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Status of monitoring and evaluation of Tonga's Special Management Area program

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ABSTRACT

Tonga's Special Management Areas (SMAs) have been widely supported by the people of Tonga as a successful approach to the comanagement of their fisheries and marine resources. However, due to the dominant focus on expansion of the program over recent years, challenges remain for the effective and consistent monitoring and evaluation needed to understand program impacts. This review compiles all known ecological, fisheries, and socio-economic monitoring and evaluation reports related to Tonga's Special Management Areas from 2010 onwards. A total of 25 projects with available reports were identified, with most examining ecological (42%) and socio-economic (42%) aspects of SMAs, whereas reporting on SMA fisheries data (e.g. catch) was limited to five available projects. Most studies also represented 'baseline' ecological and socio-economic surveys of SMAs during implementation. Only three studies have assessed the ecological impact of SMAs post intervention, and only one of these incorporated 'follow-up' surveys at a second time point. Among these, impacts remain mixed, with some SMAs resulting in larger and more abundant fish, but others showing no impact. Other monitoring challenges include no gender disaggregation of data, no monitoring of gleaning, haphazard monitoring by communities, and general concerns of cost, fit for purpose, and overinvestment. Although the limited available ecological data indicates that SMAs can increase fish size and abundance in some cases, rationalised, more efficient, and targeted monitoring is required to better understand and strengthen the functioning of SMAs and inform community and government management decisions.

Keywords: adaptive management, comanagement, ecological data, fish habitat reserve, gleaning, impacts, small-scale fisheries, socio-economic monitoring, Special Management Area.

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Introduction

The Pacific is heavily dependent on coastal fisheries resources for food, culture, and economic development (Kittinger 2013). Despite their importance, small-scale fisheries in the Pacific are subject to a range of stressors and management challenges such as unregulated harvesting, open access management systems, vulnerability to climate change, globalisation via the expansion of markets, and limited alternative livelihoods (Stevens *et al.* 2014; Mcleod *et al.* 2019). These threats are often compounded by, or lead to, overfishing due to a dependency on coastal resources as a primary source of income (Webster *et al.* 2017).

Due to continuing declines in fish stocks and limited success of centralised governance approaches, devolving power to local communities is increasingly being viewed as a highly effective approach to resource management in small-scale fisheries (Govan 2009; Cohen *et al.* 2015). Collaborative approaches, often referred to as comanagement, are relationships where local communities share the responsibility of managing natural resources with government agencies, nongovernmental organisations, civil societies and/or academia (Cinner and Huchery 2014; Smallhorn-West *et al.* 2023). A central aspect of comanagement is that it empowers local resource users to take control of 'their' resources and

influence how they are used and managed (Webster *et al.* 2017). Co-management has been shown to provide numerous benefits to resource management, including ecological benefits (McClanahan *et al.* 2006; Di Franco *et al.* 2016), improved socio-economic conditions for local communities, improved management incorporating local knowledge, and reduced conflict between fishing groups (Cinner *et al.* 2012; Cohen *et al.* 2015). However, despite widespread acceptance and implementation of co-management as an effective tool for managing small-scale fisheries, understanding programmatic impacts through monitoring and evaluation is often challenging, costly, and not fit for purpose (Kaldin *et al.* 2020).

Monitoring and Evaluation (M&E) is an essential (though nonexclusive) component of any fisheries management program, enabling managers (community and otherwise) to understand program impacts (Ferraro and Pressey 2015; Pressey *et al.* 2015). 'Impacts' are the intended or unintended consequences directly or indirectly caused by an intervention, i.e. changes that have occurred in the system because of management (anticipated or otherwise) (Ferraro 2009). In principle, understanding the attribution of changes enables managers to make evidence-based decisions and track progress towards desired objectives (Smallhorn-West *et al.* 2022*a*). A key objective of monitoring progress in a fisheries program is to inform adaptive management, a process by which management interventions can be adjusted in response to uncertainties in socio-ecological systems (Montambault *et al.* 2015). Monitoring that informs adaptive management can be especially beneficial in comanaged fisheries, given the inherently complex social-ecological nature of these systems. The field of monitoring and evaluation in tropical fisheries and ecosystems is now well established (e.g. Hill and Wilkinson 2004; Breckwoldt and Seidel 2012; Bohensky *et al.* 2014; González-Rivero *et al.* 2014; Ahmadia *et al.* 2015), with extensive methods (e.g. underwater visual census, CREEL, or recollection data) (Gurney and Darling 2017), dashboards (e.g. MERMAID, ReefCloud, CoralNet, Elinor, Ikasavea), and frameworks or experimental design in use, each with their own strengths and limitations (Adams *et al.* 2019). Indeed, often the more challenging component in current tropical fisheries monitoring programs is making efficient sense and use of discordant information across multiple platforms.

However, it should be recognised that M&E is not intrinsically a driver of change; rather, it serves to highlight the success or shortcomings of actions taken. Therefore, although an integral component of any co-management system, it is necessarily a relatively minor component. For example, monitoring can impose considerable burdens on communities and government staff that detract from other potential activities (Paul *et al.* 2016). The information generated also may not be suitable to inform community or government management decisions (Prescott *et al.* 2016). In the Pacific, M&E priorities and methodologies have often been driven by funders, external consultants, and visiting researchers rather than based on the specific outcomes and methodologies most suitable to local management responses (Johnson *et al.* 2020). Often these priorities and recommendations are for more monitoring to be conducted, using high-cost methods and expertise that are unfeasible for current program structures.

Successful M&E of fisheries co-management should, therefore, strike a strategic balance between capacity and rigour, emphasising the provision of information directly relevant to management. This balance may be most effectively addressed by establishing simple and clear monitoring strategies that rely on national expertise and community knowledge of fisheries, while ensuring maintenance of basic analytical rigour. For example, relying exclusively on community collected data to gauge community progress towards goals and objectives may incentivise biases, particularly if more external investment is contingent on positive impacts accruing from the programs. Hence, some external accountability is necessary to maintain programmatic rigour. Communities and government agencies are also often already overstretched, so implementing unrealistic and overly complex monitoring frameworks can be unfeasible. Fisheries management budgets are limited in small island developing states (Govan 2015; Marre *et al.* 2021) and, in the case of co-management, so is the time and effort of community members and small-scale fishers. Monitoring programs must balance the resource requirements, recognising that excessively costly approaches will reduce the ability to perform other important management functions such as enforcement or community awareness. In addition, poor-quality data can be more harmful than having no data. Therefore, a basic standard of quality must be upheld and this should be measured against the utility of the information generated. Accordingly, a program doing few things well may have greater success than one attempting to address many needs with limited capacity.

Here, we review the monitoring and evaluation projects surrounding the Special Management Areas (SMA) program in the Kingdom of Tonga. The SMA program provides communities with the responsibility to manage their own resources through exclusive access to the marine environment adjacent to their village and is co-managed with the Tongan Government through the Ministry of Fisheries (MoF). The program has been viewed as a substantial achievement by communities, government, and regional organisations, with much written about the success of the program (Gillett 2010; Tupou Taufa *et al.* 2016; Smallhorn-West *et al.* 2020*a*). Initial monitoring priorities of the MoF were to conduct SMA ecological and socio-economic baseline surveys every five years and regular monitoring of fisheries catch. Additionally, the original intention of SMA monitoring was to support adaptive management (Gillett 2017). Yet monitoring of SMAs has been considerably less robust than what was set out in initial targets, providing limited opportunities for assessing management effectiveness (Gillett 2017; SPREP 2019). The stated successes of the program therefore appear to be based mostly on assumptions, potentially doing a

disservice to communities and government interested in understanding the actual impacts of their actions. Thus, the objective of this review is to compile all ecological, fisheries, and socio-economic monitoring and evaluation reports related to the Special Management Areas from 2010 onwards, and suggest some ways towards an organised national program. This review of past monitoring efforts will allow for a better understanding of what has been done and where focus needs to be directed in the future.

The Special Management Area program

Fisheries management in Tonga was historically open access (Smallhorn-West *et al.* 2020*a*). However, growing concern over the depletion of marine resources prompted the development of the Fisheries Management Act in 2002, which allowed local communities to manage fisheries in partnership with the government, through the Special Management Areas (SMAs) program (Gillett 2010). SMAs consist of two components: an exclusive zone within which only the SMA community can fish, and a permanent no-take fish habitat reserve (FHR) where no fishing activities are permitted (Fig. 1). The size and location of the no-take areas are determined by the communities (MoF *et al.* 2022).

The SMA program has garnered widespread support within Tonga from local agencies and government departments, alongside strong community advocacy. Additionally, it has received support abroad through funding and involvement in SMA projects from regional and international agencies. As a result, the program has expanded rapidly, with 61 SMAs established at the time of writing (Fig. 2). Although the expansion of the program is, in many ways, indicative of very successful co-management, the capacity for the Ministry of Fisheries to address all SMA related issues is being tested (Gillett 2017). The SMA program is now entering a phase in which implementation is largely saturated and effort will need to focus on ensuring the program doesn't lose the momentum of these early successes. Effective and efficient M&E is an integral, although not exclusive, component of this. Although the program has resulted in some positive fisheries and conservation results (Smallhorn-West *et al.* 2020*b*), there is either insufficient or inappropriate data being produced by ongoing monitoring, or ineffective coordination, to understand the broader picture of SMA successes. Therefore, despite its potential for large-scale change, many of its potential impacts remain unclear.

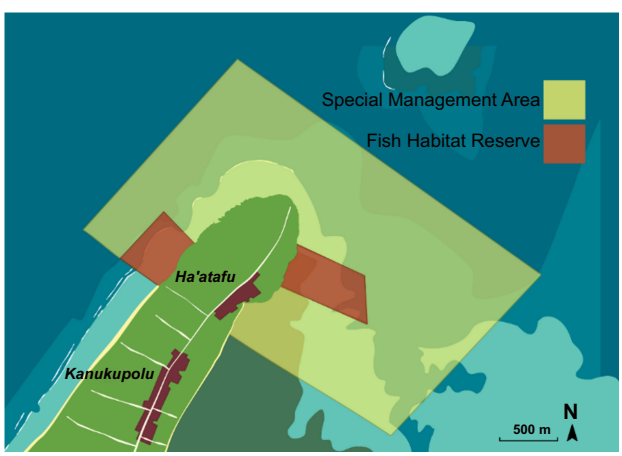

Fig. 1. Map of a typical Special Management Area (SMA) in Tonga. Within the Fish Habitat Reserve (FHR, shown in red) all fishing is prohibited. Within the Special Management Area (SMA, shown in yellow), fishing is only allowed by members of the SMA community (Ha'atafu). Adapted from Smallhorn-West *et al.* (2020*b*).

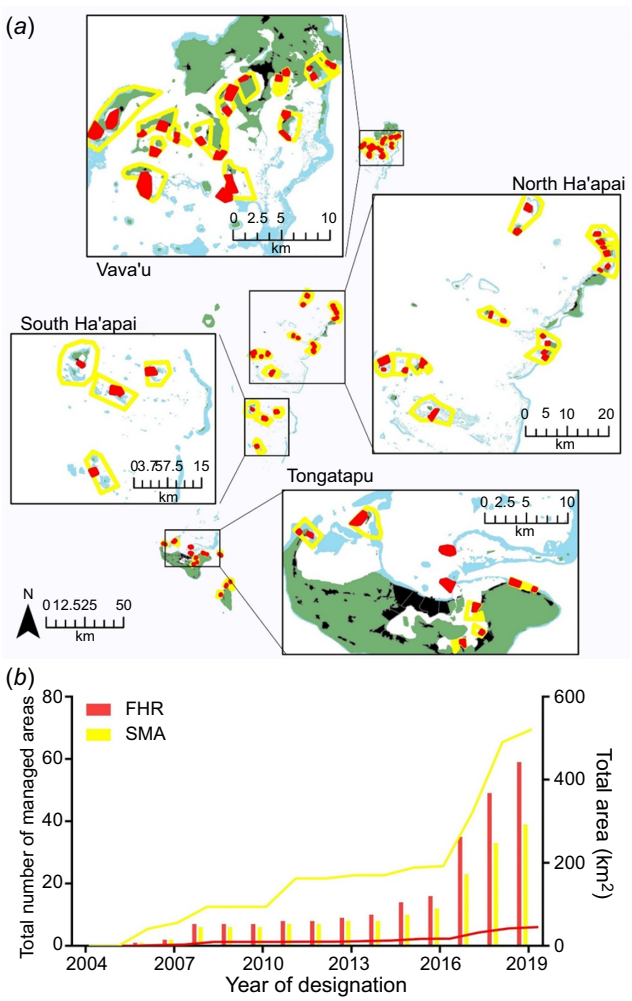

Fig. 2. (*a*) Map of Tonga showing Special Management Areas (SMAs) and Fish Habitat Reserves (FHRs). Yellow denotes SMAs, red denotes no-take FHRs, black denotes communities, and green represents land. (*b*) Growth of the SMA program from its inception in 2004–2019, with bars indicating the total numbers of SMAs and FHRs and lines representing the total area in km^2. This figure is adapted from Smallhorn-West *et al.* (2020*b*).

Methods

This research was conducted as part of an Australian Centre for International Agricultural Research (ACIAR) scoping project examining challenges and priorities of Tonga's SMA program (Fig. 3). This project was a collaboration between the Tongan Ministry of Fisheries, the Vava'u Environmental Protection Association, Civil Society Forum of Tonga, Tapuaki Mei Langi Consultancy, The Pacific Community (SPC), the Australian Institute of Marine Science, and James Cook University. First, we conducted a desktop search of all monitoring and evaluation related to Tonga's SMA program since 2010; focusing on ecological, fisheries, and socio-economic monitoring. We searched government department websites, organisation websites, Google search, and Google Scholar to source reports and publications related to the monitoring of Tonga's SMA program. We then had initial consultations with the relevant parties involved in each monitoring project to locate any monitoring reports that were missed or were not publicly available. Next, we conducted an

Fig. 3. Various aspects of the SMA program: (*a*) Ha'ano village community members; (*b*) Note-taking during community visit to discuss SMAs; (*c*) Buoy delineating SMA boundary; (*d*) Underwater data collection for SMA baseline surveys; (*e*) People fishing in an SMA; (*f*) Group photo with stakeholders from the meeting for the Australian Centre for International Agricultural Research (ACIAR) scoping project. Photo credits: A, B, C, E and F = Ministry of Fisheries, D = Chancy MacDonald.

in-depth consultation during the workshop with the aforementioned stakeholders to further discuss the availability of reports and to obtain consent for use and access to copies of any remaining previously unpublished or inaccessible reports. Lastly, we reviewed each of the monitoring reports to obtain summary information including: the basic objectives of each report, the type of data the project collected (i.e. ecological, fisheries, or socio-economic), which department or organisations conducted the project, who funded the project, and the year that the data was collected (see Table 1). This paper therefore represents the most extensive compilation of Tonga's SMA monitoring efforts and M&E framework to date.

Ecological monitoring

In total, 14 ecological monitoring projects conducted from 2010 until the present were identified. From the initial desktop search, 10 projects on ecological monitoring related to SMAs were found. Following consultations with stakeholders, an additional four projects were identified with reports that are not publicly available. SMA Baseline surveys in Makaunga and Nukuleka conducted by MoF in 2020 did not produce retrievable reports. More ecological projects have been conducted in the Vava'u Island groups (eight projects) compared to the Ha'apai (five projects) and Tongatapu Island group (four projects). Most of these reports were baseline studies and only one resurvey related to SMAs on ecological data has been completed to date. This involved a baseline survey conducted on the WAITT vessel in Vava'u in 2017 and a resurvey following the eruption of the Hunga Tonga-Hunga Ha'apai volcano in 2022.

The objectives of ecological monitoring varied, with some projects aiming to directly assess the status and impacts of the SMA program (Malimali 2013; Smallhorn-West *et al.* 2020*a*), whereas the goals of some other projects were to establish biological baseline data for proposed SMAs (e.g. Ceccarelli 2016; Stone *et al.* 2017). Other projects collected data on ecological indicators and assessed the impact of environmental and anthropogenic disturbances on reef ecosystems from coastal areas in Tonga. The ultimate goals of these projects were to establish a scientific basis for effective management and provide recommendations for government and policy (see Atherton *et al.* 2014; Purkis *et al.* 2017; Stone *et al.* 2021). Although primarily aimed at assessing Tonga's coastal environments, these projects indirectly contribute monitoring data for the SMA regime. One project focused on capacity building and training of government, nongovernment organisation staff, and local communities in data collection techniques and sampling protocols (Stone *et al.* 2017). These efforts aim to support long-term monitoring of ecosystem health within SMAs, while also facilitating baseline data collection and knowledge transfer (see Stone *et al.* 2017). Notably, most of these surveys have been major baseline studies with significant contributions from external parties and there are few examples of resurveys. It is unclear whether any regular community ecological monitoring of SMAs with the objective of informing adaptive management has been conducted.

Methodology for ecological monitoring related to the SMA program has been consistent across most projects. For example, Ceccarelli 2016; Stone *et al.* 2017; Smallhorn-West *et al.* (2020*b*) all employed comparable underwater visual census (UVC) methodologies for fish and benthic photo quadrats to quantify coral cover. Ecosystem and fisheries indicators were also standardised and included fish diversity, abundance, species richness, length and biomass, and coral cover and diversity. Habitat structure and composition were assessed using remote sensing, satellite imagery, benthic video (Purkis *et al.* 2017), and the chain and tape method (Malimali 2013). Surveys also assessed other reef health indicators including coal bleaching, coral recruitment, disease, breakage, crown-of-thorn starfish, rubbish, and pollution (e.g. Atherton *et al.* 2014; Ceccarelli 2016; Stone *et al.* 2021). Baseline intertidal surveys were conducted in Otea and Fangatapu, through World Bank funding and in Holeva and Koloa through Waitt Institute funding. However, in general, there is very limited data available on intertidal monitoring and gleaning.

Fisheries monitoring

Overall, there is limited monitoring and even less reporting available for fisheries data related to SMAs; with eight monitoring projects collecting fisheries data and only five projects with retrievable reports found on the data collected (Table 1). This includes the Ministry of Fisheries (MoF) Annual Reports that contain some information regarding fisheries and catch monitoring related to SMAs. There have also been resurveys conducted on the status of sea cucumber stocks in Tonga in 2016, 2020, and 2023. Fisheries monitoring of SMAs is primarily completed by the MoF through market surveys and landing surveys, and through catch monitoring reported by communities. Regular catch surveys (weekly) of fish landing centres in Nuku'alofa collect data on fishers, species type, and fish weight. Similarly, regular surveys of Nuku'alofa fish markets obtain data on species, weight, and price. There is some ongoing self-reported catch data collected by various communities involved in the SMA program, yet it is unclear whether this data guides community management of SMAs or how the Ministry of Fisheries utilises it. Although these monitoring efforts are ongoing, this data has not been conveyed in reports beyond the Fisheries Annual Report. However, one study conducted community monitoring and evaluated how well it can inform management (Webster *et al.* 2017). This was achieved by evaluating and comparing perception-based data from interviews and catch landings data (Webster *et al.* 2017).

Table 1. Summary of ecological, fisheries, and socio-economic monitoring and evaluation efforts related to Special Management Areas in Tonga.

Project title	Year	Data type	Institution	Funding	Report available	Brief explanation	References
Ecological monitoring							
Socioeconomic and ecological implications of Special Management Areas (SMAs) regime in the Kingdom of Tonga	2010	Ecological, socio-economic	Bangore University	Commonwealth scholarship	Yes	Investigated the ecological and socio-economic implications of SMAs on the reef communities of Tonga. Socio-economic household and fisher surveys in Ha'apai, O'ua, and Vava'u. Ecological surveys conducted in all island groups.	Malimali (2013)
Global Reef Expedition – Living Oceans Foundation	2013	Ecological	Khaled bin Sultan Living Oceans Foundation	Khaled bin Sultan Living Oceans Foundation	Yes	Measured and categorised coral reef environments in Ha'apai, Vava'u and Niuatoputapu.	Purkis *et al.* (2017)
VEPA Biorap Survey	2014	Ecological	SPREP, MLECCNR, MEIDECC, VEPA	Global Environmental Facility (GEF)	Yes	Rapid assessment of the marine and terrestrial biodiversity in the Vava'u Archipelago.	Atherton *et al.* (2014)
ADB Climate Resilience Sector project – Vava'u Special Management Areas Baseline Survey	2016	Ecological	MoF, MEIDECC	Asian Development Bank	Yes	32 sites surveyed in Vava'u as baseline for seven SMAs.	Ceccarelli (2016)
A Review of Special Management Areas in Tonga	2017	Ecological/ fisheries/socio-economic	FAO	FAO	Yes	SMA program was examined for major issues and provides recommendations for improving the program.	Gillett (2017)
James Cook University National monitoring project	2017/2018	Ecological	MoF	James Cook University, ARC CoE CRS, National Geographic Society	Yes	270 surveys for all three island groups. Surveys were conducted inside the FHR and SMAs of 49 communities throughout Tonga.	Smallhorn-West *et al.* (2020*a*) Smallhorn-West *et al.* (2020*b*) Smallhorn-West *et al.* (2022*b*)
Vava'u Ocean Initiative Marine Expedition Interim Report	2017 and 2022	Ecological	MoF/MEIDECC/ VEPA/Waitt institute	Waitt Institute	Yes (Report not available for 2022 survey)	56 sites surveyed on WAITT Vessel in 2017. The same sites and some other sites in Vava'u were resurveyed in 2022.	Stone *et al.* (2017)
Plankton, Cryptobenthic Fishes and Coral Recruitment Monitoring Report	2017	Ecological	MoF, VEPA, MEIDECC	Waitt Institute	Yes	Monitoring and assessment of coral growth and recruitment, zooplankton communities, and cryptobenthic fishes at sites in Vava'u	Buckley *et al.* (2017)
Waitt Institute Baseline Marine Resource Survey	2018	Ecological	Waitt Institute, VEPA, MoF	Waitt Institute	Yes (not publicly available)	Two outer reef sites and two intertidal sites surveyed in Holeva. Two reef sites and two intertidal sites were also surveyed in Koloa.	Stone K, Estep A, Malimalii S, Faanunu H. (2018) [unpublished]
Baseline Marine Resource Monitoring for the Development of Special Management Areas (SMAs) in Vava'u	2019	Ecological	Waitt Institute, VEPA, MoF	Waitt Institute	Yes (not publicly available)	A total of eight sites were surveyed across three proposed SMAs with three sites at both Tefisi and Olo'ua and two sites surveyed at Taoa.	VEPA (2020) [unpublished]

(*Continued on next page*)

Table 1. (*Continued*).

Project title	Year	Data type	Institution	Funding	Report available	Brief explanation	References
SMA Baseline Surveys	2020	Ecological	MoF	World Bank	Yes (not publicly available)	Nine sites were surveyed within Fangatapu FHR including three intertidal sites. Five sites within Otea SMA were also surveyed, including one intertidal site.	MoF and World Bank (2020*a*) [unpublished] MoF and World Bank (2020*b*) [unpublished]
SMA Baseline Surveys	2020	Ecological	MoF	MoF, Civil Society Forum of Tonga	No	Baseline surveys in Makaunga and Nukuleka.	N/A
International Waters R2R – Rapid Coastal Assessment (RaPCA) in the Hihifo District Tongatapu	2020	Ecological	SPC, MoF, VEPA, MLNR	Global Environmental Facility (GEF)	Yes	Rapid biological and ecological assessments in the Hihifo District of Tongatapu. Includes some data from SMAs.	Stone *et al.* (2021)
Fisheries Annual Reports	Annually	Ecological/ fisheries/socio-economic	MoF	MoF	Yes	Annual overview of the Ministry of Fisheries' achievements, outputs and challenges encountered during the year.	MoF (2016) MoF (2017) MoF (2018) MoF (2019) MoF (2020) MoF (2021) MoF (2022)
Fisheries monitoring							
Demographic Assessment of Coastal Finfish	2014	Fisheries	SPC	European Union	Yes	Assessed the demography of key coastal finfish species in Tongatapu. Also conducted training of fisheries staff.	Moore and Malimali (2016)
Detecting Fisheries Trends in Co-Managed Areas in the Kingdom of Tonga	2016	Fisheries/socio-economic	Fisheries Department of WA, MoF	Australian International Aid, MoF, ACIAR	Yes	Uses data from interviews and catch landings data to describe fishing activities, catches and socio-economic conditions since comanagement was introduced in the island of O'ua.	Webster *et al.* (2017)
SPC Sea Cucumber/benthic Surveys	2016, 2019 and 2023	Fisheries	MoF, SPC	PEUMP, NZ Ministry of Foreign Affairs and Trade, MoF	Yes (Report not available for 2023 survey)	In-water survey conducted in all three island groups to assess the status of sea cucumber stocks. Includes surveys from SMA areas.	Moore *et al.* (2017) Shedrawi *et al.* (2020)
A review of Special Management Areas in Tonga	2017	Ecological/ fisheries/socio-economic	FAO	FAO	Yes	SMA program was examined for major issues and provides recommendations for improving the program.	Gillett (2017)
Community catch monitoring	Ongoing	Fisheries	Communities	MoF	No	Some ongoing self-reported catch data from various communities involved in the SMA program.	N/A
Landing surveys	Ongoing	Fisheries	MoF	MoF	No	Regular catch surveys (weekly) of fish landing centres in Nuku'alofa. Fishers, species, and weight.	N/A
Market surveys	Ongoing	Fisheries	MoF	MoF	No	Regular surveys (weekly) of Nuku'alofa fish markets. Species, weight, and price.	N/A

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Table 1. (*Continued*).

Project title	Year	Data type	Institution	Funding	Report available	Brief explanation	References
Fisheries Annual Reports	Annually	Ecological/ fisheries/socio-economic	MoF	MoF	Yes	Annual overview of the Ministry of Fisheries' achievements, outputs and challenges encountered during the year.	MoF (2016) MoF (2017) MoF (2018) MoF (2019) MoF (2020) MoF (2021) MoF (2022)
Socio-economic monitoring							
Socioeconomic and ecological implications of Special Management Areas (SMAs) regime in the Kingdom of Tonga	2010	Ecological, socio-economic	Bangore University	Commonwealth scholarship	Yes	Investigated the ecological and socio-economic implications of SMAs on the reef communities of Tonga. Socio-economic household and fisher surveys in Ha'apai, O'ua, and Vava'u. Ecological surveys conducted in all island groups	Malimali (2013)
MACBIO SMA conference	2015	Socio-economic	IUCN, CSFT, MoF	MACBIO	Yes	'Lessons learned' conference on SMAs. 65 participants with representatives from all island groups.	Tupou Taufa *et al.* (2016)
HIES Surveys	2015/2016 and 2021	Socio-economic	Tonga Statistics Department, SPC	World Bank	Yes	Collected data on household expenditure, income, own-account production and consumption, gender, education, health, labour, primary activities, transport, info and communication and cash transfers and remittances.	Anon (2017) Menaouer *et al.* (2023)
Detecting Fisheries Trends in Co-Managed Areas in the Kingdom of Tonga	2016	Fisheries/socio-economic	Fisheries Department of WA, MoF	Australian International Aid, MoF, ACIAR	Yes	Uses data from interviews and catch landings data to describe fishing activities, catches and socio-economic conditions since comanagement was introduced in the island of O'ua.	Webster *et al.* (2017)
A review of Special Management Areas in Tonga	2017	Ecological/ fisheries/socio-economic	FAO	FAO	Yes	SMA program was examined for major issues and provides recommendations for improving the program.	Gillett (2017)
Tonga National Population and Housing Census	2016 and 2021	Socio-economic	Tonga Statistics Department	Tonga Ministry of Finance	Yes	Household surveys with some fisheries questions.	Tonga Statistics Department (2017) Tonga Statistics Department (2019) Tonga Statistics Department (2021)
ADB Climate Resilience Sector project. Baseline Socioeconomic Survey of the Vava'u Special Management Areas (SMA)	2017	Socio-economic	MAFFF, MEIDECC	Asian Development Bank	Yes	Baseline socio-economic survey across seven Vava'a SMA communities measuring a suite of 30 social indicators.	Parks (2017)

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Table 1. (*Continued*).

Project title	Year	Data type	Institution	Funding	Report available	Brief explanation	References
Tonga Health Socio-economic Surveys	2017	Socio-economic	MoF, Tonga Health	Tonga Health	No	Baseline socio-economic surveys of four communities: Ha'atafu (Tongatapu), Mango (Ha'apai), Fonoi (Ha'apai), and Matuku (Ha'apai).	N/A
FAO SMA workshop in Vava'u	2019	Socio-economic	MoF. FAO	SPC, FAO, Waitt Institute, MoF	Yes	Second national 'lessons learned' workshop regarding SMAs. 140 participants from all island groups.	FAO *et al.* (2020)
International Waters Reef to Ridge Project. – Social and economic report	2020	Socio-economic	SPC, MLNR	Global Environmental Facility (GEF)	Yes	Household survey undertaken at the villages of Ahau and Kanokupolo in the Hihifo District of Tongatapu. Questions assessed community support for SMA program.	Cara (2021)
Household survey for landlocked communities	2021	Socio-economic	MoF. VEPA, FAO, SPC	PEUMP, SPC	Yes	Assesses the impact of the SMA program on the socio-economic status of landlocked communities. A total of six communities (five in Tongatapu and one in 'Eua).	MoF *et al.* (2021)
Household survey of SMA communities	2021	Socio-economic	MoF, VEPA	PEUMP	Yes	Household survey of SMA communities for each island group.	MoF and VEPA (2022) Imhof *et al.* (2023)
MoF SMAs – Lessons learned workshop in 'Eua	2021	Socio-economic	MoF, VEPA	Waitt Institute, World Bank	Yes	Third national SMA lessons learnt workshop. 174 participants from all island groups.	MoF and VEPA (2021) [unpublished]
Fisheries Annual Reports	Annually	Ecological/ fisheries/socio-economic	MoF	MoF	Yes	Annual overview of the Ministry of Fisheries' achievements, outputs and challenges encountered during the year.	MoF (2016) MoF (2017) MoF (2018) MoF (2019) MoF (2020) MoF (2021) MoF (2022)

ACIAR, Australian Institute for Agricultural Research; ADB, Asian Development Bank; ARC CoE CRS, Australian Research Council Centre of Excellence for Coral Reef Studies; CSFT, Civil Society Forum of Tonga; FAO, Food and Agriculture Organization; GEF, Global Environmental Facility; HIES, Household Income and Expenditure Surveys; IUCN, International Union for Conservation of Nature; MACBIO, Marine and Coastal Biodiversity Management in Pacific Island Countries; MLECCNR, Ministry of Lands, Environment, Climate Change, and Natural Resources; MEIDECC, Ministry of Meteorology, Energy, Information, Disaster Management, Environment, Climate Change, and Communications; MoF, Ministry of Fisheries; PEUMP, Pacific–European Union Marine Partnership; RaPCA, Rapid coastal assessment; SPREP, Secretariat of the Pacific Regional Environment Program; SPC, Pacific Community; VEPA, Vava'u Environmental Protection Association.

Finally, it is evident that data is not gender disaggregated and there is very little to no information on gleaning activities in Tonga (Imhof *et al.* 2023).

Socio-economic monitoring

Fourteen socio-economic monitoring projects related to SMAs were identified, spread evenly across all the main island groups (Vava'u = six projects, Hapa'ai = six projects, Tongatapu = seven projects). Most of these reports were baseline surveys and, apart from the Census and Household Income and Expenditure Surveys (HIES), there has been no follow-up monitoring of socio-economic conditions pertaining to SMAs. Although most monitoring efforts have focused on assessing the socio-economic conditions of SMA communities, there was also one survey evaluating programmatic impacts on landlocked communities (MoF *et al.* 2021). Furthermore, reports from national 'lessons learned' workshops have been included in this review as they provide valuable assessments of community perceptions and understandings of the SMA program.

The objectives for socio-economic monitoring have been consistent across most surveys and have primarily focused on examining the impacts of the SMA program on local livelihoods and wellbeing, the challenges of the SMA program, the vulnerability of SMA communities to climate change risks, and the effectiveness of SMA governance. A range of socio-economic, demographic, and governance indicators have been measured to assess these objectives. For example, socio-economic indicators included community perceptions of how well SMAs secure fish for future generations. Demographic indicators encompassed age, gender, education level and health, and governance indicators included awareness of SMA management body and plan, as well as degree of perceived enforcement effectiveness. Socio-economic data has primarily relied on household surveys, with questionnaire design contingent on the department and/or funder operating the project. Multiple donors have contributed to funding of different projects including the World Bank, Tonga Health, Global Environmental Facility (GEF), Pacific Community (SPC) and Pacific–European Union Marine Partnership (PEUMP). Furthermore, these surveys were predominately conducted by MoF, VEPA, and SPC.

Known impacts of Tonga's SMA program

The authors are only aware of two specific studies that have assessed SMA ecological impact and three that have assessed socio-economic impact since SMA implementation. The first is the PhD thesis of the current acting CEO of the Tongan Ministry of Fisheries, which assessed the ecological and socio-economic impacts of five SMAs during their early stages (Malimali 2013). This study found that although the impact of the SMA program was largely unclear, there was evidence that the abundance of large target fish and invertebrate increased in FHRs compared with SMA and control sites in some locations. Malimali (2013) also assessed the socio-economic implications of the SMAs based on perceived attitudes of households and fishers towards the SMAs. The results of this study indicated that SMA households were more likely than non-SMA households to have positive attitudes towards SMA implementation due to perceived benefits of the program to their livelihoods (Malimali 2013).

The second is analysis of seven SMAs from a single dataset collected in 2017/2018 for the PhD thesis of Smallhorn-West (Smallhorn-West *et al.* 2020*b*, 2020*c*). This survey estimated levels of ecological recovery inside seven of the oldest SMAs, established prior to 2014, compared to control areas where fishing is open access. Results showed that positive ecological impacts were evident within some FHRs, specifically in terms of improving species richness, biomass, density, and size of target reef fish. However, there was limited evidence of ecological impacts inside the SMAs where fishing is allowed (Smallhorn-West *et al.* 2020*a*, 2020*c*). Additionally, from the same dataset, Smallhorn-West *et al.* (2022*b*) demonstrated that both no-take areas and areas inside SMAs where fishing is still allowed, have greater fisheries productivity (i.e. the rate at which biomass of target fishes is produced) compared with control areas, which indicates that the volumes that fishers can harvest has increased since implementation of the SMAs.

The socio-economic assessment conducted in 2021 also assessed the impact of SMAs (MoF and VEPA 2022). This survey found that, based on community perceptions, there has been an increase in the number of household members engaging in fishing and harvesting since the establishment of SMAs. However, SMA communities felt that the way they obtain fish and how much seafood they consume has not changed since the SMA program began. Results from this survey also demonstrate that there is overwhelming support for the potential of SMAs to provide seafood for future generations due to perceived increase in abundance and size of fish.

Finally, the household survey of landlocked communities in 2021 conducted by the Ministry of Fisheries also assessed some socio-economic impacts of the SMA program (MoF *et al.* 2021). Results indicate that landlocked communities are experiencing some negative impacts from the SMA program including the loss of access to previously open access fishing grounds, and greater distances to travel for access to fishing grounds. Landlocked communities may not be willing to fish in SMAs because they are unaware of fishing permits and registration options that enable them to fish in SMAs while acting in accordance with rules of the community (MoF *et al.* 2021). The survey suggests that increased awareness and education of SMAs is necessary to enhance the understanding of SMA rules and locations. Recommendations also include

expanding to district level or shared SMAs, with the inclusion of landlocked communities where applicable and practical. Multicommunity SMAs will require legal support and will also need to be tested to determine their effectiveness.

Recommendations

In the Tonga SMA program, dozens of reports document both baseline studies as well as the factors leading to successful expansion of the program, but very little is actually understood about impact on ecosystems, fisheries, or people. There is evidence that, prior to the eruption of the Hunga Tonga-Hunga Ha'apai volcano in 2022, there were some positive impacts from some older SMAs on patterns of fish size, abundance, diversity, and fisheries productivity. Whether these patterns extend to newer SMAs, or persist following this massive natural disturbance, remains unclear. There is also limited available information on fisheries or socio-economic impacts, such as whether patterns of catch are more sustainable, or whether this is in turn leading to improved food security. It is equally unclear what factors (e.g. spatial, environmental, social) might drive successes or failures for various communities. Additional gaps in current monitoring include a lack of gender disaggregated data and almost no information on gleaning, which must comprise a significant portion of national catch. Lastly, economic valuations of Tonga's inshore fishery are only recently being completed (Gillett and Fong 2023), and the economic benefits or costs that the SMA program could be generating or incurring within this sector remain unknown.

These gaps primarily stem from (1) the Tongan government's limited capacity to conduct ongoing monitoring of a rapidly expanded program, and (2) monitoring actions that may be misaligned with needs of government and communities. Similar difficulties have also been encountered by other Pacific Island nations primarily due to a lack of clear monitoring objectives, limited resources, poor engagement, costly and inappropriate methods, and no direct link to appropriate local management responses (Pauly 2006; Govan 2010; Breckwoldt and Seidel 2012). It is crucial that monitoring strategies have clear objectives and that the ways to meet these objectives are appropriate according to the specific needs of communities or institutions. These objectives may include short-term regular monitoring strategies for local communities to track and adapt to changes in the state of the fishery, or monitoring strategies that aim to inform government and policy about the monitoring program.

The objectives of community monitoring should be to regularly assess the progress or success of their management plans and to adapt their strategies accordingly (Govan *et al.* 2011). Community monitoring strategies need to be simple and fit for purpose, meaning that they should address the specific needs relevant to each circumstance. Lessons learned from long-term monitoring of The Locally Managed Marine Area (LMMA) Network in the Indo-Pacific found that the complexity of the monitoring strategies and extensive data requirements limited the ability to gauge the effectiveness of site-based management (Govan *et al.* 2011). It was also unclear whether monitoring data was collected for the purpose of community adaptive management throughout the LMMA network (Govan *et al.* 2011). Of importance is the need to select appropriate, cost-effective, and sustainable methods to generate useful information. For example, fisher perception-based approaches, relying on qualitative data, may be more appropriate, cost-effective and less transactionally expensive for local communities when used alongside quantitative methods (Govan *et al.* 2011; Ruano-Chamorro *et al.* 2017; Webster *et al.* 2017). Fisher perception-based methods may also provide more useful data to rapidly inform community adaptive management.

Additionally, the use of Household Income and Expenditure surveys (HIES) and census data provide opportunities to obtain important monitoring information regularly and with minimal extra cost (Bell *et al.* 2008; Zeller *et al.* 2015; Roscher *et al.* 2023). For example, Roscher *et al.* (2023) used data collected from HIES surveys carried out in 13 Pacific Island countries over the past decade. This study provided valuable information on how households in the Pacific interact with and generate economic value from fisheries resources, which indicates that HIES data may enable long-term analysis of fisheries trends. Furthermore, household surveys can offer valuable data on fishing capacity through questions about the number of fishers in the fishery, boat sizes, fishing methods, and fishing frequency. This information provides a straightforward and effective way to determine the level of fishing pressure within the fishery and to understand its impacts on fish stocks. The effectiveness of other monitoring methodology, such as community-based underwater visual census (UVS) for fish may need to be evaluated against other methods as they have rarely been successful at producing reliable data when operated by communities (e.g. Léopold *et al.* 2009). Calibration of such monitoring with scientific methodologies is often necessary, especially when the data is used to guide management decisions (Léopold *et al.* 2009).

Although participatory monitoring programs can be effective at providing communities with a sense of ownership over their resources (Reis-Filho *et al.* 2023), care must be taken not to incentivise biases in data collection. Hence some third-party monitoring remains necessary, and it is anticipated that this should be completed by national staff. It is acknowledged that extended support from external sources is often necessary for participatory monitoring to be beneficial in low-income contexts (Gardner *et al.* 2020), in which case it should be asked whether the anticipated advantages of community self-reporting (i.e. cost efficiency) are being realised. For example, in Madagascar's first LMMA, the permanent presence of nongovernment organisation Blue

Table 2. Overall SMA monitoring and survey strategy extracted from Tonga's National SMA strategy.

Category	How	When	Main objective
1. All SMAs	Qualitative. Committee/focus group report new questions. Locally appropriate – little training needed	Quarterly committee meetings	Tracking and problem detection of individual SMAs – for community and support staff. Immediately available data.
2. SMAs with training (as many as possible – 20–50%)	Quantitative. Basic catch/effort/size survey. Locally applicable – some training needed	Quarterly or annual (depends on advice)	Effectiveness and problem detection of SMAs. For community and government tracking. To be reported back to the next quarterly meeting (could optimally be carried out the week before the meeting).
3. One site per island (or per major habitat?)	Major survey and resurvey. Costly and must be implemented by trained officers or scientists	Every 5 years or to be determined	Performance of SMA model in each island or habitat. Scientifically robust. Trained officers or visiting academics.

Ventures facilitates adaptive management and supports participatory monitoring methods (Gardner *et al.* 2020). However, the operation of Madagascar's LMMA remains dependnt on external funding. Therefore, although direct external support is often crucial, the most practical investments with potential for long-term impact are those that enhance in-country capacity and the ability of government agencies to provide continuous support (Govan 2009).

The current review recommends that monitoring and evaluation of Tonga's SMA program could be substantially improved through the establishment of a centralised, fit-for-purpose monitoring protocol with a strategic framework focusing on: (1) clear data requirements; (2) efficient methodologies; (3) increased information accessibility, and the incorporation of; (4) gender disaggregated data; (5) data on gleaning, and; (6) an economic understanding of Tonga's inshore fisheries. It is recommended that challenges related to costs and expertise in designing the program and ensuring capacity for data analysis and reporting, are addressed by outsourcing to external experts. However, the monitoring program itself should be designed to incorporate national expertise and capacity, with opportunities for local communities to contribute in meaningful ways. It is recommended that data, analysis, and reporting conducted for all monitoring efforts are stored in a centralised SMA platform that is openly available and intuitive to use. It is important that these monitoring results are then communicated back to communities in an accessible manner and in a format that is easy to understand. For example, the national 'SMA report' (Smallhorn-West *et al.* 2020*b*), which highlighted each SMA and their impacts, is a useful and accessible resource that can be used to raise community awareness and education of the program. This report ideally could be redeveloped every 4 years (i.e. 1 year to survey each of the three island groups, and one year to write the report) and made readily available to each SMA community for their use.

This study, therefore, supports Tonga's National SMA strategy (Ministry of Fisheries *et al.* unpublished), which could be further strengthened by incorporating the considerations outlined in this review. The strategy proposes three categories of monitoring (Table 2). First, the strategy asserts that communities should conduct monitoring to obtain immediately available data and directly inform adaptive management of their SMA. It is recommended that community monitoring is conducted for all SMAs, and qualitative information is recorded regularly i.e. in quarterly committee meetings. Second, the strategy proposes that additional quantitative monitoring be conducted by SMA communities, alongside national staff, to understand the program's effectiveness and to detect any issues. It is also recommended that training should be conducted for as many SMAs as possible. Lastly, the National SMA strategy supports monitoring to be conducted through major surveys and resurveys that assess the overall performance of SMAs using robust scientific methods. These surveys would require support from officers or visiting academics and would be more costly. Initial plans of the MoF were to conduct baseline surveys and resurveys every five years, which still may be a practical target.

Conclusion

The Tongan SMA program was legally recognised in 2002, with the first SMA implemented in 2006. Two decades later, despite much discussion by communities, government, and regional authorities about successes, there has been minimal assessment of the direct impacts of the program. The SMA program has been widely supported by local communities and government, has experienced rapid expansion, and shows potential for durable, long-term change. Furthermore, an extensive groundwork of data collection has been completed from which impacts can be readily discerned. As the SMA program transitions into a new phase where implementation is effectively scaled, the next step is consolidating and refining information to better understand and strengthen the functioning of SMAs and maximise their effectiveness as a management tool.

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Data availability. The data that supports this study are available in the article. The data is included in Table 1, which was compiled from online sources as well as documents provided by Tonga's Ministry of Fisheries. Although some papers referenced in the table may not be publicly available online, they were obtained directly from the Ministry of Fisheries and may be accessed upon request.

Conflicts of interest. Several authors work for the Ministry of Fisheries, which comanages the Special Management Area Program.

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