REVIEW OF THE PACIFIC COMMUNITY MARINE MONITORING TOOLKIT TO SUPPORT COMMUNITY-BASED RESOURCE MANAGEMENT

Johanna Johnson, David J. Welch, Touasi Kalsaria, Ariyo Ake

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Authors:

Johanna Johnson, C_2O Pacific, Port Vila, Vanuatu and Cairns, Australia

David Welch, C_2O Pacific, Port Vila, Vanuatu and Cairns, Australia

Touasi Kalsaria, D.I.R.T. Consultancy, Port Vila, Vanuatu

Ariyo Ake, College of Marine & Environmental Sciences, James Cook University, Australia

Contact for further information

Johanna Johnson at C_2O Pacific: j.johnson@c2o.net.au

David Welch, C_2O Pacific d.welch@c2o.net.au

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Review of the Pacific Community Marine Monitoring Toolkit to support community-based resource management

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1. Introduction

In the Pacific Islands region, coastal marine habitats (coral reefs, seagrass and mangroves) are integral to people's culture and well-being, and support fisheries that make vital contributions to food and nutrition security, livelihoods, and economic development (Johnson et al. in press, Welch et al. forthcoming). However, these marine resources are under pressure due to over-exploitation, increasing human populations and demand for resources, coastal development, land-based pollution and sand and coral mining (UNEP 2017, Brodie et al. 2019, UNESCAP 2020, Welch et al. in press). Climate change is expected to exacerbate these pressures and further impact marine ecosystems throughout the Pacific (Moritz et al. 2018, Souter et al. 2021), with implications for the communities that depend on them for food and livelihoods (Johnson et al. 2017, Johnson and Wabnitz in press).

In the Pacific Islands region, community engagement, participation and empowerment are key to effective and sustainable coastal marine resource management, locally and nationally (Welch 2024). Pacific nations often operate under local customary systems, including marine tenure that has a traditional role in community-based resource management. Therefore tools and resources that support communities to implement sustainable management are critical, especially as governments don't have the capacity to deliver regular or extensive programs across dispersed and remote islands.

A Community Marine Monitoring Toolkit (the Toolkit) was developed in 2016 for **Vanuatu** with the participation of community monitors to inform local and traditional management. The genesis of the Toolkit is based on a co-creation approach, where community members from 27 villages in North Efate shared their coastal resource issues and needs, and what hadn't worked in the past. That is, resource intensive approaches that were overly technical, required specific equipment and external data analysis (often without results returning to communities) were unsuccessful in the long-term. The community wanted to be able to collect data from their environment and know how to apply it to local management, i.e. analyse data and inform decision-making. The monitoring methods were field tested by monitors in North Efate and improved, and the Toolkit has now been extended to communities on other islands in Vanuatu.

The Toolkit aims to empower communities with limited resources or capacity to conduct spatially extensive and regular monitoring of habitats and species, particularly where communities are dispersed and remote, and to support local decision-making to improve marine management (Johnson et al. 2020). Importantly, with growing recognition of the need for community-based and whole of ecosystem marine management (SPC 2021, Welch 2024), the Toolkit provides a standardised approach that can guide improved monitoring and management by Pacific communities throughout the region (Figure 1).

Figure 1. Community Champion collecting fish catch survey data in Vanuatu (Source: Matthew Hardwick)

Since 2016, Community Marine Monitoring Toolkits have been tailored for **Marshall Islands**, **Solomon Islands, Wallis and Futuna**, and **French Polynesia**. While the standardised monitoring methods remain largely the same, the species to monitor, ecological thresholds, and local management actions are adapted each time to suit the local conditions and traditional governance systems. The experience of adapting and tailoring the Toolkit for different contexts has delivered many learnings along the way and has meant that the Toolkit and how it is developed and implemented has evolved over time.

The Community Marine Monitoring Toolkit has been tailored for five Pacific Island Countries and Territories (PICT) to date, and has between 1 and 6 years of implementation in Vanuatu, Marshall Islands and Solomon Islands. This has resulted in a network of community members who are active in local monitoring and management, and can share their experiences and knowledge. The first Toolkit was developed in partnership with the Vanua-Tai Environment Network and Vanuatu Fisheries Department (VFD) as part of the SPC RESCCUE project. Subsequent Toolkits have been developed with funding from the World Bank, Wildlife Conservation Society (WCS), Agence Française de Développement (AFD), the Blue Action Fund, the Tiffany & Co. Foundation, and the SPC Protégé project. Each Toolkit has been tailored to the specific local social, legal and cultural context with input from communities, and has further expanded the reach of community-based monitoring and management.

Project partners who have been involved in developing Toolkit content and materials include the Pacific Community (SPC), VFD, the Marshall Islands Marine Resources Authority (MIMRA), WCS, Service de l'Agriculture, de la Forêt et de la Pêche Wallis & Futuna (DSA), Direction des Ressources Marines (DRM) French Polynesia, and the Centre de Recherches Insulaires et Observatoire de l'Environnement (CRIOBE). Having diverse partners has directed the development of tailored Toolkits, provided input to the simplified monitoring methods, and supported the comparison of methods.

As the profile of community-based fisheries management (CBFM) increases in the Pacific Islands region, various tools have been trialled and it is important to balance scientific accuracy with simplicity and feasibility of methods for communities, particularly remote communities without access to equipment and technical support. Many methods also only focus on collecting data and not delivering results to communities for management or building local capacity. The Toolkit was designed to deliver a complete cycle of monitoring to decision support, providing instant results that can inform local decisions on which management actions to implement, including actions to address issues for fisheries and habitat protection.

1.1 Description of the Toolkit

The Toolkit is designed to meet local monitoring and management needs while also recognising the importance of collaboration with government, and alignment with local traditional governance, national plans and policy (Figure 2). The Toolkit is designed also to be implemented independently or as part of a community management plan, thus providing flexibility on who and how it can be used.

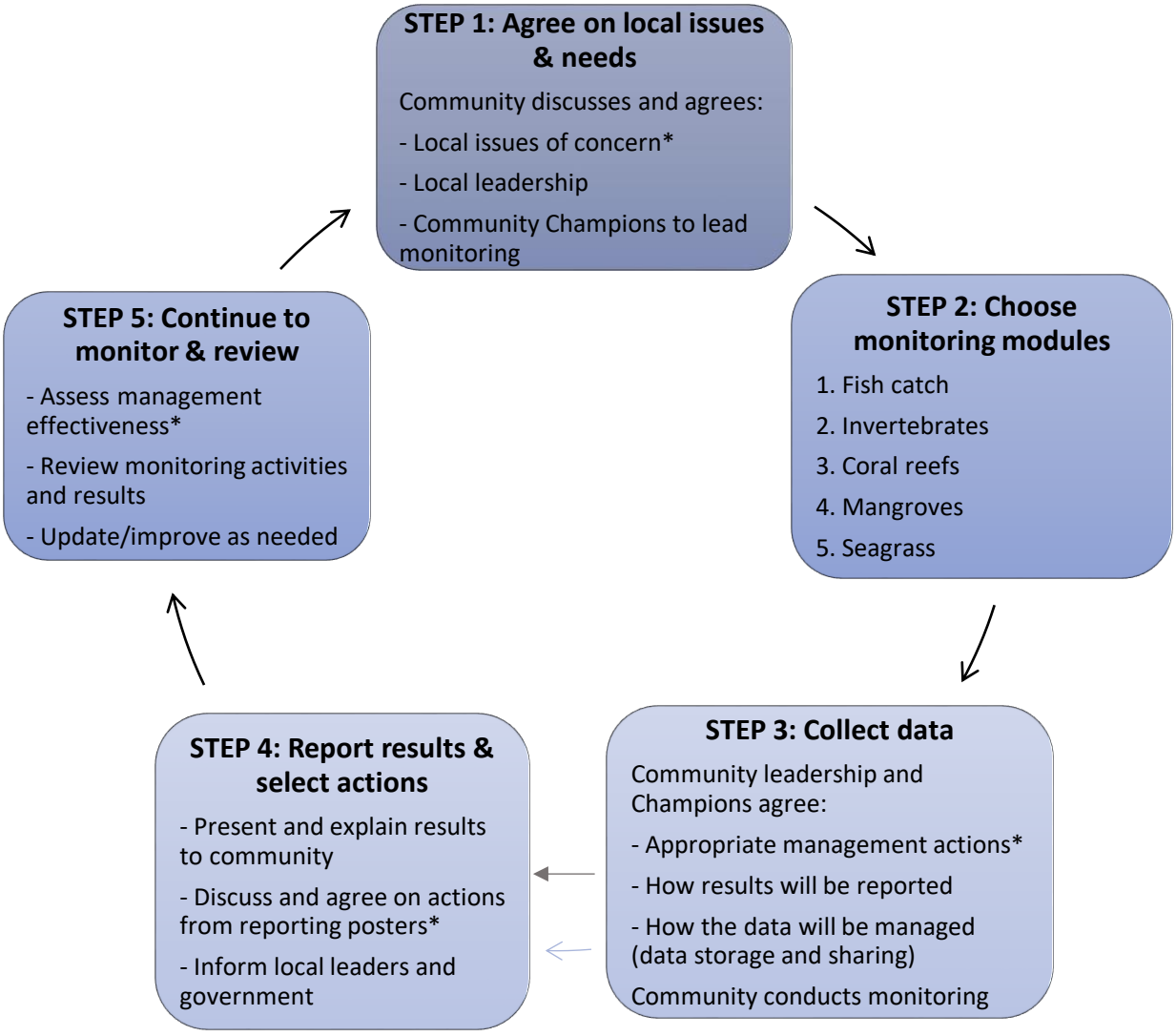


*Figure 2. Toolkit cycle that includes all steps from agreeing as a community that there are coastal marine resource issues and management is needed, to conducting monitoring, reporting results and implementing management actions. * If a community management plan is available, these elements can incorporate the management plan and enable effective implementation of CBFM actions and review of management plan effectiveness.*

The Toolkit package includes a training manual, field guide, survey sheets, reporting posters with management actions (Figure 3), and resources to raise awareness about local marine resource issues within communities. The monitoring modules include fish catch, invertebrates, coral reefs, seagrass and mangroves. Results are instant and provide an early warning of impacts and data that can inform local management and government responses to support recovery and future resilience of coastal resources and communities that depend on them for food and income. Therefore, the Toolkit aligns well with regional CBFM activities and with an ecosystem-based approach to CBFM.

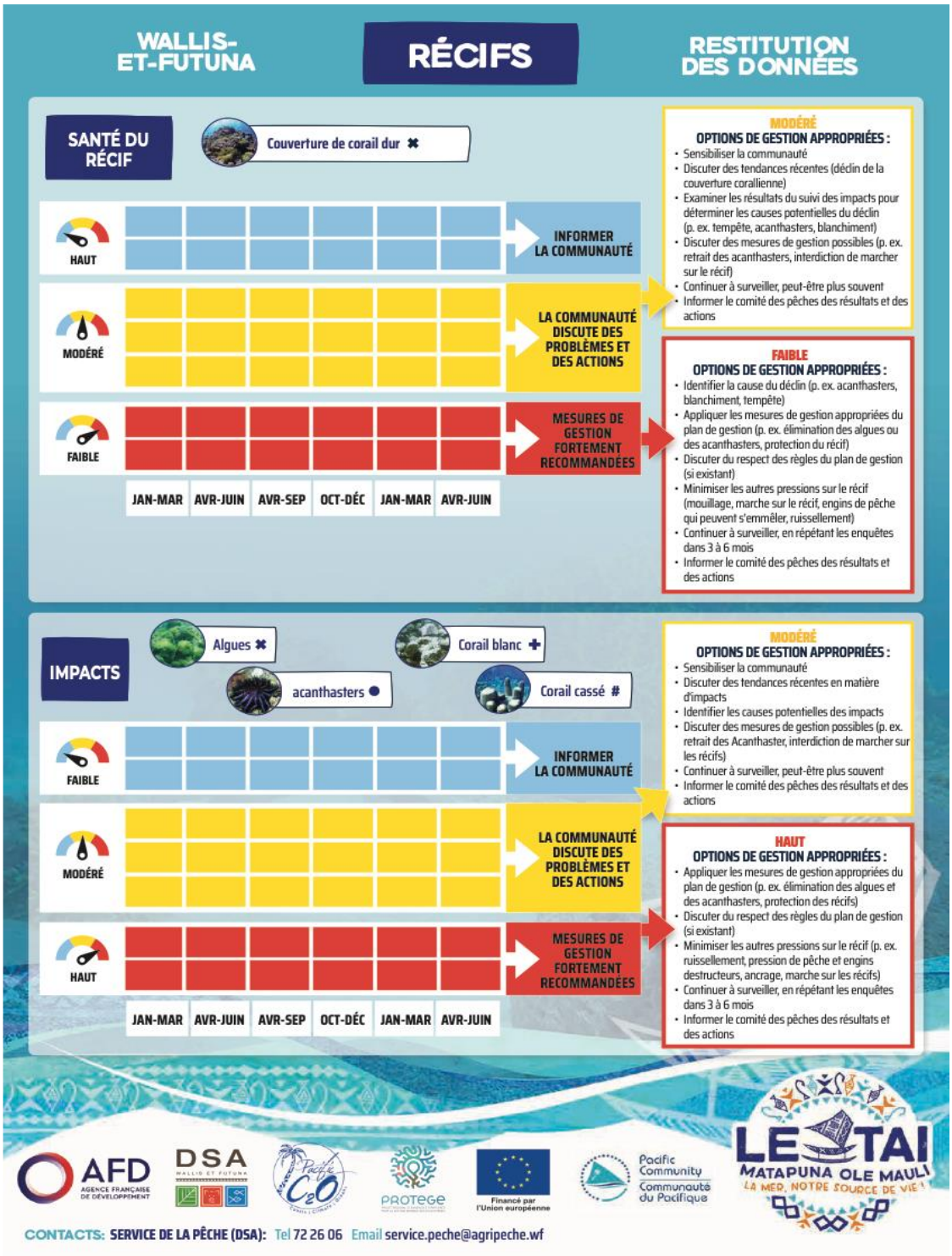


Figure 3. Monitoring data reporting poster from Wallis & Futuna showing grids where results are recorded and then guide community discussion of suitable management action options.

The Toolkit includes simplified versions of scientific monitoring methods for key species and habitats to achieve a balance between robust science and uncomplicated methods for communities. Key to its success, is the standardised process and ability for communities to use monitoring results instantly to inform local decisions, without the need for complex data analyses or external support. The Toolkit is a bottom-up approach compatible with government initiatives and communities' traditional tenure systems, providing information on resource and habitat status to address immediate and medium-term issues in the local marine environment.

The observed benefits of the Toolkit include:

- **Increased local awareness of marine issues through community-led outreach.**
- **Increased ownership of and trust in local monitoring and management.**
- **Implementation of local management actions to address issues.**
- **Enhanced understanding of the rationale for management, thereby improving compliance.**
- **Alignment with and expansion of traditional governance systems.**
- **New livelihood opportunities to generate revenue to support environmental stewardship (e.g. ecotourism).**

Solomon Islands Facilitators Manual and Field Guide.

1.2 Scope of this review

The goal of the Toolkit is to meet community needs in improving and achieving sustainable use of coastal resources. To successfully achieve this goal, it is important to periodically review progress to identify barriers and ensure continual improvement. The Toolkit was first implemented in Vanuatu in 2017 and has now been improved and adapted for use in four other PICT. While some communities are in the early stages of implementation, others have had the opportunity to collect monitoring data using the Toolkit thereby providing a greater understanding of the realised benefits and identify any barriers to its' success.

This review focused on several aspects of the Toolkit development, implementation and early outcomes, and included a preliminary assessment of the robustness of community-based data collection using the Toolkit methods. The review is organised under the following sections: an overview of the different Toolkits developed and their progress in implementation (Section 2), documenting the different development and implementation approaches for the Toolkit (Section 3), the successes and challenges of the Toolkit as reported by communities (Section 4), the robustness of the monitoring methods when compared with scientific surveys (Section 5), and understanding how the Toolkit can be scaled up to other small island states in the Pacific region and elsewhere (Section 5).

2. Implementation progress

The first national Toolkit was developed in 2017/18 for Vanuatu and subsequent national Toolkits have been developed for Marshall Islands 2021, Solomon Islands 2023, Wallis & Futuna and French Polynesia 2024. Currently, there are 35 communities in Vanuatu, 14 municipalities representing multiple communities and atolls in Marshall Islands, and four Districts in Solomon Islands using the Toolkit to monitor and manage their marine resources. Communities in Wallis and Futuna and French Polynesia are receiving training in monitoring methods in mid- to late-2024 and will start implementation once trained.

In **Vanuatu,** implementation has been variable by communities in North Efate, Ifira Island in Port Vila Harbour and Tanna Island, depending on Marine Champion motivation and other commitments. All modules of the Toolkit have been used, with the fish catch and coral reef modules applied the most. In some communities, Marine Champions have collected years of fish catch data, with over 40 surveys from Mangaliliu village collected from 2017–2023 analysed and used to generate discussions in the village about increasing the size of their marine tabu area and ban some fishing practices. Some Marine Champions are also government Fisheries Authorised Officers, meaning they can enforce fisheries rules if they detect an issue or a breach. The intertidal invertebrate module and mangrove module have been used mostly at targeted locations (e.g. Ifira Island). The mangrove module has also been incorporated into the national Vanuatu Terrestrial Monitoring Toolkit by the Department of Environmental Protection and Conservation (GoV 2024). This is increasing the use of the mangrove module with communities that have terrestrial tabu areas to monitor.

In **Marshall Islands**, the Toolkit supports step 7 of the Reimaanlok Conservation Area Management Planning Framework and Toolkit resources were distributed by MIMRA in 2022–2023 to communities that had developed their management plans and established local conservation areas. The initial focus was 4 rural communities surrounding Majuro then expanded to 13 municipalities on outer atolls. The first round of training was conducted by MIMRA in Majuro with community champions from the 14 municipalities who returned to their atolls to train other community members. The governance in Marshall Islands is a co-management approach with MIMRA staff supporting municipalities and community monitors at all stages. In late 2024, MIMRA will visit the outer atoll municipalities and review implementation progress and challenges. For example, it has been noted on some atolls that some invertebrate species are not observed and this may lead to a review of the species included and/or options for a restocking program in local conservation areas. The most commonly used modules are coral reef and invertebrate. The fish catch module has been used and monitors report it being easy, but fishers are reluctant to participate because they're tired or don't want to share their catch information. Reporting back is occurring, and local conservation area owners are using the results to share key messages and inform local actions. Data management is based on monitors sending in photos of survey sheets, but not all communities send them regularly, and MIMRA maintains a central database. The plan for 2025 is to have more regular data submissions and resolve compensation issues that a small number of communities have asked for. Encourage monitors to at least report to the community and use it for awareness raising even if they won't share data to the centralised database. The partnership between MIMRA and the municipalities has allowed for good communication and feedback, and recent discussions have identified interest from municipalities to fund officers to coordinate Toolkit monitoring in their area. As monitoring is step 7 of the Reimaanlok Framework, results can support funding requests to MIMRA to implement targeted management actions to address impacts or issues in their area.

In **Solomon Islands**, communities have been collecting fish catch data over a 3-month period, aligning with the monitoring schedule described in their Community Fisheries Management Plans, that specifies a round of surveys every 6 months. One community with significant mangrove habitats is also using the mangrove module. Communities have reported that the Toolkit methods are simple for local community members to understand and implement, and the only recommendation for improvement is the need to put together sets of monitoring equipment that communities can borrow or share to conduct surveys. Challenges identified so far include ensuring that community monitors get out on a regular basis to conduct monitoring activities, which may require a documented monitoring schedule posted in the village and a support budget that can cover fuel and other small costs.

The Vanuatu Toolkit has been implemented the longest and, despite having minimal national support that has varied with personnel changes, has seen continued use by community members. Community members continue to share monitoring data for digital storage. The method being used the most in Vanuatu is the fish catch survey, with data now collected since 2017. An example of the type of information being generated by these data collections is given in Figure 4. The use of the critical size and the proportion of the catch larger than this as an indicator of sustainability, and reference levels for this in the module, provide a simple framework to guide communities in their management decision-making. For example, in Vanuatu, while the target is for 90% of the catch to be larger than the critical size, the Toolkit provides precautionary management guidance when the percentage of the catch smaller than the critical size is between 70 and 90%. Below 70% guides communities to take urgent action with suggested management options. Figure 4 demonstrates that large portions of coastal catches are of fish likely to be smaller than breeding size; this is generally well known but few (or no) data exist to demonstrate this.

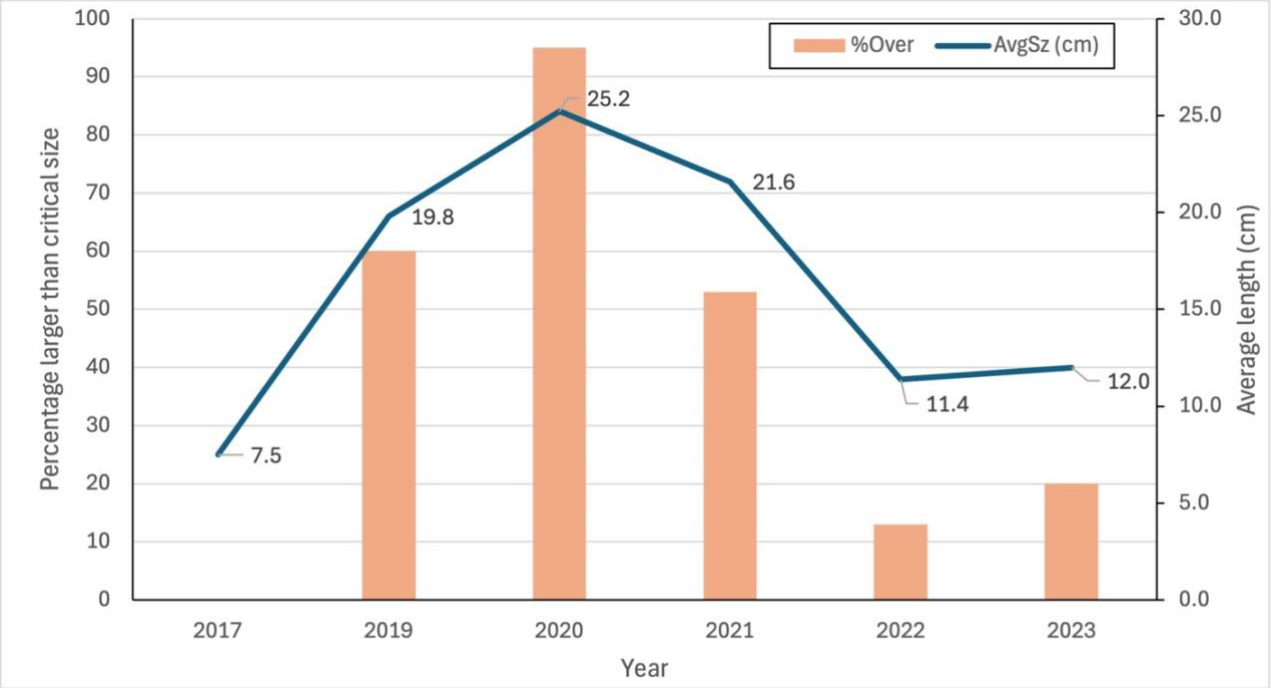


Figure 4. Summary of fish catch survey data collected for Strongskin (Surgeonfishes; Family Acanthuridae) from north Efate Island in Vanuatu from 2017–2023. Bars indicate the percentage of the catch that are larger than the critical size given on the left axis (a proxy for minimum catch size based on size at maturity); the target is 90%. The plotted line shows the average fork length (cm) in each year given on the right axis, with the average length value shown. N.B. The critical size for Strongskin is 20cm.

2.1 The 'prototype'

The first Community Marine Monitoring Toolkit was developed by international experts in partnership with community members from North Efate, Vanuatu, who specifically requested a tool that they could take responsibility for all stages of monitoring, including data interpretation and management decision-making. The Vanuatu Toolkit took 2 years to develop (2016–2017), with several testing and validation phases during which time, the concept of community Champions was established with a core team of 12 Community Champions training the first round of resource monitors from 27 communities. Since 2018, the Toolkit has been expanded to Vanuatu communities on Ifira Island and Port Resolution, Tanna Island, and current estimates are that there are 20 Champions and 52 trained resource monitors in over 30 communities on six islands.

Community Champions

Key to the success of the Community Marine Monitoring Toolkit is the involvement of local Community Champions in the development, training and delivery of monitoring methods and activities. Community Champions are local individuals nominated by their community based on their demonstrated interest in environmental stewardship and prior experience as local leaders or resource monitors. Developing and training the Toolkit methods to be locally appropriate and responsive to community needs gives the Champions and their communities the capacity to monitor and manage their resources without the need for external support, analysis or input. Community Champions build leadership and teaching skills, so they can lead community training, monitoring activities and meetings in their village to discuss the results. This has resulted in additional benefits where Community Champions have reported a greater standing of respect in their community, and noting that their experience and enhanced local profile have created numerous opportunities such as access to competitive scholarships for further education or election as a local Councilor.

2.2 The evolution in development processes

Initial engagement and community consultation

Early and inclusive initial engagement with local leaders and environment networks or village committees are an important step in developing each Toolkit. Local leaders are always consulted as an initial step to gain their endorsement, and all communities nominated local Champions to be involved and lead future training and awareness sessions, including community review and discussion of monitoring results. Through a series of community meetings that educate about Toolkit monitoring, coastal resource issues, and management solutions, whole communities become involved, which is a key tenet of CBFM (SPC 2021).

Testing and feedback

The Toolkit builds capacity at the local level by enhancing understanding of marine coastal ecosystems and issues, and facilitates active local coastal resource management. Each Toolkit is tailored to address specific local coastal resource issues (e.g. overfishing, coral reef damage) and this process incorporates testing of monitoring methods by local communities and feedback to make any updates or improvements. For example, early mangrove modules included six indicators for health and impacts, and two indicators that were difficult for community monitors, and returned highly variable results, were removed. This testing process is led by Community Champions and is essential to ensure the monitoring methods and modules included are locally appropriate, robust and will be implemented by the community long-term.

Toolkit development

The Toolkit development process is collaborative between specialist scientists, community members and government. The focus is on selecting modules that monitor the key species and habitats important in the PICT, and identifying fish and invertebrate species that are exploited for food and/or livelihoods. The thresholds for indicators in all modules are based on local data where they are available (e.g. average hard coral cover), or sub-regional and regional data where local data are limited (e.g. invertebrate density estimates). The development process is iterative and responsive to local government and traditional knowledge, and the outcomes of the testing and feedback step. During Toolkit development, local coastal resource issues and the potential management actions to address these issues are discussed. This raises awareness of local issues and the need for local management, and it has been noted that both developing and implementing the Toolkit has prompted some villages to review and/or develop a local coastal resource management plan.

Final training

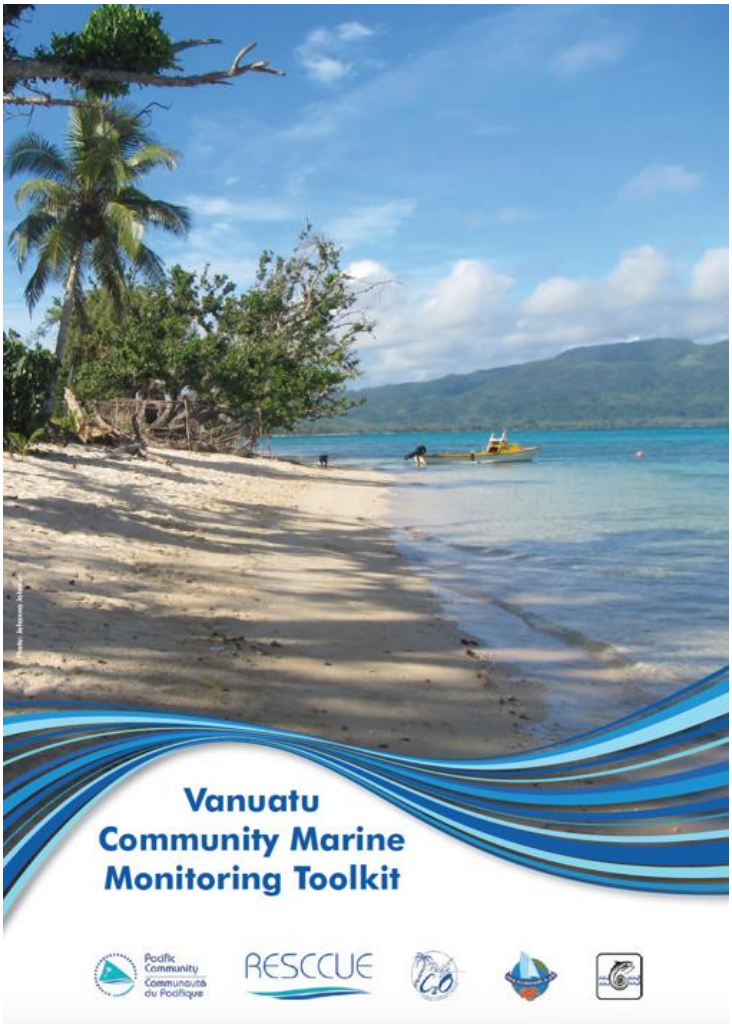
The training of Toolkit monitoring methods and conducting monitoring strongly promotes a participatory approach with key members of the community. The Champions teach Toolkit survey methods based on their areas of interest and knowledge. Training by Community Champions provides skills and leadership development of Champions, and increases capacity of local community members. It also facilitates local delivery of monitoring methods, including practical field sessions led by Champions and supported by specialists. Ultimately, training is an ongoing process, and it is recommended that Champions work together to refresh their monitoring skills, and also deliver training annually in their villages to refresh monitors and upskill new and emerging local monitors, particularly youth.

Governance mechanisms

Throughout the Pacific, local land and sea custom tenure is key to local management and is recognised in the development and implementation of each tailored Toolkit. The Community Marine Monitoring Toolkit has been developed using a range of approaches across different PICT, from community-driven bottom-up approaches to more top-down approaches. Similarly, once developed the Toolkit has been implemented using different approaches. With several years of lessons learned and with the Toolkit implemented in multiple PICT, it is clear that a co-management approach to implementation is critical to its success. This is because the current Toolkit model necessarily involves some technical elements and minor resource requirements, however simplified, and implementation benefits from ongoing support. These resources involve minor costs, as does refresher training, training new monitors, and conducting surveys. Further, the implementation of the Toolkit using a top-down approach is no longer a community-based tool.

However, there can be many levels of co-management, based on the relative level of responsibility and control by the different partners (Figure 5). While communities are a key co-management partner, other partners used successfully in the implementation of the Toolkit among PICT so far include government departments and local NGOs, or a combination of these. The choice of co-management partners and their respective roles and responsibilities in Toolkit implementation can be tailored to the local need and context, available resources, and the political and social circumstances in the PICT. It is also noted that with more experience implementing the Toolkit, the co-management arrangements can evolve leading to greater community responsibility.

Figure 5. Co-management is central to how the Community Marine Monitoring Toolkit is developed and implemented, for which the relative level of responsibility among partners can be tailored to the local context, available resources, and the political and social circumstances.



The first Toolkit developed in Vanuatu was endorsed by the national government, however it was not implemented with external support and was therefore an approach with full community responsibility. While this first Toolkit is still being used and needed by communities in Vanuatu, the lack of ongoing support has presented many challenges while also providing many learnings in the development of subsequent Toolkits. The success of this first Toolkit in empowering communities and establishing Champions who lead resource monitoring and local management (Johnson et al. 2020) therefore, led to the tailoring of the Toolkit for communities in the Marshall Islands, Solomon Islands, Wallis and Futuna, and French Polynesia. The Marshall Islands Toolkit was developed using a co-management approach but with a strong lead by government, through the Marshall Island Marine Resources Authority (MIMRA), and under a nationally-funded initiative.

Implementation is continuing with MIMRA now engaging with Local Resource Committees on all atolls and transitioning to a co-management model that gives communities increasing responsibilities. The Solomon Islands and Wallis and Futuna Toolkits were developed using a co-creation partnership approach, with participation by different community and environment groups during the tailoring and testing of methods. Implementation is continuing under these co-management partnerships with an NGO (Wildlife Conservation Society) and government providing leadership and support in Solomon Islands and Wallis & Futuna respectively. French Polynesia has been tailored using a similar approach to the Marshall Islands, with a gradual transition to increasing community involvement and responsibility, although this is the newest Toolkit with training ongoing.

The advantages and disadvantages of these different approaches will vary by country and territory, with a summary in Table 1. Noting that a comprehensive review of the successes and challenges of monitoring and management over time are outlined in Section 4.

Table 1. Benefits and challenges of the different approaches to develop and implement the Toolkit.

Approach	Advantages	Disadvantages
Bottom-up / community-led	- Grass roots initiative that empowers communities - Community owned and led - Doesn't require external support - Addresses local resource issues - Increases awareness and environmental stewardship	- Lack of support may limit sustainable use of the Toolkit - Government ownership can be limited - National benefits may not be realised - Coordination at national scale more difficult - Quality of data may be compromised with lack of technical support - Requires good organisation at the local level
Equal share responsibility	- Ownership by communities and government - Builds trust and partnerships - Addresses local resource issues and national policy - Technical and funding support from government (as needed)	- Requires local coordination and co-management governance system
Government or NGO led	- Coordination at national scale - Addresses national issues and policy - Technical and funding support from government (as needed)	- Loss of community ownership - May not address local resource issues - May be subject to political influence - Tendency for more technical methods - Additional resources needed to engage communities and deliver training and awareness

3. Successes and challenges of the Community Marine Monitoring Toolkit

As the Toolkit scales up through the Pacific region, further information on how implementation is progressing and lessons can inform further development and improvements. Therefore, feedback from communities and NGOs using the Toolkit in Vanuatu, Marshall Islands and Solomon Islands was documented from February 2022 to May 2024. It included formal interviews of 20 Vanuatu Champions (5 females and 15 males) in 2022, surveys of community monitors from four Districts in Western Province, Solomon Islands in 2024, and structured feedback from MIMRA and WCS in 2023 and 2024 who were involved in Toolkit development and training. Informal discussions with eight community members and the Service de l'Agriculture, de la Forêt et de la Pêche in Wallis & Futuna in August 2024 after initial training described the Toolkit methods as useful and easy to use.

Figure 5. Marshall Islands Facilitators Manual and Field Guide.

Interviews were conducted with individuals or in a group setting, and all feedback was anonymous, if requested. Each respondent spoke passionately about their experience using the Community Marine Monitoring Toolkit, training others in the methods, the simplicity of the methods, and how they have applied the results to local management. Below is a summary of the feedback in terms of the successes and challenges with the Toolkit, and future opportunities for improvement and expansion.

Pacific government agencies and community resource monitors have provided general feedback on the Toolkit (Figure 6), and some factors to be considered for future training and implementation include:

- The modules are practical and easy to follow, with the most commonly used modules being Module 1: fish catch, Module 2: invertebrates, and Module 3: coral reefs.
- The Toolkit is at the appropriate level for many community members who often have low literacy and numeracy skills.
- The Toolkit is a great resource to empower communities for marine resource monitoring and management.
- Monitoring is not planned in advance but generally opportunistic when monitors are available.
- Champions/monitors are more comfortable using the monitoring modules that they have delivered training on.

Figure 6. Feedback received regarding the Community Marine Monitoring Toolkit from resource monitors.

3.1 Successes

- The Toolkit is the first of its kind and complements existing conservation programs (e.g. Reimaanlok – National Conservation Area Plan in Marshall Islands) and traditional marine tenure systems (e.g. local Tabu areas in Vanuatu).
- Government and community members appreciated how the Toolkit is designed to meet local/national needs and governance systems.

- Champions and community monitors reported that they used their training to train others as monitors or to educate community members about concepts such as the importance of healthy marine resources and sustainable fishing practices.
- Awareness information has been used to educate community members and change behaviours that improve marine management (e.g. Ifira tabu area mangrove clean-up and replanting, engagement of primary school classes in monitoring on Moso Island, banning of small mesh nets and hooks in Sunae village (see case study)).
- Champions and community monitors note that training in the Toolkit equipped them with tools, skills and confidence that they have applied to a range of other areas (e.g. sustainable crop initiatives, applying for technical training courses), and helped them be adaptable during disasters (e.g. Covid-19 pandemic). It has particularly empowered the female Champions to become more active in decision-making in their community.
- Champions who had an interest in environmental matters before the Toolkit training remain passionate and committed to marine monitoring and management. They also continue to be inspired by those they have trained and worked with in communities.
- Reporting back is occurring, and local conservation area owners are using the monitoring results to share key messages and inform local management actions.
- Delivering monitoring and awareness training in their communities broadened monitor's appreciation of what being a local leader and champion is. It resonated on a personal level and gave community monitors the confidence to engage more broadly on issues.
- Active management for a healthy marine ecosystem, including fish populations and coral reefs, has provided ecotourism opportunities and access to funding for villages to promote their marine environment and upgrade communal water and sewage systems.

Case Study: Sunae village, Moso Island, Vanuatu

In Sunae village on Moso Island, two community members have been identified and trained as Marine Champions, and they have led several village community days that included youth, elders and pikininis (children). The Champions taught Toolkit survey methods which included conducting intertidal surveys of sea cucumber species and in doing so, developed a novel field data recording system using sections of palm branches. The raised awareness has led the village Environment Committee to extend the boundaries of their tabu area to be one of the largest in Shefa Province. Further, the Champions conducted fish catch surveys and the results were presented to the village leadership groups for discussion. The results of the surveys showed that, for all except one of the fish family groups caught by local fishers, the majority had very high proportions of juvenile fish in the catch (Figure 7).

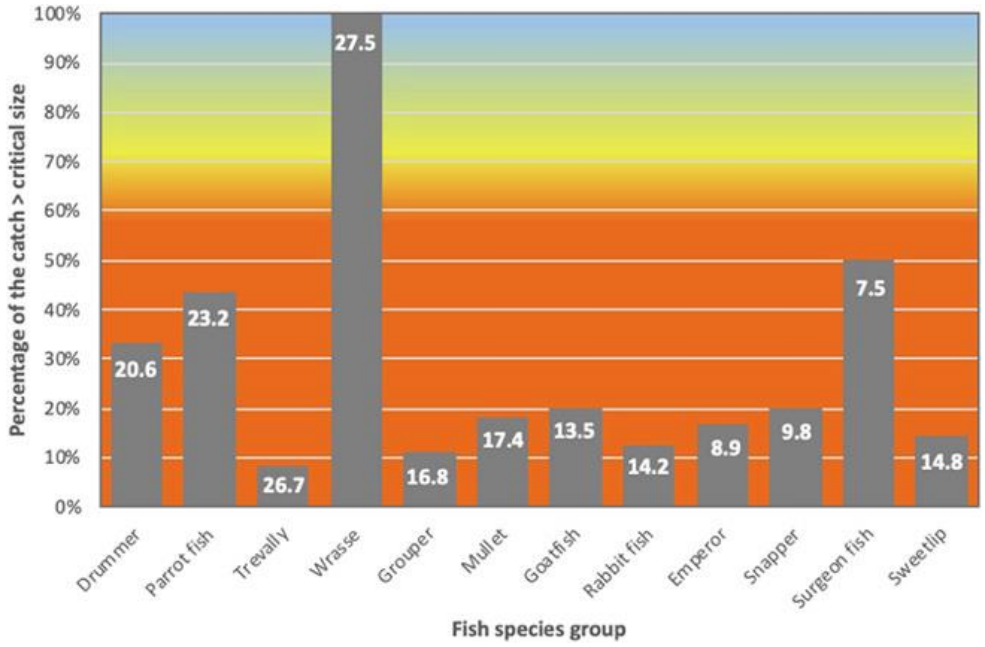


Figure 7. Fish catch survey data from Sunae village showing the percentage of each key fish species group larger than the critical (breeding) size. The background colours represent those on the Data Reporting Posters that show the level of action required (see Fig 3). The average size of fish caught for each species group is given in cm.

This provided locally relevant evidence for discussion about the impacts of catching fish before they were large enough to breed, and provided a powerful basis for discussing local management strategies that would reduce the catch of juvenile fish by addressing poor fishing practices. The outcome for Sunae village was that village leaders agreed to introduce three new management measures: (i) ban the use of parachute (cast) nets; (ii) introduce a minimum mesh size of 3 fingers for gillnets; and (iii) introduce a minimum hook size for line fishing.

3.2 Challenges

- Motivation: Maintaining regular monitoring for voluntary monitors is difficult and other commitments (paid or essential for growing or collecting food and water) are prioritised.
- Community-driven implementation without support through a co-management approach can result in irregular monitoring and poor data management and storage.
- In Vanuatu, there is some confusion about Module 1: fish catch surveys and the SPC TAILS App. However, there are important differences in the data collected between the two methods, with TAILS developed to monitor nearshore FAD catches, and currently

only the Toolkit provides instant results, so communities continue to use it. A new App has recently been developed by SPC – IKASAVEA – for surveyors to collect market, landing and socio-economic data, and alignment between these methods is needed.

- Accessing financial support for print monitoring sheets and reporting posters, coordination and communication within the network, and maintaining data systems. NGOs and government partners who support communities should ideally have a budget that support regular monitoring and environment committee meetings.
- The “reporting back to communities” step isn’t always completed because the importance of monitoring and the data being collected isn’t always well recognised by village leadership and committees. This speaks to a potential governance issue.
- It has been noted on some atolls in Marshall Islands that some invertebrate species are not observed and this may require a review of the species included and/or options for a restocking program in local conservation areas.
- The fish catch module has been used in Marshall Islands and monitors report it being easy, but fishers are reluctant to participate because they’re tired or don’t want to share their catch information.

Figure 8. Wallis & Futuna Facilitators Manual and Field Guide.

3.3 Future Opportunities

- Some additional skill areas were identified to support community monitors in their role, such as leadership, governance, communication, and proposal writing.
- Future Toolkits should maintain the model that communities nominate Champions/ monitors who are interested in environmental matters as a pathway to engaged and effective implementation.
- Importance of sub-national or national networks where monitors can share experiences, deliver training together, and discuss results and management actions. A regional network of monitors (either new or linked to an existing group) to facilitate peer-to-peer exchanges across PICT would enhance knowledge sharing and learning.
- Champions/monitors should be trained in all Toolkit modules, and receive refresher training every year, if possible. Engaging youth in monitoring will also expand the program and maintain long-term momentum.
- Training fishers to use Module 1: fish catch, is an effective way to increase data collection and raise awareness about fishing practices and resource condition.
- Consultation with SPC FAME Division to align the Toolkit and TAILS/IKASAVEA Apps, noting that the methods are consistent but data management and instant access to results is a feature only of the Toolkit.
- Effective coordination, and a secure and easier data management and storage system.
- There is increased concern for food security and a desire to create opportunities to discuss this with all levels of the community, particularly youth groups and families, as part of the Toolkit engagement.
- Identify members of the community who interact more with a particular resource or habitat to be involved with leading or coordinating monitoring of that resource/habitat. For example, women are more ideally suited to carry out seagrass monitoring as they spend more time in this habitat than the men.
- It is also advisable to include community schools with resource monitoring activities as part of their school program, and actively engage youth in monitoring.
- An effective partnership between government and communities or local municipalities provides mechanisms to share results widely and potentially to fund officers to coordinate Toolkit monitoring in their area. There is also the opportunity for government to support funding requests to implement targeted management actions to address impacts or issues in their area supported by monitoring results.

4. Comparison of monitoring methods

In the face of growing pressures on coastal marine resources, monitoring tropical marine habitats and key species is important to inform sustainable coastal resource management (D'Angelo and Wiedenmann 2014). However, there is limited capacity within governments or NGOs in many Pacific nations to conduct regular or spatially extensive monitoring, particularly if monitoring requires substantial technical skills, equipment or is expensive. These challenges are exacerbated in island and atoll nations that are geographically dispersed and/or isolated. This makes communities primary actors to conduct local monitoring that can identify impacts and inform local actions to manage their marine resources. With simple, robust and affordable monitoring tools that link directly to traditional management systems, communities become empowered and trusted to make effective and informed decisions to manage their marine resources and adapt to future changes (Danielsen et al. 2005, Johnson et al. 2020). Monitoring data can also be shared with government to inform national management and policy.

A summary comparison of the community Toolkit coral reef monitoring method with scientific surveys in terms of frequency, purpose and requirements is provided in Table 2. A more comprehensive analysis of coral reef Toolkit monitoring results with scientific survey results is provided in Sections 4.3–4.4. The Toolkit is designed for people with no scientific training and little to moderate monitoring experience who have an interest in their marine resources. One of the strengths of the Toolkit is that it can be used to monitor the same site regularly and document changes over time. It can also be used to get a snapshot of reef health at less frequently monitored sites and as an early warning of impacts. The survey can be completed in a short time, with minimal equipment and the method is designed for people without a scientific background.

Notably, since the Toolkit reef monitoring method is based on citizen science programs in other locations (e.g. Great Barrer Reef[1]) and is a simplified version of the benthic transect method, there is consistency in many aspects, such as indicators and transect length. However, scientific monitoring is variable by program in terms of the recommended frequency and purpose, the taxonomic detail recorded, and requires substantially more time, equipment, analysis, and specialist technical training.

[1] https://www2.gbrmpa.gov.au/help/eye-on-the-reef

Table 2. Comparison of requirements of the community Toolkit monitoring and scientific reef survey methods

	Toolkit method (Module 3)	**Scientific benthic reef surveys**
Recommended frequency	Annual or if there is an acute disturbance (e.g. cyclone)	Varies depending on the monitoring program
Purpose	i. assess condition of local reefs ii. early warning of impacts affecting reef condition iii. raise awareness in communities about marine management iv. assess if management is effective	Varies depending on the monitoring program
Indicators	• Hard coral cover • Macroalgae cover • White (bleached) coral • Crown-of-thorns starfish • Broken coral	• Habitat complexity • Benthos composition (coarse) • Macroalgae observations (% cover, morphology, growth height) • Hard coral observations (% cover, morphology, dominant genus) • Coral bleaching (% bleached, severity) • Coral disease (colonies affected, % coral affected) • Coral predation (COTS scars, Drupella scars, % coral affected) • Recent coral damage (% corals affected, colonies affected, severity, cause)
Transect length	50 m x3*	50 m x3
Time to complete	20 mins	60 mins
Technical capacity	Requires training in - estimating percent (%) cover (of hard coral, macroalgae, broken coral), - recognising bleached coral, and - finding COTS	Scientific skills in identifying hard coral to genus level, SCUBA diving qualifications
Equipment	Underwater slate or paper, pencil, mask & snorkel (fins optional)	SCUBA gear, 50 m transect tape, underwater slate/data sheet, pencil
Cost	Low	High

** Note that different PICT have selected different transect lengths for their Toolkit methods, with some opting for 2x 100 m transects (Wallis & Futuna) and others having 3x 50m transects (Vanuatu). Some have also preferred the use of timed-swims that correspond to 100m transect (Marshall Islands and Solomon Islands). For the purposes of this comparison, the same 3x 50 m transects were used.*

 # Different monitoring programs focus on different indicators, usually identifying hard coral to genus level and some other benthic species. Notably, the GCRMN global and Pacific status and trends analyses only use hard coral cover and macroalgae cover due to disparate methods. For this comparison, data from the same 5 indicators were compared statistically.

4.1 Data collection

This review presents a preliminary analysis of coral reef monitoring data collected in Vanuatu and French Polynesia in 2023. In Vanuatu, survey data from four sites collected by experienced community monitors using the Module 3 Toolkit method (see Appendix A) was compared with scientific data collected using a benthic line-intercept transect method by a scientist. The data was collected at the same time using both Toolkit and scientific monitoring methods that included measures for five reef health indicators: live hard coral cover, macroalgae cover, bleached (white) coral, crown-of-thorns starfish (COTS), and broken coral. The review evaluated the consistency and alignment between community data and scientific surveys, identified areas of convergence and divergence, and provides valuable insights into whether Toolkit methods are fit-for-purpose to determine coral reef condition and inform local management.

Scientific surveys used a benthic transect method at the Vanuatu sites, collected by C_2O Pacific scientists. The benthic line-intercept transect method quantified four indicators as an average percent cover for each 50 m transect, and a fifth indicator for density of COTS present. The surveys were conducted using snorkel along three replicate transect lines (50 x 1 m) placed on the reef slope along the same depth contour at each site. The distance between the three replicates was at least 10 m. Both methods recorded the site details (depth, visibility, habitat type, tide) and indicators for each replicate transect at varying degrees of detail, with the scientific surveys collecting more taxonomic information. The results were then averaged across replicates for each site. Monitoring survey sheets for both methods are provided in Appendix B.

In French Polynesia, data collected by three newly trained community monitoring teams from the same site on the same day was compared. This allowed evaluation of observer bias and areas where Toolkit training needs to focus more. Data was collected in Moorea, French Polynesia using the Module 3 community monitoring method of the Toolkit (see Appendix A).

Observer and method biases can be a factor in collecting inaccurate or disparate monitoring data (Vallès et al. 2019, Bernard et al. 2013), and this was minimised as much as possible for the Vanuatu comparison by ensuring surveys were conducted by the same experienced community monitor using the Toolkit method, and the same scientist using the benthic transect method on the same day. While in French Polynesia, differences between observer teams was the focus of the comparison across three newly training monitoring teams to quantify variability and if that affects results enough to impact local decision-making.

4.2 Statistical analysis

While scientific surveys provide valuable and fine-scale data, local communities have long-term knowledge of their local reefs, often accumulated over generations, and can monitor sites more regularly, particularly in remote areas. This analysis aimed to understand the accuracy of results between community (Toolkit) and scientific monitoring methods in assessing coral reef condition and as an early warning of impacts, and ultimately consider its value to inform local management actions.

The data were analysed using Excel and due to the limited data points, the results are indicative only. The analysis was conducted using the following tasks:

1. Imported the data and assigned a column to the data source, i.e. scientific and Toolkit.
2. Conducted Standard Deviation and 95% confidence level analysis on the three replicate scientific transects for each indicator.
3. Used the Excel chart tool to construct bar plots for each reef indicator.

Bar plots were used to visualize the results and identify the differences for each reef health indicator across four sites between the community Toolkit and scientific methods in Vanuatu.

Consistency of results between observers was tested using community monitoring data from French Polynesia that plotted results for the five coral reef indicators separately for each of the three monitoring teams at the same site. The monitoring teams all had a similar level of training, having received 5-hours of foundational training that same week.

4.3 Results: Vanuatu Community Toolkit method and scientific survey method

Live hard coral

Comparison of live hard coral cover between the Toolkit and scientific monitoring methods (Figure 9) showed minor differences across all sites in estimated percent cover, most notable at two sites. Calculation of the 95% confidence level for the scientific survey data showed that results for the Toolkit method are within the range observed using the scientific method except at one site (Port Havannah).

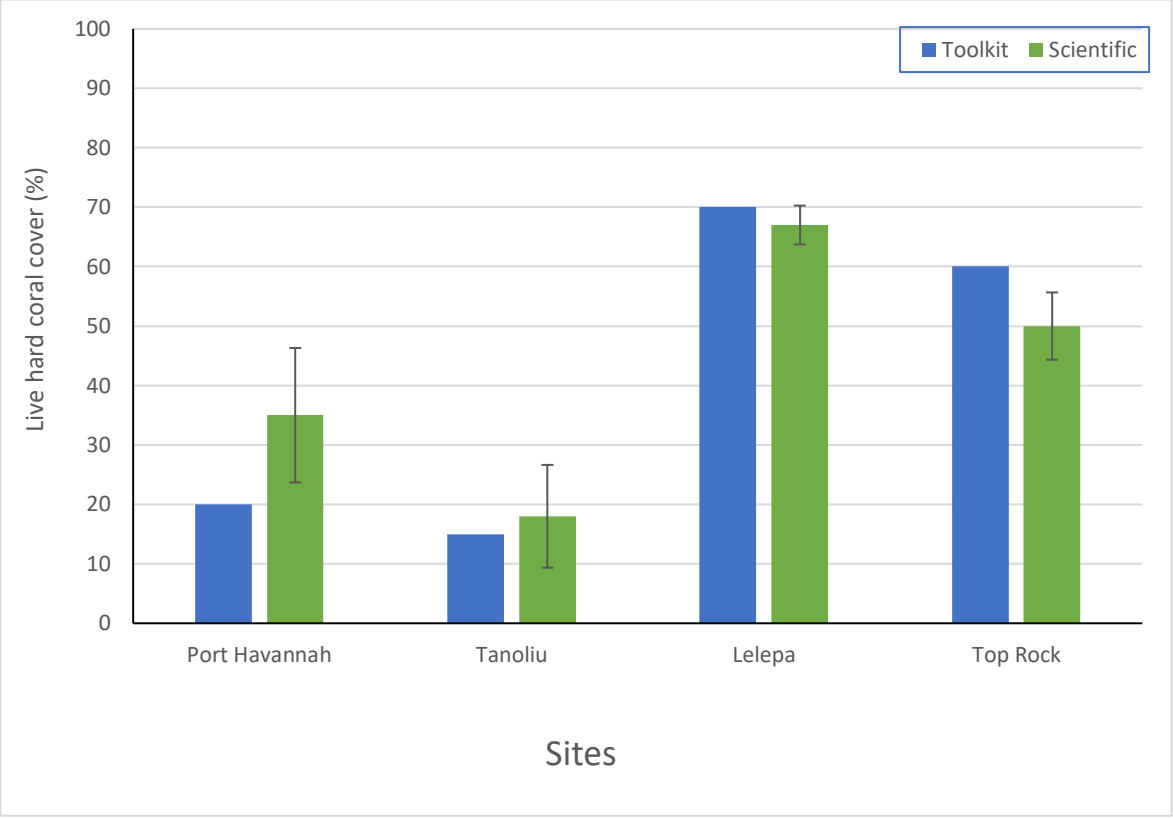


Figure 9. Comparison of live hard coral cover survey results for all sites in Vanuatu using Toolkit and scientific methods. Bars represent the 95% confidence level for the scientific method only.

Macroalgae cover

Comparison of macroalgae cover between the Toolkit and scientific monitoring methods showed minor differences of 2–3%, and no variability in the scientific data for all sites (Figure 10). Macroalgae cover was recorded as being in the 'low' category at all sites using both monitoring methods.

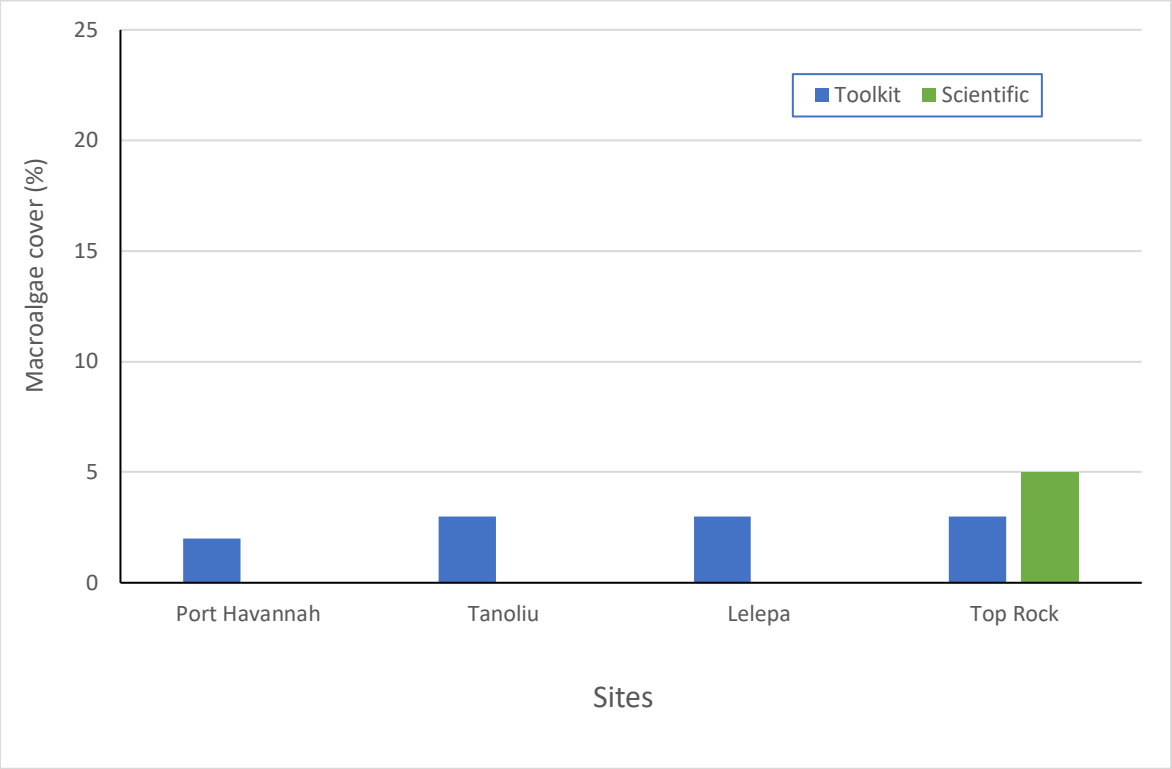


Figure 10. Comparison of macroalgae cover for all sites in Vanuatu using Toolkit and scientific methods.

Bleached hard coral

The scientific method did not record any bleached hard corals, while the Toolkit method recorded a low percentage of bleached corals (2%) at only one site – Top Rock. These results likely demonstrate the differences in observer experience, since bleached or pale corals occur on most reefs, and can be a sign of stress, such as disease, or naturally pale colonies growing in shallow reef areas exposed to high light levels. While scientists are familiar with this, community monitors may require further training for this indicator and greater familiarity with recognising stressed (bleached) corals.

Broken hard coral

Comparison of the percent of broken hard coral between the Toolkit and scientific monitoring methods showed no significant difference in results for all sites (Figure 11). Calculation of the 95% confidence level for the scientific survey data showed that results for the Toolkit method are within the range observed using scientific methods at all sites.

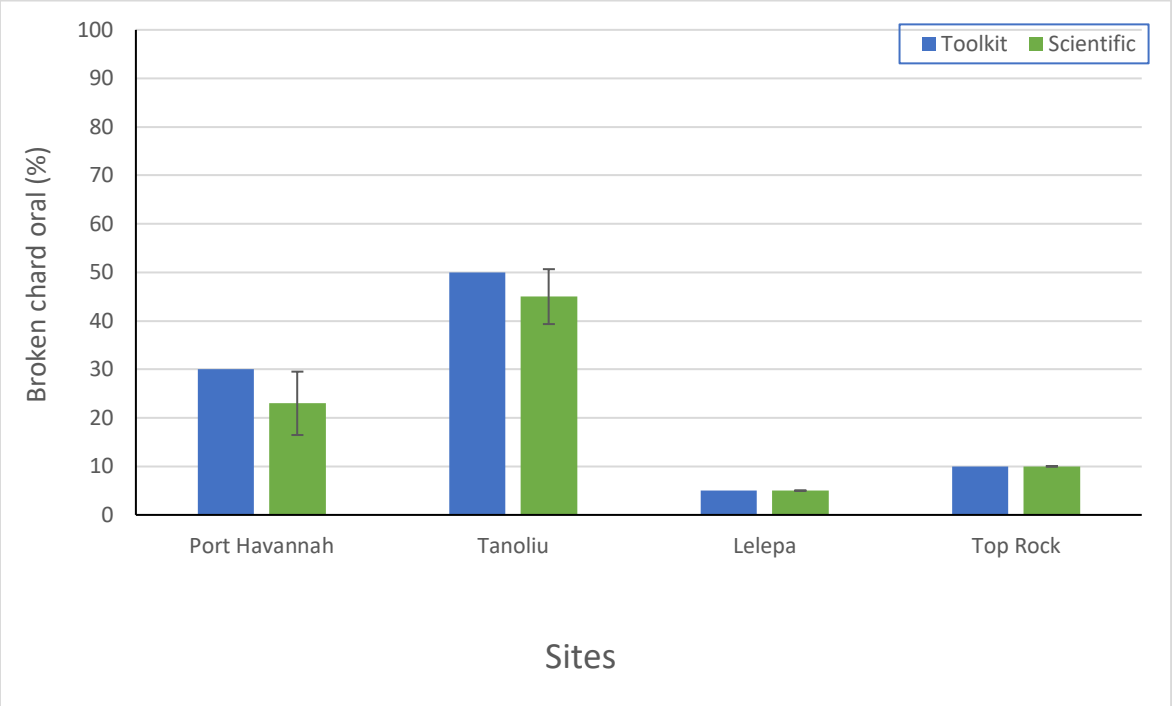


Figure 11. Comparison of percentage of broken hard coral survey results for all sites in Vanuatu using Toolkit and scientific methods. Bars represent the 95% confidence level for the scientific method only.

Crown-of-thorns starfish

No COTS were observed at any sites by either the Toolkit or scientific method, and therefore results are consistent and considered accurate.

4.4 Results: French Polynesia newly trained monitors

A comparison of the Module 3 reef monitoring data from three teams of newly trained monitors in French Polynesia (Figure 12) found that there is variability across teams, and for some indicators, e.g. macroalgae cover, this is substantial. The range of estimated percent cover for live hard coral cover was 30% (from 50% to 80% cover) and for macroalgae cover was 38% (from 12% to 50% cover). The range of results for bleached coral, number of COTS observed, and broken coral was smaller. These results indicate that additional practice is needed on more accurately estimating percent cover, a challenge many new monitors report, as well as recognising key impact indicators, such as different types of macroalgae and bleached coral.

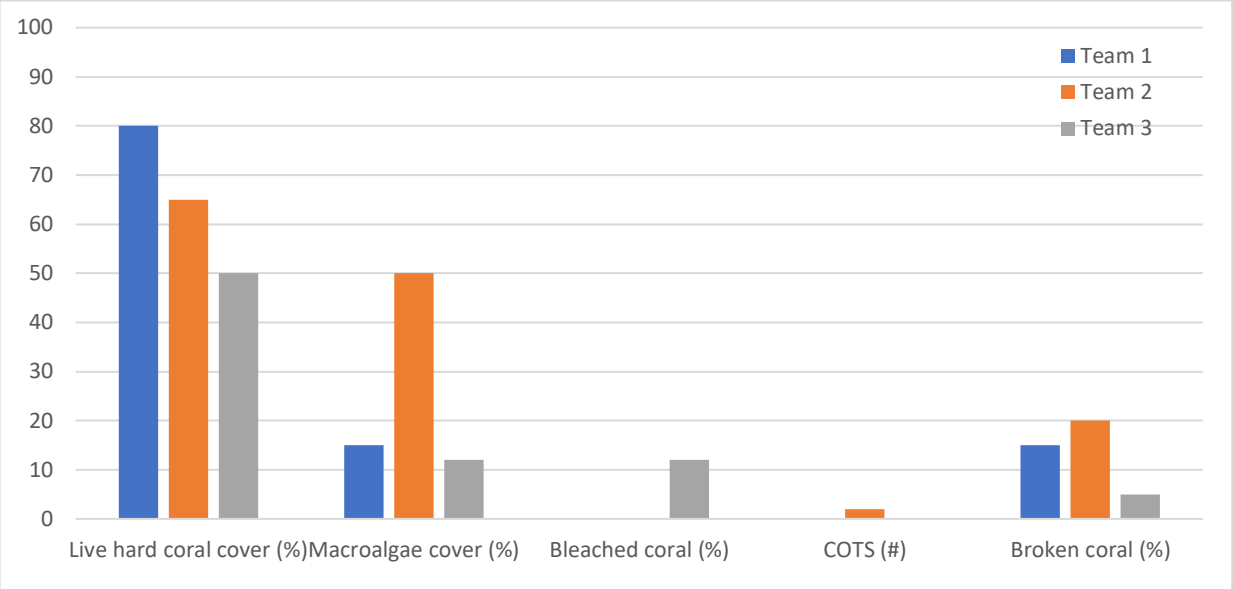


Figure 12. Comparison of reef monitoring data collected by three teams of newly trained monitors in Moorea, French Polynesia using the Toolkit Module 3 method.

4.5 Conclusions

In summary, the comparison between the monitoring results using the Toolkit and scientific reef survey methods revealed minimal variation for all five indicators when experienced community monitors use the Toolkit methods. However, there is substantial variability in results between newly trained monitors, particularly for reef impact indicators, which indicates that additional practice on key skills is required. This includes estimating percent cover and recognising impacts such as different types of macroalgae and bleached coral. It also supports recommendations that annual refresher training for community monitors is important.

Consideration of these results based on the three categories that inform management actions indicated that experienced monitors would record reef health and reef impacts consistently in the same category as scientific surveys, and therefore the resultant interpretation and management actions are the same (Figure 13). However, inexperienced or newly trained monitors may inaccurately record reef health or reef impacts, thus mis-informing local management decisions. This reinforces the importance of effective initial training, additional skills practice, regular refresher training, and partnering with experienced community monitors.

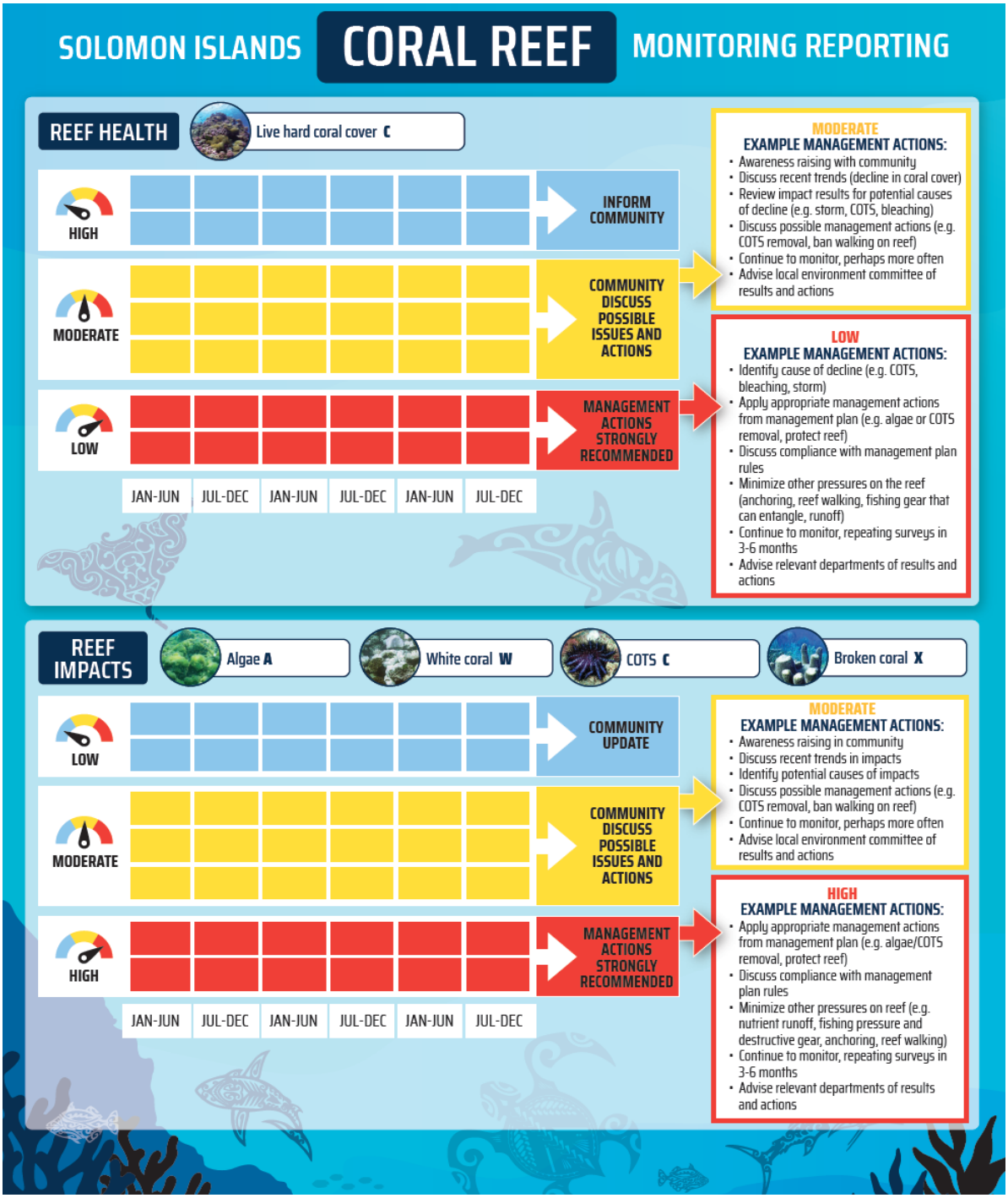


Figure 13. Data reporting poster for coral reef monitoring (Module 3) that allows for instant recording of monitoring results in the community, and provides guidance for appropriate community-based management actions.

5. Scaling up the Community Marine Monitoring Toolkit

Future updates and review of the Toolkit will increase its general utility in a wider range of countries, with the primary beneficiaries being small island developing states and developing nations that depend on their coastal resources. All countries and territories with dispersed and remote communities could apply the Toolkit, as it is a robust and easy-to-use citizen science method. The Toolkit is primarily aimed at empowering communities in countries with governments that don't have the resources or capacity to conduct spatially extensive and regular monitoring of marine habitats and species, and to support local decision-making to improve management and conservation. It also provides education and awareness opportunities for the communities involved (Figure 14).

Figure 14. Example community awareness poster from French Polynesia on marine issues and the need for monitoring and management.

A co-benefit is that the monitoring data collected can be provided to national governments to support policy and planning. Important improvements to the Toolkit include an online or mobile application version, data feeds into national or regional databases for secure data storage, and online practice and refresher training. At any scale, the monitoring Toolkit is supporting communities to understand impacts on their local environment and motivating them to change their management and behaviour. Critically, the Toolkit acts to facilitate the long overdue need for even basic coastal resource management to halt the widespread decline of coastal resources and habitats, and through local community networks and systems is the most appropriate means in regions like the Pacific (Johnson et al. 2020).

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APPENDIX A: TOOLKIT CORAL REEF MONITORING METHODS

QUICK GUIDE TO CORAL REEF SURVEYS

Site selection

- Choose sites that are typical of the main reef type in the local area
- Choose sites that are easy and safe to access at low and high tide
- Choose sites that are less than 26 ft (8 m) deep

Method

- Carry out monitoring surveys once every 12 months
- If you are monitoring after an impact, monitor within 1 month of the impact, e.g. storm or long hot water period
- At least 2 people should monitor together but more people can do the survey at the same time

- Choose 2 random sites for each survey
- Sites should be at least 30 m apart, if possible
- Sites can be inside or outside your MPA

Equipment you will need includes:

- Underwater slate or paper
- Pencil
- Mask & snorkel (fins optional)

- Start at one end and swim steadily over the reef **parallel** to the shore for 10 minutes and record information on the 5 reef indicators
- Once you finish the first site, complete the second site, then return to the shore to discuss as a team

Reporting

- Discuss what you recorded with the other monitors and reach consensus to fill in a **single** survey sheet together for each site
- Transfer the survey results onto the reef data reporting poster

APPENDIX B: MONITORING SURVEY SHEETS

CORAL REEF SURVEY SHEET : TOOLKIT

SITE DESCRIPTION (ONE FORM PER SITE)		
Who	Monitor names:	
Where	Village:	Site:
When	Date:	Time:
Conditions	Weather:	Tide:
Habitat (circle one or more)	Reef lagoon	Reef front
	Reef flat	Reef slope

WHAT DID YOU SEE?			
1. Hard coral cover	Comments:		
	0%	10% – 30%	100%
	Low	Moderate	High

WHAT IMPACTS DID YOU SEE?			
1. Algae Cover	Comments:		
	0%	10% – 25%	>50%
	Low	Moderate	High
2. White Coral	Comments:		
	0%	10% – 25%	100%
	Low	Moderate	High
3. Crown-of-thorn starfish (COTS)	Comments:		
	0%	1 – 5	50+
	Low	Moderate	High
4. Broken coral:	Comments (note type of damage):		
	0%	10% – 25%	100%
	Low	Moderate	High

Litter present? (circle)	Lots	Some	None
Photos Taken? (circle)	Yes	No	
Photo Notes:			

REEF HEALTH AND IMPACT SURVEY SHEET

OBSERVER AND SITE DETAILS

Observer name				Date:			Time:			
Organisation:							Snorkel ☐☐☐	or Dive ☐☐☐		
Site information										
Lat:				Reef name:						
Long:				Site:						
				SITE CONDITIONS:						
Survey depth:			m	Plume:		(F/A)	**BENTHOS:**			
Visibility:			m	Sea temp:		℃	Macroalgae			%
							Live coral			%
ASPECT:	HABITAT:			COMPLEXITY:			Dead coral			%
NW | NE	lagoon	☐ ☐ ☐		1 (smooth/nil)	☐ ☐ ☐		Live rock (CCA)			%
SW | SE	reef flat	☐ ☐ ☐		2 (low)	☐ ☐ ☐		Coral rubble			%
	crest	☐ ☐ ☐		3 (moderate)	☐ ☐ ☐		Sand			%
	slope	☐ ☐ ☐		4 (high)	☐ ☐ ☐		TOTAL:	100	100	100 %
				5 (very high)	☐ ☐ ☐					

BENTHOS

Macroalgae observations					**Present Y/N**	**Photos Y/N**
TYPE:	Slime	Filamentous	Entangled/Mat	Leafy/Fleshy	Tree/Bush	
% of total cover	%	%	%	%		
Average height	%	%	%	%		

*Macroalgae height: A=1-3 cm; B=>3-25 cm; C=>25 cm

Coral observations								**Present Y/N**	**Photos Y/N**
LIFEFORM:	Soft Coral	Branching	Bushy	Plate	Encrusting	Vase/Fol	Massive		
% of total cover	%	%	%	%	%	%	%		
Dominant genus									

* Acr=Acropora; Poc=Pocillopora; Mon=Monitpora; Fav=Favids; Por=Porites; Gon=Goneastrea; Tur=Turbinaria; Mil=Millipora

IMPACTS

Coral bleaching								**Present Y/N**	**Algae Y/N**	**Photos Y/N**
LIFEFORM:	Soft Coral	Branching	Bushy	Plate	Encrusting	Vase/Fol	Massive			
% bleached	%	%	%	%	%	%	%			
Common severity										

*Bleaching severity: 1=bleached upper surfaces; 2=pale/fluoro (very light or yellow); 3=totally white; 4=recently dead with algae

Coral disease								**Present Y/N**	**Algae Y/N**	**Photos Y/N**
LIFEFORM:	Soft Coral	Branching	Bushy	Plate	Encrusting	Vase/Fol	Massive			
#colonies affected										
% coral affected	%	%	%	%	%	%	%			

*If disease identified use codes: Bl=black-band; Br=brown-band; Wh=white syndromes

Coral predation								**Present Y/N**	**Algae Y/N**	**Photos Y/N**
LIFEFORM:	Soft Coral	Branching	Bushy	Plate	Encrusting	Vase/Fol	Massive			
# COTS scars										
# Drupella scars										
% coral affected	%	%	%	%	%	%	%			

Recent coral damage: % cover affected ____% ____%								**Present Y/N**	**Algae Y/N**	**Photos Y/N**
LIFEFORM:	Soft Coral	Branching	Bushy	Plate	Encrusting	Vase/Fol	Massive			
#colonies affected										
Severity										
Possible cause										

*Severity: 1=edge/tips; 2=part/branches; 3=whole colonies; 4=reef structure

**Possible cause: A=anchor; D=divers; S=snorkellers; W=weather/storm; V=vessel; C=animal; U=unknown

Rubbish						**Present Y/N**	**Photos Y/N**
TYPE:	Fishing line	Plastic	Fishing net	Rope	Other		
# pieces rubbish							