International Journal of Biological Engineering and Agriculture
ISSN: 2833-5376
Volume 03 Number 01 (January) 2024
Impact Factor: 9.51
SJIF (2023): 3.916

www.inter-publishing.com

Preliminary Monitoring of Whale Shark (Rhincodon typus) Migration Patterns in the Waters Botubarani Village Gorontalo Based on Satellite Marker Monitoring

Sukirman DJ. Tilahunga
Gorontalo State University Postgraduate Marine Science Study Program
Corresponding author: email: sukirmantilahunga24@gmail.com

Abdul Hafidz Olii
Department of Aquatic Resources Management, Faculty of Fisheries and Marine Sciences, Gorontalo State University

Femy Mahmud Sahami
Department of Marine Science, Faculty of Fisheries and Marine Sciences, Gorontalo State University

Abdy Wunanto Hasan
Indonesian Conservation Foundation

Moch. Iqbal Herwata Putra
Indonesian Conservation Foundation

Mark V. Erdmann
Indonesian Conservation Foundation

ABSTRACT

This research aims to determine the migration patterns of Whale Sharks using satellite markers in the waters of Botubarani Village, Bone Bolango Regency, Gorontalo Province. This research was conducted from April 2023 to December 2023 using satellite-based technology by installing satellite tagging (Finmount Tag) on two individual whale sharks that often appear at the research location with codes ID 53 and ID 55. Tagging was carried out using the containment method. using nets and boats. The results showed that the two individuals showed different migration patterns both spatially and temporally. The individual with ID code 53 was recorded as having migrated for 79 days and the individual with ID code 55 was recorded as having migrated for 54 days to return to Botubarani beach, Gorontalo. Based on monitoring results, the two of them have different migration patterns but are still in the Tomini Bay waters. The results of this research have contributed to knowledge about the behavior of Whale Sharks (Rhincodon typus) in the waters of Tomini Bay which can be useful as a basis for future management.

KEYWORDS: Whale shark, Rhincodon typus, satellite marker, fish migration.

International Journal of Biological Engineering and Agriculture
ISSN: 2833-5376
Volume 03 Number 01 (January) 2024
Impact Factor: 9.51
SJIF (2023): 3.916
www.inter-publishing.com

INTRODUCTION

The waters of Botubarani Village, Kabila Bone District, Bone Bolango Regency, which is part of the Tomini Bay area, are the location where Whale Sharks appear in Indonesia. Based on information from local fishermen, the appearance of whale sharks in Botubarani waters and its surroundings has actually been around for a long time, but the exact time is not known. This can be proven by the mention of this fish with the local name Munggiangohulalo.

This fish usually only appears at certain times. They sometimes appear every day but sometimes they don't appear and then disappear from Botubarani waters. According to local fishermen, these fish are usually a nuisance during the nike fish emergence season because they usually swim near boats and prey on the nike fish that are the target of catching them.

Nike fish are small fish that appear in the waters of Gorontalo Bay at the end of the month to the beginning of the month in the Hijri calendar year (Olii, et al. 2017; Bahani, et al. 2019). Based on information from local fishermen and from observations, this fish will usually move to locations where there is nike fishing. It is suspected that the presence of Whale Sharks in Botubarani waters and its surroundings is related to food (Jonahson and Harding, 2007; Rahman, et al. 2017). The results of recent research on the sustainability of nike fish in the waters of Tomini Bay show that of the 5 dimensions analyzed there are 4 dimensions that are unsustainable (Sahami, et al. 2024). This will certainly be a threat to the continued emergence of Whale Sharks in Botubarani.

The existence of Whale Sharks in the waters of Botubarani Gorontalo has become known to the wider public since 2016 and with the power of social media, now Botubarani has become one of the Whale Shark tourist attractions in Indonesia which is well known and has even reached foreign countries. This of course must receive serious attention for good management so that its existence is sustainable.

Several researches related to this fish in Botubarani have been carried out, including by Rahman, et al. (2017) who conducted an initial study on the emergence of whale sharks in Tomini Bay which was linked to physical and biological factors in the water. Then Rombe, et al. (2022) who conducted a study on the condition of the whale shark population and measured several water quality parameters. Meanwhile, information about the distribution pattern of Whale Sharks that appear in Botubarani waters is not yet available. Whale sharks can influence community structure and function through top-down density effects and risk-based effects on the distribution and abundance of their prey (Heithaus, et al. 2008). Predicting migration and aggregation patterns as well as anthropogenic impacts is very important (Hammerschlag, et al. 2010).

Information about whale shark migration patterns is very important considering that Gorontalo is one of the regions in Indonesia which is a priority for marine biodiversity conservation, especially whale sharks. Rahman, et al. (2017) stated that the appearance of whale sharks in the waters of Tomini Bay cannot currently be predicted accurately. Documenting the movement and behavior of marine animals poses great challenges due to their high mobility and the influence of diverse water conditions (Martin, et al., 2009). With current advances in technology, tracking using satellite tags can enable scientists to understand the movement and roaming patterns of animals with satellite tags attached (Bailey, et al. 2010). Therefore, the research has used satellite markers to determine the migration patterns of Whale Sharks that appear in Botubarani waters over a long and continuous period of time to obtain accurate data and information. It is hoped that the results of this research can contribute to the development of knowledge about Whale Sharks, especially in Botubarani and

International Journal of Biological Engineering and Agriculture
ISSN: 2833-5376
Volume 03 Number 01 (January) 2024
Impact Factor: 9.51
SJIF (2023): 3.916
www.inter-publishing.com

Indonesia as well as in all countries that are migration areas for this fish, so that comprehensive management can be carried out.

RESEARCH METHODOLOGY

This research was carried out during the period April to December 2023. To determine the migration pattern of the Botubarani Gorontalo Whale Shark, a satellite tag method was used which was attached to the Whale Shark to be observed. Migration pattern observations were carried out on two individual whale sharks which were identified with codes ID 53 and ID 55.

The satellite marker used in this research is the SPLASH10-346A type made by Wildlife Computers with dimensions of 198 mm x 84 mm x 23 mm. This tool has been specially designed for mounting on the dorsal fin of a Whale Shark with a large battery pack. This marker has the ability to work up to 450 days if it does not experience physical damage.

The tag installation uses a confinement method using a fine net (resembling a mosquito net) measuring 20 x 50 meters so as not to injure the Whale Shark specimen. In this installation, 3 boat aids and scuba diving equipment and an underwater camera were used.

Retrieval of data from satellite signal receivers via the wildlife computer portal on Whale Sharks ID 53 and ID 55 which have satellite tags installed. Through this wildlife computer portal tool, the condition of the parameters of temperature, depth and migration coordinates of Whale Sharks can also be known. The Whale Shark migration data studied both spatially and temporally were analyzed descriptively.

I. RESULTS

The results of observations of the spatial temporal distribution patterns of 2 (two) individual Whale Sharks with ID GT 53 and ID GT 55 which had satellite tagging installed showed different patterns. After embedding the satellite tagging device, the two individuals gave their first signal to the satellite which was successfully read by the wildlife computer application software at different time intervals. The research results provide interesting results. These two individuals show different spatial migration patterns horizontally and vertically. Likewise, the temporal migration pattern shows that the two spend different times completing their migration process to return to Botubarani waters after migrating in the Tomini Bay area.

Whale Shark Horizontal Migration Patterns

The results of the analysis of the horizontal spatial distribution patterns of the two observed individuals are presented in Figure 1.

International Journal of Biological Engineering and Agriculture
ISSN: 2833-5376
Volume 03 Number 01 (January) 2024
Impact Factor: 9.51
SJIF (2023): 3.916
www.inter-publishing.com

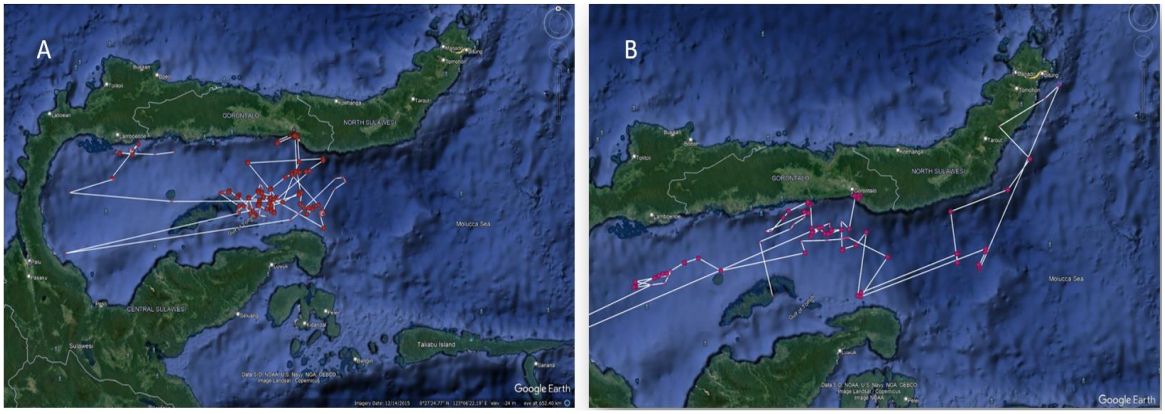

Figure 1. Spatial distribution pattern of Whale Sharks in the waters of Tomini Bay. A). Individual with ID 53; B). Individual with ID 55.

Observation results show that the satellite tag on individual ID 53 sent its first signal after 7 (seven) days after the satellite tagging device was embedded in his body on December 23 2022, namely on December 30 2022. The first signal that was read was that the coordinate position was in Regency waters. Pohuwato, East Wonggarasi District. Furthermore, on January 23 to February 5 2023, Individual ID 53 was detected in the waters of Central Sulawesi, precisely in the waters of Parigi Moutong. Then, from February 13 to March 9 2023, its position was detected in the waters of the Togean Islands, Central Sulawesi, and on March 11 2023, the Whale Shark ID 53 returned to the waters of Botubarani Beach, Bone Bolango Regency, Gorontalo Province (Figure 1A).

Based on the results of this research, it shows that the Whale Shark ID 53 migrated out of Botubarani beach, then migrated into the waters of Tomini Bay and returned to Botubarani beach. The length of time recorded was 79 days with a migration distance of 703.49 km.

Observation results for the individual with ID 55 show that the satellite marker for this individual has been providing signals since the first day it was installed on December 24 2022 with the coordinate position still remaining around Botubarani beach. This is different from individual ID 53 who gave his first signal 7 days after being tagged.

The results of monitoring the migration movement pattern of Whale Shark ID 55 show that from December 24 2022 to January 7 2023, this individual was still in Botubarani coastal waters. However, on May 4 2023, it was observed from the signals given that the coordinate position was already in the middle of the waters of Tomini Bay and on May 16 2023 it was already in the waters of the Banggai Islands, Central Sulawsi Province. Furthermore, on May 19 2023, the position will be in Bolaang Uki Waters, South Bolaang Mongondow Regency, North Sulawesi Province. On May 20 2023, individual ID 55 was observed along the coast of East Bolaang Mongondow from Nuangan District to Kotabunan and on May 22 2023 he was in the waters of Kombi District, Minahasa Regency.

Based on the signal results provided, it was observed that on the same day ID 55 was in Lembeh Waters, North Sulawesi Province. Based on monitoring, the coordinate point is the farthest location of the ID 55 whale shark migration. This location is in the furthest part to the north of Tomini Bay from Botubarani beach, Gorontalo. After returning from Lembeh Waters, follow the same route and on July 17 2023 you will enter Banggai Islands Waters. Next, it will continue its movement towards Central Sulawesi, namely around the

International Journal of Biological Engineering and Agriculture
ISSN: 2833-5376
Volume 03 Number 01 (January) 2024
Impact Factor: 9.51
SJIF (2023): 3.916
www.inter-publishing.com

waters of Parigi Moutong from 31 July 2023 to 15 August 2023. On 26 August 2023 ID 55 has started to enter the waters of the southern coast of Gorontalo Province, until on 18 October 2023 the Whale Shark This returns to Botubarani Beach, Kabila Bone District, Bone Bolango Regency, Gorontalo Province (Figure 1B).

Based on observations, the ID 55 migration pattern is different from the ID 53 migration pattern both spatially and temporally. Spatially, the individual's movement pattern is shown in Figure 1. Temporally, it also shows that the migration pattern shown by ID 55 still persisted for 9 days in Botubarani waters after the satellite tag was installed. But it only took 54 days to return to Botubarani beach. Meanwhile, ID 53 immediately left Botubarani waters on the first day after being attached to the satellite tag and returned in a relatively longer time than ID 55.

1) 4.1.2. Whale Shark Vertical Migration Patterns

The results showed that the two individuals observed had different vertical migration patterns as presented in Figure 2 (ID 53) and Figure 3 (ID 55).

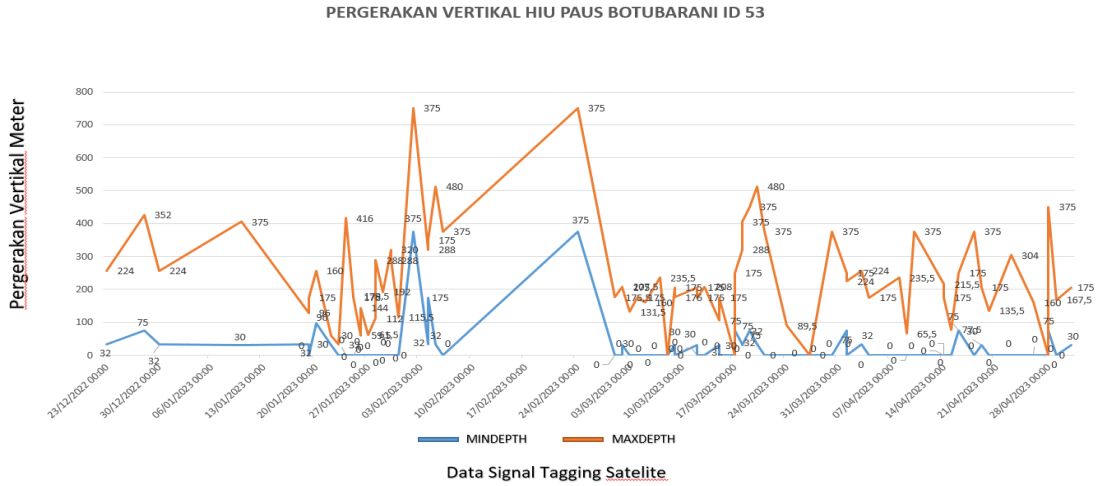

Figure 2. Vertical Movement Graph of Whale Shark ID 53 during the research

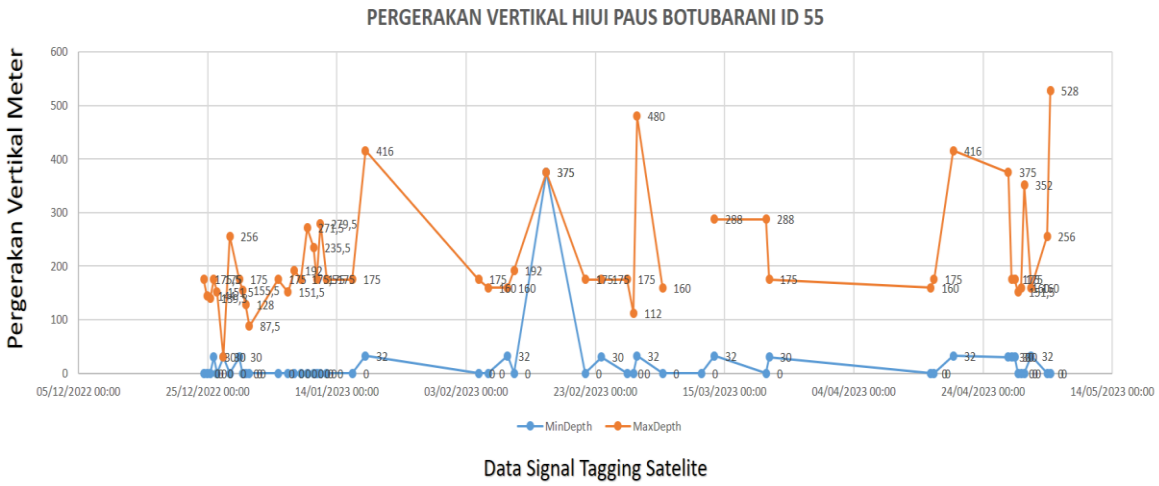

Figure 3. Vertical Movement Graph of Whale Shark ID 55 during the research

Figure 2 shows the results of monitoring the vertical migration pattern of Whale Shark ID 53, showing that its movements were detected predominantly at the surface of the waters with a depth of 030 meters and

International Journal of Biological Engineering and Agriculture
ISSN: 2833-5376
Volume 03 Number 01 (January) 2024
Impact Factor: 9.51
SJIF (2023): 3.916
www.inter-publishing.com

the maximum depth recorded was 480 meters (Figure 2). The presence of the ID 53 Whale Shark at its maximum depth was observed twice, namely on February 5 2023 and March 20 2023. From Figure 2, the vertical movement of the ID 53 Whale Shark is often at a depth of 375 meters with a frequency recorded 10 times at that depth. .

The graphic data on the vertical movement of whale shark ID 53 shows that their activity is mostly on the surface, which is thought to be due to their search for food on the surface of the waters. Figure 2 also shows that the vertical migration pattern of individual ID 53 tends to have the same pattern between minimum depth and maximum depth.

The vertical movement of the Gorontalo Botubarani Whale Shark ID 55 is almost the same as individual ID 53, where it is more dominant at the surface of the water, namely 030 meters, which is also thought to be looking for food. The deepest depth recorded based on satellite tagging results is 528 meters, but the ID 55 whale shark is often also at a depth of 175 meters, which was recorded 10 times in its vertical movement phase during the 5 months since the satellite tagging device was installed. The vertical migration pattern at minimum and maximum depth of individual ID 55 is presented in Figure 3. Figure 3 shows that the vertical migration pattern of individual ID 55 is different from ID 53. This vertical migration pattern may be caused by foraging activities towards the water surface and the availability of food at the migration location. The behavior of stopping for a moment before continuing spatial migration activities cannot be known with certainty.

The results of recording temperature data using data from the ID 53 satellite tagging show that the ID 53 Whale Shark individual has an activity niche at a temperature of 29oC to 30oC, which is the ideal temperature for the whale shark's habitat environment. The lowest temperature fluctuation based on data is 27.5oC and the highest is 31oC. Temporary The results of recording temperature data on ID 55 show that the water temperature conditions for the ID 55 aggregation were recorded as the highest being 32.7oC and the lowest being 27.9oC. The temperature detected is the temperature of the environment according to the movement where the whale shark is, both vertical movement and horizontal movement of the whale shark.

DISCUSSION

The horizontal movement of whale sharks during migration is their attempt to find food (Handoko, 2017). The movement of whale sharks is also influenced by many factors, one of which is the availability of food at a whale shark aggregation location which has been proven through the results of research on seven individual whale sharks who were tagged and released from the Ningallo Reef area into the Indian Ocean, the results of which have shown that the movement of whale sharks following the movement of plankton as animal food carried by surface currents in the Indian Ocean (Sleeman, et al. 2010). Whale sharks have a pelagic habitat, which means that whale sharks prefer to spend time on the surface of the waters, but are often found in open waters to coastal waters, sometimes even entering lagoon areas (Rahman, et al. 2017).

According to Rosalina et al. (2021) that the wandering nature of Whale Sharks while feeding by filtering has caused Whale Sharks to move in and out of Botubarani waters. When there are no tourists or management providing shrimp waste or small fish, the Whale Sharks will move to other places to look for more food. The phenomenon that can be seen is during the nike fish season. Maruanaya, et al. (2022) reported that the number of individuals appearing in Kwatisore waters is closely related to the catch of anchovies by Bagan fishermen.

Migration to the surface is often carried out in order to find food in the form of plankton and small fish as well as crustaceans and squid. According to Rosalina, et al. (2021) that Whale Sharks in Botubarani waters tend to spend their time in shallow waters at a depth of less than 50 meters or close to the surface because

International Journal of Biological Engineering and Agriculture
ISSN: 2833-5376
Volume 03 Number 01 (January) 2024
Impact Factor: 9.51
SJIF (2023): 3.916
www.inter-publishing.com

these fish are plankton-eating fish and are filter feeder animals. The behavior of diving into deep water is thought to be due to following the movement of the food. Maruanaya, et al. (2022) reported that whale sharks are more likely to be on the surface of the waters during the day than at night and the behavior of whale sharks appearing on the surface of the waters is an effort to meet their daily food needs.

Rahman, et al. (2017) reported the results of direct surface temperature measurements at the research location, ranging from 30.3-31.6oC. Rombe, et al. (2022) reported that the results of measuring the average value of water quality parameters for Botubarani water temperature during research were 29°C.

This temperature difference is a factor that influences the vertical movement of whale sharks. If at the surface, the temperature will rise according to surface water conditions, and vice versa if at depth or at night conditions this will of course influence this temperature data. The same condition occurred inin Mozambique waters asbyRohner, et al. (2018).

Satellite tracking has provided new insights into the ecological behavior of various taxa, including whales, where studies like this provide valuable information for fisheries and ecosystem management (Thys, et al. 2015). Whale sharks are solitary animals (like to be alone) and are rarely seen in groups. This type of shark is a slow swimmer, with a speed of no more than 5 km/hour. This fish swims by moving its entire body from side to side (not just relying on its tail, like some other types of shark) (Colman in Graham, 2003).

CONCLUSION

Based on the research results, it can be concluded that Whale Sharks with ID 53 and ID 55 have different spatial and temporal migration patterns to go to and return to Botubarani Beach with the migration location only being in the waters of Tomini Bay (not leaving the bay). The results of this research could be the basis for establishing Tomini Bay as a special whale shark conservation area.

REFERENCE

1. Azourmanian, Z., Holmberg & Norman. 2005. An Astronomical Pattern matching algorithm for Computer aided identification of Whale sharks Rhincodon typus. Journal of Applied Ecology, 42: 999-1011.
2. Best, PB & Mate, B. 2007, Sighting history and observations of southern right whales following satellite tagging off South Africa.
3. Bradshaw, CJA, FitzPatrick, BM, Steinberg, CC, Brook, BW, & Meekan, MB 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(7): 1894-1905.
4. Breed, M & Sanchez, L. 2010. Both Environment and Genetic Makeup Influence *Behaviour*.Available inhttps://www.nature.com/scitable/knowledge/library/both-environment-andgenetic- makeup-influence-behavior-13907840.
5. Brooks, K. Rowat, D., Pierce, S.J., Jouannet, D., & Vely, M. 2010. Seeing Spots: Photo-identification as a Regional Tool for Whale Shark Identification. Western Indian Ocean J. Mar. Sci, 9(2): 185-194.
6. Brunnschweiler, JM, Baensch, H, Pierce, SJ & Sims, DW 2009. Deep-diving Behavior of a Whale shark Rhincodon typus during Long-distance movement in the Western Indian Ocean. Journal of Fish Biology, 74: 706-714.

7. Chaves, LCT, Hall, J., Fetiosa, JLL, & Cote, IM 2015. Photo-identification as a simple tool for studying invasive lionfish Pterois volitans populations. Journal of Fish Biology.
8. Colman, JG 1997. A Review Of The Biology And Ecology Of The Whale Shark. Journal of Fish Biology. 51: 1219–1234.
9. Colman J. 1997. Whale Shark Interaction Management with Particular Reference to Ningaloo Marine Park 1997–2007 Wildlife Management Program No. 27. Department of Conservation and Land Management, Perth.
10. Compagno, LJV 2001. Sharks Of The World: An Annotated And Illustrated Catalog Of Shark Species Known To Date, Vol. 2: Bullhead, Mackerel And Carpet Sharks (Heterodontiformes, Lamniformes And Orectolobiformes). FAO Species Catalog For Fishery Purposes No. 1. Rome.
11. CITES. 2004. Convention on International Trade in Endangered Species of Wild
12. Den Hartog, J. & Reijns, R. 2014. I3S Manual Interactive Individual Identification System, V.4.0.2. Available inhttp://reijns.com/i3s/download/I3S%20Pattern.pdf/
13. Director of Area and Fish Species Conservation. 2015. General Guidelines for Monitoring Whale Sharks in Indonesia. Jakarta: Directorate of Conservation of Areas and Fish Species, Directorate General of Marine, Coastal and Small Islands, Ministry of Maritime Affairs and Fisheries.
14. Dive-bohol. 2015. Why we don't swim with Whale Sharks in Oslob. Available at http://dive-bohol.com/conservation/5-reasons-not-go-oslob/ [21 september 2017].
15. Eckert, SA & BS Stewart. 2001. Telemetry and satellite tracking of a whale shark, Rhincodon typus, in the Sea of Cortez, Mexico and the northern Pacific Ocean. Environmental Biology of Fishes, 60:299–308.
16. Ecocean. 2007. Whale Shark Photo-Identification Library. Field Station Manual Version. 2.0. 11-15 Pg.
17. Fauna and Flora. Available inhttp://www.cites.orgCraven S. 2012. Whale Shark Of Oslob. A Report On The Status Of The Whale Shark Watching Tourist Industry In Tan-Awan, Oslob, Cebu. Philippines: Larga Marine Vertebrate Project.
18. Fowler, SL 2000. Whale Shark (Rhincodon typus)-Policy And Research Scoping Study. UK: Nature Conservation Bureau. www.naturebureau.co.uk/whaleshark/
19. Gayanilo Jr., FC, Sparre, P. & Pauly, D. 2005. FAOICLARM stock assessment tools II (FiSAT II). User's guide. FAO Computerized Information Series (Fisheries), 4(8).
20. Graham, RT 2003. Behavior and Conservation of Whake Shark on the Belize Barrier Reef. Thesis in Environmental Sciences University of York.
21. Gunn, J.S., Stevens, JD., Davis, TLO., & Norman, BM. 1999. Observations on the short-term movements and behavior of whale sharks (Rhincodon typus) at Ningaloo Reef Western Australia. Marine Biology. 135, 553-559.
22. Handoko, et al. 2017.Population characteristics of whale sharks (rhincodon typus) and behavior patterns. They live on Botubarani Beach, Bone Bolango, Gorontalo..Makasar: Makassar Coastal and Marine Resources Management Center.
23. Handoko Kris, Himawan MR, Tania C, Syarifuddin Urif, Jakasukma Munandar, Maduppa H, Subhan B, Hadriana S. 2019. Whale sharks at Botubarani Beach, Gorontalo. Makassar (ID): Coastal and Marine Resources Management Center.

24. Heyman WD, Graham RT, Kjerive B, Johannes RE 2001. Whale Shark (Rhincodon typus) Aggregate to Feed on Fish Spawn in Belize. Marine Ecology Progress Series. 215: 275-282.
25. Hermawan, E. 2010. Grouping Rainfall Patterns that Occur in Several Regions of P. Sumatra Based on the Results of Spectral Engineering Analysis. Center for the Utilization of Atmospheric and Climate Science, Institute of Aeronautics and Space (LAPAN).
26. Himawan, MR, Tania, C., Noor, BA, Wijonarno, A., Subhan, B & Madduppa. 2015. Sex and Size Range Composition of Whale Shark (Rhincodon typus) and Their Sighting Behavior in Relation with Fishermen lift-net within Cenderawasih Bay National Park, Indonesia. AACL Bioflux,(8): 2.
27. Hoffmayer, E.R., Franks, JS., Shelley, J.P. 2005 Recent observations of the whale shark (Rhincodon typus) in the north central Gulf of Mexico. Gulf and Caribbean Research, 17: 117−120.
28. Honasan, AB 2012, March 2014. Please don't feed the big fish. The Philippine Daily Inquirer. Retrieved fromhttp://lifestyle.inquirer.net/40461/pleasedont-feed-the-big-fish
29. Hsu, HH., Joung, SJ., Liao, YY., & Liu, KM. 2007. Satellite tracking of juvenile whale sharks, Rhincodon typus, in the North western Pacific. Fisheries Research, 4: 25−31.
30. Huffard, CL, Erdmann, MV, & Gunawan, TRP 2012. Geographic Priorities for Marine Biodiversity Conservation in Indonesia. Jakarta : USAID project number.www.uscti.org
31. Maruanaya, Y., BA Noor, C. Tania. 2019. Behavior of Whale Sharks (Rhincodon typus) in Kwatisore Waters, Yaur District in the Cenderawasih Bay National Park Area, Papua. TABURA Journal of Fisheries Science, 1(1): 43-53.
32. Maruanaya, Y., ASW Retraubun, SF Tuhumury, J. Abrahamsz. 2022. Feeding Habits and Frequency of Appearance of Whale Sharks (Rhincodon typus) in Kwatisore Waters within the Marine Customary Rights of Akudiomi Village in Cenderawasih Bay National Park. J. Tropical Marine Science and Technology, 14(1): 109-129.
33. McKinney, J., Hoffmayer, E.R., Wu, W., Fulford, R., & Hendon, J.M. 2012. Feeding habitat of the whale shark Rhincodon typus in the Northern Gulf of Mexico Determined using species distribution modeling. Marine Ecology Progress Series, 458: 199–211.
34. Quiros, AL 2007. Tourist Compliance To A Code Of Conduct And The Resulting Effects On Whale Shark (Rhincodon typus) Behavior In Donsol, Philippines. Fisheries Research, 84(1): 102-108.
35. Rahman, A., Haryadi, J., Sentosa, AA, Mujiyanto. 2017.Initial Study of the Appearance of Whale Sharks (Rhyncodon typus, Smith 1828) in Tomini Bay is Linked to Physical and Biological Water Factors.Indonesian Aquatics Journal Vol. 2 No. 2. 128-136.
36. Rosalina, D., Y. Arafat., I. Anjaya, K. Jamil. 2021. Monitoring Whale Sharks (Rhyncodon typus) in Botubarani Waters, Kabila Bone District, Bone Bolango Regency, Gorontalo Province. Aquatic Science. Journal of Aquatic Sciences. 3(2): 9-16.
37. Sharei, FM, Kepel, RC, Olii, AH, Pratasik, SB 2019.What species make up the Nike fish assemblages at the macrotidal estuary in Gorontalo Bay, Indonesia? F1000Reasearch, 8:1654. https://doi.org/10.12688/f1000research.19501.1.
38. Bahani, FM, Hamzah, SN, Tome, AH, Habibie, SA,puluhulawa, MRU, 2024. Sustainability status of amphidromous nike fish, postlarva gobioidei, in estuarine water. Global J Environ. Sci. Manage., 10(2): 1-18. DOI: 10.22035/gjesm.2024.02.***.

39. Thys, T.M., Ryan, J.P., Dewar, H., Perle, C.R., Lyons, K., O'Sullivan, J., Farwell, C., Howard, M.J., Kevin C. Weng, K.C., Lavaniegos, B.E., Gaxiola -Castro, G., Bojorquez, LEM, Elliott L. Hazen, E.L., Steven J. Bograd. SJ, 2015. Ecology of the Ocean Sunfish, Mola mola, in the southern California Current System. Journal of Experimental Marine Biology and Ecology 471: 64–76. http://dx.doi.org/10.1016/j.jembe.2015.05.005.
40. White, WT & Cavanagh, RD 2007. Whale shark Landings in Indonesian artisanal shark and ray Fisheries. Fisheries Research, 84: 128-131.
41. Wilson, SG., Taylor, JG., & Pearce, A.F. 2001. The seasonal aggregation of whale sharks at Ningaloo Reef, Western Australia: currents, migrations and the El Niño/Southern Oscillation. Environmental Biology of Fishes, 61: 1−11.
42. WWF. (2015). World Wide Foundation. Study of Whale Sharks and Management Efforts in Cenderawasih Bay National Park. Internship Activity Report, Version 1.0. Matter. 1.