GILI SHARK CONSERVATION

TECHNICAL REPORT 2019

Raditya Andrean Saputra

Gili Air, January 2020

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Words from the Director

Another year comes to an end. It is time for closure because we humans are like that: we draw conclusions, add full stops, analyse facts, look back, and then make efforts to move on.

In April our research team went to Singapore to attend the ceremony for the International Seakeepers Society Asian Achievement Award, and the unbelievable thing happened – WE WON!! The annual Seakeepers Award is given to individuals or organizations who show extraordinary commitment to the cause of marine conservation in Asia. We also started an official partnership with SeaKeepers International and they sponsored the first 30 hex domes of our brand-new coral restoration project.

As marine conservationists, it is difficult to accept the damage that our own kind is causing to the world we love so dearly. We refuse to sit back and watch this devastation unfold and will do anything in our power to implement positive changes to the environment through research and education. The act of restoration is bringing a damaged ecosystem as near as possible to its original condition. The aim of our coral restoration project is to assist the recovery of an area on the North of Gili Air, which is host to a blacktip reef shark nursery, however, this site has historically been impacted by dynamite fishing, coral bleaching, and earthquake impact. We are also developing a new PADI Specialty course about coral restoration which will be available for everyone who joins our research team in 2020.

This year, we've also become a partner of Reef Check and our research team got certified as Reef Check Eco-divers by Reef Check Indonesia. Reef Check partners with a global network of trained and certified Eco-Diver volunteers. We are sure that by partnering up, we can share and learn from each other's experiences. And most importantly – support each other in our shared mission to save the coral reefs.

The greatest threat to our planet is the belief that someone else will save it. With our #PlasticFreeParadise campaign we want to create awareness for the use of single-use-plastic and reduce the amount that's being used on the Gili Islands. It's a wholehearted project that we keep building up with new ideas. This year we went from teaching 60 children to teaching 120 children on a weekly basis about conservation. We also introduced the concept of Gili Green on the island. Every business on the island that is a Refill Station, serve drinks without plastic straws, and offers plastic-free packaging for take-away, receives the Gili Green certification and will be on the Gili Green Map. We believe that the secret of change is to focus our energy not on fighting the old but on building the new. Our goal is to make it visible for everyone visiting the Gili Islands which businesses are 'green' and are part of the solution. Because in the end, we don't need a handful of people doing zero waste perfectly. We need millions of people doing it imperfectly

It's our dream to educate, train and empower local talent to become leaders of the Gili Island's growing tourism industry and guardians of its natural environment. I'm very proud to share with you that our guide Katon from Lombok became an instructor this year and I hope that in the future we can support more Indonesians who want to pursue a career in marine conservation but don't have the financial or emotional support to make it happen.

2020. A new decade. A fresh start. A new chapter waiting to be written. New questions to be asked and embraced and answers to be discovered. We are ready!

Warm greetings,

Rose Huizenga

Director Gili Shark Conservation Project

Acknowledgment from the Author

Personally, 2019 is the year of achievement, both for the project and for me. The Gili Shark Conservation Project has grown exponentially in its research methods and number of projects. We adopted two well-known methods to assess the health of the reefs around the Gili Islands: Reef Check and Coral Health Index. Our brand-new coral restoration project started in June in partnership with The International SeaKeepers Society, who also awarded us with Asia Achievement Award for our commitment to conservation. Regarding community engagement, we are now teaching 120 kids in the primary school at our weekly conservation class, four times the number compare to when we start at the beginning of 2018.

In addition, we were invited to several conferences/workshops/collaborations as listed below:

- *Operationalizing the Social-Ecological Systems Concept Using Network Analysis in the Context of SCUBA Diving Tourism on the Gili Islands, Indonesia.* Collaboration with ZMT Leibniz Centre, Germany.
- *Resilience and Coastal Tourism in South-East Asia (RESCOAST 19) workshop.* Hosted by Universitas Gadjah Mada and the University of Kent, Yogyakarta, Indonesia.
- *Shark and Ray Tourism Workshop*. Hosted by Project AWARE, Orlando, FL, USA.
- *Benchmark in Marine Protected Area in the Eastern Indonesia region*. Hosted by BKKPN Kupang, Lombok.

On top of the list above, we were involved in a lot of meetings with the local government regarding MPA and trash management. All those things made me realize the world now starting to take us seriously as an organization that is trying to do good for Gili Islands and the ocean in general.

In the process, I would like to thank several individuals below for their time and energy in giving us support. Without the people below, the project would not go this far.

- Sander and Oceans5 Dive Resort team.
- Zul and BKKPN Gili Matra Team.
- Ikram and BKKPN Kupang Team.
- Project AWARE.
- The International SeaKeepers Society
- Our participants who dedicated their holiday doing research and conservation.
- Rose, Andreas, and Charlie for the constant support.
- Katon for being the best research dive guide in the Gili Islands.

- Zara for being there, making everything possible every single day.

I realise we are still far from the finish line. Or maybe the finish line does not even exist. I hope this report would be beneficial for future research and better management in Gili Matra Marine Recreational Reserve. One step forward for ocean protection.

Raditya Andrean Saputra

Lead Scientist Gili Shark Conservation Project

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Summary

A total of 342 underwaters survey conducted in 2019 by Gili Shark Conservation team including 14 dropped and viewed Remote Underwater Videos (RUV), 210 roving surveys, 39 coral health index surveys, 27 reef check surveys, 50 dives against debris survey and 16 coral restoration dives. In addition, we identified 181 green turtles (*Chelonia midas*), 51 hawksbill turtles (*Eretmochelys imbriata*) and 18 white tip reef sharks (*Triaenodon obesus*) through Photo Identification, and 1106 data entries from Unite Gili. Furthermore, we keep track of the type of debris we have removed from our "adopted" dive site, Meno Slope. The most seen shark on RUV is blacktip reef shark (*Carchahinus melanopterus*) compared to white tip reef shark (*Triaenodon obesus*) in contrast to other methods suggested. It indicates that the blacktip reef shark is not susceptible to external disturbance and its shallow water habitat. Roving Survey method results have pointed out that the most seen bony fish species, elasmobranch, and turtle are humpback snapper (*Lutjanus gibbus*), white tip reef shark (*T. obesus*), and green turtle (*C. midas*) respectively. Comparing the data from 2017, 2018, and 2019 the number of bony fishes sighted per dive decreased significantly from 2017 to 2018 and remained the same in 2019 while shark, ray, and turtles' sightings are constant. Similarly, elasmobranch sighting from Unite Gili is dominated by white tip reef shark. July - October is the period when shark sighting was the highest along with high rare animals such as oceanic manta rays (*Mobula alfredi)*, whale shark (*Rhincodon typus*) common thresher shark (*Alopias vulpinus*), and spinetail devil ray (*Mobula japanica*). Previous research has suggested that June -October is the colder period for the Lombok Strait region and hence can explain this phenomenon. Unite Bali data suggested most of the elasmobranch sighted in the Nusa Islands, 70 km southwest from Gili Islands, dominated by reef manta ray (*M. alfredi)* by 94% of total elasmobranch sightings. Dive sites around Gili Trawangan (Sunset Point, Shark Point, and Halik) are giving the most sighting for bony fish, shark, and ray. Only Turtle City at Gili Meno which provides most turtle sighting. It could be related to living coral cover and reef fish density where the highest percentage is around Gili Trawangan (Halik) according to Reef Check and Coral Health Index surveys.

Introduction

Our mission is to promote shark conservation efforts through education and research. Meanwhile, we are collecting abundance data from around the three Gili Islands to build a case strong enough to propose to the government to make the Gili Matra Marine Recreational Reserve (GMMRR) the first recognized shark nursery ground in Indonesia. In short, if the area will be recognized as a shark nursery area, sharks and other marine life within Gili Matra Marine Recreational Reserve will have better protection.

To achieve this, we gathered scientific data to prove that this area is, in fact, a shark nursery and to assess reefs' health within GMMRR. We had multiple projects that work towards this goal including remote underwater video (RUV), roving survey dives, photographic identification, Coral Health Index, Reef Check, Unite Gili, and community outreach. In addition, we also had one extra project: coral reef restoration in Gili Air in collaboration with The International SeaKeepers Society and Oceans5 Dive Resort Gili Air.

Remote Underwater Video (RUV)

Because of the nature of shark research in the wild, new techniques had to be invented to answer our questions about the lives of sharks. One of these techniques is the Remote Underwater Video (RUV). This shark study method has been used in numerous studies around the world and has been shown to be very successful. One significant change compared to last year, we removed the bait element in this method hence now called RUV. The idea behind the change was to observe marine life in their very natural behavior without any human manipulation and to do shark habitat exploration.

Roving Survey

Being able to conduct rapid species assessments is becoming increasingly more important as a conservation research tool. Our research team uses the ‘Roving Diver Technique”, a visual surveying method designed specifically for actively seeking out and positively identifying indicator species (especially fisheries targeted species) during a dive.

Data on species composition, sighting frequency, and abundance of all relevant fishes are collected using this surveying method. The data is inputted into several online databases to contribute to various marine biologist studies of current shark and ray populations, as well as our own data log for fisheries management strategies.

Coral Health Index

COREMAP-CTI Coral Health Index (CHI) is a national monitoring guideline that is applied throughout Indonesia, allowing data at various spatial and temporal scales to be comparable. This is extremely valuable in its ability to highlight how reef health is changing spatially and temporally, thus providing an insight into where and how management actions would be best applied. The current study uses an index for coral reef health (Figure 1) that constitutes a variety of parameters; Benthic recent condition, benthic recovery potential, and fish biomass. Thus, allowing the index to provide a more accurate measurement of reef health, rather than provided by a single parameter such as coral cover.

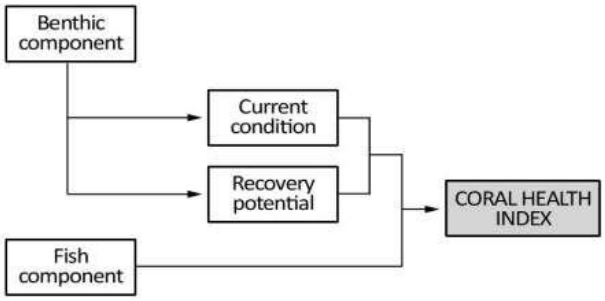


Figure 1. The parameters used to determine CHI. (Giyanto et al., 2017).

Reef Check

The Reef Check method was designed to produce a standardized global technique that can be used by citizen scientists all over the world to monitor coral reefs.

We collect data using this method on behalf of our partners at Reef Check which aids their research on an international scale and is essential for our own research objectives. The data helps us to identify trends in any changes taking place over time and produce management strategies to improve areas where necessary through education, research, and restoration.

Coral Reef Restoration Project

Data from the Gili Shark Conservation Fish and Benthic surveys – a method to assess the health of the reef, estimate that over 50% of coral coverage has been lost and therefore it calls for a fast and more efficient method of restoring back the GMMRR's pristine coral reef.

Coral restoration has shown promising results around the world, with the closest example being the Blue Corner coral restoration project in Nusa Lembongan, Lesser Sunda Islands which is located only 2 hours away from the GMMRR. They have been able to transplant species-specific coral to that area onto various Hex dome structures through a process called coral micro fragmentation. The Gili Shark Conservation team, after proper training and planning, would like to determine the potential for restoring coral in the GMMRR using this same method.

Photo Identification

For marine conservation to be effective we need to know about the populations of the species we aim to protect and learn about their life history and the environment they chose to live in. Our photographic identification program is a very useful tool for us to be able to identify the sharks and turtle's resident in the area and monitor their behavior.

With the use of an underwater camera, we can identify individual sharks and turtles living within the Gili Matra Marine Recreational Reserve and track their behavior and populations in a non-invasive way. The full side profile of a shark and side profile of a turtle's face is unique to an individual can be used as a unique fingerprint to create an individual profile for each individual that we managed to get an identifiable picture of.

Unite Gili and Unite Bali

Due to limitations in the number of dives and area coverage for the Gili Shark Conservation team, we initiated Unite Gili. Unite Gili is citizen science – we relied on dive professionals within Gili Air to report their elasmobranch sightings to us on a weekly basis. This way, the data volume is larger compare to our primary data such as roving surveys. Hence, we have a stronger case to prove that the Gili Islands is a shark nursery area. Furthermore, Unite Gili keeps the dive professionals in Gili Air updated about Gili Shark Conservation status and recent research findings. Since 2018, we expanded our citizen science to the Bali area. We had been working together with our partner from Nusa Lembongan (Bali) submitting their elasmobranch sightings in order to have a comparison in elasmobranch diversity between the Gili Islands and the Nusa.

Dive Against Debris

The Gili Shark Conservation Project has adopted the dive site Meno Slope through the Adopt a Dive Site program of Project Aware. Meno Slope is a famous dive site just of the west coast of Gili Meno – with underwater statues that attract snorkelers. Once a week our research team does an underwater clean-up dive at this site, and more than often we find rather interesting things. Such as large pieces of wood, metal poles, and kites. We also find plastic bags, wrappers, and plastic straws. The Adopt A Dive Site program allows us to lend a hand in keeping the ocean free from toxic and unsafe marine debris.

Underwater and Aerial Time-Lapse

Coral reefs play a crucial role in the health of marine ecosystems and it is now in the brink of extinction because of multi-level stressors. One of them is coral bleaching that is caused by sea temperature anomaly. In 2018 we started our Underwater Time-Lapse project on the Gili Islands. To be more specific on a dive site called Meno Slope, the same dive site for our Dive Against Debris project. The goal of the project is to record any changes by making a time-series of images of the same corals. We record the temperature and the salinity with every photo taken so that we can track how the change of water physical parameters affected our coral samples.

Because we believed that the changes happen not only underwater, but also on land, we started to take an aerial photo with a drone every week. The idea is to see how the Gili Air coastline and reef shape change through time. Furthermore, with the developing tourism activity, we are aiming to see land-use change on the island as well.

Methods

All the programs were conducted within GMMRR in thirteen dive sites (Figure 2) including Sunset Point, Shark Point, Halik, Deep Turbo, Shallow Turbo, Bounty Wreck, Meno Slope, Meno Wall, Turtle City, Mirko's Reef, Air Wall, 7 Seas Reef (Statue Garden) and Han's Reef. However, the data density is higher around Gili Trawangan since we encountered most of the sharks at the dive sites around Gili Trawangan; Sunset Point, Shark Point, and Halik.

Most of the data were taken by SCUBA diving except for Unite Gili and Bali which is a secondary data reported by dive professionals around Gili Air and the Nusa Islands (Bali). All the data then gets stored in the Gili Shark Conservation Project database and then was analysed by the Lead Scientist using multiple software such as Microsoft Excel for calculation and statistical analysis, Coral Point Counter

with Excel extension (CPCe) for substrate identification, and Geographic Information System (GIS) software for spatial analysis.

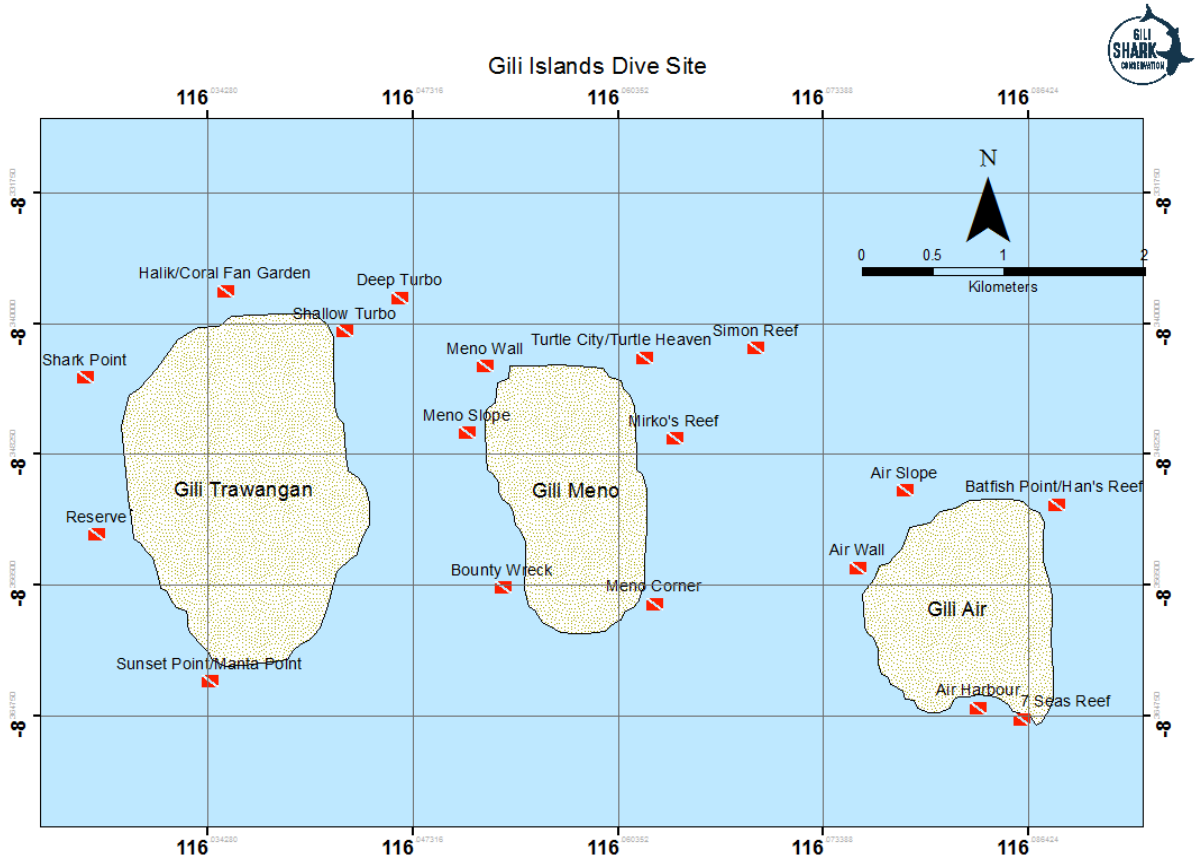


Figure 2. Dive Sites in the Gili Matra Marine Recreational Reserve.

RUV

RUV's consist of a video camera inside an underwater housing that is mounted on an aluminum frame. Weights are added to the aluminum frame to make sure the RUV stays in one position (Figure 3).

Figure 3. RUV set up underwater.

This shark study method removes diver impacts on species behaviors as it requires us to deploy the camera in a location within the MPA at hours when divers are not active in that zone and leave it there for a minimum of one hour before we return to collect it.

RUV sampling was conducted throughout the GMMRR surrounding the three islands of Gili Trawangan, Gili Meno, and Gili Air. We collect data from recognized dive locations. For keeping track of our drops, the most important information is the GPS coordinates. These allow our team to map exactly where the RUVs have been dropped and inform where we could drop in the future to ensure we cover as much of the area around the Gili islands as we can to better asses all perimeters within the GMMRR.

We watched the footage collected from each drop and record all indicator bony fish, sharks, rays, turtles and species of interest that came along to get a better understanding of which areas within the GMMRR are successful and which areas need better protection.

By analysing the data collected from our RUV we could learn more about the behavior of the species of sharks commonly found within the reserve and begin to understand the perimeters where sharks tend to be at certain times of the day and year. By keeping a record of the depths, the sharks have been sighted based on where the RUV was placed, we can see if the different species of sharks tend to be indifferent perimeters of the reef. By recording where the most bony fish/moray eels/other species of interest are seen on the footage collected, we should be able to access the health of the reef in that zone. We were also interested to assess the distance from the GMMRR red zones that sharks are most commonly seen on the footage to will again help us to access the success and failures of the zoning within the reserve and how it affects the life on the surrounding reefs.

Roving Survey

Our research team went out for a minimum of four dives per week to conduct Roving Survey dives throughout the GMMRR. During these dives, we count all indicator species that are bigger than 30 cm Total Length (fisheries targeted species including snappers, groupers, emperors, trevally, barracuda, tuna and mackerel) as well as shark, ray and turtle sightings. Giant clam, bump head parrotfish, and hump head wrasse were also recorded as species of interest. In this report, we use terminology bony fish for the indicator species. We record the number of individuals observed, species information, size estimation, sex of sharks, rays and turtles and the depth and dive time at which we encounter each individual indicator species.

Each member of the research team has their own slate and record a set of data (Figure 4). When we returned to the office we compared and combined the data collected and recorded our findings into one set of data per survey dive to be next used for biomass calculation, spatial variability, and temporal variability of the indicator species.

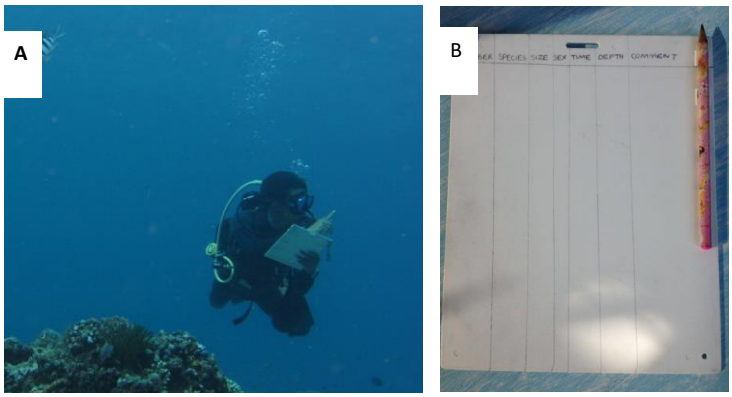


Figure 4. A) A team member writing down indicator species on the slate. B) Slate with table headings used during roving survey dive.

Coral Health Index

Coral Health Index survey consists of two parts Underwater Photo Transect and Underwater Visual Census.

The Underwater Photo Transect (UPT) methodology was used to measure the benthic community composition at 11 sites in the GMMRR at a depth of shallower than 10 meters. Measurements were replicated three times at each site. At each site, a 50m transect was laid parallel to the shore and a 44x58 cm quadrat was placed on the reef at the 0-meter mark. Using an underwater camera, a photo was then taken off the quadrat perpendicular to the reef (Figure 5). Using the exact same technique photos were taken at each meter of the transect, providing 50 photos for each transect. At the end of the transect, after the final photo was taken, divers waited 5 minutes for the fish to acclimatize to their presence.

Then proceeded to conduct an Underwater Visual Census (UVC) to measure the fish biomass and diversity. Divers swam back along the transect recording the occurrences and estimated 6 the total fish length of the targeted fish families that were present within 2.5m either side of the transect. Each UVC represents 250m^2 of the reef.

Coral Point Count with Excel extension (CPCe) software version 4.1 was used to analyze the photos taken from each UPT. In CPCe, benthic categories were identified using 'KODE KARANG COREMAP' classification. A total of 30 random points was used for analysing each image; thus, the cover percentage of benthic categories was quantified (Figure 6). Fish component data were analyzed using

Microsoft Excel software. Abundance, biomass, and diversity of the six targeted families, were determined by summing up the number of species per family sighted, converting length to the biomass of each species sighted and finally, calculating the number of individual species per family. The cover percentage of benthic categories and fish biomass were then used to generate the Coral Health Index (CHI) as outlined by Giyanto et al. (2017).

Figure 5. Two divers doing Underwater Photo Transect (UPT) as part of the Coral Health Index survey.

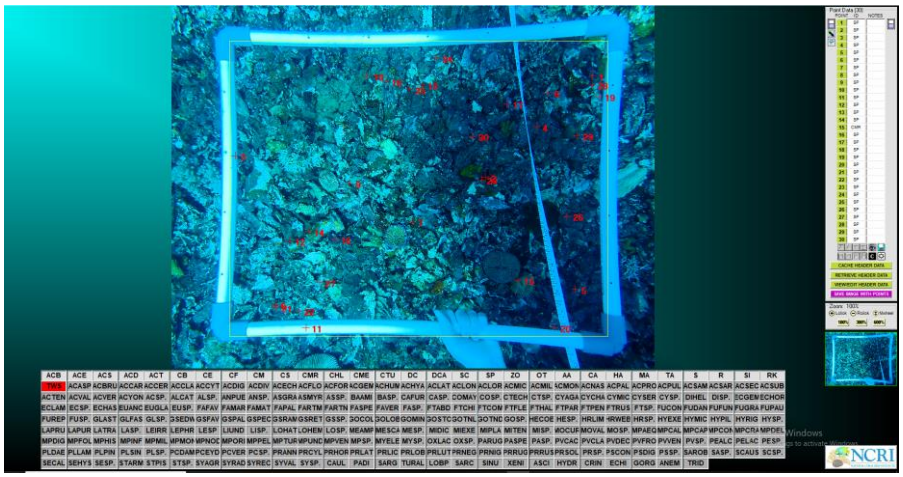


Figure 6. CPCe screenshot during UPT data analysis.

Reef Check

The Reef Check surveys were directed subsequent to Reef Check Instruction Manual (Hodgson, 2006). The team did the surveys at 2-6 m (shallow) and 6-12 m (mid) depth at the best area of the reef. There are three main types of data, fish, invertebrate and impact, and substrate.

Fish Belt Transect

The fish belt transect was the first survey completed because fish could easily be disturbed by divers. After the transect had been deployed, the divers waited for 5 minutes in a location away from the transect before starting the survey. This waiting period was necessary to allow fish to resume normal behavior after being disturbed by the divers deploying the transect. The maximum height above the transect to record fish was restricted to 5 m in the water column. This could be estimated as two body lengths including outstretched arms and fins. Each diver assigned to count fish swam slowly along the transect counting the indicator fish. The diver then stopped every 5 m and then waited one minute for indicator fish to come out of hiding before proceeding to the next 5 m stop point. The fish were counted while swimming and while stopped along the entire length of each 20 m transect (Figure 7). This is a combined timed and area restricted survey: four segments x 20 m long x 5 m wide = 400 m2. As with each of the surveys, there were four 5 m gaps where no data are collected. At each depth contour, there were sixteen "stop-and-count" points, and the goal was to complete the entire 400 m2 belt transect in a maximum of one hour. The indicator fish had been selected because they are typically shot out of reefs by spearfishing, removed as targets of cyanide fishing, and caught using hand lines. Indicator fish family/species for Indo-Pacific region including butterflyfish, sweetlips, snapper, barramundi cod, humphead wrasse, bumphead parrotfish, moray eel, parrotfish, and grouper. Size minimums had been placed on two families of food fish (> 30 cm for Grouper, > 20 cm for Parrotfish). Grouper and parrotfish smaller than these limits were not counted. Rare animal sighted such as shark, ray, and turtle were also recorded.

Invertebrate and Impact Belt Transect

When the fish belt transect was complete, the invertebrate team then carried out the belt transect survey for invertebrates using the same belt transect that was used for the fish survey. Each belt transect was 5 m wide (2.5 m on either side of the transect line). The invertebrate survey was similar to the fish survey, however, the diver did not need to stop every 5 m. Each team also recorded the level of bleaching and the presence of coral disease, trash and coral damage in the survey area. Each

diver swam slowly along using an S-shaped pattern along the transect counting the indicator invertebrates. Indicator invertebrate for Indo-Pacific region including banded coral shrimp, Diadema urchin, pencil urchin, collector urchin, three species sea cucumbers (redfish, greenfish, and pinkfish), crown-of-thorns starfish, giant clam, triton shell, and lobster.

Line Transect (Substrate)

When the invertebrate belt transect was almost completed, the next buddy pair began the line transect. We used a “point sampling” method for the substrate survey because it was the least ambiguous and fastest method and easily learned by non-scientists. It involved recording the substrate type that lies directly below the tape at 0.5 m intervals i.e. at 0.0 m, 0.5 m, 1.0 m, 1.5 m, etc. up to 19.5 m (40 data points per 20 m transect segment).

Reef Check has a specific substrate category and abbreviation as explained below:

Hard Coral (HC): Live coral including bleached live coral. Also, include fire coral (Millepora), and in the Indo-Pacific, blue coral (Heliopora) and organ pipe coral (Tubipora) because these are reef builders.

Soft Coral (SC): Include zoanthids, but not sea anemones (the latter go into "Other"). Sea anemones do not occupy space in the same manner as zoanthids or soft corals, which can compete with hard corals. In the Atlantic, this category is for zoanthids.

Recently Killed Coral (RKC): The aim is to record coral that has died within the past year. The coral may be standing or broken into pieces. RKC appears fresh and white or with corallite structures still recognizable (i.e. their structure is still complete/not yet eroded). Please write the estimated percentage of RKC that is the result of bleaching at the bottom of the datasheet.

Nutrient Indicator Algae (NIA): The aim is to record blooms of algae that may be responding to high levels of nutrient input. In 2006, the NIA definition was changed to include all algae except coralline, calcareous (such as Halimeda) and turf.

Sponge (SP): All sponges (but no tunicates) are included. The aim is to detect sponge blooms that cover large areas of reef in response to disturbances.

Rock (RC): Any hard substrate whether it is covered in e.g. turf or encrusting coralline algae, barnacles, oysters, etc. Rock also includes dead coral that is more than about 1 year old, i.e. is worn down so that few corallite structures are visible and covered with a thick layer of encrusting organisms and/or algae.

Rubble (RB): Includes rocks between 0.5 and 15 cm diameter in the longest direction. If it is larger than 15 cm it is rock, if it is smaller than 0.5 cm it is sand.

Sand (SD): Particles smaller than 0.5 cm. In the water, sand falls quickly to the bottom after being dropped.

Silt/Clay (SI): Sediment that remains in suspension if disturbed. Note that these are practical definitions, not geotechnical. Often, silt is present on top of other indicators such as rock. In these instances, silt is recorded if the silt layer is thicker than 1 mm or covers the underlying substrate such that you cannot observe the color of what is underneath. If the color of the underlying substrate can be discerned, then the contact will be counted as the underlying substrate NOT silt.

Other (OT): Any other sessile organism including sea anemones, tunicates, gorgonians or non-living substrate.

Figure 7. A team member is recording fish data on Reef Check slate.

Coral Reef Restoration Project

Batfish Point/Hans Reef was selected as the location for this restoration scheme as there are a high variety and abundance of fish species. BRUV footage retrieved by the Gili Shark Conservation research team has indicated that this site is also a habitat for both juvenile and adult blacktip reef sharks. Additionally, by facing the northern ocean, it receives lots of water circulation, which could potentially bring coral larvae, and aid in natural recruitment. Together, these factors give this site high recovery potential that is favorable for undertaking restoration projects.

It was decided that the Gili Coral Restoration Program started start on July 2019. Thirty-six hex-domes structures were dropped in Batfish point/Hans Reef dive site. Micro fragments from a specific genus of coral including, *Acropora*, *Echinopora*, *Porites*, *Pocillopora*, and *Heliopora* (blue coral), which are all coral communities that thrive in this area, were transplanted onto half the hex dome structures (Figure 8). The other half will remain as the control with no coral transplants, which will allow for the potential growth of coral through natural recruitment.

Figure 8. Two divers were attaching coral fragment to a hex-dome structure.

Photo Identification

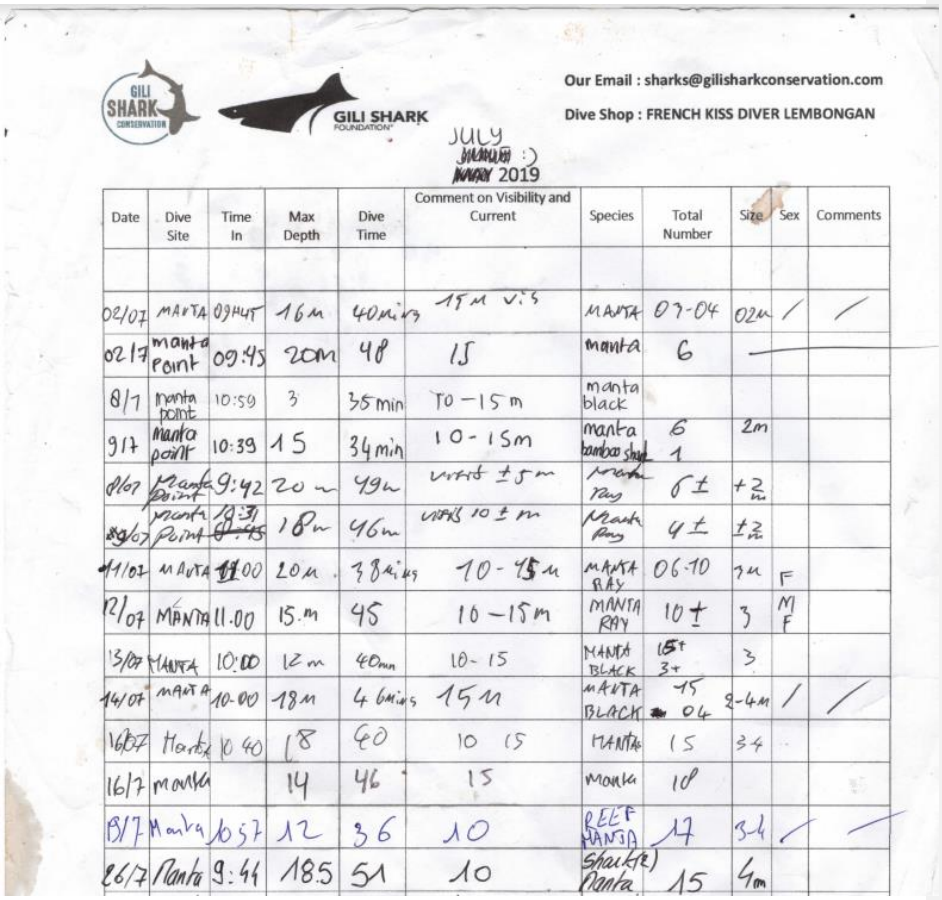
On each photo identification survey dive, we brought an underwater camera, a slate and a T-stick (a PVC pipe that is one m long and three cm wide and helps us to properly measure the length and width of the turtles or shark) as shown in Figure 9. For turtles, we prioritized the cheek area of the face because unlike the fins, shell, or tail, the scales on their faces are not likely to change throughout the turtle's lifetime and the cheek offers an easy, flat surface to photograph. For the shark, we tried to take the full body from the side perpendicularly. The goal was to get a clear picture of blotches on the shark body.

Figure 9. A diver places a T-stick above a turtle to measure Curved Carapace Length (CCL) and Curved Carapace Width (CCW).

We used a program called "I3S" where we input our photographs and identify individuals. This program recognizes patterns in individuals pictured allowing us to create profiles for newly identified individuals or allowing us to track already identified individuals.

Unite Gili and Unite Bali

Not like other programs, Unite Gili is a citizen science and hence it is secondary data. We asked dive professionals in dive shops around Gili Air to write down sharks and rays sighted during their dives on the sheet provided by the Gili Shark Conservation team. The sheet contained information such as date, species, numbers species seen, diving condition, size, sex, and comment on the sharks and rays (Figure 10). One of the GSC team-members would collect the sheets from every dive shop once a week. After, the sheets then copied to the GSC database for further analysis. Whereas, for Unite Bali, the data was sent every end of the month by our collaborator.



GILI SHARK FOUNDATION

Our Email : sharks@gilisharkconservation.com

Dive Shop : FRENCH KISS DIVER LEMBONGAN

JULY 2019

Date	Dive Site	Time In	Max Depth	Dive Time	Comment on Visibility and Current	Species	Total Number	Size	Sex	Comments
02/07	MANTA	09H45	16m	40mins	15m vis	MANTA	07-04	02m	/	/
02/7	manta point	09:45	20m	48	15	manta	6			
8/7	manta point	10:59	3	35 min	10 – 15 m	manta black				
9/7	manta point	10:39	15	34 min	10 - 15m	manta bamboo shark	6 1	2m		
9/07	~~Manta Point~~	9:42	20 m	49m	visib ± 5m	~~Manta~~ ray	6 ±	+ 2 m		
8/07	~~manta point~~	~~9:31~~	18m	46m	visib 10 ± m	Manta Ray	4 ±	± 2 m		
11/07	MANTA	~~11~~00	20m	38mins	10 - 15 m	MANTA RAY	06-10	3m	F	
12/07	MANTA	11.00	15.m	45	10 – 15m	MANTA RAY	10 ±	3	M F	
13/07	MANTA	10:00	12 m	40mn	10- 15	MANTA BLACK	15+ 3+	3		
14/07	manta	10.00	18m	4 6mins	15m	MANTA BLACK	~~15~~ 04	3-4m	/	/
16/07	Manta	10 40	18	60	10 15	MANTA	15	3-4		
16/7	manta		14	46	15	manta	10			
18/7	Manta	10:57	12	36	10	REEF MANTA	17	3-4	/	/
26/7	Manta	9:44	18.5	51	10	Shark(2) Manta	15	4m		

Figure 10. Example of filled Unite Gili datasheet reported by a dive shop.

Dive Against Debris

Once a week (mostly Friday morning), we did a reef-clean up dive at our adopted dive site, Meno Slope. This program was started in October 2017.

There was no big difference in equipment used and the diving rules compared to our normal survey dive. However, in addition, we brought mesh bags for trash containers, gloves for sharp objects, and scissors to cut discarded fishing gear. We were focusing to look for debris, anything that did not belong to the ocean. We normally went down to 25 m as the maximum depth and 45 minutes as the maximum dive time. Working in pairs, one person collected the debris while the other held the mesh bag (Figure 11).

After the dive, we gathered all the debris in the dive shop to be classified and tallied. At the end of the survey, we reported the data to *Project Aware* database.

Figure 11. A Diver with a mesh bag filled with trash at Meno Slope.

Underwater and Aerial Time-Lapse

Our underwater sample images were taken at the north side of Meno Slope, our adopted dive site every Friday morning before Dive Against Debris. We took images of four samples, two hard corals (one branching and one massive), one soft coral, and one recently killed coral (Figure 12) at 4 m depth. For the aerial images, we chose four sides of Gili Air, South, East, North, and West (Figure 13). Aerial time-lapse was done at least once a month of each sample mostly during mid-day to get uniform lighting to the landscape.

Figure 12. An underwater time-lapse sample of a branching coral colony taken at 4 m depth.

Figure 13. A sample of aerial time-lapse taken from 200 m altitude at the south-east side of Gili Air.

Results

RUV

From 14 RUV drops in 2019, all the footages were watched by GSC team-members. The minimum and maximum depths are 5 m and 9.8 m with an average depth of 7.2 m. During the RUV dropping process, we also recorded the surface water quality where the BRUV was dropped. The highest temperature is 30^{o} C on 25th April 2019 while the lowest is 26^{o} C on 5th September 2018. The highest salinity was 33.77 ppt on 27th November 2019 and the lowest was 30 ppt on 24th April 2019. The number of viewed RUV varies between month, with May 2019 has the most with 5 BRUVs viewed while June, July, and November 2019 have the least with 1 viewed RUV (Table 1). However, there was no RUV drop in January, February, March, and August due to logistical difficulty.

A total of 90 individuals including indicator species (snapper, grouper, emperor, tuna/mackerel, barracuda, jacks), sharks and turtles are recorded. Grouper was the most sighted bony fish family with 31 sightings while blacktip reef sharks (three sightings) and green turtle (eight sightings) are the

most seen shark and turtle species on the RUV footage. In terms of location, Halik has the most species of interest sighting with 50% of all sightings. This includes two sightings of a black-tip reef shark. An example of the RUV screenshot is shown in Figure 14.

Table 1. Number of watched RUVs footage from each month.

Month	Number of RUV
January	0
February	0
March	0
April	2
May	5
June	1
July	1
August	0
September	2
October	2
November	1
December	0

Figure 14. Example of RUV screenshots for species of interest. A) A blacktip reef shark passing by the RUV. B) A hawksbill turtle eating on the reef.

Roving Survey

Total of 210 roving surveys conducted in 2019. The GSC team covered 14 dive sites around the Gili Islands with Han's Reef has the most survey (Table 2). The lowest maximum depth is 17 m, the highest maximum depth is 30 m, making an average maximum depth of 22.56 m. Roving survey method gave us a sighting abundance of 8747 bony fishes (average 41.65 per dive), 129 sharks (average 0.61 per dive), 129 rays (average 0.61 per dive), and 601 turtles (average 2.86 per dive).

Table 2. Number of Roving Surveys from each dive site.

Dive Site	Number of Surveys
Air Wall (Gili Air)	12
Batfish Point (Gili Air)	4
Bounty Wreck (Gili Meno)	21
Halik (Gili Trawangan)	18
Deep Turbo (Gili Trawangan)	8
Han's Reef (Gili Air)	26
Statue Garden (Gili Air)	3
Sunset Point (Gili Trawangan)	14
Meno Slope (Gili Meno)	15
Meno Wall (Gili Meno)	14
Mirko's Reef (Gili Meno)	9
Shallow Turbo (Gili Trawangan)	14
Shark Point (Gili Trawangan)	21
Turtle City (Gili Meno)	18

Humpback snapper, *L. gibbus* (Figure 15) with 30-40 cm size is the most seen bony fish species on Roving Survey with 2959 sightings which are 33.82% of all bony fish sightings (n=8747). Shark sightings are dominated by whitetip reef sharks, *T. obesus* (46%) as shown in Figure 16. There are occasional encounters with blacktip reef shark, *C. melanopterus* (4.4%) at dive sites around Gili Trawangan. In addition, blue spotted stingray, *Neotrygon kuhlii* is the most sighted ray compared to blue spotted ribbon tail ray, *Taeniura lymma* and spotted eagle ray, *Aetobatus narinari*. However, there were occasional sightings of rare species such as spinetail mobula, *Mobula japanica* in October 2019. For the turtle, green turtle, *C. midas* is taking 86.2% of all turtle sightings compare to hawksbill turtle, *E. imbriata* (Figure 17). In addition, there was an olive ridley turtle sighting, *Lepidochelys olivacea* first ever recorded sighting in the GSC database (Figure 18).

In terms of distribution among the dive sites, Shark Point was reported to have the most bony fish sightings per dive, 135.9 (n=21) bony fishes per dive. The highest average number of sharks per dive is also located at Shark Point with 2.38 sharks per dive. In addition, Turtle City provided the highest

average number of turtles per dive with 9.1 turtles per dive. Lastly, the highest probability to see a ray is at Shark Point, 1.83 rays per dive (Table 3). Similar to turtle sightings, Turtle City has the most clam sightings with 23 sightings. Figure 19 -22 are showing the maps of shark, ray, bony fish, and turtle sighted on each dive site in proportional symbols. The bigger the symbol means the more sightings.

Figure 15. A school of humpback snappers, *L. gibbus* as the most seen bony fish from roving survey dives. (Living Oceans Foundation, 2019).

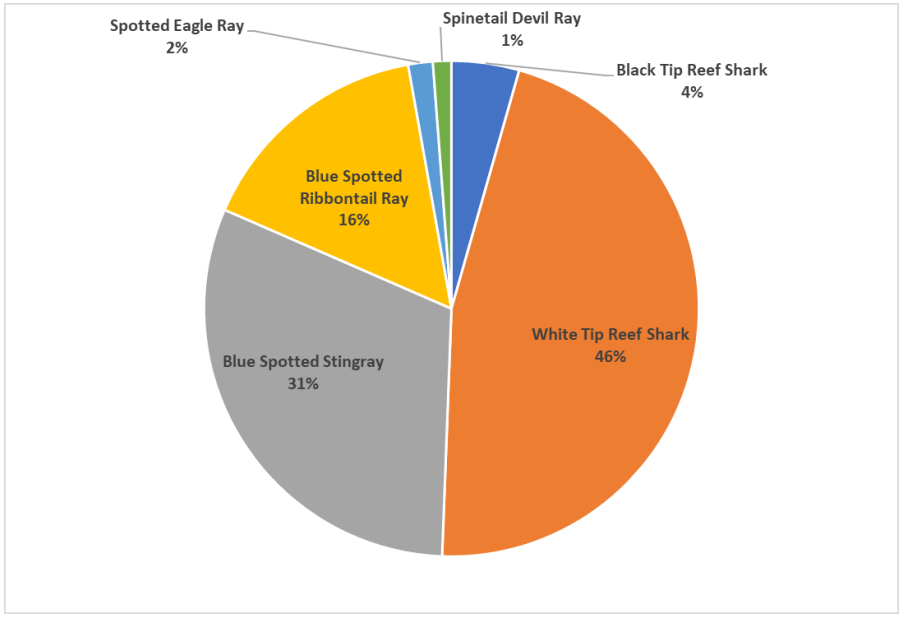


Figure 16. A pie chart of elasmobranch sightings from roving survey dives in 2019 (n=258).

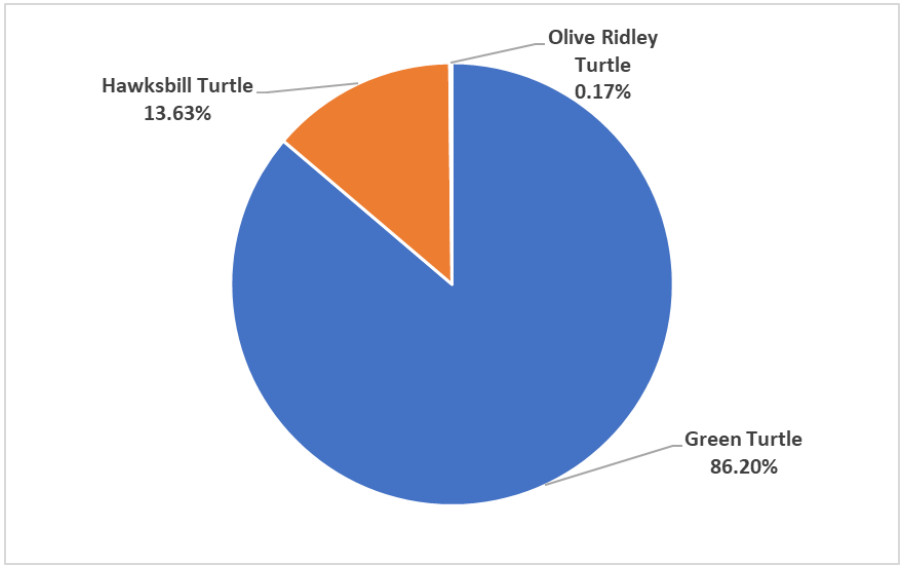


Figure 17. A pie chart of turtle sightings from roving survey dives in 2019 (n=601).

Figure 18. Olive ridley turtle (World Wildlife Fund, 2019).

Table 3. Average shark, ray, and turtle sighting per dive for each dive site based on roving survey dives in 2019. The cells highlighted in light blue are the highest value of each category.

Dive Site	Average Shark	Average Ray	Average Turtle
Air Wall (Gili Air)	0.00	0.33	1.67
Batfish Point (Gili Air)	0.00	1.25	1.25
Bounty Wreck (Gili Meno)	0.00	0.14	1.33
Halik (Gili Trawangan)	1.06	1.22	2.28
Deep Turbo (Gili Trawangan)	1.00	0.75	2.13
Han's Reef (Gili Air)	0.00	0.42	2.62
Statue Garden (Gili Air)	0.00	0.33	1.00
Sunset Point (Gili Trawangan)	1.71	0.36	1.93
Meno Slope (Gili Meno)	0.07	0.40	3.93
Meno Wall (Gili Meno)	0.07	0.14	2.79
Mirko's Reef (Gili Meno)	0.44	0.44	0.33
Shallow Turbo (Gili Trawangan)	1.36	0.07	2.07
Shark Point (Gili Trawangan)	**2.38**	**2.48**	3.86
Turtle City (Gili Meno)	0.00	0.00	**9.11**

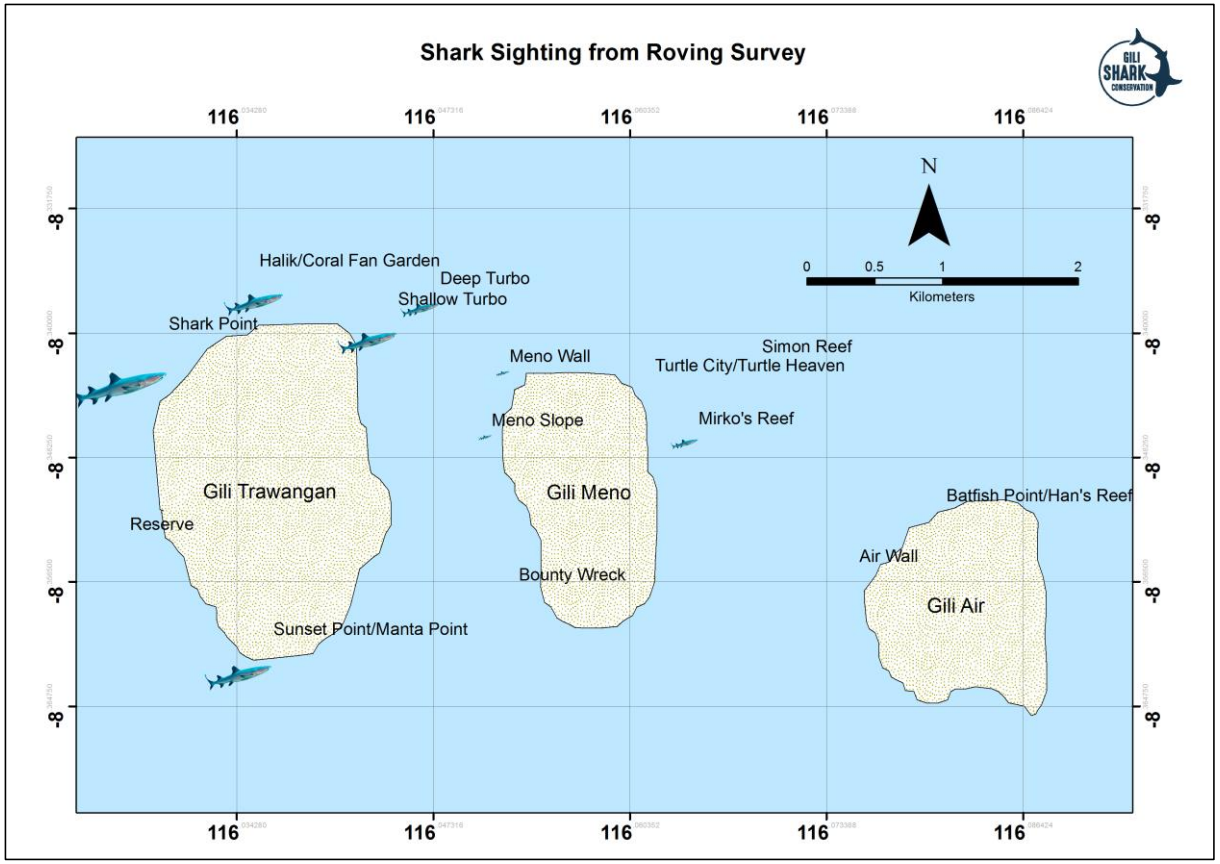


Figure 19. Shark sighting distribution from Roving Survey is represented by a proportional symbol of white tip reef shark on the map. The symbol at Shark Point (north-west of Gili Trawangan) is representing 50 shark sightings.

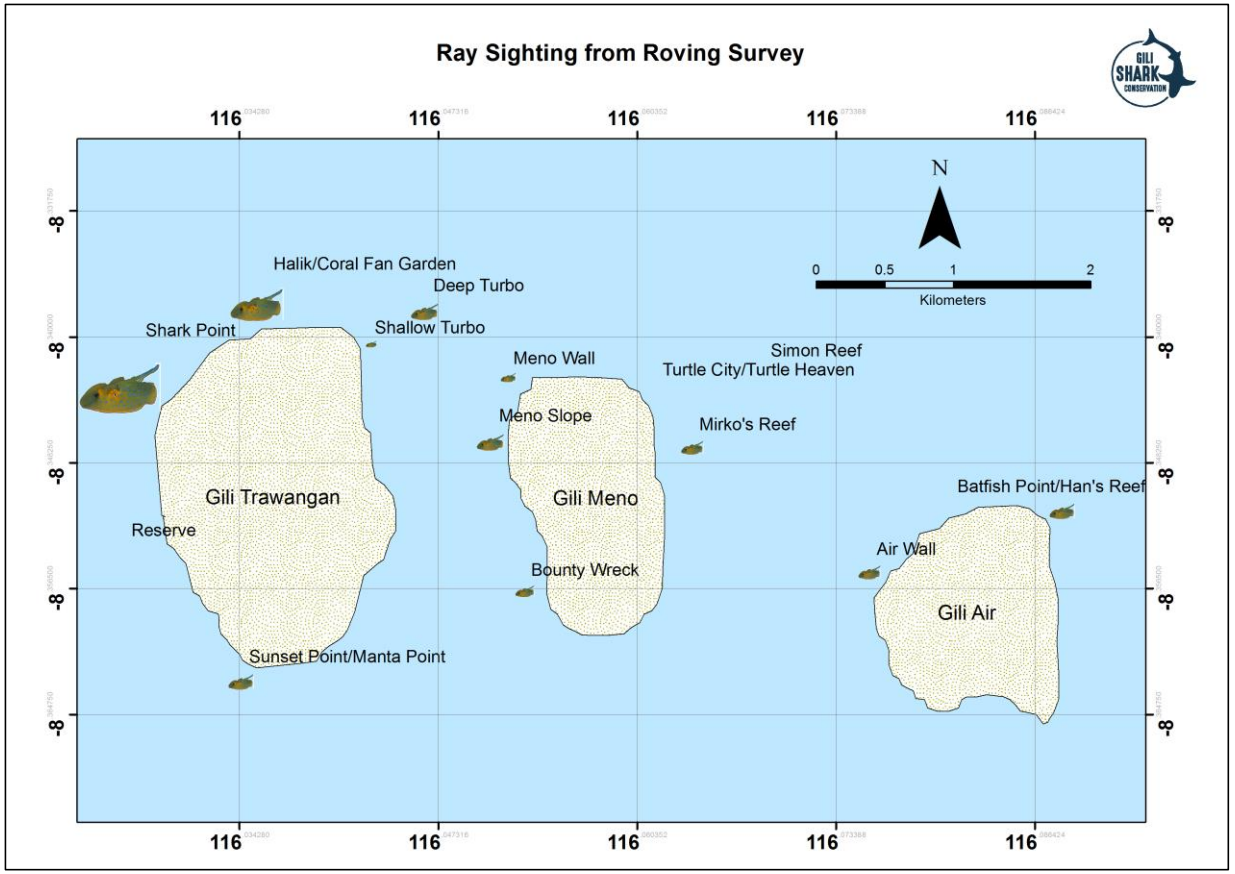


Figure 20. Ray sighting distribution from Roving Survey is represented by a proportional symbol of blue-spotted ribbon tail ray on the map. The symbol at Shark Point (north-west of Gili Trawangan) is representing 52 ray sightings.

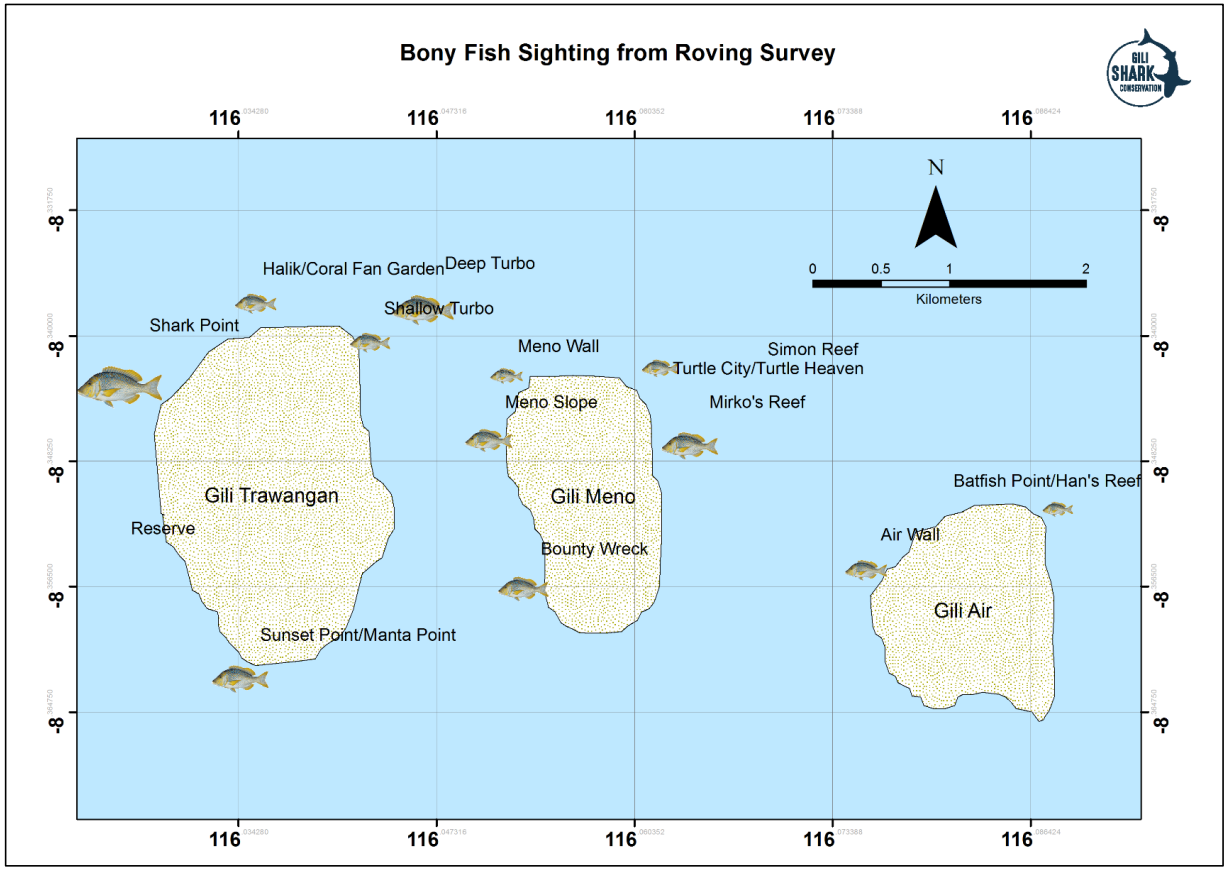


Figure 21. Average bony fish sighting per dive from Roving Survey is represented by a proportional symbol of the emperor on the map. The symbol at Shark Point (north-west of Gili Trawangan) is representing 135.9 bony fish sightings per dive.

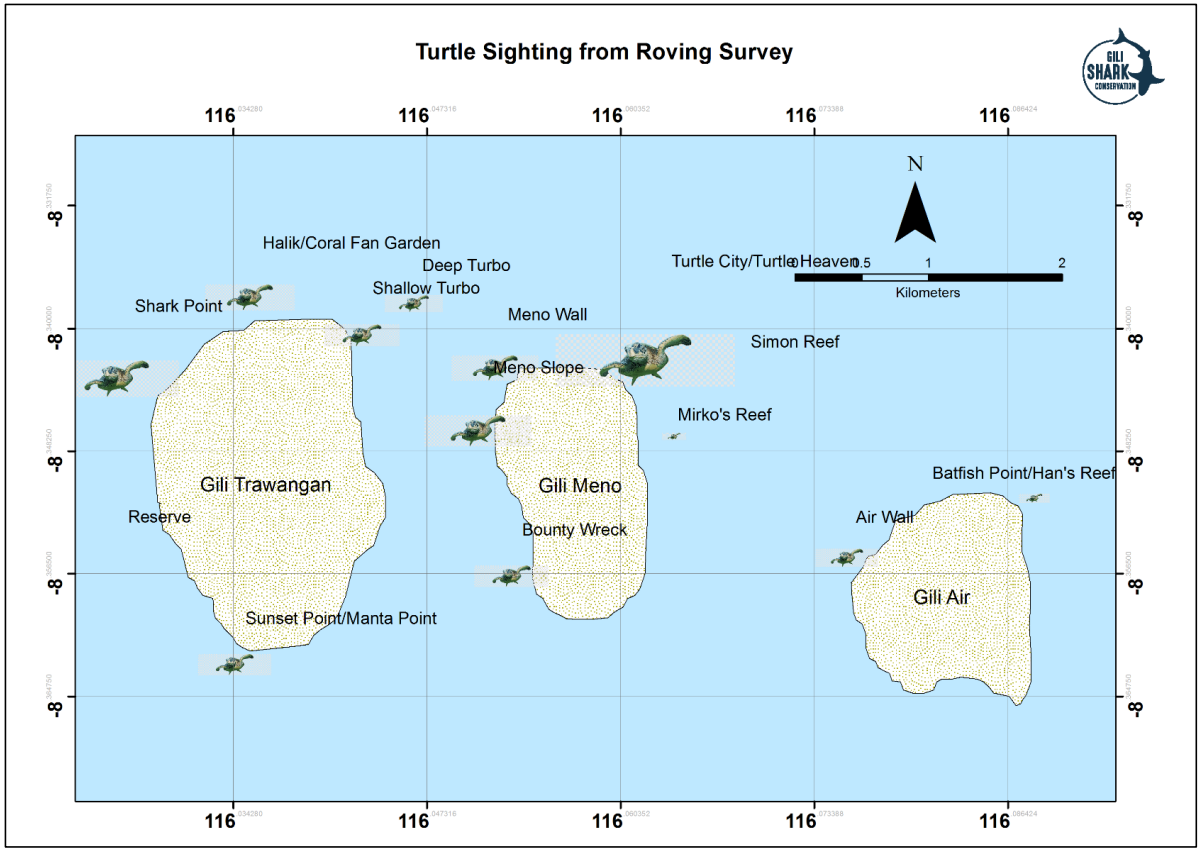


Figure 22. Turtle sighting distribution from Roving Survey is represented by a proportional symbol of the green turtle on the map. The symbol at Turtle City (north-east of Gili Meno) is representing 164 turtle sightings.

Coral Health Index

CHI Score

Within the GMMRR most dive sites had a CHI of 3 (Figure 23). The healthiest sites were Halik (6), Shark Point (5) and Statue Garden (5). With comparison to the CHI scores calculated in 2014, by Giyanto et al. (2017), it is evident that the health of the reef at Turtle City has severely declined with the CHI score dropping from 6 to 3 (Figure 24). The reef health has also declined, although less severely, at Halik and Shark Point. The only site at which the CHI score has increased, is Sunset Point, going from 2 to 3. The 2014 survey only indexed six of these sites, therefore the current study provides a valuable baseline measurement for the health of the following four dive sites: Bounty Wreck, Shallow Turbo, Statue Garden and Meno Wall.

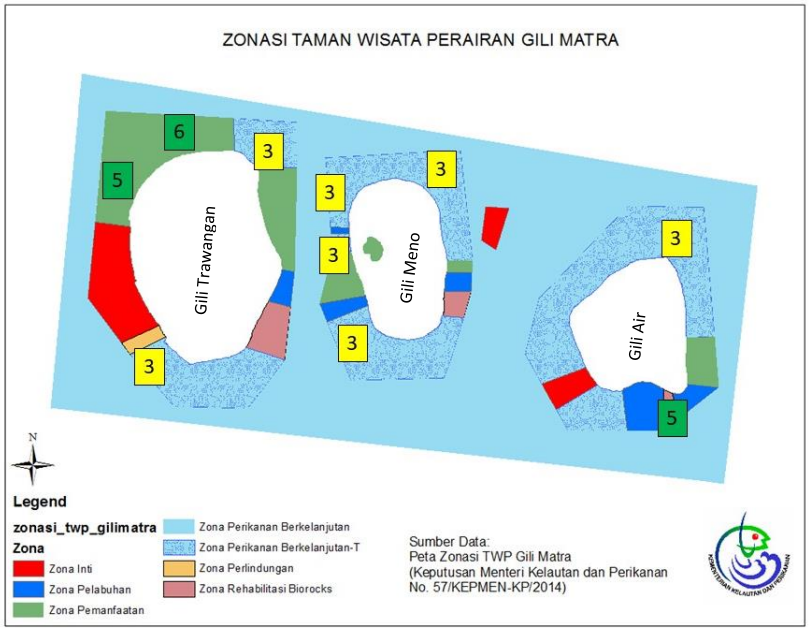


Figure 23. Coral Health Index value overlaid on top of the GMMRR zonation map.

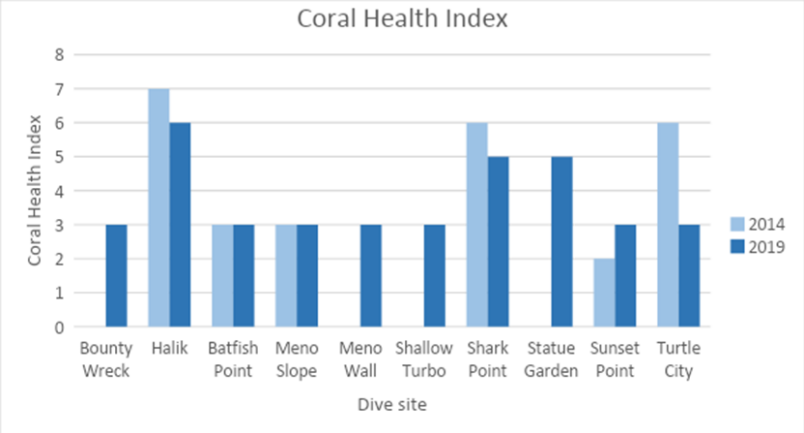


Figure 24. CHI scores of 10 dive sites within the GMMRR, compared with the scores calculated by Giyanto et al. in 2014.

Benthic community

The benthic cover within the GMMRR is dominated by dead coral smothered in algae, 38.4% ± 3.4 SE (Figure 25). Hard coral constituted 20.4% ±2.8 SE of the reef and sponges constituted 16.6% ±3.9 SE. The benthic community has a low percentage cover of soft coral 4.4% ±1.3 SE and fleshy seaweed 0.1% ±0.1 SE. Figure 26 is showing an example of two UPTs dominated by dead coral with algae and hard coral as the most dominant substrate in the GMMRR.

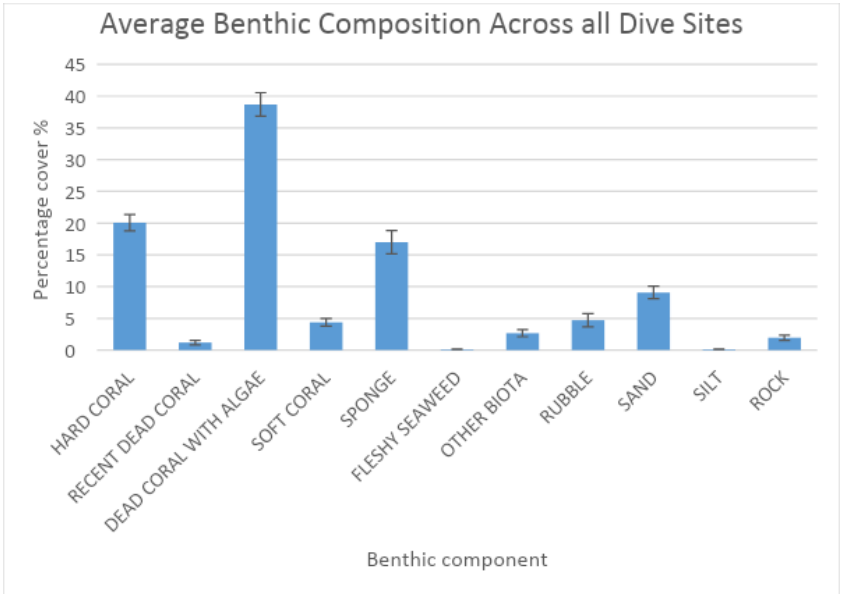


Figure 25. Benthic community composition averaged across all dive sites within the GMMRR.

There was notable variation between dive sites in their percentage cover of hard coral (Figure 27). The highest cover was found at Halik 37.8% ±4.6 SE, Shark Point 31.4% ±9.9 SE and Statue Garden 32.1% ±3.2 SE. The hard-coral cover at the other sites ranged from 11.5% ±3.6 SE to 18.1% ±3.1 SE.

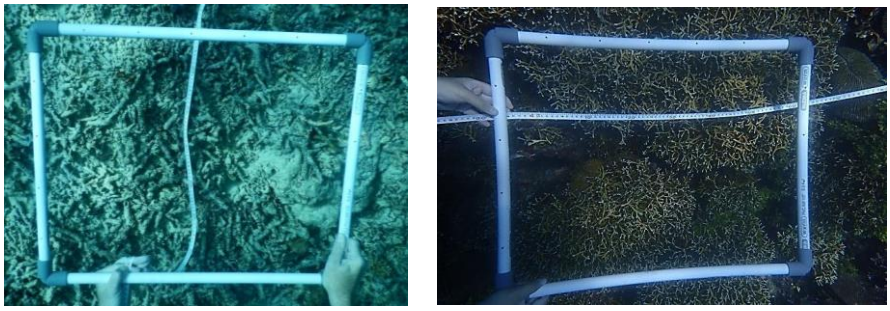


Figure 26. Two dominant categories of substrate: dead coral with algae (left) and hard coral (right) in GMMRR.

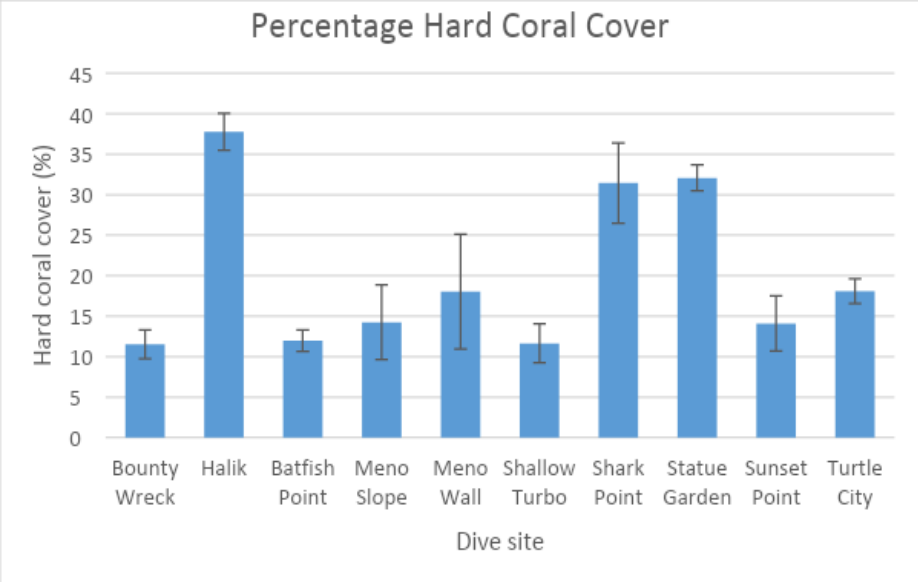


Figure 27. Percentage of hard coral cover at 10 sites within the GMMRR.

Fish community

The density of the targeted fish families (Snapper, Grouper, Parrotfish, Rabbitfish, Surgeonfish, Butterflyfish) ranged from 42.0 ±14.0 SE at Sunset Point to 121.7±40.9 SE at Turtle City. The density of butterflyfish, which are considered a reliable indicator of reef health (Hourigan, Timothy, Reese., 1988), was highest at Halik, which is consistent with the current study's CHI index scores. Interestingly, the biomass of the target fish families was lowest at Turtle City 17.3kg/ha ±7.4, and highest at Shallow Turbo 129.1kg/ha ±20.1 (Figure 28). Across all dive sites, there was a large variation in fish density between the target fish families, with a notably low density of Snappers, Groupers, Rabbitfish and Parrotfish relative to Butterflyfish and Surgeonfish (Figure 29). The most common fish was the Lined Bristtletooth, *Ctenochaetus striatus* from the Surgeonfish family (Figure 30) and the least common fish were from the Snapper family.

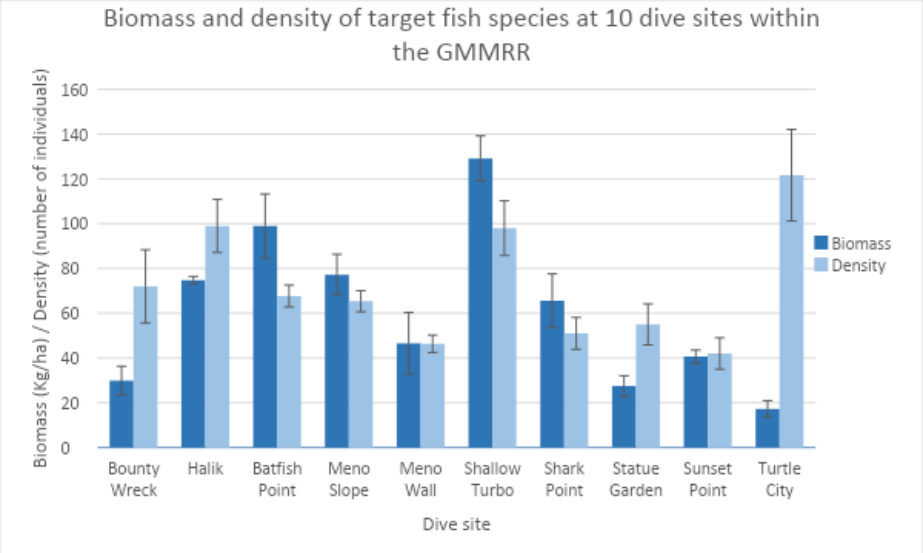


Figure 28. Biomass (kg/ha) and density (number of individuals) of target fish families (Snapper, Grouper, Parrotfish, Rabbitfish, Surgeonfish, Butterflyfish) at 10 sites within the GMMRR.

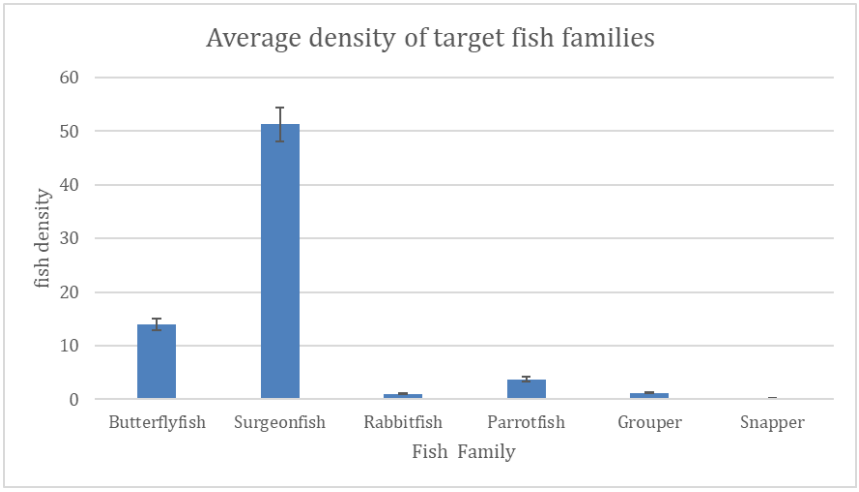


Figure 29. Density of the six target fish families averaged across all dive sites within the GMMRR.

Figure 30. Lined Bristtletooth, *C. striatus* as the most abundant fish species (IUCN Red List of Threatened Species, 2019).

Reef Check Survey

In seven months, the GSC team conducted a total of 27 reef check surveys at seven dive sites (Table 4). The team did surveys at two depths 2-6 m and 6-12 m for each dive site following reef check protocol to get information both in the shallow and deeper part of the reef.

Table 4. Number of Reef Check survey from each dive site.

Dive Site	Number of Surveys
Batfish Point (Gili Air)	2
Halik (Gili Trawangan)	4
Han's Reef (Gili Air)	3
Meno Slope (Gili Meno)	6
Shark Point (Gili Trawangan)	4
Statue Garden (Gili Air)	3
Turtle City (Gili Meno)	5

Substrate

Figure 31 is showing substrate composition in each dive site. Halik was reported to have the highest hard coral (HC) cover with 52.03% whereas the lowest HC cover was at Meno Slope (9.29%). The team also found high rubble (RB) cover ranging from 5% at Han's Reef up to 42% at Shark Point.

Fish

From all the surveyed dive sites, it was suggested that butterflyfish (Chaetodontidae) abundance is significantly higher than other indicator species (Figure 32). There was zero Barramundi Cod reported from all 27 surveys. In addition, the average sighting of predatory/commercial fish such as sweetlips (Haemulidae) and snapper (Lutjanidae) have less than two individuals per 100 m^2.

Invertebrate and Impact

Long-spined sea urchin (*Diadema antillarum*) was reported as the most common invertebrate indicator species. Batfish Point and Shark Point had more than five long-spined sea urchin on average per survey (Figure 33). In contrast, there was a low number of other invertebrates – Triton's trumpet (*Charonia tritonis*) was absent and there was only one sighting of lobster from 27 surveys.

Most of the impact found were general trash such as plastic bag and plastic fragment. There were less than 2% bleached coral colonies on average reported from all the surveys.

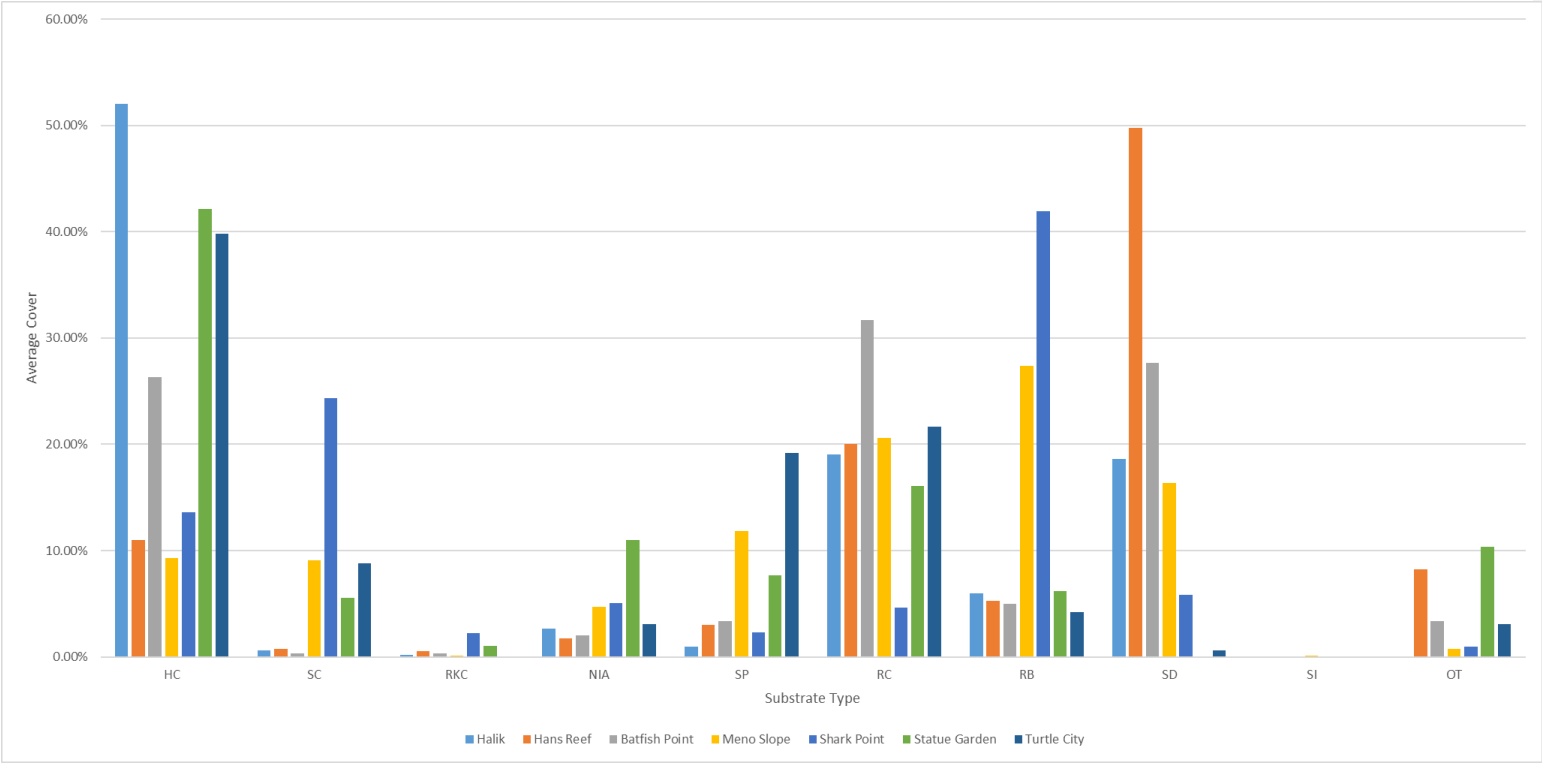


Figure 31. Substrate composition at each dive site from Reef Check survey.

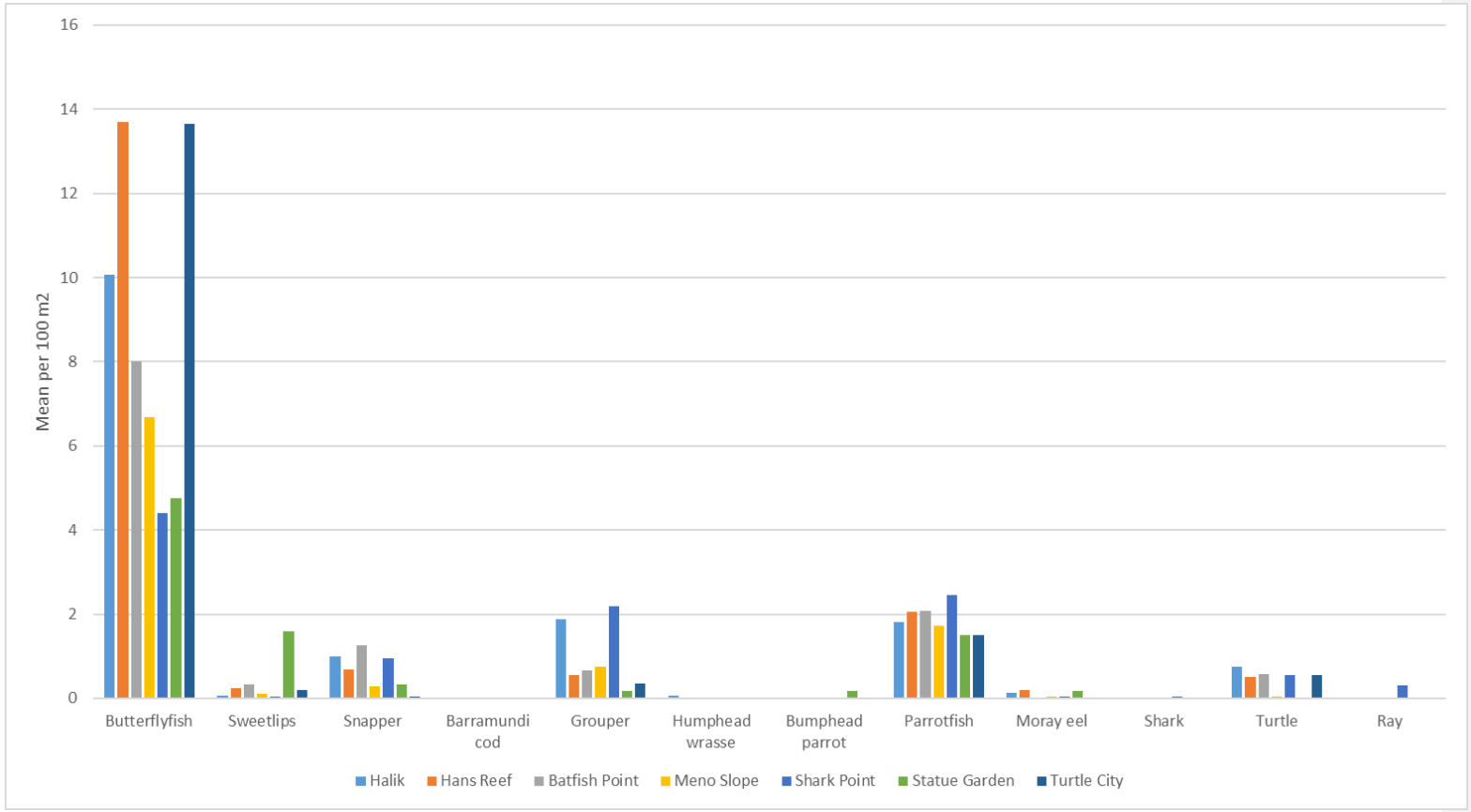


Figure 32. Fish abundance at each dive site from Reef Check survey.

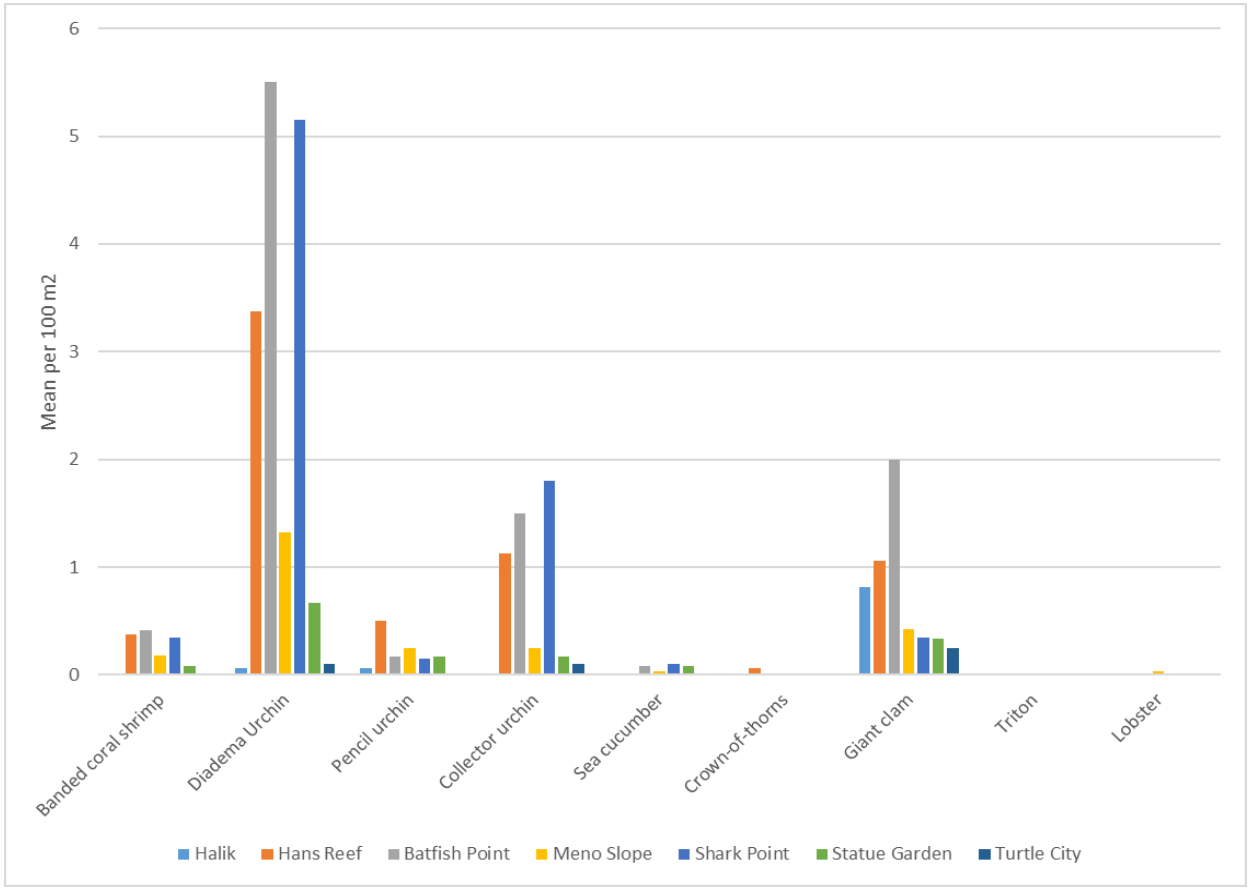


Figure 33. Invertebrate abundance at each dive site from Reef Check survey.

Coral Reef Restoration Project

The GSC team managed to drop 36 hex-domes at the restoration site (6 m depth) with more than 600 coral fragments planted on 27 hex-domes. There are four coral genera used on the restoration site: *Acropora* (two hex-domes), *Porites* (eleven hex-domes), *Heliopora* (six hex-domes), and *Pocillopora* (two hex-domes). Figure 34 is showing the example of one hex-dome with *Pocillopora* fragments.

Within four months period (August-December), Porites seemed to have a higher survival rate compared to other genera. Based on visual observation, more Porites started to overgrow the zip-ties and get attached to the hex-dome.

Figure 34. A hex dome with Pocillopora coral fragments at the restoration site.

Photo Identification

Total 181 green turtles (*C. midas*), 51 hawksbill turtles (*E. imbriata*) and 18 white tip reef sharks (*T. obesus*) have been successfully identified using i3s software. Figure 35-37 are showing examples of green turtles, hawksbill turtles, and white tip reef sharks that have been identified. However, several pictures were not taken by GSC team members but other dive professionals who are willing to share their photographs.

Figure 35. Green Turtle (*C. midas*) G149 Marnie.

Figure 36. Hawksbill turtle (*E. imbriata*) H50 Femke.

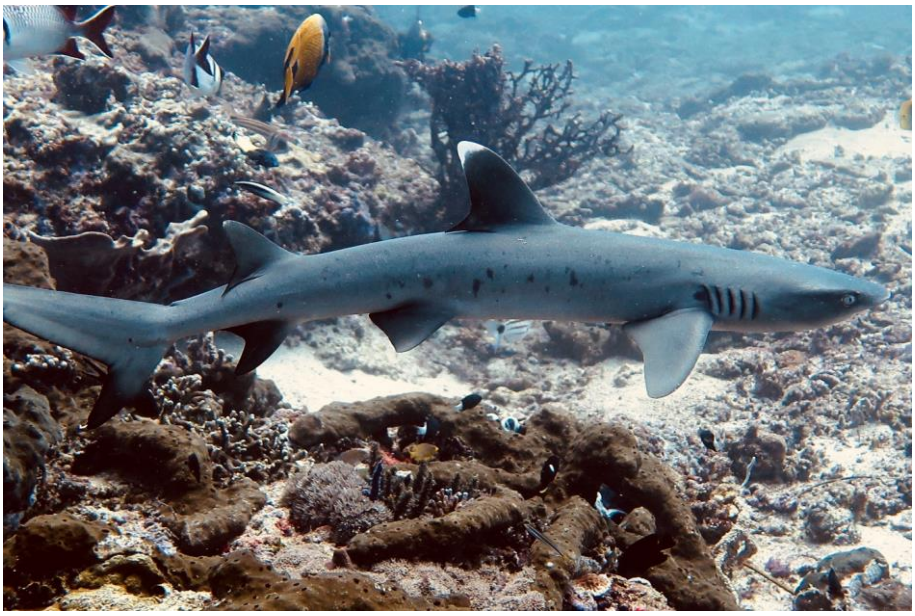


Figure 37. Whitetip reef shark (*T. obesus*) W17 Carina.

Unite Gili and Unite Bali

Since it is citizen science, Unite Gili provides GSC with a bigger elasmobranch (shark and ray) sighting dataset compared to GSC Roving Survey dataset in 2019. A total of 1106 data entry was provided by 12 dive shops around Gili Air. From a total of 1106 elasmobranch reported, 799 sightings (72%) were white tip reef shark (*T. obesus*). Therefore, white tip reef shark is the most sighted elasmobranch around the Gili Islands (Figure 38). Several migratory species were also reported such as reef manta ray (*Mobula alfredi*), whale shark (*Rhincodon typus*), common thresher shark (*Alopias vulpinus*), and spinetail devil ray (*Mobula japanica*) with most of them sighted in October 2019. In addition, we have also our partner from Nusa Lembongan (Bali) submitting their elasmobranch sightings in order to have a comparison in elasmobranch diversity between the Gili Islands and the Nusa. Their data suggested most of elasmobranch sighted is dominated by reef manta ray (*M. alfredi*) by 94% sightings (N=986) as shown in Figure 39. Two shark species are sighted in the Nusa Islands, common thresher shark (*A. vulpinus*) and bamboo shark (*Chiloscyllium plagiosum*).

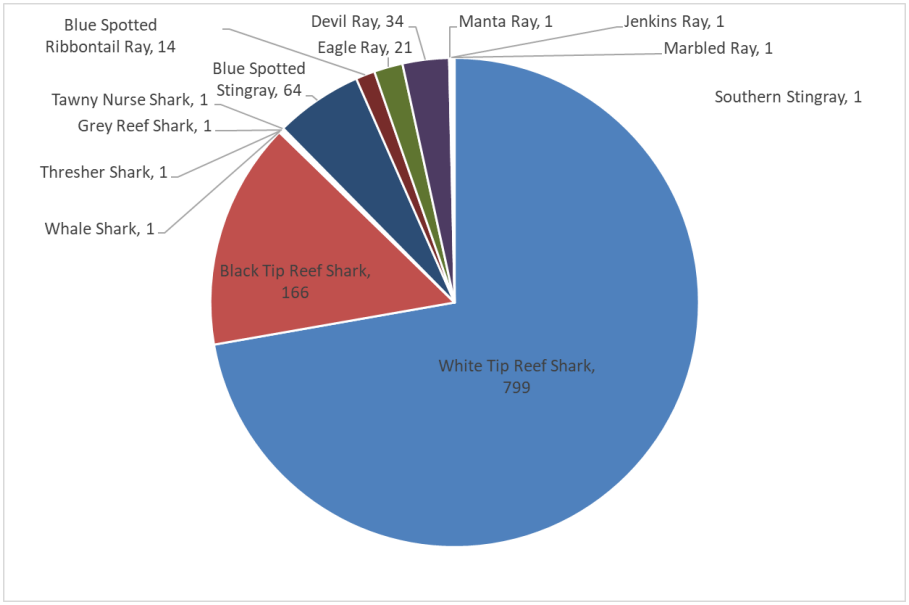


Figure 38. Pie chart of elasmobranch sightings from Unite Gili in 2019.

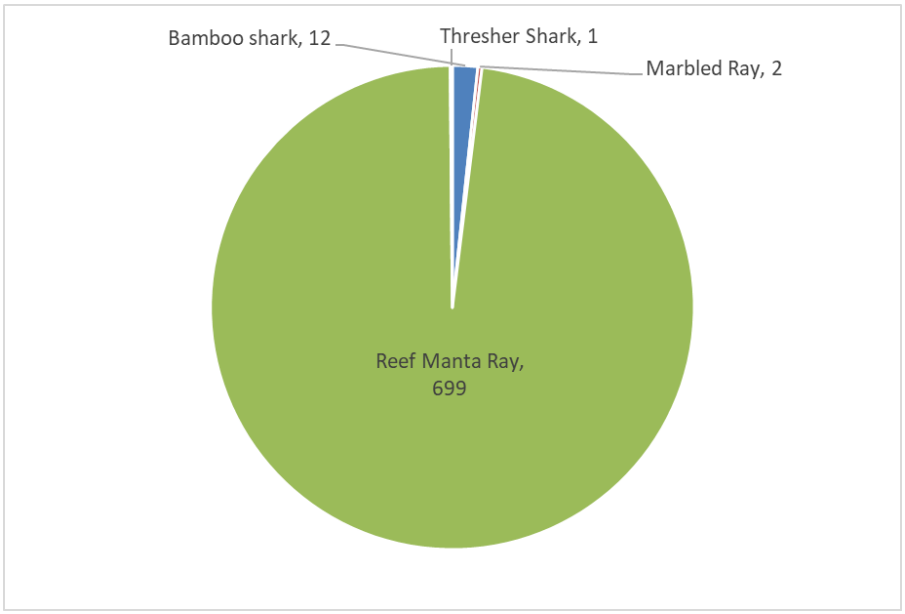


Figure 39. Pie chart of elasmobranch sightings from Nusa Islands (Bali) in 2019.

In one year, it can be concluded that August 2019 has the most elasmobranch sightings (Figure 40). This data suggested not only there was cooler water temperature during July-August 2019, but also there was a high density of tourists coming to Gili Islands - dive shops were diving more often hence more diving effort.

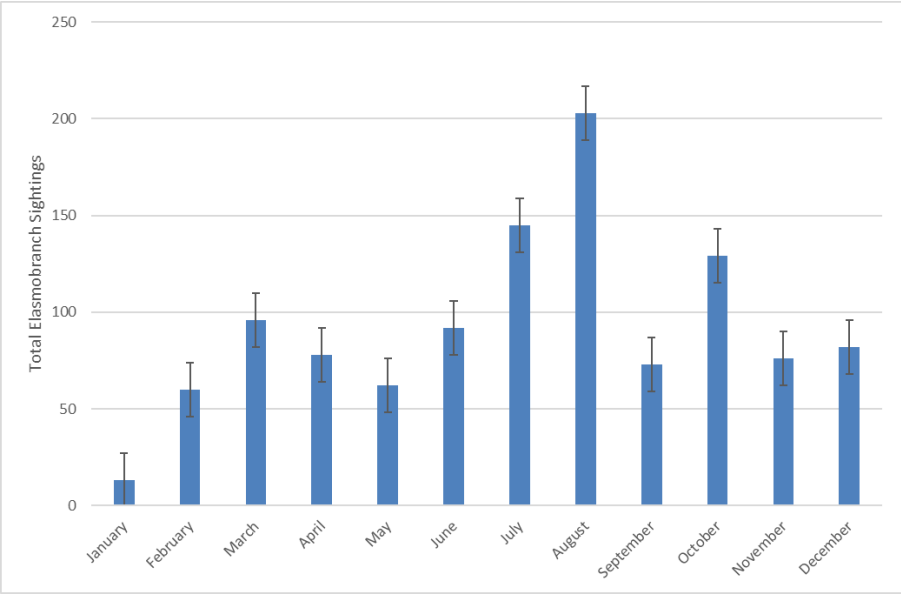


Figure 40. Elasmobranch sighting (n ± SE) around Gili Islands from each month in 2019.

Like Roving Survey data, most of the sharks (white tip reef sharks and blacktip reef sharks) are reported seen around Gili Trawangan with most sightings were at Shark Point (n=586) as shown in proportional symbol in Figure 41. It is showing that Unite Gili helped the project to get the complete picture of shark distribution around the Gili Islands and shark species passing by the area.

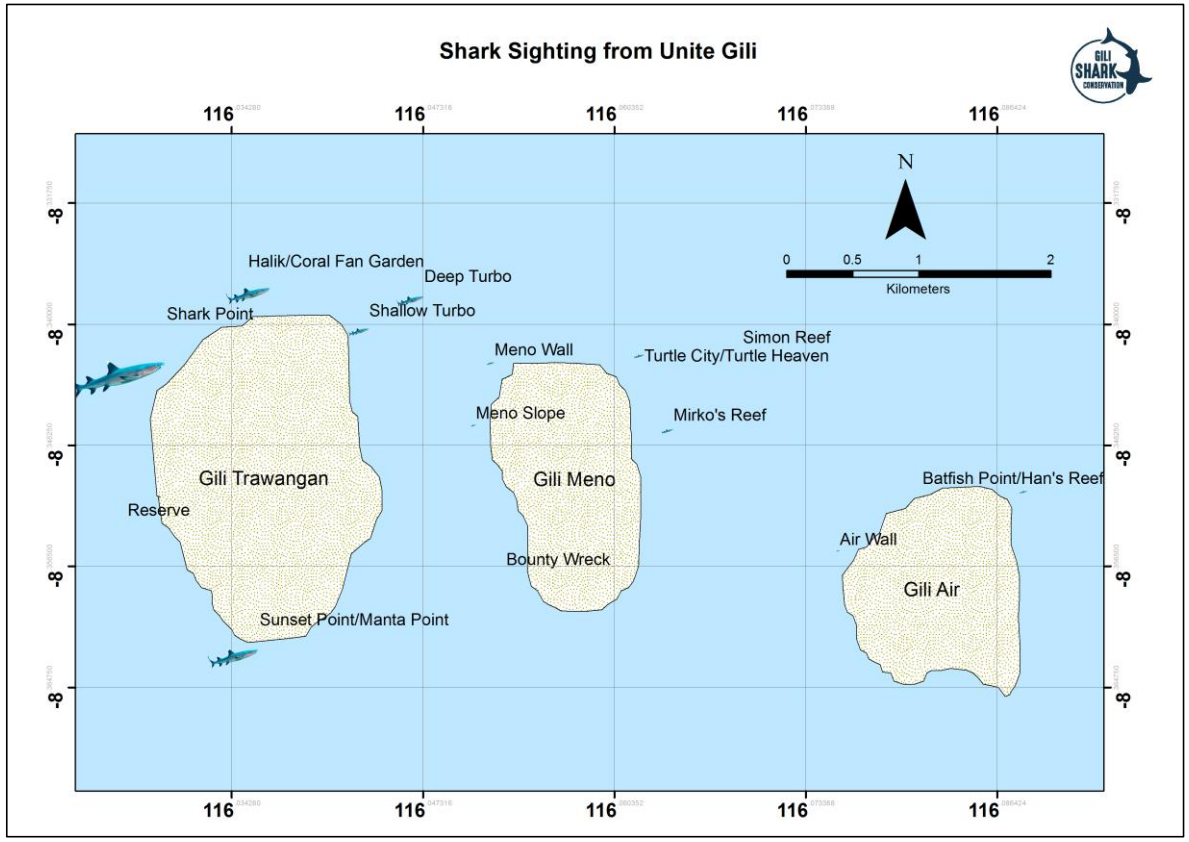


Figure 41. Shark sighting distribution from Unite Gili is represented by the proportional symbol of the whitetip reef shark on the map. The symbol at Shark Point (northwest of Gili Trawangan) is representing 586 shark sightings while the symbol on Air Wall (northwest Gili Air) is representing one sighting.

Dive Against Debris

Total 95 Dive Against Debris surveys were conducted in 2019. Inside a 6.7 km^2 area/survey and depth range from 5 – 24 m, 2331 debris were taken out from Meno Slope (Figure 42). The debris is dominated by plastic (69%), ranging from beverage bottles, food wrappers, diapers to SCUBA gear. Our surveys also suggested that food wrapper, laundry liquid wrapper, and liquid shampoo wrapper are the most problematic debris around the Gili Islands.

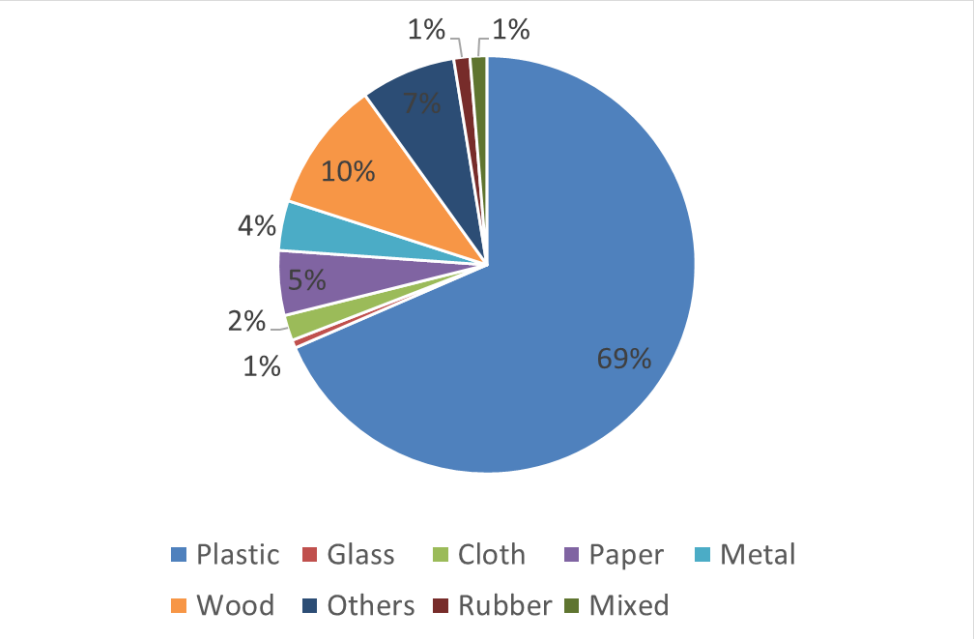


Figure 42. A pie chart showing the proportion of debris type found from 95 Dive Against Debris surveys in 2019.

In the time-series graph (Figure 43), it is suggested that the number of debris goes up and down from one week to another. However, starting from October 2019, the total number of debris per survey never exceeded eleven pieces of debris (mean per survey = 24 debris). This trend could be related to extended dry season in the Gili Islands.

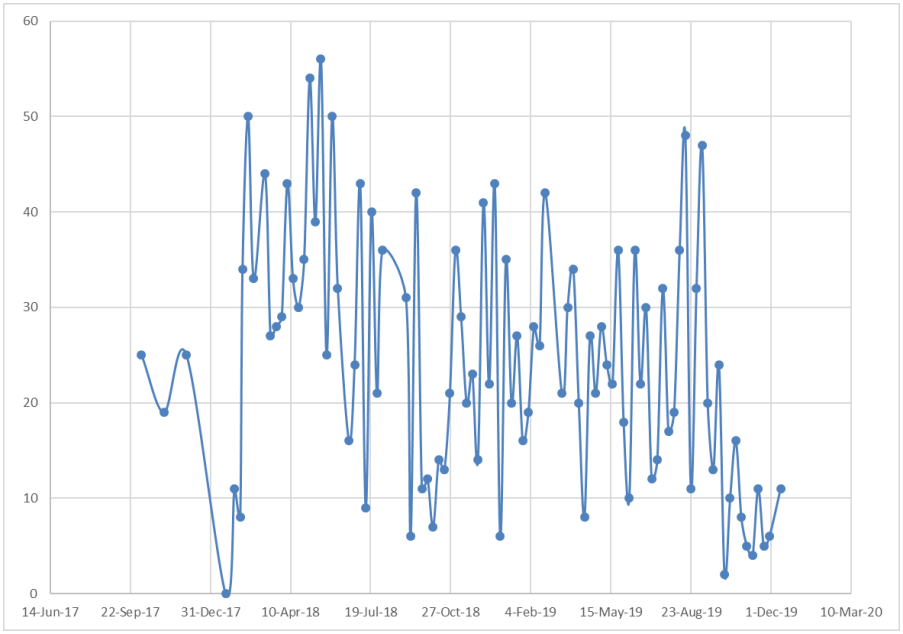


Figure 43. Total number of debris through time from October 2017 until December 2019.

Underwater and Aerial Time-Lapse

Two out of four underwater time-lapse samples are showing changes within eight months. The changes are caused by several factors such as seawater temperature, salinity, and wave action. Time-series of sea surface temperature (SST) from May 2019 until December 2019 suggests that the Gili Islands experienced low SST anomaly from July-September (Figure 44). Figures 45 and 46 are showing how cooler seawater temperature (26-27 C) stimulates corals to grow, including soft and hard coral.

There are two main findings from the aerial time-lapse project. First, there is a slight change in seagrass and cover on the east side of Gili Air (Figure 47). Second, there is an observable sand accretion added up to a sandbank in the south-east corner of Gili Air within 20 months period (Figure 48). Both changes are caused by alongshore sediment transport during the north-easterly wind season in August 2019.

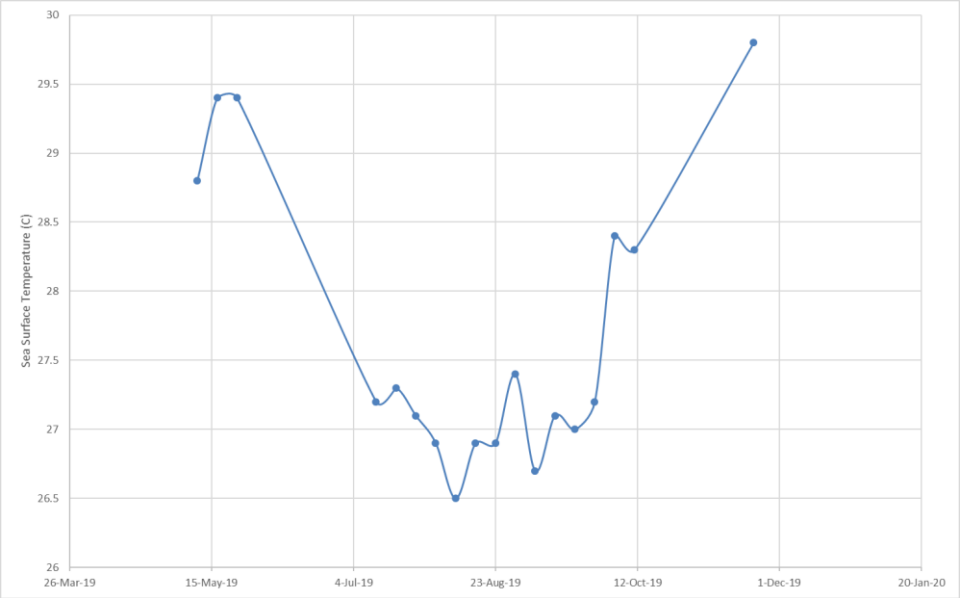


Figure 44. Sea surface temperature (SST) at Meno Slope from May 2019 until December 2019.

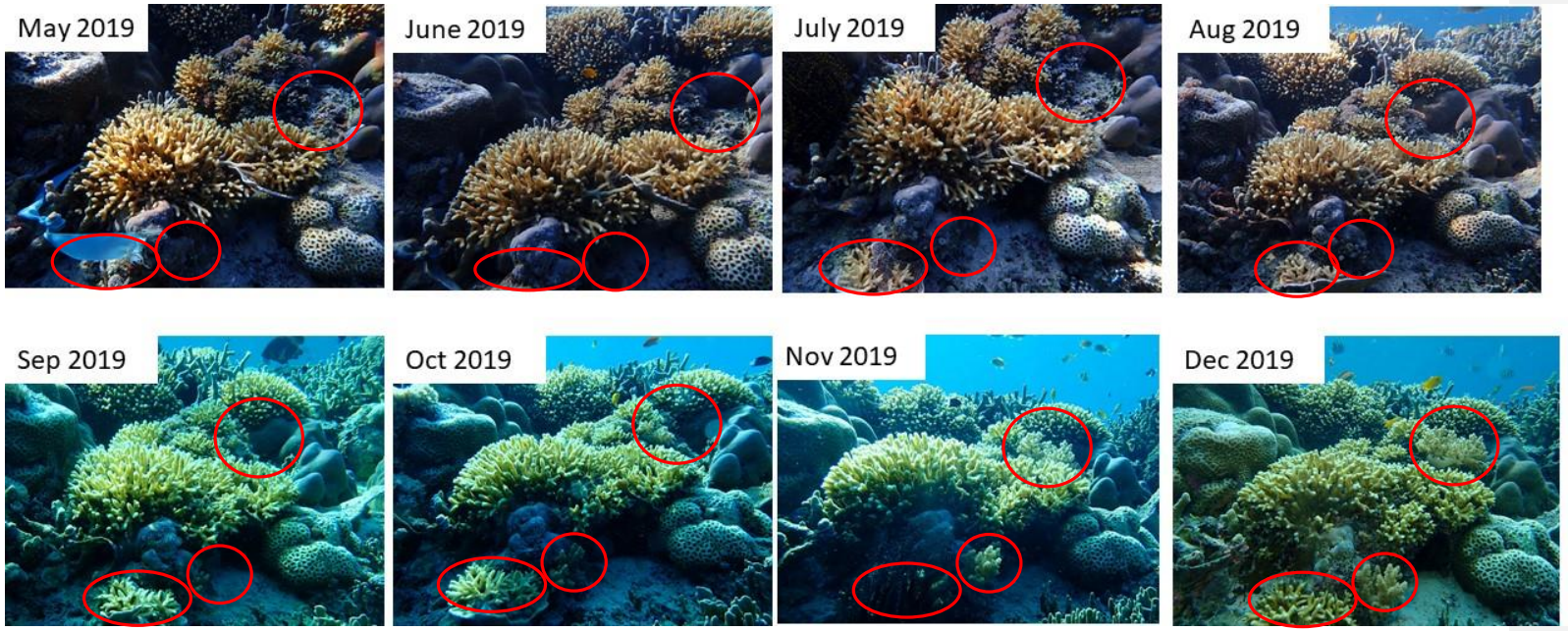


Figure 45. Branching hard coral sample comparisons within 8 months period at Meno Slope. Red circles are showing new soft coral colonies growing around the branching hard coral sample in the middle and a growing branching coral colony in the bottom.

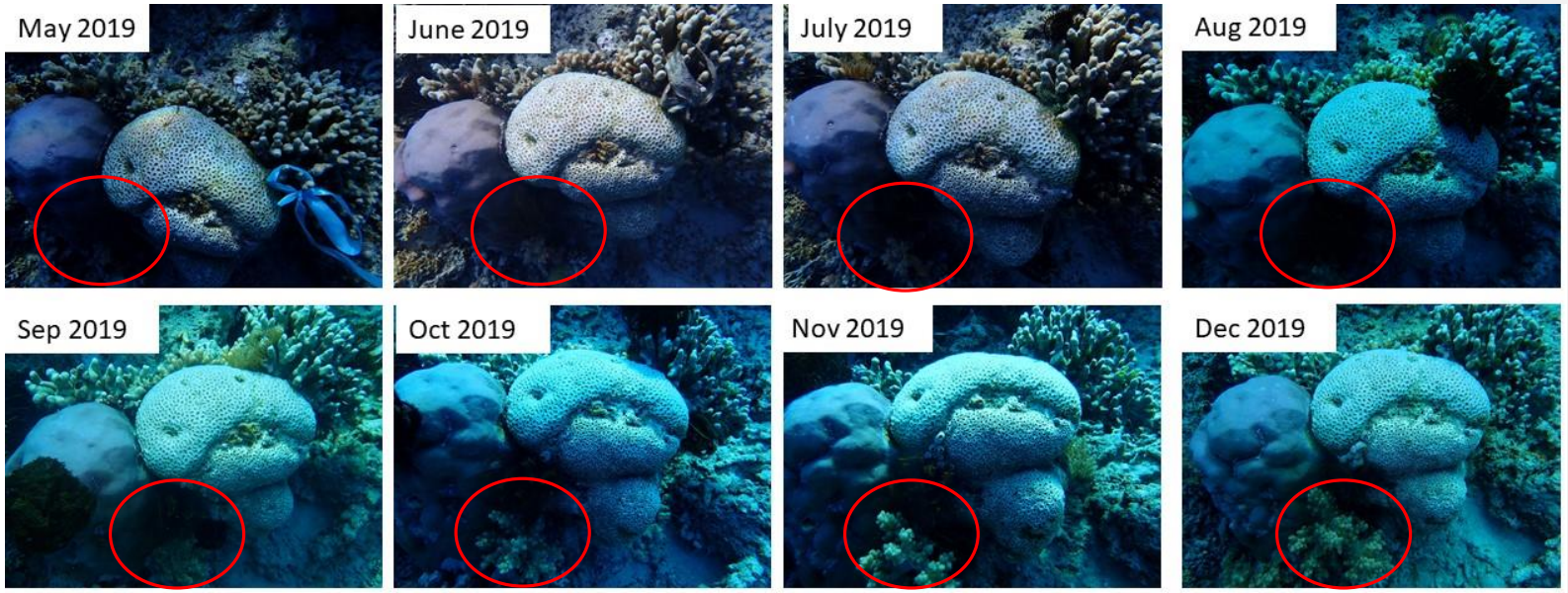


Figure 46. Massive hard coral sample comparisons within 8 months period at Meno Slope. The red circle is showing a new soft coral colony growing in the bottom of the massive hard coral sample.

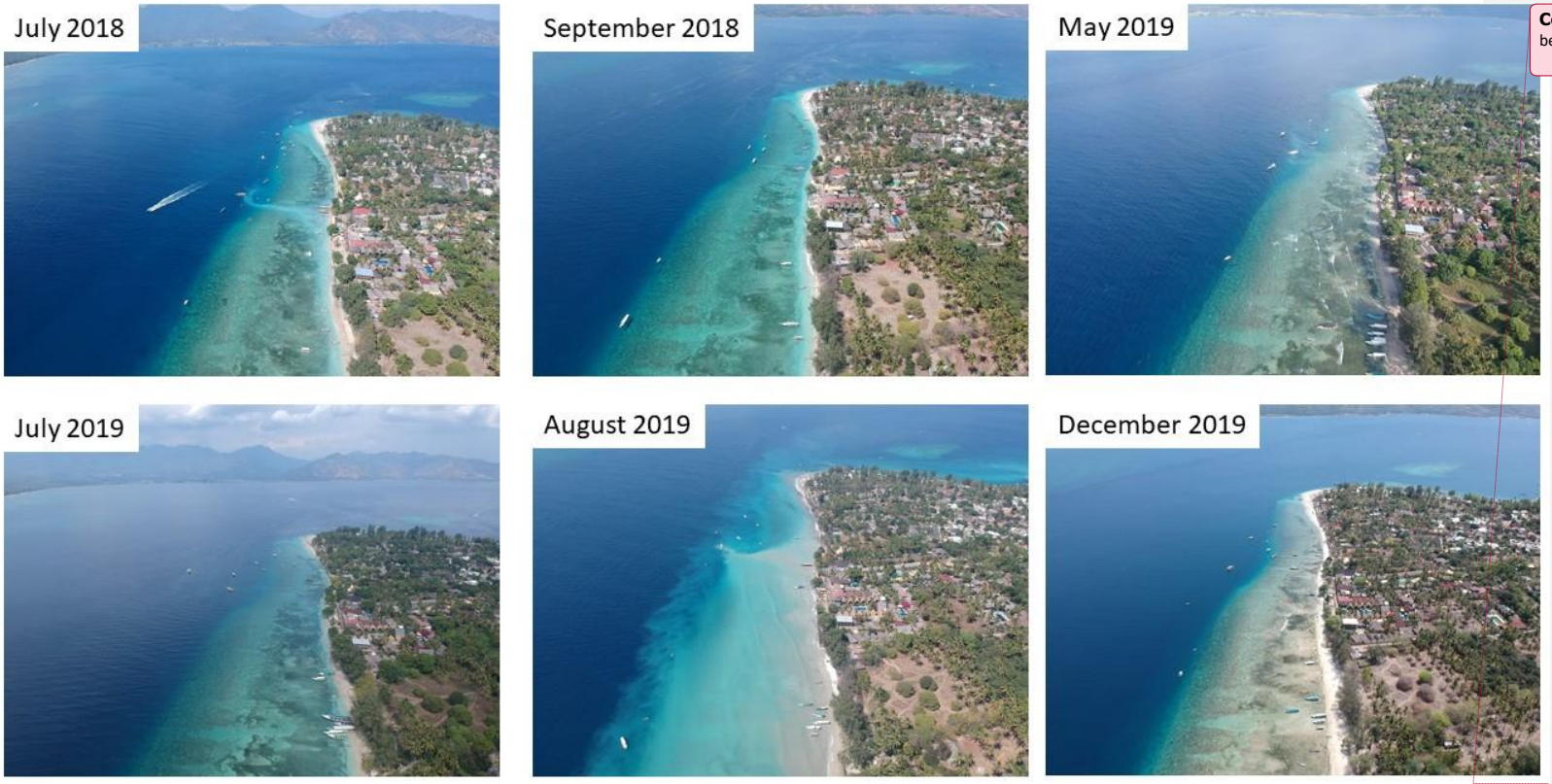


Figure 47. The comparisons within 20 months period of drone photographs at the East side of Gili Air.

Commented [U1]: Are all picutres taken in 2019 or is it a mix between 2018 and 2019?

Figure 48. The comparisons within 20 months period of drone photographs at the Southside of Gili Air.

Discussion

The GSC team reduce the number of RUV drop in 2019 compared to 2018. The focus for RUV use in 2019 was to monitor the GSC coral restoration site. As stated by King et al., 2017, RUV has been a valuable tool for sampling and monitoring fish abundance in a difficult environment. In this case, the GSC coral restoration site has a strong current, making the traditional fish monitoring method difficult to conduct.

Indicator species including bony fish, shark, ray, and turtle sightings stay the same in comparison to 2018 data (Figure 50 and 51). This data suggested that the GMMRR is keeping the bony fish, shark, ray, and turtle population at the same level. In terms of spatial distribution, most bony fish and sharks sightings are concentrated around Gili Trawangan where the biggest red zone (Figure 49) is located which has been the GSC hypothesis since 2016.

CHI and Reef Check survey data is showing GMMRR lacks predatory and parrotfish fish in the shallow reef. In addition, only a few invertebrate indicator species sighted during the surveys. This is a common issue in a tropical island with high tourist density. To solve the problem, stakeholders have to do integrated and large scale approach since local action alone will not give a significant impact on reef recovery (Bruno, Côté and Toth, 2019).

CHI and Reef Check results are indicating a similar conclusion. For example, Halik has the highest hard coral cover among the surveyed dive sites. CHI surveys estimated 37.8%±4.6 SE (n=3) while Reef Check surveys pointed out 52.03%±12.4% SE (n=4) hard coral cover at Halik. This implied that Reef Check overestimated the hard coral cover since the method has fewer sample points compare to CHI hence less accurate and precise.

A cooler sea surface temperature range (26-27^{o} C) between July until October had a significant impact on soft coral growth from the time-lapse sample (Figure 45) and Several migratory species sightings in October including reef manta ray, whale shark, common thresher shark, and spinetail devil ray). It is indicating 26-27^{O} C is the comfortable temperature range for the marine life to thrive inGMMRR.

According to the Photo Identification data, the green turtles and white tip reef shark stay in one reef for an extended period of time. Furthermore, one of the white tip reef sharks, W12 Dani came back to the same reef after she gave birth (Figure 52). Similarly, Barnett et al., 2012, reported that the white tip reef shark movement range limited to approximately 10 km. This data suggested that in the Gili Islands area, the marine protected area is an effective reef shark and turtle conservation strategy.

Since the GSC team started the coral restoration project, Porites has a higher survival rate compared to other genera. Correspondingly, other research such as Morikawa and Palumbi, 2019, pointed out Porites is the naturally selected heat-tolerant genus.

Recommendation

From the data analysis and daily observation in the three years period, we suggest a list of actions that need to be considered by stakeholders as follow:

- **Protect herbivorous fish such as parrotfish in order to keep algae level in check**
- **Invest in coral reef restoration research to find out the best configuration in restoring the reef in Gili Matra Marine Recreational Reserve.**
- **Promote four-stroke engines for boats as a standard to operate within Gili Matra Marine Recreational Reserve.**
- **Design a sustainable fish/fishing guide for fishermen and restaurants.**
- **Make the "MPA" title in the Gili Islands as a marketing tool to promote sustainable tourism.**
- **Protect white tip reef shark and blacktip reef shark locally within the Gili Matra Marine Recreational Reserve, considering its value to the ecosystem and local economy.**
- **Divers, snorkelers, and boat quota per day to reduce the stress to the reefs and marine life.**
- **Enlarge the red/core zone to limit extraction activities.**
- **Place more mooring lines at popular dive/snorkeling sites to reduce damage on coral reefs from anchoring.**

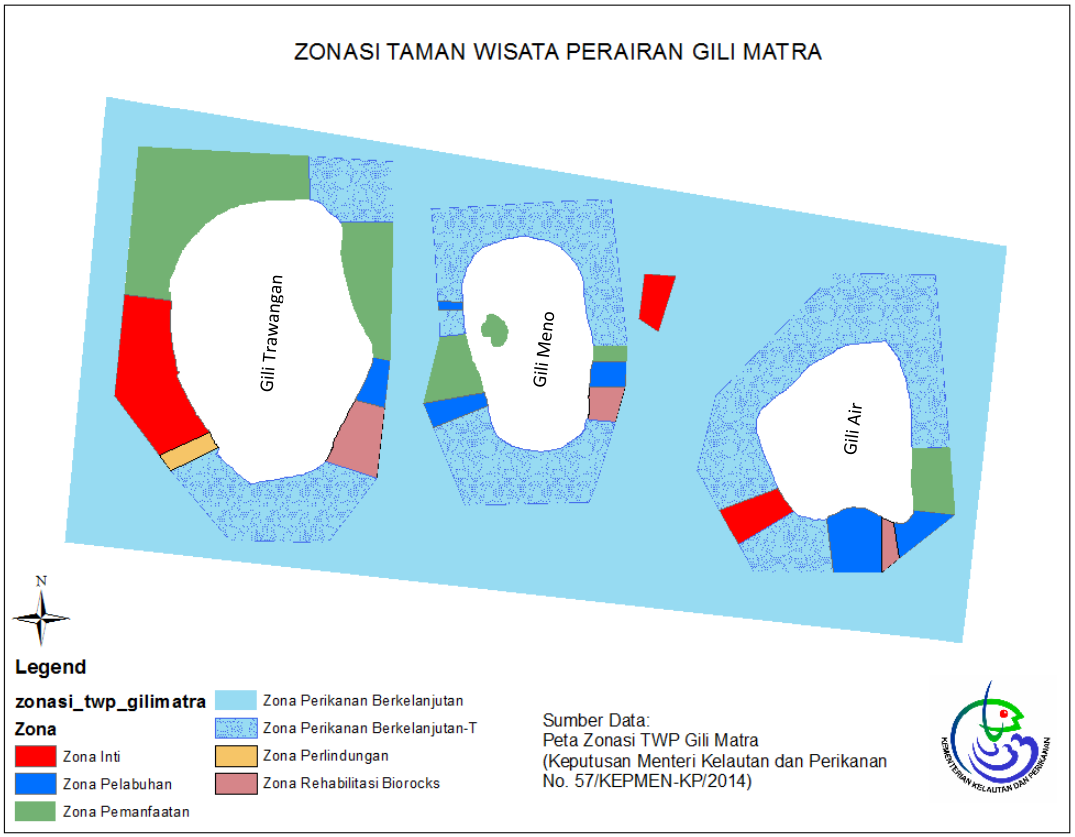


Figure 49. Gili Matra Marine Recreational Reserve zonation. Note that the largest protected area is on the west-southwest side of Gili Trawangan.

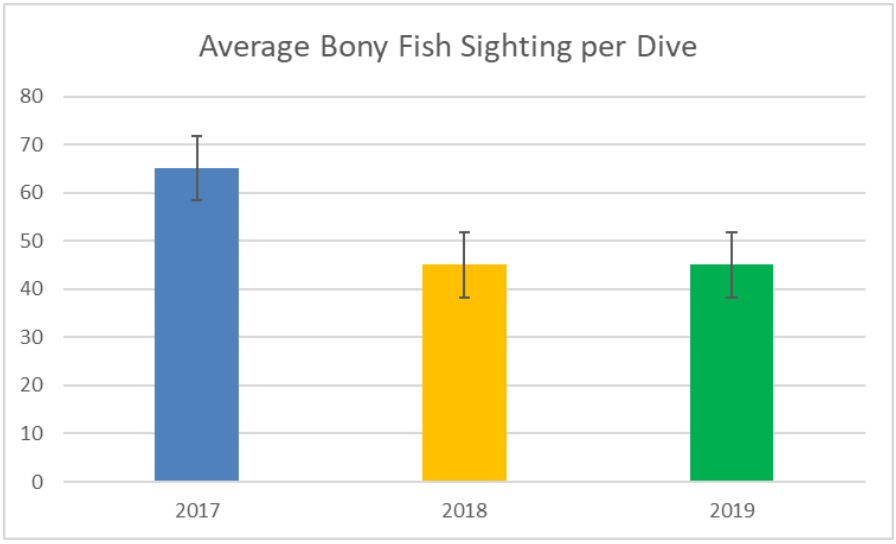


Figure 50. Average number (mean ± SE) of the bony fish sighting from 2017, 2018, and 2019 from Roving Survey.

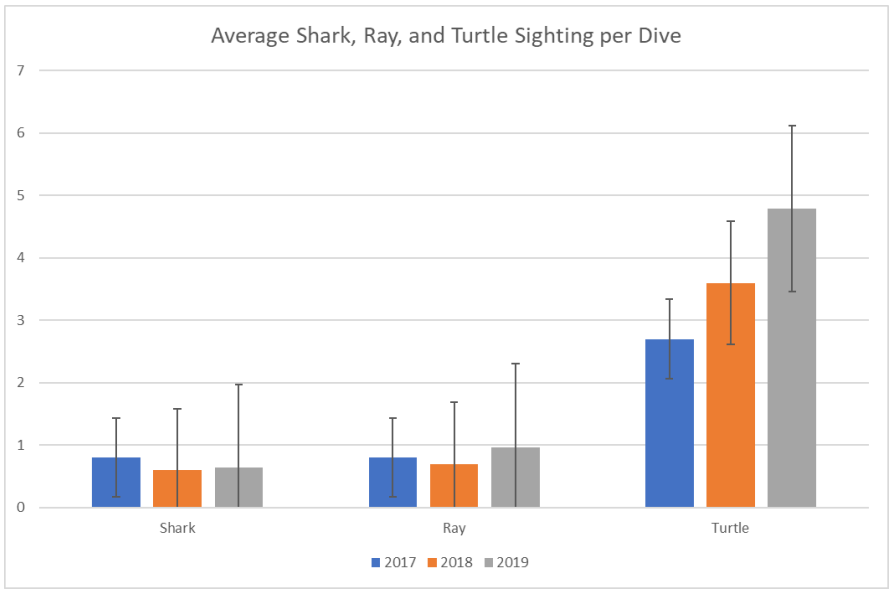
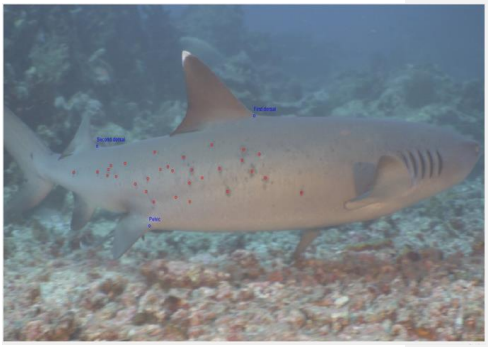


Figure 51. Average number (mean ± SE) of shark, ray, and turtle sighting from 2017, 2018, and 2019 from Roving Survey.

W12 Dani - April 4th 2019



W12 Dani - August 2nd 2019

Figure 52. W12 Dani was found pregnant on April 4th and not pregnant anymore on August 2nd. Both pictures were taken in the same area at Shark Point.

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