Fishes of New Caledonia unveiled

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Fish diversity is highest on habitat-rich reefs, with up to 300 species per hectare. © R.-F. Myers

How many fish in the lagoons?

Reef fish are the most diverse vertebrates on the planet, and New Caledonia has an exceptional number of species (KULBICKI *et al.*, 2013; LABOUTE and GRANDPERRIN, 2016). However, the exact number is unknown as it is difficult to account for all species in a reef. Many species are very difficult to catch or detect, either because they live hidden in reef crevices, because they live in deep waters or because they have a behavior that makes them inaccessible. Furthermore, once caught or photographed, it is sometimes difficult to identify a species with certainty, especially when there are many

other species that look similar and species checklists are very heterogeneous. Although the surroundings of Nouméa or Ouvéa have been well explored, the North Province, Maré, Tiga, the Côte Oubliée or the Isle of Pines, as well as most of the distant reefs (Astrolabe, Petri, Durand, Surprises, etc.) have been less documented. However, numerous visual censuses and occasional faunal inventories make it possible to regularly add to the fish diversity of New Caledonia.

The most comprehensive checklist was published in 2011 (FRICKE *et al.*, 2011). It listed 1,740 reef fish species out of a total of 2,343 marine fish species known to exist in New Caledonia. Since then, knowledge has evolved, and the number of known reef fish species

is approximately 1,800. The total number will probably never be known but is unlikely to exceed 2,000 species. In comparison, over the whole of Europe, only 900 species are known for the continental shelf (down to 100 m deep) from the north of Norway to the southeastern Mediterranean, an area about 30 times larger than the lagoons and reefs of New Caledonia. This exceptional diversity is directly related to the proximity of the "Coral Triangle" delimited by Indonesia, the Philippines and the China Sea. The highest levels of diversity in the Indian and Pacific oceans is found in this particular region, where diversity exceeds 2,500 species in some areas (Fig. 1).

Moving away from this Coral Triangle, the diversity decreases eastward as islands become smaller and more isolated. A similar decrease is observed north and south towards higher latitudes and as the water temperature cools down. For example, in Tahiti, the number of reef fish species is only 740, in Easter Island it is 148 and in Norfolk, which represents the southern boundary for tropical fauna, there are only 304 species.

The result of history and geography

The underlying reason for the considerable diversity of New Caledonia's reef fishes is essentially historical. New Caledonia is part of the "Southwest Pacific Province" (KULBICKI *et al.*, 2013), which encompasses the southern Coral Sea, the southern Great Barrier Reef, Norfolk, Lord Howe, Elisabeth and Middleton reefs.



Figure 1: Distribution of the number of reef fish species according to biogeographic zones in the tropical Pacific. New Caledonia is indicated by a red circle. Adapted from KULBICKI *et al.*, 2013a

The Southwestern Province is adjacent to the central Indo-Pacific region, which includes the "Coral Triangle". The very high number of species in this region (3,160 species) and province (2,490 species) has been linked to the evolutionary history of these areas as the seawater temperature and salinity have fluctuated considerably over geological ages. This resulted in large variations of sea level and coral cover. During the Quaternary glacial episodes, the sea level was very low and there were only a few areas where corals persisted. These areas were refuges for the fauna of areas where corals had disappeared. The central Indo-Pacific region included large areas of such refuges, and except for during the coldest periods, New Caledonia was one of them.

This is how New Caledonia has accumulated a marine fauna whose diversity is exceptional but also largely shared with neighboring regions that have had a very similar evolutionary history. The reef fish fauna of New Caledonia includes a majority of species that are also found on the Great Barrier Reef to the west (about 60%), a smaller proportion (30%) coming from the Melanesian arc formed by Papua, Solomon and Vanuatu, and a few species from the south (Norfolk and Loyalty ridges) (10%). As a consequence, in New



Figure 2: Number of reef fish species for an area of 250 m² according to the type of reef. Adapted from KULBICKI *et al.*, 2013a

Caledonia, fish endemism (chap. 36) is low and it has been estimated, depending on the methods, that only 1.8% to 3.8% of the species are unique to the archipelago.

A number of geographical factors also contributed to the species richness of the New Caledonian lagoons. It has been shown, for example, that in the Indo-Pacific, the number of species is proportional to the available reef area, the size of the islands and their degree of isolation. The smaller, more isolated and reefless an island is, the fewer species it will have. Due to its large size and vast reef and lagoon areas, Grande Terre has over 1,400 species of reef fish, while the smaller Loyalty Islands have only about 800 species, although these two geographical areas are relatively close. Similarly, the Chesterfield Reefs, which are very isolated and have virtually no land, harbor only 800 reef species despite large submerged reef areas. Likewise. Polynesia, which is made up of small remote islands, has only 900 reef species, which can be related to its total land surface (4,200 km² versus 18,700 km² in New Caledonia) and its remoteness to the Coral Triangle.

Water temperature is also an important factor influencing the number of species, as reefs with warm water support more species. This temperature gradient is significant over large geographical scales, but its effects are already noticeable for Grande Terre as studies have shown that the number of reef species is higher in the north of Grande Terre than in the south. However, in New Caledonia, the specific richness and composition of reef fish populations vary mainly according to the type of reef habitat (Fig. 2).

Generally, the number of species increases from the coast to the barrier reef, a gradient which is more pronounced in areas where fringing reefs are under strong terrigenous influence, for example when they are located in large bays. Ouvéa is an exception (with very little terrestrial input), as the low number of coastal species is explained by a relatively small number of reefs along the coast. Early studies based on fish censuses carried out over restricted areas (250 m²) did not show a marked gradient in the mean number of species per sample along the north-south or east-west axes. However, more recent studies have revealed important differences

between the southern end (Isle of Pines, Walpole) and the northern end (Grand Lagon Nord) of the archipelago. In addition, it has been observed that the specific composition varies more between samples in the north than in the south, and on Grande Terre compared to the Loyalty Islands. This means that the number of species per unit area changes only moderately, but, the variability of their composition changes significantly.

Identity card of the lagoon inhabitants

The 1,800 reef fish species of New Caledonia belong to 125 families. The size of these families is very uneven, with 10 families accounting for 51% of the species and 20 families representing two-

thirds. Many families are represented by only one species (30 families) or up to five species (63 families). The families that are best represented are gobies (190 species), followed by wrasses (129 species), damselfish (Pomacentridae, 109 species) and cardinalfish (Apogonidae, 87 species). An examination of reef species' life history traits indicates that over 50% of species are less than 15 cm in maximum size, and only 9% are over 80 cm in maximum size. This type of distribution is found throughout the tropical Pacific, where the distribution of sizes is largely related to the number of species. When the species richness is high, the proportion of small species increases and, generally, the abundance of fish is higher when the number of species is high. Consequently, the proportion of large species will be higher in Polynesia or in the south of the Great Barrier Reef than in



Figure 3: Distribution of size and diet from coast to ocean. P: Piscivorous species. C: Carnivorous species. PL: Plankton feeders. HD: Herbivorous species. Adapted from KULBICKI et al., 2013b

New Caledonia. This has important management implications. Smaller species are generally less vulnerable than larger species, which means that populations in New Caledonia may be more stable and resistant (chap.38).

Reef fish diets are dominated by species that consume mobile invertebrates (40% of species). The next three most common categories are plankton feeders (19%), piscivores (15%) and omnivores (13%). Herbivores account for only 7% of species and corallivorous fish for 3.5%. These proportions are fairly similar to those in the biogeographical provinces adjacent to New Caledonia. However, the proportion of piscivores increases towards colder regions and towards small and isolated islands, with less plankton feeding and omnivorous species and more species that are less specialized in their habitat. This is likely to be related to the distribution of species sizes (the larger the species, the more likely they are to have high trophic levels) and to the proportion of generalist species, which is higher when fish species are large and when there are only a few species.

The distribution of fish life history traits also varies according to habitat, particularly between coastal and offshore habitats (Fig. 3). For example, the proportion of small species is higher on coastal reefs and conversely, the proportion of large species is higher on oceanic reefs. In terms of diet, the increase in herbivorous and plankton feeding species increases with oceanic influence, differences which appear to be related to the stability of environmental conditions. On the coast, nutrient inputs from runoff enhance primary production, which in turn increases the available level of primary resources compared to oceanic reefs.

However, this difference does not translate into more species, and may even have a tendency to translate into fewer species. In contrast, coastal reefs are exposed to very large variations in salinity, turbidity and sediment inputs which can significantly interfere with sedentary species, the most abundant on these reefs. In addition, coastal species have shorter larval durations and are more restricted geographically compared to oceanic reef species. Most reef fish species disperse during their pelagic larval phase and the larvae can remain in the ocean for several weeks.

The longer this period (pelagic larval duration, PLD) is, the more likely the species are to colonize distant reefs. Species with long PLDs tend to be generalist species (for habitat and/or food) and the proportion of generalist species increases with distance to the coast. This means that populations in sheltered areas are mainly renewed locally, which makes them more vulnerable to significant environmental changes

New Caledonia has a diversity of top quality reef fish species which provides a wide range of services to the environment and people. It provides reef fish populations with more stability, resistance and resilience to disturbance (chap. 38) and also allows for better ecological performance leading to the production of more fish. Preserving this diversity requires both the preservation of habitats and the connections between them (chap. 43).

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