Master's thesis

On the importance of including metadata when dealing with Traditional Ecological Knowledge

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Declaration

I hereby confirm that I am the sole author of this thesis and it is a product of my own academic research.

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Abstract

Not only in respect to the marine realm, but for a broad catalog of research and management purposes, use of Traditional Ecological Knowledge (TEK) and its hybridization with scientific knowledge has increased in popularity. Scientists thereby mostly use geo-spatial tools, and Geographic Information System (GIS) in particular, to join hard data with applied knowledge. However, a rather problematic aspect when utilizing TEK is the existing deficit in systematic, and rigid methodologies for TEK collection, and a general lack in analyzing methods which hinder TEK to become as powerful as conventional scientific knowledge. By critically assessing the Community Based Coastal Resource Mapping Project (CBCRMP) conducted in the Bay of Fundy in the mid 1990s, this study presents a document of metadata descriptors which support the systematic documentation of TEK and hence facilitate its use in GIS, as well as its fusion with other knowledge systems. By analyzing the methodology applied to gather TEK of resources for the entire Bay (e.g. information on ground fisheries, lobster fisheries, etc.) and identifying gaps in the data documentation and reporting procedure in retrospect, we deduce essential features to document when gathering TEK.

Keywords: Bay of Fundy, Marine Conservation, Traditional Ecological Knowledge, Research Methodology, GIS, Metadata

1. Introduction

The Bay of Fundy, located between New Brunswick and Nova Scotia on the east coast of Canada, is an ecologically significant area containing a great variety of unique marine and coastal ecosystems with diverse marine life. Its waters are highly productive due to upwelling of nutrient rich waters (Bredin et al. (2001)), which support large populations of fish and serves as a primary nursery and feeding ground for whales including the North Atlantic Right Whale and the Blue Whale which are both federally-listed endangered species (Murison and Gaskin (1989)). The intertidal and shallow subtidal areas in the upper Bay are significant as well, characterized by productive salt marshes and mudflats which, being rich in clams, shrimps and snails (Graham et al. (2002)), provide a critical feeding region for migratory and non-migratory seabirds and shorebirds (Hicklin (1987)), as well wintering area for many other bird species such as the semipalmated sandpiper (Wilson Jr (1990)).

However, in recent years a range of human activities is threatening this complex ecosystem. Intense bottom trawling and scallop dragging resulted in a dramatic decline of commercial and uncommercial fish species, and many traditional fisheries like hake, herring, mackerel, and salmon no longer exist (Graham et al. (2002)). Especially the inshore groundfish catches have drastically decreased, and groundfish spawning areas have progressively been lost. Fishermen who once were involved in a multi-species fishery harvesting different species in different

seasons now mostly make their living exclusively on lobster, or were obliged to search for other income sources (Graham et al. (2002); Lotze and Milewski (2004); Lotze et al. (2006)). In addition, bridges and dam constructions in rivers surrounding the Bay, as well as the implementation of turbines for the tidal power plant at the Bay mouth have not only killed large numbers of fish that migrate to the head of the Bay (Gordon and Longhurst (1979)), but also changed sediment transport, water flow and natural tidal waterways (Wells (1999)). Ecotourism and increased shipping mainly to the ports of Saint John, Bayside, Eastport, and Hantsport interferes with feeding, nursing and mating activities of marine mammals. Increase of fatal collisions between ships and Right Whales has been reported hampering the growth of this endangered whale population (Kraus (1990); Jensen et al. (2004); Ward-Geiger et al. (2005)).
Sewage contamination and waste from aquaculture operations have also destroyed habitats, and productive clam flats in particular.

Parks Canada, a federal government agency with a mandate to conserve both terrestrial and marine ecosystems, has a long-standing commitment to establish a National Marine Conservation Area (NMCA) in the Bay of Fundy as part of Canadas proposed nationwide NMCA system. The target is to establish 29 NMCAs (one in each of Canada's representative marine regions (Fenton et al. (2000))), but Parks Canada is badly lagging behind achieving this goal, having only designated the Lake Superior National Marine Conservation Area under Canada's NMCA Act (Parks Canada (2009a)). For the Bay of Fundy in particular, Parks Canada has not even identified a location for the establishment of a future NMCA, but has recently posted

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a request for proposals for a "Study to Identify Preliminary Representative Marine Areas for the Bay of Fundy Marine Region" (CPAWS (2010)). In general, conservation initiatives in the Bay of Fundy remain rather sporadic or have failed in the past (Flournoy (2003)). Lien (1999) depict numerous reasons for Parks Canada failing in the establishment of NMCAs in the Maritimes. In great detail the study analyzes the abandonment of a proposal and the abrupt end of a feasibility study for the possible establishment of an NMCA in Bonavista Bay: firstly a clear vision of an NMCA was missing and experience with conservation initiatives lacking by all players involved. The Advisory Committee (consisting of representatives of the fishing industry, officials of Parks Canada, the Department of Fisheries and Oceans (DFO) and the province) were given an impossible task without enough expert support. Budgets were too small given the size of the task. Access and timely acquisition of technical and support resources lacking. DFO failed to express clear, constructive views of their role in an NMCA, as well as work as partners with Parks Canada in identifying park functions. In addition, a general mistrust and opposition from local groups, including representatives of the fishing and aquaculture industries was present, who feared economic impact from potential restrictions on fishing. Clearly, many factors came together to hinder the successful implementation of an NMCA for the Bay of Fundy. However, at the very end it was the stiff opposition by local groups that forced the abrupt end.

The general lack of support from the local community as seen in the case of Bonavista Bay can often be traced back to a lack of local involvement and participation early in the planning stage. It is known that community-based management plans tend to work better than top-down approaches (Cox (2000)) and the support from communities is one of the most important factors in determining the success of long-term efficacy of conservation plans. Already in early stages of selecting high priority sites for protection, it is crucial to not only use scientific approaches and decide using scientific information only, but also consult with all user groups and include *"Traditional Ecological Knowledge"* (TEK) held by local and indigenous peoples. Especially when dealing with the management and governance of the complex marine system studies suggest the combination of TEK with different knowledge systems, the *"hybrid approach"*, to be beneficial (Neis et al. (1999); Lauer and Aswani (2008)).

In the process of identifying "hotspots" for conservation in the Bay of Fundy scientists are using a broad range of scientific information. A wide spectrum of site selection procedures are being applied, varying from the single species approach to highly sophisticated mathematical siting algorithms, but hardly any study includes the knowledge held by resource users. Within the Community Based Coastal Resource Mapping Project (CBCRMP) conducted in the Bay of Fundy in the mid 1990s under the Department of Fisheries and Oceans (DFO) as the leading agency, a comprehensive inventory of community valued resources that exist in significant concentrations along the entire coast was mapped from TEK collected through interviews. Although this data set presents a rich source of information varying from data on aquatic plants, shellfish re-

sources, marine resources (groundfish, pelagic fish, and diadromous fish) to marine mammals, its applicability and potential for identifying areas of ecological importance has not been assessed.
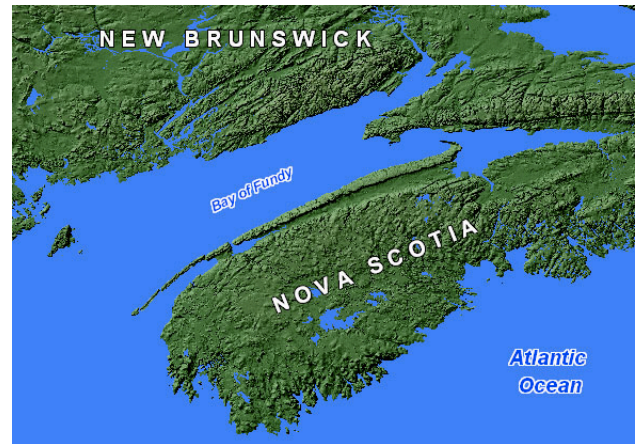

Figure 1: Bay of Fundy, Canada, Web Team Associates (2009)

This study sets out to expand our current knowledge of the Bay of Fundy ecosystem by utilizing TEK from the CBCRMP project and assessing its usefulness in supporting the NMCA site selection process. Crucial in identifying which parts of the CBCRMP can still be used roughly 15 years after the projects' completion is the analysis of TEK gathering and documentation methodologies. Identifying weaknesses or errors in the methodology and gaps in the data documentation and reporting procedure in retrospect helps deducing which information can still be safely utilized to expand our current knowledge base, and which data should be handled with caution. In addition this analysis will also make recommendations for future use of TEK in marine conservation more widely, in particular developing a suite of metadata descriptors for the systematic documentation of TEK which could serve as the basis for a Geographic Information System (GIS) metadata extension file in the future. This will help researchers better incorporation TEK into GIS-based assessments for the selection of suitable sites for marine protected areas.

2. Methods

In order to analyze the Community Based Coastal Resource Mapping Project (CBCRMP) of the Bay of Fundy and assess which of its deliverables can still be utilized to support the NMCA candidate site selection process background information about the CBCRMP was gathered. Through web-based research and by tracking down and consulting former project participants, general details on the project, and its methodological approach were investigated. Since questions being asked were simple and straightforward, and interviews rather short, telephone interviews were chosen as main research method as suggested by Sullivan (2001). Snowball sampling, a procedure able to generate an ever-increasing set of interviews through a

referral process in which interviewees are asked to provide additional, appropriate names for interviewing (Mackinson and Nottestad (1998); Babbie (2009)), was utilized as the main approach to identify key persons that were involved and could provide information on the CBCRMP and methodologies in particular. Semi-directive interviews, which are more a conversation than a question-and-answer session without fixed questionnaire, or limit on the time for topics to be covered were conducted and informants were asked to give as many project details as they could remember. Interviews were conducted until *"theoretical saturation"* was reached, i.e. *"no additional data are being found whereby the (researcher) can develop properties of the category. As he sees similar instances over and over again, the researcher becomes empirically confident that a category is saturated"* (Glaser and Strauss (1967)). In addition, peer reviewed publications were searched which referred to the CBCRMP or made direct use of the project data, and their authors were also contacted if possible. By analyzing these studies and their way of incorporating the projects' data additional details could be tracked down.

Despite all efforts and the utilization of the entire spectrum of available information sources, large gaps in the documentation of TEK were identified, which complicate the reconstruction of the project methods and hence constraint the direct use of the CBCRMP data for supporting the NMCA process. However, although this lack in documenting the TEK collection process does hinder its use in the regional context, it enables to identify general key documentation features that should be incorporated into every single TEK collection process. Analyzing the documentation gathered about the CBCRMP and deducing which information is missing to allow using the project data for the identification of significant areas for conservation in the Bay of Fundy, this study assesses the minimum documentation required to enable the TEK's long-term secondary use. Since most of the TEK is processed with GIS for which standard metadata descriptors that support data documentation exist, this study builds upon the GIS metadata framework. The set of standard ecological metadata descriptors presented by Michener et al. (1997) serve thereby as point of origin to formulate a metadata extension for the documentation of TEK.

3. Traditional Ecological Knowledge

In the past, inclusion of knowledge held by local and indigenous people, the *"Traditional Ecological Knowledge"* (TEK), has tended to be neglected in scientific research and management plans due to the notion of its highly subjective and fragmented nature, and concerns about its reliability (Huntington (2000); Close and Hall (2006)). In recent years however, this picture has drastically changed and especially for marine conservation and fisheries management purposes (Berkes et al. (2000); Huntington (2000); Folke (2004); Drew (2005)) benefits from utilizing TEK and its potential when combining it with scientific data and approaches have been acknowledged. Traditional Ecological Knowledge (TEK) is the *"cumulative body of knowledge, practice and belief evolving by adaptive processes and handed down through generations by cultural transmission, about the relationship of living beings (including humans) with one another and with their environment"* (Berkes et al. (2000)). This applied knowledge is information that, being created, revised, and accumulated through trial and error over a long period of time and passed on through many generations, is able to reflect modern changes in peoples' environment or culture (Ellis and West (2005); Drew (2005)). TEK can improve scientific research by providing researchers with new kinds of data to help test their hypotheses (Drew (2005)), fill gaps and complement the existing scientific database through regional specific knowledge which might not be recorded in the scientific literature (Heyman et al. (2001)). Especially in remote, infrequently visited areas where ecological and social systems are often poorly studied because of logistical and financial limitations (Jones (2006)), TEK can be a valuable source of information. In addition to expanding the often patchy scientific data, the potential of TEK in resource management is also increasingly acknowledged. As described by Cox (2000), the acquisition and appreciation of TEK offers opportunities for building truly collaborative and mutually respectful long-term relationships. The use and incorporation of TEK can potentially improve resource management by increasing stakeholder participation, and heighten awareness of benefits from effective management regimes.

Related to marine conservation and fisheries science in particular, TEK can help identifying different habitat areas (e.g. spawning areas, juvenile habitats), as well as fish species (both commercial and uncommercial) with their distributions and interactions (Drew (2005)). Because of their dependence on local resources, fishermen are a rich source of detailed information into the biology of their targets, their distribution, habitat preferences, feeding behavior, as well as interactions. Through many years of observation they have gained deep understanding into spatial and temporal changes occurring in their daily environment which can be useful in guiding scientists and decision makers. For example the diversity of names fishermen use for one particular fish species can already serve marine conservationists as a hint that those species are of particular importance for local fisheries, and should be further studied when considering resource use and fisheries management (Drew (2005)). In Newfoundland, fishers' taxonomic terms for Atlantic cod were combined with tagging research, landings data, and information on spawning locations to retrieve and interpret observations on the timing, location, and depth of particular cod fisheries (Neis et al. (1999)). Interaction with local fishermen has led to the discovery of unknown fish species, improved our understanding on mating behaviors and ontogenetic shifts in fish populations, as well as helped locating harvest "hot spots" where fishing pressure is high, and specific management approaches required (Hall and Close (2007)). Similarly, spawning sites have gained protected area status through the interaction of researchers and local fishermen (Drew (2005)) and the use of different knowledge systems.

Besides improving the scientists' understanding of the complex marine system and their recommendations (Mackinson and Nottestad (1998)), incorporating TEK enhances resource users' acceptability towards fisheries science. Management de-

cisions which are at least partly based on TEK not only provide fishermen with a sense of pride, but also foster greater responsibility towards their resource, and simultaneously helps successfully implement management decisions. Information sharing and dialogue has the potential to develop a mutual respect between scientists and fishermen, which is crucial when co-managing fish stocks (Mackinson and Nottestad (1998)).

4. Results

The Community Based Coastal Resource Mapping Project (CBCRMP) of the Bay of Fundy was conducted from the year 1993 to 1997 under the Department of Fisheries and Oceans (DFO) as the leading agency (DFO (1997)). The objective of the project was to collect TEK and combine it with relevant governmental information to create a comprehensive inventory of community valued resources that exist in significant concentrations along the entire coast. This document was supposed to serve the community to better understand and plan future economic activities. Parameters included into the coastal resource inventory consisted of data on aquatic plants, shellfish resources, marine resources (groundfish, pelagic fish, and diadromous fish), and marine mammals (see Figure 1 for an original map section with details on various species and Figure 2 for the legend of the original maps). According to the CBCRMP manual, information on known spawning areas, juvenile rearing areas, and adult living areas were supposed to be collected. In addition, other resources identified for potential economic development or protection from over-exploitation and pollution were also collected, like e.g. tourism-related resources. Fishery infrastructure (aquaculture, fish processing plants, lobster pounds, etc), coastal industries (wharves, boat building), ocean dumping sites (location and type of sludge being disposed), geological features (e.g. glacial deposits), shipping lanes, conservation areas, and a shoreline classification were also included (see exemplary map section (Figure 1)).

The DFO provided funding to contract qualified project managers with cartographic and organizational skills that were responsible for training data collectors, supervise/co-ordinate the data collection phase, and conduct the final data compilation. Other government agencies provided funding to hire data collectors. Since past resource investigations failed partly because of poor community response to government initiatives (local people have been skeptical of their value and generally a lack of understanding about the purpose of such studies existed), data collectors engaged in the CBCRMP were always hired locally in order to increase their level of acceptance in the community. Data collectors generally had a history in the fisheries industry and would be comprehensively trained to gather on the one hand TEK from the community and on the other hand additional information from government or industry sources.

Included into the final CBCRMP data set were databases only if they either contained at that time current information paired with a geographical (latitude/longitude) position, were outdated databases but could be updated, or were non-georeferenced databases but could be paired with a position. Through field work, data collectors also gathered information which could not be obtained through interviews, did not exist at all, or were available only at a for the resource mapping project useless scale.

However, the main basis of the project was the collection of TEK through interviews in selected communities throughout the Atlantic coast of Nova Scotia and the Bay of Fundy. All information obtained through community consultation was whenever possible visually verified by collectors who would personally visit e.g. wharfs or slipways and proof their existence and functioning. Information which could not be verified in person would only be included if it could be confirmed by at least two other sources, e.g. the government, members of the community, or a combination of both. A lobster habitat e.g. would only appear on the final resource map if a total of at least three independent persons identified it as a spot where they fish or have fished lobster. Open house events were held to give the general public chances to review, identify and correct any inaccuracy in the gathered and mapped data. Only after maps were updated, modified and approved by the community, final copies of the manuscript maps were produced in form of both, a publication quality hardcopy atlas and a digital mapping application (including digital maps databases). For hard copy maps, symbols representing the various resources were chosen to be as recognizable as possible and were included directly on the map eliminating the need for constant reference to a legend (see map section (Figure 1) and legend (Figure 2)). For the digital maps colors were utilized and selected in a way that most clearly indicates the original color of the resource. For example sandy beaches were colored yellow, intertidal mud brown, etc. QUIKMap, a geographically oriented, data-centered mapping tool, was utilized as the software to read and process both the database and basemap files. According to the CBCRMP manual every piece of information gathered was linked to the contact person, a telephone number, a reference and a comment on the status of that resource. This would ensure that additional information on a resource could be acquired whenever required and needed to be updated. In addition, persons involved in a resource would more easily be contactable in case of an environmental emergency, ensuring a quicker disaster response and potentially supporting impact mitigation.

The CBCRMP was a quite advanced study in the 1990s, at a time where the use of TEK was just slowly gaining recognition. However, we can in retrospect recognize that many parts of the documentation we were hoping for are lacking or appear to be lost, complicating the access and exploration of the CBCRMP data set. This was recognized from very early on when trying to discover additional background information on the projects' procedures. Beside the available hard-copy maps it was hard to detect all deliverables that resulted from the CBCRMP. Names of leading scientists could not be derived from the hard-copy maps, and only little information was available online or could be gained from pure literature research. Once the principal investigator was identified and contacted, a project manual

could be obtained but still, since this document was never finished and lacking specific details, most methodological aspects could not be reconstructed. Memory loss of the principal data investigator, a typical process reflecting the natural tendency of information being gradually degraded from the moment they were gathered onwards (Michener et al. (1997)), also impeded acquisition of additional information. GIS layers corresponding to the hard-copy maps were also not easily accessible, and did neither contain metadata files, nor were they accompanied by a well structured manual. In addition, these are stored in a data format (.MAP files) which is not easily manageable. For example, in order to import these files into ArcGIS, the most commonly utilized GIS software, the user must first create a MapInfo Interchange Format (MIF) file in MapInfo which only then can be imported into ArcGIS. The fact that apart from few details contained within the CBCRMP manual no information on the method of gathering TEK can be reconstructed does not allow for a straight forward utilization of the mapped resources. Especially lack of details on the interview procedure, data verification process, and geo referencing approach impedes the reuse of the existing GIS layers and hard copy maps.

Ideally, for second users to be able to reuse the CBCRMP data to its full capacity and in a proper manner, a metadata file with rigid structure and equal format for each single investigated resource (e.g. one data file and corresponding metadata file for each shellfish resource, each marine resource, etc.) would be beneficial, if not essential. Therefore, metadata descriptors

for TEK are delineated here in the following for every data layer (i.e. for every investigated resource when considering the CBCRMP). These descriptors allow for a systematic documentation of TEK and can be used as a supporting guideline to data collectors until a standard metadata file/extension for TEK exists, which may include the here presented descriptors as their basis. The outlined descriptors were identified through the critical analysis of the CBCRMP and particularly through the identification of documentation gaps that minimize the data set utility. Literature research on other projects/studies involving the use of TEK provided additional important insights that were also included. The existing standard ecological metadata descriptors (Michener et al. (1997, 1987, 1990); FGDC (1994); Kirchner et al. (1995)) that are commonly utilized for documenting ecological data provide the foundation and overarching framework for the proposed TEK descriptors. These standard descriptors are categorized into five different classes:

CLASS I. DATA SET DESCRIPTORS
CLASS II. RESEARCH ORIGIN DESCRIPTORS
CLASS III. DATA SET STATUS AND ACCESSIBILITY
CLASS IV. DATA STRUCTURAL DESCRIPTORS
CLASS V. SUPPLEMENTAL DESCRIPTORS

Class I. (*"Data set descriptors"*) introduces the data set contents and provides the research objectives and general experimental or sampling design, and would e.g. describe one
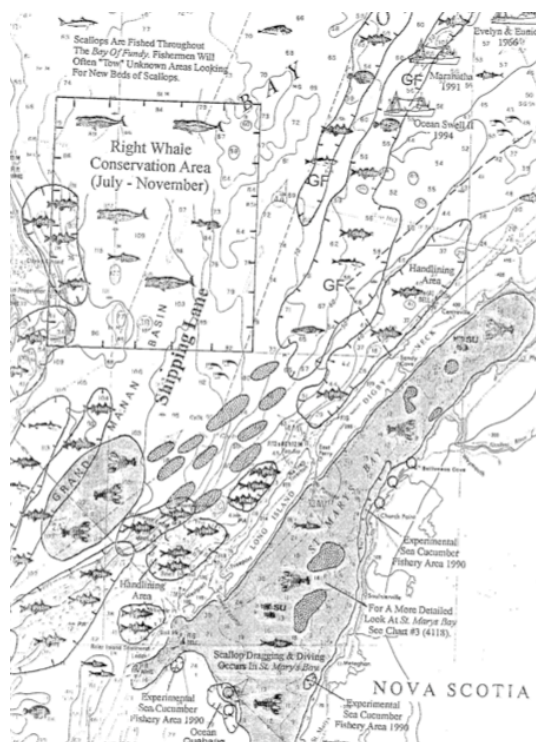

Figure 2: Map section (St. Marys Bay and Digby Neck, Nova Scotia) from the Community Based Coastal Resource Mapping Project (CBCRMP), DFO (1997)
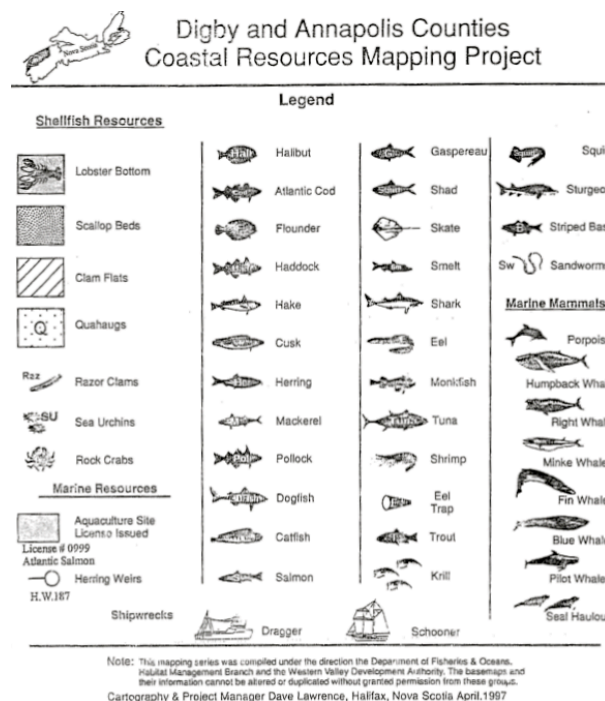

Figure 3: Symbol legend corresponding to maps produced in the CBCRMP, DFO (1997)

data layer containing resource information obtained through TEK. Figure 3 (see Appendix) presents exemplary the Class I. for the already existing standard descriptors (descriptors on the left-hand side and examples on the right-hand side, from Michener et al. (1997)), and Table 1 presents the proposed Class I. for documenting TEK (note: italic font serves differentiating between standard ecological and TEK related descriptors).

When dealing with TEK oftentimes not only one variable is investigated. For example in the CBCRMP many different resources were documented, which were grouped into categories, like e.g. marine resources, marine mammals, shellfish resources, etc. For a more structured documentation when gathering TEK from different categories, it appears to be beneficial to present already within the Class I the category to which the data set belongs. A problem when analyzing the CBCRMP was the detection of all existing deliverables resulting from the entire project as well as pertaining to every single resource. For second users to immediately be informed of the different data products available (e.g. maps, data tables, GIS layers, etc), a list of deliverables should be provided for both the "overall" project (see Class II), and each data set (Class I).

Note: for the following Class II. - Class V. only tables with the proposed descriptors for documenting TEK will be provided. For the original ecological standard descriptors the reader is referred to Michener et al. (1997).

Class II. (*"Research origin descriptors"*) is divided into two parts (see Table 2 and 3):

Part A. (Table 2) gives insight into the broader scientific scope of the "overall" research project and states the projects' objectives and purposes. Project name, principal investigator(s), funding sources, as well as the temporal dimension of the entire project are included into this class. Here it is important to specify why exactly the research was carried out, e.g. if the project was directed towards issues of resource management or planning, since this might help second users to identify the applicability of the project information for their own study purposes. For the incorporation of TEK it might be also helpful to further expand this section by clearly specifying not only the principal investigator associated with the project, but also outline the institutional background (e.g. government, NGO, research institute, etc.) of the project initiator if different to the principal investigator, since this might potentially influence the support/acceptance towards the project by participating communities and individuals.

Part B. (Table 3) of the original standard ecological descriptors presents the "specific subproject". It includes a detailed characterization on the site type (like e.g. geography, habitat, geology, landform, watersheds, hydrology, climate, etc.) and information on the experimental/sampling design (including statistical/sampling design, data collection period/frequency. etc.). In addition, descriptors delineating the research methods like e.g. field and laboratories procedures, instrumentation, etc. also belong to this class. Clearly, while descriptors on the site type

and experimental design are rather secondary when considering TEK, research methods descriptors are essential since they allow for a transparent description of the project procedures. Since the use of TEK by second-users greatly depends on the documentation of the research methods utilized, this subclass needs to be further expanded in order to comprise all the relevant information. Not only the main research tool (e.g. semi-structured interviews, telephone surveys, questionnaires, etc.) needs to be specified, moreover all encompassing aspects of a chosen research tool needs to be included. Since TEK is mostly gathered through consultation procedures and interviews in particular, TEK descriptors should describe every interview process in sufficient detail.

Probably one of the most problematic issues when researching TEK is the identification and selection of *"experts"*, a process which appears untraceable for the CBCRMP. Neither the CBCRMP manual, nor any other of the still available information sources clearly reveal how the interviewed persons were chosen and identified as experts in their field. A study by Davis and Wagner (2003) discusses this matter in great detail and outlines how quality and impact of data assembled during TEK research strongly depend on who is identified as "knowledgeable" and how important it is that TEK is being gathered systematically from a large enough group of knowledgeable individuals. Their study analyzes journal articles concerning TEK in the fields of resource management, environmental assessment or development issues in respect to what basis, if any, TEK researchers identify expertise (for more detailed information on how these studies were selected the reader is referred to Davis and Wagner (2003)). Only three out of ten examined case studies provided some description of the expert identification process. For example the study by Olsson and Folke (2001) documented the knowledge of crayfish harvesters by first surveying a "focus group" consisting of all households (73 in total) with rights to harvest crayfish, and asking each of them to identify the in their eyes most knowledgeable cray harvesters. The authors additionally reviewed records of the local fish association in order to identify those who consistently held a leadership role in the association and hence were supposed to be strongly involved in crayfish management issues. Combining these two information sources the authors then identified 10 persons as experts for in-depth interviews. Although a systematic approach was utilized and these methods presented, Olsson and Folke (2001) neither describe how many peer recommendations were considered sufficient to qualify them as "experts", nor do they specify the relative weight given to peer recommendation as compared with leadership roles in the association (Davis and Wagner (2003)). The second case study conducted by Neis et al. (1999) followed the snowball sampling technique together with referrals from local resource user associations to select local "experts" among fishers living along the northeast coast of Newfoundland, but does not address the issue of *who* should be asked to identify local experts. The third study by Ferguson and Messier (1997) investigated Inuit knowledge about the Arctic tundra caribou by interviewing participants (mostly elders or active older hunters) selected on the base of recommendations from local

Hunting and Trapping Associations (HTAs) and local Inuit "advisors". Similar to the study by Neis et al. (1999) also here, authors do not provide details on the qualifications of those within the local associations who made referrals. Analyzing these different case studies, Davis and Wagner (2003) conclude that researchers do not report critical details of their research designs and methodologies, and that the literature does not allow isolating effective measures to use in identifying experts. The authors hence propose a peer-referenced systematic methodological approach for expert identification which enables to consider the most knowledgeable persons within a community/group while assuring that less knowledgeable are not mistaken as local experts.The authors further demand researchers conducting interviews on the basis of referrals from just a few personal contacts, or the availability during a short period of time, to make their research process transparent whenever publishing their results. For the documentation of TEK it is therefore essential to include information on how experts were identified, and give an account on the number of individuals included in the study compared to the total population of the communities and/or resource-user groups involved.

Class III. (*"Data set status and accessibility"*, see Table 4) of the standard ecological descriptors contains the essential archival information that enables second users to access the data sets. It contains the storage location, and contact information pertaining to the data set and its metadata, as well as gives insight into the medium utilized for storage and the date the information was lastly modified. In addition, copyright and proprietary restrictions outline if any restrictions exist that prohibit the use of all or portions of the data set. The date the data was released and its appropriate citation name are also both provided in this category.

Class IV. (*"Data structural descriptors"*, see Table 5) introduces in detail the structure of the data set file and gives information on the analyzed variable. Unique file names and codes, size, format and storage mode of the data set are presented.

Class V. (*"Supplemental descriptors"*, see Table 6) includes details on new information about the data which resulted during the analysis, synthesis, and publication of the data and aims facilitating secondary utilization. It also gives information on publications/results and provides a data log of who requested data for what purpose, and how the data set was actually used. Archival procedures for long-time storage are described and a update history outlines any updates performed on the data set. Room is additionally provided for comments or unusual data discovered by second users, problems encountered with the data, or any further questions or remarks which can be beneficial for further use.

5. Conclusions

This study critically analyzes Traditional Ecological Knowledge (TEK) of community valued resources that exist in significant concentrations along the entire Bay of Fundy (BoF). TEK was gathered within the Community Based Coastal Resource Mapping Project (CBCRMP) in the mid 1990s and consisted, among others, of data on aquatic plants, shellfish resources, marine resources (groundfish, pelagic fish, and diadromous fish), and marine mammals. Focus of this study thereby lay on assessing the usefulness of the data set in supporting the National Marine Conservation Area (NMCA) site selection process.

Information collected during the CBCRMP has shown to be highly detailed including a broad spectrum of resource categories. However, roughly fifteen years after completion of the resource inventory, information can not safely be used to expand the current scientific database existing on the BoF ecosystem. Improper data documentation and lack of transparent information on the project's methodology and particularly interview procedures, strongly inhibit a reuse of this vast data set. Although the main objective of the CBCRMP was not the collection of TEK for marine conservation purposes but rather meant to serve the community to better understand and plan future economic activities in general, missing documentation complicates data reuse of most mapped components in general. Only non-static information like e.g. details on ship accident dates and shipwrecks locations which do not change over time are still usable. Information on the position of conservation areas, fishery infrastructure (aquaculture, fish processing plants, lobster pounds, etc), coastal industries (wharves, boat building), shipping lanes, etc. can also still be utilized, but should be proofed since they potentially have altered over time. TEK collected through fishermen consultation on e.g. fish species appearance and distribution should be treated with caution when utilized for identification of ecologically significant areas for protection. Species aggregation and distribution can give insight into the areas of potential ecological importance in the past and serve as a starting point for further research, but should not be compared with present species distributions since we do not know the time frame species information refers to.

Fifteen years after the projects' completion both, data and metadata have strongly degraded, and the saying *"an undocumented dataset is a worthless data set"*, shows its trueness for the CBCRMP data set. Clearly, utility of the data set and chances of its reuse by secondary users would have been greatly improved through a systematic TEK collection approach and rigid documentation. The production and safe storage of a metadata file with a clear structure is crucial for a clear understanding and proper interpretation of the projects' outcomes. Based on the existing standard ecological metadata descriptors used in GIS, this study therefore additionally developed a set of metadata descriptors which support the systematic data documentation when gathering TEK. By studying how TEK was gathered in the past CBCRMP and analyzing how useful the data is now that not the original authors with their expertise and memories of the process of data collecting are available, weaknesses and errors in the past procedure are identified. Tracing which

methodological aspect is missing for a resource information to still be useful is used as an indicator for the importance of its inclusion into a metadata file.

Clearly, for TEK to become as powerful as conventional scientific knowledge, standard, structured methods have to be utilized and details reported. Systemization will not only improve upon acceptability and validity of hybrid models, but also help TEK loose its subjective and unsystematic reputation which still oftentimes makes its application and straight forward utilization problematic for science and management purposes.

6. Acknowledgements

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8. Appendix

```
Class I. Data set descriptors
A. Data set identity                    Title or theme of data set
B. Data set identification code         Database accession numbers or site-specific codes used to uniquely identify
                                           data set

C. Data set description
   1. Originator(s)                     Names and addresses of principal investigator(s) associated with data set
   2. Abstract                          Descriptive abstract summarizing research objectives, data contents (includ-
                                           ing temporal, spatial, and thematic domain), context and potential uses of
                                           data set
D. Key words                            Location (spatial scale), time period and sampling frequency (temporal
                                           scale), theme or contents (thematic scale)
```

Figure 4: Class I. :Standard ecological metadata descriptors and examples based on Michener et al. (1997)

Class I. Data set descriptors for TEK

A. Data set identity

Title or theme of data set

B. Data set category

Superordinate category

C. Data set identification code

Database accession numbers or site-specific codes *(also include corresponding inter-view codes, map codes, etc.) used to uniquely identify data set*

D. Data set description
    1. Originator(s)   Names and addresses of principal investigator(s) associated with data set
    2. Abstract   Descriptive abstract summarizing research objectives, data contents (including temporal, spatial, and thematic domain), context and potential uses of data set

F. Deliverables

List deliverables associated with data set e.g. GIS data layer, map, data tables, etc.

G. Key words

Location (spatial scale), time period and sampling frequency (temporal scale), theme or contents (thematic scale)

Table 1: Class I.: Standard ecological metadata descriptors with proposed changes for TEK

Class II. Research origin descriptors

```
A.”Overall” project description       Section essential if data represents a component of a larger database
   1. Identity                        Project title or theme
   2. Originator(s)                   Name(s) and address(es) of principal investigator(s) associated with project
   3. Project initialization          Names and addresses of project initiator (e.g. community initiated, government initi-
                                        ated, etc.)
   4. Objectives                      Scope and purpose of research program
   5. Abstract                        Descriptive abstract summarizing broader scientific scope of ”overall” research
                                        project
   6. Project Deliverables            GIS layers, digital map database, final report, hard-copy atlas, or other relevant
                                        documents
   7. Project Categories              List of different categories investigated
   8. Source(s) of funding            Grant and contract numbers, names and addresses of funding sources. Specify in-
                                        stitutional characteristics of financial support, e.g. governmental/ NGO/ scientific
                                        institution
```

Table 2: Class II.: Standard ecological metadata descriptors with proposed changes for TEK, Part A

Class II. Research origin descriptors

B."Specific subproject" description
    1. Site description

a. Site type	Descriptive *(e.g. description of coastal community)*
b. Geography	Location (e.g. latitude/longitude)

    2. Research Methods

a. Main research instrument(s)	*Description of TEK assessment method, e.g. (semi-directive) interview, questionaire/survey, etc.*
b1. Interview procedure	Section essential if interview main research method
1. Date	*Date(s) of interview(s)*
2. Length	*Total interview duration*
3. Interviewees per interview	*e.g. one-by-one interviews, group interviews*
4. Supporting material	*e.g. data collection sheet, maps, species photos, etc.*
5. Recording types	*e.g. audio, video, annotation of verbal responses, etc.*
b2. Interview participants	
1. Number	*Number of total interview team*
2. Setup	*List role of each participant (e.g. Interviewer, Interviewee, recorder, translator)*
3. Role of each participant	*Description of each role (e.g. interviewer: poses questions, translates, etc.)*
4. Training	*Description of how personnel was trained*
b3. Interviewee	
1. Total number of Interviewees	*Give number relative to entire population (e.g. relative to all resource-users)*
2. Affiliation of Interviewees	*e.g. fisherman*
3. History/Background	*e.g. 30 years experience in lobster fishing*
4. Remuneration	*e.g. per hour/per interview, cash/cheque*
5. Selection Criteria	*Give criteria describing how interviewee was chosen*
6. Training Interviewee	*e.g. description of how interviewee was made familiar with interview material*
c. Permit history	References to pertinent scientific and collecting permits
d. Legal/organizational requirements	Relevant laws, decision criteria, compliance standards, etc.

Table 3: Class II. :Standard ecological metadata descriptors with proposed changes for TEK, Part B

Class III. Data set status and accessibility
A. Status
    1. Latest update   Date of last modification of data set
    2. Latest archive date   Date of last data set archival
    3. Metadata status   Date of last metadata update and current status

B. Accessibility
    1. Storage and Location medium   Pointers to where data reside
    2. Contact person(s)   Name, address, phone, fax, electronic mail
    3. Copyright restrictions   Whether copyright restrictions prohibit the use of all/portions of the data set
    4. Proprietary restrictions   Any other restrictions that may prevent use of all or portions of data set
        a. Release date   Date when proprietary restrictions expire
        b. Citation   How data may be appropriately cited
        c. Disclaimer(s)   Any disclaimers that should be acknowledged by secondary users
    5. Costs   Costs associated with acquiring data

Table 4: Class III.: Standard ecological metadata descriptors with proposed changes for TEK

CLASS IV. DATA STRUCTURAL DESCRIPTORS

A. Data set file
    1. Identity   Unique file names or codes
    2. Size   Number of records, record length, total number of bytes, etc.
    3. Format and storage mode   File type (e.g. ASCII, binary, etc.), compression schemes employed (if any), etc.

B. Variable Information
    1. Variable identity   Unique variable name or code
    2. Variable definition   Precise definition of variables in data set
    3. Data type
        a. Storage type   Integer, floating point, character, string, etc.
        b. List and definition of variable codes   Description of any codes associated with variables

Table 5: Class IV.: Standard ecological metadata descriptors with proposed changes for TEK

CLASS V. SUPPLEMENTAL DESCRIPTORS

A. Data acquisition
    1. Data forms or acquisition methods   Description or examples of data forms, automated data loggers, digitizing procedures, etc.

    2. Location of completed data forms
    3. Data entry verification procedures   Procedures employed to verify that digital data set is error free

B. Quality assurance   Description of quality assessments

C. Related materials   References and location of maps, photographs, videos, GIS data layers, physical specimens, field notebooks, comments, etc.

D. Computer programs/algorithms   Description or listing of any algorithms used in deriving, processing, or transforming data

E. Archiving
    1. Archival procedures   Description of how data are archived for long-term storage and access
    2. Redundant archival sites   Locations and procedures followed

F. Publications and Results   Electronic reprints, lists of publications resulting from or related to the study, graphical/statistical data representations, etc.

G. History of data set usage
    1. Data request history   Log of who requested data, for what purpose, and how data set was actually used
    2. Data set update history   Description of any updates performed on data set
    3. Review history   Last entry, last researcher review
    4. Questions/comments from 2. users   Questionable or unusual data discovered by secondary users, limitations or problems encountered in specific application of data, unresolved questions or comments

Table 6: Class V.: Standard ecological metadata descriptors with proposed changes for TEK