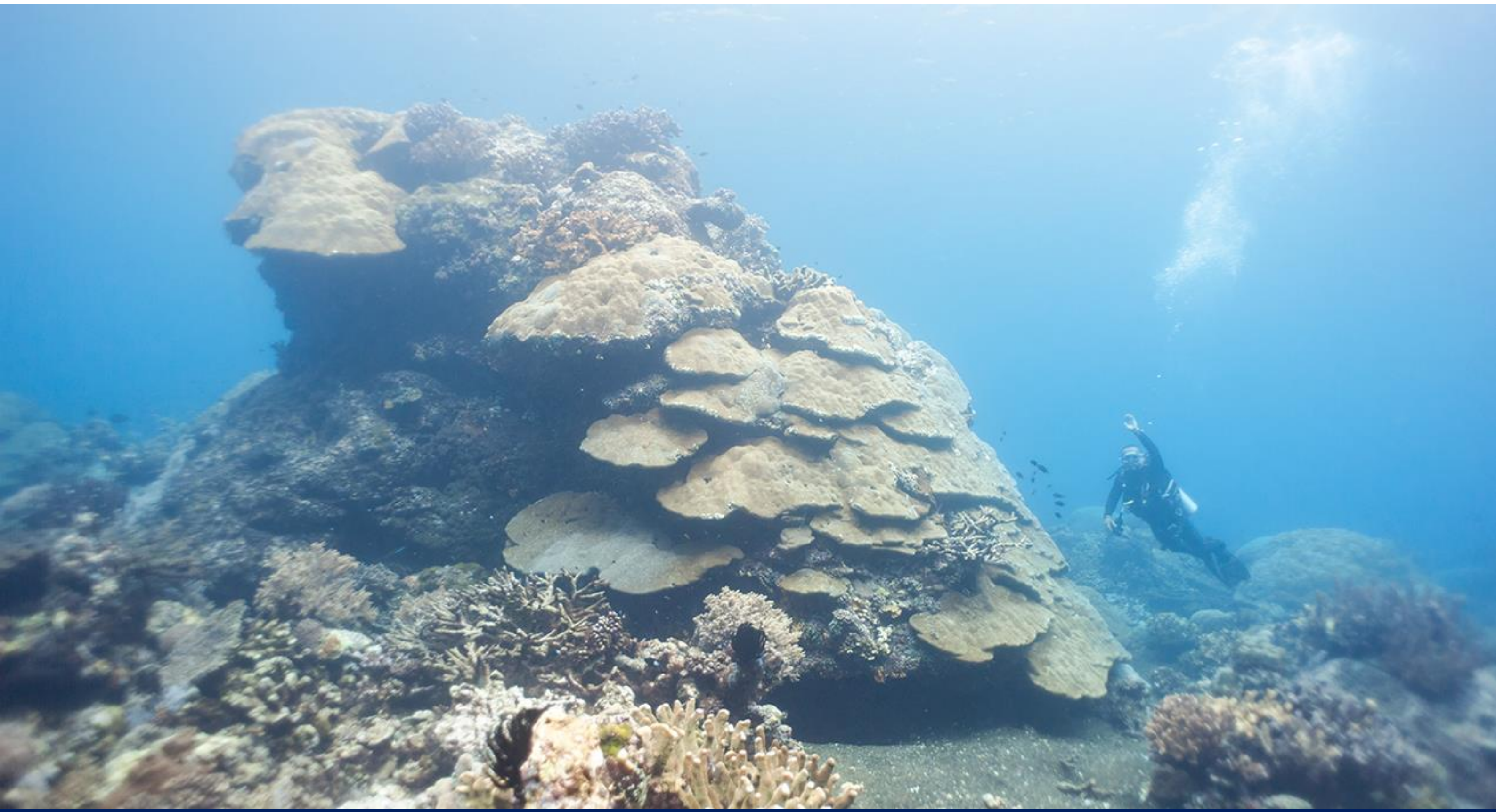

RESILIENT MARINE PROTECTED AREA NETWORK DESIGN FOR THE ARAFURA AND TIMOR SEAS

This report is prepared by Yayasan Konservasi Alam Nusantara and Coral Triangle Center for The Arafura and Timor Seas Ecosystem Action Phase 2 (ATSEA-2) Project.
July 2022

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EXECUTIVE SUMMARY

The Arafura and Timor Seas (ATS) are part of the North Australian Shelf large marine ecosystem, a tropical marine area located between the Pacific and Indian Oceans. The region extends from the Timor Sea to the Torres Strait and includes the Arafura Sea and Gulf of Carpentaria. The ATS Region contains both near pristine and highly threatened coastal and marine ecosystems, which play important ecological and economic roles in the four littoral nations bordering the region: Indonesia, Timor-Leste, Australia, and Papua New Guinea.

A variety of anthropogenic factors threaten marine resources in the ATS Region, such as illegal, unreported and unregulated fishing, bycatch, unsustainable harvesting, and climate change. Marine debris and pollution originating from maritime activities such as oil and gas exploration and extraction, fishing and shipping pose additional hazards to marine life. Consequently, globally threatened coastal marine megafauna are at risk (including migratory, rare, and threatened species of turtles, dugongs, seabirds/shorebirds, sea snakes, cetaceans, sharks and rays), and fisheries species are overharvested in some parts of the region.

Marine Protected Areas (MPAs) can be powerful tools to address local threats and protect biodiversity, maintain or enhance fisheries productivity, and increase ecosystem resilience to changes in climate and ocean chemistry. They can also help maintain or enhance food security and sustainable livelihoods for communities and other stakeholders. However, MPAs can only achieve their objectives if they are well designed and managed effectively.

While there are many existing or proposed MPAs in the Arafura and Timor Seas, they were not designed to form a network at the regional scale. Therefore, they do not take large-scale patterns of biophysical, socioeconomic and cultural considerations into account, such as region wide patterns of connectivity of fisheries, charismatic, rare, threatened and protected species and transboundary uses and threats (e.g., fishing and climate change). Therefore, there is a need for the four countries in the ATS Region to work together to design a regional scale MPA network.

The Arafura and Timor Seas Ecosystem Action (ATSEA 2) Program is supporting the protection of priority coastal and marine habitats and the conservation of protected species in this region. In this study, we contribute to this process by designing a resilient network of Marine Protected Areas (MPAs) for the ATS Region (an area of approximately 1.6 million hectares). Our approach is to conduct a marine gap analysis by considering existing and proposed MPAs (and Areas of Interest for potential new MPAs) in each of the four countries, and using the best available science, data and MPA design practices to identify potential gaps in the MPA network throughout the region by:

- Using the goals of ATSEA-2 Project including: recovering and sustaining fisheries, restoring degraded habitats to provide sustainable ecosystem services, protecting key marine species and adapting to impacts of climate change.
- Using biophysical, socio-economic, and cultural design criteria required to achieve the goals including: representing and replicating habitats; protecting critical, special and unique areas; incorporating connectivity; protecting healthy areas and avoiding local threats; adapting to changes in climate and ocean chemistry; and supporting the needs and

interests of stakeholders (particularly regarding protecting food security, livelihoods, traditional areas and uses, and marine heritage sites).

- Delineating two planning area where: the first includes all waters within the boundary of the ATS Region extended to the highest astronomic tide level to include mangroves; and the second extends beyond the ATS Region to consider connectivity with MPAs in adjacent areas.
- Using stratification units that represent the range of environmental, geographic and political jurisdictions in the region, based on marine ecoregions and boundaries of the territorial waters of each country.
- Identifying important conservation features to protect including: shallow water habitats ($\leq$ 200m: coral reefs, mangroves, seagrass beds and estuaries); deep-water benthic habitats (>200m: e.g., seamounts, canyons and ridges); critical, special and unique areas for focal fisheries, endangered, threatened and protected species (e.g., turtle nesting beaches, fish spawning areas and migratory corridors) and important socioeconomic and cultural areas (e.g., shipwrecks and important traditional areas).
- Identifying areas to avoid where there are threats to conservation features or areas allocated for other uses that may be incompatible with MPAs. Where threats include overfishing and destructive fishing practices (poison, blast fishing, and reef gleaning), poaching (of turtles and their eggs), hot water from power plants, waste, mangrove logging, and shark finning; and other uses include military areas, transportation and fishing ports, international shipping lanes, oil and gas mining areas, underwater cable pipe lanes, and sea mine areas (unexploded ordinance).
- Compiling and processing 114 spatial data layers needed to apply the design criteria regarding existing and proposed MPAs in each country, conservation features, threats, fishing pressure and other uses, which we verified and processed (where possible) to use a consistent GIS format, geographic extent and nomenclature.
- Analysing the data and designing an MPA network by conducting a marine gap analysis to identify and fill gaps in the existing and proposed MPA network using the systematic conservation planning tool Marxan. Inputs included:
    - Planning units (5 km^2 and 25 km^2 for shallow and deep-water habitats respectively);
    - Targets for protecting each conservation feature (30% for shallow water habitats, 10% to 100% for deepwater habitats, and 30 to 50% for critical, special and unique areas);
    - Lock in areas to include in the network (existing and proposed MPAs, and Areas of Interest for new MPAs in National Spatial Plans);
    - Lock out areas to exclude from the network (where MPAs cannot be established because they have been allocated for other uses); and
    - Cost, which are non-monetary values assigned to planning units so Marxan will select areas for potential new MPAs that will minimize impacts on other uses (i.e. fishing, transportation ports and fishing ports).

The result was a draft MPA network design for the ATS Region. We then used GIS processing to examine the degree to which the MPA network design met the targets for protecting conservation features before and after the analysis.

- *Reviewing and refining the draft MPA Network Design with input from stakeholders.* We presented the data layers, analysis and draft MPA network design for review by government representatives, scientists and non-government organisations from all four ATS region countries in both national and regional consultation workshops. Following the workshops, we refined and modified the data layers, analysis and design based on their advice, particularly regarding: using upwellings as a conservation feature (with a 5% target for protection); incorporating coral and seagrass vulnerability assessments to climate change; using more data layers to address larval connectivity; and considering areas identified as priorities for MPAs in other studies.

The result was the first iteration of a MPA network design for the ATS Region (Figure A) that includes:

- All 93 existing and proposed MPAs allocated in National Marine Spatial Plans (comprising 271,588 km^2);
- Thirteen Areas of Interest for establishing new MPAs identified in previous MPA Network design processes in Indonesia and Timor-Leste (comprising 14,772 km^2); and
- Seven Areas of Interest for establishing new MPAs identified in this study (comprising 14,613 km^2).

Before these Areas of Interest are established as new MPAs, some may need to be validated (ground-truthed to ensure they will provide the expected benefits for the MPA network), and proposals for new MPAs will need to be discussed appropriately with local stakeholders. Since completing our design, feedback from the countries indicates that of the seven new Areas of Interest identified in this study, two are being considered as potential areas for new MPAs in Australia (Adele Island and Cox Peninsula).

In this study, we provide the first iteration of an MPA network design for the ATS Region, which is an important first step in the four ATS countries collaborating on this important initiative. However, while our analysis is based on the best available information using best practices for conservation planning, it was conducted with limited time and resources. Therefore, we recommend that the design be refined in future by:

- Conducting more detailed and comprehensive stakeholder consultations in each of the four countries.
- Zoning all MPAs in the region using scientific design criteria and compiling the zoning plans in a regional database. This data can then be used to refine the design of the MPA Network for the ATS region by applying design criteria to specific zones based on the best available science (e.g., protecting at least 30% of each major habitat in no take areas).
- Addressing research priorities to refine the design, particularly regarding modelling and mapping connectivity (larval dispersal), fishing pressure and the impacts of climate change on key habitats and species throughout the region.

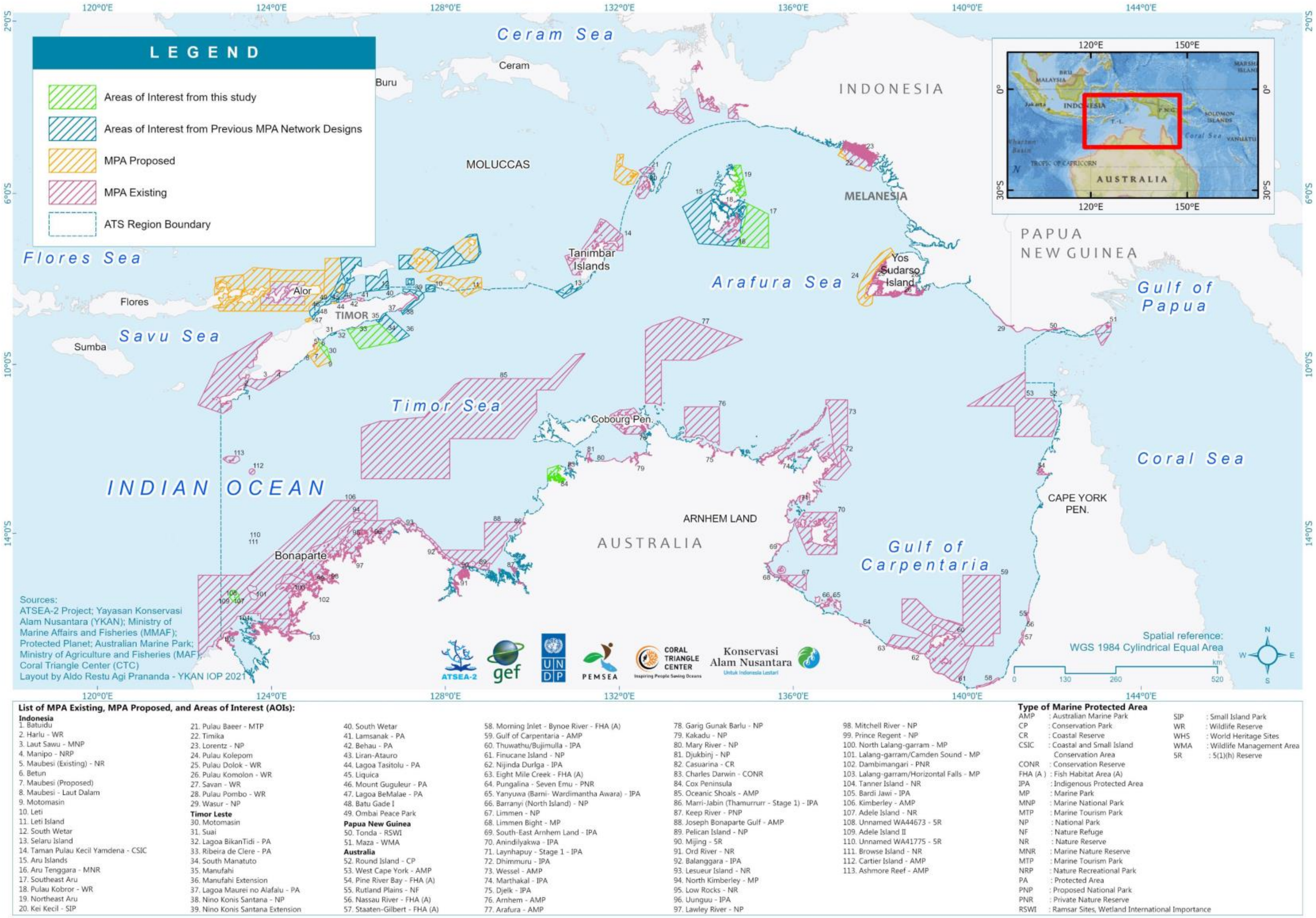

Figure A. A resilient MPA Network design for the Arafura and Timor Seas, consisting of existing and proposed MPAs in National Marine Spatial Plans, Areas of Interest for establishing new MPAs identified in previous MPA network designs and this study.

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This work was jointly funded by the Global Environment Facility (GEF), United Nations Development Program (UNDP) and Partnerships in Environmental Management for the Seas of East Asia (PEMSEA) under the auspices of the Arafura and Timor Seas Ecosystem Action Phase II (ATSEA-2) project. The Regional Project Management Unit (RPMU) of ATSEA-2 gratefully acknowledges the work of the author and the inputs from national and regional consultation participants conducted in March 2021. The RPMU extends gratitude to the ATSEA-2 Regional Steering Committee (RSC) for its guidance and approval in December 2021. Ministry of Marine Affairs and Fisheries (MMAF) of Indonesia provided a formal endorsement and written inputs in June 2022 (Letter No. 825/BRSDM.3/KS.100/VI/2022).

INTRODUCTION

THE ARAFURA AND TIMOR SEAS

The Arafura and Timor Seas (ATS) are part of the North Australian Shelf large marine ecosystem, a tropical marine area located between the Pacific and Indian Oceans. The ATS Region extends from the Timor Sea to the Torres Strait and includes the Arafura Sea and Gulf of Carpentaria, covering an estimated 1.6 million hectares (Figure 1 and Table 1). The region includes coastal areas, islands and reefs in southeastern Indonesia and Timor-Leste, northern Australia and southern Papua New Guinea (PNG: Figure 1). The ecosystems in the ATS Region play important economic and ecological roles in each of these four countries (ATSEA2 PEMSEA, 2020).

The ATS Region borders on the Coral Triangle, which is the epicenter of the world's marine biodiversity (Veron et al. 2009). The Region comprises all or part of nine marine ecoregions (areas of relatively homogeneous species composition clearly distinct from adjacent systems: Figure 2 and Table 1), where species composition in each ecoregion is determined by the ecosystems present and/or a distinct suite of oceanographic or topographic features.

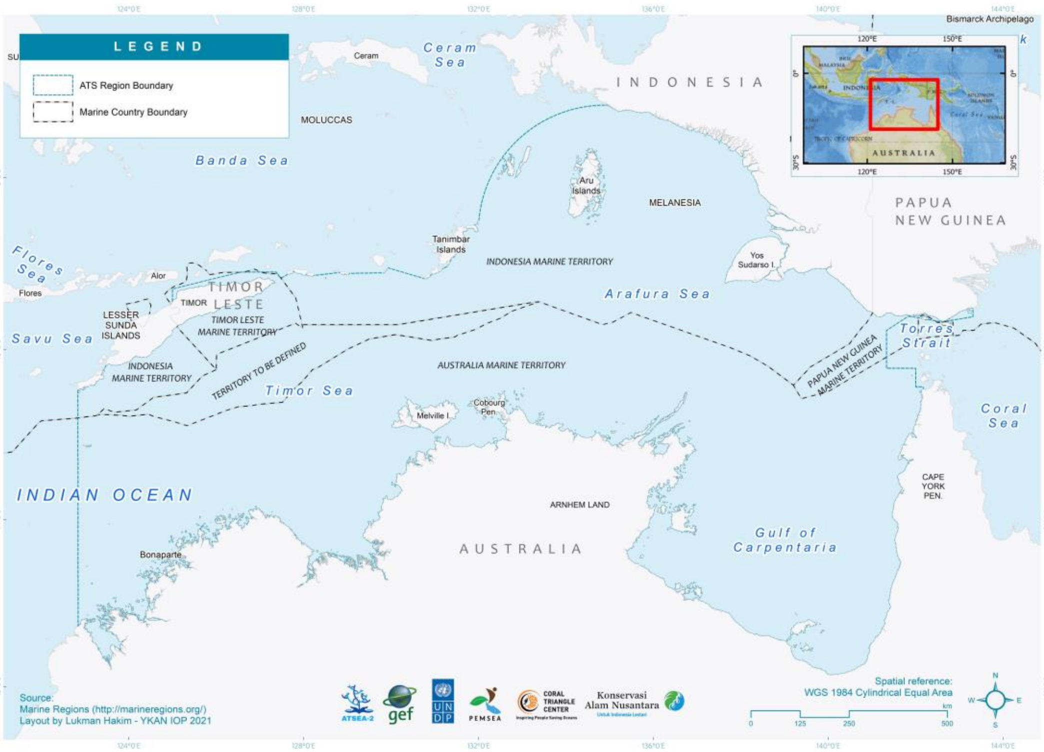


Figure 1. Marine territories of the four littoral nations bordering the ATS Region: Indonesia, Timor-Leste, Australia, and Papua New Guinea.

The ATS Region contains both near pristine and highly threatened coastal and marine ecosystems. Marine resources in the Region are threatened by a variety of anthropogenic activities, including illegal, unreported and unregulated fishing, bycatch, unsustainable harvesting, and climate change. Marine debris and pollution originating from maritime activities (such as oil and gas exploration and extraction, fishing and shipping) also pose additional hazards to marine life. Consequently, populations of globally threatened coastal marine megafauna are at risk (including migratory, rare, and threatened species of turtles, dugongs, seabirds/shorebirds, sea snakes, cetaceans, sharks and rays), and fisheries species are overharvested in some parts of the region (ATSEA2 PEMSEA 2020).

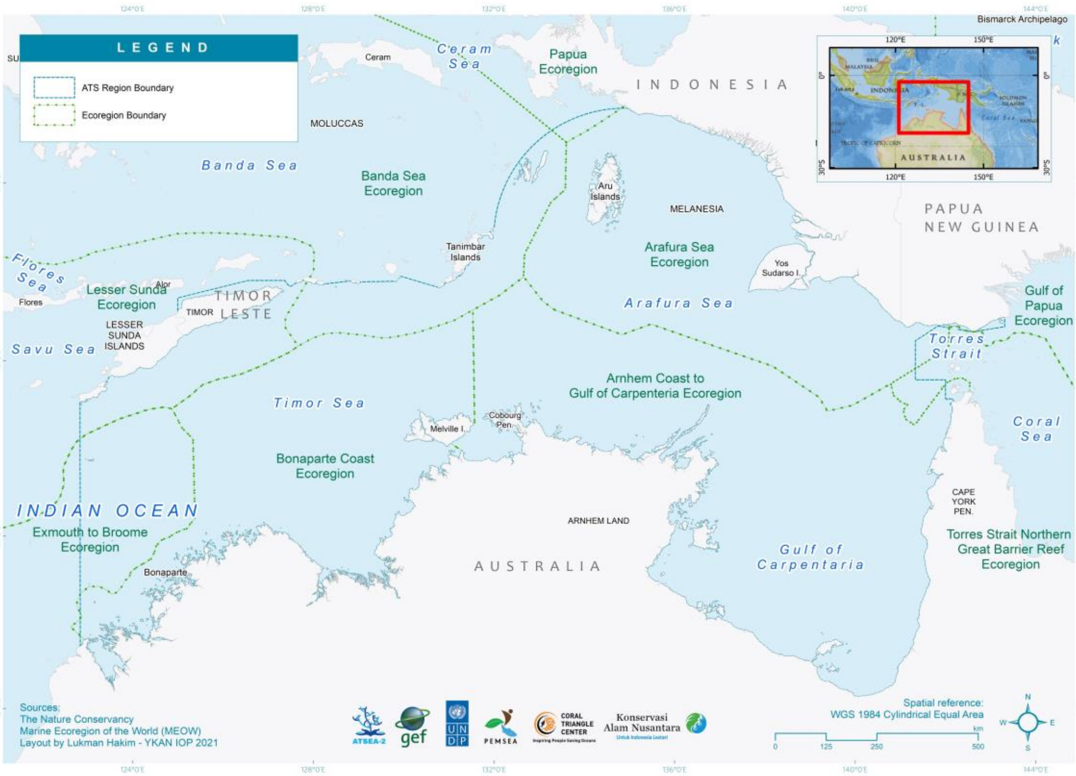


Figure 2. Nine marine ecoregions in ATS Region.

TABLE 1. AREA OF EACH MARINE ECOREGION WITHIN THE ARAFURA AND TIMOR SEAS REGION		
NO	MARINE ECOREGION	TOTAL AREA (KM²)
1	Arafura Sea	375,543.87
2	Arnhem Coast to Gulf of Carpentaria	586,383.58
3	Banda Sea	102,099.90
4	Bonaparte Coast	359,394.18
5	Exmouth to Broome	99,799.65
6	Gulf of Papua	1,572.76
7	Lesser Sunda	74,057.70
8	Papua	5,284.38
9	Torres Strait Northern Great Barrier Reef	9,438.55
Grand Total		**1,613,574.58**

EXISTING MARINE PROTECTED AREAS IN THE ARAFURA AND TIMOR SEAS

Marine Protected Areas (MPAs)[1], particularly no-take zones (NTZs), can be powerful tools to address local threats and protect biodiversity, maintain and enhance fisheries productivity, and increase ecosystem resilience to changes in climate and ocean chemistry (Green et al. 2014, Roberts et al. 2017). They can also enhance food security and sustainable livelihoods for communities and other

[1] MPA is a clearly defined geographical space, recognised, dedicated, and managed, through legal or other effective means, to achieve the long-term conservation of nature with associated ecosystem services and cultural values (IUCN, 2008)

stakeholders. MPA networks, collections of individual MPAs that are ecologically connected, can deliver additional benefits (e.g., by acting as mutually replenishing networks to facilitate recovery after disturbances: Green et al. 2020a). However, MPAs and MPA networks can only achieve their objectives if they are well designed and managed effectively (Green et al. 2014, Gill et al. 2017, Giakoumi et al. 2018).

All four countries whose waters intersect with the Arafura and Timor Seas have existing MPAs and/or spatial plans that identify potential areas for new MPAs based on comprehensive planning exercises that include the ATS Region including:

- The Lesser Sunda Ecoregion MPA Network Design in Indonesia and Timor-Leste (Wilson, 2011);
- The Fisheries Management Area (FMA) 715 and Six Associated Provinces MPA Network Design in Indonesia (Fajariyanto et al., 2019);
- The Timor-Leste National Protected Area Design (Grantham et al., 2010);
- Australia's Commonwealth and State Marine Park Plans (Commonwealth Australia, 2018); and
- Papua New Guinea's National Marine Conservation Assessment (PNG Government, 2015).

When we combine the results of all of these planning processes, at present there are 93 existing and proposed MPAs (comprising 271,489 km^2) in the ATS Region (Figure 3, Table 2). Thirteen Areas of Interest (comprising 14,772 km^2) have also been identified as potential areas for establishing new or expanded MPAs through comprehensive MPA design processes in Indonesia and Timor-Leste (Grantham et al. 2010, Wilson et al 2011, Fajariyanto et al. 2019: Figure 3, Table 2). These Areas of Interest (AOIs) comprise important biophysical, socioeconomic and/or cultural sites not currently protected within existing or proposed MPAs in the National/Provincial Spatial Plans. Zoning information is not available for many MPAs in the region.

All four countries with marine waters in the ATS Region are parties to the Convention on Biological Diversity, and are therefore committed to achieving Aichi 11 target of conserving 10% of their coastal and marine ecosystems by 2020 (https://www.cbd.int/sp/targets/), which may be increased to 30% by 2030 in future. Together, the existing and proposed MPAs and Areas of Interest of the four countries comprise 286,262 km^2 (17.7%) of the ATS region, of which 16.4% is within existing MPAs (Table 2). Australia comprises the highest cover of their marine waters in existing MPAs within the ATS Region 26%), followed by Papua New Guinea, Indonesia and Timor-Leste (each with less than 5%: Figure 4 and Table 2)[2].

MMAF's Inputs. Detailed background information on connectivity issues between MPAs should be provided to demonstrate the importance of establishing a regional MPA network.

It is necessary to add background information on why the establishment of a network of MPAs in Fisheries Management Area (FMA) 718 is deemed necessary (both from the ecological and socio-economic aspects).

It is necessary to explain how the existence of a network of MPAs can provide benefits to support the goal to increase fish stocks in FMA, especially in FMA 718.

[2] Please note that the percent composition does not represent Aichi Target achievement or underachievement by each country overall, because we only examined their marine waters within the ATS Region boundary.

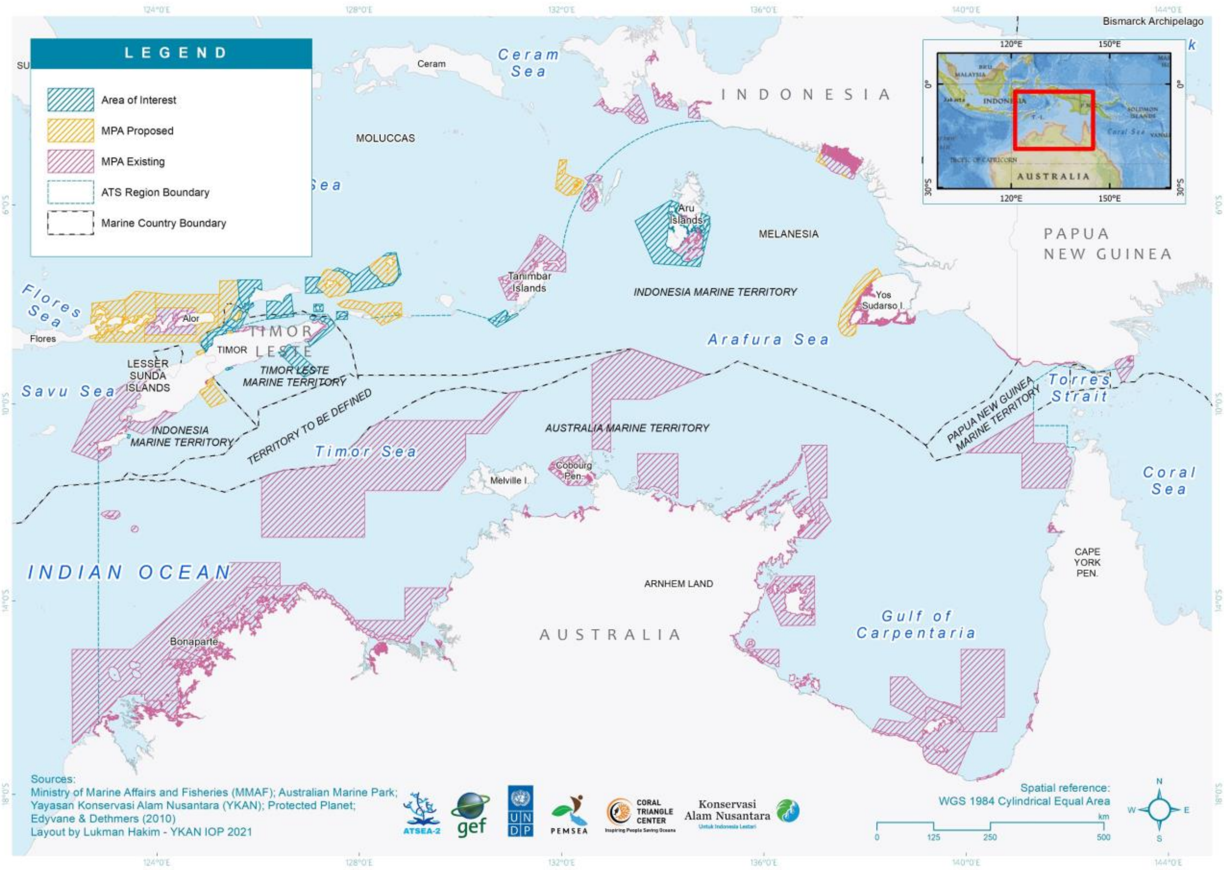


Figure 3. Marine Protected Areas in the ATS Region consisting of existing and proposed MPAs in National Marine Spatial Plans, and Areas of Interest for establishing new MPAs identified in previous MPA Network Design processes.

Table 2. Marine protected areas within the Arafura Timor Seas Region (area in km²)*

NO	COUNTRY	MPA EXISTING	MPA PROPOSED	AOIS FROM PREVIOUS MPA NETWORK DESIGN	UNCOVERED	TOTAL
1	Australia	249,802.10			715,814.65	965,616.76
2	Indonesia	13,680.50	6,180.62	10,179.92	476,310.83	506,351.87
3	Papua New Guinea	906.66			23,372.71	24,279.37
4	Timor-Leste	935.23	83,17	4,592,40	30,598.52	36,209.32
5	Territory to be Defined				81,117.26	81,117.26
Total		265,324.49	6,263.79	14,772.32	1,327,213.97	1,613,574.58

*Data sources include the World Database on Protected Areas, national databases in each country, and existing MPA designs and spatial plans in each country (Grantham et al. 2010, Wilson et al. 2011, PNG Government 2015, Commonwealth of Australia 2018, Fajariyanto et al 2019).

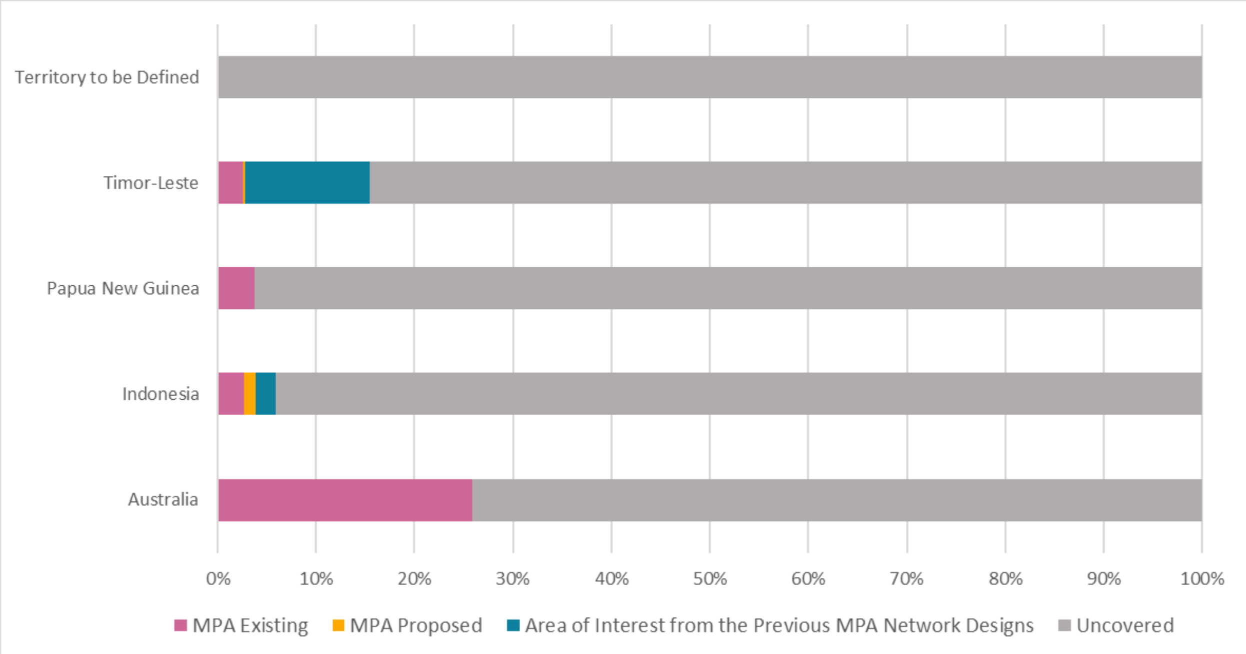


Figure 4. Current MPA cover within the marine waters of each country in the ATS Region.

DESIGNING A RESILIENT NETWORK OF MARINE PROTECTED AREAS FOR THE ARAFURA TIMOR SEAS

While there are many existing or proposed MPAs or MPA Networks in the ATS Region (Figure 3), each was established or proposed independently by one or two countries. Therefore, they were not designed to form an MPA network by taking regional scale patterns of biophysical, socioeconomic and cultural considerations into account, such as large-scale patterns of connectivity of fisheries, charismatic, rare, threatened and protected species and transboundary uses and threats (e.g., fishing and climate change). Therefore, there is a need for the four countries in the ATS Region to work together to design a regional network of MPA for the Arafura Timor Seas.

ATSEA 2 is the 2nd phase of the GEF-financed, UNDP-supported Arafura Timor Seas Program, which is building upon the foundational results realized in the first phase of the ATSEA Program including Indonesia, Timor-Leste, Papua New Guinea, and Australia. This 5-year project is supporting the protection of priority coastal and marine habitats and the conservation of protected species through the implementation of the governance and environmental objectives in the ATS Regional Strategic Action Program. They include: (i) Strengthening of ATS regional governance; (ii) Recovering and sustaining fisheries; (iii) Restoring degraded habitats for sustainable provision of ecosystem services; (iv) Reducing land-based and marine sources of pollution; (v) Protecting key marine species; and (vi) Adapting to the impacts of climate change. The first step in the ASTSEA-2 program is a regional stocktaking of key biodiversity habitats, including coral reef, seagrass, and mangrove ecosystems, and identifying priority conservation areas.

In this study, we are contributing to the ATSEA 2 Program by designing a resilient network of MPAs for the ATS Region. Our approach is to conduct a marine gap analysis by considering the existing and proposed MPAs (and Areas of Interest for establishing new MPAs) in each of the four countries, and using the best available science, data and MPA design practices to identify potential gaps in the MPA network in the region.

METHODS

Recently, with technical assistance from The Nature Conservancy through the Indonesia Sustainable Ecosystems Advanced (SEA) Project, the Ministry of Marine Affairs and Fisheries (MMAF) provided a framework for designing MPAs and MPA Networks in Indonesia (Green et al. 2020b). The document provides a simple, easy to use logical framework (including goals and design criteria) for managers to use to design MPAs and MPA networks, which takes biophysical, socioeconomic, and cultural considerations into account. We have already used this approach to design MPA networks for the marine waters of Indonesia and Timor-Leste that lay within the ATS Region (Wilson et al. 2011, Fajariyanto et al. 2019). Here we use the same approach to design a resilient network of MPAs for the entire ATS Region by:

- Identifying goals, and design criteria required to achieve these goals.
- Delineating planning areas and stratification units.
- Identifying conservation features to protect, and threats and other uses to avoid.
- Compiling and processing spatial data layers needed to apply the design criteria.
- Analyzing data and designing a draft MPA network using Marxan, which is the most widely used systematic conservation planning tool supporting the design of MPA networks worldwide (Ball *et al.* 2009).
- Conducting a gap analysis to examine the degree to which the ATS Region MPA network achieves targets for protecting conservation features.
- Reviewing and refining the results with key stakeholder from each of the four ATS countries.

IDENTIFYING GOALS AND DESIGN CRITERIA

We defined the goals for the MPA network, and the design criteria required to achieve these goals.

Goals

MPA goals should be clearly defined and compatible with each other, which helps facilitate broader acceptance of MPAs by a range of stakeholders who may have different objectives with respect to their interests (Giakoumi et al. 2018). To design an MPA network for the ATS Region, we use the goals already defined by the ATSEA-2 Project regarding:

- Recovering and sustaining fisheries;
- Restoring degraded habitats for sustainable provision of ecosystem services;
- Protecting key marine species; and
- Adapting to impacts of climate change.

Design Criteria

Design criteria are guidelines that provide specific advice on how to design MPAs and MPA Networks to achieve their goals (Green et al. 2020b). We used two types of design criteria based on those provided by the ATSEA-2 Project, adapted and refined using the latest science and best practices for MPA network design in the region (e.g., see Green et al. 2020a,b):

- Biophysical criteria aimed at achieving ecological objectives by taking key biological and physical processes into account; and
- Socioeconomic and cultural criteria aimed at maximizing benefits and minimizing costs to local communities and sustainable industries.

We used biophysical criteria that address the need to (where possible):

- Protect adequate, representative and replicate examples of shallow (≤ 200 m) and deep-water (≥ 200m) habitats;
- Protect critical, special and unique areas for fisheries, endangered, threatened, protected and migratory species (i.e., sea turtles, marine mammals and sharks), particularly important areas in their life history (e.g., spawning, breeding and nursery areas) and migratory corridors.
- Incorporate connectivity by considering variations in oceanography, and patterns of larval dispersal and movement of adults and juveniles.
- Protect viable areas by protecting healthy areas and avoiding local threats; and
- Adapt to changes in climate and ocean chemistry by protecting habitats (e.g., coral reefs and seagrasses) likely to be less vulnerable to global environmental change.

We use socioeconomic and cultural criteria that address the need to (where possible):

- Involve stakeholders in the design process;
- Prioritize establishing MPAs in areas supported by stakeholders;
- Support multiple, environmentally friendly uses (e.g., sustainable fishing and tourism);
- Support community welfare (livelihoods and food supplies);
- Protect marine heritage sites (e.g., ship and airplane wrecks);
- Ensure local communities have access to marine and fisheries resources; and
- Protect areas that have important cultural values, traditional uses and practices.

DELINEATING PLANNING AREAS AND STRATIFICATION UNITS

Planning Areas

We use two planning area for the MPA network design for the ATS Region. The first includes all waters within the Arafura Timor Sea Boundary extended to the highest astronomical tide level to include mangroves as conservation features in the MPA design (Figure 5). The second includes the same area as the first, expanded to include adjacent areas to consider connectivity among MPAs within and outside the ATS Region (Figure 6).

Stratification Units

We divided the planning area into stratification units that represent the range of environmental, geographic and political (Country) jurisdictions in the region by stratifying by:

- Country (see Figure 1), so the results can used to refine or develop MPA network designs in each country.
- Ecoregion (see Figure 2), so we can apply biophysical design criteria (e.g., regarding protecting adequate, representative and replicate examples of each habitat and critical, special and unique areas) within each ecoregion.

Figure 5. Planning Area 1 for designing the MPA network delineated using the boundary of the ATS Region extended to the highest astronomic tide level to include mangroves.

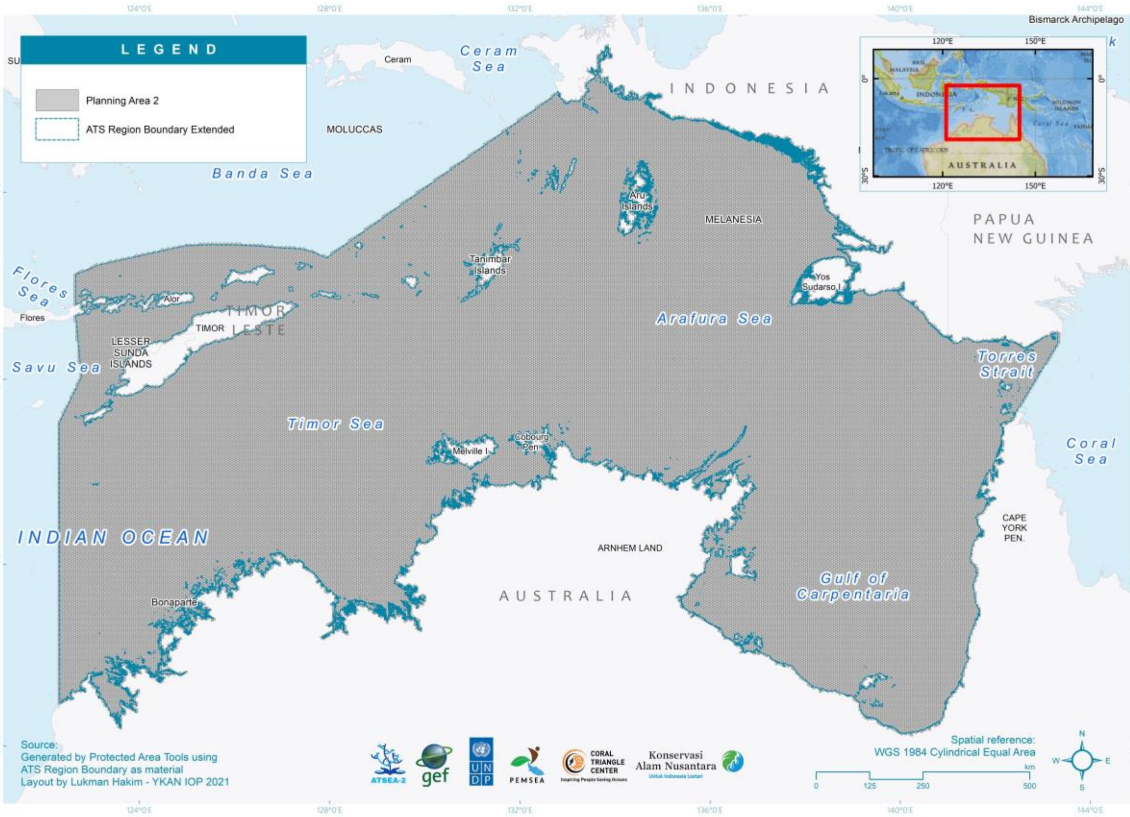


Figure 6. Planning Area 2 for designing the MPA network, which extends beyond the ATS Region (Figure 5) to consider connectivity with MPAs in adjacent areas.

IDENTIFYING CONSERVATION FEATURES, THREATS AND OTHER USES

We identified conservation features to protect in the MPA network design, threats to these conservation features (where we should avoid placing new MPAs) and areas allocated for other uses (where MPAs can't or should not be established).

Conservation Features

Conservation features include:

- Shallow water habitats (≤ 200m) including coral reefs, mangroves forests, seagrass beds, and estuaries.
- Deep-water benthic habitats (>200m) including seamounts, canyons and other features (i.e. abyssal, basin, bridge, escarpment, hadal, ridge, shelf, sill, slope, terrace, trench and trough habitats).
- Critical, special and unique areas for focal fisheries, endangered, threatened and protected species i.e., turtle nesting beaches, turtle feeding grounds, persistent pelagic habitats (upwellings), fish spawning aggregations sites (FSAS), Important Bird Areas (IBAs), Important Marine Mammal Areas, Migratory Corridors of Turtle, Cetacean and Whale Shark, etc.
- Critical, special and unique socioeconomic and cultural areas i.e., dive sites, ship and aircraft wrecks, and important traditional areas (i.e., local wisdom areas in Indonesia, and aboriginal heritage places in Australia).

Threats

Threats to conservation features in the region include overfishing and destructive fishing practices (poison, blast fishing, and reef gleaning), reef mining, sand mining, poaching (of turtles and their eggs), hot water from power plants, waste, mangrove logging, and shark finning.

Uses

Fishing and tourism are important uses of marine resources in all four countries. Other uses include military areas, transportation and fishing ports, international shipping lanes, oil and gas mining areas, underwater cable pipe lanes, and sea mine areas (unexploded ordinance). In Indonesia, MPAs cannot be established in areas allocated for these other uses in National/Provincial Spatial Plans. However, in the other three countries, MPAs may be established in areas allocated for other uses, although it may not be desirable (if the uses are incompatible with achieving the goals of the MPA network).

COMPILING AND PROCESSING SPATIAL DATA LAYERS

We compiled 107 spatial data layers (Annex 1) to apply the MPA design criteria. They include data layers regarding:

- MPAs: existing and proposed, and areas of interest for new MPAs (Figure 3).
- Conservation features including: shallow water habitats (Figure 7), coral reef classification (Figure 8), deep-water benthic habitats (Figure 9) and critical, special and unique areas (Figure 10 and Figure 11);
- Fishing pressure (Figure 12).
- Threats to conservation features and other uses (Figure 13 and Figure 14).

We processed and verified each data layer e.g., by validating the accuracy of the data by comparing it with other spatial and non-spatial information for the same area (i.e., conservation features, threats and other uses).

We reviewed all of the data and identified 44 data layers (Annex 1) that we used in the Marxan analysis because they are: comprehensive (available for the entire planning areas); unbiased (information is not only available for certain areas); and reliable. We prepared each of the spatial data layers to use in Marxan, by intersecting them with the planning areas, stratification and planning units (see *Planning Areas*, *Stratification Units* and *Planning Unit Layers*).

We also identified 63 data layers that we used manually (see Annex 1) to refine the results of the Marxan analysis to define Areas of Interest for new MPAs (see below). These data layers were reliable and unbiased but were not available for the entire planning area (so we could not use them in Marxan).

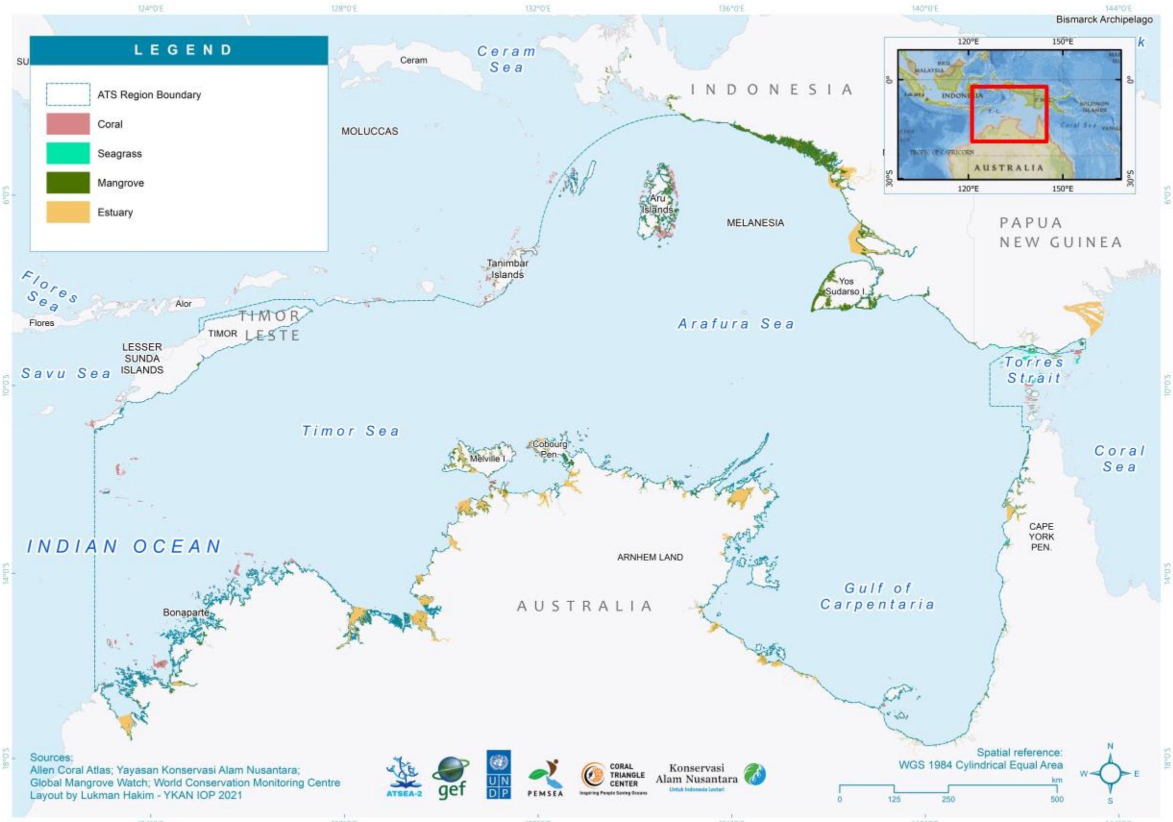


Figure 7. Conservation features: shallow water habitats.

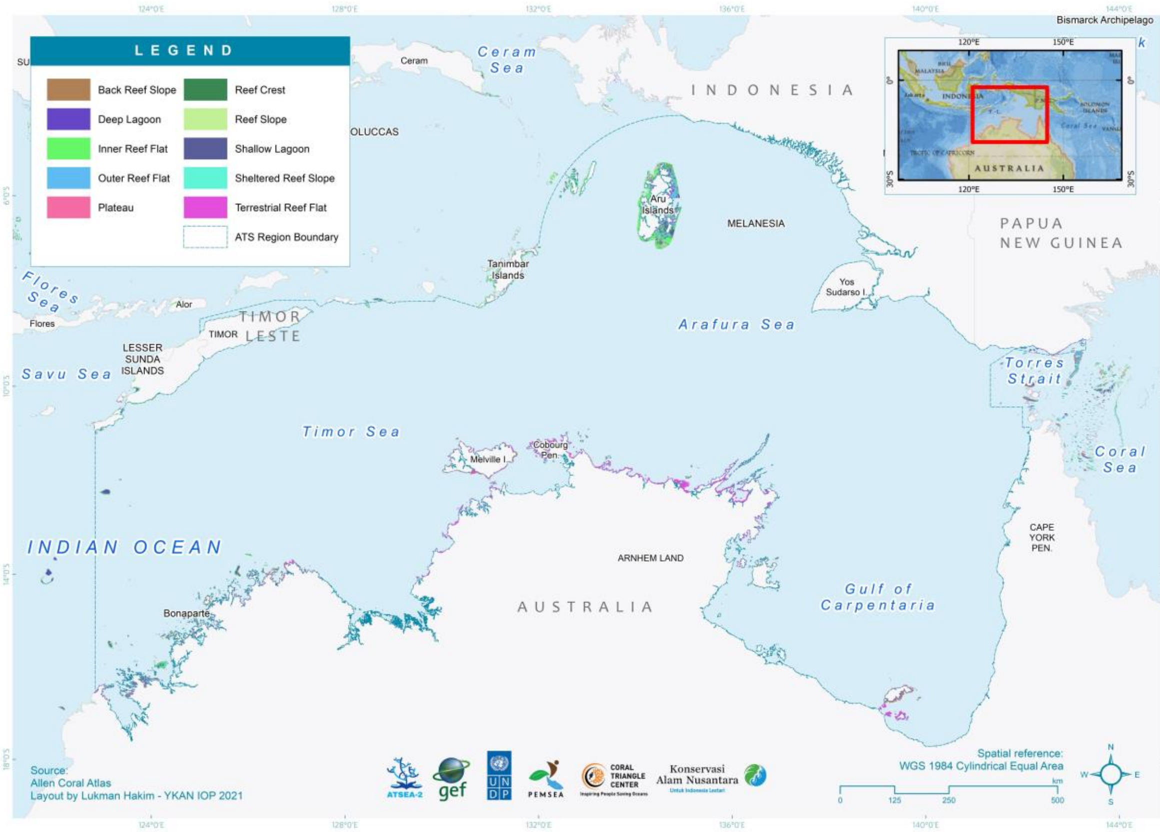


Figure 8. Conservation features: coral reef classification.

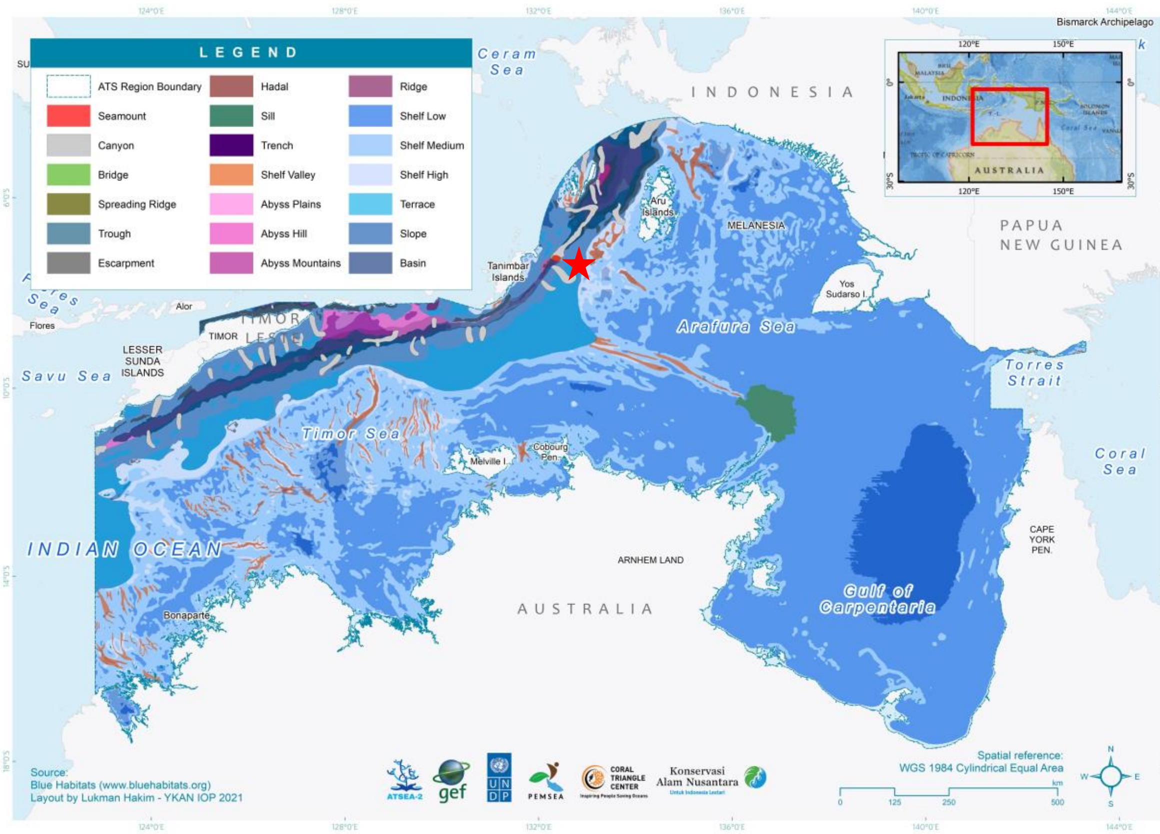


Figure 9. Conservation features: deep-water benthic habitats.

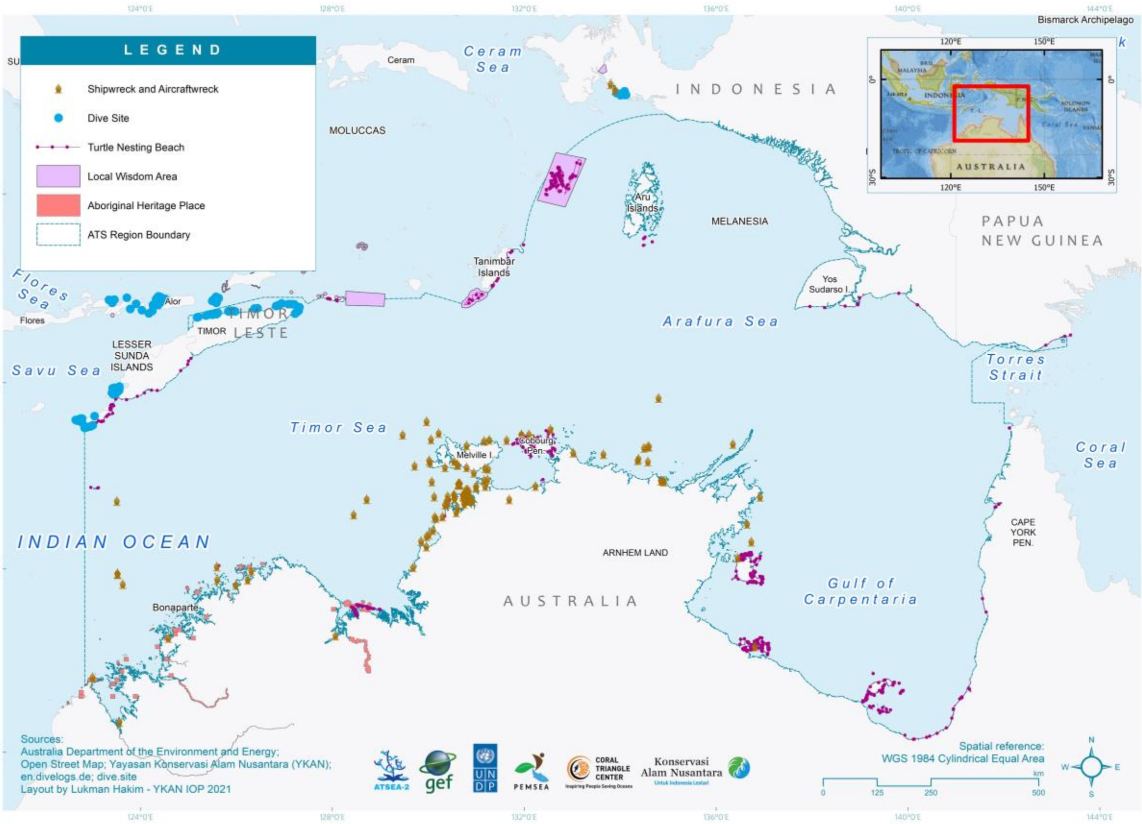


Figure 10. Conservation features: critical, special and unique areas.

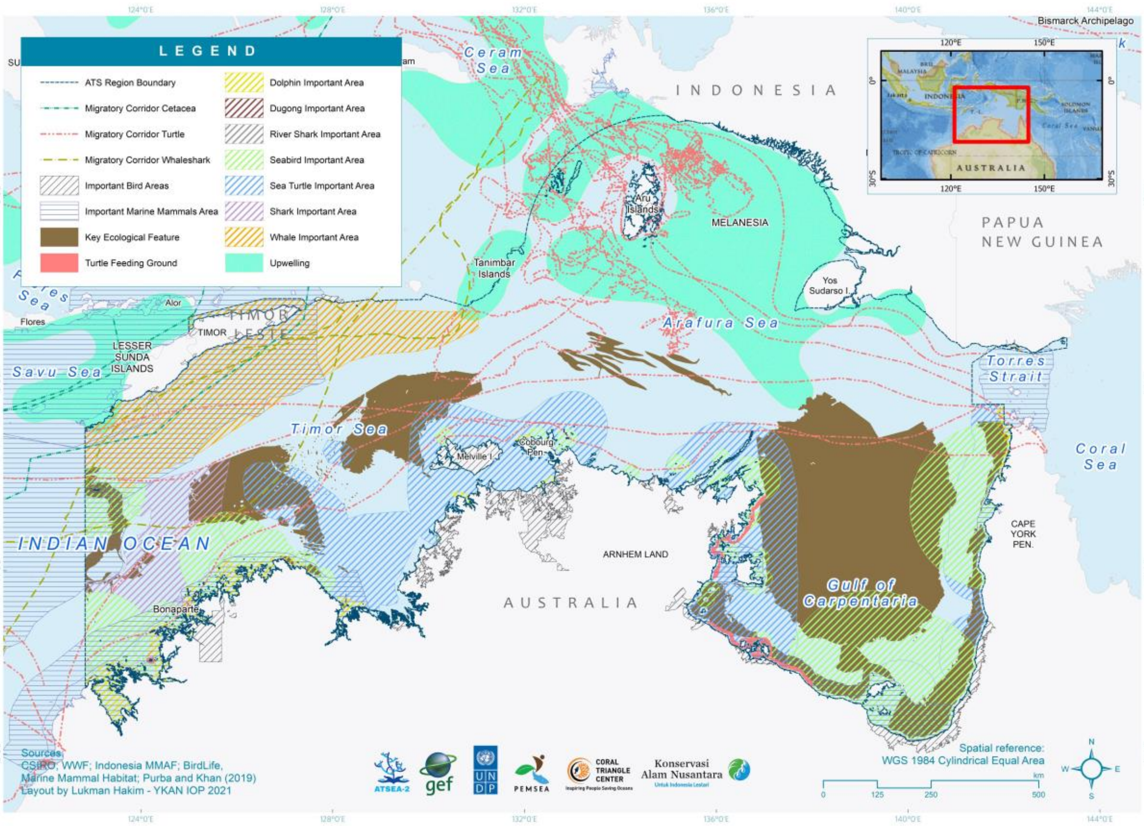


Figure 11. Conservation features: other critical, special, and unique areas.

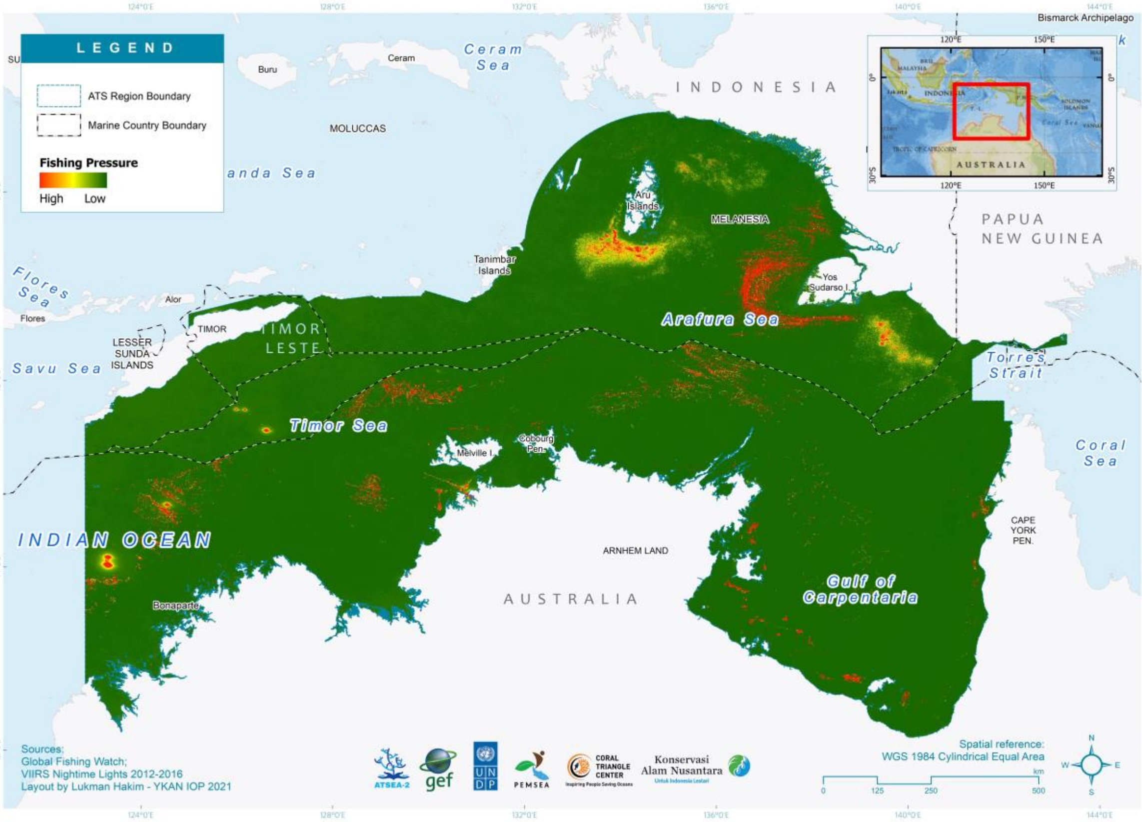


Figure 12. Fishing pressure.

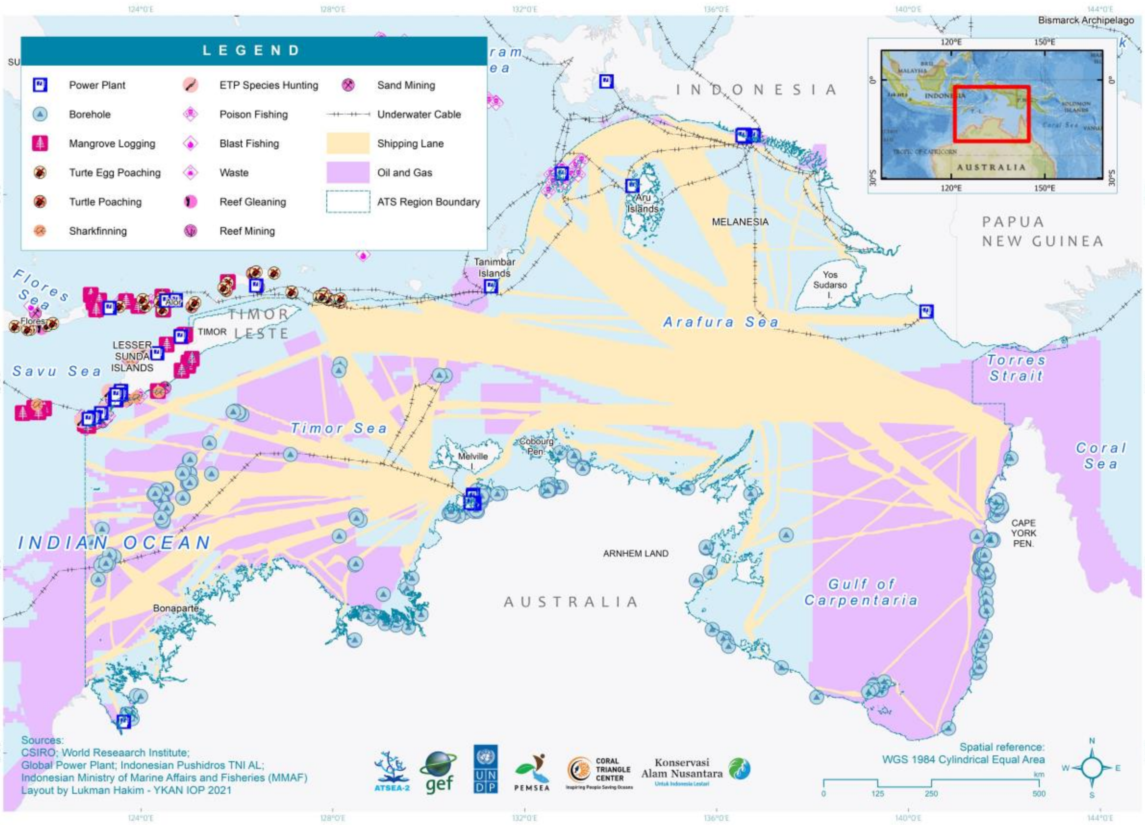


Figure 13. Threats to conservation features and other uses.

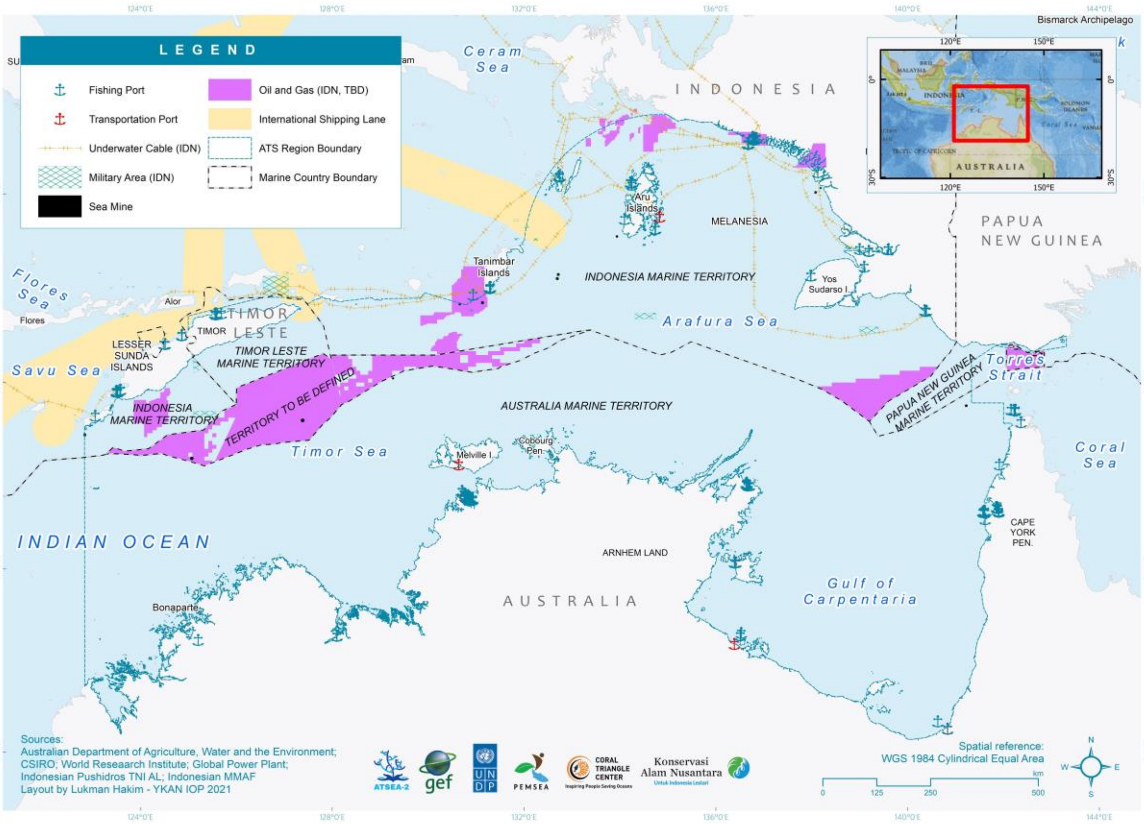


Figure 14. Locked out features (areas allocated for other uses in National Spatial Plans in Indonesia).

ANALYSING DATA AND DESIGNING A DRAFT MARINE PROTECTED AREA NETWORK USING MARXAN

We used GIS processing to conduct a marine gap analysis to identify the degree to which the existing MPA network (Figure 3) is already achieving targets for protecting conservation features in the ATS Region (see *Targets*: Table 3), and to identify gaps in the network. Then we used Marxan and other information to identify Areas of Interest for establishing new MPAs that may fill the gaps in the network as follows.

Shallow and Deep-water Analyses

We conducted the Marxan analysis in two steps, because we had better quality data (higher resolution with more validation) for shallow water (≤200 m) than deep-water (> 200m) habitats. First, we ran Marxan for the shallow water habitats only. Then we locked in the sum solution from the shallow water analysis and ran the shallow and deep-water analysis combined. This ensured that higher priority was given to using the better quality data in the analysis. It also prioritized protecting shallow water habitats and critical, special and unique areas, while considering connectivity between shallow and deep-water habitats.

To do this, we used different data layers and planning units for each analysis.

For the shallow water only analysis, we used:

- Data layers for MPA status (existing and proposed MPAs and Areas of interest in National Spatial Plans), conservation features (shallow water habitats and critical, special and unique areas), and other uses (Table 3); and
- Smaller planning units for a finer scale analysis (see *Planning Unit Layers*).

For the combined shallow and deep-water analysis, we used:

- Data layers for the result (sum solution) from the shallow water analysis, conservation features (deep-water habitats) and other uses (Table 4);
- Larger planning units for a coarser scale analysis (see *Planning Unit Layers*).

Planning Unit Layers

Planning units provide the individual unit of choice for selection in the analysis and can be a variety of shapes and sizes. We used hexagons because they share a boundary with all neighbouring units.

We used two planning unit layers with hexagons of different sizes for each planning area (Figure 15 and Figure 16), based on the resolution of the data and the scale of conservation features. For each planning area, we used smaller planning units for the shallow water analysis only (5 km^2 in size), which reflected the finer resolution of the data for these habitats and the smaller size of the conservation features for protection. We used larger planning units for the combined shallow and deep-water analysis (25 km^2 in size), which reflected the coarser resolution of the spatial data available for deep-water habitats and the larger size of many of the deep-water conservation features:

- For Planning Area 1 (Figure 15): The planning unit layer for the shallow water analysis only (≤200m deep) consisted of 279,026 smaller hexagons. While the planning unit layer for the combined shallow and deep-water (>200m deep) analysis consisted of 68,132 larger hexagons.
- For Planning Area 2 (Figure 16): The planning unit layer for the shallow water analysis only (≤200m deep) consisted of 293,996 smaller hexagons. While the planning unit layer for the combined shallow and deep-water (>200m deep) analysis consisted of 79,823 larger hexagons.

The size of these planning units also allows us to keep the processing time for Marxan within manageable time frames.

Targets

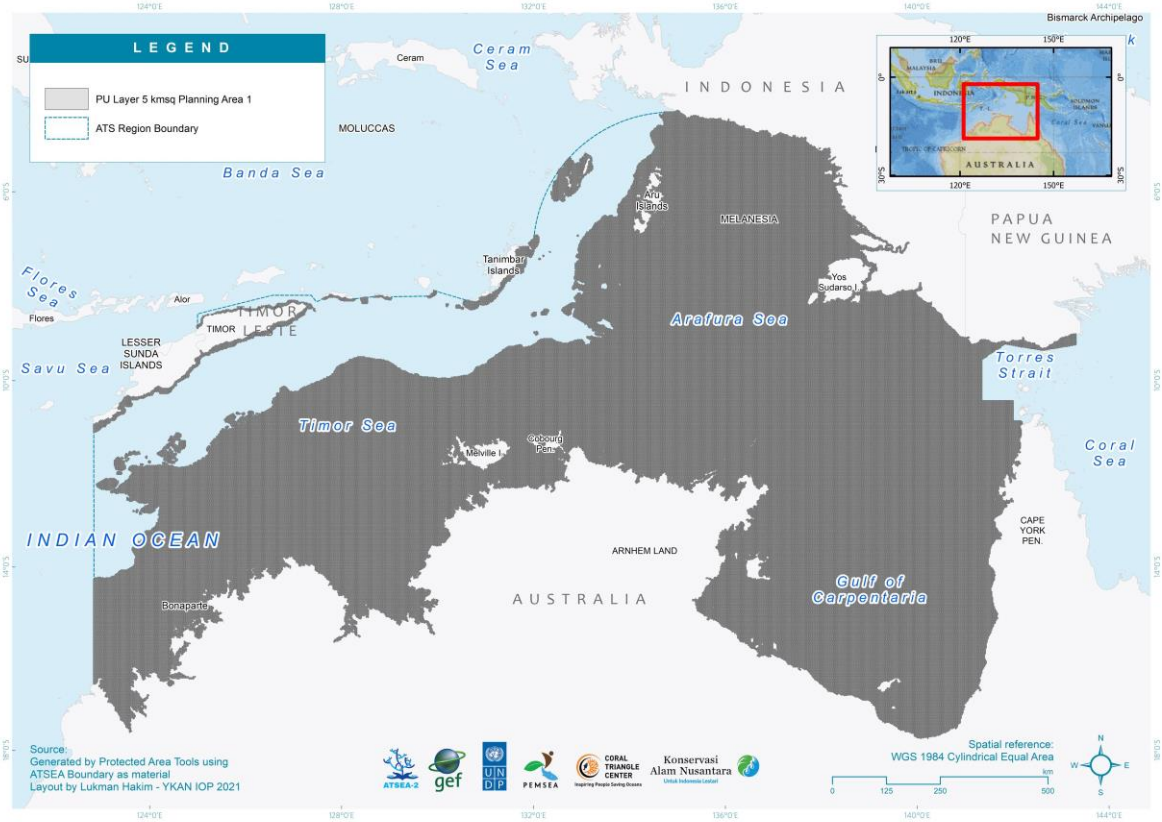
Targets are how much of each conservation feature we aim to protect in the MPA network. Marxan identifies ways to meet these targets efficiently, while minimizing the impacts on utilization by minimizing the "cost" of including them in the network (see *Cost Surface*) (Ball *et al.* 2009: http://marxan.org).

We set the following targets for the biophysical, socioeconomic and cultural conservation features:

- 30% of each shallow water habitat (coral reefs, coral reef classification, mangroves, seagrasses, and estuaries) in each country and ecoregion (Table 3).
- 10 to 100% of each deep-water habitat (100% of seamounts, 30% of canyons, and 10% of each of the others: Table 4) in each ecoregion. We allocated higher targets for seamounts and

canyons than for other habitats, because of their importance for protecting biodiversity and as feeding areas for cetaceans and large pelagic fishes.

- 30% of most critical, special and unique areas (turtle nesting beaches, dive sites, tourism areas, shipwrecks and aircraft wrecks: Table 3), and 50% of important traditional areas (aboriginal heritage places and local wisdom areas: Table 3).



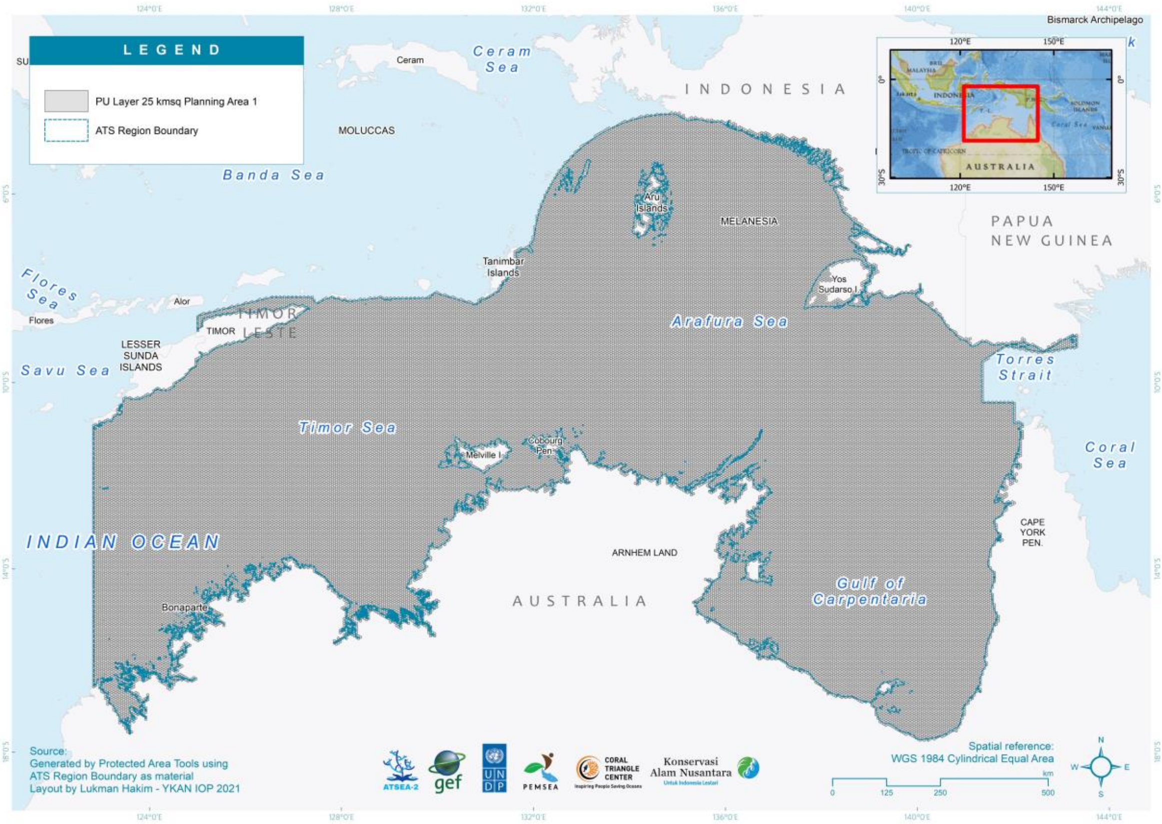
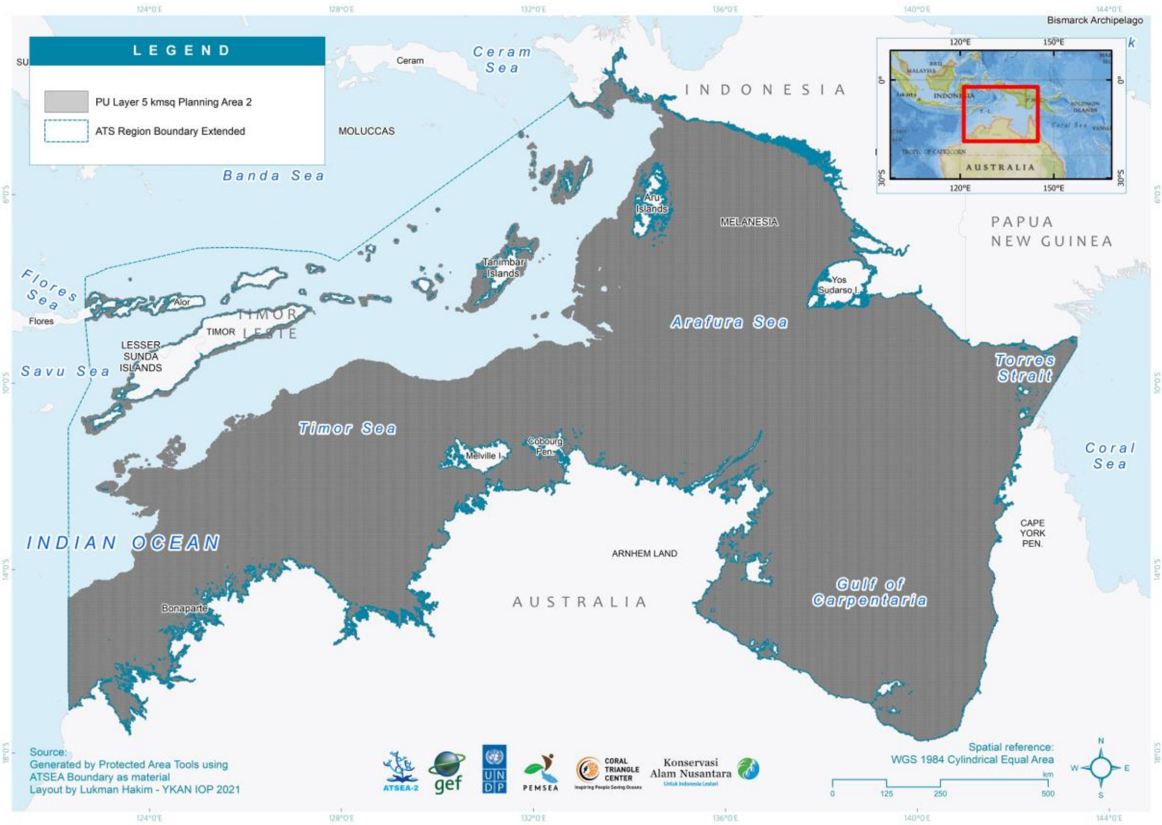


Figure 15. Planning Area 1: one planning unit layer was used for the shallow water analysis only (with smaller planning units 5 km² in size: top) and the other was used for the combined shallow and deep-water analysis (with larger planning units 25 km² in size: bottom).



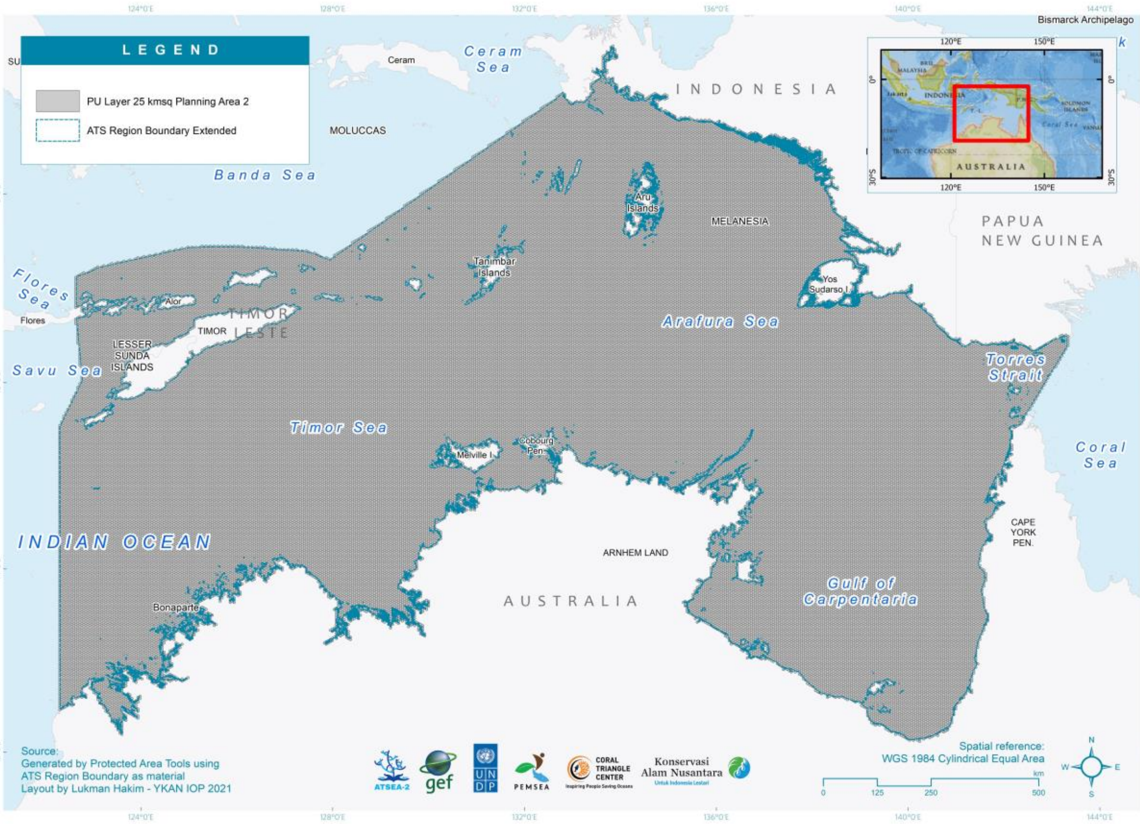


Figure 16. Planning Area 2: one planning unit layer was used for the shallow water analysis only (with smaller planning units 5 km² in size: top) and the other was used for the combined shallow and deep-water analysis (with larger planning units 25 km² in size: bottom).

Table 3. Spatial data layers and how we used them in the Marxan analysis for shallow water habitats only (including targets for protecting each conservation feature, features locked in and locked out of the analysis, and data used for the cost surface).

CATEGORY	DATA LAYER	TARGETS (%), LOCKED IN AND LOCKED OUT FEATURES, AND DATA USED FOR COST SURFACE
MPA status **(Figure 3).**	Existing, proposed MPAs, and AOIs in Country Spatial Plans	Locked in
Conservation features: shallow water **habitats (Figure 7 and Figure 8).** Stratified by country and ecoregion = 119 strata.	Coral Reefs Distribution	30%
	Coral Reefs Classification	30%
	Mangroves	30%
	Seagrasses	30%
	Estuaries	30%
Conservation features: critical, special and unique areas **(Figure 10).**	Turtle nesting beaches	30%
	Dive sites	30%
	Tourism Areas	30%
	Important traditional areas (i.e., Local wisdom, Aboriginal Heritage Places)	50%
	Shipwrecks and Airplane wrecks	30%
Other **Uses (Figure 13 and Figure 14).**	Fisheries Port (Timor-Leste, Australia, and Papua New Guinea)	Locked out
	Transportation Port (Timor-Leste, Australia, and Papua New Guinea)	Locked out

	Military areas (Indonesia)	Locked out
	Underwater cable pipe lanes (Indonesia)	Locked out
	Sea mine areas (unexploded ordinance) (Indonesia)	Locked out
	Oil and gas mining areas (Indonesia)	Locked out
	Underwater cable pipe lanes (Timor-Leste, Australia, and Papua New Guinea)	Cost
	Oil and gas mining areas (Timor-Leste, Australia, and Papua New Guinea)	Cost
	Power plant waste water impact	Cost
	Fishing Pressure	Cost

Table 4. Spatial data layers and how we used them in the Marxan analysis for combined shallow and deep-water habitats (including targets for protecting each conservation feature, features locked in and locked out of the analysis, and data used for the cost surface).

CATEGORY	DATA LAYER	TARGETS (%), LOCKED IN AND LOCKED OUT FEATURES, AND DATA USED FOR COST SURFACE
Result (sum solution) from shallow water analysis (Figure 18).	Sum solution 70-100	Locked in
Conservation features: deep-water habitats (Figure 9). Stratified by ecoregion = 85 strata **(see GEBCO Undersea Feature Names for definitions)**	Canyon	30%
	Seamount	100%
	Abyss Hill	10%
	Abyss Mountain	10%
	Abyss Plain	10%
	Basin	10%
	Bridge	10%
	Escarpment	10%
	Ridge	10%
	Shelf Low	10%
	Shelf Medium	10%
	Shelf High	10%
	Shelf Valley Small	10%
	Shelf Valley Moderate	10%
	Sill	10%
	Slope	10%
	Terrace	10%
	Trough	10%
	Abyss Hill	10%
	Abyss Mountain	10%
	Abyss Plain	10%
Other Uses (Figure 13 and Figure 14).	Fisheries Port (Indonesia, Timor-Leste, Australia, and Papua New Guinea)	Locked out
	Transportation Port (Indonesia, Timor-Leste, Australia, and Papua New Guinea)	Locked out
	Military areas (Indonesia)	Locked out
	Underwater cable pipe lanes (Indonesia)	Locked out
	Sea mine areas (unexploded ordinance) (Indonesia)	Locked out
	Oil and gas mining areas (Indonesia)	Locked out
	Underwater cable pipe lanes (Timor-Leste, Australia, and Papua New Guinea)	Cost

	Oil and gas mining areas (Timor-Leste, Australia, and Papua New Guinea)	Cost
	Power plant waste water impact	Cost
	Fishing Pressure	Cost

Locked In and Locked Out Features

Some areas should be included in the MPA network design, because they are important to achieve the goals. We locked in these areas for the analysis (see Table 3 and Table 4), which means that Marxan should select these as priority areas to include in the MPA network design. They included existing MPAs, proposed MPAs, and Areas of Interest in National Spatial Plans (Figure 3), because they have already been allocated for that purpose.

In contrast, some areas have already been allocated for other uses [i.e., transportation and fisheries ports, underwater cable pipe lanes, military areas, oil and gas mining areas, and sea mine areas (unexploded ordinance)]. Each of the four countries have their own regulations and policies regarding the compatibility of these uses with MPAs. In Indonesia these types of uses are considered incompatible with MPAs, so MPAs cannot be established in those areas. Therefore, we locked these areas out of the analysis in Indonesia (see Table 3 and Table 4, and Figure 14). This means that Marxan will not select these areas for inclusion in the MPA network. However, since Australia, Timor-Leste, and Papua New Guinea do allow MPAs to be established in areas allocated for these other uses, they were not locked out of the analysis in those countries (instead they were included in the *Cost Surface*: see below).

Where areas are included in both locked in and locked out areas, Marxan will not select locked out areas for inclusion in the MPA network.

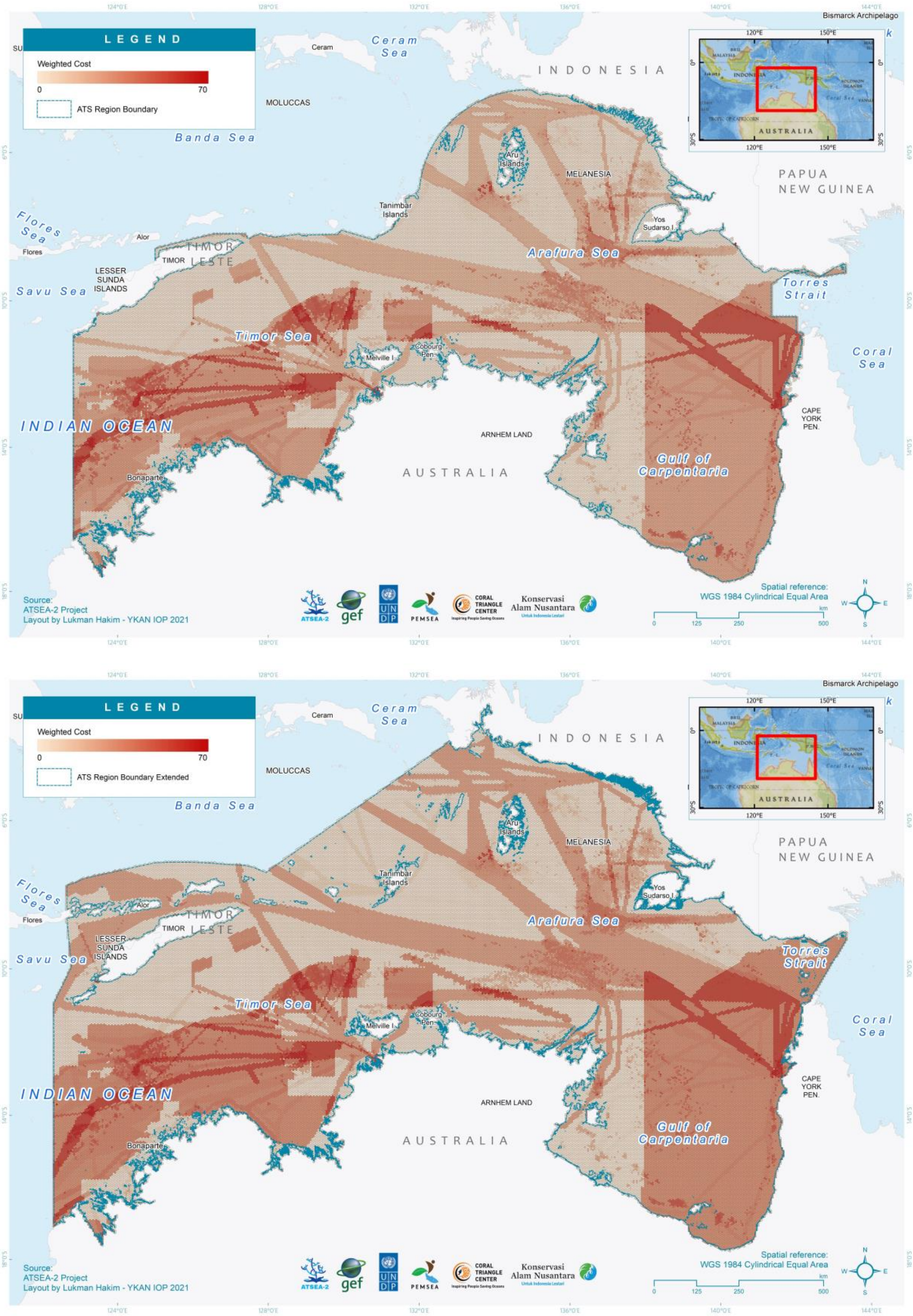


Figure 17. Weighted costs for Planning Area 1 (top) and Planning Area 2 (bottom)

Cost Surface

"Costs" are values assigned to planning units to help minimize the impact of the MPA network on the utilization of marine resources (e.g., for fisheries, ports and other industries), and to avoid placing MPAs in areas that have threats and uses that are incompatible with the goals of the network. The values reflect the "cost" of including each planning unit in the MPA network, which is not necessarily a monetary value (e.g., it may be loss of an area for fishing or other uses).

Practitioners use a variety of methods to assign costs to planning units. We used two cost surfaces to design an MPA network for ATS Region where:

- Costs are the same for all planning units for the shallow water analysis only.

Costs vary among planning units for the combined shallow and deep-water analysis. This is based on a cost surface (Figure 17) that we developed using a weighted sum of costs related to fishing pressure, and other uses (shipping, power plants, underwater cables, oil and gas). For more information, see Annex 2. **Error! Reference source not found.**Marxan will avoid placing MPAs in d arker areas (Figure 17) e.g., to minimize impacts on fisheries, transportation ports and fishing ports.

Scenarios

Scenarios are different ways of carrying out the analysis. For example, we explored several scenarios that used different data layers, planning areas, cost surfaces, locked in and locked out areas, and/or other parameters for targets and costs.

We selected a scenario that uses:

- All of the data layers, targets for conservation features, and locked in and locked out features in Table 3 and Table 4).
- The cost surfaces described above (see ***Error! Reference source not found.***).

Running Marxan

We ran Marxan 100 times for the scenario described above, which produced 100 possible solutions for the MPA network design.

We set up Marxan to develop solutions that generate a compact network (with more clumping i.e., less, larger areas) and avoid fragmentation (i.e., many small areas).

Using Marxan Outputs and GIS Processing to Design a Draft MPA Network

Marxan provided several outputs (for both the shallow water analysis only and the combined shallow and deep-water analysis) that we used to design the MPA network including:

- 100 individual solutions, where each solution identifies areas that efficiently met the targets for the conservation features while minimizing costs.
- The sum solution, which shows how often each planning unit is selected in the 100 solutions (i.e., areas that were always, often, rarely or never selected).
- The best solution, which identifies areas that most efficiently meet the targets for minimal cost. This is not necessarily the ideal solution, rather it is a very good solution based on the information available.

We used the results of the Marxan analysis as follows:

- We used the priority areas identified in the sum solution for the shallow water analysis only (areas selected in 70-100 solutions: Figure 18), and locked them in for the combined shallow and deep-water analysis; and
- We used the sum solution for the combined shallow and deep-water analysis (Figure 19) to identify priority areas for including in the MPA network (areas selected in 70-100 solutions: (Figure 20).

Priority areas identified in the sum solution for the Marxan analysis for shallow water only (Figure 18) met the targets for protection for most of the conservation features in Table 3. However, it could not meet the targets for some features e.g. for:

- Estuaries in Papua, Indonesia (Figure 7) which could not be selected, because they overlap with ports, oil and gas areas, and underwater cable pipe lanes that were locked out (Figure 14) and with a high density shipping lanes (Figure 13) used in the cost layer (Figure 17); and
- Estuaries, shipwrecks and aircraft wrecks in Australia (Figure 7 and Figure 10), because they overlap with other uses in the cost layers (oil and gas mining areas, underwater cable pipe lanes, power plants and high density shipping lanes: Figure 13 and Figure 17).

For the combined shallow and deep-water analysis, some areas were selected in a few to many (1-69) solutions, while others were selected in most or all solutions (70-100: Figure 20). Some areas were not selected for inclusion in the MPA network, because they included locked out features (Figure 14) or they overlapped with other uses in the cost layer (Figure 17) e.g., some areas southwest of Tanimbar Island, in Papua and south of Timor Island. Of particular concern is that the only seamount in the ATS region (located east of Tanimbar Island: Figure 9) was not selected for inclusion in the network, because it overlaps with a locked out area in Indonesia (where underwater cable pipelines are located: Figure 13).

Priority areas for inclusion in the draft MPA network were identified as areas selected by Marxan in 70 to 100 solutions for the combined shallow and deep-water analysis (**Error! Reference source not f ound.**). These areas maximized achieving conservation targets while avoiding threats and minimizing impacts on other uses such as fisheries, oil and gas mining areas, shipping lanes, underwater cable pipelines, and power plants (Figure 14 and Figure 17).

Priority areas for inclusion in the MPA network (**Error! Reference source not found.**) included many a reas already allocated as existing or proposed MPAs in National Marine Spatial Plans (which were locked in). However, there is one Area of Interest southwest of Tanimbar Island, which was identified in a previous MPA Network Design that was not selected by Marxan (**Error! Reference s ource not found.**) because it overlaps with a locked out feature (oil and gas mining area: Figure 14).

Marxan also identified priority areas for establishing new MPAs in the ATS Region MPA Network that are required to:

- Achieve targets for protecting both shallow and deep-water habitats, particularly high priority deep-water habitats for protection such as canyons (e.g., on the southern side of the Lesser Sunda Islands in Indonesia and Timor-Leste); and some types of coral reefs and estuaries (e.g. at Adele Island and the Cox Peninsula in Australia).
- Achieve targets for protecting critical, special and unique areas such shipwrecks and aircraft wrecks, and turtle nesting beaches in Australia (e.g., Cox Peninsula and Adele Island).

We used the priority areas identified in the Marxan analysis to develop a draft MPA network design for the ATS Region that included existing MPAs, proposed MPAs, and Areas of Interest for establishing new MPAs**Error! Reference source not found.**. We then used simple GIS processing to c onduct a gap analysis to examine the degree to which the MPA network design achieves our targets for protecting each conservation feature (see Table 3 and Table 4), and to identify gaps in the existing network. We then used the gap analysis and Marxan to refine the design until we achieved our targets as far as possible.

The result was the draft MPA network design for the ATS Region (Figure 21), which included:

- Ninety-three existing and proposed MPAs allocated in National Marine Spatial Plans (Annex 3);
- Thirteen Areas of Interest for establishing new MPAs identified in previous MPA Network design processes in Indonesia and Timor-Leste (Annex 3);
- Four new Areas of Interest identified in this process: two on the southern side of Timor Island in Timor-Leste and Indonesia (South Manatuto and Motamasin), and two in Australia (Adele Island II and Cox Peninsula). The rationale for adding each of these new Areas of Interest is provided in Annex 4.

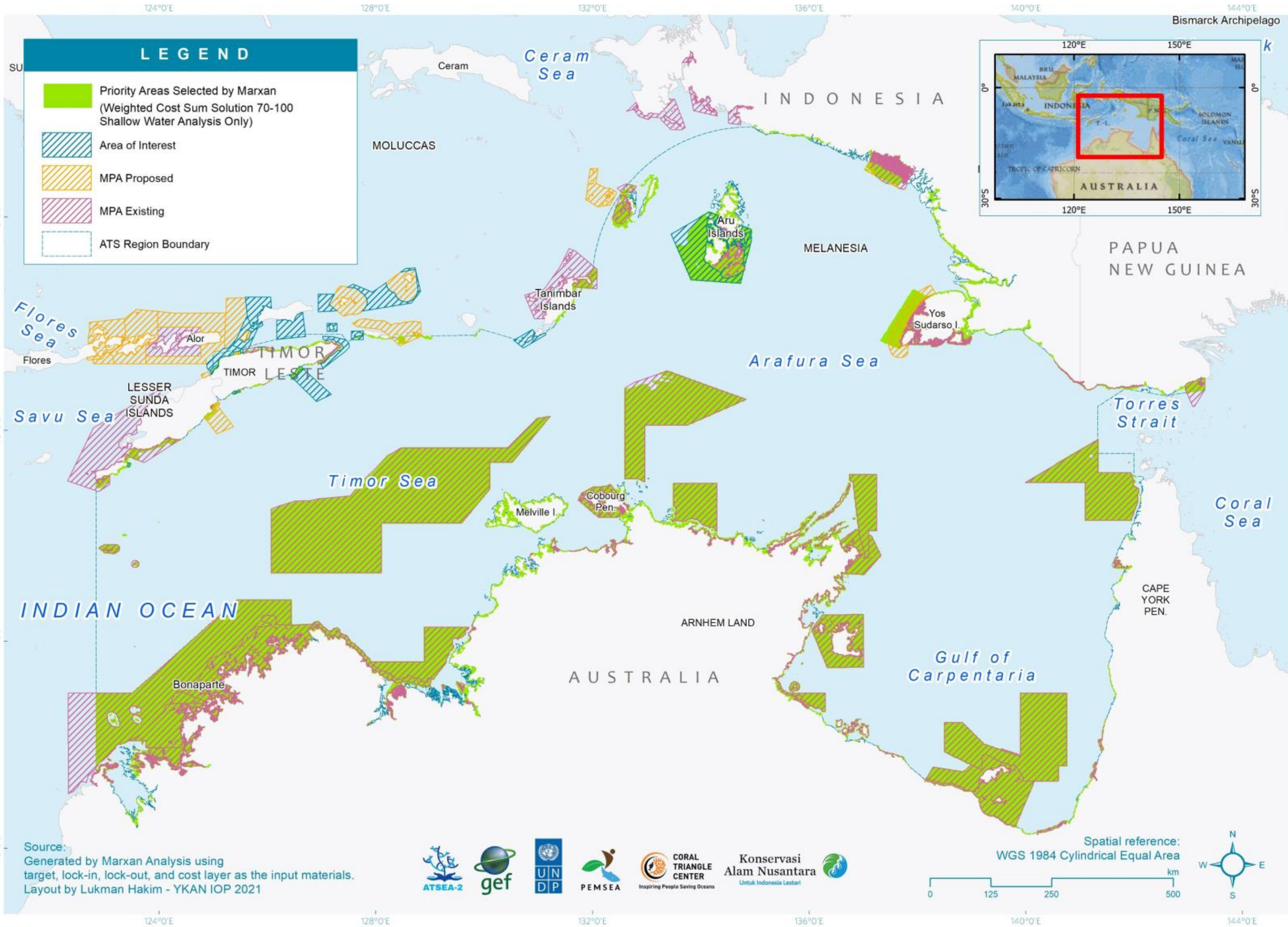


Figure 18. Priority areas identified in the sum solution for the shallow water Marxan analysis (areas selected in 70-100 solutions), overlaid with existing and proposed MPAs in the National Marine Spatial Plans and Areas of Interest for establishing new MPAs identified by previous MPA Network designs.

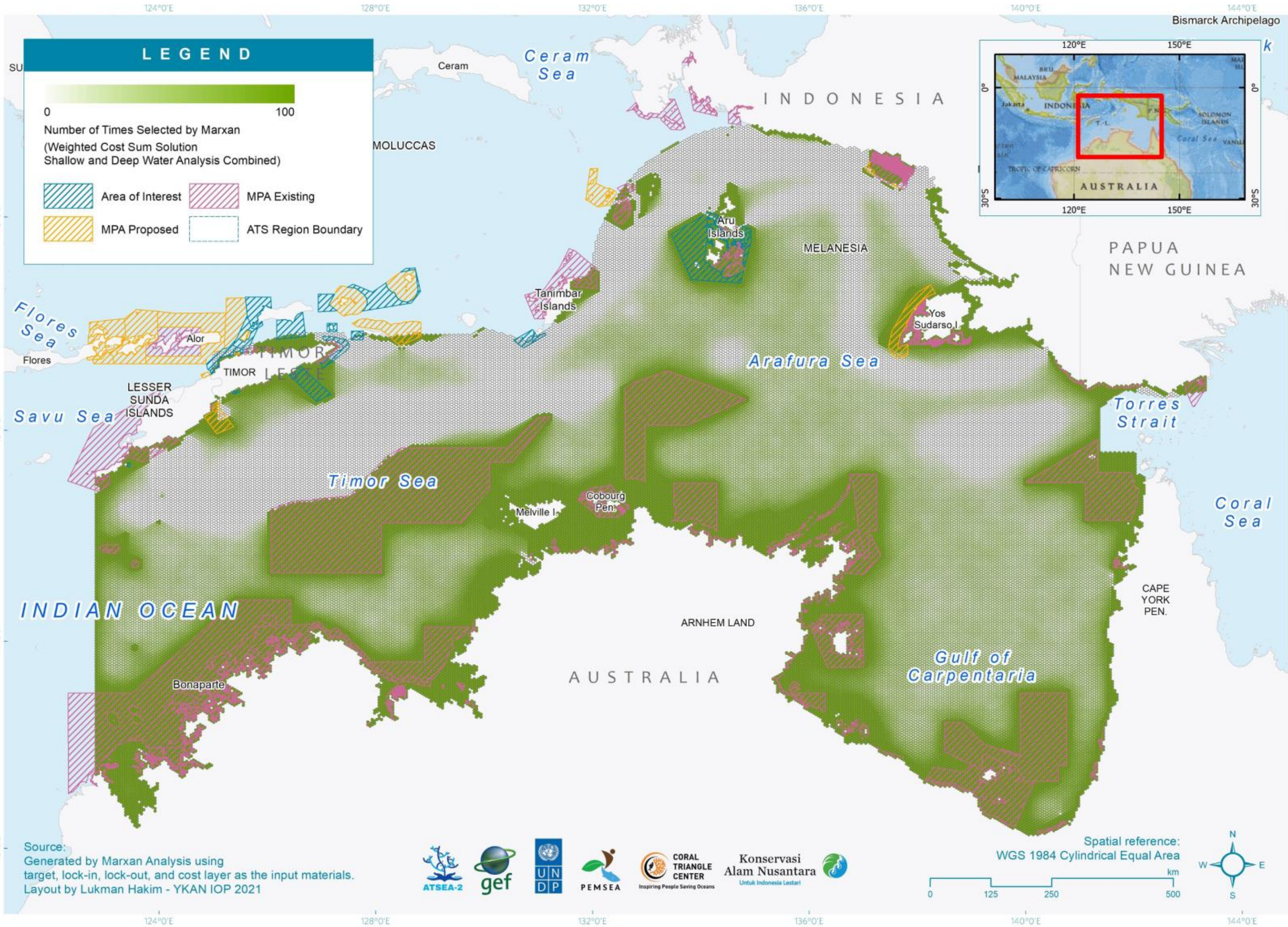


Figure 19. Sum solution for the combined shallow and deep-water analysis from the Marxan analysis, overlaid with existing and proposed MPAs in the National Marine Spatial Plans and Areas of Interest for establishing new MPAs identified by previous MPA Network designs.

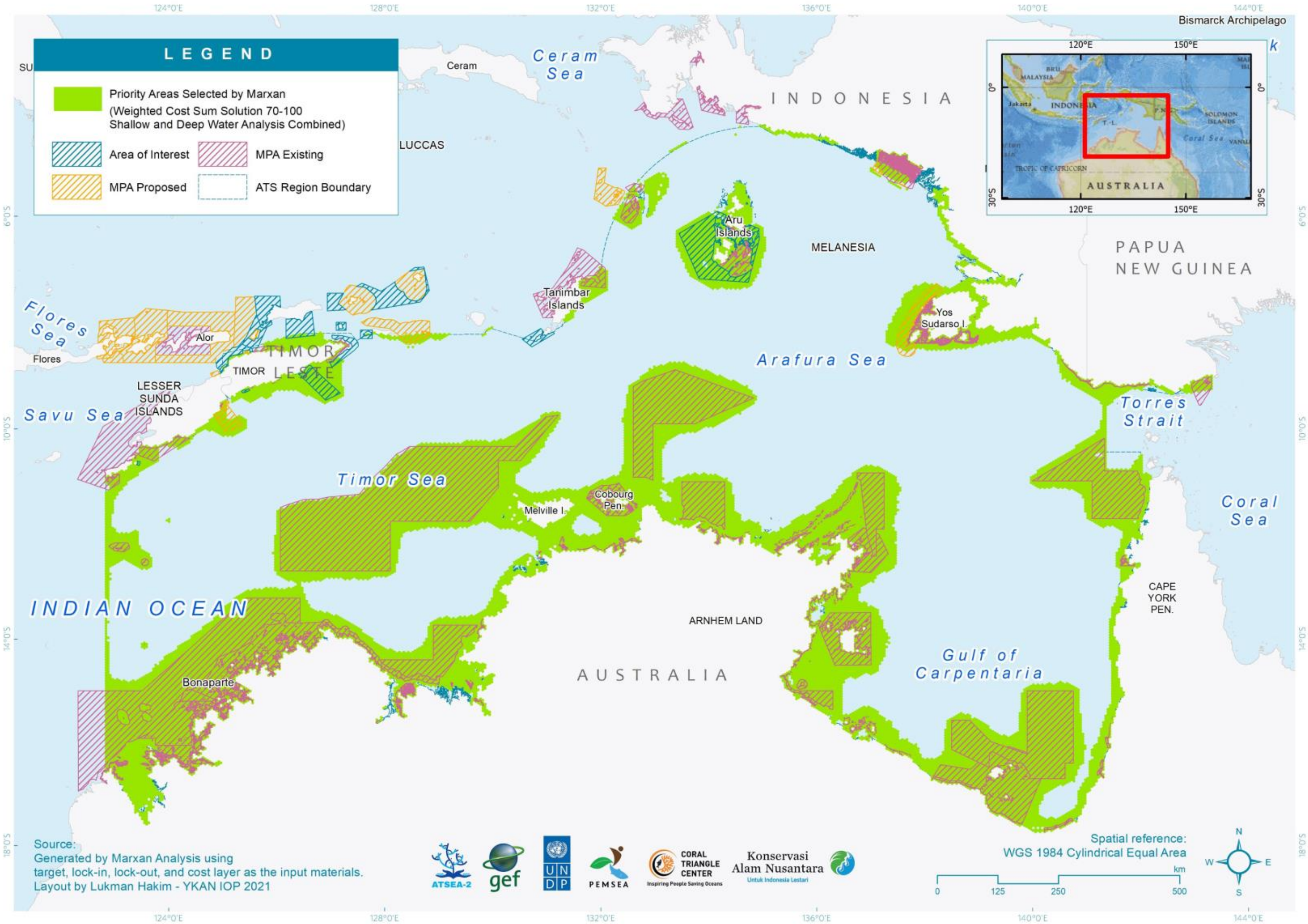


Figure 20. Priority areas for inclusion in the draft MPA network identified by the Marxan analysis (areas selected in 70-100 solutions) for the combined shallow and deep-water analysis, overlaid with existing and proposed MPAs in the National Marine Spatial Plans and Areas of Interest for establishing new MPAs identified by previous MPA Network designs.

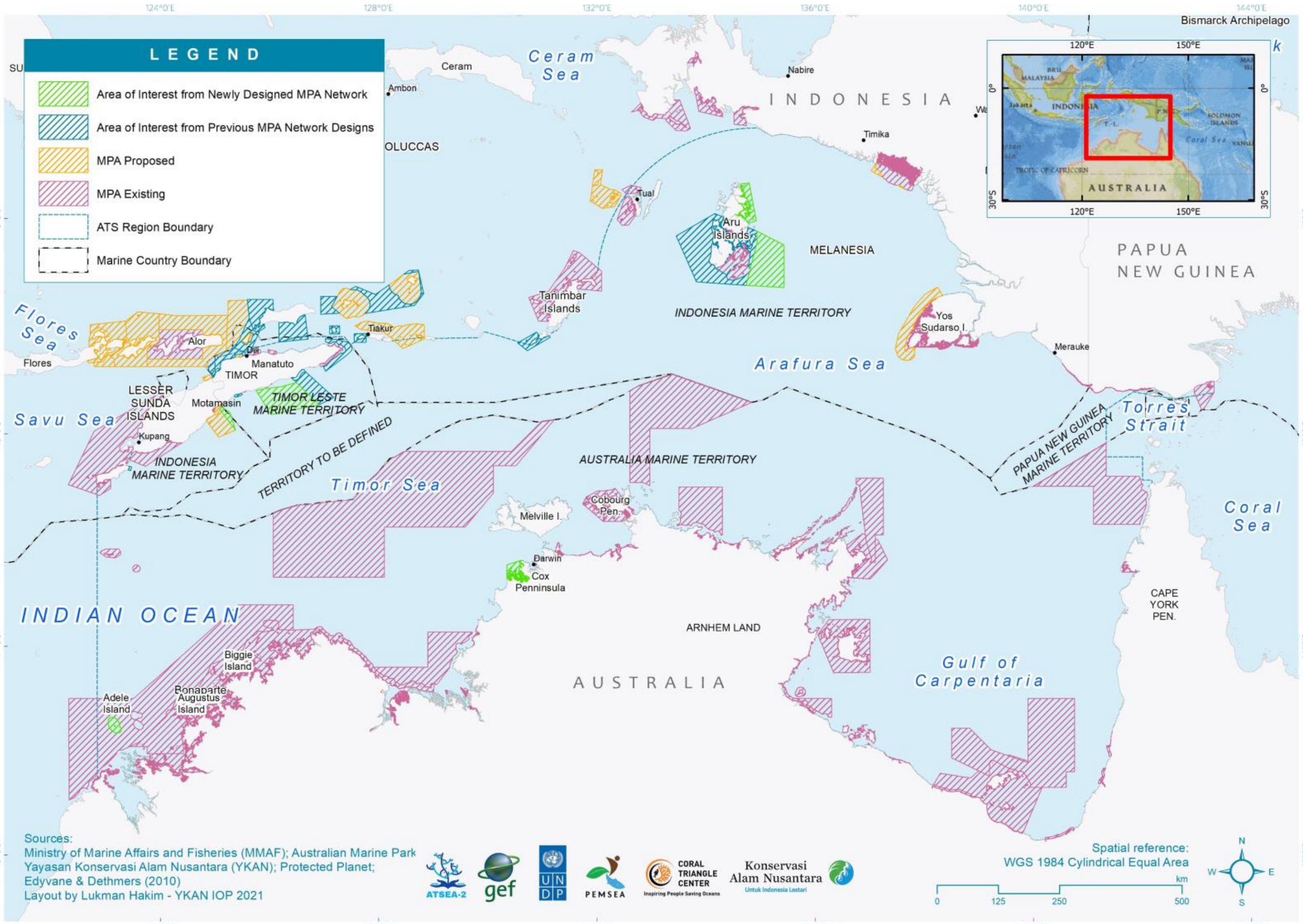


Figure 21. Draft MPA Network Design for Arafura and Timor Sea region, consisting of existing and proposed MPAs in National Marine Spatial Plans, and Areas of Interest for establishing new MPAs identified in previous MPA network designs and in the newly designed MPA Network in this study

REVIEWING AND REFINING THE MPA NETWORK DESIGN WITH INPUT FROM STAKEHOLDERS

We reviewed and refined the draft MPA network design (Figure 21**Error! Reference source not found.**) with input from stakeholders who comprised representatives from each ATS Country, MPA practitioners, and scientists from the ATS Region by:

1. Presenting the draft MPA Network design (Figure 21) to stakeholders at a series of National Consultation Workshops for their review and input.
2. Refining the design based on their advice and producing a final MPA Network design.
3. Presenting the final MPA network design to stakeholders at a Regional Consultation Workshop.

More details are provided below.

National Consultations

We conducted national consultation workshops with stakeholder from all four countries in the ATS Region to review the draft MPA Network for the ATS Region**Error! Reference source not found.**. Because of the covid 19 pandemic, all consultations were conducted online using a virtual platform (zoom). To facilitate detailed discussions with each country, we conducted the consultations in three different sessions with the consultation for:

- Indonesia held on 17th of March 2021 with 178 participants;
- Australia and Papua New Guinea held on the 18th of March 2021 with 28 participants; and
- Timor-Leste held on the 24th of March 2021 with 36 participants.

Participants included representatives from national, provincial and local governments, universities, non-governmental organizations (NGOs), donors, women's groups and the private sector (ANNEX 5).

The aim of the national workshops was to seek input from stakeholders to review the draft MPA Network Design. To facilitate the discussion, we described the background for the project (see *Introduction*), and the methods we used (including the goals, design criteria, conservation features, threats and other uses we used; and how we compiled and processed the data layers and used them to design an MPA network using Marxan and GIS processing: see *Methods*).

We then asked the stakeholders if they had any advice that we should use to refine the draft MPA network design based on their knowledge of the study area (particularly regarding the data layers that we used, and how we did the analysis). A summary of the feedback is provided in **Table 5**.

Table 5. Recommendations to refine the draft MPA Network design for the ATS Region provided by the four countries during national consultation workshops, and our response (how we modified the design based on this advice).

Recommendation	Response
It is essential to include the upwelling layer in the design process, since it is one of the most vital aspects of the ATS Region's oceanography related to fisheries.	We used information provided in Purba and Khan (2019) to identify three primary upwelling areas in the region (Figure 11). We added upwellings as special and unique features for protection, with a target of including at least 5% of these features in the MPA network design.

It is important to consider connectivity in more detail by considering papers by Treml *et al* (2015) and Thompson et al. (2018)'s on dispersal barriers and flow corridors.	We examined these studies that used biophysical models to understand broad scale patterns of connectivity of multiple taxa in the Indo west Pacific and Coral Triangle, which included the ATS Region. These studies identified potential broad scale patterns of connectivity including potential sources/sinks and dispersal boundaries. Treml et al. (2015) also identified eight areas overlapping the ATS Region that appear to be distinct in terms of connectivity. We added a data layer for Treml's areas, and applied our targets for protecting conservation features within each area in the MPA network design (as we did with the marine ecoregions).
It is important to consider Veron *et al* (2009)'s coral ecoregions (in addition to the marine ecoregions in Figure 2).	Veron et al. (2009) identified 11 coral ecoregions that overlap with the ATS Region (which are similar to the marine ecoregions). We added a data layer for Veron's ecoregions, and applied our target of protecting 30% of coral reefs within each coral ecoregion in the MPA network design.
The design should be enriched by adding the coral and seagrass vulnerability assessment to climate change.	We used data layers on the vulnerability assessment of corals and seagrasses to climate change provided by Johnson *et al* (2021) when they became available. We used corals and seagrasses with different levels of vulnerability to climate change (low, moderate and high) as conservation targets, and set targets of protecting 30% of each in each of Veron et al.'s ecoregions.
Please consider the Areas of Interest identified for Northern Territory of Australia by Edyvane and Dethmers (2010).	We compared these with the draft MPA network design and found that most were already included in the design.

Indonesia provided additional input to have more background on connectivity issues to demonstrate the importance of establishing a regional MPA network and why it is necessary from ecological and socio-economic aspects. Moreover, the network shall provide benefits to support the goal to increase fish stocks, especially for Fisheries Management Area 718.

Refining the MPA Design based on Advice Provided During National Consultations

We refined the MPA network design based on the input we received at the national workshops as described in Table 5. Adding the additional resources recommended by stakeholders at the national consultations required adding four additional data layers to the analysis regarding:

- Upwellings (based Purba and Khan 2019) (Figure 11);
- Coral ecoregions (by Veron et al. 2009) (Figure 24);
- Low, moderate and high vulnerability of corals and seagrasses to climate change (from Johnson et al. 2021) (Figure 22, Figure 23);
- Connectivity multitaxon dispersal barriers and flow corridors (Treml et al 2015) (Figure 24).

We addressed the issues raised in the national workshops without rerunning Marxan. Instead, we manually refined the MPA Network design until we met our targets as far as possible (confirmed using GIS processing). This required adding two new Areas of Interest to the MPA network design in areas where there is a low level of threat and no incompatible uses (Annex 4):

- Southeast Aru Extension primarily to increase the representation of upwellings: and
- Northeast Aru primarily to increase the representation of areas with low vulnerability seagrasses and corals.

Based on this input, we produced the final version of the MPA network design for the ATS Region, and conducted a gap analysis to examine the degree to which the network achieves targets for protecting conservation features.

Regional Consultation

We conducted a regional consultation workshop online via zoom with stakeholders from all four countries in the ATS Region on March 31st 2021, which included 50 participants from national governments, universities, non-governmental organizations (NGOs), donors, and the private sector (ANNEX 5). The agenda for the workshop was similar to the one we used for the national workshops (see above), except that we described how we had modified the design based on the feedback we received in the national consultations and presented the final MPA Network design for the ATS Region. We received positive feedback from all four countries on the design, who saw it as an important first step for collaborating on designing an MPA network in the region.

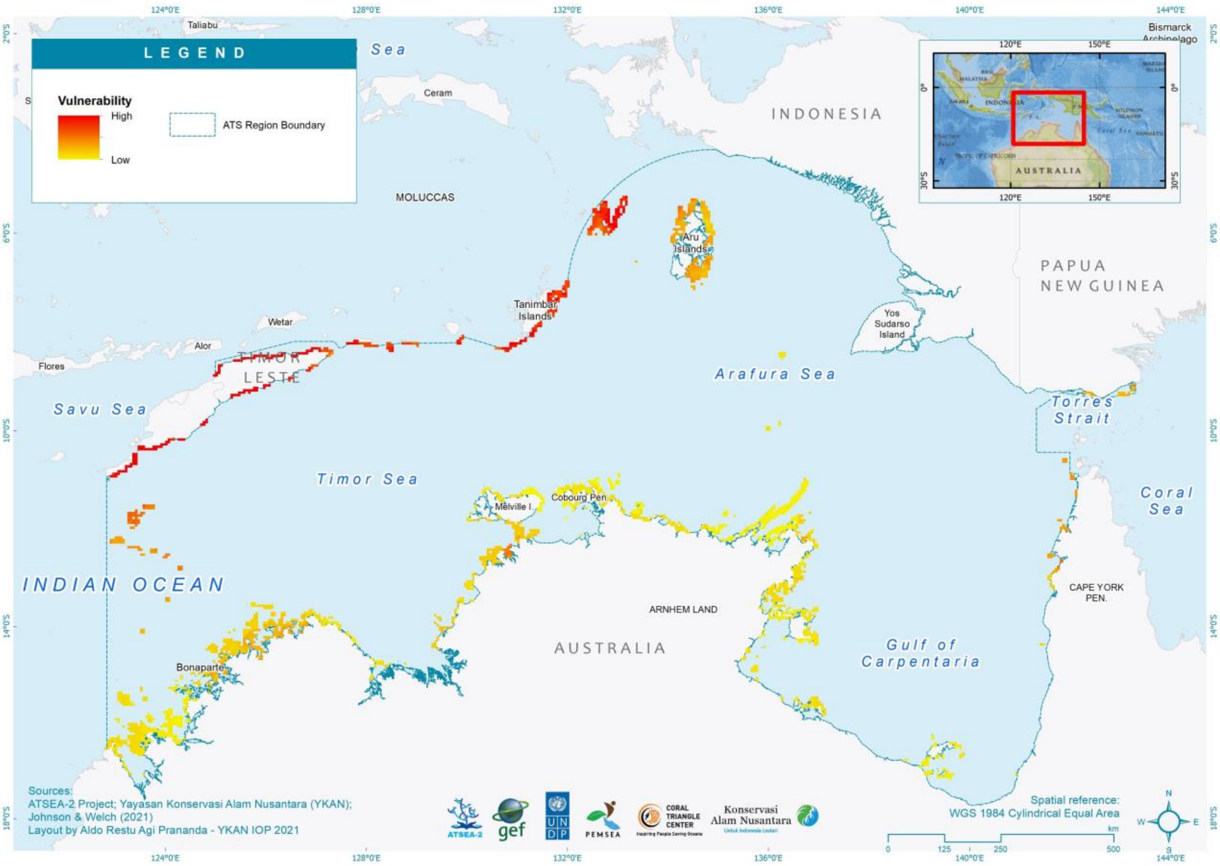


Figure 22. Coral vulnerability assessment to climate change (Johnson et al. 2021)

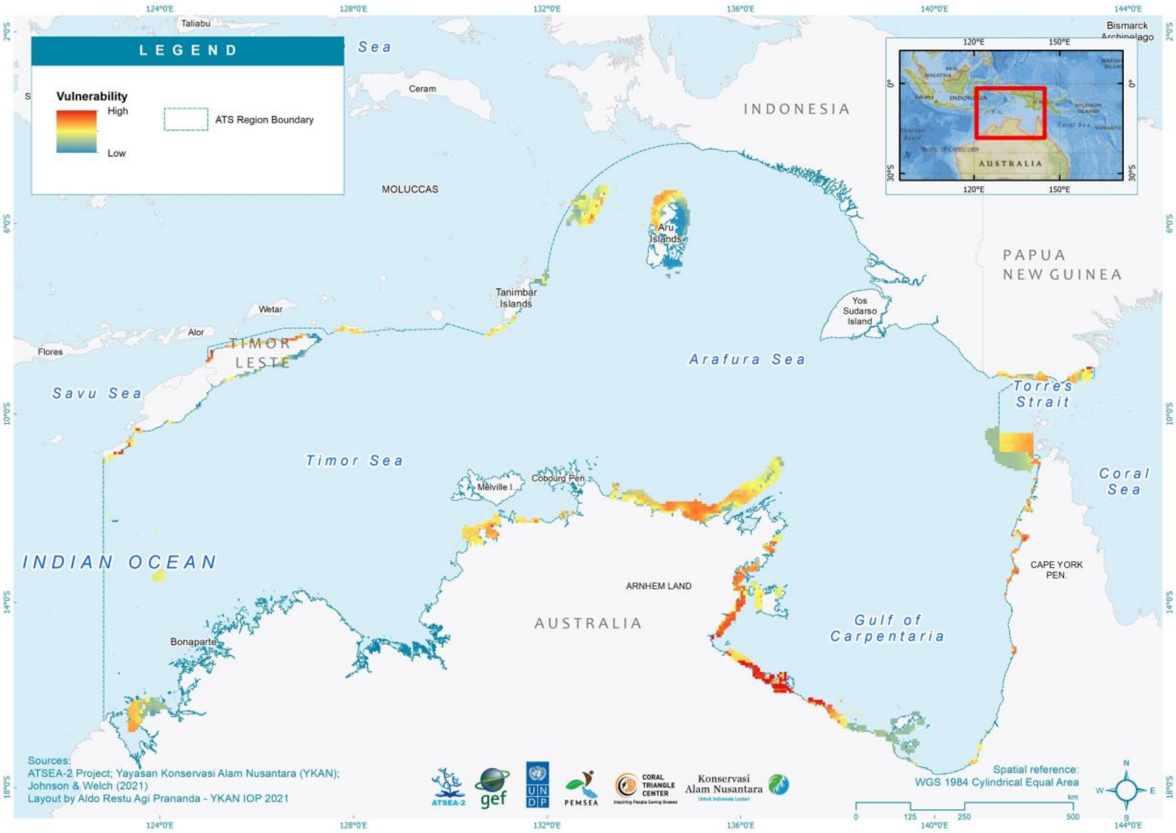


Figure 23. Seagrass vulnerability assessment to climate change (Johnson et al. 2021)

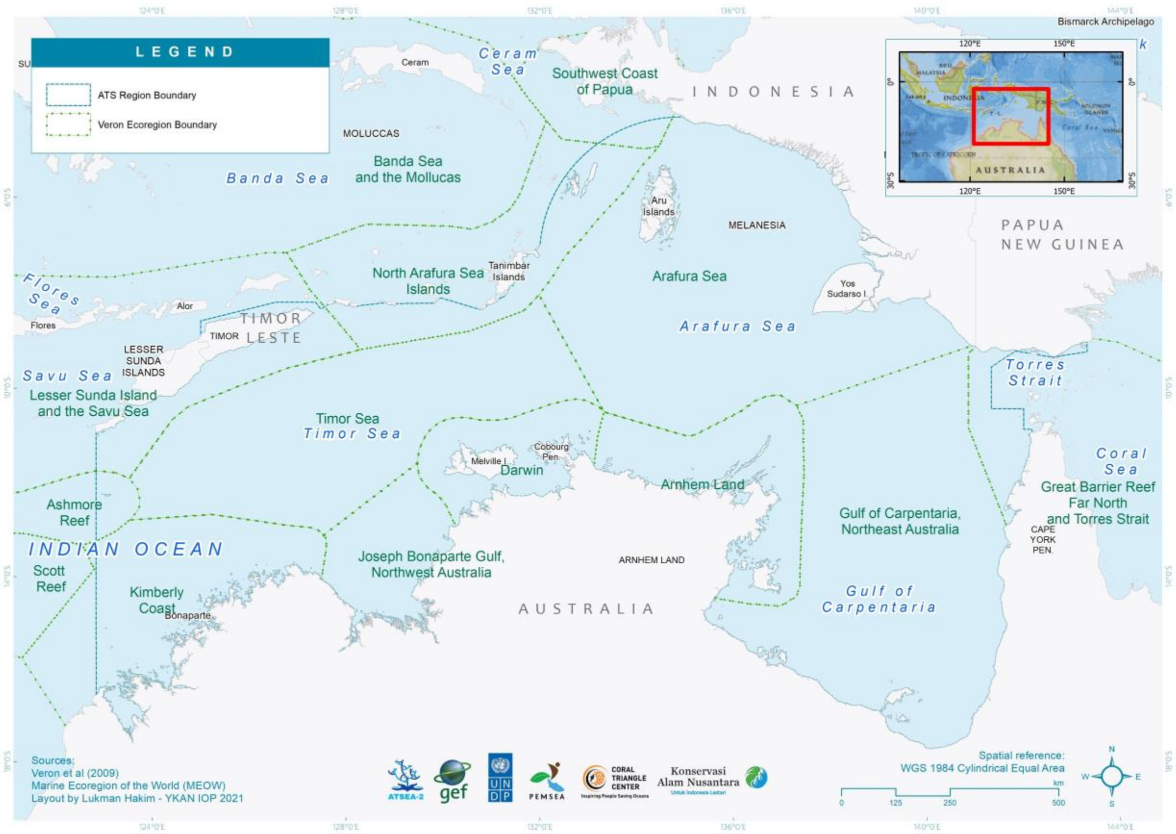


Figure 24. Coral ecoregions (Veron et al. 2009)

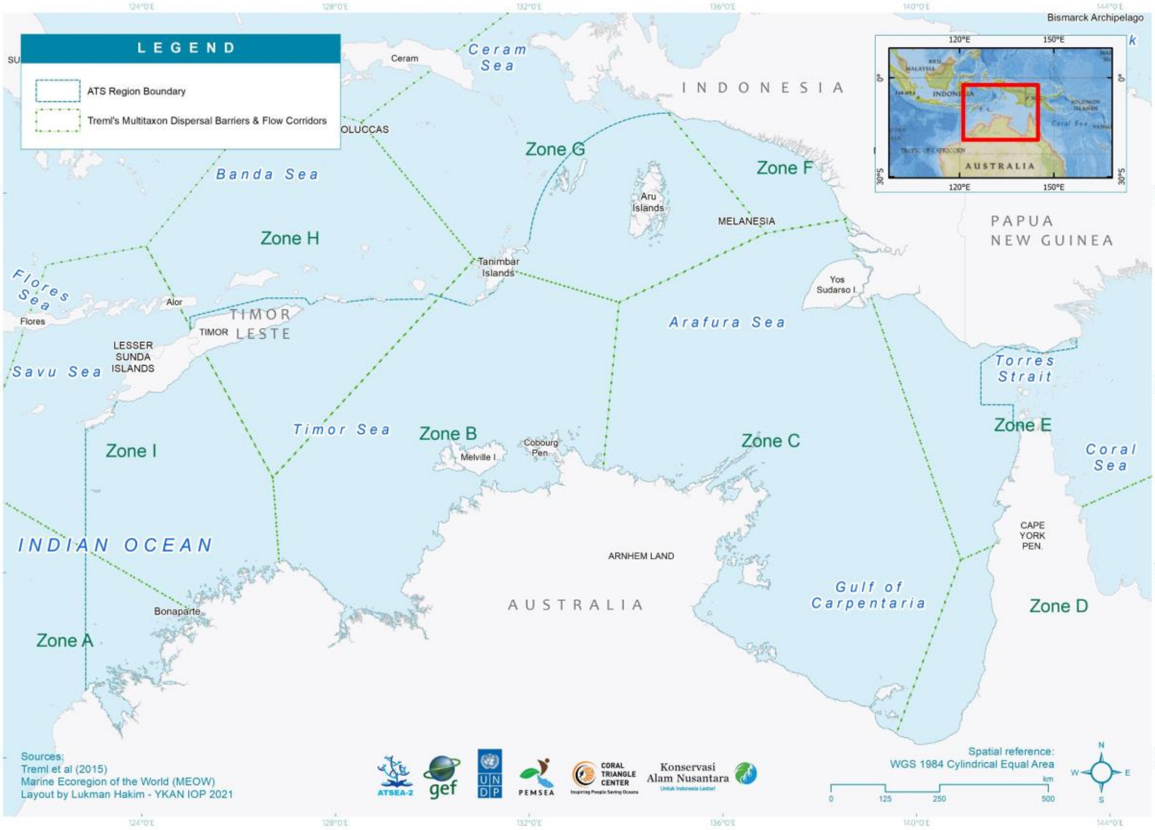


Figure 25. Connectivity multitaxon dispersal barriers and flow corridors (Treml et al 2015)

RESULTS

A MARINE PROTECTED AREA NETWORK DESIGN FOR THE ARAFURA AND TIMOR SEAS REGION

The result is the first iteration of a MPA network design for ATS Region (Figure 27**Error! Reference source not found.**) that includes:

- All 93 existing and proposed MPAs allocated in National Marine Spatial Plans (comprising 271,588 km^2: Table 6 and Annex 3);
- Thirteen Areas of Interest for establishing new MPAs identified in previous MPA Network design processes (comprising 14,772 km^2: Table 6 and Annex 3); and
- Seven Areas of Interest for establishing new MPAs in the newly designed MPA Network for the ATS Region in this study (comprising 14,613 km^2: Table 6 and Annex 4).

All Areas of Interest were identified as potential areas for establishing new MPAs, because they comprise important biophysical, socioeconomic and/or cultural sites not currently protected within existing or proposed MPAs in National Marine Spatial Plans. If all 20 Areas of Interest are established as new MPAs, they would increase the total area of existing and proposed MPAs in Arafura Timor Sea from 271,588 to 300,973 km^2 (Table 6).

The seven new Areas of Interest identified in this study include:

- Adele Island II and Cox Peninsula in Australia:
- Motamasin, Northeast Aru and Southeast Aru extension in Indonesia; and
- Motamasin and South Manatuto in Timor-Leste.

Where Motamasin is a transboundary area between Indonesia and Timor-Leste. We did not identify any new Areas of Interest in PNG. The rationale and recommendations for including each new Area of Interest identified in this study are provided in Annex 4.

Table 6. Existing and proposed marine protected areas and areas of interest for establishing new marine protected areas in the Arafura Timor Seas Region
(including existing and proposed MPA in National Marine Spatial Plans, and Areas of Interests (AOIs) identified in previous MPA network designs and in the newly designed MPA Network in this study). For more details see Annex 3 and Annex 4)

NO.	COUNTRY	EXISTING MPA	PROPOSED MPA	AOI FROM PREVIOUS MPA NETWORK DESIGN	AOI FROM NEWLY DESIGNED MPA NETWORK
1	Australia	249,802.10	-	-	1489.58
2	Territory to be Defined	-	-	-	
3	Timor-Leste	935.23	83.17	4,592.40	4,971.98
4	Indonesia	13,680.50	6,180.62	10,179.92	8,151.50
5	Papua New Guinea	906.66	-	-	-
	Total (km²)	265,324.49	6,263.79	14,772.32	14,613.06

The information we used to design the final MPA Network for the ATS Region includes:

- 116 spatial data layers (Annex 1), 44 of which we used in the Marxan analysis and 72 of which we used manually to refine the results of the analysis.

- Existing and proposed MPAs and Areas of Identified in previous planning processes that were locked in for the analysis (Figure 3);
- 61 Conservation features including 19 shallow water habitats, 18 deep-water habitats, and 24 critical and unique areas (Figure 7, Figure 8, Figure 9, Figure 10, and Figure 11);
- Targets for each conservation feature ranging from 10 to 100%:
- Threats and other uses (Figure 13), some of which were locked out of the analysis (Figure 14) while the others were used to develop the cost layer (Figure 17).

MARINE PROTECTED AREAS WITHIN EACH COUNTRY

The following is a summary of the components of the ATS Regional MPA Network Design that lay within each of the four countries.

Indonesia

The components of the ATS Regional MPA Network Design that are within Indonesia's marine waters (Figure 27) include:

- Twenty-one existing and proposed MPAs already allocated in National Marine Spatial Plans (comprising 19,861 km^2); and
- Eight Areas of Interest for establishing new or expanded MPAs identified in previous MPA network designs and this study (comprising 18,331 km^2).

If these Areas of Interest are established as new or expanded MPAs, they would increase the total area of existing and proposed MPAs in Indonesia's waters within the ATS Region from 19,861 to 38,192 km^2.

Timor-Leste

The components of the ATS Regional MPA Network design that are within Timor-Leste's marine waters (Figure 28) include:

- Ten existing and proposed MPAs already allocated in National Marine Spatial Plans (comprising 1,018 km^2); and
- Ten Areas of Interest for establishing new or expanded MPAs identified in previous MPA network designs and this study (comprising 9,564 km^2).

If these Areas of Interest are established as new or expanded MPAs, they would increase the total area of existing and proposed MPAs in Timor-Leste waters within the ATS Region from 1,018 to 10,582 km^2.

Australia

The components of the ATS Regional MPA Network design that are within Australia's marine (Figure 29) includes:

- Sixty existing and proposed MPAs already allocated in the National Marine Spatial Plans (comprising 249,802 km^2); and
- Two Areas of Interest for establishing new or expanded MPAs identified in this study (comprising 1,489 km^2).

If these Areas of Interest are established as new or expanded MPAs, they would increase the total area of existing and proposed MPAs in Australia waters within the ATS Region from 249,802 to 251,291 km^2.

Papua New Guinea

The components of the ATS Regional MPA Network design that are within PNG's marine waters include two existing MPAs with total area is 906 km2 (Figure 30). The new MPA Network Design for the ATS Region does not recommend adding any new MPAs in PNGs.

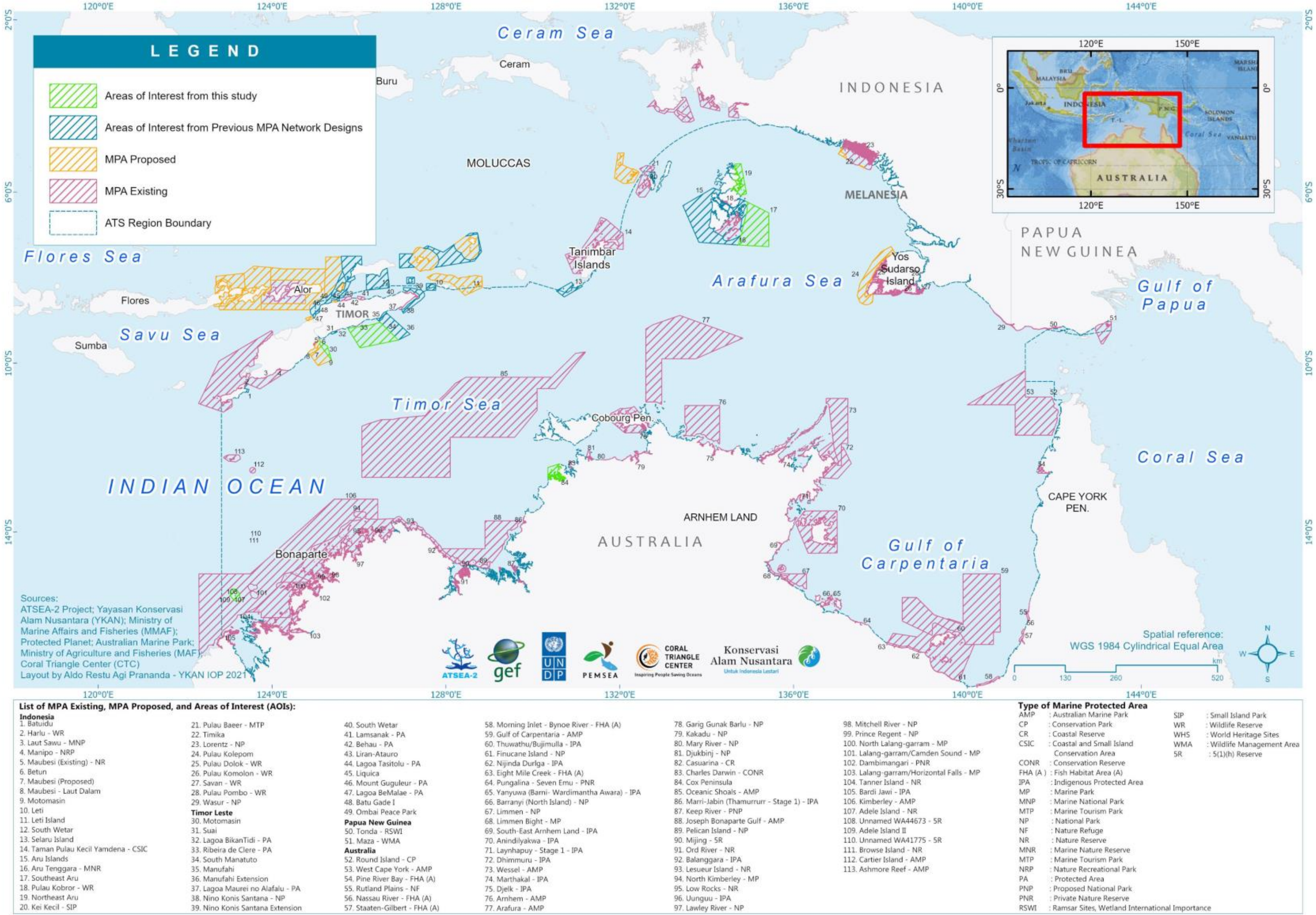


Figure 26. MPA Network Design for the Arafura and Timor Sea Region, consisting of existing and proposed MPAs in National Marine Spatial Plans, and Areas of Interest for establishing new MPAs identified in previous MPA network designs and in the newly designed MPA Network (this study).

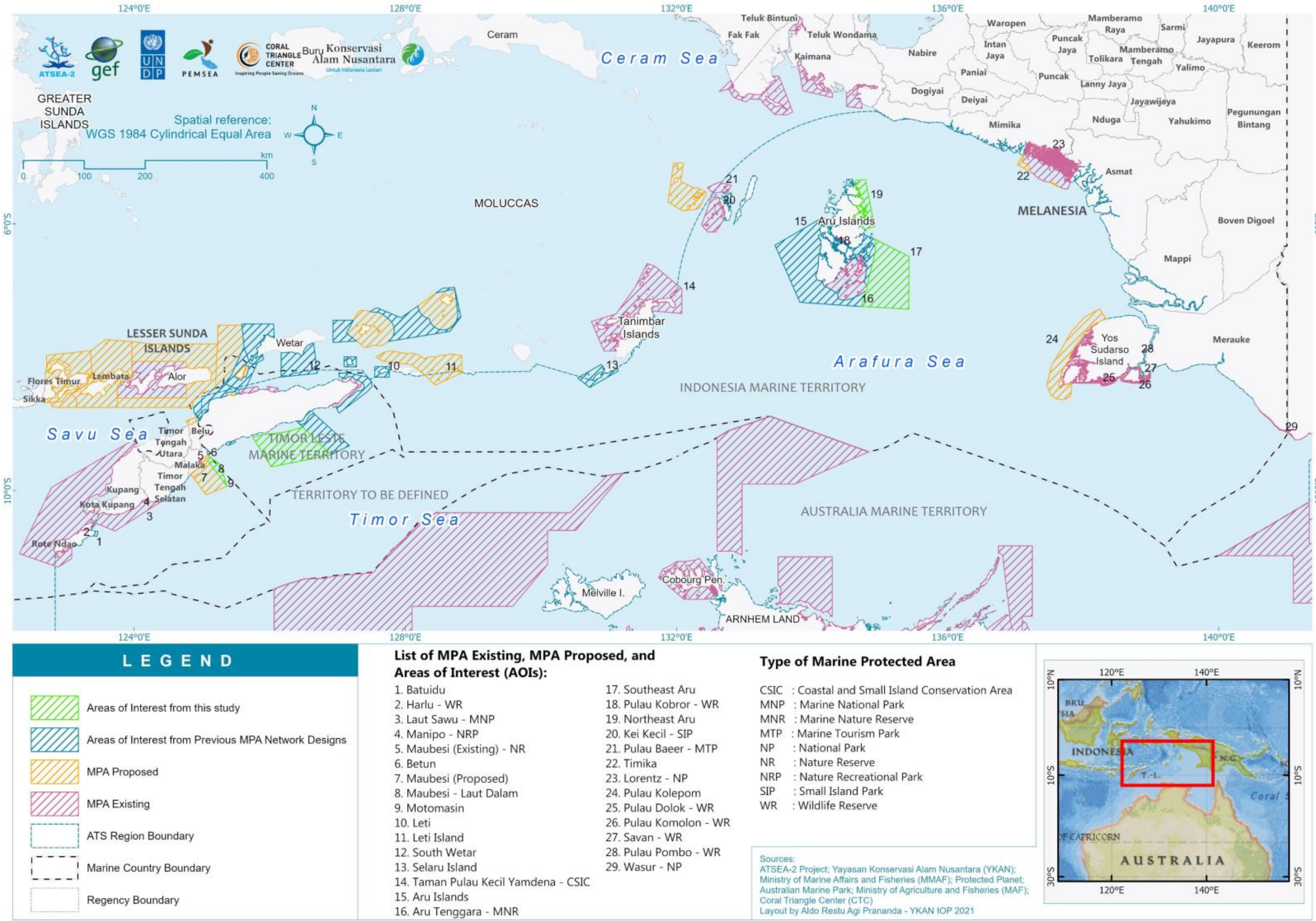


Figure 27. MPA Network Design for Indonesia's waters within the ATS Region, consisting of existing and proposed MPAs in National Marine Spatial Plans, and Areas of Interest for establishing new MPAs identified in previous MPA network designs and in the newly designed MPA Network in this study.

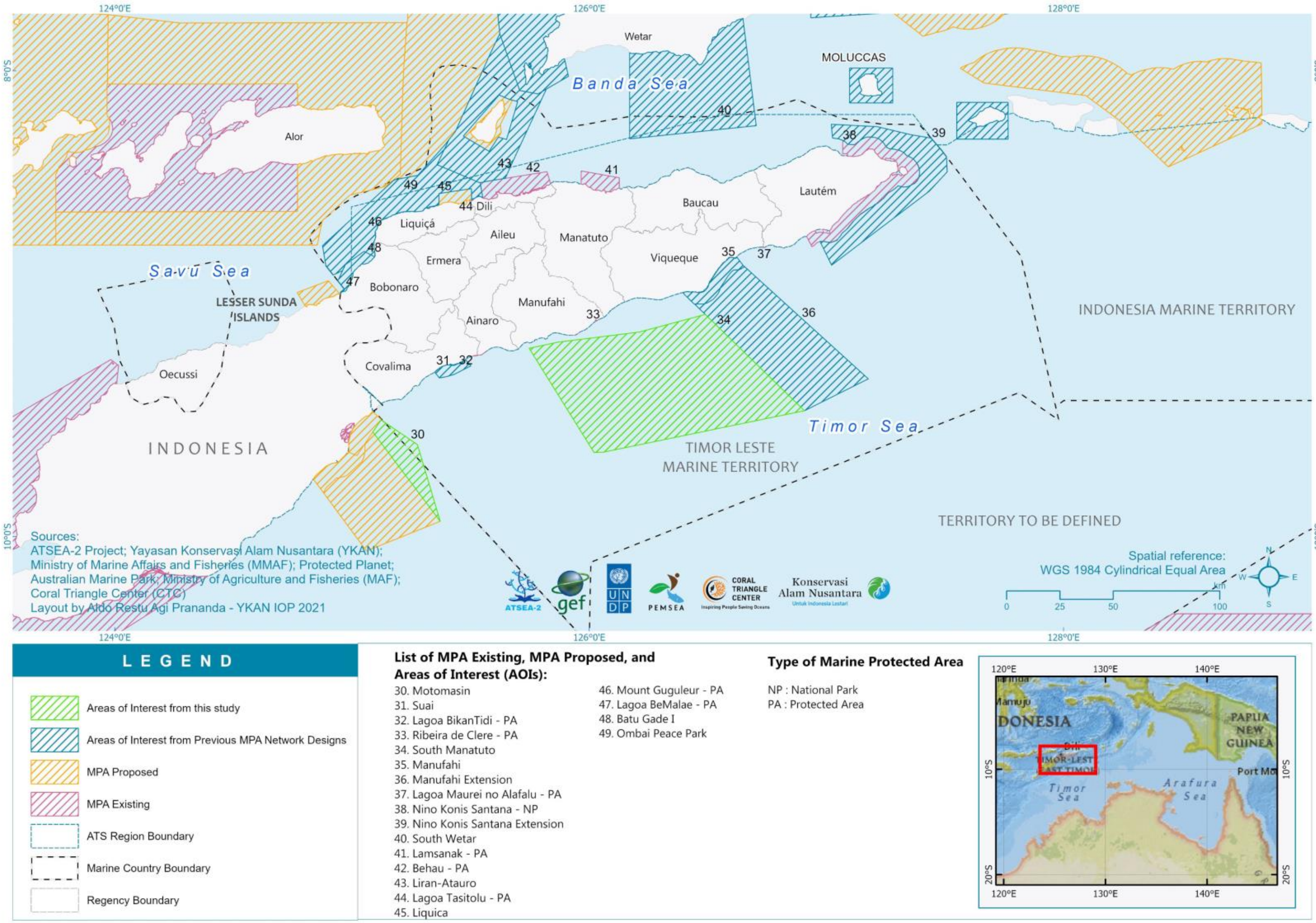


Figure 28. MPA Network Design for Timor-Leste's waters within the ATS Region, consisting of existing and proposed MPAs in National Marine Spatial Plans, and Areas of Interest for establishing new MPAs identified in previous MPA network designs and in the newly designed MPA Network in this study.

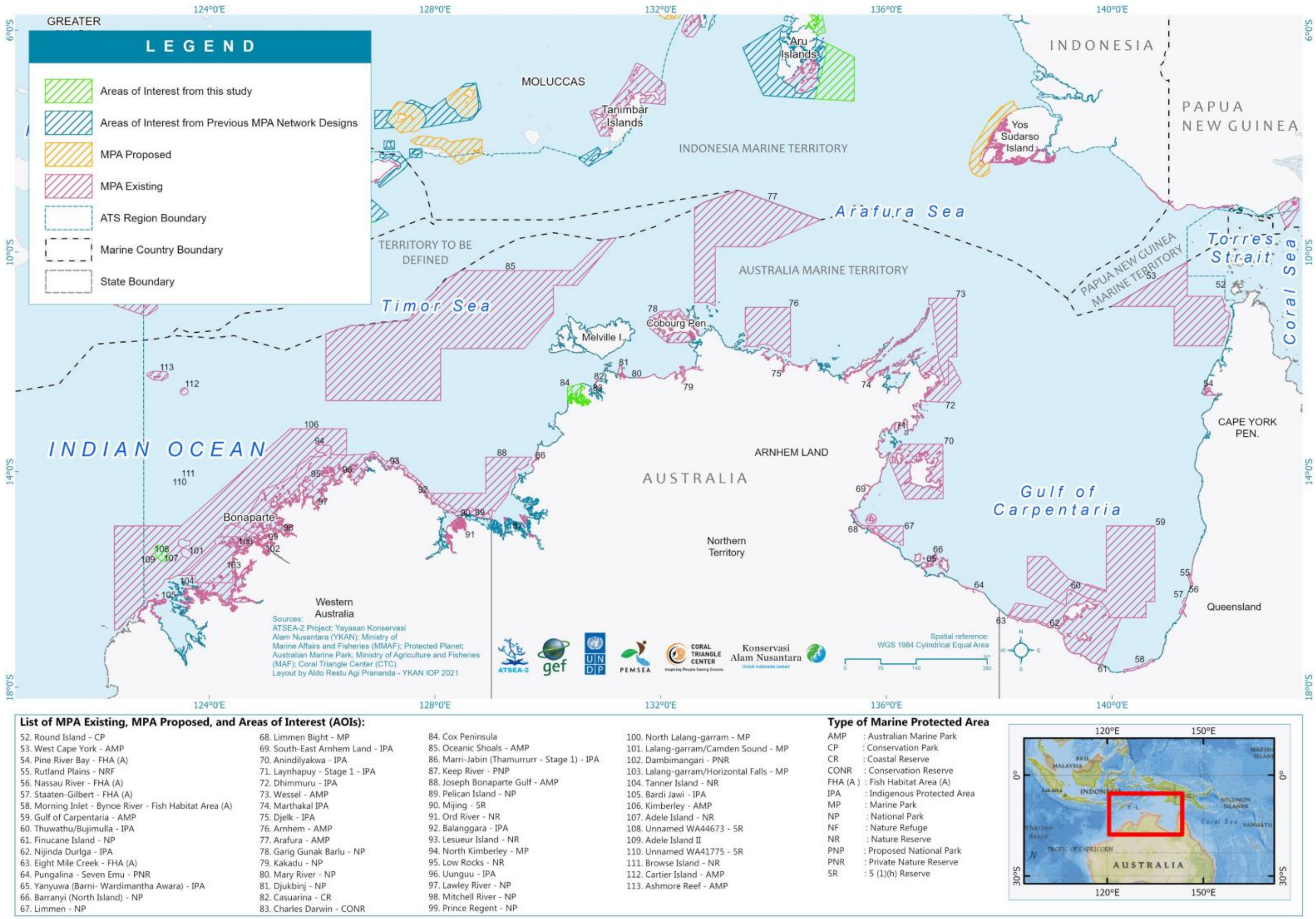


Figure 29. MPA Network Design for Australia's waters within the ATS Region, consisting of existing MPAs in National Marine Spatial Plans, and Areas of Interest for establishing new MPAs identified in the newly designed MPA Network in this study.

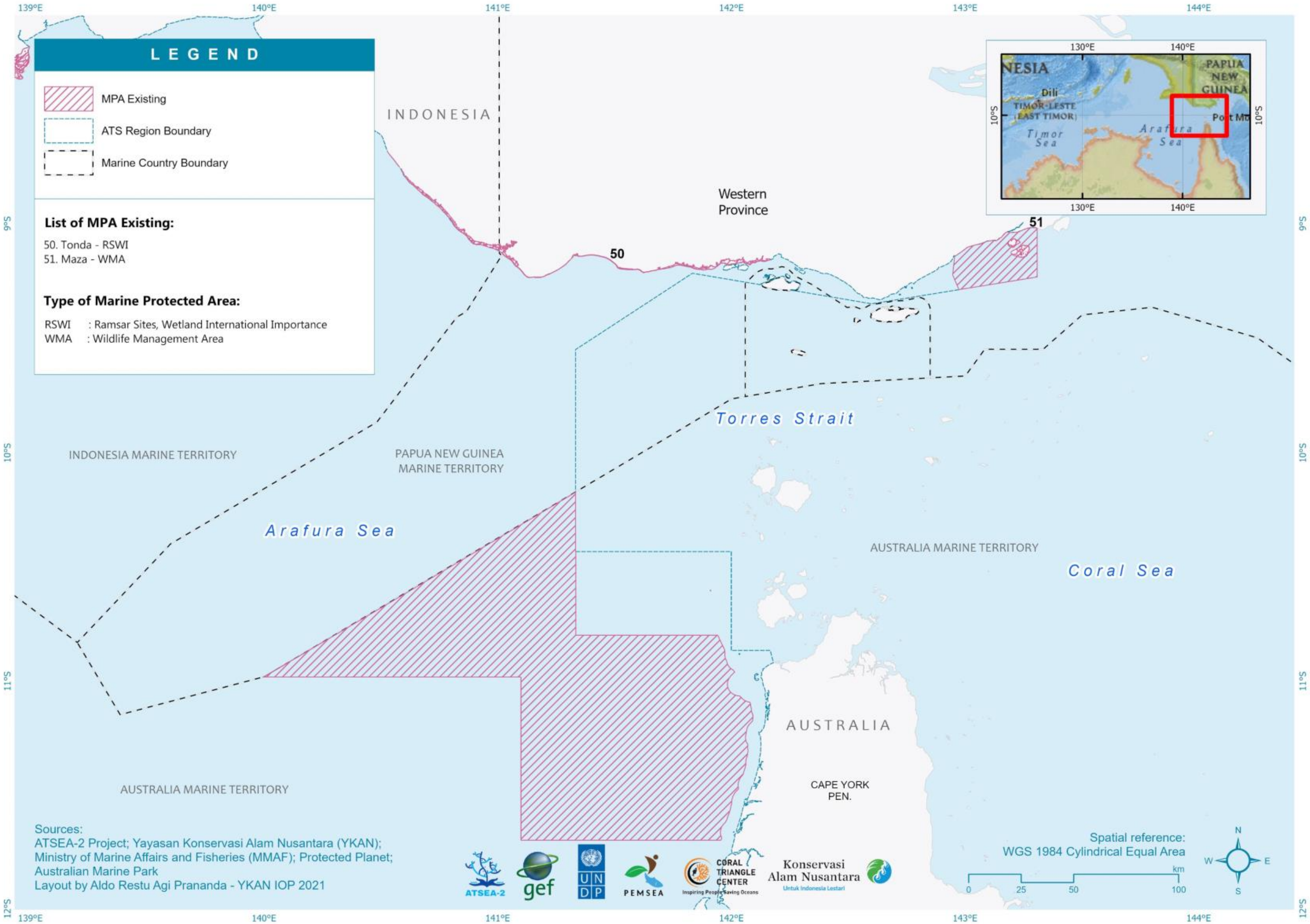


Figure 30. MPA Network Design for Papua New Guinea's waters within the ATS Region, consisting of existing MPAs.

MARINE GAP ANALYSIS

The gap analysis shows that the final MPA network design for the ATS Region achieves most of the targets for protecting conservation features, although some gaps remain as described below.

Shallow Water Habitats

We set a target of protecting at least 30% of each of four shallow water habitats in MPAs in the ATS Region: coral reefs, mangroves, seagrasses, and estuaries (Figure 7). More than 30% of each of these habitats is already included in existing or proposed MPAs in the Region, except for estuaries (Figure 31). We achieved the target of protecting at least 30% of each of these habitats in MPAs for the marine waters of each country within the Region also, except for estuaries in Australia, Indonesia and Timor-Leste and seagrasses in Papua New Guinea (Figure 32). In the MPA network design for the ATS Region, we tried to increase the coverage of estuaries in Areas of Interest in each country where they occur (and seagrasses in PNG). However, it was not possible because these habitats occur in areas that were either locked out or where there were high costs associated with other uses (e.g., shipping lanes, ports, oil and gas areas and underwater cables).

We also set a target of 30% protection for each of the 10 classes of coral reefs in the ATS Region (Figure 8). More than 30% of each coral reef class is already included within existing MPAs (ranging from 30-70% for each class), with more included in proposed MPAs and Areas of Interest in the Region (Figure 33). This is because, with a few exceptions, 30-100% of each habitat is already included in existing or proposed MPAs in each of the four countries (Figure 34). We increased the area of some of these habitats in Areas of Interest identified in the new ATS Region MPA Network Design, so at least 30% of most classes are now included within the MPA network. The exception is in Indonesia and Timor-Leste, where 30% of a few classes could not be included in the MPA network because they occur in locked out areas (Figure 14) or areas where there were high costs associated with other uses (Figure 17).

Deep Water Habitats

We set targets for protecting deep-water habitats (Figure 9) in the ATS Region MPA Network Design at 100% for seamounts, 30% for canyons and 10% for the other habitats.

The level of protection of most of these habitats in existing or proposed MPAs and Areas of Interest in the MPA Network is currently low (<5-10%), and levels of protection do not meet our targets for including 10% of most habitats in the MPA Network Design (with many habitats currently at 0 to <8% protection: Figure 35). The exceptions are basins, escarpments, shelves and sills, which range from 12 to 48% protection in existing MPAs, proposed MPAs and Areas of Interest in the MPA network (Figure 35). Similarly, we do not meet our target of protecting 30% of canyons (currently 18%) and 100% of seamounts (currently 0%) in the MPA Network (Figure 35).

The degree to which deep-water features are protected varies among countries in the ATS Region MPA Network design (Figure 36):

- In Australian waters, 7 out of 10 habitats are already achieving their targets of more than 10% protection in existing MPAs, although three are still underrepresented (escarpments, slopes and terraces).
- In Indonesian waters, most habitats (except some shelves and sills) are underrepresented.
- In PNG waters, two of the four habitats are underrepresented.
- In Timor-Leste, most targets are achieved by the addition of new MPAs identified in this study (including 60% of canyons).
- No habitats are protected in the territory still to be defined.

The main reason why targets for deep-water habitats cannot be met in each country, is that they occur in areas that were either locked out or where there were high costs associated with other uses (e.g., shipping lanes, ports, oil and gas areas and underwater cables). For example, the only seamount in the Region (east of Tanimbar Island: Figure 9) could not be included in the MPA Network design, because it overlaps with a locked-out area in Indonesia (where underwater cable pipelines are located: Figure 13).

Critical, Special and Unique Areas

We set targets for protecting critical, special and unique areas (Figure 10) in the ATS Region MPA Network Design of 30% for dive sites, tourism areas, turtle nesting beaches, shipwrecks and airplane wrecks, and 50% for important traditional areas (Table 3).

More than 60% of dive sites, 50% of tourism areas and more than 50% of turtle nesting beaches and Aboriginal Heritage Place, and 30% of local wisdom are included in the network (Figure 37). However, less than 20% of shipwrecks and aircraft wrecks are included.

There is a lot of variation among countries in the degree to which each feature is protected within their waters in the MPA Network design**Error! Reference source not found.**:

- More than 50% of Important traditional area (Aboriginal Heritage Place) well protected in the network in Australia, and 30 % of local wisdom area in Indonesia is include in the network in Indonesia. The local wisdom cannot meet the target (50%) because some of the area are overlap with locked out area (underwater cable) and with high density shipping lines.
- More than 30% of turtle nesting beaches are included in the network in Australia (>60%), Indonesia (>30%) and Timor-Leste (90%). However, only 5% are included in PNG.
- Dive sites are well protected in the network in both Indonesia (100%) and Timor-Leste (almost 70%), and tourism sites in Indonesia (>50%). However, no dive site are protected in Australia as there are only 4 dive sites and they are overlap with ports and high density shipping lines.
- In Australia, less than 20% of shipwrecks are protected in MPA Network. Others could not be included because they overlap with high density shipping lines, underwater cables, military areas, and ports.

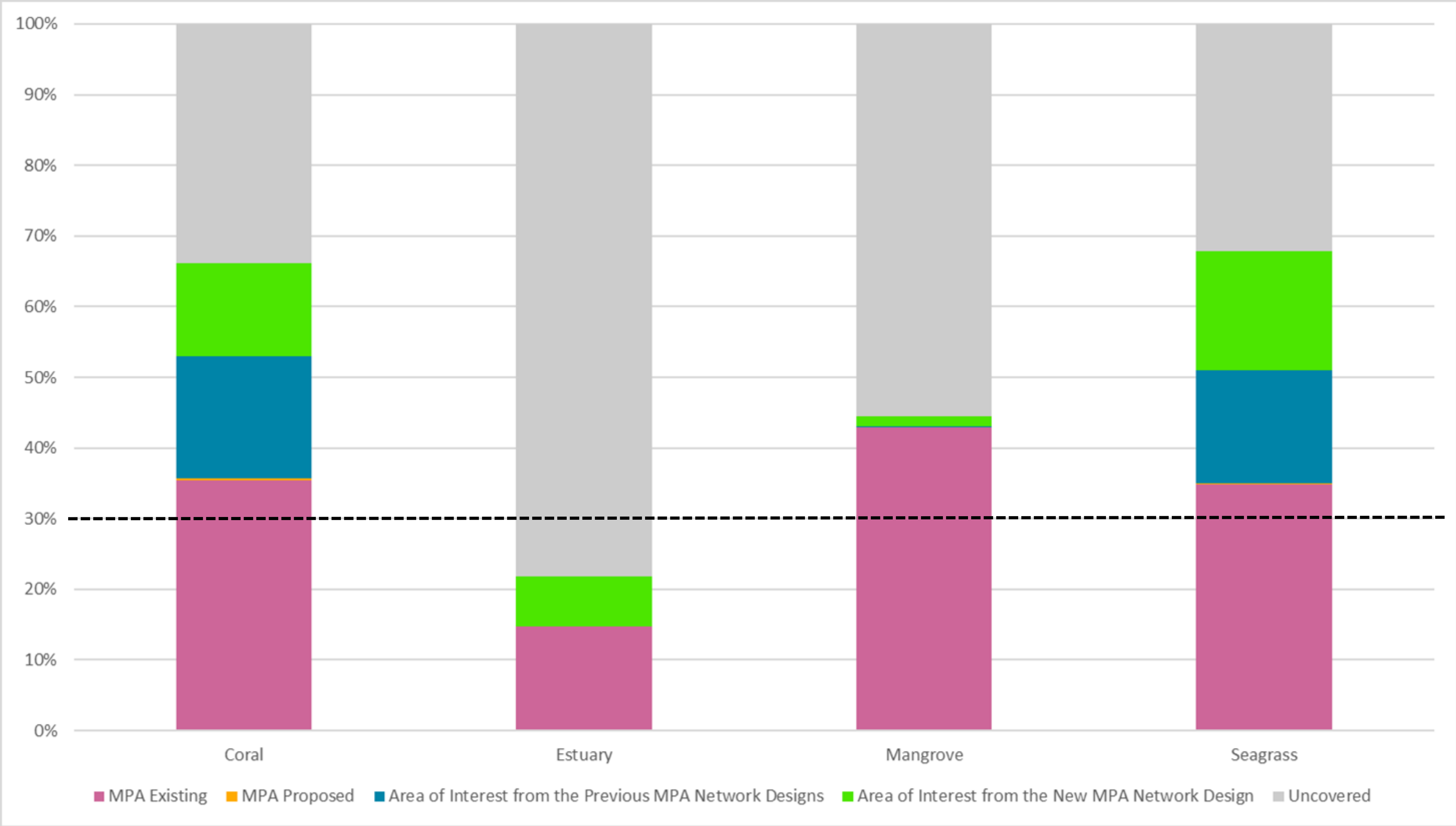


Figure 31. Percentage of each shallow water habitat in existing and proposed MPAs, and Areas of Interest identified in previous planning processes and in the newly designed MPA network (this study) for establishing new MPAs, in the ATS Region. Where the target for protecting each feature in MPAs is at least 30%.

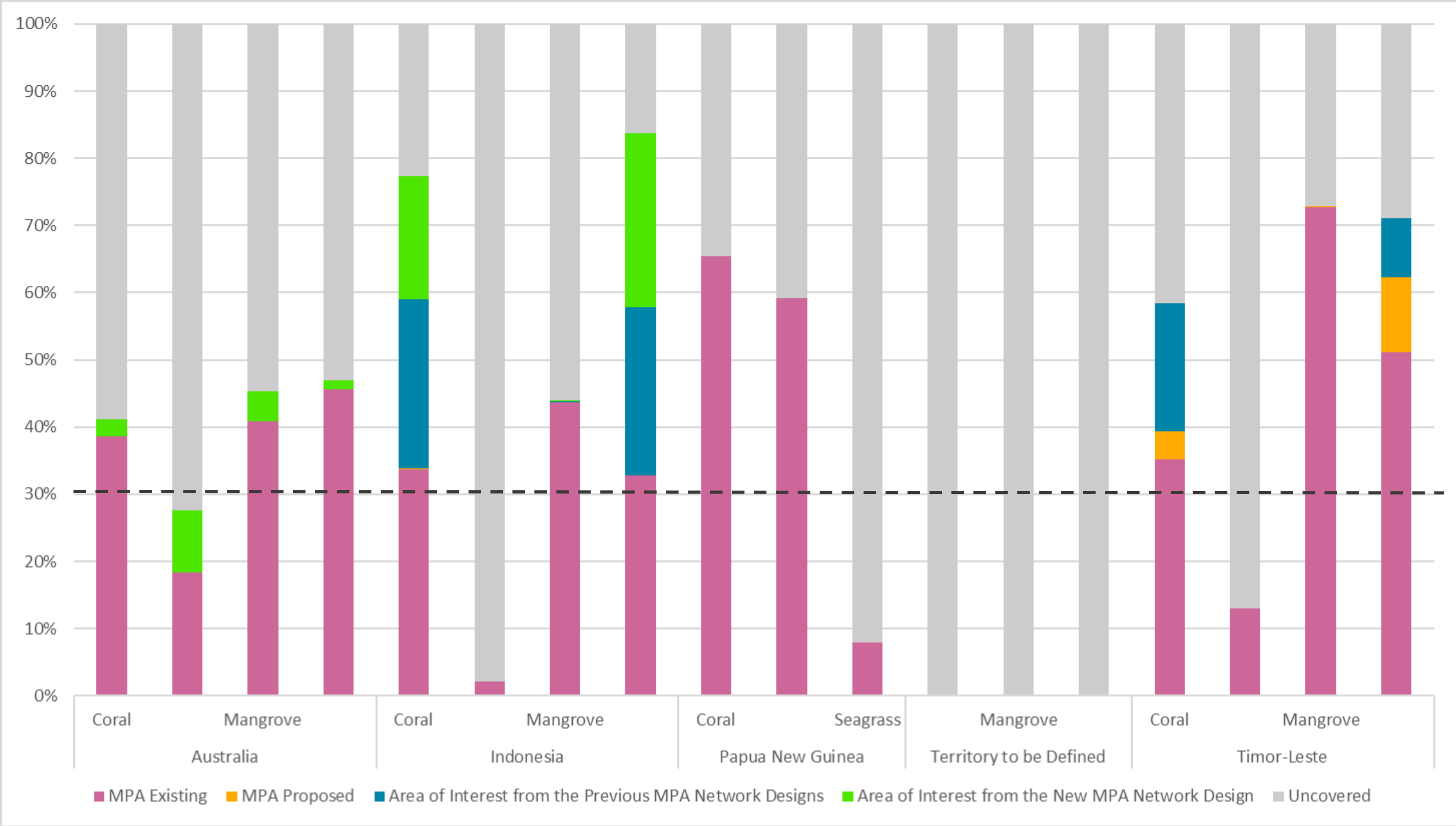


Figure 32. Percentage of each shallow water habitat in existing and proposed MPAs, and Areas of Interest identified in previous planning processes and in the newly designed MPA network (this study) for establishing new MPAs, in each country in the ATS Region. Where targets for protecting each feature in MPAs is at least 30%.

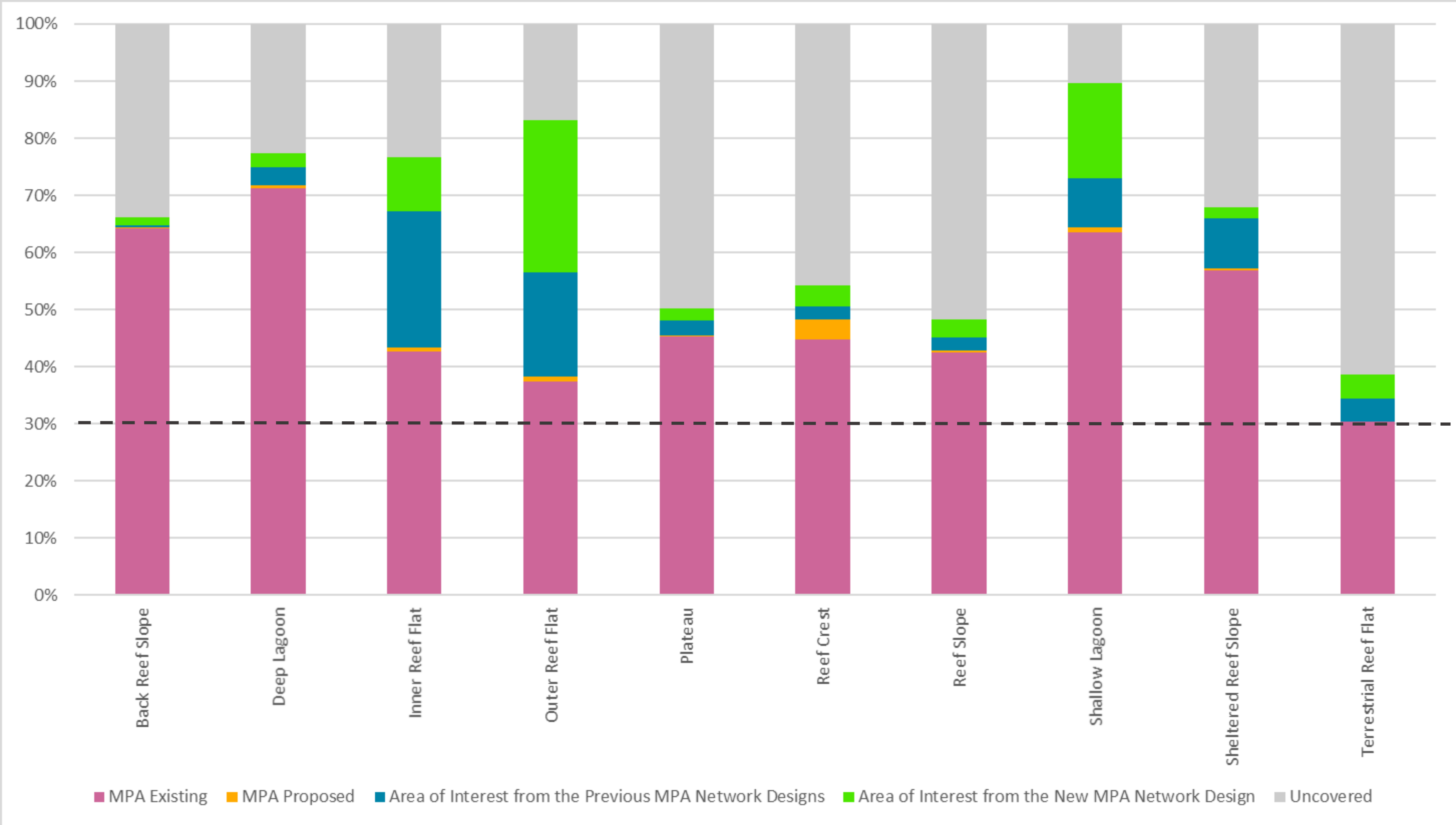


Figure 33. Percentage of each coral reef classification in existing and proposed MPAs, and Areas of Interest identified in previous planning processes and in the newly designed MPA network (this study) for establishing new MPAs, in the ATS Region. Where targets for protecting each feature in MPAs is at least 30%.

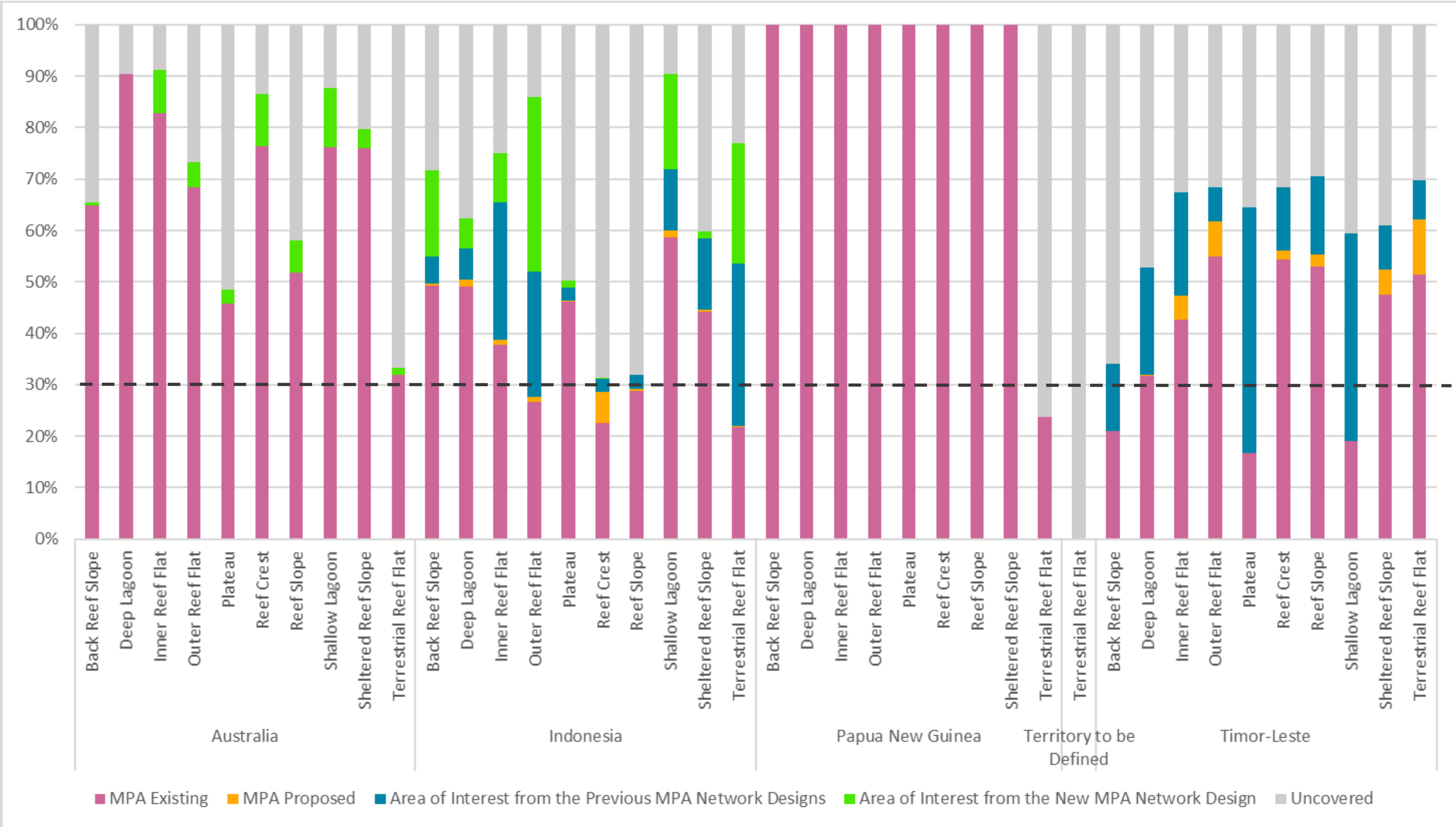


Figure 34. Percentage of each coral reef classification in existing and proposed MPAs, and Areas of Interest identified in previous planning processes and in the newly designed MPA network (this study) for establishing new MPAs, in each country in the ATS Region. Where targets for protecting each feature in MPAs is at least 30%.

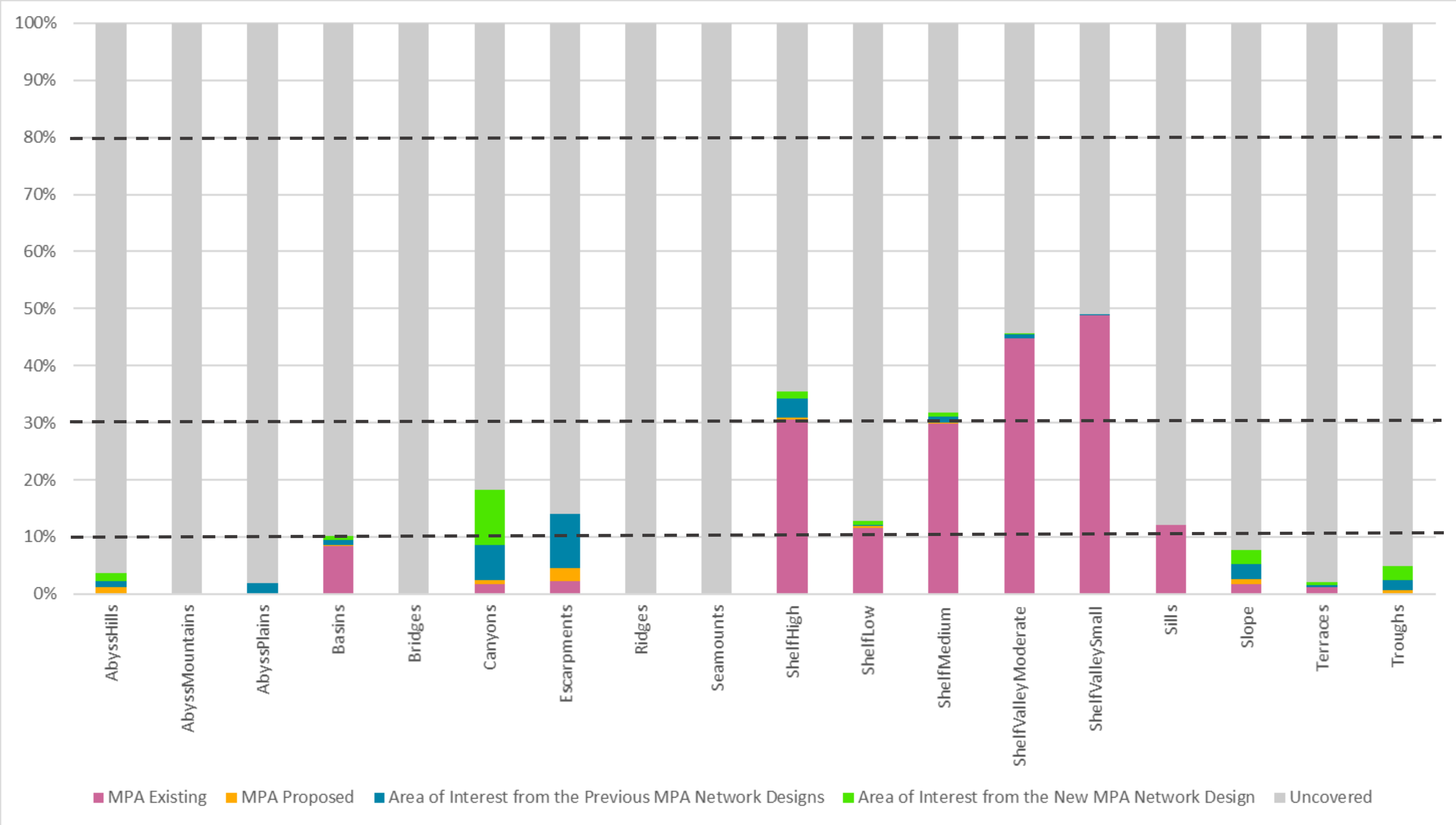


Figure 35. Percentage of each deep-water habitat in existing and proposed MPAs, and Areas of Interest identified in previous planning processes and in the newly designed MPA network (this study) for establishing new MPAs, in the ATS Region. Where targets for protection in MPAs are 10% for all habitat types, except for canyons and seamounts, which are 30% and 80% respectively.

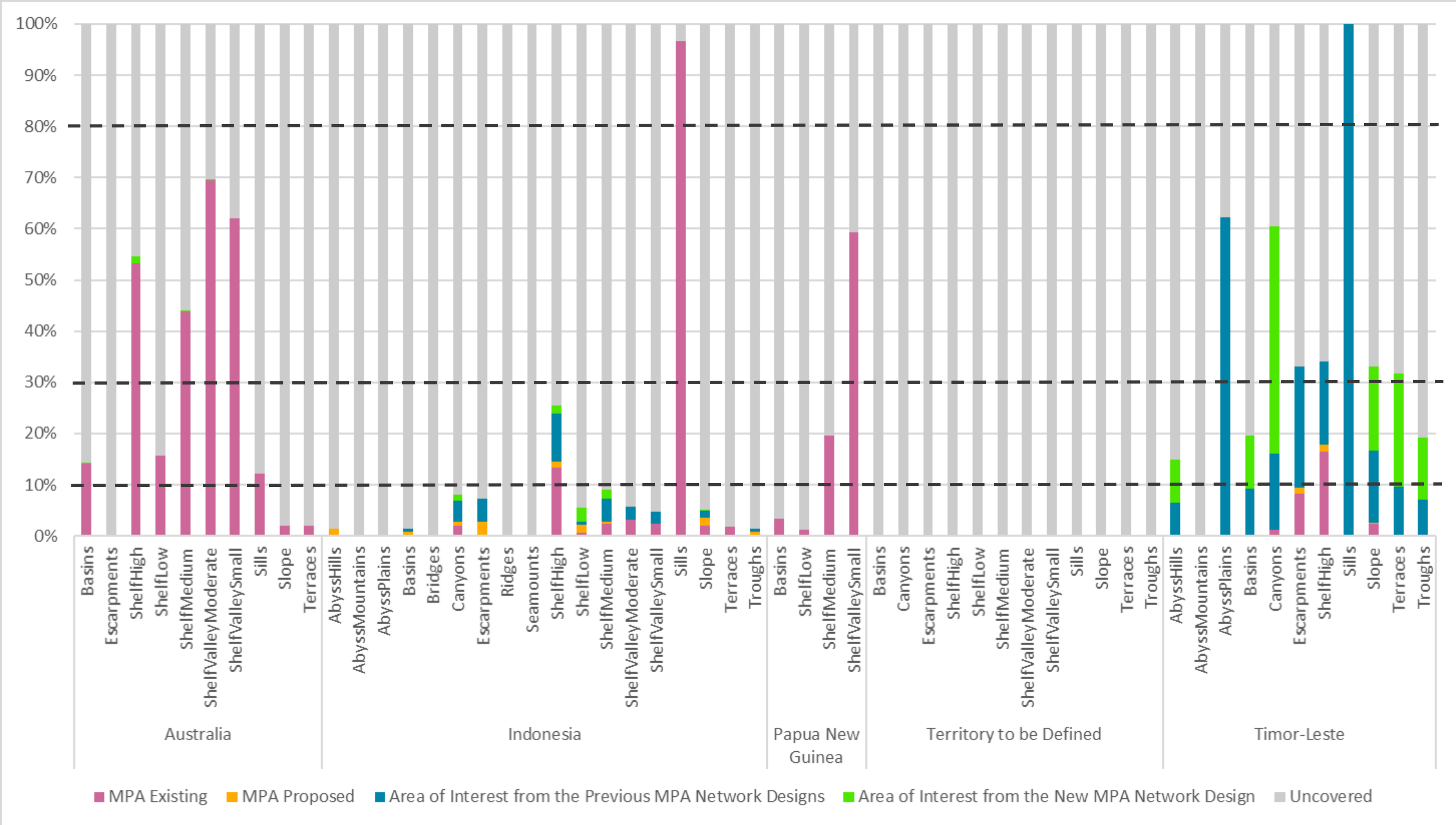


Figure 36. Percentage of each deep-water habitat in existing and proposed MPAs, and Areas of Interest identified in previous planning processes and in the newly designed MPA network (this study) for establishing new MPAs, in each country in the ATS Region. Where targets for protection in MPAs are 10% for all habitat types, except for canyons and seamounts, which are 30% and 80% respectively.

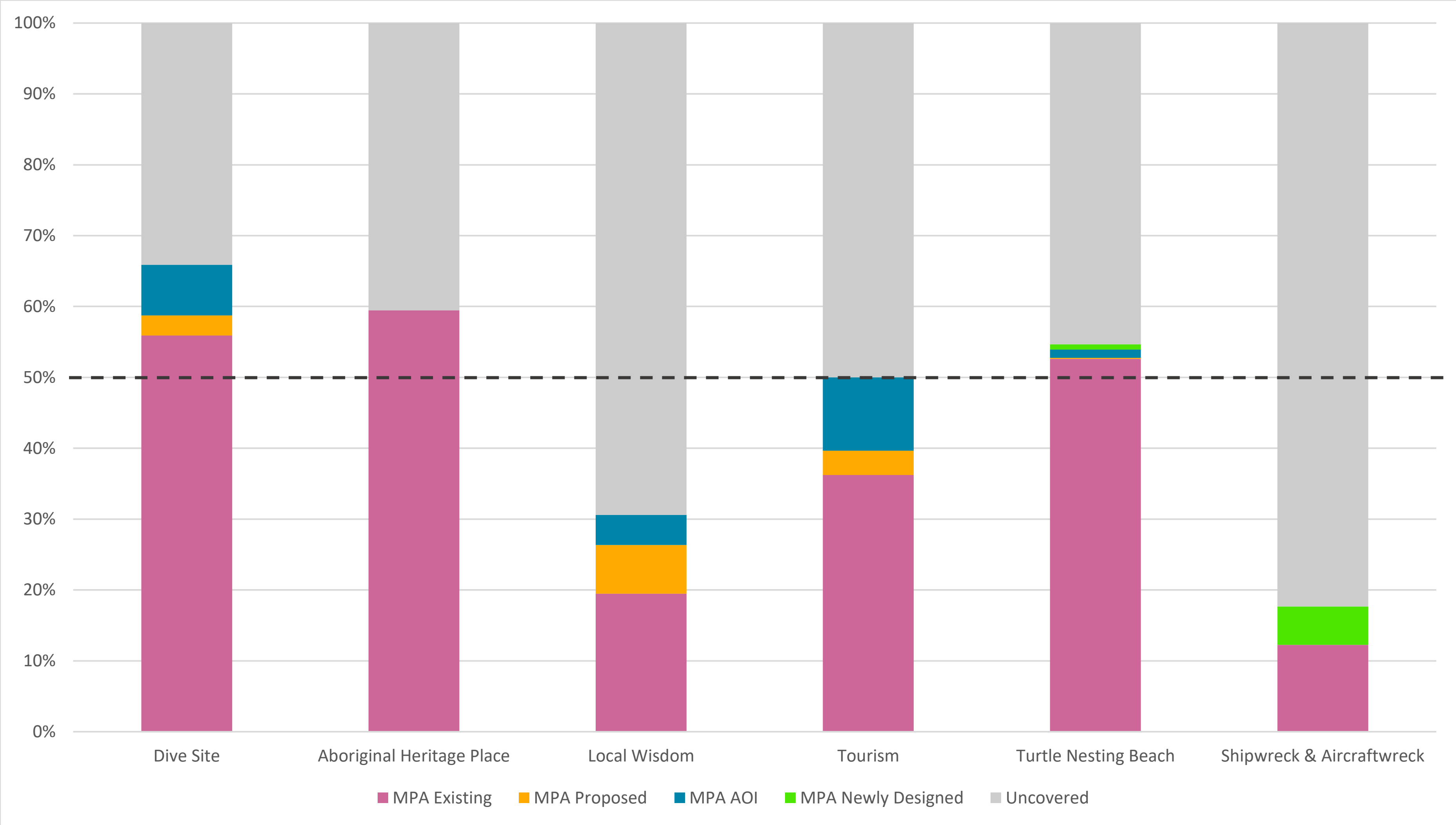


Figure 37. Percentage of each critical, special, and unique area in existing and proposed MPAs, and Areas of Interest identified in previous planning processes and in the newly designed MPA network (this study) for establishing new MPAs, in the ATS Region. Where targets for protecting each feature in MPAs is 30% except important traditional areas (Aboriginal Heritage Place and Local Wisdom) which are 50%.

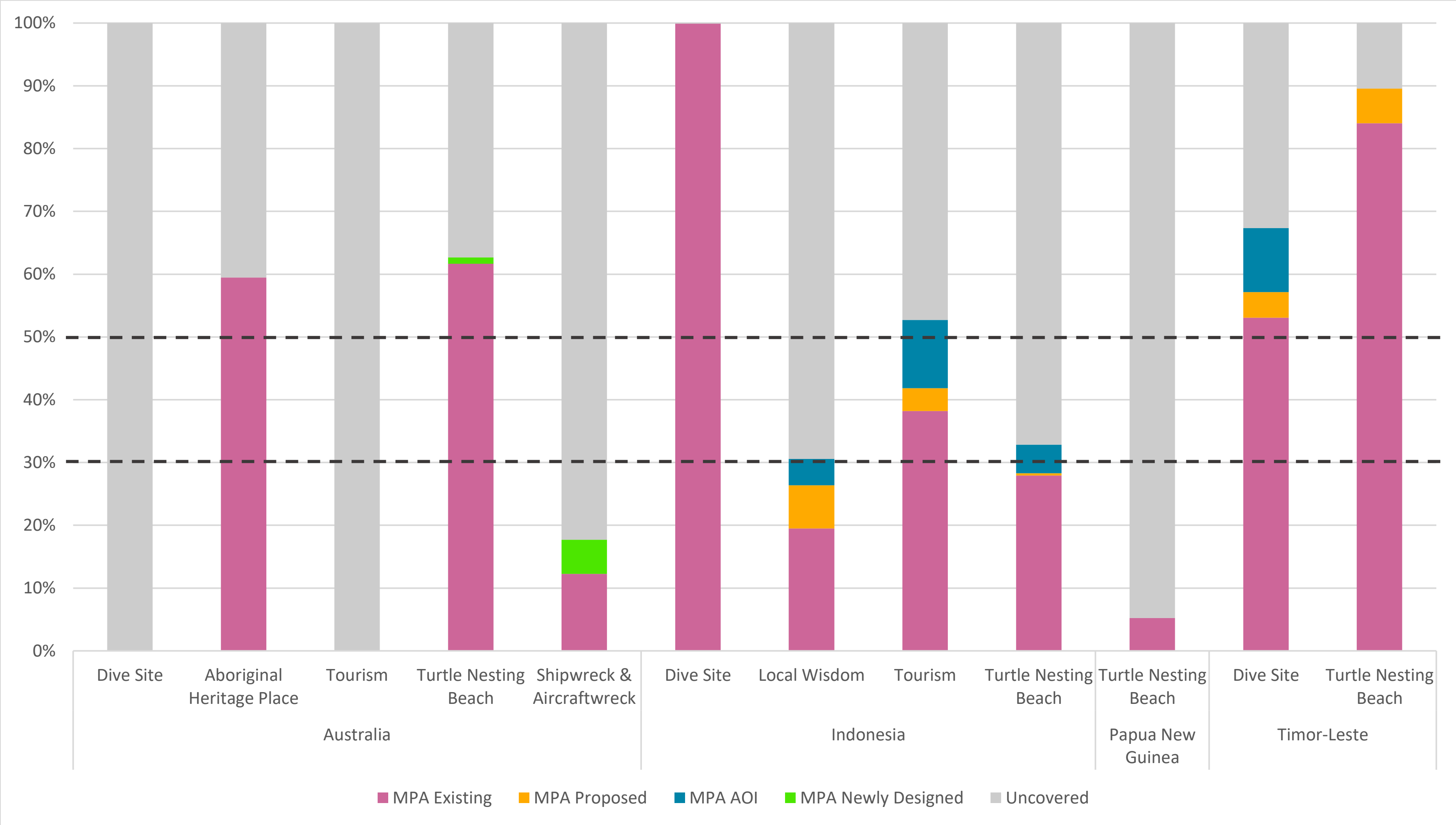


Figure 38. Percentage of each critical, special, and unique area in existing and proposed MPAs, and Areas of Interest identified in previous planning processes and in the newly designed MPA network (this study) for establishing new MPAs, in each country in the ATS Region. Where targets for protecting each feature in MPAs is 30% except important traditional areas (Aboriginal Heritage Place and Local Wisdom) which are 50%.

INCORPORATING LARGE SCALE PATTERNS OF CONNECTIVITY

We evaluated the extent to which large scale patterns of connectivity were addressed in the MPA network design for the ATS Region, by incorporating broad scale patterns of movement, larval dispersal and migratory corridors in the MPA network design based on the best available information as follows.

Movement and Larval Dispersal of Coral Reef Species

We took broad scale patterns of connectivity into account using the results of biophysical models of larval dispersal of coral reef species in the region (see Table 5). To do this, we protected 30% of coral reefs in each of areas that appear distinct in terms of connectivity (Treml et al. 2015).

We also examined the size and spacing of MPAs and Areas of Interest (Figure 39) to determine if they comply with size and spacing recommendations to incorporate connectivity of coral reef fishes and invertebrates in MPA network design (Green et al. 2020a). We found that the ATS Region MPA network design appears to accommodate connectivity patterns of many species, since most MPAs and Areas of Interest are either large enough to be self-sustaining (e.g., Oceanic Shoal in Australia) or close enough to form mutually replenishing networks (e.g., the MPA network design in Timor-Leste and the Lesser Sundas: Figure 39). However, a more rigorous scientific analysis is required to confirm it this is the case.

Migratory corridors

It is important to protect migratory corridors for species (cetaceans, dugong, and sea turtles: Figure 11, Figure 40), which are important at the national, regional, and international scales (Green et al. 2020a). The ATS Region MPA network is designed to protect important migratory corridors in MPAs e.g., for sea turtles (specifically leatherback and green turtles) past Yamdena, Kei, and Aru Islands toward the Pacific Ocean. Therefore, we expanded the Southeast and Northeast Aru Areas of Interest to include more of their migratory corridors in MPAs. Similarly, the Adele Island II Area of Interest includes a node for local sea turtle migration in the Northern Australian Waters. Green turtles also pass by Adele Island on broader scale migrations from the Indian to the Pacific Ocean, connecting MPAs and Areas of Interest at Adele and Aru Islands.

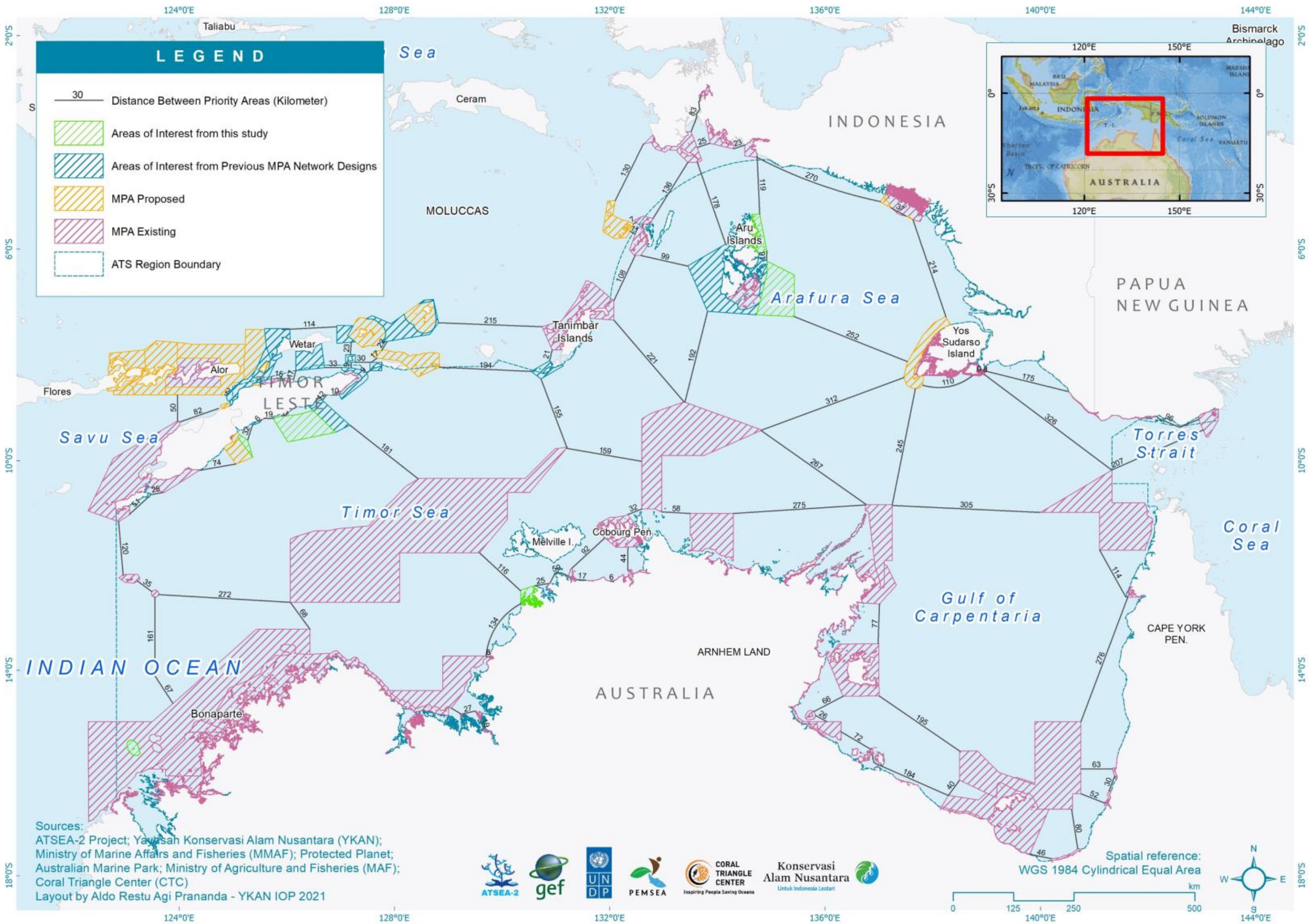


Figure 39. Size and spacing of existing and proposed MPAs and Areas of Interest in the MPA network design for ATS region.

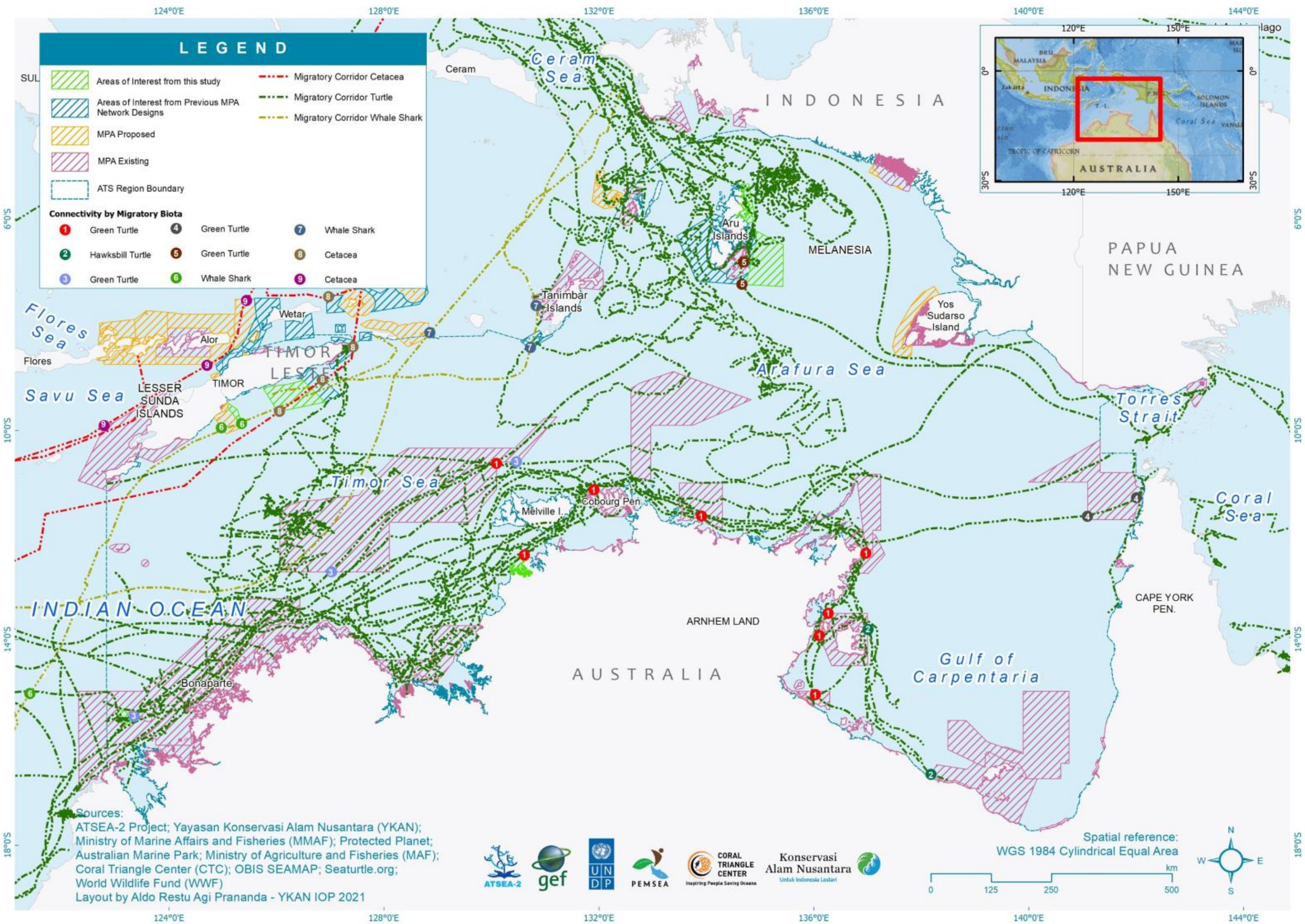


Figure 40. Migratory corridors for rare, threatened and protected species (cetaceans, whaleshark, and turtle) from satellite tracking overlaid with the MPA network design (including existing and proposed MPAs in Marine Spatial Plans, and Areas of Interest for new or expanded MPAs).

DISCUSSION

RESILIENT MARINE PROTECTED AREA NETWORK DESIGN FOR THE ARAFURA TIMOR SEAS

Marine Protected Areas (MPAs) can be powerful tools to address local threats and protect biodiversity, maintain or enhance fisheries productivity, and increase ecosystem resilience to changes in climate and ocean chemistry. However, MPAs can only achieve their objectives if they are well designed and managed effectively (Green et al. 2014).

At present, there are many existing or proposed MPAs in the Arafura and Timor Seas. However, they were not designed to form a network at the regional scale. Therefore, they do not take large-scale patterns of biophysical, socioeconomic and cultural considerations into account, such as region wide patterns of connectivity of fisheries, charismatic, rare, threatened and protected species and transboundary uses and threats (e.g., fishing and climate change).

In this study, we provide the first iteration of a resilient MPA network design for ATS Region (Figure 26), which is design to take large scale patterns of connectivity, uses and threats into account. The design, if implemented and managed effectively, will contribute substantially towards achieving the goals of the ATSEA-2 Project by:

- Protecting marine species by increasing the level of protection of shallow water habitats (coral reefs, mangroves and seagrasses), deep-water habitats, and critical, special and unique areas (i.e., turtle nesting beaches, migratory corridors and upwellings).
- Contributing towards recovering or sustaining fisheries by increasing the protection of stocks of fisheries species in MPAs (Green et al. 2014, 2020a). This will lead to the export of adults, juveniles and larvae to support fisheries in adjacent waters.
- Minimizing impacts on marine resource use, by avoiding placing MPAs in areas with high fishing intensity and maintaining access to fisheries ports.
- Adapting to impacts of climate change, by protecting corals and seagrasses that appear less vulnerable to rising sea temperatures (Johnson et al. 2021).
- Supporting community livelihoods by improving management of marine resources (habitats and populations of fisheries, rare and threatened species) and maintaining access to important areas for fishing and tourism (i.e., dive sites).
- Supporting cultural heritage, by protecting important traditional areas, ship and aircraft wrecks.

The MPA network includes all 93 existing and proposed MPAs in the four countries in the region (Indonesia, Timor-Leste, Australia and PNG), and 20 Areas of Interest for establishing new MPAs. These Areas of Interest are designed to address gaps in the current MPA network to increase protection of important shallow water habitats (i.e., coral, seagrass, estuary, and several coral classification), deep-water habitats (i.e., canyons) and critical, special and unique areas (i.e., shipwreck and aircraft wreck).

However, before the Areas of Interest are established as new MPAs, they should be validated (ground-truthed to ensure they will provide the expected benefits for the MPA network), and proposals for new MPAs should be discussed appropriately with local stakeholders.

IMPLEMENTING THE MARINE PROTECTED AREA NETWORK DESIGN

Each of the four countries in the ATS Region have existing MPA network designs, and some have National Marine Spatial Plans that include MPAs. We recommend that each country consider refining these documents to include the Areas of Interest identified in the ATS Regional MPA Network Design. A more detailed plan for implementing this design in each country is available in the ATSEA-2 Report "*Roadmap New MPAs and Improvement Existing MPA Management Effectiveness*".

ADDRESSING CONFLICTS AMONG MARINE PROTECTED AREAS AND OTHER USES

The MPA network design for the ATS Region highlights the issue of conflicting use, since there is a lot of overlap between some high priority areas for protecting conservation features in MPAs and other uses or threats.

For example, there is a need to include more conservation features (such as estuaries) in MPAs in the region. Where possible, these conservation features should be included in MPAs where there are healthy ecosystems and low levels of threat. However, that is not always possible, and many important conservation features remain unprotected (particularly in deepwater), because they are located in areas where there are other uses and threats (e.g., high fishing pressure, oil and gas mining, underwater cable pipe lanes, power plants and high density shipping areas). For example, the only seamount in the ATS Region is located in an Indonesian Oil & Gas Concession Area, which is an area allocated for underwater cables in National Marine Spatial Plan. According to the national regulations, MPAs cannot be established in areas allocated for other uses, so the seamount remains unprotected.

Meanwhile, some existing and proposed MPAs are already located in areas allocated for other uses in the Marine Spatial Plans. For example, in Indonesia, Yamdena Coastal and Small Islands Conservation Area (No. 14 in Figure 27) and Lorentz National Park (No. 23 in Figure 27) overlap Oil & Gas Concessions, which should not be possible. We are not proposing that existing or proposed MPAs be removed. However, this demonstrates the need for MPAs to be integrated with other approaches to manage other uses and threats.

These results demonstrate that there is still an issue of conflicting use between MPAs and other uses that needs to be addressed by the Government, particularly in Indonesia (Fajariyanto et al., 2019). Some useful lessons may be learned from other ATS countries regarding how to address this issue. For example, the Great Barrier Reef Marine Park in Australia accommodates many uses (e.g., shipping etc.) through a variety of zones.

RECOMMENDATIONS FOR IMPROVING THE MPA NETWORK DESIGN

In this study, we provide the first iteration of an MPA network design for the ATS Region, which is an important first step in the four ATS countries collaborating on this important initiative. However, while our analysis is based on the best available information using best practices for conservation planning, it was conducted with limited time and resources. Therefore, we recommend that the design be refined in future by conducting more detailed and comprehensive

stakeholder consultations in each of the four countries, including gathering more detailed local data through expert and participatory mapping to accommodate a more detailed analysis.
It is also important to note that while the level of protection for some conservation features in the MPA network design may seem high (e.g., Figure 31), these calculations are based on all of the zones in existing and proposed MPAs and Areas of Interest. However, the latest science and best practices for MPA network design recommends that at least 30% of some features (e.g., coral reefs) should protected in no take areas, which provide the greatest ecological benefits for enhancing fisheries productivity, protecting biodiversity, and supporting the ecosystem goods and services that marine resources provide for coastal communities (Green et al. 2014, 2020a). Unfortunately, we could not assess how much of each conservation feature is included in no take areas in the Region, because many MPAs have not yet been zoned or the spatial data for existing or proposed zoning plans for MPAs is not available. However, the best available information indicates that the percentage of no take areas in MPAs in the region is low, particularly in Indonesia. Therefore, the MPA network is still a long way from achieving scientific design criteria for protecting some features such as coral reefs. This will need to be taken into account when zoning individual MPAs (i.e., each MPA should aim to protect at least 20-30% of each habitat in no take areas: Green et al. 2014, 2020b). Zoning information for each MPA should also be compiled in a regional database, so the MPA network design can be refined using this information in future.

There are also many research priorities for improving the spatial data required to improve the MPA network design that should be addressed in future. They include:

- Mapping the distribution and condition of conservation features, particularly critical, special and unique areas (such as fish spawning aggregation sites);
- Modelling and mapping connectivity (particularly regarding larval dispersal), fishing pressure and other uses and threats;
- Modelling and mapping the potential effects of changes in climate and ocean chemistry on the ecology of focal species and the associated changes in communities, ecosystem function and dynamics.
- Identifying climate refugia (i.e., mangrove and turtle nesting beaches that have room to move as sea levels rise) to apply design criteria regarding adapting to changes in climate.

When this information becomes available, the MPA network design should be reviewed and refined as necessary.

ANNEX 1. SPATIAL DATA LAYERS

Biophysical, socioeconomic and cultural spatial data layers compiled for ATS Region, their coverage and how they were used to design the MPA network. Where coverage provides the spatial extent of the data including for all of the planning area (whole area) or for one or more of the countries (AUS: Australia, INA: Indonesia, TL: Timor-Leste, PNG: Papua New Guinea).

NO	ASPECT	CATEGORY	FEATURE CATEGORY	COVERAGE	HOW USED
1	BIOPHYSICAL	MPA Status	Existing and Proposed MPAs in Marine Spatial Plans	Whole area	Marxan shallow water analysis only
2			Areas of Interest for new MPAs identified in previous comprehensive planning processes.	INA and TL.	Marxan shallow water analysis only
3		Conservation Features: Shallow Water Habitats	Coral Reef Distribution	Whole area	Marxan shallow water analysis only
4			Coral Reef Classification	Whole area	Marxan shallow water analysis only
5			Coral Reef Vulnerability to Climate Change - Low	Whole area	Manually in the final design
6			Coral Reef Vulnerability to Climate Change - Moderate	Whole area	Manually in the final design
7			Coral Reef Vulnerability to Climate Change - High	Whole area	Manually in the final design
8			Coral Reef Potential Larval Dispersal Barriers	Whole area	Manually in the final design
9			Coral Ecoregion	Whole area	Manually in the final design
10			Mangrove Distribution	Whole area	Marxan shallow water analysis only
11			Seagrass Distribution	Whole area	Marxan shallow water analysis only
12			Seagrass Vulnerability to Climate Change - Low	Whole area	Manually in the final design
13			Seagrass Vulnerability to Climate Change - Moderate	Whole area	Manually in the final design
14			Seagrass Vulnerability to Climate Change - High	Whole area	Manually in the final design
15			Estuary Distribution	Whole area	Marxan shallow water analysis only
16			Mangrove Biomass Very Low	AUS	Manually
17			Mangrove Biomass Low	AUS	Manually
18			Mangrove Biomass Moderate	AUS	Manually
19			Mangrove Biomass High	AUS	Manually
20			Mangrove Biomass Very High	AUS	Manually
21		Conservation Features: Critical, Special, and Unique Species and/or Areas	Important Bird Areas	Whole area	Manually
22			Important Marine Mammal Areas	Whole area	Manually
23			Migratory Corridor Cetaceans	INA, TL	Manually
24			Migratory Corridor Turtles	Whole area	Manually

NO	ASPECT	CATEGORY	FEATURE CATEGORY	COVERAGE	HOW USED
25			Migratory Corridor Whale Sharks	Whole area	Manually
26			Turtle Nesting Beaches	AUS, INA, PNG	Marxan shallow water analysis only
27			Turtle Feeding Grounds	AUS	Manually
28			Dolphin Important Areas	AUS	Manually
29			Dugong Important Areas	AUS	Manually
30			River Shark Important Areas	AUS	Manually
31			Sea Turtle Important Areas	AUS	Manually
32			Seabird Important Areas	AUS	Manually
33			Shark Important Areas	AUS	Manually
34			Whale Important Areas	Whole area	Manually
35			Key Ecological Features	INA, AUS	Manually
36			Sightings Dolphins	INA, TL	Manually
37			Sightings Dugong	INA	Manually
38			Sightings Whales	INA, TL	Manually
39			Fish Spawning Aggregation Areas (FSAS)	INA	Manually
40		Conservation Features: Deep-water Habitats	Canyons	Whole area	Marxan combined shallow and deep-water analysis
41			Seamounts	Whole area	Marxan combined shallow and deep-water analysis
42			Abyss Hills	Whole area	Marxan combined shallow and deep-water analysis
43			Abyss Mountains	Whole area	Marxan combined shallow and deep-water analysis
44			Abyss Plains	Whole area	Marxan combined shallow and deep-water analysis
45			Basins	Whole area	Marxan combined shallow and deep-water analysis
46			Bridges	Whole area	Marxan combined shallow and deep-water analysis
47			Escarpments	Whole area	Marxan combined shallow and deep-water analysis

NO	ASPECT	CATEGORY	FEATURE CATEGORY	COVERAGE	HOW USED
48			Ridges	Whole area	Marxan combined shallow and deep-water analysis
49			Shelf Low	Whole area	Marxan combined shallow and deep-water analysis
50			Shelf Medium	Whole area	Marxan combined shallow and deep-water analysis
51			Shelf High	Whole area	Marxan combined shallow and deep-water analysis
52			Shelf Valley Small	Whole area	Marxan combined shallow and deep-water analysis
53			Shelf Valley Moderate	Whole area	Marxan combined shallow and deep-water analysis
54			Sills	Whole area	Marxan combined shallow and deep-water analysis
55			Slopes	Whole area	Marxan combined shallow and deep-water analysis
56			Terraces	Whole area	Marxan combined shallow and deep-water analysis
57			Troughs	Whole area	Marxan combined shallow and deep-water analysis
58		Oceanography	Upwelling	INA	Manually in the final design
59			Current Pattern Southeast Monsoon	Whole area	Manually
60			Current Pattern Northeast Monsoon	Whole area	Manually
61			Current Pattern Transition 1 Monsoon	Whole area	Manually
62			Current Pattern Transition 2 Monsoon	Whole area	Manually
63			Persistent Pelagic Habitats (Upwelling)	Indonesia	Manually
64			Chlorophyll a Southeast Monsoon	Whole area	Manually
65			Chlorophyll a Northeast Monsoon	Whole area	Manually
66			Chlorophyll a Transition 1 Monsoon	Whole area	Manually
67			Chlorophyll a Transition 2 Monsoon	Whole area	Manually
68			Salinity Southeast Monsoon	Whole area	Manually
69			Salinity Northeast Monsoon	Whole area	Manually

NO	ASPECT	CATEGORY	FEATURE CATEGORY	COVERAGE	HOW USED
70			Salinity Transition 1 Monsoon	Whole area	Manually
71			Salinity Transition 2 Monsoon	Whole area	Manually
72			Sea Surface Temperature Southeast Monsoon	Whole area	Manually
73			Sea Surface Temperature Northeast Monsoon	Whole area	Manually
74			Sea Surface Temperature Transition 1 Monsoon	Whole area	Manually
75			Sea Surface Temperature Transition 2 Monsoon	Whole area	Manually
76	SOCIOECONOMIC & CULTURAL	Conservation Features: Critical, Special, and Unique Areas	Important Traditional Areas (Aboriginal Heritage Places)	AUS-NT	Marxan shallow water analysis only
77			Important Traditional Areas (Native Tiles Determination)	Whole area	Manually
78			Important Traditional Areas (Local Wisdom)	INA, TL	Marxan shallow water analysis only
79			Shipwrecks and Aircraft wrecks	Whole area	Marxan shallow water analysis only
80			Dive Sites	Whole area	Marxan shallow water analysis only
81		Other Uses and Threats	Tourism (General Marine Tourism)	Whole area	Marxan shallow water analysis only
82			Tourism (Beach Recreation)	INA	Manually
83			Tourism (Sport Fishing)	INA	Manually
84			Tourism (Snorkelling)	INA	Manually
85			Aquaculture (Seaweed Farming)	INA	Manually
86			Aquaculture (Pearl Farming)	INA	Manually
87			Aquaculture (Floating Cage Farming/KJA)	INA	Manually
88			Aquaculture (Ponds)	INA	Manually
89			Community Fishing Ground	INA, TL	Manually
90			Fishing Pressure	Whole area	Marxan combined shallow and deep-water analysis
91			Ecosystem Threat (Blast Fishing)	INA	Manually
92			Ecosystem Threat (ETP Species Hunting)	INA	Manually
93			Ecosystem Threat (Land use Conversion)	INA	Manually
94			Ecosystem Threat (Mangrove Logging)	INA	Manually
95			Ecosystem Threat (Manta ray Hunting)	INA	Manually
96			Ecosystem Threat (Other Threats)	INA	Manually

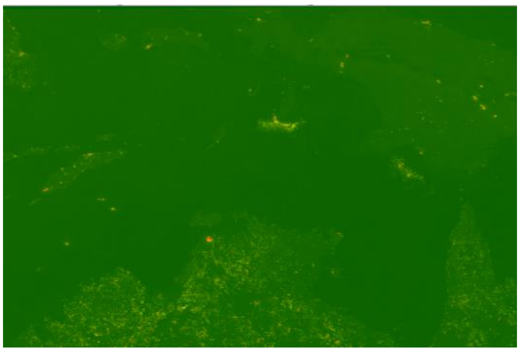
NO	ASPECT	CATEGORY	FEATURE CATEGORY	COVERAGE	HOW USED
97			Ecosystem Threat (Poison Fishing)	INA	Manually
98			Ecosystem Threat (Reef Gleaning)	INA	Manually
99			Ecosystem Threat (Sand Mining)	INA	Manually
100			Ecosystem Threat (Shark Finning)	INA	Manually
101			Ecosystem Threat (Turtle Egg Poaching)	INA	Manually
102			Ecosystem Threat (Turtle Poaching)	INA	Manually
103			Ecosystem Threat (Waste)	INA	Manually
104			Building	AUS, INA, TL	Manually
105			Shipping Line Density Low	Whole area	Marxan combined shallow and deep-water analysis
106			Shipping Line Density Medium	Whole area	Marxan combined shallow and deep-water analysis
107			Shipping Line Density High	Whole area	Marxan combined shallow and deep-water analysis
108			Military Area	Whole area	Marxan combined shallow and deep-water analysis
109			Oil and Gas Concession	Whole area	Marxan combined shallow and deep-water analysis
110			International Shipping Lane (ALKI)	Whole area	Marxan combined shallow and deep-water analysis
111			Underwater Cable	Whole area	Marxan combined shallow and deep-water analysis
112			Fishing Port	Whole area	Marxan combined shallow and deep-water analysis
113			Transportation Port	Whole area	Marxan combined shallow and deep-water analysis
114			Power plant (Low Impact)	Whole area	Marxan combined shallow and deep-water analysis
115			Power plant (Moderate Impact)	Whole area	Marxan combined shallow and deep-water analysis
116			Power plant (High Impact)	Whole area	Marxan combined shallow and deep-water analysis

ANNEX 2. CREATING A COST SURFACE

We created a cost surface (Figure 17) as a weighted sum of impacts to fishing pressure and other uses (shipping, power plants, underwater cables, oil and gas). To do this, we created cost layers for fishing pressure and other uses, and then added them to develop a single cost surface using different weights for each cost layer as described below.

Creating a Fishing Pressure Cost Layer

1. We extracted the main source of fishing ground information from the Global Fishing Watch (GFW) Daily Fishing Hours. This data contains a record of the voyage of larger fishing vessels through Automatic Identification System (AIS) tracking, producing a raster with hour/km^2 as the unit.
2. To better represent fishing grounds, we need to include smaller vessels. To do this, we assume that by using data on night-lights, we can infer the location of smaller traditional fishing vessels using the VIIRS Monthly Average Nighttime raster (where the unit is nanoWatts/cm^2/sr).
3. In order to ensure that the two data sets are comparable, we averaged both GFW and VIIRS data from the same time period (2012-2016).

4. To combine these two datasets in one analysis, we rescaled both datasets. With the basic assumption that the data has a normal distribution, we calculated a standardization (z-score) using the following formula

$$Z = \frac{x - \mu}{\sigma}$$

Where
x = *input value*
μ = mean
σ = standard deviation

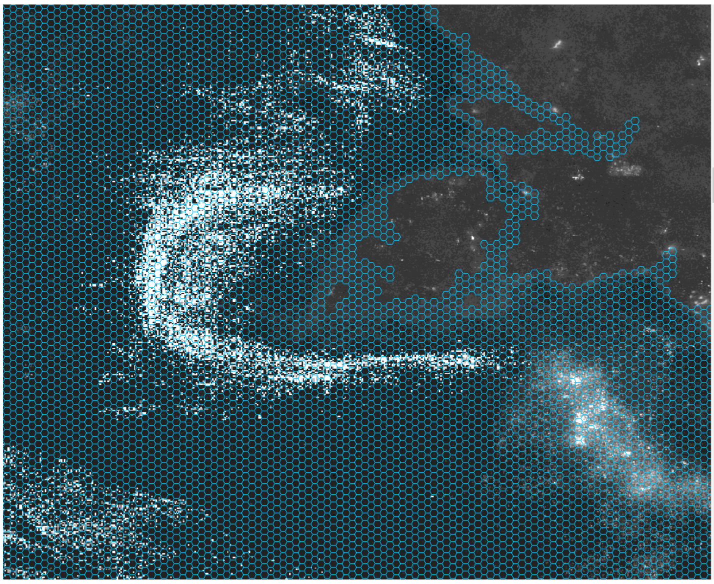
We then normalized the data to stretch it into an evenly scaled data range from 0 – 1 using the following formula

$$z = \frac{x - \min(x)}{\max(x) - \min(x)}$$

Where
x = *input value*
min(x) = *minimum value of dataset*
max(x) = *maximum value of dataset*

Since the data still did not reach the desired scaling, we modified it further using standard deviation ranking into 8-bit data (1-255), and combined the two data sets using a maximum operator resulting in the completed mosaic. We then rescaled the mosaic by dividing it by 255, and then multiplied it by 100 so that the range stays between 0 – 100. This process of rescaling is vital as we also generated another layer using the same 0 – 100 scale (see below).

We then applied zonal statistics to assign a value to each hexagon in the planning unit layer using the maximum operator.



Table

cost_PU_5km_scenario1

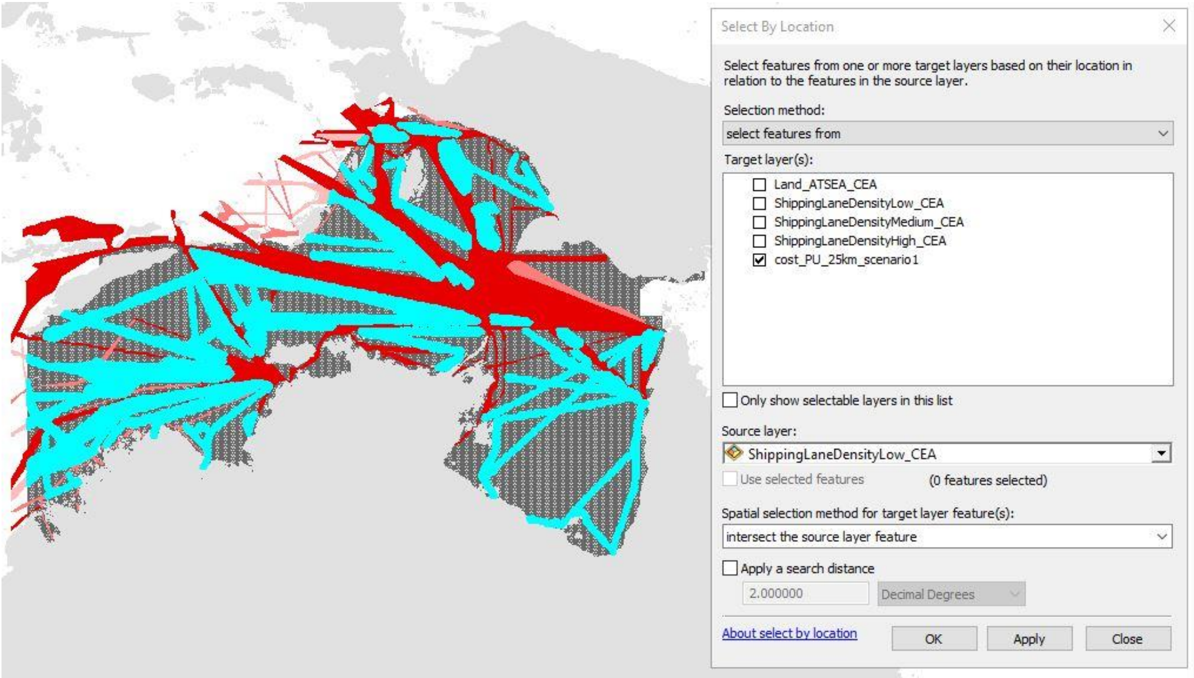
FID	Shape	UNIT_ID	Fishing_Gr
27596	Polygon	275968	0.393701
27596	Polygon	275969	0
27596	Polygon	275970	0.393701
27597	Polygon	275971	10.23622
27597	Polygon	275972	2.755906
27597	Polygon	275973	6.299213
27597	Polygon	275974	36.614173
27597	Polygon	275975	0.787402
27597	Polygon	275976	1.181102
27597	Polygon	275977	0.393701
27597	Polygon	275978	5.905512
27597	Polygon	275979	0.787402
27597	Polygon	275980	0.787402
27598	Polygon	275981	0.787402
27598	Polygon	275982	0.787402
27598	Polygon	275983	1.181102
27598	Polygon	275984	0.787402
27598	Polygon	275985	0.393701
27598	Polygon	275986	0.393701
27598	Polygon	275987	0
27598	Polygon	275988	0
27598	Polygon	275989	0
27598	Polygon	275990	0
27599	Polygon	275991	0
27599	Polygon	275992	0
27599	Polygon	275993	0

0

(0 out of 279026 Selected)

Creating a Combined Cost Layer for Other Uses

1. Selecting Cost Layers
    - We selected cost layers for other uses (shipping line density, power plants, underwater cables, oil and gas) that intersected with each planning unit.
    - We used selection by location to determine which cost layers intersected with each planning unit (or not). We then assigned a cost value that intersected with the planning unit to represent each of the cost layers present.



2. Creating a Field Table with Cost Values
   - We created cost values for each cost layer to provide a value in each planning unit. To do this, we used a cost field table function to assign the cost value using a specific data scale. We generated values for a cost layer on a scale from 0 and 100 (where 0 means the cost layer does not exist in a planning unit, while 100 means that the cost layer exists in a planning unit).
   - We used the cost values we created as the measures (numbers) to use in the weighting formulae (see below).

Table

cost_PU_25km_scenario1

FID	Shape	UNIT_ID *	Fishing_Gr	Port_Dista	Cable	Oil_Gas	PP_High	PP_Low	PP_Mod	Ship_Mod	Ship_Low	Ship_High
21	Polygon	22	0.393701	0.019769	0	100	0	0	0	0	100	0
22	Polygon	23	0.393701	0.01918	0	100	0	0	0	0	100	0
23	Polygon	24	0.393701	0.018597	0	100	0	0	0	0	100	0
24	Polygon	25	0	0.018024	0	100	0	0	0	0	100	0
25	Polygon	26	0.393701	0.017465	0	100	0	0	0	0	100	0
26	Polygon	27	0.393701	0.016922	0	100	0	0	0	0	100	0
27	Polygon	28	0.393701	0.016397	0	100	0	0	0	0	100	0
30	Polygon	31	31.889764	0.014937	0	100	0	0	0	0	100	0
31	Polygon	32	19.685039	0.01449	0	100	0	0	0	0	100	0
32	Polygon	33	36.220472	0.014061	0	100	0	0	0	0	100	0
33	Polygon	34	4.330709	0.013651	0	100	0	0	0	0	100	0
34	Polygon	35	0	0.01326	0	100	0	0	0	0	100	100
55	Polygon	56	0.393701	0.008015	0	100	0	0	0	0	100	0
56	Polygon	57	0.393701	0.007861	0	100	0	0	0	0	100	0
57	Polygon	58	0.393701	0.007711	0	100	0	0	0	0	100	0
58	Polygon	59	0.393701	0.007567	0	100	0	0	0	0	100	0
59	Polygon	60	0.393701	0.007429	0	100	0	0	0	0	100	0
60	Polygon	61	0.393701	0.007294	0	100	0	0	0	0	100	0
69	Polygon	70	1.968504	0.00803	0	100	0	0	0	0	100	0

0 (16278 out of 67465 Selected)

cost_PU_25km_scenario1

Weighting

Weighting is one method to create a single cost value from the presence of many cost layers. We developed a single cost layer value as a measure of the costs in each planning unit using a weight function. To do this, we combined the cost layers for fishing pressure and other uses (see above) using the following equation, where each cost layer has a different cost weight to represent the feature (see Table below).

Cost = ((Sum_AllCostLayerValue * Weight)).

Cost Layer	Weight
SEC_FishingPressure_py_CEA.shp	0.25
SEC_ShippingLineDensityLow_py_CEA.shp	0.025
SEC_ShippingLineDensityMedium_py_CEA.shp	0.05
SEC_ShippingLineDensityHigh_py_CEA.shp	0.15
SEC_PowerPlantLow_py_CEA	0.025
SEC_PowerPlantModerate_py_CEA	0.05
SEC_PowerPlantHigh_py_CEA	0.15
SEC_OilGas_AUS_py_CEA.shp	0.2
SEC_OilGas_PNG_py_CEA.shp	0.2
SEC_OilGas_TLS_py_CEA.shp	0.2
SEC_UnderwaterCable_AUS_ln_CEA.shp	0.1
SEC_UnderwaterCable_PNG_ln_CEA.shp	0.1
SEC_UnderwaterCable_TLS_ln_CEA.shp	0.1

ANNEX 3. DETAILS OF EXISTING AND PROPOSED MPAS, AND AREAS OF INTEREST FOR NEW OR EXPANDED MPAS, IN THE MARINE PROTECTED AREA NETWORK DESIGN FOR ARAFURA TIMOR SEA REGION.

Details of each of the existing and proposed MPAs in National Spatial Plans, and Areas of Interest for establishing new or expanded MPAs identified in previous planning processes (AOI) or in the newly design ATS Region MPA network (AOI this study). Details include: the type of MPA, its status, the management authority and area (km²).

NO	COUNTRY	NAME	TYPE OF MPA	STATUS	MANAGEMENT AUTHORITY	AREA (KM²)
1	Australia	Arafura	Australian Marine Park	Existing MPA	Department of the Environment and Energy	22,924.096
2		Arnhem	Australian Marine Park	Existing MPA	Department of the Environment and Energy	7,124.870
3		Ashmore Reef	Australian Marine Park	Existing MPA	Department of the Environment and Energy	565.631
4		Cartier Island	Australian Marine Park	Existing MPA	Department of the Environment and Energy	172.325
5		Gulf of Carpentaria	Australian Marine Park	Existing MPA	Department of the Environment and Energy	23,770.930
6		Joseph Bonaparte Gulf	Australian Marine Park	Existing MPA	Department of the Environment and Energy	8,597.063
7		Kimberley	Australian Marine Park	Existing MPA	Department of the Environment and Energy	33,063.653
8		Oceanic Shoals	Australian Marine Park	Existing MPA	Department of the Environment and Energy	71,743.210
9		Wessel	Australian Marine Park	Existing MPA	Department of the Environment and Energy	5,908.072
10		West Cape York	Australian Marine Park	Existing MPA	Department of the Environment and Energy	16,008.685
11		Kakadu	National Park	Existing MPA	Department of the Environment and Energy	211.514

NO	COUNTRY	NAME	TYPE OF MPA	STATUS	MANAGEMENT AUTHORITY	AREA (KM²)
12		Mijing	5(1)(h) Reserve	Existing MPA	Western Australian Department of Biodiversity, Conservation and Attractions	0.055
13		Unnamed WA41775	5(1)(h) Reserve	Existing MPA	Western Australian Department of Biodiversity, Conservation and Attractions	0.001
14		Unnamed WA44673	5(1)(h) Reserve	Existing MPA	Western Australian Department of Biodiversity, Conservation and Attractions	0.001
15		Casuarina	Coastal Reserve	Existing MPA	Parks and Wildlife Commission of the NT	9.942
16		Charles Darwin	Conservation Reserve	Existing MPA	Bush Heritage Australia	9.734
17		Round Island	Conservation Park	Existing MPA	Queensland Department of Environment and Science	0.001
18		Eight Mile Creek	Fish Habitat Area (A)	Existing MPA	Queensland Department of Environment and Science	329.316
19		Morning Inlet - Bynoe River	Fish Habitat Area (A)	Existing MPA	Queensland Department of Environment and Science	251.596
20		Nassau River	Fish Habitat Area (A)	Existing MPA	Queensland Department of Environment and Science	98.935
21		Pine River Bay	Fish Habitat Area (A)	Existing MPA	Queensland Department of Environment and Science	192.318
22		Staaten-Gilbert	Fish Habitat Area (A)	Existing MPA	Queensland Department of Environment and Science	157.673
23		Lalang-garram/ Camden Sound	Marine Park	Existing MPA	Western Australian Department of Biodiversity, Conservation and Attractions	6,689.042
24		Lalang-garram/ Horizontal Falls	Marine Park	Existing MPA	Western Australian Department of Biodiversity, Conservation and Attractions	3,038.002
25		North Kimberley	Marine Park	Existing MPA	Western Australian Department of Biodiversity, Conservation and Attractions	16,655.920
26		North Lalang-garram	Marine Park	Existing MPA	Western Australian Department of Biodiversity, Conservation and Attractions	1,094.509
27		Limmen	National Park	Existing MPA	Parks and Wildlife Commission of the NT	1,418.073

NO	COUNTRY	NAME	TYPE OF MPA	STATUS	MANAGEMENT AUTHORITY	AREA (KM²)
28		Limmen Bight	Marine Park	Existing MPA	Parks and Wildlife Commission of the NT	672.809
29		Barranyi (North Island)	National Park	Existing MPA	Parks and Wildlife Commission of the NT	0.301
30		Djukbinj	National Park	Existing MPA	Parks and Wildlife Commission of the NT	56.752
31		Garig Gunak Barlu	National Park	Existing MPA	Parks and Wildlife Commission of the NT	2,615.008
32		Mary River	National Park	Existing MPA	Parks and Wildlife Commission of the NT	5.372
33		Keep River	National Park	Existing MPA	Parks and Wildlife Commission of the NT	91.956
34		Finucane Island	National Park	Existing MPA	Queensland Department of Environment and Science	0.463
35		Lawley River	National Park	Existing MPA	Western Australian Department of Biodiversity, Conservation and Attractions	32.064
36		Mitchell River	National Park	Existing MPA	Victorian Department of Environment, Land, Water and Planning	26.972
37		Pelican Island	National Park	Existing MPA	National Parks Trust of the Virgin Islands	0.123
38		Prince Regent	National Park	Existing MPA	Western Australian Department of Biodiversity, Conservation and Attractions	228.550
39		Adele Island	Nature Reserve	Existing MPA	Western Australian Department of Biodiversity, Conservation and Attractions	0.237
40		Browse Island	Nature Reserve	Existing MPA	Western Australian Department of Biodiversity, Conservation and Attractions	0.054
41		Lesueur Island	Nature Reserve	Existing MPA	Western Australian Department of Biodiversity, Conservation and Attractions	0.014
42		Low Rocks	Nature Reserve	Existing MPA	Western Australian Department of Biodiversity, Conservation and Attractions	0.033
43		Ord River	Nature Reserve	Existing MPA	Western Australian Department of Biodiversity, Conservation and Attractions	597.062
44		Tanner Island	Nature Reserve	Existing MPA	Western Australian Department of Biodiversity, Conservation and Attractions	0.0002
45		Rutland Plains	Nature Refuge	Existing MPA	Queensland Department of Environment and Science	1.418

NO	COUNTRY	NAME	TYPE OF MPA	STATUS	MANAGEMENT AUTHORITY	AREA (KM²)
46		Pungalina - Seven Emu	Private Nature Reserve	Existing MPA	Australian Wildlife Conservancy	15.004
47		Anindilyakwa	Indigenous Protected Area	Existing MPA	Local Indigenous Land Council	7,318.664
48		Balanggarra	Indigenous Protected Area	Existing MPA	Local Indigenous Land Council	8.384
49		Bardi Jawi	Indigenous Protected Area	Existing MPA	Local Indigenous Land Council	263.861
50		Marthakal	Indigenous Protected Area	Existing MPA	Local Indigenous Land Council	168.713
51		South-East Arnhem Land	Indigenous Protected Area	Existing MPA	Local Indigenous Land Council	56.342
52		Uunguu	Indigenous Protected Area	Existing MPA	Local Indigenous Land Council	103.391
53		Dhimurru	Indigenous Protected Area	Existing MPA	Indigenous Management Group	3,671.570
54		Djelk	Indigenous Protected Area	Existing MPA	Indigenous Management Group	96.084
55		Laynhapuy - Stage 1	Indigenous Protected Area	Existing MPA	Indigenous Management Group	69.230
56		Marri-Jabin (Thamurrurr - Stage 1)	Indigenous Protected Area	Existing MPA	Indigenous Management Group	38.497
57		Nijinda Durlga	Indigenous Protected Area	Existing MPA	Indigenous Management Group	14.812
58		Thuwathu/Bujimulla	Indigenous Protected Area	Existing MPA	Indigenous Management Group	13,425.023
59		Yanyuwa (Barni - Wardimantha Awara)	Indigenous Protected Area	Existing MPA	Indigenous Management Group	34.554

NO	COUNTRY	NAME	TYPE OF MPA	STATUS	MANAGEMENT AUTHORITY	AREA (KM²)
60		Dambimangari	Private Nature Reserve	Existing MPA	Australian Wildlife Conservancy	153.618
					Sub Total Existing MPA of Australia	249,802.102
61		Adele Island II		AOI (this study)		601.182
62		Cox Peninsula		AOI (this study)		888.395
					Sub Total AOIs of Australia	1,489.578
					Total Existing MPA + AOIs of Australia	251,291.680
63	Indonesia	Laut Sawu	Marine National Park	Existing MPA	Ministry of Marine Affairs & Fisheries (MMAF), BKKPN Kupang	2,480.125
64		Aru Tenggara	Marine Nature Reserve	Existing MPA	Ministry of Marine Affairs & Fisheries (MMAF), BKKPN Kupang	2,686.048
65		Wasur	National Park	Existing MPA	Ministry of Environtment and Forestry (MoEF)	54.312
66		Lorentz	National Park	Existing MPA	Ministry of Environtment and Forestry (MoEF)	3,737.902
67		Yamdena	Coastal and Small Islands Conservation Area	Existing MPA	Maluku Province	998.337
68		Kei Kecil	Small Island Park	Existing MPA	Maluku Province	1,361.105
69		Pulau Baeer	Marine Tourism Park	Existing MPA	Maluku Province	279.642
70		Harlu	Wildlife Reserve	Existing MPA	East Nusa Tenggara Agency for Conservation of Natural Resources	6.451
71		Pulau Dolok	Wildlife Reserve	Existing MPA	Papua Agency for Conservation of Natural Resources	1,706.491
72		Pulau Kobror	Wildlife Reserve	Existing MPA	Maluku Agency for Conservation of Natural Resources	44.954
73		Pulau Komolon	Wildlife Reserve	Existing MPA	Papua Agency for Conservation of Natural Resources	236.818
74		Pulau Pombo	Wildlife Reserve	Existing MPA	Papua Agency for Conservation of Natural Resources	1.792

NO	COUNTRY	NAME	TYPE OF MPA	STATUS	MANAGEMENT AUTHORITY	AREA (KM²)
75		Savan	Wildlife Reserve	Existing MPA	Papua Agency for Conservation of Natural Resources	58.169
76		Manipo	Nature Recreation Park	Existing MPA	East Nusa Tenggara Agency for Conservation of Natural Resources	0.223
77		Maubesi	Nature Reserve	Existing MPA	East Nusa Tenggara Agency for Conservation of Natural Resources	28.131
					Sub Total Existing MPA of Indonesia	13,680.500
78		Betun		Proposed MPA		153.682
79		Leti Island		Proposed MPA		626.723
80		Maubesi - Deep Water		Proposed MPA		1,478.008
81		Maubesi		Proposed MPA		184.786
82		Pulau Kolepom		Proposed MPA		3,526.410
83		Timika		Proposed MPA		211.015
					Sub Total Proposed MPA of Indonesia	6,180.624
84		Aru Islands		AOI		9,495.804
85		Batuidu		AOI		37.497
86		Leti		AOI		144.058
87		Selaru Island		AOI		497.397
88		South Wetar		AOI		5.166
89		Northeast Aru		AOI (this study)		1,303.572
90		Southeast Aru		AOI (this study)		6,490.783
91		Motamasin		AOI (this study)		357.145
					Sub Total AOIs of Indonesia	18,331.423
					Total Existing and Proposed MPA + AOIs of Indonesia	38,192.546
92	Timor-Leste	Nino Konis Santana	National Park	Existing MPA	Manager and community guards under Ministry of Agriculture and Fisheries	561.859
93		Behau	Protected Area	Existing MPA	Not Reported	247.849

NO	COUNTRY	NAME	TYPE OF MPA	STATUS	MANAGEMENT AUTHORITY	AREA (KM²)
94		Lagoa BeMalae	Protected Area	Existing MPA	Manager and community guards under Ministry of Agriculture and Fisheries	0.004
95		Lagoa BikanTidi	Protected Area	Existing MPA	Manager and community guards under Ministry of Agriculture and Fisheries	0.358
96		Lagoa Maurei no Alafalu	Protected Area	Existing MPA	Manager and community guards under Ministry of Agriculture and Fisheries	0.045
97		Lagoa Tasitolu	Protected Area	Existing MPA	Manager and community guards under Ministry of Agriculture and Fisheries	0.899
98		Lamsanak	Protected Area	Existing MPA	Not Reported	123.881
99		Mount Guguleur	Protected Area	Existing MPA	Manager and community guards under Ministry of Agriculture and Fisheries	0.003
100		Ribeira de Clere	Protected Area	Existing MPA	Manager and community guards under Ministry of Agriculture and Fisheries	0.333
					Sub Total Existing MPA of Timor-Leste	935.231
101		Liquica		Proposed MPA		83.168
					Sub Total Proposed MPA of Timor-Leste	83.168
102		Batu Gade I	-	AOI	-	52.848
103		Liran-Atauro	-	AOI	-	63.438
104		Manufahi	-	AOI	-	183.189
105		Manufahi Extension	-	AOI	-	2,236.485
106		Nino Konis Santana Extension	-	AOI	-	1,115.844
107		Ombai Peace Park	-	AOI	-	628.326
108		South Wetar	-	AOI	-	245.919
109		Suai	-	AOI	-	66.352
110		Motamasin	-	AOI (this study)		59.828
111		South Manatuto	-	AOI (this study)		4,912.153
					Sub Total AOIs of Timor-Leste	9,564.382
					Total Existing and Proposed MPA + AOIs of Timor-Leste	10,582.780

NO	COUNTRY	NAME	TYPE OF MPA	STATUS	MANAGEMENT AUTHORITY	AREA (KM²)
112	Papua New Guinea	Maza	Wildlife Management Area	Existing MPA	Not Reported	818.309
113		Tonda	Wildlife Management Area; Ramsar Site, Wetland of International Importance	Existing MPA	Not Reported	88.355
		Total Existing MPA of Papua New Guinea				906.664
Grand Total						**300,973.671**

ANNEX 4. AREAS OF INTEREST FOR ESTABLISHING NEW OR EXPANDED MPAS IN THE MPA NETWORK DESIGN FOR ATS REGION, RECOMMENDATIONS, AND THE RATIONALE FOR WHY THEY WERE INCLUDED IN THE DESIGN

Areas of Interest for new or expanded MPAs in the MPA network design for ATS Region, recommendations, and the rationale for why they were included in the MPA network design.

COUNTRY	NO	NAME	RATIONALE	CONSTRAINTS AND OPPORTUNITIES	RECOMMENDATION
Australia	1	Adele Island II	Marxan identified this area as a priority for inclusion in the MPA network, because it increases the representation of seagrasses, several types of coral reef, and low vulnerability corals along the Bonaparte Coast. This area also includes a turtle nesting beach, and has been identified as an important area for birds, mammals and sharks.	This area intersects with oil and gas concessions, but otherwise has a low level of threat and no incompatible uses.	Expand the existing Adele Island MPA to include this area.
	2	Cox Peninsula	Marxan identified this area as a priority for inclusion in the MPA network, because it includes estuaries along the Bonaparte Coast. Including this area in an MPA would also: protect a shipwreck; increase the representation of low vulnerability corals; add one type of coral reef (terrestrial reef flat) and more protection for mangroves. This area has also been identified as an important area for dolphins and sea turtles.	This area has a low level of threat and no incompatible uses.	Propose as a new MPA.
Indonesia	3	Motamasin	Marxan identified this area as a priority for inclusion in the MPA network to include more deep-water habitats (especially canyons). This area has also been identified as an important area for marine mammals and as a whale shark migratory corridor.	This area has a low level of threat and no incompatible uses.	Expand the Betun proposed MPA to include this area as a transboundary MPA with Timor-Leste.
	4	Northeast Aru	This area was recommended as a priority area for inclusion in the MPA network based on advice received during the national consultation workshop in Indonesia, since it would fill a gap in representing areas with low vulnerability seagrasses and corals. Including this area would also increase the representation of mangrove and all types of coral reefs in the network. This area also intersects with a turtle migratory corridor.	This area has a low level of threat and no incompatible uses.	Propose as a new MPA.

COUNTRY	NO	NAME	RATIONALE	CONSTRAINTS AND OPPORTUNITIES	RECOMMENDATION
	5	Southeast Aru Extension	This area was recommended as a priority area for inclusion in the MPA network based on advice received during the national consultation workshop in Indonesia, since it would increase the representation of persistent pelagic features (upwelling). Including this area would also increase protection of several types of coral reef (inner reef flats, outer reef flats and shallow lagoon)s. This are also intersects with a turtle migratory corridor.	This area has a low level of threat and no incompatible uses.	Expand the existing Southeast Aru Marine Nature Reserve to include this area.
Timor-Leste	6	Motamasin	Marxan identified this area as a priority for inclusion in the MPA network to include more deep-water habitats (especially canyons). This area has also been identified as an important area for marine mammals and as a whale shark migratory corridor.	This area has a low level of threat and no incompatible uses.	Expand the Betun proposed MPA in Indonesia to include this area as a transboundary MPA.
	7	South Manatuto	Marxan identified this area as a priority for inclusion in the MPA network to include more deep-water habitats (especially canyons). This area has also been identified as important marine mammals area, and intersects with cetacean and whaleshark migratory corridors.	This area has a low level of threat and no incompatible uses.	Propose as a new MPA.

ANNEX 5. NATIONAL AND REGIONAL CONSULTATION WORKSHOP PARTICIPANTS

National Consultation Workshop Participants (Indonesia) on March, 17th 2020

No	Organization	Number of Participant
1	Ministry of Marine Affairs and Fisheries	13
2	Balai Riset Pemulihan Sumberdaya Ikan, Ministry of Marine Affairs and Fisheries	2
3	LPSPL Sorong, Ministry of Marine Affairs and Fisheries	8
4	Dit. Jasa Kelautan, Ministry of Marine Affairs and Fisheries	1
5	Dit. KKHL, Ministry of Marine Affairs and Fisheries	8
6	Dit. PRL, Ministry of Marine Affairs and Fisheries	2
7	Pusat Riset Perikanan BRSDM, Ministry of Marine Affairs and Fisheries	14
8	Pusat Penelitian Oseanografi, LIPI	2
9	Balai Taman Nasional Karimunjawa, Ministry of Environment and Forestry	2
10	BAPPENAS	1
11	BIG	1
12	Ministry of Home Affairs	1
13	Dit. KK, Ministry of Environment and Forestry	1
14	Dit. PPKL, Ministry of Environment and Forestry	1
15	Dinas Lingkungan Hidup Provinsi Sumbar	1
16	Dinas Kelautan dan Perikanan Provinsi Kepulauan Riau	1
17	Dinas Kelautan dan Perikanan Provinsi Maluku	5
18	Dinas Kelautan dan Perikanan Provinsi NTT	3
19	Dinas Kelautan dan Perikanan Provinsi Papua	1
20	Dinas Kelautan dan Perikanan Provinsi Papua Barat	2
21	Coral Triangle Initiative on Coral Reefs, Fisheries, and Food Security	1
22	UNDP Indonesia	2
23	HPPI	2
24	IPB University	11
25	Politeknik Ahli Usaha Perikanan Jakarta	26
26	TKN PSL	1
27	UMS Rappang	3
28	Universitas Andalas	2
29	Universitas Brawijaya, Malang	1
30	Universitas Bung Hatta	1
31	Universitas Diponegoro, Semarang	4
32	Universitas Dr. Soetomo Surabaya	6
33	Universitas Kristen Artha Wacana - Kupang	1
34	Universitas Lampung	1
35	Universitas Mataram	6
36	Universitas Nusa Cendana, Kupang	2
37	Universitas Pattimura	2
38	Universitas Sultan Ageng Tirtayasa	2
39	Universitas Syiah Kuala, Aceh	2
40	Universitas Udayana, Bali	1
41	University of Papua (UNIPA)	1
42	MPA practitioner	2
43	Researcher	1
44	Environmental Activities (Envacers)	1
45	MBS consultant	1
46	Destructive Fishing Watch - Indonesia	2
47	WWF Indonesia	1
48	RARE Indonesia	2

49	Reef Check Indonesia	1
50	Yayasan Cahaya Maritim	1
51	Yayasan KEHATI	1
52	Yayasan Kuan Mnasi	1
53	Yayasan TERANGI	1
54	Coral Triangle Center	2
55	Yayasan Konservasi Alam Nusantara	4
56	ATSEA-2 RPMU	7
	Total	**176**

National Consultation Workshop Participants (Australia and Papua New Guinea) on March, 18th 2020

No	Organization	Number of Participant
1	Department of Agriculture, Water and Environment, Australia	1
2	Western Australian Department of Biodiversity, Conservation and Attractions Australia	2
3	Marine Park Australia	1
4	National Fisheries Authority, Australia	1
5	Ministry of Agrarian and Spatial Planning, Indonesia	1
6	Biomaths Consulting	1
7	Cardno	1
8	Haynayan	1
9	TierraMar	1
10	Independent Consultant	1
11	The Australian Institute of Marine Science (AIMS)	1
12	Charles Darwin University	1
13	Charles Sturt University	1
14	Red Sea Research Center, KAUST	1
15	The Nature Conservancy Asia Pacific	1
16	The Nature Conservancy Australia	1
17	Coral Triangle Center	2
18	Yayasan Konservasi Alam Nusantara	2
19	ATSEA-2 RPMU	7
	Total	**28**

National Consultation Workshop Participants (Timor-Leste) on March, 19th 2020

No	Organization	Number of Participant
1	General Directorate of Fisheries, Timor-Leste	1
2	MAF Timor-Leste	5
3	UNDP Timor-Leste	2
4	Universidade Nacional Timor Lorosa'e	2
5	TLS Local Stakeholder	2
6	Starling Resources	1
7	DKP Provinsi Sulawesi Barat	1
8	Kementerian Kelautan dan Perikanan	1
9	Universitas Diponegoro, Semarang	1
10	Universitas Kristen Artha Wacana, Kupang	6
11	University of Nusa Cendana, Kupang	1
12	MPA Practitioner	1
13	Coral Triangle Center	3

No	Organization	Number of Participant
1	General Directorate of Fisheries, Timor-Leste	1
2	MAF Timor-Leste	5
3	UNDP Timor-Leste	2
4	Universidade Nacional Timor Lorosa'e	2
5	TLS Local Stakeholder	2
6	Starling Resources	1
14	Yayasan Konservasi Alam Nusantara	2
15	ATSEA-2 RPMU	7
	Total	**36**

Regional Consultation Workshop Participants (4 Countries) on March, 24th 2020

No	Organization	Number of Participant
1	BKKPN Kupang, Ministry of Marine Affairs and Fisheries, Indonesia	3
2	Fiscal Policy Agency, Indonesia	2
3	Parks Australia	1
4	Western Australian Department of Biodiversity, Conservation and Attractions Australia	1
5	Department of Agriculture, Water and Environment, Australia	1
6	MAF Timor-Leste	10
7	Coral Triangle Initiative on Coral Reefs, Fisheries, and Food Security	2
8	FAO ISLME project	1
9	UNDP Indonesia	2
10	UNDP Timor-Leste	1
11	Biomaths Consulting	1
12	Global Ocean, Inc.	1
13	Universitas Indonesia	1
14	University of Nusa Cendana, Kupang	1
15	University of Papua (UNIPA)	1
16	Universidade Nacional Timor Lorosa'e	1
17	Charles Darwin University	2
18	Red Sea Research Center, KAUST	1
19	WWF Australia	1
20	WWF Indonesia	1
21	Conservation International Indonesia	1
22	Coral Triangle Center	2
23	Yayasan Konservasi Alam Nusantara	2
24	ATSEA-2 RPMU/PEMSEA	10
	Total	**50**

ANNEX 6. RESPONSE TO DOCUMENTS OF RESILIENT MPA NETWORK DESIGN FOR THE ARAFURA AND TIMOR SEA AND SEA TURTLE REGIONAL ACTION PLAN FOR THE ARAFURA AND TIMOR SEA FROM MINISTRY OF MARINE AFFAIRS AND FISHERIES

MINISTRY OF MARINE AFFAIRS AND FISHERIES
THE AGENCY FOR MARINE AND FISHERIES RESEARCH AND HUMAN RESOURCES
KOMPLEK BINA SAMUDERA, JL. PASIR PUTIH II LANTAI 3
ANCOL TIMUR, JAKARTA UTARA 14430
TELEPON (021) 64700928 EXT 2127. FAKSIMILE (021) 64700929

Ref. No: 825/BRSDM.3/KS.100/VI/2022

Jakarta, 24th June 2022

Dr. Handoko Adi Susanto, M.Sc.
Regional Project Manager of the ATSEA-2 Project
Jl. Mertasari No. 140 Sidakarya, Denpasar, Bali 80224 Indonesia

Subject: Response to Documents of Resilient MPA Network Design for the Arafura and Timor Sea and Sea Turtle Regional Action Plan for the Arafura and Timor Sea from Ministry of Marine Affairs and Fisheries

Dear Dr. Handoko,

Warm greetings from the Center for Fisheries Research (CFR), The Agency for Marine and Fisheries Research and Human Resources, Ministry of Marine Affairs and Fisheries (MMAF) of the Republic of Indonesia.

We apologize for the delay in responding because we have to carry out intensive coordination and also the process of preparing for the integration of research into the National Research and Innovation Agency (BRIN).

Following up Regional Steering Committee Meeting last year, we have sent Memorandums to other directorates with the mandate to manage Marine Protected Areas and develop the Sea Turtle National Plan of Action and also conducted several consultation meetings with them.

Based on the input from the Memorandum received during the consultation process and referring to the contents of the two regional assessment reports, the following conclusions can be drawn:

1. Both regional assessment reports are voluntary documents. The endorsement process only focuses on the adoption of the substance of these documents, and the information contained in these documents can be used as a reference for the Government of Indonesia in preparing policy documents. Therefore, the ratification of these documents does not bind member countries to commit to implementing all the recommendations contained in this study.
2. Based on the understanding in point (a), there is no critical issue for Indonesia not to ratify the two documents. Participants during the MMAF internal consultation process only provided additional information and input for these documents, and did not raise objections to the content of the regional assessment reports.
3. As living documents, these two documents must be open for revision based on the latest information and policies of each member country. Therefore, in relation to this matter, the Government of Indonesia intends to provide technical input in the context of improving and updating the two documents based on current conditions. Inputs based on the Memorandum and the internal consultation process are as follows:
   a. **Input for "Resilient MPA Network Design for the Arafura and Timor Sea"**
      - Detailed background information on connectivity issues between MPAs should be provided to demonstrate the importance of establishing a regional MPA network.

- It is necessary to add background information on why the establishment of a network of MPAs in Fisheries Management Area (FMA) 718 is deemed necessary (both from the ecological and socio-economic aspects).
- It is necessary to explain how the existence of a network of MPAs can provide benefits to support the goal to increase fish stocks in FMA, especially in FMA 718.

b. Input for "Sea Turtle Regional Action Plan for the Arafura and Timor Sea"

- It is necessary to identify the parties that are expected to be responsible for the implementation of the regional action plan provided in the document.
- Currently, the Government of Indonesia is finalizing the National Sea Turtle Action Plan (*RAN Penyu*) for the period 2021-2025. Therefore the information in this document needs to be updated to ensure alignment with the latest information in the new national action plan.
- In accordance with MMAF's Ministerial Decree Number 18 year of 2021 regarding the prohibition of shrimp trawls and seine nets, the fishing gears that are allowed to be used are *jaring hela udang berkantong* and *jaring hela ikan berkantong*. This regulation also already stipulates the obligation to use the Turtle Excluder Device (TED) as a tool to mitigate bycatch of ETP marine species, especially sea turtles.
- In line with the strategy stated in the assessment report document, the Government of Indonesia has implemented programs related to handling lost and abandoned fishing gear with partners.
- Strategies at the regional level are needed to support technology development and recycling schemes for unused fishing nets.
- To improve monitoring and handling of ETP marine species bycatch, MMAF has issued MMAF's Ministerial Decree Number 33 year of 2021 concerning Fishing Logbooks, Onboard Monitoring, Inspection and Marking of Fishing Vessels, and Management of Fishing Vessels. It also regulates data collection of ETP marine species including sea turtles through logbook data collection and placement of observers on fishing vessels.

We hope that the input we provide can make a positive contribution to the improvement of the document on A Resilient Marine Protected Area Network Design for the Arafura and Timor Seas, as well as Regional Sea Turtle Action Plan for the Arafura and Timor Seas.

Thank you for your kind cooperation and assistance.

On behalf of Chairman of The Agency for Marine and
Fisheries Research and Human Resources,

Yayan Hikmayani, S.Pi, M.Si
Director of Center for Fisheries Research

Cc.
1. Chairman of The Agency for Marine and Fisheries Research and Human Resources
2. Head of Bureau for Public Relations and Foreign Cooperation
3. Secretary of The Agency for Marine and Fisheries Research and Human Resources

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