FIRST OBSERVATIONS ON THE FISH COMMUNITIES OF FRINGING REEFS IN THE REGION OF MAUMERE (FLORES - INDONESIA).

BY

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ABSTRACT

Total fish counts were made along 6 transects on fringing reefs in the region of Maumere (Flores - Indonesia). This represents the first description of fringing reef communities in this area of the Pacific. A total of 255 species, distributed among 36 families, were recorded. The major families were the Pomacentridae, Labridae, Serranidae, Acanthuridae and Chaetodontidae. The number of species per station was high (96 species) compared to similar counts for fringing reefs in New Caledonia. Density was 7.2 fish/m² and biomass was 187 g/m². The average weight of fish was low (21.7 g), with the Pomacentridae comprising 68% of the density. Large fish (over 40 cm) were scarce, possibly due to fishing pressure. The major contributors to the biomass were Scaridae, Caesionidae, Acanthuridae and Pomacentridae. Carnivores had the highest number of species followed by zooplanktivores and microalgae feeders. Most of the density consisted of planktivores and microalgae feeders, whereas biomass was dominated by microalgae feeders, zooplantivores and macroinvertebrate feeders. Small species with short life spans constituted most of the density. The trophic structure and distribution of life-history strategies were very similar to observations made on the fringing reefs of mainland New Caledonia, but were different from those of fringing reefs of two isolated islands (Ouvea Atoll and Chesterfield Island). There was a relationship between the number of dominant species and diversity. Structure of the fringing reef fish communities was mainly linked to habitat type, in particular, terrestrial runoffs could be a major factor.

INTRODUCTION

The reef fish fauna of Indonesia is one of the most diverse in the world, with over 2000 species. The Flores islands are at the eastern end of the Indonesian archipelago and are likely to support a species diversity lower than the larger islands further west such as Java, Sumatra or Borneo (species diversity decreases eastwards in the Pacific, and smaller islands tend to have fewer species than large ones). Other than a recent checklist (Kuiter and Allen, unpublished), very little is known of the reef fish communities of Flores. There is no account of the abundance, biomass, size distribution, trophic structure and the life history strategies of the major reef fish species in that region. The first objective of this article is to present a set of data relating to these subjects that were obtained in the Maumere region in 1993.

The second objective of this article is to compare the species rich region of Flores with a less diversified region (New Caledonia). Several questions come to mind when studying

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Manuscript received 4 June 1995; revised 1 February 1996

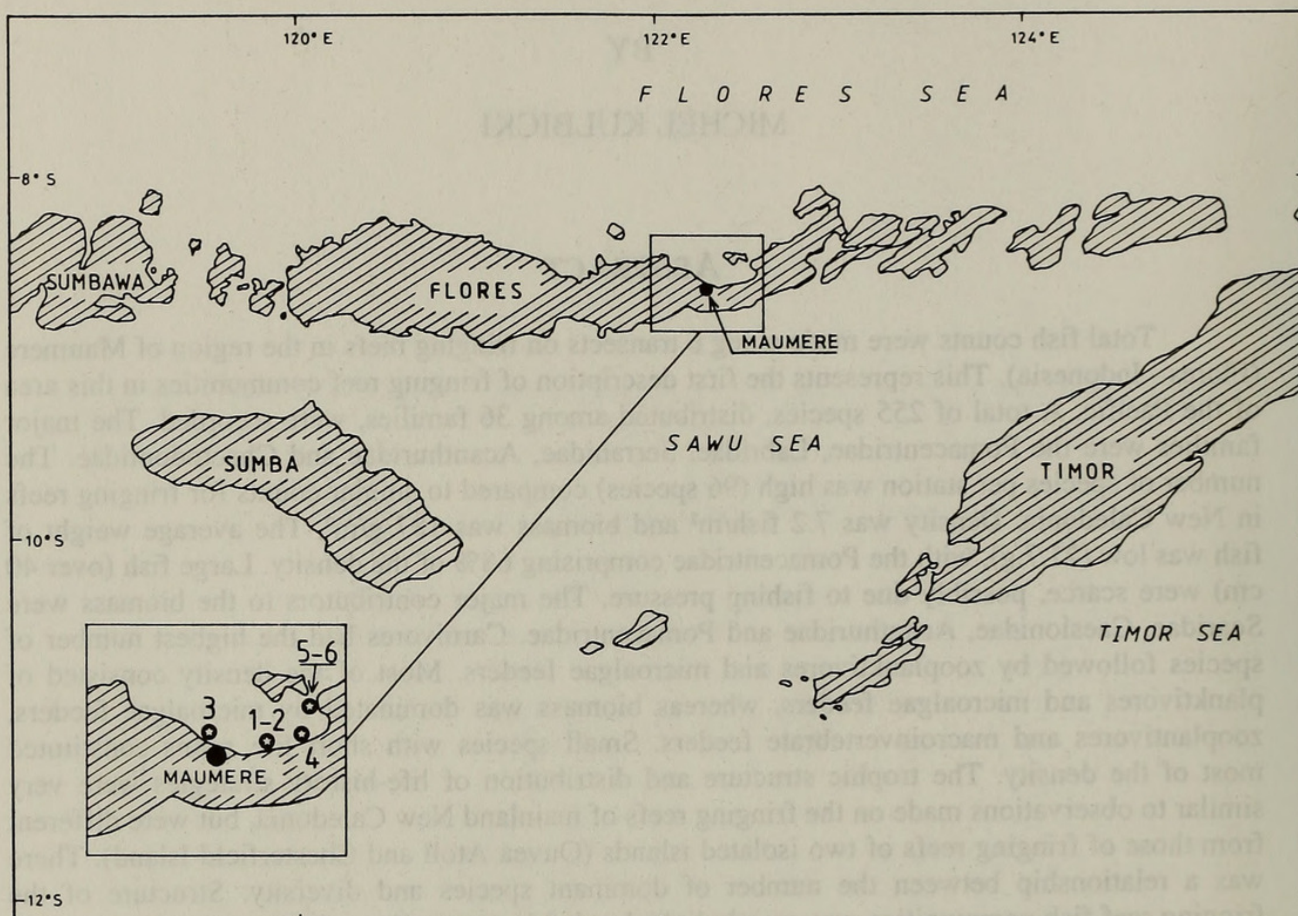

Figure 1 : map of the Maumere region. The 4 stations are indicated by a ✪ on the map inset. The numbers on the inset correspond to the transects.

communities found in a species rich area. For a given habitat, are there more species per unit area than in a less diverse region with similar habitat? Are there more "dominant species " (species making more than 2% of the density or the biomass) than in a less diverse region? Is the trophic structure or the distribution of the life-history strategies different from those observed on fish communities from a similar habitat but a different region? One of the major problems in answering such questions is to develop comparable sets of data. In the present case, the data from Flores were collected using the same methods as those used for a large set of data collected in New Caledonia (Kulbicki et al, 1994a).

Material and Methods

During the Pre-Indo-Pacific Fish Conference in Maumere (November 1993), the author had the opportunity to visit 4 fringing reefs and to perform 6 transects (Figure 1). The start of each transect was chosen at random on the reefs and the transects were laid in the direction of the slope. The transects were 50 m long. All fish, except the cryptic species (most Muraenidae, Ophichtydae, Syngnathidae, Gobiidae, Blenniidae, Synodontidae, Scorpaenidae, Antenariidae) and juveniles (newly recruited fish, usually less than 5 cm, but may be as small as 3 cm, i.e. *Chromis viridis*), were counted. For each record, the species name, number of fish observed, size of fish and distance of fish to the transect were noted. The size of the fish were noted in 1 cm classes for fish less than 10 cm, in 2 cm classes for fish between 10 and 30 cm, in 5 cm classes for fish between 30 and 50 cm and in 10 cm classes for fish more than 50 cm. The distances of the fish to the transect were estimated in 1 m classes for fish less than 5 m from the transect, and in 2 m classes for greater distances. Fish beyond 12 m from the transect were not counted. The diver covered each transect only once. The average time per transect was 90 min. Densities were calculated according to the method given by Burnham et al (1980) and Buckland et al. (1993). Fish weights were estimated from length-weight equations (Kulbicki et al., 1994a). Biomasses were estimated using these fish weights and the same method as for densities.

The diet of each fish species was either taken from the data used by Kulbicki et al. (1994a) or from information in FISHBASE (Froese et al., 1992). Species with no direct information available were assigned the same diet as the closest species within the same genus or family for which dietary information was available. The food items are divided into 9 categories: fish, macroinvertebrates, microinvertebrates, zooplankton, other plankton, macroalgae, microalgae, coral, detritus. The diet of each species is distributed among these 9 food categories. The percentage of each of these food items is taken into account when calculating the contribution of a given species to a trophic category. For instance, if species A eats 50% fish and 50% microalgae, and if this species has a density of 0.1 fish/m^2, the contribution of species A to piscivory will be of 0.1 x 0.50 =0.05 fish /m^2.

Each fish species was classified within one of the 6 life-history strategy classes defined in table 1 (see Kulbicki 1992 for a discussion on this classification). For most species the classification is given by Kulbicki et al. (1994a). For the remaining species, data from FISHBASE (Froese et al., 1992) was used to assign the species to a given class. For a number of species the information available was absent or too scant for a classification. In such a case, I used the same classification as for the closest species within the genus or the family.

Each transect was divided into five sections of 10 m each. On each section the cover of each of the substrate categories (see Kulbicki et al., 1993 for details of the method) given in Table 2 was noted (the total for each section being 100%) for a 5 m wide strip. Algae and coral cover were noted in the same manner.

RESULTS

The stations (Table 2) were between 3 and 7 m deep with a minimum depth of 1 m and a maximum of 12 m. The substrate was characterised by a large proportion of rubble (debris, small and large boulders) and a small coverage of sand, which was either muddy or coarse, no fine sand being found. Rock formations were usually from eroded reefs and not of volcanic origin, as found on land. Macroalgae were very scarce. Coral and alcyonarians were present in significant amounts at only one station.

A total of 255 fish species, distributed among 36 families, were recorded (Appendix 1). The families with more than 5 species accounted for 77 % of the total species seen (Table 3), and only 6 families (Serranidae, Chaetodontidae, Pomacentridae, Labridae, Scaridae and Acanthuridae) had more than 10 species. The number of species per transect (95.7 species), density (7.1 fish /m^2) and biomass (187 g/ m^2) were high (Table 4), but average weights were small (21.7 g) due to the dominance of Pomacentridae in the counts. Pomacentridae accounted for 16% of the diversity, 68% of the density and 9.5% of the biomass. One species, *Pomacentrus coelestis*, formed 48.7% of the total density and four other Pomacentridae (*Chromis amboinensis, Chromis xanthura, Neopomacentrus azysron, Pomacentrus amboinensis*) were among the 10 most important contributors to density. The other important species with respect to diversity and density were in the Labridae, but no particular species in this family dominated in density. Most species had a low number of individuals in the counts, even the planktivorous Labridae, which are usually found in schools elsewhere in the Pacific. The major contributors to biomass were the Scaridae and the Caesionidae. Most of the biomass for the Scaridae was made of juveniles, which cannot be easily identified underwater, but two species, *Scarus fasciatus* and *S.quoyi*, formed one-third of the Scaridae biomass. The Caesionidae, which are all schooling species, were dominated by *Pterocaesio tile* and *Pterocaesio chrysozona*. One of the major contributors to biomass was *Pomacentrus coelestis*, a very small fish (3 g average weight), but which was present in extremely high densities.

The trophic structure can be considered in species numbers, density or biomass (Table 5). Most species were carnivores (23.2% macrocarnivroes, 14.2% microcarnivores, 11.9 % piscivores), zooplanktivores and microherbivores represented respectively 21.7 and 20.5% of the species. Density was dominated by zooplanktivores (59.9%), followed by microherbivores (17.2%). The other trophic categories had little importance with respect to density. Three categories dominated biomass: microherbivores (34.9%), zooplanktivores (29.9%) and macrocarnivores (19.3%). Coral and detritus feeders were low in all respects. The low numbers for "other planktivores" are normal for reefs in the tropical Pacific. Macroherbivores were not an important group. As is usually the case in the Pacific, this group exhibits little diversity and low densities, but the large size of macroherbivores makes this category, at times, a significant contributor to the biomass. In Flores, these fish were small in size, most likely because of fishing pressure.

The distribution of the life-history strategies was dominated by the abundance of short-lived species (classes 1 and 2) (Table 6). Short-lived species were also the most diverse; however, species with an average life span (classes 3 and 4) were also represented by large number of species. Biomass was evenly distributed between short and average life-span species.

There were major differences in the distribution of the life-history strategies among trophic categories (Figure 2). In particular, zooplanktivores were essentially short-lived species whereas, the long living species were mainly macrocarnivores and piscivores. Microherbivores were split between many small, short-lived, species which dominated the density of this group, and a few large longer-lived species (Scaridae, Acanthuridae), which made up most of the biomass.

The average size of the commercially important species (essentially Serranidae, Lethrinidae, Lutjanidae, Scaridae, Acanthuridae) indicates that there are very few large fish (Appendix 1). In particular, not a single species with more than 10 individuals sighted, had an average size > 40 cm. The size frequencies for the most abundant commercial species are given on Figure 3. Most Serranidae were juveniles or small species. The Lethrinidae, Caesionidae and Scaridae were small in size (sizes at least 30% less than average reproductive size). This could be due to fishing pressure, but the high densities observed indicate that other factors could possibly be involved.

Discussion

The data set presented here are minimal and one should be cautious in generalizing these results to a large area. In the absence of other comparable data from the Flores Islands or even Indonesia, it is difficult to assess how representative are these results. In particular, it is noteworthy that the stations were sampled in a leeward zone and that on the windward side of the island the morphology of the reefs is very different, and it is likely that the reef fish communities there would be different also. However, data from New Caledonia (Kulbicki et al. , 1994a) indicate that even in a wide zone, reef fish communities from the same type of reef habitat share much in common in species richness, density, biomass and structure.

The substrate found on the stations is typical of many fringing reefs in the region. Indeed, in many cases terrestrial runoffs bring very fine sediment, and wave action induces the formation of rubble and coarse sediment. The very low algae and coral cover is not unusual either, especially in turbid areas.

It is difficult to compare the total number of species with other areas, because the sampling effort was low. However, this number (255) is higher than observations made on fringing reefs in Hawaii, 81 - 187 species (Hayes et al. , 1982) or French Polynesia, 80 species (Galzin, 1985), which have been sampled much more thoroughly. These numbers are comparable to the highest diversities found in New Caledonia, 168 - 252 species, but with a much larger sampling effort (Kulbicki, 1992). The number of species /station is a better indicator, if the stations are sampled in a similar manner. The only data (Table 7) that have been collected according to the same methods are from Kulbicki et al. (1989, 1994a). The species richness observed in Flores is higher than in any of the New Caledonian areas. It is estimated that there are 1140 reef and lagoon fish species in the Maumere area (Kuiter and Allen, unpublished), whereas there are 940 species in the SW lagoon of New Caledonia (Rivaton et al. 1989), with 550 species in the Chesterfield Islands (Kulbicki et al. , 1994b) and 630 in Ouvéa (Kulbicki et al, 1994a). The families that are best represented in Flores exhibit considerable species diversity in most parts of the tropical Pacific, but some families that contain many species elsewhere (Apogonidae, Holocentridae, Scaridae, Acanthuridae) (Thresher, 1991) did not exhibit similar diversity in our observations.

The densities observed in Flores are very high, especially for fringing reefs. Such densities have not been recorded in this type of environment in the tropical Pacific (Kulbicki, 1991). However, most of this density is due to only one species, *Pomacentrus coelestis*, a planktivore. Large densities of planktivores are common on reefs (Kulbicki et al. , 1994a), and these species are usually short lived and experience large temporal variations. The other components of the density in Flores are usually found on fringing reefs in the Pacific, in particular, the Acanthuridae, Pomacentridae and small Labridae. This is confirmed by the few published studies on fringing reefs in the Pacific that give a detailed account of the contribution of the various species to density. In Hawaii (Hayes et al., 1982), the dominant species were two Acanthuridae (*A.nigrofuscus, Ctenochaetus striatus*), followed by small Labridae (*Thalassoma duperrey, Gomphosus varius*), the Pomacentridae being the third major component of the Hawaiian reef communities. In French Polynesia, Galzin (1985) also found a majority of *Ctenochaetus striatus* on the fringing reefs, the second most abundant species being another herbivore, the Pomacentridae *Stegastes nigricans*. In New Caledonia, the composition of the density varied from one zone to another. In Ouvéa (Kulbicki et al., 1994a) the most abundant fish were *Acanthurus nigrofuscus* and *Stegastes nigricans,* followed by three planktivorous Pomacentridae (*Pomacentrus coelestis, Chromis chrysura, Chrysiptera cyanea*). In the Chesterfield islands (Kulbicki et al., 1989) the most abundant species were *Mulloides flavolineatus*, juvenile Scaridae, *Acanthurus nigrofuscus, Ctenochaetus striatus*, three species of *Caesio* and three Pomacentridae, all herbivores *(Pomacentrus molluccensis, Stegastes nigricans, Pomacentrus vaiuli*). On the main island of New Caledonia (Kulbicki, unpubl.data), the major contributor to density were planktivorous Caesionidae (*Pterocaesio diagramma, P.tile*), several Pomacentridae (the two major ones being *Chromis viridis* and *Dascyllus aruanus,* which are mainly planktivores), *Acanthurus nigrofuscus*, small Labridae (*Thalassoma lunare, T.lutescens*) and juvenile Scaridae.

The biomass (187 g/m²) found in the Flores is high for fringing reefs. In Hawaii Brock et al. (1979) found 106 g/m², on the GBR (inshore reefs) Williams and Hatcher found 92 g/m²; the results for New Caledonia are given in table 7. The distribution of the biomass can be compared only to the studies from New Caledonia. There, the major contributors varied greatly from one zone to another. In Ouvéa (Kulbicki et al., 1994a) the top three species in terms of biomass were herbivores (*Hipposcarus longiceps, Acanthurus blochii, Acanthurus xanthopterus*); in the Chesterfield Islands (Kulbicki et al., 1989) the top species were two herbivores (*Kyphosus vaigiensis, Naso unicornis*) and a carnivore (*Mulloides flavolineatus*); and on the mainland the main species were planktivores (*Pterocaesio tile, P.diagramma*) and herbivores (*Acanthurus nigrofuscus*, Scaridae spp.). The similarity between Flores and New Caledonia is the presence of Acanthuridae and Scaridae as major contributors to the biomass. The differences are in the species involved, with larger species in New Caledonia than in the Flores Islands.

The comparison of some length frequencies (Figure 3) between Flores and New Caledonia show that there is usually no difference in the size range. However, no small *Siganus doliatus* were observed in Flores, which could be due to the season, small *Siganus doliatus* (less than 15 cm) being found mainly during the dry season in New Caledonia. *Monotaxis grandocculis* did not exceed 22 cm in Flores, whereas this species was found to reach 38 cm in New Caledonia, with the largest sizes found on the barrier reef.

It is often assumed that the number of species contributing in an important manner (major species; more than 2% in the present case) to the density or biomass decreases as diversity increases (Richards, 1952 and Whittaker, 1964 in McIntosh, 1967; Spight, 1977; Wahington, 1984). The relationship is not clearcut, because it is often not specified which diversity is taken into account: the observed diversity (number of species in the sample) or the potential diversity (number of species in the region). The correlation between density and biomass for major species exists both for the observed diversity and the potential diversity, but is not as good for the latter

(Table 8 and Figure 4). This result suggests that highly diverse communities have lower numbers of dominant species. In other words, one would expect the resources to be better shared and utilised in these communities that in less diverse ones. Analysis of the trophic structure and of distribution of the life-history strategies will in part answer this question.

It is difficult to compare the trophic structure found in Flores with most of the findings in the literature, because the methods were very different from one study to another (Kulbicki, 1991). The data from New Caledonia were collected and analysed with the same methods used in the present study and are, therefore, comparable (Figure 5). The distribution of species among trophic categories (Figure 5a) is very similar in all 4 studies. However, Flores had more zooplankton feeding species than the fringing reefs of New Caledonia. In density (Figure 5b) and biomass (Figure 5c) the results from Flores and mainland New Caledonia are almost identical. The latter two islands differ from Chesterfield and Ouvea, both of which are offshore islands, in having larger numbers of zooplanktivores, lower abundances of microherbivores and carnivores, and larger biomasses of zooplanktivores. This larger importance of zooplanktivores in the Flores and mainland New Caledonia could be linked with high terrestrial runoffs (these islands have similar land masses -10 000 and 20 000 km² - and average rainfall - 1500 to 2000 mm/ year). There are also trends common to all four studies. In particular, coral feeders form 2-7% of the species but account for very little in density or biomass. Detritus feeders and "other planktivores" are never an important component of the trophic structure, whereas they form between 10 and 15% of the abundance or weight for the coastal (mangroves and estuaries) areas in New Caledonia (Thollot, 1992). Fringing reefs and coastal areas are often adjacent in New Caledonia, thus indicating that the trophic structure is greatly influenced by the substrate.

Very few studies on reef fishes have treated life-history strategies (Kulbicki, 1991; Kulbicki et al., 1992, 1994a) or assimilated structures (ecological categories x size classes) (Harmelin-Vivien, 1989). Kulbicki (1992), based on original data, compared life-history strategies from several types of reefs across the Pacific using the same classification. The data of the present study can be compared with data processed in the same way for fringing reefs in New Caledonia (Figure 6).

The distribution of species among life-history strategies is almost identical for all reefs (Figure 6a). This result could be expected from the findings of Kulbicki (1992), who demonstrated that within the Western Pacific there were little differences in this structure at the species level. Flores and mainland New Caledonia also have very similar structures in terms of density and biomass (Figures 6b, c). In particular, they differ from the fringing reefs of the islands of Ouvea and Chesterfield by having more class-1 species, which have the fastest turnover. Conversely, Flores and mainland New Caledonia have a low proportion of biomass represented by long living fishes (classes 5 and 6) which are important on the Ouvea and Chesterfield islands. This suggests that in Flores the fish communities of the fringing reefs should be more sensitive to short term variations than they would be on isolated islands such as Ouvea or the Chesterfield. This is logical since most of these class 1 and 2 fish feed mainly on zooplankton and microalgae, which are variable food sources, depending on primary production and mineral inputs.

Our findings indicate, therefore, that the functioning of the fringing-reef fish community of Flores is very similar to what is observed on mainland New Caledonia where ecological conditions are similar. Conversely, fringing reef fish communities from isolated islands of New Caledonia, despite their similar species composition, have different structures. Diversity alone does not account for the major differences in the structure of these fish communities.

ACKNOWLEDGEMENTS

The author wishes to thank the following persons and organisations: Prof. Dr. Kasijan Romimohtarto and the organizing committee of the Pre Indo-Pacific Fish Conference workshop held in Maumere (November 20-25, 1993), R.Kuiter, Dr.G.Allen, G.Moutham, P.Dalzell and the two anymous reviewers.

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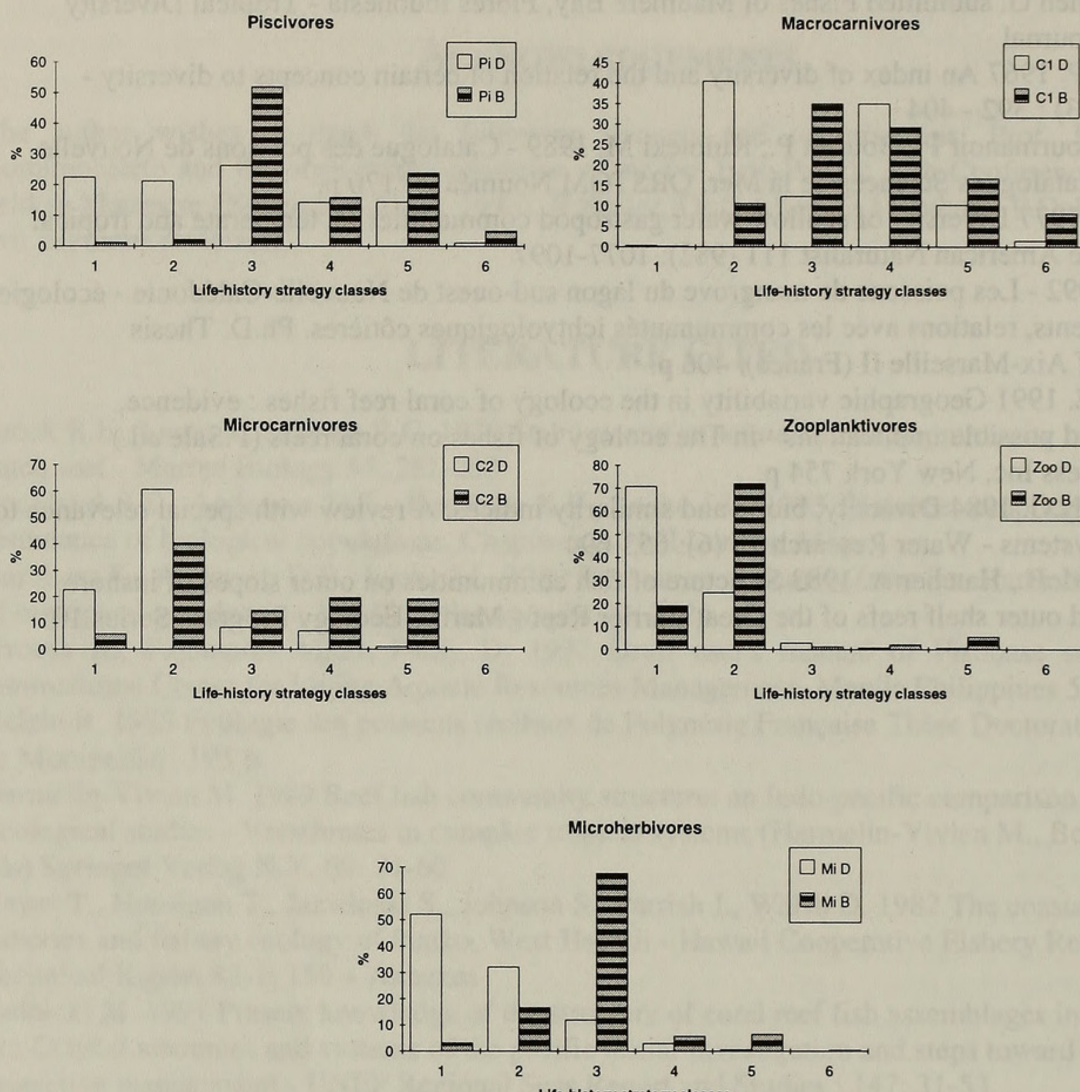

Figure 2: distribution of trophic categories according to life-history strategies. D: density; B: Biomass; Pi: piscivores; C1: macroinvertebrate feeders; C2: microinvertebrate feeders; Zoo.: zooplanktivores; Mi.: microalgae feeders

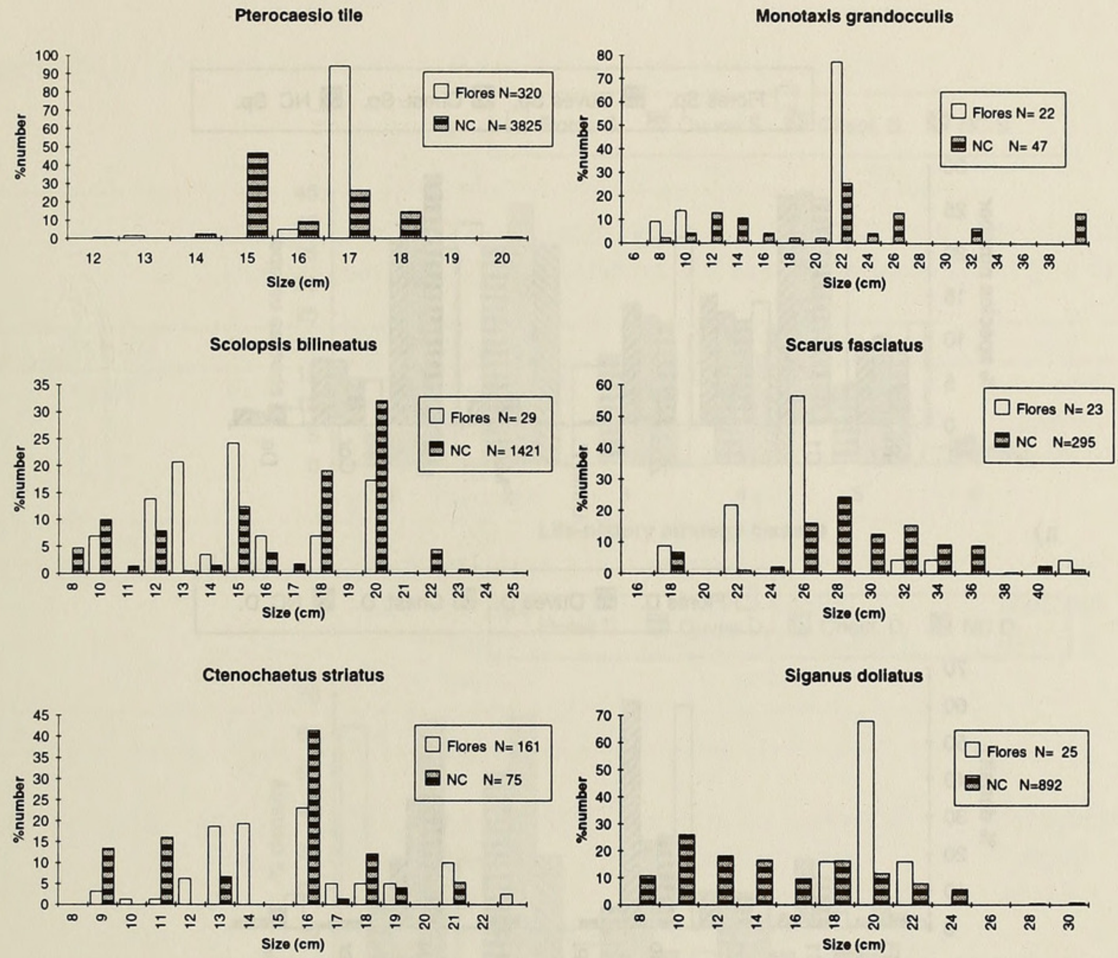

Figure 3: size distribution of the most abundant commercial species (NC: data for New Caledonia)

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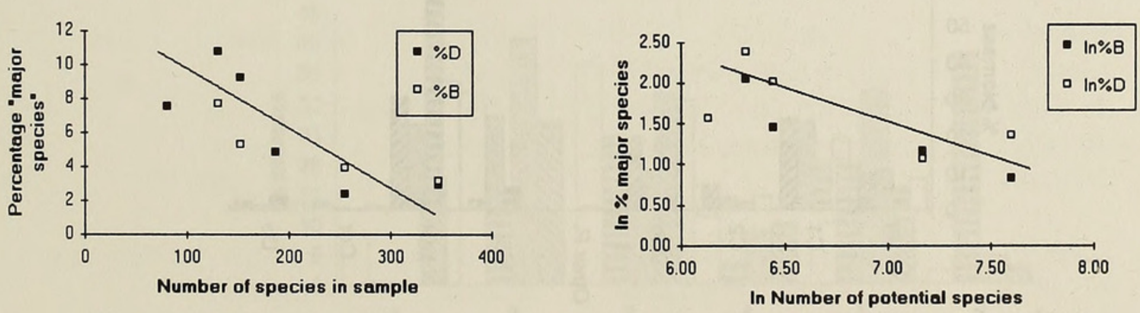

Figure 4: correlation between number of species ("major species") contributing to more than 2% of density (%D) or biomass (%B) and number of species in sample, or number of reef species known in region. Data from Table 8. Note that for second figure a log scale is used.

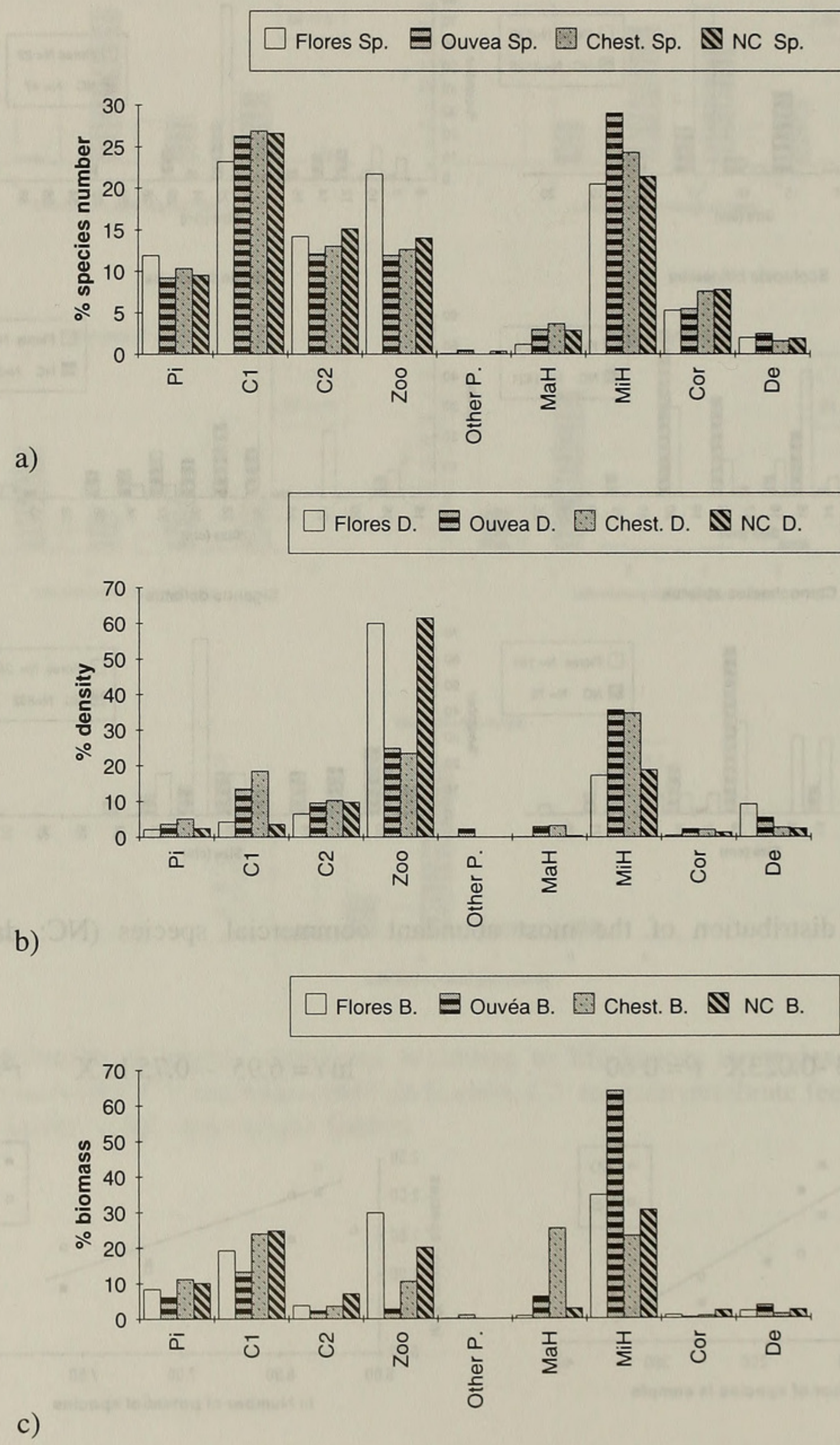

Figure 5: comparison of trophic structure (a: species, b: density, c: biomass) of fringing reefs Flores with New Caledonia: Ouvéa (Kulbicki et al., 1994a), Chesterfield islands (Kulbicki et al., 1989), main island (NC) (Kulbicki (1991). Pi: piscivores; C1: macrocarnivores; C2: microcarnivores; Zoo: zooplankton feeders; Other P.: other plankton feeders; MaH.: macroalgae feeders; MiH.: microalgae feeders; Cor.: coral feeders; De.: detritus feeders

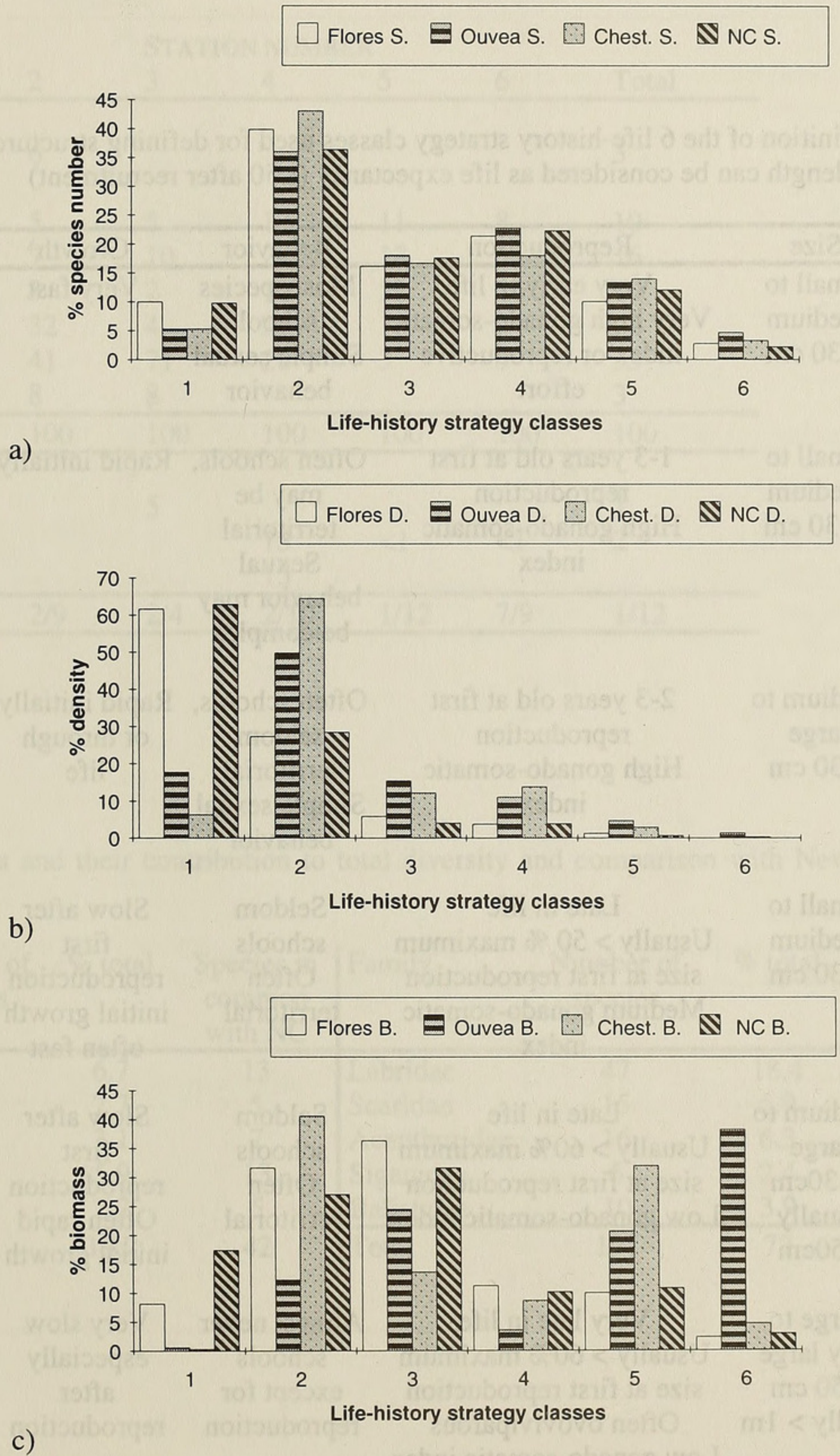

Figure 6: comparison of life-history strategy classes in Flores and New Caledonia. Key same as Figure 5.

Table 1: definition of the 6 life-history strategy classes used for defining structure. Life length can be considered as life expectancy (L50 after recruitment)

Class	Size	Reproduction	Behavior	Growth	Mortality	Life length
1	Small to medium < 30 cm	Very early in life Very high gonado-somatic index or reproductive effort	Most species school Simple sexual behavior	Very fast	High	0.5 to 3 years
2	Small to medium < 30 cm	1-3 years old at first reproduction High gonado-somatic index	Often schools, may be territorial Sexual behavior may be complex	Rapid initially	Medium	3 to 7 years
3	Medium to large > 30 cm	2-3 years old at first reproduction High gonado-somatic index	Often schools, seldom territorial Simple sexual behavior	Rapid initially or through life	Medium	3 to 7 years
4	Small to medium < 30 cm	Late in life Usually > 50 % maximum size at first reproduction Medium gonado-somatic index	Seldom schools Often territorial	Slow after first reproduction initial growth often fast	Low	7 to 12 years
5	Medium to large > 30cm usually >50cm	Late in life Usually > 60% maximum size at first reproduction Low gonado-somatic index	Seldom schools Often territorial	Slow after first reproduction Often rapid initial growth	Low	7-12 years
6	Large to very large > 50 cm usually > 1m	Very late in life Usually > 60% maximum size at first reproduction Often ovoviviparous Low gonado-somatic index	Almost never schools except for reproduction	Very slow especially after reproduction	Very low	> 12 years

Table 2: composition of substrate. Depths in m. All other numbers are percentages.

	Station number						
	1	2	3	4	5	6	Total
Substrate							
Sand - muddy	12	6					3
Sand - fine							
Sand - coarse	12	5	5	17	11	8	10
Gravel and Debris	3	7	10	24	17	36	16
Small boulder	3	3	2	10	52	16	14
Large boulder	23	32	4	21	18	34	22
Rock	47	41	71	28	3	5	33
Beachrock		8	8				3
Total	100	100	100	100	100	100	100
Organisms							
Algae			5				1
Coral				13	<1	<1	2
Alcyonarians				15			
Depth range	3/9	2/9	2/4	2/10	1/12	7/9	1/12

Table 3: major fish families and their contribution to total diversity and comparison with New Caledonia (NC)

Family	Number of species	% total	Species in common with NC	Family	Number of species	% total	Species in common with NC
Serranidae	17	6.7	13	Labridae	47	18.4	38
Caesionidae	7	2.7	5	Scaridae	15	5.9	13
Mullidae	8	3.1	7	Acanthuridae	16	6.3	15
Chaetodontidae	15	5.9	13	Siganidae	6	2.4	6
Pomacanthidae	7	2.7	5	Balistidae	10	3.9	8
Pomacentridae	49	19.2	42	Total	197	77	170

Table 4: density (fish/m²) and biomass (g/m²) of the major families and species.

Families	Density	Biomass
SERRANIDAE	0.099	6.36
Pseudanthias squamipinnis	0.047	0.17
Cephalopholis urodeta	0.013	0.99
Epinephelus fasciatus	0.010	1.10
LUTJANIDAE	0.021	3.95
Lutjanus decussatus	0.015	2.92
LETHRINIDAE	0.025	5.11
Lethrinus harak	0.006	1.92
Monotaxis grandocculis	0.012	1.85
NEMIPTERIDAE	0.040	4.28
Scolopsis bilineatus	0.021	1.67
MULLIDAE	0.042	9.48
Parupeneus indicus	0.003	4.53
Parupeneus trifasciatus	0.021	1.10
CHAETODONTIDAE	0.049	1.67
POMACANTHIDAE	0.044	2.79
POMACENTRIDAE	4.954	18.4
Chromis amboinensis	0.163	0.64
Chromis xanthura	0.226	0.23
Neopomacentrus azysron	0.139	0.48
Pomacentrus amboinensis	0.074	0.31
Pomacentrus brachialis	0.103	0.63
Pomacentrus coelestis	3.468	10.4
LABRIDAE	0.374	7.86
Cirrhilabrus cyanopleura	0.027	0.11
Cirrilabrus sp.	0.027	0.06
Halichoeres melanurus	0.056	0.29
Novaculichthys taeniourus	0.004	1.09
Thalassoma amblycephalum	0.048	0.23
SCARIDAE	0.106	33.1
Scarus spp. juvenile	0.052	13.0
Scarus fasciatus	0.016	5.56
Scarus quoyi	0.014	6.94
ACANTHURIDAE	0.132	18.4
Acanthurus leucocheilus	0.033	2.50
Ctenochaetus striatus	0.059	5.60
Naso hexacanthus	0.008	2.14
SIGANIDAE	0.023	4.85
BALISTIDAE	0.065	4.84
TOTAL	7.13	187

Table 5 : trophic structure. All numbers are percentages.

CATEGORY	DIVERSITY	DENSITY	BIOMASS
Piscivores	11.9	2.2	8.4
Macrocarnivores	23.2	4.3	19.3
Microcarnivores	14.2	6.5	3.8
Zooplanktivores	21.7	59.9	29.9
Other planktivores	0.1	0.1	0.1
Macroherbivores	1.2	0.1	0.8
Microherbivores	20.5	17.2	34.9
Coral feeders	5.3	0.5	0.9
Detritus feeders	2.0	9.2	2.0

Table 6: distribution of the life-history strategies. All numbers are percentages. Classes refer to the classification given in table 2.

LIFE-HISTORY STRATEGY CLASS	DIVERSITY	DENSITY	BIOMASS
1	10.0	61.6	8.2
2	39.8	27.3	31.7
3	16.1	5.8	36.4
4	21.3	3.8	11.3
5	10.0	1.3	10.0
6	2.8	0.1	2.3

Table 7: species richness (species /transect), density (fish/m²), biomass (g/m²) from fringing reefs in New Caledonia (SW lagoon, Chesterfield and Ouvéa)(Kulbicki, 1991; Kulbicki et al., 1989, 1994a).

REGION	SPECIES RICHNESS	DENSITY	BIOMASS
Chesterfield	64	1.2/3.3	90/200
Ouvéa	85	2.4	340
SW Lagoon	55	2.2/5.8	61/155

Table 8: number of species (N) contributing to more than 2% of density or biomass for Flores and other fringing reefs in the Pacific. Sampled species: number of species sampled. Potential species: number of reef species known in the area; %N: percentage of N in the number of species recorded during the survey.
1: Kulbicki unpublished; 2: Kulbicki et al., 1994a; 3: Kulbicki et al. 1989; 4: Galzin, 1985; Hayes et al., 1982

Region	N density	%N density	N biomass	% N biomass	Sampled species	Potential species	Land are (km²)
Flores	6	2.3	10	3.9	255	1140	≈10 000
New Caledonia (1)	10	2.9	11	3.2	348	940	20 000
Ouvéa (2)	14	7.5	8	4.3	152	630	130
Chesterfield (3)	14	10.8	10	7.8	130	550	10
Moorea (4)	6	7.5			80	630	130
Hawaii (5)	9	4.8			187	460	≈500

Appendix 1: list of species observed. St: number of stations where species was observed; N: total number of individuals seen; Sch.: average size of schools; Size: average size in cm

Name	St	N	Sch.	Size	Name	St	N	Sch.	Size
Taeniura lymma	1	1	1	30	*Pterocaesio diagramma*	1	15	15	15
Plotosus lineatus	1	50	50	6	*Pterocaesio teres*	1	20	20	15
Saurida gracilis	1	1	1	10	*Pterocaesio tile*	3	320	107	16.9
Synodus variegatus	3	3	1	10.3	*Plectorhinchus picus*	1	1	1	18
Synodus dermatogennis	1	1	1	7	*Lethrinus olivaceus*	1	1	1	25
Synodus spp.	1	1	1	10	*Lethrinus harak*	2	11	2.2	25.3
Sargocentron caudimaculatum	1	6	6	16	*Lethrinus rubrioperculatus*	1	21	10.5	18
Aulostomus chinensis	1	1	1	27	*Monotaxis grandoculis*	5	22	2.7	17.1
Pterois antennata	2	2	1	12.5	*Pentapodus caninus*	1	35	17.5	16.7
Pterois volitans	1	1	1	12	*Scolopsis affinis*	4	5	1	24.2
Pseudanthias squamipinnis	5	100	14.2	5.3	*Scolopsis bilineatus*	6	29	1.3	14.9
Pseudanthias tuka	1	2	2	6	*Scolopsis lineatus*	1	1	1	15
Anyperodon leucogrammicus	3	5	1	19	*Scolopsis margaretifer*	3	3	1	22.3
Cephalopholis argus	2	2	1	25	*Mulloides flavolineatus*	1	5	2.5	16
Cephalopholis cyanostigma	2	3	1	29	*Parupeneus barberinus*	4	8	1.1	25
Cephalopholis leopardus	3	5	1	12.6	*Parupeneus bifasciatus*	3	6	1	19.2
Cephalopholis microprion	3	3	1	12	*Parupeneus cyclostomus*	4	17	1.4	19.2
Cephalopholis miniata	1	1	1	13	*Parupeneus indicus*	1	2	2	40
Cephalopholis sexmaculatus	1	3	1	25	*Parupeneus macronema*	4	4	1	14.2
Cephalopholis spiloparea	1	1	1	9	*Parupeneus trifasciatus*	6	38	1.4	12.9
Cephalopholis urodeta	3	16	1.1	15.5	*Upeneus tragula*	1	1	1	20
Epinephelus cyanopodus	2	3	1	33.7	*Platax orbicularis*	2	5	2.5	27
Epinephelus fasciatus	6	16	1	18.1	*Chaetodon adiergastos*	1	1	1	18
Epinephelus hexagonatus	1	1	1	20	*Chaetodon baronessa*	1	5	1.7	8.2
Epinephelus merra	1	1	1	12	*Chaetodon citrinellus*	1	1	1	8
Variola louti	3	9	1	24.8	*Chaetodon kleinii*	4	22	2.4	8
Variola albomarginata	2	2	1	10.5	*Chaetodon lineolatus*	1	1	1	12
Pseudochromis exquisitus	1	2	2	7	*Chaetodon lunula*	1	6	2	11.8
Pseudochromis paccagnellae	1	4	2	5	*Chaetodon melannotus*	2	3	1.5	9
Apogon fraenatus	1	3	3	5	*Chaetodon ornatissimus*	1	1	1	12
Apogon nigrofasciatus	2	9	4.5	5	*Chaetodon pelewensis*	1	2	2	8
Cheilodipterus lineatus	1	4	4	7	*Chaetodon rafflesi*	2	3	1.5	12
Malacanthus latovittatus	2	4	1	24	*Chaetodon trifascialis*	1	3	1.5	8.3
Carangidae spp.	1	1	1	20	*Chaetodon trifasciatus*	3	10	2	8.3
Caranx para	1	4	4	20	*Chaetodon vagabundus*	5	18	1.8	11.4
Caranx tille	1	3	3	15	*Chaetodon xanthurus*	1	2	1	8
Caranx spp.	3	5	1.7	15.2	*Heniochus varius*	4	6	1.5	14.5
Gnathanodon speciosus	1	1	1	20	*Centropyge bicolor*	2	20	2	6.2
Lutjanus decussatus	6	28	1.2	21.9	*Centropyge tibicen*	1	6	2	12.3
Lutjanus fulvus	2	11	1.6	19.9	*Centropyge vrolicki*	6	31	1.5	7.7
Lutjanus rivulatus	1	1	1	23	*Genicanthus lamarcki*	1	4	4	20
Lutjanus vittus	1	1	1	20	*Pomacanthus imperator*	2	2	1	21.5
Macolor niger	1	1	1	18	*Pomacanthus xanthomethopon*	2	2	1	21.5
Caesio cuning	2	23	11.5	23.2	*Pygoplites diacanthus*	3	6	1	19.8
Caesio lunaris	2	33	16.5	17.3	*Abudefduf saxatilis*	2	95	23.7	7.5
Pterocaesio chrysozona	1	160	53.3	15.2	*Acanthochromis polyacanthus*	3	54	4.1	8.3
Caesio xanthonota	2	15	5	12.7	*Amblyglyphidodon aureus*	1	3	1.5	8.3

Name	St	N	Sch.	Size	Name	St	N	Sch.	Size
Amblyglyphidodon curacao	3	58	3.8	7.8	*Cheilinus celebicus*	2	3	1	12.3
Amblyglyphidodon leucogaster	1	30	15	8	*Cheilinus chlorourus*	3	5	1	18.6
Amphiprion clarkii	2	9	2.2	5.4	*Cheilinus diagrammus*	2	4	1	16.7
Amphiprion melanopus	1	2	2	7	*Cheilinus fasciatus*	1	2	1	16.5
Amphiprion perideraion	1	1	1	6	*Cheilinus trilobatus*	4	5	1	22.6
Chromis amboinensis	2	323	46.1	5	*Choerodon anchorago*	2	8	1.3	22.2
Chromis atripectoralis	1	62	31	5.4	*Cirrhilabrus exquisitus*	3	16	5.3	5.8
Chromis atripes	2	33	6.6	4.3	*Cirrhilabrus cyanopleura*	2	52	10.4	6.4
Chromis viridis	1	30	30	6	*Cirrhilabrus sp.*	3	53	8.8	5.3
Chromis chrysura	3	20	4	7.4	*Coris gaimard*	3	6	1	11.5
Chromis flavicauda	1	2	1	8	*Coris schroederi*	2	7	1.7	10
Chromis flavomaculata	2	5	2.5	6.2	*Diproctacanthus xanthurus*	1	1	1	8
Chromis margaritifer	5	46	3.8	4.3	*Epibulus insidiator*	4	9	1	15
Chromis retrofasciata	2	24	6	4	*Gomphosus varius*	1	1	1	8
Chromis vanderbilti	1	2	2	4	*Halichoeres argus*	2	10	5	6
Chromis spp.	1	1	1	9	*Halichoeres chrysus*	2	25	5	5.6
Chromis xanthura	3	25	4.2	8.2	*Halichoeres hortulanus*	3	6	1	13.5
Chromis weberi	6	404	21.3	6.1	*Halichoeres melanurus*	5	37	2	6.6
Chrysiptera rex	5	38	2.9	4.8	*Halichoeres miniatus*	1	1	1	7
Chrysiptera rollandi	6	38	4.2	4	*Halichoeres prosopeion*	1	1	1	8
Chrysiptera talboti	5	55	4.5	4.8	*Halichoeres podostigma*	1	1	1	10
Dascyllus aruanus	1	8	8	4	*Halichoeres nebulosus*	1	6	3	7.3
Dascyllus melanurus	1	1	1	5	*Halichoeres scapularis*	2	2	1	12
Dascyllus reticulatus	2	56	11.2	3.6	*Hemigymnus fasciatus*	1	1	1	12
Dascyllus trimaculatus	3	9	3	6.7	*Hemigymnus melapterus*	4	10	1.1	16.4
Discistodus melanotus	1	5	1.7	9.6	*Hologymnosus annulatus*	1	1	1	10
Neopomacentrus azysron	2	285	21.9	4.7	*Hologymnosus doliatus*	1	2	1	13
Neopomacentrus nemurus	1	2	2	5	*Labrichthys unilineatus*	1	5	1	8.8
Neopomacentrus violascens	3	12	2.4	5.2	*Labroides bicolor*	4	5	1.2	7
Paraglyphidodo nigroris	3	13	1.3	8.6	*Labroides dimidiatus*	6	15	1.7	5.6
Neoglyphidodon crossi	1	3	1.5	10.3	*Macropharyngod meleagris*	4	10	1.4	7.5
Plectroglyphidodon dicki	1	9	2.2	6.7	*Macropharygodo ornatus*	2	6	1.5	7.5
Plectroglyphidon lacrymatus	4	16	2	6.8	*Novaculichthys taeniourus*	3	13	1.3	24.5
Pomacentrus alexanderae	1	2	2	8	*Pseudocheilinu evanidus*	2	3	1	6.7
Pomacentrus amboinensis	3	110	9.1	4.7	*Pseudocheilinu hexataenia*	1	2	1	6
Pomacentrus bankanensis	3	57	6.3	5.6	*Pseudocheilinu octotaenia*	3	4	1.3	7
Pomacentrus brachialis	5	144	6.8	5.9	*Pseudodax mollucanus*	1	1	1	10
Pomacentrus coelestis	6	10578	240	4.9	*Stethojulis bandanensis*	1	3	1	8.7
Pomacentrus lepidogenys	2	32	4.5	6	*Stetholulis interrupta*	1	3	3	6
Pomacentrus philippinus	3	12	1.5	6.5	*Stethojulis strigiventer*	2	3	1.5	6.7
Pomacentrus reidi	1	23	5.7	7.2	*Stethojulis trilineata*	2	4	1	9
Pomacentrus simsiang	2	90	10	4.8	*Thalassoma amblycephalum*	3	83	8.3	6.8
Pomacentrus sp.	3	18	3	5.7	*Thalassoma hardwicke*	2	8	1.1	11.5
Pomacentrus taeniometopon	3	19	3.80	5.8	*Thalassoma janseni*	2	3	1	9.7
Pomacentrus vaiuli	4	27	3	4.3	*Thalassoma lunare*	6	46	1.8	8.6
Cirrhitichtys falco	1	1	1	6	*Scarus spp.*	6	111	5.	20.3
Paracirrhites forsteri	1	3	1	13	*Cetoscarus bicolor*	1	2	2	38
Sphyraena barracuda	1	1	1	50	*Scarus bleekeri*	6	13	1.4	24.9
Sphyraena japonica	1	50	50	35	*Scarus altipinnis*	1	1	1	10
Anampses caeruleopuncta	3	4	1	13	*Scarus dimidiatus*	1	2	1	23
Bodianus mesothorax	4	9	1	12.7	*Scarus flavipectoralis*	2	4	1	21.2

Name	St	N	Sch.	Size
Scarus fasciatus	4	23	2.9	23.8
Scarus forsteni	1	1	1	23
Scarus microrhinos	1	1	1	28
Scarus niger	6	25	1.3	19
Scarus oviceps	3	8	1	19.7
Scarus psittacus	1	1	1	18
Scarus quoyi	3	33	2.1	27.2
Scarus prosognathos	1	1	1	35
Scarus sordidus	3	4	1	23
Parapercis clathrata	4	8	1	10.8
Parapercis cylindrica	1	2	1	8.5
Parapercis multiplicata	2	4	1	9.7
Parapercis tetracantha	1	4	1	11.5
Ecsenius bandanus	1	20	20	4
Ecsenius bicolor	1	2	2	5
Ecsenius midas	5	17	2.8	5.5
Plagiotremus rhinorhynchos	3	9	3	6.9
Amblygobius rainfordi	3	14	3.5	4.6
Istigobius decoratus	1	1	1	6
Ptereleotris evides	1	2	2	9
Ptereleotris heteroptera	2	4	2	9
Valenciennea strigatus	4	24	2.6	7.4
Acanthurus mata	1	5	5	22
Acanthurus fowleri	1	1	1	28
Acanthurus dussumieri	1	7	1.7	23.5
Acanthurus nigricans	1	1	1	16
Acanthurus blochii	1	11	2.7	19.6
Acanthurus lineatus	2	15	2.1	24.9
Acanthurus nigrofuscus	2	4	2	14.2
Acanthurus leucocheilus	1	2	2	30
Acanthurus olivaceus	1	1	1	7
Acanthurus pyroferus	2	10	1.2	17.7
Ctenochaetus binotatus	2	16	2.6	7.5
Ctenochaetus striatus	6	161	3.8	14.4
Naso hexacanthus	3	28	5.6	22.3
Naso lituratus	1	2	1	26.5
Paracanthurus hepatus	1	1	1	20
Zebrasoma scopas	6	29	1.5	10.4
Siganus argenteus	4	9	1.8	23.4
Siganus canaliculatus	3	8	2.7	23.5
Siganus corallinus	2	2	1	21.5
Siganus doliatus	6	25	2.1	20.1
Siganus puellus	2	6	2	24
Siganus vulpinus	3	7	1.7	20.3
Zanclus cornutus	4	13	1.3	13.5
Rastrelliger kanagurta	1	15	15	30
Amanses scopas	1	4	1	11.5
Aluterus scriptus	1	1	1	40
Balistapus undulatus	6	51	1.2	13.8
Balistoides viridescens	1	1	1	50
Melichthys vidua	1	2	1	13.5

Name	St	N	Sch.	Size
Odonus niger	3	65	16.2	13.7
Pervagor melanocephalus	1	1	1	10
Rhinecanthus verrucosus	1	2	1	19
Sufflamen bursa	4	8	1	10.7
Sufflamen chrysopterus	2	32	1.9	12.3
Arothron meleagris	1	1	1	20
Arothron nigropunctatus	2	2	1	20
Canthigaster solandri	3	5	1	9.8