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Rethinking Overfishing: Insights From Oral Histories with Retired Groundfishermen

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ABSTRACT

In this paper, we propose a revised view of overfishing which addresses the effects of fishing on multiple spatial and temporal scales. This view suggests that overfishing occurs when disturbances alter ecological processes enough to disrupt functioning of the system. We advocate the need to incorporate fine spatial and temporal scale information in managing fisheries with fishing communities providing this detailed information. An empirical example that contributes to this perspective is a recent project which interviewed retired groundfishermen from coastal Maine. The Atlantic cod (*Gadus morhua*) spawning and fishing grounds derived from these interviews were compared with earlier fishing ground descriptions from Collins and Rathbun (1887) and Rich (1929). The comparisons illustrate how changes in technology and markets caused spatial and temporal changes in areas fished during the last century. The interview results and comparisons support the theory that overfishing must be interpreted across multiple spatial and temporal scales. Conclusions about fishermen providing fine scale information for more effective fisheries management and governance are made.

INTRODUCTION

According to traditional theory, overfishing occurs when fishing mortality is great enough to adversely affect the long-term viability of a fish population (Cushing, 1988; Gulland, 1988). Traditional approaches to controlling overfishing require management agencies to adjust harvest levels to a fishing mortality rate that will balance reproduction.

Implicit in this approach to overfishing is the idea that the manipulation of a single variable - fishing mortality - at a single spatial scale - the range of the stock, and a single temporal scale - year - can control overfishing. The traditional approach does not consider the effects of the multiple scales, patterns, processes, and mechanisms in marine and estuarine systems. There is good reason for this: to incorporate multiple scale complexity would demand a high level of knowledge of the patterns, processes, and mechanisms in the system and this would create an extensive and costly measurement problem. However, recent research suggests that omitting multiple scale factors from the traditional fisheries models contributes to the overfishing problem. (Crecco and Overholtz, 1990; Levin, 1990; Ricklefs, 1990; Rose and Leggett, 1990; Barry and Dayton, 1991; Mullin, 1993; Swain and Wade, 1993; Wroblewski 1997; Rose et al., 1994; Myers et al., 1995; Raloff, 1996; Pauly et al., 1998). This revised view suggests that the effects of overfishing may have widely varying results (e.g., a change in species occupying an ecological niche, changes in biological communities involving several species, and a decline in total system biomass), depending upon the ecological characteristics of each system. Fisheries managers need to understand the multiple scale causes and effects of overfishing to successfully design fisheries policies that avoid such problems.

In New England, overfishing of the groundfish resource became apparent in the late 1980s when seasonal bottom-trawl surveys conducted by the National Marine Fisheries Service revealed drastically diminished stocks of groundfish. Recently, commercial catches have dropped despite greater fishing effort. An oral history project that interviewed retired Maine groundfishermen examined the processes that led to this overfished state, especially in the near shore waters of Maine. These oral histories documented a groundfishery whose essential elements - localized spawning stocks and possibly habitat - were destroyed over a relatively long time period (beginning at least as early as the 1920's and extending to the 70's and 80's). This historical perspective is consistent with other research that recognizes a 'systems' view of overfishing.

ORAL HISTORIES AS A BASIS FOR A CASE STUDY OF MULTI-SCALE OVERFISHING

Oral histories of fishermen from the Maine inshore and nearshore groundfishery were compiled during the winter of 1995-96. Twenty-four mostly retired fishing captains, selected by knowledgeable members of local fishing organizations and fishing communities and with at least 15 years in the inshore and nearshore waters of the Gulf of Maine were interviewed. They ranged in age between 55-89 years old. The interviews took place in the fishermen's kitchens, basements or fishing sheds and were audio recorded with their permission. A standardized interview format was used.

Older groundfishermen who had been especially successful through the years in catching cod and haddock on inshore and nearshore grounds were sought as information sources. Their responses on questions about cod were of particular interest to this study. Not only were they often the remaining survivors of that collapsed fishery, but their understanding of fish behavior, the locations of productive fishing areas, and the best time of year to fish them had been well-demonstrated. Prior to the collapse of the inshore fishery, such information was highly valued and as such, held in secret and not available. (Anderson, 1972; Gatewood, 1984; Wilson, 1990; Palsson, 1994).

Fishermen discussed the number of years they spent fishing, their target species, their port(s), and their fishing methods. They then described the locations where "ripe" (i.e., full of spawn) or juvenile cod and haddock had been caught and the time of year these catches were made. Often the spawning and nursery ground locations were mapped directly on nautical charts. At other times, marks and bottom characteristics were given. The location of these grounds and the fishing grounds identified by Rich (1929) that were close to spawning areas identified in the study are included in Figures 1., 2., 3, ~~and 4.~~

Results

A. Spawning and Nursery Areas

The oral histories compiled for eastern Maine revealed that the area from Grand Manan Channel to just east of Monhegan Island, (Figures 1 and 2) had approximately 166, 000 acres of cod spawning grounds within inshore and nearshore waters. Fishermen identified 140 separate areas in this region. Of these, two or more fishermen independently identified 88 grounds, which were considered to be "confirmed" areas where spawning fish had been found. The remaining 52 grounds were considered "unconfirmed", having been identified by but one harvester; however, because they abutted "confirmed" spawning grounds, they were assumed to be extensions of them or the result of an inaccurate memory.

The oral histories compiled for the western half of the Maine coast and through northern Massachusetts (Monhegan Island, Maine to Ipswich Bay, Massachusetts, Figures 3 and 4) described 25 separate cod spawning grounds and nursery areas. These grounds comprised approximately 251,000 acres. Of these, 21 were confirmed by two or more fishermen and 4 other abutting grounds were reported by one fisherman.

In general, the locations fishermen described as cod spawning areas were basins or channels containing a bottom of gravel and mud or fringed with gravel or sand. Depths varied from 30-100 meters and eddies were often reported to be in the area.

In many instances charts show suitable bottom adjoining a spawning site identified by fishermen that may have provided spawning areas beyond those identified during this project. Clearly, the places identified were locations where fish could be caught with the technology available at the time and may not necessarily represent the only locations in that area where fish were spawning.

B. Spatial and Temporal Movements of Fish

Occasionally fishermen described the movements of spawning cod as they moved to and from the spawning areas. From Little Machias Bay West to Petit Manan (Loran chart: 13-325: "Quoddy Narrows to Petit Manan Island"), cod generally arrived to spawn in the inshore and nearshore areas from south of Cross Island and Little Machias Bay all the way west to southeast of Petit Manan between April and June. This early spring to early-summer timing of arrival in the spawning area was consistent over this entire area. From Schoodic Point West to Southeast of Isle au Haut (Loran chart: 13-312: "Frenchman and Blue Hill Bays and Approaches"), fish first arrived between March and June in the deeper depressions and channels and then migrated further inshore as the season progressed. Although the locations and arrival time of ripe cod depict a general inshore-offshore movement, they also suggest that the arrival of spawning cod varied from year to year. The fact that harvesters found ripe cod in areas further offshore either in late winter or late fall also suggests that these fish were moving inshore-offshore at different times of the spawning season (i.e., from February to July).

From South of Isle au Haut West to South of Metinic Island (Loran chart: 13-302: "Penobscot Bay and Approaches"), harvesters found ripe cod arriving in early March in the outer part of the bay and moving inshore as the season progressed.

Discussion

These groundfishermen represent most of the remaining survivors of fisheries for collapsed inshore and nearshore cod and haddock populations. Their understanding of fish behavior, locations, and timing of certain life cycle events was well-demonstrated by their fishing success. Prior to the collapse of these fisheries, this knowledge was highly valued and kept secret. These fishermen may were willing to share their knowledge because they are no longer fishing themselves and because new technology provides today's fishermen with such a window on others' activities that fishing is no longer a secretive business. The information these men can provide concerning fishing grounds, spawning behavior and history of the fisheries is largely unavailable from other sources.

Five results from these oral histories are particularly important for our understanding of the history of New England's cod and haddock fisheries and the dynamics of overfishing: 1) inshore spawning areas were not identified as fishing grounds in earlier studies because they were not targeted by the early cod fisheries (Collins and Rathbun, 1887; Rich, 1929); 2) cod spawned in inshore eastern Maine waters in similar habitat and under similar oceanographic conditions; 3) the existence of distinct "resident" inshore populations of cod; 4) the gradual extinction of inshore spawning areas 5) the inshore cod spawning areas have not yet been recolonized. The following paragraphs address each of these five points.

1.) Inshore spawning areas documented here were not identified in earlier studies as fishing grounds because they were not targeted by the early cod fisheries.

Two earlier studies also compiled descriptions of Gulf of Maine fishing grounds from fishermen who used these grounds; Collins and Rathbun, 1887 and Rich, 1929. While many of the fishermen interviewed in these two surveys listed fishing grounds that were targeted during the appropriate season for groundfish spawning (February to late June), they did not report finding ripe cod on them. Most of the spawning areas identified during the recent oral history project were located inshore of the fishing grounds noted by Collins and Rathbun, and Rich. Yet, according to the current study's oral histories, the recently identified inshore grounds had provided good catches of spawning fish until their disappearance.

At least two explanations may account for the fact that the Collins and Rathbun (1887) and Rich (1929) studies included but few of the inshore spawning areas revealed during the recent oral history project. These inshore cod spawning areas may only have been used by cod populations during periods of very high abundance. One of these abundant periods may have occurred during the fishing years of those interviewed in the current study and not during the fishing years of the fishermen interviewed earlier by Collins and Rathbun (1887) and Rich (1929). This seems unlikely because by 1931, cod landings were in precipitous decline and remained at low levels until 1946 (after WWII), when landings increased dramatically. Both periods fell within the time frame reported by the study. In addition, the purpose of the Rathbun and Rich studies was to compile the location of fishing grounds and they would have identified them as such, rather than as spawning grounds.

A second, more probable, explanation for the change in fishing grounds can be found in technological changes in harvesting and markets. Many of the fishing grounds reported by the earlier researchers may have been the feeding and gathering areas for cod and haddock en route to, or returning from, spawning areas identified in the current survey. Even though spawning aggregations would appear to provide opportunities for highly profitable fishing today, the hook and line fishing methods used during earlier years were not effective for catching spawning fish. Spawning cod generally do not feed and thus are less likely to take a hook. Additionally, in the late 19th and early 20th century, salting was the primary method of preserving fish. Spawning fish, however, made a poor product that would not have competed well in the active world market at that time. Therefore, it is likely that harvesters did not target these aggregations.

The introduction of otter trawls and gillnets during the 1920s and 1930s (e.g., Alexander et al, 1914) allowed fishermen to target spawning aggregations efficiently. At almost the same time, changes in the market dramatically increased the demand for fresh fish. The development of ice plants in the 1890s, quick freezing methods in the 1920s and faster rail and road transportation opened new markets for which spawning fish were suitable. In short, technological changes in both harvesting and marketing combined to convert previously uneconomical spawning aggregations into a highly profitable fishery.

2.) Cod spawned in eastern Maine inshore waters in areas with similar habitat and oceanographic conditions.

The harvesters reported that inshore spawning areas for cod were located in channels or basins that ranged in depth from 30 to 100 meters and had either a gravel bottom or a mud bottom with gravel or sand along the sides. They also suggested that the spawning areas coincided with tidal eddies. The relationship between substrate and eddies associated with these inshore spawning areas has not been examined extensively. However, if the eddies function like those associated with the gyre found over Georges Bank, they may entrain eggs, larvae, and other plankton in appropriate conditions for longer periods of time. As a result, these eddies could enhance survival (Sinclair, 1986; Apollonio, 1994). The currents associated with these eddies may also distribute sediment of appropriate grain size to provide shelter for post-metamorphic cod once they settle to the bottom (Apollonio, 1994).

3.) Several discrete populations of "resident" inshore cod existed.

Although cod have the ability to migrate over great distances (e.g., Gulland and Williamson, 1962), these fishermen indicated that substantial numbers of cod remained in the general area as resident inshore populations. This finding fits with those of Perkins (1982) and Langton et al. (1995) who tagged and monitored groundfish in Sheepscot Bay, Maine. According to the fishermen interviewed in this study, many fish simply moved to deep-water basins near their spawning areas where they remained until the beginning of the next spring spawning run. The wintering grounds for these resident populations were the channels and basins of the coastal shelf, particularly those connected to the major basins of the Gulf of Maine, which coincidentally were also the winter fishing grounds of the early dragger fleets of New England. Interviewed fishermen suggested that there might have been multiple populations of fish arriving in inshore Maine waters during the course of the year. One, the local resident stocks that spawned inshore and moved to nearby deeper waters for the remainder of the year and another migratory stock which moved from west to east in the early summer.

"Resident" populations in the eastern part of the Gulf of Maine (i.e., from eastern Penobscot Bay eastward) used Jordan Basin as their major wintering ground, although local basins also served as overwintering areas for these populations. "Resident" populations from western Penobscot Bay to Casco Bay appear to have used the deep water east of Cashes Ledge and the northeastern part of Wilkinson's Basin as their overwintering areas. Some portion of these resident populations may have traveled with the general southern coastal circulation out to Georges and Brown's Banks. Western Penobscot Bay was frequented by a resident stock that appeared inshore during late winter/early spring and spawned locally and moved slightly offshore in July when the predatory dogfish came inshore. While moving out, the cod would feed on herring stocks moving shoreward in June to feed on phytoplankton blooms occurring there.

A second stock of cod that had spawned beyond Penobscot Bay would appear during late June, July and August to feed on schools of herring and mysid shrimp. These different arrival times to the inshore Maine waters suggest that these may have been multiple populations of fish with the resident populations relying on local inshore areas for spawning and the migratory populations visiting the inshore areas only to feed. A greatly diminished migratory stock segment still frequents Maine waters, moving northeast along the coast from western Gulf of Maine and reaching Penobscot Bay, near the center of the Maine coast, during July and August to feed.

The inshore populations from eastern Penobscot Bay and eastward generally arrived on the lower spawning grounds in early April. Seal Island in outer Penobscot Bay was reported to have spawning cod populations in February. The locations of overwintering cod populations were sometimes proximate to overwintering populations of herring in Penobscot Bay, Green Island Channel, outer Frenchmans Bay, and Machias Bay.

4.) The gradual extinction of inshore spawning areas.

Oral histories documented the selective and sequential extinction of inshore and nearshore-spawning grounds over a period of forty yearsbefore the introduction of otter trawling, the major fishing grounds for cod in the Gulf of Maine were outcroppings located along the 100-meter depth contour. Starting in the early 1930s, with the advent of otter trawling and freezing, effort expanded to inshore waters because the new technologies made it possible to harvest spawning aggregations economically. Trawling, as a method of fishing, appears to have contributed to the collapse of local populations associated with particular spawning areas. This experience fits with the suggestion that cod may follow particular migration routes and show strong fidelity to a particular spawning area (e.g., Bigelow and Schroeder, 1953; Wise, 1958; Perkins, 1982; Hunt, J.J. and J.R. Neilson, 1993; Rose, 1993; 1997).

The depletion of those spawning areas closest to shore first, before going to those further offshore also fits with common sense economic behavior. Fishermen targeted grounds that would maximize their gains while minimizing their expenses and risk, especially during the hazardous months of winter and early spring. If marketable fish could be found close to shore, in all probability they would be fished. Once depleted, fishermen moved to the next closest ground further offshore.

(5.) The extinguished spawning areas have not yet been recolonized.

Many of today's fishermen were surprised to learn about these historical spawning sites since there is no current indication of their existence. The absence of recolonization despite nearby active spawning areas in some places and periods of high cod abundance raises numerous questions about the behavior of these populations and the nature of the damage done by fishing and/or other human activities. Some of these questions highlight our lack of knowledge about the behavior of cod populations at different scales. For example, has recolonization not occurred because a longer time period is necessary for such a shift in fish population behavior? Do individual cod have spawning site fidelity? If so, what are the mechanisms for this fidelity? Are the fish genetically predisposed to return to specific spawning sites? Could chemical imprinting of a spawning site occur in juvenile fish? If so, what happens when the reproductive-aged fish are no longer around to lead the juveniles to the spawning site for chemical imprinting or for learning the route? How might these mechanisms be affected by localized overfishing? From another perspective, have human activities such as pollution or fishing damaged or destroyed spawning habitat, other species that might be essential to successful spawning and growth of cod? Or -- do current oceanographic factors inhibit recolonization of these sites?

In sum, these oral histories demonstrate that overfishing of cod populations occurred over a much longer time period than the last two decades as suggested by the current fisheries management institutions. Further, these oral histories suggest that multiple populations of cod inhabited the Gulf of Maine and that each of these populations relied upon its own critical spawning and nursery sites. The oral histories also suggest that these multiple populations may have collectively comprised a complex, larger "metapopulation". These suggestions contrast with the traditional perspective, which treats the Gulf of Maine cod as a homogeneous population. The findings also provide empirical evidence of small scale, gradual loss of habitat, changes in species composition, and disruption of energy flows, which preceded the collapse of the whole groundishery system. These multiple spatial scale patterns and temporal processes need to be considered in interpretations of overfishing and strategies for effective fisheries management.

Conclusion: Towards an Alternative Theory of Overfishing

There were three major findings from the interviews: a) groundfish once spawned in numerous small patches in Maine's inshore and nearshore waters; b) the extinction of these inshore spawning areas was a gradual process over approximately 40 years; c) retired groundfishermen along the Maine coast demonstrated that they can provide the small spatial and temporal scale information about the historical inshore cod spawning areas. The implications of these results are as follows:

1. The protection of small-scale components of an ecosystem, such as specific spawning patches, may be as critical to effective fisheries management as understanding the effect of large-scale phenomena such as climate changes.

2. System changes may occur gradually and may not be easily interpreted -nor fixed with regulations designed to address short-term solutions.

3. Fish are not randomly distributed, particularly during critical life cycle events, and consequently, should not be managed as such.

4. Subpopulations of fish stocks should be considered in fisheries management strategies.

5. Small-scale changes have critical influences on the fisheries system and local stakeholder involvement is essential for effective management. Traditional marine science literature on former inshore and nearshore spawning grounds is particularly scarce and data on ecological changes in inshore fisheries systems is limited. (See also Collins and Rathbun, 1887; Rich, 1929; Johannes, 1981; Neitschmann, 1985; Neitschmann, 1989; Freeman and Carbyn, 1988; Jentoft and Kristoffersen, 1989; Ruddle and Akimichi, 1989; Short, 1989; Johnson, 1992; Pawluk, 1992; Mailhot, 1993; Pinkerton and Weinstein, 1995).

6. Fishermen, and other local stakeholders, can suggest relevant hypotheses for future scientific examination and fisheries management strategies.

The results of these oral histories support calls for a multiple scale, ecosystem perspective on overfishing and are consistent with multiple scale theories in terrestrial ecology (e.g., Golley et al., 1975; Wiens, 1976; Wiens, 1985; O'Neill et al., 1986; Senft et al., 1987; Kotliar and Wiens, 1990; and metapopulation theory: Levins, 1970; Kiester and Slatkin, 1973; Gilpin and Soule, 1986; Gilpin, 1987; Stamps, 1988; Brussard and Gilpin, 1989; Forney and Gilpin, 1989; Gilpin, 1990; Smith and Peacock, 1990; Bengtsson, 1991; Ray and Gilpin, 1991) Overfishing is not necessarily apparent in the community's total number of individuals or biomass, or even in the size-frequency distribution of its individuals (Murawski and Idoine, 1992) but in the spatial and temporal changes in habitat use and life cycle events. Our research suggests that the effects of overfishing will not necessarily be most apparent using traditional indices such as the total number of individuals, total biomass, or size-frequency distribution of individuals. The changes in the species composition of the community to which the individuals belong and the gradual removal of patches, or subsystems, in a progressive manner may be better indicators.

The multi-scale view of overfishing suggests that overfishing occurs when disturbances alter the basic biological processes - particularly the energy feedback loops between trophic levels - and habitats enough to disrupt the functioning of the whole system (Holling, 1973, 1986, 1987, 1994). The effects of overfishing from this perspective are most apparent in disruptions to basic biological processes and habitats in a multi-scale system (Wilson and Dickie, 1995; Wilson et al., 1996). The biotic and physical degradations of fisheries systems can disrupt life cycle events such as spawning and larval and juvenile development which occur over particular time scales as well as ecological processes which influence feeding patterns over specific spatial scales. Reduced opportunities for growth, reproduction, and survival alter the ability of the multi-scale system to perpetuate the trophic energy flows on which the fishery depends. On the lower levels of the multi-scale system, the degradation of habitat "patches" and disruption of basic life-cycle processes are associated with discrete acts at particular times and places. These lower level events can impact the multi-level system structure and can thus reflect overfishing through a loss of system resilience. As an example of this, depletion of a particular spawning ground may not disrupt the functioning of a system, but depletion of enough of the essential spawning grounds for a population may extinguish that population and alter the energy flows in that system.

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Wilson and Dickie (1995) suggest that understanding and protecting small-scale processes such as particular spawning migrations that occur at a specific time of year along a specific route may be an essential multi-scale management function. Local spawning areas may need to be protected and fishing during the spawning migration, for example, may need to be limited to permit the older migration "leaders" to teach the younger fish the successful spawning migration route to their spawning ground. Such small-scale information and management actions may be necessary to protect the system functions. Implicit in this theoretical management approach is the need to incorporate fine spatial and temporal scale information about a fishery in designing an effective management plan.

In conclusion, to effectively manage a multi-scaled fisheries system, an adaptive multi-scale governing institution should be created. Through such an institution, fisheries management should reorient its focus from maintaining a particular population level to protecting the multiple scale non-species specific aspects of the fishery system that are relatively stable (e.g., specific habitat types). This governing institution should follow the principles of federalist governance regimes in which governing bodies exist on multiple scales to address problems specific to their particular scale and locality. The scientific support behind a multi-scale fisheries governing institution would have to incorporate fishing community members who are the only people who can provide small spatial scale and multiple temporal scale information about the system.

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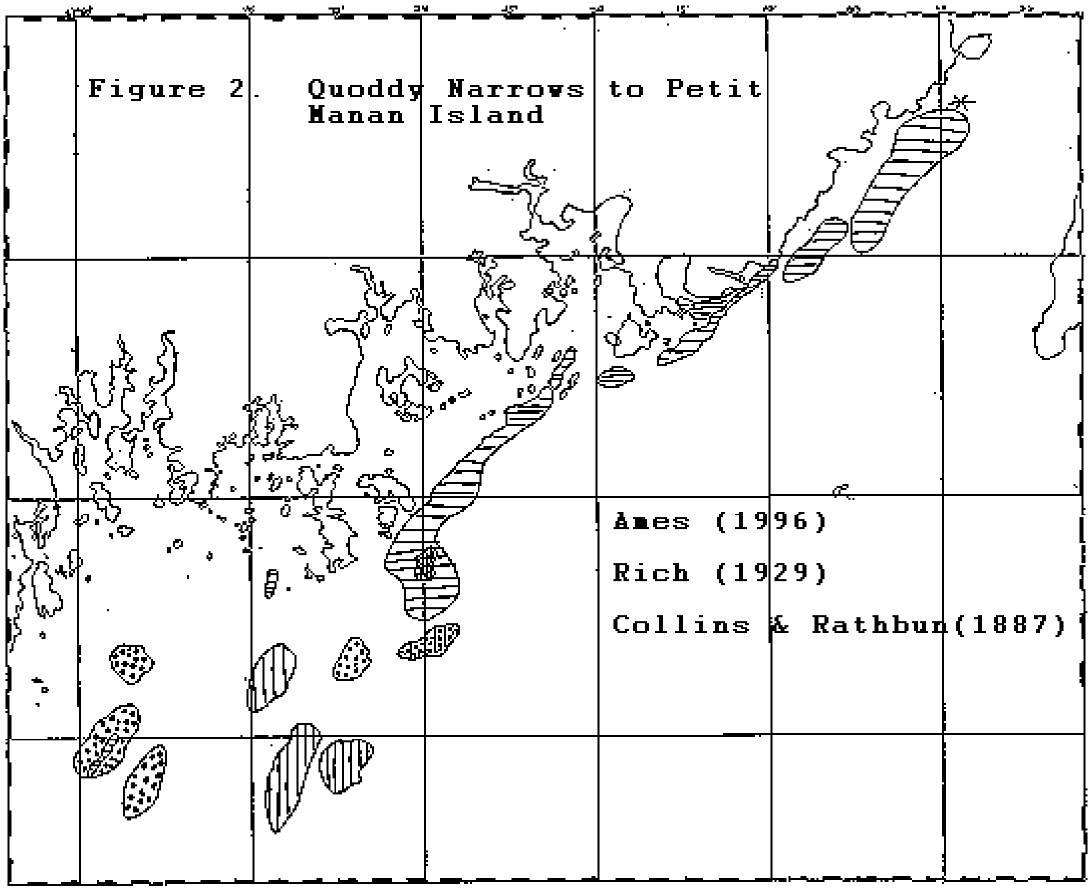
Figure 2. Quoddy Narrows to Petit Manan Island
Ames (1996)
Rich (1929)
Collins & Rathbun(1887)

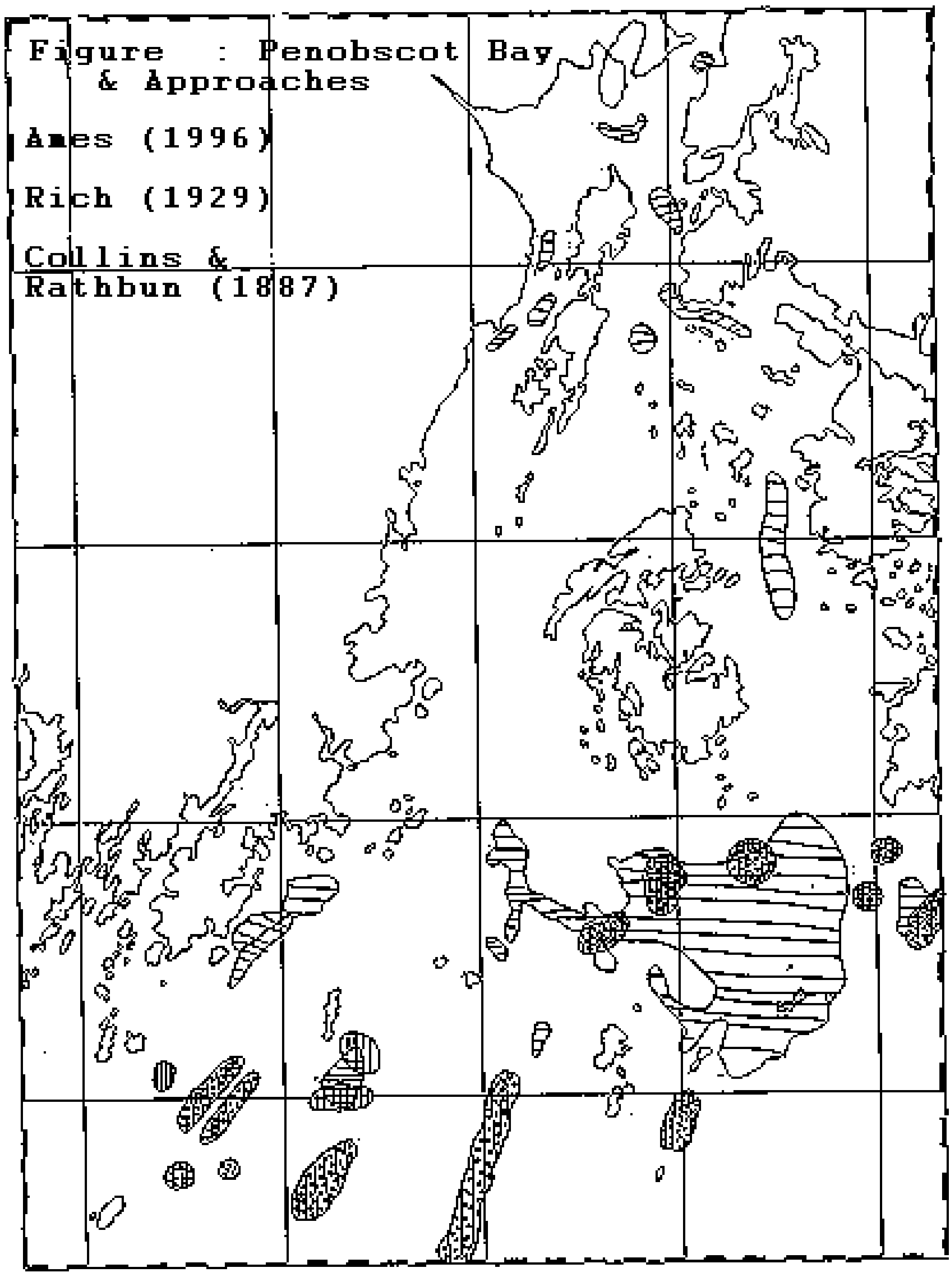
Figure : Penobscot Bay
& Approaches
Ames (1996)
Rich (1929)
Collins &
Rathbun (1887)

Figure :Frenchman and Blue Hill Bays