Newfoundland Studies

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Volume 8, Number 2, Fall 1992

URI: https://id.erudit.org/iderudit/nflds8_2art04

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Publisher(s)

Faculty of Arts, Memorial University

ISSN

1198-8614 (print)
1715-1430 (digital)

Explore this journal

Cite this article

Neis, B. (1992). Fishers' Ecological Knowledge and Stock Assessment in Newfoundland. *Newfoundland Studies*, *8*(2), 155–178.

Fishers' Ecological Knowledge and Stock Assessment in Newfoundland*

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THERE IS A GROWING literature on so-called traditional ecological knowledge in both fisheries and agriculture (Richards; Freeman; Kloppenburg). Countering the common assumption that, in the absence of formal state intervention, fisheries are open access and vulnerable to overexploitation and the dissipation of economic rent, the fisheries literature has documented the existence of local management structures and conservation practices (McCay and Acheson). In some cases, these management structures are accompanied by a richer understanding of local fisheries ecology than that found within western fisheries science (Johannes, *Words of the Lagoon*). Some aspects of this knowledge are taxonomies, knowledge of "the spatial distribution of living and non-living resources," and of the timings of significant biological events (Johannes, *Words of the Lagoon*, "Integrating Traditional Ecological Knowledge").

So-called traditional fishing peoples differ in terms of the extent and character of their ecological knowledge, as well as their adherence to a conservation ethic. In the case of Micronesia, for example, Johannes found examples of waste as well as restraint. He concluded, however, that "the existence of the former does not diminish the significance of the latter" ("Traditional ... Methods in Oceania" 355). Although not necessarily developed to meet explicit conservation goals, he noted that local management systems often work more effectively than those introduced through colonization and government initiatives.

This paper contributes to the growing literature on the nature and importance of fishers' ecological knowledge and its relationship to western fisheries science. The analysis is based on a reassessment of existing anthropological and folklorist research on the Newfoundland inshore fishery, as

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well as information on fishers' ecological knowledge contained in archival sources at Memorial University. Most of the archival and anthropological sources date from the 1960s and 1970s, a period when the handline and trap fisheries were being eroded by the expansion of offshore fishing and the introduction of gill nets and longliners. None of the above research had, as its primary goal, the collection and analysis of fishers' ecological knowledge. It does contain, however, some important insights and contradictions. When these are put together with the results from eight recent interviews with trap and handline fishers in Petty Harbour, four with fishermen in St. Shotts, recent scientific research on cod, and some identified weaknesses within stock assessment science, the results are illuminating. Looking at stock assessment science from the perspective of these fishers suggests, I will argue, that the problems this knowledge poses for science are not dissimilar to those posed by the ecosystem itself. Furthermore, an examination of current stock assessment science highlights important biases in favour of the offshore trawler fishery contained in its models and methods. In short, on the basis of a preliminary assessment of fishers' ecological knowledge in Newfoundland and Labrador, it seems that efforts to integrate this knowledge into our understanding of fisheries ecology and stock assessment should be both a rewarding and an unsettling exercise. The paper is intended to encourage both further research and meaningful discussion.

Fishers' Ecological Knowledge and the Anthropologists (1)

In his classic study of indigenous fishers in Palau, *Words of the Lagoon*, Johannes shows that gathering the ecological knowledge of such fishers can add dramatically to our often impoverished understanding of marine ecosystems or, perhaps a better term, ecowebs.[1] Until recently, however, traditional ecological knowledge has been largely neglected by social and natural scientists. While accounts of both might contain fascinating references to fragments of information, disciplinary boundaries that accorded to science the study of nature and to the social sciences the study of human societies marginalized such knowledge.

This section of the paper will concentrate on the anthropological literature. Anthropologists often lack knowledge of fisheries biology. In addition, until recently, anthropologists have tended to focus on the influence of environment on culture rather than on "what we can learn about the environment from local peoples" (*Words of the Lagoon* ix).

The scope and nature of the ecological knowledge of Newfoundland inshore fishers has never been the direct focus of either scientific or social scientific research.[2] Not even folklore, which has made local understandings its focus, has systematically addressed this. The next section of this paper will assess some of the conservation aspects of the trap and handline fisheries and

more broadly the ecological knowledge of fishers in relation to the cod fishery. The discussion will focus primarily on the insights of participants in the handline and trap fisheries as the most likely repositories of some important traditional ecological knowledge.[3] These fisheries dominated much of the northeast coast cod fishery from the late 19th century, and, where they still exist in combination, have undergone much more limited technological changes than others. In addition, they are fisheries that have generally been carried out on the same grounds, by successive generations of fishers. They are also fixed gear fisheries and hence rely more on "harvesting" rather than "hunting" the resource. For all of these reasons, these fishers are probably the most likely group to have developed a relatively rich understanding of ecological relationships such as those between cod movements and abundance, the presence of other species, as well as climatic and oceanographic changes within the micro area of local fishing grounds.[4]

Handline and trap fishers in Petty Harbour were also one of the first groups to insist that scientific assessments regarding the health of the northern cod stocks were incorrect. They played a leading role in the formation of the Newfoundland Inshore Fisheries Association (NIFA) in 1986, an organization that has challenged, from the beginning, the accuracy of stock assessments. Cabot Martin, a leading member of this organization, developed his concern about the state of the stocks through interactions he had with trap fishermen in Bay Bulls during the early 1980s (personal communication). Fishers I interviewed reported feeling skeptical about the accuracy of scientific claims that the northern cod stocks were growing as early as 1983.

Fishers' Ecological Knowledge and the Anthropologists (2): Managing Space *and* Husbanding the Resource

Ethnographies of Newfoundland fishing communities have documented the existence of local management systems in the inshore fishery. These management systems limit access to the resource, minimize gear conflicts, and distribute effort. They involve such mechanisms as patrilineal transfer of knowledge about the grounds, regulations regarding the distance between trap berths, patrilineal inheritance of trap berths or the allocation of trap berths by draw, and the creation of gear "sanctuaries" for handline and trawling (Andersen and Stiles; Firestone; McCay, "Appropriate Technology"; Martin).

Anthropological accounts from the 1970s generally maintained that these management regimes reflected efforts to manage space (i.e., reduce gear conflicts) rather than conservation goals. Thus Andersen and Stiles argue, in perhaps the most widely cited article on this subject, that "any attempt to understand the fisheries in Newfoundland, inshore *and* offshore, in terms of their approach to *resource management* must confront the very elementary fact

that Newfoundland fishermen do *not*, as a rule, manage their *resources*, but rather manage *space* — that is, points of privileged *access* to the resource." In the 1970s, according to Andersen and Stiles, fishers tended to see resources as "more or less infinite" (45). One consequence of this treatment of resources as infinite was a failure on the part of fishers to perceive overfishing in the 1960s and 1970s as an ecological crisis that might require restraint for them as well as others.

Detailed research on the Fermeuse fishery carried out by Kent Martin supports the view that management of space was a central concern of trap and handline fishers during the 1970s. Quotes such as the following also call into question the conservationist orientation of such fishermen: "The idea is to get a fish where ya can and how ya can and let tomorrow take care of itself" ("The Law in St. John's" 74). However, management of space and not the validity and nature of fishers' ecological knowledge was Martin's preoccupation. As has been the case with anthropology elsewhere, Martin and others appear to have had limited knowledge of fisheries biology and their primary interest was in documenting the impact of the environment on culture and not identifying what we might learn about fisheries ecology from fishers.

Significantly, in this anthropological research, there are also references to comments and concerns on the part of fishers that appear to reflect a commitment to husbanding local fish resources. The reasons used by some fishers to justify their opposition to gill nets noted in Anderson and Stiles and other ethnographic research of the period illustrate this commitment. Bonnie McCay, for example, in her ethnography of longlining on Fogo Island, documents inshore trap and handline fishers' and longliner owners' concern about the ecological and not simply the spatial effects of gill net technology.[5] She notes that "the relationship between the use of gill nets and fishery decline is not clear, although fishermen have a variety of theories which try to make sense of the correlation" ("Appropriate Technology" 187). These theories include the view that lost or abandoned gill nets (so-called "ghost nets") continue to fish on the bottom of the ocean, a theory that was supported by a Department of Fisheries and Oceans (DFO) study of ghost nets in the Trinity and Bonavista Bay areas in the 1970s (Way).

Another criticism of gill nets common among handline and trap fishers then and now has to do with the fact that they catch large numbers of so-called "mother" or "bottom" fish that are relatively untouched by other gear. These fish should, the fishers feel, be left in the water to spawn and breed (Martin, "The Law in St. John's" 47). The following excerpt from a recent interview with Dave Hearn, a highliner trap and handline fisherman in Petty Harbour, illustrates the inductive reasoning, taxonomy of codfish, and assumptions about the prerequisites for a healthy fishery underlying his opposition to gill nets.[6]

> Gill nets should be banned completely. There's no fisherman, maybe two or three fishermen in all Petty Harbour out of probably 130 fishermen believe in using gill nets, the rest of us are dead against it.
>
> Q. Have you always felt this way?
>
> Oh yes, as long as I've been fishing and my father and my grandfather before that....You know, they catch that bottom fish we call it and those were the breeding fish, the mother fish we call it and definitely that's what's after happening.
>
> Q. Seems to me you could have caught some of those fish with a handline?
>
> Well obviously, I'm sure we caught lots of big fish that were breeding fish, mother fish...those years we used to gut all our fish ourselves... You could tell by the roe in the fish whether it was a he fish or a she fish. Days we caught some of those big fish, cut them open, big cod roe in them, almost feel ashamed for catching them. We'd almost feel like letting them go again, but not too many do that either. Obviously we know we caught some of the breeding fish, we had to catch some of them but not near as much as the gill net caught.
>
> I remember one time I was out there, they had a gill net in our waters and the handline fishery was over. I was just out hunting ducks and I see the gill net, a balloon there so I hauled it up by hand and when I hauled it up it was mad alive with the biggest kind of fish, twenty-thirty pound fish and to put a cod jigger down there or even a bait at the same time you wouldn't catch one, there was no hope, the fishery was over. I believe that's what we call bottom fish, fish that don't really eat. They're there but they don't really eat bait. They're just all bottom fish moping around the bottom, you know, probably eating crab or whatever and the only way probably to catch those is with a dragger or a gill net, and I think a lot of those are the breeding fish.[7]

For David Hearn, then, it was important not to catch all of the breeding fish. While they might catch some of these on the handline, the fact that these fish did not tend to "eat bait" (as attested by the observation that by this time in the fall, the handline fishery was pretty well over) meant that handliners would catch some, but most would remain. Gill nets were a different matter.[8] Located on the bottom, where these fish congregated, gill nets would and, he believes, did catch them all. This fits with McCay's observation in the 1970s that fishermen believed gill nets could "fish out" grounds ("Appropriate Technology").

Whether or not it is possible to indicate clear conservation objectives in traditional systems of management, it is still important to assess the extent to which they embody practices that are conservationist in their impact. Some such practices include closed areas, closed seasons or bans on fishing during spawning, allowing a portion of the catch to escape, holding excess catch until needed, bans on taking small fish, restrictions on numbers of traps in an area, protection for species when they are particularly vulnerable (as when in

agglomerations), gear restrictions, and efforts to prevent waste (Johannes, "Traditional ... Methods in Oceania").

The trap and handline fisheries are characterized by closed seasons in that they are largely passive fisheries that wait for and are dependent on a migrating fishery resource rather than actively hunting it throughout the marine ecosystem. Fish migrations are seasonal and uncertain. To the extent that cod spawn offshore, these fisheries also do not disrupt the complex spawning process (Oceans Ltd.). This is not the case with the Atlantic Canadian trawler fisheries which fish year-round and on spawning concentrations.

Patrilineal transmission of the detailed knowledge of the grounds required to minimize effort, and locally controlled draws for trap berths, have helped exclude male nonmembers of the community and women from handline and trap fisheries (Martin, "The Law in St. John's").

The trap and handline fisheries are spatially segregated. Traps are placed in berths and minimum distances between berths are specified. Handline and trawl berths are located in the most productive areas where ledges and shoals tend to coincide with concentrations of cod. Fishing is concentrated in these berths rather than encompassing the entire local marine resource. As noted above, specific gears such as jiggers and gill nets have sometimes been excluded either by legislation or local practice from these grounds (Martin, "The Law in St. John's"). Specialized handline grounds have generally been identified as a mechanism for regulating access to space. However, by limiting the effort applied to larger fish, they may also have been an important conservation practice.[9]

In the past, there were also other mechanisms that acted to limit effort. Until the 1950s and 1960s, the east and northeast coast Newfoundland cod fishery was based on the household production of saltfish. In this household form of production, the volume of saltfish produced was limited not only by the amount harvested but also by the labour and space available for processing catches. As is well known, landings from cod traps could fluctuate dramatically during the relatively short six to eight week codfishery. In some communities trawl and handline fishers would abandon their fishery and help cod trap crews process their catch in return for a portion of the trap landings. This informal system of bartering labour for fish was efficient in that it helped match labour to supplies of fish, minimizing both effort and waste (MUNFLA, Cornelius O'Brien Interview, 91461 c14591-4).

Members of inshore fishing communities did not always fish as much as they could, nor, it seems, did they always take all that they could get. There are several communities on the Avalon Peninsula, for example, where historically trap fishermen did not participate in the fall fishery. In Bay Bulls, the local merchant chafed at this limitation on landings during the period of saltfish production prior to the 1950s (MUNFLA, Cornelius O'Brien Interview, 91461

c14591). In St. Shotts, the short fishery season seems to have been linked to a heavier reliance on farming for subsistence than was found in many other communities.

Interviews also suggest that, in the past, when handline fishers encountered small fish on the grounds, they would move elsewhere rather than catch and discard these fish. In more recent years, declining catches and technological changes in fish plants seem to have discouraged fishers from leaving any fish because they can now sell smaller fish and because, much more than in the past, they cannot be assured of future catches. With the displacement of saltfish production by the sale of fresh fish to plants for processing, the fishery was also more likely to extend into the fall.

The gear combination of trap and handline tended to distribute effort over a fairly wide range of year classes of fish as younger, smaller fish were more abundant in trap landings and larger, older fish predominated in the fall handline fishery. Prior to the introduction of offshore trawling and gill nets, this helped maintain a stock consisting of many different year classes and a relatively large population of older fish. In general, more fish were extracted from the younger year classes in traps, and less from the older year classes because of the technological constraints of the handline fisheries and limitations imposed by migration and weather. The older year classes were also protected, somewhat, by periodic annual bait shortages that reduced the fall handline fishery in many communities in the past.

Berkes argues that a Cree whitefish fishery in northern Canada that acted to maintain a stock consisting of a broad range of year classes was ecologically sensible. The preservation of older fish in which natural mortality tends to be quite low can, Berkes says, "be considered insurance against the variability of the physical environment which, in some years, results in complete reproductive failure" (75). Codfish stocks, particularly those in more southern areas, may be somewhat more resilient than subarctic whitefish and hence less reliant on the preservation of a "standing stock" of older fish. However, a harvesting strategy that preserves year class diversity would seem to be ecologically wise in any fishery, particularly one such as the northern cod fishery that includes more vulnerable northern stocks and small bay stocks (to the extent that any still exist). The known correlation between fecundity and length, together with the slow growth rate of more northern stocks, supports this view (May).

Other practices associated with the handline and trap fisheries, although not broadly conservationist in their orientation, reflect trap and handline fishers' application of their understanding about the dynamics of fish behaviour in an effort to manipulate that behaviour and enhance the local fishery. An example of "husbanding" in this sense includes handliners' practice of "baiting the grounds" (Martin, "The Law in St. John's" 47; Petty Harbour interviews). Handline fishers in Petty Harbour and Fermeuse dumped their leftover bait

overboard at the end of the day to "build up the grounds" and encourage the fish to stick around. In so doing, they "complemented the habits of the codfish" (Martin, "The Law in St. John's" 47; interviews, Petty Harbour). Given the dependence of inshore fishers on migratory fish stocks and the limited daily catching capacity of the longline fishery, mechanisms that might hold codfish to the grounds longer into the fall were important. They were another reason for opposing the use of technologies such as gill nets and bottom trawls that did not use bait.

Transcripts from the 1960s also describe the practice of "trouncing," i.e., attaching iron rings to a rope and dragging this along the bottom. The ringing noise would "make the fish move...like a crowd of sheep in the garden. You get em all goin' the once, and drive 'em" (MUNFLA, Ab Tulk Interview, c809 70-4, 1969; see also c83, 1964). Extrapolating from this practice, one might hypothesize that the pattern of fish always swimming towards the net in the otter trawl fishery could be the result of the noise created when the so called "doors," heavy weights attached to the trawl cables, drag along the ocean bottom. Like these fishers' concerns about preserving the "breeding" fish and well-known concerns about the impact of trawling on the spawning grounds, these practices reflect the focus on ecological relationships in their knowledge about the cod resource.

Stock Assessment Science and Fishers' Ecological Knowledge

The use of fishers' ecological knowledge in stock assessment seems to have received less attention in the literature than other issues. One possible reason for this is the quantitative character of current stock assessment techniques and the tendency for research to focus on areas like Micronesia where the complexity of marine ecosystems and limited scientific knowledge have been identified as barriers to stock assessment. In Johannes' work, this neglect also seems to reflect his belief that existing models work well for temperate zones, an assumption that has been challenged by recent stock crises in Newfoundland, Norway and Iceland.

Until recently, stock assessment in Newfoundland has primarily relied on data drawn from the offshore commercial trawler fishery and from research vessel surveys, also carried out using trawler technology. Scientists used several reasons to justify the neglect of inshore data in the stock assessment process. These included: the large number of fishers in the inshore; the complexity of the inshore fishery in terms of gear, local oceanographic variations, and climate; and the absence of any measurement of catch per unit of effort for the inshore (Department of Fisheries and Oceans). In contrast to the data from the offshore commercial fleet, which were relatively easy to quantify and perceived as

"rational," inshore information was "largely opaque to statistical analysis" because "results are not evaluated objectively but as an irreducible part of an individual's social and cultural reality" (Finlayson 180).

This section will explore the ecological knowledge which interviewed fishers used to conclude that scientists' assessment of the state of the northern cod stocks in the mid 1980s was incorrect. Finlayson argues that the basis for fishers' dissatisfaction with the claims of scientists was their experience with declining inshore landings and smaller fish. A closer look at the concerns of Petty Harbour fishers suggests, however, that the observed changes were somewhat more complex. I will use testimony by David Hearn, a trap and handline fisherman, and Bernard Martin, a handline fisherman, to explore the observed changes in their fisheries that made them skeptical about scientists' claims that the northern cod stocks were recovering. Hearn began fishing handline in about 1960, Martin in the early 1970s.

Hearn fished handline for about fifteen years. In 1975, he shifted to traps. After doing well with their trap the first year, he and his brother bought a second trap. Two or three years later, costs for gear were increasing and fish "seemed like it was getting a little scarcer so it seemed like there was nothing else to do only get another trap." They had no established berth for the third trap, so they would just throw it out where they could find a spot. They fished three traps for four to five years,

> and then it seemed like that wasn't enough, we were catching no more fish and we were increasing our gear and it seemed the only way to improve was to get another trap, just keep on getting gear, more gear. Started off one, now we got four. Even though we were increasing our gear the fish were getting much smaller. Fish wasn't half the size the last few years as they had been years before that. We had to catch twice as much fish for the same amount of weight.
>
> We even had to change the twine size in our traps. One time we used to use 8 inch twine in the side of the trap and the drawing twine would be 3 and 1/2, now we got to put 5 inch or 4 inch in the side to stop a lot of those smaller fish from going out through the side of the trap. But, since the early 1980s, I'd say, we noticed the fish getting much smaller.
>
> You've got to punch in a lot more time and effort at this than in the past, something like 15-18 hours a day and that's where we're at now.

In the minds of the general public and scientists, trap fish is generally assumed to be small fish. This was not, however, always the case. Hearn describes trap fish in 1965:

> I'll tell you I was looking at a picture last night, it was taken I think in 1965 and it showed these fishermen with a cod trap, trapfish. Jeezus, what a difference in the run of fish. There was twenty and twenty-five pound fish in it and the small ones were as big as the big ones we catch now. I can remember my uncle bringing in fish from the cod trap. I used to be cutting out the tongues, twelve, thirteen year

> old, I couldn't lift them out on the table. They were bigger than me. They came in out of a cod trap. There was no such a thing as a tom cod. You wouldn't get one small enough to eat out of it. If they are there you can catch big fish in the cod trap.[10]

In the past decade, trap fishing effort and competition for berths in Petty Harbour have intensified to the point where the community and DFO decided recently that because of space shortages there would be no new trap fishers in the community. Like Hearn, other Petty Harbour trap crews have bought more traps and many crews have shifted from regular to Japanese traps. Japanese traps can be placed with less risk in berths with rougher bottoms and where, owing to tides, it was difficult to hold fish in the past. They have a smaller mesh, are easier to haul, and have a roof; it is more difficult for the fish to find their way out again. Japanese traps opened up new areas to the trap fishery but by the late 1980s, even these areas were filled (Sam Lee, personal communication).

Effort, competition, and handline fishers' conviction that the stocks were in trouble also increased in response to smaller fish, longer fishing days, and a significant reduction in the length of the fishing season. Smaller fish add dramatically to the effort required of handline fishers. They have to catch more fish to make poundage and, in addition, smaller fish do not bite as readily or as firmly. Instead they "pick" at the bait. Bernard Martin estimates it takes twice as much bait to catch the same number of small fish.

Handline fishers also started to fish longer hours in the 1980s. This was facilitated by the introduction of sounders, which allowed them to locate handline berths before sunrise. Sounders have also reduced the effort involved in testing for fish where none actually exist. Because they can see whether or not there are any fish on the grounds, handline fishers tend to move more quickly between grounds, so long as there is space. Competition between these fishers seems to have been exacerbated by reduced landings on some grounds.

Hearn handlines in the fall. He commented on the declining fishery on some grounds:

> There is a certain piece of ground out here, I mean guaranteed, if you anchored there you would catch all big fish, back in the late 1970s, early 1980s. But the last 5-6 years, its a waste of time to even anchor there. There's no such thing as catching a big fish. If you caught one 40-50 pound, you'd be telling about it, but I mean ten years ago if you came in with a couple thousand pound of 40-50 fish there'd be nobody, you know they'd be telling about it but, nothing unusual. You can count on your fingers the number of big fish that you catch today.

A handline season that used to run from June to November declined, in the 1980s, to a season that started in July and ended in mid-September. Bernard Martin describes this change:

> Back when I started fishing first, people started handlining in June, and they expected a couple of good weeks in June, but nowadays it seems that period when you would expect to catch a few fish for a couple of weeks doesn't happen any more. For the past 2 years there has been very little fish caught on bait in June month. And so the trend seems to be that the handline season is getting shorter and shorter. On the other end, when you get up in September months, well usually the fish starts eating pretty good right around the end of July or early August, and then you have got about 4 or 5 weeks of like peak handlining and after that, around the middle of September, its just downhill from there. It dwindles away very quickly.

The shorter fishing season poses particular problems for inshore fishers because they are only eligible for unemployment insurance (UI) from November until the beginning of May. A shorter season means months without income from either fishing or UI.

In summary, the changes observed in the handline and trap fisheries in Petty Harbour in the 1980s that contributed to fishers' perception that stocks were not recovering included smaller fish, intensification of effort, shorter seasons, greater competition for space, and related initiatives to limit access to the resource. It is perhaps not insignificant that precisely the same changes were documented by Martin in his study of the Fermeuse fisheries in the early 1970s.[11] It is well known that the cod stocks were in trouble at this time. Recent scientific research has confirmed that there is a relationship between the density of a cod population in a particular inshore area and the range covered by this population. In other words, reduced inshore migrations could be expected to coincide with increased competition for berths as the range of area occupied is also reduced (Rose and Leggett).

Both David Hearn and Bernard Martin attribute the problems in their local fishery to gill nets and offshore draggers. They put together local trends with reports of trawler workers about the discarding of small fish, reports from the media and fishers from the west coast about the dramatic decline in stocks there that was not prevented by either scientists' assessments or stock management, and long-standing concerns about the negative effects of trawling on spawning fish and the spawning grounds (Oceans Ltd.; Baels). Like others in their harbour, they also compare the abundance and composition of the cod and caplin migrations of the 1980s with those of the past. There was a consensus among older fishers in Petty Harbour and in St. Shotts that the fishery would never again be like it was in the past. The days when cod would leap out of the water in search of caplin (so-called breaching) were acknowledged as over. As suggested by Billy Hewitt in St. Shotts: "Never again, you never see another fish over the water now, not around here. Couldn't last anyhow. Couldn't last."

"Anecdotal" Ecological Knowledge

> It should be the experience that leads to a modification of knowledge, rather than

> abstract knowledge forcing people to perceive their experience as being unreal or wrong. (Franklin 40)

According to Johannes, the neglect of fishers' ecological knowledge among scientists has been encouraged by the class backgrounds of scientists and ethnocentrism (*Words of the Lagoon* ix). In addition, the organizational structure of western fisheries science and an approach to doing science that is experimental, laboratory-based, and wedded to mathematical modelling has encouraged the relegation of fishing households to the role of passive audience — suppliers of the fish needed for experimentation and samples of rare species found in their nets. As suggested by Johannes, "scientists tend to have an attitude problem," in that they generally dismiss fishers' knowledge as "anecdotal" or "unsubstantiated," despite the historical depth and richness of experience on which it is often based ("Integrating Traditional Ecological Knowledge" 7-8). Scientists who disparage fishers' ecological knowledge identify it as "mumbo jumbo"; the more sympathetic tend to see it as not amenable to quantification.[12] As argued by one assessment scientist,

> to separate out testable elements of this view of the fishery system from the fishermen's point of view is really difficult. I imagine there is probably integration of all kinds of variables going on simultaneously in any particular fisheries situation on any given day, and also over the years, as people modify the traditional lore. You can't really do a controlled experiment under these situations to say, "we falsified the null hypothesis so now we can move on to the next step in the method." That reductionist approach would seem to me to be different from what you would consider to be traditional lore that integrates a lot of different observations and people's intuitions and gut feelings and is kind of tested but you don't know what kind of testing it's undergone from generation to generation. Have the conditions remained constant over time, or have they been changing? If they have, then how do you know what you are seeing is really the result of the causal mechanism that is attributed to it? So it's basically at odds with scientific method because traditional knowledge has so much more information in it that is unspoken or already subsumed and the scientific method says reduce it and test it at each point and control for all of the other co-occurrent variables. It is hard to integrate those two views of the system.[13]

This paper can only begin the task of teasing out the "truths" in the ecological knowledge of fishers in Newfoundland and Labrador and, in order to make sense of it, the context out of which it has been generated. Fishers' ecological knowledge seems to reflect the influence of the gear that they use (Martin, "The Law in St. John's"), the local topography (Butler), local differences in natural and fishing-induced fisheries ecology, competitive relations between fishers, possibly years of experience in the fishery, and the degree to which they apply themselves to the fishery. Fishers derive part of their understanding of fisheries ecology from social networks, the media, and other general sources. However, as competitive fishers, they trust more the

knowledge derived from direct observation, from other members of their crew, and from friends and family, than other sources of knowledge (Gary Butler, personal communication).

The ecological knowledge of handline and trap fishers has a historical dimension that has been lacking in the data used in stock assessment science. Today's actions reflect yesterday's choices (successes). They have an intimate knowledge of the names and locations of the landmarks (or "marks") that are used to find berths on the fishing grounds (Butler; Martin, "The Law in St. John's"). This obviously reduces effort and permits fishers to share knowledge across generations and with each other, thereby permitting them "to accumulate a body of information larger than [they] alone would possess, reducing [their] dependency, real and imagined on good fortune" (Butler 18). Butler notes that in the community he studied on the west coast of Newfoundland the marks have been constant for generations. He argues that information that goes into tradition like that is "not haphazard" (personal communication).[14]

The ecological knowledge of these fishers also includes awareness of the relationships between season, winds, tides, water temperature, the presence of other species, and the location and "catchability" of fish. In addition, their belief that caplin tend to spawn on the "spring tides" suggests that lunar cycles may be an element in their understanding of the marine ecosystem.[15] This latter contrasts with stock assessment for groundfish, where the timing of research vessel cruises for the same months each year points to reliance on the Gregorian calendar rather than lunar months and associated rhythms.

The relationship between fish size, value, and effort, particularly in the handline fishery, means fishers take note of the size distribution of fish. Fishers maintain, for example, that large and small fish are not found in the same places. This observation has been confirmed in recent acoustic surveys (George Rose, personal communication).

The historical dimension of fishers' ecological knowledge is important and one that needs more research, particularly in light of the problems that poor historical data for the offshore fishery create for stock assessment.[16] It is also an important ingredient in shaping these fishers' notions of the meaning of "stock recovery" for the inshore. To some extent at least, stock recovery is assessed in relation to a period of almost unimaginable abundance. While handline and trap fishers may no longer expect a return to the abundance of the past, their assessment of stock recovery will reflect their understanding of the abundance and stock structure necessary to ensure the survival of their fisheries. As suggested below, this is not an integral component of the current stock assessment process.

Fishers of all kinds are located at points of convergence in the biological/ecological and fishery-related social/cultural elements in the marine ecoweb. Both elements play an important role in their understanding of marine

ecology. The preliminary discussion above suggests, however, that the understanding they have, like that of indigenous peoples, is "essentially of an 'ecological' nature, that is to say, it seeks to understand and explain the workings of ecosystems, or at the very least biological communities" (Freeman, "Nature and Utility" 9). Fishers' ecological knowledge is a form of "vernacular knowledge" or knowledge gained from experience.[17] Franklin argues that the scientific method is, in many ways, antagonistic to vernacular knowledge. This antagonism is rooted in the fact that it is

> a way of separating knowledge from experience...The scientific method works best in circumstances in which the system studied can be truly isolated from its general context...[Unfortunately] scientific constructs have become *the* model of describing reality rather than *one* of the ways of describing life around us. As a consequence there has been a very marked decrease in the reliance of people on their own experience and their own sense. (37-8)

This discussion of the tensions between scientific and vernacular knowledge offers insight into the relationship between stock assessment science and fishers' ecological knowledge in Newfoundland. Inshore fishers' knowledge is local and influenced by variable individual experience and practices. The relationship between the local observations of fishers in Petty Harbour and the health of the whole complex of northern cod stocks is unclear. Looked at in this light, it is "ancedotal". On the other hand, the knowledge is informed by an understanding of the relationship between fishery success and social and ecological relationships.

The "scientific" data that was an integral part of the stock assessment process in Newfoundland and elsewhere in the 1980s could also be defined as "anecdotal" in that it was separated from the social and ecological relationships out of which it was generated. This decontextualization contributed to errors of interpretation.

As noted earlier, stock assessment science for the northern cod stocks has been based almost exclusively on data from offshore commercial trawlers and from the research vessel survey (also trawling data) carried out annually in October. Neither input from inshore fishers nor data based on the inshore fishery has been used to any significant extent in the assessment process. In the 1980s, DFO scientists overlooked the context of changing technology and skippers' knowledge of the resource in the commercial trawler fishery. Neglect of these changes meant scientists did not take into account their impact on catches. Because it is difficult to reconstruct these impacts "after the fact," these data are now considered to be virtually useless for the purpose of stock assessment (Jean-Jacques Maguire, personal communication). In addition, models assumed that the catchability in this fishery was unaffected by the practice of fishing on concentrations and gear mobility. There is a growing scientific literature that challenges this assumption (Rose and Leggett). Also,

research vessel cruises were scheduled according to the Gregorian calendar rather than by lunar months or other factors likely to influence the rhythms of one area. As suggested by Leslie Harris, author of a report critical of stock assessment science,

> to say we are going to do our survey in the first three weeks of October every year and that creates a constant for us is not correct because it's not constant. It's constant in terms of time, our calendar, but that's meaningless to fish who don't use our calendar. They use another calendar entirely, which is based on temperature, food availability, and salinity and a number of other environmental circumstances. (Personal communication)

Although science has long recognized that oceanographic and hydrographic changes, as well as the movements and health of other species, influence the catchability of cod in handline and trap fishing communities, the role of these factors in general stock health and their influence on catchability in the offshore trawler fisheries and research vessel cruises seem to have been ignored until recently (Templeman, *Marine Resources* 47ff.). During the 1980s, for example, scientists appear to have seen no contradiction in using cold water to explain changes in catchability in inshore fisheries while ignoring the possibility that the same cold water could be affecting the health of the northern cod stocks, thus having another, indirect impact on catchability. They overlooked as well the possibility that such oceanographic factors as water temperature might affect catchability for trawlers as well as for the handline and trap fisheries. In simple terms, the wall of cold water that was reported to be blocking inshore migrations in the 1980s might have resulted in increased catchability offshore by limiting the dispersal of the stocks and concentrating aggregations in a narrow range of warmer water areas (Department of Fisheries and Oceans). Recent scientific research suggests that oceanographic factors may affect general stock health and catchability in trawler fisheries (Cury and Roy; Gordoa and Hightower).

It has taken a succession of stock crises to make fisheries scientists confront their neglect of ecological relationships such as those between species, between stocks and oceanography, and between catches and human and marine ecology in stock assessment models (Report of the Study Group). Analysts maintain that it is precisely these relationships that provide the framework for traditional ecological knowledge (Freeman, "Nature and Utility"; Nakashima).

In her review of over twenty years of interviews with fishermen contained in archival records, Alison Carter found that their

> comments reflected a strong sense of the complexity of the conditions which affect the presence or scarcity of the fish. The winds, climate, currents and tides which affect the temperature and composition of the water, and all of which affect the availability of food sources were recognized as interwoven variables influencing the movements of the fish. Often these things would be indicated by

> the presence or absence of birds and other animals. The fishermen were quite aware of the predator/prey connection between cod and caplin, between seals and herring, and mackerel and plankton. Some fishers even seem to have included the impact of differences in salinity in their analysis of fish behaviour. (2)

The relationships fishers identify between various elements of the marine ecoweb should be the subject of debate. The knowledge on which they are based may not be correct, either in an absolute sense, or from the perspective of fisheries science. However, it could be argued that the problem such knowledge poses for a linear, reductionist science is, ironically, much like the problem the marine ecoweb itself poses for such science. In Daan's view,

> the effects of environmental conditions climb upwards through the system to meet somewhere the effects of fishing cascading from the top end. Obviously, they must ultimately mingle into almost an inextricable ball. At present, it is impossible to separate natural and man induced effects in the changes observed at various levels of the food chain. This situation can only become worse, now that even climate has become affected by man's activities and sea temperature and level are expected to rise as a consequence of the green house effect. (21-2)

Stock Assessment for Whom?

In conclusion, I would like to return to some of the criticisms of the northern cod stock assessment process implied by the above discussion. When stock assessment science is looked at from the perspective of trap and handline fishers, a bias in favour of the offshore commercial trawler fishery is revealed. Fishers' ecological knowledge is a social, technical, and cultural product. The same is true of the models of fisheries scientists (Finlayson).

The shortcomings in stock assessment science noted above were partly the result of the social/cultural and technological factors that structured the relationship between those doing this science, participants in the fishery, and the marine ecosystem. In contrast to fishers, those who design stock assessment models and carry out the analyses often spend little time at sea. They work with "paper fish," computerized data. A stock assessment scientist commented:

> most of the time, by the time I see the data, it is already in a computerized form and I deal a lot of the time with paper fish. So I spend a lot of time looking at computer files and graphs trying to figure out is this a trend going up or a trend going down. My principal tool I would say would be a computer and most of my work is in the office. (Anonymous, personal communication)

The data from the commercial trawlers that were used in stock assessment in the 1980s were not collected by scientists or technicians actually located on the vessels, interacting with skippers and crew. Located onshore and away from the fishing enterprise, these stock assessment scientists did not collect data on changes in technology and skill over time and between vessels. As a result, they overlooked the impact of these variations and the impact of changes in

management structures, such as the introduction of "enterprise allocations" (company quotas) in the offshore fishery, on logbook data and, more generally, on catches. This neglect of changes in technology, skills, knowledge, and regulations made it seem as though catches in the commercial trawler fishery were a reflection of stock health and not a result of these other changes. The negative impacts of this neglect were probably felt most and soonest by inshore fishers. It is thus not surprising that they were among the first to protest.

No fisher can ignore the actions of his/her competitors for the fishery resource. Particularly in a context of resource decline, more competitors and innovations in technology, skill, and knowledge mean more competition for space as the range of fish concentrations declines. However, in the northern cod fisheries the competitors are not equal in either their capacity to respond to these changes or in their options. In local fisheries like the trap/handline fisheries of Petty Harbour, space conflicts are confined to community fishing grounds. They may turn neighbour against neighbour and are a threat to the survival of fishing households. Under ideal conditions, trap and handline fisheries will not make these households rich but, history suggests, they can provide a living. Under conditions of increased competition and resource decline, members of trap and handline households are pressured to increase their investment in technology and hence the economic risks of the fishery. They may have to choose between education and healthy food for their children and more gear. Because they fish locally rather than following the stocks, these fishers can catch only those fish that are not taken beyond the confines of their community.[18]

Competition and innovation in the context of resource decline have a different impact on the offshore and nearshore mobile trawler and gill net fisheries. These fisheries have produced enormous wealth and enormous debt for individuals and corporations (Sinclair). Participants in these year-round fisheries can harvest the stocks before and after their inshore migration and over an enormous range of ocean. As a result, they did not feel the effects of stock decline as quickly or as intensely as those in the inshore fishery. In short, the social impact of the neglect of changes in technology and skill in the stock assessment process was, until quota cuts were introduced in the late 1980s, greater for inshore fishers than for the fishers and corporations fishing offshore. Because stock assessment science derived its data from the offshore fishery and not the inshore, it was handicapped in terms of its capacity to make sense of declining inshore landings in the 1980s. At the same time, sustained landings in the offshore fishery meant that participants in this sector were not, until recently, pressuring science to reexamine its commercial trawler data or its analysis of these data.

DFO has been criticized for concentrating on weight (the total biomass) at the expense of fish size in the stock assessment process. It has also been

criticized for managing the northern cod stocks as though they were one unit rather than several more or less discrete stocks (Finlayson; Harris, *Independent Review*). Trap and handline fishers appear to agree with scientific claims that inshore migrations and catchability for particular gears are influenced by oceanographic factors. However, the success of their fisheries also depends upon migrations by large and smaller fish to *their* grounds and a relatively long fishing season. Related to this, trap and handline fishers have an interest in maintaining local stocks, should they exist,[19] and a biomass composed of a broad range of year classes that is sufficiently large to ensure inshore migrations. The absence of these concerns in stock assessment science meant that it served the interests of the corporations and trawler owner-operators better than those of trap and handline fishers.

The broad range of conservationist practices that characterized the trap and handline fisheries (discussed above) needs to be contrasted with the conservationist practices that have dominated government management of the northern cod stocks since the extension of the 200-mile limit. This system of management has relied almost exclusively on the setting of a total allowable catch (TAC). Expanding reliance on trawler and gill net technology, which select for larger fish, coincided with the virtual disappearance of codfish of spawning age (six years and older) in 1991. Prior to the northern cod moratorium imposed in 1992, there was no attempt by managers to protect the larger, older "breeding" fish that inshore fishers like David Hearn think should be protected (Larry Coady, personal communication). In addition, technological change and rapid improvements in the knowledge of offshore and nearshore skippers seem to have produced a situation in which, it was recently argued, areas previously protected from fishing owing to ignorance or technological limits have gradually disappeared, thereby eliminating closed areas and seasons that existed by default rather than being maintained through fisheries policy (Harris, Presentation). In short, the only conservation techniques left in the offshore Newfoundland fishery by the end of the 1980s were the TAC, offshore observers to limit discarding, and mesh size. Recent downward revisions in TACs, culminating in the closure of the northern cod fishery, growing evidence regarding the problems associated with stock assessment, and acknowledgement of the varying requirements of different fisheries alluded to in this paper, highlight the need to consider a more complex approach to management based on a broader range of conservation practices (Daan; Wilson and Kleban).

The stock assessment models used to manage the northern cod stocks after the extension of the 200-mile limit de-emphasized the role of oceanographic factors and species interaction in stock health. At the same time, scientists used the impact of these factors on the inshore fishery and the complex gear compositions and practices developed by inshore fishers to respond to ecoweb uncertainty as a justification for marginalizing the

knowledge of these fishers and data from inshore fisheries in general within the stock assessment process. There is now growing recognition within stock assessment science that the fluctuations and uncertainty observed in inshore fisheries are characteristic of marine ecowebs as a whole (Daan; Cury and Roy; Gomes and Haedrich).

Trap and handline fishers' recent criticisms of stock assessment science need to be placed in the context of the stereotyped and negative visions of their own competence within that science. From the perspective of yesterday's stock assessment science, fishers' ecological understanding is deficient, local rather than general, stories rather than numbers. The inshore fishers interviewed for this paper did not share with assessment science the confidence that fish stocks could be controlled and manipulated. They did not appear to share the assumption of fisheries models that "changes in variables have predictable outcomes" (Wilson and Kleban). This uncertainty derived in part from their belief that fish have minds of their own. They saw fish as

> variable and uncontrollable...This is reflected in how large a role luck and superstition play in fishing. Even if you had a good berth and a good trap, whether or not the fish would "strike" was another thing and quite beyond the control of the fishermen. It was as though the fish had a mind of their own and a rather fickle personality. The fishermen tended to personify the fish in the way they spoke about them [to treat them as subjects rather than objects]. (Carter 2)

Fishers' ecological knowledge could provide important insights for the development of knowledge about marine ecowebs. At a time when the future of the northern cod stocks is very much in question and the limited nature of current knowledge of cold ocean ecosystems is apparent to all, an approach to stock assessment and fisheries management that starts from local ecowebs and builds on the experience of these fishers must be considered. As argued by Cabot Martin, an outspoken advocate of a new science that includes fishers' ecological knowledge, "it's a savage comment on our system that you would have to try to make the case that such knowledge is important information" (personal communication).

*An earlier version of this paper was presented at the World Fisheries Congress Meetings, Athens, May 1992. I would like to acknowledge the help of Alison Carter who diligently worked through archival sources and assembled the results into a wonderful report and Bev Brown who helped transcribe some of the interviews. I would also like to acknowledge the cooperation and active help of some members of DFO, Science Branch St. John's, particularly Larry Coady and George Rose. Chris Finlayson, Ben Davis, and three anonymous reviewers provided useful comments on earlier drafts. The fishers of Petty Harbour and St. Shotts Newfoundland endured both my invasive questioning and my seasickness. Bernard Martin accompanied me on some of my interviews to help deal with the inevitable barriers between a shore-based sociologist and fishers. Any errors are my own. This research was helped by a grant from CBC for the production of an "Ideas" programme called "The Science of the Sea" and a small grant from the Canada Employment and Immigration Commission.

Notes

[1]Like Ursula Franklin, "I much prefer to think in terms not of systems but a web of interactions. This allows me to see how stresses on one thread affect all others. The image also acknowledges the inherent strength of a web and recognizes the existence of patterns and design" (58).

[2]An exception is Larry Felt's (forthcoming) examination of the ecological knowledge of Newfoundland and Labrador salmon fishers.

[3]In *Words of the Lagoon*, Johannes argues that the nature and quality of fishers' ecological knowledge is influenced by the fishing technology and techniques used. In the case of Palauans, such knowledge is particularly intimate because they often fish underwater with spear guns. He contrasts the kind of knowledge required in, and garnered from, fishing in this way to that acquired when fishing in a trawler. This should not be taken to mean that trawler skippers would not acquire valuable ecological knowledge. Their success as skippers is dependent on their ability to find fish. However, their knowledge, mediated as it is by vessel mobility, fish finders, sonar, and other technologies can be expected to be quite different from that of fixed gear fishers.

[4]We might also expect these fishers' understanding of fish spawning and other behaviours that occur offshore to be more speculative than their knowledge of local ecoweb activities. Felt (forthcoming) argues that salmon fishers who fish close to rivers into which salmon migrate have a more detailed knowledge of salmon ecology than those who intercept migrating stocks further away from such rivers.

[5]Anderson and Stiles argue that the effort to exclude longliners from local communities "did not entail a 'conservationist' [strategy] but rather a personal *protectionist* one ... yet some recognition of resource limitation was clearly in evidence" (56-7).

[6]All excerpts from interviews have been edited for style.

[7]See also interviews with Joe Randell and George Groves (MUNFLA c804 70-04, 1969; c1969 73-46, 1971); and Drew.

[8]A recent examination of the ecological knowledge of Saami fishermen in a Norwegian community found that they maintained that gill nets would not catch the biggest cod with the highest reproductive capacity "simply because it's too big to get stuck" (Eythorsson). The difference between the two communities is interesting. However, so is the similarity in that both expressed concern about preserving large fish. As noted below, this has not been a preoccupation of stock assessment science in Atlantic Canada.

[9]Fishers' comments reveal that, in the handline fishery, catchability is closely linked to the feeding behaviour of cod. They maintain, for example, that the handline fishery normally declines during July when cod become glutted on caplin and unwilling to take the bait (Petty Harbour interviews; Templeman, "Some Instances of Cod").

[10]In a recent interview, Cornelius O'Brien, a former fish plant owner, reported that in 1954 he counted the average number of fish in ten boxes of dried fish. The majority of this fish would have been from cod traps. He found that there were about 100 salted cod per 100 pounds. In "round" (i.e., fresh) form, these fish would have averaged five pounds each and, he maintains, would have been over twenty-four inches in length. In 1991, he claimed, 30% of the trap fish were under sixteen inches (MUNFLA, 91461

c14593).

[11]George Groves, a Bonavista fisherman, commented in 1971 that it seemed as if the fish didn't come anymore in the fall of the year (MUNFLA, c1969 73-46). Fermeuse fishermen noted that the spring fishery had declined.

[12]As a result of a recommendation in the Harris *Independent Review*, there are now two scientists in Newfoundland looking for ways to use inshore data and the insights of inshore fishers in the stock assessment process.

[13]George Rose, a DFO scientist whose specialty is oceanography, has developed and tested a number of theories about fish movements on the basis of ideas he acquired from inshore trap fishers. His research findings have generally concurred with the views of fishers (interview, July 30, 1991).

[14]Butler uses the concept "cognitive map" to analyse inshore fishers' knowledge. Eythorsson uses a similar concept, "mental map," in his discussion of the ecological knowledge of Saami fishermen. He emphasizes the importance of intimate knowledge of tidal currents as critical to the success of fishing enterprises.

[15]In *Words of the Lagoon*, Johannes provides a fascinating discussion of the lunar rhythms of fish and fishing in Palau and their ecological bases. There has been some scientific investigation of the relationship between caplin spawning and lunar (tidal) cycles in Newfoundland (Templeman, "The Life History of the Caplin"; Frank and Leggett). This research links the timing of spawning to tides, water temperature, winds, and light levels. Templeman's quotes from fishermen imply that some link the timing not only to tides but also to the structure of local beaches (41).

[16]DFO recently provided funding for a research project to collect the historical knowledge of trap fishers (Newfoundland Inshore Fisheries Association).

[17]Franklin 36. There are also elements of "extended reality," i.e., "that body of knowledge ... we acquire that is based on the experience of others"; perhaps to a lesser extent "constructed reality," for example, the media; and "projected reality," their sense of the future in their thinking (36-8).

[18]This comes up in interviews with fishermen not only today but in the past. Ed Wade, a Flatrock fisherman interviewed in 1972, commented that draggers were "catchin' all the fish and it doesn't get a chance ... to get in" (MUNFLA, c1309 72-115). Sam Lee, a Petty Harbour fisherman, noted that increasing the mesh size in cod traps would simply allow cod to return to the offshore where they would be caught by trawlers.

[19]The large "mother" fish that Petty Harbour fishers maintain were wiped out by gill nets may have included some that overwintered in deep holes off the coast in the St. John's area. Eythorsson emphasizes the importance of local stocks to the fjord fishery in Norway. He also points out that the fjord stocks "do not seem to exist in the language of fisheries management officials." The zone system of management adopted in the Atlantic Canadian fishery had the effect of overriding attention to local stocks. See Halliday and Pinhorn for an interesting examination of the history of zone boundary development and negotiations around stock delineations.

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