ASSESSING ELASMOBRANCH DIVERSITY & ABUNDANCE

Using baited remore underwater video (BRUV) survey in Kiabu Island

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Introduction

The sharks, rays and skates, known as the chondrichthyes or cartilaginous fishes, are listed in the elasmobranch (or elasmobranchi) subclass. Globally, there are more than 500 species of sharks and 600 species of rays, and so far, 200 plus species of sharks and rays have been identified in Indonesia (Ali *et al.,* 2018; Ebert *et al.,* 2013). Sharks and rays keep marine ecosystems in balance, and they are great ecosystem health indicators. Moreover, coastal communities also depend on the two animals to sustain their sustainable fishing and tourism industries.

Sharks are late bloomers, they don't reach sexual maturity untill later in life and female sharks only give birth to a few offsprings in their lifetime (Bettis, 2017; Stevens *et al*., 2000). Combining this fact with the overfishing issue leads to them being highly vulnerable to extinction (Booth, 2018; Cortes, 2000).

Indonesia is one of the biggest exporters of elasmobranch animals, the country approximately catches 100,000 tonnes of sharks to be exported every year (Jaiteh *et al.,* 2016).

Anambas Islands in the Riau Archipelago is located in the South China Sea, right between Malaysia and Kalimantan. The regency is among Indonesia's northern-most border archipelagos, consisting of 225 islands with diverse and unique ocean characteristics that are included in the Regional Fisheries Management of the Republic of Indonesia (WPP-RI 711) (Purba *et al.,*2012). Its sea bottom topography is generally flat or slightly sloping down from south to north with fringing coral reefs around the islands. The waters are warm and characterized by a wide range of habitats including coral reefs, mangroves, seagrass beds, and soft-sediment habitats and mostly sandy mud in the open sea. These areas are potentially rich in biodiversity but poorly explored (Ng *et al.,* 2002).

Baited Remote Underwater Videos (BRUV) is a technique to determine which species are present in the water and analyze the relative measures of species diversity and abundance for a diverse range of species in a diverse habitat (Langlois *et al.,* 2020; Cappo, Harvey, & Shortis, 2006). BRUV can also be used to study the effects of fishing between the no-take zone and open-access zone by comparing the diversity and abundance of a species presence in those areas. BRUV method is cost effective, non-invasive and non-destructive technique, making them especially well-suited in Marine Protected Areas (MPAs) to assess large-scale sampling of elasmobranch in a relatively short time and can be used for long term monitoring and permanent records of the fish observed. BRUV can be deployed at different depths of more than 40 meters beyond the limits of SCUBA (White *et al*., 2013; Miller *et al.,* 2017; Harvey and Cappo, 2001; Stobart *et al.,* 2007). This method is proved to be useful in measuring the abundance, diversity and distribution on shark and ray populations in areas such as Raja Ampat (Beer, 2015), Morotai waters of North Maluku (Sentosa *et al*., 2020), Rote Island, Nusa Penida and Gili Air.

The baseline information on biodiversity and abundance of shark and ray species in Kiabu Island, Anambas is still limited, acquiring data on diversity and abundance of sharks and rays in the Kiabu region is essential for future shark and ray fisheries management. Occurrence and habitat data in particular, is used as basic information to determine management strategies and justification to implement MPA zones or even expanding the no-take zone within MPA (Gallagher *et al.,* 2015). Hence, the objective of this research is to investigate and collect baseline data of the diversity and abundance of sharks and rays on coastal reefs in Kiabu Island using BRUV technique.

Methodology

Study Area

Kiabu Island (2°45’3.782” N,106°13’48.221” E) is the southernmost inhabited island in South Siantan, Anambas Islands with sea surface temperature that continuously fluctuates. At the time of this writing, approximately 700 people live on this small island and almost all families depend on small-scale fishing jobs.

BRUV surveys were conducted around Kiabu Island from June 2021 until August 2021. The total sea area along the coast of Kiabu Island is approximately 1204,72 m^2 representing the different zones of the Anambas Marine Tourism Park (TWP) namely the tourism zone, rehabilitation zone, core zone and sustainable fisheries zone. Figure 2 shows the research locations of BRUV deployment. BRUV was deployed in six locations around Kiabu Island: East Kiabu Island, Gembili Island, Semut Island, Hiu Island, Sigan Island, and Raya Bay which was the only no-take zone.

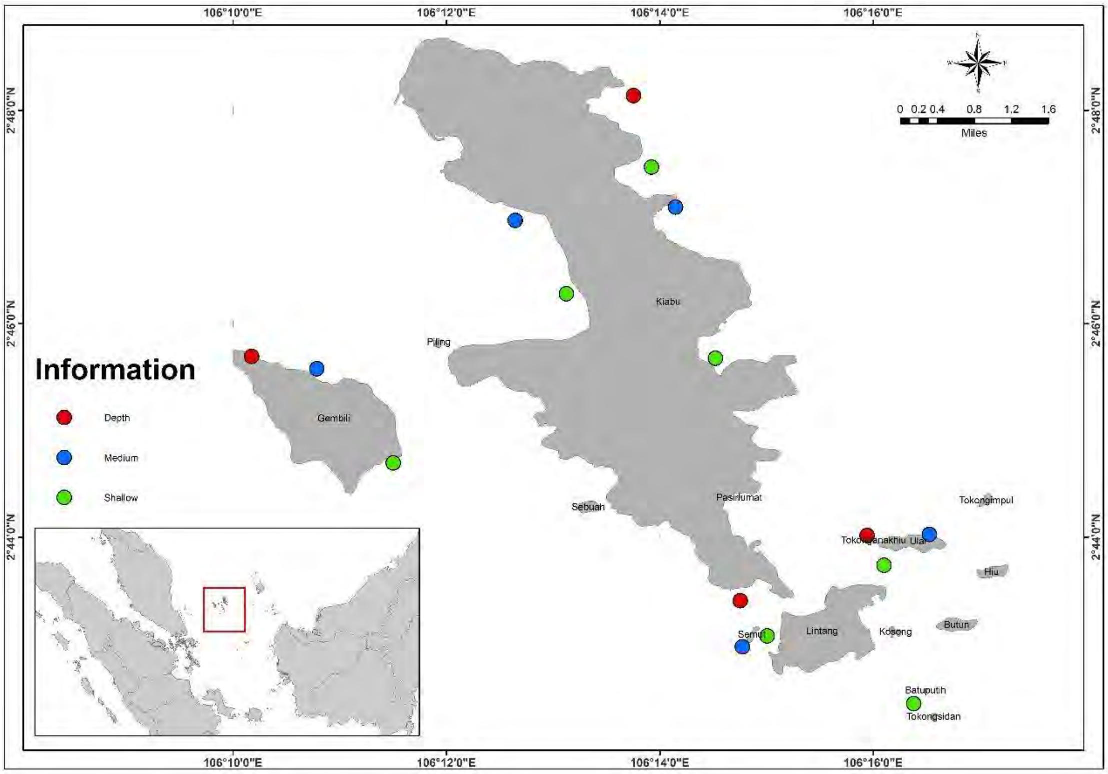

Figure 2. Map of BRUV research locations

Sampling Method

On each site, BRUV was deployed three times at different sea levels within the range of 1-35m: shallow (10 m – 20 m), medium (21 m – 30 m), and deep (30 m – 35 m), between the hours of 09:00 -15:00. Each deployment was spaced 500 m apart from each other to avoid odor overlap from the fishing bait.

The BRUV metal frame was shaped like a pyramid measuring 50x50cm for the base and 90cm in height (Figure 1.) A GoPro 9 camera in a water-proof case was mounted 50 cm above the ground on the pyramid, the camera lens facing a one-meter PVC pipe extended from the frame where the bait was placed. The GoPro is a great tool for this study because it can record in 1080p quality at 60 frames per second. Hi-res videos allow us to do species identification easier. We tied the BRUV to a buoy with a rope that was 1.5 times longer than the maximum depth of the site, that way the BRUV would not get carried away by strong currents.

The bait canister was filled with approximately 1kg of locally sourced crushed fresh tuna (*Thunnus sp*.). According to research *Thunnus sp*. was the recommended meat bait to attract predators because of its oily meat (Dorman *et al.,* 2012).

Every deployment took about 70 minutes of video footage, this was deemed as the optimal soak time for a BRUVY survey. The first 10 minutes of the footage would be excluded from the analysis because it was considered as the adjustment period after the diver ascended from the sea bottom. The depths (m) were measured with a dive computer. GPS location and environmental data were recorded before deployment and after retrieving the BRUV (Da Vos, 2017).

When everything was set and the assigned diver returned to the boat, the crew then had to move several kilometers away to minimize the disturbance.

Sites of deployment were selected using a stratified random sampling design. Sites were initially explored by the Marine Conservation team then adjusted to a local map using ArcMap to find the right depths. Random deployment points were then chosen and put into GPS.

Figure 1. BRUV Frame

Video and Data Analysis

MaxN is commonly used as a standard metric to determine the relative abundance which is defined as the maximum number of individuals from each species detected in a footage. The MaxN is used to avoid repeat counts of individuals reentering the field of view. Following previous studies, MaxN data is then converted into MaxN per hour.

Species that appeared on camera were identified up to the lowest taxon using local identification books. GPS location, deployment time, duration, field of view, species observed, time of first sighting, MaxN, time of MaxN, and habitat type should be present in the footage. All videos and data were then reviewed by the experts to ensure the validity of the results (Langlois *et al.,* 2020; Ruijs, 2017).

Total individuals that appeared in one frame were ranked based on the frequency of occurrence; H – high (>30% of deployments); M – medium (10-30% of deployments); and L – low (<10% of deployments).

Results

20 BRUV deployments from a total of 20 total hours were conducted in different locations around Kiabu Island waters for the baseline survey. Three (15%) deployments were excluded because of the strong currents and one (5%) was due to camera faulty. In total, only 16 successful deployments were analyzed. Of the four habitats targeted in Kiabu Island waters, only reef and sand habitats were successfully conducted. The habitat frequency is shown below (Figure 2).

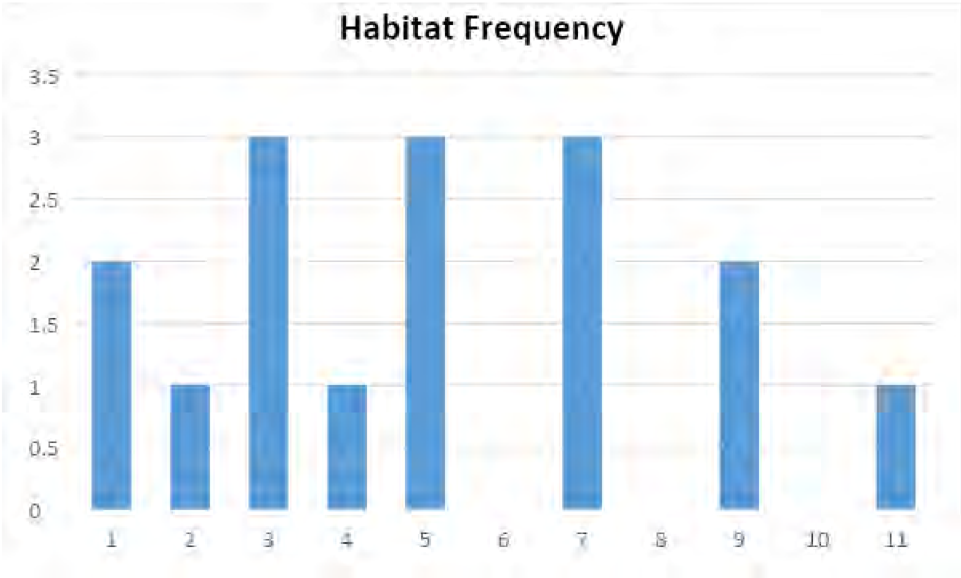

Figure 2. Habitat Frequency

We analyzed 16 deployments, 70 minutes of recording from each deployment, 10 sharks were observed and only blacktip reef sharks (*Charcharinus melanopterus, n=10)* were identified in all of the footage, that is 50% from the total 16 hours of recording. The frequency of blacktip reef shark appearance was high with 50% occurrence from all deployments. The relative shark abundance (mean MaxN/hour) was 0.625. The relative abundance of sharks were greater in Tokong Sigan and Gembili Island with MaxN of two individuals in one frame (Figure 3). The highest relative abundance was found in Gembili Island (MaxNhr^{-1}: 1 ± 0.816). The lowest was in Teluk Raya with zero elasmobranchi appearance. Kiabu Island (MaxNhr^{-1}: 0.3 ± 0.471); Hiu Island (MaxNhr^{-1}: 0.6 ± 0.471); Semut Island (MaxNhr^{-1}: 0.6 ± 0.471); Sigan Island (MaxNhr^{-1}: 0.6 ± 0.942).

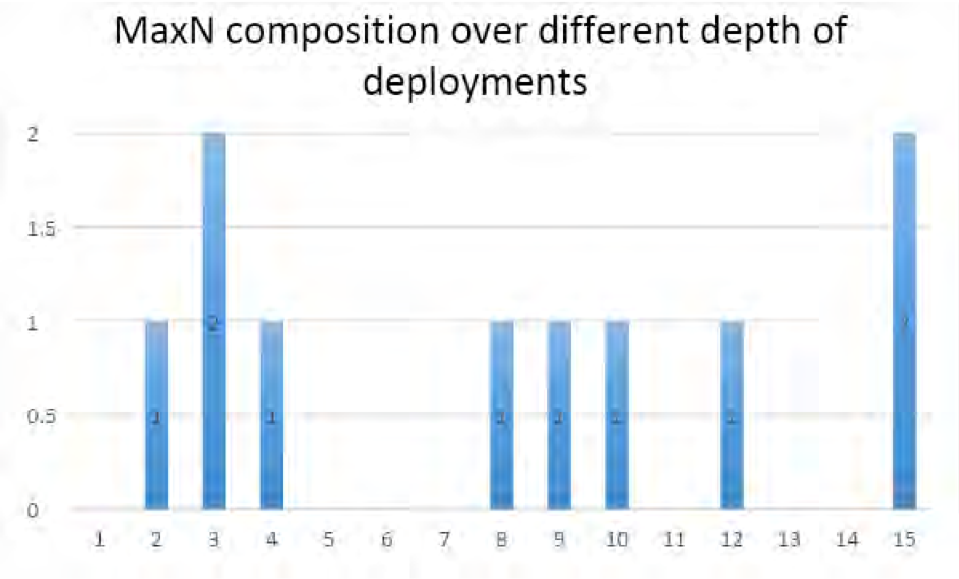

Figure 2. MaxN composition over different depth of deployments

Overall, BRUV deployment only detected one species of shark: blacktip reef shark (*Carcharhinus melanopterus).* Raya Bay was the only no-take zone site that showed no presence of elasmobranch while other sites had at least one individual shark appearance. Colored dots show the depth of deployment. Red dot indicates deep (30 m – 35 m) deployment, blue dot indicates medium (20 m – 29 m) deployment and green dot shows shallow (10 m – 19 m) deployments.

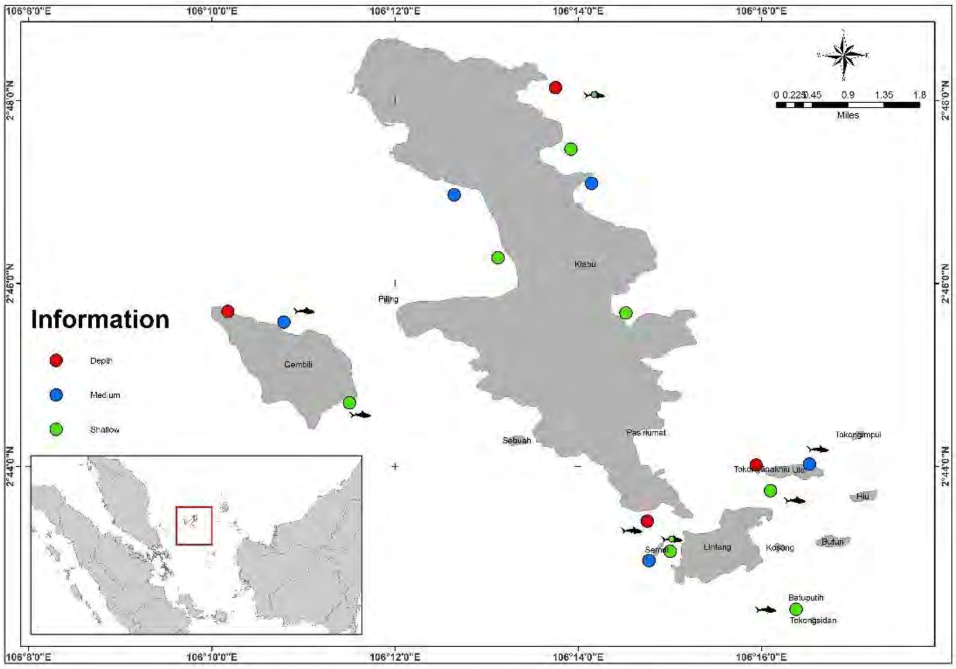

Figure 3. Distribution map of sharks occurrence in Kiabu waters

Discussion

Recent technology advancements like Baited Remote Underwater Video (BRUV) have become an effective monitoring technique in the ocean. BRUV system works like a camera trap, using bait to attract nearby predatory species. It is proven to be an efficient tool to collect species diversity and abundance for a wide range of species. The instrument is non-destructive, low cost and non-extractive that can be applied in a wide range of depths within multiple different habitats (Harvey *et al.* 2018; Langlois *et al.,* 2020). BRUV also mitigates several challenges faced by traditional monitoring methods where a diver has to be present for data collection. Monitoring elasmobranch communities in the open ocean, or in situ areas has proven to be challenging especially in remote environments or in great depths (Collins *et al.* 2017; Cambra *et al.,* 2020).

Blacktip reef shark is listed by IUCN Red List as Near Threatened. They mostly prefer shallow waters, or they inhabit coral reef ecosystems. However, this species can also be found in deeper waters.

The low diversity of species observed in BRUV can be influenced by the depth, time and habitat factors. The deployments were done during daytime as the camera only worked best during daylight, meanwhile some elasmobranch species are less active during daylight (Chin *et al.,* 2012). Based on the research of shark habitat used in Shark Bay, Australia, sharks prefer shallow depth that is surrounded with seagrass rather than sand due to distribution of potential prey. Also, some elasmobranch species may exhibit vertical migration from deeper water during daylight to shallow water at night due to prey hunting and to reduce daily energy use. Moreover, the low diversity can be caused by the bait, *Thunnus* sp., that might attract other species. (Carrier *et al.,* 2012). The difference of elasmobranch abundance at different depths can also be caused by the reach of the odor coming from the bait (Goetze *et al.,* 2012).

Based upon Conservation International research in Anambas Island in 2013, from 330 hours of diving, only four species of sharks were identified: *Chiloscyllium punctatum, Atelomycterus marmoratus, Carcharhinus melanopterus* and *Triaenodon obesus;* 5 species of rays were identified: *Himantura granulate, Neotrygon kuhlii, Taeniura lymma, Taeniura meyeni* and *Aetobatus ocellatus*.

Additionally, elasmobranch assessment in Kiabu was also done by diving, visual survey and by interviewing local fishermen. From the diving survey we also found blacktip reef sharks on sight. Cowtail ray (*Pastinachus sp.*), blacktip reef shark and unidentified ray pups were also observed on a visual survey in mangrove area. It can be assumed that this area is nursery ground for many elasmobranch (Morissey *et al.,* 1993). Local fishermen also sometimes encountered whale sharks (*Rhinchodon typus*) while they were fishing around Kiabu Island.

The low diversity may occur because of the presence of purse seine boats that deploy seine nets (>50 GT), also known as *kapal mayang* in the local language, in Kiabu Island. Even though these ships are prohibited by the law to operate in less than 12 miles from the nearest island, these boats make backdoor deals with the local community to catch fish in large quantities in the area, in exchange for gasoline and groceries. Seine fishing might affect elasmobranch's diversity and abundance. It has been known that several species of elasmobranch migrate to coastal areas to give birth, areas where the purse seine boats deploy their nets, and because of that shark pups might get caught in the purse seine. Jaiteh *et al.* 2016, states that elasmobranch diversity observed in BRUV surveys shows lower species diversity compared to fishery-dependent data from fishermen. This may suggest that BRUV technique is unable to record all species in the area. However, in Anambas Islands, there's no elasmobranch landing data available to be compared with our BRUV data.

Gembili Island and Tokong Sigan were the only areas with two sharks seen in one frame (MaxN). Based on our interviews with the Kiabu fishermen, those islands were the best spots to capture sharks, even sharks that were not the target species. Diving survey also showed that sharks were mostly seen in Gembili Island and Sigan Island compared to many dive sites around Kiabu Island. Tokong Sigan was the only site with a single deployment because of the strong currents that turned the pyramid frame upside down during the recording session, as a result plenty of footage had to be excluded from the analysis. However, while the frame was upside down, the camera managed to capture the presence of a blacktip reef shark. In Teluk Raya, zero elasmobranch was recorded by camera and diving survey, this might be because the area is the main fishing ground for the handline fishermen. Although Teluk Raya is listed as a no-take zone, still, there are many fishermen who disobey the law. As a result, human disturbance is higher in comparison to other areas. We found a significant difference in the total shark abundance between no-take zone and open access zone. These findings are not consistent with other studies where shark abundance is higher in no-take Zone as this zone has more diverse species of prey for elasmobranch (Jaiteh et al., 2020)

The average recording time was 70 minutes. From the 10 deployments in which sharks were identified, the fastest time of the first shark appearance was at 00:01:15, and the longest was at 01:09:21. The average Time of First Seen (ToFS) was in minute 32. Based on Cambra *et al.* 2020, total species identified increase gradually, directly proportional with the soak time and number of BRUV deployment. For Elasmobranch, the curve shows signs of stabilization of species diversity after 90 minutes of soak time and shows faster rate of species accumulation during the first 20 minutes compared to large teleost and megafauna. De Vos *et al.* 2018, states that the optimal soak time for each deployment is 60 minutes and it is able to record 95% of total species. However, elasmobrach may take longer when the areas are low in abundance (Meekan *et al.,* 2004). Since the GoPro camera only shot in a single direction, there might be individuals that swam outside the frame. The use of a 360^0 camera may increase the accuracy to estimate the abundance and diversity.

We acknowledge that there are many biases in comparing BRUV researches from around the world due to different techniques used. Also there are many factors that affect the results. We are aware that the lack of total deployment may affect the data that represent all areas around Kiabu Island. The best action to complete the data is to deploy more BRUV in East Kiabu Island. Reef fish analysis is excluded from the analysis, even though the data may influence elasmobranch diversity and abundance. There’s no previous research on habitat types in Kiabu Island, resulting in the habitat types not distributed equally. BRUV deployments were not executed systematically because of the weather condition.

Conclusion:

Our findings provide the first insight of the diversity and abundance of elasmobranch around Kiabu Island. Combining varieties of monitoring research might help to fully understand the species diversity where limited data are available and fishing pressure occurs. BRUV methodology needs to be standardized in future research to ensure proper data comparison which spans years over a specific location. Further studies are needed to assess elasmobranch diversity and abundance for better insight, especially habitat associations at species level that can be used as a valuable approach to identify specific areas for elasmobranch conservation. This study might serve as a complement to prior data and an important reference data for future studies.

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