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STATUS OF CORAL REEFS AND REEF FISH IN 13 MARINE PROTECTED AREAS IN MALUKU, NORTH MALUKU AND WEST PAPUA PROVINCES

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ACRONYMS AND ABBREVIATIONS

BIG	Indonesian Geospatial Information Agency
CCA	Crustose Coralline Algae
CI	Conservation International
CTC	Coral Triangle Centre
FMA	Fisheries Management Area
GOI	Government of Indonesia
LIPI	Indonesian Institute of Science
MMAF	Ministry of Maritime Affairs and Fisheries
MPA	Marine Protected Area
NGO	Non-Governmental Organisation
NTA	No-Take Area
PMI	Performance Management Indicator
POKMASWAS	Kelompok Pengawas Masyarakat (*Community Surveillance Group*)
SE	Standard Error
SEA	Sustainable Ecosystems Advanced
TA	Take Area, where fishing is permitted with some restrictions
USAID	United States Agency for International Development
WCS	Wildlife Conservation Society
WWF	World Wildlife Fund for Nature

EXECUTIVE SUMMARY

Indonesia is located in the Coral Triangle, known as the global centre of marine biodiversity, but the system is under pressure from illegal, unregulated and unreported fishing, the use of destructive fishing practices, land-based pollution, unsustainable coastal development and climate change. It is therefore recognised that protection measures, including no-take marine protected areas (MPAs), are necessary to allow habitat recovery and fish stock replenishment. The United States Agency for International Development (USAID) Sustainable Ecosystems Advanced (SEA) Project (2016-2021) aims to improve fisheries productivity, food security and sustainable livelihoods within Fisheries Management Area (FMA) 715, which spans Maluku, North Maluku and West Papua Provinces and several adjacent strategic sites. The project has 15 fisheries sites (at the district government level) and 14[1] planned marine protected areas (MPA). The MPAs are designed for multiple use, with zones assigned to no-take (core zones), regulated fishing, tourism and rehabilitation. Within each MPA, no-take areas (NTAs) range from 250 to 59,707 hectares, or 3% to 24% of the total MPA area. It is important to note that these NTAs have yet to be implemented, and fishing has continued throughout the sampling period.

This report presents the results of the initial stages of monitoring within 13 newly implemented coral reef MPAs in FMA 715 and representative control sites. In particular, the monitoring program aims to examine:

- The biophysical baseline condition represented by coral and reef fish health around the SEA Project MPA sites; and
- The change in percent coral cover and reef fish biomass in the NTAs, as part of measuring the Performance Management Indicators (PMI) of the SEA Project.

Standard, globally accepted methods were used by four different survey teams (NGOs) within the MPAs and, in most areas, at appropriate control sites. The results are presented for individual MPAs, and as composite analyses for each province and across provinces. Most MPAs were surveyed twice; for comparisons between years, analyses were done using only sites surveyed in both years.

Maluku Province

MPAs in Maluku Province had an overall average of just under 50% coral cover, with a slight decline between initial surveys and the latest surveys conducted in 2020. Serutbar and Koon MPAs had slightly lower coral cover, but there was also abundant soft coral and hard substrate available for the settlement of coral larvae. Bleaching and macroalgae were negligible and the main indicator of disturbance was coral rubble, indicative of anchor damage and the result of destructive fishing in the area. Spatial differences in coral cover within each MPA are often driven by exposure to waves, sedimentation, and other environmental factors not related to management. It is important to understand the history of human use of the area. For example, coral reefs in the area around Serutbar MPA have suffered from destructive fishing practices in the last 10 years, resulting in substantial reef degradation.

Buano, Koon and Lease MPAs appear especially promising in terms of high biomass of target species in the no-take areas (3,439, 1,129.2 and 1,826.9 kg per hectare, respectively, in 2020 surveys). Other studies have also shown a tendency for reefs in this region to be in good condition, with high coral cover and target fish biomass. However, there appeared to be a general decline in the biomass and density of target fish over time. Previous reports have indicated that Koon MPA is a spawning ground

[1] Although 14 MPAs were designated, only 13 have coral reef habitat within them; the 14th MPA is Sorong Selatan is not included in this report since it is primarily a mangrove and estuarine habitat area.

for several economically important fish species such as groupers and snapper; protecting spawning aggregations is a key priority to help the recovery of target fish populations. Currently, Maluku Province has 1.5 million hectares of MPA, soon to become 1.75 million hectares with the addition of further MPAs.

North Maluku Province

Surveyed sites in North Maluku Province were generally dominated by hard coral, with very high cover in Mare (70%) and Rao-Dehegila MPAs (57.7%), and some evidence of an increasing trend. These two MPAs had similar benthic community composition in 2020, as did Guraici and Widi, while Sula was unique. Bleaching and macroalgae do not appear to have been problematic during the survey years; only Rao-Dehegila and Sula had a low cover of macroalgae (<2%). Rubble is a clear and persistent sign of disturbance, from a combination of anchoring and destructive fishing; however, the percentage cover of rubble appears to be declining, suggesting that these practices might be abating. Previous surveys noted evidence of coral damage on reefs in the province, due to anchoring, blast fishing, sedimentation and crown-of-thorns. The results of the current study, where coral cover in Rao-Dehegila was high and increasing, suggest that the MPA was placed in favourable coral reef habitat.

North Maluku has a diverse range of coral reef formations, from isolated pinnacles, reefs exposed to prevailing weather to highly sheltered and silty fringing reefs; there is also good hydrodynamic connectivity to the highly diverse reefs in West Papua Province. Sula MPA appears especially promising in terms of high biomass of target species in the no-take areas (1,550.2 kg per hectare in 2020). Charismatic fauna such as Napoleon wrasse, dugongs, turtles and cetaceans were observed with high frequency in Sula and Rao-Dehegila MPAs, increasing the conservation value of these areas, as most of these species are listed as globally threatened. North Maluku currently has 667.000 hectares within MPAs.

West Papua Province

It is not possible to ascertain trends for the MPAs in West Papua Province yet, as 2020 data were not available. The two MPAs had different benthic communities, with more hard coral in Berau Bay (43.6%) than in Nusalasi Bay. Coral cover is generally moderate to high across the province (39%). Previous assessments focusing on fish diversity reported that the reefs of Berau Bay MPA are unique, and retain high coral cover despite high sediment load, high temperatures, and lowered salinity, showing high tolerance and adaptability to a range of stressors. They therefore have high conservation value as a refuge for coral reef species adapted to stress.

Target fish biomass in Nusalasi Bay was similar between fished areas (TAs) and NTAs (~110 kg per hectare), suggesting a baseline that is representative for the area. In Berau Bay, target fish biomass and density were much lower in the NTA (49.3 kg per hectare), indicating that this area will have some "catching up" to do before monitoring will detect an improvement. Previous biodiversity assessments confirm that the Nusalasi Bay area is much more diverse than the Berau Bay area, with average species counts of 89 and 254 species per site, respectively. The provincial government of West Papua has around 4.1 million hectares of MPA, or around 39% of total marine area in West Papua Province.

Overall Assessment

Significant increases in average hard coral cover occurred in the NTA of Mare (42 to 66%) and Rao-Dehegila MPAs (47 to 57%), while the NTA of Sula MPA experienced a significant loss of hard coral cover (59 to 35%). The average hard coral cover in Koon, Serutbar, Lease, Guraici, and Widi MPAs is considered stable. Seven out of eight MPAs therefore show a significant increase or stability; resulting in 16,596 hectares of NTA that showed a positive effect for the Performance Management Indicator (PMI) 2.2 during the 2016 to 2020 SEA Project period.

The composite analysis shows target fish biomass declining in Maluku and remaining stable in North Maluku. The average target fish biomass across all NTAs was 1,709 (+/- 176 SE) kg per hectare at the baseline and 884 (+/- 76 SE) kg per hectare at the latest survey, which was a significant decline ($p = 0.0003$) of about 48% (Table 4.3). Within individual MPAs, the average fish biomass increased in the NTA of Mare MPA, decreased in Koon, Serutbar, Rao-Dehegila and Sula MPAs, and remained stable in Lease, Guraici and Widi MPAs.

Overall, coral reefs across the SEA Project MPAs are in good condition, with relatively high coral cover and fish biomass, albeit reflecting some damage and ongoing fishing pressure. Sedimentation and a history of destructive fishing appear to be the primary forces governing changes in coral cover. However, overall average coral cover has tended to increase or remain stable during the survey period, including in 2020, suggesting a period of recovery or stability despite the heatwaves that caused extensive mortality in other parts of the world.

Rare species and predators, such as Napoleon wrasse, turtles, cetaceans and sharks, are useful indicators of fishing pressure and the overall state of coral reef ecosystems, as they are among the first species to disappear under heavy fishing pressure and intense human use. Frequent sightings of charismatic species are promising, especially for the development of tourism as an industry that can be consistent with conservation goals.

Large and significant declines in many target fish families across multiple MPAs are concerning but reflect other reports of ongoing unsustainable levels of exploitation of a large variety of target species. It is important to note that target fish biomass and density will only change when fishing pressure changes or stops; the results of this study are not surprising. Based on the results of this study, it is recommended that all the NTAs included within the MPA management plans be implemented rapidly, with adequate enforcement and the continuation of monitoring surveys.

RINGKASAN EKSEKUTIF

Indonesia terletak di Segitiga Terumbu Karang, yang dikenal sebagai pusat keanekaragaman hayati laut, tetapi sistem ini berada dibawah tekanan perikanan yang ilegal, perikanan yang belum diatur di dalam perundangan dan tidak dilaporkan, juga terpapar oleh praktik *destructive fishing*, polusi dari darat, pembangunan pesisir yang tidak memperhatikan daya dukung dan perubahan iklim. Oleh karena itu cara perlindungan seperti zona larang ambil pada Kawasan Konservasi Perairan (KK) sangat penting untuk memulihkan habitat dan mengisi kembali stok ikan. Proyek The United States Agency for International Development (USAID) Sustainable Ecosystems Advanced (SEA) (2016–2021) berupaya untuk meningkatkan produktifitas laut, keamanan pangan dan mata pencaharian yang berkelanjutan di Wilayah Pengelolaan Perikanan (WPP) 715, yang terdiri dari Provinsi Maluku, Maluku Utara, Papua Barat dan wilayah sekitarnya. Proyek ini mempunyai 15 situs perikanan (di level pemerintah kabupaten) dan 14[2] wilayah kerja Kawasan Konservasi Perairan (KK). KK-KK tersebut di desain untuk mewadahi beberapa keperluan yaitu zona yang ditujukan untuk larang ambil (zona inti), perikanan berkelanjutan, pariwisata dan rehabilitasi. Di dalam setiap KK, zona larang ambil (ZLA) mempunyai rentang luas dari 250 sampai 59,707 hektar, atau 3% sampai 24% dari total luas masing-masing KK. Sangat penting untuk diketahui, bahwa KK-KK ini belum beroperasi dan penangkapan ikan masih berlangsung dalam periode pengambilan data.

Laporan ini menggambarkan kondisi awal dari pemantauan biofisik di sekitar 13 KK berterumbu karang yang dibangun di WPP 715 dan beberapa wilayah kontrol. Secara khusus, program pemantauan ini bertujuan untuk:

- Melihat status biofisik awal di sekitar KK yang diwakilkan oleh kondisi terumbu karang dan ikan karang; dan
- Menghitung persen perubahan pada tutupan karang dan biomasa ikan karang di dalam zona larang ambil sebagai bagian pengukuran Indikator Kinerja Manajemen (*Performance Management Indicator*/ PMI) Proyek USAID SEA.

Metodologi yang standard yang dapat diterima secara global telah dilakukan oleh empat tim survei yang berbeda (*Non-Government Organisation*/ NGO) di dalam wilayah KK maupun di wilayah control yang hampir ada di semua KK. Hasil-hasil analisis dijabarkan per KK dan gabungan di setiap provinsi maupun perbandingan antar provinsi. Sebagian besar KK di pemantauan ini mempunyai dua tahun periode survei; untuk perbandingan antar tahun, hanya memakai titik lokasi survei yang diambil di dua tahun.

Provinsi Maluku

KK-KK di Provinsi Maluku mempunyai rataan tutupan karang yang sedikit di bawah 50%, dengan sedikit penurunan di tutupan karang di survei-survei Tahun 2020 dibandingkan dengan survei-survei yang dilakukan di tahun awal. KK Serutbar dan KK Koon mempunyai tutupan karang yang sedikit lebih dibawah rataan, tetapi ditemukan tutupan karang lunak dan persediaan substrat keras yang tinggi untuk tempat pertumbuhan larva karang. Hasil makroalga dan *coral bleaching* dapat diabaikan, indikator utama gangguan diwakilkan oleh pecahan karang, yang menunjukkan kerusakan dari jangkar dan hasil *destructive fishing* pada suatu daerah. Perbedaan tutupan karang antara satu daerah dengan lainnya di dalam KK yang

[2] Walaupun ada 14 KK di dalam wilayah kerja Proyek SEA, tetapi hanya 13 yang berekosistem terumbu karang, KK ke-14 yaitu Sorong Selatan tidak dilaporkan di dalam laporan ini karena habitat utama KK ini adalah mangrove dan area muara sungai.

sama di pengamatan ini biasanya disebabkan oleh paparan dengan gelombang, sedimentasi, dan faktor lingkungan lainnya yang tidak berhubungan dengan pengelolaan. Penggunaan oleh manusia di sekitar wilayah KK sangatlah penting untuk dipahami. Contohnya, KK Serutbar telah menerima dampak praktik *destructive fishing* selama 10 tahun yang mengakibatkan penurunan karang yang cukup serius.

Hasil biomasa ikan famili ikan target pada zona larang ambil di KK Buano, Koon, dan Lease menunjukkan hasil yang baik pada survei di tahun 2020 yaitu 3,439 Kg/Ha di KK Buano; 1,129.2 Kg/Ha di KK Koon; dan 1,826.9 Kg/Ha di KK Lease. Studi lain memaparkan kecenderungan pada kondisi ekosistem pada daerah-daerah ini dalam keadaan yang baik dengan tutupan karang dan biomasa ikan karang yang tinggi. Beberapa laporan sebelumnya menyatakan bahwa KK Koon adalah areal memijah ikan-ikan ekonomi tinggi seperti kakap dan kerapu; dan melindungi areal pemijahan adalah prioritas kunci untuk membantu pemulihan populasi ikan-ikan target. Saat ini Provinsi Maluku mempunya sekitar 1.5 juta hektar Kawasan Konservasi Perairan, dan akan berubah menjadi sekitar 1.75 juta hektar dengan tambahan KK-KK.

Provinsi Maluku Utara

Secara umum titik-titik survei di Maluku Utara didominasi oleh karang keras, dengan tutupan karang yang sangat tinggi dijumpai pada KK Mare (70%) dan KK Rao-Dehegila (57.7%); dan juga bukti peningkatan trend. Hasil tahun 2020, dua KK tersebut dan juga KK Guraici dan KK Widi mempunyai komposisi komunitas bentik yang serupa tetapi tidak dengan KK Sula yang mempunyai keunikan. Makroalga dan *coral bleaching* tidak menjadi masalah selama tahun-tahun survei; hanya Rao-Dehegila dan Sula yang mempunya tutupan makroalga yang rendah (<2%). Patahan karang merupakan tanda yang jelas dari gangguan berupa jangkar dan *destructive fishing*, namun persentase tutupan karang di sini menurun menunjukkan adanya berkurangnya aktivitas gangguan tersebut. Survei-survei sebelumnya mencatat bukti kerusakan terumbu karang di provinsi ini adalah akibat dari jangkar, bom ikan, sedimentasi, dan bintang laut crown-of-thorns (*Acanthaster planci*). Hasil studi terkini menunjukkan bahwa tutupan karang KK Rao-Dehegila tinggi dan meningkat, menunjukkan KK berada pada habitat terumbu karang yang tepat.

Maluku Utara mempunyai formasi terumbu karang yang beragam, dari puncak terisolasi, terumbu yang terpapar dengan perubahan cuaca sampai yang terlindungi, dan terumbu karang di pinggir pantai yang berlumpur; juga ada hubungan hidro-dinamika yang baik dengan terumbu karang yang kaya di Provinsi Papua Barat. KK Sula menunjukkan hasil yang sangat baik dari biomasa ikan target di dalam zona larang ambil (1,550.2 Kg/Ha in tahun 2020). Fauna karismatik seperti ikan Napoleon, wrasse, Dugong, penyu, Cetacea teramati sangat tinggi di KK Sula dan Rao-Dehegila yang juga meningkatkan nilai konservasi di dua KK tersebut. Saat ini Provinsi Maluku Utara mempunyai 667,000 hektar wilayah KK.

Provinsi Papua Barat

Tren kondisi biofisik di Provinsi Papua Barat tidak dapat terlihat pada studi ini karena tidak adanya data survei di tahun 2020. Dua KK di provinsi ini mempunyai komposisi bentik yang berbeda, di mana Teluk Berau mempunyai tutupan karang keras yang lebih tinggi (43.6%) dibandingkan dengan Teluk Nusalasi. Kondisi terumbu karang di provinsi ini berada pada kondisi menengah ke tinggi (39%). Penelitian sebelumnya yang berfokus pada keanekaragaman ikan karang melaporkan bahwa terumbu karang di KK Teluk Berau mempunyai keunikan, walaupun berada pada sedimentasi dan temperatur tinggi, dan salinitas yang lebih rendah, tutupan karang tetap padat menunjukkan kemampuan beradaptasi dan bertoleransi pada tekanan.

Biomasa ikan target di Teluk Nusalasi hampir sama di zona ambil (ZA) dan zona larang ambil (ZLA) yaitu berkisar di 110 Kg/Ha, menunjukkan tinjuauan awal yang mempresentasikan daerah tersebut. Di Teluk Berau, biomasa dan kepadatan ikan target ditemukan lebih rendah pada zona larang ambil (49.3 Kg/Ha), hal ini menunjukkan bahwa wilayah ini sedang dalam proses pemulihan sebelum kegiatan pemantauan di daerah ini menemuan hasil yang lebih baik. Penelitian sebelumnya menemukan bahwa Teluk Nusalasi

mempunyai keanekaragaman ikan lebih beragam dari pada yang ditemukan di Teluk Berau, dengan rataan 89 dan 254 masing-masing yang dapat ditemukan di satu titik survei. Pemerintah Provinsi Papua Barat telah memiliki sekitar 4.1 juta hektar Kawasan konservasi atau sekitar 39% dari total luas laut Provinsi Papua Barat.

Penilaian Menyeluruh

Peningkatan rataan tutupan karang keras terjadi pada zona larang ambil di KK Mare (42-66%) dan Rao-Dehegila (47-57%) di mana zona larang ambil di Sula mengalami penurutan tutupan karang keras yang drastis (59-35%). Rataan tutupan karang keras pada KK Koon, Serutbar, Lease, Guraici dan Widi dapat dinilai stabil. Tujuh dari delapan KK menunjukkan kenaikan yang signifikan maupun stabil, menghasilkan 16,596 hektar zona larang ambil menunjukan efek yang positif pada Indikator Performa Manajemen (PMI) 2.2 selama periode proyek SEA dari tahun 2016 sampai 2020.

Analisis gabungan menunjukkan penurunan biomasa ikan di Maluku dan tetap stabil di Maluku Utara. Rataan biomasa ikan target di semua zona larang ambil (ZLA) di 13 KK adalah 1,709 (+/- 176 SE) Kg/Ha pada pengamatan awal dan sebesar 884 (+/- 76 SE) Kg/Ha di survei akhir, di mana jika dilihat secara statistic mengalami penurunan secara signifikan ($p = 0.0003$) sebesar 48% (Tabel 4.3). Jika dilihat dari hasil per KK, kenaikan biomasa ikan target di dalam ZLA terjadi di KK Mare dan menurun di KK Koon, Serutbar, Rao-Dehegila dan Sula; dan KK Lease, Guraici dan Widi tidak mengalami perubahan yang berarti (stabil).

Secara umum, kondisi ekosistem terumbu karang di wilayah kerja Proyek SEA adalah baik, dengan kecenderungan tutupan karang dan biomasa ikan yang tinggi, walaupun terdapat beberapa kerusakan dan tekanan perikanan yang masih berlangsung. Sedimentasi dan riwayat *destructive fishing* masih menjadi pemicu utama yang menyebabkan perubahan pada tutupan karang. Akan tetapi, rataan tutupan karang cenderung meningkat atau tetap stabil selama periode survei, termasuk pada tahun 2020 yang menunjukkan hasil pemulihan atau stabilitas meskipun gelombang panas yang menyebabkan kematian karang yang luas di bagian lain dunia.

Spesies dan predator langka, seperti Napoleon wrasse, penyu, cetacea, dan hiu, merupakan indikator yang berguna untuk meunjukkan tekanan perikanan and kualitas ekosistem terumbu karang secara keseluruhan, karena mereka akan menjadi spesies pertama yang hilang dibawah tekanan penangkapan ikan yang berat dan pemanfaatan oleh manusia secara terus menerus. Kemunculan spesies karismatik sangat menjanjikan, terutama untuk pengembangan pariwisata sebagai industri yang dapat sejalan dengan tujuan konservasi.

Penurunan yang besar dan signifikan pada banyak famili ikan target di berbagai lokasi KK merupakan hal yang mengkhawatirkan, tetapi mencerminkan laporan lain tentang tingkat eksploitasi yang tidak berkelanjutan dari berbagai jenis spesies target. Penting untuk dicatat bahwa biomassa dan kepadatan ikan target hanya akan berubah jika tekanan penangkapan berubah atau berhenti; hasil penelitian ini tidak mengherankan. Berdasarkan hasil studi ini, direkomendasikan agar semua zona larang ambil (ZLA) di dalam rencana pengelolaan KK dilaksanakan dengan cepat, dengan penegakan hukum yang memadai dan dilakukannya survei pemantauan lanjutan.

BACKGROUND

Indonesia is located in the Coral Triangle, considered to be the global centre of marine biodiversity (Bellwood and Hughes 2001, Allen et al. 2002, Kusumoto et al. 2020). Coral reef ecosystems in this region are home to over 600 species of reef-building corals (DeVantier et al. 2020) and at least 2,000 species of reef-associated fishes (Juhel et al. 2020), representing ~70% and ~40% of the world's coral and fish species, respectively (Asaad et al. 2018). New species are regularly discovered and described (e.g. Randall and Allen 2010, Calcinai et al. 2017, Gabriela Arango et al. 2019). The origin of the extraordinary biodiversity of the Coral Triangle, and Indonesian waters in particular, is still being debated (Briggs 2009). The provinces of Maluku, North Maluku and West Papua are especially diverse and productive, and provide food security and livelihoods to over 6 million people. The Provinces are located within three distinct ecoregions (areas "…containing geographically distinct assemblages of species, natural communities, and environmental conditions") of the Coral Triangle: the Banda Sea, Halmahera and Papua ecoregions (Green and Mous 2007). However, the proximity of coral reefs in the region to large human populations that depend on them has resulted in the widespread overexploitation and degradation of marine resources and ecosystems (Cabral et al. 2012, Cruz-Trinidad et al. 2014). The system is under pressure from illegal, unregulated and unreported fishing, destructive fishing practices, land-based pollution, unsustainable coastal development and climate change (Servonnat et al. 2019, McManus et al. 2020). Dramatic declines in diversity of up to 50% were reported as early as 1998 (Edinger et al. 1998). It is now recognised that protection measures are necessary to allow habitat recovery and fish stock replenishment.

The United States Agency for International Development (USAID) Sustainable Ecosystems Advanced (SEA) Project (2016-2021) aims to improve fisheries productivity, food security and sustainable livelihoods by supporting the implementation of an Ecosystem Approach to Fisheries Management (EAFM) within Fisheries Management Area (FMA) 715 and several adjacent strategic sites. The primary focus of the project is site-based interventions, but there are also efforts to strengthen the leadership role of the Ministry of Maritime Affairs and Fisheries (MMAF) in, and the Government of Indonesia's (GOI) commitment to, sustainable fisheries and effective MPA management. The project has 15 fisheries sites (at the district government level) and 14[3] target marine protected areas (MPAs; Figure 1.1 and Table 1.1). The MPAs are designed for multiple use, with zones assigned to no-take (core zones), regulated fishing, tourism and rehabilitation (Table 1.2). No-take areas (NTAs) range from 250 (Mare MPA, North Maluku) to 59,707 (Nusalasi Bay MPA, West Papua) hectares, and amount to proportions of between 3% (Guraici and Makian-Moti MPAs, North Maluku) and 24% (Nusalasi Bay MPA, West Papua) of the total MPA area (Table 1.3).

[3] Although 14 MPAs were designated, 13 have coral reef habitat within them; the 14th MPA is not included in this report.

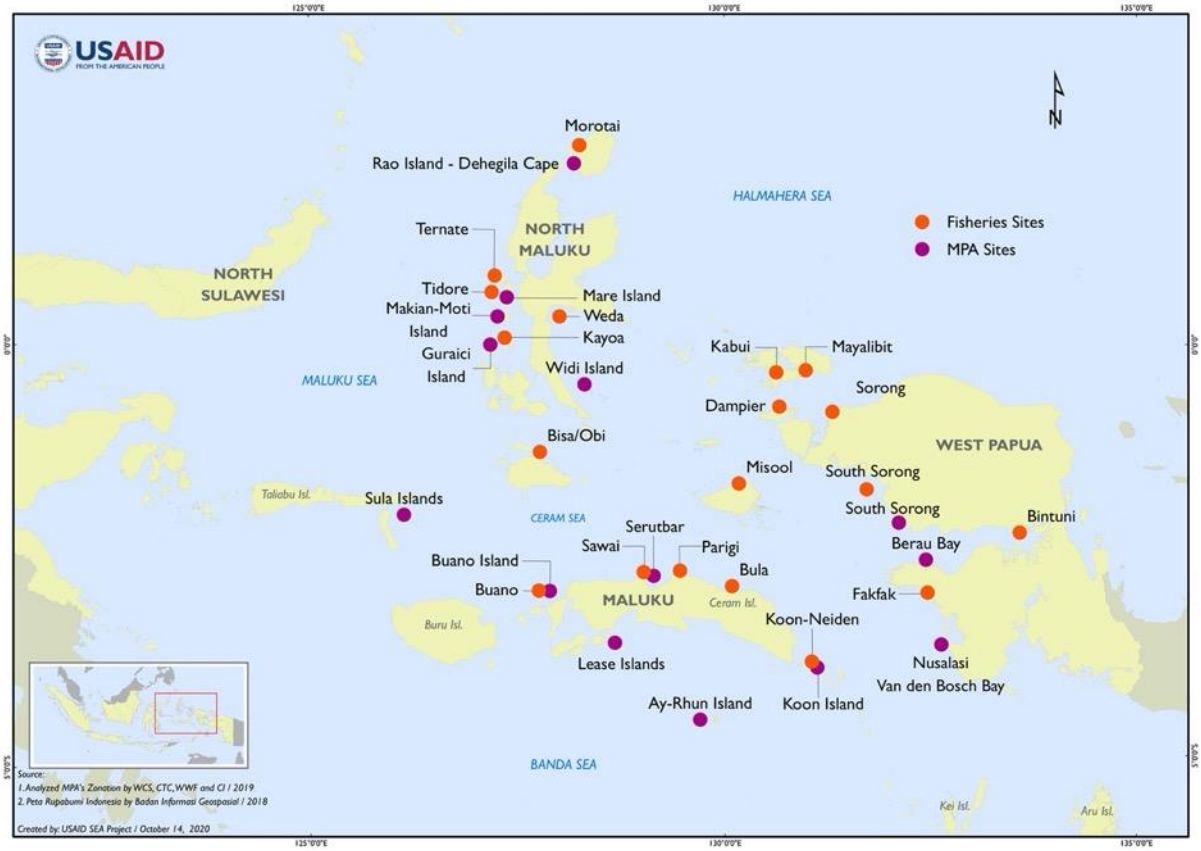

Figure 1.1 Map of fisheries and MPA sites designated under the SEA Project.

Table 1.1 Names, placement and NGOs responsible for monitoring the MPAs designated under the SEA Project.

Province	Project Activity	District	MPA Name (MPA) / Village Name (Fisheries)	Lead
North Maluku	Fisheries	Pulau Morotai	Galo-galo, Kolorai and Daruba	WCS / AP2HI
		Kota Tidore Kepulauan	Guraping, Goto, Soa Sio, Galala, Tuguiha and Kayasa	WCS / WWF-ID
		Kota Ternate	Dufa-dufa and Bastiong	WWF-ID / AP2HI / WCS
		Halmahera Tengah	Fidi Jaya	WCS /WWF
		Halmahera Selatan	Madapolo, Lelei, Laluin and Talimau	WCS / MDPI
		Kepulauan Sula	Sanana	MDPI
	MPA	Pulau Morotai	Morotai/ Rao-Degehila	WCS
		Kota Tidore Kepulauan	Mare	WCS
		Halmahera Selatan	Guraici	WCS
		Halmahera Selatan	Widi	WCS

Province	Project Activity	District	MPA Name (MPA) / Village Name (Fisheries)	Lead
		Halmahera Selatan and Kota Ternate	Makian-Moti	WCS
		Kepulauan Sula	Sula	CTC
Maluku	Fisheries	Seram Bagian Barat	Kaswari, Kawa, Buano Utara, Hatunuru, Taniwel, Hulung, Kasieh and Niwelehu	WWF-ID/ ILMMA
		Maluku Tengah	Gale-gale, Labuhan, Sawai, Parigi, Aketernate and Kobisadar	WWF-ID/ MDPI/ ILMMA
		Seram Bagian Timur	Bula, Grogos and Gorom	MDPI/ WWF-ID
		Kota Ambon	Tulehu and Tawiri	AP2HI
	MPA	Maluku Tengah	Sawai/ Serutbar	WWF-ID
		Seram Bagian Barat	Buano	CTC
		Maluku Tengah	Lease	CTC
		Maluku Tengah	Ay Rhun	CTC
		Seram Bagian Timur	Koon	WWF-ID
West Papua	Fisheries	Kota Sorong	Klademak, Wamargege, Konda, Mugibi, Mate, Ampera and Sayolo	WWF-ID
		Teluk Bintuni	Banjar Ausoy, Kampung Nelayan and	WWF-ID
			Sidomakmur	
		Fakfak	Kokas and Arguni	UNIPA and CI
		Raja Ampat	Mayalibit, Dampier, Kabui and Dampier	RARE/ UKIP
	MPA	Sorong Selatan	Sorong Selatan	WWF-ID
		Fakfak	Berau Bay	CI
		Fakfak	Nusalasi Van Den Bosch Bay	CI

Table 1.2. Multiple-use zoning and areas in hectares within the different zones in each MPA. No-take zones are shown in red font.

No.	MPA	Zone	Subzone	NTA/TA	Hectares per zone	Total Hectares
1	Ay-Rhun	Core Zone		NTA	3,384	**61,179**
		Utilization Zone	Tourism	NTA	99	
		Sustainable Fishing Zone	Regulated Fishing	TA	57,661	
		Other Zone	Port	NTA	34	
2	Buano	Core Zone		NTA	2,562	**31,887**
		Utilization Zone	Tourism	NTA	1,355	
			Regulated Fishing	TA	27,853	
			Aquaculture	NTA	32	
		Other Zone	Rehabilitation	NTA	84	
			Port	NTA	3	
3	Koon	Core Zone		NTA	250	**9,901**
		Utilization Zone	Tourism	NTA	54	
			Traditional Fishing	TA	3,015	
			Aquaculture	NTA	29	
		Other Zone	Regulated Fishing	TA	6,068	
			Rehabilitation	NTA	457	
			Other Utilization (Residential Area)	TA	28	
4	Lease	Core Zone		NTA	1,567	**67,484**
		Utilization Zone	Tourism	NTA	1,075	
			Regulated Fishing	TA	63,644	
			Traditional Fishing and Cultural	TA	883	
		Other Zone	Rehabilitation	NTA	220	
			Seasonal closure (Sasi)	TA	83	
			Port	NTA	12	
5	Serutbar	Core Zone		NTA	3,011	**106,826**
		Utilization Zone	Traditional Fishing	TA	101,440	
			Tourism	NTA	828	
		Other Zone	Rehabilitation	TA	768	
			Coral protection with small/ traditional fishing	TA	135	
			Other Utilization	TA	643	
6	Guraici	Core Zone		NTA	1,981	**91,539**
		Utilization Zone	Tourism	NTA	431	
			Aquaculture	NTA	117	
			Regulated Fishing	TA	89,010	
7	Mare	Core Zone		NTA	155	**7,061**
		Utilization Zone	Tourism	NTA	61	
		Sustainable Fishing Zone	Regulated Fishing	TA	6,811	
		Other Zone	Rehabilitation	NTA	34	
8	Makian-Moti	Core Zone		NTA	1,553	**67,349**
		Utilization Zone	Tourism	NTA	59	
		Sustainable Fishing Zone	Regulated Fishing	TA	65,633	
		Other Zone	Rehabilitation	NTA	29	
			Ship Lane	NTA	75	

No.	MPA	Zone	Subzone	NTA/TA	Hectares per zone	Total Hectares
9	Rao-Dehegila	Core Zone		NTA	1,527	**65,892**
		Utilization Zone	Tourism	NTA	2,154	
		Sustainable Fishing Zone	Regulated Fishing	TA	60,399	
			Aquaculture	NTA	834	
		Other Zone	Rehabilitation	NTA	47	
			Marine Buoy	TA	33	
			Marine Mammal Conservation	TA	796	
			Cultural Preservation	TA	103	
10	Sula	Core Zone		NTA	4,553	**120,724**
		Utilization Zone	Tourism	NTA	1,222	
			Regulated Fishing	TA	16	
			Traditional Fishing	TA	113,342	
			Aquaculture	NTA	81	
		Other Zone	Rehabilitation	NTA	1,350	
			Port	NTA	160	
11	Widi	Core Zone		NTA	8,752	**315,118**
		Utilization Zone	Tourism	NTA	8,021	
			Regulated Fishing	TA	298,345	
12	T. Berau	Core Zone		NTA	350	**98,944**
		Utilization Zone	Tourism	NTA	9,621	
			Traditional Fishing	TA	86,317	
			Salt Water Lake	TA	2,182	
			Small Island	NTA	26	
		Other Zone	Seasonal closure (Sasi)	TA	449	
13	T. Nusalasi	core Zone		NTA	29,680	**247,864**
		Utilization Zone	Tourism	NTA	29,995	
			Traditional Fishing	TA	178,098	
			Salt Water Lake	TA	9,855	
			Small Island	NTA	32	
		Other Zone	Seasonal closure (Sasi)	TA	204	

Table 1.3. Detail of the extent (hectares) and proportion (%) of each MPA allocated to no-take (NTA, shown in red font) and to various forms of regulated fishing (TA).

Province	MPA	NTA		TA		Total Hectares
		Hectares	(%)	Hectares	(%)	
Maluku	Ay-Rhun	3,518	6	57,661	94	61,179
	Buano	4,034	13	27,853	87	31,887
	Koon	790	8	9,111	92	9,901
	Lease	2,875	4	64,609	96	67,484
	Serutbar	3,839	4	102,986	96	106,826
Maluku Total		**15,056**	**5**	**262,220**	**95**	**277,276**
Maluku Average		**3,011**	**7**	**52,444**	**93**	**92,425**
North Maluku	Guraici	2,529	3	89,010	97	91,539
	Mare	250	4	6,811	96	7,061
	Makian-Moti	1,716	3	65,633	97	67,349
	Rao-Dehegila	4,562	7	61,331	93	65,892

Province	MPA	NTA		TA		Total Hectares
		Hectares	(%)	Hectares	(%)	
	Sula	7,365	6	113,359	94	120,724
	Widi	16,773	5	298,345	95	315,118
North Maluku Total		**33,195**	**5**	**634,488**	**95**	**667,683**
North Maluku Average		**5,532**	**5**	**105,748**	**95**	**190,767**
West Papua	T. Berau	9,997	10	88,947	90	98,944
	T. Nusalasi	59,707	24	188,158	76	247,864
West Papua Total		**69,703**	**20**	**277,105**	**80**	**346,808**
West Papua Average		**34,852**	**17**	**138,552**	**83**	**173,404**

No-take areas (NTAs) are the best conservation tools available to allow marine species and habitats to recover from exploitation and damage, and to conserve marine biodiversity (Graham et al. 2011, Hopf et al. 2019). Common biophysical goals of NTAs are to maintain or restore native species diversity, fish stocks, habitat diversity and heterogeneity, keystone species, connectivity and important ecological processes (Halpern and Warner 2002). Usually, achievement of these biophysical goals allows consequent achievement of socio-economic and cultural objectives linked to sustainable fishing and food security (Cruz-Trinidad et al. 2014).

The primary MPA objective under the SEA Project is to protect the marine ecosystem (mostly, in this case, coral reef ecosystems) for fisheries stock, biodiversity and charismatic species. Ecological monitoring is critical for the assessment of the performance of MPAs against their stated objectives. Indicators relevant to the desired outcomes of MPA designation must be selected and measured systematically over time. Ideally, indicators are recorded before MPA establishment to assess their baseline condition, followed by repeated surveys in the same locations to detect changes over time.

OBJECTIVES

This report presents the results of the initial stages of monitoring within 13 newly designated coral reef MPAs in FMA 715 and representative control sites. In particular, the monitoring program aims to examine:

- The biophysical baseline condition represented by coral and reef fish health around the SEA Project MPA sites; and
- The change in percent coral cover and reef fish biomass in the no-take areas of MPAs, as part of measuring the Performance Management Indicators of the SEA Project.

METHODS

3.1 SURVEY LOCATIONS

Fisheries Management Area (FMA) 715 encompasses the eastern portion of the Indonesian Archipelago, consisting of the Gulf of Tomini, Maluku, Halmahera, Ceram and Berau Bay. Its jurisdiction includes six provinces: North Sulawesi, Gorontalo, Central Sulawesi, Maluku, North Maluku and West Papua. However, under the agreement with Government of Indonesia the USAID SEA Project only covers three Provinces: Maluku, North Maluku and West Papua (Figure 3.1). Among the key coastal ecosystems, coral reefs cover the largest area, followed by seagrass meadows and mangroves (Table 3.1). The SEA Project MPAs are distributed throughout FMA715, and habitats within the MPAs are dominated by coral reefs, with smaller proportions of mangrove and seagrass ecosystems in most MPAs (

Province	MPA Site	Coral Reef (Hectare)	Mangrove (Hectare)	Sea-grass (Hectare)
North Maluku	Morotai/ Rao-Dehegila	4,635	85	2,166
	Mare	141	3	55
	Guraici	1,894	373	73
	Widi	5,628	65	284
	Makian-Moti	195	0	63
	Sula	1,309	11	1,104
Maluku	Sawai/ Serutbar	3,169	1,678	-
	Buano	413	92	161
	Lease	3,828	219	116
	Ay Rhun	167	-	55
	Koon	4,609	-	5,392
West Papua	South Sorong	67	404	-
	Berau Bay	1,008	916	-
	Nusalasi Van Den Bosch Bay	11,583	1,228	-

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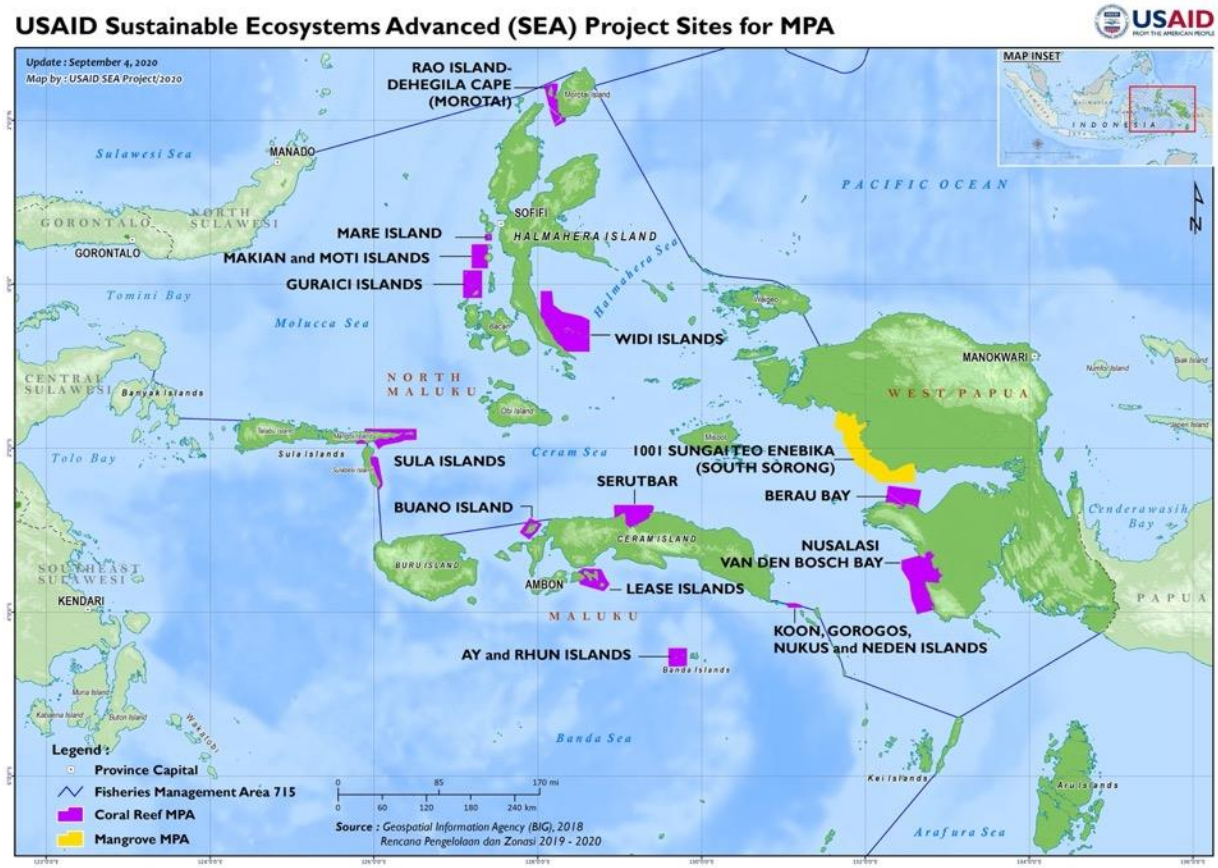


Figure 3.1 Map of SEA Project MPAs, showing locations and sizes.

Table 3.1 Attributes of the SEA Project Fisheries Management Area (FMA715)

Attribute	Area / magnitude [4] [5]
Sea surface area	51,610,929 hectares
Coral reefs	257,781 hectares
Mangroves	570,053 hectares (includes mangroves on the land)
Seagrass meadows	47,852 hectares
Fisheries potential	631,703 tonnes per year

[4] *Keputusan Menteri Kelautan dan Perikanan Republik Indonesia Nomor 82/Kepmen-KP/2016 Tentang Rencana Pengelolaan Perikanan Wilayah Pengelolaan Perikanan Negara Republik Indonesia 715* (Marine and Fisheries Affairs Ministerial Decree Number 82/Kepmen-KP/2016 Regarding Indonesian Fisheries Management Area 715.)

[5] Habitats map of Indonesia from the Indonesian Geospatial Information Agency (BIG) 2019; Geospatial Information Agency (BIG) and Indonesian Institute of Science (LIPI) collaboration data 2006-2015; The Ministry of Environmental and Forestry 2009-2017; One Map Policy Geospatian information Agency (BIG) and The Ministry of marine Affairs and Fisheries 2013.

Attribute	Area / magnitude [4] [5]
Fisheries commodities	Small and large pelagic fish, demersal fish, reef fish, penaeid shrimp, lobster, crabs and squid

Table 3.2 Extent (hectares) of zones and habitats within each MPA.

Province	MPA Site	Coral Reef (Hectare)	Mangrove (Hectare)	Sea-grass (Hectare)
North Maluku	Morotai/ Rao-Dehegila	4,635	85	2,166
	Mare	141	3	55
	Guraici	1,894	373	73
	Widi	5,628	65	284
	Makian-Moti	195	0	63
	Sula	1,309	11	1,104
Maluku	Sawai/ Serutbar	3,169	1,678	-
	Buano	413	92	161
	Lease	3,828	219	116
	Ay Rhun	167	-	55
	Koon	4,609	-	5,392
West Papua	South Sorong	67	404	-
	Berau Bay	1,008	916	-
	Nusalasi Van Den Bosch Bay	11,583	1,228	-

3.2 REEF HEALTH MONITORING SURVEY

3.2.1 SAMPLING DESIGN

Reef health surveys were conducted at multiple sites in each MPA and at appropriate control sites. Within the multiple use MPAs, surveys were also split between NTAs and areas where various levels of extraction were permitted (TA; Appendix I). The number of sites surveyed within and outside each MPA reflected the size of the MPA and the available habitat (Figure 3.2 to Figure 3.4); each site was separated into deep (~10 m) and shallow (~3 m) habitats and three transects were deployed in each depth zone (**Error! Reference source not found.**). Baseline surveys (T0) were conducted before the declaration of the MPAs, and a follow-up survey (T1) was completed in 2020. The no-take regulations have not yet been implemented as of the writing of this report; both T0 and T1 (and T2, in the case of Koon MPA) are therefore to be interpreted as "before" surveys; fishing pressure and other activities have not yet changed.

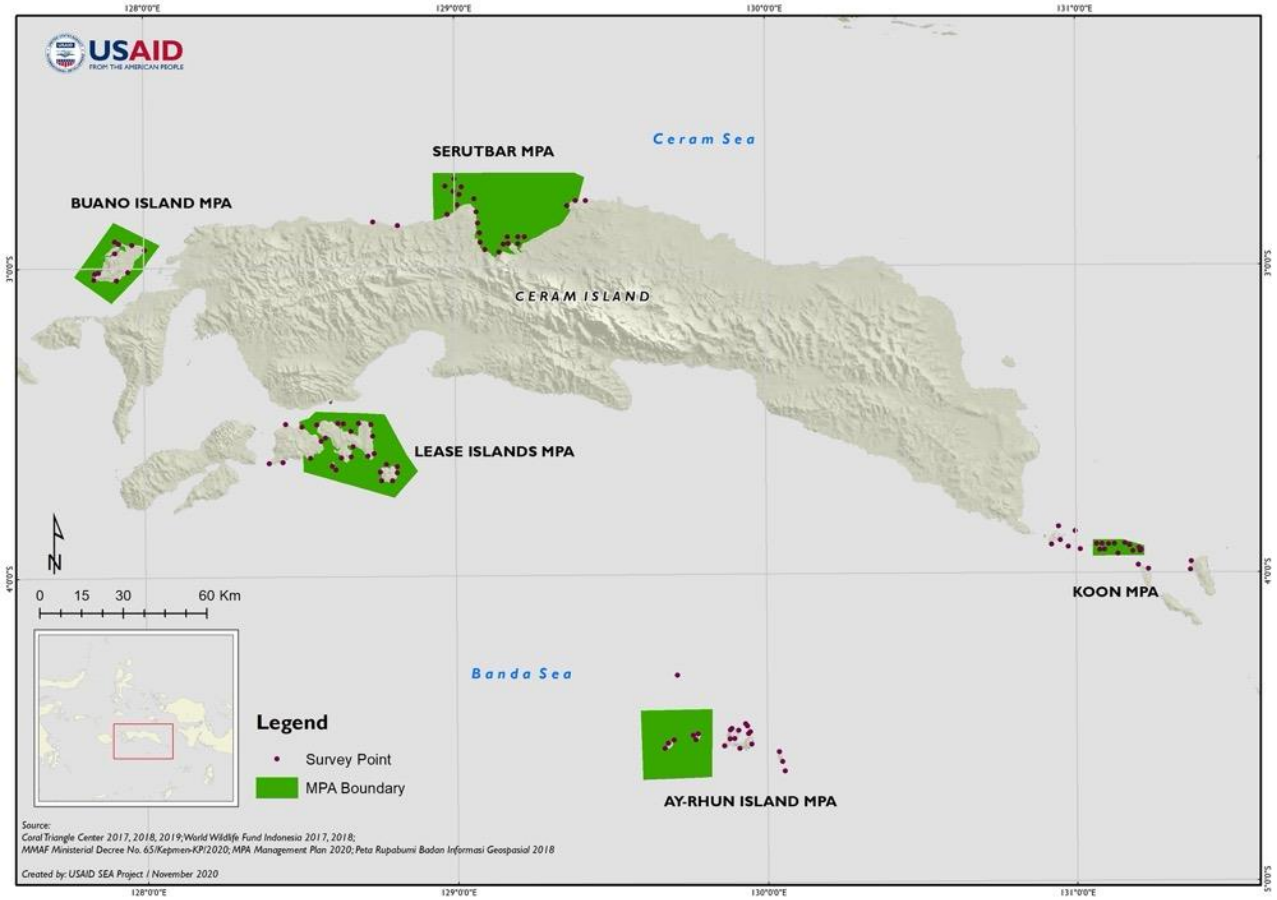


Figure 3.2 Survey sites in Maluku Province.

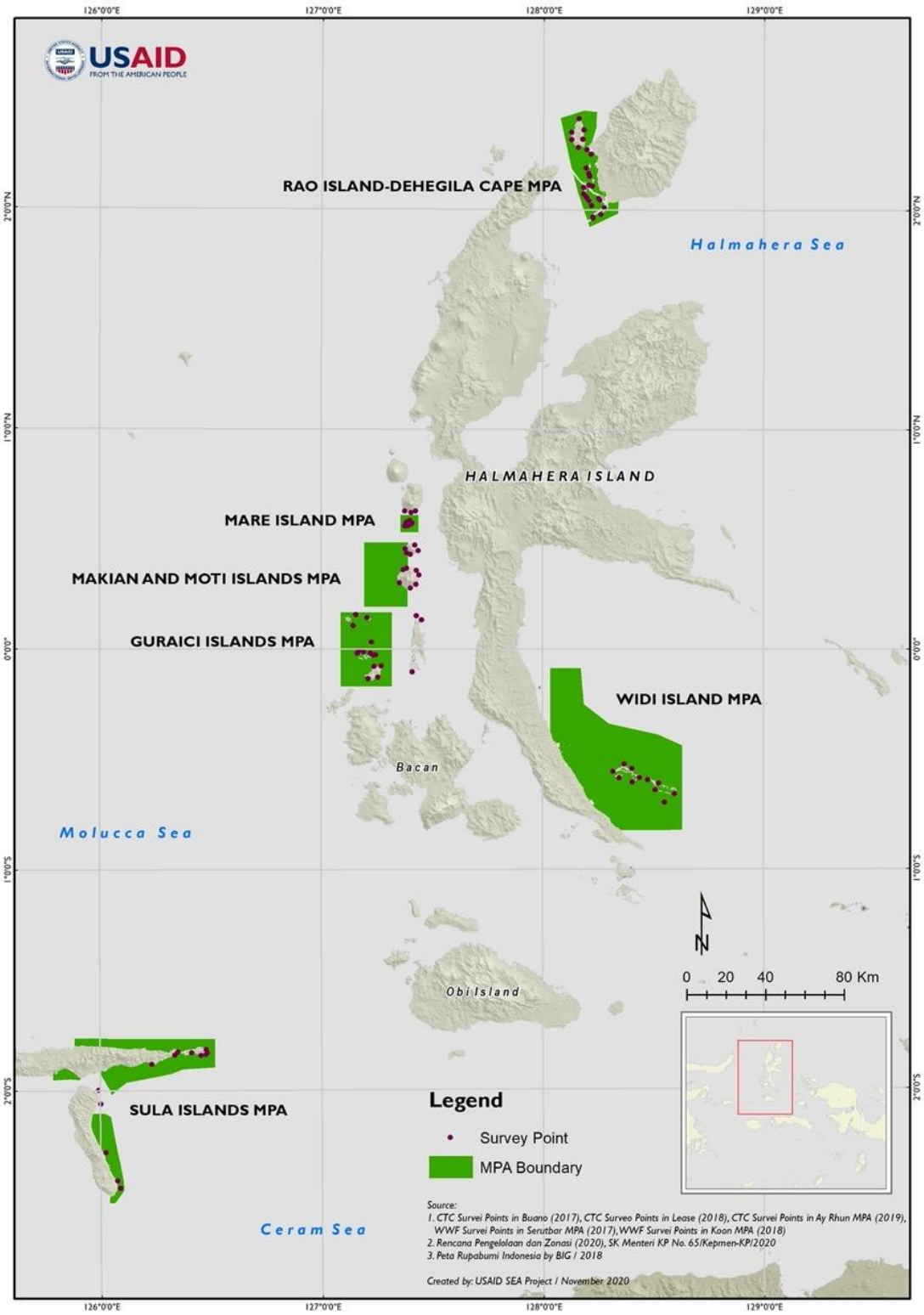


Figure 3.3 Survey sites in North Maluku Province.

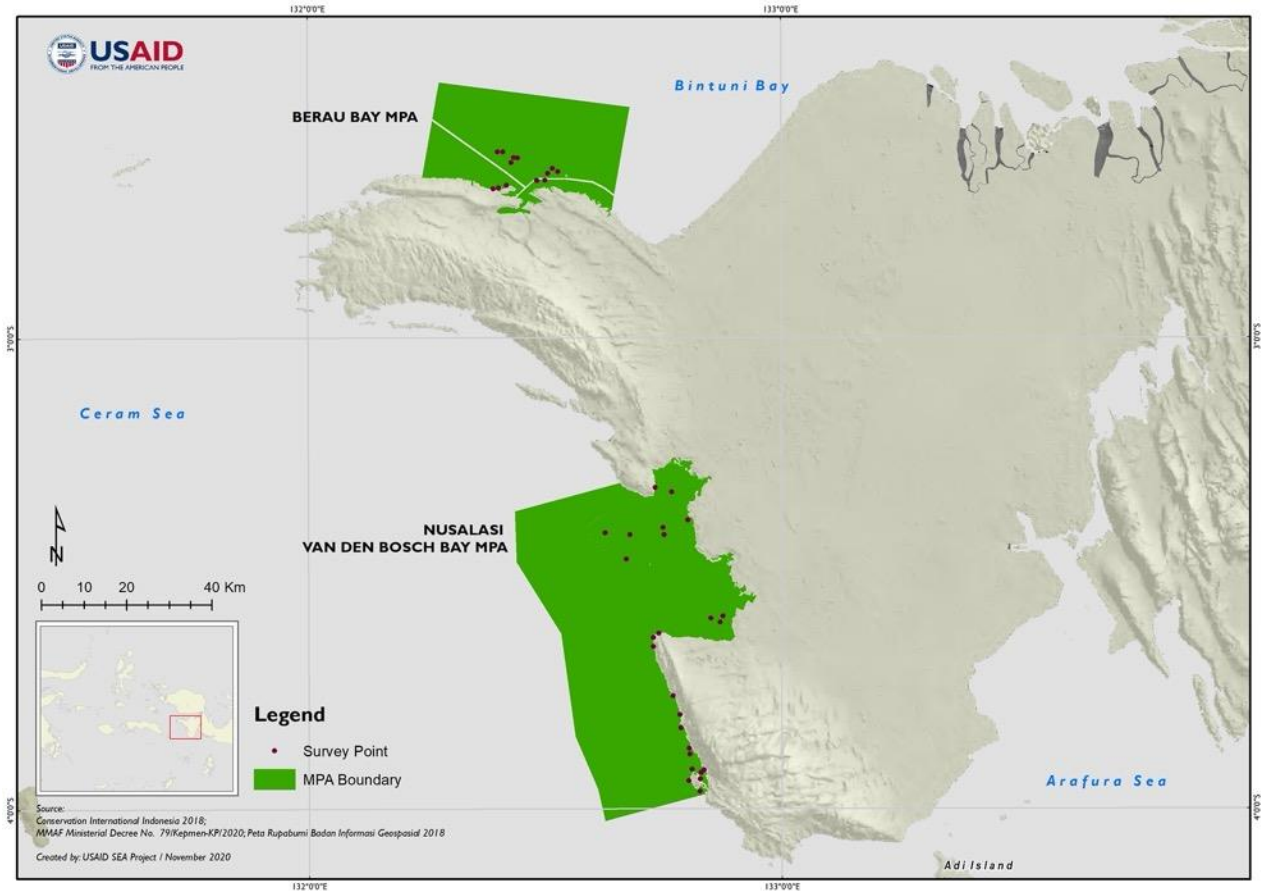


Figure 3.4 Survey sites in West Papua Province.

3.2.2 BENTHIC POINT INTERCEPT TRANSECTS

Benthic assemblages were assessed using the Point Intercept Transect (PIT) method, using three 50 m transects within each depth zone at each site (Amkieltiela and Wijonarno 2015) (Figure 3.5). An observer using SCUBA swam along each transect and recorded the lifeform category (Table 3.3) below the tape at 0.5 m intervals, resulting in 100 points per transect, and 300 points per depth zone at each site. Categories were summarised from those listed in Ahmadia et al. (2013) in a way that maximised the information and corrected for differences in data collection in the field by the different survey teams. Hard corals included all living corals with a stony skeleton, as they form the reef habitat and provide food and shelter for other organisms. Hydrocorals such as *Millepora* and *Heliopora*, while not considered reef-building corals, were also included in this category for their role in providing structural complexity. Soft coral include all Alcyonacean species, including *Xenia* spp., which some field survey teams recorded separately. For the overall analysis, hard and soft coral cover included bleached corals, as these were not yet dead at the time of recording. Algal categories recorded reliably by all teams included turf algae (favoured by grazing fishes and potentially overgrown by corals), *Halimeda* (calcified algae important in the formation of carbonate sand), macroalgae (large fleshy algae only targeted by few fishes and a potential sign of reef degradation) and CCA (crustose coralline algae important for cementing the reef framework and used as a chemical cue for settling corals). These were used as recorded. The "other" category included sessile (attached to the substrate) organisms such as sponges, hydroids, zoanthids and anemones. Abiotic (non-living substrate) categories were separated into hard (rock and dead coral) and mobile (sand, silt and rubble). Hard substrate is available to settling corals and other organisms, while mobile substrate is not suitable for colonisation, and rubble can be a sign of damaged reef that is not

recovering. To assess indicators of coral reef degradation, the cover of dead corals, bleached corals, macroalgae and rubble were also compared in a separate analysis.

Table 3.3 Benthic life form categories used for the PIT surveys at each site. Categories reproduced from Ahmadia et al. (2013); the categories used for the data analyses in this report are shown in the right-hand column.

Category		Name	Symbol
Hard corals	*Acropora* coral	*Acropora* branching	ACB
		Acropora encrusting	ACE
		Acropora submassive	ACS
		Acropora table	ACT
	Non-*Acropora* coral	Coral branching	CB
		Coral encrusting	CE
		Coral foliose	CF
		Coral massive	CM
		Coral submassive	CS
		Coral mushroom	CMR
	Non-scleractinian coral	Coral *Millepora*	CME
		Coral *Tubipora*	CTU
		Coral *Heliopora*	CHE
Soft coral	Other	Soft coral	SC
Turf algae		Turf algae	TA
Halimeda		Halimeda	HA
Macroalgae		Macroalgae	MA
Other		Sponge	SP
		Hydroids	HY
		Other	OT
Abiotic hard		Dead coral	DC
* *also analyzed separately*		Bleached coral	BC
		Rock	RCK
CCA		Crustose coralline algae	CCA
Abiotic mobile		Sand	S
		Silt	SI
* *also analyzed separately*		Rubble	RB

3.2.3 FISH UNDERWATER VISUAL CENSUS

Underwater Visual Census (UVC) was used to survey the fish assemblage at the designated sites (Amkieltiela and Wijonarno 2015) (Figure 3.5), carried out with belt transects of different widths (resulting in areas of 100 – 250 m^2 for small fish (0 – 35 cm total length(TL)), and 250 – 1000 m^2 for bigger fish (>35 cm)). This allowed for better precision when sampling fishes of different size and mobility. Five 50 m transects were deployed at a depth of 8-12 m (some sites also included shallow sites, and depths were pooled for analysis) by a diver following two fish experts, one recording small fish (10-35 cm TL) and the other recording big fish (>35 cm TL). Some survey teams (WCS) also included fishes < 10 cm. The two fish surveyors swam along the transect parallel to the shoreline, counted the fish and estimated the total length of individual fish to the closest cm for each target species. Target species included carnivorous species that are economically important, and herbivorous fishes that play an important role within the reef ecosystem by reducing algal biomass (Table 3.4). Non-target species (all species of diurnal, non-cryptic, reef-associated fishes not listed as target species) were recorded by WCS; other survey teams only recorded 3-4 non-target species at T0 and added a broader range of species at T1; non-target species were not analysed for these MPAs.

Long swims were used to capture larger, more mobile species and those that tend to be rare or have a patchy distribution (Choat and Pears 2003, Wilson and Green 2009). The long swim method was a 20-minute swim at a standardized swimming speed (about 20 m per minute), parallel to the reef crest at a depth of approximately 3-5 m on the reef front. All large individuals (>35 cm TL) of large and vulnerable reef fishes listed (Table 3.4) were counted and their size estimated to the closest cm along a 20-m wide area of reef slope (10 m either side of the observer). Optimal transect dimensions were 400 m x 20 m (with the exception of WWF, which used 300 m x 20 m transects).

Table 3.4 Fish families and trophic groups included in the SEA Project monitoring surveys. See Appendix VI for all species, including non-target taxa.

Fish family (Target Group)	Local and/or common name	Trophic group	Included in EKKP3K
Acanthuridae	Butana / Kulit pasir / Tabasan (surgeonfish)	Herbivore	Yes
Labridae - Scarinae	Kakatua (parrotfish)	Herbivore	Yes
Siganidae	Baronang (rabbitfish)	Herbivore	Yes
Labridae - *Cheilinus undulatus*	Napoleon (Napoleon wrasse)	Herbivore	Yes
Serranidae	Kerapu (groupers)	Carnivore	Yes
Lutjanidae	Kakap (snappers)	Carnivore	Yes
Lethrinidae	Lencam (emperors)	Carnivore	Yes
Carangidae	Kuwe / Selar / Kembung / Sulir (trevallies)	Carnivore	Yes
Scombridae	Tenggiri (tunas and mackerels, e.g. dogtooth tuna *Gymnosarda unicolor*)	Carnivore	Yes
Caesionidae	Yellowtail (fusiliers)	Carnivore	Yes
Haemulidae	Gerot-gerot (sweetlips)	Carnivore	Yes
Nemipteridae	Kurisi (bream)	Carnivore	Yes

Fish family (Target Group)	Local and/or common name	Trophic group	Included in EKKP3K
Sphyraenidae	Barakuda (barracudas)	Carnivore	Yes
Carcharhinidae	Requiem sharks – grey reef sharks, whitetip and blacktip reef sharks	Carnivore	Yes
Sphyrnidae	Hammerhead sharks	Carnivore	Yes
Dasyatidae	Ray	Carnivore	Yes
Kyphosidae	Drummers/Rudderfish	Herbivore	No
Mullidae	Goatfish	Benthic invertivore	No

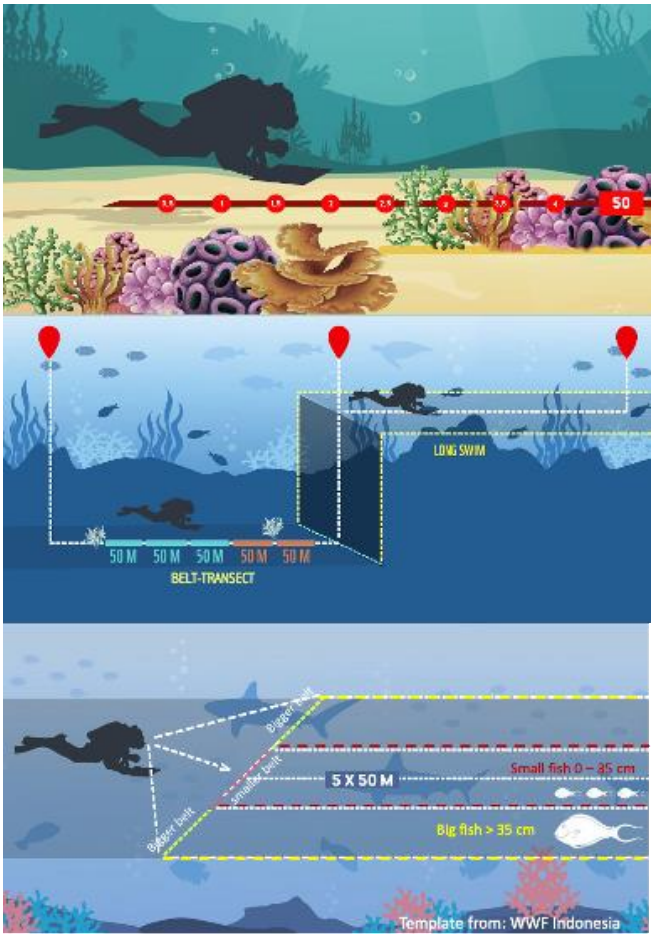


Figure 3.5 Schematic diagram showing the survey protocol, including the Point Intercept Transect (PIT) method used to record benthic communities, the Underwater Visual Survey (UVC) method to record fish abundance and the long swim method for larger, more mobile fishes and sharks.

3.3 STATISTICAL ANALYSIS

Benthic and fish communities were visualised graphically by calculating average values by depth (for benthic communities only) and zones within each MPA, and then producing average values across MPAs within each province. Benthic communities were described using % cover averages of the categories described above (see Table 3.3). Fish communities were presented using average biomass (kg per hectare) and density (individuals per hectare) and species richness (number of species per transect) of summed target and, where available, non-target species (target fish families see Table 3.4).

Survey teams that worked in Koon, Lease, Serutbar, Rao-Dehegila and Sula MPAs changed the non-target species they counted between the baseline and the follow-up surveys; non-target species are not presented for these MPAs. Benthic categories and target fish families were used in multivariate analyses to assess differences in assemblage structure between zones and MPAs. Spatial patterns of benthic and fish assemblages were explored using non-metric multidimensional scaling (MDS). The analyses were based on Bray-Curtis similarity of log(x+1) transformed percentage cover data with Primer-e Version 7.

To account for differences in sampling between NGOs and site differences between baseline (T0) and T1 surveys, data were analysed in two ways:

1. Baseline (T0) and T1 data were analysed separately, using all sites sampled in each period, and
2. Baseline (T0) and T1 data were compared for a subset of sites that were surveyed at both times.

Linear mixed effects models were conducted using the *lme* function in the statistical package R, to test for differences between zone, depth and survey period within each MPA. The analysis was conducted as follows:

1. Benthic category *or* Target/Non-target fish ~ Zone x Depth + (1/Site) for each survey period individually
2. For temporal comparisons, a number of potential models were compared, containing different combinations of Time, Zone and Depth, with Site as a random factor. The model with the lowest Akaike Information Criterion (AIC) was selected as the one that best explained the variation in the response variable (Benthic category *or* Target/Non-target fish). The significance of the factors in the chosen model were tested with Analysis of Variance. Data were log (x+1) transformed to comply with assumptions of linear model testing, and these analyses were conducted using the *lme* function in the statistical package R (Bates et al. 2015).

RESULTS AND DISCUSSION

4.1 MALUKU PROVINCE

4.1.1 AY RHUN MPA

a) Benthic community

Live coral was the dominant life form on coral reefs in Ay-Rhun MPA and was similar between shallow (44.9%) and deep (43.7%) habitats (Figure 4.1). Control sites had significantly less coral (41%) than sites inside the MPA (52.6%; Figure 4.2). Ay-Rhun had very low cover of algae, except for crustose coralline algae (CCA), which was present mostly in shallow habitats (12.7%) and provides a favourable substrate for new coral settlement. Soft coral cover was between 10 and 16%. The cover of other sessile organisms (e.g. sponges, zoanthids, hydroids, etc.) was higher in deeper areas (9.8%) than in shallow areas (3.2%). Abiotic (non-living) cover was ~ 20% and tended to be higher at control sites.

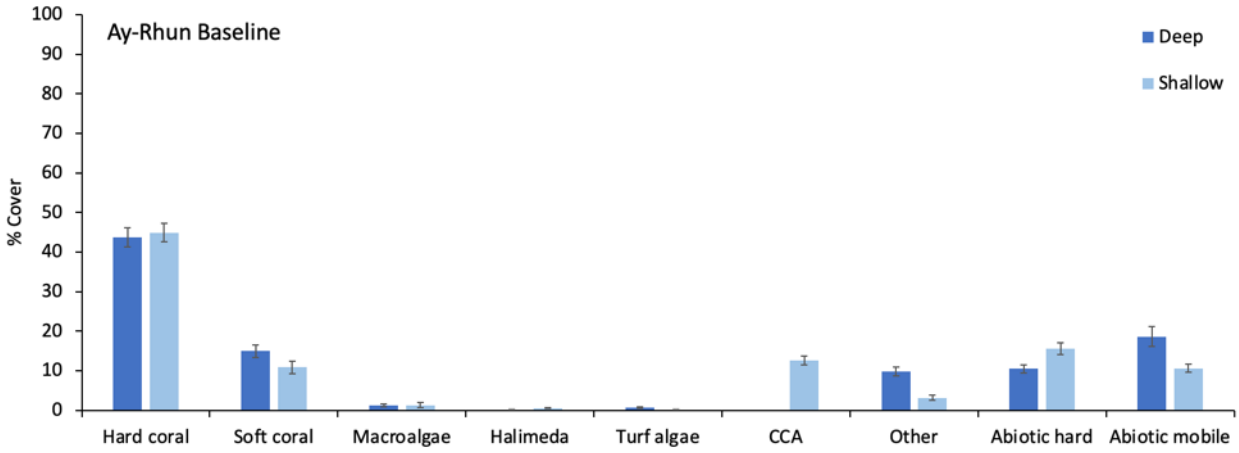


Figure 4.1 Percentage cover of key benthic categories across deep and shallow habitats in Ay-Rhun MPA during the baseline survey (T0). There was no repeat (T1) survey for this MPA. For statistical analysis of the differences in benthic communities, see Appendix II. Error bars = 1 SE.

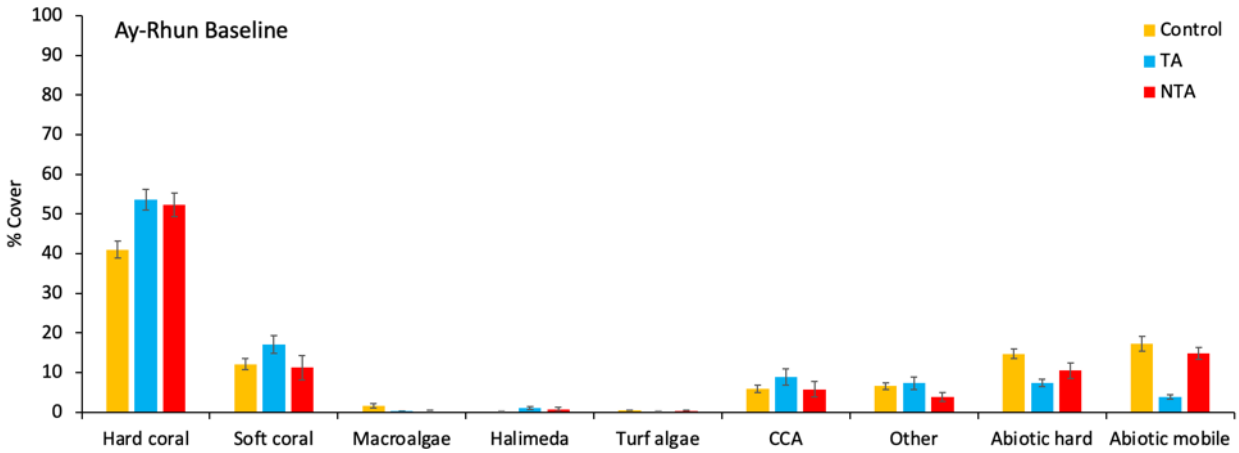


Figure 4.2 Percentage cover of key benthic categories by management zone in Ay Rhun MPA, during the baseline survey (T0). There was no repeat (T1) survey for this MPA. For statistical analysis of the differences in benthic communities, see Appendix II. Error bars = 1 SE.

b) Fish community

The biomass and density of target fish families were highly variable (large error bars in Figure 4.3). There was significantly lower biomass of target fish families at control sites than inside Ay-Rhun MPA, where biomass was 1,500-2,000 kg per hectare in both fished (TA) and no-take areas (NTA). Density was more variable, and although there was also a tendency for lower density at control sites (8,371 individuals per hectare, compared with 18,786 in the TA and 25,986 in the NTA), this difference was not significant (Appendix III).

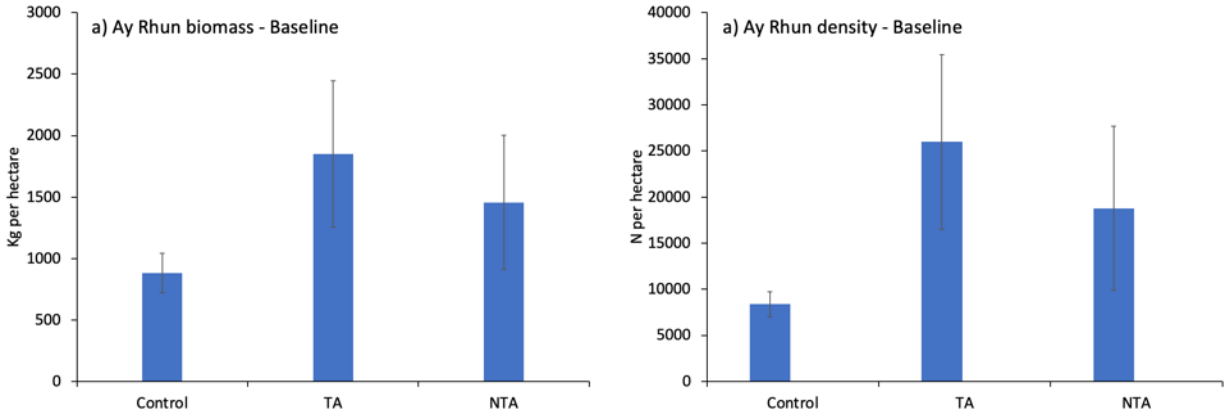


Figure 4.3 Biomass (kg per hectare) and density (individuals per hectare) of target fish families by management zone in Ay-Rhun MPA. Baseline a) biomass and b) density means recorded in Ay-Rhun MPA. For statistical analysis of the differences in fish communities, see Appendix III. Error bars = 1 SE.

c) Charismatic species

Ay Rhun MPA and surrounding islands (Banda MPA network) comprises one of the key cetacean habitats in Maluku Province, and is a known whale migration area. About 20 individual spotted dolphins (*Stenella frontalis*) and one blue whale (*Balaenoptera musculus*) were observed inside the Ay Rhun MPA boundary in 2019 (Figure 4.4). Outside the MPA boundary, melon-headed whales (*Peponocephala electra*) were observed between Hatta and Batuindang Islands, and whale sharks (*Rinchodon typus*) were recorded at the Uring site on Batuindang Island. Napoleon wrasse (*Cheilinus undulatus*) and bumphead parrotfish (*Bolbometopon muricatum*) were also abundant during the 2019 survey.

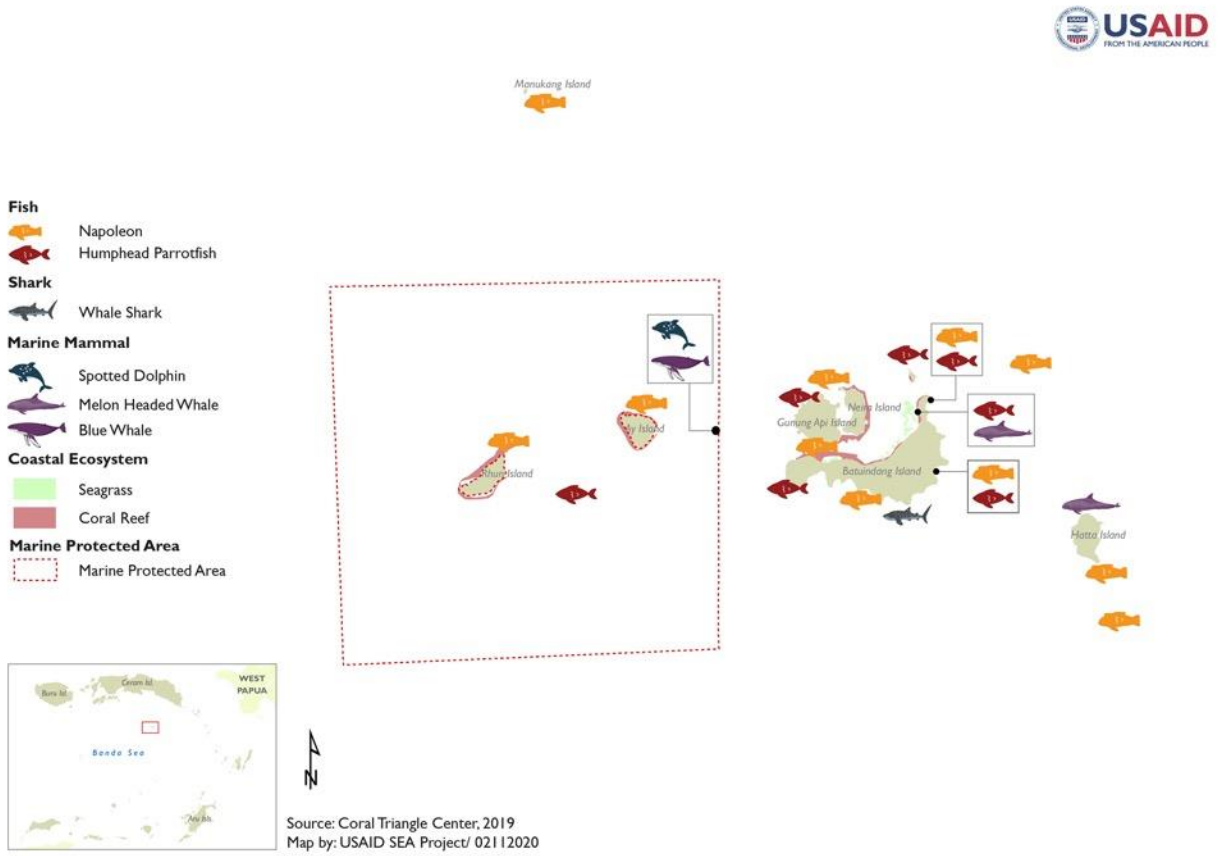


Figure 4.4 Charismatic species map around Ay-Rhun MPA (2019).

d) Management status

Ay-Rhun has not yet officially been declared by Ministerial Decree, although the area is included in the Provincial Marine Spatial Plan or RZWP3K (*Rencana Zonasi Wilayah Pesisisr dan Pulau-Pulau Kecil*). The RZWP3K has been authorized under the Provincial Regulation No. 1 Year 2018 as a conservation area. The management of the area falls under Gugus Pulau (Island Cluster) 6, which covers the entire Banda Islands. Currently, Ay-Rhun has a management plan waiting for final approval from the Ministry of Marine Affairs and Fisheries (MMAF). There is currently no or limited implementation yet of MPA regulations. The surveillance of the MPA is the responsibility of the community surveillance group POKMASWAS (*Kelompok Pengawas Masyarakat*). The POKMASWAS received official recognition from the Maluku Provincial Fisheries Agency (DKP) in 2019, and the community has conducted monitoring activities ever since.

4.1.2 BUANO MPA

a) Benthic community

In Buano MPA, deeper reef areas had similar cover of hard corals (31.6%) and abiotic (non-living) mobile cover such as sand, silt and rubble (32.4%; Figure 4.5). Deeper sites also had 19.3% cover of soft corals and 13.1% cover of other sessile organisms. In shallow areas, hard coral cover dominated the benthic community (48.1%), along with hard substrate and some turf algae (6.8% and 2.9%, respectively). Differences between depth zones were significant for almost all categories except soft corals, macroalgae and other sessile invertebrates (Appendix II).

No control sites were surveyed at T0, but no-take areas (NTA) had higher cover of hard corals (45.2% vs. 36.3%) than fished areas (TAs), different types of algae and more sessile invertebrates in the "Other" category (Figure 4.6). TAs had higher cover of soft corals (23.7% vs. 8.3%) and abiotic mobile substrates (27.4% vs. 20.1%). NTAs in Buano MPA appear to have been placed in areas with favourable coral habitat.

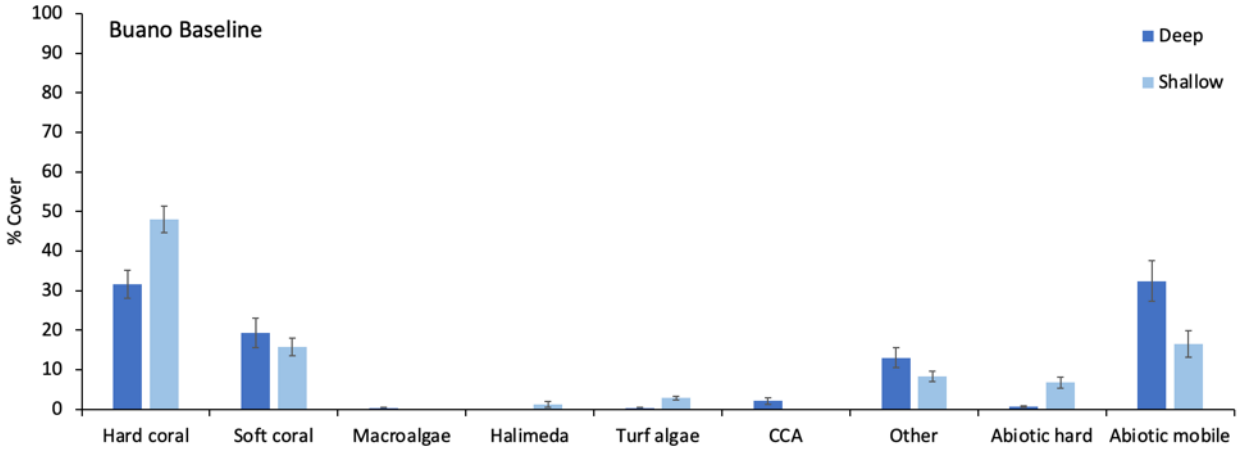


Figure 4.5 Percentage cover of key benthic categories across deep and shallow habitats in Buano MPA during the baseline survey (T0). There was no repeat (T1) survey for this MPA. For statistical analysis of the differences in benthic communities, see Appendix II. Error bars = 1 SE.

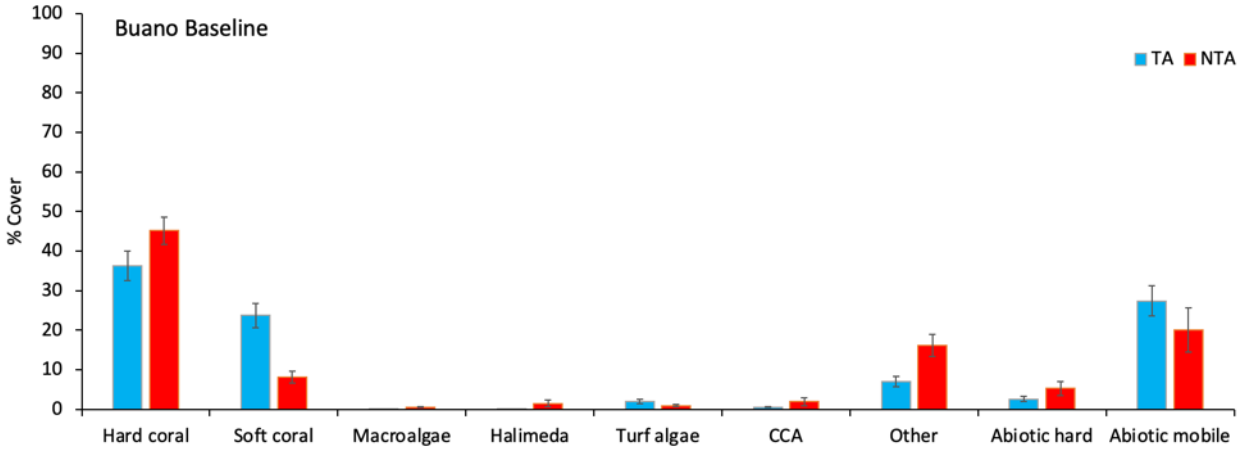


Figure 4.6 Percentage cover of key benthic categories by management zone in Buano MPA, a) during the baseline survey (T0). Note that no control sites were included in the

baseline survey, and there was no repeat (T1) survey for this MPA. For statistical analysis of the differences in benthic communities, see Appendix II. Error bars = 1 SE.

b) Fish community

The biomass of target fish in Buano MPA was higher in NTAs (3,439 kg per hectare) than in TAs (2,602 kg per hectare), but density was similar (5,660 vs. 5,021 individuals per hectare; Figure 4.7), suggesting that there were lower numbers of fish in the NTA, but fish tended to be larger.

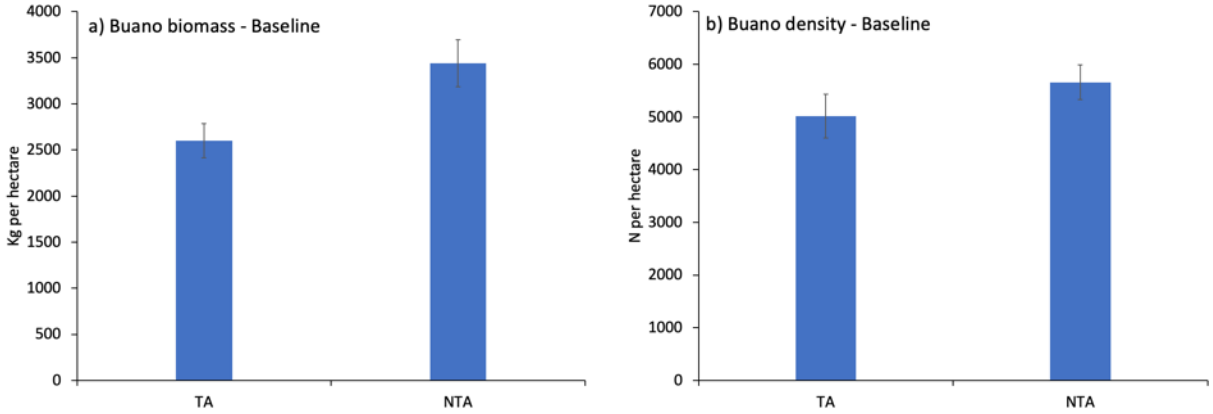


Figure 4.7 Biomass (kg per hectare) and density (individuals per hectare) of target fish families by management zone in Buano MPA. Baseline a) biomass and b) density means were calculated using all families recorded in Buano MPA; this may differ from families surveyed in other MPAs. For statistical analysis of the differences in fish communities, see Appendix III. Error bars = 1 SE.

c) Charismatic species

Risso's (*Grampus griseus*) and bottlenose dolphins (*Tursiops truncatus*), baleen (Mysticeti), melon-headed (*Peponochephala electra*) whales and dugong (*Dugon dugon*) were listed in the survey data of 2017. Additionally, 50 spotted dolphins (*Stenella frontalis*) were recorded along the east side of Buano Island. Baleen whales and dugong were observed in the south of Buano, and a whale shark (*Rhincodon typus*) and reef mantas (*Manta alfredi*) were observed in the Tanjung Pamali Core Zone. Napoleon wrasse (*Cheilinus undulatus*) were also commonly found around the Buano MPA. Green (*Chelonia mydas*), hawksbill (*Eretmochelys imbricata*) and leatherback (*Dermochelys coriacea*) turtles were spotted from Pua Island to the north site of Buano (Naiselan Village).

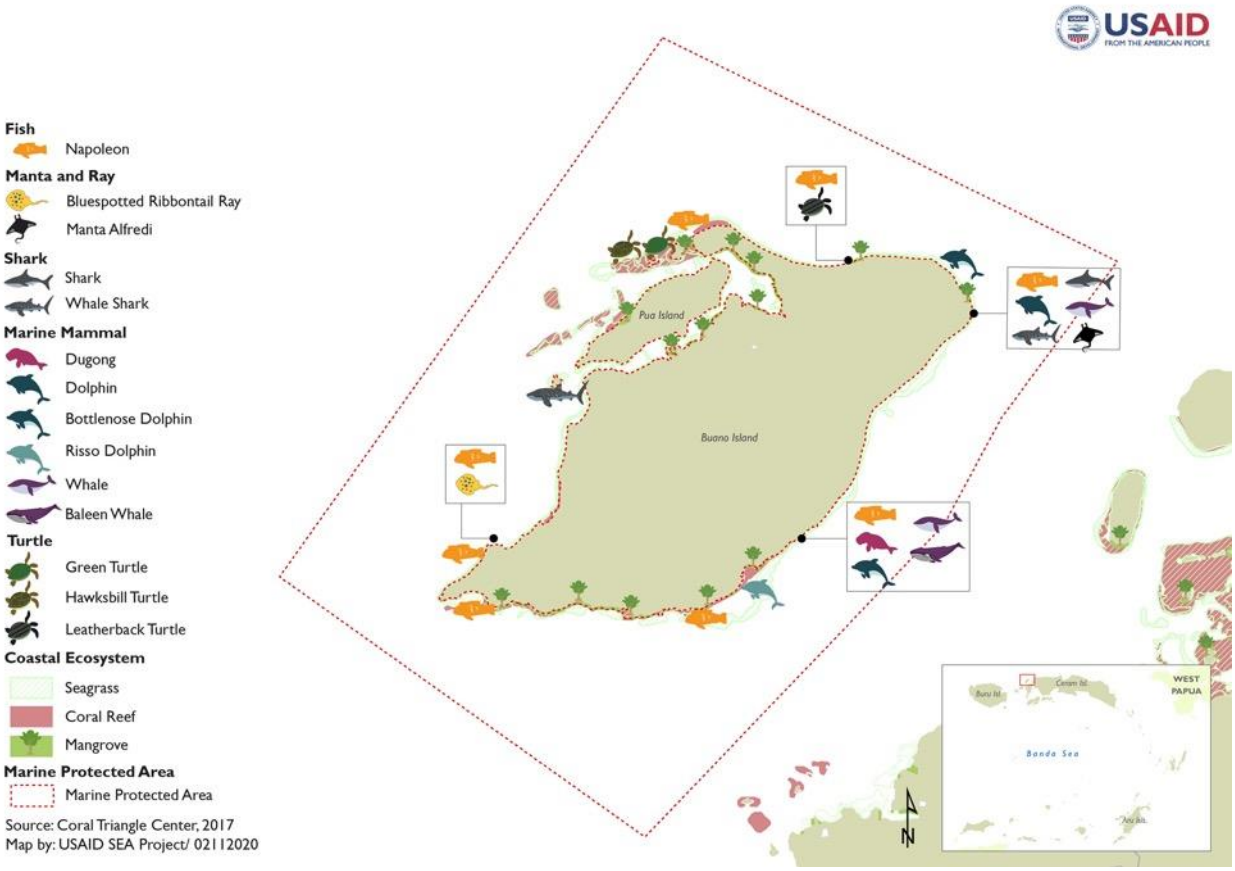


Figure 4.8 Charismatic species map around Buano MPA from 2017 survey data.

d) Status of management

Buano Island MPA has not yet been officially declared by Ministerial Decree, although the area is included in the Provincial Marine Spatial Plan or RZWP3K (*Rencana Zonasi Wilayah Pesisir dan Pulau-Pulau Kecil*) as a conservation area. The RZWP3K has been authorized under the Provincial Regulation No. 1 Year 2018. The management of the area falls under Gugus Pulau (Island Cluster) 2, which covers the entire western part of Seram Island. Currently, Buano has a management plan waiting for final approval from the Ministry of Marine Affairs and Fisheries (MMAF). Regulations have yet to be implemented in the MPA. The surveillance of the MPA will be under the jurisdiction of a community surveillance group called POKMASWAS (*Kelompok Pengawas Masyarakat*). The POKMASWAS has received official recognition from the Maluku Provincial Fisheries Agency (DKP) in 2019, and the community has conducted monitoring activities since then.

4.1.3 KOON MPA

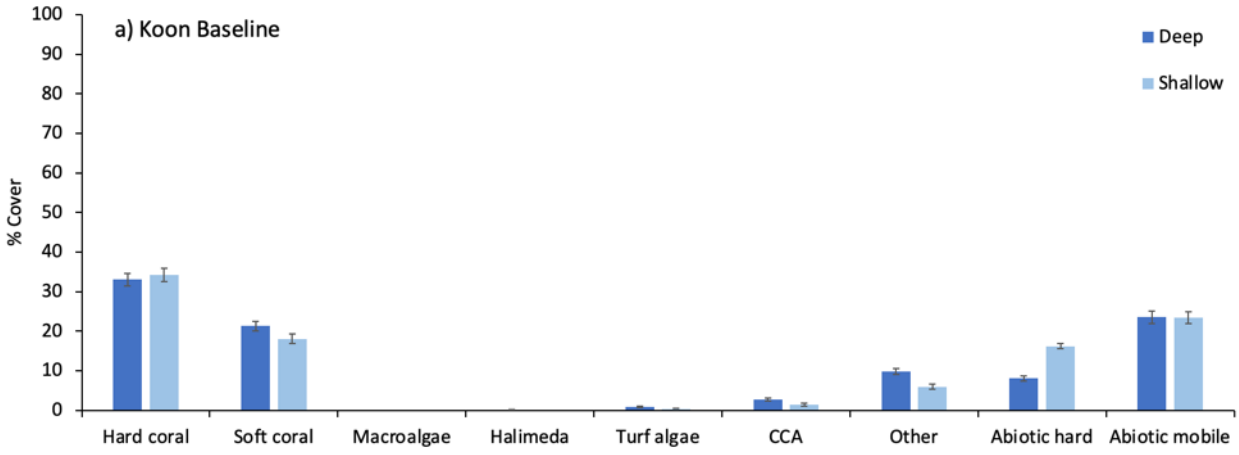
a) Benthic community

The baseline (2016) survey of Koon MPA reported hard coral cover of around 30% and abiotic (non-living) cover of around 20%, and analysis showed that these categories were similar between deep and shallow habitats (Appendix II; Figure 4.9). Deep areas had higher cover of soft coral (21.3% vs. 18.1%), turf algae, CCA and other sessile invertebrates (although all <10% cover), while shallow areas had higher cover of abiotic hard substrate such as rock or dead coral (16.2% vs. 8.1%). Baseline surveys also revealed differences between zones, with higher hard coral in TAs (39.2%) than NTAs (26.9%), higher soft coral cover at NTA sites (26.7%), higher turf algae cover at control sites (1.5%), and higher abiotic hard cover in the MPA than at control sites (11% vs. 6.5%; Figure 4.10).

Follow-up surveys in 2018 (T1) showed increased coral cover, but only in shallow areas (37.2%; Figure 4.9) and at control and TA sites (37.7%; Figure 4.10). Similar zone differences were recorded at T1 for the other categories, except other sessile invertebrates, which were highest in NTAs in 2018 (9.2%), and CCA, which was higher at MPA (in both TA and NTA; 2.1%) than control sites (0.8%). Soft coral, CCA and other sessile invertebrates all declined significantly between 2016 and 2018 (Appendix II; Figure 4.11).

During the latest survey in 2020 (T2), hard coral had declined to 31% cover (although this remains higher than the baseline value) and soft corals increased in shallow habitats (23.6%); other benthic categories remained similar to 2018 (Figure 4.9). TA sites showed the largest increase in soft corals (15.3 to 17.8%; Figure 4.10).

The overall difference in hard coral cover, when comparing only sites surveyed in all years, was not significant (Appendix II; Figure 4.11). Overall, significant differences over time included the decline and recovery of soft corals other sessile invertebrates and CCA and the increase and decline in abiotic hard substrate (Appendix II; Figure 4.11). This suggests a potential recovery of the benthic community from mortality events between the baseline and T1.



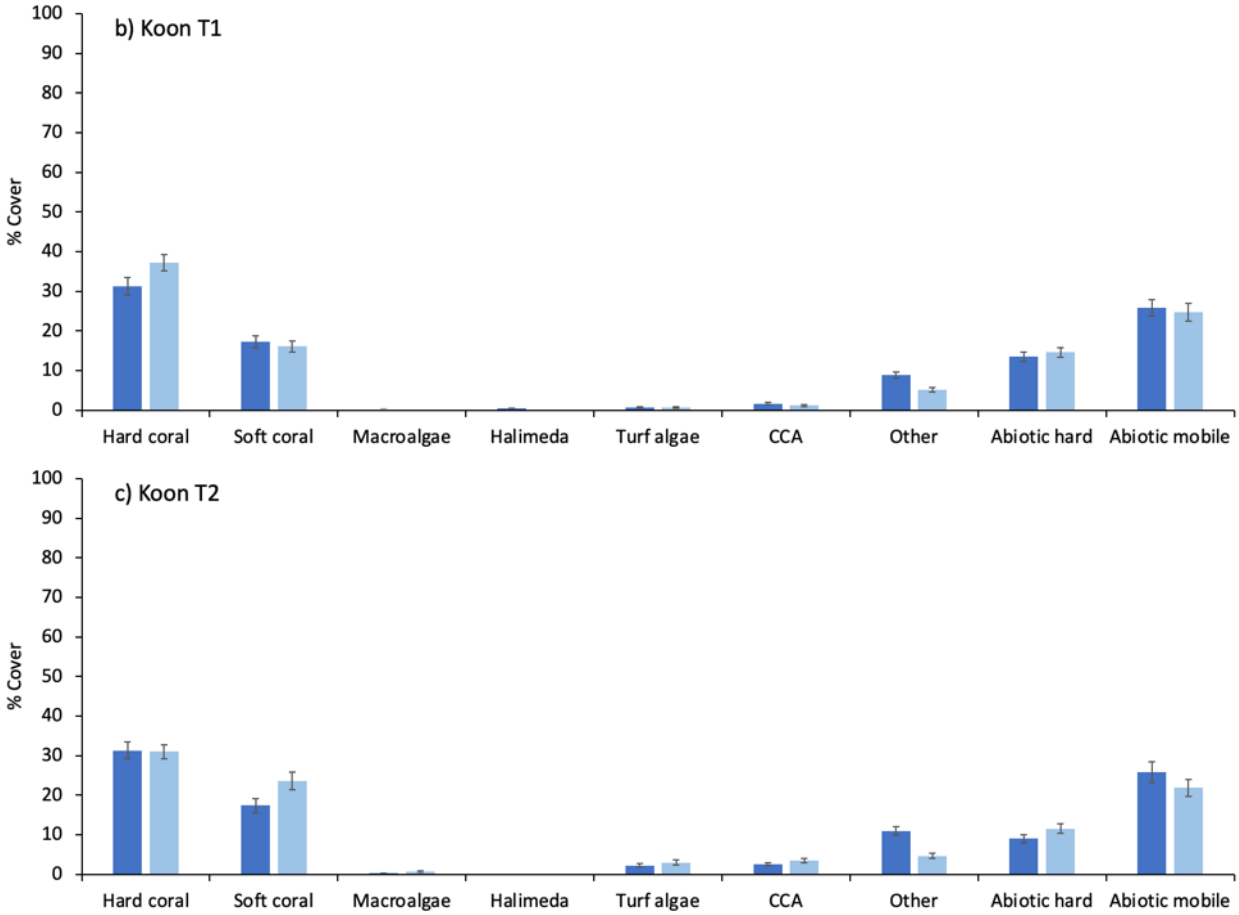
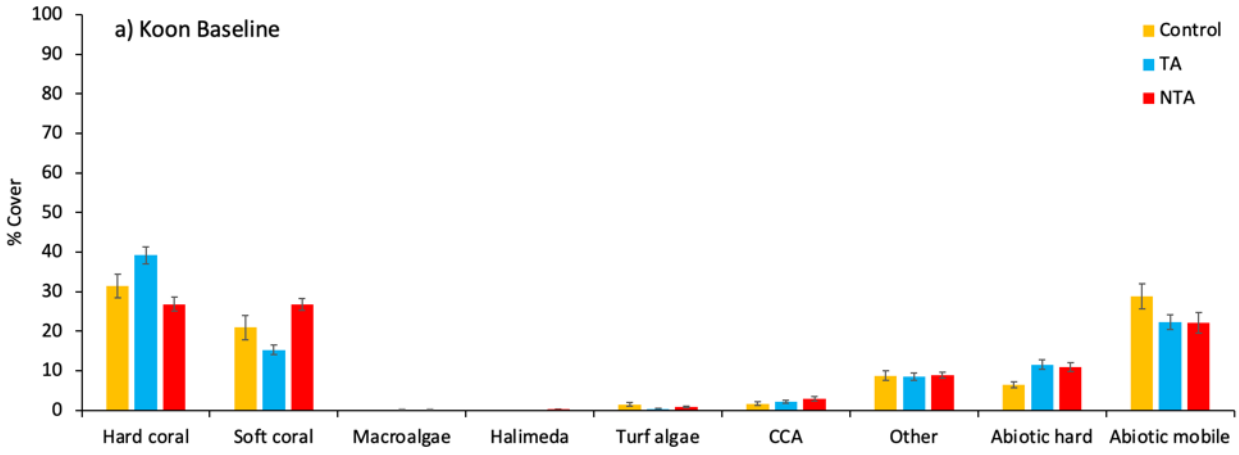


Figure 4.9 Percentage cover of key benthic categories across deep and shallow habitats in Koon MPA, a) during the baseline survey (T0); b) at the T1 repeat survey and c) at the T2 repeat survey. Note that some site differences occurred between the two survey periods. For statistical analysis of the differences in benthic communities, see Appendix II. Error bars = 1 SE.



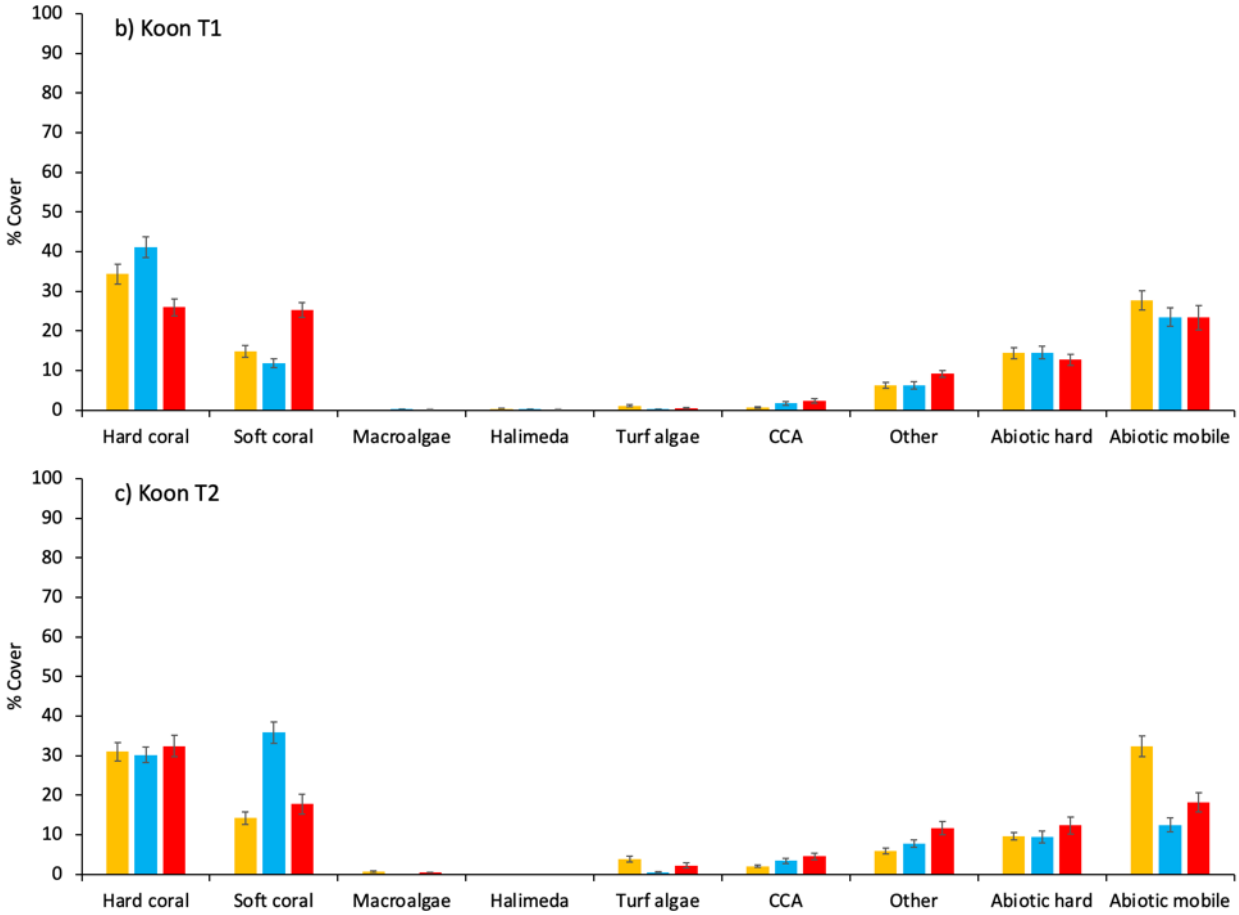


Figure 4.10 Percentage cover of key benthic categories by management zone in Koon MPA, a) during the baseline survey (T0) and b) at the T1 repeat survey. Note that some site differences occurred between the two survey periods. For statistical analysis of the differences in benthic communities, see Appendix II. Error bars = 1 SE.

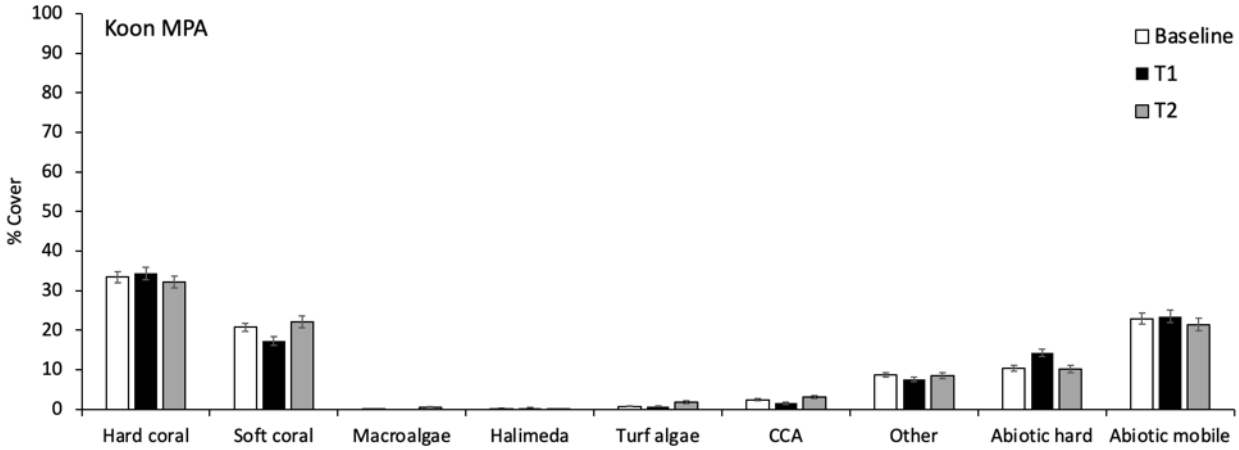
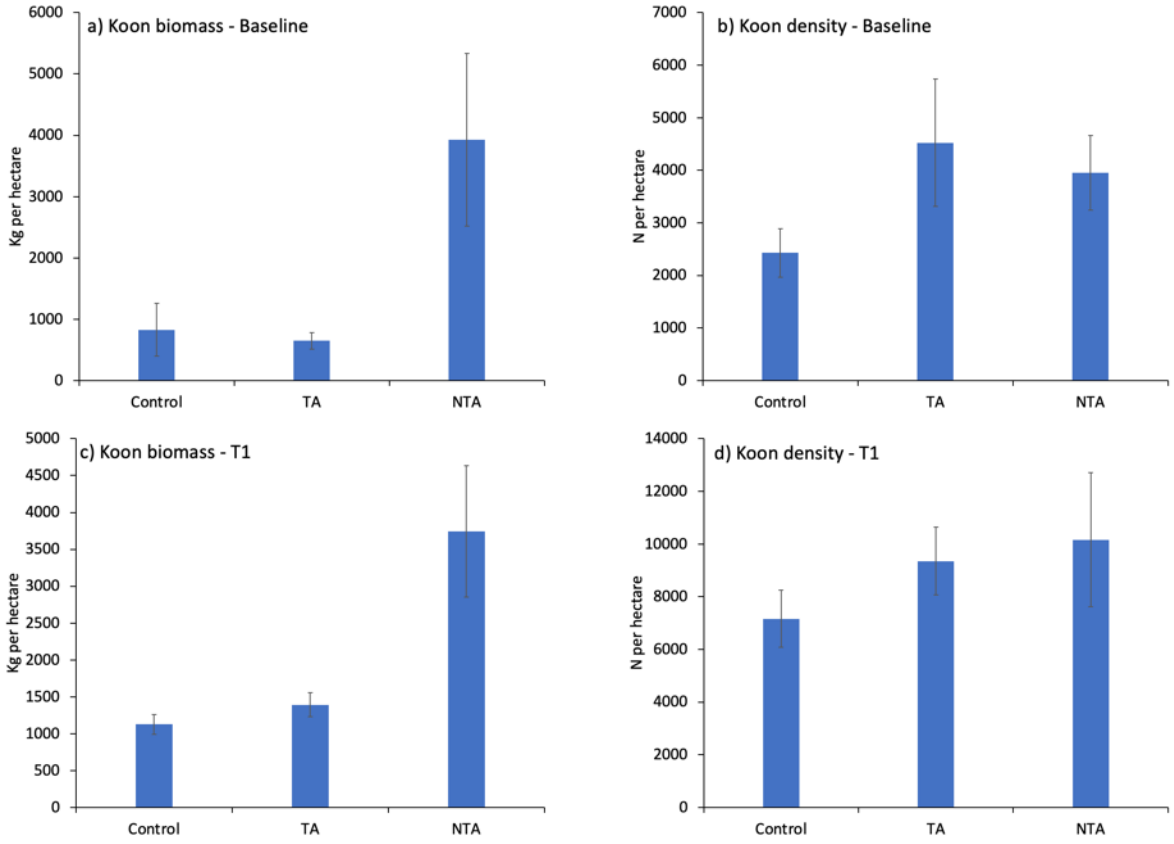


Figure 4.11 Percentage cover of key benthic categories by survey period in Koon MPA. Only sites surveyed in all three periods were included in calculating the mean values. For statistical analysis of the differences in benthic communities, see Appendix II. Error bars = 1

b) Fish community

The biomass and density of target fish families in Koon MPA showed high variability, especially for higher biomass estimates (Figure 4.12), but there was significantly higher target biomass in NTAs (3,929 kg per hectare), both during the baseline and follow-up (T1) survey (3,743 kg per hectare). Target density increased between the baseline and T1, but variability remained very high and replication was lower. During T2 surveys in 2020, the pattern of higher target biomass in NTAs (1,129 kg per hectare) than in TAs (617 kg per hectare) and control sites (609 kg per hectare) was maintained, but all three zones had lower biomass than in T1. Target fish density also declined in T2 but remained similar in NTAs (Figure 4.12); this is generally a sign that populations are remaining stable. When comparing only sites that were surveyed in all years, there was an initial increase in target biomass and density between 2016 and 2018, followed by a decline in 2020 (Figure 4.13).



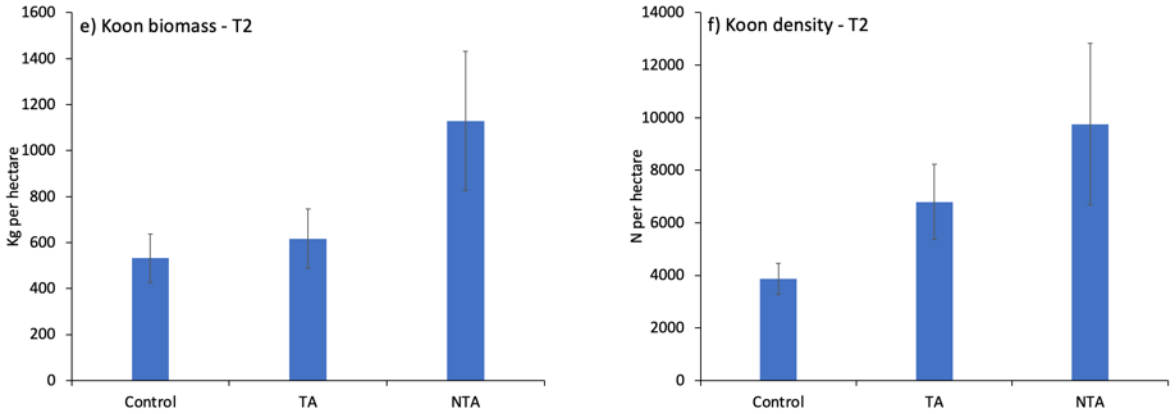


Figure 4.12 Biomass (kg per hectare) and density (individuals per hectare) of target fish families by management zone in Koon MPA. Baseline a) biomass and b) density, T1 c) biomass and d) density and T2 e) biomass and f) density means were calculated using all sites surveyed during the respective sampling periods. For statistical analysis of the differences in fish communities, see Appendix III. Note the differences between y-axes. Error bars = 1 SE.

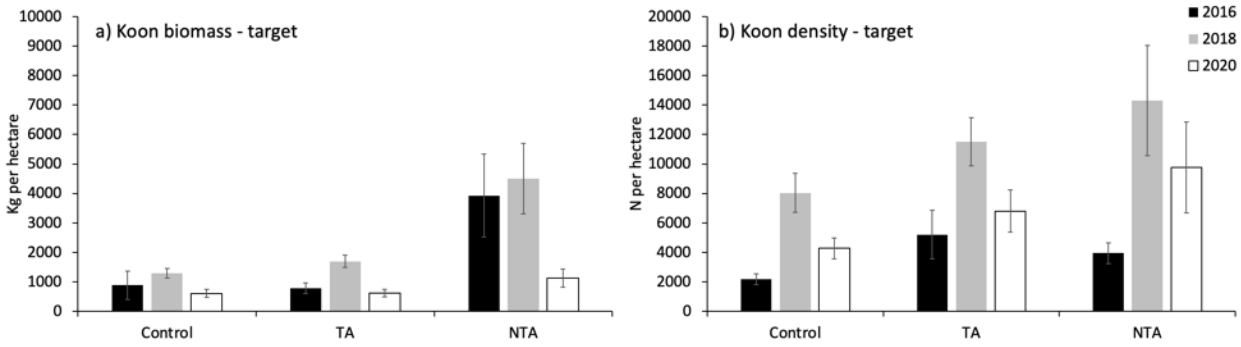


Figure 4.13 a) Biomass and b) density of target families by management zone in Koon MPA. Only sites surveyed in both periods were included in calculating the mean values. For statistical analysis of the differences in fish communities, see Appendix III. Error bars = 1 SE.

c) Charismatic species

Napoleon wrasse (*Cheilinus undulatus*) were spotted at every site during the 2018 survey; however they were only observed at three sites in 2020 (Figure 4.14 and Figure 4.15). Bluespotted ribbontail rays (*Taeniura lymma*) were abundant in 2017, but rare in 2020. Dugongs and whales were reported from around Nukus and Grogos Islands. Turtles were observed more frequently during the 2020 surveys than in 2018 (Figure 4.15); hawksbill turtles (*Eretmochelys imbricata*) and a whitetip reef shark (*Triaenodon obesus*) were seen at site KOE25 in 2020.

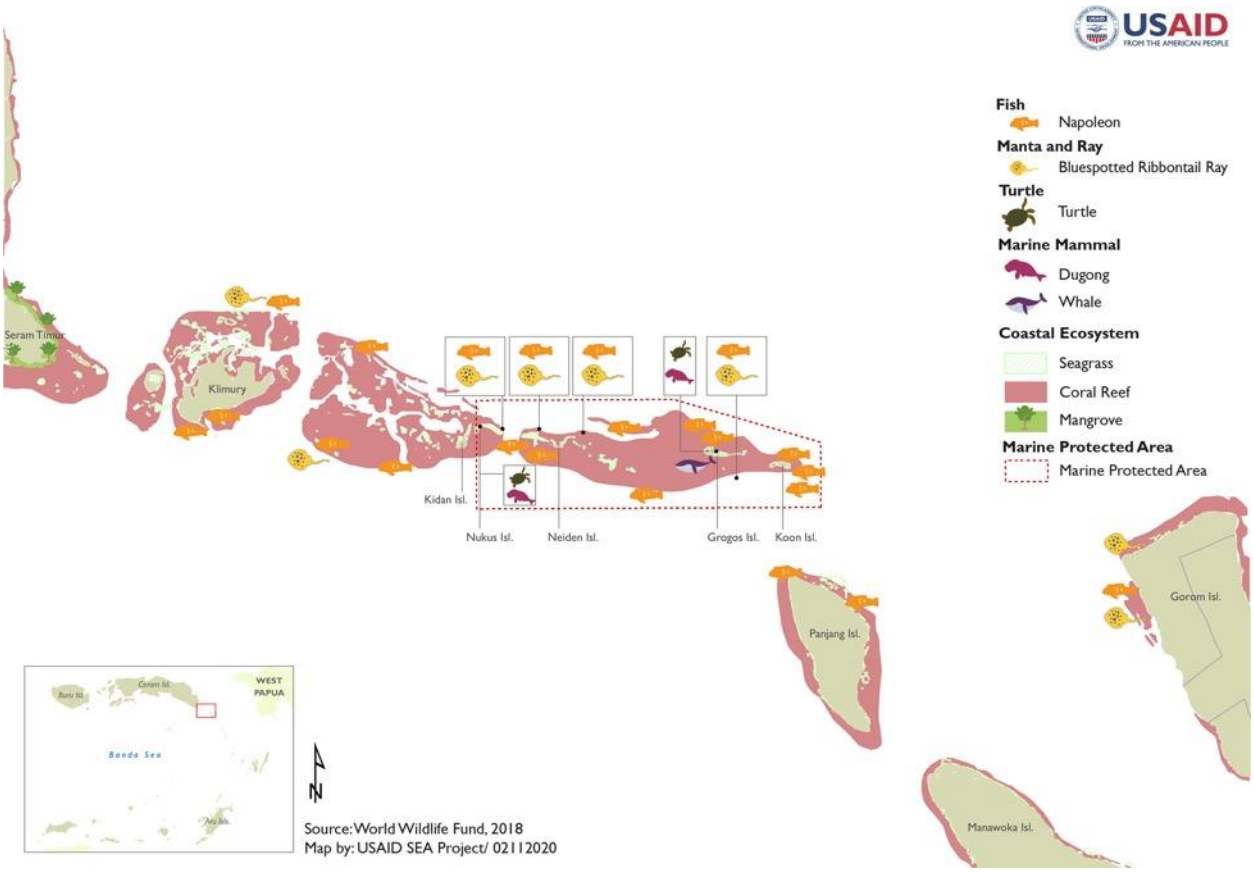


Figure 4.14 Charismatic species map around Koon MPA from 2018 survey data.

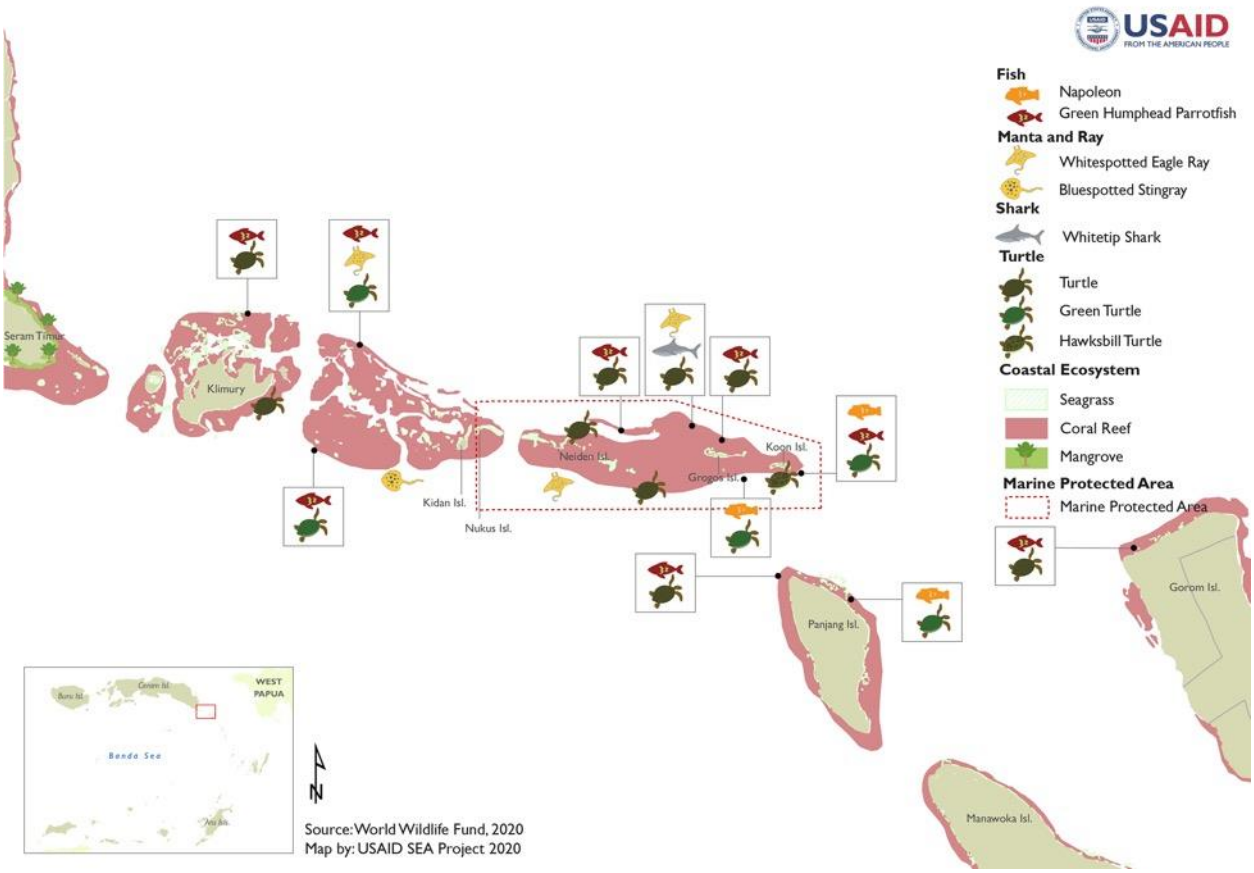


Figure 4.15 Charismatic species map around Koon MPA from 2020 survey data.

d) Status of management

Koon MPA has been protected by Ministerial Decree No. 65/Kepmen-KP/2020, and is included in the Provincial Marine Spatial Plan or RZWP3K (*Rencana Zonasi Wilayah Pesisisr dan Pulau-Pulau Kecil*) as a conservation area; this has been authorized under the Provincial Regulation No. 1 Year 2018. The management of the area falls under Gugus Pulau (Island Cluster) 4, which covers the entire eastern part of Seram Island. Currently, Koon has a management plan waiting for final approval from the Governor. MPA regulations have not been implemented. The surveillance of MPA is the responsibility of a community surveillance group called POKMASWAS (*Kelompok Pengawas Masyarakat*). The POKMASWAS has official recognition from the Maluku Provincial Fisheries Agency (DKP) in 2019, and the community has conducted the monitoring activities since then.

4.1.4 LEASE MPA

a) Benthic community

The baseline (2018) survey of Lease MPA showed a benthic community dominated by hard coral cover in both shallow (44.2%) and deep (42.1%) areas, followed by mobile abiotic (non-living) cover, which was higher in deep areas (33.1% vs. 27.4%; Figure 4.16). All categories showed a significant difference between depths except hard coral, soft coral and *Halimeda*. Shallow habitats had more turf (2.3%), CCA (2.1%) and hard substrata (15.4%), while deeper areas had higher cover of other sessile organisms (5.6%)

and abiotic mobile substrate (33.1%). NTAs in 2018 had higher hard coral cover (51.3%) than control sites (37.4%) and TAs (39%). Soft coral cover was also higher in NTAs (10.7%), while control sites had more abiotic substrata, both hard and mobile (Figure 4.17).

Follow-up surveys in 2020 (T1) showed similar patterns in benthic communities, as the differences between depths (Figure 4.16) and zones (Figure 4.17) were maintained. However, unlike the baseline surveys, turf algae (1.9%), CCA cover (2.1%) and other sessile invertebrates (5.2%) were higher in deep habitats. Hard abiotic cover was higher in shallow areas (10%). Few of the differences between the baseline and T1 were significant, but there was an increasing trend in corals and declining trend in algae and abiotic cover; the decline in abiotic hard cover was significant (Appendix II; Figure 4.18). This may be a sign of coral community recovery within the MPA.

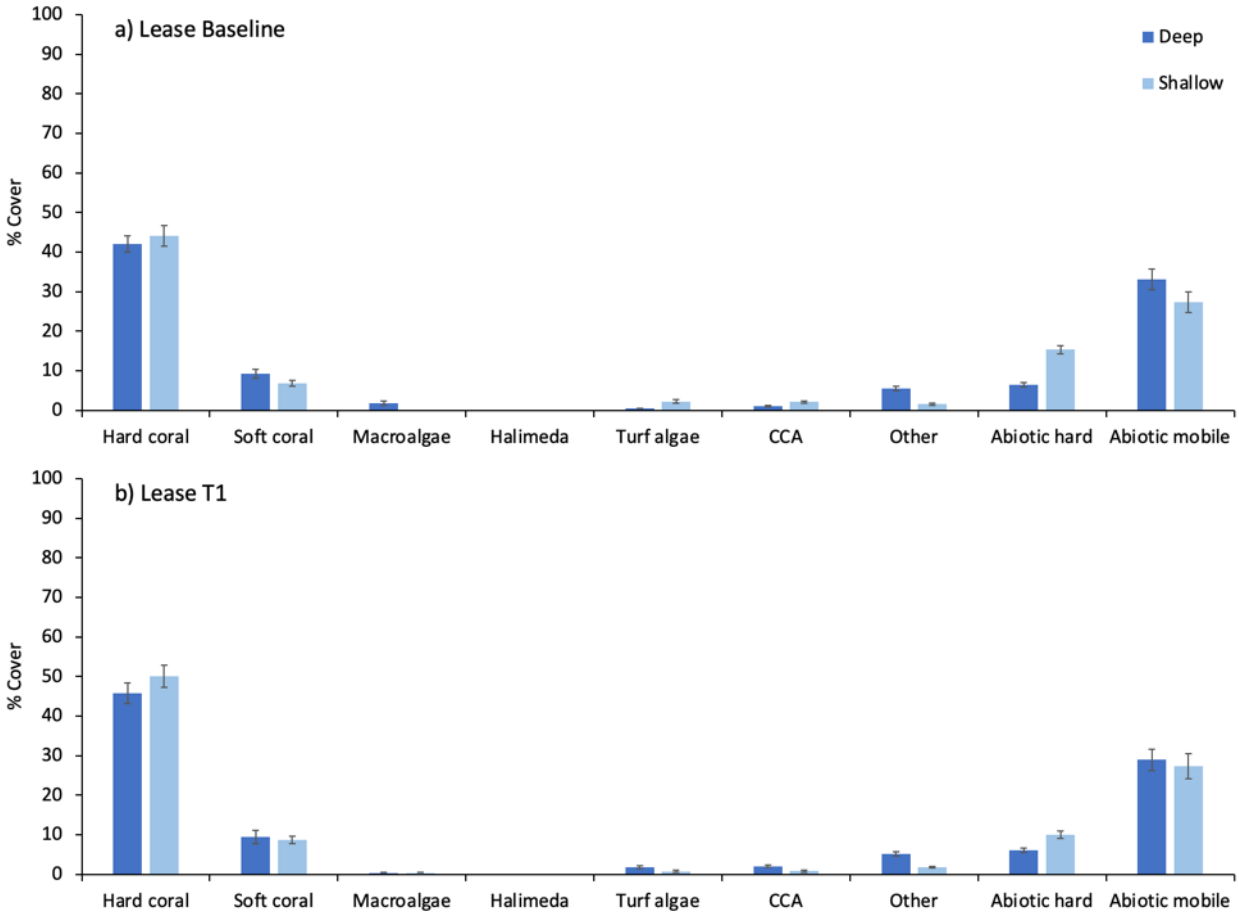


Figure 4.16 Percentage cover of key benthic categories across deep and shallow habitats in Lease MPA, a) during the baseline survey (T0) and b) at the T1 repeat survey. For statistical analysis of the differences in benthic communities, see Appendix II. Note that some site differences occurred between the two survey periods. Error bars = 1 SE.

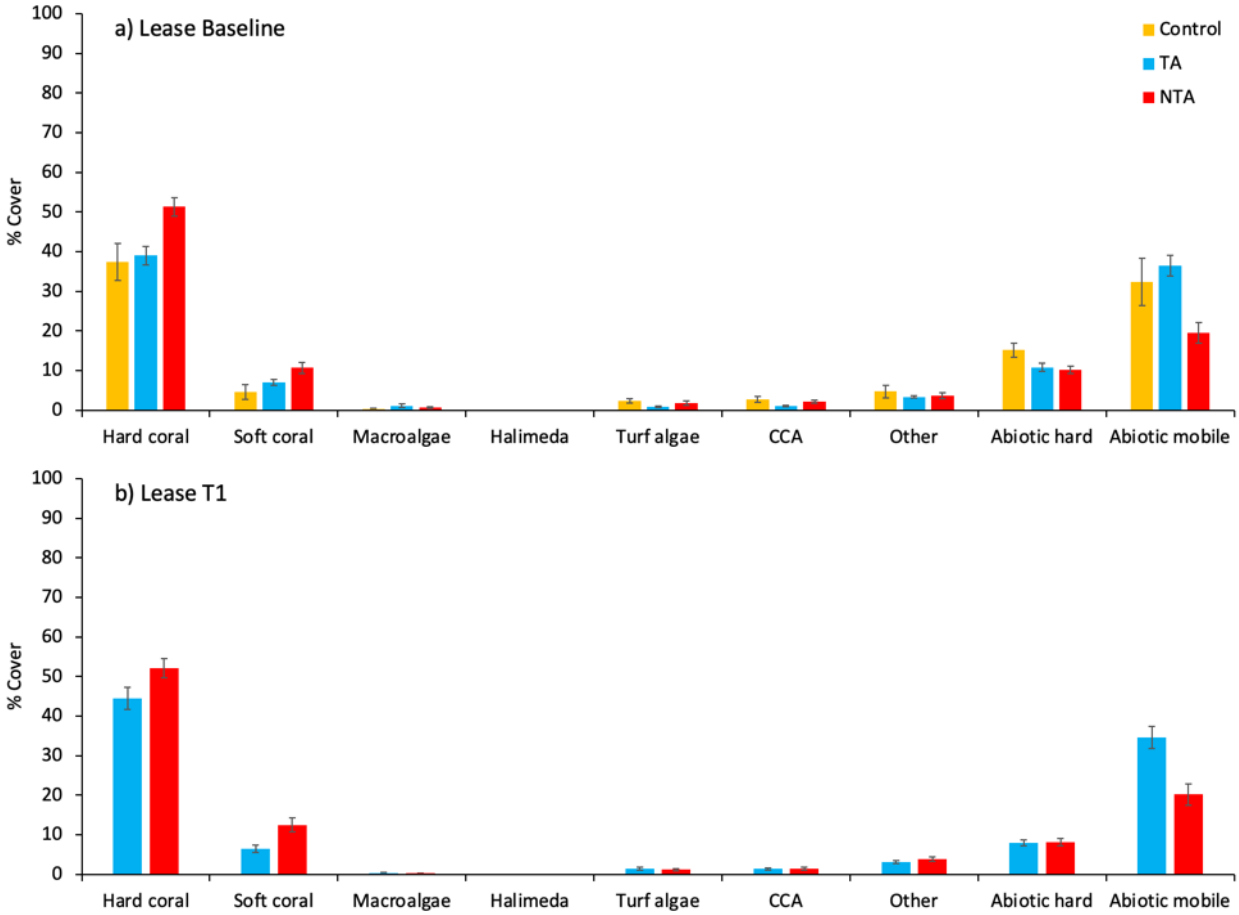


Figure 4.17 Percentage cover of key benthic categories by management zone in Lease MPA, a) during the baseline survey (T0) and b) at the T1 repeat survey. Note that no control sites were surveyed at T1, and some site differences occurred between the two survey periods. For statistical analysis of the differences in benthic communities, see Appendix II Error bars = 1 SE.

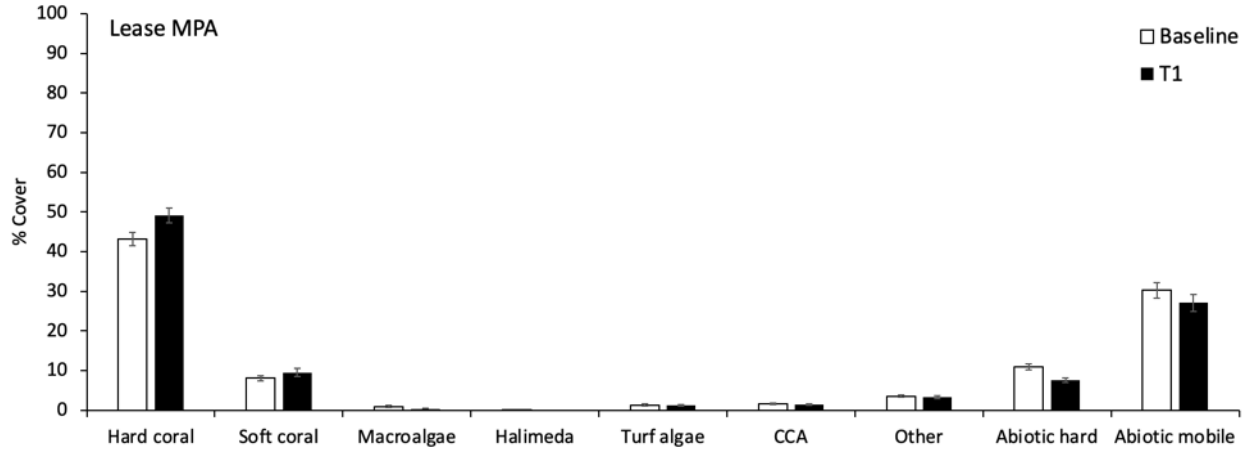
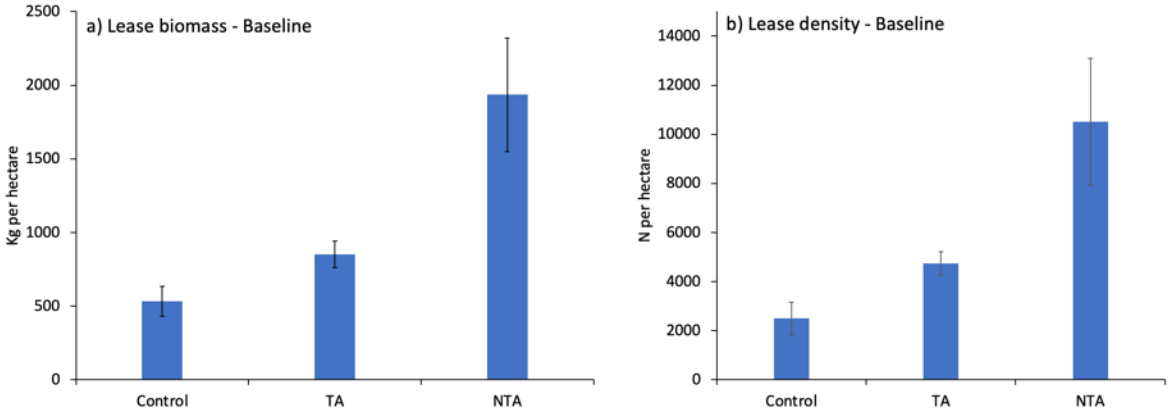


Figure 4.18 Percentage cover of key benthic categories by survey period in Lease MPA. Only sites surveyed in both periods were included in calculating the mean values. For statistical analysis of the differences in benthic communities, see Appendix II. Error bars = 1 SE.

b) Fish community

There was a gradual increase in target fish biomass and density from the control sites (524 kg and 2,495 individuals per hectare) to NTAs (1,936 kg and 10,510 individuals per hectare) detected during the baseline survey in 2018 in Lease MPA (Figure 4.19). The differences in target biomass and density between fished areas (TA) and NTAs were also present during the follow-up survey in 2020 (T1). A different pattern was observed when using only estimates from sites surveyed in both years, which was caused primarily by the loss of fish biomass from one site, LS08 (1,132 kg per hectare in 2018 and 253 in 2020). NTAs had lower target biomass and density than TAs, which declined between 2018 and 2020 (Figure 4.20).



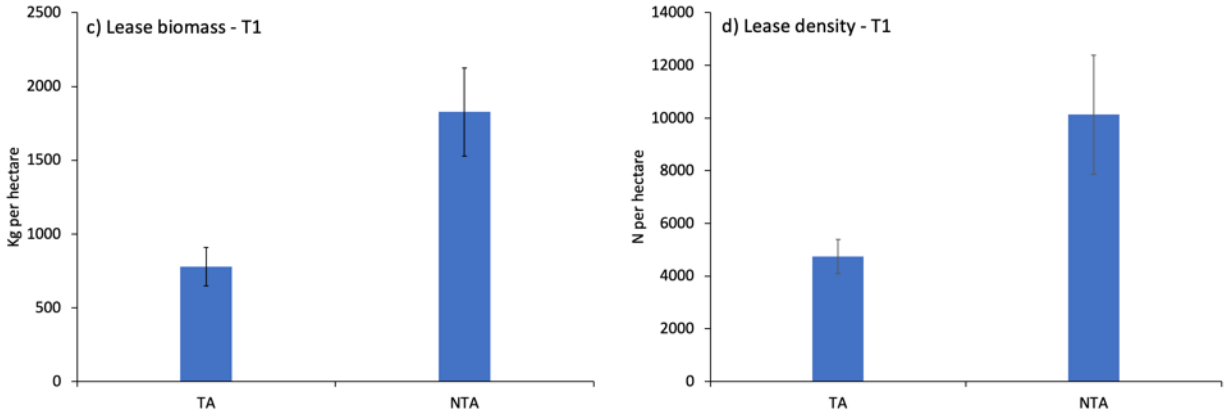


Figure 4.19 Biomass (kg per hectare) and density (individuals per hectare) of target fish by management zone in Lease MPA. Baseline a) biomass and b) density and T1 c) biomass and d) density means of target families were calculated using all sites surveyed during the respective sampling periods. No control sites were surveyed in 2020 (T1). For statistical analysis of the differences in fish communities, see Appendix III. Error bars = 1 SE.

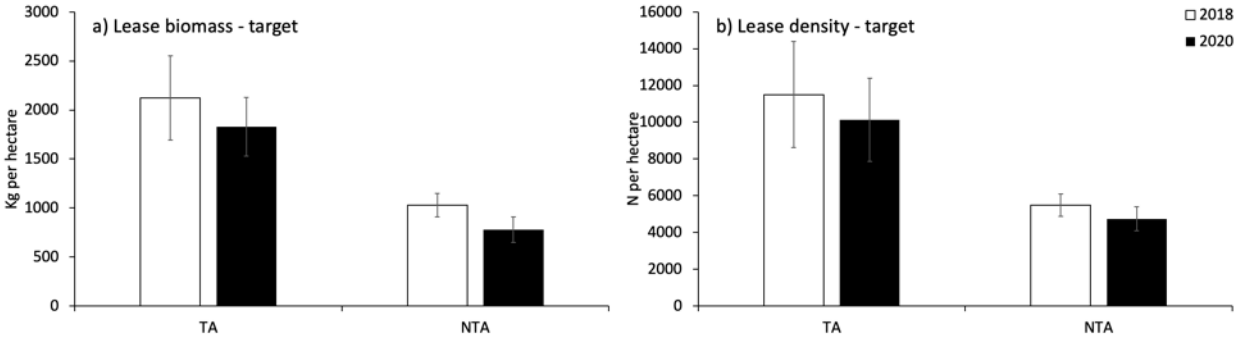


Figure 4.20 Biomass (a) kg per hectare) and density (b) individuals per hectare) of target fish families by management zone in Lease MPA. Only sites surveyed in both periods were included in calculating the mean values. For statistical analysis of the differences in fish communities, see Appendix III. Error bars = 1 SE.

c) Charismatic species

The three islands in Lease MPA are habitat for cetaceans, sharks, rays, turtles and Napoleon wrasse (*Cheilinus undulatus*; Figure 4.21, Figure 4.22). In 2018 a cetacean survey was conducted around the three islands in Lease MPA. The marine mammals observed in 2018 included dugong (*Dugong dugon*), bottlenose dolphins (*Tursiops truncatus*), spinner dolphins (*Stenella longirostris*), pygmy blue whale (*Balaenoptera musculus brevicauda*), blue whale (*Balaenoptera musculus*) and sperm whale (*Physeter macrocephalus*). Between the two surveys periods of 2018 and 2020, green and hawksbill turtles and Napoleon wrasse were observed in coastal waters of Haruku, Saparua and Nusalaut Island.

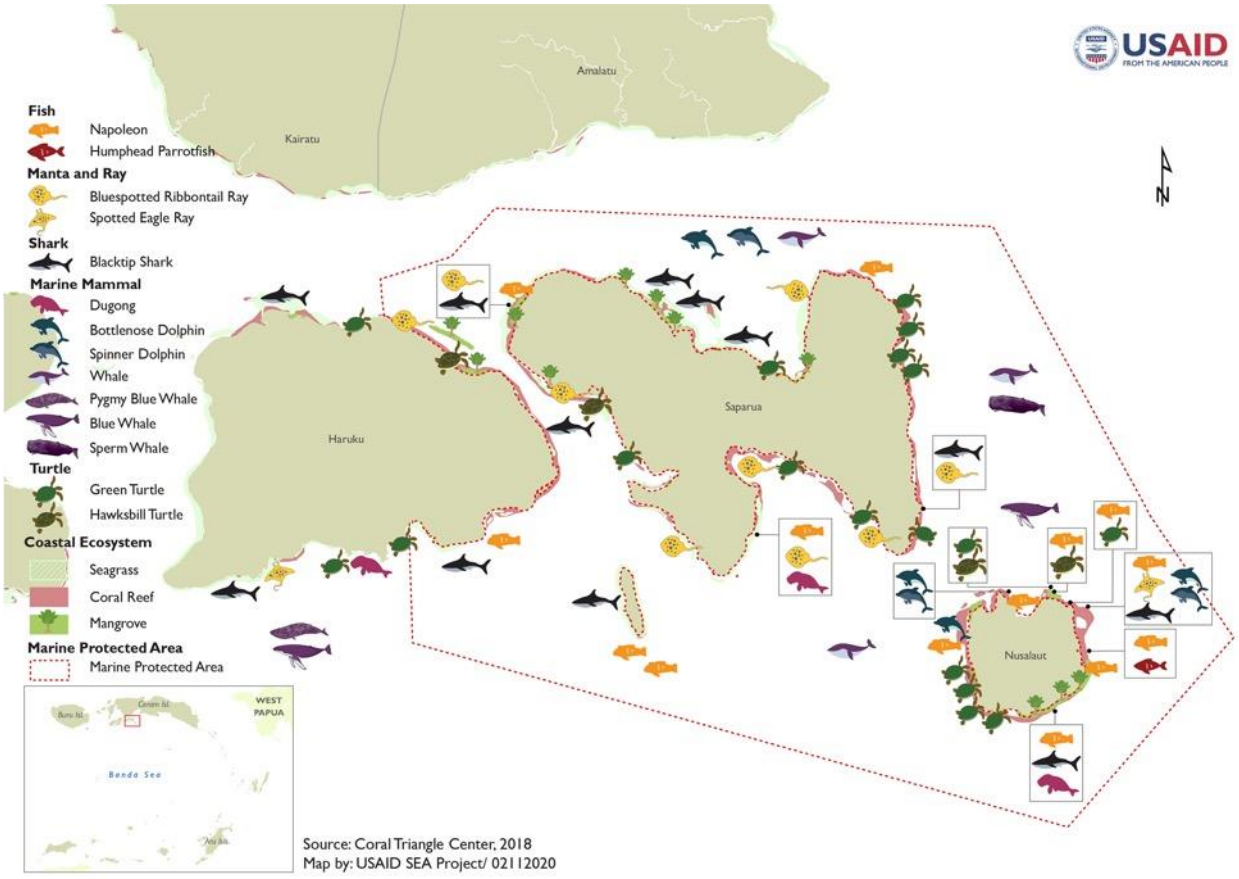


Figure 4.21 Charismatic species map around Lease MPA from 2018 survey data

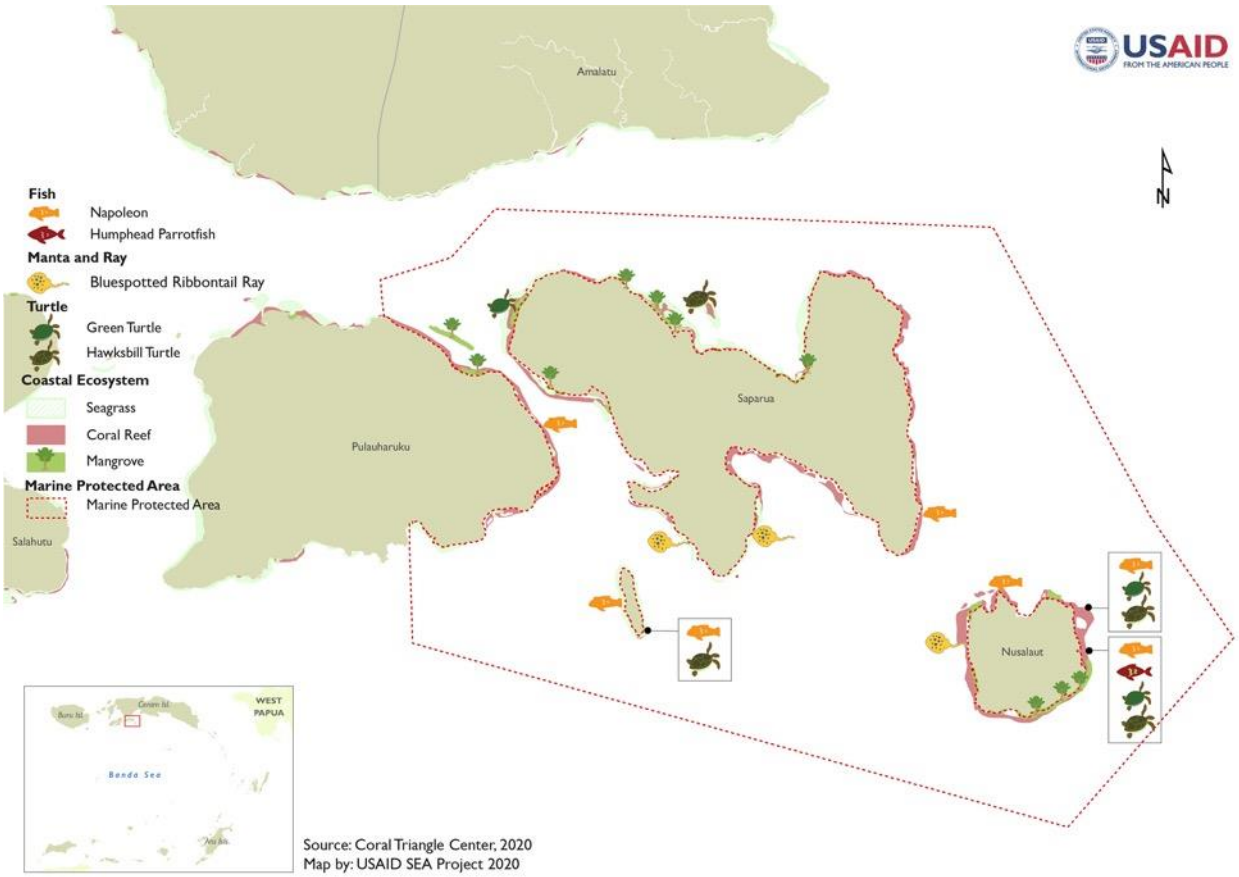


Figure 4.22 Charismatic species map around Lease MPA from 2020 survey data.

d) Status of management

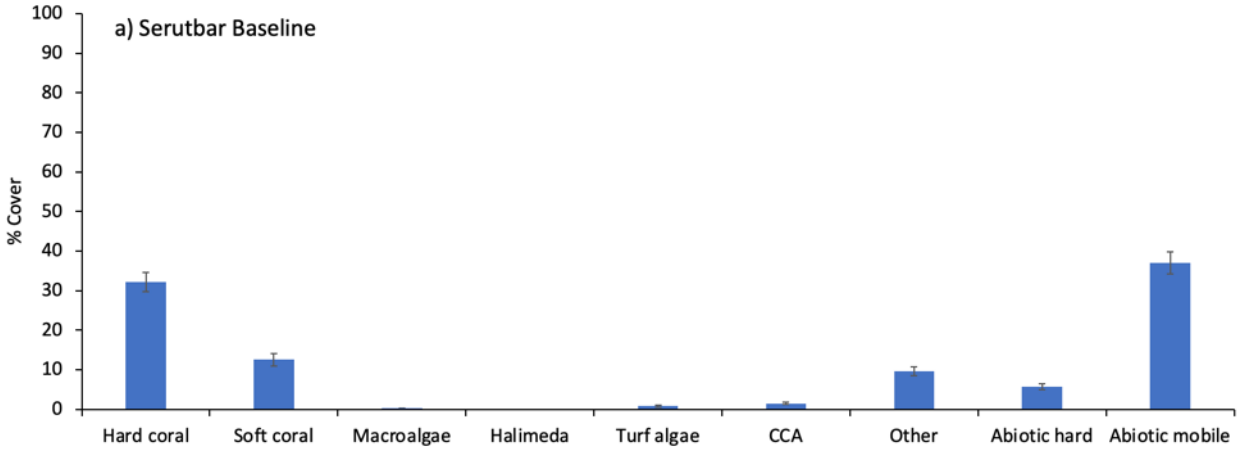
The Lease Islands consists of 3 main islands, Haruku, Saparua and Nusa Laut. Lease MPA is not yet officially protected by Ministerial Decree, although the area is included in the Provincial Marine Spatial Plan or RZWP3K (*Rencana Zonasi Wilayah Pesisisr dan Pulau-Pulau Kecil*) as a conservation area, and is stated under the Provincial Regulation No.1 Year 2018. The management of the area falls under Gugus Pulau (Island Cluster) 7, which covers the Ambon and Lease Islands. Currently, Lease Islands MPA has a management plan waiting for final approval from the Ministry of Marine Affairs and Fisheries (MMAF). Regulations have not yet been implemented in the MPA. The surveillance of MPA is the responsibility of a community surveillance group called POKMASWAS (*Kelompok Pengawas Masyarakat*). The POKMASWAS received official recognition from the Maluku Provincial Fisheries Agency (DKP) in 2019, when the community began to conduct the monitoring activities.

4.1.5 SERUTBAR MPA

a) Benthic community

Unlike other MPAs, Serutbar MPA had higher cover of abiotic mobile substrate (37%) than hard coral (32.3%) during the baseline survey (Figure 4.23). However, only deep habitats were included in the baseline survey, while follow-up surveys (T1) also included shallow areas. There were some differences between management zones; control sites had higher cover of other sessile invertebrates such as zoanthids, sponges and hydroids (23.8%), and lower cover of soft coral (2.7%; Figure 4.24) than sites inside the MPA.

During T1 surveys, the difference between abiotic mobile cover (45.6%) and hard coral cover (28.1%) was larger than during baseline surveys, and this difference was evident both deep and shallow. Although there is no clear evidence, this pattern is consistent with destructive fishing still occurring in the area. Hard and soft coral cover were slightly higher in shallow (30.6% and 13%, respectively) than deep habitats (34.7% and 7.7%, respectively) during T1 surveys. Although cover of other categories was low, deep habitats had significantly greater cover of CCA (1.5% vs. 0.8% in shallow), other sessile invertebrates (6.4% vs. 4.4%) and abiotic mobile cover (50.6% vs. 40.7%), while shallow habitats had more soft corals (13% vs. 8.5%) and abiotic hard substrate (6.3% vs. 3.7%; Figure 4.23). There was also greater variability between zones during T1 surveys, with a significant increase in hard (17.5%, 25.1%, 39.5%) and soft corals (2.8%, 10.6%, 14.8%) and a decline in abiotic mobile substrate (68.6%, 48.4%, 29%) with increasing protection (Control, TA, NTA). Overall, small but significant changes occurred in many of the benthic categories between baseline and T1 surveys (Appendix II, Figure 4.25). Most categories declined, except for turf algae and abiotic mobile substrate, which increased over time.



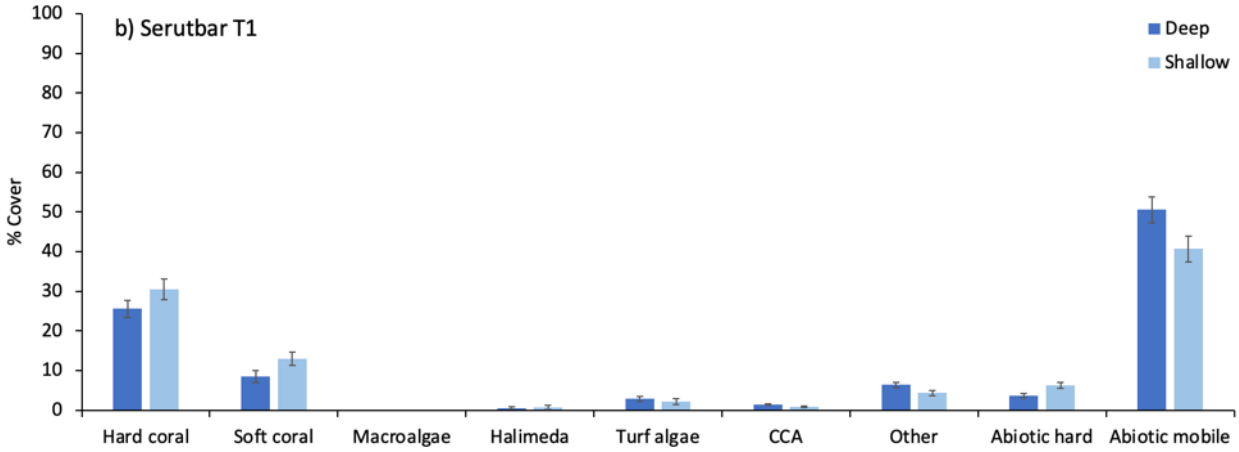


Figure 4.23 Percentage cover of key benthic categories across deep habitats in Serutbar MPA, a) during the baseline survey (T0) and b) at the T1 repeat survey. Shallow habitats were not included in the baseline survey. Note that some site differences occurred between the two survey periods. For statistical analysis of the differences in benthic communities, see Appendix II. Error bars = 1 SE.

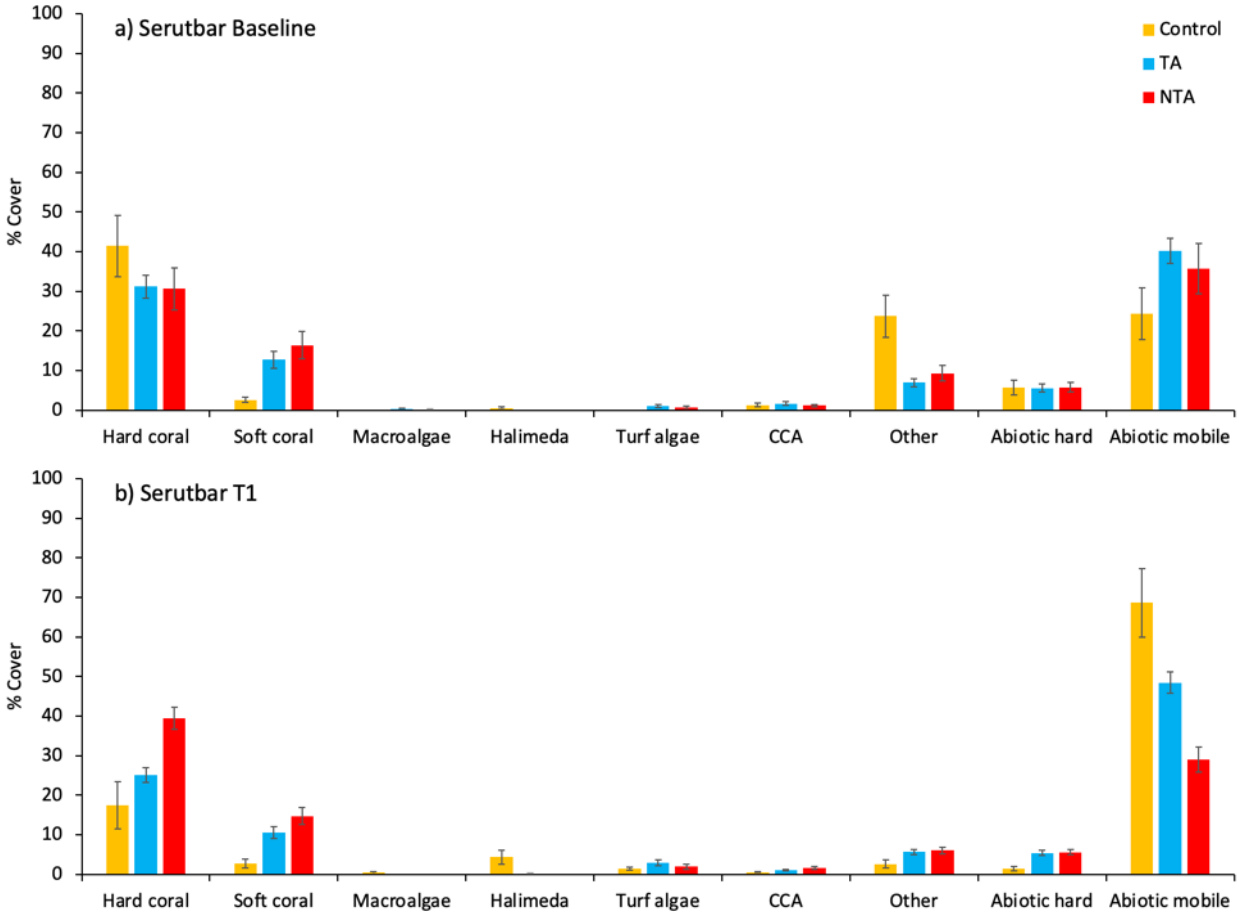


Figure 4.24 Percentage cover of key benthic categories by management zone in Serutbar MPA, a) during the baseline survey (T0) and b) at the T1 repeat survey. Note that some

site differences occurred between the two survey periods. For statistical analysis of the differences in benthic communities, see Appendix II. Error bars = 1 SE.

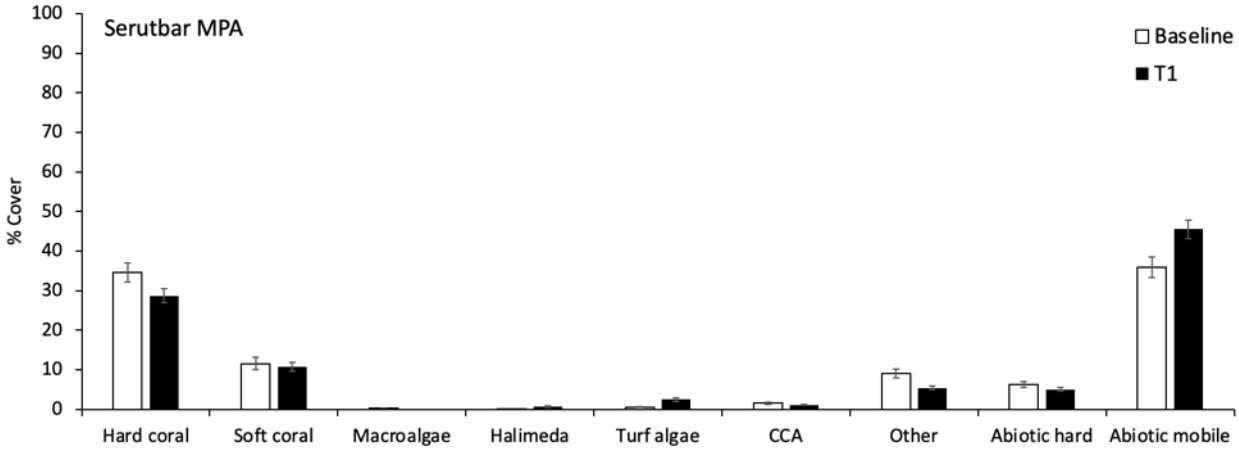
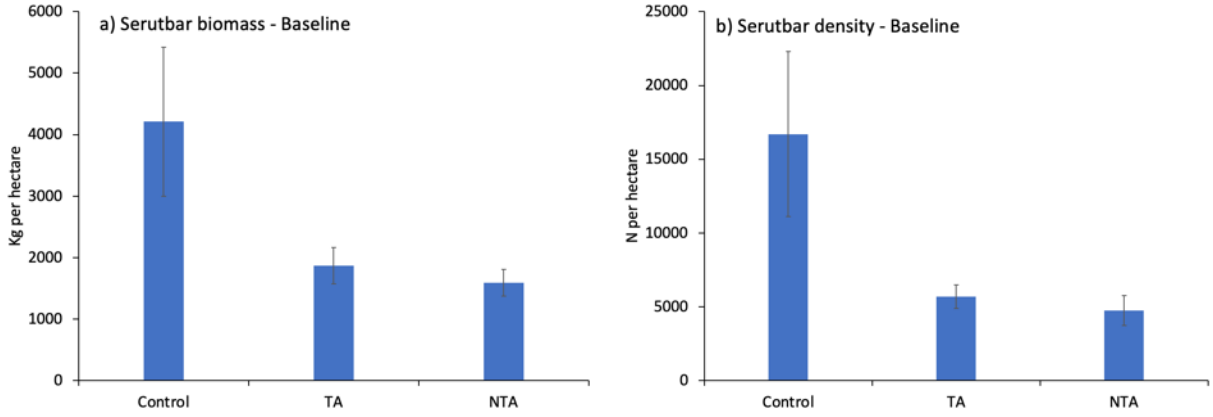


Figure 4.25 Percentage cover of key benthic categories by survey period in Serutbar MPA. Only sites surveyed in both periods were included in calculating the mean values. For statistical analysis of the differences in benthic communities, see Appendix II. Error bars = 1 SE.

b) Fish community

Target fish biomass and density in Serutbar MPA during baseline surveys was higher at control sites (4,210 kg and 16,699 individuals per hectare) than in the MPA (1,729 kg and 5,216 individuals per hectare, Figure 4.26). During follow-up surveys (T1), biomass and density of target fish families were dramatically lower across all zones (1,244 kg and 7,1367 individuals per hectare), potentially due to poor visibility at many of the sites. There were no clear differences in fish biomass between zones, but the density pattern of the baseline survey (higher at control sites) was maintained in T1, despite the lower densities overall. Using only sites surveyed at both times, the decline in target fish biomass and density was apparent across zones, but was most pronounced at control sites (4,210 kg and 16,699 individuals per hectare in 2017 and 409 kg and 6,797 individuals per hectare in 2020 Figure 4.27).



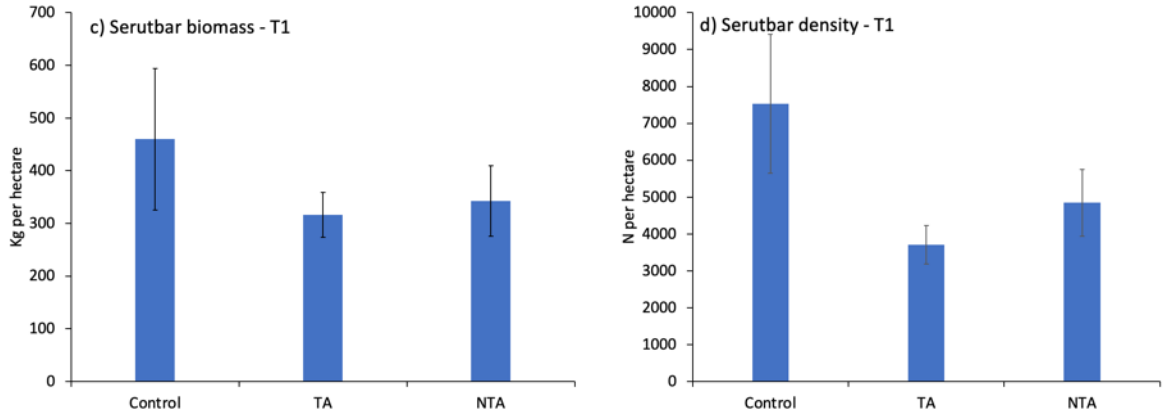


Figure 4.26 Biomass (kg per hectare) and density (individuals per hectare) of target fish families by management zone in Serutbar MPA. Baseline a) biomass and b) density and T1 c) biomass and d) density means of target families were calculated using all sites surveyed during the respective sampling periods. For statistical analysis of the differences in fish communities, see Appendix III. Error bars = 1 SE.

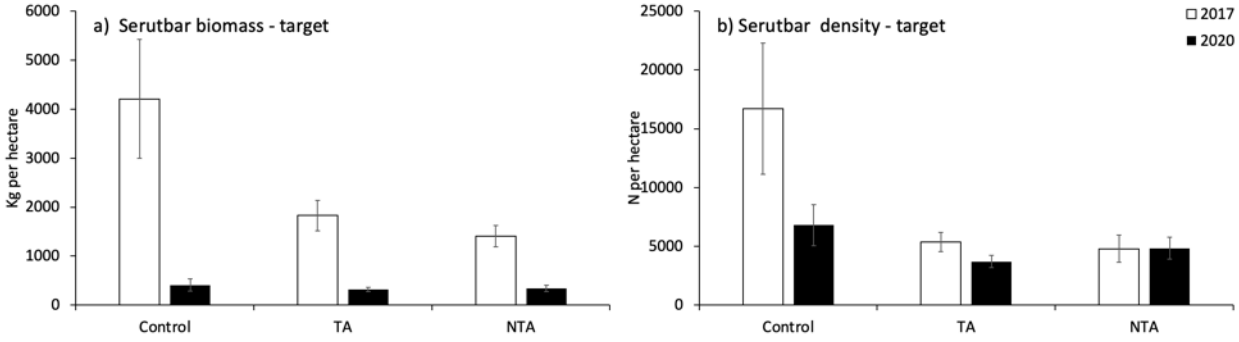


Figure 4.27 Biomass (a) kg per hectare) and density (b) individuals per hectare) of target fish families by management zone in Serutbar MPA. Only sites surveyed in both periods were included in calculating the mean values. For statistical analysis of the differences in fish communities, see Appendix III. Error bars = 1 SE.

c) Charismatic species

In 2017, information about marine biota in the areas around Serutbar MPA was collected through participation surveys. Dolphins are known to be abundant in these waters (WWF 2017). Serutbar MPA is located in Sawai Bay, which is one of the migration areas for whales; they are mostly found around Tujuh Islands and Raja Island (Figure 4.28). They were also observed in Wahai and Malaku Villages. Dugongs were reported in Saleman and Malaku Villages, and dolphins were observed around the Tujuh Islands, Raja Island, Wahai Village, Malaku Village, Sawai Island and in the North of Lusaolat. Serutbar MPA is also habitat for turtles, which were observed in 2020 at TSW09, TSW09, TSW10 around Tujuh Islands, TSW19 in Saleman Village and TSW21 in Sawai Village and TSW33, TSW34 in Malaku Village (Figure 4.29). Sharks and bluespotted ribbontail rays (*Taeniura lymma)* were observed during both survey periods while bluespotted stingrays (*Neotrygon kuhlii*) were only observed in 2017 and spotted eagle rays (*Aetobatus narinari*) in 2020.

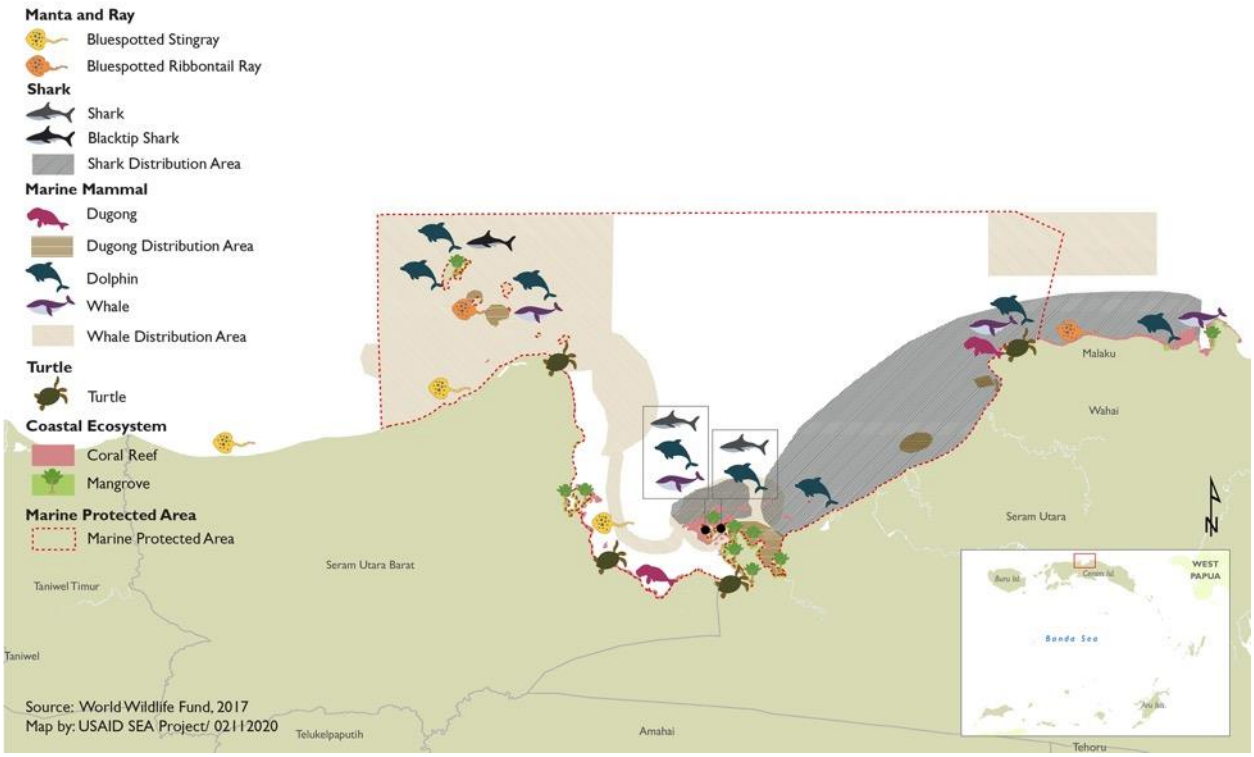


Figure 4.28 Charismatic species map around Serutbar MPA from 2017 survey data

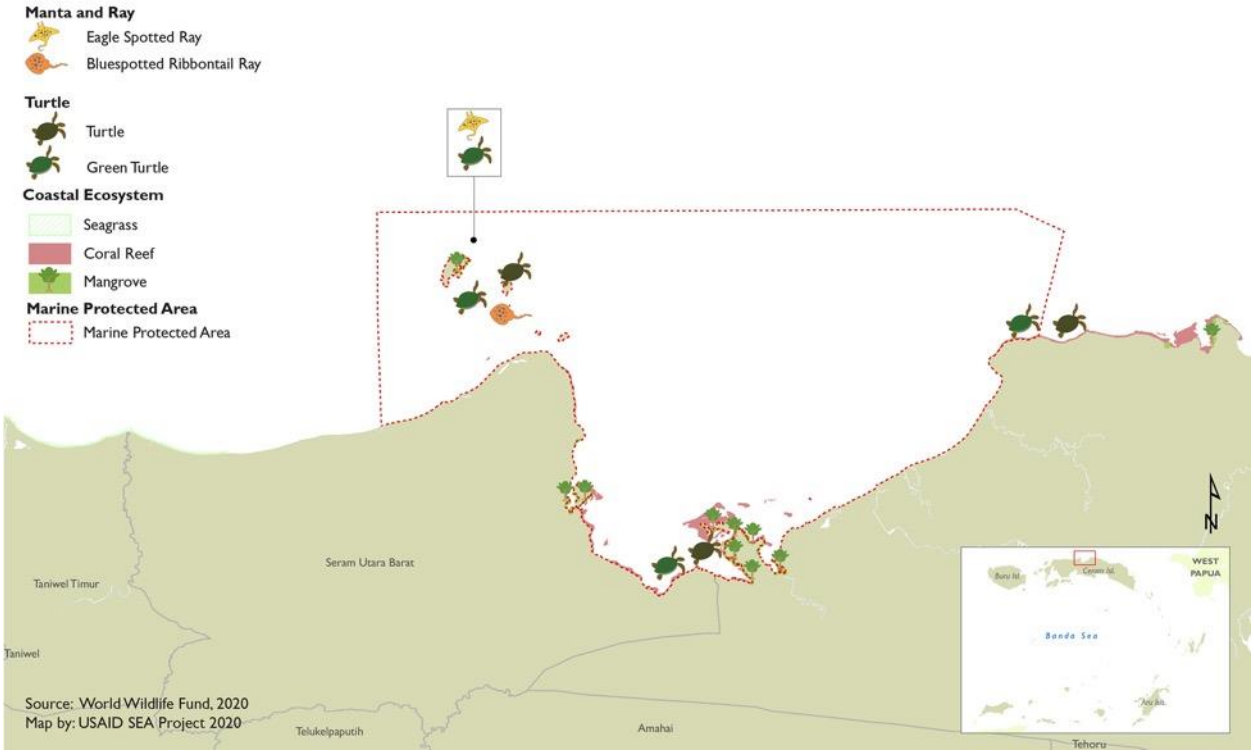


Figure 4.29 Charismatic species map around Serutbar MPA from 2020 survey data

d) Status of management

Serutbar (Seram Utara Barat), also known as Teluk Sawai, is not yet officially protected by Ministerial Decree, although the area is included in the Provincial Marine Spatial Plan or RZWP3K (*Rencana Zonasi Wilayah Pesisisr dan Pulau-Pulau Kecil*) as a conservation area and is stated under the Provincial Regulation No. 1 Year 2018. The management of the area falls under Gugus Pulau (Island Cluster) 3, which encompasses the northern part of Seram Island. The area is also adjacent to the Manusela National Park. Currently, Serutbar MPA has a management plan waiting for final approval from the Governor. There is no or limited implementation of regulations in the MPA. The surveillance of MPA is the responsibility of a community surveillance group called POKMASWAS (*Kelompok Pengawas Masyarakat*). The POKMASWAS received official recognition from the Maluku Provincial Fisheries Agency (DKP) in 2019, when the community commenced the monitoring activities.

4.1.6 COMPOSITE ANALYSIS OF MALUKU PROVINCE

a) Benthic community

Live hard coral cover was, on average, 39.2% across all MPAs in Maluku Province (Figure 4.30). The highest coral cover in deep habitats was recorded in Ay-Rhun MPA (43.8%), while Buano MPA had the highest coral cover in shallow habitats (48.1%). Serutbar and Koon MPA had slightly lower coral cover (32.3% and 33.6% cover overall, respectively). Overall, abiotic (non-living) substrate made up 25.2% of benthic community estimates across the province. Mobile substrates such as sand and rubble were more abundant in deeper areas, while shallow habitats tended to have higher cover of hard substrate such as rock and dead corals. This may be a sign of ongoing destructive fishing practices. Koon, Ay-Rhun and Buano MPAs had higher proportions of soft corals than the other MPAs (19.7%, 12.9% and 17.6%, respectively); soft corals provide habitat for a different set of species than hard corals, contributing to overall biodiversity. The most obvious change in Maluku Province in the follow-up survey (T1) was an increase in abiotic mobile cover.

Multivariate analysis revealed that each MPA had a distinctive benthic community, shown by the fact that the MPA "clouds" did not overlap (Appendix 4). The vectors show which benthic categories drove the differences between MPAs. Therefore, Ay-Rhun and Lease MPAs were differentiated from the other MPAs by their greater proportion of hard coral, CCA and abiotic hard substrate, while Buano was "pulled" to the left of the plot by its higher proportions of soft corals and other sessile invertebrates. The shape of the Serutbar MPA "cloud" of points was influenced by a high cover of abiotic mobile substrate, especially at control sites. This separation of Serutbar MPA's control sites from all other MPAs was exacerbated in T1, where it was pulled even further towards the left side of the plot by a dominance of *Halimeda*, abiotic mobile, and to a lesser extent turf and macroalgae. This may signal reef degradation at these sites. Sites within Serutbar MPA, and in Koon and Lease MPAs, maintained a higher abundance of corals, hard substrate, CCA and other sessile invertebrates.

Among the four indicators of potential damage to coral reefs, rubble was the most prominent, and was highest in Serutbar and Lease MPAs, where it reached 22.3% and 18.5% cover, respectively (Figure 4.31). Dead coral, as an indicator of recent mortality, was highest in Koon MPA at 7.5% cover. Macroalgal cover was negligible throughout Maluku Province, and there were minor signs of bleaching (0.4%) in Koon MPA at the time of the baseline survey. In T1, rubble was present in similar amounts in Koon, Lease and Serutbar (~17%). Dead coral cover had declined, and evidence of bleaching was recorded in Lease MPA, but not in Koon MPA.

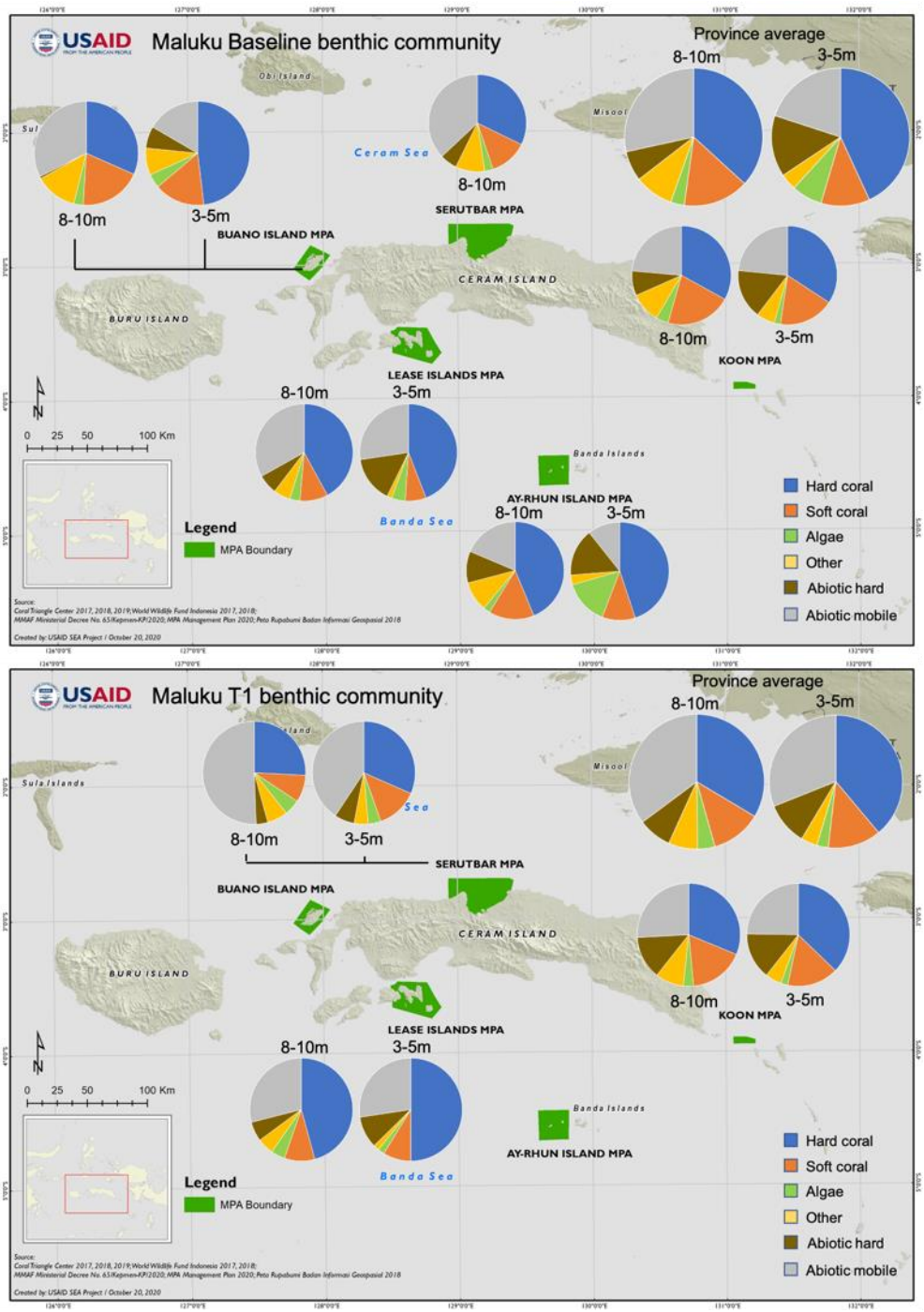


Figure 4.30 Summary of benthic categories in deep and shallow reef habitats of the MPAs in Maluku Province. Algae and mobile abiotic categories were combined. Shallow habitats were not surveyed in Serutbar MPA during the baseline study, and T1 surveys did not include Ay-Rhun and Buano MPAs. Top panel: baseline averages, bottom panel: T1 averages.

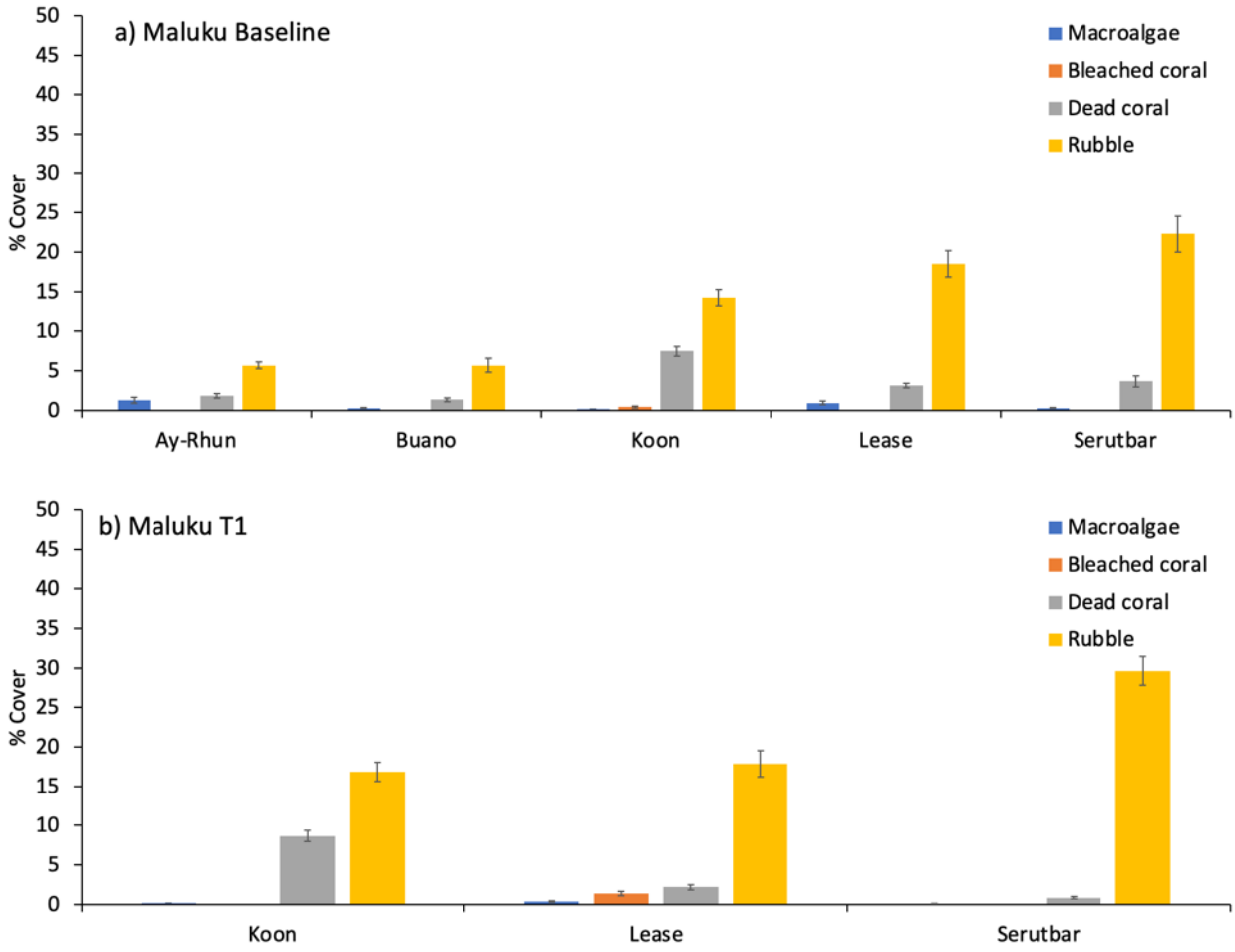


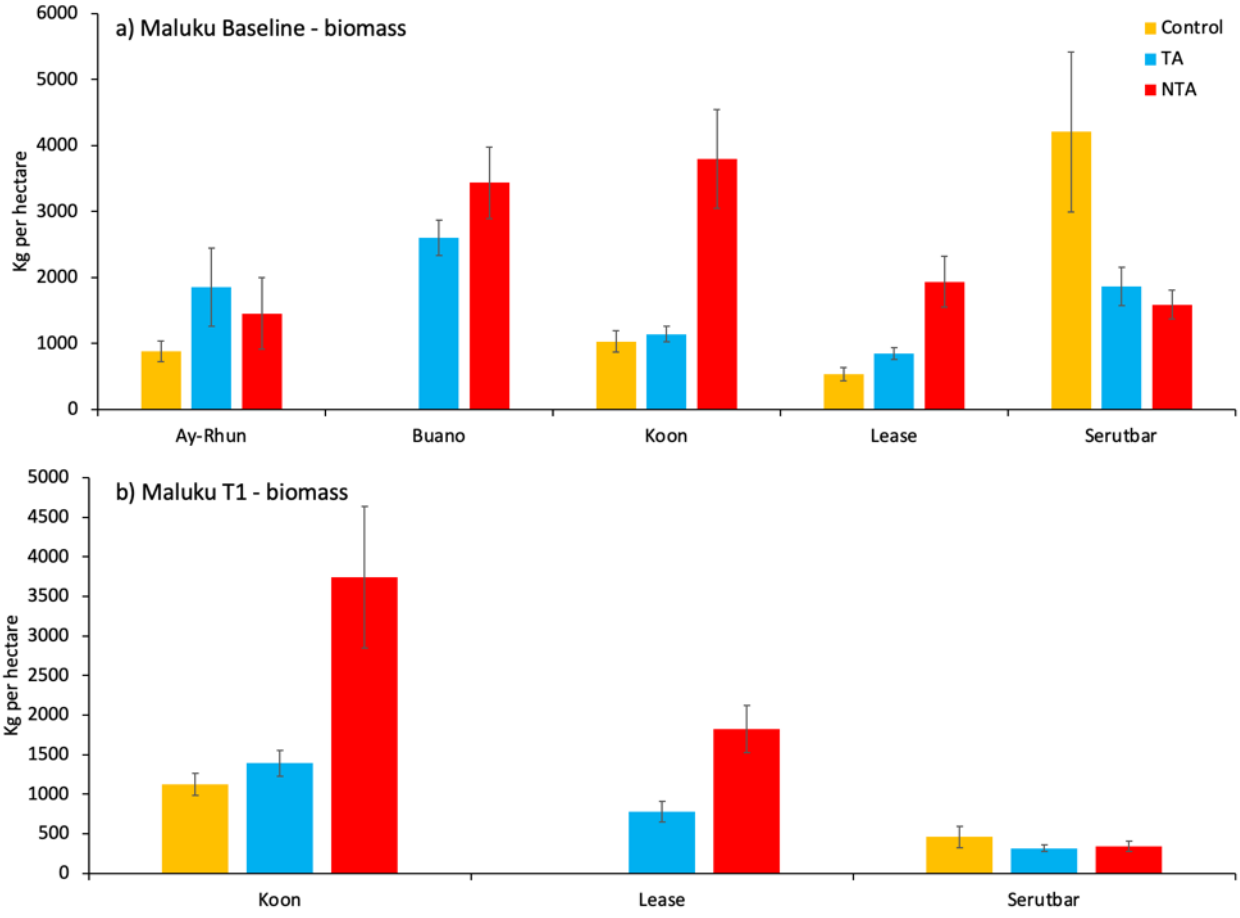
Figure 4.31 Mean percent cover of four indicators of reef stress: macroalgae, typically increasing with chronic disturbances; bleached coral, indicating rising temperatures; dead coral, indicating a recent mortality event and rubble, which often increases as a result of coral mortality and destructive fishing. Mean values are shown for each MPA in Maluku Province, a) during the baseline survey, and b) at T1. Error bars = 1 SE.

b) Fish community

The biomass and density of target fish families was as high or higher in no-take areas (NTAs) than at control sites or TAs (areas with regulated fishing within the MPA) across MPAs in Maluku Province (average of 2,444 kg and 9,623 individuals per hectare, vs. 1,663 kg and 9,156 individuals per hectare), both during the baseline survey and, in the case of Koon and Lease MPAs, during T1 surveys (Figure 4.32). The exception was Serutbar MPA, where biomass and density of target fish were distinctly higher at control sites (16,699 kg and 5,594 individuals per hectare) than in the MPA (5,216 kg and 906 individuals per hectare). Higher biomass in NTAs was particularly pronounced in Koon and Lease MPAs (3,796 and 1,936 kg per hectare, respectively), while Ay-Rhun and Buano MPAs had similar estimates between the zones. Differences in density were less pronounced, although Lease MPA had higher densities in NTAs and Serutbar MPA had higher densities at control sites.

The highest species richness of target fishes was recorded in Buano MPA (an average of ~24 species per transect), and the lowest in Lease and Ay-Rhun MPAs with less than 10 species per transect (Figure 4.33.). Other MPAs in Maluku Province had between 15 and 20 species per transect during baseline and T1 surveys. There was evidence of a decline in target species richness in Serutbar MPA between the baseline and T1 surveys.

As with benthic communities, multivariate analysis revealed that each MPA had a distinctive fish community, shown by the fact that the MPA "clouds" did not overlap (Appendix 4). The vectors show which fish families drove the differences between MPAs. Most of the vectors point towards the top half of the plot, suggesting that MPAs in the bottom half had lower abundance of all fish families, and MPAs situated in the top half had a richer fish community. Ay-Rhun and Koon MPA appear to have less abundant fish communities, while Buano and Serutbar are characterised by a diverse group of different fish families, especially grazing fishes such as rabbitfish (Siganidae) and surgeonfish (Acanthuridae), carnivores such as bream (Nemipteridae) and emperors (Lethrinidae) and large piscivores such as tunas and mackerels (Scombridae). Lease MPA, on the other hand, was "pulled" towards the right side of the plot by a high abundance of sharks (Carcharhinidae). During T1, the three MPAs that were surveyed in 2020 were characterised by a unique combination of target fish families. Koon MPA was the most diverse, represented by 10 fish families in different trophic groups. Lease MPA retained a high proportion of sharks (Carcharhinidae), but also wrasses (Labridae) and grazing drummers (Kyphosidae). Serutbar MPA was distinguished by planktivorous fusiliers (Caesionidae) and to a lesser extent goatfish (Mullidae) and mackerels (Scombridae).



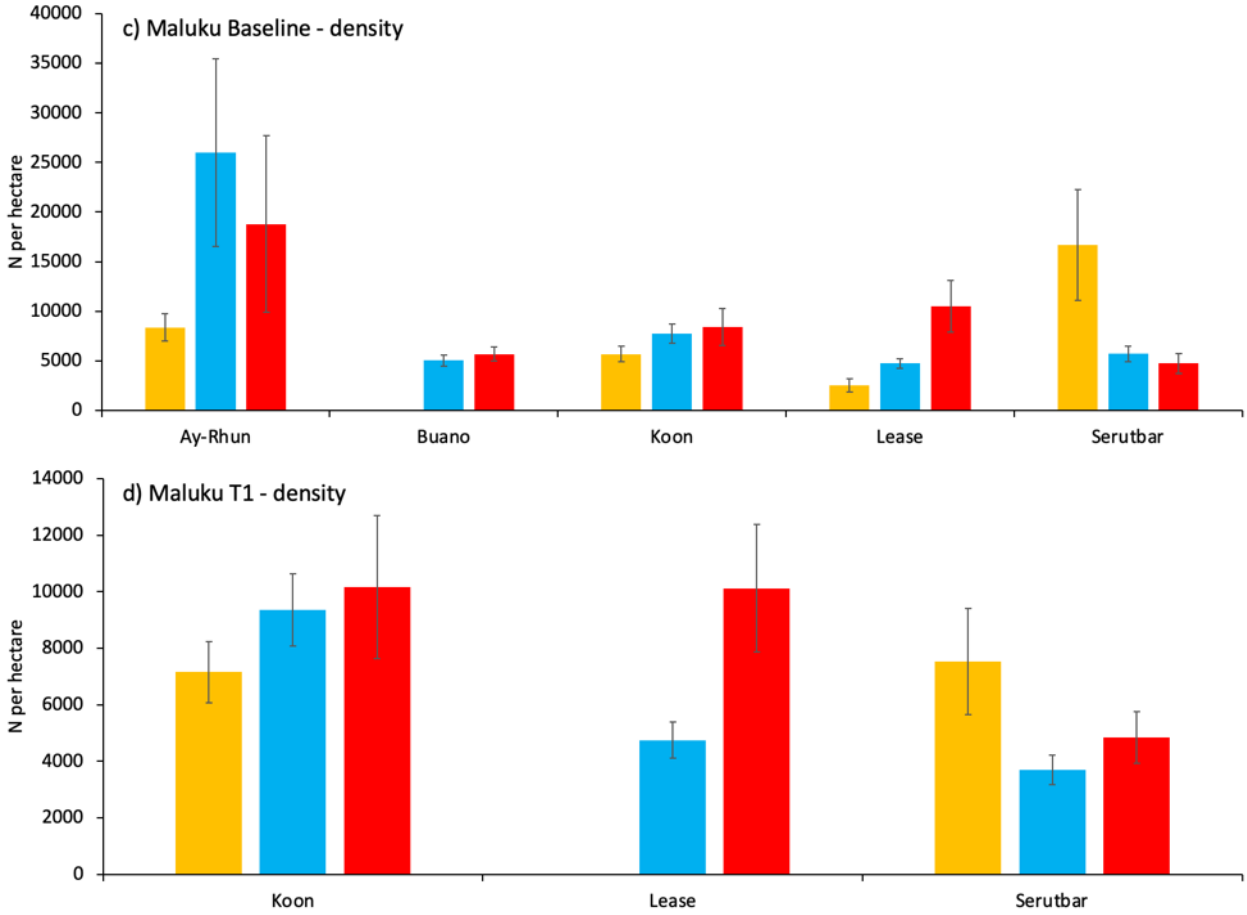


Figure 4.32 Mean biomass and density of target fish families across all MPAs in Maluku Province, showing differences between zones a) and b) during baseline surveys, c) and d) at T1. Error bars = 1 SE.

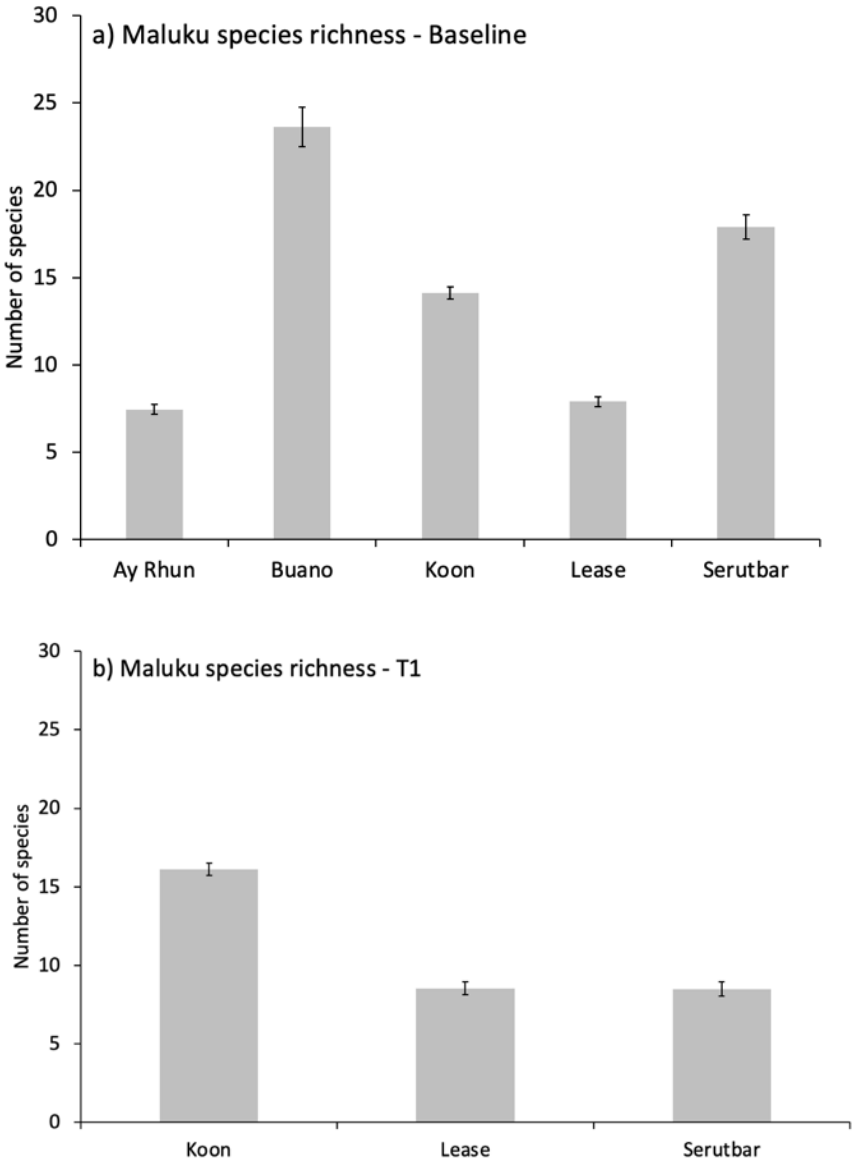


Figure 4.33 Number of target species per transect observed at a) the baseline surveys and b) T1 across all MPAs in Maluku Province. Error bars = 1 SE.

4.1.7 DISCUSSION MALUKU PROVINCE

Surveyed sites in Maluku Province had just under 40% coral cover, with a slight decline in 2020. Serutbar and Koon MPAs have slightly lower coral cover, but there is also abundant soft coral and hard substrate available for the settlement of coral larvae. Areas of hard substrate and dead corals colonised by turf are often correlated with higher abundances of parrotfish (Dwirama Putra et al. 2018). Bleaching and macroalgae do not appear to have been problematic during the survey years. Previous reports about a number of the MPAs raise concerns about the abundance of rubble (Firmansyah et al. 2018, Ihsan et al. 2018), which was also found to be the main indicator of disturbance in these latest surveys.

Surveys of coral reefs around Ambon Island, just west of Lease MPA, found that corals had high growth rates even in areas affected by sedimentation, suggesting that corals in this area may have adopted strategies to persist successfully even in high turbidity (Limmon 1996). It is important to note spatial differences in coral cover within each MPA, irrespective of the location of different zones. For example, surveys by the CTC (2017) found higher coral cover in the southern sites of Buano Island than in the northern sites. Different drivers may influence the different aspects and sides of islands, because of exposure to waves, sedimentation and other environmental factors not related to management. It is also important to understand the history of human use of the area. For example, coral reefs in the area around Serutbar MPA have suffered from destructive fishing practices in the last 10 years, resulting in substantial reef degradation (WWF 2017).

Buano, Koon and Lease appear especially promising in terms of high biomass of target species in the no-take areas. The coastal reefs of Ceram Island near Buano MPA also had healthy reefs and high target fish biomass in a separate study, showing a tendency for reefs in the region to be in good condition (Huliselan et al. 2019). However, there appears to be a general decline in the biomass and density of target fish over time, which makes it important to implement the no-take regulations in a timely manner. Previous reports have reported Koon MPA to be a spawning ground for several economically important fish species such as groupers and snapper. Coral cover has been stable in the past, and the increase in target fish biomass was noted between 2016 and 2018. The slight difference between previous estimates of the differences and those recorded here is likely to be because previous surveys considered a reduced set of target species compared to this analysis (Firmansyah et al. 2018). The communities in the Koon and Buano area are heavily dependent on marine resources (CTC 2017, Firmansyah et al. 2018), but several coral reefs around Koon are also known as excellent diving spots and their protection from fishing could encourage revenue through tourism (Firmansyah et al. 2018).

Characteristics of the Banda Sea ecoregion, which includes Maluku Province, include upwelling and downwelling areas promoting high productivity, anecdotal evidence of one of the biggest fish spawning areas in Indonesia around Pulau Koon, comparatively low habitat and species diversity, and important habitat for cetaceans (Green and Mous 2007). The provincial government of Maluku has a target of 4.7 million hectares to be included within MPAs by the year 2030. Currently, Maluku has 1.5 million hectares of MPA, soon to become 1.75 million hectares with the addition of further MPAs.

4.2 NORTH MALUKU PROVINCE

4.2.1 GURAICI MPA

a. Benthic community

Baseline surveys of Guraici MPA revealed higher coral cover in shallow areas (47.9% vs. 33.9%), while deep areas had higher cover of other sessile invertebrates (7.4% vs. 3.2%) and mobile abiotic (non-living) cover such as sand and rubble (35.5% vs.19.2%) (Figure 4.34). Hard coral was the dominant benthic category in shallow habitats, but in deeper areas there was similar cover between hard corals and abiotic mobile substrate (~35%). Among zones, hard coral cover was lowest in TAs (27.6%), and slightly higher at control sites (56.7%) than in NTAs (44.9%; Figure 4.35). Other categories less abundant, but some (soft coral, abiotic mobile) showed the opposite pattern to hard coral.

Depth and zone differences were very similar in the follow-up surveys (T1) to the baseline surveys, with the exception of turf, which was significantly higher in shallow reef areas (Appendix II; Figure 4.34). Soft coral cover declined significantly between the baseline and T1 (12.5% to 8.8%; Figure 4.36). For other categories, the depth and zone differences described above were larger than changes over time.

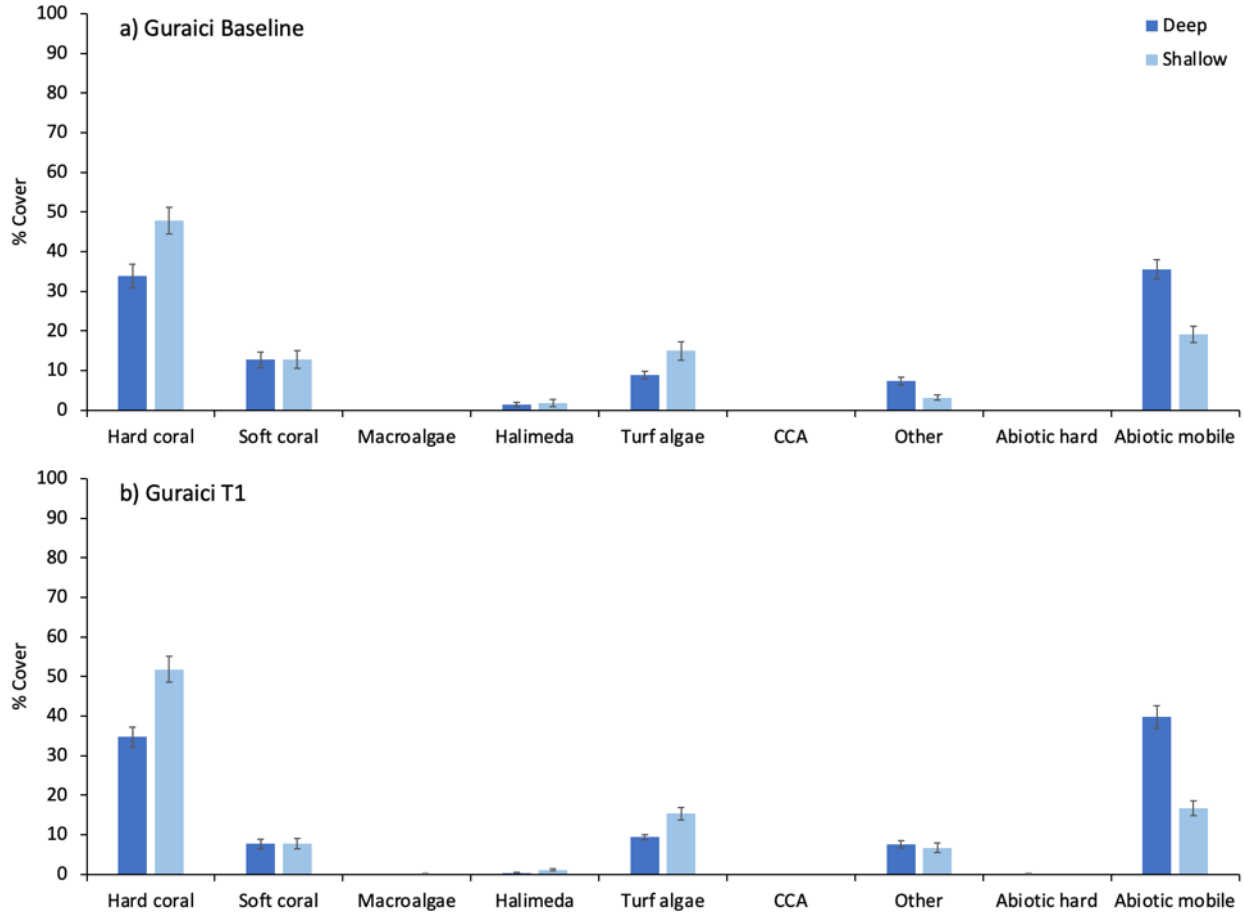


Figure 4.34 Percentage cover of key benthic categories across deep and shallow habitats in Guraici MPA, a) during the baseline survey (T0) and b) at the T1 repeat survey. Note that

some site differences occurred between the two survey periods. For statistical analysis of the differences in benthic communities, see Appendix II Error bars = 1 SE.

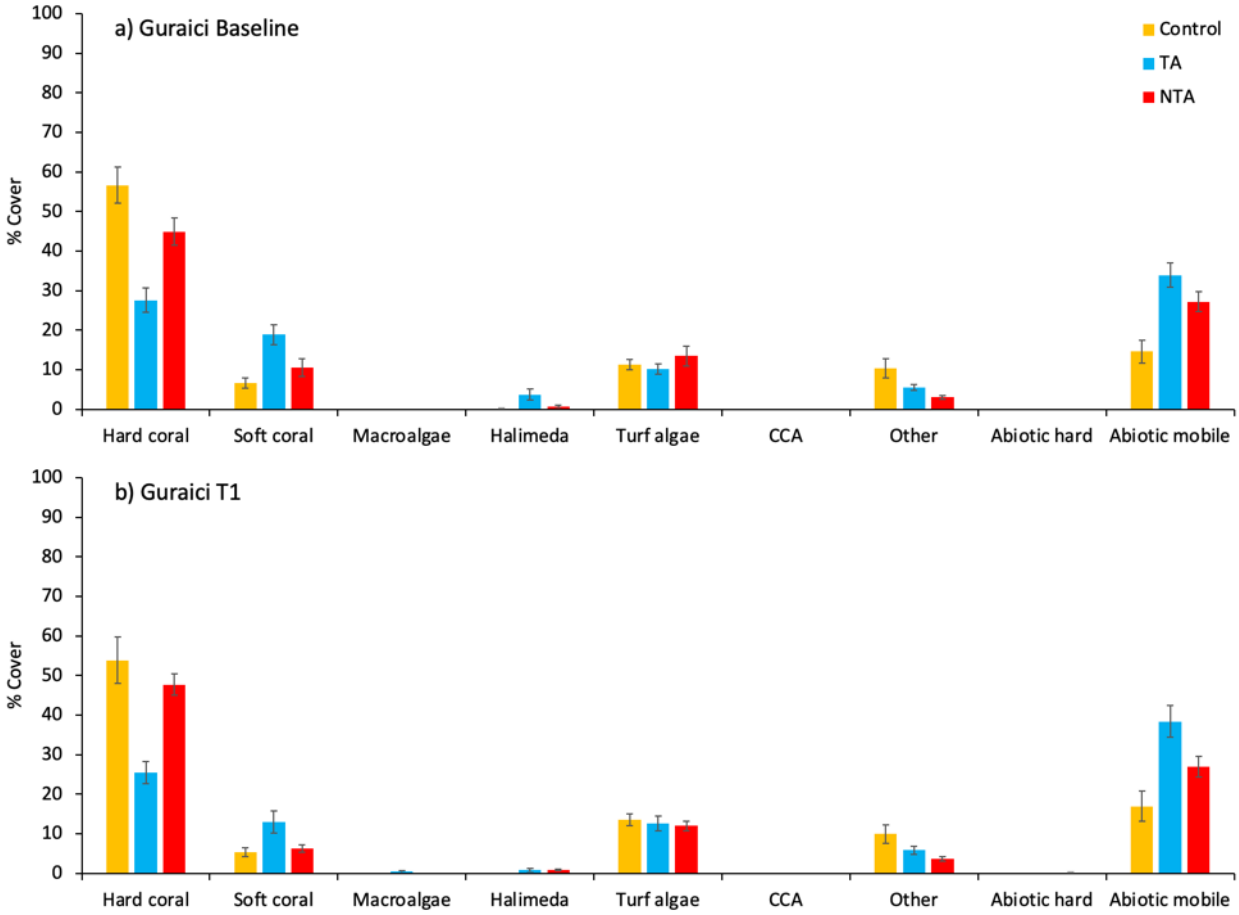


Figure 4.35 Percentage cover of key benthic categories by management zone in Guraici MPA, a) during the baseline survey (T0) and b) at the T1 repeat survey. Note that some site differences occurred between the two survey periods. For statistical analysis of the differences in benthic communities, see Appendix II. Error bars = 1 SE.

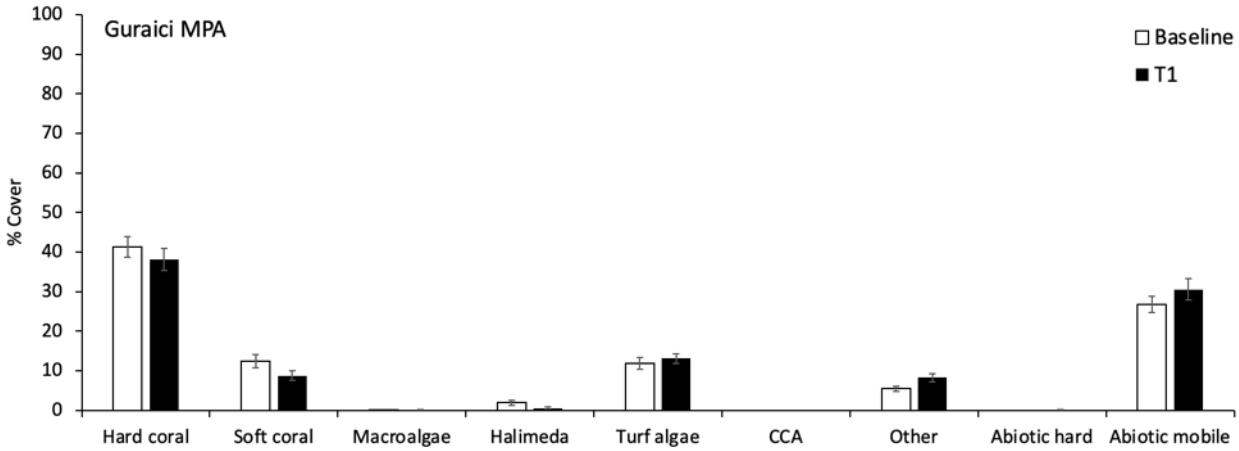


Figure 4.36 Percentage cover of key benthic categories by survey period in Guraici MPA. Only sites surveyed in both periods were included in calculating the mean values. For

statistical analysis of the differences in benthic communities, see Appendix II. Error bars = 1 SE.

b. Fish community

Target fish families in Guraici MPA generally had lower biomass and density than non-target species (425 vs. 618 kg per hectare and 1,816 vs. 35,554 individuals per hectare) during baseline surveys in 2017 (Figure 4.37). Target biomass was higher in control sites (622 kg per hectare) and NTAs (477 kg per hectare) than in TAs (258 kg per hectare). Non-target biomass and density were higher at control sites (1,106 kg and 53,671 individuals per hectare) than within the MPA (513 kg and 31,834 individuals per hectare) during the baseline survey; these differences were smaller in the follow-up survey (T1; 268 kg and 33,130 individuals per hectare at control sites and 169 kg and 24,615 individuals per hectare in the MPA). Biomass and density of target families were similar between the baseline and T1, but they were much lower for non-target species.

Target species density increased significantly between the baseline (1,965 individuals per hectare) and T1 (3,224 individuals per hectare) across all zones, and was higher at control sites than in MPAs during both survey years (Figure 4.38). The decline in the biomass and density of non-target species were also significant, and the estimates were also higher in control areas than within the MPAs in both years. A variety of non-target species were counted in both years, making it likely that this constitutes a real decline.

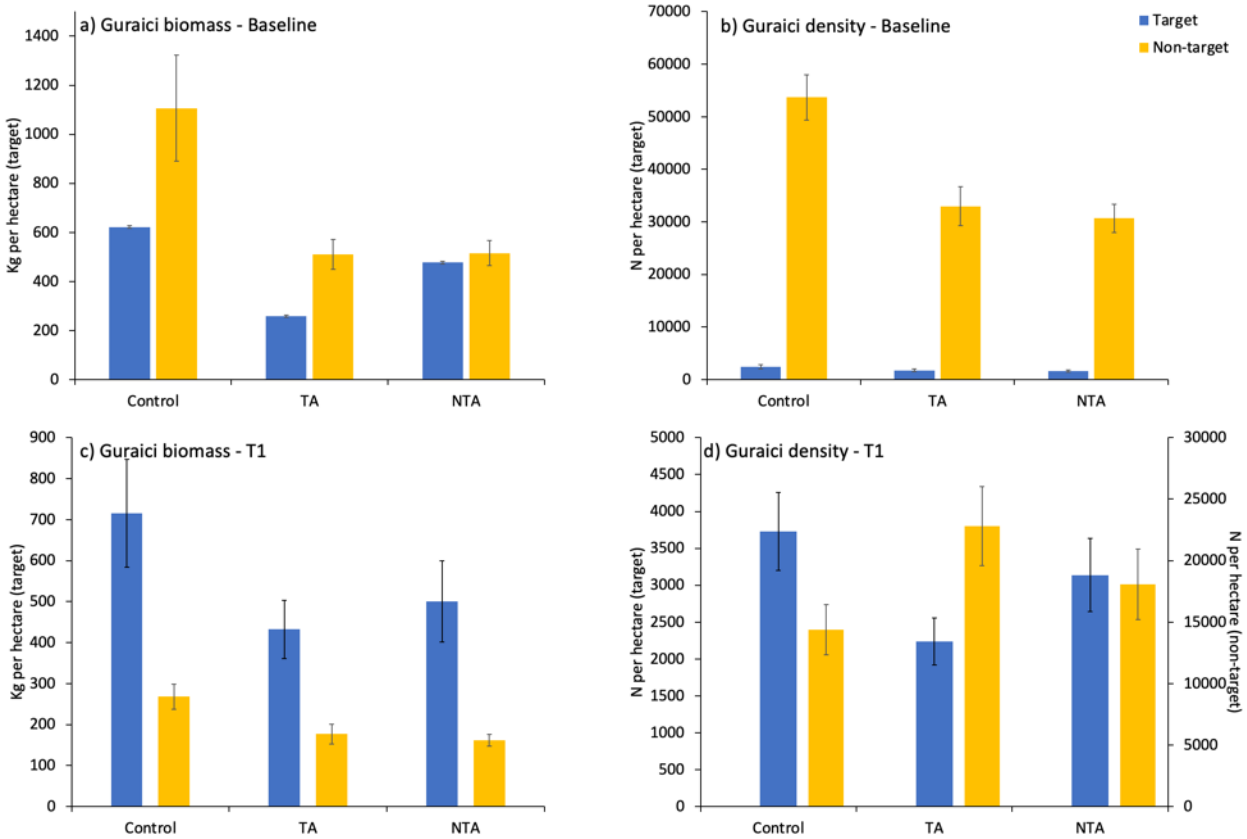


Figure 4.37 Biomass (kg per hectare) and density (individuals per hectare) by management zone in Guraici MPA. Baseline a) biomass and b) density and T1 c) biomass and d) density

means were calculated using all sites surveyed during the respective sampling periods. Note that non-target estimated of density at T1 were plotted on a separate axis. For statistical analysis of the differences in fish communities, see Appendix III. Error bars = 1 SE.

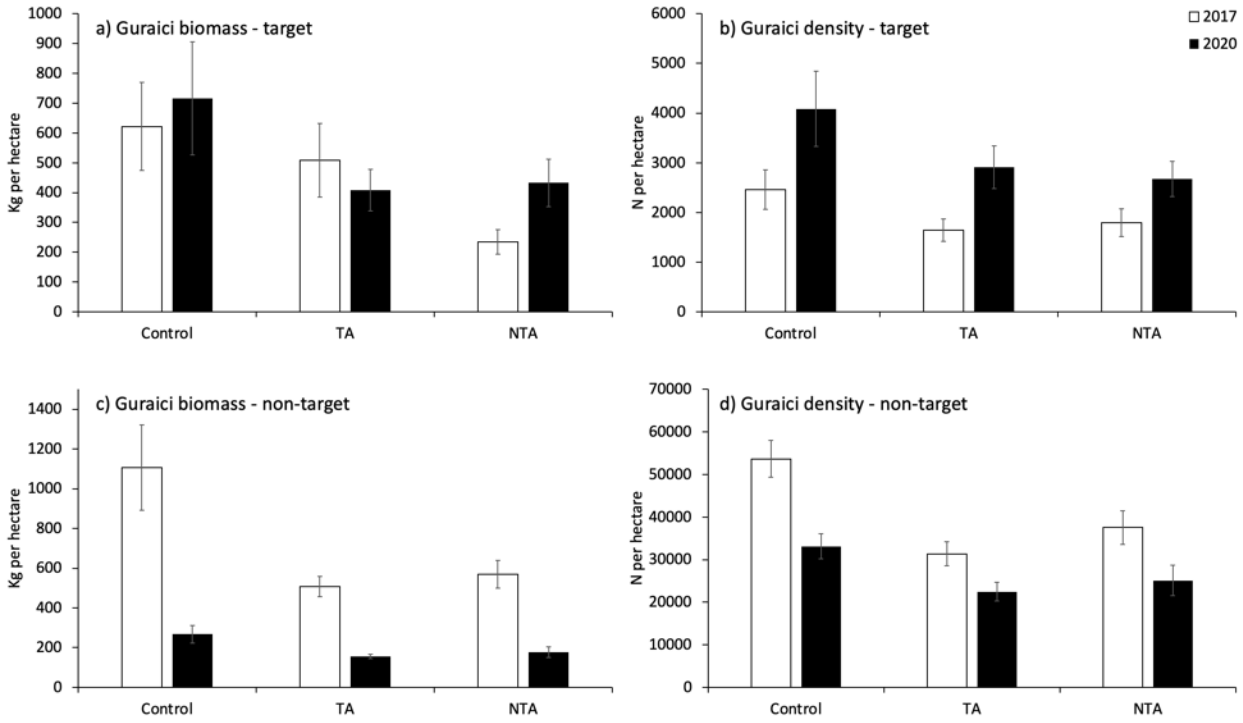


Figure 4.38 Biomass (a) kg per hectare) and density (b) individuals per hectare) by management zone in Guraici MPA. Only sites surveyed in both periods were included in calculating the mean values. For statistical analysis of the differences in fish communities, see Appendix III. Error bars = 1 SE.

c. Charismatic species

In 2017, blacktip reef sharks (*Carcharhinus melanopterus*) were found around Legoma Island, Doro Lamo Island and outside the MPA boundary in North Kayoa (Figure 4.39), while in 2020 they were found at all sites (Figure 4.40). Whitetip reef sharks (*Triaenodon obesus*) were encountered around Doro Lamo Island in 2017 and Kayoa Island in 2020; reef manta rays (*Manta alfredi*) were encountered at Doro Lamo and Talimau Islands in 2017 (Figure 4.39). Napoleon wrasse (*Cheilinus undulatus*) were also observed at almost every site in 2020 (Figure 4.39).

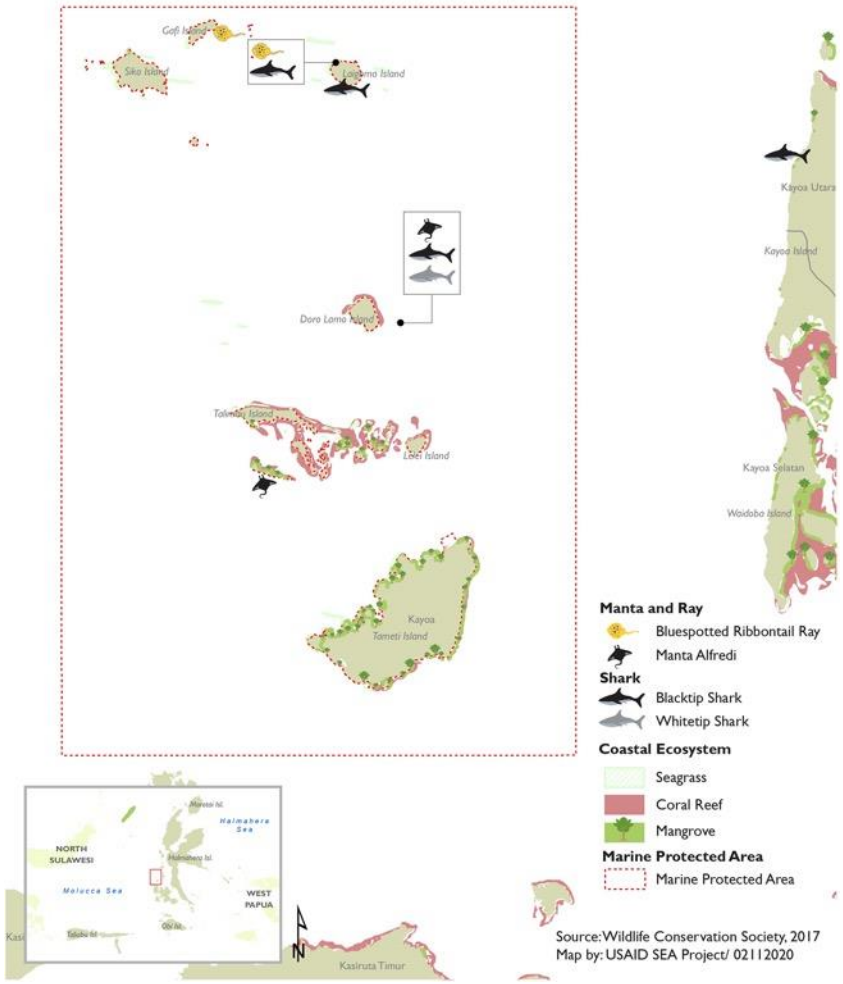


Figure 4.39 Charismatic species map around Guraici MPA from 2017 survey data

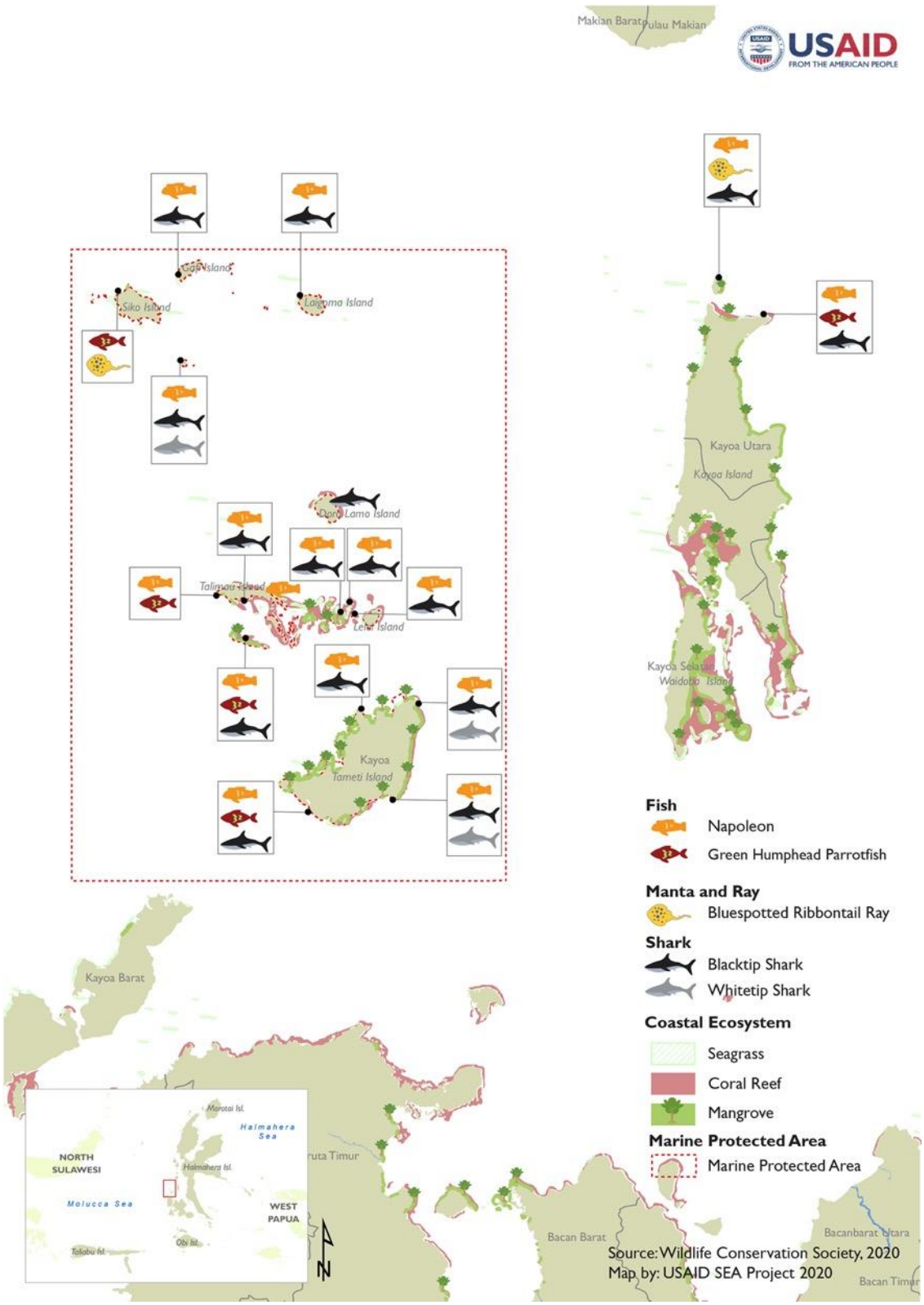


Figure 4.40 Charismatic species map around Guraici MPA from 2020 survey data

d. Status of management

Guraici MPA has been protected by Ministerial Decree No. 103 Year 2020, and is also included in the Provincial Marine Spatial Plan or RZWP3K (*Rencana Zonasi Wilayah Pesisisr dan Pulau-Pulau Kecil*) as a conservation area. It is stated under the Provincial Regulation No. 2 Year 2018. Management of the area falls under the UPTD (*Unit Pelaksana Tekhnis Daerah* – Provincial Technical Unit) MPA of North Maluku. Currently, Guraici MPA has a management plan waiting for final approval from the Governor, and no regulations have yet been implemented in the MPA. The surveillance of the MPA is the responsibility of the community surveillance group called POKMASWAS (*Kelompok Pengawas Masyarakat*). The POKMASWAS received official recognition from the North Maluku Provincial Fisheries Agency (DKP) in 2019, and the community has conducted the monitoring activities ever since.

4.2.2 MAKIAN-MOTI MPA

a. Benthic community

The Makian-Moti MPA coral reef was dominated by hard corals (48.8%), followed by abiotic (non-living) mobile cover such as sand and rubble (20-30%; Figure 4.41.). The rest of the benthic cover was mostly made up of turf algae (12.7%) and other sessile organisms (5.3%). Hard coral cover was significantly higher in shallow areas (53.6% vs. 44.1%), while deeper areas had higher cover of other sessile organisms (7.7% vs. 2.8%) and abiotic mobile substrate (33.3% vs. 25%). There was a trend for hard abiotic cover, *Halimeda* and other sessile organisms to be higher and abiotic mobile cover to be lower in TAs, but this pattern was only significant for *Halimeda* (Figure 4.42).

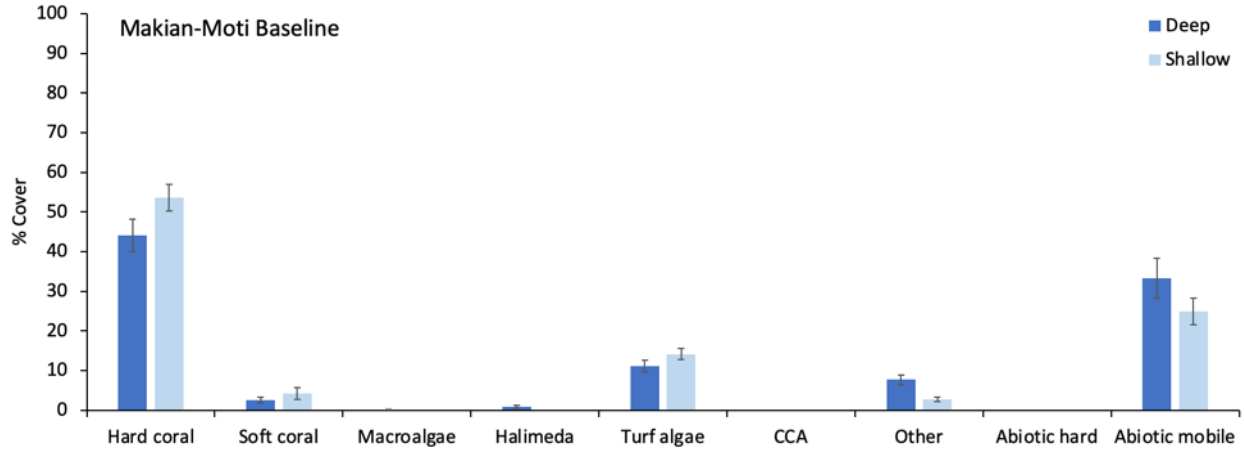


Figure 4.41 Percentage cover of key benthic categories across deep and shallow habitats in Makian-Moti MPA during the baseline (T0) survey. Only one site was surveyed during T1 and is not included in analyses. For statistical analysis of the differences in benthic communities, see Appendix II. Error bars = 1 SE.

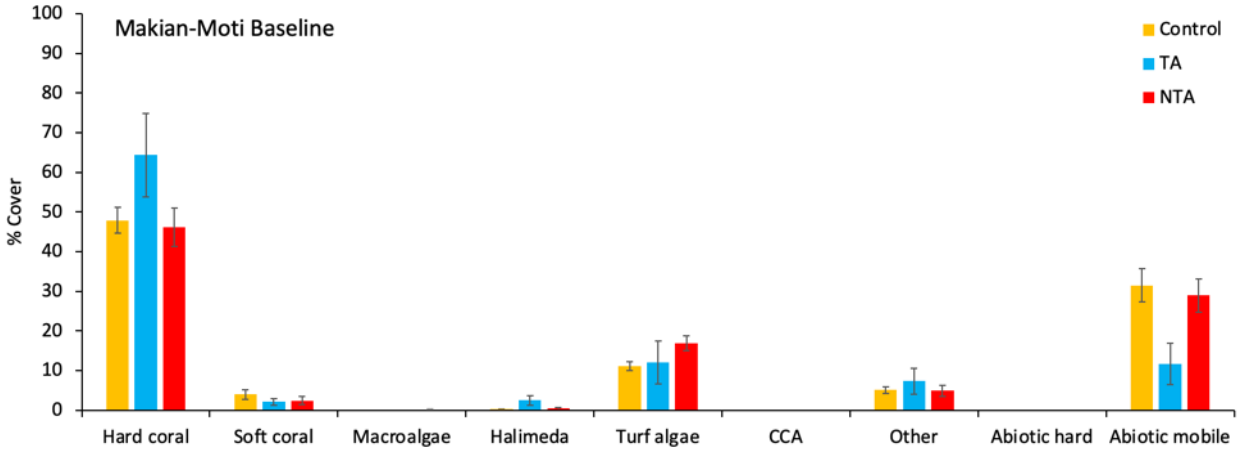


Figure 4.42 Percentage cover of key benthic categories by management zone in Makian-Moti MPA, during the baseline survey (T0). Only one site was surveyed during T1 and is not included in analyses. For statistical analysis of the differences in benthic communities, see Appendix II. Error bars = 1 SE.

b. Fish community

The biomass and density of both target and non-target fish families was highly variable (see the large error bars in Figure 4.43), Both biomass and density of target and non-target species were on the lower end of the scale among all the surveyed MPAs in North Maluku Province.

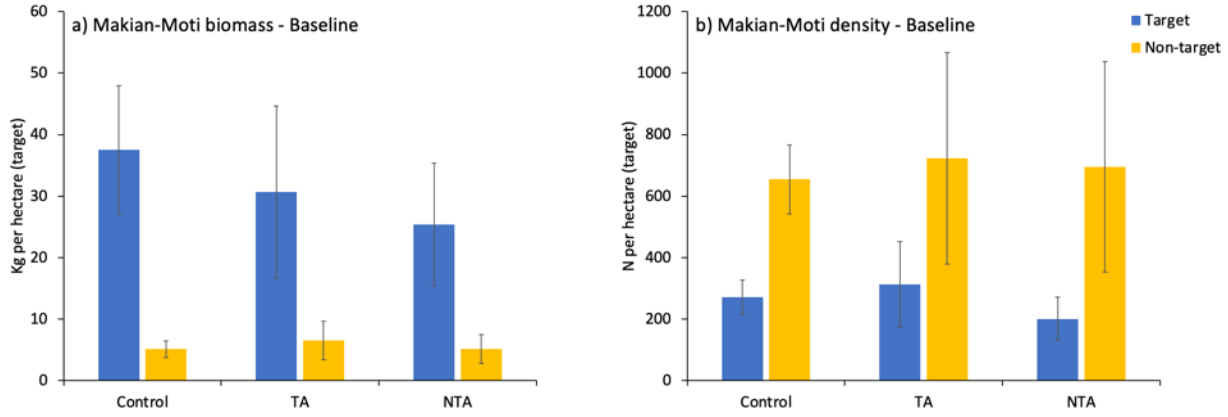


Figure 4.43 Biomass (kg per hectare) and density (individuals per hectare) by management zone in Makian-Moti MPA. For statistical analysis of the differences in fish communities, see Appendix III. Error bars = 1 SE.

c. Charismatic species

Napoleon wrasse (*Cheilinus undulatus*) were commonly observed in Makian-Moti MPA and the surrounding waters. In the 2019 survey, Napoleon wrasse were found around the Moti and Makian Islands. Sharks (*Carcharhinus melanopterus*) were encountered in the southwest and east of Moti Island and south of Makian Island. Green turtles (*Chelonia mydas*) were encountered at West Moti and southeast of Makian Island. Bluespotted ribbontail rays (*Taeniura lymma*) were only encountered at Moti Island during the 2019 survey.

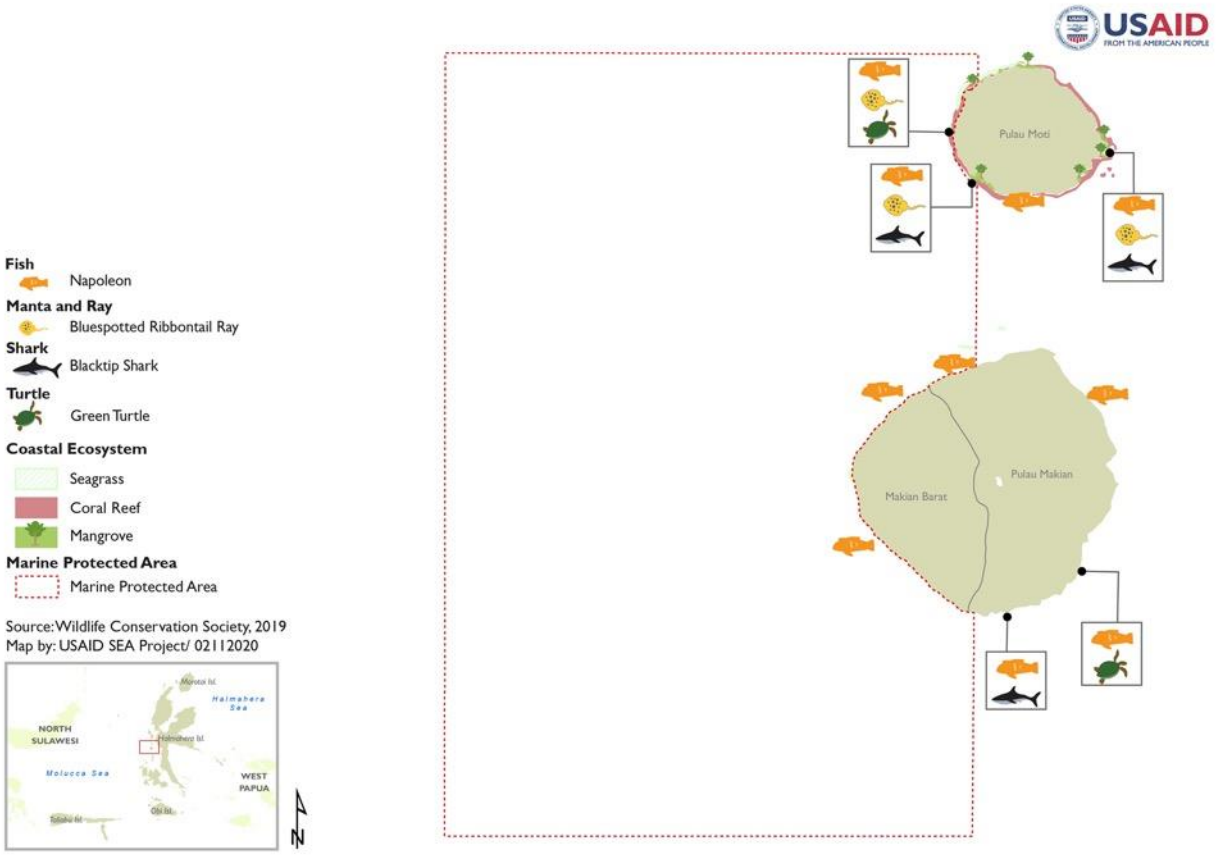


Figure 4.44 Charismatic species map around Makian-Moti MPA from 2019 survey data

d. Status of management

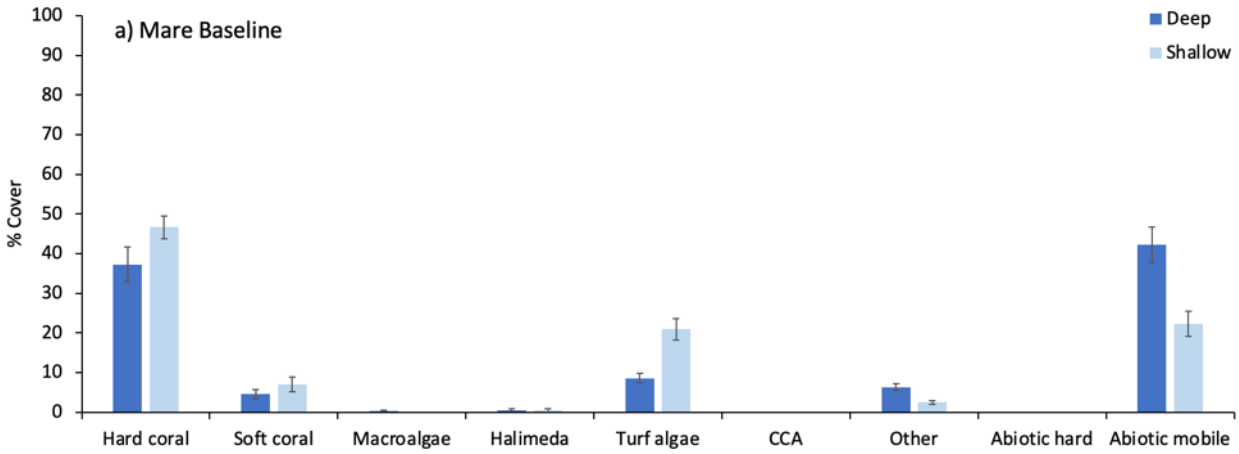
Makian - Moti MPA consist of 2 major islands, Makian and Moti; the MPA has been protected by Ministerial Decree No. 104 Year 2020 and included in the Provincial Marine Spatial Plan or RZWP3K (*Rencana Zonasi Wilayah Pesisisr dan Pulau-Pulau Kecil*) as a conservation area. It is stated under the Provincial Regulation) No. 2 Year 2018. The management of the area falls under the UPTD (*Unit Pelaksana Tekhnis Daerah* – Provincial Technical Unit) MPA of North Maluku. Currently, Makian-Moti MPA has a management plan waiting for final approval from the Governor, and no regulations have been implemented yet in the MPA. The surveillance of the MPA is the responsibility of the community surveillance group called POKMASWAS (*Kelompok Pengawas Masyarakat*). The POKMASWAS received official recognition from the North Maluku Provincial Fisheries Agency (DKP) in 2019, and the community has been conducting the monitoring activities ever since.

4.2.3 MARE MPA

a. Benthic community

In Mare MPA, baseline surveys found that the benthic community was dominated by hard corals (42%) and abiotic (non-living) mobile cover such as sand and rubble (32.2%; Figure 4.45). The cover of hard corals and turf algae were significantly higher in shallow areas (46.6% vs. 37.3% and 21% vs. 8.6%, respectively), while mobile abiotic cover and other sessile invertebrates such as sponges, zoanthids and hydroids (42.2% vs. 22.3% and 6.4% vs. 2.5%, respectively) were more abundant in deeper habitats. No-take areas (NTA) had higher cover of soft corals (10.5%) and lower cover of turf algae (10.3%) than other zones (Figure 4.46). The cover of *Halimeda* was highest at control sites outside the MPA (1.6%), and the cover of other sessile invertebrates was lowest in fished areas (TA) inside the MPA (3.1%).

The follow-up survey in 2020 (T1) showed higher coral cover (70%) and lower cover of most other benthic categories (Figure 4.45). Hard and soft coral cover was significantly higher in shallow areas (77.4% and 8.2%, respectively), while abiotic mobile cover and other sessile invertebrates were more abundant in deeper habitats (18.1% and 5.4%, respectively). The effects of zone during T1 surveys were only significant for soft corals, with the lowest cover at control sites (3.4%), and macroalgae, with the highest cover occurring at control sites (0.4%; Figure 4.46). There was a dramatic and significant increase in coral cover between the baseline and T1 surveys; the declines in *Halimeda*, turf algae, other sessile invertebrates and abiotic mobile cover were smaller but also statistically significant (Appendix II; Figure 4.47).



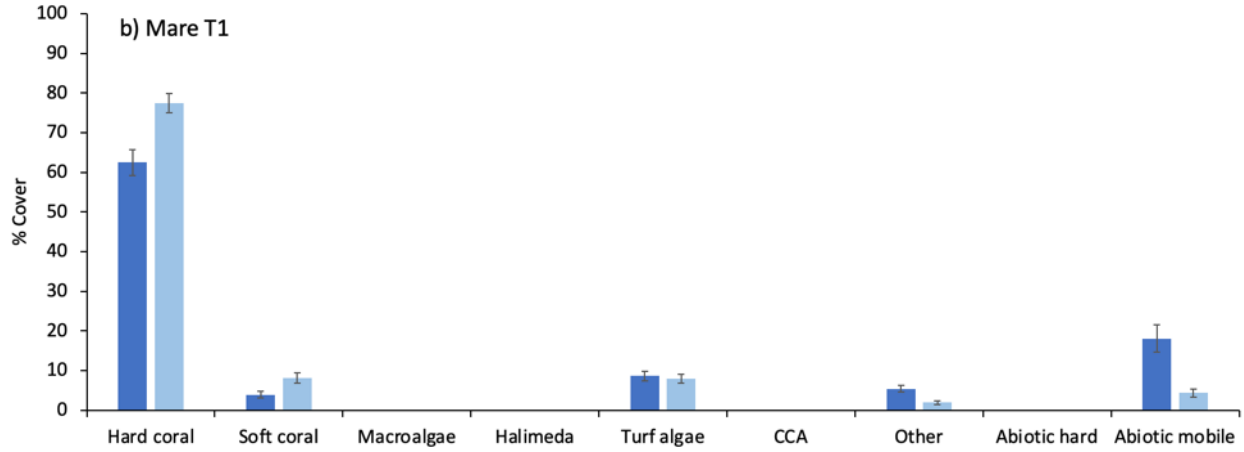


Figure 4.45 Percentage cover of key benthic categories across deep and shallow habitats in Mare MPA, a) during the baseline survey (T0) and b) at the T1 repeat survey. Note that some site differences occurred between the two survey periods. For statistical analysis of the differences in benthic communities, see Appendix II. Error bars = 1 SE.

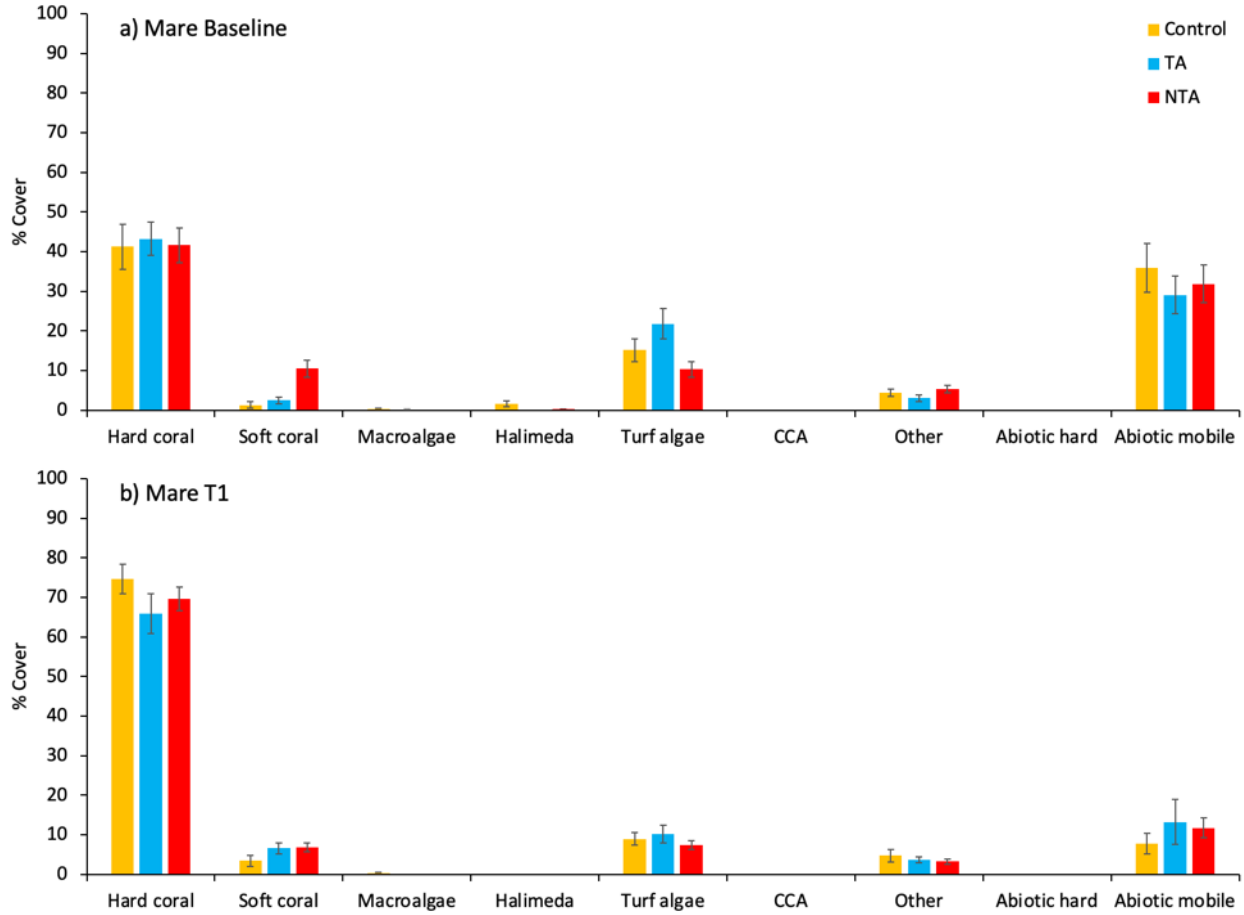


Figure 4.46 Percentage cover of key benthic categories by management zone in Mare MPA, a) during the baseline survey (T0) and b) at the T1 repeat survey. Note that some site differences occurred between the two survey periods. For statistical analysis of the differences in benthic communities, see Appendix II. Error bars = 1 SE.

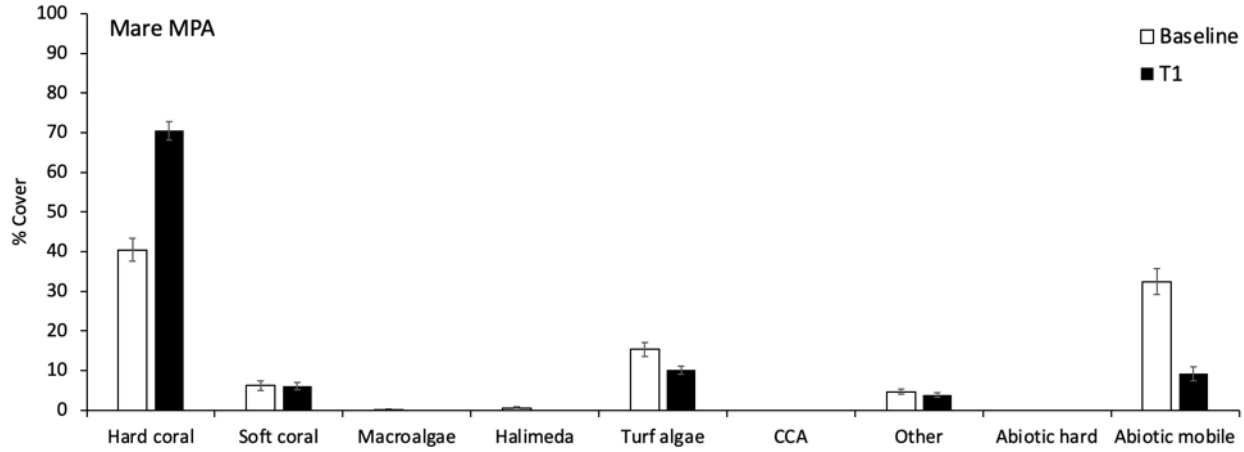
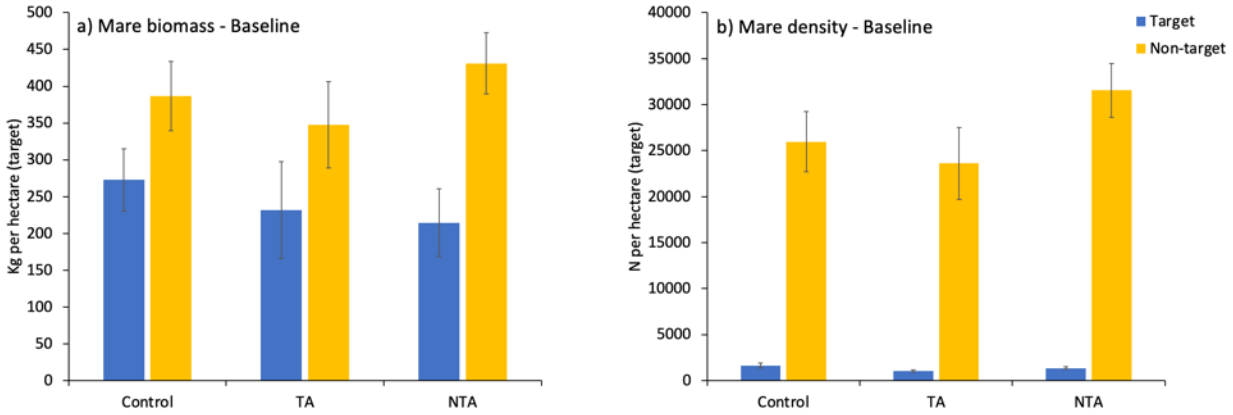


Figure 4.47 Percentage cover of key benthic categories by survey period in Mare MPA. Only sites surveyed in both periods were included in calculating the mean values. For statistical analysis of the differences in benthic communities, see Appendix II. Error bars = 1.

b. Fish community

The biomass and density of non-target fish families (388 kg and 27,037 individuals per hectare) during the baseline surveys of Mare MPA were higher than those of target fish families (240 kg and 1,335 individuals per hectare), and both groups were similar between control sites, TAs and NTAs (Figure 4.48). Follow-up surveys in 2020 (T1) showed that biomass of target species (470 kg per hectare) was higher than non-target species (349 kg per hectare), although the density of non-target fish (33,774 individuals per hectare) remained an order of magnitude higher than target fish (3,755 individuals per hectare). The increase in biomass and density of target fish families was significant when considering only sites surveyed in both periods (Appendix III), and this increase was greatest in TAs and smallest at control sites (Figure 4.49). The biomass of non-target fish families did not change significantly between 2017 and 2020, but the density increased in the MPA, both in TAs and NTAs (Figure 4.49).



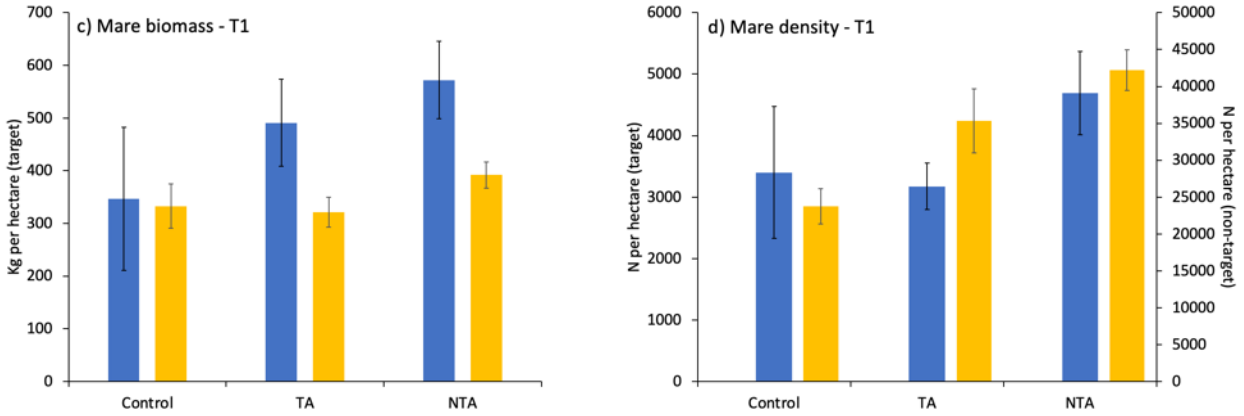


Figure 4.48 Biomass (kg per hectare) and density (individuals per hectare) by management zone in Mare MPA. Baseline a) biomass and b) density and T1 c) biomass and d) density means were calculated using all sites surveyed during the respective sampling periods. Note that non-target estimates of density at T1 were plotted on a separate axis. For statistical analysis of the differences in fish communities, see Appendix III. Error bars = 1 SE.

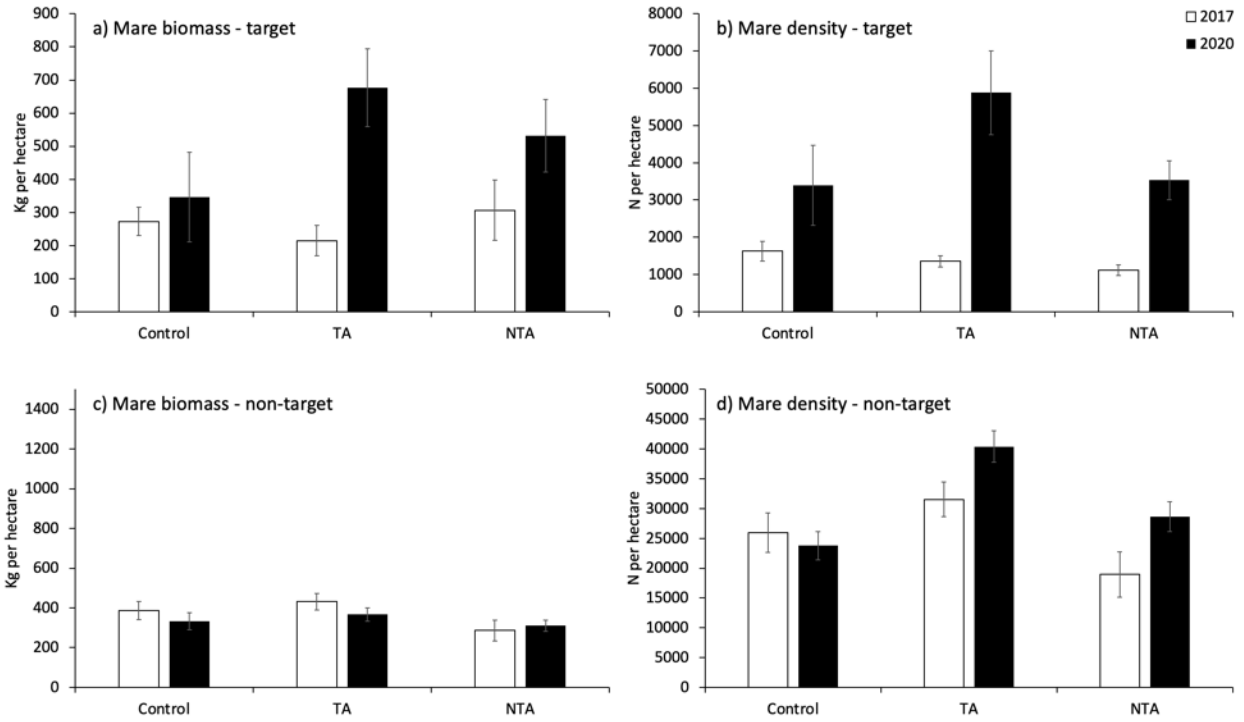


Figure 4.49 Biomass (a) kg per hectare) and density (b) individuals per hectare) by management zone in Mare MPA. Only sites surveyed in both periods were included in calculating the mean values. For statistical analysis of the differences in fish communities, see Appendix III. Error bars = 1 SE.

c. Charismatic species

Mare Island is considered a key habitat for dolphins, particularly in Kahiya Masolo Bay, where dolphins frequently rest and search for food. Blacktip reef sharks (*Carcharhinus melanopterus*) were also observed during both surveys, especially in 2020, when they were recorded at every site (Figure 4.51). Napoleon wrasse (*Cheilinus undulatus*) were also commonly found in Mare Island in 2020, however the 2017 survey only encountered them in one place in the northwest of Mare Island.

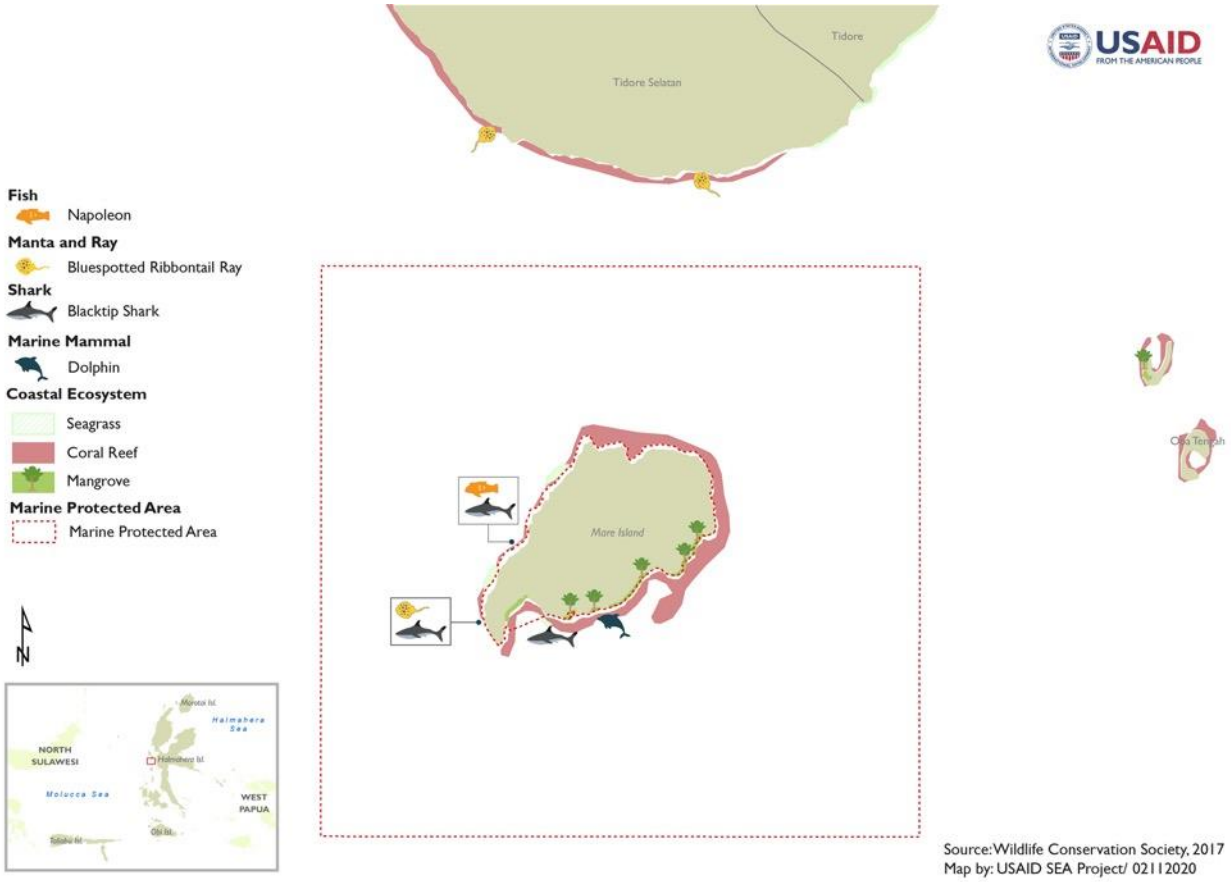


Figure 4.50 Charismatic species map around Mare MPA from 2017 survey data.

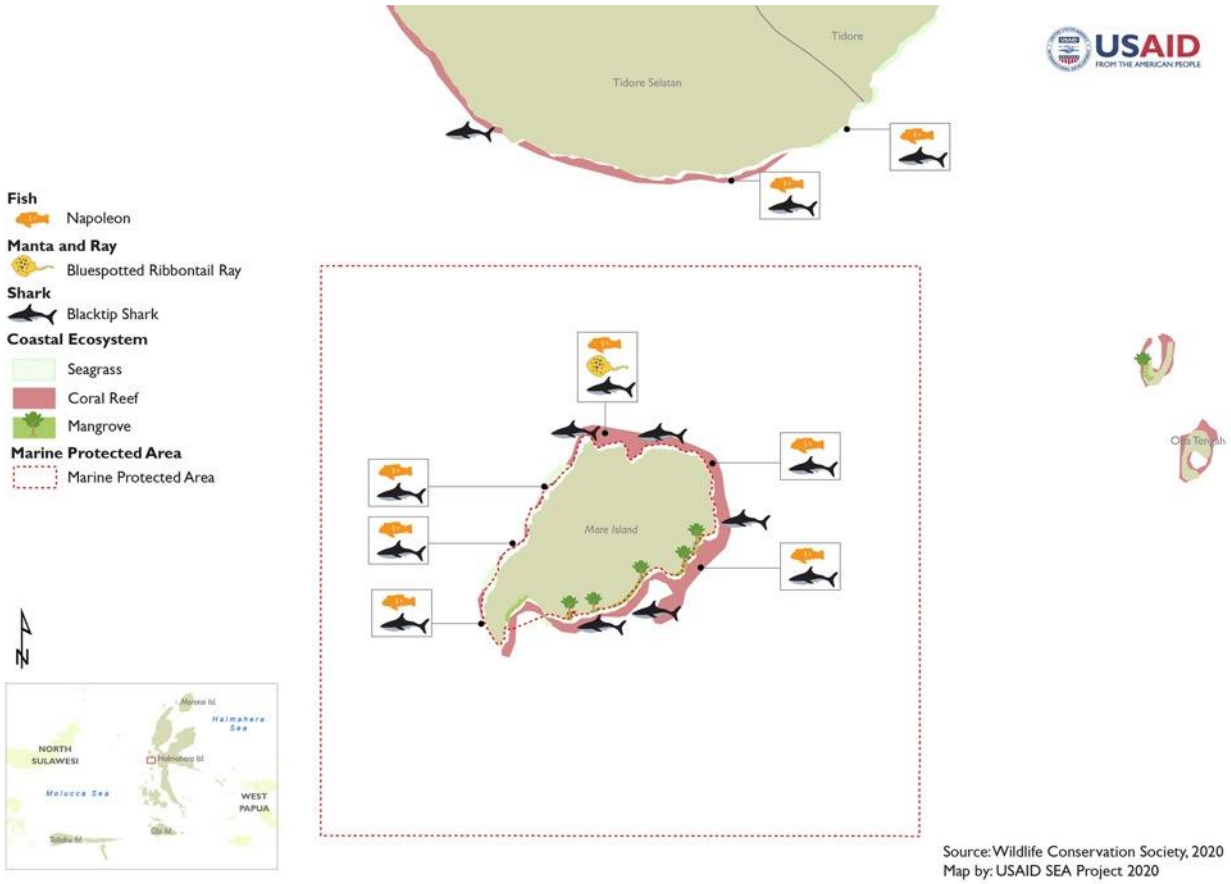


Figure 4.51 Charismatic species map around Mare MPA from 2020 survey data.

d. Status of management

Mare MPA has been protected by Ministerial Decree No. 66/Kepmen-KP/2020, and it is also included in the Provincial Marine Spatial Plan or RZWP3K (*Rencana Zonasi Wilayah Pesisisr dan Pulau-Pulau Kecil*) as a conservation area. The RZWP3K of North Maluku Province has a PERDA (*Peraturan Daerah* - Provincial Regulation) No. 2 Year 2018. The management of the area falls under the UPTD (*Unit Pelaksana Tekhnis Daerah* – Provincial Technical Unit) MPA of North Maluku. Currently, Mare MPA has a management plan waiting for final approval from the Governor, and no regulations have been implemented yet in the MPA. The surveillance of the MPA is the responsibility of the community surveillance group called POKMASWAS (*Kelompok Pengawas Masyarakat*). The POKMASWAS received official recognition from the North Maluku Provincial Fisheries Agency (DKP Maluku) in 2019, and the community has been conducting the monitoring activities ever since.

4.2.4 RAO-DEHEGILA MPA

a) Benthic community

During both baseline and follow-up (T1) surveys of Rao-Dehegila MPA, hard coral cover dominated the benthic community (40-60%) in both deep (43.2% at T0, 53.4% at T1) and shallow habitats (56.6% at T0, 61.4% at T1; Figure 4.52). Other benthic categories were present in low amounts, and deep areas had higher cover of CCA (0.5%), abiotic (non-living) mobile substrate such as sand or rubble (11.5%), and other sessile invertebrates such as sponges, zoanthids and hydroids (5.8%).

Differences between zones during baseline surveys were not significant for hard coral cover, although it was slightly lower at control sites (42.5%, Appendix II; Figure 4.53). There was higher cover of soft corals (21.8%) and abiotic hard substrate such as rock and dead coral (8%) at control sites, while the algae categories were more abundant within the MPA. During the follow-up surveys (T1), soft coral cover was highest in NTAs (18.6%) and macroalgal cover was highest at control sites (4.1%; Figure 4.53.). When considering only sites that were surveyed in both periods, there was a significant increase in hard coral cover (51.6% to 60%) and other sessile invertebrates (4.4% to 9.3%) and a decline in the cover of abiotic mobile substrate (19.5% to 8.9%; Figure 4.54).

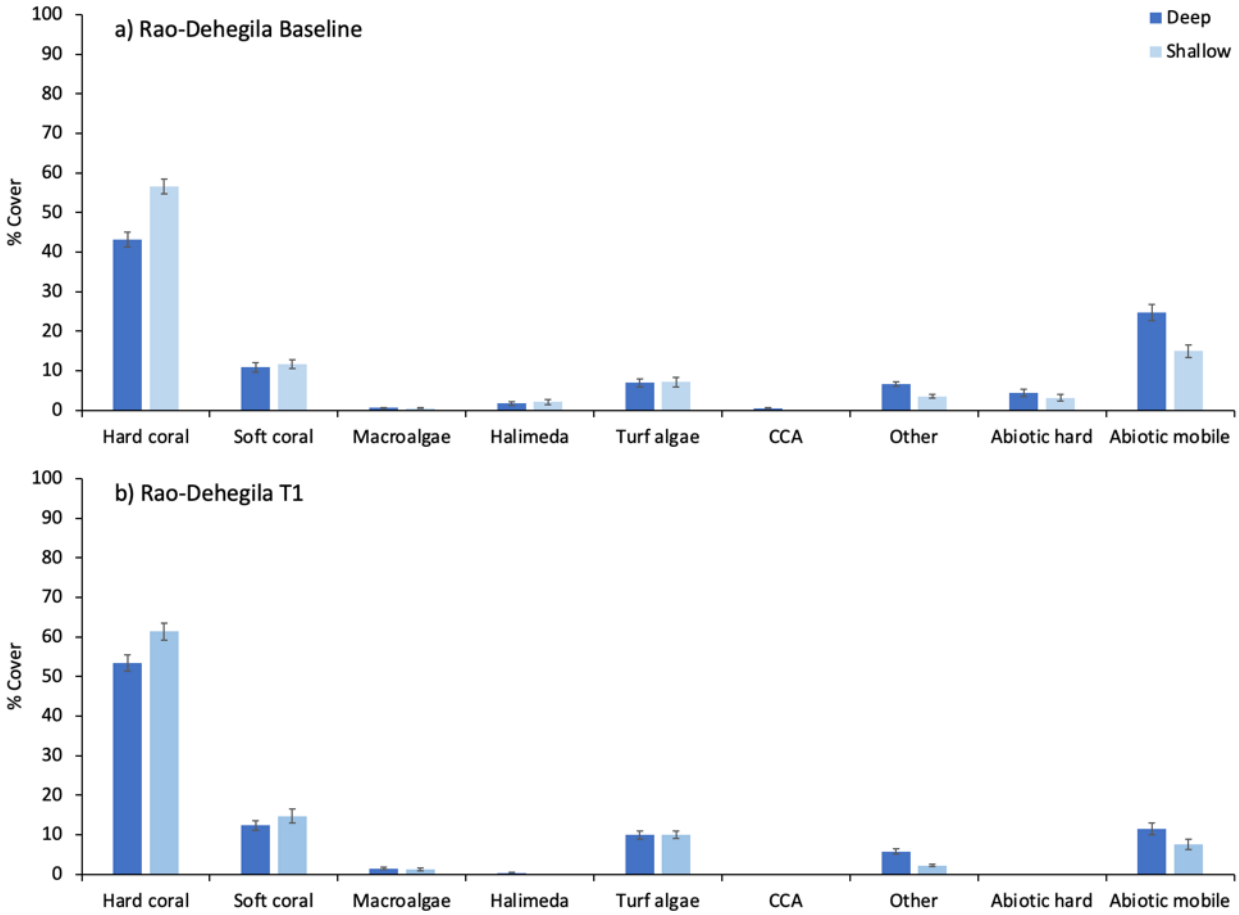


Figure 4.52 Percentage cover of key benthic categories across deep and shallow habitats in Rao-Dehegila MPA, a) during the baseline survey (T0) and b) at the T1 repeat survey. For statistical analysis of the differences in benthic communities, see Appendix II. Note that some site differences occurred between the two survey periods. Error bars = 1 SE.

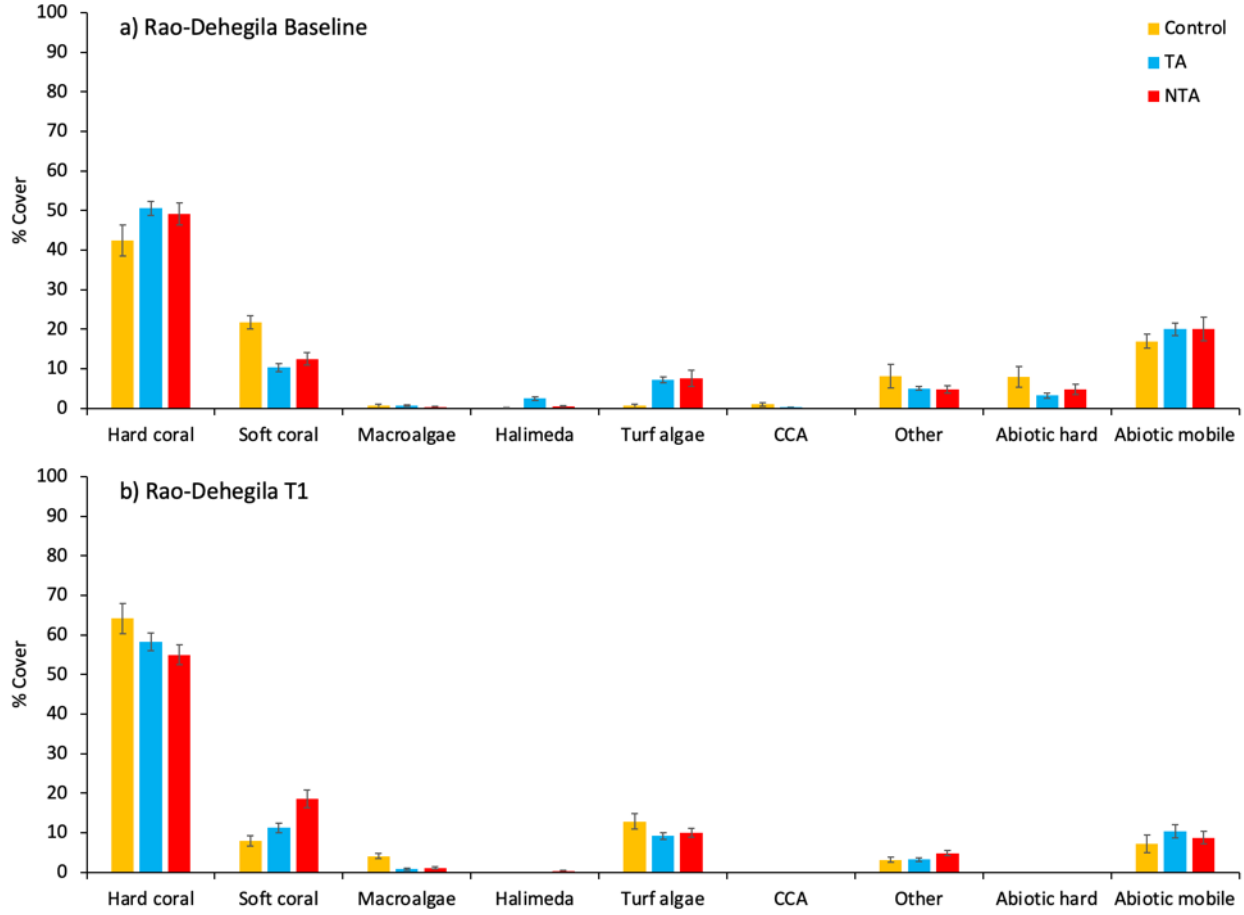


Figure 4.53 Percentage cover of key benthic categories by management zone in Rao-Dehegila MPA, a) during the baseline survey (T0) and b) at the T1 repeat survey. Note that some site differences occurred between the two survey periods. For statistical analysis of the differences in benthic communities, see Appendix II. Error bars = 1 SE.

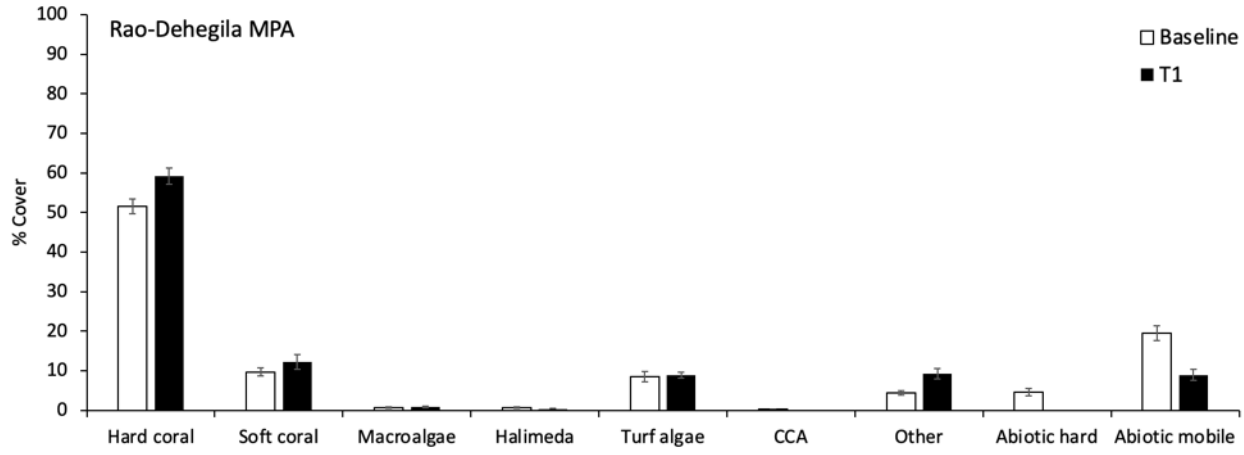


Figure 4.54 Percentage cover of key benthic categories by survey period in Rao-Dehegila MPA. Only sites surveyed in both periods were included in calculating the mean values. For

statistical analysis of the differences in benthic communities, see Appendix II. Error bars = 1 SE.

b) Fish community

During baseline surveys of Rao-Dehegila MPA, control sites had the highest biomass of target fish (5,641 kg per hectare; Figure 4.55). Follow-up surveys (T1) showed much lower biomass and density of target fish. The density of target fish at T1 was higher in NTAs (3,809 kg per hectare) than in the two fished zones (3,421 in TAs, 3,167 in controls; Figure 4.55). Biomass declined significantly in both TAs and NTAs, between 2017 and 2020 and the decline was greater in NTAs (2,405 kg to 456 kg per hectare; Figure 4.56). Target fish density remained similar between the two sampling periods in both zones (~4,1200 individuals per hectare).

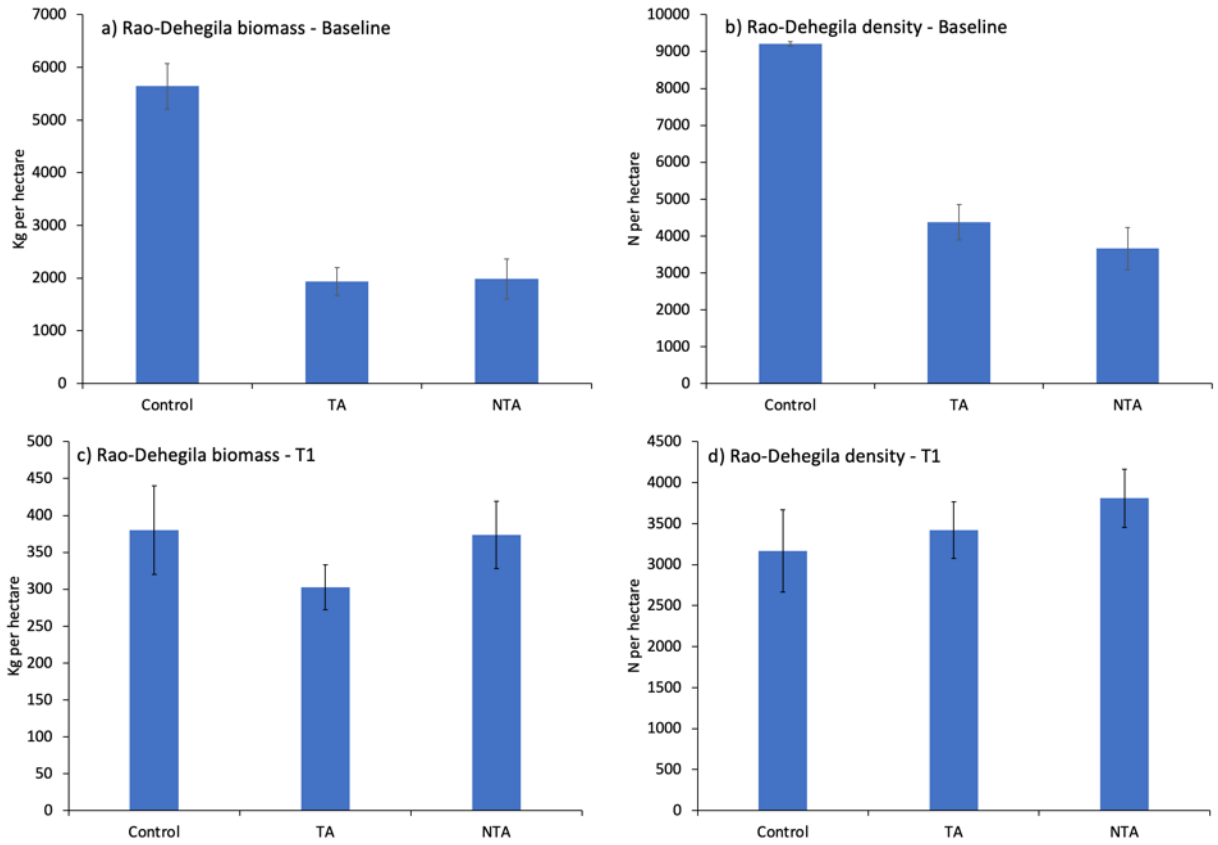


Figure 4.55 Biomass (kg per hectare) and density (individuals per hectare) by management zone in Rao-Dehegila MPA. Baseline a) biomass and b) density and T1 c) biomass and d) density means of target families were calculated using all sites surveyed during the respective sampling periods. For statistical analysis of the differences in fish communities, see Appendix III. Error bars = 1 SE.

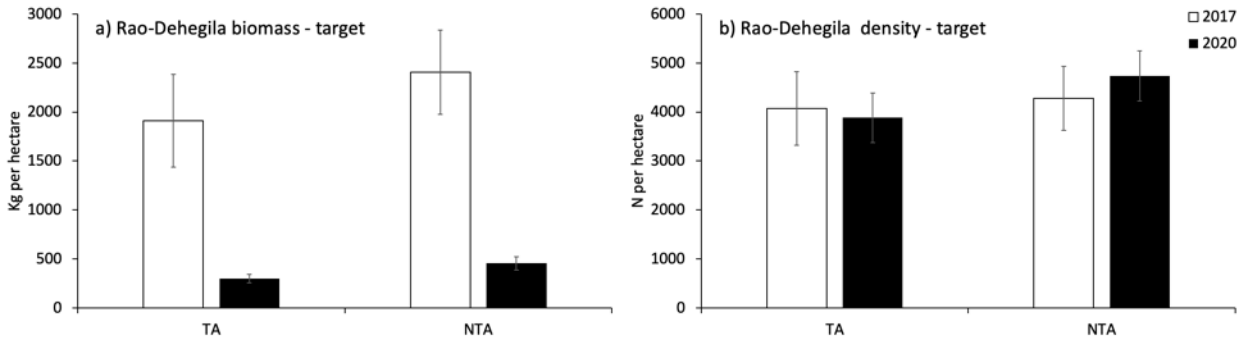


Figure 4.56 Biomass (a) kg per hectare) and density (b) individuals per hectare) by management zone in Rao-Dehegila MPA. Only sites surveyed in both periods were included in calculating the mean values. For statistical analysis of the differences in fish communities, see Appendix III. Error bars = 1 SE.

c) Charismatic species

Blacktip (*Carcharhinus melanopterus*) and whitetip (*Triaenodon obesus*) reef sharks were found during both survey periods in Rao-Dehegila MPA (Figure 4.57 and Figure 4.58). In 2017, they were found around sites from the north to the south, while in 2020 they were observed only in the southern area of Morotai Island. Rao-Dehegila has seagrass beds along the west coast, extending to the south coast of Morotai and surrounding islands; this is a suitable habitat for dugongs (*Dugong dugon*). According to information from the community in 2017, dugongs were observed several times around Kokoya and Dodola Islands and also along the southwest side of Morotai Island. Mitita, Kokoya and Dodola receive high visitation from tourism, especially around Morotai. Turtles were only recorded in 2017 in Kolorai and Daruba, including hawksbills (*Eretmochelys imbricata*) with carapace lengths of 20-70 cm. Dolphins and whales were also reported near Rao Island and south of Morotai.

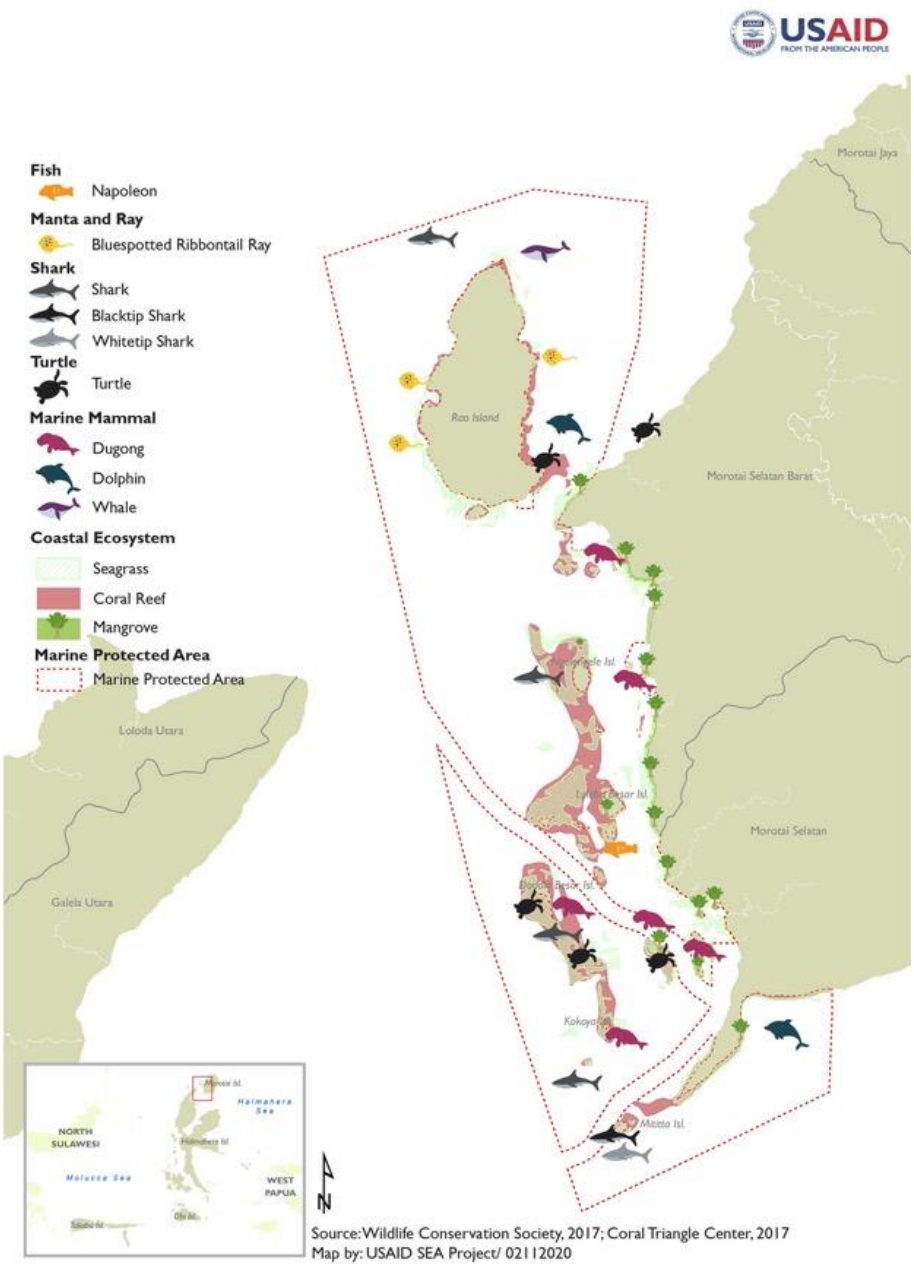


Figure 4.57 Charismatic species map around Rao-Dehegila MPA from 2017 survey data.

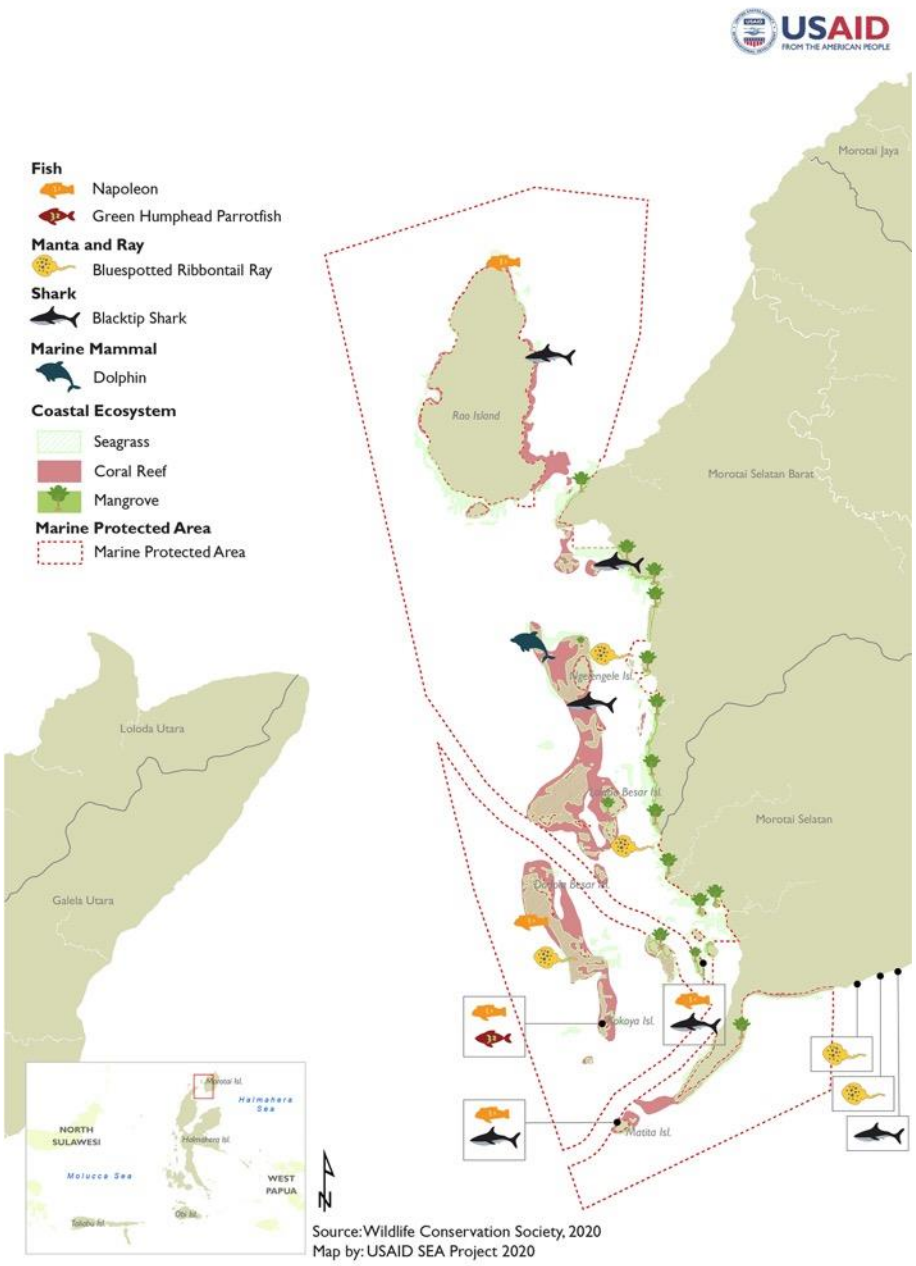


Figure 4.58 Charismatic species map around Rao-Dehegila MPA from 2020 survey data.

d) Status of management

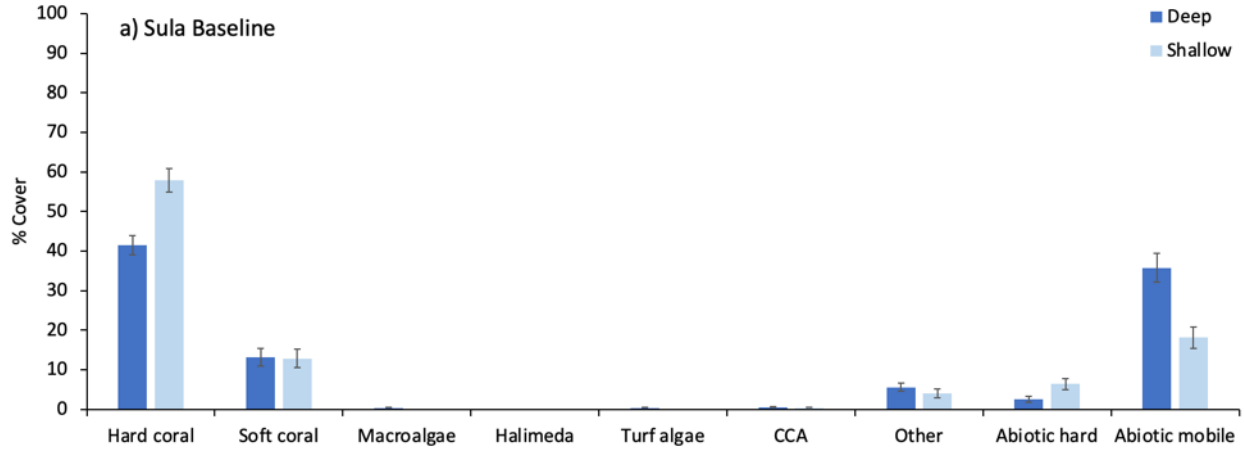
Rao – Dehegila MPA is the enlargement of the Rao Island MPA that was declared by the Morotai Regent in 2012. It is also known as Morotai MPA and has been established recently by Marine Affairs and Fisheries Ministerial Decree No. 67/Kepmen-KP/2020. It is included in the Provincial Marine Spatial Plan or RZWP3K (*Rencana Zonasi Wilayah Pesisir dan Pulau-Pulau Kecil*) as a conservation area and stated in the Provincial Regulation No. 2 Year 2018. The management of the area falls under UPTD (*Unit Pelaksana Tekhnis Daerah* – Provincial Technical Unit) MPA of North Maluku. Currently, Rao-Dehegila MPA has a management plan waiting for final approval from the Governor. There are no or limited regulations implemented in the MPA. The surveillance of the MPA is the responsibility of the community surveillance group called POKMASWAS (*Kelompok Pengawas Masyarakat*). The POKMASWAS received official recognition from the North Maluku Provincial Fisheries Agency (DKP Maluku Utara) in 2019, and the community has conducted the monitoring activities ever since.

4.2.5 SULA MPA

a) Benthic community

Baseline surveys of Sula MPA recorded high coral cover (49.7%), moderate abiotic (non-living) mobile cover such as sand and rubble (27%), and low cover of soft coral (13%), abiotic hard substrate such as rock and dead coral (4.5%), and other sessile invertebrates (4.9%; Figure 4.59). Hard coral cover was significantly higher in shallow (57.9%) than in deep habitats (41.5%), while abiotic mobile cover was higher in deeper areas (35.8% vs. 13.2%). The MPA had higher cover of soft coral (14.8%), abiotic hard substrate (4.8%) and other sessile invertebrates (5.7%), while control sites had more abiotic mobile substrate (50%; Figure 4.60).

Differences between depths persisted in the follow-up survey (T1), although coral cover was lower overall (42.2%; Figure 4.61), and soft coral cover was higher in shallow habitats (14.6%). No control sites were surveyed at T1, and NTAs had lower coral cover (34.7% vs. 51.2%) and higher cover of abiotic mobile substrate (28.5% vs. 19.6%) and other sessile invertebrates (9.9% vs. 4%).



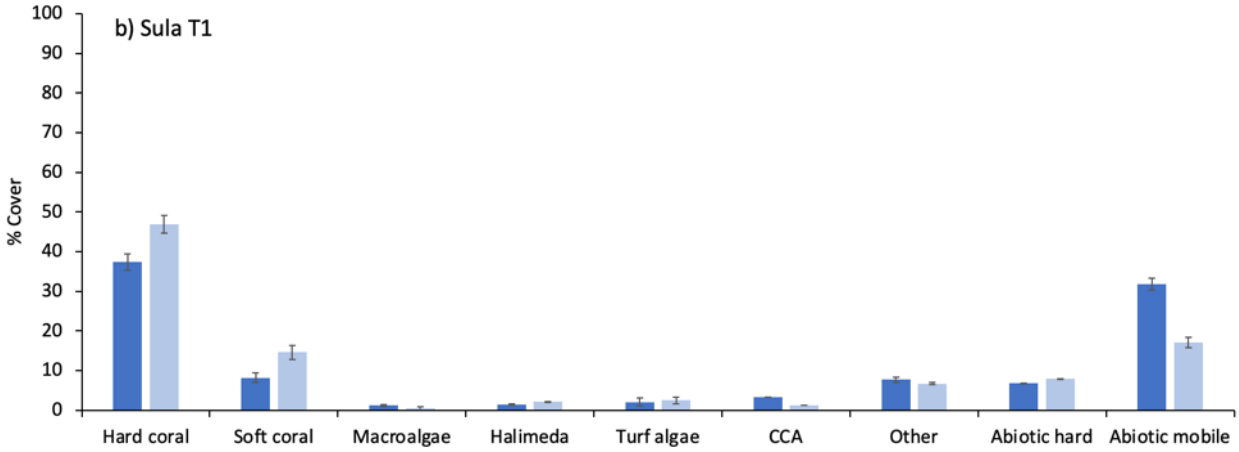


Figure 4.59 Percentage cover of key benthic categories across deep and shallow habitats in Sula MPA, a) during the baseline survey (T0) and b) at the T1 repeat survey. Note that some site differences occurred between the two survey periods. For statistical analysis of the differences in benthic communities, see Appendix II. Error bars = 1 SE.

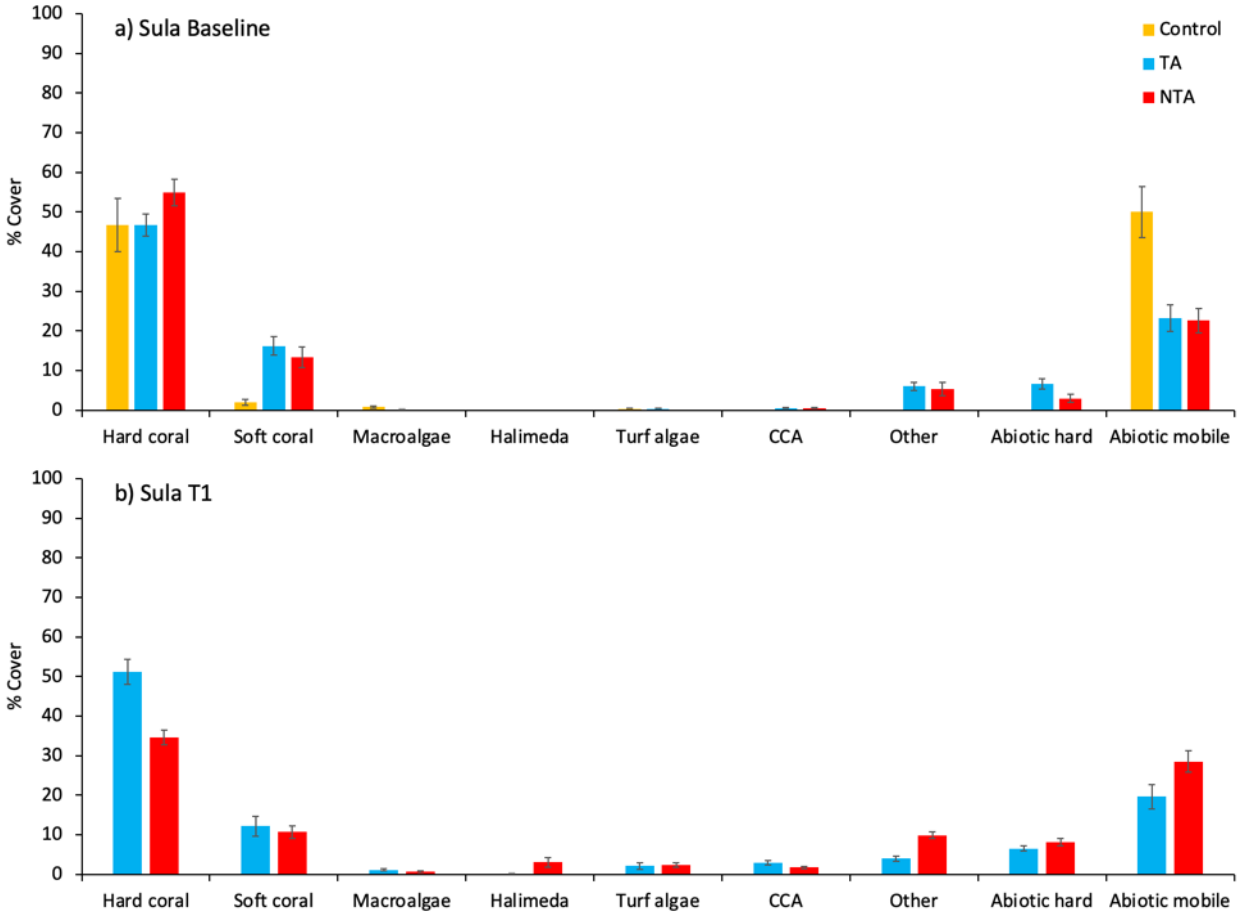


Figure 4.60 Percentage cover of key benthic categories by management zone in Sula MPA, a) during the baseline survey (T0) and b) at the T1 repeat survey. Note that control sites were not surveyed at T1, and some site differences occurred between the two survey periods. For statistical analysis of the differences in benthic communities, see Appendix II. Error bars = 1 SE.

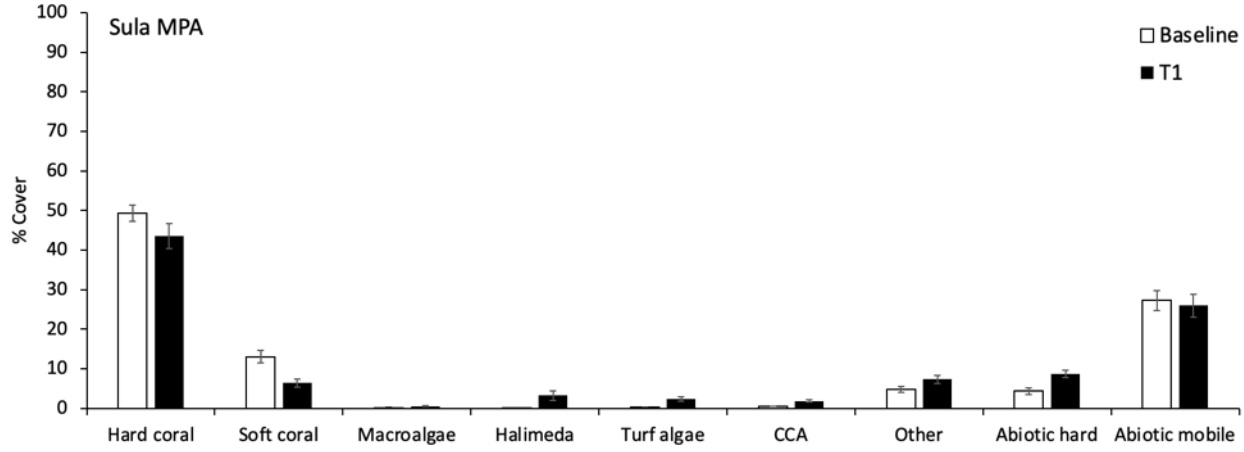
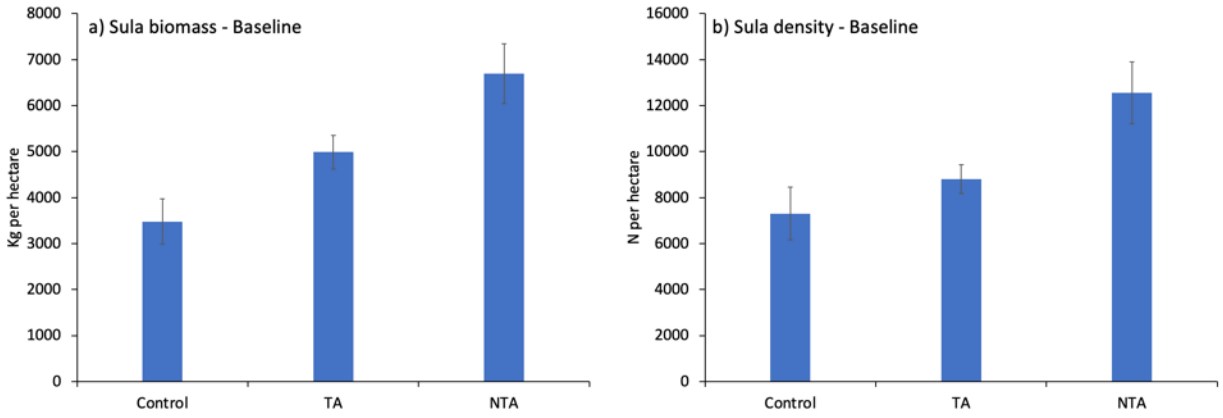


Figure 4.61 Percentage cover of key benthic categories by survey period in Sula MPA. Only sites surveyed in both periods were included in calculating the mean values. For statistical analysis of the differences in benthic communities, see Appendix II. Error bars = 1.

b) Fish community

Target fish biomass and density in Sula MPA showed an increasing trend with increasing protection during the baseline survey, with 3,481, 4,909 and 6,695 kg and 7,307, 8,804 and 12,558 individuals per hectare in control, TAs and NTAs, respectively, but this was not significant (Figure 4.62). The follow-up surveys (T1) recorded lower target biomass (1,346 vs. 5,055 kg per hectare), but similar target density (9,419 vs. 9,556 individuals per hectare). Using only sites surveyed in both years, there was a dramatic decline in biomass, both in TAs (2,989 to 1,141 kg per hectare) and NTAs (6,695 to 1,550 kg per hectare; Figure 4.63). Target density remained similar, suggesting that there was a sudden decline in larger individuals.



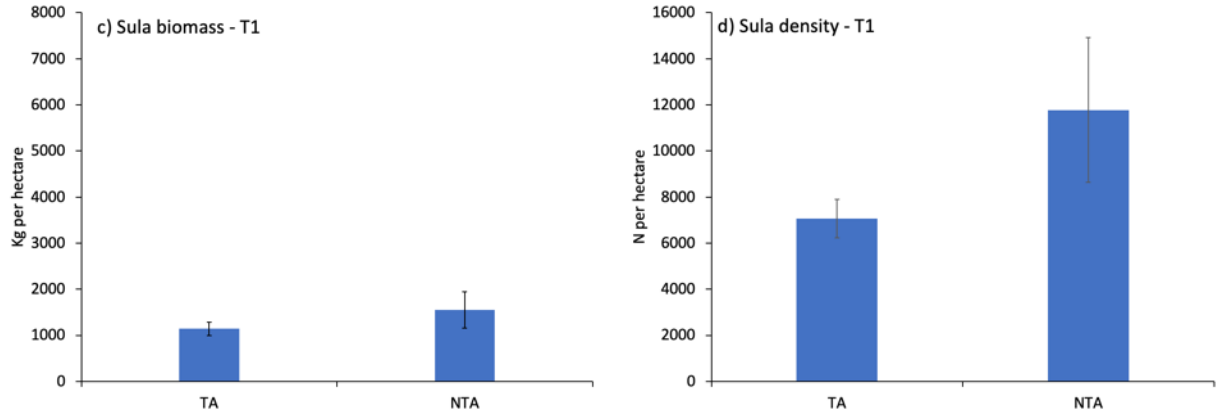


Figure 4.62 Biomass (kg per hectare) and density (individuals per hectare) by management zone in Sula MPA. Baseline a) biomass and b) density and T1 c) biomass and d) density means were calculated using all sites surveyed during the respective sampling periods. Note that no control sites were surveyed at T1. For statistical analysis of the differences in fish communities, see Appendix III. Error bars = 1 SE.

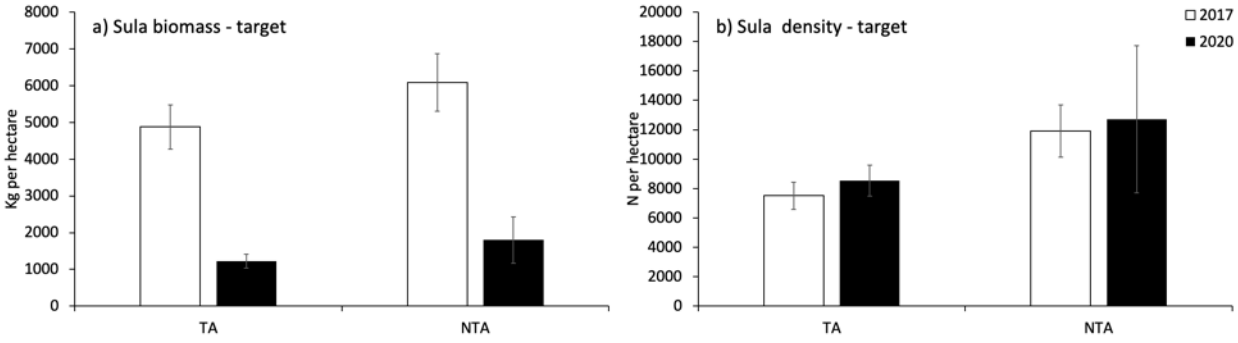


Figure 4.63 Biomass (a) kg per hectare) and density (b) individuals per hectare) by management zone in Sula MPA. Only sites surveyed in both periods were included in calculating the mean values. For statistical analysis of the differences in fish communities, see Appendix III. Error bars = 1 SE.

c) Charismatic species

Coastal habitats around Sula MPA are habitat for turtles; in the 2017 survey, observers encountered 40-50 turtles in a single dive. Hawksbill turtles (*Eretmochelys imbricata*) were more common in Sula MPA than other MPAs in the SEA Project area. Napoleon wrasse (*Cheilinus undulatus*) were also frequently observed in both 2017 and 2020 (Figure 4.64 and Figure 4.65). Bumphead parrotfish (*Bolbometopon muricatum*) were recorded at some sites in 2017 and 2020. Bluespotted stingray (*Neotrygon kuhlii*) and bluespotted ribbontail rays (*Taeniura lymma*) were observed mostly at Mangoli and Lifmatola Islands in the north of Sula MPA. Sharks were only found during the 2017 survey. Shark sightings consisted of blacktip (*Carcharhinus melanopterus*) and whitetip (*Triaenodon obesus*) reef sharks around the three big Islands of Sula MPA (Mangoli, Lifmatola and Sulabesi). Dolphins (spinner, *Stenella longirostris* and spotted, *Stenella frontalis*) were encountered in 2017 in North East Mangoli and Lifmatola Islands. Humpback whales (*Megaptera novaeangliae*) were also reported from around North Sanana at Sulabesi Island (Figure 4.64).

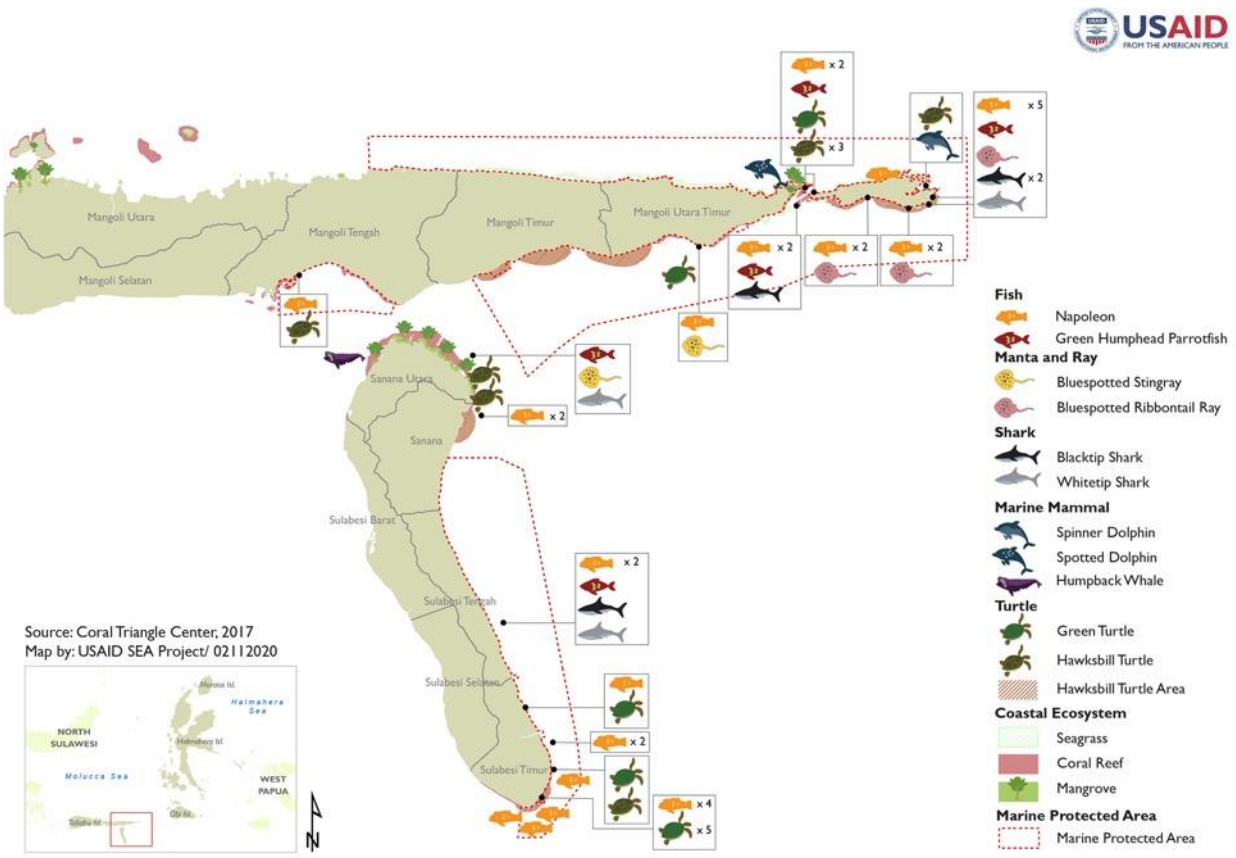


Figure 4.64 Charismatic species map around Sula MPA from 2018 survey data.

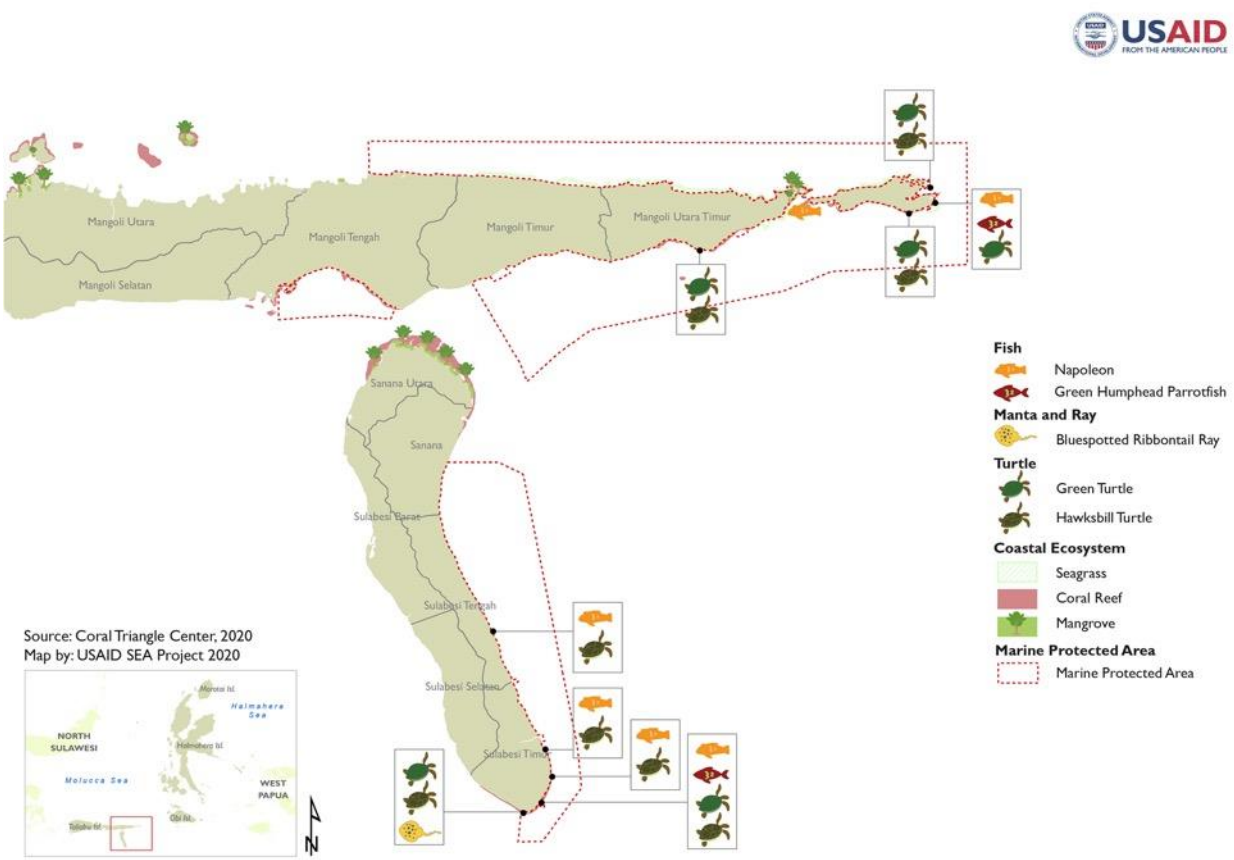


Figure 4.65 Charismatic species map around Sula MPA from 2020 survey data.

d) Status of management

Sula MPA is protected by Ministerial Decree No. 68/Kepmen-KP/2020, and is also included in the Provincial Marine Spatial Plan or RZWP3K (*Rencana Zonasi Wilayah Pesisisr dan Pulau-Pulau Kecil*) as a conservation area. It is stated under the Provincial Regulation No. 2 Year 2018. The management of the area falls under UPTD (*Unit Pelaksana Tekhnis Daerah* – Provincial Technical Unit) MPA of North Maluku. Sula MPA has a management plan waiting for final approval from the Governor. There are no or limited regulations implemented in the MPA. The surveillance of the MPA is the responsibility of the community surveillance group called POKMASWAS (*Kelompok Pengawas Masyarakat*). The POKMASWAS received official recognition from the North Maluku Provincial Fisheries Agency (DKP Maluku Utara) in 2019, and the community has conducted the monitoring activities ever since.

4.2.6 WIDI MPA

a) Benthic community

In 2017, survey sites in Widi MPA were dominated by hard corals (47.1% cover), but also had moderate soft coral cover (25.7%), which was higher than most other MPAs (Figure 4.66). There was also low cover of turf algae (11.6%), other sessile invertebrates (8.5%) and abiotic mobile substrate (4.5%). Only the "other" category showed a significant difference, with higher cover in deep (14.4%) than shallow (2.5%) habitats. No control sites were included in the baseline surveys and hard coral cover was similar between TAs (52.6%) and NTAs (45%; Figure 4.67). NTAs had higher cover of soft corals (29.2% vs. 16.6%) and other sessile invertebrates (9.6% vs. 5.3%), while TAs had more turf algae (18% vs. 9.2%).

During the follow-up surveys (T1), coral cover was lower (40.6%) and there were more differences between deep and shallow habitats. Cover of macroalgae (although very low in cover), other sessile invertebrates and abiotic mobile substrate was higher in deep habitats, while cover of turf algae was higher in shallow areas (Figure 4.66). Zone differences between TAs and NTAs remained the same. Control sites were added in T1; these sites had lower cover of hard coral (33.7%) and turf algae (14.2%), but higher cover of abiotic mobile substrate (25.6%) than sites inside the MPA (Figure 4.67). Between the baseline and T1 surveys there was a significant decline in soft corals (28.2% to 17.8%) and *Halimeda* (2.8% to 0.3%), and an increase in turf algae (10.2 to 21.5%) and abiotic mobile substrate (9% to 25.3%; Figure 4.68).

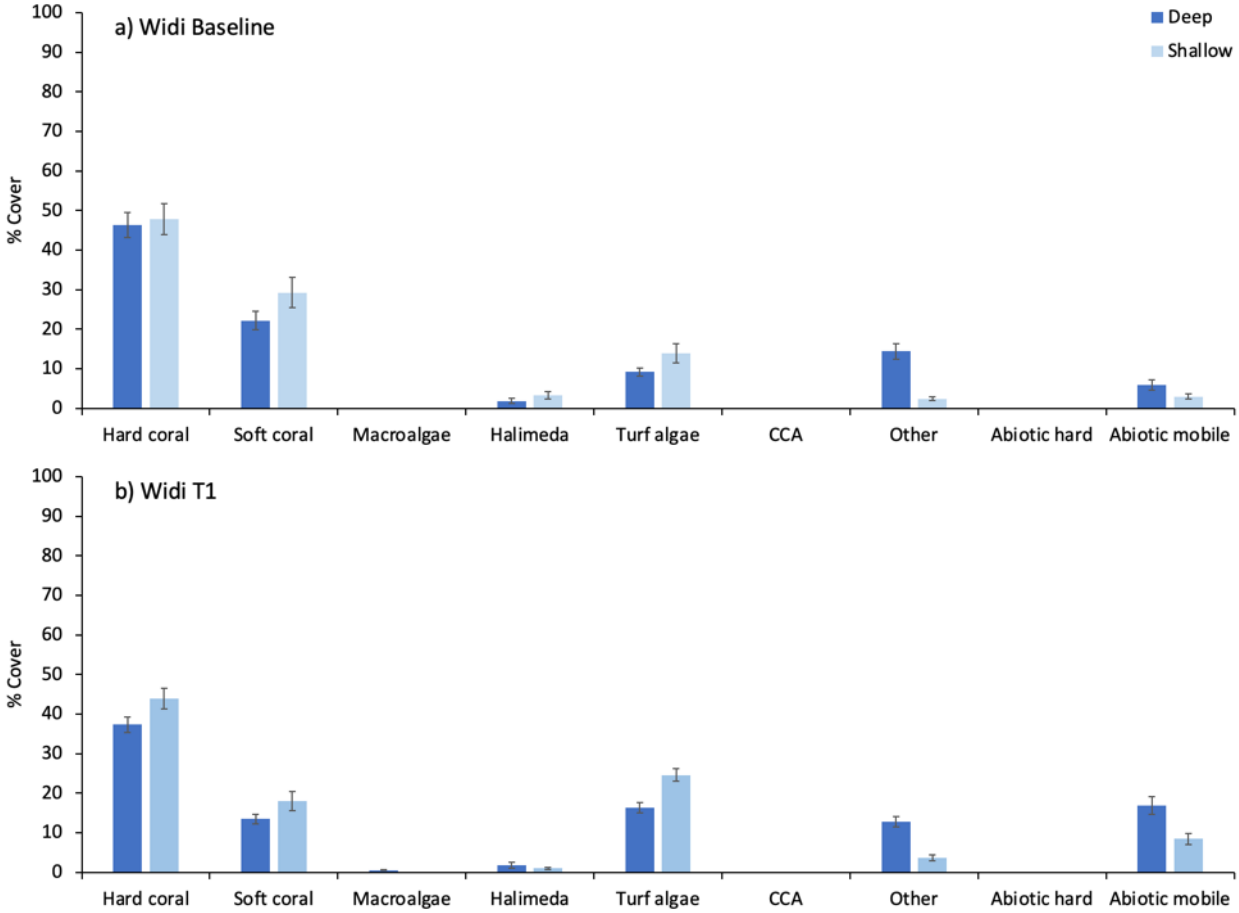


Figure 4.66 Percentage cover of key benthic categories across deep and shallow habitats in Widi MPA, a) during the baseline survey (T0) and b) at the T1 repeat survey. Note that some site differences occurred between the two survey periods. For statistical analysis of the differences in benthic communities, see Appendix II. Error bars = 1 SE.

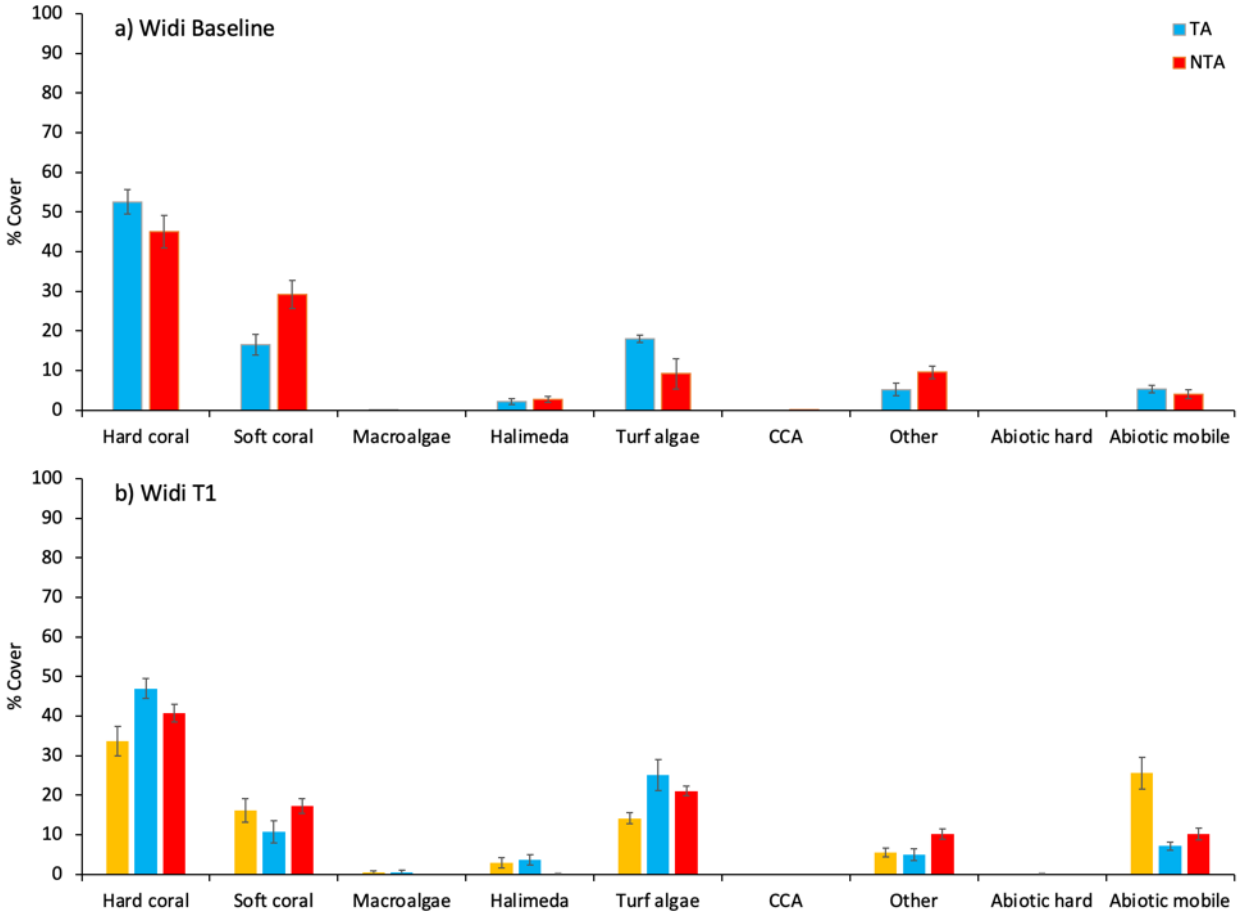


Figure 4.67 Percentage cover of key benthic categories by management zone in Widi MPA, a) during the baseline survey (T0) and b) at the T1 repeat survey. Note that no control sites (orange bars) were included in the baseline survey, and some site differences occurred within the MPA areas between the two survey periods. For statistical analysis of the differences in benthic communities, see Appendix II. Error bars = 1 SE.

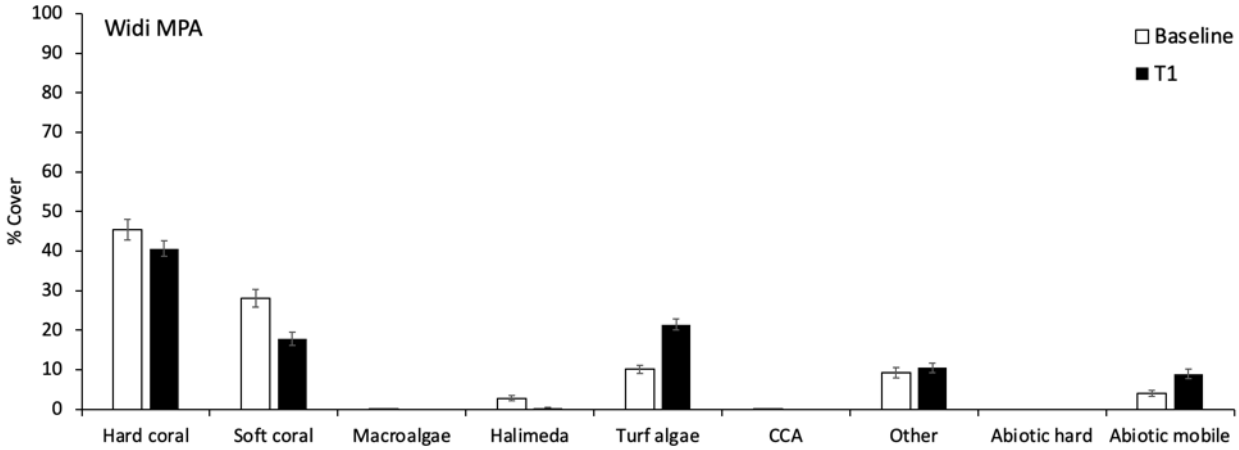


Figure 4.68 Percentage cover of key benthic categories by survey period in Widi MPA. Only sites surveyed in both periods were included in calculating the mean values. For statistical analysis of the differences in benthic communities, see Appendix II. Error bars = 1.

b) Fish community

The baseline survey of Widi MPA recorded greater biomass of target species than non-target species (982 vs. 742 kg per hectare), but greater density of non-target species (30,482 vs. 2,718 individuals per hectare), suggesting that target families are dominated by fewer large fishes, while non-target families are characterised by larger numbers of small fish (Figure 4.69). There were not clear differences between fished (TA) and no-take areas (NTA) for target and non-target biomass or density.

The follow-up survey (T1) of Widi MPA recorded a very high biomass of target fish in NTAs (5,887 kg per hectare), driven by one site with a large school of barracuda. Densities of target and non-target fish families were similar among zones, but TAs had higher densities of non-target (30,639 individuals per hectare) than target fish (3,945 individuals per hectare). Comparing sites surveyed in both years revealed an increase in the density of target fish, especially in NTAs (from 2858 to 5,586 kg per hectare), and a decline in non-target biomass (from 841 to 457 kg per hectare; Figure 4.70).

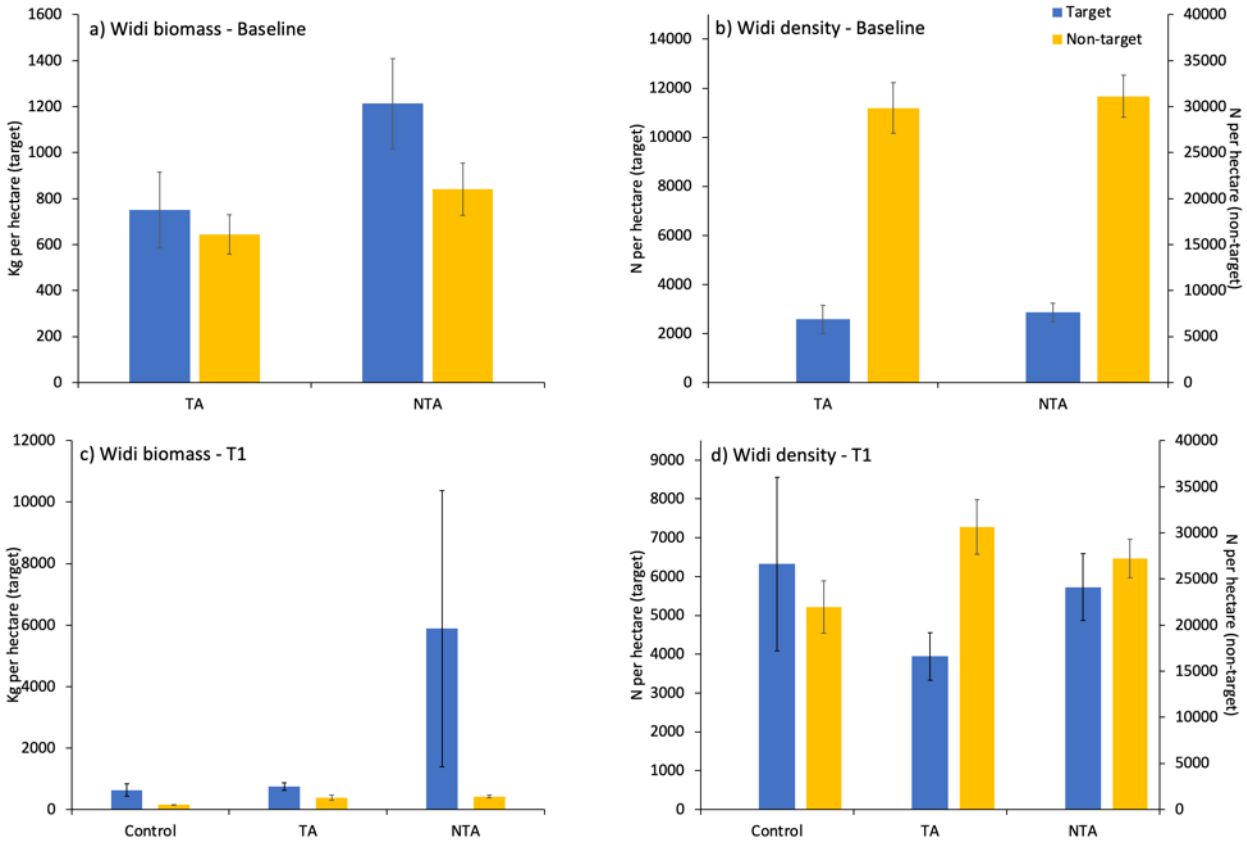


Figure 4.69 Biomass (kg per hectare) and density (individuals per hectare) by management zone in Widi MPA. Baseline a) biomass and b) density and T1 c) biomass and d) density means were calculated using all sites surveyed during the respective sampling periods. For statistical analysis of the differences in fish communities, see Appendix III. Error bars = 1 SE.

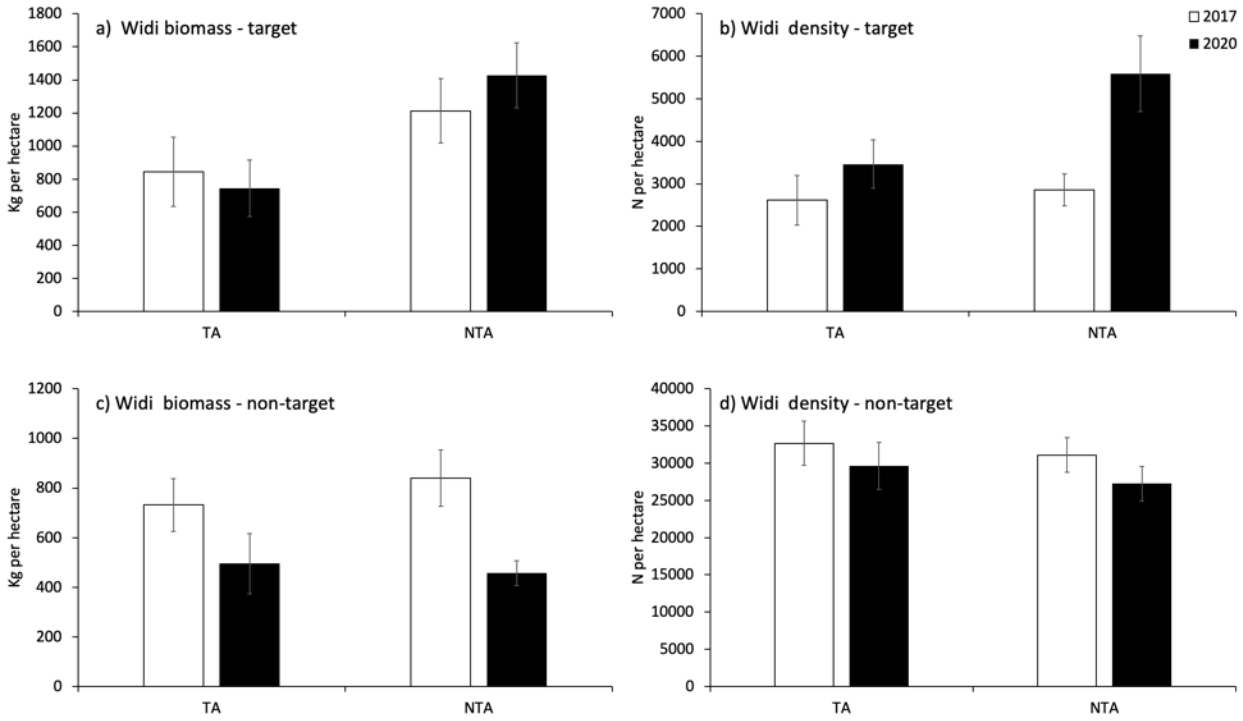


Figure **4.70** Biomass (a) kg per hectare) and density (b) individuals per hectare) by management zone in Widi MPA. Only sites surveyed in both periods were included in calculating the mean values. For statistical analysis of the differences in fish communities, see Appendix III. Error bars = 1 SE.

c) Charismatic species

In Widi MPA, blacktip and whitetip sharks (*Carcharhinus melanopterus* and *Triaenodon obesus*) were frequently found in both 2017 and 2020, while grey reef shark (*Carcharhinus amblyrhynchos*) only occurred in 2020 (Figure 4.71 and Figure 4.72). In 2017, sharks were encountered in 6 of 11 survey areas, including whitetip reef sharks in one of the locations. In 2020, sharks were observed in 12 of 15 locations, including 2 areas where shark observations included whitetip reef sharks, in Hilang (WID7) and Ngafit (WID6), and one location where grey reef sharks were reported, in Site Hilang (WID7). In 2020, Napoleon wrasse (*Cheilinus undulatus*) were observed more frequently than in 2017; 12 out of 15 sites had Napoleon wrasse, compared with only two sites in 2017. Bumphead parrotfish (*Bolbometopon muricatum*) were also present at one site in 2020 (Daga/WID3). Charismatic rays, such as spotted eagle rays (*Aetobatus narinari*), were found at one site in 2017 (Gembira/WID4), while in 2020, ribbontail stingrays were recorded in Kontrol Foya/WID 14 outside the Widi MPA. The community reported that green turtles (*Chelonia mydas*) are common on the southern side of Widi Island.

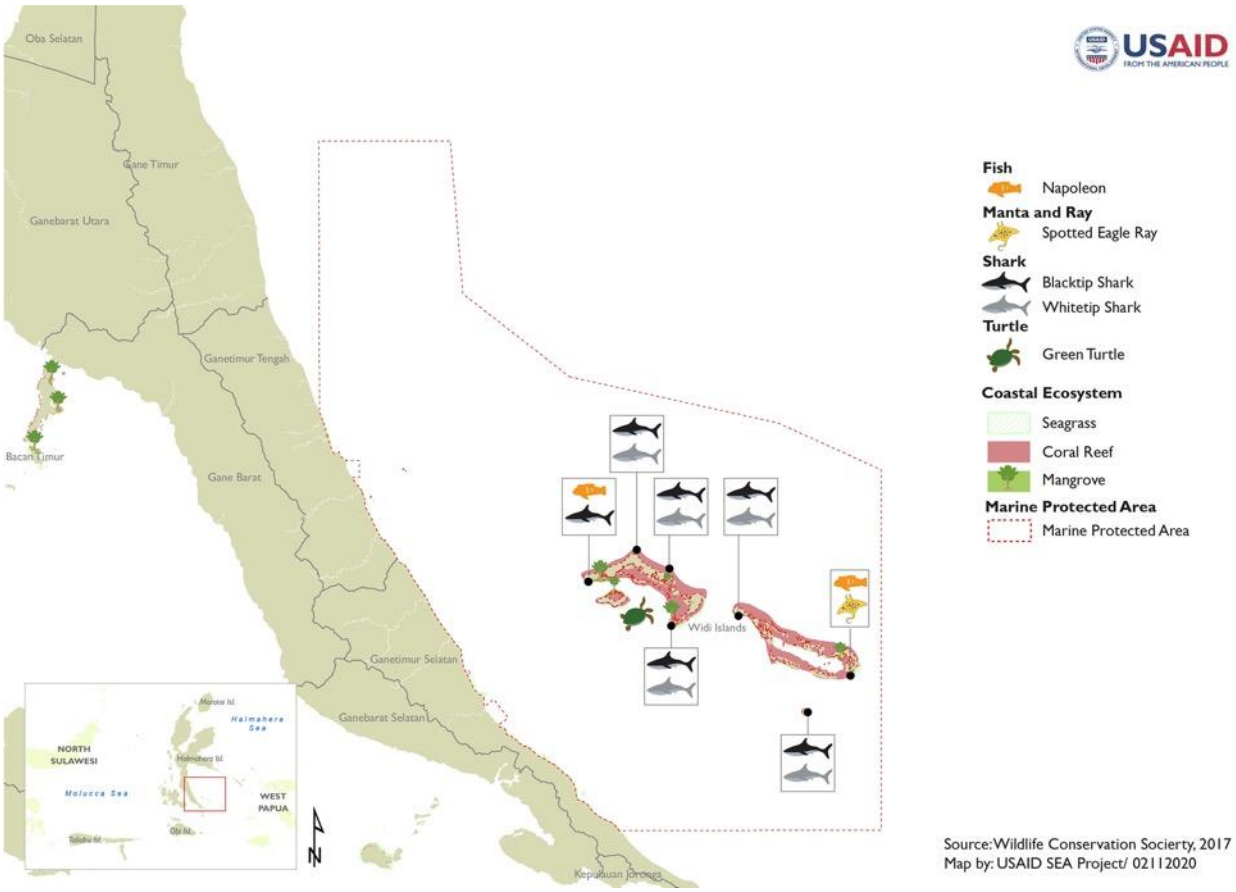


Figure 4.71 Charismatic species map around Widi MPA from 2017 survey data

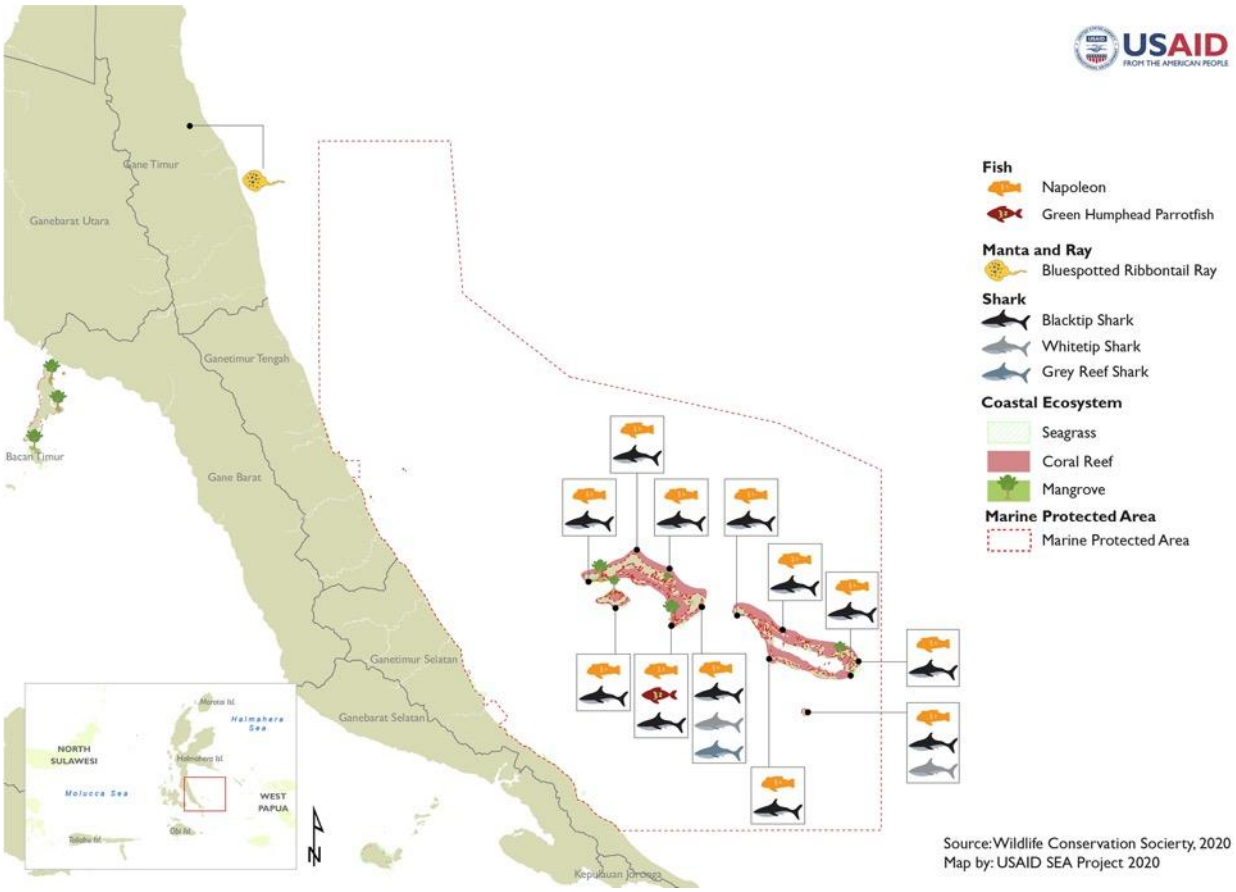


Figure 4.72 Charismatic species map around Widi MPA from 2020 survey data

d) Status of management

Widi MPA has been protected by Ministerial Decree No. 102 Year 2020 and is included in the Provincial Marine Spatial Plan or RZWP3K (*Rencana Zonasi Wilayah Pesisisr dan Pulau-Pulau Kecil*) as a conservation area. It is stated under Provincial Regulation No. 2 Year 2018. The management of the area falls under UPTD (*Unit Pelaksana Tekhnis Daerah* – Provincial Technical Unit) MPA of North Maluku. Widi MPA has a management plan waiting for final approval from the Governor. There are no or limited regulations implemented in the MPA. The surveillance of the MPA is the responsibility of the community surveillance group called POKMASWAS (*Kelompok Pengawas Masyarakat*). The POKMASWAS received official recognition from the North Maluku Provincial Fisheries Agency (DKP Maluku Utara) in 2019, and the community has conducted the monitoring activities ever since.

4.2.7 COMPOSITE ANALYSIS OF NORTH MALUKU PROVINCE

a) Benthic community

Both baseline and T1 surveys of MPAs in North Maluku Province showed a high proportion of coral cover in both deep (40.9% to 45.1%) and shallow habitats (52.3 to 57.1%; Figure 4.73). The proportion of coral to other benthic categories was greater in T1 than the baseline, suggesting a recovering or generally expanding coral community. The exceptions to this pattern were Sula and Widi MPAs, where coral cover across all sites was lower in T1. The next most abundant category after hard corals was abiotic (non-living) mobile substrate such as sand and rubble (23.5%-17.2%); these MPAs have a high

proportion rubble, which could be a product of blast fishing and other sources of coral mortality. Mobile substrate is not favourable for the settlement and survival of hard corals or other benthic organisms. There was no evidence of high macroalgal cover in any of the MPAs.

Multivariate analysis showed that some of the MPAs have similar benthic communities, while others are unique (Appendix 4). Where the MPA circles or "clouds" didn't overlap in the MDS plot, it means that the benthic community in each MPA was different from all the others. During the baseline surveys, Widi, Sula and Rao-Dehegila MPAs were unique, while Guraici, Makian-Moti and Mare MPAs were similar to each other. The vectors (or arrows) show which benthic categories were most influential in driving the differences. Widi, Guraici, Mare and Makian-Moti MPAs had more *Halimeda* and turf algae, while Rao-Dehegila and Sula MPAs had more macroalgae and abiotic mobile substrate. There were also some differences within MPAs, shown by the spread of points within the cloud in a vertical direction. Control sites in Sula had more abiotic mobile substrate, while the MPA sites in Sula and all the Rao-Dehegila sites had more soft coral and other sessile invertebrates. The same analysis for benthic communities in the follow-up surveys (T1) separated the MPAs into three groups. One group contained Widi and Guraici MPAs, which were characterised by a high proportion of turf algae; the second group was composed by Rao-Dehegila and Mare MPAs, which both had a higher dominance of hard coral cover than the other MPAs; and the last group was Sula, which had a higher diversity of categories such as CCA, abiotic hard substrate, soft coral and other sessile invertebrates than the other MPAs. Only one site was surveyed in Makian-Moti MPA in 2020, and this was excluded from analyses.

Rubble was the main indicator of potential damage to the reefs and occurred in moderate amounts; in Makian-Moti and Mare MPAs the cover of rubble reached 25% during the baseline survey (Figure 4.74). Widi MPA had the lowest cover of rubble, at less than 5%. Low cover of dead corals and macroalgae were recorded at Rao-Dehegila and Sula MPAs; there was no evidence of bleaching. Rubble appeared to decline between the baseline and T1 surveys, except in Widi where more rubble was recorded at T1.

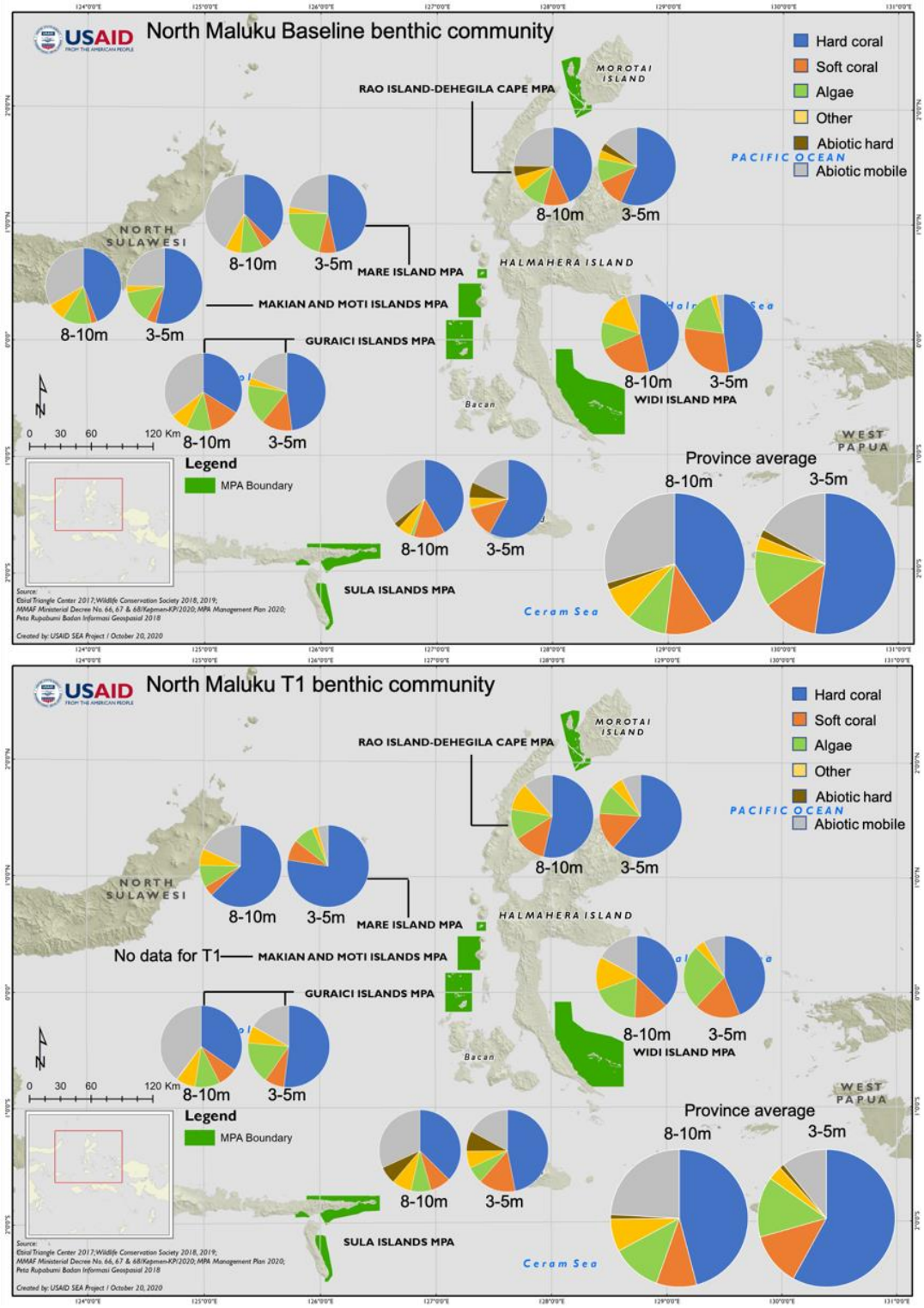


Figure 4.73 Summary of benthic categories in deep and shallow reef habitats of the MPAs in North Maluku Province. Algae and abiotic mobile categories were combined. Top panel: baseline averages, bottom panel: T1 averages.

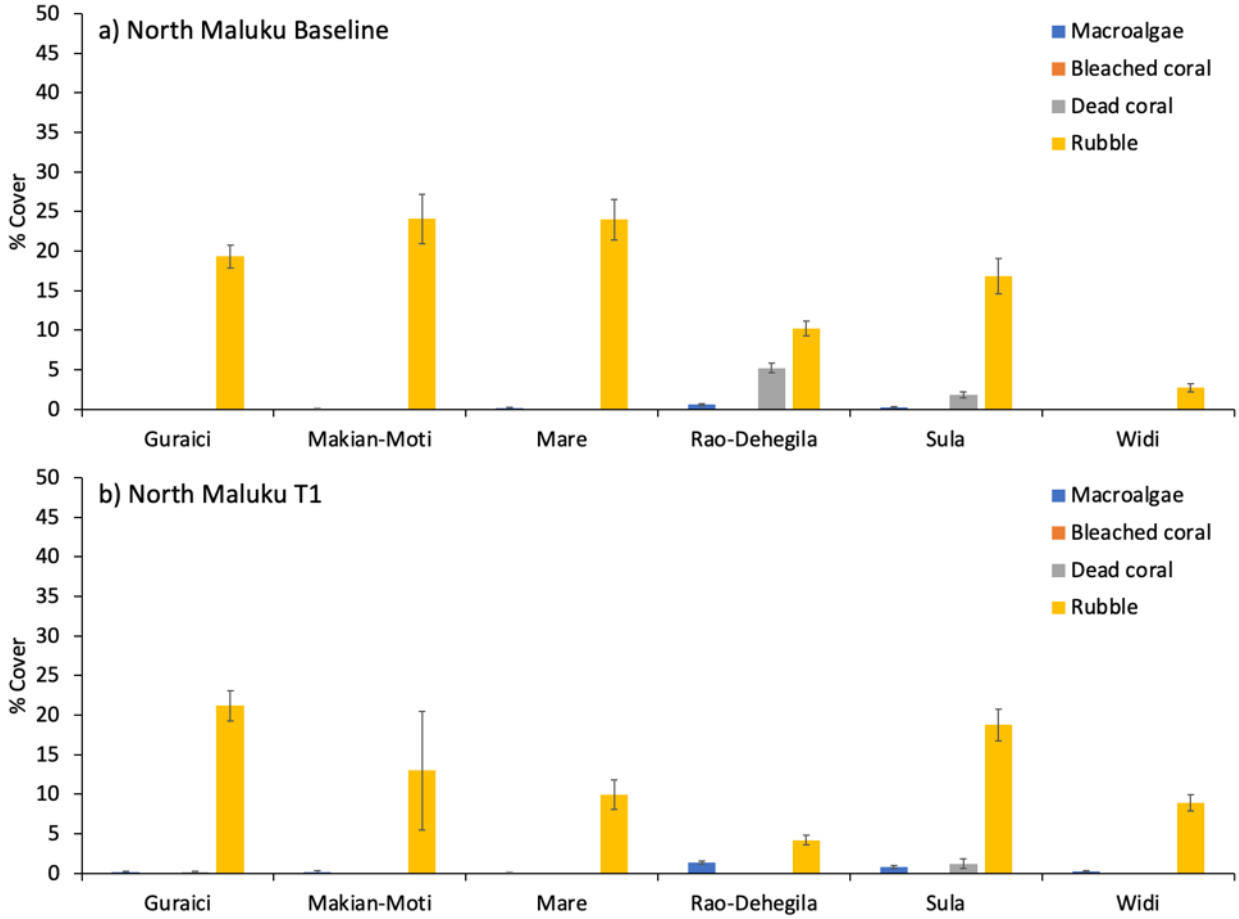


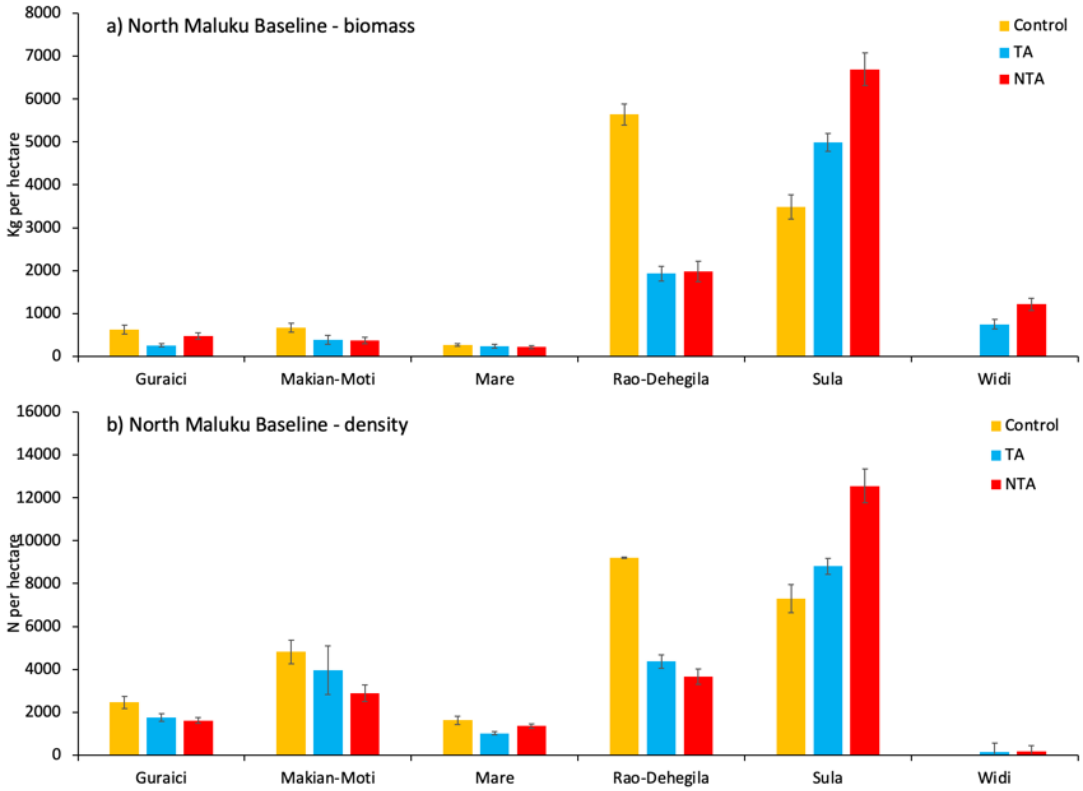
Figure 4.74 Mean percent cover of four indicators of reef stress: macroalgae, typically increasing with chronic disturbances; bleached coral, indicating rising temperatures; dead coral, indicating a recent mortality event and rubble, which often increases as a result of coral mortality and destructive fishing. Mean values are shown for each MPA in North Maluku Province, a) during the baseline survey, and b) at T1. Note: T1 data from Makian-Moti MPA was only obtained from one site. Error bars = 1 SE.

b) Fish community

Comparisons between the MPAs across North Maluku Province showed a general pattern of lower target fish biomass (<1,000 kg per hectare) in Guraici, Makian-Moti and Mare MPAs, and higher target fish biomass (>1,000 kg per hectare) in Rao-Dehegila and Sula MPAs, with moderate biomass in Widi MPA (Figure 4.75). Target fish density was more variable, but followed a similar pattern, with the exception of Widi MPA, which had the lowest density. During T1 surveys, a very high biomass estimate (~6,000 kg per hectare) in the NTA of Widi MPA swamped the other estimates, which appeared more similar to each other than during the baseline surveys. Furthermore, density was an order of magnitude (10 times) higher across all MPAs at T1 than during the baseline; Sula MPA had particularly high densities.

The highest total species richness of surveyed fishes was recorded in Widi MPA (an average of ~50 species per transect) during the baseline surveys, and in Mare MPA (just under 60 species per transect) at T1 (Figure 4.76). The lowest total species richness was in Sula MPA with less than 30 species per transect during both survey periods. Other MPAs in North Maluku Province had between 30 and 40 species per transect during the baseline, and between 30 and 50 at T1. Target species richness was much lower than total species richness throughout all MPAs except Sula during the baseline, where the two values were similar.

Multivariate analysis showed that the MPAs in North Maluku Province had unique target fish communities during the baseline surveys, but became more similar in T1 surveys (Appendix 4). Where the MPA circles or "clouds" did not overlap in the MDS plot, it means that the fish community in each MPA was different from all the others. The vectors (or arrows) show which fish families were most influential in driving the differences. Guraici, Mare and Widi MPAs had less fish overall, shown by the fact that most of the vectors point towards the top half of the plot, and clouds for those three MPAs were towards the bottom right of the plot. Makian-Moti MPA had higher proportions of surgeonfish (Acanthuridae) and bream (Nemipteridae), and Sula and Rao-Dehegila MPAs had a broader variety of target fish families. In T1, Mare, Rao-Dehegila and Guraici MPAs became more similar, in that they had higher proportions of grazers such as surgeonfish (Acanthuridae) and rabbitfish (Siganidae), carnivores such as bream (Nemipteridae), and benthic invertivores such as goatfish (Mullidae). Sula MPA had a high proportion of carnivores and piscivores such as mackerels (Scombridae), snappers (Lutjanidae) and barracudas (Sphyraenidae), and planktivores such as fusiliers (Caesionidae). Widi MPA in T1 was differentiated by having very different fish assemblages at control sites than at sites inside the MPA.



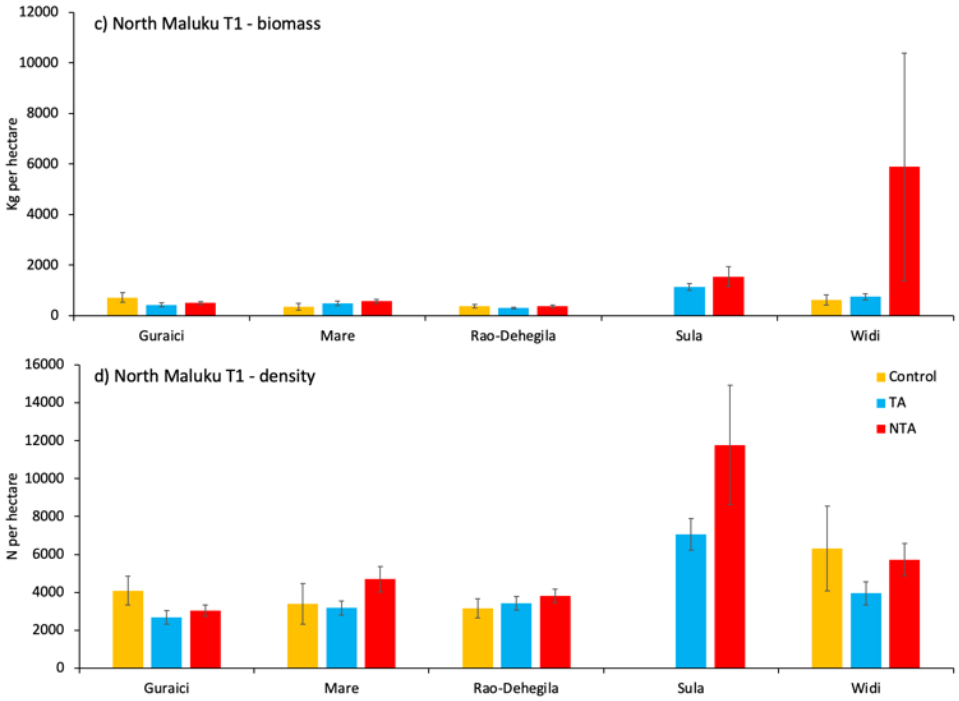
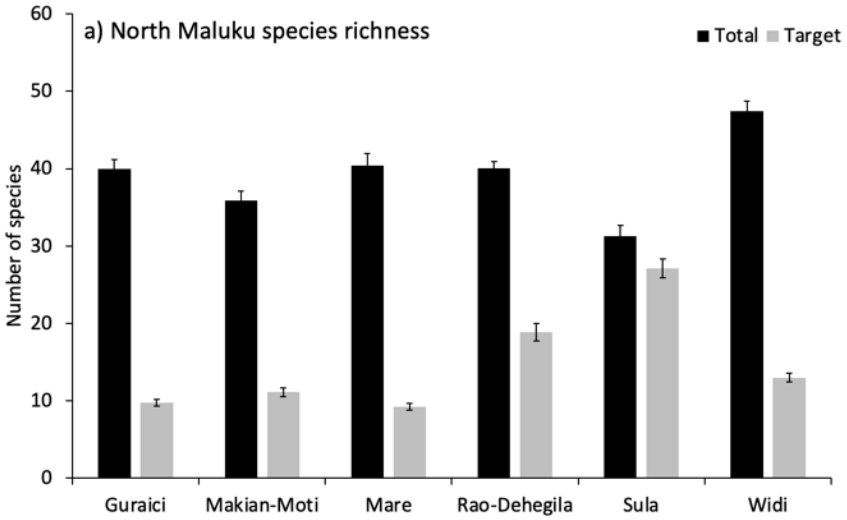


Figure 4.75 Mean biomass and density of target fish across all MPAs in North Maluku Province, showing differences between zones a) and b) during baseline surveys, c) and d) at T1. Makian-Moti was represented by only 1 site during T1 surveys, and was therefore excluded from T1 analysis. Error bars = 1 SE.



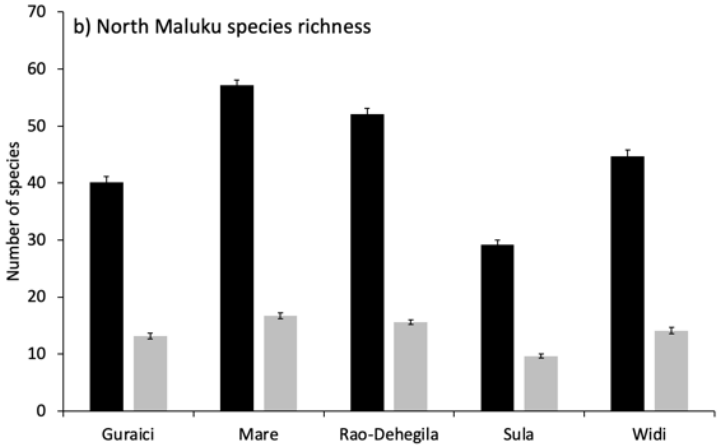


Figure 4.76 Number of species per transect observed at a) the baseline surveys and b) T1 across all MPAs in North Maluku Province. Mean species richness is shown for all recorded species, and for target species only. Error bars = 1 SE.

4.2.8 DISCUSSION NORTH MALUKU PROVINCE

Surveyed sites in North Maluku Province are generally dominated by hard coral, with especially high cover in Mare and Rao-Dehegila MPAs, and some evidence of an increasing trend between the baseline and 2020 surveys. Surveys conducted to a higher taxonomic level documented at least 80 genera across Mare, Rao-Dehegila, Guraici and Widi MPAs (Turak and DeVantier 2008, Muttaqin et al. 2017). These two MPAs were relatively similar in 2020, as were Guraici and Widi, while Sula was unique. Bleaching and macroalgae do not appear to have been problematic during the survey years; only Rao-Dehegila and Sula had some macroalgae, but in very low percentage cover. Rubble is a clear and persistent sign of disturbance, from a combination of anchoring, destructive fishing and other causes or coral mortality (Muttaqin et al. 2017); however, the percentage cover of rubble appears to be declining, suggesting that these practices might be abating. Previous surveys noted evidence of coral damage due to anchoring, blast fishing and sedimentation (Welly et al. 2017b, a). In 2013, crown-of-thorns were reported from the area around Guraici MPA (Baird et al. 2013); reefs appear to have largely recovered. Surveys around Morotai Island reported that many sites were dominated by soft sediment and had low coral cover (Welly et al. 2017a); the results of the current study, where coral cover in Rao-Dehegila was high and increasing, suggest that the MPA was placed in favourable coral reef habitat.

The habitats across survey sites in Sula MPA were relatively homogeneous, with similar fish assemblages (Welly et al. 2017b). Based on previous fish surveys and the calculation of the CFDI[6] (Allen and Werner 2002), the number of fish species from selected families in North Maluku Province is estimated at 728 (Muttaqin et al. 2017). MPAs that cover different types of habitats, such as coral reefs, seagrass beds and mangroves, are often more successful at encompassing high biomass and diversity of marine life because they protect species that use different habitats during different stages of their life cycles, as well as species restricted to each type of habitat (Verweij et al. 2006, Unsworth et al. 2008, Olds et al. 2013). North Maluku has a diverse range of coral reef formations, from isolated pinnacles and reefs exposed to prevailing weather to highly sheltered and silty fringing reefs; there is also good hydrodynamic

[6] Coral Fish Diversity Index

connectivity to the highly diverse reefs in West Papua Province (Muttaqin et al. 2017). Sula appears especially promising in terms of high biomass of target species in the designated no-take areas. Previous surveys reported intermediate fish biodiversity, lower than that reported from Fakfak Peninsula, but higher than other surveyed locations in Maluku (Welly et al. 2017b).

There were variable trends in target fish biomass: Guraici had little change, Sula and Rao-Dehegila declined, Widi and Mare increased. Charismatic fauna such as Napoleon wrasse, dugongs, turtles and cetaceans were observed with high frequency in Sula and Rao-Dehegila (Welly et al. 2017b, a), increasing the conservation value of these areas, as most of these species are listed as globally threatened.

Characteristics of the Halmahera ecoregion, which includes North Maluku Province, include strong currents and good connectivity to the Papua-Bird's Head seascape, high diversity of habitats and species due to the wide range of environmental conditions from the highly exposed eastern side to the very protected southwestern side, whale sharks and endemic species (Green and Mous 2007). The provincial government of North Maluku has a target to include around 1.2 million hectares within MPAs; currently North Maluku has 667.000 hectares within MPAs.

4.3 WEST PAPUA PROVINCE

4.3.1 BERAU BAY MPA

a) Benthic community

Only shallow habitats were surveyed during the baseline surveys of Berau Bay MPA; these had a high cover of hard corals (43.6%), and lower cover of abiotic (non-living) mobile substrate (25.3%), other sessile invertebrates (16.5%) and turf algae (10.2%; Figure 4.77). Benthic categories were similar between fished (TA) and no-take areas (NTA) of the MPA (Figure 4.78). There was no follow-up (T1) survey.

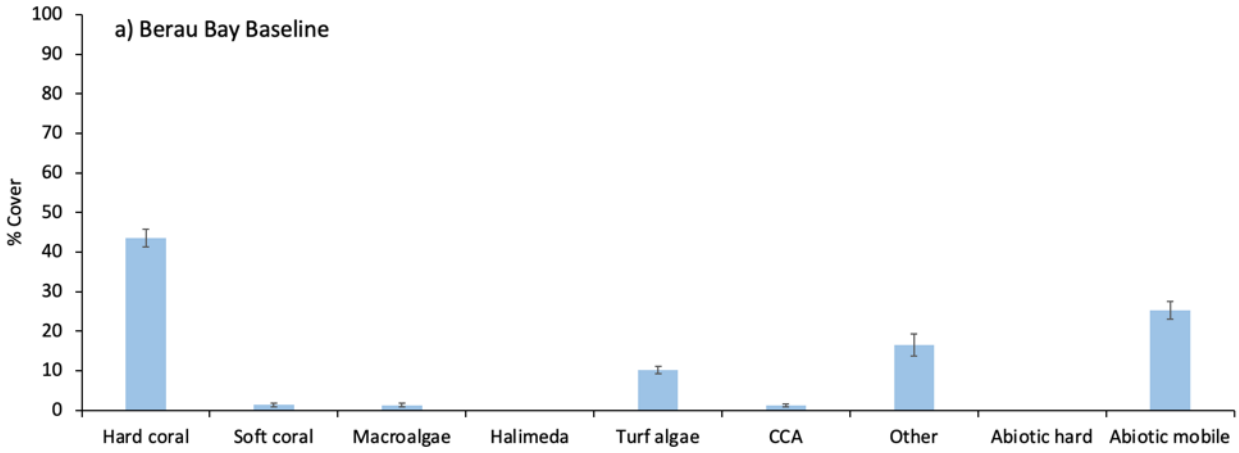


Figure 4.77 Percentage cover of key benthic categories across shallow habitats in Berau Bay MPA during the baseline survey. Deep habitats were not included in the baseline survey, and there was no follow-up (T1) survey. Note that some site differences occurred between the two survey periods. For statistical analysis of the differences in benthic communities, see Appendix II. Error bars = 1 SE.

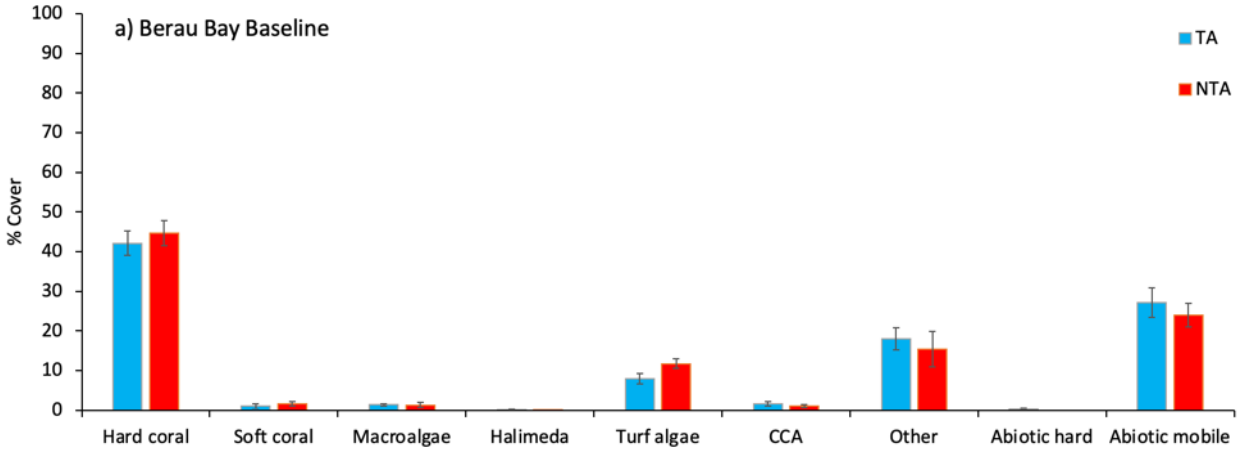


Figure 4.78 Percentage cover of key benthic categories by management zone in Berau Bay MPA, a) during the baseline survey (T0) and b) at the T1 repeat survey. Note that no control sites (orange bars) were included in the baseline survey, and some site differences occurred within the MPA areas between the two survey periods. For statistical analysis of the differences in benthic communities, see Appendix II. Error bars = 1 SE.

b) Fish community

Only target species were included in the Berau Bay MPA baseline survey. Both the biomass and density of target fish families were lower in NTAs (49 kg and 181 individuals per hectare) than in TAs (90 kg and 454 individuals per hectare; Figure 4.79).

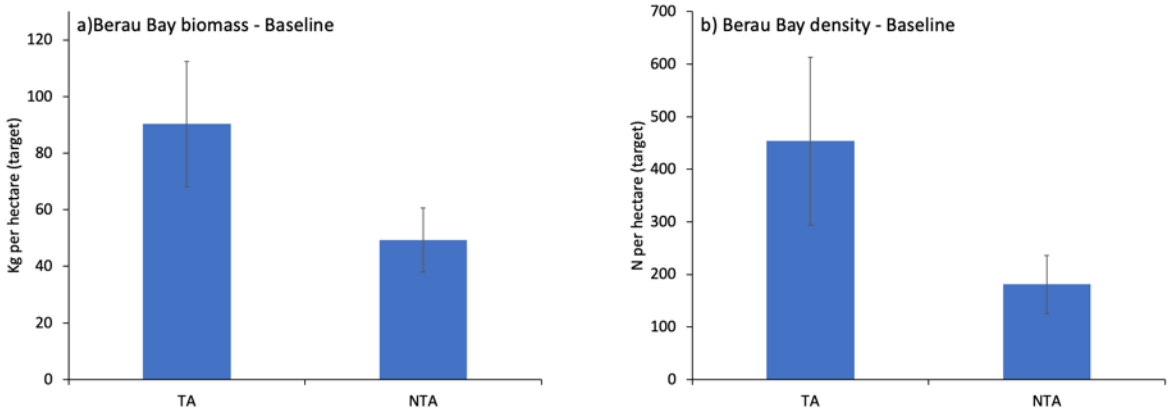


Figure 4.79 Biomass (a) kg per hectare) and density (b) individuals per hectare) by management zone in Berau Bay MPA. No control sites or non-target species were surveyed in this MPA. Error bars = 1 SE.

c) Charismatic species

Berau Bay MPA is one of the key habitats in the region for turtles, whales, sharks and manta rays (Figure 4.80). Three types of sharks (blacktip (*Carcharhinus melanopterus*) and whitetip (*Triaenodon obesus*) reef sharks and whale sharks (*Rhincodon typus*)) have been recorded in the Kokas area of the MPA and confirmed by the community. Reef manta rays (*Manta alfredi*) and turtles were also observed in the Kokas area. The white sandy beaches on Ugar and Arguni Islands are potential turtle nesting areas.

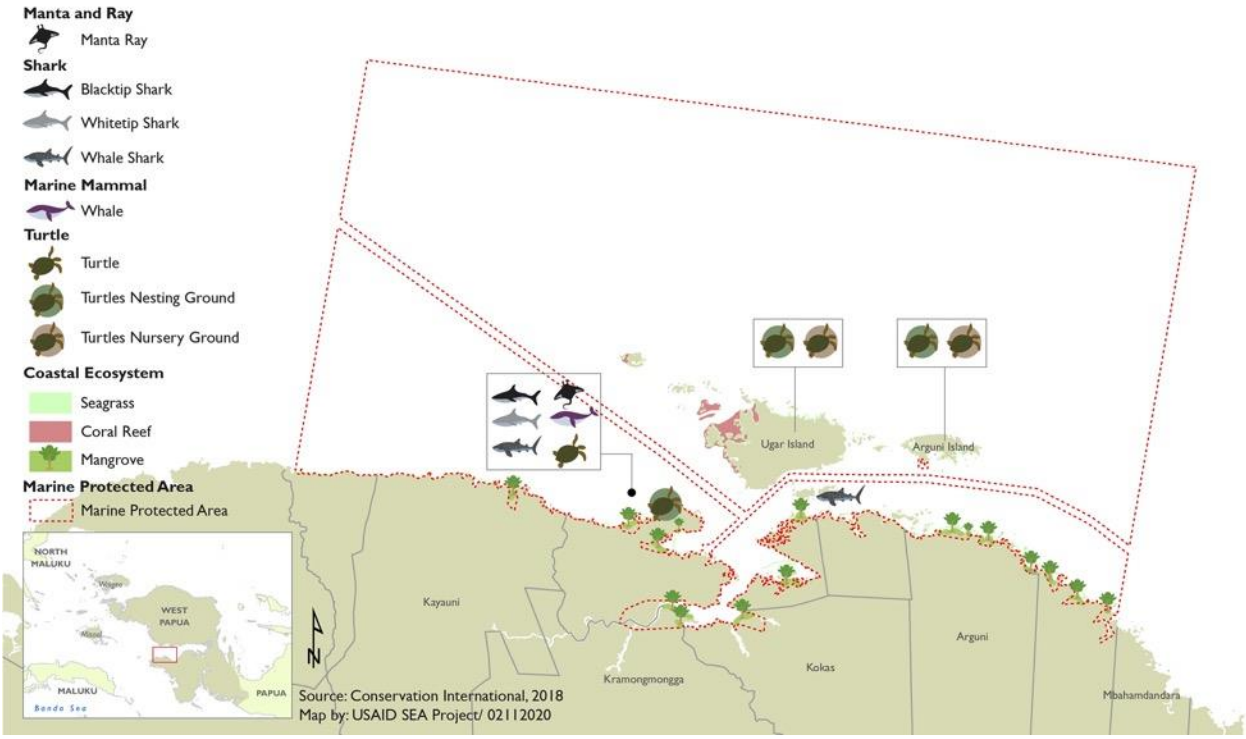


Figure 4.80 Charismatic species map around Berau Bay MPA in 2018 survey data.

d) Status of management

Berau Bay MPA has been protected by Ministerial Decree No. 79/Kepmen-KP/2020 and included in the Provincial Marine Spatial Plan or RZWP3K (*Rencana Zonasi Wilayah Pesisisr dan Pulau-Pulau Kecil*) as a conservation area. It is stated under the Provincial Regulation No. 13 year 2019. The management of the area falls under an UPTD (*Unit Pelaksana Tekhnis Daerah* – Provincial Technical Unit) together with Kaimana MPA and Nusalasi Bay MPA. Together with Nusalasi Bay, Berau Bay has already had its MPA management plan approved by the West Papua Governor in 2018 (No. 523/239/11/2018). However, implementation of regulations within the MPA is still limited, caused by low capacity and lack of resources within the MPA management unit. Like all other MPAs under the SEA Project, the surveillance of this MPA is actively driven by a community surveillance group called POKMASWAS (*Kelompok Pengawas Masyarakat*). The POKMASWAS received official recognition from the West Papua Provincial Fisheries Agency (DKP) in 2019, and the community has conducted the monitoring activities ever since.

4.3.2 NUSALASI VAN DEN BOSCH BAY

a) Benthic community

The benthic community in Nusalasi Bay MPA had similar cover of hard corals (38.2%) and abiotic (non-living) mobile substrate such as sand and rubble (32.3%; Figure 4.81). Only macroalgae, CCA and other sessile invertebrates showed a difference between depths; all were present in low cover and tended to be higher in deeper habitats. Hard coral cover tended to be lower in NTAs (35.1%) than in TAs (41.1%).

Other sessile invertebrates, CCA and abiotic hard substrate such as rock and dead coral had higher cover in NTAs, although their cover was low overall (Figure 4.82).

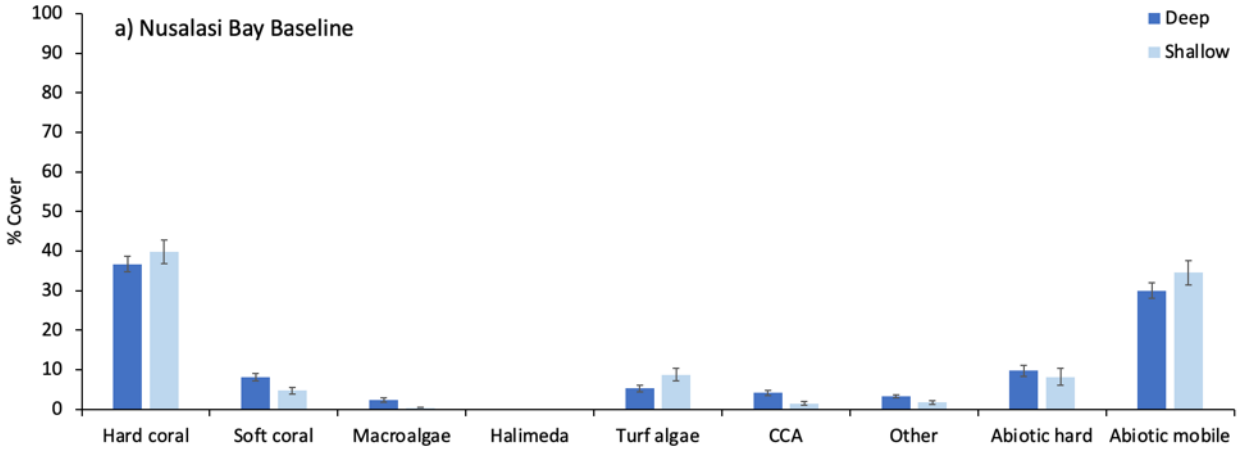


Figure 4.81 Percentage cover of key benthic categories across deep and shallow habitats in Nusalasi van den Bosch Bay MPA during the baseline survey. Note that some site differences occurred between the two survey periods. For statistical analysis of the differences in benthic communities, see Appendix II. Error bars = 1 SE.

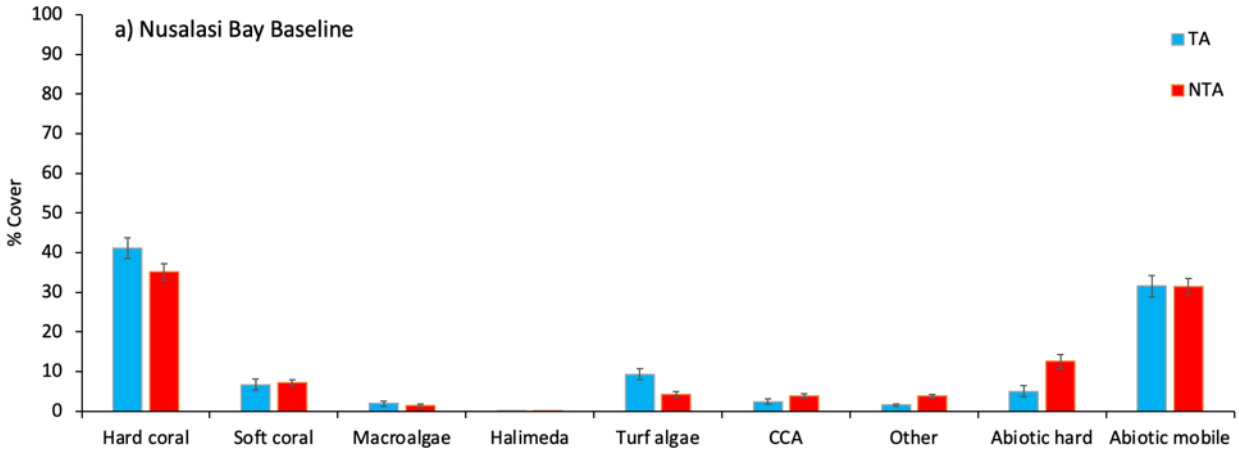


Figure 4.82 Percentage cover of key benthic categories by management zone in Nusalasi van den Bosch Bay MPA, a) during the baseline survey (T0) and b) at the T1 repeat survey. Note that no control sites (orange bars) were included in the baseline survey, and some site differences occurred within the MPA areas between the two survey periods. For statistical analysis of the differences in benthic communities, see Appendix II. Error bars = 1 SE.

b) Fish community

Only target species were included in the Nusalasi Bay MPA baseline survey. Both the biomass and density of target fish families were similar in NTAs and TAs, at around 100 kg and 420 individuals per hectare (Figure 4.83).

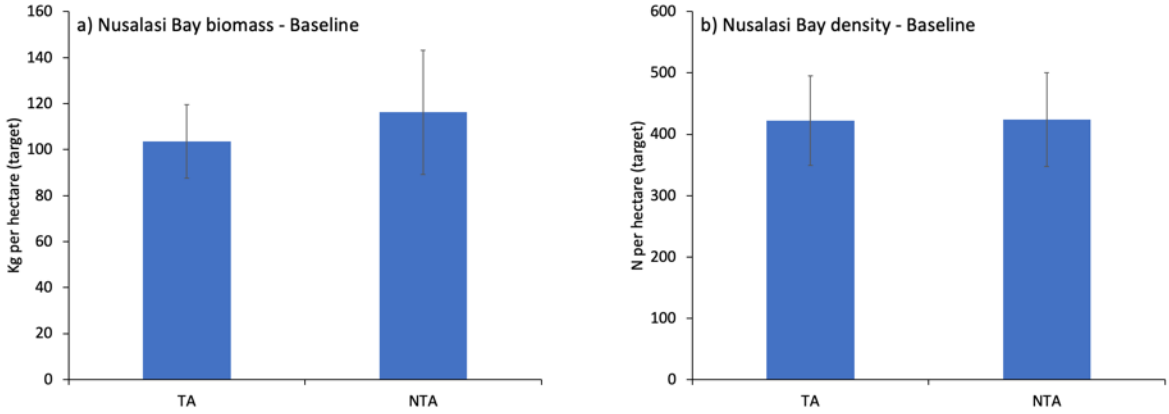


Figure 4.83 Biomass (a) kg per hectare) and density (b) individuals per hectare) by management zone in Nusalasi Bay MPA. No control sites or non-target species were surveyed in this MPA. Error bars = 1 SE.

c) Charismatic species

In contrast to the survey in Berau Bay, the survey in Nusalasi Bay encountered Napoleon wrasse (*Cheilinus undulatus*) at some sites within the MPA (Bardawan, Tanjung Tonggerai and Uremun). There are turtle nesting beaches on Karas Island and in the south of Nusalasi MPA. Karas Island is also thought to be a leatherback turtle migration area. Blacktip (*Carcharhinus melanopterus*) and whitetip (Triaenodon obesus) reef sharks, whale sharks (*Rhincodon typus*), whales, reef manta rays (*Manta alfredi*) and coconut crabs (*Birgus latro*) were also found around Karas Island (Figure 4.84).

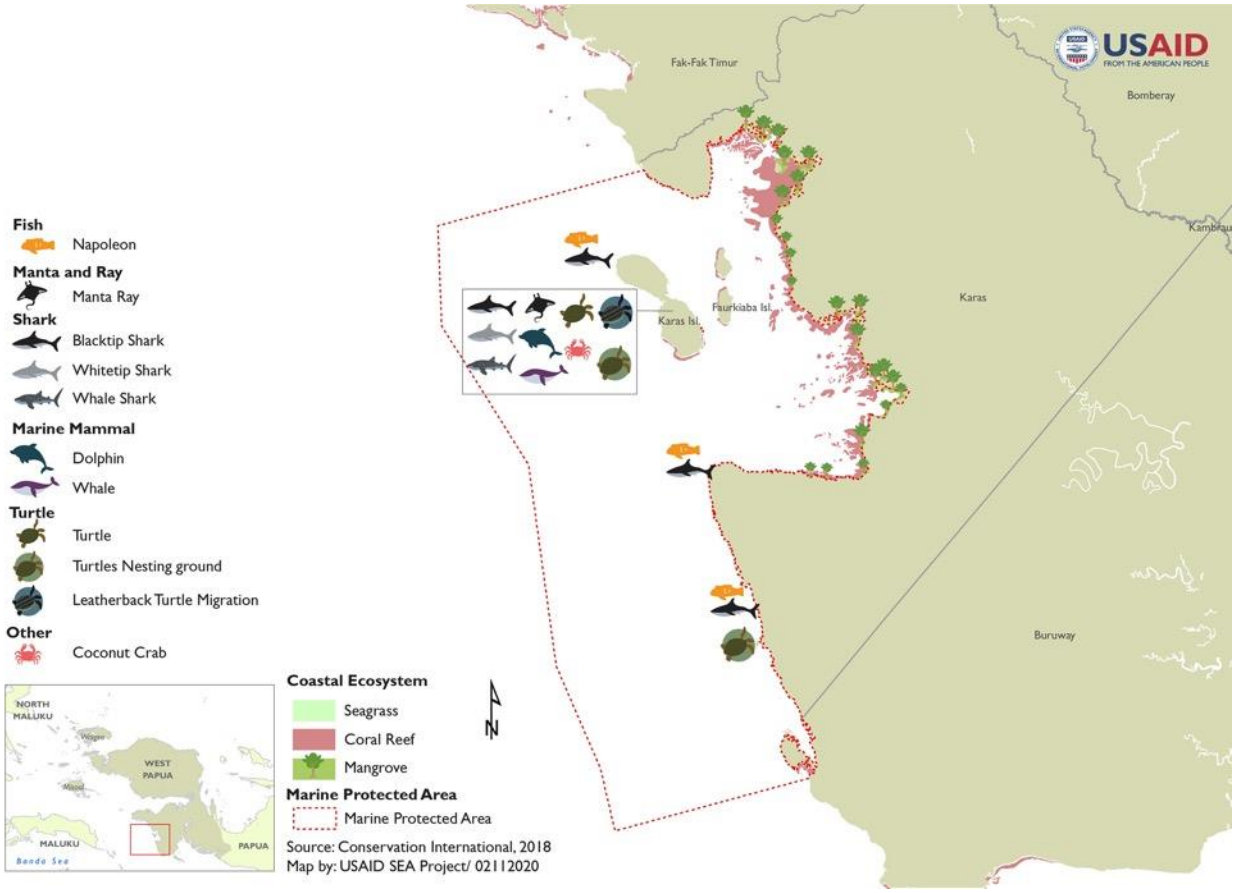


Figure 4.84 Charismatic species map around Nusalasi Bay MPA from 2018 survey data.

d) Status of management

Nusalasi Bay MPA has been protected by Ministerial Decree No. 79/Kepmen-KP/2020 and is included in the Provincial Marine Spatial Plan or RZWP3K (*Rencana Zonasi Wilayah Pesisisr dan Pulau-Pulau Kecil*) as a conservation area. It is stated under the Provincial Regulation No. 13 year 2019. The management of the area falls under an UPTD (*Unit Pelaksana Tekhnis Daerah* – Provincial Technical Unit) together with Kaimana MPA and Berau Bay MPA. Together with Berau Bay MPA, Nusalasi Bay has a management plan approved by the West Papua Governor in 2018 (No. 523/239/11/2018). However, implementation of regulations within the MPA is still limited, caused by low capacity and resources within the MPA management unit. Like all other MPAs under the SEA Project, the surveillance of this MPA is actively driven by a community surveillance group called POKMASWAS (*Kelompok Pengawas Masyarakat*). The POKMASWAS received official recognition from the West Papua Provincial Fisheries Agency (DKP) in 2019, where the community has conducted the monitoring activities ever since.

4.3.3 COMPOSITE ANALYSIS OF WEST PAPUA PROVINCE

a) Benthic community

Live hard coral cover was, on average, 39% across the two MPAs in West Papua Province (Figure 4.85), with higher cover in Berau Bay (43.6%) than Nusalasi Bay MPAs (38.2%). Overall, abiotic (non-living) substrate was the second most abundant category, especially in Nusalasi Bay MPA. Multivariate analysis revealed that the two MPAs in West Papua Province were very different from each other, shown by the fact that the MPA "clouds" did not overlap (Appendix 4). The vectors (or "arrows") show which benthic categories drove the differences between MPAs. Berau Bay MPA had higher proportions of hard coral, turf algae and other sessile invertebrates, and to a lesser extent (because the vectors are shorter), macroalgae and *Halimeda*. Among the four indicators of potential damage to coral reefs, rubble was the most prominent, and was higher in Nusalasi Bay MPA, where it reached around 20% cover overall (Figure 4.86). Macroalgal cover was the only other indicator, but was present in very low cover.

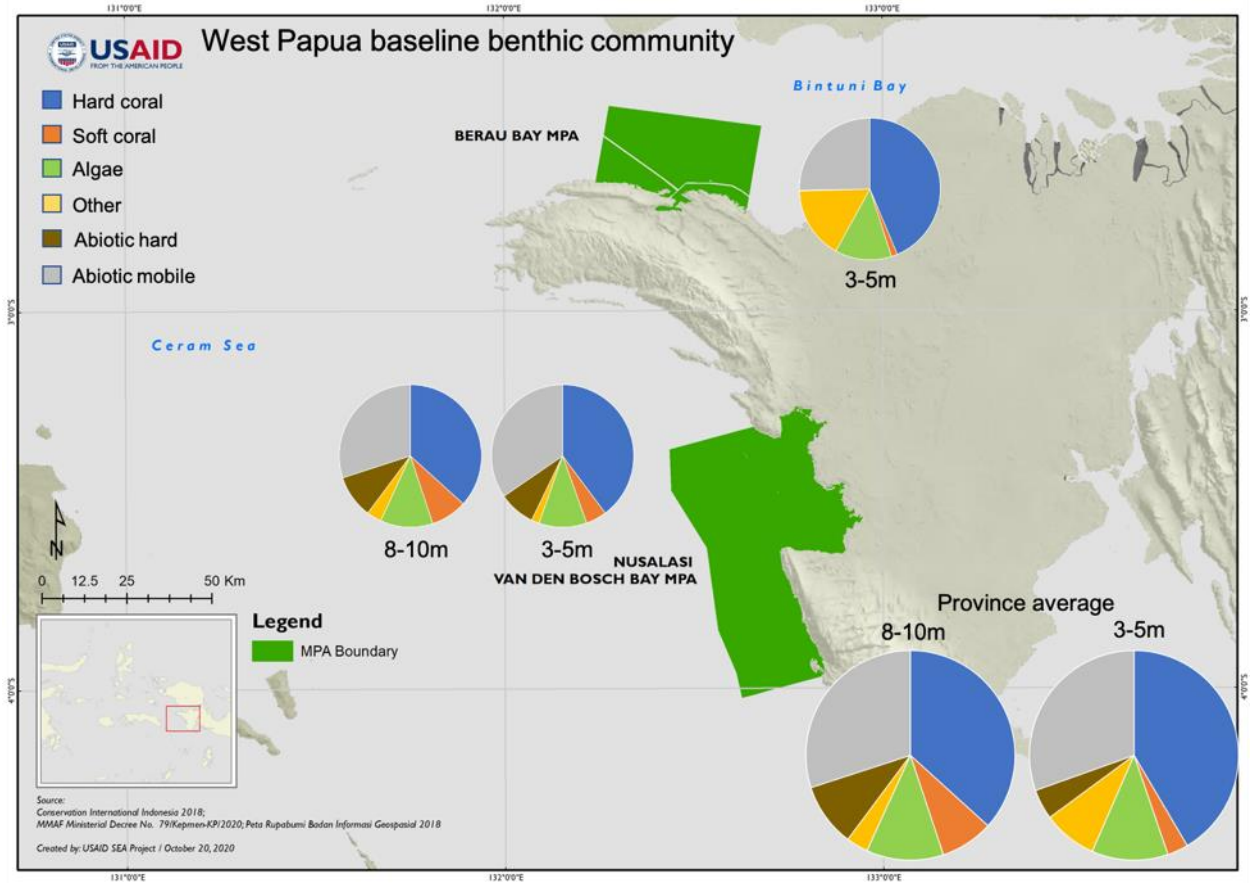


Figure 4.85 Summary of benthic categories in deep and shallow reef habitats of the MPAs in West Papua Province, recorded during the baseline survey. Algae and abiotic mobile categories were combined.

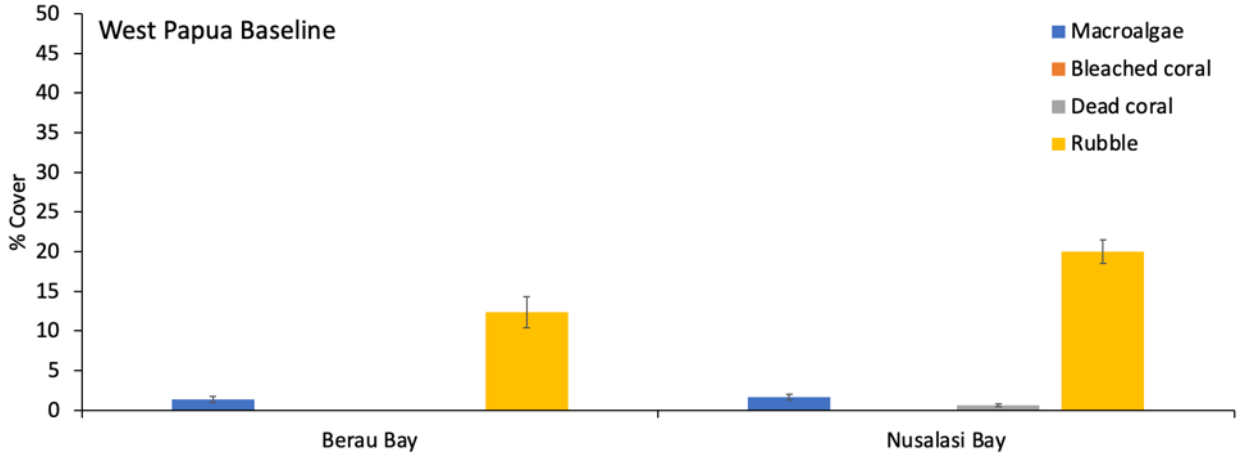


Figure 4.86 Mean percent cover of four indicators of reef stress. Mean values are shown for both MPAs in West Papua Province during the baseline survey. Error bars = 1 SE.

b) Fish community

Biomass and density of target fish families were similar across TA and NTA sites of Berau Bay and Nusalasi Bay MPAs, except for lower estimates in Berau Bay NTAs (Figure 4.87). Species richness of target species was higher in Nusalasi Bay than Berau Bay (Figure 4.88). Berau Bay fish communities were characterised by higher proportions of predators such as trevallies (Carangidae) and groupers (Serranidae), while in Nusalasi Bay there was a large separation between fish communities in TAs and NTAs (Appendix 4). The NTA had fish communities more similar to the Berau Bay MPA assemblage, while the TA had higher proportions of grazers such as surgeonfish (Acanthuridae), rabbitfish (Siganidae) and parrotfish (Labridae/Scarinae), and carnivores such as bream (Nemipteridae) and emperoros (Lethrinidae).

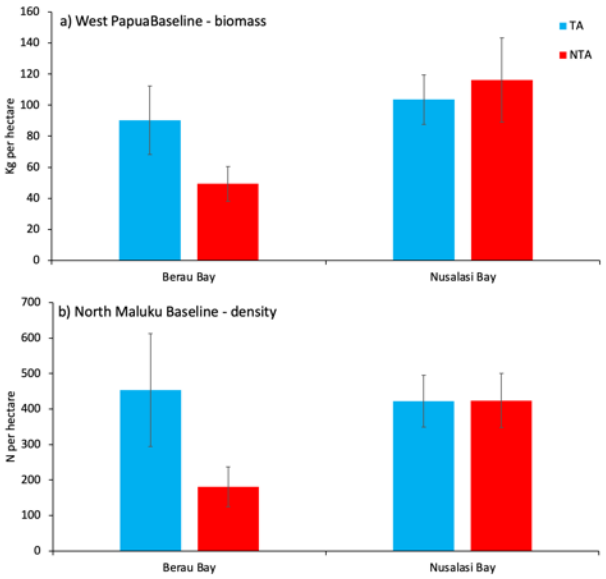


Figure 4.87 a) Mean biomass and b) density of target fish across both MPAs in West Papua Province, showing differences between zones during baseline surveys. Error bars = 1 SE.

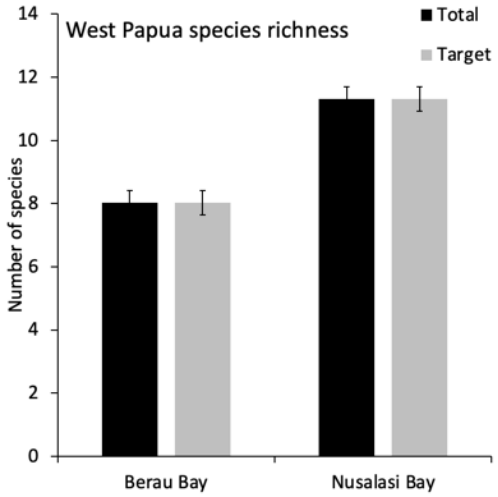


Figure 4.88 Number of species per transect observed during the baseline surveys across both MPAs in West Papua Province. Mean species richness is shown for all recorded species, and for target species only. Error bars = 1 SE.

4.3.4 DISCUSSION WEST PAPUA PROVINCE

It is not possible to ascertain trends for the MPAs in West Papua Province yet, as 2020 data were not available. The two MPAs have different benthic communities, with more hard coral in Berau Bay and soft coral in Nusalasi Bay. Coral cover is generally high across the province. Previous assessments focusing on fish diversity reported that the reefs of Berau Bay MPA are unique in the region, and retain high coral cover despite high sediment load, high temperatures, and lowered salinity, showing high tolerance and adaptability to a range of stressors (Allen and Erdmann 2018). They therefore have high conservation value as a refuge for coral reef species adapted to stress, in the face of future changes predicted with a changing climate.

Target fish biomass in Nusalasi Bay was similar between TAs and NTAs, suggesting a good baseline where effective protection is likely to result in higher fish abundance in the NTAs over time. In Berau Bay, target fish biomass and density were much lower in the NTA, indicating that this area will have some "catching up" to do before monitoring will detect an improvement. Biodiversity assessments for reef fishes exist for the areas around both MPAs; 1,133 reef fish species are listed for the Fakfak Peninsula. The Nusalasi Bay area was much more diverse than the Berau Bay area, with average species counts of 254 and 89 species per site, respectively. A number of endemic species occur here, and new species continue to be discovered, even as late as 2018 (Allen and Erdmann 2018). This coincides with the findings of these baseline surveys, where despite a reduced number of species counted, Nusalasi Bay MPA had higher species richness than Berau Bay MPA. Nusalasi Bay MPA offers a wide range of different habitats, which has resulted in very high biodiversity, even compared with other reefs in the region (Allen and Erdmann 2018).

Characteristics of the Fakfak ecoregion, where Berau Bay and Nusalasi Bay MPAs are located, include large tides and large freshwater flow into Berau Bay, reefs in good condition, very high endemism, the highest biodiversity in the Coral Triangle due to the proximity to Raja Ampat, extensive mangroves and habitat for cetaceans (Green and Mous 2007). The provincial government of West Papua has around 4.1

million hectares of MPA, or around 39% of total marine area in West Papua Province. The number will be increase in the near future and will include mangrove area of South Sorong.

4.4 COMPOSITE ANALYSIS ALL PROVINCES

Benthic communities in MPAs and control sites across the three provinces were similar to each other during baseline surveys (Figure 4.89). In all three, hard coral was the most abundant benthic category, followed by abiotic (non-living) mobile substrate such as sand or rubble. Together, these two categories occupied approximately 75% of the surveyed reef areas. There were some differences in the cover of other benthic categories between provinces. Soft coral was more abundant in Maluku and North Maluku than in West Papua. West Papua had a relatively even spread of other categories, while Maluku had more abiotic hard substrate and other sessile invertebrates, and North Maluku had more turf algae than the other provinces. West Papua MPAs were not resurveyed during T1, and Maluku and North Maluku Provinces did not exhibit dramatic changes in their benthic communities between the baseline and T1 surveys.

Fish species richness was highest in North Maluku and lowest in West Papua, when considering only fish families included in surveys by all NGOs across all MPAs (Figure 4.90). Species richness estimated ranged from an average of ~13 species per transect to ~20 species per transect, although some estimates within provinces are much higher (~40 species per transect), reflecting a wider range of species recorded by individual surveyors (see North Maluku Province estimates). Species richness remained similar during T1 surveys in Maluku and North Maluku. The total biomass of reef fishes was similar across provinces, and density showed the same trend as species richness. Biomass declined somewhat in Maluku and North Maluku (Figure 4.91).

Multivariate analysis (Appendix 4) showed that the MPAs were separated horizontally across the MDS plot by those with higher proportions of surgeonfish (Acanthuridae), wrasses (Labridae) and groupers (Serranidae) on the left side (Mare, Guraici, Makian-Moti, Widi) and those with higher proportions of all other families (Buano and Sula). MPAs located towards the bottom half of the plot also tended to have lower densities of fish in general, but were especially different from the North Maluku MPAs named above. Points closer together indicated MPAs with similar fish assemblages. This shows that Sula MPA had a fish assemblage more similar to Buano MPA than to other MPAs in North Maluku. Koon and Serutbar were more similar to Nusalasi Bay than to some of the other MPAs in Maluku Province, such as Buano, Lease and Ay-Rhun MPAs. Fish communities in Maluku Province overlapped with those of both North Maluku and West Papua, but North Maluku and West Papua did not share as many similarities and therefore formed separate groups. During T1, Maluku and North Maluku are drawn apart by higher proportions of wrasses (Labridae) and groupers (Serranidae) in North Maluku, and individual MPAs were distinguished by a more diverse community on the lower left side of the plot, while on the other side are MPAs with greater densities of mackerels (Scombridae) and fusiliers (Caesionidae).

Destructive fishing was considered the most pervasive problem throughout the SEA Project region, with poison and blast fishing occurring in 10 out of the 13 MPAs (Table 5). Other widespread threats include fishing with nets, bycatch of endangered and threatened species, coral mining, plastic debris and anchor damage to coral reefs. Out of all the MPAs, Rao-Dehegila was perceived to be affected by the largest variety of different impacts (23 types), while Makian-Moti and Lease MPAs were less affected (8 and 6 types, respectively).

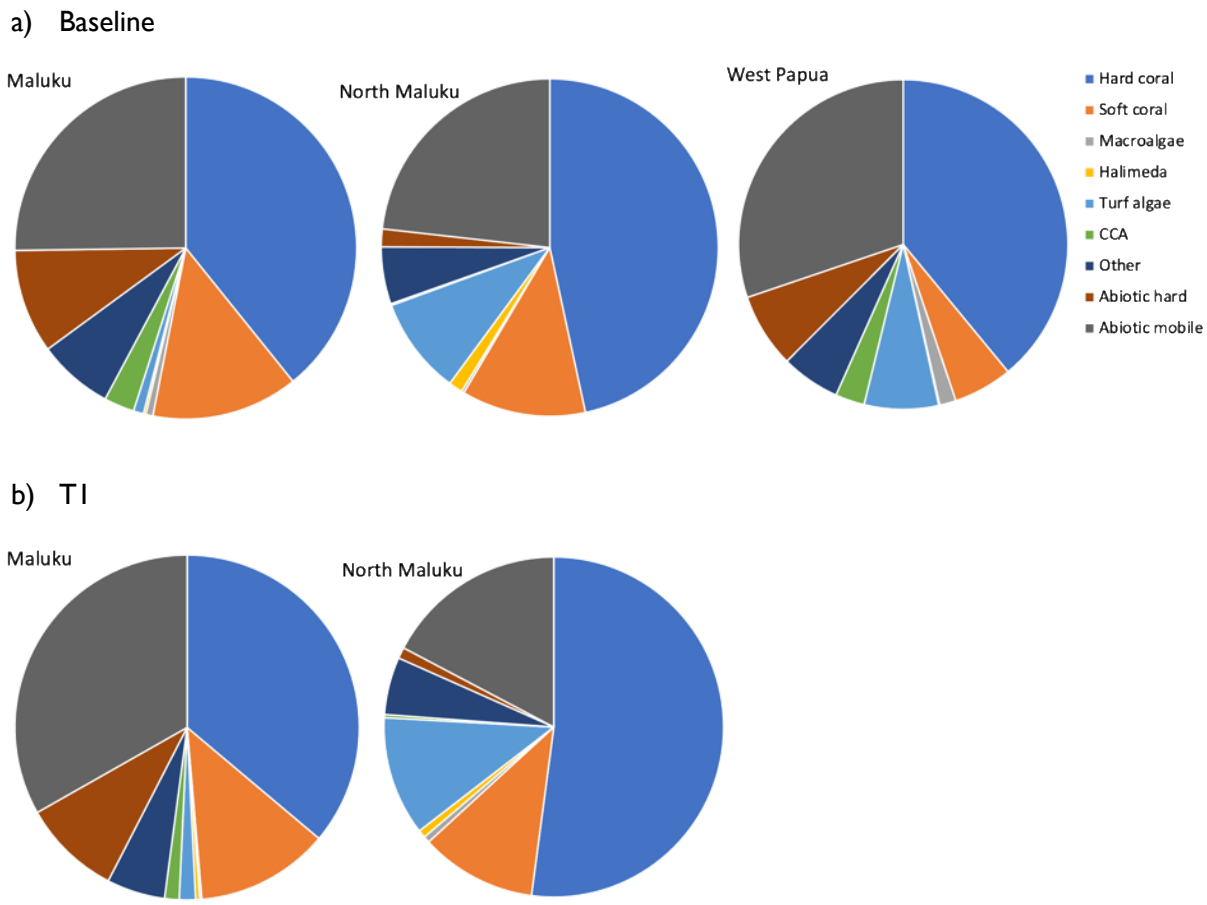


Figure 4.89 Mean percent cover of benthic categories found across all MPAs within each province.

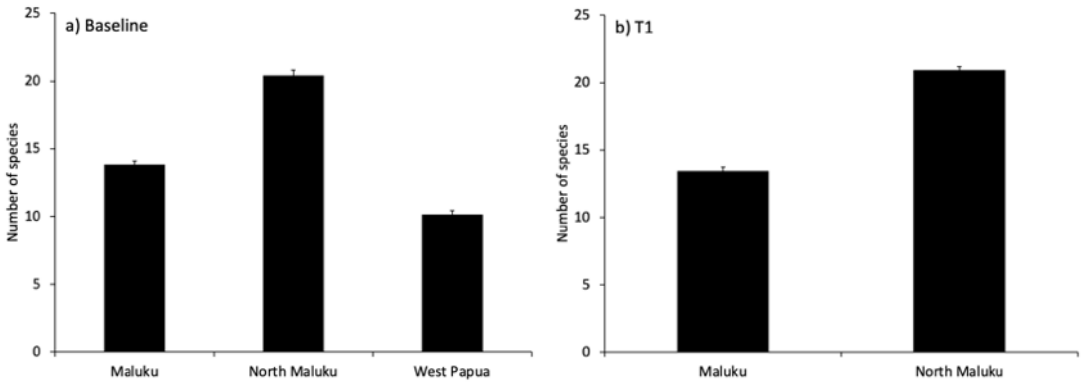


Figure 4.90 Mean number of target fish species per transect found across all MPAs within each province, using only families surveyed by all NGOs. Error bars = 1 SE.

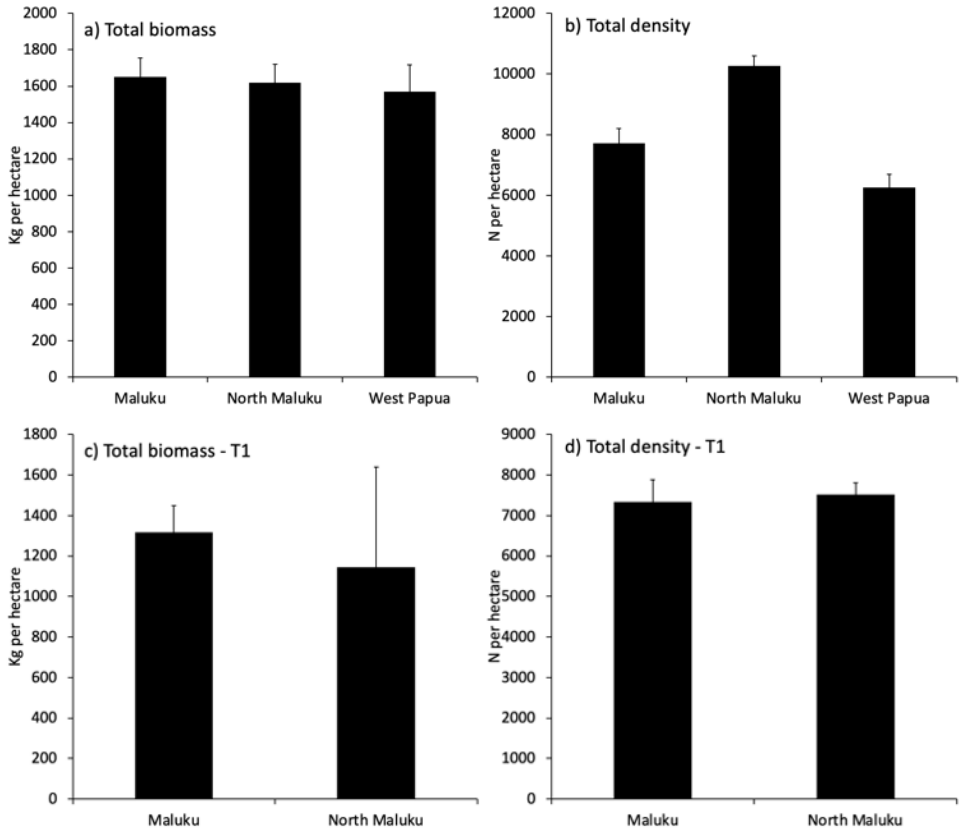


Figure 4.91 Mean a) biomass and b) density of all fish species across all MPAs within each province, based on families surveyed by all NGOs. Error bars = 1 SE.

Table 5. Impacts currently occurring across the SEA Project MPAs, from perceptions recorded during interviews with local communities and stakeholders.

Threats in Marine Protected Areas															
Threats		North Maluku						Maluku					West Papua		
		Rao-Dehegila	Mare	Makian-Moti	Guraici	Widi	Sula	Serutbar	Koon	Buano	Lease	Ay-Rhun	Berau Bay	Nusalasi Bay	South Sorong
Destructive Fishing	Cyanide/ Potassium /Poison	✓	✓	✓	✓	✓		✓	✓		✓		✓	✓	
	Boom	✓	✓	✓	✓	✓		✓	✓	✓			✓	✓	
	Net	✓	✓		✓	✓						✓	✓	✓	
	Trawl						✓	✓		✓					
	Illegal/ Poaching	✓	✓		✓		✓		✓						
	Overfishing	✓	✓		✓	✓		✓							
	Spear gun											✓			
	Low tide fishing (bameti)											✓			
	fishing in spags in spawning areas								✓		✓				
	Compressor							✓	✓				✓	✓	
ETP Species	Hunting	✓		✓				✓	✓	✓		✓			
	Consumption	✓		✓	✓		✓	✓	✓	✓		✓			
	Exploitation	✓			✓					✓		✓			
	By catch	✓			✓		✓	✓		✓		✓	✓	✓	
	ETP hit by boat	✓			✓	✓									
	Boat disturb mammals migration lane											✓			
	Wildlife trade									✓					
	Turtle	✓			✓		✓		✓	✓					
	Shark	✓		✓											
	Dugong	✓		✓					✓						
	Dolphin	✓													
	Bambu laut (*Isis* spp.)											✓			
	Whale								✓						
Habitat Destruction	Coral mining	✓	✓		✓		✓	✓		✓			✓	✓	
	Sand mining	✓			✓	✓	✓						✓	✓	
	Sedimentation						✓						✓	✓	✓
	Coastal development	✓									✓		✓	✓	
	Trash	✓	✓	✓	✓	✓	✓	✓			✓				✓

Threats in Marine Protected Areas															
Threats		North Maluku						Maluku					West Papua		
		Rao-Dehegila	**Mare**	**Makian-Moti**	**Guraici**	**Widi**	**Sula**	**Serutbar**	**Koon**	**Buano**	**Lease**	**Ay-Rhun**	**Berau Bay**	**Nusalasi Bay**	**South Sorong**
	Oil/Gasoline	✓	✓									✓			✓
	Climate change						✓								
	Fisherman Anchor	✓	✓	✓	✓	✓			✓		✓	✓			
	Oil & gas concession												✓	✓	
	Mangrove cutting	✓	✓		✓	✓	✓			✓	✓				✓
Tourism	Tourism Boat Anchor	✓	✓		✓	✓									
	Merchandise		✓		✓	✓									
	Step on coral	✓			✓										

4.5 USAID SEA PROJECT PERFORMANCE MANAGEMENT INDICATOR (PMI) ANALYSIS

Using the reef health monitoring survey data, the PMI results are used to determine the impact of the MPA program of the SEA Project under USG assistance. Specifically, changes in two indicators of the biophysical condition of the coral reefs are investigated. SA 2.2 is the number of hectares of biological significance and or natural resources (represented by % live hard coral cover) showing improved biophysical condition, and SA 2.5 is the percent change in reef fish biomass in selected MPAs. The results are represented by the change in hard coral cover and target fish biomass inside the no-take areas (NTAs) of each MPA. There are eight MPAs from Maluku and North Maluku that can be compared for the PMI: Koon, Serutbar, Lease, Guraici, Mare, Rao-Dehegila, Sula and Widi; only the NTA sites that were surveyed in both years are included in this PMI analysis.

4.5.1 SA 2.2 NUMBER OF HECTARES OF BIOLOGICAL SIGNIFICANCE AND / OR NATURAL RESOURCES SHOWING IMPROVED BIOPHYSICAL CONDITIONS AS A RESULT OF USG ASSISTANCE

Significant increases in average hard coral cover occurred in the NTA of Mare and Rao-Dehegila MPAs, while the NTA of Sula MPA experienced a significant loss of hard coral cover (Table 4.6). Overall, the average hard coral cover in Koon, Serutbar, Lease, Guraici, and Widi MPAs is considered stable. In summary, seven out of eight MPAs show a significant increase or stability; resulting in 16,596 hectares of NTA that showed a positive effect during the 2016 to 2020 SEA Project period.

Table 4.6. Percent live hard coral cover inside the NTA of each MPA. The p-value was generated from an F-test (Analysis of variance) of the average T0-T1 values, using only sites surveyed in both years. Values in brackets are Standard Errors. P-values with a "*" are significant.

MPA	N sites	T0 survey	3m	10m	Av	T1 survey	3m	10m	Av	*(P value)*	Status	NTZ ha
			% HC T0	% HC T0	% HC T0		% HC T1	% HC T1	% HC T1			
NORTH MALUKU												
Morotai	5	2017	50.93 (4.2)	42.47 (3.5)	**46.70 (2.8)**	2020	58.89 (4.8)	59.00 (3.1)	**58.93 (3.1)**	*0.02**	increase	**1,387**
Guraici	6	2017	49.39 (6.1)	37.78 (5.5)	**43.58 (4.2)**	2020	52.17 (6.6)	29.61 (5.4)	**40.89 (4.6)**	*0.55*	stable	**980**
Mare	5	2017	43.53 (5.3)	39.73 (7.0)	**41.63 (4.3)**	2020	71.53 (4.3)	61.33 (6.2)	**66.43 (3.8)**	*<0.001***	increase	**188**
Widi	8	2017	45.63 (5.2)	44.46 (3.5)	**45.04 (3.1)**	2020	42.25 (2.3)	36.88 (2.1)	**39.56 (2.3)**	*0.5*	stable	**8,981**
Sula	3	2017	69.33 (3.0)	47.67 (5.7)	**58.50 (4.1)**	2020	41.67 (4.4)	28.00 (1.8)	**34.83 (2.8)**	*<0.001**	decrease	929
MALUKU												
Lease	8	2018	59.92 (2.9)	44.58 (3.7)	**52.25 (2.6)**	2020	54.92 (3.4)	49.25 (3.4)	**52.08 (2.4)**	*0.9*	stable	**1,069**
Sawai	6	2017	NA	31.61 (6.1)	**31.61 (6.1)**	2020	NA	34.94 (3.2)	**34.94 (3.2)**	*0.15*	stable	**3,708**
Koon-Neiden	4	2016	NA	29.50 (2.9)	**29.50 (2.9)**	2020	28.67 (3.2)	32.58 (2.2)	**32.58 (2.2)**	*0.31*	stable	**283**
* = significant ** = highly significant										**TOTAL NTZ AREA**		**16,596**

4.5.2 SA 2.5 PERCENT CHANGE IN REEF FISH BIOMASS IN SELECTED MPAS

Many fish families declined in biomass between baseline surveys and T1 monitoring surveys within the NTA zones of most MPAs. This is not surprising, given that no-take regulations have not yet been implemented in many of the MPAs, and fishing therefore continues. Mare MPA showed the most promising trends in terms of fish families that increased significantly within the NTA between the two time periods (189 vs 559 kg per hectare). Many of the declines in overall biomass and density may be driven by Caesionidae, which, as schooling planktivores, are often present in very high densities and make up a large part of the fish biomass on Indonesian reefs (Campbell et al. 2020), but are also highly vulnerable to fishing pressure (Ackiss et al. 2013).

Target fish families in Appendix VII with significantly increased biomass in the NTAs were:

- Caesionidae (fusiliers) in Guraici and Mare MPAs;
- Lethrinidae (emperors) in Koon, Guraici and Mare MPAs;
- Lutjanidae (snappers) in Mare MPA;
- Mullidae (goatfish) in Serutbar, Lease and Mare MPAs;
- Nemipteridae (bream) in Lease MPA;
- Scaridae (parrotfish) in Mare MPA; and
- Siganidae (rabbitfish) in Mare and Widi MPAs.

Target fish families with significantly decreased biomass in the NTAs were:

- Almost all families in Serutbar MPA;
- Almost all families in Rao-Dehegila MPA;
- Five out of 14 families in Sula MPA;
- Acanthuridae (surgeonfish) in Lease, Serutbar and Rao-Dehegila MPAs;
- Lutjanidae (snappers) in Koon, Serutbar, Rao-Dehegila MPAs;
- Scaridae (parrotfish) in Koon, Serutbar and Sula MPAs;
- Groupers (Serranidae) in Rao-Dehegila and Sula MPAs;
- Carangidae (trevallies) in Guraici MPA.

The composite analysis shows fish biomass declining in Maluku and remaining stable in North Maluku. The average target fish biomass in Maluku at the baseline was 2,222 (+/- 369 SE), and at the end of project was significantly lower at 1,073 (+/- 154 SE) kg per hectare. In North Maluku, the change was from 1,417 (+/- 176 SE) kg per hectare to 756 (+/- 85 SE) kg per hectare at the end of project, but this change was not statistically significant. The average biomass across all NTAs was 1,709 (+/- 176 SE) kg per hectare at the baseline and 884 (+/- 76 SE) kg per hectare at the latest survey, which was a significant decline ($p = 0.0003$) of about 48% (Table 4.2).

Within individual MPAs, the average fish biomass increased in the NTA of Mare MPA, decreased in Koon, Serutbar, Rao-Dehegila and Sula MPAs, and remained stable in Lease, Guraici and Widi MPAs. The decline in target fish biomass is most likely due to continued heavy fishing pressure in the region, as the no-take regulations have yet to be implemented and all the MPAs continue to be fished. Consistent increases in target fish biomass is only expected following a decline or complete cessation of fishing pressure. Furthermore, while recovery of the populations of some species can be rapid after NTA protection (Williamson et al. 2004, Russ et al. 2008, Bejarano et al. 2019), many preferred target species are long-lived and will take longer to return to their previous density and biomass (Russ and Alcala 2004, Campbell et al. 2020). A secondary potential reason for the lower biomass estimates during the

follow-up surveys is a change in observers and methodology in some MPAs. In Koon, Lease, Serutbar and Sula MPAs, survey teams recorded only two or three non-target species during the baseline surveys, and added over 100 non-target species to T1 surveys. The addition of non-target species may therefore have confounded the counts of target species during T1. Supporting this assumption is the fact that target species did not decline significantly in most of the MPAs where the same number of species (target and non-target) were counted in both years.

Table 4.7 Percent change and average biomass of selected target fish families inside the NTA of each MPA as the PMI results. The p-value was generated from an F-test (Analysis of variance) of the average T0-T1 values, using only sites surveyed in both years. Values in brackets are Standard Errors. P-Values with a "*" are significant.

Percent change of selected target fish biomass per MPA									
Selected MPAs	Year	N sites	T0 avg. fish biomass (Kg/Ha)	Target	T1 avg. fish biomass (Kg/Ha)	Margin (Kg/Ha)	% change	*P value*	Status
Maluku									
Koon	2016 - 2020	4	3839 (1338.7)	Stable or increasing	686 (124.9)	-3154	-82%	*0.02**	Decrease
Serutbar	2017 - 2020	6	1388 (214.0)		342 (66.7)	-1045	-75%	*<0.001**	Decrease
Lease	2018 - 2020	8	2029 (421.1)		1814 (297.3)	-215	-11%	*0.18*	Stable
Average Maluku	2016 - 2020	18	2,222		1,073	-1,149	-52%	*<0.001**	Decrease
North Maluku									
Guraici	2017 - 2020	6	399 (91.4)	Stable or increasing	363 (58.3)	-36	-9%	*0.72*	Stable
Mare	2017 - 2020	5	189 (26.8)		559 (99.9)	370	196%	*0.002**	Increase
Morotai	2017 - 2020	5	2303 (394.4)		406 (49.8)	-1897	-82%	*<0.001**	Decrease
Sula	2017 - 2020	3	6012 (786.9)		1781 (620.2)	-4231	-70%	*<0.001**	Decrease
Widi	2017 - 2020	8	1036 (178.5)		1290 (192.9)	254	25%	*0.35*	Stable
Average North Maluku	2017 - 2020	27	1,417		756	-661	-47%	*0.15*	Stable
Overall average	2016 - 2020	45	1,709		884	825	-48%	0.0003*	Decrease

CONCLUSIONS

Coral reefs across the SEA Project MPAs are mostly in good condition, with coral cover and fish communities largely reflecting the presence of human pressure. Sedimentation and a history of destructive fishing appear to be the primary forces governing variability in coral cover, along with other forms of direct damage to the coral and fishing pressure tends to drive fish biomass and abundance. However, overall average coral cover has tended to increase or remain stable during the survey period, including in 2020, suggesting that the bleaching events in 2016 and 2017 that devastated the northern Great Barrier Reef and parts of the Pacific (Hughes et al. 2018) caused minimal mortality in this region. As reefs around the world decline, areas that show resistance to global disturbance events can be further supported by reducing local stressors.

Comparisons with surveys at other reef locations show that coral cover of between 25-50% can be considered "fair", and between 51 and 75% is generally considered "good" (White et al. 2018). In 2020, none of the SEA project MPAs had values below 25%; Lease, Guraici and Mare MPAs had coral cover over 51%. This is similar to recent surveys in the Philippines and Borneo, where most sites also had between 25 and 50% coral cover (Waheed et al. 2015, White et al. 2018) and Malaysia where the overall average was 40% cover (Reef Check Malaysia 2019). SEA Project reefs had coral cover similar or slightly higher than the Bird's Head Seascape (Ahmadia et al. 2013). Coral cover on these reefs also tended to be higher than the Solomon Islands, where records show cover of between 29 and 47% (Green et al. 2006), and the Great Barrier Reef, where large-scale coral cover estimates are below 25% (AIMS 2020). However, there was evidence of rubble in all the MPAs, thought to be caused by a history of (and potentially ongoing) blast fishing (Atkani 2003). The establishment of NTAs, together with education about fishing and anchoring practices and activities that cause erosion on land are key recommended local management actions (see recommendations below) to support reefs in Maluku, North Maluku and West Papua Provinces.

Large and significant declines in a number of target fish families across multiple MPAs are concerning, but reflect other reports of ongoing unsustainable levels of exploitation, especially of carnivorous fishes such as groupers and emperors (Andamari et al. 2007), and grazers such as surgeonfish and rabbitfish (McKenna et al. 2002). The artisanal fisheries in the region are very diverse, consisting of over 200 species, affecting reef communities at a range of trophic levels (Limmon et al. 2020). Comparisons with surveys at other reef locations show that fish biomass below 50 kg per hectare can be considered very poor, while biomass above 750 kg per hectare is considered very high (White et al. 2018). At T1 in the SEA Project MPAs, biomass ranged from ~300 (moderate) to ~1,800 (very high) kg per hectare, and most MPAs had moderate to high biomass despite the declining trends. These values are lower than those recorded in the Philippines (White et al. 2018), but similar to the Bird's Head Seascape before NTA regulations were implemented (Ahmadia et al. 2013). Densities of target species recorded by Reef Check in Malaysia, although made up of slightly different taxa, ranged from 20 to 1,000 individuals per hectare (Reef Check Malaysia 2019) and was generally lower, on average, than densities recorded here (overall average of ~5,500 individuals per hectare). The biomass of food fishes in the Solomon Islands was higher, with many sites surveyed in a 2005 marine assessment yielding over 1,000 kg per hectare (Green et al. 2006).

It is important to note that target fish biomass and density will only change when fishing pressure changes or stops; the results of this study are not surprising given that fishing continues throughout the MPAs. These results are useful because rather than just one baseline estimate before the implementation of the NTAs, they provide two points of reference from which we can infer a trend.

The declining trend in target fish shows that the implementation of NTAs is warranted and necessary, as current fishing pressure appears to be driving down fish stocks.

Rare species and predators, such as Napoleon wrasse, turtles, cetaceans and sharks, are useful indicators of fishing pressure and the overall state of coral reef ecosystems, as they are among the first species to disappear under heavy fishing pressure and intense human use (Sadovy and Suharti 2008, Baum and Worm 2009). The export of Napoleon wrasse is banned in Indonesia, but catch rates are thought to remain high in many areas (Sadovy and Suharti 2008). Frequent sightings of charismatic species are promising (Sadovy de Mitcheson et al. 2019), especially for the development of tourism as an industry that can be consistent with conservation goals.

Evidence from other MPAs in Indonesia and around the world indicates that with effective no-take protection, target fish can increase very rapidly (Williamson et al. 2004, Ardiwijaya et al. 2008, Russ et al. 2008, Bejarano et al. 2019), and provide subsidies for local fisheries in the form of broodstock (Harrison et al. 2012) and adult spillover (Russ et al. 2003, Russ et al. 2004). Previous research has shown that a combination of different zones, including areas where sustainable fishing can continue, is more successful than simply establishing no-take zones, with a better likelihood of compliance with the zoning system (Grantham et al. 2013, Campbell et al. 2020).

The protection of coral reef assemblages from fishing within the multiple-use SEA Project MPAs can have benefits for the wider region of the Maluku Sea reefs, as there are indications of high genetic connectivity within the area covered by the three provinces (Barber et al. 2006, DeBoer et al. 2008, Ackiss et al. 2013). This means that the MPAs, given adequate compliance, could function together effectively as a network (Carpenter et al. 2011). Importantly, the different MPAs appear to capture different benthic and fish communities, creating higher overall diversity across the network. Combining NTA protection with other fisheries management practices such as gear restrictions, catch and size limits, ceasing destructive fishing practices, as well as managing erosion and pollution from land and encouraging a sense of pride in coral reef ecosystems in local communities are the most effective ways to give these highly biodiverse coral reefs the best chance to persist into the future.

RECOMMENDATIONS

Based on the biophysical condition of coral reef benthic and fish communities across the SEA Project MPAs, and previous reports on the key threats to these reefs, the following actions are recommended:

1. Develop a clear set of guidelines to encourage compliance with the NTAs. Compliance with no-take regulations is one of the five key characteristics of the success of MPAs worldwide.
2. Establish a monitoring program that is guaranteed to continue into the future. The benefits of NTAs typically take at least three years to manifest, after the no-take regulations are put in place and complied with.
    a. Continue to develop the methodology and protocols of monitoring so that they are consistent at least within each MPA.
    b. Ensure the re-survey of at least three sites within each zone: NTAs, TAs and Control Sites. This will allow for the direct comparison of the condition within and between zones between years.
    c. Consistency of observers, especially for the fish surveys, is strongly encouraged.
    d. Any changes in the protocol (e.g. reduced number of transects or sites due to strong currents or poor weather conditions) must be carefully documented.
3. Encourage the end of blast and cyanide fishing, as this destroys the habitat and erodes the potential of recovery and future fishing (Atkani 2003) through the implementation of community-based compliance programs and stricter law enforcement where illegal fishing is persistent and rampant.
4. Develop conservation activities on both land and sea concurrently, so that coral reefs in NTAs are not struggling to recover due to land-based pollution and sedimentation. A comparison of reefs in Maluku, South Sulawesi and Java Seas found that the primary driver of coral reef community structure was sedimentation from the land (Edinger et al. 2000).
5. Improve environmental awareness within local communities close to the NTAs. Include information on the benefits of NTAs for local fisheries replenishment, using examples from existing NTAs that have been established for a long time. Support for NTAs already exists in Indonesia, together with a form of traditional resource management (sasi), suggesting that a combination of the different forms of management has a high likelihood of being successful (Hamid et al. 2017).
6. Encourage participation in conservation through community programs, especially in schools. Encourage the sense of stewardship and care for the NTAs and coral reef communities in general. Poaching in NTAs often results in a lack of increase in biomass and biodiversity, but can be prevented through adequate enforcement and engaging with community members so they support protected areas (Brown et al. 2018).
7. Improve infrastructure for tourism, so that recreational diving and snorkeling can generate income for local communities, and so that the reefs are more valuable if they are well-protected. This must be done together with education of tourism operators to minimise the impacts of divers and snorkelers on the reefs.

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In 2017, the USAID SEA Project facilitated coral reef ecosystem health monitoring surveys around five MPAs in Maluku, six MPAs in North Maluku and two MPAs in West Papua. The monitoring program is intended to support the development of MPAs, establishing the baseline of coral reef ecosystems inside and outside the No-Take zones. The surveys also provided data to enable the calculation of changes in the biophysical condition of coral reefs during MPAs establishment. USAID SEA Project conducted a second survey in 2020 in eight MPAs in Maluku and North Maluku Provinces.

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REFERENCES

Ackiss, A. S., S. Pardede, E. D. Crandall, M. C. A. Ablan-Lagman, Ambariyanto, N. Romena, P. H. Barber, and K. E. Carpenter. 2013. Pronounced genetic structure in a highly mobile coral reef fish, Caesio cuning, in the Coral Triangle. Marine Ecology Progress Series **480**:185-197.

Ahmadia, G. A., J. R. Wilson, and A. L. Green. 2013. Coral Reef Monitoring Protocol for Assessing Marine Protected Areas in the Coral Triangle. Coral Triangle Support Partnership.

AIMS. 2020. Long-term Reef Monitoring Program - Annual Summary Report on coral reef condition for 2019/20.

Allen, A. P., J. H. Brown, and J. F. Gillooly. 2002. Global biodiversity, biochemical kinetics, and the energetic-equivalence rule. Science **297**:1545-1548.

Allen, G. R., and M. V. Erdmann. 2018. Coral reef fishes of Fakfak Peninsula, West Papua Province, Indonesia. WWF, Indonesia.

Allen, G. R., and T. B. Werner. 2002. Coral Reef Fish Assessment in the 'Coral Triangle' of Southeastern Asia. Environmental Biology of Fishes **65**:209-214.

Amkieltiela, and A. Wijonarno. 2015. Protokol Pemantauan Kesehatan Terumbu Karang di Kawasan Konservasi Perairan. WWF-Indonesia, Jakarta, Indonesia.

Andamari, R., S. B. Moria, and G. N. Permana. 2007. Aspects of leopard coral grouper (*Plectropomus leopardus*) reproduction in Indonesia. Indonesian Aquaculture Journal **2**:51-57.

Ardiwijaya, R. L., A. H. Baird, T. Kartawijaya, and S. J. Campbell. 2008. Changes in reef fish biomass in Karimunjawa National Park: a test of the effectiveness of government gazetted marine parks in Indonesia. Pages 7-11 *in* Proceedings of the 11th International Coral Reef Symposium, Ft. Lauderdale, Florida.

Asaad, I., C. J. Lundquist, M. V. Erdmann, R. Van Hooidonk, and M. J. Costello. 2018. Designating Spatial Priorities for Marine Biodiversity Conservation in the Coral Triangle. Frontiers in Marine Science **5**.

Atkani, U. 2003. Fish communities as related to substrate characteristics in the coral reefs of Kepulauan Seribu Marine National Park, Indonesia, five years after stopping blast fishing practices. Ph. D. Thesis. Zentrum für Marine Tropenökologie, Bremen.

Baird, A. H., M. S. Pratchett, A. S. Hoey, Y. Herdiana, and S. J. Campbell. 2013. Acanthaster planci is a major cause of coral mortality in Indonesia. Coral Reefs **32**:803-812.

Barber, P. H., M. V. Erdmann, and S. R. Palumbi. 2006. COMPARATIVE PHYLOGEOGRAPHY OF THREE CODISTRIBUTED STOMATOPODS: ORIGINS AND TIMING OF REGIONAL LINEAGE DIVERSIFICATION IN THE CORAL TRIANGLE. Evolution **60**:1825-1839.

Bates, D., M. Mächler, B. Bolker, and S. Walker. 2015. Fitting linear mixed-effects models using lme4. Journal of Statistical Software **67**:1-48.

Baum, J. K., and B. Worm. 2009. Cascading top-down effects of changing oceanic predator abundances. Journal of Animal Ecology **78**:699-714. doi:610.1111/j.1365-2656.2009.01531.x.

Bejarano, S., S. Pardede, S. J. Campbell, A. S. Hoey, and S. C. A. Ferse. 2019. Herbivorous fish rise as a destructive fishing practice falls in an Indonesian marine national park. Ecological applications **29**:e01981.

Bellwood, D. R., and T. P. Hughes. 2001. Regional-scale assembly rules and biodiversity of coral reefs. Science **292**:1532-1535.

Briggs, J. C. 2009. Diversity, endemism and evolution in the Coral Triangle. Journal of Biogeography **36**:2008-2010.

Brown, C. J., B. Parker, G. N. Ahmadia, R. Ardiwijaya, Purwanto, and E. T. Game. 2018. The cost of enforcing a marine protected area to achieve ecological targets for the recovery of fish biomass. Biological Conservation **227**:259-265.

Cabral, R., A. Cruz-Trinidad, R. Geronimo, and P. Alino. 2012. Opportunities and Challenges in the Coral Triangle. Environmental Science & Technology **46**:7930-7931.

Calcinai, B., A. Bastari, G. Bavestrello, M. Bertolino, S. B. Horcajadas, M. Pansini, D. M. Makapedua, and C. Cerrano. 2017. Demosponge diversity from North Sulawesi, with the description of six new species. ZooKeys:105+.

Campbell, S. J., E. S. Darling, S. Pardede, G. Ahmadia, S. Mangubhai, Amkieltiela, Estradivari, and E. Maire. 2020. Fishing restrictions and remoteness deliver conservation outcomes for Indonesia's coral reef fisheries. Conservation Letters **13**:e12698.

Carpenter, K. E., P. H. Barber, E. D. Crandall, M. C. A. Ablan-Lagman, Ambariyanto, G. N. Mahardika, B. M. Manjaji-Matsumoto, M. A. Juinio-Meñez, M. D. Santos, C. J. Starger, and A. H. A. Toha. 2011. Comparative Phylogeography of the Coral Triangle and Implications for Marine Management. Journal of Marine Biology **2011**:396982.

Choat, J. H., and R. Pears. 2003. A rapid, quantitative survey method for large, vulnerable reef fishes.*in* C. Wilkinson, A. Green, J. Almany, and S. Dionne, editors. Monitoring Coral Reef Marine Protected Areas. A Practical Guide on How Monitoring Can support Effective Management MPAs. Australian Institute of Marine Science and the IUCN Marine Program Publication.

Cruz-Trinidad, A., P. M. Aliño, R. C. Geronimo, and R. B. Cabral. 2014. Linking Food Security with Coral Reefs and Fisheries in the Coral Triangle. Coastal Management **42**:160-182.

CTC. 2017. Summary report: Buano baseline data collection. Government of Indonesia and USAID, Jakarta, Indonesia.

DeBoer, T. S., M. D. Subia, M. V. Erdmann, K. Kovitvongsa, and P. H. Barber. 2008. Phylogeography and limited genetic connectivity in the endangered boring giant clam across the Coral Triangle. Conserv Biol **22**:1255-1266.

DeVantier, L., E. Turak, and R. Szava-Kovats. 2020. Species Richness and Abundance of Reef-Building Corals in the Indo-West Pacific: The Local-Regional Relation Revisited. Frontiers in Marine Science:NA.

Dwirama Putra, R., A. Suryanti, D. Kurniawan, A. Pratomo, H. Irawan, T. Said Raja'I, R. Kurniawan, G. Pratama, and Jumsurizal. 2018. Responses of Herbivorous Fishes on Coral Reef Cover in Outer Island Indonesia (Study Case: Natuna Island). E3S Web Conf. **47**:04009.

Edinger, E. N., J. Jompa, G. V. Limmon, W. Widjatmoko, and M. J. Risk. 1998. Reef degradation and coral biodiversity in indonesia: Effects of land-based pollution, destructive fishing practices and changes over time. Marine Pollution Bulletin **36**:617-630.

Edinger, E. N., J. Kolasa, and M. J. Risk. 2000. Biogeographic variation in coral species diversity on coral reefs in three regions of Indonesia. Diversity and Distributions **6**:113-127.

Firmansyah, F., Amkieltiela, M. B. Raharjo, T. Abdillah, and N. Nurbandika. 2018. Coral reef monitoring for ecological impact evaluation of KKP3K Pulau Koon, Pulau-Pulau Kecil dan Perairan Sekitarnya 2018. USAID SEA Project, Jakarta, Indonesia.

Gabriela Arango, B., H. T. Pinheiro, C. Rocha, B. D. Greene, R. L. Pyle, J. M. Copus, B. Shepherd, and L. A. Rocha. 2019. Three new species of Chromis (Teleostei, Pomacentridae) from mesophotic coral ecosystems of the Philippines. ZooKeys:1+.

Graham, N. A. J., T. D. Ainsworth, A. H. Baird, N. C. Ban, L. K. Bay, J. E. Cinner, D. M. De Freitas, G. Diaz-Pulido, M. Dornelas, S. R. Dunn, P. I. J. Fidelman, S. Foret, T. C. Good, J. Kool, J. Mallela, L. Penin, M. S. Pratchett, and D. H. Williamson. 2011. From microbes to people: tractable benefits of no-take areas for coral reefs. Oceanography and Marine Biology: an Annual Review **49**:105-136.

Grantham, H. S., V. N. Agostini, J. Wilson, S. Mangubhai, N. Hidayat, A. Muljadi, Muhajir, C. Rotinsulu, M. Mongdong, M. W. Beck, and H. P. Possingham. 2013. A comparison of zoning analyses to inform the planning of a marine protected area network in Raja Ampat, Indonesia. Marine Policy **38**:184-194.

Green, A., P. Lokani, W. Atu, P. Ramohia, T. P., and Almany J. (eds.). 2006. Solomon Islands Marine Assessment: Technical report of survey conducted May 13 to June 17, 2004. TNC Pacific Island Countries Report No. 1/06.

Green, A. L., and P. J. Mous. 2007. Delineating the Coral Triangle, its ecoregions and functional seascapes. The Nature Conservancy, Brisbane.

Halpern, B. S., and R. R. Warner. 2002. Marine reserves have rapid and lasting effects. Ecology Letters **5**:361-366.

Hamid, S. K., W. A. Teniwut, R. M. K. Teniwut, M. A. Rahantoknam, C. L. Hasyim, and M. Hungan. 2017. The Support of MPA (Marine Protected Area) in Coral Triangle Area: Evidence from Kei Islands, Indonesia. IOP Conference Series: Earth and Environmental Science **89**:012025.

Harrison, H. B., D. H. Williamson, R. D. Evans, G. R. Almany, S. R. Thorrold, G. R. Russ, K. A. Feldheim, L. van Herwerden, S. Planes, M. Srinivasan, M. L. Berumen, and G. P. Jones. 2012. Larval export from marine reserves and the recruitment benefit for fish and fisheries. Current Biology **22**:1023-1028.

Hopf, J. K., G. P. Jones, D. H. Williamson, and S. R. Connolly. 2019. Marine reserves stabilize fish populations and fisheries yields in disturbed coral reef systems. Ecological applications **e01905**.

Hughes, T. P., K. D. Anderson, S. R. Connolly, S. F. Heron, J. T. Kerry, J. M. Lough, A. H. Baird, J. K. Baum, M. L. Berumen, T. C. Bridge, D. C. Claar, C. M. Eakin, J. P. Gilmour, N. A. J. Graham, H. Harrison, J.-P. A. Hobbs, A. S. Hoey, M. Hoogenboom, R. J. Lowe, M. T. McCulloch, J. M. Pandolfi, M. Pratchett, V. Schoepf, G. Torda, and S. K. Wilson. 2018. Spatial and temporal patterns of mass bleaching of corals in the Anthropocene. Science **359**:80-83.

Huliselan, N. V., D. Sahetapy, M. A. Tuapattinaja, and M. Wawo. 2019. Community structure of target reef fish at four tiny islands coral reefs in inner Kotania bay, Maluku Province, Indonesia. IOP Conference Series: Earth and Environmental Science **339**:012015.

Ihsan, E. N., Purwanto, A. Capriati, I. N. Suardana, W. Sanjaya, R. Purnama, D. Dimas, A. Masykur, M. Arya, H. Alkharis, and H. Widodo. 2018. Lease Islands biophysic condition 2018. Tetra Tech – USAID SEA Project, Jakarta, Indonesia.

Juhel, J.-B., R. S. Utama, V. Marques, I. B. Vimono, H. Y. Sugeha, Kadarusman, L. Pouyaud, T. Dejean, D. Mouillot, and R. Hocdé. 2020. Accumulation curves of environmental DNA sequences predict coastal fish diversity in the coral triangle. Proceedings of the Royal Society B: Biological Sciences **287**:20200248.

Kusumoto, B., M. J. Costello, Y. Kubota, T. Shiono, C.-L. Wei, M. Yasuhara, and A. Chao. 2020. Global distribution of coral diversity: Biodiversity knowledge gradients related to spatial resolution. Ecological Research **35**:315-326.

Limmon, G., E. Delrieu-Trottin, J. Patikawa, F. Rijoly, H. Dahruddin, F. Busson, D. Steinke, and N. Hubert. 2020. Assessing species diversity of Coral Triangle artisanal fisheries: A DNA barcode reference library for the shore fishes retailed at Ambon harbor (Indonesia). Ecology and Evolution **10**:3356-3366.

Limmon, G. V. 1996. An assessment of coral reefs in Ambon, Indonesia. Masters Thesis. McMaster University.

McKenna, S. A., G. R. Allen, and S. Suryadi, editors. 2002. A marine rapid assessment of the Raja Ampat Islands, Papua Province, Indonesia. RAP Bulletin of Biological Assessment 22. Conservation International, Washington, D. C.

McManus, L. C., V. V. Vasconcelos, S. A. Levin, D. M. Thompson, J. A. Kleypas, F. S. Castruccio, E. N. Curchitser, and J. R. Watson. 2020. Extreme temperature events will drive coral decline in the Coral Triangle. Global Change Biology **26**:2120-2133.

Muttaqin, A., S. Pardede, S. A. Tarigan, F. Setiawan, Muhidin, M. Welly, Elisnawaty, M. Korebima, Wirasanjaya, F. Rijoly, A. Ahmad, I. Marus, and B. Kaidat. 2017. Ecosystem profile of coral reefs in North Maluku's marine protected areas. Wildlife Conservation Society - Indonesia Program, Bogor, Indonesia.

Olds, A. D., S. Albert, P. S. Maxwell, K. A. Pitt, and R. M. Connolly. 2013. Mangrove-reef connectivity promotes the effectiveness of marine reserves across the western Pacific. Global ecology and biogeography **22**:1040-1049.

Randall, J. E., and G. R. Allen. 2010. Two new labrid fishes of the Genus Halichoeres from the East Indies. The Raffles Bulletin of Zoology **58**:281-289.
Reef Check Malaysia. 2019. Status of coral reefs in Malaysia. Reef Check, Malaysia.
Russ, G. R., and A. C. Alcala. 2004. Marine reserves: long-term protection is required for full recovery of predatory fish populations. Oecologia **138**:622-627.
Russ, G. R., A. C. Alcala, and A. P. Maypa. 2003. Spillover from marine reserves: the case of *Naso vlamingii* at Apo Island, the Philippines. Marine Ecology Progress Series **264**:15-20.
Russ, G. R., A. C. Alcala, A. P. Maypa, H. P. Calumpong, and A. T. White. 2004. Marine reserve benefits local fisheries. Ecological applications **14**:597-606.
Russ, G. R., A. J. Cheal, A. M. Dolman, M. J. Emslie, R. D. Evans, I. Miller, H. Sweatman, and D. H. Williamson. 2008. Rapid increase in fish numbers follows creation of world's largest marine reserve network. Current Biology **18**:R514-R515.
Sadovy de Mitcheson, Y., S. R. Suharti, and P. L. Colin. 2019. Quantifying the rare: Baselines for the endangered Napoleon Wrasse, Cheilinus undulatus, and implications for conservation. Aquatic Conservation: Marine and Freshwater Ecosystems **29**:1285-1301.
Sadovy, Y. J., and S. Suharti. 2008. Napoleon fish, *Cheilinus undulatus*, Indonesia. NDF Workshop Case Studies, Mexico.
Servonnat, M., R. Kaye, F. P. Siringan, J. Munar, and H. T. Yap. 2019. Imperatives for Conservation in a Threatened Center of Biodiversity. Coastal Management **47**:453-472.
Turak, E., and L. DeVantier. 2008. Biodiversity and conservation priorities of reef building corals in North Halmahera – Morotai. Report prepared for Conservation International and The Nature Conservancy.
Unsworth, R. K. F., P. S. De LeÃƒÂ³n, S. L. Garrard, J. Jompa, D. J. Smith, and J. J. Bell. 2008. High connectivity of Indo-Pacific seagrass fish assemblages with mangrove and coral reef habitats. Marine Ecology Progress Series **353**:213-224.
Verweij, M. C., I. Nagelkerken, D. de Graaff, M. Peeters, E. J. Bakker, and G. van der Velde. 2006. Structure, food and shade attract juvenile coral reef fish to mangrove and seagrass habitats: a field experiment. Marine Ecology Progress Series **306**:257-268.
Waheed, Z., H. G. J. van Mil, S. H. M. A., R. Jumin, B. Golam Ahad, and B. W. Hoeksema. 2015. Coral reefs at the northernmost tip of Borneo: An assessment of scleractinian species richness patterns and benthic reef assemblages. PLoS ONE **10**:e0146006. doi:0146010.0141371/journal.pone.0146006.
Welly, M., Elisnawaty, W. Sanjaya, M. Korebima, F. Rijoly, A. Ahmad, I. Marus, and B. Kaidat. 2017a. Biophysical and socioeconomic condition, Morotai Island, North Maluku. Tetra Tech – USAID SEA Project, Jakarta, Indonesia.
Welly, M., Elisnawaty, W. Sanjaya, M. Korebima, F. Rijoly, A. Ahmad, I. Marus, and B. Kaidat. 2017b. Biophysics and economic condition, Sula Island, North Maluku. Tetra Tech – USAID SEA Project, Jakarta, Indonesia.
White, A. T., B. Stockwell, J. Apurado, E. White., A. Sabonsolin, and A. J. Lozada. 2018. Summary field report: coral reef monitoring expedition to Tubbataha Natural Park, Sulu Sea, Philippines, April 21-27,
2018. The Coastal Conservation and Education Foundation, Inc., Cebu City, 86 p.
Williamson, D. H., G. R. Russ, and A. M. Ayling. 2004. No-take marine reserves increase abundance and biomass of reef fish on inshore fringing reefs of the Great Barrier Reef. Environmental Conservation **31**:149-159.
Wilson, J. R., and A. L. Green. 2009. Biological monitoring methods for assessing coral reef health and management effectiveness of Marine Protected Areas in Indonesia. Version 1.0. TNC Indonesia Marine Program Report 1/09. 44 pp.
WWF. 2017. Baseline report Teluk Sawai, Maluku Province. Ecology, fisheries, and social's status. Government of Indonesia and USAID, Jakarta, Indonesia.

APPENDICES

8.1 APPENDIX I – SITE DETAILS AND MAPS

PROVINCE	MPA	SITE-ID	SITE_NAME	T0	T1	T2	ZONE (Indonesia)	ZONE (English)	NTA/TA	YEAR (T0)	YEAR (T1)	YEAR (T2)
Maluku	**AY RHUN**	Rhun	**ARU1**	yes	no	NA	Zona Inti	Core zone	NTA	2019	NA	
Maluku	**AY RHUN**	Nailaka	**ARU2**	yes	no	NA	Subzona Perikanan Tangkap	Fishing zone	TA	2019	NA	
Maluku	**AY RHUN**	Ay Barat	**ARU3**	yes	no	NA	Subzona Perikanan Tangkap	Fishing zone	TA	2019	NA	
Maluku	**AY RHUN**	Ay Timur	**ARU4**	yes	no	NA	Subzona Pariwisata	Tourism zone	NTA	2019	NA	
Maluku	**AY RHUN**	Manukang Timur	**ARU5**	yes	no	NA	Control	Control	Control	2019	NA	
Maluku	**AY RHUN**	Karaka	**ARU6**	yes	no	NA	Control	Control	Control	2019	NA	
Maluku	**AY RHUN**	Gunung Api Timur	**ARU7**	yes	no	NA	Control	Control	Control	2019	NA	
Maluku	**AY RHUN**	Gunung Api Selatan	**ARU8**	yes	no	NA	Control	Control	Control	2019	NA	
Maluku	**AY RHUN**	Lava Flow	**ARU9**	yes	no	NA	Control	Control	Control	2019	NA	
Maluku	**AY RHUN**	Batu Kapal	**ARU10**	yes	no	NA	Control	Control	Control	2019	NA	
Maluku	**AY RHUN**	Syahrir Timur	**ARU11**	yes	no	NA	Control	Control	Control	2019	NA	
Maluku	**AY RHUN**	Wali	**ARU12**	yes	no	NA	Control	Control	Control	2019	NA	
Maluku	**AY RHUN**	Hatta	**ARU13**	yes	no	NA	Control	Control	Control	2019	NA	
Maluku	**AY RHUN**	Sekaru	**ARU14**	yes	no	NA	Control	Control	Control	2019	NA	
Maluku	**AY RHUN**	Hatta Selatan	**ARU15**	yes	no	NA	Control	Control	Control	2019	NA	
Maluku	**AY RHUN**	Pohon Miring	**ARU16**	yes	no	NA	Control	Control	Control	2019	NA	
Maluku	**AY RHUN**	Waer	**ARU17**	yes	no	NA	Control	Control	Control	2019	NA	
Maluku	**AY RHUN**	Uring	**ARU18**	yes	no	NA	Control	Control	Control	2019	NA	
Maluku	**AY RHUN**	Batu Belanda	**ARU19**	yes	no	NA	Control	Control	Control	2019	NA	
Maluku	**AY RHUN**	Mangku Batu	**ARU20**	yes	no	NA	Control	Control	Control	2019	NA	
Maluku	**AY RHUN**	Rhun Utara	**ARU21**	yes	no	NA	Subzona Perikanan Tangkap	Fishing zone	TA	2019	NA	

PROVINCE	MPA	SITE-ID	SITE_NAME	T0	T1	T2	ZONE (Indonesia)	ZONE (English)	NTA/TA	YEAR (T0)	YEAR (T1)	YEAR (T2)
Maluku	**AY RHUN**	Ay Selatan	**ARU22**	yes	no	NA	Subzona Perikanan Tangkap	Fishing zone	TA	2019	NA	
Maluku	**BUANO**	Pelabuhan Ferry Buano	**BUA1**	yes	no	NA	Subzona Perikanan Tangkap	Fishing zone	TA	2017	NA	
Maluku	**BUANO**	Tanjung Loaloa	**BUA2**	yes	no	NA	Subzona Pariwisata	Tourism zone	NTA	2017	NA	
Maluku	**BUANO**	Nusa Uni	**BUA3**	yes	no	NA	Subzona Perikanan Tangkap	Fishing zone	TA	2017	NA	
Maluku	**BUANO**	Desa Nai Puti	**BUA4**	yes	no	NA	Subzona Perikanan Tangkap	Fishing zone	TA	2017	NA	
Maluku	**BUANO**	Pantai Sama	**BUA5**	yes	no	NA	Subzona Perikanan Tangkap	Fishing zone	TA	2017	NA	
Maluku	**BUANO**	Selat Valentine_Alapau	**BUA6**	yes	no	NA	Subzona Pariwisata	Tourism zone	NTA	2017	NA	
Maluku	**BUANO**	Kasuari Belakang	**BUA7**	yes	no	NA	Zona Inti	Core zone	NTA	2017	NA	
Maluku	**BUANO**	Tanjung Pamali	**BUA8**	yes	no	NA	Subzona Perikanan Tangkap	Fishing zone	TA	2017	NA	
Maluku	**BUANO**	Tanjung Nasela	**BUA9**	yes	no	NA	Subzona Pariwisata	Tourism zone	NTA	2017	NA	
Maluku	**BUANO**	Selat Valentine_Sahana Ain	**BUA10**	yes	no	NA	Subzona Perikanan Tangkap	Fishing zone	TA	2017	NA	
Maluku	**KOON**	KOE01	**KOE01**	yes	yes	yes	Subzona Pariwisata	Tourism zone	NTA	2016	2018	2020
Maluku	**KOON**	KOE02	**KOE02**	yes	yes	yes	Zona Inti	Core zone	NTA	2016	2018	2020
Maluku	**KOON**	KOE03	**KOE03**	yes	yes	yes	Zona Inti	Core zone	NTA	2016	2018	2020
Maluku	**KOON**	KOE04	**KOE04**	yes	yes	yes	Control	Control	Control	2016	2018	2020
Maluku	**KOON**	KOE05	**KOE05**	yes	yes	yes	Subzona Perikanan Tangkap	Fishing zone	TA	2016	2018	2020
Maluku	**KOON**	KOE06	**KOE06**	yes	yes	yes	Subzona Perikanan Tangkap	Fishing zone	TA	2016	2018	2020
Maluku	**KOON**	KOE07	**KOE07**	yes	yes	yes	Subzona Perikanan Tangkap	Fishing zone	TA	2016	2018	2020
Maluku	**KOON**	KOE08	**KOE08**	yes	yes	no	Subzona Perikanan Tangkap	Fishing zone	TA	2016	2018	NA
Maluku	**KOON**	KOE09	**KOE09**	yes	yes	no	Subzona Perikanan Tangkap	Fishing zone	TA	2016	2018	NA
Maluku	**KOON**	KOE10	**KOE10**	yes	yes	yes	Subzona Perikanan Tangkap	Fishing zone	TA	2016	2018	2020
Maluku	**KOON**	KOE11	**KOE11**	yes	yes	yes	Control	Control	Control	2016	2018	2020
Maluku	**KOON**	KOE14	**KOE14**	yes	yes	yes	Zona Inti	Core zone	NTA	2016	2018	2020
Maluku	**KOON**	KOE15	**KOE15**	yes	yes	yes	Subzona Perikanan Tangkap	Fishing zone	TA	2016	2018	2020
Maluku	**KOON**	KOE16	**KOE16**	yes	no	no	Control	Control	Control	2016	NA	NA
Maluku	**KOON**	KOE17	**KOE17**	yes	yes	yes	Control	Control	Control	2016	2018	2020

PROVINCE	MPA	SITE-ID	SITE_NAME	T0	T1	T2	ZONE (Indonesia)	ZONE (English)	NTA/TA	YEAR (T0)	YEAR (T1)	YEAR (T2)
Maluku	**KOON**	KOE18	**KOE18**	yes	yes	yes	Control	Control	Control	2016	2018	2020
Maluku	**KOON**	KOE20	**KOE20**	yes	yes	yes	Control	Control	Control	2016	2018	2020
Maluku	**KOON**	KOE21	**KOE21**	yes	yes	yes	Control	Control	Control	2016	2018	2020
Maluku	**KOON**	KOE23	**KOE23**	yes	yes	yes	Control	Control	Control	2016	2018	2020
Maluku	**KOON**	KOE24	**KOE24**	yes	yes	yes	Control	Control	Control	2016	2018	2020
Maluku	**KOON**	KOE25	**KOE25**	no	yes	yes	Subzona Pariwisata	Tourism zone	NTA	2016	2018	2020
Maluku	**KOON**	KOE26	**KOE26**	no	yes	yes	Control	Control	Control	2016	2018	2020
Maluku	**KOON**	KOE27	**KOE27**	no	yes	no	Subzona Rehabilitasi	Rehabilitation zone	NTA	2016	2018	NA
Maluku	**KOON**	KOE29	**KOE29**	no	yes	yes	Control	Control	Control	2016	2018	2020
Maluku	**LEASE**	Pelauw	**LH01**	yes	no	NA	Control	Control	Control	2018	NA	
Maluku	**LEASE**	Waitimal	**LH02**	yes	yes	NA	Subzona Perikanan Tangkap	Fishing zone	TA	2018	2020	
Maluku	**LEASE**	Hulaliu	**LH03**	yes	yes	NA	Subzona Pariwisata	Tourism zone	NTA	2018	2020	
Maluku	**LEASE**	Aboru	**LH04**	yes	no	NA	Subzona Rehabilitasi	Rehabilitation zone	NTA	2018	NA	
Maluku	**LEASE**	Oma	**LH05**	yes	no	NA	Control	Control	Control	2018	NA	
Maluku	**LEASE**	Batu Kapal	**LH06**	yes	no	NA	Control	Control	Control	2018	NA	
Maluku	**LEASE**	Molana Timur	**LM01**	yes	yes	NA	Zona Inti	Core zone	NTA	2018	2020	
Maluku	**LEASE**	Molana Barat	**LM02**	yes	yes	NA	Subzona Perikanan Tangkap	Fishing zone	TA	2018	2020	
Maluku	**LEASE**	Nalahia	**LN01**	yes	yes	NA	Subzona Perikanan Tangkap	Fishing zone	TA	2018	2020	
Maluku	**LEASE**	Leinitu	**LN02**	yes	yes	NA	Subzona Pariwisata	Tourism zone	NTA	2018	2020	
Maluku	**LEASE**	Tittawai	**LN03**	yes	yes	NA	Subzona Perikanan Tangkap	Fishing zone	TA	2018	2020	
Maluku	**LEASE**	Abubu	**LN04**	yes	yes	NA	Zona Inti	Core zone	NTA	2018	2020	
Maluku	**LEASE**	Akoon	**LN05**	yes	yes	NA	Subzona Pemanfaatan Tradisional	Fishing zone	TA	2018	2020	
Maluku	**LEASE**	Ameth	**LN06**	yes	yes	NA	Subzona Pariwisata	Tourism zone	NTA	2018	2020	
Maluku	**LEASE**	Porto Hutan	**LS01**	yes	no	NA	Subzona Perikanan Tangkap	Fishing zone	TA	2018	NA	
Maluku	**LEASE**	Kulur	**LS02**	yes	yes	NA	Subzona Perikanan Tangkap	Fishing zone	TA	2018	2020	
Maluku	**LEASE**	Porto Teluk	**LS03**	yes	no	NA	Subzona Perikanan Tangkap	Fishing zone	TA	2018	NA	

PROVINCE	MPA	SITE-ID	SITE_NAME	T0	T1	T2	ZONE (Indonesia)	ZONE (English)	NTA/TA	YEAR (T0)	YEAR (T1)	YEAR (T2)
Maluku	**LEASE**	Kali Titawai	**LS05**	yes	no	NA	Subzona Perikanan Tangkap	Fishing zone	TA	2018	NA	
Maluku	**LEASE**	Pia	**LS04**	yes	yes	NA	Subzona Perikanan Tangkap	Fishing zone	TA	2018	2020	
Maluku	**LEASE**	Ihamahu	**LS06**	yes	yes	NA	Subzona Perikanan Tangkap	Fishing zone	TA	2018	2020	
Maluku	**LEASE**	Noloth	**LS07**	yes	yes	NA	Subzona Pariwisata	Tourism zone	NTA	2018	2020	
Maluku	**LEASE**	Ittawaka	**LS08**	yes	yes	NA	Subzona Pariwisata	Tourism zone	NTA	2018	2020	
Maluku	**LEASE**	Tanjung Ouw	**LS09**	yes	yes	NA	Subzona Perikanan Tangkap	Fishing zone	TA	2018	2020	
Maluku	**LEASE**	Ouw	**LS010**	yes	no	NA	Subzona Perikanan Tangkap	Fishing zone	TA	2018	NA	
Maluku	**LEASE**	Siri Sori Serani	**LS011**	yes	no	NA	Subzona Perikanan Tangkap	Fishing zone	TA	2018	NA	
Maluku	**LEASE**	Booi	**LS012**	yes	yes	NA	Subzona Pariwisata	Tourism zone	NTA	2018	2020	
Maluku	**LEASE**	Haria Pantai	**LS013**	yes	yes	NA	Subzona Perikanan Tangkap	Fishing zone	TA	2018	2020	
Maluku	**SERUTBAR**	TSW01	**TSW01**	yes	yes	NA	Control	Control	Control	2017	2020	
Maluku	**SERUTBAR**	TSW03	**TSW03**	yes	yes	NA	Control	Control	Control	2017	2020	
Maluku	**SERUTBAR**	TSW06	**TSW06**	yes	no	NA	Subzona Perikanan Tradisional	Fishing zone	TA	2017	NA	
Maluku	**SERUTBAR**	TSW07	**TSW07**	yes	yes	NA	Subzona Perikanan Tradisional	Fishing zone	TA	2017	2020	
Maluku	**SERUTBAR**	TSW08	**TSW08**	yes	yes	NA	Subzona Perikanan Tradisional	Fishing zone	TA	2017	2020	
Maluku	**SERUTBAR**	TSW09	**TSW09**	yes	yes	NA	Zona Inti	Core zone	NTA	2017	2020	
Maluku	**SERUTBAR**	TSW10	**TSW10**	yes	yes	NA	Subzona Perikanan Tradisional	Fishing zone	TA	2017	2020	
Maluku	**SERUTBAR**	TSW11	**TSW11**	yes	yes	NA	Subzona Perikanan Tradisional	Fishing zone	TA	2017	2020	
Maluku	**SERUTBAR**	TSW12	**TSW12**	yes	yes	NA	Subzona Pariwisata	Tourism zone	NTA	2017	2020	
Maluku	**SERUTBAR**	TSW13	**TSW13**	yes	no	NA	Subzona Pariwisata	Tourism zone	NTA	2017	NA	
Maluku	**SERUTBAR**	TSW14	**TSW14**	yes	yes	NA	Subzona Perikanan Tradisional	Fishing zone	TA	2017	2020	
Maluku	**SERUTBAR**	TSW15	**TSW15**	yes	no	NA	Subzona Perikanan Tradisional	Fishing zone	TA	2017	NA	
Maluku	**SERUTBAR**	TSW16	**TSW16**	yes	yes	NA	Subzona Perikanan Tradisional	Fishing zone	TA	2017	2020	
Maluku	**SERUTBAR**	TSW18	**TSW18**	yes	yes	NA	Subzona Perikanan Tradisional	Fishing zone	TA	2017	2020	
Maluku	**SERUTBAR**	TSW19	**TSW19**	yes	yes	NA	Subzona Pariwisata	Tourism zone	NTA	2017	2020	
Maluku	**SERUTBAR**	TSW20	**TSW20**	yes	yes	NA	Subzona Rehabilitasi	Rehabilitation zone	TA	2017	2020	

PROVINCE	MPA	SITE-ID	SITE_NAME	T0	T1	T2	ZONE (Indonesia)	ZONE (English)	NTA/TA	YEAR (T0)	YEAR (T1)	YEAR (T2)
Maluku	**SERUTBAR**	TSW21	**TSW21**	yes	yes	NA	Subzona Rehabilitasi	Rehabilitation zone	TA	2017	2020	
Maluku	**SERUTBAR**	TSW22	**TSW22**	yes	yes	NA	Zona Inti	Core zone	NTA	2017	2020	
Maluku	**SERUTBAR**	TSW23	**TSW23**	yes	yes	NA	Subzona Perikanan Tradisional	Fishing zone	TA	2017	2020	
Maluku	**SERUTBAR**	TSW24	**TSW24**	yes	yes	NA	Subzona Perikanan Tradisional	Fishing zone	TA	2017	2020	
Maluku	**SERUTBAR**	TSW25	**TSW25**	yes	yes	NA	Zona Inti	Core zone	NTA	2017	2020	
Maluku	**SERUTBAR**	TSW31	**TSW31**	yes	yes	NA	Subzona Perikanan Tradisional	Fishing zone	TA	2017	2020	
Maluku	**SERUTBAR**	TSW32	**TSW32**	yes	yes	NA	Zona Inti	Core zone	NTA	2017	2020	
Maluku	**SERUTBAR**	TSW33	**TSW33**	yes	yes	NA	Subzona Perikanan Tradisional	Fishing zone	TA	2017	2020	
Maluku	**SERUTBAR**	TSW34	**TSW34**	yes	yes	NA	Control	Control	Control	2017	2020	
North Maluku	**GURAICI**	Dorolamo	**GUR1**	yes	no	NA	Zona Inti	Core zone	NTA	2017	NA	
North Maluku	**GURAICI**	Gafi	**GUR2**	yes	no	NA	Subzona Penangkapan Ikan	Fishing zone	TA	2017	NA	
North Maluku	**GURAICI**	Gunange	**GUR3**	yes	yes	NA	Zona Inti	Core zone	NTA	2017	2020	
North Maluku	**GURAICI**	Guraici	**GUR4**	yes	yes	NA	Subzona Penangkapan Ikan	Fishing zone	TA	2017	2020	
North Maluku	**GURAICI**	Legoma	**GUR5**	yes	yes	NA	Zona Inti	Core zone	NTA	2017	2020	
North Maluku	**GURAICI**	Lelei	**GUR6**	yes	yes	NA	Subzona Pariwisata Alam Perairan	Tourism zone	NTA	2017	2020	
North Maluku	**GURAICI**	Lepa	**GUR7**	yes	no	NA	Zona Inti	Core zone	NTA	2017	NA	
North Maluku	**GURAICI**	South taneti	**GUR8**	yes	yes	NA	Subzona Penangkapan Ikan	Fishing zone	TA	2017	2020	
North Maluku	**GURAICI**	Tamako	**GUR9**	yes	yes	NA	Subzona Penangkapan Ikan	Fishing zone	TA	2017	2020	
North Maluku	**GURAICI**	Taneti 1	**GUR10**	yes	yes	NA	Subzona Penangkapan Ikan	Fishing zone	TA	2017	2020	
North Maluku	**GURAICI**	Taneti 2	**GUR11**	yes	yes	NA	Zona Inti	Core zone	NTA	2017	2020	
North Maluku	**GURAICI**	Tanjung Lepa	**GUR12**	yes	yes	NA	Zona Inti	Core zone	NTA	2017	2020	
North Maluku	**GURAICI**	Tanjung Marikoko	**GUR13**	yes	yes	NA	Subzona Penangkapan Ikan	Fishing zone	TA	2017	2020	
North Maluku	**GURAICI**	West taneti	**GUR14**	yes	yes	NA	Zona Inti	Core zone	NTA	2017	2020	
North Maluku	**GURAICI**	Miskin	**GUR15**	yes	yes	NA	Control	Control	Control	2017	2020	
North Maluku	**GURAICI**	Tanjung Modayama	**GUR16**	yes	yes	NA	Control	Control	Control	2017	2020	
North Maluku	**GURAICI**	Sagawele	**GUR17**	yes	yes	NA	Control	Control	Control	2017	2020	

PROVINCE	MPA	SITE-ID	SITE_NAME	T0	T1	T2	ZONE (Indonesia)	ZONE (English)	NTA/TA	YEAR (T0)	YEAR (T1)	YEAR (T2)
North Maluku	GURAICI	Inti Gafi	GUR18	no	yes	NA	Zona Inti	Core zone	NTA	NA	2020	
North Maluku	GURAICI	Inti Siko	GUR19	no	yes	NA	Zona Inti	Core zone	NTA	NA	2020	
North Maluku	GURAICI	Joronga	GUR20	no	yes	NA	Subzona Budidaya	Aquaculture zone	NTA	NA	2020	
North Maluku	GURAICI	Pulau Kelo	GUR21	no	yes	NA	Subzona Budidaya	Aquaculture zone	NTA	NA	2020	
North Maluku	GURAICI	Pulau Rajawali	GUR22	no	yes	NA	Subzona Pariwisata Alam Perairan	Tourism zone	NTA	NA	2020	
North Maluku	GURAICI	Shark Point	GUR23	no	yes	NA	Zona Inti	Core zone	NTA	NA	2020	
North Maluku	GURAICI	Temo Madofa	GUR24	no	yes	NA	Subzona Budidaya	Aquaculture zone	NTA	NA	2020	
North Maluku	MAKIAN-MOTI	Timur Laut Moti	MOT1	yes	no	NA	Control	Control	Control	2019	NA	
North Maluku	MAKIAN-MOTI	Timur Moti	MOT2	yes	no	NA	Control	Control	Control	2019	NA	
North Maluku	MAKIAN-MOTI	Selatan Moti	MOT3	yes	no	NA	Control	Control	Control	2019	NA	
North Maluku	MAKIAN-MOTI	Barat Daya Moti	MOT4	yes	no	NA	Control	Control	Control	2019	NA	
North Maluku	MAKIAN-MOTI	Barat Moti	MOT5	yes	no	NA	Zona Inti	Core zone	NTA	2019	NA	
North Maluku	MAKIAN-MOTI	Timur Makian	MAK6	yes	no	NA	Control	Control	Control	2019	NA	
North Maluku	MAKIAN-MOTI	Tenggara Makian	MAK7	yes	no	NA	Control	Control	Control	2019	NA	
North Maluku	MAKIAN-MOTI	Selatan Makian	MAK8	yes	no	NA	Control	Control	Control	2019	NA	
North Maluku	MAKIAN-MOTI	Timur Laut Makian	MAK9	yes	no	NA	Control	Control	Control	2019	NA	
North Maluku	MAKIAN-MOTI	Barat Daya Makian	MAK10	yes	no	NA	Zona Inti	Core zone	NTA	2019	NA	
North Maluku	MAKIAN-MOTI	Barat Laut Makian	MAK11	yes	no	NA	Zona Inti	Core zone	NTA	2019	NA	
North Maluku	MAKIAN-MOTI	Utara Makian	MAK12	yes	no	NA	Subzona Penangkapan Ikan	Fishing zone	TA	2019	NA	
North Maluku	MAKIAN-MOTI	Makian 10	MAK13	no	yes*	NA	Zona Inti	Core zone	NTA	NA	NA	
North Maluku	MARE	Dokiri	MAR1	yes	yes	NA	Control	Control	Control	2017	2020	
North Maluku	MARE	Tomalou	MAR2	yes	yes	NA	Control	Control	Control	2017	2020	
North Maluku	MARE	Tunguwai	MAR3	yes	yes	NA	Control	Control	Control	2017	2020	
North Maluku	MARE	Marekofo	MAR4	yes	no	NA	Subzona Penangkapan Ikan	Fishing zone	TA	2017	NA	
North Maluku	MARE	West Mare	MAR5	yes	yes	NA	Zona Inti	Core zone	NTA	2017	2020	
North Maluku	MARE	West Mare 2	MAR6	yes	yes	NA	Subzona Penangkapan Ikan	Fishing zone	TA	2017	2020	

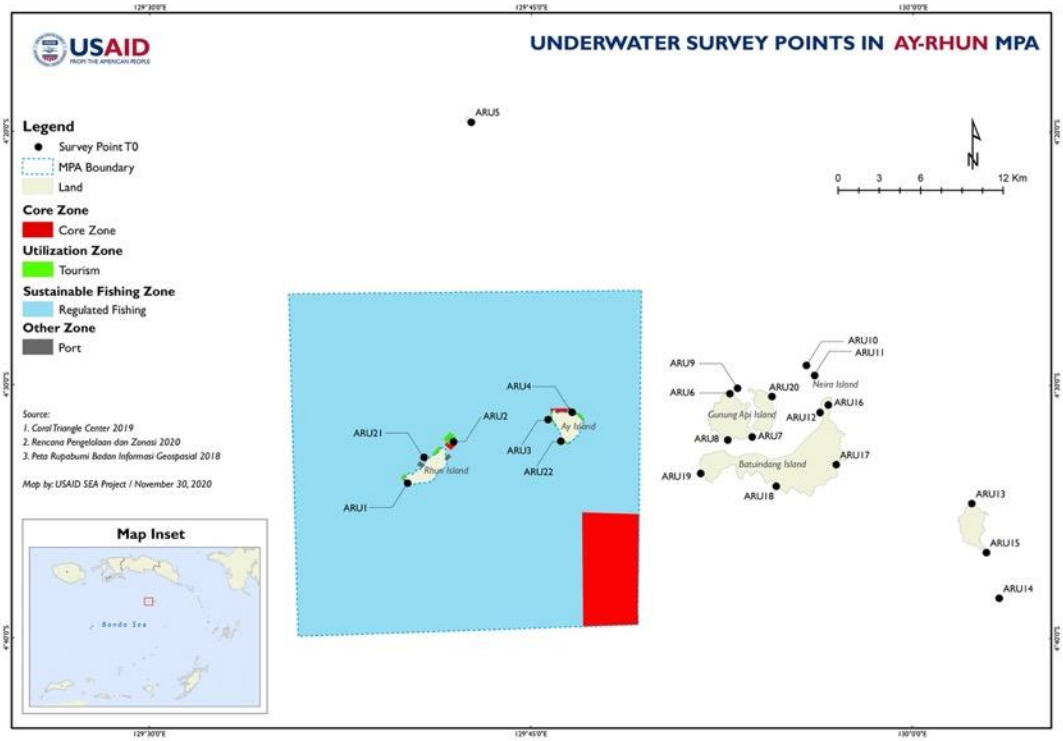
PROVINCE	MPA	SITE-ID	SITE_NAME	T0	T1	T2	ZONE (Indonesia)	ZONE (English)	NTA/TA	YEAR (T0)	YEAR (T1)	YEAR (T2)
North Maluku	**MARE**	East Mare	**MAR7**	yes	yes	NA	Subzona Rehabilitasi	Rehabilitation zone	NTA	2017	2020	
North Maluku	**MARE**	North Mare	**MAR8**	yes	yes	NA	Subzona Pariwisata Alam Perairan	Tourism zone	NTA	2017	2020	
North Maluku	**MARE**	South Mare	**MAR9**	yes	yes	NA	Subzona Penangkapan Ikan	Fishing zone	TA	2017	2020	
North Maluku	**MARE**	Batu Nona	**MAR10**	yes	yes	NA	Zona Inti	Core zone	NTA	2017	2020	
North Maluku	**MARE**	Maregam	**MAR11**	yes	yes	NA	Subzona Rehabilitasi	Rehabilitation zone	NTA	2017	2020	
North Maluku	**MARE**	Marekofo-T1	**MAR15**	no	yes	NA	Zona Inti	Core zone	NTA	NA	2020	
North Maluku	**MARE**	Site 10	**MAR12**	no	yes	NA	Sub Zona Pariwisata Alam Perairan	Tourism zone	NTA	NA	2020	
North Maluku	**MARE**	Site 11	**MAR13**	no	yes	NA	Zona Inti	Core zone	NTA	NA	2020	
North Maluku	**MARE**	Site 8	**MAR14**	no	yes	NA	Subzona Penangkapan Ikan	Fishing zone	TA	NA	2020	
North Maluku	**RAO-DEHEGILA**	Mitita Selatan	**RAO1**	yes	yes	NA	Subzona Pariwisata Alam Perairan	Tourism zone	NTA	2017	2020	
North Maluku	**RAO-DEHEGILA**	Mitita Utara	**RAO2**	yes	no	NA	Control	Control	Control	2017	NA	
North Maluku	**RAO-DEHEGILA**	Kokoya	**RAO3**	yes	yes	NA	Subzona Penangkapan Ikan	Fishing zone	TA	2017	2020	
North Maluku	**RAO-DEHEGILA**	Kolorai Selatan	**RAO4**	yes	no	NA	Subzona Penangkapan Ikan	Fishing zone	TA	2017	NA	
North Maluku	**RAO-DEHEGILA**	Kolorai Barat	**RAO5**	yes	yes	NA	Subzona Penangkapan Ikan	Fishing zone	TA	2017	2020	
North Maluku	**RAO-DEHEGILA**	Kolorai Barat Daya	**RAO6**	yes	no	NA	Subzona Penangkapan Ikan	Fishing zone	TA	2017	NA	
North Maluku	**RAO-DEHEGILA**	Dodola Selatan	**RAO7**	yes	yes	NA	Subzona Pariwisata Alam Perairan	Tourism zone	NTA	2017	2020	
North Maluku	**RAO-DEHEGILA**	Dodola Utara	**RAO8**	yes	no	NA	Subzona Penangkapan Ikan	Fishing zone	TA	2017	NA	
North Maluku	**RAO-DEHEGILA**	Zum-Zum	**RAO9**	yes	yes	NA	Subzona Pariwisata Alam Perairan	Tourism zone	NTA	2017	2020	
North Maluku	**RAO-DEHEGILA**	Kapa-Kapa	**RAO10**	yes	yes	NA	Zona Inti	Core zone	NTA	2017	2020	
North Maluku	**RAO-DEHEGILA**	Juanga	**RAO11**	yes	no	NA	Subzona Penangkapan Ikan	Fishing zone	TA	2017	NA	
North Maluku	**RAO-DEHEGILA**	Tanjung Dehegila	**RAO12**	yes	no	NA	Subzona Penangkapan Ikan	Fishing zone	TA	2017	NA	
North Maluku	**RAO-DEHEGILA**	Gosong Ngele-Ngele Besar	**RAO13**	yes	no	NA	Subzona Penangkapan Ikan	Fishing zone	TA	2017	NA	
North Maluku	**RAO-DEHEGILA**	Ngele-Ngele Besar	**RAO14**	yes	no	NA	Subzona Penangkapan Ikan	Fishing zone	TA	2017	NA	
North Maluku	**RAO-DEHEGILA**	Ngele-Ngele Kecil	**RAO15**	yes	no	NA	Subzona Penangkapan Ikan	Fishing zone	TA	2017	NA	
North Maluku	**RAO-DEHEGILA**	Galo-Galo Kecil	**RAO16**	yes	yes	NA	Subzona Penangkapan Ikan	Fishing zone	TA	2017	2020	
North Maluku	**RAO-DEHEGILA**	Loleba Besar	**RAO17**	yes	no	NA	Subzona Pariwisata Alam Perairan	Tourism zone	NTA	2017	NA	

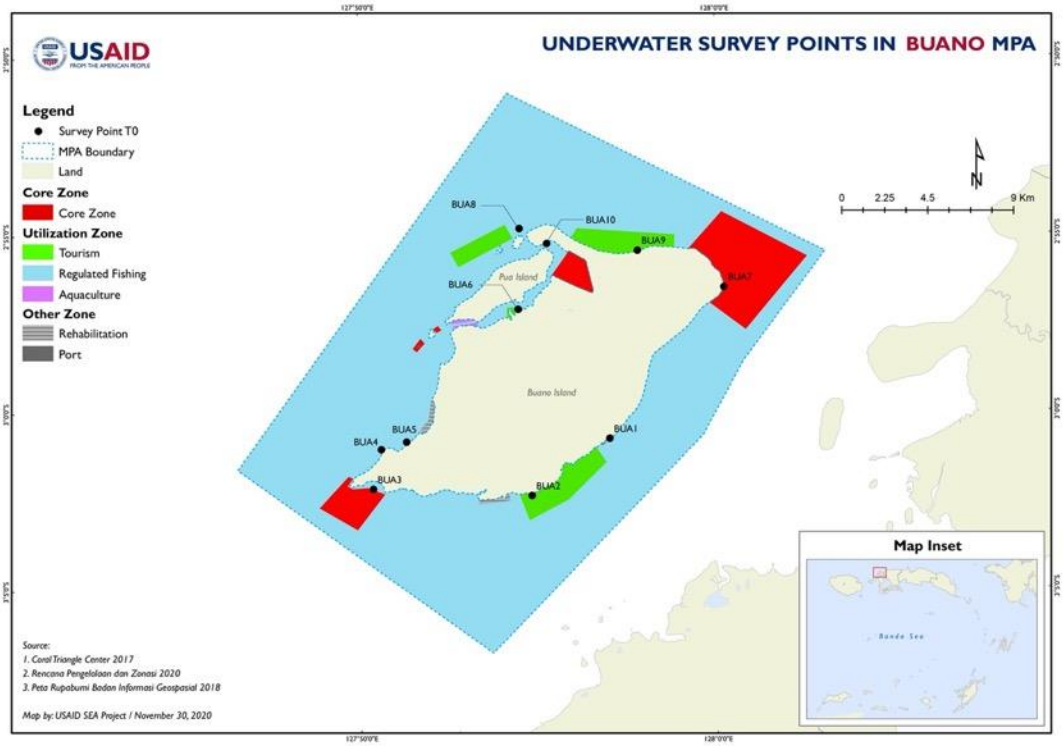
PROVINCE	MPA	SITE-ID	SITE_NAME	T0	T1	T2	ZONE (Indonesia)	ZONE (English)	NTA/TA	YEAR (T0)	YEAR (T1)	YEAR (T2)
North Maluku	RAO-DEHEGILA	Loleba Kecil	RAO18	yes	no	NA	Subzona Penangkapan Ikan	Fishing zone	TA	2017	NA	
North Maluku	RAO-DEHEGILA	Aru Burung	RAO19	yes	yes	NA	Subzona Penangkapan Ikan	Fishing zone	TA	2017	2020	
North Maluku	RAO-DEHEGILA	Posi-Posi	RAO20	yes	yes	NA	Subzona Penangkapan Ikan	Fishing zone	TA	2017	2020	
North Maluku	RAO-DEHEGILA	Saminyamau	RAO21	yes	yes	NA	Subzona Penangkapan Ikan	Fishing zone	TA	2017	2020	
North Maluku	RAO-DEHEGILA	Laumodoro	RAO22	yes	yes	NA	Zona Inti	Core zone	NTA	2017	2020	
North Maluku	RAO-DEHEGILA	Leo-Leo	RAO23	yes	yes	NA	Subzona Penangkapan Ikan	Fishing zone	TA	2017	2020	
North Maluku	RAO-DEHEGILA	Leo-Leo 2	RAO24	yes	no	NA	Subzona Penangkapan Ikan	Fishing zone	TA	2017	NA	
North Maluku	RAO-DEHEGILA	Gosong Wayabula	RAO25	yes	no	NA	Subzona Penangkapan Ikan	Fishing zone	TA	2017	NA	
North Maluku	RAO-DEHEGILA	Kontrol Joubela	RAO26	no	yes	NA	Control	Control	Control	NA	2020	
North Maluku	RAO-DEHEGILA	Kontrol Momojiu	RAO27	no	yes	NA	Control	Control	Control	NA	2020	
North Maluku	RAO-DEHEGILA	Kontrol Totodoku	RAO28	no	yes	NA	Control	Control	Control	NA	2020	
North Maluku	RAO-DEHEGILA	Leo-Leo2	RAO29	no	yes	NA	Subzona Penangkapan Ikan	Fishing zone	TA	NA	2020	
North Maluku	RAO-DEHEGILA	Site 10	RAO30	no	yes	NA	Subzona Penangkapan Ikan	Fishing zone	TA	NA	2020	
North Maluku	RAO-DEHEGILA	Site 11 Ngele-Ngele Besar S	RAO31	no	yes	NA	Subzona Penangkapan Ikan	Fishing zone	TA	NA	2020	
North Maluku	RAO-DEHEGILA	Site 12	RAO32	no	yes	NA	Subzona Penangkapan Ikan	Fishing zone	TA	NA	2020	
North Maluku	RAO-DEHEGILA	Site 19	RAO33	no	yes	NA	Subzona Perlindungan Mamalia Laut	Marine mammals conservation zone	TA	NA	2020	
North Maluku	RAO-DEHEGILA	Site 7	RAO34	no	yes	NA	Zona Inti	Core zone	NTA	NA	2020	
North Maluku	RAO-DEHEGILA	Site 8 Raja	RAO35	no	yes	NA	Zona Inti	Core zone	NTA	NA	2020	
North Maluku	RAO-DEHEGILA	Site 9 W Ngele-Ngele	RAO36	no	yes	NA	Zona Inti	Core zone	NTA	NA	2020	
North Maluku	SULA	Kiamasol	SUL1	yes	yes	NA	Subzona Pariwisata	Tourism zone	NTA	2017	2020	
North Maluku	SULA	Waisum	SUL2	yes	yes	NA	Subzona Perikanan Berkelanjutan	Fishing zone	TA	2017	2020	
North Maluku	SULA	Lifmatola Kecil	SUL3	yes	no	NA	Subzona Perikanan Berkelanjutan	Fishing zone	TA	2017	NA	
North Maluku	SULA	Lifmatola Penyu	SUL4	yes	yes	NA	Zona Inti	Core zone	NTA	2017	2020	
North Maluku	SULA	Lifmatola Selatan	SUL5	yes	yes	NA	Subzona Perikanan Berkelanjutan	Fishing zone	TA	2017	2020	
North Maluku	SULA	Lifmatola Selat	SUL6	yes	no	NA	Subzona Pariwisata	Tourism zone	NTA	2017	NA	
North Maluku	SULA	Pagama	SUL7	yes	yes	NA	Subzona Pariwisata	Tourism zone	NTA	2017	2020	

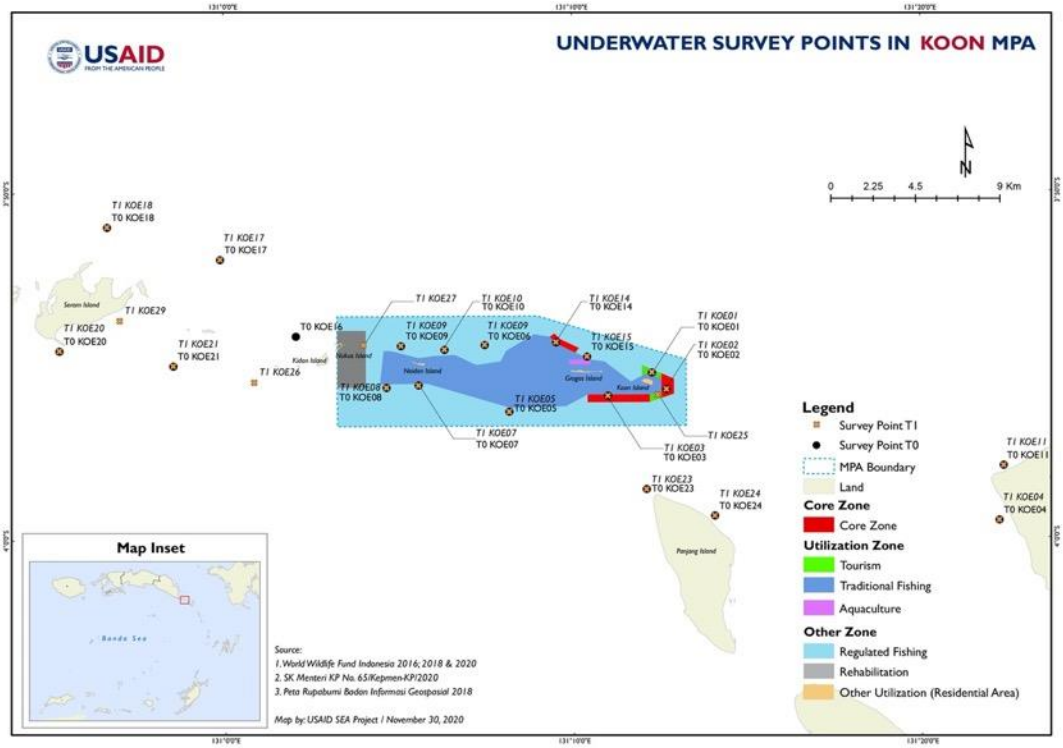
PROVINCE	MPA	SITE-ID	SITE_NAME	T0	T1	T2	ZONE (Indonesia)	ZONE (English)	NTA/TA	YEAR (T0)	YEAR (T1)	YEAR (T2)
North Maluku	**SULA**	Fatpinakoa	**SUL8**	yes	no	NA	Subzona Perikanan Berkelanjutan	Fishing zone	TA	2017	NA	
North Maluku	**SULA**	Kampung Bajo	**SUL9**	yes	no	NA	Control	Control	Control	2017	NA	
North Maluku	**SULA**	Swering	**SUL10**	yes	no	NA	Control	Control	Control	2017	NA	
North Maluku	**SULA**	Fatkauyon	**SUL11**	yes	no	NA	Subzona Perikanan Berkelanjutan	Fishing zone	TA	2017	NA	
North Maluku	**SULA**	Tanjung Waka	**SUL12**	yes	no	NA	Subzona Perikanan Berkelanjutan	Fishing zone	TA	2017	NA	
North Maluku	**SULA**	Fatmok	**SUL13**	yes	no	NA	Subzona Perikanan Berkelanjutan	Fishing zone	TA	2017	NA	
North Maluku	**SULA**	Batu Kuning	**SUL14**	no	yes	NA	Zona Inti	Core zone	NTA	NA	2020	
North Maluku	**SULA**	Tanjung Waka-T1	**SUL15**	no	yes	NA	Zona Inti	Core zone	NTA	NA	2020	
North Maluku	**SULA**	Fat Dona Dona	**SUL16**	no	yes	NA	Subzona Perikanan Berkelanjutan	Fishing zone	TA	NA	2020	
North Maluku	**SULA**	Fatmok-T1	**SUL18**	no	yes	NA	Subzona Pariwisata	Tourism zone	TA	NA	2020	
North Maluku	**SULA**	Desa Sama	**SUL17**	no	yes	NA	Subzona Perikanan Berkelanjutan	Fishing zone	TA	NA	2020	
North Maluku	**SULA**	Fatpinakoa-T1	**SUL19**	no	yes	NA	Subzona Pariwisata	Tourism zone	TA	NA	2020	
North Maluku	**WIDI**	Dadawe Gane	**WID1**	yes	yes	NA	Subzona Pariwisata Alam Perairan	Tourism zone	NTA	2017	2020	
North Maluku	**WIDI**	Dadawe Weda	**WID2**	yes	yes	NA	Zona Inti	Core zone	NTA	2017	2020	
North Maluku	**WIDI**	Daga	**WID3**	yes	yes	NA	Subzona Pariwisata Alam Perairan	Tourism zone	NTA	2017	2020	
North Maluku	**WIDI**	Gembira	**WID4**	yes	yes	NA	Subzona Penangkapan Ikan	Fishing zone	TA	2017	2020	
North Maluku	**WIDI**	Kokota	**WID5**	yes	yes	NA	Subzona Pariwisata Alam Perairan	Tourism zone	NTA	2017	2020	
North Maluku	**WIDI**	Ngafit	**WID6**	yes	yes	NA	Zona Inti	Core zone	NTA	2017	2020	
North Maluku	**WIDI**	Hilang	**WID7**	yes	yes	NA	Subzona Pariwisata Alam Perairan	Tourism zone	NTA	2017	2020	
North Maluku	**WIDI**	Morota	**WID8**	yes	yes	NA	Subzona Penangkapan Ikan	Fishing zone	TA	2017	2020	
North Maluku	**WIDI**	Sukar	**WID9**	yes	yes	NA	Zona Inti	Core zone	NTA	2017	2020	
North Maluku	**WIDI**	Kapuraca	**WID11**	yes	yes	NA	Zona Inti	Core zone	NTA	2017	2020	
North Maluku	**WIDI**	Baku-Boku	**WID12**	no	yes	NA	Subzona Penangkapan Ikan	Fishing zone	TA	NA	2020	
North Maluku	**WIDI**	Baracuda Point	**WID13**	no	yes	NA	Zona Inti	Core zone	NTA	NA	2020	
North Maluku	**WIDI**	Boku-Boku	**WID10**	yes	no	NA	Subzona Penangkapan Ikan	Fishing zone	TA	2017	NA	
North Maluku	**WIDI**	Kontrol Foya	**WID14**	no	yes	NA	Control	Control	Control	NA	2020	

PROVINCE	MPA	SITE-ID	SITE_NAME	T0	T1	T2	ZONE (Indonesia)	ZONE (English)	NTA/TA	YEAR (T0)	YEAR (T1)	YEAR (T2)
North Maluku	**WIDI**	Kontrol Maffa	**WID15**	no	yes	NA	Control	Control	Control	NA	2020	
North Maluku	**WIDI**	Kontrol Waimili	**WID16**	no	yes	NA	Control	Control	Control	NA	2020	
West Papua	**BERAU BAY**	Neksumar	**BER1**	yes	no	NA	Subzona Kerakera (Sasi)	Open-close fishing zone	TA	2018	NA	
West Papua	**BERAU BAY**	P Faraiboban	**BER2**	yes	no	NA	Subzona Kerakera (Sasi)	Open-close fishing zone	TA	2018	NA	
West Papua	**BERAU BAY**	Kuradam	**BER3**	yes	no	NA	Subzona Perlindungan Pulau Kecil	Coastal	NTA	2018	NA	
West Papua	**BERAU BAY**	Musmanawas	**BER4**	yes	no	NA	Subzona Perikanan Tradisional	Fishing zone	TA	2018	NA	
West Papua	**BERAU BAY**	Musmanawas North	**BER5**	yes	no	NA	Subzona Perlindungan Pulau Kecil	Coastal	NTA	2018	NA	
West Papua	**BERAU BAY**	Giginusa	**BER6**	yes	no	NA	Subzona Perikanan Tradisional	Fishing zone	TA	2018	NA	
West Papua	**BERAU BAY**	Pulau Kambing	**BER7**	yes	no	NA	Subzona Wisata	Tourism zone	NTA	2018	NA	
West Papua	**BERAU BAY**	Ugar East	**BER8**	yes	no	NA	Subzona Wisata	Tourism zone	NTA	2018	NA	
West Papua	**BERAU BAY**	Fuum	**BER9**	yes	no	NA	Subzona Wisata	Tourism zone	NTA	2018	NA	
West Papua	**BERAU BAY**	Kokas West	**BER10**	yes	no	NA	Subzona Wisata	Tourism zone	NTA	2018	NA	
West Papua	**BERAU BAY**	Tanjung Pamali Berau	**BER11**	yes	no	NA	Zona Inti	Core zone	NTA	2018	NA	
West Papua	**BERAU BAY**	Pasir Panjang	**BER12**	yes	no	NA	Subzona Wisata	Tourism zone	NTA	2018	NA	
West Papua	**BERAU BAY**	Sariga East	**BER13**	yes	no	NA	Subzona Kerakera (Sasi)	Open-close fishing zone	TA	2018	NA	
West Papua	**BERAU BAY**	Sariga West	**BER14**	yes	no	NA	Subzona Kerakera (Sasi)	Open-close fishing zone	TA	2018	NA	
West Papua	**NUSALASI BAY**	Reef Tiporat	**NUS15**	yes	no	NA	Subzona Perikanan Tradisional	Fishing zone	TA	2018	NA	
West Papua	**NUSALASI BAY**	Batu Putih	**NUS16**	yes	no	NA	Subzona Perikanan Tradisional	Fishing zone	TA	2018	NA	
West Papua	**NUSALASI BAY**	Reef Sebakor	**NUS17**	yes	no	NA	Subzona Perikanan Tradisional	Fishing zone	TA	2018	NA	
West Papua	**NUSALASI BAY**	Tanjung Tonggerai	**NUS18**	yes	no	NA	Subzona Wisata	Tourism zone	NTA	2018	NA	
West Papua	**NUSALASI BAY**	Tonggerai East	**NUS19**	yes	no	NA	Subzona Wisata	Tourism zone	NTA	2018	NA	
West Papua	**NUSALASI BAY**	Tonggerai West	**NUS20**	yes	no	NA	Subzona Perikanan Tradisional	Fishing zone	TA	2018	NA	
West Papua	**NUSALASI BAY**	Antalisa Utara	**NUS21**	yes	no	NA	Subzona Perikanan Tradisional	Fishing zone	TA	2018	NA	
West Papua	**NUSALASI BAY**	Batu Lubang	**NUS22**	yes	no	NA	Subzona Wisata	Tourism zone	NTA	2018	NA	
West Papua	**NUSALASI BAY**	Sariripuan sanganua	**NUS23**	yes	no	NA	Subzona Kerakera (Sasi)	Open-close fishing zone	TA	2018	NA	
West Papua	**NUSALASI BAY**	Faram	**NUS24**	yes	no	NA	Subzona Kerakera (Sasi)	Open-close fishing zone	TA	2018	NA	

PROVINCE	MPA	SITE-ID	SITE_NAME	T0	T1	T2	ZONE (Indonesia)	ZONE (English)	NTA/TA	YEAR (T0)	YEAR (T1)	YEAR (T2)
West Papua	**NUSALASI BAY**	Keramba Tarak	**NUS25**	yes	no	NA	Subzona Perikanan Tradisional	Fishing zone	TA	2018	NA	
West Papua	**NUSALASI BAY**	Tanjung Tuberwasa	**NUS26**	yes	no	NA	Subzona Perikanan Tradisional	Fishing zone	TA	2018	NA	
West Papua	**NUSALASI BAY**	Air Fatar	**NUS27**	yes	no	NA	Subzona Wisata	Tourism zone	NTA	2018	NA	
West Papua	**NUSALASI BAY**	Tebing Fatar	**NUS28**	yes	no	NA	Subzona Wisata	Tourism zone	NTA	2018	NA	
West Papua	**NUSALASI BAY**	Bardawan	**NUS29**	yes	no	NA	Subzona Perikanan Tradisional	Fishing zone	TA	2018	NA	
West Papua	**NUSALASI BAY**	Ewarong	**NUS30**	yes	no	NA	Subzona Perikanan Tradisional	Fishing zone	TA	2018	NA	
West Papua	**NUSALASI BAY**	Uremun	**NUS31**	yes	no	NA	Subzona Wisata	Tourism zone	NTA	2018	NA	
West Papua	**NUSALASI BAY**	Reef Tengah	**NUS32**	yes	no	NA	Subzona Wisata	Tourism zone	NTA	2015	NA	
West Papua	**NUSALASI BAY**	Buka Karu	**NUS33**	yes	no	NA	Subzona Wisata	Tourism zone	NTA	2015	NA	
West Papua	**NUSALASI BAY**	Damar	**NUS34**	yes	no	NA	Subzona Wisata	Tourism zone	NTA	2015	NA	
West Papua	**NUSALASI BAY**	P. Paniki	**NUS35**	yes	no	NA	Subzona Wisata	Tourism zone	NTA	2015	NA	
West Papua	**NUSALASI BAY**	Reef Panjang	**NUS36**	yes	no	NA	Subzona Wisata	Tourism zone	NTA	2015	NA	
West Papua	**NUSALASI BAY**	Batu Foto	**NUS37**	yes	no	NA	Subzona Wisata	Tourism zone	NTA	2015	NA	
West Papua	**NUSALASI BAY**	Mon-mon	**NUS38**	yes	no	NA	Subzona Wisata	Tourism zone	NTA	2015	NA	
West Papua	**NUSALASI BAY**	Labuan Krosi	**NUS39**	yes	no	NA	Subzona Wisata	Tourism zone	NTA	2015	NA	


USAID
FROM THE AMERICAN PEOPLE
UNDERWATER SURVEY POINTS IN AY-RHUN MPA
Legend
Survey Point T0
MPA Boundary
Land
Core Zone
Core Zone
Utilization Zone
Tourism
Sustainable Fishing Zone
Regulated Fishing
Other Zone
Port
Source:
1. Coral Triangle Center 2019
2. Rencana Pengelolaan dan Zonasi 2020
3. Peta Rupabumi Badan Informasi Geospasial 2018
Map by: USAID SEA Project / November 30, 2020
Map Inset
Banda Sea
N
0 3 6 12 Km
ARU5
ARU4
ARU2
ARU21
ARU3
ARU22
ARU1
Ay Island
Rhun Island
ARU10
ARU11
ARU9
ARU6
ARU20
Neira Island
ARU16
Gunung Api Island
ARU12
ARU8
ARU7
ARU17
Batuindang Island
ARU19
ARU18
ARU13
ARU15
ARU14


USAID
FROM THE AMERICAN PEOPLE
UNDERWATER SURVEY POINTS IN BUANO MPA
Legend
Survey Point T0
MPA Boundary
Land
Core Zone
Core Zone
Utilization Zone
Tourism
Regulated Fishing
Aquaculture
Other Zone
Rehabilitation
Port
Source:
1. Coral Triangle Center 2017
2. Rencana Pengelolaan dan Zonasi 2020
3. Peta Rupabumi Badan Informasi Geospasial 2018
Map by: USAID SEA Project / November 30, 2020
Map Inset
Banda Sea
N
0 2.25 4.5 9 Km
BUA8
BUA10
BUA9
BUA7
BUA6
Pua Island
Buano Island
BUA5
BUA4
BUA1
BUA3
BUA2


USAID
FROM THE AMERICAN PEOPLE
UNDERWATER SURVEY POINTS IN KOON MPA
N
0 2.25 4.5 9 Km
TI KOE18
T0 KOE18
TI KOE17
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TI KOE24
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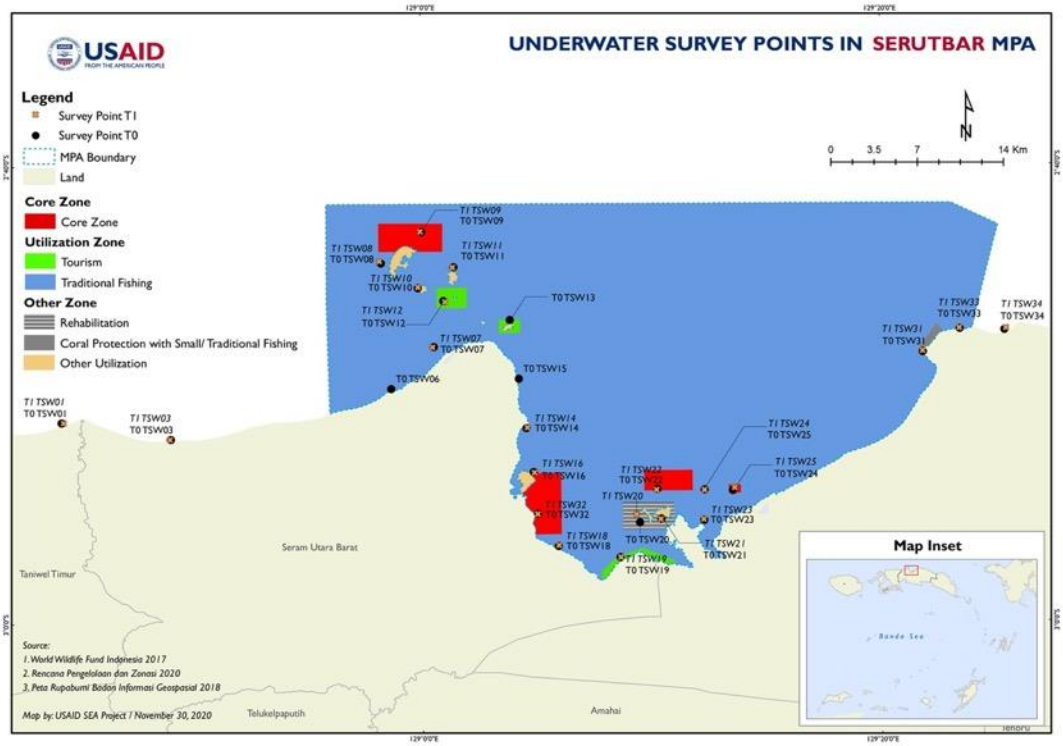
TI KOE11
T0 KOE11
TI KOE04
T0 KOE04
Legend
Survey Point TI
Survey Point T0
MPA Boundary
Land
Core Zone
Core Zone
Utilization Zone
Tourism
Traditional Fishing
Aquaculture
Other Zone
Regulated Fishing
Rehabilitation
Other Utilization (Residential Area)
Map Inset
Source:
1. World Wildlife Fund Indonesia 2016; 2018 & 2020
2. SK Menteri KP No. 65/Kepmen-KP/2020
3. Peta Rupabumi Badan Informasi Geospasial 2018
Map by: USAID SEA Project / November 30, 2020


USAID
FROM THE AMERICAN PEOPLE
UNDERWATER SURVEY POINTS IN SERUTBAR MPA
N
0 3.5 7 14 Km
Legend
Survey Point TI
Survey Point T0
MPA Boundary
Land
Core Zone
Core Zone
Utilization Zone
Tourism
Traditional Fishing
Other Zone
Rehabilitation
Coral Protection with Small/ Traditional Fishing
Other Utilization
TI TSW09
T0 TSW09
TI TSW08
T0 TSW08
TI TSW11
T0 TSW11
TI TSW10
T0 TSW10
T0 TSW13
TI TSW12
T0 TSW12
TI TSW07
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T0 TSW15
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TI TSW14
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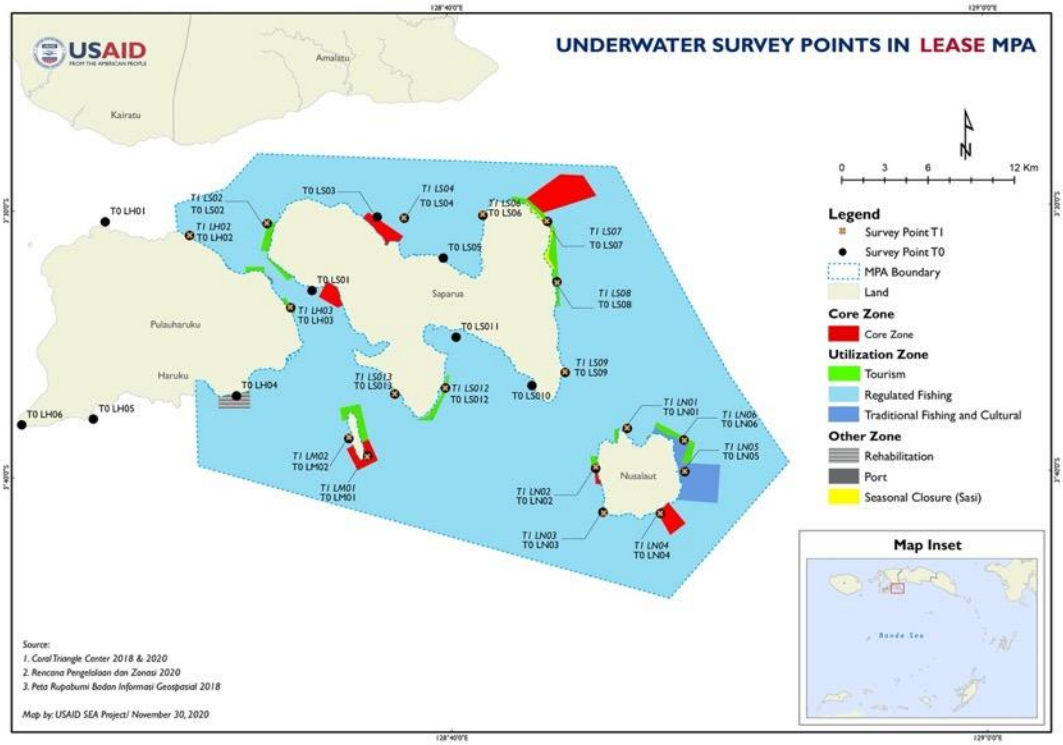
TI TSW34
T0 TSW34
TI TSW31
T0 TSW31
Seram Utara Barat
Taniwel Timur
Telukelpaputih
Amahai
Map Inset
Source:
1. World Wildlife Fund Indonesia 2017
2. Rencana Pengelolaan dan Zonasi 2020
3. Peta Rupabumi Badan Informasi Geospasial 2018
Map by: USAID SEA Project / November 30, 2020


USAID
FROM THE AMERICAN PEOPLE
UNDERWATER SURVEY POINTS IN LEASE MPA
Amalatu
Kairatu
Pulauharuku
Haruku
Saparua
Nusalaut
T0 LH01
T1 LS02
T0 LS02
T1 LH02
T0 LH02
T0 LS03
T1 LS04
T0 LS04
T1 LS06
T0 LS06
T1 LS07
T0 LS07
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T1 LH03
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T0 LS011
T1 LS08
T0 LS08
T1 LS09
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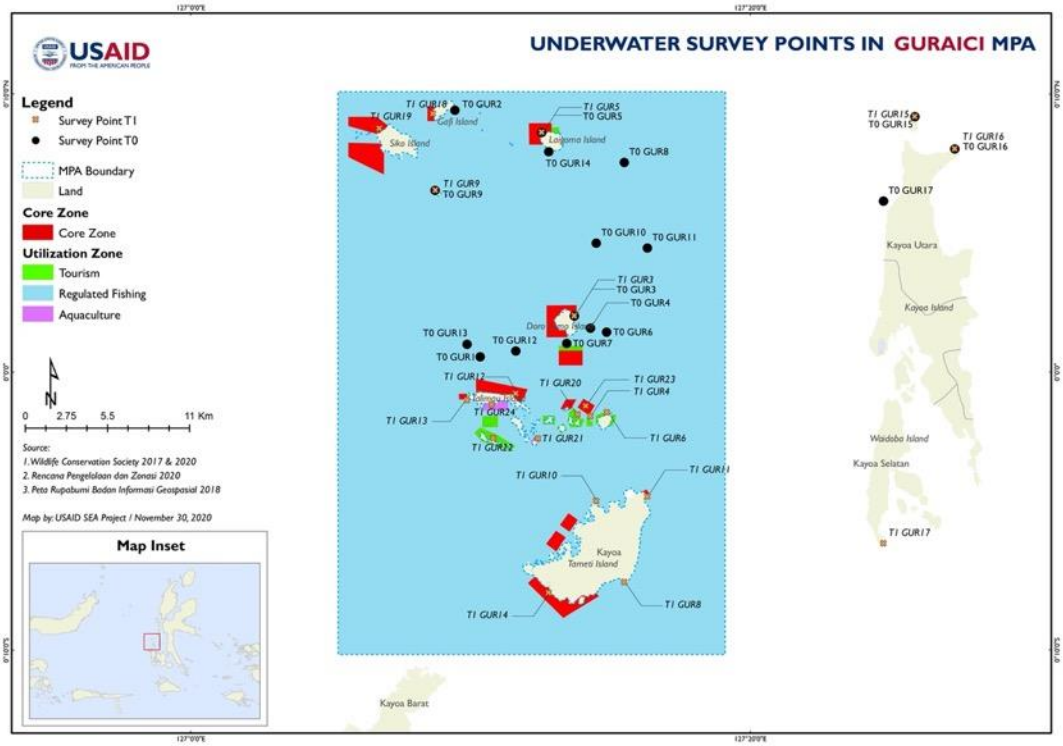
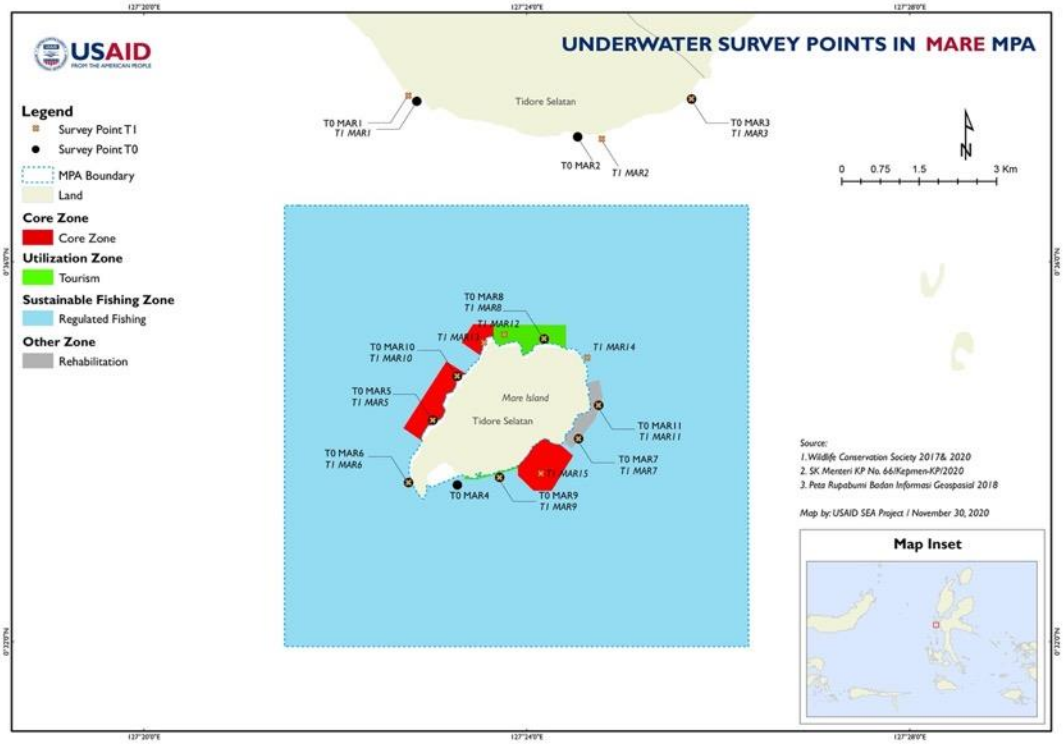
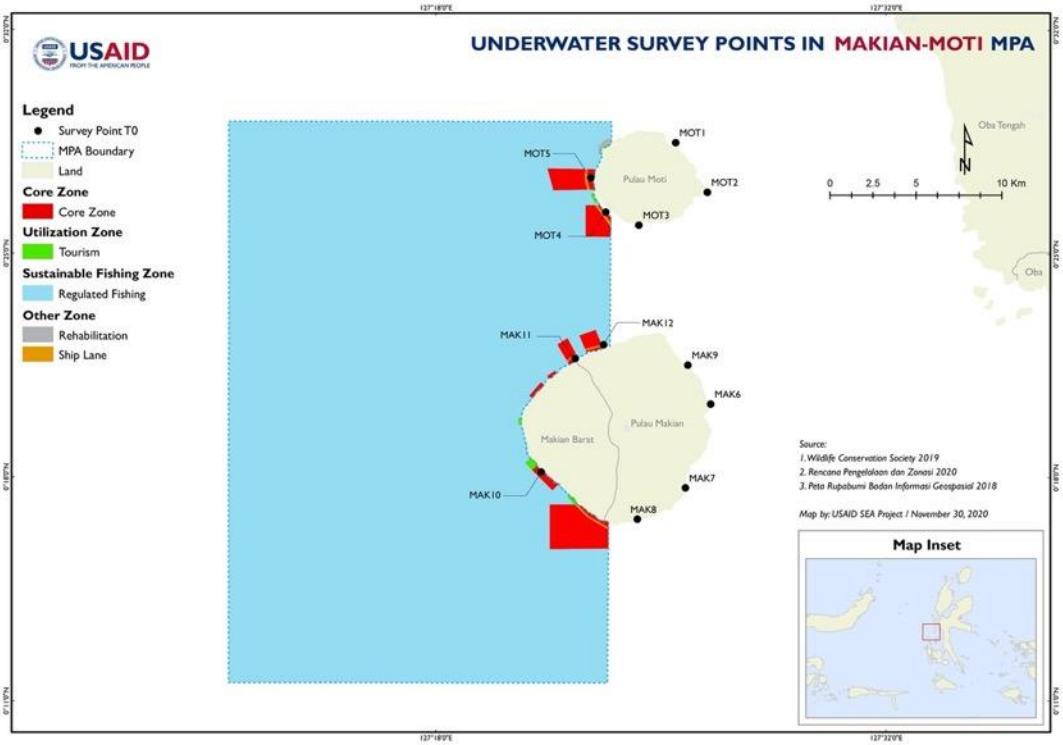
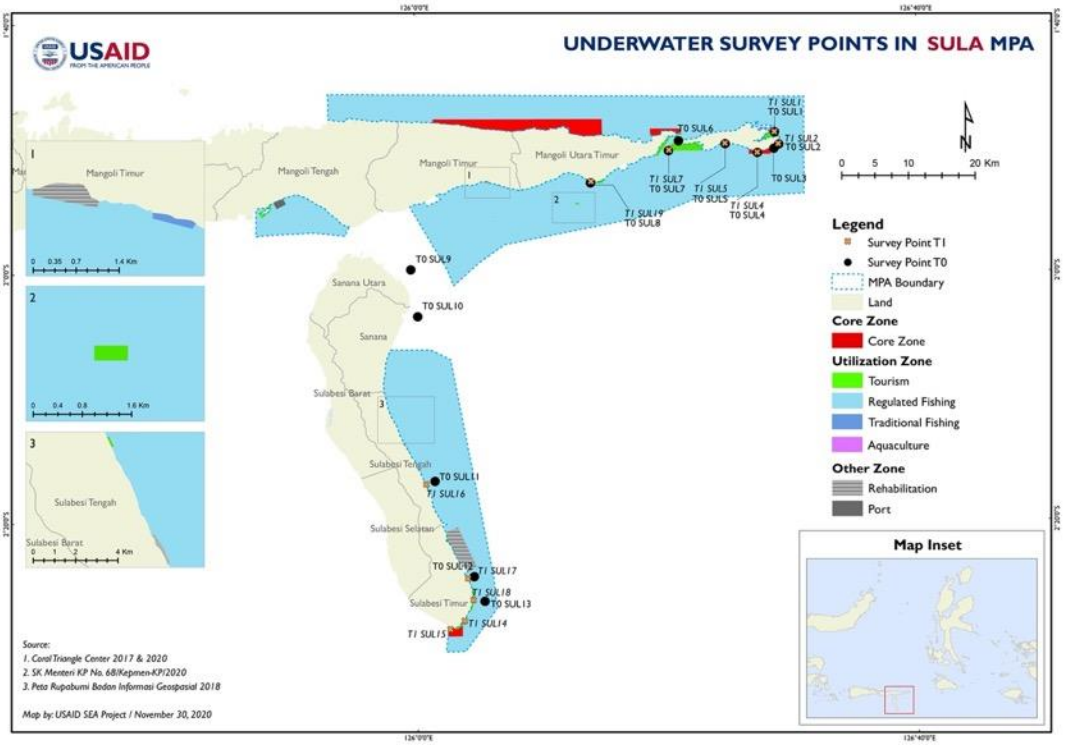
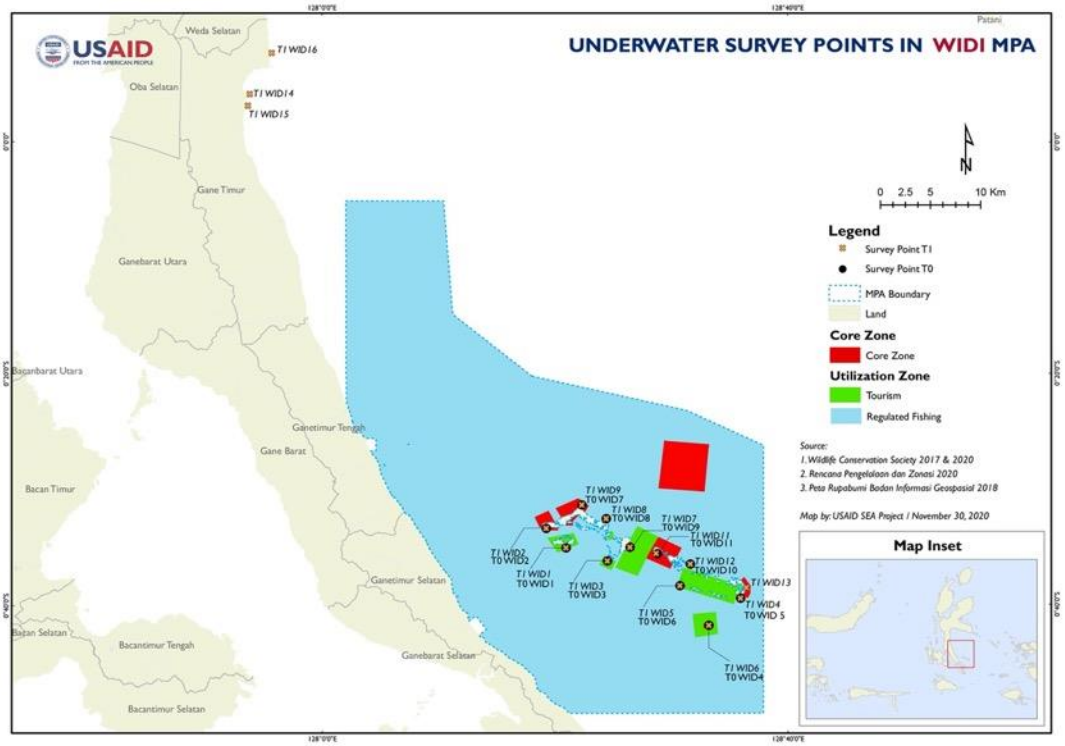
T0 LS010
T1 LS012
T0 LS012
T1 LS013
T0 LS013
T0 LH04
T0 LH06
T0 LH05
T1 LM02
T0 LM02
T1 LM01
T0 LM01
T1 LN01
T0 LN01
T1 LN06
T0 LN06
T1 LN05
T0 LN05
T1 LN02
T0 LN02
T1 LN03
T0 LN03
T1 LN04
T0 LN04
0 3 6 12 Km
Legend
Survey Point T1
Survey Point T0
MPA Boundary
Land
Core Zone
Core Zone
Utilization Zone
Tourism
Regulated Fishing
Traditional Fishing and Cultural
Other Zone
Rehabilitation
Port
Seasonal Closure (Sasi)
Map Inset
Banda Sea
Source:
1. Coral Triangle Center 2018 & 2020
2. Rencana Pengelolaan dan Zonasi 2020
3. Peta Rupabumi Badan Informasi Geospasial 2018
Map by: USAID SEA Project/ November 30, 2020

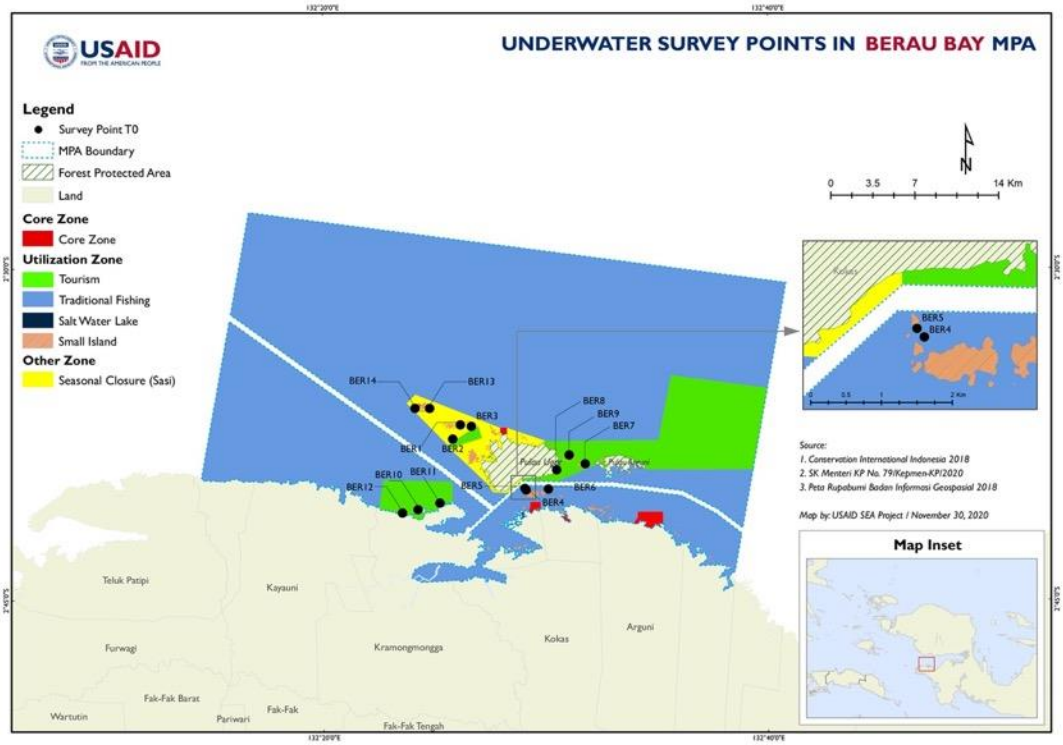

USAID
FROM THE AMERICAN PEOPLE
UNDERWATER SURVEY POINTS IN GURAICI MPA
Legend
Survey Point T1
Survey Point T0
MPA Boundary
Land
Core Zone
Core Zone
Utilization Zone
Tourism
Regulated Fishing
Aquaculture
0 2.75 5.5 11 Km
Source:
1. Wildlife Conservation Society 2017 & 2020
2. Rencana Pengelolaan dan Zonasi 2020
3. Peta Rupabumi Badan Informasi Geospasial 2018
Map by: USAID SEA Project / November 30, 2020
Map Inset
T1 GUR18
T0 GUR2
T1 GUR19
Gefi Island
Sika Island
T1 GUR5
T0 GUR5
Laiama Island
T0 GUR8
T0 GUR14
T1 GUR9
T0 GUR9
T0 GUR10
T0 GUR11
T1 GUR3
T0 GUR3
T0 GUR4
T0 GUR13
T0 GUR12
T0 GUR7
T0 GUR6
T0 GUR1
T1 GUR12
T1 GUR20
T1 GUR23
T1 GUR4
T1 GUR13
T1 GUR24
T1 GUR22
T1 GUR21
T1 GUR6
T1 GUR10
T1 GUR11
Kayoa
Tamesi Island
T1 GUR14
T1 GUR8
Kayoa Barat
T0 GUR15
T1 GUR15
T1 GUR16
T0 GUR16
T0 GUR17
Kayoa Utara
Kayoa Island
Waidoba Island
Kayoa Selatan
T1 GUR17

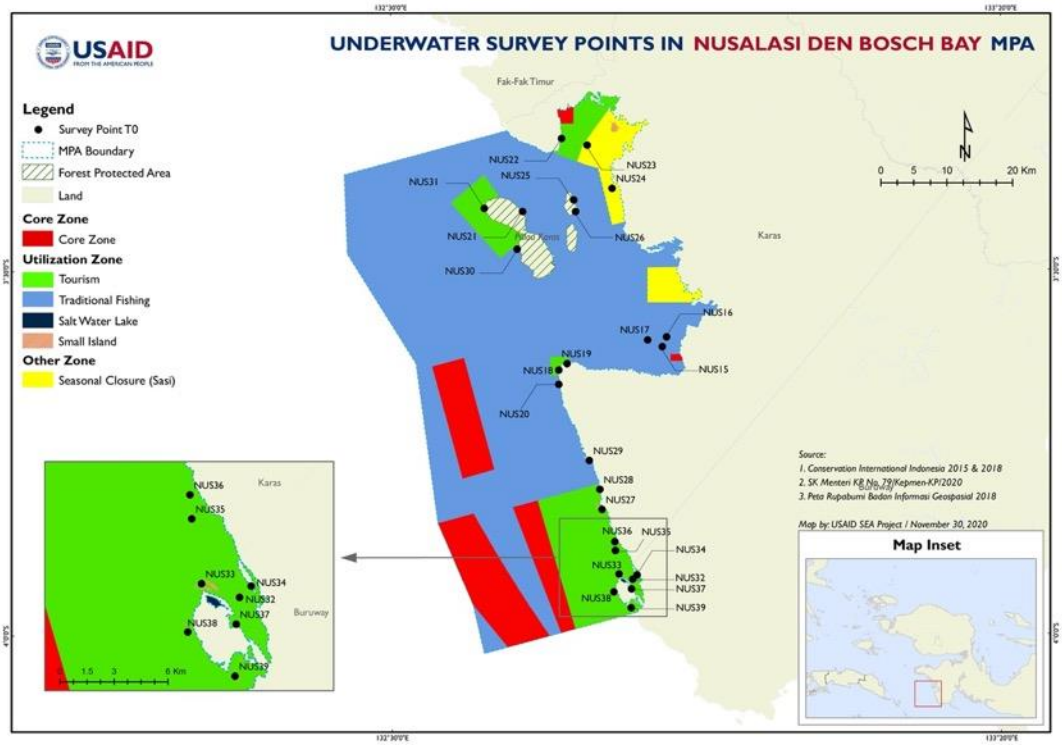

USAID
UNDERWATER SURVEY POINTS IN MARE MPA
Legend
Survey Point T1
Survey Point T0
MPA Boundary
Land
Core Zone
Core Zone
Utilization Zone
Tourism
Sustainable Fishing Zone
Regulated Fishing
Other Zone
Rehabilitation
Tidore Selatan
T0 MAR1
T1 MAR1
T0 MAR2
T1 MAR2
T0 MAR3
T1 MAR3
0 0.75 1.5 3 Km
T0 MAR8
T1 MAR8
T1 MAR12
T1 MAR14
T0 MAR10
T1 MAR10
T0 MAR5
T1 MAR5
Mare Island
Tidore Selatan
T0 MAR11
T1 MAR11
T0 MAR6
T1 MAR6
T0 MAR7
T1 MAR7
T1 MAR15
T0 MAR4
T0 MAR9
T1 MAR9
Source:
1. Wildlife Conservation Society 2017& 2020
2. SK Menteri KP No. 66/Kepmen-KP/2020
3. Peta Rupabumi Badan Informasi Geospasial 2018
Map by: USAID SEA Project / November 30, 2020
Map Inset


USAID
UNDERWATER SURVEY POINTS IN MAKIAN-MOTI MPA
Legend
Survey Point T0
MPA Boundary
Land
Core Zone
Core Zone
Utilization Zone
Tourism
Sustainable Fishing Zone
Regulated Fishing
Other Zone
Rehabilitation
Ship Lane
MOT1
MOT5
Pulau Moti
MOT2
MOT3
MOT4
Obi Tengah
0 2.5 5 10 Km
Obi
MAK11
MAK12
MAK9
MAK6
Pulau Makian
Makian Barat
MAK7
MAK10
MAK8
Source:
1. Wildlife Conservation Society 2019
2. Rencana Pengelolaan dan Zonasi 2020
3. Peta Rupabumi Badan Informasi Geospasial 2018
Map by: USAID SEA Project / November 30, 2020
Map Inset


USAID
UNDERWATER SURVEY POINTS IN SULA MPA
Mangoli Timur
Mangoli Tengah
Mangoli Utara Timur
Sanana Utara
Sanana
Sulabesi Barat
Sulabesi Tengah
Sulabesi Selatan
Sulabesi Timur
TI SUL1
T0 SUL1
T0 SUL6
TI SUL2
T0 SUL2
T0 SUL3
TI SUL7
T0 SUL7
TI SUL5
T0 SUL5
TI SUL4
T0 SUL4
TI SUL9
T0 SUL8
T0 SUL9
T0 SUL10
T0 SUL11
TI SUL16
T0 SUL12
TI SUL17
TI SUL18
T0 SUL13
TI SUL14
TI SUL15
0 5 10 20 Km
Legend
Survey Point TI
Survey Point T0
MPA Boundary
Land
Core Zone
Core Zone
Utilization Zone
Tourism
Regulated Fishing
Traditional Fishing
Aquaculture
Other Zone
Rehabilitation
Port
Map Inset
Source:
1. Coral Triangle Center 2017 & 2020
2. SK Menteri KP No. 68/Kepmen-KP/2020
3. Peta Rupabumi Badan Informasi Geospasial 2018
Map by: USAID SEA Project / November 30, 2020


USAID
UNDERWATER SURVEY POINTS IN WIDI MPA
Weda Selatan
Oba Selatan
Gane Timur
Ganebarat Utara
Bacanbarat Utara
Ganetimur Tengah
Gane Barat
Bacan Timur
Ganetimur Selatan
Bacan Selatan
Bacantimur Tengah
Ganebarat Selatan
Bacantimur Selatan
Patani
TI WID16
TI WID14
TI WID15
TI WID9
T0 WID7
TI WID8
T0 WID8
TI WID7
T0 WID9
TI WID11
T0 WID11
TI WID2
T0 WID2
TI WID1
T0 WID1
TI WID3
T0 WID3
TI WID12
T0 WID10
TI WID13
TI WID4
T0 WID 5
TI WID5
T0 WID6
TI WID6
T0 WID4
0 2.5 5 10 Km
Legend
Survey Point TI
Survey Point T0
MPA Boundary
Land
Core Zone
Core Zone
Utilization Zone
Tourism
Regulated Fishing
Source:
1. Wildlife Conservation Society 2017 & 2020
2. Rencana Pengelolaan dan Zonasi 2020
3. Peta Rupabumi Badan Informasi Geospasial 2018
Map by: USAID SEA Project / November 30, 2020
Map Inset


USAID
FROM THE AMERICAN PEOPLE
UNDERWATER SURVEY POINTS IN BERAU BAY MPA
Legend
Survey Point T0
MPA Boundary
Forest Protected Area
Land
Core Zone
Core Zone
Utilization Zone
Tourism
Traditional Fishing
Salt Water Lake
Small Island
Other Zone
Seasonal Closure (Sasi)
N
0 3.5 7 14 Km
BER14
BER13
BER3
BER8
BER9
BER7
BER1
BER2
BER10
BER11
BER12
BER5
BER6
BER4
Source:
1. Conservation International Indonesia 2018
2. SK Menteri KP No. 79/Kepmen-KP/2020
3. Peta Rupabumi Badan Informasi Geospasial 2018
Map by: USAID SEA Project / November 30, 2020
Map Inset
Teluk Patipi
Kayauni
Furwagi
Kramongmongga
Kokas
Arguni
Fak-Fak Barat
Wartutin
Pariwari
Fak-Fak
Fak-Fak Tengah


USAID
FROM THE AMERICAN PEOPLE
UNDERWATER SURVEY POINTS IN NUSALASI DEN BOSCH BAY MPA
Legend
Survey Point T0
MPA Boundary
Forest Protected Area
Land
Core Zone
Core Zone
Utilization Zone
Tourism
Traditional Fishing
Salt Water Lake
Small Island
Other Zone
Seasonal Closure (Sasi)
Fak-Fak Timur
N
0 5 10 20 Km
NUS22
NUS23
NUS24
NUS25
NUS31
NUS21
NUS26
NUS30
Karas
NUS16
NUS17
NUS19
NUS18
NUS15
NUS20
NUS29
NUS28
NUS27
NUS36
NUS35
NUS534
NUS33
NUS532
NUS537
NUS538
NUS539
Source:
1. Conservation International Indonesia 2015 & 2018
2. SK Menteri KP No. 79/Kepmen-KP/2020
3. Peta Rupabumi Badan Informasi Geospasial 2018
Map by: USAID SEA Project / November 30, 2020
Map Inset
Karas
NUS536
NUS535
NUS533
NUS534
NUS532
NUS537
NUS538
Buruway
1.5 3 6 Km
NUS539

8.2 APPENDIX II – BENTHIC COMMUNITY ANALYSIS RESULTS

Table 4.1.1.1. Results of linear model analysis testing the differences in the benthic community in **Ay-Rhun MPA** between management zones and depths, with site as a random factor. HC: Hard coral, SC: Soft coral, MA: Macroalgae, HA: Halimeda, TA: Turf algae, OT: Other, AH: Abiotic hard, AM: Abiotic mobile. Significant results are shown in bold.

		HC	SC	MA	HA	TA	CCA	OT	AH	AM
Model	R^2	0.06	0.01	0.01	0.18	0.02	0.62	0.3	0.11	0.19
	F	2.6	1.4	1.2	6.7	1.6	43	12.3	4.4	7
	p	0.03	0.23	0.32	<0.001	0.17	<0.001	<0.001	<0.001	<0.001
Zone	F	**5.4**	1.5	1.6	**10.9**	0.8	**3.6**	0.8	**5.4**	**14.4**
	p	**0.005**	0.22	0.21	**<0.001**	0.45	**0.03**	0.47	**0.005**	**<0.001**
Depth	F	0.1	3.3	2.7	2.9	**5.9**	**202.4**	**58.6**	**10.4**	3.5
	p	0.72	0.07	0.1	0.09	**0.02**	**<0.001**	**<0.001**	**0.001**	0.06
Zone x Depth	F	0.9	0.3	0.01	**4.5**	0.2	2.7	0.8	0.4	1.4
	p	0.39	0.72	0.99	**0.01**	0.84	0.07	0.47	0.66	1.25

Table 4.1.2.1. Results of linear model analysis testing the differences in the benthic community in **Buano MPA** between management zones and depths, with site as a random factor. HC: Hard coral, SC: Soft coral, MA: Macroalgae, HA: Halimeda, TA: Turf algae, OT: Other, AH: Abiotic hard, AM: Abiotic mobile. Significant results are shown in bold.

		HC	SC	MA	HA	TA	CCA	OT	AH	AM
Model	R^2	0.2	0.2	0.08	0.25	0.43	0.16	0.08	0.39	0.13
	F	6	6	2.8	7.6	15.6	4.7	2.7	14	3.9
	p	0.001	0.001	0.04	<0.001	<0.001	0.005	0.05	<0.001	0.01
Zone	F	**4.7**	**17.9**	**5**	**6.7**	1.6	1.1	**7.6**	0.6	**5.6**
	p	**0.03**	**<0.001**	**0.03**	**0.01**	0.21	0.31	**0.008**	0.43	**0.02**
Depth	F	**13.3**	0	1.3	**9.3**	**31.2**	**11.5**	0.6	**41.1**	**5.9**
	p	**<0.001**	0.98	0.25	**0.003**	**<0.001**	**0.001**	0.43	**<0.001**	**0.02**
Zone x Depth	F	0.01	0.1	2	**6.8**	**14.1**	1.6	0.01	0.4	0.4
	p	0.91	0.74	0.16	**0.01**	**<0.001**	0.22	0.92	0.54	0.54

Table 4.1.3.1. Results of linear model analysis testing the differences in the benthic community in **Koon MPA** between management zones and depths, with site as a random factor. This analysis had a spatial focus, and was therefore conducted separately for Baseline and T1 data, to include all sites surveyed in each period. For the temporal comparison, see Table 4.1.3.2. HC: Hard coral, SC: Soft coral, MA: Macroalgae, HA: Halimeda, TA: Turf algae, OT: Other, AH: Abiotic hard, AM: Abiotic mobile.

Baseline		HC	SC	MA	HA	TA	CCA	OT	AH	AM
Model	R^2	0.07	0.17	0.01	0.04	0.08	0.21	0.02	0.29	0.01
	F	3.6	7.9	1.4	2.4	4.1	10.3	1.9	15.4	1.5
	p	0.008	<0.001	0.22	0.05	0.003	<0.001	0.12	<0.001	0.21
Zone	F	**6.9**	**12.2**	1.9	0.5	**5.8**	0.8	0.9	**4.5**	2.9

Baseline		HC	SC	MA	HA	TA	CCA	OT	AH	AM
	p	**0.001**	**<0.001**	0.16	0.63	**0.004**	0.46	0.42	**0.01**	0.06
Depth	F	0.2	**5.7**	1.2	1.4	**4.6**	**13.5**	**5.1**	**23.9**	0.09
	p	0.62	**0.02**	0.28	0.23	**0.03**	**<0.001**	**0.03**	**<0.001**	0.77
Zone x Depth	F	0.3	1.8	0.9	**7.3**	0.3	**26.2**	0.6	**28.5**	0.01
	p	0.57	0.18	0.36	**0.008**	0.59	**<0.001**	0.45	**<0.001**	0.91
T1		HC	SC	MA	HA	TA	CCA	OT	AH	AM
Model	R^2	0.14	0.14	0.08	0.06	0.07	0.34	0.18	0.19	-0.01
	F	5.3	5.4	3.5	2.7	3.1	15.3	6.9	7.3	0.7
	p	<0.001	<0.001	0.005	0.03	0.01	<0.001	<0.001	<0.001	0.62
Zone	F	**6.4**	**13.2**	**3.8**	0.5	**5.7**	**5.6**	**5.9**	0.2	1.6
	p	**0.002**	**<0.001**	**0.03**	0.61	**0.004**	**0.005**	**<0.001**	0.83	0.21
Depth	F	**6.5**	0.1	2.1	**9.1**	0.04	1.5	**12.5**	1.2	0.3
	p	**0.01**	0.71	0.15	**0.003**	0.85	0.22	**<0.001**	0.28	0.59
Zone x Depth	F	**3.7**	0.3	**3.9**	1.6	2	**31.9**	**5.1**	**17.6**	0.05
	p	**0.03**	0.73	**0.02**	0.21	0.13	**<0.001**	**0.007**	**<0.001**	0.96
T2		HC	SC	MA	HA	TA	CCA	OT	AH	AM
Model	R^2	-0.002	0.21	0.05	0.03	0.08	0.06	0.32	-0.01	0.22
	F	0.95	7.46	2.38	1.77	3.06	2.40	12.05	0.71	7.58
	p	0.45	<0.001	0.04	0.13	0.01	0.04	<0.001	0.62	<0.001
Zone	F	0.99	**15.89**	2.67	2.46	**6.59**	2.46	**10.79**	0.21	**17.87**
	p	0.37	**<0.001**	0.07	0.09	**0.002**	0.09	**<0.001**	0.81	**<0.001**
Depth	F	0.56	3.76	0.26	1.64	0.06	0.72	**38.51**	2.31	0.71
	p	0.45	0.05	0.61	0.20	0.80	0.40	**<0.001**	0.13	0.40
Zone x Depth	F	1.11	0.86	**3.15**	1.14	1.02	**3.17**	0.08	0.40	0.71
	p	0.33	0.43	**0.046**	0.32	0.36	**0.045**	0.92	0.67	0.49

Table 4.1.3.2. Results of linear model analysis testing the differences in the benthic community in **Koon MPA** between survey periods, management zones and depths, with site as a random factor. This analysis was conducted only with sites surveyed during both periods. For each benthic category, nine combinations of factors were tested and the best model is presented here, along with the model R^2 and the results of the accompanying analysis of variance test. HC: Hard coral, SC: Soft coral, MA: Macroalgae, HA: Halimeda, TA: Turf algae, OT: Other, AH: Abiotic hard, AM: Abiotic mobile.

		HC	SC	MA	HA	TA	CCA	OT	AH	AM
Model		Zone + Depth	Time + Zone	Time + Zone x Depth	Time + Zone x Depth	Time x Zone	Time x Zone x Depth	Zone x Depth	Time x Zone x Depth	Time x Zone
	R^2	0.05	0.18	0.06	0.07	0.06	0.20	0.16	0.18	0.08
	F	7.29	19.39	3.90	4.76	3.62	6.26	13.67	5.67	4.73
	p	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Time	F		**4.21**	**4.03**	**7.58**	2.47	**8.68**		**10.46**	1.55
	p		**0.02**	**0.02**	**<0.001**	0.09	**<0.001**		**<0.001**	0.21
Zone	F	**10.28**	**34.57**	2.78	0.99	**5.40**	**4.99**	**6.41**	1.45	**10.87**

		HC	SC	MA	HA	TA	CCA	OT	AH	AM
	p	**<0.001**	**<0.001**	0.06	0.37	**0.005**	**0.007**	**0.002**	0.24	**<0.001**
Depth	F	1.30		0.01	**10.55**		0.85	**43.84**	**10.08**	
	p	0.26		0.93	**0.001**		0.36	**<0.001**	**0.002**	
Time x Zone	F					**3.31**	0.64		1.53	**3.24**
	p					**0.01**	0.63		0.19	**0.01**
Time x Depth	F						**4.04**		2.89	
	p						**0.02**		0.06	
Zone x Depth	F			**6.82**	2.81		**10.73**	**5.84**	**12.75**	
	p			**0.001**	0.06		**<0.001**	**0.003**	**<0.001**	
Time x Zone x Depth	F						**13.24**		**6.45**	
	p						**<0.001**		**<0.001**	

Table 4.1.4.1. Results of linear model analysis testing the differences in the benthic community in **Lease MPA** between management zones and depths, with site as a random factor. This analysis had a spatial focus, and was therefore conducted separately for Baseline and T1 data, to include all sites surveyed in each period. For the temporal comparison, see Table 4.1.4.2. HC: Hard coral, SC: Soft coral, MA: Macroalgae, HA: *Halimeda*, TA: Turf algae, OT: Other, AH: Abiotic hard, AM: Abiotic mobile. Significant results are highlighted in bold.

Baseline		HC	SC	MA	HA	TA	CCA	OT	AH	AM
Model	R^2	0.12	0.05	0.15	-0.002	0.18	0.15	0.31	0.3	0.17
	F	5.38	2.68	6.59	0.94	7.66	6.49	14.68	14.4	7.18
	p	<0.001	0.02	<0.001	0.46	<0.001	<0.001	<0.001	<0.001	<0.001
Zone	F	**8.24**	**5.16**	0.4	0.7	**5.52**	**5.65**	0.86	**3.74**	**13.42**
	p	**<0.001**	**0.007**	0.67	0.5	**0.004**	**0.004**	0.43	**0.03**	**<0.001**
Depth	F	0.2	0.43	**31.88**	1.96	**25.46**	**7.81**	**62.22**	**61.62**	**4.01**
	p	0.65	0.51	**<0.001**	0.17	**<0.001**	**0.006**	**<0.001**	**<0.001**	**0.047**
Zone x Depth	F	**5.07**	1.32	0.14	0.7	0.89	**6.66**	**4.74**	1.44	2.52
	p	**0.007**	0.27	0.87	0.5	0.41	**0.002**	**0.01**	0.24	0.08
T1		HC	SC	MA	HA	TA	CCA	OT	AH	AM
Model	R^2	0.04	0.07	-0.003	-0.03	0.05	0.15	0.22	0.10	0.12
	F	2.41	3.79	0.89	0.13	2.98	7.20	10.82	5.07	6.04
	p	0.07	0.01	0.45	0.94	0.03	<0.001	<0.001	0.003	<0.001
Zone	F	**6.35**	**9.84**	0.0004	0.17	0.01	0.05	0.82	0.001	**16.68**
	p	**0.01**	**0.002**	0.98	0.68	0.91	0.83	0.37	0.97	**<0.001**
Depth	F	0.86	1.51	0.46	0.03	**8.82**	**16.39**	**29.39**	**14.83**	1.35
	p	0.36	0.22	0.50	0.87	**0.004**	**<0.001**	**<0.001**	**<0.001**	0.25
Zone x Depth	F	0.02	0.01	2.19	0.18	0.11	**5.17**	2.25	0.40	0.09
	p	0.90	0.90	0.14	0.67	0.74	**0.03**	0.14	0.53	0.77

Table 4.1.4.2. Results of linear model analysis testing the differences in the benthic community in **Lease MPA** between survey periods, management zones and depths, with site as a random factor. This analysis was conducted only with sites surveyed during both periods. For each benthic category, nine combinations of factors were tested and the best model is presented here, along with the model R^2 and the results of the accompanying analysis of variance test. HC: Hard coral, SC: Soft coral, MA: Macroalgae, HA: Halimeda, TA: Turf algae, OT: Other, AH: Abiotic hard, AM: Abiotic mobile.

		HC	SC	MA	HA	TA	CCA	OT	AH	AM
Model		Zone x Depth	Time + Zone	Time x Zone x Depth	Time	Time x Zone x Depth	Time	Time x Zone + Depth	Time + Zone + Depth	Zone x Depth
	R^2	0.05	0.04	0.12	0.02	0.1	-0.005	0.28	0.2	0.12
	F	4.88	5.77	5.25	4.99	4.14	0.03	20.72	17.69	10.59
	p	0.003	0.004	<0.001	0.03	<0.001	0.87	<0.001	<0.001	<0.001
Time	F		0.28	1.71	**4.99**	0.22	0.03	0.13	**4.59**	
	p		0.59	0.19	**0.03**	0.64	0.87	0.72	**0.03**	
Zone	F	**7.49**	**11.25**	0.03		1.36		0.21	0.01	**23.91**
	p	**0.007**	**<0.001**	0.86		0.24		0.65	0.91	**<0.001**
Depth	F	0.37		**20.12**		1.35		**76.61**	**48.46**	**5.5**
	p	0.54		**<0.001**		0.25		**<0.001**	**<0.001**	**0.02**
Time x Zone	F			0.02		0.18		**5.91**		
	p			0.88		0.68		**0.02**		
Time x Depth	F			**12.97**		**25.83**				
	p			**<0.001**		**<0.001**				
Zone x Depth	F	**6.79**		0.5		0.01				2.36
	p	**0.01**		0.48		0.91				0.13
Time x Zone x Depth	F			1.37		0.0001				
	p			0.24		0.99				

Table 4.1.5.2. Results of linear model analysis testing the differences in the benthic community in **Serutbar MPA** between survey periods and management zones, with site as a random factor. This analysis was conducted only with sites surveyed during both periods. Depth was not included in the test, as baseline surveys did not include shallow habitats. HC: Hard coral, SC: Soft coral, MA: Macroalgae, HA: Halimeda, TA: Turf algae, OT: Other, AH: Abiotic hard, AM: Abiotic mobile. Significant results are listed in bold.

		HC	SC	MA	HA	TA	CCA	OT	AH	AM
Model	R^2	0.22	0.09	0.08	0.19	0.03	0.02	0.13	0.06	0.13
	F	11.91	4.64	4.57	10.25	2.40	1.82	6.80	3.38	6.77
	p	<0.001	<0.001	<0.001	<0.001	0.04	0.11	<0.001	0.006	<0.001
Time	F	**7.47**	**0.26**	**8.34**	3.67	**10.55**	1.74	**8.10**	1.51	**6.77**
	p	**0.007**	**0.61**	**0.004**	0.06	**0.001**	0.19	**0.005**	0.22	**0.01**
Zone	F	**11.88**	**10.61**	2.87	**20.64**	0.09	0.68	0.32	**5.76**	**6.60**

		HC	SC	MA	HA	TA	CCA	OT	AH	AM
	p	**<0.001**	**<0.001**	0.06	**<0.001**	0.91	0.51	0.73	**0.004**	**0.002**
Time x Zone	F	**14.15**	0.85	**4.38**	**3.16**	0.62	3.01	**12.62**	1.95	**6.94**
	p	**<0.001**	0.43	**0.01**	**0.04**	0.54	0.05	**<0.001**	0.15	**0.001**

Table 4.2.1.1. Results of linear model analysis testing the differences in the benthic community in **Guraici MPA** between management zones and depths, with site as a random factor. This analysis had a spatial focus, and was therefore conducted separately for Baseline and T1 data, to include all sites surveyed in each period. For the temporal comparison, see Table 4.2.1.2. HC: Hard coral, SC: Soft coral, MA: Macroalgae, HA: Halimeda, TA: Turf algae, OT: Other, AH: Abiotic hard, AM: Abiotic mobile.

Baseline		HC	SC	MA	HA	TA	CCA	OT	AH	AM
Model	R^2	0.22	0.13	-0.02	0.06	0.06	N	0.29	N	0.26
	F	6.61	3.91	0.66	2.34	2.34	N	9.19	N	8.28
	p	<0.001	0.003	0.66	0.047	0.047	N	<0.001	N	<0.001
Zone	F	**12.37**	**7.86**	0.11	**5.78**	0.82	N	**8.8**	N	**8.17**
	p	**<0.001**	**<0.001**	0.9	**0.004**	0.45	N	**<0.001**	N	**<0.001**
Depth	F	**6.63**	0.49	2.85	0.02	1.34	N	**23.99**	N	**22.81**
	p	**0.01**	0.48	0.09	0.89	0.25	N	**<0.001**	N	**<0.001**
Zone x Depth	F	0.83	1.66	0.11	0.11	0.45	N	2.19	N	1.12
	p	0.44	0.19	0.9	0.89	0.64	N	0.12	N	0.33
T1		HC	SC	MA	HA	TA	CCA	OT	AH	AM
Model	R^2	0.25	0.01	0.08	0.01	0.1	N	0.19	-0.01	0.33
	F	9.51	1.28	3.1	1.35	3.75	N	6.72	0.77	13.16
	p	<0.001	0.28	0.01	0.25	0.003	N	<0.001	0.57	<0.001
Zone	F	**15.51**	2.84	2.42	1.47	0.83	N	2.30	1.09	**9.82**
	p	**<0.001**	0.06	0.09	0.23	0.44	N	0.1	0.34	**<0.001**
Depth	F	**15.74**	0.02	0.19	2.45	**8.81**	N	3.67	0.17	**44.85**
	p	**<0.001**	0.89	0.67	0.12	**0.004**	N	0.06	0.68	**<0.001**
Zone x Depth	F	0.4	0.34	**5.24**	0.67	**4.12**	N	**12.71**	0.75	0.65
	p	0.67	0.71	**0.007**	0.51	**0.02**	N	**<0.001**	0.47	0.52

Table 4.2.1.2. Results of linear model analysis testing the differences in the benthic community in **Guraici MPA** between survey periods, management zones and depths, with site as a random factor. This analysis was conducted only with sites surveyed during both periods. For each benthic category, nine combinations of factors were tested and the best model is presented here, along with the model R^2 and the results of the accompanying analysis of variance test. HC: Hard coral, SC: Soft coral, MA: Macroalgae, HA: Halimeda, TA: Turf algae, OT: Other, AH: Abiotic hard, AM: Abiotic mobile.

		HC	SC	MA	HA	TA	CCA	OT	AH	AM
Model		Time + Zone + Depth	Time + Zone	Time	Time x Zone	Zone x Depth	N	Time x Zone x Depth	N	Zone + Depth

		HC	SC	MA	HA	TA	CCA	OT	AH	AM
	R^2	0.24	0.07	0.02	0.06	0.08		0.26		0.38
	F	14.24	5.44	4.33	3.02	3.86		6.45		35.01
	p	<0.001	0.001	0.04	0.01	0.003		<0.001		<0.001
Time	F	1.99	**4**	**4.33**	2.39			**4.27**		
	p	0.16	**0.047**	**0.04**	0.12			**0.04**		
Zone	F	**16.96**	**6.16**		**3.89**	1.83		**6.10**		**18.38**
	p	**<0.001**	**0.002**		**0.02**	0.16		**0.002**		**<0.001**
Depth	F	**21.07**				**7.92**		**19.73**		**68.27**
	p	**<0.001**				**0.006**		**<0.001**		**<0.001**
Time x Zone	F				2.47			1.19		
	p				0.09			0.31		
Time x Depth								2.88		
								0.09		
Zone x Depth	F					**3.85**		**12.24**		
	p					**0.02**		**<0.001**		
Time x Zone x Depth								2.52		
								0.08		

Table 4.2.2.1. Results of linear model analysis testing the differences in the benthic community in **Makian-Moti MPA** between management zones and depths, with site as a random factor. HC: Hard coral, SC: Soft coral, MA: Macroalgae, HA: Halimeda, TA: Turf algae, OT: Other, AH: Abiotic hard, AM: Abiotic mobile. Significant results are shown in bold.

		HC	SC	MA	HA	TA	CCA	OT	AH	AM
Model	R^2	0.07	0.08	0.006	0.35	0.08	N	0.17	-0.05	0.05
	F	1.99	2.15	1.08	8.36	2.27	N	3.74	0.39	1.79
	p	0.09	0.07	0.38	<0.001	0.06	N	0.005	0.85	0.13
Zone	F	1.15	0.03	0.62	**9.47**	2.95	N	0.24	0.25	1.3
	p	0.32	0.97	0.54	**<0.001**	0.06	N	0.79	0.78	0.28
Depth	F	**4.67**	0.002	1.08	**9.92**	2.32	N	**13.18**	0.96	0.02
	p	**0.03**	0.96	0.3	**0.002**	0.13	N	**<0.001**	0.33	0.88
Zone x Depth	F	1.49	**5.33**	1.55	**6.48**	1.58	N	2.53	0.25	**3.17**
	p	0.23	**0.007**	0.22	**0.003**	0.21	N	0.09	0.78	**0.048**

Table 4.2.3.1. Results of linear model analysis testing the differences in the benthic community in **Mare MPA** between management zones and depths, with site as a random factor. This analysis had a spatial focus, and was therefore conducted separately for Baseline and T1 data, to include all sites surveyed in each period. For the temporal comparison, see Table 4.2.3.2. HC: Hard coral, SC: Soft coral, MA: Macroalgae, HA: Halimeda, TA: Turf algae, OT: Other, AH: Abiotic hard, AM: Abiotic mobile.

Baseline		HC	SC	MA	HA	TA	CCA	OT	AH	AM
Model	R^2	0.04	0.29	0.17	0.07	0.25	N	0.29	N	0.07
	F	1.48	6.22	3.69	1.99	5.41	N	6.27	N	1.99
	p	0.21	<0.001	0.006	0.09	<0.001	N	<0.001	N	0.09
Zone	F	0.39	**14.59**	2.48	**4.71**	**5.4**	N	**3.63**	N	0.06
	p	0.68	**<0.001**	0.09	**0.01**	**0.007**	N	**0.04**	N	0.95
Depth	F	**6.05**	0.47	**8.51**	0.3	**14.2**	N	**23.51**	N	**7.48**
	p	**0.02**	0.49	**0.005**	0.59	**<0.001**	N	**<0.001**	N	**0.008**
Zone x Depth	F	0.29	0.73	2.48	0.11	1.04	N	0.29	N	1.17
	p	0.75	0.49	0.09	0.9	0.36	N	0.75	N	0.32
TI		**HC**	**SC**	**MA**	**HA**	**TA**	**CCA**	**OT**	**AH**	**AM**
Model	R^2	0.17	0.13	0.13	N	-0.03	N	0.20	N	0.13
	F	4.42	3.47	3.3	N	0.48	N	5.08	N	3.54
	p	0.001	0.007	0.009	N	0.79	N	<0.001	N	0.006
Zone	F	1.34	**3.36**	**6.72**	N	0.97	N	0.42	N	0.05
	p	0.27	**0.04**	**0.002**	N	0.38	N	0.66	N	0.96
Depth	F	**13.71**	**7.17**	0.49	N	0.06	N	**20.60**	N	**11.08**
	p	**<0.001**	**0.009**	0.49	N	0.81	N	**<0.001**	N	**0.001**
Zone x Depth	F	2.86	1.72	1.28	N	0.2	N	1.97	N	**3.26**
	p	0.06	0.19	0.28	N	0.82	N	0.15	N	**0.04**

Table 4.2.3.2. Results of linear model analysis testing the differences in the benthic community in **Mare MPA** between survey periods, management zones and depths, with site as a random factor. This analysis was conducted only with sites surveyed during both periods. For each benthic category, nine combinations of factors were tested and the best model is presented here, along with the model R^2 and the results of the accompanying analysis of variance test. HC: Hard coral, SC: Soft coral, MA: Macroalgae, HA: Halimeda, TA: Turf algae, OT: Other, AH: Abiotic hard, AM: Abiotic mobile.

		HC	SC	MA	HA	TA	CCA	OT	AH	AM
Model		Time + Zone + Depth	Zone x Depth	Zone x Depth	Time x Zone	Time x Zone x Depth	N	Time + Zone + Depth	N	Time
	R^2	0.33	0.2	0.15	0.15	0.22		0.22		0.33
	F	15.66	8.59	5.05	5.21	4.11		9.28		59.3
	p	<0.001	<0.001	<0.001	<0.001	<0.001		<0.001		<0.001
Time	F	**54.2**			**10.14**	**4.2**		**6.05**		**59.3**
	p	**<0.001**			**0.002**	**0.04**		**0.02**		**<0.001**
Zone	F	0.36	**16.05**	**6.06**	**3.97**	**7.17**		0.03		
	p	0.7	**<0.001**	**0.003**	**0.02**	**0.001**		0.97		
Depth	F	**7.7**	**4.1**	**8.66**		**4.41**		**31.01**		
	p	**0.006**	**0.045**	**0.004**		**0.04**		**<0.001**		
Time x Zone	F				**3.97**	2.66				
	p				**0.02**	0.07				

		HC	SC	MA	HA	TA	CCA	OT	AH	AM
Time x Depth	F					**13.68**				
	p					**<0.001**				
Zone x Depth	F		**5.66**	2.23		1.19				
	p		**0.005**	0.11		0.31				
Time x Zone x Depth						0.44				
						0.66				

Table 4.2.4.1. Results of linear model analysis testing the differences in the benthic community in **Rao-Dehegila MPA** between management zones and depths, with site as a random factor. This analysis had a spatial focus, and was therefore conducted separately for Baseline and T1 data, to include all sites surveyed in each period. For the temporal comparison, see Table 4.2.4.2. HC: Hard coral, SC: Soft coral, MA: Macroalgae, HA: Halimeda, TA: Turf algae, OT: Other, AH: Abiotic hard, AM: Abiotic mobile.

Baseline		**HC**	**SC**	**MA**	**HA**	**TA**	**CCA**	**OT**	**AH**	**AM**
Model	R^2	0.1	0.03	0.003	0.02	0.03	0.16	0.11	0.05	0.06
	F	4.31	1.79	1.08	1.74	1.96	6.77	4.71	2.52	2.87
	p	0.001	0.12	0.38	0.13	0.09	<0.001	<0.001	0.03	0.02
Zone	F	0.14	**4.21**	0.82	**4.19**	**3.68**	**4.6**	1.56	**4.82**	0.18
	p	0.87	**0.02**	0.44	**0.02**	**0.03**	**0.01**	0.21	**0.009**	0.83
Depth	F	**19.89**	0.44	1.17	0.14	0.78	**15.28**	**20.36**	0.93	**13.85**
	p	**<0.001**	0.51	0.28	0.7	0.38	**<0.001**	**<0.001**	0.34	**<0.001**
Zone x Depth	F	0.67	0.04	1.29	0.09	0.82	**4.69**	0.03	1.02	0.07
	p	0.51	0.96	0.28	0.92	0.44	**0.01**	0.97	0.36	0.93
T1		HC	SC	MA	HA	TA	CCA	OT	AH	AM
Model	R^2	0.04	0.07	0.24	0.02	0.04	N	0.14	-0.01	0.06
	F	2.18	3.09	9.43	1.54	2.14	N	5.60	0.72	2.77
	p	0.06	0.01	<0.001	0.18	0.06	N	<0.001	0.61	0.02
Zone	F	1.93	**5.92**	**20.11**	0.63	1.56	N	**3.55**	0.87	0.83
	p	0.15	**0.003**	**<0.001**	0.53	0.21	N	**0.03**	0.42	0.44
Depth	F	**4.61**	0.94	3.18	3.2	0.09	N	**19.83**	0.62	**6.87**
	p	**0.03**	0.33	0.08	0.08	0.76	N	**<0.001**	0.43	**0.009**
Zone x Depth	F	1.21	1.35	1.86	1.61	**3.74**	N	0.53	0.63	2.65
	p	0.3	0.26	0.16	0.2	**0.02**	N	0.59	0.53	0.07

Table 4.2.4.2. Results of linear model analysis testing the differences in the benthic community in **Rao-Dehegila MPA** between survey periods, management zones and depths, with site as a random factor. This analysis was conducted only with sites surveyed during both periods. For each benthic category, nine combinations of factors were tested and the best model is presented here, along with the model R^2 and the results of the accompanying analysis of variance test. HC: Hard coral, SC: Soft coral, MA: Macroalgae, HA: Halimeda, TA: Turf algae, OT: Other, AH: Abiotic hard, AM: Abiotic mobile.

		HC	SC	MA	HA	TA	CCA	OT	AH	AM
Model		Time + Zone + Depth	Zone + Depth	Time x Zone + Depth	Time + Zone + Depth	Time x Zone	Time x Zone x Depth	Time + Zone + Depth	Time x Zone	Time + Zone + Depth
	R^2	0.07	0.05	0.09	0.04	0.08	0.14	0.18	0.22	0.21
	F	4.51	4.62	4.69	3.05	5.05	4.26	11.35	14.72	13.54
	p	0.004	0.01	0.001	0.03	0.002	<0.001	<0.001	<0.001	<0.001
Time	F	**6.66**		1.73	**5.18**	**9.11**	**10.43**	**12.05**	**37.01**	**33.22**
	p	**0.01**		0.19	**0.02**	**0.003**	**0.002**	**<0.001**	**<0.001**	**<0.001**
Zone	F	2.68	**8.81**	1.85	0.11	3.7	1.3	**4.90**	3.14	0.19
	p	0.1	**0.004**	0.18	0.74	0.06	0.26	**0.03**	0.08	0.66
Depth	F	**4.19**	0.42	**5.57**	3.87		**7.53**	**17.10**		**7.2**
	p	**0.04**	0.52	**0.02**	0.05		**0.007**	**<0.001**		**0.008**
Time x Zone	F			**9.6**		2.35	1.63		**4.02**	
	p			**0.002**		0.13	0.2		**0.047**	
Time x Depth	F						**7.73**			
	p						**0.006**			
Zone x Depth	F						0.6			
	p						0.44			
Time x Zone x Depth	F						0.58			
	p						0.45			

Table 4.2.5.1. Results of linear model analysis testing the differences in the benthic community in **Sula MPA** between management zones and depths, with site as a random factor. This analysis had a spatial focus, and was therefore conducted separately for Baseline and T1 data, to include all sites surveyed in each period. For the temporal comparison, see Table 4.2.5.2. HC: Hard coral, SC: Soft coral, MA: Macroalgae, HA: Halimeda, TA: Turf algae, OT: Other, AH: Abiotic hard, AM: Abiotic mobile.

Baseline		**HC**	**SC**	**MA**	**HA**	**TA**	**CCA**	**OT**	**AH**	**AM**
Model	R2	0.17	0.15	0.19	-0.03	0.05	0.1	0.22	0.19	0.29
	F	3.97	3.6	4.36	0.62	1.85	2.66	5.24	4.46	7.18
	p	0.003	0.006	0.007	0.69	0.12	0.03	<0.001	0.001	<0.001
Zone	F	2.41	**8.74**	**7.73**	0.45	0.94	2.29	**11.38**	**7.68**	**7.38**
	p	0.09	**<0.001**	**<0.001**	0.64	0.4	0.11	**<0.001**	**<0.001**	**0.001**
Depth	F	**14.42**	0.04	**4.17**	1.13	0.22	3.29	2.21	**5.72**	**13.72**
	p	**<0.001**	0.85	**0.045**	0.29	0.27	0.07	0.14	**0.02**	**<0.001**
Zone x Depth	F	0.29	0.24	1.08	0.53	3.06	2.71	0.62	0.62	**3.71**
	p	0.75	0.79	0.34	0.59	0.05	0.07	0.54	0.54	**0.03**
T1		HC	SC	MA	HA	TA	CCA	OT	AH	AM
Model	R2	0.12	0.02	0.03	0.04	-0.008	0.14	0.43	0.01	0.2
	F	4.09	1.45	1.66	1.99	0.81	4.48	17.61	1.32	6.56
	p	0.01	0.24	0.18	0.12	0.49	0.007	<0.001	0.28	<0.001

Baseline		HC	SC	MA	HA	TA	CCA	OT	AH	AM
Zone	F	6.32	1.46	0.09	**5.55**	1.79	0.07	**39.57**	0.38	1.69
	p	1	0.23	0.76	**0.02**	0.19	0.79	**<0.001**	0.54	0.2
Depth	F	**4.53**	2.89	**4.87**	0.34	0.4	**13.31**	**5.19**	0.01	**17.97**
	p	**0.04**	0.09	**0.03**	0.56	0.53	**<0.001**	**0.03**	0.94	**<0.001**
Zone x Depth	F	1.4	0.004	0.01	0.08	0.25	0.07	**8.07**	3.58	0.002
	p	0.24	0.95	0.9	0.78	0.62	0.79	**0.006**	0.06	0.96

Table 4.2.5.2. Results of linear model analysis testing the differences in the benthic community in **Sula MPA** between survey periods, management zones and depths, with site as a random factor. This analysis was conducted only with sites surveyed during both periods. For each benthic category, nine combinations of factors were tested and the best model is presented here, along with the model R^2 and the results of the accompanying analysis of variance test. HC: Hard coral, SC: Soft coral, MA: Macroalgae, HA: Halimeda, TA: Turf algae, OT: Other, AH: Abiotic hard, AM: Abiotic mobile.

		HC	SC	MA	HA	TA	CCA	OT	AH	AM
Model		Time x Zone + Depth	Time	Time	Time x Zone	Time	Time + Zone + Depth	Time x Zone x Depth	Time x Zone x Depth	Zone x Depth
	R^2	0.65	-0.02	0.13	0.18	0.38	0.43	0.52	0.37	0.65
	F	28.4	0.02	9.83	5.39	36.92	16.13	9.99	5.93	7.96
	p	<0.001	0.88	0.003	0.003	<0.001	<0.001	<0.001	<0.001	<0.001
Time	F	**23.98**	0.02	**9.83**	**9.88**	**36.92**	**29.49**	**20.4**	**22.33**	
	p	**<0.001**	0.88	**0.003**	**0.003**	**<0.001**	**<0.001**	**<0.001**	**<0.001**	
Zone	F	**36.38**			3.14		0.68	**14.54**	2.03	**34.37**
	p	**<0.001**			0.08		0.41	**<0.001**	0.16	**<0.001**
Depth	F	**34.89**					**18.22**	**6.87**	**7.13**	**64.9**
	p	**<0.001**					**<0.001**	**0.01**	**0.01**	**<0.001**
Time x Zone	F	**18.33**			3.14			**18.7**	1.03	
	p	**<0.001**			0.08			**<0.001**	0.31	
Time x Depth	F							1.35	**7.71**	
	p							0.25	**0.008**	
Zone x Depth	F							**7.95**	0.05	**14.6**
	p							**0.007**	0.83	**<0.001**
Time x Zone x Depth	F							0.19	1.21	
	p							0.67	0.28	

Table 4.2.6.1. Results of linear model analysis testing the differences in the benthic community in **Widi MPA** between management zones and depths, with site as a random factor. This analysis had a spatial focus, and was therefore conducted separately for Baseline and T1 data, to include all sites surveyed in each period. For the temporal comparison, see Table 4.2.6.2. HC: Hard coral, SC: Soft coral, MA: Macroalgae, HA: Halimeda, TA: Turf algae, OT: Other, AH: Abiotic hard, AM: Abiotic mobile.

Baseline		HC	SC	MA	HA	TA	CCA	OT	AH	AM
Model	R^2	-0.003	0.19	0.05	0.005	0.12	-0.02	0.49	N	0.03
	F	0.93	6.19	2.23	1.09	3.86	0.57	22.05	N	1.59
	p	0.43	<0.001	0.09	0.36	0.01	0.64	<0.001	N	0.2
Zone	F	2.48	**13.89**	2.82	0.0003	**8.25**	0.37	**9.58**	N	3.26
	p	0.12	**<0.001**	0.09	0.99	**0.006**	0.55	**0.003**	N	0.08
Depth	F	0.01	0.95	1.06	2.85	1.05	0.98	**55.83**	N	1.46
	p	0.91	0.33	0.31	0.09	0.31	0.33	**<0.001**	N	0.23
Zone x Depth	F	0.31	3.73	2.82	0.45	2.28	0.37	0.72	N	0.05
	p	0.58	0.06	0.09	0.51	0.14	0.55	0.4	N	0.82
TI		**HC**	**SC**	**MA**	**HA**	**TA**	**CCA**	**OT**	**AH**	**AM**
Model	R^2	0.14	0.13	0.07	0.3	0.33	N	0.34	0.06	0.21
	F	3.82	3.69	2.36	8.8	9.96	N	10.14	2.21	5.71
	p	0.004	0.005	0.047	<0.001	<0.001	N	<0.001	0.06	<0.001
Zone	F	**5.43**	**6.61**	1.78	**20.84**	**6.38**	N	**3.98**	1.85	**9.13**
	p	**0.006**	**0.002**	0.17	**<0.001**	**0.003**	N	**0.02**	0.16	**<0.001**
Depth	F	3.32	0.19	**6.62**	0.05	**20.18**	N	**41.77**	1.47	**9.46**
	p	0.07	0.66	**0.01**	0.82	**<0.001**	N	**<0.001**	0.23	**0.003**
Zone x Depth	F	2.46	2.5	0.79	1.14	**8.42**	N	0.49	2.95	0.41
	p	0.09	0.09	0.45	0.33	**<0.001**	N	0.61	0.06	0.66

Table 4.2.6.2. Results of linear model analysis testing the differences in the benthic community in **Widi MPA** between survey periods, management zones and depths, with site as a random factor. This analysis was conducted only with sites surveyed during both periods. For each benthic category, nine combinations of factors were tested and the best model is presented here, along with the model R^2 and the results of the accompanying analysis of variance test. HC: Hard coral, SC: Soft coral, MA: Macroalgae, HA: Halimeda, TA: Turf algae, OT: Other, AH: Abiotic hard, AM: Abiotic mobile.

		HC	SC	MA	HA	TA	CCA	OT	AH	AM
Model		Time + Zone	Time + Zone x Depth	Time + Zone + Depth	Time + Zone + Depth	Time x Zone x Depth	Time	Time + Zone + Depth	Time	Time + Zone + Depth
	R^2	0.007	0.25	0.07	0.19	0.35	0	0.57	0.03	0.15
	F	1.44	10.66	3.86	10.48	10.27	1	54.18	4.21	7.96
	p	0.24	<0.001	0.01	<0.001	<0.001	0.32	<0.001	0.04	<0.001
Time	F	0.5	**17.2**	**5.18**	**21.99**	**55.35**		3.81	**4.21**	**17.16**
	p	0.48	**<0.001**	**0.02**	**<0.001**	**<0.001**		0.05	**0.04**	**<0.001**
Zone	F	2.39	1.56	3.89	**4.24**	2.28		2.62		0.18
	p	0.13	0.21	0.05	**0.04**	0.13		0.11		0.68
Depth	F		0.71	2.51	**5.21**	2.83		**156.10**		**6.53**
	p		0.41	0.12	**0.02**	0.09		**<0.001**		**0.01**
Time x Zone	F					2.61				
	p					0.11				

		HC	SC	MA	HA	TA	CCA	OT	AH	AM
Time x Depth	F					1.61				
	p					0.21				
Zone x Depth	F		**23.18**			**4.55**				
	p		**<0.001**			**0.04**				
Time x Zone x Depth	F					2.68				
	p					0.1				

Table 4.3.1.1. Results of linear model analysis testing the differences in the benthic community in **Berau Bay MPA** between management zones, with site as a random factor. HC: Hard coral, SC: Soft coral, MA: Macroalgae, HA: Halimeda, TA: Turf algae, OT: Other, AH: Abiotic hard, AM: Abiotic mobile. Significant results are shown in bold.

Baseline		**HC**	**SC**	**MA**	**HA**	**TA**	**CCA**	**OT**	**AH**	**AM**
Model (Zone)	R^2	-0.02	0.01	0.03	0.03	0.06	-0.005	0.06	0.08	-0.002
	F	0.09	1.58	2.13	2.36	3.77	0.77	3.68	**4.49**	0.89
	p	0.76	0.22	0.15	0.13	0.06	0.39	0.06	**0.04**	0.35

Table 4.3.2.1. Results of linear model analysis testing the differences in the benthic community in **Nusalasi van den Bosch Bay MPA** between management zones and depths, with site as a random factor. HC: Hard coral, SC: Soft coral, MA: Macroalgae, HA: Halimeda, TA: Turf algae, OT: Other, AH: Abiotic hard, AM: Abiotic mobile.

Baseline		**HC**	**SC**	**MA**	**HA**	**TA**	**CCA**	**OT**	**AH**	**AM**
Model	R^2	0.01	0.03	0.05	-0.01	0.04	0.05	0.16	0.12	0.003
	F	1.74	2.61	3.35	0.28	3.3	3.89	10.57	7.66	1.15
	p	0.16	0.05	0.02	0.84	0.02	0.01	<0.001	<0.001	0.33
Zone	F	2.22	**0.04**	0.78	0.17	**8.81**	**5.87**	**19.57**	**20.23**	0.67
	p	0.14	**0.046**	0.38	0.68	**0.003**	**0.02**	**<0.001**	**<0.001**	0.42
Depth	F	0.001	3.33	**8.64**	0.13	0.53	**5.14**	**5.99**	0.69	1.51
	p	0.97	0.07	**0.004**	0.72	0.47	**0.02**	**0.02**	0.41	0.22
Zone x Depth	F	2.99	0.49	0.63	0.52	0.57	0.65	**6.15**	2.06	1.26
	p	0.09	0.49	0.43	0.47	0.45	0.42	**0.01**	0.15	0.26

8.3 APPENDIX III – ANALYSIS RESULTS OF FISH COMMUNITIES

Table 4.1.1.2. Results of linear model analysis testing the differences in target and non-target fish families in **Ay-Rhun MPA** between management zones, with site as a random factor. Target and non-target species were tested separately.

	Target			Non-Target		
	R^2	F	p	R^2	F	p
Biomass	0.04	3.24	0.04	0.02	2.31	0.1
Density	0.03	2.82	0.06	-0.01	0.38	0.68

Table 4.1.2.2. Results of linear model analysis testing the differences in target and non-target fish families in **Buano MPA** between management zones, with site as a random factor. Target and non-target species were tested separately.

	Target			Non-Target		
	R^2	F	p	R^2	F	p
Biomass	-0.02	0.23	0.63	-0.02	0.21	0.65
Density	-0.02	0.27	0.61	-0.02	0.18	0.68

Table 4.1.3.3. Results of linear model analysis testing the differences in target fish families in **Koon MPA** between survey periods (2016, 2018, 2020) and management zones, with site as a random factor. Target and non-target species were tested separately. Significant results are shown in bold.

		R^2	F	p
Biomass	Model	0.09	7.70	<0.001
	Time		1.96	0.16
	Zone		**15.69**	**<0.001**
	Time x Zone		2.58	0.08
Density	Model	0.06	4.92	<0.001
	Time		**7.19**	**0.007**
	Zone		**8.68**	**<0.001**
	Time x Zone		0.03	0.97

Table 4.1.4.3. Results of linear model analysis testing the differences in target fish families in **Lease MPA** between survey periods and management zones, with site as a random factor. Target and non-target species were tested separately. Significant results are shown in bold.

		R^2	F	p
Biomass	Model	0.07	5.47	0.001
	Time		**35.02**	**0.02**
	Zone		**9.43**	**0.002**
	Time x Zone		1.82	0.18
Density	Model	0.05	4.02	0.008

		R^2	F	p
	Time		**4.03**	**0.046**
	Zone		**7.61**	**0.006**
	Time x Zone		0.43	0.52

Table 4.1.5.3. Results of linear model analysis testing the differences in target fish families in **Serutbar MPA** between survey periods and management zones, with site as a random factor. Target and non-target species were tested separately. Significant results are shown in bold.

		R^2	F	p
Biomass	Model	0.38	26.4	<0.001
	Time		**125.80**	**<0.001**
	Zone		2.73	0.07
	Time x Zone		0.38	0.69
Density	Model	0.06	3.60	0.004
	Time		**5.49**	**0.02**
	Zone		**5.14**	**0.007**
	Time x Zone		1.20	0.34

Table 4.1.5.6. Results of linear model analysis testing the differences in target and non-target fish families in **Guraici MPA** between survey periods and management zones, with site as a random factor. Target and non-target species were tested separately. Significant results are shown in bold.

		Target			Non-Target		
		R^2	F	p	R^2	F	p
Biomass	Model	0.02	2.00	0.08	0.47	36.19	<0.001
	Time		0.39	0.53		**152.21**	**<0.001**
	Zone		**3.21**	**0.04**		**13.84**	**<0.001**
	Time x Zone		1.59	0.21		0.52	0.59
Density	Model	0.07	3.96	0.002	0.16	8.84	<0.001
	Time		**11.77**	**0.001**		**22.07**	**<0.001**
	Zone		**3.94**	**0.02**		**10.64**	**<0.001**
	Time x Zone		0.07	0.93		0.41	0.66

Table 4.2.2.2. Results of linear model analysis testing the differences in target and non-target fish families in **Makian-Moti MPA** between management zones, with site as a random factor. Target and non-target species were tested separately.

	Target			Non-Target		
	R^2	F	p	R^2	F	p
Biomass	-0.01	0.61	0.55	0.03	1.93	0.15
Density	0.00	1.01	0.37	**0.10**	**4.70**	**0.01**

Table 4.1.5.6. Results of linear model analysis testing the differences in target and non-target fish families in **Mare MPA** between survey periods and management zones, with site as a random factor. Target and non-target species were tested separately. Significant results are shown in bold.

		Target			Non-Target		
		R^2	F	p	R^2	F	p
Biomass	Model	0.19	7.42	<0.001	0.003	1.10	0.37
	Time		**21.06**	**<0.001**		0.33	0.56
	Zone		1.72	0.18		1.86	0.16
	Time x Zone		**6.29**	**0.002**		0.71	0.49
Density	Model	0.40	19.07	<0.001	0.19	7.27	<0.001
	Time		**77.15**	**<0.001**		**8.71**	**0.004**
	Zone		**3.39**	**0.04**		**11.45**	**<0.001**
	Time x Zone		**5.70**	**0.004**		2.38	0.09

Table 4.1.5.6. Results of linear model analysis testing the differences in target fish families in **Rao-Dehegila MPA** between survey periods and management zones, with site as a random factor. Target and non-target species were tested separately. Significant results are shown in bold.

		R^2	F	p
Biomass	Model	0.18	12.25	<0.001
	Time		**19.11**	**<0.001**
	Zone		**14.04**	**<0.001**
	Time x Zone		3.60	0.06
Density	Model	0.04	3.41	0.02
	Time		**4.00**	**0.047**
	Zone		**6.04**	**0.02**
	Time x Zone		0.20	0.66

Table 4.1.5.6. Results of linear model analysis testing the differences in target and non-target fish families in **Sula MPA** between survey periods and management zones, with site as a random factor. Target and non-target species were tested separately. Significant results are shown in bold.

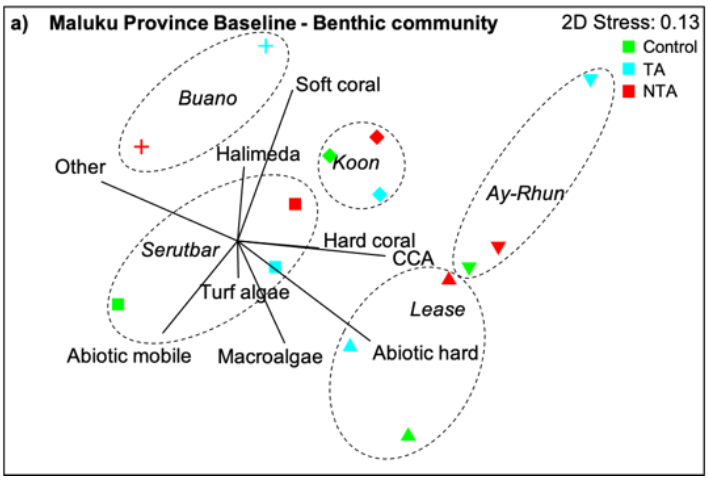
		R^2	F	p
Biomass	Model	0.41	17.24	<0.001
	Time		**50.93**	**<0.001**
	Zone		0.11	0.75
	Time x Zone		0.68	0.41
Density	Model	-0.01	0.80	0.50
	Time		0.63	0.43
	Zone		0.45	0.51
	Time x Zone		1.31	0.26

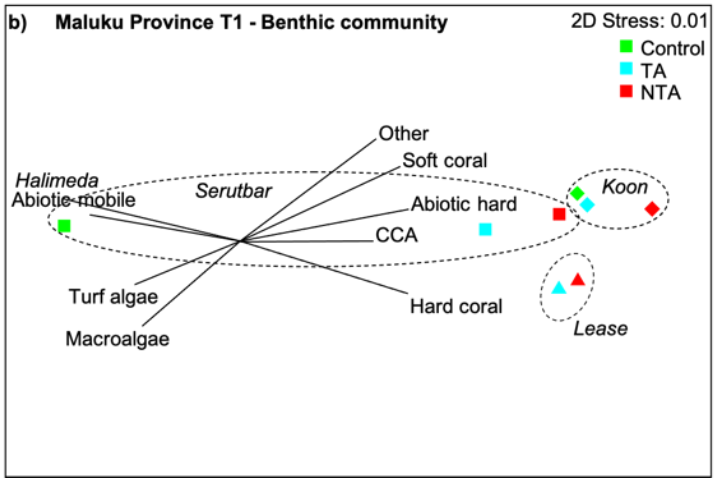
Table 4.1.5.6. Results of linear model analysis testing the differences in target and non-target fish families in **Widi MPA** between survey periods and management zones, with site as a random factor. Target and non-target species were tested separately. Significant results are shown in bold.

		Target			Non-Target		
		R^2	F	p	R^2	F	p
Biomass	Model	-0.01	0.69	0.81	0.14	8.37	<0.001
	Time		0.06	0.81		**25.09**	**<0.001**
	Zone		1.56	0.21		0.001	0.98
	Time x Zone		0.45	0.50		0.03	0.87
Density	Model	0.04	2.79	0.04	0.02	1.79	0.15
	Time		**7.89**	**0.006**		3.45	0.07
	Zone		0.22	0.64		1.89	0.17
	Time x Zone		0.25	0.62		0.04	0.84

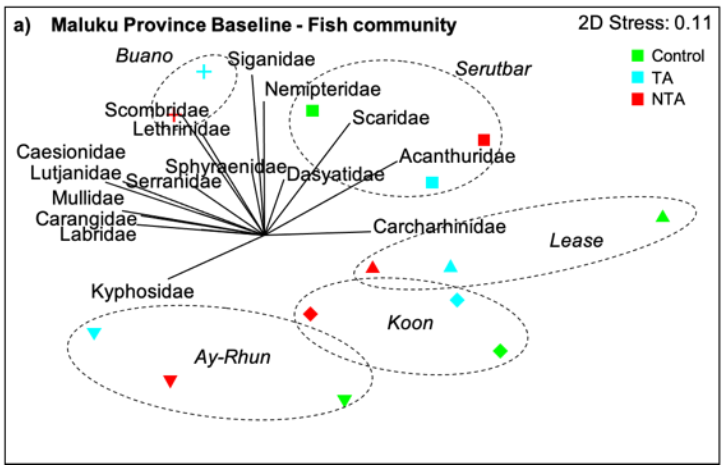
8.4 APPENDIX IV – MULTIVARIATE ANALYSIS PLOTS

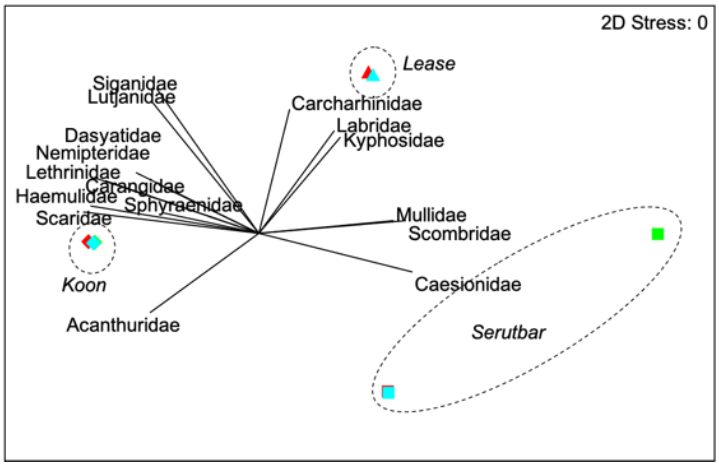
How to read the MDS plots: These plots were created through an analysis called Multidimensional Scaling (MDS), which shows the similarities and differences between sites or MPAs by calculating a matrix of similarities using all variables (benthic categories or fish families). The colored symbols are the zones within each MPA (circled and labelled with the MPA name; see legend). Symbols close together have similar benthic or fish community composition; those further apart have different benthic or fish communities. The vectors (lines in the graphs arranges as a star shape) represent the different benthic categories or fish families and show which are more abundant in different MPAs. Long vectors have a larger influence in showing differences between MPAs, which shorter vectors have a smaller influence. MPAs with higher proportions of certain benthic categories or fish families are arranged on the side of the plot where the corresponding vector is pointing.



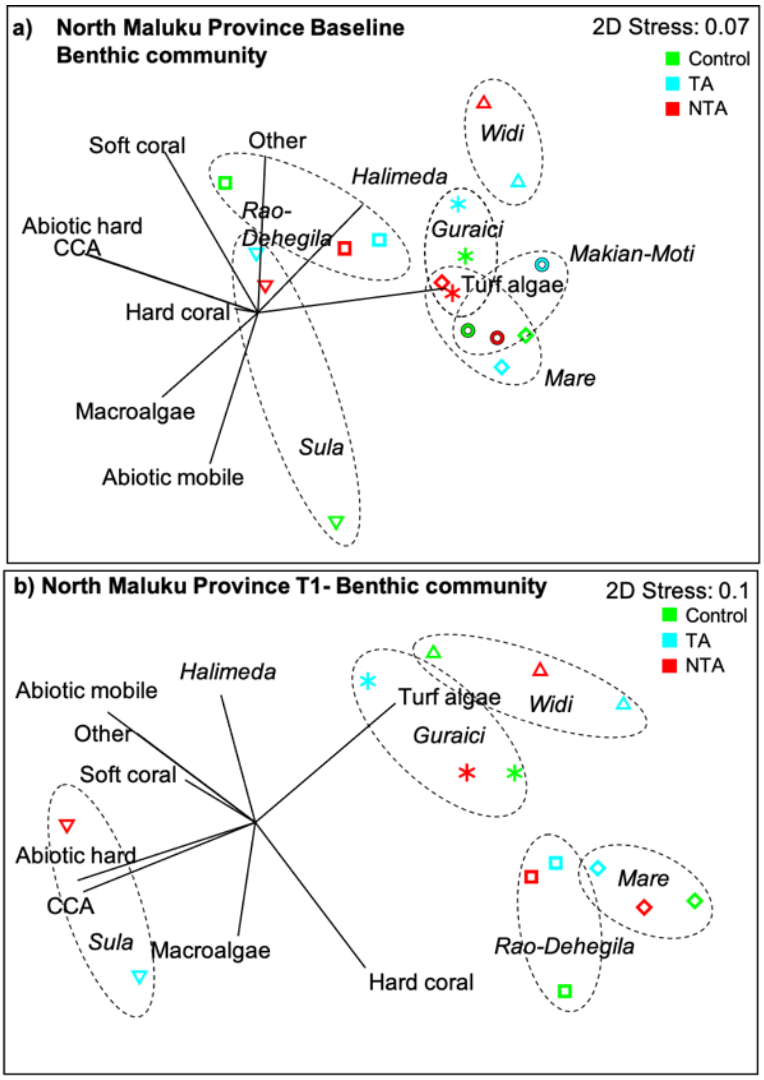


Maluku Province. Non-metric multidimensional scaling (MDS) plot of benthic community composition across the MPA zones in Maluku Province a) recorded during baseline surveys and b) recorded at T1. The MDS was conducted on the Bray-Curtis similarity matrix of the log (x+1) transformed data. Dots are average values for each zone within each MPA. MPAs are shown with dashed lines containing the means for control (where available), TA and NTA zones.

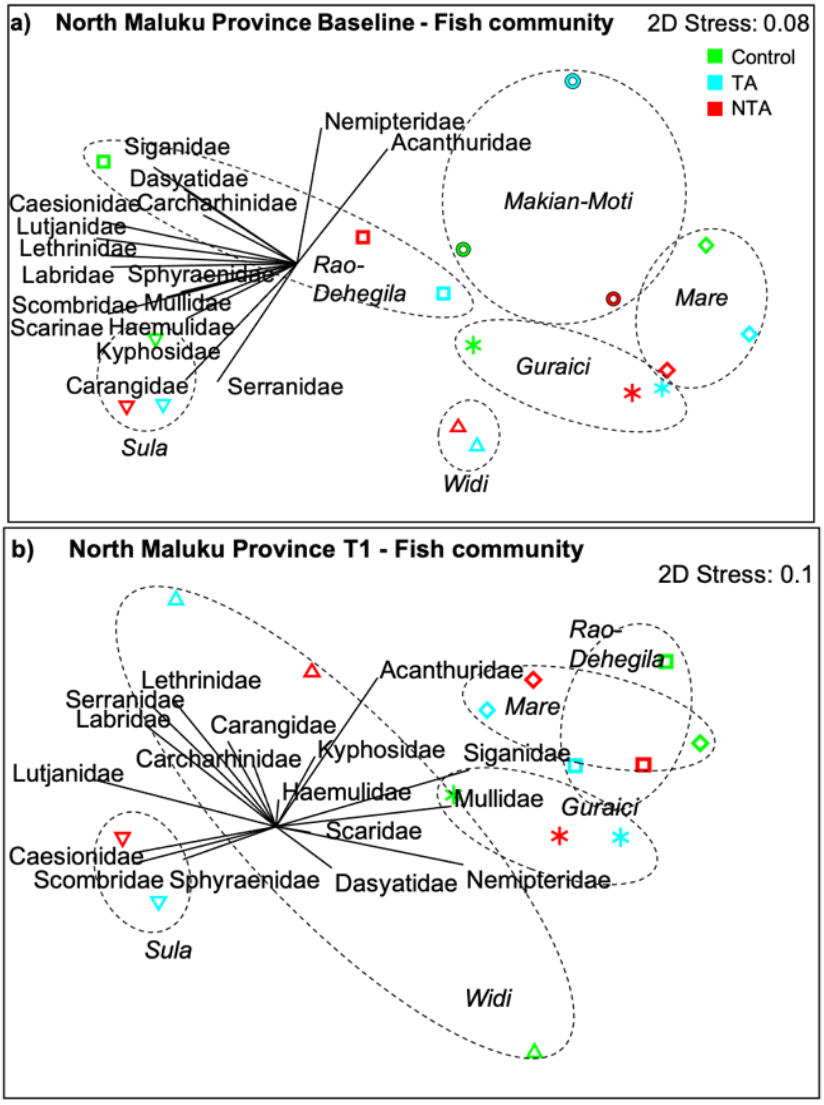




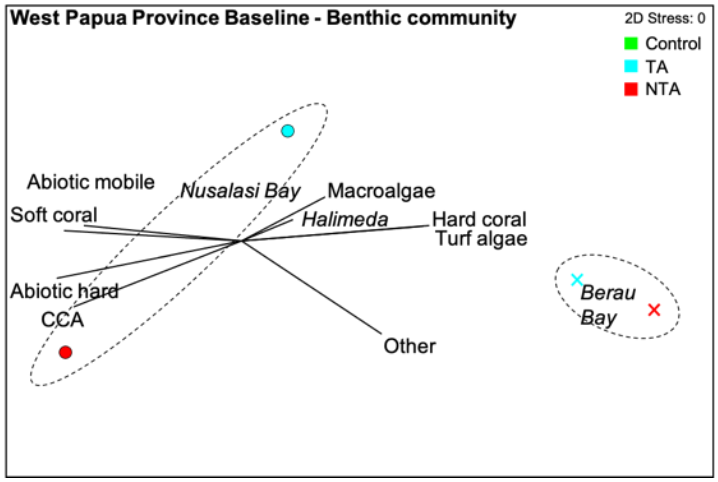
Maluku Province. Non-metric multidimensional scaling (MDS) plot of fish community composition across the MPA zones in Maluku Province a) recorded during baseline surveys and b) recorded at T1. The vectors show individual families making up the target species dataset. The MDS was conducted on the Bray-Curtis similarity matrix of the log (x+1) transformed data. Dots are average values for each zone within each MPA. MPAs are shown with dashed lines containing the means for control (where available), TA and NTA zones.



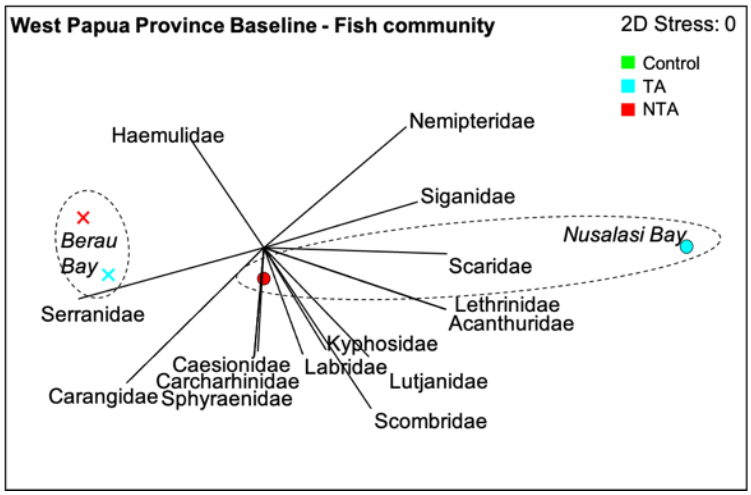
North Maluku Province. Non-metric multidimensional scaling (MDS) plot of benthic community composition across the MPA zones in North Maluku Province a) recorded during baseline surveys and b) recorded at T1. The MDS was conducted on the Bray-Curtis similarity matrix of the log (x+1) transformed data. Dots are average values for each zone within each MPA. MPAs are shown with dashed lines containing the means for control (where available), TA and NTA zones. Note: T1 surveys for Makian-Moti MPA included only one site; this MPA was excluded for the MDS.



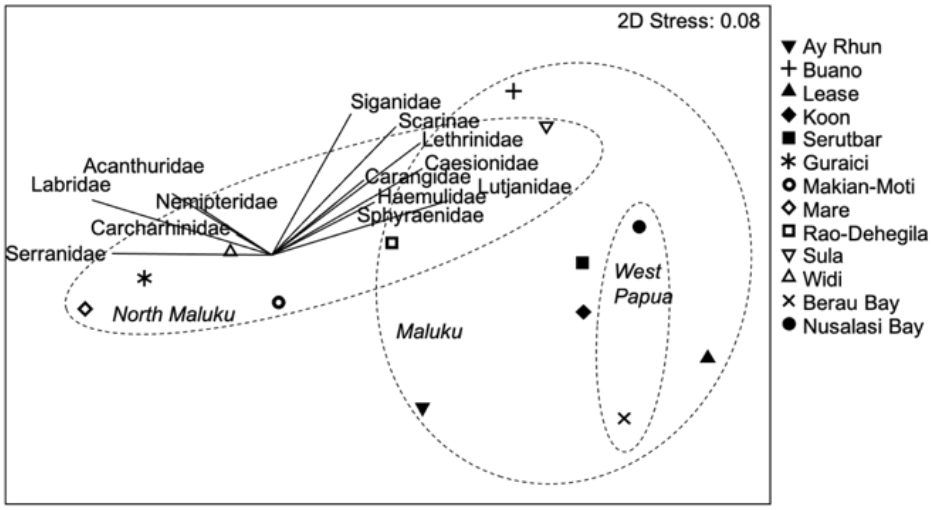
North Maluku Province. Non-metric multidimensional scaling (MDS) plot of fish community composition across the MPA zones in North Maluku Province a) recorded during baseline surveys and b) recorded at T1. The vectors show individual families making up the target species dataset. The MDS was conducted on the Bray-Curtis similarity matrix of the log (x+1) transformed density data. Dots are average values for each zone within each MPA. MPAs are shown with dashed lines containing the means for control (where available), TA and NTA zones. Makian-Moti was represented by only 1 site during T1 surveys, and was therefore excluded from T1 analysis.

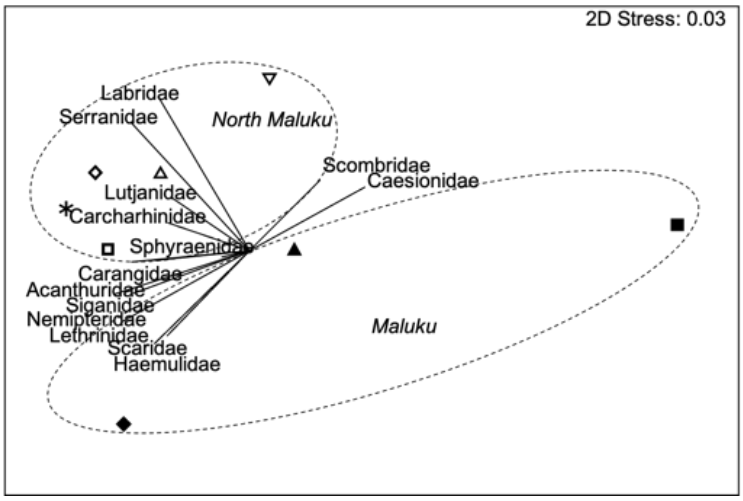


West Papua Province. Non-metric multidimensional scaling (MDS) plot of benthic community composition across the MPA zones in West Papua Province recorded during baseline surveys. The MDS was conducted on the Bray-Curtis similarity matrix of the log (x+1) transformed data. Dots are average values for each zone within each MPA. MPAs are shown with dashed lines containing the means for control (where available), TA and NTA zones.



West Papua Province. Non-metric multidimensional scaling (MDS) plot of fish community composition across the MPA zones in West Papua Province recorded during baseline surveys. The vectors show individual families making up the target species dataset. The MDS was conducted on the Bray-curtis similarity matrix of the log (x+1) transformed data. Dots are average values for each zone within each MPA. MPAs are shown with dashed lines containing the means for TA and NTA zones.





Province Comparison. Non-metric multidimensional scaling (MDS) plot of fish community composition across the MPAs in Maluku, North Maluku and West Papua Provinces recorded during baseline surveys (top panel) and T1 (bottom panel). The vectors show individual families that were included in surveys by all NGOs. The MDS was conducted on the Bray-Curtis similarity matrix of the log (x+1) transformed data. Dotes are average values for each MPA. Provinces are shown with dashed lines containing the means for MPAs.

8.5 APPENDIX V – AVERAGE PERCENT COVER OF BENTHIC PER SAMPLING SITE

MPA	SITE-ID	NTA/TA	Hard-coral	Soft-coral	Macroalgae	Halimeda	Turf-algae	CCA	Other	Abiotic-hard	Abiotic-mobile
Ay-Rhun	ARU01	NTA	50	14	1	-	0	7	2	14	13
Ay-Rhun	ARU02	TA	61	10	1	1	0	9	3	12	4
Ay-Rhun	ARU03	TA	64	13	-	3	-	8	4	5	4
Ay-Rhun	ARU04	NTA	55	9	-	2	1	5	6	7	17
Ay-Rhun	ARU05	Control	44	11	-	2	0	9	4	13	18
Ay-Rhun	ARU06	Control	69	4	0	-	-	1	9	9	9
Ay-Rhun	ARU07	Control	39	3	15	-	1	-	1	3	38
Ay-Rhun	ARU08	Control	11	5	0	-	0	-	24	29	30
Ay-Rhun	ARU09	Control	69	1	2	-	-	8	2	15	4
Ay-Rhun	ARU10	Control	31	15	2	-	0	6	8	24	14
Ay-Rhun	ARU11	Control	53	16	1	-	1	-	6	16	8
Ay-Rhun	ARU12	Control	35	13	1	0	0	2	3	10	36
Ay-Rhun	ARU13	Control	25	34	-	-	0	2	7	7	26
Ay-Rhun	ARU14	Control	31	31	-	1	0	11	3	8	15
Ay-Rhun	ARU15	Control	30	6	-	-	-	10	3	34	17
Ay-Rhun	ARU16	Control	70	6	-	-	-	7	3	7	7
Ay-Rhun	ARU17	Control	47	9	4	-	3	14	6	13	6
Ay-Rhun	ARU18	Control	44	22	1	-	1	12	4	11	6
Ay-Rhun	ARU19	Control	24	12	2	-	1	10	12	27	14
Ay-Rhun	ARU20	Control	36	7	-	-	-	3	12	13	31
Ay-Rhun	ARU21	TA	41	29	-	0	1	7	13	8	3
Ay-Rhun	ARU22	TA	49	18	1	0	0	11	11	5	6
Ay-Rhun MPA			44.34	12.94	1.27	0.39	0.43	6.43	6.51	13.05	14.64
Buano	BUA01	TA	43	6	0	0	0	1	18	3	29
Buano	BUA02	NTA	54	9	1	6	2	-	14	2	14
Buano	BUA03	TA	66	19	-	-	1	-	1	1	13
Buano	BUA04	TA	23	49	-	-	3	2	10	5	9
Buano	BUA05	TA	50	23	-	0	2	0	3	5	17
Buano	BUA06	NTA	40	1	-	-	0	-	2	0	57
Buano	BUA07	NTA	41	10	-	0	1	7	28	12	2
Buano	BUA08	TA	24	35	-	-	4	-	5	1	31
Buano	BUA09	NTA	46	13	1	1	1	1	22	7	8
Buano	BUA10	TA	12	11	0	0	3	-	6	1	67
Buano MPA			39.85	17.55	0.25	0.67	1.62	1.10	10.73	3.72	24.52
Koon	KOE01	NTA	23	37	0	0	1	4	13	14	8
Koon	KOE02	NTA	25	26	-	-	0	2	10	11	26
Koon	KOE03	NTA	29	30	-	0	2	2	5	5	27
Koon	KOE04	Control	43	17	0	0	4	0	2	9	23
Koon	KOE05	TA	19	12	0	0	2	3	7	20	38
Koon	KOE06	TA	40	12	-	0	1	1	11	7	28
Koon	KOE07	TA	41	22	0	0	1	3	7	11	13
Koon	KOE08	TA	19	20	-	-	0	2	9	15	35
Koon	KOE09	TA	53	11	1	-	-	1	5	11	18
Koon	KOE10	TA	53	8	0	0	1	3	8	17	11

MPA	SITE-ID	NTA/TA	Hard-coral	Soft-coral	Macroalgae	Halimeda	Turf-algae	CCA	Other	Abiotic-hard	Abiotic-mobile
Koon	KOE11	Control	59	8	0	0	1	0	5	6	19
Koon	KOE14	NTA	38	30	1	1	1	5	10	8	7
Koon	KOE15	TA	42	20	0	0	0	4	13	8	12
Koon	KOE16	Control	30	2	-	-	0	-	9	10	49
Koon	KOE17	Control	32	19	-	0	2	3	10	10	24
Koon	KOE18	Control	34	10	-	-	1	1	13	12	29
Koon	KOE20	Control	8	24	1	0	2	2	4	19	38
Koon	KOE21	Control	20	14	1	-	1	3	4	12	46
Koon	KOE23	Control	33	31	0	0	1	1	10	13	9
Koon	KOE24	Control	42	12	0	1	2	1	10	7	25
Koon	KOE25	NTA	32	26	-	0	0	3	8	17	13
Koon	KOE26	Control	26	7	-	-	6	2	2	13	43
Koon	KOE27	NTA	11	16	0	-	1	0	6	14	52
Koon	KOE29	Control	24	15	0	-	4	1	4	8	43
Koon MPA			33.01	19.14	0.25	0.20	1.32	2.28	7.90	11.65	24.25
Lease	LH01	Control	29	1	1	-	3	3	4	14	46
Lease	LH02	TA	29	1	-	-	1	1	3	14	51
Lease	LH03	NTA	68	11	0	0	1	2	3	10	4
Lease	LH04	NTA	44	16	1	-	3	4	6	11	16
Lease	LH05	Control	46	8	0	-	2	3	5	16	19
Lease	LM01	NTA	59	19	1	-	1	1	5	7	7
Lease	LM02	TA	56	9	0	-	2	2	2	7	21
Lease	LN01	TA	40	6	0	-	0	1	5	6	41
Lease	LN02	NTA	53	9	1	0	0	1	1	9	26
Lease	LN03	TA	42	15	1	-	0	2	2	10	28
Lease	LN04	NTA	47	23	1	-	2	4	7	10	5
Lease	LN05	TA	61	9	1	-	2	2	4	8	13
Lease	LN06	NTA	62	7	-	-	2	2	3	9	15
Lease	LS01	TA	24	10	-	-	1	0	2	5	58
Lease	LS010	TA	47	11	-	-	1	1	2	13	26
Lease	LS011	TA	29	17	3	-	3	2	4	12	28
Lease	LS012	NTA	37	13	1	-	4	2	2	8	32
Lease	LS013	TA	58	9	1	-	-	-	3	6	24
Lease	LS02	TA	27	5	1	0	3	2	4	14	44
Lease	LS03	TA	14	-	1	-	0	-	2	4	81
Lease	LS04	TA	20	3	0	-	1	0	4	16	56
Lease	LS05	TA	42	4	8	1	1	3	5	10	27
Lease	LS06	TA	64	1	-	0	0	0	2	6	27
Lease	LS07	NTA	45	4	0	-	1	0	4	11	35
Lease	LS08	NTA	46	5	-	-	2	0	3	10	35
Lease	LS09	TA	41	6	1	-	1	1	5	13	32
Lease MPA			45.08	8.53	0.71	0.05	1.34	1.54	3.55	9.78	29.41
Serutbar	TSW01	Control	14	4	-	-	1	1	20	5	55
Serutbar	TSW03	Control	10	0	-	-	0	-	10	1	79
Serutbar	TSW06	TA	3	9	-	-	0	-	4	2	83
Serutbar	TSW07	TA	27	1	-	-	0	1	15	5	50

MPA	SITE-ID	NTA/TA	Hard-coral	Soft-coral	Macroalgae	Halimeda	Turf-algae	CCA	Other	Abiotic-hard	Abiotic-mobile
Serutbar	TSW08	TA	21	6	-	-	0	2	5	6	61
Serutbar	TSW09	NTA	39	32	0	-	0	2	11	5	10
Serutbar	TSW10	TA	36	6	-	-	0	1	16	6	34
Serutbar	TSW11	TA	52	10	0	0	0	2	4	7	25
Serutbar	TSW12	NTA	53	1	-	-	0	1	11	5	29
Serutbar	TSW13	NTA	25	39	0	-	-	3	24	2	7
Serutbar	TSW14	TA	12	18	0	0	5	0	5	5	55
Serutbar	TSW15	TA	17	12	2	-	9	-	14	0	46
Serutbar	TSW16	TA	27	32	-	-	0	1	2	3	34
Serutbar	TSW18	TA	17	31	0	1	5	2	5	11	28
Serutbar	TSW19	NTA	22	17	-	-	6	3	2	10	40
Serutbar	TSW20	TA	27	1	0	-	1	-	2	2	67
Serutbar	TSW21	TA	39	2	-	-	4	2	7	4	42
Serutbar	TSW22	NTA	19	9	-	0	0	1	4	5	62
Serutbar	TSW23	TA	12	23	0	-	-	1	5	5	53
Serutbar	TSW24	TA	26	12	0	-	1	0	1	4	56
Serutbar	TSW25	NTA	37	14	0	0	2	0	4	4	37
Serutbar	TSW31	TA	38	5	0	0	9	2	6	13	27
Serutbar	TSW32	NTA	56	11	0	-	1	0	6	6	19
Serutbar	TSW33	TA	37	1	0	0	4	4	5	3	45
Serutbar	TSW34	Control	52	5	1	8	2	2	3	3	24
Serutbar MPA			30.03	11.45	0.17	0.48	1.92	1.29	6.96	5.26	42.44
Guraici	GUR01	NTA	64	8	-	0	17	-	0	-	11
Guraici	GUR02	TA	18	27	-	1	12	-	7	-	35
Guraici	GUR03	NTA	59	2	-	-	6	-	3	-	30
Guraici	GUR04	TA	32	9	-	-	7	-	5	-	47
Guraici	GUR05	NTA	17	25	0	-	35	-	6	-	17
Guraici	GUR06	NTA	40	5	-	3	4	-	1	-	47
Guraici	GUR07	NTA	34	9	-	-	7	-	6	-	44
Guraici	GUR08	TA	34	26	1	0	6	-	7	0	27
Guraici	GUR09	TA	21	13	-	10	17	-	9	-	31
Guraici	GUR10	TA	22	19	0	3	10	-	11	-	36
Guraici	GUR11	NTA	30	5	0	0	11	-	9	1	44
Guraici	GUR12	NTA	38	8	0	0	21	-	8	-	25
Guraici	GUR13	TA	30	9	0	-	17	-	5	-	40
Guraici	GUR14	NTA	70	11	-	1	5	-	3	0	10
Guraici	GUR15	Control	49	9	0	0	10	-	8	-	24
Guraici	GUR16	Control	68	5	-	0	11	-	9	0	7
Guraici	GUR17	Control	49	4	0	-	16	-	14	-	17
Guraici	GUR18	NTA	55	6	-	-	20	-	10	-	10
Guraici	GUR19	NTA	47	15	-	0	12	-	4	-	22
Guraici	GUR20	NTA	49	6	0	0	10	-	3	0	33
Guraici	GUR21	NTA	59	2	0	3	7	-	5	0	24
Guraici	GUR22	NTA	53	7	0	5	9	-	7	0	19
Guraici	GUR23	NTA	72	4	-	-	7	-	3	-	14
Guraici	GUR24	NTA	40	1	0	-	13	-	3	-	44

MPA	SITE-ID	NTA/TA	Hard-coral	Soft-coral	Macroalgae	Halimeda	Turf-algae	CCA	Other	Abiotic-hard	Abiotic-mobile
Guraici MPA			42.21	10.02	0.12	1.18	12.19	0.00	6.31	0.09	27.87
Makian-Moti	MAK06	Control	70	-	-	1	13	-	5	-	12
Makian-Moti	MAK07	Control	52	-	-	0	23	-	9	0	16
Makian-Moti	MAK08	Control	46	15	0	-	10	-	7	-	22
Makian-Moti	MAK09	Control	71	0	1	1	11	-	8	-	7
Makian-Moti	MAK10	NTA	48	2	-	0	14	-	5	-	30
Makian-Moti	MAK11	NTA	29	5	0	0	24	-	9	-	32
Makian-Moti	MAK12	TA	64	2	-	3	12	-	7	-	12
Makian-Moti	MAK13	NTA	66	2	0	-	6	-	6	1	19
Makian-Moti	MOT01	Control	37	2	-	-	12	-	6	-	43
Makian-Moti	MOT02	Control	24	9	-	0	2	-	2	-	64
Makian-Moti	MOT03	Control	30	1	0	-	10	-	2	-	56
Makian-Moti	MOT04	Control	60	4	-	-	9	-	1	-	26
Makian-Moti	MOT05	NTA	61	1	0	1	12	-	1	-	25
Makian-Moti MPA			50.20	3.30	0.12	0.46	12.20	0.00	5.29	0.08	28.36
Mare	MAR01	Control	77	1	0	-	13	-	2	-	7
Mare	MAR02	Control	45	4	1	2	9	-	4	-	36
Mare	MAR03	Control	52	3	0	1	14	-	8	-	22
Mare	MAR04	TA	58	2	-	-	9	-	2	-	30
Mare	MAR05	NTA	73	3	-	-	12	-	2	-	10
Mare	MAR06	TA	48	5	0	-	26	-	6	-	15
Mare	MAR07	NTA	46	14	-	-	9	-	9	-	22
Mare	MAR08	NTA	51	18	0	0	7	-	5	-	19
Mare	MAR09	TA	62	3	-	-	15	-	2	-	18
Mare	MAR10	NTA	72	5	-	0	12	-	3	-	8
Mare	MAR11	NTA	28	7	-	0	10	-	3	-	52
Mare	MAR12	NTA	84	5	-	-	2	-	6	-	4
Mare	MAR13	NTA	72	8	-	-	5	-	12	-	3
Mare	MAR14	TA	49	10	0	-	4	-	4	-	33
Mare	MAR15	NTA	69	1	-	-	4	-	0	-	26
Mare MPA			57.64	5.96	0.13	0.25	11.19	0.00	4.37	0.00	20.47
Rao-Dehegila	MAR12	TA	44	17	0	-	10	-	6	-	24
Rao-Dehegila	RAO01	NTA	39	31	0	-	3	0	4	3	19
Rao-Dehegila	RAO02	Control	43	22	1	0	1	1	8	8	17
Rao-Dehegila	RAO03	TA	48	14	1	1	5	1	2	11	19
Rao-Dehegila	RAO04	TA	59	3	-	-	2	-	5	8	24
Rao-Dehegila	RAO05	TA	65	3	0	0	6	1	4	3	18
Rao-Dehegila	RAO06	TA	70	5	-	1	-	-	6	10	9
Rao-Dehegila	RAO07	NTA	66	18	1	0	3	-	5	1	6
Rao-Dehegila	RAO08	TA	41	13	-	3	1	0	4	3	35
Rao-Dehegila	RAO09	NTA	52	7	1	0	7	-	1	5	26
Rao-Dehegila	RAO10	NTA	51	13	3	2	6	-	4	5	18
Rao-Dehegila	RAO11	TA	19	18	2	2	3	-	2	5	50
Rao-Dehegila	RAO12	TA	59	26	1	-	0	2	3	7	3
Rao-Dehegila	RAO13	TA	53	5	1	2	10	-	6	-	24
Rao-Dehegila	RAO14	TA	41	7	-	17	10	-	12	-	13

MPA	SITE-ID	NTA/TA	Hard-coral	Soft-coral	Macroalgae	Halimeda	Turf-algae	CCA	Other	Abiotic-hard	Abiotic-mobile
Rao-Dehegila	RAO15	TA	32	3	1	11	12	-	6	-	36
Rao-Dehegila	RAO16	TA	53	7	1	1	10	-	5	-	23
Rao-Dehegila	RAO17	NTA	61	10	0	1	7	-	9	-	13
Rao-Dehegila	RAO18	TA	54	7	2	1	15	-	4	-	17
Rao-Dehegila	RAO19	TA	55	8	0	0	9	-	19	-	9
Rao-Dehegila	RAO20	TA	63	7	1	1	11	0	8	0	8
Rao-Dehegila	RAO21	TA	57	14	-	0	6	-	6	0	17
Rao-Dehegila	RAO22	NTA	57	4	0	0	23	-	13	0	2
Rao-Dehegila	RAO23	TA	64	2	2	1	15	-	11	-	5
Rao-Dehegila	RAO24	TA	54	14	1	0	11	-	7	-	14
Rao-Dehegila	RAO25	TA	44	34	0	2	4	-	4	-	12
Rao-Dehegila	RAO26	Control	62	9	6	-	11	-	5	-	8
Rao-Dehegila	RAO27	Control	65	8	3	-	11	-	3	-	9
Rao-Dehegila	RAO28	Control	66	7	3	-	17	-	3	0	5
Rao-Dehegila	RAO29	TA	54	19	1	-	5	-	18	-	4
Rao-Dehegila	RAO31	TA	50	27	0	-	7	-	2	-	14
Rao-Dehegila	RAO32	TA	48	18	1	-	14	-	7	-	12
Rao-Dehegila	RAO33	TA	64	1	5	-	14	-	4	-	14
Rao-Dehegila	RAO34	NTA	60	14	2	-	18	-	2	0	4
Rao-Dehegila	RAO35	NTA	43	33	1	-	12	-	2	0	9
Rao-Dehegila	RAO36	NTA	54	23	-	-	6	-	11	-	6
Rao-Dehegila MPA			53.66	12.44	0.98	1.11	8.49	0.14	6.29	2.02	14.86
Sula	SUL01	NTA	36	17	-	9	3	1	5	3	26
Sula	SUL02	TA	64	12	0	1	1	1	3	7	11
Sula	SUL03	TA	38	6	0	-	-	-	12	12	32
Sula	SUL04	NTA	55	7	0	-	1	2	7	8	20
Sula	SUL05	TA	63	2	1	-	1	2	3	9	20
Sula	SUL06	NTA	45	29	-	-	-	1	12	2	12
Sula	SUL07	NTA	50	1	0	-	1	0	9	6	33
Sula	SUL08	TA	33	3	-	0	-	0	9	9	45
Sula	SUL09	Control	30	2	2	-	1	-	0	-	67
Sula	SUL10	Control	64	2	0	-	-	-	-	-	34
Sula	SUL11	TA	29	29	1	-	1	2	9	6	23
Sula	SUL12	TA	52	15	-	-	1	0	2	0	31
Sula	SUL13	TA	44	39	-	-	0	1	8	6	2
Sula	SUL14	NTA	34	23	1	-	1	2	13	5	21
Sula	SUL15	NTA	41	14	2	-	3	3	7	9	23
Sula	SUL16	TA	41	4	2	-	5	2	8	3	35
Sula	SUL17	TA	40	14	1	0	1	1	5	7	31
Sula	SUL18	TA	47	32	1	-	2	6	3	6	5
Sula	SUL19	TA	29	2	-	-	3	1	7	12	48
Sula MPA			46.00	12.28	0.53	0.84	1.22	1.32	5.99	5.82	26.00
Widi	WID1	NTA	57	13	-	2	18	-	7	-	4
Widi	WID10	TA	63	1	-	1	26	-	-	-	9
Widi	WID11	NTA	28	42	0	1	9	-	13	-	8
Widi	WID12	TA	51	-	1	9	29	-	1	0	9

MPA	SITE-ID	NTA/TA	Hard-coral	Soft-coral	Macroalgae	Halimeda	Turf-algae	CCA	Other	Abiotic-hard	Abiotic-mobile
Widi	WID13	NTA	51	10	-	1	21	-	2	0	15
Widi	WID14	Control	35	26	-	0	11	-	4	-	24
Widi	WID15	Control	40	4	-	7	15	-	7	-	28
Widi	WID16	Control	26	19	1	2	17	-	10	-	26
Widi	WID2	NTA	38	25	-	4	15	-	5	-	12
Widi	WID3	NTA	20	32	-	0	14	-	22	-	11
Widi	WID4	TA	44	25	-	4	14	-	8	0	5
Widi	WID5	NTA	48	19	-	1	19	0	10	-	4
Widi	WID6	NTA	31	31	-	-	19	-	8	0	12
Widi	WID7	NTA	50	17	-	4	14	-	13	-	3
Widi	WID8	TA	48	15	0	1	23	-	8	-	5
Widi	WID9	NTA	67	11	0	-	14	-	7	0	2
Widi MPA			43.36	19.99	0.16	1.96	16.74	0.01	8.54	0.04	9.21
Berau Bay	BER01	TA	35	0	-	-	13	-	25	0	27
Berau Bay	BER02	TA	45	0	2	-	-	0	5	-	47
Berau Bay	BER03	NTA	41	5	7	-	13	5	18	-	11
Berau Bay	BER04	TA	31	4	2	1	8	7	39	1	7
Berau Bay	BER05	NTA	22	2	0	-	2	3	69	-	1
Berau Bay	BER06	TA	60	-	0	-	9	1	17	-	14
Berau Bay	BER07	NTA	54	-	0	-	14	-	10	-	21
Berau Bay	BER08	NTA	38	-	-	-	19	-	3	-	40
Berau Bay	BER09	NTA	30	2	3	0	16	-	16	-	34
Berau Bay	BER10	NTA	66	1	0	-	10	-	1	-	21
Berau Bay	BER11	NTA	61	4	-	-	7	-	3	-	25
Berau Bay	BER12	NTA	46	-	-	-	12	0	3	-	39
Berau Bay	BER13	TA	30	3	2	1	14	2	19	-	28
Berau Bay	BER14	TA	48	-	1	-	4	2	10	1	34
Berau Bay MPA			43.65	1.40	1.36	0.12	10.18	1.32	16.53	0.14	25.30
Nusalasi Bay	NUS15	TA	53	3	-	-	10	3	4	-	27
Nusalasi Bay	NUS16	TA	30	8	1	-	20	2	2	8	31
Nusalasi Bay	NUS17	TA	66	5	-	-	12	1	1	4	12
Nusalasi Bay	NUS18	NTA	44	0	0	0	1	-	1	1	52
Nusalasi Bay	NUS19	NTA	54	4	1	-	4	-	1	5	31
Nusalasi Bay	NUS20	TA	26	31	1	-	1	-	1	30	11
Nusalasi Bay	NUS21	TA	37	3	0	0	1	0	0	0	59
Nusalasi Bay	NUS22	NTA	19	10	1	0	22	4	6	16	24
Nusalasi Bay	NUS23	TA	25	1	3	-	5	1	1	-	64
Nusalasi Bay	NUS24	TA	28	3	8	1	17	1	2	-	41
Nusalasi Bay	NUS25	TA	62	0	4	-	7	4	1	0	23
Nusalasi Bay	NUS26	TA	19	1	6	0	22	8	2	7	37
Nusalasi Bay	NUS27	NTA	53	9	-	0	1	5	7	8	16
Nusalasi Bay	NUS28	NTA	23	7	2	-	9	10	5	20	25
Nusalasi Bay	NUS29	TA	67	1	0	-	5	3	1	-	22
Nusalasi Bay	NUS30	TA	40	19	-	-	5	4	4	7	21
Nusalasi Bay	NUS31	NTA	45	10	1	-	5	4	3	5	28
Nusalasi Bay	NUS32	NTA	58	7	1	-	-	1	2	3	29

MPA	SITE-ID	NTA/TA	Hard-coral	Soft-coral	Macroalgae	Halimeda	Turf-algae	CCA	Other	Abiotic-hard	Abiotic-mobile
Nusalasi Bay	NUS33	NTA	21	13	-	-	1	7	2	21	36
Nusalasi Bay	NUS34	NTA	40	8	0	-	0	2	3	9	38
Nusalasi Bay	NUS35	NTA	27	11	4	-	4	3	3	26	22
Nusalasi Bay	NUS36	NTA	12	2	11	0	5	5	4	33	29
Nusalasi Bay	NUS37	NTA	52	1	0	-	-	0	7	4	36
Nusalasi Bay	NUS38	NTA	22	16	0	-	6	8	5	25	19
Nusalasi Bay	NUS39	NTA	22	7	-	-	2	6	5	3	56
Nusalasi Bay MPA			37.76	7.00	1.68	0.09	6.50	3.30	2.86	9.27	31.54

8.6 APPENDIX VI – LIST OF FISH SPECIES FOUND IN MPA

Group	Fish Family	Fish Species	Ay Rhun	Buano	Koon	Lease	Serutbar	Guraici	Makian Moti	Mare	Rao Dehegila	Sula	Widi	Beru Bay	Nusalasi Bay
Target	Acanthuridae	*Acanthurus achilles*	-	-	-	-	-	-	✓	-	✓	-	-	-	-
Target	Acanthuridae	*Acanthurus albipectoralis*	-	-	-	-	-	✓	-	-	-	-	-	-	-
Target	Acanthuridae	*Acanthurus auranticavus*	-	✓	✓	-	✓	✓	✓	✓	✓	✓	✓	✓	✓
Target	Acanthuridae	*Acanthurus bariene*	-	-	✓	-	✓	-	-	✓	✓	-	✓	-	-
Target	Acanthuridae	*Acanthurus blochii*	-	-	✓	-	✓	✓	✓	-	✓	✓	✓	-	-
Target	Acanthuridae	*Acanthurus dussumieri*	-	-	-	-	✓	✓	-	✓	✓	-	✓	-	-
Target	Acanthuridae	*Acanthurus fowleri*	-	✓	✓	✓	✓	-	-	✓	✓	-	-	-	-
Target	Acanthuridae	*Acanthurus grammoptilus*	-	-	✓	-	✓	✓	✓	✓	-	-	✓	-	-
Target	Acanthuridae	*Acanthurus guttatus*	-	-	-	-	-	✓	✓	-	✓	-	-	-	-
Target	Acanthuridae	*Acanthurus japonicus*	-	-	✓	-	-	-	-	-	-	-	-	-	-
Target	Acanthuridae	*Acanthurus leucocheilus*	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	-	-
Target	Acanthuridae	*Acanthurus lineatus*	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	-	✓
Target	Acanthuridae	*Acanthurus maculiceps*	-	-	✓	-	-	✓	✓	✓	✓	-	✓	-	-
Target	Acanthuridae	*Acanthurus mata*	-	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	-	-
Target	Acanthuridae	*Acanthurus nigricans*	✓	-	✓	-	-	✓	✓	✓	✓	-	✓	-	-
Target	Acanthuridae	*Acanthurus nigricauda*	-	-	✓	✓	✓	✓	✓	✓	✓	-	✓	-	-
Target	Acanthuridae	*Acanthurus nigrofuscus*	-	-	✓	✓	✓	✓	✓	✓	✓	-	✓	-	✓
Target	Acanthuridae	*Acanthurus nigroris*	-	-	✓	-	-	-	-	✓	✓	-	-	-	-
Target	Acanthuridae	*Acanthurus nubilus*	-	-	✓	-	-	✓	-	✓	✓	-	✓	-	-
Target	Acanthuridae	*Acanthurus olivaceus*	-	✓	✓	✓	✓	✓	✓	✓	-	✓	✓	-	✓
Target	Acanthuridae	*Acanthurus pyroferus*	✓	-	✓	✓	✓	✓	✓	✓	✓	✓	✓	-	-
Target	Acanthuridae	*Acanthurus spp.*	✓	-	✓	✓	-	-	-	-	-	✓	-	✓	✓
Target	Acanthuridae	*Acanthurus tennenti*	-	-	-	-	-	-	✓	-	-	-	-	-	-
Target	Acanthuridae	*Acanthurus tennentii*	-	-	-	-	-	-	✓	-	-	-	✓	-	-
Target	Acanthuridae	*Acanthurus thompsoni*	-	✓	✓	-	✓	✓	✓	✓	✓	-	✓	-	-
Target	Acanthuridae	*Acanthurus triostegus*	-	-	✓	-	-	✓	✓	✓	✓	-	✓	-	-
Target	Acanthuridae	*Acanthurus tristis*	-	-	✓	-	✓	✓	✓	✓	✓	-	✓	-	-
Target	Acanthuridae	*Acanthurus xanthopterus*	-	✓	✓	-	✓	-	-	✓	✓	✓	-	-	-
Target	Acanthuridae	*Ctenochaetus binotatus*	-	-	✓	-	✓	✓	✓	✓	✓	-	✓	-	-
Target	Acanthuridae	*Ctenochaetus cyanocheilus*	-	-	✓	-	✓	✓	✓	✓	✓	-	✓	-	-
Target	Acanthuridae	*Ctenochaetus marginatus*	-	-	-	-	-	✓	-	✓	✓	-	✓	-	-
Target	Acanthuridae	*Ctenochaetus striatus*	✓	-	✓	✓	✓	✓	✓	✓	✓	-	✓	-	-
Target	Acanthuridae	*Ctenochaetus strigosus*	-	-	-	-	-	✓	-	-	-	-	-	-	-
Target	Acanthuridae	*Ctenochaetus tominiensis*	-	-	✓	-	✓	✓	✓	✓	✓	-	✓	-	-

Group	Fish Family	Fish Species	Ay Rhun	Buano	Koon	Lease	Serutbar	Guraici	Makian Moti	Mare	Rao Dehegila	Sula	Widi	Berau Bay	Nusalasi Bay
Target	Acanthuridae	*Naso annulatus*	✓	-	✓	-	-	✓	-	✓	✓	✓	-	-	✓
Target	Acanthuridae	*Naso brachycentron*	-	-	✓	-	✓	-	-	-	✓	✓	-	-	-
Target	Acanthuridae	*Naso brevirostris*	-	✓	✓	-	✓	✓	✓	✓	✓	✓	✓	-	-
Target	Acanthuridae	*Naso caeruleacauda*	-	-	✓	-	✓	✓	✓	✓	✓	-	✓	-	-
Target	Acanthuridae	*Naso caesius*	-	✓	✓	-	-	-	-	✓	✓	✓	-	-	-
Target	Acanthuridae	*Naso elegans*	-	-	-	-	✓	✓	-	✓	✓	-	✓	-	-
Target	Acanthuridae	*Naso hexacanthus*	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	-	✓
Target	Acanthuridae	*Naso lituratus*	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	-	-
Target	Acanthuridae	*Naso lopezi*	✓	✓	✓	✓	✓	✓	-	-	-	✓	-	-	✓
Target	Acanthuridae	*Naso minor*	-	✓	-	✓	-	✓	-	✓	✓	✓	✓	-	✓
Target	Acanthuridae	*Naso spp.*	✓	-	-	✓	-	-	-	-	-	✓	-	-	✓
Target	Acanthuridae	*Naso thynnoides*	-	✓	✓	-	✓	✓	✓	✓	✓	✓	✓	-	-
Target	Acanthuridae	*Naso tuberosus*	-	-	✓	-	-	-	-	-	-	-	-	-	-
Target	Acanthuridae	*Naso unicornis*	✓	✓	✓	-	-	✓	✓	✓	✓	✓	-	-	-
Target	Acanthuridae	*Naso vlamingii*	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	-	-
Target	Acanthuridae	*Paracanthurus hepatus*	-	-	-	-	✓	✓	-	✓	✓	-	✓	-	-
Target	Acanthuridae	*Zebrasoma flavescens*	-	-	-	-	-	✓	-	✓	✓	-	-	-	-
Target	Acanthuridae	*Zebrasoma scopas*	✓	-	✓	✓	✓	✓	✓	✓	✓	✓	✓	-	-
Target	Acanthuridae	*Zebrasoma veliferum*	-	-	✓	-	✓	✓	✓	✓	✓	-	✓	-	-
Target	Caesionidae	*Caesio caerulaurea*	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	-	-
Target	Caesionidae	*caesio cuning*	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Target	Caesionidae	*Caesio lunaris*	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	-	✓
Target	Caesionidae	*Caesio spp.*	-	-	✓	✓	-	-	-	-	-	-	-	✓	✓
Target	Caesionidae	*Caesio teres*	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	-	✓
Target	Caesionidae	*Caesio xanthonota*	-	-	-	-	-	-	-	✓	✓	✓	-	-	-
Target	Caesionidae	*Dipterygonotus balteatus*	-	-	✓	-	-	-	-	-	-	-	-	-	-
Target	Caesionidae	*Pterocaesio chrysozona*	-	✓	✓	-	✓	✓	-	✓	✓	-	✓	-	-
Target	Caesionidae	*Pterocaesio digramma*	-	✓	✓	✓	✓	✓	✓	✓	✓	-	✓	-	-
Target	Caesionidae	*Pterocaesio lativittata*	-	-	-	-	✓	-	-	-	-	-	-	-	-
Target	Caesionidae	*Pterocaesio marri*	✓	-	✓	-	✓	✓	✓	✓	✓	✓	-	-	✓
Target	Caesionidae	*pterocaesio pisang*	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	-	✓
Target	Caesionidae	*Pterocaesio randalli*	-	-	✓	-	✓	✓	-	✓	✓	✓	✓	-	-
Target	Caesionidae	*Pterocaesio spp.*	-	-	✓	-	-	-	-	-	-	✓	-	-	-
Target	Caesionidae	*Pterocaesio tessellata*	-	-	✓	-	✓	-	-	-	✓	✓	-	-	-
Target	Caesionidae	*Pterocaesio tessellata*	-	-	✓	-	✓	✓	-	✓	✓	-	✓	-	-
Target	Caesionidae	*Pterocaesio tile*	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	-	-
Target	Caesionidae	*Pterocaesio trilineata*	-	-	-	-	-	-	-	-	✓	-	✓	-	-
Target	Carangidae	*Atule mate*	-	-	-	-	✓	-	-	-	-	-	-	-	-
Target	Carangidae	*Carangoides bajad*	-	-	✓	-	✓	✓	-	-	-	-	✓	-	✓

Group	Fish Family	Fish Species	Ay Rhun	Buano	Koon	Lease	Serutbar	Guraici	Makian Moti	Mare	Rao Dehegila	Sula	Widi	Berau Bay	Nusalasi Bay
Target	Carangidae	*Carangoides ferdau*	-	-	✓	-	✓	✓	-	✓	✓	-	✓	-	-
Target	Carangidae	*Carangoides gymnostethus*	-	-	-	-	-	✓	-	-	✓	-	-	-	-
Target	Carangidae	*Carangoides orthogrammus*	-	✓	-	-	-	-	-	✓	✓	✓	✓	-	-
Target	Carangidae	*Carangoides plagiotaenia*	-	-	-	-	✓	✓	✓	-	-	-	-	-	-
Target	Carangidae	*Carangoides spp.*	-	-	-	-	-	-	-	-	-	-	-	✓	-
Target	Carangidae	*Caranx ignobilis*	✓	-	✓	✓	✓	✓	-	✓	✓	✓	✓	✓	✓
Target	Carangidae	*Caranx lugubris*	-	-	-	-	-	-	✓	-	-	-	-	-	-
Target	Carangidae	*caranx melampygus*	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	-	✓
Target	Carangidae	*Caranx papuensis*	-	-	-	✓	-	-	-	-	-	-	-	-	-
Target	Carangidae	*Caranx sexfasciatus*	✓	✓	✓	✓	✓	-	✓	-	✓	✓	✓	-	✓
Target	Carangidae	*Caranx spp.*	-	-	-	-	-	-	-	-	-	-	-	✓	✓
Target	Carangidae	*Decapterus russelli*	-	-	-	-	-	-	-	✓	✓	-	-	-	-
Target	Carangidae	*Elagatis bipinnulata*	✓	✓	✓	✓	✓	✓	-	-	✓	✓	✓	-	✓
Target	Carangidae	*Gnathanodon speciosus*	-	-	-	-	-	✓	-	✓	-	-	✓	✓	✓
Target	Carangidae	*Scomberoides commersonnianus*	-	-	-	-	-	-	-	✓	-	-	-	-	-
Target	Carangidae	*Scomberoides lysan*	-	✓	✓	✓	✓	-	-	-	-	✓	-	-	✓
Target	Carangidae	*Scomberoides tol*	-	-	✓	-	-	✓	✓	-	-	✓	-	-	-
Target	Carangidae	*Selar boops*	-	-	-	-	-	✓	-	-	-	-	-	-	-
Target	Carangidae	*Selar crumenophthalmus*	-	-	-	-	-	-	✓	-	-	-	✓	-	-
Target	Carangidae	*Seriola lalandi*	-	-	-	-	-	-	-	-	-	✓	-	-	-
Target	Carangidae	*Seriola rivoliana*	-	-	✓	-	-	-	-	-	-	-	-	-	-
Target	Carangidae	*Trachinotus baillonii*	-	-	✓	-	-	-	-	-	-	-	-	-	-
Target	Carangidae	*Trachinotus blochii*	-	-	✓	✓	✓	-	-	-	-	-	-	-	-
Target	Carcharhinidae	*Carcharhinus melanopterus*	-	-	-	✓	✓	✓	✓	✓	✓	✓	✓	-	✓
Target	Carcharhinidae	*Triaenodon obesus*	-	-	-	-	-	✓	-	-	-	-	✓	-	-
Target	Dasyatidae	*Neotrygon kuhlii*	-	-	✓	-	✓	-	-	-	✓	✓	-	-	-
Target	Dasyatidae	*Taeniura lymma*	-	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	-	-
Target	Haemulidae	*Diagramma melanacrum*	-	-	✓	-	✓	-	-	-	✓	-	✓	✓	✓
Target	Haemulidae	*Diagramma pictum*	-	-	✓	-	-	-	-	-	✓	-	✓	✓	✓
Target	Haemulidae	*Diagramma spp.*	-	-	-	-	-	-	-	-	-	-	-	✓	-
Target	Haemulidae	*Plectorhinchus albovittatus*	✓	-	✓	✓	✓	-	-	-	-	✓	✓	✓	-
Target	Haemulidae	*Plectorhinchus chaetodonoides*	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Target	Haemulidae	*Plectorhinchus chrysotaenia*	✓	-	-	✓	✓	-	-	-	✓	✓	-	✓	✓
Target	Haemulidae	*Plectorhinchus gibbosus*	-	-	✓	-	-	✓	-	-	-	-	✓	-	-
Target	Haemulidae	*Plectorhinchus lessonii*	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Target	Haemulidae	*Plectorhinchus lineatus*	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	-	✓
Target	Haemulidae	*Plectorhinchus obscurus*	-	-	✓	-	-	-	-	-	-	-	-	-	-
Target	Haemulidae	*Plectorhinchus picus*	✓	-	✓	-	✓	-	-	✓	✓	-	-	-	-
Target	Haemulidae	*Plectorhinchus polytaenia*	✓	✓	✓	✓	✓	✓	-	✓	✓	✓	✓	-	✓

Group	Fish Family	Fish Species	Ay Rhun	Buano	Koon	Lease	Serutbar	Guraici	Makian Moti	Mare	Rao Dehegila	Sula	Widi	Berau Bay	Nusalasi Bay
Target	Haemulidae	*Plectorhinchus spp.*	-	-	✓	✓	-	-	-	-	-	-	-	-	-
Target	Haemulidae	*Plectorhinchus vittatus*	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	-	-
Target	Kyphosidae	*Kyphosus bigibbus*	-	-	-	-	-	-	✓	-	✓	-	✓	-	-
Target	Kyphosidae	*Kyphosus cinerascens*	-	-	-	-	-	-	-	✓	✓	-	-	-	-
Target	Kyphosidae	*Kyphosus spp.*	-	-	-	-	-	-	-	-	-	-	-	-	✓
Target	Kyphosidae	*kyphosus vaigiensis*	✓	✓	-	✓	✓	✓	✓	✓	✓	✓	✓	-	✓
Target	Labridae	*Cheilinus undulatus*	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	-	✓
Target	Lethrinidae	*Gnathodentex aureolineatus*	✓	-	✓	✓	✓	✓	✓	✓	✓	✓	✓	-	✓
Target	Lethrinidae	*Lethrinus amboinensis*	-	-	✓	-	-	✓	-	-	✓	-	-	-	-
Target	Lethrinidae	*Lethrinus atkinsoni*	-	-	-	-	✓	-	-	✓	-	-	-	-	-
Target	Lethrinidae	*Lethrinus erythracanthus*	-	-	✓	-	-	-	-	-	✓	-	-	-	-
Target	Lethrinidae	*Lethrinus erythropterus*	-	✓	✓	-	✓	✓	-	✓	✓	✓	✓	✓	✓
Target	Lethrinidae	*Lethrinus genivittatus*	-	-	✓	-	-	-	-	-	-	-	-	-	-
Target	Lethrinidae	*Lethrinus harak*	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	-	-
Target	Lethrinidae	*Lethrinus lentjan*	-	-	✓	-	-	✓	✓	-	✓	-	✓	-	-
Target	Lethrinidae	*Lethrinus microdon*	-	✓	✓	-	✓	-	-	✓	-	✓	-	-	-
Target	Lethrinidae	*Lethrinus miniatus*	-	-	-	-	✓	-	-	-	-	-	-	-	-
Target	Lethrinidae	*Lethrinus nebulosus*	-	-	-	-	✓	-	-	-	-	-	-	-	-
Target	Lethrinidae	*Lethrinus obsoletus*	-	-	-	-	✓	-	-	✓	✓	✓	✓	-	-
Target	Lethrinidae	*Lethrinus olivaceus*	✓	-	✓	✓	✓	✓	-	-	✓	✓	✓	-	✓
Target	Lethrinidae	*Lethrinus ornatus*	-	✓	✓	-	✓	✓	-	✓	✓	✓	✓	-	-
Target	Lethrinidae	*Lethrinus rubrioperculatus*	-	-	✓	✓	-	-	-	-	-	-	-	-	-
Target	Lethrinidae	*Lethrinus semicinctus*	-	-	✓	✓	-	-	-	-	-	-	-	-	-
Target	Lethrinidae	*Lethrinus spp.*	-	-	-	✓	-	-	-	-	-	✓	-	✓	✓
Target	Lethrinidae	*Lethrinus variegatus*	-	✓	-	-	-	-	-	-	✓	✓	-	-	-
Target	Lethrinidae	*Lethrinus xanthochilus*	-	-	✓	-	✓	-	-	✓	-	-	-	-	-
Target	Lethrinidae	*Monotaxis grandoculis*	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	-	-
Target	Lethrinidae	*Monotaxis heterodon*	✓	-	✓	✓	✓	✓	✓	✓	✓	✓	✓	-	✓
Target	Lutjanidae	*Aphareus furca*	-	✓	✓	-	✓	✓	-	✓	✓	✓	✓	-	✓
Target	Lutjanidae	*Aprion virescens*	-	-	✓	✓	✓	-	-	✓	✓	✓	-	-	✓
Target	Lutjanidae	*Lutjanus argentimaculatus*	-	-	✓	-	✓	✓	-	-	-	✓	-	✓	-
Target	Lutjanidae	*Lutjanus biguttatus*	-	✓	-	✓	✓	✓	-	✓	✓	-	✓	-	✓
Target	Lutjanidae	*Lutjanus bohar*	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	-	✓
Target	Lutjanidae	*Lutjanus boutton*	-	-	✓	-	-	-	-	-	-	-	-	-	✓
Target	Lutjanidae	*Lutjanus carponotatus*	-	✓	-	✓	✓	✓	✓	-	✓	-	✓	✓	✓
Target	Lutjanidae	*Lutjanus decussatus*	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Target	Lutjanidae	*Lutjanus ehrenbergii*	-	-	✓	-	✓	✓	✓	✓	✓	-	✓	-	-
Target	Lutjanidae	*Lutjanus erythropterus*	-	-	✓	-	-	✓	-	-	-	-	✓	-	-
Target	Lutjanidae	*Lutjanus fulviflamma*	✓	✓	✓	✓	✓	-	✓	✓	✓	✓	-	-	-

Group	Fish Family	Fish Species	Ay Rhun	Buano	Koon	Lease	Serutbar	Guraici	Makian Moti	Mare	Rao Dehegila	Sula	Widi	Berau Bay	Nusalasi Bay
Target	Lutjanidae	*Lutjanus fulvus*	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Target	Lutjanidae	*Lutjanus gibbus*	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	-	✓
Target	Lutjanidae	*Lutjanus goldiei*	-	-	-	-	✓	-	-	-	-	-	-	-	-
Target	Lutjanidae	*Lutjanus kasmira*	✓	-	✓	✓	-	✓	✓	-	✓	✓	-	-	✓
Target	Lutjanidae	*Lutjanus lunulatus*	-	-	✓	-	✓	-	-	-	-	-	-	-	-
Target	Lutjanidae	*Lutjanus lutjanus*	-	-	✓	✓	✓	-	-	-	-	-	-	-	-
Target	Lutjanidae	*Lutjanus madras*	-	-	-	-	✓	-	-	-	-	-	-	-	-
Target	Lutjanidae	*Lutjanus monostigma*	✓	-	✓	✓	✓	✓	✓	✓	✓	✓	✓	-	✓
Target	Lutjanidae	*Lutjanus quinquelineatus*	-	-	✓	✓	✓	-	-	✓	✓	✓	✓	-	✓
Target	Lutjanidae	*Lutjanus rivulatus*	✓	-	✓	✓	✓	✓	-	-	-	✓	-	✓	-
Target	Lutjanidae	*Lutjanus rufolineatus*	-	-	-	-	✓	-	-	-	-	-	-	-	-
Target	Lutjanidae	*Lutjanus russelli*	-	✓	-	-	-	-	-	-	-	-	-	✓	✓
Target	Lutjanidae	*Lutjanus russellii*	-	-	-	-	-	-	-	-	✓	-	-	-	-
Target	Lutjanidae	*Lutjanus sebae*	-	-	✓	-	-	-	-	-	-	-	-	-	-
Target	Lutjanidae	*Lutjanus semicinctus*	-	✓	✓	✓	✓	-	-	✓	✓	✓	✓	-	✓
Target	Lutjanidae	*Lutjanus spp.*	-	-	✓	✓	-	-	-	-	-	✓	-	✓	✓
Target	Lutjanidae	*Lutjanus vitta*	-	-	✓	-	✓	-	-	-	✓	-	-	✓	-
Target	Lutjanidae	*Macolor macularis*	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	-	✓
Target	Lutjanidae	*Macolor niger*	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	-	✓
Target	Lutjanidae	*Paracaesio sordida*	-	-	✓	-	-	-	-	-	-	-	-	-	-
Target	Lutjanidae	*Symphorus nematophorus*	-	-	-	-	-	-	-	-	-	-	-	✓	✓
Target	Mullidae	*Mulloidichthys flavolineatus*	✓	✓	✓	✓	-	✓	✓	✓	✓	✓	-	-	-
Target	Mullidae	*Mulloidichthys vanicolensis*	✓	✓	✓	✓	-	✓	✓	✓	✓	✓	-	-	-
Target	Mullidae	*Parupeneus barberinoides*	-	-	-	-	-	✓	✓	✓	-	-	✓	-	-
Target	Mullidae	*Parupeneus barberinus*	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	-	-
Target	Mullidae	*Parupeneus bifasciatus*	-	-	-	-	-	✓	-	✓	✓	-	✓	-	-
Target	Mullidae	*Parupeneus crassilabris*	✓	✓	-	✓	-	✓	✓	✓	✓	✓	✓	-	-
Target	Mullidae	*Parupeneus cyclostomus*	-	✓	✓	-	✓	✓	✓	✓	✓	✓	✓	-	-
Target	Mullidae	*Parupeneus indicus*	-	✓	✓	-	✓	✓	✓	✓	✓	✓	✓	-	-
Target	Mullidae	*Parupeneus macronemus*	✓	-	✓	-	-	✓	✓	✓	✓	-	✓	-	-
Target	Mullidae	*Parupeneus multifasciatus*	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	-	-
Target	Mullidae	*Parupeneus pleurostigma*	-	-	-	-	-	✓	✓	-	✓	-	✓	-	-
Target	Mullidae	*Parupeneus spp.*	-	-	-	-	-	-	-	-	-	✓	-	-	-
Target	Mullidae	*Parupeneus trifasciatus*	-	-	✓	-	✓	✓	-	-	✓	-	✓	-	-
Target	Mullidae	*Upeneus tragula*	✓	✓	-	-	-	-	-	✓	✓	-	-	-	-
Target	Myliobatidae	*Aetobatus narinari*	-	-	✓	-	-	-	-	-	-	-	-	-	-
Target	Nemipteridae	*Pentapodus aureofasciatus*	-	-	-	-	-	✓	-	✓	✓	-	-	-	-
Target	Nemipteridae	*Pentapodus bifasciatus*	-	-	-	-	-	-	-	-	✓	-	✓	-	-
Target	Nemipteridae	*Pentapodus caninus*	-	-	-	-	✓	✓	-	✓	✓	-	-	-	-

Group	Fish Family	Fish Species	Ay Rhun	Buano	Koon	Lease	Serutbar	Guraici	Makian Moti	Mare	Rao Dehegila	Sula	Widi	Berau Bay	Nusalasi Bay
Target	Nemipteridae	*Pentapodus emeryii*	-	-	✓	-	✓	✓	-	✓	✓	-	-	-	-
Target	Nemipteridae	*Pentapodus trivittatus*	✓	-	✓	-	✓	✓	✓	-	✓	-	✓	-	-
Target	Nemipteridae	*Scolopsis affinis*	✓	-	✓	-	✓	-	✓	✓	✓	-	-	-	-
Target	Nemipteridae	*Scolopsis aurata*	-	-	-	-	-	✓	-	-	-	-	-	-	-
Target	Nemipteridae	*Scolopsis bilineata*	✓	-	✓	-	✓	✓	✓	✓	✓	-	✓	-	-
Target	Nemipteridae	*Scolopsis bilineatus*	-	-	-	✓	-	-	-	-	-	✓	-	-	-
Target	Nemipteridae	*Scolopsis ciliata*	-	-	✓	-	✓	✓	-	-	✓	-	✓	-	-
Target	Nemipteridae	*Scolopsis lineata*	-	-	✓	-	✓	✓	✓	✓	✓	-	-	-	-
Target	Nemipteridae	*Scolopsis margaritifera*	-	-	✓	✓	✓	✓	✓	✓	✓	-	✓	-	-
Target	Nemipteridae	*Scolopsis monogramma*	-	✓	-	-	-	-	-	✓	✓	✓	-	-	-
Target	Nemipteridae	*Scolopsis spp.*	-	-	-	-	✓	-	-	-	-	-	-	✓	✓
Target	Nemipteridae	*Scolopsis temporalis*	-	-	-	-	✓	✓	-	-	✓	-	✓	-	-
Target	Nemipteridae	*Scolopsis trilineata*	-	-	-	-	-	✓	-	✓	✓	-	✓	-	-
Target	Nemipteridae	*Scolopsis xenochroa*	-	-	-	-	✓	-	-	-	-	-	-	-	-
Target	Scaridae	*Bolbometopon muricatum*	✓	✓	✓	✓	✓	✓	-	-	✓	✓	✓	-	✓
Target	Scaridae	*Calotomus carolinus*	-	-	✓	-	✓	-	-	-	-	-	-	-	-
Target	Scaridae	*Calotomus spinidens*	-	-	✓	-	-	-	-	-	-	-	-	-	-
Target	Scaridae	*Cetoscarus bicolor*	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	-	-
Target	Scaridae	*Cetoscarus ocellatus*	-	-	✓	-	-	✓	-	✓	✓	-	✓	-	-
Target	Scaridae	*Chlorurus bleekeri*	-	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	-	-
Target	Scaridae	*Chlorurus bowersi*	-	✓	✓	-	✓	✓	-	-	✓	✓	✓	-	-
Target	Scaridae	*Chlorurus capistratoides*	-	-	✓	-	✓	✓	✓	✓	✓	-	✓	-	-
Target	Scaridae	*Chlorurus japanensis*	-	✓	✓	-	✓	✓	-	✓	✓	✓	✓	-	-
Target	Scaridae	*Chlorurus microrhinos*	✓	-	✓	✓	✓	✓	✓	✓	✓	✓	✓	-	-
Target	Scaridae	*Chlorurus sordidus*	✓	✓	✓	-	✓	✓	✓	✓	✓	✓	✓	-	✓
Target	Scaridae	*Chlorurus spp.*	-	-	✓	-	-	-	-	-	-	-	-	-	-
Target	Scaridae	*Chlorurus troschelii*	-	-	-	-	-	✓	-	-	-	-	✓	-	-
Target	Scaridae	*Hipposcarus harid*	-	-	✓	-	✓	✓	-	✓	✓	-	-	-	-
Target	Scaridae	*Hipposcarus longiceps*	-	✓	✓	-	-	✓	✓	✓	✓	✓	✓	-	-
Target	Scaridae	*Leptoscarus vaigiensis*	-	-	-	-	-	-	-	-	✓	-	✓	-	-
Target	Scaridae	*Scarus altipinnis*	-	-	✓	✓	✓	-	-	-	-	-	-	-	-
Target	Scaridae	*Scarus bowersi*	-	-	-	-	✓	-	-	-	-	-	-	-	-
Target	Scaridae	*Scarus caudofasciatus*	-	-	-	-	✓	-	-	-	-	-	-	-	-
Target	Scaridae	*Scarus chameleon*	-	-	✓	-	✓	✓	-	✓	✓	-	✓	-	-
Target	Scaridae	*Scarus dimidiatus*	✓	✓	✓	-	✓	✓	✓	✓	✓	✓	✓	-	-
Target	Scaridae	*Scarus festivus*	-	✓	✓	-	✓	-	-	✓	✓	✓	-	-	-
Target	Scaridae	*Scarus flavipectoralis*	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	-	-
Target	Scaridae	*Scarus forsteni*	-	✓	✓	-	✓	✓	-	✓	✓	✓	✓	-	-
Target	Scaridae	*Scarus frenatus*	-	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	-	-

Group	Fish Family	Fish Species	Ay Rhun	Buano	Koon	Lease	Serutbar	Guraici	Makian Moti	Mare	Rao Dehegila	Sula	Widi	Berau Bay	Nusalasi Bay
Target	Scaridae	*Scarus fuscocaudalis*	-	-	-	-	✓	-	-	-	-	-	-	-	-
Target	Scaridae	*Scarus ghobban*	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Target	Scaridae	*Scarus globiceps*	-	-	✓	-	-	-	-	✓	✓	✓	-	-	-
Target	Scaridae	*Scarus hypselopterus*	-	-	-	-	✓	-	-	-	-	-	-	-	-
Target	Scaridae	*Scarus microrinus*	-	-	✓	-	-	-	-	-	-	-	-	-	-
Target	Scaridae	*Scarus niger*	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	-	-
Target	Scaridae	*Scarus oviceps*	-	✓	✓	-	✓	✓	✓	✓	✓	✓	✓	-	-
Target	Scaridae	*Scarus prasiognathos*	-	-	✓	-	✓	✓	✓	✓	✓	✓	✓	-	-
Target	Scaridae	*Scarus psittacus*	-	✓	✓	-	✓	✓	-	✓	✓	✓	✓	-	-
Target	Scaridae	*Scarus quoyi*	✓	-	✓	✓	✓	✓	✓	✓	✓	✓	✓	-	-
Target	Scaridae	*Scarus rivulatus*	-	-	✓	-	✓	✓	✓	✓	✓	-	✓	-	-
Target	Scaridae	*Scarus rubroviolaceus*	-	-	✓	✓	✓	✓	-	✓	✓	✓	✓	-	-
Target	Scaridae	*Scarus russelii*	-	-	✓	-	✓	-	✓	✓	✓	-	✓	-	-
Target	Scaridae	*Scarus scaber*	-	-	✓	-	✓	-	-	-	-	-	-	-	-
Target	Scaridae	*Scarus schlegeli*	-	✓	✓	✓	✓	✓	-	✓	✓	-	✓	-	-
Target	Scaridae	*Scarus sordidus*	-	-	-	-	✓	-	-	-	-	-	-	-	-
Target	Scaridae	*Scarus spinus*	-	✓	✓	-	✓	✓	✓	✓	✓	✓	✓	-	-
Target	Scaridae	*Scarus spp.*	✓	-	✓	✓	✓	✓	-	✓	✓	✓	✓	✓	✓
Target	Scaridae	*Scarus tricolor*	✓	✓	✓	✓	✓	✓	-	✓	✓	✓	✓	-	-
Target	Scaridae	*Scarus xanthopleura*	-	-	-	-	-	✓	-	✓	-	-	✓	-	-
Target	Scombridae	*Gymnosarda unicolor*	✓	-	✓	✓	✓	-	-	✓	-	✓	-	-	✓
Target	Scombridae	*Rastrelliger kanagurta*	✓	✓	✓	✓	✓	✓	-	✓	✓	✓	✓	-	-
Target	Scombridae	*Scomberomorus commerson*	✓	-	✓	✓	✓	-	-	-	-	-	✓	✓	✓
Target	Scombridae	*Scomberomorus commersoni*	-	-	-	✓	✓	-	-	-	-	✓	-	-	-
Target	Scombridae	*Selaroides leptolepis*	-	✓	-	-	-	-	-	-	-	-	-	-	-
Target	Scombridae	*Thunnus albacares*	-	-	✓	-	-	-	-	-	-	-	-	-	-
Target	Scombridae	*Thunnus maccoyii*	-	-	✓	-	-	-	-	-	-	-	-	-	-
Target	Serranidae	*Aethaloperca rogaa*	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	-	✓
Target	Serranidae	*Anyperodon leucogrammicus*	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	-	✓
Target	Serranidae	*Cephalopholis argus*	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Target	Serranidae	*Cephalopholis boenak*	-	✓	✓	✓	✓	-	-	-	✓	-	-	✓	✓
Target	Serranidae	*Cephalopholis cyanostigma*	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Target	Serranidae	*Cephalopholis formosa*	-	-	✓	-	-	-	-	-	✓	-	-	-	-
Target	Serranidae	*Cephalopholis leopardus*	✓	✓	✓	✓	-	✓	✓	✓	✓	✓	✓	-	✓
Target	Serranidae	*Cephalopholis microprion*	-	-	✓	✓	-	✓	✓	✓	✓	-	✓	-	-
Target	Serranidae	*Cephalopholis miniata*	✓	✓	✓	✓	✓	✓	-	✓	✓	✓	✓	✓	✓
Target	Serranidae	*Cephalopholis sexmaculata*	-	✓	✓	-	-	-	✓	-	✓	-	✓	-	✓
Target	Serranidae	*Cephalopholis sonnerati*	-	-	✓	-	-	-	-	-	-	-	-	-	-
Target	Serranidae	*Cephalopholis spiloparaea*	-	✓	✓	-	-	✓	-	-	✓	✓	✓	-	-

Group	Fish Family	Fish Species	Ay Rhun	Buano	Koon	Lease	Serutbar	Guraici	Makian Moti	Mare	Rao Dehegila	Sula	Widi	Berau Bay	Nusalasi Bay
Target	Serranidae	*Cephalopholis spp.*	-	-	✓	-	-	-	-	-	-	✓	-	-	-
Target	Serranidae	*Cephalopholis urodeta*	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	-	✓
Target	Serranidae	*Cromileptes altivelis*	-	-	✓	-	-	-	-	-	✓	✓	-	-	✓
Target	Serranidae	*Epinephelus areolatus*	-	-	✓	-	✓	-	-	-	-	✓	-	-	-
Target	Serranidae	*Epinephelus bilobatus*	-	-	-	-	-	-	-	-	-	-	-	-	✓
Target	Serranidae	*Epinephelus bleekeri*	-	✓	-	-	-	-	-	✓	-	-	-	-	-
Target	Serranidae	*Epinephelus caeruleopunctatus*	✓	-	✓	-	✓	✓	-	✓	✓	-	✓	✓	-
Target	Serranidae	*Epinephelus fasciatus*	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Target	Serranidae	*Epinephelus flavocaeruleus*	-	-	✓	-	-	-	-	-	-	-	-	-	-
Target	Serranidae	*Epinephelus fuscoguttatus*	✓	-	✓	-	✓	-	-	-	-	-	-	-	✓
Target	Serranidae	*Epinephelus hexagonatus*	-	-	-	-	-	✓	-	-	✓	-	-	-	-
Target	Serranidae	*Epinephelus lanceolatus*	-	-	-	-	-	-	-	-	-	-	✓	-	-
Target	Serranidae	*Epinephelus macrospilos*	-	-	-	-	-	-	-	-	✓	-	-	-	-
Target	Serranidae	*Epinephelus malabaricus*	-	-	✓	-	-	-	-	-	-	-	-	-	-
Target	Serranidae	*Epinephelus melanostigma*	-	-	✓	-	-	✓	-	-	-	-	-	-	-
Target	Serranidae	*Epinephelus merra*	✓	✓	✓	✓	✓	✓	-	✓	✓	✓	✓	-	-
Target	Serranidae	*Epinephelus ongus*	-	✓	-	-	-	-	-	✓	✓	-	-	✓	✓
Target	Serranidae	*Epinephelus polyphekadion*	-	-	-	-	-	-	-	-	-	-	-	-	✓
Target	Serranidae	*Epinephelus quoyanus*	-	✓	✓	-	-	✓	-	✓	✓	✓	✓	-	-
Target	Serranidae	*Epinephelus spilotoceps*	-	✓	-	-	-	✓	-	✓	✓	-	✓	-	-
Target	Serranidae	*Epinephelus spp.*	✓	-	✓	-	✓	-	-	-	-	✓	-	✓	-
Target	Serranidae	*Gracila albomarginata*	✓	✓	✓	✓	✓	✓	-	✓	✓	✓	✓	-	✓
Target	Serranidae	*Plectropomus areolatus*	✓	-	✓	✓	✓	✓	✓	✓	✓	-	-	-	✓
Target	Serranidae	*Plectropomus laevis*	-	-	✓	✓	✓	-	-	-	-	-	-	-	✓
Target	Serranidae	*Plectropomus leopardus*	-	-	-	✓	✓	-	-	-	-	-	-	-	✓
Target	Serranidae	*Plectropomus maculatus*	-	-	-	-	✓	-	✓	✓	✓	✓	-	✓	✓
Target	Serranidae	*Plectropomus oligacanthus*	-	-	-	✓	✓	-	-	-	✓	-	-	-	✓
Target	Serranidae	*Plectropomus oligocanthus*	-	-	-	✓	-	-	-	-	-	-	-	-	-
Target	Serranidae	*Plectropomus spp.*	-	-	✓	-	-	-	-	-	-	-	-	-	-
Target	Serranidae	*Variola albimarginata*	-	✓	✓	✓	-	✓	✓	✓	✓	✓	-	-	✓
Target	Serranidae	*Variola louti*	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	-	-	✓
Target	Siganidae	*Siganus argenteus*	-	-	✓	-	✓	✓	-	✓	✓	-	✓	-	-
Target	Siganidae	*Siganus canaliculatus*	-	✓	✓	-	-	-	-	✓	✓	-	-	-	-
Target	Siganidae	*Siganus corallinus*	-	✓	✓	✓	✓	✓	✓	✓	✓	✓	-	-	✓
Target	Siganidae	*Siganus doliatus*	✓	✓	✓	✓	✓	✓	-	✓	✓	✓	✓	✓	✓
Target	Siganidae	*Siganus fuscescens*	-	✓	-	-	-	✓	-	-	✓	✓	✓	-	✓
Target	Siganidae	*siganus guttatus*	-	-	✓	✓	✓	✓	✓	✓	✓	-	✓	-	✓
Target	Siganidae	*Siganus javus*	-	-	✓	✓	-	✓	-	✓	✓	-	✓	✓	-
Target	Siganidae	*Siganus lineatus*	-	✓	✓	✓	✓	✓	-	✓	✓	✓	✓	✓	✓

Group	Fish Family	Fish Species	Ay Rhun	Buano	Koon	Lease	Serutbar	Guraici	Makian Moti	Mare	Rao Dehegila	Sula	Widi	Berau Bay	Nusalasi Bay
Target	Siganidae	*Siganus puelloides*	-	-	-	-	-	✓	-	-	-	-	-	-	-
Target	Siganidae	*Siganus puellus*	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Target	Siganidae	*Siganus punctatissimus*	✓	✓	✓	✓	✓	✓	✓	✓	✓	-	✓	-	✓
Target	Siganidae	*Siganus punctatus*	✓	✓	✓	-	✓	-	-	✓	✓	✓	✓	-	✓
Target	Siganidae	*Siganus punctatussimus*	-	-	-	✓	-	-	-	-	-	-	-	-	-
Target	Siganidae	*Siganus spinus*	-	✓	✓	-	-	-	✓	✓	✓	-	-	-	-
Target	Siganidae	*Siganus spp.*	-	-	-	✓	-	-	-	-	-	-	-	-	✓
Target	Siganidae	*Siganus stellatus*	-	-	✓	-	-	-	-	-	-	-	-	-	-
Target	Siganidae	*Siganus vermiculatus*	-	-	-	-	-	-	-	-	-	✓	-	-	-
Target	Siganidae	*siganus virgatus*	-	✓	✓	-	✓	✓	✓	✓	✓	-	✓	-	✓
Target	Siganidae	*Siganus vulpinus*	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	-	✓
Target	Sphyraenidae	*Sphyraena barracuda*	✓	✓	✓	✓	-	-	✓	-	✓	✓	✓	-	✓
Target	Sphyraenidae	*Sphyraena flavicauda*	-	-	-	-	-	✓	-	-	✓	-	-	-	-
Target	Sphyraenidae	*Sphyraena forsteri*	-	-	✓	-	✓	-	-	-	-	-	-	-	-
Target	Sphyraenidae	*Sphyraena jello*	-	-	✓	-	✓	-	-	-	-	-	✓	-	-
Target	Sphyraenidae	*Sphyraena qenie*	-	-	✓	-	✓	-	-	-	-	-	-	-	✓
Target	Sphyraenidae	*Sphyraena spp.*	-	-	-	✓	-	-	-	-	-	✓	-	-	-
Non-Target	Apogonidae	*Apogon kallopterus*	-	-	-	-	-	✓	-	✓	-	-	-	-	-
Non-Target	Apogonidae	*Apogon spp.*	-	-	-	-	-	-	-	-	✓	-	-	-	-
Non-Target	Apogonidae	*Cheilodipterus artus*	-	-	-	-	-	✓	-	-	✓	-	-	-	-
Non-Target	Apogonidae	*Cheilodipterus intermedius*	-	-	-	-	-	-	-	✓	✓	-	✓	-	-
Non-Target	Apogonidae	*Cheilodipterus isostigmus*	-	-	-	-	-	✓	✓	-	✓	-	-	-	-
Non-Target	Apogonidae	*Cheilodipterus macrodon*	-	-	-	-	-	✓	✓	✓	✓	-	✓	-	-
Non-Target	Apogonidae	*Cheilodipterus nigrotaeniatus*	-	-	-	-	-	-	-	✓	-	-	-	-	-
Non-Target	Apogonidae	*Cheilodipterus quinquelineatus*	-	-	-	-	-	✓	-	✓	✓	-	✓	-	-
Non-Target	Apogonidae	*Nectamia bandanensis*	-	-	-	-	-	-	-	-	✓	-	-	-	-
Non-Target	Apogonidae	*Ostorhinchus aureus*	-	-	-	-	-	✓	-	✓	✓	-	-	-	-
Non-Target	Apogonidae	*Ostorhinchus chrysopomus*	-	-	-	-	-	-	✓	✓	✓	-	-	-	-
Non-Target	Apogonidae	*Ostorhinchus compressus*	-	-	-	-	-	✓	✓	✓	✓	-	✓	-	-

Group	Fish Family	Fish Species	Ay Rhu n	Buan o	Koo n	Leas e	Serutba r	Guraic i	Makia n Moti	Mar e	Rao Dehegil a	Sul a	Wid i	Bera u Bay	Nusalas i Bay
Non-Target	Apogonidae	*Ostorhinchus cookii*	-	-	-	-	-	-	-	✓	✓	-	-	-	-
Non-Target	Apogonidae	*Ostorhinchus cyanosoma*	-	-	-	-	-	✓	-	✓	✓	-	-	-	-
Non-Target	Apogonidae	*Ostorhinchus fleurieu*	-	-	-	-	-	✓	-	✓	✓	-	-	-	-
Non-Target	Apogonidae	*Ostorhinchus hartzfeldii*	-	-	-	-	-	-	-	✓	✓	-	-	-	-
Non-Target	Apogonidae	*Ostorhinchus multilineatus*	-	-	-	-	-	✓	-	✓	✓	-	-	-	-
Non-Target	Apogonidae	*Ostorhinchus nigrofasciatus*	-	-	-	-	-	✓	-	✓	✓	-	✓	-	-
Non-Target	Apogonidae	*Ostorhinchus parvulus*	-	-	-	-	-	✓	-	✓	✓	-	✓	-	-
Non-Target	Apogonidae	*Ostorhinchus sealei*	-	-	-	-	-	✓	✓	✓	✓	-	-	-	-
Non-Target	Apogonidae	*Pristiapogon kallopterus*	-	-	-	-	-	-	-	✓	✓	-	-	-	-
Non-Target	Apogonidae	*Pterapogon kauderni*	-	-	-	-	-	-	-	✓	✓	-	-	-	-
Non-Target	Apogonidae	*Rhabdamia gracilis*	-	-	-	-	-	-	-	✓	✓	-	✓	-	-
Non-Target	Apogonidae	*Sphaeramia nematoptera*	-	-	-	-	-	✓	-	✓	✓	-	-	-	-
Non-Target	Apogonidae	*Taeniamia biguttata*	-	-	-	-	-	-	✓	✓	✓	-	-	-	-
Non-Target	Apogonidae	*Taeniamia fucata*	-	-	-	-	-	✓	-	-	✓	-	-	-	-
Non-Target	Apogonidae	*Taeniamia zosterophora*	-	-	-	-	-	✓	-	-	-	-	-	-	-
Non-Target	Apogonidae	*Zoramia fragilis*	-	-	-	-	-	-	-	-	✓	-	-	-	-
Non-Target	Aulostomidae	*Aulostomus chinensis*	-	-	✓	-	✓	✓	✓	✓	✓	-	✓	-	-
Non-Target	Balistidae	*Balistapus undulatus*	✓	-	✓	✓	✓	✓	✓	✓	✓	✓	✓	-	-
Non-Target	Balistidae	*Balistoides conspicillum*	✓	-	✓	✓	✓	✓	✓	✓	✓	✓	✓	-	-
Non-Target	Balistidae	*Balistoides viridescens*	✓	-	✓	-	✓	✓	-	✓	✓	-	✓	-	-
Non-Target	Balistidae	*Melichthys indicus*	-	-	✓	-	-	✓	✓	✓	✓	-	-	-	-

Group	Fish Family	Fish Species	Ay Rhun	Buano	Koon	Lease	Serutbar	Guraici	Makian Moti	Mare	Rao Dehegila	Sula	Widi	Berau Bay	Nusalasi Bay
Non-Target	Balistidae	*Melichthys niger*	✓	-	✓	✓	-	✓	✓	✓	✓	✓	-	-	-
Non-Target	Balistidae	*Melichthys vidua*	✓	-	✓	✓	✓	✓	✓	✓	✓	✓	✓	-	-
Non-Target	Balistidae	*Odonus niger*	✓	-	✓	✓	✓	✓	✓	✓	✓	✓	✓	-	-
Non-Target	Balistidae	*Pseudobalistes flavimarginatus*	-	-	-	-	-	✓	✓	✓	✓	-	-	-	-
Non-Target	Balistidae	*Rhinecanthus aculeatus*	-	-	-	-	-	-	-	✓	-	-	-	-	-
Non-Target	Balistidae	*Rhinecanthus rectangulus*	-	-	-	-	✓	✓	-	-	-	-	-	-	-
Non-Target	Balistidae	*Rhinecanthus verrucosus*	-	-	-	-	-	✓	✓	✓	✓	-	-	-	-
Non-Target	Balistidae	*Sufflamen bursa*	✓	-	✓	✓	✓	✓	✓	✓	✓	✓	✓	-	-
Non-Target	Balistidae	*Sufflamen chrysopterum*	✓	-	✓	✓	✓	✓	✓	✓	✓	✓	✓	-	-
Non-Target	Balistidae	*Sufflamen fraenatum*	-	-	-	-	✓	✓	-	-	-	-	✓	-	-
Non-Target	Balistidae	*Sufflamen fraenatus*	-	-	-	-	-	-	✓	-	-	-	-	-	-
Non-Target	Balistidae	*Xanthichthys auromarginatus*	-	-	-	-	-	-	-	✓	✓	-	-	-	-
Non-Target	Belonidae	*Tylosurus crocodilus*	-	-	-	-	-	✓	-	✓	✓	-	✓	-	-
Non-Target	Blenniidae	*Aspidontus dussumieri*	-	-	-	-	-	-	-	✓	✓	-	-	-	-
Non-Target	Blenniidae	*Aspidontus taeniatus*	-	-	-	-	-	-	-	✓	-	-	-	-	-
Non-Target	Blenniidae	*Atrosalarias fuscus*	-	-	-	-	-	-	✓	✓	✓	-	-	-	-
Non-Target	Blenniidae	*Blenniella chrysospilos*	-	-	-	-	-	-	-	✓	✓	-	-	-	-
Non-Target	Blenniidae	*Cirripectes auritus*	-	-	-	-	-	-	-	-	✓	-	-	-	-
Non-Target	Blenniidae	*Cirripectes castaneus*	-	-	-	-	-	-	-	-	✓	-	-	-	-
Non-Target	Blenniidae	*Cirripectes filamentosus*	-	-	-	-	-	✓	-	-	-	-	✓	-	-
Non-Target	Blenniidae	*Cirripectes springeri*	-	-	-	-	-	-	-	✓	✓	-	-	-	-

Group	Fish Family	Fish Species	Ay Rhun	Buano	Koon	Lease	Serutbar	Guraici	Makian Moti	Mare	Rao Dehegila	Sula	Widi	Berau Bay	Nusalasi Bay
Non-Target	Blenniidae	*Ecsenius bandanus*	-	-	-	-	-	-	-	-	✓	-	-	-	-
Non-Target	Blenniidae	*Ecsenius bicolor*	-	-	-	-	-	-	-	✓	✓	-	-	-	-
Non-Target	Blenniidae	*Ecsenius midas*	-	-	-	-	-	-	-	✓	-	-	-	-	-
Non-Target	Blenniidae	*Ecsenius ops*	-	-	-	-	-	-	✓	✓	✓	-	-	-	-
Non-Target	Blenniidae	*Ecsenius opsifrontalis*	-	-	-	-	-	-	-	✓	✓	-	-	-	-
Non-Target	Blenniidae	*Ecsenius stigmatura*	-	-	-	-	-	-	✓	✓	✓	-	-	-	-
Non-Target	Blenniidae	*Meiacanthus atrodorsalis*	-	-	-	-	-	✓	-	✓	✓	-	-	-	-
Non-Target	Blenniidae	*Meiacanthus ditrema*	-	-	-	-	-	-	-	✓	-	-	-	-	-
Non-Target	Blenniidae	*Meiacanthus grammistes*	-	-	-	-	-	✓	✓	✓	✓	-	✓	-	-
Non-Target	Blenniidae	*Meiacanthus lineatus*	-	-	-	-	-	-	-	-	✓	-	-	-	-
Non-Target	Blenniidae	*Meiacanthus smithi*	-	-	-	-	-	✓	-	-	✓	-	-	-	-
Non-Target	Blenniidae	*Plagiotremus rhinorhynchos*	-	-	-	-	-	✓	✓	✓	✓	-	✓	-	-
Non-Target	Blenniidae	*Plagiotremus tapeinosoma*	-	-	-	-	-	-	-	✓	✓	-	-	-	-
Non-Target	Blenniidae	*Salarias ceramensis*	-	-	-	-	-	-	-	-	✓	-	-	-	-
Non-Target	Blenniidae	*Stanulus talboti*	-	-	-	-	-	-	-	-	✓	-	-	-	-
Non-Target	Blenniidae	*Valenciennea strigata*	-	-	-	-	-	✓	-	✓	✓	-	✓	-	-
Non-Target	Carcharhinidae	*Triaenodon obesus*	-	-	-	-	-	-	-	-	✓	✓	-	-	-
Non-Target	Centriscidae	*Aeoliscus strigatus*	-	-	-	-	-	✓	✓	✓	✓	-	-	-	-
Non-Target	Chaetodontidae	*Chaetodon adiergastos*	✓	-	✓	✓	✓	✓	✓	✓	✓	✓	✓	-	-
Non-Target	Chaetodontidae	*Chaetodon auriga*	✓	-	✓	✓	✓	✓	✓	✓	✓	✓	✓	-	-
Non-Target	Chaetodontidae	*Chaetodon baronessa*	✓	-	✓	✓	✓	✓	✓	✓	✓	✓	✓	-	-

Group	Fish Family	Fish Species	Ay Rhun	Buano	Koon	Lease	Serutbar	Guraici	Makian Moti	Mare	Rao Dehegila	Sula	Widi	Berau Bay	Nusalasi Bay
Non-Target	Chaetodontidae	*Chaetodon bennetti*	✓	-	✓	✓	-	✓	✓	✓	✓	✓	✓	-	-
Non-Target	Chaetodontidae	*Chaetodon citrinellus*	✓	-	✓	✓	✓	✓	-	✓	✓	✓	✓	-	-
Non-Target	Chaetodontidae	*Chaetodon collare*	-	-	-	-	-	-	-	-	✓	-	-	-	-
Non-Target	Chaetodontidae	*Chaetodon decussatus*	-	-	✓	-	✓	✓	✓	✓	✓	-	✓	-	-
Non-Target	Chaetodontidae	*Chaetodon ephippium*	✓	-	✓	✓	✓	✓	✓	✓	✓	-	✓	-	-
Non-Target	Chaetodontidae	*Chaetodon falcula*	-	-	✓	-	✓	✓	✓	✓	✓	-	✓	-	-
Non-Target	Chaetodontidae	*Chaetodon fasciatus*	-	-	✓	-	✓	-	-	-	-	-	-	-	-
Non-Target	Chaetodontidae	*Chaetodon guentheri*	-	-	-	-	-	-	✓	-	-	-	-	-	-
Non-Target	Chaetodontidae	*Chaetodon guttatissimus*	-	-	-	-	-	-	✓	-	✓	-	✓	-	-
Non-Target	Chaetodontidae	*Chaetodon interruptus*	-	-	✓	-	✓	-	-	-	-	-	-	-	-
Non-Target	Chaetodontidae	*Chaetodon kleini*	-	-	-	✓	-	-	-	-	-	-	-	-	-
Non-Target	Chaetodontidae	*Chaetodon kleinii*	✓	-	✓	-	✓	✓	✓	✓	✓	✓	✓	-	-
Non-Target	Chaetodontidae	*Chaetodon lineolatus*	-	-	✓	-	✓	✓	✓	✓	✓	-	✓	-	-
Non-Target	Chaetodontidae	*Chaetodon lunula*	✓	-	✓	✓	-	✓	✓	✓	✓	✓	✓	-	-
Non-Target	Chaetodontidae	*Chaetodon lunulatus*	✓	-	✓	✓	✓	✓	✓	✓	✓	✓	✓	-	-
Non-Target	Chaetodontidae	*Chaetodon melannotus*	✓	-	✓	✓	✓	✓	✓	✓	✓	✓	✓	-	-
Non-Target	Chaetodontidae	*Chaetodon mertensii*	-	-	✓	-	-	-	-	-	-	-	-	-	-
Non-Target	Chaetodontidae	*Chaetodon meyeri*	✓	-	✓	✓	✓	✓	✓	✓	✓	✓	✓	-	-
Non-Target	Chaetodontidae	*Chaetodon ocellicaudus*	✓	-	-	✓	-	-	-	-	-	✓	-	-	-
Non-Target	Chaetodontidae	*Chaetodon octofasciatus*	-	-	-	-	✓	✓	-	✓	✓	-	-	-	-
Non-Target	Chaetodontidae	*Chaetodon ornatissimus*	✓	-	✓	✓	✓	✓	✓	✓	✓	✓	✓	-	-

Group	Fish Family	Fish Species	Ay Rhun	Buano	Koon	Lease	Serutbar	Guraici	Makian Moti	Mare	Rao Dehegila	Sula	Widi	Berau Bay	Nusalasi Bay
Non-Target	Chaetodontidae	*Chaetodon oxycephalus*	✓	-	✓	-	✓	✓	✓	✓	✓	-	✓	-	-
Non-Target	Chaetodontidae	*Chaetodon pelewensis*	-	-	-	-	-	✓	-	✓	✓	-	-	-	-
Non-Target	Chaetodontidae	*Chaetodon plebeius*	-	-	-	-	-	✓	-	-	✓	-	-	-	-
Non-Target	Chaetodontidae	*Chaetodon punctatofasciatus*	✓	-	✓	✓	✓	✓	✓	✓	✓	✓	✓	-	-
Non-Target	Chaetodontidae	*Chaetodon rafflesi*	✓	-	✓	✓	✓	✓	✓	✓	✓	✓	✓	-	-
Non-Target	Chaetodontidae	*Chaetodon reticulatus*	-	-	-	-	✓	-	-	✓	-	-	-	-	-
Non-Target	Chaetodontidae	*Chaetodon selene*	-	-	-	-	-	✓	✓	-	-	-	-	-	-
Non-Target	Chaetodontidae	*Chaetodon semeion*	-	-	-	-	✓	✓	✓	✓	✓	-	✓	-	-
Non-Target	Chaetodontidae	*Chaetodon speculum*	✓	-	✓	✓	✓	✓	✓	✓	✓	✓	✓	-	-
Non-Target	Chaetodontidae	*Chaetodon striatus*	-	-	-	-	✓	-	-	-	-	-	-	-	-
Non-Target	Chaetodontidae	*Chaetodon triangulum*	-	-	-	-	✓	✓	✓	✓	✓	-	-	-	-
Non-Target	Chaetodontidae	*Chaetodon trifascialis*	✓	-	✓	✓	✓	✓	✓	✓	✓	✓	✓	-	-
Non-Target	Chaetodontidae	*Chaetodon trifasciatus*	-	-	✓	-	✓	-	-	-	-	-	-	-	-
Non-Target	Chaetodontidae	*Chaetodon ulietensis*	✓	-	✓	✓	-	✓	-	✓	✓	✓	✓	-	-
Non-Target	Chaetodontidae	*Chaetodon unimaculatus*	✓	-	✓	✓	✓	✓	✓	✓	✓	✓	✓	-	-
Non-Target	Chaetodontidae	*Chaetodon vagabundus*	✓	-	✓	✓	✓	✓	✓	✓	✓	✓	✓	-	-
Non-Target	Chaetodontidae	*Chaetodon xanthurus*	-	-	-	-	-	✓	-	-	-	-	-	-	-
Non-Target	Chaetodontidae	*Coradion altivelis*	-	-	-	-	-	-	-	✓	✓	-	-	-	-
Non-Target	Chaetodontidae	*Coradion chrysozonus*	-	-	-	✓	✓	✓	✓	✓	✓	-	-	-	-
Non-Target	Chaetodontidae	*Coradion melanopus*	-	-	-	-	-	-	✓	-	-	-	✓	-	-
Non-Target	Chaetodontidae	*Forcipiger flavissimus*	✓	-	✓	✓	✓	✓	✓	✓	✓	✓	✓	-	-

Group	Fish Family	Fish Species	Ay Rhu n	Buan o	Koo n	Leas e	Serutba r	Guraic i	Makia n Moti	Mar e	Rao Dehegil a	Sul a	Wid i	Bera u Bay	Nusalas i Bay
Non-Target	Chaetodontidae	*Forcipiger longirostris*	✓	-	✓	-	✓	✓	✓	✓	✓	✓	✓	-	-
Non-Target	Chaetodontidae	*Hemitaurichthys polylepis*	✓	-	✓	✓	✓	✓	✓	✓	✓	✓	✓	-	-
Non-Target	Chaetodontidae	*Hemitaurichthys zoster*	-	-	✓	-	✓	-	-	-	✓	-	-	-	-
Non-Target	Chaetodontidae	*Heniochus acuminatus*	-	-	-	-	✓	✓	✓	✓	✓	✓	✓	-	-
Non-Target	Chaetodontidae	*Heniochus chrysostomus*	✓	-	✓	✓	✓	✓	✓	✓	✓	✓	✓	-	-
Non-Target	Chaetodontidae	*Heniochus diphreutes*	-	-	-	-	-	-	-	✓	-	-	-	-	-
Non-Target	Chaetodontidae	*Heniochus monoceros*	-	-	✓	-	-	✓	✓	✓	✓	-	✓	-	-
Non-Target	Chaetodontidae	*Heniochus pleurotaenia*	-	-	-	-	✓	✓	✓	✓	✓	-	✓	-	-
Non-Target	Chaetodontidae	*Heniochus singularius*	✓	-	✓	✓	✓	✓	✓	✓	✓	✓	✓	-	-
Non-Target	Chaetodontidae	*Heniochus varius*	✓	-	✓	✓	✓	✓	✓	✓	✓	✓	✓	-	-
Non-Target	Cirrhitidae	*Cirrhitichthys falco*	-	-	-	-	-	✓	✓	✓	✓	-	✓	-	-
Non-Target	Cirrhitidae	*Cirrhitichthys oxycephalus*	-	-	-	-	-	-	✓	✓	✓	-	✓	-	-
Non-Target	Cirrhitidae	*Paracirrhites arcatus*	-	-	-	-	-	✓	✓	✓	✓	-	✓	-	-
Non-Target	Cirrhitidae	*Paracirrhites forsteri*	-	-	✓	-	✓	✓	✓	✓	✓	-	✓	-	-
Non-Target	Cirrhitidae	*Paracirrhites xanthus*	-	-	-	-	-	✓	-	-	-	-	-	-	-
Non-Target	Diodontidae	*Diodon holocanthus*	-	-	-	-	-	✓	✓	-	✓	-	-	-	-
Non-Target	Diodontidae	*Diodon liturosus*	-	-	-	-	-	-	-	✓	-	-	-	-	-
Non-Target	Echeneidae	*Echeneis naucrates*	-	-	-	-	-	✓	-	-	-	-	-	-	-
Non-Target	Echeneidae	*Remora remora*	-	-	-	-	-	✓	✓	-	✓	-	✓	-	-
Non-Target	Ephippidae	*Platax batavianus*	✓	-	-	✓	-	-	-	-	-	-	-	-	-
Non-Target	Ephippidae	*Platax boersii*	-	-	✓	-	✓	✓	✓	✓	✓	✓	✓	-	-

Group	Fish Family	Fish Species	Ay Rhun	Buano	Koon	Lease	Serutbar	Guraici	Makian Moti	Mare	Rao Dehegila	Sula	Widi	Berau Bay	Nusalasi Bay
Non-Target	Ephippidae	*Platax orbicularis*	-	-	-	-	-	-	-	-	✓	-	✓	-	-
Non-Target	Ephippidae	*Platax pinnatus*	-	-	-	-	-	✓	✓	✓	✓	-	✓	-	-
Non-Target	Ephippidae	*Platax teira*	✓	✓	✓	✓	✓	✓	-	✓	✓	✓	✓	-	-
Non-Target	Fistulariidae	*Fistularia commersoni*	-	-	-	-	-	✓	✓	✓	✓	-	✓	-	-
Non-Target	Fistulariidae	*Fistularia commersonii*	-	-	-	-	✓	✓	✓	✓	✓	-	-	-	-
Non-Target	Gobiidae	*Ctenogobiops maculosus*	-	-	-	-	-	-	-	-	✓	-	-	-	-
Non-Target	Gobiidae	*Koumansetta rainfordi*	-	-	-	-	-	-	-	-	✓	-	-	-	-
Non-Target	Grammistidae	*Grammistes sexlineatus*	-	-	-	-	-	-	-	-	-	-	✓	-	-
Non-Target	Hemiramphidae	*Hyporhamphus dussumieri*	-	-	-	-	-	-	-	✓	-	-	-	-	-
Non-Target	Hemiscyllidae	*Hemiscyllium halmahera*	-	-	-	-	-	-	-	✓	-	-	-	-	-
Non-Target	Holocentridae	*Myripristis adusta*	-	✓	✓	-	✓	✓	-	✓	✓	-	✓	-	-
Non-Target	Holocentridae	*Myripristis berndti*	-	✓	✓	-	✓	✓	✓	✓	✓	✓	✓	-	-
Non-Target	Holocentridae	*Myripristis chryseres*	-	-	-	-	-	-	-	-	-	-	✓	-	-
Non-Target	Holocentridae	*Myripristis hexagona*	-	-	✓	-	-	✓	✓	-	-	-	✓	-	-
Non-Target	Holocentridae	*Myripristis kuntee*	-	✓	✓	-	-	✓	✓	✓	✓	✓	✓	-	-
Non-Target	Holocentridae	*Myripristis murdjan*	-	✓	✓	-	✓	✓	-	✓	✓	✓	✓	-	-
Non-Target	Holocentridae	*Myripristis pralinia*	-	-	-	-	-	✓	-	✓	✓	-	✓	-	-
Non-Target	Holocentridae	*Myripristis violacea*	-	✓	-	-	-	✓	✓	✓	✓	-	✓	-	-
Non-Target	Holocentridae	*Myripristis vittata*	-	-	-	-	-	✓	✓	✓	✓	-	✓	-	-
Non-Target	Holocentridae	*Neoniphon argenteus*	-	✓	-	-	✓	-	-	-	✓	-	-	-	-
Non-Target	Holocentridae	*Neoniphon opercularis*	-	✓	-	-	-	✓	-	✓	✓	✓	✓	-	-

Group	Fish Family	Fish Species	Ay Rhun	Buano	Koon	Lease	Serutbar	Guraici	Makian Moti	Mare	Rao Dehegila	Sula	Widi	Berau Bay	Nusalasi Bay
Non-Target	Holocentridae	*Neoniphon sammara*	-	✓	-	-	✓	✓	✓	✓	✓	✓	✓	-	-
Non-Target	Holocentridae	*Neoniphon spp.*	-	-	-	-	-	-	-	-	-	✓	-	-	-
Non-Target	Holocentridae	*Sargocentron caudimaculatum*	-	✓	✓	-	-	✓	✓	✓	✓	✓	✓	-	-
Non-Target	Holocentridae	*Sargocentron cornutum*	-	✓	-	-	✓	-	-	✓	✓	-	-	-	-
Non-Target	Holocentridae	*Sargocentron diadema*	-	-	-	-	-	-	-	✓	✓	-	✓	-	-
Non-Target	Holocentridae	*Sargocentron microstoma*	-	✓	-	-	-	-	✓	-	-	-	-	-	-
Non-Target	Holocentridae	*Sargocentron rubrum*	-	-	-	-	-	✓	✓	✓	✓	✓	✓	-	-
Non-Target	Holocentridae	*Sargocentron spiniferum*	-	✓	-	-	-	✓	-	-	✓	✓	✓	-	-
Non-Target	Holocentridae	*Sargocentron spp.*	-	-	-	-	-	-	-	-	-	✓	-	-	-
Non-Target	Holocentridae	*Sargocentron violaceum*	-	-	-	-	-	-	-	-	✓	-	-	-	-
Non-Target	Labridae	*Anampses caeruleopunctatus*	-	✓	-	✓	-	✓	✓	✓	✓	-	-	-	-
Non-Target	Labridae	*Anampses geographicus*	-	-	-	-	-	✓	-	✓	✓	-	✓	-	-
Non-Target	Labridae	*Anampses melanurus*	✓	-	-	✓	-	-	-	✓	-	-	✓	-	-
Non-Target	Labridae	*Anampses meleagrides*	✓	-	✓	✓	-	✓	✓	✓	✓	✓	✓	-	-
Non-Target	Labridae	*Anampses twisti*	-	-	-	-	-	✓	-	-	-	-	✓	-	-
Non-Target	Labridae	*Anampses twistii*	✓	-	-	✓	-	✓	-	✓	✓	✓	-	-	-
Non-Target	Labridae	*Bodianus axillaris*	-	-	✓	-	✓	✓	-	✓	✓	-	✓	-	-
Non-Target	Labridae	*Bodianus bilunulatus*	-	-	-	-	✓	-	-	-	-	✓	-	-	-
Non-Target	Labridae	*Bodianus diana*	-	-	-	-	-	✓	✓	✓	✓	-	✓	-	-
Non-Target	Labridae	*Bodianus dictynna*	✓	-	-	✓	-	-	-	-	-	✓	-	-	-
Non-Target	Labridae	*Bodianus mesothorax*	✓	-	✓	✓	✓	✓	✓	✓	✓	✓	✓	-	-

Group	Fish Family	Fish Species	Ay Rhun	Buano	Koon	Lease	Serutbar	Guraici	Makian Moti	Mare	Rao Dehegila	Sula	Widi	Berau Bay	Nusalasi Bay
Non-Target	Labridae	*Cheilinus bimaculatus*	-	-	-	-	-	✓	-	✓	-	-	-	-	-
Non-Target	Labridae	*Cheilinus chlorourus*	-	✓	-	-	✓	✓	✓	✓	✓	✓	✓	-	-
Non-Target	Labridae	*Cheilinus diagramma*	-	-	✓	-	✓	-	-	-	-	-	-	-	-
Non-Target	Labridae	*Cheilinus fasciatus*	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	-	-
Non-Target	Labridae	*Cheilinus oxycephalis*	-	-	-	-	-	-	-	✓	✓	-	-	-	-
Non-Target	Labridae	*Cheilinus spp.*	-	-	-	-	✓	-	-	✓	✓	-	✓	-	-
Non-Target	Labridae	*Cheilinus trilobatus*	-	✓	✓	-	✓	✓	✓	✓	✓	✓	-	-	-
Non-Target	Labridae	*Cheilinus unifasciatus*	-	-	✓	-	✓	-	-	-	-	-	-	-	-
Non-Target	Labridae	*Cheilio inermis*	-	✓	-	-	-	✓	✓	✓	✓	-	-	-	-
Non-Target	Labridae	*Choerodon anchorago*	-	✓	✓	-	✓	✓	✓	✓	✓	✓	✓	-	-
Non-Target	Labridae	*Choerodon margaritiferus*	-	-	-	-	-	-	-	✓	-	-	-	-	-
Non-Target	Labridae	*Cirrhilabrus aurantidorsalis*	-	-	-	✓	-	-	-	-	-	-	-	-	-
Non-Target	Labridae	*Cirrhilabrus cyanopleura*	-	-	-	-	-	✓	✓	✓	✓	✓	✓	-	-
Non-Target	Labridae	*Cirrhilabrus exquisitus*	-	-	-	-	-	✓	-	-	-	-	✓	-	-
Non-Target	Labridae	*Cirrhilabrus filamentosus*	-	-	-	-	-	-	-	✓	-	-	-	-	-
Non-Target	Labridae	*Cirrhilabrus flavidorsalis*	-	-	-	-	-	-	-	-	✓	-	-	-	-
Non-Target	Labridae	*Cirrhilabrus lubbocki*	-	-	-	-	-	✓	✓	✓	✓	-	-	-	-
Non-Target	Labridae	*Cirrhilabrus solorensis*	-	-	-	-	✓	✓	✓	✓	✓	-	✓	-	-
Non-Target	Labridae	*Cirrhilabrus walindi*	-	-	-	-	-	-	✓	-	-	-	-	-	-
Non-Target	Labridae	*Coris batuensis*	-	-	-	✓	-	✓	✓	✓	✓	✓	✓	-	-
Non-Target	Labridae	*Coris gaimard*	✓	-	✓	✓	✓	✓	-	✓	✓	✓	✓	-	-

Group	Fish Family	Fish Species	Ay Rhun	Buano	Koon	Lease	Serutbar	Guraici	Makian Moti	Mare	Rao Dehegila	Sula	Widi	Berau Bay	Nusalasi Bay
Non-Target	Labridae	*Coris pictoides*	-	-	-	-	-	✓	-	✓	✓	-	-	-	-
Non-Target	Labridae	*Diproctacanthus xanthurus*	✓	-	✓	✓	✓	✓	✓	✓	✓	✓	✓	-	-
Non-Target	Labridae	*Epibulus brevis*	-	-	-	✓	-	-	-	✓	-	✓	-	-	-
Non-Target	Labridae	*Epibulus insidiator*	✓	-	✓	✓	✓	✓	✓	✓	✓	✓	✓	-	-
Non-Target	Labridae	*Gomphosus caeruleus*	-	-	-	-	-	✓	-	✓	✓	-	✓	-	-
Non-Target	Labridae	*Gomphosus varius*	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	-	-
Non-Target	Labridae	*Halichoeres argus*	-	-	-	-	-	✓	✓	-	-	-	-	-	-
Non-Target	Labridae	*Halichoeres bicolor*	-	-	-	✓	-	-	-	-	-	✓	-	-	-
Non-Target	Labridae	*Halichoeres binotopsis*	-	-	-	-	-	-	-	✓	✓	-	-	-	-
Non-Target	Labridae	*Halichoeres biocellatus*	-	-	-	-	-	✓	✓	-	✓	-	✓	-	-
Non-Target	Labridae	*Halichoeres chloropterus*	-	-	-	-	-	-	-	✓	✓	-	-	-	-
Non-Target	Labridae	*Halichoeres chrysotaenia*	-	-	-	-	-	✓	-	✓	-	-	✓	-	-
Non-Target	Labridae	*Halichoeres chrysus*	✓	-	-	✓	✓	✓	✓	✓	✓	✓	✓	-	-
Non-Target	Labridae	*Halichoeres claudia*	✓	-	-	-	-	-	-	-	-	-	-	-	-
Non-Target	Labridae	*Halichoeres hortulanus*	✓	-	✓	✓	✓	✓	✓	✓	✓	✓	✓	-	-
Non-Target	Labridae	*Halichoeres leucoxanthus*	-	-	-	-	-	-	-	✓	✓	-	-	-	-
Non-Target	Labridae	*Halichoeres leucurus*	-	-	-	✓	-	✓	✓	✓	✓	-	✓	-	-
Non-Target	Labridae	*Halichoeres margaritaceus*	-	-	-	-	-	✓	✓	✓	✓	-	✓	-	-
Non-Target	Labridae	*Halichoeres marginatus*	-	-	-	-	-	✓	✓	✓	✓	-	✓	-	-
Non-Target	Labridae	*Halichoeres melanochir*	-	-	-	-	-	✓	✓	✓	✓	-	-	-	-
Non-Target	Labridae	*Halichoeres melanurus*	-	-	-	-	-	✓	✓	✓	✓	✓	✓	-	-

Group	Fish Family	Fish Species	Ay Rhu n	Buan o	Koo n	Leas e	Serutba r	Guraic i	Makia n Moti	Mar e	Rao Dehegil a	Sul a	Wid i	Bera u Bay	Nusalas i Bay
Non-Target	Labridae	*Halichoeres melasmapomus*	✓	-	-	-	-	-	-	-	-	-	-	-	-
Non-Target	Labridae	*Halichoeres miniatus*	-	-	-	-	-	-	-	-	-	-	✓	-	-
Non-Target	Labridae	*Halichoeres nebulosus*	-	-	-	-	-	✓	✓	✓	✓	-	✓	-	-
Non-Target	Labridae	*Halichoeres podostigma*	-	-	-	-	-	✓	-	✓	✓	-	✓	-	-
Non-Target	Labridae	*Halichoeres prosopeion*	✓	-	✓	✓	-	✓	✓	✓	✓	✓	✓	-	-
Non-Target	Labridae	*Halichoeres purpurescens*	-	-	-	-	-	✓	-	✓	✓	-	✓	-	-
Non-Target	Labridae	*Halichoeres richmondi*	-	-	✓	-	✓	✓	✓	✓	✓	-	✓	-	-
Non-Target	Labridae	*Halichoeres scapularis*	-	-	-	-	✓	✓	✓	✓	✓	-	-	-	-
Non-Target	Labridae	*Halichoeres solorensis*	-	-	-	✓	✓	✓	-	✓	✓	✓	-	-	-
Non-Target	Labridae	*Halichoeres spp*	-	-	-	-	-	-	-	-	✓	-	-	-	-
Non-Target	Labridae	*Halichoeres trimaculatus*	-	-	-	-	-	✓	-	✓	✓	-	-	-	-
Non-Target	Labridae	*Halichoeres vrolikii*	-	-	-	-	-	✓	-	✓	✓	-	✓	-	-
Non-Target	Labridae	*Hemigymnus fasciatus*	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	-	-
Non-Target	Labridae	*Hemigymnus melapterus*	-	✓	✓	-	✓	✓	✓	✓	✓	✓	✓	-	-
Non-Target	Labridae	*Hologymnosus annulatus*	-	-	-	-	-	✓	-	✓	-	-	-	-	-
Non-Target	Labridae	*Hologymnosus doliatus*	✓	-	-	-	-	✓	-	✓	✓	-	✓	-	-
Non-Target	Labridae	*Iniistius celebicus*	-	-	-	-	-	✓	-	-	-	-	-	-	-
Non-Target	Labridae	*Labrichthys unilineatus*	-	-	✓	✓	✓	✓	✓	✓	✓	-	✓	-	-
Non-Target	Labridae	*Labroides bicolor*	✓	-	✓	✓	✓	✓	✓	✓	✓	✓	✓	-	-
Non-Target	Labridae	*Labroides dimidiatus*	✓	-	✓	✓	✓	✓	✓	✓	✓	✓	✓	-	-
Non-Target	Labridae	*Labroides pectoralis*	✓	-	✓	✓	-	✓	✓	✓	✓	✓	✓	-	-

Group	Fish Family	Fish Species	Ay Rhun	Buano	Koon	Lease	Serutbar	Guraici	Makian Moti	Mare	Rao Dehegila	Sula	Widi	Berau Bay	Nusalasi Bay
Non-Target	Labridae	*Labropsis alleni*	✓	-	-	✓	-	-	-	✓	✓	-	✓	-	-
Non-Target	Labridae	*Labropsis manabei*	-	-	-	-	-	-	✓	-	-	✓	-	-	-
Non-Target	Labridae	*Leptojulis cyanopleura*	-	-	-	-	-	✓	-	-	✓	-	-	-	-
Non-Target	Labridae	*Macropharyngodon meleagris*	-	-	-	-	-	✓	✓	✓	✓	-	✓	-	-
Non-Target	Labridae	*Macropharyngodon ornatus*	-	-	✓	-	-	-	-	✓	✓	-	✓	-	-
Non-Target	Labridae	*Novaculichthys taeniourus*	-	-	-	-	-	✓	-	✓	✓	-	✓	-	-
Non-Target	Labridae	*Oxycheilinus arenatus*	-	-	-	-	-	-	-	-	✓	-	-	-	-
Non-Target	Labridae	*Oxycheilinus bimaculatus*	-	-	-	-	-	✓	-	✓	✓	-	-	-	-
Non-Target	Labridae	*Oxycheilinus celebicus*	-	✓	-	✓	✓	✓	✓	✓	✓	✓	✓	-	-
Non-Target	Labridae	*Oxycheilinus digramma*	-	✓	✓	✓	✓	✓	✓	✓	✓	-	✓	-	-
Non-Target	Labridae	*Oxycheilinus orientalis*	-	-	-	-	-	✓	-	✓	✓	-	✓	-	-
Non-Target	Labridae	*Oxycheilinus rhodochrous*	-	-	-	-	-	✓	-	✓	✓	-	✓	-	-
Non-Target	Labridae	*Oxycheilinus unifasciatus*	-	-	✓	-	-	✓	✓	✓	✓	-	✓	-	-
Non-Target	Labridae	*Paracheilinus cyaneus*	-	-	-	-	-	✓	-	-	-	-	-	-	-
Non-Target	Labridae	*Paracheilinus filamentosus*	-	-	-	-	-	✓	-	✓	-	-	-	-	-
Non-Target	Labridae	*Pseudocheilinus evanidus*	-	-	-	-	-	✓	-	✓	✓	-	✓	-	-
Non-Target	Labridae	*Pseudocheilinus hexataenia*	-	-	-	-	-	✓	✓	✓	✓	✓	✓	-	-
Non-Target	Labridae	*Pseudocheilinus octotaenia*	-	-	-	-	-	-	-	✓	✓	-	✓	-	-
Non-Target	Labridae	*Pseudocoris bleekeri*	-	-	-	-	-	-	-	-	✓	-	-	-	-
Non-Target	Labridae	*Pseudocoris yamashiroi*	-	-	-	-	-	-	-	-	✓	-	-	-	-
Non-Target	Labridae	*Pseudodax moluccanus*	✓	✓	✓	✓	-	✓	-	✓	✓	✓	✓	-	-

Group	Fish Family	Fish Species	Ay Rhun	Buano	Koon	Lease	Serutbar	Guraici	Makian Moti	Mare	Rao Dehegila	Sula	Widi	Berau Bay	Nusalasi Bay
Non-Target	Labridae	*Pteragogus cryptus*	-	-	-	-	-	-	✓	-	-	-	-	-	-
Non-Target	Labridae	*Stethojulis albovittata*	-	-	-	-	-	-	-	✓	-	-	-	-	-
Non-Target	Labridae	*Stethojulis bandanensis*	-	-	-	-	✓	✓	✓	✓	✓	-	✓	-	-
Non-Target	Labridae	*Stethojulis interrupta*	-	-	-	-	-	-	-	✓	✓	-	-	-	-
Non-Target	Labridae	*Stethojulis spp.*	-	-	-	-	-	-	-	✓	✓	-	✓	-	-
Non-Target	Labridae	*Stethojulis strigiventer*	-	-	-	-	-	✓	-	✓	✓	-	-	-	-
Non-Target	Labridae	*Stethojulis trilineata*	-	-	✓	-	-	✓	✓	✓	✓	-	✓	-	-
Non-Target	Labridae	*Thalassoma amblycephalum*	✓	-	✓	✓	✓	✓	-	✓	✓	✓	✓	-	-
Non-Target	Labridae	*Thalassoma hardwicke*	✓	-	✓	✓	-	✓	✓	✓	✓	✓	✓	-	-
Non-Target	Labridae	*Thalassoma janseni*	-	-	-	-	-	✓	✓	✓	✓	-	✓	-	-
Non-Target	Labridae	*Thalassoma lunare*	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	-	-
Non-Target	Labridae	*Thalassoma lutescens*	-	-	-	-	-	✓	✓	✓	✓	-	✓	-	-
Non-Target	Labridae	*Thalassoma purpureum*	-	-	-	-	-	-	-	✓	✓	-	-	-	-
Non-Target	Malacanthidae	*Malacanthus brevirostris*	-	-	✓	-	-	-	-	-	-	-	-	-	-
Non-Target	Malacanthidae	*Malacanthus latovittatus*	-	-	-	-	✓	✓	-	✓	✓	-	✓	-	-
Non-Target	Microdesmidae	*Nemateleotris decora*	-	-	-	-	-	-	-	-	-	-	✓	-	-
Non-Target	Microdesmidae	*Nemateleotris magnifica*	-	-	-	-	-	✓	-	✓	✓	-	✓	-	-
Non-Target	Microdesmidae	*Ptereleotris evides*	-	-	✓	-	-	✓	-	✓	✓	-	✓	-	-
Non-Target	Microdesmidae	*Ptereleotris heteroptera*	-	-	-	-	-	-	-	-	-	-	✓	-	-
Non-Target	Microdesmidae	*Ptereleotris zebra*	-	-	-	-	-	-	-	✓	-	-	-	-	-
Non-Target	Mobulidae	*Manta alfredi*	-	-	-	-	-	✓	-	-	-	-	-	-	-

Group	Fish Family	Fish Species	Ay Rhun	Buano	Koon	Lease	Serutbar	Guraici	Makian Moti	Mare	Rao Dehegila	Sula	Widi	Berau Bay	Nusalasi Bay
Non-Target	Monacanthidae	*Aluterus scriptus*	-	-	-	-	-	✓	-	-	-	-	✓	-	-
Non-Target	Monacanthidae	*Amanses scopas*	-	-	-	-	-	✓	✓	✓	✓	-	✓	-	-
Non-Target	Monacanthidae	*Cantherhines pardalis*	-	-	-	-	-	✓	✓	✓	✓	-	✓	-	-
Non-Target	Monacanthidae	*Oxymonacanthus longirostris*	-	-	-	-	-	✓	✓	✓	✓	-	-	-	-
Non-Target	Monacanthidae	*Pervagor janthinosoma*	-	-	-	-	-	-	-	-	✓	-	-	-	-
Non-Target	Monocanthidae	*Aluterus monoceros*	-	-	-	-	-	-	-	✓	-	-	-	-	-
Non-Target	Monocanthidae	*Aluterus scriptus*	-	-	-	-	-	-	-	✓	✓	-	-	-	-
Non-Target	Monocanthidae	*Amanses scopas*	-	-	✓	-	-	✓	-	✓	✓	-	✓	-	-
Non-Target	Monocanthidae	*Cantherhines dumerilii*	-	-	-	-	-	-	-	-	✓	-	-	-	-
Non-Target	Monocanthidae	*Cantherhines pardalis*	-	-	-	-	-	-	-	✓	✓	-	-	-	-
Non-Target	Monocanthidae	*Oxymonacanthus longirostris*	-	-	-	-	-	-	-	✓	✓	-	-	-	-
Non-Target	Monocanthidae	*Paraluteres prionurus*	-	-	-	-	-	-	✓	-	-	-	-	-	-
Non-Target	Mugilidae	*Crenimugil crenilabis*	-	-	-	-	-	-	-	-	✓	-	-	-	-
Non-Target	Muraenidae	*Gymnothorax favagineus*	-	-	-	-	-	-	-	-	✓	-	-	-	-
Non-Target	Muraenidae	*Gymnothorax flavimarginatus*	-	✓	-	-	-	✓	✓	✓	✓	✓	-	-	-
Non-Target	Muraenidae	*Gymnothorax javanicus*	-	-	-	-	-	✓	-	✓	✓	-	✓	-	-
Non-Target	Muraenidae	*Gymnothorax spp.*	-	✓	-	-	-	-	-	-	-	✓	-	-	-
Non-Target	Muraenidae	*Rhinomuraena quaesita*	-	-	-	-	-	✓	-	✓	-	-	-	-	-
Non-Target	Myliobatidae	*Aetobatus narinari*	-	-	-	✓	-	-	✓	-	-	-	✓	-	-
Non-Target	Myliobatidae	*Aetobatus ocellatus*	-	-	-	-	-	-	-	-	✓	✓	-	-	-
Non-Target	Opistognathidae	*Opistognathus spp.*	-	-	-	-	-	-	-	✓	-	-	-	-	-

Group	Fish Family	Fish Species	Ay Rhun	Buano	Koon	Lease	Serutbar	Guraici	Makian Moti	Mare	Rao Dehegila	Sula	Widi	Berau Bay	Nusalasi Bay
Non-Target	Ostraciidae	*Ostracion cubicus*	-	-	-	-	-	✓	✓	✓	✓	-	✓	-	-
Non-Target	Ostraciidae	*Ostracion meleagris*	-	-	-	-	✓	✓	✓	✓	✓	-	✓	-	-
Non-Target	Ostraciidae	*Ostracion solorensis*	-	-	-	-	-	-	✓	✓	✓	-	-	-	-
Non-Target	Pempheridae	*Parapriacanthus dispar*	-	-	-	-	-	-	✓	-	-	-	-	-	-
Non-Target	Pempheridae	*Parapriacanthus ransonneti*	-	-	-	-	-	-	-	-	✓	-	-	-	-
Non-Target	Pempheridae	*Pempheris adusta*	-	-	✓	-	-	✓	-	✓	✓	-	-	-	-
Non-Target	Pempheridae	*Pempheris oualensis*	-	-	-	-	-	✓	✓	-	✓	-	✓	-	-
Non-Target	Pempheridae	*Pempheris vanicolensis*	-	-	✓	-	-	✓	-	✓	✓	-	✓	-	-
Non-Target	Pholidichthyidae	*Pholidichthys leucotaenia*	-	-	-	-	-	-	-	✓	✓	-	-	-	-
Non-Target	Pinguipedidae	*Parapercis clathrata*	-	-	-	-	✓	✓	-	✓	✓	-	✓	-	-
Non-Target	Pinguipedidae	*Parapercis hexophtalma*	-	-	✓	-	-	✓	-	✓	✓	-	-	-	-
Non-Target	Pinguipedidae	*Parapercis hexophthalma*	-	-	-	-	-	-	✓	-	-	-	✓	-	-
Non-Target	Pinguipedidae	*Parapercis millepunctata*	-	-	-	-	-	✓	-	✓	✓	-	✓	-	-
Non-Target	Pinguipedidae	*Parapercis spp.*	-	-	-	-	-	-	✓	-	✓	-	-	-	-
Non-Target	Pinguipedidae	*Parapercis tetracantha*	-	-	-	-	-	-	-	✓	-	-	-	-	-
Non-Target	Platycephalidae	*Papilloculiceps longiceps*	-	-	-	-	-	-	-	-	✓	-	-	-	-
Non-Target	Plotosidae	*Plotosus lineatus*	-	-	-	-	-	✓	-	✓	✓	-	✓	-	-
Non-Target	Pomacanthidae	*Apolemichthys trimaculatus*	✓	-	✓	-	-	✓	-	✓	✓	✓	✓	-	-
Non-Target	Pomacanthidae	*Apolemichthys trimaculatus*	-	-	-	-	-	-	-	✓	✓	-	✓	-	-
Non-Target	Pomacanthidae	*Apolomichthys trimaculatus*	-	-	-	✓	✓	-	-	-	-	-	-	-	-
Non-Target	Pomacanthidae	*Centropyge bicolor*	✓	-	✓	✓	✓	✓	✓	✓	✓	✓	✓	-	-

Group	Fish Family	Fish Species	Ay Rhun	Buano	Koon	Lease	Serutbar	Guraici	Makian Moti	Mare	Rao Dehegila	Sula	Widi	Berau Bay	Nusalasi Bay
Non-Target	Pomacanthidae	*Centropyge bispinosa*	✓	-	-	✓	-	✓	✓	✓	✓	✓	✓	-	-
Non-Target	Pomacanthidae	*Centropyge eibli*	-	-	-	-	-	-	✓	-	-	-	✓	-	-
Non-Target	Pomacanthidae	*Centropyge fisheri*	-	-	-	-	-	✓	-	✓	-	-	✓	-	-
Non-Target	Pomacanthidae	*Centropyge heraldi*	-	-	✓	-	-	-	-	-	-	-	-	-	-
Non-Target	Pomacanthidae	*Centropyge nox*	-	-	-	-	-	✓	-	✓	✓	-	-	-	-
Non-Target	Pomacanthidae	*Centropyge spp.*	-	-	✓	-	-	-	-	-	-	-	-	-	-
Non-Target	Pomacanthidae	*Centropyge tibicen*	✓	-	✓	✓	✓	✓	✓	✓	✓	✓	✓	-	-
Non-Target	Pomacanthidae	*Centropyge vroliki*	-	-	-	✓	-	✓	✓	✓	✓	✓	✓	-	-
Non-Target	Pomacanthidae	*Centropyge vrolikii*	✓	-	-	-	✓	✓	✓	✓	✓	-	✓	-	-
Non-Target	Pomacanthidae	*Chaetodontoplus caeruleopunctatus*	-	-	-	-	-	-	-	✓	-	-	-	-	-
Non-Target	Pomacanthidae	*Chaetodontoplus mesoleucus*	-	-	-	✓	✓	✓	✓	✓	✓	-	✓	-	-
Non-Target	Pomacanthidae	*Chaetodontoplus poliourus*	-	-	-	✓	-	-	-	-	-	-	-	-	-
Non-Target	Pomacanthidae	*Genicanthus lamarck*	-	-	✓	-	-	✓	-	-	✓	-	-	-	-
Non-Target	Pomacanthidae	*Pomacanthus annularis*	-	-	-	-	-	-	✓	✓	✓	-	-	-	-
Non-Target	Pomacanthidae	*Pomacanthus imperator*	✓	-	✓	✓	✓	✓	✓	✓	✓	✓	✓	-	-
Non-Target	Pomacanthidae	*Pomacanthus navarchus*	✓	-	✓	✓	✓	✓	✓	✓	✓	✓	✓	-	-
Non-Target	Pomacanthidae	*Pomacanthus semicirculatus*	-	-	-	-	-	-	-	✓	✓	-	-	-	-
Non-Target	Pomacanthidae	*Pomacanthus sexstriatus*	-	-	✓	-	-	✓	✓	✓	✓	-	✓	-	-
Non-Target	Pomacanthidae	*Pomacanthus xanthometopon*	✓	-	✓	-	✓	✓	✓	✓	✓	✓	-	-	-
Non-Target	Pomacanthidae	*Pygoplites diacanthus*	✓	-	✓	✓	✓	✓	✓	✓	✓	✓	✓	-	-
Non-Target	Pomacentridae	*Abudefduf bengalensis*	-	-	✓	-	✓	-	-	-	✓	-	-	-	-

Group	Fish Family	Fish Species	Ay Rhun	Buano	Koon	Lease	Serutbar	Guraici	Makian Moti	Mare	Rao Dehegila	Sula	Widi	Berau Bay	Nusalasi Bay
Non-Target	Pomacentridae	*Abudefduf sexfasciatus*	-	-	✓	✓	✓	✓	✓	✓	✓	-	✓	-	-
Non-Target	Pomacentridae	*Abudefduf vaigiensis*	✓	-	✓	✓	✓	✓	✓	✓	✓	✓	✓	-	-
Non-Target	Pomacentridae	*Acanthochromis polyacanthus*	-	-	-	-	-	✓	✓	✓	✓	-	✓	-	-
Non-Target	Pomacentridae	*Altrichthys curatus*	-	-	-	-	-	-	✓	-	-	-	-	-	-
Non-Target	Pomacentridae	*Amblyglyphidodon aureus*	✓	-	✓	✓	✓	✓	✓	✓	✓	✓	✓	-	-
Non-Target	Pomacentridae	*Amblyglyphidodon batunai*	-	-	-	-	-	✓	-	✓	✓	-	✓	-	-
Non-Target	Pomacentridae	*Amblyglyphidodon curacao*	✓	-	✓	✓	✓	✓	✓	✓	✓	✓	✓	-	-
Non-Target	Pomacentridae	*Amblyglyphidodon leucogaster*	✓	-	✓	✓	✓	✓	✓	✓	✓	✓	✓	-	-
Non-Target	Pomacentridae	*Amblyglyphidodon ternatensis*	-	-	✓	-	✓	-	✓	✓	✓	-	-	-	-
Non-Target	Pomacentridae	*Amphiprion akallopisos*	-	-	-	-	-	✓	-	✓	✓	-	✓	-	-
Non-Target	Pomacentridae	*Amphiprion biaculeatus*	-	-	-	✓	-	-	-	-	-	-	-	-	-
Non-Target	Pomacentridae	*Amphiprion clarkii*	✓	-	✓	✓	✓	✓	✓	✓	✓	✓	✓	-	-
Non-Target	Pomacentridae	*Amphiprion ephippium*	-	-	-	-	-	-	-	-	✓	-	-	-	-
Non-Target	Pomacentridae	*Amphiprion melanopus*	-	-	-	-	-	✓	-	✓	✓	✓	✓	-	-
Non-Target	Pomacentridae	*Amphiprion ocellaris*	-	-	-	✓	-	✓	✓	✓	✓	-	✓	-	-
Non-Target	Pomacentridae	*Amphiprion perideraion*	✓	-	-	✓	-	✓	✓	✓	✓	✓	✓	-	-
Non-Target	Pomacentridae	*Amphiprion sandaracinos*	-	-	-	✓	-	✓	✓	-	✓	-	✓	-	-
Non-Target	Pomacentridae	*Amphiprion sebae*	-	-	-	-	-	-	-	-	✓	-	-	-	-
Non-Target	Pomacentridae	*Cheiloprion labiatus*	-	-	-	-	-	-	✓	-	✓	-	-	-	-
Non-Target	Pomacentridae	*Chromis alpha*	-	-	-	-	-	✓	-	-	-	-	-	-	-
Non-Target	Pomacentridae	*Chromis amboinensis*	-	-	-	✓	-	✓	✓	✓	✓	✓	✓	-	-

Group	Fish Family	Fish Species	Ay Rhun	Buano	Koon	Lease	Serutbar	Guraici	Makian Moti	Mare	Rao Dehegila	Sula	Widi	Berau Bay	Nusalasi Bay
Non-Target	Pomacentridae	*Chromis analis*	✓	-	✓	✓	✓	✓	✓	-	✓	✓	✓	-	-
Non-Target	Pomacentridae	*Chromis atripectoralis*	-	-	-	-	-	✓	✓	✓	✓	-	✓	-	-
Non-Target	Pomacentridae	*Chromis atripes*	✓	-	-	-	-	✓	✓	✓	✓	-	✓	-	-
Non-Target	Pomacentridae	*Chromis caudalis*	✓	-	-	✓	-	✓	✓	✓	✓	✓	✓	-	-
Non-Target	Pomacentridae	*Chromis fumea*	-	-	-	-	-	-	✓	✓	✓	-	✓	-	-
Non-Target	Pomacentridae	*Chromis lepidolepis*	-	-	-	-	-	✓	✓	✓	✓	-	✓	-	-
Non-Target	Pomacentridae	*Chromis lineata*	-	-	-	✓	-	✓	✓	✓	✓	-	✓	-	-
Non-Target	Pomacentridae	*Chromis margaritifer*	-	-	-	✓	-	-	-	✓	✓	-	✓	-	-
Non-Target	Pomacentridae	*Chromis margaritifera*	-	-	-	-	-	✓	✓	✓	✓	✓	✓	-	-
Non-Target	Pomacentridae	*Chromis opercularis*	-	-	✓	-	-	-	✓	✓	✓	-	-	-	-
Non-Target	Pomacentridae	*Chromis retrofasciata*	✓	-	-	✓	-	✓	✓	✓	✓	✓	✓	-	-
Non-Target	Pomacentridae	*Chromis scotochilloptera*	-	-	-	✓	-	-	-	-	-	-	-	-	-
Non-Target	Pomacentridae	*Chromis scotochiloptera*	-	-	✓	-	✓	✓	✓	-	✓	-	✓	-	-
Non-Target	Pomacentridae	*Chromis ternatensis*	✓	-	-	✓	-	✓	✓	✓	✓	✓	✓	-	-
Non-Target	Pomacentridae	*Chromis viridis*	-	-	-	✓	-	✓	✓	✓	✓	✓	✓	-	-
Non-Target	Pomacentridae	*Chromis weberi*	-	-	-	-	✓	✓	✓	✓	✓	-	✓	-	-
Non-Target	Pomacentridae	*Chromis xanthochira*	✓	-	✓	-	-	-	-	✓	✓	✓	-	-	-
Non-Target	Pomacentridae	*Chromis xanthura*	-	-	✓	-	✓	✓	✓	✓	✓	-	✓	-	-
Non-Target	Pomacentridae	*Chrysiptera bleekeri*	-	-	-	-	-	-	✓	-	-	-	-	-	-
Non-Target	Pomacentridae	*Chrysiptera caeruleolineatus*	-	-	-	-	-	-	-	-	✓	-	-	-	-
Non-Target	Pomacentridae	*Chrysiptera cyanea*	-	-	-	-	-	✓	-	✓	✓	-	-	-	-

Group	Fish Family	Fish Species	Ay Rhun	Buano	Koon	Lease	Serutbar	Guraici	Makian Moti	Mare	Rao Dehegila	Sula	Widi	Berau Bay	Nusalasi Bay
Non-Target	Pomacentridae	*Chrysiptera giti*	-	-	-	-	-	-	✓	-	-	-	-	-	-
Non-Target	Pomacentridae	*Chrysiptera glauca*	-	-	-	-	-	-	-	-	✓	-	-	-	-
Non-Target	Pomacentridae	*Chrysiptera hemicyanea*	-	-	-	✓	-	✓	✓	✓	✓	-	-	-	-
Non-Target	Pomacentridae	*Chrysiptera oxycephala*	-	-	-	-	-	✓	✓	✓	✓	-	✓	-	-
Non-Target	Pomacentridae	*Chrysiptera parasema*	-	-	-	-	-	✓	✓	✓	✓	-	✓	-	-
Non-Target	Pomacentridae	*Chrysiptera rex*	-	-	-	-	-	✓	✓	✓	✓	-	✓	-	-
Non-Target	Pomacentridae	*Chrysiptera rollandi*	-	-	-	✓	-	✓	✓	✓	✓	✓	✓	-	-
Non-Target	Pomacentridae	*Chrysiptera springeri*	✓	-	-	✓	-	✓	✓	✓	✓	✓	✓	-	-
Non-Target	Pomacentridae	*Chrysiptera talboti*	✓	-	-	✓	-	✓	✓	✓	✓	✓	✓	-	-
Non-Target	Pomacentridae	*Dascyllus aruanus*	✓	-	-	-	-	✓	✓	✓	✓	✓	✓	-	-
Non-Target	Pomacentridae	*Dascyllus carneus*	-	-	-	-	-	✓	✓	✓	✓	-	✓	-	-
Non-Target	Pomacentridae	*Dascyllus melanurus*	✓	-	-	-	-	✓	-	✓	✓	-	✓	-	-
Non-Target	Pomacentridae	*Dascyllus reticulatus*	✓	-	✓	✓	✓	✓	✓	✓	✓	✓	✓	-	-
Non-Target	Pomacentridae	*Dascyllus trimaculatus*	✓	-	✓	✓	✓	✓	✓	✓	✓	✓	✓	-	-
Non-Target	Pomacentridae	*Dischistodus fasciatus*	-	-	-	-	-	-	-	-	✓	-	-	-	-
Non-Target	Pomacentridae	*Dischistodus melanotus*	-	-	-	-	-	✓	✓	✓	✓	✓	-	-	-
Non-Target	Pomacentridae	*Dischistodus perscipillatus*	-	-	-	-	-	-	-	-	✓	-	-	-	-
Non-Target	Pomacentridae	*Dischistodus perspicillatus*	-	-	-	-	-	✓	-	-	✓	-	-	-	-
Non-Target	Pomacentridae	*Dischistodus prosopotaenia*	-	-	-	-	-	✓	-	✓	✓	-	-	-	-
Non-Target	Pomacentridae	*Dischistodus pseudochrysopoecillus*	✓	-	-	-	-	-	-	-	-	-	-	-	-
Non-Target	Pomacentridae	*Hemiglyphidodon plagiometapon*	-	-	-	-	-	✓	✓	✓	✓	-	✓	-	-

Group	Fish Family	Fish Species	Ay Rhun	Buano	Koon	Lease	Serutbar	Guraici	Makian Moti	Mare	Rao Dehegila	Sula	Widi	Berau Bay	Nusalasi Bay
Non-Target	Pomacentridae	*Lepidozygus tapeinosoma*	-	-	-	-	-	✓	-	✓	✓	-	✓	-	-
Non-Target	Pomacentridae	*Neoglyphidodon crossi*	-	-	-	-	-	✓	-	✓	✓	-	✓	-	-
Non-Target	Pomacentridae	*Neoglyphidodon melas*	-	-	✓	-	✓	✓	✓	✓	✓	-	✓	-	-
Non-Target	Pomacentridae	*Neoglyphidodon nigroris*	✓	-	✓	✓	✓	✓	✓	✓	✓	✓	✓	-	-
Non-Target	Pomacentridae	*Neoglyphidodon oxyodon*	-	-	-	-	-	-	-	-	-	✓	-	-	-
Non-Target	Pomacentridae	*Neoglyphidodon polyacanthus*	-	-	-	-	-	✓	-	-	-	-	-	-	-
Non-Target	Pomacentridae	*Neoglyphidodon thoracotaeniatus*	-	-	-	✓	-	✓	✓	✓	✓	✓	-	-	-
Non-Target	Pomacentridae	*Neopomacentrus anabatoides*	-	-	-	-	-	-	-	-	✓	-	-	-	-
Non-Target	Pomacentridae	*Neopomacentrus azysron*	-	-	-	-	-	✓	✓	✓	✓	-	✓	-	-
Non-Target	Pomacentridae	*Plectroglyphidodon dickii*	✓	-	-	✓	-	✓	✓	✓	✓	✓	✓	-	-
Non-Target	Pomacentridae	*Plectroglyphidodon lacrymatus*	-	-	-	-	-	✓	✓	✓	✓	✓	✓	-	-
Non-Target	Pomacentridae	*Pomacentrus adelus*	-	-	-	-	-	✓	✓	✓	✓	-	✓	-	-
Non-Target	Pomacentridae	*Pomacentrus alexanderae*	-	-	-	-	-	✓	-	-	-	-	✓	-	-
Non-Target	Pomacentridae	*Pomacentrus alleni*	-	-	-	-	-	✓	-	-	-	-	-	-	-
Non-Target	Pomacentridae	*Pomacentrus amboinensis*	✓	-	-	✓	-	✓	✓	✓	✓	✓	✓	-	-
Non-Target	Pomacentridae	*Pomacentrus auriventris*	✓	-	-	✓	-	✓	✓	✓	✓	✓	✓	-	-
Non-Target	Pomacentridae	*Pomacentrus bankanensis*	-	-	-	-	-	✓	✓	✓	✓	✓	✓	-	-
Non-Target	Pomacentridae	*Pomacentrus brachialis*	-	-	-	✓	-	✓	✓	✓	✓	-	✓	-	-
Non-Target	Pomacentridae	*Pomacentrus burroughi*	-	-	-	-	-	✓	✓	-	✓	-	-	-	-
Non-Target	Pomacentridae	*Pomacentrus chrysurus*	-	-	-	-	-	✓	✓	✓	✓	-	✓	-	-
Non-Target	Pomacentridae	*Pomacentrus coelestis*	-	-	-	-	-	✓	✓	✓	✓	-	✓	-	-

Group	Fish Family	Fish Species	Ay Rhun	Buano	Koon	Lease	Serutbar	Guraici	Makian Moti	Mare	Rao Dehegila	Sula	Widi	Berau Bay	Nusalasi Bay
Non-Target	Pomacentridae	*Pomacentrus grammorhynchus*	-	-	-	-	-	✓	-	✓	-	-	-	-	-
Non-Target	Pomacentridae	*Pomacentrus lepidogenys*	-	-	-	-	-	✓	✓	✓	✓	✓	✓	-	-
Non-Target	Pomacentridae	*Pomacentrus moluccensis*	✓	-	-	✓	-	✓	✓	✓	✓	✓	✓	-	-
Non-Target	Pomacentridae	*Pomacentrus nigromanus*	✓	-	-	✓	-	✓	✓	✓	✓	-	✓	-	-
Non-Target	Pomacentridae	*Pomacentrus nigromarginatus*	-	-	-	✓	-	✓	-	-	✓	-	✓	-	-
Non-Target	Pomacentridae	*Pomacentrus opisthostigma*	-	-	-	-	-	-	✓	-	-	-	-	-	-
Non-Target	Pomacentridae	*Pomacentrus philippinus*	-	-	-	-	-	✓	✓	✓	✓	-	✓	-	-
Non-Target	Pomacentridae	*Pomacentrus reidi*	✓	-	✓	✓	✓	✓	✓	✓	✓	✓	✓	-	-
Non-Target	Pomacentridae	*Pomacentrus simsiang*	-	-	-	-	-	✓	✓	-	✓	-	-	-	-
Non-Target	Pomacentridae	*Pomacentrus smithi*	-	-	-	-	-	✓	-	-	✓	-	-	-	-
Non-Target	Pomacentridae	*Pomacentrus stigma*	-	-	-	-	-	-	-	-	-	-	✓	-	-
Non-Target	Pomacentridae	*Pomacentrus vaiuli*	-	-	-	-	-	✓	✓	✓	✓	-	✓	-	-
Non-Target	Pomacentridae	*Premnas biaculeatus*	✓	-	-	-	-	✓	✓	✓	✓	-	✓	-	-
Non-Target	Pomacentridae	*Stegastes nigricans*	-	-	-	-	-	-	-	-	✓	-	-	-	-
Non-Target	Priacanthidae	*Heteropriacanthus cruentatus*	-	-	-	-	-	-	-	-	✓	-	-	-	-
Non-Target	Priacanthidae	*Priacanthus hamrur*	-	✓	-	-	-	✓	-	-	✓	-	✓	-	-
Non-Target	Pseudochromidae	*Labracinus cyclophthalmus*	-	-	-	-	-	✓	-	✓	✓	-	-	-	-
Non-Target	Pseudochromidae	*Manonichthys splendens*	-	-	-	-	-	✓	-	✓	✓	-	✓	-	-
Non-Target	Pseudochromidae	*Pictichromis paccagnellae*	-	-	-	-	-	✓	-	-	✓	-	-	-	-
Non-Target	Pseudochromidae	*Pictichromis porphyrea*	-	-	-	-	-	-	-	-	✓	-	-	-	-
Non-Target	Pseudochromidae	*Pseudochromis porphyreus*	-	-	-	-	-	-	-	-	-	-	✓	-	-

Group	Fish Family	Fish Species	Ay Rhun	Buano	Koon	Lease	Serutbar	Guraici	Makian Moti	Mare	Rao Dehegila	Sula	Widi	Berau Bay	Nusalasi Bay
Non-Target	Pseudochromidae	*Pseudochromis bitaeniatus*	-	-	-	-	-	✓	-	-	-	-	-	-	-
Non-Target	Pseudochromidae	*Pseudochromis fuscus*	-	-	-	-	-	✓	-	✓	✓	-	✓	-	-
Non-Target	Pseudochromidae	*Pseudochromis paccagnellae*	-	-	-	-	-	✓	-	-	-	-	-	-	-
Non-Target	Pseudochromidae	*Pseudochromis porphyreus*	-	-	-	-	-	✓	-	-	-	-	✓	-	-
Non-Target	Pseudochromidae	*Pseudochromis spp.*	-	-	-	-	-	-	-	-	✓	-	-	-	-
Non-Target	Ptereleotridae	*Nemateleotris magnifica*	-	-	-	-	-	-	✓	✓	✓	-	✓	-	-
Non-Target	Scaridae	*Scarus russelli*	-	-	-	-	-	-	-	-	✓	-	-	-	-
Non-Target	Scorpaenidae	*Pterois antennata*	-	-	-	-	-	✓	✓	✓	✓	-	✓	-	-
Non-Target	Scorpaenidae	*Pterois radiata*	-	-	-	-	-	-	-	✓	-	-	✓	-	-
Non-Target	Scorpaenidae	*Pterois volitans*	-	-	-	-	✓	✓	-	✓	✓	-	✓	-	-
Non-Target	Scorpaenidae	*Scorpaenopsis macrochir*	-	-	-	-	-	✓	-	-	-	-	-	-	-
Non-Target	Scorpaenidae	*Scorpaenopsis spp.*	-	-	✓	-	-	-	-	-	-	-	-	-	-
Non-Target	Serranidae	*Belonoperca chabanaudi*	-	-	-	-	-	-	-	✓	✓	-	-	-	-
Non-Target	Serranidae	*Diploprion bifasciatum*	-	-	-	-	✓	-	-	✓	✓	-	-	-	-
Non-Target	Serranidae	*Luzonichthys waitei*	-	-	-	-	-	-	-	-	-	-	✓	-	-
Non-Target	Serranidae	*Pogonoperca punctata*	-	✓	-	-	-	-	-	-	-	✓	-	-	-
Non-Target	Serranidae	*Pseudanthias dispar*	✓	-	✓	-	✓	✓	-	-	✓	✓	✓	-	-
Non-Target	Serranidae	*Pseudanthias evansi*	-	-	-	-	-	-	-	-	✓	-	-	-	-
Non-Target	Serranidae	*Pseudanthias huchtii*	✓	-	-	-	✓	✓	✓	✓	✓	✓	✓	-	-
Non-Target	Serranidae	*Pseudanthias pascalus*	-	-	-	-	-	-	-	✓	✓	-	-	-	-
Non-Target	Serranidae	*Pseudanthias pleurotaenia*	-	-	✓	-	-	✓	-	-	✓	-	-	-	-

Group	Fish Family	Fish Species	Ay Rhun	Buano	Koon	Lease	Serutbar	Guraici	Makian Moti	Mare	Rao Dehegila	Sula	Widi	Berau Bay	Nusalasi Bay
Non-Target	Serranidae	*Pseudanthias randalli*	-	-	-	-	-	✓	-	-	-	-	✓	-	-
Non-Target	Serranidae	*Pseudanthias squamipinnis*	-	-	✓	-	-	✓	-	✓	✓	-	✓	-	-
Non-Target	Serranidae	*Pseudanthias tuka*	-	-	-	-	-	✓	✓	✓	✓	✓	✓	-	-
Non-Target	Serranidae/Anthiinae	*Pseudanthias dispar*	-	-	-	✓	-	-	-	-	-	-	-	-	-
Non-Target	Serranidae/Anthiinae	*Pseudanthias huchtii*	-	-	-	✓	-	-	-	-	-	-	-	-	-
Non-Target	Serranidae/Anthiinae	*Pseudanthias tuka*	-	-	-	✓	-	-	-	-	-	-	-	-	-
Non-Target	Syngnathidae	*Dunckerocampus dactyliophorus*	-	-	-	-	-	-	-	✓	-	-	-	-	-
Non-Target	Synodonthidae	*Synodus dermatogenys*	-	-	-	-	-	✓	✓	✓	✓	-	-	-	-
Non-Target	Synodonthidae	*Synodus jaculum*	-	-	-	-	-	-	✓	-	-	-	-	-	-
Non-Target	Synodonthidae	*Synodus variegatus*	-	-	-	-	-	✓	-	-	-	-	-	-	-
Non-Target	Synodontidae	*Saurida gracilis*	-	-	-	-	-	-	-	✓	-	-	-	-	-
Non-Target	Synodontidae	*Synodus dermatogenys*	-	-	-	-	-	✓	-	✓	✓	-	-	-	-
Non-Target	Synodontidae	*Synodus jaculum*	-	-	-	-	-	-	-	✓	✓	-	-	-	-
Non-Target	Synodontidae	*Synodus variegatus*	-	-	-	-	-	-	-	✓	✓	-	-	-	-
Non-Target	Tetraodontidae	*Arothron hispidus*	-	-	-	-	-	-	-	✓	✓	-	-	-	-
Non-Target	Tetraodontidae	*Arothron mappa*	-	-	-	-	-	-	✓	✓	✓	-	-	-	-
Non-Target	Tetraodontidae	*Arothron nigropunctatus*	-	-	✓	-	✓	✓	✓	✓	✓	-	✓	-	-
Non-Target	Tetraodontidae	*Arothron reticularis*	-	-	-	-	-	-	-	✓	-	-	-	-	-
Non-Target	Tetraodontidae	*Arothron stellatus*	-	-	-	-	-	✓	✓	✓	✓	-	✓	-	-
Non-Target	Tetraodontidae	*Canthigaster amboinensis*	-	-	-	-	-	-	-	✓	✓	-	-	-	-
Non-Target	Tetraodontidae	*Canthigaster bennetti*	-	-	-	-	-	✓	-	-	✓	-	-	-	-

Group	Fish Family	Fish Species	Ay Rhun	Buano	Koon	Lease	Serutbar	Guraici	Makian Moti	Mare	Rao Dehegila	Sula	Widi	Beru Bay	Nusalasi Bay
Non-Target	Tetraodontidae	*Canthigaster compressa*	-	-	-	-	-	✓	-	-	✓	-	✓	-	-
Non-Target	Tetraodontidae	*Canthigaster papua*	-	-	-	-	-	✓	✓	✓	✓	-	✓	-	-
Non-Target	Tetraodontidae	*Canthigaster valentini*	-	-	-	-	-	✓	✓	✓	✓	-	✓	-	-
Non-Target	Zanclidae	*Zanclus cornutus*	-	-	✓	-	✓	✓	✓	✓	✓	-	✓	-	-

8.7 APPENDIX VII – THE PMI RESULTS OF THE AVERAGE BIOMASS OF SELECTED TARGET FISH FAMILIES IN EACH MPA. RED INDICATED SIGNIFICANT INCREASE.

MPA	Koon		
Year	2016 - 2020		
N site	4		
Target Families	Biomass T0 (Kg/Ha)	Biomass T2 (Kg/Ha)	P Value
Acanthuridae	294.70 (96.4)	103.53 (21.6)	0.68
Caesionidae	502.78 (284.5)	347.87 (90.2)	0.57
Carangidae	983.05 (479.6)	21.56 (10.6)	0.26
Haemulidae	1314.88 (1042.2)	17.45 (6.9)	0.12
Kyphosidae	NA	NA	NA
Labridae – *(Cheilinus undulatus* only)	NA	NA	NA
Lethrinidae	7.08 (6.3)	52.97 (27.4)	0.04*
Lutjanidae	586.11 (213.6)	66.6 (20.4)	0.008*
Mullidae	NA	3.48 (1.1)	NA
Nemipteridae	10.07 (6.7)	0 (0)	0.06
Scaridae	83.16 (22.1)	44.70 (16.2)	0.01*
Scombridae	7.50 (5.5)	NA	NA
Serranidae (Grouper only)	49.56 (9.2)	27.13 (5.1)	0.29
Siganidae	0.48 (0.5)	0.44 (0.4)	0.98
Overall average	**3839.38 (1338.7)**	**685.77 (124.9)**	**0.02***

MPA	Serutbar		
Year	2017 - 2020		
N site	6		
Target Families	Biomass T0 (Kg/Ha)	Biomass T1 (Kg/Ha)	P Value
Acanthuridae	191.51 (43.7)	29.54 (8.6)	<0.001*
Caesionidae	625.56 (199.5)	209.03 (62.6)	0.45
Carangidae	45.18 (25.9)	0 (0)	0.008*
Haemulidae	19.23 (13.0)	2.45 (1.6)	0.12
Kyphosidae	NA	NA	NA
Labridae – *(Cheilinus undulatus* only)	3.45 (2.4)	0 (0)	0.16
Lethrinidae	30.44 (10.6)	4.59 (2.4)	0.08
Lutjanidae	86.73 (22.6)	7.05 (2.0)	<0.001*
Mullidae	0 (0)	7.71 (2.5)	<0.001*
Nemipteridae	29.71 (8.7)	4.22 (2.2)	<0.001*
Scaridae	220.94 (40.6)	61.77 (14.5)	<0.001*
Scombridae	0.76 (0.8)	1.02 (1.02)	0.95
Serranidae (Grouper only)	17.64 (4.8)	7.16 (2.1)	0.07
Siganidae	116.82 (47.0)	7.97 (3.3)	<0.001*
Overall average	**1387.98 (214.0)**	**342.49 (66.7)**	**<0.001***

MPA	Lease		
Year	2018 - 2020		
N site	8		
Target Families	Biomass T0 (Kg/Ha)	Biomass T1 (Kg/Ha)	P Value
Acanthuridae	230.24 (102.7)	206.56 (67.9)	0.048*
Caesionidae	740.80 (216.4)	512.38 (151.7)	0.26
Carangidae	195.78 (175.8)	16.47 (6.8)	0.19
Haemulidae	26.86 (15.6)	28.32 (14.1)	0.49
Kyphosidae	0 (0)	192.11 (111.9)	0.01*
Labridae – *(Cheilinus undulatus* only)	3.81 (2.1)	1.78 (1.4)	0.47
Lethrinidae	20.67 (5.6)	53.5 (17.9)	0.36
Lutjanidae	565.73 (208.5)	534.17 (117.6)	0.16
Mullidae	0 (0)	13.67 (6.7)	<0.001*
Nemipteridae	0 (0)	2.54 (0.7)	<0.001*
Scaridae	98.75 (22.7)	60.48 (10.0)	0.66
Scombridae	1.4 (1.4)	5.30 (4.0)	0.52
Serranidae (Grouper only)	16.80 (3.6)	13.41 (2.8)	0.43
Siganidae	127.71 (56.6)	173.19 (77.1)	0.57
Overall average	**2028.53 (421.1)**	**1813.91 (297.3)**	**0.18**

MPA	Guraici		
Year	2017 - 2020		
N site	6		
Target Families	Biomass T0 (Kg/Ha)	Biomass T1 (Kg/Ha)	P Value
Acanthuridae	147.75 (32.9)	42.48 (7.0)	<0.001*
Caesionidae	53.47 (39.7)	159.24 (45.2)	0.03*
Carangidae	62.48 (29.1)	13.73 (10.5)	0.02*
Haemulidae	0.53 (0.53)	3.12 (1.9)	0.2
Kyphosidae	NA	NA	NA
Labridae – *(Cheilinus undulatus* only)	0 (0)	12.44 (7.8)	0.13
Lethrinidae	3.31 (2.2)	7.07 (2.0)	0.02*
Lutjanidae	10.84 (3.8)	25.60 (9.4)	0.1
Mullidae	7.92 (2.0)	5.41 (1.1)	0.3
Nemipteridae	3.57 (1.1)	4.03 (1.3)	0.8
Scaridae	93.02 (40.5)	67.85 (13.7)	0.35
Scombridae	NA	NA	NA
Serranidae (Grouper only)	11.09 (2.5)	10.81 (1.8)	0.88
Siganidae	5.32 (2.0)	11.27 (3.4)	0.08
Overall average	**399.29 (91.4)**	**363.03 (58.3)**	**0.72**

MPA	Mare		
Year	2017 - 2020		
N site	5		
Target Families	Biomass T0 (Kg/Ha)	Biomass T1 (Kg/Ha)	P Value
Acanthuridae	77.59 (10.9)	75.54 (8.4)	0.98
Caesionidae	34.64 (16.2)	251.42 (95.4)	<0.001*
Carangidae	2.26 (1.6)	7.87 (3.7)	0.28
Haemulidae	4.77 (3.5)	25.97 (10.8)	0.07
Kyphosidae	2.11 (2.11)	0.92 (0.6)	0.79
Labridae – *(Cheilinus undulatus* only)	10.06 (10.06)	6.06 (5.0)	0.71
Lethrinidae	1.76 (1.1)	13.39 (3.7)	<0.001*
Lutjanidae	5.13 (2.5)	33.80 (6.4)	<0.001*
Mullidae	6.64 (1.3)	19.20 (6.2)	0.15
Nemipteridae	4.32 (1.1)	6.13 (1.4)	0.53
Scaridae	24.11 (5.1)	85.19 (12.4)	<0.001*
Scombridae	0 (0)	5.92 (3.6)	0.13
Serranidae (Grouper only)	8.90 (1.6)	15.87 (2.9)	0.16
Siganidae	2.08 (0.9)	13.18 (3.1)	<0.001*
Overall average	**189.38 (26.8)**	**559.48 (99.9)**	**0.002***

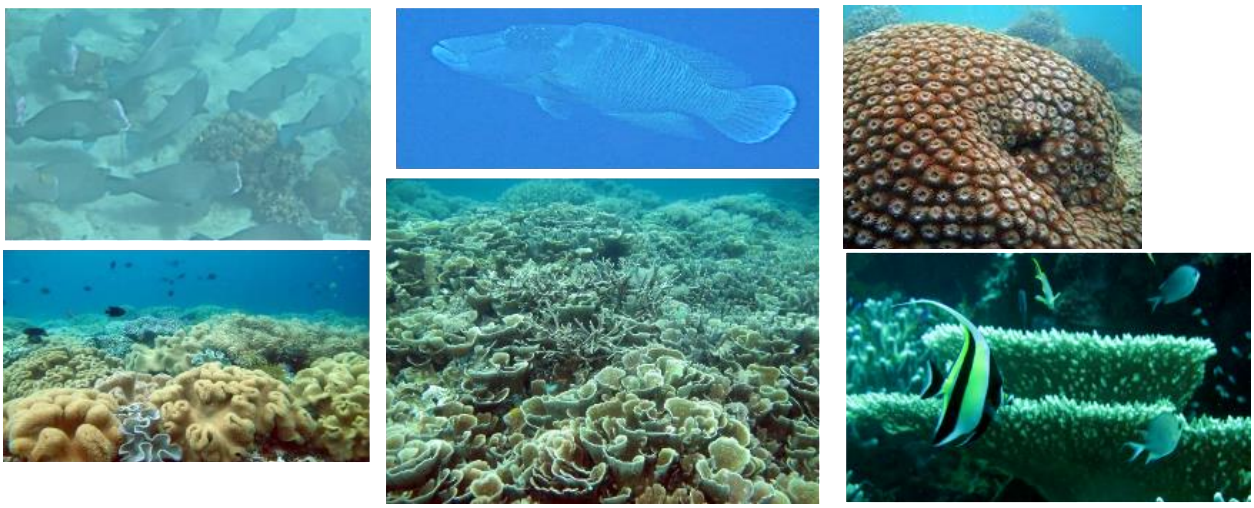
MPA	Rao - Dehegila		
Year	2017 - 2020		
N site	5		
Target Families	Biomass T0 (Kg/Ha)	Biomass T1 (Kg/Ha)	P Value
Acanthuridae	156.91 (15.6)	55.10 (12.3)	<0.001*
Caesionidae	1066.04 (221.1)	136.35 (25.7)	0.27
Carangidae	12.87 (12.9)	0.84 (0.5)	0.89
Haemulidae	27.33 (6.9)	20.30 (8.6)	0.009*
Kyphosidae	3.47 (2.2)	3.70 (2.6)	0.71
Labridae – *(Cheilinus undulatus* only)	26.03 (11.3)	0 (0)	0.005*
Lethrinidae	78.32 (19.2)	8.36 (3.4)	<0.001*
Lutjanidae	200.99 (41.3)	29.63 (6.7)	<0.001*
Mullidae	82.67 (14.8)	47.27 (16.3)	0.009*
Nemipteridae	109.11 (19.2)	6.70 (2.0)	<0.001*
Scaridae	301.15 (114.7)	73.81 (13.3)	0.25
Scombridae	13.73 (10.1)	0 (0)	0.09
Serranidae (Grouper only)	28.13 (7.0)	6.13 (1.7)	0.01*
Siganidae	196.06 (24.5)	17.42 (4.5)	<0.001*
Overall average	**2302.81 (394.4)**	**405.62 (49.8)**	**<0.001***

MPA	Sula		
Year	2017 - 2020		
N site	3		
Target Families	Biomass T0 (Kg/Ha)	Biomass T1 (Kg/Ha)	P Value
Acanthuridae	474.41 (71.3)	798.99 (474.9)	0.04*
Caesionidae	3851.87 (614.1)	218.67 (108.8)	<0.001*
Carangidae	19.30 (11.8)	16.98 (15.9)	0.45
Haemulidae	55.91 (13.2)	59.82 (35.9)	0.07
Kyphosidae	62.79 (43.7)	0 (0)	0.08
Labridae – *(Cheilinus undulatus* only)	20.99 (11.2)	4.1 (2.5)	0.56
Lethrinidae	267.55 (60.2)	45.82 (17.3)	0.001*
Lutjanidae	345.62 (65.4)	543.64 (235.0)	0.61
Mullidae	249.55 (50.8)	9.50 (5.7)	<0.001*
Nemipteridae	10.87 (8.4)	1.67 (0.9)	0.85
Scaridae	421.99 (98.5)	55.92 (14.2)	<0.001*
Scombridae	46.82 (37.9)	0 (0)	0.16
Serranidae (Grouper only)	125.46 (20.9)	21.36 (4.2)	<0.001*
Siganidae	58.67 (18.8)	4.35 (1.8)	0.07
Overall average	**6011.82 (786.9)**	**1780.83 (620.2)**	**<0.001***

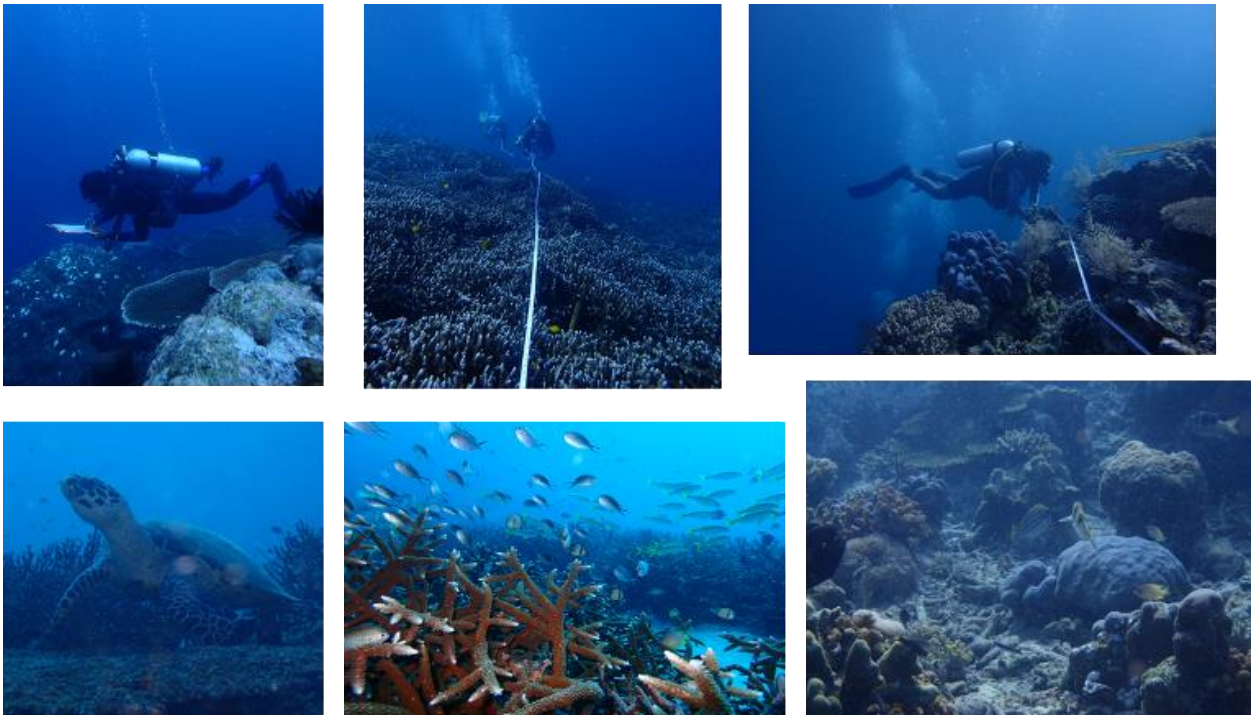
MPA	Widi		
Year	2017 - 2020		
N site	8		
Target Families	Biomass T0 (Kg/Ha)	Biomass T1 (Kg/Ha)	P Value
Acanthuridae	430.63 (128.1)	350.28 (71.9)	0.34
Caesionidae	293.36 (81.1)	417.18 (106.1)	0.37
Carangidae	9.76 (5.0)	24.42 (11.5)	0.05
Haemulidae	13.45 (7.4)	23.66 (8.3)	0.13
Kyphosidae	5.19 (4.3)	1.40 (0.7)	0.94
Labridae – *(Cheilinus undulatus* only)	3.74 (3.7)	26.29 (21.8)	0.22
Lethrinidae	19.63 (10.8)	20.58 (5.8)	0.06
Lutjanidae	78.18 (35.3)	211.39 (76.9)	0.05
Mullidae	7.28 (2.1)	4.89 (1.5)	0.3
Nemipteridae	2.99 (0.7)	2.26 (0.6)	0.2
Scaridae	133.99 (24.2)	98.87 (16.5)	0.17
Scombridae	0 (0)	10.75 (8.7)	0.22
Serranidae (Grouper only)	25.66 (2.8)	32.04 (10.1)	0.19
Siganidae	14.51 (7.7)	66.01 (25.2)	0.01*
Overall average	**1036.38 (178.5)**	**1290.03 (192.9)**	**0.35**

8.8 APPENDIX VIII – PHOTOS OF SURVEYS

Photos from the survey in Ay-Rhun MPA in 2019. From top left to bottom left clockwise: a) Green turtle (*Chelonia mydas*); b) the survey team c) soft coral was abundant in Ay Timur (Site ARU4); d) and e) moray eels; f) high coral coverage in Pohon Miring (ARU16) site outside Ay-Rhun MPA boundary inside the Banda MPA network. Photos credits: a, b, e, f: Rudyanto / USAID-SEA Project; d and e: Coral Triangle Center.

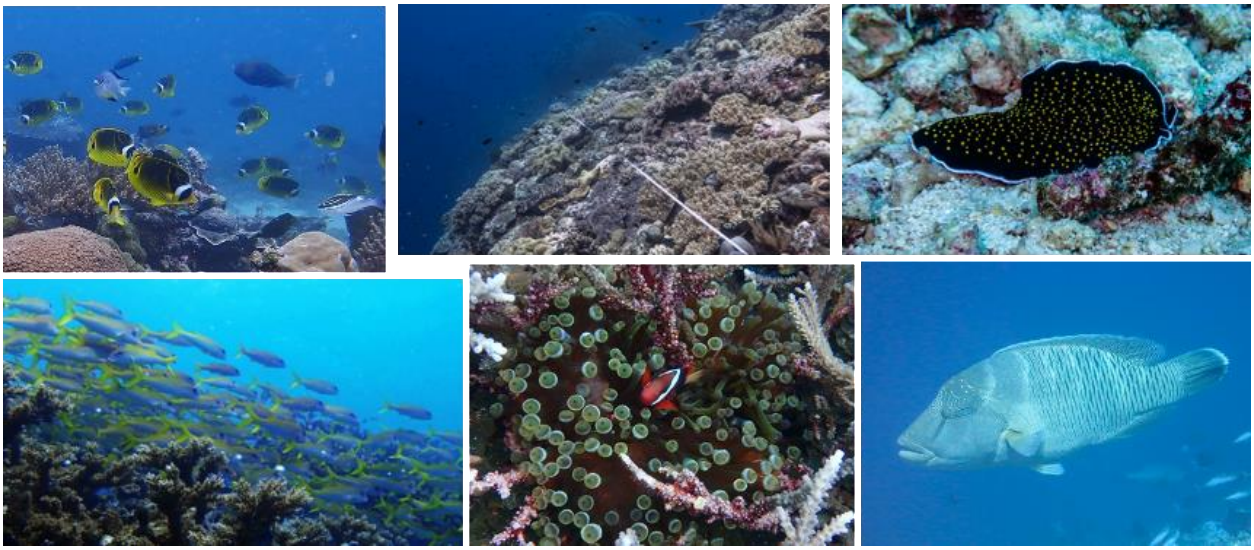


Photos from the survey in Buano MPA in 2017. From top left to bottom left clockwise: a) green bumphead parrotfish (*Bolbometopon muricatum*) b) Napoleon wrasse (*Cheilinus undulatus*); c) *Diploastrea heliopora* n Sahana Ain (Site BUA10) d) Moorish idol (*Zanclus cornutus*) near tabulate *Acropora*; e) dense foliose coral (*Oxypora lacera*) in Nusa Uni (Site BUA3); f) dense soft coral was observed in Desa Nai Puti (Site BOA4). Photo credit: Coral Triangle Center.

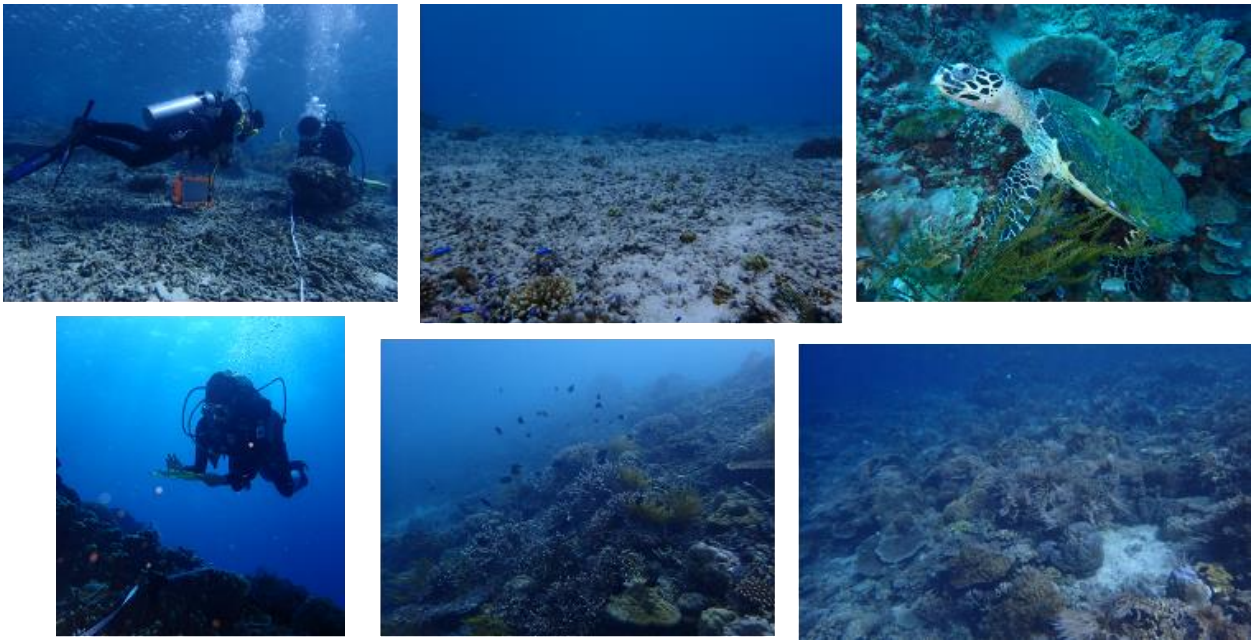


Photos from the survey in Koon MPA in 2020. From top left to bottom left clockwise: a) to c) the survey team in the field; d) the benthic community; e) Branching *Acropora* and planktivores; f) green turtle (*Chelonia mydas*). Photo credit: WWF Indonesia.

Photos from the survey in Lease MPA in 2018. From top left to bottom left clockwise: a) blacktip reef shark (*Carcharhinus melanopterus*) in Pelauw (Site LH01); b) a diver records the benthic community along the transect line; c) a dugong (*Dugon dugong*) was spotted in Booi (Site LS01); d) drummers and midnight snapper found at Ameth (Site LN06); e) old massive *Porites* colony found at Akoon (Site LN05); f) 100% foliose cover at Ihamahu (Site LS06). Photo credit: Coral Triangle Center.

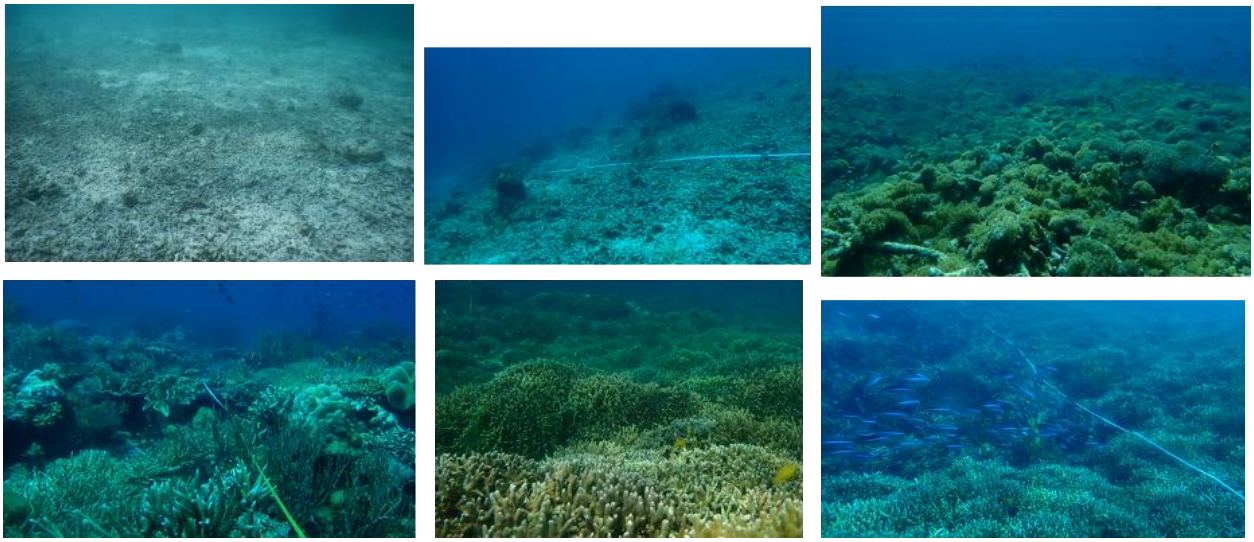


Photos from the survey in Lease MPA in 2020. From top left to bottom left clockwise: a) Raccoon butterflyfish (*Chaetodon lunula*); b) a transect line on the reef slope; c) the flatworm *Thysanozoon nigropapillosum*; d) Napoleon wrasse (*Cheilinus undulatus*); e) anemonefish (*Amphiprion* sp.); f) a large school of goatfish. Photo credits: a and e: Andreas Muljadi; b and d: Evi Ihsan/ Coral Triangle Center; c and e: Purwanto/ Coral Triangle Center.



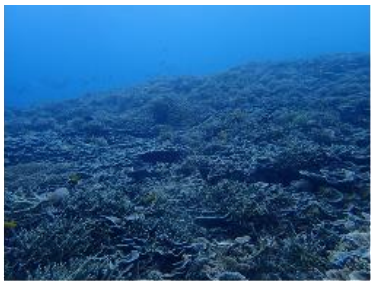
Photos from the survey in Serutbar MPA in 2020. From top left to bottom left clockwise: a) the survey team observing benthic characteristics; b) rubble and sand were abundant at some sites; c) green turtle (*Chelonia mydas*); d and e) dense cover of live coral; f) a surveyor conducting point intercept transect surveys. Photo credit: WWF Indonesia.

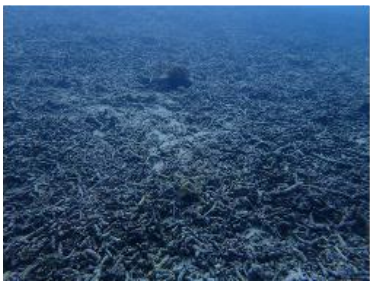
Photos from the survey in Guraici MPA in 2017. From left to right: a) a manta ray in Rajawali Bay (Site GUR22); b) and c) the coral outside Guraici MPA was in a good condition, Tanjung Modayama (Site GUR16). Photos credit: Wildlife Conservation Society.



Photos from the survey in Guraici MPA in 2020. From top left to bottom left clockwise: a) rubble and sand cover at the Kelo (GUR21) aquaculture no-take zone; b) rubble in the core zone at Taneti 2 (GUR11); c) abundant soft coral in the Tamako (GUR9) fishing zone; d) dense coral cover at West Taneti (GUR14) core zone; e) dense coral cover at Lelei (GUR6) core zone; e) a transect line on dense coral. Photo credit: Muhidin/Wildlife Conservation Society.


Photos from the survey in Mare MPA in 2017. From left to right: a) a healthy coral reef in a fishing zone Marefoko (MAR4) site; b) Kahiya Masolo is often frequented by dolphins around Mare MPA. Photo credits: a) Wildlife Conservation Society; b) Paul Eka/ Marine Change.


Photos from the survey in Mare MPA in 2020. From top left to bottom left clockwise: a) high coral cover in East Mare (MAR7) rehabilitation zone; b) high coral cover in Maregam (MAR11) coral rehabilitation zone; c) a turtle spotted at Site Mar11; d) a no-fishing sign in the core zone at Marekofo-T1 (MAR15); e) a rubble field in the coral rehabilitation zone (MAR11); e) rubble at core zone (MAR15). Photo credit: Wildlife Conservation Society.

Photos from the survey in Rao-Dehegila MPA in 2017. From left to right: a) rubble and sand field in Rao-Dehegila MPA; b) a healthy reef in the fishing zone Leo-leo (site RAO23). Photo credit: Wildlife Conservation Society.

Photos from the survey in Rao-Dehegila MPA in 2020. From top left to bottom left clockwise: a) a transect line on healthy coral dominated by foliose colonies in the core zone of Aru Burung (Site RAO19); b) two observers recording data; c) a giant clam in Dodola Selatan (RAO7) tourism zone; d) a blacktip reef shark (*Carcharhinus melanopterus*) in Mitita Selatan (RAO1) tourim zone; e) abundant reef fish at Kolorai Barat (RAO5) fishing zone; f) abundant soft coral at core zone in Ngele-ngele besar (Site RAO14). Photo credit: Muhidin/ Wildlife Conservation Society.

Photos from the survey in Sula MPA in 2017. From top left to bottom left clockwise: a) rubble field in Kampung Bajo (SUL9) control site; dolphins swimming in the tourism zone Kiamasol (Site SUL1); c) a leatherback turtle (*Dermochelys coriacea*) was photographed at Lifmatola penyu (SUL4) core zone; d) encrusting coral (*Agaricia grahamae*) dominated the Fatkauyon (SUL11) site at 10 meter depth; e) Napoleon wrasse (*Cheilinus undulatus*) were frequently found during the survey; f) a sea cucumber on *Acropora palifera,* the coral that dominated fishing zone Waisum (SUL2) site. Photo credit: Coral Triangle Center.

Photos from the survey in Sula MPA in 2020. From top left to bottom left clockwise: a) an observer swimming above reef slope; b) rubble field at tourism zone, Fatpinakoa (SUL19) site; c) complex and dense hard coral cover at fishing zone Waisum (SUL2); d) a healthy reef and reef fish at the core zone Lifmatola penyu (SUL4). Photo credit: Evi Ihsan/ Coral Triangle Center.

Photos from the survey in Widi MPA in 2017. From top left to right: a) a healthy reef in core zone in Dadawe weda (WID2) site; b) a green turtle (*Chelonia mydas*) was spotted around Widi MPA; c) a blacktip reef shark (*Carcharhinus melanopterus*). Photo credit: Wildlife Conservation Society.

Photos from the survey in Widi MPA in 2020. From top left to bottom left clockwise: a) school of barracudas in a new core zone site Barakuda point (WID13); b) blacktip reef shark (*Carcharhinus melanopterus*) and abundant red-toothed trigger fish (*Odonus niger*) at tourism zone in Hilang (WID7) site; c) core zone condition at Sukar (WID) site; d) dense soft coral cover at tourism zone Dadawe gane (WID1); *Acropora* tabulates and healthy coral cover at fishing zone in Boku-boku (WID10). Photo credit: Muhidin/ Wildlife Conservation Society.