Mapping Marine Ecosystem Service Values and Threats

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Abstract

Recognizing that local knowledge and values should play a prominent role in natural resource decision-making, we tested a semi-structured interview protocol to solicit the verbal articulation, spatial identification and a quantitative measure of local monetary values, non-monetary values and threat intensity associated with marine ecosystem services. Ecosystem services are the ecological processes through which nature provides benefits to people. Interviewees identified and characterized a wide range of ways in which they value marine ecosystems in the Regional District of Mount Waddington in British Columbia, Canada. This research is intended to inform an ongoing marine spatial planning process in this region. A total of 30 semi-structured interviews were conducted based on non-proportional quota sampling to target interviewees with a variety of marine-related occupations who live across the district. There was significant spatial overlap among all three pair-wise comparisons of monetary values, non-monetary values, and threat intensity values. Employment in salmon aquaculture correlated with the perception that the ocean does not face environmental threat associated with this industry. A minority of respondents refused to participate in the spatial and quantitative components of this research, yet all verbally identified the importance of marine ecosystems. The results of this research and the methods could complement deliberative processes to enable decision makers to more fully consider stakeholder's non-monetary values and threats associated with ecosystem services.

Key words: ***ecosystem services, marine spatial planning***

1. INTRODUCTION

Around the world, marine ecosystems show signs of distress, including drastically diminished fish stocks, habitat destruction and pollution (Worm et al. 2006). An array of commercial activities have degraded marine ecosystems with some detrimental impacts on human well-being (Dayton et al. 2005; UNEP 2006; MA 2003). In order to work towards more biologically diverse and productive oceans, many countries are conducting marine spatial planning (MSP)(Ehler and Douvere 2009). MSP is a public process that involves the analysis and allocation of human activities over space and time (Ehler and Douvere 2009). This process promises to advance ecosystem-based management, which recognizes both the dynamic relationships among human activities and ecosystem conditions as well as the cumulative impacts of different sectors on ecosystems (McLeod et al. 2005; McLeod and Leslie 2009). MSP also aims to protect, maintain, and restore ocean ecosystem health, reduce conflicts among ocean users and facilitate development that integrates ecological, social and economic objectives (Botsford, Castilla, and Peterson 1997; Lubchenco et al. 2003; Pauly et al. 2002; Foley et al. 2010). By providing a common language and set of metrics for evaluating the flow of benefits and trade-offs associated with natural resource decisions (Daily et al. 2009), an ES framework may help to achieve the goals of MSP. In turn, MSP has the potential to contribute to the long term provision of ecosystem services (ES)(Foley et al. 2010), the ecological processes through which nature provide benefits to people (Levine and Chan in press).

Biophysical features and economic values are often used to identify priorities for and evaluate trade-offs in conservation planning (Naidoo et al. 2006; Klein et al. 2008; Ban and Klein 2009). A framework has been developed for land use planning for biodiversity and ES, which includes locating and prioritizing management effort associated with the production of multiple ES and high levels of biodiversity (Chan et al. 2006; Chan, Hoshizaki, and Klinkenberg submitted). In marine conservation planning, fisheries-focused socioeconomic considerations have been incorporated into the design of networks of marine protected areas (Ban and Klein 2009; Klein et al. 2008). The quality of ecological and economic information used for planning processes is crucial, but it is broadly recognized that the success of changing marine resource policies including marine zoning largely depends on the extent to which stakeholders support the changes. Many who rely on commercial fishing may perceive changes in spatial regulations as a potential loss of commercial use of areas or foreclosed harvests if restrictions are applied (Stewart and Possingham 2005; Sumaila et al. 2000; Roberts et al. 2003). Community support for different marine spatial plans can depend on what people value in the marine environment and perceptions of who benefits and who suffers from changes in management. To improve marine management, understanding context, history and how people affect and are affected by the ocean is important (Shackeroff, Hazen, and Crowder 2009; NCCOS 2007).

To conserve ecosystems and sustain livelihoods as well as other benefits tied to the productivity of ecosystems, a broader accounting of the highly valued tangible and intangible ES values associated with the oceans is needed (Carpenter et al. 2006). Influential decision-making bodies, such as the National Oceanic and Atmospheric Administration (NOAA) and the Environmental Protection Agency (EPA) have begun to use ES frameworks and conduct ES research (Tallis et al. 2010; SAB 2009). Substantial progress has been made to account for the monetary value of ES (Boyd and Banzhaf 2007; TEEB 2009; Daily and Ellison 2002).

Economic valuation of ES, however, has been criticised for the limitations inherent in the commodification of benefits people get from nature, particularly ES with substantial cultural and non-use value (Spash 2008; Chan et al. 2010). Use value is the utility associated with consuming a good. Non-use (or passive use) values refer to non-consumptive benefits that do not require observable use (Arrow et al. 1993; Pearce and Moran 1994). One type of non-use value is existence value, defined as the satisfaction in knowing something exists (Pearce and Moran 1994). Another non-use value is bequest value, which is the fulfillment from giving something to others (Gilipin 2000). Many ES values, including non-use values, simply do not translate into monetary terms. The limitations in reducing benefits from nature to monetary values are apparent when considering values based on a principle or virtue (Chan, Satterfield, and Goldstein in prep; Sagoff 1998). For example, it would likely be offensive to quantify in dollars the moral opposition to allowing the extinction of species like salmon, which are expensive to conserve.

Another set of values that do not translate well into monetary terms is spiritual values, which are related to metaphysical forces that exist beyond the individual (e.g., the spiritual value of a sacred place). The value of transformative experiences enabled by certain ES that change how we think cannot be expressed appropriately or effectively in monetary terms (e.g., the value of a transformative experience of watching a massive salmon migration) (Chan et al. in press).

Although ES frameworks are designed to account for a wide variety of reasons as to why nature is important, they have been critiqued for facilitating only the expression of anthropocentric perspectives. The representation of bio or eco-centric perspectives is not explicitly part of the ES concept (Moore and Russell 2009).

MSP attempts to coordinate planning for a wide variety of ocean-based activities. Currently, MSP calls for additional mapped layers of human use of the ocean. Various projects have used interviews and community workshops to document fishing grounds (St Martin and Hall-Arber 2008; Scholz et al. 2006), but MSP research has yet to focus on spatially identifying non-monetary values associated with particular places in the marine environment and integrating this information with areas of monetary value. Research has been conducted to map stakeholder values and perception of threat on land (Raymond et al. 2009; Brown 2005), but there is no explicit distinction between monetary and non-monetary values in this research. Given the wide array of potential values associated with ES, it is speculated that there is need for a variety of processes that can facilitate the articulation of these values, particularly non-monetary values that can be overlooked or marginalized in decision-making (Chan et al. in prep). This research is an innovative effort to bridge a gap in the literature by documenting spatial local knowledge to map not only areas associated with monetary value but also non-monetary value and places under environmental threat.

This research was conducted through an interview-based mapping exercise in the Regional District of Mount Waddington (RDMW), a sub-region of the Pacific North Coast Integrated Management Area (PNCIMA). To address marine-related conservation, sustainable use, and economic development, Fisheries and Oceans Canada (DFO) identified PNCIMA as a priority for marine use planning. This research contributes to PNCIMA's marine spatial planning efforts through the demarcation of places that provide ES that are considered particularly valuable and places where the benefits that people receive from marine ecosystems are under threat.

1.1. Research Objectives

A methodological contribution from this research is testing the feasibility of an innovative protocol that combines verbal value elicitation with spatial identification as well as quantification of monetary, non-monetary and threat values. It is expected that some of the findings are particular to the case study and others likely apply more broadly.

A major research goal was to map monetary, non-monetary and threat values, where and when it was appropriate to map such values. This research addressed the question of how acceptable for interviewees is the protocol for eliciting spatial values? If participants were unwilling to share spatial information, were the refusals attributed to the method used or the intrinsic nature of the value and threat mapping exercise? It was anticipated that some people would not be willing to share this type of information that could be seen as too personal, sensitive or simply not applicable.

Using the information willingly shared, another research goal was to identify the spatial distribution and correlation of monetary, non-monetary and threat values across individuals and aggregated categories of value and threat. A research objective was to identify places of high value and threat in the RDMW.

The analysis of the spatial correlation of monetary, non-monetary and threat values tests hypotheses with potentially overlapping predictions. Part of the place-based theory of environmental evaluation states that the intensity of values associated with places are discounted the further away the places are from people's homes (Brown, Reed, and Harris 2002; Norton and Hannon 1997). This research tests the hypothesis that people put more value on places that are closer to where they live. This assumes that places that are closer to people's home are also more accessible, more visited and therefore more valued by the people who live nearby.

Although research has been done to map monetary value, particularly related to fisheries landings (Watson et al. 2004), this has not been complemented with maps pertaining to non-monetary values. It has been speculated that people associate non-monetary benefits with the places and practices from which they derive monetary benefits, in part because these various categories of benefits may stem from the same or concomitant activities (Chan, Satterfield, and Goldstein in prep; Chan, Hoshizaki, and Klinkenberg in press). Therefore, two hypotheses are that areas of non-monetary and monetary value correlate at the level of the individual and these values correlate when aggregated across respondents. This would occur if people derive both monetary and non-monetary benefits from the same places.

Alternatively, people may deeply value pristine places where people have had minimal impact. Hypotheses from this speculation are that 1) non-monetary value is not spatially correlated with monetary value; and 2) non-monetary value is not spatially correlated with threat value. The first hypothesis could be explained in light of people placing a higher non-monetary value on pristine areas chiefly because these regions are relatively untouched and not used for economic activities. Consequently, areas valued for non-monetary importance would have little monetary value. A possible explanation for this second hypothesis is that areas under threat are assumed to be heavily used and impacted by people. If people only value pristine areas, non-monetary value would not be associated with areas under threat.

Expression of environmental threat to ecosystems may be correlated with specific professions, particularly in regions similar to the case study site where job opportunities are scarce and/or declining. It is possible that people who are employed in a specific industry may be less likely to perceive environmental threats associated with the activities of their employer. It was speculated that this may be the case in the RDMW with regards to perceived threats associated with the salmon aquaculture industry in the region. From the local to national scale, salmon aquaculture is arguably Canada's most controversial, divisive and intense industrial development conflict (Young and Matthews 2010). In the last 20 years, particularly in this study region, net-pen salmon aquaculture has grown along with controversy over the ecological consequences of this industry's operations (Young and Matthews 2010). Given the polarization on this politically charged topic (Gross 1998; Young and Matthews 2010), it was expected that people whose employment was directly associated with the industry would not articulate, spatially identify or assign relative value to threats associated with their employer.

In addition to these hypotheses and advancing academic understanding of the spatial distribution of values and threats, this spatial analysis has local relevance. This type of spatial data derived from these methods could contribute to elucidating local perspectives on ES in this other locations and contribute toward other marine spatial planning processes that incorporate local knowledge and perceptions of value and threat.

2. METHODS

This project was a collaboration involving the marine conservation organization, Living Oceans Society (LOS), the RDMW and the University of British Columbia (UBC). This project is complemented by an economic assessment of the contributions of the marine environment to the region's economy including regional economic data on wild fish harvests, aquaculture and marine tourism operations (LOS in prep).

2.1. Study Area

This ES value elicitation and mapping method was tested within the RDMW the northern region of Vancouver Island in British Columbia, Canada (Figure 2.1).

Figure 2.1 Regional District of Mount Waddington

In British Columbia, the RDMW spans 20,288 km^2 of land and 9,880 km^2 of ocean. In 2006, the population was 11,651, of which 23.4% are First Nation (Aboriginal), 73.5% are Caucasian and 3.1% are other visible minorities (BCStats). Between 2001 and 2006, the population declined by 11.1%. Life expectancy is 75.8 years compared to 82.1 in Greater Vancouver. The average family income is $65,683 as compared to the average BC family income of $80,511 (BCStats).

Several communities in the RDMW, particularly Alert Bay and Sointula, historically relied on timber and fishing industries. Forestry was the main economic driver for much of coastal British Columbia. During the past 20 years, forestry along Canada's Pacific coast has declined sharply due to many factors including trade liberalization. Declines in forestry combined with a substantial reduction in fishing fleets have created economic challenges in the RDMW and much of rural, coastal BC (Young 2008).

2.2. Fisheries Context

The BC fishing industry has undergone drastic change since the mid 1980s. In an effort to reduce pressure on fish stocks, much of the BC fishing fleet was consolidated. The activity of fishing fleets based in the RDMW and many other communities in BC has declined sharply in the past two decades (Brown 2005). Fleet reductions have been accompanied by some fisheries-related spatial management efforts, including Rockfish Conservation Areas (RCAs).

2.2.1. Existing Marine Spatial Management Measures

After a precipitous drop in rockfish abundances, Rockfish Conservation Areas (RCAs) were implemented in 2002 to rebuild populations of these fish (Yamanaka and Logan 2010). Within RCAs, fishing gear that disturbs benthic habitat is prohibited. In BC, RCAs cover ~4,847 km^2. RCAs cover ~1,036km^2 of the waters in the RDMW, which is ~10% of the waters of this regional district (DFO 2007).

The waters of the RDMW, particularly Johnstone Strait, are summer habitat for BC's northern resident orca (killer) whales, *Orcinus orca*. Whale watching is a popular activity in this Strait. Recognized as critical orca habitat, the Robson Bight Michael Bigg Ecological reserve is closed to recreational boat traffic and it is a voluntary no-entry zone for commercial boats. Orca whales tend to aggregate in this location and use it preferentially over other habitat for beach rubbing as well as feeding (Williams, Lusseau, and Hammond 2009).

2.2.2. Salmon Aquaculture

Net-pen salmon aquaculture is Canada's biggest and most profitable type of aquaculture. As of 2005, the gross domestic product (GDP)[1] contribution of aquaculture to the BC economy was $274 million, sportfishing was $248 million, fish processing was $173 million and commercial fishing was $103 million. Fisheries and aquaculture accounted for 0.6% of BC's GDP in 2005 (MOE 2007).

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[1] GDP measures the value added by an industry or activity to the economy. It is calculated by the total revenue from the sale of goods or services produced by an industry minus the cost of materials and purchased services consumed in the production process.

As of 2007, a total of 42 finfish farm tenures exist in the RDMW. Of these, 26 farms are located in the Broughton Archipelago (MAL 2007; LOS 2007). Salmon net-pen aquaculture is a major source of employment in this region. The expansion of this industry has been accompanied by controversy over the environmental, social and economic ramifications of this industry's operations. From the local to national scale, salmon aquaculture is arguably Canada's most controversial, divisive and intense industrial development conflict (Young and Matthews 2010).

2.3. Interview Sample

People who play an active role in marine resource management as well as others whose income relies on the ocean were interviewed using non-proportional quota sampling. The sampling method was used to solicit a wide range of values from engaged and knowledgeable stakeholders rather than trying to get a sufficiently high sample size for proportional quota sampling (Tashakkori and Teddlie 2003). Project partners at the regional district government and a local marine conservation NGO provided recommendations on who to select for the in-depth interviews. The 30 people who were interviewed represent a wide range of employment activities and live in several communities across the RDMW (Figure 2.2 and Figure 2.3). Due to time and travel constraints, interviewees lived in towns accessible by roads, frequent ferries or short boat rides. This limited the representation of more remote communities in this study.

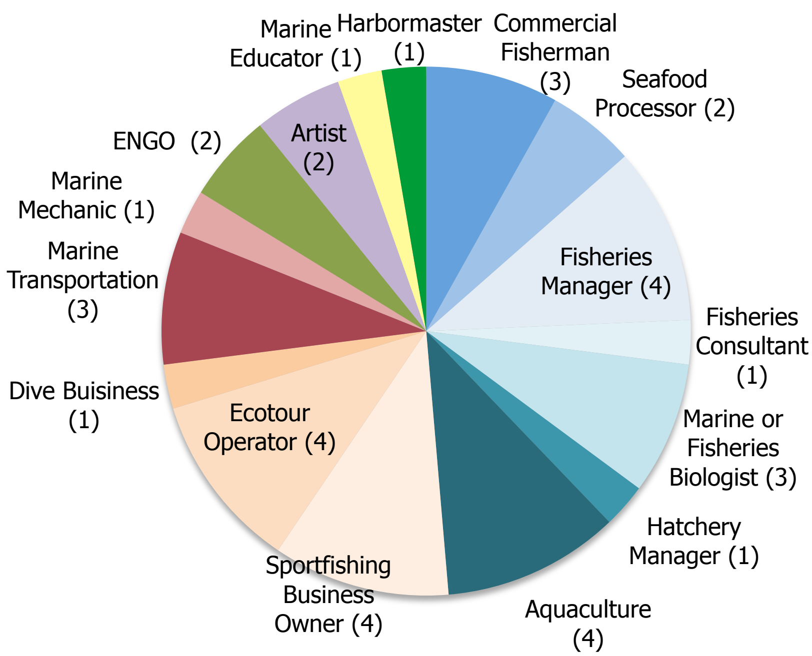

Figure 2.2 Interviewees by profession.
The total is 37 because seven interviewees had two professions. Several occupations, particularly related to tourism, are seasonal, part-time and/or contract-based in this region, which is why some have several jobs. Also, many who invest in boats use them for multiple purposes, e.g., marine transportation for industrial purposes and ecotourism.

A total of seven women and 23 men were interviewed; two were of First Nations descent, and 28 were Caucasians. Participants had lived in the RDMW from 8 to over 65 years with an average duration of 30 years. Interviewees represented a wide range of professions related to the ocean (Figure 3.1) and lived in towns across the regional district (Figure 3.2).

Figure 2.3 Hometown and number of interviewees (n= 30).
Spatial population data was not available for other small communities in the RDMW.

2.4. Interview Design

A total of 30 interviews were conducted between April 9 and June 7, 2010 by one interviewer. After 45 potential interviewees were sent a contact letter inviting them to participate, interviews were scheduled in locations convenient and comfortable for the interviewees. A total of 15 were unresponsive or unavailable for interviewing. When possible, interviews were conducted in people's homes or private offices to maximize their comfort level. Two interviews were conducted in boats belonging to the interviewees, three were done in quiet cafes, eight took place in the interviewees' offices, and 17 occurred in interviewee's homes. Interviews began with signing a consent form and confidentiality agreement along with a brief project description, both in writing and verbalized by the interviewer. Interviews lasted from 54 minutes to 3 hours and 30 minutes. A total of 56 hours of interviews were transcribed.

Open-ended questions were asked to gain insight into how the individual came to have a profession related to the ocean. This was followed with questions pertaining to possible links between the ocean's health and personal as well as community well-being. Interviewees were asked questions about what he/she values from the ocean. Questions about non-monetary value were framed around cultural ES identified in the Millennium Ecosystem Assessment (MA 2003).

The subject was also asked what, if anything, threatens the physical things (e.g., fish and shellfish harvests) or experiences (e.g., recreational boating and fishing) that he/she values in association with the ocean. For an analysis of the verbal content of the in-depth interviews refer to Klain *et al.* (in prep).

A 1m x 2m laminated compilation of nautical charts covering the RDMW at a scale of 1:400,000 was unfurled, usually on a large table or the floor. The chart compilation was made with ten digital nautical charts in ArcGIS 9.3 using the Albers Equal Area projection (NAD83). A mosaic of charts was required to cover the study area because no existing single nautical chart extended across the entire study region with adequate detail.

Interviewees were asked to identify areas in the ocean that they rely on for their economic livelihood by drawing polygons with a green pen around these locations. Interviewees were asked why each area is important to him/her. Relative importance was assessed by asking interviewees to allocate a set number of units symbolizing relative value (Raymond et al. 2009). Building on methods used in other marine planning processes (Scholz et al. 2006), the interviewee was asked to distribute 100 tokens according to the relative monetary importance of each area to him/her.

After open-ended questions on cultural ES to encourage people to think about the connection between place and heritage, identity, activities including subsistence food collection, spirituality, art, education and intergenerational values, interviewees were asked to use a blue marker to identify regions important for non-monetary reasons. Once the locations were marked, he/she was asked to distribute 100 blue wooden tokens that represented non-monetary value. No specific metric of non-monetary value was provided to the interviewees. Each individual decided how to allocate relative non-monetary value based on a wide range of experiences, benefits, and emotions associated with natural elements of particular places.

The final interview questions covered threats to the marine ES that people value. Interviewees were asked to draw polygons with a red pen around areas that are threatened and/or sources of threat. In some cases, the sources of threat were not spatially explicit (e.g., ocean acidification, marine debris, PCB and heavy metal contamination). These non-localized threats were recorded, but not mapped.

The sequence of value elicitation, starting with monetary, then non-monetary and lastly threat, was consistent for all interviews. The rationale behind this order was that asking the more straightforward, concrete questions about monetary value helped interviewees become accustomed to the style of the questions asked, particularly the spatial prompt. This was followed with several questions intended to facilitate the articulation of intangible ways in which marine ecosystems contributed to their well-being. The semi-structured style of these interview questions likely helped interviewees develop a higher level of comfort with the interviewer. Given the affective and sensitive nature of information regarding non-monetary values, this rapport likely contributed to interviewees sharing their areas of non-monetary importance with the interviewer. When identifying threatened areas or sources of threat, interviewees often referenced their areas of monetary and non-monetary importance and the associated notes about why areas were important.

Initially, interviewees were provided wooden tokens, which they placed on the polygons that they drew. Distributing three sets of 100 1x0.25 cm discs proved difficult to keep track of so later interviewees allocated relative value by writing numbers in erasable pen within the polygons drawn on the nautical chat. The participants often erased and adjusted units as he/she distributed them.

A D-SLR Nikon D70s on a tripod was used to photograph the chart marked with each interviewee's green, blue, and red polygons with notes on associated values as well as numerical relative values. The nautical chart was then erased after the photos were taken. These photos were imported as images (jpg files) into ArcGIS 9.3, set to semi-transparent, overlaid on top of base layers of land, coastline the regional district boundaries and the appropriate digital nautical chart. The images were georeferenced based on these layers. Shapefiles were created by digitally tracing interviewees' polygons from the georeferenced photo. In the table associated with each shapefile, the relative value and different ES value was recorded. For each interview with spatial information, a total of three shapefiles were created, each with polygons associated with monetary, non-monetary or threat values.

2.5. Spatial Analysis

2.5.1. Calculating Relative Value

The relative value by area was calculated by dividing the number of monetary, non-monetary or threat tokens associated with the shape by the area of the polygon. Each shapefile was overlaid with a grid of 500x500m cells. This cell size (0.25-km^2) was chosen as being slightly larger than the smallest polygon drawn by an interviewee (0.2-km^2), which we assumed to indicate roughly the scale at which interviewees conceive of areas of value and threat. This cell size provided a reasonable level of detail given the extent of the study region (9,880 km^2 of ocean) and allowed us to avoid artificial autocorrelation by analyzing data at a resolution smaller than that of responses. A coarser resolution would have diminished the level of spatial detail that the interviewees provided.

Each grid cell was assigned a unique numerical identification number. The shapes drawn by interviewees were overlaid and intersected with the grid to spatially summarize the monetary value, non-monetary value or threat intensity by each cell. The relative value associated with each grid cell was calculated according to the following methods. The relative importance of each grid cell was weighted based on the number of assigned discs and the area of the polygons of each type drawn by the interviewee. Polygons representing monetary, non-monetary and threat values were overlaid separately.

Each interviewee was constrained by a budget of 100 units of monetary, non-monetary and threat value. Some proportion of this value, T, was allocated to each polygon, i.

Given:
i = polygon
j = interviewee
A_{ij} = area (km^2) of polygon i drawn by an interviewee j
V_{ij} = relative value per grid cell within i
T_{ij} = assigned relative value to i
n_j = number of polygons drawn by j^{th} interviewee
k = grid cell

Where:

$$\sum_{i=1}^{n_j} T_{ij} = 100$$

V_{jk} is calculated as follows where k belongs to i:

$V_{jk} = T_{ij}/A_{ij}$

Some interviewees said that they valued each area the same as any other area where they drew a polygon. In these cases, the relative value by area was calculated in proportion to the area of each polygon. Each grid cell overlaid on a particular polygon was assigned the same relative value. Interviewee responses were interpreted in this way so that all cells within the polygons considered important for non-monetary reasons would be assigned identical value.

When the j^{th} interviewee said all areas were valued equally:

$$V_{jk} = 100 / \sum_{i=1}^{n_j} A_{ij}$$

The monetary, non-monetary or threat values across all interviews was added for a total monetary, non-monetary or threat value for each cell. Spatially overlapping grid cells derived from shapes drawn by different interviewees for the same type of value (monetary, non-monetary, or threat) were calculated according to the following equation:

$$V_k = \sum_{i=1}^{n_j} V_{jk}$$

Relative value was calculated in this way to understand the difference in value intensities across the study region.

2.5.2. Overlap Analysis

An overlap analysis was done to test the hypotheses pertaining to spatial correlation. Overlap analysis was conducted rather than correlation due to the abundant zeros and little variation in the values associated with cells for each individual. To determine the extent to which monetary, non-monetary and threat values spatially coincide in relation to the expected overlap by chance alone, the ratio of observed to expected overlap was calculated for each individual and for the summed responses. Data on the presences or absence of monetary value, non-monetary and threat value for each interviewee was summarized to 0.25-km^2 cells associated with a unique identification number. The overlap analysis was conducted with this tabular data. The relative value or threat intensity associated with each cell was not considered in the overlap analysis but is addressed in the correlation analysis.

Given:
E = expected overlap
C_m = cells (0.25-km^2) of monetary value
C_n = cells (0.25-km^2) of non-monetary value
C_{th} = cells (0.25-km^2) of threat value
C_{tot} = total cells (0.25-km2) in study area

The following equations were used to calculate expected overlap proportion, which could range from 0 to 1:
$E(C_m,C_n) = (C_m/C_{tot})*(C_n/C_{tot})$
$E(C_m,C_{th}) = (C_m/C_{tot})*(C_{th}/C_{tot})$
$E(C_n,C_t) = (C_n/C_{tot})*(C_t/C_{tot})$

For any two values, the observed overlap proportion is the union of two sets divided by the study area. That is, given:
S = observed overlap proportion
A = number of overlapping cells (0.25-km^2)

The following equations were used to calculate observed overlap:
$S(C_m,C_n) = A(C_m,C_n)/C_{tot}$
$S(C_m,C_{th}) = A(C_m,C_{th})/C_{tot}$
$S(C_n,C_t) = A(C_n,C_t)/C_{tot}$

If two sets of values were randomly distributed relative to each other, the observed:expected overlap ratio would equal 1. Frequency distributions were calculated across individuals based on the observed overlap over the expected overlap.

Given:
OE = observed to expected overlap probability ratio

These equations were used to calculate the observed:expected overlap probability ratio:

$OE = S(C_m,C_n)/E(C_m,C_n)$
$OE = S(C_m,C_{th})/E(C_m,C_{th})$
$OE = S(C_n,C_t) /E(C_n,C_t)$

2.5.3. Relative Value Spatial Correlation

Bivariate correlations were used to explore the relationships between the summed relative values assigned to 0.25-km^2 cells of monetary value, non-monetary value and areas under threat across all interviewees. Since the aggregate values were not normally distributed across cells, the nonparametric Spearman's rank correlation coefficient or Spearman's rho correlation was calculated for each pair (monetary, non-monetary; monetary, threat; non-monetary, threat) to determine the statistical dependence between the two variables. This statistic converts each variable to ranks, thus overcoming statistical issues with the non-normality of the variables.

2.6. Employment and Perception of Threat

To test the correlation of perception of threat and employment (hypothesis 5), a chi-square test was performed with Excel. This tested the hypothesis that full and part time employment in salmon aquaculture is correlated with not identifying aquaculture as a threat to marine ecosystems.

3. RESULTS AND DISCUSSION

Adding the valuation scores is a rough estimate of the relative monetary, non-monetary and threat values associated with particular locations. Data was mapped based on responses from a wide range of stakeholders but a relatively small sample (n=30). Justifications for not participating in the mapping exercise are also important research findings.

3.1. General Refusals to Identify Locations

Two interviewees did not answer any spatial questions. One interviewee with a background in community planning said, "as soon as you start isolating things and say this is important to me, you lose the rest…that's the risk...we start drawing lines, suddenly what's outside of the line becomes available for development." This participant was worried that assigning importance to specific places signifies a lack of importance outside of the areas identified, which is a valid concern. This perception may also be based on past negative experiences with spatial planning processes.

Another reason for not drawing polygons on the map reflected an interviewee's rejection of hard boundaries and preference for gradients. He explained, "I like things that have continuity, that don't have edges, that's part of my values and spirituality and aesthetics." He also said, "the only way we have here to prevent open access to fishing grounds …for food, for recreational, even for commercial purposes, is by … keeping your knowledge private….[Sharing this knowledge] is like handing somebody a key to your food, to your house, to your front door." This justification for not drawing on the nautical charts can be interpreted as believing that sharing spatial knowledge of important resources could result in potentially losing access to these resources or contributing to the degradation of these resources. This is an important concern based on the historical and current conflict over access to both land and sea resources in the RDMW where First Nations continue to struggle for resource rights in treaty negotiations (Tobias 2009).

Another respondent simply did not think that any areas are more valuable than others. This respondent did not conceive of value being tied to specific locations, but he did articulate non-spatial ways in which marine ecosystem were important to him.

3.2. Refusals to Specific Spatial Identification Prompts

A total of 23 out of 30 people interviewed drew polygons over the areas that are monetarily important to their work. The remaining seven had income that did not rely on specific locations (e.g., an artisan whose work was inspired by the region, but not specific places and managers concerned with fisheries governance issues related to the region as a whole, not particular locales).

Out of the 30 interviewees, 25 identified areas important for non-monetary reasons. Justifications for not identifying areas of non-monetary importance ranged widely. One interviewee did not want to identify culturally sensitive locations (e.g., a shell midden or a setting from a culturally important First Nation myth) or other areas of non-monetary importance out of fear that the information would be misused. The three others chose not to identify areas of personal significance because they felt this importance was based on places where they had memorable experiences with friends and family in certain natural areas, but the natural area itself was not particularly unique, special or valuable. These interviewees interpreted the spatial prompting as asking for aggregate place value, rather than the importance of the area to themselves as individuals. Every interviewee was encouraged to share areas of personal importance even if they felt geographically limited by their own experiences. Despite this encouragement, these three interviewees refrained from identifying areas of non-monetary importance.

Out of the 25 who identified areas of non-monetary importance, 16 allocated tokens of relative non-monetary importance, whereas the remaining nine interviewees said that no one place that they identified was any more important than any other place (Figure 3.1).

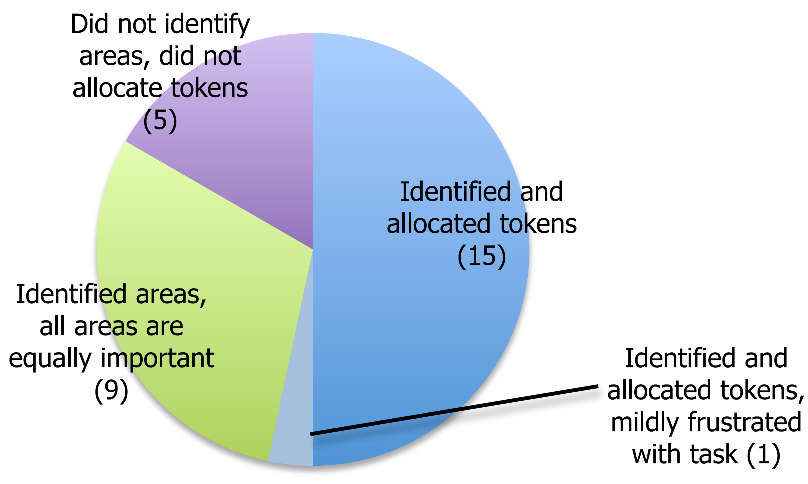

Figure 3.1 Interviewee responses to non-monetary value prompt for spatial identification and relative value allocation.

A total of 17 interviewees drew polygons around areas that are under threat. Several people who did not identify threatened areas explained that the major threats they perceive, including pollution, toxins, acoustic concerns, and marine debris, are not spatially explicit threats. Some said they lacked the expertise to identify areas under threats. Six interviewees did not think that there are threats to their local marine ecosystems.

3.3. Spatial Precision

Given the broad interview topics of monetary value, non-monetary value and threats, there is inherent subjectivity in the responses of interviewees based on each person's expertise, opinions and biases. Similar to local fishing knowledge interviews conducted in 2002 and 2004 in a subsection of the RDMW (Ardron 2005), some interviewees refused to draw shapes, some drew large polygons covering hundreds of square kilometers and others drew small ones covering less than one square kilometer. Some drew polygons carefully while others drew bigger shapes with less precision. It is important to note that there is likely variation in the precision of shapes drawn by an individual; it's not certain that the exact location and shape would be repeated if the interviewee was asked to do the same task at another time. There may also be some variation in accuracy, which is the match between what an interviewee drew and the shape of the area of importance. This could result from the nautical chart being misread.

3.4. Trimming Spatial Data to the Study Area

It is important to note that this research was bounded within the waters of the RDMW. This ignores ecological boundaries and does not include the full extent of many ocean activities and threats. Despite the focus on the waters of the RDMW, some interviewees identified areas of importance and threat outside of the boundaries, such as fishing grounds of economic importance extending beyond the boundaries or a heavily trawled areas outside of the RDMW perceived as being under threat. These shapes were trimmed to fit within the RDMW boundaries and the associated relative value or relative threat was assigned to the smaller shape to consistently allocate 100 units of monetary, non-monetary and threat values.

Although the interviews were intended to focus on marine ecosystems, the polygons that interviewees drew included land because several people expressed value associated with the coastline, particularly specific beaches. Also, many identified threats to marine ecosystems associated with land-based practices, such as logging. The confluence of certain ecosystems, particularly where salmon rivers flow into the ocean, are considered highly valuable for both monetary and non-monetary reasons. For the analysis, the polygons were trimmed to the coastline, but the values that included the interface of land and/or rivers with ocean were recorded in association with the trimmed polygons in GIS.

3.5. Types of ES Values and Threats

Interviewee responses were categorized by activity or associated value. The categories of monetary activity reflect the variety of professions of the interviewees. The relative value associated with each type of activity reflects the relative intensity of value or threat across 28 interviewees (Table 3.1).

Table 3.1 Activities and values associated with marine ecosystems across all participants. The number of polygons represents the total number of each type of polygon drawn during the interviews. The relative value is the sum of the monetary, non-monetary or threat units assigned to the corresponding type of polygon (monetary, non-monetary, threat) per interviewee. The number of participants is the number of interviewees who drew a particular type of polygon. The green section relates to the interviewee's various types of employment.

Category	No. of Polygons	Relative Value	Area (km^2)	No. of Participants
Economic Activity				
Commercial fishing	32	570	5,411	6
Sportfishing	25	415	4,383	5
Marine Transport	19	297	3,774	4
Eco-tourism	20	524	10,762	7
Science & Biological Monitoring	9	314	2,683	4
Artistic	4	100	217	1
Fisheries Management	2	115	2,148	2
Education	1	30	88	1
Tangible Non-Monetary Benefit				
Biodiversity/Wildlife	61	839	6,151	18
Natural Beauty	59	318	2,144	9
Cultural Heritage Site	37	505	727	10
Outdoor Recreation, Unspecified	30	44	663	2
Recreation, Fishing	24	421	2,516	11
Safe Anchorage	14	126	24	4
Recreation, Coastal Hiking	12	52	93	3
Unique Natural Feature	10	118	246	9
Recreation, Boating	7	223	227	5
Ceremonial Site	4	8	25	1
Recreation, Exploring	3	56	923	2
Dive Site	3	21	9	2
Stewardship Activities	2	11	7	2
Scientific Study Site	2	85	129	2
Intangible Non-Monetary Benefit				
Spiritual/Inspiration/Awe	28	417	1,320	9
Education	8	72	2,434	5
Peace	5	10	49	2
Sense of Place/Home	4	121	465	4
Transformational	3	72	811	2
Intergenerational	3	170	143	2

Category	No. of Polygons	Relative Value	Area (km^2)	No. of Participants
Community Identity	2	53	6	1
Existence	1	77	880	1
Threat Activity				
Salmon Aquaculture	53	1442	13,190	17
Commercial development	5	51	9	3
Logging	5	23	77	3
Pollution (from wood or sewage)	4	74	377	3
Boat traffic congestion	2	20	12	1
Fish Processing Plant	2	6	4	1
Overfishing	2	107	1,001	2
Pulp Mill	2	105	3	2
Potential Dam	2	22	28	2
Dragging	1	80	591	1
Dredging	1	80	591	1
Fisheries Mismanagement	1	10	28	1
Gravel Mining	1	1	6	1
Poaching	1	7	22	1

Value ascribed to biodiversity and wildlife was higher than value assigned to other non-monetary values (Table 3.1 and Figure 3.2). This can be partially explained by the categorization systems and the range of interviewees' activity preferences. Biodiversity/wildlife was summarized as one category rather than species by species because interviewees tended to mention multiple species associated with the same location. People with different recreational and other activity preferences (e.g., sportfishing, boating, hiking, stewardship activities) identified locations associated with wildlife in addition to places where they recreate outdoors or enjoy other tangible non-monetary benefits from the ocean. Consequently, the number of polygons, relative value, area and number of participants who identified particular activities is lower than for wildlife/biodiversity.

One interviewee expressed existence value for a region where he had never been that has a high density of nesting seabirds. The other interviewees assigned relative value associated with wildlife based on personal experiences on the water with marine animals and plants, often associated with seeing large congregations of wildlife or awe-inspiring wildlife behavior (e.g., orca whales rubbing themselves on pebble beaches). Wildlife is clearly a prominent and valued feature in the RDMW.

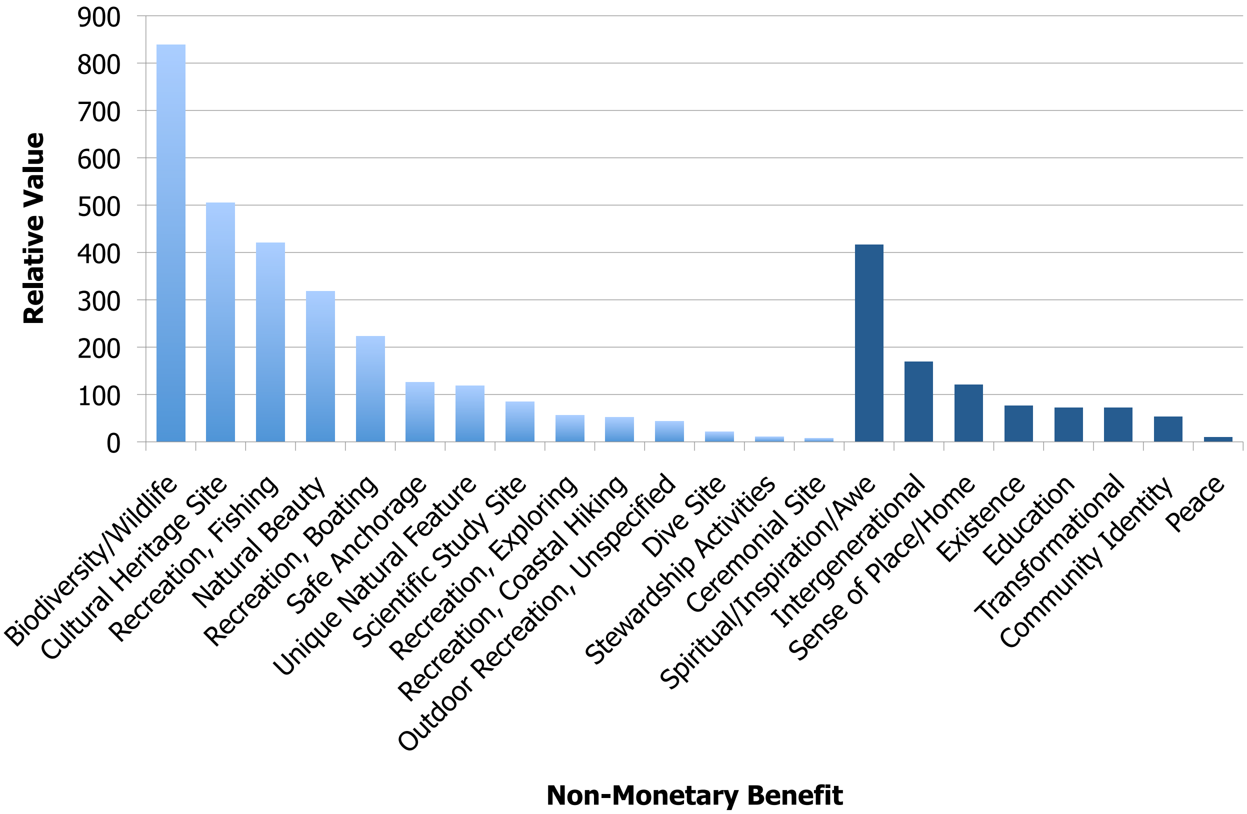

Figure 3.2 Relative value assigned to non-monetary benefits.
Light blue denotes tangible non-monetary benefits and dark blue denotes intangible non-monetary benefits.

It is likely that it is more straightforward and comfortable for interviewees to assign value to places associated with tangible non-monetary benefits as compared to intangible non-monetary benefits. Given the personal and sensitive nature of spiritual value, it was unexpected that people identified numerous areas associated with spiritual value, inspiration and/or awe (Table 3.1). Respondents also assigned more relative value to areas associated with spirituality, inspiration or awe than any other intangible non-monetary benefit (Figure 3.2). These results provide indication of the success of the interview protocol in verbally, spatially and to a limited degree quantitatively eliciting a wide array of benefits from nature.

According to the 17 interviewees, salmon aquaculture was associated with the highest number of threat polygons, greatest area (km^2) under threat, and highest relative threat value (Table 3.1). Commercial development, logging and pollution were considered threats by 4 or more interviewees.

3.6. Intensity of ES Values and Threats

The resulting maps of ES values and threats reflect the responses of 28 individuals with expertise related to working on the ocean. Many cells were not associated with a value or threat (Figure 3.6). The areas of high value include areas with considerable overlap among the different respondents and/or areas assigned a high number of tokens by one or several respondents (Figure 3.3). It is important to recognize that this spatial method isolating specific locations tends to privilege spatially compact and/or concentrated values over diffuse and/or diluted values.

The *Value by Number of Interviewees* column (Figure 3.3) maps the number of interviewees who assigned value to any cell. This does not consider relative value but does convey the spatial extent of the values and how many interviewees assigned value to the same location. As shown in the *Value by Quantile* column (Figure 3.3) in which relative values are colored according to eight ranges that each span 12.5% of the data, there is considerable variation in the intensity of values assigned across the seascape. Some interviewees drew small shapes and attributed high relative value to these small areas. Consequently, the relative value of the cells within these small polygons was sometimes orders of magnitude higher than cells overlaid on larger polygons in which the relative value was spread over a bigger area. This is apparent in the *Value by Standard Deviation* column (Figure 3.3). Relative value assigned to large polygons was diffused whereas value to small polygons was concentrated. Therefore, when the data was aggregated, areas where people assigned high values to small areas are associated with far higher relative value scores than areas where people had drawn large polygons.

The spatial methods used required respondents to represent value in conjunction with discrete polygons. The implications of conceptualizing value across the seascape based on the maps in the *Value by Standard Deviation* column (Figure 3.3) may overemphasize small, specific places without recognizing the connectivity of marine ecosystems. If monetary and non-monetary values linked to places and activities on the ocean are perceived as discrete and isolated, MSP efforts and ocean zoning plans may not adequately consider how activities in one zone may impact an adjacent zone. MSP could be reduced to assigning locations in the ocean to particular uses deemed as highly valuable for particular activities without accounting for how the broader ecosystem will be impacted. Focusing on small, discrete locations associated with relatively high monetary, non-monetary or threat value could also detract from accounting for gradients of value across space.

The resulting maps, particularly those in the *Value by Standard Deviation* column, may reflect the cognitive difficulty in tying value to spatial locations, a task that respondents had likely never or rarely done before. The methods used to ask people to identify particularly important or threatened areas may have biased respondents towards representing fewer, particularly high value places. Interviewees tended to identify locations important to them for specific provisioning and cultural services, but they did not explicitly identify areas valued for the supporting role that those locations or habitat types play in providing the products and experiences that people value. Also, some interviewees may have responded strategically by assigning high value to only a few distinct places to call attention to the places with issues that are most important to them personally rather than thinking more broadly about values and threats associated with the ocean.

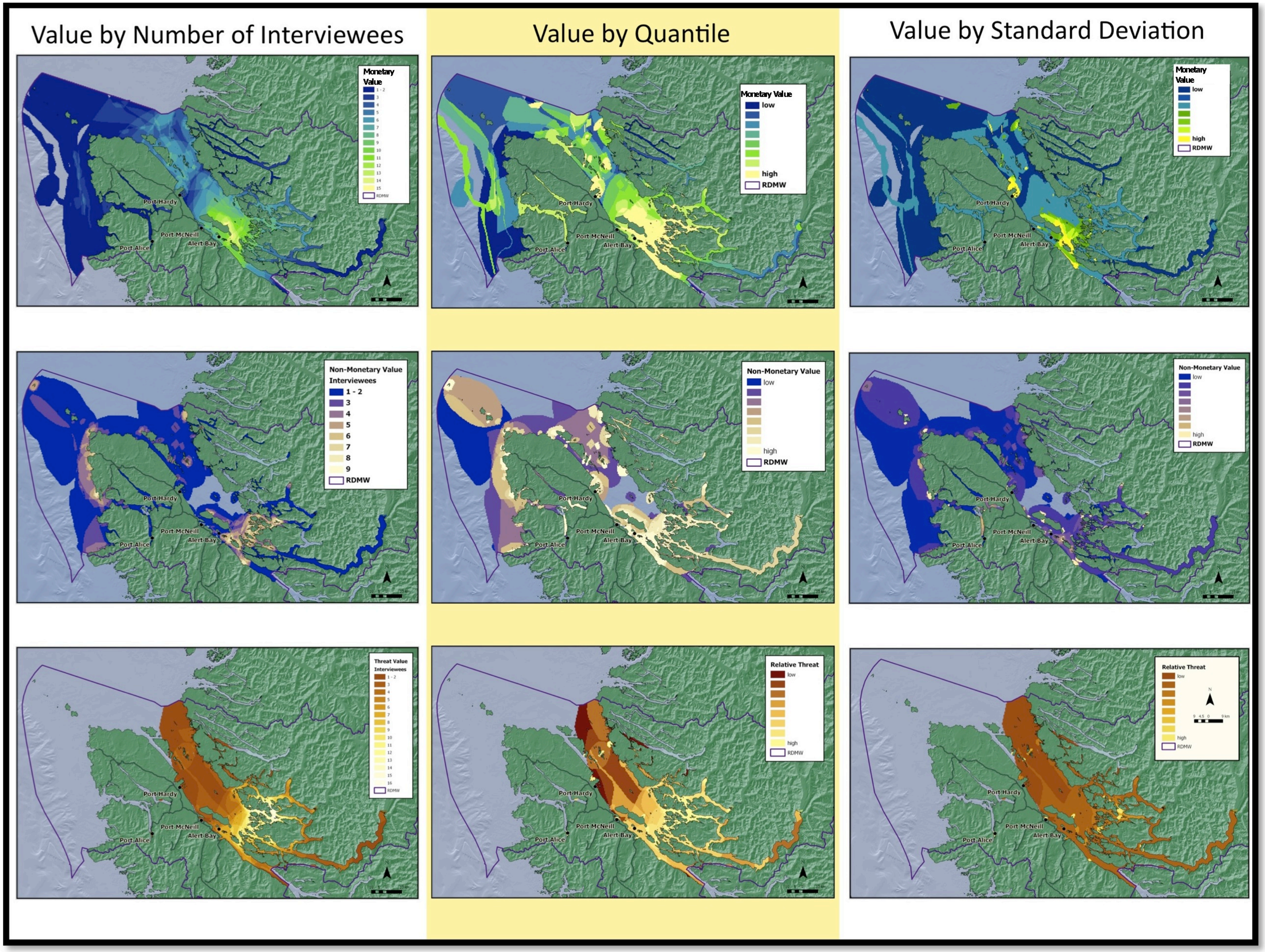

Figure 2.6 Stakeholder perspectives on marine ecosystem service values and threats. These maps reflect aggregate values across all interviewees. In the *Value by Number of Interviewees* column, each cell is colored according to the number of respondents who identified monetary value, non-monetary or threat value. Quantiles are sets of values that contain an equal fraction of the total number of values. In the *Value by Quantile* column, each color includes 12.5% of the cells associated with a set range of values or threats. The maps in the *Value by Standard Deviation* column are colored according to equal data value intervals set according to half standard deviations of the distribution of relative economic, non-monetary or threat values. For all maps, lighter colors indicate greater aggregate monetary, non-monetary or threat value. For aggregation methods, see section 2.5.1 Calculating Relative Value.

3.6.1. Place-Based Environmental Evaluation

The importance of proximity in explaining high non-monetary value conforms to predictions based on the place-based theory of environmental evaluation (Norton and Hannon 1997) since the highly valued places, both for non-monetary and monetary importance tended to be close to inhabited areas (Figure 3.3). Due to research time constraints, statistics relating the proximity of interviewees' homes to the places that they valued were not calculated. Consequently, these results are not statistically substantiated but they are supported in the verbal responses of interviewees and intuitively when viewing the resulting maps (Figure 3.3). Although one individual explicitly expressed existence value for a place that he had never visited, most people identified areas with which they were familiar. The relatively low value associated with the western region of the case study area (Figure 3.3) likely reflects the smaller number of people in the study sample who have experience in this remote and largely uninhabited region.

3.7. Correlation Among Aggregated Responses

The aggregate relative values were not normally distributed across the 0.25-km^2 cells. Given the non-normal data distribution, the nonparametric Spearman's rho correlation was calculated to compare value and threat data summarized to 0.25-km^2 cells (n=43,988). The overlap is significant ($p < 0.001$)(Table 3.2). This overlap analysis, however, does not account for spatial autocorrelation, the extent to which, for example, monetary values of a given cell tend to be more similar to those of nearby cells than expected by chance alone. This also assumes that the spatial fragmentation of the shapes drawn in association with the values and threats is similar.

Table 3.2 Correlation of non-monetary, monetary and threat values.

	Correlation
Non-Monetary & Monetary	0.371**
Non-Monetary & Threat	0.394**
Monetary & Threat	0.579**

** Correlation is significant at the 0.01 level (2-tailed).

The significant value intensity correlation is highest for threat and monetary values (0.579)(Table 3.2). Interviewees tended to identify high levels of threat in areas important to their economic livelihoods and low levels of threat in areas that are less important to them economically. The magnitude of overlap is greater for most individuals (Figure 3.4) than for the aggregate values (Table 3.3). This suggests that people tend not to perceive their activities as threats. Given the complexity of issues facing the ocean and the multiple stressors in the ocean (Halpern et al. 2008), this result is not surprising since it is in people self-interest not to associate environmental threat with their livelihoods.

3.8. Overlap Analysis of Individual Responses

For individual interviewees, 38 out of 55 (69%) of the observed:expected overlap ratios are greater than one across all three pair-wise comparisons of monetary, non-monetary and threat value (Figure 3.4). Thus, for the majority of individuals, values overlapped more than would be predicted by chance alone.

The non-normality of the observed:expected overlap ratios (Figure 3.4) are due to a minority of respondents who drew largely non-overlapping polygons for each of the three categories or completely non-overlapping polygons as reflected by 0 overlap ratios. These individuals separate areas of monetary, non-monetary and threat value. The majority drew overlapping shapes reflecting value and threats covering some of the same areas across the seascape.

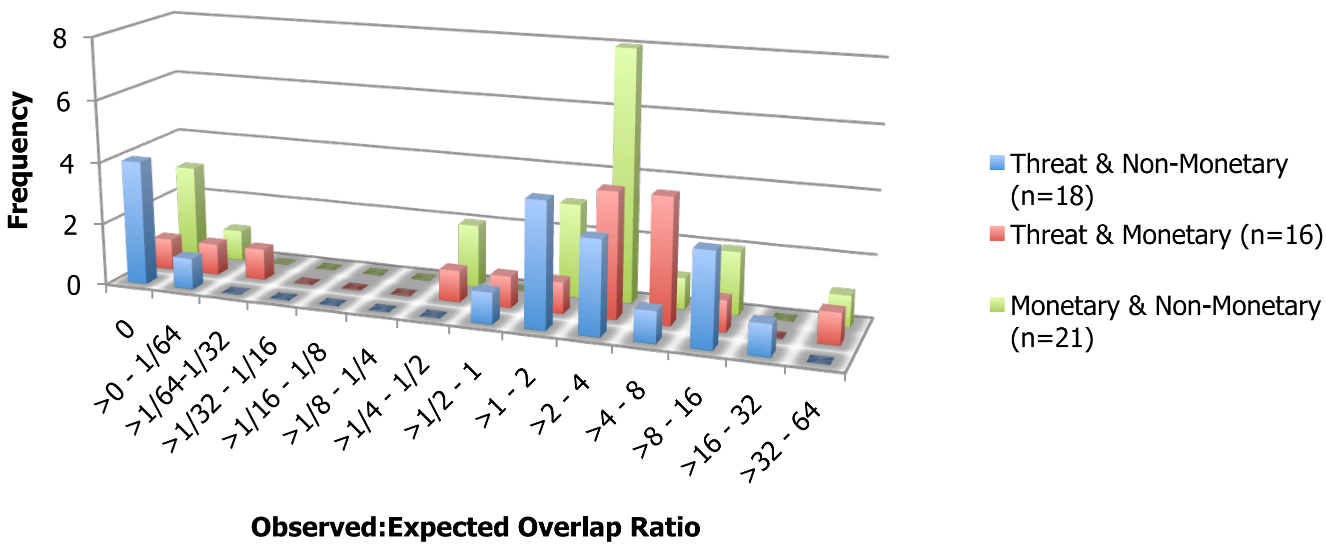

Figure 3.4 Histogram of observed:expected overlap ratio for individuals.
A geometric scale was used to provide symmetry in the range of ratio frequencies displayed. This scale emphasizes the bimodal distribution of the ratio of observed:expected overlap.

3.8.1. Overlapping Monetary and Non-Monetary Values for individuals

The majority or interviewees that spatially identified monetary and non-monetary values (~81% or 17/21) had overlapping areas of monetary and non-monetary importance, but a minority (~19% or 4/21) drew polygons that did not overlap (Figure 3.4). Many interviewees qualified their responses with the recognition that their expertise was limited to a particular part of the study region, so their responses reflect their geographically bounded knowledge and experience of specific locations. This research supports the hypothesis that areas associated with monetary and non-monetary value correlate. Klain *et al.* (in prep) provides additional evidence for this interdependence of monetary and non-monetary value.

3.9. Overlap Analysis of Aggregated Responses

When the areas of observed:expected overlap were considered using every cell identified in association with a value or threat across all interviewees, the ratios were slightly greater than 1 (Table 3.3). A high percentage of cells are included in the aggregate values and threats (Table 3.3). Thus, the expected overlaps are far higher for the aggregate overlaps (Table 3.3) than when considering individual overlaps (Figure 3.4). This is reflected in the aggregate observed:expected overlap ratios being close to one (Table 3.3).

Table 3.3 Observed:expected overlap probability ratios and percentage of cells assigned value or threat across all interviews.
This ratio includes every cell identified by at least one interviewee in association with a value or threat.

	Observed:Expected Overlap Probability Ratio	Percentage of 0.5km^2 cells assigned value
Non-Monetary & Monetary	1.054	67.1%
Non-Monetary & Threat	1.103	29.0%
Monetary & Threat	1.110	36.9%

The implications of the significant correlations between threats and values as well as the overlap ratios greater than one among monetary value, non-monetary value and threat (Figure 3.4 and Table 3.3) are expressed in the paraphrased words of an interviewee: to have a healthy ecosystem, we need to learn how to work with the ecosystem rather than just take from it. Developing employment opportunities that minimize environmental risks and support livelihoods without degrading the long-term provision of ES is a central challenge for communities around the world. In this case study, given the prevalence and intensity of threats associated with economically important areas, it would be wise to invest management resources into involving stakeholders, businesses and scientists to better address these threats.

3.9.1. Valuing Pristine Places

The hypothesis of a negative correlation between threat and non-monetary value can be rejected. This would imply that people value places more when they are pristine and less when they become threatened. The high degree of overlap of monetary, non-monetary and threat values in the study area reflects high value associated with places that people perceive as being under threat. People also associate non-monetary value with locations that they or others rely on for their incomes that are assumed to be far from pristine. This data shows that people value both pristine and threatened regions of the seascape. For instance, the Scott Islands near the northwestern boundary of the study site (Figure 3.3) are a remote location with minimal impact from anthropogenic factors. The high non-monetary, medium monetary, and zero threat value assigned to this area supports provides evidence that people value pristine areas.

3.10. Correlation of Employment and Threat Perception

The correlation between employment associated with open net-pen salmon aquaculture and not identifying threat from this industry is -0.81 ($p<0.001$) based on Phi (Pearson's coefficient of mean-square contingency)(Table 3.4).

Table 3.4 Contingency table of employment association with salmon aquaculture and perception of environmental threat associated with the salmon aquaculture industry.

	Salmon aquaculture is threat	Salmon aquaculture is not a threat	Total
Employment associated	0	5*	5

with salmon aquaculture			
Employment not associated with salmon aquaculture	23	2	25
Total	23	7	30
Phi	-0.811**		

* This number differs from the 4 people working in aquaculture (Figure 2.2) because an additional interviewee's work relied on grants from salmon aquaculture even though he is not an employee of a salmon aquaculture company.
** $p<0.001$

3.10.1. Perception of Threat and Profession

Employment in open net-pen salmon aquaculture was correlated with not identifying threats from this industry (Table 3.4). For this case study, this correlation supports the hypothesis that perception of environmental threat can correlate with type of employment. It should be noted that is based on a non-random sample, which breaks the assumption of the statistical test. This correlation suggests that people employed by the salmon aquaculture industry tend not to perceive environmental threat associated with the operations of their employers. It is possible that net-pen salmon aquaculture employees feel that it is part of their job to downplay the environmental threat of this industry. It could also be possible that only people who do not perceive environmental threats with regards to the industry find employment in this line of work. Another explanation is that people whose economic livelihoods do not depend on salmon aquaculture are more receptive to information about the environmental risks associated with this industry. The generalizability of this strong correlation may not apply to other places, people and industries since this information was collected from a small sample (n=30) within one geographic region. The sample is not fully independent since there were only two salmon aquaculture companies employing people in the sample.

3.11. Limited Representation

In order to better assess community values, representative surveys are needed (Brown 2005). The study aimed for variety rather than proportional representation. In particular, this study does not provide a wide variety of indigenous perspectives on ES values and threats within the study site. The members of the Kwakwaka'wakw First Nation who live in the region are united by their traditional language group (Galois 1994), but the 17 different Kwakwaka'wakw band governments have differing opinions on a range of topics. First Nations represent 23.4% of the region's population (BCStats) but they were only 6.6% of the interviewees (2 out of 30). Effort was made to schedule interviews with additional First Nation fishermen and fisheries managers, but they were not possible due to time constraints and remoteness of many of their communities. Also, representatives of two aquaculture companies (Marine Harvest and Mainstream) were sent contact letters requesting their participation in this study. Mainstream did not respond and the public relations representative of Marine Harvest vocally refused to be part of the study.

3.12. Limitations of Mapping Marine ES

3.12.1. Indigenous People, Power and Mapping

The results of these mapping methods need to be understood in the context of the study region. This research was conducted where indigenous people, through protest or partnership, are more capable than ever before in influencing development in their traditional territories. Aboriginal claims in BC to not only land but also ocean resources and marine areas are heatedly disputed (Young and Matthews 2010). Cultural spatial knowledge plays a prominent role in First Nations exerting their right to control land and sea resources in their traditional territories. Locations of culturally significant places, such as historical or sacred sites, are not readily shared with outsiders. The emphasis of this project was on the perceptions of ES according to a wide range of people who professionally rely on the ocean. It is not representative of the region's diverse First Nation perspectives, nor does it take the place of traditional use and occupancy mapping.

3.12.2. Many values are not spatially explicit

Three interviewees expressed mild frustration with drawing shapes on the chart because they did not think that the monetary and/or non-monetary values they associate with the ocean are appropriately expressed as pegged to discrete locations. One said that drawing arbitrary boundaries around distinct locations misses the point that marine ecosystems have gradients rather than discrete boundaries and they are highly interconnected as well as dynamic. For the practical purpose of colleting local knowledge and values in a way that's conducive to a spatial planning process, interviewees were asked to draw boundaries around areas important to them or under threat and did not have the option of assigning gradients across areas.

3.12.3. Recognition without spatial identification of supporting ES

Supporting ES are inputs to final product from ecosystems that contribute to human well-being (MA 2003). Habitat can be considered a supporting ES that provides, e.g., wildlife for ecotourism, such as whales, and/or for sustenance, such as fish. When asked about the non-monetary importance of marine ecosystems, many focused not on the value of specific places as habitat, but rather on how much they value wildlife. Several of this region's most culturally and economically valuable species, including orca whales, salmon, and herring, are highly migratory and inhabit different habitats during different life stages. Capturing the value of certain species to people and tying it to specific locations can be problematic. Several interviewees did not draw polygons around areas where they had encounters with wildlife because the species are so transitory. Some questioned the utility of isolating different patches as more valuable than others given the extensive range of the valued species. Sometimes, interviewees circled large swaths of ocean and assigned high value to it to broadly account for the significance of wildlife encounters. They verbally recognized the supporting role that other places and habitats play in the lives of the animals that they enjoy, but they did not identify areas important to other life stages of the animal.

3.13. Implications for Management and Decision Making

This method of directly linking an ES-related activity or value to discrete locations could help inform MSP processes through the identification of places that are important to stakeholders for a variety of reasons. In descending order of frequency, people from the RDMW identified areas associated with biodiversity/wildlife, natural beauty, cultural heritage sites, and sites for outdoor recreation (Table 3.1). It is likely that memorable encounters with wildlife contribute to this high value for places associated with animals. When zoning for future development, protecting these valued attributes and locations for particular activities should be a priority in MSP.

To make the outputs of this research better reflect a wider range of people, stakeholders ought to be engaged in reviewing the aggregate spatial data and identifying potential gaps in the information. This line of research could help stakeholders, marine spatial planners and managers visualize various types of values and threats across the seascape according to a wide range of people whose livelihoods are closely associated with the ocean. Given that the interviews and data analysis are time and labor intensive, getting a representative sample of the general population would likely be difficult. However, similar to Raymond *et al.* (2008), this type of research could sample a targeted list of decision-makers and leaders of various sectors that rely on the ocean. A larger sample size including more decision-makers and leaders representing their constituencies would strengthen the representativeness of the results.

Despite the fact that people spoke at length about intangible values (Klain, Chan, and Satterfield in prep), it was less common for interviewees to spatially identify areas associated with less tangible values, such as spiritual value, education, peace, or sense of place/home (Table 3.1). Given the varied response to the spatial prompts pertaining to non-monetary values (Figure 3.1), isolating non-monetary values should not be the only method to solicit information pertaining to such values. This relative infrequency of spatially identifying areas associated with intangible values signals that the intangibles are difficult to map, *not* that they are less important. This means that the aggregate maps and correlation analyses do not fully represent intangible values. If a MSP process was based on a similar mapping and valuation process, it too would be incomplete. Mapping and valuation cannot represent the full range of intangible values.

More could be done unrelated to both spatial prompting and “quantifying the unquantifiable” to explicitly recognize, respect and accommodate intangible values associated with ecosystems when choices are made regarding ocean-based development. In recognition of these limitations with mapping and quantifying non-monetary values, using maps in this interview protocol was very useful for eliciting a wide variety of reasons explaining why parts of the seascape are highly valued. There is complimentarity between this mapping-interview process and a deliberative process. The intangible values represented in deliberative processes involving stakeholders could compliment the results from this type of mapping. Deliberative processes include social learning and the exchange of information as values are carefully considered and discussed (Spash 2008; Sagoff 1998).

Maps of the relative importance of places based on aggregated responses to questions about marine ES and threats could inform and prime a deliberative MSP process. ES often involve a public good, defined as a good from which one person can benefit without reducing the availability for others to benefit from it and no one can be excluded from using the good. Given the public good characteristics of many ES, deliberative processes based on outcomes of groups of citizens that work together to valuate ES (Wilson and Howarth 2002). Therefore, determining the relative importance of multiple values and identifying trade-offs, particularly when it comes to intangible ES values, should be a deliberative process rather than primarily based on aggregated responses of multiple individuals. After being reviewed and where necessary updated with input from multiple stakeholders, the mapped identification and relative intensity of values and threats (Figure 3.3 and Table 3.1) could provide a useful starting point for a deliberative MSP process. This process would entail public discourse on what is at stake (tangible and intangible, monetary and non-monetary) and what social, economic and environmental trade-offs exist when choices are made regarding where or if to site different types of marine economic activities (e.g., offshore wind energy, aquaculture pens, shipping routes) and conservation zones (e.g., marine reserves). Such a process should allow stakeholders to voice their concerns as to whether a proposed spatial plan will adequately protect their intangible values. This type of research could inform the deliberative creation of MSP priorities that could account for a wider array of ES provided by the ocean, including the monetary value of activities in particular places as well as the meaning and importance that people associate with the marine environment.

4. CONCLUSION

This research piloted an innovative interview protocol that facilitated verbal elicitation, spatial identification and quantification of monetary, non-monetary and threat values. The findings support the theory of place-based environmental valuation in that areas of high value tend to be near people's homes. Areas of monetary and non-monetary value overlap. This can be partially explained based on the geographically bounded knowledge and experience of people in these locations and a tendency to apply non-monetary values to places that are also associated with monetary value. This research also shows that people highly value both threatened and pristine areas.

Many research findings are specific to the RDMW. The places valued for biodiversity and wildlife were assigned the highest relative value. The Broughton archipelago (the southeast region of the cases study) was assigned high relative threat attributed to salmon aquaculture. People who are employed by the open net-pen salmon aquaculture companies do not associate environmental threats with this industry.

These methods facilitate the articulation of a broad range of spatial and non-spatial values associated with marine ecosystems. People ascribe meaning to places and parts of ecosystems that goes beyond instrumental and monetary value. This research documents substantial differences in ES values and perceptions of threat across the study area. Summarized spatial information from these methods can be used to identify relative monetary, non-monetary and threat value associated with particular places. Non-monetary values, however, are only partially represented spatially.

The outputs of this method can augment biophysical and economic information on ES and complement a deliberative process to enable decision makers to more fully consider stakeholder's non-monetary values and threats associated with ES. This method holds promise for integrating local perspectives on ES to support inclusive and informed environmental decision-making.

Acknowledgements

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