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Comparing the social values of ecosystem services in US and Australian marine protected areas

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ABSTRACT

Spatially explicit models for conservation planning often rely on environmental and economic indicators to prioritize management decisions. Consideration of social values in relation to landscape metrics is less common, especially across different biophysical contexts. In this paper, we compare social values mapped by outdoor recreationists who visited Santa Cruz Island within Channel Islands National Park, USA, and Hinchinbrook Island National Park, Australia using a Social Values for Ecosystem Services mapping tool that interfaced with Maximum Entropy modeling. Specifically, we determine the relative importance of 12 social values and evaluate how the relationship between three highly rated social values (*Aesthetic*, *Biological Diversity*, and *Recreation*) and four biophysical metrics (distance to the coast, distance to management infrastructure, slope, and elevation) differed between two marine protected areas. Our results provide insight into the spatial dynamics of social-ecological data to identify high and low priority locations in protected areas as well as enable resource management agencies to make more informed decisions about how best to engage with stakeholders. This research also supports public involvement in policy-making about land and seascapes in the USA and Australia.

1. Introduction

Understanding how people value nature provides a foundation for ecosystem services research and practice to support human well-being while maintaining ecological integrity (Díaz et al., 2015; Millennium Ecosystem Assessment, 2005). Marine and coastal ecosystems warrant particular attention because they embody a plurality of values and accommodate multiple uses, yet they are increasingly threatened by forces such as global environmental change and resource extraction (Halpern et al., 2008; Worm et al., 2006). Previous studies have focused on understanding the benefits provided by marine and coastal ecosystems (van Riper et al., 2012); however, most have relied on economic metrics (e.g., tourism funding, timber harvesting, commercial fishing) as well as ecological structures and functions (e.g., species density and composition) to demonstrate their value (De Groot, 2006; Millennium Ecosystem Assessment, 2005). Social values of ecosystem services are utilized less often but have the capacity to encompass both tangible (e.g., *Recreation*) and intangible (e.g., *Aesthetic*) qualities of nature (Kumar and Kumar, 2008; Raymond et al., 2009; Ives and Kendal, 2014). We define social values as qualities or benefits associated with a landscape or its functions to support human well-being (Brown, 1984). Previous research has further defined social values as individual valuations of cultural ecosystem services (CES) aggregated at a societal scale (Raymond et al., 2014).

Since the 1980s, social values research has gained traction in multiple disciplines such as psychology, sociology, ecological economics, the arts and humanities, and geography (Brown, 1984; Ives and Kendal, 2014; Raymond et al., 2018; Chan et al., 2018). An array of methodological and conceptual foundations within these fields have guided measurement of social values (Rawluk et al., 2019); however, monetary valuation schemes have dominated the ecosystem services literature. Non-monetary valuation and deliberative methods that consider ecological and economic aspects of conservation in conjunction with social values are increasingly recognized as integral for broadly characterizing the multiple values of nature (Chan et al., 2012; Masood, 2018; Millennium Ecosystem Assessment, 2005; Díaz et al., 2015; TEEB, 2010). Previous research espousing the use of non-monetary metrics (Alessa et al., 2008; Alexander et al., 2012; Christie et al., 2012; van Riper et al., 2017a) has strived to capture the tangible and intangible qualities of nature given that both serve as key motivators for fostering

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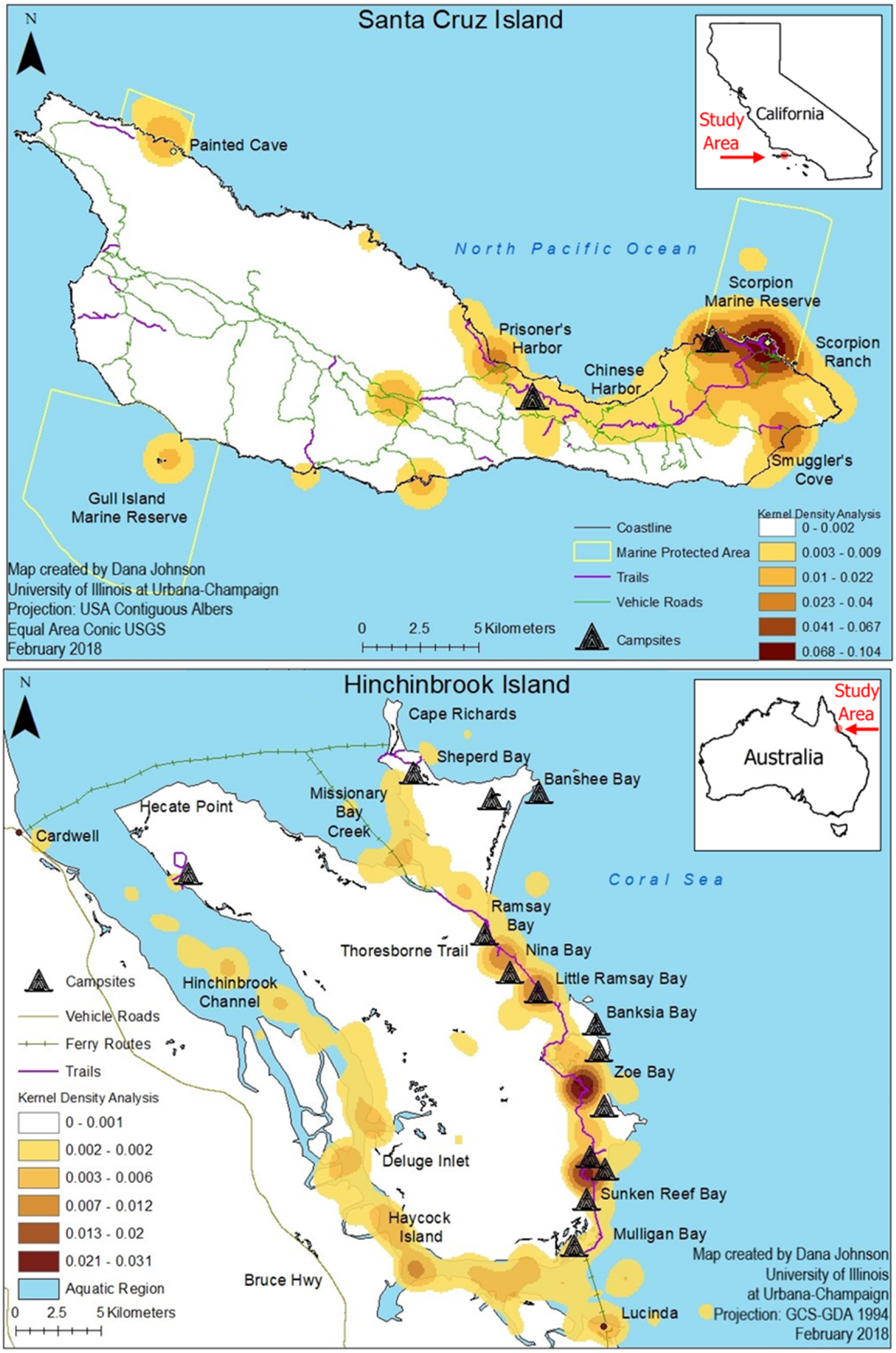

Fig. 1. Kernel density analysis of three social values of ecosystem service (i.e., *Aesthetic*, *Biological Diversity*, and *Recreation*) assigned by survey respondents to Sana Cruz Island within Channel Islands National Park and Hinchinbrook Island National Park.

public stewardship and support for environmental sustainability (Chan et al., 2012; Pascual et al., 2017).

The values of marine and coastal environments are important to incorporate in decision-making processes because these settings constitute some of the largest, most vulnerable, and publicly appreciated ecosystems in the world (Blasiak et al., 2015). Marine protected areas more broadly provide a suite of benefits to stakeholders through recreational opportunities, education and preservation of cultural histories (Manning et al., 2016), as well as conserve and restore species, habitats, ecosystems, and ecological functions due to their roles as biological refuges (NRC, 2001). Given that resource management agencies aim to engage stakeholders across sectors in decisions about protected areas, it is critical that governance is designed to balance competing interests and recognize long-term changes in values (van

Table 1
Key characteristics of the two study sites.

Study site	Santa Cruz Island, California	Hinchinbrook Island, Queensland
Designation	National Park/Biosphere Reserve/Monument	National park and reserve
Size	1010.1 km^2	398.86 km^2
Native cooperation	The Chumash Maritime Association partners with the National Park Service to protect native maritime culture through activities such as the annual Chumash tomol crossing	The Girringun Aboriginal Corporation represents the interests of Traditional Owners within the park through formal and informal agreements and cooperative programs
Recreation visitation (year of research)	364,808 (total visitation in 2016)	Unknown
Operating budget	$7,547,000 (as reported in 2012)	Unknown
Partnerships and employment	National Park Service, The Nature Conservancy, Channel Islands National Marine Sanctuary, Island Packers, Channel Islands Aviation, US Navy, National Oceanic and Atmospheric Administration, California Fish, and Game, Chumash natives, Ventura and Santa Barbara School Districts	Department of National Parks, Sports, and Racing, Residential employment (as of 2011) in the agriculture, forestry, and fishing industry, Great Barrier Reef Marine Park Authority, National Parks, Sports and Racing, Hinchinbrook Local Marine Advisory Committee Girringun Aboriginal Corporation
Habitat types	Grasslands, coastal sage scrub, woodlands, chaparral, riparian coasts, vernal pools, marshy wetlands	Estuarine, palustrine, riverine, mangroves, salt flats and marshes, non-floodplain tree swamps, floodplain tree swamps, eucalypt communities, shrublands, alluvial flats, woodlands

Riper et al., 2018). However, there is limited information on the social values of marine and coastal protected areas (Garcia-Rodrigues et al., 2017). Moreover, values are often only implicitly represented in management decisions due to their contentious nature and potential for representing points of social conflict (Maczka et al., 2019). This is problematic because sustaining ecosystems requires explicit representation of values to assess the tradeoffs people are willing to make between benefits and threats (Klain and Chan, 2012; Martín-López et al., 2014), which can inform development of conservation strategies that benefit ecosystems and diverse stakeholders (van Riper et al., 2012).

Over the past three decades, increasing levels of environmental degradation have spurred interest in research across cultural and biophysical contexts that responds to complexity in global environmental issues (Schwartz et al., 2001). Although nascent, comparative research has provided insight on variation in factors that affect environmental stewardship such as ethnicity (Milfont et al., 2006), nature-based beliefs (Bechtel et al., 1999) and environmental values (Schultz and Zelezny, 1998). For example, Brown et al. (2015) used internet-based Public Participation in GIS (PPGIS) techniques in Norway and Poland to identify stakeholders' values and preferences for management associated with regional protected areas. These authors emphasized the need to better understand the tangible and intangible values of different protected areas. Osmond et al. (2010) also conducted comparative research between the US and Australia and suggested that management agencies adopt place-based approaches to shaping marine policies and tailor decisions to work within local governance structures. These cross-national comparisons underlined the importance of documenting global trends such as the establishment of marine and coastal protected areas in different cultural contexts. Opportunities for knowledge exchange between countries carry great potential to influence policies that flow from research (de Groot et al., 2002), especially when supported by information about biological resources coupled with social values that vary across spatial scales (Douvere, 2008; Douvere and Ehler, 2009).

To address the need for comparative research on social values in coastal and marine protected areas in different countries, this study examined the three social values of *Aesthetic* (i.e., sights, sounds and smells), *Biological Diversity* (i.e., the variety of organisms in a specific area) and *Recreation* (i.e., outdoor activities) that were associated with terrestrial and aquatic ecosystems of Santa Cruz Island in Channel Islands National Park, USA, and Hinchinbrook Island National Park, Australia. Social values were compared to the landscape metrics of distance to the coast, distance to management infrastructure, slope, and elevation. These metrics were chosen to reflect the physical characteristics of these islands and extend previous research (e.g., Sherrouse et al., 2011). Using participatory mapping methods and the Social Values for Ecosystem Services (SolVES) software, we characterized the diversity of social values associated with protected areas that shared biophysical features. We were guided by three objectives: (1) Determine the relative importance and spatial distribution of 12 social values; (2) Examine how a suite of landscape metrics are related to three highly-rated social values; and (3) Compare social-ecological models across marine and coastal protected areas in the USA and Australia.

2. Methods

2.1. Study context

2.1.1. Channel Islands National Park

Channel Islands National Park is a marine protected area that spans 1010.1 km^2 of terrestrial and aquatic landscapes off the coast of southern California, USA. Santa Cruz is the largest of five islands within the protected area (250.01 km^2), located 32.19 km from the coast in the Pacific Ocean and approximately 145 km east of the city of Los Angeles (see Fig. 1). Dominated by a Mediterranean climate, the island is covered by grasslands and home to a myriad of flora and fauna including endemic species such as the Island Fox (*Urocyon littoralis*) and Santa Cruz Island Scrub Jay (*Aphelocoma insularis*). There is a total of 790 plant taxa of which about 578 are native. Throughout the Channel Islands, 23 endemic species have been identified including 11 bird species that are Channel Island subspecies. The Nature Conservancy and National Park Service co-manage 76% and 24% of the island respectively, while agencies such as NOAA manage the marine sanctuaries off the coast of the island (NPS, 2018). These agencies provide a suite of educational opportunities enjoyed by tourists—364,808 of whom visited in 2016. The marine regions around the protected area are biologically diverse (NPS, 2015), housing kelp forests intertwined with a biotic community ranging from small invertebrates to giant black sea bass (*Stereolepis gigas*). The highest peak in the interior mountain range reaches 0.747 km with large sea caves, tidepools and expansive beaches located at its base (see Table 1). Visitors to Santa Cruz Island have opportunities to engage in a variety of recreational activities such as hiking, camping, fishing, kayaking, snorkeling, and diving (NPS, 2015). Many visitors camp at Scorpion Ranch, which is the only established campground on Santa Cruz Island, while others set up camp in the backcountry.

2.1.2. Hinchinbrook Island National Park

Hinchinbrook Island National Park is 398.86 km^2 and is located 8 km off the coast of northeastern Queensland, Australia. The Department of National Parks, Sport and Racing (previously

Table 2
Definitions of social values for ecosystem services.

Assigned Value	Description
Recreation	I value these places because it provides a place for my favorite outdoor recreation activities.
Aesthetic	I value these places because I enjoy the attractive scenery, sights, sounds, or smells
Biological Diversity	I value these places because they provide a variety of fish, wildlife, plant life, etc.
Future	I value these places because it allows future generations to experience this place as it is now
Therapeutic	I value these places because it makes me feel better, physically and/or mentally
Intrinsic	I value these places in and of itself for its existence
Economic	I value these places because it provides economic benefits from recreation and tourism opportunities.
Learning	I value these places because I can learn about natural and cultural resources
Life Sustaining	I value these places because they help produce, preserve, clean, and renew air, soil, and water
Spiritual	I value these places because it is spiritually significant to me
Cultural	I value these places because it preserves historic places and archaeological sites that reflect human history of the island
Scientific[1]	I value these places because it provides an opportunity for scientific observation or experimentation
Historic[2]	I value these places because they have natural and human historical significance that matters to me, others, or the country

[1] Value type only examined in the context of Hinchinbrook Island.
[2] Value type only examined in the context of Santa Cruz Island.

Queensland Parks and Wildlife Service) has jurisdiction over the terrestrial system while the Great Barrier Reef Marine Park Authority oversees the aquatic region surrounding the park. The topography of this island ranges from mangrove forests and alluvial flats on the shoreline to the mountain's highest peak, Mt. Bowen, at 1.121 km. Hinchinbrook Island includes a diverse community of species such as estuarian crocodiles (*Crocodylas porosus*), dugong (*Dugong dugon*) and beach stone curlew (*Esacus magnirstris*), which are of conservation concern. There are 700 species and 30 communities of flora recorded in this region including dicots (*Buchanania mangoides*), mangroves (*Avicennia marina*), fern (*Huperizia phlegmaria*), eucalyptus (*Eucalyptus raveretiana*), and palms (*Livistona drudei*; van Riper et al., 2012). There are more than 19 mammal, 32 reptile and 150 bird species on the island. The most common recreational activities are fishing in mangrove forests and hiking the Thorsborne Trail. Visitor use on Hinchinbrook Island and in its adjacent waters occurs year round. Permits are issued to limit use to 40 people on the island at one time (QPWS, 2017; see Table 1).

3. Research approach

The field of PPGIS was formalized in 1996 (Sieber, 2006) to represent a method that combines academic uses of GIS and mapping with local communities to create knowledge of places (Brown and Reed, 2012; Tulloch, 2008), as well as empirically understand how people relate to their environments (Bagstad et al., 2014; Brown and Reed, 2012). Research involving PPGIS has been conducted in natural resource management contexts such as marine protected areas and forests to overlay participatory data with existing biophysical conditions (Brown and Weber, 2011; Bagstad et al., 2017). This body of past work has engaged multiple perspectives in the marine planning process, facilitated a dialogue between diverse stakeholders, and encouraged collaboration. Insights have also been provided on perceptions of environmental impact and preferences for future resource use (Bagstad et al., 2014; van Riper et al., 2017b) as well as the competing objectives of protected areas to sustain ecological integrity while maximizing the enjoyment of visitors (Brown and Weber, 2011).

Multiple survey modes have been used to generate point, line, and polygon data associated with particular geographic locations that reflect social values in online (Kobryn et al., 2018; Pocewicz et al., 2010), in-person (Rehn et al., 2018; van Riper et al., 2012), and mail-back surveys (Brown and Weber, 2011). The inclusive nature of PPGIS has allowed the public to play a role in the decision-making process, thereby increasing efficacy and inclusivity in the implementation of new policies. The application of PPGIS has the potential to incorporate human activities into GIS analyses of marine and coastal ecosystems for more comprehensive environmental planning (Halpern et al., 2008). This methodology can also build trust and transparency by creating opportunities for the public to contribute to land-use decisions (Brown and Reed, 2000).

To engage in more coordinated and sustainable practices that support public involvement, marine spatial planning was developed as a science-based tool to facilitate decisions about entire ocean ecosystems rather than considering individual species in isolation (Douvere and Ehler, 2009; Liu et al., 2007; Santos et al., 2013). This is a form of multi-use planning that maintains ecological integrity while including stakeholders in decisions with an eye toward ecosystem-based and adaptive management (Douvere, 2008; Foley et al., 2010; Holling 1973). Marine spatial planning research has largely drawn on spatial technologies to visually represent cumulative impacts from human communities on marine ecosystems and integrated science, policy and public inclusion (Crowder and Norse, 2008; Cudney-Bueno and Basurto, 2009; St. Martin and Hall-Arber, 2008). The present study extends the marine spatial planning literature given our goals to generate a better understanding of social drivers of change, establish a collaborative environment for stakeholders to engage in conflict resolution and negotiation, and ensure more balanced representation of competing interests in planning for competing objectives (Blake et al., 2017; Kobryn et al., 2018).

3.1. Data collection

Data for this research were drawn from two-step participatory mapping exercises included in on-site surveys conducted on Santa Cruz Island in 2012 and Hinchinbrook Island in 2011. Respondents were asked to assign 100 hypothetical "preference points" across 12 different value types in increments that reflected the reasons why the protected areas were seen as important (see Table 2). Preference points rather than dollars were used because values such as *Aesthetic* and *Spirituality* were less easily monetized (Sherrouse et al., 2011). The values included in the two typologies were adapted from past research (Brown and Reed, 2000) and tailored to the study contexts in consultation with public land management agencies (van Riper and Kyle, 2014; van Riper et al., 2012).

During the mapping exercises, respondents were asked to identify locations that embodied social values by marking points on maps that were included in the two self-administered surveys distributed by trained administrators. On Santa Cruz Island, an 863.6 mm by 330.2 mm map created by the National Geographic Society was on display at the survey station. Respondents pointed to places that embodied social values and trained survey administrators recorded points on ASUS Transformer TF3000T tablets. Respondents were then prompted to identify which values should be ascribed to the dot from a list of 12 value types. On Hinchinbrook Island, respondents were presented with a 210.82 mm by 297.18 mm map of the island and asked to draw dots with a dark colored pen that identified places of personal importance and then ascribe value to each dot. From these two steps, the spatial locations and point densities of social values of ecosystem services were determined. The mapping exercises were just one component of the on-site survey, but generated our main data for analysis in this study. Each on-site survey included a range of questions about topics such as trip characteristics, socio-demographics, and a two-step mapping exercise.

The sampling strategies were similar in both study contexts. Visitors over the age of 18 were approached over a six-week period during the high use season (June-October on Hinchinbrook and June-August on Santa Cruz). Drawing from intercept survey methods (Flint et al., 2016), particularly in protected areas (van Riper and Kyle, 2014), visitors were approached during different days of the week (weekdays and weekends), different times of day (mornings and afternoons), and at different sampling sites to obtain a representative sample. Visitors to Santa Cruz Island were approached at multiple locations around Scorpion Ranch, which is a popular tourist site on the island. When in groups, the individual with the most recent birthday was asked to participate to minimize selection bias (Battaglia et al., 2008). Surveys took approximately 20 minutes to complete. Contact logs were used to estimate response rates in both contexts and the overall sample size on Santa Cruz Island was 344 (94% response rate). On Hinchinbrook, on-site sampling occurred at two boat ramps, a fishing pier, two ferries that provide transportation to and from the island, a caravan park, and the Hinchinbrook Island Fishing Club meeting in the town of Ingham. Following methods outlined by Young (2006), an additional mail-back survey was distributed by two ferry operators that asked visitors to complete the survey at the end of their visit and return it via a postage paid envelope. A total of 59 of the 200 survey questionnaires were returned by mail resulting in a sample size of 209 and a response rate (52%) that was lower than the project in Santa Cruz Island.

3.2. Data analysis

The social value points collected on Santa Cruz Island and Hinchinbrook Island were digitized using ArcMap V10.5 and entered into an ArcGIS geodatabase (Santa Cruz n = 2245; Hinchinbrook n = 1748). Hypothetical preference points were uploaded to the geodatabase and associated with a unique identifier, such that the preference ratings were joined with the digitized points for the same value types. Four spatial layers representing natural resource conditions were then loaded into the geodatabase, including (1) distance to the coast (shortest straight-line distance to each cell using spatial analyst); (2) distance to infrastructure (i.e., shortest straight-line distance to each cell using spatial analyst); (3) slope (i.e., derived from a digital elevation model using the surface analyst tool in spatial analyst) and; (4) elevation (i.e., digital elevation model) (see Table 3). Next, we calculated a single kernel density surface including all digitized points in the ArcGIS geodatabase to observe overall spatial patterns of survey responses from which the SolVES mapping application (Sherrouse et al., 2011) derived a 10-point Value Index (VI). The VI is a non-monetary metric derived from survey data to quantify social values of ecosystem services (Sherrouse et al., 2011).

For each protected area, kernel density analyses were performed, following a quadratic kernel function that defined a smoothly curved surface that fit over each point and extended to a defined search radius (Silverman, 2018). The volume below each surface was determined by a weight assigned to each point, and we assigned all points to a default weight of 1.0. For Santa Cruz, the kernel density output cell size of 100 m was selected with a search radius specified at 1500 m. For Hinchinbrook, the kernel density output cell size of 150 m was selected with a search radius specified at 1500 m. All analyses were performed in ArcGIS V10.5, with the SolVES 2.0 application (Sherrouse and Semmens, 2015) and SPSS V23.0.

Next, SolVES was used to determine the spatial distribution and density of social value points assigned to places in the two protected areas. We focused specifically on *Aesthetic*, *Biological Diversity*, and *Recreation* because these value types were most highly rated across both of the study sites. SolVES provided a systematic framework to link survey data about social values of ecosystem services to the four landscape metrics. The output from SolVES created a value layer that was normalized against the highest overall weighted kernel density value and standardized to generate a VI integer surface for each value type. This allowed us to produce maps that compared the VI scores for select value types against landscape metrics. We then used spatial regression analyses to statistically compare each of the three value types to the four landscape metrics. Results from SolVES were interfaced with maximum entropy (MaxEnt) modeling to analyze the relationships between the social and ecological data (Sherrouse and Semmens, 2015). MaxEnt was originally created to spatially generate predictive models of species presence but is used here to spatially model social values (Phillips et al., 2006; Phillips and Dudík, 2008). Using the results from MaxEnt, we created maps that spatially indicated the probability of presence of multiple social values of ecosystem services in the two protected areas.

4. Results

4.1. Socio-demographics and trip characteristics

On Santa Cruz, there was a nearly even gender ratio among respondents with slightly more females (52.40%) than males (47.60%) and an average age of 43.53 years old ($SD = 14.83 \pm 0.87$). Respondents were highly educated with 76% holding a bachelor's degree or higher. The average annual income before taxes was $150,000 USD, and the average number of people per household was

Table 3
Social and ecological data used to examine social values of ecosystem services and landscape metrics on Hinchinbrook Island and Santa Cruz Island.

Data	Description	Source
Distance to Coast	Distance between value points and the coastline of each island	Computed as the distance to 0 meters in elevation (mean sea level)
Distance to Management Infrastructure	Distance between value points and the Thorsborne Trail on Hinchinbrook; Distance between value points and infrastructure that facilitated recreational activities, including trails, educational centers, boat ramps, and docks on Santa Cruz	Derived from U.S. National Park Service spatial data and created using tools available in the Spatial Analyst extension of ArcGIS (Santa Cruz); Calculated from digitized features (Hinchinbrook)
Slope	Percent slope	Derived from a Global Digital Elevation Model
Elevation	Raster elevation data	U.S. Geological Survey's National Elevation Dataset (Santa Cruz); Calculated from digitized features (Hinchinbrook)
Important park features for visitors	Roads, foot trails, vehicle roads, campsites, ferry routes, popular tourist locations	Derived from ArcGIS online data and U.S. National Park Service Spatial data (Santa Cruz); Derived from Queensland Department of Natural Resources, Mines and Energy, and geospatial referencing tools (Hinchinbrook)

approximately two ($SD = 1.30 \pm 0.07$). The average number of total visits to the park was 4.91 ($SD = 15.86 \pm 0.92$), and the majority (60.90%) had visited on only one occasion previously. Approximately half (52.80%) of respondents traveled with family and were considered day users (52.20%), while just under one quarter (20.80%) visited the park with friends. The most common recreational activities on Santa Cruz Island were hiking (94.10%), experiencing nature (78.70%), and taking photographs (75.10%), while few reported recreational fishing (4.20%), sailing (2.50%), and commercial fishing (0.30%). The origin of visitors to Channel Islands was unavailable.

On Hinchinbrook, 60.60% were male with an average age of approximately 45 years ($SD = 15.79, \pm 1.13$). Respondents on Hinchinbrook Island visited from Australia (88%), Belgium (20%), Germany (15%), and the United States (10%). Those who lived in Australia were from Townsville (11.40%), Brisbane (5.70%), and Cairns (5.70%). Respondents were well educated with slightly under half holding a bachelor's degree or higher (41.50%). The average annual income before taxes was $75,550 USD and the average number of people per household was just under three ($SD = 2.24 \pm 0.16$). The average number of visits to the park in the last 12 months was 23 ($SD = 39.89 \pm 4.28$), which included people in caravan parks and locals who reported each boat trip as an individual visit. Over half of respondents traveled in a family group type (55.10%), and day users visited the park for an average of six hours. The most common recreational activities on Hinchinbrook Island were hiking (51%), fishing (57%), camping (51%), taking photographs (52%), wildlife viewing (41%), kayaking (2%), and birding (10%) (see Table 4).

Table 4
Socio-demographics and trip characteristics for visitors to Santa Cruz Island and Hinchinbrook Island. Hyphens indicate data were not available.

Socio-demographics	Santa Cruz N (%)	Hinchinbrook N (%)
Gender		
Male	168 (47.59)	120 (59.41)
Female	185(52.41)	81 (40.10)
Age	$M = 43.53$ $SD = 14.83 \pm 0.87$	$M = 45.06$ $SD = 15.79 \pm 1.13$
Education		
Less than high school	3 (0.85)	24 (12.18)
High school graduate	23 (6.53)	54 (27.41)
Vocational/trade school certificate	12 (3.41)	27 (13.71)
Two-year college degree	47 (13.35)	-
Four-year college degree	133 (37.78)	43 (21.83)
Honors	-	7 (3.55)
Graduate degree	134 (38.07)	42 (21.32)
Income		
Less than $20,000	19 (5.64)	17 (10.24)
$20,000 to $49,999	51 (15.13)	28 (16.87)
$50,000 to $99,999	97 (28.78)	54 (32.53)
$100,000 to $149,999	84 (24.93)	33 (19.88)
$150,000 to $199,999	49 (14.54)	15 (9.04)
Greater than $200,000	37 (10.98)	19 (11.44)
Ethnicity		
Hispanic or Latino	40 (11.33)	-
Not Hispanic or Latino	313 (88.67)	-
Race		
American Indian or Alaska Native	6 (1.71)	-
Asian	31 (8.83)	-
Black or African American	5 (1.42)	-
Native Hawaiian or other Pacific Islander	2 (0.57)	-
Not a native descent	-	196 (97.50)
Native descent	-	5 (2.50)
White	293 (83.48)	-
Household size	$M = 2.86$ $SD = 1.30 \pm 0.071$	$M = 2.84$ $SD = 2.24 \pm 0.159$

4.2. Distribution of social values

The first phase of our analysis examined how social values of ecosystem services were distributed across each of the study areas. Respondents evaluated 12 social value types and reported that the protected areas were important for multiple reasons. The three most important social values were *Aesthetic* (435), *Biological Diversity* (416) and *Recreation* (369 digitized points) on Santa Cruz Island, and were therefore investigated further in the present study (see Table 5). These three value types were unevenly distributed and thus indicated that places of value abundance (i.e., "hotspots) existed on the islands. These high priority locations emerged from our assessment of respondents' social values in relation to on-ground conditions. The most important places marked by respondents on Santa Cruz were near Scorpion Ranch, Scorpion Marine Reserve, Smuggler's Cove, and Prisoner's Harbor.

Spatial clustering of all digitized social value points suggested that respondents valued areas along the coastline and within marine protected area boundaries (see Fig. 1). These areas were easily accessible and provided multiple activities such as fishing, camping, boating, and snorkeling. Using the SolVES application, average nearest neighbor statistics were calculated including R-values (i.e., ratio of observed versus expected distance among points) and Z-scores (i.e., number of standard deviations from the mean of each R-value). This analysis showed statistically significant spatial clustering of the digitized points. Also, VI scores were generated to illustrate the relative importance of social values, and indicated scores for *Aesthetic*, *Biological Diversity*, and *Recreation* and were five or greater on a 10-point scale (see Table 5). The value types of *Learning* and *Scientific* values also emerged as important reasons why visitors valued Santa Cruz Island.

The three social values of ecosystem services on Hinchinbrook Island were unevenly distributed in space, denoting hotspots of important places across the land and seascapes of this protected area, similar to Santa Cruz. All three social values of ecosystem services were represented by *Aesthetic* (236), *Biological Diversity* (226) and *Recreation* (399 digitized points). The most valued places mapped by respondents were on the Thorsborne Trail near Nina Bay, Little Ramsey Bay, Zoe Bay, and Sunken Reef Bay. Overall, respondents valued the main trail and coastal regions surrounding the island (see Fig. 1). These areas had high visitation likely due to accessibility and diverse recreational opportunities such as sailing, fishing, swimming in freshwater waterfalls, and hiking along beaches. The average nearest neighbor statistics showed statistically significant spatial clustering of digitized points. Specifically, the VI scores for the three value types were 5.0 or greater on a 10-point scale (see Table 5).

4.3. Comparison between study contexts

Patterns in value types and landscape conditions were examined across both protected areas to identify high and low priority settings (see Fig. 2). Distance to infrastructure was the most powerful predictor of social values of ecosystem services across all three value types on Santa Cruz Island (*Aesthetic*: $R^2 = 0.84$; *Biological Diversity*: $R^2 = 0.75$; *Recreation*: $R^2 = 0.51$) and Hinchinbrook Island (*Aesthetic*: $R^2 = 0.90$; *Biological Diversity*: $R^2 = 0.88$; *Recreation*: $R^2 = 0.77$). All value assignments on Santa Cruz Island decreased exponentially and both *Aesthetic* and *Recreation* decreased logarithmically on Hinchinbrook Island.

The rate of decrease of the VI scores on Santa Cruz Island was generally higher than on Hinchinbrook Island, which suggests that Santa Cruz visitors had lower distance ranges or tolerance of distance to

Table 5
Average nearest neighbor statistics and Value Index (VI) scores of all social values of ecosystem services.

	Santa Cruz Island				Hinchinbrook Island			
	Maximum VI score	N	R-ratio	Z-score	Maximum VI score	N	R-ratio	Z-score
Recreation	7.20	369	0.24	−27.97	9.30	399	0.45	−20.90
Aesthetic	9.20	435	0.22	−31.26	9.00	236	0.38	−18.24
Biological Diversity	6.50	416	0.51	−19.26	5.60	226	0.55	−13.09
Future	3.80	110	0.42	−11.66	3.70	100	0.62	−7.35
Therapeutic	2.60	143	0.37	−14.36	2.80	96	0.49	−9.69
Intrinsic	2.80	97	0.36	−12.13	1.90	86	0.59	−7.32
Economic	0.90	16	0.98	−0.13	1.00	37	0.60	−4.68
Learning	6.90	206	0.12	−24.22	0.90	27	0.61	−3.90
Life Sustaining	2.00	45	0.48	−6.72	0.90	19	0.53	−3.89
Spiritual	1.90	88	0.27	−13.06	0.90	20	0.51	−4.21
Cultural	3.80	86	0.26	−13.21	0.60	10	0.57	−2.59
Scientific[1]	2.80	200	0.51	−13.14	-	-	-	-
Historic[2]	-	-	-	-	0.90	33	0.63	−4.07

[1] Value type only examined in the context of Hinchinbrook Island.
[2] Value type only examined in the context of Sana Cruz Island.

infrastructure compared to Hinchinbrook Island. We found strong linear relationships between all three social values of Santa Cruz Island (*Aesthetic*: $R^2 = 0.22$; *Biological Diversity*: $R^2 = 0.41$; *Recreation*: $R^2 = 0.50$) and Hinchinbrook Island (*Aesthetic*: $R^2 = 0.03$; *Biological Diversity*: $R^2 = 0.29$; *Recreation*: $R^2 = 0.44$) in relation to the distance to coast landscape metric. Hinchinbrook visitors had a strong tendency to map social values as close to the water as possible (less than 500 m away) as did Santa Cruz visitors, but in contrast, the range of distance for Hinchinbrook respondents was higher (up to 2500 m). There were few discernable patterns in relationships between all three social values and slope across both parks with the exception of *Recreation* which showed a positive linear relationship on Santa Cruz ($R^2 = 0.29$) and negative linear relationship on Hinchinbrook Island ($R^2 = 0.29$). We found linear relationships between both *Biological Diversity* ($R^2 = 0.29$) and *Recreation* ($R^2 = 0.44$) and the mean elevation on Hinchinbrook Island.

On Santa Cruz Island, the VI score of all three social values showed both increases and decreases as elevation increased. This suggested that some respondents preferred both higher and lower elevation. Similar to the kernel density outputs, the spatial projections from the SolVES and MaxEnt analyses revealed similar patterns in probability of presence ascribed to areas near the coastline and park infrastructure with increasing distance from these metrics (see Fig. 3). Additionally, on Hinchinbrook Island we observed larger VI scores associated with aquatic regions of the park.

5. Discussion

5.1. Cross-site comparisons

Drawing on survey data from two protected areas, we generated spatially-explicit indicators of social values of ecosystem services that enabled us to better understand stakeholder viewpoints and link this information to underlying biophysical data. We observed strikingly similar patterns in the distribution of social values, particularly *Aesthetic*, *Biological Diversity*, and *Recreation,* indicating similar social-ecological relationships on Santa Cruz Island within Channel Islands National Park, USA and Hinchinbrook Island National Park, Australia. We extend previous research that has suggested these social values are important indicators of how people connect with nature (Brown et al., 2002; Brown and Raymond, 2007; Sherrouse et al., 2014), particularly in marine and coastal ecosystems (Klain and Chan, 2012; van Riper et al., 2012). We also observed that distance to infrastructure and distance to coast were the strongest predictors of the spatial patterns of social value allocations in both settings and suggest that access is instrumental in facilitating park users' social valuations (Coffin et al., 2012). The clear pattern of effects observed in this research underscores the utility of deliberative techniques such as PPGIS and marine spatial planning for operationalizing social values as group-level reflections of cultural ecosystem services. This cross-site study provided insight on variation in social values across diverse land-use contexts (Schwartz et al., 2001; Gould et al., 2015) and advanced knowledge of recreational use in two public land management contexts (Manning et al., 2016).

We observed similar social value patterns that decreased logarithmically or exponentially with increasing distance to infrastructure and coastline in both protected areas. We believe there are several reasons for these similarities. First, the samples from Santa Cruz Island and Hinchinbrook Island included highly educated, upper-middle class, middle-aged citizens, and a nearly even gender ratio. These socio-demographics may account for the commensurate valuations of different features in the parks (Blankenberg and Alhusen, 2018). Results from the kernel density analyses indicated social values were concentrated near places where visitors had physical experiences. Given that past research has shown survey respondents with greater knowledge are more likely to ascribe value to places that they have not experienced firsthand (van Riper and Kyle, 2014), it could be that segmenting the sample would have revealed variation in the relationships between direct-use patterns and perceived values of land and seascapes. Additionally, the relationship between VI scores and proximity to landscape features was more pronounced across all three value types on Hinchinbrook Island, especially in relation to the coastline. Given that approximately half of the Hinchinbrook sample consisted of anglers, the values from marine biodiversity and other services may have been associated with the coastlines where there was overlap between marine and terrestrial recreation.

Select differences between the two study sites emerged. We observed a small amount of variability in the relationship between social values and landscape metrics. Santa Cruz visitors had a higher tolerance for being further away from the coastline and infrastructure, likely due to a landscape that was easier to traverse and encouragement from management agencies to venture off trail. Tighter restrictions on Hinchinbrook Island, such as the visitor permitting processes and denser vegetation which can limit use likely concentrated recreationists on the Thorsborne Trail and aquatic resources directly adjacent to the coastline. In other words, these spatial patterns can be explained by use structures within each park. We also observed different experience-user-histories, in that respondents on Hinchinbrook Island reported visiting on over 20 occasions whereas respondents on Santa Cruz Island reported around five visits in the previous year. Finally, the Hinchinbrook sample was more diverse in origin than visitors to Santa Cruz given the homogeneity of visitation in most US national parks (Schuett et al., 2010). Although both samples ascribed largely similar

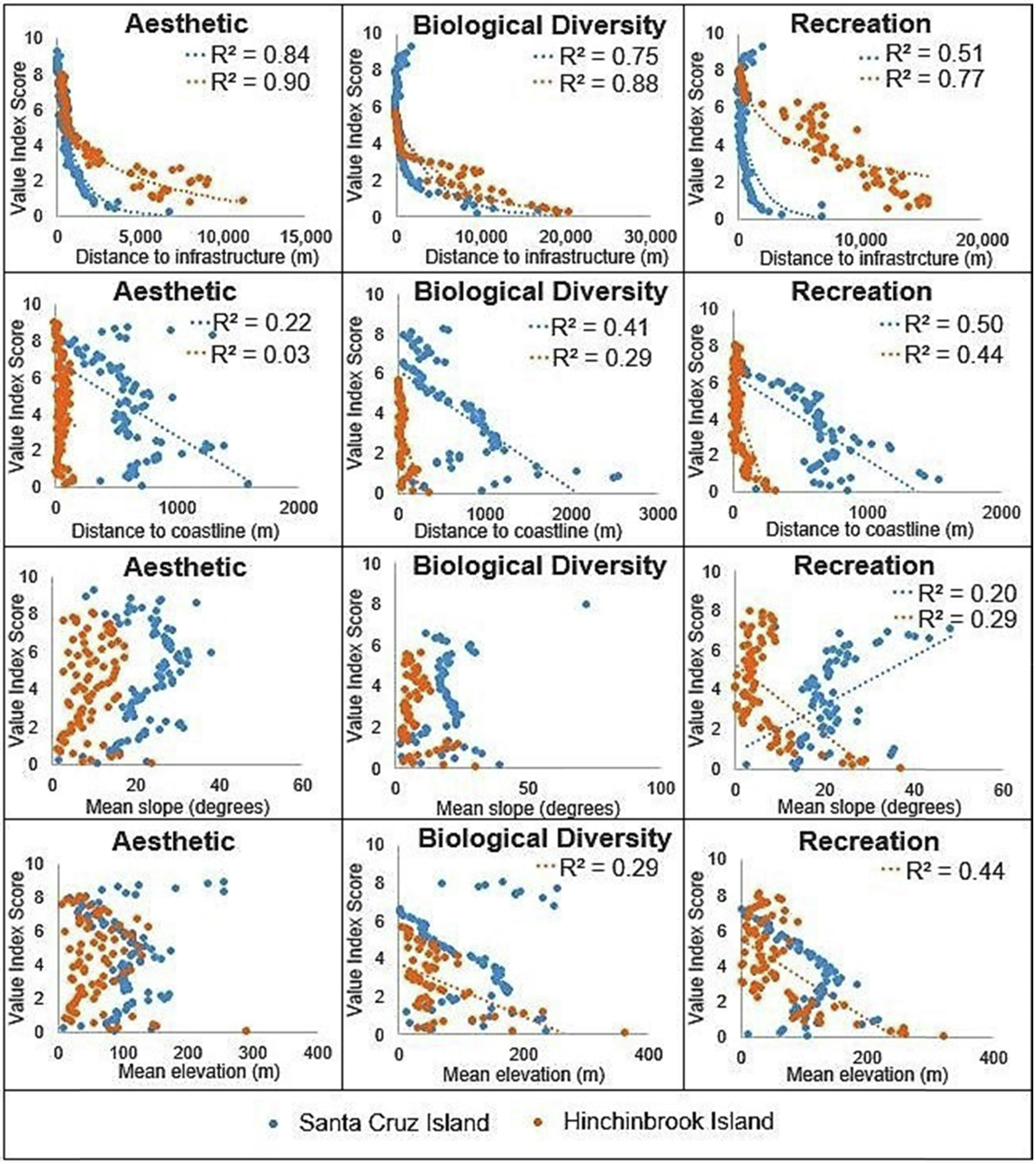

Fig. 2. Comparison between four landscape metrics (i.e., distance to coast, distance to management infrastructure, slope, and elevation) and Value Index scores for three social value types across the two study sites.

values to places, these were important differences between the two samples that may account for the patterns that emerged from our comparative research.

5.2. Managing for social values of ecosystem services

The spatial distribution and point density of social values indicated that stakeholders had clear preferences for landscape features. Building on previous research that has generated typologies for measuring social values (Brown and Reed, 2000, 2012; Chan et al., 2012), our findings suggested marine and coastal ecosystems embodied a range of 'place meanings' or social indicators of the reasons why stakeholders viewed marine protected areas as important. These results emphasize that human well-being is linked to ecosystems, their services, and the physical world while acknowledging that there are multiple, 'bundled' reasons why places are valued (Martín-López et al., 2014). Participatory and place-based approaches to park planning can accommodate the co-creation of knowledge and build deeper understandings of ecosystem services of marine and coastal protected areas (Lopes and Videira, 2017).

With a growing concern for the future of marine and coastal ecosystems, researchers have stressed integration across value approaches to better understand social-ecological change (Berkes et al., 2008; Klain and Chan, 2012; Raymond et al., 2018; van Riper et al., 2018). The importance of choosing appropriate valuation methods to broadly reflect values throughout the decision-making process cannot be

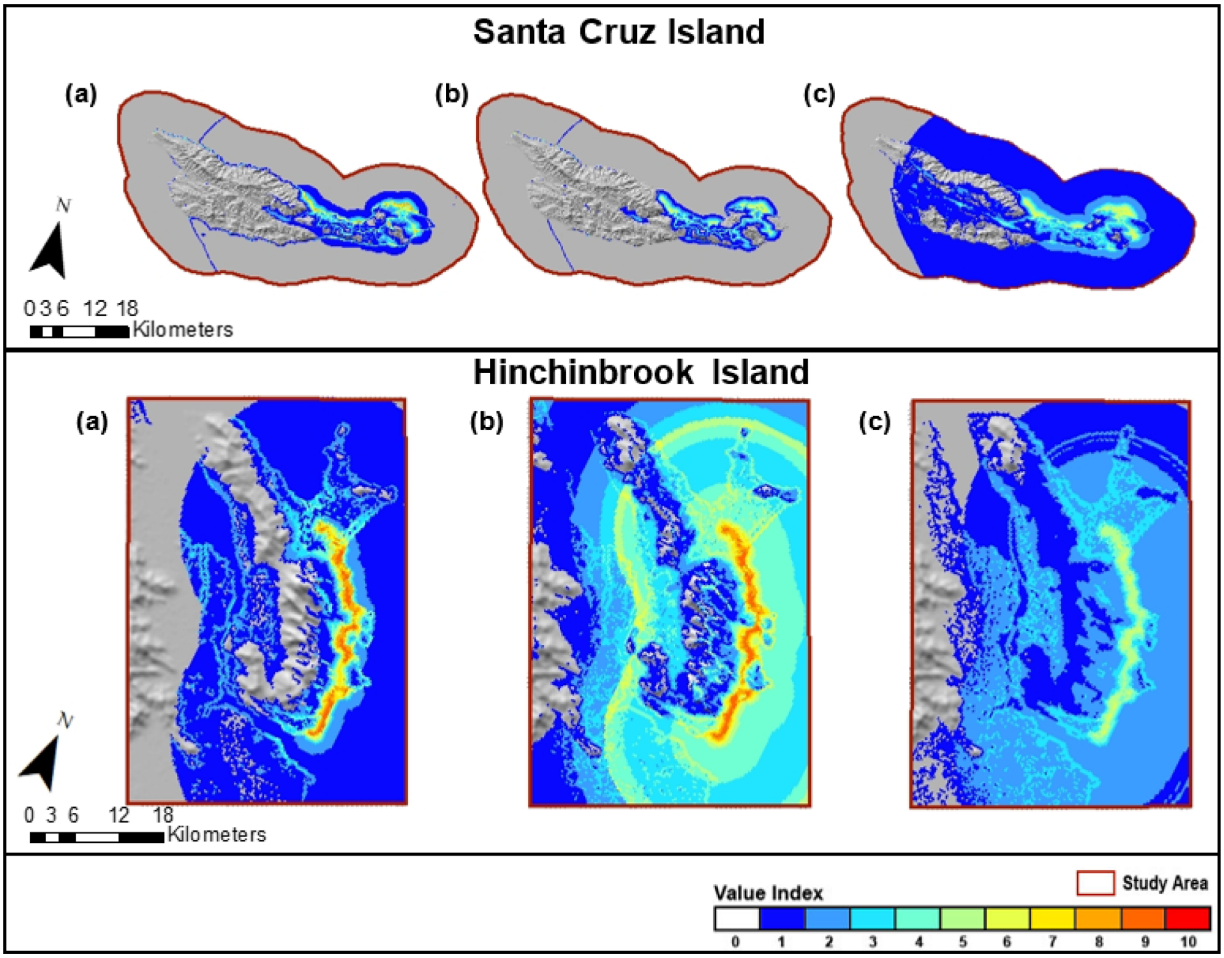

Fig. 3. Spatial projections for probability of presence of (a) *Aesthetic*, (b) *Biological Diversity*, and (c) *Recreation* social values of ecosystem services for the two study sites.

overstated because research approaches can either equitably represent community interests or ignore underrepresented voices in policy change (Gasparatos 2010). We suggest that monetary and non-monetary valuations should be embraced in the study of human values, which aligns with a growing body of research focused on maintaining value pluralism (Kenter et al., 2016; van Riper et al., 2017b). Such holistic approaches facilitate the potential for recognizing the symbolic meanings of instrumental objects that may be reduced by solely monetizing ecosystem services (Gómez-Baggethun and Ruiz-Perez, 2011; Spangenberg and Settele, 2016). There is increasing recognition that research should account for intangible values and services (Chan et al., 2012), yet few schemes incorporate these services alongside monetary metrics of the importance of nature. Therefore, in this paper we adopted a method that captured a range of social values drawn from different forms of knowledge about what values represent (Lopes and Videira 2016). Specifically, we explored and quantified a range of social values and measured their relative importance in relation to the environment.

Comparing social value allocations and landscape metrics across two parks that share biophysical features demonstrated how PPGIS could explicitly capture perceived tangible and intangible social values of ecosystem services in diverse contexts. The relationships examined in this study were quantified, mapped and analyzed using SolVES and MaxEnt (Sherrouse et al., 2011). Uncovering the similarities and differences in park geography, visitation, and the sample populations on both islands can help decision-makers and researchers better understand value preferences to support sustained stewardship of protected areas. Although other tools such as LUCI, InVEST, and Co$ting Nature have advanced understanding of ecosystem service valuation (Bagstad et al., 2013), SolVES incorporated non-spatial survey data and engaged with MaxEnt modeling instead of relying solely on biophysical models to quantify ecosystem services. Across all of these tools, there is an assumption that findings are transferable across different contexts. We acknowledge there is important information not captured by predictive models, and suggest that future research support the use of deliberative techniques alongside models of social values. This research approach will be more likely to accommodate different ways of representing knowledge, articulate broader values of nature and respond to nuanced differences in environmental governance regimes.

Measuring social values will provide public land management agencies with knowledge of the preferences, priorities, and tradeoffs of stakeholders in relation to on-ground conditions, as well as enable managers to incorporate this information into marine spatial planning processes. In particular, points of value abundance can be used as a guide to direct managerial attention to places of perceived importance and/or areas where user-user and user-environment conflicts are likely to occur. Our findings identified value hotspots concentrated near infrastructure and along coastlines and provided insight on the reasons why these settings warrant special attention. On Santa Cruz Island, the three highly rated values explained why places were valued, yet *Learning* and *Scientific* values were also highly rated. These additional values aligned with the National Park Service's goals to promote visitor learning through interpretation and offer a living laboratory for studying the environment. In addition to exploring places of value abundance, agencies may also focus on "cold spots" for conservation where there were limited perceived values but potential for generating public support (Bagstad et al., 2017; van Riper et al., 2012). The west sides of both islands, for instance, may contain undervalued resources that could be highlighted provided this garnered attention does not compromise conservation objectives.

5.3. Limitations and future research directions

We provided a foundation for understanding social values associated with different marine and coastal protected areas but also faced important limitations. First, while the SolVES tool enabled us to empirically evaluate the social values of ecosystem services, the transferability of our findings to other contexts should be carefully considered. For agencies to apply this tool, models can be generalized across geographic and cultural contexts to support social value transfers (e.g., Bagstad et al., 2013), with the understanding that upscaling social value data risks overlooking nuances that emerge from place-based conservation. Secondly, this research did not directly draw from value theories (e.g., Schwartz et al., 2001) or connect our study findings to behavioral patterns. Future research should continue assembling the empirical building blocks necessary for establishing a theoretical framework to guide interpretation of social values research (Chan et al., 2018; Raymond et al., 2018). Third, our study focused on two island national parks within socio-cultural contexts that were governed by different customs, histories and management practices; however, we did not assess culture or use it as a basis for our comparison. Although our sites were biophysically comparable, this study would have benefited from an explicit indicator of culture to help explain differences in social valuation and anticipate management responses to our results. Fourth, the value typology we adopted was drawn from previous research rather than developed through in-depth processes such as focus groups or interviews. Although we were reflexive in our preliminary site visits and able to draw from personal knowledge of each context, our research could have been enhanced with qualitative information that supported bottom-up processes at the beginning and ends of the research process. Fifth, data collection methods varied across sites with both including an on-site survey, but the Hinchinbrook study also including a mail-back survey. Though we contend that the variation in survey methods had negligible impacts on the results (only about 28% of the Hinchinbrook sample returned completed mail-back surveys), future research should remain consistent in data collection methods.

6. Conclusion

Our research links social and ecological data by focusing attention on the landscape scale and facilitating a dialogue about how best to advance ecosystem-based management of human activities in marine settings. Our results indicate that the same three social values (i.e., *Aesthetic, Biological Diversity*, and *Recreation*) are highly valued in two settings and their spatial patterns can be predicted by four landscape metrics (i.e., distance to coast, distance to management infrastructure, slope, and elevation). We also suggest values are more likely to be ascribed to places near infrastructure and along coastlines, particularly in the context of Hinchinbrook. Finally, there are similar spatial patterns of social and ecological data on both Santa Cruz Island and Hinchinbrook Island National Park. The social-ecological relationships that we modeled identify high and low priority locations for management considerations. We assert that value pluralism can and should be maintained in protected areas such as Channel Islands and Hinchinbrook Island National Park due to the myriad reasons why these public resources are valued. Our results also emphasize the importance of accessibility in anticipating the social values of nature and advance knowledge of how to sustainably manage marine and coastal ecosystems in a way that incorporates public viewpoints into resource management decisions.

Declaration of interests

None.

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