AACL BIOFLUX
Aquaculture, Aquarium, Conservation & Legislation
International Journal of the Bioflux Society

Sex and size range composition of whale shark (*Rhincodon typus*) and their sighting behaviour in relation with fishermen lift-net within Cenderawasih Bay National Park, Indonesia

[1]Mahardika R. Himawan, [2]Casandra Tania, [2]Beny A. Noor, [3]Anton Wijonarno, [1]Beginer Subhan, [1]Hawis Madduppa

[1] Marine Biodiversity and Biosystematics Laboratory, Department of Marine Science and Technology, Faculty of Fisheries and Marine Sciences, Bogor Agricultural University, Indonesia, Bogor, Indonesia; [2] WWF-Indonesia Teluk Cenderawasih Project, Teluk Wondama, West Papua, Indonesia; [3] WWF-Indonesia, South Jakarta, Indonesia.
Corresponding author: H. Madduppa, hawis@ipb.ac.id

Abstract. The study was conducted to identify sex and size range composition of whale shark individuals from sightings and their appearance behavior in Cenderawasih Bay National Park, Indonesia. A total of 74 fishermen lift-nets '*bagans*' in Sowa, Kwatisore, and Yaur areas from March to June 2013 were visited to document date, time, location, sex, size range, and number of whale sharks seen each day. Photographic identification was used as a non-invasive means to describe the population throughout the study period. Shark sizes were estimated using a diver body as reference length. A total of 134 whale sharks sightings was recorded within study areas. The highest frequency appearance of whale shark was within Sowa region with 76 sightings, followed by 51 sightings in Kwatisore region, and 7 sightings in Yaur region. From 37 whale sharks identified individual observed in Cenderawasih Bay, there were 36 individuals were identified as male and one as female with a size range of 3-7 meter, dominated by individual with size under 4 meter. From all the observed whale sharks, 44.44% were found not having any scars on their body, but some were having scars on their fins and mouth. Whale sharks in Cenderawasih Bay National Park can be seen moving around in water surface near the lift-net as their feeding behaviour. The fishermen activities might also have an impact on this behaviour, as the fishermen catching activities might drive whale sharks to move to the surface. The large percentage of juveniles recorded in this Cenderawasih Bay National Park population suggests that the area serves as an important habitat for young whale sharks.
Key Words: marine fish, coral triangle, photo identification, animal behavior, whale shark aggregation.

Introduction. Whale shark *Rhincodon typus* (Smith, 1829) is one of the largest known fish on earth. Their habitat covers from warm tropical to subtropical waters and commonly feed on plankton, krill, coral, and fish eggs (Heyman et al 2001). More recent accounts of feeding have appeared in Clark & Nelson (1997), and in Heyman et al (2001) who observed whale sharks feeding on snapper spawn in Belize, as well as on jellyfish. Norman (1999) recorded whale sharks at Ningaloo Reef feeding on coral spawn, and in the same area Wilson & Newbound (2001) and Jarman & Wilson (2004) documented predation on the krill *Pseudeuphausia latifrons*. Duffy (2002) observed whale sharks feeding on schools of anchovy in New Zealand.

Whale shark can reach up to 20 meter in length and weighing up to 34 ton (Last & Stevens 1994; Chen et al 2002). The male adults averaging in 7.05-10.26 meter long while females are usually around 10.6 meter (Compagno 2002). A number of researchers have studied the growth of whale shark in captivity. For example, Uchida et al (2000) recorded a mean annual growth rate of 29.5 cm for a 365 cm female, 21.6 cm for a 450 cm male, and 25.5 cm for a 485 cm total Length (TL) male that were kept for between 458 and 1040 days in the Okinawa aquarium. Chang et al (1997) provided growth information on a whale shark pup held in captivity which grow to TLs of 139 cm in 120

days. A female grew from 4 m to nearly 8 m over an 8-year period in the Osaka aquarium, and a male grew from about 4.5 to 5.5 m in 4 years (Kitafuji & Yamamoto 1998).

From previous studies, females were quite frequent with 17 individuals being sighted in Ningaloo water, Australia, an area which directly facing Indian Ocean (Sequeira et al 2013). On individual studies based on sex and age, it was still unknown whether whale sharks mate in pairs or in large groups (Schmidt et al 2010).

Whale shark is a prominent species in Cenderawasih Bay (Stewart 2011; Hoeg-Guldberg et al 2009), and has gone on to become an ecotourism icon due to their friendly behavior and routine existence (Stewart 2011). In Cenderawasih Bay, whale shark is known as “Gurano Bintang” and their existence can be a great potential revenue for marine protected areas and local communities as well as to raise awareness to the people, improve regional conservation, and promotion as an iconic species for the Cenderawasih Bay and the coral triangle region in general (Hoeg-Guldberg et al 2009). In Indonesia, the Ministry of Marine Affairs and Fisheries Decree No.18/Kepmen-KP/2013 has released policy to fully protect the whale shark. Nevertheless the number of whale shark has been declining globally and is currently listed as vulnerable in the IUCN Red List (Norman 2005). Since 2011, whale sharks in Cenderawasih Bay National Park (TCNP) have been growing as a popular attraction for tourists because of the sharks' regular association with lift net fisheries (bagan) (BBTNTC–WWF 2009). There have been anecdotal reports of year-round presence of whale sharks near those fishing operations, though there are few empirical data to determine actual patterns.

The species has been recognized as highly mobile and migratory species (Eckert & Stewart 2001; Wilson et al 2006), while at the same time the whale sharks have been collected in some countries for international trade, which resulted in the species to being highly threatened. Some threats to whale sharks include catching fish in nets, poor tourism settings, collisions with ships, arrests and illegal whaling, as well as climate change (Sequeira et al 2013). Whale sharks have also slow growth rate and late maturity stage (Bradshaw et al 2008; Schmidt et al 2009). In Australia, the main threat to whale shark is the reduction of food resources and increased tourists in the whale sharks sightings area, and illegal capture (Environment Australia 2005). However, studies regarding whale shark in Indonesia has been rarely conducted. Therefore, this study become important to be conducted. This study aimed to identify individual and their composition based on sex and size and their movement behaviour in Cenderawasih Bay National Park.

Materials and Methods

Time and location. Data sampling were conducted for 52 days in April-June 2013 in Sowa, Kwatisore and Yaur regions in Cenderawasih Bay National Park, within Nabire District, Papua Province, Indonesia (Figure 1). The study was conducted with daily monitoring in fishermen’s lift net located within the study area (Table 1).

Table 1

Details on observation, whale shark appearance frequency and number of lift net within study area visited

Study area	*Number of day observation*	*Whale shark encountered frequency (times)*	*Number of lift nets*
Yaur	2	7	2
Kwatisore	22	51	23
Sowa	28	76	32

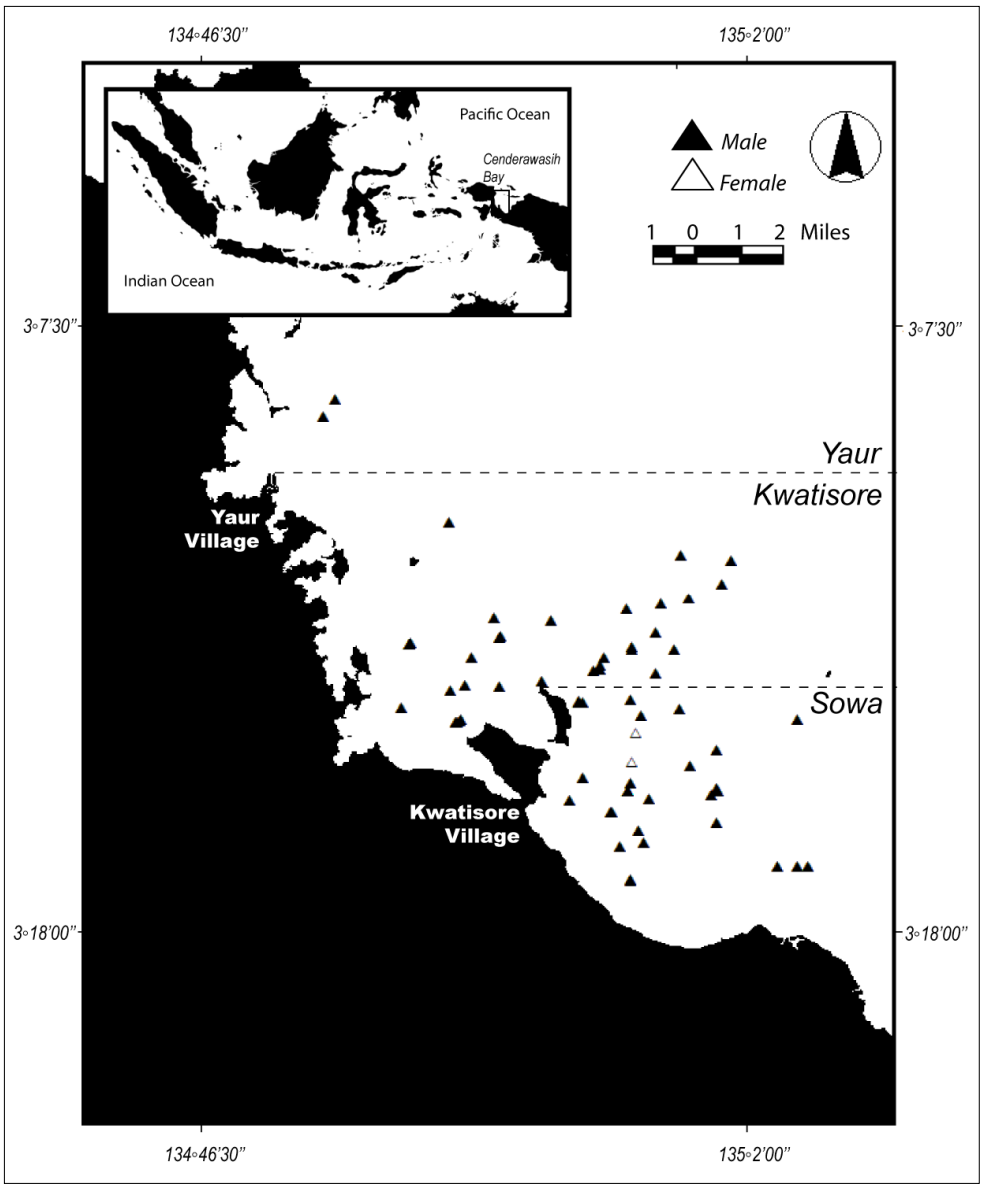

Figure 1. Study location and whale shark distribution encountered in Sowa, Kwatisore, and Yaur regions (white triangle: female, black triangle: male), in Cenderawasih Bay National Park, Papua, Indonesia (original drawing).

Individual identification, sightings frequency, and condition of whale sharks. Individual identification was conducted with Photographic Identification (Photo ID) method and Interactive Individual Identification System (I3S) software (Pierce 2007). This method of identification was done by using white spot pattern on the right and left side of the body that stretches from the gills to the tip of pectoral fin as an indicator to distinguish every individual (den Hartog & Reijns 2007). The individual determination was conducted through comparing the photos taken and the ones with I3S software. The coordinate position of whale shark was recorded when they emerge to the surface using GPS. The condition of whale sharks individual were recorded through photo and divided into three separate scars i.e., fin scar, body scar, and mouth scar. If there were no/few scars then it was categorized as no scars.

Sex and size identification. Sex determination was done through visual observation of the presence of reproductive organ such as clasper which was located around the anal area. Male has a pair of elongated claspers on the anal fin, while females do not have one (Figure 2). The whale shark size determination was done through comparing the body

size with height (Norman & Stevens 2007). The comparative observation was done by swimming right beside the whale shark and record the size estimation.

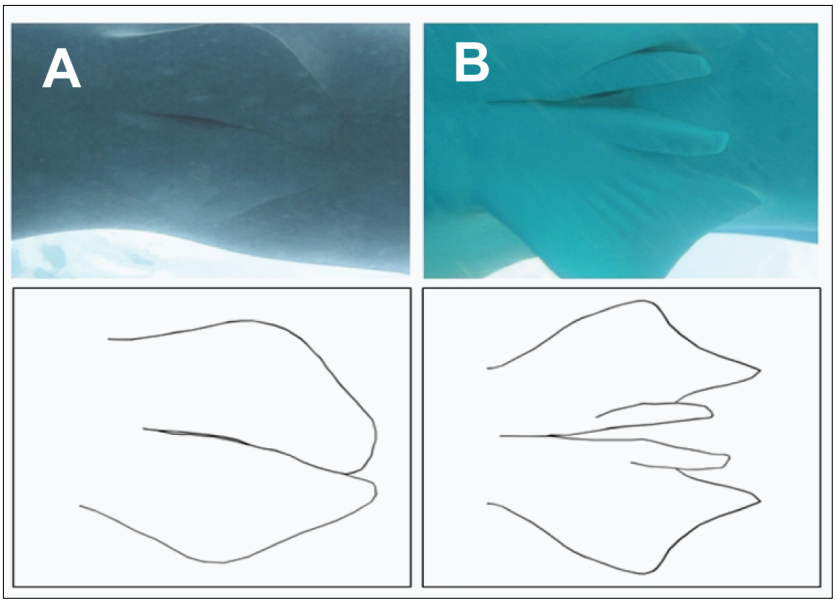

Figure 2. Whale shark sex identification: female (A) and male (B) (original photos and drawings).

Lift-net fishermen catch. Data sampling was conducted by visiting the lift nets to record the obervations. Fish catch was obtained by interviewing fishermen while observation from the lift net was conducted to support the data (one box = 30 kg). Moreover, additional data from the fishermen were collected when the authors could not be present at the designated time.

Data analysis. ArcView GIS 3.3 software was used to create distribution map. Appearances frequency was calculated by recording the number of individuals appeared in every study area. The scars frequency on the body were also recorded to obtain the general condition. The relationship between bagan catch and whale shark sightings was analysed.

Results and Discussion

Sightings frequency, individual identification, and condition of whale sharks. A total of 134 times whale shark frequency appearance during 52 days of observation in Cenderawasih Bay was recorded (Table 1). Whale sharks were distributed surrounding Cenderawasih Bay National Park (Figure 1). The highest frequency was found in Sowa region (76 times), followed by Kwatisore region (51 times), and Yaur region (7 times). It was highly possible that the high appearance sighting in Sowa was due to the high number of lift nets compare to the other two study sites (Kwatisore and Yaur).

A total of 37 different whale shark individuals were identified based on photo identification. Aggregations of whale sharks with different number of individual have been routinely reported off Ningaloo Reef in Australia (Taylor 1996; Wilson et al 2001; Wilson et al 2006), Gladden Spit in Belize (Heyman et al 2001), Yucatan peninsula Mexico (Motta et al 2010), Baja California in Mexico (Clark & Nelson 1997) India (Pravin 2010), Taiwan (Joung et al 1996), Thailand (Theberge & Dearden 2006), and the Philippines (Colman 1997; Taylor & Pearce 1999; Stewart & Wilson 2005).

More than 50% of the whale sharks who appeared in the study site had scars on their bodies (Figure 3). The scars were spread throughout their body, 20% of the scars were found on the fins such as dorsal, pectoral or caudal. Around 20% of the scars are found around their main bodies including gills and the other 15.56% are found near the

mouth area. Whale sharks who have scars around their body tend to be more frequent than the ones who have scars on their fins and mouth area. Whale shark could get scars due to their monstrous size and slow movement, therefore they are vulnerable to collision with hard elements such as ships or bagan itself. There were also scars caused by human activity such as spearing and other means of driving them away from the lift net due to their presence who are thought to distract the fishermen fishing activity. Scars on fins and mouth are mostly because they often get entangled with the fishermen net. Several mouth scars are also caused by the whale shark activity of sucking the fishermen net which is made by rope.

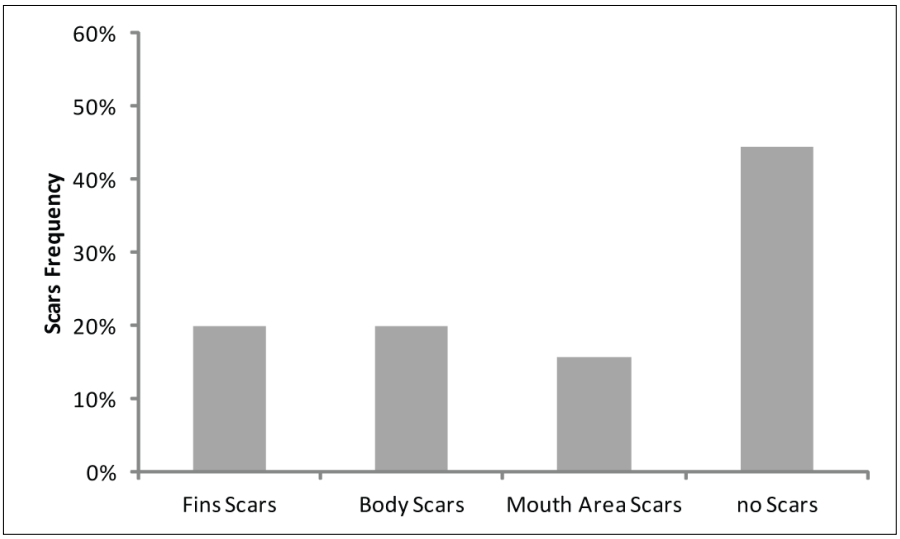

Figure 3. Scars frequency (%) observed on whale shark bodies (n = 37).

Composition of whale shark individual based on sex and body size. The appearance frequency of whale shark in Sowa, Kwatisore, and Yaur was dominated by males. From a total of 37 individuals, 36 of them were males and only one was female (Figure 4). The highest frequency of male appearance in Sowa reached 74 times, in Kwatisore the male appearance was 51 times, and in Yaur only 7 times. Female appearance were very seldom with only 2 times throughout the study, and it only occurred in Sowa. Female individual sighting in Cenderawasih Bay was lower than in the California Bay and Cortez Sea (7 individuals) (Eckert & Stewart 2001), in Philippines (19 individuals) (Araujo et al 2014), in Ningaloo of Australia (17 individuals) (Sequeira et al 2013), while in Mexico, 19 individual whale sharks were identified, including nine males, three females, and seven whose sex was not identified (Nelson & Eckert 2007). This showed that Cenderawasih Bay possesses low population of female whale shark.

The whale shark individual based on size composition was dominated by size ranged of 3–3.9 m in total length (Figure 5). The highest appearance frequency was from those who have a length range of 3–3.9 m (31 times) in Sowa, while a length range of 4–4.9 m have the same number of appearances in Sowa and Kwatisore (11 times). The largest length range of whale shark found in the study site was in a range of 6–6.9 m (7 times in Sowa and once in Kwatisore). Group of length range of 5–5.9 m was the least appearance sighting (once in Sowa and two times in Kwatisore). Yaur was the area where the least frequency of whale shark sighting occurred, for 3–3.9 m individuals only one time and 4–4.9 meter 7 times. The possible explanation for this might be due to least observed area.

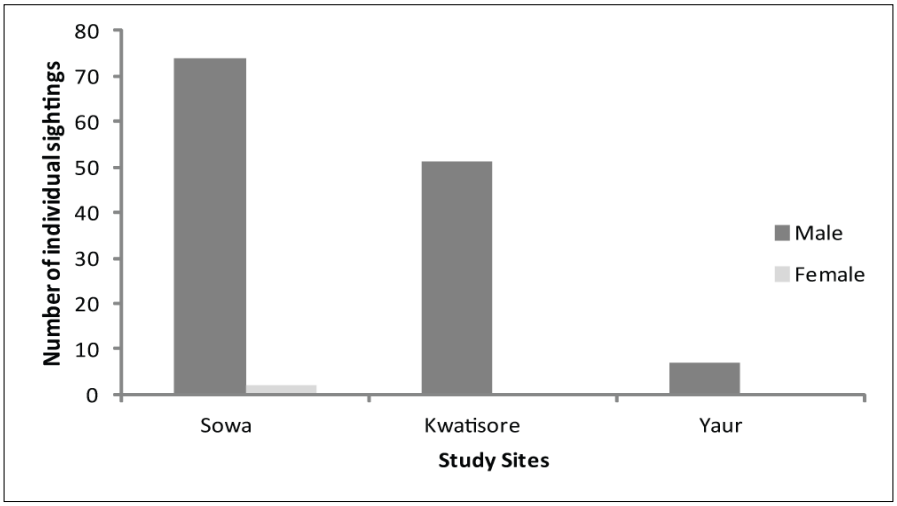

Figure 4. Whale shark sightings frequency based on sex (male and female) at each study sites (Sowa, Kwatisore, and Yaur).

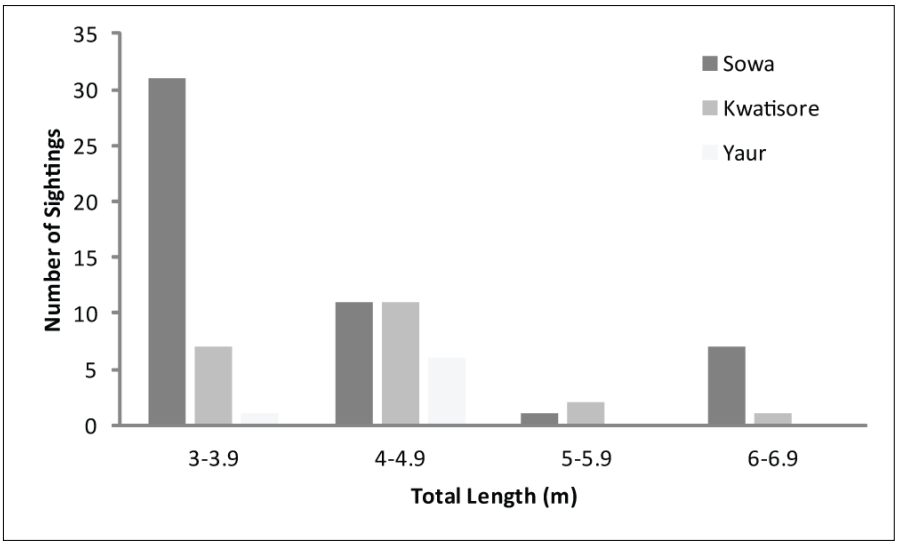

Figure 5. Whale shark sightings frequency based on total length (m) at each study sites (Sowa, Kwatisore, and Yaur).

Data on size at maturity of whale sharks is limited. The recorded whale shark size during the study ranges from three to seven meter which is categorized as juveniles and not yet matured (Compagno 2002). Colman (1997) and Beckley et al (1997) note that the sparse evidence available suggests that size at maturity in both sexes is in excess of 9 m, while others are immature. Beckley et al (1997) examined that the largest female of 870 cm in TL is immature. However, the same 859 cm TL male noted as immature in Beckley et al (1997) was recorded as mature in Wintner (2000), who also recorded a 577 cm TL female as adolescent. This seems very small for a maturing animal. Norman & Stevens (2007) provide some data, based on underwater observations in Western Australia, that length at first maturity of males is about 8 m TL and that 95% of males are mature by about 9 m TL. These facts suggests that individuals observed in Cenderawasih Bay National Park were categorised as juveniles or immature.

The relation between whale shark sighting and number of lift net catch. The number of whale shark surface appearance was tend to follow the fishermen catch (Figure 6). During the study period, the most whale shark activity was observed in Sowa (76 times).

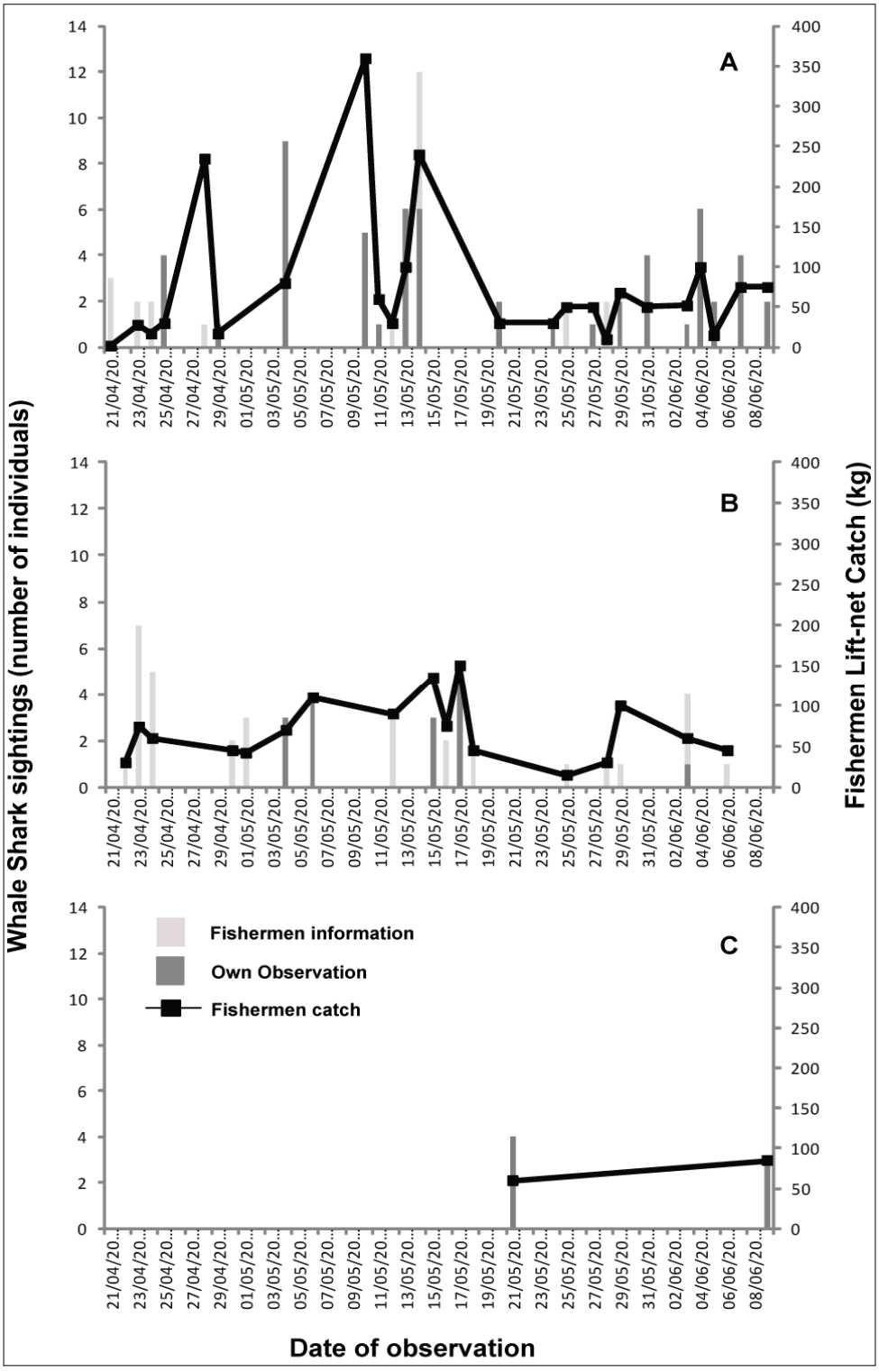

Figure 6. Whale shark sightings frequency based on own observation and fishermen information towards fishermen lift-net catch in Sowa (A), Kwatisore (B) and Yaur (C).

A high abundance of smaller fishes that were caught in Sowa could attract the high number of whale shark appearances in the area. The highest appearance was 14 individuals on May 14th 2013. The fishermen catch in this area was relatively fluctuative with the highest catch being 365 kg on May 9th 2013. The first full moon did not affect the catch due to cloudy weather while the second full moon yielded low catch steadily over the course of the season. Whale shark activity in Kwatisore was lower than Sowa, with as many as 51 appearances during study, with the highest being 7 individuals on

April 23rd 2013. Most of the data was obtained from the fishermen. The largest catch from the lift net is 155 kg on May 17th 2013. The first full moon did not affect the catch due to cloudy weather while the second full moon yielded less catch compare to the first one. Yaur is the area where there are least whale shark activity found. There are only 7 times of whale shark appearance sightings during the study. The highest appearance of whale shark occurred on May 21st 2013 with 4 individuals. On the next observation, which is on June 9th 2013, there are 3 whale sharks encountered. The fishermen catch in this area is relatively fluctuative with the highest catch being 80 kg on June 9th 2013. Other study found that whale sharks may target baitfish (sardines, anchovies) to locate zooplankton, as these fish can be indicators of plankton rich patches (Nelson & Eckert 2007).

It is likely that the catch from the lift net is affected by moon period, where during the full moon it would yield less catch compare to that during the new moon. Fishermen use lighting as a mean to attract fish to the surface, therefore during the full moon the light is evenly spread out, while during new moon the only source of light is the lighting itself. During the new moon, the number of fish in the net often attracts the whale shark to come up to the surface, unlike during the full moon period. But that is not always the case, because there are other factors such as clouds and rain which could block the sunlight, therefore fishes would attracted to the lighting instead. Whale sharks form temporary aggregations of mostly sub-adult juvenile males near tropical and subtropical coastlines (Nelson 2004; Meekan et al 2006; Riley et al 2010; Rowat & Brooks 2012) that are most likely driven by seasonal blooms in food (Rowat & Brooks 2012; Martin 2007; Stevens 2007). Tagging and sighting data (Sequeira et al 2013) suggests whale sharks from aggregation sites within ocean basins are connected on at least regional (100s - 1000s km) scales.

From the data obtained from three sites, it is indicated that the fishermen catch was relatively higher during the new moon period than full moon period, and the catch seems to have a significant effect on the appearance of the whale shark in the area. Whale shark appearances are high during the new moon period, although there are some appearances during the full moon with less frequency. Observation done by Clark & Nelson (1997) shows that whale shark would change their movement pattern towards areas with high concentration of plankton, although other factors such as chemical concentration, bioelectric stimuli and others are yet to be known. The genetic study result shows that whale sharks are not all part of a single global meta-population as indicated by both microsatellite and mitochondrial DNA (Vignaud et al 2014).

Conclusions. Whale sharks in Cenderawasih Bay National Park were dominated by males with a size range of 3–6 m which were still categorized as juveniles. They often emerged to the surface as a feeding behavior and largely depend on the fishermen catch. The feeding behavior of whale shark may be altered by these activities. Representation of only juveniles or immature in this Cenderawasih Bay National Park population suggests the area serves as important habitat for young whale sharks.

Acknowledgements. The study was facilitated by WWF-Indonesia with funding from WWF-Denmark. We would like to thank the Cenderawasih Bay National Park for providing the research permit (SI.19/BBTNTC-2/Tek/2013), (Marine Biodiversity and Program Monitoring Manager – WWF Indonesia) for providing help for the research, Kali Lemon Dive Resort, and bagan fishermen at Sowa, Kwatisore, and Papua for helping data collection during the research.

References

Araujo G., Lucey A., Labaja J., So C. L., Snow S., Ponzo A., 2014 Population structure and residency patterns of whale sharks, *Rhincodon typus*, at a provisioning site in Cebu, Philippines. PeerJ 2:e543.

BBTNTC–WWF (Balai Taman Nasional Teluk Cenderawasih and WWF-Indonesia), 2009 [Cenderawasih Bay National Park Zonation]. Penerbit Andi, Yogyakarta [in Indonesian].
Beckley L. E., Cliff G., Smale M. J., Compagno L. J. V., 1997 Recent strandings and sightings of whale sharks in South Africa. Environmental Biology of Fishes 50:343–348.
Bradshaw C. J. A., Fitzpatrick B. M., Steinberg C. C., Brook B. W., Meekan M. G., 2008 Decline in whale shark size and abundance at Ningaloo Reef over the past decade: the world's largest fish is getting smaller. Biological Conservation 141:1894–1905.
Chang W. B., Leu M. Y., Fang L. S., 1997 Embryos of the whale shark, *Rhincodon typus*: early growth and size distribution. Copeia 97:444–446.
Chen C. T., Liu K. M., Joung S. J., 2002 Preliminary report on Taiwan's whale shark fishery. In: Fowler S. L., Reed T. M., Dipper F. A. (eds). Elasmobranch biodiversity, conservation and management: proceedings of the international seminar and workshop, Sabah, Malaysia, July 1997 IUCN SSC. Shark Specialist Group, IUCN, Gland, Switzerland, pp. 162–167.
Clark E., Nelson D. R., 1997 Young whale sharks, *Rhincodon typus*, feeding on a copepod bloom near La Paz, Mexico. Environmental Biology of Fishes 50:63-73.
Colman J. G., 1997 A review of the biology and ecology of the whale shark. Journal of Fish Biology 51:1219-1234.
Compagno L. J. V., 2002 Sharks of the world: an annotated and illustrated catalogue of shark species known to date. Volume 2: Bullhead, mackerel and carpet sharks (Heterodontiformes, Lamniformes and Orectolobiformes). FAO, Rome, Italy, 269 pp.
den Hartog J., Reijns R., 2007 I3S manual interactive individual identification system, Version 2. Available at: www.reijns.com/about/ 13S_Classic.html. Accessed Oct 18, 2014.
Duffy C. A. J., 2002 Distribution, seasonality, lengths, and feeding behaviour of whale sharks (*Rhincodon typus*) observed in New Zealand waters. New Zealand Journal of Marine and Freshwater Research 36:565–570.
Eckert S. A., Stewart B. S., 2001 Telemetry and satellite tracking of whale sharks, *Rhincodon typus*, in the Sea of Cortez, Mexico, and the north Pacific Ocean. Environmental Biology of Fishes 60:299–308.
Environment Australia, 2005 Whale shark (*Rhincodon typus*) recovery plan, 2005-2010. Environment Australia, Canberra, 5 pp.
Heyman W. D., Graham R. T., Kjerfve B., Johannes R. E., 2001 Whale sharks *Rhincodon typus* aggregate to feed on fish spawn in Belize. Marine Ecology Progress Series 215:275-282.
Hoegh-Guldberg O., Hoegh-Guldberg H., Veron J. E. N., Green A., Gomez E. D., Lough J., King M., Ambariyanto, Hansen L., Cinner J., Dews G., Russ G., Schuttenberg H. Z., Penaflor E. L., Eakin C. M., Christensen T. R. L., Abbey M., Areki F., Kosaka R. A., Tewfik A., Oliver J., 2009 The coral triangle and climate change: ecosystems, people and societies at risk. WWF Australia, Brisbane, 276 pp.
Jarman S. N., Wilson S. G., 2004 DNA-based species identification of krill consumed by whale sharks. Journal of Fish Biology 65:586–591.
Joung S. J., Chen C. T., Clark E., Uchida S., Huang W. Y. P., 1996 The whale shark, *Rhincodon typus*, is a livebearer: 300 embryos found in one 'megamamma' supreme. Environmental Biology of Fishes 46(3):219-223.
Kitafuji M., Yamamoto K., 1998 Rearing of the whale shark, *Rhincodon typus*, in the Osaka aquarium 'Kaiyukan'. Journal of Japanese Association of Zoological Gardens and Aquariums 39:47–54.
Last P. R., Stevens J. D., 1994 Sharks and rays of Australia. CSIRO, Melbourne, 513 pp.
Martin R. A., 2007 A review of behavioural ecology of whale sharks (*Rhincodon typus*). Fisheries Research 84:10–16.
Meekan M. G., Bradshaw C. J. A., Press M., McLean C., Richards A., Quasnichka S., Taylor J. G., 2006 Population size and structure of whale sharks *Rhincodon typus* at Ningaloo Reef, Western Australia. Marine Ecology Progress Series 319:275–285.

Ministry of Marine Affairs and Fisheries Decree Number 18/KEPMEN-KP/2013, Year 2013 on regulation for fully protected for Whale Shark (*Rhincodon typus*) in Indonesia.
Motta P. J., Maslanka M., Hueter R. E., Davis R. L., de la Parra R., Mulvany S. L., Habegger M. L., Strother J. A., Mara K. R., Gardiner J. M., Tyminski J. P., Zeigler L. D., 2010 Feeding anatomy, filter-feeding rate, and diet of whale sharks *Rhincodon typus* during surface ram filter feeding off the Yucatan Peninsula, Mexico. Zoology 113:199–212.
Nelson J. D., 2004 Distribution and foraging ecology by whale sharks (*Rhincodon typus*) within Bahia de Los Angeles, Baja California Norte, Mexico. MSc Thesis, University of San Diego, 118 pp.
Nelson J. D., Eckert S. A., 2007 Foraging ecology of whale sharks (*Rhincodon typus*) within Bahia de Los Angeles, Baja California Norte, Mexico. Fisheries Research 84:47–64.
Norman B. M., 1999 Aspects of the biology and ecotourism industry of the whale shark *Rhincodon typus* in north-western Australia. MPhil. MSc Thesis, Murdoch University, Western Australia, 280 pp.
Norman B., 2005 *Rhincodon typus*. The IUCN Red List of Threatened Species. Version 2014.3. <www.iucnredlist.org>. Downloaded on 16 March 2015.
Norman B. M., Stevens J. D., 2007 Size and maturity status of the whale shark (*Rhincodon typus*) at Ningaloo Reef in Western Australia. Fisheries Research 84:81-86.
Pierce S. J., 2007 Processing photographic identification of whale shark using the Interactive Individual Identification System (I3S). Manta Ray & Whale Shark Research Centre Tofo Beach, Mozambique.
Pravin P., 2010 Whale shark in the Indian coast – need for conservation. Current Science 79(3):310-315.
Riley M. J., Hale M. S., Harman A., Rees R. G., 2010 Analysis of whale shark *Rhincodon typus* aggregations near South Ari Atoll, Maldives Archipelago. Aquatic Biology 8:145–150.
Rowat D., Brooks K. S., 2012 A review of the biology, fisheries and conservation of the whale shark *Rhincodon typus*. Journal of Fish Biology 80:1019–1056.
Schmidt J. V., Schmidt C. L., Ozer F., Ernst R. E., Feldheim K. A., Ashley M. V., Levine M., 2009 Low genetic differentiation across three major ocean populations of the whale shark, *Rhincodon typus*. PLoS ONE 4:e4988.
Schmidt J. V., Chen C. C., Sheikh S. I., Meekan M. G., Norman B. M., Joung S. J., 2010 Paternity analysis in a litter of whale shark embryos. Endangered Species Research 12:117–124.
Sequeira A. M. M., Mellin C., Meekan M. G., Sims D. W., Bradshaw C. J. A., 2013 Inferred global connectivity of whale shark *Rhincodon typus* populations. Journal of Fish Biology 82:367-389.
Stevens J. D., 2007 Whale shark (*Rhincodon typus*) biology and ecology: a review of the primary literature. Fisheries Research 84:4–9.
Stewart B. S., 2011 Workshop and monitoring training for whale sharks in Cendrawasih Bay National Park, West Papua. 2–7 May 2011, Nabire, Papua. Hubbs-SeaWorld Research Institute Technical Report 2011-375: 1-27.
Stewart B. S., Wilson S. G., 2005 Threatened fishes of the world: *Rhincodon typus* (Smith 1828) (Rhincodontidae). Environmental Biology of Fishes 74:184-185.
Taylor J. G., 1996 Seasonal occurrence, distribution and movements of the whale shark, *Rhincodon typus*, at Ningaloo Reef, Western Australia. Marine and Freshwater Research 47:637-642.
Taylor J. G., Pearce A. F., 1999 Ningaloo Reef currents: implications for coral spawn dispersal, zooplankton and whale shark abundance. Journal of the Royal Society of Western Australia 82:57-65.
Theberge M. M., Dearden P., 2006 Detecting a decline in whale shark *Rhincodon typus* sightings in the Andaman Sea, Thailand, using ecotourist operator-collected data. Oryx 40(3):337-342.

Uchida S., Toda M., Kamei Y., Teruya H., 2000 The husbandry of 16 whale sharks *Rhincodon typus*, from 1980 to 1998 at the Okinawa expo aquarium. American Elasmobranch Society 16th Annual Meeting June 14–20, 2000 La Paz, B.C.S., México, U.S.A. Okinawa Expo Aquarium, Okinawa, Japan.

Vignaud T. M., Maynard J. A., Leblois R., Meekan M. G., Vázquez-Juárez R., Ramírez-Macías D., Pierce S. J., Rowat D., Berumen M. L., Beeravolu C., Baksay S., Plane S., 2014 Genetic structure of populations of whale sharks among ocean basins and evidence for their historic rise and recent decline. Molecular Ecology 23:2590–2601.

Wilson S. G., Newbound D. R., 2001 Two whale shark faecal samples from Ningaloo Reef, Western Australia. Bulletin of Marine Science 68:361–362.

Wilson S. G., Taylor J. G., Pearce A. F., 2001 The seasonal aggregation of whale sharks at Ningaloo reef, western Australia: currents, migrations and the El Nino/Southern oscillation. Environmental Biology of Fishes 61:1-11.

Wilson S. G., Polovina J. J., Stewart B. S., Meekan M. G., 2006 Movements of whale sharks (*Rhincodon typus*) tagged at Ningaloo Reef, Western Australia. Marine Biology 148:1157-1166.

Wintner S. P., 2000 Preliminary study of vertebral growth rings in the whale shark, *Rhincodon typus*, from the east coast of South Africa. Environmental Biology of Fishes 59:441–451.

Received: 11 January 2015. Accepted: 20 March 2015. Published online: 25 March 2015.
Authors:
Mahardika Rizqi Himawan, Marine Biodiversity and Biosystematics Laboratory, Department of Marine Science and Technology, Faculty of Fisheries and Marine Sciences, Bogor Agricultural University, Indonesia, Jl. Agatis No. 1, Darmaga 16680, Bogor, Indonesia, e-mail: mahardikarizqihimawan@gmail.com
Casandra Tania, WWF-Indonesia Teluk Cenderawasih Project, Jl. Raya Manggurai-Iriati, Teluk Wondama, West Papua 98362, Indonesia, e-mail: ctania@wwf.or.id
Beny Ahadian Noor, WWF-Indonesia Teluk Cenderawasih Project, Jl. Raya Manggurai-Iriati, Teluk Wondama, West Papua 98362, Indonesia, e-mail: benynoor@gmail.com
Anton Wijonarno, WWF-Indonesia, Graha Simatupang Tower 2 Unit C 7th Floor, Jl. Letjen TB Simatupang Kav. 38, South Jakarta 12540, Indonesia, e-mail: awijonanrno@wwf.ac.id
Beginer Subhan, Marine Biodiversity and Biosystematics Laboratory, Department of Marine Science and Technology, Faculty of Fisheries and Marine Sciences, Bogor Agricultural University, Indonesia, Jl. Agatis No. 1, Darmaga 16680, Bogor, Indonesia, e-mail: begi_ners@yahoo.com
Hawis Madduppa, Marine Biodiversity and Biosystematics Laboratory, Department of Marine Science and Technology, Faculty of Fisheries and Marine Sciences, Bogor Agricultural University, Indonesia, Jl. Agatis No. 1, Darmaga 16680, Bogor, Indonesia, e-mail: hawis@ipb.ac.id

How to cite this article:
Himawan M. R., Tania C., Noor B. A., Wijonarno A., Subhan B., Madduppa H., 2015 Sex and size range composition of whale shark (*Rhincodon typus*) and their sighting behaviour in relation with fishermen lift-net within Cenderawasih Bay National Park, Indonesia. AACL Bioflux 8(2):123-133.