ICES CM/ O:28

Scientists as facilitators: An objective technique to illustrate a zone of stakeholder consensus

Dorothy Jane Dankel[*1,2,3], Mikko Heino[1,2,3] and Ulf Dieckmann[3]

Abstract

The inherent conflicts between objectives in fisheries management (e.g. yield maximization vs. conservation interests) often create problems for managers, scientists and stakeholders. However, some seemingly contrasting objectives may be compatible (e.g. economic yield and ecosystem preservation) and could promote stakeholder consensus. Formalized scientific facilitation through the framework we present here aids stakeholders in objective-setting and managers in the policy-making process. The purpose of this study is to outline a quantitative approach to defining fisheries management objectives through stakeholder-specific utility functions. To achieve this, we link a biological model with a socio-economic model, both calibrated for a capelin fishery and a cod fishery. Second, we define multiple objectives in a quantified utility function for each stakeholder group. Finally, we conduct simulations that calculated the resulting stakeholder groups' utility for different levels of harvest and minimum sizes. Our results illustrate that low harvest rates and minimum-size regulations that select for bigger fish represent a management consensus zone among five modeled stakeholders. We put forward a **new technique of scientific facilitation through quantification of bio-socio-economic objectives** leading to sustainable resource use through stakeholder consensus.

[*] *Contact author: Dorothy J. Dankel, Phone: +47 55 90 65 30, Fax: +47 55 23 86 87; E-mail: dorothy@imr.no*

[1] *Institute of Marine Research, PO Box 1870 Nordnes, 5817 Bergen, Norway;*

[2] *Department of Biology, University of Bergen, PO Box 7800, N-5020 Bergen, Norway*

[3] *Evolution and Ecology Program, International Institute for Applied Systems Analysis (IIASA), Schlossplatz 1, A-2361 Laxenburg, Austria*

Keywords: fisheries management, stakeholders, stakeholder integration, utility functions, stakeholder preferences, population modeling, stakeholder consensus, management objectives, consensus building, ecosystem preservation

Introduction

The general aim of marine fisheries management is to control human activity involved in fishing at sea, and there accordingly exists an essential human dimension to fisheries management (Dwyer et al. 2008). Fishers' behavior towards management regulations, for example, can challenge the implementation of scientifically advised quotas. Ideally, management strategies should include social and economic considerations along with natural science input (Beddington et al. 2007; Jentoft 2007; Symes and Phillipson 2009). Fisheries management has integral and synergetic aspects of biology, sociology, economy and politics and should therefore be viewed as a holistic system (Charles 2001) dependent on multi-disciplinary knowledge (Jentoft and McCay 1995). Management changes that only address part of the system can thus go awry. Due to the complexity of integrating biological, sociological and economic components in management strategy evaluations, objective scientific facilitation is needed.

The fisheries system is driven by stakeholder objectives (Baelde 2005; Paramor et al. 2005). However, these objectives are not often made explicit in management plans (Dankel et al. 2008; Symes and Phillipson 2009). Sometimes the objectives of some stakeholder groups are also assumed incorrectly by managers. The latter problem may arise due to the diversity and complexity of the stakeholder community and their requests tied to the fisheries, which are perceived as being conflicting (Horwood and Griffith 1992 ; Cochrane et al. 1998; Hilborn 2007).

It is often helpful to quantify stakeholder satisfaction. One approach for doing so is through a more formal, scientific approach utility function quantification. Utility is a measure of satisfaction or efficacy for a given value of a variable or component. A stakeholder group can set a utility argument according to the principle they define for that variable. A utility function consists of setting stakeholder utility arguments connected to different outputs of a management strategy to be mapped as a function of different harvest strategies (Quinn and Deriso 1999; Jørgensen et al. 2007). In this study we develop a method for examining how conflicting objectives in fisheries can be reconciled through the use of utility functions distinct for specific stakeholder groups. The optimizing of a utility function enables the objective derivation of a management strategy, even though defining a utility function will always be subjective.

Fisheries managers and politicians may opt for objectives that minimize potential conflict between stakeholders (termed "minimum sustainable whinge" by J. Pope, cited in (Hilborn 2007); (Daw and Gray 2004)). Hilborn (Hilborn 2007) used qualitative reasoning to show that some objectives, such as ecosystem preservation and maximum economic profit, may not be in conflict with each other. Hilborn stipulates the existence of a "zone of new consensus" in which profit maximization and ecosystem preservation are favored management objectives. This is in contrast to the "zone of traditional management", in which high employment, associated with fishing levels over maximum sustainable yield, are preferred ((Hilborn 2007). Hilborn's outline of the origins of fisheries conflicts, illustrated by Hilborn (2007), typifies the common problem of overexploitation in marine fisheries. It also illustrates how the integration of socio-economic indicators (e.g. employment and profit) in management may promote sustainable fisheries.

Integration of biological and socio-economic models to provide expert advice to fisheries managers, although mandated by many countries, is rarely applied. This study creates a bridge between a simple biological model and a simple socio-economic model to address this methodological gap in fisheries science. Because qualitative arguments (e.g., Hilborn 2007) may be open to debate, it is crucial to enhance credibility by corroborating them with quantitative results. Therefore, the aim of this paper is to outline a quantitative framework that explicitly includes the definition of stakeholder objectives for evaluating stakeholder benefits across a range of harvest strategies. The framework we present here accounts for the human dimension of fisheries, still often largely neglected in modern management despite clear government directions to include stakeholders in management plans. This is achieved first through acknowledging stakeholder heterogeneity, and second, through the use of socio-economic utility components in stakeholder-specific utility functions. Our second objective is to quantify the notion of a zone of consensus among our modeled stakeholder groups. In doing so, we introduce, outline and test a method for the exploration of management strategies with focus on compatible management goals in the zone of new consensus (Hilborn 2007).

Methods

This study uses a biological model calibrated for two different fish populations, capelin and cod. In addition, we calibrate a socio-economic model to represent two sectors of the fishery industry for each stock: fishing at sea and processing on shore. We subsequently link the biological and the socio-economic models and create stakeholder groups. We quantify the stakeholders' agendas by weighting their management preferences for four utility components, two from the biological model (yield and ecosystem conservation) and two from the socio-economic model (employment and profit). Finally, we calculate overall utility for each stakeholder by multiplying the utility component values from a model simulation by the stakeholder-specific weight on that component.

Stakeholders and their utility functions

We use three different broadly defined stakeholder groups: fishers, societal decision-makers and conservationists. Fishers and society are further characterized into two specific categories: industrial and artisanal fisheries (representing, e.g., large-scale and coastal small-scale fleets) and employment-prioritizing and profit-prioritizing decision-makers, for a total of five stakeholders.

Total utility of a stakeholder is a function of the values of the utility components. Because the utility components are measured in different units, we express utility values as normalized utilities (absolute values should still be maintained as a reality check). The maximum of each utility component across the considered management options is set to 100%, and other utility values are expressed relative to this reference value. Notice that yield, employment and spawning stock biomass are then bounded to interval between 0 and 100%, whereas profit can take negative values.

Here we determine the total utility as a weighted average of component-specific utilities. The stakeholders' preferences are expressed through the weighting factors (Table 1).

Table 1. Utility components (yield, employment, profit and stock level) and corresponding weights, chosen to represent differences between stakeholders, for each stakeholder group (fishers, decision-makers and conservationists). Total utility is based on normalized, dimensionless utilities. For each stakeholder, the utility weights add up to 1.

	Yield	Employment	Profit	Stock level
Industrial fishers	0.3	0	0.7	0
Artisanal fishers	0.5	0.1	0.1	0.3
Employment-prioritizing decision-makers	0.2	0.5	0	0.3
Profit-prioritizing decision-makers	0.2	0	0.6	0.2
Conservationists	0.1	0.2	0.2	0.5

Weight on a utility component for a given stakeholder's utility function represents the stakeholder group's preference for that utility component, and these weights differ among the stakeholder groups. We assume that each stakeholder group holds a consensus of preferences within its group. If there is not homogeneity within a stakeholder group, our framework allows the separation of the heterogeneous group into a homogenous subgroup until it becomes unified. For the stakeholder groups thus defined, we may consequently assume that preferences are reasonably homogenous. We also assume each stakeholder group differs between the other stakeholder groups in order to reproduce traditional multi-user conflicts of a fish stock (Table 1).

Biological model

For this study, we use mathematical modeling to define two separate single stock operating models resembling population dynamics of respectively capelin and cod. We define these biological populations by abundance $N_a\ t$, where N is the number of individuals at time t and a represents age classes where $a = 0, 1, \ldots, a_{\max}$. Individuals that reach $a_{\max}$ die (Equation 1). Fecundity, length, maturation, weight, natural mortality, and total mortality are age-dependent, whereas fishing selectivity is length-dependent. The fish are harvested each year and recruitment to the population occurred at age 0. We use recruitment based on the fecundity of the spawning stock (population fecundity) with Beverton-Holt density dependency on the egg survival at the egg stage (N_0).

Socio-economic model

We followed Hilborn's (2007) logic by using four utility components that correspond to specific management objectives: (1) realized yield; (2) total employment; (3) total profit, and (4) ecosystem preservation, our proxy being spawning stock biomass.

Employment and profit are each the total of two components: employment/profit from activity at sea (fishing boat captains and crew members) and employment/profit from activity on shore (catch processing). Employment on shore is derived by multiplying effort for the production sector on shore, by the amount of person hours per production day; effort on shore is proportional to the amount of realized yield and a scaling parameter converts realized yield to effort on shore. The total employment is the sum of the realized employment at sea and employment on shore. Profit is the difference between revenue and cost. We assume fixed price per biomass unit both at sea and on shore. Cost is comprised of fixed costs and effort-dependent costs.

Stochasticity may cause qualitative changes in predictions relative to deterministic models (Lande et al. 1994; Lande et al. 1995; Lande et al. 2003) and is therefore included in our approach. We implemented stochasticity in the form of log-normally distributed multipliers in (1) the recruitment function to mimic variations in environment, and in (2) the implementation of fishing mortality to mimic variations in fishing.

Model calibration

We calibrated the biological models for generic capelin and cod populations by adjusting the following life-history parameters accordingly: maximum age, age at maturation, length and weight at age, fishing selectivity and mortality at age. We used natural mortality rate, M , values from the Arctic Fisheries Working Group Report (ICES 2007). Length at age for the cod population is derived from a von Bertalanffy growth function whereas the length at age for the capelin population is taken from the Barents Sea capelin lengths at age from the ICES Arctic Working Group Report (ICES 2007).

We calibrated the socio-economic model with effort, employment and cost data from the Barents Sea capelin fishery (human consumption component) and the Barents Sea cod fishery for two sectors: the industrial fleet component at sea and the filet processing component on shore. The parameters specifically calibrated for the capelin fishery and the cod fishery include the number of employment days per year, the coefficient to convert employment on shore to yield, hours per production day on shore, fixed costs on shore, and the selling and landing prices for capelin and cod. We also used calibrated parameters that are assumed common for both fisheries: the amount of hours per vessel day at sea, hourly salary at sea, and fixed costs at sea.

We used the values for stakeholder groups' preferences on four utility components based on the hypothesis of contrasting stakeholder objectives (Table 1). Thus we drew upon a heuristic stakeholder preference/utility component matrix which provides us with adequate resolution between the stakeholders reflected in their preference values.

Simulation set-up

After model calibration, we conducted two separate sets of model simulations: a regime where only one control parameter, harvest proportion (0-100%) and a regime where we vary minimum harvest size limit together with a harvest proportion.

In this paper, we present a technique for scientific facilitation by presenting the minimum over all stakeholders' utilities for each combination of minimum size and harvest proportion for both capelin and cod fisheries in the Barents Sea.

Results

Figure 1 is a plot of the minima over stakeholder groups for varying minimum size and harvest proportion combinations. An area where all stakeholders can achieve a high utility would represent a "consensus zone". For capelin, we observe a consensus zone for high size limits and low to high harvest rates. The capelin stakeholders' common maximum in the zone of consensus is at a minimum size limit of 18 cm at harvest rate of 95% (left panel, Figure 1). This is just below the harvest level that brings maximum yield (18 cm, 100% harvest) when two control dimensions are simulated. For cod a consensus zone is observed for intermediate size limit (relative to the maximum size) and low to high harvest rates. The cod stakeholders' common maximum within the consensus zone occurs at a minimum size of 100 cm and 35% harvest proportion (right panel, Figure 1). The common maximum over the minimum utility for all stakeholders is 70% for capelin, but 97% for cod.

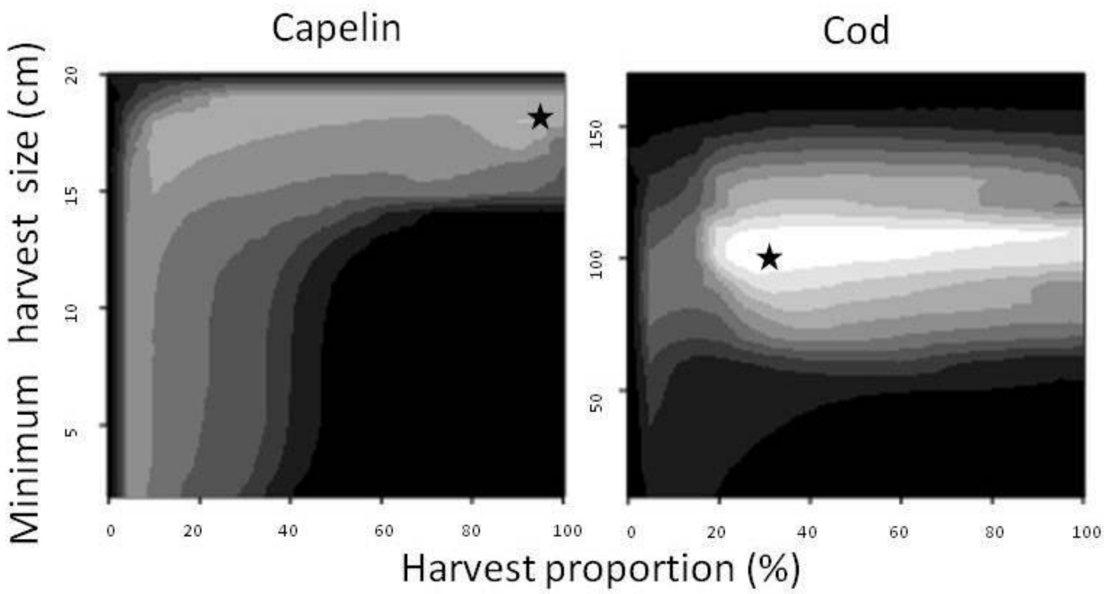

Figure 1. Illustration of the consensus zone using the minimum utility across stakeholder groups for each minimum size and harvest proportion combination for the two modeled fish stocks. The black stars in the top panel indicate where all five stakeholders reach the collective "maxima of minimum whinge", and we defined the zone of consensus as the contour

surrounding them. The lightest color shading indicates the 90% contour line and negative utility values are plotted using a value of zero with the darkest shading.

Discussion

Conflicts of seemingly incompatible objectives in fisheries management have led to unproductive prejudices that can stand as a barrier to successful management. The link between biological and socio-economic models is not routinely made in fisheries policy exploration making it difficult to include stakeholders and their preferences in standard management strategy evaluations. In this study, we bridge the biological and socio-economic gap by integrating socio-economic indicators of employment and profit into a biological model. By doing so, we elaborate on a discussion outlined by Hilborn (Hilborn 2007) around the increasing awareness that different stakeholder objectives may not be as conflicting as traditionally thought. Our results demonstrate the benefits of mapping the area of mutual agreement between stakeholder groups (the zone of consensus), specifically due to the win-win situation that emerges when profit and ecosystem preservation are consistent with each other at low harvest rates (Christensen and Walters 2004 ; Hilborn 2007; Bue et al. 2008). These results hold true for two fish stocks with differing life histories (capelin and cod) and with including empirical data of actual costs and employment (at sea and on shore) in the fisheries. Our results also show that a minimum size regulation can supplement management when catch control is not enough in order to select for older, larger fish. The most important result from this study is that even when we set stakeholder utility component preference values to produce seemingly large conflicts of interest, our results show that it is possible find harvest regimes where all stakeholders can achieve a high utility. Our results also suggest that the zone of consensus is more robust for our modelled cod fishery than for capelin. For cod, there is relatively little need for a compromise as all stakeholders can achieve as much as 97% of maximum utility. Whereas for capelin the best consensus strategy represents "only" 70% of maximum utility, the bottleneck being the employment-prioritizing decision-makers.

The basics of our economic modeling are standard and simplified; we assumed that landed fish prices, fixed costs (overhead costs) and employment costs for the capelin and cod fishing fleets are constant for the two different fish stocks. Employment is the utility component we include that is not standard for biological and economic models. Therefore, one of the key assumptions in our model is how we formulate fishing effort at sea. We assume employment demand at sea to increase non-linearly with increasing harvest proportion to infinity when the fishers are searching for the very last fish; we postulate an investment of effort in searching for the last catch when the majority of a stock has already been caught. Thus, if a stakeholder was to put more emphasis on employment at sea, their utility would increase with increasing fishing effort, thus potentially broadening the range of the consensus zone towards higher harvest rates. Even though individual fishers may claim that more time on the water equals more money in their pocket, stakeholder group acting co-operatively, like a single businessman, would not prefer increased sea time beyond the point of a sustained profit.

It is pertinent to point out the difference between stakeholders' stated preferences versus their revealed preferences, although this distinction does not arise in the simplified stakeholder model used here. Revealed preferences can only be observed by stakeholder behavior after a management strategy has been implemented. It is well known that humans tend to renege on uxorious stated promises, so more faith is warranted on revealed preferences.

In fisheries management experiences in Europe and other parts of the world, stakeholder collaboration in the development and review of management strategies has been recognized ad-hoc (Jentoft and McCay 1995; Daw and Gray 2005 ; Anonymous 2007). This can raise misaligned incentives (Beddington et al. 2007) and represents a fragmentation of what ideally should be an integrated approach. Efforts towards an integrated consensus policy can be easily stymied when "either – or" ultimatums dominate the dialogue. Late in the nineteenth century, influential political and business philosopher and social anthropologist Mary

Parker Follett pioneered the idea that an “integrated solution” was superior to compromise to resolve conflicts. The integrated solution consists of breaking each stakeholder’s interests up into small parts, as an analytical method to revaluate the groups’ desires, in an effort to create a new unity. The fractional elements may even be discovered as symbols for a different, underlying desire in which multiple desires are represented (Follett 1955). Traditional fisheries management that focused on large yields and high employment (Hilborn 2007) alludes to Follett’s notion of domination as a strategy for an undemocratic conflict resolution whereas the “zone of new consensus” refers to Follett’s preferred, democratic and diversity-embracing idea of the integrated approach.

The central result of this study is the quantitative formulation of the zone of consensus for each of our modeled fish populations found in Figure 1. This figure shows the utility of the stakeholder with lowest utility for all minimum sizes and harvest proportions which may be summed up as the “minimum of maximum whining”. One advantage of our framework that scientifically facilitates through quantification and subsequent mapping the consensus zone (Figure 1) is that it aids stakeholder groups in “revaluation” of their desires, which Follett deems an important component towards an integrated solution for conflict resolution (Follett 1955).

Our modeled results also showed that, with the exception of the employment-prioritizing stakeholders for capelin, the zone of consensus converges at minimum size limits that are large compared with the present status quo for capelin and cod in the Barents Sea. Current minimum size and harvest levels for Barents Sea capelin are 11 cm and a harvest proportion of 16%; for Northeast Arctic cod in Norwegian waters: 47 cm, and a harvest proportion of 33% (ICES 2008; ICES 2008; www.fisheries.no 2008). The employment-prioritizing society could perhaps be persuaded to adjust their preferences, through revaluation, to come closer to the consensus zone as their utilities are not at sustainable harvest levels and they do not sacrifice much at a lower harvest rate and larger minimum size.

Science for policy support would require further biological and socio-economic model calibration beyond the scope of this paper. Even so, we feel some results from our simplified fishery system model are interesting in the light of practical implementation. One such implementation of our results suggests that reducing effort from status quo levels may be a first logical policy step in reaching the “zone of new consensus”. Overcapacity of the fishing fleet is a common barrier to successful management (Beddington et al. 2007) and decommissioning small vessels only to let the largest, and most effective, boats survive does not help in reducing overall fishing effort. One can easily foresee stakeholder discontent as a result of fisheries scientists advising lower effort levels. But when decisions are explored and then reached from a collaborative, bottom-up approach instead of an authoritative, top-down approach, stakeholder understanding and acceptance of management decisions are more likely to occur (Follett 1955).

We believe that the most important practical implication of this study is the development of a simplified framework as a starting point for future research in the area of consensus building in fisheries management. Social sciences and lessons learned from fisheries management tell us that stakeholder diversity needs to be embraced instead of ignored in order to develop collective strategies for a common pool resource (Follett 1955; Regan et al. 2006; Dankel et al. 2008). This can arguably only be achieved with models that can adequately describe the bio-socio-economic components of the fishery by a team of interdisciplinary scientists. Clarification of stakeholder objectives and relevant management strategies comes naturally with bio-socio-economic quantification. We have shown that data exists for these new, more holistic, models and encourage more exploration of the development of bio-socio-economic models to aid in scientific facilitation of management opportunities that build on consensus.

Acknowledgements

This project was completed in the Evolution and Ecology Program of the International Institute of Applied Systems Analysis (IIASA), during the Young Scientists Summer Program, graciously funded by the Norwegian Research Council and a grant from the European Marie Curie Research Training Network FishACE (Fisheries-induced Adaptive Changes in Exploited Stocks), funded through the European Community's Sixth Framework Program (Contract MRTN-CT-2004-005578). D. Dankel recognizes the Norwegian Research Council for full funding of her doctoral research. D. Dankel gives special thanks to Bjørn Inge Bendiksen from Nofima, an industry-oriented research group in Tromsø, Norway, for data regarding employment on shore and to Tove Aasheim for guidance regarding data from the Norwegian Fisheries Directorate as well as to two anonymous sources, for providing costs and profit data in the processing sector. M. Heino acknowledges funding from the Norwegian Research Council and Bergen Research Foundation.

References

Anonymous (2007). "Resources and relations with stakeholders, Interinstitutional relations and dialogue with the sector, programming and evaluation." European Commission.

Baelde, P (2005). "Interactions between the implementation of marine protected areas and right-based fisheries management in Australia." Fisheries Management and Ecology 12: 9-18.

Beddington, J et al. (2007). "Current problems in the management of marine fisheries." Science 316.

Belton, S and Stewart, T (2002). Multiple Criteria Decision Analysis. An Integrated Approach, Kluwer Academic Publishers, Massachusetts.

Bue, BG et al. (2008). "Optimal harvesting considering biological and economic objectives." Can. J. Fish: Aquat. Sci. 65: 691-700.

Cardinale, M and Svedäng, H (2008). "Mismanagement of fisheries: Policy or science?" Fisheries Research 93(1-2): 244-247.

Charles, AT (2001). Sustainable Fishery Systems, Blackwell Science Ltd.

Christensen, V and Walters, CJ (2004). "Trade-offs in ecosystem-scale optimization of fisheries management policies." Bulletin of Marine Science 74(3): 549-562.

Cochrane, KL et al. (1998). "Management procedures in a fishery based on highly variable stocks and with conflicting objectives: experiences in the South African pelagic fishery." Reviews in Fish Biology and Fisheries 8: 177-214.

Dankel, DJ et al. (2008). "Fisheries management in practice: A review of 13 commercially-important fish stocks " Reviews in Fish Biology and Fisheries 18 201-233.

Daw, T and Gray, T (2004). "Fisheries science and sustainability in international policy: a study of failure in the European Union’s Common Fisheries Policy." Marine Policy 29: 189-197.

Daw, T and Gray, T (2005). "Fisheries science and sustainability in international policy: a study of failure in the European Union’s Common Fisheries Policy." Marine Policy 29: 189-197.

Delaney, AE and Hastie, JE (2007). "Lost in translation: Differences in role identities between fisheries scientists and managers." Ocean & Coastal Management 50(8): 661-682.

Dwyer, PD et al. (2008). "Managing shark fishermen in southern Australia: A critique." Marine Policy 32(3): 263-273.

Follett, MP (1955). Dynamic Administration: the collected papers of Mary Parker Follett. New York, Harper & Row Publishers.

Hajkowicz, S (2008). "Supporting multi-stakeholder environmental decisions." Journal of Environmental Management 88(4): 607-614.

Hauge, KH et al. (2005). "A framework for making qualities of indicators transparent." ICES J. Mar. Sci. 62(3): 552-557.

Hilborn, R (2007). "Defining success in fisheries and conflicts in objectives." Marine Policy 31: 153-158.

Hilborn, R and Walters, CJ (1992). Quantitative Fisheries Stock Assessment: Choice, Dynamics and Uncertainty. New York, Chapman and Hall.

Horwood, J and Griffith, DdG (1992). "Management strategies and objectives for fisheries." Privately published: 38 pp.

ICES (2007). "Report of the Arctic Fisheries Working Group." ICES Advisory Committee on Fishery Management, ICES CM 2007/ACFM:16.

ICES (2008). "ICES Advice for Barents Sea capelin." ICES Advice 2008 Book 4.

ICES (2008). "Report of the Arctic Fisheries Working Group." ICES Advisory Committee, ICES CM 2007/ACOM:01.

Jentoft, S (2007). "Beyond fisheries management: The Phronetic dimension." Marine Policy 30: 671-680.

Jentoft, S and McCay, B (1995). "User participation in fisheries management – Lessons drawn from international experiences " Marine Policy 19: 227-246.

Jørgensen, C et al. (2007). "Managing Evolving Fish Stocks." Science 318.

Kain, J-H and Söderberg, H (2008). "Management of complex knowledge in planning for sustainable development: The use of multi-criteria decision aids." Environmental Impact Assessment Review 28(1): 7-21.

Lande, R et al. (2003). Stochastic Population Dynamics in Ecology and Conservation, Oxford University Press

Lande, R et al. (1994). "Optimal harvesting, economic discounting and extinction risk in fluctuating populations." Nature 372(3).

Lande, R et al. (1995). "Optimal harvesting of fluctuating populations with a risk of extinction " The American Naturalist 145 728-745.

Mendoza, GA and Martins, H (2006). "Multi-criteria decision analysis in natural resource management: A critical review of methods and new modelling paradigms." Forest Ecology and Management 230(1-3): 1-22.

Needle, CL (2002). "Recruitment models: diagnosis and prognosis." Reviews in Fish Biology and Fisheries 11: 95-111.

Paramor, OAL et al. (2005). Involving fishers in the development of a fisheries ecosystem plan. ICES CM 32.

Pestes, LR et al. (2008). "Bayesian Decision Analysis for Evaluating Management Options to Promote Recovery of a Depleted Salmon Population." Conservation Biology 22(2): 351-361.

Quinn, TJ and Deriso, RB (1999). Quantitative Fish Dynamics Oxford University Press.

Regan, H et al. (2006). "A formal model for consensus and negotiation in environmental management." Journal of Environmental Management 80: 167-176.

Safina, C et al. (2005). "OCEANS: U.S. Ocean Fish Recovery: Staying the Course." Science 309(5735): 707-708.

Symes, D and Phillipson, J (2009). "Whatever became of social objectives in fisheries policy?" Fisheries Research 95(1): 1-5.

www.fisheries.no. (2008). "Northeast Arctic cod."   Retrieved October 20, 2008, from http://www.fisheries.no/marine_stocks/fish_stocks/cod/north_east_arctic_cod.htm.