




A scoping review of Indigenous Cultural Mapping of coastal, island, and marine environments

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ABSTRACT

Indigenous Cultural Mapping (ICM) has the capacity to contribute to sustainably managing Sea Country. While there is a growing community of practice using ICM of marine, island, and coastal areas to incorporate Indigenous knowledge and cultural values into sustainability and conservation efforts, the literature is widely dispersed, and the method is not clearly defined or described. This scoping review evaluates the breadth and depth of practice undertaking ICM in island, coastal, and marine areas as captured within the English language scientific and grey literature. The objectives of this review were: 1) to determine the extent to which ICM is used a tool to manage Sea Country; 2) to evaluate the methods used throughout the process of ICM; and 3) to assess the studies against Arnstein's (1969) ladder of participation. We used the Population Concept Context framework, searched Scopus, Web of Science, and Informit databases and Google Scholar, and identified studies that mapped Indigenous culture and/or cultural values in Sea Country. We included 54 studies that used ICM methods and were focused on Sea Country. These studies contribute to a growing body of work that demonstrates the value Indigenous knowledge adds to the sustainability of Sea Country now and into the future. High-level power-sharing and partnership throughout the research process is critically important. However, a lack of consistent standards of practice perpetuates research practices that exclude Indigenous communities from the research cycle. This limits the ability of ICM to improve sustainable practices that conserve and protect Sea Country.

1. Introduction

Australia's Indigenous Sea Country refers to the traditional Indigenous estate associated with the marine and coastal environment (Smyth, 1994). These areas hold spiritual, cultural, ecological, and economic significance for Indigenous communities (Benjamin et al., 2021; DAWE, 2016; GBRMPA, 2019a, 2019b). As the world faces the urgent need for environmental sustainability, understanding and respecting Sea Country is crucial. Sea Country is not just a geographical location, it is the nexus of Indigenous identity and is a vital source of well-being (Ash et al., 2010; McNiven, 2003, 2008; Sharp, 2002). However, despite the cultural significance of Sea Country, it is increasingly at risk due to

accumulating impacts caused by multiple factors. Recognising its importance goes beyond cultural sensitivity, it is essential for sustainably managing our oceans, coastal systems, and the preservation of Indigenous heritage.

Heritage preservation is the conscious effort to safeguard and pass down the cultural, historical, and natural legacies of a community or society to future generations (Byrne and Ween, 2015; DAWE, 2016; DCCEW, 2021; Lowenthal, 2005; Harrison and O'Donnell, 2010; UNESCO, 1992–2022, 2021). This involves protecting tangible and intangible aspects of heritage (Harrison, 2013; Ray and McCormick-Ray, 2014) and mapping serves as a bridge between these by transforming heritage into a visual and spatial format (Duxbury et al., 2015, p.2).

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However, while the importance of preserving Sea Country and Indigenous heritage is undeniable, the act of mapping these complex ecosystems and cultures presents significant challenges. Western approaches to conservation and heritage management use Cartesian methods of mapping that establish boundaries to protect and conserve (Harrison, 2013; Rundstrom, 1995). Yet in practice they fragment Sea Country into discrete polygons and lines, failing to acknowledge or capture the fluidity and interdependence of these environments. Perhaps raster datasets and fuzzy logic models may provide better approximations for considering perceptions of environment without hard categorical boundaries (Potter et al., 2016). Nevertheless, the predominant approach to mapping remains a process that places the power to decide what is worthy of preservation into the institutions of power, perpetuating the impacts of colonisation (Omland, 2006; Shackleton et al., 2022; Simpson et al., 2022). This further results in some heritage being more protected than others, and too often Indigenous cultural heritage fails to be protected altogether (Hammam, 2022). Balancing the need for accurate representation with the imperative to protect and conserve Sea Country requires a more nuanced approach than standard western mapping methods.

Historically, western methods of mapping have been a tool used to wield power and control, functioning as the interface between political power and knowledge. Reflecting the world view of the cartographer (Foley, 2017; Foucault and Gordon, 1980, p.69; Harley, 1988; Harley, 1989), maps often neglect or dismiss Indigenous perspectives and knowledge systems as less valid or of lesser value (Cole and Sutton, 2013; Larrain and McCall, 2019; Palmer and Korson, 2020). Indigenous knowledge systems are as diverse as the Indigenous communities around the globe, but they can generally be characterised as being deeply rooted in the lived experience of a specific place (Ellen and Ellen, 2009; Nakashima and Roué 2002). The value of these knowledge systems, particularly in contributing to conservation and stewardship, has been recognised for decades (Baines and Williams, 1993, p.1; Naidoo and Hill, 2006; Robinson et al., 2021; and others). These knowledge systems are often referred to as Traditional Ecological Knowledge, a term that is limited in scope due to its explicit links to ecology (Baines and Williams, 1993; Nakashima and Roué 2002). This term has been redefined and superseded by the term Indigenous knowledge which is more comprehensive and inclusive, recognising the rich and diverse body of knowledge that Indigenous peoples hold (Baines and Williams, 1993). Unfortunately, these knowledge systems remain marginalised at best, and in some cases, entirely excluded, particularly where mapping is concerned.

Moving from exclusive to inclusive practice is necessary for long term sustainable solutions to climate change, as every resource and all knowledge systems need to be considered (Lawrence et al., 2022; Nurse-Bray et al., 2019). Current approaches that rely predominantly on western scientific knowledge fall short of addressing the complex challenges posed by climate change (Tollefson, 2022). In response to these challenges, Indigenous Cultural Mapping (ICM) offers a promising alternative that respects and incorporates Indigenous knowledge into the mapping process. This method recognizes that Country (and specifically Sea Country) represents more than just geographical space; it is a repository of cultural and ecological wisdom (Duxbury et al., 2015; Lobo and Parsons, 2023; Simpson et al., 2022). ICM is a collaborative, transdisciplinary method of mapping that goes beyond academic disciplines actively involving Indigenous communities as key participants and knowledge holders (Baker et al., 2023; Duxbury et al., 2015). Transdisciplinary methods integrate diverse worldviews to address complex problems through collaboration and knowledge co-creation across disciplines, between academics and non-academics, and as well as including other knowledge systems such as Indigenous knowledge to produce more nuanced outcomes (Baker et al., 2023). This can include anthropologists, marine scientists, archaeologists, geographers, ecologists, Indigenous knowledge authorities and community members, and many more (Hayashi et al., 2021). This is a process that combines

tangible and intangible heritage with both quantifiable and qualitative data, which means that ICM provides a richer more holistic representation of Sea Country, (Taylor, 2014). Centring Indigenous voices and perspectives in this process preserves and integrates Indigenous knowledge into contemporary sustainability practices, creating a “cultural interface” (Nakata, 2002, p.285–6, Nakata, 2007, p.9). This interface provides an opportunity to decolonise how maps are used to manage, protect, and plan for Sea Country sustainability.

While ICM has been applied internationally to integrate Indigenous knowledges and cultural values into planning frameworks (Duxbury et al., 2015), this review seeks to evaluate the extent of its use in Sea Country contexts. ICM’s transdisciplinary approach allows it to be used across a wide range of disciplines as either a primary, or additional method to incorporate Indigenous knowledge into mapping projects (Duxbury et al., 2015). Despite its mid-20th century origins and its application in land claims, cultural heritage protection, intercultural dialogue, and other priorities identified by Indigenous communities (see Crawhall, 2009; Holcombe, 2023; Merson and Hooper, 2005; Vaarzon-Morel and Kelly, 2020; and others), ICM methods are often poorly described or defined in the literature. This variability presents an opportunity for a scoping review of the literature to identify key concepts, gaps in the research, and the types and sources of evidence to inform practice, policymaking, and research (Pham et al., 2014), as well as highlight areas that require further enquiry.

This scoping review evaluates the breadth and depth of a community of practice undertaking ICM in island, coastal, and marine areas as captured within the scientific and grey literature on a global scale as published in English. To achieve this aim, we have the following objectives:

1. To determine the extent to which ICM is used as a tool to manage Sea Country.
2. To evaluate the methods used throughout the process of ICM.
3. To assess the studies against Arnstein’s (1969) ladder of participation.

2. Methods

Our scoping review was conducted to establish the state of the literature and identify gaps for a larger project to co-develop a framework to improve cross-cultural approaches to managing Sea Country using two-way knowledge sharing. We position ourselves as researchers in this project (Maclean et al., 2022; Smith, 2012; Thambinathan and Kinsella, 2021). We are academic researchers who are committed to improving ethical research and cross-cultural engagement practices for researchers and Indigenous communities.

The authors include a Choctaw early career researcher (First Nation from the area now known as Mississippi, Louisiana, and Alabama in the USA) who is the lead author. One author is a Wiradjuri (First Nation from what is now known as central New South Wales, Australia) archaeologist whose research focus includes Indigenous epistemologies, ontologies, and axiologies. The authors include Indigenous American, Indigenous Australian, Australian, and European academics who address issues of inequality and marine resource management while supporting Indigenous aspirations. As a collective they are committed to protecting cultural heritage and building Indigenous capacity in the Indo-Pacific and Oceania. The diversity within the research team also reflects a commitment to developing culturally sensitive frameworks for improving how Indigenous Cultural Mapping is conducted.

We developed our protocol for this scoping review based on the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA-P) guideline (Tricco et al., 2018) (Fig. 1). We followed the Joanna Briggs Institute (JBI) scoping review methods (Peters et al., 2020) using the PRIMA-ScR checklist (Tricco et al., 2018) to develop our reporting method. Using the Population Concept Context (PCC) Framework (Table 1) (Peters et al., 2020), we searched three

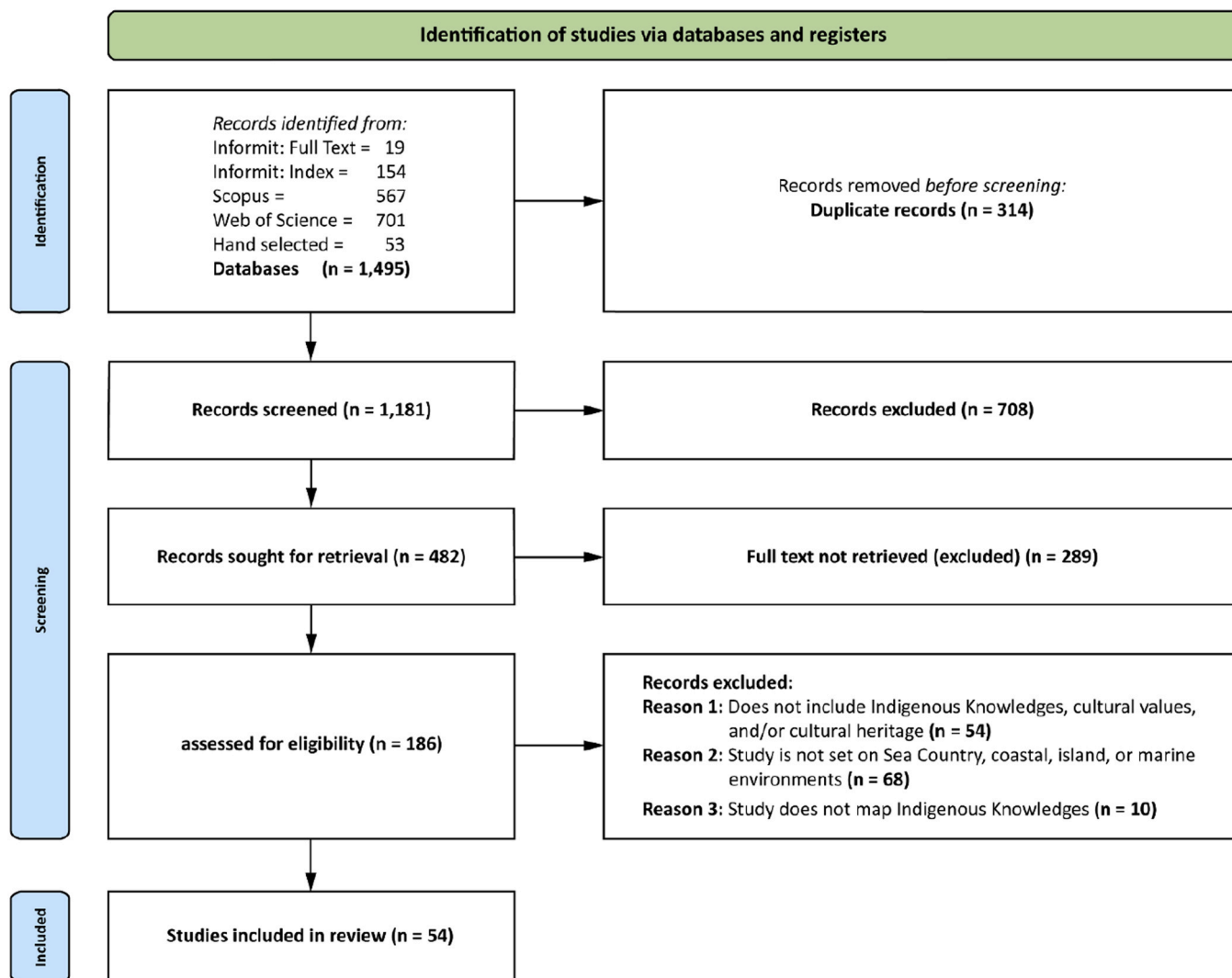


Fig. 1. PRISMA Flow Diagram based on Page et al.'s (2021) reporting template.

Table 1
People Concept Context (PCC) Framework developed from the JBI method (Peters et al., 2020).

PCC Framework	
Participants	Indigenous Communities
Concept	Indigenous Cultural Mapping, Indigenous knowledges, Indigenous cultural values
Context	Sea Country, coastal, island, marine

bibliographic databases and grey literature to identify studies that mapped Indigenous culture and/or cultural values in Sea Country.

2.1. Eligibility criteria

Studies were eligible for inclusion in this review if they broadly included ICM, Indigenous knowledges, Indigenous cultural values and/or heritage, and were focused on Sea Country, coastal, island, and/or marine localities/environments. We used evidence sources from existing literature, including primary research studies, meta-analysis, grey literature, and reports using English terms only. Relevant international literature published in English such as books, journal articles, and technical reports were also included. We did not restrict the year of publications considered because research on Indigenous cultural values

has been sporadic throughout the previous century (Wolfe, 2006).

2.2. Search strategy

We identified literature for this review through a 3-step strategy (Peters et al., 2020).

Step 1: We searched Google Scholar and Scopus and analysed titles, abstracts, and keywords to identify keywords and index terms for the search equation (Table 2).

Step 2: We combined the sub-strings of the search equation with “AND” and searched titles, abstracts, and keywords of Scopus, Web of Science, Informit Full Text, and Informit Index databases for sources.

Step 3: We searched reference lists of relevant publications to identify additional sources for inclusion which we located using Google Scholar.

2.3. Source selection

After removing duplicates and non-English sources, 1,181 records remained. We further screened the title and abstract of each record to evaluate whether they met our minimum inclusion criteria (Table 3). We excluded 708 records that included studies not on human populations;

Table 2 –
Single search string of terms, keywords, and Boolean operators used to identify relevant studies.

Search string of terms and keywords
("Indigenous" AND ("indigenous cultural mapping" OR "indigenous mapping" OR "counter mapping" OR "cultural mapping" OR "map*" OR "landscape mapping" OR "cultural values" OR "cultural resource mapping") AND ("coast*" OR "sea country" OR marine OR "island*"))

Table 3
Inclusion and exclusion criteria for studies included in the PRISMA review.

Inclusion Criteria	Exclusion Criteria
1. Includes Indigenous knowledges, cultural values, and/or cultural heritage.	1. Does not include Indigenous knowledges, cultural values, and/or cultural heritage.
2. Study is set on Sea Country, coastal, island, or marine environments.	2. Study is not set on Sea Country, coastal, island, or marine environments
3. Includes descriptions, methods, and/or definitions of cultural mapping, indigenous mapping, counter-mapping, and/or indigenous values mapping.	3. Study does not map Indigenous Knowledges

studies from education, healthcare sciences, social work, genetics, and criminology; and websites, blogs, and conference abstracts. Excluding records where we could not retrieve full text ($n = 289$) resulted in 186 records reviewed for eligibility. The remaining records were assessed using this review's three exclusion criteria (Table 3), however most of the sources excluded were identified during the first two screening stages. Using the exclusion criteria, 54 records (publications) remained. Appendix A lists excluded records and the reason(s) for exclusion.

2.4. Objective 1 – Determine the extent to which ICM is used as a management tool for Sea Country

To evaluate the extent to which ICM is used as a management tool for Sea Country we collected the names of the publications, and then grouped them by disciplinary focus. Overall trends of publications incorporating Indigenous values were collated by year. If the publication used their results to benefit any aspect of Sea Country, it was categorised as being used as a management tool for Sea Country. We used the location of the first author of the publication to provide an insight into which countries are funding research using ICM for Sea Country management.

2.5. Objective 2 – Evaluate the methods used throughout the process of ICM

We evaluated the methods as described in each study by extracting and categorising them based on the authors' descriptions. Methods were grouped by similar terms or descriptions to facilitate comparison. Ethical research practices were evaluated by examining details such as human ethics approval, informed consent processes, open access data availability, and if data was withheld or considered private. This information was used to identify similarities and/or differences in methods used.

2.6. Objective 3 – Assess the studies against Arnstein's (1969) ladder of participation

We assessed each publication to compare the level of participation and community engagement throughout the research cycle. We used Arnstein's (1969) ladder of participation (Fig. 2) to assess the levels of community power sharing and participation. Arnstein's (1969) ladder illustrates the relationships between the community and the power-holders, providing a tool to evaluate the levels of community participation and engagement used by the studies in this review. We evaluated the research cycle, which is defined as having four key stages, 1) conceptualising the research, 2) collecting the data, 3) analysing the data, and 4) communicating the research (Arnstein, 1969). A participation ranking for each stage of the research cycle was determined from the

descriptions in the publications. These scores were averaged into an overall participation ranking for each study. In addition, Indigenous co-authorship was evaluated by researching authors online. If authors self-declared as Indigenous, they were categorised as such. When it was ambiguous, we took a conservative approach and did not categorise them as Indigenous. If one author could be categorised as Indigenous, then Indigenous co-authorship was indicated.

3. Results

3.1. Objective 1 – Determine the extent to which ICM is used as a management tool for Sea Country

Over the last 22 years publications have fluctuated, with a notable increase of 81 % ($n = 44$) published in the last decade (Fig. 3). The highest number of studies in a single year occurred in 2019 and 2021 with seven articles in each year ($n = 7$). The studies span 10 disciplines, with 30 % ($n = 16$) focusing on marine management and planning, and followed by climate change adaptation representing 15 % ($n = 8$) of the studies. The studies were published in 40 different journals (Table 4). The studies had over 300 different keywords with *Indigenous* ($n = 8$), *traditional ecological knowledge* ($n = 7$), and *GIS* ($n = 6$) being the most frequently used, followed by *marine protected areas*, *Indigenous knowledge*, *indigenous mapping*, and *cultural values* ($n = 5$).

The largest number of studies were identified from the United States ($n = 17$), Australia ($n = 13$), and Canada ($n = 12$), followed by New Zealand ($n = 5$) and South Africa ($n = 2$) (Fig. 4). Single studies were from Chile, Indonesia, Malaysia, Mexico, the Netherlands, and Norway ($n = 1$ each). The concentrations of the studies from the United States, Australia, and Canada may reflect language biases of the databases, as the review only includes English language publications. These countries also share a British colonial past.

3.2. Objective 2 – Evaluate the methods used throughout the process of ICM

The studies reviewed describe their methods using diverse terminology, with none of the studies using the term 'ICM' ($n = 0$) or 'cultural mapping' ($n = 0$). Only one study each ($n = 1$) used the term 'indigenous mapping' (Breton-Honeyman et al., 2016), 'native mapping' (Brattland, 2013), 'counter mapping' (Bishop et al., 2022), and 'cultural opportunity mapping' (Tipa and Nelson, 2012). Over one-third, 37 % of the studies ($n = 20$), used 'participatory mapping' methods (Fig. 4). Collectively, methods described as 'participatory' appeared in 87 % ($n = 47$) of the studies.

Studies with the highest rank of community participation on Arnstein's (1969) ladder of participation (level 7 or 8, $n = 30$), incorporated citizen-controlled community participation across all levels of the

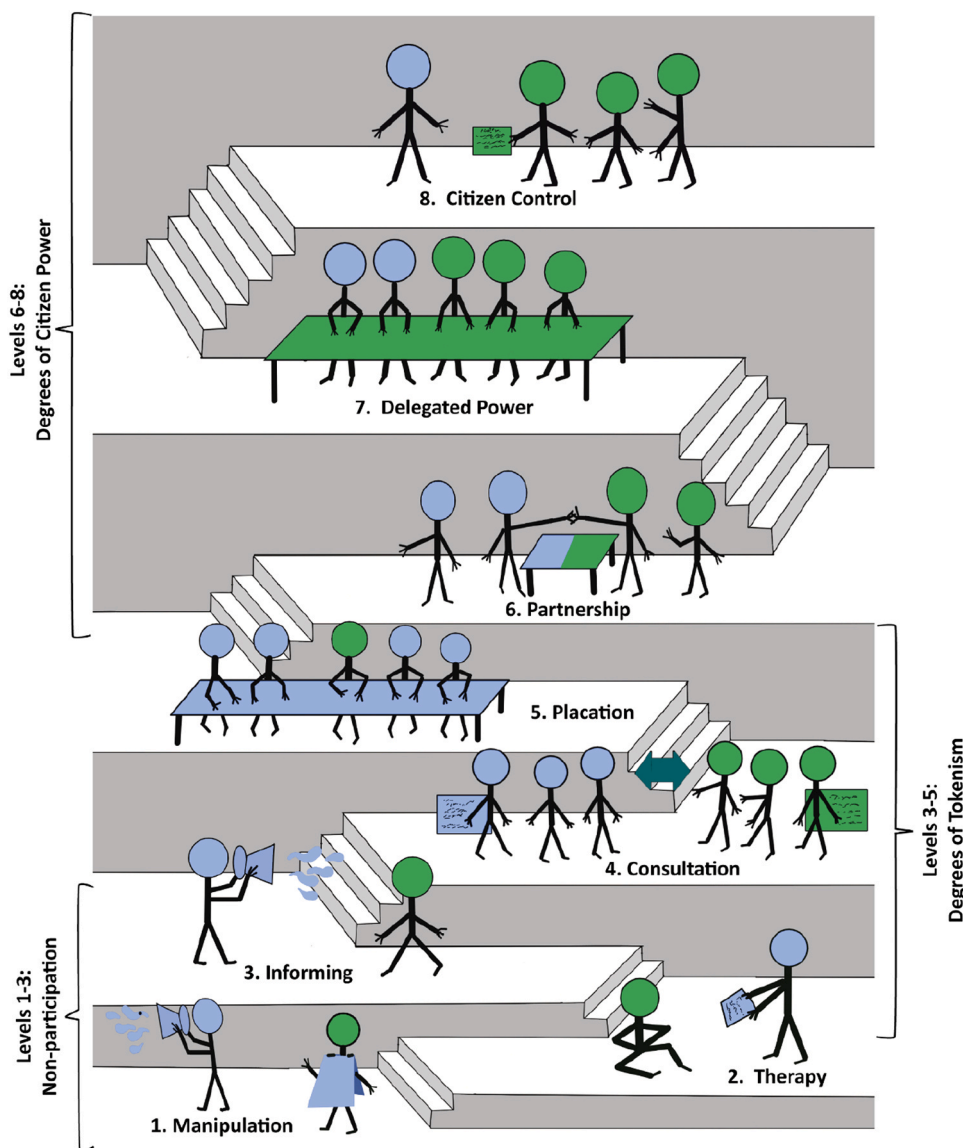


Fig. 2. Levels of community engagement based on Arnstein’s (1969) ladder of participation. The green figures are the community, and the blue are the power holders. Levels 1 and 2 are levels of non-participation, where power holders aim to educate or influence the community without true involvement. Levels 3–5 indicate tokenism, allowing the community to be informed and heard but without any influence over decisions. Levels 6–8 reflect community power, with level 6 allowing negotiation and levels 7 and 8 granting full decision-making authority.

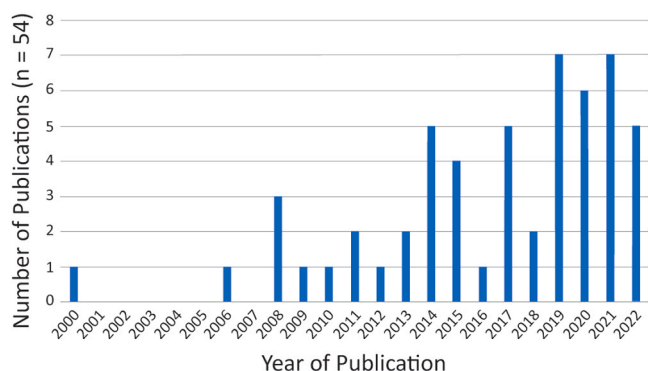


Fig. 3. Number of publications by year of studies included in the review.

research cycle (Fig. 2 and Fig. 4) (Arnstein, 1969). Among these studies, ‘participatory’ methods dominated (83 %, n = 25) with nearly half (47 %, n = 14) using ‘participatory mapping’. Anthropological and qualitative methods appeared independently or in combination with other methods in one third of the publications in 33 % (n = 10) of the studies. One-third (33 %, n = 10), of the studies were labelled as ‘Indigenous-led’ (n = 5) or ‘culturally appropriate’ (n = 5), while over half (53 %, n = 16) used ‘partnership’ (n = 1), ‘community’ (n = 4), ‘collaborative’ (n = 5), or ‘co-’ research methods (n = 6).

Less than one third of the studies (30 %, n = 16) reported obtaining Human Research Ethics approvals or using informed consent processes. Only 8 % (n = 2) provided open access datasets, and 19 % (n = 10) indicated that data was withheld or was considered private (Fig. 5). The majority of studies (70 %, n = 38) did not disclose ethics approval or informed consent processes, and 78 % (n = 42) did not specify if their datasets are open access or if data was withheld or considered private.

Table 4
Studies included in the review grouped according to disciplinary focus area and publication.

Study Focus	Publication	Reference
Archaeology & Heritage	Ecosystems	(Lepofsky et al., 2021)
	Geoheritage	(Gravis et al., 2017)
	International Journal of Historical Archaeology	(Ash et al., 2010)
	Journal of Maritime Archaeology	(McKinnon et al., 2014)
Biology & Conservation	Local Environment	(McIntyre-Tamwoy et al., 2013)
	Applied Geography	(Brown et al., 2018)
	Canadian Journal of Zoology	(Breton-Honeyman et al., 2016)
	Ecology & Society	(Housty et al., 2014)
Climate Adaptation	Polar Biology	(Martinez-Levasseur et al., 2017; Martinez-Levasseur et al., 2021)
	Arctic	(Herman-Mercer et al., 2019; Huntington et al., 2021)
	Canadian Geographer-Geographe Canadien	(Gearheard et al., 2011)
	Journal of Coastal Research	(Gorokhovich et al., 2014)
	Journal of Environmental Management	(Bethel et al., 2022)
Disaster Management	Journal of Cultural Geography	(Bishop et al., 2022)
	Water (Switzerland)	(Hutton and Allen, 2020)
	World Development	(Neef et al., 2018)
Ecology	Ecology & Society	(Choudhury et al., 2021)
	International Journal of Disaster Risk Management	(Membele et al., 2022)
Environmental Restoration	Australian Geographical Studies	(Hill et al., 2000)
	Ecosystem Services	(Pert et al., 2015b)
	Pacific Science	(Kurashima et al., 2017; Lincoln et al., 2020)
	Plos One	(Lim et al., 2021)
Hydrology & Water Management	Journal of Coastal Research	(Bethel et al., 2011; Bethel et al., 2014)
	Parks Stewardship Forum	(McGuire, 2022)
	Pacific Sciences	(Winter and Lucas, 2017)
	Regional Environmental Change	(Damastuti and de Groot, 2019)
Marine management & planning	New Zealand Journal of Marine & Freshwater Research	(Crow et al., 2020; Langhans and Schallenberg, 2021)
	Hydrological Sciences Journal	(Hayashi et al., 2021)
	Oceania	(McDonald et al., 2008)
Natural Resource Management	Water, cultural diversity, and global environmental change: emerging trends and sustainable futures?	(Tipa and Nelson, 2012)
	Arctic	(Carter et al., 2019)
	Biodiversity & Conservation	(Grech et al., 2014)
	Conservation Biology	(Ban et al., 2009)
	Current Issues in Tourism	(Munro et al., 2019)
	Ecosystem Services	(Outeiro et al., 2015)
	Environmental Conservation	(Aswani and Lauer, 2006)
	Environmental Science & Policy	(Dawson et al., 2020)
	Frontiers in Marine Science	(Davies et al., 2020; Lombard et al., 2019)
	Human Ecology	(Aswani and Vaccaro, 2008)
	ISPRS Annals of the Photogrammetry, Remote Sensing and Spatial Information Sciences	(Clyne et al., 2021)
	Journal of Environmental Management	(Moore et al., 2017; Noble et al., 2019)
	Maritime Studies	(Lalancette and Mulrennan, 2022)
	Norsk Geografisk Tidsskrift	(Brattland, 2013)
Ocean & Coastal Management	(Lauer and Aswani, 2008)	
Science of the Total Environment	(Pert et al., 2015a)	
Urban Planning & Design	International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences - ISPRS Archives	(Suhari et al., 2019)

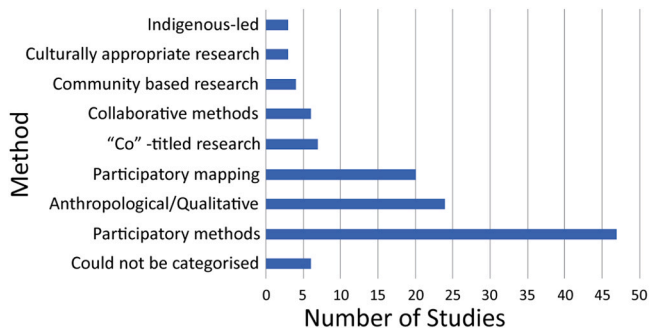


Fig. 4. Analysis of mapping methods used by the studies included in the review.

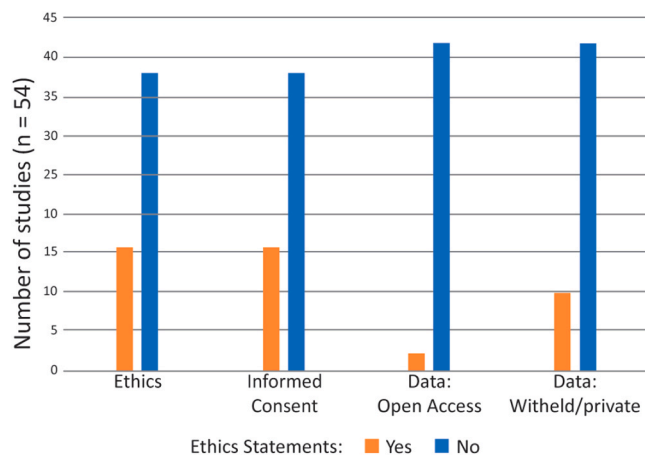


Fig. 5. Analysis of ethical research processes used by the studies included in the review.

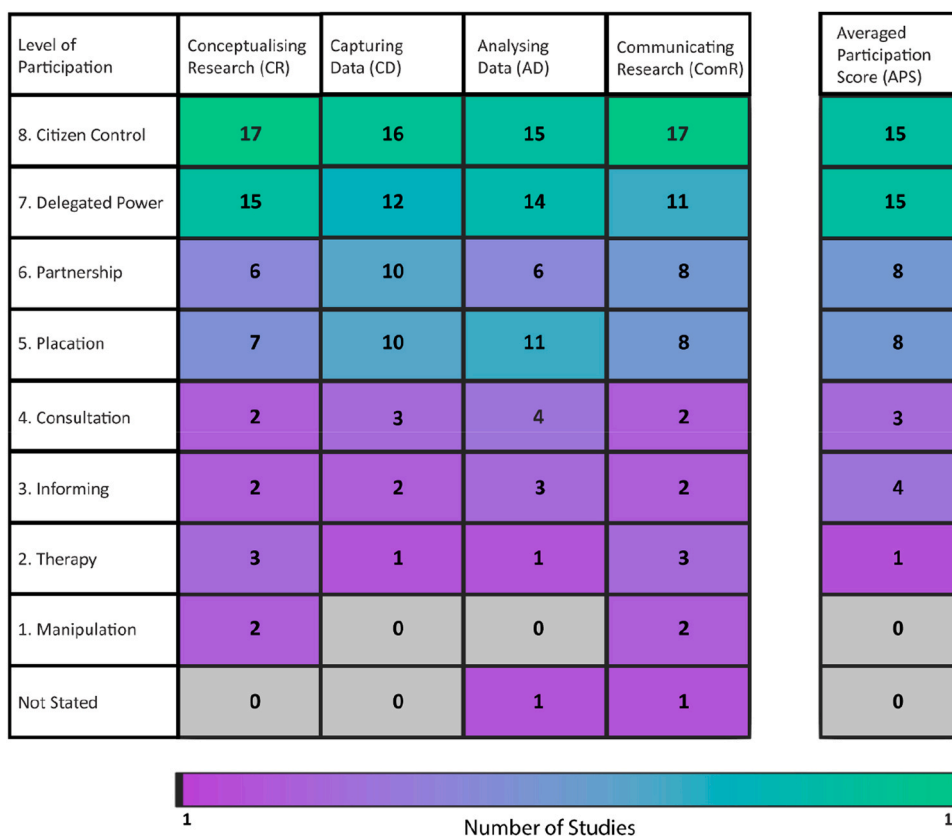


Fig. 6. Level of participation scores for the stages of the research cycle. The averaged participation score is the mean of a paper’s scores throughout the research cycle ((CR + CD + AD + ComR)/4) = APS.

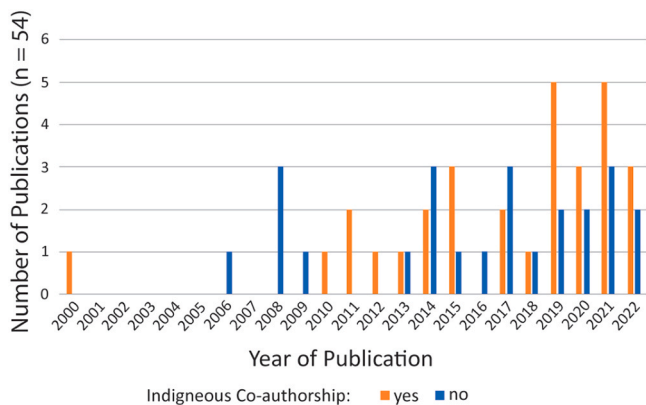


Fig. 7. Analysis of studies included in the review with Indigenous co-authorship by year, 2000–2022.

3.3. Objective 3 – Evaluate the level of participation using Arnstein’s (1969) ladder of participation

Although a majority of the studies used participatory methods (87 %, n = 47), less than one-third (28 %, n = 15) of the studies achieved the highest level of community participation (level 8) in the research cycle. Fig. 6 illustrates the distribution of studies at each level of participation for each stage of the research cycle. Scores for each stage were averaged by summing the stage scores and dividing by the number of stages (four). When combining the top two levels of participation (levels 7 and 8), this rises to just over half of the publications (57 %, n = 31). Charting the studies by year, the highest standard of participatory engagement was in 2014 and 2020 (n = 3 each). Although the majority (81 %,

n = 44) of the studies were published in the last decade, low-levels of participation indicate persistent tokenism (Arnstein, 1969). Over a quarter (27 %, n = 12) of the studies fall into this range of tokenism, with the lowest level of community participation (level 2 and below, non-participation) occurring in 2017 (n = 1). This indicates that although participatory terminology is prevalent, its application varies widely.

Indigenous co-authorship occurs in more than half (55 %, n = 30) of the studies, with an upward trend since 2010 (Fig. 7). The highest rate of Indigenous co-authorship occurred in 2019, with 63 % (7 out of 11) of studies featuring Indigenous co-authors. Although the increase in Indigenous co-authorship combines with the fact that one-third of the studies were Indigenous-led or culturally appropriate to indicate more meaningful participation in the research cycle, there is a persistence of lower-ranked participatory practices.

4. Discussion

4.1. Extent of ICM use in managing Sea Country

The increasing trend of using ICM as a tool for managing Sea Country is evident from the dramatic rise in published studies incorporating Indigenous knowledges and values through ICM over the past twenty years, particularly in the last decade. This trend reflects the growing recognition of Indigenous knowledges as essential for sustainably managing Sea Country today and into the future. The 54 studies included in this review were published in 40 journals, spanning 10 disciplines. Despite the broad disciplinary representation (Table 4), 76 % of the funding for ICM research comes from the United States, Australia, and Canada, with other countries only funding English language publications sporadically. This trend likely stems from the shared colonial history of these three countries, their successful land tenure

movements (Chapin et al., 2005), and legislative changes such as Australia's *Native Title Act* 1993 (Cth). This identified data trend could reflect the English language bias of the databases used in the search strategy, and/or because this review only included English language publications. Including non-English studies in future reviews could offer additional insights, especially from countries with a colonial history.

4.2. Evaluating ICM methods

ICM is a method that incorporates qualitative and quantitative data to map what, and how, the community identifies as important and relevant to the project (Duxbury and Redaelli, 2020; Duxbury et al., 2015). However, ICM must be conducted with a high level of community participation and control throughout the entire research cycle, from conceptualising the research, selecting methods, capturing and processing the data, and communicating results (Vaarzon-Morel and Kelly, 2020). This process should be Indigenous-led and culturally appropriate, using participatory mapping methods combined with anthropological and qualitative data collection strategies (Vaarzon-Morel and Kelly, 2020). Projects should have Human Ethics Research Approval from relevant ethics boards, follow Free Prior and Informed Consent processes, and respect community values and culturally appropriate protocols regarding data accessibility (Bowrey et al., 2022; FAO, 2016; Sherwood and Anthony, 2020). This includes determining whether data should be open access, restricted, or withheld from non-Indigenous audiences, especially when it is private or culturally sensitive. As research conducting ICM and using participatory methods becomes more prevalent, ensuring best practices for community engagement is critically important.

4.3. Community engagement and Arnstein's ladder of participation

Researchers and practitioners must ensure the highest levels of community participation at all stages of the research cycle (Fig. 2 and Fig. 3) (Arnstein, 1969; Koster et al., 2012). This means that Indigenous communities are not just participants, they must share power as research partners and contributors throughout the research cycle, from conceptualising the study to data collection, analysis, and communicating the results. Co-publishing with Indigenous co-authors is one strategy to ensure power-sharing. Adhering to minimum standards for best practice in participatory research methods is crucial (Arnstein, 1969; Banks and Brydon-Miller, 2018; Koster et al., 2012; UN, 2007). Participatory research methods should be democratic, empowering, and educational (Banks and Brydon-Miller, 2018). Genuine power-sharing enables Indigenous communities to move from being objects of research, 'research on', to working alongside the researchers, 'research with', and ultimately to becoming full partners in the research cycle, 'research by' (Koster et al., 2012). Several of the studies in this scoping review showcase this best practice approach as evaluated under Objective 2.

4.4. Best practice in ICM

Among the studies using best practice methods is Brattland's (2013) study of Sami culture and mapping of the biodiversity of cod fisheries. Brattland (2013) observed that the way that spatial questions are asked can result in seemingly incompatible, or misaligned, layers of information. This is not because of different mapping methods or knowledge differences between scientific or Indigenous contributors, instead it is the result of their varying perspectives on what matters in the spawning process (Brattland, 2013). By working with the Indigenous and scientific communities to define key variables, the researcher can align the perspectives to produce complimentary layers of information (Brattland, 2013). These integrated layers illustrate the intersecting values, improving the management and protection of the spawning grounds, benefiting all of the communities that rely on them (Brattland, 2013).

Lauer and Aswani (2008, p.502) integrated scientific data and

Indigenous ecological knowledge into supervised classification analysis to produce marine habitat maps with accuracy within published ranges (64.5 %). Their hybrid approach produced separate layers based on each of the knowledge systems, Indigenous ecological knowledge and scientific benthic data, before combining those layers into a single marine map (Lauer and Aswani, 2008). Using an inclusive participatory partnership, they produced accurate broad-scale marine habitat maps of Roviana Lagoon in the Solomon Islands using broad habitat categories across a large spatial area ($n = 10,323.47$ ha) to support resource cataloguing for planning and management (Lauer and Aswani, 2008). These maps were widely accepted by the community and proved valuable to both managers and decision-makers (Lauer and Aswani, 2008).

Lepofsky and colleagues (2021) applied remote sensing techniques and archaeological methods in an Indigenous-led project to investigate the clam gardens of the Pacific Northwest Coast of North America. The Kwakwaka'wakw (Laich-kwil-tach) and northern Coast Salish First Nations peoples built rock-walled terraces in the island embayments, stabilising the foreshore and creating habitats for various clam species (Lepofsky et al., 2021). Lepofsky and colleagues (2021) argue that this form of Indigenous intertidal management can inform contemporary approaches for better environmental outcomes.

The studies in this review that achieved the highest averaged participation scores are either indigenous-led or use culturally appropriate research methods (Fig. 6). Even studies that did not achieve a high averaged participation score still contribute important insights into ethical research practice. For example, Martinez-Levasseur and colleagues (2017, 2021) provide an excellent example through the evaluation of their methods. They used reflective practice to recognise the spatial bias in their maps was a result of how they structured their interview questions. This insight contributes to scientific research literature and addresses a frequent critique of the limitations of traditional knowledge systems (Brattland, 2013). We suggest that their community participation, ranked at level 5 on Arnstein's (1969) ladder within the range of tokenism, contributed to this bias. If Martinez-Levasseur and colleagues had partnered with the indigenous community from the start, co-developing the research program, they could have avoided this issue. Acknowledging this limitation in their data set is an important first step, but to fully address it, they must continue their reflective practice and consider deeper power-sharing and partnerships throughout their entire research cycle.

Another key aspect of the research cycle is communicating research. It is encouraging to see that co-authorship with Indigenous authors is increasing, indicating growing recognition for the contributions of Indigenous communities to ICM research. In addition to co-authorship, if studies are not searchable, their ability to communicate and contribute to Sea Country sustainability is limited. For ICM research to benefit the communities it engages with and contribute to Sea Country sustainability, it needs to be easily findable in databases like Google Scholar and Scopus. Keywords, when carefully selected, improve the visibility and retrieval of research in searches, extending the profile of the published study beyond the title and abstract (Corrin et al., 2022; Grant, 2010). However, the published studies included in this review used more than 300 different keywords. This variability reduces the studies' visibility in searches, which in turn restricts the retrieval rates and the reach of the research. Many of the publications in this review were not easily searchable through simple keyword searches and were only found after developing the final search string for this review. The most frequently used keyword, *indigenous*, only appeared eight times despite all of the studies engaging with Indigenous knowledge and values. To have the impact it should, ICM research for Sea Country must be more searchable, findable, shareable, and accessible.

4.5. Implications for future ICM practices

As research incorporating Indigenous knowledges and values continues to increase, it is important and necessary to have clearly defined

methods and standards of practice to decolonise research practices, reduce tokenism and marginalisation, while increasing inclusion and power-sharing throughout the research cycle. The published literature currently lacks a clear definition of ICM and fails to establish minimum standards for best practice when engaging with Indigenous knowledges and values throughout the research cycle. This gap in the published literature leads to inconsistent levels of community participation and continues to exclude Indigenous communities from the research cycle, limiting ICM's potential to advance sustainable practices that protect and conserve Sea Country.

5. Conclusion

ICM is a transdisciplinary method of mapping that incorporates qualitative and quantitative data (Duxbury et al., 2015). This method must be conducted within an Indigenous-led and culturally appropriate research project that uses participatory mapping methods combined with anthropological and qualitative data collection strategies. Researchers and practitioners should always conduct research with the highest levels of community participation at all stages of the research process (Fig. 2 and Fig. 3) (Arnstein, 1969). This means that Indigenous communities are active participants and contributors throughout the research cycle, from conceptualising the program of research, to capturing, processing, and analysing the data, and communicating the results through strategies such as co-publishing with Indigenous co-authorship. While Indigenous communities may need to delegate technical tasks in projects due to limited capacity or access to specialised tools, this should not diminish Indigenous leadership or participation in decision-making authority. Projects must also prioritise capacity building, equipping communities with the skills and resources needed to sustain Indigenous autonomy and leadership. This approach supports Indigenous self-determination and strengthens the community's ability to manage their Sea Country.

ICM has the capacity to contribute to sustainable management practices for Sea Country. There is a growing community of practice throughout the world that is using ICM of coastal, island, and marine areas. We have evaluated the breadth and depth of the community of practice using ICM of coastal, island, and marine areas in the scientific and grey literature. Our findings highlight the value of ICM as a management tool for Sea Country and the fundamental importance of genuine and meaningful community participation in all aspects of the research cycle. The studies included in this review contribute to a growing body of work that clearly demonstrates the value that Indigenous knowledges and values adds to managing the sustainability of Sea Country now and into the future. The importance of how Indigenous knowledge systems can contribute to meeting the dual challenges of climate change and anthropogenic impacts cannot be overstated. This scoping review provides a foundation for researchers by bringing together and identifying key concepts and types and sources of evidence to inform practice, policymaking, and research. To ensure Sea Country sustainability, all knowledge needs to be considered and valued.

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CRediT authorship contribution statement

Redbird Stanley Ferguson: Writing – review & editing, Writing – original draft, Visualization, Project administration, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Christian Reepmeyer:** Writing – review & editing, Supervision. **Karen E. Joyce:** Writing – review & editing, Visualization, Supervision,

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Declaration of Generative AI and AI-assisted technologies in the writing process

During the preparation of this work the author(s) used ChatGPT during the editing and revision of the paper for concise direct language. After using this tool/service, the author(s) reviewed and edited the content as needed and take(s) full responsibility for the content of the publication.

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Appendix A. Supporting information

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Data availability

Data will be made available on request.

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