ANALYZING THE ELECTION OF THE BASIC HABITAT CORAL REEF FISHES BASED ON CORAL LIFEFORMS AT PASI ISLAND, SELAYAR ISLANDS DISTRICT, SOUTH SULAWESI

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GRADUATE SCHOOL
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2010

STATEMENT ON THESIS AND SOURCE OF INFORMATION

I declare that this thesis *"Analyzing the Election of the Basic Habitat Coral Reef Fishes Based on Coral Life-forms at Pasi Island, Selayar Islands Distric, South Sulawesi"* is my own work and has not been submitted in any form or another degree or diploma at any university or other institution of tertiary education. Source of information derived or quoted from the published or unpublished work of others has been acknowledged in the text and list of references are put at the end of the thesis.

Bogor, September 2010

Wendy Fadri Ariansyah
SRN C252080234

ABSTRACT

WENDY FADRI ARIANSYAH. Analyzing the Election of the Basic Habitat Coral Reef Fishes Based on Coral Life-forms at Pasi Island, Selayar Islands District, South Sulawesi. Under direction of SULISTIONO and M. MUKHLIS KAMAL

This research was aimed to observe the habitat preference of coral reef fishes on coral life-forms and its association form between them. This study was carried out on Pasi Island from March to April 2010. Ten 5x5 m2 permanent quadrant transect were put on 10 sites laid around the Island from which total 250 photos transect (1x1 m2) were obtained and used to assess the life-forms of benthic community. *Acropora* branching (ACB) was found dominantly at six sites with 46,09 -89,16% coral cover whereas *Acropora* tabular (ACT) with 22,87-34,99% coral cover at 3 sites. Coral reef habitat analysis by Bray-Curtis Similarities Index revealed three groups of habitats. In this study, a total of 3.990 individual of fishes were counted representing 135 species belonging 29 families. In term of species richness, Pomacentridae found dominantly 56,39% while Labridae 8,97%, Acanthuridae 5,54%, Chaetodontidae 4,81%, Caesioniidae 4,51% and others 24 families 19,77%. Shannon-wiener diversity index at all sites ranged from 3,49 to 4,13. Sorensen Similarity Index for coral reef fishes exposed 21 groups of fish. Fidelity index exposed Pomacentridae associated with *Acropora* branching. Habitat dominated by *Acropora* tabular (ACT), coral encrusting (CE) and coral massive (CM) with sand (S) life-forms were highly preference for *Amphiprion akindynos, Pomacanthus imperator, Chaetodon baronessa, Chlorurus sordidus, Pomacanthus sexstriatus*. Habitat dominated by coral encrusting (CE), coral branching (CB), coral massive (CM), soft coral (SC) with dead coral (DC), dead coral with algae (DCA) and rubble lifeforms elected by *Aeoliscus strigatus, Parupeneus spilurus, Caesio teres, Cirrhilabrus ryukyuensis, Parupeneus barberinus, Siganus virgatus, Cetoscarus bicolour, Amphiprion akindynos, Pomacanthus imperator, Pterocaesio tile, Ptereleotris evides, Rhinomuraena quaesita.*

Keywords: habitat, habitat preference, reef fish, coral reef, coral life-forms

ABSTRAK

WENDY FADRI ARIANSYAH. Analisis Pemilihan Habitat Spesies Ikan Karang Berdasarkan Bentuk Pertumbuhan Terumbu di Perairan Pulau Pasi, Kabupaten Kepulauan Selayar, Sulawesi Selatan. Dibimbing oleh SULISTIONO dan M. MUKHLIS KAMAL.

Penelitian ini bertujuan untuk mengetahui preferensi habitat ikan-ikan karang pada berbagai bentuk pertumbuhan terumbu serta mengkaji assosiasi diantara keduanya. Penelitian ini dilakukan pada Pulau Pasi pada bulan Maret sampai April 2010. Sepulauh transek kuadrat permanen berukuran 5x5 m^2 yang dilengkapi transek kecil berukuran 1 x 1 m^2 di dalamnya dipasang sejajar garis pantai di sekelling pulau untuk mendapatkan total 250 foto yang akan digunakan untuk mengamati *lifeform* komunitas karang. *Acropora* bercabang (ACB) ditemukan dominan di enam lokasi dengan tutupan karang berkisar antara 46,09 -89,16% sedangkan (ACT) *Acropora* tabular ditemukan dominan pada 3 lokasi dengan tutupan karang berkisar antara 22,87-34,99%. Terumbu karang dianalisa dengan menggunakan Indeks kesamaan Bray-Curtis dan diperoleh tiga kelompok habitat. Ikan-ikan yang ditemukan pada 10 stasiun pengamatan berjumlah 3.990 ekor yang mewakili 29 famili. Famili yang banyak ditemukan adalah Pomacentridae (56,39%), Labridae (8,97%), Acanthuridae (5,54%), Chaetodontidae (4,81%), Caesionidae (4,51%), dan 24 famili lainnya (19,77%). Ikan-ikan yang ditemukan jika dikelompokkan menurut English *et al.* (1997), dari 10 stasiun pengamatan ditemukan 135 spesies, 74 spesies merupakan ikan-ikan mayor, 34 spesies merupakan ikan-ikan target dan 27 spesies merupakan ikan-ikan indikator. Hasil identifikasi berdasarkan Fishbase (2010) terhadap ikan-ikan yang ditemukan di Pulau Pasi ternyata 13,78% ikan merupakan herbivora, 22,56 % adalah karnivora, 31,63% merupakan omnivora, 3,76% merupakan corallivora, 26,04% merupakan planktivora dan 2.23% adalah detritivora. Hasil perhitungan menunjukkan bahwa nilai Indeks Keanekaragaman (H') berkisar antara 3,49 sampai 4,13, Indeks Keseragaman (E) berkisar antara 0,91 sampai 0,95 dan nilai Dominansi berkisar antara 0,02 sampai 0,04. Perhitungan Indeks Fidelitas (F_{ij}) menunjukkan bahwa Pomacentridae berasosiasi dengan karang bercabang. Habitat yang didominasi oleh A*cropora tabular* (ACT), *coral encrusting* (CE) dan *coral massive* (CM) dengan substrat berpasir (S) memiliki preferensi yang tinggi bagi *Amphiprion akindynos, Pomacanthus imperator, Chaetodon baronessa, Chlorurus sordidus* dan *Pomacanthus sexstriatus*. Habitat yang didominasi oleh *coral encrusting* (CE), *coral branching* (CB), *coral massive* (CM), *soft coral* (SC) serta adanya *dead coral* (DC), *dead coral with algae* (DCA) serta adanya patahan karang (*rubble*) sangat disukai oleh *Aeoliscus strigatus, Parupeneus spilurus, Caesio teres, Cirrhilabrus ryukyuensis, Parupeneus barberinus, Siganus virgatus, Cetoscarus bicolour, Amphiprion akindynos, Pomacanthus imperator, Pterocaesio tile, Ptereleotris evides* dan *Rhinomuraena quaesita*.

Kata kunci: habitat, pemilihan habitat, ikan karang, terumbu karang, bentuk pertumbuhan karang

PREFACE

Praise and gratitude be to Allah, the Most Gracious and Merciful, without His blessing, I could not have completed my work. This thesis has made as one of the requirement to qualify the graduate school of Bogor Agricultural University with the title “Analyzing the Election of the Basic Habitat Coral Reef Fishes Based on Coral Life-forms at Pasi Island, Selayar Islands Distric, South Sulawesi”.

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I realized that this thesis is still not perfect, so that constructive suggestions and criticisms would be welcomed for improvement of this recent work.

Bogor, September 2010

Wendy Fadri Ariansyah

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WENDY FADRI ARIANSYAH

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LIST OF CONTENTS

Page

LIST OF TABLES

Page

LIST OF FIGURES

Page

LIST OF APPENDICES

1. INTRODUCTION

1.1 Background

Coral reefs provide several shape and different size of space for many fishes. Every species have preference to certain habitat. Reef fishes use coral reef as feeding ground, spawning ground and some of them using as nursery ground (Nybakken 1997). Reef fishes could be as permanent residence or only whereas living in the ecosystems. Choat and Belwood (1991) noted that there is a number of fish which always associated with the coral reefs. Existences of fishes in this ecosystem varied within habitat and influence by reef complexity as its substrate.

Every group of fishes have different habitat. Generally, each species have preferences for certain habitat (Hutomo 1986). Selection of shelter sites of appropriate size in the habitat may be a major factor determining the distribution of reef fish (Friedlander & Parrish 1998). According to previous studies, several reef fish species live in close association with colony of branching corals e.g. *Chaetodon, Chromis, Dascyllus* and *Thalassoma* (Nybakken 1997), *Pomacentrus* (Ohman & Rajasuria 1998), Gobiidae (Choat & Bellwood) and damselfish *Plectroglyphidodon lachrymatus* (Sale 1991; Wilson & Wilson 1985; Kuiter 1992; Meekan *et al.* 1995; Allen 2000); and Scaridae *(parrotfish)* were associated with massive coral (Nybakken 1997).

Besides habitat size and shape factor of reefs, distribution and existences of fishes on the reefs is influenced by physical and chemical factor such as waves and currents, sedimentation, depth and topographic condition of reef substrate (Galzin *et al* 1994, Chabanet *et al.* 1997). Ecological parameter such as live coral cover, feeding diversity and reproduction also influence the diversity of reef fishes (Galzin *et al.* 1994).

The complexity of coral reefs habitat emerges as of shape existing colony. English et al. (1997) divide life form category become: *Acropora* branching (ACB), *Acropora* digitate (ACD), *Acropora* tabulate (ACT), coral branching (non Acropora) (CB), coral encrusting (CE), coral foliose (CF), coral massive (CM), coral sub massive (CS), coral mushroom (CMR), *Millepora* (CME), *Heliopora* (CHL), other organism (OT) (including: soft corals, sponges, zoanthids, other benthic organism), Algae (AL) (including: macro algae, *Halimeda)*, dead coral

(DC) (including: dead coral with algae, rubble, and dead coral with massive formation).

Harriott and Banks (2002) reviewed a wide range of factors that influence coral-dominated communities to form reefs, such as water temperature, coral reproduction and recruitment, competition for space with macro-algae, oceanographic processes and the physical environment, light availability, and the potential for coral calcification and growth. Kleypas *et al*. (1999) acknowledged that biological factors and regional physical conditions are also likely to be locally significant.

Coral reef has a complex function but still not supported by the resistance to damage caused by natural and human activities. Damage to coral reefs is characterized by a decrease in live coral cover which affect to diversity and abundance of reef fish and other biota that inhabit.

To maintain its function, coral reef ecosystems with their reef fishes needs to manage effectively and sustainably. Research on biological and ecological aspects that can provide information about the condition of reef fish in coral reef ecosystems is needed by parties concerned in determining the suitable management system with the characteristics of these ecosystems.

Observations on habitat selection of reef fishes species on coral life forms was conducted in Pulau Pasi which administratively located in Kecamatan Bontoharu, Selayar Islands District. The Coastal water of this island is important as it has been initiated as a Marine Protected Area (MPA).

1.2 Problem Formulation

Establishment of Pasi Island as a Marine Protected Area (MPA) should be supported with ecological information, particularly related to the association coral reef with fish communities. The data are not available until now. These data are needed as an ecological basis for management of fishery resources and habitat conservation.

There is an association between fish and their habitats. The fish that live in coral reefs have interests and preferences in that ecosystem. Live coral cover and coral's life forms can affect the species, abundance and community structure of reef fish are associated with. Associations and habitat selection of reef fish communities in a variety of life forms become a main problem that studied in the present study (Figure 1).

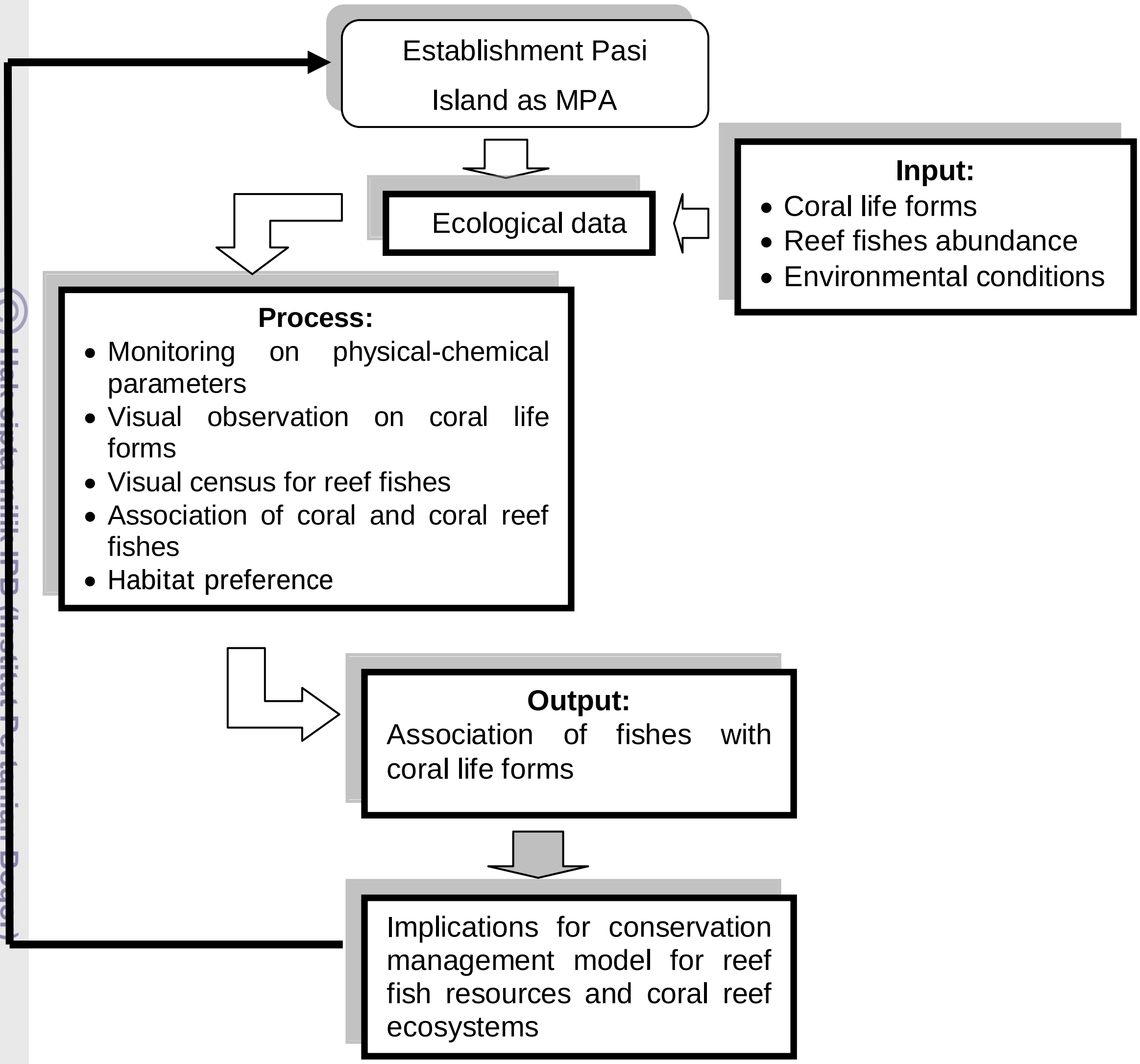

Figure 1 Flowchart of the problem formulation.

1.3 Objectives and Benefits

This study was aimed to examine the relationship of habitat selection of reef fish species through coral lifeforms with:

1. Observing reef communities in the location of observation based on lifeforms
2. Observing reef fishes associated with coral reefs
3. Assessing the preferences/habitat selection of reef fishes in coral communities

This research is expected to get information about the fish species that associated with coral communities and habitat selection factors on various coral life forms at the site of observation for giving an advice in the management of marine conservation areas, especially conservation of fish resources.

2. LITERATURE REVIEW

2.1 Coral Reefs

2.1.1 Coral Biology

Coral reefs are an ecosystem that is formed from the deposition of calcium carbonate ($CaCO_3$) produced mainly by corals with accretion from calcareous algae and other organism which produce calcium carbonate (Nybakken 1997). Odum (1971) defined coral reef as a part of ecosystem that built by some biota, animal and plant that continuously trapping calcium and carbonate ion from sea water for constructing skeleton thus in a whole process forming a reef.

Corals are another name of Scleractinian order which has a hard limestone. Corals may be colonial or solitary. As individual, coral consist of polyps and the skeleton. Coral polyps (Figure 2), the mouth is situated at the top and also functions as an anus. Coral tissue composed of ectoderm, mesoglea and endoderm (Veron 1986). Ectoderm is the outer tissue that has cilia, mucus and nematocysts. Mesoglea is a layer that lies between the ectoderm and the endoderm, formed like a jelly. Endoderm is deeper layer and contains zooxanthellae (Nybakken 1997).

According to Barnes (1980), the diameter of colonies of coral polyps usually 1-3 mm, whereas there is a solitary species reaches 25 cm. Reef structure consists of crystals of calcium carbonate and is secreted by the epidermis which is in the upper of the polyp. This secretion process will form skeletal cup where the polyps live. The cup is called *calyx*, the wall surrounding is *theca* and the base of the cup called *basal plate*. As its function to providing a place for the polyps, shells also provide protection. If there is any threat from predators, the polyps would be contracted and become small and hidden in the shell making it difficult for predators to prey.

Corals have one-celled algae called zooxanthellae living in their internal tissues. This symbiotic relationship allows for the production of enough calcium carbonate for coral reefs to originate and grow. Zooxanthella is producers. Almost 90 % of zooxanthella production transfer to coral tissue.

There are two group corals, one called hermapatypic that can produce reefs and the other called ahermatypic that do not produce reef. The first group have symbiotic with zooxanthellae and need sunlight for their live and to form reef. This group also called reef building corals. The second group cannot forming reef which are called non-reef building corals and normally in their live do not depend on sunlight (Veron 1986).

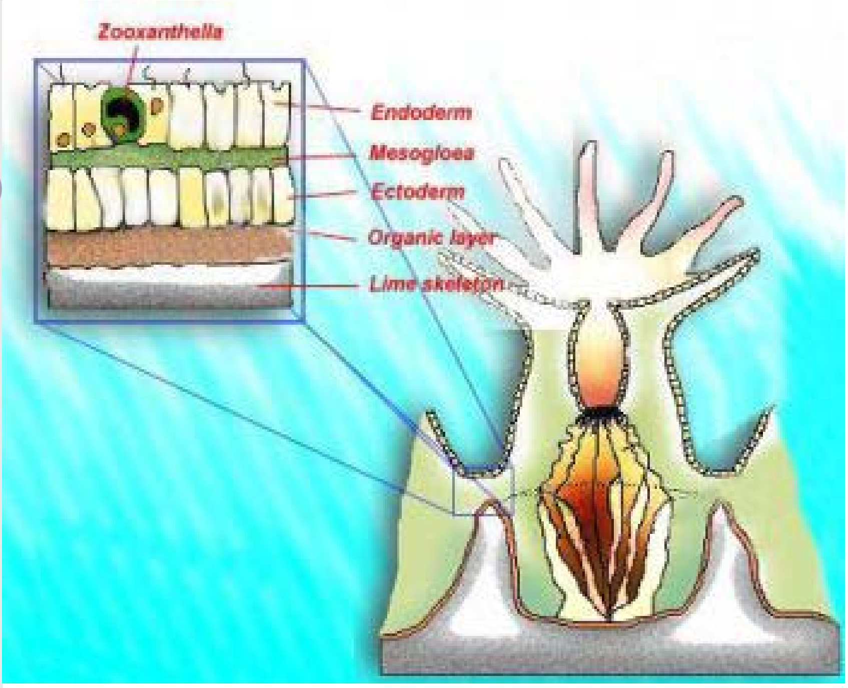

Figure 2 Zooxanthella in the tissues of a coral polyp.

Hermatypic corals are the most part hard corals (scleractinians), but also include the octocoral *Heliopora* (blue coral) and the hydrocoral *Millepora* (fire coral). All hermatypic corals are zooxanthellate but not all zooxanthellate corals are hermatypic. Some ahermatypic zooxanthellate corals include the mushroom coral (*Fungia*) and Neptune's Cap (*Halomitra*).

2.1.2 Limiting Factor for Coral Reef

There is some physical factor influence on coral reef development. At minimum level on this factor they cannot grow well. This factor called limiting factor. Nybakken (1997) noted six major limiting factors for coral reef: light, temperature, depth, salinity, sedimentation and emergence into air.

The first requirement for active coral reef development and growth is light (Nybakken 1997). If corals are unable to get enough light (whether due to increased water turbidity and the increased suspended sediment clouding the water column, or due to a dramatic and rapid increase in water depth), they stop growing and eventually die (Nybakken 1997). Light is necessary to promote photosynthesis within the corals symbiotic zooxanthallae. Light also enhances oxygen production, which stimulates the coral metabolism and leads to increased calcium carbonate deposition and therefore coral reef growth. Corals require water depth where light intensity is at least 1-2% of surface intensity (Nybakken 1997). This dependence on light limits the depth of waters where corals are found. No species of coral has been found to develop in waters deeper than 70 meters, with most corals growing in waters less than 25 meters (Nybakken 1997).

Another factor limiting coral growth and distribution is temperature. Coral reefs dominate between the latitudes of 25^{o}South and 25^{o}North where water temperatures tend to remain consistently warm year round (Hoegh-Guldberg 1999). Nybakken (1997) finds corals prefer a mean annual water temperature between 23-25^{o}C, although various coral species are known to exist in the temperature range of 18^{o}C – 30^{o}C (Hoegh-Guldberg 1999).

Another factor that limits the growth of coral reefs is the salinity. Hermatypic coral cannot survive at salinities deviating from 32 – 35‰, but there are exceptions such as those found in the Persian Gulf, where coral reefs can grow despite the salinity reached 42 ‰ (Nybakken 1997).

Sedimentation also affects coral growth. The sediment was derived from the activities of the river which through away to the waters will cover coral polyp and inhabit feeding process. Another disturbing thing is the limitation of the intensity of light coming into coastal waters due to sedimentation and dissolved particles that interfere with the process of photosynthesis of zooxanthellae (Nybakken 1997). *Porites* is dominant in such hydrographic conditions because it has a tolerance to sedimentation, probably due to a cleaning mechanism to remove sediments through mucus secretions or ciliary action (Goh and Sasekumar 1980), while *Acropora* and *Montipora* have lower tolerance to sedimentation (Riegl 1999).

2.1.3 Types and Forms of Coral Reefs

Coral reefs developed by the same processes, but their geomorphology is shaped by the formation on which they grow and sea level history. Actually, most of coral reefs were established less than 10,000 years ago, after sea level rise associated with the melting of glaciers caused flooding of the continental shelves. When the coral reefs were established, they began building reefs that grew upward together with continued sea level rise. The geomorphology of reefs caused by two main aspects: relative sea level rise and the nature of the underlying substrate.

There are several theories about how coral structures are formed. Charles Darwin originally described 3 major types of coral reefs and all the types make an evolution pathway. The types are (Figure 3):

- Fringing reef. An area along the shore where coral colonies have been able to grow. Fringing reefs occur close to land and often extend out to sea for long distances.
- Barrier reef. A well defined coral zone separated from land by a lagoon. The lagoon is a shallow area with a sandy floor, patch reefs, and patches of seagrass.
- An atoll. The landmass is a small such as a volcano, it may eventually disappear below the ocean surface, and the reef becomes an atoll. An atoll is a ring-like formation of reefs with a lagoon inside the ring.

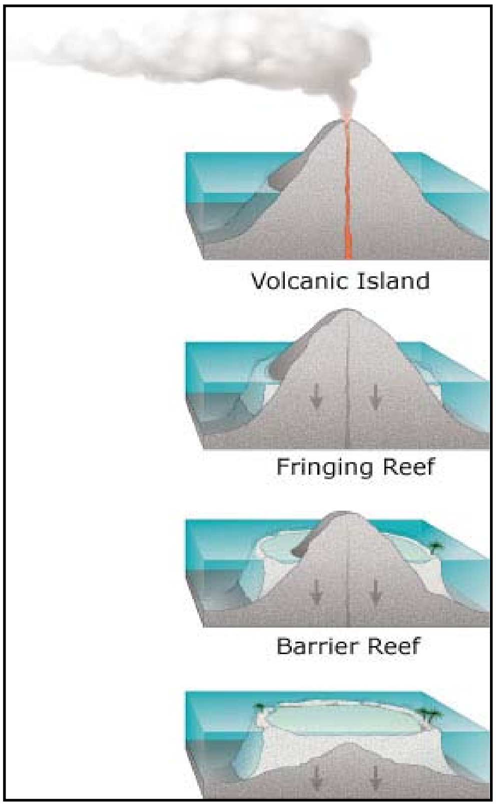

Figure 3 Darwin’s three stages of atoll formation (Coral reef info 2008).

According to their growth, scleractinian which can form a reef divided to *Acropora* and non-*Acropora* (English *et al*. 1997). The differencies *Acropora* and non-*Acropora* based on their structural skleton. Some formation to non-Acropora:

1. Branching: have branches longer than its diameters. Abundant along edge of reef. At least 2^o branching
2. Encrusting : major portion attached to substrate as laminar plate
3. Foliose : coral attached at one or more poits, leaf-like or plate-like appearance
4. Massive : have solid boulder or mound
5. Sub massive : tend to form small columns, knobs ar wedges
6. Mushroom : solitary, free-living coral of the Fungia
7. Heliopora : blue coral, knowing with it's blue skeleton
8. Millepora: fire coral, hot if touched.
9. Tubipora : formation with tube, organ pipe-coral

Formations of Acropora are:

1. Branching : have branches like tree, at least 2^o branching
2. Encrusting : usually the base-plate of immature Acropora form
3. Submassive : robust with knob or wedge-like form
4. Digitate : no 2^o branching
5. Tabular: horizontal flattened plates.

2.1.4 Reefs as Habitat

Coral reefs productivity were high due to the mutual relationship between coral polyps (coral animals) with zooxanthellae (algae) that live in these polyps (Odum 1971). Results showed that primary productivity of coral reefs reach 1.500 - 3.500 gC/m2/year whereas open water only 18 - 50 gC/m2/year (Nybakken 1997).

The high productivity of coral reef and the space of reef structures attract fish to associate. Fish have different spatial requirements and habitat usage. Fish that have a fixed association with a habitat are known as resident or site-attached. Individuals that are not associated with any single habitat and move between different areas are known as transient or vagile. Both resident and transient fish are found associated with microhabitats (Almany 2003).

McCoy and Bell (1991) define habitat structure: heterogeneity, complexity and scale. Heterogeneity is the amount of variance accountable to the relative abundance of the different structural components (per area or unit volume); the complexity is the total abundance (per area or unit volume) of individual structural components; and scale is the size of the area or volume used to measure heterogeneity and complexity. According to Friedlander and Parrish (1998), key habitat characteristics have been known to affect fish assemblages on continuous coral reef habitats.

Microhabitat components are important factors in fish assemblages living on coral reefs. According to Khalaf and Kochzius (2002), fish species richness was positively correlated with hard substrate cover and habitat diversity but Sale et al (2005) said that responses to microhabitat, at or soon after settlement, help determine distribution of fish recruits at small scales, but microhabitat does not have an effect fish distribution over large scales.

The other study also reported positive correlations between benthic diversity and fish diversity, species richness, and abundance on coral and rocky reefs (Garcı´a-Charton & Pe´rez-Ruzafa 2001). Sites with higher benthic diversity offer a wider variety of habitats and resources to meet the needs of more species. Crustose coralline algae were found to correlate positively with several fish parameters and families with Pomacentridae and herbivore abundance. Members of the Pomacentridae family guard algal territories, where there is potential for macroalgae to take hold where coral is unable to colonize. In other study, Maduppa (2004) stated that 40% of reef fishes found in *Acropora branching (ACB)* are Pomacentridae and also in foliose coral (CF) around 48,6% but in massive coral (CM) dominated by Labridae 27,4%.

2.2 Reef Fishes

Sale (1991) define reef fishes are fish that live from juvenile to mature in coral reef. The existence of fish on reefs related with physical condition of coral reef. Differences in live coral cover will affect the density of coral reef fishes, especially those that have strong linkages with live coral (Chabanet *et al.* 1997; Suharsono 1995).

The reef fishes diversity marked by species diversity. One cause of the high diversity of species on the reef is due to the variation of the existing habitat. It is also influenced by several factors: substrate complexity, food availability, water quality, currents, waves, hiding area, live coral cover, etc. (Bouchon-Navaro *et al.* 1996).

From the PPTK-UNHAS results (2007) found 14 Family and 80 species of coral reef and also found 213 species of fish representing the 31 family of reef fish in a location that will be observed in the Selayar District.

2.2.1 Grouping Reef Fish

English *et al. (*1997) classifying species of reef fish into three main groups, namely:

a. Target fish, which is economically important and favored target of fishermen. These groups used coral reefs as spawning and nursery ground. These groups consist of Serranidae, Lutjanidae, Lethrinidae, Nemipteridae, Caesionidae, Siganidae, Haemulidae, Scaridae and Acanthuridae;
b. Indicator fish, that typical reef fishes inhabit the coral reef ecosystem and as an indicator for healthy ecosystem. This group represented by Chaetodontidae;
c. Major fish are small fishes with 5–25 cm length, with varying discoloration characteristics and became known as the ornamental fish. These groups are generally abundance, both in number and type of individuals, and tend to be territorial. Major fish spend all their life in coral reefs, represented by Pomacentridae, Apogonidae, Labridae, and Blenniidae.

Lowe and McConnel (1987) classified reef fishes community divided into two groups:

1. Group of fishes that sometimes occurs in coral reef area like Scombridae and Myctophydae, and
2. Group of fishes that depend to coral reef as feeding ground, settlement or both.

Daily distribution of coral reef divided into two groups: diurnal, and nocturnal. According to Lowe and McConell (1987), mostly reef fishes are diurnal (active during the day); and nocturnal fishes (active at night) usually act as carnivores. According to Randall *et al.* (1990), diurnal fishes mostly herbivores with clearly colour which are hide and shelter at the night in hole around reefs and some of them drowned in sand.

Randall (1990) describes families of reef fishes included:

1. Achanthuridae: known as Surgeonfish, grazing on benthic algae and have a long intestine; some feed mainly on zooplankton or detritus. Surgeon

fishes are able to slash other fishes with their sharp caudal spines by a rapid side sweep of the tail.

2. Balistidae: group of triggerfish, solitary diurnal carnivores, feeding on a wide variety of invertebrates including hard-shelled mollusks and echinoderms; some also feed on algae or zooplankton.
3. Blennidae : living in little hole on reef, mostly bottom dwelling species feeding on a mixed diet of algae and benthic invertebrates; some are planktivores, and some are specialized to feed on skin or fins of larger fishes, with mimic as cleaner.
4. Caesonidae: known as yellow tail, during the day they occur in large zooplankton feeding schools in mid-water over the reef, along steep outer reef slopes and around deep lagoon pinnacles. Although they are active swimmers, they often pause to pick zooplankton and at cleaning stations, and shelter within the reef at night.
5. Centriscidae : Swims in vertical position with the snout downwards; feeds on small zooplankton
6. Caetodontidae : called butterfly fishes, most with bright coloration, a dark band across the eye and an 'eyespot' dorsally, many feed on a combination of coelenterate polyps or tentacles, small invertebrates, fish eggs, and filamentous algae while others are specialists or planktivores
7. Ephippidae : compressed laterally and deep-bodied, mouth small, omnivores of algae and small invertebrates
8. Gobidae: mostly found in shallow coastal waters and around coral reefs. Most are cryptic bottom dwelling carnivores of small benthic invertebrates; others are planktivores. Some species have symbiotic relationships with invertebrates (e.g. shrimps) and others are known to remove ecto-parasites from other fishes
9. Labridae: called wrasses, an important food fishes, have size, shape and colour very diversified. Most species are sand burrowers; carnivores on benthic invertebrates; also planktivores, and some small species remove ectoparasites of larger fishes
10. Mullidae: called with goatfishes, have chin with 2 long barbels, which contain chemosensory organs and are used to probe the sand or holes in the reef for benthic invertebrates or small fish, many brightly colours.

11. Nemipteridae : known as threadfin breams or whiptail breams, carnivorous fishes that feed mainly on benthic small fishes, cephalopods, crustaceans and polychaetes; some species are planktivores
12. Pomacentridae: called with damselfishes, have variable coloration with individuals and with locality for the same species. Many species are highly territorial herbivores, omnivores, or planktivores. Damselfishes lay elliptical demersal eggs that are guarded by the males. Included are the anemone fishes (Amphiprioninae), which live in close association with large sea anemones
13. Scaridae: known as parrotfish, herbivorous, usually scraping algae from dead coral substrates. Bits of rock eaten with the algae are crushed into sand and ground with the algae to aid in digestion, making parrotfish some of the most important producers of sand on coral reefs. Scaridae are important food fishes.
14. Serranidae: known as Sea basses: groupers, bottom-dwelling predators and highly commercial food, they feed on crustaceans and fishes. Subfamilies Anthiinae, Epinephelinae (tribes Epinephelini, Niphonini, Liopropomatini, Diploprioni, Grammistini) and Serranidae.
15. Sygnathidae: knowing as seahorses or pipe fishes. Some very colourful. Usually limited to shallow water. Feed on minute invertebrates sucked into a tubular snout. Males have a brood pouch in which the eggs are laid and where they are fertilized and incubated.
16. Zanclidae: Acanthuridae from which it differs mainly in lacking a peduncle spine. Feed on mainly on sponges, also benthic invertebrates

According to Sale (1991), reef fish groups most closely associated with coral reef environments into three main groups namely:

a. *Labroid* : Labridae (wrasses), Scaridae (parrot fish), and Pomacentridae (damselfishes)
b. *Acanthuroid* : Achanturidae (surgeon fishes), siganidae (rabbit fishes), and Zanclidae (Moorish idols)
c. *Chaetodontoid*: Chaetodontidae (butterfly fishes) and Pomachantidae (angelfishes).

2.3 Interaction between Coral Reef and Reef Fishes

Variance in species richness has been correlated with variance in habitat complexity (Friedlander *et al.* 2003). Both schooling and solitary fishes are essential residents of the reef ecosystem. According to Robertson (1986), coral reef communities (abundance and structure) are influenced by specific interaction within species.

Interaction between coral reef and reef fishes divided into 3 forms (Choat & Bellwood 1991) such as:

1. Direct interaction as a shelter from predators for young fish.
2. Interactions in search of food for fish that consume benthic biota, including the relationship between reef fish and biota that live on coral and algae.
3. Indirect interactions between coral reef structure and hydrological conditions and sedimentation with foraging habits of planktivores and carnivores.

According to Nybakken (1997), interaction that happened between coral reef and fish in coral reef ecosystems are:

1. Predation. There are two groups of fish that are grazing actively to the coral colonies. Included in this category: (a) species that consume the coral polyp themselves such as puffers (Tetraodontidae), file fish (Monacanthidae), trigger fish (Balistidae) and butterfly fish (Chaetodontidae), and (b) a group of omnivores that remove the coral polyps to obtain either the algae in the coral skeleton or various invertebrates that have bored into the skeleton such as surgeon fish (Acanthuridae) and parrot fish (Scaridae).
2. Grazing. Activity of herbivorous fishes such as Siganidae, Pomacentridae, Acanthuridae and Scaridae to make a pressure for algae and keep the algae reduce to minimum and enhance the survival of coral recruit.

Based on their food habit, Wootton (1992) classified reef fishes into 6 types such as: omnivores, detritivores, herbivores, zooplanktivores, molluscivores and carnivores. Coral fishes make their living in many specialized ways. Some are herbivores, cropping algae, or, like parrot fishes (Scaridae), scraping and biting off coral to obtain the algal symbiont. Others, such as puffer fishes (Tetraodontidae), box fish (Ostraciontidae), gobies, and some damselfishes, eat invertebrates, and these include the filefishes (Monacanthidae) and butterfly fishes that eat the coral polyps themselves, picking their food with their forcepslike mouth. Yet others prey on fishes, such as the trumper fishes (Aulostomatidae) which stalk small fishes by swimming close to other non-predatory fishes (Bone & Moore 2008).

Coral reefs are not only prepared by the reef, but also have a sandy substrate, has a cave, area of algae, as well as other shallow water. Variations in these habitats also resulted in increased diversity of species in coral reefs. Fish species may show a preference for certain habitats. Elliot and Marsical (1995) found different Pomacentridae also showed specific interactions as well as *Amphipiprion* Sp associated with anemones. According to Sale (1991), Reef fish like certain habitats that can support their survival e.g. *Pomacentrus coelestis* that associated with *rubble.*

Fishes can play an essential role in the reef's food web, acting as both predators and prey. Their leftover food scraps and wastes provide food and nutrients for other reef inhabitants. Some of fish like Parrotfish are herbivores and eat the algae within the coral. After they grind the coral's exoskeleton to get to the algae, they form sands.

Some species are known as cleaners, and set up cleaning stations along the reef. When a larger fish want to a cleaning station, a cleaner wrasse removes parasites from the fish. If the same two fish met anywhere else, the larger fish would eat the smaller one. But it appears that different rules apply at the cleaning stations.

The dominance of one or two microhabitat components can have an effect upon the dominance of certain fish families (e.g. Sargassum rich bommies have the highest proportion of fish from the Labridae family). Fish species interact closely with their habitat for the majority of their lives and therefore, there is reason to hypothesize that the distribution and structure of reef fish communities should correlate with variables of the habitats present (McGehee 1994; Ohman & Rajasuriya 1998). Factors previously found to influence reef fish community structure include benthic diversity, habitat complexity, live coral cover, macroalgal cover, depth and exposure. Topographically complex reef habitats or those with high numbers of lifeforms or high benthic diversity might provide more microhabitats, refuge sites, and food resources for a higher number of individuals and species.

Benfield (2008) found a positive relationship between live branching coral cover and the Serranidae. Serranidae that associated closely with branching corals in both habitats and used these structures as refuge sites (e.g. *Epinephelus analogus* and *Serranus psittacinus*).

Herbivores also were positively correlated with live branching coral cover within coral community sites (Ohman & Rajasuriya 1998). Filamentous algae grow on and between the colonies and branches of the coral provide a food source (Ohman & Rajasuriya 1998) and many of the herbivorous members of the Pomacentridae, which were common in this habitat, utilize branching coral for shelter (Wellington 1982; Ohman & Rajasuriya 1998).

Another correlation found by (Dominici-Arosemena & Wolff 2006) who found the presence of massive corals was related to higher levels of species richness and diversity. Thus, massive corals, especially when it reach 1 m diameter increase the variety of growth forms and provide areas of topographical complexity in a landscape of low variability, which attract fish. Massive corals provide microhabitats that offer some food (e.g. crabs, tunicates, bivalves and brittlestars) that increase the fish species richness and change the abundance of certain groups, e.g. Balistidae, invertivores and omnivores.

The positive relationship between Tetradontidae and the abundance of massive corals can be explained by the preference of this family for this food resource (Guzman & Robertson, 1989). In this observation, they found some species found associated with the massive corals were generally larger which would account for the correlation between massive corals and the species length ordination for coral community sites.

Maneuverability is important in the reef habitat, and, as a result, many coral reef fishes have abandoned normal oscillatory swimming except in emergencies and instead flap their pectoral fins (wrasse, parrot fish, and surgeon fishes (Acanthuridae) or the dorsal and ventral unpaired fins (Trigger fishes (Balistidae)), or undulate unpaired fins (seahorses, pipe fishes and trumpet fishes) (Bone & Moore 2008).

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).

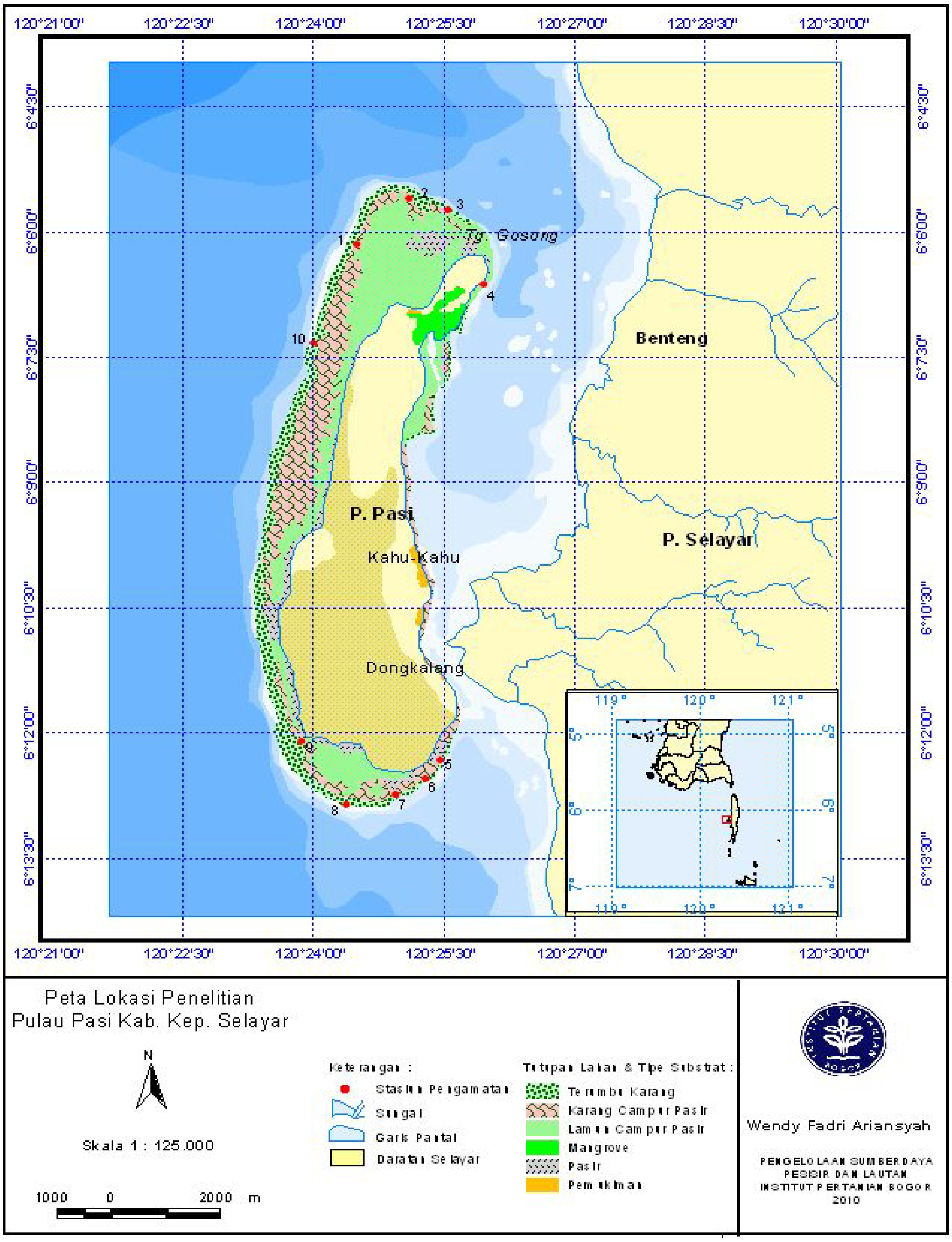

Figure 4 Study sites at Pasi Island.

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 (2001[a,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 m^2 equipped with smaller sized transects 1 x 1 m^2 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 m^2 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 m^2 with the observers were static at one point in the transect (Fig. 6) and record all the fishes contained in this transect (Maduppa 2004).

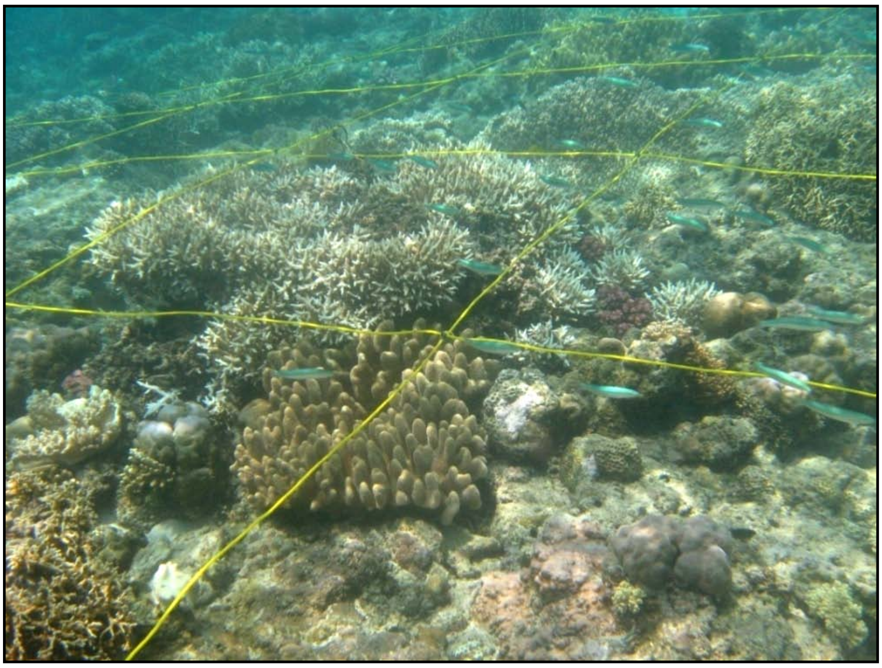

Figure 5 Permanent Quadratic Transect 5 x 5 m^2.

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.

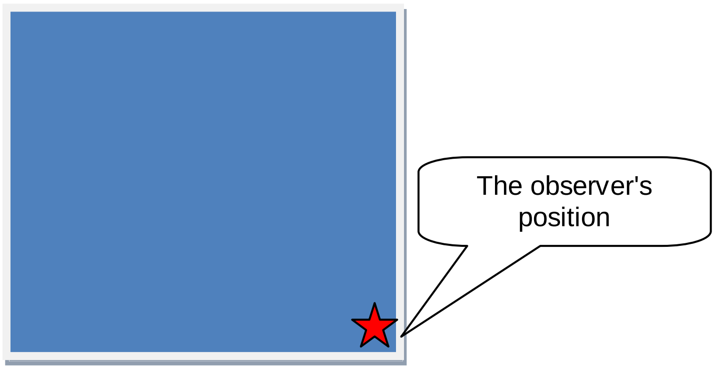

Figure 6 Observer's position on the transect.

3.3 Data Analysis

3.3.1 Life forms Coverage

Life form coverage calculated with:

$$\mathbf{N} = \frac{\mathbf{n_i}}{\mathbf{A}} \mathbf{x\ 100}\ \%$$

where: N = density of coral (colony/m^2)

n_i = coverage of i-life form

A = area coverage (1 x1 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:

$$\mathbf{H'} = \sum_{\mathbf{i=1}}^{\mathbf{s}} \mathbf{pi\ \ln\ pi}$$

where: H' = Shannon-Wiener Diversity Index

s = number of reef fishes species

p = abundance proportion of reef fishes species

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

H’ ≤ 2.30 : slight diversity, very powerful environmental pressure

2.3 < H’ ≤ 3.30 : moderate diversity, intermediate environmental pressure

H’ > 3.30 : high diversity, ecosystem in balance

3.3.2.2 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:

$$\mathbf{E} = \frac{\mathbf{H'}}{\mathbf{H\ max}}$$

where:

E = Evenness Index

Hmax = maximum balance of the species

Index value ranges from 0-1 with the Brower and Zar (1977) criteria:

E ≤ 0.4 : small, depressed communities

0.4 < E ≤ 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:

$$C = \sum_{i=1}^{s} pi^2$$

Where: C = Simpson Dominance Index

Pi = 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:

$$\mathbf{D} = \frac{\sum_{i=0}^{n} |\mathbf{y_{i1}} - \mathbf{y_{i2}}|}{\sum_{i=0}^{n} (\mathbf{y_{i1}} + \mathbf{y_{i2}})}$$

where: D = Bray-Curtis similarity index
Y_{i1} = value of i- parameter on the 1 site
Y_{i2} = 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):

$$C_{ij} = \frac{a_{ij}}{n_i \, . \, n_j}$$

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:

$$F_{ij} = \frac{C_{ij}}{\left(\sum_j a_{ij}\right) / \left(n_i \sum_j n_j\right)}$$

where: F_{ij} = Fidelity index

C_{ij} = Constancy index

- F_{ij} ≥ 2 show a strong level of preference of i-group fish species in j-group of habitats.
- F_{ij} ≤ 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:

a. Extracting important information stored in a table / matrix of large data

b. Producing a graph that facilitates for interpretation

c. Observing a table / matrix data from the similarity viewpoint between individual and the relationship between variables.

4. RESULT AND DISCUSSION

4.1 Environmental Condition at Pasi Island

The result of observation due to physical - chemical parameters and environmental condition at Pasi Island were shown in Table 1. Physical and chemical parameters may indicate whether the coral reefs are in optimal condition for growth or not.

Table 1 The data of physical - chemical parameters at Pasi Island

Parameters	Study Sites										
	1	2	3	4	5	6	7	8	9	10	Avg.
Temperature (^{0}C)	31.4	31.4	31.3	30.2	31.2	31.2	31.5	31.6	31.6	31.0	31.23
Depth (m)	5	7	3	3	6	3	3	3	3	7	4.30
Brightness (%)	100	100	100	100	100	100	100	100	100	100	100%
Current velocity (m/sec)	0.12	0.04	0.04	0.02	0.08	0.03	0.03	0.03	0.03	0.10	0.05
Salinity (‰)	33	32	32	30	32	32	32	32	32	32	31.90

Variation of temperature at each site measured in small value, ranging from 30,2 ^{0}C to 31,6 ^{0}C. The lowest value was obtained at site no. 4 located in the eastern part of the island. The highest value was obtained at site no. 9 located in the southern part of the island. The range of temperature was obtained from the observed at all sites still in a good range for coral growth.

Salinity was obtained at all sites ranged from 30 ‰ to 32 ‰. The lowest value was obtained at site no. 4 while the salinity at other sites is relatively the same. The range of values was obtained show that the salinity in the Pasi Island within the tolerance ranges for coral growth.

Surface current velocity at the sites of the study ranged from 0.02 to 0.12 m / sec. The lowest current velocity at site no. 4 is 0.02 m / s because the station is close to the jetty and near the coast that could reduce its drive, while the highest current velocity at site no. 1 with 0.12 m / sec. Current velocity can affect coral growth because it not only can bring nutrients but also clean up sediments on the reefs. Current velocity also gives negative impact on coral reefs. Current those are too heavy can break the reef and stirring the bottom of waters. The waters become muddy and will disrupt the photosynthesis process of zooxanthellae (Nugeus 2002).

Brightness values were obtained at all sites are 100%. This is related to the depth of water for all sites located in the shallow waters between 3-7 m depth. If the reefs are in the shade or protected from light, the growth will be vulnerable even death if light availability is not sufficient to live. Light were needed by the zooxanthellae whose existence is closely related to the coral growth (Nybakken 1997).

Physical-chemical parameters measured in waters Pasi Island in general are in good condition for supporting coral growth optimally. The results showed that types of coral reefs in Pasi Island, Selayar Islands District categorized as fringing reef. According to Nybakken (1997), fringing reef is coral reef that grew and developed around the islands along the coastline with less than 40 m depth.

4.2 Coral Reef Lifeforms

The observed coral reef ecosystems vary from each station which can be caused by differences in biology, physics and chemistry of waters. Percentage of coral lifeformss obtained is presented in Table 2.

Table 2 shows that the branching *Acropora* (ACB) emerged as dominant at sites no. 2, 4, 6, 7, 8 and 9 with a range value of 46.09% - 89.16%. These high percentages of ACB are due to a fairly shallow waters and slow currents that can help the coral to grow optimally. At site no. 1 dominated by tabular *Acropora* (ACT), encrusting coral (CE) and massive corals (CM). The high presence of coral massif (CM) at this site can be caused by the current that is strong enough compared with other sites. At this site was also obtained for 10.70% of seagrass communities due to the location that the station is bordered by seagrass bed, but was chosen because of the diverse composition of the substrate.

Tabular *Acropora* found in a large quantity at site no. 1, 8 and 10. The existence of this *Acropora* species can provide shading effects to the coral beneath. This shading may slow growth or even increase mortality rates effect for branching corals but does not give impact to the reefs that have massive and encrusting lifeforms (Stimson 1985). Comparison of the composition of each lifeforms can be seen in Figure 7.

Habitat grouping based on coral lifeformss were observed using Bray-Curtis similarity index based on similarity value of coral cover from each site. Sites can be grouped based on similarity characteristics lifeforms. From the result that there are three groups of habitat that have the same characteristics from 10 sites that were observed (Figure 8).

Group of habitats 1 consisting of sites no. 6, 9, 4, 7, 2 and 8 are dominated by branching *Acropora* (ACB), dead coral with algae (DCA) and the presence of *Halimeda* (HA). Group of habitats 2 consists of site no. 1 and 10 are dominated by tabular *Acropora* (ACT), encrusting coral (CE) and massive corals (CM) with a sandy substrate (S). Group of habitats 3 consists of site no. 3 and 5 are dominated by encrusting coral (CE), branching corals (CB), massive coral (CM), soft coral (SC) and the presence of dead coral (DC), dead coral with algae (DCA) and rubble.

Table 2 Percentage of coral lifeforms (in %) from 10 study sites

Category		STUDY SITES									
		1	2	3	4	5	6	7	8	9	10
	DCA	0,52	8,26	3,63	9,11	4,46	1,53	7,58	2,29	2,09	5,66
	DC	1,67	3,86	7,30	1,02	1,79	0,52	0,70	5,50	-	4,10
Acropora	ACB	2,62	46,09	8,90	85,07	30,46	86,66	80,00	40,62	89,16	4,04
	ACD	0,35	0,31	0,70	0,27	0,21	-	-	-	-	0,25
	ACE	0,83	-	0,27	-	0,64	-	-	-	-	-
	ACS	0,64	5,48	0,65	0,13	0,48	-	0,35	0,69	0,15	0,49
	ACT	24,29	1,25	0,38	-	4,92	3,05	1,93	34,99	0,45	22,87
Non Acropora	CB	1,27	5,76	12,59	1,53	-	2,57	0,25	1,84	0,87	18,03
	CE	22,89	13,66	37,32	1,67	44,02	0,93	0,59	1,58	1,20	19,59
	CF	0,49	0,22	0,31	-	0,14	-	-	0,04	-	1,84
	CM	20,99	6,32	5,65	0,13	7,60	0,27	0,13	1,47	0,66	8,41
	CS	0,52	0,30	0,89	-	0,20	0,29	0,38	1,37	0,02	0,26
	CHL	-	-	-	0,06	-	-	-	-	-	-
	CMR	-	-	-	0,42	0,04	-	-	-	-	0,01
Other Fauna	SC	2,69	3,51	15,01	0,15	1,16	0,11	-	0,18	0,03	0,27
	Z0	-	-	0,08	-	0,06	-	-	-	-	0,02
	OT	10,70	0,35	0,36	0,08	1,13	0,01	0,03	-	0,02	0,01
Algae	AA	0,19	-	0,13	-	0,28	0,09	0,41	0,14	0,81	-
	HA	-	-	-	-	0,02	3,96	6,81	2,54	4,29	0,02
	MA	0,04	0,02	-	-	-	-	-	0,03	-	0,20
Abiotic	S	9,30	2,12	4,27	0,36	1,19	0,01	0,84	3,64	-	9,68
	R	-	2,49	1,56	-	1,20	-	-	3,08	0,25	4,25

Group of habitats and their similarities are presented in Table 3. Similarity between sites can be influenced by the physico-chemical factors. Currents affect coral lifeformss, if it too strong can break branching coral and turn around tabular lifeforms, but massive coral more adaptive to the current.

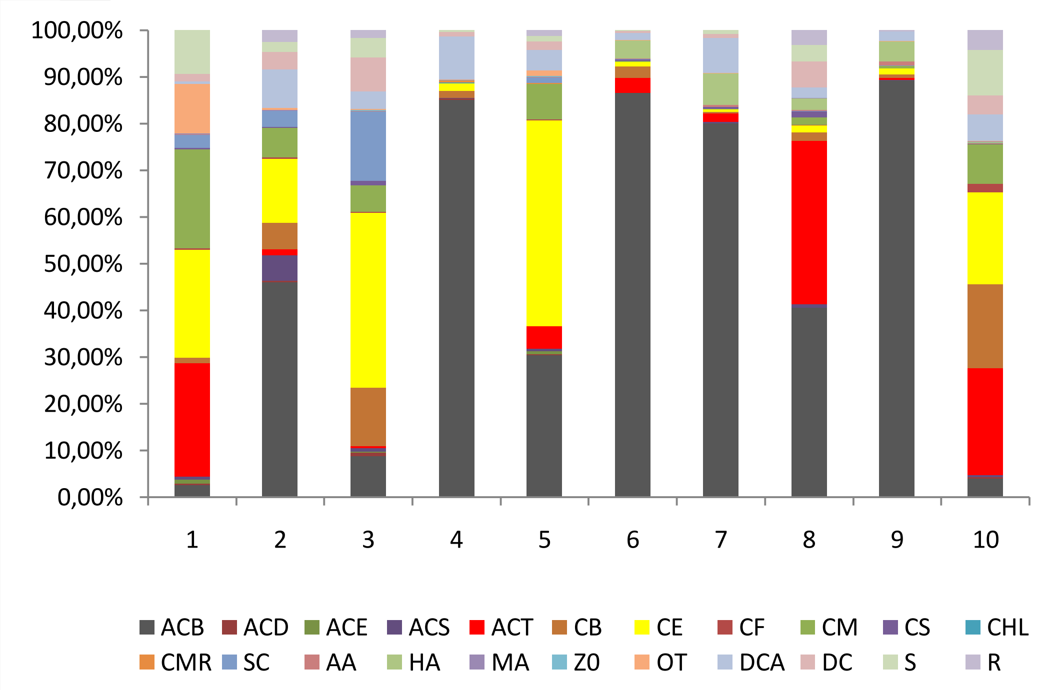

Figure 7 Comparative composition of coral lifeforms (ACB = *Acropora branching*, ACD = Acropora digitate, ACE = *Acropora encrusting*, ACS = Acropora submassive, ACT = *Acropora tabulate*, CB = *coral branching*, CM = *coral massive*, CS = *coral submassive*, CHL = *coral heliopora*, CMR = *coral mushroom*, SC = *soft coral*, AA = *algae assemblages*, HA = *Halimeda*, MA = *macro algae*, ZO = *Zoanthids*, OT = *others*, DCA = *death coral with algae*, DC = *death coral*, S = *sand*, R = *rubble*).

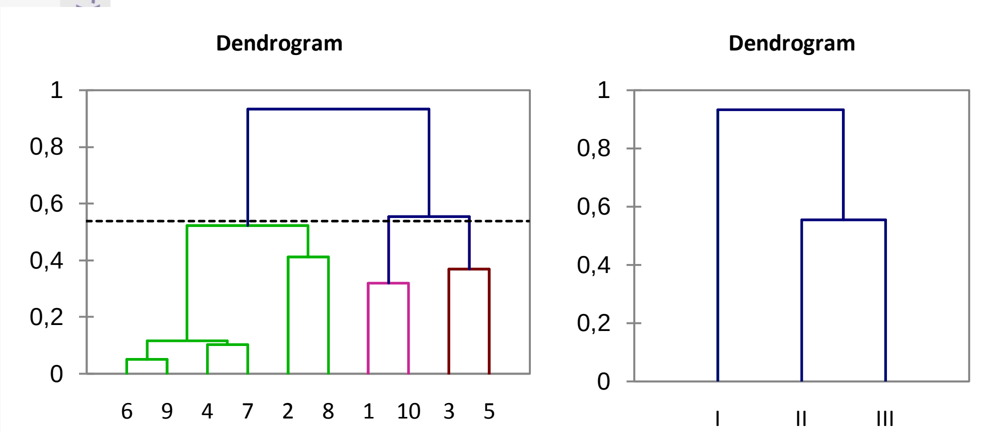

Figure 8 Dendrogram grouping of habitats based on Bray-Curtis Similarity Index.

Coral reef formation requires conditions favorable for the dispersal and recruitment of key species, and the presence of environmental conditions suitable for those species to build reefs (Harriott & Banks 2002). According to Wood (1983), currents not only help the spread of coral larvae, oxygen and food, but also spread the warm water that is necessary for development of reproductive organs and manufacture of calcium carbonate structure of stony corals. From the observation of larvae is known that certain species of coral larvae will attach to the type characteristic of certain waters, such as the larvae that will be the type of massive coral reefs will choose the waters that have low sedimentation, in contrast to coral reefs that have branched lifeforms that can live in areas with highly sedimentation and generally fix to the wall-shaped substrate (Dunno 1982 *in* Babcock & Smith 2000).

Table 3 Characteristics of group of habitats in Pasi Island waters

Group of habitats	Sites	The similarity in the characteristics
I	Sites no. 6, 9, 4, 7, 2 and 8	The habitat dominated by branching Acropora (ACB) lifeforms about 40,62 – 89,16%, dead coral with algae (DCA) about 1,53 – 9,11% and the presence of Halimeda (HA) about 2,54 – 6,81%
II	Sites no. 1 and 10	The habitat dominated by Acropora tabular (ACT) lifeforms about 22,87 – 24,29 %, coral encrusting (CE) about 19,59 – 22,89 % and coral massive (CM) about 8,41 – 20,99 % with a sandy substrate (S) about 9,30 – 9,68 %.
III	Sites no. 3 and 5	The habitat dominated by coral encrusting (CE) lifeforms about 37,32 – 44,02 %, coral massive (CM) about 5,65 – 7,60 %, coral branching (CB) about 12,59 %, soft coral (SC) about 1,16 – 15,01 % and the presence of dead coral (DC) about 1,79 – 7,30 %, dead coral with algae (DCA) about 3,63 – 4,46 % with rubble about 1,20 – 1,50 %.

Porites massive (radial growth rates of 1–2 cm year–1) is relatively slow growing, while *Acropora* corals are capable of very rapid growth (lateral rates of 5–20 cm year–1) once established in a habitat (Done *et al*. 1988; Doherty *et al*. 1997). *Porites*, these corals are considered to have a high tolerance to fluctuations in water quality and other environmental conditions (Nasir 2004; Veron 1992).

4.3 Reef Fish Communities

Fishes were found at 10 study site were 3,990 representing 29 families. Families which are found are Pomacentridae (56.39%), Labridae (8.97%), Acanthuridae (5.54%), Chaetodontidae (4.81%), Caesionidae (4.51%), and 24 other families (19.77%). According to Bell and Galzin (1984), Pomacentridae is the most fishes found on coral reefs and have the highest abundance compared to other families. Observations at several sites show that some genus of

Pomacentridae emerged with a great quantity such as *Abudefduf, Amblyglyphidodon, Chromis, Dascyllus* and *Pomacentru*s.

From the observation, the number of families, species and individuals were found varies between each station at the first and second observations (Table 4). At site no. 1, 3 and 5 there is a difference data between the number of families and species between the first and second observations, while 7 other sites are quite similar. This difference could be due to absent of Dasyatiidae, Muraneiidae, Pomacanthidae, Haemuliidae, Holocentridae, Tetraodontidae, Syngnathidae and Zanclidae. Dasyatiidae and Muraneiidae are a group of hiding fishes, especially on sandy substrate (Kuiter & Tonozuka 2001a) and thus require carefulness in visual observation. Holocentridae is a group of nocturnal fishes that take refuge in the cave during the day (Kuiter & Tonozuka 2001a). Pomacanthidae are a group of fishes that likes to hide in caves and rock crevices and are usually found in deep waters while Tetraodontidae liked the muddy substrate and can be found through estuaries (Kuiter & Tonozuka 2001b).

According to English et al. (1997), from 10 study sites, found 135 species, 74 species are the major fishes, 34 species are the target fishes and 27 species are indicators. Composition for each group is dominated by the major fishes with 75.36%, the target fishes 16.84% and 7.79% indicators fishes.

Density of fishes at all sites varies in the range from 6.08 to 11.32 fishes / m^2; with an average density are 7.98 fishes / m^2. The highest density was obtained at site no. 2 with a range from 10.36 to 11.32 fishes / m^2 and the lowest density was obtained at the site no. 3 with a value of 6.08 to 6.40 fishes / m^2.

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

Reef fish community condition can be known from the Diversity Index (H ') which indicates the size of the community property that is based on the number of species in one site the following number of individuals in the species. Evenness Index (E) is similarity between the number of individuals in one community between species, and dominance index (C) was used to observe whether there is dominance by a particular species in an ecosystem.

Table 4 shows that the diversity index (H ') ranged with value from 3.49 to 4.13. The highest values found at a first observation on site no. 1. This indicates that this site has a more diverse species than any other site.

Table 4 Shannon-Wiener Diversity Index (H'), Evenness Index (E) and Simpson Dominance Index (C)

First observation

	Sites									
	1	2	3	4	5	6	7	8	9	10
Number of Fishes	259	265	156	176	229	172	183	204	160	195
Families	24	23	25	19	21	20	21	19	19	21
Species	81	73	59	55	66	56	47	58	47	66
Density	10.36	10.60	6.24	7.04	9.16	6.88	7.32	8.16	6.40	7.80
Diversity Index (H')	4.13	3.91	3.88	3.75	3.89	3.80	3.52	3.87	3.49	3.84
Evenness Index (E)	0.94	0.91	0.95	0.94	0.93	0.94	0.91	0.95	0.91	0.92
Dominance Index (C)	0.02	0.03	0.02	0.02	0.02	0.02	0.04	0.02	0.04	0.03

Second observation

	Sites									
	1	2	3	4	5	6	7	8	9	10
Number of Fishes	248	283	155	179	266	172	155	202	152	179
Families	19	25	20	19	24	23	21	19	19	18
Species	61	65	59	57	82	57	51	58	45	61
Density	9.92	11.32	6.20	7.16	10.64	6.88	6.20	8.08	6.08	7.16
Diversity Index (H')	3.75	3.82	3.76	3.78	4.11	3.82	3.61	3.87	3.58	3.91
Evenness Index (E)	0.91	0.92	0.92	0.93	0.93	0.94	0.92	0.95	0.94	0.95
Dominance Index (C)	0.03	0.03	0.02	0.02	0.02	0.02	0.03	0.02	0.03	0.02

Evenness Index (E) ranged from 0.91 to 0.95. This value is close to value 1 which means that the number of individuals among species in all sites is almost the same. Simpson Dominance Index (C) ranges from 0.02 to 0.04. The smaller value of dominance index, especially that close to the value 0, meaning that the least of dominance of a species in the site.

The difference values were obtained are influenced by environmental factors. Different environmental factors were giving a different effect on reef fish communities (Chabanet & Letourneur 1995). The physical properties of complex habitats on the reef have a correlation to the diversity of fish communities (Luckhurst & Luckhurst 1978; Chabanet et al. 1997).

Abundance of fishes related with habitat characteristics, especially the coral cover and the complex nature of topography (Conell & Kingsford 1998). This is supported by the arrangement of the complex architecture of the substrate that form a variety of refuge (shelter) for a variety of fauna (Chabanet *et al.* 1997).

4.3.2 Grouping of Fishes Based on Sorensen Similarity Index

Fish were observed at all study sites are grouped at the species level to form a dendrogram based on Sorensen similarity index. The results from the

Sorensen similarity index at the level 66.7% indicated that there were 21 groups of reef fish species that exist on the Pasi Island.

Grouping is meant to find the similarities of fish species observed at all study sites based on the number of stations that have certain fish species. Characteristics of each group of fishes species based on Sorensen similarity index are presented in Appendix 4.

4.3.3 Association of Coral Reefs and Reef Fish

Groups of reef fishes have a preference for certain habitats. Grouping of reef fishes based on its habitat shown in Table 5 and comparisons between groups of fish indicators, major and target are presented in Figure 9.

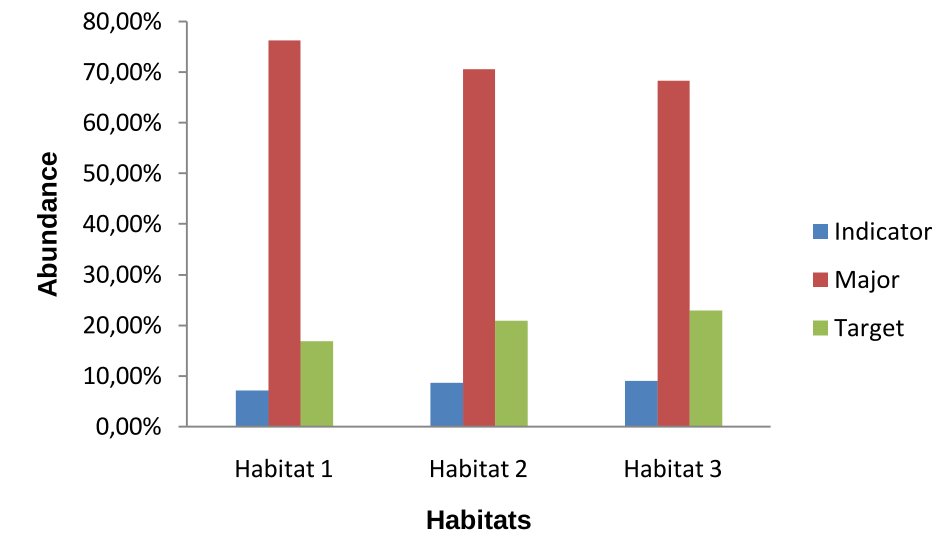

Figure 9 Comparison of groups of reef fishes based on habitat.

Figure 10 shows that group of the habitat 1, which is dominated by branching *Acropora* (ACB), dead coral with algae (DCA) and the presence of *Halimeda* (HA) has a fewer percentage of the fish indicators than other habitats, but this habitats are favored by group of small major fish from Pomacentridae supported by a higher presence than any other habitat. Branching corals provide shelter for small fish from predators. Chaetodontidae as indicators species found abundant in this habitat, this is consistent with the opinion of Bouchon Navarro *et al.* (1985) which states that the fish Chaetodontidae generally associated with the branching *Acropora*, while Gomez *et al.* (1988) found an association between *Chaetodon trifasciatus* with a high percentage of branching *Acropora*. The existence of the Chaetodontidae on group of habitats no. 1 does not directly make the percentage indicators species in this group became abundant. This is influenced by the absence of the family Scaridae as another indicator species which are also associated with the corals. According Nybakken (1997), Scaridae (parrotfish) prefer a massive lifeforms.

Habitat also affects the composition of fish. Composition of fish based on the dominant family is presented in Figure 10. Group of target fishes, found with the highest percentage obtained in the group of habitats no. 3. This is because the group of this habitat has a substrate ranging from coral encrusting (CE), massive coral (CM), branching corals (CB), soft coral (SC) and the presence of dead coral with algae (DCA) so that the fish target generally carnivores and herbivores like this habitat because it provides a variety of food it needs. Group of fishes target with a prominent presence on group of habitats no. 3 is *Acanthurus leucocheilus* and *Siganus virgatus* which is the algae-feeder herbivores and Caesioniidae specifically *Caesio cuning* and *Caesio teres* which are planktivora.

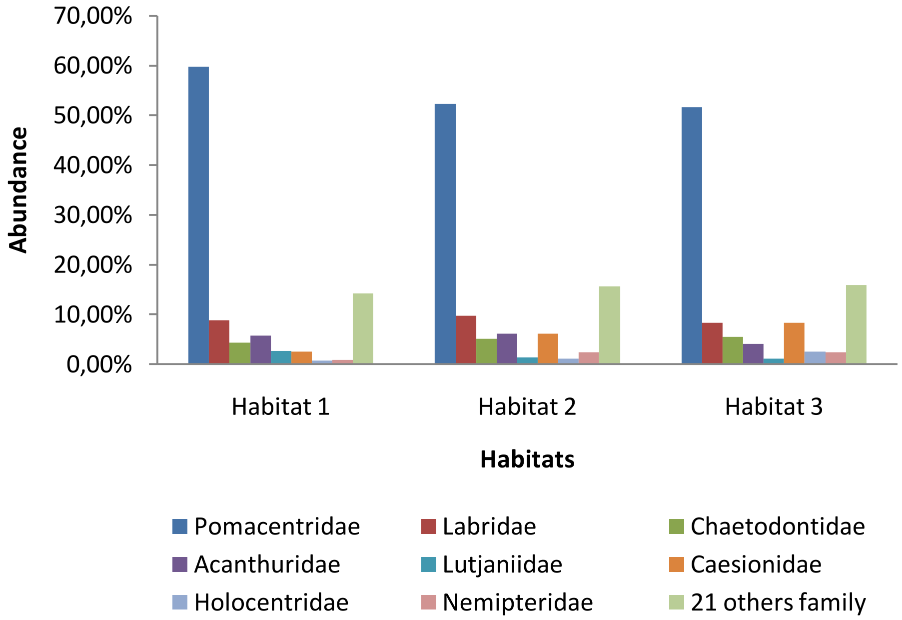

Figure 10 Comparison of families of reef fish based on habitats.

Figure 10 shows that Pomacentridae found dominantly with the range of values from 51.61 to 59.66%. Composition of five largest families were found in habitat no 1: Pomacentridae with 59.66%, Labridae with 8.90%, Acanthuridae with 5.82%, Chaetodontidae with 4.43% and Lutjaniidae 2.69%. Habitat no 2 are dominated by Pomacentridae with 52.21%, Labridae with 9.76%, Acanthuridae with 6.13%, Chaetodontidae with 6.13% and Caesioniidae with 5.11% while habitat no. 3 are dominated by Pomacentridae with 51.61%, Labridae with 8.31%, Caesioniidae with 8.31%, Chaetodontidae with 5.58% and Acanthuridae with 4.09%.

Pomacentridae as the dominant families found in this study were small fishes, territorial and living on the reef. Pomacentridae can be omnivor, planktivor and herbivore. Pomacentridae generally with small size, found usually hiding among the cracks and branching corals. A numbers of species that have different trophic levels are able to tolerate a variety of habitats caused Pomacentridae could associated with various coral lifeforms, so that these groups can be found dominant in all groups of habitats.

The results showed that Caesioniidae were found abundant in group of habitats no. 3 which is dominated habitat by encrusting coral (CE) and coral massif (CM) than in group of habitats no. 2, which is dominated tabular *Acropora* (ACT) as well as a group of habitats no. 1 that dominated by branching *Acropora* (ACB). Caesoniidae like coral cliffs and slope structure and take advantage of hydrological characteristics to hold, maintain and collect plankton (Choat & Bellwood 1991).

The fish that have been grouped will be known preferences based on their habitat through the nodules analysis. The nodules analysis is based on the results of grouping habitat and reef fish by combining data obtained from Bray-Curtis index and the Sorensen Index which then formed a data matrix by placing the group of fishes on the row and the group of habitats on the side of the column. Nodules analysis composed of Constancy Index and Fidelity Index. The value of Constancy Index of all groups of fishes to groups of habitat throughout the study sites were presented in Table 5.

Table 5 Grouping of reef fish based on habitat

Habitat	Sites	Lifeforms	Fishes			
			Group	Family	The dominant species	%
1	2, 4, 6, 7, 8, 9	Habitat dominated by branching *Acropora* lifeforms (ACB), dead coral with algae (DCA) and the presence of *Halimeda* (HA).	Indicators	Chaetodontidae, Pomachantidae, Scaridae, Zanclidae	*Chaetodon auriga, Chaetodon citrinellus, Chaetodon trifasciatus, Zanclus cornutus*	7,08%
			Major	Apogonidae, Aulostomidae, Balistidae, Blenniidae, Gobiidae, Labridae, Nemipteridae, Ostraciidae, Plotosidae, Pomacentridae, Pseudochromidae, Syngnathidae, Tetraodontidae	*Apogon apogonides, Cirrhilabrus cyanopleura, Thalassoma hardwickii, Abudefduf sexfasciatus, Amblyglyphidodon curacao, Amblyglyphidodon leucogaster, Chromis margaritifer, Chromis viridis, Dascyllus aruanus, Pomacentrus bankanensis*	76,16%
			Target	Acanthuridae, Caesionidae, Dasyatidae, Ephippidae, Haemulidae, Holocentridae, Lethrinidae, Lutjanidae, Mullidae, Muraenidae, Serranidae, Siganidae,	*Acanthurus leucocheilus, Naso caeruleacaudus, Caesio cuning, Lutjanus ehrengergii, Macolor niger,*	16,76%
2	1, 10	Habitat dominated by tabular *Acropora* lifeforms (ACT), encrusting coral (CE) and massive corals (CM) with a sandy substrate (S).	Indicators	Chaetodontidae, Pomachantidae, Scaridae, Zanclidae	*Heniochus varius, Chaetodon citrinellus, Scarus dimidiatus*	8,63%
			Major	Aulostomidae, Balistidae, Blenniidae, Labridae, Nemipteridae, Plotosidae, Pomacentridae, Pseudochromidae, Syngnathidae, Tetraodontidae	*Amblyglyphidodon batunai, Abudefduf sexfasciatus, Amblyglyphidodon curacao, Amblyglyphidodon leucogaster, Chromis retrofasciata, Pomacentrus nigromarginatus*	70,49%
			Target	Acanthuridae, Caesionidae, Dasyatidae, Ephippidae, Haemulidae, Holocentridae, Lethrinidae, Lutjanidae, Mullidae, Muraenidae, Serranidae, Siganidae,	*Acanthurus leucocheilus, Caesio cuning, Caesio teres*	20,89%
3	3, 5	Habitat dominated by encrusting coral lifeforms (CE), branching corals (CB), massive coral (CM), soft coral (SC) and the presence of dead coral (DC), dead coral with algae (DCA) and rubble.	Indicators	Chaetodontidae, Pomachantidae, Scaridae, Zanclidae	*Chaetodon citrinellus, Chaetodon auriga, Chelmon rostratus, Scarus bleekeri*	8,93%
			Major	Aulostomidae, Balistidae, Gobiidae, Labridae, Nemipteridae, Ostraciidae, Plotosidae, Pomacentridae, Pseudochromidae, Syngnathidae, Tetraodontidae	*Amblyglyphidodon batunai, Abudefduf sexfasciatus, Amblyglyphidodon curacao, Chromis retrofasciata, Pomacentrus nigromarginatus, Chrysiptera oxycephala*	68,24%
			Target	Acanthuridae, Caesionidae, Dasyatidae, Ephippidae, Haemulidae, Holocentridae, Lethrinidae, Lutjanidae, Mullidae, Muraenidae, Serranidae, Siganidae,	*Acanthurus leucocheilus, Caesio cuning, Caesio teres, Siganus virgatus*	22,83%

Table 6 Constancy Index (C_{ij}) groups of fishes to groups of habitats

Group of fishes	Species	Groups of habitat		
		I	II	III
1	*Acanthurus leucocheilus, Ctenochaetus truncates, Abudefduf sexfasciatus, Amblyglyphidodon curacao, Chromis amboinensis, Chromis margaritifer, Chromis viridis, Chrysiptera parasema, Dascyllus trimaculatus, Zanclus cornutus, Acanthurus pyroferus, Ctenochaetus striatus, Chrysiptera unimaculata, Lethrinus olivaceus, Chromis retrofasciata, Pomacentrus bankanensis, Stegastes fasciolatus, Dascyllus aruanus, Chaetodon wiebeli, Chromis xanthochira, Labracinus cyclophthalmus, Platax teira, Ctenochaetus binotatus, Zebrasoma scopas, Cheilinus fasciatus, Scarus hypselopterus, Heniochus varius, Amblyglyphidodon leucogaster, Pomacentrus nigromarginatus, Chromis lepidolepis, Chrysiptera oxycephala, Naso lituratus, Thalassoma lunare, Aulostomus chinensis, Halichoeres hortulanus, Chrysiptera rollandi, Hologymnosus annulatus, Chaetodon auriga, Scarus flavipectoralis, Chaetodon citrinellus, Cirrhilabrus adornatus, Amblyglyphidodon aureus, Amblyglyphidodon batunai, Coris gaimard, Pomacentrus auriventris, Hemigymnus melapterus, Dischitodus melanopus, Pomacentrus moluccensis, Pomacentrus alexanderae, Labrichthys unilineatus, Pseudanthias huchtii, Lethrinus harak, Lutjanus ehrengergii, Macropharyngidon ornatus, Scolopsis ciliata, Cephalopholis boenak, Abalistes stellatus, Chelmon rostratus, Plotosus lineatus, Scarus dimidiatus, Caesio cuning, Gymnothorax fimbriatus, Corythoichthys intestinalis, Halichoeres melanurus, Taeniura lymma, Thalassoma hardwickii, Scolopsis bilineatus, Plectropomus areolatus, Diproctacanthus xanthurus, Siganus vulpinus*	0.70	0.82	0.86
2	*Chaetodon lineolatus, Heniochus acuminatus, Myripristis adusta, Cephalopholis argus*	0.50	0.38	0.63
3	*Melichthys indicus, Chello inermis, Sufflamen bursa, Centropyge vrolikii*	0.50	0.38	0.25
4	*Plectorhynchus lineatus, Lutjanus decussatus, Scolopsis margaritifer, Canthigaster solandri, Acanthochromis polyacanthus, Cheilinus celebicus, Scolopsis lineata*	0.43	0.57	0.64
5	*Aeoliscus strigatus, Parupeneus spilurus, Caesio teres, Cirrhilabrus ryukyuensis, Parupeneus barberinus, Siganus virgatus, Cetoscarus bicolor*	0.19	0.50	0.71
6	*Chaetodon melanotus, Halichoeres prosopeion, Bodianus mesothorax, Chaetodon rafflesii, Plectorhynchus vittatus, Diagramma pictum, Plectorhynchus gatterinoides, Halichoeres richmondi, Pomacanthus semicirculatus, Cirrhilabrus cyanopleura*	0.57	0.55	0.65
7	*Choreodon anchorago, Parupeneus multifasciatus, Doryrhampus dactiliophorus, Arothron nigropunctatus, Cephalopholis micropion, Lethrinus lentjan*	0.44	0.58	0.42
8	*Amphiprion akindynos, Pomacanthus imperator*	0.08	0.50	0.50
9	*Naso caeruleacaudus, Chaetodon kleinii*	0.33	0.75	0.25
10	*Chaetodon trifasciatus, Scarus bleekeri*	0.58	0.00	0.50
11	*Sufflamen chrysopterus, Coris pictoides, Chaetodon vagabundus, Epinephelus bontoides*	0.54	0.63	0.13
12	*Meiacanthus ditrema*	0.33	0.50	0.00
13	*Myripristis vittata, Pictichromis paccagnellae, Macolor niger, Parupeneus bifasciatus*	0.29	0.50	0.63
14	*Pterocaesio tile, Ptereleotris evides*	0.17	0.25	0.50
15	*Rhinomuraena quaesita*	0.17	0.00	0.50
16	*Apogon apogonides*	0.17	0.00	0.00
17	*Lutjanus lutjanus, Lutjanus vitta*	0.33	0.25	0.00
18	*Heniochus pleurotaenia*	0.17	0.00	0.00
19	*Lactoria cornuta, Pygoliptes diacanthus*	0.33	0.00	0.25
20	*Chaetodon baronessa, Chlorurus sordidus*	0.00	0.50	0.00
21	*Pomacanthus sexstriatus*	0.00	0.50	0.00

The result of Constancy Index (C_{ij}) showed that there were no groups of fish species that have high constancy in a group of habitats (C_{ij} = 1) because there is no group of fishes that can exist on all members of a particular group of habitats. There were 10 groups of fish species from 21 groups of species that have a moderate level (0.5 < C_{ij} <1) of the groups of habitat: group of fishes no. 1 against group of habitats I, II and III, group of fishes no. 2 to groups of habitat III, group of fishes 4 to groups of habitat II and III, group of fishes no. 5 to the groups of habitat III, group of fishes 6 to groups of habitat I, II and III, group of fishes no. 7 to the groups of habitat II, group of fishes no. 9 to the groups of habitat II, group of fishes no. 11 of groups of habitat I and II habitats and group of fishes no. 13 to groups of habitat III.

Almost all the fishes of Pomacentridae and Achanthuridae, most fishes from the families Labridae and Scaridae and some fishes from the family Chaetodontidae were included in the group of fishes no. 1 has a high constancy of all groups of habitats. This group has the largest member with 70 species of fishes.

Other species groups that have a moderate level above 0.70 was group of fishes no. 5 which membered *Aeoliscus strigatus, Parupeneus spilurus, Caesio teres, Cirrhilabrus ryukyuensis, Parupeneus barberinus, Siganus virgatus, Cetoscarus bicolour* prefer to the groups of habitat III that dominated by encrusting coral lifeforms (CE), branching corals (CB), massive coral (CM), soft coral (SC) and the presence of dead coral (DC), dead coral with algae (DCA) and rubble and group of fishes no. 9 which member *Naso caeruleacaudus dan Chaetodon kleinii* that prefer to the groups of habitat II that dominated by tabular *Acropora* lifeforms (ACT), encrusting coral (CE) and massive corals (CM) with a sandy substrate (S).

Some groups of fishes have low levels of constancy (0.0 < Cij <0.5) and there was even a group of fishes species that did not have a level of constancy (Cij = 0). The Value at low levels of constancy means that most members of the group of fishes did not appear on the habitat. This value was related to the small number of fish species of the group members which are in a group of fishes such as no. 8, 9, 10, 14, 17, 19 and 20 which only has two members of fish species. The absence of species in small groups would have implications for the low level of constancy.

The results obtained in Constancy Index (C_{ij}) were used to find level of fidelity a group of fishes to certain habitats. Groups of fishes will have high preferences if the value of $F_{ij} \geq 2$. Groups of fish species that have a moderate preference with $1.0 \leq Fij \leq 2.0$ whereas those fish species that have a low preference with $0.0 \leq Fij \leq 1.0$ and even have a group of fishes species that are considered not like or tend to avoid of particular a groups of habitat if its value $Fi_j = 0$. Fidelity Index groups of fish species against groups of habitat can be seen in Table 7.

According to Table 7, group of habitats I which was dominated by branching *Acropora* lifeforms (ACB), dead coral with algae (DCA) and the presence of *Halimeda* (HA) was a habitat that has medium and low preference for almost all groups of fish species. Fidelity Index (F_{ij}) showed that there were no groups of fish species that have a high preference of this group of habitats.

Branching Acropora (ACB) was a habitat that is occupied by several groups of fishes, serve as a refuge for small fish from predators and the place settled during the day for nocturnal fishes. The fishes were identified prefer sheltering in branching corals are *Amblyglyphiddodon curacao, Chromis amboinensis, Chromis viridis, Chromis retrofasciata, Chrysiptera parasema, Dascyllus aruanus, Hemigymnus melapterus, Labrichthys unilineatus, Pomacentrus molluccensis* dan *Siganus vulpinus* (Fishbase 2010).

Pomacentridae found in abundance in group of habitats I. This group of habitats was not preferred or tend to be avoided by the group of fishes no. 20 (*Chaetodon baronessa, Chlorurus sordidus*) and group of fishes no. 21 (*Pomocanthus sexstriatus*) based on the value of $F_{ij} = 0$. Allen (2004) was stated that *Pomacanthus sextriatus* can be found in areas which have rich coral growth and high vertical relief of lagoon and seaward reefs.

Group of habitats II was habitat dominated by tabular *Acropora* lifeforms (ACT), encrusting coral (CE) and massive corals (CM) with a sandy substrate (S) a habitat that has a high preference for the fish from the group of fishes no. 8 (*Amphiprion akindynos, Pomocanthus imperator*), group of fishes no. 20 (*Chaetodon baronessa, Chlorurus sordidus*) and group of fishes no. 21 (*Pomacanthus sexstriatus*). *Pomacanthus imperator* inhabits ledges and caves in areas of rich coral growth on clear lagoon, channel, or seaward reefs, feed on sponges and other encrusting organisms.

Table 7 Fidelity Index (F_{ij}) groups of fish species against groups of habitats

Group of fishes	Species	Groups of habitat		
		I	II	III
1	*Acanthurus leucocheilus, Ctenochaetus truncates, Abudefduf sexfasciatus, Amblyglyphidodon curacao, Chromis amboinensis, Chromis margaritifer, Chromis viridis, Chrysiptera parasema, Dascyllus trimaculatus, Zanclus cornutus, Acanthurus pyroferus, Ctenochaetus striatus, Chrysiptera unimaculata, Lethrinus olivaceus, Chromis retrofasciata, Pomacentrus bankanensis, Stegastes fasciolatus, Dascyllus aruanus, Chaetodon wiebeli, Chromis xanthochira, Labracinus cyclophthalmus, Platax teira, Ctenochaetus binotatus, Zebrasoma scopas, Cheilinus fasciatus, Scarus hypselopterus, Heniochus varius, Amblyglyphidodon leucogaster, Pomacentrus nigromarginatus, Chromis lepidolepis, Chrysiptera oxycephala, Naso lituratus, Thalassoma lunare, Aulostomus chinensis, Halichoeres hortulanus, Chrysiptera rollandi, Hologymnosus annulatus, Chaetodon auriga, Scarus flavipectoralis, Chaetodon citrinellus, Cirrhilabrus adornatus, Amblyglyphidodon aureus, Amblyglyphidodon batunai, Coris gaimard, Pomacentrus auriventris, Hemigymnus melapterus, Dischitodus melanopus, Pomacentrus moluccensis, Pomacentrus alexanderae, Labrichthys unilineatus, Pseudanthias huchtii, Lethrinus harak, Lutjanus ehrengergii, Macropharyngidon ornatus, Scolopsis ciliata, Cephalopholis boenak, Abalistes stellatus, Chelmon rostratus, Plotosus lineatus, Scarus dimidiatus, Caesio cuning, Gymnothorax fimbriatus, Corythoichthys intestinalis, Halichoeres melanurus, Taeniura lymma, Thalassoma hardwickii, Scolopsis bilineatus, Plectropomus areolatus, Diproctacanthus xanthurus, Siganus vulpinus*	0.92	1.09	1.14
2	*Chaetodon lineolatus, Heniochus acuminatus, Myripristis adusta, Cephalopholis argus*	1.00	0.75	1.25
3	*Melichthys indicus, Chello inermis, Sufflamen bursa, Centropyge vrolikii*	1.18	0.88	0.59
4	*Plectorhynchus lineatus, Lutjanus decussatus, Scolopsis margaritifer, Canthigaster solandri, Acanthochromis polyacanthus, Cheilinus celebicus, Scolopsis lineata*	0.86	1.14	1.29
5	*Aeoliscus strigatus, Parupeneus spilurus, Caesio teres, Cirrhilabrus ryukyuensis, Parupeneus barberinus, Siganus virgatus, Cetoscarus bicolor*	0.53	1.40	2.00
6	*Chaetodon melanotus, Halichoeres prosopeion, Bodianus mesothorax, Chaetodon rafflesii, Plectorhynchus vittatus, Diagramma pictum, Plectorhynchus gatterinoides, Halichoeres richmondi, Pomacanthus semicirculatus, Cirrhilabrus cyanopleura*	1.19	1.15	1.35
7	*Choreodon anchorago, Parupeneus multifasciatus, Doryrhampus dactiliophorus, Arothron nigropunctatus, Cephalopholis micropion, Lethrinus lentjan*	0.95	1.25	0.89
8	*Amphiprion akindynos, Pomacanthus imperator*	0.33	2.00	2.00
9	*Naso caeruleacaudus, Chaetodon kleinii*	0.83	1.88	0.63
10	*Chaetodon trifasciatus, Scarus bleekeri*	1.30	0.00	1.11
11	*Sufflamen chrysopterus, Coris pictoides, Chaetodon vagabundus, Epinephelus bontoides*	1.14	1.32	0.26
12	*Meiacanthus ditrema*	1.11	1.67	0.00
13	*Myripristis vittata, Pictichromis paccagnellae, Macolor niger, Parupeneus bifasciatus*	0.73	1.25	1.56
14	*Pterocaesio tile, Ptereleotris evides*	0.67	1.00	2.00
15	*Rhinomuraena quaesita*	0.83	0.00	2.50
16	*Apogon apogonides*	1.67	0.00	0.00
17	*Lutjanus lutjanus, Lutjanus vitta*	1.33	1.00	0.00
18	*Heniochus pleurotaenia*	1.67	0.00	0.00
19	*Lactoria cornuta, Pygoliptes diacanthus*	1.33	0.00	1.00
20	*Chaetodon baronessa, Chlorurus sordidus*	0.00	5.00	0.00
21	*Pomacanthus sexstriatus*	0.00	5.00	0.00

Chaetodon baronessa occur in lagoon and seaward reefs and feed exclusively on the polyps of the tubular *Acropora* corals and swim in pairs and territorial (Myers 1991). *Chlorurus sordidus* inhabit both coral rich and open pavement areas of shallow reef flats and lagoon and seaward reefs, as well as drop-offs, behaving differently in various areas, feed on benthic algae (Nguyen & Nguyen 2006).

Group of habitats II was not preferred / avoided by the group of fishes no. 10 (*Chaetodon trifasciatus, Scarus bleekeri*), group of fishes no.15 (*Rhinomuraena quaesita*), group of fishes no.16 (*Apogon apogonides*), group of fishes no.18 (*Heniochus pleurotaenia*) and group of fishes no.19 (*Lactoria cornuta, Pygoliptes diacanthus*). *Chaetodon trifasciatus* occur in coral-rich lagoons and semi-protected seaward reefs, territorial and aggressive to other *Chaetodon*, swim in pairs. This species feed exclusively on coral polyps, particularly of the *Pocillopora* type (Kuiter & Tonozuka 2001b) are classified into branching coral (CB). *Scarus bleekeri* found in clear coastal and inner reefs; in lagoons and channel reefs; feed mainly on algae (Kuiter & Tonozuka 2001b). *Apogon apogonides* didn't like group of habitats II because this fishes are a nocturnal predator, usually inhabit rocky substrates along the shore (Letourneur *et al.* 2004). Other species that avoid this group of habitats is *Lactoria cornuta* that inhabit the coast on sandy or muddy habitats, can also be found near the harbor and estuary. This fish can also be found in weedy areas near rocks or reefs (Kuiter & Tonozuka 2001c).

Group of habitats III was habitat dominated by encrusting coral lifeforms (CE), branching corals (CB), massive coral (CM), soft coral (SC) and the presence of dead coral (DC), dead coral with algae (DCA) and rubble highly preferred by group of fishes no. 5 (*Aeoliscus strigatus, Parupeneus spilurus, Caesio teres, Cirrhilabrus ryukyuensis, Parupeneus barberinus, Siganus virgatus, Cetoscarus bicolour*), group of fishes no. 8 (*Amphiprion akindynos, Pomacanthus imperator),* group of fishes no. 14 (*Pterocaesio tile, Ptereleotris evides)* and group of fishes no. 15 (*Rhinomuraena quaesita*). According to Kuiter and Tonozuka (2001a), *Aeoliscus strigatus* live in seagrass beds, and may also inhabit open sandy substrate and rubble. *Caesio teres* found primarily around coral reefs, with a preference for coralline lagoons, often on outer reef slopes or in passes washed by strong currents (Carpenter 1988). *Parupeneus barberinus* inhabit large sand patches as well as sand and rubble areas of reef flats, and lagoon and seaward reefs (Broad 2003). *Siganus virgatus* from the group of fishes no. 5, inhabit shallow coastal waters, around hard coral reefs and areas of sand with patches of rock and soft coral, tolerant of murky waters (Kuiter & Tonozuka 2001c). *Cetoscarus bicolor usually* inhabit dense coral and algae habitats (Kuiter & Tonozuka 2001c). *Amphiphirion akyndinos* occurs in lagoon and outer reefs and asscociated with soft coral (Randall *et al.* 1990). *Rhinomuraena quasita,* a secretive species normally hidden in sand or rubble, sometimes with only its head protruding (Allen 2004).

This group of habitats III avoided by group of fishes no. 12 (*Meiacanthus ditrema*), group of fishes no. 16 (*Apogon apogonides*), group of fishes no. 17 (*Lutjanus lutjanus, Lutjanus vita*), group of fishes no. 18 (*Heniochus pleurotaenia*), group of fishes no. 20 (*Chaetodon baronessa, Chlorurus sordidus)* group of fishes no. 21 (*Pomacanthus sexstriatus*). According to Kuiter & Tonozuka (2001a), *Meicanthus ditrema* usually inhabit reef slopes with large soft-coral communities, form schools in shallow protected reefs and feeds on zooplankton. *Lutjanus lutjanus,* a carnivore that likes sandy or muddy substratum (Shao & Chen 1992), while *Lutjanus Vitta* occurs in inshore waters of the continental shelf, inhabits the vicinity of coral reefs, also areas with flat bottoms and occasional low coral outcrops, sponges, and sea whips (Broad 2003).

Analysis using Principle Component Analysis (PCA) for 3 groups of habitats and group of fishes can be found on Figure 11. The result was shown that diversity on the first factorial axis is very high. The power of information at each major axis is measured from the eigenvalue, because with the eigenvalue, characteristic can be evaluated to explain variety from the each axis. Two main axes can explain 92.61% total variance. The first factorial axis with eigenvalue 2.40 can explain 79.99% of variance from cluster data while the second factorial axis has eigenvalue 0.38 and explain 12.62% of variance.

Fishes that asscociated with group of habitats 1 were no. 108 (*Pomacentrus bankanensis*), 106 (*Pomacentrus moluccensis*), 109 (*Stegastes fasciolatus*), 101 (*Dascyllus aruanus*), 94 (*Chromis retrofasciata*), 98 (*Chrysiptera parasema*), 91 (*Chromis amboinensis*), 95 (*Chromis viridis*), 103 (*Dischitodus melanopus*), 135 (*Zanclus cornutus*). These groups dominated by Pomacentridae with small and flatfish. group of habitats I which was dominated by branching *Acropora* lifeforms (ACB), dead coral with algae (DCA) and the presence of *Halimeda* (HA) was a habitat preference by Pomacentridae because these habitat provide space for shelter from predators for small fish on the sidelines of the branching corals.

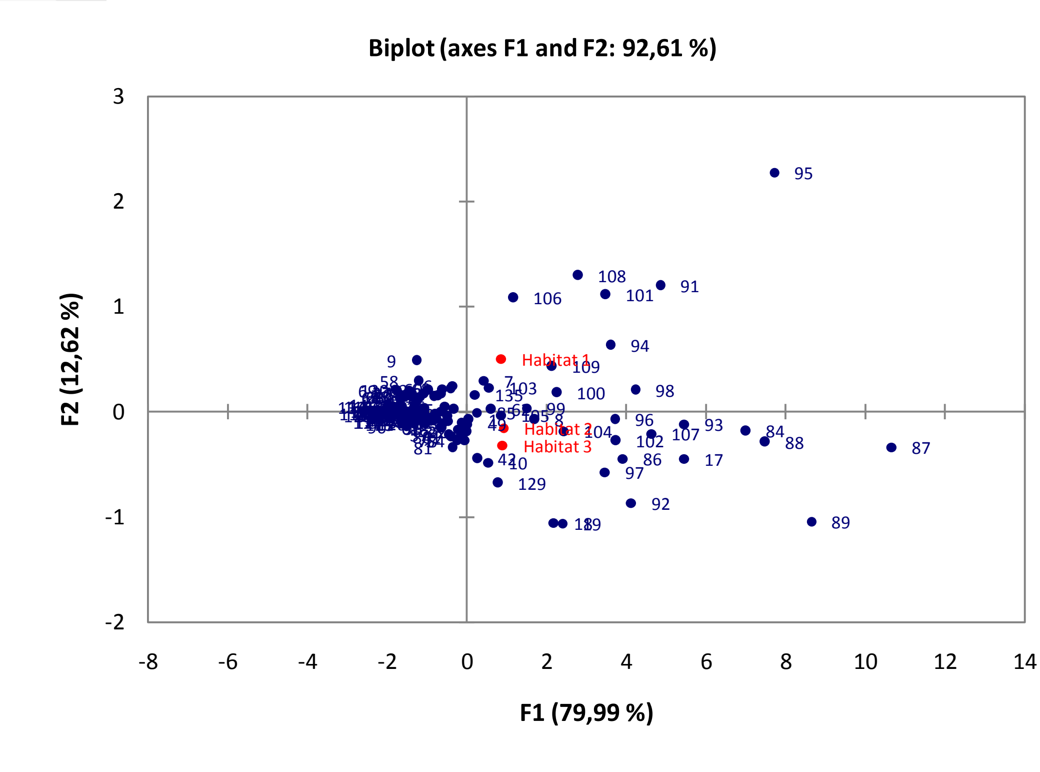

Figure 11 Principle Component Analysis (PCA) for 3 groups of habitats.

Fishes that asscociated with group of habitats 2 were no. 52 (*Coris pictoides*), 49 (*Cirrhilabrus cyanopleura*), 8 (*Zebrasoma scopas*), 104 (*Pomacentrus alexanderae*), 96 (*Chromis xanthochira*), 102 (*Dascyllus trimaculatus*), 107 (*Pomacentrus nigromarginatus*), 93 (*Chromis margaritifer*), 84 (*Abudefduf sexfasciatus*), 88 (*Amblyglyphidodon leucogaster*). This fishes prefer to habitat that dominated by tabular Acropora lifeforms (ACT), encrusting coral (CE) and massive corals (CM) with a sandy substrate (S)

Group of habitats III was habitat dominated by encrusting coral lifeforms (CE), branching corals (CB), massive coral (CM), soft coral (SC) and the presence of dead coral (DC), dead coral with algae (DCA) and rubble preferred by fishes no. 42 (*Myripristis vittata*), 10 (*Aeoliscus strigatus*), 129 (*Siganus virgatus*), 18 (*Caesio teres*), 19 (*Pterocaesio tile*), 97 (*Chrysiptera oxycephala*), 86 (*Amblyglyphidodon aureus*), 17 (*Caesio cuning*), 92 (*Chromis lepidolepis*), 89 (*Amblyglyphidodon batunai*).

4.3.4 Preference of Habitat by Reef Fishes Based on Coral Lifeforms

Various lifeforms of corals provide habitat for various types of reef fishes. Most of reef fishes active in the daytime (diurnal) and only a few species are active at night (nocturnal). When rest in the daytime, nocturnal fishes burrow in the reef and will be replaced by diurnal fish at night. The function as a sanctuary of coral reefs for fishes was one of the associations between fishes and habitat structure (Sale 1991). Most of reef fishes are sedentary, associated with certain coral lifeforms and territory, but as moving organism, its existence in a habitat is strongly influenced by environmental factors.

Corals with fish grow faster and have greater reproductive output than those without fish (Liberman et al. 1995). The resident fish can benefit their host coral through several mechanisms.

1. The coral can utilize nutrients excreted by the fish, enhancing its growth (Meyer & Schultz 1985).
2. The fish can protect the coral from predators such as the crown-of-thorns sea star *Acanthaster planci* (Weber and Woodhead 1970) and butterfly fishes (Liberman et al. 1995).
3. The fish swimming in and out of the coral during the day may resuspend sediment and clear the coral branches of settling particles (Liberman et al. 1995).

During the day, the fishes forage for zooplankton near the coral, using the coral as a shelter from occasional predators or other dangers (e.g., storms). After sunset, the fishes retreat to the coral and spend the entire night among its branches (Fishelson & Avidor 1974).

If environmental conditions are changing and not suitable for a type of fishes will encourage fish to move. Movement related to tidal conditions and time (Samiloys 1998; Conel & Kingsford 1998). In addition, environmental condition, especially current, water quality and wave will also affect the behavior of fishes. According to Bell and Galzin (1984) on the sandy substrate, predation has important factor affecting on reef fish abundance than the percentage of coral cover.

Pomacentridae as the dominant family found in this study were small fishes, territorial and stay close to the substrate and was influenced by morphological characteristics of the substrate (Roberts & Ormond 1987), even some of them utilize corals as habitat rather than as a food source (Sano *et al.*

1984 *in* Chabanet *et al.* 1997), but some of these groups also erode the mucus in Scleractenia coral colonies (Sorokin 1993). Herbivorous Pomacentridae was territorial and usually in a group less than planktivorous. Plantivorous was usually schooling. Small-sized fishes were usually hiding among the cracks and branching of the corals, while others can be found on open reefs and sandy substrate and will swim fast if get disturbance. A number of species that have different trophic levels were able to tolerate a variety of habitats caused Pomacentridae be associated with various coral lifeforms and made these groups can be found at all study sites.

Labridae as the second largest group generally liked the complex reef structure that was able to provide shelter for a variety of sizes and groups of invertebrates. Labridae can be found in all coral lifeformss because these group able to tolerate a variety of habitats (Chabanet & Letourneur 1995).

Acanthuridae was the third largest group found in this study. The group was classified as herbivorous fish; eat filamentous and unicellular algae that covered surface of the death corals (Montgomery 1990; Gerking 1994; Kuiter & Tonozuka 2001c).

Chaetodontidae was a group of fishes that has a wide variety of food ranging from coral, plankton, invertebrates, algae, sponges, and some types of algae (FishBase 2010). Chaetodontidae have strong relationships with coral reefs and they were obligate corralivores (Bouchon-Navarro *et al.* 1985). Metabolism or energy requirements of the Chaetodontidae highly related to the health of coral reefs so these coral predator species was a potential as an indicator of the change on coral reefs (Crosby & Reese 1996). Some of species from Chaetodontidae that have been studied as indicators of environmental change is *Chaetodon multicinctus, C. ornatissimus, C. trifasciatus, and C. unimaculatus* (Hourigan *et al.* 1988).

Caesioniidae are planktivorous fishes, usually form schooling to find food (Kuiter & Tonozuka 2001b). According to Choat and Bellwood (1991), Caesoniidae prefer to coral cliffs and use hydrological characteristics on coral reefs to hold, maintain and collect plankton.

4.3.5 Reef Fishes Trophic Level at Study Sites

Reef fish have different food preferences. Identification using by FishBase (2010) of the fishes at Pasi Island found was 13.78% of fishes were herbivore, 22.56% were carnivore, 31.63% were omnivores, 3.76% were corallivora, 26.04% were planktivora and 2.23% were detritivora. The composition of reef fishes at the Pasi Island was presented in Figure 12.

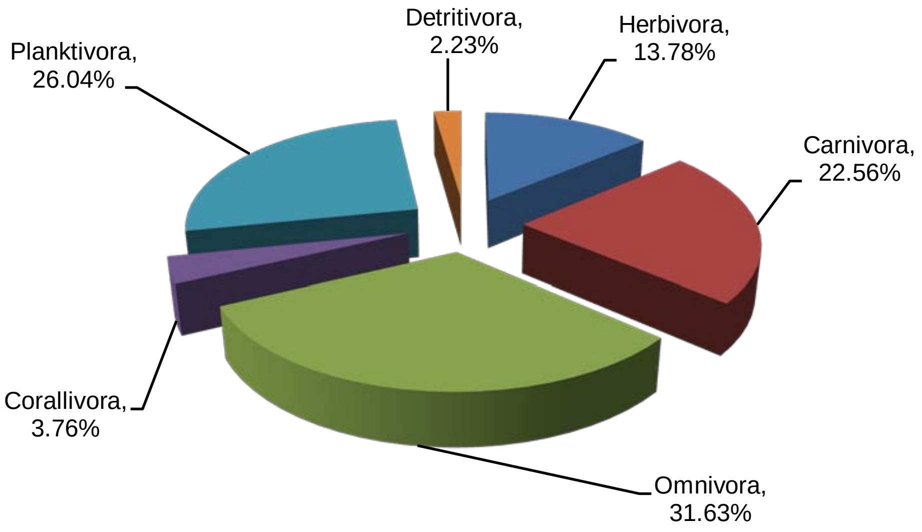

Figure 12. The composition of reef fishes at the Pasi Island.

Figure 13 presents the composition of reef fish based on site and time observation (in the morning and afternoon). There are no significant differences on reef fish's trophic levels composition between 2 times observations.

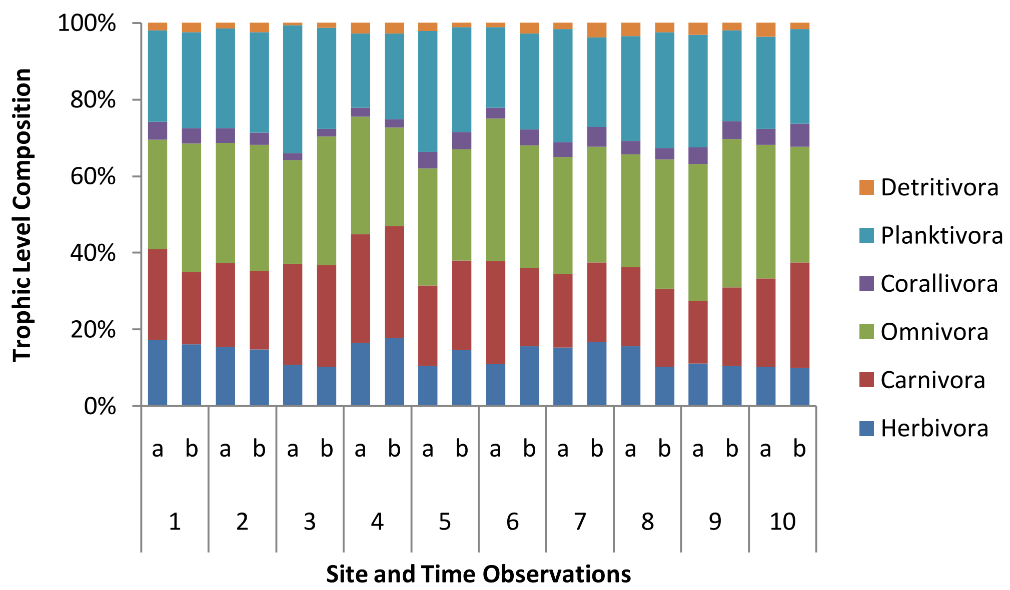

Figure 13 Reef fishes trophic levels composition (a = morning; b = afternoon).

Based on group of habitats, the presence of reef fish on trophic levels can be observed in Figure 14. Different group of habitats give approximately the same result of trophic level composition. Group of habitats I which was dominated by branching *Acropora* lifeforms (ACB), dead coral with algae (DCA) and the presence of *Halimeda* (HA) consist of herbivore (14,37%), carnivore (21,97%), omnivore (32,22%), corallivora (3,52%), planktivora (25,45%), detritivora (2,48%).

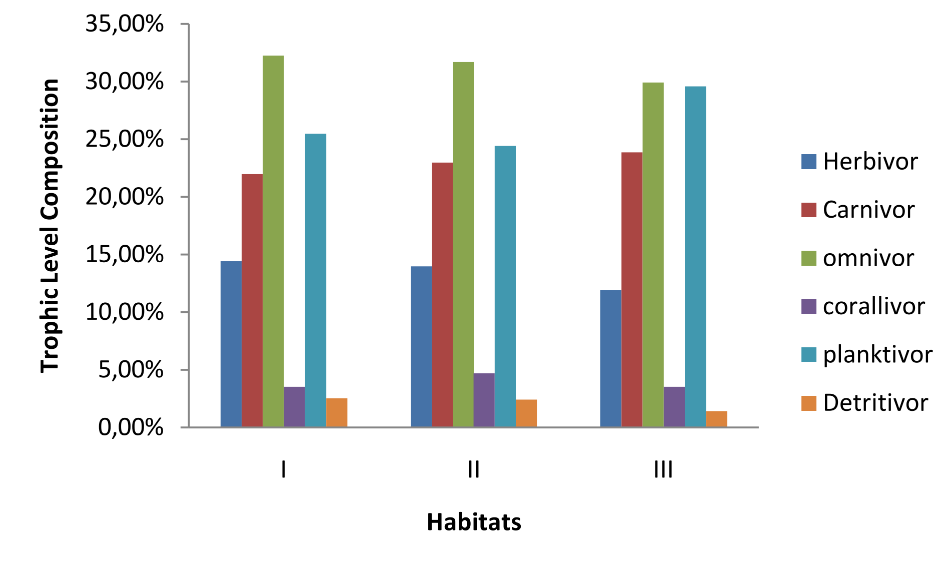

Figure 14 Reef fishes trophic levels based on group of habitats.

Group of habitats II was habitat dominated by tabular Acropora lifeforms (ACT), encrusting coral (CE) and massive corals (CM) with a sandy substrate (S) consist of herbivore (13,96%), carnivore (22,93%), omnivore (31,67%), corallivora (4,65%), planktivora (24,40%), detritivora (2,38%) while Group of habitats III was habitat dominated by encrusting coral lifeforms (CE), branching corals (CB), massive coral (CM), soft coral (SC) and the presence of dead coral (DC), dead coral with algae (DCA) and rubble forming by herbivore (11,91%), carrnivore (23,82%), omnivore (29,90%), corallivora (3,47%), planktivora (29,53%) and detritivora (1,36%).

The difference can be observed from this result that number of herbivores from group of habitats 1 was more than other habitats due to the presence of death coral with algae (DCA) in this habitat. The presence of DCA was able to attract Acanthurus and Zebrasoma from Acanthuridae and Siganus from Siganiidae to come and exploit filamentaus algae that cover rocks and the death corals. The presence of algae in the coral reef ecosystem supported herbivorous fish (Chabanet *et al.* 1997; Gobler *et al.* 2006, FishBase 2010).

Group of habitats III which was an area that has an open topography with rock cliffs and the rubble was preferred by predators such as *Lutjanus* from Lutjaniidae, *Cephalopholis* from Serranidae and *Chello* and *Heliocheres* of the Labridae. Huntsman and Waters (1981*) in* Connell and Kingsford (1998) argues that life in the bottom waters is a very important factor for the fish predators such as the Serranidae and Lutjaniidae especially in asscociation to habitats that provide the potential prey. *Cheillinus, Coris, Heliochoeres* and *Thalassoma* were the main group of the Labridae generally identified as a carnivore that exploit existing sessile biota on coral reefs by eating invertebrates such as crustaceans, mollusca and small fishes (Choat & Belwood 1991; Kuiter 1992; Pattengill *et al.* 1997; FishBase 2010). In this group of habitats found abundant planktivorous fishes due to the existence of Caesioniidae that eat zooplankton (Kuiter 1992).

Pomacentridae as the largest group generally omnivore, consumption different kinds of invertebrates, zooplankton and algae (Kuiter 1992; FishBase 2010). The group that identified as omnivor are *Abudefduf, Amblyglyphidodon, Dascyllus* and *Pomacentrus*, most of Chromis and Chrysiptera are planktivor while group consist of Dischitodus and Premnas feed on algae (FishBase 2010). Group of Stegastes that was found was *Stegastes fasciolatus*, prefer to habitat that consist of dead coral dense with filamentous algae (Gobler *et al.* 2006) and generally feed on detritus (detritivor) and algae (FishBase 2010).

Chaetodontidae was a group of fishes commonly used as an indicator of the coral reefs condition (Hourigan et al. 1998). Chaetodontidae feed on coral polyps and invertebrate animals hiding around the coral. Algae were also found as an important food component for many species of Chaetodontidae (Choat & Bellwood, 1991).

Serranidae (grouper) was a carnivore groups that are economically important fish in the fishery. The existence of this group at certain location estimated with it behavior, because this fishes are classified as large predators that are always moving and not an ordinary territorial species (Samiloys 1997).

Scaridae feed on algae. With strong and sharp teeth, this fishes eroded dead coral and rock to obtain algae (Kuiter 1992). Because of this behavior, Scaridae caused erosion on coral reefs and was active to form the coral sand. One adult Scaridae can produce 500 kg / year of sand (White 1987).

Parupeneus classified into Mullidae that live close to the substrate. These fishes are carnivorous, living by eating invertebrate animals (invertebrate feeders) in coral reefs (Pattengil *et al.* 1997).

At sites no. 6, 7, 8 dan 9 found 2,54 – 6,81 % *Halimeda* Sp. The existence of *Halimeda* which was plant did not increase the abundance of herbivorous fishes. *Halimeda* less preferred by the fish because it contains the structure of calcium carbonate in their tissue. McClanahan *et al.* (2002) states that some types of Pomacentridae, Scaridae, Acanthuridae and Labridae were observed did not give positive effect to reduce the amount of macro algae *Halimeda*.

4.4 Management of Reef Fishes

Total of 135 species from 29 families of reef fish found in the waters of Pasi Island, Selayar Islands District. Majority of this fishes have high economical value and important for ornamental and fish consumption. The development of mariculture through the floating net cages in this area with using natural seed would increase the activity to exploit the reef fish resources. Coral reef ecosystems as a shelter to reef fishes will also get more ecological pressure. The increased pressure is certainly to threaten the existence and survival of coral reef ecosystems and its biota.

Observation for all reef fishes species, 127 species classified into not evaluated (NE) in the IUCN Red List Status which means that these species have not been evaluated according to IUCN criteria, whereas 8 species have been included in the list. The fishes were included in the IUCN Red List status is presented in Table 8.

Taeniura lymma classified as target fishes; inserted into stingrays; migrates in groups into shallow sandy areas during the rising tide to feed on mollusks, worms, shrimps, and crabs; disperses on falling tide to seek shelter in caves and under ledges; commonly caught by fisheries operating over shallow coral reefs and probably adversely affected by dynamite fishing (Michael 1993). *Cephalopholis argus* was classified as grouper; highly economic fishes; in Hong Kong live fish markets (Lee & Sadovy 1998). *Cephalopholis boenak* used as a food fish and ornamental fish (Fisbase 2010); inhabit sandy habitats and dead corals (Kuiter & Tonozuka 2001a). *Cephalopholis microprion* and *Epinephelus bontoides* inhabit reef habitats in shallow water and muddy (Kuiter & Tonozuka 2010a); are fish consumption. *Plectropomus areolatus* before actual spawning around full moon, the species aggregates along channels and are responsive to baited hooks, making them vulnerable to fishermen; upward movements of some to take baited hooks presumably mistaken for courtship or spawning behavior. In the Hong Kong live fish markets (Myers 1999). According to Cheung *et al.* (2005) *Plectropomus areolatus* has *high vulnerability*.

Table 8 The fishes were included in the IUCN Red List status at Pasi Island

Species	Category	Explanations
Taeniura lymma	*Lower Risk: near threatened (LR/NT)*	Reduction of the stock and starting vulnerable in the future
Cephalopholis argus	*Least Concern (LC)*	Reduction of the stock
Cephalopholis boenak	*Least Concern (LC) , IUCN Grouper and Wrasse Specialist Group*	Reduction of the stock
Cephalopholis microprion	*Least Concern (LC)*	Reduction of the stock
Epinephelus bontoides	*Data deficient (DD) , IUCN Grouper and Wrasse Specialist Group*	Inadequate information to make a direct, or indirect, assessment of its risk of extinction based on its distribution and/or population status.
Plectropomus areolatus	*Vulnerable (VU)*	The existence of species in danger, a decline in population size of ≥ 50% in 10 years in some areas, A reduction is a decline in the number of mature individuals so that populations become smaller and limited.
Cromileptes altivelis	*Vulnerable (VU), IUCN Grouper and Wrasse Specialist Group*	The existence of species in danger, a decline in population size of ≥ 50% in 10 years in some areas, A reduction is a decline in the number of mature individuals so that populations become smaller and limited.
Doryrhamphus dactyliophorus	*Data deficient (DD)*	Inadequate information to make a direct, or indirect, assessment of its risk of extinction based on its distribution and/or population status.

Cromileptes altivelis generally inhabits lagoon and seaward reefs and are typically found in dead or silty areas; also found around coral reefs and in tide pools; growth was very slow (Myers 1999); feed on small fishes and crustaceans; juveniles are commonly caught for the aquarium trade while adults are utilized as a food fish; in Hong Kong live fish markets (Lee & Sadovy 1998). *Doryrhamphus dactyliophorus* inhabits tide pools, lagoons, and outer reef slopes; found in caves and crevices; the male carries the eggs in a brood pouch which is found under the tail (Breder & Rosen 1966 *in* Fishbase 2010); has been reared in captivity (Lange 1989 *in* Fishbase 2010).

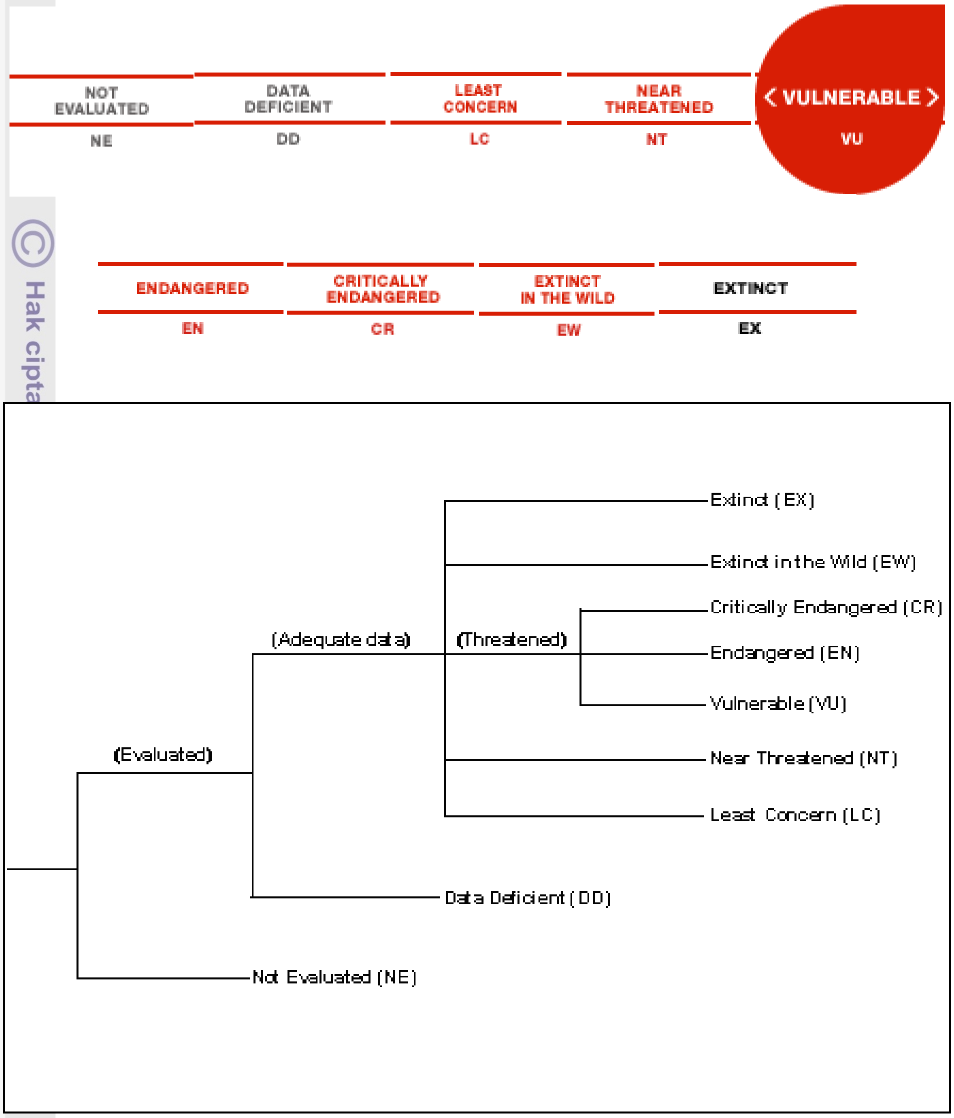

Figure 15. The V*ulnerability level in* IUCN Red List status.

4.5 Management of Coral Reefs as Fish Sanctuary

The declaration of Pasi Island as Marine Protected Area (MPA) is an effort to maintain the condition of coral reef ecosystems in this as well as to ensure sustainability of fish resources. Reef fish resources are renewable dynamical aquatic resources that recovery capabilities determined by the productivity of aquatic environment to support the process of recruitment and growth to achieve a dynamic balance due to natural mortality or fishing activities. The presence of reef fish stocks is strongly influenced by fishing activities or natural death or other activities that can inhibit the growth and recruitment (habitat destruction of coral reefs and ecosystem imbalances).

According to PP no. 60 / 2007, Conservation of fish species was conducted in order: (a) to protect endangered fish species, (b) to maintain the diversity of fish species, (c) to maintain balance and stability of ecosystems, and (d) use of fish resources sustainably.

Observations on habitat preference of coral reef fishes based on their habitats becomes important because of certain reef fish like certain habitats as well as avoid some of the other habitats. This is important as basic management of reef fish resources as well as overall management of conservation areas.

Important things to manage MPA at Pasi Island in order to function as expected:

1. Reducing the rate of degradation of coral reef ecosystems
   - Identifying and mapping the causes of damage to coral reefs. Observation of the damage to coral reefs in Pasi Island, most identified is the result of human activities such as the discovery of bleaching tabular Acropora coral colonies due to destructive fishing; fracture of branched corals caused by ship anchors; and damage to reefs caused by the installation of trap to catch fish.
   - Perform counselling against destructive activities, including destructive fishing
   - Perform planning rehabilitation of damaged coral reef ecosystem
2. Empowering people whom deal directly with coral reefs:
   - Developing new sources of income in the form of sustainable alternative livelihoods
   - Develop community awareness of the importance of managing coral reef ecosystems, so that will appears a sense of responsibility through counselling, training and education
   - Provide authority for communities to manage coral reef ecosystem themselves in accordance with local wisdom
3. Manage and develop a conservation area in accordance with the characteristics of ecosystems and its potential
   - Identify potential utilization of MPA
   - Balancing economic aspects of utilization of MPA with the preservation of ecosystems to sustainable development.

5. CONCLUSIONS AND SUGGESTIONS

5.1 Conclusions

Based on this research, the relationship between coral lifeforms and reef fishes in the waters of Pasi Island, Selayar Islands District can be summarized as follows:

1. There are 3 groups of reef habitats in the waters of Pasi Island such as habitat that dominated by branching *Acropora* (ACB), dead coral with algae (DCA) and the presence of *Halimeda* (HA); habitat that dominated by tabular *Acropora* ACT), encrusting coral (CE) and massive corals (CM) with a sandy substrate (S); and habitat that dominated by encrusting coral (CE), branching corals (CB), massive coral (CM), soft coral (SC) and the presence of dead coral (DC), dead coral with algae (DCA) and rubble.
2. Pomacentidae found dominant in the branching corals which use it as shelter from predators. The existence of death coral with algae (DCA) are able to attract the fishes *Acanthurus* and *Zebrasoma* from Acanthuridae and *Siganus* from Siganiidae to come and exploit filamentaus algae that cover rocks and the death corals. Caesoniidae like coral cliffs habitats that capable of holding, maintaining and collecting plankton.
3. Habitat that dominated tabular *Acropora* ACT), encrusting coral (CE) and massive corals (CM) with a sandy substrate (S) are the habitats with highly preferences for *Amphiprion akindynos, Pomacanthus imperator, Chaetodon baronessa, Chlorurus sordidus, Pomacanthus sexstriatus*; habitat that dominated by encrusting coral (CE), branching corals (CB), massive coral (CM), soft coral (SC) and the presence of dead coral (DC), dead coral with algae (DCA) and rubble preferred by *Aeoliscus strigatus, Parupeneus spilurus, Caesio teres, Cirrhilabrus ryukyuensis, Parupeneus barberinus, Siganus virgatus, Cetoscarus bicolour, Amphiprion akindynos, Pomacanthus imperator, Pterocaesio tile, Ptereleotris evides, Rhinomuraena quaesita*.

5.2 Suggestions

To obtain a comprehensive understanding of the relationship between reef fish species, habitat selection based on coral lifeforms to support the conservation areas and conservation of aquatic species need to be done a variety of advanced research on:

1. Observation for specific fishes, mainly for territorial fishes; fish that have strong preference to certain coral lifeforms and fish began endangered both diurnal and nocturnal observations.
2. Community structure in temporary; feeding habits of reef fish, especially fish that strong associated with coral lifeforms.

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APPENDICES

Appendix 1. The fishes were found at Pasi Island, Selayar Islands District

NO	Family	Species	GR	T.L	Site no. 1		Site no. 2		Site no. 3		Site no. 4		Site no. 5		Site no. 6		Site no. 7		Site no. 8		Site no. 9		Site no. 10	
1	**Acanthuridae**	*Acanthurus leucocheilus*	T	H	5	2	2	2	0	1	0	2	2	2	2	0	1	1	2	0	2	0	2	0
2		*Acanthurus pyroferus*	T	H	1	0	1	0	1	1	1	1	0	1	0	0	0	1	1	1	1	1	1	0
3		*Ctenochaetus binotatus*	T	D	2	1	1	2	1	2	2	0	2	0	0	2	0	1	2	2	0	0	2	0
4		*Ctenochaetus striatus*	T	H	1	0	1	0	1	1	0	2	0	1	0	0	2	0	1	1	2	0	1	1
5		*Ctenochaetus truncatus*	T	H	2	1	2	1	1	0	0	2	1	0	2	2	0	2	0	2	0	2	2	0
6		*Naso caeruleacauda*	T	H	0	4	5	5	0	0	0	0	0	0	0	0	0	0	5	4	0	0	0	5
7		*Naso lituratus*	T	H	0	0	3	0	3	3	4	0	0	0	0	3	3	3	4	3	3	4	3	3
8		*Zebrasoma scopas*	M	H	4	4	5	8	4	0	0	5	0	5	3	3	0	3	0	0	0	0	4	3
9	**Apogonidae**	*Apogon apogonides*	M	C	0	0	0	0	0	0	10	12	0	0	0	0	0	0	0	0	0	0	0	0
10	**Aulostomidae**	*Aeoliscus strigatus*	M	C	4	4	0	0	4	0	0	0	4	4	0	0	0	0	4	4	0	0	0	0
11		*Aulostomus chinensis*	M	C	0	0	1	0	0	1	1	1	0	1	0	0	0	0	0	1	0	0	1	0
12	**Balistidae**	*Abalistes stellatus*	M	C	0	1	0	1	0	1	0	0	1	0	0	1	0	0	0	0	1	1	0	0
13		*Melichthys indicus*	T	O	1	0	0	0	0	1	0	0	0	0	1	0	0	1	0	0	0	0	0	0
14		*Sufflamen bursa*	M	O	0	0	0	0	0	0	0	1	0	0	1	0	0	1	0	0	0	0	0	0
15		*Sufflamen chrysopterus*	M	C	1	0	0	0	0	1	0	1	0	0	0	0	0	1	0	0	1	0	0	0
16	**Blenniidae**	*Meiacanthus ditrema*	M	P	5	5	0	0	0	0	0	0	0	0	0	0	0	0	5	5	1	0	0	0
17	**Caesionidae**	*Caesio cuning*	T	P	5	10	15	15	5	0	0	0	15	12	4	5	0	0	5	10	0	0	0	0
18		*Caesio teres*	T	P	15	7	0	0	5	0	0	0	5	5	0	0	0	0	0	0	0	0	0	0
19		*Pterocaesio tile*	T	P	10	7	0	0	0	0	0	0	8	12	0	0	5	0	0	0	0	0	0	0
20	**Chaetodontidae**	*Chaetodon auriga*	I	O	1	2	2	1	2	2	2	1	2	1	1	2	0	0	1	2	0	0	0	0
21		*Chaetodon baronessa*	I	CO	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
22		*Chaetodon citrinellus*	I	O	2	2	0	2	2	2	2	2	2	2	2	2	0	0	0	2	0	0	0	2
23		*Chaetodon kleinii*	I	CO	0	0	0	2	0	0	0	0	2	0	0	0	0	0	2	0	0	0	0	2
24		*Chaetodon lineolatus*	I	O	2	0	2	0	2	2	2	2	0	0	0	0	0	0	0	0	2	0	0	0
25		*Chaetodon melanotus*	I	CO	0	0	0	0	0	0	0	0	0	2	2	0	0	0	0	0	0	0	2	2
26		*Chaetodon rafflesii*	I	CO	0	0	0	0	0	0	0	2	0	2	0	2	0	0	0	0	0	0	2	4
27		*Chaetodon trifasciatus*	I	CO	0	0	2	2	0	0	0	0	2	0	0	0	0	2	2	2	0	2	0	0
28		*Chaetodon vagabundus*	I	O	2	0	0	0	0	0	0	2	0	0	0	0	2	0	0	2	0	2	0	0
29		*Chaetodon wiebeli*	I	H	2	0	0	0	0	2	2	0	0	2	0	0	2	0	2	2	2	0	0	2
30		*Chelmon rostratus*	I	CO	2	2	0	2	2	2	0	0	2	0	2	0	0	2	0	0	2	0	0	0
31		*Heniochus acuminatus*	I	CO	2	0	2	0	0	0	2	0	0	2	0	0	2	2	0	0	2	0	0	0
32		*Heniochus pleurotaenia*	I	CO	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
33		*Heniochus varius*	I	CO	2	2	2	1	1	1	0	0	2	2	0	1	2	0	0	2	0	2	2	2
34	**Dasyatidae**	*Taeniura lymma*	T	C	0	1	0	1	0	0	0	0	1	0	0	1	0	0	0	0	0	0	1	1
35	**Ephippidae**	*Platax teira*	T	O	0	0	0	0	2	2	2	0	0	2	2	0	2	2	2	2	2	2	2	2
36	**Gobiidae**	*Ptereleotris evides*	M	P	0	0	0	0	0	0	0	0	0	2	0	0	4	2	0	0	0	0	0	0

Appendix 1. (continue)

NO	Family	Species	GR	T.L	Site no. 1		Site no. 2		Site no. 3		Site no. 4		Site no. 5		Site no. 6		Site no. 7		Site no. 8		Site no. 9		Site no. 10	
37	**Haemulidae**	*Diagramma pictum*	T	C	2	0	0	0	0	0	1	1	0	1	2	0	0	0	0	0	0	0	2	2
38		*Plectorhynchus gatterinoides*	T	C	0	0	2	2	0	0	1	0	2	0	2	2	0	0	0	0	0	0	2	2
39		*Plectorhynchus lineatus*	T	C	2	0	0	0	1	1	2	0	0	3	3	2	0	0	0	0	0	0	0	0
40		*Plectorhynchus vittatus*	T	C	0	0	0	0	0	0	1	0	0	1	1	0	0	0	0	0	0	0	2	2
41	**Holocentridae**	*Myripristis adusta*	T	C	3	0	3	5	0	0	0	3	5	5	0	0	0	0	0	0	0	0	0	0
42		*Myripristis vittata*	T	P	0	0	3	4	4	5	0	0	0	2	0	0	0	0	0	0	0	0	3	4
43	**Labridae**	*Bodianus mesothorax*	M	C	0	0	1	1	0	0	0	0	1	0	2	1	1	1	0	0	2	1	0	2
44		*Cheilinus celebicus*	M	CO	1	0	0	0	0	0	2	2	0	2	1	0	0	0	0	0	0	0	0	0
45		*Cheilinus fasciatus*	T	C	0	2	2	2	1	1	1	1	2	1	1	1	0	1	0	0	0	0	2	1
46		*Chello inermis*	M	C	4	0	0	0	0	3	4	0	0	0	2	0	5	2	2	2	0	0	0	0
47		*Choreodon anchorago*	T	C	0	0	0	0	0	0	2	0	0	2	0	0	0	0	0	0	0	0	2	0
48		*Cirrhilabrus adornatus*	M	C	2	2	1	1	1	1	0	2	1	0	1	2	0	0	0	1	0	0	1	1
49		*Cirrhilabrus cyanopleura*	M	P	0	0	0	0	1	2	3	7	0	3	3	0	0	0	0	0	0	0	4	4
50		*Cirrhilabrus ryukyuensis*	M	C	1	0	0	0	0	0	0	0	0	1	1	0	0	0	1	1	0	0	0	0
51		*Coris gaimard*	M	C	2	3	2	2	0	0	1	0	2	1	0	1	0	0	2	3	0	0	1	0
52		*Coris pictoides*	M	C	2	3	0	0	0	0	0	2	0	0	0	0	3	2	0	0	2	3	0	0
53		*Diproctacanthus xanthurus*	M	CO	3	4	2	2	0	0	0	0	2	0	0	2	0	0	0	0	0	0	0	0
54		*Halichoeres hortulanus*	M	C	3	2	2	2	2	1	0	2	2	2	0	0	0	0	2	0	0	0	0	3
55		*Halichoeres melanurus*	M	C	0	1	1	1	1	1	0	0	1	0	2	1	0	0	0	0	0	0	0	0
56		*Halichoeres prosopeion*	M	O	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	1	1	1	1
57		*Halichoeres richmondi*	M	C	0	0	3	2	2	3	0	2	2	2	0	2	0	0	0	0	0	0	0	2
58		*Hemigymnus melapterus*	M	C	0	0	0	0	0	0	2	1	0	2	2	1	2	1	2	2	2	2	0	0
59		*Hologymnosus annulatus*	M	C	0	1	1	1	0	1	1	1	1	0	0	0	0	0	0	0	0	1	1	1
60		*Labrichthys unilineatus*	M	CO	2	0	0	0	0	0	0	0	0	2	0	2	3	2	3	2	3	3	2	1
61		*Macropharyngidon ornatus*	M	C	2	0	0	0	2	1	0	0	0	2	0	0	0	0	2	2	1	2	1	2
62		*Thalassoma hardwickii*	M	C	3	4	3	5	0	0	0	0	2	2	5	5	2	0	0	0	0	0	3	3
63		*Thalassoma lunare*	M	C	0	0	2	2	1	1	2	3	2	0	0	2	0	2	2	0	0	2	0	0
64	**Lethrinidae**	*Lethrinus harak*	T	C	0	0	0	0	0	0	0	0	0	1	2	0	2	0	0	2	2	0	0	0
65		*Lethrinus lentjan*	T	C	0	0	2	0	0	0	2	0	0	0	0	0	0	2	0	0	0	2	2	0
66		*Lethrinus olivaceus*	T	C	0	1	1	1	1	1	1	1	1	0	0	1	1	1	0	0	1	1	1	1
67	**Lutjanidae**	*Lutjanus decussatus*	T	C	1	0	0	0	1	0	1	2	0	2	2	1	0	0	0	0	0	2	0	0
68		*Lutjanus ehrengergii*	T	C	0	0	0	0	0	0	0	0	0	3	3	0	0	5	2	5	2	3	0	5
69		*Lutjanus lutjanus*	T	C	0	0	0	0	0	0	4	0	0	0	0	0	0	0	3	2	0	0	0	0
70		*Lutjanus vitta*	T	C	0	0	0	0	0	0	0	3	0	0	0	0	0	0	3	4	0	0	0	3
71		*Macolor niger*	T	C	0	0	7	3	3	0	0	0	0	0	0	0	3	2	0	0	0	0	3	0

Appendix 1. (continue)

NO	Family	Species	GR	T.L	Site no. 1		Site no. 2		Site no. 3		Site no. 4		Site no. 5		Site no. 6		Site no. 7		Site no. 8		Site no. 9		Site no. 10	
72	**Mullidae**	*Parupeneus barberinus*	T	O	2	0	0	0	0	0	0	0	0	2	2	1	0	0	2	1	0	0	0	0
73		*Parupeneus bifasciatus*	T	C	0	0	2	0	0	2	2	0	0	0	0	0	2	0	0	0	0	0	2	0
74		*Parupeneus multifasciatus*	T	C	0	0	0	0	0	0	0	2	0	2	0	0	0	2	0	0	0	0	0	2
75		*Parupeneus spilurus*	T	C	2	0	0	0	2	0	0	0	0	2	3	0	0	0	2	3	0	0	0	0
76	**Muraenidae**	*Gymnothorax fimbriatus*	T	C	0	1	1	1	0	1	0	0	1	0	0	1	0	0	1	1	0	0	0	0
77		*Rhinomuraena quaesita*	T	C	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	1	0	0
78	**Nemipteridae**	*Scolopsis bilineatus*	M	C	2	2	2	2	1	1	0	0	2	2	0	2	0	0	0	0	0	0	2	2
79		*Scolopsis lineata*	M	C	2	0	0	0	0	0	0	2	0	0	2	0	0	0	0	0	0	0	0	0
80		*Scolopsis margaritifer*	M	C	2	2	2	2	2	2	0	2	2	2	0	2	0	0	0	0	0	0	0	0
81		*Scolopsis ciliata*	M	C	2	2	0	0	2	1	0	0	1	2	0	0	2	0	1	0	0	0	2	2
82	**Ostraciidae**	*Lactoria cornuta*	M	C	0	0	1	0	1	1	0	0	0	0	0	0	0	0	0	0	1	1	0	0
83	**Plotosidae**	*Plotosus lineatus*	M	C	3	4	4	3	3	0	0	0	3	0	0	1	1	1	0	0	0	0	0	0
84	**Pomacentridae**	*Abudefduf sexfasciatus*	M	O	7	5	5	10	5	10	5	6	10	5	7	5	5	8	5	4	4	7	8	5
85		*Acanthochromis polyacanthus*	M	H	0	5	5	5	2	5	6	0	0	0	0	3	0	0	0	0	0	0	2	0
86		*Amblyglyphidodon aureus*	M	P	0	5	12	5	7	8	0	2	10	2	0	5	0	0	12	5	0	0	2	4
87		*Amblyglyphidodon curacao*	M	O	10	25	25	12	5	7	5	7	12	12	5	7	4	5	6	5	4	7	4	5
88		*Amblyglyphidodon leucogaster*	M	O	5	25	12	25	7	5	0	0	10	0	0	0	5	0	5	7	5	5	5	5
89		*Amblyglyphidodon batunai*	M	O	6	6	6	6	4	6	6	6	6	12	6	6	0	0	6	7	0	0	25	12
90		*Amphiprion akindynos*	I	O	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	1	2
91		*Chromis amboinensis*	M	P	0	2	5	8	2	2	10	8	3	4	7	8	8	6	8	10	6	8	10	7
92		*Chromis lepidolepis*	M	P	4	0	10	12	5	7	0	0	5	8	0	0	0	2	0	0	0	2	9	7
93		*Chromis margaritifer*	M	C	6	7	5	10	5	8	3	4	8	5	5	3	5	6	5	5	5	5	4	2
94		*Chromis retrofasciata*	M	H	10	9	4	5	0	0	5	5	3	2	5	5	7	5	8	4	2	5	4	2
95		*Chromis viridis*	M	P	4	5	10	12	4	3	10	10	3	4	10	10	25	15	5	7	25	10	5	8
96		*Chromis xanthochira*	M	P	4	5	0	0	4	3	5	7	6	5	5	3	5	3	3	5	5	5	5	3
97		*Chrysiptera oxycephala*	M	P	5	7	4	6	6	5	0	0	6	5	0	4	0	0	5	8	3	0	2	2
98		*Chrysiptera parasema*	M	P	3	4	7	6	5	5	0	2	5	7	5	6	5	6	8	6	5	6	3	2
99		*Chrysiptera rollandi*	M	P	5	5	3	4	2	1	4	4	4	0	0	0	0	0	5	3	2	3	2	3
100		*Chrysiptera unimaculata*	M	H	2	4	3	4	3	2	7	8	4	6	0	0	7	4	5	3	3	0	0	2
101		*Dascyllus aruanus*	M	O	5	2	6	8	0	0	0	0	5	5	10	8	10	6	8	6	10	8	3	2
102		*Dascyllus trimaculatus*	M	O	5	3	5	6	5	4	4	3	6	8	3	4	4	2	3	4	2	3	2	3
103		*Dischitodus melanopus*	M	H	0	5	0	0	0	0	3	5	3	5	3	3	4	3	2	0	3	4	0	0
104		*Pomacentrus alexanderae*	M	O	5	2	0	0	0	0	5	0	8	12	5	5	0	0	7	5	5	4	0	0
105		*Pomacentrus auriventris*	M	O	3	0	3	4	0	0	2	2	0	2	0	0	0	0	2	5	0	0	5	10
106		*Pomacentrus moluccensis*	M	O	5	2	0	0	0	0	7	5	2	0	7	5	8	10	3	2	5	7	0	0
107		*Pomacentrus nigromarginatus*	M	O	8	5	7	10	5	10	0	0	3	3	0	0	5	5	5	7	5	5	5	3
108		*Pomacentrus bankanensis*	M	O	3	4	7	5	0	0	10	5	3	4	8	7	7	5	3	5	10	8	0	2

Appendix 1. (continue)

NO	Family	Species	GR	T.L	Site no. 1		Site no. 2		Site no. 3		Site no. 4		Site no. 5		Site no. 6		Site no. 7		Site no. 8		Site no. 9		Site no. 10	
109		*Stegastes fasciolatus*	M	D	3	5	3	5	0	0	3	5	3	3	2	3	3	5	5	3	5	3	5	3
110	**Pomachantidae**	*Centropyge vrolikii*	I	H	1	0	0	0	0	0	0	1	0	0	1	0	0	1	0	0	0	0	0	0
111		*Pomacanthus imperator*	I	O	0	0	0	0	0	0	0	0	0	2	0	0	2	0	0	0	0	0	4	0
112		*Pomacanthus semicirculatus*	I	O	0	0	1	1	1	1	0	1	1	0	0	1	0	0	0	0	0	0	0	2
113		*Pomacanthus sexstriatus*	I	O	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
114		*Pygoliptes diacanthus*	I	C	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
115	**Pseudochromidae**	*Labracinus cyclophthalmus*	M	C	3	3	0	0	0	2	3	0	0	3	2	0	2	0	3	0	2	0	0	2
116		*Pictichromis paccagnellae*	M	c	0	0	3	5	2	1	0	0	0	0	0	0	0	0	0	0	0	0	2	0
117	**Scaridae**	*Cetoscarus bicolor*	I	H	3	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
118		*Chlorurus sordidus*	I	H	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
119		*Chlorurus bleekeri*	I	H	0	0	2	3	0	0	0	0	2	2	0	0	2	0	0	1	0	0	0	0
120		*Scarus dimidiatus*	I	H	2	2	1	2	1	0	0	0	1	1	2	0	0	2	0	0	0	0	0	0
121		*Scarus flavipectoralis*	I	H	1	1	1	1	0	1	1	0	1	1	0	1	0	0	2	0	0	0	0	0
122		*Scarus hypselopterus*	I	H	1	1	1	1	1	0	0	1	1	1	1	0	0	1	0	0	0	0	1	0
123	**Serranidae**	*Cephalopholis argus*	T	C	0	0	1	0	0	1	1	1	1	0	0	0	1	0	0	0	0	0	0	0
124		*Cephalopholis boenak*	T	C	2	0	0	0	0	0	0	0	0	2	0	0	2	0	2	0	0	0	2	2
125		*Cephalopholis micropion*	T	C	1	0	0	0	0	0	1	1	0	1	0	0	0	0	0	0	1	0	1	1
126		*Epinephelus bontoides*	T	C	1	0	0	0	0	0	1	0	0	0	0	0	1	0	1	0	0	0	1	1
127		*Plectropomus areolatus*	T	C	0	1	1	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0	1	0
128		*Pseudanthias huchtii*	M	C	1	0	0	0	0	1	0	0	0	1	1	0	0	1	0	1	0	1	1	0
129	**Siganidae**	*Siganus virgatus*	T	H	8	0	0	0	0	0	0	0	5	10	0	5	0	0	0	0	0	0	0	0
130		*Siganus vulpinus*	T	H	0	2	4	5	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0
131	**Syngnathidae**	*Corythoichthys intestinalis*	M	P	2	0	0	2	2	0	0	0	2	0	2	2	0	0	0	2	0	0	0	0
132		*Doryrhamphus dactyliophorus*	M	P	0	0	0	0	0	0	2	0	0	2	0	0	2	2	0	0	0	2	2	0
133	**Tetraodontidae**	*Arothron nigropunctatus*	M	O	0	0	0	0	0	0	2	0	0	2	0	0	2	2	2	2	2	0	2	0
134		*Canthigaster solandri*	M	O	2	0	2	3	2	0	0	3	0	0	3	1	0	0	0	0	0	0	0	0
135	**Zanclidae**	*Zanclus cornutus*	I	C	2	0	2	3	2	2	2	2	0	2	2	3	0	2	2	2	2	2	2	2

TOTAL	259	248	265	283	156	155	176	179	229	266	172	172	183	155	204	202	160	152	195	179
abundance / m^2	10,36	9,92	10,60	11,32	6,24	6,20	7,04	7,16	9,16	10,64	6,88	6,88	7,32	6,20	8,16	8,08	6,40	6,08	7,80	7,16

where : T.L = Trophic level

I : Indicators
M : Majors
T : Targets
C : Carnivora
H : Herbivora
O : Omnivora

CO : Corallivora
P : Planktivora
D : Detritivora

Appendix 2. Trophic level composition of reef fishes at Pasi Island

Site		Herbivore	Carnivore	Omnivora	Corallivora	Planktivora	Detritivora
1	a	17,37%	23,55%	28,57%	4,63%	23,94%	1,93%
	b	16,13%	18,95%	33,47%	4,03%	25,00%	2,42%
2	a	15,47%	21,89%	31,32%	3,77%	26,04%	1,51%
	b	14,84%	20,49%	32,86%	3,18%	26,15%	2,47%
3	a	10,90%	26,28%	26,92%	1,92%	33,33%	0,64%
	b	10,32%	26,45%	33,55%	1,94%	26,45%	1,29%
4	a	16,48%	28,41%	30,68%	2,27%	19,32%	2,84%
	b	17,88%	29,05%	25,70%	2,23%	22,35%	2,79%
5	a	10,48%	20,96%	30,57%	4,37%	31,44%	2,18%
	b	14,66%	23,31%	28,95%	4,51%	27,44%	1,13%
6	a	11,05%	26,74%	37,21%	2,91%	20,93%	1,16%
	b	15,70%	20,35%	31,98%	4,07%	25,00%	2,91%
7	a	15,30%	19,13%	30,60%	3,83%	29,51%	1,64%
	b	16,77%	20,65%	30,32%	5,16%	23,23%	3,87%
8	a	15,69%	20,59%	29,41%	3,43%	27,45%	3,43%
	b	10,40%	20,30%	33,66%	2,97%	30,20%	2,48%
9	a	11,25%	16,25%	35,63%	4,38%	29,38%	3,13%
	b	10,53%	20,39%	38,82%	4,61%	23,68%	1,97%
10	a	10,26%	23,08%	34,87%	4,10%	24,10%	3,59%
	b	10,06%	27,37%	30,17%	6,15%	24,58%	1,68%

Appendix 3. Binary data of reef fishes at study sites

NO	FAMILY	SPECIES	SITES									
			1	2	3	4	5	6	7	8	9	10
1	Acanthuridae	*Acanthurus leucocheilus*	1	1	1	1	1	1	1	1	1	1
2		*Acanthurus pyroferus*	1	1	1	1	1	0	1	1	1	1
3		*Ctenochaetus binotatus*	1	1	1	1	1	1	1	1	0	1
4		*Ctenochaetus striatus*	1	1	1	1	1	0	1	1	1	1
5		*Ctenochaetus truncatus*	1	1	1	1	1	1	1	1	1	1
6		*Naso caeruleacaudus*	1	1	0	0	0	0	0	1	0	1
7		*Naso lituratus*	0	1	1	1	0	1	1	1	1	1
8		*Zebrasoma scopas*	1	1	1	1	1	1	1	0	0	1
9	Apogonidae	*Apogon apogonides*	0	0	0	1	0	0	0	0	0	0
10	Aulostomidae	*Aeoliscus strigatus*	1	0	1	0	1	0	0	1	0	0
11		*Aulostomus chinensis*	0	1	1	1	1	0	0	1	0	1
12	Balistidae	*Abalistes stellatus*	1	1	1	0	1	1	0	0	1	0
13		*Melichthys indicus*	1	0	1	0	0	1	1	0	0	0
14		*Sufflamen bursa*	0	0	0	1	0	1	1	0	0	0
15		*Sufflamen chrysopterus*	1	0	1	1	0	0	1	0	1	0
16	Blenniidae	*Meiacanthus ditrema*	1	0	0	0	0	0	0	1	1	0
17	Caesionidae	*Caesio cuning*	1	1	1	0	1	1	0	1	0	0
18		*Caesio teres*	1	0	1	0	1	0	0	0	0	0
19		*Pterocaesio tile*	1	0	0	0	1	0	1	0	0	0
20	Chaetodontidae	*Chaetodon auriga*	1	1	1	1	1	1	0	1	0	0
21		*Chaetodon baronessa*	1	0	0	0	0	0	0	0	0	0
22		*Chaetodon citrinellus*	1	1	1	1	1	1	0	1	0	1
23		*Chaetodon kleinii*	0	1	0	0	1	0	0	1	0	1
24		*Chaetodon lineolatus*	1	1	1	1	0	0	0	0	1	0
25		*Chaetodon melanotus*	0	0	0	0	1	1	0	0	0	1
26		*Chaetodon rafflesii*	0	0	0	1	1	1	0	0	0	1
27		*Chaetodon trifasciatus*	0	1	0	0	1	0	1	1	1	0
28		*Chaetodon vagabundus*	1	0	0	1	0	0	1	1	1	0
29		*Chaetodon wiebeli*	1	0	1	1	1	0	1	1	1	1
30		*Chelmon rostratus*	1	1	1	0	1	1	1	0	1	0
31		*Heniochus acuminatus*	1	1	0	1	1	0	1	0	1	0
32		*Heniochus pleurotaenia*	0	1	0	0	0	0	0	0	0	0
33		*Heniochus varius*	1	1	1	0	1	1	1	1	1	1
34	Dasyatidae	*Taeniura lymma*	1	1	0	0	1	1	0	0	0	1
35	Ephippidae	*Platax teira*	0	0	1	1	1	1	1	1	1	1
36	Gobiidae	*Ptereleotris evides*	0	0	0	0	1	0	1	0	0	0
37	Haemulidae	*Diagramma pictum*	1	0	0	1	1	1	0	0	0	1
38		*Plectorhynchus gatterinoides*	0	1	0	1	1	1	0	0	0	1
39		*Plectorhynchus lineatus*	1	0	1	1	1	1	0	0	0	0
40		*Plectorhynchus vittatus*	0	0	0	1	1	1	0	0	0	1
41	Holocentridae	*Myripristis adusta*	1	1	0	1	1	0	0	0	0	0
42		*Myripristis vittata*	0	1	1	0	1	0	0	0	0	1
43	Labridae	*Bodianus mesothorax*	0	1	0	0	1	1	1	0	1	1
44		*Cheilinus celebicus*	1	0	0	1	1	1	0	0	0	0
45		*Cheilinus fasciatus*	1	1	1	1	1	1	1	0	0	1
46		*Chello inermis*	1	0	1	1	0	1	1	1	0	0
47		*Choreodon anchorago*	0	0	0	1	1	0	0	0	0	1
48		*Cirrhilabrus adornatus*	1	1	1	1	1	1	0	1	0	1
49		*Cirrhilabrus cyanopleura*	0	0	1	1	1	1	0	0	0	1
50		*Cirrhilabrus ryukyuensis*	1	0	0	0	1	1	0	1	0	0
51		*Coris gaimard*	1	1	0	1	1	1	0	1	0	1
52		*Coris pictoides*	1	0	0	1	0	0	1	0	1	0
53		*Diproctacanthus xanthurus*	1	1	0	0	1	1	0	0	0	0
54		*Halichoeres hortulanus*	1	1	1	1	1	0	0	1	0	1
55		*Halichoeres melanurus*	1	1	1	0	1	1	0	0	0	0
56		*Halichoeres prosopeion*	0	0	0	0	1	1	0	0	1	1
57		*Halichoeres richmondi*	0	1	1	1	1	1	0	0	0	1
58		*Hemigymnus melapterus*	0	0	0	1	1	1	1	1	1	0
59		*Hologymnosus annulatus*	1	1	1	1	1	0	0	0	1	1
60		*Labrichthys unilineatus*	1	0	0	0	1	1	1	1	1	1
61		*Macropharyngidon ornatus*	1	0	1	0	1	0	0	1	1	1
62		*Thalassoma hardwickii*	1	1	0	0	1	1	1	0	0	1
63		*Thalassoma lunare*	0	1	1	1	1	1	1	1	1	0
64	Lethrinidae	*Lethrinus harak*	0	0	0	0	1	1	1	1	1	0
65		*Lethrinus lentjan*	0	1	0	1	0	0	1	0	1	1
66		*Lethrinus olivaceus*	1	1	1	1	1	1	1	0	1	1
67	Lutjanidae	*Lutjanus decussatus*	1	0	1	1	1	1	0	0	1	0

Appendix 3. (continue)

NO	FAMILY	SPECIES	SITES 1	2	3	4	5	6	7	8	9	10
68		*Lutjanus ehrengergii*	0	0	0	0	1	1	1	1	1	1
69		*Lutjanus lutjanus*	0	0	0	1	0	0	0	1	0	0
70		*Lutjanus vitta*	0	0	0	1	0	0	0	1	0	1
71		*Macolor niger*	0	1	1	0	0	0	1	0	0	1
72	Mullidae	*Parupeneus barberinus*	1	0	0	0	1	1	0	1	0	0
73		*Parupeneus bifasciatus*	0	1	1	1	0	0	1	0	0	1
74		*Parupeneus multifasciatus*	0	0	0	1	1	0	1	0	0	1
75		*Parupeneus spilurus*	1	0	1	0	1	1	0	1	0	0
76	Muraenidae	*Gymnothorax fimbriatus*	1	1	1	0	1	1	0	1	0	0
77		*Rhinomuraena quaesita*	0	0	0	0	1	0	0	0	1	0
78	Nemipteridae	*Scolopsis bilineatus*	1	1	1	0	1	1	0	0	0	1
79		*Scolopsis lineata*	1	0	0	1	0	1	0	0	0	0
80		*Scolopsis margaritifer*	1	1	1	1	1	1	0	0	0	0
81		*Scolopsis ciliata*	1	0	1	0	1	0	1	1	0	1
82	Ostraciidae	*Lactoria cornuta*	0	1	1	0	0	0	0	0	1	0
83	Plotosidae	*Plotosus lineatus*	1	1	1	0	1	1	1	0	0	0
84	Pomacentridae	*Abudefduf sexfasciatus*	1	1	1	1	1	1	1	1	1	1
85		*Acanthochromis polyacanthus*	1	1	1	1	0	1	0	0	0	1
86		*Amblyglyphidodon aureus*	1	1	1	1	1	1	0	1	0	1
87		*Amblyglyphidodon curacao*	1	1	1	1	1	1	1	1	1	1
88		*Amblyglyphidodon leucogaster*	1	1	1	0	1	0	1	1	1	1
89		*Amblyglyphidodon batunai*	1	1	1	1	1	1	0	1	0	1
90		*Amphiprion akindynos*	0	0	0	0	1	0	0	0	0	1
91		*Chromis amboinensis*	1	1	1	1	1	1	1	1	1	1
92		*Chromis lepidolepis*	1	1	1	0	1	0	1	0	1	1
93		*Chromis margaritifer*	1	1	1	1	1	1	1	1	1	1
94		*Chromis retrofasciata*	1	1	0	1	1	1	1	1	1	1
95		*Chromis viridis*	1	1	1	1	1	1	1	1	1	1
96		*Chromis xanthochira*	1	0	1	1	1	1	1	1	1	1
97		*Chrysiptera oxycephala*	1	1	1	0	1	1	0	1	1	1
98		*Chrysiptera parasema*	1	1	1	1	1	1	1	1	1	1
99		*Chrysiptera rollandi*	1	1	1	1	1	0	0	1	1	1
100		*Chrysiptera unimaculata*	1	1	1	1	1	0	1	1	1	1
101		*Dascyllus aruanus*	1	1	0	0	1	1	1	1	1	1
102		*Dascyllus trimaculatus*	1	1	1	1	1	1	1	1	1	1
103		*Dischitodus melanopus*	1	0	0	1	1	1	1	1	1	0
104		*Pomacentrus alexanderae*	1	0	0	1	1	1	0	1	1	0
105		*Pomacentrus auriventris*	1	1	0	1	1	0	0	1	0	1
106		*Pomacentrus moluccensis*	1	0	0	1	1	1	1	1	1	0
107		*Pomacentrus nigromarginatus*	1	1	1	0	1	0	1	1	1	1
108		*Pomacentrus bankanensis*	1	1	0	1	1	1	1	1	1	1
109		*Stegastes fasciolatus*	1	1	0	1	1	1	1	1	1	1
110	Pomachantidae	*Centropyge vrolikii*	1	0	0	1	0	1	1	0	0	0
111		*Pomacanthus imperator*	0	0	0	0	1	0	1	0	0	1
112		*Pomacanthus semicirculatus*	0	1	1	1	1	1	0	0	0	1
113		*Pomacanthus sexstriatus*	0	0	0	0	0	0	0	0	0	1
114		*Pygoliptes diacanthus*	0	1	0	0	0	0	0	0	1	0
115	Pseudochromidae	*Labracinus cyclophthalmus*	1	0	1	1	1	1	1	1	1	1
116		*Pictichromis paccagnellae*	0	1	1	0	0	0	0	0	0	1
117	Scaridae	*Cetoscarus bicolor*	1	0	0	0	1	0	0	0	0	0
118		*Chlorurus sordidus*	1	0	0	0	0	0	0	0	0	0
119		*Scarus bleekeri*	0	1	0	0	1	0	1	1	0	0
120		*Scarus dimidiatus*	1	1	1	0	1	1	1	0	0	0
121		*Scarus flavipectoralis*	1	1	1	1	1	1	0	1	0	0
122		*Scarus hypselopterus*	1	1	1	1	1	1	1	0	0	1
123	Serranidae	*Cephalopholis argus*	0	1	1	1	1	0	1	0	0	0
124		*Cephalopholis boenak*	1	0	0	0	1	0	1	1	0	1
125		*Cephalopholis micropion*	1	0	0	1	1	0	0	0	1	1
126		*Epinephelus bontoides*	1	0	0	1	0	0	1	1	0	1
127		*Plectropomus areolatus*	1	1	1	0	1	0	0	0	0	1
128		*Pseudanthias huchtii*	1	0	1	0	1	1	1	1	1	1
129	Siganidae	*Siganus virgatus*	1	0	0	0	1	1	0	0	0	0
130		*Siganus vulpinus*	1	1	0	0	0	1	0	0	0	0
131	Syngnathidae	*Corythoichthys intestinalis*	1	1	1	0	1	1	0	1	0	0
132		*Doryrhampus dactiliophorus*	0	0	0	1	1	0	1	0	1	1
133	Tetraodontidae	*Arothron nigropunctatus*	0	0	0	1	1	0	1	1	1	1
134		*Canthigaster solandri*	1	1	1	1	0	1	0	0	0	0
135	Zanclidae	*Zanclus cornutus*	1	1	1	1	1	1	1	1	1	1

Appendix 4. Group of Fishes Characteristics Based on Sorensen Similarity Index at 66,7% level (Fishbase 2010).

Group of Fishes 1

Species members and their characteristics:
Acanthurus leucocheilus occurs in clear seaward reefs near drop-offs *Ctenochaetus truncates* inhabits sheltered inner reef crests and slopes, usually among large corals or in gutters, singly or in small groups. *Abudefduf sexfasciatus* inhabits inshore and offshore coral or rocky reefs, also in shallow coastal reef flats or crests, usually where lots of tall soft corals or hydroid colonies are present; feeds on zooplankton and algae and aggregates high in the water column. *Amblyglyphidodon curacao* inhabits lagoons, coastal embayments, reef passages and outer reefs. Juveniles often found among *Sarcophyton* and *Sinularia* soft corals; feeding aggregations are frequently observed over growths of the staghorn coral *Acropora*, feeds on zooplankton and filamentous algae. *Chromis amboinensis* inhabits coral-rich areas of clear lagoon and seaward reefs, abundant on steep outer reef slopes below 24 m, uncommon in lagoons, juveniles in large branching corals, adults mainly in caves. *Chromis margaritifer* usually seen singly or in small groups on coastal reefs, amongst mixed algae-coral reef or rocky reefs, found on exposed seaward reefs; less abundant in lagoons and channels; feeds on zooplankton.. *Chromis viridis* found in large aggregations above thickets of branching *Acropora* corals in sheltered areas such as subtidal reef flats and lagoons. *Chrysiptera parasema* inhabits coral-rich areas of sheltered lagoon and inshore coral reefs, occurs in small groups on *Acropora* patches. *Dascyllus trimaculatus* inhabits coral and rocky reefs, juveniles often commensal with large sea anemones, sea urchins, or small coral heads. *Zanclus cornutus* inhabit turbid inner lagoons, reef flats, and clear seaward rocky and coral reefs. *Acanthurus pyroferus* occurs in lagoon and seaward reefs; prefers areas of mixed coral, rock, or sand at the base of reefs or ledges, also on silty reefs, found singly. *Ctenochaetus striatus* inhabits reef flats and lagoon and seaward reefs to a depth of over 30 m, occurs over coral, rock, pavement, or rubble substrates; may occur singly or in small to very large, often mixed-species aggregations; feeds on surface film of blue-green algae and diatoms (making this species a key link in the ciguatera food chain) as well as on various small invertebrates. *Chrysiptera unimaculata* found solitarily or in small groups among coastal algal reefs, rubble or over open beach-rock of reef flats exposed to moderate surge and feeds mainly on benthic algae. *Lethrinus olivaceus* are carnivores eating fish, crustaceans and squid. *Chromis retrofasciata* inhabits coral-rich areas of clear lagoon and seaward reefs, occurs singly or in small groups and remains close to thickly branching coral shelter. *Pomacentrus bankanensis* occurs solitarily or in small groups in lagoons, reef flats, passages, and outer reef slopes. Usually amongst coarse rubble or rock; feeds primarily on algae, but also takes copepods, isopods, and pelagic tunicates.. *Stegastes fasciolatus* inhabits rocky and coral reefs exposed to mild to moderate surge, benthopelagic, occurs solitary among boulders, territorial in areas where filamentous algae cover rocks and dead coral. *Dascyllus aruanus* is territorial; inhabit shallow lagoon and subtidal reef flats, form large aggregations above staghorn *Acropora* thickets or in smaller groups above isolated coral heads; feed on zooplankton, benthic invertebrates, and algae. *Chaetodon wiebeli* occur in rocky and coral reef areas, where they are found in pairs and small groups; feed on algae. *Chromis xanthochira* primarily found along deep outer reef walls occurs singly or in small groups in outer reef slopes; feed on plankton..

Appendix 4. (continue)

Labracinus cyclophthalmus is a carnivorous feed on small fish. Platax teira usually look for protected areas among the reefs. *Ctenochaetus binotatus* feed on detritus and algae. *Zebrasoma scopas* occurs in coral-rich areas of lagoon and seaward reefs, graze on algae, usually in groups of 20 individuals, adults usually in small groups and sometimes schooling, juveniles solitary and usually among corals. *Cheilinus fasciatus* is a carnivorous feed on hard-shelled animals such as mollusks, shrimp and crab. *Scarus hypselopterus* inhabit sandy habitats on the outer reef. *Heniochus varius* is corallivor that feed on algae and other invertebrates. *Amblyglyphidodon leucogaster* inhabits lagoons, reef passages, and the outer reef slopes as solitary individuals or in small groups; feeds on copepods, amphipods, mysids, fish eggs, crustacean larvae, and a small portion of algae. *Pomacentrus nigromarginatus* occurs in outer reef slopes of coral reefs, usually around rocky outcrops in sandy areas, also along deep walls with caves to 50 m depth; feeds on zooplankton and algae. *Chromis lepidolepis* occurs in coral-rich areas of lagoon and seaward reefs, aggregates close to shelter; feeds on zooplankton. *Chrysiptera* found among live corals of sheltered lagoon and inshore reefs; feeds on zooplankton, occurs solitary or in pairs. *Naso lituratus is* found in areas of coral, rock, or rubble of lagoon and seaward reefs, benthopelagic, adults usually in small groups. *Thalassoma lunare* generally feed on small benthic invertebrate and fish eggs. *Aulostomus chinensis* is eating small fish and shrimp. *Halichoeres hortulanus* feed on shelled animals such as mollusks, crabs and sea urchins. *Chrysiptera rollandi* occurs singly or in small groups in lagoons, harbors, and outer reef slopes, found among corals and coral rubble; feeds mainly on zooplankton. *Hologymnosus annulatus* is a carnivorous fish and crustacean feeders. *Chaetodon auriga m*ay be seen in a variety of habitats ranging from rich coral reefs to weedy and rubble covered areas, maybe found singly, in pairs, and in aggregations that roam over large distances in search of food, feed mainly by tearing pieces from polychaetes, sea anemones, coral polyps, and algae. *Scarus flavipectoralis* herbivores, feed on plants. *Chaetodon citrinellus* feed on worms, benthic invertebrate, coral polyps, and filamentous algae. *Cirrhilabrus adornatus* is a carnivorous crustacean eaters. *Amblyglyphidodon aureus* occurs in steep outer reef, occasionally in deep lagoons and along channel walls, usually in current prone habitats and where there are abundant gorgonian and long sea-whip corals on which they lay and guard eggs, feeds on zooplankton *Amblyglyphidodon batunai* occurs in silty lagoons with large staghorn coral colonies, usually congregating in small groups. *Pomacentrus auriventris* mainly inhabits inner reef slopes with mixed rubble, coral and algae, aggregates close to the bottom, usually in small groups. *Hemigymnus melapterus* usually found on branching coral, generally feed on small invertebrates. *Dischitodus melanopus* occurs in lagoon reefs and generally prefers small patch reefs with sand or rubble substrates; feeds on benthic algae which it aggressively guards against other herbivores. *Pomacentrus moluccensis* inhabits clear lagoon and seaward reefs among branching corals, occurs in small aggregations; feeds mainly on algae and planktonic crustaceans. *Pomacentrus alexanderae* occur in lagoon, inshore, and offshore reefs, usually seen solitary, often swimming well above substrate; feed on algae, barnacle nauplii, copepods, fish eggs, and small gastropods. *Labrichthys unilineatus* usually found near coral branching and eat *Acropora* polyps. *Pseudanthias huchtii* is a carnivore that is territorial. *Lethrinus harak* is a carnivorous feed on polychaeta, crustaceans, mollusks and small fish. Lutjanus ehrengergii is a carnivorous eating small fish

Appendix 4. (continue)

and invertebrates. *Macropharyngidon ornatus* is carnivorous usually solitary or forming small groups. *Scolopsis ciliate* inhabits sandy bottoms close to coral reefs, also near mangroves, occurs often in small groups; feeds on benthic invertebrates and small fishes. *Cephalopholis boenak* inhabits silty dead reefs in protected waters. *Abalistes stellatus* inhabits mud and silt sand bottoms. *Chelmon rostratus* is corallivor usually solitary or in pairs. *Plotosus lineatus* usually sweep the sand to look for crustaceans, mollusks and worms. *Scarus dimidiatus* is an algae feeder, inhabit the reef area is bright with good cover, protective *Caesio cuning* Inhabits coastal areas, usually over rocky and coral reefs, forms schools in midwater and feeds on zooplankton. *Gymnothorax fimbriatus* are nocturnal, feed on fish and invertebrate. *Corythoichthys intestinal* usually inhabit shallow waters and sandy or mixed areas between coral, sand and rubble. *Halichoeres melanurus* is carnivore, a small invertebrate feeder such as copepods. *Taeniura lymma* migrates in groups into shallow sandy areas during the rising tide to feed on mollusks, worms, shrimps, and crabs; disperses on falling tide to seek shelter in caves and under ledges. *Thalassoma hardwickii* is an invertebrate feeder, small fish and foraminifera. *Scolopsis bilineatus* common on coral reefs, adults occur on most reef habitats, usually in pairs, and juveniles inshore or in lagoons or rubble zones, occurs singly or in small aggregations; feeds on small fishes and benthic invertebrates. *Plectropomus areolatus* is carnivore, solitary or to form a small group. *Diproctacanthus xanthurus* usually form small groups, feed on coral polyps. *Siganus vulpinus* usually clustered in *Acropora* and feed on algae that grow on dead coral branch.

Group of Fishes 2
Species members and their characteristics:
Chaetodon lineolatus occur in lagoon and seaward reefs, usually in pairs in coral rich areas, benthopelagic, feed mainly on coral polyps and anemones, but also on small invertebrates and algae. *Heniochus accuminatus* inhabit deep, protected lagoons and channels, and the deeper parts of outer reef slopes, a planktivorous species that generally remains within a few meters of the reef. *Myripristis adusta* is a nocturnal species that hide in cracks or branches of coral in the day. *Cephalopholis argus* is a carnivore that can be found in various forms of reef habitat.

Group of Fishes 3
Species members and their characteristics:
Melichthys indicus inhabits coral-rich seaward reef slopes, occurs singly, digs holes below coral bases for shelter; feeds on sponges, algae, crustaceans and small invertebrates. *Chello inermis* inhabit seagrass and algae-covered plains, usually solitary; eat crustaceans, mollusks and sea urchins. *Sufflamen bursa* inhabits outer and clear reef habitats, eating crabs, clams, gastropods, algae, tunicate, worms and detritus. *Centropyge vrolikii* inhabits coral-rich areas of reef flats, lagoons, and seaward reefs

Group of Fishes 4
Species members and their characteristics:
Plectorhynchus lineatus, feed on benthic invertebrate on the open plains of sand and seagrass beds at night. *Lutjanus decussatus* inhabits both inshore and offshore coral reefs where it occurs singly or in schools, small juveniles on

Appendix 4. (continue)

shallow protected reef flats and are used in the aquarium trade. *Scolopsis margaritifer* is feed on crustaceans, polychaeta, mollusks and small fish. *Canthigaster solandri* is an algae feeder of red and green filamentous algae, corraline algae as well as corals, mollusks, krustacea, tunicate, and echinoderms Bryozoans. *Acanthochromis polyacanthus* usually schooling, feed on plants and zooplankton. *Cheilinus celebicus* reside in the area that has a mix of hard coral and soft corals, corallivor and invertebrate feeder. *Scolopsis lineata* common on coral reefs usually associated with sandy areas, adults inhabit outer lagoon reef flats and seaward reefs flats, often in groups, juveniles are found singly near the shelter of corals on clear shallow lagoon reefs; adults form schools or small groups; feeds on small fishes, crustaceans and benthic invertebrates, primarily polychaetes.

Group of Fishes 5
Species members and their characteristics:
Aeoliscus strigatus is found in open substrate with white sand or rubble. *Parupeneus spilurus* mainly found on deep reefs adjacent to strong currents. *Caesio teres* found primarily around coral reefs, with a preference for coralline lagoons, often on outer reef slopes or in passes washed by strong currents. *Cirrhilabrus ryukyuensis* occurs inshore, feeds 1 to 2 m above the substratum. *Parupeneus barberinus* inhabit large sand patches as well as sand and rubble areas of reef flats, and lagoon and seaward reefs. *Siganus virgatus* Inhabit shallow coastal waters, around hard coral reefs and areas of sand with patches of rock and soft coral, tolerant of murky waters. *Cetoscarus bicolor* is *usually* found in dense coral and algae habitats.

Group of Fishes 6
Species members and their characteristics:
Chaetodon melanotus usually solitary or in pairs in coral-rich areas of reef flats, lagoons, and seaward reefs to a depth of over 15 m, feed on octocorallian and scleractinian coral polyps. *Halichoeres prosopeion* inhabits lagoon and seaward reefs, which has a high coral cover. *Bodianus mesothorax* inhabit the outer reef slope which has a high coral cover, especially near the crevices of coral. *Chaetodon rafflesii* is corallivor that feed on anemones, polychaeta and coral polyps. *Plectorhynchus vittatus* inhabits coral reefs and rocks on the beach. *Diagramma pictum* is a benthic invertebrate-feeder and small fish. *Plectorhynchus gatterinoides* is generally found in crevices under rocks and the outer reef slope. *Halichoeres richmondi* is usually found in a shallow lagoon, protecting corals, clams, shrimp and snails. *Pomocanthus semicirculatus* is feed on sponges, tunicates and algae. Cirrhilabrus cyanopleura is a zooplankton feeder in the water column.

Group of Fishes 7
Species members and their characteristics:
Choreodon anchorago inhabits reef flats and lagoon reefs, in areas with seagrass or mixed sand, rubble, and coral, feeds mainly on hard-shelled prey including crustaceans, mollusks and sea urchins. *Parupeneus multifasciatus* feed on small crabs and shrimp and fish eggs at the bottom. *Doryrhampus dactiliophorus* usually swim down among the corals to hunt amphipoda and copepod. *Arothron nigropunctatus* is feed on sponges, mollusks, crustaceans, tunicates and algae.

Appendix 4. (continue)

Cephalopholis micropion inhabit shallow waters and coral sand. *Lethrinus lentjan* is a carnivorous eating crustaceans and mollusks.

Group of Fishes 8
Species members and their characteristics:
Amphiprion akindynos occurs in lagoon and outer reefs, associated with anemone. *Pomacanthus imperator* large adults inhabit ledges and caves in areas of rich coral growth on clear lagoon, channel, or seaward reefs, feed on sponges and other encrusting organisms.
Group of Fishes 9
Species members and their characteristics:
Naso caeruleacaudus found in schools, mainly along outer reef walls to moderate depths in pursuit of plankton. *Chaetodon kleinii* occur in deeper lagoons and channels, and seaward reefs, benthopelagic, occur singly or in pairs, common, omnivorous individuals that feed mainly on soft coral polyps (mainly on *Sarcophyton tracheliophorum* and *Litophyton viridis*), algae and zooplankton.

Group of Fishes 10
Species members and their characteristics:
Chaetodon trifasciatus occur in coral-rich lagoons and semi-protected seaward reefs, territorial and aggressive to other *Chaetodon*, small juveniles secretive in corals, swim in pairs, feed exclusively on coral polyps, particularly of the *Pocillopora* type. *Scarus bleekeri* found in clear coastal and inner reefs; in lagoons and channel reefs, feed mainly on algae.

Group of Fishes 11
Species members and their characteristics:
Sufflamen chrysopterus inhabit coastal to outer reefs, habitats from silty lagoons to pristine outer reef walls, occur in shallow lagoon and seaward reefs; solitary and territorial; feed on a wide variety of invertebrates. Coris pictoides is usually found in areas that have little coral with sand and rubble substrate, sometimes entering into estuaries. *Chaetodon vagabundus* found on reef flats, lagoons and sometimes in turbid waters close to the run-off, swim in pairs, are omnivorous, eating algae, coral polyps, crustaceans and worms. *Epinephelus bontoides* found on mud or rocky or cobble bottoms.

Group of Fishes 12
Species members and their characteristics:
Meiacanthus ditrema is found on reef slopes with large soft-coral communities. Form schools in shallow protected reefs and feeds on zooplankton.

Group of Fishes 13
Species members and their characteristics:
Myripristis vittata forms large aggregations in caves and ledges of steep drop-offs; often in small groups and sometimes forms large schools, nocturnal and feeds on plankton. *Pictichromis paccagnellae* inhabit rubble, zoobenthos-feeder. *Macolor niger* reside in the area outside the lagoon and reef slope, eating fish and crustaceans. *Parupeneus bifasciatus* inhabits lagoon and seaward reefs, feed on crustaceans and fish during the day as well as crab larvae at night.

Appendix 4. (continue)

Group of Fishes 14
Species members and their characteristics:
Pterocaesio tile occurs inshore. *Ptereleostris evides* occurs in outer reef slopes, also inhabits lagoons and bays.

Group of Fishes 15
Species members and their characteristics:
Rhinomuraena quaesita is secretive species normally hidden in sand or rubble, sometimes with only its head protruding.

Group of Fishes 16
Species members and their characteristics:
Apogon apogonides Inhabits rocky cliffs, lives in coastal rocky reefs, a nocturnal predator.

Group of Fishes 17
Species members and their characteristics:
Lutjanus lutjanu and Lutjanus vitta occurs in inshore waters of the continental shelf, inhabits the vicinity of coral reefs, also areas with flat bottoms and occasional low coral outcrops, sponges, and sea whips

Group of Fishes 18
Species members and their characteristics:
Heniochus pleurotaenia often on shallow reef crest with some surge, usually in mixed algae and coral habitats to about 15 m depth, but may go offshore.

Group of Fishes 19
Species members and their characteristics:
Lactoria cornuta inhabit inshore on coastal muddy or sandy habitats in still bays, and commonly found in harbours and estuaries, small juveniles on protected shallow mudflats, found in weedy areas near rocks or reefs, juveniles often near river mouths and in brackish water. *Pygolipthes diacanthus* occurs in coral rich areas of lagoon and seaward reefs to a depth of 48 m or more, often found in the vicinity of caves and feeds on sponges and tunicates.

Group of Fishes 20
Species members and their characteristics:
Chaetodon baronessa occur in lagoon and seaward reefs, feed exclusively on the polyps of the tubular *Acropora* corals, swim in pairs and are territorial. *Chlorurus sordidus* Inhabit both coral rich and open pavement areas of shallow reef flats and lagoon and seaward reefs, as well as drop-offs, behaving differently in various areas, feed on benthic algae.

Group of Fishes 21
Species members and their characteristics:
Pomacanthus sexstriatus adults occur in areas of rich coral growth and high vertical relief of lagoon and seaward reefs.