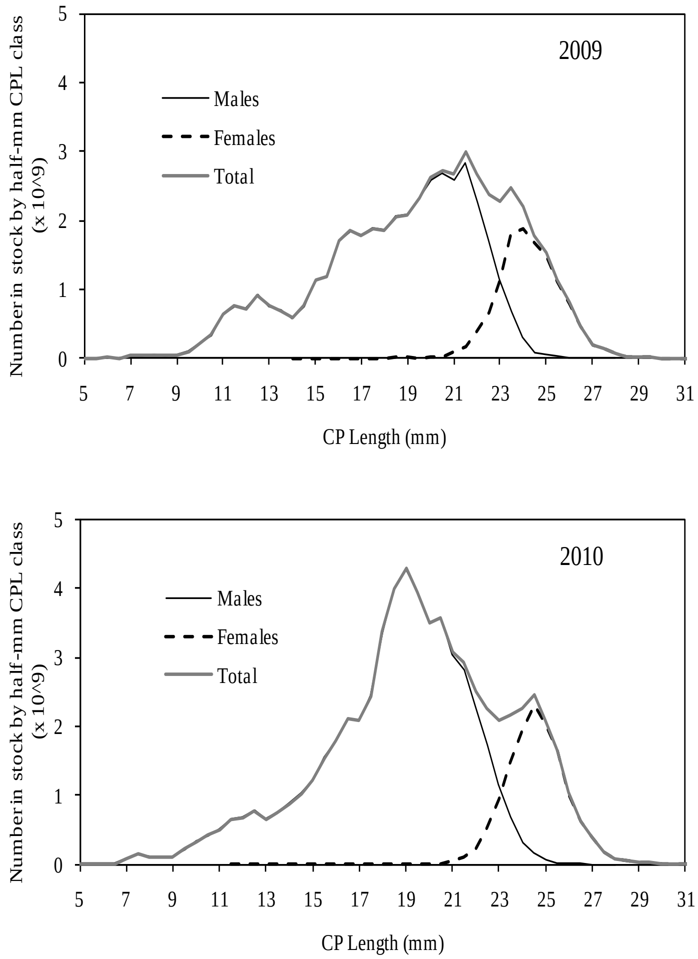


Fig. 3.5. Shrimp in SA 1 and Canadian SFA 1: Length frequencies in the West Greenland trawl survey in 2009 and 2010.

Recruitment Index. The number at age 2 is a predictor of fishable biomass 2–4 years later (SCR Doc. 03/76). This index, estimated by modal analysis using MIX, was high in 2001, decreased in 2002, was near average in 2003 and 2004 but then fell to even lower values in 2005 and 2006. Corresponding modal-analysis estimates for more recent years were not available for the present assessment. As a substitute, a series of numbers of small shrimps in the roughly corresponding length classes, i.e. 9–14.5 mm CPL, was constructed for 2006–2010. This small-shrimp index decreased markedly from 2006 to 2007. It has been higher and increasing in the subsequent years, more than doubling by 2010, but any recruitment index based on survey numbers of small shrimps is still at levels that are low compared with previous values in the series.

The change, in 2005, of the trawl used in the survey has complicated the interpretation of these index series. The new *Cosmos* trawl is only about 2/3 as good as the old *Skjervøy* at catching shrimps at CP lengths of 10.5–15 mm, and index series have not been adjusted for the gear change.

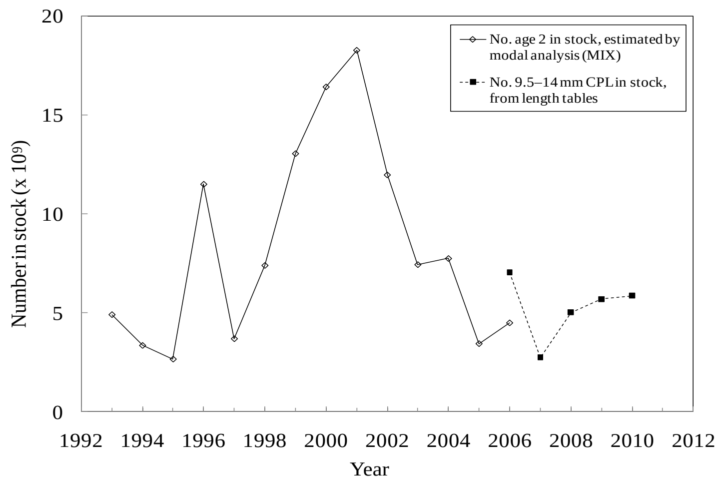


Figure 3.6. Shrimp in SA 1 and Canadian SFA 1: Indices of numbers of pre-recruits from trawl survey, 1993-2010.

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 4 069 t for the 2009 estimate from the German survey (SCR Doc. 09/65), indicating 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, was estimated at only 2 400 t (SCR Doc. 09/65). In 2010 the nominal cod biomass increased to 14 000 t but the index of overlap dropped to 0.315, giving an effective cod stock of only 4 400 t (SCR Doc. 10/58).

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 2010 was the same as that used in 2009. The model fitted well to the data and uncertainties of parameter estimates were similar to those in 2009. 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 147 000 t, a negligible decrease from the 2009 estimate.

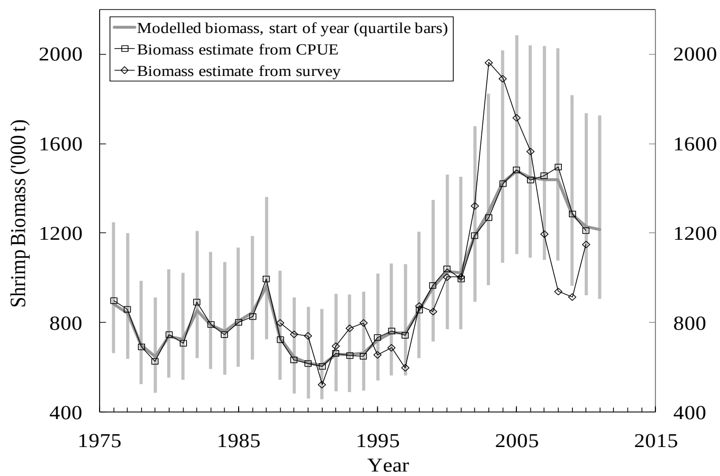


Fig. 3.7: Shrimp in SA 1 and Canadian SFA1: trajectory of the median estimate of stock biomass at start of year, with the year's median CPUE and survey indices.

Stock-dynamic and fit parameters from fitting a Schaefer stock-production model to data on the West Greenland stock of the northern shrimp in 2010 were estimated as follows:

	2010						2009 assessment
	Mean	S.D.	25%	Median	75%	Est. Mode	Median
Max.sustainable yield	157	47	132	147	167	128	148
B/B_{msy}, end current year (proj.)	1.17	0.33	0.97	1.16	1.37	1.13	1.28
Z/Z_{msy}, current year (proj.)	0.92	0.29	0.75	0.92	1.09	0.91	0.65
Carrying capacity	2786	2405	1676	2123	2940	797	1922
Max. sustainable yield ratio (%)	13.8	4.4	10.8	13.9	16.7	14.1	15.5
Survey catchability (%)	29.2	13.2	19.9	28.0	37.5	25.5	30.9
CV of process (%)	8.9	2.0	7.5	8.9	10.2	8.9	9.4
CV of survey fit (%)	20.8	3.4	18.4	20.5	22.8	19.8	21.2
CV of CPUE fit (%)	3.8	1.5	2.7	3.6	4.7	3.2	3.6

ii) Assessment Summary

Recruitment. A recruitment index based on survey numbers of small shrimps fell to low levels in 2005-2006. A second index remained near its 2006 level until 2010.

Biomass. A stock-dynamic model showed a maximum biomass in 2005 with a decline since; the probability that biomass will be below B_{msy} at end 2010 with projected catches at 138 500 t was estimated at 28% and of its being below B_{lim} (30% of B_{msy}) 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 2010 projected at 138 500 t the risk that total mortality in 2010 would exceed Z_{msy} was estimated at about 37.5%.

State of the Stock. Modelled biomass is estimated to have been declining since 2005. However, at the end of 2010 biomass is projected to be still above B_{msy} and total mortality below Z_{msy}. Recent estimates of recruitment indices have been low.

d) Precautionary Approach

The fitted trajectory of stock biomass showed that the stock had been below B_{msy} from the late 1970s to the late 1990s, with mortalities mostly near Z_{msy} 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 1.4 times B_{msy} in 2003–2006. Recent increases in the cod stock coupled with high catches have been associated with slight declines in the modelled biomass, although mortality remains below Z_{msy} and the biomass still above B_{msy}.

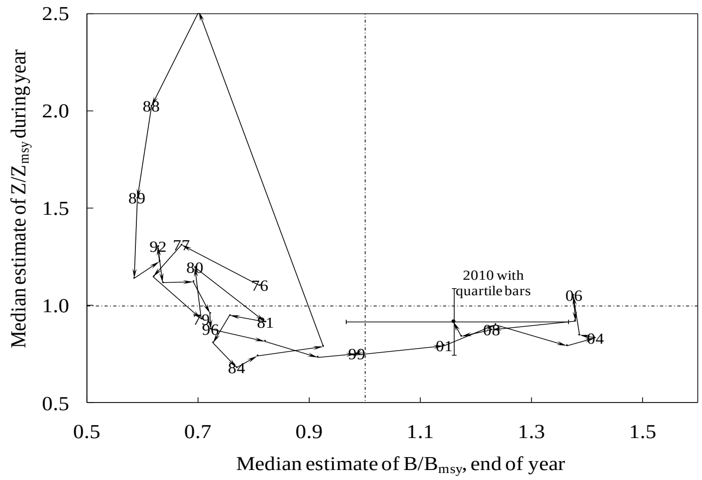


Fig. 3.8: Shrimp in SA 1 and Canadian SFA1: trajectory of past relative biomass and relative mortality.

Stock-dynamic modelling estimates the present stock status to be in the precautionary safe zone with biomass above B_{msy} and mortality below Z_{msy}, but the risks that these limits might be transgressed by the end of the current year is 28 and 37.5%, respectively, are now estimated to be greater than in recent years.

e) Projections

With an 'effective' cod stock assumed at 5 000 t in 2011, catches up to 115 000 t would be associated with risks below 20% of exceeding Z_{msy}, while the risk of falling below B_{msy} would remain about where it is now, near 28%. Higher catches in 2011 would be associated with rapidly increasing risks of exceeding Z_{msy}.

Predicted probabilities of transgressing precautionary limits in 2011 (risk table) under five catch options and predation by a cod stock with an effective biomass of 5 000 t:

5 000 t cod	Catch option ('000 t)				
Risk of:	105	115	125	135	145
falling below B_{msy} end 2011 (%)	26.6	27.8	28.4	30.2	31.4
falling below B_{lim} end 2011 (%)	0.3	0.3	0.3	0.4	0.4
exceeding Z_{msy} during 2011(%)	7.6	15.1	24.8	35.2	46.4

In the medium term, with a 5 000 t cod stock, model results estimate catches of 125 000 t/yr to be associated with a stationary stock, above B_{msy}, and with mortality below Z_{msy}. Catches of 135 000 t would be associated with a stock that still after 5 years would more likely than not be within the safe zone. Higher catches would cause rapid deterioration of the state of the stock. With a 10 000 t cod stock, annual catches of 125 000 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 5 000 t and 10 000 t were:

Catch (kt/yr)	Prob. biomass < B_{MSY} (%)		Prob. biomass< B_{lim} (%)		Prob. mort > Z_{msy} (%)	
	5 kt	10 kt	5 kt	10 kt	5 kt	10 kt
105	17.9	19.8	0.2	0.2	5.6	7.8
115	22.3	24.4	0.2	0.3	13.1	17.4
125	27.7	30.5	0.3	0.3	24.6	29.7
135	33.7	36.8	0.4	0.3	38.1	44.1
145	39.9	41.9	0.5	0.6	50.5	55.9

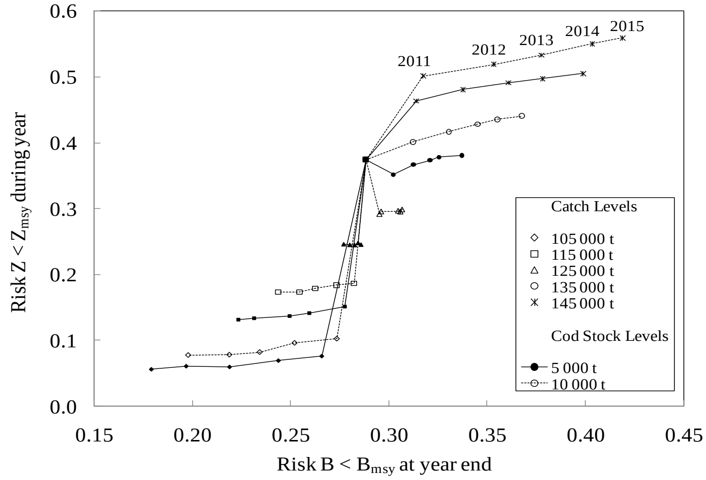


Fig. 3.9. Shrimp in SA 1 and Canadian SFA1: Risks of transgressing mortality and biomass precautionary limits for catches at 105 000–145 000 t projected over five years with 'effective' cod stock assumed at 5 000 (closed symbols) or 10 000 (open symbols) t.

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 5 000 t change in the cod stock is practically equivalent to a 5 000 t change in catch. For catches of 105 000 t or 115 000 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 125 000 t the stock is nearly stationary above B_{msy} if the effective cod stock is assumed near 5 000 t. With a cod stock at 10 000 t and a 125 000 t catch the risk of falling below B_{msy}, which starts at about 30%, would increase slowly with time as the stock was fished down. Catches of 135 000 t or 145 000 t are associated with higher and increasing risks of transgressing both precautionary limits whether the cod stock is assumed at 5 000 t or 10 000 t.

e) Review of recommendations from 2009

NIPAG recommended in 2009 that, for shrimp off West Greenland (NAFO SA 0 and 1):

Collaborative efforts should be made to standardise a means of predicting recruitment to the fishable stock;

STATUS: no concrete progress has been made on this recommendation.

The adjustment of CPUE index series to take account of changes in the area of distribution of the fishery should be investigated;

STATUS: Some investigations were reported, in which the area of distribution of the fishery was measured by the effective number of 'FixPos' cells (approx. 4 sq.n.mi.) from which catches were taken (SCR Doc. 10/56). This fine-scale distribution index was not well correlated with the index, based on larger statistical areas, that has given the impression of a contracting fishery. It showed an increase in fished area between 1996 and 2002 that was not evident in the large-area index series, and a less decided decrease in recent years. The standard CPUE series used as a biomass index in the accepted standard assessment was adjusted simply by being multiplied by this distribution index. The adjusted series was slightly better correlated with the survey biomass series than the unadjusted, standard, CPUE series. When both CPUE series were offered to the assessment model as biomass indices, it preferred the unadjusted series. When only the adjusted series was offered, the modelled biomass trajectory followed that series closely and took little notice of the survey series; process error increased, because the adjusted CPUE series was more erratic, while the survey cv decreased very slightly owing to the better correlation with the adjusted series. Owing to the increase in fished area, and therefore in the adjusted CPUE, before 2002, an assessment run with the adjusted series was more optimistic about the present state of the stock than with the unadjusted series. The measurement of the area of distribution of the fishery is more complex than at first appeared, large- and small-area indices giving different results. More investigation of how to measure distribution might be needed before trying to incorporate such measures into assessments.

Methods of 'modal analysis' for estimating age-class numbers should be further developed;

STATUS: No progress has been made on this recommendation.

Improvements in the estimation of weight-length relationships, and their use in estimating sex-specific biomasses, should be investigated;

STATUS: The relationship between weight and length was thoroughly investigated for the 2009 survey data (SCR Doc. 10/52). A weight-length curve fitted to 2009 length-weight data for individually weighed shrimps differed from the standard weight-length curve, based on historical data, that has been in use, giving rise to some doubts as to existing estimates of class-specific biomasses. It appeared from the analysis that the length frequencies in the weighed cod-end samples taken in the 2009 survey differed enough from one another to allow a weight-length curve to be fitted to cod-end sample data alone, without the need to refer to a separate data set of individual weights and lengths. This method of estimating a weight-length curve has the advantage that it is based on the same cod-end-sample data as that to which the curve is subsequently applied for partitioning the stock biomass. NIPAG recommended that the method should be evaluated further over several years to check that it is consistent and reliable; and that complete tables of numbers by length class and age class should be presented in documents that report demographic analyses.

Downweighting of older data in the assessment model should be investigated.

STATUS: It was reported that some initial investigations have been carried out, but no document was available to be presented to the meeting.

f) Research recommendations

NIPAG **recommended** that

- *the estimate of the biomass of Atlantic cod from the W. Greenland trawl survey should be explicitly included in the stock-production model used for the assessment;*
- *estimating weight-length curves from length-sample data alone, and using them for partitioning the estimated stock biomass, should be further compared with the method based on weighing individuals and its usefulness and reliability further evaluated.*
- *numbers at length for all the components of the stock identified by modal analysis should be tabulated, to allow confirmation that they tally to the estimated survey total numbers at length;*
- *demographic analyses of past survey data should be thoroughly revised, including adjustment for the 2005 gear change, with a view to obtaining a consistent series.*

Sources of Information: SCS Doc. 04/12; SCR Doc. 04/75, 76, 08/62, 10/51, 52, 53, 54, 56, 57, 58.

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

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. Since 2008 about 10% of the total catch has been taken in the southern area.

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 bycatch of fish are mandatory. Discarding of shrimp is prohibited in both areas.

As the fishery developed, catches increased rapidly to more than 15 000 t in 1987-1988, but declined thereafter to about 9 000 t in 1992-1993. Following the extension of the fishery south of 65°N catches increased again reaching 11 900 t in 1994. From 1994 to 2003 catches fluctuated between 11 500 and 14 000 t (Fig. 4.1). In 2004 the catches started dropping from 10 000 t to a low of 2 800 t in 2008. The total catch in 2009 was 4 550 t and the total catch for 2010 is expected to be at the same level. 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:

	2001[1]	2002[1]	2003[1]	2004	2005	2006	2007	2008	2009	2010[2]
Recommended TAC, total area	9 600	9 600	9 600	12 400	12 400	12 400	12 400	12 400	12 400	12 400
Actual TAC, Greenland	10 600	10 600	10 600	15 043	12 400	12 400	12 400	12 400	12 835	11 835
North of 65°N, Greenland EEZ	2 227	4 113	5 480	4 654	3 987	3 887	3 314	2 529	3 945	3 556
North of 65°N, Iceland EEZ	10	1 231	703	411	29	0	0	0	0	0
North of 65°N, total	2 237	5 344	6 183	5 065	4 016	3 887	3 314	2 529	3 945	3 556
South of 65°N, Greenland EEZ	11 674	5 985	6 522	4 951	3 737	1 302	1 286	266	610	505
TOTAL NIPAG	13 911	11 329	12 705	10 016	7 753	5 189	4 600	2 794	4 555	4 061

[1] Estimates corrected for “overpacking”.
[2] Catches till October 2010

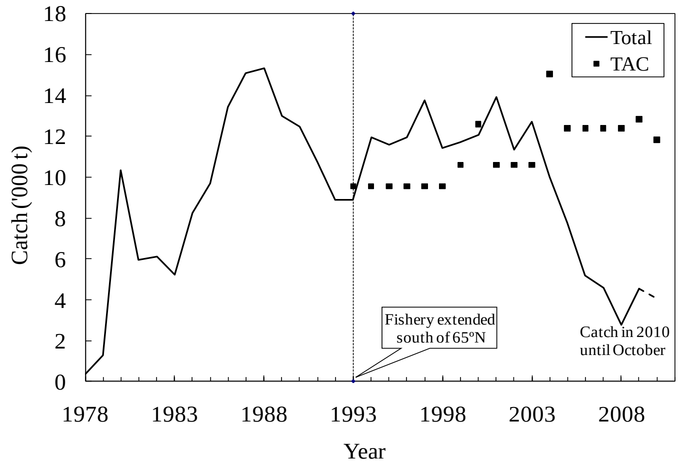


Fig. 4.1. Shrimp in Denmark Strait and off East Greenland: Total catches and TACs.

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 2004 more than 60% of all hauls were performed with double trawls and the 2010 assessment included both single and double trawls in the standardized catch rate calculations.

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

The Greenlandic fishing fleet, catching 40% of the total catch from 1998 to 2005 and between 0% 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 increased by 50%. In 2010 the catch rate using provisional data went down to the level seen in the period from 2004-2008 (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 increased by 25% compared with 2008. In 2010 the index was similar to the 1999-2008 level (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. In 2010 the combined standardized catch rate index went down again to the level seen from the beginning of the 2000s (Fig. 4.4).

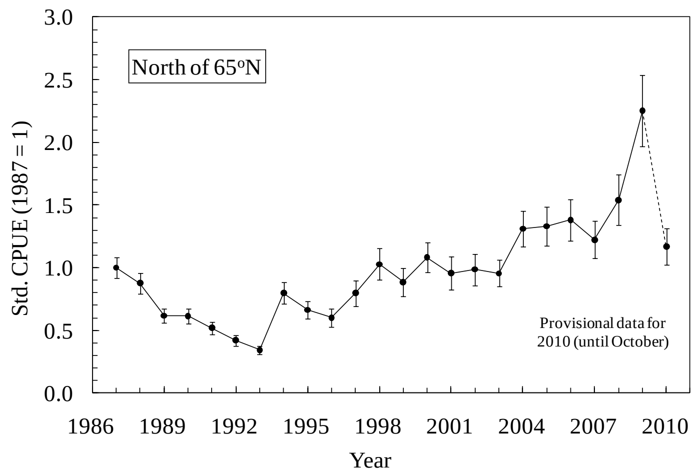


Fig. 4.2. Shrimp in Denmark Strait and off East Greenland: annual standardized CPUE (1987 = 1) with ±1 SE calculated from logbook data from Danish, Faeroese, Greenland, Icelandic and Norwegian vessels fishing north of 65°N.

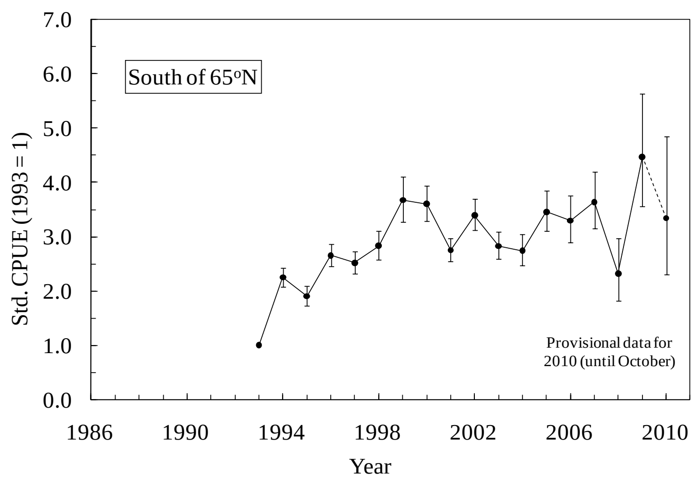


Fig. 4.3. Shrimp in Denmark Strait and off East Greenland: annual standardized CPUE (1993 = 1) with ±1 SE calculated from logbook data from Danish, Faeroese, Greenland and Norwegian vessels fishing south of 65°N.

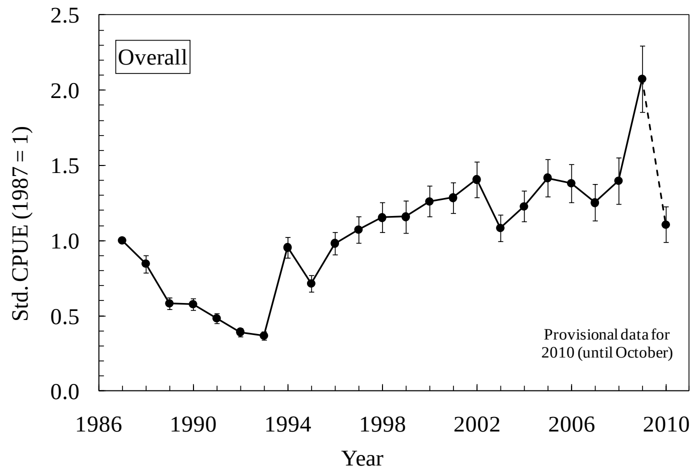


Fig. 4.4. Shrimp in Denmark Strait and off East Greenland: annual standardized CPUE-indices (1987 = 1) with ± 1 SE combined for the total area.

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).

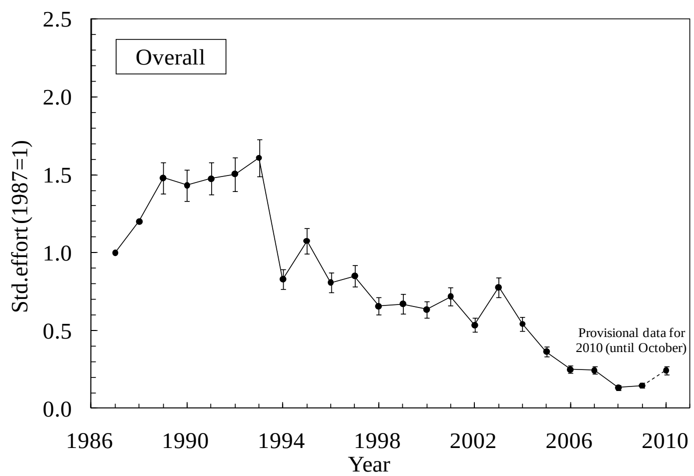


Fig. 4.5. Shrimp in Denmark Strait and off East Greenland: annual standardized effort indices, as a proxy for exploitation rate (± 1 SE; 1987 = 1), combined for the total area.

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

Since 2008 stratified-random trawl surveys has been conducted to assess the stock status of northern shrimp (SCR Doc. 10/59) in East Greenland. The main objectives were to obtain indices for stock biomass, abundance, recruitment and demographic composition. The area was also surveyed in 1985-1988 (Norwegian survey) and in 1989-1996 (Greenlandic survey). The historic survey is not directly comparably with the recent survey due to different area coverage, survey technique and trawling gear. However, both showed similar levels of biomass and abundance and the presence of large shrimps (Fig. 4.6). Absence of the smaller male and juvenile shrimp in the survey area stresses that the total area of distribution and recruitment patterns of the stock are still unknown.

Biomass estimate. The biomass estimates (in metric tons) for the entire survey area are:

Year	Biomass	St Dev.
2008	1 953	1 764
2009	8 446	3 852
2010	5 758	3 928

The surveys conducted since 2008 shows that the shrimp stock is concentrated in the area North of 65°N.

Stock composition. The total number of shrimp for 2008, 2009 and 2010 was estimated to 206, 909 and 519 million respectively (Fig 4.6). In 2009 and 2010 female numbers was at the same level, but the numbers of males declined considerable from 2009 to 2010 (Fig 4.6).

The demography in East Greenland shows a lack of males smaller than 20 mm CL (Fig. 4.7), which means that no recruitment index is available.

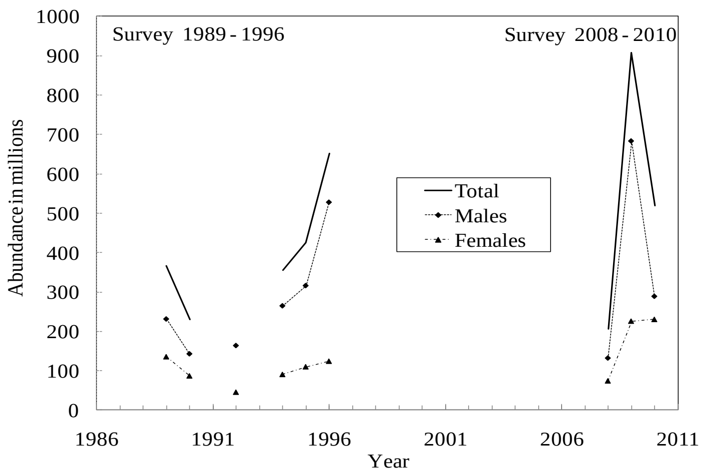


Fig. 4.6. Abundance of males and females in two different surveys series from 1989-1995 and 2008-2010 for the areas North of 65°N.

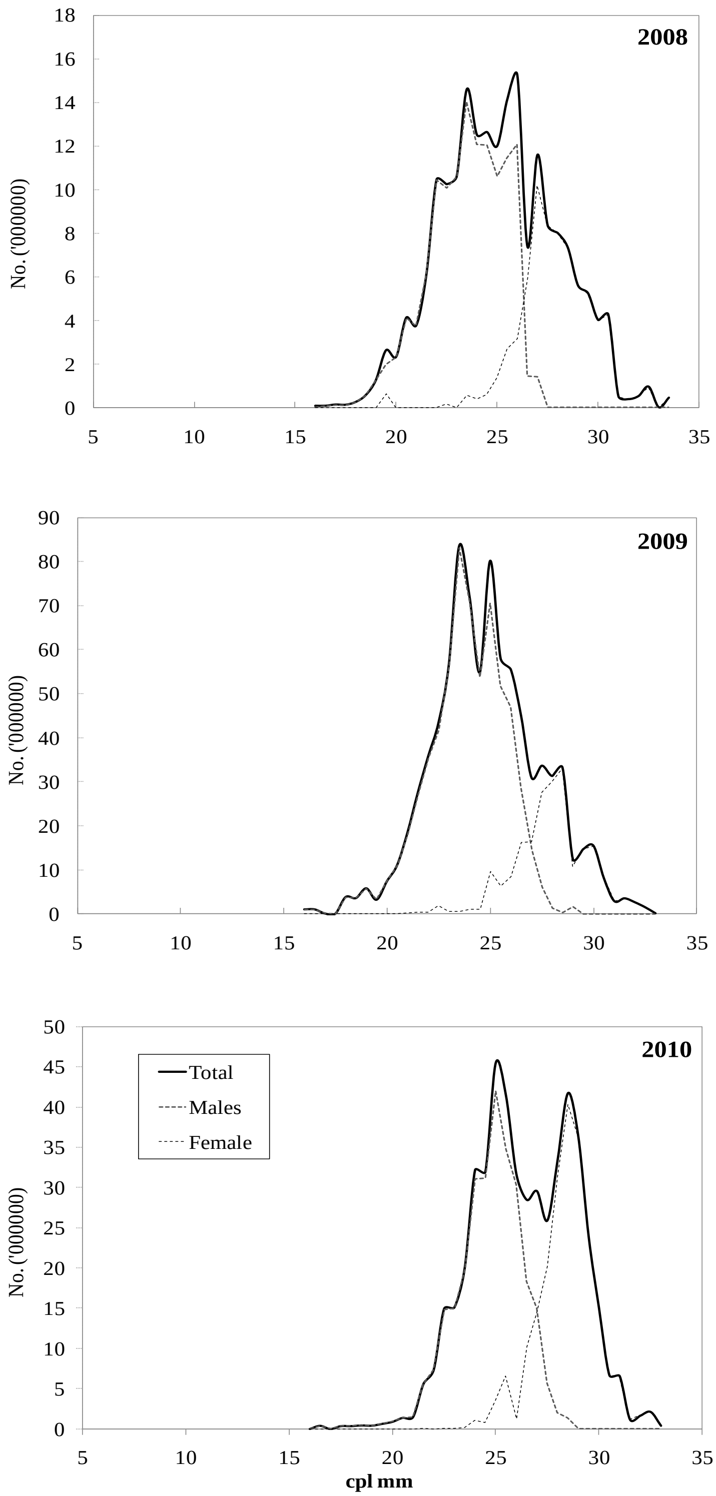


Fig. 4.7. Numbers of shrimp by length group (CL)in the total survey area in 2008, 2009 and 2010, based on pooling of samples weighted by catch and stratum area.

Other studies

There were no additional studies during 2009.

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 the standardized catch rate rose to the highest level ever seen, but probably does not reflect a corresponding increase in biomass. In 2010 the standardized catch rate is back to the level seen from the beginning of the 2000s.

Recruitment. No recruitment estimates were available.

Biomass. The biomass index from 2008-2010 varied greatly with no clear trend.

Exploitation rate. Since the mid 1990s, the exploitation index (standardized effort) has decreased, reaching the lowest levels seen in the time series from 2008 to 2010.

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) Review of Research Recommendations from 2009

NIPAG **recommended** in 2009 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*.

STATUS: No progress

Sources of Information: SCR Doc. 03/74, 10/59, 69.

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

a) Introduction

The shrimp in the northern part of ICES Div. IIIa (Skagerrak) and the eastern part of 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 19^{th} century, while the Danish fishery started in the 1930s. All fisheries expanded significantly in the early 1960s. By 1970 the landings 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 was around 16 500 t in 2006-2009 decreased, however to 14 558 t in 2010 (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 overall TAC is shared according to historical landings, giving Norway 60%, Denmark 26%, and Sweden 14%. The recommended TACs until 2002 were based on catch predictions. However, since 2003 when the cohort based analytical assessment was abandoned no catch predictions have been available, and the recommended TACs have been based on perceived stock development in relation to 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. 10/069) and is used by an increasing number of vessels in all fleets. However, at present it is mandatory only in Swedish national waters.

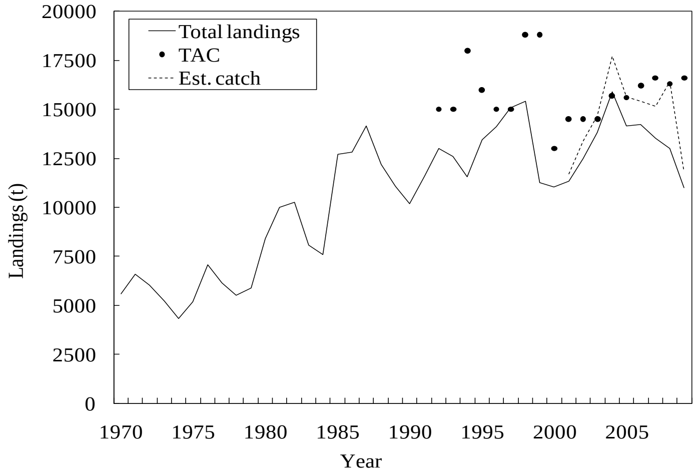


Fig. 5.1. Northern shrimp in Skagerrak and Norwegian Deep: TAC, total landings by all fleets, and total catch including estimated Swedish high-grading discards for 2001-2009, Norwegian discards for 2007-2009 and Danish discards for 2009.

Total landings have varied between 10 000 and 16 000 t during the last 20 years. The Norwegian and Swedish landings have been corrected for weight loss caused by boiling and raised a factor of 1.13. Total catches are estimated as the sum of landings and discards and have varied between 11 000 and 18 000 t in 2001-2009. In 2005 to 2008 the catches were around 15 000 to 16 000 t. The increase in total catches in 2008 compared with 2007 was due to the high estimates of Norwegian and Swedish discards in 2008. Danish and Norwegian landings have decreased since 2007 (Table 5.1 and Fig. 5.1). Total landings in 2009 decreased by 2 000 t compared with 2008. This was mainly due to a decrease in Norwegian landings.

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

	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Recommended TAC	19 000	11 500	13 400	12 600	14 700	15 300	13000	14 000	14 000	15 000	15 000
Agreed TAC	18 800	13 000	14 500	14 500	14 500	15 690	15,600	16 200	16 600	16 300	16 600
Denmark	2 072	2 371	1 953	2 466	3 244	3 905	2 952	3 061	2 380	2 259	2 155
Norway	6 739	6 444	7 266	7 703	8 178	9 544	8 959	8 669	8 686	8 260	6 364
Sweden	2 445	2 225	2 108	2 301	2 389	2 464	2 257	2 488	2 445	2 479	2 483
Total landings	11 256	11 040	11 327	12 470	13 811	15 913	14 168	14 218	13 511	12 998	11 002
Est. Danish discards[1]											29
Est. Swedish high-grading			375	908	868	1 797	1 483	1 186	1 124	2 003	671
Est.Norwegian discards[2]									526	1 408	115
Est. total catch			11 702	13 378	14 679	17 710	15 651	15 404	15 161	16 409	11 817

[1] Collection of Danish discard data begun in 2009
[2] Collection of Norwegian discard data begun 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 2009. It is mostly the small (<24 m LOA) and less efficient trawlers which have left the fishery and in 2009 the Danish fleet consisted of vessels with an average length of 26 m (SCR Doc. 10/70). The efficiency of the gear has also increased due to the introduction of twin trawl technology and increased trawl size.

In Norway the number of vessels participating in the shrimp fishery has decreased from 423 in 1995 to 238 in 2009. The number of smaller vessels (10-10.99 m LOA) has increased from the mid-1990s until present, while the number of larger vessels (11-20.99 m LOA) has decreased. The length group 10-10.99 m LOA has been the numerically dominant one since 2005 (40% of all vessels in 2009), owing to the fact that vessels <11 m do not need a licence to fish. Vessels ≥21 m LOA constitute 10% of the fleet, which illustrates the difference between the Norwegian and

Danish fleets. Twin trawl was introduced around 2002, and the use is increasing. In 2009 twin trawls are estimated to be in use by 40-50 Norwegian trawlers.

The Swedish specialized shrimp fleet (catch of shrimp ≥ 10 t/yr) has been around 40-50 vessels for the last decade and there has not been any major change in trawl size or trawl design according to the Swedish net manufacturer. In Sweden twin trawls have been in use since 2006 and the use is increasing. In 2009 eleven twin trawlers caught 26% of the Swedish shrimp landings (SCR Doc. 10/70).

Catch and discards. Discarding of shrimp may take place in two ways: 1) discards of shrimp <15 mm CL which are not marketable, and 2) high-grading discards of medium-sized and lower-value shrimp. 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 amount of high-grading discards in the Swedish fisheries was estimated to around 670 t in 2009 based on comparison of length distributions in Swedish and Danish landings (Fig. 5 in SCR Doc 10/70). 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 in recent years 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.

Norwegian discards have since 2007 been estimated using the same method as described above (SCR Doc. 10/62). The length distributions of Norwegian unprocessed commercial catches are compared with those of Norwegian sorted landings. In 2009 Norwegian discards from Skagerrak was estimated to 115 t. Too few samples from the Norwegian Deep prevented estimation of discards from this area. However, as the catches from the Norwegian Deep comprise very few 1-year old shrimp, it is probable that discards from this area are very low. The Norwegian discards are probably mainly made up of non-marketable shrimp, but high-grading cannot be ruled out.

Bycatch and ecosystem effects. Shrimp fisheries in the North Sea and Skagerrak have bycatches of 10-20% (by weight) 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. Log-book information shows that 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 52% of Swedish shrimp effort in 2009.

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 by the *Pandalus* fishery in 2009. Combined data from Danish and Swedish logbooks and Norwegian sale slips (t). The figures for cod and saithe for the trawl with grid is likely to be misreported landings.

	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	7 654	83.7	923	96.9	2 126	77.0
Norway lobster	51	0.6	3	0.3	76	2.8
Angler fish	58	0.6	0	0.0	74	2.7
Whiting	9	0.1	0	0.0	5	0.2
Haddock	80	0.9	0	0.0	24	0.9
Hake	40	0.4	1	0.1	41	1.5
Ling	42	0.5	1	0.1	31	1.1
Saithe	581	6.3	15	1.6	233	8.4
Witch flounder	86	0.9	1	0.1	4	0.1
Norway pout	0	0.0	0	0.0	0	0.0
Cod	373	4.1	9	0.9	101	3.7
Other market fish	170	1.9	1	0.1	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, 10/70) to provide indices of stock biomass. A GLM standardisation of the LPUE series was performed on around 20 500 shrimp fishing trips conducted in the period 1987-2009:

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

where 'vessel' denotes the horse power of the individual vessels, 'year' covers the period 1987-2009, '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 (2000-2010) (SCR Doc. 10/62) a similar model was applied, but gear type (single and twin trawl) was also included as a variable:

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

Information on gear use (single- or twin- trawl) was corrected by interviews with fishers. In 2009, catches recorded in log-books only made up 14% and 17% 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.

Since the mid-1990s the Danish standardised LPUE has fluctuated without trends. The two time series show similar fluctuations, increasing from 2000 to 2004, decreasing in 2005 and then increasing again until 2007. In 2008 and 2009 both LPUE indices decreased and the Norwegian index decreased further in 2010 (based on data until July).

The Swedish LPUE data were not used in the assessment (SCR Doc. 10/70) because of uncertainties caused by discarding due to high-grading and lack of information necessary for standardisation.

In previous assessments harvest rates (H.R.) were estimated from landings and corresponding biomass indices from the Norwegian survey. Since the new survey only covers five years, time series of standardised effort indices (total landings/Danish and Norwegian standardised LPUE indices) have been estimated in addition to H.R. estimates for

2006-2009 (Fig. 5.3) Standardised effort seems to have been fluctuating without any clear trend since the mid-1990s indicating stability in the exploitation of the stock.

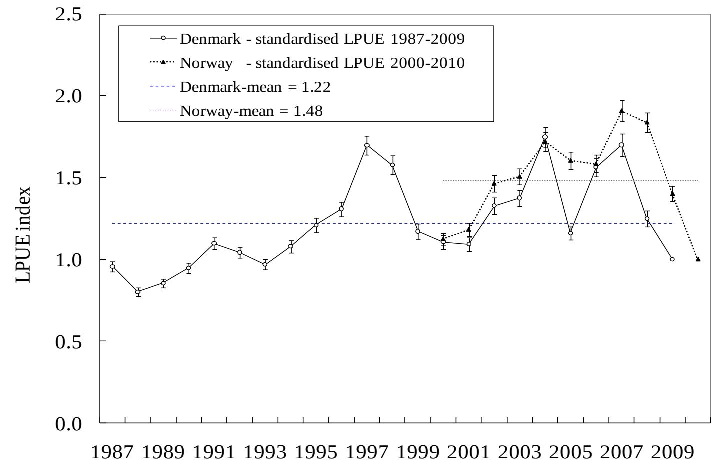


Fig. 5.2. Northern shrimp in Skagerrak and Norwegian Deep: Danish standardised LPUE until 2009 and Norwegian standardised LPUE until August 2010. Danish 2010 data were not available.

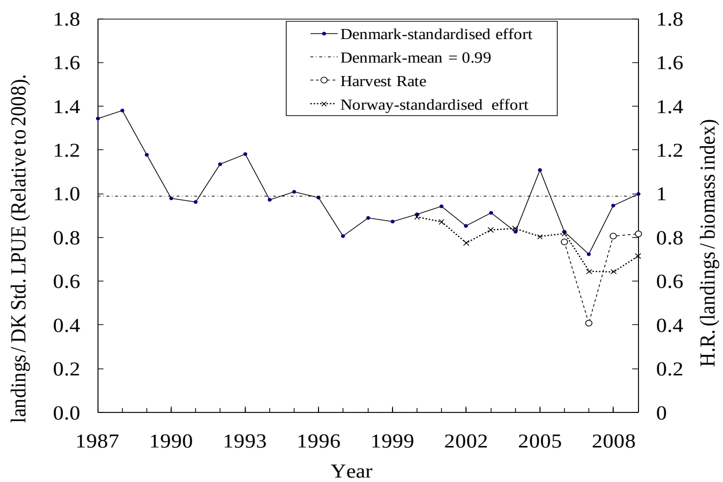


Fig. 5.3. Northern shrimp in Skagerrak and Norwegian Deep: Harvest rate (total landings/survey indices of biomass) and estimated standardised effort based on total landings and Danish and Norwegian standardised LPUE. Long term DK mean = 0.99

ii) Sampling of landings

Information on the size and subsequently age distribution of the landings are obtained by sampling the landings. The samples provide information on sex distribution and maturity (SCR Doc. 10/70). This information has not been used in the current assessments, but is expected to be used in future improved analytical assessments.

iii) Survey data

The Norwegian shrimp survey has gone through large changes in recent years (SCR Doc. 10/67) resulting in four different survey series, 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. In 2003 the survey was carried out using a different trawl in use only that year. 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 and 2010 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. Since 2007 the recruitment (age 1) has declined and in 2010 it is only 1/10 of the 2006 and 2007 indices (Fig 5.5).

SSB (female biomass) has been calculated for the years 2006-2010 (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 and 2010.

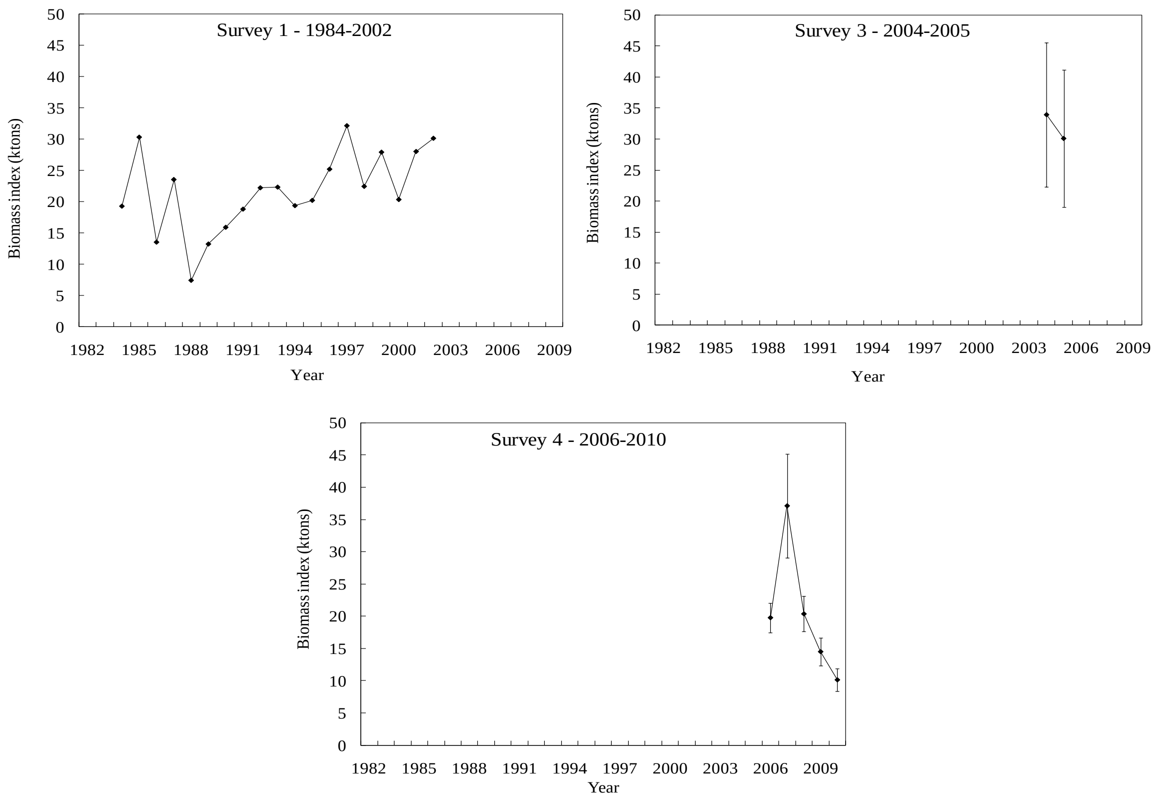


Fig. 5.4. Northern shrimp in Skagerrak and Norwegian Deep: Estimated survey biomass indices in 1984 to 2010. The four surveys are not calibrated to a common scale. Standard errors (error bars) have been calculated for the 2004-2010 surveys. Survey 1: October/November 1984-2002 with Campelen-trawl; Survey 2: October/November 2003 with shrimp trawl 1420 (not shown); Survey 3: May/June 2004-2005 with Campelen trawl; Survey 4: January/February 2006-2010 with Campelen trawl.

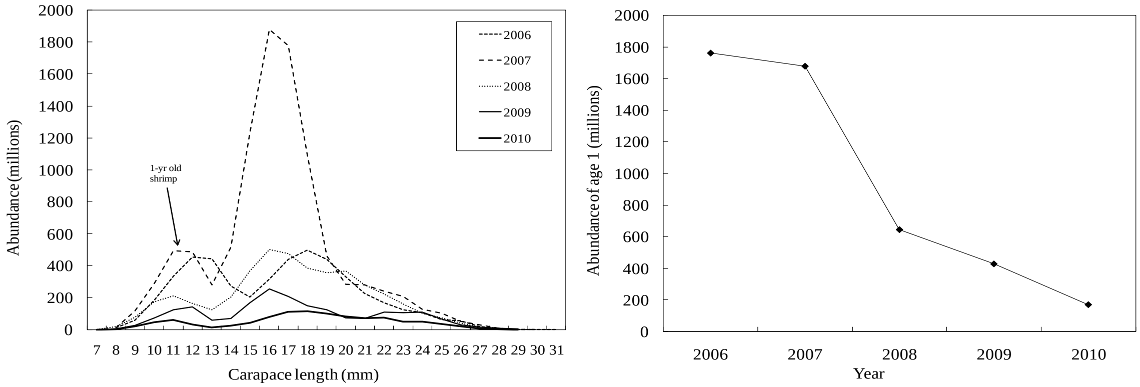


Fig. 5.5. Northern shrimp in Skagerrak and Norwegian Deep: Estimated length frequency distribution from the Norwegian shrimp surveys in 2006-2010, and recruitment indices from the same years. The recruitment index is calculated as the abundance of age 1 shrimp (the first mode in the length frequency distribution).

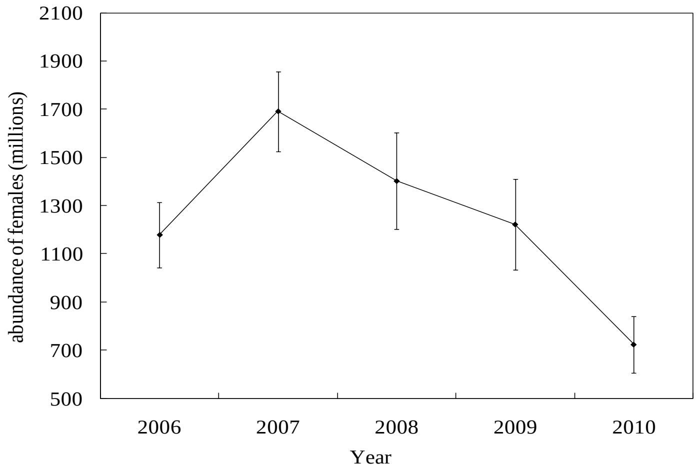


Fig. 5.6. Northern shrimp in Skagerrak and Norwegian Deep: SSB abundance from the Norwegian shrimp surveys in 2006-2010. The abundance index of the spawning stock is calculated as the abundance of females. Error bars are S.E.

The large inter-annual variation in the predator biomass index is mainly due to variations in the saithe and roundnose grenadier indices. The sizes of these indices are heavily influenced by which stations are trawled as saithe is found on the shallowest stations and roundnose grenadier on the deepest ones. An index without these species is shown at the bottom of Table 5.3. The total index of shrimp predator biomass excluding saithe and roundnose grenadier has been at the same level during the 4 last years (Table 5.3).

Table 5.3. Northern shrimp in Skagerrak and Norwegian Deep: Estimated indices of predator biomass (catch in kg per towed nautical miles) from the Norwegian shrimp survey in 2006-2010.

	biomass index				
Species	2006	2007	2008	2009	2010
Blue whiting	0.13	0.13	0.12	1.21	0.27
Saithe	7.33	39.75	208.32	53.89	18.53
Cod	0.51	1.28	0.78	2.01	1.79
Roundnose Grenadier	3.22	6.85	19.02	19.03	10.05
Rabbit fish	2.24	2.15	3.41	3.26	3.51
Haddock	0.97	4.21	1.85	3.18	3.46
Redfishes	0.18	0.40	0.26	0.43	0.80
Velvet Belly	1.31	2.58	1.95	2.42	2.52
Skates, Rays	0.41	0.95	0.64	0.17	0.60
Long Rough Dab	0.22	0.64	0.42	0.28	0.47
Hake	0.98	0.78	0.64	2.56	1.60
Angler	0.15	0.91	0.87	1.25	1.70
Witch	0.24	0.74	0.54	0.16	0.13
Dogfish	0.31	0.19	0.28	0.14	0.11
Whiting	0.00	0.05	0.05	0.15	0.09
Blue Ling	0.35	1.01	1.35	3.02	2.42
Ling	0	0	0	0	0.00
Fourbearded Rockling	0.04	0.11	0.34	0.79	0.64
Cusk	0.06	0.14	0.04	0.03	0.05
Halibut	0.20	0	0.02	0.05	0.13
Pollack	0.08	0.07	3.88	0.09	0.20
Greater Fork-beard	0.06	0.25	0.03	0.13	0.12
Total	18.99	63.19	244.81	94.26	49.23
Total (except saithe and roundnose grenadier)	8.44	16.59	17.47	21.34	20.65

c) Assessment Results

This year's assessment was based on evaluation of both Danish and Norwegian standardised LPUEs and standardised effort from the fishery in 1987-2009, and the survey indices of recruitment and biomass in 2006-2010.

LPUE. The standardised Danish and Norwegian LPUEs have shown similar fluctuations since 2000 (Fig. 5.2). However, in 2008 and 2009 both LPUE indices decreased and the Norwegian index decreased further in 2010 (preliminary data). Both LPUE indices are now below the respective long term means.

Recruitment. The recruitment index (age 1) has decreased since 2007 and in 2010 seems to be only 10% of the recruitment in 2006-2007.

Survey biomass. The biomass index has decreased since 2007.

State of the stock. The Danish LPUE has been fluctuating without any clear trends since the mid-1990s and has since 2007 shown a decline. The Norwegian LPUE indicates a further decline in 2010. The same recent trend is also shown by the survey biomass index. These indices taken together indicate a decrease in stock biomass from 2007 to 2010. The recruitment indices for 2008-2010 have been lower than in 2006-2007 and may presage a further decline in stock biomass in 2011.

d) Biological Reference Points

No reference points were provided in this assessment.

e) Research Recommendations from the 2008 and 2009 meetings

collaborate efforts should be made to standardise a means of predicting recruitment to the fishable stock.

STATUS: Work in progress.

the Norwegian shrimp survey should be continued on an annual basis

STATUS: The survey was conducted in 2010 and will most likely be conducted also in 2011.

Differences in recruitment and stock abundance between Skagerrak and the Norwegian Deep should be explored.

STATUS: This forms part of the research projects described below

the ongoing genetic investigations to explore the relation/connection/mixing between the shrimp (stock units) in Skagerrak and the Norwegian Deep on the one hand and the Fladen Ground shrimp on the other hand should be continued until these relationships have been clarified.

STATUS: A 3-year Norwegian-Swedish-Greenlandic project on shrimp genetics is financed from 2010 onwards. The project's main goal is to explore shrimp stock structure in the whole North Atlantic. Another 3-year Norwegian-Swedish-Danish project on shrimp genetics is financed from August 2010 onwards. This project's main goal is to explore shrimp stock structure in Skagerrak and surrounding fjords.

1) a further development of the Bayesian stock production model presented in 2005 and 2) comparison with and exploration of other assessment models, e.g. new cohort based models, available for this shrimp stock should be carried out.

STATUS: Work in progress

f) 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.*

g) Research Recommendations

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

- *The Swedish effort data should be standardised*
- *Implementation of the SAM model as described in SCR Doc.10/70 and establishment of MSY reference points.*
- *A benchmark assessment is carried out before next NIPAG meeting as suggested by the 2009 Review Group.*

Sources of Information: SCR Doc. 10/62, 67, 70.

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

a) Introduction

Northern shrimp (*Pandalus borealis*) in the Barents Sea and in the Svalbard fishery protection zone (ICES Sub-areas I and II) is considered as one stock (Fig. 6.1). Norwegian and Russian vessels exploit the stock in the entire area, while vessels from other nations are restricted to the Svalbard fishery zone.

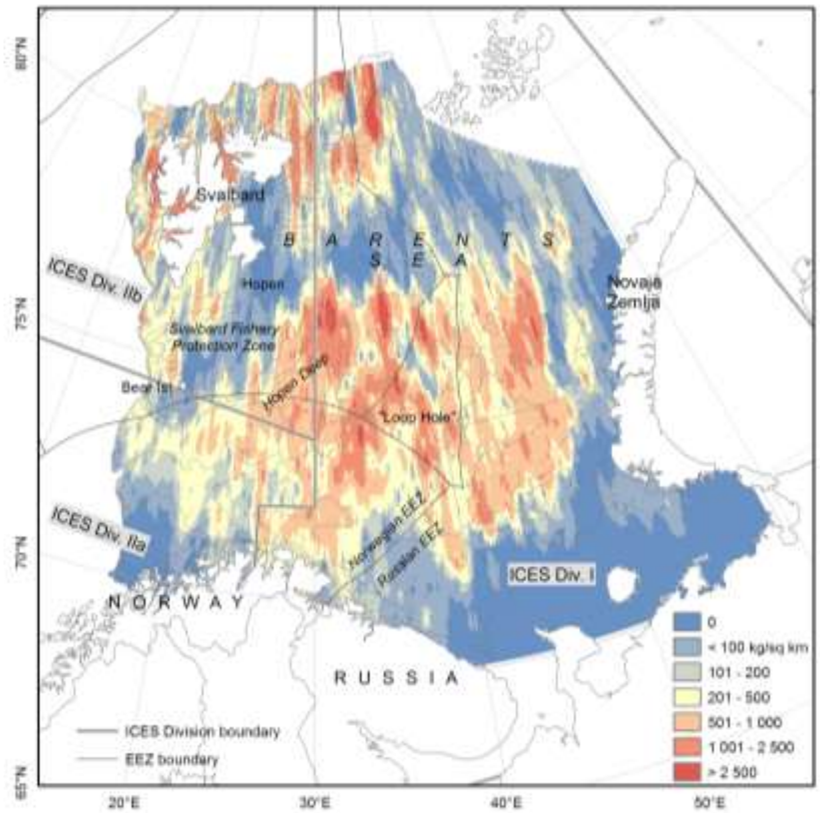


Fig. 6.1. Shrimp in the Barents Sea: stock distribution mean density (kg/km^2) based on survey data 2000-2010.

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. 6.2). During the recent decade catches have varied between 22 000 and 61 000 t/yr, about 75–92% 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 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 (Fig. 6.1). The fishery takes place in all months but is in some 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. 6.2). The most recent peak was seen in 2000 at approximately 83 000 t. Catches thereafter declined to about 23 000 t in 2009 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 2010 catches are predicted to reach 22 200 t.

Table 6.1. Shrimp in ICES SA I and II: Recent catches (2000–2010) in metric tons, as used by NIPAG for the assessment.

	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010[1]
Recommended TAC	-	-	-	-	-	41 299[2]	40 000	50 000	50 000	50 000	50 000
Norway	55 333	43 031	48 799	34 172	35 918	36 966	27 352	25 403	20 638	18 973	18 000
Russia	19 596	5 846	3 790	2 186	1 170	933	0	9	370	370	200
Others	8 241	8 659	8 899	1 599	4 211	3 519	2 282	3 765	5 129	4 000	4 000
Total	83 170	57 536	61 488	37 957	41 299	41 418	29 634	29 177	26 137	23 343	22 200

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

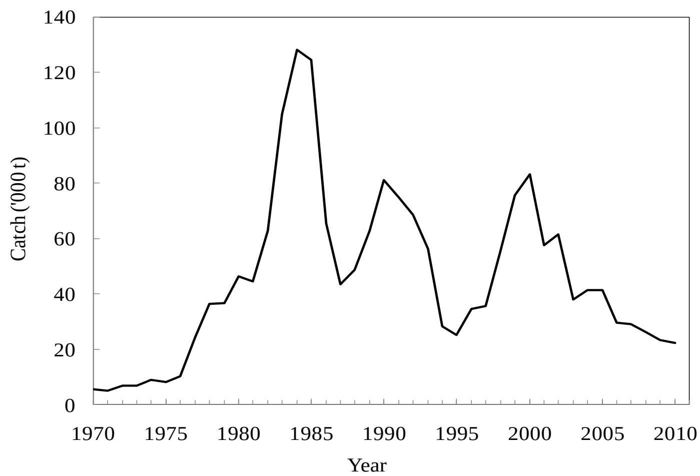


Fig. 6.2. Shrimp in ICES SA I and II: total catches 1970–2010 (2010 projected to the end of the year).

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. 6.3). 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.

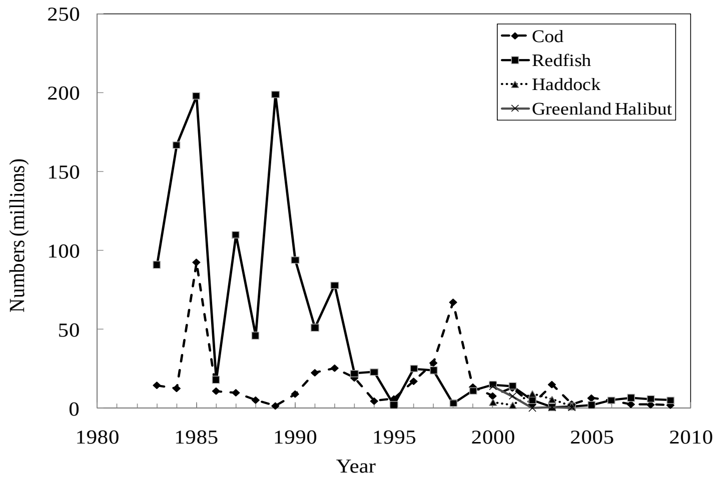


Fig. 6.3. Shrimp in ICES SA I and II: Estimated bycatch of cod, haddock, Greenland halibut and redfish in the Norwegian shrimp fishery (million individuals). No data available for 2010.

Environmental considerations. Temperatures in the Barents Sea have been high during the last eight years, mostly due to the inflow of warm water masses from the Norwegian Sea. The typical temperature increase in spring did not occur in 2008. The low temperatures in April and May of that year may have increased the mortality of young shrimp.

In 2010, temperatures close to the bottom were in general slightly lower than in 2009, but still above the long-term mean by 0.1-0.6°C in most of the surveyed area (Anon., 2010). Only small areas with temperatures below 1°C were observed. Shrimps were only caught in areas where bottom temperatures were above 0°C. Highest shrimp densities were found between zero and 4°C, while the upper limit of temperature preference appeared to lie at about 6-8°C. The wedge of cold near-zero degrees water observed in 2009 in the central Barents Sea which appeared to drive the distribution of shrimps more easterly (Fig. 6.4), has in 2010 shifted/decreased, allowing for potentially increased presence of shrimps in central shelf areas again.

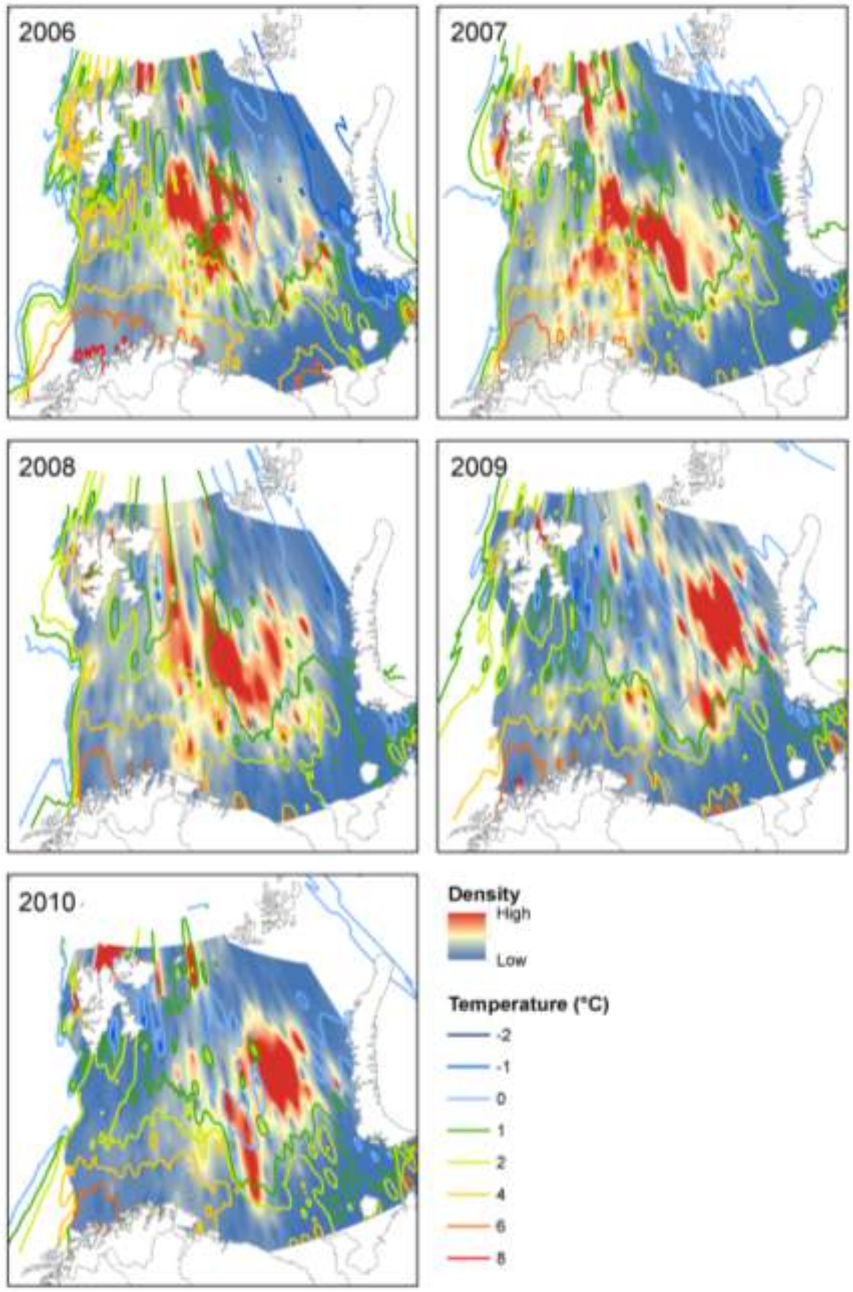


Fig. 6.4. Shrimp in ICES SA I and II: Bottom temperature contour overlays from the 2006 to 2010 ecosystem surveys on shrimp density distributions.

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 HP; 10 years later this value had increased to more than 6 000 HP (Fig. 6.5). 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: 40% of the effort in 2010 is accounted for by this fishing method (Fig. 6.6). An individual vessel may alternate between single and multiple trawling depending on what is appropriate on given fishing grounds.

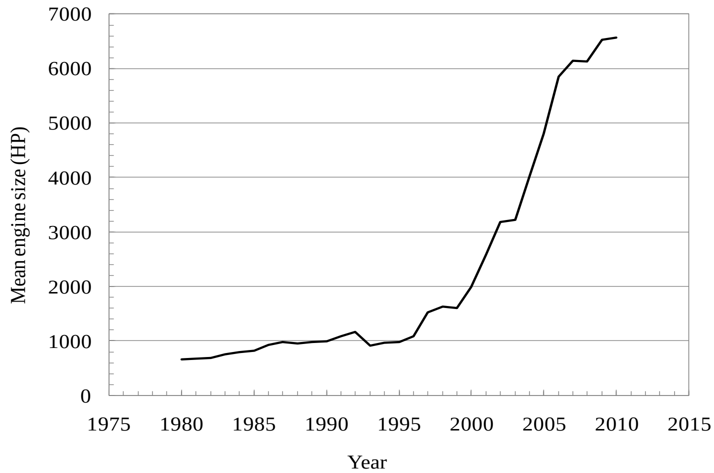


Fig. 6.5. Shrimp in ICES SA I and II: Mean engine size (HP) of trawling in the years 1980–2010.

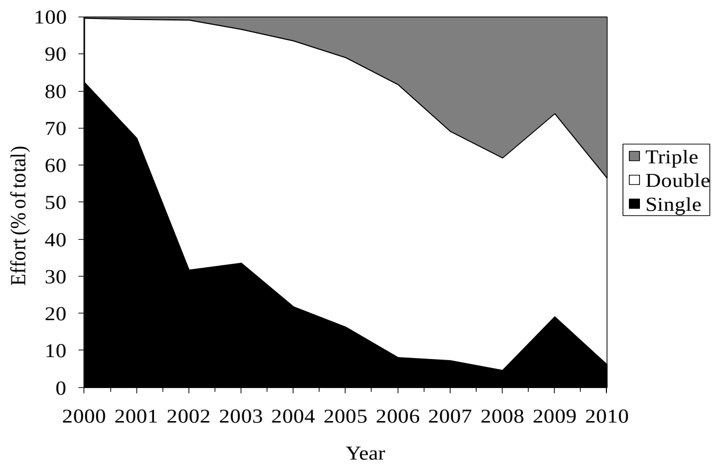


Fig. 6.6. Shrimp in ICES SA I and II: Percentage of total fishing effort spent by using single, double or triple trawls 2000–2010 (Norwegian data).

The fishery is mainly conducted in the Hopen area (central Barents Sea) which, along with the Svalbard shelf (Fig. 6.1), is considered the most important fishing ground. Logbook data from 2009 and 2010 show decreased activity in the Hopen Deep, coupled with increased effort further east in international waters in the so-called "Loop Hole" (SCR Doc. 10/55). Information from the industry points to high densities of shrimp in the Loop Hole and area closures in the traditional Hopen Deep due to juvenile redfish bycatch regulations as the main reasons for the change in fishing pattern.

Norwegian logbook data were used in a multiplicative model (GLM) to calculate standardized annual catch rate indices (SCR Doc. 10/55). A 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. 6.7). Since then it has showed an overall increasing trend. A new peak was reached in 2006. The 2007 to 2010 mean values are all about 10% lower than the 2006-value, but is still above the average of the series. The standardized effort (Fig. 6.8) has shown a decreasing trend since 2000.

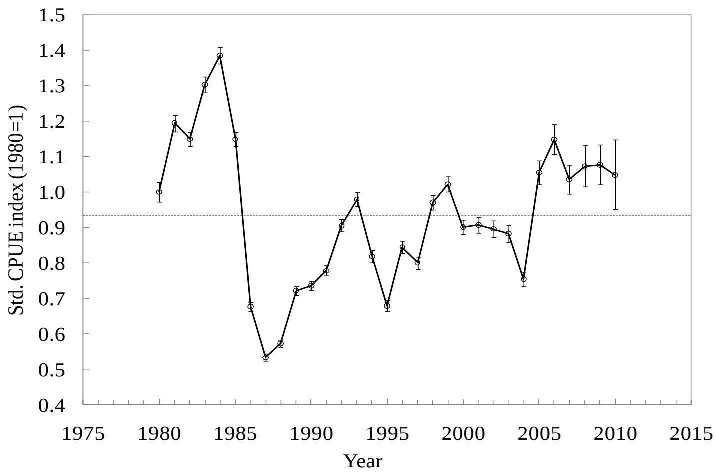


Fig. 6.7. Shrimp in ICES SA I and II: standardized CPUE based on Norwegian data. Error bars represent one standard error; dotted line is the overall mean of the series.

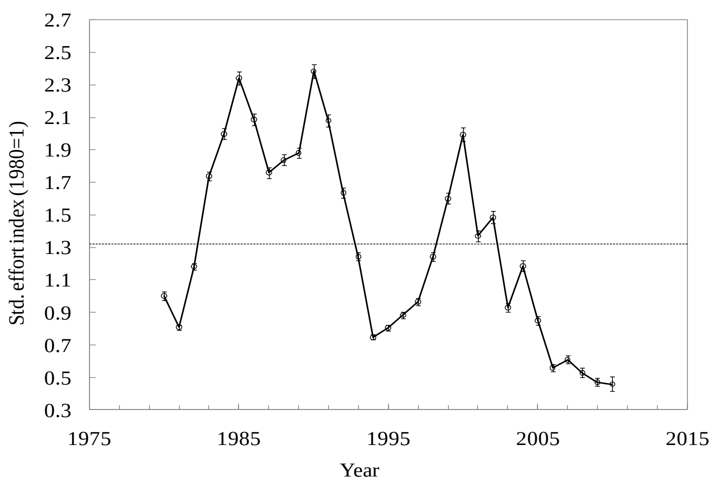


Fig. 6.8. Shrimp in ICES SA I and II: Standardized effort (Catch divided with standardized CPUE). Error bars represent one standard error; dotted line is the overall mean of the series.

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 with periods of approximately 7 years since the start of the series in 1982 (Fig. 6.9). 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 back to the 2004-value in 2008 (Fig. 6.9). The 2010 value is up again by 60% compared to 2008.

The geographical distribution of the stock in 2009-2010 is more easterly compared to that of the previous years (Fig. 6.10).

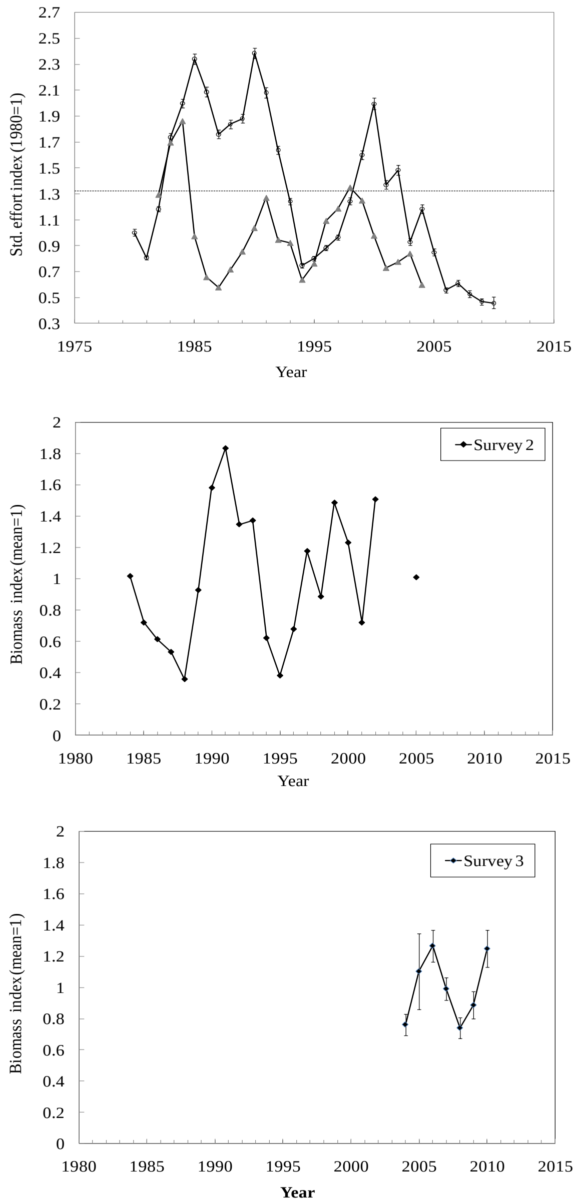


Fig. 6.9. Shrimp in ICES SA I and II: Indices of total stock biomass from the (1) 1982-2004 Norwegian shrimp survey, (2) the 1984-2005 Russian survey, and (3) the joint Russian-Norwegian ecosystem survey. Error bars represent one standard error.

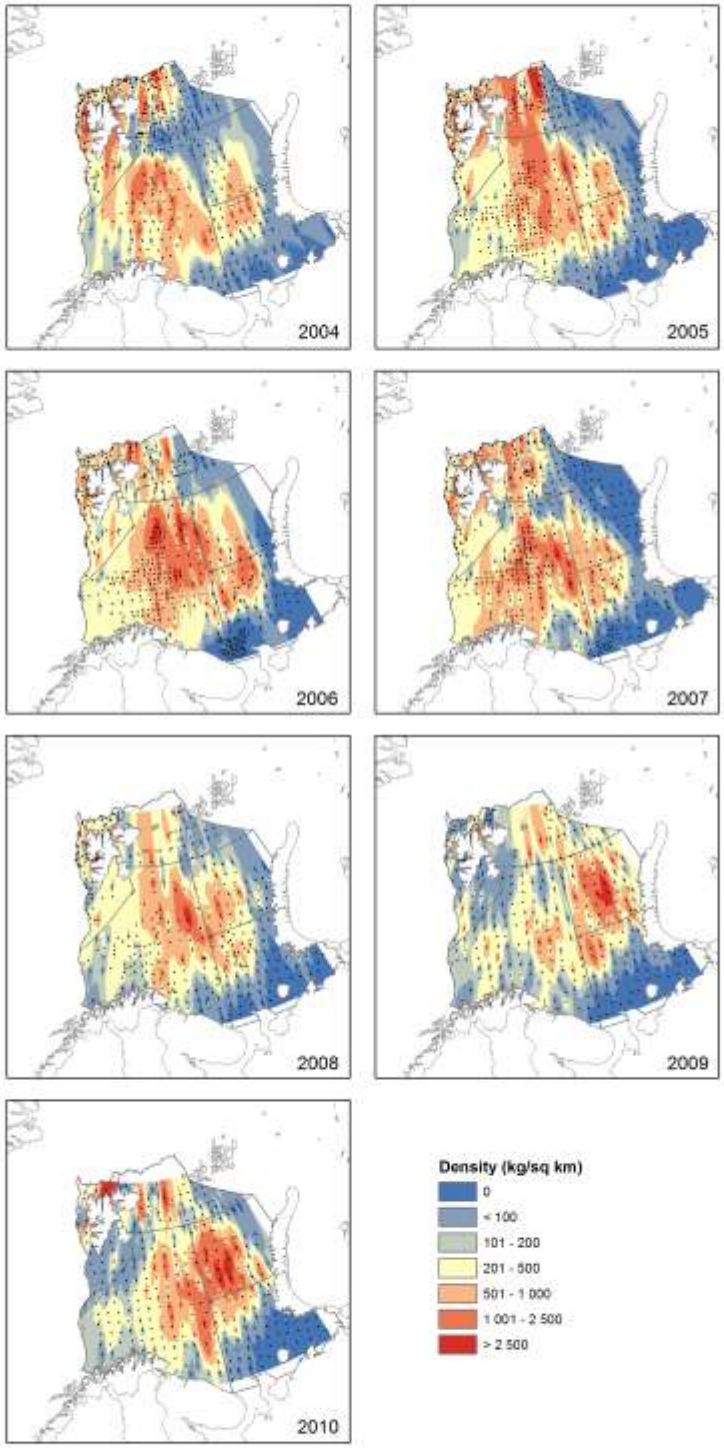


Fig. 6.10. Shrimp in ICES SA I and II: Shrimp density (kg/km^2) as calculated from the Ecosystem survey data 2004–2010).

Length composition. Overall size distributions (Fig. 6.11) indicate a relatively large amount of smaller shrimp in 2004 which may have resulted in the increase in stock biomass until 2006 (Fig. 6.9). A large amount of smaller shrimp is seen again in 2009 (Fig. 6.11).

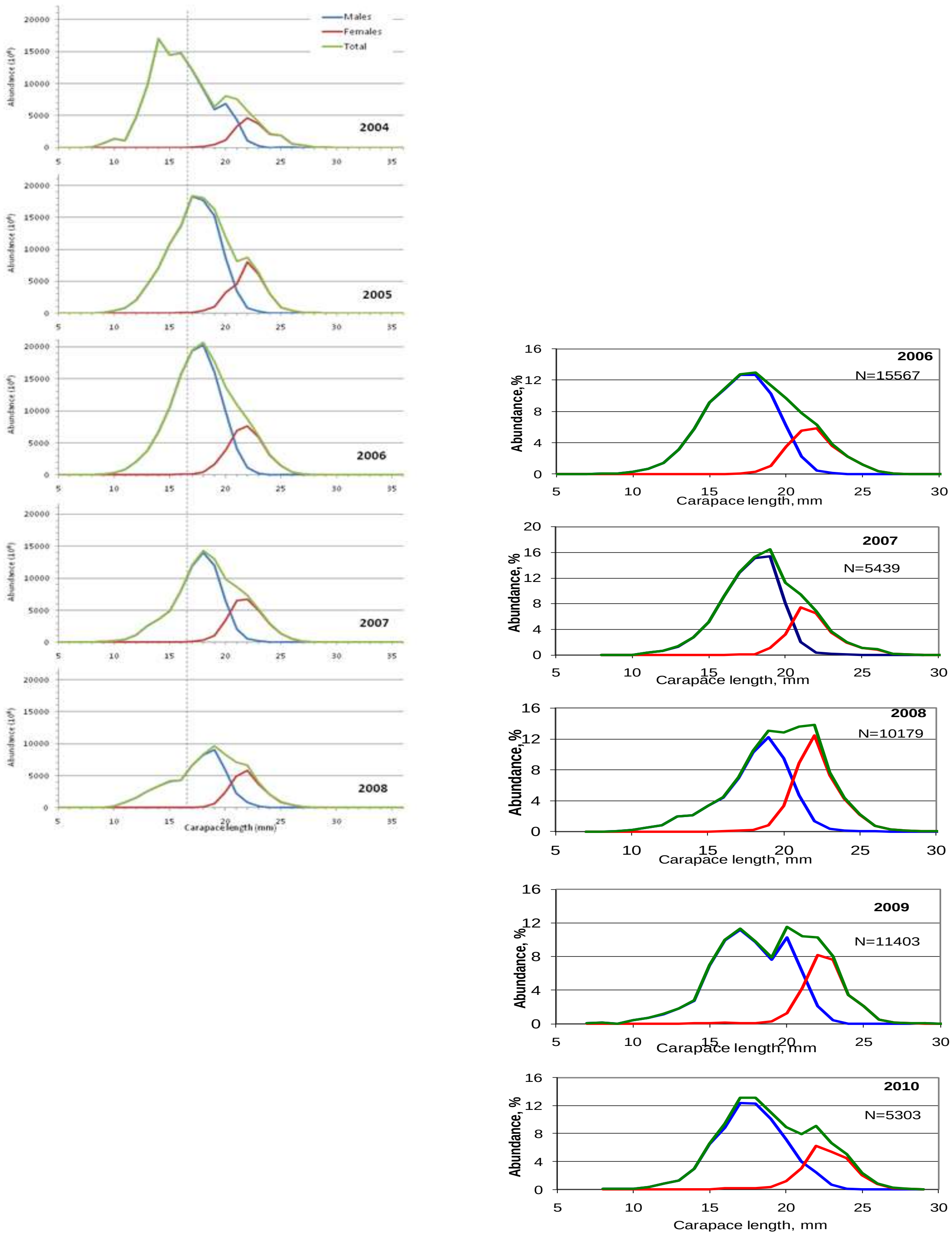


Fig. 6.11. Shrimp in ICES SA I and II: size distribution of males (blue), females (red) and of the total (green) 2004–2008 Norwegian samples (abundance) and 2006-2010 Russian samples (% of the total stock). N = sample size.

Recruitment indices – estimated abundance of shrimp at 13 to 16 mm CL supposed to enter the fishery in the following one-two years have decreased from 2004 to 2008 but were higher in in 2009 and 2010 (Fig. 6.12).

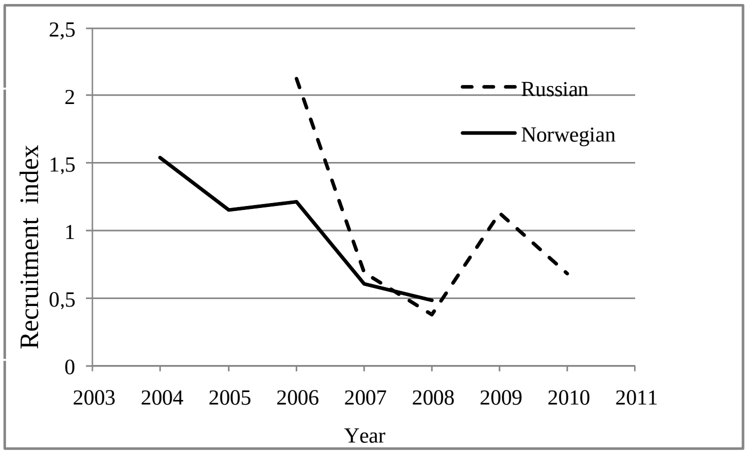


Fig. 6.12. Shrimp in ICES SA I and II: Indices of recruitment: abundance of shrimp at size 13–16 mm CL based on Norwegian survey samples 2004-2008 and Russian survey samples 2006-2010.

c) Estimation of Parameters

The modelling framework introduced in 2006 (Hvingel, 2006) was used for the assessment. Model settings were kept similar to the ones used in previous years except that biomass was estimated to the end of the year instead of to the beginning.

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. 10/61).

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 1980–2010 (Fig. 6.7, SCR Doc. 10/55); and two trawl-survey biomass index for 1982–2004 and 2004–2010 (Fig, 6.9, SCR Doc. 07/75, 10/60). These indices were scaled to true biomass by catchability parameters and lognormal observation errors were applied. Total reported catch in ICES Div. I and II 1970–2010 was used as yield data (Fig. 6.2, SCR Doc. 10/61). 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 on a relative scale where $B_{MSY} = 1$ and the carrying capacity (*K*) equals 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 .

Summaries of the estimated posterior probability distributions 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, B_{msy} = biomass that produces MSY, *r* = intrinsic growth rate, *qC, qR* and *qE* are catchability parameters, P_0 = the 'initial" stock biomass in 1969, σ = CV of CPUE and surveys, and σ_p = the process error.

	Mean	sd	25 %	Median	75 %
MSY (kt)	252	187	114	200	337
K (kt)	3 279	1 821	1 909	2 872	4 240
Bmsy (kt)	1 640	911	955	1 436	2 120
r	0.32	0.16	0.20	0.31	0.43
q_R	0.14	0.11	0.07	0.11	0.17
q_E	0.19	0.15	0.10	0.15	0.24
q_C	5.0E-04	3.8E-04	2.5E-04	3.8E-04	6.1E-04
P_0	1.50	0.26	1.33	1.50	1.67
P_{2010}	2.00	0.55	1.66	1.96	2.30
σ_R	0.18	0.03	0.16	0.18	0.20
σ_E	0.17	0.04	0.15	0.17	0.20
σ_C	0.13	0.02	0.11	0.12	0.14
σ_P	0.19	0.03	0.17	0.19	0.21

Reference points

In 2009 ICES decided also to include a "Maximal Sustainable Yield (MSY) framework" (ACOM. ICES Advice, 2010. Book 1. Section 1.2) for deriving advice. There are now 3 reference points to be considered in relation to ICES type advice: F_{msy}, $B_{trigger}$ and B_{lim}. In the MSY management approach the F_{lim} is somewhat redundant, however, recent discussions on the setting of a F_{lim} reference can be found in the 2009 NIPAG report. F_{msy} and the probability of exceeding it can readily be estimated (Table 6.3 and 6.4) as well as the risk of exceeding B_{lim} which is set at 30% B_{msy} (NIPAG, 2006) and F_{lim} suggested to be 1.7F_{msy} (NIPAG, 2009).

The $B_{trigger}$ is derived from B_{msy}: "$B_{trigger}$ should be selected as a biomass that is encountered with low probability if F_{msy} is implemented" (WKFRAME, 2010). If Fmsy is implemented, then the stock will eventually vary around B_{msy} (Fig. 6.13). Thus, the estimate of B_{msy} that comes from the assessment model will provide the probability distribution needed to quantify what "biomass that is encountered with low probability" under F_{msy} exploitation once "low probability" is quantified.

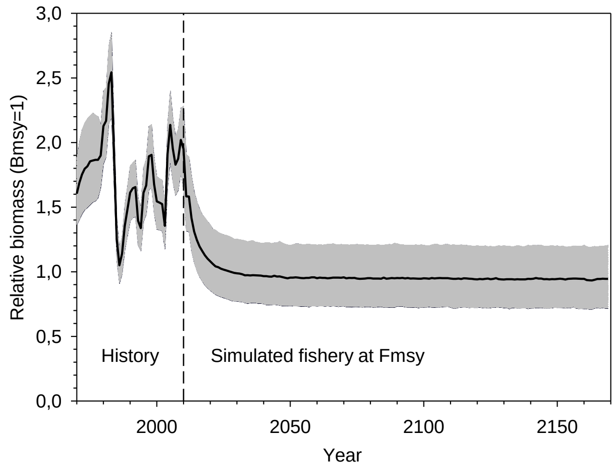


Fig. 6.13**.** Dynamics of stock relative biomass1970-2010 (median and inter-quartile range) and projected 2011 to 2170 assuming exploitation at *Fmsy* and environmental fluctuations within those seen in the modeled period 1970-2010.

Candidate $B_{trigger}$ is found from the lower end of the probability distribution of B_{msy} which in relative biomass terms ($B/B_{msy} = P$) is:

	mean	2.50 %	5.00 %	10%	25%
P_{msy}	1.00	0.299	0.402	0.524	0.715

The 2.5th percentile is right at 0.3 (30% B_{msy}) i.e. the value currently defined as B_{lim}. The 5th percentile is probably too close to B_{lim} to provide much justification for a new reference point. NIPAG suggests as a first approach to set $B_{trigger}$ = 50%B_{msy} which is approximately the 10th percentile of the B_{msy} estimate.

d) Assessment Results

The results of this year's model run are similar to those of the previous years (model introduced in 2006).

Stock size and fishing mortality. Since the 1970s, the estimated median biomass-ratio has been above its MSY-level (Fig. 6.14) and the probability that it had been below B_{msy} was small for most years, *i.e.* it seemed likely that the stock had been at or above B_{msy} since the start of the fishery.

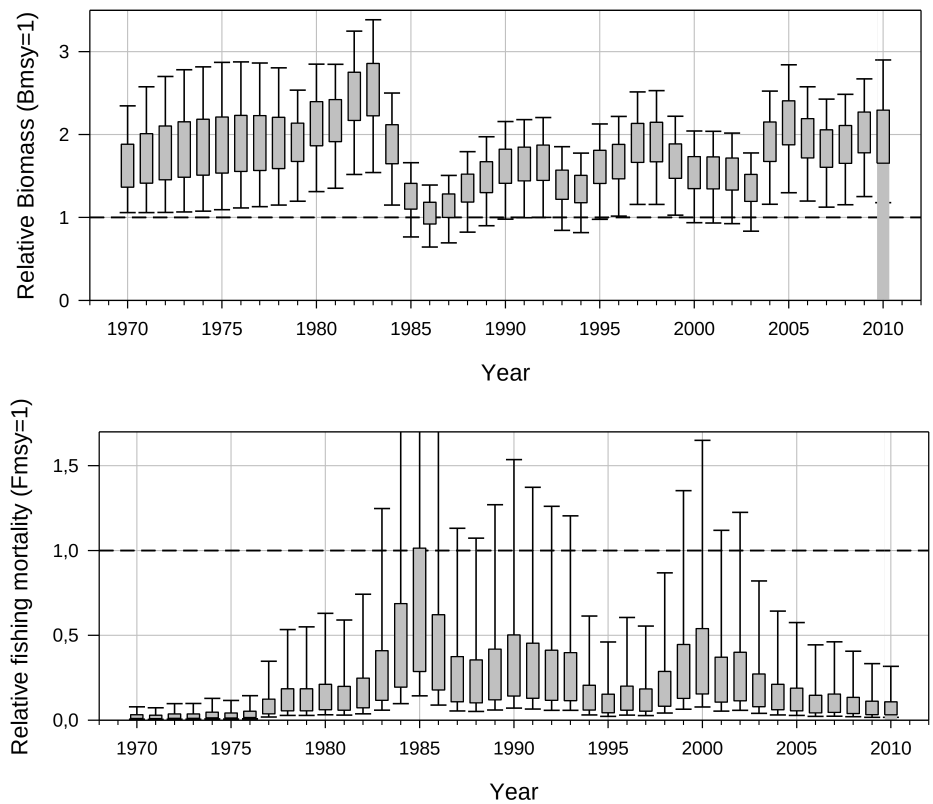


Fig. 6.14. Shrimp in ICES SA I and II: estimated relative biomass (B_t/B_{msy}) and fishing mortality (F_t/F_{msy}) for the years (t) 1970–2010. Boxes represent inter-quartile ranges and the solid black line at the (approximate) centre of each box is the median; the arms of each box extend to cover the 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 B_{msy} (Fig. 6.14). Since the late 1990s the stock has varied with an overall increasing trend and reached a level in 2010 estimated to be close to K. The estimated risk of stock biomass being below B_{msy} in 2010 was 2.5% (Table 6.3). The median fishing mortality ratio (F-ratio) has been well below 1 throughout the series (Fig. 6.14). In 2010 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 2009 and predicted to the end of 2010. (1.7 F_{msy} = fishing mortality that corresponds to a B_{lim} at 0.3B_{msy}).

Status	2009	2010*
Risk of falling below B_{lim} (0.3B_{MSY})	0.0 %	0.0 %
Risk of falling below $B_{trigger}$ (0.5B_{MSY})	0.1 %	0.2 %
Risk of falling below B_{msy}	2.2 %	2.6 %
Risk of exceeding F_{msy}	0.9 %	0.9 %
Risk of exceeding 1.7F_{msy}	0.4 %	0.4 %
Stock size (B/B_{msy}), median	2.04	1.96
Fishing mortality (F/F_{msy}), median	0.06	0.06
Productivity (% of *MSY*)	-8 %	7 %

*Predicted catch = 22.2 kt

Estimated median biomass has been above B_{lim} and fishing mortality ratio has been below F_{msy} throughout the time series (Fig. 6.15). At the end of 2010 there is less than 1% risk that the stock would be below $B_{trigger}$, while the risk that F_{msy} will be exceeded is 1% (Table 6.3).

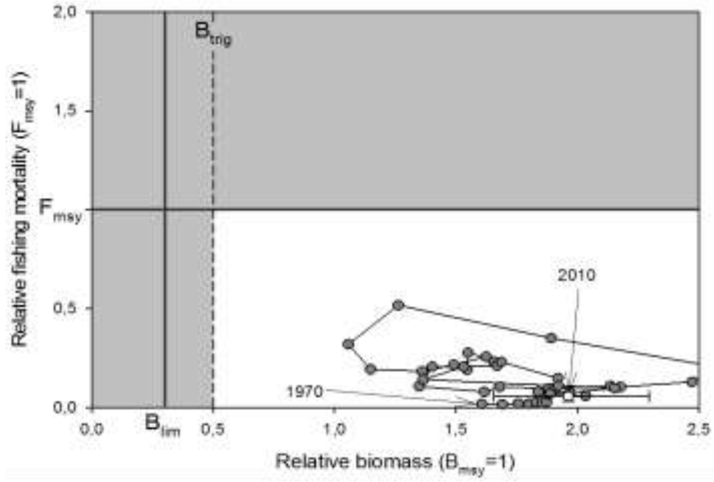


Fig. 6.15. Shrimp in ICES SA I and II: Estimated annual median biomass-ratio (B/B_{msy}) and fishing mortality-ratio (F/F_{msy}) 1970–2010. The reference points for stock biomass, B_{lim}, and fishing mortality, F_{msy}, are indicated by the red (bold) lines and $B_{trigger}$ is shown as black dashed line. Error bars on the 2010 value are inter-quartile range.

Predictions. Catch options of up to 60 kt/yr for 2011 have a low risk (<5%) of exceeding F_{msy} and is likely to maintain the stock at its current high level (Table 6.4), however, the stock may likely sustain catches higher than that.

Table 6.4. Shrimp in ICES SA I and II: Predictions of risk and stock status associated with six optional catch levels for 2011. (1.7 F_{msy} = fishing mortality that corresponds to a B_{lim} at 0.3B$_{msy}$).

Catch option 2011 (kt)	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 $B_{trigger}$ (0.5B_{msy})	0.2 %	0.2 %	0.3 %	0.3 %	0.3 %	0.3 %
Risk of falling below B_{msy}	3.1 %	3.1 %	3.2 %	3.3 %	3.4 %	3.7 %
Risk of exceeding F_{msy}	1.4 %	2.2 %	3.3 %	4.5 %	5.8 %	8.9 %
Risk of exceeding 1.7F_{msy}	0.7 %	1.0 %	1.4 %	1.9 %	2.5 %	4.0 %
Stock size (B/B_{msy}), median	1.92	1.91	1.90	1.89	1.89	1.87
Fishing mortality (F/F_{msy}),	0.08	0.10	0.13	0.16	0.18	0.24
Productivity (% of *MSY*)	16 %	17 %	18 %	20 %	22 %	24 %

The risk associated with ten-year projections of stock development assuming annual catch of 30 000 to 90 000 t were investigated (Fig. 6.16). For all options the risk of the stock falling below B_{msy} in the short to medium term (1-5 years) is low (<10%) and all of these catch options result in a probability of less than 5% of going below $B_{trigger}$ over a 10 year period (Fig. 6.14). Catch options up to 60 000 t, have a low risk (<5%) of exceeding F_{msy} in the short term (Fig. 6.15).

Taking 70 000 t/yr will increase the risk of going below B_{msy} to more than 10% during the ten years of projection (Fig. 6.16). However, the risk of going below $B_{trigger}$ remains under 5%. The risk that catches of this magnitude will not be sustainable (*prob* ($F > F_{MSY}$) in the longer term increase as compared to the 60 000 t option but is still below 10% after ten years.

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

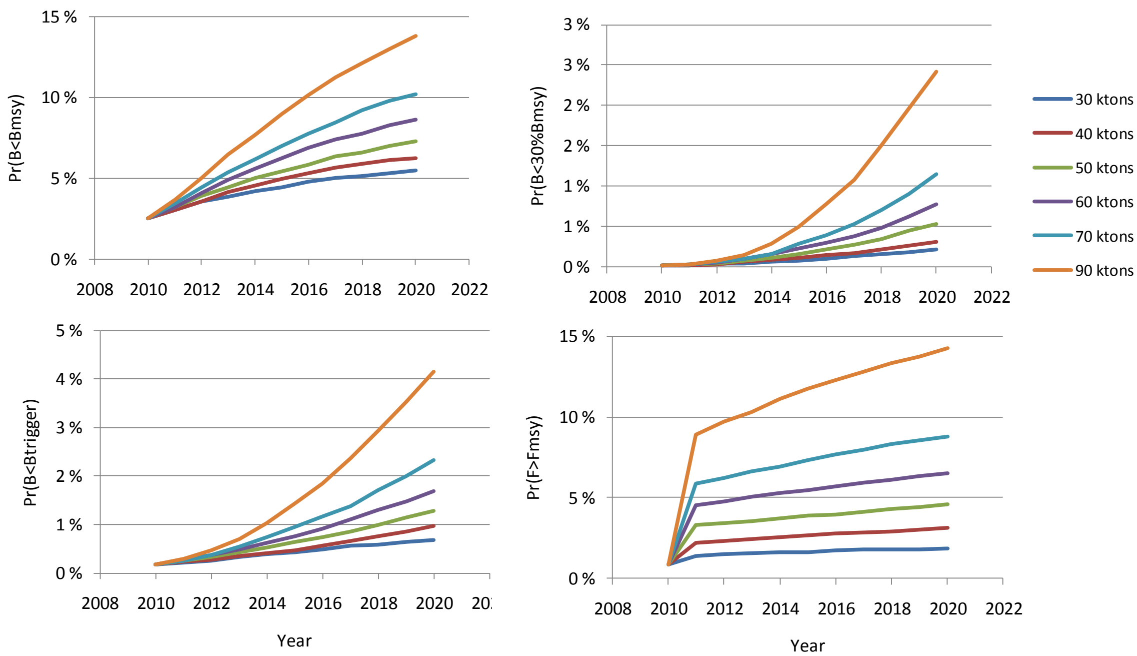


Fig. 6.16. Shrimp in ICES SA I and II: Projections of estimated risk of going below B_{msy} and B_{lim} (top) and of going below $B_{trigger}$ and of exceeding F_{msy} (bottom) given different catch options (see legend).

Yield predictions can be made for fishing mortalities at F_{msy}, but such estimates will have high uncertainty attached as absolute biomass can only be estimated with relatively high variances (see section on "estimation of parameters") and therefore point estimates should be interpreted with caution. However, the risk of exceeding F_{msy} at different catch options may be read of such prediction tables as the percentiles of the estimated probability distribution of the yield prediction (Table 6.5). At a 5% probality of exceeding F_{msy} the yield would be 68 kt for 2011, at 10% it would be 100 kt, etc.

Table 6.5. Shrimp in ICES SA I and II: Predictions of yield (kt) at F_{msy}, mean, standard error and percentiles (= risk of exceeding F_{msy}).

Year	mean	sd	2.5 %	5 %	10 %	25 %	median	75 %	90 %	95 %	97.5 %
2011	404	307	44	68	100	180	324	544	825	1029	1214
2012	405	307	44	66	99	180	323	547	832	1029	1213
2013	363	274	43	63	93	164	290	486	738	921	1082
2014	336	254	41	60	88	153	269	448	681	848	1005
2015	317	242	39	57	84	145	251	421	645	809	958
2016	304	234	38	55	80	138	240	403	624	776	918
2017	294	228	37	54	78	132	231	388	604	760	898
2018	287	224	36	53	75	128	224	378	583	740	882
2019	281	220	35	51	73	125	219	370	572	727	868
2020	276	218	35	50	72	122	214	363	567	720	864

Additional considerations

Model performance. The model was able to produce reasonably good simulations of the observed data (Fig. 6.17) and the observations did not lie in the extreme tails of their posterior distributions (SCR Doc. 10/61) 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. 6.18).

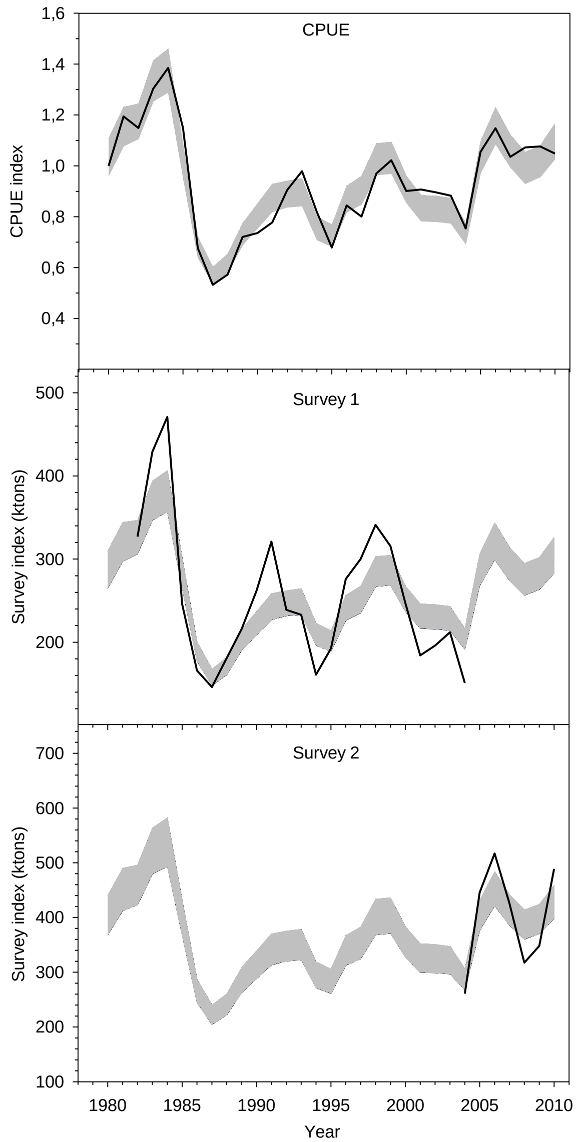


Fig. 6.17. Shrimp in ICES SA I and II: Observed (solid line) and estimated (shaded) series of the included biomass indices: the standardized catch-per-unit-effort (CPUE), the 1982–2004 shrimp survey (survey 1) and the joint Norwegian-Russian Ecosystem survey (survey 2). Grey shaded areas are the inter-quartile range of the posteriors.

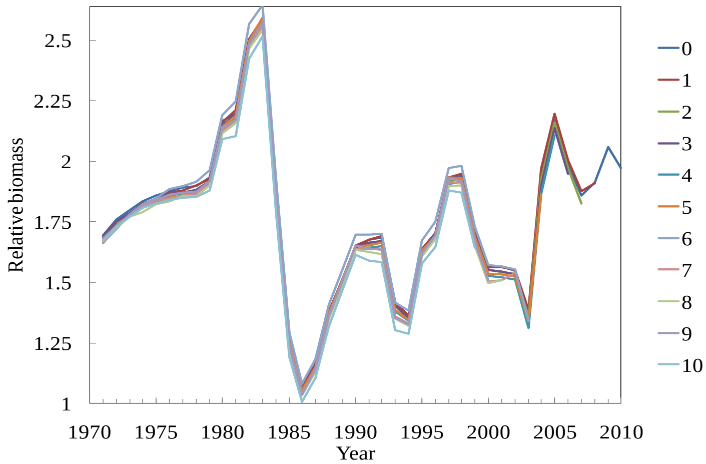


Fig. 6.18. Shrimp in ICES SA I and II: Retrospective plot of median relative biomass (B/B_{msy}). Relative biomass series are estimated by consecutively leaving out from 0 to 10 years of data.

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 large amounts of shrimp. If predation on shrimp were to increase rapidly outside the range previously experienced by the shrimp stock within the modelled period (1970–2010), 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.

Biomass exceeding K. NIPAG discussed the significance of the model estimating it likely that the stock was larger than *K* (carrying capacity) particularly in the early 1980s. The model has no constraint on the magnitude on the possible values of stock biomass. *K* overshoots are likely events due to year to year variability in *K* for the fishable fraction of the stock alone (shrimp ≥17 mm CL). But may also result from the variability of “carrying capacities” of the different lifestages of shrimp smaller than 17 mm CL not nessesarily match.

e) Summary

Mortality. The fishing mortality has been below F_{msy} throughout the exploitation history of the stock. The risk that F will exceed F_{msy} in 2010 is estimated at about 1%, given a projected 2010 catch of 22 200 t.

Biomass. The Stock is estimated to be close to the carrying capacity. The estimated risk of stock biomass being below B_{msy} at end 2010 is 3%, and less than 1% of being below $B_{trigger}$ and B_{lim}.

Recruitment. Recruitment indices have decreased from 2004 to 2008 but were higher in 2009 and 2010

State of the Stock. The stock biomass estimates have been above B_{msy} throughout the history of the fishery. Biomass at the end of 2010 is estimated to be well above B_{msy} and fishing mortality well below F_{msy}.

Yield. A catch option of up to 68 000 t for 2011 would have less than 5% risk of exceeding F_{msy}. Catch options up to 60 000 t/yr, have a low risk (<5%) of exceeding F_{msy} in the coming 4 years.

f) Review of Recommendations from 2009

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

Demographic information continue to be collected.

STATUS: No progress

Collaborative efforts should be made to standarsize a means of predicting recruitment to the fishable stock.

STATUS: No progress.

Work to include explicit information on recruitment in the assessment model should be continued.

STATUS: Work in progress.

g) Review of Management Recommendations from 2009

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).*

STATUS: No progress.

h) Research Recommendations

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

- *Demographic information (length, sex and stage etc.) be collected also from the Norwegian part of* ***the Barents Sea ecosystem survey.***
- *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.*

Sources of Information: SCR Doc. 04/12, 06/64, 70; 07/75, 86; 08/56; 10/55, 60, 61 68.

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	2009
Denmark	3 022	2 900	1 005	1 482	1 263	1 147	999	23	10	0	0	0	0
Norway	9	3	9		18	9	8	0	0	0	0	0	0
Sweden							1	0	0	0	0	0	0
UK (Scotland)	365	1 365	456	378	397	70		0	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	0

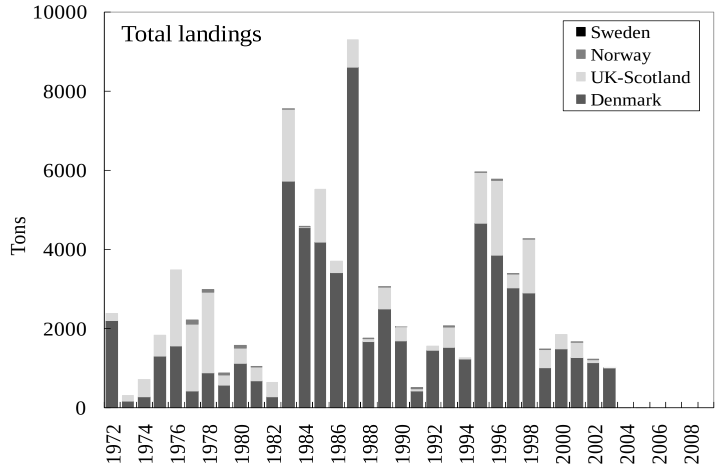


Fig. 6.1. Northern shrimp in Fladen Ground: Catches

8. PA reference points for shrimp in Div. 3LNO - NAFO

This request from Fisheries Commission was also addressed to Scientific Council in 2009 (*NAFO Sci. Coun. Rep.*, 2009, page 232). NIPAG has been working to provide values for these reference points. Appropriate models have not yet been developed to a point where they have been accepted as a basis for the determination of reference points, and so NIPAG is unable to provide appropriate reference points to address this request.