

# **Fishes of North Keeling Island (Pulu Keeling National Park) and the impact of the lagoon closure**



Reef fish community on the eastern side of North Keeling Island. Photo JP Hobbs.

## **Report to Parks Australia Cocos (Keeling) Islands November 2009**

**Jean-Paul Adrian Hobbs**

School of Marine and Tropical Biology, James Cook University, Townsville QLD 4811



## **EXECUTIVE SUMMARY**

Underwater visual surveys of the fish fauna of North Keeling Island (Pulu Keeling National Park) were conducted in shallow waters (0-15 m) around the island, and in the lagoon, in July and November 2008. A total of 193 fish species from 40 families were identified. Eight of these species have not been reported on the southern atoll and represent new records for the Cocos Islands. The most speciose family recorded was Labridae (39 species), however cryptic and nocturnal families went unnoticed in the visual censuses and are better surveyed using ichthyocides and anaesthetics. The natural closure of the lagoon in 2005 has resulted in substantial habitat loss, including the local extinction of extensive seagrass beds, which have been replaced by cyanobacteria mats. The lagoon was an important fish nursery area that once teemed with life but the 2008 surveys found there was little life surviving in the closed lagoon. Bonefish and mud crabs appear to have gone locally extinct. The effect of the closure on marine invertebrates is unknown, but likely to be considerable for lagoonal species. The lagoon closure may be permanent, and if this is the case, then fishes that use lagoonal habitats as juveniles may go locally extinct in the future if they do not find alternative nursery habitat. The closure may also negatively impact on the populations of two listed species – the sculptured pipefish and the endemic buff-banded rail. Further monitoring is required to determine the long-term impacts of the closure. This lagoon closure highlights the importance of constructing species lists to determine the effect of future impacts and to evaluate the effectiveness of reserve management practices in conserving biodiversity.

## INTRODUCTION

The Cocos (Keeling) Islands are located in the tropical, eastern Indian Ocean, approximately 1000 km southwest of Java, Indonesia. The Islands are comprised of two atolls. The southern, inhabited, atoll (12°12'S, 96° 54'E) is approximately 12 km wide, and 15 km long, and has a ring of 26 islands situated around the perimeter of a central lagoon. Lying 24 km to north is the uninhabited northern atoll (96°49'E, 11°50'S). This atoll is much smaller (about 1.3 km wide and 2 km long) and contains a single island (North Keeling Island) that surrounds most of the lagoon (Cochrane, 2004).

In 1995, Pulu Keeling National Park was established to protect the unique biodiversity of the northern atoll and ensure its long-term conservation (Cochrane, 2004). The National Park includes the island, central lagoon and the marine environment within 1.5km of the shoreline (Cochrane, 2004). Within the National Park, the land and lagoon are designated as a “strict nature reserve”, which is the highest level of reserve protection in Australia. In 1996, the National Park was listed as a Ramsar wetland due to its international important ecological communities (Cochrane, 2004). The National Park is inhabited by 31 species protected under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) (Cochrane, 2004). Many of these species nest or breed on the island, including some that are listed as endangered or vulnerable (Cochrane, 2004).

The marine section of the National Park encompasses extensive coral reefs that encircle the island. Coral reefs are high diversity systems, yet little is known of species that occur on the reefs within the National Park. North Keeling Island is likely to contain a unique marine community because it lies on a biogeographic border that represents the mixing of Indian and Pacific Ocean species (Hobbs and Salmond, 2008; Hobbs et al. 2009). Lagoons are also represent important habitat and contribute substantially to the diversity of marine life that occurs on coral atolls. Although the lagoon on the southern atoll supports a diverse array of marine species (Allen and Smith-Vaniz 1994; Wells, 1994; Williams, 1994), little is known of the species that inhabit the lagoon at North Keeling Island. This lagoon is shallow (depth

1 – 2 m: Lincoln-Smith et al, 1995), covered in extensive seagrass beds (Woodroffe and McLean, 1994) and considered “an important fish nursery area”(Cochrane, 2004).

Habitat loss has been one of the main causes of extinctions and biodiversity loss in both the terrestrial and marine environment. For coral reefs, approximately 20% of the world’s reefs are already destroyed beyond repair and a further 50% are at risk of collapse (Wilkinson, 2004). Coral bleaching appears to be the major cause of recent habitat loss, with the 1998 bleaching event destroying 16% of the world’s reefs (Wilkinson, 2004). Remote reefs in the Indian Ocean were severely affected by the 1998 bleaching event (75–99% mortality of corals on many isolated reefs – Goreau et al. 2000) and these reefs have been slow to recover (Graham et al. 2006). This indicates that remote locations are not immune to the impacts of coral bleaching, but are particularly vulnerable because they have reduced resilience due to their isolation. The broadscale loss of habitat from coral bleaching events has caused dramatic decreases in fish biodiversity and local extinctions (Graham et al. 2006; Pratchett et al. 2008). Coral bleaching is predicted to increase in the Indian Ocean (Sheppard, 2003) and the associated habitat loss presents a real threat to reef fishes. To determine the effects of habitat loss and other impacts on fish biodiversity requires a baseline species list. This list provides a reference to determine if a species has gone extinct and can be used to evaluate the effectiveness of reserve management practices in preserving biodiversity.

Approximately 550 fish species have been recorded at the Cocos (Keeling) Islands with Allen and Smith-Vaniz (1994) providing a detailed list of 533 of these species. This species list is largely based on surveys done on the southern atoll and does not identify which of the species also occur on the northern atoll (i.e. within Pulu Keeling National Park). Given the high variability in species list between island locations in the region (e.g. Christmas Island versus the Cocos Islands: Allen et al. 2007; Allen and Smith-Vaniz, 1994), it cannot be assumed that all the species present on the southern atoll also occur on the northern atoll, and vice versa. Therefore, detailed surveys around North Keeling Island are required to construct a list of fish species present in Pulu Keeling National Park. A start to this list was the 15 species identified by Lincoln Smith et al (1995) during preliminary surveys at 3 sites

on the western side of North Keeling Island during November 1992. They also observed numerous other species, however these species were grouped into families or genera and no species level identification was provided. Similarly, the underwater visual surveys conducted by Parks Australia North on the western side of the island (several times since 1997), focussed on a small selection of fishes and grouped the species into families (Hobbs et al. 2005). No surveys have been conducted on the southern, eastern or northern coastlines or in the lagoon of North Keeling Island.

The aim of this study was to survey the majority of shallow water habitat 0-15m at North Keeling Island to provide a species list of fishes that occur in Pulu Keeling National Park. The lagoon at North Keeling Island has been closed to the ocean since 2005 and surveys were also conducted within the lagoon to determine what impact the closure has had on the fish community.

## **METHODS**

Underwater visual surveys were done by the author whilst snorkelling and diving around North Keeling Island on the 2<sup>nd</sup> of June and on the 12<sup>th</sup> and 13<sup>th</sup> of November, 2008. Surveys were undertaken on all four coastlines of the island (north, south, east, west) and within the lagoon. Diving surveys (to 15 m) took place at Parks Australia's ReefCheck survey site, located near "The Landing" on the western side of the island. The remainder of the island was surveyed whilst snorkelling and free-diving (to 15 m). Snorkel surveys involve closely approaching fish whilst swimming between the shoreline and the beginning of the outer reef dropoff (usually 15 m).

The names of fishes were recorded on an underwater slate only if their identity was certain. Species that could not be readily identified were photographed using an underwater camera and their identity was later confirmed using fish identification guides (Allen et al. 2007; Froese and Pauly, 2007). In addition to the visual surveys, a small number of well-known fishes were added to the species list based on communications or photographs from local

divers and fishers. No fishes were collected during the visual surveys, and therefore fishes that are most accurately identified using ichthyocides (e.g. cryptic and nocturnal species) were missed in the visual surveys (Ackerman and Bellwood, 2000).

To determine what impact the lagoon closure has had on the fish community the lagoon was surveyed by walking and wading around the perimeter and snorkelling through the middle. The results of this survey were compared with a species list that the author compiled for the lagoon based on discussions with local people (mainly Cocos-Malays) who had visited the lagoon prior to its 2005 closure.

## **RESULTS**

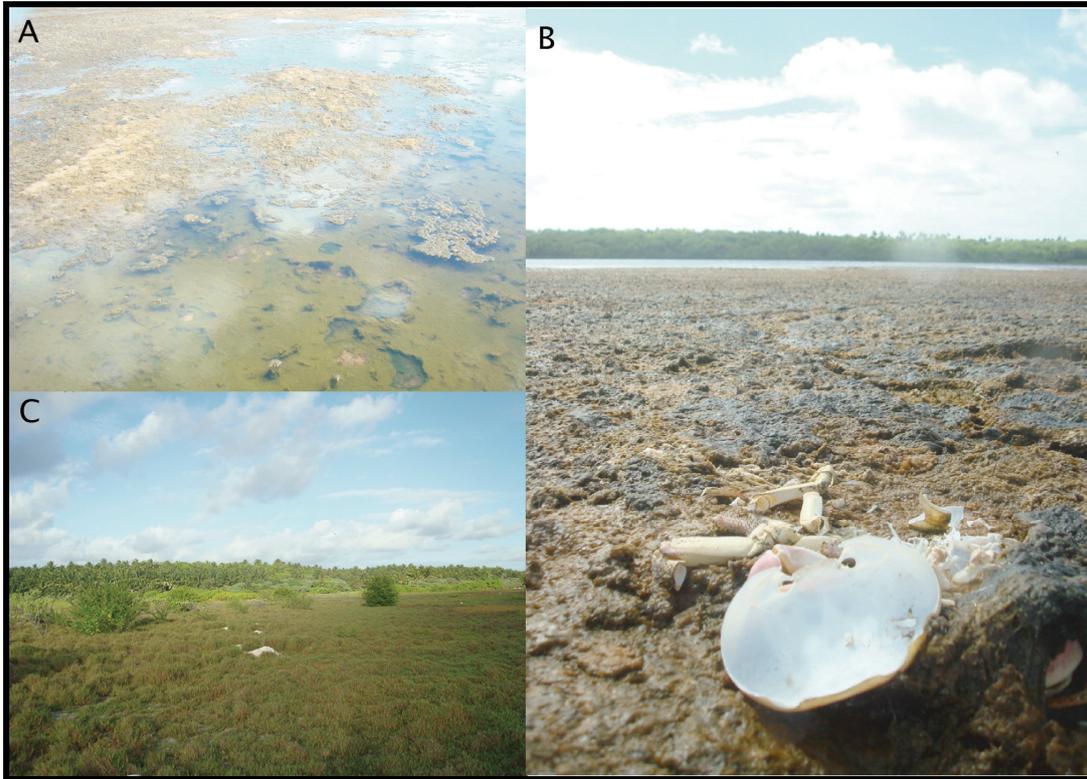
187 fish species were positively identified during visual surveys at North Keeling Island (Appendix 1). An additional 6 species were added to the species list based on previous surveys (Lincoln Smith et al, 1995), photographs and communications with local people. Therefore, a total of 193 species of fish from 40 families were recorded in Pulu Keeling National Park. This number will certainly increase with further surveys, although it is unlikely to exceed the 550 species recorded on the southern atoll (Allen and Smith-Vaniz, 1994). The majority (83.4%) of fish species recorded at North Keeling Island are widely distributed throughout the world or Indo-Pacific. However, a mixture of Pacific (10.4%) and Indian Ocean (6.2%) species were also present, and for many of these species, North Keeling Island represents the western or eastern edge (respectively) of their geographic range.

The most speciose family at North Keeling Island was Labridae (wrasses and parrotfishes = 39 species), followed by Pomacentridae (damselfishes = 20 species), Acanthuridae (surgeonfishes and unicornfishes = 20 species) and Chaetodontidae (butterflyfishes = 18 species). On the southern atoll, Labridae are also the most speciose family with Pomacentridae ranked third, Acanthuridae ranked sixth and Chaetodontidae ranked eighth (Allen and Smith-Vaniz, 1994). Species rich families from the southern atoll that were poorly represented in the North Keeling Island species list include groups that are generally

difficult to identify using visual census methods due to their cryptic or nocturnal lifestyles (e.g. Gobiidae, Apogonidae, Muraenidae, Blennidae and Holocentridae). Surprisingly, eight species (4.1% of the species list) observed in surveys at North Keeling Island have not been reported from the southern atoll and represent new records for the Cocos Islands.

The lagoon at North Keeling Island has remained closed since 2005 and the shallow entrance has now built up with sand and rubble that has been colonised by grasses and trees (Figure 1). As a consequence, the lagoon has shrunk in size and become stagnant. Underwater surveys revealed that there is a dense mat of cyanobacteria, varying in thickness from 1 to 50 cm, covering the bottom of the entire lagoon (Figure 1). Underneath the mat is a thin layer (0 – 2 cm) of black sediment that lies on top of the sand. In areas where the mat is thick, swimming and walking through the mat releases a pungent smell (like rotten eggs) that is indicative of hydrogen sulfide. Seagrass was absent throughout all the areas surveyed both inside and outside the lagoon. No animal life was observed on the surface of the sediment, but rather a profusion of small dead shells was found throughout the lagoon. The only animal life observed was an abundance of small shrimp (> 4 cm in total length) hovering in the water column above the cyanobacteria mat, and 10 – 20 large milkfish (*Chanos chanos*).

Discussions with the local people revealed that prior to the 2005 lagoon closure the lagoon was largely sandy with extensive seagrass beds. Muddier areas occurred on the northern, southern and western shores of the lagoon and were inhabited by large mud crabs (*Scylla* sp.). Some small corals lived near the lagoon entrance and green turtles (*Chelonia mydas*) often entered the lagoon to feed on seagrass. The lagoon supported at least 12 species of fish (from 10 families) including: *Albula glossodonta*, *Carcharhinus melanopterus*, *Chanos chanos*, *Crenimugil crenilabis*, *Epinephelus fuscoguttatus*, *Gerres acinaces*, *Liza vaiensis*, *Lutjanus fulvus*, *L. monostigma* and species of trevally (Carangidae), emperor (Lethrinidae) and goatfish (Mullidae). Based on these descriptions it is clear that the lagoon has undergone substantial change since its closure in 2005. Extensive seagrass beds have been replaced by cyanobacteria mats and most forms of life have now gone extinct within the lagoon.



**Figure 1:** A) The cyanobacteria mat covering the lagoon floor. B) A dead crab on top of the cyanobacteria mat. C) The closed lagoon entrance is now built up and colonised by grasses and trees.

## **DISCUSSION**

The number of fish species recorded at North Keeling Island now stands at 193. This number will certainly increase, particularly with more detailed studies of cryptic and nocturnal groups, which make up a significant proportion of the species on the southern atoll (Allen and Smith-Vaniz, 1994). Visual censuses are not suitable for detecting cryptic and nocturnal fishes and these groups are best surveyed by making collections using ichthyocides and anaesthetics (Ackerman and Bellwood, 2000, 2002). Due to its smaller size and lower range of habitats, the number of fishes at North Keeling Island is unlikely to exceed the southern atoll. Most species of fish present on the southern atoll are capable of dispersing 24 km to North Keeling Island, and therefore the fish community of North

Keeling Island is likely to be a subset of the southern atoll. Whether a species can successfully colonise North Keeling Island will largely be dependent on the availability of suitable habitat. With the closure of the lagoon, it may be difficult for lagoonal species to establish themselves.

It will not be possible to use the fish species list developed for the southern atoll (Allen and Smith-Vaniz, 1994) to determine if any species have become extinct within the Pulu Keeling National Park. This is because not all species present at the southern atoll are present at North Keeling Island. Also, some species may be present at North Keeling Island that have not been recorded on the southern atoll (e.g. the 8 new records in this study). Species lists developed for other marine taxa at the Cocos Islands have largely been based on studies of the southern atoll (Woodroffe and Berry, 1994), and species richness and composition is likely to differ between the southern and northern atolls. Therefore, to determine the effect of future impacts on North Keeling Island, and to assess the effectiveness of Pulu Keeling National Park in protecting marine biodiversity, requires the development of marine species lists specific to North Keeling Island.

Pulu Keeling National Park provides a refuge for terrestrial flora and fauna that are rare, or have become extinct, on the southern atoll largely due to habitat destruction and hunting (Cochrane, 2004). For the marine environment, the amount of habitat destruction is likely to be minimal and similar at both atolls and determined mostly by broadscale impacts (e.g. coral bleaching) rather than local impacts. Reef fishes (and all coral reef organisms) in Pulu Keeling National Park are protected from fishing and harvesting and therefore this acts as a refuge for species that have become overfished in the southern atoll. The local people rely on marine species for food and some species are heavily fished (Hender et al. 2001). If populations of fish (or other target marine species) decline, or species go extinct, then populations at North Keeling Island may replenish the southern atoll. However, species may still go extinct at the southern atoll if the amount of individuals removed by fishing is greater than the level of replenishment received from North Keeling Island, or if no population exists at North Keeling Island.

The closure of the lagoon at North Keeling Island appears to be due to the natural process of lagoon infilling. This gradual accumulation of sediment at shallow lagoon entrances has also been noted in southern atoll, and is considered a feature of coral atolls in general (see Smithers, 1994). It has been suggested that North Keeling Island was formed by the infilling of passages and the joining of a number of smaller islands (Woodroffe and McLean, 1994; Cochrane, 2004). Although the lagoon entrance has closed periodically before (Cochrane, 2004), natural reopening of the lagoon entrance this time will be difficult due to the build up of sand and rubble and the colonisation by grasses and trees that has occurred over the last three years. Elsewhere, lagoons that have been closed for some time can be reopened by storms, however these entrances soon close again (Allen and Robertson, 1996). It appears that the recent lagoon closure may be permanent.

The lagoon closure at North Keeling Island parallels that of the remote Clipperton Atoll in the eastern Pacific Ocean, and this may provide insights into the future of the North Keeling lagoon. The lagoon at Clipperton Atoll is much larger and deeper than that of North Keeling Island. Allen and Robertson (1996) summarise the history of the lagoon at Clipperton Atoll and provide a description of its aquatic life as follows. The lagoon entrances became blocked towards the end of the 1800's. In 1980, divers found the deeper waters to be lifeless and the bottom was muddy and contained hydrogen sulfide. When Allen and Robertson visited the lagoon in 1994 they found the shallow waters to be brackish and dominated by freshwater weeds with some reeds and sedges. They did not see any fish, and the only animals they saw were mid-water isopods. The description presented by Allen and Robertson (1996) matches many of the findings of this study and thus the future state of the lagoon North Keeling Island may resemble that of Clipperton Atoll.

The closure of the lagoon at North Keeling Island, and the subsequent extinction of seagrass, represents a significant loss of habitat within Pulu Keeling National Park. The lagoon represented “an important fish nursery area” and an internationally significant Ramsar wetland (Cochrane, 2004). Once the lagoon closed, the loss of seagrass and fluctuations in physical conditions (e.g. salinity, temperature and dissolved oxygen) probably killed most inhabitants. Based on the surveys it appears that seagrass, mud crabs

(*Scylla* sp) and bonefish (*Albula glossodonta*) have gone extinct. The local people who visited North Keeling lagoon prior to its closure provided detailed descriptions based on fishes that they caught in the lagoon (prior to it being declared a National Park) and other obvious organisms that they had seen in the lagoon (e.g. corals, seagrass and mud crabs). The lagoon and its seagrass habitat would have supported many small fishes and invertebrates that went unnoticed by the local people and some of these species are likely to have gone extinct. Therefore, the total number of species that have gone extinct in the National Park due to the lagoon closure is likely to be much higher. Furthermore, many adult fishes (e.g. blacktip reef sharks, mullets, emperors, trevallies, cods) encountered in the surveys on the coral reefs around North Keeling Island utilise lagoons as juveniles and these species may go extinct in the future if they can not find alternative nursery habitats.

Some species listed under the EPBC Act may be negatively affected by the lagoon closure. The sculptured pipefish (*Choeroichthys sculptus*) is a listed marine species that inhabits seagrass beds (Froese and Pauly, 2007) and is likely to be significantly affected by the extinction of seagrass. This cryptic species has been recorded from the southern atoll (Allen and Smith-Vaniz, 1994), but was not observed in the visual censuses at North Keeling Island. More detailed surveys are required to determine its status. The green turtle (*Chelonia mydas*), which is listed as vulnerable, used to feed on seagrass in North Keeling lagoon. There is an abundance of seagrass in the southern atoll and this species moves regularly between feeding (southern atoll) and breeding grounds (North Keeling Island)(Whiting et al. 2008), and therefore the lagoon closure at North Keeling Island will have little impact on this species. The buff-banded rail *Gallirallus philippensis andrewsi* is listed as endangered and is endemic to North Keeling Island. This species “frequently forages along the lagoon shore, eating crustacea, which are abundant in the seagrass deposited along the tide line” (Cochrane, 2004). The extinction of seagrass, and the presumed decline or loss of the associated crustacea, could impact considerably on the buff-banded rail population. The level of impact will depend on the rail’s ability to switch its diet and consume other food sources, and the abundance of those other foods. It is unclear what negative effects the lagoon closure will have on other terrestrial species. One positive impact of the lagoon closure is that the colonisation of the lagoon entrance by

plants and trees provides extra habitat for breeding seabirds. Several masked booby birds were already observed nesting in this area during the 2008 visit.

Pulu Keeling National Park has been designated as a strict nature reserve and Ramsar wetland to “ensure the long-term conservation of the unique biodiversity” of North Keeling Island (Cochrane, 2004). However, the natural closure of the lagoon has caused significant habitat loss and local extinctions. The loss of biodiversity may continue as species that rely on the lagoon as nursery habitats may become extinct when their adult populations die out. Listed species such as the sculptured pipefish and buff-banded rail may be also be affected by the extinction of seagrass. The lagoon closure could well become permanent and further monitoring of those species most reliant on lagoonal habitat or seagrass is required to document the full effect of this impact. While the true number of species lost by the lagoon closure will never been known, this impact highlights the importance of establishing comprehensive species list of the flora and fauna present in both the terrestrial and marine environments of Pulu Keeling National Park. Without such lists, the effects of future impacts cannot be determined, and the effectiveness of the National Park in conserving biodiversity cannot be evaluated.

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**Appendix 1:** A list of fish species occurring at North Keeling Island. The list follows the format and nomenclature used by Allen and Smith-Vaniz 1994, although the family Scaridae is now included within the Labridae, and Ptereleotridae is now classed as a family. The method of identification is given as: observed [O], photographed [P], communicated by others [C], and previously recorded by Lincoln Smith et al. 1995 [L]. The geographic distribution of listed species follows that of Allen and Smith-Vaniz, 1994 “Asterisk or numbers preceding species names indicate the following distributional data: \* = also known from Christmas Island (Allen et al. 2007); 1 = widespread Indo-Pacific or Indo-west Pacific; 2 = West Pacific species that reach their western distributional limit at Cocos (Keeling); 3 = Indian Ocean species (may include western extremity of west Pacific); 4 = Circumtropical or cosmopolitan”. Species that are new records for the Cocos Islands are listed in bold.

#### Carcharhinidae - Requiem sharks

- 1 \**Carcharhinus amblyrhynchos* (Bleeker, 1856) [O]
- 1 \**C. melanopterus* (Quoy and Gaimard, 1824) [O]

#### Mobulidae - Manta rays

- 4 \**Manta birostris* (Donndorff, 1798) [O]

#### Muraenidae - Moray eels

- 1 \**Gymnothorax pictus* (Ahl, 1789) [O]

#### Albulidae - bonefishes

- 1 *Albula glossodonta* (Forsskål, 1775) [C]

#### Chanidae - Milkfishes

- 1 *Chanos chanos* (Forsskål, 1775) [O]

#### Belonidae - Needlefishes

1 \**Tylosurus crocodilus* (Peron and LeSueur, 1821) [O]

Holocentridae - Squirrelfishes

1 \**Myripristis pralinia* Cuvier, 1829 [O]

1 \**Sargocentron diadema* (Lacepède, 1802) [O]

1 \**S. microstoma* (Günther, 1859) [O]

1 *S. spiniferum* (Forsskål, 1775) [O]

Scorpaenidae - Scorpionfishes

1 \**Pterois radiata* Cuvier, 1829 [O]

Caracanthidae - Orbicular velvetfishes

1 \**C. unipinna* (Gray, 1831) [O]

Serranidae - Sea basses

1 \**Anyperodon leucogrammicus* (Valenciennes, 1828) [L]

1 \**Cephalopholis argus* Bloch and Schneider, 1801 [O,L]

1 \****C. miniata* (Forsskål, 1775) new record** [O]

1 *Epinephelus fuscoguttatus* (Forsskål, 1775) [O,L]

1 \**E. hexagonatus* (Bloch and Schneider, 1801) [O]

1 \**E. merra* Bloch, 1793 [O]

1 \**E. spilotoceps* Schultz, 1953 [O]

1 \**E. tauvina* ((Forsskål, 1775) [O]

1 \**Gracila albomarginata* (Fowler and Bean, 1930) [O,L]

1 \**Grammistes sexlineatus* (Thunberg, 1792) [O]

3 \**Pseudanthias evansi* Smith, 1954 [O]

2 \**P. smithvanizi* (Randall and Lubbock, 1981) [O]

1 \**Variola louti* (Forsskål, 1775) [O,L]

Kuhliidae - Flagtails

1 \**Kuhlia mugil* (Bloch and Schneider, 1801) [O]

Apogonidae - Cardinalfishes

1 \**Apogon taeniophorus* Regan, 1908 [O]

Carangidae - Trevallies

1 \**Carangoides ferdau* (Forsskål, 1775) [O]

1 \**C. orthogrammus* (Jordan and Gilbert, 1882) [O]

1 \**Caranx ignobilis* (Forsskål, 1775) [O]

4 \**C. lugubris* Poey, 1860 [P]

1 \**C. melampygus* Cuvier, 1833 [O]

4 \**Decapterus macarellus* (Cuvier, 1833) [O]

4 \**Elagatis bipinnulatus* (Quoy and Gaimard, 1825) [C]

1 \**Trachinotus bailloni* (Lacepède, 1801) [O]

1 *T. blochii* (Lacepède, 1801) [O]

Lutjanidae - Snappers

1 \**Aphareus furca* (Lacepède, 1801) [O,L]

1 \**Aprion virescens* Valenciennes, 1830 [O,L]

1 \**Lutjanus bohar* (Forsskål, 1775) [O,L]

1 \**L. fulvus* (Bloch and Schneider, 1801) [O,L]

1 \**L. gibbus* (Forsskål, 1775) [O,L]

1 \**L. monostigma* (Cuvier, 1828) [O,L]

1 \****L. rivulatus* (Cuvier, 1828)** new record [O]

1 \**Macolor niger* (Forsskål, 1775) [O]

Caesionidae - Fusiliers

1 \****Caesio lunaris* Cuvier, 1830** new record [O]

1 \**C. teres* Seale, 1906 [O]

1 \**Pterocaesio tile* (Cuvier, 1830) [O]

Lethrinidae - Emperors

- 1 \**Gnathodentex aurolineatus* (Lacepède, 1801) [O,L]
- 2 *Lethrinus atkinsoni* Seale, 1909 [O]
- 1 *L. obsoletus* (Forsskål, 1775) [O]
- 1 *L. xanthochilus* Klunzinger, 1870 [O]
- 1 \**Monotaxis grandoculis* (Forsskål, 1775) [O,L]

Gerreidae - Mojarras

- 1 *Gerres acinaces* Bleeker, 1854 [C]

Mullidae - Goatfishes

- 1 \**Mulloidichthys flavolineatus* (Lacepède, 1801) [O]
- 1 \**M. vanicolensis* (Valenciennes, 1831) [O]
- 1 \**Parupeneus trifasciatus* (Lacepède, 1801) [O]
- 1 \**P. cyclostomus* (Lacepède, 1801) [O]
- 1 \**P. macronemus* (Lacepède, 1801) [O]

Kyphosidae - Rudderfishes

- 1 \**Kyphosus vaigiensis* (Quoy and Gaimard, 1825) [O,L]

Pempheridae - Sweepers

- 1 \**Pempheris oualensis* Cuvier, 1831 [O]

Chaetodontidae - Butterflyfishes

- 1 \**Chaetodon auriga* (Forsskål, 1775) [O]
- 1 \**C. citrinellus* Cuvier, 1831 [O]
- 3 \**C. decussatus* Cuvier, 1929      **new record** [O]
- 1 \**C. ephippium* Cuvier, 1831 [O]
- 3 \**C. guttatissimus* Bennett, 1831 [O]
- 1 \**C. lineolatus* Cuvier, 1830 [P]
- 1 \**C. lunula* (Lacepède, 1801) [O]

1	* <i>C. melannotus</i> Bloch and Schneider, 1801	[O]
1	* <i>C. meyeri</i> Bloch and Schneider, 1801	[O]
1	* <i>C. ornatissimus</i> Cuvier, 1831	[O]
1	* <i>C. trifascialis</i> Quoy and Gaimard, 1824	[O]
1	* <i>C. trifasciatus</i> Park, 1797	[O]
2	<i>C. ulietensis</i> Cuvier, 1831	[O]
1	* <i>C. unimaculatus</i> Bloch, 1787	[O]
1	* <i>Forcipiger flavissimus</i> Jordan and McGregor, 1898	[O]
2	* <i>Hemitaurichthys polylepis</i> (Bleeker, 1857)	[O]
1	* <i>Heniochus chrysostomus</i> Cuvier, 1831	[O]
1	* <i>H. monoceros</i> Cuvier, 1831	[O]

#### Pomacanthidae - Angelfishes

1	* <i>Apolemichthys trimaculatus</i> (Lacepède, 1831)	[O]
1	* <i>Centropyge flavissimus</i> (Cuvier, 1831)	[O]
3	* <i>C. joculator</i> Smith-Vaniz and Randall, 1974	[O]
2	<i>Paracentropyge multifasciatus</i> (Smith and Radcliffe, 1911)	[O]
1	* <i>Pomacanthus imperator</i> (Bloch, 1787)	[O]
1	* <b><i>Pygoplites diacanthus</i> (Boddaert, 1772)</b> <b>new record</b>	<b>[O]</b>

#### Pomacentridae - Damsel fishes

1	* <i>Abudefduf notatus</i> (Day, 1869)	[O]
1	* <i>A. septemfasciatus</i> (Cuvier, 1830)	[O]
1	* <i>A. sordidus</i> (Forsskål, 1775)	[O]
1	* <i>A. vaigiensis</i> (Quoy and Gaimard, 1825)	[O]
1	* <i>Amphiprion clarkii</i> (Bennett, 1830)	[O]
2	* <i>Chromis margaritifer</i> Fowler, 1946	[O]
3	* <i>C. nigrura</i> Smith, 1960	[O]
3	* <i>C. opercularis</i> (Günther, 1867)	[O]
1	* <i>C. ternatensis</i> (Bleeker, 1856)	[O]
1	* <i>Chrysiptera glauca</i> (Cuvier, 1830)	[O]

1 <i>Dascyllus aruanus</i> (Linnaeus, 1758)	[O]
1 * <i>D. trimaculatus</i> (Rüppell, 1828)	[O]
1 * <i>Plectroglyphidodon dickii</i> (Liénard, 1839)	[O]
1 * <i>P. imparipennis</i> (Vallant and Sauvage, 1875)	[O]
1 * <i>P. johnstonianus</i> Fowler and Ball, 1924	[O]
1 * <i>P. lacrymatus</i> (Quoy and Gaimard, 1825)	[O]
1 * <i>P. phoenixensis</i> (Schultz, 1943)	[O]
1 * <i>Stegastes albifasciatus</i> (Schlegel and Müller, 1839)	[O]
1 * <i>S. fasciolatus</i> (Ogilby, 1889)	[O]
1 <i>S. nigricans</i> (Lacepède, 1802)	[O]

#### Cirrhitidae - Hawkfishes

1 * <i>Paracirrhites arcatus</i> (Cuvier, 1829)	[O]
1 * <i>P. forsteri</i> (Schneider, 1801)	[O]
2 * <i>P. hemistictus</i> (Günther, 1874)	[O]

#### Mugilidae - Mulletts

1 * <i>Crenimugil crenilabis</i> (Forsskål, 1775)	[O]
1 <i>Liza vaigiensis</i> (Quoy and Gaimard, 1824)	[C]

#### Sphyraenidae - Barracudas

4 * <i>Sphyraena barracuda</i> (Walbaum, 1792)	[O,L]
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#### Labridae – Wrasses and Parrotfishes

1 * <i>Anampses caeruleopunctatus</i> Rüppell, 1829	[O]
1 * <i>A. meleagrides</i> Valenciennes, 1840	[O]
1 * <i>A. twistii</i> Bleeker, 1856	[O]
1 * <i>Bodianus anthioides</i> (Bennett, 1830)	[O]
1 * <i>B. axillaris</i> (Bennett, 1831)	[O]
1 * <i>Cheilinus trilobatus</i> Lacepède, 1801	[O]
1 * <i>C. undulatus</i> Rüppell, 1835	[O]

1	* <i>Cheilio inermis</i> (Forsskål, 1775)	[O]
1	* <i>Chlorurus sordidus</i> Forsskål, 1775	[O]
3	<i>C. strongylocephalus</i> Bleeker, 1854	[O]
1	* <i>Coris aygula</i> Lacepède, 1801	[O]
1	* <i>C. gaimard</i> (Quoy and Gaimard, 1824)	[O]
2	* <i>Gomphosus varius</i> Lacepède, 1801	[O]
1	* <i>Halichoeres hortulanus</i> (Lacepède, 1801)	[O]
2	* <i>H. margaritaceus</i> (Valenciennes, 1839)	[O]
1	* <i>H. marginatus</i> Rüppell, 1835	[O]
2	* <i>H. ornatissimus</i> (Garrett, 1863)	[O]
2	* <i>H. trimaculatus</i> (Quoy and Gaimard, 1834)	[O]
1	* <i>Hemigymnus fasciatus</i> (Bloch, 1792)	[O]
<b>3</b>	<b><i>Hipposcarus harid</i> (Forsskål, 1775)    new record</b>	<b>[O]</b>
<b>1</b>	<b>*<i>Hologymnosus annulatus</i> (Lacepède, 1801)    new record</b>	<b>[O]</b>
1	* <i>Labroides bicolor</i> Fowler and Bean, 1928	[O]
1	* <i>L. dimidiatus</i> (Valenciennes, 1839)	[O]
1	* <i>Labrichthys unilineatus</i> (Guichenot, 1847)	[O]
2	<i>Macropharyngodon meleagris</i> (Valenciennes, 1839)	[O]
1	* <i>Novaculichthys taeniourus</i> (Lacepède, 1801)	[O]
2	* <i>Oxycheilinus unifasciatus</i> (Streets, 1877)	[O]
1	* <i>Pseudocheilinus hexataenia</i> (Bleeker, 1857)	[O]
2	* <i>Scarus forsteni</i> (Bleeker, 1861)	[O]
1	<i>S. globiceps</i> Valenciennes, 1840	[O]
1	* <i>S. rubroviolaceus</i> Bleeker, 1847	[O]
2	* <i>Stethojulis bandanensis</i> (Bleeker, 1851)	[O]
1	* <i>Thalassoma amblycephalum</i> (Bleeker, 1856)	[O]
1	* <i>T. hardwicke</i> (Bennett, 1828)	[O]
1	* <i>T. janseni</i> (Bleeker, 1856)	[O]
1	* <i>T. lutescens</i> (Lay and Bennett, 1839)	[O]
1	* <i>T. purpureum</i> (Forsskål, 1775)	[O]
1	* <i>T. quinquevittatum</i> (Lay and Bennett, 1839)	[O]

1 \**T. trilobatum* (Lacepède, 1801) [O]

Pinguipedidae - Sandperches

1 \**Parapercis clathrata* Ogilby, 1911 [O]

1 *P. hexophthalma* (Cuvier, 1829) [O]

Ptereleotridae - Dartfishes

1 \**Ptereleotris evides* (Jordan and Hubbs, 1925) [O]

Acanthuridae – Surgeonfishes and Unicornfishes

1 \**Acanthurus blochii* Valenciennes, 1835 [O]

2 \**A. guttatus* Bloch and Schneider, 1801 [O]

3 \**A. leucosternon* Bennett, 1832 [O]

1 \**A. lineatus* (Linnaeus, 1758) [O]

2 \**A. nigricans* (Linnaeus, 1758) [O]

1 \**A. nigricauda* Duncker and Mohr, 1929 [O]

1 \**A. nigrofuscus* (Forsskål, 1775) [O]

2 \**A. olivaceus* Bloch and Schneider, 1801 [O]

1 \**A. thompsoni* (Fowler, 1923) [O]

1 \**A. triostegus* (Linnaeus, 1758) [O]

1 \**A. xanthopterus* Valenciennes, 1835 [O]

1 \**Ctenochaetus striatus* (Quoy and Gaimard, 1825) [O]

3 \**C. truncatus* Randall & Clements, 2001 [O]

1 ***Naso annulatus* (Quay and Gaimard, 1825) new record** [O]

3 \**N. elegans* (Rüppell, 1829) [O]

1 \**N. hexacanthus* (Bleeker, 1855) [O]

2 \**N. lituratus* (Bloch and Schneider, 1801) [O]

1 \**N. unicornis* (Forsskål, 1775) [O]

3 \**Zebrasoma desjardini* (Bennett, 1835) [O]

1 \**Z. scopas* (Cuvier, 1829) [O]

Zanclidae - Moorish Idols

1 \**Zanclus cornutus* (Linnaeus, 1758) [O]

Siganidae - Rabbitfishes

1 *Siganus argenteus* (Quoy and Gaimard, 1825) [O]

Scombridae - Tunas

4 \**Acanthocybium solandri* (Cuvier, 1831) [P]

1 \**Gymnosarda unicolor* (Rüppell, 1836) [P,L]

4 \**Thunnus albacares* (Bonnaterre, 1788) [P]

Bothidae - Flounders

1 \**Bothus mancus* (Broussonet, 1782) [O]

Balistidae - Triggerfishes

1 \**Balistapus undulatus* (Park, 1797) [O]

1 \**Balistoides viridescens* (Bloch and Schneider, 1801) [O]

1 \**Melichthys indicus* Randall and Klausewitz, 1973 [O]

4 \**M. niger* (Bloch, 1786) [O]

1 \**M. vidua* (Solander, 1844) [O]

1 *Rhinecanthus aculeatus* (Linnaeus, 1758) [O]

1 \**R. rectangulus* (Bloch and Schneider, 1801) [O]

1 \**Sufflamen bursa* (Bloch and Schneider, 1801) [O]

1 \**S. chrysopterus* (Bloch and Schneider, 1801) [O]

Monacanthidae - Leatherjackets

4 \**Aluterus scriptus* (Osbeck, 1765) [O]

1 \**Cantherines dumerilii* (Hollard, 1854) [O]

Ostraciontidae - Boxfishes

1 \**Ostracion cubicus* Linnaeus, 1758 [O]

Tetraodontidae - Puffers

1 \**Canthigaster amboinensis* (Bleeker, 1865) [O]

Diodontidae - Porcupinefishes

4 \**Diodon hystrix* Linnaeus, 1758 [O]