ASSESSMENT OF REEF AND LAGOON ASSOCIATED FINFISH IN SAMOA (PROCFISH SITES)

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The main objective of the study is to assess the coastal finfish fishery in Samoa. This was done by estimating the stock size within the four selected sampled sites. The sites were divided into four habitats (strata) including the coastal reef, lagoon patches, back reef and outer reef. Variability of finfish biomass density was obtained among habitats and sites. ANOVA was used to test such differences which resulted in habitats within the sites as significantly different while among the sites was the same. The trend among the habitats was biomass density, abundance, size range increases with increase distance from the shore. With known catches from the socio-economic data, the status of exploitation of the stock was evaluated. Sites with large fishing area have a higher biomass, catches, and low fishing pressure, which was vice versa for the small fishing area sites. Therefore considering the population size, the fishing pressure has an inverse relationship with accessible fishing area.

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1. INTRODUCTION

Reef fisheries, coastal fisheries, inshore fisheries or small-scale artisanal fishery are all various terms used in describing fishing of reef and lagoon associated finfish. All these terms do fit and have been commonly used in fisheries reports. However, they fail to clearly describe the defined area of fishing which is from the coastline to the outer reefs. It is of relative importance because such fishing includes various gears, species and unique habitats. Samoan coastal communities largely depend on inshore resources for their livelihood and fisheries contribute a large proportion of the animal protein diet consumed in the country. In 2000, the nation wide household fisheries census recorded the average seafood consumption per capita to be 57 kg per annum consisting of 44 kg fish, 13 kg invertebrates and seaweed (Mulipola, 2001) which is very high compared to the regional average of 35kg/person/year (Vunisea, *et al*., 2008).

However, proximity and easy access to coastal reosurces also results in challenges such as overfishing, destructive fishing and other anthropogenic impacts as evidenced by increased number of fishing households from 6,700 in 1999 to 8,377 in 2000 (Mulipola, 2001). Three quarters of the villagers on the main island Upolu are engaged in fishing with an average of four fishing trips per week (Zann, 1992). At a regional level, Samoa belongs to a group of Polynesian islands which are considered to have a higher fishing effort than that of the Melanesian islands (Dalzell *et al*., 1996). Indeed, the question is, will Samoa be able to sustain its vital fisheries?

Various actions have been implemented by the Government through the Fisheries Division to sustain these important fisheries. These interventions include providing assistance in formulating village level regulations and management plans, establishing marine protected areas and implementing restocking projects. However these management guidelines are generally based on qualitative analysis with limited availability of robust scientific data. This gave rise to this study which looks into the scientific data collected as part of the Pacific Regional Oceanic and Coastal Fisheries Development Programme (PROCFish) carried out in Samoa in 2005. PROCFish was the first comprehensive multi-country comparative assessment of reef fisheries in the Pacific Islands and it aimed to provide the Pacific Island countries and territories with basic information necessary to identify and alleviate critical problems in the management of reef fisheries (Secretariat of the Pacific Community, 2007)

1.1 Objective of the Study

The main objective of the study is to assess coastal finfish fishery in Samoa. This will be done by estimating the stock size within the selected sampled sites. The sites will be divided into four habitats (strata) types, which are the coastal reef, lagoon patches, back reef and outer reef (Vunisea *et al*., 2008). Comparisons will be carried out between these sites and strata in terms of density and abundance. Furthermore, the study will identify any variability of finfish density by species and families within each stratum and their proportion in the overall area of each site. With known catches from the socio-economic data, the status of exploitation of the stock will be evaluated. Hence, the study will result in a recent status of the finfish fishery which will help fill in this information gap that hinders the effective management of this fishery. In addition it is expected to foresee any improvements on the data collection with results obtained from analysis. Lastly to build the confidence, skills and knowledge for one of the fisheries staff to carry out such work.

2. SAMOA

Located between the 13°25’-14°05’ latitudes south and 171°23’-172°48’ longitudes west are the mountainous, volcanic origin islands of Samoa (Skelton *et al.*, 2000). The chain of islands lies parallel to the south east trade winds having absence of strong windward and leeward effects (Skelton *et al.*, 2000). The total land area is 2,935 km^2 which is mainly contributed by the two main islands Upolu and Savaii. The country has the smallest Exclusive Economic Zone (EEZ) in the Pacific Region with 120,000 km^2 (Solofa and Samuelu, 2008) due to the close proximity of neighbouring countries. The population is estimated to be 179,186 in 2006, compared to the last census in 2001 a growth rate of 1.4% (Samoa Department of Statistics, 2007). Community settlements are mainly along the 447 km coastline with 461 people per kilometer of the coastline in 2001 (Samoa Statistics Department, 2001). Adjacent to these communities are shallow lagoons (2-3 m depth) which are enclosed by fringing coral reefs that can extend 3 km seaward (Skelton *et al*., 2000).

Location of Samoa in the South Pacific and its scattered islands

2.1 Coastal Fisheries

There have been various studies on Samoa's biodiversity however they are either incomplete, or in a foreign language, or mostly covering the neighbouring country American Samoa (Skeleton *et al*., 2000). According to Wass (1984), 890 fish species are considered shallow-water (depths less than 60 m); 56 are considered deeper demersal fishes (depths of 60-500 m); and 45 are considered pelagic (depths less than 200 m). Recent studies on marine algae have added 89 new records (Skeleton and South, 1999). The Fisheries Division has been collecting and updating such collection from various research (Table 1).

Samoans harvest, consume and market a wide range of marine species from finfish, bivalves, invertebrates; crustaceans to seaweed (Fisheries Division, 2005). They are harvested with simple and non-mechanised tools like canoes, spears, casting nets and by gleaning (collecting). Each method reflects the targeted species. For instance, spear diving is the most commonly used method to target finfish often within the lagoons (Eriksson, 2006). Second in rank is gleaning where collecting sedentary invertebrates on the reef flats is mainly carried out by women (Passfield *et al*., 2002). Overall, different species of finfish are targeted and finfish is dominantly sold in the market outlets. For instance, in 2005 the inshore market landed 115 mt valuing at $469,711 USD with finfish contributing 63% while processed food (cooked or already gutted products), seaweed and bivalves contributed about 30% (Fisheries Division, 2005).

Both natural and human induced environmental disturbances have contributed to problems with inshore fisheries. A series of tropical cyclones have struck Samoa in 1990 (Ofa), 1991 (Valerie) and 2004 (Heta) but cyclone Ofa was disastrous which reported cyclone banks along the northern coast of Upolu measuring up to 2-3meters high (Rearic,1990). Recovery of habitats has been shown in the increased coral coverage in permanent fish reserve from 2004 to 2007 (Wilkinson, 2008). Furthermore, an outbreak of crown-of-thorns starfish, *Acanthaster planci*, was experienced from 1978 to 1983 (Zann and Sua, 1991). As well as invasive species like *Codium arenicola* and *Codium prostratum* seaweeds which have replaced the local animals and plants along the Apia wharf (Skelton and Robin, 2007).

However, continuous human activities it will slow ecosystem recovery. The unplanned developments along coastlines have resulted in overfishing, pollution, and eutrophication of reefs (Zann, 1994). Also a number of destructive fishing methods have been recorded such as dynamite fishing and coral breaking destroying individual coral stands or coral reefs (Solofa and Samuelu, 2008). In addition, with increased population evidence of overfishing has in some instances become apparent like the decline of giant clams to a point of local extinction (Horsman and Mulipola,1995) and over-harvesting of sea cucumbers when the export market was open (Eriksson, 2006). An overall record of inshore market annual landings were declining from 250 mt (1986) to about 50 mt (1993) (Figure 1) but recent landings have been stable in a range of 97 – 146 mt (Table 2). According to Samoilys and Carlos (1991) in less fished deep slopes there was a higher biomass while the heavily fished and shallow (lagoon) areas was low. Similarly lagoons were also noted by Zann (1992) as the main fishing area from anecdotal data.

2.1.1 Management Measures

Village Fono Act (1990) was an act to validate and empower the exercise of authority by villages in accordance with the custom and usage of their villages and to confirm or grant certain powers. One of these powers was allocating the management of the adjacent coastal waters to the villages and traditional regulations. The Government removed itself from a centralised management of coastal fisheries to act a supporting role to the villages. These roles were observed in various management programs implemented for the coastal waters.

Community-Based Fisheries Management Programme was initiated under the Fisheries Extension Training Project (1995-2001) with the assistance of AUSAID (King and Faasili, 1998). The aim was to help the villages set up their management plans by identifying key problems, possible solutions through regulations and provide continuous biological assessments (King and Faasili, 1998). The Fisheries Act (1988) and Fisheries regulation (1996) governs marine resource, conservation and monitoring, prohibit certain fishing, authorize scientific research and provide regulations to regulate and manage any fishery (Skelton *et al*., 2000).

Traditional management only applies to villagers within a particular community but is not recognised publicly. Village bylaws under the Fisheries Act allow legal recognition of village by laws to solve consequences of neighbouring villages illegally fishing (Mulipola, 2002). At present, 57 villages (Mulipola *et al.*, 2004) are under this program and the Fisheries Division aims to include more and maintain the activeness of existing stakeholders. Promotion of ownership and awareness is the overall objective targeted by the programme.

With such awareness in local communities most have become interested in development and protection of their coastal waters. Development projects such as coral restoration, mangrove replanting and introduction of species for restocking purposes. Conservation initiatives include fish reserves which are included in the above mentioned management plans. As well as district level marine protected areas (MPA) with collaboration with other NGOs and government departments which are bided by National Parks and Reserves Act (1974). As illustrated in Safata and Aleipata MPA districts under the Marine Biodiversity Protection and Management Project carried out by World Conservation Union (IUCN) and the Ministry of Natural Resources and Environment in 2002 (Solofa and Samuelu, 2008). This conservation measures are also incorporated in the National Parks and Reserves Act (1974) and The Lands, Surveys and Environment Act (1989) (Mulipola, 2002).

2.1.2 Ongoing Data collection

The Fisheries Division is mandated to monitor the status of the fish reserves as well as the resources exploited (Mulipola, 2002). Annual UVC assessments are carried out for fish reserve for both existing and newly established ones. Samoa is also part of the Global Coral Reef Monitoring Network (South-West Pacific Node) since 2001 with 10 permanent sites which are assessed along side with the fish reserves. Furthermore training of community members in assessing their own coastal waters was conducted in a two-year project funded by the Project Development Fund (Solofa and Samuelu, 2008). This was to assist with the time constraints, budget and shortage of staff faced by Fisheries Division since it may not possible to conduct annual assessments of all Fish Reserves.

As for the exploited resources, regular (3 x week) surveys are conducted randomly in three main market outlets (Apia Fish market, Salelologa Market and Fugalei Agricultural Market) and along roadside (Fisheries, 2007) for marine inshore products. These surveys record abundance, weight, length of species ranging from fishes, invertebrates, crustaceans, bivalves and crustaceans. Additional information on the method used, habitat and village are also noted from interviewing sellers, proprietors and vendors (Fisheries, 2005). “Faaoso” which refers to fish packed as gifts for overseas relatives is considered as export for inshore fisheries. Fisheries Division issues permits for such export and through this inspection progress the abundance and weight are also recorded.

3. ASSESSMENT METHODS

Various methods of assessing fish stocks such as production models, yield per recruit models and cohort analysis have been established and implemented. No method has been prescribed that is appropriate for the situation in most tropical countries like Samoa since the models are dependent on age based data. This is mainly due to the fact that in the tropics annual marks on scales and otoliths are usually difficult to distinguish (Munro and Fakahau, 1986).

The alternative is the length converted catch curve which gives a reasonable estimate of the total mortality on the fish stock (Pauly, 1984). However, there is a shortage of research based information and a tendency to obtain social and economical information based on household surveys and underwater visual census.

3.1 Underwater Visual Census (UVC)

Results from household and creel census however do not give any real insight into the potential productivity of a fishery let alone the status of particular fish stocks (Munro and Fakahau, 1986). UVC method is the use of divers´ visual senses to record fish and it provides estimates of relative abundance, biomass and length frequency distributions (Samoilys and Carlos, 2000). It has been widely used and recognised since 1970s due to its rapid assessment, low cost and non-destructive to underwater habitats (Connel *et al*., 1998). However, fisheries scientists are not so willing to use such method because of lack of general agreement on a standardised method (Samoilys and Carlos, 2000). This is mainly due to the fact that reef and lagoon associated fishes are multispecies, patchy distribution, different behaviours and in diverse habitats.

According to Watson and Quinn (1997) UVC transects (line observation of fish) have negative bias when fish was moving away and positive moving towards the observer while no such bias was experienced in the point count (radius observation of fish). Indeed, the natural movement of the fish is of decisive importance to the amount of bias in the fish density estimations. Fish behave differently, some are cryptic, roving or sedentary (Samoilys and Carlos, 2000). This can seen in comparison of two herbivores fish where surgeon fish are nomadic while damsel fish tends remain stationary to algae gardens (Mcginley *et al*., 2008). Fish also react differently to light can be either diurnal or nocturnal and crepuscular (Hobson, 1965). Diurnal fish have a direct response to light level where slow rate descent of fishes towards reefs at dusk is in response to slow decrease of light (Jennings *et al*., 1998).

When applying UVC, these limitations should be considered in order to limit ways of under or over estimating fish counts. Past surveys have tackled this by surveying and analysing at a species level and grouping species into the above mentioned movements (Stobutzki, 1997). Others have looked at a limit number of fish species to survey. Furthermore, UVC is more applicable to survey fish species that are abundant, non cryptic and not highly mobile (Samoliys and Carlos, 1997).

However, in order to get overview of all fish within the reefs and lagoons it will be a tedious task to survey and analyse by species level. Most of these overall surveys were analysed at fish family level (Samoilys and Carlos, 1991). A question rises whether the grouping in families would be appropriate since within families grouping tend to mask the importance of individual species. Stobutzki (1997) notes from his finding that clear differences in swimming ability among species may vary their detectability within both the Chaetodontidae and Pomacentridae but the extent of the variation is family dependent.

Speed of observer census may bias visual estimates as well either by efficiency of observer or its presence. It is favourable to obtain the optimal speed and standardise it, however in most cases, the speed is dependable on cost of the assessment (Watson and Quinn, 1997). Samoilys and Carlos (1997) recommend the slow 50 x 5m transect in contrast to bigger area transects because it showed high abundance in most species recorded moreover the assumption was the higher estimates the greater the accuracy. This of course requires a large number of replicates in order to lower variance and limit the area surveyed to have sufficient search or detection of fish (Labrosse *et al.*, 2002). There is likelihood of overestimation with smaller areas but generally UVC underestimate fish abundance (Samoilys and Carols, 1997). To lower the level of such bias, divers should be trained to gain experience as well as investigating any significant difference in estimates between buddy divers (Graham *et al.*, 2004). In addition, divers or observers need continuous re-training in these estimations in order to sustain their standard visual census.

3.2 Creel census and Socio-economic

In small scale fishing, landing sites are dispersed along the coast with other characteristics than mixed multispecies fishing. This is one of the problems in successfully maintaining an application of an established statistical system to monitor this fishery (Munro, and Fakahau. 1988). Creel census and questionnaires set out for fishermen to estimate catches are often a method used in this situation, particularly Samoa. The catches can then be used to estimate finfish removed from the estimated standing stock. Moreover, it determines the exploitation rate of the estimated unbiased biomass from the UVC survey. However, the relation of creel and questionnaire surveys was noted by Connell and collegues (1998) as closely related than that of UVC.

Perhaps a reasonable approach is the one set out by Kulbicki (1998) to survey fishing where a longline survey was carried out in the SW lagoon of New Caledonia and the visual census showed a high correlated catch per unit effort in numbers and weights. Its considered reasonable since it minimises bias that arise from questionnaires which were dependent on fisher‘s behaviour as well as having standardised sites, time and exploited species for both visual counts and catches (Connell *et al*.,1998). This can be illustrated where UVC was usually carried out at day time while creel and questionnaires varies from day to night fishing. Both UVC and socioeconomic data are considered and accepted to give an estimate but may not be the absolute value (Connell *et al*., 1998).

4. METHODOLOGY

4.1 Site Characteristics

Selection of the sites and number was relative to the aims and objectives of the PROCfish survey as well as interests shown by the Samoa’s Fisheries Division (Figure 2). The characteristics considered was diverse habitats, appropriate size, accessibility and a comparable number to same surveys that was carried out in other Pacific Island countries (Vunisea *et al*., 2009). Furthermore, the sites should be representative of Samoa which resulted in four sites Manono Uta, Salelavalu, Vailoa and Vaisala (Vunisea *et al*., 2009)(Table 3).

At the west end of Upolu island is Manono Uta and four kilometres east is Manono (Tai) island of only 3 km^2 land area situated within the shallow lagoon that was formed by the barrier reefs of Upolu (Samoa Department of Statistics, 2007). These two Manono Uta and Tai are of the same clan having common access to fishing area from the island to the west coast of Upolu which was the surveyed area covering the coastal reefs, lagoon, back reef and outer reef. Consumption of fresh finfish within this site was estimated to be 79 kg/person/year which were mainly sourced from lagoon and outer reefs (Vunisea *et al*., 2008). The lagoon has a sandy silt bottom where suspension of the sand would cause poor visibility (Mulipola *et al*., 2004). In addition it had a few patches of algae assemblages, sea grasses and live corals. In contrast, excellent visibility was observed in the back reefs and steep outer reefs with good coral coverage (Vunisea *et al*., 2008).

Further west of Manono (Tai) island is the big island Savaii where the second site Salelavalu is situated in the east coast. Being a neighbouring community to Salelologa wharf and commercial town it provides good access to markets for Salelavalu fishers. Finfish are mainly caught in easy accessible habitats because of limited number of boats. Furthermore the consumption of finfish within the community is 58 kg/person/year (Vunisea *et al*., 2008). Adjacent coastal water from Salelavalu stretching up north to Lalomalava villages was surveyed. Similar to Manono Uta four habitats were surveyed. The coral reefs in this area have been noted as healthy and complex (Vunisea *et al*., 2008). Furthermore, it has a larger reef than Vaisala, moreover one of the largest reefs in Samoa.

Vaisala is another community in Savaii on the north western coast with once a thriving Asau Bay of economic development that included logging operations(MNRE, 2007). Finfish is mainly for consumption (51 kg/person/year) purposes due to isolation from Apia and Salelologa center towns (Vunisea *et al*., 2008). The survey of this site only covered the back reef and outer reef habitats. The outer reef crest is about 240m from the beach with a reef passage midway along the Vaisala Bay and bordered by a major passage at the eastern end into the Asau Bay (MNRE, 2007). In 1999 the bay was characterized as two areas the eastern part consisting of dead coral boulders and western part with good coral coverage. The lagoon is relatively small and shallow with sandy bottoms and scattered sea grass patches (Mulipola *et al*., 2004).

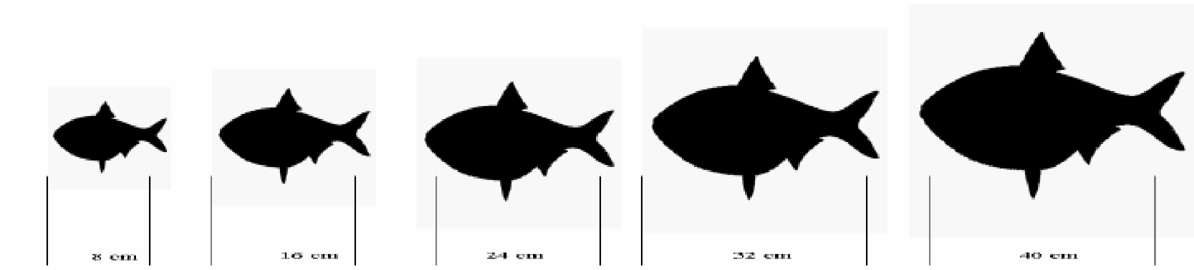
The last site, Vailoa within the Aleipata district is located at the far east end of Upolu. Similarly this Vaisala, this site is far from main markets thus finfish harvest is mainly for consumption (47 kg/person/year) and lesser degree of income generation (Vunisea *et al*., 2008). The adjacent coastal waters of three villages in this district was surveyed stretching from Vailoa, Ulutogia to Satitoa. This was carried out only for coastal reef, backreef and outer reefs. As well as the outer reefs of the nearby uninhabited islands Nuutele and Nuulua (Vunisea *et al*., 2008). This was mainly due to the fact that adjacent communities to the islands also fish in this area. The outer reef was characterised by pavement of coralline algae and algal ridge in the reef edge. Reef slopes were mostly steep with generally low in coral cover in some areas (Vunisea *et al*., 2008).

4.2 Data collection

4.2.1 Finfish Fisher Survey

Fishers (men and women) within the random selected households of each site were enquired on fishing strategies, quantitative and qualitative data on average catches for each fishing habitat (Vunisea *et al*., 2008). Fishing strategies included frequency of fishing trips and habitats, time of fishing, use of catch, techniques used and so forth. As for the average catches the Fishers gave vernacular or local names, number and length estimates of fish caught which was assisted by size field survey charts. The field chart consisted of five major size classes in 8 cm intervals but length more than these classes was estimated with tape measure. Lengths were then converted to weights (Kulbicki *et al*., 2005) for the overall weighted catches by habitat and sites.

The use of aerial photographs, maps, hydrologic charts for detail description of habitats by fisher was used to taken challenging of fisher identifying habitats. Also photographic indices were used to assist in identification of local fish names to matching scientific names. Additional information on species seasonality was recorded and catches with commonly used fishing techniques were encouraged to provide (Vunisea *et al*., 2008).

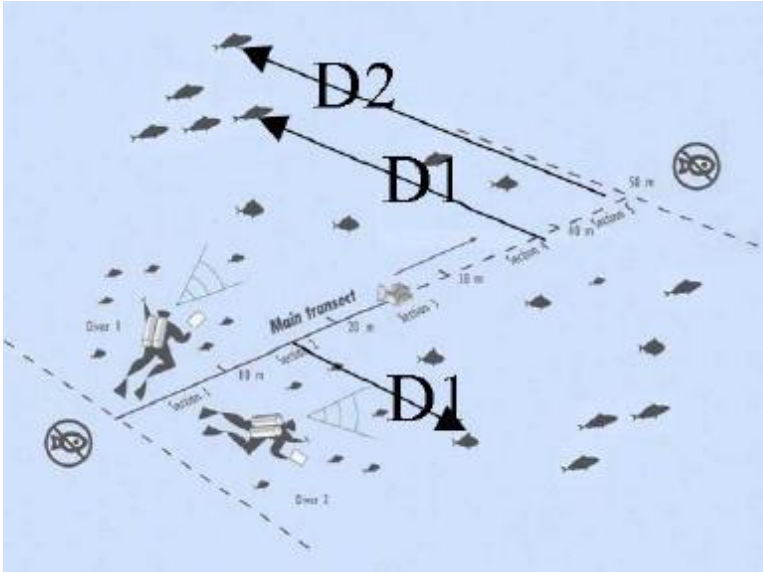


Finfish size field survey chart for estimating average length of reef and lagoon fish (including 5 size classes from 8 cm to 40 cm, in 8 cm intervals). (Vunisea et al., 2008)

4.2.2 Finfish Survey

A transect to 50 meters with tape was laid on the seafloor for the distance underwater visual census (D-UVC) method. Basically, two observers were on both sides of the tape recording abundance of fish species; length estimates and the distance of individual fish from transect (Vunisea *et al*., 2008). When group (school) of fish was sighted two distances were recorded. The distance of the closest fish to the transect and the farthest fish from transect are recorded (Labrosse *et al*., 2002). A two or three minutes stationary wait by the observer before recording such data was carried out so that surrounding fish would be calm and familiarise with observers presence. Care was taken by both observer to swim at a same speed rate and recordings along the transect were in a 10 meters intervals to avoid recounting fish and safety issues (Labrosse *et al*., 2002).

The probability of detecting fish decreases with increase distance therefore transects were limited to about 5 meters on left and right of transect (Vunisea *et al*., 2008). This was according to the observers visualisation of such distance therefore one transect has an estimate area 500m^2(50 x 10). These transects were randomly laid within four habitats; coastal reef, lagoon patches, back reef and outer reef for each four selected sites. The overall total number of transects was 101 as for the number within each site and habitat varied depending on the scale of the area as well as to logistical and time constraints. At least maximum of 24 transects was targeted for each site and at about 12 transects for shallow habitats (coastal reef, lagoon) and 12 transects for deeper waters (outer reefs) (Vunisea *et al*., 2008).



A diagram illustrating the procedure of the D-UVC method (Vunisea et al., 2008)

4.3 Data Analysis

4.3.1 Finfish fisher survey

The focus of this study is to obtain catches by habitat to compile with UVC biomass by habitat. However, the fishing habitats recorded in the data collection showed either combination of habitats or shifting of habitats in a fishing trip. Therefore, the overall sum of these catches by sites would be more appropriate than the sum of habitat catches.

The data made available from SPC (PROCfish project) was the annual catches and average size of grouped fish families by each fisher of household surveyed. The total catches of the fisher for each household was calculated at fish family level. Then the average catches of households within the sites was calculated. This was then scaled to the number of households within the site to be of representative of the whole community (one site).

4.3.2 Finfish Survey

Application of stratified random sampling (Conquest, *et al*., 1996): where the subpopulations or strata were referred to as the four habitats within a site. Thus species richness (mean total number), fish abundance and fish biomass were calculated for each habitat at each site. Biomass was calculated with length-weight relationship data. These calculations were for each fish species recorded which were later summarised into fish families.

In order to estimate biomass, the observed lengths were converted to weight using the following formula:

$$W = \propto L^{\beta}$$

The parameters $\propto$ and β which are species specific were obtained from Kulbicki (1993) and are given in table 13 in the appendix.

For each site, mean density (per 500 m^2) within each habitat (strata), either in terms of number (N) or biomass (B) was calculated as:

$$\overline{N_h} = \sum_{t=1}^{T} \frac{N_t}{n}$$

$$\bar{B}_h = \sum_{t=1}^{T} \frac{B_t}{n}$$

Where h stands for habitat and s stands for site, n is the total number of transect sampled within a habitat. The total number is N_t and B_t is the total biomass of finfish sampled in transect (t). The variance in the estimates within each habitat was calculated by:

$$N^{S_h^2} = \sum_{t=1}^{H} \frac{(N_t - \overline{N_h})^2}{(n-1)}$$

$$B^{S_h^2} = \sum_{t=1}^{H} \frac{(B_t - \bar{B}_h)^2}{(n-1)}$$

Standard deviation (s), standard error (se) and coefficient of variation (cv) are calculated the conventional way:

$$N^S = \sqrt{N^{S_h^2}} \ and \ B^S = \sqrt{B^{S_h^2}}$$

$$N^{CV} = \frac{N^S}{\overline{N}} \ and \ B^{CV} = \frac{B^S}{\bar{B}}$$

$$\mathbf{N}^{se} = \frac{\mathbf{NS}}{\sqrt{\mathbf{n}}} \ \mathbf{and} \ B^{se} = \frac{\mathbf{BS}}{\sqrt{\mathbf{n}}}$$

Assuming a catchability of one, the estimated total abundance in term of numbers and total biomass of a site was calculated as:

$$N = \sum_{t=1}^{H} [\frac{\overline{N_h}}{W_t} \cdot (W]_h \cdot 100000)$$

$$B = \sum_{t=1}^{H} \frac{\bar{B}_h}{W_t} [\cdot (W]_h . 100000)$$

Where H is the number of habitats, W_t the total area of transect and W_h is the area of each habitat which is converted to similar units (m^2) as transect area. The variance of the total biomass estimates was calculated by:

$$V_B = \sum_{t=1}^{H} \frac{W_h^2 s_h^2}{n}$$

$SE_B = \sqrt{V_B}$: is then simply the standard error of the total biomass estimates

4.3.3 Statistical test

The analysis of variance (ANOVA) was used to test the difference of biomass density between habitats of sites and within each site. Logarithm of the weights was taken for this analysis. This was followed by the Tukey HSD (Tukey Honest Significant Difference) multiple comparison procedure. The Tukey procedure was followed to identify the group (site and habitat) showing significant difference at the 95% family-wise confidence level (Cochran, 1997).

$$\sum_{j=1}^{k}\sum_{i=1}^{n}(x_{ij} - \bar{\bar{x}})^2 = n\sum_{j=1}^{k}(\bar{x}_j - \bar{\bar{x}})^2 + \sum_{j=1}^{k}\sum_{i=1}^{n}(x_{ij} - \bar{x}_j)^2$$

$SS_{TOT} = SS_{BG} + SS_{WG}$ (abbreviation of the above equation)

$MS_{BG} = \frac{SS_{BG}}{df_{BG}}$ (calculating mean sum of squares between groups)

$MS_{WG} = \frac{SS_{WG}}{df_{WG}}$ (calculating mean sum of squares within groups)

$$F = \frac{MS_{BG}}{MS_{WG}}$$

SS_{BG} = Sum of squares between groups
SS_{WG} =Sum of squares within groups
SS_{TOT} =Total sum of squares
MS_{BG} =Mean sum of squares between groups
MS_{WG} =Mean sum of squares within groups
df_{BG} =Degress of freedom between groups (number of groups - 1)
df_{WG} =Degress of freedom within groups (total degrees of freedom - 1)
F =F ratio

4.3.4 Combined Analysis

With known catches from the socioeconomic survey and the average standing stock biomass calculated from the D-UVC data one can get a proxy of the fishing pressure by taking the ration of annual catch over the standing biomass:

$$E = \frac{Y}{B}$$

If the catchability in the UVC survey is one, i.e. the density estimates are a true reflection of the biomass and if the biomass estimates in the UVC survey is the same as the mean annual biomass, then the above fishing pressure proxy is equivalent to instantaneous fishing mortality (F), i.e.

$$F = \frac{Y}{\bar{B}}$$

If natural mortality (M) is known, the exploitation rate (the relative amount taken by fishing compared with the total amount removed) can be calculated by:

$$\mathbf{E} = \frac{\mathbf{F}}{(\mathbf{F}+\mathbf{M})}$$

$$\mathbf{E} = \frac{\mathbf{C}}{\mathbf{P}} = \frac{\mathbf{F} \cdot \bar{\mathbf{B}}}{\mathbf{Z} \cdot \bar{\mathbf{B}}} = \frac{\mathbf{F}}{\mathbf{Z}} = \frac{\mathbf{F}}{\mathbf{F}+\mathbf{M}} \mathbf{E} = \frac{\mathbf{C}}{\mathbf{P}} = \frac{\mathbf{F} \cdot \bar{\mathbf{B}}}{\mathbf{Z} \cdot \bar{\mathbf{B}}} = \frac{\mathbf{F}}{\mathbf{Z}} = \frac{\mathbf{F}}{\mathbf{F}+\mathbf{M}}$$

5. RESULT

A total of 27 fish families was recorded from the UVC survey that was used in the analysis. Within the four sites a range of 22 – 16 families, 56-43 generas and 140-114 species was obtained. Vailoa and Vaisala have diverse abundance of these finfish classes than that of Manono uta and Salelavalu (Table 4). Only 13 of these families was composed in the catches obtained from the Fisher survey.

1. Acanthuridae
2. Aulostomidae
3. Balistidae
4. Belonidae
5. Caesionidae
6. Carangidae
7. Chaetodontidae
8. Cirrhitidae
9. Diodontidae
10. Haemulidae
11. Holocentridae
12. Kyphosidae
13. Labridae
14. Lethrinidae
15. Lutjanidae
16. Mugilidae
17. Mullidae
18. Nemipteridae
19. Pempheridae
20. Pomacanthidae
21. Scaridae
22. Scombridae
23. Scorpaenidae
24. Serranidae
25. Siganidae
26. Tetraodontidae
27. Zanclidae

5.1 Relative abundance and biomass

The density of fish both in terms of numbers and biomass is highly influence by habitat (Table 5). An ANOVA test of biomass density between habitats within sites was highly significant for Manono uta, Salelavalu and Vailoa but not for Vaisala (Table 6). A pairwise test showed that the biomass density in the outer and back reef is the same as well as the lagoon and backreef. In contrast, the biomass density in the coastal reef is significantly different to all other habitats. The only exception was in Vailoa where the coastal reef and back reef were the same and back reef and outer reef significantly different.

The overall pattern (Figures 3 & 4) is that the outer reefs have highest densities (average of 138-217 kg/500m^2) with lagoons and back reef showing moderate densities (average of 45-95 kg/500m^2) while the coastal habitat have the lowest biomass (average of 10-27 kg/500m^2).

To test for difference in densities between sites one must take into account the influence of habitat on densitites. An ANOVA test on the biomass density where habitat is a factor showed that the densities in coastal reef, back reef and coastal reefs are the same at all four sites (Table 7). The density of the lagoon habitat was however significantly different in Manono Uta and Salelavalu, the only two sites where this habitat was found.

The size pattern among the different habitats is relatively consistent among different sites (Figure 5-8), with the modal size decreasing from 20-15 cm in the outer reef to 15-10 cm in the back reef and lagoons to 10-5 cm in the coastal reef. A number of very small (< 4 cm) and large (46-70 cm) fish lengths were recorded mainly within the Vailoa and Vaisala.

5.2 Major Families of Biomass Density

Acanthuridae, *Scaridae* are the two dominant fish families within the outer reefs (Figure 9). These fish families are herbivores often foraging in daytime for food with life span varying from 5 to 20 years. Second in rank was the carnivorous fish *Lutjanidae* that are often sited along the reefs in schools during the day. Other noticeable families with such moderate density in the outer reefs were *Caesonidae* (planktivore), *Balistidae* and *Lethrinidae* both carnivorous fish.

Among the sites these families do not show a uniform density. The *Caesonidae* family are often in schools feeding along the reef slopes was particularly dense in Vailoa and Manono uta. While in Vaisala the *Balistidae* family had the highest biomass and lowest in *Lethrinidae* finfish. *Mullidae* family, also carnivorous and sand dwellers, are often solitary were denser in Salelavalu than other sites.

In close proximity to outer reefs, the back reef show similar fish family dominance but of lower biomass. As illustrated by the high biomass density of *Acanthuridae* and *Scaridae* with other fish families below 5 kg per transect (Figure 10). An exception was observed in Manono uta where *Mullidae* and *Nemipteridae* were of higher biomass compared to other sites. In addition *Siganidae*, herbivore family was very low in the Savaii sites (Salevalu and Vaisala).

The lagoons of only two sites show relative high biomass of families *Acanthuridae* and *Scaridae* (Figure 11). *Lutjanidae* and *Caesionidae* in Manono uta have become more important (dense) than the *Scaridae* and *Acanthuridae*. On the other hand Salelavalu still maintains the dominance of *Scaridae* and *Acanthuridae* with *Lutjanidae* and *Nempteridae* as moderate biomass density.

Coastal reefs show a decline in the two dominant herbivore families from the outer reefs. Other families like *Siganidae* and *Nemipteridae* have become relatively higher than in the deeper habitats. Manono uta had a significant high biomass of *Siganidae* compared to all other sites (Figure 12). *Scaridae* and *Acanthuridae* still show high density in Salelavalu and Vailoa but not in Manono uta. Other families show relative spread among the sites like *Nemipteridae* and *Mullidae*. Vailoa was the only site to have *Mugilidae* family at a moderate biomass.

5.3 Total Biomass and Catches

The estimated total biomass among the four sites was 8289, 1557, 1471 and 664 tonnes at Manono, Salalavalu, Vailoa and Vaisala respectively (Table 8). Among the habitats the biomass increases with distance towards the outer reefs. However the lagoons of 1948 (Manono uta) and 682 (Salelavalu) tonnes is higher than that of back reefs ranging from 896 - 109 tonnes. Manono uta has the highest biomass in all the four habitats surveyed with

Salelavalu commonly second in rank. Except in the outer reefs the biomass of 1314 tonnes was high compared to Salelavalu (561 tonnes) and Vaisala (432 tonnes).

The annual catches obtained in the sites follow the similar decline as biomass. Manono uta with highest catches of 284 tonnes is only a threefold difference to the lowest of 101 tonnes (Vaisala). While Saleavalu and Vailoa is only about 20 tonnes difference. The decline in biomass and catches from site to site reflects on the decreasing fishing area (Table 8). Obviously with high available biomass the fishing community correspondingly obtains a high yield of finfish (Figure 13). A proxy of the fishing pressure from these estimates (biomass and catches) showed that Vaisala the lowest biomass site had the highest fishing pressure and Manono uta the lowest (Figure 14).

The main targeted fish families among the sites are the dominant biomasses namely *Acanthuridae*, *Scaridae* and *Lutjanidae*. Taking into consideration the natural mortality of these fish families and comparing it to the fishing the exploitation rate obtained is low. This is considering a reference of above 0.5 is a high exploitation rate. These characteristics were noted in most fish families in Manono uta and Salelavalu sites (Table 9, 10). The exceptional fish family in Salelavalu site was *Kyphosidae* family (0.49) that had a high fishing effort that is of similar value to its natural mortality having a moderate high exploitation rate (Table 10).

Other fish families that had higher catches than the estimated biomass were mainly within the Vailoa and Vaisala site. These families included *Holocentridae* and *Siganidae* while *Lethrinidae, Serranidae* were particular to Vaisala site and *Labridae* and Mugilidae in Vailoa (Table 11,12). In comparison to its respective natural mortality these families showed a higher fishing mortality resulting in a higher exploitation rate (>0.5).

6. DISCUSSION

Among habitats of each site the biomass density was significantly different (ANOVA).
The biomass and abundance density increases with distance from the shore. Similar trend was reported by the PROCfish report and in Aleipata waters by Samoilys in 1991. Generally the diversity or abundance of reef fishes increases with habitat complexity and relief (Levey, 2004). Thus the complex, high coral coverage of the outer reefs had higher biomass than the less complex scatter of algal assemblages and live coral in the coastal reefs and lagoons. Therefore the biomass density is largely attributed by different biological complexity of habitats rather than the fishing intensity among the habitats. This was clearly observed in two sites. Salelavalu with CPUE of 1.5 kg/hour was relatively the same throughout the habitats in comparison to Vailoa with highest CPUE (2kg/hour) in outer reef both had the similar trend of increasing biomass density (Vunisea *et al*., 2009).

The major fish families noted were the *Scaridae*, *Acanthuridae*, *Letherinidae* and *Lutjanidae* but mainly within the outer reefs. In the lagoon and coastal reefs (shallow habitats) other families like *Siganidae*, *Holocentridae* and *Caesonidae* became denser or densely related to the major fish families. *Holocentridae* is a nocturnal fish which may result in the low biomass as recorded in other habitats since the D-UVC survey was carried out only in the daytime where as the fishing was done in both the day and night (Vunisea *et al*., 2009). *Siganidae* was significantly high in Manono uta coastal waters but low in outer reefs. It was suggested that the lower percentage of coral and high percentage of hard bottom which would result in more herbivores (*Signidae*) than carnivorous finfish and that the decline in

Acanthuridae and *Scaridae* (herbivores) is due to the high catch per unit effort (about 2kg/hour) on this habitat (Vunisea *et al*., 2009).

Particularly the above low biomass of Acanthuridae and Scaridae may as well been existing for a long time. Since the major size range of this *Siganidae* family was of bigger fish from 10-24 cm than other families. Hence, it may as well be a school of adults feeding in the coastal reef resulting to this exceptionally high biomass. Detectability would be another reason where this large mean length was easier to be recorded than the small mean size. For instance the coastal habitats (coastal reef and lagoon) of Manono uta was particularly described as turbid due to the easy suspension of the sandy silt bottom.

The dominant size range within habitats increases with distance from the shore. The size difference the coastal and lagoon habitats are good nursery grounds for juveniles due to abundant algal assemblages and decrease predation with distance from the reefs (Carr and Hixon, 1995., Shulman, 1985). A corresponding high biomass fish families (e.g. *Acanthuridae* and *Scaridae*) in the outer reefs also prevailed in the coastal reefs. However the biomass of these juveniles are much lower than that of the outer reefs. Considering they are nursery grounds, one would expect a higher biomass. This large scale biomass differences can be related to high natural mortality, recruitment and movement of juvenile finfish (Gillanders, 2006). Moreover, the more likely of natural mortality (predation) and together with fishing mortality these juveniles are in low biomass.

Total biomass among the habitats and sites resulted in Manono Uta as the highest and the lowest was Vaisala. This does not entirely reflect the biomass density where Vailoa was the highest then Manono Uta, Vaisala and Salelavalu as the lowest. The main reason behind this biomass variation is the different fishing area. As illustrated by the lagoon habitat where the area of Manono Uta had fourfold difference than Salelavalu (84kg/transect) resulted in the higher biomass in Manono Uta. Furthermore, this was the only habitat among sites that the ANOVA test showed significant difference of biomass density while the rest was the same. One has to keep in mind that these were the only two sites surveyed for this habitat.

The surveyed sites have a small range of catch per unit effort from 1-2 kg/hour and the population is relatively the same (Vunisea *et al*., 2009). This correlates to the annual yields among sites obtained which was only a threefold difference. In comparison to the estimated biomass the sites have about a 13 times difference in biomass. Again the available fishing area is contributing to such difference of the biomass. With decreasing biomass and area correlated to decreasing catches from Manono Uta to Vaisala site.

The fishing area also determines the fishing pressure where Manono uta (13fisher/km^2) had a lower fishing pressure than that of Vaisala (52fisher/kg) (Vunisea *et al*., 2009). In other words, considering the population size the fishing pressure has an inverse relationship with accessible fishing area. Therefore Vailoa and Vaisala sites are considered highly fished. In addition the estimated MSY by Munro (1984) of the neighbouring country American Samoa was 20tons/km^2/year (Dalzell *et al*., 1996). Such idea similarly shows Vailoa and Vaisala as being above such estimated MSY. It also reflected on the high exploitation of some fish families like *Holocentridae* and *Siganidae* that was particularly in these two sites.

However, the overall the catches obtained for the surveyed sites are lower than that of the available estimated biomass. Kulibicki (1994) states that a 10% of the estimated standing stock is the MSY fishable stock of the coral reefs which means all sites are not being highly fished. Thus overfishing is questionable but there is surely a difference of fishing pressure of the sites. In addition one should consider such overfishing conclusion carefully due to the following various reasons.

The high variance in the biomass estimates which is problematic in determining a precise increase or decrease of the biomass when having a series of reassessments. Comparison in coefficient of variance showed that coastal reefs, lagoons and back reefs have higher variance than that of outer reefs. Hence an increase in sampling numbers and on certain habitats would decrease such variance. Furthermore the average number of fish recorded per transect by the two divers do not show any correlation (Figure 16). The trend observed in the density along the four habitats simultaneously show that diver 2 was recording more fish than diver 1. The underwater visual census should be standardised to lower such level of errors.

7. CONCLUSION

Biomass density of the four sites did not show significant difference among sites, but there was a difference within habitats. The habitats showed increase in biomass, abundance and size length as distance from shore increases which is related to the biological recruitment, predation and movement of finfish. Hence the fishing pressure does not largely attribute on such pattern among the habitats. The fishing area does largely attribute to the biomass calculated as shown in the lagoon habitats where the area is greater than that of back reefs and having higher biomass.

The four sites had relatively the same in population numbers and catch per unit effort. The yield obtained are closely related, only a threefold difference while the biomass is of 13 fold difference. Again among the sites the fishing area is contributing largely to the available biomass. With high biomass corresponds to high yield but of low fishing pressure as shown in Manono uta. The Vailoa and Vaisala site with small fishing area have a higher fishing pressure and low catches. In terms of fish families *Scaridae*, *Acanthuridae* and *Lutjanidae* are of high importance in both the catches and biomass of all the sites. This is unlike the low biomasses of *Holocentridae* and *Signidae* which are highly exploited in Vaisala and Vailoa. Therefore, considering the population size, the fishing pressure has an inverse relationship with accessible fishing area.

Overall the catches obtained for the surveyed sites are lower than that of the available estimated biomass. The fishable stock is still below the 10% of the MSY fishable stock of the coral reefs which considers all sites as not being highly fished. Thus overfishing is questionable but there is surely a difference of fishing pressure of the sites. In addition one should consider such overfishing conclusion carefully since the number of samples used is low, the high variance and the errors associated with the method used.

On the other hand, with the conclusions obtained from this study it is possible to advice managers that the management measures within Manono Uta cannot be readily apply to these other two sites due to the results obtained. Vailoa and Vaisala may focus on extension of fishing area to the outer reef rather than coastal reefs. Since the coastal reefs are of smaller areas and already of low biomass and with high fishing pressure may reach a high exploitation of finfish in these near shore habitats. Furthermore, data collection and analysis of socio economic (catches) data and biological data (D-UVC) should be undertaken. Since it is often separately collected and analysed that such conclusions made from this report cannot be obtained. Also improvement of monitoring schemes should be considered.

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9. REFERENCE

Carrr, M.H. and Hixon, M.A., 1995. Predation effects on early post settlement survivorship of coral reef fishes [Electronic version]. *Marine Ecology Progress Series*. Vol 124, pp 31-42.

Cochran, W. G. 1997, *Sampling Techniques*, John Wiley and Sons, New York.

Conquest, L. Burr, R. Donnelly, R. Chavarria, J. and Galluci, V. 1996."Sampling methods for stock assessment for small scale fisheries in developing countries". In: Galluci, V.F. Saila, S.B., Gustafon, D.J. and Rothshchild, B.J. (eds). *Stock Assessment: Quantitaive methods and applications for small scale fisheries*. CRC Press, Lewis Publications. United States.

Connell, S.D., Samoilys, M.A., Smith, M.P.L. and Leqata, J. 1998. Comparisons of abundance of coral reef fish: Catch and effort surveys vs visual census [Electronic version]. *Australian Journal of Ecology*. Vol 23, pp 579-586.

Dalzell, P., Adams, J.H. and Polunin, N.V.C. 1996. Coastal Fisheries in the Pacific Islands [Electronic version]. *Oceanography and Marine Biology: an Annual Review*. Vol 34, pp 395-531.

Eriksson, H. 2006. *Sea cucumber abundance diversity and fishery in Samoa: An assessment of lagoon occurring sea cucumbers*. Uppsala University.

Fisheries Division, 2005. *Fisheries Annual Report 04-05*. Ministry of Agriculture and Fisheries, Samoa. Unpublished report.

Fisheries Division, 2007. *Inshore Section Scientific Technical Report*. Ministry of Agriculture and Fisheries, Samoa. Unpublished report.

Gillanders, B.M. 1997. Comparison of growth rates between esturarine and coastal reef populations of Achoerodus viridus (Pisces:Labridae). *Marine Ecology Progress Series*. Vol 146, pp 283-287.

Graham, J.E., Barrett, N.S. and Morton, A.J. 2004. Biases associated with the use of underwater visual census techniques to quatify the density and size structure of fish populations. *Journal of Experimental Marine Biology and Ecology*. Vol 308, pp 269-290.

Hobson E.S. 1965. Diurnal-noctural activity of some inshore fishes in the gulf of California [Electronic version].*Copeia*.Vol 3, 291-302

Horsman, N. & Mulipola, A. 1995. *Catch data and collection from market surveys in Western Samoa*. South Pacific Commission and Forum Fisheries Agency Workshop on the management of South Pacific Inshore Fisheries. Integrated Coastal Fisheries Management Project Technical Document. South Pacific Commission, Noumea.

Jennings, S., Bustamante, R.H., Collins, K. and Mallison, J. 1998. Reef fish behaviour during a total solar ellipse at Pinta island, Galapagos [Electronic version]. *Journal of Fish biology*. Vol 53, pp 683-686.

King, M. & Faasili, U. 1998. "Community based management of fisheries and the marine environment". In Seeto, J., & Bulai. N. (eds). *Fisheries and Marine Resources - Papers presented at Symposium 8, VIIIth Pacific Science Inter-Congress*. Marine Studies Programme Technical Report. Vol 98(3), pp 115-125. The University of the South Pacific.

Kulbicki, M., Guillemot, N. & Amand, M. 2005. A general approach to length-weight relationships for New Caledonian lagoon fishes [Electronic version]. *Cybium* Vol 29(3), pp 235-252.

Kulbikic, M. 1998. *Correlation between catch data from bottom longlines and fish censures in the SW lagoon of New Caledonia*, Proceedings of the 6th International Coral Reef Symposium, Australia 1988, Vol 2. Department of Oceanography ORSTOM BP A5, Noumea, New Caledonia.

Labrosse, P., Kulbicki, M. and Ferraris, J. 2002. *Underwater visual fish census survey: Proper use and implementation*. Secretariat of the Pacific Community, Noumea, New Caledonia.

Levy, M. *Reef fish habitat associations in the gulf of California*. Moss landing Marine Laboratories <http://ichthy.mlml.calstate.edu/levey.htm> [Febuary, 2009]

McGinley, Mark (Lead Author); Judith S. Weis (Topic Editor). 2008. *Coral reef fish feeding behavior in the Caribbean*. In: Encyclopedia of Earth. Eds. Cutler J. Cleveland (Washington, D.C.: Environmental Information Coalition, National Council for Science and the Environment).<http://www.eoearth.org/article/Coral_reef_fish_feeding_behavior_in_the_Caribbean>[November 30, 2008]

MNRE, 2007. *Coastal Ecosystem recovery plan Vaisala*, Ministry of Natural Resources, Environment and Meterology. Unpublished report.

Munro, J.L. and Fakahau, S.T. 1988. *A cost effective approach to stock assessment and monitoring of small-scale coastal fisheries in the South Pacific Region: Workshop and Pacific Inshore Fishery Resources*. International Centre for Living, Noumea, New Caledonia.

Munro, J.L. and Fakahau, S.T. 1986. *Methods for appraisal and assessment of coastal fisehery resources in the South Pacific region*. Nearshore Marine Resources of the South Pacific: Information for fisheries development and management. Forum Fisheries Agency.

Mulipola, A., Samuelu, J., Solofa, A. and Tausa, N. 2004. *Current Status of Coral Reefs in Samoa*, Report Submission to the 10th International Coral Reef Symposium, Fisheries Division, Ministry of Agriculture and Fisheries. Unpublished report.

Mulipola A,. 2002. *Marine resources of Samoa. Report prepared for the World Summit on Sustainable Development, Johannesburg, South Africa, July 2002*. Fisheries Division, Ministry of Agriculture, Forests, Fisheries and Meteorology, Samoa.

Mulipola, A. 2001. *Profile of village fisheries in Samoa: Fisheries Division, Ministry of Agriculture., Forests, Fisheries and Meterology*. GRM International Pty Ltd, Australia.

Pauly, D. 1984. Length converted catch curves: a powerful tool for fisheries research in the tropics (Part III: Conclusion) [Electronic version]. *Fishbyte*, *Newsletter of the Network of Tropical Fisheries Scientists*. Vol 2(3), pp 8-10.

Passfield, K., King, M., Mulipola, A. and Ropeti, E. 2002. *Report of a household fisheries and dietary survey October-November 2000.* Ministry of Agriculture , Forests, Fisheries and Meterology, Samoa. <www.mnre.gov.ws/documents/forum/2002/12>[November 28, 2008]

Rearic, D.M. 1990. S*urvey of cyclone Ofa damage to the northern coast of Upolu, Western Samoa*. SOPAC technical report 104.

Samoa Statistics Department. 2001. *Population Size and Growth.* Samoa Department of Statistics.
<http://www.spc.int/prism/Country/ws/stats/Products&Services/Reports/PDF/PopCensus/Ch.%201-%20Population%20size.pdf>[November27,2008]

Samoa Department of Statistics. 2007. *2008 Population Estimates*. Samoa Department of Statistics. <http://www.spc.int/prism/Country/ws/stats> [November 27, 2008]

Samoa Department of Statistics. 2008. *2006 Population Estimates.* Samoa Department of Statistics.<http://www.sbs.gov.ws/Portals/138/PDF/census%20survey/Table%202.%20Population%20byregion,%20faipule%20district%202006.pdf>
[November 27, 2008]

Samoilys, M., Carlos, G. 2000. Determining methods of underewater visual census for estimating the abundance of coral reefs [Electronic version]. *Environmental Biology of Fisheries*. Vol 57, pp 289-304.

Samoilys, M., Carlos, G. 1991. *A survey of reef fish stock in Western Samoa: Application of underwater visual census methods 1991*, Report to Forum Fisheries Agency and FAO, Queensland Dept of Primary Industries, Cairns, Australia, Unpubl, Report 6. SM/89/002.

Samoilys, M. 1997. Underwater visual census surveys. In: Samoilys, M. (ed). *Manual for Assessing Fish stocks on Pacific Coral Reefs*, Queensland Department of Primary Industries, Townsville.

Shulman, M.A., 1985. Recruitment of coral reefs fisheries:effects of distribution of predators and shelter [Electronic version]. *Ecology*. Vol 66, pp 1056-066

Skelton, P.A. and Robin, G. 2007. *Marine Invasive species survey of the Apia Harbour, Samoa : Preliminary Report*. National Marine Biodiversity Conservation project, Ministry of Natural Resource and Environment. Unpublished report.

Skelton, P., Bell, L. Mulipola, A. and Trevor, A. 2000. *The Status of coral reefs and marine resources of Samoa, Coral Reefs in the Pacific: Status and monitoring, resource and management*. International Coral Reef Initiative (ICRI). <http://www.icriforum.org/secretariat/pdf/207-316.pdf>[November 27, 2008]

Skelton, P.A., and G.R. South, 1999. "A preliminary checklist of the benthic marine algae of the Samoan archipelago". *Marine Studies Programme Technical Report.* The University of the South Pacific. Vol 99(1), pp 1-30.

Solofa, A. and Samuelu, J. 2008. "Status of coral reef in Samoa". In: Wilkinson, C. (ed.): *Status of coral reefs of the world: 2004*. Vol 2, pp 337-362. Australian Institute of Marine Science, Townsville, Queensland, Australia.

SPC, 2007. *Pacific ACP and OCT Regional Oceanic and Coastal fisheries development programme.* Annual workplan, SPC.

Stobuzki, I.C. 1998. Interspecific variation in sustained swimming ability of late pelagic stage reef fish from two families (Pomacentridae and Chaetodonidae) [Electronic version]. *Coral Reefs*. Vol 17, pp 111-119.

Vunisea, A., Friedman, K., Awira, R., Kronen, M. Pinca, S. Chapman, L., Magron, F. Sauni, S., Pakoa, K. and Lasi, F. 2008. *Samoa Country Report: Profiles and Results from survey work at Manono-uta, Salelavalu, Vailoa and Vailoa*. Secretariat of the Pacific Community.

Wass, R.C., 1984. An annotated checklist of the fishes of Samoa [Electronic version]. *NOAA Technical Report SSRT.* Vol 781, pp 43.

Watson, R.A. and Quinn, T.J. 1997. Performance of transect and point count underwater visual census methods [Electronic version]. *Ecological Modelling*. Vol 104, pp 103-112.

Zann, L.P. 1994. The status of coral reefs in South Western Pacific Islands [Electronic version]. *Marine Pollution Bulletin* Vol. 29, no. 1-3, pp 52-61.

Zann, L.P. 1992. *The inshore resources of Upolu, Western Samoa: Coastal Inventory and fisheries database*. Unpubl, Report 5. SAM/89/002.

Zann and Sua, 1991. *Effects of cyclones of Ofa on the fisheries and coral reefs of Upolu*, Western Samoa in 1990. Government of Western Samoa. Unpubl, Field Report 2. FAO/UNDP SAM/89/002.

10.APPENDICES

10.1 List of Tables

Table 1: Known Marine Biodiversity of Samoa (Wilkinson, 2008)

Taxa	Number of species
Hard Corals	124
Fish	991
Sea grass	2
Algae	287
Turtles	5
Mangroves	3
Giant clams	4

Table 2: Inshore fishery landings from market outlets in fiscal year 98/99-07/08 (Fisheries Division)

Year	Weight (tons)
1998/99	50.75
1999/00	72.40
2000/01	127.00
2001/02	146.56
2002/03	463.71
2003/04	97.30
2004/05	120.60
2005/06	114.63
2006/07	126.68
2007/08	144.34

Table 3: Description of each site by four surveyed habitats

Site	Habitat Description	Habitat				Total
		Coastal reef	Lagoon	Back reef	Outer reef	
Manono	Area (km^2)	2.71	17.60	4.70	12.20	37.21
Population: 1997	% area	7.28	47.30	12.63	32.79	100
	# transect	6	6	6	6	24
	Depth(m)	1(1-2)	3 (1-7)	1(1-3)	9(4-14)	4(1-14)
Salelavalu	Area (km^2)	4.03	4.06	1.58	1.66	11.33
Population: 1841	% area	35.57	35.83	13.95	14.65	100
	# transect	6	7	5	6	24
	Depth(m)	1 (1-2)	3 (1-9)	4 (1-9)	7(2-13)	3(3-13)
Vailoa	Area (km^2)	1.12	NULL	1.22	3.18	5.52
Population: 1755	% area	20.29		22.10	57.61	100

	# transect	10		6	12	28
	Depth(m)	1(1-2)		2(1-2)	9(2-15)	6(1-15)
Vaisala	Area (km^2)	NULL	NULL	1.71	1.57	3.28
Population: 1501	% area			52.13	47.87	100
	# transect			17	8	25
	Depth(m)			2(1-4)	7(4-12)	3(1-12)

Table 4:Number of Finfish Families, Genera, Species recorded from D-UVC surveys of each site.

	Families	Genera	Species	# Fish
Manono uta	16	43	122	10,844
Salelavalu	19	46	120	8,715
Vailoa	22	52	140	12,322
Vaisala	22	46	114	10,027

Table 5: Mean abundance and biomass density estimates (per 500m^2), standard deviation and coefficient of variance (CV) for each habitat among the four study sites.

		Habitat			
Site	Description	Coastal	Lagoon	Back reef	Outer reef
Manono	Biomass (W(kg)/transect)	27±26	55±88	95±11	217±62
	Abundance (No/transect)	329±167	773±841	949±697	1402±221
	CV (W)	0.97	1.59	1.14	0.29
	CV (NO)	0.51	1.09	0.73	0.16
Salelavalu	Biomass (W(kg)/transect)	10±5	84±41	75±24	169±70
	Abundance (No/transect)	224±91	806±168	708±159	977±419
	CV(W)	0.53	0.49	0.32	0.41
	CV (NO)	0.41	0.21	0.23	0.43
Vailoa	Biomass (W(kg)/transect)	22±16	NULL	45±18	207±114
	Abundance (No/transect)	38±295		594±175	1153±486
	CV(W)	0.75		0.40	0.55
	CV (NO)	0.77		0.29	0.42
Vaisala	Biomass (W(kg)/transect)	NULL	NULL	68±64	138±105
	Abundance (No/transect)			782±463	771±467
	CV(W)			0.95	0.76
	CV (NO)			0.59	0.61

Table 6: ANOVA test of biomass in habitats within each site (numbering in differences applies to significance between habitats e.g. 1-4 between coastal reef and outer reef)

Site	P Value	Differences
1. Manono Uta	1.99×10^{-3}	1-4(p=$1.5\text{x}10^{-3}$) 2-4(p=$14.9\text{x}10^{-3}$)
2. Salelavalu	3.58×10^{-9}	1-2 (p=$1 \text{x}10^{-6}$) 1-3(p=$2.8\text{x}10^{-6}$) 1-4(p=0.0000000) 2-4(p=0.03)
3. Vailoa	2.16×10^{-6}	1-4 (p=$1.3 \text{x}10^{-6}$)

		3-4($p=7.8 \times 10^{-3}$)
4. Vaisala	0.09	

Table 7: ANOVA test of biomass in habitats between sites

Habitat	P value
1. Coastal reef	0.60
2. Lagoon	0.04
3. Back reef	0.75
4. Outer reef	0.17

Table 8: Density biomass (by transect) of habitats by sites which are raised to total biomass and their total catches

Sites	Description	Coastal reef	Lagoon	Back reef	Outer reef	Total Biomass (tons)	Total Catches (tons)
Manono uta	Bdensity(kg/tr)	27±26	55±88	95±11	217±62	8289±705	285
	Area (km^2)	2.71	17.60	4.70	12.20		
	Rbiomass (kg)	146,014.8	1,948,672.0	896,196.0	5,298,216.0		
	TBiomass (tons)	146±141	1949±3098	896±103	5298±1513		
Salelavalu	Bdensity(kg/tr)	10±5	84±41	75±24	169±70	1557±81	153
	Area (km^2)	4.03	4.06	1.58	1.66		
	Rbiomass (kg)	76,570.0	681,998.8	237,726.8	560,914.0		
	TBiomass (tons)	77±40	682±333	238±76	561±232		
Vailoa	Bdensity(kg/tr)	22±16		45±18	207±114	1471±105	136
	Area (km^2)	1.12		1.22	3.18		
	Rbiomass (kg)	48,070.4		109,263.2	1,313,912.4		
	TBiomass (tons)	48±36		109±44	1314±725		
Vaisala	Bdensity(kg/tr)			68±64	138±105	664±64	102
	Area (km^2)			1.71	1.57		
	Rbiomass (kg)			231,534.0	431,969.8		
	TBiomass (tons)			232±219	432±330		

Note: Bdensity=Biomass Density, Rbiomass=Raised biomass, Tbiomass=Total biomass

Table 9: Catches by biomass by Fish families in Manono Uta

Family	Total Biomass (kg)	Catches (kg)	Y/B	M	Z (F + M)	E (F/Z)
Acanthuridae	3,153,160.4	62,911.4	0.020	1.202	1.222	0.016
Scaridae	1,925,060.2	48,612.1	0.025	1.338	1.363	0.019
Lutjanidae	1,011,938.6	20,075.9	0.020	0.695	0.714	0.028
Lethrinidae	246,938.2	40,322.0	0.163	0.829	0.992	0.165
Siganidae	224,611.4	15,362.1	0.068	0.692	0.760	0.090

Mullidae	207,406.8	14,935.5	0.072	0.596	0.668	0.108
Balistidae	138,308.6	1,594.6	0.012	0.935	0.947	0.012
Holocentridae	78,175.8	17,676.1	0.226	0.549	0.776	0.292
Labridae	75,271.4	4,598.9	0.061	0.612	0.673	0.091
Serranidae	60,467.2	9,574.8	0.158	1.153	1.311	0.121
Total	7,121,338.6	235,663.3	0.033	8.602	8.635	0.004

Table 10: Catches by biomass by Fish families in Salelavalu

Family	Total Biomass (kg)	Catches (kg)	Y/B	M	Z (F + M)	E (F/Z)
Acanthuridae	484,858.6	32,356.8	0.067	1.202	1.269	0.053
Scaridae	480,017.6	23,351.0	0.049	1.338	1.387	0.035
Lutjanidae	151,929.2	5,945.9	0.039	0.695	0.734	0.053
Mullidae	95,003.8	4,515.1	0.048	0.596	0.644	0.074
Lethrinidae	64,568.0	22,691.4	0.351	0.829	1.180	0.298
Balistidae	37,845.0	929.8	0.025	0.935	0.960	0.026
Holocentridae	37,538.6	14,466.6	0.385	0.549	0.935	0.412
Labridae	35,876.6	1,037.9	0.029	0.612	0.641	0.045
Siganidae	18,410.2	9,560.9	0.519	0.692	1.211	0.429
Serranidae	11,725.2	7,484.7	0.638	1.153	1.791	0.356
Carangidae	5,940.8	2,927.5	0.493	1.523	2.016	0.244
Kyphosidae	763.6	1,238.4	1.622	1.677	3.299	0.492
Total	1,424,477.2	126,506.0	0.089	11.802	11.890	0.007

Table 11: Catches by biomass by Fish families in Vailoa

Family	Total Biomass (kg)	Catches (kg)	Y/B	M	Z (F + M)	E (F/Z)
Acanthuridae	730,677.2	27,973.2	0.038	1.202	1.240	0.031
Scaridae	262,690.0	23,869.0	0.091	1.338	1.429	0.064
Lutjanidae	61,692.0	9,014.0	0.146	0.695	0.841	0.174
Balistidae	60,032.4	1,368.3	0.023	0.935	0.958	0.024
Lethrinidae	51,876.8	18,549.6	0.358	0.829	1.187	0.301
Holocentridae	13,299.2	8,417.0	0.633	0.549	1.182	0.535
Serranidae	13,100.8	8,728.4	0.666	1.153	1.819	0.366
Siganidae	11,593.6	10,522.9	0.908	0.692	1.599	0.568
Kyphosidae	10,875.6	937.0	0.086	1.677	1.763	0.049
Labridae	7,236.8	5,770.6	0.797	0.612	1.410	0.566
Carangidae	4,613.2	2,942.1	0.638	1.523	2.161	0.295
Mugilidae	4,054.4	5,092.1	1.256	0.808	2.064	0.608
Total	1,231,742.0	123,184.1	0.100	12.013	12.113	0.008

Table 12: Catches by biomass by Fish families in Vaisala

Family	Total Biomass (kg)	Catches (kg)	Y/B	M	Z (F + M)	E (F/Z)
Acanthuridae	300,854.0	28,177.4	0.094	1.202	1.296	0.072
Scaridae	184,904.8	25,365.4	0.137	1.338	1.475	0.093
Balistidae	64,453.2	1,260.9	0.020	0.935	0.955	0.020
Lutjanidae	36,109.4	4,246.0	0.118	0.695	0.812	0.145
Holocentridae	12,574.6	10,430.3	0.829	0.549	1.379	0.602
Mugilidae	8,344.8	2,282.0	0.273	0.808	1.082	0.253
Lethrinidae	7,579.8	11,874.2	1.567	0.829	2.396	0.654

Mullidae	6,561.0	3,014.5	0.459	0.596	1.056	0.435
Serranidae	4,596.6	5,520.8	1.201	1.153	2.354	0.510
Labridae	4,530.2	1,244.9	0.275	0.612	0.887	0.310
Carangidae	1,287.4	476.3	0.370	1.523	1.893	0.195
Siganidae	513.0	911.2	1.776	0.692	2.468	0.720
Total	632,308.8	94,803.9	0.150	10.933	11.083	0.014

Table 13: The alpha and beta coefficients of fish species for in length weight conversion

ID	NanSis Code	Latin_Name	Common_Name	Coeff α	Coeff β	Family
1	POMPO00	Pomacentrus sp.	Damsel	0.028000	3.024000	Pomacentridae
2	LABHO03	Hologymnosus doliatus	Pastel ringwrasse	0.013800	3.018000	Labridae
3	POMDA04	Dascyllus aruanas	Humbug damsel	0.041500	2.989000	Pomacentridae
4	POMCH02	Chrysiptera cymatilis	Blue damsel	0.029400	2.950500	Pomacentridae
9	BALAB01	Abalistes stellaris	Starry triggerfish	0.047168	2.759504	Balistidae
80	CHNCH01	Chanos chanos	Milkfish	0.004740	3.389107	Chanidae
81	LUTAF02	Aphareus furca	Small toothed jobfish	0.016736	3.022152	Lutjanidae
83	LUTAF01	Aphareus rutilans	Rusty jobfish	0.016736	3.022152	Lutjanidae
84	LUTAP01	Aprion virescens	Green jobfish	0.022967	2.886269	Lutjanidae
89	SCMAC01	Acanthocybium solandri	Wahoo	0.018091	2.835906	Scombridae
96	SCMEU02	Euthynnus affinis	Kawakawa	0.018091	2.835906	Scombridae
106	SCMGY01	Gymnosarda unicolor	Dogtooth tuna	0.018091	2.835906	Scombridae
107	SCMKA01	Katsuwonus pelamis	Skipjack tuna	0.018091	2.835906	Scombridae
111	SCMRA01	Rastrelliger kanagurta	Indian mackerel	0.018091	2.835906	Scombridae
114	SCMSA02	Sarda orientalis	Striped bonito	0.018091	2.835906	Scombridae
121	SCMSM03	Scomberomorus commerson	Narrow-barred Spanish mackerel	0.016174	2.856131	Scombridae
143	SCMTH02	Thunnus albacares	Yellowfin tuna	0.018091	2.835906	Scombridae
156	LUTLU18	Lutjanus kasmira	Common bluestripe snapper	0.008425	3.246964	Lutjanidae
159	LUTLU14	Lutjanus lutjanus	Bigeye snapper	0.018204	2.969095	Lutjanidae
166	LUTLU57	Lutjanus monostigma	Onespot snapper	0.022185	2.912522	Lutjanidae
172	LUTLU23	Lutjanus quinquelineatus	Five-lined snapper	0.014601	3.099583	Lutjanidae
173	LUTLU11	Lutjanus rivulatus	Blubberlip snapper	0.008427	3.260164	Lutjanidae
176	LUTLU20	Lutjanus russellii	Russell's snapper	0.016584	2.977892	Lutjanidae
179	LUTLU58	Lutjanus semicinctus	Black-banded snapper	0.003984	3.428015	Lutjanidae
184	LUTLU53	Lutjanus vitta	Brownstripe red snapper	0.012500	3.075173	Lutjanidae
186	LUTMA02	Macolor macularis	Midnight snapper	0.016736	3.022152	Lutjanidae
187	LUTMA01	Macolor niger	Black and white snapper	0.016736	3.022152	Lutjanidae
214	LUTSP01	Symphorichthys spilurus	Sailfin snapper	0.016736	3.022152	Lutjanidae
215	LUTSM01	Symphorus nematophorus	Chinamanfish	0.014664	3.046171	Lutjanidae
261	LUTLU16	Lutjanus fulviflammaus	Dory snapper	0.020479	2.959850	Lutjanidae
262	LUTLU33	Lutjanus fulvus	Blacktail snapper	0.021061	2.974332	Lutjanidae
265	LUTLU56	Lutjanus gibbus	Humpback red snapper	0.013093	3.137521	Lutjanidae
374	CARDE08	Decapterus russelli	Indian scad	0.013898	2.962796	Carangidae
387	CARSA01	Selar crumenophthalmus	Bigeye scad	0.009701	3.193776	Carangidae
412	CAREL01	Elagatis bipinnulata	Rainbow runner	0.008334	3.197238	Carangidae

793	LUTLU50	Lutjanus ehrenbergii	Blackspot snapper	0.015114	3.056842	Lutjanidae
858	SHACA14	Carcharhinus albimarginatus	Silvertip shark	5.48E-05	4.267800	Carcharhinidae
861	SHACA2E	Carcharhinus amblyrhynchos	Grey reef shark	0.002266	3.372659	Carcharhinidae
877	SHACA24	Carcharhinus melanopterus	Blacktip reef shark	0.001298	3.507763	Carcharhinidae
896	SHACAA1	Negaprion acutidens	Sicklefin lemon shark	0.000960	3.565558	Carcharhinidae
907	SHACAB1	Triaenodon obesus	Whitetip reef shark	0.001797	3.343934	Carcharhinidae
918	CAECA01	Caesio caerulaurea	Blue and gold fusilier	0.019962	2.991406	Caesionidae
919	CAECA03	Caesio cuning	Redbelly yellowtail fusilier	0.014873	3.121332	Caesionidae
920	CAECA05	Caesio lunaris	Lunar fusilier	0.009289	3.252731	Caesionidae
923	CAECA04	Caesio teres	Yellow and blueback fusilier	0.009289	3.252731	Caesionidae
933	CAEPT03	Pterocaesio digramma	Double-lined fusilier	0.006911	3.341319	Caesionidae
935	CAEPT04	Pterocaesio marri	Marr's fusilier	0.009145	3.233787	Caesionidae
936	CAEPT01	Pterocaesio pisang	Banana fusilier	0.009145	3.233787	Caesionidae
938	CAEPT05	Pterocaesio tessellata	One-stripe fusilier	0.009145	3.233787	Caesionidae
939	CAEPT06	Pterocaesio tile	Dark-banded fusilier	0.009145	3.233787	Caesionidae
966	BALME01	Melichthys niger	Black triggerfish	0.005696	3.393028	Balistidae
977	BELTY01	Tylosurus crocodilus crocodilus	Hound needlefish	0.000569	3.284806	Belonidae
988	CARAL03	Alectis ciliaris	African pompano	0.008334	3.197238	Carangidae
998	CARNA01	Naucrates ductor	Pilotfish	0.008334	3.197238	Carangidae
1002	CARPS01	Pseudocaranx dentex	White trevally	0.027096	2.885978	Carangidae
1022	DIODI01	Diodon hystrix	Spot-fin porcupinefish	0.193426	2.471791	Diodontidae
1235	SPHSP05	Sphyraena barracuda	Great barracuda	0.006171	3.010951	Sphyraenidae
1250	RAYMY31	Aetobatus narinari	Spotted eagle ray	0.005900	3.130000	Myliobatidae
1255	ACAAC14	Acanthurus mata	Elongate surgeonfish	0.022242	3.007953	Acanthuridae
1256	ACAAC04	Acanthurus dussumieri	Eyestripe surgeonfish	0.042561	2.868264	Acanthuridae
1258	ACAAC13	Acanthurus lineatus	Lined surgeonfish	0.028033	2.982884	Acanthuridae
1260	ACAAC18	Acanthurus triostegus	Convict surgeonfish	0.083063	2.569683	Acanthuridae
1261	ACAAC19	Acanthurus xanthopterus	Yellowfin surgeonfish	0.026730	2.984487	Acanthuridae
1262	ACACT03	Ctenochaetus striatus	Striated surgeonfish	0.023132	3.063472	Acanthuridae
1263	ACANA05	Naso hexacanthus	Sleek unicornfish	0.020165	2.955825	Acanthuridae
1264	ACANA07	Naso lituratus	Orangespine unicornfish	0.008481	3.249644	Acanthuridae
1265	ACANA01	Naso unicornis	Bluespine unicornfish	0.017880	3.035454	Acanthuridae
1266	ACAZE03	Zebrasoma veliferum	Sailfin tang	0.034252	2.865806	Acanthuridae
1309	AUSAU01	Aulostomus chinensis	Chinese trumpetfish	0.000214	3.514432	Aulostomidae
1311	BALOD01	Odonus niger	Redtoothed triggerfish	0.005696	3.393028	Balistidae
1312	BALSU01	Sufflamen fraenatus	Masked triggerfish	0.028652	2.965828	Balistidae
1314	BELPL01	Platybelone argalus platyura	Keeled needlefish	0.000749	3.203147	Belonidae
1315	BELST01	Strongylura leiura	Banded needlefish	0.001084	3.101073	Belonidae
1407	LUTLU09	Lutjanus argentimaculatus	Mangrove red snapper	0.028001	2.844262	Lutjanidae
1410	LUTLU54	Lutjanus biguttatus	Two-spot banded snapper	0.015114	3.056842	Lutjanidae
1417	LUTLU06	Lutjanus bohar	Two-spot red snapper	0.015628	3.058646	Lutjanidae

1424	LUTLU55	Lutjanus carponotatus	Spanish flag snapper	0.015114	3.056842	Lutjanidae
1428	LUTLU59	Lutjanus decussatus	Checkered snapper	0.015114	3.056842	Lutjanidae
1494	CLUHE01	Herklotsichthys quadrimaculatus	Bluestripe herring	0.004534	3.492449	Clupeidae
1832	LETGN01	Gnathodentex aureolineatus	Striped large-eye bream	0.018040	3.062543	Lethrinidae
1837	LETGY03	Gymnocranius euanus	Japanese large-eye bream	0.022513	3.000939	Lethrinidae
1842	LETLE25	Lethrinus erythropterus	Longfin emperor	0.016500	3.043427	Lethrinidae
1845	LETLE11	Lethrinus microdon	Smalltooth emperor	0.016500	3.043427	Lethrinidae
1846	LETLE21	Lethrinus nebulosus	Spangled emperor	0.018714	2.996165	Lethrinidae
1847	LETLE27	Lethrinus obsoletus	Orange-striped emperor	0.017330	3.025828	Lethrinidae
1848	LETLE14	Lethrinus rubrioperculatus	Spotcheek emperor	0.012792	3.108071	Lethrinidae
1850	LETLE04	Lethrinus variegatus	Slender emperor	0.016500	3.043427	Lethrinidae
1851	LETLE15	Lethrinus harak	Thumbprint emperor	0.017006	3.042260	Lethrinidae
1852	LETLE29	Lethrinus xanthochilus	Yellowlip emperor	0.020065	2.963903	Lethrinidae
1853	LETLE23	Lethrinus amboinensis	Ambon emperor	0.016500	3.043427	Lethrinidae
1854	LETLE24	Lethrinus atkinsoni	Pacific yellowtail emperor	0.017799	3.057375	Lethrinidae
1858	LETLE18	Lethrinus miniatus	Trumpet emperor	0.006570	3.276712	Lethrinidae
1862	LETLE06	Lethrinus erythracanthus	Orange-spotted emperor	0.016500	3.043427	Lethrinidae
1863	LETLE02	Lethrinus lentjan	Pink ear emperor	0.019697	2.986180	Lethrinidae
1864	LETLE19	Lethrinus olivaceus	Longface emperor	0.029361	2.850635	Lethrinidae
1865	LETLE26	Lethrinus genivittatus	Longspine emperor	0.017923	2.995465	Lethrinidae
1866	LETLE28	Lethrinus ornatus	Ornate emperor	0.016500	3.043427	Lethrinidae
1869	LETMO01	Monotaxis grandoculis	Humpnose big-eye bream	0.022959	3.022235	Lethrinidae
1886	CAEPT07	Pterocaesio trilineata	Three-stripe fusilier	0.010654	3.177842	Caesionidae
1893	CARAT01	Atule mate	Yellowtail scad	0.016574	2.948713	Carangidae
1895	CARCA06	Caranx ignobilis	Giant trevally	0.016383	3.058693	Carangidae
1906	CARCA05	Caranx melampygus	Bluefin trevally	0.023398	2.917987	Carangidae
1909	CARCS21	Carangoides orthogrammus	Island trevally	0.015593	3.025618	Carangidae
1910	CARCS09	Carangoides plagiotaenia	Barcheek trevally	0.036119	2.812473	Carangidae
1917	CARCA04	Caranx sexfasciatus	Bigeye trevally	0.019833	2.986046	Carangidae
1921	CARCS02	Carangoides ferdau	Blue trevally	0.036826	2.851155	Carangidae
1923	CARCS13	Carangoides bajad	Orangespotted trevally	0.036119	2.812473	Carangidae
1926	CARCS04	Carangoides fulvoguttatus	Yellowspotted trevally	0.032849	2.808200	Carangidae
1928	CARCA10	Caranx tille	Tille trevally	0.019833	2.986046	Carangidae
1936	CARCA13	Caranx lugubris	Black jack	0.019833	2.986046	Carangidae
1947	CARPA01	Parastromateus niger	Black pomfret	0.008334	3.197238	Carangidae
1950	CARSC02	Scomberoides commersonnianus	Talang queenfish	0.010806	2.930034	Carangidae
1951	CARSC04	Scomberoides lysan	Doublespotted queenfish	0.010847	2.923019	Carangidae
1953	CARSC01	Scomberoides tol	Needlescaled queenfish	0.015431	2.78748	Carangidae
1963	CARTC07	Trachinotus blochii	Snubnose pompano	0.008334	3.197238	Carangidae
1978	CARTC05	Trachinotus baillonii	Smallspotted dart	0.008334	3.197238	Carangidae
2061	RAYMO21	Manta birostris	Giant manta	0.016400	3.000000	Myliobatidae
2300	BALBS02	Balistoides conspicillum	Clown triggerfish	0.019004	3.078240	Balistidae

2467	ECNEC01	Echeneis naucrates	Live sharksucker	0.000755	3.357789	Echeneidae
3602	CHACH12	Chaetodon capistratus	Foureye butterflyfish	0.045008	2.814159	Chaetodontidae
4275	MONAL03	Aluterus scriptus	Scrawled filefish	0.006947	3.262196	Monacanthidae
4278	BALCA01	Canthidermis maculatus	Spotted oceanic triggerfish	0.005696	3.393028	Balistidae
4306	ACAAC21	Acanthurus achilles	Achilles tang	0.028033	2.982884	Acanthuridae
4307	ACAAC07	Acanthurus bariene	Black-spot surgeonfish	0.028033	2.982884	Acanthuridae
4355	SCACL01	Calotomus carolinus	Carolines parrotfish	0.022237	2.970682	Scaridae
4360	SCALE01	Leptoscarus vaigiensis	Marbled parrotfish	0.016286	2.990520	Scaridae
4441	CARCS05	Carangoides chrysophrys	Longnose trevally	0.026677	2.901949	Carangidae
4444	MULUP03	Upeneus moluccensis	Goldband goatfish	0.017011	3.022300	Mullidae
4456	SIGSI01	Siganus canaliculatus	White-spotted spinefoot	0.014478	3.121693	Siganidae
4457	SIGSI19	Siganus spinus	Little spinefoot	0.015018	3.092509	Siganidae
4460	SEREP12	Epinephelus fuscoguttatus	Brown-marbled grouper	0.013354	3.057234	Serranidae
4461	SEREP07	Epinephelus tauvina	Greasy grouper	0.012237	3.052671	Serranidae
4464	CARGN01	Gnathanodon speciosus	Golden trevally	0.019922	2.994962	Carangidae
4465	PODDI01	Diagramma pictum	Painted sweetlips	0.014413	2.987563	Haemulidae
4466	BALPS01	Pseudobalistes fuscus	Yellow-spotted triggerfish	0.072553	2.760281	Balistidae
4508	RAYDA13	Dasyatis kuhlii	Bluespotted stingray	0.009203	3.357203	Dasyatidae
4561	SIGSI21	Siganus vermiculatus	Vermiculated spinefoot	0.014478	3.121693	Siganidae
4588	SIGSI08	Siganus guttatus	Orange-spotted spinefoot	0.014478	3.121693	Siganidae
4611	SIGSI10	Siganus corallinus	Blue-spotted spinefoot	0.002340	3.820790	Siganidae
4614	SIGSI09	Siganus argenteus	Streamlined spinefoot	0.010903	3.154186	Siganidae
4616	SIGSI12	Siganus fuscescens	Mottled spinefoot	0.013733	3.068162	Siganidae
4617	SIGSI15	Siganus puellus	Masked spinefoot	0.017612	3.028394	Siganidae
4620	SIGSI16	Siganus punctatissimus	Peppered spinefoot	0.014478	3.121693	Siganidae
4621	SIGSI17	Siganus punctatus	Goldspotted spinefoot	0.009493	3.276164	Siganidae
4622	SIGSI23	Siganus stellatus	Brownspotted spinefoot	0.014478	3.121693	Siganidae
4623	SIGSI11	Siganus doliatus	Barred spinefoot	0.010360	3.272080	Siganidae
4625	SIGSI13	Siganus lineatus	Golden-lined spinefoot	0.021904	2.998321	Siganidae
4626	SIGSI18	Siganus randalli	Variegated spinefoot	0.014478	3.121693	Siganidae
4629	SIGSI22	Siganus vulpinus	Common foxface	0.014478	3.121693	Siganidae
4631	SIGSI20	Siganus uspi	Bicolored foxface	0.014478	3.121693	Siganidae
4632	SIGSI14	Siganus niger	Black foxface	0.014478	3.121693	Siganidae
4659	DIODI02	Diodon holocanthus	Long-spine porcupinefish	0.045519	2.864599	Diodontidae
4699	HOLSA01	Sargocentron diadema	Crown squirrelfish	0.025048	2.955222	Holocentridae
4733	ACAAC32	Acanthurus nubilus	Bluelined surgeon	0.028033	2.982884	Acanthuridae
4734	ACAAC17	Acanthurus thompsoni	Thompson's surgeonfish	0.028033	2.982884	Acanthuridae
4736	ACAAC25	Acanthurus guttatus	Whitespotted surgeonfish	0.028033	2.982884	Acanthuridae
4738	ACAAC29	Acanthurus nigroris	Bluelined surgeonfish	0.028033	2.982884	Acanthuridae
4739	ACAAC16	Acanthurus nigrofuscus	Brown surgeonfish	0.026370	3.028367	Acanthuridae
4741	ACAAC26	Acanthurus leucocheilus	Palelipped surgeonfish	0.028033	2.982884	Acanthuridae
4742	ACAAC31	Acanthurus pyroferus	Chocolate surgeonfish	0.028033	2.982884	Acanthuridae
4744	ACAAC30	Acanthurus olivaceus	Orangespot surgeonfish	0.028033	2.982884	Acanthuridae
4745	ACAAC24	Acanthurus fowleri	Fowler's surgeonfish	0.028033	2.982884	Acanthuridae

4746	ACAAC27	Acanthurus maculiceps	White-freckled surgeonfish	0.028033	2.982884	Acanthuridae
4747	ACAAC15	Acanthurus nigricauda	Epaulette surgeonfish	0.016785	3.167725	Acanthuridae
4748	ACAAC23	Acanthurus auranticavus	Orange-socket surgeonfish	0.028033	2.982884	Acanthuridae
4750	ACAAC11	Acanthurus blochii	Ringtail surgeonfish	0.025056	3.031929	Acanthuridae
4817	MUGVA01	Valamugil buchanani	Bluetail mullet	0.010108	3.104433	Mugilidae
4825	SEREP50	Epinephelus sexfasciatus	Sixbar grouper	0.012237	3.052671	Serranidae
4826	SERPL02	Plectropomus leopardus	Leopard coralgrouper	0.011753	3.059545	Serranidae
4886	SERPL04	Plectropomus maculatus	Spotted coralgrouper	0.010685	3.086210	Serranidae
4891	LABAN02	Anampses geographicus	Geographic wrasse	0.022609	2.792711	Labridae
4907	HOLSA05	Sargocentron caudimaculatum	Silverspot squirrelfish	0.021915	3.047387	Holocentridae
4908	HOLSA08	Sargocentron tiere	Blue lined squirrelfish	0.021915	3.047387	Holocentridae
4909	HOLSA09	Sargocentron violaceum	Violet squirrelfish	0.021915	3.047387	Holocentridae
4910	HOLMY05	Myripristis berndti	Blotcheye soldierfish	0.027694	3.003364	Holocentridae
4911	HOLNE03	Neoniphon sammara	Sammara squirrelfish	0.027615	2.888354	Holocentridae
4922	SERAN01	Anyperodon leucogrammicus	Slender grouper	0.001418	3.548062	Serranidae
4923	SEREP27	Epinephelus merra	Honeycomb grouper	0.015835	2.966364	Serranidae
4968	SCASC10	Scarus flavipectoralis	Yellowfin parrotfish	0.023374	2.956463	Scaridae
4969	SCASC21	Scarus rivulatus	Rivulated parrotfish	0.017448	3.074048	Scaridae
4970	SCASC13	Scarus globiceps	Globehead parrotfish	0.023374	2.956463	Scaridae
4971	SCASC18	Scarus prasiognathos	Singapore parrotfish	0.023374	2.956463	Scaridae
4973	SCASC09	Scarus dimidiatus	Yellowbarred parrotfish	0.023374	2.956463	Scaridae
4974	SCASC24	Scarus spinus	Greensnout parrotfish	0.023374	2.956463	Scaridae
4975	SCASC23	Scarus schlegeli	Yellowband parrotfish	0.023059	2.969192	Scaridae
4976	SCACR01	Chlorurus bleekeri	Bleeker's parrotfish	0.022237	2.970682	Scaridae
4978	SCACR03	Chlorurus japanensis	Palecheek parrotfish	0.022237	2.970682	Scaridae
4981	SCASC15	Scarus longipinnis	Highfin parrotfish	0.023374	2.956463	Scaridae
5195	SCRPT01	Pterois volitans	Red lionfish	0.035807	2.696588	Scorpaenidae
5348	SEREP03	Epinephelus fasciatus	Blacktip grouper	0.013826	3.040660	Serranidae
5349	SEREP57	Epinephelus cyanopodus	Speckled blue grouper	0.011051	3.113732	Serranidae
5350	SEREP56	Epinephelus maculatus	Highfin grouper	0.011037	3.061971	Serranidae
5354	SERVA01	Variola louti	Yellow-edged lyretail	0.012188	3.079131	Serranidae
5367	SEREP08	Epinephelus areolatus	Areolate grouper	0.011421	3.048121	Serranidae
5398	SYNSY04	Synodus variegatus	Variegated lizardfish	0.003143	3.483799	Synodontidae
5399	RAYDA61	Taeniura lymma	Bluespotted ribbontail ray	0.009374	3.352487	Dasyatidae
5406	HOLSA06	Sargocentron cornutum	Threespot squirrelfish	0.021915	3.047387	Holocentridae
5408	HOLMY02	Myripristis murdjan	Pinecone soldierfish	0.027619	3.030413	Holocentridae
5425	TETAR03	Arothron hispidus	White-spotted puffer	0.063381	2.755967	Tetraodontidae
5443	MULUP04	Upeneus tragula	Freckled goatfish	0.013654	3.068002	Mullidae
5444	FISFI02	Fistularia commersonii	Bluespotted cornetfish	0.00046	3.048269	Fistulariidae
5446	CHACH03	Chaetodon kleinii	Sunburst butterflyfish	0.045008	2.814159	Chaetodontidae
5447	PMOCE06	Centropyge vrolikii	Pearlscaled angelfish	0.074481	2.576934	Pomacanthidae
5454	PMOCE01	Centropyge bicolor	Bicolor angelfish	0.074481	2.576934	Pomacanthidae
5457	PMOCE03	Centropyge flavissimaus	Lemonpeel angelfish	0.074481	2.576934	Pomacanthidae

5458	PMOCE02	Centropyge bispinosaus	Twospined angelfish	0.091950	2.457987	Pomacanthidae
5472	CHACH48	Chaetodon oxycephalus	Spot-nape butterflyfish	0.045008	2.814159	Chaetodontidae
5483	CHACH02	Chelmon rostratus	Copperband butterflyfish	0.042051	2.847332	Chaetodontidae
5498	LABBO08	Bodianus axillaris	Axilspot hogfish	0.010815	3.173052	Labridae
5501	LABBO10	Bodianus mesothorax	Splitlevel hogfish	0.010815	3.173052	Labridae
5502	LABCO03	Choerodon anchorago	Orange-dotted tuskfish	0.015111	3.122482	Labridae
5537	SCABO01	Bolbometopon muricatum	Green humphead parrotfish	0.022237	2.970682	Scaridae
5538	SCACE01	Cetoscarus bicolor	Bicolour parrotfish	0.022237	2.970682	Scaridae
5539	SCAHI01	Hipposcarus longiceps	Pacific longnose parrotfish	0.022237	2.970682	Scaridae
5540	SCASC07	Scarus altipinnis	Filament-finned parrotfish	0.018396	3.029321	Scaridae
5541	SCASC25	Scarus xanthopleura	Red parrotfish	0.023374	2.956463	Scaridae
5542	SCACR06	Chlorurus bowersi	Bower's parrotfish	0.022237	2.970682	Scaridae
5543	SCASC08	Scarus chameleon	Chameleon parrotfish	0.023374	2.956463	Scaridae
5544	SCASC26	Scarus festivus	Festive parrotfish	0.023374	2.956463	Scaridae
5545	SCASC11	Scarus forsteni	Forsten's parrotfish	0.023374	2.956463	Scaridae
5546	SCASC12	Scarus frenatus	Bridled parrotfish	0.023374	2.956463	Scaridae
5547	SCACR02	Chlorurus frontalis	Tan-faced parrotfish	0.022237	2.970682	Scaridae
5548	SCASC01	Scarus ghobban	Blue-barred parrotfish	0.016505	3.041159	Scaridae
5550	SCASC16	Scarus niger	Dusky parrotfish	0.013346	3.159957	Scaridae
5551	SCASC17	Scarus oviceps	Darkcapped parrotfish	0.023374	2.956463	Scaridae
5553	SCASC19	Scarus psittacus	Common parrotfish	0.010451	3.318709	Scaridae
5554	SCASC20	Scarus quoyi	Quoy's parrotfish	0.023374	2.956463	Scaridae
5555	SCASC22	Scarus rubroviolaceus	Ember parrotfish	0.023374	2.956463	Scaridae
5556	SCACR05	Chlorurus sordidus	Daisy parrotfish	0.024311	2.969306	Scaridae
5557	CHACH04	Chaetodon auriga	Threadfin butterflyfish	0.040397	2.829431	Chaetodontidae
5558	CHACH26	Chaetodon baronessa	Eastern triangular butterflyfish	0.045008	2.814159	Chaetodontidae
5559	CHACH27	Chaetodon bennetti	Bluelashed butterflyfish	0.038395	2.885079	Chaetodontidae
5561	CHACH28	Chaetodon citrinellus	Speckled butterflyfish	0.035299	2.834138	Chaetodontidae
5562	CHACH29	Chaetodon ephippium	Saddle butterflyfish	0.022485	3.060922	Chaetodontidae
5564	CHACH31	Chaetodon lineolatus	Lined butterflyfish	0.069265	2.621507	Chaetodontidae
5565	CHACH32	Chaetodon lunula	Raccoon butterflyfish	0.045008	2.814159	Chaetodontidae
5566	CHACH34	Chaetodon melannotus	Blackback butterflyfish	0.026693	3.0486	Chaetodontidae
5567	CHACH35	Chaetodon mertensii	Atoll butterflyfish	0.004297	3.793382	Chaetodontidae
5568	CHACH36	Chaetodon meyeri	Scrawled butterflyfish	0.045008	2.814159	Chaetodontidae
5570	CHACH19	Chaetodon octofasciatus	Eightband butterflyfish	0.045008	2.814159	Chaetodontidae
5571	CHACH49	Chaetodon punctatofasciatus	Spotband butterflyfish	0.045008	2.814159	Chaetodontidae
5572	CHACH40	Chaetodon quadrimaculatus	Fourspot butterflyfish	0.045008	2.814159	Chaetodontidae
5573	CHACH41	Chaetodon rafflesii	Latticed butterflyfish	0.045008	2.814159	Chaetodontidae
5574	CHACH42	Chaetodon reticulatus	Mailed butterflyfish	0.045008	2.814159	Chaetodontidae
5575	CHACH43	Chaetodon semeion	Dotted butterflyfish	0.045008	2.814159	Chaetodontidae
5576	CHACH21	Chaetodon speculum	Mirror butterflyfish	0.066371	2.693022	Chaetodontidae
5578	CHACH45	Chaetodon trifascialis	Chevron butterflyfish	0.025777	2.969077	Chaetodontidae

5580	CHACH46	Chaetodon ulietensis	Pacific double-saddle butterflyfish	0.031142	2.874117	Chaetodontidae
5581	CHACH47	Chaetodon unimaculatus	Teardrop butterflyfish	0.053303	2.833279	Chaetodontidae
5582	CHACH17	Chaetodon vagabundus	Vagabond butterflyfish	0.027755	2.973465	Chaetodontidae
5584	CHAFO01	Forcipiger flavissimus	Forcepsfish	0.042051	2.847332	Chaetodontidae
5585	CHAFO02	Forcipiger longirostris	Longnose butterflyfish	0.042051	2.847332	Chaetodontidae
5586	CHAHM01	Hemitaurichthys polylepis	Pyramid butterflyfish	0.042051	2.847332	Chaetodontidae
5588	CHAHE01	Heniochus acuminatus	Pennant coralfish	0.024699	3.105802	Chaetodontidae
5589	CHAHE03	Heniochus chrysostomus	Threeband pennantfish	0.016134	3.262174	Chaetodontidae
5590	CHAHE04	Heniochus monoceros	Masked bannerfish	0.016997	3.210582	Chaetodontidae
5591	CHAHE05	Heniochus singularius	Singular bannerfish	0.025152	3.082177	Chaetodontidae
5592	CHAHE06	Heniochus varius	Horned bannerfish	0.025152	3.082177	Chaetodontidae
5597	LABOX03	Oxycheilinus celebicus	Celebes wrasse	0.010669	3.17765	Labridae
5598	LABCH06	Cheilinus chlorourus	Floral wrasse	0.019725	2.993152	Labridae
5599	LABOX01	Oxycheilinus digrammus	Cheeklined wrasse	0.010669	3.177650	Labridae
5600	LABCH07	Cheilinus fasciatus	Redbreast wrasse	0.015508	3.057917	Labridae
5602	LABCH08	Cheilinus oxycephalus	Snooty wrasse	0.015508	3.057917	Labridae
5603	LABCH04	Cheilinus trilobatus	Tripletail wrasse	0.016233	3.059470	Labridae
5604	LABCH03	Cheilinus undulatus	Humphead wrasse	0.011310	3.136202	Labridae
5605	LABOX02	Oxycheilinus unifasciatus	Ringtail maori wrasse	0.010669	3.177650	Labridae
5606	LABEP01	Epibulus insidiator	Slingjaw wrasse	0.016138	3.081018	Labridae
5610	LABNO01	Novaculichthys taeniourus	Rockmover wrasse	0.010669	3.177650	Labridae
5623	LABCH01	Cheilio inermis	Cigar wrasse	0.003491	3.081569	Labridae
5624	LABCR02	Coris aygula	Clown coris	0.00266	3.488575	Labridae
5625	LABCR03	Coris gaimard	Yellowtail coris	0.006501	3.254414	Labridae
5635	LABHM01	Hemigymnus fasciatus	Barred thicklip	0.024790	2.912845	Labridae
5636	LABHM02	Hemigymnus melapterus	Blackeye thicklip	0.024234	2.922618	Labridae
5649	LABTH02	Thalassoma trilobatum	Christmas wrasse	0.012306	3.097020	Labridae
5653	MUGCR01	Crenimugil crenilabis	Fringelip mullet	0.012719	3.046375	Mugilidae
5656	MUGMU07	Liza vaigiensis	Squaretail mullet	0.014057	3.022847	Mugilidae
5659	MUGVA02	Valamugil seheli	Bluespot mullet	0.006055	3.275027	Mugilidae
5660	PMOCH02	Chaetodontoplus mesoleucus	Vermiculated angelfish	0.058435	2.718278	Pomacanthidae
5661	PMOPO09	Pomacanthus navarchus	Bluegirdled angelfish	0.066943	2.722333	Pomacanthidae
5662	PMOPO11	Pomacanthus xanthometaopon	Yellowface angelfish	0.066943	2.722333	Pomacanthidae
5663	PMOPO05	Pomacanthus semicirculatus	Semicircle angelfish	0.066943	2.722333	Pomacanthidae
5734	SPHSP04	Sphyraena forsteri	Bigeye barracuda	0.005336	3.034063	Sphyraenidae
5737	EPHPL03	Platax orbicularis	Orbicular batfish	0.044306	2.951489	Ephippidae
5739	EPHPL01	Platax teira	Tiera batfish	0.044306	2.951489	Ephippidae
5791	PRIPR03	Priacanthus hamrur	Moontail bullseye	0.029966	2.800846	Priacanthidae
5805	KYPKY02	Kyphosus cinerascens	Blue seachub	0.012853	3.150589	Kyphosidae
5806	KYPKY03	Kyphosus vaigiensis	Brassy chub	0.019983	3.036957	Kyphosidae
5825	SYASY01	Synanceia verrucosa	Reef stonefish	0.004347	3.694222	Synanceiidae
5830	CIRCI03	Cirrhitichthys oxycephalus	Coral hawkfish	0.009273	3.268401	Cirrhitidae

5836	MONCA05	Cantherhines dumerilii	Whitespotted filefish	0.032397	2.904667	Monacanthidae
5837	SEREP71	Epinephelus spilotoceps	Foursaddle grouper	0.012237	3.052671	Serranidae
5838	BALME02	Melichthys vidua	Pinktail triggerfish	0.005696	3.393028	Balistidae
5839	BALRH01	Rhinecanthus aculeatus	Blackbar triggerfish	0.005696	3.393028	Balistidae
5840	BALRH03	Rhinecanthus rectangulus	Wedge-tail triggerfish	0.005696	3.393028	Balistidae
5841	HOLSA07	Sargocentron microstoma	Smallmouth squirrelfish	0.021915	3.047387	Holocentridae
5842	BALSU02	Sufflamen chrysopterus	Halfmoon triggerfish	0.032441	2.929115	Balistidae
5867	NEMPE01	Pentapodus caninus	Small-toothed whiptail	0.017121	3.003869	Nemipteridae
5873	NEMPE04	Pentapodus trivittatus	Three-striped whiptail	0.017121	3.003869	Nemipteridae
5876	NEMSC10	Scolopsis ciliatus	Saw-jawed monocle bream	0.015738	3.054293	Nemipteridae
5877	NEMSC11	Scolopsis lineatus	Striped monocle bream	0.015738	3.054293	Nemipteridae
5878	NEMSC12	Scolopsis margaritifer	Pearly monocle bream	0.015738	3.054293	Nemipteridae
5880	NEMSC13	Scolopsis temporalis	Bald-spot monocle bream	0.018473	2.981168	Nemipteridae
5881	NEMSC14	Scolopsis trilineatus	Three-lined monocle bream	0.015738	3.054293	Nemipteridae
5884	NEMSC09	Scolopsis auratus	Yellowstripe monocle bream	0.015738	3.054293	Nemipteridae
5885	NEMSC05	Scolopsis bilineata	Two-lined monocle bream	0.013828	3.173777	Nemipteridae
5890	NEMSC08	Scolopsis affinis	Peters' monocle bream	0.015738	3.054293	Nemipteridae
5895	SHAGI21	Nebrius ferrugineus	Tawny nurse shark	0.02109	2.6979	Ginglymostomatidae
5950	ZANZA02	Zanclus cornutus	Moorish idol	0.014704	3.369908	Zanclidae
5951	ACAZE02	Zebrasoma scopas	Twotone tang	0.029053	2.99274	Acanthuridae
5953	CIRPA01	Paracirrhites hemistictus	Whitespot hawkfish	0.009273	3.268401	Cirrhitidae
5983	MULMU02	Mulloidichthys flavolineatus	Yellowstripe goatfish	0.011974	3.101093	Mullidae
5984	MULMU03	Mulloidichthys vanicolensis	Yellowfin goatfish	0.010406	3.223581	Mullidae
5986	MULPA20	Parupeneus barberinoides	Bicolor goatfish	0.014446	3.12992	Mullidae
5987	MULPA10	Parupeneus barberinus	Dash-and-dot goatfish	0.013067	3.122492	Mullidae
5988	MULPA03	Parupeneus bifasciatus	Doublebar goatfish	0.014446	3.12992	Mullidae
5989	MULPA21	Parupeneus ciliatus	Whitesaddle goatfish	0.011633	3.219917	Mullidae
5990	MULPA08	Parupeneus cyclostomus	Goldsaddle goatfish	0.014446	3.12992	Mullidae
5991	MULPA22	Parupeneus heptacanthus	Cinnabar goatfish	0.0169	3.078022	Mullidae
5992	MULPA12	Parupeneus indicus	Indian goatfish	0.01415	3.114207	Mullidae
5993	MULPA23	Parupeneus multifasciatus	Manybar goatfish	0.014446	3.12992	Mullidae
5994	MULPA19	Parupeneus pleurostigma	Sidespot goatfish	0.014446	3.12992	Mullidae
6001	SEREP70	Epinephelus rivulatus	Halfmoon grouper	0.011387	3.086201	Serranidae
6011	ACAAC28	Acanthurus nigricans	Whitecheek surgeonfish	0.028033	2.982884	Acanthuridae
6012	ACACT02	Ctenochaetus binotatus	Twospot surgeonfish	0.039157	2.874629	Acanthuridae
6013	ACACT05	Ctenochaetus hawaiiensis	Chevron tang	0.023712	3.055814	Acanthuridae
6014	ACACT06	Ctenochaetus marginatus	Striped-fin surgeonfish	0.023712	3.055814	Acanthuridae
6015	ACACT01	Ctenochaetus strigosus	Spotted surgeonfish	0.023712	3.055814	Acanthuridae
6016	ACACT07	Ctenochaetus tominiensis	Tomini surgeonfish	0.023712	3.055814	Acanthuridae
6017	ACAPA01	Paracanthurus hepatus	Palette surgeonfish	0.030061	2.945768	Acanthuridae
6018	ACAZE04	Zebrasoma flavescens	Yellow tang	0.037834	2.856767	Acanthuridae
6019	ACANA08	Naso annulatus	Whitemargin unicornfish	0.051032	2.71537	Acanthuridae

6020	ACANA06	Naso brachycentron	Humpback unicornfish	0.008481	3.249644	Acanthuridae
6021	ACANA03	Naso brevirostris	Spotted unicornfish	0.010649	3.242973	Acanthuridae
6022	ACANA12	Naso lopezi	Elongate unicornfish	0.008481	3.249644	Acanthuridae
6023	ACANA02	Naso tuberosus	Humpnose unicornfish	0.008481	3.249644	Acanthuridae
6024	ACANA04	Naso vlamingii	Bignose unicornfish	0.008481	3.249644	Acanthuridae
6025	BALBT01	Balistapus undulatus	Orange-lined triggerfish	0.005696	3.393028	Balistidae
6026	BALBS01	Balistoides viridescens	Titan triggerfish	0.024422	3.018285	Balistidae
6027	BALPS02	Pseudobalistes flavimarginatus	Yellowmargin triggerfish	0.072553	2.760281	Balistidae
6028	BALRH04	Rhinecanthus verrucosus	Blackbelly triggerfish	0.005696	3.393028	Balistidae
6029	BALSU05	Sufflamen bursa	Boomerang triggerfish	0.032441	2.929115	Balistidae
6030	BALXA02	Xanthichthys auromarginatus	Gilded triggerfish	0.005696	3.393028	Balistidae
6082	SERPL03	Plectropomus areolatus	Squaretail coralgrouper	0.010685	3.08621	Serranidae
6360	CARCA26	Caranx papuensis	Brassy trevally	0.02354	2.922789	Carangidae
6362	PODPL13	Plectorhinchus albovittatus	Two-striped sweetlips	0.019663	2.969262	Haemulidae
6363	PODPL16	Plectorhinchus celebicus	Celebes sweetlips	0.019663	2.969262	Haemulidae
6364	PODPL17	Plectorhinchus chaetodonoides	Harlequin sweetlips	0.017328	3.040327	Haemulidae
6366	PODPL11	Plectorhinchus gibbosus	Harry hotlips	0.022614	2.961962	Haemulidae
6368	PODPL21	Plectorhinchus obscurus	Giant sweetlips	0.027031	2.884829	Haemulidae
6369	PODPL22	Plectorhinchus orientalis	Oriental sweetlips	0.019663	2.969262	Haemulidae
6370	PODPL23	Plectorhinchus picus	Painted sweetlip	0.011508	3.088918	Haemulidae
6380	MURGY13	Gymnothorax javanicus	Giant moray	0.000518	3.303143	Muraenidae
6396	SERCE07	Cephalopholis argus	Peacock hind	0.009293	3.180743	Serranidae
6400	TETAR05	Arothron nigropunctatus	Blackspotted puffer	0.035235	2.901326	Tetraodontidae
6401	TETAR07	Arothron meleagris	Guineafowl puffer	0.035235	2.901326	Tetraodontidae
6438	SCASC05	Scarus tricolor	Tricolour parrotfish	0.023374	2.956463	Scaridae
6439	SEREP09	Epinephelus malabaricus	Malabar grouper	0.012067	3.051888	Serranidae
6440	SEREP61	Epinephelus coeruleopunctatus	Whitespotted grouper	0.018	2.937798	Serranidae
6441	SERAE01	Aethaloperca rogaa	Redmouth grouper	0.013415	3.030514	Serranidae
6444	SERCE05	Cephalopholis boenak	Chocolate hind	0.01462	3.01915	Serranidae
6445	SERCE16	Cephalopholis cyanostigma	Bluespotted hind	0.011457	3.109346	Serranidae
6448	SERCE17	Cephalopholis leopardus	Leopard hind	0.011457	3.109346	Serranidae
6449	SERCE10	Cephalopholis microprion	Freckled hind	0.011457	3.109346	Serranidae
6450	SERCE09	Cephalopholis miniata	Coral hind	0.010656	3.114101	Serranidae
6453	SERCE12	Cephalopholis sexmaculata	Sixblotch hind	0.011457	3.109346	Serranidae
6454	SERCE14	Cephalopholis sonnerati	Tomato hind	0.006609	3.276551	Serranidae
6456	SERCE15	Cephalopholis urodeta	Darkfin hind	0.028223	2.817751	Serranidae
6457	SERCH01	Cromileptes altivelis	Humpback grouper	0.096187	2.489277	Serranidae
6465	SEREP62	Epinephelus coioides	Orange-spotted grouper	0.009897	3.101785	Serranidae
6466	SEREP63	Epinephelus corallicola	Coral grouper	0.012237	3.052671	Serranidae
6471	SEREP67	Epinephelus melanostigma	One-blotch grouper	0.012237	3.052671	Serranidae
6472	SEREP68	Epinephelus ongus	White-streaked grouper	0.018995	2.927803	Serranidae

6473	SEREP69	Epinephelus polyphekadion	Camouflage grouper	0.008333	3.165759	Serranidae
6477	SERGC01	Gracila albomarginata	Masked grouper	0.013415	3.030514	Serranidae
6478	SERVA02	Variola albimarginata	White-edged lyretail	0.012188	3.079131	Serranidae
6504	PMOPO01	Pomacanthus imperator	Emperor angelfish	0.066943	2.722333	Pomacanthidae
6505	HOLMY11	Myripristis vittata	Whitetip soldierfish	0.027619	3.030413	Holocentridae
6506	HOLMY04	Myripristis adusta	Shadowfin soldierfish	0.027619	3.030413	Holocentridae
6507	HOLSA03	Sargocentron spiniferum	Sabre squirrelfish	0.015406	3.118811	Holocentridae
6513	CHACH25	Chaetodon aureofasciatus	Golden butterflyfish	0.045008	2.814159	Chaetodontidae
6525	PMOAP01	Apolemichthys trimaculatus	Threespot angelfish	0.058435	2.718278	Pomacanthidae
6526	TETAR02	Arothron stellatus	Starry toadfish	0.091496	2.672389	Tetraodontidae
6527	CHACH30	Chaetodon flavirostris	Black butterflyfish	0.025097	3.113247	Chaetodontidae
6548	PMOCE05	Centropyge tibicen	Keyhole angelfish	0.049231	2.794514	Pomacanthidae
6550	CHACH37	Chaetodon ornatissimus	Ornate butterflyfish	0.045008	2.814159	Chaetodontidae
6555	OSTOS01	Ostracion cubicus	Yellow boxfish	0.128822	2.519495	Ostraciidae
6564	PMOPO10	Pomacanthus sexstriatus	Sixbar angelfish	0.066858	2.723779	Pomacanthidae
6572	PMOPY01	Pygoplites diacanthus	Royal angelfish	0.058435	2.718278	Pomacanthidae
6582	HOLNE02	Neoniphon opercularis	Blackfin squirrelfish	0.028791	2.867153	Holocentridae
6597	LABCO06	Choerodon jordani	Jordan's tuskfish	0.015111	3.122482	Labridae
6606	CHACH38	Chaetodon pelewensis	Sunset butterflyfish	0.015326	3.296587	Chaetodontidae
6613	CHACH39	Chaetodon plebeius	Blueblotch butterflyfish	0.060611	2.627817	Chaetodontidae
6625	HOLSA02	Sargocentron rubrum	Redcoat	0.027516	2.998402	Holocentridae
6626	MULPA24	Parupeneus spilurus	Blackspot goatfish	0.019174	3.021705	Mullidae
6635	MONCA01	Cantherhines pardalis	Honeycomb filefish	0.032397	2.904667	Monacanthidae
6650	CHACH01	Chelmon marginalis	Margined coralfish	0.042051	2.847332	Chaetodontidae
6660	SEREP64	Epinephelus hexagonatus	Starspotted grouper	0.012237	3.052671	Serranidae
6661	SEREP66	Epinephelus macrospilos	Snubnose grouper	0.013199	3.030716	Serranidae
6672	MONAM01	Amanses scopas	Broom filefish	0.068300	2.563000	Monacanthidae
6932	ACANA13	Naso thynnoides	Oneknife unicornfish	0.008481	3.249644	Acanthuridae
6938	MULPA17	Parupeneus trifasciatus	NULL	0.011359	3.210819	Mullidae
6940	PODPL20	Plectorhinchus lineatus	Yellowbanded sweetlips	0.019663	2.969262	Haemulidae
7305	HOLMY07	Myripristis hexagona	Doubletooth soldierfish	0.025013	3.088965	Holocentridae
7306	HOLMY08	Myripristis kuntee	Shoulderbar soldierfish	0.009912	3.467647	Holocentridae
7308	HOLMY09	Myripristis pralinia	Scarlet soldierfish	0.022698	3.095007	Holocentridae
7309	HOLMY10	Myripristis violacea	Lattice soldierfish	0.036397	2.94026	Holocentridae
7310	HOLNE01	Neoniphon argenteus	Clearfin squirrelfish	0.031648	2.823264	Holocentridae
7319	SERPL06	Plectropomus oligacanthus	Highfin coralgrouper	0.010685	3.08621	Serranidae
7348	SEREP65	Epinephelus howlandi	Blacksaddle grouper	0.015254	2.999094	Serranidae
7372	SERPL05	Plectropomus laevis	Blacksaddled coralgrouper	0.005908	3.237744	Serranidae
7625	PODPL04	Plectorhinchus flavomaculatus	Lemon sweetlip	0.019663	2.969262	Haemulidae
7659	HOLMY12	Myripristis trachyacron	Roughscull soldierfish	0.027619	3.030413	Holocentridae
7734	LABBO09	Bodianus perditio	Golden-spot hogfish	0.011849	3.148753	Labridae
7814	PMOCE04	Centropyge loriculaus	Flame angel	0.074481	2.576934	Pomacanthidae

7937	SPHSP15	Sphyraena flavicauda	Yellowtail barracuda	0.004394	3.083004	Sphyraenidae
7939	SPHSP20	Sphyraena qenie	Blackfin barracuda	0.005757	3.012756	Sphyraenidae
8128	LABCO05	Choerodon graphicus	Graphic tuskfish	0.01512	3.121976	Labridae
10472	PMOCH01	Chaetodontoplus melanosoma	Black-velvet angelfish	0.058435	2.718278	Pomacanthidae
10547	EPHPL02	Platax batavianus	Humpback batfish	0.044306	2.951489	Ephippidae
10938	PMOAP02	Apolemichthys xanthopunctatus	Goldspotted angelfish	0.058435	2.718278	Pomacanthidae
11250	CHACO02	Coradion altivelis	Highfin coralfish	0.042051	2.847332	Chaetodontidae
12537	CHACH44	Chaetodon trichrous	Tahiti butterflyfish	0.045008	2.814159	Chaetodontidae
12625	ACAPR01	Prionurus maculatus	Yellowspotted sawtail	0.030061	2.945768	Acanthuridae
12663	LABHA05	Halichoeres hortulanus	Checkerboard wrasse	0.016013	2.987420	Labridae
12707	SCASC14	Scarus hypselopterus	Yellow-tail parrotfish	0.023374	2.956463	Scaridae
12722	LABCO04	Choerodon fasciatus	Harlequin tuskfish	0.015111	3.122482	Labridae
12744	LABBO05	Bodianus loxozonus	Blackfin hogfish	0.010815	3.173052	Labridae
13059	LABHO01	Hologymnosus longipes	Sidespot longface wrasse	0.010669	3.177650	Labridae
13770	ACAAC22	Acanthurus albipectoralis	Whitefin surgeonfish	0.028033	2.982884	Acanthuridae
13774	BALRH02	Rhinecanthus lunula	Halfmoon picassofish	0.005696	3.393028	Balistidae
14300	CHACH33	Chaetodon lunulatus	Oval butterflyfish	0.045008	2.814159	Chaetodontidae
15628	ACANA11	Naso caesius	Gray unicornfish	0.008481	3.249644	Acanthuridae
25706	PODPL24	Plectorhinchus vittatus	Indian Ocean oriental sweetlips	0.019663	2.969262	Haemulidae
25802	ACAZE05	Zebrasoma rostratum	Longnose surgeonfish	0.037834	2.856767	Acanthuridae
26201	HOLMY06	Myripristis botche	Blacktip soldierfish	0.029168	3.0237	Holocentridae
50052	PODPL19	Plectorhinchus lessonii	Lesson's sweetlips	0.019663	2.969262	Haemulidae
56810	PODPL18	Plectorhinchus chrysotaenia	Yellow-striped sweetlips	0.019663	2.969262	Haemulidae
59589	ACACT04	Ctenochaetus flavicauda	NULL	0.023712	3.055814	Acanthuridae
60479	SCACR04	Chlorurus microrhinos	Pacific steephead parrotfish	0.024694	2.955476	Scaridae
200012	ACAAC00	Acanthurus sp.	NULL	0.028033	2.982884	Acanthuridae
200020	ALBAL00	Albula sp.	NULL	0.029679	2.779863	Albulidae
200091	TETAR00	Arothron sp.	NULL	0.035235	2.901326	Tetraodontidae
200117	BALBT00	Balistapus sp.	NULL	0.005696	3.393028	Balistidae
200118	BALBA00	Balistes sp.	NULL	0.005696	3.393028	Balistidae
200131	LABBO00	Bodianus sp.	NULL	0.010815	3.173052	Labridae
200149	CAECA00	Caesio sp.	NULL	0.009289	3.252731	Caesionidae
200162	CARCS00	Carangoides sp.	NULL	0.036119	2.812473	Carangidae
200163	CARCA00	Caranx sp.	NULL	0.019833	2.986046	Carangidae
200166	SHACA10	Carcharhinus sp.	NULL	0.001298	3.507763	Carcharhinidae
200185	PMOCE00	Centropyge sp.	NULL	0.074481	2.576934	Pomacanthidae
200188	SERCE00	Cephalopholis sp.	Hind	0.011457	3.109346	Serranidae
200196	CHACH00	Chaetodon sp.	NULL	0.045008	2.814159	Chaetodontidae
200218	SCACR00	Chlorurus sp.	Parrotfish	0.022237	2.970682	Scaridae
200231	CIRCI00	Cirrhitichthys sp.	NULL	0.009273	3.268401	Cirrhitidae
200252	LABCR00	Coris sp.	NULL	0.006501	3.254414	Labridae
200265	ACACT00	Ctenochaetus sp.	NULL	0.023712	3.055814	Acanthuridae

200290	RAYDA10	Dasyatis sp.	NULL	0.009374	3.352487	Dasyatidae
200292	CARDE00	Decapterus sp.	NULL	0.013928	2.96378	Carangidae
200305	DIODI00	Diodon sp.	NULL	0.045519	2.864599	Diodontidae
200324	CAREL00	Elagatis sp.	NULL	0.008334	3.197238	Carangidae
200342	SEREP00	Epinephelus sp.	NULL	0.012237	3.052671	Serranidae
200363	FISFI00	Fistularia sp.	NULL	0.000460	3.048269	Fistulariidae
200388	GERGE00	Gerres sp.	NULL	0.019403	3.070188	Gerreidae
200422	LETGY00	Gymnocranius sp.	NULL	0.030171	2.909379	Lethrinidae
200424	MURGY00	Gymnothorax sp.	NULL	0.000518	3.303143	Muraenidae
200443	HEMHE00	Hemiramphus sp.	NULL	0.000676	3.575489	Hemiramphidae
200446	CHAHE00	Heniochus sp.	NULL	0.025152	3.082177	Chaetodontidae
200507	KYPKY00	Kyphosus sp.	NULL	0.012853	3.150589	Kyphosidae
200549	LETLE00	Lethrinus sp.	NULL	0.014087	3.064758	Lethrinidae
200570	LUTLU00	Lutjanus sp.	NULL	0.015114	3.056842	Lutjanidae
200635	MUGMU00	Mugil sp.	NULL	0.010847	3.088498	Mugilidae
200643	HOLMY00	Myripristis sp.	NULL	0.027619	3.030413	Holocentridae
200647	ACANA00	Naso sp.	NULL	0.008481	3.249644	Acanthuridae
200662	HOLNE00	Neoniphon sp.	NULL	0.028791	2.867153	Holocentridae
200709	OSTOS00	Ostracion sp.	NULL	0.128822	2.519495	Ostraciidae
200712	LABOX00	Oxycheilinus sp.	NULL	0.010669	3.177650	Labridae
200726	LUTPA00	Paracaesio sp.	NULL	0.016736	3.022152	Lutjanidae
200731	CIRPA00	Paracirrhites sp.	NULL	0.009273	3.268401	Cirrhitidae
200755	NEMPE00	Pentapodus sp.	NULL	0.017121	3.003869	Nemipteridae
200781	EPHPL00	Platax sp.	NULL	0.044306	2.951489	Ephippidae
200785	PODPL00	Plectorhinchus sp.	NULL	0.019663	2.969262	Haemulidae
200787	SERPL00	Plectropomus sp.	Coralgrouper	0.010685	3.08621	Serranidae
200802	PMOPO00	Pomacanthus sp.	NULL	0.066943	2.722333	Pomacanthidae
200813	PRIPR00	Priacanthus sp.	NULL	0.029681	2.803791	Priacanthidae
200852	CAEPT00	Pterocaesio sp.	NULL	0.009145	3.233787	Caesionidae
200875	BALRH00	Rhinecanthus sp.	NULL	0.005696	3.393028	Balistidae
200899	HOLSA00	Sargocentron sp.	NULL	0.021915	3.047387	Holocentridae
200907	SCASC00	Scarus sp.	NULL	0.023374	2.956463	Scaridae
200916	NEMSC00	Scolopsis sp.	NULL	0.015738	3.054293	Nemipteridae
200917	SCMSC00	Scomber sp.	NULL	0.018091	2.835906	Scombridae
200919	CARSC00	Scomberoides sp.	NULL	0.010806	2.930034	Carangidae
200932	CARSA00	Selar sp.	NULL	0.009701	3.193776	Carangidae
200936	CARSE00	Seriola sp.	NULL	0.008334	3.197238	Carangidae
200946	SIGSI00	Siganus sp.	Spinefoot	0.014478	3.121693	Siganidae
200984	BALSU00	Sufflamen sp.	NULL	0.032441	2.929115	Balistidae
201014	SCMTH00	Thunnus sp.	Tuna	0.018091	2.835906	Scombridae
201048	MULUP00	Upeneus sp.	NULL	0.010310	3.214897	Mullidae
201055	SERVA00	Variola sp.	NULL	0.012188	3.079131	Serranidae
201067	ZANZA00	Zanclus sp.	NULL	0.014704	3.369908	Zanclidae
201068	ACAZE00	Zebrasoma sp.	NULL	0.037834	2.856767	Acanthuridae

10.2 List of Figures

Figure 1: Inshore Fishery Landings from the markets outlets from 1986-94(Fisheries Division)

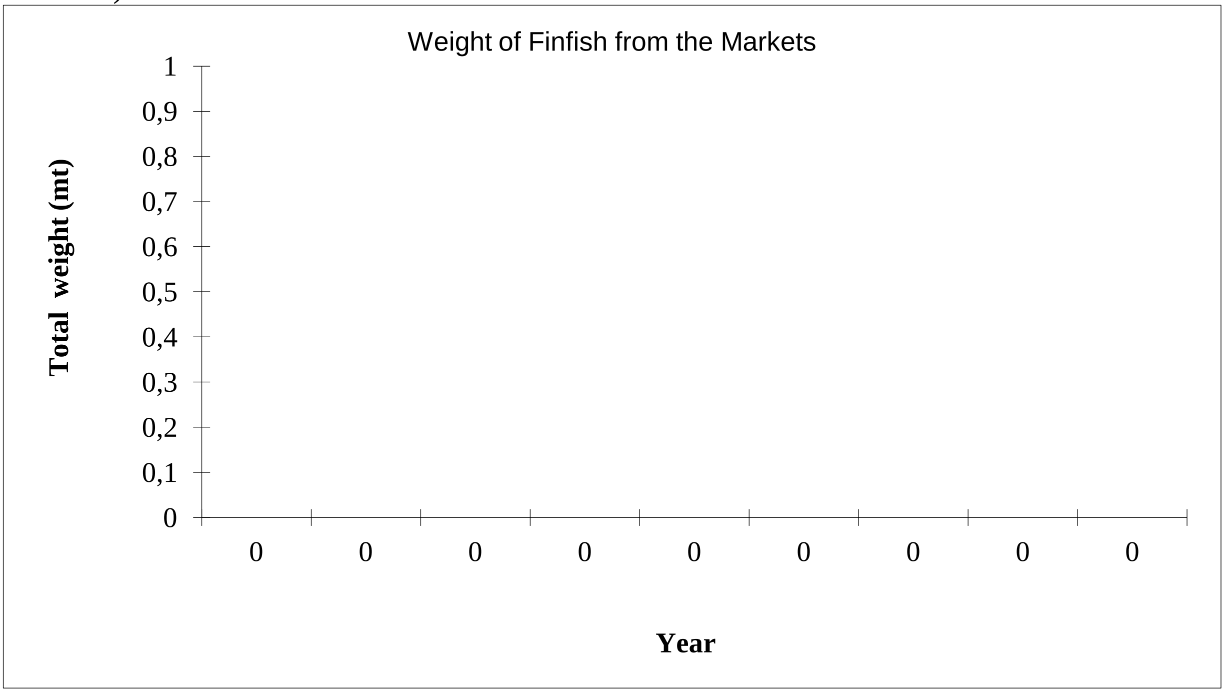

Figure 2: The four survey sites in Samoa where the balloon s indicate the locations of transects (BALLOONS: green=outer reef, yellow=back reef, blue=lagoon, purple=coastal reef

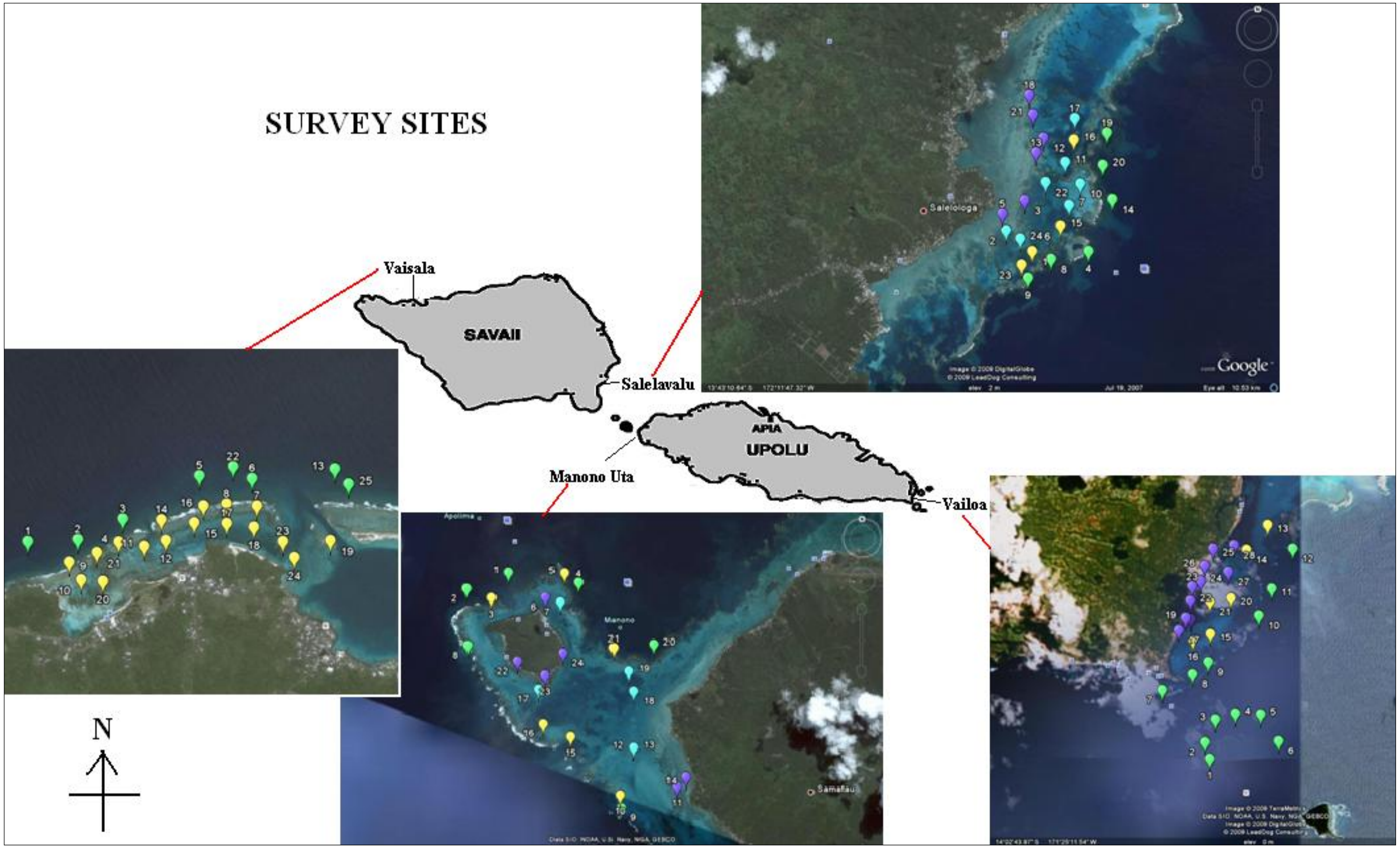

Figure 3: Density (weight (kg)/transect) of Finfish within each habitat of the four sites

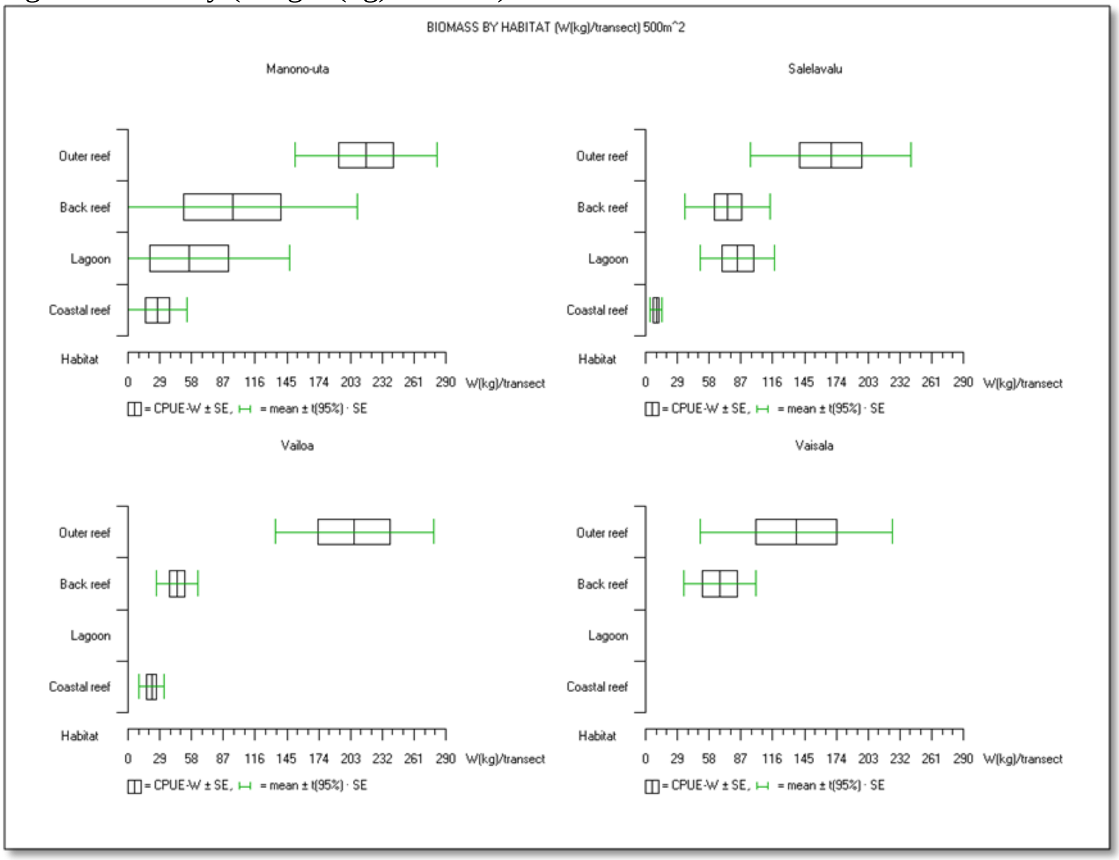

Figure 4: Density (NO/transect) of finfish within each habitat by site

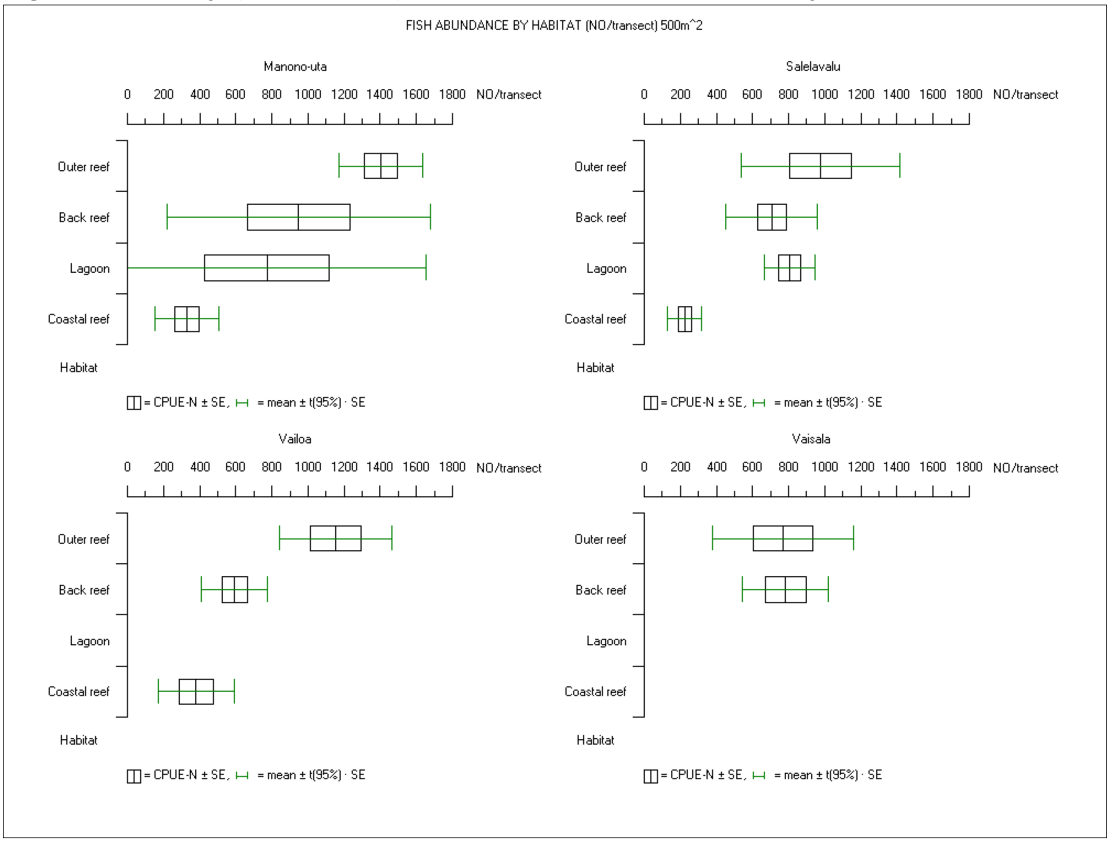

Figure 5: Length distribution (cm) in Outer reefs of the four sites

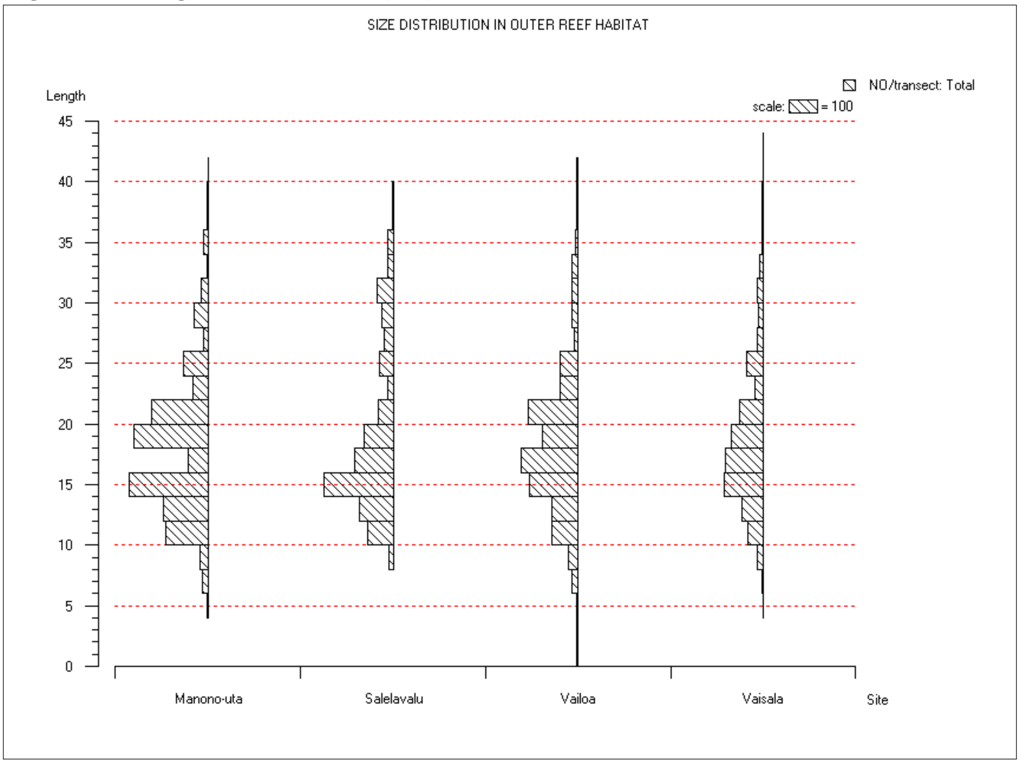

Figure 6: Length distribution (cm) in back reefs of the four sites

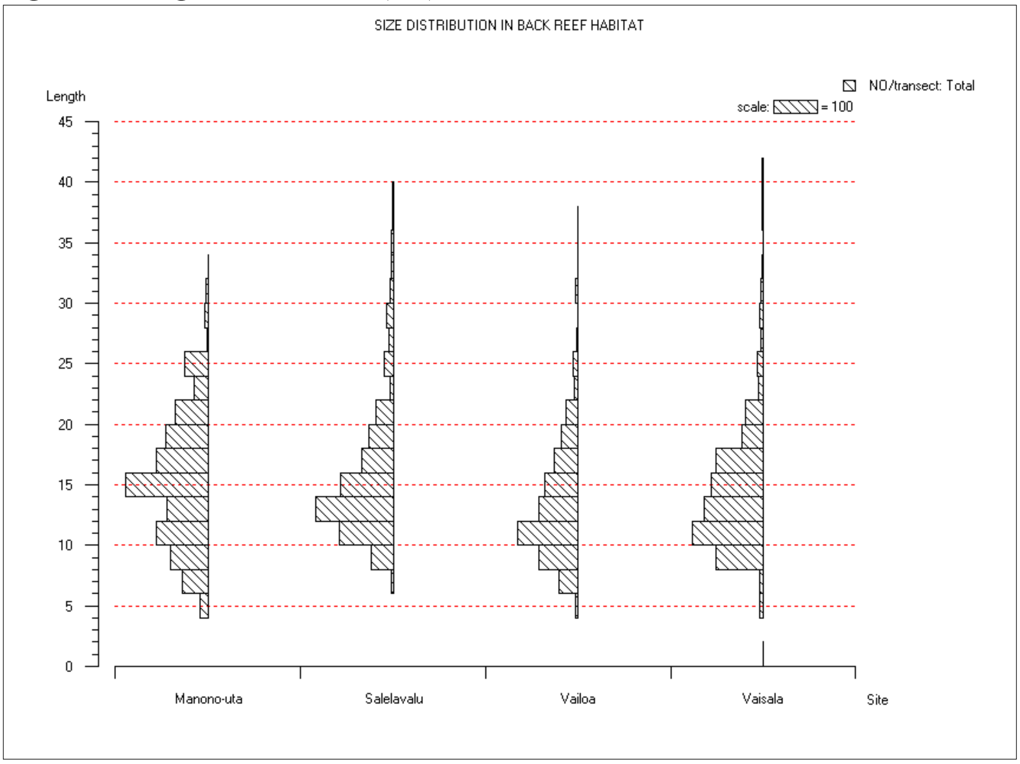

Figure 7: Lengths distribution (cm) in the lagoon habitats of Manono and Salelavalu

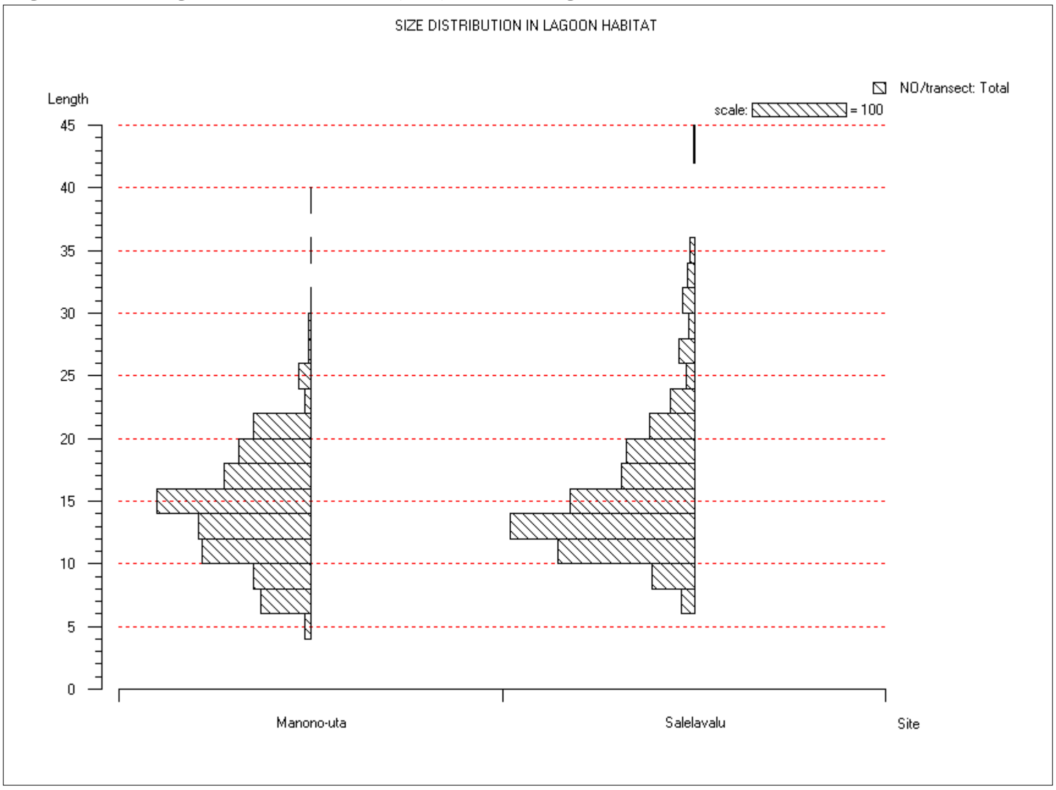

Figure 8: Length distribution (cm) in coastal reefs of the four sites

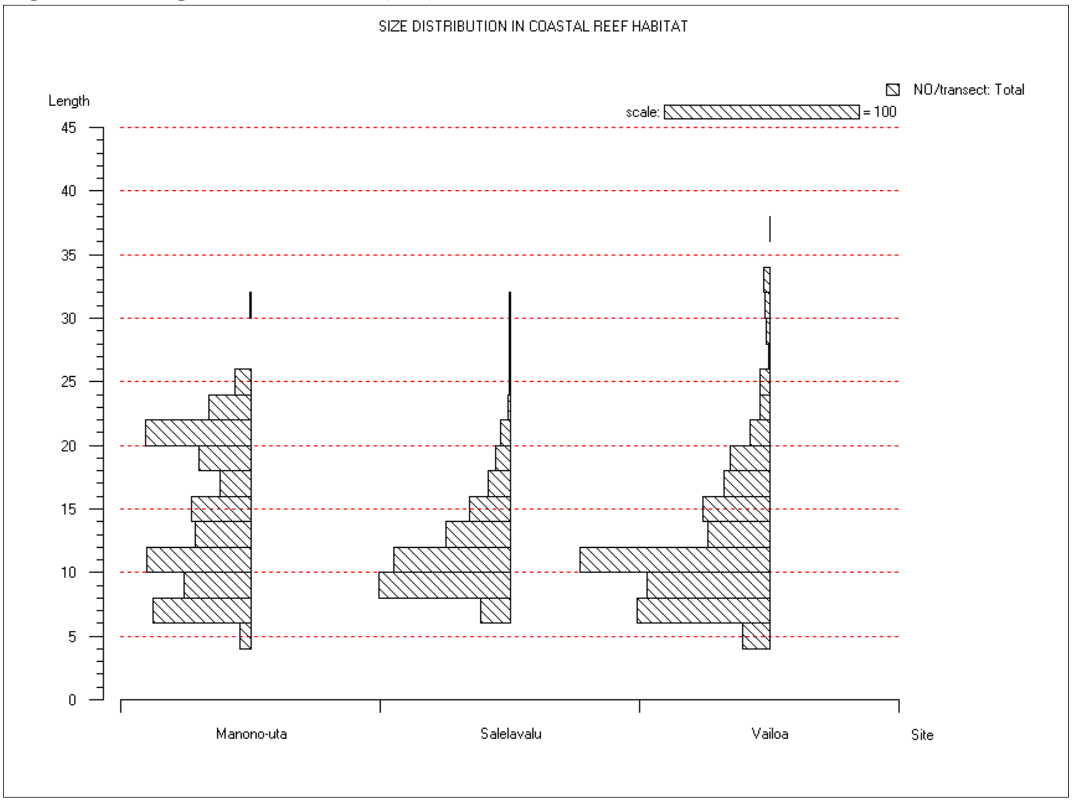

Figure 9: Fish Family density in outer reefs among sites.

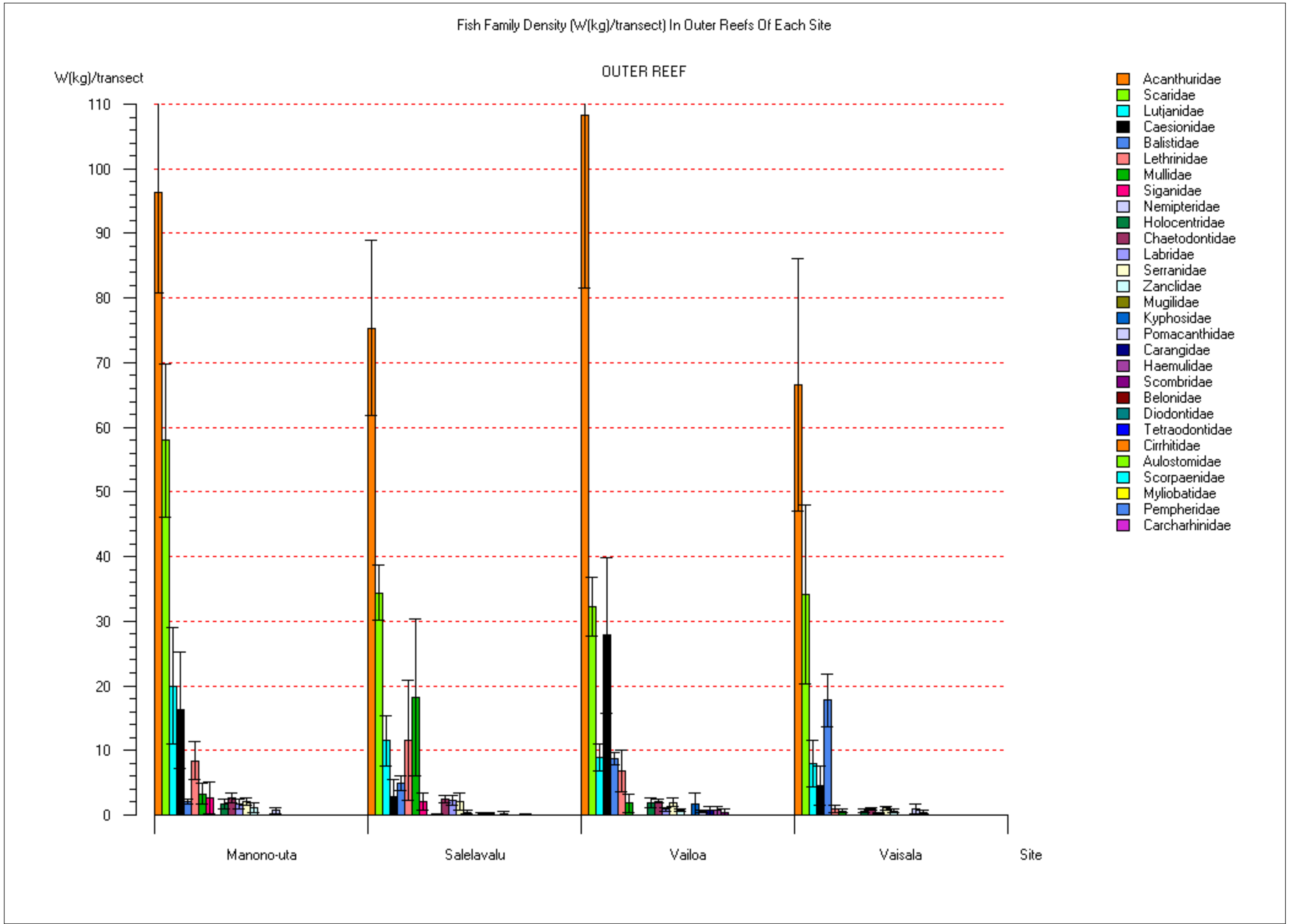

Figure 10: Fish family density in back reefs among sites

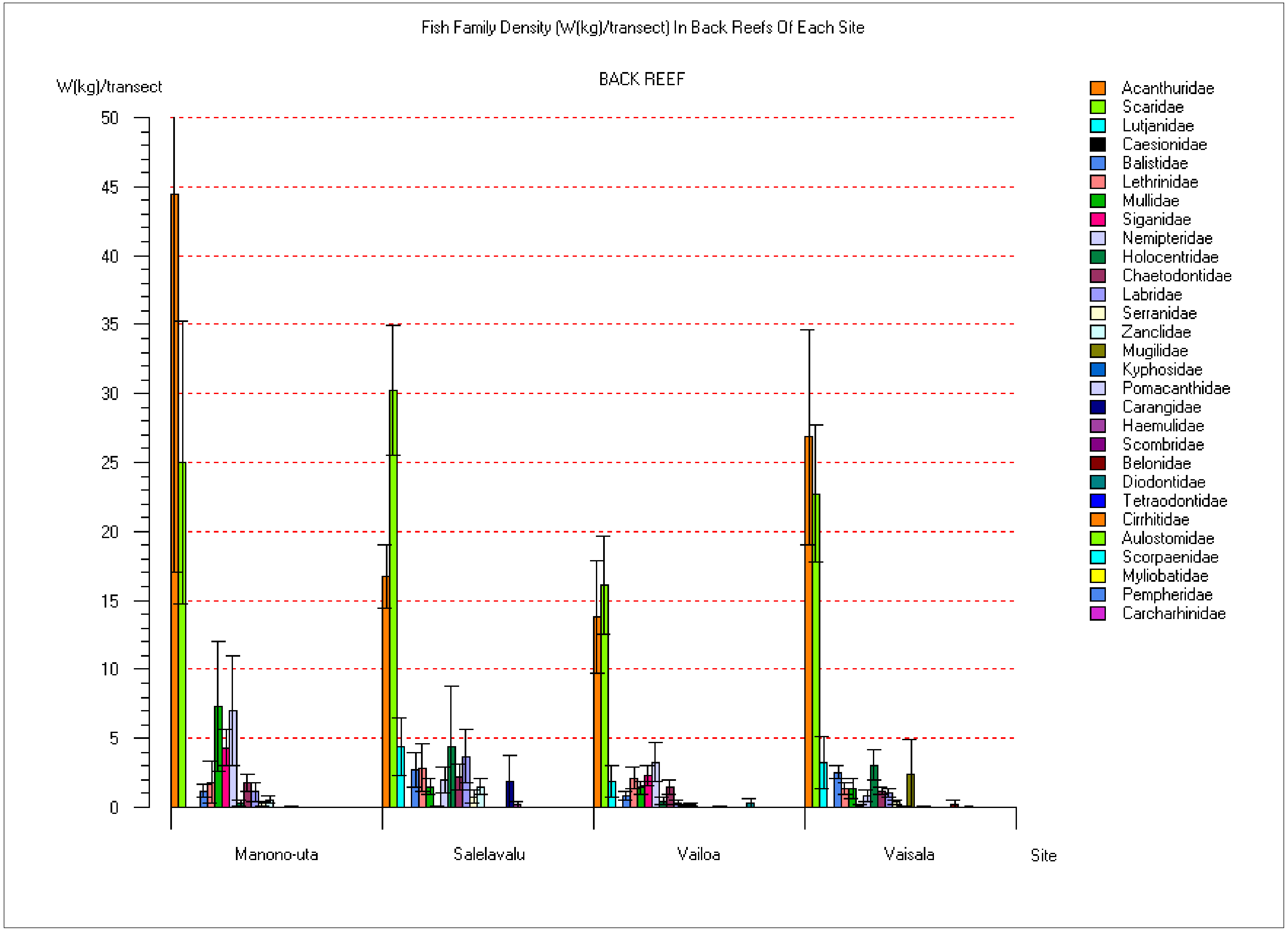

Figure 11: Fish family density in lagoons among sites

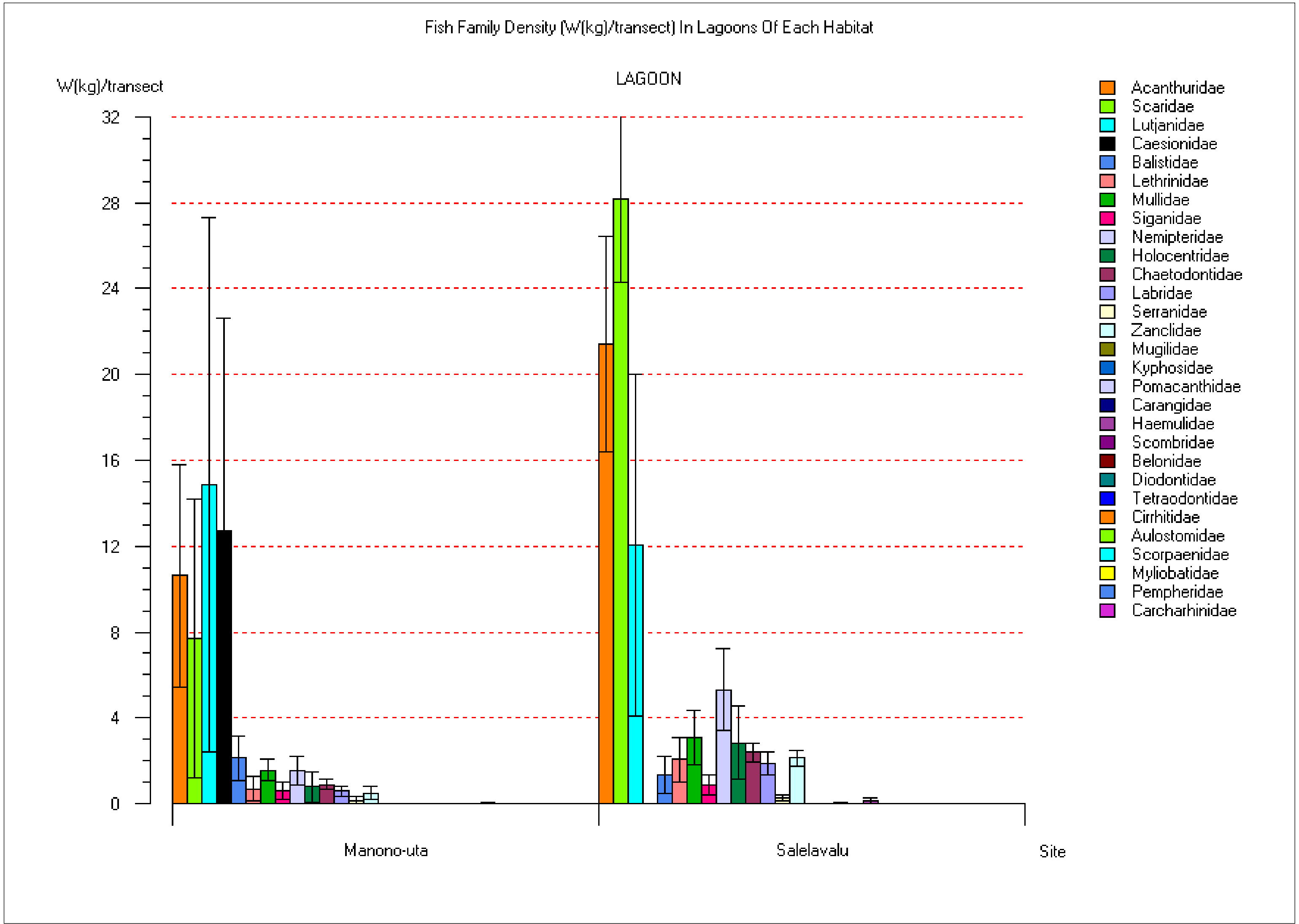

Figure 12: Fish family density in coastal reefs among sites

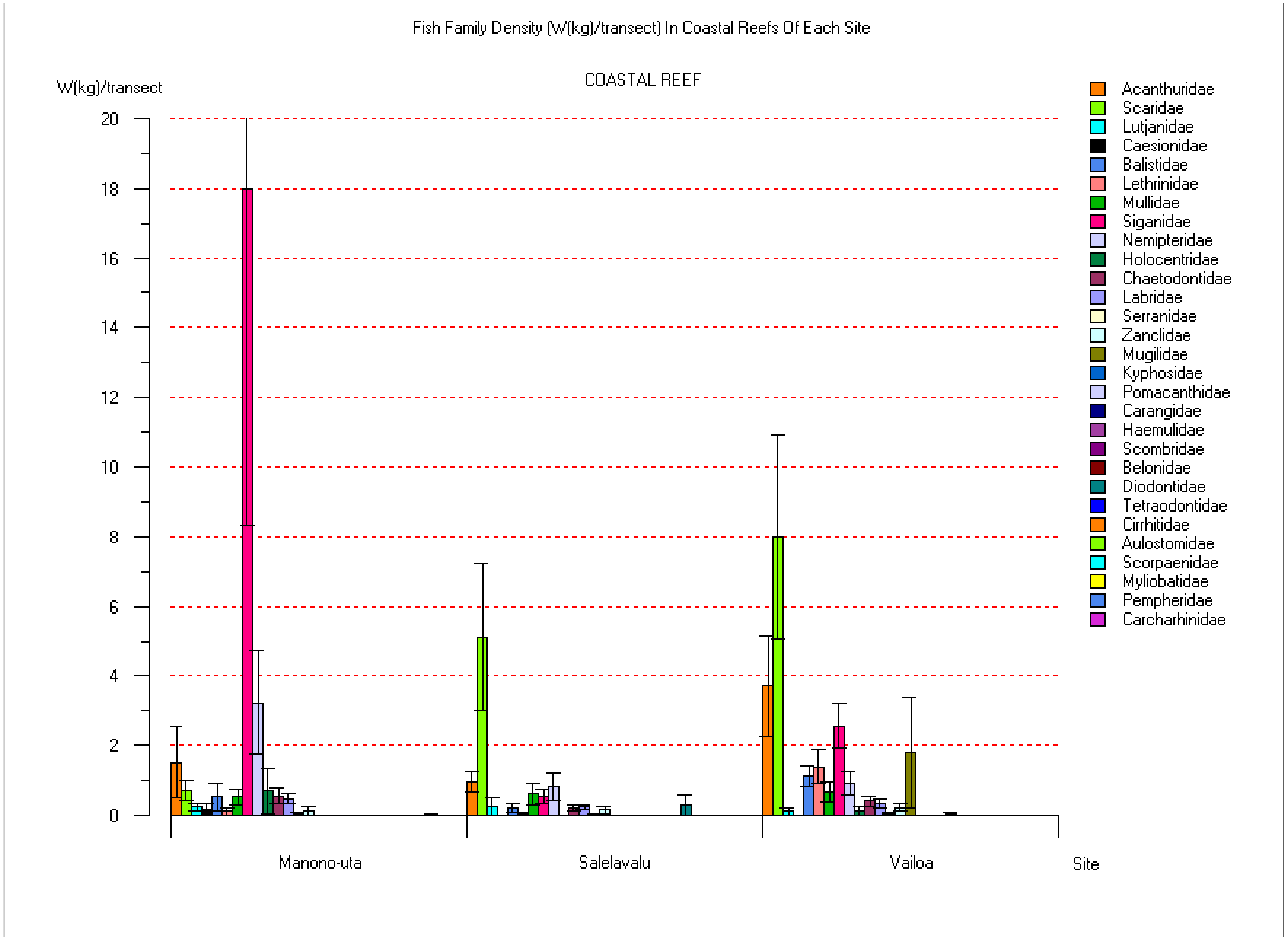

Figure 13: Annual Yield of catches and estimated biomass of the four surveyed sites (Red=Vaisala, Green=Salelavalu, Black=Vailoa, Blue=Manono uta).

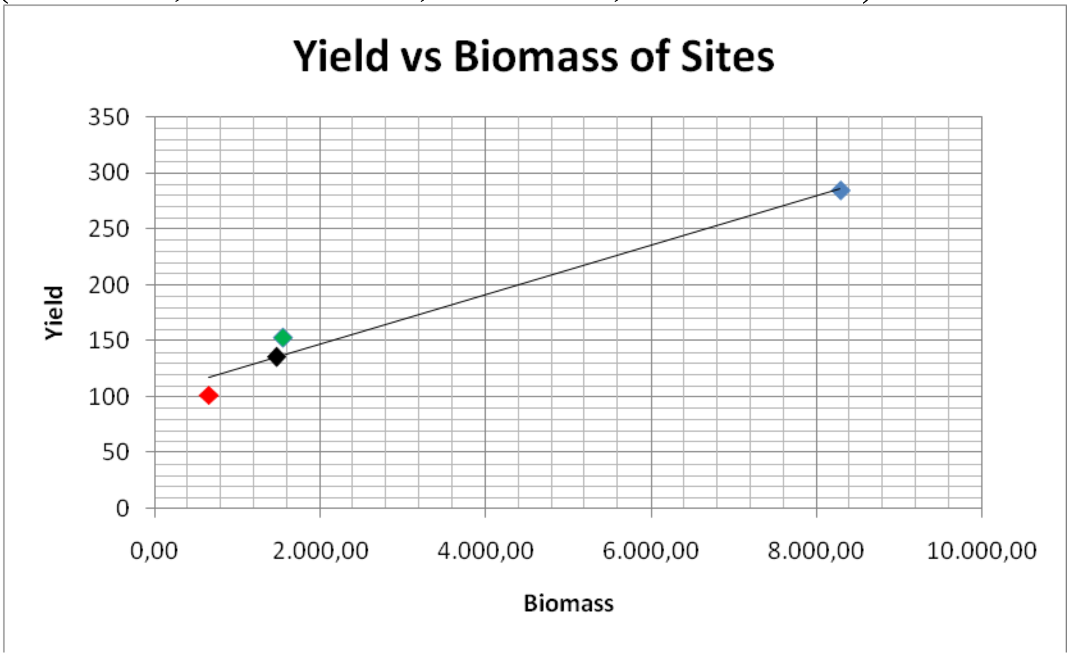

Figure 14: Proxy of fishing pressure on the estimated biomass of the surveyed sites (Red=Vaisala, Green=Salelavalu, Black=Vailoa, Blue=Manono uta).

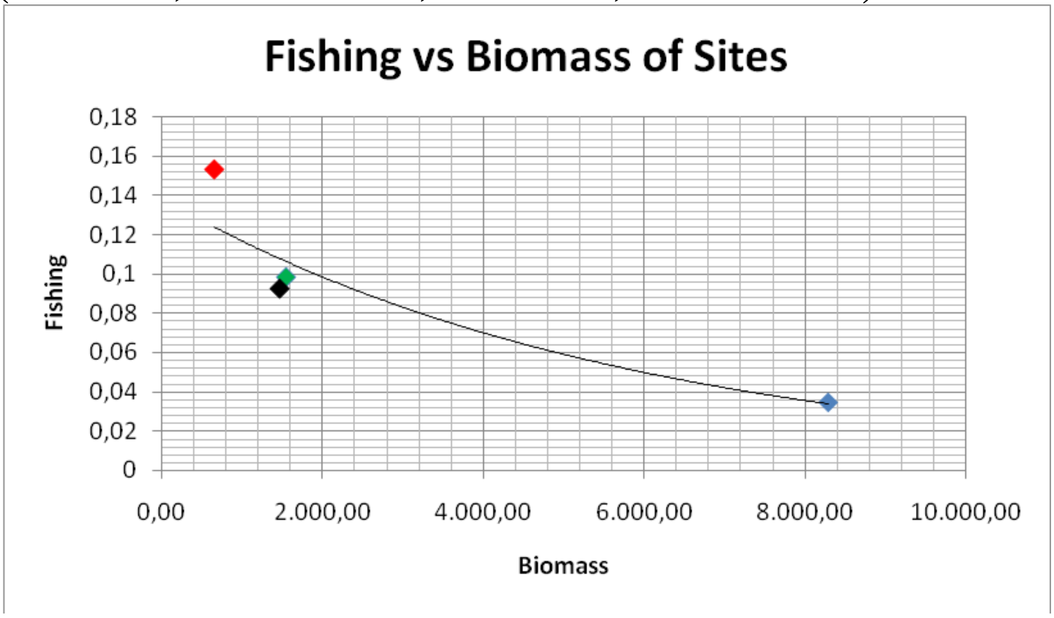

Figure 15: Fish density comparison between the left and right diver.