



Colorada MPA Coral  
Fish Survey Report  
July 2019



## Introduction: Survey Aims and Rationale

MPAs provide a range of benefits for fisheries, local economies and the marine environment including:

- Conservation of biodiversity and ecosystems.
- Arresting and possibly reversing the global and local decline in fish populations and productivity by protecting critical breeding, nursery and feeding habits.
- Raising the profile of an area for marine tourism and broadening local economic options.
- Providing opportunities for education, training, heritage and culture.
- Providing broad benefits as sites for reference in long-term research.

Marine protected areas generate significant benefits for biological diversity conservation and also enhance surrounding fisheries. Reef Ball restoration activities generate a mixture of habitat types, structure and coral species which over time will lead to higher fish biodiversity. The protection of restoration areas within the MPA should also ensure that fish communities develop without fishing pressure, leading to increased biodiversity, abundance, biomass and species richness. These metrics contribute to overall reef health and also enhance fisheries in waters surrounding the MPA.

In order to quantify the development of fish communities in Colorada MPA and assess future MPA management and habitat restoration activities, regular scientific monitoring is required.

Between 13-19<sup>th</sup> July 2019 underwater video visual census (UVC) surveys were conducted inside MGP's Colorada Marine Protected Area. These surveys aimed to quantify the following metrics of fish assemblage structure and compare them between Reef Ball and non-Reef Ball sites:

- Overall fish biodiversity (using the popular Shannon-Weiner Index,  $H'$ ),
- Species richness (a raw measure of species present for each survey or habitat type),
- Abundance (numbers of individuals) of fisheries type species.

## Methods and Analysis

Transects were conducted by two-person dive teams using a high-definition underwater camera (Olympus Tough in PT-058 housing). Two Reef Ball sites within the MPA boundaries, RB2 and RB3 were surveyed together with two adjacent areas of similar sandy/patch reef and rubble habitat where Reef Balls have not been installed.

Five 2-minute timed-swim surveys were conducted at each site. Videos were then analyzed in detail on-shore, where each individual fish observed within a standardized area of the screen was counted and identified to species level. Statistical analysis was conducted using the statistical software R and *vegan* package. To assess the numbers of different species supported across the different habitat types, two indices of diversity (Shannon and species richness) were calculated and used to compare the two habitat types. Abundance of likely fisheries species were also calculated as a subset of the total dataset. These species were chosen using the FishBase online resource ([www.fishbase.org](http://www.fishbase.org)) and prior knowledge of popular fisheries species from across the Coral Triangle.

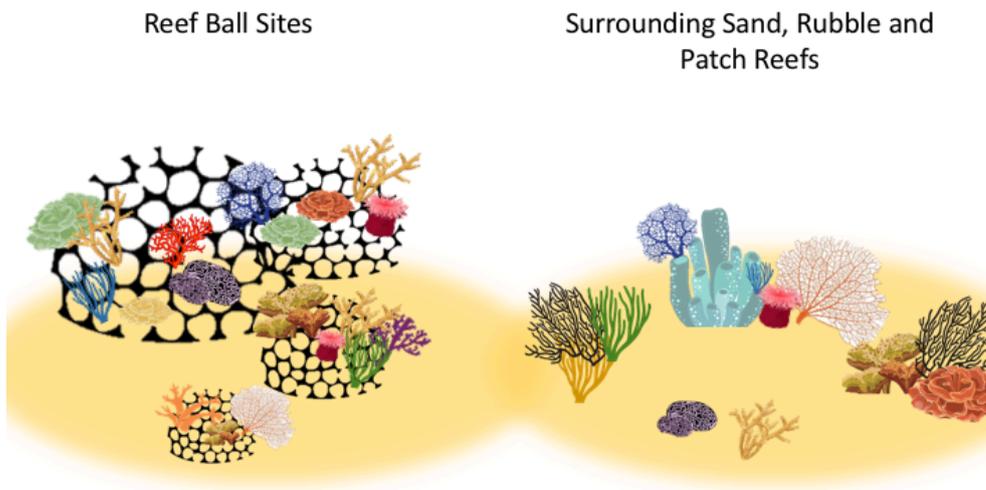


Figure 1. Survey sample design; all surveys we conducted within the MPA and aimed to assess differences in fish communities at sites with and without Reef Balls.

## Results

Mean diversity of all fish species was found to be significantly higher at sites with Reef Balls installed (average of  $2.14 \pm 0.3SE$ ) compared to those without Reef Balls installed (average of  $1.48 \pm 0.2SE$ , Wilcoxon Rank Sum Test,  $W = 83$ ,  $p = 0.01$ ). This suggests that the Reef Balls are providing additional and diverse habitat for a wider variety of fish species than would be found on sand, rubble and small patch reefs alone.

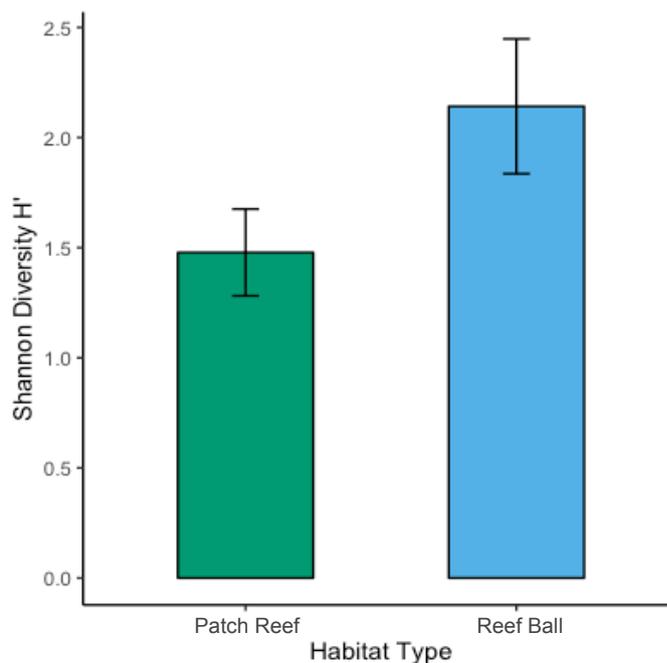
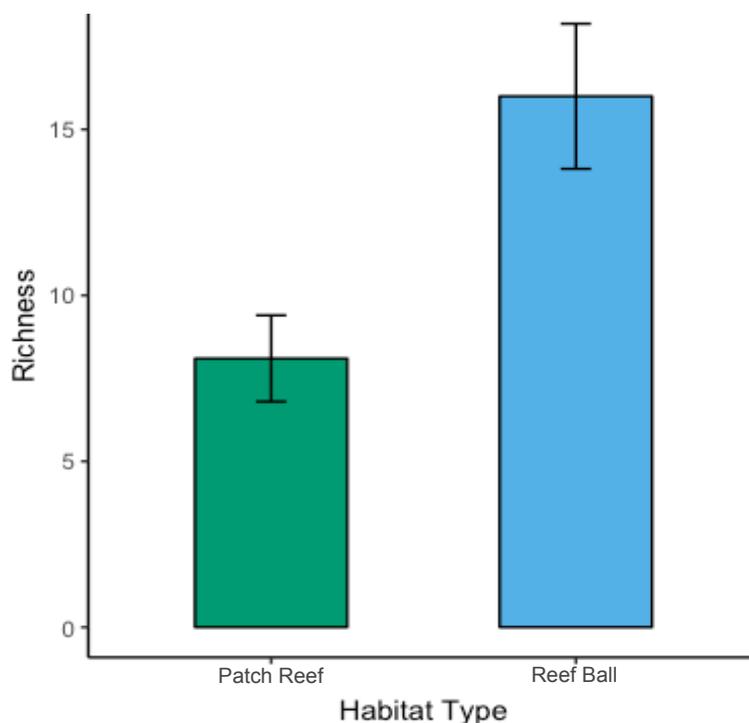


Fig. 2 Average) fish diversity based on Shannon Weiner Index ( $H'$ ) per transect at Reef Ball and non-Reef Ball (surrounding sand/rubble/patch reef) sites inside MGP Colorado MPA

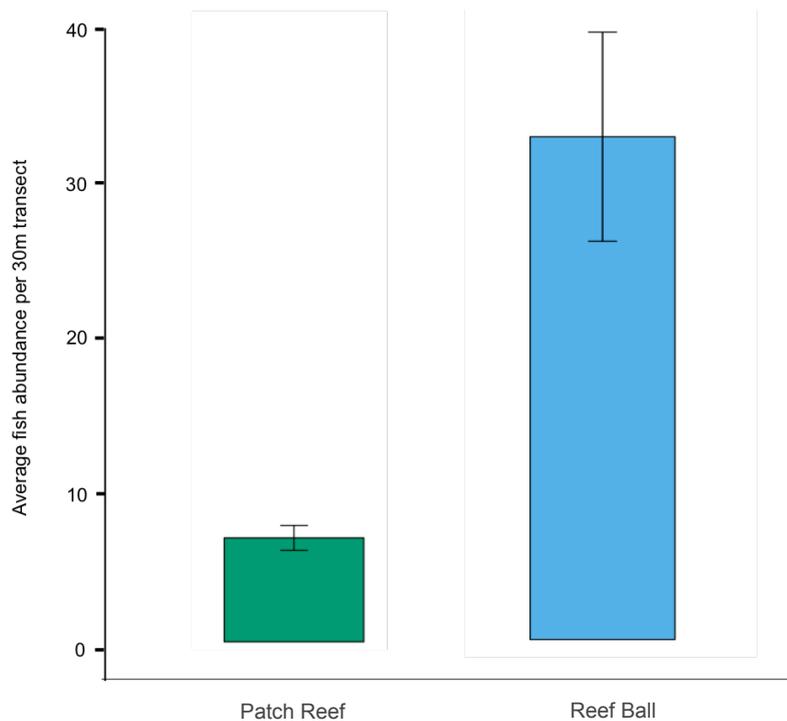
Species richness provided similar results. Species richness is simply the total number of species present per transect or habitat type and was also found to be almost double at Reef Ball sites (average of  $16 \pm 2.2SE$ ) compared with species richness at non-Reef Ball sites (average of  $8.1 \pm 1.3SE$ , Wilcoxon Rank Sum Tests,  $W = 95.5$ ,  $p = <0.01$ ), again suggesting the effectiveness of the Reef Balls in enhancing biodiversity in the MPA.



*Fig 3. Average fish species richness (number of species) per transect at Reef Ball and non-Reef Ball (surrounding sand/rubble/patch reef) sites inside MGP Colorado MPA*

Diversity of fish community alone is just one avenue for investigating the effect of Reef Balls or other restoration intervention measures. Another factor of likely interest to a variety of stakeholders is the effect of restoration on the abundance of fishes of interest to local fisheries. A very recent study (<http://theconversation.com/no-take-marine-areas-help-fishers-and-fish-far-more-than-we-thought-119659>) showed that an MPA can produce 5x the quantity of fish than an equivalent non-protected area and it is likely that restoration measures within an MPA will further enhance this figure.

The abundance (number of individual fish) of important fisheries species was significantly higher in Reef Ball sites (average of  $32 \text{ fish} \pm 7SEM$ ) than sites where only sand, rubble and patch reef were found ( $7 \text{ fish} \pm 1SEM$ ,  $W = 94$ ,  $p < 0.001$ ). This is perhaps the best indicator of the MPA and Reef Ball restoration achieving benefits for fisheries. Where diversity and species richness indication that biodiversity is being enhanced at Reef Ball sites, this achieving conservation goals: higher abundance of fisheries species within the Reef Ball area and the MPA in general should, over time, translate to benefits for adjacent fishing areas.



*Fig 4. Average fish abundance (total numbers of fish per transect) at Reef Ball and non-Reef Ball (surrounding sand/rubble/patch reef) sites inside Colorada MPA.*

## Discussion

### ***Conservation Benefits of Marine Protected Areas***

Properly designed and managed MPAs play important roles in the conservation of local marine ecosystems. The most immediate benefits of MPAs are that they provide natural areas with lower human impacts, protecting critical sites for reproduction and growth of species. Restoration activities within MPAs provide additional benefits where damage has been done to the natural habitat by protecting enhanced settlement and growth areas for marine species. For fish, the presence of complex structures is important for shelter, especially as juveniles, and also provides greater feeding opportunities for many species.

In the Colorada MPA we observed higher species diversity and richness of fish species at Reef Ball sites compared to sand/patch reef and rubble sites. This indicated that the Reef Balls are performing well, even in the early stages of their establishment, to enhance fish diversity within the MPA. Higher diversity in marine ecosystems is important for biological communities to withstand other disturbances like storms and temperature induced bleaching. Termed “resilience”, the number of species found on a coral reef is an essential part of maintaining the function of the coral reef ecosystem.

As the natural coral and fish communities within the Colorada MPA restoration sites develop, this initial trend in higher diversity should continue. However, further survey efforts will be required to assess the effectiveness of enforcement and guide management options for the reserve into the future.

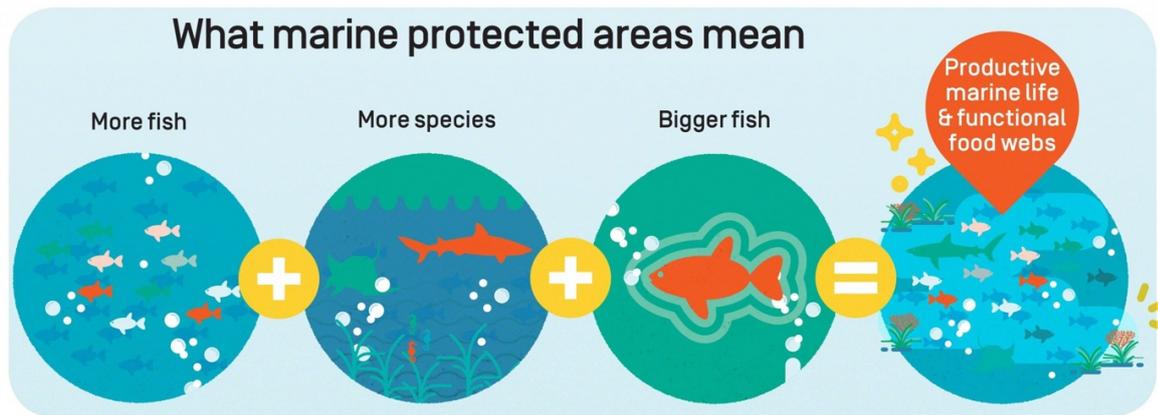


Figure 5. Conservation benefits of marine protected areas. Inside well-managed marine protected areas, there are more animals and plants and a great diversity of species and bigger individuals. Together these mean more marine life and healthier ecosystems.

Image adapted from: [www.saveourseasmagazine.com](http://www.saveourseasmagazine.com)

### Fisheries Benefits of Marine Protected Areas

Benefits to fisheries are a well-studied effect of the establishment of an MPA. Where the protected area provides habitat free from fishing pressure, fish can attain large sizes and are more reproductively productive. This results in the well-documented “spill-over” effect where larger mature fish produce high numbers of juveniles which eventually spill out of the MPA and into surrounding areas where they can be fished.

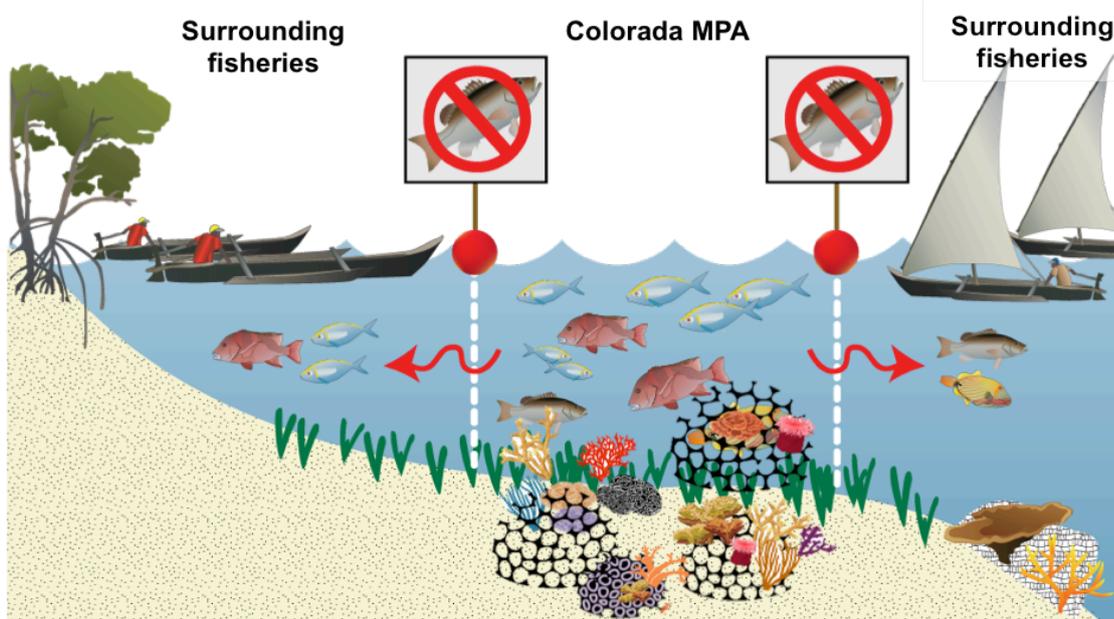


Fig 6. Conceptual diagram illustrating the benefits of a participatory planned marine protected area. Called the “spillover effect” it describes the net movement of fishes to outside the MPA area thus benefiting the fishery and local fishermen overall. Diagram courtesy of the Integration and Application Network.

The abundance of important fisheries species was significantly higher at Reef Ball sites compared to sand/rubble/patch reef. Although all surveys were conducted within the MPA, these results suggest that the Reef Balls are having a positive effect on the abundance of fisheries species, which, over time will translate into spillover to the surrounding areas and enhance local fishing.



Fig 7. Local fish market in Masbate City – images courtesy of <http://www.ivanhenares.com>

During our analysis of the abundance of key food fish within the reserve, we counted species usually considered important “fisheries species” generally from the families Nemipteridae (breams), Lutjanidae (snappers), Scaridae (Parrotfish), Carangidae (Jacks) Labridae (Wrasses). More detailed surveys of local fish markets would help to identify key families and specific species most valuable to local fisheries and communities.

#### ***Additional Benefits of Colorada MPA Reef Ball Restoration Sites***

- Education and tourism

As well as providing tangible benefits for biodiversity and fisheries, the Colorada MPA and Reef Ball restoration project has significant scope for providing focal points for education about marine ecosystems and human interactions with them. Reef Balls are also ideal sites for nature-based recreation and tourism. The access, trained crew and vessels that MGP already has in place makes the development of local educational outreach and tourism activities highly feasible.

- Scientific research

The Colorada MPA also has great potential for providing undisturbed control or reference sites serving as a baseline for scientific research and for design and evaluation of management of other areas.

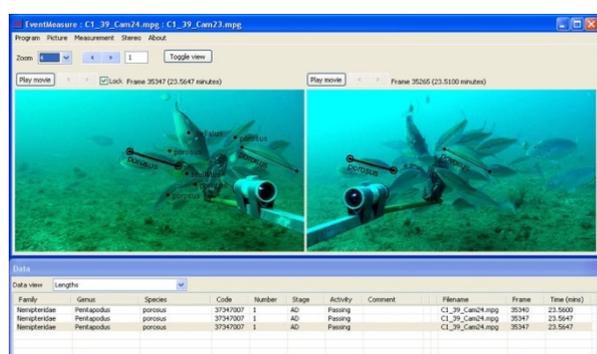
There has been a recent emphasis on developing more sophisticated tools for observing and measuring the physical, chemical and biological characteristics of marine ecosystems. There are many new techniques available for scientific research and monitoring of coral reef ecosystems including; in situ current and temperature loggers, sediment and turbidity monitors, acoustic water quality loggers all designed to measure ocean wave heights, currents and phytoplankton productivity. Additionally, high-definition underwater video techniques are now available for improved census of fish populations.

## Recommendations

### ***Continued fish stock monitoring – including biomass***

To assess the medium to long-term benefits to local fisheries, the biomass of fish within the protected area will be a major consideration for the management of MGP's Colorada MPA. Biomass is the total weight of fish stock and represents a measure of large, mature fish with the capacity to produce high numbers of recruits to the fishery. These in turn then contribute to the spillover effect into surrounding fisheries.

Stereo-video technology facilitates the accurate and rapid measurement of fish lengths which can be used to calculate weight and eventually, overall biomass of fisheries species within the reserve. Although size estimates can be made underwater, these methods are prone to observer error and can restrict survey efficiency. In contrast, video survey techniques can be conducted by a suitable trained diver and the video data later analyzed, either on site or remotely.



*Fig 8. Stereo-Video analysis software and camera bar (SeaGis Australia) used in the accurate measurement of fish lengths for biomass calculations.*

### ***Fishing pressure surveys, enforcement and outreach to the local community***

During this survey period, high occurrences of fishing line were observed within the MPA, both on Reef Ball sites and surrounding natural reef, sand and rubble. Additionally, three vessels were observed fishing by the survey team and the Lady J crew inside the MPA boundaries. It is therefore clear that fishing activities are still prevalent within the MPA, and, unless addressed, will hinder the progress of restoration activities and also have an impact monitoring data.

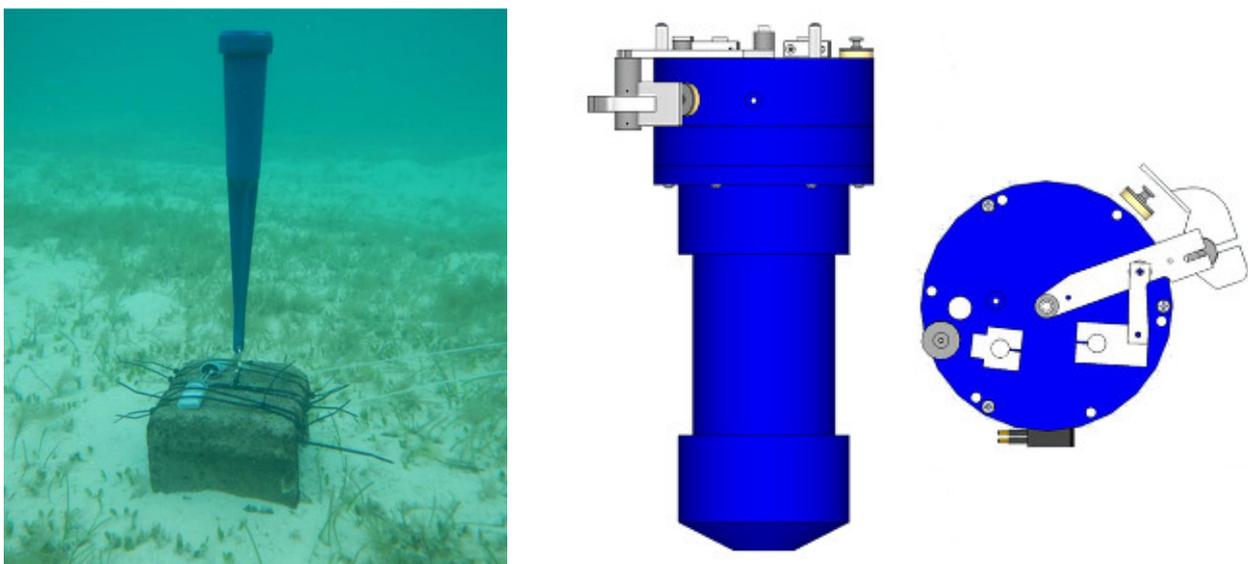
To quantify the extent of observed fishing pressure, simple surveys with the aim of collecting and measuring fishing line and nets within the MPA can be conducted. Once removed, future surveys will then be able to monitor the re-occurrence of fishing gear being deposited on the reef and continue to enhance enforcement. Surveys of local fish markets would also be a beneficial activity to identify highly targeted species and gauge relative fishing effort.

During the survey trip, wardens were noted as present within the MPA area. However, as fishing activity is clearly still prevalent within the MPA greater efforts to address enforcement are required. The application of small vessel tracking systems may provide a solution to assessing the effectiveness of warden patrols. In this way, patrol routes, timings and frequencies can be assessed and modified. Additionally, sharing knowledge and progress of the MPA amongst local communities can facilitate self-enforcement activities. Community presentations, visits to the restoration sites and other outreach activities are effective methods to encourage local “buy-in”.

### ***Expanded scientific monitoring***

To assess fine-scale patterns of biological community development and identify potential modifications to restoration site design, the deployment of in-situ environmental quality loggers would be advantageous to the project. Currents play a huge role in determining local environments and can modify water temperature, settlement patterns and productivity.

Deposition of sediment and the amount of mixing occurring in the water column are two key variables which can affect the success of coral recruit settlement, survival and growth. There are multiple instruments available to monitor these marine parameters which provide relatively low cost and low-effort solutions to gathering such fine scale environmental knowledge. These are currently in use around the globe including parts of the Coral Triangle and the Great Barrier Reef.



*Fig 9. Marotte High Sensitivity Current Meter (left) and Nephelometer (right), two in-situ logging devices which can measure fine scale environmental variables around monitoring sites.*

See <https://www.marinegeophysics.com.au/> for further details.

The advantages of in-situ loggers include easy deployment and retrieval, logging periods of between 2 and 6 months before requiring change out and download and the ability to share digital data for analysis via cloud storage upload.

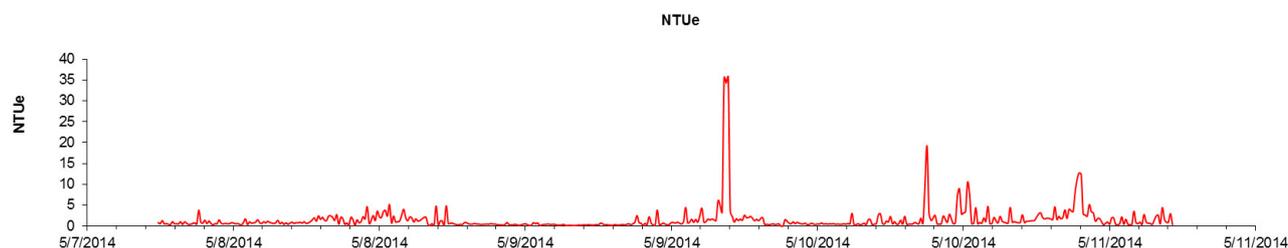


Fig 10. Sample data from a “Nephelometer” deployed on the Great Barrier Reef to measure the deposition of sediment.

## Summary

The MPA is showing positive signs of achieving benefits for both conservation of biodiversity and for local fisheries – good news for the environment and the surrounding human population. Reef Ball areas are enhancing these advances, particularly showing the following gains compared to surrounding habitat:

- Higher fish diversity
- Higher fish species richness
- Higher fisheries species abundance

Continued environmental monitoring will provide data to guide management and assessment of MPA benefits:

- Stereo-Video fish surveys for biomass measurement
- Continued fish surveys to measure biodiversity and abundance of fishes
- Extended fish surveys outside of the reserve to assess “spillover” effect and fisheries benefits
- Deployment of in-situ environmental quality loggers at Reef Ball sites

Recommendations for monitoring of fishing pressure, effective enforcement and community outreach required:

- Removal study of all fishing gear within MPA
- Fish market surveys to identify highly targeted species
- Assessment of enforcement effectiveness and monitoring
- Community outreach and presentations to disseminate MPA information