Summary

Inshore fishermen along the Fundy coast in Southwest New Brunswick have been the backbone of the local economy since European settlement. They have also played a significant role in the provincial economy, exporting herring, lobster, scallops and other seafood products to markets in the U.S. northeast and abroad. Over time, however, they have lost access to important fishing grounds through environmental degradation (as in Passamaquoddy Bay) and to alternative industries. Most recently, finfish aquaculture has played an important role in this displacement of fishing activities. Finfish aquaculture sites have proven particularly incompatible with herring weirs, but other fisheries have also been affected. A recent study conducted among fishermen in Southwest New Brunswick recorded their observations as to the impact of finfish aquaculture on their fisheries. Fishermen involved in lobster, herring, scallop, and sea urchin fisheries all reported observing significant environmental changes around aquaculture sites. Within two years of an operation being established, fishermen report observing that berried female lobsters abandon the area, scallop and sea urchin shells become brittle, scallop meat and sea urchin roe becomes discolored and herring no longer come into the area. Aquaculture operations are also linked to lobster, crab and shrimp kills in the down-current area. These and other concerns suggest that more comprehensive and detailed studies are required to establish the environmental and economic costs of finfish aquaculture, especially their affects on the capture fishery and the stocks on which that fishery rely. It also points out the need for more effective, community-driven integrated management institutions.

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Introduction

Since 2006, members of the Coastal CURA, a Maritimes-wide community university research alliance investigating the role of communities in integrated management, have been examining the interaction of finfish aquaculture and the capture fisheries in Southwest New Brunswick (SWNB). In the winter of 2009, the press reported that many lobsters were found dead from pesticide poisoning in several locations in SWNB. This was not the first time such lobster mortalities had been reported. Subsequent testing determined that a pesticide that was not approved for marine use, but that could be used to control sea lice in salmon aquaculture had killed these lobsters. Several other lobster kills followed, and the resulting tension reinforced the need for appropriate integrated management institutions that meaningfully incorporated local communities. One such management organization was the Traditional Fisheries and Aquaculture Working Group, which had been formed in 2008 to address conflicts between these two industries. This group included members of local fishermen's organizations and aquaculture operators in the area, as well as government representatives. It rapidly became obvious given claims and counter claims (see Gustafson 2011) that little was known about the interactions between aquaculture and the inshore fishery. Thus, in order to inform the deliberations of this group and to gain some understanding of the fishermen's perspective, the Coastal CURA and Fundy North Fishermen's Association undertook a preliminary and small-scale study of recent ecological change as observed by fishermen.

The SWNB local ecological knowledge (LEK) project was subsequently designed to investigate fishermen's observations of recent environmental changes in their fishing grounds, particularly those in the areas where aquaculture has been introduced. The emphasis was placed on the perceptions of active fishermen, who are on the water at various times of year and using various types of fishing gear, including scallop draggers, lobster traps, and urchin diving equipment. Using 'kitchen meeting' type focus groups, fishermen in affected areas of SWNB were invited to discuss the changes they have observed in the marine environment. They were then asked about their theories linking these changes to aquaculture. They were also asked if they thought these changes were affecting their fisheries and in what way. Finally they were asked about any other concerns they have with aquaculture in their area (see Appendix I).

The focus groups took place over a two-week period in October 2010. This short time frame was necessary, as fishermen were gearing up for the upcoming winter lobster season beginning in mid-November.

History of the Fishery in Southwest New Brunswick

The inshore fishery in Southwest New Brunswick began when Europeans first settled the area in the mid-18th century. Many of today's inshore fishermen are fifth and sixth generation fishermen. The species caught included groundfish (cod, pollock, haddock), anadromous species (salmon, gaspereau, alewife), invertebrates (lobster, scallop, crab, clams, urchin) as well as herring. Cod was an early target species, and by 1875, dried cod sales had escalated and remained lucrative throughout the 19th century; however, cod went into decline soon after. The earliest recorded herring weir was in 1797 (Doucet and Wilber 2000:5). In 1885, Connors Brothers of New Brunswick began harvesting and selling sardines (herring). Connors Brothers remains the largest sardine company in the world. Demand for lobsters was high during the 1800s and this continued until a decline in the resource occurred at the turn into the 20th century. Lobster stocks rebounded after the collapse of the groundfish stocks, and today the lobster stocks in this region of New Brunswick are at an all-time high.

Despite changes in fisheries technology and in fish processing, which have varied over the centuries, and despite the decline of many groundfish stocks, the commercial inshore fishery continues to be the principal economic activity in the region. Presently, the majority of fishing effort is concentrated on lobster with approximately 175 lobster licenses issued for southwest New Brunswick. The export of live lobsters from southwestern New Brunswick waters is the economic mainstay for most coastal communities. Other inshore fisheries include scallop, shrimp, herring, groundfish and less traditional species such as sea urchins and sea cucumbers.

Salmon aquaculture began in this area in 1979 with a single experimental lease (Walters 2007:144). Deer Island and Grand Manan were early growth areas, and by 2000, Deer Island had 21 sites. Early development of the industry was based on small local operators, many of them previous herring weir operators. However, fierce international competition, and supportive provincial policies and incentives soon led to greater concentration of ownership in the hands of multinational corporations (ibid. 145; Marshall 2001). Problems with disease and sea lice infestations led to increased government regulation, including the recent introduction of the “three bay policy”, which requires that each operator have a different site for the three stages of growth and that each site gets a regular fallow period in rotation (see Maps 6 and 7).

Unpublished provincial reports (Anonymous 2007 and Desjardins 2007) provide some figures on the total value of the seafood industry in New Brunswick, as well as comparative figures for fishing and aquaculture. Both reports are based on 2005 figures. The province is ranked as number four in seafood exports in Canada, with the total exports at 832 million dollars[1]. Primary export markets are to the US (at 84.9% of the market), followed by Japan (at 7.4% of the market). Lobster is the most important export by value (401.8 million dollars). Farm raised salmon, in comparison, nets 175.7 million dollars in sales (ibid.). A comparison of employment figures is also interesting. Fisheries harvesting employs roughly 7000 people province wide and fisheries processing employs a further 5020 (ibid.). Aquaculture employs roughly 1400 province wide, and aquaculture processing employs a further 560 (ibid.). Desjardins (2007) reports that lobster alone generated 332.7 million dollars in sales revenue, 3061.4 person years of jobs and contributed 170.2 to the provincial Gross Domestic Product.

Management of these valuable resources is complex. Section 31 of Canada’s *Oceans Act* (1996) states that the Minister of Fisheries and Oceans Canada will collaborate with other ministers and bodies including:

> … boards and agencies of the Government of Canada, with provincial and territorial governments and with affected aboriginal organizations, coastal communities and other persons and bodies, including those bodies established under land claims agreements,

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[1] See http://www.gnb.ca/9999/Industry-Profile-SAG-Report-Annex-EN.pdf, accessed January 27, 2011.

and shall:

> … lead and facilitate the development and implementation of plans for the integrated management of all activities or measures in or affecting estuaries, coastal waters and marine waters that form part of Canada or in which Canada has sovereign rights under international law.

Under subsequent agreements, the federal and provincial governments each hold responsibilities for management, with the province granted a larger management role in aquaculture, while the federal department of Fisheries and Oceans manages the capture fishery. Management committees that include local fishermen have been established for all commercial stocks. Integrative planning has also been furthered by the Southwest New Brunswick Marine Resources Planning Process, which was jointly launched by the provincial and federal governments in 2004, as part of a wider planning effort for the Bay of Fundy. The work of this committee has been impressive, with several public consultations and reports leading up to a "Preferred Future of the Bay" work plan in 2010[2]. To date, however, there has been no implementation of the recommendations made in this work plan.

The Study Area

This project focused on both coastal waters containing aquaculture sites and those relatively free from aquaculture. Geographically, the study area was located at the mouth of the Bay of Fundy, along the southwest coast of the province of New Brunswick and in the waters adjacent to the U.S. state of Maine (for the study area see Map 1). It was restricted to those fishing areas along the coast from Saint John to the U.S. Border and on the New Brunswick side of Grand Manan. It included fishermen with experience in fishing the waters of Passamaquoddy Bay (often called Saint Andrews Bay by local fishermen), Deer Island, Campobello Island, Letete, Back Bay, the Wolves, Maces Bay, Dipper and Saint John Harbours. This area was selected for three reasons. First, the Coastal CURA project had a partner organization (Fundy North Fishermen's Association), which both advocated for and participated in the research. Second, the area has long been important as fishing grounds and recent records indicate the area remains important for lobster, scallop, herring, groundfish and sea urchin harvest (see Maps 2-5 for harvest areas)[3]. Third, the western-most stretch of the coast here has the heaviest concentration of finfish aquaculture in New Brunswick, and includes aquaculture Bay Management Areas 1, 2a and 3a (see Map 6)[4]. The primary finfish product is salmon

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[2] Information on this planning process and copies of the report can be found on the Southwest New Brunswick Marine Resources Planning website at http://bofmrp.ca/home/ last accessed February 8, 2011.

[3] Aside from Map 1, all maps for this report have been provided by the provincial department of Agriculture, Aquaculture and Fisheries. All maps show Grand Manan Island, which was not included in the LEK study area. At the request of the provincial department, Maps 2-7 have not been modified in any way for this report.

[4] Bay Management Areas (BMA) were introduced by the province of New Brunswick to control disease and pest infestation by regulating the stocking of marine aquaculture sites

(*Salmo salar*). In some of these bay management areas, the province has allowed for controlled growth, while other areas are being excluded from further expansion of aquaculture (see Map 6).

It is also important to note that this area has been documented as containing significant habitat for key commercial species (see Maps 2-5). Historically it contained spawning areas for cod (*Gadus morhua*), haddock (*Melanogrammus aeglefinus*), and pollock (*Pollachius virens*) (Graham et al. 2002). It is still important for lobster (*Homarus americanus*) spawning areas and for lobster nursery areas – both are found along the mainland coast from Maces Bay to the St. Martins area and around both Deer and Campobello Island[5]. It also contains at least two important herring (*Clupea harengus*) spawning grounds (see Map 3), and many pockets of rich scallop (*Placopecten magellanicus*) (see Map 5) and sea urchin (*Strongylocentrotus droebachiensis*) beds.

Framing Local Ecological Knowledge

Recent literature on local ecological knowledge (LEK) has suggested that fishermen's knowledge can be useful to managers in both data-poor and data-rich contexts (Hill et al. 2010), particularly where multiple users may be leading to deleterious interactions (Heaslip 2008). Fishermen's knowledge is "dynamic as it responds to changing circumstances" and is "time sensitive, location specific and holistic" (Hill et al. 2010:659). As a result, LEK can be used to "prioritize and focus limited scientific resources in the form of a knowledge partnership" (ibid. See also Felt 2010).

In his discussion of traditional ecological knowledge, Berkes (1999) referred to four levels of knowledge: (1) recognizing distinct living and nonliving components of the ecosystem and having linguistic labels for them; (2) perceiving functions and uses for each component (for both human and nonhuman parts of the ecosystem); (3) understanding the resource management systems that govern them; and finally, (4) having worldviews and cosmologies that provide ethical guidelines in using the ecosystem. It was within this complex sense of ecological knowledge that advocates call for better integration of fishermen's knowledge into resource policy and management planning (Neis and Felt 2000, Felt 2010). But as Hill et al. (2010) point out, there are pitfalls to LEK studies that are not appropriately designed and that do not recognize the complex and contested nature of fishermen's knowledge (see also Curtis and Wiber nd.).

In order to avoid these pitfalls, it is important to revisit what is meant by *knowledge*. A dictionary definition is "a result or product of knowing; information or understanding acquired through experience; practical ability, or skill" (Avis 1989:749). But the dictionary entry goes on to add that knowledge also includes the contribution of the mind in understanding data, perceiving relationships, elaborating concepts, formulating principles and making evaluations. This is important to any understanding of fishermen's knowledge – individuals make use of their knowledge to understand data,

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and to allow for regular fallow periods. Aquaculture operators must have sites in multiple bay areas to rotate site use and provide for fallow cycles.

[5] As will be discussed in the section on lobster, fishermen from Campobello reported several bays and coastal areas around the island that were known to them as lobster nursery areas – these are not recorded on Map 4.

perceive relations, and make evaluations that direct their future behaviour. And all bodies of knowledge are situational, contested, and contingent.

Hill et al. (2010) argue that it is important to distinguish between fisher's observations and their theories about those observations, and to acknowledge when fishers diverge in observations or in explanations. We argue here that it is also important to track the ways in which fishermen's knowledge directs their behavior. In this study, we adapted the Hill et al. characterization of LEK (see Figure 1), to acknowledge the complex relationship between types of fisher knowledge and the theories they generate about on-the-water observations. Fishermen are not only knowledgeable about fishing behavior (their own and others that they can observe on the water or at the wharf), but also about the resources (especially those resources on which they rely), and of the environment (including the characteristics of ocean bottom, currents, weather and changes in species habitats). In addition, they are knowledgeable about the management regimes that affect them, and of many scientific findings that are discussed at stakeholder management meetings in support of various management measures. Finally, in developing their theories, they test much of this information against their ethical guidelines for appropriate behavior with respect to the environment. In this more complex characterization of LEK, research design must take account of the many diverse sources of information that contributes to fisher's knowledge. Separating theory from direct observation and experience, as Hill et al. advise, is an important first step to contextualizing LEK. But following up and asking how their knowledge has changed their fishing behavior is equally important.

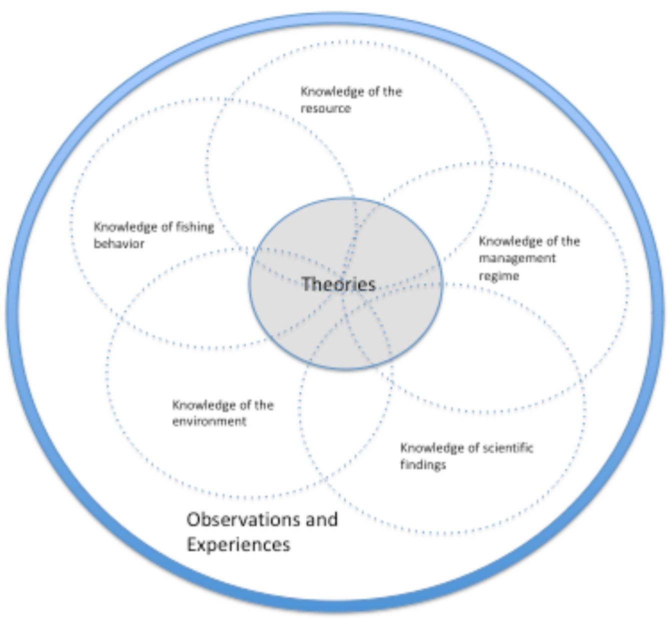

Figure 1. Characterization of Local Ecological Knowledge (adapted from Hill et al. 2010:664). Theories are based on observations and experiences, but components of LEK have various sources. LEK in turn affects fishermen's behavioral choices.

The Study Methodology

Focus groups are useful when in-depth qualitative data is required to study a specific situation (Morgan 1997), particularly where participants may have divergent views. Participants are thought to respond more freely in the security of a homogenous group concentrating on a single problem, and to generate "rich understanding of the participants' experiences and beliefs" (Morgan 1998:11). In this study, a semi-structured interview schedule was developed in order to solicit information from small numbers of focus group participants on selected topics, to allow room for clarification and explanations from participants, and to permit room for disagreement and/or elaboration (see Appendix 1). The University of New Brunswick Ethical Review Board conducted an ethical review of this research methodology and approved it (REB 2010-104).

Recruitment was designed to capture active fishermen with experience in fishing both waters with and without aquaculture sites. The Fundy North Fishermen's Association facilitated recruitment. The total population of all commercial license holders in the inshore sector in this area is difficult to estimate as most fishermen are engaged in a multispecies inshore fishery and hold multiple licenses, so that numbers of licenses are misleading. The Federal Department of Fisheries and Oceans statistics list 340 core fishermen for the Scotia-Fundy region of New Brunswick[6]. The most important species for this inshore fishery, however, is lobster, followed by scallops, herring, groundfish and other species such as sea urchins. A more accurate estimate for the total universe of relevant fishermen in our study area, then, can be based on the lobster licenses for Lobster Fishing Area (LFA) 36, which number approximately 176. Fundy North Fishermen's Association has approximately 75 members, including crewmembers that are not license holders.

Aquaculture in this area of southwest New Brunswick has primarily been developed in several distinct areas and through several phases of development. In the study area, the Deer Island area (including adjacent Letete and Back Bay) has the longest history and the heaviest concentration of sites. Campobello Island has a number of sites on the New Brunswick side of the island, while the Maces Bay area has only recently been allocated aquaculture sites (see Map 6). Recent changes to the provincial regulations over aquaculture site management have required site rotation over a three-year cycle, which must include a fallow year at each site (see Map 7).

Kitchen meetings (focus groups) were set up in these three areas: two focus groups on Deer Island, two on Campobello Island and one in the Maces Bay area (see Map 1). Fundy North Fishermen's Association announced these kitchen meetings through talk mail messages to all members, and to phone calls to key informants in selected areas, asking them to attend and to encourage others to do so. On average, three participants attended each meeting. The project was designed to take advantage of the small window of opportunity between fisheries in this multi-species inshore fishery, where fishermen fish multiple species and have multiple fishing seasons. The focus groups were originally to take place during a one-week period, but bad weather extended the study period for a further week.

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[6] See http://www.dfo-mpo.gc.ca/stats/commercial/licences-permis/fishers-pecheurs/fp07-eng.htm, last accessed January 27, 2011. The statistics listed are for 2007.

Two academics from the Coastal CURA and one employee of Fundy North Fishermen's Association were involved in the focus groups, with all but the Maces Bay meeting having at least two researchers present (following Krueger 1998:100). At each meeting, research notes were taken by the researchers who were present. Tape recordings were also made of the sessions in order to check the accuracy of note taking.

Fifteen fishermen participated in the five focus groups. Two men had over 50 years of experience, four men had over 30 years, four men had over 20 years, three men had over 10 years, and two did not report how many years experience that they had. All the fishermen who participated fished in the study area, but several had fished in other locations as well. All fishermen interviewed had experience in fishing in areas both with and without aquaculture sites.

The semi-structured interview schedule covered the following topics: background information on the fishermen; general ecological changes fishermen have observed; the impact of salmon aquaculture on their fisheries; the spatial effects of aquaculture; the recent sea lice chemical problems and any other issues fishermen wished to discuss (see Appendix 1).

All research notes were collated, and subsequent analysis of the notes was undertaken using a qualitative analytic method that focuses on common themes (Palys 1992, Krueger 1998). Several themes emerged including: loss of species habitat; changes to health of commercial stocks; significant environmental problems and their indicators; loss of fishing ground; poor management of aquaculture sites; the impact of the management of aquaculture operations on local communities; and the impact on commercial fish stocks. The last theme was organized around specific fisheries (lobster, herring, scallop, groundfish, sea urchins). A few fishermen also mentioned shrimp, crab and quahog. The results of this analysis are presented below. In our findings, we present the most commonly reported or consensus response within these themes. Where there was no consensus, or where only one or two fishermen reported an observation, we make note of this. We also make note of the differences in observations recorded in the three focus group areas, Maces Bay (least affected), Campobello Island, and Deer Island (most affected).

Results

In the following results section, fishermen's observations have been divided into three categories, general environmental change including changes in distribution of commercial species, changes in the general condition of commercial species, and specific concerns with aquaculture operations. Fishermen's concerns with general environmental changes are summarized in Table 1, concerns with respect to commercial species are summarized in Table 2, and concerns with the operations of aquaculture sites are summarized in Table 3. All three tables are found in the Appendices.

General Environmental Change

There was a general consensus among fishermen that environmental changes followed the introduction of aquaculture[7]. For example, fishermen commonly reported that when they work near aquaculture sites they often notice foul odors of "sewage" or "rotten fish". They also reported changes in species commonly found in the area before and after the introduction of aquaculture (see also Felt 2010). However, the three focus group areas reported slightly different patterns to these consequences. In the Dipper Harbour and Maces Bay area, where aquaculture sites are fewer in number and of more recent introduction, fishermen did not observe as much environmental change around the aquaculture sites (see Map 7, Bay Management Area 3a). Fishermen from that area, as did fishermen from other focus group areas, observed that environmental changes seemed to follow a sequence. In the first year of stocking a salmon cage, lobsters seemed to move in close to the cages. In the second year, lobster numbers fall off and crab and starfish increase. In the third year of using the site, starfish seem to dominate. Finally, in a fallow year, the situation seems to improve, with commercial stock moving back into the area. In the Deer Island and Campobello areas, on the other hand, where salmon cages have a longer history, all fishermen report significant environmental deterioration around long-term aquaculture sites. They particularly noticed that aquaculture changes the "bottom". Fishermen report that "good bottom" is required for many commercial species. Good bottom is "hard bottom", or gravel areas, which are preferred by lobster, scallop and sea urchin. In those cases where hard bottom areas have been allocated to aquaculture, fishermen report that long-term consequences are common. For example, bottom near long standing salmon cages was extensively described as "mildewed or moldy" – whitish in color and largely a "dead zone" as nothing else was found there. Such dead zones do not appear to recover as quickly[8].

Loss of good bottom translates into a loss of habitat for important commercial species. In those areas where aquaculture has been concentrated, as around Deer Island and Letete (see Map 6), similar changes are now found to those previously observed in Passamaquoddy Bay. Older fishermen recall Passamaquoddy Bay as a rich fishing ground, but all fishermen interviewed now describe it as a "marine desert"[9]. Fishermen from all three locations reported that many of the small scallop beds scattered throughout their fishing grounds became preferred areas for aquaculture operations. Map 5, for example, shows that in 1997 scallop were fished in many areas around Passamaquoddy Bay, Campobello and Deer Islands and near Maces Bay. None of these areas were harvest areas in 2008. In sum, loss of scallop habitat has affected all three areas where focus groups were conducted.

A second commercial species that has been widely affected is lobsters. Map 4 shows spawning and nursery areas for lobsters, however, fishermen reported several more areas

[7] For an extensive review of the evidence for the Bay of Fundy see Milewski (2001). For surveys of the wider literature see Black 2010 and Cubitt et al. 2010.

[8] Cubitt et al. (2010:149) report varied recovery times for bottom affected by aquaculture, ranging from one to over seven years. Felt (2010:180) notes that fishermen refute recovery times claimed by aquaculture in Newfoundland.

[9] For scientific support for this assessment of environmental changes in Passamaquoddy Bay, see Lotze and Milewski (2004).

for lobster nurseries than appear on Map 4, especially around Campobello Island. Many of these areas have proven ideal locations for aquaculture sites, and fishermen reported that lobster larvae are no longer observed in those locations in their former numbers. Fishermen from Deer Island and Campobello also reported that berried female lobsters have been found in specific locations by generations of island fishermen, but once aquaculture moved into those areas, berried females were no longer found there. In a few cases where aquaculture operations proved unfeasible in a location, fishermen report that berried female lobsters have returned. In general, fishermen reported that lobsters are now more likely to be found in mud bottom areas, further off shore[10].

Herring fishermen from Deer Island and Campobello uniformly report that herring distribution has also been affected by aquaculture (see also Felt 2010:180). Herring no longer enter many bays and areas close to shore where aquaculture sites are found (compare Map 3 and Map 6 for impact on herring spawning grounds and nursery areas). In the experience of herring fishermen in our focus groups, where aquaculture sites have been placed near pre-existing herring weirs, those weirs no longer catch herring[11]. Weir fishermen have also noted that when divers are working on herring weirs, it is possible to observe them at depths never before possible - the water has become increasingly clear – fishermen theorize that this water clarity is linked to a loss of krill and other small crustaceans. In the past when the tide and winds were right, large numbers of krill would wash up on the beaches, but this has not been observed for three years.

Fishermen also reported changes in the behavior of a number of marine species, particularly those that feed on krill or small copepods. For example, the Maces Bay focus group agreed that high concentrations of zooplankton accompanied by feeding schools of fish are not observed now as they were in the past. The Campobello and Deer Island fishermen noted that whales are less frequently found feeding close to shore, and gulls and other birds are not observed feeding on shrimp as in the past.

On the other hand, starfish are much more common in many areas. Sea urchin divers and scallop draggers have reported areas of very high starfish "blooms". Starfish particularly cluster around aquaculture sites and are viewed as a sign of "the end of the fishery" as they are associated with poor water quality and "bad bottom".

Fishermen also reported that several species of seaweed seem to be impacted by aquaculture operations, including rockweed, which is thought to be a preferred habitat for juvenile lobster[12]. Green kelp and brown apron kelp are also becoming less common; sea urchin fishermen observed that in areas without these kelp beds, sea urchin produce less roe, and less roe of marketable quality.

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[10] For an assessment of the new aquaculture Bay Management Areas and possible influence on preferred lobster habitat see Chang et al. (2007). For critical comments on the limits of knowledge on lobster recruitment and environmental change, see Fogarty and Gendron (2004). For a recent study employing fishermen's knowledge of lobster habitats, see Rowe (2002).

[11] This was reported for the Southwest New Brunswick fishery as early as 1990 (see R. Stephenson 1990).

[12] Lotze and Milewski (2004:1437) report 40% percent declines of perennial rockweed cover in some eutrophied sites.

Changes in General Condition of Commercial Species

Observed changes in commercial species could be due to any number of environmental factors, including climate change, other contaminants and overfishing. However, fishermen uniformly reported changes in commercial stock, which they had observed in areas with high concentrations of salmon aquaculture[13]. They reported that they did not observe many of these changes in areas without aquaculture sites. They also routinely reported that they had changed their fishing practices as a result of these observations.

Direct and Indirect Impacts

In the following sections, we report on fishermen's observations of the direct impact of aquaculture on specific commercial species. However, fishermen also drew attention to indirect consequences. Fishermen from all three areas where focus groups were conducted reported that loss of fishing grounds to aquaculture operations has begun to affect the entire region. Weir operators note that herring weirs cannot coexist with aquaculture sites. Formerly productive areas of scallop, especially those with very productive meat/shell ratios, have been lost to aquaculture. Many of these scallop beds were in protected areas where it was possible to fish in the adverse conditions of a winter fishery. As is reported below, number of fishermen reported that they had "given up" on a winter scallop fishery. The placement of aquaculture on "good bottom" for commercial stocks has also forced lobster fishermen further off shore, which increases costs for steaming time and requires more costly gear, engines and boats. Fishermen who set lobster traps in areas frequented by aquaculture boats have experienced gear entanglement and gear loss. Fishermen in adjacent fishing grounds observe that the pressure on their stocks has increased, as fishermen displaced from aquaculture locations are moving into adjacent waters.

Lobster

Fishermen from all three areas where focus groups were conducted refuted the claim sometimes made that aquaculture has improved lobster stocks. Their observation is that lobster stocks increased as groundfish declined, and that lobster landings have increased in all lobster fishing areas within the Bay of Fundy, including those without aquaculture.

Fishermen from all three areas reported a concern that they are losing fishing ground to aquaculture. But Deer Island fishermen reported more concern about lobster than the other two areas. Fishermen from all three areas reported that lobster distribution has changed. Fishermen from Deer Island reported that lobster are no longer found in the same numbers in formerly productive fishing grounds, and that they are routinely steaming out into deeper waters to set lobster traps in (soft bottom) areas where they formerly did not find large numbers of lobster. Fishermen from Maces Bay and from Campobello Island report that increasing numbers of fishermen from Deer Island have moved into their traditional fishing grounds.

Fishermen from Deer Island and from Campobello also reported a sharp increase in lobster mortality. Dead lobsters have been pulled up in traps, observed on the bottom by sea urchin divers, and have also been washed ashore near aquaculture sites. Lobster

[13] For an attempt to develop a methodology to study the cumulative impacts of aquaculture in the Grand Manan area, see Sutherland et al (2005).

fishermen who hold lobster for market in lobster pounds reported significant increases in "shrink" or lobster mortality. This problem is discussed further below.

While lobster landings are doing well now, there is concern for the future as the local media reported that chemicals employed by aquaculture operators to kill sea lice[14] have been the cause of lobster kills (French 2010a, Raynor 2009, 2010). Fishermen theorize that juvenile lobsters must also be adversely affected[15]. They fear that future year classes could show sharp drops as a result of chemical use and due to loss of habitat in nursery areas. Fishermen felt that it could take seven to eight years to see the impact.

Fishermen are also concerned about the impact on their industry if traceability requirements or adverse affects among consumers result in reports of Bay of Fundy lobsters having absorbed chemicals used in aquaculture[16]. Lobstermen have had problems in the past when trace elements of paralytic shellfish poisoning closed Asian markets to Bay of Fundy lobster. As markets have been very sensitive to contamination problems, any trace of chemicals in the lobster could lead to long-term damage to their industry. Furthermore, as lobsters have been reported to migrate up and down the eastern seaboard, fishermen theorize that the effects of chemical damage may not be localized but could extend throughout the Bay of Fundy and adjacent areas of Maine.

Scallop

Fishermen from all three areas report that aquaculture has displaced the many small pockets of scallop beds that they relied on to provide flexibility in fishing patterns and in stock health. There are two reasons for this. First, scallop habitat is destroyed by "bad bottom". Second, scallop draggers cannot fish around aquaculture sites. Fishermen in Campobello Island, for example, reported that there were formerly sheltered areas where they could fish in windy conditions that are now restricted aquaculture sites. Fishermen from the Maces Bay area reported that numerous scallop beds that would each provide them with a few days fishing are now restricted aquaculture sites.

Scallop fishermen from Deer Island and Campobello uniformly reported a concern for the health of the scallop stocks. Fishermen reported that scallops are no longer found in areas with heavy concentrations of aquaculture and that in adjacent "down current" areas, there is a noticeable decline in the appearance of the meat and shells. The meat to shell ratio appears to be adversely affected. Fishermen report that previously they would obtain six to seven pounds per basket, but now scallops are smaller, with less meat per shell and many more "clappers" or empty shells. The quality of meat and the general appearance of shell are also affected. In Friar's Bay, for example, where there is now a salmon site, previously thick scallop shells are now very thin, and appear to have been

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[14] Black (2010:104) reports that two varieties of sea lice affect farmed salmon in the Atlantic, including *Lepeophthierus salmonis* and *Caligus elongatus.*

[15] Studies into the effects of chemicals on lobster lifecycle and reproduction are suggestive (see Boudreau et al. 1993, Abgrall et al 2000) but little follow up research has been conducted.

[16] Recent harmful algae blooms in the Bay of Fundy have been linked to toxins in lobster (see Sephton et al 2007). A recent European study has highlighted the need to research the transfer of contaminants to marine species consumed by humans (Swartenbroux et al 2010).

eroded from the outside. Scallop fishermen report that they would not eat scallops from this site, as a black or discolored matter (described as "mildewed") is sometimes found inside the shell and that thin shells are hard to process (shuck) as they "shatter" and "leave bits of shell in the meat". Scallop fishermen who fish other areas adjacent to aquaculture sites also report a "mildewed" appearance within the shells. Fishermen reported avoiding scallop beds with this characteristic.

The impact of aquaculture on scallop is reported to have affected fishing practices. A number of fishermen reported that it is not worthwhile to fish scallop in the months of January and February. They acknowledged that this was a hardship for their crews who formerly earned good money in that fishery. But they reported that the inshore areas that used to support a winter scallop fishery are no longer productive and even the beds further off shore are not productive enough to return their boat costs.

Fishermen from all three locations associate aquaculture sites with water quality problems and note that starfish seem to be attracted to those areas. They are concerned that increased starfish could lead to increased predation of scallops.

Herring

Herring weir fishermen have observed over the years that herring schools are sensitive to light, to noise and to the scent of dead herring. Herring weir fishermen on Deer Island and Campobello believe that the recent pattern of herring decline in specific weir areas began with the introduction of salmon aquaculture in those areas. They reported that formerly productive herring weirs in inshore waters close to Deer Island, Campobello Island and Grand Manan are no longer productive. One fisherman has documented over 67 coves where herring weirs were formerly located now lost to weir fishermen due to aquaculture sites. It has long been the experience of weir fishermen that any weir containing "smothered" or dead herring would not attract additional herring until cleaned up. Fishermen theorize that oil from aquaculture feed travels long distances in the water and as herring are sensitive to scent, the economic viability of weirs is directly affected by the placement of aquaculture operations in the area.

In addition, herring weir operators theorize that aquaculture sites block or deflect the passage of herring schools because of the lights and noise associated with aquaculture operations or because of changes to the way the tide flows; they theorize that the herring will take another path, which affects the viability of traditional herring weir locations – some of which have been held in one family for generations[17]. A few fishermen theorized that without krill to attract herring into the inshore waters, herring were staying further offshore. Fishermen also report that coves that were once useful "shut off" locations to catch herring, are no longer useful as aquaculture operators have left "nets laying on the bottom" or "too much junk on the beaches".

Also, herring weir fishermen reported that in the summer of 2010, herring did not fattening up in the normal way. Fat content on harvested herring normally averages around twelve percent but this year it was averaging around three percent (lean fish are sometimes called "slinks"). Herring also failed to achieve their normal length – four inch herring at the beginning of the summer were still four inches at the end of the summer, instead of the five to six inches common in the past. Herring caught in weirs did not have

[17] Also reported in Milewski (2001:171).

to be held in the weir to empty their digestive tracts before going to market for canning or freezing, and fishermen theorized that this is because they have not been feeding.

Sea Urchins

Sea urchin divers reported that sea urchins near aquaculture cages often have very thin shells. Sea urchin divers in Deer Island and in Campobello report that they are more frequently finding poor quality roe that is not marketable as it is discolored (grayish/whitish and not vibrant orange). They theorize that the quality of sea urchin roe is affected by proximity to aquaculture sites. Sometimes the roe looks "diseased", "cancerous", "mildewed", or "discolored". They reported that buyers do not want this roe. One diver recalled that this discoloration was first noticed in the Letete area, which used to produce up to 30 percent of urchin roe for the market. He theorized that disinfectants used in the 1990s to keep aquaculture gear and boats clean after an infectious salmon anemia (ISA) infection destroyed the roe industry in the Letete area[18].

A number of divers expressed concern that sea urchins will be vulnerable to sea lice chemicals – the future of the resource stock may be affected by sea lice chemical kills which divers report they have observed near aquaculture sites. One diver reported that sea urchin beds adjacent to aquaculture sites contained many dead urchins this fall. Fewer urchins have good roe production, even where urchin beds are highly populated.

One urchin diver reported that the feed used by aquaculture operators appears to affect sea urchin roe. Moist food, more commonly used in the past and still used for starter feed for young fish, appears to be better tolerated by sea urchins as divers find the resulting roe is healthier than is the case where dry feed is used.

Shrimp and Crab

Fishermen in Deer Island and Campobello reported observing a number of consequences from the operation of well boats[19] in the area over the summer of 2010. When the well boats were discussed as an alternative to chemical treatments in the cages, fishermen expected that the boats would use hydrogen peroxide. However, two other chemicals were approved just before the well boats were used, allowing aquaculture operators to change the expected protocol[20]. Fishermen noticed that when these

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[18] ISA is a viral disease of the Atlantic salmon. Outbreaks have affected salmon aquaculture operations all over the world. A recent outbreak was recorded in Chile in November of 2010. A serious outbreak devastated the Chilean industry in 2007 and 2008 (see Zarnikow 2010, http://en.mercopress.com/2010/11/11/isa-virus-outbreak-detected-on-salmon-farm-in-southern-chile last downloaded January 27, 2011).

[19] Chemicals for the control of sea lice can be applied to fish in the aquaculture cages if tarps are used to contain the chemical application for the duration of the treatment. With well boats, on the other hand, fish are pumped out of the cages and into the hold of a boat, where the chemical is then applied and the fish retained for the duration of the treatment. After the treatment, fish are then pumped back into the aquaculture cages and the wastewater from the treatment can be disposed of.

[20] The chemicals approved under "emergency registration" for use in well boats and in tarp treatments were Salmosan® and Alphamax® (see Raynor 2010b). It should be noted that other "therapeutic" treatments are common in aquaculture (see Black 2010: 103;

chemicals were disposed of at sea, large volumes of dead shrimp and crab were observed in the water around well boat locations. Dead crabs and lobsters have also washed up onto beaches subsequent to the well boat operations. The Campobello fishermen also reported seeing dead crabs, periwinkles and shrimp on the beach after sea lice treatments in adjacent aquaculture sites.

Other Concerns with Aquaculture

Fishermen uniformly expressed the view that aquaculture was here to stay, but that it needed to be better managed. The majority of fishermen reported that in their view, environmental consequences could be lessened or eliminated with better management.

Management of Open Cage Finfish Aquaculture Sites/Feed/Waste

Fishermen share the water with aquaculture operators and frequently observe practices that they believe harm the marine environment. They know that the federal Fisheries Act (R.S., 1985, c. 4-14, Sec. 35-43) prohibits putting any substance into marine waters that can adversely affect fish habitat, and have observed that aquaculture operators frequently put materials (feed, chemicals, and disinfectants) into the water without penalty. Fishermen regard this as poisoning the water. They have observed that disposal of aquaculture waste (discarded nets, garbage, plastics, rope, feed bags) is not done properly. They regularly reported hauling up gear that is fouled with nets, rope or other detritus from aquaculture operations. An observation of tidal patterns allows fishermen to recognize the source of such garbage. They also observe beaches and former aquaculture sites that are littered with the remains of aquaculture operations.

Fishermen uniformly reported that fish cages are “overstocked” to boost production – they theorize that this has led to high fish disease, pest infestation and fish mortality. They believe that aquaculture operators are caught in a “vicious cycle” of losing fish to sea lice infestation, overstocking to compensate, and then losing even more fish to sea lice and other effects of crowding. They theorize that this overstocking, along with poor feed management, is also fouling adjacent waters, as waste material flows away from the sites in “plumes”. Several fishermen also reported that they had observed aquaculture boats dumping ‘blood water’ from processing salmon into coastal waters. Others reported that they had hauled up dead salmon in their scallop gear, and theorized that this is because the disposal of dead or diseased salmon does not always follow regulations for secure land-based disposal[21]. Fishermen believe this may lead to more spread of disease as well as destruction of viable habitat for other species.

Fishermen from Deer Island also reported that dead or diseased fish do not appear to be transported through the closest harbour – for example, fishermen report that aquaculture operators in Passamaquoddy Bay do not appear to use St. Andrews Harbour. Deer Island fishermen have observed aquaculture waste being transported on their highways and through the local public ferry services, and they believe this is to avoid the tourists in St. Andrews.

Cubitt et al. 2010:132). For a critical comment on the terminology applied to such toxic chemicals, see Saner (2010:118).

[21] For an ethnographic description of salmon aquaculture and technologies of fish control see Law and Lien (n.d.) and Lien and Law (n.d.).

Spatial problems are also a concern. Fishermen uniformly reported that aquaculture operations frequently extend beyond their lease borders (taking up additional marine space) and cite examples of aquaculture operators running compensatory lines out hundreds of yards past their grid systems. Fishermen from Deer Island and Campobello also report that aquaculture has increased the number of marine hazards. They have heard reports of divers getting caught up in old aquaculture nets or ropes. Several fishermen reported having their gear snag on unmarked abandoned aquaculture sites with concrete anchorage still in place. Fishermen expressed concern that such hazards will result in deaths or injuries and that the current fines for such infractions are inadequate as deterrents. In addition, fishermen noted that abandoned aquaculture sites are sometimes retained under lease, as the lease fee is cheaper than the clean up costs would be. They point out that this practice keeps that area of bottom from recovering, and also prevents fishermen from making use of that area. This is particularly a concern for scallop draggers and for "shut off" herring fishermen who use natural coves to trap herring.

Fishermen uniformly blamed aquaculture management for these practices, some of which they class as "irritants" and some of which they feel are more serious. They reported that aquaculture management has changed since the beginning of the industry in SWNB, when small operators were more closely involved with their operations and with local businesses in coastal communities. Current operations are managed from large headquarters, and fishermen believe that there is less interaction with or oversight of local workers. There is also less economic gain for coastal communities, as larger operators do not utilize local suppliers. This has increased tension between the two industries. Fishermen from Deer Island in particular showed consensus that their communities have reached a "tipping point", such that aquaculture is no longer viewed as a sustainable contributor to the local economy.

Fishermen question why there is no independent company that monitors aquaculture operations in the way that the capture fishery is monitored. Without such independent monitoring, the expansion of sites and use of toxic chemicals is not stopped and overstocking of cages is not caught through recording of landings from specific sites.

Use of Chemicals

Fishermen on both Deer Island and Campobello report that they "share the water" and "share the wharfs" with aquaculture employees and in some cases their houses overlook aquaculture sites (see the cover photos on this report). Fishermen are able to observe the operations at aquaculture sites, including patterns of feed application, removal of dead fish and the application of chemicals. Fishermen expressed concern that the frequency of chemical treatments on individual aquaculture sites does not match those announced by the aquaculture industry. Fishermen theorized that the cycle of chemical use does not seem to be well documented or understood by the higher levels of aquaculture management.

Tests on dead lobster in the past have shown that lobster kills were the result of chemicals not approved for use in the marine environment. Fishermen believe that the current practice on some sites is to encourage production through bonus packages for site managers based on volume of delivery, and they question this approach. For example, they fear this may be encouraging site managers to use chemicals not approved for marine use to control problems such as sea lice

Focus groups in Deer Island and Campobello included fishermen whose lobster holding facilities are near aquaculture sites (see Map 7 for the high frequency of this situation). These men reported that lobster mortalities in such lobster pounds have increased dramatically after the use of chemicals for sea lice in the aquaculture sites in their area. Lobstermen call this percent of lobster loss in holding facilities “shrink”. They report that they must now factor in a higher percentage of “shrink” in their facilities, which they reported as less common in the past. One account illustrates the problem. In 2007, one lobster pound owner reported a four percent loss of stored lobster over three months. In contrast, the same operator lost all lobsters held in his pound in November of 2008, which amounted to over 2400 pounds of dead lobster. He reported that all lobster pounds in his area lost their entire holdings that November. In 2009, with the lower prices, he didn’t store lobster, arguing that he was “gun shy” after the 2008 loss. Lobsters from some pounds are reported to be showing symptoms that resemble Parkinson’s disease in humans. Other lobsters show signs of extreme lethargy. One man who owns a lobster pound reported that he has experienced tingling and numbness in his arms and hands after handling dead lobster. Lobster pound operators argue that chemical use in adjacent aquaculture sites is destroying their businesses. They feel that it is no longer safe to store lobster in those areas that are adjacent to aquaculture sites – and this has a direct affect on returns to investment in lobster marketing infrastructure.

Discussion

The environmental changes that result from aquaculture operations as reported by the inshore fishermen are consistent with recent findings in other locations in the Canadian Maritimes[22]. Changes documented here and elsewhere include broad ecosystem changes (Cabello 2006, Carroll et al 2003, Findlay et al. 1995, Haya et al. 2001, Heaslip 2008, Milewski 2001, Wu 1995), changes in the adjacent inshore fisheries (King and Pushchak 2008, Lane et al. 2009), and changes in adjacent coastal communities (Costa-Pierce 2008, Wiber and Turner 2010). Eutrophication of waters around aquaculture sites in SWNB has been recorded in the literature (Lotze and Milewksi 2004). Fishermen in SWNB are familiar with the effects of eutrophication in the marine environment as a result of the environmental history of Passamaquoddy Bay. Many fishermen involved in this study drew attention to the situation in Passamaquoddy Bay and expressed concern that other areas would also soon become “marine deserts” or “dead zones”. As one fisherman put it: “St Andrews Bay was a rich fishing ground in the 1950s. Now it’s all gone. Pulp and paper mills killed that bay. Now the aquaculture industry is doing the same thing on a larger scale.”

Other environmental changes as reported by fishermen have not been reported in the literature, including loss of specific species of seaweed and kelp, starfish blooms, the adverse effects on scallop and sea urchin shells, discoloration of meats and roe, lobster kills and kills of other marine species (crab and shrimp) that have been associated with use of various chemicals to kill sea lice on salmon. The literature has also generally been

[22] See references cited throughout the report. For an example from “citizen science”, see the Friends of Port Mouton Bay website (www.friendsofportmountonbay.ca).

silent on how these changes have affected the fishing patterns of the capture fishery as well as the economic health of coastal communities.

Fishermen in this study rejected the argument that aquaculture is good for the economy of coastal communities. They noted that when aquaculture was being developed in SWNB, most people in coastal communities were supportive as they saw it as a source of economic growth for coastal communities affected by the downturn in the commercial fisheries. And in the beginning, aquaculture operators bought supplies such as fuel and nets from local businesses and offered competitive wages. The community benefitted as banks and businesses did well and young people would remain in the community to work rather than moving way. However, fishermen believe that as aquaculture has become concentrated in fewer hands, fewer benefits have accrued to local coastal communities. For example, fishermen noted that fish processing plants are now employing foreign workers rather than local people while wages for those working on the cages have dropped to an average of twelve dollars per hour. As a result, there is less support for aquaculture and more willingness to speak up about the potential to harm other local economic generators such as the inshore fishery. Fishermen noted that an independent fisherman can make a much better income than can a wage employee of an aquaculture operation, and even seasonal crewmembers on fishing boats earn more than employees of aquaculture companies. Fishermen reported that they felt perplexed that the government would support one at the expense of the other.

As in other places in the Canadian Atlantic Provinces, the inshore fishery has been resilient despite dramatic downturns in key commercial stock (such as groundfish) and despite loss of access to historically important species such as cod, haddock and pollock. Given the importance of lobster as the primary commercial species for this sector of the commercial fishery, inshore fishermen are particularly concerned about potential harm to the lobster stocks. Other species they are concerned about include scallop and herring. The herring weir fishery has been the most severely impacted. Displacement from fishing grounds adjacent to coastal communities, increased costs for fuel, gear and monitoring, different patterns of fishing, and loss of vital "flexibility" in fishing locations have all contributed to difficulties in the inshore sector. A major concern for many fishermen we spoke to was the food chain and the consequences for all fisheries if loss of krill and other zooplankton affects the overall marine productivity of the Bay of Fundy.

Fishermen reported that they would like to see targeted research into the consequences of aquaculture on the productivity of the marine environment, on nursery or spawning grounds, and on the effects of the loss of key habitat for commercial stocks. Fishermen were frustrated that they were unable to get small amounts of funding to do a study of cumulative effects of aquaculture chemicals on lobster reproduction, growth and development. They contrast this with the significant amounts of public dollars that the aquaculture industry has received, including funding for research, for marketing, and for relief of economic downturns linked to disease. Fishermen felt that it was unfair that there is no similar government support for local businesses damaged by aquaculture chemical use, such as lobster pounds. Many fishermen reported feeling a distrust of the federal Fisheries and Oceans department, which they believe has a conflict of interest, in that it both supports research to expand aquaculture and also regulates impact of aquaculture on marine ecosystems. Some fishermen reported that they would like to see the aquaculture companies absorbing some of the costs of environmental monitoring the way that fishermen do with the recent introduction of the “black box” vessel monitoring system in the groundfish fishery[23]. They believe that aquaculture should pay for water quality testing, for example, and for cumulative impact studies on sediment under the sites and on marine species. Most fishermen said that they would like to see a self-sufficient aquaculture industry (rather than one supported by public dollars).

Fishermen uniformly reported that they had tried to work with the aquaculture industry and had relied on the traditional fisheries and aquaculture working group to develop solutions to their mutual problems. For example, fishermen developed, built and tested propeller cages for aquaculture boats to reduce lobster gear entanglement. They were pleased when the aquaculture companies adopted these propeller cages. However, recent events have discouraged this cooperation. For example, many fishermen reported that they had signed a petition in support of well boat treatments for sea lice and that they had supported government subsidies to bring the well boats into New Brunswick. Their endorsement for well boats was obtained after receiving information that hydrogen peroxide would be used in these well boats, as hydrogen peroxide was reportedly a more benign chemical for sea lice treatment as it breaks down into hydrogen and water (see French 2010b). But fishermen later discovered that the aquaculture industry had not been forthcoming with them, as aquaculture operators had submitted an application to use more toxic chemicals in the well boats without discussing this with fishermen in the working group. Fishermen report that this undercut their trust in the working group and as a result, the Fundy North Fishermen’s Association has withdrawn from the traditional fisheries and aquaculture working group, as have other fishermen’s associations from Southwest New Brunswick.

What is clear from this LEK study is that additional scientific research is needed into the effects of aquaculture operations on the marine environment and on the commercial species on which the inshore fishery relies. Further, this study suggests that independent socio-economic analysis of the aquaculture industry should be undertaken to assess the real contribution of aquaculture to coastal communities, as well as the impact of aquaculture operations on those communities. Fishermen accept that aquaculture is here to stay, but the consistent message we received from all involved in this study is that aquaculture should be conducted in a sustainable way, and not at the cost of other viable coastal fisheries.

Recommendations and Follow Up

Research Needs

The significant role that the inshore fishery contributes to the regional economy, by exporting herring, lobster, scallops and other seafood products to markets in the U.S. and abroad, should be protected as aquaculture expands in the region. A recent review of the literature has concluded that a great deal of research is needed to better understand the environmental impacts of finfish aquaculture and its interaction with other commercial

[23] Vessel monitoring systems (VMS) are becoming more widely utilized in commercial fisheries as a mechanism of surveillance. They monitor the position, time of position and course and speed of vessels on a regular basis so that regulators can track spatial and temporal aspects of fishing effort.

species (Milewski 2001, Maurstad et al. 2007, Lane et al. 2010). Little is known about how the effects of aquaculture are mitigated by currents, seawater temperature, season and storm events (Findlay et al. 1995). Given the lack of information, future science should be targeted to address specific concerns.

This study suggests that future research on the environmental impact of aquaculture could benefit from input from fishermen. Evidence from local knowledge suggests, for example, that in SWNB the impact of aquaculture must be measured with a cognizance of long-term impacts; comparison of long-term sites with more recent sites is indicated, as well as a study of remediation times given the new system of bay management areas. Also, this study indicates that more work needs to be done on the potential cumulative impacts of repeated use of a variety of pesticides. Lobsters, crab, shrimp, zooplankton and other organisms are likely to receive numerous exposures to sea lice pesticides over the course of their lifespan. We know very little about how this may be impacting individual organisms, populations, or ecosystems. Fishermen are concerned with sub-lethal effects of these pesticides on commercial species, especially lobster. Both laboratory and field studies of repeat exposure to a suite of pesticides should include both adult and larval lobsters as well as other sentinel species. Studies could also target the changes in habitat for berried female lobsters, for lobster mortality, reproductive success and changes in growth rate and development (following on Haya et al 2001). Similar research should target the patterns of change in scallop and sea urchin shells, meat and sea urchin roe. Efforts to control sea lice that have been linked to lobster, crab and shrimp kills should be thoroughly investigated. Dye dispersion appears to be a very useful tool in ascertaining where the pesticide plume goes and could ensure the organisms are placed within the zone of exposure (see Ernst et al. 2001). Fishermen expressed concern not only about pesticide bath treatments but also about consumption of infeed pesticides. The frequency of treatments over the past several years is of grave concern and fishermen would like to see studies that mimic real life situations. Longitudinal studies should be balanced with quick studies that can indicate where there may be commercial stock health problems. With pesticide treatments ongoing, the situation is urgent.

Also, fishermen are very concerned about the evidence that herring are not feeding in the bay. Frequent reports of herring being harvested from weirs with empty stomachs have been recorded for the past two years; herring are rarely found with bellies full of krill as fishermen are used to seeing. Fish that enter the bay are not growing during the summer. Given their observations, fishermen theorized that sea lice pesticides may be killing herring feed. Therefore they would like to see the shrimp/krill species that herring feed on be included in the laboratory studies of pesticide effects including effects of exposure to multiple chemicals with repeated usage. Aquaculture sites have proven particularly incompatible with herring weirs and the reasons for this should be researched and more appropriate ground rules for sharing the waters be worked out.

Monitoring and research for “best practices” in the aquaculture industry should include management for ecosystem sustainability. Fishermen believe that overstocking of salmon cages and poor husbandry by the aquaculturalists has resulted in wide spread sea lice and disease outbreaks, although some acknowledge that warmer summertime water temperatures may also be a factor. Approval of “emergency chemicals”, based on an industry in crisis, cannot be ongoing. The industry must be monitored (by a responsible third party) and both federal and provincial laws enforced. Use of sea lice chemicals should be rigorously controlled within three kilometers of lobster pounds (see Map 7) and the aquaculture industry should be held responsible for lobster losses in such pounds when aquaculture chemicals are found to be the cause. Fishermen feel that aquaculturalists should be held accountable for their actions in the same way that fishermen are held accountable by mandatory third party dockside monitoring and as well as vessel monitoring systems aboard their vessels. The fines imposed in the case of an aquaculture act violation is comparable to that of a traffic violation; fishermen are concerned that these fines do not reflect the real environmental consequences of mismanagement. For example, fishermen feel that having unmarked abandoned aquaculture debris or moorings on the ocean floor represents an extreme safety hazard that is not tracked or properly reported on charts.

In sum, this study suggests that more scientific study should be undertaken into the significant environmental changes around aquaculture sites (Wu 1995, Black 2010, Cubitt et al. 2010). More comprehensive and detailed studies are required to establish the environmental and economic costs of aquaculture, especially the affects on the adjacent industries that make a significant contribution to local economies.

Integrated Management Institutions

Fishermen's organizations had hoped that the working group formed to address conflicts between the traditional fisheries and the aquaculture industry would be an effective integrated management forum. But this group has recently foundered through distrust and lack of sound scientific information. The Southwest New Brunswick Marine Resources Planning Committee, which has done a great deal of research, filed a report to the provincial government making recommendations for management of the coasts and oceans of SWNB. But this committee also seems to have little momentum for future deliberations and their recommendations have not been followed to date. Government support for such grassroots integrated management institutions is vital. It is hoped that various provincial and federal regulatory bodies could work more closely together to effectively resolve environmental issues such as the recent lobster poisonings through such integrated management institutions.

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