

Marine spatial planning in Barbuda: A social, ecological, geographic, and legal case study

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ABSTRACT

This paper details the process by which the Caribbean island of Barbuda created comprehensive marine spatial planning regulations. The Barbuda Council (the island's governing body), with invited support from the Waitt Institute, navigated complex tradeoffs between spatial uses to design and legally codify zoning for their entire marine jurisdiction. After a year of intensive community engagement under this Blue Halo Initiative, regulations were adopted in August 2014 that established zones for sanctuaries, fish net prohibitions, anchoring/mooring, and shipping. Key data used included a habitat map and a heatmap of fishing value. Barbudans designed all zones, with technical support, using the software program SeaSketch. Throughout the process, the Council incorporated input from fishers and other community members, seeking a final zoning design that would minimize negative impacts on livelihoods and earn broad community support. The final zoning plan balances economic, conservation, and cultural uses. It includes thirteen zones and meets the pre-agreed goals of protecting one-third of the waters overall and approximately one-third of each habitat type. The consultation process included seven community consultation meetings, five fisher consultation meetings, and two meetings of a stakeholder committee. The initiative is now in the implementation phase, however Hurricane Irma devastated Barbuda in September 2017, creating substantial challenges for ongoing implementation. Overall lessons learned include the importance of being flexible and transparent, considering enforcement from the outset, building political will through documenting stakeholder and expert perspectives, and not allowing a pursuit of unanimous agreement to hinder progress.

1. Introduction

Akin to zoning on land, ocean zoning is a big-picture management approach employed to ensure key uses of marine resources – from fishing to shipping, energy, aquaculture, recreation, conservation, and more – are legally allocated appropriate spaces. Through a process of marine spatial planning (MSP, which can result in ocean zoning) governments can provide a transparent framework for balancing economic,

environmental, security, social, and cultural interests. More specifically, it can reduce conflicts between uses, safeguard ecologically important areas, allow commercial activities to develop with certainty, support international cooperation, facilitate sustainable economic growth, and enable ecosystem-based management [1,2].

Around seventy countries are engaged in some phase of MSP as a tool to manage their maritime jurisdictions [3]. Examples include Australia's Great Barrier Reef Marine Park zonation, Germany's plans for the North

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and Baltic Seas, and Rhode Island's Special Area Management Plan [4–7]. There are now twenty-two countries with government-approved marine spatial plans [8]. However, in developing country contexts, while there are numerous examples of successful marine protected area (MPA) planning and implementation, and some examples of MSP for a portion of an island's waters, there are few examples where that planning has resulted in legally-codified ocean zones around the entire island [9]. However, Caribbean islands with notable MSP initiatives include Bonaire, St. Lucia, St. Vincent and the Grenadines, St. Kitts and Nevis, and Jamaica [10–14].

Many elements and steps are required to ensure successful design and implementation of MSP, including: organizing stakeholder participation, defining principles and goals, gathering mapped information, identifying and evaluating alternative zoning plans, and incorporating the final zones into enforceable legal frameworks [15].

The objective of this paper is to detail the Blue Halo Initiative (BHI) in Barbuda (further described in section 1.2), an MSP process by which the Caribbean island of Barbuda engaged in an effort to restore and sustainably manage their waters, based on science and stakeholder priorities, and resulting in a comprehensive and legally-codified set of ocean zones. More specifically, the aim of this work was to (a) design and adopt coastal zones to balance various uses of ocean space, (b) improve the sustainability of fisheries management, and (c) protect vulnerable ecosystems and species. Here we present details on zoning principles and guidelines, stakeholder input, key scientific data, legal framework, evolution of the zoning map, outcomes, and lessons learned. This serves as an informative and nuanced case study with relevance for small island states and coastal nations broadly.

1.1. The island of Barbuda

Barbuda is a small island in the northeast Caribbean, part of the country of Antigua and Barbuda. In recent years it has had a population of around 1,600 [16]. In September 2017, Hurricane Irma ravaged Barbuda and altered almost every aspect of life on the island. In this paper, unless otherwise noted, the descriptions refer to pre-Hurricane Irma conditions, the state of affairs during the planning phase of ocean zoning.

Fishing (in particular for spiny lobster, *Panulirus argus*) is central to both food security and the economy. As of 2017, there were approximately 30 people for whom fishing was their primary source of income, and perhaps up to 100 who fished occasionally for supplementary income or subsistence. Apart from employment in tourism or government, this was the largest sector of the economy, and comprised a portion of income in many households, in addition to its cultural importance. Dominant forms of fishing include diving for lobster and conch, setting traps for lobster, conducting hook-and-line and spearfishing for finfish, and in more recent years using gill nets to target herbivorous fish (*Scaridae* (parrotfish) and *Acanthuridae* (surgeonfish)).

Tourism on Barbuda consisted of four small seaside resorts and guesthouses, with approximately 50 total rooms. Barbuda attracts some yachts, although prior to 2016 all vessels were required to clear customs in Antigua before visiting Barbuda. Other important economic activities related to the ocean include export of sand (mined on the island) and transportation of goods to and from Antigua via the River Dock, the island's only commercial port facility.

The local culture is deeply intertwined with the ocean. Camping on the beach is a popular pastime for entire families, especially during the Easter holidays. Sportfishing is rare but considered by locals to have economic potential, especially for bonefish found in the lagoon. Swimming and bathing in the sea, recreational fishing, and fish fries are popular activities across generations.

There were two previous efforts at establishing marine protected areas. First, the national government of Antigua and Barbuda established a marine reserve (closed to fishing) at Palastar Reef, off the southern coast of the island, using its authority under the Marine Areas

(Preservation and Enhancement) Act, 1972. The community was largely unaware of this reserve, and unaware of its exact boundaries; it was never enforced. Second was a temporary closure of the Codrington Lagoon, which is a critical nursery habitat for lobster, snappers, and other commercial fish species. In this instance, Barbudans closed the Lagoon to allow lobster populations to recover. When the community noticed a dramatic increase in lobster, poaching commenced and then the closure was abandoned before its planned expiry date. However, the community recalls that closure as an ecological success. Thus, there was a common understanding from the start of the Initiative that protected areas can be effective tools for fisheries management, and an openness to considering them again.

The Government of Antigua and Barbuda manages fisheries and other coastal and ocean uses throughout the nation's exclusive economic zone, including around Barbuda. However, under the Antigua and Barbuda Constitution and the National Maritime Areas Act, the Barbuda Council (the island's governing body) also has limited jurisdiction of the waters from the shore of Barbuda out to three nautical miles, as well as the inland lagoon, a total area of 456 km². Within this nearshore area, the Council has the authority to regulate fishing and other marine uses, so long as its regulations are consistent with national laws and regulations.

1.2. The Blue Halo Initiative

The goal of this Blue Halo Initiative is to, in partnership with island governments, envision, create, and implement comprehensive ocean policies to “foster the sustainable, profitable, and enjoyable use of ocean resources for present and future generations” [17]. In other words, it is a people-centered effort with the goal of maximizing ecological, economic, and cultural benefits.

After researching legal frameworks and socio-economic contexts across the Caribbean, the Waitt Institute⁵ approached Barbuda about a potential partnership for ocean zoning because of the existing (a) political will, (b) stakeholder support, and (c) enabling legislation that provided the legal framework for MSP regulations. Further, the island's small size (in terms of both ocean jurisdiction and human population), enabled a small team to conduct a scientific assessment of coastal resources and extensive and deep community engagement. Fishers and government officials expressed concern about the degradation of their reefs and fisheries, saw the need for improved ocean management, and were keen to collaborate.

The initiative commenced in December 2012 with a formal invitation from the Barbuda Council to the Waitt Institute to support the design and implementation of ocean zoning. Guided by the questions “What do you want your ocean to look like? How can we help you get there?” this joint effort came to be called the Blue Halo Initiative. As part of the zoning effort, Barbuda developed and passed in tandem new local fisheries and park regulations, and developed implementation and enforcement plans. These complementary regulations and plans provided necessary components for public support, implementation, and enforcement of the zoning effort [18,19]. The initiative was both geographically comprehensive (considering the entire area under the Council's jurisdiction) and comprehensive in its consideration of ocean uses (including all uses the community deemed in need of zones).

The Barbuda Council, Waitt Institute and its contractors, the Barbuda Fisheries Division, and Codrington Lagoon National Park played key roles, while other government agencies, including the national Fisheries and Environment divisions and the Legal Affairs Department, provided important advice and essential support. The Council served as the government lead. The staff of both the Fisheries Division and National Park

⁵ The Waitt Institute is an American, nonprofit operating foundation funded by the Waitt Foundation, with the mission of “empowering communities to restore their ocean.” See www.waittinstitute.org.

supported stakeholder engagement and ecological research, and provided expertise on historical ocean uses and management. The Waitt Institute facilitated and funded the program, supporting a team of technical experts, engaging the community, making policy recommendations, and building local capacity. The Waitt Institute had staff located in Barbuda for approximately 50% of the planning phase, focused on conducting a scientific assessment of the reefs and fisheries [20], extensive community consultations and stakeholder interviews (with a focus on engaging fishers), legal analysis and drafting, and capacity-building for monitoring and enforcement. The University of California Santa Barbara, Environmental Law Institute, and WildAid provided expertise on mapping, law, and monitoring and enforcement, respectively. Unless otherwise cited, the information in this article is drawn from the direct experience of the authors during the project.

In the community, the BHI team used the term “ocean zoning” as opposed to “marine spatial planning” to be clear that the goal was to designate zones where certain activities would be permitted or prohibited through enforceable legal frameworks. Opting for this term embraced challenging discussions about potential outcomes and bolstered efforts to ensure the zones would meet economic, cultural, and conservation needs.

In August 2014, after three months of planning and research, a full year of community consultation, and five months of legal processing and paperwork (Fig. 1), the Council adopted new regulations that zoned Barbuda’s waters [21].

2. Planning principles and zoning guidelines

The following planning principles were drafted by the BHI team, adopted by the Barbuda Council early in the initiative, and shared with the community. They guided the overall process of developing comprehensive policies for sustainable ocean management:

1. Plan with the goal of sustainable, profitable, and enjoyable use of coastal resources over the long-term – for next year and for future generations.
2. Plan with a focus on increasing fisheries’ catches and preserving traditional uses of coastal areas.
3. Plan with the premise that zoning well-supported by the community will result in higher voluntary compliance.
4. Plan with consideration of maximizing ease of enforcement, including gear-based management and design of zone boundaries based on known landmarks, where possible.
5. Plan with an understanding of the necessity for strong legal support for enforcement, including prosecuting and penalizing infractions.
6. Plan with an aim of long-term financial independence and viability of implementation.
7. Plan with the awareness that revisions and adjustments may be needed over time to maximize effectiveness.

Additionally, for developing the zone boundaries, the following guidelines and goals were developed by the Waitt Institute, with support from the Sustainable Fisheries Group at University of California, Santa Barbara, and then adopted by the Council:

1. *Fully protect one-third of the marine area.* This goal was based on research showing significant marine habitat degradation even in Australia’s Great Barrier Marine Park, which has one-third of its area designated as no-take [22].
2. *Protect one-third of each type of habitat.* This was to ensure that the protected areas were not located only around, for example, low-diversity sandy bottom habitat, but included significant portions of each major habitat type: continuous coral reef, patch reefs, seagrass, sand and deep water.
3. *Ensure a minimum reserve diameter of approximately 3.2 km and ideally over 3.8 km to protect species with a spectrum of ranges.* For scale,



Fig. 1. Blue Halo Initiative timeline from initial scoping trip in October 2012 through adoption of new regulations in August 2014. A&B is Antigua and Barbuda.

Caribbean reef fish have home ranges from approximately 13 m (*Holocentridae* (squirrelfish)) to 220 m (*Labridae* (Wrasses)) [23], sharks' home ranges span from several km to several hundred km [24], and *Panulirus argus* (spiny lobster) can range 900 m in a single day [25].

4. *Protect as much nursery habitat as possible* to restore and continually replenish local fisheries.
5. *Minimize conflict between ocean users*, such as recreational swimmers and boaters.

3. Stakeholder input

With Barbuda's economy and culture deeply connected to the ocean, all Barbuda residents can be considered stakeholders [26]. Therefore, broad efforts were made to engage the island population in the process of developing and designing new ocean zones and management. However, as fishing and tourism are the island's primary marine activities, stakeholders from those sectors were engaged most deeply, which ensured that their voices would be appropriately considered in a new management system.

To adhere to the planning principles, gathering stakeholder input was a top priority, along with being comprehensive and science-based. The Waitt Institute organized community engagement and designed its approach with the understanding that, though invited, the Institute and associated experts were guests on the island. Thus, the key role of these outside experts was to compile community input, provide scientific information and technical support, and make recommendations in line with the approved principles and guidelines, with the understanding that, ultimately, the outcome would reflect the community's goals and priorities.

3.1. Stakeholder interviews

As an initial form of community engagement, 50 current and former fishers were interviewed by the lead author in April and May 2013 using a detailed survey. There were questions on types of boats and gear used, how catches have changed over time, causes of declining catches, locations of nursery habitats and spawning areas, and support for potential management measures. Interview methods were similar to those described in Johnson and Jackson, 2015 [27]. Initial interviewees were recommended by members of the Barbuda Council, Fisheries, and Lagoon Park staffs, then all interviewees were asked to recommend others to interview, in what is termed a snowball sampling approach [28]. The interviews were focused on engaging key members of the fishing sector and those whose views politicians were most keen to hear from, including those expected to be most strongly in opposition. The survey included questions about fishing habits, how ecosystems and catches are changing, and support for current and potential management measures.

For lobster, conch, and fish, a majority of fishers reported (a) catching less or much less, and catching smaller individuals; (b) having to go further, and into deeper waters for their catches; and (c) a perceived overall decline in abundance (Table 1). Those who perceived a decline were asked about suspected causes, and the most common responses were overfishing (by Antiguans, foreigners, and Barbudans), catch of juveniles and of pom (i.e., gravid) lobsters, and loss or degradation of habitat (Fig. 2). Tourism and coastal development were the least common responses, which was logical given the minimal number of visitors and small footprint of those buildings and infrastructure. Pollution was also not a concern, which is in accord with the ecological assessment finding excellent water quality [20]. Notably, few respondents considered taxa declines to be due to the "will of God," indicating that changes in resource management would be expected to

Table 1

Responses from fifty current and former fishers on Barbuda to interview questions posed in April and May 2013 about changes in lobster, conch, and fish populations around the island.

Questions	Answers	% of interviewees		
		Lobster	Conch	Fish
Compared to what you used to catch when you started fishing, do you now catch much more, more, less, much less, or the same on a normal day of fishing?	much more	0	4	0
	more	6	16	2
	less	40	24	30
	much less	34	29	44
	same	14	27	14
	don't know	2	0	2
	no answer	4	0	8
Compared to what you used to catch when you started fishing, do you now catch larger, smaller, or the same?	larger	2	0	0
	smaller	52	54	54
	same	38	38	36
	no answer	8	8	10
Do you have to go further from shore now to catch?	yes	76	62	64
	no	16	24	28
	don't know	0	2	6
	no answer	12	12	2
	Do you have to go deeper now to catch?	yes	70	58
no		22	28	30
don't know		2	2	10
no answer		6	12	0
Is the number in Barbuda's waters declining?		yes	96	74
	no	4	20	4
	don't know	0	4	8
	no answer	0	2	2

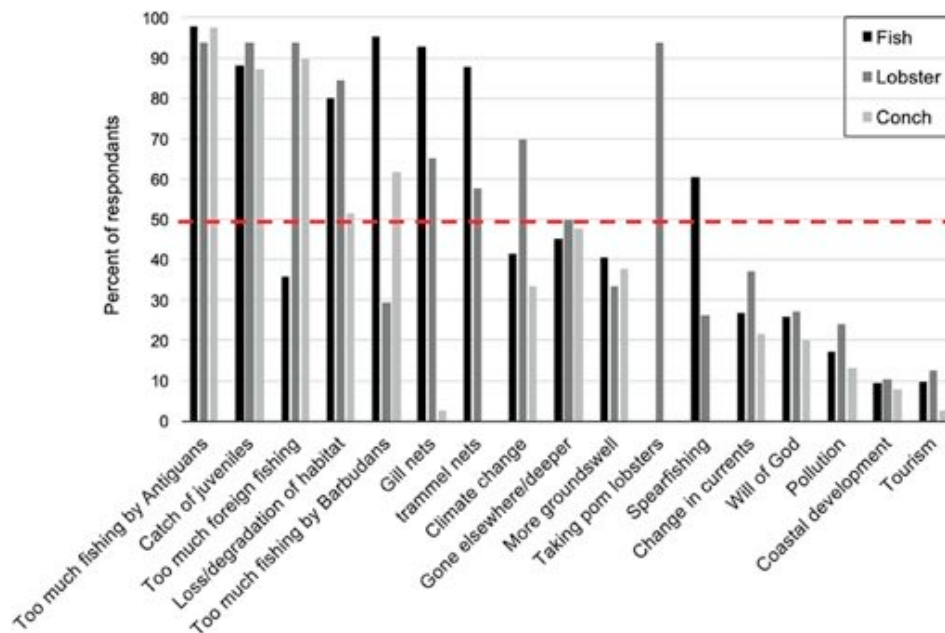


Fig. 2. The percentage of fishers who perceived each of these potential causes to be a reason for population decline of each taxa. Pom lobster is the local term for gravid female lobster.

Table 2 Support among interviewed fishers for potential management measures.

Management measure	% of fishers in support	
Ban	Using chemicals to fish	98
	Fishing during spawning	90
	Fishing with gill nets on reefs	86
	Catching juveniles	76
	Cutting down mangroves	62
Further control	Spearfishing	98
	Fishing with traps (by requiring escape gaps)	92
	Fishing with gill nets	70
	Fishing with traps	68
Protected Areas	Fishing for parrotfish	60
	Fish sanctuaries	98
	Temporary or permanent closure of lagoon	98

have an effect.

When asked about management measures, fishers expressed strong support (60–98%) for a range of options including banning unsustainable fishing practices (use of chemicals, catching spawning fish or juveniles, fishing with gill nets on the reefs, and cutting mangroves) and further controlling other fishing practices (spearfishing, use of gillnets and traps, and fishing for parrotfish, Table 2). While there was moderate support for further controlling trap fishing in general (68%), there was strong support (98%) specifically for requiring use of escape gaps that allow bycatch (i.e., juvenile and ornamental fish) to escape [29]. Most notably for informing zoning, 98% of respondents supported the creation of sanctuary zones closed to all fishing, and a temporary or permanent closure of the lagoon to fishing.

These results were presented to the Council and community, and fishers’ strong support for improving ocean management was critical to ensuring political will.

3.2. Community consultation meetings

To engage the broadest possible spectrum of stakeholders, the BHI team sought input on the design of ocean zones via six community

consultation meetings, five fisher consultation meetings, and two meetings of a stakeholder committee (which included Council-appointed representatives from fishing, enforcement, tourism, and transportation).

There were also opportunistic meetings specifically targeting fishers who did not attend scheduled meetings. This involved speaking with fishers at docks and on the side of the road to identify zoning options they would support.

In consultation meetings, stakeholders were (1) informed about the goals and process of the Blue Halo Initiative, (2) provided with summary information on key fishing areas, areas of cultural use, spawning areas, and areas of illegal fishing, (3) offered technical support to sketch and evaluate prospective zoning plans, (4) provided information on complementary regulatory proposals for fishing restrictions and species protections, and (5) encouraged to discuss and debate the relative merits of alternative plans, restrictions and protections.

3.3. Use of media

To ensure the community was aware of and could access the draft zoning maps, the maps were posted in prominent public places, in the local newspaper, and online. New drafts were also announced on the radio and via social media. Members of the BHI team were also regularly interviewed by the press. In addition, as approximately one-third of the population of Antigua and Barbuda had Facebook accounts, a Facebook page was created and advertised to residents of Antigua & Barbuda. All

Table 3 Thematic data layers in SeaSketch. Data, except those with privacy restrictions, may be viewed at <http://barbuda.seasketch.org>.

Theme	Layers	Examples
Base Layers	34	Study area boundary (territorial sea), nautical charts, aerial photos, coastline, roads, and place names.
Surveys	36	Seafloor habitats (Fig. 3), Fishing hotspots (Fig. 4), boat storage locations, species reproduction areas, boating areas, size and abundance of conch, fish, lobster and key benthic species.
Formal Proposals	6	4 full zoning proposals (Fig. 5), and 2 partial proposals

project updates and draft maps were posted on Facebook to ensure community members who did not attend meetings, as well as members of the diaspora, could stay informed.

Amidst these community consultations, there were twenty-two meetings of the Council where community feedback was discussed and (with technical support from the Waitt Institute) the Council iterated upon the map and regulatory initiatives. To maximize the likelihood of gathering fully representative feedback, this intensive engagement on potential zone designs and fishing regulations lasted for a year, from March 2013 to March 2014 (Fig. 1).

4. Key GIS data

In early 2013, all available geographic information system (GIS) layers were gathered from government sources. This included place names, administrative boundaries, and infrastructure locations. Initially, the database was only comprised of terrestrial data as no geospatial data existed for Barbuda's coastal waters. Over the course of three months, new data were collected that described the ecology, habitats, and fishing value of the waters around the island. These data were transformed into map layers (Table 3) and input into SeaSketch, a web-based platform for participatory mapping developed at the University of California Santa Barbara [30,31]. SeaSketch provided the publicly-available platform for visualizing maps, sketching and analyzing prospective zones, and collaboratively designing comprehensive zoning scenarios.

4.1. Ecological data

Prior to 2013, little ecological information had been published on Barbuda's marine ecosystems, though fishers reported during interviews that the reef ecosystems were dramatically degraded relative to their state a few decades prior. During twelve days in May 2013, a team of ten marine biologists conducted an ecological assessment of the marine resources around Barbuda in collaboration with local fishers and newly certified local SCUBA divers from Fisheries and the Lagoon Park. These new divers were certified by an instructor brought to the island by the Waitt Institute (there is no local dive shop or instructor) to ensure local officials would be able to participate in the research and observe data collection. The Waitt Institute also donated SCUBA, dive safety, and other equipment to ensure local staff would be able to continue monitoring efforts.

This was the first systematic marine assessment ever conducted in Barbuda's jurisdictional waters [20]. Data on lobster, conch, fish, corals, algae, and overall species diversity were collected at 234 sites around the island and in Codrington Lagoon. Water samples were also collected to assess water quality. All data were georeferenced and loaded into SeaSketch, so they were available to inform the zoning process. This data was intended to provide a baseline against which to assess the effects of the new regulations. A subsequent comprehensive ecological survey has not yet been conducted.

4.2. Habitat data

A seafloor habitat model was derived from Ikonos-2 satellite imagery collected in 2012, with a per-pixel spatial resolution of 4 by 4 m. Seafloor habitats were classified using Definiens eCognition software, which allows spectral, textural, edge-detection, and landscape properties of seafloor features to be applied in a classification workflow. This enabled the classification of seafloor habitats in waters up to 30 m depth, which includes approximately 90% of Barbuda's coastal waters (Fig. 3).⁶ Ultimately, habitat was classified into six types: sand, seagrass, patch

⁶ A more detailed description of the classification process is available at <http://bit.ly/BarbudaHabitatMetadata>.

reef, continuous reef, and hard-bottom (Sam Purkis, pers comm.), with the rest categorized as deep water. This map was ground-truthed by the scientific divers, and refined to more accurately reflect habitat boundaries.

4.3. Fishing data

A map of fishing area value (Fig. 4) was developed using a methodology derived from Scholz et al. that was developed for marine protected area planning in California's Marine Life Protection Act Initiative [32]. Over a four-month period in 2013, AEJ interviewed thirty-one individuals (the majority of active fishers) and collected data in SeaSketch on (a) where in Barbuda's waters they fish, and (b) the relative value (i.e., importance to them) of each fishing area. To quantify relative importance, fishers were asked, out of a total of 100 points, how many they would assign to each area they had identified as important for their fishing.

From these responses, the BHI team developed a spatial access priority (SAP) map [33] of Barbuda's coastal ocean by dividing the importance assigned to a fishing area by its size. The values for overlapping priority areas were summed to produce a cumulative SAP/km². Therefore, small areas of high importance received a higher value than large areas of low importance, and areas that were important for multiple fishers received a high value.

Fishers were also asked to identify spawning areas, areas where illegal fishing⁷ was common, and any areas of important cultural use (e.g., traditional community fishing locations). To maximize participation and promote candor from fishers, all individual contributions in SeaSketch were kept confidential and only the summary data product (i.e., the heatmaps, Fig. 4) was shared publicly – first among the fishing community, and then with the Council and the general public. Fishers indicated the summary heatmap matched their understanding of the distribution of fishing value. These data were critical for ensuring fishers were not unduly impacted by new zones.

5. Legal context

To ensure the outcome of the planning process could become law, the initiative incorporated legal analysis from an early stage. The Environmental Law Institute conducted a legal framework assessment as an initial step in this process, which was completed and made public in March 2013 [34]. Key issues addressed in the assessment included how Barbuda's legal system operates in the context of the national laws of the twin island state of Antigua and Barbuda and, given that context, how the Barbuda Council could implement the zones developed through the planning process. This required understanding whether and how the Council could use its existing legal authority to protect key habitats and species and to sustainably manage fishing in Barbuda's coastal waters. The assessment identified regulatory options for managing fisheries, coastal zoning, and national parks.

The Council's local government authority is enshrined in the Constitution of Antigua and Barbuda and associated legislation. However, its powers are limited to those set out in relevant legislation, and its regulations cannot contradict national laws and regulations. These constraints affected the regulatory options available to the Council, and the regulations ultimately adopted were carefully designed to fall within the Council's powers, to avoid preemption issues arising under national law. For example, the regulations do not differentiate between Antiguan and Barbudan fishermen, instead allowing any fisherman with appropriate permits from the national government to fish in Barbuda after

⁷ Fishers in Barbuda often consider any fishing by non-Barbudans in Barbuda's waters to be illegal. While fishing by foreign vessels is illegal, fishing in these areas by Antiguan vessels was in fact legal and there was no separate Barbuda registration requirement prior to this initiative.

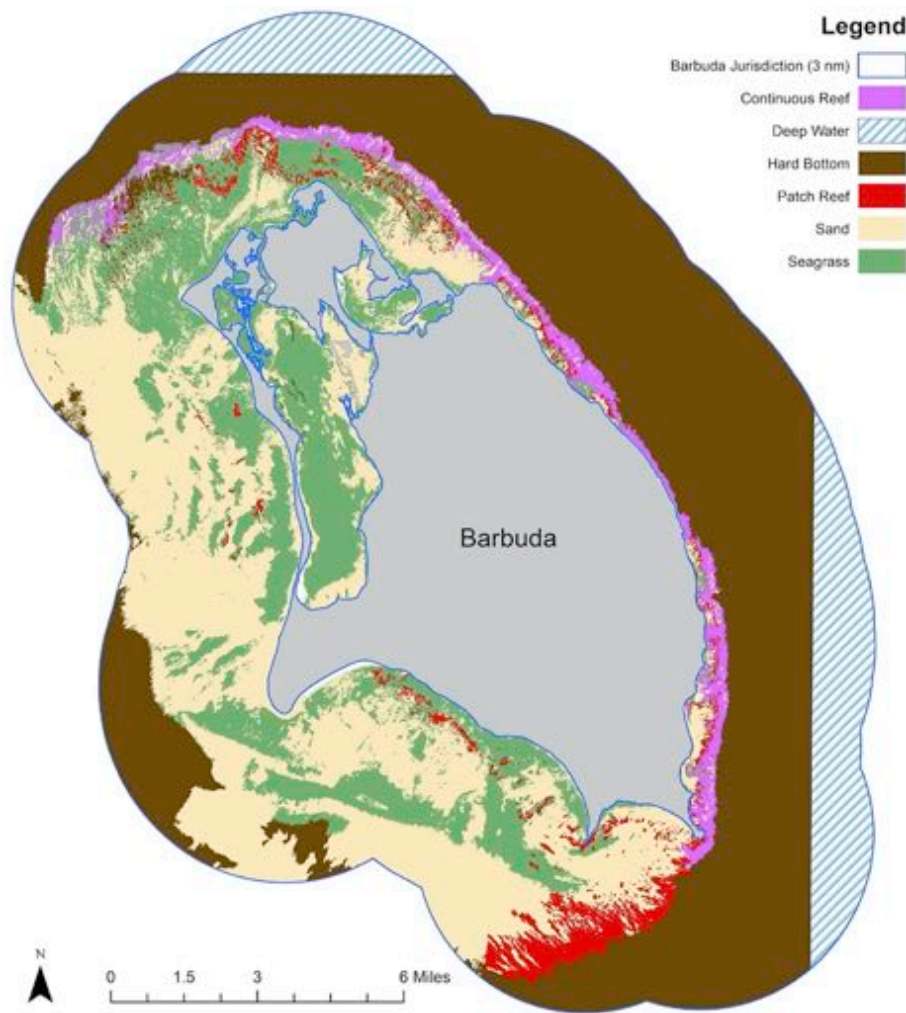


Fig. 3. Habitat map for Barbuda seafloor derived from an IKONOS-2 satellite image.

registering with the Council. In other respects, drafters discovered existing authorities in national legislation that had not been implemented to date by the Council – notably, the National Parks Act authorized the creation of a National Parks Authority for Barbuda, but the Authority had never been established. By issuing regulations to implement existing authorities, the Council was able to accomplish its desired regulatory goals without needing to seek legal change at the national level.

During the legal assessment, and throughout the period of legal drafting and review, there was direct engagement and collaboration among Environmental Law Institute and Waitt Institute staff, the Council, the people of Barbuda, and the Antigua and Barbuda national government (specifically the Office of the Attorney General, Department of Environment, and Fisheries Division). This collaboration included regular meetings with agency staff, the public, and the Council to share ideas and drafts and to identify acceptable language for regulations. These efforts substantially improved early drafts, for example by identifying existing laws with accepted model language authorizing non-judicial enforcement mechanisms. Deep and regular engagement by legal staff throughout the process thus enabled development of regulations specifically tailored to the context and needs of Barbuda.

6. Zone types

Within the framework of the planning principles and zoning guidelines (see Section 2), a variety of zone types were proposed throughout

the MSP process. Only one type of zone, sanctuaries, was predefined as essential; all other types were proposed by stakeholders. Zone types included in the final map and regulations were:

- **Sanctuaries:** All fishing is prohibited, except “(a) when conducting scientific research with the express permission of the Council; or (b) when participating in a Council-sanctioned event intended to control invasive alien species” (e.g., lionfish tournaments). These no-take zones were designed to protect habitat, restore biomass of marine life, and improve fisheries in neighboring areas by way of adult spillover and export of eggs and larvae.
- **No-net zones:** All use of nets is prohibited. These zones were designed to protect reefs from over-exploitation and damage from net-fishing, and to prevent conflict with boat traffic.
- **Anchoring and mooring zones:** Boats are permitted to anchor or moor only in these areas, except “(a) when fishing with a valid Barbuda Special Area Permit; (b) when diving; or (c) as necessary for safeguarding life and property at sea.” These zones were designed to constrict impacts of anchoring and mooring to sandy habitats, and create the legal framework for collecting fees from visiting boats.
- **Shipping zone:** It is prohibited to “anchor or moor a vessel, fish, dive or swim in a shipping area except (a) anchoring or mooring when actively loading or unloading cargo or stores or embarking or debarking passengers; (b) mooring when using a dock in the area; or (c) with the prior written permission of the Council.” This zone was

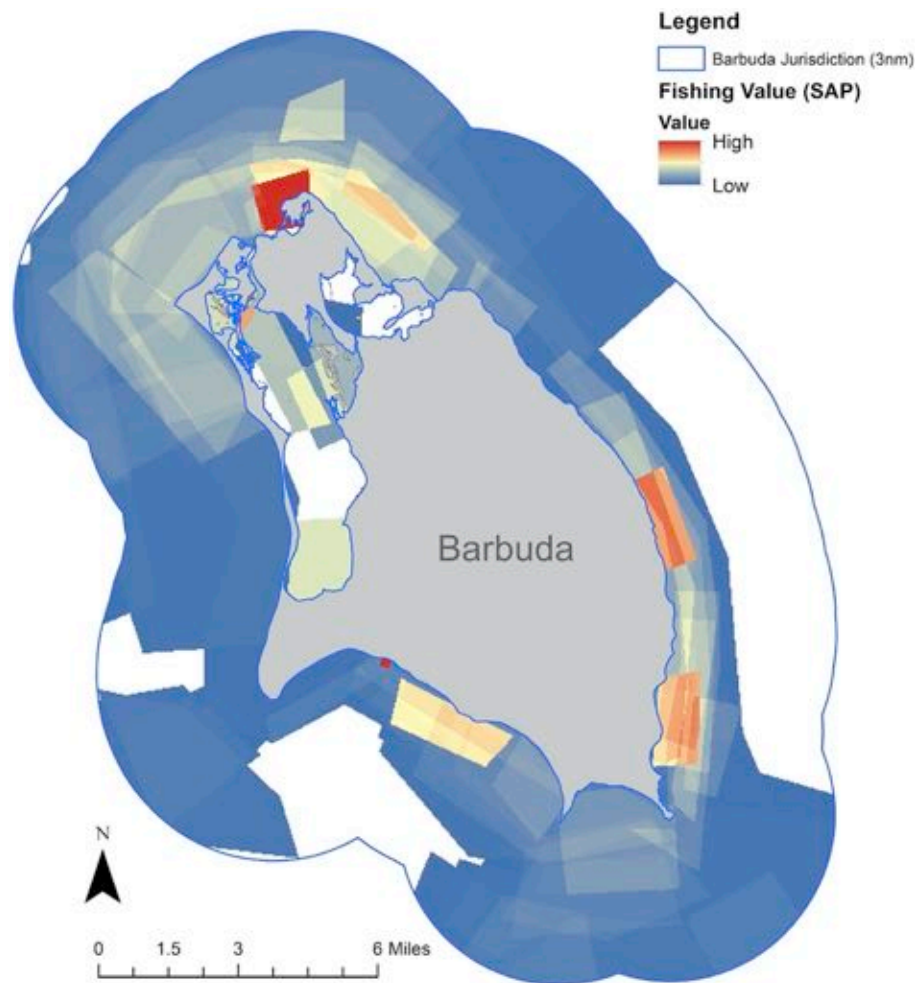


Fig. 4. Heatmap of fishing value in Barbuda's coastal waters, developed with data from fisher interviews and calculated as spatial access priority (SAP) per km².

designed to reduce conflict between vessel traffic and other ocean uses and ensure safety, particularly around River Dock.

Other types of zones stakeholders considered, but ultimately did not use, included fishing priority zones and tourism zones.

7. Map iterations

There were three draft zoning maps released for community consultation, starting in August 2013, before the map was finalized in August 2014 (Fig. 5). All proposed zones were designed by stakeholders and the Barbuda Council, and recorded, along with key comments, in SeaSketch by SeaSketch and Waitt Institute staff (Fig. 6, Appendix A).

In meetings, SeaSketch was used to give real-time feedback on prospective zones, answering a wide array of questions, such as: How will this affect fisher's preferred fishing areas? If we change this zone boundary will there still be enough coral reef protected? Where are the important nursery habitats? What would be the best place to install moorings? The data and analytical reports in SeaSketch enabled discussions of potential zoning plans to be concrete instead of speculative, with real-time feedback on proposals. If the analytics could not address the concerns raised, stakeholder comments were recorded in map-based forums accessible to Council members.

Draft A: Based on key map data layers (base maps, fishing heatmap, habitats), the approved planning principles and zoning guidelines, and intuition about what their constituents might support, the Council created an initial draft zoning plan (Fig. 5a). This draft was released for

public comment in August 2013 (see process described in section 3), and geographically-specific critiques from stakeholders were recorded in SeaSketch forums (Fig. 6). This first draft contained only sanctuary zones. The lagoon was included as a sanctuary zone because it is an important nursery habitat for lobster and reef fish.

Draft B: Based on consultations with stakeholders and scientific experts, the Council released a second draft map in October 2013 that included radically altered sanctuary zones and the addition of anchoring and mooring zones (Fig. 5b). The following changes were made to sanctuary zones: (a) two prospective sanctuary zones on the east coast were merged into one, so fishermen would have larger continuous areas for fishing; (b) boundaries of other reserves were shifted to keep a larger portion of preferred hard-bottom habitat (ideal for lobster) open to fishing; and (c) the bay at the southern tip of the island was excluded from the Palastar Reef Sanctuary zone because it is a culturally-significant fishing area where community members conduct subsistence fishing while camping. The anchoring and mooring zones were designed to ensure boats only anchored in sandy habitats and were sited in locations already most frequently used by visiting boats. The Council's goal for this zone type was to formalize the existing preferred areas and facilitate the collection of fees.

Draft C: Based upon additional stakeholder input, the Council developed the third draft zoning map in December 2013 (Fig. 5c), which, at the request of fishers, included (a) the addition of a no-net zone that encompassed all the coral reefs with a 20 m buffer around them, to protect reefs from damage caused by use of nets; and (b) the creation of an additional sanctuary zone in Goat Island Flash, a key

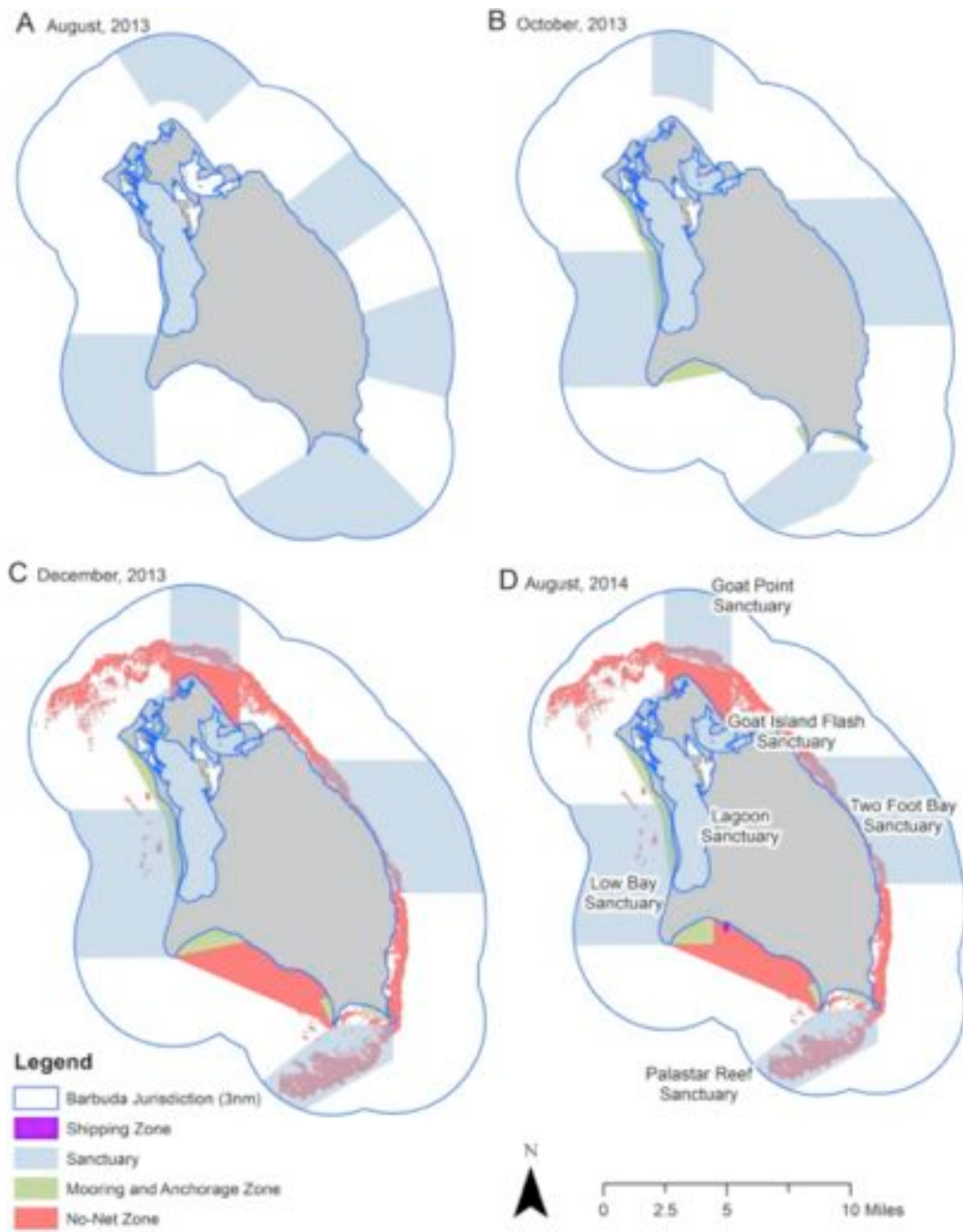


Fig. 5. Draft zoning proposals (A–C) and the final zoning map (D), all designed based on stakeholder consultations, scientific data, and Barbuda Council decisions between August 2013 to August 2014.

nursery habitat. Also, the boundaries of two sanctuaries were straightened to ease compliance with and enforcement of those zones.

Draft D: The final, August 2014, version (Fig. 5d) included minor adjustments to the shapes of the anchoring and mooring zone boundaries and the addition of a shipping zone. The shipping zone was created to ensure boats were given priority in the area around the island main dock, and fishing and swimming are prohibited in that area. The national Palastar Marine Reserve is fully included within the bounds of the

new Palastar Reef Sanctuary.

Overall, the most contentious zone was the lagoon sanctuary, where there is a long history of subsistence fishing and thus strong resistance to permanent closure. Ultimately, the fishers and Council agreed upon a two-year closure, with re-opening to be based on scientific evidence of ecological recovery and establishment of a management plan. Fishing also remains allowed in the flashes (shallow areas at the northeast and northwest edges of the lagoon), as does hook-and-line fishing from

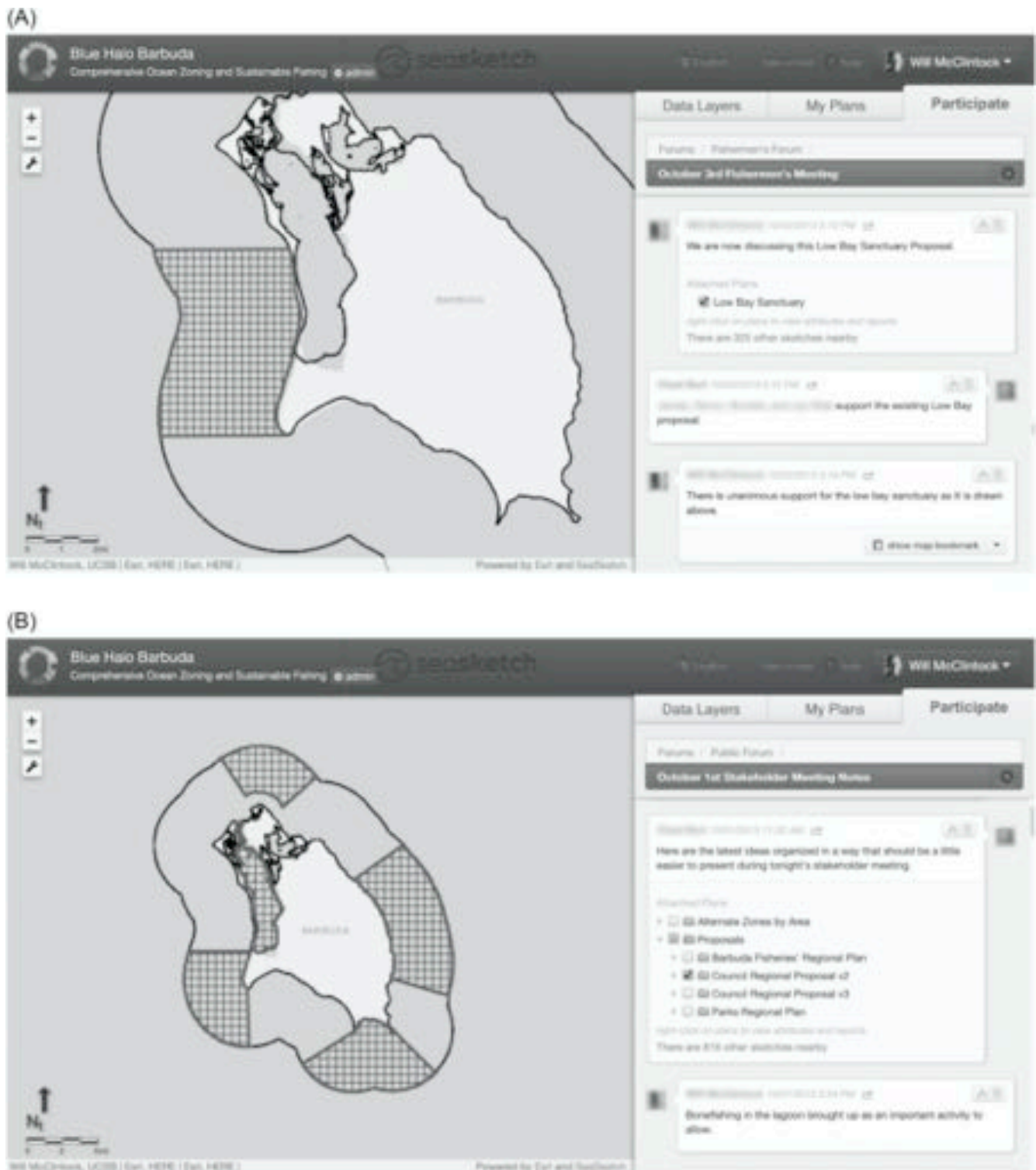


Fig. 6. SeaSketch as it was presented during (a) a meeting with approximately 20 fishermen (comments may be read in full at <http://bit.ly/SeaSketchBarbudaFishers>), and (b) a public consultation meeting with a group of community members (<http://bit.ly/SeasketchBarbudaCommunity>). Two facilitators recorded stakeholder input regarding zoning options.

shore, both important cultural uses. Catch-and-release fishing also remains permitted in the lagoon to enable the development of a tourist sportfishing industry.

Each of the draft zoning maps met, or nearly met, the zoning guidelines while accommodating a large number of stakeholder preferences. A total of 582 zone shapes were drafted and 417 comments were collected. Among the draft zones not included in the final map was

an extension of the Palastar Reef Sanctuary to include an area the scientific assessment had determined to be a nursery habitat for conch. While the Council considered all input, not all stakeholder preferences could be accommodated because some conflicted with each other or would have required abandoning the guidelines.

Table 4

The types and number of zones, their size, and percentage of coastal waters covered by each in Barbuda.

Zone Type	# Zones	Total Zone Area (km ²)	% of Barbuda's waters
Coastal Sanctuary	5	139.1	33
Lagoon Sanctuary	1	24.6	5 (86% of Codrington Lagoon)
No-net	3	70	16
Anchoring and mooring	4	9.3	2
Shipping	1	0.16	<0.5
<i>Totals</i>	14	243.16	56.5

Table 5

Habitats captured within each zone type, as a percent of Barbuda's waters. Note that the shipping lane, not listed here, covers less than 0.05% of each habitat, and the Codrington Lagoon is included with the sanctuaries.

Habitat	% in Sanctuaries (including lagoon)	% in No-Net Zones	% in Anchoring and Mooring Zones
Continuous Reef	32.7	100	0
Deep Water	36.4	0	0
Hard Bottom	31.5	1.3	0
Patch Reef	59.3	100	0
Sand	39.8	15.2	3.2
Seagrass	35.5	23.7	5.6

Table 6

Summary of initial recommendations presented by the Waitt Institute and final regulations as adopted by the Barbuda Council.

Initial policy recommendations	Regulations signed into law
Ban catch of all key herbivores	Ban catch of parrotfish and urchins (but not doctorfish)
Shark ban or permits	Allow traditional, local consumption of sharks; prohibit all export of sharks or their fins
Ban use of nets	Ban nets on or within 20 m of reefs
Ban artificial reefs	Require permit for use of artificial reefs
Permanently close Codrington Lagoon to fishing	Closed for 2 years, line fishing from shore and catch-and release allowed
Prohibit all mangrove damage	Require permit for any damage of mangroves or seagrasses
Ban Fish Aggregating Devices (FADs)	Regulated under national law; no new local regulations
Establish a Coastal Management Committee	<i>(recommendation accepted)</i>
Require Barbuda Fishing Permit	<i>(recommendation accepted)</i>
Require use of escape gaps in fish pots	<i>(recommendation accepted)</i>
No fishing on spawning aggregations	<i>(recommendation accepted)</i>
Establish Fisheries and Park Funds	<i>(recommendation accepted)</i>

8. Policy outcomes

Upon finalization of the ocean zones and regulatory texts, the Barbuda Council adopted three sets of regulations to (a) create the coastal zones, (b) reform fisheries in coastal waters, and (c) establish a National Parks Authority for Barbuda.⁸

The Council signed into law the comprehensive zoning regulations in August 2014 as "The Barbuda (Coastal Zoning and Management) Regulations" [21]. The regulations include and legally codify the final zoning map (Fig. 5d), which represents a balance between community preferences, scientific guidelines, and legal constraints. The map reflects the key stakeholder priorities: (a) ensuring that several culturally and economically important areas remained open to fishing, (b) limiting damaging types of fishing, and (c) creating anchoring/mooring zones to limit where anchoring occurs and create a framework for charging fees. The final zoning plan includes a total of fourteen zones, collectively

establishing specific restrictions for 243.16 km², or 56.5%, of Barbuda's waters, and designating 33% of waters as protected in sanctuaries (Table 4).

The goal of protecting one-third of each key habitat in sanctuaries was met or exceeded for seagrass, sand, patch reef, and deep water, and effectively met for continuous reef and hard-bottom (Table 5). The no-net zones covered 100% of the continuous reef and patch reef, while incidentally (within the 20 m buffer around the reef) covering a small portion of sand, seagrass, and hard-bottom habitats. The regulations restricted anchoring and mooring zones to small areas of mostly sand and some seagrass and completely avoided coral reef habitats. A total of 31% of the fishing value was displaced by sanctuaries. An additional 38% was partially displaced by no-net zones. The small shipping area covered less than 2% of the valued fishing areas.

The zoning regulations also include measures that apply to the entire waters under the Council's jurisdiction. Most notably, (1) all seagrasses and mangroves are now designated as protected, unless a special permit is granted for their removal; (2) a system is established to charge fees and fines for various ocean uses and violations; and (3) a system is established to hold liable for costs and damages anyone who harms

⁸ This authority for a National Parks Authority for Barbuda was repealed with the repeal of the Barbuda Lands Act in 2018.

marine natural resources.

Overall, the zoning regulations were designed to be the foundation of an adaptive approach to management, so they include the possibility of changing zone boundaries, adding new zones, and changing fees and fines via a notice in the national *Gazette* (legal publication), which is less onerous than passing a regulatory amendment. For example, if new ocean uses arise and require zones or fees (e.g., aquaculture, wind energy) those can be added. If new scientific research reveals an important nursery habitat to protect, sanctuary boundaries can be adjusted.

Concurrent with the zoning regulations, the Council signed “The Barbuda (Fisheries) Regulations” and “The Barbuda (National Parks Authority) (Establishment) Regulations” to ensure that in addition to specific zones, there is a robust legal framework for sustainable use and conservation of coastal resources [18,19]. The park regulations set up the composition and process for an Authority which became the legal management entity on Barbuda under the National Parks Act, and gave its officers enforcement authority inside Codrington Lagoon National Park. This was not initially envisioned as part of the initiative, but was identified during the MSP process as necessary to establish authority for implementation.

The new fishing regulations are additive to the national fisheries regulations, which still apply. The Barbuda regulations provide additional restrictions on fishing in Barbuda’s coastal waters and tools for local management and enforcement of fisheries. Management measures include (a) establishing a Barbuda fishing registration system to serve as a foundation for local management and to constrain illegal fishing; (b) fully protecting parrotfish and urchins (key herbivores needed to control algal overgrowth); (c) limiting capture of sharks to local consumption (no export of sharks or shark fins); (d) requiring use of escape gaps in fish traps [29]; (e) potential to protect spawning aggregations; and (f) setting up a permitting framework for artificial reefs [18]. These fishing regulations evolved from initial recommendations presented by the Waitt Institute (Table 6). Five of the recommendations were fully accepted and seven were altered based on stakeholder feedback, further exemplifying the extent to which community concerns were heeded by the Council, while key conservation and sustainability issues were still addressed.

To ensure that stakeholder engagement is built into local marine resource management in the long term, beyond the extensive input into regulatory development, the fisheries regulations establish a seven-member Barbuda Coastal Management Advisory Committee. The Committee has seats for representatives from the Council, fisheries, parks, fishing, conservation, tourism, and Coast Guard. Although the Committee has no regulatory authority, it has a broad advisory mandate.

9. Implementation

Following passage of the regulations, the initiative has turned to implementation, which includes outreach and education, capacity-building, science and monitoring, and enforcement. The focus has been on maximizing compliance, by ensuring all parties are fully informed about the regulations and the ramifications of breaking them. To this end, the first steps were (a) erecting signs with zone maps and a list of the regulations in the center of town, at the Fisheries building, outside the Barbuda Council Hall, and at the main port; (b) installing buoys and shore-based markers to delineate coastal zones⁹; (c) holding community meetings; and (d) making announcements via newspapers and radio in Antigua, local outlets in Barbuda, and Facebook posts.

To build local capacity, a core aim of the initiative, training has been provided in enforcement, boat operations and safety, ecological and fisheries monitoring, and fisheries market development. In some instances, trainers visited Barbuda to work with key management

⁹ Hurricane Irma destroyed almost all of the buoys and shore-based markers. The BHI team plans to only install shore-based markers in the future, and in the long-term focus on shore-based notices and electronic marking.

authorities. In other instances, the Waitt Institute funded individuals to attend various meetings and events. Additionally, the Institute donated a boat, uniforms, and other key equipment for monitoring and enforcement.

The first training was a legal workshop, to ensure all enforcement and fisheries staff understood the new rules. Notably, this was the first time representatives from Fisheries, National Park, Police, and Coast Guard had ever gathered to discuss collaborative enforcement efforts. Another early implementation step was the Barbuda Fisheries Division registering fishers. This ensured that fishers were licensed at both the national and local levels, as required by the new regulations, and provided a chance to ensure they understood the details of the new regulations. Also, to bolster compliance in addition to focusing on enforcement, each fisher was given a waterproof card printed with the zoning maps and regulations, and a gauge for measuring the legal size of conch and lobster.

To-date, scientific monitoring has included documentation of lobster landings, establishment of Global Coral Reef Monitoring Network sites for long-term monitoring, surveying sea turtle nesting sites, conducting shark surveys, and researching lobster population genetics. Finfish landing monitoring efforts have been patchy thus far due to understaffing and inconsistent landings.

Community engagement to enhance stewardship of ocean resources includes the annual Blue Halo Ocean Summer Camp for kids, held in partnership with Montserrat-based Fish ‘N Fins, Barbuda teachers, and the Barbuda Fisheries Division, and sponsored by Waitt Institute. There are also periodic beach cleanups and lionfish tournaments, and a new partnership with the SEA Semester program, which brings a tall ship to Barbuda to work with students to conduct ecological surveys in Barbuda’s waters.

Not all implementation efforts have succeeded. According to Barbuda Fisheries officers, some enforcement action has taken place, though the extent of enforcement has not been researched. Despite substantial efforts, a new law that would increase enforcement penalties and create a special fund for coastal management has yet to be enacted. The Council continues to struggle with enforcement and compliance, though prior to Hurricane Irma, the Barbuda Fisheries Division and police had an effective enforcement collaboration. Anecdotal evidence indicates that illegal fishing increased post-hurricane, though these claims have not been researched. Another major challenge has been standing up the advisory committees as laid out in the regulations.

Overarching in all of these implementation challenges is the impact from Hurricane Irma. In September 2017, Hurricane Irma hit Barbuda as a Category 5 + storm. Its impacts are profound and have substantially affected the community and ecosystem. That said, efforts of the initiative are ongoing, indicating the resilience of the partnership and community.

10. Lessons learned

10.1. Have a plan. Be ready to abandon the plan

A process this multifaceted requires extensive planning and preparation [21]. The up-front investments by the Waitt Institute in developing a framework and process provided critical structure, but that structure needed to be highly flexible. The planning principles and zoning guidelines proved useful and were adhered to, likely because they weren’t overly prescriptive or constraining. Many different zoning configurations would have met the guidelines; local priorities and preferences were readily accommodated.

10.2. Being comprehensive leads to greater support for conservation

Stakeholders appeared to be more open to the establishment of sanctuaries because they were being considered in the context of a larger zoning plan. Zoning enables people to consider the tradeoffs between

various uses, including but not limited to conservation [35]. Alternatively, initiatives focused exclusively on establishing zones closed to fishing can engender strong opposition because they are perceived as focusing exclusively on stopping stakeholders from accessing the resources on which their livelihoods depend. In this case, fish sanctuaries were combined with other reforms beneficial to the fishing community, notably including efforts to address illegal fishing through augmented fisheries regulations and enforcement capacity.

10.3. Documenting stakeholder and expert views builds political will

It was invaluable to have survey results of community perspectives and to have a record of who said what about proposed zoning plans. This information was presented to politicians so they could understand why stakeholders were proposing or opposing various zone boundaries. Understanding constituents' preferences built political will through providing political cover, as majority opinion strongly supported key conservation measures.

10.4. Good data are critical, but some data are more useful than others

Being able to ground discussion in facts was essential. However, while it is tempting to gather as much data as possible, only five of the seventy-six GIS data layers that were collected ended up being central to decision making:

- A. map of coastal habitats (to determine how to achieve the guideline to protect one-third of each type),
- B. high-resolution satellite image (to see terrestrial and marine landmarks),
- C. place names (to orient stakeholders),
- D. heatmap of fishing value (to calculate potential displacement from valuable locations), and
- E. zoning region boundary (in this case, the Council's jurisdiction extends one league from shore).

For similar future efforts, it could be useful to have more data on spawning and nursery areas. Ability to model fisheries impacts (e.g., Rassweiler et al. [36]) and enforceability could also be highly informative.

10.5. Provide accessible and transparent tools

Most stakeholders engaged with SeaSketch by way of Waitt Institute or SeaSketch staff acting as "chauffeurs." Although SeaSketch was publicly web-accessible, only rarely did stakeholders use SeaSketch independently, perhaps in part because of lack of familiarity with mapping software, internet availability, and the expense of pay-by-data internet. Therefore, BHI team members held "office hours" at the Fisheries building, and staff also went door-to-door with wireless hotspots to gather input. Nonetheless, making all data, designs, and analytics publicly available sent the important message of transparency. Stakeholders and members of the public *could have* accessed any of this information via the web even when project staff were not on the island. (And, in fact, they still can at <http://barbuda.seasketch.org>). Of note, the technology does not make paper maps obsolete; they are complementary. Paper maps on bulletin boards or spread on the table instigated interaction and conversation in ways technology did not.

10.6. Informal public-private partnerships can be effective

This zoning effort was effective in large part because a private foundation provided support to an under-resourced government interested in improving ocean management via a comprehensive, science-based, and community-driven approach. The Council saw the need and had the will, and the Waitt Institute provided resources and

technical expertise. While the two entities entered into a dialogue and exchanged letters of support to set the terms of their relationship, they did not enter into a contract or exchange money. In hindsight, signing a Memorandum of Understanding (MOU) up front would have been useful to formalize roles and commitments, thus MOUs have been signed between the Waitt Institute and governments at subsequent Blue Halo Initiative sites.

10.7. People want things to be different, but they don't necessarily want to change their own behavior

Fishers keenly perceived their local ecosystems and catches as being in severe decline, and thus saw the need for better management. In theory, they supported the zoning effort and the creation of sanctuaries. However, when proposed zone boundaries would require them to change their fishing practices they objected, sometimes rebutting that they only wanted the restrictions to apply to foreign and non-resident fishers, who many blamed exclusively for stock declines. However, the year-long duration of public comment allowed time for them to come to terms with the necessary tradeoffs.

10.8. Traditions don't necessarily scale, but are sticky

Often, the argument for certain ocean uses is that is the way it has always been done. While preservation of traditional uses was prioritized in this process, fishing practices that may be sustainable on an island of 500 may not be sustainable with over 1,500 people and worsening climate change in a globalized economy. This can lead to difficult conversations and tradeoffs. For example, there is a tradition of catching juvenile lobster in the lagoon, which is not sustainable as more people rely on it. While the community recognizes that the lagoon is depleted and this activity was barred by the zoning regulations (and is a violation of national law), compliance has been difficult in practice, as it remains an important subsistence food source and fishing there is a long-standing cultural practice.

10.9. Be deliberate about seeking input from women in the community

While fishermen were the primary group extracting marine resources, and the Council and community were concerned about preserving their livelihoods, the entire island depends on a healthy ocean. Thus, stakeholder engagement efforts focused on fishers resulted in inadvertently neglecting to effectively engage the women of the island. Community consultation meetings were open to all, but given current patriarchal cultural dynamics, engagement would have needed to be much more deliberate about separately seeking input from women. Some very productive feedback and ideas were likely missed. Notably, women are shown to be more financially patient than men, a trait shown to be correlated with more support for long-term conservation, such as marine reserves [37,38]. Omitting deep engagement of women and matriarchs was a missed opportunity to engage natural allies of conservation.

10.10. Think about enforcement early and often

The initial plan was for a four-year partnership between the Council and Waitt Institute: two years for developing the regulations and two years to ramp up implementation. Without this up-front commitment to supporting the enforcement phase, the community may have been reluctant to engage. Stakeholders repeatedly voiced that they didn't want more rules on paper if there was no plan to see it through so that the benefits from all these measures actually came to fruition. The regulations were explicitly designed for ease of enforcement and to maximize compliance, including through a ticketing authority that avoids the need for a judge to rule on minor violations. In addition, the Waitt Institute brought in WildAid and Shah Selbe as contractors to help

consider enforcement options early in the process.

10.11. Early incorporation of legal analysis is critical

Successful development and adoption of the regulations required understanding the law as written, the law as implemented, and the political, social, and economic frameworks affecting legal development and implementation. Early integration of legal expertise was critical to inform zoning processes, identify policy options, and ensure that legal drafters built relationships and an on-the-ground understanding of the social, economic, and environmental conditions on Barbuda to provide context for their work. Engaging with government legal experts and personnel early and often was key to the success of the legal process – an important consideration in developing countries where legal expertise is scarce and valuable. Tailoring laws and regulations to the existing capacity, technical skills, and needs of the community was essential. Ensuring legal experts were regularly present on Barbuda enabled them to understand the local context and integrate the practical insights of community members into policy and regulatory development.

10.12. Make it fun

The project successfully built engagement and buy-in via social activities. Community activities from an art contest to design the initiative's logo, to a silly photo booth, to lionfish tournaments, beach cleanups, dance parties, the kids' steel drum band playing at events, and the now annual kids' ocean camp were all key elements. These aspects of engagement helped to build a sense of trust between the partners and to engage a broader swath of the community.

10.13. At some point you have to just call it good

The iterations can be infinite, and there is unlikely to be any plan that perfectly pleases everyone. In a context like this, the quest for complete consensus can be derailing [39]. There will always be a vocal minority, so political and social leaders must accept that and commit to implementing a plan that best meets the community's needs and has the potential to restore and sustain marine resources. Building in provisions for adaptive management, with set timelines for reconsideration, ensures it will be possible to make needed adjustments and also helped get over the hurdle of finalizing the map.

11. Conclusion

Accommodating the preferences of scores of stakeholders, balancing various ocean uses, ensuring science and data are the foundation of decision-making, and reflecting those choices in binding regulations is no small undertaking [40]. Barbuda's new regulations represent an enormous shift in management. For such an overhaul to be successful, it is critical to build stakeholder awareness, support, and (to the extent possible) consensus through a rigorous and robust engagement process. It is also key to foster and sustain local leadership if the zoning effort is going to have long-term success.

As the planning guidelines noted, it is important to “plan with the awareness that revisions and adjustments may be needed over time to maximize effectiveness.” Despite concerted efforts to leverage science and engage the community, these zones may need to be altered, for example in response to new scientific information, the development of new ocean uses, or the impacts of hurricanes. To that end, in order to facilitate adaptive management, the final zoning regulations include a clause that enables the Council to “amend the zones created in these Regulations or create additional types of zones and restrictions on activities in those zones to manage and accommodate other uses of Barbuda coastal waters.”

Two of the key pitfalls of ocean zoning in practice are that (1) it is often simply sectoral planning, focusing on enabling a single use, and (2)

the decision making process is top-down, with a disconnected stakeholder engagement process that does not actually have a strong influence on the zoning outcome [41,42]. The process in Barbuda was designed to minimize those pitfalls. While the community was most concerned with sustainable fishing, that was balanced with protected areas, tourism, and recreational uses. The process was primarily bottom-up, with the Council often accepting proposals from fishers and other community members – almost all zone boundaries were drawn by stakeholders – and seeking a final zoning design that could minimize negative impacts on livelihoods and have the broadest possible community support. The process also adhered to the steps for marine spatial planning recommended by UNESCO, with the exception of “mapping future demands for ocean space” (such as aquaculture or offshore wind) which the Council decided to omit for the time being [5].

Implementation and enforcement of these new zones ramped up slowly but is now underway and local officials appear committed to making it work. The impacts of Hurricane Irma are a major setback, but with a long-term commitment to this management framework, the ecosystem and economic benefits may soon begin to accrue. Following the successful planning and regulatory development in Barbuda, in February 2015 the Waitt Institute launched the Blue Halo Initiative on Montserrat and Curaçao in partnership with those island governments. The lessons learned in Barbuda and being learned in these other very different Caribbean socio-economic, ecological, and political contexts, can help inform ocean zoning efforts around the world.

Declaration of competing interest

AEJ and ST are former staff of the Waitt Institute, and KM and AE are current staff. WJM, KM, and RP were contracted by Waitt Institute to support the Barbuda Blue Halo Initiative.

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CRediT authorship contribution statement

Ayana Elizabeth Johnson: Conceptualization, Methodology, Investigation, Resources, Writing - original draft, Writing - review & editing, Supervision, Project administration, Funding acquisition. **William James McClintock:** Conceptualization, Methodology, Software, Validation, Formal analysis, Investigation, Resources, Data curation, Writing - original draft, Writing - review & editing, Visualization. **Ogden Burton:** Conceptualization, Writing - review & editing. **Wayde Burton:** Conceptualization, Writing - review & editing. **Andrew Estep:** Conceptualization, Investigation, Writing - review & editing, Project administration. **Kathryn Mengerink:** Conceptualization, Investigation, Writing - review & editing. **Read Porter:** Conceptualization, Investigation, Writing - review & editing. **Stephanie Tate:** Conceptualization, Investigation, Writing - review & editing, Project administration.

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Appendix A. Select quotes from stakeholders

- Fisher 1: "People must learn that they must participate if they want to be heard." <http://seasket.ch/O0w2o0HdwA>
- Fisher 2: "Not concerned about lack of continuous reef habitat if the alternate tTwo fFoot bBay zone is used and gGoat iIsland sSanctuary is left unaltered, because many of those areas are protected naturally by weather and other factors most of the year." <http://seasket.ch/ywflIMHdwQ>
- Fisher 3: "People coming in from outside to fish are the biggest problem." <http://seasket.ch/ywtyyxXt0A>
- Fisher 4: "The no-fishing zones would be difficult to implement. The bigger issue is size limits and enforcement. Goat Point Sanctuary seems like a good plan. Folks free dive there – it's a traditional place to fish." <http://seasket.ch/2w6EkhXZ0Q>
- Fisher 4: "The lagoon is an important nursery habitat. Even though this would eliminate the take of lobster from the lagoon, it is an important place to close. The flashes should be kept open because people only catch a handful of fish here." <http://seasket.ch/2Mlr6hXJ04>
- Stakeholder 1: "Prior to the Blue Halo project, in the prior decades, there have been fishing bans at certain times of the year, for certain fish and lobster ... Banning leads to increases. But, overtime, people overrule these bans and this is the reason why we have a current depletion in lobster, conch and fish ... we should adhere strongly to whatever ban is put in place." <http://seasket.ch/y05YJhrtw4>
- Fisheries staff 1: "There's good lobster in the tTwo fFoot bBay sSanctuary but not a lot of lobster fishing goes on there. It's OK to close this because it's important habitat but not fished a lot." <http://seasket.ch/2gRG30HJM4>
- Park staff 1: "I agree with the Council's proposal for the lagoon proposal. The fisheries division need to be aware of what's being taken from the flashes, the size being taken, etc. We just need to be clear about what can/can't be taken from the flashes." <http://seasket.ch/2MUhViXZ0A>
- Park staff 1: I support the fisheries proposal for tTwo Foot bBay sSanctuary. This will probably be met with objections from those that like to troll here. But this is a simple design that eases enforcement. There shouldn't be exception for trolling, however. The entire sanctuary should be a no-fishing zone." <http://seasket.ch/iMKvY6sFOQ>
- Scientist 1: "The Palmetto Point Sanctuary likely includes a significant amount of soft-bottom (sand and seagrass) habitat, which may be important for conch. As with other sanctuaries, including areas of conch spawning would be ideal, but we currently lack that information. Still, this sanctuary should protect some areas important for conch." <http://seasket.ch/201MamYpi4>
- Scientist 2: "I have some concerns about lack of protection in the area of Low Bay, up to Cedar Tree Point and around to Billy Point. That area contains both seagrasses and sandy areas as well as patch reefs

that harbor living coral and associated fishes. It appears that this area is where visiting vessels moor, so it could be very important for tourism (now and in the future). Protection of some (perhaps small) areas of patch reef could provide benefits to both species recovery and tourism." <http://seasket.ch/y0V8wKw-g3>

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