6.4.28 Northern Shrimp (*Pandalus borealis*) in the Barents Sea, ICES Divisions I and II

State of the stock

Spawning biomass in relation to precautionary limits	Fishing mortality in relation to precautionary limits	Fishing mortality in relation to highest yield	Fishing mortality in relation to agreed target	Comment
Acceptable	Acceptable	Below $\mathbf{F}_{msy}$	NA	This year's assessment was based on a new quantitative assessment framework.

The stock estimates have varied above the $\mathbf{B}_{MSY}$ level throughout the history of the fishery. Biomass at the end of 2006 is estimated to be well above $\mathbf{B}_{msy}$ and fishing mortality well below $\mathbf{F}_{msy}$.

Management objectives

There are no explicit management objectives for this stock.

Reference points

For stocks assessed with production models, the NAFO Scientific Council has developed limit reference points for stock size ($\mathbf{B}_{lim}$ at 30% of $\mathbf{B}_{msy}$) and for fishing mortality ($\mathbf{F}_{lim} = \mathbf{F}_{msy}$) (SCS Doc. 04/12). ICES proposes that these limit reference points should also apply to the Barents Sea shrimp stocks.

Single-stock exploitation boundaries

Exploitation boundaries in relation to precautionary limits

ICES recommends that a TAC management system should be implemented. The TAC for 2007 should not be set higher than 50 000 t in order to have a high probability of F being below $\mathbf{F}_{lim}$ and B being above $\mathbf{B}_{lim}$.

Short-term implications

Outlook for 2007

Because the stock is estimated to be considerably above $\mathbf{B}_{msy}$, risk of stock biomass falling below $\mathbf{B}_{msy}$ within one year is low. In order to keep the risk of F exceeding $\mathbf{F}_{lim}$ to below 5%, a total catch of 50 000 t could be taken. Risk associated with six optional catch levels for 2007 are presented below:

Catch option (ktons)	30	50	70	90	110	130
Risk of falling below B_{lim}	<1%	<1%	<1%	<1%	<1%	1 %
Risk of falling below B_{MSY}	4 %	4 %	5 %	5 %	5 %	6 %
Risk of exceeding F_{MSY}	2 %	4 %	8 %	12 %	17 %	21 %

Management considerations

There is no overall management system for Barents Sea Pandalus fishery. Fishing licences are required for all shrimp vessels. In the Svalbard Fishery Protection Zone (SFPZ), effort regulations based on historical rights are implemented. However, this has not limited the fishing effort of Russian and Norwegian fleets because the high effort ceiling has not been reached. The effort regulations are restrictive for third countries fishing in the SFPZ. In the Russian zone a TAC is applicable.

Predation of shrimp by cod has been estimated to be on average five times the catches. If predation on shrimp were to increase rapidly outside the previously observed range, the shrimp stock might decrease in size more than the model results have indicated.

Management plan evaluations

The risk profile associated with ten-year projections of stock development assuming annual catches of 50, 70, and 90 kt indicates that for all options the risk of the stock falling below $\mathbf{B}_{msy}$ in the short to medium term (1–5 years) is below

11% (Figure 6.4.28.4). The stock has a less than 1% risk of being below $\mathbf{B}_{lim}$ and none of these catch options are likely to increase that risk above 5% over a 10-year period. Catch levels of 70 and 90 kt imply probabilities of exceeding $\mathbf{F}_{lim}$ that are above 5%.

Factors affecting the fisheries and the stock

Regulations

The fishery is regulated by effort control. Licences are required for the Russian and Norwegian vessels, and third-country fleets operating in the Svaldbard zone are regulated 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 with excessive bycatch of juvenile cod, haddock, Greenland halibut, redfish, and shrimp <15 mm carapace length (CL).

Changes in fishing technology and fishing patterns

A major restructuring of the fleet towards fewer and larger vessels has taken place since the mid-1990s. In 1995 6% of the catches reported in logbooks were taken by large factory trawlers (>2000 HP); this fleet component accounted for more than 95% in 2006.

The environment

Shrimp consumption by cod is estimated to be on average five times that of the catches. Nevertheless, the effect of predation is only weakly correlated with the dynamics of the shrimp stock. The scaling and variation originating from the underlying spatial structure of the shrimp stock and the consumption by cod could be an explanation for the lack of correlation.

Scientific basis

Method and data

The available data consists of landings by country, a Norwegian standardized commercial CPUE series, and two surveys: (1) a Norwegian shrimp survey (1982–2004) and (2) a joint Norwegian-Russian ecosystem survey (2004–2006). The new ecosystem survey has not been calibrated with the old shrimp survey and has been treated as a separate survey. A Russian shrimp survey which was discontinued in 2003 (except for a one-off survey in 2005) was not used in the assessment.

A Bayesian version of a surplus-production model was used to assess the stock. Absolute biomass estimates had relatively high variances. To reduce the uncertainty in the estimates, biomass was expressed on a scale relative to $\mathbf{B}_{msy}$ and F relative to $\mathbf{F}_{msy}$.

Comparison with previous assessment and advice

Last year the advice was based on trends in LPUE and surveys. This year a Bayesian stock-production model was used to estimate stock trends. The overall perception of stock dynamics is similar to last year.

The advice last year was to keep catches at the recent average (40 000 t). This year the advice is based on a long-term simulation approach which indicates that a catch of 50 000 t gives a low risk of exceeding $\mathbf{F}_{lim}$ or going below $\mathbf{B}_{lim}$.

Source of information

Report of the NAFO/ICES *Pandalus* Assessment Group, Copenhagen, 25 October–2 November 2006 (ICES CM 2007/ACFM:37).

Year	ICES Advice	Single-stock exploitation boundaries	Predicted lndgs corresp. to advice	Predicted lndgs corresp. To single-stock exploitation boundaries	Agreed TAC	ACFM Landings
2005	No increase compared to 2004			43.6	-	40.8
2006	No increase in catch above recent level			40	-	39
2007	Catch that will prevent exceeding $\mathbf{F}_{lim}$ in the long term			50		

Weights in thousand tonnes.

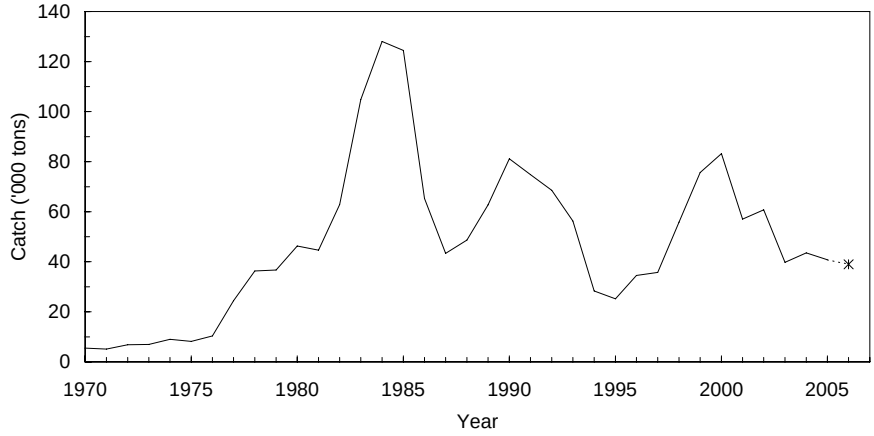

Figure 6.4.28.1 *Pandalus borealis* in the Barents Sea, ICES Div. I and II. Landings estimated by ICES (2006 projected to the end of the year).

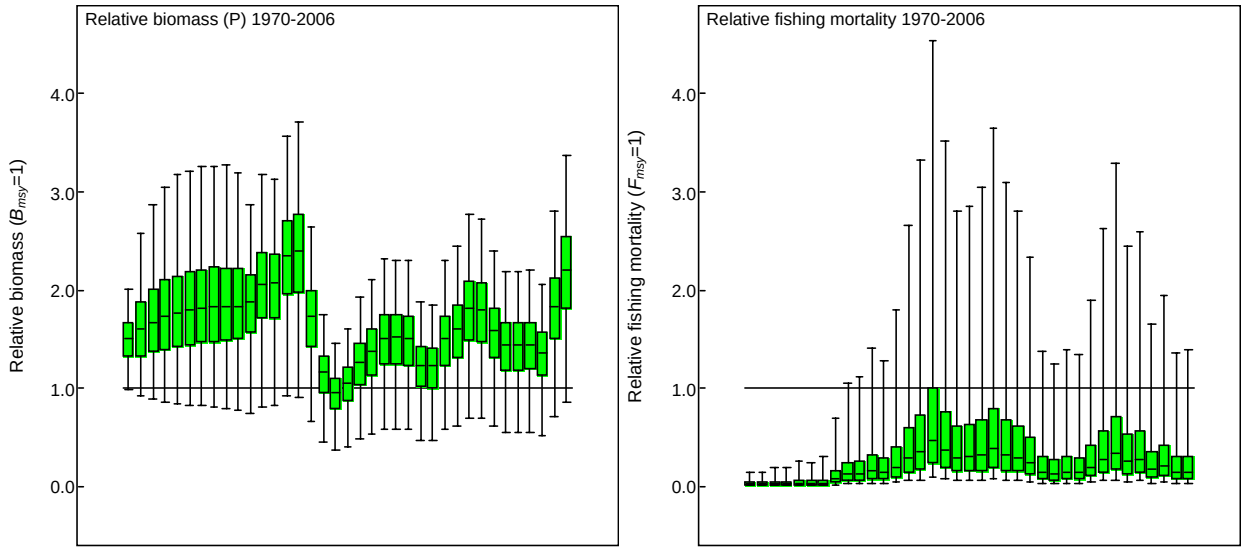

Figure 6.4.28.2 *Pandalus borealis* in the Barents Sea, ICES Div. I and II. Estimated relative biomass ($\mathbf{B}_t/\mathbf{B}_{msy}$) and fishing mortality ($\mathbf{F}_t/\mathbf{F}_{msy}$) 1970–2006. Boxes represent inter-quartile ranges and the solid black line at the (approximate) centre of each box is the median; the arms of each box extend to cover the central 95 per cent of the distribution.

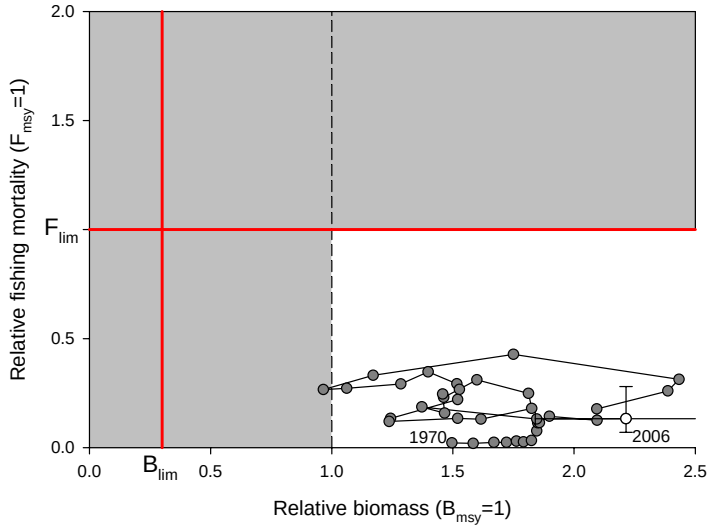

Figure 6.4.28.3 *Pandalus borealis* in the Barents Sea, ICES Div. I and II. Estimated annual median biomass-ratio ($B/\mathbf{B}_{MSY}$) and fishing mortality-ratio ($F/\mathbf{F}_{MSY}$) 1970–2006. $\mathbf{B}_{lim}$, and $\mathbf{F}_{lim}$, are indicated by red lines. Error bars on the 2006 value mark the inter-quartile range.

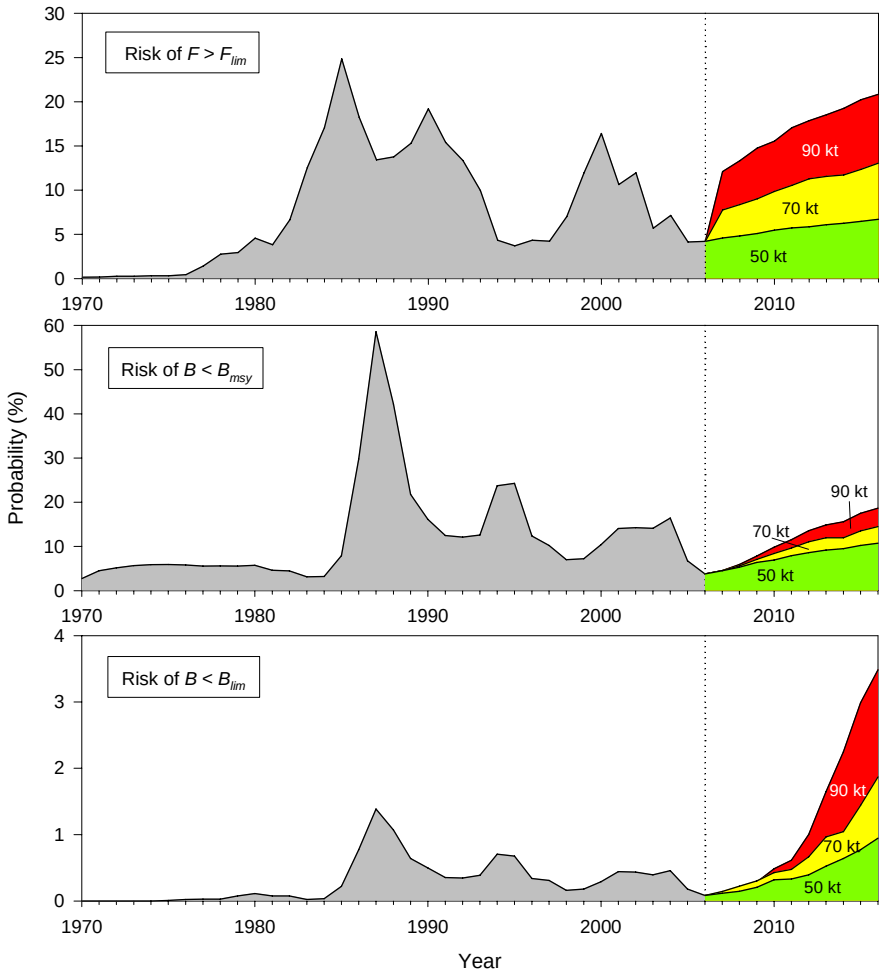

Figure 6.4.28.4 *Pandalus borealis* in the Barents Sea, ICES Div. I and II. Shrimp in the Barents Sea: Estimated risk of exceeding $\mathbf{F}_{lim}$ (upper panel) or going below $\mathbf{B}_{msy}$ (middle panel) and $\mathbf{B}_{lim}$ (lower panel) for the period 1970–2006 (greyed area) and future (coloured area) until 2016. Projections are shown for 3 optional catches 50 (green), 70 (yellow), and 90 kt/yr (red). The dotted line is at 2006.

Table 6.4.28.1 *Pandalus borealis* in the Barents Sea, ICES Div. I and II. Model input data series: Catch by the fishery; three indices of shrimp stock biomass – a standardized catch rate index based on fishery data (CPUE), a research survey index (the "shrimp survey", discontinued in 2004), and the current "Ecosystem survey" started in 2004.

Year	Catch (ktons)	CPUE (index)	Survey 1 (ktons)	Survey 2 (ktons)
1970	5.5	-	-	-
1971	5.1	-	-	-
1972	6.8	-	-	-
1973	6.9	-	-	-
1974	9.0	-	-	-
1975	8.2	-	-	-
1976	10.3	-	-	-
1977	24.4	-	-	-
1978	36.3	-	-	-
1979	36.7	-	-	-
1980	46.3	0.767	-	-
1981	44.6	0.890	-	-
1982	62.8	0.845	327	-
1983	104.8	0.963	429	-
1984	128.1	1.006	471	-
1985	124.5	0.799	246	-
1986	65.3	0.482	166	-
1987	43.4	0.365	146	-
1988	48.7	0.400	181	-
1989	62.7	0.522	216	-
1990	81.2	0.522	262	-
1991	74.9	0.551	321	-
1992	68.6	0.634	239	-
1993	56.3	0.678	233	-
1994	28.3	0.536	161	-
1995	25.2	0.472	193	-
1996	34.5	0.606	276	-
1997	35.7	0.594	300	-
1998	55.8	0.716	341	-
1999	75.7	0.731	316	-
2000	83.2	0.656	247	-
2001	57.0	0.659	184	-
2002	60.7	0.650	196	-
2003	39.3	0.645	212	-
2004	43.4	0.577	151	129
2005	41.3	0.841	-	145
2006	0.0	1.000	-	188