geographic priorities
for marine biodiversity conservation in indonesia

Editor:
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Tiene Gunawan

Kementerian Kelautan dan Perikanan
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GEOGRAPHIC PRIORITIES
FOR MARINE BIODIVERSITY CONSERVATION IN INDONESIA

Editor :
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Directorate of Concervation for Area and Fish Species,
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Ministry of Marine Affairs and Fisheries

and

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GEOGRAPHIC PRIORITIES FOR MARINE BIODIVERSITY CONSERVATION IN INDONESIA

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NOTE: The data utilized in the analyses within this report were provided by the biodiversity experts surveyed herein and represent literally centuries' worth of personal research efforts on behalf of these experts. Much of these data are not yet formally published. The editors of this report therefore kindly request that anyone wishing to use these data in further publications please contact the experts to which the data are attributed to request their permission to do so.

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Table of Contents

List of Table

List of Figure

Foreword

Director General of Marine, Coasts and Small Islands
Ministry of Marine Affairs and Fisheries

Indonesia lies at the heart of the Coral Triangle, a region that is home to the richest marine biodiversity on Earth. Even amongst these rich waters, Indonesia is notable for the diversity of its coastal ecosystems, which contain 18 percent of the world's coral reefs, over 70 genera and 500 species of coral, 2,500 species of fish, 2,500 species of mollusc, 1,500 species of crustacea, and a variety of other marine biota.

The conservation of marine resources is vital to the protection and sustainability of a wide range of human activities and livelihoods. Consequently, conservation efforts cannot be separated from the management of fisheries or of the environment as a whole. Furthermore, given the sensitivity of marine biological resources to climate change and the strong ecosystem linkages across large areas, conservation approaches must adopt a precautionary principle. At the same time, approaches must be tailored to local ecological, social and cultural contexts.

The Ministry of Marine Affairs and Fisheries commitment to improve the conservation of marine biological resources is intricately linked to our mission to manage marine and fishery resources sustainably. One of our approaches is the development of a national system of marine protected areas. This approach is in line with efforts to encourage the utilization of coastal zones and small islands in accordance with the principles of a Blue Economy. In other words, the sustainable development and management of marine resources will require harmonization of economic and environmental interests and the engagement of all stakeholders.

I welcome the publication of *Geographic Priorities for Marine Biodiversity Conservation in Indonesia* and hope that it will serve as a valuable resource to all parties with a connection to the marine environment. At the same time I hope that it will motivate and assist these parties to continue striving to preserve Indonesia's marine biological resources for the welfare of current and future generations.

Sudirman Saad

Foreword

Director of Environment Office, United States Agency for International Development (USAID) Indonesia

All life comes from the oceans, and Indonesia may have more ocean life than any other country on the planet. For those of us who are interested in sustaining this life as a source of food, jobs, income, genetic richness and wonder, we must do everything within our means to conserve it.

There are powerful economic forces that are systematically destroying marine life. Therefore, for us to achieve conservation success, we must understand the resources—What do we have? How much is left? What is of greatest value? Where is it most threatened? When we understand such matters, we can develop a strategy and program to maximizes our chances to efficiently and effectively achieve our goal of conserving this life.

This book is a humble attempt to understand marine biodiversity in Indonesia so that we can develop such strategy and program. It was funded by the US Agency for International Development (USAID) to target its resources in partnership with the GOI's Ministry of Marine Affairs and Fisheries (MMAF) to effectively conserve marine life in the heart of the Coral Triangle.

It gives me great pleasure to present this book to you, together with my esteemed colleagues in the MMAF. The task of marine conservation is huge, but MMAF has been an extraordinary partner. It has been an honor and privilege for USAID to work on such a critical issue in this important country with such a committed Ministry.

Alfred Nakatsuma

Foreword

Director of Conservation for Area and Fish Species, Ministry of Marine Affairs and Fisheries

Fisheries conservation is an effort to protect, preserve, and utilize the resource, including its ecosystems, species, and its genetic. This is to ensure the availability, stock and sustainability by maintaining and increasing the quality of the fish resource and its biodiversity. One of the efforts in ecosystem conservation is the establishment and the management of marine protected areas. The management of these areas needs to be carried out in a bioecological region, considering the dynamics of marine ecosystem and the characteristics of the biota that is indiferent to the administrative boundaires.

The Government of Indonesia is committed to establish Marine Protected Areas (MPAs) to reach 20 million hectares by 2020. This commitment has resulted in considerable progress over the past five years to identify potential sites for new national MPAs initiated by the Ministry of Marine Affairs and Fisheries, and new district MPAs initiated by local governments. As of July 2012 the total area of protected marine and coastal ecosystems in Indonesia has reached 15.5 million hectares, including the recently established Anambas Marine Tourism Park and Southeast Moluccas district MPA. A further 4.5 million hectares must still be established within the next eight years if the Government commitment is to be achieved. At the same time, we must ensure that the proposed MPAs are compatible with local conditions, development potential and aspirations.

This book entitled *Geographic Priorities of Marine Biodiversity for Marine Protected Area Development in Indonesia* is the culmination of a series of assessments to identify priority locations for MPA development in Indonesia. It represents the opinions and recommendations of experts from Indonesia and from around the world. Sites were assessed by key ecological criteria including: (a) their irreplaceability, based on levels of endemism, taxonomic uniqueness, and the existence of rare species; (b) their vulnerability to changes and disturbances, and (c) their representation of critical habitats and ecosystems.

We sincerely hope that this book become one of the references in the establishment and management of marine protected areas. The result of the scientific assessment presented in this book may serve as bio-ecological consideration in defining priority regions for establishing future MPAs as network of marine conservation sites for the wellbeing of Indonesia's coastal and small island communities.

We hope this book serves as a useful resource.

Toni Ruchimat

Preface

"*Geographic priorities for marine biodiversity conservation in Indonesia*" represents the first comprehensive review of Indonesia's marine conservation priorities since 1984's landmark "*Indonesia Marine Conservation Data Atlas,*" produced for the Indonesian Department of Nature Conservation by IUCN and WWF. With Indonesia's international commitment to both the Coral Triangle Initiative and achieving a goal of 20 million hectares of marine protected areas by 2020, we were tasked to provide a scientifically comprehensive geographic prioritization strategy to guide these efforts. The prioritization exercise reported in this document was designed to fulfill this request.

The prioritization exercise was conducted primarily through an electronic expert opinion questionnaire that sought to compile as much quantitative data as possible in ranking Indonesian geographies for marine biodiversity conservation investment. Comprehensive responses were compiled from 21 globally-recognized experts on Indonesian marine biodiversity, utilizing data sets that literally represent centuries worth of field work across the archipelago. Utilizing the "marine ecoregions of the world" standardized geographic delineation, experts were requested to provide quantitative data on patterns of species richness and endemism for their respective taxonomic area of expertise for each of Indonesia's 12 marine ecoregions.

The resulting document includes a tremendous wealth of information on Indonesia's global marine biodiversity heritage, and will be important in guiding governmental and other priorities for conservation investment far into the future. While providing an explicit ranking of geographic priorities, the document should be used as far more than a simple ranking sheet, as it provides detailed information on all twelve of Indonesia's marine ecoregions and highlights both gaps in conservation coverage and the importance of each of these marine ecoregions. Finally, the document provides a set of six key recommendations to ensure that Indonesia's national system of marine protected areas not only covers those areas of highest species richness and endemicity, but also is truly representative of Indonesia's globally outstanding marine diversity and is designed for optimal resilience to climate change.

This document certainly is not a panacea that provides answer to all prioritization questions. Other prioritization exercise with different parameters such as social-economic and geopolitics will assist further the governmental or other decision to develop strategy and programs in the future for marine resource conservation.

Editor

Acknowledgment

This document "Defining Geographic Priorities For Marine Biodiversity Conservation in Indonesia" is a joint publication of the Directorate of Marine Area and Species Conservation, Directorate General of Marine, Coasts and Small Islands, the Ministry of Marine Affairs and Fisheries and the USAID's Marine Protected Area Governance Program.

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• Zulhansni	Minstry of Environment

And the others parties contributed to this document.

Executive Summary

Background

Indonesia is the largest archipelagic country in the world, stretching across three time zones, encompassing more than 17,000 islands, 86,700 square kilometers of coral reefs, and 24,300 square kilometers of mangrove areas, and supporting nearly 230 million people. Importantly, the people of Indonesia are increasingly dependent on marine resources for their food and income. Presently about 70% of the country's protein sources comes from fish (in some poor coastal communities this figure approaches 90%), while nearly 20% of the country's GDP is derived from fisheries and other marine-related industries.

The Ministry of Marine Affairs and Fisheries (MMAF) has the challenging task of institutional oversight of marine resources in Indonesia. This includes ensuring that marine resources are used sustainably while at the same time increasing the value of the marine and fishery sector with the ultimate goal of increasing the quality of life for all Indonesian citizens. The MMAF has increasingly sought to achieve these two objectives by including marine protected areas (MPAs) as a key tool in its national fisheries and biodiversity management, and conservation planning. Effective marine protected areas are critical to achieving MMAF's national objectives and require the development of ecologically-connected networks of MPAs at both the provincial and regional scales to address concerns such as spawning aggregation sites, juvenile grow-out areas and adult migration routes for the country's most important commercial and food fish species. Development of effective MPA networks is even more important given the expected negative impacts of climate change to biodiversity and fisheries-based food security.

Coral Triangle Support Partnership Indonesia (CTSP-I) is part of Coral Triangle Support Partnership works in six Coral Triangle countries. CTSP-I is a consortium of three conservation NGOs Conservation International (CI), The Nature Conservancy (TNC), dan WWF Indonesia. CTSP Indonesia received a mandate to support the Government of Indonesia, Ministry of Marine Affairs and Fisheries in establishing the national MPA system. CTSP-I transformed into Marine Protected Area Governance (MPAG) with similar goal with additional consortium members (Coral Triangle Center - CTC and Wildlife Conservation Society – WCS). MPAG works in the priority areas to support the Government of Indonesia in achieving effective MPA management.

Need for Prioritization Exercise

Blessed with nearly 18% of the world's coral reefs, Indonesia sits firmly at the center of the "Coral Triangle", the region with the world's highest marine biodiversity (Gray, 1997). Although the causes for this pattern of maximum species richness in the Coral Triangle are still debated, this does not preclude the urgent need to prioritize geographic areas within the region for conservation investment and action. Brooks *et al*. (2006) reviewed the importance of prioritization in conservation planning and the numerous approaches that are currently practiced by governments and conservation NGOs; most of these utilize various measures of "irreplaceability" (e.g., degree of endemism, taxonomic uniqueness, presence of rare species, etc.) and vulnerability to rank priority areas for biodiversity conservation investment. For the purposes of a national level prioritization such as that needed to inform the selection of CTSP priority geographies, an additional important consideration is "representativeness". Indonesia sits at a bio-geographic crossroads, with components of Indian Ocean and western Pacific faunas (as well as Indonesian endemics) represented to varying degrees across the archipelago. A national system of marine protected areas should strive to represent each of these faunal components.

The first comprehensive conservation prioritization of Indonesia's vast marine resources was recorded in the Indonesia Marine Conservation Data Atlas produced for the Indonesian Department of Nature Conservation (PHPA) by IUCN/WWF (Salm and Halim, 1984). This landmark effort compiled for the first time all of the known information about the distribution of Indonesia's marine ecosystems, threatened marine species, fisheries and other marine commercial activities. Based on this information, the Atlas categorized 179 marine sites in Indonesia according to four tiers of prioritization, which formed the basis for recommendations guiding the development of a national marine protected area system. This analysis has largely provided the blueprint for marine conservation investments in Indonesia for the past 3 decades. Djohani (1989) provided further guidance for the Indonesian government's ambitious plans at that time to gazette 10,000,000 ha of MPAs during the five-year planning period 1988-1993. In doing so he refined the Salm and Halim (1984) prioritization to focus on 17 sites (in 3 tiers of priority) for immediate conservation investment.

In its 1996 summary of Indonesian marine policies, strategies, actions and issues, the State Ministry of Environment noted the urgent need for continued designation of high priority areas for marine conservation in order to meet the 10,000,000 hectare MPA target. Unfortunately, this call has not been met with efforts to refine and update the priorities of Salm and Halim based on the considerable amount of new data now available on biogeography, species richness, and genetic connectivity, and population subdivision across Indonesia.

The need for a revised geographic prioritization has never been greater. In December 2007, the President of Indonesia declared Indonesia's commitment to the Coral Triangle Initiative, a six-country, multi-donor initiative to transform coral reef management in the center of marine biodiversity. Furthermore, after achieving its goal to gazette 10,000,000 ha of MPAs by 2010, Indonesia now needs to double this achievement in order to reach its subsequent commitment of 20,000,000 hectares by 2020. The Indonesian government urgently requires new guidance on ma-

rine biodiversity conservation priorities in order to design an effective and representative national system of MPAs and MPA networks. The prioritization exercise reported herein was designed to address this need, and had three primary objectives:

1. Solicit input from internationally-recognized experts to establish what constitutes the essential marine biodiversity of Indonesia;
2. Provide a science-based ranking of the marine ecoregions of Indonesia in terms of their priority for marine biodiversity conservation investment by the Government of Indonesia, CTSP and other interested parties;
3. Identify priority "gap" areas which currently lack marine protected area coverage necessary for the further development of a comprehensive national system of MPAs in Indonesia.

Prioritization Process

The prioritization exercise was conducted primarily through an electronic expert opinion questionnaire that sought to compile as much quantitative data as possible for use in ranking Indonesian geographies for marine biodiversity conservation investment. In order to ensure comparability of expert inputs and rankings, it was necessary to select a standardized delineation of the marine regions of Indonesia. Given that that the primary goal of the exercise was to identify top priority geographies for conservation investments that will frequently involve ecologically-connected networks of MPAs, we have selected the marine ecoregions of the world (MEOW) defined by Spalding *et al.* (2007) as the default delineation for this exercise, as these ecoregions generally represent the scale at which such networks will be defined and implemented. Within Indonesia, the MEOW classification defines 12 marine ecoregions (see Figure XS1 below).

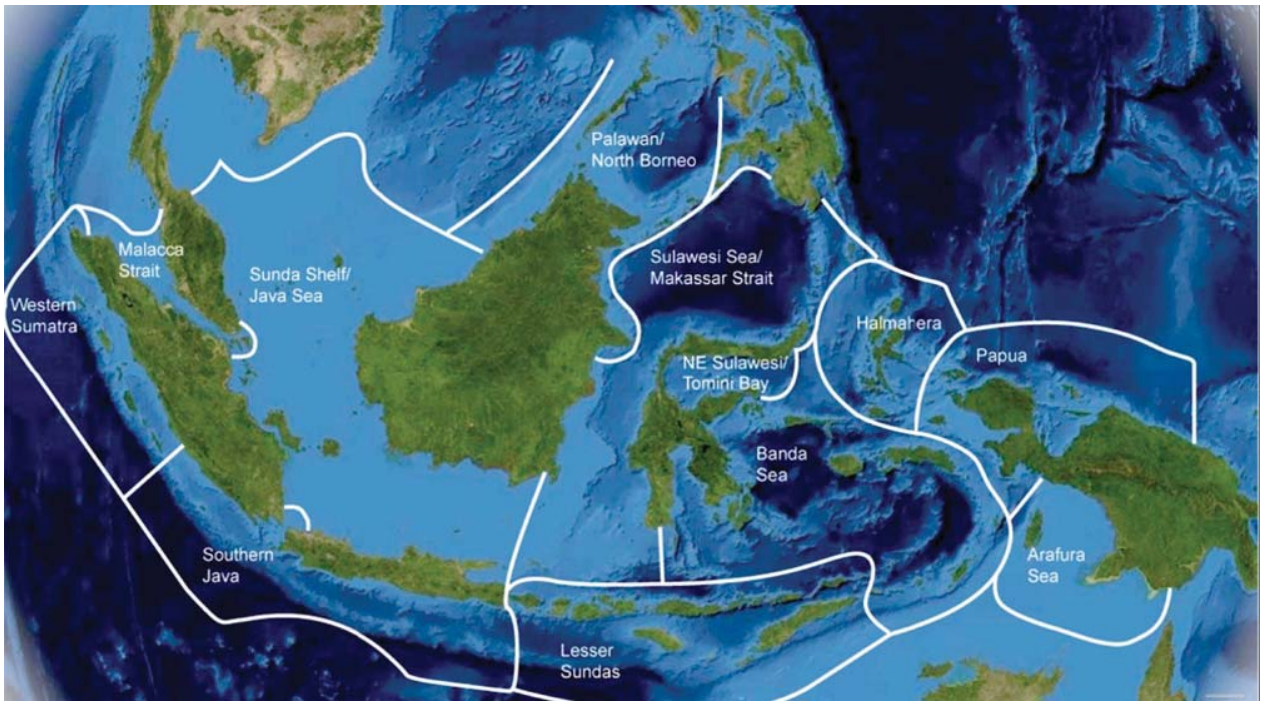


Figure XS1. Map showing the twelve Indonesian marine ecoregions as defined in the Marine Ecoregions of the World (MEOW) classification scheme; redrawn from Spalding *et al.* (2007)

Many conservation prioritization methodologies in practice; however, almost all, including this exercise, use a combination of the following measures to rank sites/regions:

- Irreplaceability (degree of endemism, taxonomic uniqueness, presence of rare species/habitats, etc)
- Vulnerability (different methodologies prioritize either low risk regions or highly threatened regions)
- Representativeness (particularly when a planning unit such as a country's national boundaries cross biogeographic realms)

The expert opinion questionnaire was used to compile following aspects of marine biodiversity for a range of taxonomic groups for each of Indonesia's 12 marine ecoregions:

a. Species richness of the ecoregion, including alpha diversity and genetic diversity;
b. Endemism documented in the ecoregion, including evidence of genetic breaks or "private haplotypes";
c. Significant aggregations of or essential habitats for globally threatened or restricted range species. Migration corridors, nesting beaches, spawning and feeding aggregation sites, and nursery areas were treated under this category.
d. Uniqueness of the ecoregion, including presence of rare species or presence of unique habitats such as marine lakes;
e. Other important biodiversity considerations for the ecoregion, such as unique ecosystem services provided, vulnerability and/or resilience to climate change, and conservation opportunities.

In addition to providing the biodiversity assessments listed above for each marine ecoregion, experts were also asked to 1) idenfity specific sites within each ecoregion that merit targeted conservation investment, 2) identify sites or ecoregions that are highly data-deficient and in urgent need of further survey work, and 3) based on the data they presented, rank on a scale of 1-12 the priority of each marine ecoregion in Indonesia for marine biodiversity conservation investment and improved management of marine resources.

Results

Sixteen globally-recognized experts on Indonesian marine biodiversity, representing a wide range of taxonomic interests, completed the questionnaire and ranking process, and an additional four experts contributed important supplementary information. Respondents provided extensive quantitative data representing several centuries' worth of their combined research efforts across Indonesia, including inputs from several major international databases. Summaries of these data inputs are reported here, while the complete set of completed questionnaires can be found in Appendix V.

Rankings

The rankings provided by the 16 respondents who completed the questionaires were compiled and averaged, and the results shown in graphical format below (Figure XS2).

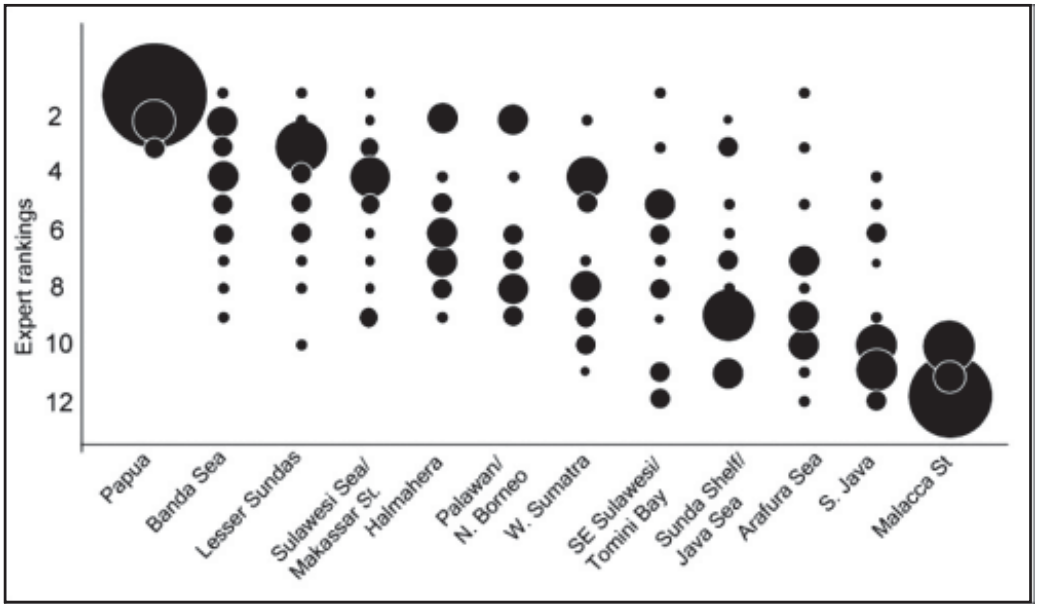


Figure XS2. Tally of expert rankings of conservation priority for marine ecoregions of Indonesia based on biodiversity considerations, with an emphasis on irreplaceability and representativeness criteria. Ecoregions are displayed on the X-axis from left to right in order of their final prioritization rank. Size of circle corresponds with the number of votes for that rank.

Brief summary of rankings on a per-ecoregion basis is given below:

1. Papua was overwhelmingly ranked the top marine biodiversity conservation priority in Indonesia—ten of 16 experts ranked Papua number 1, while the remaining six ranked it either second or third. Papua tops most counts of coral reef biodiversity and boasts numerous animals, habitats, and genetic clades that are rare elsewhere in Indonesia, including 1) record numbers of endemic fish, corals and stomatopods, 2) Sperm whale calving grounds, 3) the world's largest Pacific Leatherback turtle rookery, 4) major Green turtle rookeries, 5) resident Bryde's whales in Kaimana, and 6) healthy populations of Dugongs and Estuarine crocodiles. Low human population density adds to the conservation potential for this area, though aligning forces of exploitation intensify the urgency for marine conservation action in this region.

2. The Banda Sea ranks second for marine conservation priority in Indonesia based on its 1) high diversity of coral reef species, 2) high reef habitat diversity including abundant nearshore yet deep-sea habitats, which are otherwise rare throughout the world, 3) strategic role in connectivity based on current patterns, 4) significant role in sea turtle life cycles, and 5) significance to highly endangered oceanic cetaceans such as blue whales. As a very deep basin, the Banda Sea has provided an important refuge for reefs during past sea level regressions, and may play a similar role in the future of tropical marine species as global climate change heats up shallower seas. Like Papua, human population density in the Banda Sea is low. However the Banda Sea is considered to be heavily fished, a factor that threatens the attributes listed above.

3. In addition to having very high levels of biodiversity and endemicity, which are surpassed only by Papua, the Lesser Sundas function as an extremely important migration corridor for many large marine animals. Cetaceans (including blue whales) and commercially important pelagic fishes travel between the Indian and Pacific Oceans via the multiple nearshore, deep-sea channels between these islands. Cold-water upwelling along the southern coastlines of the Lesser Sundas drive extremely high levels of primary productivity that forms the basis of rich food webs supporting these large pelagics.

   Coldwater upwellings along the southern coastlines of the Lesser Sundas may also help buffer this region from climate change.

4. The Sulawesi Sea/Makassar Strait ranks fourth in conservation priority based on its 1) integral role in connectivity and larval dispersal via the Indonesian Throughflow, 2) very high species richness, 3) importance to cetaceans, and 4) high taxonomic and genetic representativeness of diversity from across Indonesia. Existing infrastructure and capacity in Bunaken National Park should serve as a sound expansion point for additional conservation measures, which should include the creation of a network of MPAs running north to south and creating a "connectivity corridor" along the Makassar Strait.

5. Halmahera ranks fifth as a marine conservation priority in Indonesia based on its exceedingly high biodiversity and habitat diversity, representativeness of Asian and Australian fauna, and important role in connectivity between Papua and Sulawesi. Several experts suggested that Halmahera should perhaps be viewed as an extension of the Bird's Head Seascape within the Papua marine ecoregion.

6. The Palawan/North Borneo ecoregion, which spans waters in Indonesia, Malaysia, and the Philippines, is ranked sixth for marine conservation priority in Indonesia. The biodiversity of this ecoregion represents a subset of others nearby, especially the higher ranked Sulawesi Sea/Makassar Strait. Its extensive mangrove forests and seagrass meadows sustain endangered Irrawaddy dolphins, finless porpoises, seabirds, and sea turtles. The Palawan/North Borneo marine ecoregion is considered of global significance to Green and Hawksbill sea turtle populations, and includes SE Asia's largest Green sea turtle rookeries in East Kalimantan's Berau MPA.

7. Western Sumatra ranks seventh for marine conservation priority, despite being considered the most data deficient ecoregion in terms of marine biodiversity . Although its biodiversity is not well surveyed, most experts agreed that Western Sumatra hosts the best reef development and widest range of reef habitat types along Indonesia's Indian Ocean coast, and captures Indian Ocean assemblages better than any other ecoregion. From a genetic diversity perspective, Western Sumatra is considered second in importance only to Papua, and contains a host of distinct genetic lineages not found elsewhere in Indonesia. All six sea turtle species found in Indonesia forage and/or nest in Western Sumatra, although their spatial use patterns are not well known. This ecoregion ranked as the most urgent priority for follow-up survey work to better understand the biodiversity contained within, and many experts noted that its ranking for conservation priority might rise with further surveys and increased data inputs.

8. The Northeast Sulawesi/Tomini Bay ecoregion is ranked eighth based on its high biodiversity, distinctive genetic clades and endemic taxa, especially in the Togean Islands. The recently declared Togean Islands National Marine Park will largely protect the representative biodiversity of Tomini Bay, pending the cooperative implementation of an integrated coastal zone management plan by the provincial governments that surround the bay.

9. The Sunda Shelf/Java Sea ecoregion is ranked ninth for marine conservation priority in Indonesia. This ecoregion is characterized by marginal reefs that were established following the end of the last glacial maximum. Overall, it has relatively low marine species richness compared to the rest of Indonesia, and almost no endemism. However, this ecoregion has a high diversity of soft bottom fauna including stomatopods and other benthic infauna. Significant stressors to marine populations in the Sunda Shelf/Java Sea include freshwater run off, high sediment input, and anthropogenic impacts. Despite these characteristics, this ecoregion offers very important feeding and nesting areas for Green and Hawksbill turtles, with perhaps the most important Hawksbill rookeries in SE Asia located in the Anambas and Natuna Islands. The ecoregion is also home to regionally significant mangrove stands. Finally, birds that migrate along the eastern coast of Sumatra use the Sunda Shelf/Java Sea as an important flyway.

10. The Arafura Sea ranks tenth for marine biodiversity conservation priority in Indonesia because of its overall low degree of reef development and hence lowered biodiversity, both taxonomically and genetically. Nonetheless, some of the world's most extensive and biodiverse mangrove stands are found along this southern coast of Papua, which generally lacks habitat variability but is globally important to mangrove and seagrass communities sustaining threatened seabirds, Dugongs, sea turtles, estuarine crocodiles, whale sharks and possibly sawfish. This large shallow shelf and wooded shore is considered prime undisturbed habitat for coastal cetaceans. The Arafura Sea is also home to one of the most important Green turtle rookeries in Indonesia (in the Aru Islands), and is an important foraging ground for migrating Hawksbill, Olive Ridley and possibly Flatback turtles. This region is considered data poor, and of high priority for further surveys.

11. Southern Java is ranked eleventh for marine biodiversity conservation priority in Indonesia. Where known, this area exhibits low species richness, all of which is already captured in the Western Sumatra ecoregion and to a lesser extent in the Lesser Sunda ecoregion (both of which are given higher priority). Sheer drop-offs, low coral reef coverage, high wave energy, and rough sea conditions limit most fishing activities, however those coastal fisheries that are accessible proceed with high intensity. This ecoregion is nonetheless very important to sea turtles; Greens, Hawksbills, Leatherbacks and Olive Ridleys all nest along the beaches of southern Java. and the Cilicap/Segera Anakan lagoon has locally significant mangrove stands, which are important to seabirds as well.

12. The Malacca Strait ranks the lowest of all 12 ecoregions for marine conservation priority in Indonesia. While this ecoregion represents a unique shallow-water habitat that is globally significant to many seabirds, and is a potential corridor for dispersal between Indonesia and the Eastern Indian Ocean, it is also extremely depauperate for reef diversity and highly impacted by

human activities, sedimentation, and pollution due to major population centers and Malacca Strait shipping traffic.

Gap Assesment of MPA Coverage and Concervation Priority

In comparing the results of the present ranking with the current coverage of MPAs in Indonesia's marine ecoregions, several important gaps become immediately obvious. Without question Halmahera ranks first in this gap analysis. This ecoregion ranks fifth based on its extremely high biodiversity, habitat richness, and representativeness of both Sulawesi and Papuan fauna. Yet it has only a single local candidate MPA, and as such is in urgent need of conservation efforts including the delineation of new MPAs. The next most important gap in current marine conservation efforts in Indonesia is Western Sumatra. Although this ecoregion is small in size, it has high representation of Indonesia's Indian Ocean marine biodiversity, and a relatively high degree of endemism and unique genetic lineages.

The Sulawesi Sea/Makassar Strait ecoregion represents an equally critical gap in Indonesia's MPA coverage. Although this area has the highest number of MPAs (32) of any ecoregion in Indonesia, the majority of these are small community-based marine reserves that together comprise a relatively insignificant total coverage for this large and important ecoregion. Given its exceptional biodiversity and the critical importance of this ecoregion as a "connectivity corridor", significant effort should be directed towards developing a network of MPAs that span the entire western coast of Sulawesi, southward into the Flores Sea.

Finally, the experts surveyed here also highlighted Papua, the Arafura Sea, the Lesser Sundas, and the Banda Sea as important targets for expansion of MPA coverage due to their high biodiversity, habitat richness, and important role in providing essential habitats for a range of threatened or restricted range species.

Data Deficient Regions

Most experts consider the entire Western Sumatra marine ecoregion to be highly data deficient and in urgent need of biodiversity survey work, with a strong potential for discovery of high biodiversity and likely additional endemic species. Other regions that were specifically highlighted as being in need of urgent survey work include the Anambas/Natuna Islands, Halmahera, and the inner and outer Banda arcs in the Banda Sea.

Recommendations

Six recommendations (below) have been produced for consideration by the Indonesian government, based upon the combined data inputs of 20 internationally-recognized experts on Indonesian marine biodiversity, ranking of each marine ecoregion's priority for conservation investment, a gap analysis comparing existing MPA coverage to each ecoregion's ranking, and intensive discussions at a national prioritization workshop held in Bali on 16-17 July 2009:

1. Irreplaceability and representativeness criteria strongly underscore the importance of marine biodiversity conservation efforts focusing on Papua, the Lesser Sundas, the Banda Sea, and Western Sumatra – including strengthening and building upon current MPA networks. However, ecoregion ranking alone does not capture all the rich detail and habitat diversity of Indonesia's marine heritage. Many individual sites within lower-ranked ecoregions stand out as regionally or even globally important and these also need to be prioritized in a national strategy/system of MPAs (e.g. Natuna/Anambas in the Sunda Shelf/Java Sea, Alas Purwo and Segara Anakan in Southern Java, Aru in the Arafura Sea, Togean Islands in Northeast Sulawesi/Tomini Bay). Moreover, the current focus on coral reefs and their associated biota has the potential to obscure important conservation priorities for less high-profile diversity targets including mangrove and seagrass habitats and their associated fauna. Although the Arafura Sea, Sunda Shelf, and Malacca Strait are amongst the lowest priorities from a coral reef perspective, each of these ecoregions is globally significant from the perspective of mangroves, seagrasses, seabirds, and other related fauna, and this should be taken into account in developing Indonesia's national MPA strategy.

2. Given the overwhelmingly top prioritization ranking of Papua, the Department of Fisheries and the GoI should focus urgent and significant human, financial, and policy resources on this ecoregion, particularly given the very high vulnerability of this area to immediate threats from coastal mining and logging, ill-conceived transmigration projects, and poorly-planned coastal development including island/coastal ring roads. Indonesia's top marine conservation priorities in Papua, namely largely intact ecosystems and globally outstanding marine biodiversity, will be irrevocably destroyed unless government agencies urgently collaborate to enact and strictly-enforce spatial planning best practices.

3. While this prioritization exercise has highlighted important gaps in MPA coverage in Indonesia (see recommendation #5), it also highlights areas of critical biodiversity importance which are already covered but not effectively protected by MPAs (e.g. the Savu Sea MPA in the Lesser Sundas). Strengthening the management and enforcement of current high priority MPAs is every bit as important as designating new ones in gap areas.

4. The maintenance of both species richness, and genetic haplotype diversity within species is critically important as insurance for the ability of populations to survive and reproduce through global climate change. This diversity gives populations and species a better chance that at least some individuals bear the traits necessary to endure environmental changes. Genetic diversity represents the very building blocks of adaptation and natural selection, and serves as a primary buffer against extirpations and even extinction. To minimize marine extinctions, Indonesia's national marine conservation and MPA strategy must include a focus on maintaining genetic

diversity. Besides protecting the unique genetic diversity present in the eastern and western sectors of the country (e.g., in Papua and Western Sumatra), a "connectivity corridor" focused along the western coastline of Sulawesi (the primary genetic mixing zone with the longest contiguous reef-fringed coastline in Indonesia) should be a top priority for establishment to ensure the gene flow that will be necessary to distribute those genetic variants which are best able to tolerate to the new environmental conditions predicted as we undergo global climate change.

5. Based on the above considerations, areas that show important gaps in MPA coverage and should be considered top priorities for new MPA coverage include:
   - **Halmahera (top priority due to near absence of MPAs in this ecoregion)**
   - **Western Sumatra (next highest priority)**
   - Sulawesi Sea/Makassar Strait "connectivity corridor" from the northern Sangihe-Talaud Archipelago, down the western coast of Sulawesi to the Postiljon/Sabalana Islands in the Flores Sea
   - Banda Sea (particularly the outer island arcs, Lucipara, Watubela, Seram, Banggai, Tanimbar)
   - Papua (particularly FakFak, Kokas, outer Cendrawasih Bay)
   - Arafura Sea
   - Lesser Sundas (Alor/Solor, Nusa Penida)

6. Several ecoregions/sites stand out for their lack of quantitative biodiversity data, and are considered an urgent priority for comprehensive survey work in order to better understand the distribution of Indonesia's marine biodiversity and how to best manage it. Those areas in most urgent need of survey work include:
   - **Western Sumatra**
   - **Natuna/Anambas Islands in the Sunda Shelf/Java Sea marine ecoregion**
   - **Halmahera (particularly southern sector)**
   - **Banda Sea (especially inner and outer Banda Arcs)**
   - Also important and not well-surveyed are Alor-Wetar-Savu (Lesser Sundas ecoregion), Teluk Cendrawasih (Papua ecoregion), and Arafura Sea

1 Introduction

Background

Indonesia is the largest archipelagic country in the world, stretching across three time zones, encompassing more than 17,000 islands, with 86,700 square kilometers of coral reefs, and 24,300 square kilometers of mangrove areas, and nearly 230 million people. Importantly, the people of Indonesia are increasingly dependent on marine resources for their food and income. Presently about 70% of the country's protein comes from fish (in some poor coastal communities this figure approaches 90%), while nearly 20% of the country's GDP is derived from fisheries and other marine-related industries. Indonesia estimates that the number of coastal fishers increased by more than 40% over the last 10 years. Unsustainable fishing pressure and habitat destruction via destructive fisheries and coastal development contribute to the plummeting decline in Indonesia's fishery stocks. These trends, especially in the light of climate change and continued population growth, strongly suggest that Indonesia's coastal waters will require substantially more protection and integrated management.

The Ministry of Marine Affairs and Fisheries (MMAF) has the challenging task of institutional oversight of marine resources in Indonesia. This includes ensuring that marine resources are used sustainably, while at the same time increasing the value of the marine and fishery sector with the ultimate goal of increasing the quality of life for all Indonesian citizens. The MMAF has increasingly sought to achieve these two objectives by including marine protected areas (MPAs) as a key tool in its national fisheries and biodiversity management, and conservation planning. Effective marine protected areas are critical to achieving MMAF's national objectives and require the development of ecologically-connected networks of MPAs at both the provincial and regional scales to address concerns such as protecting spawning aggregation sites, juvenile grow-out areas, and adult migration routes for the country's most important commercial and food fish species. Development of effective MPA networks is even more important given the expected negative impacts of climate change to biodiversity and fisheries-based food security.

Coral Triangle Support Partnership Indonesia (CTSP-I) is part of Coral Triangle Support Partnership works in six Coral Triangle countries. CTSP-I is a consortium of three conservation NGOs Conservation International (CI), The Nature Conservancy (TNC), dan WWF Indonesia. CTSP Indonesia received a mandate to support the Government of Indonesia, Ministry of Marine Affairs and Fisheries in establishing the national MPA system. CTSP-I transformed into Marine Protected Area Governance (MPAG) with similar goal with additional consortium members (Coral Triangle Center - CTC and Wildlife Conservation Society – WCS). MPAG works in the priority areas to support the Government of Indonesia in achieving effective MPA management.

Need for Prioritization Exercise

Blessed with nearly 18% of the world's coral reefs, Indonesia sits firmly within the center of the "Coral Triangle", the region with the world's highest marine biodiversity (Rosen 1988; Gray, 1997; Hoeksema 2007). Although this pattern of global maxima of marine species richness in the Indo-Malayan region has been recognized for over half a century (Ekman, 1953), the proximal mechanisms resulting in this pattern are a matter of vigorous scientific debate to this day (Briggs 2005a, 2005b; Renema et al. 2008). Many authors have in fact suggested that this region is an active center of speciation (e.g., Barber *et al*., 2006), while others have hypothesized that the high species richness found here is due to other factors ranging from overlapping distributions, increased survival of species in the region, and a variety of other causes summarized in Hoeksema (2007).

Although the causes for this pattern of maximum species richness in the Coral Triangle are still debated, this does not preclude the urgent need to prioritize geographic areas within the region for conservation investment and action. Brooks *et al.* (2006) reviewed the importance of prioritization in conservation planning and the numerous approaches that are currently practiced by governments and conservation NGOs; most of these utilize various measures of "irreplaceability" (e.g., degree of endemism, taxonomic uniqueness, presence of rare species) and vulnerability to rank priority areas for biodiversity conservation investment. For the purposes of a national level prioritization such as that needed to inform CTSP geography selection, an additional important consideration is "representativeness"; Indonesia sits at a bio-geographic crossroads (Wallace 1997; Wallace et al., 2003) of Indian and western Pacific faunas represented to varying degrees across the archipelago. Representativeness is therefore considered an important factor for consideration in the overall CTSP geography selection process, as a national system of marine protected areas (MPAs) should strive to represent each of these faunal components.

Within Indonesia, the first comprehensive conservation prioritization of the archipelago's vast marine resources is recorded in the Indonesia Marine Conservation Data Atlas produced for the Indonesian Department of Nature Conservation (PHPA) by IUCN/WWF (Salm and Halim, 1984). This landmark effort compiled for the first time all of the known information about the distribution of Indonesia's marine ecosystems, threatened marine species, fisheries and other marine commercial activities. Based upon this information, the Atlas provided in its concluding pages three prioritization analyses: 1) priority areas for protection of habitat to safeguard fisheries, 2) identification of marine areas of highest vulnerability to oil spills, and 3) a prioritization of 179 marine sites in Indonesia which were recommended to form the basis of a marine protected area system for the country. This last analysis in particular, which presented four tiers of priority for these proposed MPAs (see Appendix I and Figure 25), has largely provided the blueprint for marine conservation investments in Indonesia for the past 3 decades. Djohani (1989), in providing guidance for the Indonesian government's ambitious plans at that time to gazette 10,000,000 ha of MPAs during the five-year planning period 1988-1993, further refined the Salm and Halim (1984) prioritization to focus on 17 sites (in 3 tiers of priority) for immediate conservation investment (summarized in Appendix II).

In its 1996 summary of Indonesian marine policies, strategies, actions and issues, the State Ministry of Environment noted the urgent need for continued designation of high priority areas for marine conservation in order to meet the 10,000,000 hectare MPA target. Unfortunately, this call has not been met with efforts to refine and update the priorities of Salm and Halim based on the considerable amount of new data now available on biogeography, species richness, and genetic connectivity, and population subdivision across Indonesia (e.g. Barber *et al.* 2002).

The need for a revised geographic prioritization has never been greater. In December 2007, the President of Indonesia declared Indonesia's commitment to the Coral Triangle Initiative, a six-country, multi-donor initiative to transform coral reef management in the center of marine biodiversity. Furthermore, after achieving its goal to gazette 10,000,000 ha of MPAs by 2010, Indonesia now needs to double this achievement in order to reach its subsequent commitment of 20,000,000 hectares by 2020. The Indonesian government urgently requires new guidance on marine biodiversity conservation priorities in order to design an effective and representative national system of MPAs and MPA networks. The prioritization exercise reported herein was designed to address this need. We note that although there has not been any systematic marine biodiversity conservation prioritization process for Indonesia over the past two decades, there has been a surge in regional and global prioritization efforts since 2000, many of which highlight particular regions within Indonesia for their global biodiversity importance. As these efforts may inform the present exercise, some of the better-known results are summarized below with respect to their mention of Indonesian regions. We note that finer-scale

national level prioritizations such as the present one will necessarily differ slightly in methodology (especially with regards to the issue of representativeness in a national system of MPAs), but the following results should nonetheless inform this exercise.

One of the first global marine conservation prioritization efforts (Olson and Dinerstein, 2002) was conducted as part of WWF's "Global 200 Priority Ecoregions" initiative. It identified three "marine eco-regions" within Indonesia as being among the top 43 global conservation priorities: the Sulu-Sulawesi Seas, Banda-Flores Sea, and Bismarck Solomon Seas (which includes the Bird's Head region of Papua). In the same year, Roberts and colleagues (2002) used a "marine hotspots" approach to prioritize regions for conservation action based on degree of endemism and perceived level of extinction threat. This effort highlighted the Sunda Islands (Java to Timor) as the top coral reef conservation priority within Indonesia, and third globally after the Philippines and the Gulf of Guinea.

Allen (2007) reviewed conservation hotspots for protecting biodiversity and endemism of Indo-Pacific coral reef fishes, and ranked Indonesia as first globally in terms of coral reef fish species richness (2122) and second in terms of number of endemic reef fish species (78). By comparison, Australia is second in terms of alpha diversity (1827 species) but has the most endemics (93). Within Indonesia, Allen highlighted Raja Ampat (Papua marine ecoregion), the Molluccas (Halmahera marine ecoregion) and Northern Sulawesi (Sulawesi Sea/Makassar Strait marine ecoregion) as the top three areas for reef fish species richness, and the Lesser Sundas and Bird's Head Peninsula of Papua as the top areas for reef fish endemism.

Finally, Carpenter and Springer (2005) examined patterns of marine biodiversity across the Indo-Malay-Philippines Archipelago based on distribution maps of 2983 species (mostly fishes, but also including a number of seaweeds, and a sampling of cetaceans, marine reptiles, and commercially-important invertebrates; note: their study included a large number of commercially-important soft-bottom fisheries species). They highlighted the following areas within Indonesia as top priorities for conservation attention: NE Sumatra/N Java from the perspective of overall marine biodiversity; Sulawesi and the northern Sunda islands for coral reef biodiversity; and NE Sumatra and S Kalimantan for soft bottom and estuarine biodiversity.

This exercise is based on the combination of the following measures to rank sites/regions and conservation planning:

- Irreplaceability (degree of endemism, taxonomic uniqueness, presence of rare species/habitats, etc)
- Vulnerability (different methodologies prioritize either low risk regions or highly threatened regions)
- Representativeness (particularly when a planning unit such as a country's national boundaries cross biogeographic realms)

Objectives of Prioritization

The prioritization exercise reported herein had three primary objectives:

1. Solicit input from internationally-recognized experts to establish what constitutes the essential marine biodiversity of Indonesia;
2. Provide a science-based ranking of the marine ecoregions of Indonesia in terms of their priority for marine biodiversity conservation investment by the Government of Indonesia, CTSP and other interested parties;
3. Identify priority "gap" areas which currently lack marine protected area coverage necessary for the further development of a comprehensive national system of MPAs in Indonesia.

2 Questionnaire and Prioritization Workshop Process

Prioritization Questionnaire

The prioritization exercise was conducted primarily through an electronic expert opinion questionnaire (Appendix IV) that sought to compile as much quantitative data as possible for use in ranking Indonesian geographies for marine biodiversity conservation investment. In order to ensure comparability of expert inputs and rankings, it was necessary to select a standardized delineation of the marine regions of Indonesia. Possible delineations considered for use in the exercise included biogeographic boundaries [e.g. the Marine Ecoregions of the World (MEOW) treated in Spalding *et al*., 2007], political boundaries (e.g. provincial or kabupaten boundaries), and management boundaries (such as those defined by Indonesia's fisheries capture regions). Given that that the primary goal of the exercise is to identify top priority geographies for conservation investments that will frequently involve ecologically-connected networks of MPAs, the delineation used should optimally focus at the scale at which such networks will be defined and implemented. Bearing this in mind, we have selected the marine ecoregions of the world defined by Spalding and colleagues (2007) as the default delineation for this exercise; the 12 marine ecoregions within Indonesia (Figure 1) are based largely on Green and Mous' "functional seascapes" (2006).

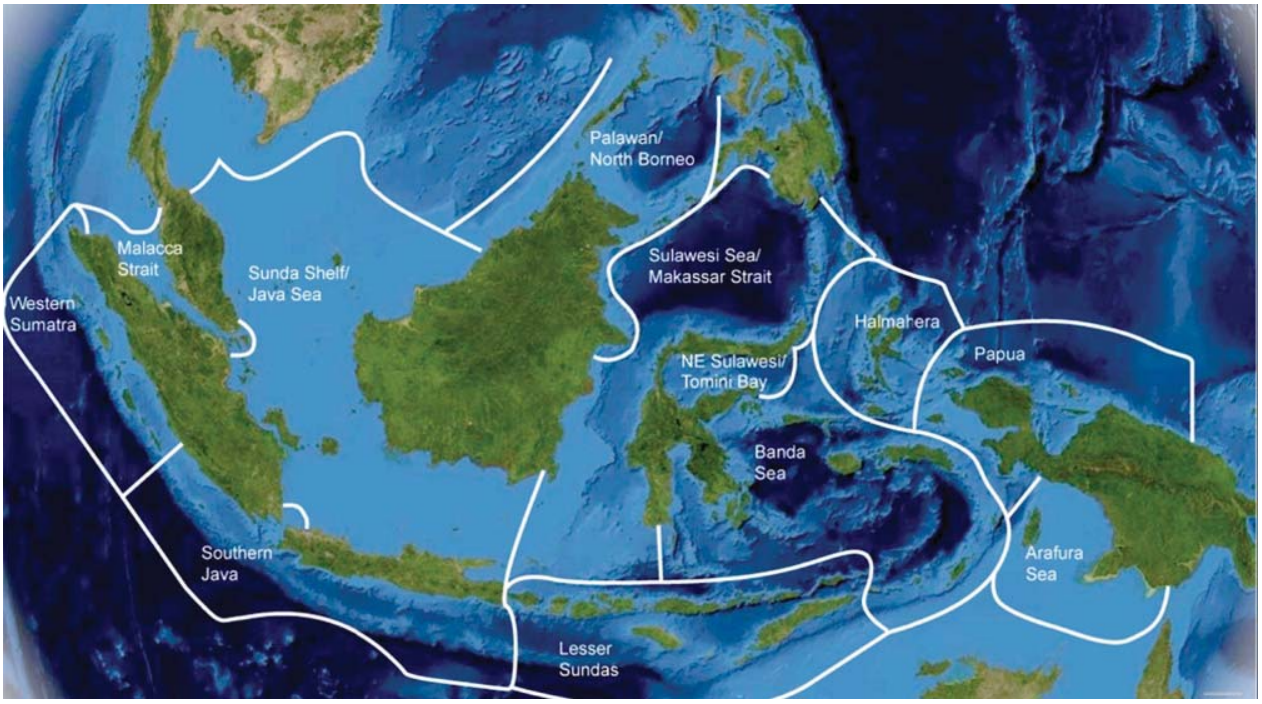


Figure 1. Map showing the twelve Indonesian marine ecoregions as defined in the Marine Ecoregions of the World (MEOW) classification scheme; redrawn from Spalding *et al*. 2007.

The expert opinion questionnaire was used to compile following aspects of marine biodiversity for a range of taxonomic groups for each of Indonesia's 12 marine ecoregions:

a. Species richness of the ecoregion, including alpha diversity and genetic diversity;
b. Endemism documented in the ecoregion, including evidence of genetic breaks or "private haplotypes";
c. Significant aggregations of or essential habitats for globally threatened or restricted range species. Migration corridors, nesting beaches, spawning and feeding aggregation sites, and nursery areas were treated under this category.
d. Uniqueness of the ecoregion, including presence of rare species or presence of unique habitats such as marine lakes;
e. Other important biodiversity considerations for the ecoregion, such as unique ecosystem services provided, vulnerability and/or resilience to climate change, and conservation opportunities.

In addition to providing the biodiversity assessments listed above for each marine ecoregion, experts were also asked to 1) idenfity specific sites within each ecoregion that merit targeted conservation investment, 2) identify sites or ecoregions that are highly data-deficient and in urgent need of further survey work, and 3) based on the data they presented, rank on a scale of 1-12 the priority of each marine ecoregion in Indonesia for marine biodiversity conservation investment and improved management of marine resources.

Selection of Experts for Prioritization Exercise

Many factors will eventually influence the decisions on where the Government of Indonesia, donors and conservation groups invest marine conservation and resource management funding and effort. These influencing factors range from biodiversity to cultural priorities, feasibility of success, presence of local enabling conditions for effective management, donor priorities, as well as purely political considerations. The aim of the present prioritization process was to create a scientifically-defensible prioritization of regions within Indonesia based purely on marine biodiversity considerations, primarily irreplaceability and representativeness attributes. As such, experts who were invited to complete the prioritization questionnaire generally fulfilled the following three criteria:

a) Have conducted extensive field observations/research that spans the entire Indonesian Archipelago, optimally from Sumatra to Papua, Bali to North Sulawesi;
b) Were able to complete the prioritization questionnaire based upon their own observations and datasets, and reference those datasets as necessary within the questionnaire;
c) Are recognized internationally as an expert on a specific component of Indonesian marine biodiversity and have a strong publication record in this regard.

Questionnaire Responses

Questionnaires were distributed in June 2009 and were returned by 15 July 2009. In total, sixteen experts completed the questionnaire and ranking process, and an additional four experts provided important supplementary information Respondents provided extensive quantitative data representing several centuries' worth of their combined research efforts across Indonesia, including inputs from several major international databases, and based on a broad taxonomic sample.

A brief summary of the questionnaire responses is provided below:

- *Scientists submitting full questionnaires and rankings (in alphabetical order):*
  Dr. Gerald Allen, Dr. Paul Barber, Dr. Stuart Campbell, Dr. Lyndon Devantier, Dr. Mark Erdmann, Dr. Matheus Halim, Tetha Hitipeuw, Dr. Guswindia, Dr. Bert Hoeksema, Dr. Malikusworo Hutomo, Benjamin Kahn, Dr. Yus Noor, Dr. M. Kasim Moosa, Ketut Sarjana Putra, Dr. Suharsono, Dr. Emre Turak
- *Scientists providing supplementary information:*
  Dr. Jack Randall, Dr. Rod Salm, Dr. Charlie Veron, Dr. Carden Wallace
- *Inputs from major comprehensive databases:*
  Indonesian Institute of Sciences' Research Centre for Oceanography (P2O LIPI) coral reef database, Coral Geographic database, Gerald Allen/Conservation International's Indo-Pacific Fish Distribution Mapping Program, Leiden Museum (Netherlands) database on fungiid distribution, Wetlands International database
- *Taxonomic coverage in questionnaire responses:*
  Respondents provided detailed information on the following taxonomic groups: coral reef fishes, reef-building hard corals, fungiid corals, mangroves, reef and soft bottom stomatopods, other

crustaceans, sea turtles, cetaceans, anguillid eels, waterfowl, crocodiles, Dugongs, and seagrasses. Additionally, marine population genetic data was provided for 25 marine taxa including but not limited to corals, clams and fishes.

Prioritization Workshop Process

The results of the expert opinion questionnaires were compiled and analyzed to produce a first iteration ranking of Indonesia's marine ecoregions, and a preliminary gap analysis that compared priority rankings to current MPA network coverage. These compiled results were then presented at a workshop in Bali on 16 July 2009 attended by top biodiversity scientists (from LIPI and other institutions), members of Indonesia's Coral Triangle Initiative National Coordination Committee and members of USAID's Coral Triangle Support Partnership. Workshop participants discussed the results in detail and refined a series of recommendations to the Indonesian government based on the ranking results and gap analysis.

On the following day (17 July 2009), a high-level workshop of Indonesian government officials (including the Ministry of Fisheries, Ministry of Environment, LIPI, the Indonesia National Planning Agency BAPPENAS, and the CTI National Coordination Committee), Indonesian biodiversity scientists and members of USAID's Coral Triangle Support Partnership (see participant list in Appendix II) was convened. The results of the prioritization exercise (including the gap analysis and set of 6 primary recommendations resulting from the exercise) were presented at the workshop and discussed in detail. Workshop participants provided additional inputs to the prioritization process, namely considerations of vulnerability, conservation opportunities, and constraints. These inputs have been incorporated into the final gap analysis and recommendations listed at the end of this report.

3 Data Inputs from Questionnaires

Respondents provided a wealth of both quantitative data and qualitative insights on the distribution of marine biodiversity in Indonesia. We will not attempt to summarize and discuss all of these inputs herein, as the completed expert questionnaires are included in Appendix V of this report. Rather, we provide below a brief summary of archipelago-wide patterns in species richness and endemism for selected taxonomic groups. Where possible, figures and tables present these data for quick and comprehensive understanding of these patterns. This section is followed presentation of selected inputs on other important aspects of Indonesian marine biodiversity for each ecoregion, including aggregations of globally threatened species, presence of unique habitats/rare species, and other considerations.

Archipelago-Wide Patterns of Species Richness and Endemism

1. CORAL REEF FISHES: Inputs from G.R. Allen, M. Hutomo, J.E. Randall

Species richness of coral reef fishes in Indonesia was estimated per ecoregion using a comprehensive mapping program developed by Dr. Gerald Allen, which overlays individual species distribution maps for over 3900 Indo-Pacific coral reef fish species (Allen, 2008). The results of this ecoregional analysis of reef fish species richness are summarized in Figure 2 and Table 1. Ecoregional species richness is estimated to exceed 1700 species in five of the 12 ecoregions of Indonesia (Sulawesi Sea/Makassar Strait, Banda Sea, Lesser Sundas, Papua, and Halmahera), peaking at 1785 species predicted to occur in the Sulawesi Sea and Makassar Strait ecoregion. All of these five sites are considered to harbor extremely high diversity of reef fishes. Using direct field observations, the Papua ecoregion tops the list at 1,511 reef fish species recorded to date, while the Lesser Sundas ranks a distant second at 1,121 species and Halmahera third at 991 species recorded to date. Papua also tops the list in terms of site richness; a total of 331 species of reef-associated fishes have been recorded from a single site in Kaimana.

Patterns of endemism of coral reef fishes differ only slightly from patterns in species richness. Here again, the Papua ecoregion stands out with twenty-five endemic reef fish species recorded to date plus an additional two species that are found only in Papua and Halmahera (Figure 2; Tables 1 and 2). The Lesser Sundas place second in this analysis with 19 endemic fishes recorded, while Palawan/North Borneo hosts 15 endemic reef fishes (though many of these are known only from outside of Indonesia). The Sulawesi Sea/Makassar Strait comprises a mixing zone for these faunas, and thus is home to no endemics despite extremely high estimated species richness. Additional endemics are recorded from Tomini Bay, Western Sumatra, Banda Sea, Halmahera, and Malacca Strait respectively.

Table 1. List of ecoregional/regional endemic coral reef fishes and stomatopods. Undescribed species denoted by a capital letter (e.g., *Gonodactylellus* sp. A).

Marine Ecoregion	N	Reef fish species ecoregional endemics G. Allen Taxa	N	Stomatopod Regional endemics (max four ecoregions) M.V. Erdmann, M.K. Moosa Taxa	N	Stomatopod ecoregional endemics M.V. Erdmann, M.K. Moosa Taxa
Papua	25	*Hemiscyllium freycineti, H. galei, H. henryi, Diancistrus niger, Kalyptatherina helodes, Manonichthys jamali, Pictichromis caitlinae, Pseudochromis sp. A., Stalix sp. A, Opistognathus rufilineatus, Apogon oxygrammus, A. leptacanthus, Siphamia sp. A, Hoplolatilus erdmanni, Pterocaesio monikae, Chromis athena, Chromis unipa, Chrysiptera pricei, Pomacentrus fakfakensis, Cirrhilabrus cenderawasih, Paracheilinus nursalim, P. waltoni, Callionymus brevianalis, Calumia sp. A, Eviota raja.* Shared with Halmahera*: Pentapodus numberii, Pseudochromis jace*	12	Gonodactylellus sp. A, Gonodactylellus sp. G, Gonodactylopsis sp. A, Gonodactylopsis sp. C, Odontodactylus sp. A, Chorisquilla mehtae, Haptosquilla sp. A, Haptosquilla sp. C, Haptosquilla sp. E, Haptosquilla trigibbosa, Siamosquilla sp. A, Lysiosquilloides sp. A	4	Gonodactylellus sp. G, Odontodactylus sp. A, Haptosquilla sp. E, Siamosquilla sp. A
Lesser Sundas	19	*Heteroconger tricia, Alionematichthys n. sp., Paradiancistrus lombokensis, Ungusurculus komodensis, Myripristis aulacodes, Bhanotia pauciradiatus, Pseudochromis arulentus, P. cometes, P. flavopunctatus, P. mooi, Pseudochromis n. sp., Apogon microspilus, Chromis pura, Helcogramma kranos, H. randalli, H. solorensis, Callogobius stellatus, Platygobiopsis akihito, Prionurus chrysurus.*	5	Gonodactylopsis drepanophora, Gonodactylopsis komodoensis, Gonodactylopsis sp. A, Chorisquilla mehtae, Haptosquilla sp. B	2	Gonodactylopsis drepanophora, Gonodactylopsis komodoensis
Banda Sea	3	*Pterapogon kauderni, Callionymus amboina, C. obscurus*.	5	Gonodactylopsis sp. A , Gonodactylus sp. A, Chorisquilla mehtae, Haptosquilla trigibbosa, Haptosquilla sp. C	1	Gonodactylus sp. A
Sulawesi Sea/ Makassar Strait	0	0	3	Gonodactylellus barberi, Gonodactylopsis sp. A, Chorisquilla mehtae	1	Gonodactylellus barberi
Halmahera	2	*Ecsenius randalli, Pseudochromis matahari*. Shared with Papua*: Pentapodus numberii, Pseudochromis jace*	8	Gonodactylellus sp. A, Gonodactylellus sp. B, Gonodactylellus sp. F, Gonodactylopsis sp. A, Gonodactylopsis sp. C, Chorisquilla mehtae, Haptosquilla sp. A, Lysiosquilloides sp. A	2	Gonodactylellus sp. B, Gonodactylellus sp. F
Palawan/North Borneo	15	*Atherinomorus reginae, Manonichthys alleni,Pomacentrus armillatus, Pomacentrus geminatus, Ecsenius trilineatus, Meiacanthus gemminatus, Eviota irrasa*, and undescribed species of *Pseudochromis, Apogon, Opistognathus, Stalix (2 species), Pomacentrus, Halichoeres, Pandaka*	0	0	0	0
Western Sumatra	4	*Pseudanthias cichlops, Cirrhilabrus adornatus Cirrhilabrus joanallenae, Ecsenius polystictus*.	3	Gonodactylopsis sp. B, Chorisquilla sp. B, Haptosquilla moosai	1	Chorisquilla sp. B
NE Sulawesi/Tomini Bay	6	Sargocentron shimizui, Plesiops facicavus, Cirrhilabrus aurantidorsalis, Paracheilinus togeanensis, Ecsenius caeruliventris, Meiacanthus sp. A	3	Gonodactylopsis sp. A, Chorisquilla mehtae, Haptosquilla togianensis	1	Haptosquilla togianensis
Arafura sea	0	0	0	0	0	0
Sunda Shelf	0	0	0	0	0	0
Southern Java	0	0	0	*Gonodactylopsis sp. B, Haptosquilla sp. B, Haptosquilla moosai*	0	0
Malacca Strait	2	*Cryptocentrus russus,Cirrhilabrus naokoae*	2	0	0	0

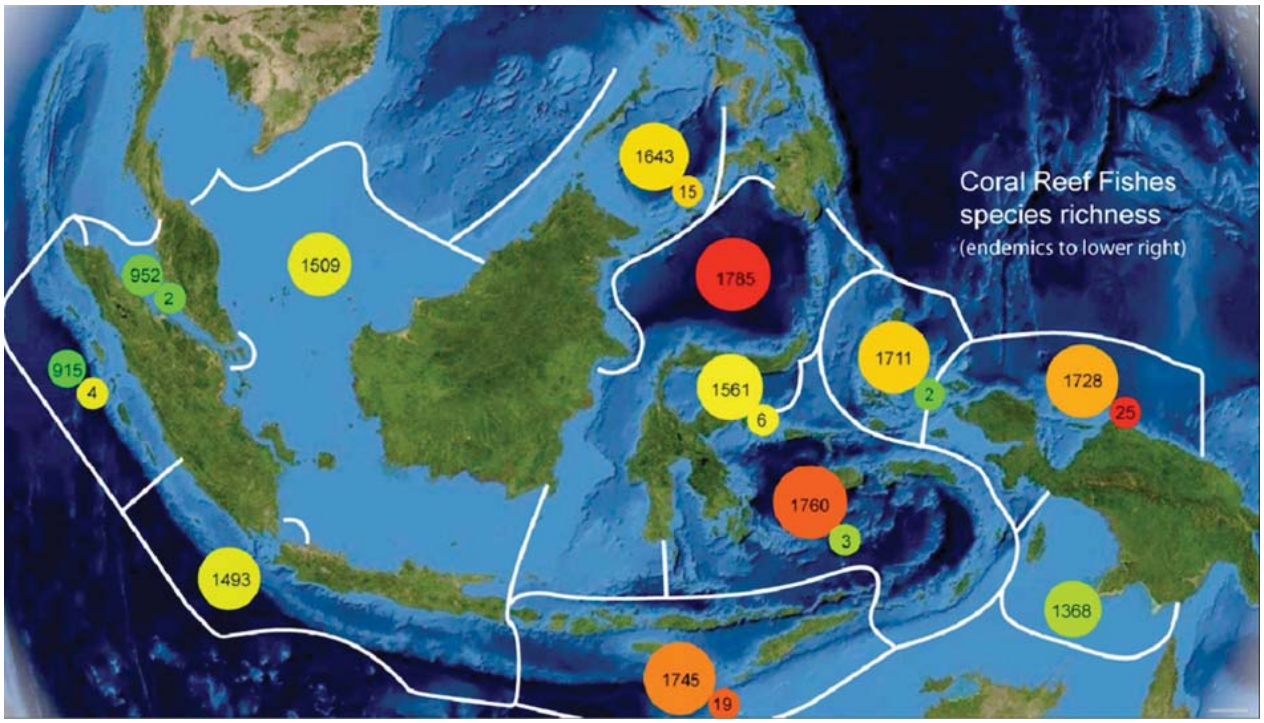
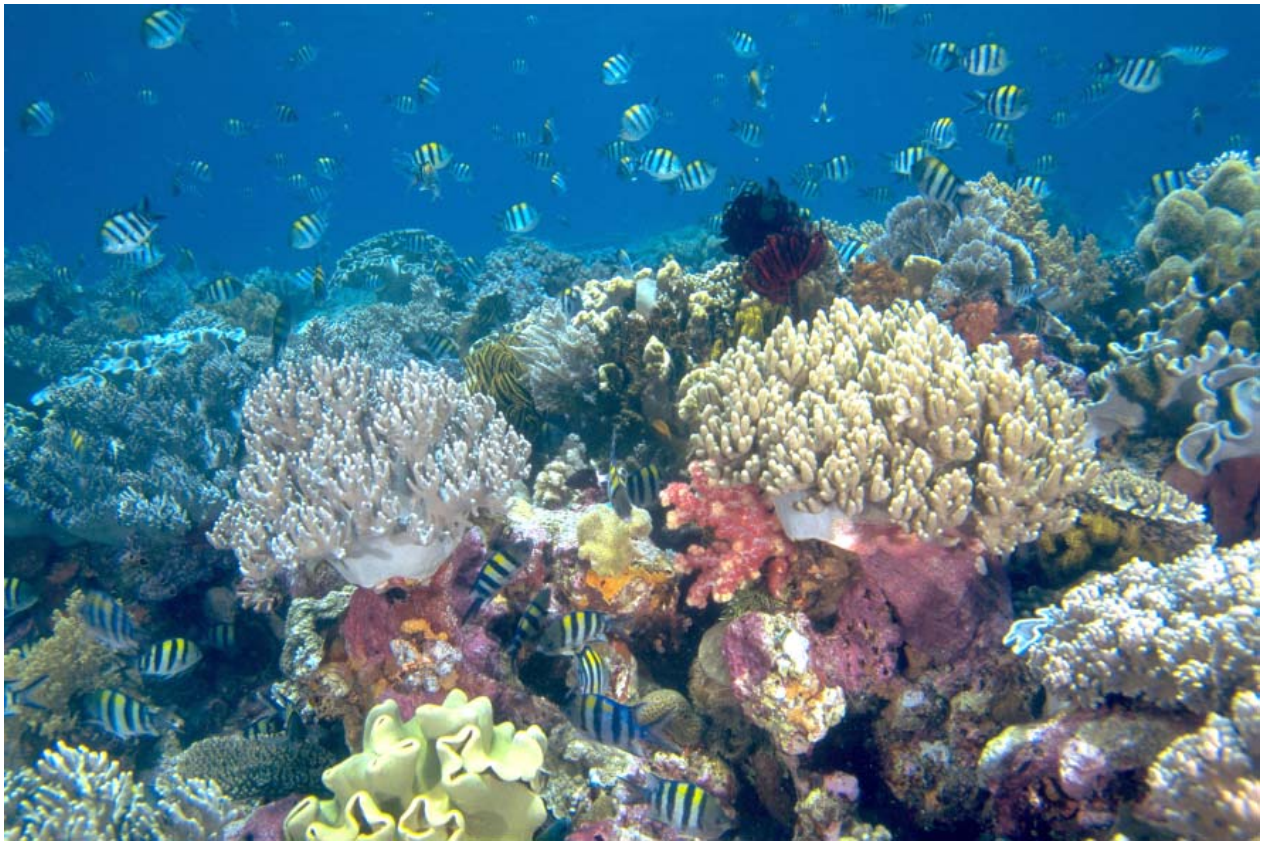


Figure 2. Map showing coral reef fish species richness (estimated based on overlays of over 3900 reef fish species distribution maps) and endemism (direct survey data) per ecoregion. Numbers in large circles are the number of reef fish species estimated to occur in that ecoregion, while numbers in small lower right circles are the number of endemic species recorded from the ecoregion. (G. Allen).



2. CORAL REEF-ASSOCIATED STOMATOPOD CRUSTACEANS: Inputs from M.K. Moosa and M.V. Erdmann

Largely mirroring the patterns observed for reef fishes, the species richness of reef-associated stomatopod crustaceans is highest in eastern Indonesia, with the Papua ecoregion again topping the list (Figure 3; Table 1). Species richness is also extremely high in the Sulawesi Sea/Makassar Strait, Lesser Sundas, Banda Sea, and Halmahera (Figure 3). This same pattern is also reflected in the distribution of endemics, with more endemics being found in species rich areas (Figure 4; Tables 1 and 2). With the exception of one species in Western Sumatra, all endemic reef-associated stomatopod species in Indonesia occur within and east of the Sulawesi Sea/Makassar Strait/Lesser Sundas. In essence, ecoregions that are exposed during glacial maxima are now known to harbor endemics, while those inundated do, in particular those with isolated seas that may facilitate speciation during these conditions.

We note that the patterns of species richness change slightly if the taxonomic scope of this analysis is expanded to include both soft-bottom and reef-associated stomatopods; in this case, the Banda Sea ecoregion tops the list at 65 species recorded, whereas Papua and the Sunda Shelf/Java Sea ecoregions tie for second with 62 species recorded (Table 1). These figures may be biased by uneven sampling effort of soft-bottom stomatopod assemblages, with much higher effort focused on the Sunda Shelf/Java Sea and Banda Sea ecoregions, respectively.

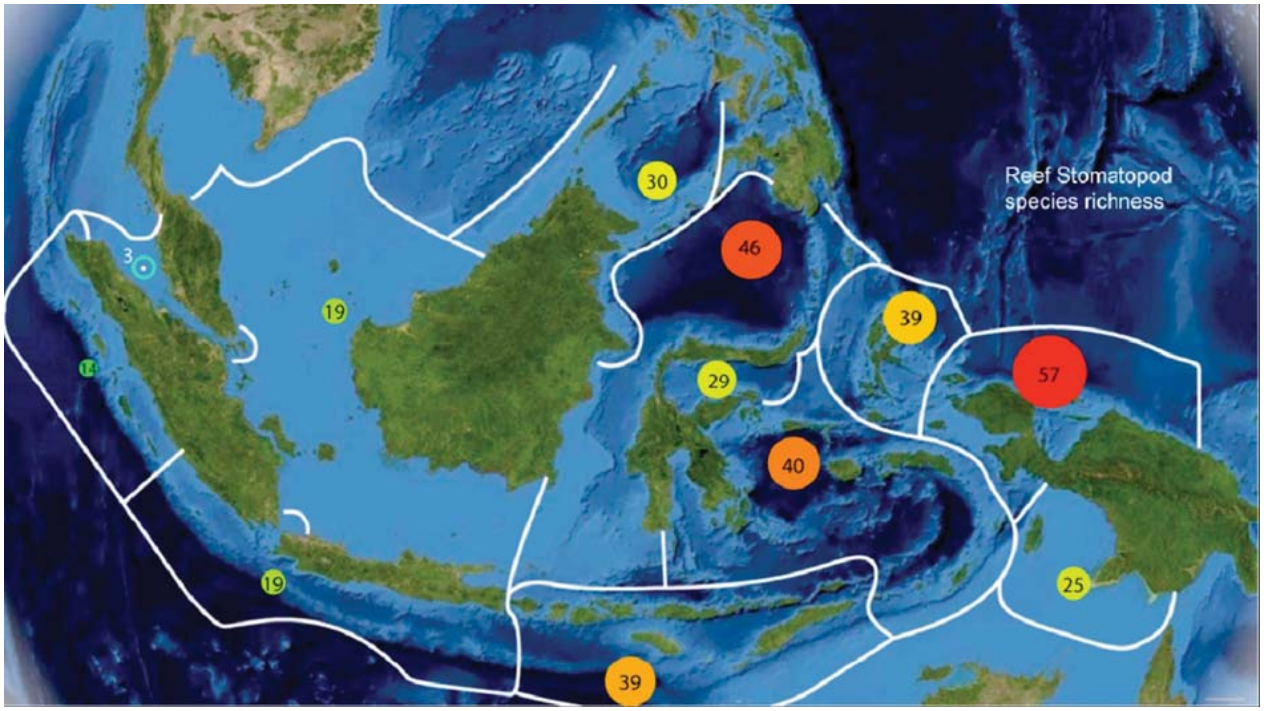


Figure 3. Reef-associated stomatopod species richness per ecoregion. Numbers within circles represent the number of reef associated stomatopod species known from that ecoregion (M.V. Erdmann, M.K. Moosa)

Table 2. Summary of species richness and endemism data per marine ecoregion for select taxonomic groups as compiled from completed Prioritization Questionnaires. *a stomatopod ecoregional endemic is known only from that ecoregion; a regional endemic is found in no more than 4 adjacent ecoregions. UNK indicates species richness unknown.

Marine Ecoregion	Reef Fish Species Richness G. Allen	Reef Fish Endemics G. Allen	Fungiid Species Richness B. Hoeksema	Reef-associated Stomatopod Species Richness M.V. Erdmann, M.K. Moosa	Total Stomatopod Species Richness (including soft-bottom habitats) M.K. Moosa, M.V. Erdmann	Stomatopod Regional (Ecoregional) Endemics* M.V. Erdmann, M.K. Moosa	Mangrove-associated and Oceanic Birds Species Richness Y.R. Noor	Mangrove Vegetation Species Richness Y.R. Noor	Sea Turtle Species Richness M. Halim. K. S.Putra, C. Hitipeuw, Guswindia
Papua	1728	25	40	57	62	12 (4)	96	35	4
Lesser Sundas	1745	19	39	39	42	5 (2)	206	22	5
Banda Sea	1760	3	36	40	65	5 (1)	173	12	5
Sulawesi Sea/ Makassar St	1785	0	46	37	54	3 (1)	318	23	2
Halmahera	1711	2	*amat kaya*	38	40	8 (2)	157	UNK	4
Palawan/N. Borneo	1643	15	40	30	34	0 (0)	UNK	UNK	3
Western Sumatra	915	4	18	14	17	3 (1)	19	UNK	6
NE Sulawesi/ Tomini Bay	1561	6	28	29	29	3 (1)	144	8	2
Arafura sea	1368	0	UNK	25	29	0 (0)	202	53	5
Sunda Shelf/Java Sea	1509	0	26	19	62	0 (0)	374	31	6
Southern Java	1493	0	29	19	38	3 (0)	115	25	4
Malacca Strait	952	2	15	3	10	0 (0)	63	35	3

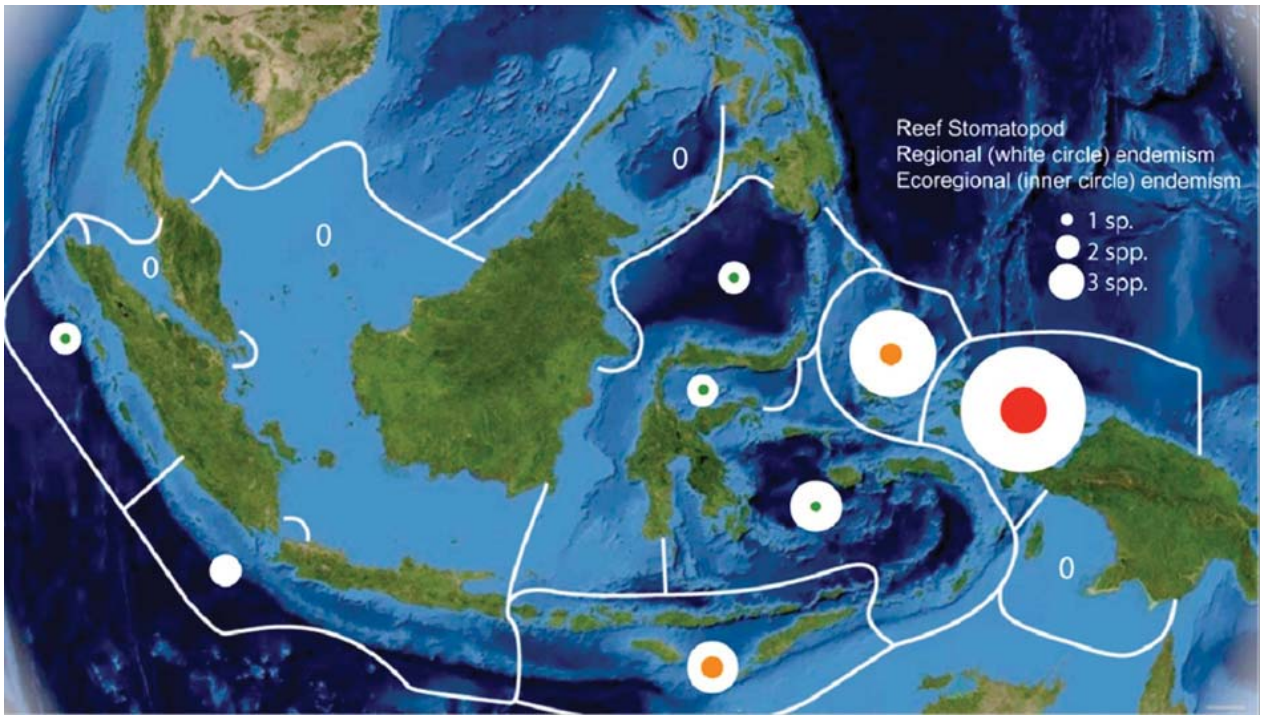


Figure 4. Reef-associated stomatopod ecoregional and regional endemism per ecoregion. An ecoregional endemic is found only in that ecoregion; a regional endemic is recorded from no more than 4 adjacent ecoregions. The size of the white circle indicates number of regional endemics, while the size of the inner coloured circle indicates number of ecoregional endemics (M.V. Erdmann, M.K. Moosa).

3. CORALS: Inputs from Suharsono, B. Hoeksema, E. Turak, L. DeVantier, C. Wallace and J.E.N. Veron

Hard coral species richness also peaks in eastern Indonesia, with the Sulu/Sulawesi Seas and Makassar Strait forming the western boundary and the Lesser Sundas forming the southern boundary of the 500 species isocline that defines the Coral Triangle (Figure 5). The most comprehensive database of hard coral species distributions in the region is Veron and colleague's Coral Geographic (www.coralreefresearch.org); however, those authors utilize 16 "coral ecoregions" that divide Indonesia more finely than the 12 MEOW ecoregions used in this exercise, making it difficult to compare directly (Figure 6; Table 3). Nonetheless, the coral ecoregion boundaries are close enough to the MEOW boundaries to compare general patterns of species richness across Indonesia. The total species richness of all hard corals is once again highest in Papua; 553 hard coral species are found in the Raja Ampat Islands alone. This is closely followed by the Celebes Sea (within the Sulawesi Sea/Makassar Strait ecoregion, with 545 species), and Halmahera (544 species). Patterns in fungiid (mushroom coral) species richness (Figure 7; Table 1) are similar on the large scale (higher in eastern Indonesia), although richness is highest by far in the Sulawesi Sea/Makassar Strait ecoregion (46 species), followed closely by Papua and Palawan/North Borneo (40 species respectively).

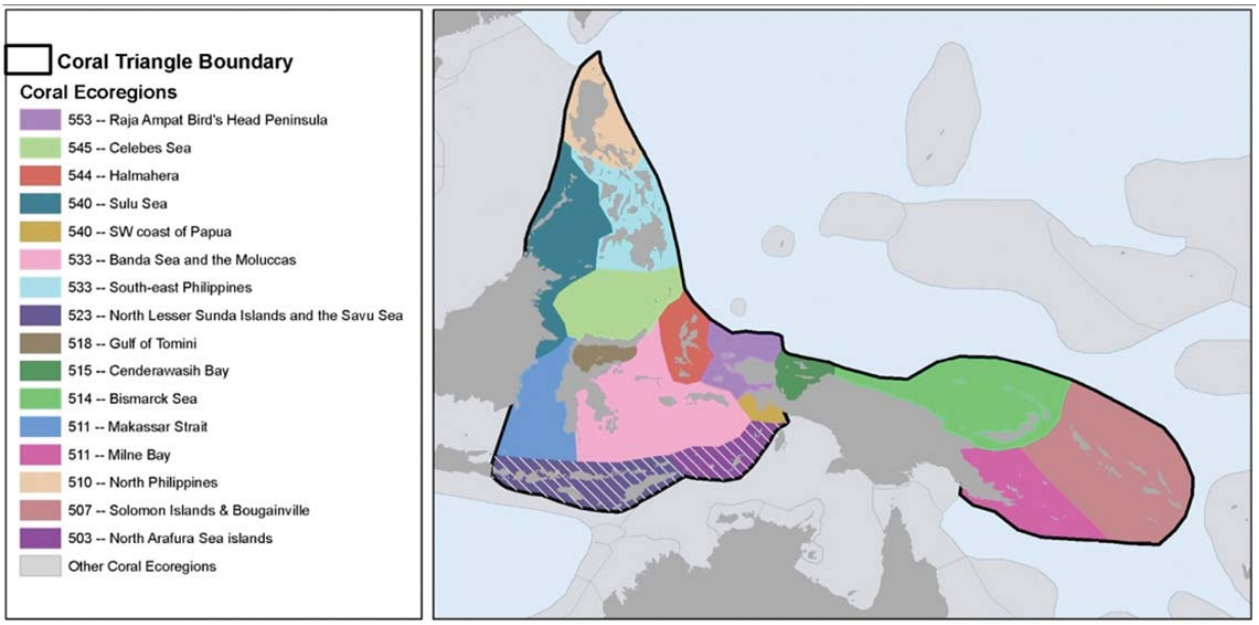


Figure 5. Coral ecoregions of the Coral Triangle (CT), which is defined by the 500 species isocline. Some islands of southern Indonesia (the two hatched ecoregions), especially their southern coastlines, and other areas, remain data-deficient. Each coral ecoregion within the Coral Triangle has >500 species. The CT as a whole has 605 species, of which 66% are common to all ecoregions. Figure used with permission from Veron and colleague's *Coral Geographic* database.

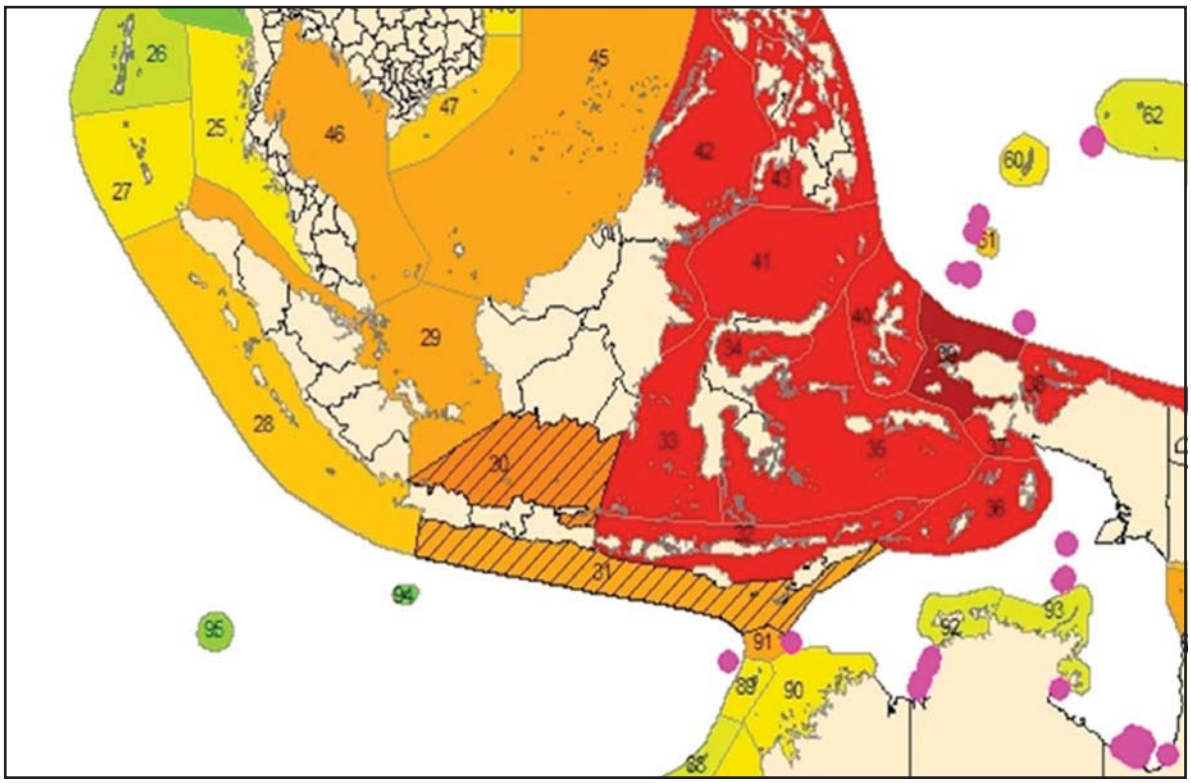


Figure 6. **Map of Coral Ecoregions defined in Coral Geographic (Veron *et al*. unpublished data www.coralreefresearch.org). The boundaries between ecoregions 31, 32 and 36 (Java, Lesser Sundas/ Savu Sea, and North Arafura Sea) are not yet clear, hence the hatching in the map.**

Table 3. Comparison of hard coral species richness between the coral ecoregions (ER) mapped in Coral Geographic (Veron *et al*. unpublished data www.coralreefresearch.org); ecoregion numbers refer to the map in Figure 6.

Coral Ecoregion	Name of Coral Ecoregion	Number of Hard Coral Species	MEOW Ecoregions represented within Coral Ecoregion
27	Nicobar Islands	306	Western Sumatra
28	West Sumatra	387	Western Sumatra
29	Malacca Strait and Selat Karimata	408	Malacca Strait, Sunda Shelf/Java Sea
30	Java Sea	455	Sunda Shelf/Java Sea
31	Java	517	Southern Java, Lesser Sundas
32	Lesser Sunda Islands and Savu Sea	523	Lesser Sundas
33	Makassar Strait	511	Sulawesi Sea/Makassar Strait
34	Gulf of Tomini	518	NE Sulawesi/ Tomini Bay
35	Banda Sea and the Moluccas	533	Banda Sea
36	North Arafura Sea islands	UNK	Banda Sea, Arafura Sea
37	SW coast of Papua	540	Papua
38	Cendrawasih Bay	515	Papua
39	Raja Ampat, Bird's Head Peninsula	553	Papua
40	Halmahera	544	Halmahera
41	Celebes Sea	545	Sulawesi Sea/Makassar Strait
42	Sulu Sea	540	Palawan/North Borneo
45	South China Sea	478	Sunda Shelf/Java Sea, Palawan/North Borneo

With respect to endemicity, many of the coral researchers noted their discomfort in labeling any given coral species as endemic to an ecoregion, citing numerous examples of species that were once thought to be endemic but with further research efforts were eventually recorded 100's to 1000's of kilometers from their originally described ranges. In general, it seems that the life histories and patterns of evolution in corals may render the concept of endemicity less relevant for this group. Nonetheless, several ecoregions were noted as hosting possible coral species endemics, including Papua's Cendrawasih Bay (>10 species), the Lesser Sundas (6 species), Western Sumatra (2 species), and Tomini Bay and the Sunda Shelf (1 species each).

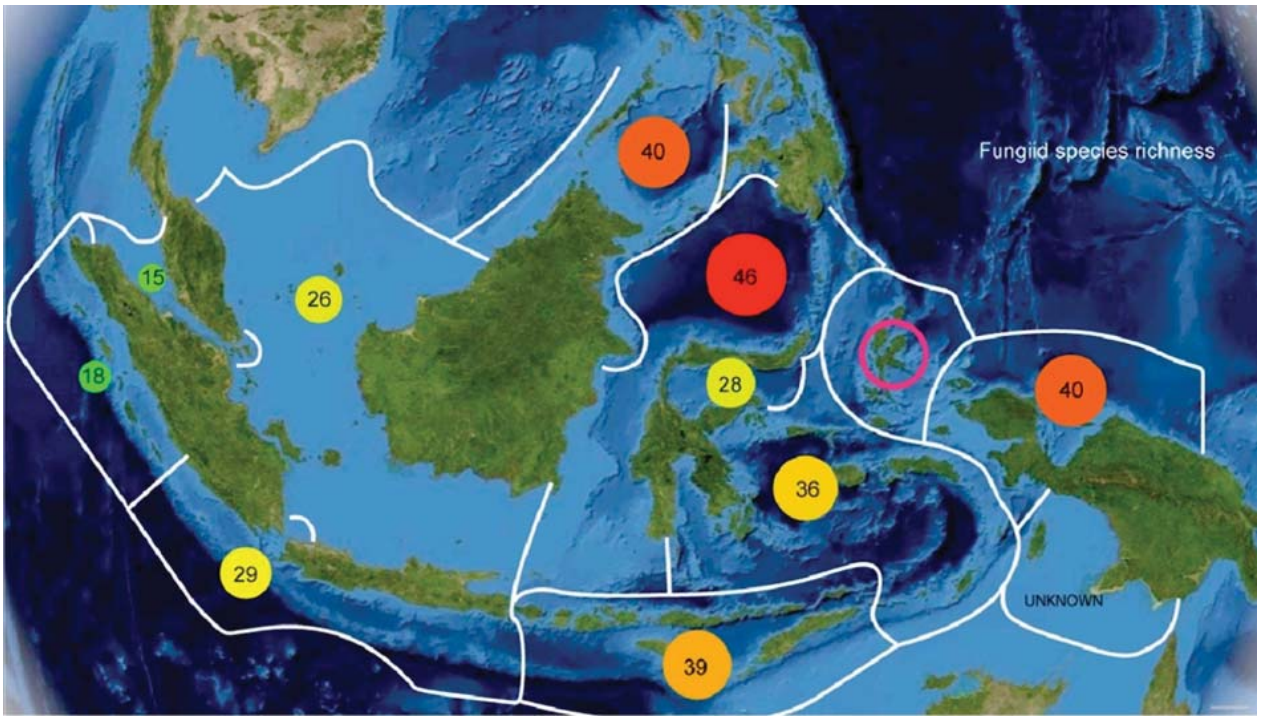


Figure 7. Fungiid coral species richness per ecoregion. Fungiid species richness in Halmahera is expected to be very high but remains unknown. (B. Hoeksema).

4. CETACEANS: Inputs from B. Kahn

The population status and diversity of cetaceans is largely unknown throughout most of Indonesia. Because of the large home ranges utilized by many species in this group, ecoregion boundaries may offer little utility for prioritization. Rather, two main habitats across Indonesia are of concern; deep-sea habitats sustain great whales and oceanic dolphins while coastal cetaceans rely on nearshore waters, particularly those with relatively undisturbed coastlines such as those found on the southern coast of Papua and eastern coast of Kalimantan. Particularly rich in marine mammal diversity and food sources are those coastlines that offer deep-sea environments near to shore, including but not limited to seamounts and the deep-water channels that cut through the Lesser Sundas. Several existing MPAs, such as Bunaken National Park in North Sulawesi and the Raja Ampat MPA network in Papua, lend themselves to slight expansion offshore in order to capture these oceanographic features that are so important to cetaceans. In particular at least 9 areas, contained within 6 ecoregions, stand out for their special importance to cetaceans (Figure 8). Although comprehensive data on species richness of cetaceans found throughout Indonesia does not yet exist, Table 4 provides an indication of the levels of diversity recorded for several sites within the Papua and Lesser Sunda Ecoregions.

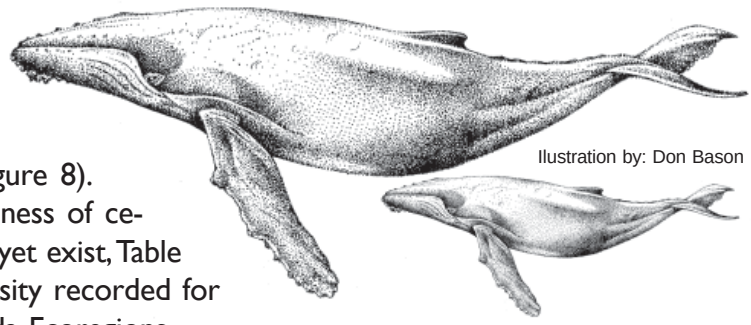


Illustration by: Don Bason

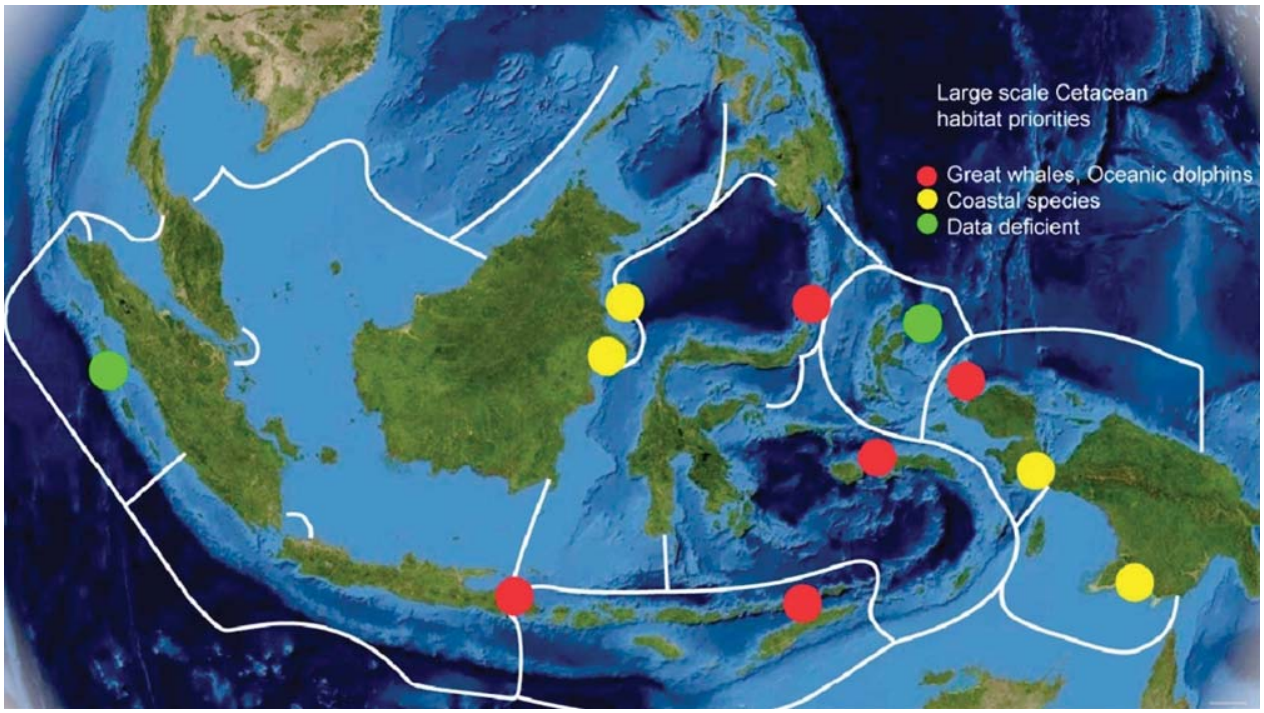


Figure 8. Areas of special concern for oceanic and coastal cetaceans. Red circles indicate areas of special concern for great whales and oceanic dolphins; yellow circles for coastal cetaceans, and green circles indicate data-deficient areas that are nonetheless suspected to be highly diverse in cetaceans (B. Kahn).

Table 4. Lists of marine mammal species recorded from the Lesser Sundas and Papua during surveys in 2005, 2006 and 2007. An X denotes species recorded during survey (B. Kahn).

Common Name	Taxon Name	Raja Ampat (on going)	Solor Alor/ Savu Sea (on going)	Bali – Lombok (3 days survey)
Toothed whales – Odontocetes				
Killer whale	Orcinus orca	X	X	
False killer whale	Pseudorca crassidens	X	X	X
Pygmy killer whale	Feresa attenuata		X	X
Sperm whale	Physeter macrocephalus	X	X	
Dwarf sperm whale	Kogia sima	X	X	
Pygmy sperm whale	Kogia breviceps	X	X	
Spinner dolphin	Stenella longirostris	X	X	
Pan tropical spotted dolphin	Stenella attenuata	X	X	X
Risso's dolphin	Grampus griseus	X	X	
Indo-Pacific bottlenose dolphin	Tursiops aduncus	X	X	
Common bottlenose dolphin	T. truncatus	X	X	X
Fraser's dolphin	Lagenodelphus hosei	X		X
Indo-Pacific humpback dolphin	Sousa chinensis	X		
Long-nosed spinner dolphin	S. longirostris			X
Rough-toothed dolphin	S. bredanensis		X	X
Melon-headed whale	Peponocephala electra	X	X	
Short Fined pilot whale	Globicephala macrorhynchus	X	X	X
Cuvier's beaked whale	Ziphius cavirostris		X	
Baleen whales - Mysticetes				
Blue whale	Balaenoptera musculus			
Bryde's whale	B. brydel	X	X	X
Pygmy Bryde's whale	Balaenoptera edeni	X	X	
Humpback whale	Megaptera novaeangliae		X	
Sea cows – Sirenidae				
Dugong	Dugong dugon	X	X	

5. SEA TURTLES: Inputs from M. Halim, K.S. Putra, C. Hitipeuw, Guswindia

Indonesia plays a globally significant role in sustaining six of the world's seven sea turtle species (all but the Kemp's Ridley; Figure 9). Numerous tagging studies have demonstrated the migratory connectivity of adult Green turtles moving between important nesting and feeding grounds in Indonesia, Malaysia, the Philippines and Australia. Leatherbacks that nest along the north coast of Papua have been shown to migrate to as far as coasta California to feed (Benson *et al.*, 2007; Hitipeuw *et al.*, 2007). Thus the long-term survival of sea turtles in Southeast Asia and beyond relies on the successful protection of Indonesia's nesting beaches from habitat destruction via coastal development, erosion, and pollution. While important turtle nesting beaches and foraging grounds span the entire archipelago, with each species favoring different areas, several regions stand out as playing a particularly important role in sea turtle reproduction.

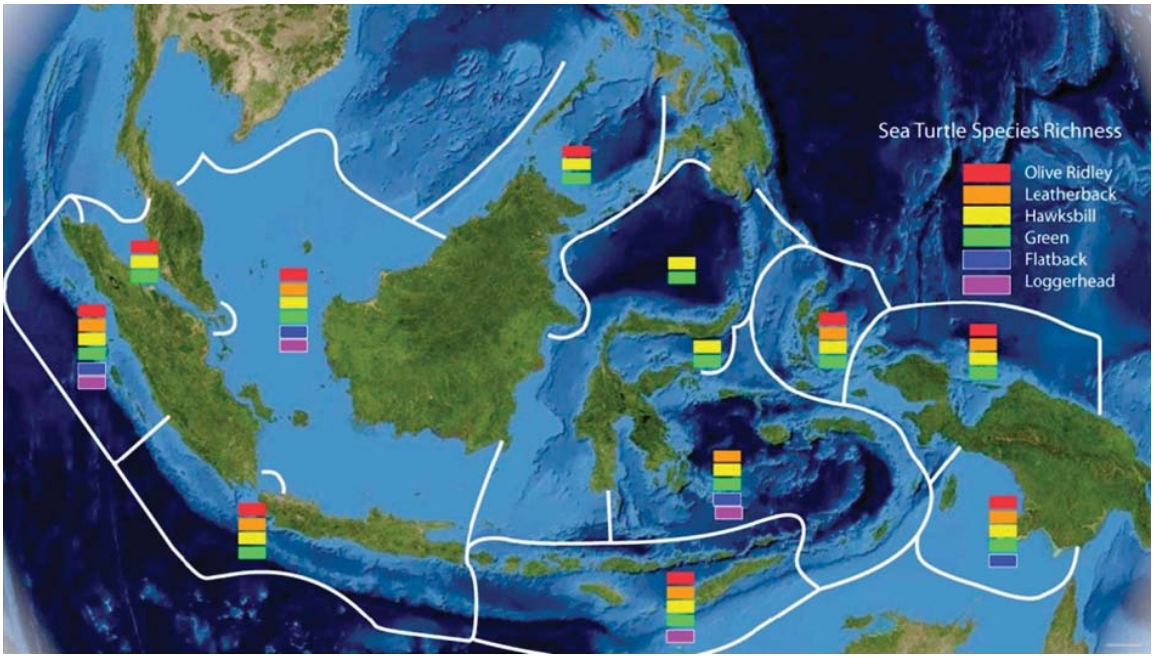


Figure 9. Sea Turtle species diversity in the marine ecoregions of Indonesia (M. Halim, T. Hitipeuw, Guswindia, K. Putra).

All six sea turtles found in Indonesia can be found in both the Western Sumatra and the Sunda Shelf/Java Sea ecoregions. These regions provide essential nesting grounds for thousands of Green and Hawksbill turtles each year (Figures 10 and 11). Hawksbills from Thailand forage and mate in Western Sumatra. The largest Green turtle rookeries in all of SE Asia are found in the Palawan/North Borneo ecoregion (East Kalimantan within Indonesia), whereas the Leatherback turtle nesting beaches on the north coast of Papua are the largest in the Pacific Ocean (Figure 12). Other ecoregions with important Leatherback nesting sites include South Java (particularly Alas Purwo National Park) and Western Sumatra, while the Banda Sea holds important foraging grounds for

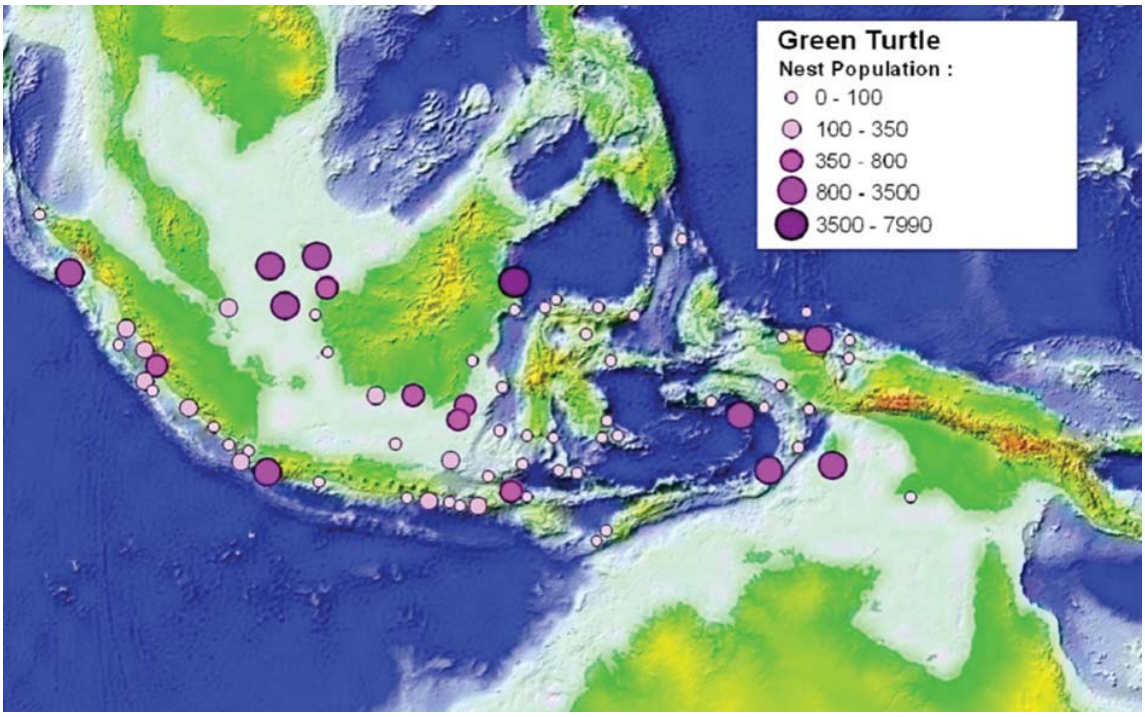


Figure 10. Green turtle nesting populations across Indonesia. (K. Putra).

Leatherbacks. The Arafura Sea is a major nesting region for Green turtles, foraging ground for Greens and Olive Ridleys, and migration corridor for Greens, Olive Ridleys and Leatherbacks. Finally, Papua and South Java also have significant nesting beaches for Green turtles.

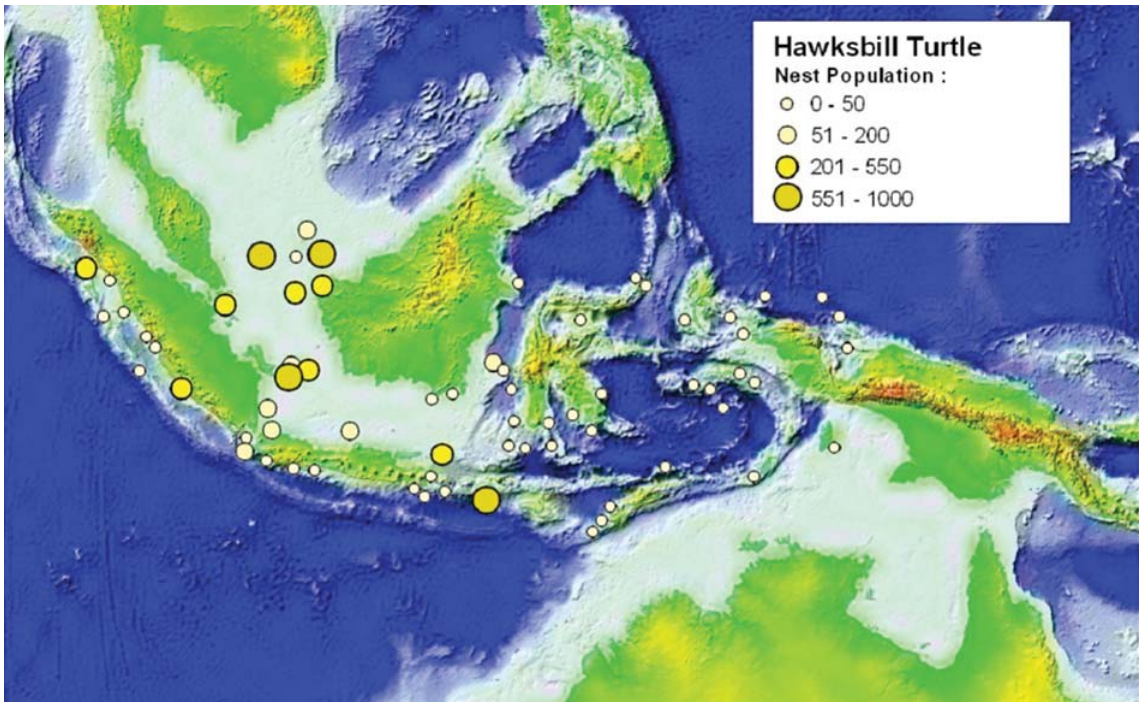


Figure 11. Hawksbill turtle nesting populations across Indonesia. (K. Putra).

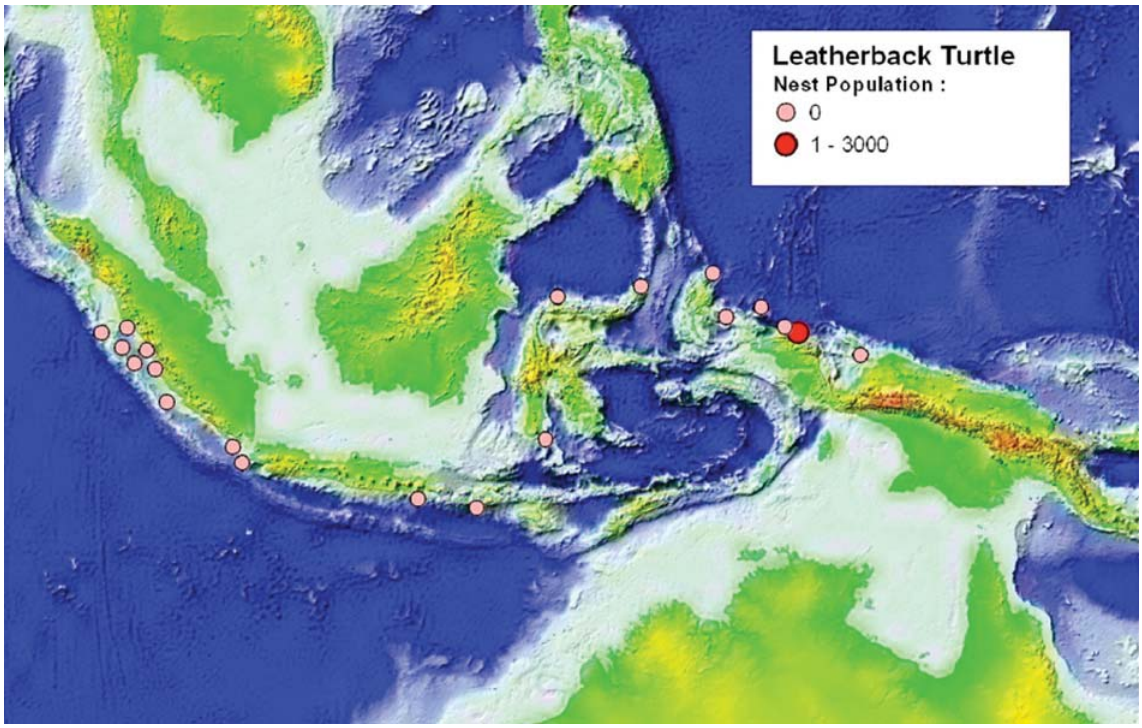


Figure 12. Leatherback turtle nesting populations across Indonesia. The small pink circles indicate areas that are known or reported as nesting sites but for which accurate population figures are not available (K. Putra).

6. MANGROVE COMMUNITIES, SEAGRASS, DUGONGS, and SEABIRDS: Inputs from Y. Noor, M. Hutomo, and S. Campbell

The mangrove and seagrass habitats of Indonesia, and their associated fauna including Dugongs and seabirds, reveal strikingly different patterns in ecoregional diversity compared to that seen with coral reef biota, highlighting the need for a multi-faceted approach to prioritization of marine ecoregions in this expansive and habitat-rich archipelago. In stark contrast to the results presented above for coral reef fauna, the shallow waters of the Arafura Sea and the Sunda Shelf/Java Sea are exceedingly important to mangrove and seagrass communities as well as seabirds and Dugongs. The Malacca Strait, which is sparse for coral reef habitat and heavily impacted by human activities, boasts plentiful aggregations of vulnerable or critically endangered seabirds. This ecoregion is the most important habitat globally for the Milky Stork *Mycteria cinerea,* one of the most critically endangered birds in the world. MPAs prioritized and designed to protect coral reefs will not necessarily encompass these critical habitats sustaining mangrove and wetland communities, and the seabirds, reptiles, and marine mammals that rely upon them. As such, it is exceedingly important for Indonesia's national MPA strategy and representative system of MPAs to explicitly consider mangrove and seagrass priorities in addition to the more commonly-highlighted coral reef priorities.

For mangrove ecosystems, the Arafura Sea ranks top in terms of mangrove species richness with 53 species, followed by Papua and the Malacca Strait, each with 35 species recorded (Figure 13; Table 5). Mangrove areas of special conservation concern include the Aru Island and Lorentz Na-

Table 5. Data on extent of seagrass habitats and areas of special concern for threatened species. Abbreviations: Avifauna Areas: CS = Colonial Seabirds, CW = Colonial Waterbirds, MW = Migratory Waterbirds; Marine Mammals: C = Coastal marine mammals, O = Oceanic marine mammals including great whales, DD = Data deficient; Dugongs: UNK = Unknown; Crocodiles: N = No, Y = Yes; Seagrass: F = Seagrass associated with Fringing Reef; M = Seagrass associated with Mangrove.

Marine Ecoregion	Avifauna Areas of Special Concern: Type (No. sites) Y. R. Noor	Priority Sites for Marine Mammals (No. sites) B. Kahn	Dugong populations S. Campbell, M. Hutomo	Significant Crocodile populations Y. R. Noor	Seagrass Habitat M. Hutomo, S. Campbell
Papua	0	O(1), C(1)	>100	Y	F, Large
Lesser Sundas	MW(2)	O(2)	>100	Y	F,M Large
Banda Sea	MW(2), CS(1)	O(1)	>50	Y	F,M Large
Sulawesi Sea/Makassar St	MW(2)	O(1)	>100	Y	F,M Large
Halmahera	0	DD	>50	Y	F, Large
Palawan/N. Borneo	MW(1)	C(2)	>5	Y	F,M Present
Western Sumatra	MW(1)	DD	>1	Y	F,M Medium
NE Sulawesi/Tomini Bay	0	0	UNK	Y	F Small
Arafura sea	MW(2)	C(1)	>200	Y	M Large
Sunda Shelf/Java Sea	MW(6), CW(2)	0	>100	T	F Large
Southern Java	CW(1)	0	UNK	T	F,M Present
Malacca St	MW(1)	0	UNK	Y	M few

tional Park in the Arafura Sea, Bintuni Bay in Papua, the Banyuasin Delta in the Sunda Shelf ecoregion, and Karang Gading in the Malacca Strait (Figure 14, Table 3).

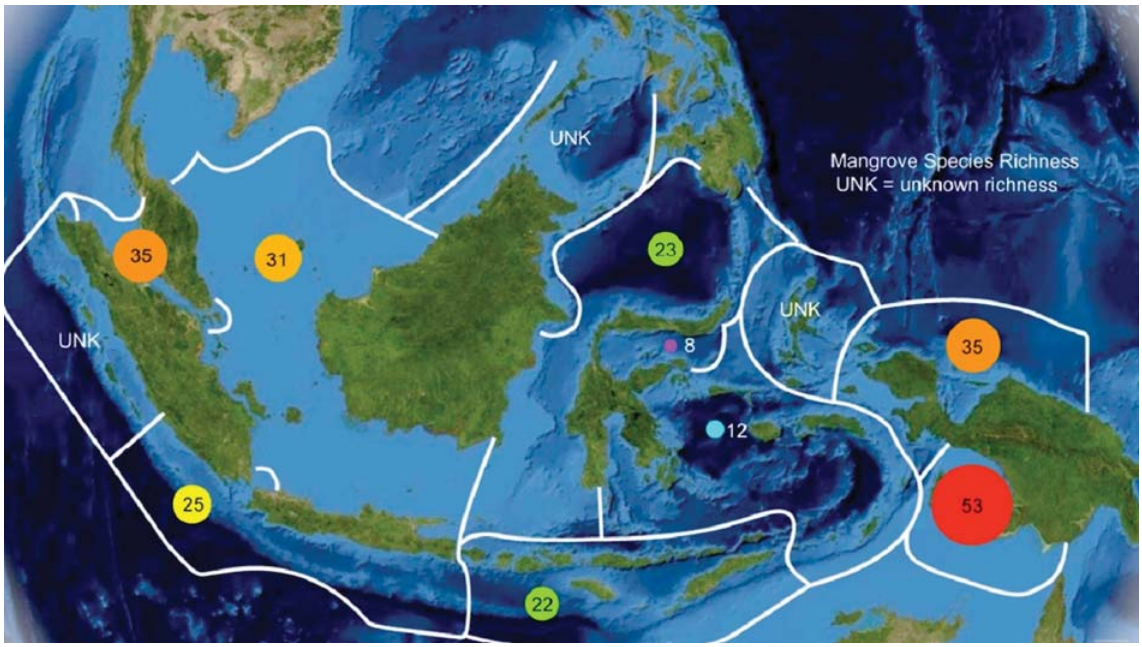


Figure 13. Map of mangrove species richness across Indonesian ecoregions (Y. Noor).

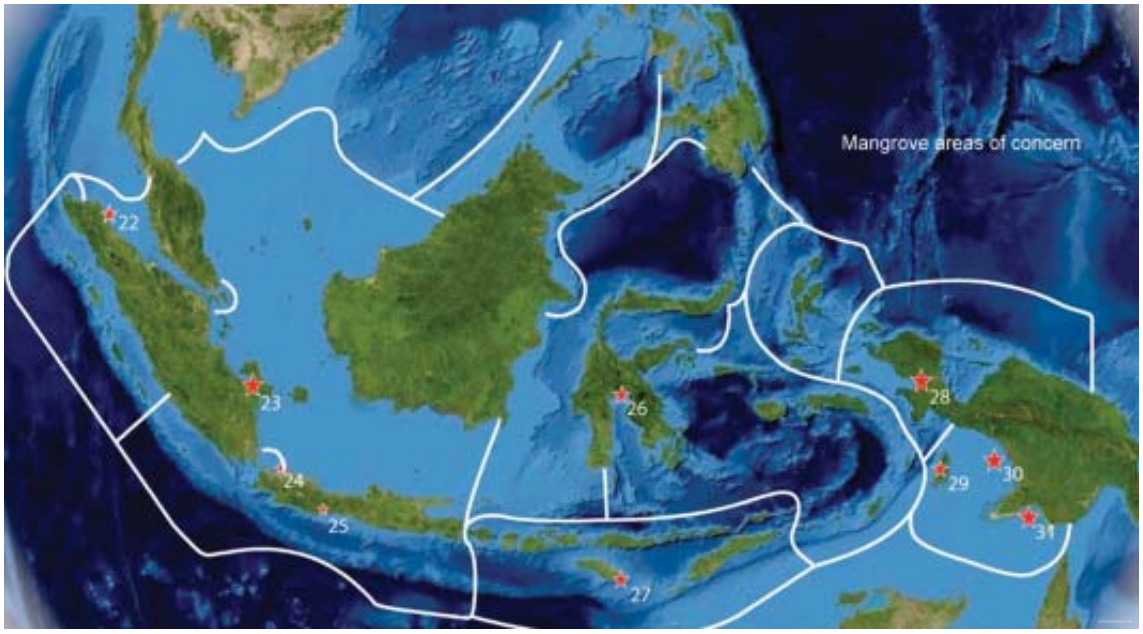


Figure 14. Map of mangrove areas of special conservation concern in Indonesia. Size of red star indicates relative importance; numbered site names listed in Table 3. (Y. Noor).

The Sunda Shelf/Java Sea ecoregion is the most critical and globally significant ecoregion in Indonesia with respect to the conservation of mangrove-associated, migratory and colonial seabirds and waterbirds. This ecoregion is the most species-rich for these groups (374 species recorded), and hosts a large number of endemic and threatened (vulnerable to critically endangered) species (Figures 15 and 16; Table 6). The Sulawesi Sea/Makassar Strait ecoregion ranks second in terms of seabird richness (318 species), followed by the Lesser Sundas (206 species) and Arafura Sea (202 species). The Arafura Sea (Wasur National Park and Rawa Biru) also contains regionally important stopping and foraging grounds for seabirds along international migratory routes, as do the Lesser Sunda ecoregion (specifically Teluk Kupang and Sumba Timur) and the Java Sea (including Indramayu and the Bengawan Solo Delta). The Banda Sea (Pulau Manuk) is perhaps the most important area in Indonesia for colonial seabirds, while the Sunda Shelf/Java Sea (Banyuasin Delta, Pulau Rambut and Ujung Pangkah) and Southern Java (Pulau Dua) ecoregions are well known for their importance to colonial waterbirds (Figure 17, Table 3).

The most expansive seagrass beds are found in the Arafura Sea, Papua, the Sunda Shelf/Java Sea, and the Lesser Sundas (Figure 18, Table 6). Not surprisingly, the distribution and estimated population sizes of Dugongs in Indonesia closely mirror patterns of seagrass extent, with the Arafura Sea, Papua, and the Lesser Sundas topping the rankings (Figure 19).

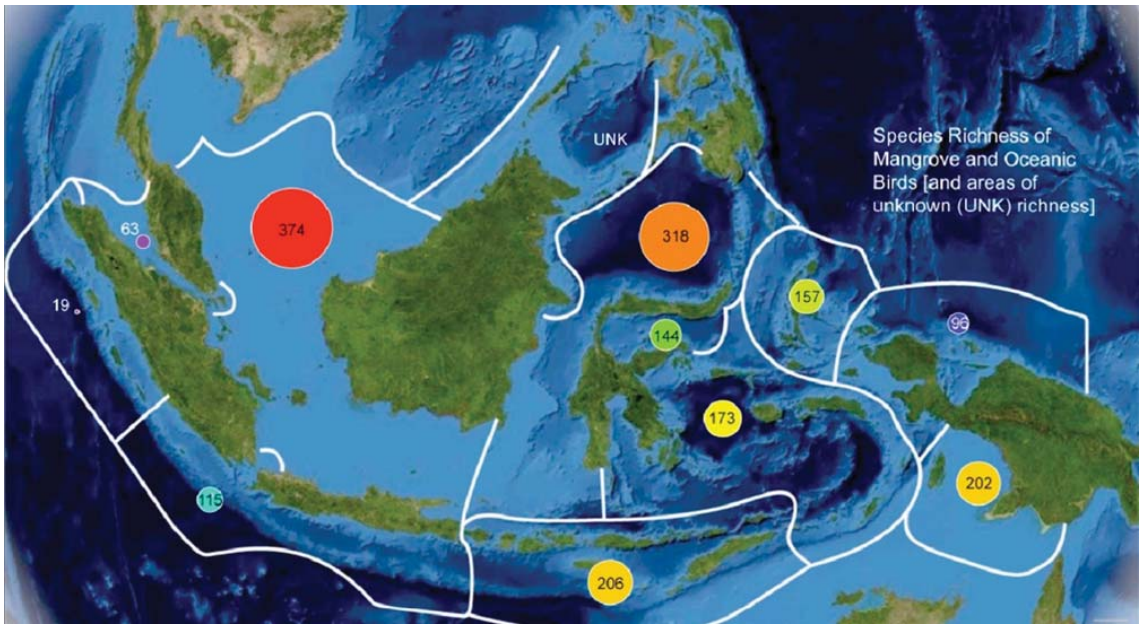


Figure 15. Species richness of mangrove-associated and oceanic avifauna (Y. Noor).

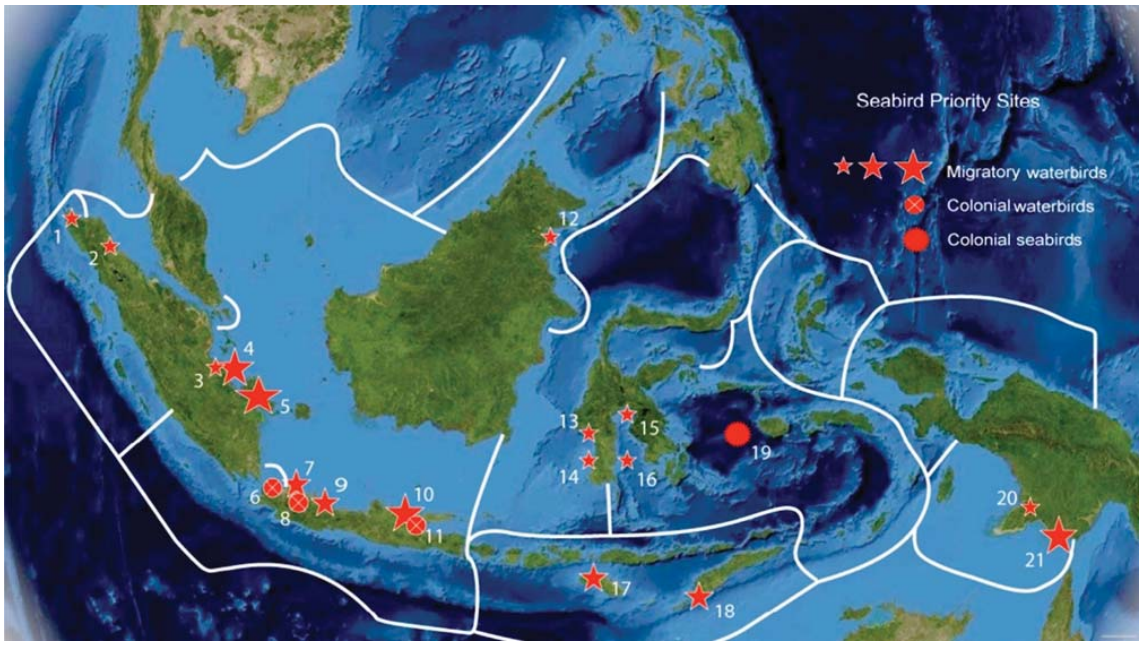


Figure 16. Conservation status of mangrove associated and oceanic seabirds in Indonesia. Numbers within each colored rectangle indicate number of species in that conservation status category as per figure legend (Y. Noor)

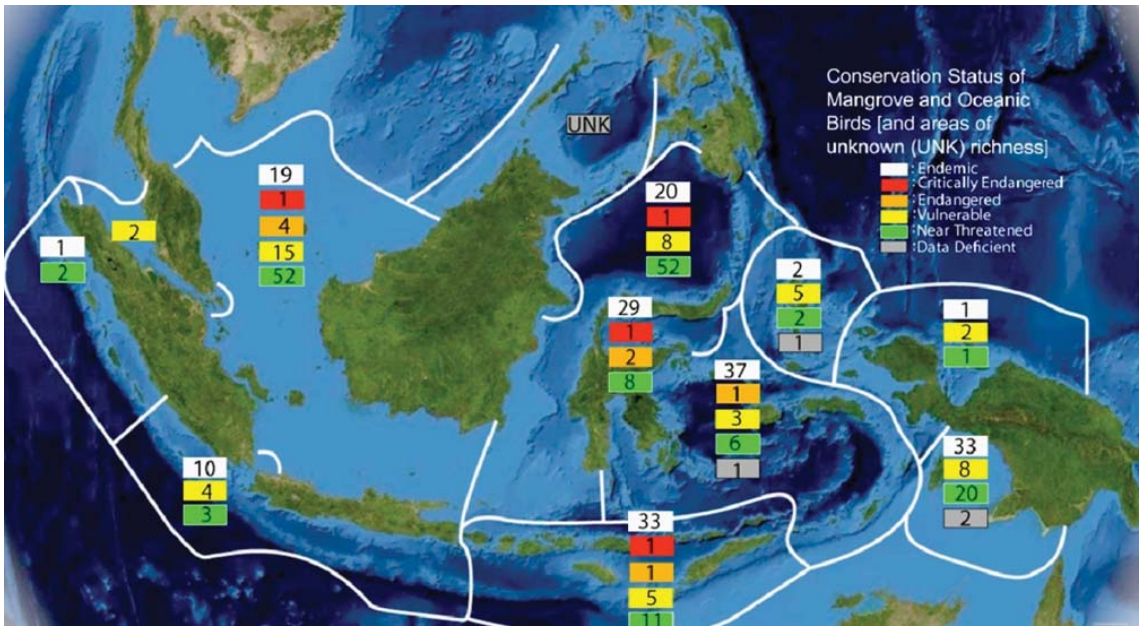


Figure 17. Map of priority sites for seabird conservation in Indonesia. Size of red star indicates relative importance to migratory waterbirds; medium red circles indicate important areas for colonial waterbirds while large red circles indicate important colonial seabird sites; numbered site names listed in Table 3. (Y. Noor)

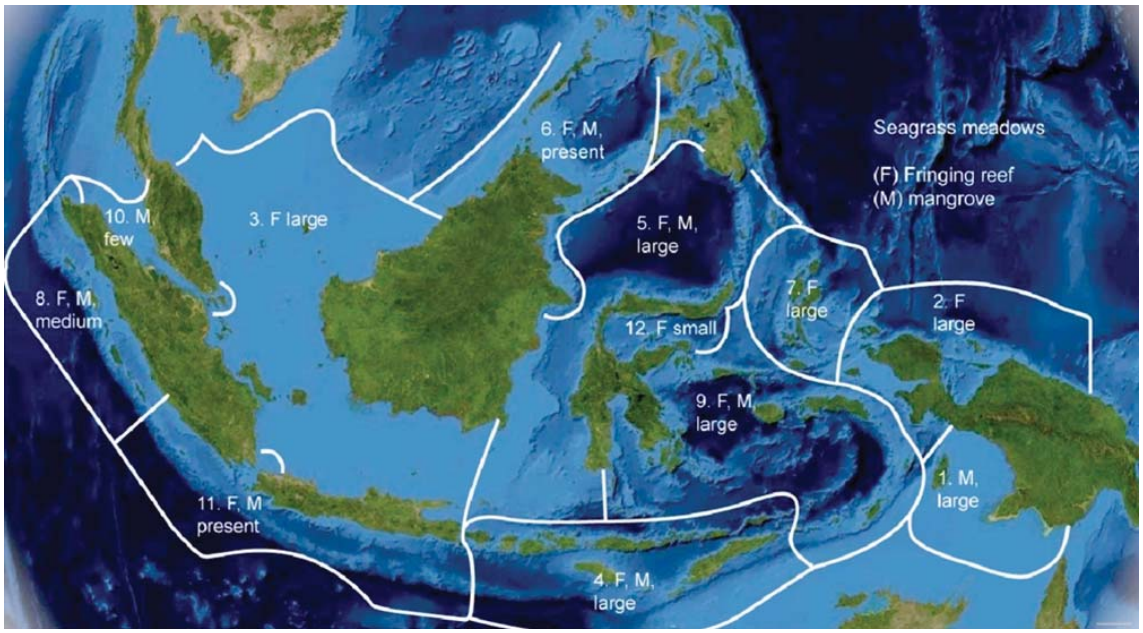


Figure 18. Ranking of importance of seagrass habitats across Indonesia, indicating size of seagrass meadows (large, medium, small, present) and typical associated habitats (fringing reefs or mangroves). (M. Hutomo, S. Campbell)

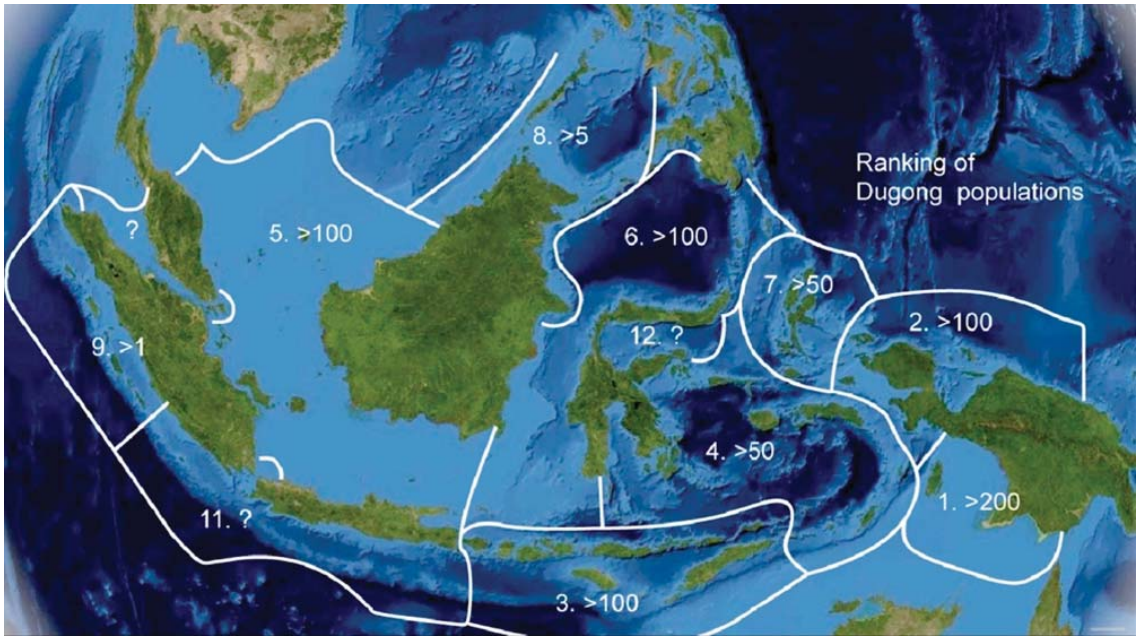


Figure 19. Estimated size of Dugong populations across Indonesian ecoregions, with a ranking of ecoregion importance for Dugongs. (S. Campbell)

Table 6. List of sites of special conservation concern for mangroves and seabirds (site numbers mapped in figures 14 and 17). (Y. Noor)

Site Number	Site Name	Biota of Special Concern
1	Krueng Aceh	Migratory waterbirds
2	Bagan Percut	Migratory waterbirds
3	Tanjung Bakung	Migratory waterbirds
4	Tanjung Datuk, Cemara, Hutan Bakau pantai Timur	Migratory waterbirds
5	Banyuasin Delta	Migratory waterbirds
6	CA. Pulau Dua	Colonial waterbirds
7	Muara Gembong, Muara Angke, Kamal Muara	Migratory waterbirds
8	SM. Pulau Rambut	Colonial waterbirds
9	Indramayu – Cirebon	Migratory waterbirds
10	Delta Bengawan Solo – Delta Brantas	Migratory waterbirds
11	Ujung Pangkah	Colonial waterbirds
12	Pulau Jawa, Muara Ulu, Pulau Berau, Senipah, Pulau Bukuan, Tanjung Sembilang, Pulau Layangan	Migratory waterbirds
13	Lampuko Mampie	Migratory waterbirds
14	Lanteboeng, Ujung Pandang, Maros	Migratory waterbirds
15	Pantai Utara Teluk Bone	Migratory waterbirds
16	Muara Sungai Salowatu (Banjare – Patiro, Ujung Patiro, Palima Bajuwa – Tipulwe, Banawatu)	Migratory waterbirds
17	Pantai Sumba Timur	Migratory waterbirds
18	Teluk Kupang	Migratory waterbirds
19	Pulau Manuk	Colonial Seabirds
20	Pulau Kimaam (Rawa Dembuwuan, Rawa Cumoon)	Migratory waterbirds
21	TN. Wasur dan Rawa Biru	Migratory waterbirds
22	SM. Karang Gading Langkat Timur	Mangroves
23	TN. Sembilang – Banyuasin Delta	Mangroves
24	Muara Gembong, Muara Angke, Kamal Muara	Mangroves
25	Laguna Segara Anakan	Mangroves
26	Teluk Bone	Mangroves
27	Pantai Timur Sumba	Mangroves
28	Teluk Bintuni	Mangroves
29	SM. Baun – Kepulauan Aru	Mangroves
30	TN. Lorentz	Mangroves
31	P. Kimaam	Mangroves

7. PATTERNS IN MARINE POPULATION GENETICS: Inputs from P. Barber and M.K. Moosa

Although perhaps not immediately obvious, understanding patterns of genetic diversity across Indonesia is exceedingly important for designing conservation strategies in the face of global change, climate and otherwise. Because genetic diversity represents the very building blocks of adaptation for living organisms, it is critical that Indonesia's national marine conservation strategy recognize the importance of safeguarding the genetic diversity that exists across Indonesia, which in turn requires extensive knowledge of how this diversity is distributed. Fortunately, the past decade has seen an explosion in the amount of research conducted on marine population genetic structure across Indonesia (e.g. Barber *et al*., 2000; DeBoer *et al*., 2008; Kochzius and Nuryanto, 2008). Thorough sampling across the archipelago and subsequent analysis of genetic structure for over 25 different marine organisms (including but not limited to clams, corals, shrimp, seastars, and fishes) reveals at least 4 concordant patterns of population structuring seen repeatedly in various taxa:

1) Clear division of Indonesia into three primary clades (western, eastern, and central Indonesia populations (e.g. Figure 20 for the giant clam *Tridacna crocea*) with strong barriers to connectivity between them. The most common barrier between eastern and central Indonesia is across the region of Halmahera, and is likely a result of the oceanographic feature known as the Halmahera Eddy (see Barber *et al*., 2006). The barrier separating central and western clades is more variable, sometimes seen across the Java and Flores Seas or through the Sunda Strait;
2) A strong genetic break, typically seen either across Halmahera or across the Flores and Java Seas, divides Indian Ocean and Pacific Ocean clades. This break is exemplified in the seastar *Linckia laevigata*;
3) Complete homogeneity (i.e. no genetic structure) across the archipelago, as typically seen for pelagic fishes such as tunas and the shrimp *Periclemenes soror*;
4) Exceedingly fine-scale genetic structure across the archipelago, with individual clades potentially representing numerous cryptic species. The mantis shrimp *Hoplosquilla said* demonstrates this pattern.

It is important to note that although it takes many generations to build patterns of genetic structure, these patterns are erased very quickly by gene flow. As such, it is safe to assume that the barriers to connectivity discussed above are still very much operational today, which has important implications for conservation. Because these barriers divide populations that are demographically independent, it is important to ensure that conservation efforts focus on both sides of these barriers to ensure that maximum genetic diversity is maintained, and that larval sources are protected throughout the country. This genetic diversity is potentially one of the best strategies we have in preparing for global climate change.

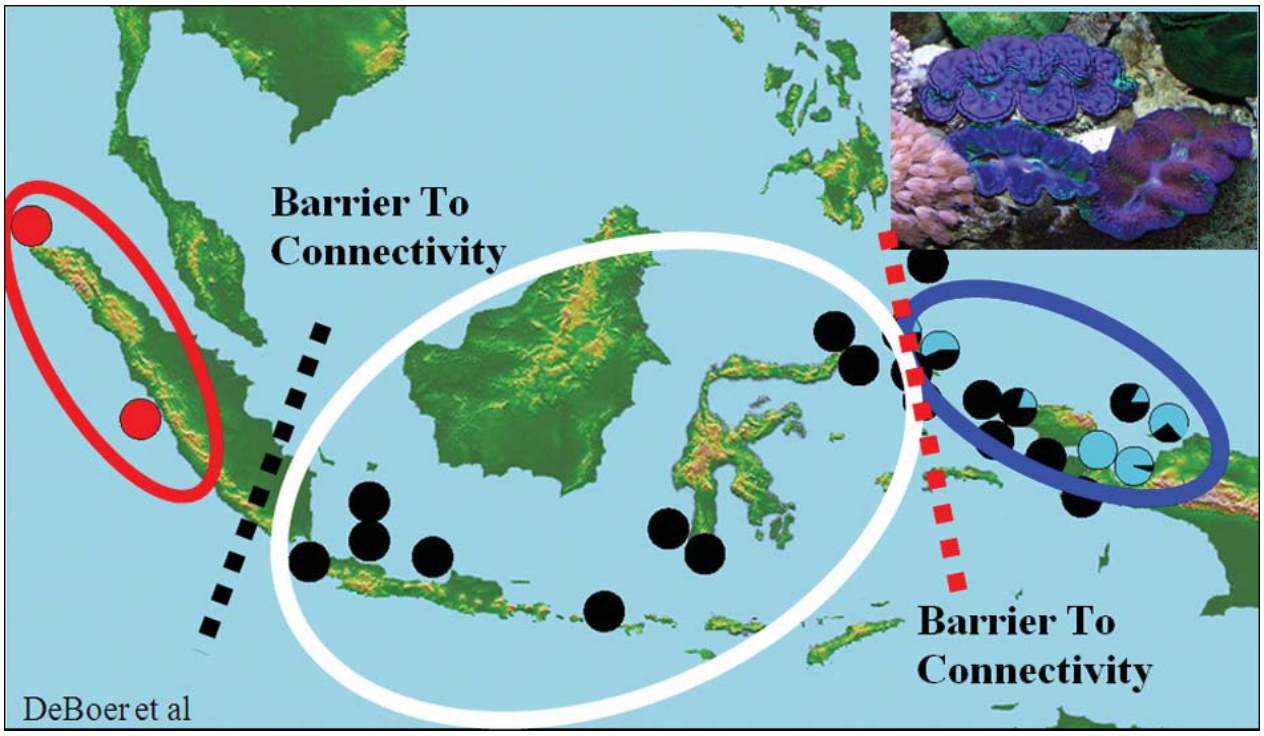


Figure 20. Map of haplotype distributions for the giant clam *Tridacna crocea* depicting a common pattern of eastern (blue haplotypes), western (red haplotypes) and central Indonesian (black haplotype) clades separated by barriers to connectivity. Pie diagrams refer to haplotype frequencies (P. Barber, redrawn from DeBoer *et al*, 2008).

Although patterns of population genetic structure across Indonesia do not always conform precisely to ecoregion boundaries, some ecoregions do stand out from genetic connectivity and diversity perspectives. Papua harbors the highest number of distinct genetic lineages of all ecoregions in Indonesia, with Teluk Cendrawasih meriting particular mention as a region which frequently shows highly unique clades, likely as a result of its repeated isolation over the geologic past (Allen, 2008; DeBoer *et al*, 2008). Western Sumatra is second to Papua in genetic diversity, and also ranks as a top priority for preserving unique genetic diversity. Other regions of specific note with respect to presence of unique clades include Tomini Bay (another relatively isolated bay) and the Lesser Sundas. The Banda Sea is not well-sampled but is expected to potentially harbor important, distinct genetic lineages as well.

The Sulawesi Sea/Makassar Strait ecoregion, by contrast to the above regions with significant numbers of unique clades, is a central zone of genetic mixing of eastern and western clades, and Indian and Pacific Ocean clades (Figures 21 and 22). It is in essence the genetic crossroads of Indonesia. With the longest contiguous reef-fringed coastline in Indonesia (greatly facilitating longshore dispersal of larvae), this ecoregion is of extremely high conservation value as a larval dispersal corridor. Its has high potential value as a future connectivity corridor for distributing genetic variants able to tolerate any new environmental conditions experienced with global climate change. Indonesia's developing national strategy for MPAs should not underestimate this important factor.

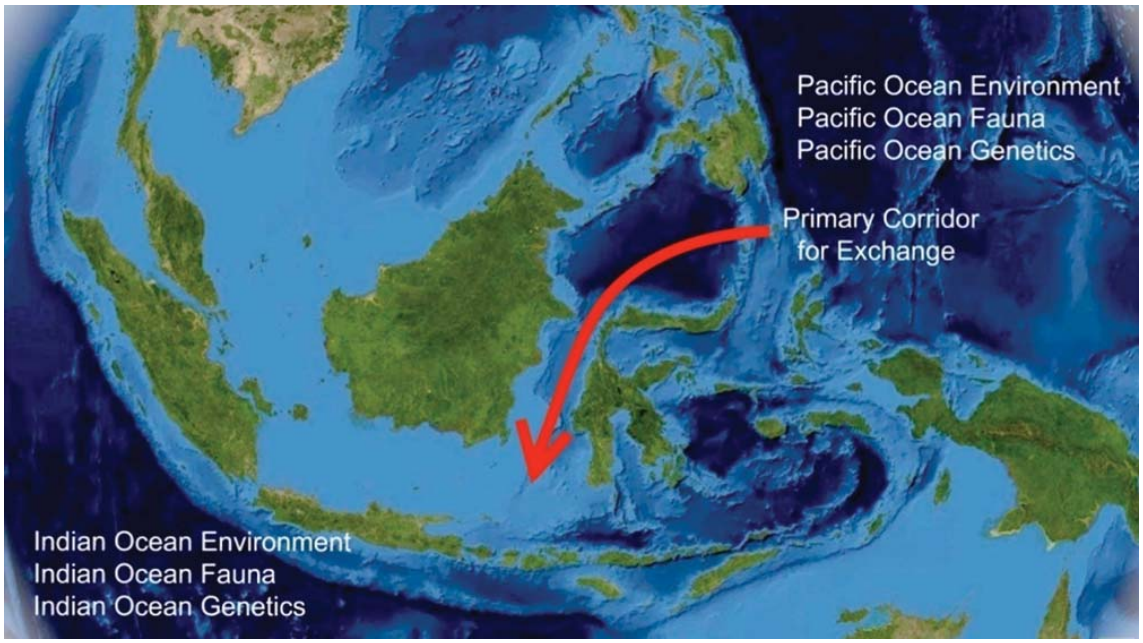


Figure 21. The Sulawesi Sea/Makassar Strait ecoregion is the primary corridor for exchange of genetic diversity between the Pacific Ocean and Indian Oceans (P. Barber).

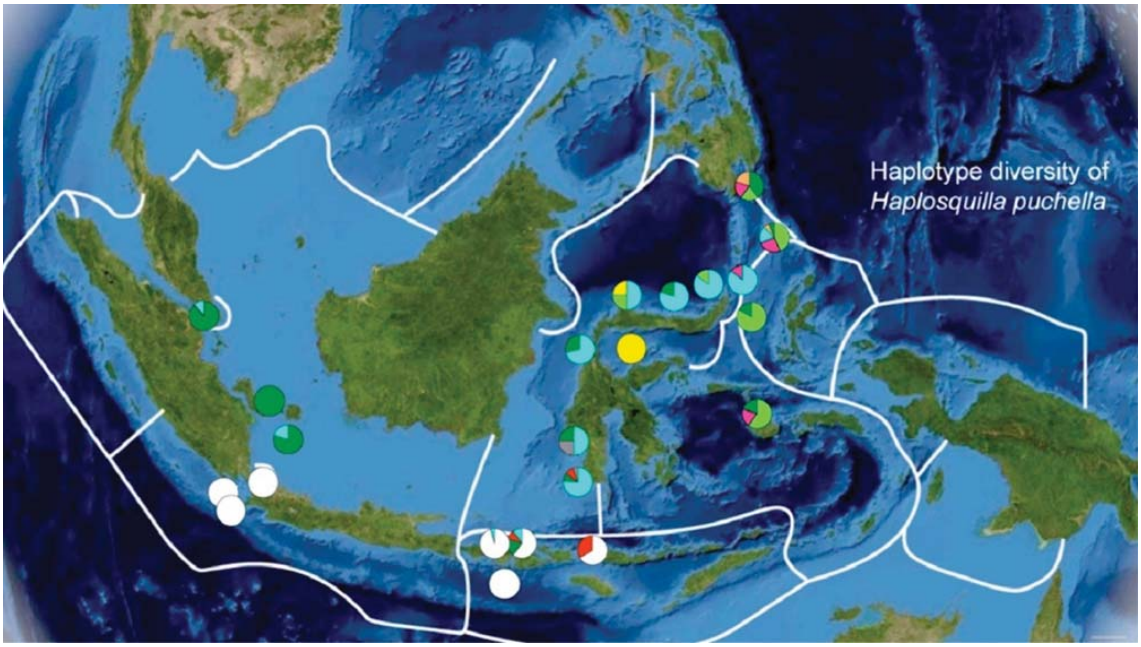


Figure 22. Map depicting the mixing of haplotypes along the coastline of western Sulawesi (example shown is for the stomatopod *Haptosquilla pulchella*). Pie diagrams indicate relative haplotype frequencies, with each color representing a unique haplotype (P. Barber, redrawn from Barber *et al.*, 2006).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4 Additional Data Inputs for Each Ecoregion

In addition to the archipelago-wide patterns in species richness and endemism described above, respondents provided a wide range of inputs on other important aspects of Indonesian marine biodiversity for each ecoregion, such as aggregations of globally threatened species, presence of unique habitats, rare species, and other considerations). Below we summarize some of the key points under each of these headings by ecoregion. Completed data questionnaires can be viewed in Appendix V.

1.Papua

Regionally or globally significant aggregations of threatened or restricted range species (migration corridors, nesting beaches, spawning or feeding aggregation sites, nursery areas)

In addition to the high representation of endemics in Papua, numerous vulnerable and endangered animals inhabit these waters. The Jamursbamedi-Abun areas comprise the world's largest Pacific Leatherback turtle nesting beaches, while Sayang-Piai, Ayau, Mapia, Pisang, Pulau Venu, and Wairundi are regionally important rookeries for Green turtles. Bryde's whales, Indo-Pacific Humpbacked dolphins, Sperm whales, Dwarf Spinner dolphins, and Dugongs use Papua for critical activities

including foraging, breeding, calving grounds, and migration. Triton Bay along the south coast of Papua's Bird's Head Peninsula is a prime habitat for coastal cetaceans that are now largely eliminated from other areas of Indonesia. Papua harbors some of the greatest remaining populations of Dugongs and Estuarine crocodiles in Indonesia (and likely SE Asia). Regionally significant aggregations of reef sharks, jacks, Manta rays, and Napoleon wrasse have been detected at Triton and Cenderawasih bays. Whale shark aggregations are known in Cendrawasih Bay and off the Fak Fak Peninsula. Ayau, Kaimana, Mapia, and Tg. Mangguar in Cendrawasih, at least historically, hosted significant grouper spawning aggregation sites. Finally, a host of karst-associated marine lakes throughout the Papuan ecoregion, especially in Raja Ampat and Kaimana, contain endemic and otherwise rare species.

Taxonomic uniqueness/presence of rare species/presence of unique habitats (eg, euryhaline lakes)

Papua boasts numerous animals and habitats that are rare elsewhere throughout Indonesia including Sperm whale calving grounds, the world's largest Pacific Leatherback rookery, major Green turtle rookeries, resident Bryde's whales in Kaimana, and healthy Dugong populations. Nearshore but deep-sea habitats are particularly important to marine mammals, and may facilitate connectivity between shallow-water and deep-sea communities by providing pelagic

species with high prey densities. This ecoregion and especially the included Raja Ampat Islands are characterized by an incredible diversity of habitats, including extensive enclosed mangrove bays with lagoonal reefs, karst channels that are akin to saltwater streams, and a large number of marine lakes. These marine lakes are also found in abundance in the Kaimana area. Arguni Bay is a unique karst fjord system that cuts nearly 100 km into mainland Papua. Papua also is home to the most extensive mangrove stands remaining in Indonesia and perhaps the world. The limestone overhangs and long narrow karst inlets of Southwest Misool support unusual coral growth forms, and coral communities that are normally found in much deeper waters. Additionally, Cendrawasih Bay, which appears to have been repeatedly isolated over the past 10 million years, is an evolutionary natural laboratory that requires significant further research. This richness of rare and unique coral habitats means that some coral species are not found elsewhere in Indonesia west of the Raja Ampat islands off the Bird's Head Peninsula. Overall, the taxonomic uniqueness and presence of rare species and unique habitats in Papua is phenomenal.

Other important considerations on biodiversity of this ecoregion (unique ecosystem services provided, vulnerability/resilience to climate change, overall vulnerability or conservation opportunity considerations)

Throughout Papua, some reefs area are naturally subject to a massive 16□ C variability in sea surface temperature, suggesting they may also be resilient to temperature conditions that will be associated with climate change. Sea surface variability is one of the key factors associated with environmental buffering to coral bleaching. The oceanographic conditions of Teluk Cendrawasih are uniquely stable by comparison, and the genetic structure of its inhabitants, ranging from endemic coral reef fishes to giant clam algal symbionts (*Symbiodinium spp.*), suggest selection for tolerance of and/or adaptation to these conditions. It is unknown whether these traits preclude tolerance to fluctuations, and if environmental perturbations may be particularly detrimental to the assemblages therein.

The Bird's Head Seascape (BHS) of Papua comprises the epicenter of marine biodiversity in the Coral Triangle and plays a crucial role in the sustenance and connectivity of coral reef populations throughout the broader Indo-Pacific. Papua hosts significant migratory corridors for whales, dolphins, sea turtles and other marine megafauna, many of which are endangered or vulnerable. Prime migratory fisheries targets may utilize this region for key life stages or the sustenance of stocks. Leatherback turtles satellite tagged in Jamursbamedi have later migrated to Korea, Philippines, United States, and/or Japan, showing extensive connectivity to these populations well beyond the Coral Triangle. Finally, the complex historical bathymetry of this region may enable speciation providing continued sources of biodiversity in the distant future. In short, Papua seeds the greater Coral Triangle with essential elements of tropical marine ecosystems, such as healthy larval stocks, feeding grounds, migratory pathways, diverse habitats, and the production of biodiversity.

Papua's rich habitat diversity helps form the foundation of its high priority status, yet also imparts challenges to management. Ideally, each habitat requires a unique management strategy to ensure optimal survival. In practice the strong connectivity of coral reefs to mangrove, seagrass, and some soft-sediment habitats offers overlapping protection efforts for these ecosystems. By contrast, near-shore but deep-sea waters and anchaline lakes are not as easily linked to coral reefs, and will require different forms of protection. For example, new monitoring approaches should be implemented to look after remote pelagic ecosystems and their inhabitants. Additionally, anchialine lakes are very vulnerable due to their isolated character and small size, and should be protected from terrestrial disturbances, introduction of non-native species, and in some cases tourist activities. The richness of the terrestrial environment, this habitat's vulnerability to resource extraction and development, and its connections to the marine realm should be underscored. Logging and mining are major threats to marine ecosystems via sedimentation and contamination.

Besides its unrivalled marine biodiversity and endemism, Papua has low human population density and still largely intact ecosystems that make it a highly favorable area for marine conservation investment. Due to the strong dependence of indigenous Papuan coastal communities on ecosystem services, and their direct marine tenure systems of ownership, local support for marine conservation initiatives is typically very high and governments are generally receptive to conservation initiatives. Unfortunately however, for both the environment and the inhabitants of Papua, mining, trans-migration, and poorly-planned coastal development are major threats that can progress rapidly to destroy large habitat stands in a short period of time. The healthy regeneration times of these habitats are typically well beyond a human lifespan, while the economic and public health benefits will likely be short-lived (as in the Amazon—Rodrigues *et al.*, 2009).

Particular Sites of Conservation Noteworthiness:

- Arguni Bay
- Biak
- Bird's Head Peninsula (extended beach of Jamursbamedi, Warmon, Mubrani-Kaironi, Sidey; Sayang and Piai Islands; Small islands of SE Misool; Small islands around Kaimana; Pulau Venu and Sabuda Tartaruga)

- Cendrawasih Bay (7 respondents)
- Dampier Strait region including Batanta (2 respondents)
- Fakfak-Kaimana/Triton Bay coastlines (8 respondents)
- Kofiau
- Kokas (outer Bintuni Bay; 2 respondents)
- Jambursba Medi (2 respondents)
- Mamberamo River estuary and mangroves
- Misool, including the southeast coastline (2 respondents)
- Padaido Islands including Mapia (2 respondents)
- Pami River Estuary (*Anguilla megastoma*)
- Raja Ampat (6 respondents)
  - Kawe
  - Wayag Islands
  - Waigeo, including the western coastline (2 respondents)
- Selassi Bay (FakFak)

2. Banda Sea

Regionally or globally significant aggregations of threatened or restricted range species (migration corridors, nesting beaches, spawning or feeding aggregation sites, nursery areas)

The Banda Sea is at a dispersal crossroads between the Indonesian and Papuan faunal regions, and no doubt serves as an important corridor. It forms a migration route from the Pacific to Indian Oceans for adults of many threatened animals, including whales (Monk *et al.*, 1997, in: Wagey and Arifin, 2007) and Dugongs in the Lease Islands (Haruku, Saparua Nusa Laut; De Longh *et al*., 2009). Exceptionally high abundance of oceanic dolphin and whale species including Sperm whales occurs in Wakatobi and throughout the deeper waters of this ecoregion. Blue whales, which are normally solitary, are reported to aggregate in the Ambon/Buru/West Ceram area, in all spending up to three months a year in the Banda Sea. The Blue whales found in Yamdena Island may also be of global significance. The Watubela Islands are home to what is likely the largest remaining grouper spawning aggregation site in Indonesia, representing the reproductive effort and potential for what may be a very large region.

The Banda Sea ecoregion also has a number of important areas for reptiles and avifauna. Sea turtles nest and forage in large numbers thoughouth this ecoregion. Pacific Leatherbacks nest on the north coast of Seram and feed in Kei Islands, while Greens nest on the islands of Lucipara, Ambon, Banggais, Wakatobi and Taka Bone Rate. Flatback turtles are typically found in Australia but can also be found in the Banda Sea. Moromaho, Lucipara and Penyu islands are important for seabirds including *Sterna bergii*. Taka Bone Rate, Inner Band Arc, Wakatobi also host a number of important sea snake nesting colonies. The nationally protected Estuarine crocodile is also found in the Banda Sea.

Taxonomic uniqueness/presence of rare species/presence of unique habitats (eg, euryhaline lakes)

The Banda Sea is characterized by deep water with active volcanism yielding Indonesia's largest number of isolated oceanic reefs, seamounts and atolls with associated unique lagoonal environments. Overall habitat diversity is very high, ranging from coastal areas along southern and western coasts of Sulawesi to open ocean and very deep water ecosystems that are not well represented elsewhere in Indonesia. Perhaps emblematic of this ecoregion is an arc of active volcanic oceanic islands rising from extreme depths of > 5000m in the East Banda Sea. These and other shallow-water projections experience open exchange of water from surrounding regions such as Sulawesi Sea, and a diversity of near-shore yet deep-sea habitats within inter-island passages. Some of the deepest parts of the Indonesian Seas and even the world are found here (to max. charted depths of 7376m at 5 □36.82 S/ 130□51.56 E). Deep-sea species richness in the Banda Sea is considered very high.

Early data from the Alpha Helix expedition suggests that faunal assemblages in the Banda Sea may include high rates of endemism or cryptic speciation, perhaps due to isolation during previous low sea level stands. For example, up to 32 endemic species of cryptic holothurians (sea cucumbers) are found here and so far nowhere else. From shallow waters, the Banggai cardinal fish are unique to this region. Data from stomatopods suggests that the northern Banda Arc may be an important series of stepping-stones facilitating connectivity between the Southern coast of Papua and Eastern Sulawesi.

Other important considerations on biodiversity of this ecoregion (unique ecosystem services provided, vulnerability/resilience to climate change, overall vulnerability or conservation opportunity considerations)

Low human population density and a general reliance on pelagic (as opposed to reef) fisheries make this a very attractive region from a conservation opportunity perspective. National Park infrastructure has been initiated in Wakatobi and Taka Bone, offering a starting point for additional conservation measures. Wakatobi National Marine Park in particular has gained full support by local government partners to safeguard pelagic fauna by protecting critical corridor habitats for migratory whales, dolphins and other marine megafauna such as whale sharks, sea turtles, mola mola, tuna and billfish. The success of these parks offers economic potential in the form of "Cetacean watch ventures" and marine mammal tourism. Additional conservation of pelagic species must include fisheries by-catch control programs for marine mammals, which will be required to access EU and USA tuna/pelagic fisheries markets from 2012 and onwards. Marine stewardship initiatives also demand such measures to be in place. Being one of the least studied regions of Indonesia, there may be unexpected challenges to management. A systematic assessment of the marine environments in this region may reduce this uncertainty.

As with the Lesser Sundas, the deep waters and rich upwellings of the Banda Sea may help to reduce heat stress leading to mass bleaching of corals and offer resistance to the negative impacts of climate change. Due to upwelling of cooler deep water, central Indonesia and Banda Sea coral reefs had Indonesia's highest survival rates after the 1998 mass bleaching event (Wallace et al., 2001). On a larger time scale this deep-water basin may act as a refuge for marine fauna during glaciations, when sea-level fall transforms many shallower regions of Indonesia into terrestrial environments.

Particular Sites of Conservation Noteworthiness:
- Taman Nasional Manusela
- Ambon –East Buru –West Ceram
- Banda Islands (3 respondents)
- Banda Arc- Inner, including Damar, and islands to south-west to P. Wetar (3 respondents)
- Banda Arc- Outer, including Tanimbar and Kei (2 respondents)
- Banggai Islands (2 respondents)
- Barbar and Leti Islands (2 respondents)
- Gunung Api
- Kei islands, including western coast and Tayando Islands (3 respondents)
- Kotania Bay (seagrasses)
- Lease Islands (Dugongs)
- Lucipara/Pulau Tujuh (3 respondents)
- Pulau Mai
- Marsegu Islands
- Pulau Nila
- Nusa Laut
- Taka Bone Rate (3 respondents)
- Wakatobi, including Kaledupa reef (4 respondents)
- Watubela and Gorong Islands (2 respondents)
- Wetar Canyon
- Pulau Serua
- Pulau Teun
- Seram Cagar Alam Yamdena (2 respondents)

3. Lesser Sundas

Regionally or globally significant aggregations of threatened or restricted range species (migration corridors, nesting beaches, spawning or feeding aggregation sites, nursery areas)

The Lesser Sundas contain some of the most important dispersal corridors in the Indonesian Archipelago, including several globally significant passages. The Indonesian Through Flow in this ecoregion is the main conduit between the Indian and Pacific Oceans, via flow through the Lombok Strait and corridors around Flores and Timor. Flow is primarily north to south, but

with some (mostly sub-surface) flow in the opposite direction. For many taxa these productive waters and complex current regimes are important for the sustenance, gene flow, and mechanical transport of all life history stages, from larvae/newborns/hatchlings to adults. The Savu Sea is a migration corridor for several species of whales from the Pacific to Indian Oceans (Monk *et al*., 1997 in Wagey and Arifin, 2008). Upwelling zones and other foraging areas provide globally and regionally significant foraging grounds for both great whales and coastal marine mammals. Dugongs are also present. The Lesser Sundas also serve as mating and calving grounds for Sperm whales and numerous oceanic dolphin species. Finally, the endemic Komodo Dragon, the world's largest extant lizard, typifies the global significance of this region's terrestrial biodiversity.

Taxonomic uniqueness/presence of rare species/presence of unique habitats (eg, euryhaline lakes)

Mixing of tropical-temperate, deep-shallow, and Indian Ocean-Pacific communities in the Lesser Sundas permits a rare diversity of habitats supporting high species richness and endemism of coral reef fishes, stomatopods and corals. A marine lake with stromatolites exists in Pulau Satonda. Additionally, several widespread marine species may be unusually accessible compared to their typical ranges. For example, near-shore deep-sea and upwelling areas may offer shallow, coastal access to otherwise open-ocean and deep-sea fauna. The strong connectivity between coastal to oceanic ecosystems supports at least 18 species of cetaceans found in the Lesser Sundas in exceptional relative abundance. Along the coast, the mangroves of Kupang Bay have very high biodiversity with three species of mangroves (*Avicennia sp., Rhizopora apiculata* and *R. stylosa*), and approximately 133 bird species including migratory species. As many as 27 species of birds have been noted from the mangroves of Pulau Sumba alone. Other extremely important coastal habitats include 1) Wilayah Beach in Komodo National Park, which hosts 23 species of beach and mangrove trees, more than 500 species of fish, 77 species of bird, 32 mammal species, and 25 reptiles, 2) Maumere Bay in Flores, especially near Pomana Besar and Damilahan

Islands, which hosts 14 species of bird (including 4 seabirds), two marine mammals, and one marine reptile, and 3) the small mangrove area in Bali Barat National Park, which hosts 10 species of mangroves, 19 coastal and migratory birds, 10 mammals, and four reptiles. In addition to these unique species, this ecoregion may be a reservoir of Indian Ocean fauna, and hence may prove very important in capturing that biogeographic element.

At least 12 red-listed species (*Balaenoptera acutorostrata, B. musculus, Dugong dugon, Chelonia mydas, Eretmochelys imbricate, Varanus komodoensis, Bos javanicus, Hystrix brachyura, Felis bengalensis, Dugong dugon, Eretmochelys imbricate, Crocodylus porosus*) inhabit the Lesser Sundas. Of these, *Eretmochelys imbricate* is Critically Endangered.

Other important considerations on biodiversity of this ecoregion (unique ecosystem services provided, vulnerability/resilience to climate change, overall vulnerability or conservation opportunity considerations)

The Lesser Sundas already include the largest MPA coverage of any ecoregion in Indonesia, offering the capacity for conservation refinement rather than ground-up management. However improved management and enforcement is necessary to protect this large area including sensitive and globally significant offshore marine habitats, where threats may procede undetected (Kahn, 2008). Easily accessible seamounts, upwelling zones, and mining resources are the target of rapidly expanding fisheries and possibly extractive activities.

The rich diversity of shallow coral reefs, cold water upwelling, coastal deep-sea systems, major current systems, and wetlands offer promise and challenges alike to conservation efforts. Constant water movement from both currents and wave exposure, and strong seasonal upwelling of deep cold water may reduce heat stress of reefs in this region. The coral reefs of the Lesser Sundas may be resilient to some negative effects of climate change as evidenced by the stability of coral cover in Komodo (Snellius-II exped. 1984 and TNC-survey in 2002; Hoeksema & Moka, 1989, Best *et al*., 1989). Perhaps paradoxically, because the currents are so strong and swift the main areas of Through-Flow (e.g. Lombok Strait, East Flores and Timor) may be considered as both contributing to and restricting dispersal. Larvae may freely ride these currents but those on a perpendicular course may be unable to cross. During glaciations when sea water levels were considerable lower and current regimes quite different, the Savu and Flores Seas were important refugia. Thus these areas remain potentially very important for the maintenance of coral reef ecosystems from evolutionary perspective.

Particular Sites of Conservation Noteworthiness:
- Alor-Wetar-Solor (5 respondents)
- Bali (4 respondents)
- Flores northern coast
- Komodo National Park, including nearby passages (5 respondents)
- Kupang Bay

- Lombok, including nearby passages (5 respondents)
- Lombok Strait
- Southeast of Lombok and Sumbawa (Teluk Cempi/Dompu)
- Menjangan
- Maumere Bay region (2 respondents)
- North Pantar (Pulau Rusa, Kaming, Marisa)
- Nusa Penida/Nusa Lembongan (4 respondents)
- Rote Island
- Sabalana Islands
  Savu Sea (2 respondents)
- Sumba Island, including the northern coast (3 respondents)
- Tengah Islands
- Timor/Roti (2 respondents)
- Tulamben

4. Sulawesi Sea/Makassar Strait

Regionally or globally significant aggregations of threatened or restricted range species (migration corridors, nesting beaches, spawning or feeding aggregation sites, nursery areas)

The Sulawesi Sea/Makassar Strait is an extremely important dispersal corridor (particularly for larvae) via the Indonesian Throughflow, from the Philippines in the north and southward towards the Lesser Sundas and Nusa Tenggara Timur. Oceanic species, both wide-ranging and resident, also enjoy these coastines with their rich, swift waters for migratory routes and critical reproductive grounds. Whale sharks aggregate in the Spermonde islands from yet-uknown origins. The Sulawesi Sea area is critically important for many cetacean species, especially Sperm whales that calve north of Sulawesi. The Lembeh Strait historically had large aggregations of cetaceans, Manta rays, and whale sharks, though the regional significance of these cannot be assessed as they were severely depleted by experimental trap netting in late 1990's. Flying fish spawn in the Sulawesi Sea/Makassar Strait, providing important and potentially vulnerable fishing grounds for their eggs. The northern coast of Sulawesi hosts numerous nesting sites for Pacific Leatherback turtles. Green and Hawksbil turtles nest on the Bira, Sambar Gelap and Pulau Laut Islands, as well as the small islands off the west coast of south Sulawesi. The Makassar Strait probably serves as a migration and dispersal corridor for some reef fish species, however Palawan and the Sulu Islands appear to be more important in this regard. Finally, mangrove stands and surrounding waters in South Sulawesi, Mampie and Bulukumba regions provide important stopping and foraging grounds for seabirds ranging from ducks to frigates. For example, the latter site is important for approximately 28 species of coastal and migratory seabirds.

Taxonomic uniqueness/presence of rare species/presence of unique habitats (eg, euryhaline lakes)

The Sulawesi Sea/Makassar Strait ecoregion is rich in rare species and unique habitats. Irrawaddy dolphins, Sperm whales, Pilot whales and the endangered and highly restricted Sulawesi coelacanth (*Latimeria menadoensis*) all can be found here. In addition to seamount communities, unique fauna may be associated with the extreme conditions on undersea volcanoes found off North Sulawesi. The soft sediment environments along Sulawesi host exceptional densities of unusual cryptic fishes and invertebrates, as typified by The Lembeh Strait.

Coastal communities are also regionally important. A new species of seagrass *Halophila sulawesii* has been described recently from the Spermonde Islands. Mangrove stands in this region, including Lariang – Lumu, are unique in their close proximity to coral reefs, enabling land-sea connectivity. Inhabitants there include the Estuarine crocodile *Crocodylus porosus* (Malili, South Sulawesi). Bunaken National Park inhabitants include: *Balaenoptora borealis* (Vulnerable - Appendix I) and *B. physallus* (Endangered – Appendix I), Dugong *Dugong dugon* (Vulnerable – Appendix I). Land mammals: *Macaca nigra* (Endangered) and *Physeter macrocephalus* (Vulnerable – Appendix I). Reptiles: *Chelonia mydas* (Endangered – Appendix I), *Eretmochelys imbricate* (Critically endangered). Beach Forest Asuansang, Kalimantan Barat inhabitants include: *Helarctos malayanus* (Appendix I), *Nasalis larvatus* (Vulnerable – Appendix I), *Chelonia mydas* (Endangered – Appendix I), *Eretmochelys imbricate* (Critically endangered). In Kutai National Park can be found the bird *Alcedo euryzona*, mammal *Cynogale benetii* (Endangered), *Felis planiceps* (Vulnerable – Appendix I), *Nasalis larvatus* (Vulnerable – Appendix I), Macan *Neofelis nebulosa* (Vulnerable) and reptile *Crocodylus porosus* (Vulnerable). Sangalaki hosts *Chelonia mydas* (Endangered – Appendix I), and *Eretmochelys imbricata* (Critically endangered).

Other important considerations on biodiversity of this ecoregion (unique ecosystem services provided, vulnerability/resilience to climate change, overall vulnerability or conservation opportunity considerations)

Marine protected area Infrastructure and management capacity at Bunaken National Park are well-established. This area is well-known for having excellent local human resources in marine sciences and marine resource management (both in Makassar and Manado) and a long history of marine conservation investment and conservation-minded marine tourism operators. Despite this, diving tourism and its associated threats (trampling, local eutrophication, and mechanical damage from fins and anchoring) may have to be monitored. Additional threats include high garbage input from population centers.

The exceptional degrees of mixing and importance to the dispersal of all life stages in the Sulawesi Sea/Makassar Strait marine ecoregion make this area of particular interest to conservation efforts, especially when considering the need for downstream larval seeding of southern Indonesia. As a transition zone from the Pacific to the Indian Ocean, and from East to Western Indonesia, this marine ecoregion contains a significant mixture of clades characteristic of the aforementioned regions. It is likely a very important larval dispersal corridor via the Indonesian Throughflow. As such an important stepping-stone along the Throughflow, the health of this region is critical for sustained larval supply to downstream populations. The Sangihe-Talaud Islands are exposed on their eastern sides to the North Pacific, and hence potentially important from biogeographic perspective. Some studies report slightly depressed levels of diversity in Sulawesi populations, but most do not.

The Sulawesi Sea/Makassar Strait is critical from a climate change perspective. Most reefs there are located in areas that are immediately juxtaposed with deep water, strong currents and tidal upwellings. They experience regular and periodic cool-water flushings that may offer environmentally mediated resilience to some impacts of climate change. Furthermore, for regions without these buffering systems, this main corridor and mixing region for Pacific and Indian Oceans genes should be prioritized to facilitate the transport of warm-adapted genes that may aid in both the short-term regeneration and long-term survival of coral reefs stressed by temperature rise. However, immediate resilience to the impacts of climate change in this area is variable. Sangihe-Talaud reefs were severely impacted by the 1998 bleaching event. By 2002 apparent recovery was patchy, while Bunaken recovered rapidly from this event.

Particular Sites of Conservation Noteworthiness:
- Teluk Bone, South Sulawesi
- Bunaken and nearby islands (5 respondents)
- Kutai National Park
- Lariang-Lumu, South Sulawesi
- Lembeh Strait (3 respondents)

- Part of Makassar Strait as spawning ground of flying fish
- The Nanusa group open to clear Pacific Ocean waters
- Poigar and Dumoga Estuaries to conserve migration route of many species of anguillid eels
- Southeast Siao
- Spermonde Islands (2 respondents)
- Sangihe-Talaud Islands (4 respondents)
- Talaud Islands
- Selected sites along the north (offshore islands) and west Sulawesi coastline, as at the NW corner where coast bends to the south; and further as Pulau Simatang and surrounding area; and section of coast from P. Simatang south to Palu.
- Tolitoli/Teluk Dondo

5. Halmahera

Regionally or globally significant aggregations of threatened or restricted range species (migration corridors, nesting beaches, spawning or feeding aggregation sites, nursery areas)

Halmahera has a heterogeneous range of habitats, complex oceanography, and very high diversity.
This area forms a continuum as part of large area of exceptionally high reef species diversity extending from the Birds Head Peninsula and connecting to Philippines through the Sulu-Sulawesi Sea region. Halmahera is the point furthest east before the Maluku Sea. As such, this area is likely an important stepping-stone between Eastern Indonesian and Centeral Indonesian populations. Mixing of distinct clades in many species in this region suggests this is the case. Although not confirmed, native fisherfolk report seasonal aggregations of whale sharks in enclosed Kao Bay. Halmahera is particularly important for reptiles. Suaka Margasatwa Memberamo – Foja have the world's largest populations of the crocodiles *Crocodylus porosus* and *C. novaegunineae*. The Leatherback turtle population from Jamursbamedi Papua forages in Halmahera. This ecoregion also hosts scattered nesting beaches for Green and Hawksbill turtles. Indonesia's highest concentrations of coconut crab are found in this ecoregion.

Taxonomic uniqueness/presence of rare species/presence of unique habitats (eg, euryhaline lakes)

Halmahera boasts exceptionally high species richness per site, with two sites having the highest known recorded coral species richness per hectare of reef. Several very large corals of potentially very old age (up to 1000 years or more) indicate long-standing healthy coral populations. This ecoregion shares all but four of its coral species with the Bird's Head Seascape of Papua, with the possible exception of several potentially undescribed species found recently. The overall high similarity in coral species composition of Halmahera with the BHS and Sulu-Sulawasi Seas notwithstanding, several important differences were apparent among these regions in the structure of their coral communities. Halmahera showed moderate to high levels of dissimilarity from most other regions, notably from Sangihe-Talaud and Raja Ampat, respectively. Kao Bay in north-central Halmahera is a unique nearly enclosed, large bay. Reef development in the bay is minimal, but nonetheless the biodiversity seen here is unique in some respects, with high habitat diversity resulting from active techtonics. The volcanic chain of islands from Ternate to Makaian and the long straits that cut through Bacan are unique habitats of interest in Halmahera. The north coast of Morotai is also unique in Indonesia in facing the full open oceanic Pacific swells. *Craterastrea leavis*, a rare deeper water coral known from Chagos and the Red Sea, was recorded here.

Other important considerations on biodiversity of this ecoregion (unique ecosystem services provided, vulnerability/resilience to climate change, overall vulnerability or conservation opportunity considerations)

The extreme habitat diversity and high rugosity of the coastline, and the tectonically rich undersea structures of Halmahera will require a multi-fascited approach to marine spatial planning. Halmahera may be the ecoregion with the highest coral diversity on the planet. Upcurrents of cooler deep waters may help to reduce heat stress of these corals from sea temperature rise, which may otherwise induce mass bleaching during climate change. Remaining diverse habitats beyond typical coral reefs must be protected to conserve this area's globally significant biodiversity. The high connectivity of Halmaheran populations to those in Papua and Sula/Sulawesi may call for joint conservation efforts. Halmahera and Morotai are exposed to the north Pacific, and may be important in capturing this biogeographic element in Indonesia's MPA system.

The provincial government, local communities (especially in Goraici area) and local University of Khairun are very interested in conservation initiatives as evidenced by the Ternate Declaration. This statement declares the area as a developing nexus for evolutionary and biodiversity research, acknowledging Halmahera's central importance in the development of Alfred Russel Wallace's seminal theories on evolution. However supportive legislation and enforcement remain to be implemented in a way that addresses the widespread threats to these positive attributes. Several pervasive and disastrous environmental actvities persist. Destructive fishing results in the death of coral, high fatalities to bycatch, and even leveling of former reef structures (as occurs after 'blast' fishing). Coastal mining for nickel, manganese, and other

metals is another massive and growing threat to marine ecosystem survival in the area. Kao Bay suffers harmful algal blooms each year.

Particular Sites of Conservation Noteworthiness:
- Akelamo River Estuary where *Anguilla obscura* is found
- Bacan Islands (2 respondents)
- Buloi Bay
- Goraici Islands/ Kayoa Island (2 respondents)
- Kao Bay and its mangrove forest (2 respondents)
- Southern and Northern Loloda Islands
- Karang Ngele-ngele
- Morortai Islands (5 respondents)
- Suaka Margasatwa Memberamo - Foja
- South Palau Rao
- Tobelo reefs and
- Widi Islands (3 respondents)

6. Palawan/North Borneo

Regionally or globally significant aggregations of threatened or restricted range species (migration corridors, nesting beaches, spawning or feeding aggregation sites, nursery areas)

This region may be an important corridor between Indonesia and the Philippines, and as such may warrant special attention. A satellite tracking and tag study found that Green turtles migrate into Berau from Malaysia, Philippines, and Palau to forage. This ecoregion hosts Southeast Asia's largest Green turtle rookery in Derawan, Berau which then exhibit post-nesting migrations to Socol Island in the Philippines and Banggi Islads in Sabah Malaysia. In addition to its global significance for feeding and nesting by Green and other turtles, this ecoregion is important for Dugongs, Manta rays, Zebra sharks, and Estuarine crocodiles. Anchialine lakes contain endemic and otherwise rare species. Finally, the mangrove system in East Kalimantan (Mahakam, Berau Rivers) is particularly important to vulnerable Irrawaddy dolphins.

Taxonomic uniqueness/presence of rare species/presence of unique habitats (eg, euryhaline lakes)

The presence of many endemic species and good overall diversity should facilitate conservation efforts to capture unique elements in this ecoregion. Examples include 1) Anchialine lakes in Kakaban and Maratua, which harbor distinct species assemblages including stingless jellyfish and other endemics, and 2) Panjang Reefs with extremely high diversity of reef habitats and important populations of fleshy Euphyllid corals, including *Nememzophyllia turbida*.

Other important considerations on biodiversity of this ecoregion (unique ecosystem services provided, vulnerability/resilience to climate change, overall vulnerability or conservation opportunity considerations)

The Palawan/North Bornei ecoregion has high habitat heterogeneity. Riparian networks, mangroves, seagrasses, marine lakes and different reef types sustain key onshore - offshore gradients. The area is exceedingly vulnerable to poor land management. Extensive logging in Borneo's forests leads to terrestrial runoff, which is widely known to smother coral reefs and even serve as a major coral disease vector. Furthermore the Derawan Islands are subject to the impact of unsustainable mangrove cutting at Berau Delta and conversion of this ecosystem into shrimp ponds for aquaculture. The anchialine lakes are particularly susceptible to the introduction of alien species that competitively exclude native species and can cause extinctions; preventing these extinctions should be a primary consideration in the event of tourism delevopment.

The presence of many endemic species and good overall diversity presents conservation opportunities to preserve this unique element of Indonesian fauna. The high gene flow with adjacent regions, including Sabah and Philippines, confers benefits to downstream populations but highlights the need to protect upstream populations. International migration of animals from this region would require special consideration and communication with nearby countries. In the short-term, the deep waters of Sulawesi Sea may help to reduce heat stress leading to mass bleaching of corals. In the long-term, Sulu and Sulawesi Seas may be important refugia during glaciations and may be centers of speciation.

Particular Sites of Conservation Noteworthiness:

- Balikpapan Bay and its mangrove forest as well as seagrass bed as Dugong feeding ground
- Berau District (Cape Batu to Cape Mangkalihat) (2 respondents)
- Derawan islands (2 respondents)
- Kakaban and Maratua
- Mahakam Delta and estuary
- Northern Palawan

- Turtle Islands
- Tubbataha/Cagayan Ridge

7. Western Sumatera

Regionally or globally significant aggregations of threatened or restricted range species (migration corridors, nesting beaches, spawning or feeding aggregation sites, nursery areas)

Coastal and oceanic habitat diversity in Western Sumatra is high, and fed by rich upwelling systems. More data are necessary to confirm the behaviors of marine mammals and turtles in the region. Six species of sea turtle nest in Western Sumatra, but their post-nesting migration behavior is not well known. Weh Island and nearby coastlines on the tip of Northern Sumatra are foraging grounds for Hawksbill turtles migrating from Thailand. Western Sumatra is likely to include migratory corridors for great whales, and overall serve as a significant habitat for oceanic whales and dolphins. Blue whale strandings confirm the presence of this species in Western Sumatra. Sperm whales and other species may also be abundant (Salm and Halim, 1984).

Western Sumatra hosts several threatened species including Megamouth Shark, *Megachasma pelagicos* (Critically endangered), *Dugong dugon* (Vulnerable), *Macaca pagensis* (Critically endangered) and *Presbytis potenziani* (Vulnerable), *Chelonia mydas* (Endangered – Appendix I), *Dermochelys coriacea* (Critically endangered), *Eretmochelys imbricate* (Critically endangered) and *Crocodylus porosus* (Vulnerable). The presence of highly distinct clades of Tridacnids in this region may represent cryptic species, and would thus represent a unique area of concern for Indonesia.

Taxonomic uniqueness/presence of rare species/presence of unique habitats (eg, euryhaline lakes)

Despite great potential in this regard, the sweeping lack of research on almost all taxa of interest in Western Sumatra hampers conservation efforts in this eoregion. A number of endemic coral reef associated stomatopods and fishes can be found. One potentially critical region is Sarabua Bay (Siberut), a deep inland bay with unique coral assemblages and perhaps Indonesia's best example of Indian Ocean fauna.

Taxonomic uniqueness of Western Sumatra lies in its representativeness of Indian Ocean fauna, which is poorly exemplified elsewhere in Indonesia. This ecoregion is situated at the perimeter of the Indonesian Archipelago and Asian land mass. Being farther west than any other region of Indonesia, Western Sumatra has a higher number of Indian Ocean species and is important as a conservation priority because of the pronounced mixing of Indian Ocean and Pacific faunal communities. It is likely to be a major Indonesian 'reservoir' of corals with distribution ranges restricted to the Indian Ocean or parts thereof, along with South Java and the Lesser Sundas to the east. In particu-

lar there may be strong connectivity with the Nicobar and Andaman Islands. This ecoregion is also likely to be important as a genetic connectivity corridor for Indian Ocean species that range farther eastward to Java, Bali and the Lesser Sunda Islands. About 85 percent of the reef fish species found at Weh Island are the same as those present at the Maldive Islands in the central Indian Ocean.

Other important considerations on biodiversity of this ecoregion (unique ecosystem services provided, vulnerability/resilience to climate change, overall vulnerability or conservation opportunity considerations)

Western Sumatra is subject to significant water movement, both from currents and constant oceanic swell, and has deep water in close vicinity to many reefs. This proximity of cool water near many shallow reefs may confer significant temperature buffering and ultimately offer environmental mitigation of larger-scale warming events from climate change impacts. However moderate habitat diversity and coldwater upwelling does not eliminate the threats of environmental perturbation in Western Sumatra. Episodic influence of the Indian Ocean Dipole (IOD) can cause anomalous upwelling, low sea surface temperatures, and low sea surface heights along the north-eastern Indian Ocean, and this phenomenon can work alone or in concert with other factors to yield high coral mortality in a short period of time (as in 1997: Abram *et al*. 2004; van Woesik 2004). Significant damage has occurred from both the IOD and the 2004 tsunami, particularly along the northern reaches of this ecoregion (references in Kunzmann 2000, 2002; Hoeksema and Cleary, 2004).

Overharvesting may unsustainably target certain taxa in Western Sumatra. The ornamental reef fish trade continues unmonitored. Banyak, Bengkaru, and Simelue islands seem promising as potential turtle nesting sites and should be surveyed. However extensive egg collection continues to support local sales in Padang. The mangrove stands in Pulau Siberut (Teluk Siberut) are significant collecting grounds of mangrove crab, *Scylla spp* and serve as major crab supplier to Padang, Sibolga and Medan (Hutomo, personal observation).

Western Sumatra has significant marine tourism potential. Surfers come from the world over to ride the perfectly formed, consistent waves of the Mentawai barrier islands. Presently, of the order of 40 charter yachts operate during the main season (April – October), mostly on 1 – 2 week charters. In all, thousands of surfers use the resource annually, generating millions of dollars. Some adverse associated impacts from pollution must be mitigated. This region may benefit from the establishment of 'surfing reserve' style MPAs with user-fees if deemed appropriate. Surfers and especially accompanying non-surfer guests may be extremely interested in ecotourism activities linked to conservation initiatives focusing on the important indigenous human communities and endemic terrestrial wildlife assemblages which inhabit the outer island chain.

Particular Sites of Conservation Noteworthiness:
- Pulau Bangkaru
- Pulau Banyak (4 respondents)

- Mentawai Islands (5 respondents)
- Nias Island (4 respondents)
- Nilas dan Nilas Tengah
- Pagai Islands
- Sarabua Bay. Deep inland bay with unique coral assemblages (Kunzmann 2000, 2002).
- Pulau Seribut - N Coast and offshore waters > 1000m (6 respondents)
- Simeulue Island – N Coast and offshore waters > 2000m (4 respondents)
- Weh Island ("Kilometre Zero" for Indonesia) (3 respondents)

8. Northeast Sulawesi/Tomini Bay

Regionally or globally significant aggregations of threatened or restricted range species (migration corridors, nesting beaches, spawning or feeding aggregation sites, nursery areas)

The white sand beaches of Bakiriang, Towari Bay, Central Sulawesi are important for the Maleo bird *Macrocephalon maleo.* Green turtles *Chelonia mydas* (Endangered – App. I), and Hawksbill turtles *Eretmochelys imbricata* (Critically endangered) nest in the Togean Islands. The rare *Isopora togianensis* is found here and also in Cenderwasih Bay. Finally, several threatened cetaceans are known to visit the deep waters of Tomini Bay.

Taxonomic uniqueness/presence of rare species/presence of unique habitats (eg, euryhaline lakes)

The northern coastline of Tomini Bay boasts distinctive steep high-forested ridges that plunge into the ocean and immediately drop off into the abyss, with no continental shelf. The Togian Islands in this ecoregion are delineated by a very unique coastline of sheltered bays with a disproportionately large number of rare and lagoonal taxa. The endemicity and genetic isolation seen there have been hypothesized to be a result of both ongoing speciation due to isolation as well as relictual Tethyan faunal elements enclosed as the arms of Sulawesi collided to form the deep bay while the Tethys seaway disappeared. This rich geologic history has contributed to exceptionally high representation of endemic species for such a small area, including reef associated fishes, stomatopods, and an anguillid eel. Several regional coral endemics are shared with Halmahera.

The rare bird *Caloenas nicobarica* (Appendix I), wild pig Babi Rusa *Babyrousa babyrousa* (Vulnerable – Appendix I), Dugong *Dugong dugon* (Vulnerable), Estuarine crocodile *Crocodylus porosus (Vulnerable*) are found in the Togeans. Rare animals in Morowali include the parrot *Cacatua sulphurea* (Critically endangered – Appendix I), *Gorsachius goisagi* (Vulnerable), *Macrocephalon maleo (vulnerable);* Babi rusa *Babyrousa babyrussa* (Vulnerable – Appendix I), *Bubalus quarlesi* (Endangered – Appendix I), *Sus verucossus* (Endangered) and Estuarine crocodile *Crocodylus porosus* (Vulnerable), as well as the largest known presence of *Isopora togianensis*.

Other important considerations on biodiversity of this ecoregion (unique ecosystem services provided, vulnerability/resilience to climate change, overall vulnerability or conservation opportunity considerations)

Although it remains to be determined by oceanographic studies, the topology of the Bay of Tomini strongly suggests limited water exchange. The presence of genetically isolated populations, and in some cases the presence of unique clades in this region attests to the limited connectivity of the Bay of Tomini with outside sources. This limited water flow appears to support an environmental gradient from oceanic to terrigenous from east (outside) to west (inside).

Although the smallest of the Indonesian marine ecoregions, it has high diversity and significant endemism. Fortunately, the main reef areas of the Togean Islands are now within a large marine national park, while the dynamic Governor of Gorontalo is working hard with other provinces to manage Tomini Bay in a sustainable manner.

Particular Sites of Conservation Noteworthiness:

- Ampana coastline
- Northern Balinggara Peninsula reefs
- Gorontalo region (2 respondents)
- Cagar Alam Morowali
- Togian Islands (7 respondents)
- Tomini Bay as large seascape marine management area
- Two estuaries, such as Estuary of Poso River and Bone River, as migration corridors of anguillid eels

9. Sunda Shelf/Java Sea

Regionally or globally significant aggregations of threatened or restricted range species (migration corridors, nesting beaches, spawning or feeding aggregation sites, nursery areas)

The presence of Indian Ocean species in the South China Sea suggests the Sunda Shelf/Java Sea may be an important for the dispersal and migrations of animals between the Indian and Pacific Oceans. This ecoregion offers important foraging grounds for Green, Hawskbill, and Leatherback turtles in the ASEAN region, a migration corridor for adult Green turtles, and a post-nesting migration corridor for Green turtles between Malaysia – Bangka – Natuna –North Sabah –Philippines Islands, and Vietnam –Riau, Indonesia – Philippines (www.ditjenphka.go.id). The Natuna islands in particular have very important nesting beaches for Hawksbill turtles, with this ecoregion has perhaps the highest Hawksbill population numbers in all of Southeast Asia. Natuna and Anambas clearly used to harbor significant reef fish (grouper and Napoleon wrasse) spawning aggregations that may have once seeded an expansive area, but now seem to be exterminated by overfishing. Deltaic structures of islands along the North Sumatra coast may provide important habitats for coastal dolphin species whose populations are in decline throughout Asia (such as the Indo-Pacific Humpbacked dolphin *Sousa chinensis*). The threatned Estuarine crocodile *Crocodylus porosis* is common in the mangrove forests of Kalimantan and Sumatra.

This region hosts globally significant seabird habitat. North and East Java, and east Sumatra are important regions for the Milky Stork *Mycteria cinerea.* North Java hosts several expansive mangrove stands that are key nesting and stopping grounds for water birds in Pangkah Tip, the Brantas River Delta, the Solo River (East Java), the Island Wildlife Reserve of Rambut (the Jakarta Gulf) and the Island Nature Reserve of Dua (Banten). Approximately 100 species of birds have been recorded in Pulau Dua, including approximately 40,000 nesting individuals per year. The beaches of north Java, including the Wonorejo Fishpond (East Java) and the Cirebon Coast - Indramayu – Subang – Karawang – Bekasi (West Java), are important stopping grounds for migratory water birds.

Taxonomic uniqueness/presence of rare species/presence of unique habitats (eg, euryhaline lakes)

Overall the taxonomic diversity of this region is low compared to others in Indonesia. However, based on maps alone, the Natuna and Anambas Islands appear to harbor high habitat diversity and may well divulge rare/unique species upon further survey. This ecoregion also has a significant number of species that are generally considered Indian Ocean faunal elements. As with the Malacca Strait, the shallow Sunda Shelf/Java Sea likely harbors high diversity in soft-bottom fish and invertebrates, representing a unique habitat type in the Coral Triangle.

The northern coast of Java hosts numerous endangered species including the Frigate birds *Fregata andrewsi* (Vulnerable – Appendix I), *Heliopais personata* (Vulnerable), the Wilwo Heron *Mycteria cinerea* (Vulnerable – Appendix I), the Leptoptilos Heron *Leptoptilos javanicus* (Vulnerable), the Tongtong Heron *Leptoptilos javanicus* (Lesser Adjutant). The latter species had been listed previously as Vulnerable, and nests in mangrove stands. Populations have been found on the east coast of Sumatra (South Sumatra, Jambi and Riau), the north coast of Java (the Sungai Brantas Delta and the Solo River) and the south coast of Java (Segara Anakan). A rare seagrass is also common here.

Other important considerations on biodiversity of this ecoregion (unique ecosystem services provided, vulnerability/resilience to climate change, overall vulnerability or conservation opportunity considerations)

The Sunda Shelf/Java Sea in characterized by relatively marginal reef environments with low salinity and high sediment input. Quick recovery after the 1997/1998 El Nino event suggests prior adaptation to stressful conditions including warm temperatures. However this recovery may have resulted in part from the surprising positive impact of sediment on bleached coral as has been demonstrated elsewhere. Whether this quick recovery stems from food and shading offered by ambient sediment, or if these corals have adapted to exibit high stress thresholds reminas to be shown. Either way these reefs have demonstrated some level of resilience to some conditions predicted to accompany climate change. Species richness in the semi land-enclosed shelf seas may be restricted due to relatively poor habitat diversity and a lack of oceanic influence. However this is a very large area. More than likely the Sunda Shelf and the Java Sea are ecologicaly and therefore faunasticaly very different and of different importance.

Because of its proximity to Jakarta, Pulau Seribu might warrant special consideration. Although the lack of enforcement has been a long-standing issue, and the reefs are degraded and far from diverse and pristine, it has high visibility locally, adding conservation value to this region. The high human population density in this ecoregion is accompanied to strong harvesting pressure on marine species, including but not limited to the collection of seaturtle turtle eggs on Tambelan Island. To the north-west, however, in the southern reaches of the South China Sea, are several archipelagos that are poorly-known and may contain a moderate degree of habitat heterogeneity and conservation value.

Particular Sites of Conservation Noteworthiness:

- Pulau Airabu
- Anambas and Natuna islands (5 respondents)
- Pulau Bajau
- Berhala Strait Coastal deltas and reef-fringed islands surrounding
- Blangkong Island to Linta Island
- Cagar Alam Pulau Dua, Banten
- Pulau Jemaja
- Karimunjawa (2 respondents)
- Pulau Matak
- Pulau Mubur and satellite islands
- West coast of Paloh (Sambas-west Kalimantan)
- Riau islands for Hawksbill nesting and foraging areas
- Pulau Seribu (3 respondents)
- Pulau Siantan
- Pulau Telaga

10. Arafura Sea

Regionally or globally significant aggregations of threatened or restricted range species (migration corridors, nesting beaches, spawning or feeding aggregation sites, nursery areas)

The Arafura Sea is a potentially an important stepping-stone uniting populations from Papua to populations in Sulawesi through dispersal across the Banda Arc. It is also a potential link between Indonesian and Australian population of many marine taxa. Specifically, this ecoregion may be a corridor for 1) larval dispersal between the high diversity regions of Southern Papua and Sulawesi, 2) Whale Sharks, 3) Green, Olive Ridley, and Leatherback turtles, and 4) additional Australian species that penetrate northward to S. New Guinea. In particular the Aru islands are extremely important for nesting and foraging Green turtles.

The Aru-Kai region is an important habitat for all six seaturtles found in Indonesia: Green turtles *Chelonia mydas* (Endangered – Appendix I), Hawksbill turtles *Eretmochelys imbricate* (Critically endangered – Appendix I), Loggerhead turtles *Caretta caretta* (Endangered – App. I), Olive Ridley turtles *Lepidochelys olivaceae* (endangered – Appendix I), the Flatback turtle *Natator depresus* (Vulnerable – Appendix I), and the Pacific Leatherback *Dermochelys coriacea* (critically endangered). Yamdena and Tanimbar are additional important grounds for Green turtles *Chelonia mydas* (Endangered – Appendix I), Hawksbill turtles *Eretmochelys imbricate* (Critically endangered – Appendix I). Biru Swamp is extremely important for coastal and migrating waterbirds.

Taxonomic uniqueness/presence of rare species/presence of unique habitats (eg, eury-haline lakes)

Like the Sunda Shelf, the Sahul Shelf in the Arafura Sea is a large region of shallow continental shelf, a habitat type that is relatively rare in Indonesia. This ecoregion encompasses what may be the most important mangrove forests in Indonesia. Contributing to this exceptional habitat, the Aru Islands provide extensive narrow river-like extensions of the sea between the various islands.

Wasur and CA National Parks, and Biru Swamp are important for Jabiru *Ephippiorhynchus asiaticus* (Appendix I) and Estuarine crocodile *Crocodylus porosus* (Vulnerable). The Aru-Kai regions are in-

habited by the Estuarine crocodile *Crocodylus porosus* (Vulnerable) and Dugong *Dugong dugon* (Vulnerable – Appendix I), while Yamdena and Tanimbar are noted to host Dugongs *Dugong dugon* (Vulnerable – Appendix I). The Arafura Sea is also home to 21 endemic brachyuran crab species and 26 endemic anomuran crustaceans.

Other important considerations on biodiversity of this ecoregion (unique ecosystem services provided, vulnerability/resilience to climate change, overall vulnerability or conservation opportunity considerations)

The remoteness of the Arafura Sea and associated lack of infrastructure both attest to its intact nature in many ways, but would also make conservation activities difficult. Indonesia's largest shrimp fishery proceeds legally, supporting massive trawling efforts. In addition to the devastating habitat destruction caused by trawl fisheries, deep-sea snapper are also at risk. Targeted fishing activities in Aru-Kai seriously threaten Dugong, Green turtles, and Leatherback turtles. The latter are additionally threatened as bycatch of trawling.

The mangrove stands along the South coast of Papua are among the largest and most diverse in Indonesia, if not the world. These extensive and intact lowland swamp areas may offer room for the natural migration of coastal habitats and species during minor sea level fluctuation.

While this ecoregion is not well-known from a reef perspective and, while not expected to have significant reef development due to the high input of freshwater and sediment from Papuan mainland, it is possible there may be some interesting lower-salinity adapted reefs along the Papuan mainland or low patch reefs in the shallow Arafura Sea. Having evolved in marginal conditions, they may be somewhat resilient to some of the negative impacts of climate-change.

Particular Sites of Conservation Noteworthiness:
- Aru Island (5 respondents), and to the east and southeast, including seagrass beds
- Kai Island
- Pulau Kimaam aman Nasional Wasur
- Mangrove/wetlands and coastal waters and estuaries of South Papua (3 respondents) to protect Dugongs, seagrass beds, Bryde's whales and Indo-Pacific Humpbacked dolphins
- Overall Arafura sea

11. Southern Java

Regionally or globally significant aggregations of threatened or restricted range species (migration corridors, nesting beaches, spawning or feeding aggregation sites, nursery areas)

The seasonal upwelling system of Southeast Java is one of the most productive and expansive upwellings of all the Lesser Sundas, and unique in northeast Indian Ocean. This feature, along with the surrounding pelagic habitat may be regionally important for a wide range of megafauna such as whales and whalesharks, particular near upwelling systems on eastern Java coast. Kahn (2008) identified deep-sea yet nearshore habitats for the Lesser-Sunda/Timor Leste ecoregion, which are significant for a wide range of marine mammals. Alas Purwo National Park and other areas of this coastline are exceedingly important as turtle nesting beaches (including Pacific Leatherbacks, Greens, Olive Ridley's, and Hawksbill turtles), while the tip of the Plengkung area in the Alas Purwo region is a confirmed feeding ground for Pacific Leatherbacks foraging on jellyfish blooms. Finally, post-nesting Green turtles from Alas Purwo National Park migrate across the Indian Ocean to the west coast of Australia. Segara Anakan is an important stopping ground for migratory birds.

Taxonomic uniqueness/presence of rare species/presence of unique habitats (eg, euryhaline lakes)

Pulau Anak Krakatau and Rakata are natural experimental locations for studying marine colonization processes and larval dispersal (Barber *et al.*, 2002). This extremely unique situation should be maintained unmolested. Two genera, *Periclemenes* and *Tridacna* have highly differentiated clades on the islands of Krakatau. Despite extensive surveys elsewhere, no other similar populations have been found throughout the Coral Triangle. However, it must be noted that this region is extremely poorly sampled, so results may reflect sampling bias rather than lack of unique diversity.

While this ecoregion has no significant diversity patterns, a small number of species including *Haptosquilla pulchella* and *Patelloidea profunda* show signs of genetic distinctiveness, although these clades represent western extensions of those present in the Lesser Sundas.

Southern Java holds the last remaining mangrove stands in Java (in Cilicap/ Segara Anakan), and is rich with bird diversity. The Tongtong Heron *Leptoptilos javanicus* (Lesser Adjutant) nests in the mangrove stands. A significant portion of their population is found along the east (South Sumatra, Jambi and Riau), north (the Sungai Brantas Delta and the Solo River), and the south coasts of Java (Segara Anakan). Several coastal waterbirds are rare and threatened with extinction, including the Wilwo Heron *Mycteria cinerea* and the Drum Heron of *Leptoptilos javanicus*. The terrestrial fauna is also vulnerable. Cikepuh and Sukabumi host *Hylobates moloch* (Critically endangered), *Boss javanicus* (Endangered), the leopard *Panthera pardus* (Endangered), and the turtles *Chelonia mydas* (Endangered), *Dermochellys coriacea* (Critically endangered), and *Eretmochelys imbricata* (Critically endangered). In Leuweung Sancang Nature Reserve several endangered species have been found, including the *Leptoptilos javanicus* (Vulnerable), the Peacock *Pavo muticus* (Vulnerable), and the leopard *Panthera pardus* (Endangered).

Other important considerations on biodiversity of this ecoregion (unique ecosystem services provided, vulnerability/resilience to climate change, overall vulnerability or conservation opportunity considerations)

Most of the southern Java and Sumatra coast hosts little reef development. High exposure to oceanic swell and cold Indian Ocean upwelling may inhibit the development of species-rich reefs. Rather, this region hosts important pelagic, benthic and abyssal habitats on and over the continental shelf edge, supporting one of Indonesia's most productive sardine fisheries, primarily in the Bali Strait next to Alas Purwo. This fishery may compete directly with significant marine mammal populations and conservation efforts in Southern Java. These harsh conditions may also confer benefits. Because of the relative inaccessibility of the area governments could relatively easily enact no-take reserves. Strong water movement (currents and wave action) mean this area may be resilient to warming events caused by climate change in the limited reefs and varied habitats in Sunda Strait and around Krakatau Islands.

With only minimal MPA coverage in this ecoregion, The Ujung Kulon National Park could be expanded further for the coastal marine elements. Additonal MPAs may prioritize protecting the last remaining mangroves in this region, which are not currently well protected.

Particular Sites of Conservation Noteworthiness:
- Alas Purwo (2 respondents)
- Cilacap Mangrove and Estuary including Segara Anakan Lagoon (2 respondents) – for waterfowl and mangroves
- Enggano Island
- Krakatau (2 respondents)
- Nusakambangan Sukamade and Meru Betiri beach for turtle nesting
- Panaitan
- Pangumbahan Beaches (Sukabumi)
- Sukamade
- Sunda Strait/Seribu Islands (3 respondents)
- Ujung Kulon Extension around Sunda Strait (2 respondents)

12. Malacca Strait

Regionally or globally significant aggregations of threatened or restricted range species (migration corridors, nesting beaches, spawning or feeding aggregation sites, nursery areas)

The Malacca Strait may be the only vital link for transfer of Andaman Sea/Indian Ocean fauna east into South China Sea and the Pacific Ocean. Recent work in the South China Sea area has found examples of Indian Ocean fauna, including 'vagrant' fish and coral species. In addition some Pacific coral species were recorded from Phuket area in Thailand and not found elsewhere in the Indian Ocean. This ecoregion is an important migratory corridor for some charismatic vertebrates, especially sea birds and turtles. Eastern Sumatra and the Malacca Strait are among the most globally significant stopover locations for migrating waterbirds, especially from the families Charadriidae and Scolopacidae, which undertake yearly migrations from nesting grounds in the northern hemisphere through East Asia and Australasia towards the southern hemisphere. Several of these birds are rare and threatened with extinction, including the Asian Mud Trinil *Limnodromus semipalmatus*, *Tringa guttifer* (Endangered), and the Chinese Heron *Egretta eulophotes.* Malacca strait is an important migratory pathway used by Hawksbill and Green turtles, including some moving from Upeh Islands-Malaysia to foraging grounds in Riau. Although it remains to be confirmed, this ecoregion may also be a significant shallow migratory corridor for cetaceans.

Taxonomic uniqueness/presence of rare species/presence of unique habitats (eg, euryhaline lakes)

This large shallow strait is unique in this part of Indonesia, and is potentially comparable to Torres Strait between Australia and Papua New Guinea. Reef habitats are most likely characterized by strong siltation from large rivers entering the Malacca Strait and diversity at most local sites is probably comparatively low. However low-lying brackish swamps of the Riau islands appear to have high diversity and endemicity of fishes and invertebrates.

The Malacca Strait is globabbly significant to numerous coastal vertebrates, which exemplify land-sea connectivity. The Estuarine crocodile *Crocodylus porosus* (Vulnerable) inhabits mangrove forests in this region, namely Banyuasin – the Musi River Delta, the Sembilang National Park, the mangrove stands of the Dumai Strait. This, the world's largest living reptile, reproduces in the mangroves of Muara Kampar, Riau. The Malacca Strait ecoregion is the world's most important habitat for Milky Storks *Mycteria cinerea,* one of the most endangered birds in the world. During the 1990's the worldwide population totaled approximately 5000 – 6000 individuals, of which more than 90% were located in the coastal mangrove forests of eastern Sumatra and the north and south Java coasts (Segara Anakan). They have been found almost exclusively in the Pantai Timur Mangrove Forest (Jambi), the Koyan Cape, Tanjung Selokan and the Banyuasin Peninsula in South Sumatra. The Vulnerable Tongtong Heron *Leptoptilos javanicus* (Lesser Adjutant) nests in the mangroves of the Malacca Strait, with most of their populations found on the coasts of East Sumatra (South Sumatra, Jambi, Riau, North Sumatra), North Java (the Brantas River Delta and the Solo River) and South Java (Segara Boneka). Finally, *Chitra indica* (Critically Endangered) has been recorded in the Malacca Strait.

The East Sumatran coastal region is of global significance to terrestrial fauna as well, hosting the best population of the Sumatran Tiger *Panthera tigris sumatranus* (Endangered – Appendix I), and several other rare mammals including *Cynogale benettii* (Endangered), the Bengal Tiger *Felis bengalensis* (Appendix I), the Otter *Lutra lutra* (Appendix I), and the Sumatran elephant *Elephas maximus*.

Other important considerations on biodiversity of this ecoregion (unique ecosystem services provided, vulnerability/resilience to climate change, overall vulnerability or conservation opportunity considerations)

This area is one of the most heavily trafficked shipping routes in the world, and serves the developed areas of Singapore and Batam. These shipping routes conflict directly with migratory bird and turtle paths. However the reefs of Singapore and those of Batam and Bintan have some recreational relevance, and Sembilang National Park, South Sumatra (approximately 200,000 ha), was strengthened in 2003.

The impacts and threats of shipping on any cetaceans in the area may be the most severe for the SE Asia region:

1. Extreme exposure to underwater noise leading to acoustic habitat degradation and possibly displacement.
2. Waste disposal at sea and chronic oil spillage
3. Ballast water treatment , which introduces non-native marine species and pathogens
4. Collision risk for whales via ship strikes

Mangrove products form the basis of local livelihoods including building materials (*Rhizopora apiculata*, *Bruguiera gymnorrhiza*), Charcoal (*Sonneratia* sp., *Avicennia* sp.), shipbuilding materials (*Avicennia* sp., *Sonneratia* sp), food and drink production (juice, syrup; *Avicennia* sp., *Sonneratia* sp.), and honey. Coastal functions include natural sperm plasma for medicines, coastal protection from wave erosion and water intrusion, and the production of fish, shrimp and crabs.

Particular Sites of Conservation Noteworthiness:

- Merupakan mangrove stands are among the most important in South-East Asia, and may be the second largest in South-East Asia after the Bintuni, Papua.
- Berbak National Park, Jambi
- The Riau Islands
- Pulau Mesanak to Pulau Singkep and their smaller satellite islands
- Pelagic, benthic and abyssal habitats

5 Prioritization Ranking Results Overall Assement

Given the wide range of biodiversity expertise represented within the respondents to the questionnaire, it is perhaps not surprising that the summary of the rankings depicted in Figure 23 and Table 7 shows significant differences in opinion on the prioritization of Indonesia's marine ecoregions for marine biodiversity conservation investment. Nonetheless, the respondents were nearly unanimous in their ranking of three of the ecoregions: Papua was highlighted as far and away the top priority ecoregion in Indonesia (10 of 16 respondents ranked it number 1), while Southern Java and the Malacca Strait were almost universally ranked at the bottom of the prioritization list (see also Figure 24). The remaining 9 ecoregions each showed a wide spread of rankings, though in averaging their rankings these ecoregions naturally divide into three groups. The Banda Sea, Lesser Sundas, and Sulawesi Sea/Makassar Strait are ranked 2-4 respectively, though statistically are nearly equivalent in their ranking. Likewise, Halmahera, Palawan/North Borneo, and Western Sumatra are ranked 5 through 7, though are statistically very close in rank. Finally, Tomini Bay, the Sunda Shelf/Java Sea, and Arafura Sea (ranked 8-10) are also nearly indistinguishable in overall rank.

Differences between past and current prioritizations likely reflect not only significant advances in the understanding of the distribution of Indonesian marine biodiversity in the past several

decades, but also different criteria for rankings. The present exercise highlights patterns in vulnerability, irreplaceablity, and representativeness of Indonesia's globally significant biodiversity. By contrast, criteria used by Salm and Halim (1984) required at least one MPA near each major population center, which was not a consideration here. While the educational value of reefs near population centers is mentioned by a few respondents (e.g. for Pulau Seribu), this report generally considers human-reef interactions from the perspective of anthropogenic influences on reef condition, habitat integrity, and resulting impacts on diversity. For example, reef degradation from destructive fisheries in Halmahera, and shipping in the Malacca Strait, are viewed as being detrimental to the ranking of these ecoregions.

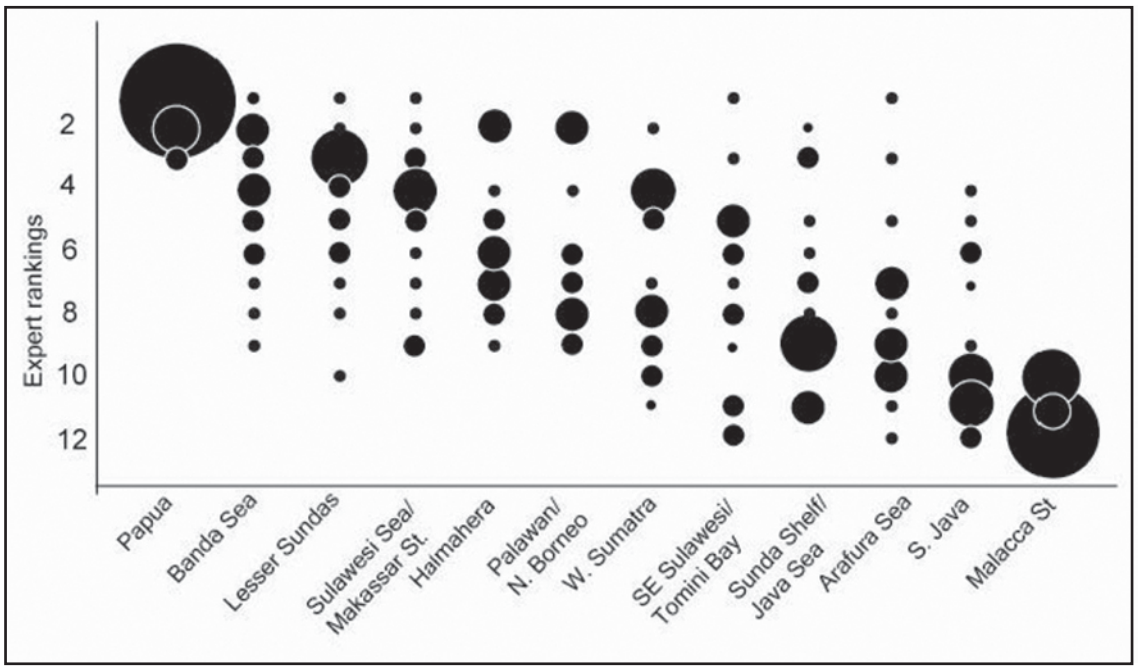

Figure 23. Tally of expert rankings of conservation priority for marine ecoregions of Indonesia based on biodiversity considerations. Ecoregions are displayed on the X axis from left to right in order of their final prioritization rank. Size of circle corresponds with the number of votes for that rank.

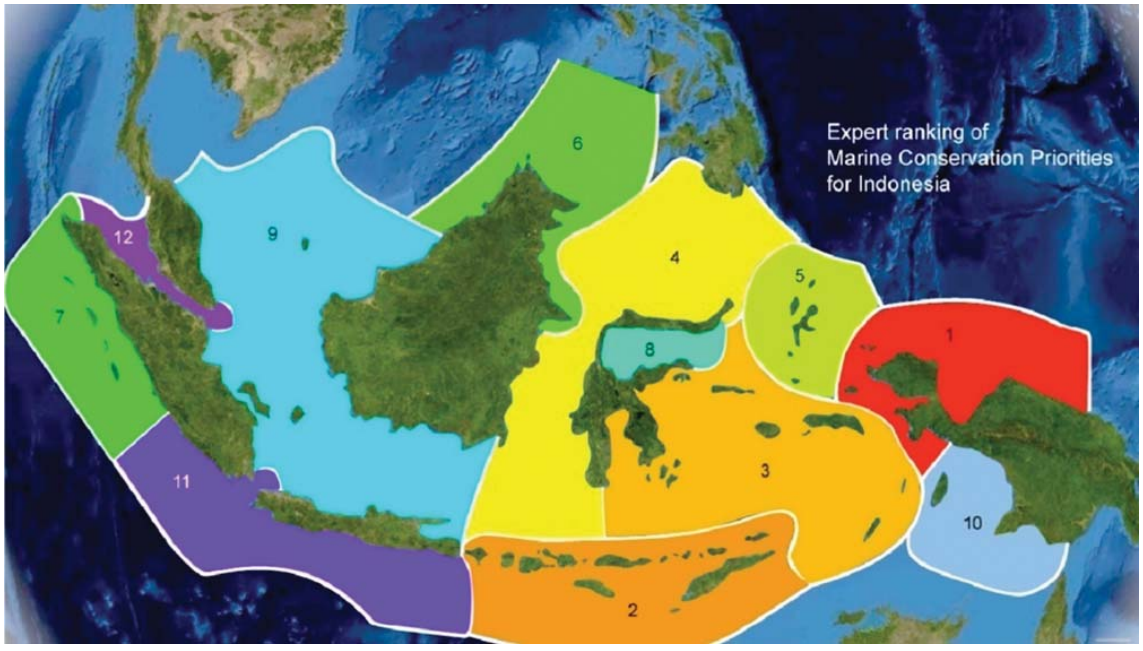

Figure 24. Map showing final expert rankings of conservation priority for marine ecoregions of Indonesia based on biodiversity considerations. Bold number within ecoregion denotes final rank; warmer colors in figure denote higher rankings.

Table 7. Table of ecoregion prioritization rankings by expert.

Ekoregion \ Respondent	Papua	Banda Sea	Lesser Sundas	Sulawesi Sea/ Makassar Strait	Halmahera	Palawan/ North Borneo	Western Sumatera	Tomini Bay	Sunda Shelf/ Jawa Sea	Arafura Sea	Southern Java	Malaka Strait
G. Allen	1	6	3	9	2	4	5	8	7	10	11	12
P. Barber	1	4	6	3	7	9	2	5	11	8	12	10
S. Campbell	2	9	4	5	7	6	8	12	3	10	11	10
L. DeVantier	1	8	3	7	2	6	4	5	9	12	10	11
M. V. Erdmann	1	2	3	5	6	9	4	7	8	10	11	12
M. H. Halim	1	6	10	8	9	2	7	12	3	5	4	11
C. Hitipeuw	1	4	7	—	8	2	9	11	6	3	5	12
B. W. Hoeksema	1	7	3	4	6	2	8	5	9	9	10	10
M. Hutomo	2	5	4	1	8	7	10	3	9	7	11	12
B. Kahn	3	2	1	4	5	—	8	—	9	7	6	10
Y. R. Noor	2	4	8	3	5	—	10	6	7	1	9	11
K. Putra	1	2	3	9	7	8	4	11	5	9	6	12
J. Randall	1	3	2	4	—	—	5	6	11	—	10	12
Suharsono	3	5	6	2	4	8	9	1	11	7	10	12
E. Turak	1	3	5	6	2	7	4	8	9	11	12	10
K. Moosa	2	1	5	4	6	8	11	9	2	9	7	12
Overall Ranking	1	2	3	4	5	6	7	8	9	10	11	12
Average	1.50	4.44	4.56	4.93	5.60	6.00	6.75	7.27	7.44	7.87	9.06	11.19
Mode	1	4	3	4	2	2	4	5	9	10	11	12

6 Individual Ecoregion Rankings

1. Papua

Based on its unparalleled marine biodiversity and endemism, habitat richness, and relatively intact nature of its ecosystems, experts almost unanimously considered Papua to be the top priority for marine conservation efforts in Indonesia (Figures 23 and 24; Table 7). Current data indicate that this region should be considered the epicenter of the Coral Triangle, with the planet's highest diversity of coral reef species (e.g. hard corals, reef fishes, and reef stomatopods), reef habitat, and coral community types. Both Asian and Australian fauna are represented in some cases, as well as a rich assemblage of marine lakes and their diverse inhabitants. Furthermore, the dynamic interactions between sea-level rise and fall, and isolation due to bathymetry and active tectonics appear to make this region a 'species factory' that may supply the greater Coral Triangle with biodiversity in evolutionary time. The high number of endemics as compared with other tropical regions may be evidence of this. Papua hosts relatively healthy populations of animals that are otherwise rare and threatened elsewhere throughout their ranges, as well as habitats that are essential for their survival. For example, four sea turtle species use regions in Papua as major nesting sites and/or migration corridors. Over 1000 Green turtle nests per year are laid on the small islands of Sayang

and Piai in Raja Ampat alone, while Ayau and Misool islands, Cendrawasih Bay and Kaimana support additional nests. The Bird's Head Seascape hosts the largest Leatherback nesting beaches in the Pacific Ocean, with over 3000 nests laid per year. A significant population of endangered Olive Ridley turtles lays an estimated 500 nests per year in Papua. All three areas so far surveyed in this ecoregion have identified important marine mammal habitats for species in oceanic, delta, and coastal island ecosystems. Despite being one of the least known marine areas for cetaceans in the world, critical habitats have been identified for coastal whale species (e.g. Bryde's whales).

Low human population density adds to the conservation potential for this area, though aligning forces of exploitation intensify the urgency for marine conservation action in this region. The globally significant coastal and marine ecosystems of Papua are immediately threatened by an explosion of poorly-planned coastal ring roads, coastal and inshore mining, logging (both legal and illegal), coastal development, mangrove loss, land reclamation activities associated with special autonomy and ill-conceived transmigration projects.

2. Banda Sea

The Banda Sea ranks second for conservation priority in Indonesia based on its high diversity of coral reef species, high reef habitat diversity (including abundant nearshore yet deep sea habitats, otherwise rare throughout the world), strategic role in connectivity based on current patterns, significant role in sea turtle life cycles, and significance to highly endangered oceanic cetaceans such as Blue whales. The positive attributes of the Banda Sea may far exceed these listed here, as this ecoregion is extremely poorly known. The reportedly low level of endemism seen here may easily reflect insufficient sampling rather than a true pattern, as this ecoregion harbors a significant variety of habitats including extensive reef areas next to deep oceanic waters. The reefs and seamounts of the deep Banda Sea basin may act as stepping-stones uniting eastern and central Indonesian fauna, and may provide a refuge during glaciations and sea level fall. Five sea turtles use this ecoregion and isolated islands therein for important foraging and nesting grounds. Pacific Leatherbacks aggregate and forage in the Kei islands, where they are threatened by traditional hunting of over 50 individuals per year. Olive Ridley and Green turtles, especially those from Eastern Indonesia, find important nesting, foraging, and migratory grounds in Wakatobi and Takabone Rate. Although their behavior in the Banda Sea is not well known, Flatback turtles can also be found here.

Like Papua, human population density in the Banda Sea is low. However, many experts consider the Banda Sea to be heavily fished, putting the above attributes at risk.

3. Lesser Sundas

In addition to having very high diversity and levels of endemicity surpassed only by Papua, the Lesser Sundas function as an extremely important migration corridor for many forms of large migratory marine life (including cetaceans and commercially important pelagic fishes) that move between the Indian and Pacific Oceans via the multiple nearshore, deepwater channels in this ecoregion. Cold-water upwelling along the southern coastlines of the Lesser Sundas drive extremely high levels of primary productivity that forms the basis of rich food webs

supporting large pelagic fishes and cetaceans, including Blue whales. Indeed, the Solor - Alor – Wetar island region is one of the most important habitats for oceanic cetaceans in the Indonesian Seas and possibly SE Asia. The Lesser Sundas contain an extremely important corridor and possibly sink for larvae coming from the north via the Indonesian Throughflow. Faunal communities have high species diversity of Indian Ocean taxa and clades, but also incorporate elements of tropical, temperate, and Pacific Ocean assemblages. These attributes along with high reef habitat diversity may make the Lesser Sundas a potential repository for clades suited to survive changing environmental conditions. While turtle density was initially perceived to be low based on the scattering of nesting beaches in this ecoregion, tagging studies have shown that coastal coral reefs and seagrass beds here are important developmental and foraging grounds for turtles that nest elsewhere in the Indian Ocean. Finally, this area has relatively high mangrove diversity and is important to seabirds.

4. Sulawesi Sea/Makassar Strait

The Sulawesi Sea/Makassar Strait ranks fourth in conservation priority based on its integral role in connectivity and larval dispersal via the Indonesian Throughflow, high species richness, and high taxonomic and genetic representativeness of diversity from throughout Indonesia. This ecoregion represents a contact zone between Pacific and Indian Ocean populations and Eastern and Western Indonesian populations as both a mixing zone of divergent faunas and as a larval source for large downstream populations. However, despite its high biodiversity, this ecoregion largely hosts a subset of eastern Indonesia fauna, with only minimal endemism. Furthermore the majority of this biodiversity is contained within the small but incredibly habitat-rich and biodiverse area of North Sulawesi (Bunaken-Likupang-Lembeh). The Lembeh Strait in particular is home to especially unusual, cryptic animals thought to occur in naturally low numbers and therefore in need of particularly attentive conservation measures. The prevelance of seamounts, dynamic currents, and deep-sea environments in this ecoregion are very important to cetaceans, and Sperm whales are known to use the Sulawesi Sea as an important calving ground.

Existing MPA infrastructure and management capacity in Bunaken National Park should serve as a sound expansion point for additional conservation measures, which should include the creation of a network of MPAs running north to south and creating a "connectivity corridor" through the Makassar Strait.

5. Halmahera

Halmahera ranks fifth as a marine conservation priority in Indonesia based on its exceedingly high biodiversity, representativeness of Asian and Australian fauna, and important role in connectivity between Papua and Sulawesi. Habitat diversity and per-site species richness in Halmahera is exceptional, with among the highest per-site fish counts in the world and coral species richness expected to far exceed 500. Hawksbill and Green turtles nest on the white sand beaches of this ecoregion, while Olive Ridley and Pacific Leatherbacks nest on the black sand beaches. Leatherbacks from Papua also feed along Halmahera's western coast. Unfortunately this ecoregion has been relatively degraded by destructive fishing.

Because of its proximity to Papua, the fact that much of its biodiversity is a subset of the Papuan ecoregion, and its potentially important role as a stepping-stone in linking Sulawesi and Papuan populations, several experts suggested that Halmahera should perhaps be viewed as an extension of the Bird's Head Seascape within the Papua marine ecoregion. This area deserves immediate conservation attention in close collaboration with the enthusiastic provincial government and Universitas Khairun, perhaps focused in the southwest corner, where mining threats are not yet of concern.

6. Palawan/ North Borneo

The Palawan/North Borneo ecoregion, which spans waters in Indonesia, Malaysia, and the Philippines, is ranked sixth for marine conservation priority in Indonesia. While this ecoregion hosts unique habitats, including anchialine lakes, relatively high endemism among coral reef associated fishes (though mostly from Palawan and western Borneo, not Indonesian Borneo), and some genetically distinct groups, data strongly suggest that faunal assemblages have strong genetic affinities with the higher-ranked Sulawesi Sea ecoregion. In general the biodiversity of this ecoregion represents a subset of others nearby. The Palawan/North Borneo ecoregion is very important to non-reef associated animals. The exceptional mangrove forests and seagrass beds sustain endangered Irrawaddy dolphins, Finless porpoises, sea turtles and seabirds. This ecoregion is of global significance to Green and Hawksbill turtle populations. The Berau MPA hosts the largest Green turtle population in SE Asia. More than 8000 nests are laid year round, with strong connectivity to populations in at least three countries spread across the Sulu Sea and Micronesia. The coastline along north Borneo is also an important migration corridor for Green and Hawksbill turtles, while coral reefs on the southern part of the island groups also serve as significant foraging area for Hawksbill turtles.

7. Western Sumatera

Western Sumatra ranks seventh for marine conservation priority, despite being considered the most biodiversity data deficient ecoregion in Indonesia. Although its biodiversity is not well surveyed, most experts agreed that Western Sumatra hosts the best reef development and widest range of reef habitat types along Indonesia's Indian Ocean coast, and captures Indian Ocean assemblages better than any other ecoregion. From a genetic diversity perspective, Western Sumatra is considered second in importance only to Papua, and contains a host of distinct genetic lineages not found elsewhere in Indonesia. All six sea turtles found in Indonesia forage and/or nest here, though their spatial use patterns are not well known. This ecoregion ranked as the most urgent priority for follow-up survey work to better understand the biodiversity contained within, and many experts noted that its ranking might well rise with further surveys.

8. Northeast/Tomini Bay

The Northeast Sulawesi/Tomini Bay ecoregion is ranked eighth for marine conservation priority in Indonesia. This ecoregion is diverse for its small size, and hosts a variety of rare habitats, high endemicity, and abundant sea turtles. Being isolated from the greater Banda Sea ecoregion by

currents and bathymetry, Tomini Bay hosts distinctive genetic clades and endemic taxa, especially in the Togean Islands. Northeast Sulawesi/Tomini Bay may also be important to cetaceans, though this requires further verification.

The recently declared Togean Islands National Marine Park will largely protect the representative biodiversity of Tomini Bay, pending the cooperative implementation of an integrated coastal zone management plan by the provincial governments that surround the bay.

9. Sunda Shelf/Java Sea

The Sunda Shelf/Java Sea ecoregion is ranked ninth for marine conservation priority in Indonesia. This region is characterized by marginal reefs that were established after the last glacial maximum, with relatively low species richness and almost no endemism. Significant stressors to marine ecosystems there include freshwater run off, sediment input, and anthropogenic impacts. Despite these conditions, based on preliminary data and prevailing surface currents, this ecoregion encompasses elements of South China Sea and Indian Ocean faunas (likely to be found in the Reefs of Kepuluan Anambas, Pulau Jemaja, Pulau Telaga, Pulau Siantan, Pulau Airabu, Pulau Bajau, Pulau Matak, Pulau Mubur and satellite islands; and further north-east the Natuna Islands; Ablan *et al*., 2002), including unique sediment-adapted reef assemblages. The region offers very important feeding and nesting areas for Green and Hawksbill turtles, with perhaps the most important Hawksbill rookeries in SE Asia located in the Anambas and Natuna Islands. The ecoregion is also home to regionally significant mangrove stands, and birds that migrate along the eastern coast of Sumatra use the Sunda Shelf/Java Sea as an important flyway. Finally, though depauperate in reef fauna, this ecoregion has a high diversity of soft bottom fauna including stomatopods and other benthic infauna.

10. Arafura Sea

The Arafura Sea ranks tenth for marine conservation priority in Indonesia because of its overall low degree of reef development and hence lowered biodiversity, both taxonomically and genetically. Nonetheless, some of the world's most extensive and biodiverse mangrove stands are found along this southern coast of Papua, which generally lacks habitat variability but is globally important to mangrove and seagrass communities sustaining threatened seabirds, Dugongs, sea turtles, Estuarine crocodiles, Whale sharks and possibly Sawfish. This large shallow shelf and wooded shore is considered prime undisturbed habitat for coastal cetaceans. The Arafura Sea is also home to one of the most important Green turtle rookeries in Indonesia (in the Aru Islands), and is an important foraging ground for migrating Hawksbill, Olive Ridley and possibly Flatback turtles. This region is considered of high importance for further survey work, as it is not well known.

11. Southern Java

Southern Java is ranked eleventh for marine conservation priority in Indonesia. Where known, this area exhibits low species richness, all of which is already captured in the Western Sumatra ecoregion and to a lesser extent in the Lesser Sunda ecoregion, both of which are given higher priority. Southern Java is marked by steep bathymetry with high deep-sea biodiversity apparent in the Java

Trench. Sheer drop-offs, low coral reef coverage, high wave energy, and rough sea conditions limit most fishing activities, however those coastal fisheries that are accessible proceed with high intensity. Beaches on along Southern Java yield over 5000 turtle nests per year, and are considered significant nesting habitats for Green turtles in southern Indian Ocean and a minor nesting site for Pacific Leatherbacks. Olive Ridleys and Hawksbills also nest along this coastline. These turtles are threatened by biophysical changes to beaches potentially due to seawater rise, in-water mortality by coastal fishing activities and boat strikes, and collection of eggs for commercial purposes. Also, the Cilicap/Segera Anakan lagoon has locally significant mangrove stands, which are important to seabirds.

Although overall this region ranks low in priority, the islands of Krakatau merit high conservation priority as a natural laboratory in which to study coral reef colonization and succession. The Pulau Seribu and Sunda Strait areas already have MPA protection (despite major anthropogenic impacts) and are important for their role in public education.

12. Malacca Strait

The Malacca Strait ranks twelfth and lowest for marine conservation priority in Indonesia. While this ecoregion represents a unique shallow-water habitat that is globally significant to seabirds, and a potential corridor for dispersal between Indonesia and the Eastern Indian Ocean, it is also extremely depauperate for reef diversity and highly impacted by human activities, sedimentation, and pollution due to major population centers and Malacca Strait shipping traffic. The extent of human impacts led several experts to question whether the Malacca Strait even qualifies as an ecoregion. Its shallow depth combined with proximity to terrestrial environments with high run off and sediment load suggests that reef systems in this area are largely marginal with low-diversity, and not a high conservation priority. Despite these conditions being poor for the development and maintenance of coral reef communities, the Malacca Strait is globally significant to a diverse assemblage of coastal and migratory seabirds, many of which are threatened with extinction but aggregate here in large numbers. Finally, Hawksbill turtles use these heavily trafficked waters as an important post-nesting migration route, forming a corridor between the Andaman and South China Seas.

7 Gap Assessment of MPA Coverage and Conservation Priority

Figure 25 summarizes the distribution of the 179 Salm and Halim (1984) marine conservation priority sites across the twelve ecoregions of Indonesia, while Figure 26 includes a summary of the number and areal coverage of existing MPAs in each of the ecoregions. While gaps certainly do exist between current MPA coverage in Indonesia and the prioritization rankings outlined in this exercise, current conservation efforts reflect a high degree of correlation with both historical priorities and the new assessments reported herein. Both this exercise and Salm and Halim (1984) place a high priority on Papua, the Lesser Sundas, the Banda Sea, and the Sulawesi Sea/Makassar Strait, the first three of which now have significant MPA coverage. Furthermore, almost all of the sites prioritized by Djohani (1989) remain high on experts' lists today:

- *Djohani First Priority:* Togean Islands (7 respondents), Aru Islands (5 respondents), Teluk Cendrawasih (7 respondents), Wakatobi/Tukang Besi (3 respondents)
- *Djohani Second Priority*: Taka Bone Rate (3 respondents), Bunaken (5 respondents), Kei Islands (3 respondents), Raja Ampat (6 respondents), Komodo (5 respondents), Karimunjawa (2 respondents)
- *Djohani Third Priority*: Riau (1 respondent), Karimata (0 respondents), Pulau Widi/Halmahera (3 respondents), Pulau Pombo/Kassa/Banda (3 respondents), Teluk Maumere (2 respondents), Pulau Seribu (6 respondents), Bali Barat (1 respondent)

Perhaps the most striking difference in the original Salm and Halim priorities versus those identified in the present exercise is the high importance accorded the Sunda Shelf/Java Sea marine ecoregion in the Salm and Halim priorities, whereas this ecoregion ranked only ninth in the current survey. This strong difference is potentially due to either a significant decline in the value of marine biodiversity in this ecoregion over the past 30 years, or perhaps that advances in our knowledge of marine biodiversity in Indonesia have now clearly shown this area to be not as important as many of the other ecoregions. Another possible explanation is that an explicit goal of the Salm and Halim prioritization was to ensure at least one MPA in the vicinity of every major population center in Indonesia. The Sunda Shelf/Java Sea ecoregion has by far the highest density of major human population centers of any of Indonesia's ecoregions; by comparison, the present exercise has no such criteria of prioritizing reefs and marine ecosystems near population centers.

A brief examination of the current MPA coverage depicted in Figure 26 shows that of the twelve ecoregions in Indonesia, only four have significant areal coverage of MPAs: the Lesser Sundas, Papua, the Banda Sea, and the Sunda Shelf/Java Sea. Of these, the Lesser Sundas has by far the highest coverage, the majority of which is comprised of the massive 3.5 million hectare Savu Sea MPA declared in May 2009. By comparison, those ecoregions with the least coverage in MPAs include Halmahera, the Arafura Sea, Tomini Bay, and Southern Java. Halmahera in fact does not yet have any officially gazetted MPAs, with only a single candidate MPA nominated from northern Halmahera.

In comparing the results of the present ranking with the current coverage of MPAs in Indonesia's marine ecoregions, several important gaps become immediately obvious (see Figure 27). Without question Halmahera ranks first in this gap analysis; with only a single local candidate MPA and ranking fifth based on its extremely high biodiversity, habitat richness, and representativeness of both Sulawesi and Papuan fauna, this ecoregion is in urgent need of conservation efforts including delineation of new MPAs. The next most important gap in current marine conservation efforts in Indonesia is Western Sumatra; the small degree of areal coverage in this region belies its importance in representing the Indian Ocean component of Indonesia's marine biodiversity and the relatively high degree of endemism and unique genetic lineages found there.

Of equal importance as a critical gap in MPA coverage at this time is the Sulawesi Sea/Makassar Strait ecoregion; although it has the highest number of MPAs (32) of any ecoregion in Indonesia, the majority of these are small community-based marine reserves that together comprise a relatively insignificant areal coverage of MPAs for this large and important ecoregion. Given its exceptional biodiversity and the critical importance of this ecoregion as a "connectivity corridor" (Figure 21), significant effort should be directed towards developing a network of MPAs that span the entire western coast of Sulawesi and down into the Flores Sea.

Finally, the experts surveyed here also highlighted Papua, the Arafura Sea, the Lesser Sundas, and the Banda Sea as important targets for expansion of MPA coverage due to their high biodiversity, habitat richness, and role in providing essential habitats for a range of threatened or restricted range species (Figure 27).

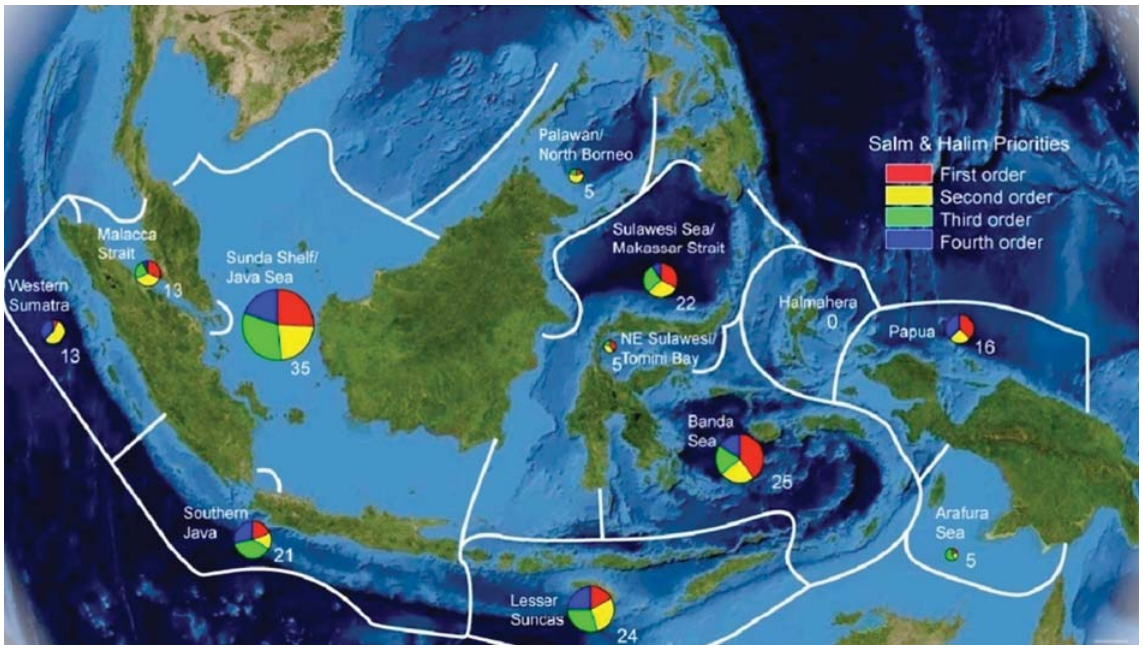

Figure 25. Number of first through fourth order conservation priorities (from Salm and Halim, 1984) per Indonesian ecoregion. Relative size of pie chart corresponds to the number of priorities in this ecoregion, while size of pie sections represent relative proportions of ordered priorities.

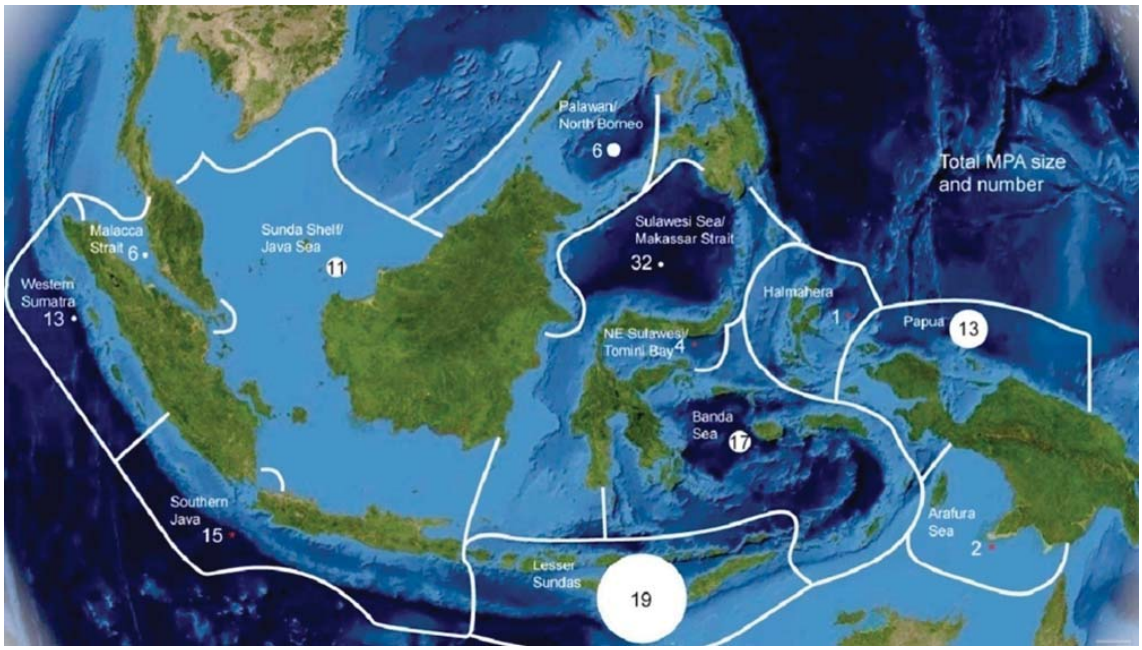

Figure 26. The number of current MPAs and relative MPA coverage per ecoregion in Indonesia. The number within the white circle represents the number of MPAs in that ecoregion, while the size of white circle is proportional to the number of hectares of MPA coverage in that ecoregion. Red asterisks denote MPA coverage too small to represent at this scale.

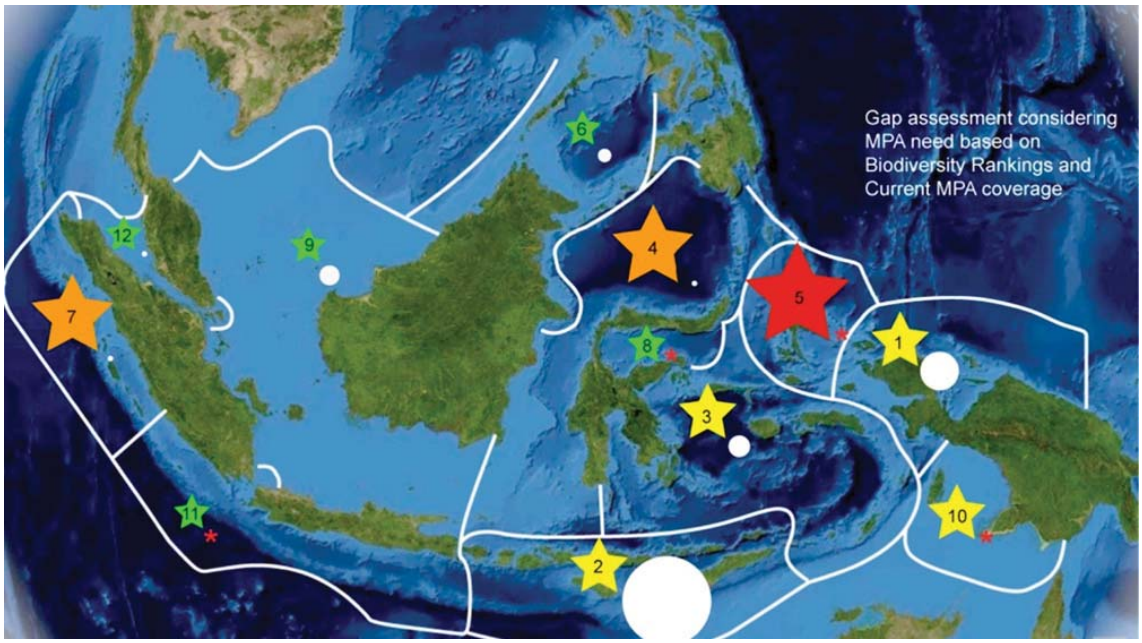

Figure 27. Map showing top priorities for increased MPA coverage based upon gap assessment qualitatively comparing current MPA coverage versus marine conservation priority ranking per ecoregion. Size and color of star indicates the relative priority for increased MPA coverage (grading from red to green in decreasing priority). Number indicated within each star is the overall marine conservation priority ranking for that ecoregion as determined in this exercise, while the size of the white circle indicates current MPA coverage (as shown in Figure 26). Red asterisks denote MPA coverage too small to represent at this scale.

8 Data Deficiencies

Figure 28 and Table 8 summarize the collective inputs of the experts surveyed in this prioritization exercise on those ecoregions and important sites within Indonesia that are most data deficient with respect to biodiversity knowledge. Most experts consider Western Sumatra as an entire ecoregion to be highly data deficient and in urgent need of biodiversity survey work, with a strong potential for discovery of high biodiversity and likely additional endemic species. The frequent mention of the offshore Mentawai Islands implies that these islands would be a logical choice as a starting point for future biodiversity survey work in Western Sumatra. Other regions that were strongly highlighted as being in need of urgent survey work include the Anambas/Natuna Islands in the Sunda Shelf ecoregion, Halmahera (particularly southern Halmahera), and the inner and outer Banda arcs in the Banda Sea. A third tier of high priority areas for additional survey work (garnering the votes of at least 5 respondents) includes the Arafura Sea, Lesser Sundas, Papua (especially Cendrawasih Bay), and the Sulawesi Sea/Makassar Strait (particularly the North Sulawesi area including Bunaken National Park and Lembeh Strait).

Table 8. Marine ecoregions and specific sites within those ecoregions that were highlighted by respondents as being data deficient.

Marine Ecoregion	Specific Sites Noted (number of respondents)	Number of Respondents Citing Ecoregion as Data Deficient and in need of Survey Work
Western Sumatra		9
Malacca Strait		0
Sunda Shelf/Java Sea		7
	Natuna/Anambas (7)	
Southern Java		1
Palawan/Northern Borneo		0
Sulawesi Sea/Makassar Strait		4
	Bunaken/Lembeh (2)	
	Southeast Kalimantan (1)	
	Talaud (1)	
Tomini Bay		1
Lesser Sundas		6
	Sumba (1)	
	Savu Sea/Roti/Timor (5)	
	Alor (3)	
Banda Sea		7
	Inner Banda Arc (5)	
	Outer Banda Arc (5)	
	Banggai Islands (1)	
Halmahera		7
Papua		5
	Cendrawasih Bay (4)	
Arafura Sea		
	Aru Islands (1)	6

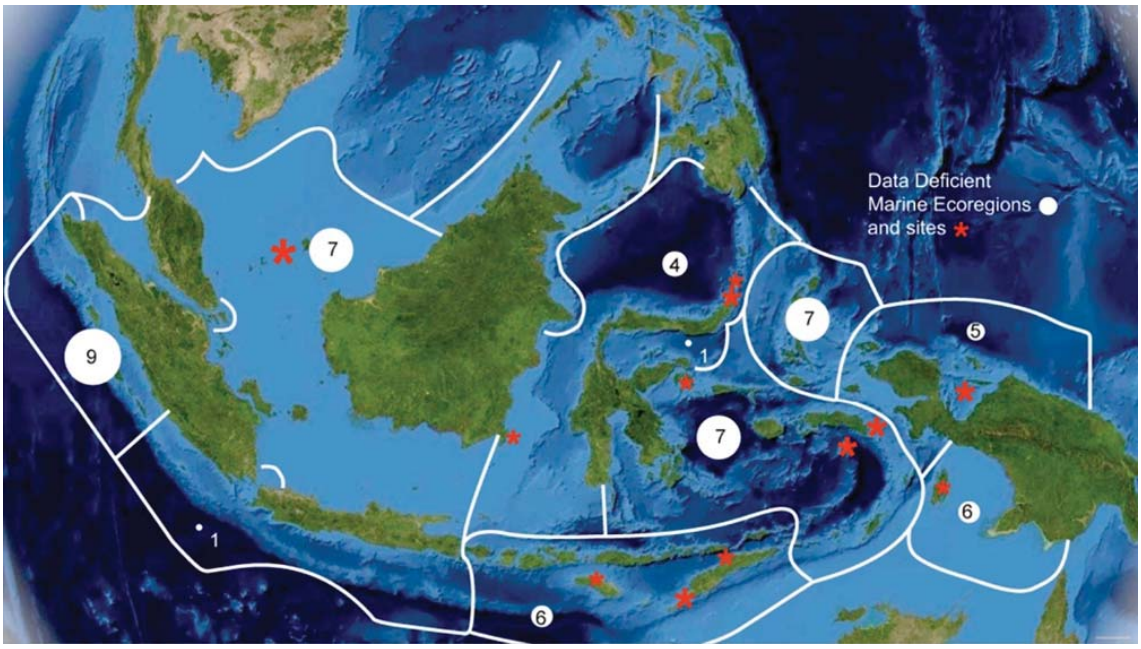

Figure 28. Relative biodiversity data deficiency for Indonesia's twelve marine ecoregions. Relative size of white circle (and number within) denotes number of experts suggesting the need for further research in this ecoregion to address biodiversity data deficiencies. Red stars identify the location of specific sites within ecoregions that were identified as being of interest for future survey work. This figure corresponds with Table 8.

Recommendations

Based upon the results of the prioritization exercise, the gap analysis reported above, and intensive discussions at the prioritization workshops held in Bali on 16-17 July 2009, the following six recommendations are provided to the Government of Indonesia for its consideration:

1. Irreplaceability and representativeness criteria strongly underscore the importance of marine biodiversity conservation efforts focusing on Papua, the Lesser Sundas, the Banda Sea, and Western Sumatra – including strengthening and building on current MPA networks. However, ecoregion ranking alone does not capture all the rich detail and habitat diversity of Indonesia's marine heritage. Many individual sites within lower-ranked ecoregions stand out as regionally or even globally important and these also need to be prioritized in a national strategy/system of MPAs (e.g. Natuna/Anambas in the Sunda Shelf/Java Sea, Alas Purwo and Segara Anakan in Southern Java, Aru in the Arafura Sea, Togean Islands in Northeast Sulawesi/Tomini Bay). Moreover, the current focus on coral reefs and their associated biota has the potential to obscure important conservation priorities for less high-profile diversity targets including mangrove and seagrass habitats and their associated fauna. Although the Arafura Sea, Sunda Shelf and Malacca Strait are amongst the lowest priorities from a coral reef perspective, each of these ecoregions is globally significant from the perspective of mangroves, seagrasses, seabirds, and other related fauna, and this should be taken into account in developing Indonesia's national MPA strategy.

2. Given the overwhelmingly top prioritization of Papua, DKP and the GoI should focus urgent and significant human, financial, and political resources on this ecoregion, particularly given the very high vulnerability of this area to immediate threats from coastal mining, logging, ill-conceived transmigration projects, and poorly-planned coastal development including island/coastal ring roads. A focus on proper and strictly enforced spatial planning is urgently needed so that the largely intact ecosystems and globally outstanding marine biodiversity earning it top conservation priority are not irrevocably destroyed.

3. While this prioritization exercise has highlighted important gaps in MPA coverage in Indonesia (see recommendation #5), it also highlights areas of critical biodiversity importance which are already covered but not effectively protected by MPAs (e.g.,the Savu Sea MPA in the Lesser Sundas). Strengthening the management of current high priority MPAs is every bit as important as designating new ones in gap areas.

4. The maintenance of both species richness, and genetic haplotype diversity within species is critically important as insurance for the ability of populations to survive and reproduce through global climate change. This diversity gives populations and species a better chance that at least some individuals bear the traits necessary to endure environmental changes. Genetic diversity represents the very building blocks of adaptation and natural selection, and serves as a primary buffer against extirpations and even extinction. To minimize marine extinctions, Indonesia's

national marine conservation and MPA strategy must include a focus on maintaining genetic diversity. Besides protecting the unique genetic diversity present in the eastern and western sectors of the country (e.g., in Papua and Western Sumatra), a "connectivity corridor" focused along the western coastline of Sulawesi (the primary genetic mixing zone with the longest contiguous reef-fringed coastline in Indonesia) should be a top priority for establishment to ensure the gene flow that will be necessary to distribute those genetic variants which are best able to tolerate the new environmental conditions predicted as we undergo global climate change.

5. Based on the above considerations, areas that show important gaps in MPA coverage and should be considered top priorities for new MPA coverage include:
   - **Halmahera (top priority due to near absence of MPAs in this ecoregion)**
   - **Western Sumatra (next highest priority)**
   - Sulawesi Sea/Makassar Strait "connectivity corridor" from the northern Sangihe-Talaud Archipelago, down the western coast of Sulawesi to the Postiljon/Sabalana Islands in the Flores Sea
   - Banda Sea (particularly the outer island arcs, Lucipara, Watubela, Seram, Banggai, Tanimbar)
   - Papua (particularly FakFak, Kokas, outer Cendrawasih Bay)
   - Arafura Sea
   - Lesser Sundas (Alor/Solor, Nusa Penida)

6. Several ecoregions/sites stand out for their lack of quantitative biodiversity data, and are considered an urgent priority for comprehensive survey work in order to better understand the distribution of Indonesia's marine biodiversity and how to best manage it. Those areas in most urgent need of survey work include:
   - **Western Sumatra**
   - **Natuna/Anambas Islands in the Sunda Shelf/Java Sea marine ecoregion**
   - **Halmahera (particularly southern sector)**
   - **Banda Sea (especially inner and outer Banda Arcs)**
   - Also important and not well-surveyed are Alor-Wetar-Savu (Lesser Sundas ecoregion), Teluk Cendrawasih (Papua ecoregion), and Arafura Sea

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Appendix I

Prioritized areas for inclusion in a national network of marine protected areas based upon Salm and Halim's (1984) Marine Conservation Data Atlas.

Objectives of Prioritization:

1. To safeguard the critical habitats (feeding, breeding, nursery areas) of commercial species
2. To safeguard the critical habitats of threatened species and to rebuild the stocks of those which are depleted to harvestable levels
3. To preserve the value of at least one marine site near each major urban center and at least one marine site in each province for tourism
4. To protect representative examples of the full range of marine and coastal habitats found in Indonesia
5. To preserve the biotic diversity of Indonesia's marine resource heritage
6. To protect sites with high value for research and education

First Order Priorities

Aru Tenggara
Aru Tenggara
Bakau Muara Kaupas
Bali Barat/P. Menjangan seaward extension
Batugendang
Cikepuh-Cibanteng seaward extension
Hutan Sambas Paloh
Indonesia Whale Sanctuary (all Indonesian seas)
Jamursbamedi
Kakabia
Karimunjawa
Karompa Tjadi
Kepulauan Banggai
Kepulauan Kai Barat
Kepulauan Lucipara
Kepulauan Sermata Barat
Kepulauan Togian
Komodo-Padar-Rinca seaward extension
Krakatau seaward extension
Kuala Jambu Air
Kuala Langsa
Moromaho
Muara Bobos
Muara Gembong
Muara Kayan
Muara Kwandawangan
Nusa Penida
Pamukan
Pangumbahan
Pantai Barat Kalimantan Selatan
Perairan Kangean Utara
Perluasan Tanjung Putting
Pleihari Tanah Laut seaward extension
Pulau Mapia
Pulau Pasoso
Pulau Penyu
Pulau-Pulau Bunaken
Raja Ampat
Sangi Sangiang
Suanggi
Taka Bone Rate
Tanjung Api seaward
Tanjung Sinebu-Pulau Alang Besar
Teluk Adang
Teluk Apar
Teluk Bintuni
Teluk Cendrawasih-Kepulauan Auri
Ujung Kulong seaward extension
Wewe-Koor

Second Order Priorities

Aruah
Bakau Selat Dumai
Batu Kapal
Benoa – Sanur
Djawi Djawi – Pulau Panjang-Simmal
Gili Air
Gunung Lorenz west/south extension
Inggresau
Jef Jus (Raja Ampat)
Karang Muaras-Maratua
Kayu Ara
Kelompok Hutan Kahayan
Kepulauan Banyak Bangkaru
Kepulauan Laut Kecil
Kepulauan Riau Selatan –Lingga Utara
Kepulauan Sembilan
Lamikomiko
Lau Tapus
Madu
Mamberamo – Foja
Mandariki
Meru Betiri seaward extension
Muara Gunting
Muara Sebuku
Muara Siberut
Nusa Barung seaward extension
Nusa Kambangan/Segara Anakan
Pantai Samarinda/Muara Mahakam
Perairan Kepulauan Batu
Polewai
Pulau Angwarmase
Pulau Burung
Pulau Lengkuas – Kepayang
Pulau Manuk seaward extension
Pulau Rotan – Perairan Manggar Tenggara
Pulau Samalona-Spermonde
Pulau Sebuku Barat
Pulau Semama/Pulau Sangalaki
Pulau Suwangi
Pulau Tikus
Pulau-pulau Tujuhbelas
Sei Prapat
Singkil Barat
Tambelan
Tanjung Dewa Barat
Tanjung Panjang
Teluk Bolok/Kepulauan Lima
Teluk Lasolo/Dalam
Teluk Lelintah (Raja Ampat)
Uluwatu

Third Order Priorities

Bakau Landu
Gunung Jagatamu
Karang Gading Langkat Timur littoral extension
Kebatu
Kepulauan Anambas Selatan
Kepulauan Asia/Ayau (Raja Ampat)
Kepulauan Balangan-Pulau Uwi
Kepulauan Kalukalukuang
Kepulauan Sangihe-Talaud
Kepulauan Tengah-Sabalana
Mawuk
Muara Porong – Welang
Mubrani-Kaironi
Pallima
Pulah Birah-Birahan
Pulau Bangka Timur
Pulau Dana
Pulau Dolongan seaward extension
Pulau Kobroor
Pulau Panjang
Pulau Pasir Panjang
Pulau Pombo
Pulau Rambut seaward extension
Pulau Sabuda-Tataruga seaward extensi n
Pulau Sangiang
Pulau Satonda
Pulau Sayang (Raja Ampat)
Pulau-pulau Tiga
Sausapor
Sidei-Wibain
Tanah Perdauh seaward extension
Tangkoko-Dua Saudara seaward extension
Tanjung Matop seaward extension
Tanjung Penghujan
Tanjung Sedari
Teluk Ambon
Teluk Ayer
Teluk Datuk
Teluk Gorontalo
Teluk Kau
Teluk Kupang-Pulau Kera
Teluk Pelikan – Bakau Pahatu
Terusan Dalam
Tukang Besi (Wakatobi)
Wae Apo
Waigeo Barat seaward extensi n
Wasur littoral extension west
Way Kambas littoral extension
Zona Pesisir Teluk Banten Barat

Fourth Order Priorities

Baluran seaward extension
Banyuwangi Selatan seaward extension
Bukit Barisan Selatan seaward extension
Dataran Bena seaward extension
Karimata
Leweung Sancang seaward extension
Maura Pemalang
Maura Serang Selatan
Muara Pemali
Muara Teripa
Muara Teunom
Muara Toru
Muara Wotya
Pangandaran seaward extension
Pulau Menipo seaward extension
Pulau Merah
Pulau Moyo seaward extension
Pulau Noko-Pulau Nusa seaward extension
Pulau Penyengat
Pulau Rakit
Pulau Sepanjang
Pulau Weh extension
Pulau-Pulau Mas-Popaya-Raja seaward extension
Rongkop
Selat Muna
Selat Wowoni
Tanjung Keluang
Tanjung Oisina
Wae Bula
Yamdena

Appendix II

Prioritized areas for inclusion in a national network of marine protected areas based upon Djohani's (1989) recommendations for marine conservation development in Indonesia.

First Order Priority Areas for Protection
Togian Islands
Aru Islands
Teluk Cendrawasih
Tukang Besi (Wakatobi)

Second Order Priority Areas for Protection
Taka Bone Rate
Bunaken
Kei Islands
Raja Ampat
Komodo
Karimunjawa

Third Order Priority Areas for Protection
Riau
Karimata
Halmahera (Pulau Widi)
Pulau Pombo, Kassa, Banda
Teluk Maumere
Pulau Seribu Islands
Bali Barat

Appendix III

Participant list for Marine Biodiversity Prioritization Workshop 16 – 17 July 2009, Sanur, Bali

No	Participant	Affiliation
1	Syahril Araup	Fisheries Resource (DG for Capture Fisheries)
2	Scott Atkinson	Conservation International
3	Dr. Paul Barber	University of California, Los Angeles
4	Riyanto Basuki	Head of Sub Directorate for Marine Conservation Area
5	Dr. Stuart Campbell	WCS Marine Director
6	Dr. Kent Carpenter	GMSA/Conservation International
7	Dr. Darmawan	CTI Regional Secretariat
8	Kim DeRidder	CTSP
9	Ir. Agus Dermawan, MSi	Director of Marine and National Park Conservation, MMAF
10	Rili Djohani	The Nature Conservancy
11	Dr. Mark Erdmann	Conservation International
12	Firdaus	Directorate for Marine Conservation Area
13	Dr. Abdul Ghofar	(KOMNAS KAJISKAN) - Fisheries
14	Dr. Tiene Gunawan	Conservation International
15	Dr. Subhat Nur Hakim	Research Bureau for Marine and Fisheries (BRKP, MMAF)
16	Abdul Halim	The Nature Conservancy
17	Tommy Hermawan	Directorate for Coastal Affairs, BAPPENAS
18	Dr. Christine Huffard	Conservation International
19	Dr. Malikusworo Hutomo	LIPI
20	Dr. Benjamin Kahn	APEX International
21	Maurice Knight	CTSP
22	Dr. M. Kasim Moosa	P2O LIPI
23	Taswien Munier	USAID Indonesia Mission
24	Alfred Nakatsuma	USAID Indonesia Mission
25	Yus Rusila Noor	Wetlands International
26	Agung Tri Prasetyo	Planning Bureau, MMAF
27	Narmoko Prasmadji	Executive Secretary for Indonesia's CTI National Coordination Committee
28	Mirza M. Pedju	CTSP Coordinator, WWF Indonesia
29	Ketut Sarjana Putra	Conservation International
30	Rizky Ray	National Coordination Committee
31	Wawan Ridwan	Director of Marine Program, WWF Indonesia
32	Rudyanto	The Nature Conservancy
33	Didi Sadeli	Directorate for Coastal, Marine and Small Islands Spatial Planning, MMAF
34	Nico Sinaga	Conservation Area, PHKA
35	Dr. Jusuf Surachman	Director of Technology for Natural Resource Inventory, BPPT
36	Dr. Alan White	The Nature Conservation
37	Dr. Joanne Wilson	The Nature Conservancy
38	Dr. Budy Wiryawan	Institut Pertanian Bogor
39	Zulhasni	Ministry of Environment

Appendix IV

MARINE BIODIVERSITY PRIORITIZATION QUESTIONNAIRE

Questionnaire

Defining Geographic Priorities for Marine Biodiversity Conservation in Indonesia – 2009

Please fill out the following questionnaire as completely as possible, using quantitative data and references wherever possible. We have created a datasheet for each of the 12 marine ecoregions in Indonesia as defined by Spalding et al (2007) and based on Green and Mous (2006); these 12 ecoregions are depicted in the figure in Appendix 3 of the background document that accompanies this questionnaire. Please enter data/expert opinion for each of these ecoregions and, based upon the various criteria listed, rank each of these ecoregions (from 1 to 12) in order of their overall priority for marine biodiversity conservation investment. If you prefer a different biogeographic characterization of Indonesia's marine realm ("functional seascapes", "coral ecoregions", etc), please feel free to use this (providing references for the basis of this characterization where possible); simply replace the current marine ecoregion name on each data sheet based on your preferred characterization. Please make sure to thereby include a thorough prioritization of Indonesia's entire marine realm, and please bear in mind that the preferred scale of this prioritization process is at the level within which networks of marine protected areas might be designed and implemented (i.e., this is not a site-level prioritization, but a more regional one).

Please return this questionnaire in its entirety by email by 10 July 2009 to Mark Erdmann and Christine Huffard (mverdmann@gmail.com; chuffard@conservation.org) . If you have any questions please also address to Mark and Christine. In returning your questionnaires, please feel free to add appendices of maps/data tables/references (see note below on intellectual property), while noting that Indonesian email servers are not able to handle overly large attachments (typically anything over 6Mb is problematic). Thank you for your participation in this important exercise.

Name and Title of Respondent:_____

Institutional Address :_____

Email Address: _____

Expertise (eg, Taxonomic Group or Element of Biodiversity): _____

_____

***NOTE:** All data provided for this questionnaire are acknowledged as the intellectual property of the respondent and will not be used for any purposes beyond that of this prioritization exercise. Respondents will be properly acknowledged for the use of this data in the prioritization report. If any of the data presented are particularly sensitive and not to be used explicitly within the final report on this prioritization exercise, please note this and we will certainly honor this request.

The following questions are asked for the Ecoregions: Western Sumatra, Southern Java, Sunda Shelf/Java Sea, Malacca Strait, Sulawesi Sea/Makassar Strait, Palawan/North Borneo, NE Sulawesi/Tomini Bay, Lesser Sundas, Halmahera, Papua, Banda Sea, and Arafura Sea. These questions are followed by a "Wrap-up" section

Ecoregion Data and Ranking Section

Marine Ecoregion (or similar characterization):
Name of Respondent:
The data/expert opinions below are based upon (check all that apply):

___ My personal data/observations in this ecoregion
___ Colleague's data or other published literature
___ Inference from knowledge of surrounding areas

To the extent possible, please provide data/input for each of the following aspects of biodiversity for this ecoregion with respect to your element of expertise. Quantitative data are preferable when available, but expert opinion is acceptable when data are lacking. Note that you should not feel constrained to single page answers for each ecoregion – enter as much or as little input for each ecoregion as you feel comfortable doing.

Species Richness/Alpha Diversity (include also any comments on genetic diversity):

Endemism (may also include discussion of genetic breaks/"private haplotypes"in this region):

Regionally or globally significant aggregations of threatened or restricted range species (migration corridors, nesting beaches, spawning or feeding aggregation sites, nursery areas, etc.):

Taxonomic uniqueness/presence of rare species/presence of unique habitats (eg, euryhaline lakes):

Other important considerations on biodiversity of this ecoregion (unique ecosystem services provided, vulnerability/resilience to climate change, overall vulnerability or conservation opportunity considerations):

Are there any particular ***sites*** within this ecoregion which standout as being top priorities for conservation investment? Please list.

Based upon the above data inputs, and also taking into consideration the importance for Indonesia to include representativeness of the full range of biodiversity present (including Indian and Pacific Ocean elements) in its national system of MPAs, please rank this ecoregion for its overall prioritization for marine biodiversity conservation investment. Feel free to include below any explanation of your ranking if you care to do so.

Ranking: _____
Explanation of Ranking:

Wrap-up Section

1. After reviewing your own and colleagues' knowledge of the various ecoregions of Indonesia, are there specific areas that now particularly stand out as needing additional research in order to better understand patterns of biodiversity distribution in Indonesia? If so, then please list these areas in order of priority.
2. Overall, how confident do you feel in your ranking of geographic priorities for marine biodiversity conservation investment in Indonesia (*very confident, sufficiently confident, confident though with some reservations, or not very confident*)? Do you anticipate that with further research as per the question above that your rankings might change significantly?
3. A number of authors (e.g., Briggs 2005a, Brooks et al. 2006) have noted that marine biodiversity conservation investments should optimally seek to safeguard the evolutionary processes that generate and maintain biodiversity (i.e., if one accepts the concept of "centers of origin", that these centers would naturally be of top priority to protect). Do you believe this is an important consideration in conservation prioritization, and if so, can you please comment on how this has been factored into your rankings and especially if there are specific regions of Indonesia that stand out as priorities in this regard?
4. Please use the space below to list any references you may have referred to in this questionnaire. Please also let us know if you have a preferred means for us to cite any unpublished data that you might have included in this questionnaire. Once again, thank you very much for providing your highly valuable input into this process for the benefit of Indonesia's marine ecosystems and people!

Index

D

E

F

G

H

I

J

K

L

M

N

O

P

Q

R

S

T

U

V

W

Y

Z