Demonstrating the effectiveness of a participatory geographic information systems (PGIS) approach in supporting ecosystem-based marine management for fisheries

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ABSTRACT

Increasing interest in implementing ecosystem-based management approaches has made stakeholder involvement vital and has highlighted the need for an effective participatory framework. In this case study of the transboundary Grenadine Islands, we illustrate how the application of a participatory geographic information systems (PGIS) approach was successful in developing user-centred, demand-driven information that could be easily accessed and understood by resource users, whilst also serving the needs of decision makers. PGIS provided a platform for transparent multi-level and multi-scale communication, information exchange and problem-solving, allowing for collective agreement on: an appropriate mapping scale, a locally-relevant habitat classification scheme, resource use profiles and a number of fishing-related attributes. The high level of stakeholder engagement necessary for successful PGIS not only provided uniquely useful information, but also created a strong sense of ownership in information produced, increased inter- and intra-stakeholder understanding, and validated the critical role of stakeholder participation in research and governance. Furthermore, the GIS framework and its integration with other freely available easy-to-use information technology applications has provided access to information for all stakeholders that will allow continued engagement, update and use of information for multiple purposes in support of an ecosystem-based approach to marine governance.

KEYWORDS: ecosystem-based management; participatory geographical information system; Grenadine Islands

Demostrar la eficacia de un sistema de información geográfica participativos (SIGP) enfoque en el apoyo a la gestión basada en los ecosistemas marinos de la pesca

El creciente interés en la aplicación de los enfoques de gestión basados en el ecosistema ha hecho vital y participación de los interesados ha puesto de relieve la necesidad de un marco de participación efectiva . En este estudio de caso de las Islas Granadinas transfronterizos , se ilustra cómo la aplicación de un sistema de información geográfica participativos enfoque (SIGP) tuvo éxito en el desarrollo de la información centrada en el usuario , basado en la demanda que podrían ser de fácil acceso y comprensión para los usuarios de los recursos , al tiempo que atender las necesidades de los tomadores de decisiones . SIGP proporcionan una plataforma para la comunicación , el intercambio de información transparente multi-nivel y multi- escala y la resolución de problemas , lo que permite convenio colectivo sobre : una escala de mapeo apropiado , un esquema localmente relevante hábitat clasificación, perfiles de uso de los recursos y un número de la pesca - atributos relacionados . El alto nivel de participación de los actores necesarios para SIGP éxito no sólo proporciona información única útil, sino que también creó un fuerte sentimiento de identificación con información producida , mayor inter e intra comprensión partes interesadas , y se valida el papel crítico de la participación de los interesados en la investigación y la gobernanza . Por otra parte , el marco de los SIG y su integración con fácil de utilizar otras aplicaciones informáticas de libre disposición ha facilitado el acceso a la información para todos los interesados que permitan la participación continua , actualización y uso de información para múltiples propósitos en apoyo de un enfoque basado en los ecosistemas la gobernanza marítima.

PALABRAS CLAVES: gestión basada en los ecosistemas; sistema de información geográfica participativo; Islas Granadinas

INTRODUCTION

Conventional top-down management approaches have failed to achieve the goals of sustainable development and have been insufficient to respond to the complex nature of the social, economic, political and environmental challenges of marine resource management (Pomeroy *et al.* 2004, Wiber *et al.* 2004, Christie and White 2007; Ogden 2010). The application of a comprehensive strategy using multiple sources of information to address complex socio-ecological problems is recognised as essential for effective marine governance (Berkes 2007, Ostrom *et al.* 2007) and an ecosystem- approach to fisheries (EAF) (FAO 2012). As such there is a need to apply a practical integrated systems approach to natural resource management which allows for the incorporation of a wide range of interdisciplinary information in order to augment more informed decision-making (Armitage *et al.* 2008, Mahon *et al.* 2008). This process can aid an 'interactive governance' approach by mobilising local knowledge as well as facilitating dialogue and understanding amongst stakeholders (Bavinck *et al.* 2005, Kooiman *et al.* 2005). The employment of multi-sectoral collaboration which includes meaningful community participation in the information gathering, research and evaluation processes can maximise resources and management efforts thereby better guiding sustainable management initiatives, aiding equity and ownership in decision-making.

As marine resource management has a spatial component and requires the integration of information from a variety of sources at multiple scales, geographical information systems (GIS) have gained wide acceptance for environmental management and planning applications (Carocci *et al.* 2009). Although the application of GIS for climate change adaptation and disaster risk management has been prominent (FAO 2008), the role of GIS in fisheries management is still limited (Meaden and Aguilar-Manjarrez 2013, Baldwin 2012). In recent years the use of GIS as a tool coupled with participatory and collaborative approaches has emerged as a novel science known as participatory GIS (PGIS) (Chambers 2006, Corbett *et al.* 2006). A focus on the application of a GIS in terms of the development of demand-driven, user-centred products has been emerging in the PGIS practice. Ultimately stakeholder engagement through the principles of good governance (i.e. inclusiveness, transparency, efficiency, appropriate, ownership) underlies the approach (McCall 2003). Furthermore by promoting the engagement of stakeholders in the development of a technical representation of spatial knowledge, PGIS can allow for a comprehensive understanding of the social aspects of natural resource use patterns (Aswani and Lauer 2006, St. Martin and Hall-Arber 2008, Dalton *et al.* 2010). This process not only demonstrates the relevance of information provided by stakeholders, but supports an ecosystem approach by promoting the collection and utilisation of local knowledge together with conventional scientific knowledge, hence allowing for a broader understanding of human-environment interactions (Balram *et al.* 2004, Aswani and Lauer 2006, Dalton *et al.* 2010). As such, stakeholder engagement throughout the PGIS process can build capacity for effective participation in marine governance (*e.g.* De Freitas and Tagliani 2009).

Study area

The Grenadine Islands provide a good locality to evaluate the application of PGIS and assess its implications for governance within a complex coastal marine management environment. Located in the Eastern Caribbean, the transboundary Grenadine Island chain lies on the Grenada Bank which extends more than 100 km in length between two countries, Grenada, and St. Vincent and the Grenadines (Figure 1). There are over 30 islands, islets and cays, of which nine have permanent settlements. Three quarters of the Grenada Bank is shallower than 60 m and supports the most extensive coral reefs and related habitats in the south-eastern Caribbean (CCA 1991a, 1991b). Marine-based activities are the foundation of the economies of the Grenadine Islands in which fishing, tourism and inter-island transportation are the major sources of employment (Baldwin *et al.* 2006). Although coastal and marine resources are of vital importance to the people of the Grenadines, increasing pressures from tourism development and the non-sustainable use of these resources are making the planning and management of marine resource use on the Grenada Bank increasingly complex (Mahon *et al.* 2004). To date, management of the Grenada Bank marine resources has primarily been focused on the fisheries sector using a conventional top-down approach with a limited information base from which to make management decisions (Mahon *et al.* 2004, Daniel 2005, FAO 2007). Furthermore, marine management of the Grenada Bank has not been integrated amongst disciplines, between nations or knowledge systems (Culzac-Wilson 2003, Joseph 2006). This segregated management approach has not been effective and has failed to prevent the environmental degradation of the Grenada Bank (ECLAC 2004, SusGren 2005).

In this study of marine space use in the transboundary Grenadines Islands, a participatory geographical information system (PGIS) approach is employed as a conceptual framework to integrate conventional biophysical and management information with information derived from the practical knowledge of marine resource users (Baldwin 2012). Here we detail the ways in which stakeholders were engaged to develop a participatory geographical information system (PGIS) entitled the Grenadines Marine Resource and Space-use Information System (MarSIS), in terms of both the research approach (process) and the final geodatabase (product). To evaluate the utility of PGIS for an ecosystem-based approach to marine management and planning this research explored two propositions. The first was to investigate ways of developing an integrated baseline of the extent and distribution of marine resources, associated patterns of use and the identification of threats for use in planning ecosystem-based management. The second was to explore the feasibility of various approaches to illustrate to other practitioners the ways in which multi-knowledge information on coastal and marine resources and human activities can be brought together, analysed and used in scenario development as a starting point for collaborative marine spatial planning and management.

METHODS

The overall process for PGIS in the research comprised several parts: data scoping and preliminary appraisal; development of communication and information exchange mechanisms; marine resource use inventory and assessment; mapping exercises; marine habitat classification scheme and habitat map development; definition and compilation of the MarSIS geodatabase structure; demonstration of PGIS applications to provide a baseline picture of the extent and distribution of marine resources, associated patterns of use and the identification of threats of use in the development of various scenarios as a starting point for collaborative ecosystem-based management; and an evaluation of the PGIS process and product (Figure 2). Each of the steps and the participatory approaches adopted are briefly described in the following sub-sections (see Baldwin 2012 for detailed review).

Stakeholder engagement

Stakeholder engagement was used to: (1) review and refine research objectives; (2) guide methodologies; (3) acquire information and document local knowledge; (4) share and validate information produced; (5) develop locally relevant and accessible information; and (6) appraise the application of PGIS (Baldwin *et al.* 2013).

At the outset, one year was taken to conduct a preliminary appraisal (Berkes *et al.*, 2001; Bunce and Pomeroy, 2003; IIRR, 1998; Walters *et al.*, 1998). This was done to identify existing information, better understand the levels and types of stakeholders and institutions across the scale of the Grenada Bank (Figure 1), share research objectives; explain guiding principles (e.g. inclusive, appropriate, transparent, comprehensive, participatory, equitable, accessible) and build the working relationships necessary for a collaborative (partnership) approach. To allow for transparent, inclusive and equitable cross-scale interactions, stakeholders were engaged through one and two-way communication mechanisms at every stage. These included the regular distribution of newsletters, press releases, flyers, technical reports and a website/blog (www.grenadinesmarsis.com) as well as periodic summary and validation meetings and email through a dedicated internet e-group (www.GrenadinesMarSIS.yahoogroups.com). The e-group and website facilitated transparent group discussion and provided easy access to information across the scale of the Grenada Bank. All information collected as part of the preliminary appraisal was compiled and shared via DVD, the e-group and website.

Participatory research methods were employed to collect additional data required for the comprehensive MarSIS. To start, a marine resource user (MRU) assessment (drawing upon Berkes *et al.*, 2001; Bunce and Pomeroy, 2003; Quan *et al.*, 2001) was conducted to quantify the number, distribution and socio-economic conditions of each group (Baldwin *et al.* 2006). Validation meetings were held to obtain feedback on the MRU assessment and support transparent cross-scale learning amongst stakeholders. Next, incremental iterative mapping exercises (drawing upon IIRR, 1998; Quan *et al.*, 2001; Walters *et al.*, 1998) were conducted over a three-year period to document local spatial knowledge (see Baldwin, 2012 for detailed review). Mapping exercises were conducted incrementally with MRUs in the form of individual (or sometimes small group) interviews using hard-copy basemaps. The first mapping exercise was used to determine the toponymy (locally-used place names) for the beaches, bays and cays of the Grenada Bank. Next, space-use patterns (e.g. anchorages, dive sites, ferry routes, fishing grounds, shipping lanes) of each MRU group were documented and the final series of mapping exercises sought to identify the distribution of key resources (e.g. baitfish bays, nursery grounds, oyster beds, seabird nesting sites, sea moss, whelks), areas of use (e.g. aquaculture, cultural/historical sites, recreation, ship building, vending) and areas of threat (e.g. dumping, desalination outfall, dredging, erosion, mangrove cutting, sand mining). The mapping exercise and MRU assessment data were spatially translated into GIS and incorporated in the MarSIS.

Marine habitat mapping

A multi-layered marine habitat map was developed using a PGIS approach primarily intended to facilitate collaboration, access to information from all sources and production of locally relevant map products (Baldwin and Oxenford 2013). The steps and participatory approaches were applied in: (1) choosing a map scale and habitat classification scheme; (2) using and incorporating local knowledge to improve the accuracy of the interpretation of habitats (remote sensing); and (3) collecting additional habitat and resource use data in the field survey.

Existing habitat information (e.g. GIS datasets, satellite imagery, aerial photos, habitat maps and other collateral marine habitat information) was summarised and shared with marine resource managers in both countries to determine the most locally-relevant (comprehensive and meaningful) scale and habitat classification. To create a classification scheme that was relevant and clear across a wide range of users (e.g. resource managers and resource users), a 'habitat flashcard' exercise was conducted with a variety of stakeholder representatives (Baldwin and Oxenford 2013). This exercise was used to examine both the number of habitat classes that stakeholders would 'naturally' use and the names they would apply to these classes. The selected classes were then shared with the larger stakeholder group via the e-group, and included: seagrass, coral reef, mixed live bottom, hard bottom, sand and mangrove.

A baseline habitat map for the Grenada Bank was created using two methods: conventional passive remote sensing techniques for areas less than 20 m deep, and a marine field survey for the deep areas (> 20 < 60 m) of the Grenada Bank (Baldwin and Oxenford 2013). Remote sensing was conducted using ArcGIS 9.2 and the 'Habitat Digitizer' software extension was applied following the techniques of Kendall *et al.* (2001). Next, a participatory validation step was undertaken with MRU stakeholders in an attempt to improve the accuracy of the habitat interpretations. A marine field survey was conducted by a collaborative research team comprising two marine biologists and two local fishers to ground-truth and evaluate derived habitats in the shallow areas (< 20 m) and collect new data for the deep areas (> 20 < 60 m). Information was collected on: the habitat type, an estimate of benthic cover or density of habitat (low, medium, high); and habitat rugosity (low, medium, high). Each site was also judged by the local fisher for: its suitability as a fishing ground; an assessment of the likely fishery species that would be available (conch, lobster, reef fish); the fishing gear that would likely be used there (line, net, fish pot, SCUBA tank, spear gun); the apparent quality of the fishing ground (poor, okay, good, very good); and whether he would choose to fish at the site (yes, no).

Following these assessments, the shallow water portion of the habitat map was updated using ArcGIS by editing all habitat polygons that were found to have been wrongly interpreted in the remote sensing exercise and field survey, thereby increasing the accuracy of this portion of the habitat map. The deep water field survey resulted in discrete nominal habitat point data. ArcGIS was used to expand each survey point's assigned habitat class 1.5 km (thereby creating a surface with 3 km^2 habitat cells) to create a continuous modelled surface for the deep water portion of the habitat map. Although two marine habitat layers were created initially (i.e. shallow water habitat and deep water habitat); ultimately these were merged into a single Grenada Bank marine habitat map product using standard geoprocessing tools. The fishing-related data comprised ordinal point data, such that Inverse Distance Weighted (IDW) interpolation was an appropriate modelling technique to create additional map layers. This exercise produced one layer for each target fishery species (conch, fish, lobster); one layer for each type of fishing gear likely to be used (fish trap, line, net, spear gun, SCUBA); as well as layers indicating the apparent quality and suitability of the habitat for fishing respectively. Additionally, the Spatial Analyst 'Weighted Overlay' geoprocessing tool was used to identify areas of spatial overlap (one layer for fishery type and one for fishing gear) thereby creating two fishing density surfaces.

Geospatial framework

The geodatabase design was driven by the need to understand the environment and influence of human activities to support transboundary ecosystem-based management for the Grenadine Islands. Collecting data, defining the geodatabase structure and populating the geodatabase was an iterative process initially taking about 18 months, but continuing throughout the remainder of the research (additional 36 months). Ultimately the MarSIS geodatabase consisted of 11 feature datasets, comprising 81 feature classes (e.g. 46 vector, 28 raster and 1 annotation), of which 63% was derived in part, based on the use of local knowledge sources (Baldwin *et al.* in press, Baldwin and Oxenford 2013). This created a baseline of the ecological distributions of marine resources, physical environmental features, human activities and jurisdictional boundaries. To illustrate the ways in which multi-knowledge information on coastal and marine resources and human activities can be brought together, analysed and used in scenario development as a starting point for collaborative marine spatial planning and management, the MarSIS was used to demonstrate practical GIS applications that serve to define and analyse the existing environmental conditions of the Grenada Bank (Baldwin and Mahon submitted).

Information provided for community use should be in an understandable format, useable and accessible to stakeholders in order to facilitate a more equitable, transparent and collaborative decision-making environment (McCall, 2003, Rambaldi, *et al.* 2006). Google Earth, a user-friendly and freely-accessible platform, was identified by stakeholders the most appropriate means to provide public access to the Grenadines MarSIS (Baldwin 2012). The entire geodatabase, as well as a series of underwater pictures/videos from the field survey, were translated into Google Earth (Stewart and Baldwin 2012) and made freely available for download via the research website.

Stakeholder evaluation

After the compilation of the MarSIS geodatabase, three one-day workshops were conducted with stakeholders. The practical application of the MarSIS (product) through either an ArcGIS or Google Earth interface was tested by the stakeholders themselves and reviewed in detail by Stewart and Baldwin (2012). A four-page questionnaire was administered to assess each of the participatory methods utilised (process), examine the effectiveness of the resulting Grenadines MarSIS geodatabase (product), and understand the usefulness of PGIS to support marine governance (Baldwin *et al.* 2013).

RESULTS / DISCUSSION

In this study a framework for PGIS was developed, applied and found to be a practical approach to aid the collection, integration and understanding of multi-knowledge interdisciplinary information (Baldwin 2012). Extensive stakeholder engagement in the development of the MarSIS provided a means for civil-society to contribute to the information base for transboundary decision-making and management of the Grenada Bank. We found PGIS resulted in the production of comprehensive and accessible information tailored to the needs of the Grenada Bank stakeholders. The PGIS process also served to strengthen cross-scale linkages, promote a transparent and inclusive working environment and build capacity for adaption and resilience across a transboundary scale (Baldwin *et al.* 2013). Here we provide a brief assessment of each engagement mechanism and illustrate how PGIS can strengthen ecosystem-based marine management.

In a complex geopolitical environment such as the Grenadine Islands nearly two years were required to conduct a thorough preliminary assessment; yet this was found to be essential for a PGIS in many ways. The application of clearly defined research principles (i.e. inclusiveness, equity, transparency, appropriate, accessibility) from the outset was found to be of key importance to the collaborative construction of a locally-relevant ecosystem-based PGIS. The preliminary assessment also allowed the time to collect existing information and the opportunity to understand the local context of the various levels of stakeholders and institutions across the scale of the two countries. This process was crucial in providing a clear understanding of the capacity for participation of each of the various stakeholder groups. Time was also required to allow stakeholders, many of them not accustomed to thinking in terms of data and information, to understand the research objectives and what knowledge they could contribute. The preliminary appraisal was seen as essential to develop appropriate engagement mechanisms, produce relevant information and gain creditability from such a large and diverse set of stakeholder groups from the outset (Baldwin et al 2013).

The importance of assembling widely understandable information is a tenet of PGIS (Corbett *et al*. 2006). Thus it was essential to develop a habitat classification scheme and base maps that were locally-relevant. The GIS interface allowed for the effective collation of a variety of source and scales of secondary spatial information in an accessible format. The PGIS approach provided a mechanism to share and collaboratively evaluate the information acquired and mapping products. Likewise, the need to develop a habitat scheme and mapping products at a scale relevant for local and transboundary management was resonated in interviews with marine resource managers and corroborated by the results of the habitat flashcard exercise. Ultimately the collaboratively developed habitat scheme was shared with the wider stakeholder group using the e-group before being finalised and applied.

Participatory research practices made it possible to incorporate stakeholders' practical knowledge within a GIS framework. Mapping exercises allowed for the systematic collection of each island community's spatial knowledge of resources and use patterns. The incremental approach to mapping exercises (starting with the toponymy, then identifying livelihood space-use patterns and lastly moving on to resources, uses, and areas of threat) allowed the time needed to build capacity in the MRUs as well as the trust required for them to share sensitive information (such as illegal activities). Merging the results of socio-economic surveys with spatial data derived from mapping exercises allowed for the development of socio-economic space-use profiles for the various Grenadine marine resource users (i.e. day tour and water taxi operators, charter yacht companies, dive shops, ferries and ships) to be incorporated in the GIS interface (Baldwin and Mahon submitted). Local knowledge validation exercises easily improved the accuracy of the remotely-sensed shallow water habitat map by 12% demonstrating the value that stakeholder engagement can add to this conventional geomatic technique (Baldwin and Oxenford 2013). Incorporating fishers as part of the field research team and including their knowledge in the marine survey variables allowed for the production of information on human-habitat interactions. Field survey variables to record fisher's spatial understanding of the 'physical environment' or benthic substrate and the 'biological resources' or associated species which occur, allowed for the tacit associations to be captured and modelled in the GIS (Baldwin and Oxenford 2013). These modifications to integrate local knowledge with conventional scientific approaches allowed for ecosystem-based information to be created and easily incorporated into habitat mapping products.

We found PGIS useful for collecting, integrating and producing a wide variety of comprehensive qualitative and quantitative socio-ecological information that is relevant at a transboundary scale and at the levels of communities, islands and nations. Ultimately local knowledge accounted for 63% (54 feature classes) of the MarSIS geodatabase, the majority of which comprised distinctive, spatially-based, socio-ecological information (Baldwin 2012). This collaborative working environment together with the use of validation meetings and access to information via the website provided for quality assurance and resulted in the ownership and shared understanding of ecosystem-based information.

PGIS was found to be useful to facilitate stakeholder understanding of the abundance and distribution of resources and use patterns. The GIS and Google Earth interfaces were found to aid stakeholder comprehension by allowing spatial information to be visualised (Stewart and Baldwin 2012). Simple marine resource and associated human activity maps allowed for an understanding of human-environmental interactions that occur. Geoprocessing tools were used with marine survey data and information from MRUs to model the deep water habitat, the location of fishing grounds and human fishing preferences of the Grenada Bank. Geoprocessing tools were used to quantify the coastal and marine habitats and of resource use occurring on the Grenada Bank and allowed for the effectiveness of the existing MPAs to be assessed and for each country's progress towards the achievement of marine conservation targets to be gauged. Locational queries were used to identify representative reef ecosystems and provide management insight regarding the important areas for conservation on the Grenada Bank. Cumulative use analyses identified conservation priority, human activity and potential threat areas thereby increasing the understanding of space-use patterns on the Grenada Bank. These analyses have implications for marine spatial planning and management by identifying relationships between the coastal marine environment and human activity and can assist in the determination of management feasibility and the identification of options with the fewest user conflicts.

The stakeholder evaluation underscored the importance of a PGIS approach in the development of user-centred, demand driven information that could be easily accessed and understood by a wide range of stakeholders (Baldwin *et al.* 2013). Participation, in terms of equitable and informed multi-level stakeholder involvement, was supported by the use of a number of low-cost, easy-to-use communication mechanisms at every stage. Participants found the research was inclusive and transparent and the information produced was appropriate, unique and useful for their respective groups. Participants reported that the compilation of the MarSIS was a group effort and overall, 78% expressed a sense of ownership in the MarSIS (Baldwin *et al.* 2013).

Beyond the benefits identified above, a participatory approach may also facilitate improved governance by building adaptive capacity and resilience (Baldwin *et al.* 2013). The application of PGIS resulted in a broad set of ecosystem-based information which has been actively used by a broad range of stakeholders since its public release. The MarSIS has been used to: quantify the economic value provided by reef ecosystem services in St. Vincent and the Grenadines (Joslyn, O 2012, pers. comm., 15 March); support a transboundary marine multi-use zoning design for the Grenadine Islands (SusGren 2010); apply for a transboundary designation of the Grenadine Islands as an UNESCO marine mixed World Heritage Site (DeGraff and Baldwin, 2013); check the validity of environmental impact assessments submitted to the government; and contest environmentally unsustainable coastal development projects (Price 2011, PIA 2011). These examples substantiate the importance of PGIS in strengthening connectivity for learning systems and empowering stakeholders to participate in governance as suggested Kooiman *et al.* (2005).

CONCLUSION

There are clear benefits to utilising a PGIS approach in the development of marine resource space-use information system in the Grenadine Islands. As compared to conventional GIS, a more complete socio-ecological understanding of the human uses of coastal and marine resources in regards to conservation and to the livelihoods of the Grenadine people was realised. In addition, the various participatory processes involved in implementing a PGIS not only allowed for the production of locally-relevant and useful information, but also: (a) built multi-level stakeholder capacity in the understanding of the marine environment and related human uses; (b) provided legitimacy to the 'tacit' knowledge of MRUs; (c) increased confidence and ownership in information produced; and (d) demonstrated to other practitioners the role that stakeholders can and should play in marine governance. This process also engendered a willingness to participate by the various stakeholders (e.g. community, NGO and government) across a transboundary scale.

The collaborative development of a PGIS can lay the foundation for an ecosystem approach to place-based marine resource management. The advantages of the approach are seen as being two-fold. It creates engagement of the stakeholders and also supports informed decision-making for the transboundary management of marine resources (Baldwin *et al.* 2013). This engagement takes several forms: the definition of the role of participation in research and governance, ownership of information produced, increased inter- and intra-stakeholder understanding and access to information as well as a platform for transparent multi-scale and multi-level communication, information exchange and problem-solving. To this end, this study found a PGIS approach to be a practical mechanism to realise EBM as well as can serve to strengthen fisheries governance.

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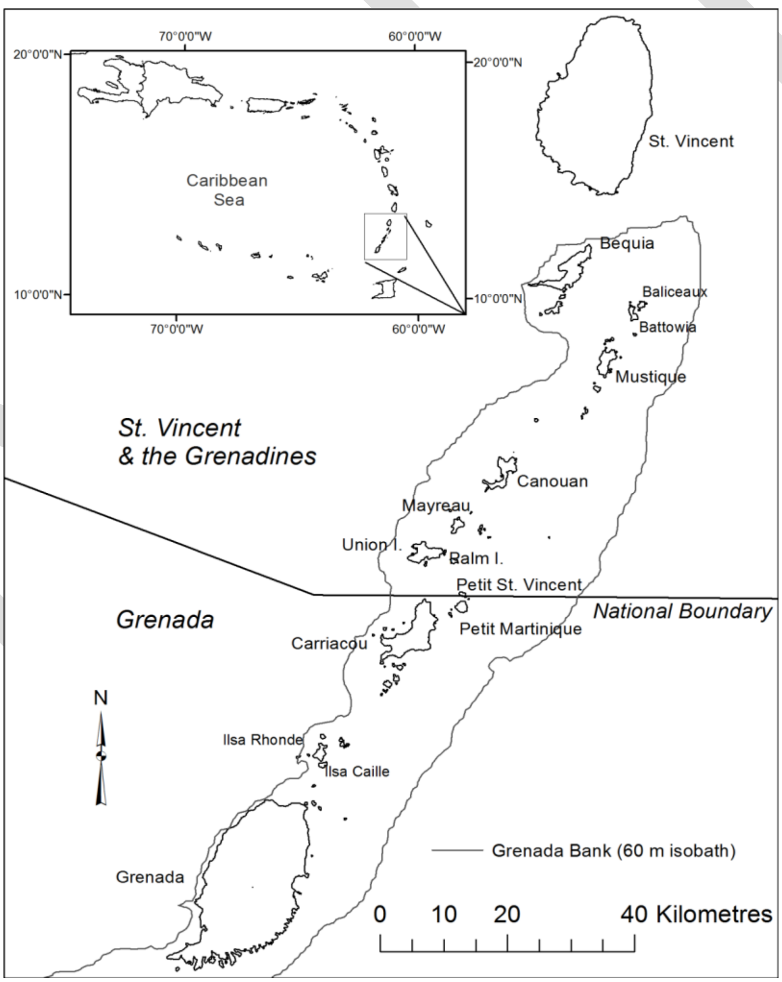
LIST OF FIGURE CAPTIONS

Figure 1. Geographic location of the countries of St. Vincent and the Grenadines and the tri-island state of Grenada and detail of the Grenadine Islands of the transboundary Grenada Bank (60 m isobath) study area.

Figure 2. Schematic of the application of PGIS listed with corresponding sub-components in which stakeholder feedback was applied (Adapted from Baldwin et al. 2013).

FIGURES



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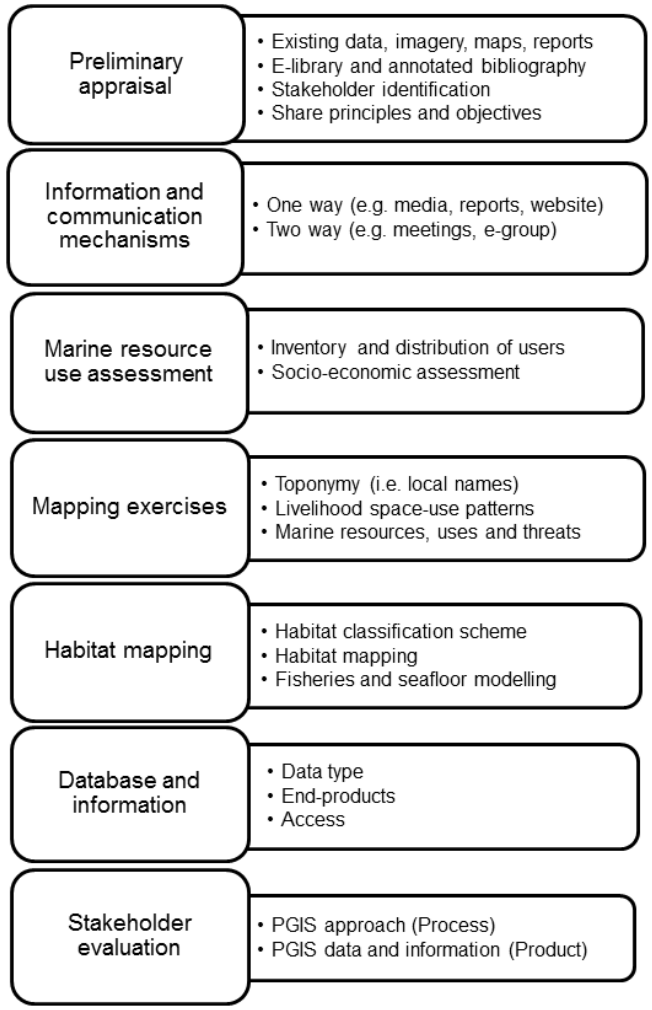

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