Analysis

Navigating coastal values: Participatory mapping of ecosystem services for spatial planning

Sarah C. Klain *, Kai M.A. Chan [1]

Institute for Resources, Environment and Sustainability, University of British Columbia, 2202 Main Mall, Vancouver, Canada V6T 1Z4

ABSTRACT

Monetary values and biophysical features tend to dominate spatial planning data, yet intangible cultural values have a large role to play in decision-making. If left implicit, such considerations may be represented poorly in planning. To foster explicit inclusion of intangible values alongside material values connected to ecosystems, we elicited verbal articulation, spatial identification and quantified marine-related values and threats across the seascape of northern Vancouver Island, Canada. We address: (1) how do our spatial interviews—involving maps and semi-structured interviews—enable and/or impede the elicitation of intangible values? (2) What categories of ecosystem benefits do participants identify as most important? (3) Are spatial distributions of monetary values correlated with non-monetary values and threats? Our findings indicate that (1) while maps were provocative, sizable minorities of interviewees refused to assign different numerical non-monetary values to specific locations (30%), or refused to identify locations of non-monetary importance (16%); (2) people allocated the highest non-monetary values to places notable for wildlife, outdoor recreation, then cultural heritage; and (3) significant pair-wise overlap occurred, but also sizable deviations, among monetary, non-monetary and threat distributions. Despite limitations to representing non-monetary values spatially and quantitatively, these methods offer a straightforward approach to catalog and map ecosystem services to inform spatial planning.

© 2012 Elsevier B.V. All rights reserved.

1. Introduction

Around the world, marine ecosystems show signs of distress, including drastically diminished fish stocks, habitat destruction and pollution (Worm et al., 2006). In order to address these and other marine environmental issues, many countries are conducting marine spatial planning (MSP) (Ehler and Douvere, 2009). A central goal of MSP is to improve and sustain the provision of ecosystem services (ES) (Foley et al., 2010), the ecological processes through which nature provides benefits to people (Levine and Chan, 2011). Several MSP initiatives and toolkits have adopted ES frameworks to more fully account for the costs and benefits of different zoning options (Carr, 2011; Guerry, 2011). One strength of the ES framework is that it provides 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). Ecologists and economists have made substantial progress to account for the monetary value of ES, particularly regarding provisioning, supporting and regulating services (Boyd and Banzhaf, 2007; Daily and Ellison, 2002; TEEB, 2009).

Major branches of ecological and environmental economics have focused on non-market valuation, assigning dollar values to environmental benefits not typically traded in markets. Common quantitative techniques for non-market valuation include hedonic pricing methods, travel cost methods, damage cost avoided/replacement cost/substitute cost, contingent valuation, contingent choice method and benefit transfer methods (Daly and Farley, 2010). These methods might potentially feed into cost–benefit analyses (CBA) but valuating many intangible benefits including cultural ecosystem services (CES) is fraught with challenges (Chan et al., 2012). These valuation methods generally attempt to express consumer or individual preferences without explicitly addressing linked citizen or societal preferences, which yields numerous problems and inconsistencies (Daly and Farley, 2010; Sagoff, 1998; Spash, 2008). The reliance of such methods on dollar metrics—without the flexibility often needed to express moral and ethical concerns—compromises their ability to express 'cultural' values. CBA assumes that ES or ES bundles can be valuated in monetary terms that represent the values of all people (Pearce et al., 2006) despite the likelihood that several ES, particularly CES, may be inextricably linked to provisioning and other ES in ways specific to individual people or stakeholder groups.

We investigated the possibility that social value mapping of ES might help better account for CES to inform decision-making. According to the Millennium Ecosystem Assessment, CES are "the non-material benefits people obtain from ecosystems through spiritual enrichment, cognitive development, reflection, recreation and esthetic experiences" (MA, 2003). CES can also be defined as "ecosystems' contributions to the non-material benefits (e.g., capabilities and experiences) that arise from human–ecosystem relationships" (Chan et al., 2012). These largely intangible CES, such as sense of place, stewardship obligations and

* Corresponding author. Tel.: +1 778 227 8190.
  E-mail address: s.klain.ubc@gmail.com (S.C. Klain).
[1] Tel.: +1 604 882 9250.

spiritual value linked to nature, are worthy of additional research attention since they can contribute substantially to well-being (Chan et al., 2011; Chan et al., 2012; Chiesura and de Groot, 2003; WHO, 2005). These intangible benefits, often linked fundamentally to moral concerns, also motivate people to protect and restore ecosystems (Butler and Oluoch-Kosura, 2006; Safina, 2005).

Several participatory mapping initiatives to inform marine planning have focused on select commercial and recreational activities, mainly fishing (Scholz et al., 2011; St Martin and Hall-Arber, 2008). We used social value mapping methods, including prompts with locally appropriate non-technical language, to facilitate the articulation of not only where important activities occur but also the tangible *and* intangible values associated with particular locations, in part to highlight potentially underappreciated ways in which ecosystems are important to people.

Our research builds on landscape values methodology and public participation GIS literature (Brown, 2005b; Brown and Raymond, 2007; Brown and Reed, 2012; Gunderson and Watson, 2007). By linking landscape values methods with ES frameworks, researchers have begun to investigate mapping social and cultural ES values (Bryan et al., 2010; Donovan et al., 2009; Raymond et al., 2009; Sherrouse et al., 2011). These studies have mapped various categories of services, but we home in on three major categories: monetary, non-monetary and threats. We chose these categories to concisely communicate distinct sets of values to resource managers and stakeholders who may be unfamiliar with ES terminology. We emphasize this value distinction to map important places that may be overlooked if spatial planning focuses on monetary values with little explicit consideration of non-monetary values, which tends to be common in planning efforts.

Another important issue is the extent to which these values are quantifiable and mappable, which is a crucial issue given our goal to inform spatial planning. We investigate (1) the extent to which it is possible for people to assign spatial locations to these kinds of values and threats, and if not, why not? We seek to understand precisely why people might refuse to map or quantify these values because many participatory mapping studies do not explore participant justifications for refusing to map areas of importance (e.g., Donovan et al., 2009; Raymond et al., 2009; Ruiz-Frau et al., 2011; Sherrouse et al., 2011). Furthermore, are interviewees able to assign relative importance to quantify non-monetary values, in a manner similar to the quantification of monetary values? Understanding such refusals is crucial for improving methods to elicit such values and inform MSP (Ruiz-Frau et al., 2011).

We also investigate (2) which categories of non-monetary benefits were deemed most important by participants? Lastly, we assessed (3) how well correlated non-monetary values are with monetary values and threats. The investigation of this correlation sheds light on the extent to which monetary values could serve as a proxy for non-monetary or threat values. The strength of the correlation may indicate whether the spatial distributions of monetary values could serve as proxies for non-monetary or threat values.

Our central purpose was to assess the utility of a protocol that is both compatible with a marine spatial planning process and feasible to employ on a relatively short time line with a modest budget. We field-test methods intended to enable people to articulate, and where possible, spatially identify and quantify the relative monetary and non-monetary value of ES and environmental threats. We employed our interview-based mapping protocol in the Regional District of Mount Waddington (RDMW), a sub-region of the Pacific North Coast Integrated Management Area (PNCIMA).

2. Methods

2.1. Study Area

In collaboration with the NGO Living Oceans Society (LOS) and the RDMW government, we tested this ES value elicitation and mapping method within the RDMW, the northern region of Vancouver Island in British Columbia, Canada (Fig. 1). The RDMW spans 20,288 km^2 of land and 9880 km^2 of ocean. In 2006, the population was 11,651, of whom 23.4% are First Nation (Aboriginal), 73.5% are Caucasian and 3.1% are other visible minorities (BCStats, 2011). Between 2001 and 2006, the population declined by 11.1%. The average family income was $65,683 as compared to the average BC family income of $80,511 (BCStats, 2011). Several communities in the RDMW, particularly Alert Bay and Sointula, relied historically on timber and fishing industries. 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).

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, 2005a). Fleet reductions have been accompanied by some fisheries-related spatial management efforts, including Rockfish Conservation Areas (RCAs) intended to rebuild populations of rockfish by prohibiting gear that disturbs benthic habitat (Yamanaka and Logan, 2010).

Net-pen salmon aquaculture is Canada's biggest and most profitable type of aquaculture (Young and Matthews, 2010). As of 2007, a total of 42 finfish farm tenures exist in the RDMW. Of these, 26 farms are located in the Broughton Archipelago (LOS, 2007; MAL, 2007), part of our study area. Salmon net-pen aquaculture is a major source of employment in this region (LOS, 2011). The expansion of this industry has been accompanied by controversy over the environmental, social and economic ramifications of this industry's operations (Young and Matthews, 2010).

2.2. Interview Sample

We sought people whose profession and/or means of livelihood are linked to the marine environment. Using non-proportional quota sampling (Tashakkori and Teddlie, 2003), our sample included those who play an active role in marine resource management as well as others whose income indirectly or directly relies on the ocean. The sampling method was used to solicit a range of values from engaged and knowledgeable community members, targeting those who are involved with and/or have a vested stake in marine resource decision-making. Project partners at the regional district government and a local marine conservation NGO (LOS) provided recommendations on whom to invite for the in-depth interviews.

In-person interviews with narrative-based methods and appropriate probes can be well-suited for exploring subjective and experiential topics (Lindlof and Taylor, 2002), arguably helping people reflect on their values more deeply than paper or web-based surveys. We effectively chose quality over quantity, engaging a smaller sample in an in-depth exploration.

When conducting in-depth interviews, the number of new concepts associated with each additional interview generally tends to diminish between 20 and 30 interviews (Morgan 2002). Accordingly, this research used a sample size of 30 since the goal was to identify the diversity of ways in which marine ecosystems are important to people. The 30 people we interviewed represent a wide range of employment activities (17 types of marine-related professions) and live in several communities across the RDMW (Fig. 1). A total of seven women and 23 men were interviewed; two interviewees were of First Nations descent, and 28 were Caucasian. Participants had lived in the RDMW from 8 to over 65 years with an average duration of 30 years.

2.3. Interview Design

We created a semi-structured interview protocol to enable interviewees to verbalize why the ocean is important to them. Several
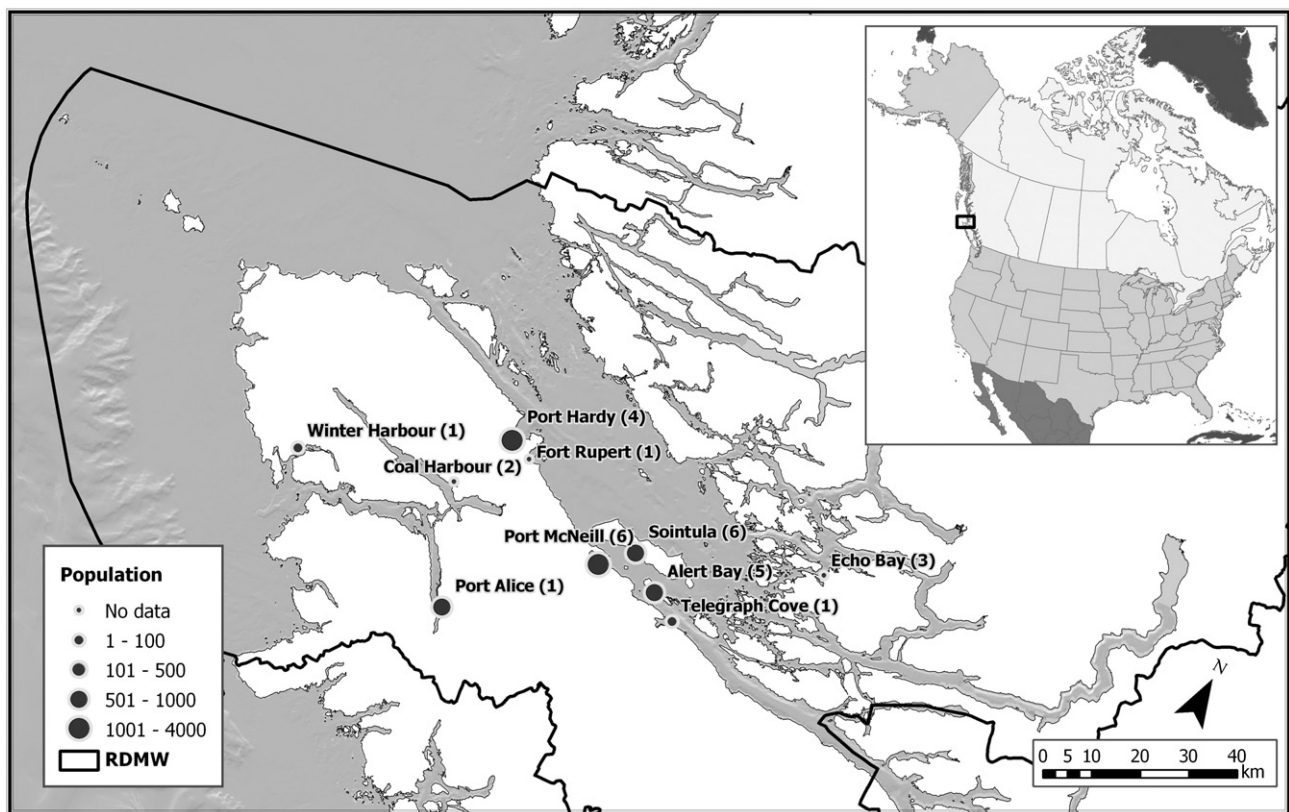
Fig. 1. Hometown and number of interviewees (n = 30) in the Regional District of Mount Waddington. Population data was not available for other small communities in the RDMW.

prompts were designed to enable people to articulate non-monetary values associated with the marine environment (Klain, 2010; Supplementary Information, A. Interview Protocol).

Author SK conducted 30 interviews between April 9 and June 7, 2010. 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. 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 interviewees' 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 min to 3 h and 30 min. A total of 56 h of interviews were transcribed. Our interview protocol (see Supplementary Information A) involved five parts.

Part 1 Each interview began with open-ended questions 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. Each interviewee was asked questions about what he/she values from the ocean. We framed questions about non-monetary values based on the 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 (2010).

Part 2 The interviewer unrolled a 1 m × 2 m laminated compilation of nautical charts, covering the RDMW at a scale of 1:400,000. Interviewees, all of whom were familiar with local nautical charts due to their marine-related profession, were asked to identify areas in the ocean that they rely on for their income by drawing green polygons around these locations. Each interviewee was 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). Following 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.

Part 3 The interviewer asked open-ended questions on cultural ES. We designed the protocol to encourage people to think about the connection between values associated with place and heritage, identity, activities including subsistence food collection, spirituality, art, education and intergenerational bequests.

Part 4 Interviewees were asked to identify regions important for non-monetary reasons with a blue pen. Once the locations were marked, he/she was asked to distribute 100 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.

Part 5 The interview concluded with questions about threats to the marine ES that people value. Interviewees were asked to draw red polygons around areas that are threatened and/or sources of threat, then allocate 100 tokens across these polygons. In some cases, the threats were not spatially explicit (e.g., ocean acidification, marine debris, and PCB and heavy metal contamination). These non-localized threats were recorded, but not mapped.

A D-SLR Nikon D70s was used to photograph the chart marked with each interviewee's monetary, non-monetary and threat polygons with notes on associated types of values and threats

as well as numerical relative values (Fig. 2). The nautical chart was erased after the photos were taken. These photos were georeferenced in ArcGIS 9.3. Shapefiles were created by tracing interviewees' polygons from the georeferenced photo. The interviewer recorded the quantitative value and value descriptions for all shapes. For each interview with spatial information, a total of three shapefiles were created, each with polygons associated with monetary, non-monetary or threat values.

2.4. Spatial Analysis

2.4.1. Trimming Spatial Data to the Study Area

We bounded our study to 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. These shapes were trimmed to fit within the RDMW boundaries and the associated relative value or relative threat was concentrated in the smaller shape to consistently allocate 100 units of monetary, non-monetary and threat values within the study area.

2.4.2. 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 500×500 m cells. This cell size (0.25 km^2) was chosen after the polygons were digitized because it was slightly larger than the smallest polygon drawn by an interviewee (0.2 km^2), which we assumed to indicate roughly the resolution at which interviewees represented areas of value and threat (such that finer resolutions of analysis would be assuming a higher than justified spatial accuracy of the hand-drawn boundaries). The 0.25-km^2 cell size provided a reasonable level of detail given the extent of the study region

(9880 km^2 of ocean). A coarser cell resolution would have diminished the level of spatial detail to which the relative values and threat scores were summed across interviewees.

Each grid cell was assigned a unique numerical identification number. We intersected the shapes drawn by interviewees with the grid to spatially summarize the monetary, non-monetary or threat intensity for each cell. For each value/threat type, the total value/threat of each cell was the sum of the value/threat associated with each cell across all interviewees. For each interviewee, the relative value/threat was derived from the number of tokens each interviewee assigned to his/her polygon divided by the area of the polygon. Polygons representing monetary, non-monetary and threat values were overlaid separately. For detailed methods, see Supplementary Information B. Methods to Summarize Value Across Interviewees.

After the relative value/threat of each cell was calculated, the cells in each layer (monetary, non-monetary and threat) were dissolved according to their relative value. This approximately restored the polygon boundaries while preventing pseudo replication: the unit of analysis is not the cell, which was crucial for summarizing value across interviewees, but rather the polygons associated with different levels of relative value/threat. These three layers were intersected, then the monetary, non-monetary and threat values associated with each polygon were used to calculate bivariate correlations.

2.4.3. Spatial Correlation of Monetary, Non-Monetary and Threat Values

For each type of value (monetary, non-monetary and threat), we calculated the distance at which spatial autocorrelation is minimized based on empirical semivariograms of each layer (see Supporting Information, Section C. Semivariograms). The monetary and threat layer semivariograms (Moran's $I = 0.291$ and Moran's $I = 0.202$, respectively) showed weak spatial autocorrelation, but the semivariogram for the non-monetary layer (Moran's $I = 0.350$) showed that spatial autocorrelation diminished after a separation distance of 2.729 km. Accordingly, we applied a bootstrap sampling technique to select 100

Fig. 2. Example of interview data collected. Green polygons denote areas where the interviewee derived his/her income. Blue areas are important for non-monetary reasons. Interviewees drew red polygons in places associated with an environmental threat.

sets of 80 random polygons with centroids sufficiently far apart to minimize spatial autocorrelation (80 was the highest number of polygons that could be selected with centroids separated by $\geq$ 2.729 km).

Since the values were not normally distributed across the polygons, we calculated the nonparametric Spearman's rank correlation coefficient for each pair (monetary, non-monetary; monetary, threat; and non-monetary, threat) for 100 sets of random samples. We calculated correlations as well as the mean and standard deviation to estimate the uncertainty in the correlation statistic.

3. Results and Discussion

3.1. General Refusals to Identify Locations

A minority of respondents refused to assign relative value to particular locations. Two out of the 30 interviewees did not answer any spatial questions (Fig. 3). Their refusals can be classified as (1) a rejection of hard boundaries; (2) concern for the sovereignty over local knowledge; and (3) a rejection of particular places being of greater value than others. The first of these interviewees, who has 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." 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." These perceptions may be based on past negative experiences with spatial planning processes. After commenting on the dynamic nature of ecological and social systems, this interviewee also refused to draw polygons because he rejects assigning hard boundaries around places that are important to him. He believes that gradients offer a better representation of human values and ecological characteristics of the ocean.

3.1.1. Refusals to Specific Spatial Questions

A total of 23 out of 30 people interviewed drew polygons over the areas that are monetarily important to their work and distributed tokens to represent relative values (Fig. 3). The remaining seven had income that did not rely on specific locations (e.g., an artist 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—two more than those who spatially identified areas for monetary reasons (Fig. 3). 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 seemed to interpret the spatial prompting as asking for values of areas to the community, not only 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.

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 single place that they identified was any more important than any other place (Fig. 3).

A total of 17 interviewees drew polygons around areas that are under threat (Fig. 3). 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, four of whom worked in salmon aquaculture, did not think that there are threats to their local marine ecosystems.

3.2. Intensity of Values and Threats

The resulting maps reflect the responses of 28 individuals with expertise related to the ocean, since two out of 30 participants refused to spatially identify values and threats. The Value by Number of Interviewees column (Fig. 4) maps the number of interviewees who assigned value across the study region. This does not consider relative value but does convey the spatial extent of the values and how
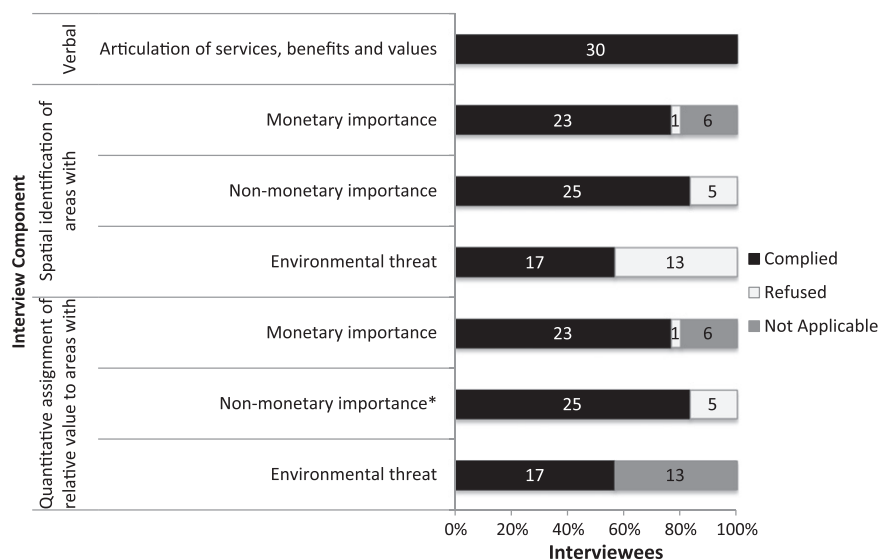

Fig. 3. Interviewee responses to verbal, spatial and quantitative interview components. *Out of the 25 interviewees who allocated relative non-monetary value, 9 assigned identical value to mapped locations.

many interviewees assigned value to the same location. The Value by Quantile column (Fig. 4), in which relative values are colored according to eight value-ranges that each span approximately 12.5% of the spatial area, illustrates the variation in value intensity across the seascape using a logic analogous to ranks and percentiles. 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 concentration of values is apparent in the Absolute Aggregated Value column (Fig. 4), in which compact and/or concentrated values are privileged over diffuse and/or diluted values. 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 methods used to ask people to identify particularly important or threatened areas may have biased respondents towards representing fewer, high-value places. Interviewees tended to identify locations important to them for specific provisioning and cultural ES, but they did not explicitly identify areas valued for the supporting role that those locations or habitat types play in providing products and experiences. Also, some interviewees may have responded strategically by assigning high value to only a few distinct places to call

attention to the places and issues that are most important to them personally.

3.3. Spatial Correlation of Non-Monetary, Monetary and Threat Values

All three pair-wise comparisons were significantly ($\alpha < 0.001$) and positively correlated (Table 1). These correlations likely reflect a combination of factors. Many of the most highly valued places, for both monetary and non-monetary reasons, are close to towns. Consequently, perceptions of importance may reflect how these locations are more accessible and potentially more frequently visited. Also, in such places, the environmental threats are likely better-known and possibly more acute due to greater human impact than locations far from inhabited regions.

Although we found significant spatial correlations, somewhat analogous to the positive correlations that Ruiz-Frau et al. (2011) found between specific monetary (i.e., fisheries and industry) and non-monetary (e.g., leisure and heritage) values, monetary values should not be interpreted as proxies for non-monetary or threat values due to the relatively low Mean Spearman's Rank correlation coefficients associated with pairwise comparisons (all are below 0.6 as shown in Table 1). There are substantial overlaps but also
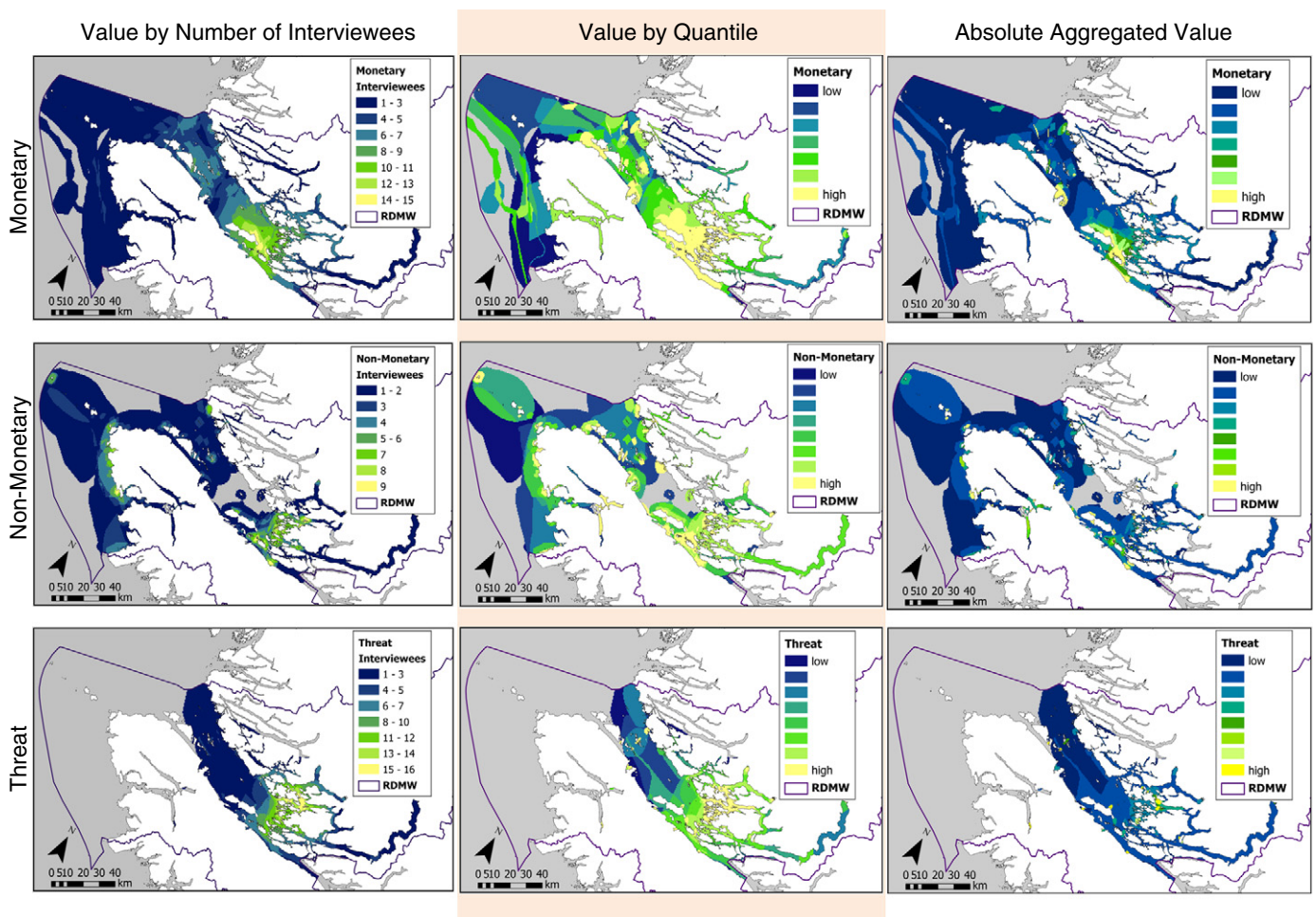

Fig. 4. Stakeholder perspectives on marine ecosystem service values and threats. These maps reflect aggregate values across all interviewees. In the Value by Number of Interviewees column, each cell is colored according to the number of respondents who identified monetary value, non-monetary or threat 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. For all maps, lighter colors indicate greater aggregate monetary, non-monetary or threat value. For aggregation methods, see Section 2.4.1 Calculating Relative Value.

Table 1
Correlation between pairwise comparisons of monetary, non-monetary and threat value. The sample units are polygons associated with three values: monetary, non-monetary and threat values, each summed across all interviewees.

	Mean Spearman's Rank correlation coefficient	SD
Monetary vs. non-monetary	0.2673[a]	0.09773
Monetary vs. threat	0.5541[a]	0.0708
Non-monetary vs. threat	0.3615[a]	0.1001

[a] Using the p-values associated with each correlation, we calculated the test statistic for each pair-wise correlation using Fisher's combined probability test. This was subject to a chi-square test to determine that the overall p-value for each set of pairwise comparisons was <0.001.

differences in the location and intensity of these values across the seascape (Fig. 3).

3.4. Relative Importance of Types of ES and Threats

Based on the 28 interviewees who provided spatial information, 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 the interviewees (Table 2). Value ascribed to biodiversity/wildlife was higher than value assigned to other non-monetary values (Table 2 and Fig. 5). 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., sport-fishing, boating, hiking, and stewardship activities) tended to identify locations associated with wildlife in addition to places where they recreate outdoors or enjoy other tangible non-monetary benefits from the ocean.

One interviewee expressed existence value for a region where he had never been that has a high density of nesting seabirds. Many 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 (Table 2).

Despite the personal and sensitive nature of spiritual value, some people identified numerous areas associated with spiritual value, inspiration and/or awe (Table 2). Respondents also assigned more relative value to areas associated with spirituality, inspiration or awe than any other intangible non-monetary benefit (Fig. 5). These results provide indication of the success of the interview protocol in eliciting a wide array of reasons why nature is important to locals.

According to the 17 interviewees who identified threats, salmon aquaculture was associated with the highest number of threat polygons, greatest area (km^2) under threat, and highest relative threat value (Table 2). The four people whose employment was associated with the salmon aquaculture industry did not consider the industry as an environmental threat. Commercial development, logging and pollution were considered threats by 4 or more interviewees.

3.5. Limited Representation

In order to better assess community values, representative surveys are needed (Brown, 2005b). Our study targeted people with a variety of marine-related professions rather than aiming for proportional representation. In particular, this study did not include the diversity of indigenous perspectives on ES values and threats within the study site. First Nations represent 23.4% of the region's population (BCStats, 2011) but they were only 6.6% of the interviewees (2 out of 30). Also, we requested the participation of representatives from two

Table 2
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, and threat) per interviewee. The number of participants is the number of interviewees who drew a particular type of polygon.

Category	No. of polygons	Relative value	Area (km^2)	No. of participants
Economic activity				
Commercial fishing	32	570	5411	6
Sportfishing	25	415	4383	5
Marine transport	19	297	3774	4
Eco-tourism	20	524	10,762	7
Science and biological monitoring	9	314	2683	4
Artistic	4	100	217	1
Fisheries management	2	115	2148	2
Education	1	30	88	1
Tangible non-monetary benefit				
Biodiversity/wildlife	61	839	6151	18
Natural beauty	59	318	2144	9
Cultural heritage site	37	505	727	10
Outdoor recreation, unspecified	30	44	663	2
Recreation, fishing	24	421	2516	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	1320	9
Education	8	72	2434	5
Peace	5	10	49	2
Sense of place/home	4	121	465	4
Transformational	3	72	811	2
Intergenerational	3	170	143	2
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	1001	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

aquaculture companies. One representative did not respond and the other refused to be part of the study.

3.6. Limitations of Mapping Marine ES

3.6.1. Indigenous People, Power and Mapping

The results of these mapping methods need to be understood in the context of the study region 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 ocean resources and marine areas are heatedly disputed (Young and
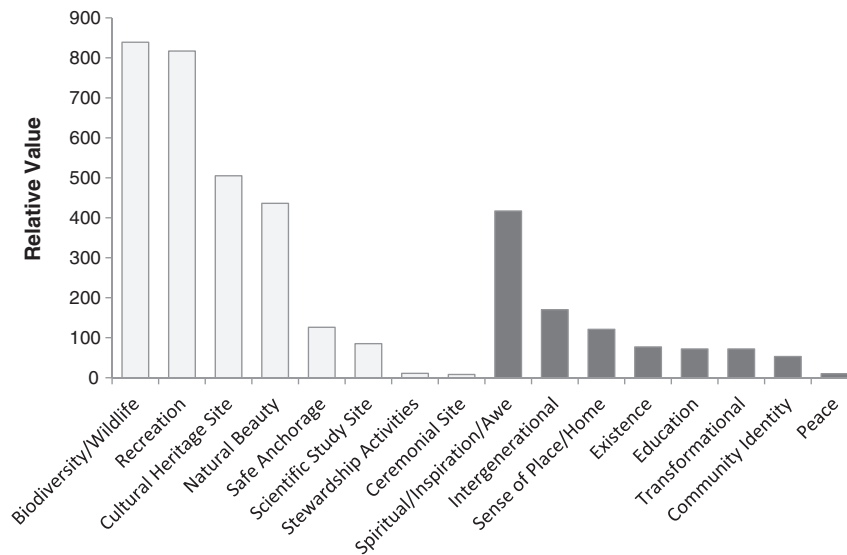
Fig. 5. Relative value assigned to non-monetary benefits. Light gray denotes tangible non-monetary benefits and dark gray denotes intangible non-monetary benefits.

Matthews, 2010). Documenting use, occupancy and, consequently, importance to indigenous people 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 benefits associated with marine ecosystems according to a wide range of people who rely on the ocean professionally. Although the maps synthesize multiple perspectives on areas that are important to residents, it is not representative of the region's diverse First Nation perspectives, nor does it take the place of traditional use and occupancy mapping, e.g., participatory mapping as explained by Tobias (2009), which can be used to defend claims to traditional territories in court systems. Although we did not provide a thorough representation of indigenous perspectives on value tied to the ocean due to time constraints, the special legal and ethical position of First Nation peoples merits special consideration in management and planning (DOJ, 1996; Gardner, 2009).

3.6.2. Lack of Spatial Identification of Supporting ES

The resulting maps omit explicit recognition of supporting ES, the inputs to final products 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. These findings are consistent with previous studies. Bryan et al. (2010) found that participants assigned supporting services the lowest social value as compared to cultural, provisioning and regulating services. Ruiz-Frau et al. (2011) found that only interviewees from the academic sector and environmental government agencies mentioned supporting ES.

Capturing the value of certain species to people and tying it to specific locations can be problematic. Several of RDMW's most culturally and economically valuable species, including orca whales, salmon, and herring, are highly migratory and inhabit different habitats during different life stages. 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 wildlife.

To more accurately map such values, future research could employ the promising but as yet not widely tested framework and methods that Semmens et al. (2011) propose for quantifying the relative contribution of different habitats in supporting valued migratory species. This entails 1) identifying all of the ES that a migratory species provides throughout its range; and 2) estimating the extent to which a specific location contributes to providing ES in other places via contributing to this migratory population's viability.

3.7. Implications for Management and Decision Making

This research demonstrates the power of map-based interviews for evoking a rich set of values linked to ES and place. However, many of the values that interviewees discussed are not adequately represented spatially and quantitatively. Other methods are necessary to properly account for such values in planning.

Interviewees identified hundreds of places important for ES-related activities and values. 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 2). To reflect what matters to people in RDMW, protecting these valued attributes and locations for particular activities should be a priority in MSP.

People derive monetary value from places that are considered under environmental threat. The challenge remains to manage environmental threats without undermining income generation. These maps could be used to focus regional management and regulatory efforts on places recognized for both high monetary value and environmental threat value. For example, in the RDMW, one of the major environmental threats identified by interviewees – salmon aquaculture – could abate with creating and enforcing stricter aquaculture regulations, including more frequent fallowing of net-pens, decreasing the density of net-pens and chemical treatments to reduce parasite loads in farmed fish stocks during wild juvenile salmon out-migration.

Despite the fact that people spoke at length about intangible values (Klain, 2010), 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 2). Given the varied response to the spatial prompts pertaining to non-monetary

values, including refusals (Table 2), isolating non-monetary values should not be the only method to solicit information pertaining to such values. Based on survey respondents assigning lower spiritual and intrinsic value scores on maps, Brown and Raymond (2007) suggest that people have difficulty assigning intangible qualities to features of the landscape. Our research supports this contention. 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. If a MSP process was based on a similar mapping and valuation process, it would be incomplete because such aggregate maps and correlation analyses do not fully represent intangible values.

Spatial prompting and, in the words of an interviewee, "quantifying the unquantifiable" are a starting point, but additional methods are required to explicitly recognize, respect and accommodate intangible values associated with ecosystems when development choices are made. The results from this research could launch discussions in a deliberative process that involves stakeholders sharing information and learning from each other as values and options are carefully considered and discussed (Sagoff, 1998; Spash, 2008). Similar to Cutts et al. (2011), stakeholders and policy-makers could review the existing aggregate spatial data, identify potential gaps in the information and discuss and prioritize the non-spatial values articulated during the research process (see Klain, 2010, Chapter 1 for a qualitative assessment of the interviews). This review could make the outputs from combined individual responses more salient, legitimate and credible for informing policy.

Another option for moving forward is using these research outputs to inform a deliberative multi-criteria evaluation (Bryan and Kandulu, 2011), or multi-criteria (or multi-objective) decision analysis (Gregory et al., 2012; Linkov et al., 2006; Mendoza and Martins, 2006). This type of research could be structured in such a way as to result in a list of priority ES considerations that reflects not only the income-related value of activities in particular places but also the meaning and importance that people associate with the marine environment. Embedding this type of research in a Participatory Action Research (PAR) framework with ongoing community collaboration (such as those outlined in Kindon et al., 2007) could also contribute to better consideration of values that are not appropriately expressed quantitatively or spatially.

4. Conclusion

From this pilot application of an interview protocol for eliciting stakeholder perceptions of ES in a spatial context, we conclude the following: 1) The protocol was successful at eliciting many people's perceptions of monetary (income-related) value, non-monetary value and environmental threat, although an important minority of respondents refused to quantify these, or represent them spatially. 2) Respondents identified many distinct justifications for valuing sites for reasons other than income generation. Most notably, people assigned high value to areas associated with prominent wildlife, natural beauty and cultural heritage. 3) Aggregated across individuals, monetary and non-monetary values are spatially correlated with each other, and also with perceived threats. These are likely places that people visit most frequently and with which they are most familiar.

Many existing planning processes do not explicitly assess the kinds of strong non-monetary values tied to ecosystems that participants in our research expressed verbally, spatially and/or quantitatively. Our study in the context of the growing field of landscape values research reveals that there is considerable impetus—and also opportunity—for better integrating CES values into planning through methods like our proposed interview protocol. We found that many people attach strong and diverse values to nature, but that spatially identifying and quantifying the importance of particular places is

only possible for some people and values. This suggests that planning and decision-making will be most effective and appropriate when they include a deliberative component.

Appendix A. Supplementary Data

Supplementary data to this article can be found online at http://dx.doi.org/10.1016/j.ecolecon.2012.07.008.

References

BCStats, 2011. Regional District 43 — Mount Waddington, Statistical Profile. Provincial Government of British Columbia, Victoria, BC.
Boyd, J., Banzhaf, S., 2007. What are ecosystem services? The need for standardized environmental accounting units. Ecological Economics 63, 616–626.
Brown, D., 2005a. Salmon Wars: The Battle for the West Coast Salmon Fishery. Harbour Publishing, Madeira Park.
Brown, G., 2005b. Mapping spatial attributes in survey research for natural resource management: methods and applications. Society and Natural Resources 18, 17–39.
Brown, G., Raymond, C., 2007. The relationship between place attachment and landscape values: toward mapping place attachment. Applied Geography 27, 89–111.
Brown, G.G., Reed, P., 2012. Social landscape metrics: measures for understanding place values from Public Participation Geographic Information Systems (PPGIS). Landscape Research 37, 73–90.
Bryan, B.A., Kandulu, J.M., 2011. Designing a policy mix and sequence for mitigating agricultural non-point source pollution in a water supply catchment. Water Resources Management 25, 875–892.
Bryan, B.A., Raymond, C.M., Crossman, N.D., Macdonald, D.H., 2010. Targeting the management of ecosystem services based on social values: where, what, and how? Landscape and Urban Planning 97, 111–122.
Butler, C.D., Oluoch-Kosura, W., 2006. Linking future ecosystem services and future human well-being. Ecology and Society 11.
Carr, S., 2011. Coastal and Marine Spatial Planning Tools. In: E.-B.M.T. Network (Ed.), NatureServe, Arlington, VA.
Chan, K.M.A., Hoshizaki, L., Klinkenberg, B., 2011. Ecosystem services in conservation planning: targeted benefits vs. co-benefits or costs? PloS One 6, e24378.
Chan, K.M.A., Satterfield, T., Goldstein, J., 2012. Rethinking ecosystem services to better address and navigate cultural values. Ecological Economics 74, 8–18.
Chiesura, A., de Groot, R., 2003. Critical natural capital: a socio-cultural perspective. Ecological Economics 44, 219–231.
Cutts, B.B., White, D.D., Kinzig, A.P., 2011. Participatory geographic information systems for the co-production of science and policy in an emerging boundary organization. Environmental Science & Policy 14, 977–985.
Daily, G.C., Ellison, K., 2002. The New Economy of Nature: The Quest to Make Conservation Profitable. Island Press, Washington, D.C.
Daily, G.C., Polasky, S., Goldstein, J., Kareiva, P.M., Mooney, H.A., Pejchar, L., Ricketts, T.H., Salzman, J., Shallenberger, R., 2009. Ecosystem services in decision making: time to deliver. Frontiers in Ecology and the Environment 7, 21–28.
Daly, H.E., Farley, J., 2010. Ecological Economics: Principles and Applications. Island Press, Washington, DC.
DOJ, 1996. Oceans Act. In: Justice, D.O. (Ed.), (Ottawa, Canada.).
Donovan, S.M., Looney, C., Hanson, T., León, Y.S.D., Wulfhorst, J.D., Eigenbrode, S.D., Jennings, M., Johnson-Maynard, J., Pérez, N.A.B., 2009. Reconciling social and biological needs in an endangered ecosystem: the Palouse as a model for bioregional planning. Ecology and Society 14 (art. 9.).
Ehler, C., Douvere, F., 2009. Marine spatial planning: a step-by-step approach toward ecosystem-based management. IOC Manual and Guides No. 53, ICAM Dossier No. 6. Intergovernmental Oceanographic Commission and Man and the Biosphere Programme. UNESCO, Paris.
Foley, M.M., Halpern, B.S., Micheli, F., Armsby, M.H., Caldwell, M.R., Crain, C.M., Prahler, E., Rohr, N., Sivas, D., Beck, M.W., Carr, M.H., Crowder, L.B., Duffy, J.E., Hacker, S.D., McLeod, K.L., Palumbi, S.R., Peterson, C.H., Regan, H.M., Ruckelshaus, M.H., Sandifer, P.A., Steneck, R.S., 2010. Guiding ecological principles for marine spatial planning. Marine Policy 34, 955–966.
Gardner, J., 2009. First Nations and Marine Protected Areas. Canadian Parks and Wilderness Society (CPAWS), BC Chapter, Vancouver, BC, pp. 1–90.

Gregory, R., Failing, L., Harstone, M., Long, G., McDaniels, T., Ohlson, D., 2012. Structured Decision Making: A Practical Guide to Environmental Management Choices. Wiley-Blackwell, West Sussex, UK.

Guerry, A., 2011. From Practice to Theory and Back: Ecosystem Services and Marine Spatial Planning AAAS Annual Meeting. AAAS, Washington, D.C.

Gunderson, K., Watson, A., 2007. Understanding place meanings on the Bitterroot National Forest, Montana. Society and Natural Resources 20, 705–721.

Kindon, S., Pain, R., Kesby, M., 2007. Participatory action research approaches and methods: connecting people, participation, and place. Routledge, New York.

Klain, S., 2010. Navigating marine ecosystem services and values. Resource Management and Environmental Studies. University of British Columbia, Vancouver, p. 104.

Levine, J., Chan, K.M.A., 2011. Global Human Dependence on Ecosystem Services, In: Köllner, T. (Ed.), Ecosystem Services and Global Trade of Natural Resources: Ecology, Economics and Policies. Routelage, New York.

Lindlof, T., Taylor, B.C., 2002. Qualitative Communication Research Methods, 2nd edition. Sage Publications, Thousand Oaks, CA.

Linkov, I., Satterstrom, F.K., Kiker, G., Batchelor, C., Bridges, T., Ferguson, E., 2006. From comparative risk assessment to multi-criteria decision analysis and adaptive management: recent developments and applications. Environment International 32, 1072–1093.

LOS, 2007. British Columbia Salmon Farm Licences and Applications. Living Oceans Society, Vancouver, BC.

LOS, 2011. The marine economy and the regional district of Mt. Waddington in BC. Living Oceans Society. prepared by GSGilason & Associates Ltd, Sointula, BC.

MA, 2003. Millennium Ecosystem Assessment, Ecosystems and Human Well-being: A Framework for Assessment. Island Press, Washington, DC, p. 245.

MAL, 2007. Marine Water Farm Sites, December 31, 2007. Ministry of Agriculture and Lands.

Mendoza, G.A., Martins, H., 2006. Multi-criteria decision analysis in natural resource management: a critical review of methods and new modelling paradigms. Forest Ecology and Management 230, 1–22.

Morgan, M.G., 2002. Risk communication: a mental models approach. Cambridge University Press, Cambridge; New York, p. 76.

Pearce, D.W., Atkinson, G., Mourato, S., 2006. Cost–Benefit Analysis and the Environment: Recent Developments. Organisation for Economic Co-operation and Development Publishing, Paris.

Raymond, C.M., Bryan, B.A., MacDonald, D.H., Cast, A., Strathearn, S., Grandgirard, A., Kalivas, T., 2009. Mapping community values for natural capital and ecosystem services. Ecological Economics 68, 1301–1315.

Ruiz-Frau, A., Edwards-Jones, G., Kaiser, M.J., 2011. Mapping stakeholder values for coastal zone management. Marine Ecology Progress Series 434, 239–249.

Safina, C., 2005. A Sea Ethic: Floating the Ark.

Sagoff, M., 1998. Aggregation and deliberation in valuing environmental public goods: a look beyond contingent pricing. Ecological Economics 24, 213–230.

Scholz, A.J., Steinback, C., Kruse, S.A., Mertens, M., Silverman, H., 2011. Incorporation of spatial and economic analyses of human-use data in the design of marine protected areas. Conservation Biology 25, 485–492.

Scholz, A.J., Steinback, C., Mertens, M., Birney, K., 2006. Commercial Fishing Grounds and their Relative Importance off the Central Coast of California. Ecotrust.

Semmens, D.J., Diffendorfer, J.E., López-Hoffman, L., Shapiro, C.D., 2011. Accounting for the ecosystem services of migratory species: quantifying migration support and spatial subsidies. Ecological Economics 70, 2236–2242.

Sherrouse, B.C., Clement, J.M., Semmens, D.J., 2011. A GIS application for assessing, mapping, and quantifying the social values of ecosystem services. Applied Geography 31, 748–760.

Spash, C.L., 2008. How much is that ecosystem in the window? The one with the bio-diverse trail. Environmental Values 17, 259–284.

St Martin, K., Hall-Arber, M., 2008. The missing layer: geo-technologies, communities, and implications for marine spatial planning. Marine Policy 32, 779–786.

Tashakkori, A., Teddlie, C., 2003. Handbook of Mixed Methods Sampling in Social and Behavioural Research. Sage Publications, London, UK.

TEEB, 2009. The Economics of Ecosystems and Biodiversity for National and International Policy Makers — Summary: Responding to the Value of Nature. Wesseling, Germany.

Tobias, T., 2009. Living Proof. Ecotrust Canada, Vancouver.

WHO, 2005. Ecosystems and Human Well-Being, Health Synthesis. World Health Organization, Geneva, Switzerland.

Worm, B., Barbier, E.B., Beaumont, N., Duffy, J.E., Folke, C., 2006. Impacts of biodiversity loss on ocean ecosystem services. Science 314, 787–790.

Yamanaka, K., Logan, G., 2010. Developing British Columbia's inshore rockfish conservation strategy. Marine and Coastal Fisheries: Dynamics, Management, and Ecosystem Science 2, 28–46.

Young, N., 2008. Radical neoliberalism in British Columbia: remaking rural geographies. The Canadian Journal of Sociology 33, 1–36.

Young, N., Matthews, R., 2010. The Aquaculture Controversy in Canada: Activism, Policy, and Contested Science. UBC Press, Vancouver, Toronto.