Fishing season and participatory mapping of the fishing ground of target fish in Depapre Bay, Jayapura Regency, Papua Indonesia

Y P Paulangan¹, K Rumbiak² and B Barapadang²

¹Marine Science, Cenderawasih University, Jayapura, Papua, Indonesia
²Fisheries Science, Cenderawasih University, Jayapura, Papua, Indonesia

E-mail: ypaulkan@gmail.com

Abstract. Fisheries resources, especially small-scale fisheries in the Depapre Bay, Jayapura Regency, which is quite potential, have not been utilized optimally. However, the damage to supporting ecosystems has begun to occur. The aims of this study were to inventory the target fish resources, study the pattern of the fishing season, and determine the fishing ground area in the Depapre Bay in a participatory manner. The method approach used in this study is a semi-structured study to document and evaluate small-scale fisheries management systems in a participatory manner with several data collection techniques, namely with focus group discussions, in-depth interviews, and recording and documentation. There are around 14 target fish families in the Depapre Bay that have been identified, which are grouped into pelagic fish and demersal fish. The pelagic fish group of the Scrombidae family has a fishing season of around May-November, namely in the east to the west season with the fishing ground outside the bay, while the demersal fish group generally has a fishing season of around May-February or occurs from the beginning to the end of the western season with the fishing ground in the bay and around Tanjung Tanah Merah, which is caused by the physiographical and oceanographical factors of the Depapre Bay. Considering the above conditions, it is necessary to pay attention to stakeholders, especially the local government. In addition to the community empowerment to improve technology, the limited reach of fishermen should also be taken into consideration. Conservation zoning should be based on the fishing ground areas by paying attention to the existing the Tiaitiki local wisdom system.

1. Introduction
Depapre Bay is located on the east part of Papua's north coast with an area of about 9541.14 ha [1, 2] overlooking the Pacific Ocean. Viewed from the potential of fisheries resources, the Depapre Bay has relatively large potential, especially small-scale fishery resources. Overall, the total capture fisheries production in Jayapura Regency is 48.47% supported by sea capture fisheries [3]. Ironically, currently the contribution of the fisheries sector, especially small-scale fisheries to the region's original income is still low. The income of fishermen is still low and the ecosystem seems to have been damaged.

The potential of fisheries resources through the management of small-scale fisheries in the Depapre Bay should be managed properly and optimally by taking into account various aspects, including fish resources, technology, economy, environment (habitat), socio-culture and institutions so that they can be used sustainably for the improvement of public welfare. Small-scale fisheries play an important role in human life since they serve as a source of food and employment for coastal communities [4].
the main livelihood and a source of protein for most of the global population [5,6]. On the other hand, small-scale fisheries face the threat of the decrease in catch results but the increase in environmental degradation so that small-scale fisheries management requires efforts to increase management capacity which are integrated to lead to sustainability [5,7].

The aims of this study are to inventory the target fish, study the fishing season pattern, and map the fishing ground areas. The inventory of fish resources is very important. Without resources (fish), fishery activities would not exist. Likewise, resources without utilization, fisheries activities also do not exist. Fishing is seasonal or highly dependent on the season. Often, the fish season is based on the wind season. Determination of the characteristics of the fishing season pattern needs to be done as an alternative in preserving fish resources [8]. The determination of the fishing ground area is very important and needs to be known by every fisherman in order to get the fish as desired. The existence of a fishing ground area greatly determines the accessibility of fishermen, reducing high operational costs. In addition, the fishing ground areas also need to be known in terms of allocation and zoning for conservation purposes.

2. Research methods

2.1. Type and source of data

There are two types of data in this study--primary data and secondary data. The primary data were obtained by conducting depth interviews and focus group discussions (FGD) of key respondents and fishing groups. The secondary data were obtained through literature studies from journals and reports relevant to the study.

2.2. Data collecting techniques

The data were collected in three approaches:

2.2.1. Focus group discussion (FGD). The FGD process is intended to gather information, build consensus, clarify existing information and gather various opinions. The FGD was conducted by gathering selected fishermen to discuss issues related to the research objectives.

2.2.2. In-depth interview. The aim is to get a more in-depth overview of what is happening on the ground. This method is done by visiting and interviewing key fishermen (respondents) directly in the field.

2.2.3. Recording and documentation. Every finding in the form of qualitative data and quantitative data is recorded as material in the data analysis. Documentation is carried out to complement the data and information obtained from the field.

2.3. Data analysis

2.3.1. Inventory. The respondents were asked to name the fish that are often and become the catch target. The fish caught by fishermen will be recorded and tabulated in a datasheet using Microsoft Excel.

2.3.2. Catching season. The respondents were asked to mention fish season based on their experience according to the month, the season which is usually based on wind season. When the respondents’ answers are considered valid, the next thing to do is to make a checklist on the datasheet format that has been prepared which contains a list of the target fish’s name, month and season.

2.3.3. Fishing ground. In determining the location of fishing ground, the respondents are asked to show the catching locations of each target fish species on a map that has been prepared previously and to describe the conditions of the locations, including mileage, fuel use and time of capture. The determination of the fishing ground area is analyzed and discussed using descriptive methods [9].
Making maps of fishing area distribution is carried out in a participatory manner and analyzed qualitatively [10] and visualized through a geographic information system [11], using the ArcMap 10.4.1 application.

3. Results and discussion
The fishermen in Depapre Bay are still categorized as subsistence fishermen with fairly simple fishing gear such as fishing rods, spears, arrows and some have used nets [2]. As fishermen, their income depends on the number of fish they catch that is greatly influenced by the conditions at sea. If the number is higher, their income will be higher. But ironically, when the number of catches is high (fish season), the price in the market goes down. The number of fish caught depends on the season (Table 1), for example, in the calm-sea season when the number of fish catches is higher chance than the wave season. The people in Depapre Bay are also familiar with the catching of fish using anchored FADs, the people call it sero apung and rumpo berlabuh, while new aquaculture activities are being introduced such as floating net cages in Tablanusu Kampong and anchored fish cages in Kendate village and even the installation of FADs has been initiated by the Maritime Agency and Jayapura Regency Fisheries and Papua Province Maritime and Fisheries Agency.

3.1. Fish resources.
Generally, the families of the target fish species caught by fishermen in the Depapre Bay include the families of Scrombidae, Carangidae, Engraulidae, Lethrinidae, Belonidae, Labridae, Caesionidae, Serranidae, Clupeidae, Acanthuridae, Hemiramphidae, Mullidae, Siganidae, Trichiuridae, and Dasyatidae. Carangidae family is a type of pelagic fish group, clustered and lives in high-salinity waters that have important economic value. The fish from this family are very popular with the community, especially from the type of Carangoides (giant trevally). These fish are caught by fishermen around the Depapre Bay using fishing rods, gill nets, traps and charts. Giant travel fish spawn throughout the year and usually follow the moon phase. The spawning takes place at night along with the arrival of the tide, and planktonic eggs can be under the current and hatch in the seagrass fields or mangrove roots crevices before finally returning to the open sea [12]. Yellow stripe scad (Selar sp) is one of the smallest species of pelagic fish caught compared to other types of Depapre Bay fish. Yellow stripe scad (Selar sp) are caught using nets and floating sero. One indicator of the presence of grouper from the family Serranidae is the presence of coral. The nature of the grouper, which is nocturnal or actively foraging at night, keeps the fish quiet and less active during the day. Usually, they hide in burrows and rock bottoms. The area of grouper fish distribution is quite extensive, but of course, there are areas that are specific enough for its distribution. Grouper or geropa fish are often found in Depapre Bay which are more commonly found in reef crest areas [13]. One of the economic fish of the Belonidae family in the Depapre Bay is needlefish (Thylosorus sp) which lives near the surface, is not clustered and difficult to catch in large numbers because of their very nimble movements and it is usually caught using surface gill nets, drift gills and drift nets trolling rod.

The main food for cendro (needlefish) is smaller fish, which are caught by ambushing to the side of the head [14]. The Lethrinidae family is dominated by snapper. Red snapper (Lutjanus sp) is a type of demersal fish from the Lutjanidae family of high economic value. Red snapper is one of the export commodities from the fisheries subsector whose demand continues to increase [15]. The fishing gear used for red snapper generally are longline fishing line, stretching line, gill net or gill net, and bubu. Scrombidae family generally includes mackerel fish, narrow-barred spanish mackerel, skipjack and bluefine tuna. Mackerel are commonly caught using charts and nets, while narrow-barred spanish mackerel, skipjack and bluefine tuna are caught using fishing rods. Napoleon fish (Napoleon wrasse) from the Labridae (Wrassess) family are protected fish, but they are often still the target of catch.

Napoleon fish are caught using arrows called jubi by local people. Siganidae family, especially rabbit fish (Siganid sp), is one of the target fish, but it also includes temporally protected fish with the Taititiki system in the Depapre Bay. Rabbit fish are usually caught using spears when the water recedes in the seagrass area. Sardines fish are one of the Clupeidae families that are targeted by fishermen in
the Depapre Bay. Sardines fish are usually caught using a lift net. Jumping halfbeak (Hemiramphus sp) fish from the Hemiramphidae family are often caught using nets. Jackfruit seeds / Goldband goatfish (Upeneus moluccensis) from the Mullidae family are caught using fishing rods and arrows / spearguns. Yellow-tailed fish (Caesio cuning) from the Caesionidae family, including target fish in the Depapre Bay. Yellow tail fish live in schooling and are caught using nets. Yellow tail fish are economically important fish because they have a savory taste that is very popular with the market. Anchovy (Stelophorus sp) from the Engraulidae family is an important economical fish in the Depapre Bay. In addition to being sold for consumption, anchovies are also used as bait for other target fish, especially for large pelagic fish, including narrow-barred spanish mackerel, skipjack and bluefin tuna. Anchovies are usually caught using floating sero (lift net). Largehead hairtail fish (Trichiurus lepturus) from the Trichiuridae family are caught using drift nets or using handline. Largehead hairtail fish are easily known for their long and slender body shape, very popular in Asian countries because the meat is chewy and not too fishy, not greasy and their bones have been removed [16]. Stingrays (Dasyatis sp) from the family Dasyatidae are one of the fish that are relatively not the main target, but sometimes they become by-catch. Stingrays are usually caught using spears and nets.

3.1.2. Catching season.
In general, wind patterns in the Depapre Bay and its surrounding areas can be divided into 4 patterns based on the existing seasons [2], namely the west season (December, January, February), the transitional season I (March, April, May), the east season (June, July, August) and the transitional season II (September, October, November). Depapre Bay is a fishing ground area of various fisheries resources that are targeted by the surrounding communities. This can be seen by finding small pelagic fish resources such as anchovy (Stolephorus sp), flying fish (Decapterus sp), mackerel (Restrelinger sp), and yellostripe scad (Selar sp) and large pelagic fish such as bluefin tuna (Thunnus sp), skipjack (Katsuwonus pelamis), narrow-barred spanish mackerel (Scomberomorus sp). As presented in Table 1, small pelagic fishes are found in large populations from May to September or in the calm season.

| Season and fishing season conditions | Target Fish species | Famili |
|--------------------------------------|---------------------|--------|
| Wave season                          | Transition I        | Transition II |
| Shady season                         | East season         | West season |
| Mar Apr May Jun Jul Aug Sep          | Oct Nov Dec Jan Feb | |
| Mackrel (Restrelinger sp)            | Scombridae          | ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ |
| Narrow-barred spanish mackerel (Scomberomorus sp) | Scombridae | ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ |
| Skipjack (Katsuwonus pelamis)       | Scombridae          | ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ |
| Bluefin tuna (Thunnus sp)            | Scombridae          | ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ |
| Giant trevally (Carangoides)         | Carangidae          | ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ |
| Flying fish (Decapterus sp)          | Carangidae          | ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ |
| Yellowstripe scad (Selar sp)         | Carangidae          | ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ |
| Andarvish (Stelophorus sp)           | Engraulidae         | ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ |
| Needlefish (Dlysomorus sp)           | Belonidae           | ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ |
| Red snapper (Lutjanus allisaudor)   | Lethiniidae         | ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ |
| Barramundi (Lates calcarifer)        | Lethiniidae         | ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ |
| Yellowtail snapper (O chirurus Chrysurus) | Lethiniidae | ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ |
| Groupper fish (Epinephelus sp)       | Semanidae           | ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ |
| Napoleon (Chelonus undulatus)        | Labridae            | ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ |
| Yellow-tailed fish (Caranx cuning)   | Carangidae          | ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ |
| Sardines (Sardinella sp)             | Clupeidae           | ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ |
| Jumping halfbeak (Hemiramphus sp)    | Hemiramphidae       | ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ |
| Goldband goatfish (Upeneus moluccensis) | Mullidae           | ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ |
| Rabbit fish (Siganus sp)             | Siganidae           | ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ |
| Largehead hairtail (Trichiurus lepturus) | Trichiuridae | ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ |

Source: Data processed, 2020
Large pelagic fish season starts around May until November or in the east season until the beginning of the west season. Meanwhile, demersal fish such as red snapper (*Lutjanus altilfrantalis*), baramundi (*Lates calcarifer*), yellowtail snapper (*Ocyurus chrysurus*), grouper fish (*Epinephelus* sp) are caught around September to March or in the western season, where ocean waters are wavy. Although yellow-tailed fish (*Caesio cuning*), sardines (*Sardinella* sp) and halfback jumping (*Hemiramphus* sp) and largehead hairtail (*Trichiurus lepturus*) can be caught most of the year, they have a season around the end of the I transition season to the east (May-October). Stingray (*Dasyatis* sp), goldband goatfish (*Upeneus moluccensis*) and rabbit fish (*Siganus* sp) are mostly caught in the transitional season II and the western season which is around September to January. Needlefish (*Thylosorus* sp) are from the beginning of the west season until the beginning of the transition season I.

### 3.1.3. Fishing ground.

Physiographically, the waters of the Depapre Bay are open to the influence of winds, especially northwestern to north winds and are relatively protected in the east monsoon causing high sea waves and impacting geomorphological processes along the coast, especially in the outer part of the bay. While inside of the bay, the waters are relatively calm, serving for spawning ground, nursery ground and feeding ground areas that are good for fisheries resources, especially pelagic and demersal fish and other economic biota. The physiographic condition divides the two fishing seasons in general, namely the wave season and calm season. The wave season occurs when the west season occurs, where the waters become wavy making activities difficult. Conversely, in the east season, the waters become calm and not wavy so that fishing activities can be carried out both inside the bay and outside the bay. Large pelagic fishing is generally carried out outside the bay where it is strongly influenced by conditions at sea, while the fishing of small pelagic and demersal fish is generally carried out inside the bay so that it is still relatively comparable. Ironically, fish catching, especially small pelagic fish in the bay, still often uses explosives (fish bombs), so that not only damage the existing fishery resources but also endanger the user. Several locations of coral reefs are damaged due to the destructive fishing [1].

On the one hand, Tiaitiki local wisdom is still applied from generation to generation, namely the protection of coastal and marine resources by opening and closing certain areas at certain times [2,17,18,19]. Local people in Depapre Bay have traditionally owned traditional catchment areas (Figure 1), and to this day it still applies so that each village has its own fishing ground. The fishing ground area based on the target fish family is in general presented in Figure 2. In addition, the local government through the Jayapura Regency Maritime Affairs and Fisheries Office and the Provincial Maritime Affairs and Fisheries Office assisted the community through the installation of FADs in 2015, so that at present the community from each village through a group of fishermen formed has a fishing area based on the FAD installed.
Figure 1. Map of Traditional Fishing Ground

Figure 2. Map of target fishing areas
4. Conclusion and recommendations

There are around 14 target fish families in the Depapre Bay that have been identified, which are grouped into pelagic fish and demersal fish. Pelagic fish groups of the Scrombidae family, especially mackerel, narrow-barred spanish mackerel, bluefin tuna and skipjack, have a fishing season around the month of May-November, ie in the east to the west season while demersal fish groups, especially red snapper (Lutjanus alifrontalis), barramundi (Lates calcarifer), yellowtail snapper (Ocyurus chrysurus), grouper fish (Epinephelus sp.), goldband goatfish (Upeneus moluccensis), rabbit fish (Siganus sp.) and stingray (Dasyatis sp.), have seasons around May-February or occur early to the end of the western season. The fishing ground area of the scrombidae family, primarily narrow-barred spanish mackerel, bluefin tuna and skipjack, is outside the bay, which is towards the Pacific Ocean, except mackerel (Restrelinger sp.), which is located inside the bay. Meanwhile demersal fish, reef fish and other small pelagic fish are in the bay and around the Tanjung Tanah Merah area, which is caused by oceanographic factors. Considering the above conditions, it is necessary to pay attention to stakeholders, especially the local government. In addition to the community empowerment to improve technology, the limited reach of fishermen should also be taken into consideration. Conservation zoning should be based on fishing ground areas by paying attention to the existing Tiatiiki local wisdom system.

References

[1] Paulangan Y P, Fahrudin A, Sutrisno D, Bengen D G 2019 Distribution and condition of coral reef ecosystem in Tanah Merah Bay, Jayapura, Papua, Indonesia. AACL Bioflux. 12(2): 502-512.
[2] Paulangan Y P 2019 Pengembangan dan Pengelolaan Kawasan Terumbu Karang Berbasis Tiatiiki di Teluk Depapre Jayapura. [Disertasi]. Sekolah Pascasarjana IPB. Bogor.
[3] Badan Pusat Statistik Kabupaten Jayapura 2016 Produk Domestik Regional Bruto Kabupaten Jayapura.
[4] Alfaro-Shigueto J, Mangel J C, Pajuelo M, Dutton P H, Seminoff J A, Godley B J 2010 Where Small Can Have a Large Impact: Structure and Characterization of Small-Scale fisheries in Peru. Fisheries Research. 106: 8-17.
[5] Hauzer M, Dearden P, Murray G 2013 The Effectiveness of Community-Based Governance of Small-Scale Fisheries, Ngazidja Island, Comoros. Marine Policy. 38: 346 – 354.
[6] FAO 2014 Petunjuk Sukarela untuk Menjamin Perikanan Skala kecil yang Berkelanjutan dalam Konteks Ketahanan Pangan dan Pengentasan Kemiskinan. Diterjemahkan oleh Tim Penterjemah Ditjen Perikanan Tangkap T.A. 2014. Direktorat Jenderal Perikanan Tangkap.
[7] Pomeroy R S 2012 Managing Overcapacity in Small-Scale fisheries in Southeast Asia. Marine Policy. 36: 520-527.
[8] Situmorang D M, Agustriani F, Fauziyah 2018 Determination Analysis Mackerel (Scomberomorus Sp.) Fishing Season Landed in Sungailiat Fishing Port, Bangka. Maspardi Journal. 10(1):81-88.
[9] Matakupan H, Hiariey J, Tupamahu A, Baskoro M S 2018 Dinamika Daerah Penangkapan Ikan Pelagis di Kota Ambon. Jurnal Akuatika Indonesia. 3(2):136-143.
[10] Selvika Z, Mustaruddin, Yusfiandayani R 2018 Determination Fishing Ground and Superior Fishing Gear for Pelagic Fish in Bengkulu City. Jurnal Teknologi Perikanan dan Kelautan 9(2):137-147.
[11] Ihsan, Wiyono E S, Wisudo S H, Haluan J 2014 Season and Patterns of Catching Swimming Crab (Portunus pelagicus) in Pangkiep Waters Regency. Marine Fisheries. 5(2):193-200.
[12] Nontji A 1992 Laut Nusantara. Penerbit Djambatan Jakarta. Jakarta.
[13] Paulangan Y P, Fahrudin A, Sutrisno D, Bengen D G 2019 Diversity and similarity of reef profile form based on reef fishes and reef lifeform in Depapre Bay, Jayapura, Papua Province, Indonesia. Jurnal Ilmu dan Teknologi Kelautan Tropis. 11(2): 249-262.
[14] Luasunaung A and Reppie E 2016 The Study of Artificial Bait on the Catch of Kite Fishing in Bangka Strait, North Sulawesi. Marine Fisheries. 7(2): 117-123.
[15] Wahyuningsih, Prihatiningsih, Ernawati T 2013 Population Parameters of Red Snapper *Lutjanus malabaricus* in Eastern Java Sea. *BAWAL*. 5(3): 175-179.

[16] Rahaningmas J M, Puspito G, Diniah, Wahju R I 2014 Hairtails fishing (*Trichiurus* sp.) Effectiveness using artificial bait. *Jurnal Teknologi Perikanan dan Kelautan*. 5(1): 33-40.

[17] Paulangan Y P, Fahrudin A, Sutrisno D, Bengen D G, Al-Amin M A, Taryono, Wahyudin Y 2019 Socio-economic and institutional sustainability management of coral reef ecosystem based on local communities in Teluk Tanah Merah (Depapre), Jayapura, Indonesia. *IOP Conf. Series: Earth and Environmental Science* 241 (2019) 012034.

[18] Yarisetou W 2009 *Tiaitiki*: Konsep dan Praktek. Jayapura (ID): Penerbit ARIKA Publiser.

[19] Paulangan Y P, Al Amin M A, Wahyudin Y, Taryono. 2018. *Tiaitiki*: Pengetahuan Lokal dan Lembaga Lokal untuk Mendukung Konservasi Laut di Teluk Depapre Provinsi Papua, Indonesia. In: Adrianto, L., Irianto, O., Wardiatno, Y., Fahrudin, A. Taryono., Krisanti, M., Hariyadi, S., Mashar, A. (eds.), Bentang Laut Lesser Sunda dan Bismärck Solomon. IPB Press, Bogor, pp 37-59.

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