3. MATERIALS AND METHODS

3.1 Study Sites

This study was carried out in Pasi Island water of Selayar Islands Districts, South Sulawesi Province from March to April 2010. Ten study sites were selected representing the environmental variation of coastal area (Figure 4).

Figure 4  Study sites at Pasi Island.
To maintain ecosystems, Selayar Islands District has initiated the formation of regional Marine Protected Area (MPA) as an effort to manage the rate of damage to the ecosystem while preserving the sustainability of resources for the community. Pasi island has an area of 2.388.78 ha with 29.545, 66 m coastline; 66, 62 ha of mangrove; 408, 36 ha of coral reefs; 603, 61 ha coral reefs with sands; 799, 53 ha seagrass with sands, 171, 32 ha sandy inundated by sea water; 58, 95 ha white sandy beaches; 25, 99 ha settlement; 845, 42 ha coconut plantation and 1.391, 40 ha patch (PPTK Unhas 2007).

The selection of this area as study site is based on the introduction of Selayar Islands District as the Maritime District. According to PPTK Unhas (2007), live coral cover in this area was around 60%. This area has tremendous potential for tourism but still not explored.

A total of 10 selected study sites scattered around the island, 3 sites at the north of island, 1 site on the east, 5 sites on the south and 1 site on the west. The selections are based on the good condition of coral cover and dominance of the life forms branching Acropora and tabular Acropora in study sites. On the east and west of the island only one transect was taken because of the coral cover in the eastern part of the observation area that is not too large, while in the western part due to strong waves at the time of observation that is not possible to take more than one site.

Equipment and materials used in this study were divided into two parts, namely:

1. To observe the physical-chemical parameters of waters such as: temperature (thermometer), brightness (seichi disc), current velocity (floating dredge), depth (depth gauge), salinity (refractometer)

2. To observe coral reefs and reef fishes such as: Self-contained Underwater Breathing Apparatus (SCUBA), GPS (Global Positioning System), underwater cameras (Canon and Olympus 5 MP 5 MP), a permanent plastic transect with size 5 x 5 m² created in which 1 x 1 m² transect (Figure 6), stationery underwater, and roll meters. Coral reefs identified based on English et al. (1997) and fish identified based on Kuiter & Tonozuka (2001a,b,c).

3.2 Methods and Techniques of Data Collection

Before study sites determined, preliminary observations made by snorkeling to get an overview of the area to be defined as a study site.
Observations carried out only in shallow water with 3-7 m depth. The area selected must have good coral cover to represent coral reef ecosystems.

Reef communities’ observation was made by Permanent Quadratic Transect Method (PQT). Permanent transects 5 x 5 m² equipped with smaller sized transects 1 x 1 m² in it will be installed parallel to the shoreline at 10 study sites. To fit a transect involving three divers, two divers on the bottom to install a permanent transect and one other diver directed to be installed perfectly transects cover the preferred life forms. For each site, the small transect 1 x 1 m² was photographed 1 (one) time continuously without a break so that each site was covered by 25 photos. Thus a total of 250 photos were obtained from the overall 10 study sites. The photo were analyzed by using the IMAGE J (by pixel) for calculate the percentage cover of different coral life forms of each site.

Observations on reef fishes and benthic biota used stationary visual census on each PQT. Observations was conducted at permanent transects 5 x 5 m² with the observers were static at one point in the transect (Fig. 6) and record all the fishes contained in this transect (Maduppa 2004).

![Figure 5 Permanent Quadratic Transect 5 x 5 m².](image)

Each observation was conducted for 30 minutes for each transect consistently to reduce bias. Two times observations conducted for each station. The first observations made at about 9:00 a.m. to 10:00 a.m. and the second
observation at about 3:00 p.m. to 4:00 p.m. The data were recorded for analysis of habitat preference of reef fishes.

![Observer's position on the transect.](image)

Figure 6 Observer's position on the transect.

### 3.3 Data Analysis

#### 3.3.1 Life forms Coverage

Life form coverage calculated with:

\[
N = \frac{n_i}{A} \times 100 \%
\]

where:

- \(N\) = density of coral (colony/m²)
- \(n_i\) = coverage of i-life form
- \(A\) = area coverage (1 x 1 m)

#### 3.3.2 Shannon-Wiener Diversity Index \((H')\), Evenness Index \((E)\) and Simpson Dominance Index \((C)\)

##### 3.3.2.1 Shannon-Wiener Diversity Index \((H')\)

Shannon-Wiener Diversity Index \((H')\) is used to get the representation of the population through a number of individuals of each species in a community (Odum 1971), with the following formula:

\[
H' = \sum_{i=1}^{s} p_i \ln p_i
\]

where:

- \(H'\) = Shannon-Wiener Diversity Index
- \(s\) = number of reef fishes species
- \(p_i\) = abundance proportion of reef fishes species

Shannon-Wiener Diversity Index calculated according to Brower and Zar (1977) criteria:
2.3.2.2 Evenness Index (E)

Evenness Index (E) index is used to measure the balance of the community. This is based on the similarity of individuals among species in a community. Evenness Index (E) calculated with the following formula:

\[ E = \frac{H'}{H_{\text{max}}} \]

where:
- \( E \) = Evenness Index
- \( H' \) = maximum balance of the species

Index value ranges from 0-1 with the Brower and Zar (1977) criteria:
- \( E \leq 0.4 \): small, depressed communities
- \( 0.4 < E \leq 0.6 \): moderate, community labile
- \( E > 0.6 \): high, stable communities

3.3.2.3 Simpson Dominance Index (C)

Dominance index is used to calculate domination of a species. This index is calculated by Simpson's dominance index (Simpson in Odum 1971) with the following formula:

\[ C = \sum_{i=1}^{s} p_i l^2 \]

Where:
- \( C \) = Simpson Dominance Index
- \( p_i \) = proportion of individual species of reef fish

Index values range from 1-0 which means if the value approached 1, there is a tendency of a species to dominate others.

3.3.3 Bray-Curtis Similarity Index

Bray-Curtis similarity index is used to determine patterns of habitat groupings based on cluster analysis using the percentage composition of the benthic biota (biological parameters). Biological parameters of the data is used to classify this habitat are the percentage of life forms coverage obtained at each site (Legendre & Legendre 1983).
Bray-Curtis similarity index calculated with the following formula:

\[
D = \frac{\sum_{i=0}^{n} |y_{1i} - y_{2i}|}{\sum_{i=0}^{n} (y_{1i} + y_{2i})}
\]

where:
- \( D \) = Bray-Curtis similarity index
- \( y_{1i} \) = value of \( i \)- parameter on the 1 site
- \( y_{2i} \) = value of \( i \)- parameter on the 2 site
- \( n \) = number of parameters compared

### 3.3.4 Sorensen Similarity Index

Sorensen similarity index is used to classify and arrange the reef fish species using cluster analysis. To calculate the Sorensen similarity index, numerical data on reef fish number of individuals is transformed into a binary form (Krebs 1985). Sorensen similarity index calculated with the following formula:

\[
S_o = \frac{2a}{2a + b + c}
\]

where:
- \( S_o \) = Sorensen similarity index
- \( a \) = number of site with fish A and B species
- \( b \) = number of site with only A species
- \( c \) = number of site with only B species

Sorensen similarity index used to create a matrix that will form a dendrogram of groups of reef fishes based on average linkage method.

### 3.3.5 Nodules Analysis, Constancy Index \((C_{ij})\) and Fidelity Index \((F_{ij})\)

The result of grouping coral habitats and reef fishes were used for nodules analysis. The technique used to combine these two cluster analysis is forming a two-way binary matrix, groups of habitats on the row and groups of fish occupying the column.

The binary data from the nodules analysis is used to analyse constancy level group of fishes in certain habitat based on constancy index as following (Boech 1977 in Aktani 1990):
where:

\[ C_{ij} = \frac{a_{ij}}{n_i \cdot n_j} \]

where:

- \( C_{ij} \) = Constancy index
- \( a_{ij} \) = the number of presence members of i-group fish species in j-group of habitat
- \( n_i \) = number of element i-group of fishes
- \( n_j \) = number of element j-group of habitats

Constancy index values range from 0 – 1, with criteria:

- \( C_{ij} = 0 \) there is no one member of i-group fishes species exist on j-group habitats.
- \( C_{ij} = 1 \) all member of of i-group fishes species exist on j-group habitats.

Constancy index can be seen the level of specificity / fidelity of i-group fishes species in j-group habitats based on fidelity index (Murphy & Edwards 1982 in Aktani 1990) as following:

\[ F_{ij} = \frac{C_{ij}}{(\sum_{j} a_{ij}) / (n_i \sum_{j} n_j)} \]

where:

- \( F_{ij} \) = Fidelity index
- \( C_{ij} \) = Constancy index

- \( F_{ij} \geq 2 \) show a strong level of preference of i-group fish species in j-group of habitats.
- \( F_{ij} \leq 1 \) shows level of disapproval of i-group fish species in j-group of habitats.
- \( F_{ij} = 0 \) shows a strong lack of fondness / tend to avoid of i-group fish species in j-group of habitats.

### 3.3.6 Principal Component Analysis (PCA)

Principal Component Analysis is used in order to identify fish species population that specific to a particular habitat. Principal component analysis is based on the presence or absence of fish populations in different groups of habitat. This would indicate the existence of similarities or differences between fish communities from different groups of habitat were observed.

The purposes of principal components analysis in a large data matrix (Bengen 2000) are:

- Extracting important information stored in a table / matrix of large data
- Producing a graph that facilitates for interpretation
Observing a table / matrix data from the similarity viewpoint between individual and the relationship between variables.