Marine Pollution Bulletin 159 (2020) 111498

Contents lists available at ScienceDirect

Marine Pollution Bulletin

journal homepage: www.elsevier.com/locate/marpolbul

Community Marine Monitoring Toolkit: A tool developed in the Pacific to inform community-based marine resource management

Johanna E. Johnson[a,b,*], Eryn Hooper[a], David J. Welch[a,c]

[a] C_2O Pacific, Port Vila, Vanuatu & Auckland, New Zealand
[b] College of Science & Engineering, James Cook University, Queensland, Australia
[c] C_2O Fisheries, Cairns, Australia

ARTICLE INFO

Keywords:
Monitoring
Community resource management
Citizen science
Marine habitats

ABSTRACT

In the Pacific region, community engagement, participation and empowerment are key to effective and sustainable marine resource management at the local level. With the prevalence of a local marine tenure systems and the widespread decline of coastal resources, communities need to be part of the solution to facilitate recovery. A novel marine monitoring toolkit was developed in Vanuatu with the participation of community resource monitors to inform local management actions. The Toolkit includes simplified versions of established monitoring methods for marine habitats and resources to achieve a balance between robust science and methods appropriate for communities. Key to its success is that it was developed in response to community needs using a participatory approach and implemented through a series of training workshops with local environmental leaders. Of particular note, the Toolkit includes a standardised process for communities to use monitoring results instantly, without the need for complex data analyses or external support. Using the Toolkit, communities are able to adapt their traditional management to address immediate and medium-term issues in their local marine environment. The observed benefits of the Toolkit include increased local awareness through community-led environmental outreach, increased ownership of and motivation for local monitoring and management, implementation of local management actions, expansion of traditional marine managed areas, and new local ecotourism initiatives to generate revenue to support environmental stewardship.

1. Introduction

Marine resources are under pressure in the Pacific due to coastal development, over-exploitation, increasing human populations and demand for resources, land-based pollution and sand and coral mining (UNEP, 2018; UNESCAP, 2020). Climate change is expected to exacerbate these pressures and modify marine ecosystems throughout the Pacific (IPCC, 2019), with implications for the communities that depend on them for food and livelihoods (Bell et al., 2011; Johnson et al., 2017). Further, the United Nations review of progress towards achieving the 2030 Sustainable Development Goals (SDG) found that there was a lack of progress (and in some cases regression) on environmental sustainability in the Pacific region. This includes managing the impact of human activities on marine and coastal ecosystems under SDG 14 'life under water' (UNESCAP, 2020). The limited progress towards SDG 14 is exacerbated by challenges in measuring targets due to lack of data, with 9 of the 10 indicators having *no* or *insufficient* data, highlighting the importance of standardised and consistent monitoring. However, there is limited capacity within government departments in many Pacific nations to conduct regular or extensive monitoring, making communities a key group to identify impacts and implement local actions in their marine ecosystems. With simple and robust monitoring tools that link directly to management, communities become empowered to make effective and informed decisions to manage their marine resources and adapt to future changes (Danielsen et al., 2005).

Participatory approaches to monitoring and management have been shown to maintain engagement in the long-term (DellaSala et al., 2003) and are more likely to succeed than top-down monitoring (Reed et al., 2016; Govan et al., 2009; Rodríguez et al., 2007). It has long been documented that local involvement with biological monitoring drives better conservation outcomes than when external groups conduct monitoring (Danielsen et al., 2007), and there are examples that degradation of habitats increases when local communities are not involved in decision-making (Galabuzi et al., 2014). Importantly, empirical studies have shown that compliance and local governance of

* Corresponding author at: PO Box 3041, Cairns, Queensland 4870, Australia.
E-mail address: j.johnson@c2o.net.au (J.E. Johnson).

https://doi.org/10.1016/j.marpolbul.2020.111498
Received 10 October 2019; Received in revised form 19 June 2020; Accepted 19 July 2020
Available online 05 August 2020
0025-326X/

managed areas tends to break down in the absence of effective monitoring and enforcement (Ostrom, 1990; Acheson, 2006; Rustagi et al., 2010). However, developing local capacity to monitor and manage marine resources has been trialled throughout the Pacific with varying levels of success (e.g. Mellors et al., 2008; Abernethy et al., 2014; Cinner et al., 2006; Leopold et al., 2013). Key factors that determine the success of local monitoring and management include leadership and social cohesion (Gutiérrez et al., 2011), effective implementation and community ownership of the process (Jupiter et al., 2017).

Developed nations have fared best in terms of long-term sustainability of citizen science (e.g. GBR Eye on the Reef,[1] Reef Check Australia,[2] Range Extension Database and Mapping [Redmap],[3] New Zealand Participatory Science Platform[4]). While many governments have long recognised the challenges associated with trying to monitor marine areas over meaningful spatial and temporal scales, and turned to citizen science, Pacific Island nations have been slow to embrace the approach. Despite the resources allocated by governments and practitioners for monitoring, often the right things are not being monitored in the right way or frequently enough to identify emerging issues or assess the benefits of conservation and management (Gurney and Darling, 2017).

Some of the main challenges of successful and sustainable local monitoring in Pacific Island nations are limited resources, poor engagement and training, complex methods, costly or technical equipment, reliance on external data analyses and no direct link to appropriate local management responses. Given the importance of having effective monitoring strategies to support local management and facilitate sustainable local actions, appropriate and effective monitoring tools are needed.

2. A new paradigm for citizen science in the Pacific

Most Pacific nations are large ocean states with subsistence-based coastal communities that are highly dependent on coastal and marine resources for food and income (Gillett and Tauati, 2018; Johnson et al., 2019). They are often geographically remote with dispersed islands and significant cultural diversity, making routine centralised monitoring very resource intensive. Critically, when faced with multiple challenges of health, education, climate hazards and low national economic revenue, environmental sustainability and associated monitoring becomes a lower priority for governments. Thus, the status of coastal resources throughout the Pacific region are poorly understood, management is limited, and monitoring is mostly conducted in isolated locations and sporadic timeframes as part of short-term foreign aid projects. Therefore, in order to collect and deliver continuous and reliable monitoring information to inform effective management, a new approach that engages and partners with communities is needed. Such a 'citizen science' approach empowers communities to understand and use their monitoring data to inform local decisions and improve local management of marine resources.

3. Methods

3.1. Developing a local marine monitoring toolkit

A local marine monitoring toolkit (Toolkit) was developed between 2016 and 2017 in North Efate, Vanuatu in response to community requests to deliver simple but robust monitoring methods that could directly inform local management actions. The Toolkit was field tested in North Efate to make improvements and has been expanded to communities on other islands in Vanuatu and a tailored version prepared for the Marshall Islands. The Toolkit provides a novel approach to community monitoring that was co-developed with community nominated *Marine Champions* from two local community-based resource networks – Nguna-Pele Marine and Land Protected Area Network and Tasi-Vanua Environmental Network – representing 27 coastal communities, and with the Vanuatu Fisheries Department. Like much of the Pacific, these areas have relatively little infrastructure and poor communication networks. As such, the Toolkit does not rely on equipment or online systems and therefore has the potential to be used across the Pacific, including in remote areas.

The Toolkit supports local monitoring of marine and coastal environments to detect changes caused by human activities and natural events. Community monitoring is important as it provides regular information from multiple and remote locations collected by people familiar with their environment, and can also support national initiatives.

Notably, community monitoring can:

- Provide an early warning of changes or impacts (e.g. coral bleaching, crown-of-thorns starfish outbreaks).
- Raise awareness within communities about the condition of their marine environment.
- Raise awareness about the impacts of fishing methods and gears.
- Raise awareness about the types of management actions appropriate for local issues.
- Empower communities to take better control of local marine resource management through an inclusive and informed process.
- Determine if local management actions are effective and facilitate adaptive management.

3.2. Toolkit monitoring modules

The Toolkit includes six survey modules that are independent of each other and communities select one or more module(s) depending on their local issues and resources: (1) fish catch, (2) intertidal invertebrates, (3) reef health, (4) mangroves, (5) seagrass, and (6) crown-of-thorns starfish. Using both qualitative and quantitative methods in the local Bislama language, each module collects standardised data that are easily plotted onto a scale from *nogat* (none/unhealthy) to *fulap* (full/healthy). For each module, relevant published scientific information was used as the basis for determining the scale of what is a 'healthy' or 'unhealthy' state. For example, sea cucumber density estimates from unfished areas around the Pacific were used to provide an estimate of *fulap* (healthy) population status for the three key intertidal species monitored (Toral-Granda et al., 2008; Anon, 2003; Drumm, 2004; Chambers, 1990; Stewart, 1993; Purcell et al., 2009). The reef health module has seven indicators of reef habitat condition and impacts, and the *fulap* (healthy) to *nogat* (unhealthy) scales for hard coral cover and macroalgae are based on long-term reef status and trends from the Pacific region (Moritz et al., 2018) and local scientific survey data (e.g. Johnson et al., 2016; Johnson et al., 2018).

In some modules, the measures of healthy or unhealthy are derived. For example, the fish catch survey uses 'size at maturity' estimates from the scientific literature to derive the 'healthy' to 'unhealthy' scale. The scale is based on the concept that if local catches are made up of a high proportion of juveniles (pre-breeding size), then spawning biomass will decline and recruitment will be compromised (King, 2007). By using the fish catch surveys, communities can identify if local catches contain too many immature fish. Given the diversity of reef fish species typically taken in local coastal reef fisheries, and the range of sizes at maturity, the scale was developed using maturity data for the most common species within key families. Due to the need to keep survey methods simple for community use, identification of fish is to family

[1] http://www.gbrmpa.gov.au/our-work/our-programs-and-projects/eye-on-the-reef

[2] https://www.google.com/search?client=safari&rls=en&q=reefcheck+australia&ie=UTF-8&oe=UTF-8

[3] http://www.imas.utas.edu.au/community/citizen-science/citizen-science-lbs/citizen-science/redmap

[4] http://scienceintoaction.nz/psp/

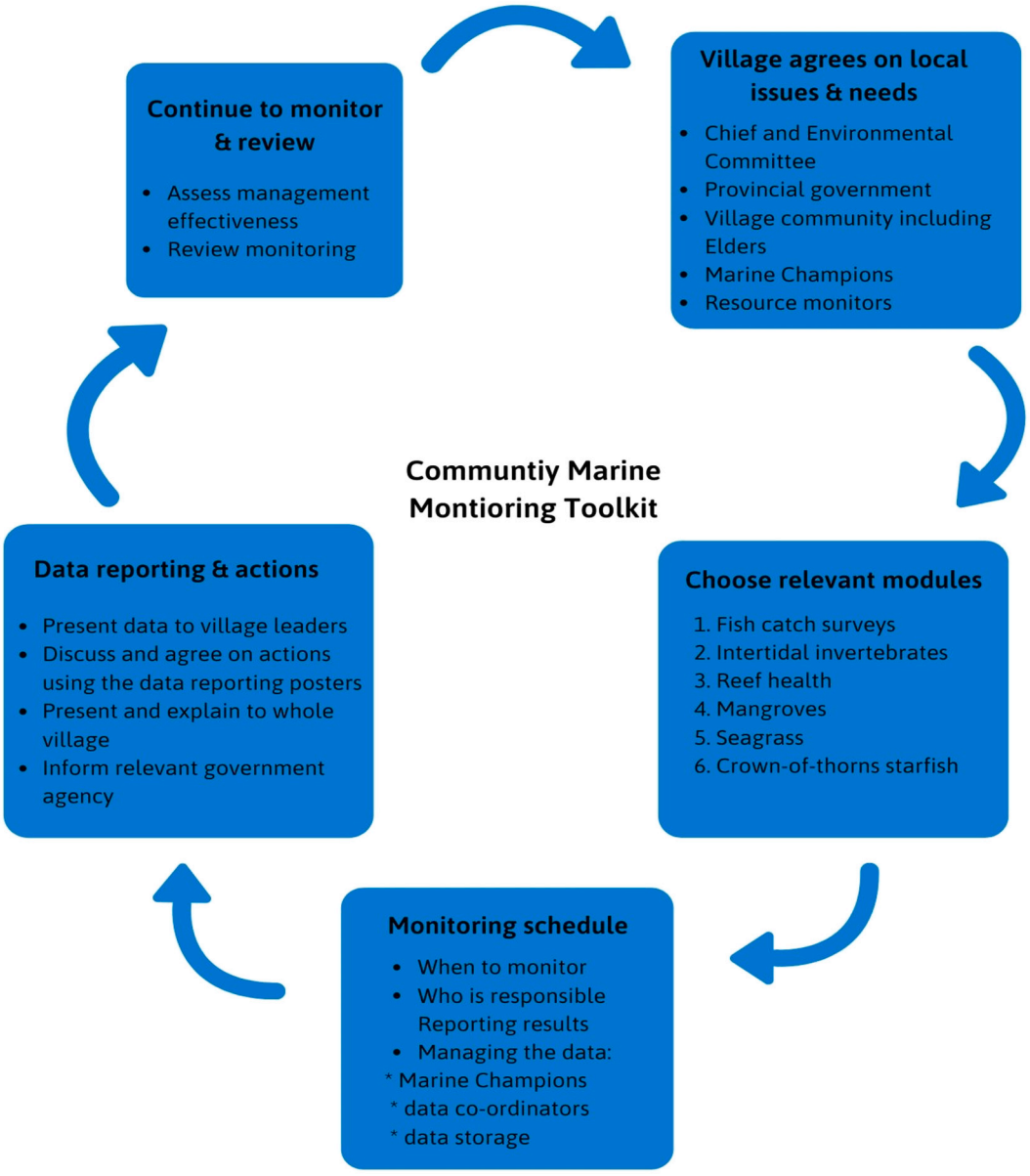

Fig. 1. Process for applying the community marine monitoring toolkit from setting local objectives (issues and needs) to choosing relevant modules, monitoring, review and management actions.

level, and therefore a critical fish size is derived as a composite family-level size limit. The key fish species groups to monitor were determined through feedback from local communities and the relevant Fisheries Department. The data collected in the fish catch surveys also identify the types of gears most likely to cause an issue, thereby directly guiding the appropriateness of different management options in response. The surveys also collect data on gear-specific catch rates.

The scientific basis for the reporting scale is fundamental to providing robust information for local decision-making while still keeping the methods simple. Community members across a wide age range can be involved in the monitoring, reporting, management and review process (Fig. 1). Importantly, this process also serves as an effective engagement and awareness-raising tool in communities.

The Toolkit has drawn on established survey methods and known species and ecosystem thresholds to apply standardised interpretation of monitoring results instantly, translating information from community surveys directly into management actions that target key local issues. Results from field surveys are translated directly onto data reporting posters that are displayed in the village and used to inform community decisions on actions to target key areas of concern. This is achieved by plotting the survey results from the *nogat* to *fulap* scale directly onto the Data Reporting poster, which is displayed on a board in the community, and guides appropriate management responses so results are readily available and the process is transparent (Fig. 2). The Data Reporting posters use the same colours as the regional cyclone warning colours, which are well known by communities; blue indicates no concern, yellow indicates there is a possible issue and red indicates there is an immediate issue. This means communities do not need to rely on outside expertise to interpret the results, empowering them to use the monitoring results to inform local management actions.

The Toolkit provides information that can be used by communities for local decisions as well as governments to inform national initiatives or can be scaled-up for regional assessments. For example, Module 1: Fish Catch surveys focuses on subsistence catch, which fills a national and regional data gap in many Pacific countries and complements national data monitoring of commercial catches. The fish catch surveys focus on size data to inform community decision-making while also collecting catch per unit effort (CPUE) data that provide a long-term

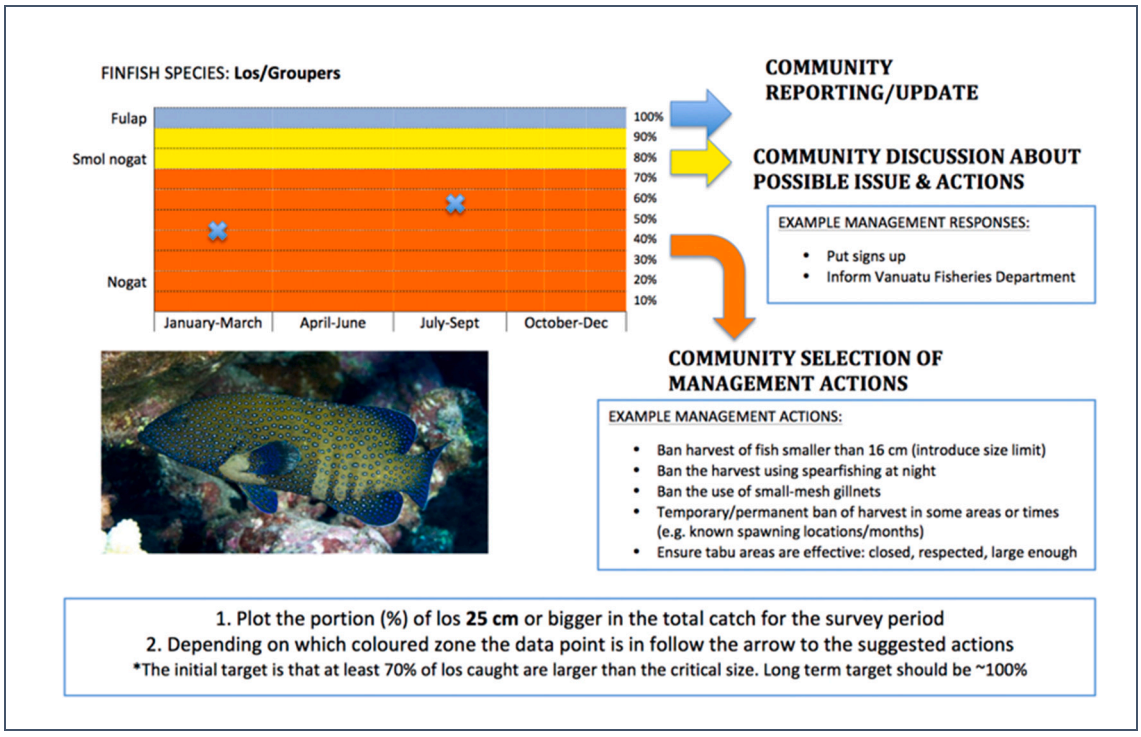

Fig. 2. An example Data Reporting poster, showing the translation of fish catch monitoring results (Module 1) for groupers onto a graph that guides communities to appropriate management actions for discussion and implementation.

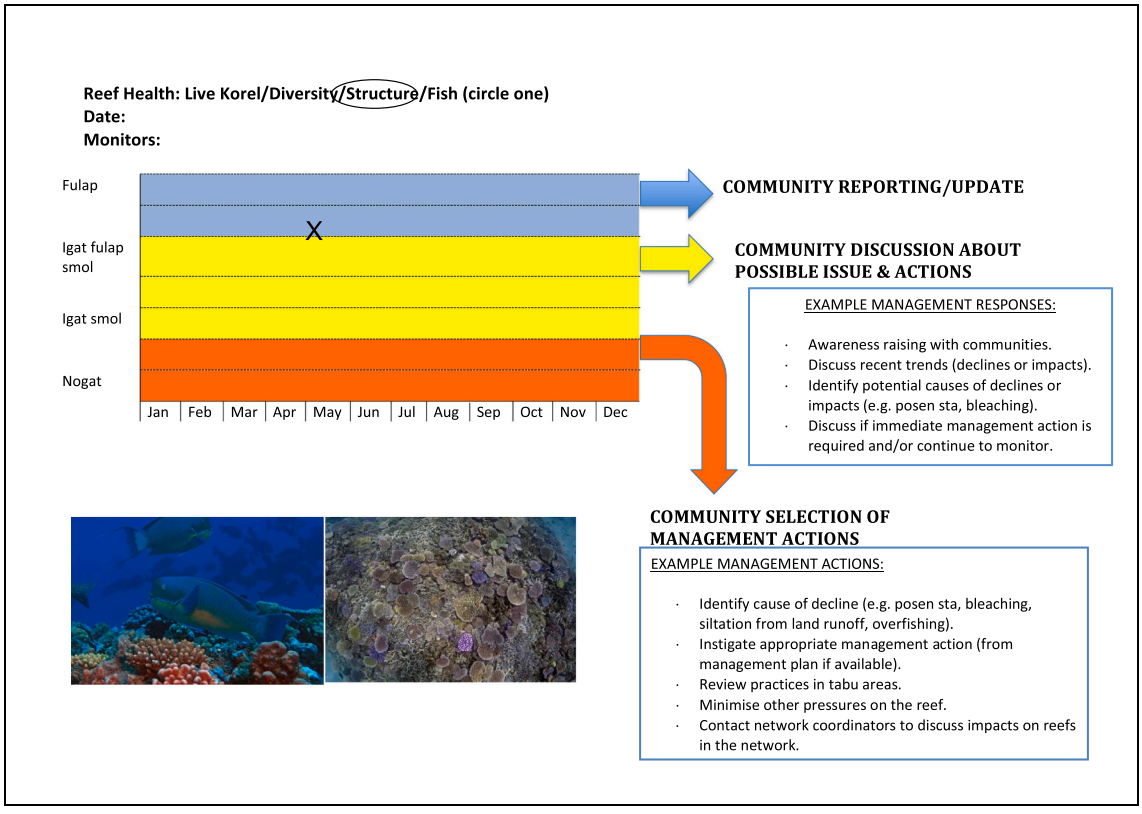

Fig. 3. Data Reporting poster showing the monitoring results of reef health indicators in the *Reef Health Survey* (Module 3) and how results are used instantly to identify appropriate and agreed management actions.

dataset consistent with needs identified in national and regional policies and regulations (e.g. Government of Vanuatu, 2017, 2019). Similarly, the methods for Module 4: Mangroves, and Module 5: Seagrass, were adapted from regional approaches (Ellison et al., 2012; MESCAL, 2013; McKenzie and Campbell, 2002) to deliver methods that were easy for communities to understand and apply while also collecting data that

Fig. 4. Marine Champions are key to the success of the Toolkit and are trained in the Toolkit monitoring methods (left) and how to teach them so they can then lead community training and monitoring sessions (right) in their village.

are comparable to monitoring in other Pacific nations. Module 3: Reef Health monitors indicators of reef health (Fig. 3) as well as reef impacts, including crown-of-thorns starfish (COTS) outbreaks. COTS are also a separate module (Module 6) to link directly with a current Vanuatu national initiative to report COTS sightings online or via a mobile App.

Importantly, the scientific basis of the data reporting scale means that community monitoring can complement more technical scientific and regional monitoring that is conducted less frequently. This multi-level approach means that management actions are informed by consistent data and streamlined towards common goals. Key to the success of the Toolkit is the involvement of community Marine Champions in the training and delivery of monitoring methods and activities (Fig. 4). Marine Champions are local individuals nominated by their communities based on their demonstrated interest in environmental stewardship and prior experience as local leaders or resource monitors. Keeping the Toolkit responsive to community needs gives the Marine Champions and their communities the capacity to monitor and manage their resources without the need for external support, analysis or input.

4. Results and discussion

4.1. Empowering communities

The Toolkit builds capacity at the local level by enhancing understanding of marine ecosystems and environmental issues, and another key aspect is that it facilitates active local marine resource management. The process of training on the Toolkit methods and conducting monitoring strongly promotes a participatory approach with the entire community. In the Pacific, local land and sea tenure belongs to particular communities or villages, so participatory management is important. Through a series of community meetings that educate about Toolkit monitoring, environmental and resource issues, and management solutions, whole communities become involved, which is a key tenet of Community-Based Resource Management (e.g. SPC, 2010). While this inherently empowers the community in their local resource management, there are two key aspects of the Toolkit that additionally empower communities: (1) data is collected, analysed and owned by the community, and (2) results of monitoring directly inform the selection of management options to address the issue. The community is in control of the entire process through to decision-making, management actions and reviews (Fig. 1).

4.2. Benefits and outcomes

The Toolkit has been applied by communities in North Efate, Ifira Island in Port Vila Harbour and on Tanna Island in Vanuatu, and is scheduled to be implemented in the Marshall Islands from 2020. While in each instance, the process has been tailored to the community circumstances, in terms of participants, training length and activities, and the support needed, there are consistent elements. For example, local leaders were always consulted as an initial step to gain their endorsement, all communities nominated local Champions to be involved and lead future training, and training always included practical field elements led by Champions and supported by specialists. This flexibility of the Toolkit to be tailored to specific community needs and circumstances is one of the main strengths. Another important benefit of the Toolkit is the associated awareness raising that is delivered in communities about marine issues and fishing practices, and it has been included in many community conservation monitoring days and school awareness days (Fig. 5). Additional benefits of this work include increased local awareness of climate change and overfishing issues, the expansion of locally managed (no take) areas in some villages, long-

Fig. 5. Community monitoring days demonstrate the utility of the Toolkit methods and awareness raising benefits.

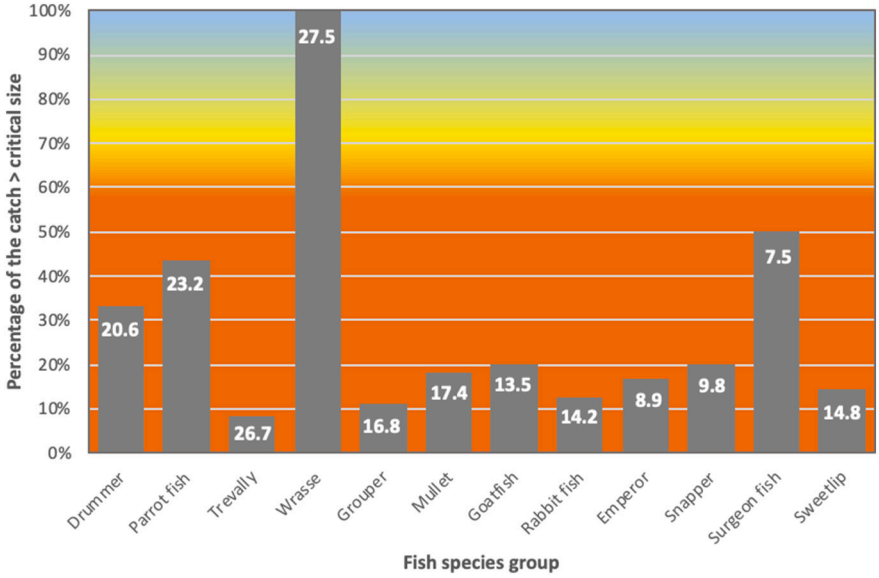

Fig. 6. Catch survey data from Sunae village showing the percentage of each of the key fish species groups that are larger than the critical (breeding) size. The background colours approximate those on the Data Reporting Posters that signify the level of action required (see Fig. 2). The average size of fish caught for each species group is also given (in cm).

term recognition and importance of conservation areas, greater awareness of the impacts of destructive fishing practices and new local ecotourism initiatives for income generation to support ongoing management and conservation activities.

On Ifira Island the Marine Champions identified the biggest threat to their mangrove forest was the build-up of litter and subsequently initiated a community clean-up day and removed > 500 kg of rubbish in one day. The mangrove forest is much healthier and the community is now looking at longer-term management of the area. The use of the Toolkit has also prompted some villages to review and/or develop a local coastal resource management plan. Indirect benefits have been that the individuals identified and trained as Marine Champions have a greater standing of respect in their communities with some claiming their experience and enhanced local profile have created numerous opportunities such as access to competitive scholarships for further education and election as a local Councillor.

In Sunae village on Moso Island, Vanuatu, 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 the 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 virtually all of the fish family groups caught by local fishers, the vast majority had very high proportions of juvenile fish in the catch (Fig. 6). 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 and therefore mitigate 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.

4.3. Complementing local, national and regional management

Further, the Toolkit has been developed to align with government initiatives and policy, in particular the Vanuatu *National Coastal Fisheries Strategy 2018–30*. Although the Toolkit helps to meet a number of actions and activities listed under the 6 Focal Action Areas, in particular it aligns with Focal Action 3.4: *Strengthen communities (and connections between community and VFD) to manage fisheries resources*. While some marine habitats and species are managed or protected by national Regulations, Policies and Plans with harvest restrictions or bans[5] or international treaties,[6] most coastal resources are currently poorly managed throughout the Pacific. The Toolkit can complement relevant national regulations as well as support implementation of regional strategies, such as *A new song for coastal fisheries - pathways to change: The Noumea Strategy* (SPC, 2015) and the *Regional Roadmap for Sustainable Pacific Fisheries* (FFA and SPC, 2014). Monitoring of fish, invertebrates, coral reefs, seagrass and mangroves provides information that can inform local and national decisions to secure food and nutrition, provide environmental protection in the face of climate change and natural disasters, improve fisheries compliance and build partnerships. Community-based monitoring can provide early warning and condition information to national programs, and request formal support from government if impacts are observed.

The Toolkit can also support an important role of community monitoring in meeting the United Nations SDG 14 'life under water', and reporting at a national level against the SDG 14. The limited progress reported towards SDG 14 (UNESCAP, 2020) is in part due to challenges in measuring targets due to lack of data, and if the Toolkit can facilitate local collection of standardised and consistent monitoring data, this weakness can begin to be addressed.

5. Conclusions and recommendations

The Community Marine Monitoring Toolkit has been developed with monitoring methods that are based on established protocols used throughout the Pacific for years and long-term datasets, where available. The Toolkit provides easy to understand and robust methods for communities, and monitoring results can be used directly and instantly to inform local management decisions. The Toolkit methods can also complement other more technical approaches used nationally or regionally, and are able to accommodate available existing data. The Toolkit therefore has the potential for broad application and provides relevant and appropriate methods for empowering communities to take

[5] National Fisheries Policy; Sea Cucumber Management Plans; National Plan of Action on Sharks.

[6] Convention of International Trade in Endangered Species (CITES) to manage over-exploitation for trade of giant clam.

affirmative and immediate action in helping to ensure future food security and livelihoods from coastal resources.

The role of existing community environmental networks and Marine Champions in supporting implementation of the Toolkit is a key factor for success. For example, in Vanuatu, annual national meetings of the Vanua-tai Environment Network[7] have provided the opportunity for communities to share their experiences of using the Toolkit and communicating results. The network provides the support needed for monitors from different islands to liaise with each other and connect within the network.

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 and have dispersed and remote villages. The Toolkit is primarily aimed at empowering communities in countries that don't have the resources or capacity to conduct spatially extensive and regular monitoring of habitats and species, and to support local decision-making to improve marine management and conservation. A co-benefit is that the data that can be provided to national governments to support policy and planning. Important improvements to the Toolkit include additional modules on water quality and marine litter, an online or mobile application version, and data feeds to national or regional databases. At any scale, the monitoring Toolkit is helping 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.

Funding

This work was supported by the Vanuatu 'Restoration of Ecosystem Services and Adaptation to Climate Change' (RESCCUE) project coordinated by the Pacific Community (SPC). The project was funded by Agence Française de Développement (AFD) and the French Facility for Global Environment (FFEM).

CRediT authorship contribution statement

Johanna E. Johnson: Conceptualization, Methodology, Validation, Formal analysis, Investigation, Data curation, Writing - original draft, Writing - review & editing, Supervision, Project administration, Funding acquisition. **Eryn Hooper**: Conceptualization, Methodology, Writing - original draft, Writing - review & editing, Funding acquisition. **David J. Welch**: Conceptualization, Methodology, Validation, Formal analysis, Investigation, Data Curation, Writing - original draft, Writing - review & editing, Supervision.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Acknowledgements

The authors acknowledge funding from the French Development Agency (AFD) and the French Global Environment Facility (FFEM) under the RESCCUE project, implemented by the Pacific Community (SPC), in the initial development of the Toolkit. We also acknowledge the members of the Nguna-Pele Marine and Land Protected Area and Tasi-Vanua Environmental Networks in North Efate, Vanuatu for their passion and dedication to recognise and seek to address growing marine resource issues. Integral to the Toolkit development was the commitment of the network Marine Champions who dedicated their time to provide critical input and deliver training. The Vanuatu Fisheries Department, in particular Jeremie Kaltavara, also provided valuable support and input to the Toolkit. Further enhancements to the Toolkit have been made possible by funding from the Secretariat of the Pacific Regional Environment Programme (SPREP) under the Pacific Ecosystem-based Adaptation to Climate Change (PEBACC) project and the Marshall Islands Marine Resources Authority.

Videos about the Marine Monitoring Toolkit and testimonies from Marine Champions are available at the following links: https://www.youtube.com/user/spcnc1

[7] The national umbrella organisation for the Tasi-Vanua and Nguna-Pele networks.

References

Abernethy, K.E., Bodin, Ö., Olsson, P., Hilly, Z., Schwarz, A., 2014. Two steps forward, two steps back: the role of innovation in transforming towards community-based marine resource management in Solomon Islands. Glob. Environ. Chang. 28, 309–321.

Acheson, J., 2006. Institutional failure in resource management. Annu. Rev. Anthropol. 35, 117–134. https://doi.org/10.1146/annurev.anthro.35.081705.123238.

Anon, 2003. Invertebrate Survey for Airai State. Report Prepared for the Environment Inc., Koror, Republic of Palau.

Bell, J.D., Johnson, J.E., Hobday, A.J., Ganachaud, A., Gehrke, P., Hoegh-Guldberg, O., Le Borgne, R., Lehodey, P., Lough, J., Pickering, T., Pratchett, M., Waycott, M., 2011. Vulnerability of Tropical Pacific Fisheries and Aquaculture to Climate Change: Summary for Countries and Territories. Secretariat of the Pacific Community (SPC), Noumea, New Caledonia.

Chambers, M.R., 1990. A survey of beche-de-mer of Vanuatu. 86–91 p In: Done, T.J., Navin, K.F. (Eds.), Vanuatu marine resources. Australian Institute of Marine Science, Townsville (272pp).

Cinner, J., Marnane, M.J., McClanahan, T.R., Almany, G.R., 2006. Periodic closures as adaptive coral reef management in the Indo-Pacific. Ecol. Soc. 11 (1).

Danielsen, F., Burgess, N.D., Balmford, A., 2005. Monitoring matters: examining the potential of locally-based approaches. Biodivers. Conserv. 14 (11), 2507–2542.

Danielsen, F., Mendoza, M.M., Tagtag, A., Alviola, P.A., Balete, D.S., Jensen, A.E., Enghoff, M., Poulsen, M.K., 2007. Increasing conservation management action by involving local people in natural resource monitoring. AMBIO J. Human Environ. 36 (7), 566–571.

DellaSala, D., Martin, A., Spivak, R., Schulke, T., Bird, B., Criley, M., van Daalen, C., Kreilick, J., Brown, R., Aplet, G., 2003. A citizen's call for ecological forest restoration: forest restoration principles and criteria. Ecol. Restor. 21, 15.

Drumm, D., 2004. Habitats and Macroinvertebrate Fauna of the Reef-top of Raratonga, Cook Islands: Implications for Fisheries and Conservation Management. Unpublished Ph.D. Thesis. University of Otagao, Dunedin, New Zealand.

Ellison, J.C., Jungblut, V., Anderson, P., Slaven, C., 2012. Manual for Mangrove Monitoring in the Pacific Islands Region. Secretariat of the Pacific Regional Environment Programme (SPREP), Apia, Samoa.

FFA [Forum Fisheries Agency] and SPC [Pacific Community], 2014. Regional Roadmap for Sustainable Pacific Fisheries. (Retrieved March 2016).

Galabuzi, C., Eilu, G., Mulugo, L., Kakudidi, E., Tabuti, J., Sibelet, N., 2014. Strategies for empowering the local people to participate in forest restoration. Agrofor. Syst. 88, 719–734.

Gillett, R., Tauati, M.I., 2018. Fisheries of the Pacific Islands: Regional and National Information. Fisheries and Aquaculture Technical Paper no. 625. Food and Agriculture Organization of the United Nations, Apia, Samoa.

Govan, H., Tawake, A., Tabunakawai, K., Jenkins, A., Lasgorceix, A., Schwarz, A.-M., Aalbersberg, B., Manele, B., Vieux, C., Notere, D., Afzal, D., Techera, E., Rasalato, E.T., Sykes, H., Walton, H., Tafea, H., Korovulavula, I., Comley, J., Kinch, J., Feehely, J., Petit, J., Heaps, L., Anderson, P., Cohen, P., Ifopo, P., Vave, R., Hills, R., Tawakelevu, S., Alefaio, S., Meo, S., Troniak, S., Malimali, S., Kukuian, S., George, S., Tauaefa, T., Obed, T., 2009. Status and Potential of Locally-managed Marine Areas in the South Pacific: Meeting Nature Conservation and Sustainable Livelihood Targets Through Wide-spread Implementation of LMMAs. SPREP/WWF/WorldFish-Reefbase/CRISP, Suva, Fiji.

Government of Vanuatu, 2017. Vanuatu National Fisheries Sector Policy 2016–2031: A Policy for the Sustainable Management, Conservation and Development of the Fisheries Sector in the Republic of Vanuatu. Ministry of Agriculture, Livestock, Forestry, Fisheries and Biosecurity, Vanuatu. SPC, Noumea, New Caledonia (36pp).

Government of Vanuatu, 2019. A Roadmap for Coastal Fisheries for Vanuatu: 2018–2030. A National Coastal Fisheries Strategy. Department of Fisheries, Vanuatu.

Gurney, G.G., Darling, E.S., 2017. A Global Social-ecological Systems Monitoring Framework for Coastal Fisheries Management: A Practical Monitoring Handbook. Wildlife Conservation Society, New York (63pp).

Gutiérrez, N.L., Hilborn, R., Defeo, O., 2011. Leadership, social capital and incentives promote successful fisheries. Nature 470 (7334), 386–389.

IPCC [Intergovernmental Panel on Climate Change] (2019) Technical summary [H.-O.

Pörtner, D.C. Roberts, V. Masson-Delmotte, P. Zhai, E. Poloczanska, K. Mintenbeck, M. Tignor, A. Alegría, M. Nicolai, A. Okem, J. Petzold, B. Rama, N.M. Weyer (eds.)]. In: IPCC Special Report on the Ocean and Cryosphere in a Changing Climate [H.O. Pörtner, D.C. Roberts, V. Masson-Delmotte, P. Zhai, M. Tignor, E. Poloczanska, K. Mintenbeck, A. Alegría, M. Nicolai, A. Okem, J. Petzold, B. Rama, N.M. Weyer (eds.)].

Johnson, J.E., Waterhouse, J., Devlin, M.J., Hooper, E., 2016. Marine Ecosystem Assessment: North Efate, Vanuatu. Report to the Pacific Community (SPC), Noumea, New Caledonia, and Agence Francaise de Developpement, Paris, France. Vanuatu RESCCUE Project. (21pp).

Johnson, J.E., Bell, J.D., Allain, V., Hanich, Q., Lehodey, P., Moore, B., Nicol, S., Pickering, T., 2017. Chapter 11 – the pacific islands: fisheries and aquaculture and climate change. In: Philips, B., Ramirez, M. (Eds.), Implications of Climate Change for Fisheries & Aquaculture: A Global Analysis. Wiley Publishing, New York, USA.

Johnson, J.E., Hooper, E., Waterhouse, J., Dwyer, S., Kaltavara, J., 2018. Republic of Vanuatu chapter. In: Moritz, C., Vii, J., Tamelander, J., Thomassin, A., Anderson, P., Lee Long, W., Planes, S. (Eds.), Global Coral Reef Monitoring Network – Status and Trends of Coral Reefs of the Pacific. GCRMN, French Polynesia.

Johnson, J.E., Allain, V., Basel, B., Bell, J.D., Chin, A., Dutra, L.X.C., Hooper, E., Loubser, D., Lough, J., Moore, B.R., Nicol, S., 2019. Chapter 10: impacts of climate change on marine resources in the Pacific Island region. In: Kumar, L. (Ed.), Climate Change and Impacts in the Pacific. Springer Climate. Springer, Cham (ISBN: 978-3-030-32877-1).

Jupiter, S.D., Epstein, G., Ban, N.C., Mangubhai, S., Fox, M., Cox, M., 2017. A social–e-cological systems approach to assessing conservation and fisheries outcomes in Fijian locally managed marine areas. Soc. Nat. Resour. 30 (9), 1096–1111.

King, M., 2007. Fisheries Biology, Assessment and Management, 2nd edition. Blackwell Publishing Ltd (400pp).

Leopold, M., Beckensteiner, J., Kaltavara, J., Raubani, J., Caillon, S., 2013. Community-based management of near-shore fisheries in Vanuatu: what works? Mar. Policy 42, 167–176.

McKenzie, L.J., Campbell, S.J., 2002. Seagrass-watch: Manual for Community (Citizen) Monitoring of Seagrass Habitat. Western Pacific Edition. Queensland Fisheries Service, Cairns, Australia.

Mellors, J.E., McKenzie, L.J., Coles, R.G., 2008. Seagrass-watch: engaging Torres Strait islanders in marine habitat monitoring. Cont. Shelf Res. 28 (16), 2339–2349.

MESCAL [Mangrove Ecosystems for Climate Change Adaptation], 2013. Biodiversity Assessments and Technical Reports.

Moritz, C., Vii, J., Tamelander, J., Thomassin, A., Anderson, P., Lee Long, W., Planes, S. (Eds.), 2018. Status and Trends of Coral Reefs of the Pacific. Published by the Global Coral Reef Monitoring Network, French Polynesia.

Ostrom, E., 1990. Governing the Commons. Cambridge University Press, New York, NY.

Purcell, S.W., Gossuin, H., Agudo, N.N., 2009. Status and Management of the sea Cucumber Fishery of la Grande Terre, New Caledonia. Programme ZoNéCo. WorldFish Center Studies and Reviews No. 1901. The WorldFish Center, Penang, Malaysia (138pp).

Reed, J., Van Vianen, J., Deakin, E.L., Barlow, J., Sunderland, T., 2016. Integrated landscape approaches to managing social and environmental issues in the tropics: learning from the past to guide the future. Glob. Chang. Biol. 22, 2540–2554.

Rodríguez, J.P., Taber, A.B., Daszak, P., Sukumar, R., Valladares-Padua, C., Padua, S., Aguirre, L.F., Medellín, R.A., Acosta, M., Aguirre, A.A., Bonacic, C., 2007. Globalization of conservation: a view from the south. Science 317 (5839), 755–756.

Rustagi, D., Engel, S., Kosfeld, M., 2010. Conditional cooperation and costly monitoring explain success in forest commons management. Science 330, 961–965. https://doi.org/10.1126/science.1193649.

SPC [Pacific Community], 2010. A Community-Based Ecosystem Approach to Fisheries Management: Guidelines for Pacific Island Countries. Secretariat of the Pacific Community, Noumea, New Caledonia (65pp).

SPC [Pacific Community], 2015. A New Song for Coastal Fisheries - Pathways to Change: The Noumea Strategy. Pacific Community, Noumea, New Caledonia.

Stewart, B., 1993. Evidence for a Marked Decline of beche-de-mer Populations in the Suva and Beqa Areas of Fiji, and a Preliminary Description of a Method of Identifying beche- de-mer Based on Characteristic Body Wrinkles. University of the South Pacific (USP) Marine Studies Technical Report, No.1, Suva, Fiji.

Toral-Granda, V., Lovatelli, A., Vasconcellos, M. (Eds) (2008) Sea Cucumbers: A Global Review of Fisheries and Trade. FAO Fisheries and Aquaculture Technical Paper. No. 516. Rome, FAO. 2008. (317pp).

UN ESCAP, 2020. Asia and the Pacific SDG Progress Report. United Nations Economic and Social Commission for Asia and the Pacific. United Nations Publication, New York (ISBN: 978-92-1-120807-8).

UNEP [United Nations Environment Programme] (2018) Wastewater Pollution and Coral Reefs: Science-to-policy Brief. Johnson, J.E., Brodie, J., Waterhouse, J. (Authors). United Nations Environment Programme, Nairobi, Kenya.