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A quest for management objectives –

case study on the Barents Sea Capelin

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Abstract

The Barents Sea capelin is a short lived arctic pelagic species and a shared Norwegian-Russian stock. Although the management objectives for Barents Sea capelin have not been explicitly stated, the management authorities have agreed on a harvest control rule. The main element of the harvest control rule is a target spawning stock escapement strategy. Within Norway there are several stakeholders groups. These groups differ in their view of how the capelin resource should be utilized. Broadly speaking the views range from coastal fishers that argue that the main objective should be no capelin fishery in order to maximize cod availability (cod follows and feeds on the capelin migrating to the spawning areas near the coast) to the deep sea fishers who tend to argue for a maximization of the output (value) of the capelin fishery. The aim of the present paper is to systematize and indentify core elements in the view of the stakeholder groups in an ecological and economic context, and how communication and dialogue between stakeholders, fishery scientists and managing authorities can take place in order to obtain a consensus of how to best utilize this stock in a long term view. On a background of the biological knowledge base of the capelin, further emphasis is put on the role of the scientists in transforming a possible consensus view into an operational harvest control rule.

Keywords: Short lived pelagic species, management objectives, stakeholder views, harvest control rules.

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Introduction

The capelin is an important transformer of energy and proteins from the lower parts of the food chain (plankton) to higher levels of the food chain in the Barents Sea. This is done by direct predation by capelin (cod, sea mammals, sea birds), but also the eggs (haddock, king crab) may be important elements in the food chain. The capelin die after spawning, and the relevance of the post-spawning dead capelin as a source for food and strengthening of the coastal ecosystem is not well understood. How should such an important natural resource of the Barents Sea be utilized? The aim of the present paper is:

- To systematize viewpoints (mainly in a Norwegian context) of how the capelin stock should be utilized in the light of traditional fisheries and ecosystem considerations.

- Sketch management objectives based on possible compromise viewpoints

- Suggest viewpoints of how the work of the fisheries scientists can transform such management objectives to an operational harvest control rule

The capelin stock in an ecosystem context

In summer and autumn the adult stock is found in the central to northern part of the Barents Sea, feeding heavily on copepod and euphausiids. During late autumn the stock concentrates in an area south of the polar front, and during January- March the maturing part of the stock (3-5 years old, larger than 14 cm) start migration toward the spawning grounds near the coast of northern Norway and Russia (Fig 1). Spawning takes place in March-April and demersal eggs are laid in sand and gravel spawning beds at depths of 20-60 m. Spawning mortality is substantial and in addition there is normally a very high predation due to young cod following the migration of the capelin. The eggs hatch after 3-6 weeks, and the larvae drift with the current into the southern parts of the Barents Sea. (Gjøsæter 1998) The stock abundance has varied between 0.1 and 7 million tonnes in the later 30 years. Thus in an ecosystem context the capelin is an important transformer of energy and proteins from the lower parts of the food chain (plankton) to higher levels of the food chain. This is done by direct predation by capelin (cod, sea mammals, sea birds), but also the eggs (haddock, king crab) may be important elements in the food chain. The capelin die after spawning, and the relevance of the post-spawning dead capelin as a source for food and strengthening of the coastal ecosystem is not well understood.

The recruitment failures for capelin, which has led to three stock collapses since 1985, have to a large extent been attributed to predation by young Norwegian spring spawning herring on capelin larvae (Gjøsæter and Bogstad 1998, Huse and Toresen 2000). The Barents Sea is a nursery area for this herring stock, but the herring abundance in this area is very variable due to strong year class fluctuations in the herring stock.

The capelin stock in a historical fishery context

The term capelin fishery (loddefisket in Norwegian) was for centuries a name for the spring fishery for cod on the Finnmark coast (Solhaug 1976). It was well known that the young cod followed the capelin on the spawning migration, thus making the cod which was praying on spawning and post-spawning capelin) available for fishery (with available technology) in the coastal and outer fjord areas. Thus, in this context, the capelin and the cod were in a way strongly integrated. The capelin has also been the target for other minor fisheries, mostly for bait.

However, in the 1930s and especially after World War II, a small purse seine fishery for industrial purposes developed. This fishery took place near the coast in connection with the capelin spawning migration. With the introduction of the sonar and power block in the late 1950s the fisheries greatly

expanded, and an oceanic fishery was developed. An additional item that increased the relevance of the Norwegian capelin fishery was the reduction and collapse of important fisheries in the Norwegian Sea and North Sea (Atlanto-Scandian herring, North Sea pelagic species). The capelin fishery was at its maximum in the late 1970s when yearly catches peaked at about 3 million tonnes (Fig 2) In later years there has been much more emphasis on a fishery for high priced products, such as roe and frozen capelin.

Today, in the same fishery context, the capelin and the cod are by the fishers not so mentally integrated as before. In Norway, the sense of the word capelin fishery (loddefisket) has changed, it is now the name of the direct fishery for capelin. But during the capelin stock collapses in later years there has been put forward arguments that the capelin fishery reduced the availability of cod for the traditional spring fishery, thus again increasing the awareness that the capelin stock is necessary for a positive development of the spring cod fishery .

The capelin stock in a management context

The Barents Sea capelin is a shared stock between Norway and Russia. The regional management organization with responsibility for managing the stock is the Joint Norwegian-Russian Fisheries Commission (JNRFC). This organization was established in the mid-1970s as a response and instrument to handle the challenges regarding the changes in ocean law at that time (ie United Nations Convention of the Law of the Sea and the introduction of 200 nautical miles EEZs). The first actions made by this organization regarding Barents Sea capelin was in 1978 with an the introduction of a TAC (August 1978 to March 1979) of 1.8 million tones, and a division of this TAC of 60% to Norway and 40% to Russia (then Soviet Union). The main principle in this division seems to have been the historical catch statistics (Hønneland 2006), and this division key is still operational. There was also an agreement that the Russian fishers could take their catches in the Norwegian EEZ and vice versa. The JNRFC has since followed the scientific advice in setting TAC, and has also been able to implement its decisions, including stopping the fishery when the spawning stock has been at a low level. A harvest control rule (HCR) was adopted by JNRFC in 2002 stating that there must be a 95 % probability for the spawning stock to be above 200 000 tonnes (which is regarded as Blim) before a fishery can take place.

An important fundament within the JNRFC is the Norwegian Russian scientific cooperation. A formal cooperation exists from 1957 and has since been expandedconsiderably. The field survey work is coordinated between Norway and Russia, and the final catch recommendations are coordinated through ICES.

The current management strategy, harvest control rule and management objectives

The capelin stock has been managed by a target escapement strategy since the first TAC were set in the late 1970s, with the intention to safeguard against recruitment failure. The target escapement strategy has been developed by the scientists within the frame of ICES , and there has until now been relatively little dialogue with the managers about management objectives underlying the formulation of the HCR. The current methodology for assessment of the Barents Sea capelin stock, using a

combination of the multispecies model Bifrost (www.assessment.imr.no, Tjelmeland 2005) and the spreadsheet model Cap Tool (Gjøsæter et al 2002), has been applied since 1997. Bifrost is a multispecies model used for estimating maturation and mortality of capelin, based on capelin survey and catch data, cod abundance and cod stomach content data. It estimates predation and maturation parameters used in half-year predictions spawning stock size (Fig 3) made in Cap Tool, and is also used for long-term simulations investigating limit and target reference points (ICES 2007). At present, the quota is set according to the HCR that states that there must be a 95 % probability for the spawning stock to be above 200 000 tonnes (which is regarded as Blim) This value is above the smallest spawning stock which as given a large year class (the 1989 year class, estimated to 84 thousand tonnes). The HCR has not be formally evaluated by ICES.

Thus , the management of the Barents Sea seems to be a joint Norwegian-Russian success. These states have traditionally had different fishing traditions, fishing fleet structure and economies. In spite of this these states have managed to build an effective cooperative management of the Barents Sea capelin. The JNRFC has adopted a HCR, the managers have followed the TAC advice, and the catches have been close to the agreed TAC. The catch statistics is assumed to be reliable.

Referring to the above paragraph, can there be any "problems" in such a fishery? To look closely into this at we have to change our focus from the (inter)- governmental processes to the world of the other stakeholders. In the following we will only analyse the structure in Norway (which is allocated 60% of the TAC).

Stakeholder groups, their general view on the objectives and management of the capelin stock, and meeting arenas for stakeholder expressions

In Norway there is in general good and open channels for communication between stakeholder groups in fisheries and relevant governmental organizations . With regard to the capelin several stakeholder groups (in addition to governmental) in Norway, and their main communication channels (in addition to direct contact with the Ministry) are given in Appendix 1 and 2 (each of them a potential formal arena for drafting and possible ranking specific stakeholder objectives):

From the general views of stakeholders (Appendix 2) one can list two "opposite" (and contradicting) management objectives:

1. *The primary objective for utilizing the stock of capelin is that the value should be realized through the capelin fisheries as long as it is done in a responsible (sustainable) manner. This means the capelin fisheries should be managed as to-day. However, several stakeholder groups argue for conducting of a small fishery for human consumption even if the spawning stock is below the precautionary spawning stock level. (This may however contradict the objective of sustainability)*

2. *The primary objective for the capelin stock should be to draw fish of other species to the coast and serve as food for the cod (and other species), The capelin should be regarded as a*

fundament for the ocean and coastal ecosystems, and there should be no directed fishery for capelin. The value of the capelin is realized "through " the cod fishery, and not through a fishery for capelin.

The present authors would suggest a possible compromise management objective could be.

- *The primary objective for utilizing the stock of capelin is to recognize the fundamental importance this stock has for the ocean and coastal ecosystem as a transformer of energy and proteins, including an ubiquitous importance as food for other organisms. However, paralell to this view will be an secondary objective to keep up a small (for example less than 100 thousand tones) and stable fishery for high prized products for human consumption*

The role and tasks of the fishery scientists to implement possible compromise management objectives

Given that there is a societal wish to reconsider the present HCR for Barents Sea capelin in a broader context, scientists can contribute in different ways:

1. Communicatioon - contribute to the acceptance by stakeholders of new (compromise) management objectives.
2. Present and discuss general outlines of a new HCR
3. Formulation and testing of an operational HCR

1 – Communication. The best way for the fishery scientist is to work systematically with the stakeholders through the venues given in Appendix 1 and 2. Usually, presentations given by fishery scientists are based stock sizes and developments. The scientist should stress the point that the objectives for utilizing the stock, on a long term, are at least as important for the quota as the stock size.

2 – General outline of a new HCR. The present HCR for capelin has not been tested against either the precautionary approach (in the ICES region implemented as safeguarding against short-term harm to recruitment) or for long-term benefits. Therefore, a natural first step is to test the present rule using long-term stochastic simulation. For this, the cod-capelin-herring simulator Bifrost (www.assessment.imr.no, Tjelmeland 2005) will be used, which underlies the present probabilistic calculations used to set quotas for capelin (Gjøsæter et al 2002). For other stocks (e.g. mackerel (ICES 2008)) the probability for the spawning stock to fall below some B_{lim} during simulations has been used as a precautionary criterion. This is troublesome for capelin, as the spawning stock frequently will be low due to the influence from herring even without a fishery, a situation that will prevail in the future if the herring stock is to be kept at the present high level. Furthermore, the logics often underlying the ICES implementation of the precautionary approach – that there is a limit for the spawning stock below which the recruitment decreases with the spawning stock and above which the recruitment is unaffected by the spawning stock – is not very satisfactory, since the spawning stock always may have a marginal value.

Thus, we will base the precautionary element in a new HCR for capelin on first principles – the danger for the stock to go extinct as a result of the fishery. Because of the schooling nature of the stock and because the capelin is known to spawn in certain areas (Varanger) when the stock is small, a small error in the assessment may lead to a quota that will drive the spawning stock close to zero. If this happens 2-3 years in a row the stock might be driven to near extinction and remain in a state from which it hardly might recover, especially if the spawning stock – recruitment relation is depensatory. Two uncertainty elements enter into this – the uncertainties connected to the autumn survey and the subsequent probabilistic projections to spawning time (see Fig 3), and the uncertainties connected to whether there is a depensatory behavior for low levels of the spawning stock in an appreciable number of possible environmental scenarios. Fishermen feel alienated by the present HCR, which they (for good reason) feel is based on arbitrary parameters, and basing the precautionary element on transparent and understandable principles will provide a good climate for the researcher-fisher-management dialogue so necessary for effective implementation.

In addition to the short term precautionary element a new HCR for capelin may also be based on a long term element: what is the HCR that in the long term provides the best benefits from the stock? A long term element in the HCR has not been used for this stock since before the first (Gjøsæter et al 2008) capelin collapse and was then based on evaluations of long-term yield by simulation (Tjelmeland and Hamre 1982). What is perceived as the best benefits from the stock is ambiguous, as parts of the industry value high economic benefits from the capelin fishery and other parts value the capelin as source of food for cod, making the evaluation of a HCR a multispecies problem. The significance of capelin for cod are three-fold: the direct significance in terms of individual weight, the shielding effect against cannibalism and the significance of post-spawning dead capelin as a source of food for bottom animals, which in turn may serve as food for cod. The first two are readily tractable through Bifrost simulations, while the latter needs special treatment and perhaps further biological research.

The significance of dead post-spawning capelin for cod growth, mediated through bottom animals, is not readily observed in the data. However, it also cannot be ruled out from the data at hand. If it is a significant effect, it should be included as part of the biological foundations for a possible new HCR.

3 – Operational formulation and testing. When the general characteristics of an HCR has been decided in a dialogue between managers and stakeholders, the scientists' task is to formulate the HCR operationally, i.e. implement it into a simulation model so consequences can be tested. The spreadsheet CapTool, which is used to make the short term probabilistic simulations that decide the quota, has not been updated with parameters estimated from Bifrost since 2003, though. After 2003 Bifrost has evolved to describe the predation of capelin by cod the year around, and is now in the shape to perform the long-term simulations needed to test HCRs. A characteristic of Bifrost important for testing of HCRs is its capability of accounting for modeling uncertainty in the stock-recruitment relation. Many different relations (different functional forms, different explanatory values) are estimated before the simulations are performed. For each probabilistic trajectory one recruitment relation is drawn using Akaike's criterion (Burnham and Anderson 1998, p 60).

It is necessary that the scientists take part in the dialogue between managers and stakeholders to clarify which proposals for HCRs that can be tested through simulations, and which must be treated through a scenario approach. For instance, the significance of capelin for shielding cod recruits from cannibalism and as a direct source of food for cod are inherent in Bifrost and will automatically be taken account of during the testing. The effect of bottom animals can be estimated making the spent capelin, suitably lagged, one of the predictors for cod growth. Based on the estimation statistics the probability for different strengths of the relation can be evaluated and the relation to be used in the simulation can be drawn using Akaike's criterion before each trajectory in the same way as the recruitment function is drawn. The possibility that cod will be mor available for the coastal fishery because young cod is following the spawning migration of capelin is out of reach of contemporary models and must be treated on a what if (scenario) basis. This complicates the communication of the results of simulation runs, but is highly benefitial for the dialogue with stekeholders.

The testing of an HCR will thus be based on two elements: a precautionary element in which a danger to the extinction of the stock must be avoided and an evaluation of the long term benefits. What constitutes long term benefits is a matter of controversy and negotiation, but since the model comprises both cod and capelin, putting monetary values on cod and capelin catch will be helpful.

For a successful development and implementation of a new HCR for capelin it is mandatory that both managers and stakeholders understand both the potential and possibilities of the science and it's limitations. For a fruitful communication between these groups it is necessary to move the basis for the HCRs away from numbers that are considered arbitrary and non-founded by the stakeholders and towards principles and guidelines that can be understood, and where the implementation in the model can be communicated and accepted.

Figures

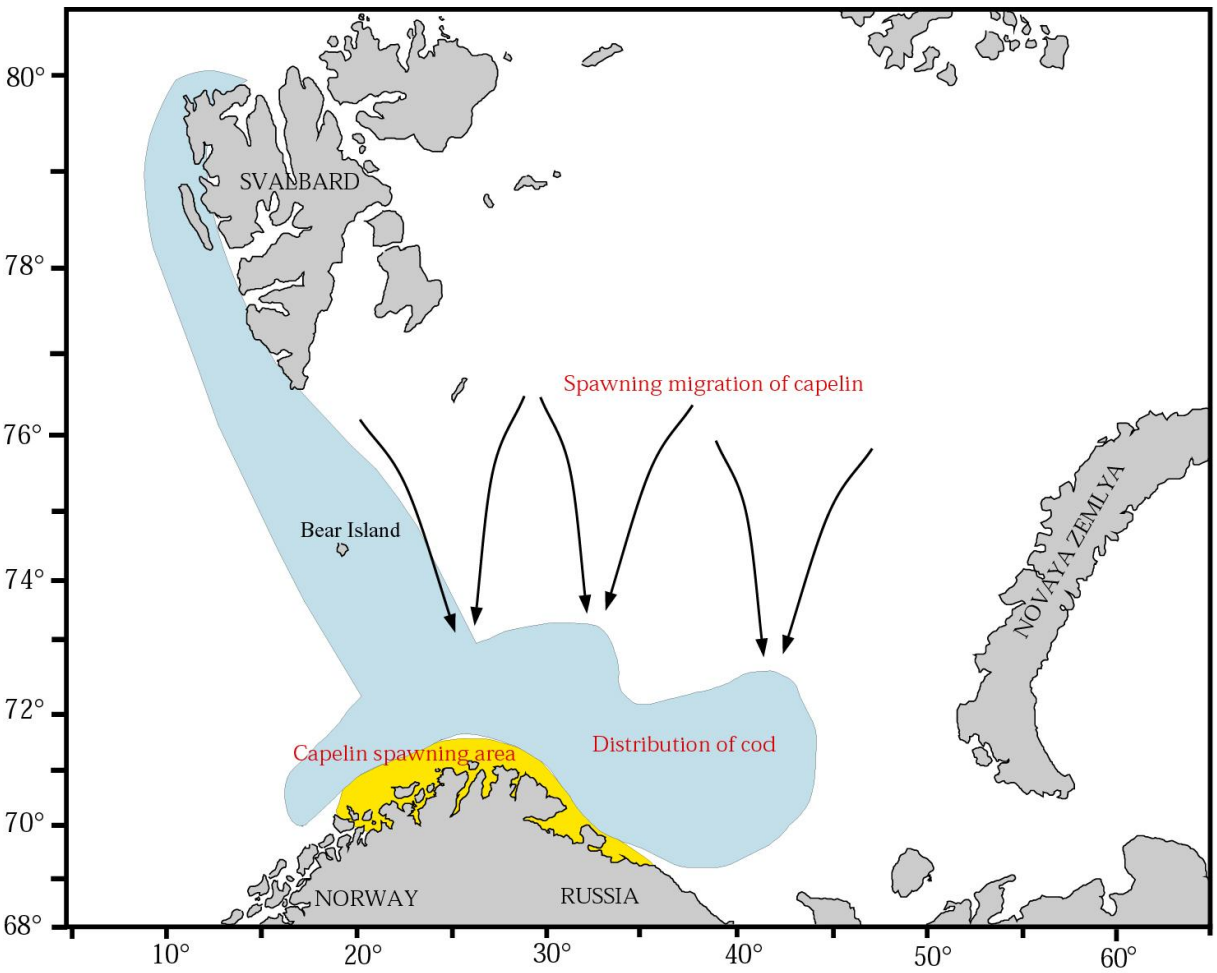

Figure 1. Spawning migration and spawning areas of Barents Sea capelin.

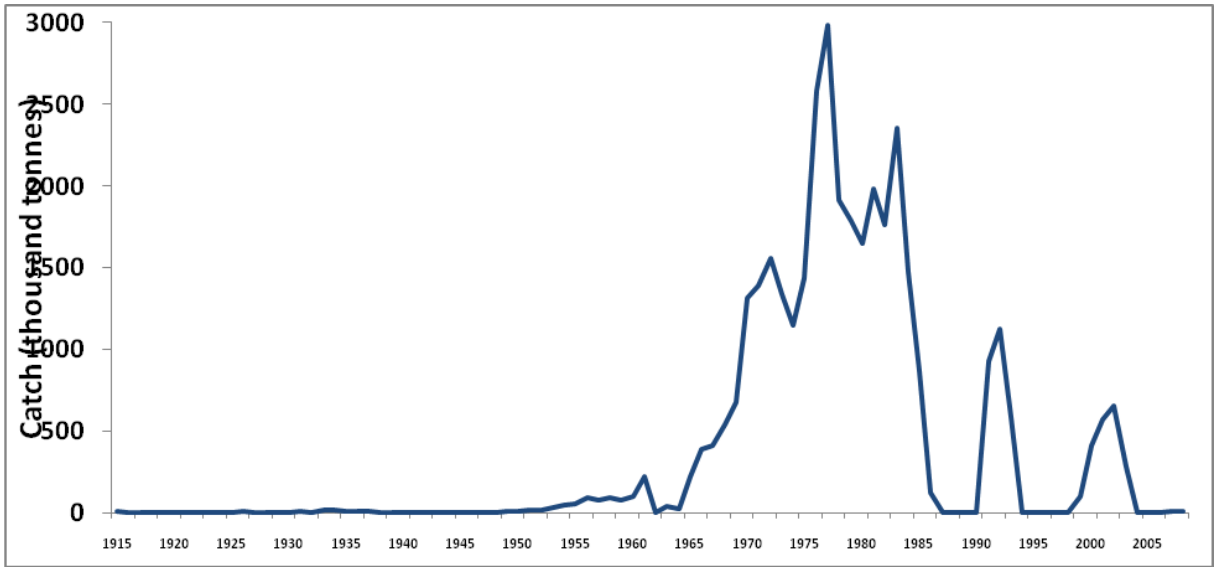

Figure 2. Catch statistics for Barents Sea capelin.

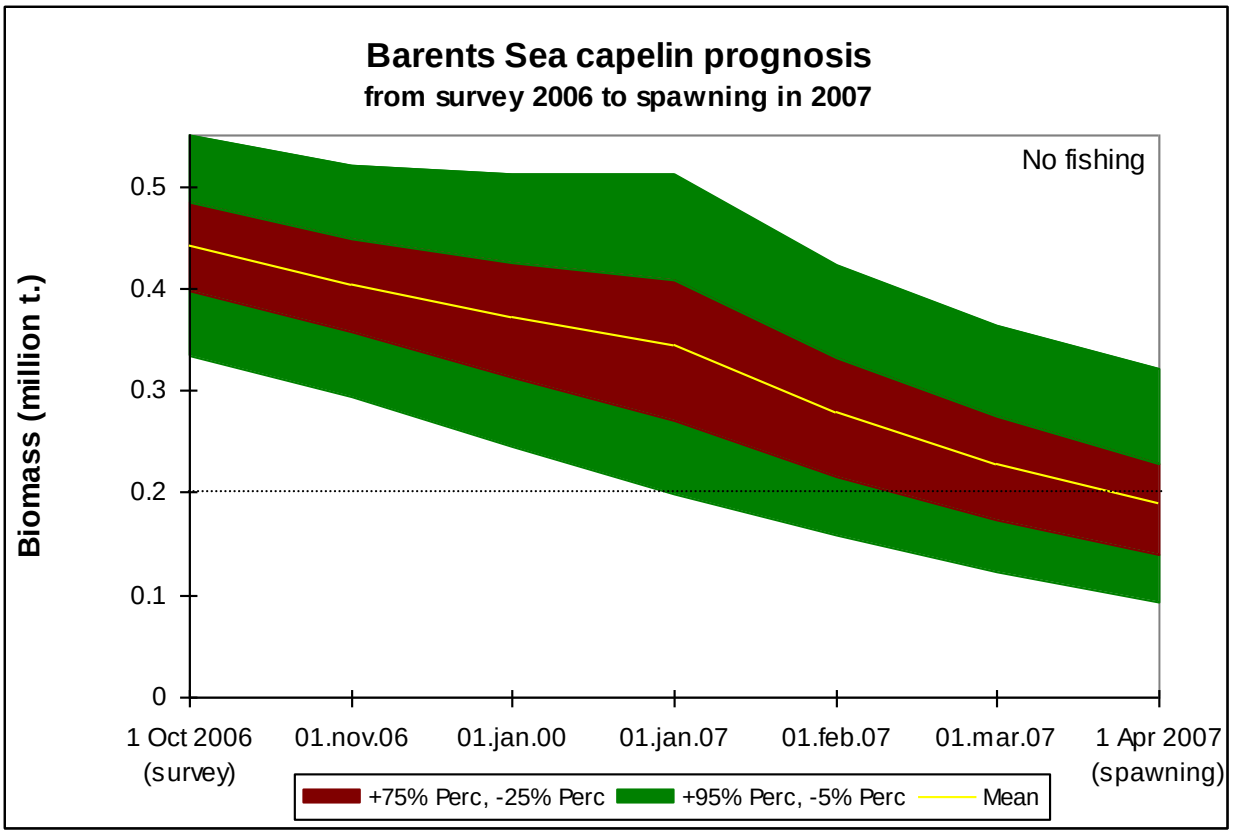

Figure 3. Probabilistic projections of mature Barents Sea capelin.

References

Burnham, K P and Anderson, D R. 1998. Model selection and multimodel inference: a practical information-theoretic approach. Springer Verlag ISBN 0-387-95364-7.

Gjøsæter; H. 1998 The population biology and exploitation of capelin (Mallotus villosus) in the Barents Sea. Sarsia 83: 453-496

Gjøsæter, H. and Bogstad, B. 1998. Effect of the presence of herring (Clupea harengus) on the stock-recruitment relationship of Barents Sea capeling (Mallotus Villosus). Fisheries Reseach 38: 57-71.

Gjøsæter, H, Bogstad, B., and Tjelmeland, S. 2002. Assessment methodology for Barents Sea capelin (Mallotus villosus, Muller). ICES Journal of Marine Science, 59: 1086-1095.

Gjøsæter, H, Bogstad, B., and Tjelmeland, S. 2008. Ecosystem effects of the three capelin stock collapses in the Barents Sea. Marine Biology Research, in press.

Hamre, J. and Tjelmeland, S. 1982. Sustainable yield estimates of the Barents Sea capelin stock. ICES CM 1982/H:45.

Huse, G. And Toresen, r. 2000. Juvenile herring prey on Barents Sea capelin larvae. Sarsia 85: 385-391.

Hønneland, G. 2006. Kvotekamp og kyststatssolidaritet. Norsk-russisk fiskeriforvaltning gjennom 30 år (In Norwegian). Fagbokforlaget, Bergen.

ICES 2007: Report on the study group on Management Strategies (SGMAS) ICES CM 2007/ACFM:14)

ICES 2008. Report on NEA mackerel long-term management scientific evaluation. ICES CM 2008/ACOM:54.

Solhaug, T. 1976. De norske fiskeriers historie 1815-1870. (In Norwegian) .Univrsitetsforlaget, Oslo 770pp.

Tjelmeland, S. 2005. Evaluating long-term optimal exploitation of cod and capelin in the Barents Sea using the Bifrost model. The 11th Joint Russian-Norwegian Symposium «Ecosystem dynamics and optimal long-term harvest in the Barents Sea fisheries». Murmansk 16-17 August, 2005.

Appendix 1 Venues in Norway for discussions on the management of the capelin fishery

(Formal) venues (in Norway)for discussions stakeholders-managers-scientists (names translated to English by the present authors)	**Comments:**
Referansegruppen for ressursforskning (Reference group for Resource Research) (meet 2 times per year)	Chaired by the Institute of Marine Research (IMR) . Formal invitation to Stakeholders of various fisheries are in advance asked to present and point out elements they see necessary to carried out within the frame in the Science program of IMR.
Reguleringsmøte (Meeting on Fisheries Regulation (meet 2 times per year))	Chaired by the Directorate of Fisheries. Area for discussion of fisheries regulations, division of Norwegian TAC into vessel and gear categories . The meeting has status as an advisory organ with regard to regulation measures for the Minsistry of Fisheries and Coastal affaires
Årsmøter I fiskarlag og salgsorganisasjoaner (Meeting in Fishers and Sales organizations (usually meet once pr year))	Makes resolutions regarding organization and management of the different fish stocks. Fisheries scientists are often asked to give summaries of developments in stocks and regulation at these meetings
Papers and magezines within the fisheries sector, especially FiskeribladetFiskaren	Discussion and articles on management issues. Fihers, managers and scientis participates
Fiskeriforhandlingsrådet (Council of Fisheries regulations)	Chaired by Mistry of Fisheries and coastal affers. Representatives from managers, scientists and fisheries organization . Discusses strategies and TAC before international organizations (not open to common discussions)

Appendix 2 Stakeholder groups in the Norwegian capelin fishery

Relevant stakeholder groups with regard to the management of the Norwegian capelin fishery (names translated from Norwegian by the present authors)	**General views on the capelin fishery and management of the Barents Sea capelin stock**
Norges Fiskarlag (Norwegian Fishers organization)	Has stated a general view that the capelin resource should be utlized as a basis for a fishery if done in a "biologically responsible" way . Positive to a stable fishery for human consumption
Fiskebåtredernes forbund (Fishboat owner association (organizes the ocean going fishing vessels). Is formally a part of the Norwegian Fishers organization	In a letter to the Ministry of Fisheries the Fishboat owners association (13 May 2008) has have formally asked the Ministry for an evaluation of the present HCR for capelin. Among the items the Fishboat owners suggest should be considered are the following: • Evaluate the minimum size of the spawning stock • Evaluate if the present precautionary reference points should be supplied by target reference points. • Evaluate if there should be allowed a small fishery for human consumption even if the spawning stock is below the precautionary spawning stock level.
Kystfiskarlaget (Coastal fishers organization)	Have stated that no capelin fishery should take place. The capelin should be regarded as food for the cod, and also stated that a high capelin stock will increase the availability of cod in the capelin spawning area.
Fylkeskommuner I Nord-Norge (Northern municipalities)	In general sceptical to a large oceanic fishery (mostly carried out by fishing vessels from the southern part of Norway)for capelin. The view of a member of the board for the municipality of Vadsø, Finnmark, may be representative: "The primary objective for the capelin stock should be to draw fish of other species to the coast . (FiskeribladetFiskaren 20.02.2008).Some are positive to a small fishery for consumption. Have pointed to the circumstance that the capelin is fished off

	Finnmark but processed and landed elsewhere.
Sametinget/Samediggi (The Sami Parliament)	Have been skeptical to the capelin fishery. Has its main focus on the conditions for small scale fishery in the fjord areas.
Norges sildesalslag (Sales organization for pelagic fish)	The capelin management on the agenda on a assembly meeting in June 2006. According to the minutes of the meeting (12 June 2008) the sales organization states: "The management of the capelin in Barents Sea is complicated and there are many elements that has to be taken into account when deciding how to utilize the stock in the best way."
Miljøvernorganisasjoner (Green NGO organizations (I e WWF))	In general satisfied with the management of the capelin stock , especially with the ability of JNRFC to implement the advice form ICES and especially the ability of the managers to stop the fishery when advised by ICES.