Chapter 8
Knowledge and Data: An Exploration of the Use of Inuit Knowledge in Decision Support Systems in Marine Management

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Abstract In increasingly data-driven marine and coastal management practices, the issue of "data" is becoming central, resulting in the development of comprehensive data hubs and spatial data infrastructures. These data hubs are often composed of different types of datasets, from oceanographic to biological and socioeconomic. In the Canadian Arctic, and in the context of co-governance arrangements and participatory approaches, these data hubs include, prominently, Inuit knowledge. This chapter explores the ontological tensions of using Inuit knowledge as data in the context of marine and coastal management, and it discusses the nature of Inuit knowledge and the transformations that take place when the knowledge is rendered into data. The authors assess the ability of existing decision support systems and tools to incorporate Indigenous knowledge and propose a number of criteria to integrate Inuit ontological approaches in the design of these systems and tools.

Keywords Canadian Arctic · Decision support systems · Indigenous knowledge · Inuit · Marine spatial planning

8.1 Introduction

As semi-nomadic people, whose livelihood and residence patterns depended on seasonal variations, mobility is at the core of the Inuit approach to the environment and their identities. Though the Canadian government's policies prompted Inuit to move to permanent settlements in the 1960s and 1970s, the social fabric of the Arctic is still based on the timing of mobility and residence patterns. The implication of this

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is that, for Inuit, *home* is not only in today's settlements but also (and mostly) *on the land*, a generic expression used to describe activities that happen outside of the settlement, including the seasonal trails that Inuit travel periodically and the marine environment of which the sea ice is fundamental. This means that while government organizations, nongovernmental organizations (NGOs), and outsiders in general may look at the Arctic environment as wilderness, a shipping corridor, a marine protected area, or a park, to Inuit these environments are intertwined with their own historic and present senses of community and homeland. This sense of place is manifested in harvesting practices, social and economic arrangements, cultural identity, and in the knowledge that Inuit have developed, transmitted, and relied upon since time immemorial. Mobility is, therefore, at the core of Inuit ontologies (Aporta 2009) and is embedded in time-honored social and environmental relations.

In the broad policy and legal contexts within which Inuit have been called to be partners in co-management and co-governance arrangements, interactions between Inuit and government invariably involve ontological tensions, as the environment may be regarded as, on the one hand, an entity to be managed, protected, used, or exploited and, on the other, as a social space or homeland. These tensions are implicit (and often unnoticed) in negotiations, management, and decision-making. They can manifest in differing and sometimes conflicting ideas regarding conservation of the environment, the structure of governance arrangements, and the validity of scientific evidence and of Inuit knowledge.

In increasingly data-driven marine and coastal management practices, which include frameworks such as ecosystem-based management, integrated coastal zone management, integrated ocean management, and marine spatial planning (MSP), the issue of "data" is becoming central, resulting in the development of comprehensive data hubs and spatial data infrastructures. These data hubs are often composed of different types of datasets, from oceanographic to biological and socioeconomic. In the Canadian Arctic, in particular, these hubs, such as the Inuvialuit Settlement Region Online Platform (ISROP), include (predominantly) Inuit knowledge. The ontological tensions referred to above are also present in the making, composition, and integration of datasets.

Decision support systems (DSSs) and decision support tools (DSTs) are broadly understood as computer-supported systems or tools that can process different types of data, visualize uses and observations, analyze dynamics and interactions, and provide estimated outcomes of potential scenarios or decisions.[1] They include standard geographic information systems (GIS), collaborative planning platforms such as SeaSketch, and complex analytical tools such as Marxan (Table 8.1). Some visualization tools such as Esri's Storymaps and open-source Nunaliit are also used in the form of atlases or to convey stories. All these tools deal with a number of challenges, including how to integrate different datasets; how to account for and represent "cultural value"; how to account for changes, both social and environmental,

[1] While these concepts may have had broader meanings when they were coined in the 1980s, DSSs and DSTs are increasingly understood today as involving information and communications technologies.

Table 8.1 Strengths and weaknesses of DSSs and DSTs

Examples	Short description	Strengths	Weaknesses
GIS platforms (e.g., ArcGIS, QGIS)	GIS are systems and tools designed to capture, store, manipulate, analyze, manage, and present all types of geographic data, including local knowledge, and to display and analyze interactions between datasets (Goodchild 2010). They provide users with access to regulatory, spatial, and temporal information outputs (Edwards and Evans 2017)	(1) GIS allows straightforward data integration including local knowledge through cartographic conventions	(1) Advanced skills and expertise are still required to use these tools in full capacity
		(2) GIS programs allow Indigenous users to work interactively with models and data, as well as to conduct spatial queries based on certain criteria and Indigenous priorities	(2) GIS platforms have very limited ways to deal with nonspatial data, such as narratives
		(3) GIS programs have tools that allow for defining and visualizing cultural values	(3) GIS platforms have limited capabilities in terms of dealing with dynamic/changing seasonal data, including representations of the sea ice dynamics
Marxan	Marxan contains a suite of spatial analysis tools, and it is the most widely used decision support software to help decision-makers find reasonably efficient solutions for conservation planning issues (Ardron et al. 2008). Marxan combines socioeconomic and ecological data, and has been widely used for designing marine protected areas (Van Kouwen et al. 2007)	(1) Marxan and Marxan with Zones can deal with a variety of data, including socioeconomic data and local knowledge	(1) The process of scenario building using algorithms is so abstract that it is often viewed as obscure and dismissed by nonexperts
		(2) They can enhance transparency in decision-making processes	(2) Marxan is limited in terms of incorporating data that cannot be quantified
		(3) They provide complex analytical and scenario-building tools based on management targets	

(continued)

Table 8.1 (continued)

Examples	Short description	Strengths	Weaknesses
SeaSketch	SeaSketch is a service-based online software platform (McClintock and Gordon 2015). It supports map-based discussions and has been used for marine spatial planning initiatives at various scales, for a variety of purposes, and for engaging all types of users and stakeholders (McClintock 2013)	(1) Easy for users to use through online platform	(1) Requires certain level of technical skills to use the online platform
		(2) Easy access to data	(2) Requires considerable funding for continued access and use
		(3) Incorporates diverse data and ideas from user groups and stakeholders	(3) Requires reliable Internet connection
		(4) Can provide immediate analytical feedback	
		(5) Advanced collaboration and engagement tools for users and stakeholders	
		(6) Allows for remote participation through the online platform	
DESYCO	DEcision support SYstem for COastal climate change impact assessment (DESYCO) is a DSS system developed in Italy for water resource management. DESYCO is a multidisciplinary DSS for analyzing risks and biophysical and socioeconomic impacts on a regional scale. It is designed particularly to facilitate engagement by means of end users' analysis and collection of preferences (Santoro et al. 2013)	(1) Recognizes users' or stakeholders' control of the decision-making process	(1) Large resources devoted to comprehensive stakeholder engagement
		(2) Integrated assessment and management on a regional scale	(2) Hazard scenarios are developed by numerical models and statistical analysis which require high degree of technical skill and research capacity
		(3) Multi-criteria decision analysis to balance differing priorities	

(continued)

Table 8.1 (continued)

Examples	Short description	Strengths	Weaknesses
Nunaliit Atlas Framework	The Nunaliit Atlas Framework aims to facilitate storytelling and participatory mapping, allowing for the use of different forms of information from a variety of sources, using maps as a central way to connect and interact with the data (GCRC 2018)	(1) Simple for users to use	(1) Acts as a visualization and data collection tool and is not a DST per se
		(2) Permits web-users to contribute additions and make changes	(2) Requires Internet access and basic software operational skills
		(3) Designed particularly for Indigenous knowledge	
		(4) Able to store text-based attributes	
		(5) Deals well with narratives by allowing multimedia objects on a map	

over time; how to deal with different views from diverse users and practitioners; and how to support participatory decision-making processes. In the case of the Canadian Arctic, an additional challenge is related to the documentation, processing, analysis, and integration of Inuit knowledge.

This chapter will explore the ontological tensions of using Inuit knowledge as data in the context of marine and coastal management. It will first discuss the nature of Inuit knowledge and the transformations that take place when the knowledge is rendered into data. It will then reflect on how some DSSs incorporate (or could incorporate) Inuit knowledge. Finally, it will propose a number of criteria to integrate Inuit ontological approaches in the design of DSSs. This chapter is exploratory, and its focus is conceptual rather than technical, with the main goals of (1) outlining some ontological tensions regarding the collection and use of Inuit knowledge in marine and coastal management in the Canadian Arctic and (2) exploring some potential ideas of designing DSSs that are culturally appropriate and informed by Inuit views and knowledge.

8.2 Inuit Knowledge as Data: Transformations and Contextualization

No experiential knowledge can be seamlessly represented and converted into data, as the process will always involve various levels of transformation and interpretation. Some information management models account for the differences between what they sometimes refer to as wisdom, knowledge, information, and data (e.g.,

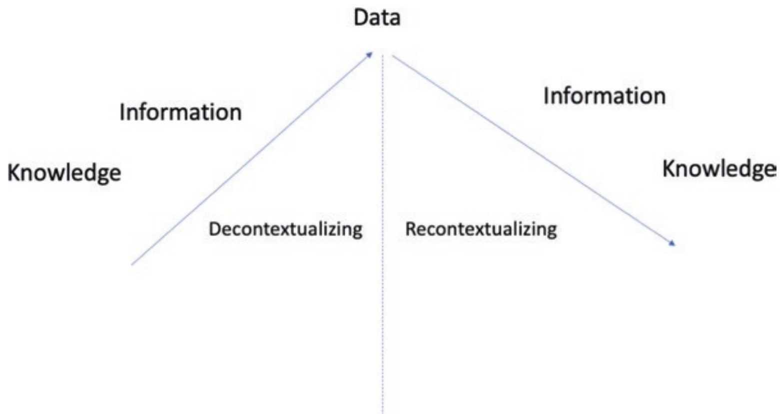

Fig. 8.1 The process of de- and recontextualization in the knowledge-information-data continuum. Wisdom has not been included in the diagram as the concept is not relevant for our discussion

Rowley 2007). Most models characterize wisdom as more abstract and contextual, while data is considered the least abstract and contextual (Cooper 2010; Aamodt and Nygård 1995). What demarcates the difference between each state is somewhat blurred, with transitions often characterized through varying degrees of ascribed meaning (Bates 2005).

For instance, we could reflect on a situation in which a decision is made on whether or not to cross a river in certain places based on the depth of the water. Wisdom may be defined as making a decision based on the knowledge of the parts of the river that are easier and those that are more difficult to cross, according to observations of depth. The depths that are good for crossing can be input into a dataset of measurements. The data itself is stripped of context and abstraction, while the decision to cross the river (or not) at a particular location will include both abstraction and context.

This model, as straightforward as it may seem, is complicated by the fact that in reality the continuum of wisdom-knowledge-information-data does not exist as a chain of discrete states in experiential observations or behaviours. Context and abstraction can be derived, for instance, from information and data. In essence, the river's depth can be used to make other assessments; for example, a biologist can use the data in defining the features of a particular ecosystem (instead of using it to make a decision about crossing). The data is decontextualized of its original meaning and practical use and recontextualized in other uses and interpretations. In other words, the data, separated from its original context, can be placed in other contexts and its meaning redefined, as illustrated in Fig. 8.1.

The process of documenting and the possible recontextualization of knowledge can potentially be a heavily loaded political process, whether intended or unintended, as Indigenous knowledge can be used to justify or inform certain decisions or claims. If the context of the knowledge is not retained, the recontextualization and subsequent uses of the data could no longer support the interests of the original knowledge holder. This problem has been identified by Indigenous groups who have introduced concepts such as Indigenous data sovereignty (Walter and Suina 2018; see also Tesar et al. 2019), guided by principles including OCAP™ (Ownership, Control, Access and Possession).

Inuit knowledge, as described in the Introduction, is intrinsically experiential and contextual. It is based on observations of states, dynamics, and relationships and is rooted in individual and collective memories and experiences. For example, knowledge related to sea ice safety is learned in the context of harvesting, traveling, and, in a broader sense, living. It is for this reason that documenting, for instance, places where harp seals can be harvested, will be invariably related to broader experiences of the environment and of others. It is possible to render the location of the harvesting site as information and eventually as data (a geographic coordinate, or *a point*, to use GIS terminology). If the context is not documented, such a point may become detached from its original context and meaning and recontextualized in different ways. This process is far from simple and straightforward. To a local hunter looking at the harvesting site on a map, the point may become reattached to its original context, but to a biologist, the point may become integrated to other knowledge, and a new context (e.g., presence of harp seals) may be created. On the other hand, if the original context is documented in relation to the point (this can be achieved, for instance, through the recording of the narratives that accompanied the documentation process and included as part of the metadata of that point feature), some contextual information of the original experiential knowledge may be retained.

The process of decontextualization and recontextualization is unavoidable,[2] but an understanding of Inuit ontologies could inform the paths through which knowledge is documented, managed, and (to a degree) interpreted, in order to avoid recontextualization practices that may substantially alter the original knowledge. The abovementioned harvesting site, for instance, can be associated (through a documented narrative) to seasonal variations, broader ecological understandings, wind directions, ice dynamics, seasonal camps, historical memories, family and community relations, place names on the shore, and open water or sea ice routes. Knowledge in this sense is embedded in a host of environmental and social experiences, making documentation of context integral to minimizing knowledge loss through decontextualization and recontextualization processes.

Inuit place names are appropriate examples of the relationships between knowledge and context. As Inuit are holders of an oral culture, place names are good indicators of collective knowledge, observations, memories, and experiences. Salliq (Fig. 8.2) is an island east of Igloolik. The name of the island refers to the fact that it is located "furthest from the mainland," and its location can be rendered into a latitude and longitude in a geographic coordinate system (69.0994346; −78.8144168).

There are many places named Salliq or Salluit (plural) in the eastern Canadian Arctic (including the settlement formally known as Coral Harbor). Salliq in Fig. 8.2,

[2] Semiologist Roland Barthes argued that any sort of "text" is actually produced through the reader's engagement with the original writing/narrative (1973).

Fig. 8.2 The island of Salliq, east of Igloolik in northern Foxe Basin

however, was properly documented in the context of an Inuit-led place names project in the Igloolik area, and a narrative of the place provided by Noah Piugattuk in the 1980s was recorded. Piugattuk's narrative unveils significant contextual knowledge that would be lost if the documentation process had only included the location and meaning of the name:

> When Noah Piugaattuk was a boy, many caribou starved to death here [in Salliq] because it had rained in the winter. The whole island was covered with ice and, since then, no one camps here. Before the arrival of traders in the Igloolik area, some Inuit would camp here from autumn until spring, hunting polar bears for trade in Pond Inlet. (unpublished material, part of the Igloolik Oral History Project database)

It is clear that the context of Salliq is multifaceted, as it includes biological and ecological information, human use, weather events, personal memories, and lessons learned. The context is surely richer, as it is embedded in broader narratives and experiences possessed by Noah Piugattuk and others in Igloolik. A process of documentation informed by Inuit ontologies would include some level of reference to or understanding of the broader and comprehensive nature of Inuit knowledge, especially regarding the limitations of fragmenting that knowledge to make it fit within western scientific or management frames of reference. In other words, documenting one type of knowledge (e.g., presence of polar bears) will only have limited value unless some process of context keeping is established.

In practical terms, a data collection process of Inuit knowledge should consider the significance of other variables, such as seasonality and sea ice dynamics. Salliq is not just a point on a map, but it is knowledge of a place that is connected to other phenomena and events. In the case of MSP, such contextual dimensions can be accounted for in the form of documenting (a) narratives associated to the feature, (b) seasonal observations including sea ice as an extension of the land, and (c) a definition of "cultural value" that would allow for representation of a given place, such as Salliq, in connection to traditional travel routes. Salliq, therefore, will become a place within a network rather than an isolated indicator of human use (the harvesting of polar bears) or a species' habitat.

The concept of "cultural value" has been coined to identify places that are not immediately defined by a single discrete piece of information (e.g., the location of a harvesting site) and as a way to represent qualitative information in a world of quantitative data. In the context of defining spaces that reflect cultural value, this could include demarcating marine and coastal spaces that are distinguished not only by the presence of a harvesting site but also by other types of use and knowledge. As mobility is at the core of Inuit environmental and social relations, it should occupy a central role in defining "cultural value" spaces, allowing for a more comprehensive approach to data collection and interpretation that would include places within broader contexts.

Data is often conceived as static states of knowledge, a conception which is contrary to the dynamic synergies between individual, community, and environment that shape core aspects of knowledge. In this sense, documenting seasonal or cyclical observations and change is another important method of contextualizing data. It should be understood that seasonal changes in the Inuit context do not necessarily follow western conceptions of the four seasons, as temporal boundaries are determined by interactions with environmental or ecological phenomena that are also in flux (Mackenzie et al. 2017; Aporta 2016). For example, throughout the year, sea ice acts as an extension of the land, allowing for mobility networks to expand or contract in response to changing sea ice conditions (Aporta 2002). Subsequently, as routes adapt, harvest patterns, ecological observations, and the social fabric of a community all respond to and revolve around such temporal changes. While accounting for all interactions may be beyond the scope of data documentation, considering seasonality or temporal cycles can provide a basis for deriving other relational contexts (e.g., through metadata).

Methodologies for mapping Indigenous knowledge in context have been extensively developed in the practice of participatory mapping, also referred to as "counter mapping" (Rundstrom 2009), as it provides cartographic representations of objects or events that otherwise would not appear on regular maps. Map biographies were fully developed in land use studies in the 1970s in Canada (see, for instance, Freeman 1976), and best practices for mapping of Indigenous knowledge have been clearly laid out (Tobias 2009). Public participatory GIS (PPGIS) are approaches to bring the academic practices of GIS and mapping to the local level to promote knowledge production by local and nongovernmental groups (Sieber 2006). The connection between counter mapping or participatory mapping and MSP, however, has been less explored, and it is certainly underdeveloped in concrete practices of marine management. While there are many examples of including Indigenous knowledge at different stages of a decision-making process (especially in situations involving co-management), the idea of adapting DSSs or DSTs according to Indigenous ontologies, such as concepts of the environment, is quite novel. It is often acknowledged that Indigenous knowledge is important for marine management, but the knowledge is usually collected and used in the context of scientific or western frames of reference, including theories, methods, and, ultimately, epistemology. The issues we will address in the next two sections are (1) how well-suited current DSSs and DSTs are in considering Indigenous ontologies and (2) criteria that could help to design culturally appropriate DSSs and DSTs that align with Indigenous approaches to knowledge production and sharing.

8.3 Indigenous Knowledge and Ontologies in Decision Support Systems and Tools

As mentioned above, DSSs and DSTs are broad concepts that involve a variety of programs and platforms (Kannen et al. 2016). Coleman et al. (2011) organized DSTs in relation to their functions and role in the different phases of the marine planning process, demonstrating that issues around knowledge documentation, data management, and community engagement are present in all stages of marine management and are embedded in DSTs (Fig. 8.3).

DSSs and DSTs have been used to support evidence-based decision-making for terrestrial, coastal, and marine management in places and on issues that often

PROCESS MATRIX

This Process Matrix shows the generic steps of a marine spatial planning process and the DST functions that can add value to each of the steps.

	PROCESS STEP					
TOOL FUNCTION	Gather data and define current conditions	Identify issues, constraints, and future conditions	Develop alternatives	Evaluate alternatives	Monitor and evaluate management measures	Refine goals and objectives
Data management	✓					
Mapping and Visualization	✓	✓	✓	✓	✓	✓
Alternative scenario development and analysis		✓	✓	✓		
Management measure option proposal			✓	✓		
Stakeholder participation and collaboration, and community outreach and engagement	✓	✓	✓	✓	✓	✓
Adaptive management and assessment of achieving objectives				✓	✓	✓

Fig. 8.3 DSTs organized by function and process within MSP. (Retreived from Coleman et al. 2011)

involve local and Indigenous communities. This section looks at three aspects of the intersection between DSSs and DSTs and Indigenous ontologies: (1) how the systems and tools deal with the process of data transformation and integration; (2) how they allow for the incorporation of Indigenous-informed decision-making; and (3) how they are suited for the implementation of cross-cultural procedures. Examples are drawn from tools and platforms that are often used in data-driven decision-making (GIS, Marxan, SeaSketch, and DESYCO), as well as from Nunaliit, an online atlas that allows for narratives and multimedia representations of knowledge.

Data integration involves pairing Indigenous knowledge data alongside other types of data, such as biophysical, oceanographic, atmospheric, geological, socio-economic, and non-Indigenous human uses (e.g., commercial shipping). In other words, Indigenous knowledge becomes one dataset among many others. In marine planning, such integration is often done through the spatial attribute (location) of the data. In addition, data integration also involves assembling quantitative and qualitative data from different sources, as well as dealing with different spatial and temporal scales, and collection methods. Hence, integrated databases (data hubs or data atlases) require dealing with datasets that are not only different in nature and composition but that also belong to different stakeholder groups or organizations. Once again, it is critical that the user understands the context of the data and that it is maintained when integrating different datasets. This often requires tiered levels of information access and flow.

As mentioned in the previous section, assigning cultural values to places is a way of rendering Indigenous knowledge into data. As shown in Table 8.1, while GIS software is not specifically designed for participatory approaches, it can be adapted to document knowledge and practices through a community-led process. Cultural values and relationships between places of importance can be assigned, visualized, and analyzed through methods such as *buffering* (identifying regions on a map within a specified distance of one or more features) and *network analysis* (examining the properties of natural and human networks in order to understand the behaviour and linkages of flows within and around them). Temporal indicators, such as seasons, can be also included in the data. GIS platforms, however, are poor at incorporating narratives and other forms of nonspatial qualitative information.

Spatial analysis tools such ArcGIS and Marxan are the most common DSTs, and they are used for visualizing, integrating, and analyzing data (Janßen et al. 2019). Marxan is also used for creating management scenarios and conservation targets based on data-driven evidence. They can combine socioeconomic and biophysical data and display complex interactions between datasets. These analytical tools can help conduct comprehensive spatial analysis to enhance transparency in the decision-making process, but they are heavily reliant on external expertise (particularly Marxan) and mostly based on quantitative and/or decontextualized data.

SeaSketch is a web-based planning tool, which is being used for MSP around the world (McClintock and Gordon 2015). It allows users to input local data and use cartographic tools to transform their knowledge into features in a way that is easily understood by other stakeholders. SeaSketch is a development of Esri's GIS platforms, and it allows participatory approaches, including online collaborative mapping by different stakeholders and users that may be situated in different parts of the world. As such, SeaSketch provides a user-friendly platform that can be used in cross-cultural settings, as long as clear parameters are set. For instance, a transportation agency could input shipping data, a conservation NGO could provide data on beluga whales' habitats, and an Indigenous organization may provide rolled-up (aggregated) data related to cultural significance. At the same time SeaSketch is costly, requires continuous expert input, and is limited in terms of including nonspatial data, such as narratives.

SeaSketch, however, is used by the Marine Planning Partnership for the North Pacific Coast (MaPP) for collaborative planning among the four subregions of British Columbia: Haida Gwaii, North Coast, Central Coast, and North Vancouver Island. MaPP has integrated Marxan outputs into SeaSketch projects to inform the design of protection management zones, which are used in discussion with stakeholders. MaPP draws upon and integrates different knowledge and data sources in planning initiatives, including traditional knowledge. For example, the Council of the Haida Nation documented cultural sites, ecologically important areas, harvesting sites, and marine species in the Haida Marine Traditional Knowledge Study through participatory mapping. To maintain the richness, complexity, and context of Haida traditional knowledge, interviews—both map-based and to record oral histories—were conducted to document spatial and temporal patterns of marine use and the stories behind their significance (Council of the Haida Nation 2011). The map in Fig. 8.4 illustrates the approach that was taken to present traditional knowledge in a holistic manner.

Some additional challenges for DSTs are the seasonal dynamics of Inuit knowledge and land/marine use patterns and the changing states and processes of the sea ice, which are difficult to represent and analyze cartographically. They are also not suited for the representation of nonspatial information, and they are challenged in their ability to account for expert opinion. Marxan and Marxan with Zones are useful analytical tools when properly incorporated into broader information and knowledge management systems.

Some of these challenges can be overcome through the use of PPGIS and participatory tools such as the atlas platform Nunaliit. The Nunaliit Atlas Framework, created by the Geomatics and Cartographic Research Centre at Carleton University, has been designed to store and display text-based attributes and "data objects" in a relatively simple way, allowing for multimedia tools to represent nonspatial dimensions of knowledge in a cartographic way. Nunaliit is open source and follows the principles of cybercartography proposed by D.R.F. Taylor. Taylor (2005) defined it as "the organization, presentation, analysis and communication of spatially referenced information on a wide variety of topics of interest to society in an interactive, dynamic, multisensory format with the use of multimedia and multimodal interfaces." Nunaliit allows users to create attributes and make changes through online platforms. However, the framework is a visualization and collaborative tool, and it has not been incorporated into broader DSSs or used in the context of decision-making in marine planning.

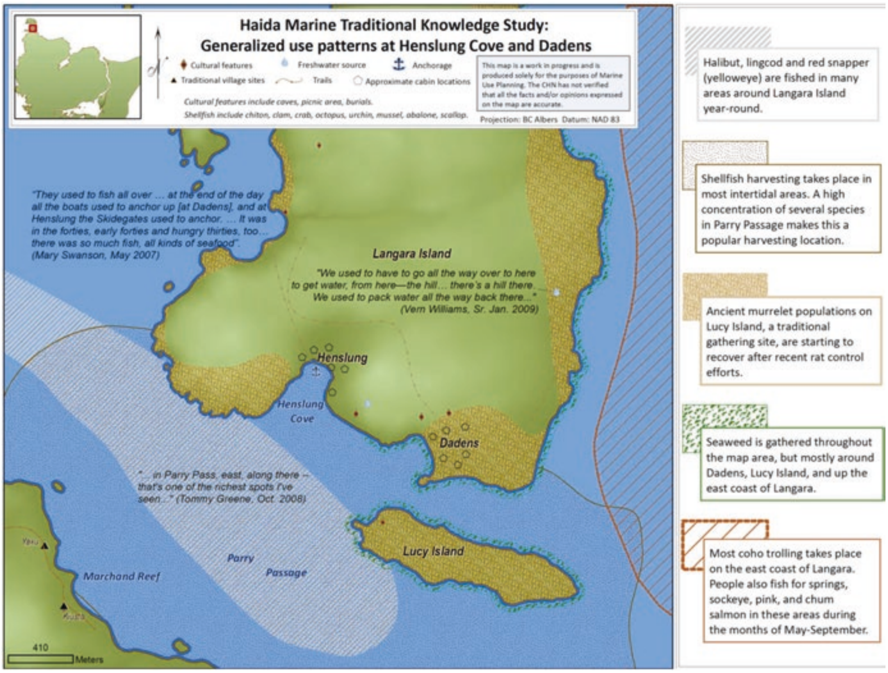

Fig. 8.4 Map showing cultural and ecological significance in Henslung Cove and Dadens (Council of the Haida Nation 2011)

Emerging data sovereignty concepts encourage Indigenous groups to play a key role in Indigenous data governance, including data collection, interpretation, management, application, and dissemination. Current DSSs and DSTs provide some opportunities for Indigenous peoples to input, analyze, edit, visualize, and share a variety of datasets but are limited in terms of reliance on outside expertise, limitations to include narratives and nonspatial data, and lack of participatory tools integrated into DSSs. Most DSSs and DSTs are not designed to focus particularly on Indigenous research needs, which results in limited functional ability of DSSs to interpret Indigenous knowledge. Furthermore, most DSSs and DSTs are highly technical, which remains an important factor preventing practitioners from using them (Janßen et al. 2019). For example, Marxan and Marxan with Zones have been accepted as the most commonly used DSTs, but they require a high level of expertise and strict data formats and lack user-friendly interfaces. In practice, these tools are not designed according to Indigenous communities and organizations' capacity. Ultimately, the outcomes of these tools could be misleading if they are not utilized properly (Janßen et al. 2019) or if they do not incorporate input by users and stakeholders. This can result in constraints and disadvantages for DSTs like Marxan to incorporate Indigenous data and knowledge.Table 8.1 summarizes some inherent strengths and weaknesses of the platforms described in this chapter, in regard to the documentation of integration of Indigenous knowledge and in terms of accounting for Indigenous ontologies. It is not a comprehensive table but rather an illustration of transformations and alignments (or misalignments) between DSSs/DSTs and Indigenous knowledge.

Some participatory DSTs and DSSs are attempting to support end users' continuous involvement throughout the decision-making process. For example, the DEcision support SYstem for COastal climate change impact assessment (DESYCO) is a participative DSS that recognizes end users' control of the entire decision-making process. It was designed particularly for involving user groups and stakeholders by means of end users' analysis and collection of preferences (Santoro et al. 2013). Within DESYCO, comprehensive engagement is conducted in each decision-making process; users and stakeholders are able to detect and check the overall usefulness of this DSS. However, involving end users in the development of DSSs is not yet common practice (Bolman et al. 2018). Most DSSs and DSTs are designed and/or used by planners, academics, and programmers and are often distrusted or little understood by Indigenous peoples (Stelzenmüller et al. 2013). Indeed, incorporating traditional knowledge into decision-making must go beyond simply integrating scientific and traditional knowledge systems and methods. Holistic approaches to coastal and marine management require power sharing and the capacity to participate in decision-making. Necessarily, tools and approaches to linking knowledge systems must ensure protections against the misuse and exploitation of traditional knowledge and that the source communities maintain control of access and use of the knowledge.

8.4 Criteria for Incorporating Inuit Ontologies in Decision Support Tools

Article 32.2 of the UN Declaration on the Rights of Indigenous Peoples (UNDRIP) stipulates:

> States shall consult and cooperate in good faith with the indigenous peoples concerned through their own representative institutions in order to obtain their free and informed consent prior to the approval of any project affecting their lands or territories and other resources, particularly in connection with the development, utilization or exploitation of mineral, water or other resources.

Through the ratification of UNDRIP, its intention to act upon the findings of the Truth and Reconciliation Commission,[3] and the creation of institutions and initiatives such the Inuit-Crown Partnership Committee, the Government of Canada is increasingly engaging Indigenous peoples in matters of governance. Community engagement in marine and coastal management is also clearly articulated in ocean policy, particularly in the Oceans Act (1996). Canada has committed to establishing

[3] The Truth and Reconciliation Commission was established by the Government of Canada in 2008 with the goal of documenting the history and lasting impacts of the Canadian Indian residential school system on Indigenous students and their families.

partnerships and collaborating with Indigenous communities in initiatives under the Oceans Protection Plan (Transport Canada 2016). In 2018, the Reconciliation Framework for Bioregional Oceans Management and Protection was signed by Canada and 14 First Nations on the North Pacific Coast, which establishes co-governance structures for marine planning initiatives in the Northern Shelf Bioregion (DFO 2019). However, a major gap persists on how to effectively and practically facilitate and enable this engagement.

Since marine management today inevitably involves data collection and integration, it is clear that not only governance arrangements but also data protocols must follow the principles of free, prior, and informed consent. The premise in this chapter is that true engagement will involve taking the appropriate steps to ensure that Indigenous knowledge is properly transformed into data and that the process of data integration will be done in a respectful and intercultural manner. This involves assuming that Indigenous cosmologies will inform the design of DSS and that the processes of data collection, analysis, and integration will take place in a cross-cultural setting.

The involvement of end users is fundamental in developing a DSS that meets users' needs (Santoro et al. 2013). In a context of co-governance and genuine participation, DSSs in the Canadian Arctic should be developed in partnership with Inuit organizations and communities, opening doors for Inuit ontologies to shape the design of the decision-making process and DSSs in accordance to Inuit practices and understandings.

Inuit Tapiriit Kanatami (ITK) recently released a policy paper entitled "National Inuit Strategy on Research" in which it emphasizes that Inuit involvement in research is a matter of self-determination (ITK 2018). The ITK document articulates Inuit expections for how research in their territories should be conducted, providing guidelines that cover the whole research process, from identifying research priorities to communicating research outcomes. The document's value extends beyond the limits of academic research, and it can be taken as a guide for defining the criteria for the improvement of DSSs and DSTs in Arctic coastal and marine planning. The criteria listed below do not constitute a comprehensive list, but an exploration of potential ways in which the issue of data can be better approached in the context of coastal and marine management. Definite criteria, in fact, would require Inuit engagement, but the ideas suggested in this policy paper align with participatory approaches and our interpretation of Inuit ontologies.

Among the preconditions for the design and applications of these decision-making systems are (a) a comprehensive engagement process with Inuit communities and organizations; (b) a clear and balanced co-governance framework and legislation; (c) appropriate funding to support initiatives, training, and implementation; and (d) consideration that, in an intercultural setting, building capacity is a two-way process involving social learning from all relevant actors. In essence, the preconditions of an Inuit-informed DSS involve a process of empowerment. An Inuit-informed DSS could/should therefore involve the following:

1. A comprehensive data management plan (DMP), which would include data sharing and data ownership agreements. The DMP must establish clear rules for access, collection, protection, integration, and use of all datasets, with special provisions for Indigenous knowledge. In the Canadian Arctic, data collection protocols should include provisions for accounting for temporal/seasonal variability and for the specific nature of the sea ice as a recurrent and dynamic feature. The DMP must also recognize the oral and experiential nature of Inuit knowledge, providing guidelines for documenting contextual information and narratives.
2. Cultural values as defined by Inuit mobility and other ontological considerations. Any Inuit-informed DSS should recognize the relationships between people and the environment and connectivity between places and between environmental phenomena. Further, such recognition must circumscribe practices of compartmentalization or data disaggregation that do not adequately support an Inuit ontological approach. It is important to sustain representations of the interconnectivity and interdependency of social-environmental relations to strengthen how cultural values are incorporated, whereby such cultural values are rooted in mobility and seasonality, and which intersect with subsequent social and environmental relations.
3. Contextualization of data. As data integration within a DSS is inevitable, ensuring that Inuit-sourced data can remain contextualized is imperative to supporting an Inuit-informed DSS. While incorporation of "cultural value" data achieves this, additional methods such as including narratives or accounting for temporal changes can help avoid knowledge loss through decontextualization processes (e.g., through data aggregation in a DSS). It could be assumed that all planners or managers interacting with a DSS may not have a deep understanding of Inuit ontological approaches. However, through creating a DSS that supports context keeping, key ontological aspects may be retained.
4. PPGIS in the planning and management process. Combined with visualization and analytical tools, PPGIS can allow Inuit users to enhance data control, share knowledge and experiences, express different perspectives, collaborate with other stakeholders, and facilitate participatory learning. PPGIS in this context is strengthened by acquiring the consent of Inuit prior to the decision-making process, recognizing Inuit priorities in decision-making and implementation, and reflecting Inuit priorities throughout planning and management processes.
5. An integrated and user-friendly DSS. Given the comprehensive nature of Inuit knowledge, and complex interactions with the environment, an integrated and user-friendly DSS is suggested, to avoid additional fragmentation of knowledge and to empower Inuit communities and organizations. This DSS would be conceptualized in consultation with Inuit, but it could involve the following features: a well-defined data hub, allowing for interoperability of datasets; a user-friendly interface, combining visualization, PPGIS, and analytical tools; web-based, allowing for remote access to enable Inuit communities and other actors to participate in decision-making; and conceptualization of the decision-making process where data-driven analysis and expert opinion could coexist.

6. Continuous funding and capacity building. Developers should create a user-friendly DSS according to research capacity of Inuit communities and organizations to support their proactive involvement in planning and management, and to increase their access to and control of data. Also, tenable funding should be provided to balance financial sustainability and technical stability of the DSS (Pınarbaşı et al. 2017). It should also be designed to facilitate participatory learning and research capacity building among Inuit and non-Inuit stakeholders. Non-Inuit stakeholders can learn about Inuit ontologies, while Inuit can learn about western science and research approaches to improve communication and understanding between those involved in decision-making.
7. Co-governance friendly systems. Ultimately, an Inuit-informed DSS should support not only decision-making but co-governance arrangements. In this sense, usership of the DSS should increase the applicability of its outputs in policy formulation and support the implementation of policies and decisions. Through the use of an Inuit-informed DSS, such outputs can perhaps reduce some of the ontological tensions that arise between Inuit and other levels of government in decision making while strengthening co-governance legitimacy by overcoming issues of policy inertia.

8.5 Conclusion

This chapter has highlighted the ontological tensions of using and integrating Inuit knowledge into DSSs and DSTs, as well as approaches to overcome some of the challenges inherent in converting Indigenous knowledge into information and data. As collaborative approaches—whereby power is redistributed to enable local communities to influence planning and decision-making processes—are becoming more prevalent as principles and processes of good governance, preservation of the context and the stories behind the ecological and sociocultural significance of Indigenous knowledge are often overlooked. Many applications of DSSs and DSTs fall short of dealing appropriately with quantitative and qualitative data of varying spatial and temporal scales, as well as narratives, seasonal changes, and broader experiential contexts. The preconditions of integrating Inuit knowledge into decision-making tools include a comprehensive data infrastructure for storage and visualization of spatial and nonspatial information, recognition of the relationship between Inuit and the environment, participatory approaches to the collection and use of data, and user-friendly systems that promote capacity building. These criteria address some of the challenges of integrating science and Indigenous or local knowledge in DSSs and DSTs to ensure information is presented in a holistic manner and ultimately to advance co-governance goals. Inuit ontological approaches to the environment should inform not only governance frameworks in the Canadian Arctic but also the design of the data and information systems and tools through which decisions are made.

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