What went wrong and what can we learn from it?

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The recent closure of the Northwest Atlantic cod and other groundfish stocks off the east coast of Canada has prompted calls from several quarters for a reconsideration of our understanding of fisheries stock dynamics. It is disturbing to acknowledge that in 1979, immediately after Canada had declared Extended Fisheries Jurisdiction off its shores, the Total Allowable Catch (TAC) of northern cod (2J3KL Cod) had been expected to rise to 402,000 tonnes by 1985 (Department of Fisheries and Oceans 1981). This outcome was expected to result from the rebuilding of the stock from the depleted state to which it had been reduced as a result of the actions of distant-water fleets over the previous two decades.

In fact, the TAC for this stock never rose above 266,000 tonnes, and beginning in 1989 the TAC was progressively reduced until the directed fishery was effectively closed in mid-1992. Subsequently, seven other cod stocks, and several flatfish and redfish stocks in the Northwest Atlantic have also been closed. This outcome would have had no credibility, even as a worst-case scenario, even

a few years ago. Indeed, the East Coast fishery was the subject of numerous studies in this period immediately after the establishment of Extended Fisheries Jurisdiction (see, for example, Government of Newfoundland and Labrador 1978; Economic Council of Canada 1980; and Task Force on Atlantic Fisheries 1982). None of these studies anticipated a problem resulting from a shortage of fish.

While stock assessment methods have been the focus of considerable attention as a result of the collapse of the groundfish stocks (see, for example, Northern Cod Review Panel 1990), the enormity of the catastrophe suggests that some aspects of fisheries bioeconomics theory deserve reconsideration as well.

My intent in this paper is to discuss the origins of the recent fisheries catastrophe in Atlantic Canada, and draw out some lessons for fisheries economics and for the future management of fisheries.

I. WHAT WENT WRONG?

We don't know for sure. There are about half a dozen (at least) explanations that are credible, in the sense that they are broadly consistent both with the evidence, and with our understanding of how fisheries work. These explanations include the following:

(1) Water which is unusually cold and/or of low salinity, possibly (and paradoxically) because global warming has resulted in greater melting of the polar icecap. These changes are hypothesized to cause a substantial increase in the natural mortality of the spawning and/or juvenile stocks, or low egg survival.

(2) Food-chain changes: either an increase in the number of non-human predators (e.g., seals) or a reduction in the number of prey (e.g., caplin). Of course, the latter change would well be induced by the former.

(3) Changes in the spatial distribution of the stocks: either there has been a long-range migration of the Northwest Atlantic stocks elsewhere, or the stocks are concentrating somewhere else in the Northwest Atlantic in a location that has yet to be discovered. These changes are sometimes ascribed

to the environmental changes delineated in (1) above.

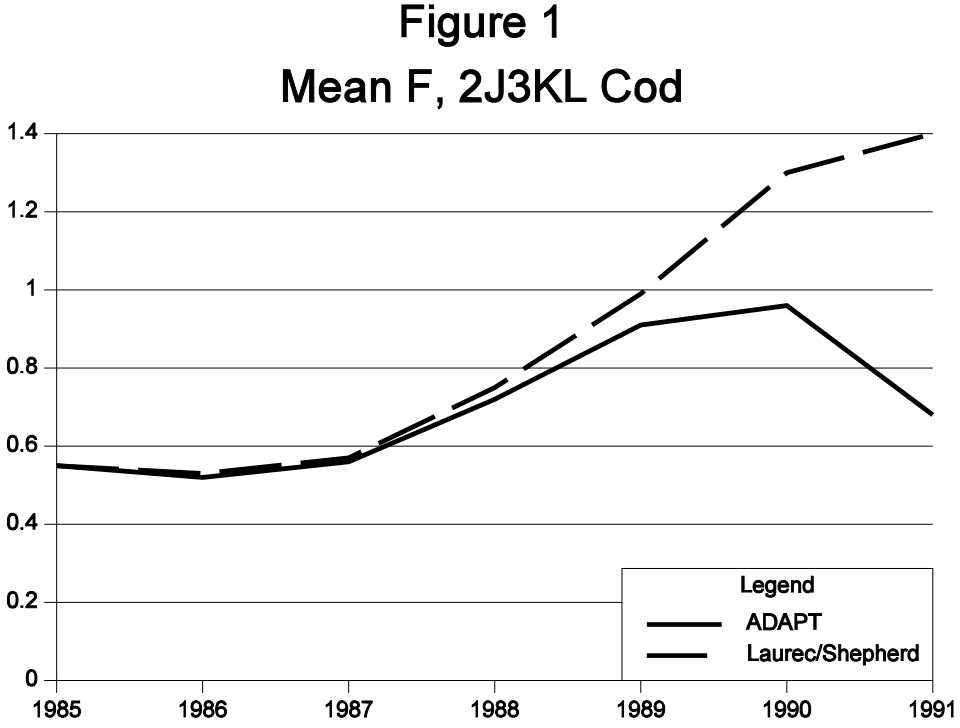
(4) Overfishing by distant water fleets.

(5) Overfishing generally.

In my view, none of these explanations is *entirely* consistent with the facts; that is to say, each of these explanations, left to stand by itself, is an unsatisfactory one. However, some of these explanations have more credibility than others.

The simplest and most parsimonious explanation is that the disaster is the result of overfishing. It is evident that massive overfishing took place in the Northwest Atlantic in the 1980's. For example, the $F_{0.1}$ policy goal adopted by the Department of Fisheries and Oceans (DFO) in the late 1970's (see Munro 1980) was generally interpreted as implying an annual rate of fishing mortality (generally denoted by F) equal to 0.2 for northern cod.

It is now clear that actual fishing mortality far exceeded this target in the 1980's. The December 1992 stock summary sheets issued by the Scientific Council of the North Atlantic Fisheries Organization (NAFO), parts



of which are represented in Figure 1[1], estimate fishing mortality for the spawning stock (ages 7-9) of northern cod in excess of 0.5 in 1985-87; in excess of 0.7 in 1988; in excess of 0.9 in 1989; and, by one measure, 1.3 in 1990 and 1.4 in 1991. Similar stories could be told for other groundfish stocks. Whether fishing cod at such high rates is sustainable is apparently open to some

[1] Figure 1 presents estimates of fishing mortality based on two methodologies for estimating population biomass, one generated by the ADAPT model and the other using the Laurent/Shepherd method. Given the uncertainties inherent in the stock assessment process, the two methods can be said to yield essentially similar estimates up to the final two or three years.

debate. While such rates seem outrageously high to the non-biologist layman, some cod stocks in Iceland and Norway have sustained similar rates of exploitation without catastrophic collapse. However, I want to raise a more fundamental point. Clearly, fishing mortality exceeded the target set by the regulator to such an extent as to represent a *fundamental policy failure* with respect to the management of virtually all groundfish stocks in the Northwest Atlantic. This failure was clearly systemic rather than accidental. The causes of this policy failure must be explained if we are to avoid repetitions in other fisheries.

Part of the blame must be assigned to what in retrospect we now know were poor policy choices. For example, in 1990 the scientific advice provided to the manager for northern cod was for a Total Allowable Catch of 125,000 tonnes. Such a catch would have all but closed down the Newfoundland offshore cod fishery, and so on 'socioeconomic' grounds the regulators chose to set a TAC at 199,000 tonnes, nearly sixty percent greater. With the benefit of hindsight, we now know that even the scientific advice proved to be well in excess of the target F of 0.2.

A more fundamental failure was an unwillingness to face the fundamental uncertainties associated with the stock assessment exercise. These uncertainties were basically treated as random error — which, since we cannot explain, we must therefore ignore. Those responsible for stock assessment only claim accuracy within ±30%, and, given the uncertainties involved, this is reasonable enough. By the late 1980's, however, it had become clear (see, for example, the Report of the Task Group on Newfoundland Inshore Fisheries, 1987) that this error had consistently been on the plus side. One would expect rational expecters, confronted with evidence of consistent upward bias in their predictors, to incorporate some allowance for this consistent prediction error in subsequent predictions. This did not happen.

One lesson that we can derive from the disaster, then, is that fisheries policy should explicitly incorporate within its formulation the existence of uncertainty and error. Policy should be based on the *knowledge* that the data on which we are formulating that policy are probably wrong. What we need here is not so much better theory, as better consistently applied practice. I will have more concrete suggestions later.

The finger points strongly toward overfishing as the main culprit underlying the disaster. However, overfishing cannot explain everything that we observe. For example, we would expect that in a conservative ecological system, overharvesting of particular target species would result in a decline in the biomass of these target species and a concomitant expansion in the biomass of less desirable species, as the latter occupy the ecological niches vacated by the former (cf. Wilson *et al.* 1991). This is broadly what has happened, at least until very recently, on the Georges Bank, off Nova Scotia and New England, as heavily harvested cod, flounder and haddock has been displaced by species such as sand lance and dogfish. Overfishing, then, has an impact less on the total biomass in the system than on the distribution of biomass across species.

This is **not** what has happened in North Atlantic waters. The devastation has hit noncommercial as well as commercial species. Division 2J, off the Labrador coast, has become a marine desert. Similar, although less devastating changes have occurred in Division 3K, off the northeast coast of Newfoundland. The more southerly divisions off Newfoundland do have some (limited) fish of commercial size. This evidence strongly suggests that

there are factors besides overfishing which are affecting the resource.

Some elements (although by no means all) within the Department of Fisheries and Oceans suggest the occurrence of an environmental disaster of unprecedented magnitude and unknown cause, but possibly related to cold water and changes in salinity. This explanation could be interpreted as somewhat self-serving, in that it tends to absolve the managers of any responsibility for the disaster. Nonetheless, the hypothesis must be taken seriously, since it **is** compatible with the evidence.

Supporting the hypothesis of an environmental cause is the fact that the Research Vessel (RV) surveys report that northern cod stocks have continued to decline throughout the so-called moratorium. However, the RV survey is a small sample of the stock, and is generally regarded as subject to high standard error of estimate (anywhere from one-third to three times the value of the assessment, depending on the stock). Therefore, the 'finding' that the northern cod stock has continued to decline must be treated as highly tentative.

Moreover, the moratorium has not been a total one. There was a so-called 'recreational' catch that has fed a

thriving black market (this fishery was closed in 1994 except for a brief period); a substantial bycatch both inside and outside Canadian waters; a directed European Union fishery in international waters (now suspended) and fishing by non-NAFO countries in international waters (which is the subject of recent disputed Canadian legislation). Much of this fishing is undocumented but has probably been in the range of 10-40,000 tonnes per year.

Inshore fishing interests have an alternative explanation. They cite the unselective harvesting methods of offshore trawlers, and the habitat damage allegedly caused by continuously dragging the ocean bottom, to explain the widespread devastation. This explanation is arguably as suspect as that of a manager blaming cold water. But it cannot be casually rejected either. If valid, this hypothesis has major implications for harvesting policy in a rejuvenated cod fishery.

The counter-argument to the 'blame the trawlers' explanation is that cod stocks are also depressed in the Gulf of St. Lawrence, which has been off limits to trawlers since the 1960's. However, inshore draggers work these waters, and these craft are not very selective

either. ITQ's may also have played a role here, as I will mention in a minute.

Other villains are cited as well. While there is little direct evidence that seals eat a lot of cod, we have to recognize that the seal (along with humanity) is a major predator at the top of the food chain in the North Atlantic. It is hard to imagine that an increase in the seal population would not have had a major impact on the ecosystem. At the same time, the extent (or even the existence) of any increase in the seal population is subject to considerable controversy. My colleague, Dr. Eugene Tsoa, has more to say about this possibility in his contribution to this volume.

Foreigners are also often blamed, although it seems clear to me that at least until the time of the moratorium, distant-water nations played a minor role in the over-fishing that took place after Canada declared Extended Fisheries Jurisdiction. This is not to say that what foreigners do, or are allowed to do, will not have a major influence on the rebuilding of the resource. We should be concerned that since the international fishery is effectively an open-access fishery, any stock recovery may simply induce additional foreign effort in the international zone, thereby aborting the recovery.

II. WHAT LESSONS CAN WE DRAW?

One home truth we have relearned is the fragility and unpredictability of the resource, which contradicts the illusion of control on which most of our models are founded. Management has been based on the premise that our knowledge of the resource is 'good enough', and our control over the harvesting process is 'good enough'. Neither has been true for Northwest Atlantic groundfish.

Fisheries management should be based on the premise that the consequences of our actions are inherently uncertain. While the existence of uncertainty creates modelling difficulties, some of the implications for management are straightforward. A bias to conservative management seems appropriate, particularly when the consequences can be irreversible. More generally, actions with consequences that are reversible should be favoured over those with consequences that are not. We should seek advice in terms of confidence intervals rather than point estimates, and base policy on estimates towards the lower end of the range of scientific advice rather than the top end. If this seems to be an obvious point, recall that so far we have been doing the exact opposite. (It has been stated that stock assessors have been reluctant to provide a

confidence interval rather than a point estimate to fisheries managers, because of an alleged tendency on the part of the latter to go to the end that benefitted the industry.) Ludwig *et al.* (1993) have further suggestions along these lines that bear careful consideration.

We should perhaps be looking at alternatives to quota management; for example, we should consider additional biological controls to ensure greater selectivity in harvesting. It is apparent to me that quota management has failed in the North Atlantic groundfishery. It is not apparent that there is a superior alternative, but we surely have to look for one. We may have overreached ourselves, in attempting to control more than we have the ability or information to do so. One implication of Tim Lauck's modelling exercises presented in this volume, is that diversification is likely to be an optimal response to the existence of uncertainty in resource management as it is in portfolio management. This hypothesis has several provocative implications, one of which is the need for diversification in management techniques. We have been putting most of our management eggs in quota techniques, to our detriment.

III. THE ROLE OF ITQ'S

It has been suggested that Individual Transferable Quotas (ITQ's) may have made some contribution to the disaster. I would like to make a few brief comments on this issue.

For several years, ITQ's have been in place in the offshore groundfishery and in the Gulf of St. Lawrence otter trawl cod fishery. All these fisheries (except for some redfish stocks) are now closed. At the very least, then, the presence of ITQ's in these fisheries did not prevent the disaster.

In my opinion, it would be unreasonable to have expected ITQ's to have done so. ITQ's are designed to achieve economic goals, not biological ones. They are designed to maximize the economic rent obtained from a given level of harvesting. For this to be successful, we have to get the global quota right. If we get this global quota wrong (as we have done), then all that ITQ's will do (at best!) is ensure that we will overexploit the resource in an economically efficient manner. ITQ's, then, are not directed to the problem that is the subject matter of this paper. However, it has sometimes been claimed that the presence of ITQ’s, by adding an element of proprietorship to the resource stock, would reduce the

incentive for harvesters to place political pressure on fisheries managers to set the quota higher than it should be. Our recent experience in Atlantic Canada does not provide much support for this hypothesis.

Could ITQ's have positively *contributed* to the disaster? ITQ's are believed to encourage discards and highgrading (Copes 1986), and in the early 1980's there was apparently a considerable amount of this activity in the offshore groundfishery. But the general view has been, at least until recently, that the introduction of onboard observers in the mid-1980's, accompanied by gear design changes at about the same time, have reduced the incidence of this behaviour. This view is currently being reassessed in the light of the retrospective analysis referred to above, which has revealed a consistent downward bias in biomass estimates for northern cod. One good candidate process for this bias is misreporting and dumping.

The Gulf cod stocks are another matter. There is considerable anecdotal evidence (and some physical evidence) in the Gulf of substantial highgrading of cod. The otter trawl fishery is characterized by dockside monitoring only. ITQ's could well have contributed to the collapse of the Gulf cod stocks.

IV. CONCLUSION

Whether overfishing actually *caused* the collapse of the Northwest Atlantic groundfish stocks is open to some debate. There are aspects of this collapse that cannot be explained by overfishing alone or by overfishing *per se*.

Nevertheless, it is incontrovertible that massive overfishing did take place in the 1980's, in the sense that actual fishing mortality far exceeded the target set by the managers. There is some suggestion, and some limited hard evidence, that this overfishing was accompanied by substantial unreported bycatch and discarding, particularly of juvenile fish. Given the enormous fecundity of most groundfish species, it is hard to see how the population declines which we are presently experiencing could have occurred without substantial mortality in juvenile, pre-spawning age-classes.

This overfishing either induced the collapse of the stocks, or seriously aggravated a population decline induced by other, unknown causes. Either way, the implications for fisheries management are serious. If overfishing is the cause of the collapse, then the

implication is that quota management as presently constituted alone cannot control fishing mortality. If the collapse is due to other causes (perhaps environmental fluctuations), then the implication is that we are unable to respond to these fluctuations sufficiently promptly to adjust our fishing effort to prevent the huge variations in fishing mortality which we have been experiencing recently. Whichever is true, major changes in the way in which we have been managing our groundfisheries is called for.

While it would be premature to recommend a specific management regime, it would seem prudent to move in the direction of greater selectivity, both with respect to species and with respect to age-class. Moreover, the existence of significant environmental uncertainties would commend techniques which either maintain fishing mortality (or at least fishing effort) at a particular (safe) level or automatically induce compensating (protective) changes in response to biomass changes. Quota management is not the technique of choice in dealing with an uncertain and rapidly changing environment. A diversified set of strategies, properly designed, will reduce risk, although it might increase costs as well. Finally, we must confront uncertainty in a fundamental sense.

REFERENCES

Coady, L..W. (1993) 'The Groundfish Resource Crisis: Ecological and Other Perspectives on the Newfoundland Fishery.' *The Newfoundland Groundfish Fisheries: Defining the Reality* (K. Storey, ed.) 56-77 (St. John's: Institute of Social and Economic Research, Memorial University)

Copes, P. (1986) 'A critical review of the individual quota as a device in fisheries management' *Land Economics* 62(3), 278-91

Department of Fisheries and Oceans (1981) *Resource Prospects for Canada's Atlantic Fisheries 1981-1987* (Ottawa: Minister of Supply and Services, Government of Canada)

Economic Council of Canada (1980) *Newfoundland: From Dependency to Self-Reliance* (Ottawa: Minister of Supply and Services, Government of Canada)

Government of Newfoundland and Labrador (1978) *Setting a Course: A Regional Strategy for Development of the Newfoundland Fishing Industry to 1985* (St. John's: Government of Newfoundland and Labrador)

Ludwig, D., R. Hilborn, and C. Walters (1993) 'Uncertainty, Resource Exploitation, and Conservation: Lessons from History.' *Science* 260 17, 36

Munro, Gordon R.(1980) *A Promise of Abundance: Extended Fisheries Jurisdiction and the Newfoundland Economy* (Ottawa: Minister of Supply and Services, Government of Canada)

Northern Cod Review Panel (1990) *Independent Review of the State of the Northern Cod Stock* (Ottawa: Minister of Supply and Services, Government of Canada)

Task Force on Atlantic Fisheries (1982) *Navigating Troubled Waters: A New Policy for the Atlantic Fisheries* (Ottawa: Minister of Supply and Services, Government of Canada)

Task Group on Newfoundland Inshore Fisheries (1987) *A Study of Trends of Cod Stocks off Newfoundland and Factors Influencing their Abundance and Availability to the Inshore Fishery* A report to the Honourable Tom Sidden, Minister of Fisheries, Canada

Wilson, J. A., J. French, P. Kleban, S. MacKay, and R. Townsend (1991) 'Chaotic Dynamics in a Multiple Species Fishery: a Model of Community Predation.' *Ecological Modelling* 58, 303-322