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Understanding coastal social values through citizen science: The example of Coastsnap in Western Australia

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ABSTRACT

The coast is socially, economically, and environmentally vital to humanity, yet at risk due to population growth, development, and climate change. Coastal managers are required to make complex decisions regarding the trade-offs that may arise because of these threats, hence evidence-based policy is essential. Advances in biophysical data have improved understanding of coastal change, yet comparative social data is limited. Innovations are required to generate social values data that: (i) links with biophysical data; (ii) is consistent, representative, and long-term; and (iii) requires low resource investment. This paper reports on a pilot program that sought to address these needs by linking with an established citizen science program, CoastSnap, to collect information on community use and values in the Peron Naturaliste region, south-west Western Australia. The program successfully monitored community use and values uncovering the importance of nature-based activities and the mental/emotional health benefits of interacting with the coast. It highlights spatial differences in use and value that can support regional coastal planning. In the longer-term, the approach could enable decision-makers to monitor change in use and values resulting from, for example, infrastructure investments or physical coastal change. Limitations include little control over respondent sample and lack of knowledge regarding barriers to participation. Further research into the factors that motivate users and their preferences for interacting with the remote survey technologies, along with an expanded network of CoastSnap Social Survey sites, would facilitate regional, national, and global comparison of use and values. The approach provides a valuable addition to coastal managers' data collection toolbox, generating social data that are temporal, integrates with biophysical data, and supports regional coastal planning, whilst increasing opportunities to interact with the public to enhance awareness, interest and support for coastal management.

1. Introduction

Global warming is contributing to sea-level rise, increased ocean temperature and enhanced storm intensity and frequency, all of which impact coastal infrastructure and environments with associated loss of ecosystem services (IPCC 2019). Population growth and urbanisation are placing further pressure on coastal areas (Neumann et al., 2015). In managing these impacts, trade-offs and compromises have become an inherent component of coastal management. Coastal managers, in consultation with stakeholders, determine which assets will be preserved and lost and these decisions will become more significant and controversial over time (Johnston et al., 2018). Coastal management seeks to 'maintain, restore or improve specified qualities of coastal ecosystems and their associated human societies' (Olsen 2002, p325).

To inform such decisions, coastal managers draw on information regarding physical coastal change and socio-ecological values, to identify projected losses and how they can be minimised. Physical coastal monitoring has long been a central pillar of coastal management (Baily and Nowell 1996). Beach profiles, wave heights, and mean-sea level, among others, are collected to provide insight into: (i) physical coastal change; (ii) human influence on the coast; and (iii) exposure to risk. Over time, data collection technologies have evolved from manual

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in-field measurements to remote sensing (e.g., LiDAR). However, physical data collection remains labour intensive and remote sensing can incur high technology costs. These limitations mean data are restricted in both space and time. The more intermittent the data collection, the longer measurement must be undertaken to resolve the range of coastal processes influencing change (Splinter et al., 2013).

Despite these limitations, physical data are more advanced and mainstreamed in coastal planning and management than social data, including public attitudes, values and behaviours, which is at a much earlier stage of development (Bennett 2019). This is despite the incorporation of concepts such as 'social wellbeing' and 'sustainable coastal communities' into coastal and marine planning policies worldwide (e.g., Gollan et al., 2019). Values are complex, diverse, and dynamic. The benefits one individual derives from the coast will differ to that of another and will change over time based on experience and the physical environment change. These values and beliefs have a direct influence on the priorities assigned to planning and management of the coast (Elrick-Barr and Smith 2022) and is increasingly sought-after knowledge for coastal managers (Acott et al., 2022; Covi et al., 2021).

To date, knowledge on coastal social values has been gained via direct consultation (e.g., workshops, surveys) with stakeholders (e.g., residents, visitors, business owners). This generally requires significant human and financial resources, specialist expertise and knowledge, and relies upon community members being available and willing to participate at a specific time and place. While these mechanisms contribute understanding of segments of the communities' views, the required resource investments mean they are generally only conducted on an as-needs basis, and often do not provide the consistent (e.g., questions, facilitators), representative (e.g., a broad cross-section of stakeholders) and/or long-term (temporal) information that is essential for adaptive coastal planning and management (Fudge et al., 2021; Human and Davies 2010; Puente-Rodriguez 2014).

Despite recognised limitations in adopted approaches to understand social values, there has been limited innovation in the social data collection space. Past innovations include linking social values to place through, for example, interactive coastal mapping (e.g., Moore et al., 2017), meeting an identified need for spatial social data that complements biophysical data (Cornu et al., 2014). Yet there are few examples in the literature of consistent temporal social data and techniques to link social and biophysical data, beyond social values mapping. This contrasts with innovation in physical coastal data collection, where new technologies (such as satellite-derived shorelines) and citizen science initiatives deliver data at higher resolution, expanded geographic coverage and greater frequency. For example, citizens have been trained to fly unoccupied aerial vehicles (UAVs) to monitor beach change (Pucino et al., 2021) and invited to take and submit photos of the coast, so over time images record coastal change (Harley and Kinsela 2022). By engaging the community a more comprehensive dataset can be obtained than relying on researchers or coastal managers alone (Harley and Kinsela 2022). Adopting similar initiatives to address gaps in social values data has not been explored, but provides an opportunity to deliver consistent, representative and temporal data.

To enhance evidence-based decision-making in coastal planning and management we need to rethink how civil society is engaged in the collection of information on social values. Complementary approaches to workshops and one-off surveys are required that are less resource intensive, engage a broader audience and provide long-term (temporal) data. This paper reports on a project that sought to meet this need, by linking with an established citizen science program to collect information on community coastal social values, implemented over a seven-month funding period (December 2021–July 2022) in the south-west of Western Australia. We outline the benefits and limitations of the approach during the project period.

2. Approach

2.1. Case context

Citizen science is part of a growing global movement to engage the community in scientific research. In this research, an established citizen science program, CoastSnap, was adopted to support the collection of data on community use and values of coastal areas. CoastSnap is a global initiative with 200 stations in 21 countries, including the USA, Canada, South Africa, Europe, and Australasia (Harley and Kinsela 2022). It provides the opportunity for beach users to contribute to coastal monitoring by taking and submitting photos of the beach. Over time CoastSnap records beach erosion and recovery cycles, and long-term changes, helping researchers understand why some beaches are more dynamic or resilient than others (Harley and Kinsela 2022).

In early 2020, the Peron Naturaliste Partnership (PNP) installed CoastSnap sites along the Peron Naturaliste coastline (Fig. 1). The PNP is a group of nine coastal local government authorities between Cape Peron and Cape Naturaliste in the southwest of Western Australia (Bunbury, Busselton, Capel, Dardanup, Harvey, Mandurah, Murray, Rockingham, Waroona) whose resident populations range from 4234 (Shire of Waroona) to 135,638 (City of Rockingham) (ABS 2021). The region is a predominately sandy coastline approximately 200 km in length. It includes coastal lagoons and estuaries internationally recognised as a Ramsar listed wetlands, including the Peel Harvey Estuarine System, the Vasse Wonnerup and Broadwater wetlands, and the Leschenault Estuary.

The Peron Naturaliste region encompasses rapidly growing peri-urban coastal communities (e.g., City of Mandurah), large regional and tourism centres (e.g., Busselton, Bunbury) and smaller coastal towns (Waroona). The coastline includes 105 km of urban coast where uses are predominately residential and commercial and there is a high demand for recreational activity, 19 km of natural coast with less intensive hinterland uses and concentrations of tourism and associated recreational and cultural activities, and 88 km of remote coast with limited opportunity for low key tourism and associated recreational and cultural activities (Acil-Tasman Pty Ltd 2012). In 2021, the population of the region was 383,000 (ABS 2021), with tourism, agriculture, mining, port-related activities, and fishing constituting the major sectors of employment.

Beaches in the region attract local, interstate, and international visitors; however, most users are residents. In a study exploring the social value of beaches in the Peron Naturaliste region conducted between September 2017 and April 2019, 45%–70% of respondents travelled less than 1 km to access the beach, and 90% less than 10 km (e.g., Bunbury and Waiki beach), with a slightly higher proportion of non-residential beach use (approximately 15% travelling more than 10 km) in recognised tourist areas (i.e., Dunsborough) (Perry et al., 2019). Beaches in the region are primarily used for light recreational activities such as walking/running, swimming, and spending time with family/friends (Perry et al., 2019).

The installation of the CoastSnap monitoring system was part of a larger monitoring program implemented by the PNP to address gaps in knowledge, raise community awareness of coastal processes and actions taken to manage coastal hazards, and support long-term coastal planning and management.

2.2. Method

There were three phases to the project: (i) integration with the CoastSnap platform; (ii) survey design, and (iii) data analysis. Each is discussed in turn.

2.2.1. Integration with the CoastSnap platform

CoastSnap sites were installed within the PNP region prior to the development of the CoastSnap app (Harley and Kinsela, 2022);

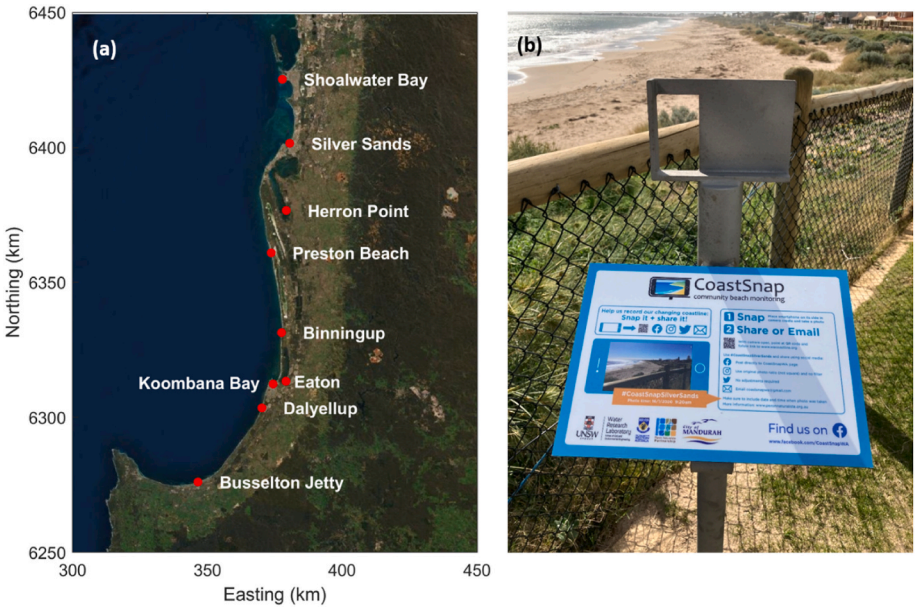

Fig. 1. (a) Overview of CoastSnapWA sites within the PNP region. (b) Example CoastSnapWA smartphone cradle and signage from Silver Sands (Mandurah, WA) (Source: Cuttler and Hansen 2022).

therefore, image upload was made possible via a site-specific QR code (linked to an Amazon S3 storage bucket), social media platforms, and email. Analysis of the first year of CoastSnap in the PNP region showed that most images were uploaded via the site-specific QR code (Cuttler and Hansen, 2020). The coastal values survey was directly integrated into the QR-based upload. When users visit a CoastSnap site, take a photo of the beach using the fixed platform, and then upload their photo via the QR code, they are invited to complete the online social values survey. At the time of survey implementation, seven of the nine installed CoastSnap sites were operational (i.e., excluding Heron Beach and Preston Beach, Fig. 1).

2.2.2. *Survey design*

The survey was designed to gather information on respondents' emotions, visitation rates, use, values, and perceptions. It differed from traditional coastal user surveys, which are often conducted in-field, face-to-face or following a face-to-face invitation (e.g., Lukoseviciute and Panagopoulos 2021; Tuohy et al., 2022). By contrast, our survey was opportunistic, remote, and allowed for repeat respondents. We sought to engage people showing an interest in coastal monitoring (through participation in CoastSnap) and had no direct interaction with respondents. CoastSnap users are often regular beach users, who take and submit a photo each time they visit the beach. While this provided a unique opportunity to explore change in use and values for individual respondents over time, it further emphasised the importance of the survey being engaging and time limited. To trace repeat survey responses whilst maintaining participant confidentiality, a unique ID code was generated and emailed to each respondent when they first completed the survey.

To support broad and repeat engagement, the survey was delivered in two parts. The response time for each was approximately 5 min. The first component collected information contributing to coastal management and planning by local government authorities, including emotions, use, values, and perceptions; while the second component collected additional information on visitation, perceptions of change, and questions to establish economic value (Travel Cost method, see Rogers et al., 2019). After completing Part 1 respondents were provided the option to complete Part 2 or exit the survey.

Connection to nature influences emotional well-being (Coventry et al., 2021; Richardson et al., 2020), yet there is limited empirical evidence measuring this relationship in a coastal context. To explore whether emotional attachment differed based on beach condition and its relationship to use and values respondents were asked, 'Looking at the beach today, how do you feel?'. Emojis are widely applied in consumer research but rarely in an environmental management context yet provide a valuable way to engage youth (Bosch and Revilla, 2021) and explore 'how much' something is valued (Davies 2017). Emojis were therefore adopted to represent the six basic human emotions identified by Ekman (1999), namely sadness, happiness, fear, anger, surprise, and disgust. The remaining questions were Likert scale with a limited number of open-ended questions (see Table 1 for further detail).

Values are complex and divergent and capturing this complexity in a time-limited survey is challenging and there are inevitable trade-offs between simplicity and detail (Spiers et al., 2019). To facilitate this process, we adopted the framework of Perry (2022) which conceives coastal values as the product of a cascading set of relationships between four 'orders' of elements: natural features, built assets, uses and benefits. Coastal uses were grouped by their location on the coast rather than individual activity (e.g., ocean-based activities such as swimming, surfing or boating; beach-based activities such as exercise, 4WD, fishing, surf-life saving; foreshore-based activities such as exercise, visiting attractions, spending time with friends or family; and nature-based activities such as wildlife watching and conservation work). This reduced response options, increasing the simplicity of the survey. Benefits were categorised into four groups: physical health, mental/emotional health, spiritual/cultural well-being and social well-being. In turn, it was possible to relate benefits to use, which were in turn linked to physical or built environment.

Survey questions to allow a Travel Cost method were incorporated to understand the economic value of beaches. Questions explored visitation (the number of visits in the last 12 months, how many people come with the respondent when they visit the beach), transport (the most common mode of transport to get to the beach, how far they travel to get to the beach) and other activities (any stops at other places during the same trip, e.g. visit while going to/from work, school, grocery shopping, or stop at a café, etc).

The survey was presented to Local Government practitioners for review prior to implementation, with minor modifications to ensure key information needs were met in the first past (Part 1) of the survey. The survey received ethics approval (University of Western Australia HREC

Table 1
Overview of survey structure and content.

Survey Component	Content and rationale
Component One: Part A	Captured information on respondents' emotional response to the beach at time of visit.
Component One: Part B	Explored motivation to visit to obtain information on beach activities, uses and their importance. Comparing use and importance across beaches can aid in planning nodes of activity; while exploring the relationship between use, importance and beach conditions can direct efforts to achieve improved condition (e.g., safety, amenity) based on the uses and values sought to be maintained or developed.
Component One: Part C	Gathered information on perceptions of beach conditions, to explore the link between beach condition and emotional engagement (Part A) and use (Part B). For instance, the survey sought to explore (i) the emotional attachment of visitors to the beach and how this compares across sites; (ii) how attributes of the coast, its visual condition and/or the activities possible, influence emotions.
Component One: Part D	Gathered information on the ability of the respondent to conduct the activities they sought, and the influence of beach condition. By understanding the link between beach condition and use, coast managers can plan for nodes of use based on projected changes in beach condition (e.g., because of natural change and/or human interventions).
Component One: Part E	Gathered information on respondents' perceptions of coastal change and drivers of change.
Component One: Part F	Collected basic information on respondent characteristics.
Component Two: Part A	Gathered additional information on perceptions of beach change, if they had previously visited the beach, and concern for and awareness of the impacts of climate change on the beach.
Component Two: Part B	Gathered the information required to perform an economic assessment of the value of the beach, using the Travel Cost method. The advantages and limitations of different economic valuation approaches were considered by the Project team and local government practitioners. The Travel Cost method was selected for its simplicity, noting that it would only provide an indication of current recreational use and value (i.e., not projected value based on future, contingent management scenarios).

number 2021/ET001035) and was implemented via the Qualtrics™ online survey platform. A full copy of the survey is provided in the Supplementary Materials.

As with all participatory data collection programs, knowledge and awareness is key to increasing engagement. Two radio interviews, one media release and a Facebook post (sharing preliminary results) were distributed during the project phase. Responses to the Facebook post suggest viewing results provided impetus for respondents to continue to contribute to the survey. Whilst limitations in the quantity of responses were encountered in some locations, these generally relate to low beach visitation (i.e., small resident and/or tourist populations).

2.2.3. Analysis

The data was analysed in Qualtrics StatsQI statistical analysis package to explore significant differences in values, use and perceptions based on (i) CoastSnap site visited; (ii) frequency of visitation; (iii) perceived condition of the beach or foreshore; and (iv) respondents' emotional reaction to the beach. Anova, Chi-square tests and cross-tabulations were performed. Results are reported as significant where $p < 0.05$. The response rate enabled cross-beach comparisons in three of the seven beaches (Dalyellup, Busselton Jetty and Shoalwater Bay), termed herein 'focus beaches'.

3. Results

3.1. Survey engagement

The period of data collection (mid-December 2021 to mid-July 2022) incorporated the main seasons of beach visitation in the south-west of WA (including the summer and Easter school holidays) and allowed capture during different seasons (summer and beginning of winter). During this period ninety-five complete survey responses were received. The proportion of CoastSnap users in the PNP region that completed the social values surveys was approximately 19%. Three of the seven CoastSnap sites contributed 75% of the responses: Dalyellup (Capel), Busselton Jetty (Busselton) and Shoalwater Bay (Rockingham) (see Supplementary Table 1). All survey respondents had uploaded a CoastSnap photo and 43% went on to complete Part 2.

CoastSnap provides an opportunity for citizen scientists to regularly contribute images of the coast and many CoastSnap sites are frequented by repeat users. It is unlikely that, for example, daily visitors will complete the survey on each visit. Therefore, to gain a better appreciation of survey response rate, we compared the number of 'first time' survey respondents with the number of unique CoastSnap users at each site. In some locations (e.g., Eaton, Bunbury) response rate was as high as 50% (with an average first-time response rate of 27.3%).

Response rate was slightly higher in summer than winter; but there remained consistent engagement during the cooler months (April–July). Some locations have more repeat responders than others, which is a function of the CoastSnap user group at each beach. For example, Busselton Jetty with high tourist visitation had a high proportion of first-time respondents, while Dalyellup had a high proportion of repeat responses from one regular and committed respondent at the site. During the period of data collection, Western Australia imposed severe travel restrictions, with interstate and international arrivals banned between January and March 2022, potentially impacting the level of non-resident engagement in the survey.

3.2. Coastal use and values

Nature-based activities (e.g., wildlife watching, conservation work) were most important for survey respondents and water-based activities least important (e.g., swimming, surfing, boating) (Supplementary Fig. S1). Significant differences in the importance of coastal activities were identified across the three focus beaches. In Busselton, beach and jetty-based activities (e.g., exercise, fishing) were prioritized (χ^2 16.7, $p < 0.034$), while water-based activities (e.g., swimming, surfing, boating) were more likely to be important to Shoalwater respondents than for respondents at Dalyellup or Busselton Jetty (χ^2 16.9, $p < 0.032$). The importance of nature-based activities was however universal, with no significant difference by beach or based on frequency of visitation.

Beach use differed based on frequency of visitation. On average, across all surveyed beaches respondents who infrequently visited the beach placed more importance on the presence and condition of built facilities, such as toilets, showers, access paths, cafes, playgrounds, than frequent visitors. Also, those who visited the beach more regularly placed greater importance on water-based activities. The frequency of visitation did not influence the importance assigned to nature-based activities, which were rated highly important regardless of visitation rate.

The most important benefit gained from visiting the beach was mental/emotional health. Mental/emotional health was rated very important by 77% of respondents, compared to 60% assigning high importance to physical health and social well-being and 56% to spiritual/cultural well-being. Physical health (χ^2 24.8, $p < 0.016$) and cultural/spiritual (χ^2 21.9, $p < 0.038$) were more important to regular (daily or weekly) beach users than less frequent visitors. The high importance of mental/emotional health is reflected in the emotions respondents felt when 'looking at the beach' with 72% reporting they were happy. The importance of these benefits did not differ significantly across the focus beaches, demonstrating respondents have an affective relationship with the beach and this relationship supports emotional health. The findings align to other research reporting the importance of a connection to nature in physical and emotional health (Gascon et al.,

2017; Coventry et al., 2021) and in promoting environmental conservation and pro-environmental behaviours (Richardson et al., 2020).

3.3. Beach condition and perceptions of change

Across all beaches, foreshore condition was considered good and dune condition moderate. Ocean condition received the most negative response. There were identifiable differences in perceived condition by beach, for example the foreshore was more positively rated in Busselton and Dalyellup compared to Shoalwater (χ^2 15.4, $p < 0.017$), while dune condition was perceived to be more positive in Shoalwater than Busselton and Dalyellup (χ^2 22.6, $p < 0.004$). The condition of the beach and foreshore rarely affected respondents' ability to conduct their intended activities (91% of respondents stated their activities were unaffected by beach condition). However, for those who reported that condition impacted use, water-based activities and foreshore-based activities were most frequently impacted (50% of cases respectively), and ocean-condition (e.g., waves and rips) the primary factor affecting use (88% of cases).

There were significant variations in perceptions of change (erosion, accretion or stable) and the drivers of change (i.e., daily tides, storms, sea-level rise, coastal development, unsure) by beach (Fig. S2). Users were invited to describe the changes they had seen since their last visit to the beach and make other comments on potential improvements. These responses (see Supplementary Tables S2 and S3) provide coastal managers with information on issues affecting use and value. For example, respondent ID33 noted "I would like to see a general ban on recreational fishing in the Shoalwater Islands marine reserve. The disregard for the conservation of the area by this particular group of users is untenable. Plastic waste, wildlife entanglements and boat strikes, and dunes used for human waste, are just some examples".

Thus, while there were differences in the perceived condition of the dunes and foreshore across beaches, this had little effect on use. This suggests coastal condition is not currently impacting visitors' affective relationship with the beach. Furthermore, respondents' perceptions of change were mostly 'natural' (storms and tides) and related to the seasonal movement of sand, with an overall view that beach and foreshore condition was good. This implies that if the foreshore/beach is seen as pristine/natural/undergoing natural change, then perceptions of change will be positive. Anthropogenic disturbance to the natural environment (e.g., rubbish; vehicle tracks) can impact an individual's ability to realise emotional benefits and they will view the beach negatively and may go elsewhere.

3.4. Emotions, use and beach state

Using time-lapse images of respondents' CoastSnap photo and their response to the question, 'Looking at the beach today, how do you feel?', we found respondents were noticing and surprised about beach change, including short term erosion, the presence of beach wrack or human impact (e.g., vehicle tracks on the beach) (Fig. 2 for sample and Fig. S3 in Supplementary Materials for interactive image). Emotions also changed with change in relative shoreline position (Fig. 3) suggesting that respondents notice and are emotionally responsive to change in beach state.

By collecting information on respondents' emotional reaction to the beach, we sought to explore the relationship between perceived condition and emotional well-being. 'Happy' was the dominant emotional reaction to the beach (72%) with a limited number of respondents selecting other emotions (15% surprised, 5% worried, 3% sad). Consequently, statistical analysis of the relationship between emotion and beach condition was not possible. Whilst respondents were often unsure of the condition of the foreshore and ocean, they were more certain of the condition of the beach (Fig. S3). Respondents who perceived the beach condition as 'moderately bad' were more likely to describe their emotional reaction as 'surprised' than any other category. The findings, though preliminary, suggest perceived physical beach condition can influence emotional response.

3.5. Economic value

We opportunistically included questions to enable estimation of a Travel Cost model, as the question set was concise, and would have provided an economic measure of value which has the potential for integration in decision support tools such as benefit-cost analysis, to directly compare the value of recreational benefits with the financial aspects of different management decisions. However, it was anticipated at the outset that it was unlikely we would achieve a sufficient sample size in the case study region, as this economic analysis typically requires large samples of unique respondents per site (e.g., >50) and does not benefit from temporal data. Part 2 of the survey, containing questions to conduct the Travel Cost method, was completed by 37 respondents. This ranged between 1 and 7 unique (first-time) visitors at each beach. As such, this mode of data collection was not conducive to economic analysis, particularly because a large proportion of the respondents completing the second part of the survey were repeat rather than first time users. Implementation of the Travel Cost model may, however, be successful in locations with higher CoastSnap engagement. The collection of data on distances travelled and visitation frequency complements interpretation of other data collected in the survey, even if not produced as an economic model.

3.6. Monitoring change over time

The temporal nature of the survey allows us to explore change in values and perceptions over time and under different beach conditions for individual and multiple respondents. During the period of data collection, one repeat respondent completed the survey frequently enough to explore change in use (Fig. S4, Supplementary Materials) and value (Fig. 4), indicating that the benefits derived through interaction

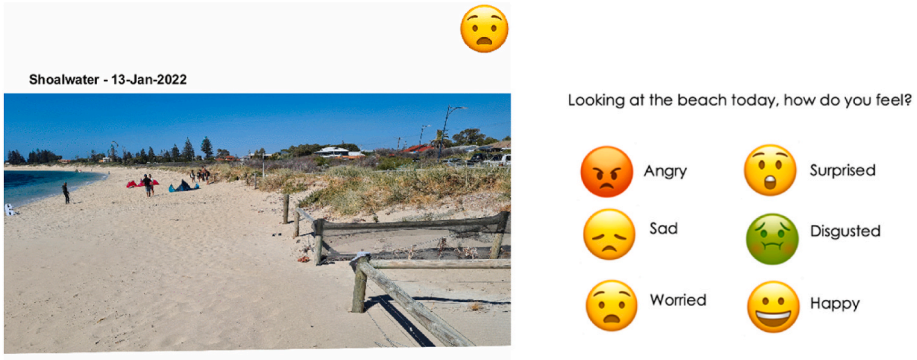

Fig. 2. *Respondent's emotional reaction linked to* their *CoastSnap photo*, Shoalwater Bay Rockingham, Western Australia.

Fig. 3. Respondents emotional reaction to the beach and relative shoreline position, Shoalwater Bay Rockingham, Western Australia.

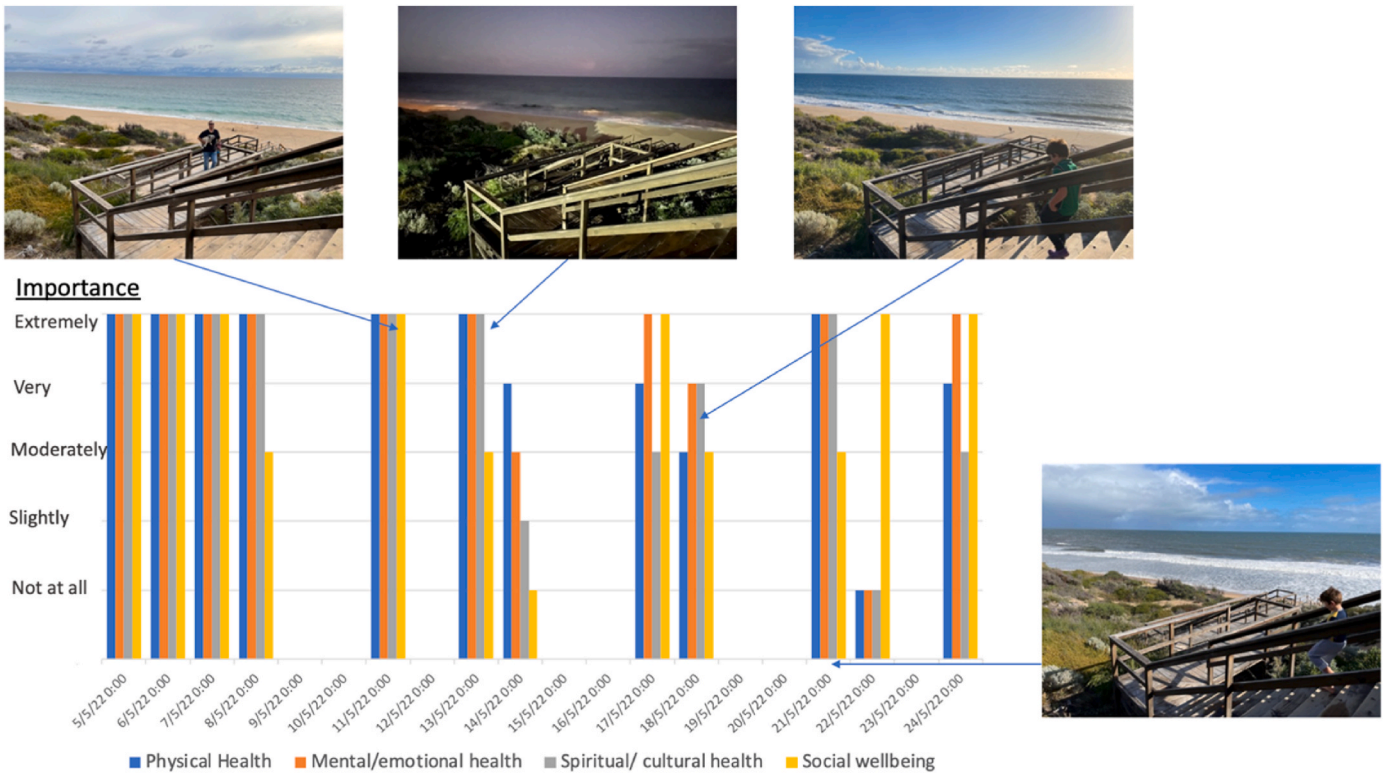

Fig. 4. The importance of benefits gained from visiting Dalyellup beach, for respondent 0409, May 2022.

with the beach may not be consistent over time.

3.7. Regional coastal planning

Differences in how users engage with the beach and the values they derive from those interactions provides valuable information to support regional coastal planning. In the PNP region, values and use differ by location, but an overall appreciation of nature-based activities is universal. The results align with those of Munro et al. (2017) who, in a study of the coastal and marine values in the Kimberley region of Western Australia, found while residents were more likely to identify general recreational and recreational fishing values and non-locals were more likely to identify biological/conservation and wilderness values, overall, the two groups were not too dissimilar. Where differences were found in Munro et al. (2017) it should be noted that their analysis did not specify whether survey respondents were of Indigenous origin, which might be reasonably expected to influence the nature of coastal values.

As population grows and the impacts of climate change are increasingly felt, regional scale planning will become increasingly important to develop nodes of use and activity. By understanding how visitors interact with the coast, and the values assigned to interactions, PNP coastal managers will be well-placed to make informed decisions regarding planning (e.g., activity nodes) and management interventions (e.g., retreat, accommodate, protect).

4. Discussion

Social data commensurate with biophysical data are critical for effective coastal and marine planning and management (Cornu et al., 2014; Redman et al., 2004). While innovations in aligning social values to 'place' have been made (e.g., mapping studies), there remain few innovations in social data collection that provide alternate approaches to link social and biophysical data or collect regionally consistent long-term social data. In this pilot project, we tested a social data collection technique that would extend existing approaches by providing temporal data across multiple sites with limited human and

financial input, whilst simultaneously connecting social and biophysical data. It was anticipated the data collection approach would provide a novel and valuable contribution to existing social values data collection approaches, which are often resource intensive and provide a snapshot of use and value at one point in time. The management applications of the approach are discussed prior to its benefits and limitations.

4.1. Management application

The complexity of coastal management has driven a focus on community engagement in Australia (Boxshall 2022; O'Toole et al., 2013) and internationally (McGinlay et al., 2021). Coastal managers must engage with the community, which includes anyone with an interest in the outcomes of coastal management (following O'Toole et al., 2013), to identify management strategies that meet diverse values and objectives. Yet concerns regarding the capacity of coastal managers to effectively engage are voiced (Serrao-Neumann et al., 2015; Uittenbroek et al., 2019), with the transition towards greater public engagement viewed both positively (e.g., an opportunity to build public stewardship, McAfee et al., 2021) and cynically (e.g., as an ongoing attempt by government authorities to 'retreat' from their coastal management responsibilities, McGinlay et al., 2021). The tool developed in this project, referred to as the CoastSnap Social Values tool, provides a complementary approach to support stakeholder engagement that extends beyond the one-off engagement 'projects' that are a defining feature of modern coastal governance (O'Toole et al., 2013).

In Australia, for example, in the absence of national coastal legislation State governments independently set coastal policy (Harvey and Clarke 2019). Recent policy changes in many States have seen coastal management integrated into land-use planning and approvals processes, placing further responsibility for coastal management on local government authorities (Elrick-Barr and Smith 2021). Local authorities are responsible for day-to-day management and longer-term coastal planning through the development of State supported climate change risk and adaptation plans or coastal management plans (Elrick-Barr and Smith 2021). Accounting for community values in plan development is mandated. For example, in Western Australia the State Planning Policy (SPP2.6) mandates community involvement in coastal hazard risk management and adaptation planning. Engagement involves one-off surveys and workshops (often ill-attended) during plan development. Plans are developed and engagement ceases.

O'Toole et al. (2013) criticise this project orientated model of engagement, noting that engagement should be an ongoing partnership not a linear relationship that concludes post management focus on a target issue. The CoastSnap Social Values tool provides an opportunity to remain engaged with the community, providing information on beach use and values whilst demonstrating an ongoing commitment to incorporating community values in coastal planning and management. The tool captures data not currently gathered via one-of community consultation events, such as change in use and levels over time, the importance of assets to different user groups (e.g., based on age, gender, residential status) and whether investments in infrastructure and/or coastal restoration translate to increased value to the community. The data generated can feed into Local Governments' community strategic plans, business plans, financial plans and local emergency management arrangements and has been well received by participating local government authorities in the Peron Naturaliste region. Following completion of the research reported here, the survey remains operational and local authorities intend to analyze the data on a 12-monthly basis to support coastal planning and management.

Beyond individual local authorities, the collection of consistent social data value over broad spatial scales (i.e., incorporating seven beaches over 200 km of coast in this pilot program) supports regional coastal planning. Understanding differences in use and value by location can inform the development of coastal nodes and support critical decisions regarding coastal management. Expansion of this program to additional beaches within Western Australia, nationally and/or globally, would add to a database of linked social and biophysical data. As human impacts on coastal and marine environments grow, approaches that integrate social and biophysical data will play an important role in increasing the understanding of complex socio-ecological systems, and in turn, an integral role in effective management for long-term sustainability.

4.2. Benefits and limitations

During the project's seven months of operation, the CoastSnap community was successfully engaged in the collection of information regarding the coast and its value to them. In some locations, this was predominantly through repeat, regular beach users. The continued participation of regular users suggests ease of use and perceived benefit in contributing information on coastal use and values to support management – achieving the reported benefits of remote citizen science programs, including greater human resources to address coastal issues and enhanced awareness, interest, and support for coastal management (Kelly et al., 2019; Lucrezi 2021). A high proportion of repeat responders in one location can however, weight data towards individual rather than community values and impact the ability to complete economic assessment, which relies on a high number of unique responses. Thus, awareness raising activities remain important in promoting broad public engagement.

There are recognised trade-offs between user engagement and optimizing for scientific precision in data collected via remote platforms (Spiers et al., 2019). Remote survey instruments generally capture quantitative data, particularly time limited surveys, and provide less depth in understanding, focusing on 'what' rather than 'why' questions (Masue et al., 2013). These trade-offs infer that the data collected would best be integrated with other data collection approaches for a holistic understanding of social use and value (Table 2).

By linking with the CoastSnap platform, survey respondents were limited to CoastSnap participants, who constitute a sub-section of all coastal users. CoastSnap participants have not previously been profiled, and therefore, the degree to which they represent the general population is unclear and an area for future investigation. It can be expected however, that following research on citizen science programs adopting smartphone technology, those participating are motivated by a pre-existing interest or concern in coastal management, have time and technological capability, and see the value in contributing to scientific research and society more generally (Andrachuk et al., 2019). These characteristics are not homogenous across coastal communities, and therefore, the data gathered represents a subset. Advantageously, despite limited knowledge of the respondent's representativeness, questions on distance travelled and frequency of visitation shed insight

Table 2
Benefits and limitations of the CoastSnap Social Values tool.

Benefits	Limitations
• Limited resource requirements • Social data linked directly to biophysical data • Longitudinal data on beach use and values • Delivers immediate (real-time) beach-user feedback to coastal managers • Survey questions tailored to capture information relevant managers (e.g., resident versus non-resident use and values of the coast). • Allows for repeat responders to monitor change in use/value at individual scale.	• Captures only a portion of coastal users, i.e., those that engage with CoastSnap • Complementary (i.e., an addition to) rather than standalone social data collection tool • Requires CoastSnap operators' permission to link with the program. • Adopts mostly closed survey questions • Sampling is opportunistic • Limited knowledge regarding drivers and barriers to participation and impact on data representativeness.

into resident versus other non-resident values. Thus, perspectives are gathered from a range of stakeholders and not limited to 'local interests', which is often the case in coastal and marine values-based planning processes (Munro et al., 2017). This emphasises the complementary nature of the approach, rather than as an alternate to other social values data collection approaches.

The data collected demonstrates the capability of this approach to contribute to long-term social values data that will assist in the protection and management of the coast. It provided data on social values that (i) links to biophysical condition and (ii) provides a long-term record. Over time, the data collected will allow coastal managers to explore in further detail the interrelationships between social use and values and biophysical condition. For example, change in use and values can be related to long-term shoreline change or daily change in beach condition (e.g., presence of wrack or rubbish). Furthermore, the impacts of physical interventions (e.g., erosion control measures, new recreational facilities) on use and value can be explored. The collection of temporal data on social values is rare yet provides important input to strategic coastal planning and improves understanding of the long-term dynamics in complex social-ecological systems.

This approach is not however a panacea to the collection of social values data. As noted, the approach complements rather than replaces other data collection techniques, and further research on user engagement and integration of outputs into coastal planning and management is required. It is unclear to what extent this approach captures 'hard to engage' publics, including the disempowered and/or unengaged. Following Andrachuk et al. (2019) we recognize the need for research on the costs and impacts of remote citizen science programs, particularly those targeting social values as they represent a transition from the more regularly adopted application of citizen science for biophysical monitoring. Future research could explore factors that motivate users and their preferences for how to interact with the remote technologies/surveys and the influence of citizen science remote data collection techniques on conservation outcomes. Formally measuring the Value of Information (e.g., Davis et al., 2019) of citizen science programs could help to guide instances where it will be most useful to implement and promote data collection.

5. Conclusion

Coastal areas are at the frontline of climate change impacts and will generate complex decisions regarding which assets will be prioritized in planning and management. Such decisions require a detailed knowledge of both physical processes and the values attached by users to coastal assets. Use patterns and values are frequently poorly understood, reflecting logistical and practical difficulties in data collection. We reported on an approach to collect long term data on values and uses associated with specific coastal sites (and biophysical condition) through adaptation of an existing citizen science monitoring programme - Coastsnap. Notwithstanding the limited period of data collection during the project phase, the data gathered provides valuable information to local coastal managers, including evidence of the benefits of coastal visitation to mental and physical health and wellbeing, the level of importance assigned to beach facilities for regular versus irregular beach users, and the relationship between beach use and condition. In the Peron Naturaliste region, the affective relationship between beach use and wellbeing was unaffected by perceived natural processes of dynamic coastal change, including changes in beach profile, although evidence of human impact such as vehicle tracks or litter resulted in negative perceptions. Such data can inform day-to-day and longer-term planning of the coast, guiding levels of investment in coastal infrastructure and informing approaches to coastal remediation.

Longer term data collection and an expanded network would enable more detailed understanding of user perceptions and values, supporting regional coastal planning and assisting managers in interacting with the public to enhance awareness, interest and support for coastal management. The approach is novel in its ability to link social and biophysical data and provide a long-term (temporal) record of beach use and value with limited resource investment. Its overall utility is however dependent on public engagement, and therefore communication activities are important in raising awareness and promoting engagement. Future research could explore the factors that motivate users and their preferences for interacting with remote surveys, whilst also developing additional remote citizen science technologies beyond CoastSnap that could facilitate the integration of social values into coastal management.

Declaration of competing interest

The authors declare the following financial interests/personal relationships which may be considered as potential competing interests: 'There are no other conflicts of interest associated with this manuscript apart from Carmen Elrick-Barr being on the Editorial Board of the journal'.

Data availability

Data will be made available on request.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.ocecoaman.2023.106563.

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