BUILDING THE CASE FOR EXPANDING MARINE CONSERVATION AREAS: AN URGENT CALL IN THE ASEAN REGION

Building the Case for Expanding Marine Conservation Areas: An Urgent Call in the ASEAN Region

PUBLISHER:
ASEAN Centre for Biodiversity
D.M. Lantican Avenue
University of the Philippines Los Baños
Laguna 4031, Philippines

CITATION: Hilomen, V. & Peñaflor, E. (2023). *Building the Case for Expanding Marine Conservation Areas: An Urgent Call in the ASEAN Region*. ASEAN Centre for Biodiversity and The Pew Charitable Trusts.

PHOTOGRAPHS: John Rey Cuyos, Yvette Lee, Danny Ocampo, Aung Ko Oo, Kyaw Kyaw Winn, D. Simorangkir

Table of Contents

PHOTO: Danny Ocampo

Executive Summary

This paper supports the call to expand Marine Protected Areas (MPA) and their networks through scientific findings on the seasonal patterns of marine larval dispersal. Larval dispersal plays a key role in the maintenance of resilient marine ecosystems and recovery of their rich biodiversity from a wide array of threats. The coastal and marine environment of the ASEAN region is globally important because it supports the highest marine biodiversity in the world and helps drive economies of the ASEAN Member States (AMS).

The current status of the coastal and marine habitats in each of the AMS is declining at varying rates. While there are successful cases of recovery, these are not sufficient to overcome the overall decline. With its current status, the coastal and marine ecosystems in the AMS may not survive the impending impacts of climate change. The preponderance of scientific evidence shows that the establishment of large effectively managed MPAs and MPA networks is an effective strategy to counter the rapid degradation of marine habitats and restore marine biodiversity and ecosystem services.

Following modelling patterns of larval dispersal in the AMS, this paper recommends the establishment of large MPAs and MPA networks in areas of high ecological connectivity in the ASEAN region and identifies three options. The first option is the establishment of large and effectively managed MPAs and MPA networks within each of the AMS based on the strong retention of marine larval propagules within each country. The second option is the establishment of partnerships to support MPA networks located between two or more adjacent AMS identified to have strong ecological connectivity. The third option is the establishment of a partnership between the AMS and other countries to cooperate in the protection of marine biodiversity in areas with strong ecological connectivity. Most importantly, this paper recommends the urgent action of the ASEAN to provide venues for AMS for further discussions on the establishment of MPA networks within national jurisdictions and the deepening of partnerships and cooperation among the AMS to conserve marine biodiversity. These dialogues will help initiate the preparatory work for cooperation and collaboration with other countries (i.e., China, Australia, India, and Bangladesh at different areas, respectively), similar to the earlier efforts in establishing the Eastern Tropical Pacific Marine Corridor (CMAR), or the bilateral agreement of cooperation for the conservation of marine turtles between Philippines and Malaysia as well as the tri-national Marine Turtle Protected Area Network between Philippines, Indonesia, and Malaysia. Similarly, partnerships between AMS with adjacent countries can be patterned with the Coral Triangle Initiative, a multilateral partnership among countries working together to address threats and safeguard the Coral Triangle.

I. Introduction

The Association of Southeast Asian Nations (ASEAN) was established in 1967 to promote regional cooperation in securing peace, stability, and development (Bangkok Declaration 1967) with Indonesia, Malaysia, Philippines, Singapore, and Thailand as charter members. Brunei Darussalam joined in 1984, followed by Viet Nam in 1995, Myanmar and Lao PDR in 1997, and Cambodia in 1999. All except Lao PDR are bestowed with varying sizes of rich coastal and marine environments with Indonesia having the largest area followed by the Philippines, Viet Nam, Myanmar, Thailand, Malaysia, Cambodia, Brunei Darussalam, and Singapore in decreasing order.

The combined area of coastal and marine ecosystems in the region covers nearly a third of the world's marine habitats. The ASEAN region holds a third of coral reefs, more than a third of mangroves, and a fifth of seagrass beds of the world and supports the highest marine coastal biodiversity in the world that form a very important economic resource base for more than 650 million people. These ecosystems provide a wide-range of services, including food and water and play a significant role in generating revenues for their respective economies derived from industries, such as tourism, navigation, fisheries and aquaculture, energy, petroleum, and natural gas.

These coastal and marine resources, however, are biodiversity hotspots and among the most threatened in the world. The current conditions of these marine ecosystems are in varying rates of decline with many in highly degraded states where the forecasts are grim if the region remains "business as usual." The combination of overexploitation, habitat loss, pollution, and poor planning for coastal development increases the marine ecosystem's vulnerability to the effects of climate change, such as increased thermal stress, sea level rise, frequent and high intensity weather disturbance, and ocean acidification, and can wipe out 70 to 90 per cent of coral reefs in the next 20 years[1].

The Living Planet Index (LPI) shows a consistent decline in the global population sizes of birds, mammals, amphibians, reptiles, and fish decreasing by an average of 68 per cent between 1970 and 2016.[2] The degradation of the condition of these marine resources coupled with the rate of decline of population sizes of the diverse species they support places the health, food security, the livelihood of 650 million people, and the economies of the AMS at serious risk.

There is sufficient scientific evidence showing that the establishment of large effectively managed marine protected areas (MPAs) is an effective strategy to arrest the rapid degradation of various marine habitats and restore ocean biodiversity and ecosystem services.[3]

An MPA network is defined as "a collection of individual MPAs or reserves operating collectively and synergistically at various spatial scales, designed to meet objectives based on ecological, social, informational, and administrative considerations that a single reserve cannot achieve alone, while also linking people and institutions involved

1 American Geophysical Union (2020)
2 WWF (2020)
3 Sala et al. (2021)

into a harmonised and holistic initiative to facilitate learning and coordination in planning and administration".[4]

Protecting large portions of coastal and marine areas provide important marine life safe home ranges that allow them to grow and accumulate biomass, increase in abundances, and improve biodiversity. Protection means unimpeded movement of target species within their home ranges, which translates to a few square kilometres for marine species with high habitat fidelity such as reef species to hundreds to thousands of square kilometres for some important pelagic species such as marine turtles, marine mammals, and other large marine vertebrates. Larger protected areas lead to better genetic diversity, higher productivity, and increased resilience to natural, anthropogenic, and climate disturbances.

Furthermore, MPAs contribute to the protection of a critical spawning stock biomass that ensures the consistent supply of fish and other marine life larvae to other habitats. With MPAs either gazetted (by law) or non-gazetted (by tradition and customs), greater protection results in effective management and long-term conservation of areas with associated ecosystem services and cultural values. Thus, adjacent degraded habitats therein recover, thrive,[5] and attract settling juveniles of fish and other marine life from other reefs,[6] ensuring successful recruitment processes (e.g. sources and sink dynamics). Populations of adult fish crowd inside MPAs and move across boundaries to adjacent fished areas. As many as 5.9 per cent of adult individuals of commercially valuable reef fish species representing eight per cent of fish biomass from MPAs spill over to adjacent fished areas.[7]

The role of coastal and marine ecosystems in climate change mitigation is monumental. MPAs with mangroves and seagrass beds sequester and lock up carbon from the atmosphere. Several scientists and experts have argued that at least 30 per cent of the sea need protection to mitigate the effects of climate change and prevent catastrophic changes in the near future.[8] On the average, the required coverage for protection to achieve, maximise, or optimise the various MPA objectives is 37 per cent of the sea.[9] These MPA objectives help: (1) protect biodiversity; (2) ensure population connectivity among MPAs; (3) minimise the risk of fisheries or population collapse and ensure population persistence; (4) mitigate the adverse evolutionary effects of fishing; (5) maximise or optimise fisheries value or yield; and (6) satisfy multiple stakeholders. Furthermore, when the management outside of protected areas is improved, the performance burden for MPAs is eased such that a little reduction of the eventual target coverage to at least 30 per cent of the sea will still achieve MPA objectives.[10]

So far, the AMS have collectively protected on the average 4 per cent of the region's coastal and marine areas despite efforts to achieve the commitment to Aichi Biodiversity Target 11[11] on the conservation of 10 per cent of coastal and marine areas of special importance to biodiversity and ecosystem services.

4 IUCN-WCPA (2008)
5 Stobart et al. (2009)
6 Ohman et al. (1998) and Montgomery et al. (2001)
7 Tupper (2007)
8 Batini and Werner (2021); Duarte et al.(2020); Woodley et al. (2019)
9 O'Leary et al. (2016)
10 O'Leary et al. (2016)
11 Aichi Biodiversity Target 11 states that by 2020 at least 17% of terrestrial and inland water, and 10% of coastal and marine areas, especially areas of particular importance for biodiversity and ecosystem services, are conserved through effectively and equitably managed, ecologically representative and well-connected systems of protected areas and other effective area-based conservation measures, and integrated into the wider landscapes and seascape.

The AMS cited 13 challenges to achieving the Aichi Biodiversity Targets and recognised the need to resolve these issues.[12] Key barriers to achieving Aichi Biodiversity Target 11 for the protection of marine areas include – a lack of widespread understanding of the functions and significance of marine biodiversity among stakeholders, gaps in sustainable financing of biodiversity programmes and capacity development that lead to ineffective management, incohesive monitoring and evaluation system with unclear measurable indicators, and weak law enforcement.

Majority of the AMS are actively addressing these barriers as reflected in national statements of support to the preparations for the Post-2020 Global Biodiversity Framework (GBF) of the Convention on Biological Diversity (CBD).

For example, several AMS support the mainstreaming and integration of biodiversity targets, across all levels of governance particularly in the economic sector to change the "business as usual" behaviour of many stakeholders. Mainstreaming is a crucial part of the implementation of National Biodiversity Strategies and Action Plans (NBSAPs), to which national governments have started allocating funds. In addition, the AMS are calling for greater financial support from private, local, and global financial sectors (e.g. Global Environment Facility [GEF] and Green Climate Fund [GCF]) to enhance mainstreaming of the implementation of NBSAPs with focus on developing countries. In addition, several AMS also seek capacity building, technology transfer, knowledge management, and communication support, among others, to help in the effective implementation of the post-2020 GBF. The AMS also supports the development of a monitoring and evaluation system that can effectively track and measure progress. Within the AMS, it is imperative to establish standard methods to measure various metric indicators and track conditions of marine habitats.

On 19 December 2022, the 15th Conference of Parties to the UN Convention on Biological Diversity adopted the post-2020 GBF, also called the Kunming-Montreal Global Biodiversity Framework, which has four goals and 23 action-oriented targets for urgent action towards 2030.

One of these new targets under the Kunming-Montreal GBF is for the protected and conserved areas. Target 3 of the Kunming-Montreal GBF states:

> "Ensure and enable that by 2030 at least 30 per cent of terrestrial, inland water, and of coastal and marine areas, especially areas of particular importance for biodiversity and ecosystem functions and services, are effectively conserved and managed through ecologically representative, well-connected and equitably governed systems of protected areas and other effective area-based conservation measures, recognizing indigenous and traditional territories, where applicable, and integrated into wider landscapes, seascapes and the ocean, while ensuring that any sustainable use, where appropriate in such areas, is fully consistent with conservation outcomes, recognizing and respecting the rights of indigenous peoples and local communities, including over their traditional territories."

This report discusses the current conditions of the coastal and marine environment in the ASEAN region, along with the important contributions of the MPAs and MPA Networks in reducing anthropogenic threats and restoring marine biodiversity and ecological services. The latter part of this report charts several ways and identifies areas with high ecological connectivity where MPAs and MPA networks can be established to contribute to achieve global conservation targets of the Kunming-Montreal GBF.

12 ACB (2017)

II. Current Conditions of the Coastal and Marine Environment of AMS

The extent of the territorial seas and Exclusive Economic Zone of the AMS

The area of the marine waters covering the Exclusive Economic Zone (EEZ) and territorial seas of the AMS vary greatly between hundreds of square kilometres to millions of square kilometres (See Figure 1 and Table 2).

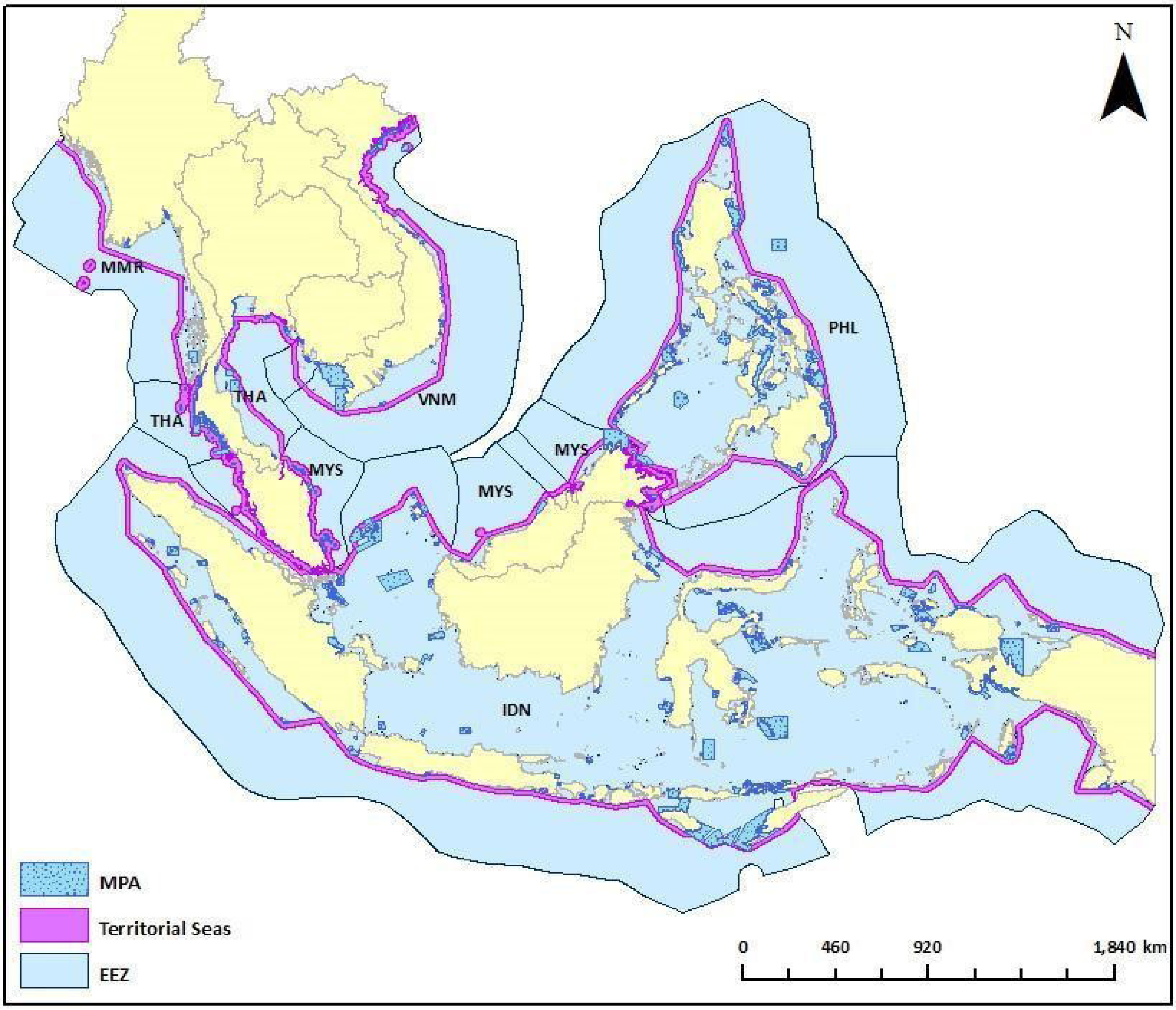

Figure 1. Distribution and relative locations of MPAs within territorial waters and EEZ of AMS.[13]

13 ASEAN Biodiversity Dashboard; Flanders Marine Institute (2019)

The area estimates of the EEZ of the AMS vary widely among the three studies as shown in Table 1. The most recent area estimates of the EEZ[14] showed the EEZ of Indonesia covers more than 6 million square kilometres. It is followed by the Philippines with > 2 million square kilometres and Viet Nam (> 1 million square kilometres). This estimate for Indonesia's EEZ, however, is nearly double the size of the sum of its coastal and marine areas (EEZ + territorial seas) (See Table 2).

Table 1. Area estimates of EEZ (in km^2) of AMS from various studies

AMS	EEZ Area (km^2)		
	Alexander 1982	UP-MSI et al. 2002	Derrick et al. 2020[a]
Brunei Darussalam	24,352	38,600	25,340
Cambodia	55, 564	55,600	47,676
Indonesia	5,409,988	5,800,000	6,024,450
Lao PDR	na	na	na
Malaysia	475,728	475,600	449,477
Myanmar	507,626	509,500	511,389
Philippines	1,785,951	1,786,000 – 2.2 M	2,263,816
Singapore	343	na	673
Thailand	324,812	85,800	305,778
Viet Nam	722,338	1,000,000	1,395,096

[a]GIS estimates (seaaroundus.org)

All of the AMS have established MPAs with the exception of Singapore and landlocked Lao PDR (see Figure 1). The Marine Conservation Institute reports that the Philippines has the highest number of MPAs (336) with 119 considered as fully or highly protected. This is followed by Indonesia (200), Malaysia (97), Thailand (47), Viet Nam (33), Brunei Darussalam (6), Cambodia (4), and Myanmar (3) (See Table 2). The average size of each MPA in the Philippines is ranked sixth among the nine AMS. Indonesia ranked first in having the largest average size of MPAs, followed by Thailand, Malaysia, Cambodia, Myanmar, Philippines, Viet Nam, and Brunei Darussalam (See Table 2).

Consequently, in terms of the percentage area of MPAs relative to the total coastal and marine area, Indonesia is the highest (7.35 per cent), followed by Malaysia (5.30 per cent), and Thailand (4.37 per cent). The Philippines, which has the most number of MPAs, has 1.4 per cent of the total marine area protected. The country, however, has one proposed MPA situated in the Pacific seaboard with an estimated area of 38,809 square kilometres, and accounts for two per cent of its total marine area.[15] The percentage of the total coastal and marine areas protected in Cambodia is a little over one per cent while the rest did not reach 1 per cent. Clearly, more consistent and effective effort is required to improve coastal-marine conservation work among the AMS.

14 Derrick et al. (2020); Polido et al. 2020; De Leon et al. (2020)
15 Marine Conservation Institute (2021)

Table 2. Estimates of the sizes (in square kilometres) of coastal and marine areas (territorial seas and EEZ) of AMS relative to the total area of protected areas (Updated as of November 2021)

AMS	Total size of coastal and marine area[d]	Marine Protected Area			
		Number of MPAs[a]	Total area of all MPAs	MPAs as % of total of "B"	Average area of MPAs
(A)	(B)	(C)	(D)	(E)	(F)
Brunei Darussalam[a]	25,698	6	52.00	0.2	8.67
Cambodia[c]	48,697	4	524.98	1.08	131.25
Indonesia[b]	3,257,483	200	239,281.28	7.35	1,196.41
Lao PDR[c]	na	na	na	na	na
Malaysia[ab]	451,742	97	23,942.00	5.30	246.82
Myanmar[b]	525,000	3	391.27	0.06	130.42
Philippines[c]	2,206,446	336	30,854.00	1.4	91.83
Singapore[b]	763	0	0	0	-
Thailand[b]	306,891	47	13,416.00	4.37	285.45
Viet Nam[c]	939,050	33	1,878.10	0.2	56.91
ASEAN	7,761,770	727	310,339.96	4.0	426.88

[a] Data from UNEP-WCMC Protected Area Profile from the World Database of Protected Areas.
[b] Updated by the AMS post-31st AWGNCB Meeting
[c] 6th National Report to the CBD
[d] Data from various sources, needs validation

Table 3 shows the distribution of a third of the world's coastal-marine habitats (seagrass beds, mangroves, and coral reefs) across the AMS. The areas covered by seagrass beds, mangroves, and coral reefs in each of the AMS vary depending on various authors (See Table 3). Of all the AMS, Indonesia has the largest area cover for the three habitats (with the exception of the seagrass estimates[16]). The Philippines, Malaysia, Myanmar, Thailand, and Viet Nam also have considerable areas of seagrass beds, mangroves, and coral reefs.

Table 3. Variation in estimates of extent cover (square kilometres) of seagrass beds, mangroves, and coral reefs in AMS

AMS	Area (km^2)								
	Seagrass			Mangrove			Coral reefs		
	Sudo et al., 2021	UNEP - WCMC, 2018	Fortes et al., 2018	Richards & Friess, 2016	FAO 2015	Burke et al., 2002	Hutomo et al., 2010	UNEP - WCMC, 2021	Burke et al., 2002
Brunei Darussalam	1.5	na	1.5	110.5	180	170	50.0	62.8	200
Cambodia	229.8	na	324.9	475.6	500	850	50.0	50.2	40
Indonesia	2,934.6	17,597.0	8,812.0	27,886.8	22,440	42,550	51,000-85,000	20,987.7	51,000
Malaysia	49.0	541.0	16.3	5,578.1	5,210	6,420	3,600-4,000	2,155.7	4,000
Myanmar	4.3	2,942.0	4.3	5,024.7	2,990	3,790	1700.0	696.0	1,700
Philippines	82.1	14,923.0	27,262.2	2,575.8	3,560	1,610	10,750-33,500	13,652.9	26,000
Singapore	2.0	127.0	0.3	5.8	10	6.0	50.0	4.1	50
Thailand	189.9	1,813.0	148.5	2,451.8	2,400	2,640	1800.0	200.6	1,800
Viet Nam	157.5	216.0	157.4	2,151.5	2,700	2,530	1100.0	486.3	1,100

Table 4 compares the diversity of species of corals, mangroves, and seagrasses across AMS. Estimates from various studies show that Indonesia, Philippines, and Malaysia consistently have the most number of coral species. The number of recorded coral species in each of the three AMS was ≥550 (See Table 4). Thailand and Viet Nam have >350 species while Myanmar and Cambodia have >200 species. Lastly, Brunei Darussalam and Singapore have >100 coral species.

The Philippines has the highest diversity in seagrass with 19 species. This is followed by Indonesia (13–16 species), Malaysia (12–16 species), and Thailand (13–15 species). For mangroves, Indonesia has the most number of species (45), followed by Malaysia (36 species), Thailand (35 species), Singapore (31 species), and Philippines (30 species).

The distribution and location of coral reefs, as well as the MPAs in the AMS is shown in Figure 2. Many of the known and mapped coral reefs are located within coastal and marine areas of the AMS. The relative estimates of area covered by coral reefs are presented in Table 3. The locations of many MPAs straddle coral reef areas.

16 Fortes et al. (2018)

Table 4. Variation in the reported numbers of species for corals, mangroves, and seagrass in AMS

AMS	Number of Species				
	Coral[a]		Mangrove	Seagrass	
	Burke et al. 2002	Hutomo et al. 2010	Burke et al. 2002	Fortes et al. 2018	Burke et al. 2002
Brunei Darussalam	na	185	29	7	4
Cambodia	272	70	5	12	1
Indonesia	581	590	45	16	13
Malaysia	>550	>550	36	16	12
Myanmar	270	270	24	13	3
Philippines	561	561	30	19	19
Singapore	186	186	36*	12	11
Thailand	357	357	35	13	15
Viet Nam	355	355	29	14	9

[a]Yang, Shufen, et. al, 2011

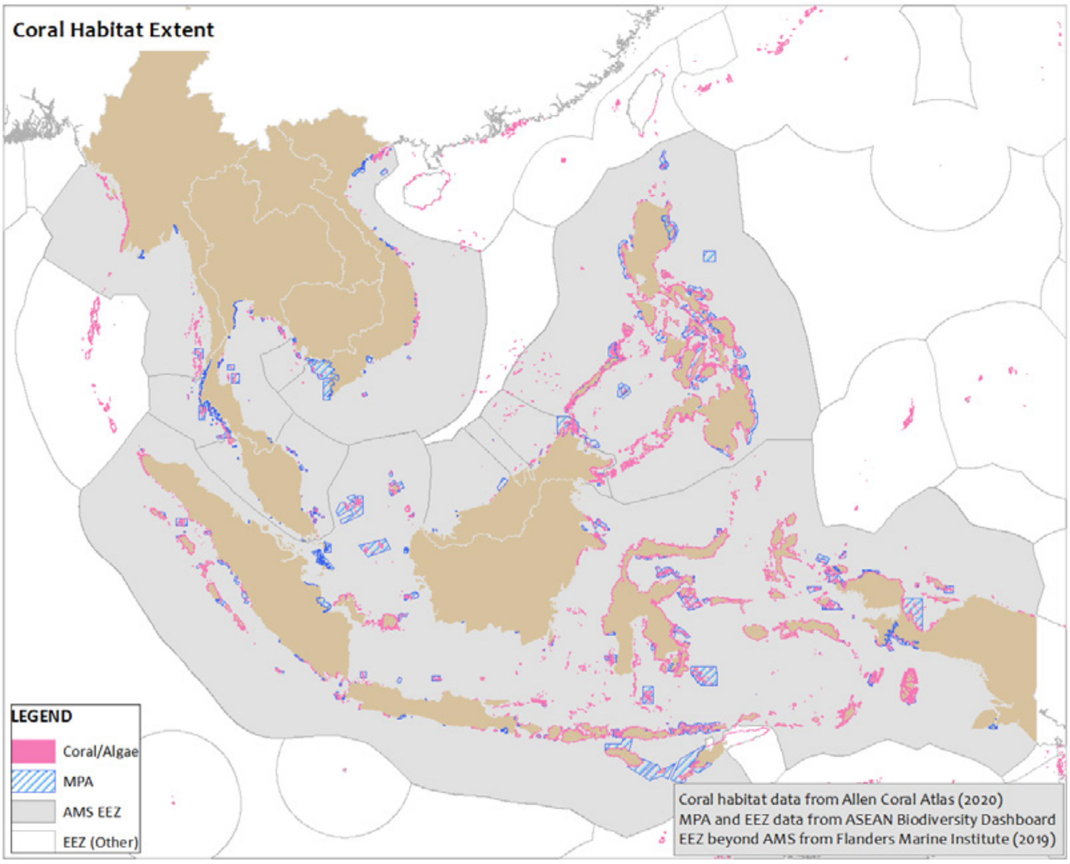

Figure 2. Distribution and relative locations of coral reefs across AMS and the locations of MPAs[17]

17 Allen Coral Atlas, (2020); ASEAN Biodiversity Dashboard; Flanders Marine Institute, (2019)

Coral reefs also thrive in areas outside existing national jurisdictions, such as those in waters between Viet Nam and the Philippines, in the west of Myanmar in Andaman Sea and Bay of Bengal, and the southeast tip of Indonesia near the northwest tip of Australia.

Figure 3 shows seagrass beds and mangroves litter the coastal and marine areas of the AMS. It also shows that seagrass beds extend outside national jurisdictions while mangroves are only adapted to spread in shallow areas. Meanwhile, the relative estimates of areas covered by seagrass beds and mangroves can be found in Table 3.

Several MPAs also cover seagrass beds and mangroves (See Figure 3). However, comparing Figures 2 and 3 show that most MPAs cover more coral reefs than seagrass beds and mangroves.

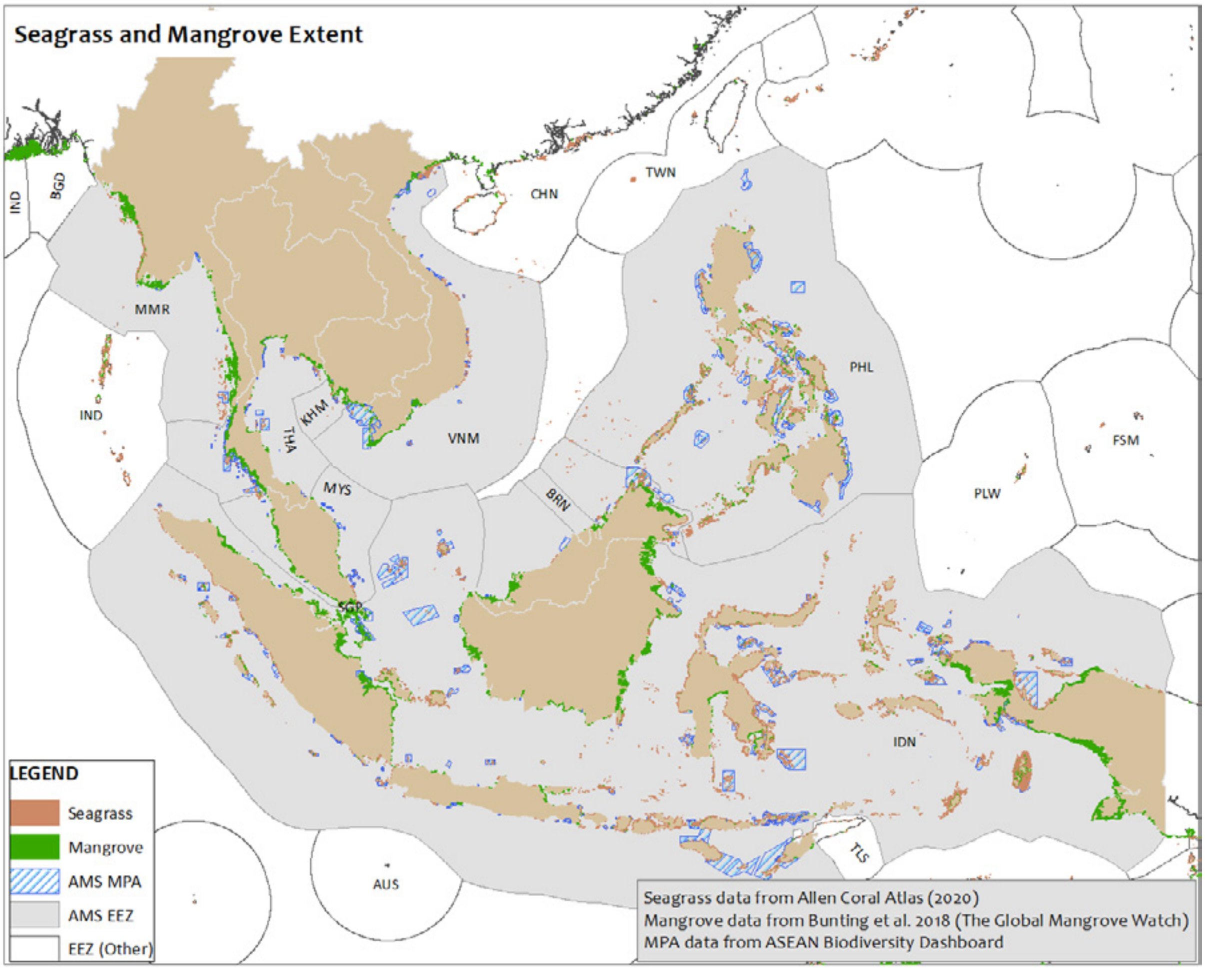

Figure 3. Distributions of the relative locations of mangrove stands and seagrass beds across AMS.

Status of marine ecosystems relative to the threats and pressures in the AMS

The Southeast Asia region is known as a global hotspot of biodiversity and endemism.[18] It has rich and diverse coastal marine resources. Chelliah et al. (2015) cited that the region has 34 per cent of the world's total reef area. With all types of reefs represented (fringing, platform, barrier, and atolls), the region holds >75 per cent of the world's coral species and >33 per cent of the world's reef fish species. It has approximately 35 per cent of the world's total mangrove area and harbours nearly 75 per cent of the world's mangrove species and >45 per cent of seagrass species.[19] The region has at least 20 per cent of the world's seagrass beds.[20]

Coral reefs

The coral reefs in the region are among the most threatened globally. Seagrass beds and mangrove forests are similarly adversely impacted. The major threats include overexploitation, coastal development, pollution (domestic, industrial, and agricultural), and a wide variety of unsustainable activities. Overfishing has greatly impacted the reefs in the region.[21] In their study, Burke presented the levels of intensity of various threats including their integrated effects.[22] Figure 4 shows that overfishing and the use of illegal and destructive fishing (blast and poison fishing) are high-intensity threats on coral reefs and widespread across the AMS.

Other significant threats on coral reefs are sedimentation and pollution from land, as well as coastal development. When local threats are integrated, the intensity level of threat results from high to very high on nearly half of the region. When thermal stress is added to the integrated local threats, the high to very high level of intensity covers nearly 60 per cent of the region. (See Figure 4). Anomalous warming led to several serious coral bleaching events in the region.


PHOTO: Danny Ocampo

18 Hughes, (2017)
19 Burke et al. (2002)
20 Fortes (2010)
21 Chelliah et al. (2015)
22 Burke et al. (2011)

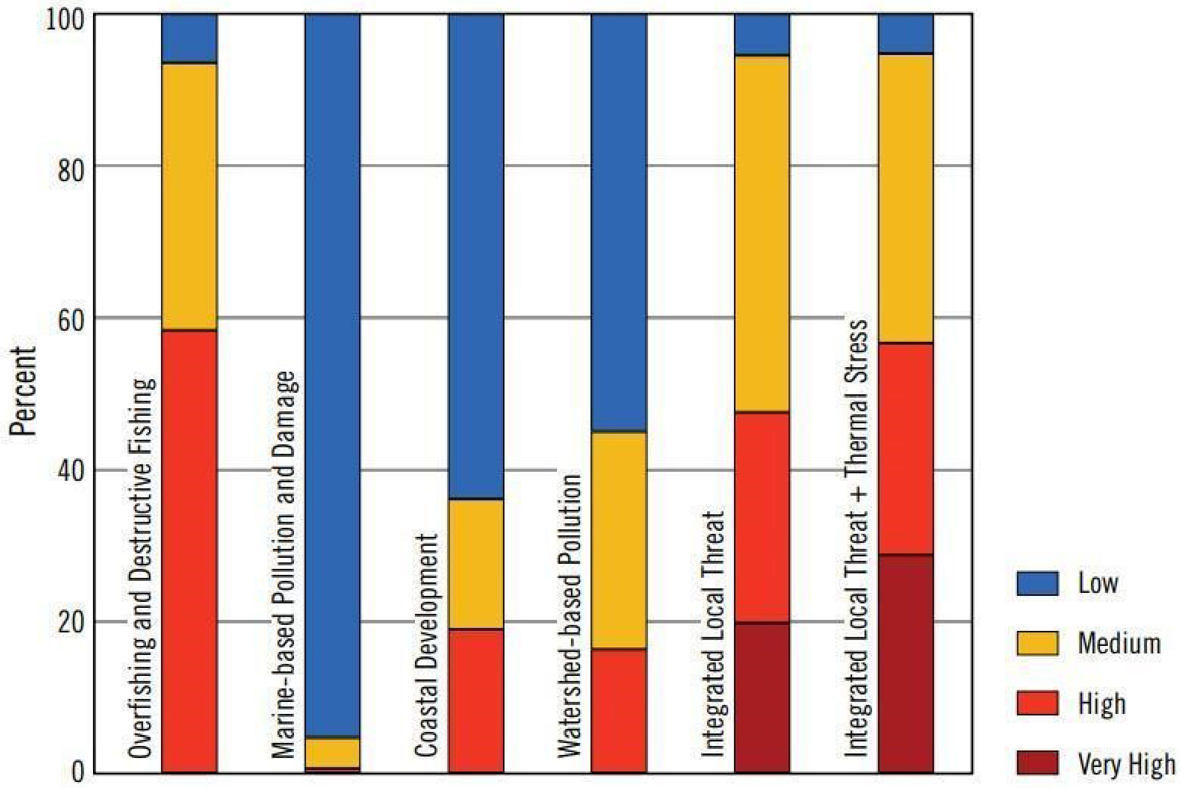

Figure 4. Distribution of the levels of intensity by each type of threat to coral reefs in the AMS[23]

23 Image from Burke et al. (2011)

Figure 5 shows that majority (~95 per cent) of coastal and marine habitats is at risk (medium to very high) from combined local threats (e.g., overfishing and destructive fishing, coastal development, watershed-based pollution, and marine-based pollution) with population centres having high to very high levels of risks. There are still few places that are in the low-threat category, but these areas are in the sparsely populated ones. Unsustainable fishing activities (overfishing and destructive fishing) are the greatest threats to coral reefs in the region.[24]

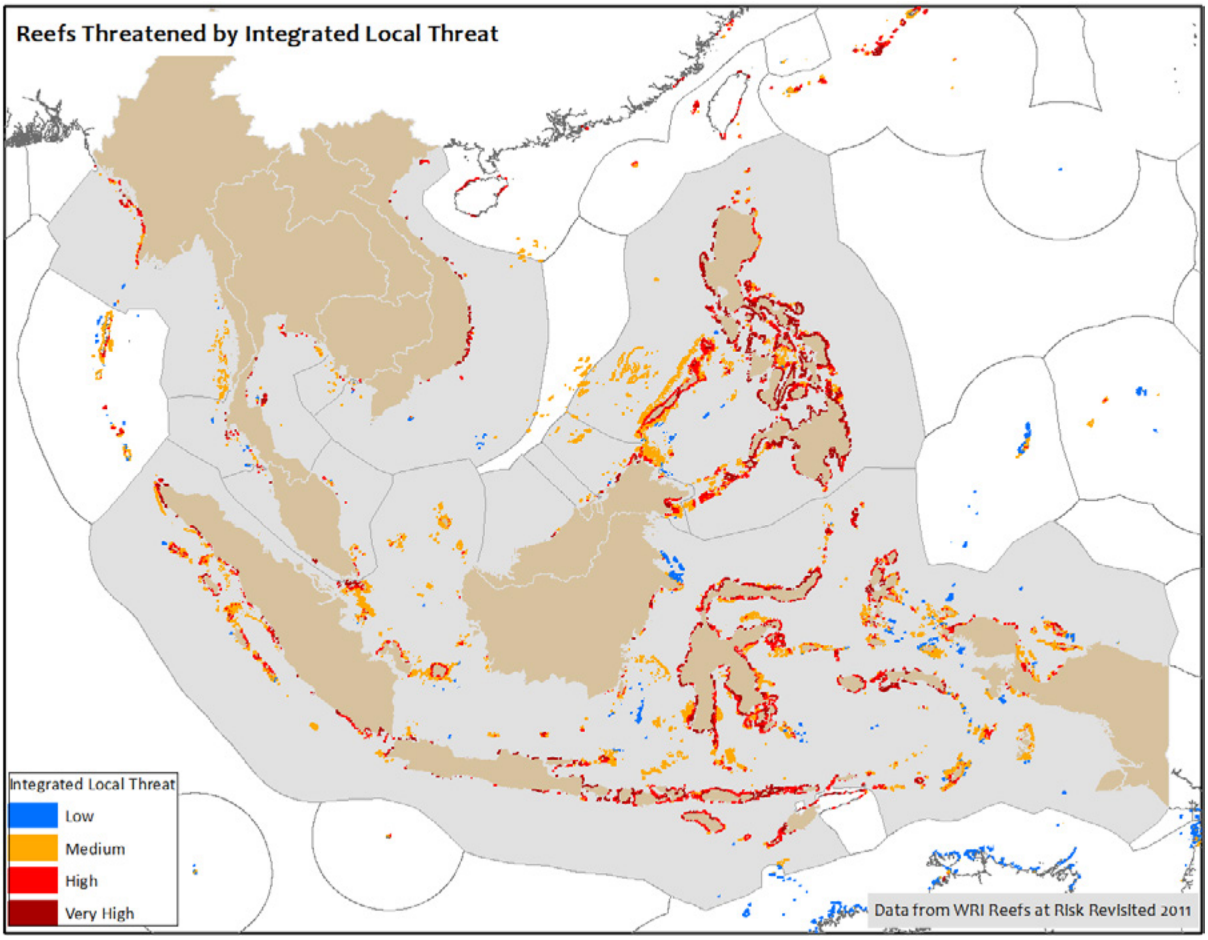

Figure 5. Distribution of varying levels of integrated local threats to coral reefs across the ASEAN region

The current status of coral reefs varies widely within and between AMS depending on the methodology being used. Despite the differences in the methodologies, all AMS share a common threat – the consistent decline of coral reefs. This trend is evident for AMS with a long-standing history of coral reef monitoring. Table 5 describes the status of coral reefs for each AMS based on available studies.

24 Burke et al. (2011)

Table 5. Status of coral reefs in each AMS based on available studies

AMS	Method	Status	Source
Brunei Darussalam	None Indicated	Approximately 50% of reefs with 50% coral cover. The coral reefs averaged 37% live coral cover in coastal communities; fringing, atolls, and patch reefs contain about 410 hermatypic coral species, 70 genera in 15 families, plus 29 species under study.	5th National Report to CBD and Tun et al. (2004)
	None indicated	Suggested that there are approximately 400 species of coral. The percentage of live coral cover of reefs in Brunei Darussalam ranged from 10% to 70% with an average of 37%.	Y. Tanaka (2016) Coral Care Programme, Dept. of Fisheries, Ministry of Industry and Primary Resources, June 2014
Cambodia	None Indicated	Information from existing data in one monitoring site; no trend indicated, listed 111 species of corals and percentage live coral cover ranged from 28% to 58%	Tun et al. 2004
Indonesia	Line Intercept Transect (LIT) Method	Conditions of coral reefs in Aceh Besar largely fall under the moderate condition with the percentage of live coral cover ranged from 33.38% to 59% using LIT. Blast and cyanide fishing are major threats and damage reefs in the area.	Fadli, N. et al. 2014
	None Indicated	Results of most monitoring indicated that in the past 50 years, the degraded reefs in Indonesia increased from 10% to 50%. Between 1989 and 2000, reefs with over 50% live coral cover declined from 36% to 29%.	Burke L. et al. 2002
	LIT Method	The percentage of reefs in good condition (with 50% live coral cover) was higher in eastern Indonesia (45%) than at western Indonesia (23%) suggesting that coral reefs thrive better in less dense areas than in highly populated islands.	Burke L. et al. 2002
	Assumed LIT Method	1,076 reefs surveyed in 2011 Poor: 331 reefs (30.76%) Fair: 396 reefs (36.90%) Good: 289 reefs (26.95%) Excellent: 60 reefs (5.58%)	ADB 2014
	LIT Method	Surveyed a total of 1,151 reefs with the following results (2019): Poor: 390 reefs (33.8%) Fair: 431 reefs (37.4%) Good: 258 reefs (22.4%) Excellent: 74 reefs (6.4%)	Biorock Indonesia (2020)

AMS	Method	Status	Source
Malaysia	Reef Check Survey Methods	From a total of 201 sites assessed in 2020 (84 sites in the Sunda Shelf region, 15 in the Malacca Strait ecoregion, and 102 in the north Borneo ecoregion): results show percentage live coral cover remains relatively high at 41.32% but has been in a consistent slow decline since five years ago falling by more than 5% points. Moreover, associated fauna, such as indicator fish and invertebrates, are low in numbers and often absent in many of the reefs.	Reef Check Malaysia 2020
	None Indicated	Some coral reefs are showing increasing amounts of algae, a situation that can lead to phase shift due to major reef imbalances. Poor to fair conditions of coral reefs in Peninsular Malaysia are due to increases in sedimentation and tourism impacts. Overfishing and blast fishing are the major threats to reefs in Sabah, while high rates in sedimentation and sand mining threaten reefs at Sarawak.	Praveena et al. 2012
Myanmar	Reef Check Method	Coral reefs in Myanmar are among the least studied and documented in the world. Best accounts of coral reefs in Myanmar are from the anecdotal accounts of divers visiting Burma Banks and Myeik archipelago reporting coral reefs are mostly in good to excellent condition; plentiful large fish, sharks, manta rays, and schools of jacks are frequently encountered. However, anthropological impacts such as scars on reefs from blast fishing were visible on reefs; debris from discarded fishing gear were also reported. The harvest of sea cucumbers for food is popular. The collection of shells and other invertebrates for ornamental and aquarium trade is also important sources of livelihood.	Tun and Heiss 2005
	Reef Check Method	75% of reefs in the southern Mergui Archipelago have 50% live coral cover.	Tun et al. 2004
	Reef Check Method	The overall coral cover within the archipelago is less than 30% and heavily degraded. However, there are still a number of individual sites that have diverse and extensive coral cover falling within the Good (51–75%) to Very Good range (76–100%). Abundances of Indicator fish species was very low across the whole archipelago, although numbers were found to be higher on those reefs further from large city centres. No sharks, rays or turtles were observed. Invertebrate abundance was dominated by long-spined sea urchins (Diadema sp.), which were found in very high numbers across most of the surveyed reefs. Sea cucumbers were in very low numbers, which is believed to be a result of over collection. No large aggregations of Crown-of-thorns starfish were observed.	Howard et al. 2014

AMS	Method	Status	Source
Philippines	Photo-transect Method	The largest and most recent updated data set on Philippine coral cover and coral generic diversity comprising 206 stations surveyed between 2014–2017 and another set of 101 stations monitored in 2015–2018 showed a weighted average of hard coral cover of 22.8% (±1.2% SE) and coral generic diversity averaged 14.5 (±0.5 SE). Moreover, no excellent category (hard coral cover of >44%) of coral reefs was found in the recent surveys in the country. A little over 90% of the reefs surveyed fall under the poor to fair category (<22% to 22–33% hard coral cover, respectively). Alarmingly, comparisons of data showed that a third of coral reefs were lost over the last decade.	Licuanan 2019
Singapore	None Indicated	Most coral reefs in Singapore have lost 65% of coral cover since 1986. Decline of coral cover on five permanent sites in 1998–1999 continued despite consistent monitoring of coral reefs. Even the best reef in Pulau Satumu located farthest from the mainland also lost 37% of coral cover over the last 13 years. Between 1998 and 1999, 90% of corals bleached and 25% failed to recover. The prognosis of the corals is not good in view of the national strategy to expand the island and increase shipping activities.	Chou 2000
	None Indicated	The hard coral diversity in Singapore is relatively high, with almost 200 species recorded. Reef status in 2004 is mixed with reefs close to shore and adjacent to high coastal development and land reclamation showing clear degradation, with deeper parts of the reefs almost completely buried under sediments. Reefs further from shore, that were protected by nearby military bases, have shown improvement in live coral cover on the shallow reef areas	Tun et al. 2004
Thailand	None indicated	Thailand's pre-2004 coral reefs data is solely limited to a 1999 coral reef monitoring study that reported the presence of about 250 species of corals at both Andaman Seas and the Gulf of Thailand. The report recorded that 15% of reefs examined contain 75% live corals while 75% of reefs only had 25% of live corals.	Tun et al. 2004
	Manta-Tow Survey Technique	Before 2006, the live coral cover of reefs in Andaman Seas were monitored and ranged from 25–58% and significantly declined to 8–22% after the 2010 coral bleaching ($p<0.05$). Similarly, the live coral cover of reefs in the Gulf of Thailand ranged from 32–39% before 2006 and declined to 22–35% after the 2010 bleaching event. The decline in live coral cover in the islands of Mun-Chang and Chumporn were significant ($p<0.05$).	Phongsuan et al. 2013

<table>
<tr><th>AMS</th><th>Method</th><th>Status</th><th>Source</th></tr>
<tr><td rowspan="3">Viet Nam</td><td>LIT Method</td><td>The status of coral reefs in six reef stations in central Viet Nam showed that the mean percentage of hard coral cover ranged from 3.8% (±4.6) to 32.2% (±18.6) with an overall mean of 19.8% (±9.4).</td><td>Dung 2020</td></tr>
<tr><td>LIT Method</td><td>A review of 200 reef sites surveyed showed that 31% fall under the poor category (<25% live coral cover), 41% under the fair category (50%>live coral cover>25%), 26% good (75%>live coral cover>50%) and only 3% under the excellent category (live coral cover>75%).</td><td>Tuan et al. 2009</td></tr>
<tr><td>Reef Check Survey Method</td><td>The live coral cover at 42 permanent monitoring sites was determined between 1994 to 1997 and 2004 to 2007 with the following results:
<table>
<tr><td>Status Category</td><td>1994–1997</td><td>2004–2007</td></tr>
<tr><td>Excellent</td><td>7.6%</td><td>2.9%</td></tr>
<tr><td>Good</td><td>33.3%</td><td>11.6%</td></tr>
<tr><td>Fair</td><td>44.5%</td><td>40.6</td></tr>
<tr><td>Bad and very bad</td><td>14.8%</td><td>50%</td></tr>
</table></td><td>Long and Tuan 2013</td></tr>
</table>

The decline of coral reefs is largely attributed to overexploitation (overfishing), loss of habitats from destructive exploitation gear, coastal development, and pollution. These factors, in the presence of the effects of climate change, increase in the level of intensity and cover wider areas.

The condition of reefs across all AMS is in an alarmingly declining state. In Indonesia, Philippines, Singapore, Viet Nam, and Thailand, the proportion of poor reefs has markedly increased and the loss of reefs over decades is significant (e.g. Philippines losing a third of its reefs in the last decade alone).[25] In the case of Malaysia, on the other hand, the condition of reefs is declining at a much slower rate than its neighbours.[26] For Myanmar, Cambodia, and Brunei Darussalam, the paucity of information and the non-comparability of results due to difference in methods suggest the need for the ASEAN Centre for Biodiversity (ACB) to explore the establishment of an agreed common scientific method of assessment and monitoring studies among AMS in the future. Monitoring available data will be important to detect the effectiveness of conservation strategies in protecting coastal and marine habitats.

Mangroves

Mangrove deforestation and degradation remains prevalent across the AMS, particularly highest in Myanmar, according to a 2016 study.[27] Myanmar lost 5.5 per cent of its mangrove cover between 2000 and 2012 (See Table 6). A considerable area of mangrove cover was also lost in Malaysia (2.83 per cent), Cambodia (2.28 per cent), Indonesia (1.72 per cent), and Thailand (1.36 per cent) during the same period. A graphical distribution of mangrove gains and losses across the ASEAN region[28] reveals higher losses of

25 Licuanan et al. (2019)
26 Reef Check Malaysia (2020)
27 Richards and Friess 2016; Gevaña et al. (2018)
28 Bunting et al. (2018)

mangroves than gained across AMS with losses more prevalent in Myanmar, Indonesia, and Malaysia (Figure 6).

Table 6. Percentage mangrove loss primarily due to conversion to various land uses[29]

AMS	% Mangrove loss 2000–2012	Percentage of the total deforested mangrove (2000–2012) converted to different land uses					
		Aqua-culture	Rice	Oil palm	Man-grove forest	Urban	Other category
Brunei Darussalam	0.37	29.2	0	27.7	12.5	15.9	14.8
Cambodia	2.28	27.7	1.5	8.9	9.8	4.6	47.6
Indonesia	1.72	48.6	0.1	15.7	22.6	1.9	11.2
Malaysia	2.83	14.7	0.1	38.2	17.6	12.8	16.7
Myanmar	5.53	1.6	87.6	1.1	0.5	1.6	7.6
Philippines	0.5	36.7	0.9	11.1	7.3	2.7	41.3
Singapore	0	0	0	0	0	0	0
Thailand	1.36	10.8	5.6	40	5.1	14.4	24.1
Viet Nam	0.25	21	10.4	0.5	0.6	62.5	4.9

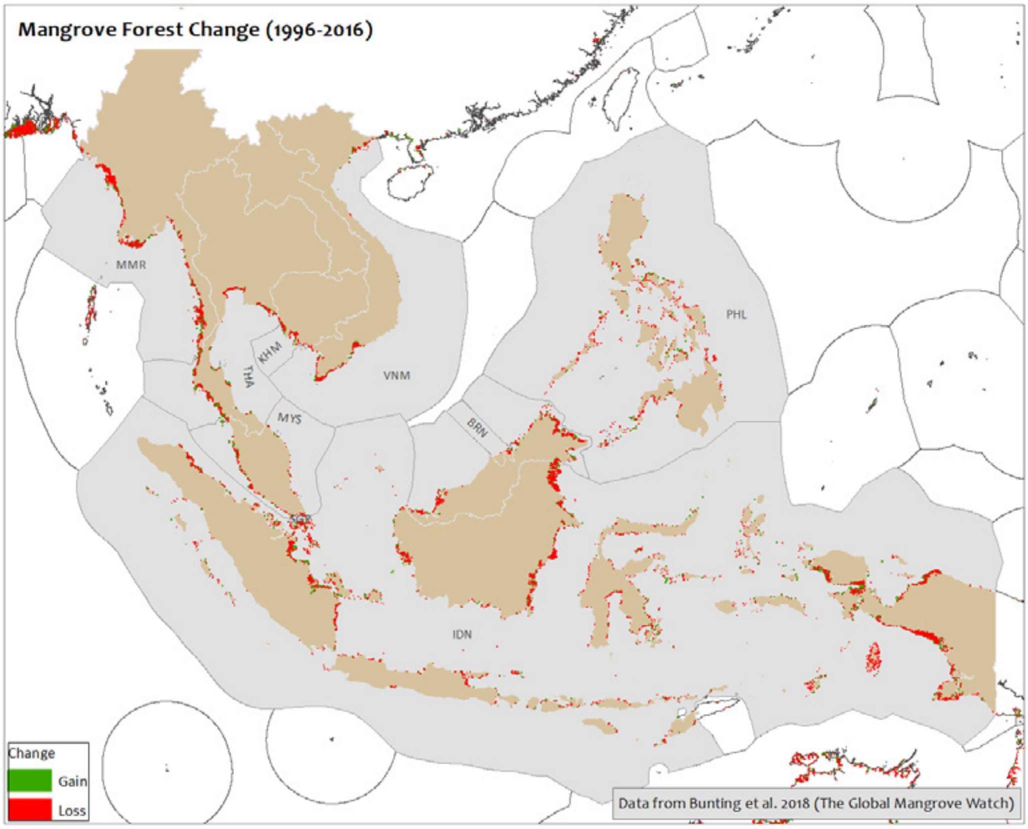

Figure 6. Graphical representation of gains and losses of mangrove forests from 1996 to 2016 from combined threats in the AMS

29 Richards and Friess (2016)

Conversion to aquaculture ponds emerges as the major driver in the mangrove loss in the region, accounting for the 30 per cent of the loss in the mangrove cover.[30] Conversion to aquaculture occurred mainly in Kalimantan and Sulawesi, Indonesia (See Figure 7). The other major threats are conversion of mangroves to rice farming and oil palm plantation (See Table 6 and Figure 7). Mangrove loss due to agricultural expansion for rice production was primarily observed in Myanmar. Moreover, mangrove conversion to oil palm plantations was observed mainly in Malaysia and Sumatra and Borneo in Indonesia. In Thailand, a large portion of its mangrove area (40 per cent) was converted to oil palm plantation (See Table 6). In July 2020, the ACB reported that the ASEAN region has lost a third of its mangrove forests during the last 40 years, shrinking the mangrove forest area by as much as 63,000 square kilometres.[31]

On a positive note, Indonesia and Malaysia were leading in the mangrove reforestation and recovered some of degraded mangrove areas (See Figure 7). There is a need to increase this effort properly by reforestation using the original species present in degraded mangrove areas. More importantly, these gains must be measured, monitored, and replicated over time.

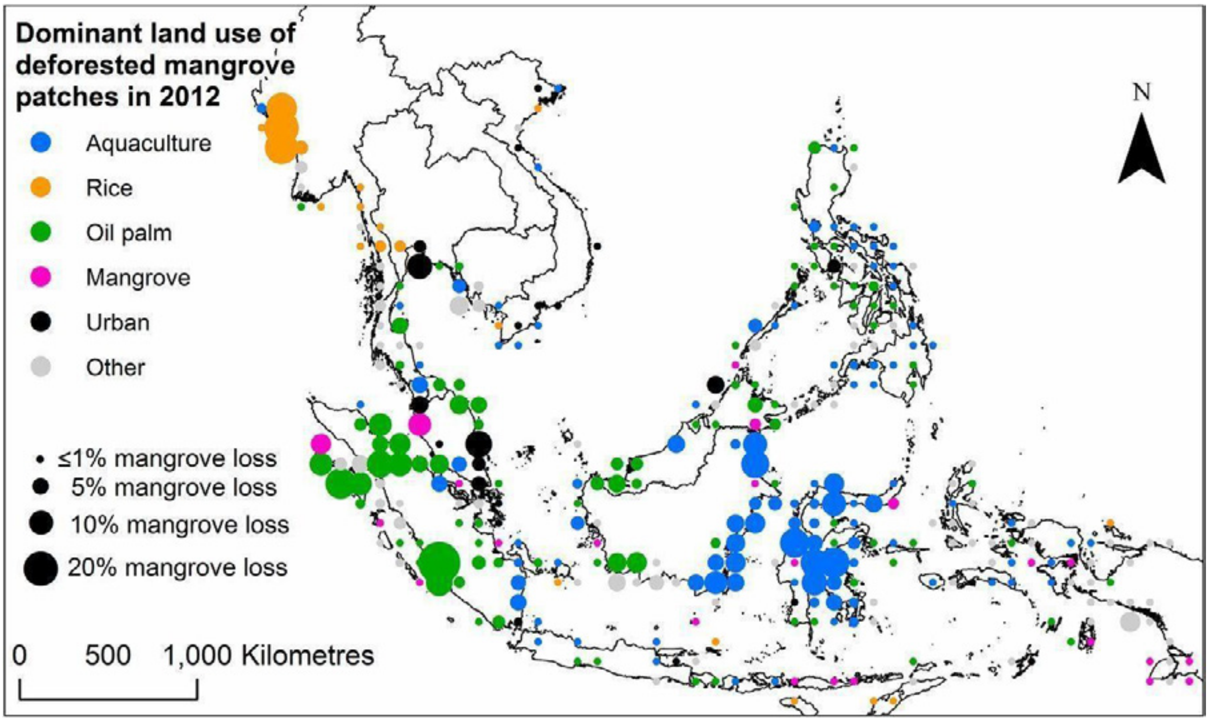

Figure 7. Graphical plot of mangroves converted to various land uses.[32]

30 Bunting et al. (2018)
31 ASEAN Centre for Biodiversity (2020)
32 Map from Richards and Friess (2016)

Seagrass beds

Various types of stressors adversely affect seagrass beds. Kirkman identified unrestrained coastal development, tourism and industry, destructive fishing techniques, aquaculture and seaweed farming, pollution and siltation, loss of mangrove and protective reefs, and natural disturbances as the causes of seagrass loss in Southeast Asia.[33] Sudo's study shows that the areal extent of the majority of the seagrass beds (data from 2000–2020) in the region has decreased.[34] These declining areas of seagrass beds were in Viet Nam, Philippines, Thailand, Malaysia, and Singapore (See Figure 8). Areas where seagrass beds were observed to increase were mostly found in Thailand and some in Viet Nam. The analysis, however, did not include seagrass beds in Indonesia, Cambodia, Myanmar, Brunei Darussalam, and Indonesia due to unavailability of data.

Activities, such as coastal development, aquaculture, destructive fishing, and water quality deterioration, cause declines in the status of seagrass beds. Tourism, shipping, mangrove plantation on supposedly seagrass beds, and natural hazards (typhoons and tsunami) were also reported as other causes of the decline.

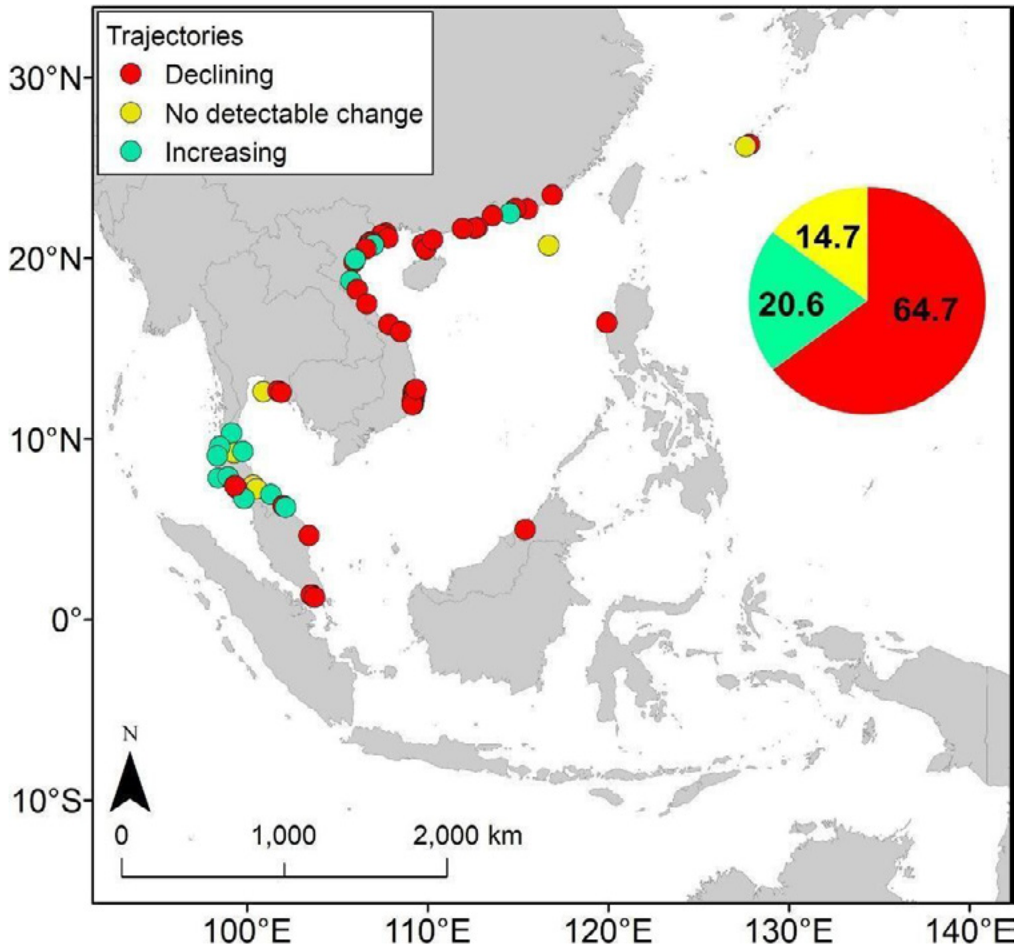

Figure 8. Relative locations of the status of seagrass beds due to various threats across the AMS[35]

33 Kirkman and Kirkman (2002)
34 Sudo et al. (2021)
35 Map from Sudo et al. (2021)

Over time, continuous threats to the health and condition of the rich and diverse coastal and marine ecosystems across AMS have had a compounded negative impact, contributing to its massive decline.

While all AMS exert varying levels of effort to conserve their marine habitats, these efforts are clearly not sufficient to reverse the rate of degradation and improve the current condition of coral reefs, seagrass beds, and mangrove forests across the ASEAN region. The marine habitats in the ASEAN region deserve more attention because of the value of their biodiversity and ecological services. The threats must be addressed to arrest the decline of these resources. The establishment of MPA and MPA networks in scales of 10's square kilometres is appealing because these are effective tools to reduce threats, allow recovery, and achieve key conservation goals to restore marine ecosystems and to recover biodiversity and ecological services.

Protection of marine habitats in deeper waters (mesophotic reefs) between two or more AMS or with other countries to conserve marine biodiversity areas

Coral reefs and seagrass beds inhabit shallow areas within and between AMS and other countries (See Figure 9). The presence of mesophotic coral ecosystems in deeper waters are significant. Mesophotic coral ecosystems are coral reefs found in deep waters (30–150 m depth) and represent approximately 80 per cent of coral reefs worldwide.[36] Yet little is known about them compared with shallow reefs. While the most profound declines in reef conditions occur on shallow reefs (<20 m in depth), mesophotic coral ecosystems have been shown to be largely free from anthropogenic and natural impacts.[37] Laverick reported that two-thirds of species on shallow reefs were present on mesophotic coral ecosystems with community overlap estimated to be as low as 26 per cent and as high as 97 per cent for some cases. This suggests a strong vertical connectivity and protecting mesophotic coral ecosystems will also help conserve shallow water species.[38] Thus, protecting large areas of marine environment within AMS as well as marine areas between two or more AMS and another country can cover and protect mesophotic reef ecosystems that form a significant part of the world's coral reefs.

Three identified areas between AMS and other countries around the ASEAN region hold significant cover of mesophotic reefs. These are the (1) waters between Viet Nam and the Philippines; (2) north-northwest area of Indonesia, west of Myanmar, and south-southwest of Bangladesh; and (3) south-southwest of Indonesia and north and northeast of Australia (Figure 9). The area between Viet Nam and the Philippines is known to be a rich fishing ground and contains extensive shallow coral reefs and possibly wide areas of seagrass beds as well as mesophotic coral ecosystems. These habitats play an important role in the maintenance, persistence, and resilience of marine biodiversity in the ASEAN region, and have significant economic contributions to the AMS, including supporting a large population of coastal communities dependent on these areas for sustenance. The management and conservation of this area will be a significant ASEAN contribution to the world in view of the Kunming-Montreal Global Biodiversity Framework.

36 Pyle and Copus (2019)
37 Bak et al. (2005)
38 Laverick et al. (2018)

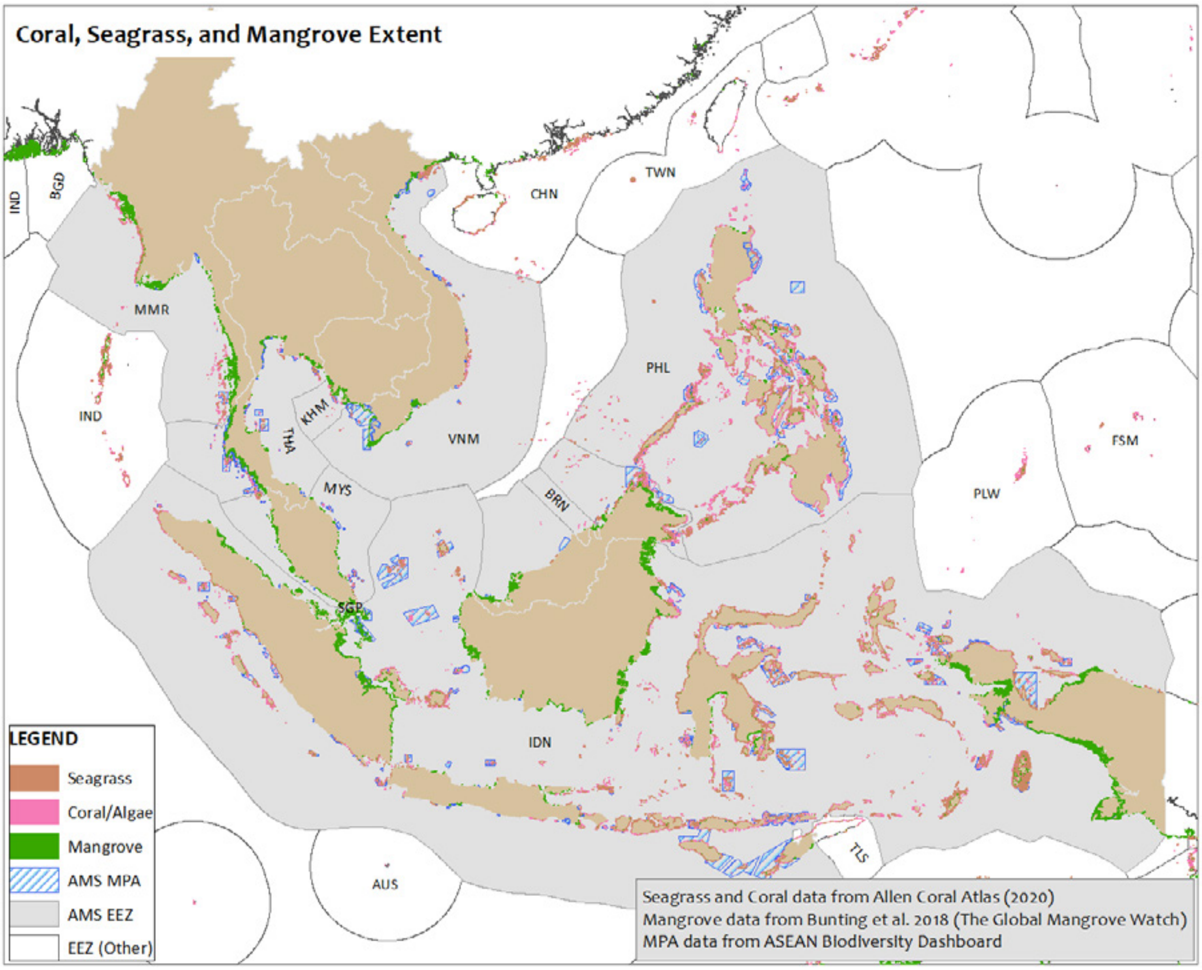

Figure 9. Distribution of the relative locations of coral reefs, mangrove stands, and seagrass beds across AMS and the possible occurrences of mesophotic reefs in deeper areas within and between AMS and other countries[39]

39 Flanders Marine Institute (2019)

III. Marine Ecological Connectivity

Ecological connectivity is among the most important ecological processes in the determination of distribution, maintenance, persistence, resilience, and productivity of coastal marine populations and ecosystems.[40] The strength of ecological connectivity is expressed as the frequency and amount of materials (e.g., genes and nutrients) shared between two or more habitats. Ecological connectivity between habitats occurs when materials from one habitat, such as genetic materials in the form of fertilised eggs, are dispersed during spawning via ocean currents and enabled to settle on other habitats along the path of the ocean current.

For example, 95 per cent of the organisms found in reefs and about the same number of organisms on seagrass beds and mangroves spawn releasing their propagules (e.g., larvae and seedling) into the water and disperse following the oceanic current. As larvae (or seedlings) do not have structures for swimming, they go with the water current. They remain dispersed by oceanic currents until after they complete their development (e.g., sensory organs developed, feeding apparatus complete, and locomotory structures complete) and begin to settle on a habitat.

The period under which the larvae remain dispersed by oceanic currents until they begin to settle is known as pelagic larval duration (PLD). The distances oceanic currents carry the larvae depend on the PLD and velocity of oceanic currents. The PLD of organisms vary widely. The PLD of some mollusks vary between a few days to 40 days and are dispersed from a few hundreds of metres to 116 kilometres; polychaetes from few hours to eight weeks and dispersed a few meters to 64 kilometres; crustaceans from two to four weeks to three to four months and dispersed 32–500 kilometres; echinoderms from 14–50 days and dispersed 22–85 kilometres; fishes from 9–12 days to 84–174 days and are dispersed 100–200 metres to 120 kilometres. The longer the PLD, the greater the distance larvae are transported. Organisms with longer PLDs are cast much farther than those with shorter PLDs.[41]

At settlement, most fish actively choose habitats and prefer corals to other types of habitats (e.g., dead corals and dead corals with algae).[42] Hence, coral reefs must have high cover of live corals to regularly attract new recruits to settle. Settling fish avoid dead corals. Fish recruitment in degraded reefs is likely to be very low because of poor live coral cover. Coral reefs exposed to high anthropogenic pressures (e.g., high fishing pressure, use of destructive fishing gears, pollution, and habitat conversion) are likely to be degraded. In contrast, MPAs are effective in preventing coral loss[43] as well as recovering reef fishes.[44]

40 Carr et al. (2017)
41 Shanks (2009)
42 Ohman et al. 1998, Montgomery et al. (2001)
43 Selig and Bruno (2010)
44 McClanahan et al. (2007)

Hence, an improved understanding of the processes of how marine populations on reefs are replenished and maintained provide the ability to scale up management efforts to optimise the benefits of protection. As Jones argued, "the extent of larval dispersal on coral reefs has important implications for the persistence of coral reef metapopulations, their resilience and recovery from an increasing array of threats and the success of protective measures."[45]

An initial particle dispersion model was run for the broad ASEAN region utilising a readily available ocean current product. The data set used was the Global Total Surface and 15m Current (COPERNICUS-GLOBCURRENT) from Altimetric Geostrophic Current and Modeled Ekman Current Reprocessing, as distributed by the Copernicus Marine Service of the European Union's Earth Observation Program. This product consists of gridded data with a 0.25 x 0.25-degree spatial resolution, available in three-hourly, daily, and monthly temporal resolution from the year 1993 to the present, and covers two levels, namely surface and 15m.

For the purpose of this study, the daily surface currents from January to March 2020 were utilised to represent the northeast monsoon, and July to September 2020 to represent the southwest monsoon. The model likewise adopted a 0.25 x 0.25-degree grid resolution with a spatial extent of 86.125° to 145.875° longitude and -15.875° to 22.125° latitude. Owing to the coarse size (approx. 27.5 x 27.5 kilometres), all grid cells adjacent to land were assumed to contain a reef, and therefore considered potential sources of larvae (represented by particles). A total of 179,000 particles (100 particles per reef cell) were released in the model, and their trajectories were tracked for 90 days, which in this study, is the assumed average pelagic larval duration for a variety of reef organisms. At the end of the simulation, all the particles that ended up in the territorial sea and EEZ of the AMS were summarised according to their source. All particles received from all AMS were accounted for and expressed as a percentage of the total particles received.

Results from the particle dispersion model covering the entire ASEAN region showed that during the northeast monsoon[46] (January to March 2020), two AMS, namely, Brunei Darussalam and Cambodia, demonstrated high larval dispersal to other states, while the remaining seven AMS exhibited high larval retention with three AMS exhibiting full retention (Myanmar, Philippines, and Singapore).

Seventy-nine per cent of the particles Brunei Darussalam received came from Malaysia while it retained the remaining 29 per cent of the particles. Cambodia was the recipient of particles from seven AMS. The largest proportion of particles was received from Viet Nam (58 per cent) and 5 per cent of particles were received each from the Philippines and Thailand, 2 per cent of particles from each of Indonesia and Malaysia, and 0.5 per cent from Brunei Darussalam and Singapore. Indonesia retained 97 per cent of particles and received 2 per cent from the Philippines and 1 per cent from Malaysia. Similarly, Malaysia retained 71 per cent of its particles and received 19 per cent from Indonesia, 8 per cent from the Philippines and 1 per cent from Brunei Darussalam. Thailand retained 86 per cent of the particles it released and received 4 per cent from Malaysia, 3 per cent from Cambodia, 2 per cent from the Philippines, and 1 per cent each from Brunei Darussalam, Indonesia, Myanmar, Singapore, and Viet Nam. Viet Nam retained 61 per cent of the particles and received 29 per cent from the Philippines, 2 per cent each from Cambodia, Indonesia, Malaysia, and Thailand, and 1 per cent each from Brunei Darussalam and Singapore (See Table 7).

45 Jones et al. (2009)
46 bit.ly/PDSNeMonsoon

Table 7. Fate of particles released from given sources (second column) to recipients from third to the eleventh column during the Northeast Monsoon (January to March 2020). Numbers are percentages of the total particles released in 9 AMS.

		RECIPIENTS								
		BRN	KHM	IDN	MYS	MMR	PHL	SGP	THA	VNM
SOURCES	BRN	29	0.5	0	1	0	0	0	1	1
	KHM	0	27	0	0	0	0	0	3	2
	IDN	0	2	97	19	0	0	0	1	2
	MYS	71	2	1	71	0	0	0	4	2
	MMR	0	0	0	0	100	0	0	1	0
	PHL	0	5	2	8	0	100	0	2	29
	SGP	0	0.5	0	1	0	0	100	1	1
	THA	0	5	0	0	0	0	0	86	2
	VNM	0	58	0	0	0	0	0	1	61

Conversely, the results of the particle dispersion modelling during the southwest monsoon[47] (July to September 2020) showed none of the AMS fully retained particles. All shared a portion of their particles with other AMS. Brunei Darussalam received 93 per cent of the particles from Malaysia, 5 per cent from Cambodia, and 2 per cent from Viet Nam. Cambodia only retained 1 per cent of the particles and received the bulk of 81 per cent from Malaysia, 9 per cent from Indonesia, 5 per cent from the Philippines, 3 per cent from Brunei Darussalam, and 1 per cent from Viet Nam. Indonesia retained 98 per cent of particles and received 1 per cent each from Malaysia and the Philippines. Malaysia retained 81 per cent of particles and received 9 per cent from Indonesia, 5 per cent from the Philippines, 3 per cent from Brunei Darussalam, and 2 per cent from Viet Nam. Myanmar retained 99 per cent of particles and received 1 per cent from Thailand. The Philippines retained 90 per cent of the particles and received 5 per cent from Viet Nam, 4 per cent from Malaysia and 1 per cent from Indonesia. Singapore retained 50 per cent of the particles and received the other 50 per cent from Indonesia. Thailand retained 69 per cent of particles and received 18 per cent from Indonesia and 13 per cent from Malaysia. Viet Nam retained 59 per cent of the particles, received 19 per cent from Thailand, 6 per cent each from Cambodia and Indonesia, 3 per cent each from Brunei Darussalam and Malaysia, and 2 per cent each from Myanmar and the Philippines (See Table 8).

Table 8. Fate of particles released from given sources (second column) to recipients from third to the eleventh column during the Southwest Monsoon (July to September 2020). Numbers are percentages of the total particles released in 9 AMS.

		RECIPIENTS								
		BRN	KHM	IDN	MYS	MMR	PHL	SGP	THA	VNM
SOURCES	BRN	0	3	0	3	0	0	0	0	3
	KHM	5	1	0	0	0	0	0	0	6
	IDN	0	9	98	9	0	1	50	18	6
	MYS	93	81	1	81	0	4	0	13	3
	MMR	0	0	0	0	99	0	0	0	2
	PHL	0	5	1	5	0	90	0	0	2.5
	SGP	0	0	0	0	0	0	50	0	0
	THA	0	0	0	0	1	0	0	69	19
	VNM	2	1	0	2	0	5	0	0	59

47 bit.ly/PDSSwMonsoon3

Initial data obtained provided information on the dynamics and strengths of the connectivity between AMS. In a subsequent modelling study, two subdomains were chosen to determine finer details of particle dispersal. The shift in the time for modelling followed the peaks of spawning for tropical reef fishes – northeast monsoon was shifted from November 2020 to January 2021 and the southwest monsoon shifted from May to July 2020.

Based on the current results of the modelling, the high retention of particles for both northeast and southwest monsoons indicates that a significant proportion of particles is retained within all AMS except Brunei Darussalam, Cambodia, and Viet Nam. The high retention of particles within each of the AMS shows that the marine larval propagules released by a state are likely to be retained by that state. Cases such as this suggest that MPA networks within an AMS will be effective. These MPA networks will be critical in the maintenance, persistence, resilience, and recovery of reefs for each constituent MPA within an AMS, particularly in big archipelagos such as Indonesia.

Dispersing particles to a receiving state show ecological interaction within the AMS. The more particles are received the higher the interaction. Table 7 reveals a strong interaction between Malaysia and Brunei Darussalam during the northeast monsoon (NE). Similarly, Viet Nam interacts with Cambodia during the NE monsoon, so do the Philippines and Thailand at a much lower magnitude. Indonesia interacts with Malaysia during the NE monsoon in the same way with the Philippines at a lower intensity. Thailand interacts with all states at a lower intensity. The Philippines interacts strongly with Viet Nam during the northeast monsoon.

There were more interactions during the southwest (SW) monsoon than the NE monsoon (See Table 8). Malaysia interacts more strongly with Brunei Darussalam during the SW than during the NE monsoon. In the same way, Cambodia interacts with Brunei Darussalam during the SW monsoon but at a much lower intensity. Malaysia strongly interacts with Cambodia in the same way as the Philippines and Indonesia but at a much lower intensity. Indonesia and the Philippines both interacted with Malaysia at a low intensity during the SW monsoon. Viet Nam interacts with the Philippines at a low intensity. Indonesia strongly interacts with Singapore. Both Indonesia and Malaysia interact with Thailand. Thailand interacted with Viet Nam in the same way as Cambodia and Indonesia interacted as well but at a lower intensity during the SW monsoon.

Finer scale particle dispersal model

Based on the results of the initial model using a coarser spatial resolution of 0.25 x 0.25 degree, a finer spatial resolution study using 0.083 x 0.083 degree scale was used on areas initially found to have a more dynamic marine connectivity. The same global model current product was used to drive the particle dispersion. The succeeding dispersion simulations made used the Hybrid Coordinate Ocean Model (HyCOM) as distributed by the Asia-Pacific Data-Research Center (APDRC). HyCOM has a resolution of 1/12 degrees (about 9.25 x 9.25 kilometres) and provides modeled current products from 1992 to 2012. For this study, the researchers used the data on the currents from November 2011 to March 2012 for the Northeast monsoon, and May to July 2012 for the Southwest monsoon.

Two subdomains were chosen based on initial results from the coarse model, the first, the Indonesia-Malaysia-Philippines subdomain (Lat: -6 to 10 degrees North; Lon: 108 to 130 degrees East), and second, the Viet Nam-Malaysia-Philippines subdomain (Lat: 7.52 to 21.52 degrees North; Lon: 105.04 to 121.76 degrees East). Similar to the initial model, all the grid cells in the subdomains that are adjacent to land cells were considered as potential reef cells, and therefore, particles were released from those cells. Whereas in the initial model, a single release was made per monsoon season, for the succeeding models, particles were released daily covering the period leading to and right after the spring tide (total of 16 days) to simulate a typical fish spawning. This was done to include all possible particle trajectories brought about by changing tidal current strength at the time of the release.

A total of 3,566,400 particles were released per season for the Indonesia-Malaysia-Philippines subdomain, while a total of 1,356,800 particles were released per season for the Viet Nam-Malaysia-Philippines subdomain. These particles were tracked for a minimum of 90 days. On the final day of tracking (Day 105), particle positions were plotted and tagged with the corresponding ASEAN EEZ of their final locations. Particle counts were then tallied and summarised in a connectivity matrix highlighting the sources and fate of the particles. One important thing to note on the fate of the particles is that, while all of them originated from ASEAN EEZs, some particles ended up in non-ASEAN EEZ waters (tagged "Other"), while some have crossed the open boundaries and have been removed from the model (tagged "Boundary").

The finer scale model was different from the initial model in two ways. First was the scale of spatial resolution. The finer model used a smaller grid of 0.083-degree x 0.083-degree (about 9.25x 9.25 kilometres) compared to the initial grid of 0.25-degree x 0.25-degree (27.75 x 27.75 kilometres). The second was the data set of the water currents. The finer scale model used the data set of water currents from November 2011 to March 2012 for the NE monsoon, and May to July 2012 for the SW monsoon in the subdomain, while the initial model used the data set for water currents obtained from January 2020 to March 2020 for the NE monsoon and July 2020 to September 2020 for the SW monsoon.

The results from the finer scale dispersal model showed a similar trend with the results of the initial model for each of the two subdomains during each seasonal monsoon, respectively. The finer scale model provided a detailed fate of the particles released from point sources and landing on a position within the subdomain after 105 days (Figures 10 and 11 for Indonesia-Malaysia-Philippines subdomain during the NE and SW monsoon seasons, respectively; and Figures 12 and 13 for the Viet Nam-Malaysia-Philippines subdomain during the NE and SW monsoon seasons, respectively).

The finer scale model also showed high retention of particles for all involved AMS except Brunei Darussalam. This finding is consistent with the initial model and confirms that more marine larval propagules are retained within an AMS. This finding in return strongly supports the establishment of large MPAs and MPA networks. The location and size of Brunei Darussalam explain its lower retention. Nevertheless, Brunei Darussalam will need to join MPA networks in Malaysia or both with Malaysia and the Philippines.

The final positions of particles after 105 days are shown in Figure 10 for the Indonesia-Malaysia-Philippines subdomain during the NE monsoon.[48] Particles are color-coded based on source. The particles dispersed from the Philippines reach eastern parts of Kalimantan and the western to northern sides of the island of Sulawesi including the northeast islands in Indonesia, as well as the northeastern side of Sabah in Malaysia. The Philippines dispersed 5 per cent of particles to Indonesia and nearly 4 per cent to Malaysia (See Table 9). Similarly, the southern part of Palawan, Sulu Islands, and the Zamboanga Peninsula in the Philippines received over 13 per cent of particles dispersed from Malaysia (See Table 9). In the same manner, close to 6 per cent of particles from Malaysia reached various islands in Indonesia.

48 bit.ly/PDSNeMonsoon2

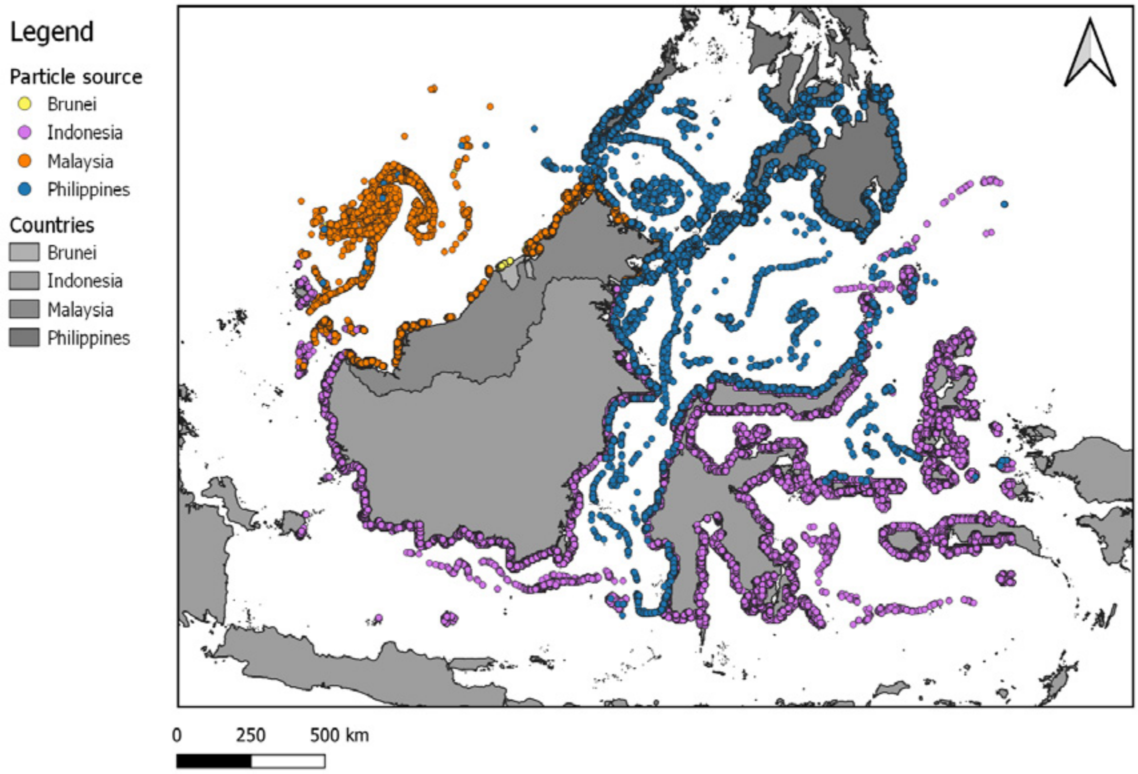

Figure 10. Final positions of released particles after day 105 at the Indonesia-Malaysia-Philippines sub-domain during a NE monsoon season

Table 9. Fate of particles released from areas in Indonesia, Malaysia, and Philippines during a NE monsoon (simulated water currents based on November 2011 to March 2012 data set)

	SOURCE				
FATE	**BRN**	**IND**	**MYS**	**PHL**	**% of total particles**
Boundary*	7.57	6.85	14.84	6.76	**7.56**
BRN	6.31	0.00	0.30	0.00	**0.07**
IND	1.89	92.18	5.96	5.04	**64.14**
MYS	34.63	0.96	64.21	3.86	**7.61**
PHL	49.33	0.00	13.44	84.34	**20.50**
VNM	0.16	0.00	0.54	0.00	**0.05**
Other**	0.11	0.00	0.71	0.00	**0.07**
Total	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**

* Boundary = particles have crossed the boundaries (removed from the model),
** Other = particles ended up in non-ASEAN EEZ locations

The model for Indonesia-Malaysia-Philippines indicated that only 0.07 per cent of the particles landed outside of the ASEAN region and 7.56 per cent of the particles were dispersed outside of the boundaries of the subdomain but remained within the boundaries of the ASEAN region during the NE monsoon.

The final positions of the dispersed particles in the Indonesia-Malaysia-Philippines subdomain after 105 days during the SW monsoon[49] (See Figure 11) appear generally the same with that for the NW monsoon (See Figure 10) except for particles dispersed from Indonesia (colour violet) and Malaysia (colour orange). The particles from Indonesia dispersed northwards reaching the left corner of the subdomain representing the waters between southern Viet Nam and northeast of Sabah, Malaysia (a little over 1 per cent of particles from Indonesia, Table 10); the right corner representing the Philippine Sea east of Mindanao, Philippines during the SW monsoon (See Figure 11). In addition, particles from Indonesia also reached the Moro Gulf particularly close to the coastal areas of Zamboanga del Sur, Maguindanao, and Sultan Kudarat in the southern Philippines. About 1.23 per cent of particles from Indonesia reached the Philippines (See Table 10).

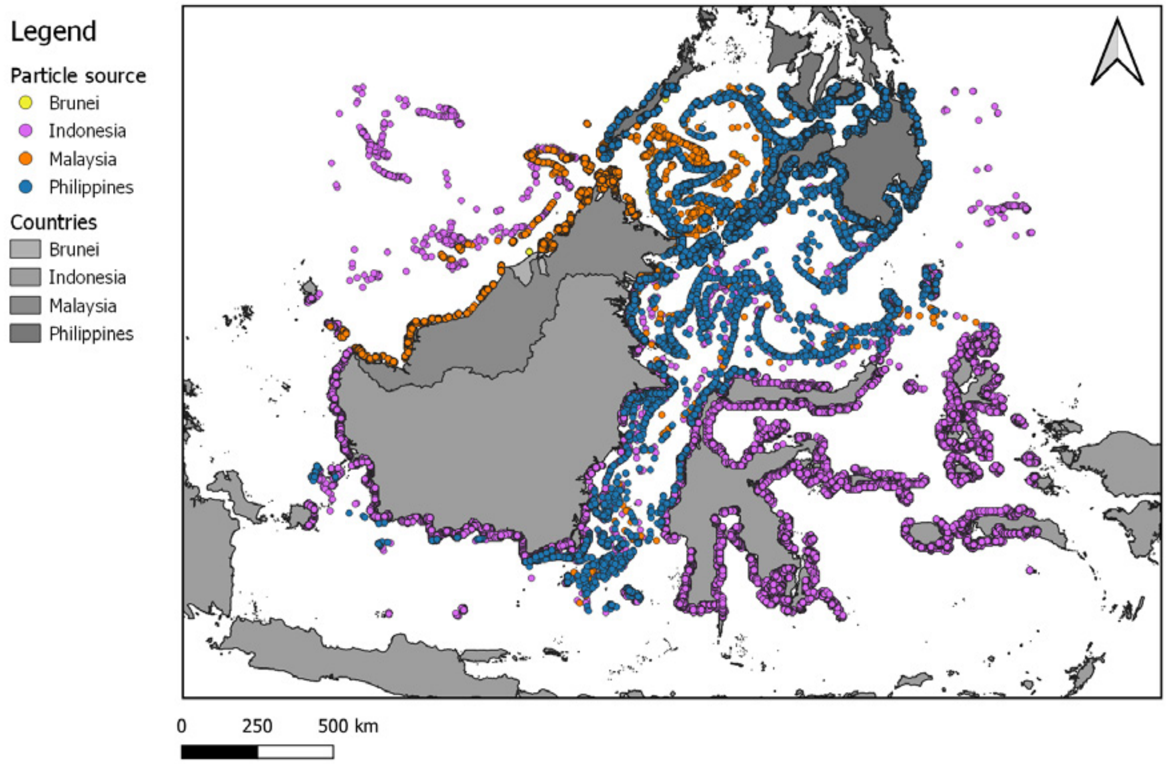

Figure 11. Final positions of released particles after day 105 at the Indonesia-Malaysia-Philippines sub-domain during a SW monsoon season

Nearly 52 per cent of particles from Malaysia are dispersed to the Philippines during the SW monsoon (Table 10). Figure 11 shows particles from Malaysia reach the waters of Cagayancillo and Tubbataha Reefs in the Sulu Sea, as well as the Sulu archipelago. Similarly, 62 per cent of particles from Brunei Darussalam reach the Philippines, particularly the Sulu archipelago and Sulu Sea-side of Palawan.

None of the particles were dispersed beyond the boundaries of ASEAN although nearly 17 per cent of particles were dispersed outside of the boundaries of the subdomain but inside the ASEAN region.

49 bit.ly/PDSSwMonsoon

Table 10. Fate of particles released from areas in Indonesia, Malaysia, and Philippines during a SW monsoon (simulated water currents based on May 2012 to July 2012 data set). Note that all particles remained within the ASEAN region.

	SOURCE				
FATE	**BRN**	**IND**	**MYS**	**PHL**	**% of total particles**
Boundary*	37.40	17.90	13.66	14.58	**16.89**
BRN	0.11	0.01	0.02	0.00	**0.01**
IND	0.00	79.76	0.82	1.87	**54.52**
MYS	0.33	1.08	34.56	1.89	**4.32**
PHL	62.16	1.23	50.93	81.66	**24.24**
VNM	0.00	0.02	0.00	0.00	**0.01**
Other**	0.00	0.00	0.00	0.00	**0.00**
Total	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**

* Boundary = particles have crossed the boundaries (removed from the model),
** Other = particles ended up in non-ASEAN EEZ locations

In the second subdomain the positions of particles 105 days after release from point sources in Viet Nam, Malaysia, Philippines, and the Kalayaan Island Group (KIG) during a NE monsoon are shown in Figure 12. The KIG[50] is in the northeastern section of the Spratly Islands in the South China Sea. The Philippines is asserting claims to the KIG, while Malaysia claims part of it. China and Taiwan are claiming the entirety of the Spratly Islands. The KIG was included in this study to showcase the value of its ecological connectivity in the region. The strategic location coupled with its rich and diverse coral reefs and other marine ecosystems make the KIG an important resource for the entire ASEAN region.

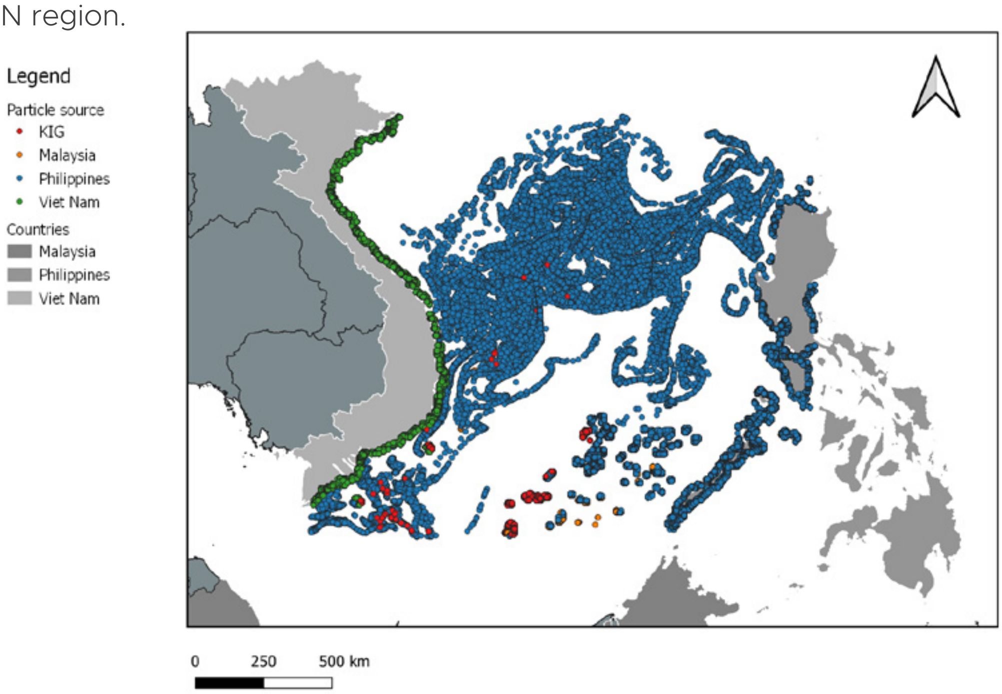

Figure 12. Final positions of released particles after day 105 at the Viet Nam-Malaysia-Philippines sub-domain during a NE monsoon season

50 NBR. (2023)


PHOTO: Aung Ko Oo

The particles released from Viet Nam dispersed following a narrow lane within the contour of its coastline during a NE monsoon season. The dispersal did not venture seawards. Eighty-four per cent of its particles (green) remained within the contour of its coastline while the remaining 16 per cent were dispersed beyond the boundaries of the subdomain but within the ASEAN region (See Table 11).

In the case of Malaysia, nearly half of its particles were dispersed outside of the subdomain within the ASEAN region during the NE monsoon (See Table 11). Nearly 32 per cent of particles from Malaysia were dispersed to the various areas in the Philippines, particularly along the eastern side of Palawan, while only about 3.5 per cent of particles landed in the KIG.

Nearly 14 per cent of particles from the Philippines were dispersed to Viet Nam. A review of the dispersal of particles showed that a large plume of particles coming from the northern tip of the Philippines flowed and mixed into the South China Sea before pushing towards south of Da Nang then moved southwards following the contours of Viet Nam. The Philippines also dispersed nearly 5 per cent of its particles to the KIG, nearly 14 per cent dispersed outside of the subdomain within the ASEAN region and a little over 4 per cent outside the boundaries of the ASEAN region (See Table 11).

In the case of the KIG, nearly 85 per cent of its particles were dispersed beyond the boundaries of the subdomain within the ASEAN region during NE monsoons supporting the notion that the area supplies the ASEAN region with marine larval propagules. About 7 per cent of particles are retained while more than 8 per cent are dispersed to Viet Nam (See Table 11).

Nearly a fifth of the particles in the Viet Nam, Malaysia, Philippines subdomain are released beyond its boundaries within the ASEAN region, while more than 2 per cent of the particles move outside the ASEAN Region (See Table 11).

Table 11. Fate of particles released from areas in Viet Nam, Malaysia, Philippines, and the KIG during a NE monsoon (simulated water currents based on November 2011 to March 2012 data set). Note that all particles remained within the ASEAN region except for 2.59 per cent of particles landing outside of the boundaries of the ASEAN region.

	SOURCE				
FATE	KIG	MYS	PHL	VNM	% of total no. of particles
Boundary*	84.64	48.60	13.95	15.82	**20.50**
KIG	6.77	3.51	4.83	0.05	**3.50**
MYS	0.00	15.02	0.08	0.00	**0.74**
PHL	0.00	31.68	63.34	0.00	**39.55**
VNM	8.59	0.63	13.53	84.13	**33.11**
Other**	0.00	0.56	4.27	0.00	**2.59**
Total	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**

* Boundary = particles have crossed the boundaries (removed from the model),
** Other = particles ended up in non-ASEAN EEZ locations

Conversely, the pattern of dispersal of particles in the Viet Nam-Malaysia-Philippines subdomain during the SW monsoon[51] is the reverse of that during the NE monsoon (See Figure 13). During the SW monsoon, close to 50 per cent of particles from the entire coastline of Viet Nam are dispersed from west to east direction towards the western side of Luzon in the Philippines (See Table 12). Of these particles, nearly 24 per cent settle along the western side of Luzon while the remaining 26 per cent of the particles overflow the northern tip of Luzon (Batanes area) outside of the subdomain boundaries but well inside the ASEAN region (See Table 12).


PHOTO: Kyaw Kyaw Winn

51 bit.ly/PDSSwMonsoon2

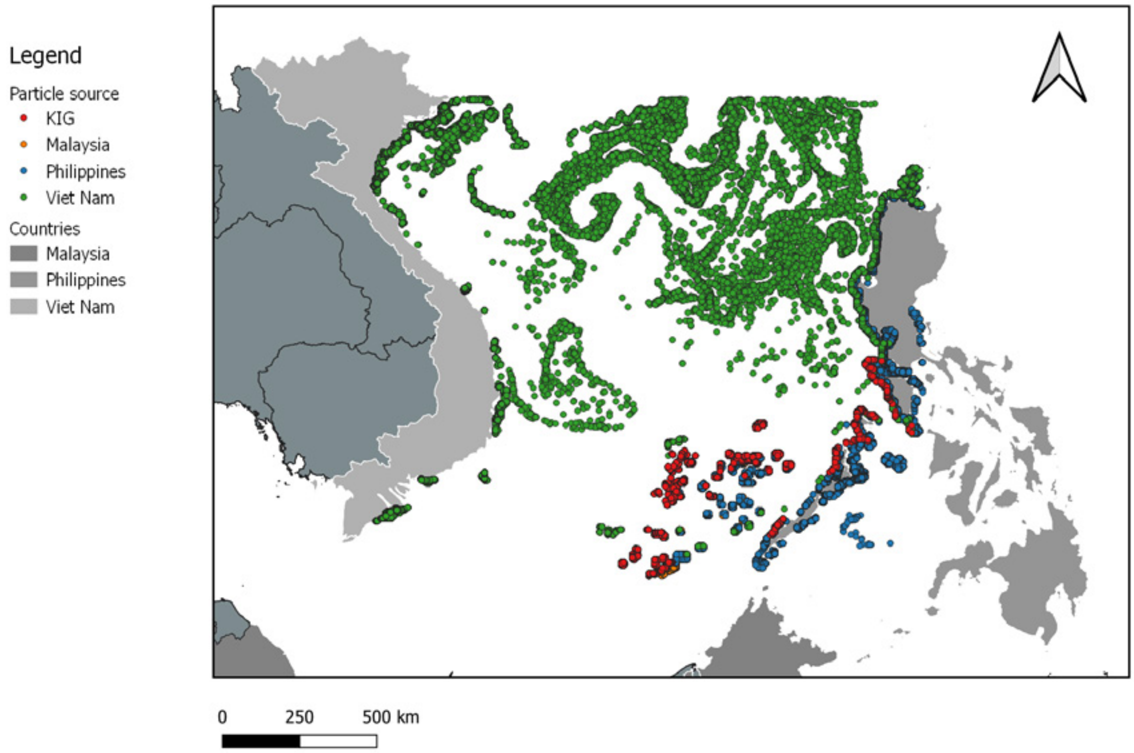

Figure 13. Final positions of released particles 105 days after release from point sources at the Viet Nam-Malaysia-Philippines sub-domain during a SW monsoon season.

In the case of the particles from Malaysia, nearly 28 per cent are retained, 23 per cent are dispersed towards the western side of Palawan in the Philippines with some particle plume entering via south of Balabac Islands at the southern tip of Palawan during the SW monsoon season. These particles then find their way to the inner reefs of the Philippine archipelago. Moreover, the remaining particles (about 49 per cent) from Malaysia are dispersed outside of the boundaries of the subdomain but within the ASEAN Region (See Table 12).

The particles from the Philippines dispersed little with more than 73 per cent of particles retained during the SW monsoon season. The remaining 27 per cent of particles are dispersed outside of the boundaries of the subdomain within the ASEAN region (See Table 12).

The KIG disperses 72 per cent of its particles to the Philippines entering via the northern tip of Palawan towards Lubang Island and the entire western side of Mindoro Occidental (See Figure 13). Similarly, more than 7 per cent of the particles from the KIG settle in Malaysia and only about 4 per cent of the particles are retained (Table 12).

The entire subdomain loses about 4 per cent of particles that are dispersed beyond the boundaries of the ASEAN Region (See Table 12), while more than a fourth of the particles are shared outside of the subdomain and within the ASEAN region.

Table 12. Fate of particles released from areas in Viet Nam, Malaysia, and Philippines during a SW monsoon (simulated water currents based on May 2012 to June 2012 data set). Note that all particles remained within the ASEAN region except for 4.17 per cent of particles landing outside of the boundaries of the ASEAN region.

	SOURCE				
FATE	KIG	MYS	PHL	VNM	% of total no. of particles
Boundary*	16.63	49.58	26.61	25.66	**26.77**
KIG	3.86	0.00	0.00	0.63	**0.42**
MYS	7.47	27.66	0.03	2.02	**2.34**
PHL	72.04	22.76	73.36	22.85	**56.30**
VNM	0.00	0.00	0.00	34.48	**10.00**
Other**	0.00	0.00	0.00	14.36	**4.17**
Total	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**

* Boundary = particles have crossed the boundaries (removed from the model),
** Other = particles ended up in non-ASEAN EEZ locations

The current scientific body of evidence shows that MPAs and MPA Networks are effective tools in reducing anthropogenic threats and restoring marine biodiversity and ecological services).[52] Bellwood argue that a large-scale crisis requires scaled-up management efforts based on an improved understanding of the ecological processes that underlie reef resilience.[53] Incorporating the role of human activity in shaping ecosystems in management provides a basis for coping with certainty, future changes, and ecological surprises. The connectivity study for the ASEAN region showed (1) a strong retention of particles within each AMS except for Brunei Darussalam and Cambodia; and (2) the varying levels of interactions between AMS during the NE and SW monsoons.

The strong retention of particles within each of the AMS means that marine larval propagules produced in each MPA when dispersed can be received by several MPAs within the AMS. In the case of MPA network, the larval propagules produced by constituent MPA are shared within MPAs of the network as well as with other MPAs outside of the network. The entire AMS benefits because with more MPAs, more marine habitats (coral reefs, seagrass beds, and mangroves) will recover over time and more recovered habitats will become available to more recruits. More recruits mean more fish for the people, thereby ensuring food security.

The varying strengths in the interaction of marine larval propagule between AMS mean that it will be possible for two or more adjacent AMS to work in partnership to conserve and manage important marine habitats. In the same manner, two or more AMS can work together with another country to conserve marine biodiversity areas that are critically important.

There is an example of conservation cooperation among the AMS. On 31 May 1996, a bilateral cooperation between the Philippines and Malaysia led to a historic signing of a Memorandum of Agreement (MOA) which formally created the first transboundary protected area for marine habitats and sea turtles over a large area independent of

52 Carr et al. (2017), Duarte et al. (2020), Sala et al. (2021)
53 Bellwood et al. (2004)

their territorial boundaries. The MOA established the Turtle Island Heritage Protected Area (TIHPA).

An article issued by the Brunei-Darussalam, Indonesia, Malaysia, Philippines-East Asia Growth Area (BIMP-EAGA) reported the conservation efforts the Philippines initiated with Indonesia and Malaysia to expand the protection of sea turtles in the ASEAN region, which resulted in a Memorandum of Understanding (MOU) on the conservation and management of marine turtles and their habitats in the Indian Ocean and Southeast Asia in 2001.[54] Following these efforts in 2009, the committee on the Sulu-Sulawesi Marine Ecoregion comprising delegates from the Philippines, Indonesia, and Malaysia approved the design for a tri-national Marine Turtle Protected Area Network. Similarly, partnerships between AMS with adjacent countries can also be patterned with how the Coral Triangle Initiative was formed (3 AMS and 3 adjacent countries).

Future partnerships between AMS to protect marine biodiversity across large interacting areas can follow or improve the processes of the above examples. For example, a simple declaration such as "The San Jose Declaration 2004" formally established the Eastern Tropical Pacific Marine Corridor (CMAR). Enright explains that CMAR is a voluntary regional cooperation mechanism created by the coastal states of Ecuador, Costa Rica, Colombia, and Panama in response to anthropogenic pressures in the Eastern Tropical Pacific, one of the world's most biodiverse and productive marine areas.[55] The four coastal states agreed to create a regional cooperation mechanism for the conservation and sustainable use of marine biodiversity in the Eastern Tropical Pacific even in the absence of a coherent, overarching regional ocean governance framework. The establishment of the Coral Triangle Initiative is another example of partnerships that could result in the protection and management of large marine areas with high ecological connectivity in the ASEAN region, which are key to counter the declining condition of its marine environment and contribute to global marine conservation efforts.

54 BIMP-EAGA (2020)
55 Enright et al. (2021)

IV. Options for AMS to Contribute to Achieving Biodiversity Targets in the Kunming-Montreal Global Biodiversity Framework

The other important aim of this work is a discussion on the ways the ASEAN region can support Kunming-Montreal GBF. The ecological connectivity exhibited in this study, which cites an abundance of scientific literature, points to the rationale of establishing effective MPAs and MPA networks, which is a key strategy to mitigate degradation and restore marine biodiversity and ecological functions in the AMS.[56] Globally established MPAs and MPA networks are effective tools for protecting a defined area of the marine environment from anthropogenic threats, promoting sustainable fisheries, and enhancing marine biodiversity.

Based on the discussions above, these are the following options the AMS may pursue:

First, each AMS can establish MPAs and MPA networks within their jurisdictions. The strong retention of particles within each of the AMS supports this strategy.

Second, create MPA Networks between two or more adjacent AMS (See numbered polygons in Figure 14 corresponding to the number designated for a partnership between AMS).

The relatively strong ecological connectivity shown in both models support the establishment of MPA Networks among the following AMS:

1. Brunei Darussalam, Malaysia (Sarawak and Sabah), Indonesia (eastern Kalimantan), and Southern Philippines (southern tip of Palawan, Sulu archipelago, Moro Gulf) – approximately 795,157 square kilometres and 10.24 per cent of the total ASEAN coastal and marine areas.
2. Viet Nam, Cambodia, and Peninsular Malaysia – approximately 590,998 square kilometres and 7.61 per cent of the total ASEAN coastal and marine areas.
3. Thailand, Malaysia, and Indonesia (Northern Sumatra Island) – approximately 531,705 square kilometres and 6.85 per cent of the total ASEAN coastal and marine areas.

Third, develop a partnership for cooperation among AMS and other countries to conserve marine biodiversity (see numbered polygons in Figure 15 corresponding to the number designated for the partnerships for cooperation between AMS and other countries).

The strong ecological connectivity shown for these areas in both models strongly supports the establishment of MPA networks to conserve important marine biodiversity at the following areas of the ASEAN region:

56 Belwood et al. (2004), Jones et al. (2009), Carr et al. (2017), Duarte et al. (2020), Sala et al. (2021)

1. Philippines, Viet Nam, Malaysia, Indonesia, Brunei Darussalam, and China – approximately 801,798 square kilometres and 10.33 per cent of the total ASEAN coastal and marine areas.
2. Indonesia (Northern Sumatra), Thailand, Myanmar, and Bangladesh and India – approximately 1,142,493 square kilometres and 14.72 per cent of the total ASEAN coastal and marine areas.
3. Indonesia (Surabaya, West Timor), Timor Leste, and Australia (Northern Territory) – approximately 799,687 square kilometres and 10.30 per cent of the total ASEAN coastal and marine areas.

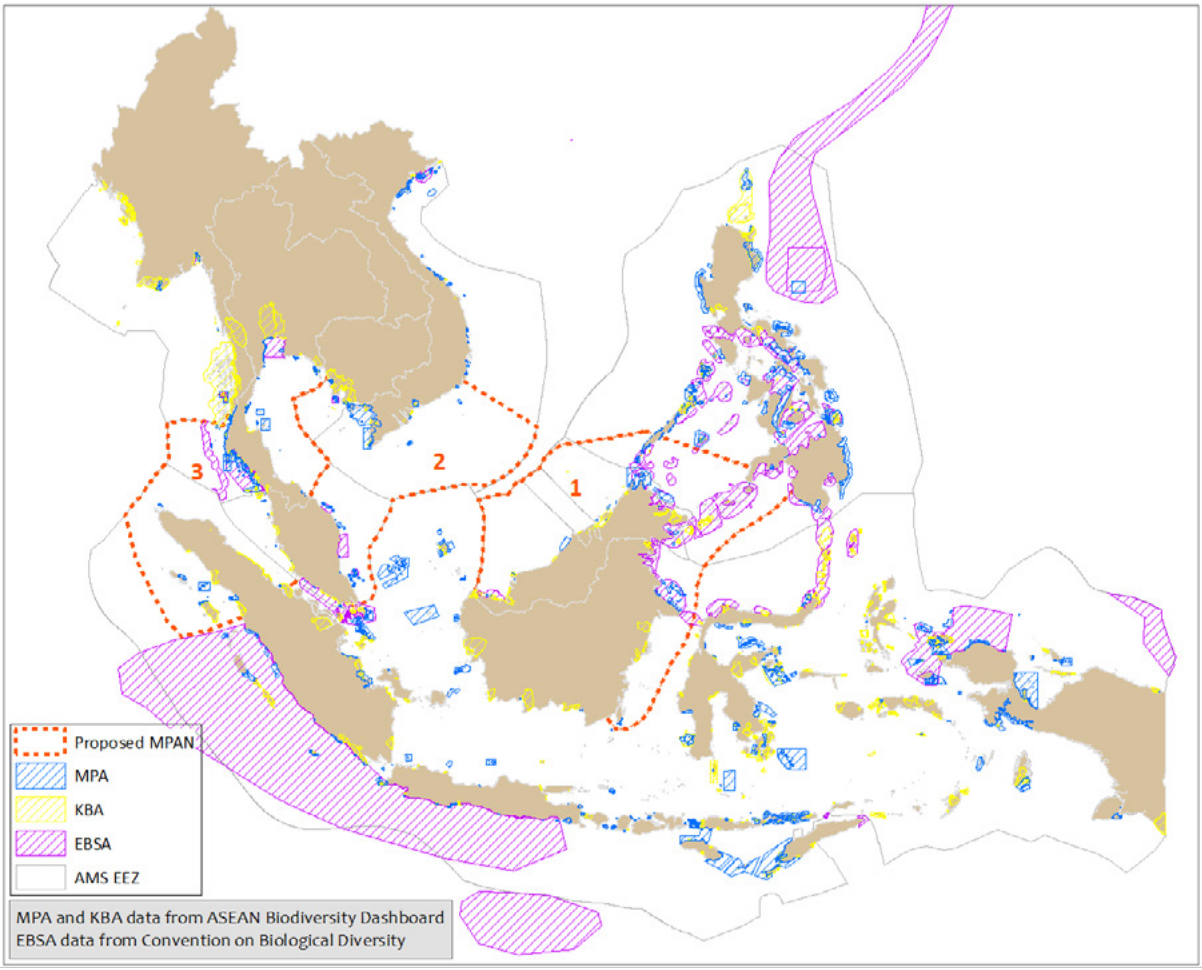

Figure 14. Map of the ASEAN Region showing potential areas for MPA networks under partnerships between respective AMS in 1, 2, and 3 polygons.

Potential MPAN	AMS involved	Estimated area (km^2)	% of ASEAN coastal and marine areas
1	Brunei Darussalam, Malaysia (Sarawak and Sabah), Indonesia (eastern Kalimantan), and Southern Philippines (southern tip of Palawan, Sulu archipelago, Moro Gulf)	795,157	10.24
2	Viet Nam, Cambodia, and Peninsular Malaysia	590,998	7.61
3	Thailand, Malaysia, and Indonesia (Northern Sumatra Island)	531,705	6.85
	Total	1,917,860	24.71

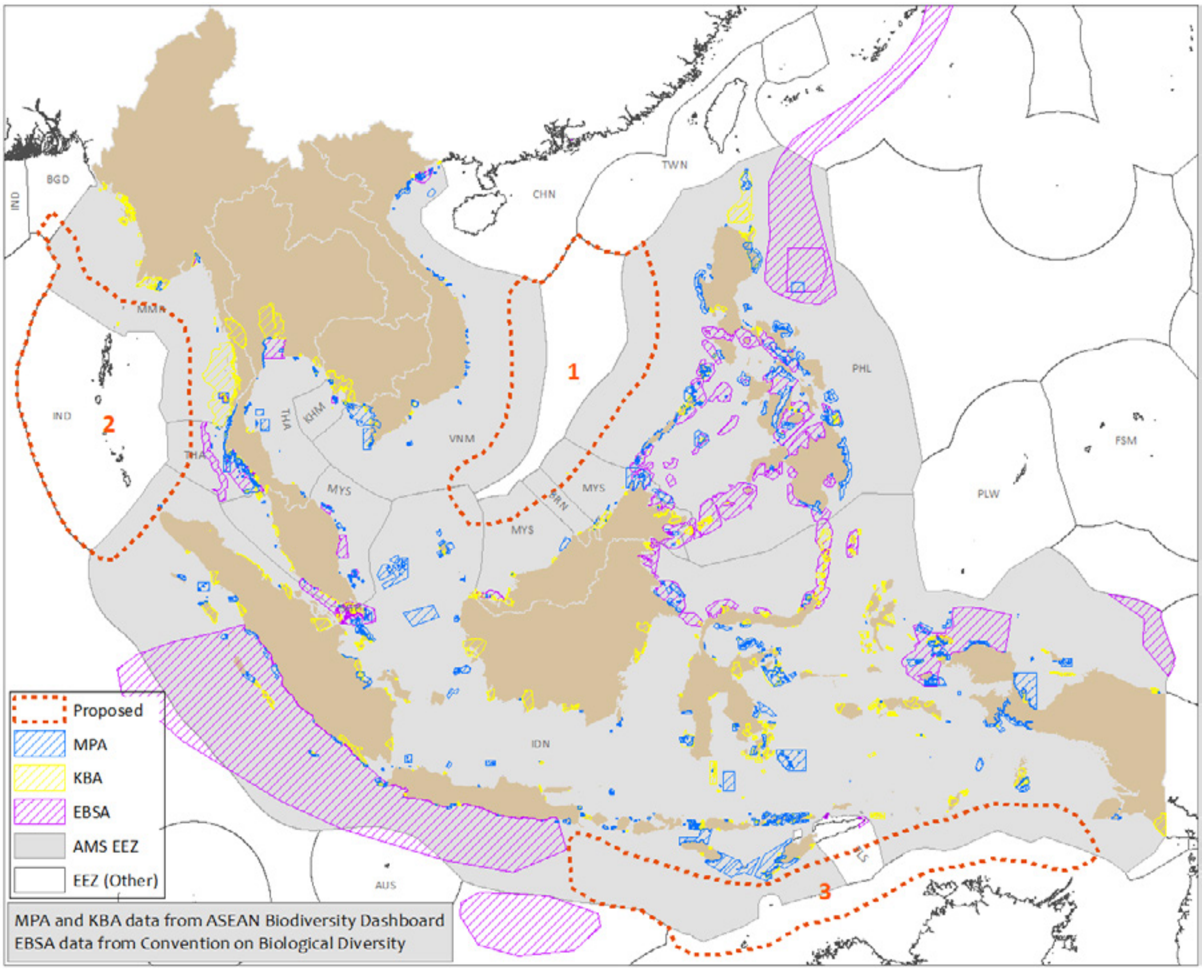

Figure 15. Map of the ASEAN region showing potential areas for conservation cooperation (e.g., MPA networks) under partnerships between respective AMS and other countries in 1, 2, and 3 polygons.

Proposed MPAN	AMS and other countries involved	Estimated area (km^2)	% of ASEAN coastal and marine areas
1	Philippines, Viet Nam, Malaysia, Indonesia, Brunei Darussalam, and China	801,798	10.33
2	Indonesia (Northern Sumatra), Thailand, Myanmar and Bangladesh and India	1,142,493	14.72
3	Indonesia (Surabaya, West Timor), Timor Leste and Australia (Northern Territory)	799,687	10.30
	Total	2,743,978	35.35

The second option comprises a potential of 1,917,860 square kilometres and when protected translates to about 24.71 per cent of the total ASEAN coastal and marine areas (See Figure 14). The third option is about 2,743,978 square kilometres and comprises 35.35 per cent of the total ASEAN coastal and marine areas (See Figure 15). The third option alone satisfies Target 3 of the Kunming-Montreal GBF for the AMS. The total area available for protection in the ASEAN region will be a very significant contribution of the ASEAN people to the world.

V. Learning Experiences in the Establishment of MPA Networks

This section shares the Philippine experience in the establishment of MPA networks. As an archipelago, the size of the coastal and marine environment of the Philippines is seven times that of its land area. Sixty per cent of the population of about 110 million people live in the coastal areas and depend on the marine environment for food and livelihood. The constant exposure of the coastal and marine environment to various forms of anthropogenic pressures,such as overexploitation, use of various destructive harvest implements, and pollution has rapidly degraded conditions of marine ecosystems, such as coral reefs, mangroves, and seagrass beds, and resulted in the decline of fisheries productivity.

Marine scientists at Silliman University established the first recorded MPA in the Philippines in 1982. In 1998, the Fisheries Code of the Philippines specified 15 per cent of municipal waters (within 15 kilometres from coastline) to be designated as fish sanctuaries (no-take portion of MPAs) by the local governments. The number of MPAs mushroomed across the country. In 2021, around 1,600 MPAs exist in the country with 80 per cent of the MPAs smaller than 50 hectares, according to the Department of Environment and Natural Resources-Biodiversity Management Bureau (DENR-BMB) in its 2021 report. Small MPAs are likely not fully achieving conservation objectives. Efforts to improve this situation included the networking of adjacent MPAs within a bay or a gulf.

Establishing MPA networks is a long tedious process and, once done,the process of strengthening begins. Currently, a total of 61 MPA networks are in the registry of the DENR-BMB of the Philippines. Of these, 13 MPA networks are in the advanced stages of strengthening their network. The 48 other MPA networks are in various stages of establishment.

The DENR-BMB implemented the project *Strengthening marine protected areas to conserve marine key biodiversity areas in the Philippines (SMARTSeas)*, which was funded by the Global Environment Facility-United Nations Development Programme (GEF-UNDP). This initiative produced a *Marine Protected Area Network Planning Toolkit* that documented the experience of the Philippines in establishing and strengthening MPA Networks. The establishment and strengthening of MPA networks is a continuing process. While this toolkit is limited to the experience of previous MPA networks, it is sufficient to start the process of MPA establishment.

Moreover, the toolkit discusses ecological guidelines, integration of human dimensions in the planning of MPA networks, enabling conditions, and the process of establishment. Briefly, the process of MPA establishment includes conceptualisation, legitimisation, and initial activities. The MPA network is deemed established after a legal instrument (e.g., Memorandum of Agreement, Declaration, Piece of Legislation) is signed, enacted, notarised, or ratified or gazetted. Once established, the MPA network must function by enforcing rules, sharing information, conducting annual fora to share and gain experience with others, and holding regular strategic planning sessions to implement the MPA network management plan, among others. All these functions need funds. The toolkit has a section on financing MPA networks. Most networks survive from member dues but over the long term, other revenue-generating mechanisms can be included in the business and financial plans, such as payment for ecosystem services and profits from biodiversity friendly enterprises.


PHOTO: D. Simorangkir

VI. Recommendations

The most important recommendation of this paper is urgent action of the ASEAN to provide platforms for the AMS to discuss the establishment of MPA networks within national jurisdictions; discuss cooperation and establish partnerships to conserve marine biodiversity between and among the AMS; and finally conduct the preparatory work to deepen cooperation in the conservation of important areas between AMS with other countries (i.e., China, Australia, India, and Bangladesh at different areas, respectively). This can be patterned after the establishment processes of the CMAR, or Turtle Island Heritage Protected Area, the tri-national Marine Turtle Protected Area Network between Philippines, Indonesia, and Malaysia, and the Coral Triangle Initiative.

This paper suggests that a properly designed network of MPAs can increase resilience and hasten recovery of degraded marine habitat populations (e.g. coral reefs, seagrass beds and mangroves) and improve the persistence of coastal and marine habitat populations. Further studies, however, are needed to improve the designs of MPA networks, including the conduct of various validation studies to quantify ecological connectivity among sources and sink habitats within jurisdictions between and among the AMS and other countries.

Strengthening the monitoring and evaluation systems in the ASEAN, including the tracking of the progress of management interventions, should be prioritised. Currently, conditions of various marine ecosystems are obtained using different methodologies that do not allow for comparison. This can be addressed by developing a set of standard methodologies to assess the condition of various marine ecosystems (coral reefs, seagrass beds, and mangroves). This is important to assess the effectiveness of the management strategy and provide opportunities for concerned agencies and organisations to fine-tune conservation efforts for a more climate-responsive and sustainable future.

VII. References

Alexander, L.M. (1982). Marine regionalism in the Southeast Asian Seas. *East-West Environment and Policy Institute, Research Report No.11*. Honolulu, Hawaii. 85p.

American Geophysical Union (2020). Warming, acidic oceans may nearly eliminate coral reef habitats by 2100. *ScienceDaily*, 18 February 2020. www.sciencedaily.com/releases/2020/02/200218124358.htm

ASEAN Center for Biodiversity (2017). *ASEAN Biodiversity Outlook 2*. Philippines 220p.

ASEAN Centre for Biodiversity. (2020, July 10). Statement for International Day for the Conservation of the Mangrove Ecosystem. https://www.aseanbiodiversity.org/2020/07/26/statement-for-international-day-for-the-conservation-of-the-mangrove-ecosystem-26-july-2020/

Asian Development Bank (2014). *State of the coral triangle: Indonesia*. ADB. Mandaluyong City, Philippines. 69p.

Bak, R.P.M., Nieuwland, G., and Meesters, E.H. (2005). Coral reef crisis in deep and shallow reefs: 30 years of constancy and change in reefs of Curacao and Bonaire. *Coral Reefs 24*, 475–479.

Batini, N. and R. Werner (2021). Conserving the Oceans. Chapter 9 in N. Batini (ed.). *The Economics of Sustainable Food: Smart Policies for Health and the Planet*. Island Press, 320p.

Bellwood, D.R., Hughes, T.P., Folke, C. and Nystrom, M. (2004). Confronting coral reef crisis. *Nature 429*: 827-833.

BIMP-EAGA (Brunei-Darussalam, Indonesia, Malaysia, Philippines-East Asia Growth Area) (2022). *A sanctuary for green turtles in southeast Asia*. https://bimp-eaga.asia/article/sanctuary-green-sea-turtles-southeast-asia

Burke, L., Selig, E., and Spalding, M. (2002). *Reefs at Risk in Southeast Asia*. World Research Institute, Washington D.C., 72p.

Burke, L., Reytar, K., Spalding, M., and Perry, A. (2011). *Reefs at Risk Revisited*. World Research Institute, Washington D.C., 112p.

Carr, M.H., Robinson, S.H., Wahle, C., Davis, G., Kroll, S., Murray, S., Schumacker, E.J., and Williams, M. (2017). The central importance of ecological spatial connectivity to effective coastal marine protected areas and to meeting the challenges of climate change in the marine environment. *Aquat. Conserv: Mar. Freshw. Ecosyst.* 27(S1): 6-29 https://doi.org/10.1002/aqc.2800

Chelliah, A.J., Chen, S.Y., Amri, A.Y., Adzis, K.A.A., and Hyde, J. (2015). Status of reefs in selected Southeast Asia countries. *Platax, 12*, 1-11.

Chou, L. M. (2000). Southeast Asian Reefs-Status Update: Cambodia, Indonesia, Malaysia, Philippines, Singapore, Thailand and Vietnam. In. *Status of the Coral Reefs of the World 2000*. Pp. 117–129.

Christie, M.R., Tissot, B.N., Albins, M.A., Beets, J.P., Jia, Y., Ortiz, D.M., Thompson, S.E., and Hixon, M. (2010). Larval connectivity in an effective network of marine protected areas. *Plos One* https://doi.org/10.1371/journal.pone.0015715

De Leon, S. and Derrick, B. (2020). Thailand: updated catch reconstruction for 2011– 2018, p. 320–328. In: Derrick, B., Khalfallah, M., Relano, V., Zeller, D., and Pauly, D. (eds). Updating to 2018 the 1950-2010 Marine Catch Reconstructions of the Sea Around Us. Part II: The Americas and Asia-Pacific. *Fisheries Centre Research Report 28(6)*. www.seaaroundus.org.

Department of Environment and Natural Resources-Biodiversity Management Bureau (DENR-BMB) (2021). Strengthening marine protected areas to conserve marine key biodiversity areas in the Philippines (DENR-SMARTSeas). UNDP-GEF Funded Project. Final Report 152p.

Derrick, B., Abucay, L., Conejar-Espedido, J., Coulter, A., Glenn Jansalin, J., Parducho, V., Polido, R., Relano, V., Tsui, G., White, R., and Pauly, D. (2020). Countries of Southeast Asia: Updating Catch reconstructions to 2018, p. 383–408. In: Derrick, B., Khalfallah, M., Relano, V., Zeller, D., and Pauly, D. (eds). Updating to 2018 the 1950–2010 Marine Catch Reconstructions of the Sea Around Us. Part II: The Americas and Asia-Pacific. *Fisheries Centre Research Report 28*(6). www.seaaroundus.org.

Duarte, C.M., Agusti, S., Barbier, E., Britten, G.L., Castilla, J.C. et al. (2020). Rebuilding marine life. *Nature, 580*, 39–51. Doi.org/10.1038/s41586-020-2146-7

Dung, L.D. (2020). The status of coral reefs in central Vietnam's coastal water under climate change. *Aquatic Ecosystem Health and Management*. 23(3): 323-331.

Enright, S.R., Meneses-Orellana, R., and Keith, I. (2021). The eastern tropical Pacific marine corridor: the emergence of a voluntary regional cooperation mechanism for the conservation and sustainable use marine biodiversity within a fragmented of regional ocean governance landscape. *Front. Mar. Sci.* https://doi.org/10.3389/fmars.2021.674825

Fadli, N., Muchlisin, Z.A., Affan, M., El Rahimi, and Sayyid, A. (2014). Status of coral reefs in Aceh Besar district, Aceh Province, Indonesia. *AACL-Bioflux*. 7 (5): 365-371.

FAO (2015). *Global Forest Resources Assessment 2015: Desk reference*. Food and Agriculture Organization, Rome, 64p.

Flanders Marine Institute (2019). *Maritime Boundaries Geodatabase: Maritime Boundaries and Exclusive Economic Zones (200NM), version 11.* www.marineregions.org

Fortes, M.D. (2010). The seagrass-mangrove connection as a climate change mitigation and adaptation factor in East Asian Coasts. Paper presented at the International Symposium on Integrated Coastal Management for Marine Biodiversity in Asia, Kyoto, 14–15.

Fortes, M.D., Ooi, J.L.S., Tan, Y.M., Prathep, A., Bujang, J.S., and Yaakub, S.M. (2018). Seagrass in Southeast Asia: a review of status and knowledge gaps, and a road map for conservation. *Botanica Marina, 61* (3), 269–288. Doi: 10.1515/bot-2018-0008

Gevaña, D.T., Camacho, L.D., and Pulhin, J.M. (2018). Conserving mangroves for their blue carbon: Insights and prospects for community-based mangrove management in Southeast Asia. In C. Makowski and C.W. Finkl (eds.). Threats to Mangrove Forests. *Coastal Research Library 25.* Pp. 579–588.

Giri, C., Ochieng, E., Tieszen, L.L., Zhu, Z., Singh, A., Loveland, T., Masek, J., and Duke, N. (2011). Status and distribution of mangrove forests of the world using earth observation satellite data (version 1.4, updated by UNEP-WCMC). *Global Ecology and Biogeography, 20,* 154–159.

Hilomen, V. & Peñaflor, E. (2023). Building the case for large marine conservation areas, an urgent call in the ASEAN region. ASEAN Center for Biodiversity.

Howard, R., Zau Lunn, Antt Maung, Salai Mon Nyi Nyi Len, Soe Thiha and Soe Tint Aung. (2014). Assessment of the Myeik Archipelago Coral Reef Ecosystem, Reef Check Surveys, January 2013 to May 2014. Report No. 5 of the Tanintharyi Conservation Programme, a joint initiative of Fauna & Flora International (FFI) and the Myanmar Forest Department. FFI, Yangon

Hughes, A.C. (2017). Understanding the drivers of Southeast Asian biodiversity loss. *Ecosphere, 8*(1), e01624. 10. 1002/ecs2.1624

IUCN-World Commission on Protected Areas (IUCN-WCPA). (2008). *Establishing marine protected area networks - making it happen*. Washington DC. IUCN-WCPA, National Oceanic and Atmospheric Administration and The Nature Conservancy. 118 p.

Jones, G.P., Almany, G.R., Russ, G.R., Sale, P.F., Steneck, R.S., van Oppen, M.J.H., and Willis, B.T. (2009). Larval retention and connectivity among populations of corals and reef fishes: history, advances, challenges. *Coral Reefs 28:* 307–325.

Kimura T., Tun, K., and Chou, L.M. (2014). *Status of coral reefs in the East Asian Seas Region: 2014.* Global Coral Reef Monitoring Network. Ministry of Environment, Japan, 236 p.

Kirkman, H. and Kirkman, J.A. (2002). The management of seagrasses in Southeast Asia. *Bulletin of Marine Science. 71*(3), 1379–1390.

Laverick, J.H., Piango, S., Andradi-Brown, D.A., Exton, D.A., Bongaerts, P., Bridge, T.C.L., Lesser, M.P., Pyle, R.L., Slattery, M., Wagner, D., and Rogers, A.D. (2018). To what extent do mesophotic coral ecosystems and shallow reefs share species of conservation interest? A systematic review. *Environ. Evid. 7* (15). https://doi.org/10.1186/s13750-018-0127-1

Licuanan, W.R.Y., Robles, R., and Reyes, M. (2019). Status and trends of coral reefs in the Philippines. *Mar. Poll. Bull. 142*: 544–550.

Long, N.V. and Tuan, V.S. (2013). Degradation trends of coral reefs in the coastal waters of Vietnam. *Galaxea (Special Issue)*: p. 79–83.

McClanahan, T.R., Graham, N.A.J., Calnan, J.M., and McNeil, M.A. (2007). Toward pristine biomass: reef fish recovery in coral reef marine protected areas in Kenya. *Ecol. Appl. 17*(4): 1055–1067.

Montgomery, J.C., Tolimiere, N., and Haine, O.S. (2001). *Active habitat selection by pre-settlement of reef fishes*. https://doi.org/10.1046/j.1467-2960.2001.00053.x

O'Leary B.C., Winther-Janson, M., Bainbridge, J.M., Aitken, J., Hawkins, J.P., and Roberts, C.M. (2016). Effective coverage targets of ocean protection. *Conserv. Lett*. Doi: https://doi.org/10.1111/conl.12247

Ohman, M.C., Munday, P.L., Jones, G.P., and Caley, M.J. (1998). Settlement strategies and distribution patterns of coral reef species. *J. Exp. Mar. Bio. 225*(2): 219–238.

Pendleton, L., Evans, K., and Visbeck, M. (2020). Opinion: We need global movement to transform ocean science for a better world. *PNAS, 117* (18), 9652–9655. Doi: 10.1073/pnas.2005485117

Phongsuan N., Changkong, A., Yamarunpatthana, C., Chansang, H., Broonpakob, R., Petchkumnerd, P., Thongtham, N., Paokantha, S., Chanmethakul, T., Panchaiyapoom, P., and Bundit, O.A. (2013). Status and changing patterns of coral reefs in Thailand during the past two decades. *Deep-Sea Research II*. 96: 19–24.

Polido, R., Chu, E., and Derrick, B. (2020). Indonesia (Central, Eastern and Indian Ocean): updated catch reconstruction to 2018, p. 314–319. In: Derrick, B., Khalfallah, M., Relano, V., Zeller, D., and Pauly, D. (eds). Updating to 2018 the 1950–2010 Marine Catch Reconstructions of the Sea Around Us. Part II: The Americas and Asia-Pacific. *Fisheries Centre Research Report 28*(6). www.seaaroundus.org.

Praveena, S.M., Siraj, S.S., and Aris, A.Z. (2012). Coral reef studies and threats in Malaysia: a mini review. *Rev. Env. Sci. Biotech. 11*: 27-39.

Pyle, R.L. and Copus, J.M. (2019). Mesophotic Coral Ecosystems: Introduction and Overview. In: Loya, Y., Puglise, K., Bridge, T. (eds) Mesophotic Coral Ecosystems. *Coral Reefs of the World, vol 12*. Springer, Cham. https://doi.org/10.1007/978-3-319-92735-0_1

Reef Check Malaysia (2020). *Status of coral reefs in Malaysia.* 2020. 128p. https://www.globalgiving.org/pfil/37985/2020_Annual_Survey_Report.pdf

Richards, D.R. and Friess, D.A. (2016). Rates and drivers of mangrove deforestation in Southeast Asia, 2000–2012. *PNAS, 113* (2), 344–349. Doi.org/10.1073/pnas.1510272113

Sala E., Mayorga, J., Bradley, D., Cabral, R.B., Atwood, T.B., Auber, A., Cheung, W., Costello, C., Ferretti, F., Friedlander, A.M. et al. (2021). Protecting the global ocean for biodiversity, food and climate. *Nature, 592*, 397–402.

Selig, E.R. and Bruno, J.F. (2010). A global analysis of the effectiveness of marine protected areas in preventing coral loss. *PLoS ONE* https://doi.org/10.1371/journal.pone.0009278

Shanks, A.L. (2009). Pelagic larval durations and dispersal distances revisited. *The Bio. Bull. 216* (3): 373-385.

Stobart, B., Warwick, R., Gonzalez, C., Malol, S., Diaz, D., Reñones, O., and Goñi, R. (2009). Long-term and spillover effects of a marine protected area on an exploited fish community. *MEPS 384*: 47–60.

Sudo K., Quiros, T.E.A.L., Prathep, A., Luong, C.V., Lin, H.J., Bujang, J.S., Ooi, J.L.S., Fortes, M.D., Zakaria, M.H., Yaakub, S.M., Tan, Y.M., Huang, X., and Nakaoka, M. (2021). Distribution, temporal change, and conservation status of tropical seagrass beds in Southeast Asia: 2000–2020. *Front. Mar. Sci. 8*, 637722. Doi: 10.3389/fmars.2021.637722

Tanaka, Y. (2016). *Coral diversity and coral environment in Brunei Darussalam*. https://doi.org/10.46537/scibru.v15i0.28

Taylor, S. (2020). Biorock Indonesia. Status of coral reefs in Indonesia 2019. http://www.biorock-indonesia.com/the-status-of-coral-reefs-in-indonesia-2019/

The National Bureau of Asian Research. (n.d.). Philippines Country Profile from the Maritime Awareness Project. Retrieved January 23, 2023, from https://www.nbr.org/publication/philippines/?fbclid=IwAR0T8J6Reob21NBePSDM7SzMFwke3FWBRjYFFdd5Jmb1h9-4ieZWZxwZG6A

Tuan, V.S., Yet, N.H., and Long, N.V. (2009). National Report: Coral reefs in the coastal waters of the South China Sea-Vietnam. In. Reversing Environmental Degradation Trends in the South China Sea and the Gulf of Thailand. UNEP/GEF South China Sea Project p. 92-118.

Tun, K. and Heiss, G. (2005). *Status of coral reefs in Myanmar: post tsunami assessment.* https://www.researchgate.net/profile/Georg-Heiss/publication/230759957_Status_of_coral_reefs_in_Myanmar_post-tsunami_assessment/links/09e41503fb22222e6c000000/Status-of-coral-reefs-in-Myanmar-post-tsunami-assessment.pdf

Tun, K., Chou, L.M., Cabanban, A., Tuan, V.S., PhilReefs, Yeemin, T., Suharsono, Sour, K., and Lane, D. (2004). Status of coral reefs, coral reef monitoring and management in Southeast Asia. In *Status of coral reefs of the world 2004*. 275p.

Tupper, M. (2007). Spillover of commercially valuable reef fish species from Marine Protected Areas in Guam, Micronesia. *Fish. Bull. 105*: 527–537.

UNEP-WCMC and Short, F.T. (2018). Global distribution of seagrasses (version 6.0). Sixth Update to the Data Layer used in Green and Short (2003). Cambridge: UN Environment World Conservation Monitoring Centre.

UNEP-WCMC, WorldFish Centre, WRI, TNC. (2021). Global distribution of coral reefs, compiled from multiple sources including the Millennium Coral Reef Mapping Project. Version 4.1, updated by UNEP-WCMC. Includes contributions from ImaRS-USF and IRD (2005), ImaRS-USF (2005) and Spalding et al. (2001). Cambridge (UK): UN Environment Programme World Conservation Monitoring Centre. Data doi: https://doi.org/10.34892/t2wk-5t34

UP-MSI, ABC, ARCBC, DENR, and ASEAN (2002). Marine Protected Areas in Southeast Asia. ASEAN Regional Centre for Biodiversity Conservation, Department of Environment and Natural Resources, Los Baños, Philippines. 142p., 10 maps.

Woodley, S., Locke, H., Laffoley, D., MacKinnon, K., Sandwith, T., and Smart, J. (2019). A review of evidence for area-based conservation targets for the post-2020 global biodiversity framework. *PARKS, 25*, 31–46.

WWF (2020). *Living Planet Report 2020: Bending the curve of biodiversity loss*. Almond, R.E.A., Grooten, M., and Petersen, T. (eds.). WWF, Gland, Switzerland.

Yang, Shufen, Rachel L. F. Lim, Sheue Chiou-Rong, and Jean W.H. Yong (2011). Nature Conservation for a Sustainable Singapore. *Proceedings of Nature Society Singapore Conference* (pp. 99–120).

ASEAN Centre for Biodiversity
D.M. Lantican Avenue
University of the Philippines Los Baños
Laguna 4031, Philippines
Tel. Nos. +6349 536-2865; +632 584-4210
contact.us@aseanbiodiversity.org

www.aseanbiodiversity.org