Unintended and perverse consequences of ignoring linkages in fisheries systems

Poul Degnbol and Bonnie J. McCay

Degnbol, P., and McCay, B. J. 2006. Unintended and perverse consequences of ignoring linkages in fisheries systems. – ICES Journal of Marine Science, 64: 793–797.

The development of fisheries management strategies within institutions such as national governments, the EU, and ICES includes explicit or implicit decisions on longer term management objectives and performance criteria, on the relevant knowledge base for tactical management decisions, on decision rules regarding fisheries in the current or forthcoming fishing season, and on the implementation framework. These decisions, moreover, must be relevant to the characteristics of the fisheries and the stocks being exploited. The development of management strategies must be based, therefore, on an understanding of the overall fisheries system and linkages among its components. Based on recent examples in Europe and North America, we discuss how a failure to understand the linkages in the fisheries system may lead to management strategies that fail to achieve their objectives, and how an understanding of these linkages can inform the development of strategies that are more likely to achieve policy objectives.

Keywords: cod, data fouling, fisheries management strategies, fisheries system, goals and objectives, stakeholders.

Received 30 June 2006; accepted 14 February 2007; advance access publication 17 May 2007.

P. Degnbol: European Commission, DG Fisheries and Maritime Affairs, 79 Rue Joseph II 02/66, B-1000 Brussels, Belgium. B. J. McCay: School of Environmental and Biological Sciences, Rutgers the State University, New Brunswick, NJ 08901, USA. Correspondence to P. Degnbol: tel:+32 2 295 73 16; fax:+32 2 299 83 96; e-mail: poul.degnbol@ec.europa.eu.

Introduction

Fisheries management navigates in a seascape of interconnected institutions, each with its own set of complexities, and all interlinked. Failure to consider important features of this seascape will almost certainly result in failure to achieve objectives and lead to tensions. In the past, various management plans have been adopted in the North Atlantic, plans that have not always been effective in achieving their stated objectives and sometimes creating considerable tension between management agencies and stakeholders. Attempts to remedy the situation have largely been through increasingly detailed and complex regulations within the framework of the agreed management plans (micromanagement).

Using three case studies of Atlantic cod (*Gadus morhua*) management, we make the case that these experiences underscore the need for fisheries management to be based on an understanding of fisheries as an interconnected system of institutions. Ignoring the characteristics of these institutions and their linkages will lead to problems such as those seen recently in recovery plans.

The fisheries system

The notion that fisheries management must be seen in context is a basic premise in social science research of fisheries, but it has also developed in the community of fisheries biologists that remain the key providers of management advice in Europe and North America. Most countries with national jurisdiction of sea areas in the North Atlantic have legislation that requires management decisions to be informed by some form of research-based evidence. International bodies with management responsibility for fisheries in international waters have similar requirements. However, the research-based evidence used has largely been the product of biological models that hardly consider the wider institutional seascape of fisheries management.

As a consequence, management decisions generally have not resulted in the outcomes predicted by the models. Among biological modellers, this has been seen as a symptom of imperfection of the models, and a solution has been sought within the modelling discourse. The problems to be addressed were identified in model terms as various sources of uncertainty and bias, including data and model error in the assessments and implementation error in management (Degnbol, 2003, 2004). Following pioneering work in the International Whaling Commission (IWC), feedback models were developed that not only considered the initial population of fish in the sea and forward projections in the presence of fisheries, but also the process of producing the data on which assessments are based, the assessment process itself, and the implementation of management decisions. These considerations were further developed in a fisheries systems approach by ICES (2000). Expanding on the IWC approach, a concept of the fisheries system was developed that not only considered the feedback within the assessment model, but identified explicitly the specific social activities and institutions constituting the feedback.

The model considered four closely interlinked subsystems: the knowledge-production system, the management-decision system, the implementation system, and the fisheries-adaptation system. This rather mechanical image of the fisheries system reflected the formal sequence of information flow and decisions

implemented in Europe at the time, which was fairly unidirectional, starting with stock assessments, biological advice leading to management decisions on that basis, then fishing taking place subject to monitoring and control. However, the image was criticized because these formal unidirectional linkages were supplemented with many informal linkages that nevertheless were conducive for communication and power.

Within the community of fisheries biologists, an understanding developed that stock assessments and biological advice could not be seen as independent, but rather as framed by other components in the fisheries system. Trivial as this may seem to social scientists, this development was important in a community where the more common diagnosis of management failure was that policy-makers and fishers did not follow the biological advice. Although this change in understanding has not yet led to wholesale adoption of a more systemic approach (as would be required in a full ecosystem-approach management regime), it also suggests the value of incremental changes within existing institutions for fisheries management, whereby the contingencies of larger fisheries systems are considered in the crafting of harvest control rules (HCRs) and other measures.

Biologists and policy-makers working within a narrower framework can be frustrated by policy failures, unaware that to some extent these are unintended consequences of policies made without paying due attention to linkages. As we show in more detail below, the link between knowledge and control may be particularly rampant when catch data are the basis both for controlling fishing activities and for producing management advice. European fisheries provide many examples of rampant couplings, where imperfect landings control results in seriously biased catch data. This leads to uncertainty in stock assessments and unreliable forecasts, resulting in agreed total allowable catches (TACs) that do not match the actual situation in the stocks and the fisheries exploiting them. The Canadian case of TAC-based management of northern cod in the 1980s is a classic and tragic example of such a vicious circle (Martin, 1995; Walters and Maguire, 1996; Finlayson and McCay, 1998), as is TAC management in North Sea flatfish fisheries (Daan, 1997).

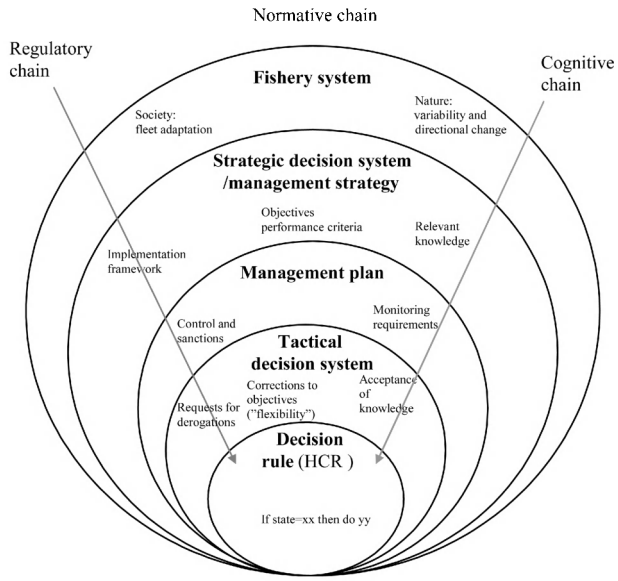

Figure 1. The management strategy hierarchy.

The linkages in the fisheries system may be simplified for analytical purposes by considering the management strategy as a decision hierarchy including normative, cognitive, and regulatory aspects of the fisheries system (Figure 1). A management strategy is based on meta-level decisions on the objectives, the implementation framework, and the relevant knowledge base for decisions and implementation. The management plan includes specific decision rules (e.g. HCRs) and decisions regarding the specifics of implementation (e.g. control and sanctions), as well as the specifics of knowledge (e.g. monitoring requirements). The decision rules stipulated in the plan are implemented within the formal framework of the management strategy, but they are also subject to informal tactical considerations. These tactical considerations are at play when specific decisions are to be made. Normative dimensions include the explicit and implicit management objectives. The knowledge base is the key cognitive aspect. Regulatory aspects range widely, from specific decision rules and their implementation to broader efforts aimed at control and monitoring.

European cod management

Our first case study concerns the North Sea cod recovery plan, which failed to achieve its stated objective of rebuilding the stock to a safe level (Horwood *et al.*, 2006). This may be interpreted as a consequence of ignoring important linkages in the fisheries system (Schwach *et al.*, 2007). Considering the recent history of this plan leads us to the assessment below.

(i) *Normative linkages.* Explicit objectives developed in the formal management process may be only a subset of the normative objectives considered important by stakeholders, and failure to include the fuller range in policy-making can work against achieving key ones. The recovery plan was designed for a single major objective (rebuilding of the stock as a prerequisite to ecological sustainability); decision-makers did not explicitly consider other objectives relating to social sustainability or short-term interests of fishers and the market, not seeing those as linked to the managed system in a relevant way. Having ignored those norms, they were either unprepared or had no mechanisms to balance objectives that were conflicting in the short term. Annual decisions on the TAC and effort should have been fairly mechanical because of an agreed HCR that linked the measures to be taken directly to the assessed state of the stock. Instead, annual decisions were subject to extended bargaining, during which process an extensive suite of other objectives was brought into play. In practice, it was not possible to adhere to the HCR stipulated in the recovery plan.

(ii) *Linkages between implementation and knowledge.* The knowledge base for management decisions is closely linked to the implementation framework. In European waters, the TAC regime and the HCR have been built on the assumption that stock biomass can be estimated and projected forwards under various assumptions about exploitation rate. However, as cod TACs were gradually reduced, ineffective implementation and illegal and unreported (IU) fishing resulted in landings data being increasingly unreliable as a basis for stock assessment. Eventually, biologists concluded that they were not in a position to assess the status of the stocks and to carry out the catch forecasts required for the HCR to be implemented (ICES, 2003, 2004, 2005).

Moreover, the relevance of the knowledge presented by the biologists was questioned; their attempts to include estimates of IU catches in the analyses were met with scepticism from stakeholders and governments. Lacking a quantitative basis to support the HCR, the management plans could no longer be implemented.

(iii) *Linkages between allocation principles and operational feasibility.* Key decisions made at the collective choice levels, particularly concerning allocation (who gets what or how much) can determine what is possible at the operational level (cf. Schlager and Ostrom, 1992). In the European arena, the distribution of access to the resources among countries is locked into the principle of relative stability: each country has a fixed percentage share in the agreed TAC for each stock. This allocation principle locks the management system into a TAC modus. When the North Sea cod recovery plan was developed, ICES (2003) advised that, based on a defective implementation history, TACs alone would not be effective in controlling fishing mortality. Therefore, the plan included supplementary measures to reduce effort to a level that would be compatible with just taking the cod TAC. The objective was that mixed fisheries would have to stop simultaneously with exhaustion of the cod TAC, so avoiding both IU fishing and extensive discarding of cod. This combination of TAC and effort management led to adaptations in fleet behaviour, which may have reduced the effectiveness of the effort restrictions. For instance, the European Commission stated in a "non-paper" on the subject (CEC, 2006): "Another weakness of the effort limitation regime is that it restricts the number of days-at-sea per vessel but does not restrict the number of vessels in each fleet segment. This has created an incentive for fishers to move from gears that traditionally targeted cod, which were subject to the biggest reductions in effort, towards smaller-mesh gears where cod is taken as a bycatch. The bycatches of cod in the small-mesh fisheries may be discarded, or may be landed if catch composition rules are not properly enforced".

(iv) *Linkages between natural and social sciences.* The recovery plan also required an extension of the knowledge base for management decisions to include detailed information about the distribution of effort and catches by fleet, and forecasts of the consequences of changing effort distributions across fleets. Thus, biologists were requested to analyse social units (fleets) and to relate to human behaviour (fishers' responses to management measures), which resulted in tensions regarding the borders of their science (Wilson and Delaney, 2005). On the management decision side, the supplementary effort system resulted in multiple requests for derogations from stakeholders claiming that special conditions applied to their fleet segment. Consequently, the system developed into an extensive micromanagement exercise, and to date it has not been effective in achieving its objective of rebuilding the cod stock.

Canadian cod management

Issues concerning knowledge, norms, allocation principles, and linkages between natural and social factors are also evident in cod recovery management in Atlantic Canada, as well as in the USA. We focus on the importance of recognizing and dealing explicitly with normative linkages, the effects of changes in the framework of collective action, and decisions that lead to mistrust of the managers or questions about the legitimacy of the knowledge basis for management.

In Canada, employment, viability of local communities, and other social objectives had not been incorporated explicitly in the management strategies adopted by government bodies. Consequently, social objectives have surfaced in ways that make it difficult to reconcile them with rebuilding objectives. This took place in the 1980s, when recommended TACs were overridden by managers under political pressure (Finlayson, 1994; Martin, 1995). This political pressure was fuelled partly by concern about the accuracy of the stock projections, another clear instance of knowledge linkages. In 1992, the federal Minister of Fisheries imposed a moratorium on northern cod catches, a drastic measure taken in response to equally drastic declines in catches. The moratorium did not result in recovery of the northern cod populations in most areas, and therefore continued. However, the implicit objectives of maintaining fishing communities—and the dependent inshore enterprises—continued to surface and to temper rebuilding plans. By the mid-1990s, the government allowed liberal recreational or subsistence fishing periods and reopened short seasons for commercial fishing combined with small TACs. Some argue that these decisions contributed to the continuing failure of northern cod restoration, although this remains a contested issue. In 2006, the federal government announced a generous "food fishery" and boat quota for the inshore fishing fleet (DFO, 2006), following the widely publicized civil disobedience that took place in 2005 when those fisheries were closed (Banks and Baker, 2006).

US cod management and NGOs

Attention to social and economic objectives is built into the formal decision-making process for federal fisheries in the USA (Fricke, 1985). Management plans must include analyses of their economic and social impacts and take account of the needs of fishing communities (McCay *et al.*, 2002a, b). Nonetheless, lack of viable institutions for reconciling multiple and potentially conflicting objectives is similar to the situation in Atlantic Canada and the EU. It contributed to delays and stalemate on the part of the multistakeholder New England Fisheries Management Council (NEFMC), which (like other regional councils) has been criticized for over-representation of industry interests as the main reason for its failure to take more aggressive measures to protect and restore depleted stocks (Eagle *et al.*, 2003).

US cod management has been marked by a major change in the collective-action framework through the entry of environmental groups as major stakeholders: non-governmental organizations (NGOs) have become active in using the law courts to require agencies to implement stricter management measures. Although NEFMC acknowledged that major demersal stocks were overfished, there was little action until the courts became involved. In 1991, the Conservation Law Foundation filed suit, leading to a settlement that forced the NEFMC to implement stronger restrictions on fishing. It was the first suit by a NGO, based solely on enforcing conservation elements of the federal fisheries law (Levin, 2002). The settlement reached in that litigation led to a new plan that became operative in 1994 and cut groundfish mortality by half over 5 years (Levin, 2002), which was implemented in the context of measures to provide economic relief to affected coastal communities (Buck, 1996). Another

NGO-initiated lawsuit in 2001 led to a negotiated legal settlement in 2003 that forced the NEFMC to adopt more explicit goals (expressed as a "target TAC", a proxy for an actual TAC (which is still resisted politically), and even more stringent cutbacks in fishing mortality. The main tool (days at sea) to achieve the target TAC is effort reduction, in combination with stationary and rolling area closures and other measures (Fletcher and Gardner, n.d.; Levin, 2002; Hogarth, 2003). The missing linkages discussed above are now being forced upon managers by law and politics.

From another perspective, the importance of cognitive and regulatory linkages can be highlighted by examining how outcomes for fishers can foster mistrust of the managers or questions about the legitimacy of the knowledge basis for management. A recent example can be found in the opening of a closed area for fishing yellowtail flounder in New England waters in 2004 (Hall-Arber, 2006). The details of this measure, specifically the overall TAC and the trip limits, were designed by the multistakeholder NEFMC, the decisions being affected by a failure to understand fully the uncertainties in a US/Canadian stock assessment (TRAC, 2003) and its effects on the allocation of catches between the two countries (Hall-Arber, 2006). Consequently, trip limits were set so high that the regional market quickly became glutted and prices plummeted, hurting the industry and generating suspicion of the scientific institutions and the management agency. Interestingly, many boats continued fishing even though prices were low. This seemingly irrational behaviour only makes sense in relation to yet another contextual linkage: between past experience and future expectations. Briefly, building up a history of high landings is widely viewed in New England as smart in the face of an uncertain management future, given the ways that limited access and days-at-sea allocations have been handled in the past (Hall-Arber, 2006). This itself is a perverse outcome of the failure to anticipate (and to take account of) linkages, given the need to reduce effort.

Discussion

A management strategy consists of at least three different types of decisions:

(i) normative: on longer term objectives and performance criteria (implicit or explicit);

(ii) cognitive: on the relevant knowledge base for tactical decisions (implicit or explicit);

(iii) regulatory: on the general implementation framework (mainly input or output control) and instruments including sanctions, HCRs, and monitoring and control requirements (usually explicit).

In the three cases discussed, explicit normative decisions were to restore stocks and reduce fishing pressure to sustainable levels. The cognitive decisions were that the relevant knowledge referred to classical stock assessment and population dynamics associated with forecasts of catch levels that were expected to lead to specific changes in biomass. The key regulatory decision in the EU was that TACs were set according to a HCR, in Canada to reduce effort and catches to nil (moratorium), and in the US to reduce effort as a proxy for achieving a catch that matched a target TAC. The implicit assumptions in all three cases were therefore that a biological objective should be the overriding concern and that rebuilding could be achieved by controlling catches based on deterministic predictions.

The outcomes have been disappointing in all three cases, for differing but related reasons, as well as for reasons as yet not understood concerning the biology of cod and the ecology of the North Atlantic. Our focus is on the lack or inadequacy of attention paid to linkages between the narrower concerns of traditional, top-down management and the dynamic contingencies that constitute the larger fisheries system. Within the top-down management institutions that we have inherited, these may be recast as external constraints, which include the future state of nature and the future behaviour of the fishing fleet in response to management measures imposed. These external constraints cannot be predicted, but management strategies can be evaluated in terms of their robustness to changes in these constraints.

Conclusion

Management can only be effective in achieving its longer term objectives if it is based on an understanding of fisheries as a system with important linkages between institutions involved in the production and evaluation of knowledge, institutions for management decision-making, the implementation framework, and adaptations in the fisheries. The development of management strategies requires explicit or implicit decisions on longer term management objectives and performance criteria, on the relevant knowledge base for tactical management decisions, on HCRs, and on the implementation framework. These decisions must be relevant to the characteristics of the fisheries and the stocks they exploit. The development of management strategies, therefore, must be based on an understanding of the overall fisheries system and the linkages between its normative, cognitive, and regulatory aspects.

Developing management schemes that incorporate such a broad understanding is not a trivial task. There are obstacles to achieving consensus on objectives, especially with strong differences among fleets and important differences in perception, attitudes, and constraints among scientists, managers, fishers, and, increasingly, "green" and consumer groups. Additionally, developing performance criteria that are measurable and appropriate for the biological and social realities of fisheries systems is challenging. Moreover, managers may be reluctant to do so because they can be held accountable for achieving specific performance objectives (an argument for co-management, so that such responsibility can be shared with industry participants). Yet it should be possible. The recent development in ICES advice on European anglerfish (*Lophius* spp.) is an example of a learning process involved in seeking this goal. The advice was changed from standard TAC advice to an effort-based adaptive approach with direct reference to the vicious circle created by the TAC regime originally in place (ICES, 2003, 2004, 2005). Therefore, greater attention to linkages within fisheries systems in designing and implementing control rules may be worth the effort, given the often perverse and sometimes dire consequences of failing to do so, as exemplified in the cases reviewed above.

Acknowledgements

We acknowledge Niels Daan and Douglas Clyde Wilson for constructive comments.

References

Banks, P., and Baker, J. 2006. To catch a cod. The Gander Beacon, 19 June, 1: 4.

Buck, E. H. 1996. IB95036: Magnuson Fishery Conservation and Management Act Reauthorization. Congressional Research Service Reports. Washington, DC: Congressional Research Service, Environment and Natural Resources Policy Division. Available through National Council for Science and the Environment. http://www.ncseonline.org/NLE/CRS/abstract.cfm?NLEid=9.

CEC. 2006. Review of the Cod Recovery Plan. Discussion Documents for Member States and Stakeholder Organisations. European Commission Document D 08373 2006.

DFO. 2006. Press Release: Minister Hearn announces 2006 management plan for 2J3KL, 3Ps and 4RST capelin fisheries. Department of Fisheries and Oceans, Canada – Newfoundland and Labrador Region. NR–NL-06–22, 20 June 2006.

Daan, N. 1997. TAC management in North Sea flatfish fisheries. Journal of Sea Research, 37: 321–341.

Degnbol, P. 2003. Science and the user perspective: the scale gap and the need for co-management. *In* The Fisheries Co-management Experience: Accomplishments, Challenges and Prospects, pp. 31–49. Ed. by D. C. Wilson, J. R. Nielsen, and P. Degnbol. Kluwer, Dordrecht.

Degnbol, P. 2004. Fisheries science in a development context. *In* Fisheries Development: The Institutional Change, pp. 131–156. Ed. by B. Hersoug, S. Jentoft, and P. Degnbol. Eburon Academic Publishers, Delft.

Eagle, J., Newkirk, S., and Thompson, B. H. 2003. Taking stock of the regional fishery management councils. Pew Science Series on Conservation and the Environment. Stanford Fisheries Policy Project, Stanford University. http://fisheries.stanford.edu/Stanford_Council_Report.pdf.

Finlayson, A. C. 1994. Fishing for truth: a sociological analysis of northern cod stock assessments from 1977–1990. Institute of Social and Economic Research, Memorial University of Newfoundland, St Johns, Newfoundland.

Finlayson, A. C., and McCay, B. J. 1998. Crossing the threshold of ecosystem resilience: the commercial extinction of northern cod. *In* Linking Social and Ecological Systems: Institutional Learning for Resilience, pp. 311–337. Ed. by C. Folke, and F. Berkes. Cambridge University Press, Cambridge, UK.

Fletcher, K. M., and Gardner, S. E. n.d. Groundfish Management Proves Daunting to Court, Fishers: Conservation Law Foundation v. Evans, 211 F. Suppl. 2d 55 (D. D.C. 2002). The National Sea Grant Law Center, University, MS. http://www.olemiss.edu/orgs/SGLC/National/SandBar/1.3groundfish.htm.

Fricke, P. H. 1985. Use of sociological data in the allocation of common property resources: a comparison of practices. Marine Policy, 9: 39–52.

Hall-Arber, M. 2006. In Hindsight: Yellowtail Flounder 2004—a case study based partially on interviews conducted by John O'Leary, F/V Captain Bligh, New Bedford Community Panel. Massachusetts Fishermen's Partnership's Community Panels Project. MIT Sea Grant College Program, Cambridge, MA.

Hogarth, W. T. 2003. Testimony of William T. Hogarth, Ph.D. Assistant Administrator for Fisheries on Magnuson-Stevens Act National Standards and Amendment 13 to the Northeast Multispecies Fishery Management Plan before the Subcommittee on Oceans, Fisheries, and Coast Guard, Commerce, Science, and Transportation Committee, US Senate, Washington, DC, 22 October 2003. http://www.senate.gov/~commerce/hearings/]testimony.cfm?id=969&wit_id=2738.

Horwood, J., O'Brien, C., and Darby, C. 2006. North Sea cod recovery? ICES Journal of Marine Science, 63: 961–968.

ICES. 2000. Report of the ICES Working Group on Fisheries Systems. ICES CM 2000/D: 02. 44 pp.

ICES. 2003. Report of the ICES Advisory Committee on Fishery Management, 2003. ICES Advice, 1–3. 975 pp.

ICES. 2004. Report of the ICES Advisory Committee on Fishery Management and Advisory Committee on Ecosystems, 2005. ICES Advice, 2. 1073 pp.

ICES. 2005. Report of the ICES Advisory Committee on Fishery Management, Advisory Committee on the Marine Environment, and Advisory Committee on Ecosystems, 2005. ICES Advice, 1–11. 1418 pp.

Levin, D. 2002. A glorious win for a troubled tradition. Conservation Matters (Summer, 2002). Conservation Law Foundation. http://www.clf.org/general/index.asp?id=428.

Martin, C. 1995. The collapse of the northern cod stocks. Fisheries, 20: 6–8.

McCay, B. J., Oles, B., Stoffle, B., Bochenek, E., St Martin, K., Graziosi, G., Johnson, T., *et al.* 2002a. Port and Community Profiles, Amendment 9, Squid, Atlantic Mackerel, and Butterfish Fishery Management Plan: A Report to the Mid-Atlantic Fishery Management Council, The Fisheries Project, Rutgers the State University, New Brunswick, NJ.

McCay, B. J., Wilson, D. C., Lamarque, J., St Martin, K., Bochenek, E., Stoffle, B., Oles, B., *et al.* 2002b. Port and Community Profiles and Social Impact Assessment, Amendment 13 of the Surfclam and Ocean Quahog Fishery Management Plan: A Report to the Mid-Atlantic Fishery Management Council, The Fisheries Project, Rutgers the State University, New Brunswick, NJ.

Schlager, E., and Ostrom, E. 1992. Property-rights regimes and natural resources: a conceptual analysis. Land Economics, 68: 249–262.

TRAC. 2003. Proceedings of the Seventh Meeting of the Transboundary Resources Assessment Committee (TRAC), 27–29 May 2003, Woods Hole, MA.

Schwach, V., Bailly, D., Christensen, A-S., Delaney, A. E., Degnbol, P., van Densen, W. L. T., Holm, P., *et al.* 2007. Policy and knowledge in fisheries management: a policy brief. ICES Journal of Marine Science, 64: 798–803.

Walters, C., and Maguire, J-J. 1996. Lessons for stock assessment from the northern cod collapse. Reviews in Fish Biology and Fisheries, 6: 125–137.

Wilson, D. C., and Delaney, A. E. 2005. Scientific knowledge and participation in the management of fisheries in the North Sea. *In* Participation in Fisheries Governance, pp. 319–342. Ed. by T. S. Gray. Springer, Dordrecht.

doi:10.1093/icesjms/fsm040