

The sustainability of Aldabra’s subsistence fishing

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Summary

*It is at the core of SIF’s mission to ensure the protection of Aldabra’s marine life. Using historic landing data from the Aldabra subsistence fishery and previously published species level extinction risk information, I identified five species whose local populations are at very high risk of decline even from low levels of fishing pressure. These species were characterised by both a very high vulnerability (potentially large declines caused by fishing) and a very low resilience (slow population recoveries). Specifically fishing of the camouflage grouper (*Epinephelus polyphkadion*), the potato grouper (*Epinephelus tukula*), the blacksaddled coral grouper (*Plectropomus laevis*), the roving coral grouper (*Plectropomus pessuliferus*), and the giant grouper (*Epinephelus lanceolatus*) is best avoided, and individuals should be released upon capture. Furthermore, I identified a set of another 8 species whose populations do not warrant full protection, but should be closely monitored for signs of decline. Limiting the landings of species at high risk is not likely to substantially affect the obtention of high quality protein for Aldabra staff, but requires small modifications to the current fishing practices. The most important one being the avoidance of deep water fishing, where barotrauma induced mortality is likely and fisheries independent monitoring is not feasible.*

Introduction

Subsistence fishing is the main source of protein for the SIF staff posted at Aldabra. This activity, not only highlights the nourishing nature of the reefs, but is also a key component in the life of Aldabra’s residents that bonds together the science and logistics team and embodies the intimate relationship that exists between Seychellois and the ocean. Nevertheless, given Aldabra’s conservation status, the possible impacts on the ecosystem of any kind of extractive activity requires careful and science-informed consideration. Ensuring the conservation of Aldabra’s marine life, which is at the core of SIF’s mission, should be given top priority.

Fishing in Aldabra is strictly allowed only for sustenance of the staff posted in the station. Currently, fishing is performed opportunistically and, with the exception of sharks, it is indiscriminated over the set of species available for catch. Nevertheless, ample evidence suggest that the populations of some coral reef fish species are at jeopardy even by low levels of fishing pressure (Cheung, Pitcher, and Pauly 2005). The direct effect of fishing on these species is characterised by a rapid population decline and particularly slow recoveries (Graham 2003). Moreover, the population decline of these species has been shown to also have important indirect effects on the structure of the fish communities as a whole and the functioning of the wider coral reef ecosystem (Dulvy, Freckleton, and Polunin 2004; Allgeier et al. 2015).

Ensuring healthy and diverse marine communities within the protected area is a central duty of SIF. However, Aldabra’s status as an UNESCO World Heritage site means that its responsibility is not limited to the management of local fish populations. Instead, Aldabra’s potential to play an important role in the recovery of species that have been decimated elsewhere, should also be reflected in Aldabra’s management policies. The Red List of the International Union for Conservation of Nature (IUCN) identifies a set of species that are considered to be facing a high risk of extinction in the wild due to either small populations, large population declines, or limited geographic ranges. Despite known limitations of the IUCN red list (Possingham et al. 2002), even if Aldabra’s local populations of threatened species are healthy, preventing their catch maximises the potential for larval export and the recovery of these species elsewhere (Harrison et al. 2012). What is more, limiting the capture of threatened species is consistent with SIF’s tradition being a regional example of conservation practices and of developing and implementing leading management practices.

Here, I use historic catch data of the Aldabra subsistence fishery and combine it with previously published species level information to identify a subset of species for which firm and actively enforced restrictions are strongly recommended. Species were included in this subset either because there is strong evidence that supports highly detrimental effects of fishing on local populations, or because of its global conservation status. Furthermore, I also identify species for which the effects of subsistence fishing should be closely monitored—through catch per unit effort, baited remote underwater video systems, and underwater fish surveys—in order to respond rapidly should declining trends be identified.

Vulnerability + resilience

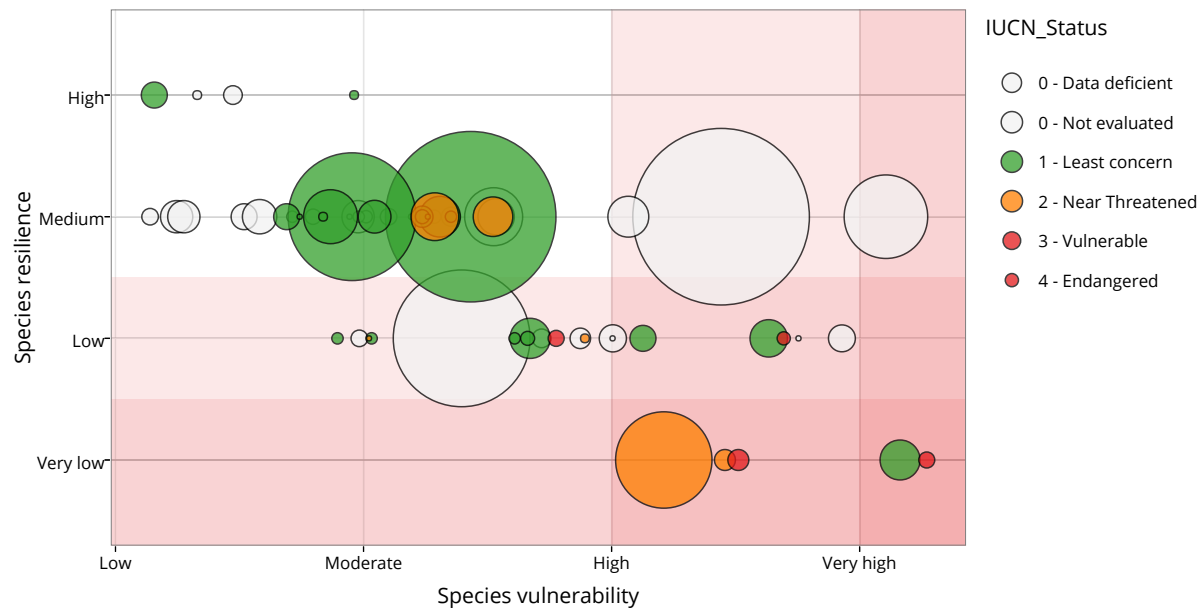
Intuitively, the effect of exploitation on a species is determined by two overarching factors: vulnerability and resilience. On one hand vulnerability is a reflection of the inherent sensitivity of a species’ population to exploitation (Cheung, Pitcher, and Pauly 2005). This is, for a fixed level of fishing pressure, the abundance of a highly vulnerable species is more rapidly and acutely affected than the abundance of a non-vulnerable species. However, a potential population decline due to fishing is just half of the story. Resilience, on the other hand, is a reflection of a species’ inherent ability to recover from disturbances (Musick 1999). This is, highly resilient species will bounce back more quickly after fishing pressure has been removed, or decreased, than species with low resilience.

In temperate fisheries, proxies for the effects of exploitation on a species are usually determined using vast data sets and sophisticated models (Graham 2003). Despite the need for improved management on diverse—and highly complex—tropical marine ecosystems, the required levels of information for a similar approach, or the time required for its collection, are not available (Reynolds, Jennings, and Dulvy 2001). Fortunately, it has been previously shown that both vulnerability and resilience are, at least partially, determined by life history parameters and ecological characteristics (Graham et al. 2011). This is because ultimately these parameters govern a species maximum rate of population growth and the strength of density dependence (Cheung, Pitcher, and Pauly 2005).

I compiled previously published estimates of resilience (Musick 1999) and vulnerability (Cheung, Pitcher, and Pauly 2005) for all species historically caught in the Aldabra subsistence fishing. For each species, these two proxies were calculated based, when available, on a diverse array of life history parameters. Parameters included (i) the intrinsic rate of population growth (which is directly related to the maximum sustainable yield) (ii) the growth coefficient, (iii) fecundity, (iv) maximum age, (v) age at first maturity, (vi) maximum length, (vii) the extent of the geographic range, (viii) the spatial behaviour, and (ix) whether the species aggregates for feeding or spawning. The paucity of life history data for several coral reef fish species implies that estimates of resilience and vulnerability are surrounded by large uncertainties. Nevertheless, these proxies have been previously shown to accurately predict population trends in several tropical fisheries (Cheung, Pitcher, and Pauly 2005).

By N° individuals	By biomass (kg)
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For each species area of the circle indicates the number of individuals caught in Aldabra to the date of this report. Species were classified in four categories of resilience suggested by the American Fisheries Society—see FishBase description (<http://www.fishbase.us/manual/English/Key%20Facts.htm#resilience>) and Musick (1999) for details. Vulnerability was quantified in an arbitrary scale from 0 to 100 using a fuzzy logic expert system (Cheung, Pitcher, and Pauly 2005). Values from 0-20 correspond to very low vulnerability, from 20-40 low to moderate, 40-60 moderate to high, 60-80 high to very high, and 80-100 to very high vulnerability.



Identifying species at risk

Compiling species parameters enable us to construct risk profiles for Aldabra's fish species. In particular, it is possible to observe the emergence of an evident risk zone in which species are imperiled by the compound effects of *both* a rapid population decline and a very slow recovery. I classified the species into five particular categories of risk—which correspond to the shades of red in the upper figure. Although the particular thresholds used in this classification are somewhat arbitrary they are in strong agreement with escalating levels of diminished resilience and increased vulnerability. Specifically, the categories are:

- 4 - Very high risk: A species is at very high risk if it has both a very low resilience *and* a very high vulnerability (>80).
- 3 - High risk: A species is at high risk if it has a low resilience and a very high vulnerability (>80) *or* a high vulnerability (>60 and <80) and a very low resilience.
- 2 - Moderate risk: A species is at moderate risk if it does not qualify as high or very high risk and has either a very low resilience *or* a very high vulnerability (>80), or a low resilience and high vulnerability (>60 and <80).
- 1 - Follow up: A species deserves follow up if it does not qualify as within the moderate, high or very high risk categories and has either low resilience or high vulnerability (>60 and <80).
- 0 - Low risk: A species is at low risk if it does not qualify into any other category

Out of the 63 fish species that have been historically caught in Aldabra, I identified two species that satisfy the criterion established for very high risk, and therefore justify a total ban on their landings. Specifically the potato grouper (*Epinephelus tukula*), and the giant grouper (*Epinephelus lanceolatus*). In addition, I identified three species at high risk, namely the camouflage grouper (*Epinephelus polyphekadion*) blacksaddled coralgroupers (*Plectropomus laevis*) and the roving coralgroupers (*Plectropomus pessuliferus*).

The consideration of fishing restrictions for species within the very high risk, and perhaps the high risk categories is fully justified based on theoretical and empirical evidence collected in other tropical coral reef fisheries (Graham et al. 2011). Restrictions on a second group of species—those at moderate risk—is however not fully justified under current evidence. Nevertheless, the status of these 8 warrant frequent reassessment based on both fisheries dependent and independent monitoring.

An alternative quantification of risk (Qr), free of arbitrary category thresholds is also presented. For each species, this metric corresponds to the mean of the percent ranks for vulnerability and resilience. Values close to 1 represent a high relative risk while values close to 0 represent a low relative risk.

Show **70** entries

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Aldabra species' risk classification. For more information click on the species scientific name or the IUCN assesment code.

Qr	Risk	Common_Name	Scientific_Name	Resl	Vuln	IUCN
0.97	4 - Very high	Giant grouper	Epinephelus lanceolatus	Very low	85.41	VU
0.96	4 - Very high	Potato grouper	Epinephelus tukula	Very low	83.26	LC
0.91	3 - High	Blacksaddled coralgroupers	Plectropomus laevis	Very low	70.22	VU

0.9	3 - High	Roving coral grouper	<u><i>Plectropomus pessuliferus</i></u> (http://www.fishbase.org/summary/7430)	Very low	69.14	NT (http://www.iucnredlist.org/details/132775/0)
0.89	3 - High	Camouflage grouper	<u><i>Epinephelus polyphekadion</i></u> (http://www.fishbase.org/summary/6473)	Very low	64.21	NT (http://www.iucnredlist.org/details/61339/0)
0.79	2 - Moderate	Great barracuda	<u><i>Sphyraena barracuda</i></u> (http://www.fishbase.org/summary/1235)	Low	78.57	N.E.
0.78	2 - Moderate	Pickhandle barracuda	<u><i>Sphyraena jello</i></u> (http://www.fishbase.org/summary/4827)	Low	75.07	N.E.
0.77	2 - Moderate	Humphead wrasse	<u><i>Cheilinus undulatus</i></u> (http://www.fishbase.org/summary/5604)	Low	73.88	EN (http://www.iucnredlist.org/details/4592/0)
0.77	2 - Moderate	Dogtooth tuna	<u><i>Gymnosarda unicolor</i></u> (http://www.fishbase.org/summary/106)	Low	72.67	LC (http://www.iucnredlist.org/details/170342/0)
0.73	2 - Moderate	Coral hind	<u><i>Cephalopholis miniata</i></u> (http://www.fishbase.org/summary/6450)	Low	62.53	LC (http://www.iucnredlist.org/details/132732/0)
0.71	2 - Moderate	Marbled coral grouper	<u><i>Plectropomus punctatus</i></u> (http://www.fishbase.org/summary/7373)	Low	60.1	DD (http://www.iucnredlist.org/details/132801/0)
0.7	2 - Moderate	Black jack	<u><i>Caranx lugubris</i></u> (http://www.fishbase.org/summary/1936)	Low	60.08	N.E.
0.69	1 - Follow up	Yellowfin hind	<u><i>Cephalopholis hemistiktos</i></u> (http://www.fishbase.org/summary/6447)	Low	57.85	NT (http://www.iucnredlist.org/details/132759/0)
0.69	1 - Follow up	Yellowlip emperor	<u><i>Lethrinus xanthurus</i></u> (http://www.fishbase.org/summary/1852)	Low	57.48	N.E.
0.68	1 - Follow up	Bigeye tuna	<u><i>Thunnus obesus</i></u> (http://www.fishbase.org/summary/146)	Low	55.53	VU (http://www.iucnredlist.org/details/21859/0)
0.67	1 - Follow up	Titan triggerfish	<u><i>Balistoides viridescens</i></u> (http://www.fishbase.org/summary/6026)	Low	54.36	N.E.
0.66	1 - Follow up	Blacktip grouper	<u><i>Epinephelus fasciatus</i></u> (http://www.fishbase.org/summary/5348)	Low	53.43	LC (http://www.iucnredlist.org/details/132817/0)
0.65	1 - Follow up	Redaxil emperor	<u><i>Lethrinus conchyliaius</i></u> (http://www.fishbase.org/summary/1868)	Low	53.23	LC (http://www.iucnredlist.org/details/155118/0)
0.65	1 - Follow up	Slender grouper	<u><i>Anypopodon leucogrammicus</i></u> (http://www.fishbase.org/summary/4922)	Low	52.18	LC (http://www.iucnredlist.org/details/132787/0)
0.6	1 - Follow up	Spangled emperor	<u><i>Lethrinus nebulosus</i></u> (http://www.fishbase.org/summary/1846)	Low	47.91	N.E.
0.52	2 - Moderate	Giant trevally	<u><i>Caranx ignobilis</i></u> (http://www.fishbase.org/summary/1895)	Medium	82.12	N.E.
0.5	1 - Follow up	Indo-Pacific sailfish	<u><i>Istiophorus platypterus</i></u> (http://www.fishbase.org/summary/77)	Low	40.65	LC (http://www.iucnredlist.org/details/170338/0)
0.49	1 - Follow up	Malabar grouper	<u><i>Epinephelus malabaricus</i></u> (http://www.fishbase.org/summary/6439)	Low	40.44	NT (http://www.iucnredlist.org/details/61338/0)
0.48	1 - Follow up	Longface emperor	<u><i>Lethrinus olivaceus</i></u> (http://www.fishbase.org/summary/1864)	Low	39.66	N.E.
0.46	1 - Follow up	Two-spot red snapper	<u><i>Lutjanus bohar</i></u> (http://www.fishbase.org/summary/1417)	Medium	68.83	N.E.
0.44	1 - Follow up	Green jobfish	<u><i>Aprion virescens</i></u> (http://www.fishbase.org/summary/84)	Medium	61.35	N.E.
0.43	1 - Follow up	Brownspotted grouper	<u><i>Epinephelus chlorostigma</i></u> (http://www.fishbase.org/summary/5524)	Low	37.9	LC (http://www.iucnredlist.org/details/132823/0)
0.35	0 - Low	Rainbow runner	<u><i>Elagatis bipinnulata</i></u> (http://www.fishbase.org/summary/412)	Medium	50.69	N.E.
0.35	0 - Low	Bluefin trevally	<u><i>Caranx melampygus</i></u> (http://www.fishbase.org/summary/1906)	Medium	50.49	N.E.

0.34	0 - Low	Brown-marbled grouper	<u>Epinephelus fuscoguttatus</u>	Medium	50.44	NT (http://www.iucnredlist.org/details/44673/0)
0.33	0 - Low	Yellow-edged lyretail	<u>Variola louti</u>	Medium	48.64	LC (http://www.iucnredlist.org/details/132738/0)
0.31	0 - Low	Redmouth grouper	<u>Aethaloperca rogaa</u>	Medium	47.05	DD (http://www.iucnredlist.org/details/132814/0)
0.31	0 - Low	Peacock hind	<u>Cephalopholis argus</u>	Medium	47.05	LC (http://www.iucnredlist.org/details/132781/0)
0.3	0 - Low	Wahoo	<u>Acanthocybium solandri</u>	Medium	46.16	LC (http://www.iucnredlist.org/details/170331/0)
0.29	0 - Low	Yellowfin tuna	<u>Thunnus albacares</u>	Medium	45.75	NT (http://www.iucnredlist.org/details/21857/0)
0.28	0 - Low	Smalltooth emperor	<u>Lethrinus microdon</u>	Medium	45.71	N.E.
0.27	0 - Low	Bigeye trevally	<u>Caranx sexfasciatus</u>	Medium	45.19	LC (http://www.iucnredlist.org/details/155130/0)
0.26	0 - Low	Tomato hind	<u>Cephalopholis sonnerati</u>	Medium	44.74	LC (http://www.iucnredlist.org/details/132757/0)
0.26	0 - Low	Tomato hind	<u>Cephalopholis sonnerati</u>	Medium	44.74	LC (http://www.iucnredlist.org/details/132757/0)
0.25	0 - Low	Black marlin	<u>Istiompax indica</u>	Medium	43.85	DD (http://www.iucnredlist.org/details/170312/0)
0.24	0 - Low	Humpnose big-eye bream	<u>Monotaxis grandoculis</u>	Medium	43.83	N.E.
0.23	0 - Low	Blubberlip snapper	<u>Lutjanus rivulatus</u>	Medium	42.02	N.E.
0.23	0 - Low	Snubnose grouper	<u>Epinephelus macrospilos</u>	Medium	40.89	LC (http://www.iucnredlist.org/details/132766/0)
0.2	0 - Low	Common bluestripe snapper	<u>Lutjanus kasmira</u>	Medium	40.21	N.E.
0.19	0 - Low	One-spot snapper	<u>Lutjanus monostigma</u>	Medium	39.61	N.E.
0.18	0 - Low	Spotcheek emperor	<u>Lethrinus rubrioperculatus</u>	Medium	39.56	N.E.
0.16	0 - Low	White-blotched grouper	<u>Epinephelus multinotatus</u>	Medium	39.07	LC (http://www.iucnredlist.org/details/132740/0)
0.15	0 - Low	Sabre squirrelfish	<u>Sargocentron spiniferum</u>	Medium	38.87	N.E.
0.14	0 - Low	Common dolphinfish	<u>Coryphaena hippurus</u>	High	39.24	LC (http://www.iucnredlist.org/details/154712/0)
0.14	0 - Low	Kawakawa	<u>Euthynnus affinis</u>	Medium	37.34	LC (http://www.iucnredlist.org/details/170336/0)
0.13	0 - Low	Skipjack tuna	<u>Katsuwonus pelamis</u>	Medium	36.74	LC (http://www.iucnredlist.org/details/170310/0)
0.12	0 - Low	Small toothed jobfish	<u>Aphareus furca</u>	Medium	35.93	N.E.
0.11	0 - Low	Masked triggerfish	<u>Sufflamen fraenatum</u>	Medium	34.85	LC (http://www.iucnredlist.org/details/154721/0)
0.1	0 - Low	Dory snapper	<u>Lutjanus fulvivlamma</u>	Medium	34.26	N.E.
0.1	0 - Low	Foursaddle grouper	<u>Epinephelus spilotoceps</u>	Medium	33.8	LC (http://www.iucnredlist.org/details/132747/0)

0.09	0 - Low	Humpback red snapper	Lutjanus gibbus (http://www.fishbase.org/summary/265)	Medium	31.62	N.E.
0.08	0 - Low	Blackfin grouper	Cephalopholis nigripinnis (http://www.fishbase.org/summary/66482)	Medium	30.37	DD (http://www.iucnredlist.org/details/132786/0)
0.06	0 - Low	Slender emperor	Lethrinus variegatus (http://www.fishbase.org/summary/1850)	Medium	25.51	N.E.
0.05	0 - Low	Pink ear emperor	Lethrinus lentjan (http://www.fishbase.org/summary/1863)	Medium	24.93	N.E.
0.04	0 - Low	Yellowmargin triggerfish	Pseudobalistes flavimarginatus (http://www.fishbase.org/summary/6027)	High	29.47	N.E.
0.03	0 - Low	Bengal snapper	Lutjanus bengalensis (http://www.fishbase.org/summary/1409)	High	26.59	N.E.
0.03	0 - Low	Snubnose emperor	Lethrinus borbonicus (http://www.fishbase.org/summary/1844)	Medium	22.79	N.E.
0.01	0 - Low	Honeycomb grouper	Epinephelus merra (http://www.fishbase.org/summary/4923)	High	23.13	LC (http://www.iucnredlist.org/details/132788/0)

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Implications

The species identified as at very high risk represent only a 1% of the total landings in terms of the number of individual fish. In terms of biomass, these species have provided 1.8 metric tones of fish, which accounts for 6% of the total fished biomass. Although it is certainly a significant contribution, the fact that both most of the fish and the biomass come from species at lower risk is encouraging. All together, these figures suggest that obtaining high quality protein for the subsistence of SIF staff posted in Aldabra will not be substantially affected by the implementation of fishing restrictions on these species. The potential inconveniences caused by the release of these species and the small reduction of catch are far outweighed by the potential conservation benefits.

The effective release and posterior survival of these species is, however, not except of challenges. This is particularly true for groupers (Serranidae) because their large swim bladders renders them highly sensitive to barotrauma. Nevertheless, increasing the survival likelihood of released fish is easily attainable with small modifications to the current fishing practices. The factors influencing fish welfare have been scientifically evaluated by the FAO (2008) and can be summarised in four simple practices relevant to Aldabra context:

- *Limit fishing depth* to 50m (initially). Research suggest that the survival of released fish that has been caught on deep water is extremely low. This is due to barotrauma, the damage of the internal organs caused by rapid changes in pressure. Venting the swim bladder with a needle, which may allow fish to swim back to depth, is an alternative that can work for fish caught at moderate depths. However, research has shown that venting does not reduces mortality of fish with severe barotrauma.
- *Minimise handling time* as there is a strong positive correlation between handling and mortality. To reduce handling time of fish to be released, Aldabra anglers should avoid air exposure when possible by releasing the fish in the water. And consider the use of barbless hooks as the amount of both the time required to remove the hook and the tissue damage are significantly reduced.
- *Reduce tissue damage*. Fish survivorship is greatly diminished when damaged is done to sensitive organs. In general for fish that should be released Aldabra anglers should, avoid touching the gills and eyes, avoid squeezing the fish or use unnecessary force while unhooking, minimise damage to the skin, and release deeply hooked fish by cutting the line and only if survival is likely.
- *Be aware of predators* and move to an alternative location if fish is likely to be eaten when returning to depth.

Ensuring that these fishing practices are appropriately enforced requires the active involvement of the whole fishing team. However, in my opinion, it would be facilitated by a change on perspective, in which fishing is seen more as a research activity. Therefore, at least during the implementation of potential restrictions, the members of the science team would assume a leadership role during the fishing trips. This includes sharing decisions with the skipper about the choice of fishing grounds, the locations and duration of the fishing sessions, and the fishing gear.

Although restricting the landings of some of the largest and most delicious inhabitants of the reef might initially be an unpopular measure, these restrictions effectively operate as an insurance against their decline. Despite the establishment of no-take and food-security zones in the forthcoming management plan, research suggest that large bodied predatory fish require substantially large no take areas for its protection. Further understanding of both the reproductive biology and the spatial behaviour of these species might reveal that Aldabra subsistence fishing, at least under certain conditions, can be done on these species without substantially affect their abundances. For now, an informed preemptive approach should at least be considered for the management of Aldabra's exceptional marine resources.

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