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Knowing in context: An exploration of the interface of marine harvesters' local ecological knowledge with ecosystem approaches to management

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ABSTRACT

Marine resource crises have initiated a search for alternative approaches to resource assessment and management that has culminated in a global focus on ecosystem approaches to management (EAM). Here, the ecosystem extends to humans as drivers and recipients of ecosystem change. More specifically, attention is being paid to identifying specific qualities of local resource users' experiences and knowledge that might productively inform resource management, while also providing local users with substantial "voice" in shaping new management policies and practices. Here an evaluation is provided of the extent to which local ecological knowledge (LEK) can provide advice for an ecosystem approach to inshore coastal management, specifically, the identification of ecologically and biologically significant areas, based on the results of two comprehensive studies of coastal Nova Scotian commercial harvesters' local ecological knowledge. While spatially explicit, local ecological knowledge displays strengths and limitations that must be explicated for it to prove useful for strengthening "voice" and providing EAM inputs.

1. Introduction

Marine resource crises have initiated a search for alternative approaches to resource assessment and management that has culminated in a global focus on ecosystem approaches to management (EAM) [1,2]. In an EAM, the concept of ecosystem is explicitly extended to embrace humans, as drivers and recipients of ecosystem change [3,4], and as holders of experiential knowledge. With respect to this, attention is being paid to local resource users' experiences and knowledge that might productively inform resource assessment and management, while also providing local users with substantial "voice" in shaping new management policies and practices [5,6]. In particular, marine harvesters' knowledge of key local ecosystem attributes is presumed important for identifying and supporting integrated resource management plans. These include new ecosystem-referenced management initiatives such as the definition of ecologically and biologically significant areas and implementation of marine protected areas (MPAs). Exploring attributes of this is a central focus of this paper.

The Canadian federal government, through Fisheries and Oceans Canada (DFO), leads the Canadian initiatives in the development and implementation of ecosystem approaches to oceans and coastal management. The collapse of many key groundfish resources on Canada's east coast in the late 1980s–early 1990s motivated the federal government to examine alternatives to obviously failed resource management policies. At more or less the same time and in response to similar situations, world governance institutions such as the United Nations launched consultative initiatives that resulted in outcomes such as the 1987 "Brundtland Commission", *Our Common Future*, and the 1992 United Nations Conference on Environment and Development. The latter produced a document titled "Agenda 21" in which commitment to sustainable development engaging protection of ecosystems was placed front and centre [7]. Canada was one of the many global signatories to this undertaking, developing and adopting in 1997 "the Oceans Act" as the major legislative initiative intended to frame future national approaches to ocean and coastal policy and management [8]. This Act provides the legislative framework for an integrated ecosystem-approach to Canadian oceans management.

The Oceans Act has enabled several Canadian initiatives intended to guide the development of specific ways to achieve ecosystem management. At the national level in 2005, DFO launched its "Oceans Action Plan" [9]. Central to this plan was the expressed commitment to achieve sustainable, ecosystem approaches to management through engaging key-stakeholders in an integrated and collaborative process ranging from harvesters and their communities, through communities of interest such as non-governmental organisations and industry groups, to all

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levels of government. In the Maritimes, the Eastern Scotian Shelf Integrated Management (ESSIM) collaboration [10], for example, attempted to build the type of broad-based collaborations requisite for effective integrated management, including EAM.[2] More recently, the federal government signed a memorandum of understanding with the Nova Scotia provincial government in which each commits to collaboration on "…facilitating integrated approaches to coastal and oceans management" [12]. Identifying and developing the ways and means to access and engage marine harvesters' experienced-based knowledge of coastal and oceans eco-systems is expressed commonly as a key attribute within these and many other integrated management initiatives.[3]

A more global ecosystem-based initiative is the definition of EBSAs, which are, among other things, precursors for marine protected areas (MPAs). The Convention for Biological Diversity, an international treaty, to which Canada is a signatory and conceived as a tool to translate the principles of Agenda 21 into reality (The Convention on Biological Diversity—http://www.cbd.int/convention/) adopted a set of seven scientific criteria to identify ecologically or biologically significant areas in need of protection in the open oceans and deep seas in 2008 (CBD Decision IX/20, Annex 1). Although Canada has endorsed the CBD criteria, prior to their development, Canada had defined its own EBSA criteria, which are comparable to those of the CBD [13].

Canada's Oceans Act authorises DFO to provide enhanced protection to areas of the oceans and coasts that are considered to be ecologically or biologically significant. Here, definition of an area as "significant" indicates that if the area was disturbed or disrupted, the ecological consequences would be greater than an equal disturbance of most other areas [14]. Significance has several dimensions and can refer to the role of habitat (benthic or pelagic), a community attribute or the role of a species in the ecosystem. An internal DFO Science meeting developed a framework in 2004 for the definition of EBSAs [14]. The framework outlines the entire process for establishing EBSAs, from their definition to their operationalisation in a management context, and is described as a "continuum of activities". All steps in this continuum are "science-based", but the role of science changes along the continuum. Here "science-based" is defined as "work[ing] from scientifically sound information", which is inclusive of experiential knowledge, defined as "a term including "Aboriginal traditional knowledge", "fishermen's knowledge", and other ways that ecological knowledge is acquired through extensive experience with the marine environment" [14,3]. Three steps are outlined, the first of which is a "Science-led process, wherein the area(s) of interest are evaluated within the framework that has been developed. "Experiential knowledge" should be fully included in these steps. These steps should lead to some structured output, such as a quantitative or qualitative ranking of different areas relative to their Biological and Ecological Significance" [14,3]. The second and the third steps relate to the degree of management aspects of EBSAs. The second is described as "…an even more inclusive Oceans-led process that considers how to match degree of management protection to sites along the ranking of areas on their Biological and Ecological Significance." [14,3]. The third step is the implementation of management regulations where it must be clearly specified "…what management measures will be used at the various sites, and under what conditions" [14,3].

Focussing on the first step, the DFO framework specifies five science-based ecological criteria for the identification of EBSAs: uniqueness, aggregation, fitness consequences, resilience, and naturalness [14]. The first three criteria are considered the main dimensions for defining EBSAs while resilience and naturalness are secondary. Each of these is a continuum and can refer to a mix of attributes such as species, communities, or an area's physical features. Uniqueness refers to areas whose characteristics are "unique, rare, distinct, and for which alternatives do not exist" [14,4]. In practice this is a relative measure and scale dependent. At the coastal level, what is unique or rare in one bay may be common to all bays. Aggregation refers to areas where species collect for part of the year for a specific life-history function (e.g. spawning) or where some specific and key ecological process takes places (e.g., convergence zones leading to aggregation of prey and nutrients). Fitness consequences refer to features that are important to the survival of one or more species. For example, an area which is the only feeding area for a species has important fitness consequences for that species. In practice, potential EBSAs are scored on all 3 criteria, then ranked, based on a prioritisation process [15].

In this paper we explore the specific directive to include "experiential knowledge" in the definition of EBSAs. Specifically, we examine how harvesters' local ecological knowledge (LEK) can contribute to the process of characterising EBSAs by focussing on the uniqueness, aggregation, and fitness consequences criteria. We present an initial description and analysis of the results of two comparable, comprehensive studies of coastal Nova Scotian commercial harvesters' local ecological knowledge, one of which was designed to collect LEK to support the identification of EBSAs.

The paper begins with a discussion of what we mean by LEK and consideration of some of the conceptual challenges associated with characterising and researching LEK. This is followed by a review of the research design and methods we have employed to document marine harvester LEK. Initial outcomes from this research are then presented and discussed. We conclude by profiling the strengths and limitations of harvester LEK with respect to developing EAM initiatives, with particular emphasis given the criteria designated as key to determining biological and ecological significance.

2. What do we mean by local ecological knowledge?

In the tradition of Odum, ecology is defined as "…the study of the structure and function of nature" [16,1], meaning that ecology encompasses intra- and inter-species interactions and species interactions with their environment. It is the science of ecosystems. Odum further characterises ecosystems as the inter-relation of an entire biological community and its non-living environment [16,4]. A scientific approach seeks to understand these relationships through repeated observations, development and testing of hypotheses and quantification of these relationships. Science-based understandings are derived from replicable, evidence tested ideas, i.e., the subjection of hypotheses to the burden of proof defines science-based epistemology.

[2] For instance, recently the ESSIM initiative issued four theme papers for the State of the Scotian Shelf Report: At Risk Species; Marine Habitats and Communities; Trophic Structure; and Ocean Noise. Also, the Technical Report of Fisheries and Aquatic Sciences #2880, *Ecological and Human Use Information for Twenty Areas on the Atlantic Coast of Nova Scotia in Support of Conservation Planning*, is now available [11], the latter is intended to provide baseline information for coastal management initiatives on the Atlantic coast of Nova Scotia, with particular relevance to DFO's Integrated Management and Marine Protected Area and Conservation Planning Programs.

[3] "Integrated management includes explicit commitments to incorporate ecosystem considerations with the understanding that: ecosystem-based management is an integrated or holistic approach to making decisions about ocean-based development and conservation activities. It means considering the environmental impact of an activity on the whole ecosystem, not simply the specific resource targeted. It also means taking into account the cumulative impact of all human activities on the ecosystem within that area" (http://www.dfo-mpo.gc.ca/oceans/management-gestion/integratedmanagement-gestionintegree/index-eng.htm).

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At a descriptive level, local ecological knowledge is taken to include at least three key attributes: a people's (1) shared system of knowledge and/or other expression about the environment and ecosystem relationships that (2) is developed through direct experience within a specific physical setting and (3) is transmitted inter-generationally (for a review of ideas see [5]). As a system of knowledge, LEK must be demonstrably shared among a community or group of marine harvesters. Individual knowledge claims, regardless of their attributes, by themselves in our view do not constitute LEK unless shown to be incorporated within a broader and shared system of understanding among marine harvesters.

Social research and resource management interest in the attributes and potentials of LEK are directly associated with the recent impetus to develop more ecologically sensitive and sustainable approaches, while also providing a means for enabling local "voice" in the shaping and implementation of management policies. The linkage of these social research and management foci with those of scientifically framed ecosystem studies has resulted in the development of interdisciplinary collaborations, with associated dilemmas and challenges [17]. This research employs the core tenets and methodological practices of science for the explicit purpose of documenting and examining local or customary ecological knowledge claims (e.g., [18,19]). In the tradition of science, science-based resource management practices should expect that knowledge claims, before being integrated into understandings and, especially, public policies, will have welcomed and been subject to tests and proofs that are evidence-referenced, reliable, and replicable.

For some social scientists this "science" expectation and practice simply continues and deepens the hegemony of Eurocentric epistemology and its related social and political–economic interests (e.g., [20]). The act of proposing to "test" scientifically specific local/customary ecological knowledge claims is interpreted by some as disrespectful, and in the end, pointless. It is disrespectful because tests are interpreted as expressions of scepticism, perhaps even disbelief, respecting knowledge claims made by richly experienced, wise, and well-respected community members and elders (e.g., [21]). Many holding this view also argue that the reductionist and positivist attributes of western science assure that any tests of knowledge claims will be pointless. Local/customary knowledge systems, from this perspective, embody non-scientific epistemologies that integrate and articulate qualities such as cultural practices, special relationships with nature, and spiritual attributes. Consequently, western science is simply not able to design appropriate and useful tests for knowledge claims embedded in and expressive of non-science epistemologies. As a result of western science's incapacity to design and conduct the requisite studies, attempts to test local/customary knowledge are anticipated predictably to disprove knowledge claims, to discredit local/customary knowledge, and to further disempower local communities and indigenous people (e.g. [22,23]).

This argument logically leads to the conclusion that customary local knowledge claims are, *ipso facto*, legitimate and true. However, sceptical enquiry is not inherently disrespectful, particularly when it begins by welcoming and treating people's knowledge claims sincerely and seriously. In fact, sceptical enquiry expressed through well-designed, systematic, evidence-referenced research and, most importantly, an inclusive research process are the only means through which customary/local knowledge claims may come to lever change, to reconstruct local engagement with natural resource management, and to empower local community and indigenous people's voice (cf. [5,6]).

Characterising local experiences and understandings as a discernible system of local/customary ecological knowledge is a relatively recent development. Indeed, few, if any, local user groups and indigenous people originally would have described their understandings and experiences as embodying a discrete system of local/customary ecological knowledge (e.g. [24]). Members of the social research and NGO communities are largely responsible for initially characterising experienced-based, local, understandings as constituting 'systems' of ecological knowledge. Failure to include and understand LEK risks missing an important opportunity to build more holistic and reliably documented understandings of people's local ecosystem experiences and sensibilities, understandings that may provide, in addition to further evidence of the richness and creativity that is the human condition, substantial, evidence-referenced, "voice" as well as meaningful inputs for the management of local resource usage (cf. [25]).

3. Research design and methods

The data treated here were gathered through two multi-phase LEK studies focused on documenting LEK among small boat marine harvesters in Atlantic Nova Scotia. The initial research was focused on Chedebucto Bay (Figs. 1–3) as part of the Social Research for Sustainable Fisheries project in collaboration with the Guysborough County Inshore Fishermen's Association [26]. Its objectives were to document thoroughly characteristics of family and fishing histories, fishing practices and local knowledge about the fishing grounds. The second was a collaborative study by DFO and the Fishermen and Scientists Research Society [27] the objectives of which were to map fishermen's knowledge of the distribution, seasonal changes in abundance, and life history and habitat associations of fish, invertebrates, birds, mammals and macrophytes, as well as to identify areas considered to be ecologically and biologically significant. It focused on nine sites along Nova Scotia's Atlantic coast, from Cape Sable to Cape North (Map 1).

Both studies used a rigorous two phase approach [28] where peer identified experts were identified through a telephone survey of licence holders in the area in the first phase. The peer nominated LEK experts were then interviewed. Peer recommended experts are persons considered to be particularly reputed as knowledgeable about the local fishing grounds. Their names were solicited by asking the question, "Other than yourself, who would you say knows the most about the local fishing ground?" The names of as many as five persons were gathered in this manner. Participants were also asked to specify whether the persons identified were either currently fishing or retired. The majority of those interviewed specified no more than three persons, with many noting only one or two.[4]

A rank ordered list of local knowledge experts for each study site was constructed from the recommendations. The rank order embodies both the total number of mentions a person received as well as the sequence of the mentions, i.e., 1st mentioned, 2nd mentioned and so on, assuming that each participant's sequence of mentions reflects an implicit ranking with the 1st person named being considered by the interviewee as most knowledgeable, the 2nd named as next most knowledgeable and so on.

[4] In the Chedebucto study all 211 current lobster licence holders were surveyed by telephone during May–June 2001 within a region extending from St. Peter's, Richmond County, through to Marie Joseph in Halifax County, achieving a participation rate of 75.4% [28]. The DFO study surveyed a sub-sample of licence holders in each of the nine sites amounting to over 300 interviews. A random sample, equivalent to 20 per cent of the licence holders fishing inshore species (e.g., lobster, herring, mackerel, clam, marine plants) was drawn from the total number of licence holders. The random sample was checked to ensure that it was broadly representative of the different fisheries in the area.

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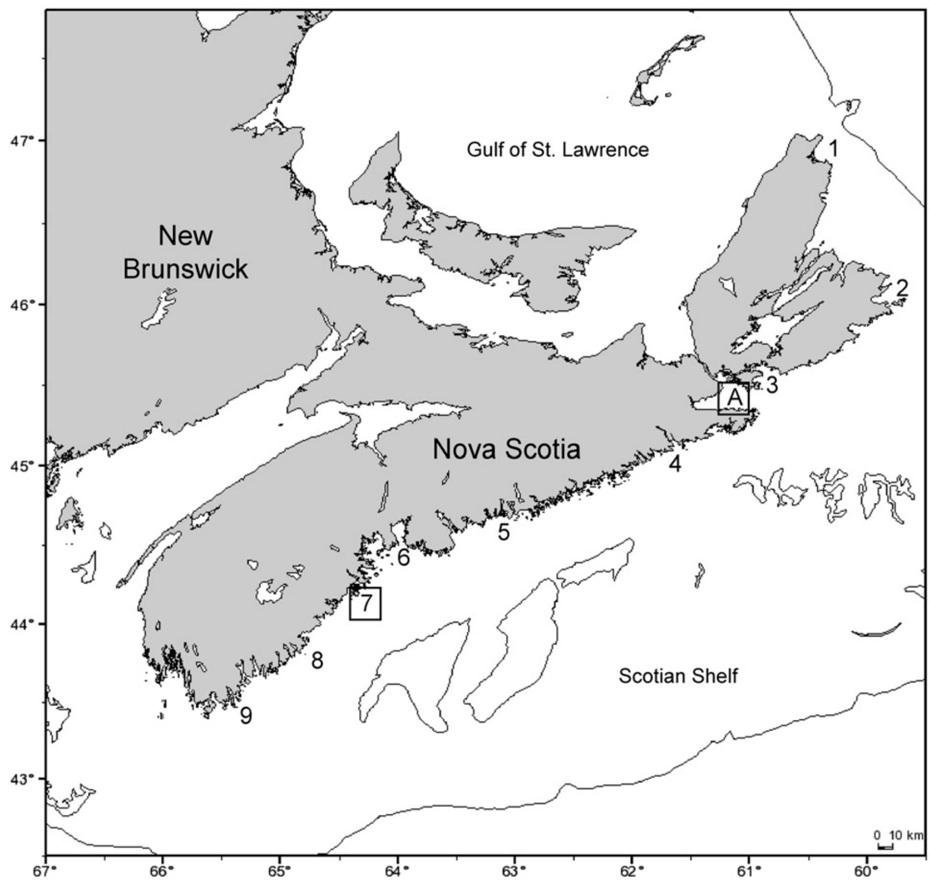

Fig. 1. Map of Nova Scotia showing the study sites of (A) the Chedebucto study and the nine study sites of the DFO-FSRS LEK study: (1) Cape North, (2) Mira Bay/Gabarus Bay, (3) St. Peters Bay, (4) Country Island, (5) Ship Harbour/Chezzetcook Bay, (6) St. Margarets Bay, (7) LaHave, (8) Port Mouton, (9) Port La Tour. Black boxes indicate the two study sites presented here.

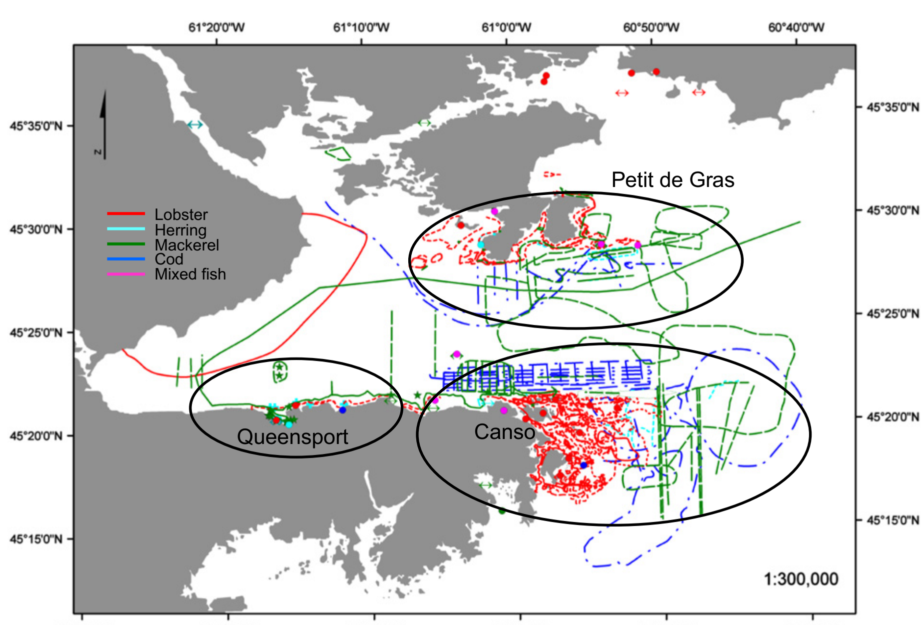

Fig. 2. Map showing Chedebucto Bay, on the eastern shore of Nova Scotia and the areas identified by experts that are important to cod (blue line), herring (turquoise line, turquoise cross), mackerel (green line, green star), lobster (red line), spawning (circles), and migration (arrows). The ovals demark a concentration of observations, indicating a possible ecological and biological sensitive area.

These persons were approached for inclusion in the second phase of the study. In this phase in-depth, face-to-face interviews were completed for the purpose of documenting local ecological knowledge. These interviews were tape-recorded and employed marine charts on which the experts were asked to locate their responses to a wide variety of questions concerning the

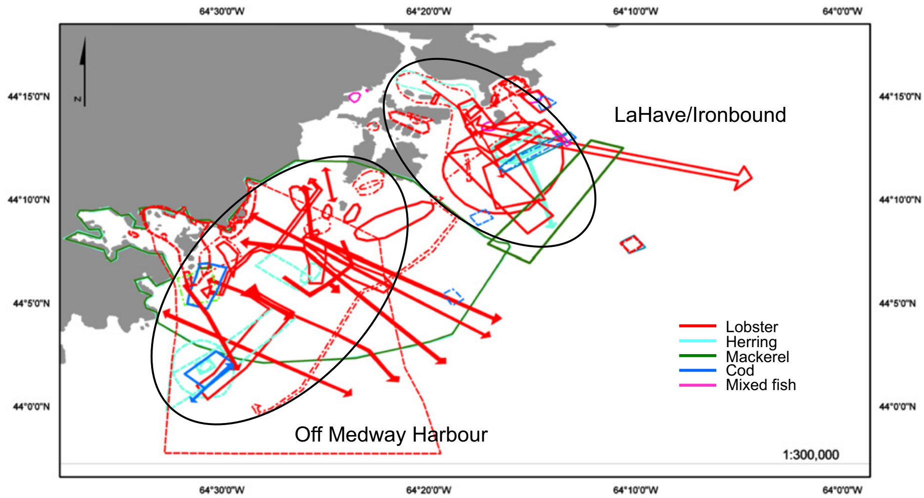

Fig. 3. Map showing LaHave on the southern shore of Nova Scotia and the areas identified by experts that are important to cod (blue), herring (turquoise), mackerel (dark green), lobster (red) and mix of species (pink). Solid lines indicate high abundance, dashed lines spawning areas, dot-dash lines nursery areas and arrows migration. The ovals demark a concentration of observations, indicating a possible ecological and biological sensitive area.

distribution and behaviour of key species. The Chedebucto study focussed on four major marine species—lobster, cod, herring and mackerel, whereas the DFO-FSRS study asked the experts to identify the species with which they were most familiar.[5] In order to characterise observations as local knowledge at least two independent observations for each knowledge claim within each time period had to be recorded since, for this study, LEK constitutes a demonstrably shared system of understandings and perceptions.

In the Chedebucto study, interviews were conducted until information saturation on key questions became evident, e.g., repeated observations on characteristics of local fishing grounds and species behaviour. This practice confirms that a comprehensive and representative body of information has been collected. The DFO-FSRS study used a more structured survey questionnaire, with the option of completing key questions for more than one species.[6] Interviews were completed by Fall 2003 in the Chedebucto study with eleven peer-nominated local knowledge experts, and by 2008 in the DFO-FSRS study with 53 peer-nominated local knowledge experts, producing thousands of pages of transcribed and charted information.

For the purposes of this initial comparative study, we have selected one site, LaHave (Fig. 1) from the DFO-FSRS study for comparisons with the Chedebucto Bay outcomes. LaHave was selected largely because a sufficient number of clustered expert interviews were completed to satisfy the requirements for repeat observations and information saturation. As well, the cluster and number of interviews completed allows for a more comprehensive comparison with the Chedebucto Bay results. The Chedebucto Bay study only asked specifically about lobster, herring, mackerel, and cod so the results below focus on these 4 species for both study sites.

[5] In the Chedebucto study, participants were asked the same questions for at least three life history in fishing periods for each species—post-1991 (current), late 1970s–1991, and mid-1970s and earlier (past). In the DFO study, participants were asked the same questions for two time periods prior to 1991 and post-1991. Time periods roughly correspond to events that have impacted on the fisheries and fisheries livelihoods, particularly the imposition of the groundfish moratorium.

[6] To view the survey and interview instruments as well as to obtain more information on research design and methods visit: http://faculty.msvu.ca/srsf and http://www.fsrs.ns.ca/projects/inshore_research.html.

Table 1
Key social and marine harvesting attributes. Atlantic Coast areas.

Background attributes	Cape Breton–Eastern shore (2006) (*N*=153) (%)		South shore (2006) (*N*=160) (%)		Chedabucto Bay (2001) (*N*=158) (%)	
Fulltime	82.4		81.9		90.6	
Licences						
Lobster	69.3		73.1		93.1	
Herring	65.4		64.4		78.6	
Mackerel	72.5		67.5		91.2	
Groundfish	61.4		61.3		68.6	
	Mean	Std. D	Mean	Std. D	Mean	Std. D
Age	43	11.8	44	10.9	50	12.2
Years fishing	26.6	11.9	27.8	12.9	27.2	13.4
Weeks fishing (Previous year)	16.9	10.2	22.9	11.5	19.4	11.0

4. Results

4.1. An overview of key social background and fishing attributes

Before contrasting and examining the coastal marine harvesters' LEK across the study areas it is important to first establish that they are sufficiently similar in key background and fishing characteristics to allow inclusion and comparisons (Table 1). These data establish that in the main the marine harvesters from the two areas are similar in the years that they have fished, the weeks that they fished in the year prior to the survey, and that the great majority of those interviewed are fulltime harvesters. Additionally, similar percentages of participants reported possessing the fishing licences, and by association, participation in the fisheries examined herein. While the Chedabucto Bay harvesters are, on average, slightly older than the other harvesters, there is a slightly wider age distribution evident among them, lending confidence to the similarity among the groups. The higher proportions of Chedabucto Bay harvesters with lobster and mackerel licences simply reflect the particular seasonal importance of mackerel in the Bay, and the intentional focus of the Chedabucto Bay study on harvesters possessing a lobster fishery licence.

Table 2
Likelihood of re-entering fishing if they had their life to live over by Atlantic Coast areas.

Response category	Cape Breton—Eastern shore (2006) (N=153) (%)	South shore (2006) (N=160) (%)	Chedabucto Bay (2001) (N=158) (%)	Atlantic Coast Captains[a] (1990) (N=126) (%)
Definitely	49.7	39.4	46.8	58.4
Probably	34.1	24.4	34.8	31.2
Probably not	11.1	20.0	10.1	7.2
Definitely not	5.2	16.3	8.2	3.2

[a] This research was conducted by Anthony Davis and Victor Theissen in the late 1980s and early 1990s (cf. [36] for a description of the research design).

The strength of similarities evident across these general and key social and fishing attributes establishes the basis for comparing and aggregating harvester LEK for particular fisheries as well as for general characteristics.

It is also important to situate LEK within its social context. Most present day Nova Scotian coastal marine harvesters are the latest descendants of a family line with a history of fisheries participation that commonly stretches over nine to ten generations, or 270–300 years (e.g. [29,30]). The consequent attachment to and embeddedness of Nova Scotia's coastal marine harvesters with respect to their fishing livelihoods and communities has been well documented (e.g. [31–33]).[7] Data generated through the Phase I surveys further affirms these qualities. When asked if they would choose to go fishing for their living if they had their lives to live over, 66–80% of respondents indicated that they definitely or probably would choose fishing (cf. Table 2).

When contrasted with the responses of fishing captains to the same question asked over a decade earlier, it is evident that high levels of livelihood attachment and satisfaction persist among Nova Scotia's coastal marine fishing captains, even though the intervening years have been characterised by resource depletions, fishing moratoria, increased costs, and more restricted and regulated access to participation in every commercial fishery.[8]

4.2. LEK and its relatedness to the main EBSA criteria

The aggregated information respecting four key marine species provided by peer-recommended LEK experts in the Chedebucto and LaHave areas is presented in Maps 2 (Chedebucto Bay) and 3 (LaHave Area). While this mapped information demonstrates observations and knowledge that are distributed throughout the areas represented, our descriptions and analyses focus especially on the locations where the most concentrated observations are evident, that is, areas that might be considered to be ecologically and biologically significant. These areas are loosely designated by the ovals presented in the maps. In Chedebucto Bay three areas were defined, corresponding to the fishing communities of Petit de Gras, Queensport and Canso while in the LaHave, two areas were defined corresponding with LaHave/Ironbound and off Medway Harbour. The density evident in the distribution of observations is simply the result of the fact that two or more experts from these locations provided information about one or more species. As required, at least two and sometimes more independent LEK observations were provided for the information displayed. Consequently, we are confident that the information portrayed comprehensively captures and represents marine harvester LEK within these settings.

Beginning with a number of general observations, it is apparent from the mapped information that harvesters fish for lobster, herring, mackerel or cod throughout most of the coastal areas represented. Numerous observations in both case studies are recorded respecting the seasonal movements and availability of various species. Additionally, in both settings the observations recorded demonstrate extensive experience and knowledge of a variety of commercially valuable and targeted species, particularly lobster, herring, mackerel, and cod. Furthermore, experience with and knowledge of each of these species often overlaps and clusters within particular stretches of the respective coastal areas represented. That is, in both case study areas lobster, herring, mackerel and cod are often harvested in similar locations, although usually at different times of the year. These attributes capture two qualities of coastal fisheries. On one hand, marine harvesters fish "grounds" that are specifically associated with each particular community and that are largely distinct from "the grounds" fished by those working out of neighbouring communities. On the other hand, due to specific environmental and ecological conditions targeted resources are distributed unevenly within each fishing ground, both spatially and temporally. Consequently, this knowledge, acquired through generations of experience, assures that harvesting will be concentrated in the locations most conducive to successful fishing. Little if any meaningful differences between the case study sites are evident with respect to these general attributes.

The information from the LEK observations in the areas outlined on the two maps was explored with respect to the three key EBSA criteria of uniqueness, aggregation, and fitness consequences (Table 3) focusing on the LEK provided in association with the four key species. In the Ironbound area of the LaHave site, three experts provided LEK information, identifying areas of aggregation for cod, mackerel, herring and lobster. Several reasons were given why these species aggregated here, including for spawning, feeding, nursery and migratory purposes. Most of the observations concerned lobster, but several respondents noted that the Ironbound Bank was a place where many species aggregated: "Lobster, all type of groundfish, herring, mackerel, tuna …. [are] here". The second site, Off Medway Harbour, appears to be an important spawning area for herring, noted by three respondents. There were also many observations of lobster high abundance, for migratory and nursery purposes. Dense nursery aggregation areas were also noted for cod and mackerel.

Similarly, areas of high aggregation throughout Chedebucto Bay were noted for the four species. As identified and described by the LEK experts these aggregations were usually associated with spawning and migration, as well as with the ocean floor's physical and biological features. Most described in some detail the seasonal distributions and aggregations of lobster, herring, mackerel and cod, offering observations such as "The Rabies were always a better place for spawning lobster" [off Canso]; "Wherever there was a patch of sand, I think, it had [herring] spawn into it" [Queensport]; "The lobsters have to migrate from out…out in the more open water here, which is off of L'Ardoise…into this area. The migration is from outside into the bays and harbours and all…that seems to be the general migration pattern of lobster" [Petit-de-Gras]; "[Mackerel] spawn, I would say, it's in June, the first two weeks of June" [Petit-de-Gras]; and,

[7] For over several decades questions with almost identical wordings have been used to measure key attributes of marine harvester livelihood attachment. For instance, a series of surveys beginning in the 1970s have asked harvesters "…if you had your life to live over, how likely do you think it is that you would go into fishing again?" Choosing fishing is interpreted to reflect high levels of satisfaction with and attachment to the livelihood.

[8] The decline in satisfaction and attachment evident between the 1990 and more recent studies no doubt is attributable to the struggles many have endured while working to sustain their livelihoods in the face of these difficult, challenging and discouraging conditions.

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Table 3

Site	Uniqueness	Aggregation		Life History Consequences
		Species	Reason	
(a) LaHave				
Ironbound	"Ironbound bank is a pretty unique one for the inshore"	Lobster, Cod, Herring, Mackerel	Spawning, feeding. nursery, migration, spawning, nursery, spawning, nursery, migration, spawning, nursery	
Off Medway	"Parts of all this area are unique"	Lobster, Herring, Cod, Mackerel	Spawning? Nursery, migration, spawning, nursery, nursery, nursery	
(b) Chedebucto				
Queensport		Herring, Mackerel, Lobster, Lobster, Cod	Spawning, migration, spawning, migration, spawning	
Petit de Gras		Lobster, Cod, Mackerel, Herring	Spawning, migration, spawning, spawning, migration, spawning, migration	
Canso		Mackerel, Lobster, Cod, Herring	Spawning, migration, spawning, migration, spawning, migration, spawning, migration	

"You know, the only thing about the fish [cod] we got down there in the Spring of the year, they were spawn fish" [Canso]. Irrespective of the location, Chedebucto Bay LEK experts expressed remarkably similar observations and details.

These results were compiled into a matrix format noting the presence or absence of observations in support of the three EBSA criteria (Table 3). It is evident that the LEK in both study sites especially captures and expresses specific qualities of species' aggregation. Many detailed descriptions and comments were recorded concerning why specific species occur (i.e. aggregate) in particular locations, either seasonally or otherwise. For instance, characteristics of ocean floor composition and topography (e.g., rocky bottom) combined with attributes of the benthic ecology (e.g., kelp beds) and water temperature are repeatedly described in both study sites as key to lobster aggregations and movements. Similar observations were made respecting oceanographic, environmental and ecological characteristics associated with the seasonal occurrence and distribution of other key species.

Notably, not one LEK expert observation was recorded in either site respecting specific fitness consequences for any species in association with their presence, behaviour, reproduction, and/or survival. In fact, if anything the LEK experts' observations point to a set of independently derived commonalities between the two sites. That is, many offered similar remarks respecting the movement and life cycle attributes of lobster, herring, mackerel and cod within their fishing grounds. For instance, similar observations in both locations were made concerning lobster preferring "hard bottom" (i.e., rocky locations), about herring spawning around sandy and mud bottom, and about the distribution and drift of lobster spawn. None of the LEK documented in either study site associated local conditions as critical to any of the key species' overall survival and sustainability, although all noted life history attributes and activities for the areas of aggregation (e.g., spawning, nursery, migration).

Finally, only LEK experts in the LaHave site provided observations describing attributes of their area as unique. For example, one expert stated: "Ironbound bank is a pretty unique one for the inshore", while another observed "[1] obster, all type of groundfish, herring, mackerel, tuna [are] also [in] this area here……" species' abundance and diversity underscore these observations. Yet, these qualities are evident, at least seasonally, in Chedebucto Bay and are not necessarily unique to the LaHave setting. This apparent difference may be no more than a consequence of the fact that the LaHave research asked LEK experts if there was anything unique to their area, while the Chedebucto Bay research did not employ the word "unique" in any of the questions asked.

5. Discussion

Employing a controlled comparative case study approach, we explored possible points of intersection between the local ecological knowledge of peer recommended experts in two coastal Nova Scotia sites and the three core criteria specified by Fisheries and Oceans Canada for determining ecologically and biologically significant areas. The sites chosen for comparison were shown to hold considerable similarities with respect to the core attributes such as the social characteristics of harvesters, fishing effort and species targeted. The demonstrated high degree of similarity enables controlled comparison of the LEK expressed by experts from the two locations who were identified employing the same research design and methodology, thereby assuring confidence that like is compared with like and that the LEK reported is representative and comprehensive.

The LEK observations concerning the four key species in both sites intersect closely with only one EBSA criterion—aggregation. While we recognise that EBSAs encompass physical, biological and ecological features beyond these four species, fish harvesters gain their knowledge while pursuing their livelihoods, and have largely focussed on these species. It makes perfect sense that LEK observations would emphasise the aggregation EBSA criterion since marine harvesters interact with the coastal ocean ecosystem for the purpose of deriving their livelihoods from the exploitation of commercially valuable resources. This is done most efficiently in areas where the target species are aggregated. The various conditions affecting fish harvesters' access to these resources, such as seasonal distribution, environmental conditions, and distribution on their fishing grounds with respect to habitat will be of particular interest and concern. These attributes will also be crucial to harvester decisions about when and where to fish for particular species when employing particular technologies.

Perhaps surprisingly, no LEK observations were recorded that could be attributed to specific fitness consequences associated with change in local ecological or environmental conditions. It should be noted that this is a term that the LEK experts never used. It is a scientific term, originating in genetics, meaning the impact of an action or change on the survival or reproduction of a species, and does not translate well into common parlance. In practise, fitness consequences are a derivative of life history activities and the DFO EBSA guidelines indicate that areas should be "[r]anked from areas where the life history activity(ies) undertaken make a major contribution to the fitness of the population or species present to areas where the life history activity(ies) undertaken make only marginal contributions to fitness" [14,4]. Therefore with regard to LEK, the fitness consequences criterion must be secondarily interpreted by the scientists processing the observations provided by the experts.

The LEK experts did identify life history relevant behaviours such as spawning or migration as reasons for areas of aggregation, which could be interpreted to have "fitness consequences". However, since in both LeHave and Chedebucto, there were multiple spawning, nursery or migration areas for each of the four species, the loss of any one area would not result in any significant fitness consequences to the population. But perhaps we have been too rigorous in our interpretation of the "fitness consequences" criterion since MacLean et al. [34], in a small LEK study of offshore fish harvester LEK, included references to spawning, nursery areas etc as fulfilling the fitness consequences criterion. Thus it could be argued that the life history observations provided in this study do result in "fitness consequences" which would fall at the marginal end of the spectrum identified above. This overlap between aggregation and fitness consequences has been formally recognised: "the overlap is taken as being consistent with the common observation that animals often congregate in areas where they undertake activities of particularly high fitness consequences" [13,3].

To obtain information about the Uniqueness criterion, we had to step outside the controlled comparison since information about uniqueness was only specifically reported from the LaHave site in response to a question designed to explore this criterion: "Are there areas that you would consider to be unique, rare or distinct either currently or in the past"? There was no such question in the Chedebucto Bay study. There was a range of responses to this question. Of the six respondents, two indicated that there were no unique areas; one initially indicated that there were none, but when answering a subsequent question indicated, in passing, that "Ironbound bank is a pretty unique one for the inshore"; one respondent noted that "all the area on Cape LeHave is pretty well that way and Indian Island and Ironbound and a certain part of Moshers Island". Only two respondents clearly identified specific areas from the outset. Of these, one area was only identified once, whereas three other areas were also identified by one or two of the other respondents. In particular, Ironbound Bank, which was described as "like an underwater reef", was mentioned by two other respondents. Thus for the LaHave area, uniqueness was attributed to underwater features and high diversity of juvenile fish, fish and seabirds.

LEK within each location is particular to that location and its spatial characteristics, yet, the results of this controlled comparison indicate that there are more similarities between these two areas, with respect to the four key species, than differences. Given their coast wide distribution, this is not surprising. Similar observations in both case study sites are made about the factors affecting the distribution and behaviour of targeted species. These results suggest that LEK is a useful source of information about representative areas, which although not a criterion used for EBSAs, is a key criterion for defining networks of MPAs [35].

By the very nature of the fishing, where harvesters fish for the same commercially valuable species, most of the ecological content of LEK will be framed by the harvesters' knowledge requirements for achieving livelihood success. It would be unreasonable to expect otherwise. For instance, systematic observations of trophic dynamics and ecosystem processes would be highly unlikely. Rather, marine harvesters' observations and the knowledge system about local fishing grounds built upon these will emphasise associations judged to most directly impact on their access and livelihood success. A commonly remarked upon illustration of this is the association of warming water temperatures with the migration of lobster to shallower grounds during spring fishing, and, conversely, the movement of lobster to deeper water as the temperature gets colder. Judging lobster movement is a critical factor in decisions about where to set traps and to achieve commercial success. The actual empirical facts impacting lobster movement are beside the point, i.e., whether lobster actually migrate from shallower to deeper water, and vice versa, in response to water temperature or whether local populations simply reduce activity and feeding in response to falling temperatures. What matters to marine harvesters is that they respond successfully to the conditions affecting their access to resources. Their knowledge of local conditions and species distributions, created over generations of fishing for their livelihoods in these settings, is critical to making a living through fishing.

These qualities underwriting marine harvesters' LEK raise an important question: are the EBSA criteria, as defined by fisheries and biological science, appropriate for the type of knowledge held by fish harvesters, gained through repeated observation in the pursuit of livelihood? Do the EBSA criteria enable the best use of LEK? The only criterion which was directly related to LEK was the aggregation criterion: the information provided about uniqueness and fitness consequences was more circumspect and required further interpretation, and in the case of uniqueness, a specific question. It is apparent from the content of the EBSA documents and the decision processes inherent to them that at no point were marine harvesters invited to engage in framing the issues and in deciding what, from their perspective, is important for determining ecologically and biologically significant areas. Scientific experts were assembled by governance authority to arrive, on the basis of their expertise, on the determination of what counts and what matters when it comes to protecting marine habitats and ecosystems. Excluding marine harvesters from this framing process arguably expresses at least three presumptions: (i) that the vested interests of fish harvesters logically exclude them from being productive and objective contributors to deriving solutions; (ii) that fish harvesters are assumed to possess, at best, incomplete knowledge, as contrasted with the merits of science-based expert understanding; and (iii) that DFO Science alone is able to arrive at the criteria without requiring external input.

From these presumptions flow several likely consequences. The first among these is that exclusion confirms for marine harvesters that their interests, experiences, and knowledge are negatively valued by experts and those that govern, irrespective of what they may on occasion hear said. In any subsequent initiative inviting harvester participation, they will be presented with a set of pre-determined criteria into which they are required to fit their experiences, concerns, and knowledge. Such circumstances only affirm the widely held opinion among harvesters that science and government resource managers neither value their experience and knowledge nor take their concerns seriously. From these qualities many harvesters will conclude that "authority" once again determines the priorities and will simply impose any restrictions on their access to and use of marine resources that arise from identifying ecologically and biologically significant areas. In short, these presumptions and processes may only deepen harvester distrust of science and government resource managers and their intentions. For instance, Fisheries and Oceans Canada specifies in its key framing document that "Experiential knowledge (a term including Aboriginal traditional knowledge, fishermen's knowledge, and other ways that ecological knowledge is acquired through extensive experience with the marine environment) should be fully included…" [14,3]. Yet, the process of identifying ecologically and biologically significant areas is emphatically specified a "…*Science-led* [emphasis in the original]…" process [14,3]. The only other mention of "experiential knowledge" within the document occurs in the 6th last paragraph and with reference to the prospect that such knowledge may "…reduce [data-rich] bias to some extent" in identifying significant areas [14,8]. This means that harvesters knowledge and experiences are valued and may be assayed as useful only in so far as they may feed additional information about data poor areas into a decision-making determination. Of course, the determination of what constitutes useful harvester knowledge and experiences reside with the science and management experts. For harvesters this only confirms suspicions and deepens distrust, leaving many convinced that scientists and managers will only pick and act on information that supports predispositions and foregone conclusions. This is certainly not a recipe for collaboration and engagement, and confirms concerns expressed by some such as Holm [23] that authorities will essentially cherry-pick from harvesters' LEK what they prefer, discrediting the rest. This process removes LEK from its context and further disempowers marine harvesters.

Within the bounds of the controlled comparison, these two studies provided information that can contribute to identifying EBSAs on the basis of aggregation and fitness consequences. A step outside this controlled study added information about the uniqueness criterion. The LaHave site was part of a larger geographic study of the Atlantic coast of Nova Scotia, designed specifically to collect LEK to support the identification of EBSAs. It included several questions not considered here, which included a broader range of species and specific questions about areas which may be significant to harvesters for different reasons (e.g., high diversity, pristine, culturally or historically). Additional research is needed, by way of next steps, to incorporate analysis of these additional questions and the additional seven sites. This will enable further examination of the extent to which the three core criterion are better explored through scaling-up to a study that captures more of the entire Atlantic coast. We have shown that aggregation was the criterion most clearly linked to LEK. However, the capacity for LEK to account for aggregation may not be sufficient, in itself, to the evaluation of the potential intersection of LEK with determining EBSAs, Yet, the detail and quality of harvesters' LEK in this one area is such that it might provide the key point of reference needed to assure that harvesters' "voice" and concerns are central in shaping any resource management policies and initiatives, such as MPAs, that are likely to arise through EBSA-based assessments. Future research and analyses are required to examine and to better understand these prospects and possibilities.

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