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What are we Managing Anyway?: The Need for an Interdisciplinary Approach to Managing Fisheries Ecosystems

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Fisheries managers should really be attempting to manage the fishing fleets and the processing industry, not the fish. Consequently we argue that effective management ought to take an eco-systems approach that is necessarily interdisciplinary, incorporating both natural and social sciences. We ascribe the inadequate results of existing management regimes to scientific uncertainty, political pressures, the regulations' lack of legitimacy among fishers, and excessive reliance on individual fishers (rather than households and communities) as the unit of analysis. In a new interdisciplinary approach, we emphasize the contribution of social science in helping to understand what is defined as scientific knowledge, how expert scientific and local or traditional knowledge might be integrated, and the role of science in the management process. We conclude by advocating an ecosystem management strategy of periodic (every three to five years) in-depth assessments with explicit requirements for sociological and economic input.

Introduction

Although most people recognize that wild fish are almost impossible to manage, the field of fisheries science is still overwhelmingly concerned with fish biology and fish population dynamics. In addition, despite the well-known unanticipated consequences of fisheries management regimes, managers have tended to persist in their reliance upon highly simplified models of human behaviour. Yet, it is the fishing fleets and the

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processing industry that agencies are really attempting to manage, not the fish. Effective management of these human elements of the ecosystem would benefit from insights found in such disciplines as sociology, anthropology, and economics. Surprisingly, very few data on the economic and social aspects of fishing communities and fishing fleets are collected, analyzed, and peer reviewed by fisheries management agencies.

In this paper, we propose a more thoroughly interdisciplinary approach to fisheries management and fisheries science to help solve some of the problems currently confronting us. We are not talking about *adding on* social science, but of a different approach based on a critique of existing fisheries science and fisheries social science. We shall proceed by reviewing some problematic aspects of recent experiences with fisheries science and management. This will include criticisms of these practices from a social science perspective, prior to offering some suggestions for change.

I. *Current Practices and Problems*

Most industrialized countries with fishing interests have set up impressive stock assessment and fisheries management machinery. The European Union, Scandinavian, and other European countries are using the machinery of the International Council for the Exploration of the Sea (ICES) to provide them with peer-reviewed stock assessments and, when appropriate, fisheries management advice. Other countries unable to use ICES have set up their own domestic systems. For transboundary stocks or highly migratory species, international organizations, such as ICCAT (International Commission for the Conservation of Atlantic Tuna), NAFO (Northwest Atlantic Fisheries Organization) and IATTC (Inter-American Tropical Tuna Commission), provide stock assessments and fisheries management advice. In most cases, the approach appears quite similar: biologists produce peer reviewed stock assessments which serve as a starting point for an elaborate set of consultations, discussions, or negotiations on TACs (total allowable catches) and other management measures, either between or within countries.

This approach was intended to improve fisheries management, conserve the fish, and help the fishers, fish plant workers and fish processors earn a decent living. Although there are a few exceptions, as a rule, it can be said that these objectives have not been achieved: neither the fish, the fishers, the fish plant workers nor the fish processors appears to have benefitted significantly from fisheries management. While many individuals in the fisheries have profited from various forms of subsidy designed to improve their vessels or their fishing plants, the fishing

communities have not benefitted in terms of stability in employment, self-reliance, and self-direction. Nor has ecological sustainability been achieved. Fisheries managers have increasingly been forced to recognize that they cannot successfully manage particular fisheries without accepting that each is part of a larger ecosystem that includes people as well as other species in a marine environment.

II. *Scientific Uncertainty*

Scientific uncertainty has contributed to the failure of management regimes to achieve their goals. The VPA-based[1] assessments for stocks in the areas covered by ICES and in eastern Canada are typically imprecise. This is easily understandable when the reliability of catch and effort data used in those assessments is examined. Not only are these data difficult to gather, but misreporting, dumping and discarding are widespread problems. Dependable data with adequate historical depth are also rare and, in combination with often unprecedented overfishing (the scale and effects of which are poorly understood), this has created additional scientific uncertainty. Scientific uncertainty is further compounded when, perhaps because of disciplinary boundaries (science studies fish), stock assessments treat technology and human behaviour as though they are constant rather than changing in response to the effects of fishing, the environment, industrial developments, and managerial initiatives. Given these multiple sources of uncertainty, scientists have been unable to achieve the precision in estimating abundance that is required to meet the expectations of fisheries managers or industry participants—that is, about plus or minus 10 percent. In fact, yearly changes of this magnitude in estimated stock status could as easily reflect variability in the data as real changes in stock size.

Fisheries biologists recognize this variability and they are willing to accept that assessments are uncertain and imprecise. They are also willing to accept that models and assessments are subject to subsequent challenge. This is the nature of science. Within the current institutional structures, however, such recognition is more elusive, especially for high profile stocks. For instance, the Advisory Committee on Fisheries Management of ICES feels comfortable rejecting new VPA-based assessments by the Southern Shelf working group, but it is considerably more reluctant to do so with higher profile stocks assessed by the Northwestern,

1. The process of VPA, or virtual population analysis, involves the reconstruction of the size of a particular year class of fish once actual catches in subsequent years are known. Thus initial estimates may be revised up or down until the natural life-span of fish born in a particular year has been reached.

North-east Arctic, or Northern Shelf Demersal Working Groups, even if the coefficients of variation are almost as high. When fisheries were still open, the Canadian east coast groundfish managers would become disturbed when an updated stock assessment showed a change of 10 percent or more from the previous year, especially if the revision was downward, because this meant that all quotas and allocations had to be discussed and renegotiated. There is no doubt that many other managers face similar problems. ICES reports show that changes in fish mortality effect catches and biomasses by 10%. Fisheries managers have been unwilling to envisage changes of greater magnitude.

One reason why fisheries science has been imprecise is the disciplinary focus on biology and the consequent lack of attention to the kinds of factors that sociologists or anthropologists would bring into assessment models. For example, although misreporting and dumping of fish at sea have long been known to occur, research scientists have not taken them into account in estimating fish mortality. Although it would be impossible to be precise about the extent to which catches exceed recorded landings, failure to make any allowance in the past meant that the number of fish killed by fishing was underestimated, leading to excessively optimistic estimates of stocks such as the northern cod. We note that the recent fisheries crisis has forced attention to this issue.[2] In recent research on Newfoundland's Great Northern Peninsula, skippers of small draggers claimed that all vessels engaged in "under the table sales" of up to 25 percent of the volume of fish formally recorded.[3] This figure was said to be based on the amount of fish that buyers could "hide" from official scrutiny.

III. *Management Issues*

Fisheries managers have been struggling to regulate both fisheries conservation and access to fisheries for several decades in most advanced industrial countries. Management decisions are influenced not only by the stock assessments but also by intellectual trends and political factors reaching far beyond the communities most directly affected by the decisions. The influence of political factors may be masked when they are not explicitly identified. For example, during periods of stock collapse when effort tends to shift to so-called "underutilized" fisheries,

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2. Canada, *Report of the Workshop on Scotia-Fundy Groundfish Management from 1977 to 1993* by J.R. Angel *et al.* (Dartmouth: Bedford Institute of Oceanography, 1994).

3. C.T. Palmer & P.R. Sinclair, "Perceptions of a Fishery in Crisis: the Attitudes of Dragger Skippers Towards the Gulf of St. Lawrence Cod Moratorium" (Paper submitted to the annual meeting of American Fisheries Society, Halifax, N.S., 1994) [unpublished].

management decisions may be made in the absence of a meaningful scientific basis for stock assessment without this being publicly acknowledged. This seems to have been the case in the lumpfish fishery in Newfoundland and Labrador in 1994. During recent interviews with fishermen,[4] their queries concerning the scientific basis for the recent management decision to expand the number of nets per fisher in the lumpfish roe fishery in Newfoundland caused a scientist participating in the research to comment that no full stock assessment had yet been completed. Indeed, the official 1994 lumpfish management plan makes no reference to any scientific data to justify its regulations, which included a net limit of 100 per licence-holder.[5] The fishers themselves believed that the lumpfish stocks were in trouble and had advocated a limit of 50 nets per fisher. They thought that science had legitimated the increase to which they were opposed. As a result, subsequent changes in management policy, if they result in a reduction of effort, will further undermine the credibility of science and management agencies in their eyes. This, in turn, could influence compliance with regulations.

The proliferation of rules and regulations and the bureaucratic nature of fisheries management have coincided, thereby hampering managers' efforts to conserve fishery resources. Low compliance is particularly common when the relevance of regulations with respect to conserving the resource or meeting the economic and social needs of communities is dubious. The end result is that all regulations are put on the same footing and even those which have important conservation aspects are just as easily disregarded. Although some form of fisheries surveillance and enforcement is clearly required, successful fisheries management will not occur if the participants do not generally agree to follow the rules and regulations.

The perceived benefits of regulation are likely to be particularly dubious where the impact is quite different from those anticipated by managers. For example, there is growing evidence that unanticipated impacts of fisheries "modernization" programmes included the "fishing out" of local populations of cod and the breaking down of local management regimes that limited access to the resource and possibly sustained

4. Based on pilot interviews by authors with Bonavista area fishers in August–September, 1994.

5. Canada, *1994 Lumpfish Management Plan. Newfoundland Region* (St. John's: Department of Fisheries and Oceans, 1994).

these populations.[6] This process, in turn, seems to have fuelled an expansion in effort as fishers found they were unable to land sufficient catches by using more traditional technologies—thus enhancing the risk of overfishing.

Licensing policy, intended to limit access and reduce excess capacity, may have contributed to overcapacity by limiting fishers' employment alternatives during periods of resource decline or low resource accessibility, thus forcing them to invest in more and more fishing technology. The model of human behaviour that has legitimized licensing policy is based on the assumption that fishers are greedy individualists who will recklessly expand effort unless they are limited. There is, however, evidence to the contrary in the history of the Atlantic Canadian fisheries in which we find numerous examples of effective local regulation.[7]

By using individual fishers as their unit of analysis, managers too often seem to overlook the differential social and ecological effects of technology. In the commonly cited explanation for fisheries crises, "too many fishermen chasing too few fish," management's contribution to the "too few fish" end of the equation is often ignored. This explanation also obscures the different ecological, economic, and social impacts of diverse fisheries technologies and ownership structures.[8] It reflects an approach to fisheries management that uses individual fishers as the unit of analysis.

An alternative approach, more commonly found in sociology and anthropology, views fishers as members of households and communities, while also highlighting technological factors and skipper-crew-corporate relations. Household and community membership influences both the options available to fishers and their decision-making processes. In some contexts, these relationships allow them to continue in the fishery despite declining earnings by drawing on the non-fishing incomes of other household members and by making informal arrangements with other members of the community. Household and community membership, particularly in the context of limited local employment alternatives, can also contribute to what appears to be "irrational" behaviour on the part of

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6. B.J. McKay, *Appropriate Technology and Coastal Fishermen of Newfoundland* (Ph.D. dissertation, Columbia University, 1976). See also Canada, *A Description of the Cod Stock Structure in Placentia Bay, NAFO Subdivision 3PS* (Department of Fisheries and Oceans Research Document 94/32) by M.B. Davis *et al.* (St. John's: Department of Fisheries and Oceans, 1994).

7. R. Matthews, *Controlling Common Property: Regulating Canada's East Coast Fisheries* (Toronto: University of Toronto Press, 1993).

8. A. Davis, *Dire Straits. The Dilemmas of a Fishery: the Case of Digby Neck and the Islands* (St. John's: Institute of Social and Economic Research, 1991).

individuals. That is, fishers may continue to fish when returns are low because abandoning the fishery can mean abandoning investments in home and community as well as risking not only their own incomes but those of other family members. Marilyn Porter argued some years ago that in making management decisions, such as which plants to close and which to keep open, it is important to ask who is married to whom.[9] Fewer fish plants might well force the remaining fishers to increase their fishing effort because they will have to support their households on fewer incomes.

Social scientists do not speak with a single voice, of course. It is noteworthy that conventional economics has been influential in making economic efficiency a criterion of policy, and more specifically in promoting various forms of limited entry and privatization of the resource. The assumption that common property in fisheries (as opposed to fully open access) is an evil that leads necessarily to overfishing has long been challenged by other social scientists based on widespread evidence of effective control at the community level.[10] Licensing and limits on boat lengths did not stop fishing capacity from increasing. Individual enterprise allocations may even make prior practices such as high grading or dumping more common.[11] These problems are seldom foreseen because of economists' underlying assumptions that people are always maximizing personal gain and that they will actually follow regulations. It is also likely that politicians are unwilling to implement new policies in the form that would give them the best chance of succeeding. Thus, even where social science has had some impact, it has still been problematic.

It could be argued that economic considerations have already had too large an impact on fisheries management decisions to the detriment of sound conservation measures and stability of fishing communities. But it is not that kind of economic input that is advocated here. Economics can make a useful contribution if it goes beyond the myopic position that

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9. M. Porter, "Peripheral Women: Towards a Feminist Analysis of the Atlantic Region" (1987) 23 Studies Pol. Economy 41.

10. B.J. McCay & J.M. Acheson, eds., *The Question of the Commons: The Culture and Ecology of Communal Resources* (Tucson: University of Arizona Press, 1987). See also E. Pinkerton, ed., *Cooperative Management of Local Fisheries: New Direction for Improved Management and Community Development* (Vancouver: University of British Columbia Press, 1989); R. Matthews, *supra* note 7; P. Marchak, N. Guppy & J. McMullan, eds., *Uncommon Property: The Fishery and Fish-Processing Industries in British Columbia* (Toronto: Metheun, 1987); J.R. McGoodwin, *Crisis in the World's Fisheries: People, Problems, and Policies* (Stanford: Stanford University Press, 1990).

11. R.I.C.C. Francis, D.J. Gilbert & J.H. Annala, "Fishery Management by Individual Quotas: Theory and Practice" (1993), 17 Marine Policy 54; J.R. Angel *et al. supra* note 2; C.T. Palmer & P.R. Sinclair, *supra* note 3.

lower catches mean lower incomes and fewer jobs. Economic assessments should take into account such factors as the real cost of the various fishing methods with regard to environmental effects, the long term economic viability of the fleets, employment multipliers, and estimates of the economic costs of stock collapses. Economic analyses need to recognize that fishers cannot be treated purely as individual actors, but must be considered as group members embedded in fishing households, which are, in turn, embedded in communities and networks of communities. What we are really advocating is a social science based on different foundations than standard economics. Rather than ignoring the household and community basis of the Atlantic Canadian fisheries, managerial initiatives might be more effective if they took this as their point of departure.

Sociologists and anthropologists also remind us that there are important equity questions that need to be addressed in fisheries management. For instance, in accounting for the persistence of large numbers within the fishery, managers often overlook the fact that many of the new entrants in the 1980s were women. Their entry into fishing was encouraged by successful Supreme Court challenges to unemployment insurance regulations that disqualified women who fished with their husbands.[12] Because most are recent entrants into fishing, women could be disproportionately affected by government efforts to "downsize" and "professionalize" fishing. More generally, managers and policy-makers have not carried out a gendered analysis of the impacts of fishery crisis response programmes on women, thereby increasing the risk that such programmes will enhance gender inequities in fishery communities.[13]

IV. *Impact on Industry Participants*

Not only assessment scientists and managers but also industry participants have difficulty coping with the uncertainty of assessments. In part this is due to inflexible investments that are wasted when assessment advice leads to a change in management plans. A recent Canadian

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12. B.J. McCay, "Fish Guts, Hair Nets and Unemployment Stamps: Women and Work in Cooperative Fish Plants" in P.R. Sinclair, ed., *A Question of Survival: The Fisheries and Newfoundland Society* (St. John's: Institute of Social and Economic Research, 1988). See also B. Neis, "From 'Shipped Girls' to 'Brides of the State': The Transition from Familial to Social Patriarchy in the Newfoundland Fishing Industry" (1993) 16 Canadian Journal of Regional Science 185.

13. Women's Committee, Consultation with Women in the Newfoundland Fishery (1994 St. John's: FFAW/CAW). See also M. Muzychka, *The Impact of the Cod Moratorium on Women in Newfoundland and Labrador: A Review of the Literature* (St. John's: Provincial Advisory Council on the Status of Women, 1994).

example is the wasted investment in gearing up for the turbot fishery that did not actually take place. Also, fishers who geared up for the cod fishery before the 1992 moratorium resented their lost investment (there are few alternative uses for most fishing technologies). In general, when a large scale commercial fishery is exhausted, unemployment is widespread and the base of social life is cut away. Even large companies like FPI (Fishery Products International) are forced into radical change in order to survive. Thus FPI has become a more diversified producer and participates in a complex global division of labour. With its Newfoundland operations much reduced, FPI is now profitable, while the local industry is in crisis.[14]

The lives of fishers and fishing communities today are considerably more complicated than before. They still depend on the vagaries of nature with respect to fish production and fish availability, but there are now additional sources of uncertainty related to the assessment of the size of the stock and the unpredictable fisheries management decisions that will be made. These decisions are influenced by intellectual trends and political factors reaching far outside the communities that will be most directly impacted by those decisions.

Among the uncertainties or complications confronting fishing communities today are the ecological, social, and economic impacts created by previous overfishing and previous management initiatives. There is growing evidence of the limited ability of science to provide accurate predictions of future outcomes not only in fisheries but in all contexts. Some who have participated, for example, in environmental impact assessment processes have begun speaking of the need to adopt initiatives that take for granted unanticipated consequences, a so-called "surprise" scientific approach. The prerequisites for a "surprise science" approach include extremely thorough social and environmental impact assessments that are carried out prior to the implementation of particular initiatives, and very thorough monitoring of both environmental and social impacts in such a way as to ensure rapid response to unanticipated impacts. Such an approach, it has been argued, requires researchers with skills and knowledge related to both the human and the environmental ends of the ecosystem, i.e. an interdisciplinary approach to management.[15] These prerequisites are not currently part of fisheries science or management.

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14. *St. John's Evening Telegram* (24 August, 1994) 1.
15. F. Berkes, "The Intrinsic Difficulty of Predicting Impacts: Lessons from the James Bay Hydro Project" (1988) 8 Environ. Impact Assess. Rev. 201.

V. *An Alternative Approach*

The circumstances we have outlined call for change in our organization of intellectual work and in management practices. Fisheries science has largely ignored people and fisheries social science has been largely ignorant of natural science. We have two quite separate schools of thought or disciplinary areas that have not been speaking to each other and that are not institutionally connected to any significant degree.[16] Although this paper stresses the improvement in management that might be achieved by adopting an interdisciplinary approach that would correct some of the problems created by the limitations of the focus on single disciplines, whether biology or economics, it should be pointed out that the other social sciences have been weakened by often ignoring the contributions of natural sciences and ecological factors in particular.[17]

The new interdisciplinary approach will need to incorporate social science, as we have argued, but social scientists will need to stop neglecting fisheries science and economics. Committed to the survival of many rural communities, sociologists and anthropologists may not always have been realistic about the employment potential of the fishery. They have also neglected both fishery workers' ecological knowledge and the social construction of scientific knowledge. More research is needed on the relationship between fisheries science and management[18] and the working of alternative decision making structures. There has also been neglect of ecological (as opposed to social and political) factors that might have contributed to changes such as the decline of the salt cod fishery and other technological transformations.

Why does the new interdisciplinary approach need social sciences? Aside from the contributions discussed above, they can draw attention to competing points of view, to social contextual factors that shape what comes to be defined as knowledge and what is marginalized or ridiculed rather than explored. Both science and management are shaped by their social context—shifting paradigms, latent assumptions and biases,

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16. We wonder why the initiative that brought noted social anthropologist Raoul Andersen to DFO in the 1970s with the task of mapping out an appropriate role for social science was not acted on earlier. See R. Andersen, "The Need for Human Science Research in Atlantic Coast Fisheries." (1978) 35 J. Fish. Res. Board Can. 1031.

17. An example of research that would have benefited from more attention to ecology is P.R. Sinclair, *From Traps to Draggers: Domestic Commodity Production in Northwest Newfoundland, 1850–1982*, (St. John's: Institute of Social and Economic Research, 1985).

18. But see especially A.C. Finlayson, *Fishing for Truth: A Sociological Analysis of Northern Cod Stock Assessments from 1977–1990* (St. John's: Institute of Social and Economic Research, 1994) for a radical social science approach to fisheries management. This work also contains a useful general introduction to issues in the sociology of science.

technologies, ethnocentrism, class bias, politics, and disciplinary boundaries. Social context influences both data collected and what becomes accepted as knowledge. This is perhaps most evident during periods of paradigm shift, crisis, and struggle between competing points of view. Thus, the science that underpins and legitimates policy is itself the product of a social process that influences what is taken as valid knowledge in stock assessment. For example, the training, experience, and theory of stock assessment scientists tend to discourage them from taking seriously the potential contributions of fishers and other industry actors. Understanding the social factors in the making of science and why scientific or expert knowledge is separated from the ecological knowledge of fishery workers could improve the quality of that science and potentially lay the basis for new management structures.[19]

A recent relevant example might be the acceptance of a Soviet spawning location map as an accurate reflection of the spawning distribution within the northern cod stocks—despite limited empirical foundations and indeed, contradictory evidence.[20] A sociological approach would ask how this spawning location map came to be accepted within DFO? And why? If fishers had been more involved in science, would this map have become dominant? We would expect that all participants in management would benefit by becoming explicitly aware of the social or institutional factors that influence what counts as truth.

Social science can also look at the relationship between science and management. What are the dominant ideas within management and science at any particular point in time? Are they related? That is, does a new management regime bring with it imperatives for different kinds of science? What happens when a management regime is challenged? Does this influence science? When is a situation of crisis declared? Why at that point in time as opposed to earlier or later? How do institutional factors and other factors shape the relationship between science and management? If science were more autonomous, would this make for a different, international, comparative research program?

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19. For an extensive recent overview that emphasizes fisheries, see B. Neis *et al.*, "An Interdisciplinary Methodology for Collecting and Integrating Fishers' Ecological Knowledge into Resource Management" (Presented to the 5th International Symposium on Society and Resource Management, Fort Collins, 1994) [unpublished]. An earlier account focuses on Newfoundland: B. Neis, "Fishers' Ecological Knowledge and Stock Assessment in Newfoundland and Labrador" (1992) 8 Newfoundland Studies 155.

20. J.A. Hutchings, R.A. Myers & G.R. Lilly, "Geographical Variation in the Spawning of Atlantic Cod, *gadus morhua*, in the Northwest Atlantic" (1993) 50 Can. J. Fish. Aquatic Sci. 1.

Conclusion

The need for social and economic input into fisheries management has long been recognized, but it has been difficult to achieve. One of the impediments has been that there is no mechanism in the present system to achieve this integration. It is difficult to see how this could be achieved when there is barely enough time to conduct all the consultations and negotiations required to adjust the management plans to the yearly updated biological assessments. A solution could be to do periodic, in-depth, multidisciplinary fisheries assessments with explicit requirements for sociological and economic input from the beginning. Multidisciplinary fisheries assessments could provide the basis for ecosystembased management, incorporating both the human and the marine ends of the ecosystem. They could provide the basis for diagnosing the state of the fishery with respect to effects of the fleets on the fish, on incomes to fishers and plant workers, and on the fishing and processing communities.

The effects of the fleets on the fish are relatively easy to assess; it is certainly easier to assess them than to predict future stock abundance. If the fishery was exerting excessive fishing mortality in the recent past, and if fishing has not been reduced, then it is easy to conclude that fishing mortality will remain excessive until something is done to restrain fishing effect. Such diagnoses need not be made every year and they need not be precise within 10 percent, especially when fishing mortality is often 4 times the desired level. Comprehensive fisheries assessments need only be done once every 3 to 5 years. The results of these assessments could be used to set multi-year courses of action to improve the biological, social, and economic aspects of the fisheries. To achieve this, it is necessary to reach agreement with stakeholders on rules to be applied when the results of routine yearly biological assessments reach certain values. Periodic checks would be required to verify that the process remains on track and that strategic biological, social, and economic targets are being achieved.

In the current context of stock collapse within the major groundfish fisheries, multidisciplinary committees could initiate research designed to identify and implement new mechanisms for stock enhancement and conservation. One such mechanism might be the development of a network of marine protected areas based on both scientific and fishery workers' knowledge of marine ecosystems and linked to local systems for managing fishery resources.[21] Multidisciplinary committees could also provide input into decision-making related to when and how to reopen

21. Barbara Neis treats this topic in a forthcoming paper.

currently closed fisheries. They could help broaden our ecological understanding of such recently commercialized species as sea urchins and help develop management approaches for multi-species fisheries in a context of stock enhancement. By integrating stock management with improved information on potential market niches and new technologies, such committees could help maximize the economic potential of our fisheries.

Some of the views on change expressed in this paper may no longer be controversial, but, if so, there has been little organizational accommodation for them. It should be evident that the changes being proposed are fundamental. It is not just a question of adding on social science. We need greater interdisciplinarity and more reflexivity on the part of science management *and* social science. Acknowledging the extent of scientific and managerial uncertainty that exists within fisheries today requires accepting the need for new approaches to research and management. We need different, more effective consultative processes that would encourage dialogue between disciplines and between "experts", policy-makers, those who depend upon the industry and environmentalists. It has been argued that the dominant approach within fisheries and other resource management regimes is analogous to a system based on the construction of an egg-cracking machine or robot that attempts to simulate the motions of a human cracking an egg. An alternative approach, better suited to the context of uncertainty, would be one that emulates the human hand. Two essential ingredients for this new "intuitive" approach to management would be feedback and learning. Human beings are much better at cracking eggs, despite initial failures because of feedback and learning.[22] It is arguable that disciplinary boundaries as well as current gaps between resource users and "experts" have inhibited both feedback and learning, thereby contributing to the current ecological, social, and economic crisis that exists in the Atlantic Canadian fisheries.

22. S. Tanaka, "On a Practical Method for Stock Assessment" in M. Freeman, "Graphs and Gaffs: A Cautionary Tale in the Common-Property Resources Debate" in *Common Property Resources: Ecology and Community-Based Sustainable Development* (London: Belhaven Press, 1989).