How does citizen science contribute to sustaining Moreton Bay? A discussion of approaches and applications.

Abstract

Citizen science in Moreton Bay *Quandamooka* has a long history of engaging the community in collecting, sharing and applying scientific information. A range of coastal and marine citizen science activities takes place within and around the Moreton Bay Marine Park, complementing research from government and academic organisations. Numerous benefits of citizen science are acknowledged, including environmental, educational, social, collaborative, policy and capacity building outcomes. Yet, the sector continues to face shared challenges in dealing with the uptake and application of data, supporting volunteer engagement, and achieving continuity through secure consistent resourcing. As the citizen science sector continues to grow in scope and scale, it prompts discussion regarding how programs can be developed to further enhance their contributions to sustaining the Bay. This chapter presents an overview of coastal and marine citizen science relevant to the Moreton Bay region and presents recommendations for fostering citizen science that contributes to sustaining the Bay.

Keywords: volunteers, monitoring, data, capacity building.

The context of citizen science in Moreton Bay

Across Moreton Bay's catchments, coasts and marine habitats, community members are variously involved in environmental research through citizen science projects. Citizen science has been broadly defined by the Australian Citizen Science Association as 'public participation and collaboration in scientific research with the aim to increase scientific knowledge'. Citizen participation in science has been longstanding in the natural history sector (1) and the methods of engagement and outcomes continue to evolve.

The diversity of citizen science activity is evident from the wide range of habitats from

which volunteers collect information across the Moreton Bay region; these encompass catchments, coasts and the marine environment. The papers in this citizen science chapter focus on citizen science projects that are directly relevant to the marine environment in Moreton Bay and are conducted in the marine and coastal zones (Fig. 1). Participants, including scuba divers, snorkellers, subtidal walkers and boaters, can collect data in the marine environment. Numerous coastal projects intend to improve understanding of environmental assets such as waterbird populations, the presence or range of threatened species and trends in marine debris.

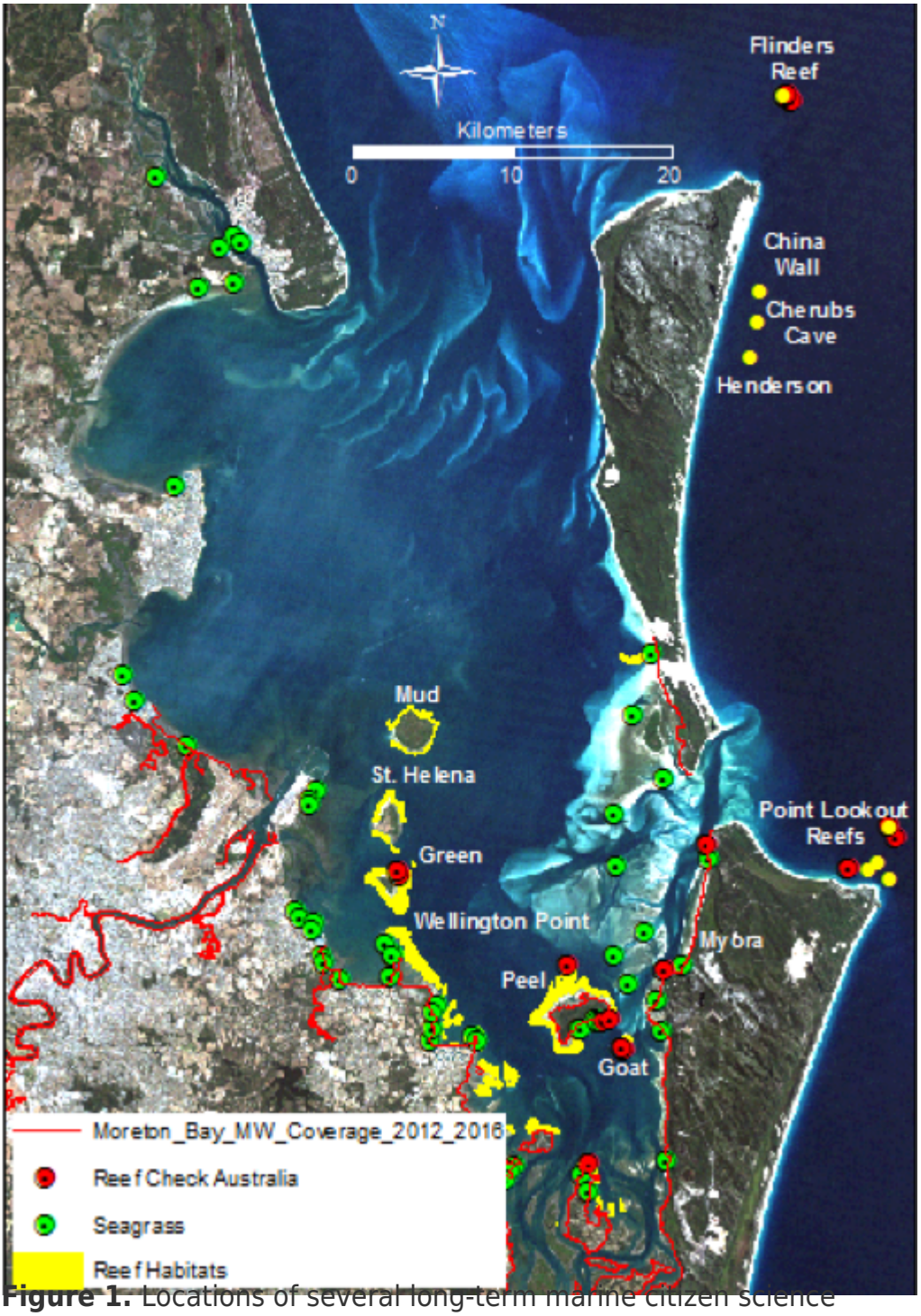

Figure 1. Locations of several long-term marine citizen science monitoring programs in Moreton Bay Marine Park, including Seagrass Watch, CoralWatch and Reef Check Australia.

Citizen science initiatives in Moreton Bay include a range of program types, most typically *contributory* or *collaborative* models of engagement (2). The *contributory* model involves the public in data collection, and is one of the most common forms of participation (3).

Universities, government agencies, schools, not-for-profits and community members

develop initiatives that support community participation in various research activities. The type of engagement in data collection varies dramatically across programs. Program participation may be quite short, such as casual photographic sightings (e.g. Project Manta), or self-guided data collection methods for simple assessments (e.g. CoralWatch). A more intermediate engagement type may require short practical training sessions with in-field facilitation (e.g. SeagrassWatch and Mangrove Watch). Other programs encompass extensive training courses with various time frames. For example, volunteers may undertake a multi-day training course to prepare for intensive data collection over short projects (e.g. UniDive Point Lookout Ecological Assessment (PLEA) project) or for ongoing engagement in annual monitoring (e.g. Reef Check Australia).

Citizen science goes beyond data collection. Volunteers can also be involved in *collaborative* project models and perform tasks such as analysing data (e.g. the production of the UniDive PLEA technical report) and sharing project findings with their local communities (e.g. the Reef Check Australia Reef Ambassadors community outreach initiative). Importantly, by integrating a better understanding of the environment with community engagement, citizen science programs can improve local knowledge and stewardship for the ecosystems or species being monitored (3). For example, data contributed by the Queensland Wader Study Group has shown a dramatic population decline in several shorebird species visiting Moreton Bay (4). Community involvement has resulted in several grassroots campaigns that address wader management in Moreton Bay (e.g. Save the Sandgate Waders).

Citizen science can be ‘top down’ to help augment or fill gaps in data or complement formal research and monitoring programs. It can also be driven by communities, or ‘bottom up’, to collect data relevant to their concerns (5–7). The number of citizen science projects is on the rise (8, 9), likely driven by factors such as community interest and concern for environmental issues (10, 11), new technology (12) and limited formal research budgets (13). The increasing trend in documented citizen science initiatives (9) offers growing opportunities for the range of stakeholders with an interest in citizen science, ranging from schools to government officials. In Australia, a national survey of 1145 marine users demonstrated that there is a high level of public interest in assisting marine research (11). Engaging marine user groups depends on many factors (such as the organisation behind the research, providing feedback, and aligning with volunteers’ interests), but the study showed that some members of the public are willing to contribute many hours to marine citizen science. For example, over half of respondents were willing to volunteer at least seven days a year.

Benefits of citizen science

Marine citizen science can provide a multitude of benefits beyond the scientific data (14). For coastal and marine environments in Australia in particular, citizen science has contributed to environmental knowledge and health, public education, social outcomes, stakeholder collaboration, conservation management, and the careers of scientists and volunteers.

Environmental knowledge

Engaging volunteers in citizen science projects can help to identify and fill gaps in available scientific data and knowledge. Local volunteers may provide additional detail, local and/or historical data, and knowledge for projects. Volunteers in citizen science programs can be highly skilled with some possessing expertise relevant to the species or system they choose to monitor. Participation from a wide range of people can help to cover temporal or geographic scales that would otherwise not be possible.

For example, community-based ambient water quality monitoring has occurred in South East Queensland since 2005. Many volunteers in community-based water quality monitoring get involved due to their previous extensive professional experience in the same field, their subsequent interest in waterway health and resulting capacity to provide input to the program (pers. comm. Apanie Wood). Since its inception, the program has monitored ambient water quality at more than 500 sites across the region. It provides long-term, comprehensive water quality data otherwise unavailable at this scale. It further provides a platform for highly skilled volunteers to enhance the program by collecting high-quality data. This affords technical interpretation for their communities and contributes valuable local-scale understanding and interpretation of data outputs.

Further regional examples of citizen science contributing to data gaps includes annual reef health monitoring data from Reef Check Australia on more than 20 reef sites across South East Queensland. Many of these sites do not have other regular monitoring programs. In another example, Redlands City Council identified the need for data on raptor nests to manage disturbance to the nesting birds. To fill this gap, Redlands City Council partnered with local community groups and residents to build a comprehensive map of the coastal raptor nests within the Redlands mainland and islands using the ‘Atlas of Living Australia Citizen Science Portal’ (https://www.ala.org.au/citizen-science-central/).

Citizen science data can also increase the temporal and spatial scale of a project (5, 15)

as the following examples demonstrate. The Australian Marine Debris Initiative program coordinated through Tangaroa Blue Foundation has helped to document marine debris hotspots and litter sources. The program targets policy action by providing standardised clean-up and data-collection protocols along with a centralised online database. In the case of the Redmap project, the public reports observational data on possible range extensions of marine species at a national level. eBird, the online bird checklist, provides a platform for citizen scientist birders to collate huge volumes of data with the goal of better understanding species distributions and population size. These programs also open-up opportunities for analysing large datasets through online platforms, greatly enhancing the processing speed for projects such as image analysis.

Educational benefits

Citizen science can deliver unique educational benefits for those actively participating, as well as the wider community. Citizen science volunteers have the opportunity to participate in authentic science activities (16). This can build knowledge and skills (3, 17), enhance awareness and ecological literacy (16, 18, 19), boost place-based connections (20) and foster environmental stewardship behaviours such as reducing plastic use (21, 22). However, the educational and behavioural outcomes from citizen science participation remain an understudied area in the field, and there is still much to be learned about how projects can lead to increased knowledge and behaviour change (21, 23, 24).

Participants in citizen science projects can also help inform the community and improve awareness of the topic (25). For example, CoralWatch offers an extensive range of educational programs that explain the biological, ecological and social implications of coral bleaching to support program participants, including a Moreton Bay education pack.

Social benefits

Citizen science programs can strengthen social relationships within participant groups (26), and between participants and scientists (17, 27, 28). Creating and maintaining social relationships between participants and the project team is integral to volunteer recruitment and retention (29). Participation in community-based groups and programs, such as citizen science, has long been known to create social cohesion and capital by bringing people together to share ideas and collaborate to address environmental issues (30, 31). At the individual level, benefits can include outcomes such as learning something new, increasing self-efficacy (or competence), appreciating nature, and being outdoors (24, 32).

Collaborative benefits

In addition to social benefits for individuals and cost-effective solutions for some types of research, citizen science offers a platform to bring together diverse and sometimes disparate stakeholder groups. This has the potential to improve stakeholder communication (33) and build trust across stakeholder groups (18, 33, 34). Collaboration between citizen science programs and Traditional Owners is particularly strong in the Bay region through collaborations with Quandamooka Yoolooburrabee Aboriginal Corporation and Quandamooka Land & Sea Management Agency. This has the potential to unite traditional knowledge with citizen science data collection and build capacity for land and sea management.

Participating in citizen science projects can help community members communicate about environmental issues in an objective language based on evidence, an outcome which is particularly important when managing environmental conflicts. For example, the Queensland Government uses WildNet to manage wildlife data collected from public and private sector sources. Data collected by the community submitted to WildNet is vetted and then made freely available from the Queensland Government, and the Atlas of Living Australia. With these data available, communities may better communicate their interests in preserving habitat for species of concern, which previously may have been unsupported by evidence.

In addition to benefitting from the time donated by volunteers, citizen science projects often partner with other stakeholders in the community such as businesses, government, and research and tourism bodies to leverage in-kind support for projects (24). This support, such as reduced fees for transport or services, data analysis or software contributions, expert advice, and/or donations of equipment can offer excellent value for investment. For example, citizen scientists partner with the Moreton Bay Environmental Education Centre to access chartered vessels for Moreton Bay MangroveWatch surveys. The education centre provides a large in-kind contribution to the program, and in return students at the centre can participate and learn from MangroveWatch citizen scientists. Citizen science and educational programs have also been highlighted as a potential marketing tool, offering benefits to local business (35).

Conservation management benefits

Informed advocates, data and products from citizen science projects provide tools for communities to drive evidence-based conservation management. Three modes of delivery have been proposed for the way in which citizen science may influence policy (14). First, citizen science can enhance data and community knowledge to support informed community advocacy on a specific issue. For instance, community seagrass

monitoring contributed to datasets that supported implementing ecofriendly moorings in the Bay with Healthy Land and Water in order to reduce damage to seagrass beds. Second, through co-created/cooperative policy change, citizen science can help identify and address an informational need with managers or policymakers. For instance, inshore reef maps and habitat inventories created through a collaborative partnership with Reef Check Australia, the Remote Sensing Research Centre (University of Queensland) and Healthy Land and Water are used in the annual Healthy Land and Water report card. They are also expected to provide some key information used by the Department of Environment and Science for reviewing zoning plans, preparing management plans or standard operating procedures, assessing applications and preparing permit conditions for activities that require permission to occur in Moreton Bay Marine Park (pers. comm. Carley Kilpatrick). Third, citizen science is used as a pathway to monitor the effectiveness of state and federal government management regimes. For instance, Grey Nurse Shark Watch aims to determine whether the management initiatives enacted to date are effective and result in population recovery (12). Further, programs that build local understanding about ecological values and management may also help communities provide informed comment and influence legislative change, such as during the review of zoning plans for Moreton Bay Marine Park.

Citizen science is increasingly recognised as a cost-efficient approach to inform natural resource management and support adaptive management (36). It has also been shown to increase the speed at which environmental decisions are made in resource management (37). For example, data collected by citizen scientists as part of the annual Glossy Black-Cockatoo Birding Day has been used to map the biology and distribution of this threatened species in the South East Queensland bioregion. These records, along with high precision records from other databases, have been used to develop Essential Habitat maps for the South East Queensland bioregion (38). This mapping contributes to protection of Essential Habitat as Regulated Vegetation under the *Vegetation Management Act 1999*. Data collection and creating this essential habitat mapping would not have been possible within the short term without the input of data collected by citizen scientists.

Career benefits

Volunteers can gain new knowledge and experiences through educational, social and collaborative activities. Potential areas of skill development include developing program leadership, fundraising, networking, fieldwork planning, data collection and analysis, species identification, mapping, modelling, photo and video skills, public education, project presentations, mapping and modelling. For undergraduates, recent graduates and those investigating a career change, the experience gained is limited only by their

availability and dedication. Many professionals also engage in citizen science as an avenue to make more meaning out of what they do day-to-day (e.g. IT/database, social media, dive instructors).

Challenges of citizen science

Along with the notable potential benefits of citizen science, there are challenges and barriers to developing, undertaking, maintaining, delivering and using data collected from citizen science programs. In addition, citizen science programs often need to identify priorities and strike a broad balance of objectives for research, education and policy outcomes (2). Identifying and maintaining this balance can be challenging, especially with diverse stakeholders.

Applying citizen science data

Whether or not data from citizen science projects is accepted and applied will be limited by how valid it is perceived to be (11, 39, 40), knowledge of its availability (41) and how accessible it is. Research indicates that stakeholders are using only a small percentage of citizen science-generated data for management decisions and research (42, 43). Many citizen science programs aim to address this through better quality assurance and control in their volunteer training and project planning, data collection methods and analysis, and program evaluation (44).

To increase the uptake and application of citizen science data for research or management applications, it has been suggested that end data users should be integrated in program development, and that projects should follow accepted data collection methods, use industry-standard quality assurance and control procedures, and follow existing data standards (20). In addition, global initiatives such as the PPSR CORE Metadata Standards (https://www.wilsoncenter.org/article/ppsr-core-metadata-standards) seek to improve citizen science data standardisation and interoperability. Citizen science associations encourage project leaders to adopt data and metadata standards to ensure data is more accessible to other stakeholders.

Volunteer engagement

There appear to be many volunteers interested in coastal and marine citizen science (11), but volunteer retention can be a significant challenge in the long term (45, 46). Volunteer management, support and communication are critical, but inconsistent

funding or resources as well as small and fluctuating support teams can limit these. Giving feedback and regularly communicating with existing and new volunteers is essential (11). However, these activities are resource intensive and may not be given adequate priority.

The skill level required in citizen science can range considerably — taking a photo to upload (e.g. Redmap), identifying a species (e.g. Reef Life Surveys) or calibrating a technically complicated instrument (e.g. water quality monitoring). The training, support and supervision must be aligned with the skills required and needs ongoing evaluation and support for volunteers to ensure that high quality data are collected.

Practitioners often identify ownership, feedback, ongoing learning, and recognition as important factors for continued volunteer engagement (31, 47). Field activities are the most common form of citizen science engagement; however, most volunteers want to see demonstrable outcomes from the data collection.

Workplace health and safety is a significant consideration for projects using volunteers. The diversity of participants may require programs to adapt methodologies to ensure they are suitable (e.g. different data collection protocols depending on training level), or to have specific safety criteria depending on the risk factors (e.g. health and medical condition criteria for fieldwork). For example, scuba diving surveys are restricted to volunteers with the appropriate diving experience and only go to specified depths. The cost of liability insurance and/or volunteer management can be a barrier for smaller community groups wanting to engage citizen scientists.

Funding and resources

As programs often receive inconsistent funding, available resources and the current level of funding may limit program activities. This can make stated project objectives difficult to achieve and also presents the challenges of continually engaging volunteers and collecting consistent monitoring data across space and time. It is clearly disempowering for volunteers to have invested time and effort into learning and contributing to a long-term project, only to find that the program ends due to lack of funding or cannot support consistent engagement activities. Experiences such as these can reduce a volunteer’s willingness to participate in future citizen science programs. To enable citizen scientists to collect high-quality data requires ongoing, long-term investment in training and capacity building of both volunteers and program managers.

Discussion

Citizen science for the future

Citizen science programs have provided and continue to provide valuable scientific, educational, social and policy contributions across Moreton Bay's natural land and seascapes. The past decade, in particular, has seen phenomenal growth in citizen science activities and this is helping to strengthen the connection between science and society. Further growth and interest in citizen science appears to be secure, following significant support and encouragement by governments in Australia and overseas (45, 48–50).

How can we strengthen programs to build opportunities for citizens to contribute to sustaining the Bay?

Citizen science can help to address environmental questions and challenges, but there is a need to amplify this capacity in order to strengthen strategic outcomes and positive impacts. Potential pathways to help achieve this for the Moreton Bay region include:

- Foster platforms and opportunities that constructively bring together citizen science, Traditional Owners, natural resource managers, government and other partners to share information, discuss priorities and collaborate.
- Construct an inventory of citizen science projects as relevant to natural resource management priorities, including for Report Card applications.
- Use case studies to build understanding of successful citizen science projects, bearing in mind that 'success' needs to be defined upfront as it will differ from project to project (51), and identify characteristics and situations that are shared across successful projects (8).
- Secure consistent investment for long-term programs that meet science or management needs to allow for long-term planning. This will in turn facilitate best-practice volunteer capacity building, community engagement and robust data collection.
- Conduct research into potential and existing volunteer interests, barriers and drivers for participation (9) to strengthen volunteer recruitment and retention. Research to better understand the benefits of citizen science programs in terms of education, social dynamics and conservation would also be beneficial.