Inventory of the tropical coral reef fishes in Wondama Bay regency, West Papua, Indonesia

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Abstract. Teluk Wondama Regency is one of the areas in West Papua that is part of the Cendrawasih Bay National Park due to its potential of coral fishes. Until now, there is no thorough information that gives the potential diversities of coral fishes species can be found in the waters, and one of the attempts to find out is to carry out an inventory. Inventories were conducted from March to May 2016 in Rariei and Auri (Roon District), Numamuran (Duairi District), Nusrowi (Rumberpon District) and Waprak (Roswar District). The results of these inventories found 28 species of coral fishes in Rariei consisting of 8 genus (\textit{Balistapus, Synodus, Pentapodus, Thalassoma, Zebrasoma, Amblyglyphidodon, Chaetodon and Labroides}) in Rariei, 11 genus (\textit{Abudefduf, Chaetodon, Amphiprion, Cheilinus, Dascyllus, Chromis, Parastromateus, Priacanthus, Epinephelus, Nemipterus and Lutjanus}) in Numamuran, 11 genus in Nusrowi (\textit{Halichoeres, Pomacentrus, Dischistodus, Heniochus, Amblyglyphidodon, Arothron, Parupeneus, Lutjanus, Plectropomus, Epinephelus and Acanthurus}), 4 genus in the waters of Waprak (\textit{Parupeneus, Pomacentrus, Chaetodon and Amblyglyphidodon}) and 10 genus in Auri (\textit{Lutjanus, Pomacentrus, Amphiprion, Chaetodon, Chromis, Dascyllus, Zanclus, Halichoeres, Siganus and Amblyglyphidodon}).

1. Introduction
Most of the regions in Indonesia are an ocean which has potential of marine resources with the diversity of biological and other resources that need to be developed. The coastal area, which is a transitional region for terrestrial and marine ecosystem, has enormous potential for natural resources, especially in the three main ecosystems which are the mangrove ecosystem, coral reef, and seagrass. Those three ecosystems have a mutual supportive role for the entirety of each ecosystem [1]. According to Rani \textit{et al.} [2] stated that reef fish is one of animals which are associated with coral reef; the existence is striking and can be found in coral reef environment.

One of the regions that hold the potential of reef fish is Teluk Wondama which is a part of the Cendrawasih Bay National Park (TNTC). According to Marasabessy [3], reef fish can be consumed by the society. The fish can also be used as ornamental fishes that are traded in and outside the country [4]. Similarity, in Teluk Wondama in Rariei waters, Numamuran waters, Nusrowi waters, and Waprak waters, the majority of the fish is consumed. The location of Auri waters is far from the society, therefore, there is only a little intervention from human activities.
Currently, there is no scientific information that can show the potential diversity of reef fish species in the marine waters, at Teluk Wondama regency. One of the efforts to find out about the potential of reef fish in those areas by conducting an inventory of reef fish species, thus it can be developed further as a source of optimal and sustainable fisheries and tourism.

2. Experimental
2.1. Place and date of the research
The research was conducted in Teluk Wondama regency, in the state expedition activity of the Negara Kesatuan Republik Indonesia (NKRI) Koridor Papua Barat 2016 which was held by Komando Pasukan Khusus (Kopassus), TNI, and Coordinating Ministry of Human Development and Culture in March - May 2016.

2.2. Tools and materials
The tools that used in the research were snorkeling equipment, underwater camera, Global Positioning System (GPS), buoy and stationery. The objects of the research were various types of reef fish found in the marine waters of Teluk Wondama.

2.3. Procedures of the research
2.3.1. Preparation stage
This stage included getting the license to conduct the research from the this stage under permitted Marine Affairs and Fisheries office at Teluk Wondama as well as collecting information and secondary data about the general condition of research location at Maritime and Fisheries Department of Teluk Wondama regency and World Wildlife Fund (WWF) of Teluk Wondama regency.

2.3.2. Location and sample
The location of the data collection was in the marine waters of Teluk Wondama regency. To determine the research location, this research used purposive sampling method, which was by observing and considering the conditions of the location of the research [5]. The data collection was adjusted to the travel time and route of the survey vessel. There were five stations selected as the locations of the research. Location of station I was in the marine waters, south of Rariei Island, at Roon district, with the sample coordinate point of S: 02°21'07.5" E: 134°30'55.2". Station II was in the marine waters, south of Numamuran Island, Teluk Duairi district, with the sample coordinate point of S: 01°48’50.3’’ E: 134°08’33.6’’. The location of station III was in the marine waters, south of Nusrowi Island, Rumberpon district, with the sample coordinate point of S: 01°48’50.3’’ E: 134°08’33.6’’. Location of station IV was in marine waters, west of Kampung Waprák Coast, Roswar district, with the sample coordinate point of S: 02°06’25.9”E: 134°19’50.1”. Location of station V was in the marine waters, south of Auri Island, Roon district with the sample coordinate point of S: 02°00’23.4” E: 134°41’50.1”. All these information can be seen in Figure 1.
2.3.3. Data collection

The data collection used fish stationary plot survey as the method of the research. According to Hill and Wilkinson [6] stated that this method is used to estimate the various types of fish. The basic of this method is using an imaginary tube by visually observing and listing all types of fish in the tube. In determining the diameter of the imaginary tube, this research used the length of the vessel. The measured diameter of the tube was ± 8 m following the length of the vessel. The depth itself is limited from the sea level to the bottom of the sea. The area inside the imaginary tube is the area to collect the data of reef fish. The water quality data is obtained from secondary data available at the Office of Marine and Fisheries of Teluk Wondama regency and WWF regency of Teluk Wondama including temperature, pH, salinity, Dissolved Oxygen (DO) and sea current.

2.3.4. Implementation of the research

The research was done by snorkeling in imaginary tube around the vessel and observing the reef fish visually without touching it. During the observation, the collection of types of fish was done by taking several pictures at 1-4 m depth. [7] stated that various species can be found in more than one pictures. Those were necessary to show the difference in colors, markings, and physical features of the same species. This information is also very important when the pictures of the fish obtained have not been identified. The pictures of reef fish that have been obtained then grouped by the types based on their morphological characteristics. Reef fish is identified by referring to books of Reef Fish Identification Tropical Pacific [7], Tropical Reef-Fishes of the Pacific Indonesia and Adjacent Waters [8], Fishes of the World Fourth Edition [9] and Field Guide to Saltwater Fish [10].

3. Results and Discussion

3.1. Results

3.1.1. The Types of Fish

The reef fish obtained during the research in each station were identified based on their colors, shapes and spots on the body by referring to the reef fish identification books (up to genus or species). Various types of reef fish that have been identified can be seen in Figure 2. The results of the types of reef fish found in five stations are shown in Table 1.
Figure 2. The Identified types of reef fish
Description: (a) *Synodus* sp., (b) *Labroides dimidiatus*, (c) *Amphiprion clarkii*, (d) *Chaetodon punctatofasciatus*, (e) *Lutjanus semicinctus*, (f) *Pomacentrus simsiang*, (g) *Heniochus chrysostomus*, (h) *Chaetodon octofasciatus*, (i) *Dascyllus melanurus*, (j) *Zanclus cornutus*, (k) *Arothron nigropunctatus*, (l) *Amblyglyphidodon curacao*, (m) *Lutjanus vita*, (n) *Siganus vulpinis* and (o) *Halicoretes leucurus*.

3.1.2. The measurement of the Water Quality
The water quality data was obtained from secondary data available at the Office of Marine and Fisheries at Teluk Wondama regency and World Wide Fund (WWF) of Teluk Wondama regency. The data of marine waters parameter of Teluk Wondama Regency in each research station are shown in table 2.

Table 1. Genus and Species of reef fishes found in each station.

| Waters of Rariei Island | Waters of the Numamuran Island | Waters of the Nusrowi Island | Waters of Kampung Waprak | Waters of Auri Island |
|-------------------------|--------------------------------|------------------------------|--------------------------|-----------------------|
| Genus / Species | Genus / Species | Genus / Species | Genus / Species | Genus / Species |
| Balistapus | *Abudefuluf* | *Halichoeres* | *Parupeneus* | *Lutjanus* |
| B.undulatus | *A. vaigiensis* | *H. leucurus* | *P. multifasciatus* | *L. kasmira* |
| 1 | 1 | 1 | 1 | 1 |
| *Synodus* | *Chaetodon* | *Pomacentrus* | *Pomacentrus* | *Pomacentrus* |
| 1 | 3 | 1 | 1 | 1 |
| Synodus sp. | C. baronessa | P. simsiang | P. octofasciatus | P. trifasciatus | A. clarkii | D. perspicillatus | C. octofasciatus | A. ocellaris |
|-------------|--------------|-------------|-----------------|---------------|-----------|-----------------|-----------------|-------------|
| C. falcata   |              |             |                 |               |           |                 |                 |             |
| C. punctatofasciatus | | | | | | | | |
| Pentapodus | Amphiprion | Dischistodus | Chaetodon | Amphiprion | A. clarkii | H. chrysostomus | A. curacao | C. lineoatus |
| P. trivittatus |              |             |                 |               |           |                 |                 |             |
| Thalassoma | Cheilinus | Heniochus | Amblyglyphidodon | Chaetodon | 1         | 1               | 1               |               |
| T. lunare | C. fasciatus | H. chrysostomus | A. curacao | C. lineoatus | 1         | 1               | 1               |               |
| Zebrasoma | Dascyllus | Amblylyphidodon | Chromis | 1        | 1         | 1               | 1               |               |
| Z. scopas | A. curacao | C. viridis | 1 |           | 1         | 1               | 1               |               |
| Amblylyphidodon | Chromis | Arothron | Dascyllus | 1 |           | 1               | 1               |               |
| A. curacao | C. xanthara | A. nigropunctatus | D. fasciatus | 1 |           | 1               | 1               |               |
| C. viridis | 1 | 2 | 1 | Zanclus | 1 | 1               | 1               |               |
| Chaetodon | Parastromateus | Parupeneus | Z. cornatus | 1 | 1 | 1               | 1               |               |
| C. baronessa | Parastromateussp. | P. bifasciatus | 1 | 1 | 1 | 1               | 1               |               |
| Labroides | Priacanthus | Lutjanus | Halichoeres | 1 |           | 1               | 1               |               |
| L. dimidiatus | Priacanthus sp. | L. Vita | H. leucurus | 1 |           | 1               | 1               |               |
| 1 | Epinephelus | Plectropomus | Siganus | 1 |           | 1               | 1               |               |
| E. areolatus | P. oligacanthus | S. vulpinis | P. leopardus | 1 | 2 | 1               | 1               |               |
| Nemipterus | Epinephelus | Amblylyphidodon | A. curacao | 1 |           | 1               | 1               |               |
| Nemipterusussp. | Epinephelussp. | 1 | 1 | A. curacao | 1 | 1               | 1               |               |
| Lutjanus | Acanthurus | A. xanopterus | 1 |           | 1               | 1               |               |               |
| L. semicinctus | A. xanopterus | | 1 | 1 |               |               |               |               |
| Total | 8 | 14 | 12 | 4 | 10 |               |               |               |
Table 2. Waters Quality.

| Parameter                        | Waters of Rariei Island | Waters of the Numamuran Island | Waters of the Nusrowi Island | Waters of Kampung Waprapk | Waters of Auri Island |
|----------------------------------|-------------------------|-------------------------------|------------------------------|---------------------------|-----------------------|
| Temperature (°C)                 | 29.5                    | 29.5                          | 29                           | 28.5                      | 29                    |
| pH                               | 7                       | 7                             | 6.5                          | 7                         | 7                     |
| Salinity (ppm)                   | 29                      | 31                            | 31                           | 31                        | 31                    |
| DO (ppm)                         | 7.1                     | 8.1                           | 8.5                          | 8.5                       | 9                     |
| Current sea (m/det) and current direction (°) | 0.08                    | 0.08                          | 0.06                         | 0.06                      | 0.09                  |
|                                  | (155°)                  | (163°)                        | (295°)                       | (170°)                    | (125°)                |

3.2. Discussion

The location of the research was divided into five stations. Those stations were in the shallow coral reef area because it had 1-4 m depth. According to Kartikasari et al. [11], shallow coral reef area with 0-4 m depth and characterized by small wave movements is an area that protects and produces high abundance of fish and coral species due to optimal light penetration for coral growth. The fish in the research location had different body shapes and colors. There were various characteristics of fish in each of the five stations, such as bright pattern of body color. According to Connaughey BH and Zottoli R [12], reef fish has a bright color because it adapts to coral reef used as disguises to predator and the color pattern is a form of morphology adaptation to trick its predators (camouflage).

Station I (waters of Rariei Island) has similarity with station II (waters of Numamuran Island). Those areas are strain and closed waters. The closed waters area is an area where the water conditions are not easily affected by the open waters [13]. Both of the waters were directly protected from environmental factors due to the presence of the land. These conditions caused the environment of both areas not to have direct influence from the open sea. Thus, the sea currents those area was quite calm with the speed of 0.08 m/s. According to Nontji [14] stated that current is a flowing motion of water mass with the direction and current strength in the surface layer is greatly determined by wind or caused by long wavy motion. Rariei and Numamuran waters have similar temperature equation of 29.5 °C and a water pH of 7. Those values are the normal limit for reef fish life. According to Pandiangan [15] all types of fish have a low tolerance toward temperature changes. A good temperature range for fish life is between 25-32 °C. According to Souhoka and Patty [16] also stated that the degree of acidity (pH) in marine waters ranged from 6.91-8.18 and this variation of value is still safe for marine life.

Salinity in Rariei waters was 29 ppm and in Numamuran waters it was 31 ppm. However, those values were still tolerable for marine life such as reef fish. According to Nontji in [16] marine organisms have 27-40ppm of salinity tolerance. The lower salinity of Rairei waters is possibly caused by the entry of freshwater that came from the river on the island and Ron Island which was facing with the sample location. Those similar with Wahyuni [17] which stated that naturally high or low salinity is influenced by various factors such as turbulence mixing, evaporation, or the presence of river flow.
The dissolved oxygen (DO) in Rariei waters was 7.1 ppm and in Numamuran waters it was 8.1 ppm. These DO values could still support reef fish life. According to Nontji [16] stated that dissolved oxygen above 5 ppm is fairly supportive for reef fish life. The DO value in Rariei waters was lower because of household wastewater coming from residents across the location (Roon Island). That household wastewater is a cause of reduced oxygen-producing organisms. According to Salmin [18], the primary source of oxygen in waters comes from a diffusion process of free air and photosynthetic products of organisms living in the marine waters. According to Simanjuntak [19] also stated that one of the factors causing the decrease of dissolved oxygen level is usually the change of water quality mixes with waste containing organic carbon from the land and the waters.

Even though both waters have similar waters condition and geographical area however, they have different types of fish. The genus of Epinephelus and Lutjanus could not be found in Rariei waters because of the intensive fishing activity of those genus. Rariei Island is a sandy coast characterized by sand and rocks that spread out on the coast. Different conditions are shown on the coast of Numamuran Island where mangrove forests are the source of food and shelter. Therefore, the types of fish in the waters of Numamuran Island are more various compared to the Rariei waters. According to [20], mangrove water is an ideal place for any types of fish as their habitation place, food source, and juvenile growth. Related with food, mangrove forest provides organic food for fish which is formed from fallen leaves and various types of invertebrate animals, such as crabs and insects. The mangrove forest is also a place for spawning, permanent habitat, and breeding ground for the fish. Therefore, mangrove forest plays an important role as it provides habitation and protects the fish from predators.

Nusrowi Island is sandy type of beach which is characterized by sand coast and it has no mangrove and its common vegetation are coconut and ketapang. According to Effendi [21] stated that non mangrove vegetation found in coastal area with sand-dominated substrate are for example ketapang, pine, and coconut. Nusrowi waters has clean coral reefs and waters condition due to the location that is far from the society. According to Burke et al. [22] stated that the condition of coral reef is strongly influenced by human activities. Excessive human activity can threaten the condition of coral reefs and marine life.

The location of the research is in the south of the island and open sea is influenced from the north of Teluk Cendrawasih. These conditions cause the location of the research not to be affected by the current of the open sea. Thus, it has low sea currents of 0.06 m/s. According to Ruswahyuni [23], the strength of currents and waves in closed waters will decrease when it reaches to the land because the waters are blocked by the mainland or island in front of it. Water temperature in Nusrowi waters was 29 °C. This temperature is generally the average water temperature in the marine waters. According to Nybakken [24], the normal temperature value on sea surface is ranged from 20-30 °C. The pH of the water was 7 that was normal and suitable for the life of sea organism. According to Hutchinson [25] stated that good pH in the waters is 7. The value of DO of 8.5 ppm is considered good for fish life. According to Assyakur dan Wiyanto [26] the higher amount of DO (dissolved oxygen) the better the water quality.

Nusrowi Island has good environmental condition which can potentially become a location for fish cultivation with floating net cage system of Keramba Jaring Apung Unit Penampungan Ikan Hidup (KJA UPH), especially for grouper fish and lobster. KJA activity can contribute to high number of species of fish in the waters due to the remains of the feed given to the cultivation and consumed by other fish surrounding the area. According to Ondang dan Tumanduk [27], explained in the research that the presence of fish species around KJA showed that the remains of food from KJA carried by sea current were able to attract reef fish [28] also stated that various fish around KJA is related to food hunting, although the food varies. The remaining food that have not been eaten by fish cultivated inside the KJA, will over time come out of it. Then, it will be attract other fish around the cage to get closer and foraging around the keramba. In addition, the nutrients from the remaining food in KJA will cause an increase in water fertility. Thus, it will affect the high quantity of phytoplankton in the waters. Phytoplankton is an oxygen producer as well as a source of food for fish.
Station IV (waters of Roswar Island) is part of the inhabited Waprak Village. The coast is a muddy type with a stretch of coral reef far from the coast. Thus, mangrove vegetation and terrestrial are the main vegetation in this area. It is also supported by current with low speed of 0.06 m/s. According to Nybakken [24], mud sediments in marine waters can only form on the base which has low waves movement or deeper location. Thus, it is not influenced by the waves. Location of the research near the mangrove vegetation caused a lower water temperature of 28.5 °C. According to Hakidah et al. [29], the greater percentage of mangrove vegetation closure, the lower the temperature in the water. The presence of mangrove vegetation is helpful in reducing the absorption of light, so the temperature on the surface of the water is not too high.

The location of the research that is near the muddy coast and very close to the village resulting in a lower pH value of the water (6.5), which is good for the growth of marine organisms. According to mardi [30] stated that aquatic organisms generally live, grow and thrive at a pH between 6.5 and 8.5. According to Mahilda [31] stated that changes in pH value can be caused by household waste. This pH value is also influenced by the mangrove vegetation that grows around the coast. According to Yani [32] suggests that the mangrove usually grows in the water pH range between 6 to 8.5. The salinity in the research location was 31 ppm. According to Patty [33] stated that salinity in Indonesian waters generally ranges from 30-35 ppm, the picture of salinity waters illustrates that the magnitude of salinity fluctuations is influenced by several factors, such as water circulation, evaporation, precipitation, and the presence of river flow. The DO (Dissolved Oxygen) water of research location is 8.5 ppm and still supports the life of marine organisms. According to Assyakur dan Wiyanto [26], the general condition of dissolved oxygen in coral waters that can still be tolerated by the marine organism growth ranges from 8.3 to 8.7 ppm. Coral reef in Waprak waters have aquatic colors that tend to get brown because it is affected by the coastal mud sediments. According to Saputra et al. [34] stated that mud can cover coral polyps caused by waves and currents which carry mud suspensions.

The types of fish found in the Waprak village waters are very few only 4 genus. It is because the coral reefs is located near the village, where many human activities take place such as fishing, household waste, and access to marine transportation. Waprak waters is also close to coast which has mud substrate. According to Supriharyono [35] stated that coral reefs cannot survive because of sediment that covers its feeding structure. The sediment can also cause the lack of sunlight required for photosynthesis. Thus, causing death to coral which also affects the decrease of reef fish species. Sedimentation and high turbidity levels in the waters will suppress the growth of coral reefs. Coral and reef fish require clear water to get enough sunlight. When the supply of sunlight decreases, coral growth becomes disturbed. Consequently, many marine life such as reef fish that utilize coral reef are decreasing in number [36].

Station V (Auri Island waters, Roon district) is the outermost island located between the clusters of islands in Teluk Cendrawasih. Therefore, the velocity of sea currents is relatively high compared to the other four waters with a speed of 0.09 m/s. According to Ruswahyuni [23] stated that open water is strongly influenced by the waves. The waters facing the open sea without any obstacles, either islands or land. According to Hutomo [37] also added that sea currents from the open water plays an important role in supplying oxygen for coral growth. In addition, the pattern of ocean currents is also very important to carry nutrients, sediment materials and fish larvae.

The coast of Auri Island is a sandy coast and it has a cluster of coral reefs and non-mangrove vegetation such as pine and coconut. According to Efendi [21], non-mangrove vegetation is generally found in coastal areas with sand-dominated substrate. Good water conditions (temperature, pH, salinity, and DO) contribute to the growth of coral reefs. The water condition is minimally affected by human activities because Auri Island and the surrounding islands are unhabited. According to Darmianti [14], coral reefs are generally more developed in large undulating areas that can provide oxygen supply for corals. The waves also provide new plankton for coral colonies that are also the source of food for reef fish. According to Sutono [38] in his research also stated that the fertility of the waters is supported by open water conditions. Thus, the circulation of running water and the coral reef ecosystem can be protected from human activity. Therefore, the coral reef ecosystem could maintain
sustainability. The waters of Auri Island have a fairly high number of genus (10 genus). However, it was still lower in number than the Numamuran and Nusrowi waters. The large number of reef fish genus are supported by good water quality that allows good growth of the coral reefs.

Based on the results in each location, it can be seen that more types of reef fish were found in Numamuran Island because it is an area protected from the direct influence of the open sea. There were mangrove ecosystems that support the life of reef fish as spawning areas, feeding areas, and habitation. The less number of fish species were found in the waters of Waprac village. According to Nybakken [24], small waves of shrapnel on the sheltered sea side (leeward), could create a diminished algae bund development and dominant coral development. On the contrary, large wave fractures on the open sea side (windward) create the development of algae borders and minimal coral development. Algae bunds play a role in resisting wave velocity and resulting in calmer water conditions. The waters of Numamuran Island, Nusrowi Island, and Auri Island had more reef fish species compared to Rariei waters and Waprac village waters. This was due to the location of Numamuran, Nusrowi, and Auri waters that are located in coral reefs and away from human activities.

The diversity of reef fish in the waters of Numamuran Island, Nusrowi, and Auri is an illustration of the potential of coral reefs that are preserved due to the minimal intervention of human activities, protected waters, and sufficient supply of food. The Pomacentridae family is the largest fish found in each of the stations, but with different genus. According to Zulfianti [39] also stated that Pomacentridae family fish is the most dominant group on coral reef ecosystem.

4. Conclusions and Suggestions
Based on the research of the inventory of reef fish species in marine waters of Teluk Wondama regency, it can be concluded that there were 48 species which includes 28 genus of the fish. They were Acanthurus, Zebrasoma, Balistapus, Parastromatus, Chaetodon, Heniochus, Cheilinus, Thalassoma, Halichoeres, Labroides, Lutjanus, Parupeneus, Nemipterus, Pentapodus, Abudefduf, Amblyglyphidodon, Amphiprion, Chromis, Dascyllus, Dischistodus, Pomacentrus, Priachantus, Epinephelus, Plectropomus, Siganus, Synodus, Arothron and Zanclus.

It is necessary to conduct further research at different locations in order to complete the data collection on reef fish to provide scientific information on reef fish species found in Teluk Wondama regency. This research results are expected to be spread to the government and Teluk Wondama society to help planning efforts to maintain the marine ecosystem in those area.

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