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Original research article

A global survey of "TURF-reserves", Territorial Use Rights for Fisheries coupled with marine reserves

Jamie C. Afflerbach [a,*], Sarah E. Lester [a,b], Dawn T. Dougherty [a,b], Sarah E. Poon [c]

[a] Bren School of Environmental Science and Management, University of California, Santa Barbara, CA 93106, USA
[b] Marine Science Institute, University of California, Santa Barbara, CA 93106, USA
[c] Environmental Defense Fund, 123 Mission Street, San Francisco, CA 94105, USA

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ABSTRACT

Overfishing and degradation of the marine environment continue to plague coastal communities worldwide, with multiple diverse solutions being proposed. Territorial Use Rights for Fisheries (TURFs) is a fishery management approach that aligns fishers' incentives with sustainability, while marine reserves have proven effective for ecosystem protection, and in some cases for fishery enhancement. These two management approaches are often used in isolation, leaving the potential utility of integrating them poorly understood. We examine cases where TURFs and marine reserves have been implemented together to create "TURF-reserves". We compiled a database of 27 TURF-reserves and collected information on the governance, management, enforcement, fishing practices, fishing rights, regulations, and design attributes for each site. We address several research questions including: what species are managed with TURF-reserves, how are TURF-reserves created and who is involved in the process? Our findings show that the majority of surveyed TURF-reserves arose from previously established TURF systems that target a range of fisheries, and multiple entities play a role in TURF-reserve development and management. We also examine the differences between two TURF-reserve archetypes and find that those developed with a strong history of customary tenure share distinct qualities from those created in a more recently established, government-mandated system.

1. Introduction

Small-scale coastal fisheries are central to local economies, poverty alleviation, and food security for millions around the world (Béné, 2006; FAO, 2005). Many of these fisheries are severely threatened by chronic overfishing (Andrew et al., 2007; Costello et al., 2012; Jackson et al., 2001), destructive fishing practices (Cinner, 2009; McClanahan et al., 2009), environmental degradation (Lotze et al., 2006; Pandolfi et al., 2003; Waycott et al., 2009), and interactions with large-scale commercial fisheries (Salas et al., 2007), all of which can have negative impacts on community livelihoods, food security, and marine ecosystem health. As these threats persist, demand for local marine resources continues to increase as coastal populations grow. These combined pressures call for integrated approaches to management that aim to ensure future sustainability of small-scale fisheries while benefiting resource users and protecting their marine environment.

The implementation of property rights as a fisheries management approach has gained more attention in recent years as a way to address the negative consequences of open access fishing. Property rights give fishers ownership over marine

* Corresponding author at: Tel.: +1 831 402 6891.
E-mail address: jafflerbach@bren.ucsb.edu (J.C. Afflerbach).

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resources, thereby providing an incentive to manage for long-term sustainability. Territorial Use Rights for Fisheries (TURFs) are a spatial form of property rights in which individuals or a collective group of fishers are granted exclusive access to harvest resources within a geographically defined area (Christy, 1982). Harvest rights in TURFs can range from privileges to fish in areas that are leased from the government to complete ownership over the delineated TURF area. TURFs have existed for centuries in some small-scale fishing communities, often in the form of customary marine tenure, as is common in traditional fishing communities in the Pacific Islands (Johannes, 1978, 2002; Ruddle et al., 1992). Drawing from these experiences and property rights theory, TURFs have been growing in popularity as a means to support sustainable fisheries, often in locations where there has been significant depletion of local marine resources (Cancino et al., 2007). The ability to control access to resources through TURFs benefits the welfare of local communities by increasing fishery sustainability as well-designed TURFs eliminate the race to fish (Cancino et al., 2007). Furthermore, the long-term ownership rights may incentivize fishers to conserve the resource and the local marine ecosystem by implementing management measures such as marine reserves within or adjacent to the TURF.

Studies have shown that marine reserves can lead to increases in fish biomass, diversity, and abundance (Lester et al., 2009); enhance resilience to the impacts of climate change and natural disturbances (Carilli et al., 2009; Micheli et al., 2012; Mumby and Harborne, 2010); conserve biodiversity and critical habitats (Halpern, 2003; Russ and Alcala, 2011); and provide alternative income through tourism (Arin and Kramer, 2002; McCook et al., 2010). Given these benefits, there are clear advantages to placing marine reserves alongside TURFs as many coastal communities have much to gain in terms of additional sources of income (Sala et al., 2013) and climate change adaptation (Badjeck et al., 2010; Micheli et al., 2012). Furthermore, marine reserves' potential role as a fisheries management tool (Gaines et al., 2010b) suggests another possible rationale for implementing reserves alongside TURFs. Studies have shown that reserves can enhance local fisheries through larval dispersal and adult spillover of targeted species that are protected within reserve boundaries (Halpern et al., 2009; Harrison et al., 2012; Pelc et al., 2010). While the added benefits to fisheries through spillover are well documented for some fisheries, without exclusive ownership over the resource surplus, fishers are not able to realize the full economic benefits of a locally implemented marine reserve. Furthermore, insufficient enforcement and compliance may limit marine reserve effectiveness (Mora et al., 2006). Therefore, the use of marine reserves as a means to improve fisheries sustainability for small-scale fisheries may be limited without application of additional management actions such as exclusive fishing rights through TURFs. Of course, it is also important to note that targeted species, even those that are benthic and sedentary, can have varying spatial scales of larval dispersal from a few meters to hundreds of kilometers (Shanks, 2009). Local larval export from nearby marine reserves could benefit TURF fishers, as found by Almany et al. (2013) in Papua New Guinea tenured areas, but larger dispersal distances of targeted species could prevent TURF fishers from fully capturing some of the added benefit of a marine reserve.

There is a growing recognition of the potential benefits of combining TURFs with marine reserves to create "TURF-reserves" (Costello and Kaffine, 2010; Gaines et al., 2010a; Poon and Bonzon, 2013). For the purposes of this study, we define a TURF-reserve[1] as a marine conservation and fisheries management approach that combines (1) allocation of harvest rights to a defined group of fishers in a designated area (TURF) with the ability to limit access, and (2) a clearly defined marine reserve located within or adjacent to the TURF. The reserve(s) can take many forms and may be permanent, temporary or seasonal, and prohibit take of some or all species within the reserve boundaries.

While various forms of TURF-reserves have been implemented around the world, a systematic evaluation of TURF-reserves as a combined marine conservation and fisheries management approach does not exist. This initial effort aims to compile and synthesize existing information on TURF-reserves and provide a preliminary analysis of TURF-reserve characteristics in order to better understand the environments and conditions in which they arise. We conducted a comprehensive review of the scientific and gray literatures to develop a global database of TURF-reserves, including information on governance, enforcement, monitoring, fishing practices, fishing rights, regulations, and site design.

By compiling this dataset of TURF-reserves and their key attributes, we are able to examine the overall trends and characteristics of these sites, such as location, size, gear types, and methods of enforcement, while also addressing some important research questions about these systems. First, we assessed whether the TURF and marine reserve are typically created simultaneously, or whether it is more common for one component to precede the other.

Second, to better understand the resource characteristics of TURF-reserves, we examined the types of species most commonly managed by TURF-reserves. Species with limited mobility, such as benthic or sedentary species, may be managed more effectively through TURFs than more mobile species because it is more likely that their home range lies within the delineated TURF. Mobile species, such as pelagic finfish, that travel outside of defined TURF boundaries may be subject to threats beyond the control of TURF managers and fishers, posing a challenge to successful TURF management. Additionally, species with an early age of maturity may lend themselves to more successful TURF-reserve adoption. Fast growing species allow local fishers to see the benefits of a TURF-reserve more quickly, keeping local communities willing to continue managing the TURF-reserve. Therefore, we hypothesize that TURF-reserves will tend to focus on managing species with more limited movement potential and higher growth rates.

Third, we examined the role different institutions play in the establishment of TURF-reserves. External influencers, such as conservation non-governmental organizations (NGOs), may be an essential part of the TURF-reserve process by taking

[1] It is important to acknowledge that there are varied definitions and understandings of TURFs. Our definition is rather inclusive, and some of the TURFs presented here may not meet stricter definitions.

Table 1
Descriptions of TURF-reserve database categories.

Database category	Description
Governance	Process by which the TURF-reserve is managed at the local and national scale by specific individuals and/or groups
Enforcement	Process by which the TURF-reserve is enforced by specific individuals and/or groups
Site characteristics	TURF-reserve design elements including size and location
Fishing practices	The species targeted and fishing gears utilized by TURF fishers
Fishing rights	Allocation, terms, and conditions of TURF fishing rights such as lease length and distribution of fishing quota
Regulations	Regulations pertaining to the TURF-reserve
Monitoring	Biological monitoring practices within the TURF-reserve

an active role in gaining support and building capacity for implementation and management. Of particular interest are cases where TURF-reserves have either developed naturally out of the local community or were driven strongly by external influence from outside groups. Examining these two scenarios can provide insight into how and why TURF-reserves are created.

Finally, we explore the idea that a distinction can be made between TURF-reserves that have been established in regions with a long history of local, community-based marine tenure practices, and those that have been more recently adopted by national government's as an alternative fisheries management strategy. Based on this observation, we developed a TURF system typology and made comparisons across sites to better understand how TURF-reserve design may be reflective of the host nation's fisheries management history and legislative framework.

2. Methods

2.1. Data collection

TURF-reserve case study sites were selected through an extensive review of peer-reviewed and gray literature, technical reports, conference proceedings, book chapters, and legislative documents in both English and Spanish. The search engines Google, Google Scholar, and Web of Science were used to search for relevant literature using the following search terms: *territorial use rights for fisheries, exclusive fishing rights, fisheries management, co-governance, community-based marine resource management, marine tenure, marine reserves, no-take zones,* and *marine protected areas*. There were a large number of potential case studies identified through the literature review, but only those sites that met our TURF-reserve definition were included in our database. This determination often relied upon clear evidence of recognized territorial rights over marine resources at the site. Once a TURF-reserve was selected for inclusion and the information available from literature exhausted, semi-structured interviews were conducted with key persons involved with the TURF-reserve in order to fill information gaps. These experts were often the authors of journal articles or reports that directly discussed the TURF-reserve, and included academics, non-governmental organization members, and Peace Corps volunteers with TURF-reserve field experience. Questions asked to each individual were driven by gaps in our database for each case study. After reaching out to personal contacts and key experts, we sought referrals to additional people that could provide information. All of the literature and personal contacts for each TURF-reserve case study can be found in the Supplemental Information (Table A1 in Appendix A).

Over 60 individual characteristics of TURF-reserve systems are included in the database. Seven broad categories are represented: governance, enforcement, monitoring, fishing practices, fishing rights, regulations, and site design (Table 1). For each case study, we compiled data on as many characteristics as possible, but there were significant information gaps. Detailed descriptions of each database category can be found in Table A2 in Appendix A.

Governance data for each case study were collected to describe the people and processes key to TURF-reserve management. Information on TURF-reserve governance focused on legislation, management bodies, and the allocation of rights. Distinctions were made between the individuals or groups that are granted TURF access rights by the government, and how individual fishers are allowed to participate in the TURF fishery. If information was available, the manner of enforcement was recorded. We also collected data regarding existing regulations for each TURF (e.g., quotas, size limits, gear restrictions, effort limits, etc.) and the associated reserve (e.g., species restrictions, duration of closure, etc.).

To better understand the site characteristics of each TURF-reserve, we collected data on the targeted species managed within the TURF, fishing gear used, size and location of both the TURF and reserve, and how much of the fishing grounds are set aside as a marine reserve. We collected information on monitoring practices and their findings, but this information was sparse and unsuitable for inclusion in our reported results.

Data were collected on the presence of groups or individuals involved in the creation, implementation, and management of each TURF-reserve. In many cases the literature relevant to each TURF-reserve detailed the history of its creation and indicated who was involved from the beginning and/or who became involved later on in the process. Often these were identified as NGOs, government agencies, universities, or specific researchers or scientists. This information was incorporated in the database as a binary entry (1 for presence, 0 for absence) for multiple categories including "Who implemented reserve" and "Who chose reserve location". Additionally a list of all involved parties was included in the category "Supporting groups".

Table 2
Assignment of TURF archetype categories to each country based upon the national legislation and history of TURFs as a form of fisheries management.

Country	TURF archetype
Fiji	1
Samoa	1
Vanuatu	1
Belize	2
Brazil	2
Chile	2
Japan	2
Mexico	2
Philippines	2
Spain	2

Definitions: Archetype 1—systems that have evolved from a history of customary marine tenure and have been formally recognized through national legislation. Archetype 2—systems where the government has developed a framework to implement TURFs to replace previously open access systems while still considering community-level ties to the local resources.

2.2. Data analysis

Much of the data collected were used to identify common characteristics in TURF-reserves worldwide. Data at the individual TURF-reserve level were summarized across all sites for the following variables: species targeted, fishing gears used, regulations implemented, area (km^2), type of reserves implemented (permanent, temporary or seasonal), and method of enforcement. In addition, comparisons were made across all ten countries in the database on how TURF rights are allocated and fishing privileges assigned. This categorical information came from national legislative policies as well as how individual TURF-reserves have established fishing privileges.

In order to compare the different conditions under which a TURF-reserve is created, we developed a typology based on the construct of the host nation's TURF system. These two archetypes are defined as follows: *Archetype* 1 systems have evolved from a history of inherited rights through customary marine tenure and have been formally recognized through national legislation, while in *Archetype* 2 systems, the government has distributed rights to implement TURFs to replace previously open access systems while still considering community-level ties to the local resources. Table 2 lists the countries included in this study and how they are categorized according to these two archetypes. Exploratory analyses using these archetypes were conducted to identify significant differences between the two classes of TURF systems and design of their associated TURF-reserves.

The major limitation to our analysis was the availability of data on the performance of TURF-reserves in terms of biomass production, fishery yields, economic gains, or conservation objectives. The lack of this information prevented us from being able to draw conclusions about the effectiveness of TURF-reserves on the whole and different TURF-reserve components.

3. Results

3.1. Site characteristics

The database consists of 27 TURF-reserves from ten countries that span the globe (Fig. 1). Species targeted by TURF-reserve fishers are very diverse with molluscs being the most commonly caught taxon followed by finfish and crustaceans (Fig. 2(A)). TURF-reserves are used to manage either a single species as in Japan, a group of species, such as Mexico and Chile's benthic resources, or all species that lie within the geographically defined TURF boundaries. The majority of surveyed cases fall into the last category, but this result is in part due to the high number of TURF-reserve case studies from Vanuatu, nine in total, where TURFs are typically allocated for all species. Eighteen of the surveyed TURF-reserves have rights to all marine species within the TURF area, while five allocate TURF rights solely for benthic resources and the four TURF-reserves found in Japan are for individual pelagic and benthic species. TURF-reserves in the Pacific Islands, including Fiji and Vanuatu, take on a more traditional form and typically encompass all resources within their geographic boundaries, while TURF-reserves created more recently tend to focus on individual species or groups of species. A TURF-reserve in Navidad, Chile is an example of the latter; Chilean TURFs are allocated to local fisher unions for their exclusive harvest of all benthic resources, but not finfish. TURF systems that allocate exclusive user rights over specific species or types of species (e.g., benthic resources) are also found in Mexico and Japan.

TURF-reserve species are targeted with a variety of gears that range in selectivity from beach gleaning to trawling, with diving and hook and line as the most commonly utilized gears (Fig. 2(B); Table A3 in Appendix A). These low-intensity gears are common in TURFs for artisanal fisheries, while the higher cost, higher intensity gears such as trawls and dredge nets were only found in Japanese and Brazilian TURF-reserves.

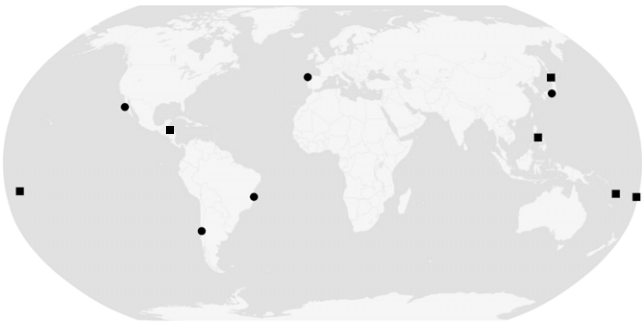

Fig. 1. Map of surveyed TURF-reserves. Points (●) indicate locations of single TURF-reserve sites while squares (■) indicate multiple TURF-reserve sites.

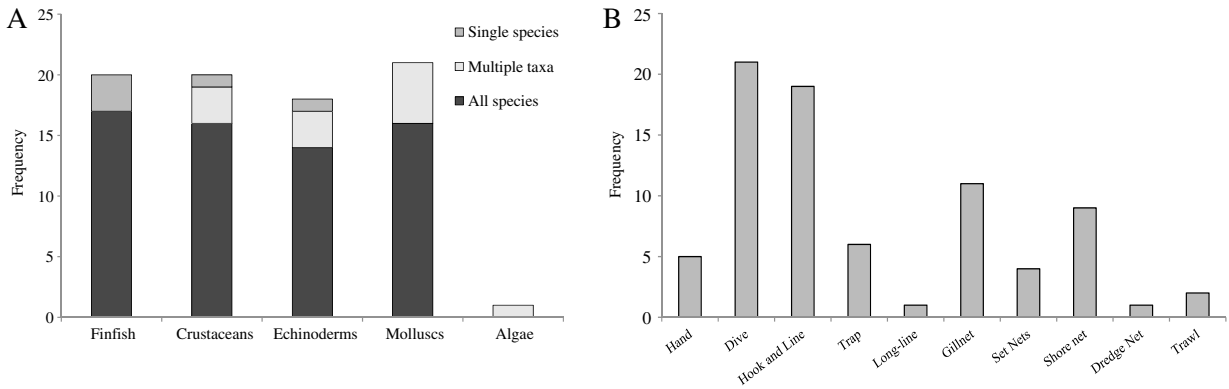

Fig. 2. Summary of fishery level data. (A) The type of species targeted by TURF-reserve fishers and their distribution among TURFs that manage single species, multiple taxa and all species, and, (B) the gear types used for fishing (Table A3 in Appendix A). Total frequency is greater than 27 (the number of sites) because many TURF-reserve fisheries target more than one type of species and use multiple gears.

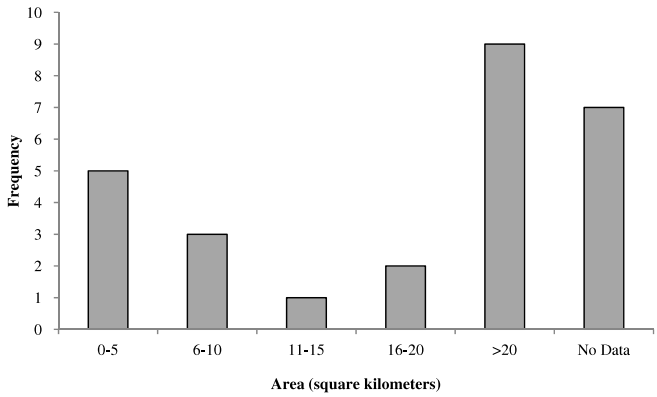

Fig. 3. Total area of individual TURF-reserve sites included in the database (in square kilometers).

The size of TURF-reserve systems across all sites ranges from 0.5 km^2 in Worasifiu, Vanuatu to 1738 km^2 in Ise Bay, Japan (Fig. 3). There is no information on the total TURF area for nine of the case studies but when information was available, the area set aside as a reserve was collected and compared to the size of the available TURF fishing grounds. The majority of marine reserves cover 5% or less of the total TURF fishing ground (Fig. 4), with no significant correlation between the total size of the TURF-reserve systems and the size of their associated marine reserves (Pearson's correlation; $r = 0.33$, $p = 0.19$).

3.2. Allocation of TURFs

Data on rights allocation for TURF-reserves (recorded at the country level) were used to identify which groups receive TURFs and how individuals are able to participate in TURF fisheries (Table 3). While the initial allocation of TURFs was given to either a community as a whole, or to a group of organized fishers, the requirements to participate in the TURF fishery

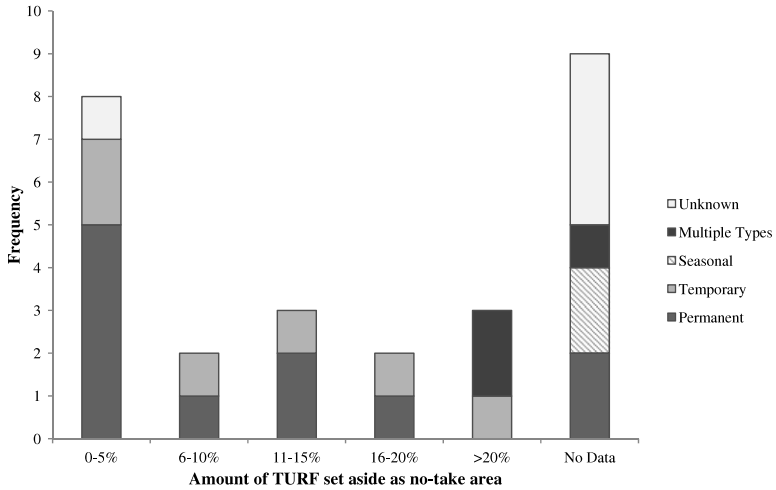

Fig. 4. The number of TURF-reserves that have set aside the specified amount of TURF fishing ground (horizontal axis) as a marine reserve. Shading indicates the various forms of marine reserves within each category. A permanent reserve is never opened to fishing, while a seasonal reserve may be implemented only during the fishing season and a temporary reserve is periodically opened for fishing. We include cases where multiple types of marine reserves are found within a single TURF-reserve.

Table 3
Allocation of TURFs. Fishing rights describes the entity that receives TURF rights. The privilege for individual fishers to participate in the TURF fishery is defined by either one or a combination of the following: being a resident of the community; being licensed, permitted or registered to fish; or being a fishing organization member. Once an entity obtains rights, individual fishers may need to fulfill one or more requirements to gain the privilege to participate in the TURF managed fishery.

	Fishing rights			Privilege to fish		
	Organized fishers	Individual fishers	Communities	Community residency	License, permit or registry	Fishing organization membership
Fiji			✓	✓	✓	
Japan	✓				✓	✓
Mexico	✓					✓
Chile	✓					✓
Philippines			✓	✓	✓	
Brazil	✓					✓
Belize		✓			✓	
Vanuatu			✓	✓		
Samoa			✓	✓		
Spain	✓				✓	✓

varied and included community residency, purchased licenses, permits or another form of registration, and membership with a fishing organization.

3.3. TURF-reserve management

There was considerable variation in the types of marine reserves set up within TURF boundaries with the majority of reserves created as permanent, no-take marine reserves, but some established as seasonal, species-specific or temporary marine reserves (Fig. 4). For all but one TURF-reserve, the marine reserves lie within the TURF boundaries.

In 18 of the 27 surveyed TURF-reserves, the TURF system was established before a marine reserve was implemented (Fig. 5). In some cases, such as Lira, Spain, and Safata and Aleipata Marine Protected Areas in Samoa, both the TURF and associated marine reserves were established together. In both the Philippines and Belize sites, TURFs were introduced after a marine reserve had already been implemented. A wide variety of fishing regulations are being utilized across current TURF-reserve systems with the most common being size limits, gear restrictions, and species bans (Table 4). Enforcement of both the TURF and reserve is often a shared responsibility between local fishers, deputized wardens, and government officials (Fig. 6).

3.4. TURF-reserve archetypes

The two TURF-reserve archetypes showed some significant differences across multiple variables (Table 5). Archetype 1 TURF-reserves, found in Fiji, Samoa and Vanuatu, are characterized by lower Human Development Indices (HDI), smaller TURF-reserves in terms of area managed, but a higher percent of the area closed to fishing when compared to Archetype 2

Table 4
Established fishing regulations specific to each TURF-reserve. ✓ = TURF-reserve applies restriction, X = the TURF-reserve does not apply restriction, – = no data. Definitions for each of the fishing regulations can be found in Table A4 in Appendix A.

TURF-reserve	Country	TURF fishing regulations					
		TAC	Size limits	Daily catch limit	Gear restrictions	Seasonal limits	Species bans
Glover's Reef	Belize	X	✓	X	✓	✓	✓
Port Honduras	Belize	X	✓	X	✓	✓	–
Corumbau	Brazil	X	✓	✓	✓	✓	–
Navidad	Chile	✓	✓	X	X	✓	X
Kubulau	Fiji	–	✓	–	✓	–	✓
Navakavu	Fiji	X	–	–	✓	–	–
Ise Bay	Japan	X	–	–	–	✓	–
Mutsu Bay	Japan	✓	✓	✓	✓	✓	–
Nishi	Japan	✓	✓	–	✓	✓	–
Rausu	Japan	✓	–	–	✓	–	–
Isla Natividad	Mexico	✓	✓	X	–	✓	✓
Candelaria	Philippines	–	–	–	✓	–	–
Mahaba Island	Philippines	–	–	–	✓	–	–
Romblon	Philippines	X	X	–	✓	–	–
Concepcion	Philippines	–	–	–	✓	–	–
Aleipata	Samoa	X	–	X	✓	–	–
Safata	Samoa	X	–	X	✓	–	–
Lira	Spain	✓	✓	✓	✓	–	–
Eratap	Vanuatu	–	✓	–	–	–	✓
Laonamoa	Vanuatu	–	✓	–	–	–	✓
Managliliu	Vanuatu	–	✓	–	✓	–	✓
Piliura	Vanuatu	–	✓	–	–	–	–
Siviri	Vanuatu	–	✓	–	✓	–	✓
Takara	Vanuatu	–	✓	–	✓	–	✓
Tanoliu	Vanuatu	–	✓	–	✓	–	✓
Unakap	Vanuatu	–	–	–	–	–	✓
Worasifiu	Vanuatu	–	–	–	–	–	✓

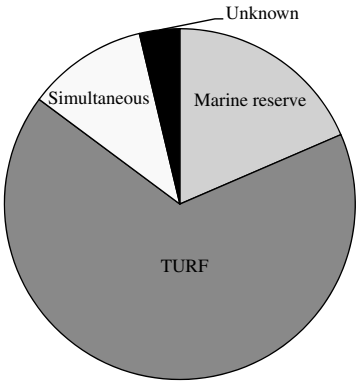

Fig. 5. Proportion of TURF-reserves for which the TURF was implemented first, the marine reserve was implemented first, or the two components were created simultaneously.

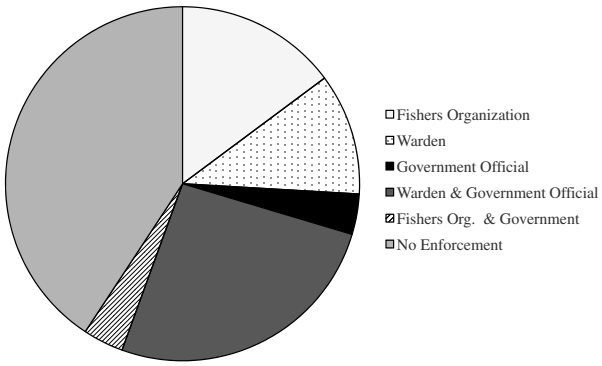

Fig. 6. Proportion of TURF-reserves that utilize various forms of enforcement for exclusive access, fishing regulations and/or marine reserves. Enforcement may be the responsibility of a fishing organization, local non-governmental warden, or a government official.

TURF-reserves. Archetype 1 TURF-reserves manage all species found within the site, while the number of species managed in Archetype 2 sites range from just one to all targeted species. Additionally, the majority of Archetype 1 sites had only one marine reserve associated with the TURF, while the majority of Archetype 2 sites had more than one reserve. For both archetypes, the majority had a TURF established before a reserve, but five of the 13 Archetype 2 sites had a reserve set up prior to the TURF. Lastly, fishing rights are allocated to entire communities in Archetype 1 TURF-reserves while most Archetype 2 sites allocate rights to organized fishers.

By examining the processes through which TURF-reserves are created, implemented, and managed, we are able to reveal a key factor that may be driving TURF-reserve implementation. A common trend we found across all sites was the diversity of stakeholders involved in either the creation and/or management of the system. Each TURF-reserve had at least two key players involved in the initial proposal, development, or management (Table A5 in Appendix A). In most cases an NGO, governmental unit, and/or community or fishers organization worked together to create either one or both aspects of the TURF-reserve. In certain cases such as Lira, Spain and Nishi, Japan, a local, well-respected scientist was also critical in gaining community support for the TURF-reserve. Thirteen of the 27 TURF-reserve case studies included in the database had at least

Table 5
Comparison of Archetypes 1 and 2 across the listed TURF-reserve characteristics. Statistical tests performed to calculate significance are listed, along with resulting *p*-values.

TURF-reserve characteristics	Archetype 1	Archetype 2	*p*-value	Statistical test
Means across all sites				
HDI	0.65	0.78	0.000096*	*Wilcoxon signed rank sum*
TURF size (km^2)	33.3	523.74	0.003*	*Wilcoxon signed rank sum*
Reserve size (km^2)	9.86	12.63	0.019*	*Wilcoxon signed rank sum*
Proportion of site closed to fishing	13.9%	7.5%	0.22	*t-test*
Percentage of TURF-reserve sites that have the following characteristics				
Number of marine reserves associated with the TURF			0.057	*Fisher's exact*
Single reserve	33.3%	14.8%		
Multiple reserves	14.8%	37%		
Species managed by TURF			0.0016*	*Fisher's exact*
All species within the TURF	50%	19%		
Multiple species (>1, <all)	0%	15.4%		
A single species	0%	15.4%		
TURF-reserve creation			0.057	*Fisher's exact*
TURF created first	42.3%	26.9%		
Reserve created first	0%	19.2%		
Created simultaneously	7.7%	3.8%		
Fishing rights allocation			0.0002*	*Fisher's exact*
Organized fishers	0%	29.6%		
Individual fishers	0%	7.4%		
Communities	48.1%	14.8%		

* Significance <0.05.

one external scientist or NGO involved in any or all steps of the TURF-reserve process, and 17 of the case studies involved at least two separate interests from outside of the community.

4. Discussion

This survey of global TURF-reserves provides insight into the diverse environments where this approach to fisheries management and marine conservation has been implemented. The heterogeneity of the case studies surveyed suggests the potential applicability of this approach to multiple socioeconomic and ecological environments, as long as they are established according to national legislation and customary norms. By examining the governance and management structures of these case studies, we begin to understand the unique characteristics that play a role in TURF-reserve development.

We examined whether TURFs and marine reserves were set up sequentially or simultaneously, which was motivated by the idea that a TURF-reserve may be created if a TURF or a marine reserve operating in isolation is underperforming. We found that the majority (85%) of sites implemented the TURF and reserve components sequentially with 66% of all sites establishing a TURF first. One potential explanation for the trend is that once a community obtains rights over a single species or group of targeted resources, they have an increased incentive to sustainably manage those marine resources and engage in conservation actions such as creating a marine reserve. This is consistent with the findings of Ovando et al. (2013) that fishing cooperatives often create private marine protected areas, especially when operating under a national TURF system. Sites that have implemented a reserve first (19%) might be explained by the legislative environment in which TURFs and reserves are established. For example, Glover's Reef and Port Honduras sites in Belize had established marine reserves for over ten years before an associated TURF fishery was created. This more recent development is due to a combined effort between environmental NGOs and the Belizean government to establish a national TURF system (Foley, 2012). With limited information on how these sites performed before and after implementation, these results can only be viewed as an indication of how TURF-reserves are implemented, which might be due to the enabling legislation as well as the compounding benefits fishers realize when TURFs and reserves are implemented sequentially rather than simultaneously.

The surveyed TURF-reserves vary widely in design, ranging from single-species TURFs with seasonal marine reserves prohibiting take of a single-species, as seen in Japan, to TURFs managing all coastal species with permanent no-take reserves, as exemplified by the Philippines sites. The majority of surveyed TURF-reserves are characterized by fishers using low-tech gears, such as diving and hook and line, to selectively target a very diverse group of marine resources. With no clear pattern for specific groups of species managed under TURF-reserves, we did not find support for our initial hypothesis that fast growing and low mobility species would be preferred for TURF-reserve adoption and management.

A comparison of two TURF-reserve archetypes highlights some common differences found between historical TURF systems (Archetype 1) and those created within a newer, government-mandated construct (Archetype 2). The most distinct characteristics of Archetype 1 TURF-reserves, found in Fiji, Samoa and Vanuatu, are their smaller sizes, management of all species found within TURF boundaries, and allocation of harvest privileges to the local community. These characteristics are linked to their long history of customary marine tenure (CMT) where nearshore marine areas are viewed as an extension

of the land boundaries (Ruddle et al., 1992; Pulea, 1993). Fisheries management is not the sole focus of CMT systems, which exist to manage ownership over land and sea territories and access to resources as well as organization of activities and political groups (Hviding and Ruddle, 1991; Ruddle et al., 1992). Rather than focusing on specific species, people or designated fishing areas, CMT has a broader focus on the whole marine ecosystem and its cultural and socioeconomic significance to the local community or clan that holds ownership (Hviding and Ruddle, 1991). Implemented regulations in these TURF-reserve sites are aligned with traditional practices such as temporary spatial closures, and gear or species bans in order to ensure stock sustainability for the local community into the future (Ruddle et al., 1992; Cinner and Aswani, 2007). The sites that fall in Archetype 2 are more strictly managed in terms of who has access to the resources and what species will or will not be managed. Additionally, Archetype 2 TURF-reserves may be created in areas where commercially important species are the management focus and both the TURF and reserve components are designed to best manage specific species. In contrast Archetype 1 TURF-reserves may not be driven by the value of local fish stocks since species are often harvested for subsistence and local consumption.

Without any indicators of success, it is not possible to conclude whether a TURF-reserve set up in one construct versus the other is more likely to meet their objectives. Instead, this comparison provides insight into what a TURF-reserve might look like if being established in a country that falls either within an Archetype 1 or 2 system.

Our results also provide some information on what types of actors are often involved in TURF-reserve creation and/or management. The TURF-reserve systems found in the Pacific Island region, and common to Archetype 1, represent a return to the more traditional, customary marine management approach of the region (Johannes, 2002). While historically, exclusive access and permanent and temporary no-take areas were the norm in many Pacific Islands, their recent resurgence can often be attributed in-part to the increased interest by outside groups. For all surveyed sites in Fiji, Vanuatu, and Samoa, outside government agencies, academics, and/or environmental NGOs were involved in some aspect of the process. TURF-reserves established in Samoa are a result of government efforts to decentralize fisheries management and support community based fisheries management. Both TURF-reserves surveyed in Fiji are heavily supported by environmental NGOs who provide technical guidance to local communities. These findings support the claim by Johannes (2002) that the recent rise in customary practices is in large part due to multiple factors, which include an increased involvement from NGOs and local governments.

The involvement of multiple external groups is not unique to the tropical Pacific TURF-reserves. In regions such as Japan and Chile where there are large TURF systems, local scientists or academics often guided the move towards coupled TURF-reserves. NGOs were involved in TURF-reserve establishment for nearly every site in Mexico, Philippines, Spain, Brazil, and Belize. These efforts to establish or re-establish TURF-reserves almost always resulted from interactions with NGOs and scientists rather than transpiring directly from the community. While the interaction between communities, NGOs and scientists in forming TURF-reserves is apparent from this database, further study is needed to identify the underlying incentives for their creation.

It is important to acknowledge the potential biases in the methodology used in this study. While an extensive literature review and discussion with experts around the globe yielded a tremendous amount of information, there are likely additional TURF-reserves that exist but were not included in this study due to their lack of published information. As indicated by our review, TURF-reserves have been established in data poor environments, for which published and easily accessible information is sparse. Additionally, the presence of an NGO or external funding source may be a reason for published information on a TURF-reserve site and therefore inherently biases our database to select those sites that have vested interest by a university, NGO, or other external party. Lastly, only English or Spanish literature was included in the search process, thereby limiting the pool of information to those described in either of these languages.

While this study provides a comprehensive look at characteristics of current TURF-reserves, it is limited in its ability to measure TURF-reserve success and identify contributing factors. The database does not include key performance indicators such as biological and fisheries outcomes, TURF-reserve financing, feasibility and success of enforcement, and adaptations in management. This information was less readily available and therefore could not be included in this analysis. We recommend further investigation into these critical TURF-reserve components through new data collection efforts in order to accurately measure TURF-reserve performance. As more information becomes available on the social, biological, and economic characteristics of successful TURF-reserves, more detailed analysis can help inform local and international efforts to implement TURF-reserves in order to better meet conservation and fisheries objectives.

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Appendix A. Supplementary data

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