Reef fishes abundance and assemblages in six islands (Kapoposang, Lanyukang, Lumu-Lumu, Badi, Ballang Lompo and Karanrang island) of spermonde archipelago during El Nino 2016, South Sulawesi, Indonesia

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Abstract. Overfishing in the Spermonde Archipelago has resulted in long-term changes in fishery composition and structure, as well as in resource utilization patterns. Later on, the patterns of resource use are highly variable, with new activities and new target species, e.g., ornamental corals and intensive coral reef fishery being a relatively recent phenomenon in the area. This research aims at measuring the coral fishes abundance and assemblages in six islands (Kapoposang, Lanyukang, Lumu-Lumu, Badi, Ballang Lompo, and Karanrang), representing off-shore and in-shore of Spermonde Archipelago waters during the occurrence of the 2016 El Nino. Underwater Visual Census (UVC) method was done to measure coral fish abundance, once every seasonal interval, totaling four times for every island, on 70 meter transects covering an area of 350 m² (2.5 m to the right and left and 5 m above). Fish species found were identified by following several coral fish identification books. Data was analyzed for their total species abundance based on the family. Results showed that coral fish abundance by the family was found to be lowest (less than 10,000 individuals/hectare) all through the year in Karanrang Island. The most abundance was found in Lanyukang Island (84,600 individu/hectare) during the month of September, followed by Badi Island (59,971 individu/hectare). In February, fish abundance of 35,743 and 46,886 individu/hectare were only found in Kapoposang and Badi islands. All in all, on average, Badi island showed for having relatively equal coral fish abundance in all four seasons. One hundred species were found in Lanyukang, while 78 species were found in Lumu-Lumu, totaling 136 species of coral fishes of 28 families. Coral fishes species always found in all trips were 20 species in Lanyukang and 11 species in Lumu-Lumu. Four species always found in both islands were Thalassoma hardwicke, Neoglyphidodon nigroris, Labroides dimidiatus, Cirrhilabrus ryukyuensis. Fishes found most abundance were from Labridae and Pomacentridae families, each of 31 and 30 species. The temporary conclusion was that Lanyukang has more species than Lumu-Lumu.

1. Introduction
Coral reef fish often live in close association with their habitat, and it has been widely acknowledged that reef fish assemblages are largely influenced by habitat structure (1–6). Degradation of coral reefs has been shown to affect associated fish communities irrespective of whether the cause of degradation is experimental (e.g. (7–10), anthropogenic by use of destructive fishing gears (e.g. [5,10-11]) or natural through, e.g., Crown-of-Thorns starfish infestations [12], storms and cyclones [13–15], or bleaching

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Several fish species are strongly associated with live coral cover (e.g. [1,4,6]), and their choice of habitat may be determined at settlement [21].

Overfishing in the Spermonde Archipelago has resulted in long-term changes in fishery composition and structure, as well as in resource utilization patterns [11]. Later on, the patterns of resource use are highly variable, with new activities and new target species, e.g., ornamental corals [22] and intensive coral reef fishery being a relatively recent phenomenon in the area. These research results and some others indicate the decrease in fish’s abundance in Spermonde due to coral reef degradation. The effect of disturbances on reefs in Spermonde islands so far has come from investigations on few selected sites and over rather short periods of time. The temporal and spatial scale of changes of coral fishes over longer periods of time, therefore, might help or even necessary to understand their responses to varieties of stressors, especially to sea temperature rise during the 2016 El Nino.

Warming ocean temperatures cause sea levels to rise, but in combination with salinity changes, they also influence the geographic distribution of marine biota and can have direct effects on the species composition, breeding and population dynamics of plankton, benthos, fish and other species. Coral reefs being the most diverse marine ecosystems and besides acting as nurseries to young fish and shellfish, also are invaluable for tourism and protect islands and coastal areas from storm surges and strong waves.

Therefore, this research as a part of “Coral Vulnerability Assessment to Temperature Stress (Bleaching) and Ocean Acidification in the Spermonde Archipelago: Conservation Strategies for Climate Resilience” 2016-2017, aims to assess coral fishes abundance that could provide a better outlook for better management leading to sustainability of its resources services.

2. Material and Methods

2.1. Study sites

For the purpose of this research, Spermonde waters were divided into in-shore to off-shore islands based on de Klerk (Moll, 1983). The in-shore or inner shelf is area closest to the main island, Sulawesi, with a depth average of 10 m and bottom substrate dominated by sand and mud, represented by Karanrang (04.85328°S to 119.38357°E) and Ballang Lompo (04.93818°S to 119.39710°E) Islands. The middle-zone, starting at 12.5 km off Sulawesi with a depth ranging from 20 to 50 m and where submerged coral reefs are found many, represented by Badi (04.97190°S to 119.28344°E) and Lumu-Lumu (04.97642°S to 119.22208°E) Islands. The off-shore zone or the outer shelf is the zone of the barrier reef, and about 30 km from the mainland of Sulawesi are represented by Lanyukan (04.97795°S to 119.08361°E) and Kapoposang (04.69777°S to 118.56240°E) islands (Figure 1.)
2.2. Material
Scuba diving, roll meter of 70 m long for transect, underwater paper, pencil, and underwater camera were used to record the coral fishes.

2.3. Sampling method and fish census
Data were collected within more or less three months intervals starting February 2016 as the first trip, May 2016, as the second trip, September 2016, as the third trip and December 2016 as the fourth trip representing monsoon seasons.

![Figure 2. Underwater Visual Census (UVC)](image)

Underwater Visual Census (UVC) method was done to measure coral fish abundance, once every seasonal interval, totaling four times for every island, on 70 meter transects covering an area of 350 m$^2$ (2.5 m to the right and left and 5 m above) following [23] (Fig. 2). Data for seawater temperatures throughout 2016 were recorded using Hobo underwater temperature data logger, which were put within the depth of five to seven meters in all those six islands.

2.4. Data analysis
The calculation of the coral fish abundance found was converted to individual/hectare from a sampling area of 350 m$^2$ and analyzed by family. All the data abundance converts to the hectare. Coral fishes were identified using the book of Tropical Reef-Fishes Of The Western Pacific “Indonesia and Adjacent Waters” by Kuiter (19) and Pictorial Guide To “Indonesian Reef Fishes” by [24]. Reef fish abundance calculates using density formula:

$$D = \frac{\sum N_i}{A}$$ (1)

Where:
- $D$ = Fish density/abundance (Ind/ha)
- $N_i$ = Number of individual fish (Ind)
- $A$ = width of area (ha)

Seawater temperatures data were used to mark the higher or lower level temperatures found in each island and to support the fish abundance discussion.

3. Results
Coral fish abundance by the family was found to be lowest (less than 10,000 individuals/hectare) all through the year in Karanrang Island. The most abundance was found in Lanyukang Island (84,600 individu/hectare) during the month of September, followed by Badi Island (59,971 individu/hectare). In February fish abundance of 35, 743 and 46,886 individu/hectare were only found in Kapoposang and Badi islands. All in all, on average, Badi island shown for having relatively equal coral fish abundance in all four seasons (Figure 3).
Of all coral fishes family, Labridae (wrasses) and Pomacentridae (damselfishes) counted the most found in those six islands. Lumu-Lumu island holds the highest record of having fish of family Labridae (a bit more than 20,000 individu/hectare) in June (Figure 4 and 5).
As for family Pomacentridae, the highest abundance was found in Lanyukang island during September and December, ranging from 60.314 to 77.543 individu/hectare. Unlike that of family Labridae, family Pomacentridae was always found in all four seasons in Badi Island, with the highest number during February and the lowest during December (Figure 6).

![Figure 6. Coral Fishes of Family Pomacentridae Abundances in six islands](image)

As for the live coral cover, Badi island had the highest coral cover during February and December, ranging from 71.8 to 80.22, while Balang Lompo island had the lowest live coral cover during February and December, ranging 3.38 to 7.9 (Figure 7).

![Figure 7. Live Coral Cover in six islands during sampling period](image)

4. Discussion
Distribution of coral fishes will differ related to the life form and coral reef physical condition. Fish species diversity, as well as its structure among functional groups, may determine the resistance and the resilience of fish assemblages to disturbance [24–26]. Most frequent coral fishes found in both islands were from the major group under the family of Labridae and Pomacentridae, both of which are herbivores. In terms of coral fish diversity, Lanyukang Island (offshore zone) has more fishes compare to Lumu—lumu Island (inshore zone), despite the fact that Lumu-lumu has better coral condition than Lanyukang. [27] found that there was an increase of invertivore species across the inshore to offshore gradient (e.g., C. auricularis, C. auratus, P. biserialis and R. sarba), which may be associated with increased food availability at greater depths or with greater water movement. Live coral cover at Lumu-lumu is up to 40%, while Lanyukang has 20%.Indicator coral fishes, found in few, were only found in Lanjukang Island. This finding was in line with a previous study by [27] who found that coral cover was positively correlated with total fish density.

The labroids include the wrasses, the parrotfishes, and the damselfishes. Wrasses are a large family of some 500 carnivorous species that specialize in taking benthonic invertebrates, primarily crustaceans and molluscs [7]. There are about 68 species of parrotfishes, and most are primarily herbivorous. Herbivore fishes are essential to maintaining healthy and resilient reefs [28,29]. The damselfishes, which total 235 species worldwide, have diets which range from herbivory to planktivory, to feeding on benthic crustaceans. Many wrasses and parrotfishes exhibit sequential hermaphroditism and have complex social systems. Territorial behavior is common among the damselfishes. Wrasses are known to be the principal cleaner fishes in the Indo-Pacific [32].

The temporary conclusion showed no relation of live coral condition with coral fishes found, which may result in less sampling replication of the transect as well as time replication.

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