LETTER

Compromises between international habitat conservation guidelines and small-scale fisheries in Pacific island countries

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Abstract

Wallis, Alofi, and Futuna are three small islands in the central Pacific Ocean, characterized by different reef geomorphologies. Following a request from the local Environment Service, we developed an indicative conservation plan for each island with two objectives: (1) representing 20% of the extent of each coral reef habitat within no-take areas while (2) keeping all subsistence fishing grounds open for extraction. The first objective was more ambitious than the current Convention on Biological Diversity (Aichi) targets. We found that both objectives could not be achieved simultaneously and that large compromises are needed. Due to the small size of these islands, and the dependence of local communities on coral reef resources, the fishery objective significantly limited the extent of most habitats available for conservation. The problem is exacerbated if the conservation plan uses larger conservation units and more complex habitat typologies. Our results indicate that international conservation guidelines should be carefully adapted to small Pacific islands and that incentives to make feasible the necessary reductions in available fishing grounds will probably be needed.

Introduction

As a response to increasing global and local threats to marine and coastal ecosystems, a worldwide system of plans of action with ambitious conservation guidelines has been established by the international community (Butchart *et al*. 2010; Wabnitz *et al*. 2010). These guidelines typically target percentage representation of marine and coastal habitats within marine-protected areas (MPAs), involving various levels of restrictions on extractive uses within the seven International Union for Conservation of Nature (IUCN)-protected area management categories (IUCN 2008; WCPA). If reached successfully, these representation objectives are expected to help protect habitats, promote the viability of species, and ensure long-term and sustainable benefits to fisheries, thus sustaining economies and livelihoods as well as biodiversity.

In 2003, participants in the Cross-cutting Theme on Marine Issues at the 5th IUCN World Parks Congress in Durban, South Africa, called on the international community to include in networks of MPAs at least 20–30% of each marine habitat by 2012 (IUCN World Parks Congress 2005). Since then, targets such as these have been identified for countries or whole regions. Regional action plans target protection in no-take areas of at least 20% of habitats associated with coral reefs (Coral Triangle Initiative 2008), or effective conservation of at least 30% of near-shore marine resources by 2020 (The Micronesia Challenge 2006). The US national conservation strategy aims at protecting at least 20% of all coral reefs and associated habitats in each major island group and Florida (United States Coral Reef Task Force 2000). In Choiseul, in Solomon Islands, the local conservation strategy aims to protect 10% of the original extent of each terrestrial and marine ecosystem (Lipsett-Moore *et al*. 2010).

In 2010, based on the last meeting of the Conference of the Parties to the Convention on Biological Diversity in Nagoya, Japan, the previous 20–30% global targets were revised and the new objective is to protect "10% of coastal and marine areas [...] through [...] systems of protected areas and other effective area-based conservation measures" by 2020 (UNEP/CBD/COP/10/X/2 2010). Yet, there is increasing recognition that (1) percentages larger than 10% are likely needed in the longer term for effective conservation (Rodrigues & Gaston 2001; Svancara *et al*. 2005; Gaines *et al*. 2010), and (2) failing to frame targets in terms of individual habitats (e.g., rezoning of the Great Barrier Reef Marine Park, Fernandes *et al*. 2009) is likely to strongly bias conservation to habitats easiest to protect and perhaps least in need of protection, as demonstrated widely on land (Scott *et al*. 2001).

Although quantitative conservation objectives are a foundation of systematic conservation planning (Margules & Pressey 2000) and a common tool in policy, many conservation plans based on such targets are either infeasible or ineffective in the short term (Agardy *et al*. 2003; Mace *et al*. 2010; Wood 2011). Important reasons include limited funds, inadequate biological or socioeconomic data, and insufficient areas available for conservation. The question of the ecological relevance of targets and general conservation guidelines is being debated within the scientific community (Carwardine *et al*. 2009) but the difficulty of complying with these recommendations is not yet well-addressed.

How achievable are these global conservation objectives in regions such as in developing Pacific Islands, where people depend heavily on marine habitats and associated resources for day-to-day survival (Dalzell *et al*. 1996; Bell *et al*. 2009; Govan *et al*. 2009)? Because of their small sizes and the dependence of local communities on coastal resources, these countries might be unable to balance food security with the closure of near-shore fisheries for protection of habitats. Finding areas available for conservation that are not used for resource extraction can be difficult in these countries and, if fishing grounds are to be closed, there is often limited scope for compensating resource users or finding them alternative livelihoods (Govan *et al*. 2009). Consequently, tensions are likely in Pacific Island countries between resource users and proponents of conservation (Hviding 2006).

In this article, we demonstrate the conflict between conservation objectives based on the previous mid to upper range of international conservation guidelines and small-scale fisheries objectives for the three Pacific islands of Wallis, Alofi and Futuna, a French overseas territory where coral reef habitats are mainly exploited for subsistence. We focus on a conservation objective of 20% of each marine habitat for two reasons. First, we believe that the present 11th Aichi target (10%) will be seen as an underestimate of required protection of near-shore marine environments (Allison *et al*. 2003; Botsford *et al*. 2003). Second, we note that some jurisdictions have specified larger percentages (20–30, or even greater) of near-shore marine habitats to be protected (Airame *et al*. 2003; Fernandes *et al*. 2009; Mills *et al*. 2011). Specifically, we show the spatial extent of the trade-off between sets of objectives for conservation and fisheries. In this case, we considered the best protection option for marine habitats and associated resources (i.e., the implementation of no-take zones) and the best-case short-term scenario for fisheries (i.e., no restriction on take in current fishing grounds). Different sizes of potential no-take zones and different habitat data were tested to understand their influence on the trade-offs between conservation and fisheries objectives.

Materials and methods

Study sites and context

Wallis, Alofi, and Futuna are three Polynesian high islands belonging to the French Territory of Wallis and Futuna Islands, in the central South Pacific (Figures 1a and b). Both Wallis and Futuna, the largest islands, are inhabited. Alofi is uninhabited but used daily by Futuna habitants for agriculture, fishing, and leisure. The three islands vary in size and in habitat complexity.

Because tourism is not well developed, demand for reef fish is confined to local communities, who exploit the reefs and lagoons for their own subsistence. Almost a third of the population practises artisanal small-scale fishing in Wallis, Alofi and Futuna, mostly with nets and speargun (Egretaud *et al*. 2007a, b). Most catches are either eaten by the fishers themselves or exchanged or given away, with the remainder sold to buy fuel for fishing boats. The total lagoon fishery production, estimated at 200–300 tonnes per year (Kronen *et al*. 2008; Ministère de l'Outre-Mer 2011), is lower than the local demand, estimated at 900 tonnes per year (Egretaud *et al*. 2007b). This indicates that reduction in production resulting from marine conservation actions will be problematic.

Thus far, there are no MPAs in Wallis, Alofi, and Futuna that have been integrated into a territorial management plan (Verducci & Juncker 2007). However, three small informal customary MPAs have been established in Wallis, based on a ad hoc decisions between local fishermen, customary authorities, and the Territorial Environment Service (Egretaud *et al*. 2007b). Wide agreement among both the local communities and authorities to increase the protection of these islands' reefs and manage their resources led the local authorities

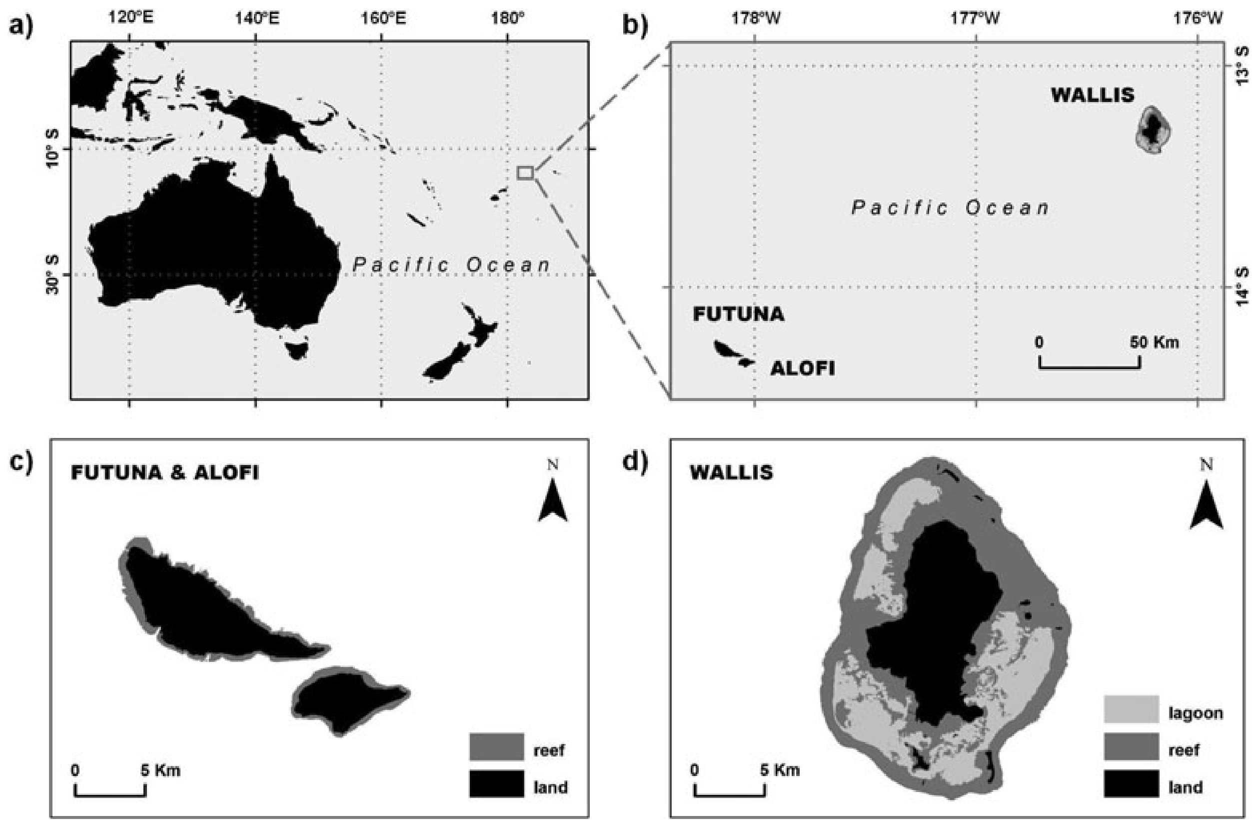

Figure 1 Location of Wallis, Alofi, and Futuna islands (a, b) and main reef features of Futuna and Alofi (c) and Wallis (d).

to launch a territorial Management Plan for Marine Areas (in French, *Plan de Gestion des Espaces Maritimes*). Based on France's national biodiversity strategy (Ministère de l'Écologie du Développement durable des Transports et du Logement 2011) which parallels the Aichi biodiversity targets (UNEP/CBD/COP/10/X/2 2010), the future territorial management plan for Wallis aims to move from the existing informal reserves to a new MPA network at the territory level.

Objectives for the indicative conservation plan for this study

An indicative conservation plan was set up for the three islands to reflect objectives of the Territorial Environment Service, with two sets of objectives based respectively on international habitat conservation guidelines and local fishery requirements. Wallis managers initially considered the guidelines of the previous 2002–2010 CBD Strategic Plan, which targeted a mid- to long-term protection of 20–30% of each habitat (IUCN World Parks Congress 2005). They also considered a network of no-take areas as the most efficient tool to provide rapid ecological benefits. Thus, for this study, the conservation objective was to include 20% of the total extent of each habitat within no-take areas: a more ambitious amount than the new CBD marine target (11th target in UNEP/CBD/COP/10/X/2 2010) and, unlike the CBD guidelines, not considering zonings that permit extractive uses.

Here, the fishery objective was intended to avoid conflicts with local communities highly dependent on reef habitats both culturally and economically. It prevented the main current fishing grounds for nets and spearguns from being identified as no-take areas. The data and analyses below allowed an assessment of the extent to which these potentially conflicting objectives can be reconciled.

Coral reef habitat maps

Two types of habitat maps with two levels of detail were used (see detailed methods in Andréfouët & Dirberg 2006). First, a high-resolution geomorphic habitat map (hereafter the "geomorphic" map) of the three islands was derived from the Millennium Coral Reef Mapping Project (Andréfouët *et al*. 2006). Millennium Coral Reef

Mapping Project maps were all created from Landsat 7 ETM+ satellite imagery at 30-m spatial resolution. Second, a very high-resolution detailed habitat map (hereafter the "geomorphic + benthic" map), combining geomorphic attributes and benthic data, was derived from digital aerial photographs at 2-m spatial resolution (see Andréfouët & Dirberg 2006; Andréfouët *et al*. 2007, and Dalleau *et al*. 2010 for more information on these maps). In Wallis, Alofi, and Futuna, geomorphic habitats were respectively described in 16, 4, and 3 thematic classes. The combination of data in the geomorphic + benthic maps allowed habitats to be described in 55, 6, and 3 thematic classes, respectively, excluding land features. To understand how map type would affect the feasibility of conservation and fishery objectives, all analyses were conducted for both habitat maps.

Fishing grounds data

In 2006, an environmental study was conducted in Wallis, Alofi, and Futuna to initiate the *Plan de Gestion des Espaces Maritimes* (Egretaud *et al*. 2007a, b). Socioeconomic and environmental data were collected to map the different uses of the marine environment and to understand the views and expectations of stakeholders in terms of management. The fishery geographic information system includes the boundaries of coral reef fishing grounds, itemized for different fishing gears and techniques (gleaning, line, speargun, net, and informal offshore fishing). For our analysis, we focused on net and speargun fisheries because they were the dominant gears. For Alofi and Futuna, only speargun data were available.

Conservation units

Each island of interest was partitioned into manageable conservation units by superimposing a grid of square cells on all areas containing coral reef habitats on the maps. To understand whether the size of conservation units would affect the feasibility of reconciling conservation and fishery objectives, all analyses were conducted for two different sizes of conservation units (500 × 500 m and 200 × 200 m, hereafter "large" and "small", respectively).

Reef area left available for conservation

The set of possible no-take areas or areas left for conservation considered in these analyses initially excluded all fished units. For each combination of island/habitat map/size of conservation unit, we first measured the proportion of conservation units available for conservation when all fishing areas were left open. Within all conservation units (fished, and unfished), we computed the number of habitats (excluding land features) and their extent, and the occurrence of net or speargun fishing. Then we measured the proportion of habitats that could potentially meet the 20% objective within unfished conservation units. All data were analysed using ESRI® ArcMap™ 10.0 and R (R Development Core Team 2008).

Trade-off between objectives for habitat conservation and small-scale fisheries

Conservation objectives were fully achieved when 100% of habitats could meet the 20% objective. Full achievement of the fishery objective meant that 100% of initial fished units were available for harvest. We measured the actual extent to which conservation objectives must be compromised to fully achieve the fishery objective, and vice versa. For this, we created trade-off curves with Marxan (Possingham *et al*. 2000; Ball *et al*. 2009), a software system for systematic conservation planning. Fished conservation units were attributed a cost of 1. Nonfished conservation units had zero cost.

We applied Marxan iteratively, starting with the set of unfished conservation units (full achievement of the fishing objective) and progressively increasing the percentage of fished conservation units to be considered as potential reserves (allowing increasing achievement of the habitat conservation objectives). To do this, we defined a series of increasing cost thresholds by the percentages of the total fished conservation units that could be moved to no-take zones: from 0 to 100% in 10% increments. For each of these 11 cost thresholds, 1,000 different sets of conservation units were selected to meet the objectives. Across these 1,000 repeat runs, we selected the best solution (with the lowest total cost) for each percentage threshold. For each threshold, we recorded the proportion of habitats that would meet their objectives in the best solution.

Results

Avoiding a priori any fishing ground in no-take areas had a large impact on the number of conservation units available for conservation, and on the extent of habitats that could be protected. At best, for both sizes of conservation units, about 60% of the potential conservation units would be left available in both Wallis and Futuna, and about 20% in Alofi (Figure 2). In these sets of available conservation units, a substantial proportion of the total number of habitats could not meet the 20% objective (unrepresented and under-represented habitats in Figure 3).

Figure 4 shows the spatial distribution of unrepresented and under-represented habitats. Figure 5 shows

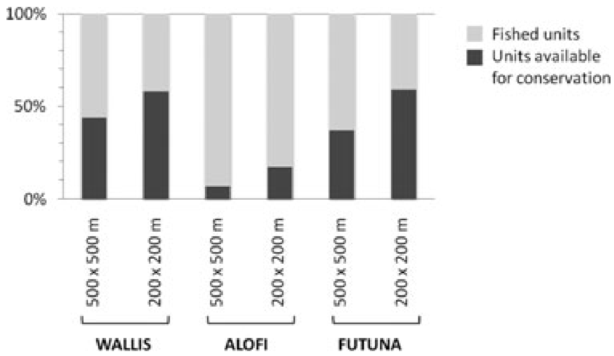

Figure 2 Percentages of large and small conservation units fished (with speargun and net) or available for habitat conservation in Wallis, Alofi, and Futuna.

the extent of each habitat left available for conservation (see Table 1 and Table 2 for lists of specific under-represented and unrepresented habitats types and percentage representation in unfished areas). Fringing reefs are of concern over the three islands. All geomorphic fringing reef classes (3/3 for either size of conservation unit; Table 1) and most geomorphic + benthic fringing reef classes (11/13 for smaller conservation units, 12/13 for larger ones; Table 2) could not meet their 20% objectives. In Wallis, barrier reef, and channel habitats would also be under-protected, especially when considering geomorphic + benthic habitats and larger conservation units (10/26 classes, against 5/26 for smaller units). In addition, none of the seagrass beds (4/4 geomorphic + benthic classes) would be represented in Wallis. Using smaller conservation units in Futuna would allow all three geomorphic + benthic habitats to meet their conservation objectives. Overall, conservation objectives cannot be fully achieved if all fishing grounds are avoided, except for Futuna when geomorphic habitats and smaller conservation units are considered.

The trade-off analyses showed that, if local communities harvested 100% of their fishing grounds (full achievement of the fishery objective), only 69% of all Wallis habitats and 75% of Alofi habitats, at best, can meet their conservation objectives (Figure 6). On the other hand, for all habitats to reach their objectives, at least 20% of fished conservation units must be made available for conservation in Wallis and Alofi. In general, geomorphic habitats could meet their conservation objectives with less impact on fisheries than geomorphic + benthic habitats. The habitat conservation objectives were also achieved with less impact on fisheries when smaller conservation units were used. A combination of geomorphic habitats and smaller conservation units reduced (Wallis, Alofi) or eliminated (Futuna) the trade-off between conservation and fishery objectives. Modifying sizes of conservation units and thematic resolution of habitat maps had the greatest impact on the trade-off in Futuna, the simpler island in terms of habitats.

Discussion

Achieving 20% habitat conservation targets within no-take areas appears incompatible with the socio-economicx context of small Pacific island countries such as Wallis, Futuna, and Alofi. Managers and conservation planners worldwide are already well aware of the trade-off needed between conservation and fisheries objectives (see Proceedings of the Fourth World Fisheries Congress: Reconciling Fisheries with Conservation, 2004), and MPA designs now account for local socio-economic constraints (Klein *et al*. 2008). Here, we quantified the extent of trade-offs needed to reconcile two conflicting types of objectives, in the particular context of small tropical coral reef islands, rich in habitats, limited in extent, and with high levels of use for daily subsistence, and thus with limited scope to favor habitat protection over food security.

To our knowledge, no study has previously assessed the extent of the compromises needed between fisheries and strict habitat conservation in this tropical island context. Our analyses, based on immediately available data sets, provide quantitative and spatially explicit answers to questions about compromises between core objectives for managing marine regions. We found that achievement of both strict conservation and fishery objectives is generally not possible in Wallis, Alofi, and Futuna, regardless of the habitat maps and sizes of conservation units considered. However, although the 20% no-take objectives were not all achievable without reducing fishing areas, the achievement of objectives for specific habitats was greatly influenced by the type of habitat maps and the size of the conservation units, so choosing these variables carefully is fundamental to understanding such trade-offs.

Our results show that using more detailed habitat maps makes the achievement of habitat objectives more difficult. Very detailed habitat maps provide a finer description of physical and biological variation across reef systems, and Dalleau *et al*. (2010) suggested that finer resolution coral reef habitats might also be better surrogates of species diversity. However, finer resolution maps also contain more habitat classes that need to be represented in conservation designs, increasing the total area required to achieve objectives. The reason for this increase is the greater mismatch between the boundaries of conservation units and those of more detailed habitat classes, as demonstrated for terrestrial planning by Pressey & Logan (1995).

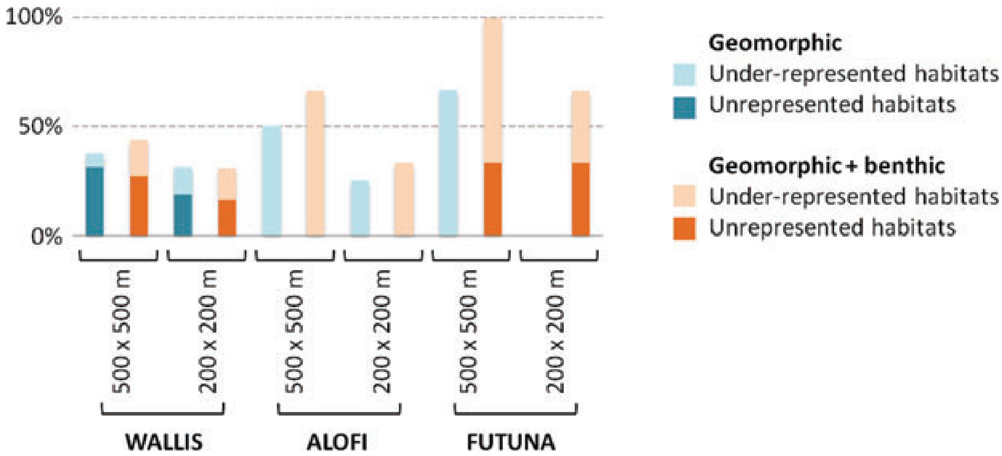

Figure 3 Percentages of habitats that were under-represented or unrepresented in units available for conservation after exclusion of fished units. Under-represented habitats are those for which conservation objectives were only partially achievable (less than 20% of total extent available for conservation). Unrepresented habitats were those that could not be protected at all because their entire extents were fished. Figures are shown for the three islands (Wallis, Alofi, and Futuna), two sizes of conservation units (500 × 500 m and 200 × 200 m), and two types of maps (geomorphic in blue, and geomorphic + benthic in red). We considered 16 geomorphic habitats and 55 geomorphic + benthic habitats for Wallis, 4 geomorphic habitats, and 6 geomorphic + benthic habitats for Alofi, and 3 geomorphic habitats and 3 geomorphic + benthic habitats for Futuna.

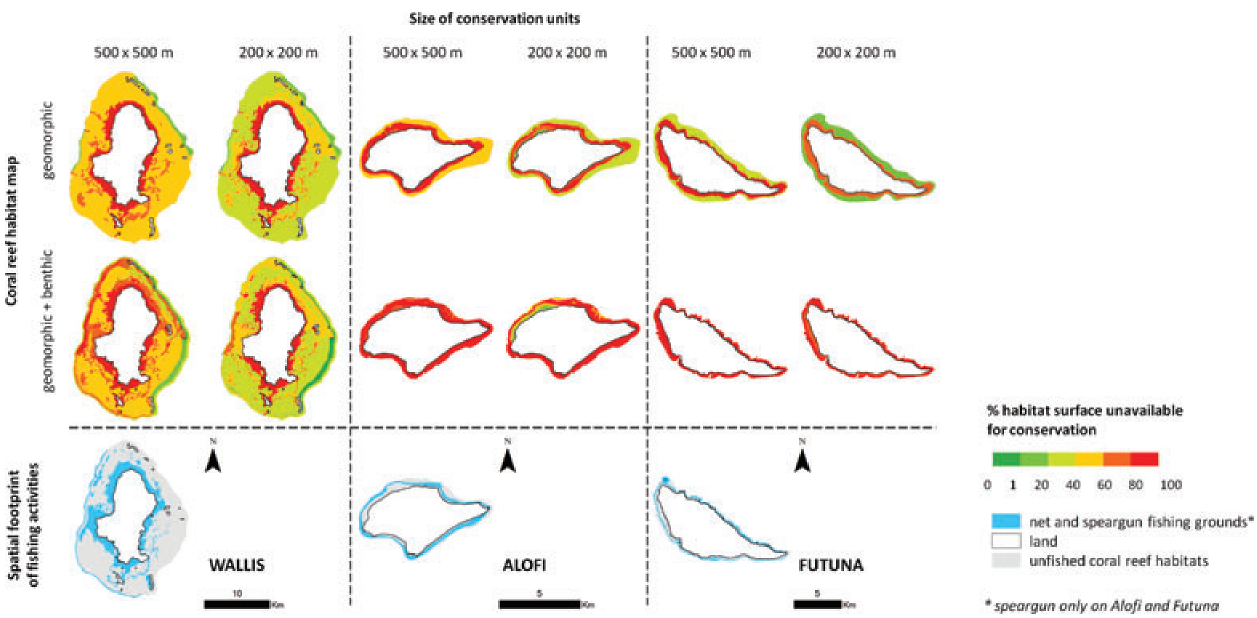

Figure 4 Spatial patterns of under-represented and unrepresented habitat types in units available for conservation after exclusion of fished units, both shown in red. Under-represented and unrepresented habitats were those for which conservation objectives were only partially achievable (more than 80% of total extent unavailable for conservation, so less than 20% available) or not achievable, respectively. Effects of exclusion of fished conservation units are shown for each island, two sizes of conservation units, and two types of maps. The lower panels show the spatial footprint of net and speargun fishing in blue. For Alofi and Futuna Islands, only data on speargun fishing could be obtained.

Decisions about the sizes of conservation units also influence the potential to achieve both habitat conservation and fishery objectives. In general, smaller conservation units allow a more exact habitat representation, for any given spatial and thematic resolution of map, in the sense that fewer objectives are over-achieved (see Mills *et al*. 2010 for coral reefs; Pressey & Logan 1995; 1998 for land systems). Our findings agree with these studies, showing that smaller conservation units lead to easier compromises. However, the appropriate size of conservation units must be decided taking account of other factors such as data resolution, manageability,

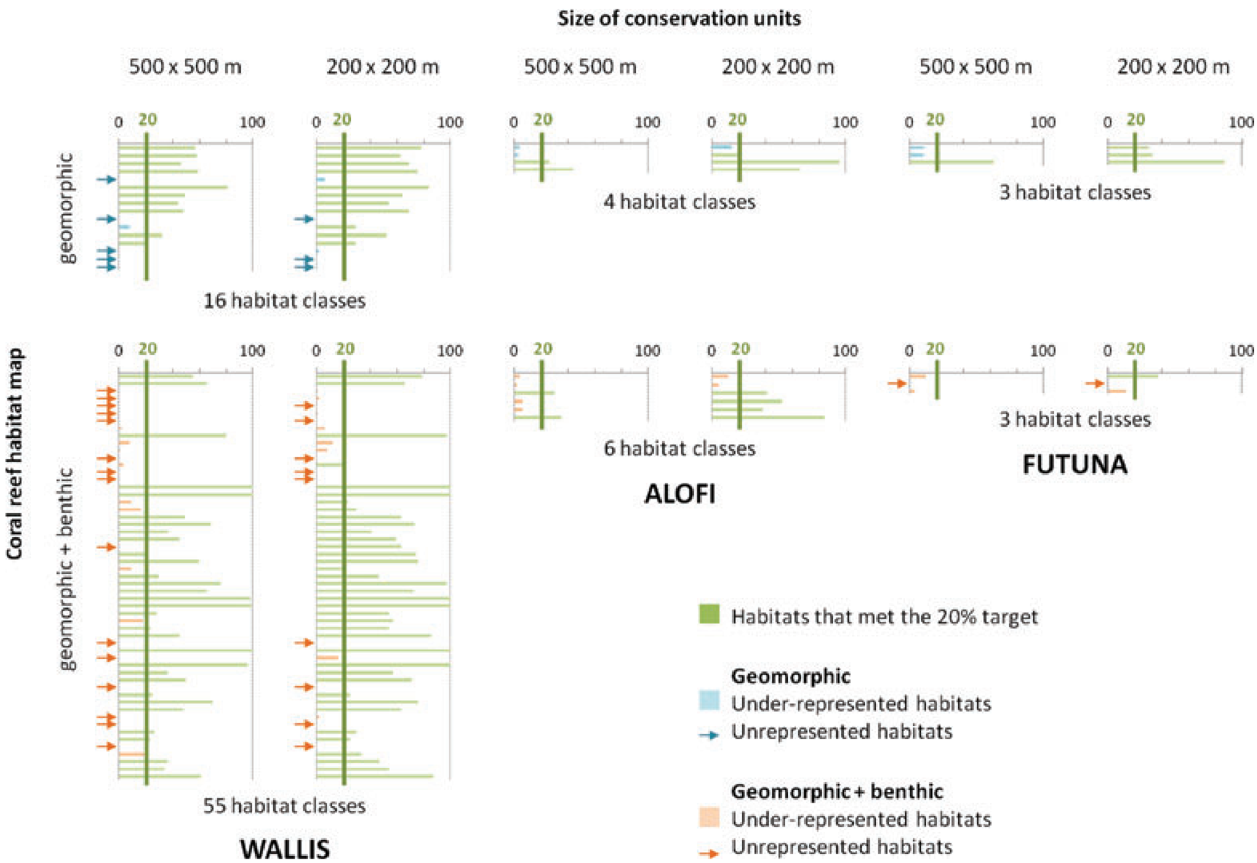

Figure 5 Effects of exclusion of fished conservation units on the extent of individual coral reef habitats available for conservation, for the three islands, two sizes of conservation units, and two types of maps. Each bar corresponds to one habitat class. Habitat class labels have been omitted for clarity. Habitats for which conservation objectives were achievable are shown in green. The vertical green line indicates the 20% objective for each habitat. Geomorphic and geomorphic + benthic habitats for which conservation objectives were not achievable (less than 20% of total extent available for conservation) are shown, respectively, in blue and red. Habitats that could not be protected at all are shown with arrows.

Table 1 Percentages of total extent of geomorphic habitats (level 5 classification) available for conservation after exclusion of all fished conservation units (500 × 500 m and 200 × 200 m) for Wallis, Alofi, and Futuna. Only under-represented and unrepresented habitats are listed. Points indicate habitat types that would not be represented at all in the set of potential reserves. Asterisks indicate habitat types for which the 20% objective could be achieved with the smaller conservation units (200 m x 200 m). Under-represented and unrepresented habitats are mapped in red in Figure 4

	Geomorphology (level 1)	Geomorphology (level 2)	Geomorphology (level 3)	Geomorphology (level 4)[a]	% surface (500 × 500 m)	% surface (200 × 200 m)
Wallis	Oceanic	Oceanic island	Outer Barrier Reef Complex	Pass	–	6
			Coastal Barrier Reef Complex	Channel	–	–
				Barrier reef pinnacle/patch	8	20[a]
			Lagoon exposed fringing	Reef flat	–	2
				Enclosed lagoon or basin	–	–
			Fringing of coastal barrier complex	Reef flat	–	–
Alofi	Oceanic	Oceanic island	Ocean exposed fringing	Forereef	4	15
				Reef flat	3	20[a]
Futuna	Oceanic	Oceanic island	Ocean exposed fringing	Forereef	11	20[a]
				Reef flat	10	20[a]

[a]Our analyses in this study were for the level 5 of the geomorphic classification, which is a combination of levels 1, 2, 3, and 4. Only unrepresented or under-represented habitats are listed here.

Table 2 Percentages of total extent of geomorphic + benthic habitats available for conservation after exclusion of all fished conservation units (500 × 500 m and 200 × 200 m) for Wallis, Alofi and Futuna. Only under-represented and unrepresented habitats are listed. Points indicate habitat types that would not be represented at all in the set of potential reserves. Asterisks indicate habitat types for which the 20% objective could be achieved with the smaller conservation units (200 × 200 m) only. Under-represented and unrepresented habitats are mapped in red in Figure 4

	Geomorphology (level 1)	Geomorphology (level 2)	Benthos (level 1)[a]	% surface (500 × 500 m)	% surface (200 × 200 m)
Wallis	Fringing reef	Reef flat	Hard substrate with dispersed coral	–	1
			Soft substrate with dispersed coral	–	2
		Terrace	Seagrass/algae bed	–	–
			Seagrass/algae bed	–	1
			Seagrass/algae bed	–	–
			Seagrass/algae bed	2	6
		Reef slope	Coral	8	12
			Soft substrate with dispersed coral	1	8
			Soft substrate	–	–
			Soft substrate	3	20[a]
			Coral	–	–
			Soft substrate	–	–
	Coastal barrier reef	Reef flat	Hard substrate with dispersed coral	9	20[a]
			Mixed substrate with dispersed coral	16	20[a]
		Terrace	Algae bed	–	20[a]
			Soft substrate with dispersed coral	9	20[a]
	Barrier reef	Reef flat	Mixed substrate with dispersed coral	18	20[a]
			Coral	–	–
		Terrace	Algae bed	–	16
			Soft substrate	–	–
		Pass	Hard substrate	–	2
			Hard substrate with dispersed coral	–	–
	Lagoon patch reef	Reef flat	Soft substrate with dispersed coral	–	–
		Terrace	Soft substrate	19	20[a]
Alofi	Fringing reef	Reef flat	Hard substrate	4	12
		Reef slope	Hard substrate with dispersed coral	2	5
		Reef flat	Hard substrate with dispersed coral	6	20[a]
			Coral	6	20[a]
Futuna	Fringing reef	Reef flat	Hard substrate	12	20[a]
			Coral	–	–
		Reef slope	Hard substrate with dispersed coral	4	13

[a]Our analyses in this study were for a combination of both geomorphology levels and benthos level 1 of the geomorphic + benthic classification. Only unrepresented or under-represented habitats are listed here.

and effectiveness of conservation actions in the long-run (Gaines *et al*. 2010; Mills *et al*. 2010).

Prioritizing the fishery objective in Wallis, Alofi, and Futuna, as requested by the Territorial Environment Service, resulted in a deficit of reef areas available for conservation. The consequences were that several habitat types could not be protected at all, or could only partially achieve their objectives. These results were expected because several types of reef habitats are preferentially used by net and speargun fishermen for their accessibility, exposure, and resource abundance.

An extreme response to avoiding conflicts between conservation and fishery objectives is to abandon heavily fished or overfished areas to further extraction. However, failing to protect such areas from further fishing is likely to preclude their ability to restore or enhance stocks, and ignores the potential benefits of spillover of larvae and adults to supplement other fished areas. Therefore, avoiding conflicts at all costs might not be the best strategy in the long run, even to maximize benefits to fishermen themselves. Although subject to controversy, there is a now a wide body of work demonstrating the benefits of MPAs for adjacent fisheries (Roberts *et al*. 2001; Hilborn *et al*. 2004; Russ *et al*. 2004; Kaiser 2005; Harrison *et al*. 2012;). To incorporate these perspectives, our indicative conservation designs could be refined by considering past fishing activities, fishing pressure and yields, and the locations of potential MPAs relative to fished areas.

The achievement of objectives for both fisheries and conservation as we defined them here for small Pacific

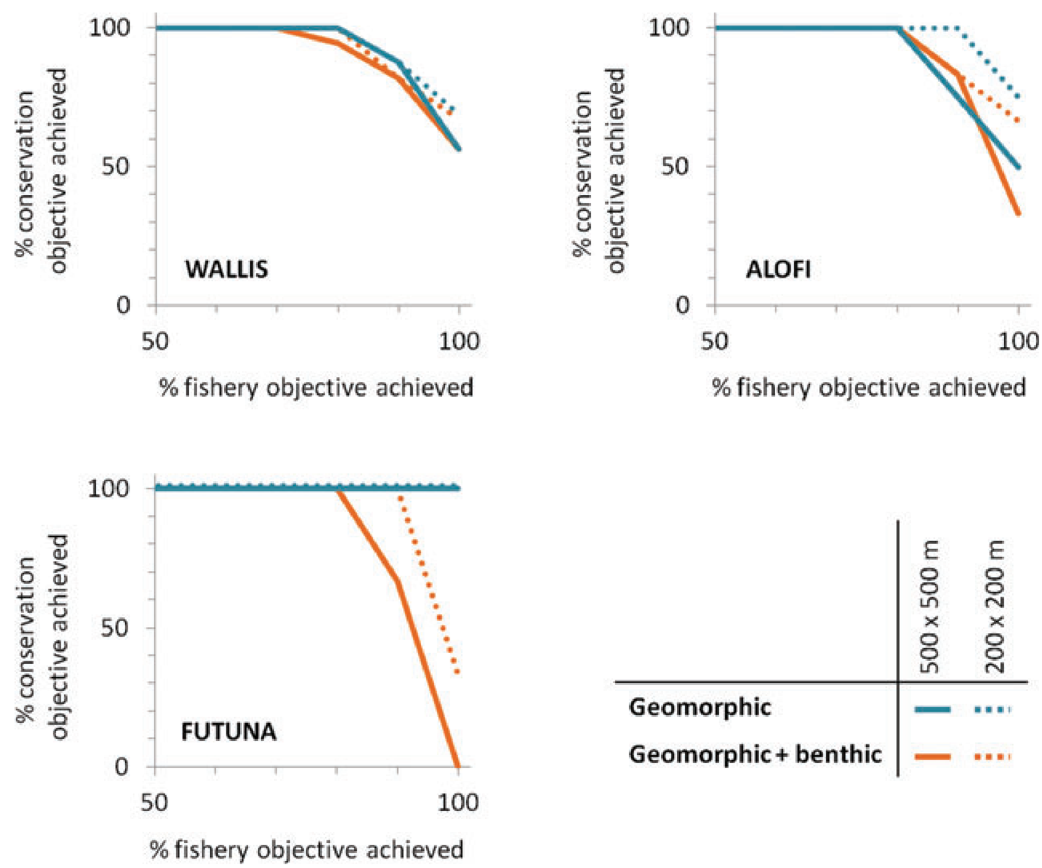

Figure 6 Trade-offs between conservation and fishery objectives in Wallis, Alofi, and Futuna, for two types of maps (geomorphic and geomorphic + benthic) and two sizes of conservation units (500 × 500 m and 200 × 200 m).Percentage of conservation objective achieved corresponds to the percentage of habitats that met their 20% objectives. Percentage of fishery objective achieved corresponds to the percentage of fished conservation units excluded from the sets of conservation units selected as potential no-take areas.

islands is clearly not feasible without compromises on both sides. Methods to identify achievable, realistic objectives early in the process of conservation planning are needed urgently for these countries. By achievable, we mean objectives that can actually be reached through effective conservation and management actions, not simply on paper. By realistic, we mean conservation objectives that converge towards the strict application of international objectives while allowing some flexibility to minimize socio-economic impacts on local communities heavily dependent on fishing. On the fisheries side, objectives must allow flexibility to minimize impacts on targeted species, other species, and physical habitats.

Current international conservation guidelines such as the CBD targets have moderated their options through time to allow some flexibility for complying countries. If no-take areas are seen by some as the best protection option for marine habitats and associated resources (see Graham *et al*. 2011 for a review on benefits for coral reefs), they are also the most difficult to implement. Low compliance can be expected, especially in small Pacific countries that depend heavily on coastal habitats and associated resources. There is now a multitude of spatial arrangements for marine management that do not require total and permanent restrictions on harvest (see for example Cinner & Aswani 2007; Gaines *et al*. 2010; Agardy *et al*. 2011; Mills *et al*. 2011). The IUCN-protected area management categories themselves offer a range of options to avoid the hard trade-offs demonstrated in this article.

Incentives to accept marine conservation measures are also being investigated and include compensatory services such as schools or medical facilities (e.g., Aswani & Weiant 2004) and buyouts or alternative livelihoods (e.g. Niesten & Gjertsen 2010; Jones & Qiu 2011). For islands where most fishing activities provide food for subsistence, incentives might also need to include additional imports of food. Our analyses show that the extent of trade-offs between objectives and the need for such incentives can be demonstrated readily. Appropriate responses to trade-offs must then be formulated amongst the affected communities, decision makers concerned with fisheries and conservation, and conservation scientists.

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