

Chapter 6: CONTINENTAL SOUTHEAST ASIA

Franco Leung¹, David Blair¹, Rebecca Chalmers², Ellen Hines³, Len McKenzie⁵, Vibol Ouk², Louisa Ponnampalam⁶, Tint Tun⁷, Long Vu⁴, Helene Marsh¹

¹ College of Science and Engineering, James Cook University, Townsville, Queensland, Australia.

² Department of Fisheries Conservation, Ministry of Agriculture, Forestry and Fisheries, Kingdom of Cambodia.

³ Estuary & Ocean Science Center, School of the Environment San Francisco State University, CA, United States of America.

⁴ Center for Biodiversity Conservation and Endangered Species (CBES), District 2, Ho Chi Minh City, Vietnam.

⁵ Centre for Tropical Water and Aquatic Research TropWATER, Cairns, Queensland, Australia.

⁶ Research Associate, IBEC, Universiti Malaysia Sarawak, Kota Samarahan, Sarawak, Malaysia.

⁷ Freelance Marine Biologist, Marine Conservationist, Regional Co-chair (Indian Ocean Region), SSG, SSC, IUCN. Member, Society for Marine Mammalogy.

Correspondence to: Helene Marsh helene.marsh@jcu.edu.au.

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Regional Findings

Continental Southeast Asia: Cambodia, Malaysia (Peninsular Malaysia only), Myanmar
Singapore, Thailand, and Vietnam

- Dugongs face significant challenges in this region, primarily from incidental bycatch, habitat loss and degradation. The underlying causes of these threats vary across Range States, but their root causes are inadequate law enforcement, coastal development, and poverty.
- The status of dugongs in the Region remains data deficient, despite the efforts by many researchers and NGOs.
- The following globally-important Important Marine Mammal Areas with the dugong as a qualifying species have been recognised or are in the process of being evaluated: (1) the 'Mersing Archipelago' IMMA, off the eastern coast of Johor in Peninsular Malaysia; (2) the transboundary 'Kien Giang and Kep Archipelago' IMMA, which spans the Kep Province in Cambodia and the Kien Giang Province in Vietnam; (3) the 'Côn Đảo' IMMA in Vietnam; (4) 'Trang' in Thailand (under evaluation).
- The Andaman coast of Thailand and the east coast of Johor in Peninsular Malaysia are the only locations with confirmed populations ranging from tens to hundreds of dugongs. Effective protection of these populations is particularly important.
- Throughout most of the region, dugongs persist in fragmented, relatively small populations in recognized locations of local importance. Thus, it may be more efficient and effective to consider dugong conservation in these locations in the context of the conservation of marine megafauna more generically than to develop specific dugong management plans.
- Increased attention to transboundary management and the conservation of seagrass meadows known to support dugongs would be highly desirable.
- The largest knowledge gaps are: (1) the inadequate mapping of seagrass in most areas, particularly Myanmar; (2) the lack of quantitative data about most of the dugong populations; (3) the lack of understanding of the contemporary transboundary movements of dugongs; (4) the limited understanding of the genetic structure of the dugong populations outside Thailand; (5) a spatial understanding of the threats posed by fisheries; and (6) the human dimensions of dugong interactions with fisheries and coastal development.

6.1 Regional Setting

6.1.1 Geographic overview

This chapter considers the status of the dugong along the ~ 11,304 km coast of Continental Southeast Asia from the coastal border of Bangladesh and Myanmar (20.71° N, 92.37° E) to the coastal border of Vietnam and China (21.53° N, 108.06° E), as well as the associated offshore islands. From west to east, the region comprises the coastal waters of Myanmar, Thailand, Peninsular Malaysia, Singapore, Cambodia, and Vietnam (Figures 6.1, 6.3).

Continental Southeast Asia is part of the Tropical Indo-Pacific seagrass bioregion (Short et al. 2007). The estimated minimum area of seagrass for each Range State (Figure 6.2), that can be confirmed with moderate to high confidence is as follows (ordered west to east, consistent with this chapter): Myanmar 5 km² (Beffasti 2008; Novak et al. 2009; Soe-Htun et al. 2015), Thailand 210 km² (Gulf coast 122 km², Andaman coast 88 km²) (Department of Marine and Coastal Resources [DMCR] 2024; McKenzie et al 2023; Sudo et al 2021; Supanwanid 2001; UNEP-WCMC and Short 2021), Peninsular Malaysia 39 km² (Heng et al. 2019; Ho et al. 2018; Hossain et al. 2015; McKenzie and Yoshida 2006; Ooi et al. 2011; Sani and Hashim 2019; Sudo et al. 2021), Singapore 1 km² (Yaakub et al. 2013; McKenzie unpublished data), Cambodia 230 km² (Hines et al. 2008; Leng et al. 2014; Leng et al. 2015; Mangroves for the Future 2013a; Sudo et al. 2021; Supkong and Bourne 2014), and Vietnam 156 km² (Nguyen et al. 2022). All areas are rounded to nearest km², standard errors are not available. Many of these estimates, particularly for Myanmar, are likely to be underestimates and do not take account of the status of the seagrass.

Dugongs in Continental Southeast Asia are scattered throughout the region's shallow coastal and island waters. The westernmost sighting of a dugong in the region was recorded at Man Aung Island (18.79° N, 93.64° E) along the Rakhine coast of Myanmar (Ilangakoon and Tun 2007; Tun and Ilangakoon 2007; Figure 6.1). On the eastern coast, the most northerly sightings were from the waters near the Hà Cối River (21.23° N, 107.56° E) in the Gulf of Tonkin, Vietnam (UNEP/CMS 2011).

Dugong abundance in this region appears to be generally low, except for the population in Trang Province on the southern Andaman coast of Thailand (Hines et al. 2005; DMCR 2011, 2018, Figure 6.1). Most records are based on direct sightings, historical accounts from interviews, bycatch records, strandings, and dugong feeding trails (Panyawai and Prathep 2022, Supplementary Material). Recorded numbers are likely lower than the actual population size due to the few comprehensive surveys with corrections for detection bias, outside the regionally important locations of Koh Libong and Koh Muk in southern Thailand.

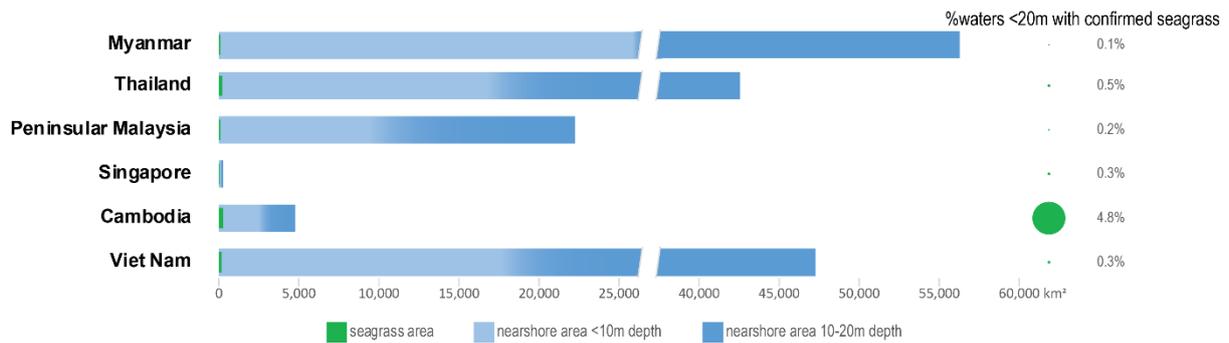


Figure 6.2. Histogram showing the known areas of seagrass and coastal waters < 10m and < 20 m deep for each dugong Range State in the Continental Southeast Asia region. The areas of seagrass are almost certainly underestimates. Figure created by Len McKenzie; reproduced with permission.

6.1.2 Geo-political and socio-economic overview

This information is provided as an indication of the challenge for each of the Range States in the region to consider the conservation of dugongs and their habitats in the context of their socioeconomic development needs. The region is populated by ~ 280 million people, increasing at an average of 0.7% p.a. (United Nations 2022). The Human Development Index (HDI) classifies Myanmar, Cambodia, and Vietnam as developing countries; Thailand, Malaysia, and Singapore as developed countries (World Population Review 2023). Further details are below.

Myanmar (Figure 6.1) has a coastline of 2,832 km in the Andaman Sea and borders Bangladesh in the north and Thailand in the south. Myanmar has a medium HDI of 0.585 (ranked 149) and a gross domestic product (GDP) of USD \$62.26 billion (The World Bank 2022). Approximately 52 million people live in Myanmar (United Nations Development Programme [UNDP] 2022). In recent years, Myanmar has been wracked by civil war (Braun et al. 2023).

Thailand (Figure 6.1) has two disjunct coastlines: (1) 750 km in the Andaman Sea bordering Myanmar in the north and Peninsular Malaysia in the south and (2) 1,670 km in the Gulf of Thailand, bordering Peninsular Malaysia in the south and Cambodia in the north. Thailand has a HDI of 0.800 (ranked 66) and a GDP of USD \$495.42 billion (The World Bank 2022); and a population of ~ 72 million people (UNDP 2022).

Malaysia comprises Peninsular Malaysia, which is considered in this chapter, and East Malaysia located in the island of Borneo (see Chapter 7). The 1,972 km coastline of Peninsula Malaysia (Figure 6.1) directly abuts Thailand in the north and Singapore in the south. Malaysia has a Very High HDI of 0.803 (ranked 62) and a GDP of USD \$407.03 billion (The World Bank 2022). Around 33 million people live in Malaysia (Peninsular and Continental; UNDP 2022).

The 64 islands of **Singapore** border Peninsular Malaysia to the north and Indonesia to the south (Figure 6.3). Singapore’s coastline is approximately 193 km. The island nation has a Very High HDI of 0.939 (ranked 12) and a GDP of USD \$466.79 billion (The World Bank 2022). Approximately 6 million people live in Singapore (UNDP 2022).

The 443 km coastline of **Cambodia** adjoins Thailand in the west and Vietnam to the east (Figure 6.1, inset). Cambodia has a Medium HDI of 0.593 (ranked 146), a GDP of USD \$29.5 billion, and a population of ~ 16 million people (UNDP 2022).

The 3,444 km coastline of **Vietnam** connects with Cambodia in the southwest and China in the northeast (Figure 6.1). Vietnam has a High HDI of 0.703 (ranked 115), a GDP of USD \$408.8 billion (The World Bank 2022) and a population of ~ 97 million people (UNDP 2022).

Table 6.1. Human Development Index (HDI) status rank and Gross Domestic Product (GDP) rank per capita rank of the Dugong Range States in Continental Southeast Asia. Consistent with the remainder of this chapter, the countries in this table are ordered west to east starting with Myanmar. The ranks are ordered so that countries with the highest HDI or GDP have the lowest ranks. 189 countries were ranked for both indices.

Range State	HDI	HDI Rank 2023 ¹	GDP per capita rank 2023 ²
Myanmar	Medium	149	146
Thailand	Very High	66	73
Malaysia (whole country)	Very High	62	54
Singapore	Very High	12	3
Cambodia	Medium	146	142
Vietnam	High	115	104

¹ 2023 HDI data from <https://hdr.undp.org/data-center/country-insights#/ranks> (downloaded from the internet January 2024);

² 2023 per capita GDP from [https://en.wikipedia.org/wiki/List_of_countries_by_GDP_\(PPP\)_per_capita](https://en.wikipedia.org/wiki/List_of_countries_by_GDP_(PPP)_per_capita) (downloaded from the internet January 2024)

6.1.3 Genetics of dugong subpopulations

For an overview of techniques, relevant genetic studies and general findings, refer to Chapter 1.

Specific genetic studies are available only for dugong populations in Thailand (Palmer 2004; Bushell 2013; Poommouang et al. 2021, 2022). The Andaman Sea coast of Thailand supports a relatively large number of dugongs, whereas the Gulf of Thailand has only a very small population. These two areas are separated by the Isthmus of Kra and Peninsular Malaysia. The shortest distance by sea between Trang on the Thai Andaman coast and Pattani on the Thai Gulf coast is about 1,900 km.

Marine organisms moving between the Gulf of Thailand and the Thai Andaman coast need to transit through the waters of Singapore. The only genetic data available for Singapore dugongs is a single mitochondrial sequence (MH704285) reported by Plön et al. (2019) and derived from material dated 1887 stored in the Bremen Überseemuseum. This sequence belongs to the Western Indian Ocean haplogroup (unknown in Thailand).

Mitochondrial sequence data (410 bp or longer) from Thailand has been reported and made publicly available by Bushell (2013) and Poommouang et al. (2021). Bushell and Poommouang et al. (2022) also analysed microsatellite data and reached slightly differing conclusions. With one exception, all mitochondrial haplotypes from Thailand fall into the northeastern haplogroup or the Andaman haplogroup (Figure 1.x). Dugongs in the northeastern haplogroup occur along both coasts of Thailand, as well as broadly from Thailand eastwards to Japan and Palau, and south to Indonesia and Ashmore Reef (on the continental shelf of north-west Australia). The Andaman haplogroup is known only from the Andaman Sea coast of Thailand. One sequence reported by Bushell from the Andaman Sea coast belongs to the Eastern Indian Ocean haplogroup (Chapter 5).

It is possible that the Andaman haplogroup emerged as a distinct cluster due to relative isolation in the Andaman Sea when sea-levels were low (see Voris 2000 for maps of the region at, and following, the glacial maximum). If so, it is surprising that this haplogroup did not disperse further in post-glacial times, given the distribution of the northeastern haplogroup. The latter haplogroup could have originated east of the Sunda Shelf but is now widespread around the Sunda region and into the western Pacific. This suggests that the Sunda Barrier (e.g., Crandall et al. 2019) has not greatly affected the distribution of dugongs.

Bushell (2013) noted that comparisons of mitochondrial haplotype and microsatellite data suggested some migration between the Andaman coast and the Gulf of Thailand. The mitochondrial data suggested strong pairwise differentiation among three regions (North Andaman, South Andaman, and Gulf of Thailand) but this was less marked for microsatellite data, suggestive of male-biased movement and female philopatry. Poommouang et al. (2022), primarily based on microsatellite data, considered that the populations in the Gulf of Thailand and the Andaman coast were genetically completely distinct.

Bushell (2013) found no strong evidence of a genetic bottleneck, inbreeding, or of recent population decline (except possibly in the Gulf of Thailand). Poommouang et al. (2021) reported little evidence of inbreeding and good genetic diversity among 118 Thai dugongs, based on inter-simple sequence repeats (nuclear markers) and mitochondrial sequences. They did note that samples collected in the last decade of the 20th Century collectively exhibited more variation than those collected

subsequently. This is suggestive of population decline. However, a follow-up study using nuclear microsatellite loci from 77 dugongs (Poommouang et al. 2022) indicated some inbreeding in Thai coastal waters.

- Thai dugongs either side of the Isthmus of Kra mainly belong to the northeastern mitochondrial haplogroup. A large minority of those on the Andaman Sea coast belong to a separate group, here termed the Andaman haplogroup, found nowhere else.
- There remains uncertainty about the extent to which Thai dugongs are genetically separated by the Isthmus of Kra.
- There is some evidence of inbreeding in Thai dugongs.

6.2 Distribution, abundance and trends in Range States

6.2.1 Myanmar

The first recorded dugong sighting in Myanmar's waters was reported by the Reverend S. Benjamin in 1853 (Mason and Theobald 1882).

'I have discussed the question as to what animal, the Sanscrit term 'jala hasti', or water elephant, was really applicable, as some scholars have supposed that it may have applied to the now extinct Hippopotamus of the Nurbudda. The conclusion, however, to which I have come is, that the 'jala hasti' really applied to the Dugong.'

The Myanmar coastline can be divided into four regions (ordered north to south): the Rakhine, the Ayeyarwady Delta, the Mawlamyine wetlands, and Tanintharyi, which includes the Myeik Archipelago (Figure 6.1). Many reports of dugongs in Myanmar come from the Rakhine region based on group discussions and individual interviews with residents of coastal villages, fisheries authorities and fishers from 2005-2007 (Tun and Ilangkoon 2006; Ilangkoon and Tun 2007).

Along the Rakhine coast, interviewees demonstrated knowledge of dugongs and their seagrass habitats, with frequent sightings of small groups of dugongs including cow-calf pairs. Man Aung island was well-known for dugongs, which were frequently sighted during the rainy season (Tun et al. 2010; Figure 6.1). Local fishers around Gwa also reported dugong sightings during the fishing season from September to April but not during the non-fishing season from May to August. Other places where dugongs were reported include the waters of Hmawylene and Shwe ya gyaing and neighbouring villages (Ilangkoon and Tun 2007; Tun and Ilangkoon 2007).

At Long Gyo village on the Rakhine coast, respondents reported that dugongs often bumped their heads against the wooden rudder of anchored artisanal fishing craft destroying the rudder. Fishers using these artisanal craft carried long bamboo poles to push dugongs away from their boats and

used iron rudders, to avoid dugong interference. Fishers in Gwa reported that dugongs often followed sea cucumber divers between the surface and the ocean floor (Ilangakoon and Tun 2007). Hines (2012) reported the results of 34 interviews she conducted with fishers and sea gypsies in the Myeik Archipelago in the Tanintharyi Region in 2007. Interviewees saw only the occasional dugong. Researchers found little potential seagrass habitat. Nonetheless, Tun (2012) reported dugong feeding trails amidst dense *Halophila ovalis* patches along the eastern coasts Nyaung Wee Islands near Lampi Island.

Although anecdotal reports of dugong bycatch have been recorded (e.g., Tun and Ilangakoon 2007), dugong strandings and bycatch are considered underreported due to the absence of established mechanisms for such reporting, and a lack of awareness about the dugong's conservation status among both coastal communities and authorities in Myanmar.

Taken together, this information suggests that the area of seagrass in Myanmar (5 km² as reported by Beffasti 2008; Novak et al. 2009; Soe-Htun et al. 2015), is likely an underestimate, especially along the Rakhine coast.

- The knowledge of the distribution and abundance of dugongs and their seagrass habitats in Myanmar is inadequate and has resulted in a lack of awareness about the dugong among both coastal communities and authorities in Myanmar.

6.2.2 Thailand

Dugongs occur on both the Andaman Sea and Gulf of Thailand coasts (Figure 6.1). These two populations are separated by ~ 1,900 km and there are reported genetic differences between them (see Section 6.1.3).

Aerial surveys in 2017 indicated that there are fewer dugongs living in the Gulf of Thailand (estimated number ~ 30) than in the Andaman Sea (estimated number ~ 191) (DMCR 2018). These aerial survey results are counts that have not been corrected for detection biases and so these numbers must be compared with caution with estimates for which such biases have been corrected. Nonetheless, the qualitative difference between the number of dugongs in Gulf of Thailand and the Andaman Sea indicated by the surveys accords with records of 282 strandings from 1962 to February 2008; 71.6% were from the Andaman Sea and 25.8% were from the Gulf. The remaining 2.6% reported no information on the stranding location (Adulyanukosol et al. 2009).

Panyawai and Prathep (2022) conducted a systematic review of the literature on dugongs in Southeast Asia. They concluded that in the Andaman Sea, where dugong research has been conducted for several decades (see Table 6.3), dugongs are distributed along the coast of Krabi (at

Koh Sri Boya and Koh Pu), Phang-nga (at Phra Thong Island, Yao Island, and elsewhere in Phang-nga Bay), off Phuket Island (at Paklok and Chalong Bays), Ranong (Sai Dam), Satun (at Lidee and Sarai Islands) and Trang (at Chao Mai and Muk, Libong, and Sukorn Islands) (Adulyanukosol et al. 1997, 1999, 2004, Hines et al. 2005; Nakanishi et al. 2006; DMCR 2018).

The dugong population in Trang, an estimated ~ 154 individuals in 2017 (DMCR 2018), is likely one of the largest in Asia (Chapters 5, 6, 7) and is certainly the most comprehensively studied. An Important Marine Mammal Area of Interest (IMMA Aoi) with the dugong as the qualifying species is under evaluation for Trang (IUCN-MMPATF).

Dugongs have been much less studied in the Gulf of Thailand where aerial surveys have been conducted only in specific areas (e.g., Rayong, Chanthaburi, Trat, Surat Thani, and Nakhon Si Thammarat; Figure 6.1). Panyawai and Prathep (2022) report: (1) evidence of live and dead dugongs from provinces such as Chon Buri, Chumphon, and Patt; and (2) that aerial surveys between 2017 and 2019 recorded dugongs off the coast of Rayong (at Paknamprasae), Chonburi (at Sattahip Bay), Trat (at Mairood and Kood Island), Surat Thani (at Phumriang Bay and Samui Island), and Nakhon Si Thammarat (Tharai Island) (DMCR 2019a, b).

- The dugong population in the coastal waters of Trang on the Andaman coast of Thailand was an estimated ~ 154 individuals in 2017 and is likely one of the largest in Asia. It is also the most comprehensively studied.
- An Important Marine Mammal Area of Interest (IMMA Aoi) with the dugong as the qualifying species is under evaluation for Trang.
- There appear to be fewer dugongs living in Thai waters of the Gulf of Thailand than in the Andaman Sea.

6.2.3 Peninsular Malaysia

The dugong was believed to be nearly extinct in the waters of Peninsular Malaysia before the late 1990s (Marsh et al. 2002). This assumption was proved incorrect by the response to the 'Si Tenang' dugong calf incident in 1999 (Section 6.3.4). To the best of current knowledge, dugongs in Peninsular Malaysia occur only in the southern state of Johor. A helicopter survey along the east coast of Johor recorded 18 dugong sightings in Pulau Sibul, and nearby Besar Island and Rawa Island (Mansor et al. 2000; Marsh et al. 2002). Dugong feeding trails were recorded in a seagrass meadow dominated by *Halophila ovalis* at the mouth of Sungai Boh (Boh River), a small tributary of Sungai Pulai (Pulai River) in Johor Strait (Marsh et al. 2002; Zulkifli Poh 2009).

Off the east coast of Johor, Ponnampalam et al. (2015) recorded 93 sightings of dugongs during aerial surveys covering 2,986 km of the Mersing Islands of Sibul, Tinggi, Besar, Rawa and Seribuat

across eight days in July 2010. Twenty-four percent (n=22) were cow-calf pairs. The largest group was five individuals. The mean encounter rate was 7.04 dugongs hour⁻¹ (Ponnampalam et al. 2015). In 2014–2016, a series of distributional, line-transect surveys covering 23,790 km over 145 flying hours were conducted primarily over the Sibiu-Tinggi Archipelago (Ponnampalam 2017). The surveys yielded 642 sightings of dugongs, of which 24.5% were groups with calves. Group sizes ranged from single individuals to a maximum of 43 animals (mean 1.9 ± 3.6) (Ponnampalam 2017). Most dugongs observed by Ponnampalam (2017) were found in approximately the same areas off the west-southwest of Sibiu Tengah Island, as in the 2010 survey (Ponnampalam et al. 2015). Dugongs were also observed in Pulau Tinggi during the 2014–2016 aerial surveys, however only adult dugongs were sighted there (Ponnampalam 2017). Research conducted by Heng et al. (2022) in 2016–2017 further supported these findings, demonstrating that the main feeding grounds of dugongs in the east coast waters of Johor were concentrated in the mid-section of the subtidal seagrass meadow in Sibiu Archipelago, particularly off the west and southwest of Pulau Sibiu Tengah. Seagrass mapping indicated that the size of the meadow at the Sibiu Archipelago 12.9 km², making it the largest continuous seagrass meadow in Malaysia (Heng et al. 2022). Eight dugongs, one individual and three groups including a cow-calf pair were sighted during a drone survey covering the northwest and southwest of Pulau Sibiu, and the south of Pulau Sibiu Tengah in 2017 (Ahmad et al. 2019).

The Sibiu-Tinggi Archipelago off the east coast of Johor, and in particular the Sibiu cluster of islands is the most significant habitat for dugongs in Peninsular Malaysia (Figure 6.1). In 2019, the area was designated as the Mersing Archipelago IMMA, with dugongs the qualifying species (IUCN-MMPATF 2022c).

Both contemporary and historical dugong studies indicate that the eastern areas, particularly the Mersing Islands off the east coast of Johor, consistently harbor a higher concentration of dugongs compared to the western or southern Johor Straits.

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6.2.4 Singapore

The Johor Strait is a narrow water body (~ 1km wide at some locations) bound by the southern tip of Peninsular Malaysia to the north and Singapore to the south (Figure 6.3). It is crossed by two bridges: the Johor-Singapore Causeway and the Second Link. The Causeway does not allow water exchange, and thus effectively divides Johor Strait into two separate areas (Ng et al. 2015). The

Singapore Strait extends from the southern coast of the main island of Singapore to the Riau Islands in Indonesia and includes 43 islands. Thus, the dugongs in Johor Strait are shared by Malaysia and Singapore; those in the Singapore Strait are shared by Singapore and Indonesia (Figure 6.3).



Figure 6.3. Geographic context of Singapore showing the place names mentioned in the text. Figure created by Adella Edwards; reproduced with permission.

Singapore is the world's second largest container port as of 2019 (World Shipping Council 2019). Ng et al. (2022a, b) reviewed records of dugongs in this hyper-urbanised environment. They recovered 69 observations of live dugongs and carcasses between 1820 and 2021 and identified eastern Johor Strait as a dugong area of regional importance, especially during the northeast (December to early March) and southwest (June to September) monsoons. Ng et al. (2022a, b) also conducted field surveys and found dugong feeding trails along the anthropogenically-disturbed Johor Strait and western Singapore Strait where extensive shoreline modification has occurred (Section 6.4.4). This

region is the strongest global example demonstrating that dugongs will continue to use anthropogenically-modified environments.

- Dugongs persist in the hyper-urbanised environment of the waters of Singapore, despite the high level of anthropogenic disturbance.
- This region is the strongest global example demonstrating that dugongs will continue to use anthropogenically-modified environments.

6.2.5 Cambodia

Dugongs were reportedly abundant in Cambodian coastal waters (Figure 6.1 inset) until ~ 1975 (Nelson 1999). Nonetheless, no scientific data were collected until the early 1990s, presumably a result of the Cambodian Civil War and associated political upheavals.

Tana (1998) reported the accidental snaring of six dugongs in gill and trawl nets during 1995 in Kampot Bay, east of Ko Kong (Figure 6.1 inset). Dugongs were also reportedly found near Stoeng Hau in Kompong Som Bay.

In Koh Kong (near the Thai border), dugongs were historically believed to be most abundant near Prek Ksach where Nelson (1999) considered them locally extinct. In 2004, comprehensive surveys conducted by Hines et al. (2004, 2008), including aerial and boat assessments at multiple locations, failed to detect any dugongs or dugong feeding trails.

Even though Hines et al. (2004) failed to sight any dugongs or feeding trails during an aerial survey of the area in 2004, the following sources suggest that dugongs occur along the southeast coast of Cambodia, adjacent the Vietnamese border (Figure 6.1 inset). (1) interview surveys conducted by Beasley et al. (2001); (2) sightings by coastal residents in Kampot and Kep Provinces (Cambodian Marine Mammal Conservation Project [CMMCP] 2023); (3) Hines et al.'s (2004) interviews of residents in fishing villages in Kampot and Kep in 2002 and 2004; and (4) a by-caught dugong in Kampot Province in 2018 (Tubbs et al. 2019).

Since 2017, the Cambodian Marine Mammal Conservation Project (CMMCP) has interviewed fishers across five communities in Kep province, Bokor City and the Chaornghuon fishing community in Kampot. The comprehensive data collected through these interviews, citizen science calendars, land surveys, and boat surveys recorded dugong sightings in the Kep Archipelago and along the seagrass meadows and reefs of Kampot in eastern Cambodia (Figure 6.1 inset). A confirmed dugong sighting was made in Kep in June 2022, and in Kampot in January 2023. In June 2023, the CMMCP project staff received information about the sale of dugong meat (suspected trawler bycatch) at Kep market (CMMCP 2023). In 2022, CMMCP staff received reports of three dugongs being killed: one was a

juvenile stranded in Koh Pho after entanglement and another was a juvenile stranded in October 2020.

In eastern Cambodia, CMMCP respondents identified various potential locations for dugong sightings. While they reported no direct observations of dugongs, local knowledge persists regarding areas where dugongs may occur. This region is close to Phú Quốc Island in Vietnam (See Section 6.2.7), where dugong hunting and sightings have been documented.

The status of the dugong in Cambodia is data deficient. The lack of regular and comprehensive surveys, combined with the proximity of western Cambodia to Thailand and eastern Cambodia to Vietnam, makes it challenging to draw definitive conclusions as individual dugongs almost certainly cross the international boundaries. Nevertheless, the relatively large area of seagrass meadows in both western and eastern Cambodia, plus observations of dugongs in the vicinity of these meadows, suggests the potential for dugong habitats in the region (Hines et al. 2008).

The IUCN Marine Mammal Protected Area Task Force (MMPATF) identified the transboundary Kien Giang and Kep Archipelago IMMA, which covers the Kep Province in Cambodia and the Kien Giang Province of in Vietnam, as an IMMA with the dugong as a qualifying species (IUCN-MMPATF 2022b).

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- The relatively large area of seagrass meadows in both western and eastern Cambodia, plus observations of dugongs in the vicinity of these meadows, suggests the potential for dugong habitats in the region.
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6.2.6 Vietnam

The coastal waters of southern Vietnam support dugongs in some areas, particularly in the south (Figure 6.1), as evidenced by opportunistic observations over the last 60 years.

- There have been persistent records of dugongs in the Côn Đảo Archipelago in the south and the Phú Quốc area near the border with Cambodia where UNEP/CMS, (2011) reported ~ 12 dugong hunters in the 1960s–1990s.
- The World Wildlife Fund for Nature (WWF) conducted an interview survey in Côn Đảo and Phú Quốc islands areas. The survey indicated that the information on the dugong was inadequate (Hines et al. 2008).

- Quang et al. (2005) compiled information on the dugong in the Phú Quốc Island Region near the border with Cambodia (Figure 2.1 inset) using a literature review, questionnaire surveys of fishers in ten villages (106 surveys returned), and opportunistic sightings. They concluded that a dugong population existed in the waters around Phú Quốc Island but that it had suffered a steep decline since the 1970s as a result of dynamite fishing, electric trawls, extensive uncontrolled use of fish corrals and illegal mesh size fishing. Nonetheless, most informants said that they regularly saw dugongs and were aware that they were caught. Some had eaten dugong meat when it was sold in local markets. Some families still kept the tusks, skin and skulls of dugongs that has been caught years ago.
- In 1977, Van Bree and Gallagher (1977) examined dugong specimens from the Côn Đảo Archipelago. Cox (2002) believed there were about 10 dugongs in this region, but this estimate was largely based on observations at one location, rather than a formal survey of the whole archipelago.
- Unpublished records from the Côn Đảo National Park included three dugong strandings between 2017 to 2018 (L. Vu, personal communication 2024).
- Fourteen dugong carcasses were reported from Côn Đảo between 1993 -2001 (Cox 2002; UNEP/CMS 2011).
- The marine patrolling team of the Côn Đảo National Park, where dugongs are protected from fishing and development, have consistently reported opportunistic sightings of dugongs. The Côn Đảo region has been declared an IMMA with the dugong as a qualifying species (IUCN-MMPATF 2022a).
- Between 2019 and 2022, the Center for Biodiversity Conservation and Endangered Species (CBES) undertook a dugong monitoring initiative in Côn Đảo Archipelago (CBES unpublished data 2024). This encompassed: (1) three opportunistic boat-based expeditions encircling the Côn Đảo main (largest) island, covering a total on-effort observation distance of 320 km; (2). land-based observations conducted from 12 strategic vantage points around the main island, with each point being observed for a total of six hours, primarily during high tides; and (3) surveys for feeding trails at four major seagrass meadows in Côn Đảo.

Unfortunately, due to the impacts of COVID-19 pandemic and limited funding, the study was not continuous. There was a pause from late 2020, with only a brief resumption in 2022. As of the last recorded data, a mere six dugong sightings had been documented, with four originating from vantage point observations and two from opportunistic boat-based surveys.

All sightings were of single animals within Côn Sơn Bay, southeast of Côn Đảo main island. Given the limited number of sightings, it remains challenging to estimate the size of this dugong population. However, the low encounter rate suggests a small population size.

Dugong feeding trails were exclusively found within Côn Sơn Bay. These trails were observed consistently across multiple surveys conducted in January, April, June, October, and November, indicating year-round utilization of this area by dugongs. Particularly noteworthy was the presence of a significant number of feeding trails in the intertidal seagrass bed at Lò Vôi Beach, suggesting the possibility of this area serving as a potential high-density area for the dugong population in the Côn Đảo Archipelago. Further investigation is warranted to confirm and elucidate these findings, emphasizing the need for cautious interpretation and ongoing monitoring efforts.

- Perrin et al. (2005) mentioned that dugongs were present in the north of Hạ Long Bay (Quảng Ninh Province) near the border with China. Nonetheless, verified occurrences are now limited to southwestern Vietnam. Especially the Côn Đảo Archipelago and Phú Quốc Island.

- The status of the dugong in Vietnam is data deficient.
- The most important, known areas for dugongs are Côn Đảo Archipelago and Phú Quốc Island.
- The Côn Đảo region has been declared an IMMA with the dugong as a qualifying species.

6.3 Cultural values

Dugongs play an important cultural role in Continental Southeast Asia. The accounts below illustrate similarities and differences between Range States.

6.3.1 Myanmar

Dugongs are known as *Ye wet* (water pig) and *Ye thu ma* (mermaid) in Myanmar (Tun et al. 2010). The Salone people or sea nomads maintain ancient beliefs that connect deceased children with dugong reincarnation. Narratives from the Tanintharyi Region, on the Andaman coast of southern Myanmar (Figure 6.1) describe an animal resembling a dolphin with a pig-like face, a transition from a dolphin to terrestrial pig. This is believed to have stemmed from the absence of pigs on isolated islands, leading locals to hypothesize their transformation from dolphins, linked by dugongs.

Dugong parts were used for medicinal purposes: skin and bone were used to treat diarrhoea; blood to remove warts. Some people preserved dried dugong skin and bones for medicinal use. Some

locals asserted that dugong meat had a superior taste to pork and advised against consuming dugong meat during pregnancy due to its perceived 'cold' nature (Tun et al. 2010).

An attempt was made to display a dugong at the Yangon Zoological Garden. The dugong known as *Man Aung Nyunt* was caught from the waters of Man Aung Island in 1966 and transported to Yangon. Seagrasses were also collected from Man Aung Island and sent to Yangon to feed the dugong. However, the animal died a few months later.

6.3.2 Thailand

Various names like *Payoon*, *Moonurn*, *Moodud*, *Nguag*, *Datong*, and *Duyong* have been used to refer to dugongs, each carrying local significance (Adulyanukosol et al. 2010a). *Moonam*, used in southern regions, was derived from the pinkish meat resembling pork, while in Chanthaburi Province *Moodud* reflects the piggish appearance and feeding behaviour of dugongs (Boonprakob et al. 1983; Adulyanukosol et al. 2010a). The name *Ban Lo Duyong* in Krabi Province originated from the dugong call, suggesting a history of dugong hunting in the area.

In the village of Ban Chao Mai in Trang Province, there is a legend in which a pregnant wife's craving for seagrass fruits leads her husband to gather them daily. Unsatisfied, she ventures into the sea, indulging in the fruits and becoming trapped in the seagrass leaves, transforming into a dugong. The husband follows his wife, choosing to live with her in the sea. The fruits of the seagrass *Enhalus acoroides* used to hold cultural significance as a snack (Adulyanukosol et al. 2010a).

Similarly, a legend from Talibong Island (Figure 6.1) linked a woman's transformation into a dugong due to cravings for seagrass (*Enhalus*) fruits, influencing the belief that dugong tears are a powerful love potion (Nateekanjanalarp and Sudara 1994). Along the Andaman coast in southern Thailand and northwestern Peninsular Malaysia, a local song and dance drama known as *Rong Ngeng*, or *Li Ke Pa* featured the coastal community of *Chao Le* or sea gypsies, reflecting the love between a man and a woman, symbolising the affection of a dugong cow for her calf. Sea gypsies believed that dugong tears are potent love potions:

'...I am thinking of the lady, I cannot eat any food because of touching the dugong tears. I cannot eat any food and I am always thinking of you all times.'

The sea gypsies emphasized that the ideal dugong tear for a love potion should come from a calf that has lost its mother, suggesting an understanding of the close relationship between dugong cows and their calves. In more recent years, new songs focusing on dugongs and conservation aim to raise awareness among local communities and the younger generation (Adulyanukosol et al. 2010a).

Cultural beliefs in Thailand attribute aphroditic, protective, and anti-rheumatic properties to various dugong body parts, including skin, bones, tears, and tusks. A pair of tusks was once valued at THB 10,000 (approximately USD \$230) and were openly traded through village officials as reported by Nateekanjanalarp and Sudara (1994).



Figure 6.4 Fountain in Trang, Thailand decorated with dugongs. Patrick Lepetit photograph; reproduced with permission, courtesy of the photographer.

In Trang Province, Muslim villagers near Hat Chao Mai National Park formerly used body parts from stranded dugongs, such as teeth and tusks, as aphrodisiacs. This raised conservation concerns, with publicized reports attributing declining dugong numbers to traditional uses of the animal. The Department of Fisheries issued warnings against possessing dugong body parts, emphasizing legal consequences. However, violations persisted as locals considered dugong meat delicious and adhered to a historical tradition of hunting them. In Trat Province, one family used dugong oil to treat muscle pain (Adulyanukosol 2002a). Rings made from dugong bone and tusks were found in Krabi Province, with reports of illegal exportation to Malaysian black markets for use in Chinese medicine by a Muslim family in Nua Khlong district (Adulyanukosol 2002b).

In the past, coastal villagers consumed dugong meat caught incidentally in their fishing gear, believing it to be halal and in accordance with their religious beliefs. Rojchanaprasart et al. (2014)

suggested that traditional ecological knowledge regarding dugongs directly influences their conservation with the dugong an important indicator of the abundance of aquatic resources. Rojichanaprasart et al. (2014) encouraged coastal villagers to participate in dugong conservation and supported their participation in conservation planning as stakeholders in co-management.

Dugong meat was considered more valuable than pork and commanded a high price within the illegal market until the early 21st Century (Adulyanukosol 2002a). Adulyanukosol's (2002a) interviewees revealed that dugong meat, including entrails, was incorporated into dishes such as coconut milk curry, stir-fry with vegetables, sweet and sour, and fried entrails.

An orphaned dugong calf found by local villagers in the Andaman Sea, was relocated to a sheltered area around Koh Libong in Trang Province in 2019. News of *Marium*, her daily interactions with her carers and the efforts to care for her, featured in news outlets around the world. *Marium* died in August 2019 from infections resulting from plastic ingestion. Her death sparked outpourings of grief on social media and resulted in the Thai government declaring 17 August as National Dugong Day. (Ponnampalam et al. 2022).

Dugongs feature in street sculptures and fountains around the town of Trang, on the Andaman coast (Figure 6.4).

6.3.4 Peninsular Malaysia and Singapore

The name dugong is derived from the Malay word *duyong* which means 'mermaid' or 'lady of the sea'. Sir Thomas Stamford Raffles (Raffles 1821), then British Governor of Sumatra, wrote that the Malays considered dugongs to be a symbol of maternal affection because of the care given by a female to her calf, and provided insights into how these strong bonds were exploited when dugongs were hunted:

'During our short possession of Singapore (not more than six months) four of these animals have been taken; but the greatest number is said to be caught during the opposite or northerly monsoon, when the sea is calmest, near the mouth of the Johore river, in the inlet of the sea between Singapore Island and the main. They are usually taken by spearing (at which the natives are particularly dexterous) during the night, when the animals give warning of their approach by the snuffling noise they make at the surface of the water.....When they succeed in taking a young one, they feel themselves certain of the mother, who follows it to the margins of the sea, and allows herself to be speared or taken with the greatest ease' (Raffles 1821 p. 345).

This account confirms that dugongs were hunted by the people of the Johor Straits. Dugong meat was described as 'excellent beef' and highly prized by the Malay people at the time. Abraham (1924)

reported that dugongs in Singapore's waters were hunted by the indigenous *Orang Laut* (sea gypsies) using a traditional harpoon called a *tempuling* fitted with a stout line fastened to the harpoon head. The *Orang Laut* 'played' with the harpooned dugong until it tired and died. The meat of the animal was then sold to Malay and Chinese people.

The Malays considered the 'congealed mucus secretion of the eye-lids' to be a powerful love potion (Gibson-Hill 1950). In Singapore, Raffles (1821) reported that when dugong calves were caught, they had 'a short sharp cry, which they frequently repeat; and it is said they shed tears' (p. 345), which were used as a charm to secure the affections of a prospective lover. Interviews with the Seletar community in the western Johor Strait, Malaysia (Zulkifli Poh 2009) indicate that the indigenous Seletar people, who once occupied the Johor Strait as sea nomads (the *Orang Laut* mentioned in Abraham (1924)), used to hunt for dugongs for their meat and body parts. Zulkifli Poh (2009) reported that senior members of the Seletar community in Gelang Patah described how: (1) they relished the meat, which was tasty like beef and best eaten in a curry; (2) amulets were made from the tusks and smoking pipes out of the teeth; some of which were sold; (3) dugong oil was used to heal burns (due to its perceived cooling properties); and (4) the skin of the dugong was used to make covers for walking sticks and drum skins. As dugong occurrences are incredibly rare in modern times, younger members of the Seletar community do not have the same cultural connection with dugongs and know about the elusive herbivore only from the tales their elders have shared (Zulkifli Poh 2009).

Throughout much of the 20th century, the dugong was considered to be extinct in the waters of Peninsular Malaysia and Singapore. In 1999, Atan Hussein, a fisherman in Johor accidentally caught a 1.5 m long dugong calf, later nicknamed 'Si Tenang,' in a fishing net. He subsequently kept and cared for Si Tenang in his *kelong*, a wooden offshore platform similar to a fish corral but primarily used for fishing (Sia 2017). Atan kept the dugong in his *kelong* and tended it for six weeks until he was forced to release the animal on the directive of the Fisheries Department. He was very upset when Si Tenang was found dead 48 hours later, followed shortly afterwards by the carcass of an adult female. The event attracted global publicity and comment from the Malaysian Prime Minister and was a catalyst for research on dugongs in Malaysia.

Gracie, a female dugong, was displayed at Underwater World in Singapore from 1998 to 2014. She was rescued as a suckling calf when her mother drowned in a fishing net in Pulau Ubin, Singapore. She grew very slowly and was very small for her age when she died (Marsh 2022).

6.3.5 Cambodia

Hines et al. (2008) interviewed fishers in Koh Kong (western Cambodia), Kampot and Kep provinces (eastern Cambodia) (Figure 6.1). All respondents from Koh Kong claimed that the dugong had never been hunted, whereas all interviewees in eastern Cambodia reported historical hunting. Dugongs in both areas were still occasionally caught accidentally and fetched a good price in the market. Since the 2006 fisheries law prohibiting catching or selling dugong was foreshadowed in 2004, the fisheries authorities claimed that dugongs caught in nets were released. Nonetheless, Beasley and Davidson (2007) reported that dugongs, which are seen as symbols of good luck, were highly sought after for their meat, internal organs, bones, and tusks, with tusks fetching up to USD \$200. Local people used dugong bones as medicine against fevers and to protect livestock from illnesses. The tusks and skull were processed and sold for medicinal use (Beasley et al. 2001; Beasley and Davidson 2007).

Recent reports indicate that the active hunting, killing, and illegal trade of dugongs persist in Cambodia (CMMCP 2023).

6.3.6 Vietnam

The cultural significance of dugongs in Vietnam manifests in whale temples, consumption practices and traditional rituals. The whale temples, along the southern and central coastlines, generally known as *Lăng Ông*, serve as repositories of natural history information, particularly marine mammals (Smith et al. 1995, 1997; Vu et al. 2020). These temples primarily venerate *Cá Ông* or 'Lord Fish,' a benevolent whale spirit integral to the lives of fishing communities that offers protection during sea-related challenges. It is believed that *Cá Ông* includes various species of whales and dolphins from Vietnam's waters. Festivals dedicated to whale worship underscore the central role of these temples in Vietnamese fishing culture (McGowen et al. 2021). However, the definition of *Cá Ông* varies between communities. A species respected as *Cá Ông* by one community may be regarded a pest by others, often resulting in the hunting of that species. This may have been true for dugongs, which may have been mistaken for whales or dolphins, becoming the subject of either worship or hunting. McGowen et al. (2021) found dugong skulls in whale temples in Đà Nẵng and Chàm Island (Figure 6.1), where the *Cá Ông* worshipping practice remained strong. No dugong skulls were found in other whale temples visited by McGowen et al. (2021).

Hines et al. (2008) used interviews to explore the cultural relevance of dugong meat. Market sellers in Dương Đông (Phú Quốc Island, Kien Giang Province; Figure 6.1) described the diminishing availability of dugong meat since 1994-1995. At the time of Hines' (2008) survey, the meat was so precious that fishers who caught dugongs no longer sold it in the market, though this may have been due to the regulations put in place to protect dugongs (L. Vu, personal communication 2024). Some

fishers in nearby Hàm Ninh and Bãi Thơm were continuing to actively catch dugongs with sting ray/shark nets imported from Japan or Korea.

Hines et al. (2008) were told that dugong meat remained a staple in the diets of these communities, with the skin used in a special hot-pot dish. Each part of the dugong was valued: large tusks fetched up to USD \$650 when sold for Chinese traditional medicine or tourism; the skin was valued at USD \$4 per kg; ear bones USD \$6.50 each, and various bone pieces, notably ribs, USD \$0.20-0.65. Tusks, bones, and dried bile ducts were used in various medicinal practices.

6.4 Threatening processes

Dugongs in Continental Southeast Asia are variously subjected to several threatening processes, most significantly: incidental catch by both small-scale and illegal commercial fishers, rapid development causing habitat loss, and habitat degradation from destructive fishing methods. Direct hunting has declined over the past decade. These threats have root causes such as: rapid population increase, poor education, inadequate law enforcement in some areas, marginalization of small-scale fishers, and poverty, albeit with variations in intensity in the various Range States. Singapore is an outlier as explained below.

The interactions between dugongs and small-scale fisheries are the most serious contemporary threat to dugongs globally (Marsh and Sobtzick 2019). Small-scale fisheries are a vital component of livelihoods across the dugong's Range States in Continental Southeast Asia, particularly in rural coastal and island areas (Pomeroy 2012; Teh and Pauly 2018). Thailand and Vietnam lead in terms of both human population size and fisheries production. Peninsular Malaysia produces a high volume of fisheries products, despite a smaller human population. Myanmar and Cambodia face the greatest economic challenges in this region. Singapore, a small yet affluent nation, plays a substantial regional role through its involvement in commercial fish trade and consumption, and large-scale shipping (Fabinyi et al. 2022).

6.4.1 Myanmar

The demand for dugong meat in Myanmar is relatively weak with only a few locals considering it a delicacy or attributing medicinal properties to body parts (Tun et al. 2010; Section 6.3.1). Direct threats to dugongs in Myanmar are considered relatively low. Occasional opportunistic killing with hand harpoons, primarily localized in areas like Taungup (Figure 6.1), has been reported (Ilangakoon and Tun 2007; Tun and Ilangakoon, 2007).

Fishing is the major source of dugong mortality in Myanmar. Although gillnets and set nets pose risks along the Rakhine coast, more destructive methods like explosives and push nets are not used

(Ilangakoon and Tun 2007; Hines 2012). However, underreporting of dugong strandings and bycatch presents a significant challenge due to a lack of established reporting mechanisms and limited awareness about dugong conservation among coastal communities and authorities (Hines 2012).

6.4.2 Thailand

The absence of significant reports of deliberate dugong hunting in the past four decades is attributed to the implementation of the *Fisheries Acts of B.E. 2490 (1947)* (Adulyanukosol, 1998, 2004; Hines 2012). Small-scale fisheries in Thailand are overshadowed by large-scale commercial fishing (Teh and Pauly 2018), aggravating coastal poverty and depleting fishery resources, making dugongs victims of intense fishing activities, whether trapped by illegal fishing gears or sold for profit if incidentally caught (Hines 2012).

The degradation of mangroves, seagrass, and coral reefs along the Andaman coast is a serious indirect threat to dugongs, driven by overfishing, destructive fishing techniques, and the removal of mangrove forests for shrimp or shellfish farming (Hines 2012; Fabinyi et al. 2022). The potential threat of seagrass community degradation due to global climate change and coastal development further compounds the challenges faced by the local dugong population (Khogkhaio et al. 2017). The rapid increase in the coastal population intensifies the pressure on natural resources, through activities like tin dredging near the shore and sedimentation from land-based mining, mainly in Phuket, Phangnga, and Ranong provinces (Hines 2012).

At the time of writing in early 2024, reports of dugong deaths and emaciated dugongs in the Trang Province in Thailand have been associated with seagrass dieback (Wipatayotin 2024).

6.4.3 Peninsular Malaysia

Fishing practices are a major threat to dugongs in Peninsular Malaysia. The risks to dugongs associated with trawling, the most extensively used fishing gear, go beyond immediate mortality due to propeller wounds and gear entanglement and include substantial habitat damage. In addition, at least two of the 18 recorded dugong deaths from around Sibul and Tinggi since 2014 (all of which were juveniles), had been caught in an illegal longline known locally as *rawai hantu* (Hines et al. 2020).

Hashim et al. (2017) conducted habitat risk assessments on dugongs in Johor. Hines et al. (2020) used the Bycatch Risk Assessment (ByRA) toolkit, based on InVEST open-source models, to identify zones of elevated risk to dugongs from fishing in the waters of Johor. Hines et al.'s (2020) modelling indicated the following high-risk locations: (1) dugongs in and around Sultan Iskandar Marine Park surrounding Sibul Island from vessels that originated from the mainland pier at Tanjung Leman; (2) near Mersing, a local fishing port, and (3) around Besar Island to the north (Figure 6.1).

Seagrass habitat degradation is further increased by land reclamation and chemical runoff from palm oil plantations (Hashim et al. 2017; Bujang et al. 2018). Coastal development, especially from 1997 to 2014 along the Johor Straits (Figure 6.3), has caused significant changes in dugong habitat conditions (see Bujang et al. 2018), suggesting a close correlation between decreased dugong presence and anthropogenic disturbance (Hashim et al. 2017).

6.4.4 Singapore

Coastal habitat loss in the region has been particularly severe, with Singapore experiencing a significant decrease in its natural coastline length between 1922 and 2011, accompanied by substantial loss of intertidal habitats (Lai et al. 2015). The urbanization of coastal areas and a subsequent surge in anthropogenic uses of sea spaces have been identified as major drivers of dugong population decline (Hines 2012). Land reclamation activities along the Johor and Singapore Straits, dating back to the mid-1800s and intensifying after 1965, have caused extensive reduction in intertidal habitats, including seagrass meadows (Lai et al. 2015).

Ng et al. (2022a, b) observed peaks in dugong observations coincident with the northeast and southwest monsoons. Distribution patterns of stranded carcasses have been associated with a combination of natural and anthropogenic factors such as seasonality in seagrass abundance, tidal cycles, wind patterns, and vessel traffic. Additionally, the high volume of vessel traffic and shipping activities in Singapore's coastal waters, coupled with the impact of wind or vessel-generated waves and noise on foraging activities, further compounds the challenges faced by dugongs in the Johor and Singapore Straits (Ng et al. 2022a, b). Ongoing and future reclamation plans for areas along the Pulai and Johor Rivers are expected to exacerbate these losses, posing a significant threat to dugong foraging, birthing, and calving grounds (Ponnampalam et al. 2022).

6.4.5 Cambodia

Dugongs are directly targeted for their body parts, making them the most highly endangered marine mammal in Cambodia's waters (Marsh 2002; Hines et al. 2004; Beasley and Davidson 2007; CMMCP 2023). The nets used by small-scale and illegal commercial fishers, particularly Spanish Mackerel fishing nets incidentally catch dugongs (Beasley and Davidson 2007). This challenge is further compounded by habitat degradation and overfishing, driven by contemporary fishing techniques and the ever-increasing coastal population and poverty (Hines 2012).

Seagrass meadows are under severe threat, especially in areas like Kep, where the meadows are not valued by local people (Marsh et al. 2002; Beasley and Davidson 2007; Hines et al. 2008). The risks are heightened by the expansion of shrimp farms and the mounting pressure from a burgeoning

coastal population, which collectively impact marine resources. The root cause of this environmental harm was reported to be poverty in the early 2010s (Hines 2012).

6.4.6 Vietnam

Direct hunting of dugongs near Phú Quốc Island (Figure 6.1) was an ongoing threat, early this century. Dugongs were hunted for various purposes, including food, medicine, and money (Hines et al. 2008; Hines 2012). Other threats include incidental catch by small-scale and illegal commercial fishers, and the escalating use and degradation of seagrass meadows (Hines et al. 2008; Hines 2012). Kiên Giang Province is home to Phú Quốc Island, a critical location for dugongs in Vietnam, and boasts 10,880 registered fishing boats and an annual seafood catch exceeding 636,170 tons (Hines et al. 2020). Numbers for Phú Quốc Island alone were unavailable at the time of writing. The intensive use of gillnets and trawling gears, exacerbate the challenges faced by dugongs (Hines et al. 2020).

While seagrasses remain abundant in some regions, their degradation is widespread due to aquaculture and sedimentation, declining water quality, overfishing, and coastal development, especially near Phú Quốc Island (Sudo et al. 2021). Additional problems include sewage discharge into seagrass areas and destructive fishing (Hines 2012). Despite a positive trend in seagrass meadow expansion in certain areas of Vietnam, a significant decline has been observed in most regions over the past two decades (Sudo et al. 2021).

In the Côn Đảo Archipelago, the management of dugong hunting appears to have been addressed through coordinated efforts involving the patrolling activities of Côn Đảo National Park and various conservation education initiatives by local and international NGOs (L. Vu, personal communication 2024). However, the recent surge in coastal development and land acquisition along the beaches in this region pose significant threats to the integrity of all seagrass beds. Notably, the emergence of six premium resorts, some of which are already constructed, in Côn Sơn Bay, southeast of the Côn Đảo main island where the majority of dugong feeding trails have been identified, exacerbates these concerns. Moreover, infrastructure development activities, including road construction and expansion along the coastline of the main island, are contributing to sediment discharge to seagrass beds. Since 2022, the construction of new speed ferry piers in Côn Sơn Bay directly threatens established dugong habitats. The growing popularity of speedboat tours within Côn Sơn Bay also raises the risk of potential boat-dugong collisions, with at least one dugong sighted by CBES displaying evidence of propeller cuts on its body (L. Vu, personal communication 2024). The escalating trend of unsustainable tourism further jeopardizes the health of seagrass beds in Con Dao, as evidenced by CBES's observations of extensive trash dumping in these critical habitats during seagrass bed surveys. Unlike the case of Phú Quốc, where dugongs can move between seagrass

beds, dugongs in the Côn Đảo Archipelago are particularly vulnerable to seagrass loss due to the relatively isolated nature of the archipelago and the absence of alternative habitats nearby. The nearest shoreline lies 80 km west of the islands, and the closest known seagrass meadow is at least 400 km away. These factors underscore the urgent need for comprehensive conservation measures to mitigate the escalating threats facing the dugong population and their habitats in the Côn Đảo Archipelago.

6.5 Conservation initiatives

6.5.1 International conventions

All Dugong Range States in Continental Southeast Asia are signatories to the Convention on Biological Diversity, the United Nations Framework Convention on Climate Change, and the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES). None is a participant in the Convention on Migratory Species of Wild Animals. Only Myanmar and Thailand have signed the Dugong Memorandum of Understanding (Dugong MOU).

6.5.2 National laws

The information in this section is based on Ezekiel's (2018) review of marine wildlife protection in Association of Southeast Asian Nations (ASEAN) including an evaluation of their strengths and weaknesses.

6.5.2.1 Myanmar

Myanmar has implemented several legal measures that safeguard dugongs including:

- The *1994 Law and Order Restoration Council Law No.6/94*, which focuses on the Protection of Wildlife and Protected Areas.
- The *2018 Law Relating Conservation of Biodiversity and Protected Areas*, which classifies dugongs as 'Completely Protected Wildlife'.
- The Myanmar *Marine Fisheries Law's Article 23*, which includes a directive that explicitly prohibits activities such as catching, killing, wounding, harassing, storing, transporting, transferring, selling, exporting without permission for whole or part of the dugong and the requirement to release a dugong immediately if it is caught alive (T. Tun, personal communication 2023).
- *Animal Health and Development Law No. 17, 1993* (amended 2010), which addresses cruelty to animals, including marine wildlife, in trade.

- The *Notification for Control of Endangered Fish Species* which deems the capture, possession, trade, or export of CITES-listed marine species, including the dugong, to be an offense.

Myanmar prohibits destructive fishing methods, including poisons and explosives, through various laws such as the *2002 Rules, Marine Fisheries Law, and Law Relating to the Fishing Rights of Foreign Fishing Vessels*. There are concerns about the overall effectiveness of these laws due to potential gaps in enforcement. Closed seasons, areas, and licensing requirements are specified, but critics argue that these regulations lack specificity and detail, relying heavily on lower-level regulations and discretionary decisions by relevant authorities, potentially impacting the comprehensive implementation and enforcement of these protective measures. There are some exemptions from the prohibition on possessing protected wild animals in the *Protection of Wildlife and Conservation of Natural Area Law*, such as the use of body parts as drugs, making the law less effective (Ezekiel 2018).

6.5.2.2 Thailand

The official protection of dugongs in Thailand dates from the *1947 Fishery Act*. The Act prohibits activities such as the possession, capture, entrapment, and destruction of dugongs. The *2015 Royal Ordinance on Fisheries B.E. 2558* replaced the *Fisheries Act* and strategically targets illegal, unreported, and unregulated (IUU) fishing. This ordinance intricately details licensing requirements, control measures, and penalties, emphasizing sustainable fisheries management.

The protection of the dugong under the *Fishery Act* is reinforced by other laws including:

- The 1992 *Wildlife Preservation and Protection Act*, which lists the dugong as one of the 15 species on Thailand's wildlife reserve list.
- The 2014 *Wild Animal Reservation and Protection Act (WARPA) (No. 3) B.E. 2557*, which governs the establishment and management of Wild Animal Sanctuaries and Non-Hunting Wild Animal Areas. This critical legislation has undergone many amendments, with a current draft proposing intensified penalties and expanded protected status, aligning with international obligations, such as CITES.
- The 2015 *Promotion of Marine and Coastal Resources Management Act B.E. 2558*, which aims to consolidate marine and coastal management. This act establishes a national committee responsible for formulating policies, management plans, and regulations and grants the authority to establish marine and coastal protected areas, enforcing penalties for violations and ensuring the prevention of severe damage to marine or coastal resources.

- The *2016 Regulation governing the Import, Export and Bringing in-transit of Marine Life B.E. 2559*, which introduced regulations focused on protecting rare marine species by banning the import, export, or transit of specified marine species without a permit.

Although this legal framework reflects Thailand's commitment to marine conservation, effective implementation remains challenging. Ongoing amendments and proposed enhancements, such as increased penalties and extended protected status, signify the intent to address ongoing challenges. The lack of specific by-catch mitigation measures in the Ordinance on Fisheries and ambiguities within *WARPA* are weaknesses.

6.5.2.3 Peninsular Malaysia

In Peninsular Malaysia, there are numerous laws to preserve marine diversity, including dugongs:

- The *Fisheries Act 1985 (Part 5, Section 27)*, and the *Fisheries (Control of Endangered Species of Fish) Regulations (Amendment) 2008*, whereby dugongs are listed as marine endangered species. It is therefore prohibited by law to catch, harass, consume, possess, hunt, trade or export a dugong or any of its body parts. If the dugong has been accidentally caught while fishing and is still alive at the time of capture, it must be released immediately. If the animal has died, its incidental capture must be reported to the Department of Fisheries Malaysia.
- The *International Trade in Endangered Species Act No. 686 of 2008* is Malaysia's principal CITES-implementing legislation. This act takes precedence over other laws regarding the protection, import, or export of plants and animals. The *International Trade in Endangered Species Act* provides comprehensive protection for CITES-listed species. It prohibits various activities, including the import, export, and possession of scheduled species without the necessary permits. The Act's detailed schedules and appendices ensure up-to-date protection.

In 2011, the Department of Fisheries Malaysia published a Dugong National Plan of Action (NPOA) to serve as a reference and guide for dugong research, conservation, monitoring, and management activities across the country. As of 2024, the NPOA is undergoing an update and will be published as the Dugong NPOA Plan 2 (L. Ponnampalam, personal communication 2024). Although Malaysia's national laws reflect its commitment to preserving its rich marine biodiversity, the effectiveness of these laws relies on vigilant enforcement and careful consideration of exemptions.

6.5.2.4 Singapore

In Singapore, the dugong is protected by four laws:

- (1) the *Endangered Species (Import and Export) Act (2006, revised 2008)*, which ratifies Singapore's commitment to CITES, by mandating permits for the import, export, re-export, and introduction from the sea of scheduled species. Penalties for violations are stringent.
- (2) The *Wild Animals and Birds Act (1965, revised 2000)* regulates the collection, possession, and trade of wildlife within Singapore.
- (3) The *Animals and Birds Act (1965, revised 2002)*, which prevents animal cruelty.
- (4) The *Fisheries Act (1966, revised 2002)*, which controls fishing activities within Singaporean waters and by nationals outside territorial waters.

Singapore's marine wildlife protection laws and the relatively robust ways in which they are enforced are evidence of the nation's commitment to environmental stewardship.

6.5.2.5 Cambodia

Cambodia's legal framework for protecting dugongs and marine resources is comprehensive, incorporating a range of measures to regulate wildlife-related activities. Nonetheless, Cambodia grapples with enforcement and compliance.

- The protection of marine resources including dugongs is underpinned by 2006 legislation, which specifies that it is illegal to catch, sell, buy, or transport dugongs due to their endangered status. This legal framework places responsibility on the Ministry of Agriculture, Forestry, and Fisheries to safeguard and preserve the habitats of dugongs (Hines 2012).
- The dugong is classed as a Critically Endangered Marine Species by *2009 Sub-Decree No. 123 2009* (Cambodia, Ministry of Information 2020). Complementing this primary legislation is *Sub-Decree No. 53*, which ratifies Cambodia's commitment to providing protected status for all CITES-listed species. In addition, the Ministry of Agriculture, Forestry and Fisheries promulgated a *Proclamation No. 571 MAFF on the Measures to Protect Endangered Fisheries Resources*.
- Destructive fishing methods are banned by the *Law on Protected Areas* and *Law on Fisheries*. Requirements for licenses, permits, vessel registration, and logbooks further enhance the comprehensive legal structure governing fishing activities.

Despite the clear legal situation, implementation challenges persist. The absence of measures to mitigate by-catch is a significant weakness, and enforcement powers are vaguely defined by the *Law on Protected Areas*. Dugongs are still being actively hunted and sold (CMMCP, personal communication 2023). There is a pressing need for enhanced law enforcement, particularly

concerning Cambodian-flagged vessels and national fishing activities extending beyond the exclusive economic zone.

6.5.2.6 Vietnam

Vietnam has made proactive efforts to protect marine resources, including dugongs using a complicated legislative process which proliferates implementing regulations for its laws (Ezekiel 2018). Laws passed by the National Assembly are often broad and general, requiring implementation regulations to be effective. Examples are listed below. Ezekiel (2018) provides a comprehensive list.

- The Red Data Book of Vietnam reinforces the Critically Endangered status of dugongs (UNEP/CMS 2016). A directive explicitly prohibits hunting, transport, or consumption of dugongs.
- *Government Decree No. 160/2013/ND-CP* outlines strict regulations for the exploitation, transfer, trade, or storage of endangered, precious, and rare species prioritized for protection, including dugongs and emphasizes scientific research and biodiversity preservation.
- *Government Decree No. 187/2013/ND-CP* provides a framework for implementing CITES by prohibiting the export of rare and precious wild animals and setting requirements for permits for CITES-listed species.
- The Ministry of Agriculture and Rural Development's *Decision No. 82/2008/QD-BNN* identifies endangered aquatic species, necessitating strict protection under current legislation.
- *Circular No. 50/2015/TT-BNNPTNT* facilitates the certification of catches, addresses market requirements and contributes to sustainable fisheries management.
- *Ministry of Fisheries Circular No. 02/2006/TT-BTS* serves as a comprehensive guide for implementing *2005 Government Decree No. 59/ND-CP*, aligning with the *2003 Fisheries Law* and regulating production and business conditions for diverse fisheries including: conditions and procedures for obtaining permits for the exploitation of aquatic resources restrictions on permits in closed seasons, no-exploitation areas, or listed entities banned from exploitation. The Circular explicitly bans fishers from using dynamite, electricity, chemicals, and mesh sizes smaller than specified. It also prohibits the exploitation of aquatic resources by fishing vessels or trades banned from operation or operating in specific areas.

While this legal framework is robust, effective implementation remains a concern. There is a need for enhanced law enforcement, especially concerning the International Plan of Action to Prevent,

Deter and Eliminate Illegal, Unreported and Unregulated Fishing activities, and ongoing efforts to combat illegal hunting.

6.5.3 Other conservation initiatives

6.5.3.1 Myanmar

- **The Coastal Development and Biodiversity Project** addresses the challenges posed by the anticipated rapid development of coastal areas, driven by increased foreign investment through summarizing available information on coastal biodiversity, identifying key areas, and assessing existing or planned development projects. The initiative seeks to promote responsible and sustainable coastal and infrastructure development, fostering partnerships for a balanced and conservation-oriented approach (Zöckler et al. 2013).
- **Building Capacity for Community-based Marine Conservation** undertook community education initiatives regarding dugong conservation including interviews, talks, and environmental education campaigns. The project was conducted along the southern Rakhine and Tanintharyi coasts, and the Myeik Archipelago (Fauna and Flora International [FFI] 2015).
- **Marine Protected Areas (MPA):** 43% of known seagrass meadows are protected in MPAs and Ecologically and Biologically Significant Areas (EBSAs) at the national park level (Sudo et al. 2021). Many surveys and assessments have been conducted recently and researchers are pushing for all seagrass areas to be protected in MPAs or by other means.

6.5.3.2 Thailand

Approximately 20% of Thailand's seagrass meadows are situated within MPAs and EBSAs. However, these areas lack specific protection designations such as Strict Nature Reserve, Wilderness Area, or National Park, and lack specified protection details (Sudo et al. 2021).

- **The SeagrassNet monitoring program** initiated in February 2006 at Haad Chao Mai National Park in Trang Province initially focussed on the Andaman Sea coast before expanding to the Gulf of Thailand. Rattanachot et al. (2018) assessed the impact of seagrass conservation efforts and found an increase of 0.7 hectares in total seagrass area.
- **SEAGONG – Community-Based Seagrass and Dugong Conservation Initiative** embarked on a mission in 2021 to empower coastal communities by co-designing and managing seagrass and dugong conservation areas. Employing participatory methodologies, the project centres on sustainable fisheries, climate change adaptation, and fostering alternative livelihoods. Aligned with Thailand's community-based marine resource management policy, SEAGONG collaborates closely with the Department of Marine and Coastal Resources (DMCR),

emphasizing local community engagement in the conservation of mangroves, coral reefs, seagrass, and marine endangered species, including training in seagrass nursery establishment, in situ propagation and dugong population monitoring using sonar and unoccupied aerial vehicles (UAVs). Alternative livelihoods are fostered through market needs assessments, financial planning, and the creation of an eco-guide training program certified by the Tourism Authority of Thailand. The initiative emphasises communication strategies regarding the vulnerability of seagrass ecosystems to climate change and pollution. By developing complementary business models and integrating eco-tourism, SEAGONG aims to alleviate poverty, reduce fishing pressure, and ensure the long-term sustainability of seagrass and dugong conservation in Thailand (IUCN 2021).

- **Save Andaman Network Foundation (SAN):** A registered environmental NGO, SAN is dedicated to preserving the distinctive environment along Thailand's Andaman coastline. Focused on the Katang District of Trang (southern Andaman coast), SAN is the Thai National Partner for the IKI Seagrass Ecosystem Services (SES) Project. The project operates under the authority of the Department of National Parks. With a commitment to sustainable resource management, community capacity building, and awareness promotion, SAN aims to provide alternative economic opportunities to the fisheries-dependent communities in the region, where a significant portion of the population relies on fisheries for their livelihoods. (Dugong and Seagrass Hub).
- **Community-Based Seagrass Monitoring and Conservation at Phra Thong Island (Ranong Province, Andaman coast)** aims to document the status of seagrass, enhance local awareness of its importance, and establish a community-based program for long-term monitoring using participatory mapping, conservation area delineation, and workshops on co-management. Educational materials for local resource centres and eco-tourism projects have been developed. Future steps include continued monitoring and documenting the outcomes of proposed initiatives, such as the establishment of a no-take zone (Mangroves for the Future 2013b).

6.5.3.3 Peninsular Malaysia

Fifteen percent of seagrass meadows in Malaysia are located within existing MPAs and EBSAs, mostly protected as Marine Parks (Sudo et al. 2021). Other relevant projects include:

- **Operationalizing the Malaysian National Plan of Action for dugongs in Pulau Sibul and Pulau Tinggi, Johor** (Project MY1, GEF Dugong and Seagrass Conservation Project): This project, initiated in 2016, focused on expanding marine park areas to include non-protected

zones with high concentrations of dugongs, sea turtles, and seagrasses. Community training programs emphasized dugongs and the seagrass ecosystem. Key deliverables included the development of a sanctuary, a comprehensive management plan, and the establishment of a strengthened Community Consultative Committee. The project integrated dugong and seagrass conservation into planning processes in Johor and implemented communication and education programs to raise public awareness in the targeted areas.

- **Community understanding and management of dugong and seagrass resources in Johor, Malaysia (Project MY3, Global Environment Facility (GEF) Dugongs and Seagrass Conservation Project):** The MY3 project began in 2016 to assist local communities in understanding the ecological and economic importance of conserving dugongs and seagrass resources, improving local capacity to manage these resources more effectively in harmony with social, cultural, and economic needs. A comprehensive public education campaign was initiated on Tinggi Island, with posters, educational materials, and a dugong-themed storybook, targeting diverse community segments. The campaign focused on educating the public about best practices in dugong and seagrass management, covering aspects like safe boating, response to stranded dugongs, seagrass habitat protection, and proper waste management. MY3 introduced a six-monthly dugong monitoring program, encouraging community engagement, documenting sightings, and creating a digital map of incidents. Key deliverables included collaborating with local communities and resorts to adopt dugong and seagrass safeguards, building local capacity for seagrass monitoring, and garnering public support for local management measures to protect seagrass and dugongs. The project aimed for at least 60% of the targeted inhabitants to endorse these measures, including reduced boat speeds, appropriate responses to strandings, improved waste management, and the promotion of dugong/seagrass-friendly tourism practices.
- **A multi-pronged approach to overcoming knowledge barriers on the ecology and status of dugongs in Johor: Towards critical habitat protection (Project MY4: GEF Dugong and Seagrass Conservation Project and Pew Marine Fellowship):** Local grassroots marine mammal research and conservation NGO, The MareCet Research Organization (MareCet) undertook several years of multidisciplinary research with local and international collaborators to assess the basic ecology and conservation needs of dugongs in the Sibutinggi Archipelago off the east coast of Johor. Aerial surveys using light aircraft were conducted, along with dugong acoustic surveys, seagrass mapping and dugong feeding behaviour research, consultations with local community members on the establishment of a Dugong Sanctuary and drafting of the management plan for the proposed Johor Dugong

Sanctuary. Following on from the GEF project, MareCet pivoted their efforts on dugong research into the IKI Seagrass Ecosystem Services Project by focusing on protecting the dugong and its seagrass habitat in the Sibutu Archipelago using UAVs and researching the biodiversity and seagrass blue carbon stocks in the seagrass meadows of Sibutu Archipelago, Setindan Island (at Mersing), and Middle Bank in Penang.

6.5.3.4 Singapore

Seagrass meadows in the waters of Singapore are not protected in MPAs (Sudo et al. 2021; Ng et al. 2022a, b). Nonetheless, TeamSeaGrass, an NGO, has been actively involved in seagrass conservation since 2007. The project involves the National Biodiversity Centre of National Parks and Seagrass-Watch. About 200 volunteers actively monitor seagrasses along key sites such as Chek Jawa, Pulau Semakau, and Cyrene Reef (Figure 6.3). The project contributes valuable baseline data. Team members engage in outreach efforts, including public exhibitions and talks, to raise awareness of marine biodiversity. Participation is open to individuals aged ≥ 19 years, regardless of scientific background, and provides with on-the-job training.

6.5.3.5 Cambodia

Only a small proportion of seagrass meadows in Cambodia are included in the categories of strict nature reserve and wilderness and only 13% of the seagrass meadows are covered by the existing MPAs and EBSAs (Sudo et al. 2021). Nonetheless, there are several projects aiming to increase the protection of seagrass meadows as outlined below:

- **Marine Conservation Cambodia (MCC)** is actively addressing the decline in fisheries resources by focusing on alternative livelihoods for coastal communities engaged in illegal and destructive fishing. Through socio-demographic analysis and marine data assessment, MCC identifies solutions for livelihood improvement that have reduced illegal fishing, leading to improved fish diversity and ecosystem health. MCC is piloting marine ranching projects with local communities, combining natural mariculture with sustainable harvest practices and working to create opportunities for local communities to diversify into marine tourism (CMMCP 2023).
- **Cambodian Marine Mammal Conservation Project (CMMCP)** was launched by MCC in 2017, in collaboration with the Fisheries Administration of the Royal Government of Cambodia. Marine mammal boat, land and citizen science surveys are undertaken regularly in Kep and Kampot provinces to monitor distribution, behavior, population trends and threats to coastal marine mammals in the area which include Irrawaddy dolphins (*Orcaella brevirostris*), dugongs (*Dugong dugon*) and Indo Pacific humpback dolphins (*Sousa chinensis*). CMMCP also runs the Marine Mammal Strandings Network which relies on

collaborating communities and fishers to report marine mammal fatalities. When a dead dugong is reported, CMMCP staff members will try to obtain information about the health of the specimen and cause of death to identify and monitor threats to marine mammals (CMMCP 2023)

- **Conservation and Anti-Trawling Structures (CANTS):** Marine Conservation Cambodia initiated the deployment of CANTS in Kep province's Marine Fisheries Management Area (MFMA) since the establishment of the region's first MFMA in 2018. These structures, also known as 'blocks,' are designed to encourage water flow, support filter feeder growth, and restore habitats damaged by bottom trawling. Communities in Kep and Kampot have actively participated in constructing and deploying these structures since 2018. The project aims to address the severe impacts of illegal destructive fishing by deploying 47 CANTS and demarcating the boundaries of the MFMA. The CANTS not only act as deterrent to illegal trawling, but also function as artificial reefs and support oyster cultivation, fostering economic opportunities for local communities.
- **The Marine Harvesting Network Project (MHN)** was set up to monitor fishing pressure within the Kep MFMA and to promote and protect small-scale and sustainable fishing practices. Not only can the MHN Project update the government on the status of these fishing activities, but can also help to strategies enforcement, conservation measures, and marine protected area management.
- **The Cambodian Seagrass Conservation Project (CSCP)** aims to conserve, protect, and expand seagrass meadows in Cambodia's coastal waters, benefiting local communities dependent on seagrass-related resources. The project, operating within the MFMA, evaluates habitat destruction and identifies key areas for protection using CANTS. The project involves underwater surveys to monitor seagrass meadow size, species distribution, and abundance, along with carbon sequestration surveys and social assessments, contributing to seagrass-specific management strategies and conservation efforts.
- **Outreach Project (Rolloc Samleng)** provides marine ecology education to local schools in the Kep community. Rolloc Samleng conducts interactive sessions covering various marine topics, using art as a medium to enhance accessibility. Field trips to Koh Ach Seh offer students a firsthand experience of the underwater world, and marine survey techniques, fostering a deeper connection with marine ecosystems.

6.5.3.6 Vietnam

Over 50% of Vietnam's seagrass meadows are found within existing MPAs, but the level of protection is generally unspecified (Sudo et al. 2021). The country's 270,000-hectares of MPA have been approved for biodiversity conservation plans. Nonetheless, seagrasses in Vietnamese MPAs have reduced, a situation attributed to tourism development in the adjacent coastal areas (Tin et al. 2023):

- Key MPAs like Ly Son, Nha Trang, and Phu Quoc act as biodiversity conservation centres, playing important roles in resource management and are often used as demonstrated examples for other protected areas in the country (Ngoc 2018). Several alternative livelihood projects have been initiated by government agencies in Vietnam, such as the Ministry of Agriculture and Rural Development, as well as foreign donors like WWF and DANIDA as a result of these MPAs (Ngoc 2018). Tourism development is a key accompanying strategy in the creation of alternative livelihoods, though in the case of Nha Trang Bay, the industry is yet to bring economic wellbeing to the communities surrounding the MPA (Pham-Do and Pham 2020). Nonetheless, the rise of ecotourism has been a key driver for indirect dugong conservation (Quy et al. 2022). Supported by substantial infrastructure investments since 2012, ecotourism has not only stabilized the local economy but also fosters social equality, environmental awareness, and the preservation of cultural and natural resources (Prime Minister of Vietnam 2004).
- **Community Education and Involvement:** Hines et al. (2008) conducted interviews to improve locally based dugong surveys, as well as understanding community perspectives and recommendations for supporting conservation strategies. In addition, various local and international NGOs such as Wildlife at Risk (WAR), WWF, FFI, IUCN Vietnam have conducted education campaigns to raise awareness on dugong conservation, with focus on the laws that protect the species and legal consequences of dugong hunting. CBES and Con Dao National Park has formed a dugong and cetacean stranding rescue group in Con Dao (L. Vu, personal communication 2024).

6.6 Conservation status

The IUCN classifies the dugong as Vulnerable a global scale (Marsh and Sobztick 2019) but has not made any subregional assessments in the Continental Southeast Asian region. The status of the dugong in individual Range States indicates high levels of concern:

- Myanmar: 'Completely Protected Animal'.

- Thailand: Only marine species on the list of 'Preserved species' issued under the *WARPA*;
- Malaysia: Totally protected and listed as a Marine Endangered Species within the *Fisheries (Control of Endangered Species of Fish) Regulations Amendment (2008)* that is contained within the *Fisheries Act 1985*.
- Singapore: 'Critically Endangered' on the Red List of Threatened Animals of Singapore (SG101 2022).
- Cambodia: 'Critical Endangered Marine Species' by *Sub-Decree No. 123* (Cambodia, Ministry of Information 2020).
- Vietnam: 'Critically Endangered' listed in The Red Data Book.

6.7 Research and monitoring

Historical documents, interviews with fishers, boat surveys, feeding trails, aircraft (fixed wing, helicopter, and UAVs) and acoustic surveys have been used to obtain information distribution, abundance and population trends as outlined in Section 6.2. Section 6.1.3 summarises the results of the research on dugong genetics. Table 6.2 summarises additional research initiatives in the Region.

Table 6.2. Research into dugong biology conducted in Continental Southeast Asia and not discussed in this chapter. See also Panyawai and Prathep (2022).

Topic	References
Age determination	Adulyanukosol (1998); Cherdsookjai et al. (2020).
Captive behavior and rearing	Adulyanukosol and Bhatiyasevi (1994); Adulyanukosol (1997); Adulyanukosol et al. (2004).
Elemental composition of dugong tusks	Nganvongpanit et al. (2017).
Feeding behavior and diet	Adulyanukosol and Thongsukdee. (2003); Adulyanukosol et al. (2010b); Tsutsumi et al. (2006); Heng et al. (2022).
Morphological and morphometric studies	Nganvongpanit et al. (2020).
Reproductive behavior	Adulyanukosol et al. (2007); Infantes et al. (2020).
Interactions between dugongs and other organisms (including humans)	Nakaoka and Aioi (1999); Nakaoka et al. (2002, 2005); Nakanishi et al. (2006); Rajamani and Marsh (2010); Juraji et al. (2018); Geraldine (2019).
Vocalizations	Ichikawa et al. (2003, 2006, 2009, 2010, 2012); Sakamoto et al. (2005); Shiraki et al. (2009); Tanaka et al. (2017, 2023).

6.8 Regional summary

In the Continental Southeast Asian region, dugongs face significant challenges, primarily from incidental bycatch, habitat loss and degradation. Although instances of direct hunting have diminished in recent years, the remaining threats continue to pose a serious risk to dugong survival. The underlying causes of these threats vary across Range States, but are usually related to inadequate law enforcement, coastal development, and poverty. The complex laws in each of the Range States are rarely implanted effectively outside Singapore. Research efforts within Continental Southeast Asia are often limited by funding constraints and a lack of capacity.

The status of dugongs in the region remains data deficient, despite efforts by many researchers and NGOs. Dugongs persist in fragmented, relatively small populations in recognized areas of local importance outlined in Table 6.3 below. The ongoing persistence of the dugong in the region will depend on evidence-based, conservation management of dugongs and their habitats in as many of these areas as possible. The Andaman coast of Thailand and the east coast of Johor in Peninsular Malaysia are the only locations with confirmed populations ranging from tens to hundreds of dugongs. Effective protection of these populations is particularly important.

The largest knowledge gaps are: (1) the inadequate mapping of seagrass in most areas, particularly Myanmar, (2) the lack of quantitative data about most of the dugong populations in the Continental Southeast Asian region, and (3) the lack of understanding of their contemporary transboundary movements.

The extent of gene flow between the Andaman Sea and the Gulf of Thailand needs further investigation. A priority should be investigating the genetics of dugongs in the waters of Peninsular Malaysia and Singapore. Extending genetic sampling to other regions of Continental SE Asia where dugongs occur has the potential to provide important insights, especially if this work included whole-genome sequencing of individuals from different localities to estimate heterozygosity, levels of inbreeding and population fluctuations in the region over time.

Fishing activity should be mapped throughout the region to enable the threats posed by fishing efforts to be better understood and the significant risks of bycatch reduced. The human dimensions of dugong interactions with fisheries and coastal development should be a high priority. Given the low numbers of dugongs in most parts of the region, it may be more effective to consider the dugong conservation in the context of the conservation of marine megafauna more generically than to develop specific dugong management plans. Increased attention to transboundary management and the conservation of seagrass meadows known to support dugongs is highly desirable.

Table 6.3. Summary of areas of regional importance in the Continental Southeast Asia region (see Figures 6.1 and 6.3).

Country	Region
Myanmar	Man Aung Island, the Rakhine coast
	Myeik Archipelago, the Tanintharyi coast
	Kan Thar Yar
Cambodia	Koh Kong Island
	Kep Archipelago, and coastal area of Kep Province
	Coastal area of Kampot Province
Vietnam	Côn Đảo Archipelago
	Phú Quốc Island
Thailand	Andaman Sea coast: Krabi (Sri Boya and Pu Islands), Phang-nga (Phra Thong Island, Yao Island, and Phang-nga Bay), Phuket Island (Paklok and Chalong Bays), Ranong (Sai Dam), Satun (Lidee and Sarai Islands), and Trang (Chao Mai and Muk, Libong, and Sukorn Islands)
	Gulf of Thailand coast: Chonburi, Chumphon, and Pattani
Peninsular Malaysia	Mersing Archipelago (especially Sibul Besar, Sibul Tengah, Sibul Kukus and Sibul Hujung Islands, Tinggi Island, Babi Besar Island)
	Western Johor Strait (especially around Pulai River estuary/Gelang Patah) and eastern Johor Strait (Pasir Gudang, Johor River estuary, Pengerang)
Singapore	Pulau Ubin Island, Changi, Tanjung Chek Jawa, Tekong Island in the eastern Johor Straits of Singapore

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6.10 References

- Abraham, H.C. (1924). A note on the occurrence of the duyong in Singapore waters. *The Singapore Naturalist* 1(3), 87.
- Adulyanukosol, K. (1997). Breathing behavior of dugong (*Dugong dugon*) in captivity. *Proceedings of the Seminar on Fisheries*. Royal Thai Department of Fisheries. Bangkok, Thailand. (In Thai).
- Adulyanukosol, K. (1998). Preliminary study on aged determination of dugong (*Dugong dugon*) in Thailand. *Proceedings of the Fourth International Scientific Symposium The role of ocean sciences for sustainable development*. UNESCO/IOC/WESTPAC. Okinawa, Japan. 369-377.

- Adulyanukosol, K. (2002a). Dugong in Phuket Province. *Thai Fish Gazette* 55, 47-50.
- Adulyanukosol, K. (2002b). *Dugong in Thailand and status of dugong in Krabi Province. Technical Paper*. Thailand: Phuket Marine Biological Center.
- Adulyanukosol, K. (2004). *Dugong and conservation of dugong in Thailand. Phuket Marine Biological Center*. Thailand: Department of Marine and Coastal Resources, Ministry of Natural Resources and Environment. (In Thai).
- Adulyanukosol, K. and Bhatiyasevi, O. (1994). Feeding behavior of dugong (*Dugong dugon*) in captivity. *Proceedings of the Seminar on Fisheries*. Royal Thai Department of Fisheries. Bangkok, Thailand. (In Thai).
- Adulyanukosol, K. and Thongsukdee, S. (2003). An observation of dugong behaviors from aerial survey and feeding trails of a cow-calf pair in seagrass habitat. *Journal of Environmental Research: Mahidol University* 1, 112–118. (In Thai).
- Adulyanukosol, K., Chantrapornsy, S. and Poovachlranon, S. (1997). An aerial survey of dugong (*Dugong dugon*) in Andaman Coast, Thailand. *Thai Fish Gazette* 50, 359-374.
- Adulyanukosol, K., Chantrapornsy, S., Poovachlranon, S. and Kittiwattaniwong, K. (1999). *Report on aerial surveys of dugong along the Andaman coast in 1997 and 1999 using the Royal Thai Navy Craft. Technical Paper Phuket Marine Biological Center*. Phuket, Thailand: Department of Fisheries. (In Thai).
- Adulyanukosol, K., Kittiwattanawong, K., Viriyakunpat, K., Prasitthipornkul, A. and Chantharatreeerat, C. (2004). An attempt on rearing a dugong calf (*Dugong dugon*) and its behaviors. *Proceedings of the International Symposium on SEASTAR2000 and Bio-logging Science (The 5th SEASTAR2000 Workshop)*. Bangkok, Thailand. Graduate school of Informatics, Kyoto University. 52-63.
- Adulyanukosol, K., Thongsukdee, S., Hara, T., Arai, N. and Tsuchiya, M. (2007). Observations of dugong reproductive behavior in Trang Province, Thailand: further evidence of intraspecific variation in dugong behavior. *Marine Biology* 151, 1887-1891.
- Adulyanukosol, K., Prasitthipornkul, C., Man-Anansap, S., and Boukaew, P. (2009). Stranding records of dugong (*Dugong dugon*) in Thailand. *Proceedings of the 4th International Symposium on SEASTAR2000 and Asian Bio-logging Science (The 8th SEASTAR2000 workshop)*. Bangkok, Thailand. Graduate school of Informatics, Kyoto University. 51-57.
- Adulyanukosol, K., Hines, E. and Boonyanate, P. (2010a). Cultural significance of dugong to Thai villagers: Implications for conservation. *Proceedings of the 5th International Symposium on SEASTAR2000 and Asian Bio-logging Science (The 9th SEASTAR2000 workshop)*. Bangkok, Thailand. Graduate school of Informatics, Kyoto University. 43-49.
- Adulyanukosol, K., Poovachiranon, S. and Boukaew, P. (2010b). Stomach contents of dugongs (*Dugong dugon*) from Trang Province, Thailand. *Proceedings of the 5th International Symposium on SEASTAR2000 and Asian Bio-logging Science (The 9th SEASTAR2000 workshop)*. Bangkok, Thailand. Graduate school of Informatics, Kyoto University. 51-57.
- Ahmad, Z., Kassim, Z., Ayob, A.F. and Rosli, N.S. (2019). Low altitude drone aerial imagery for dugong sightings: A case study in Pulau Sibul, Johor. *Malayan Nature Journal* 71 (3), 305-310.
- Beasley, I. and Davidson, P. (2007). Conservation status of marine mammals in Cambodian waters, including seven new cetacean records of occurrence. *Aquatic Mammals* 33, 368-379.

- Beasley, I., Davidson, P., Somany, P. and Samanth, L. (2001). *Abundance, distribution and conservation management of marine mammals in Cambodia's coastal waters. Interim Unpublished Report*. Phnom Penh, Cambodia: Wildlife Conservation Society.
- Beffasti, L. (2008). Seagrasses around Lampi and neighbouring islands of the Mergui Archipelago.
- Boonprakob, U., Chantrapornsyl, S. and Bhatia, O. (1983). Occurrence of Dugong (*Dugong dugon*) in coastal waters of Phuket Island and the attempt to keep dugongs in captivity. *The symposium of marine mammals of the Indian Ocean*. Columbo, Sri Lanka, 22-25 February.
- Braun, E., Church, M., Hafid, S. and Hoque Kazi, M. (2023). *The Civil War in Myanmar: 2023 Conflict Diagnostic*. https://www.burmalibrary.org/sites/burmalibrary.org/files/obl/2023-02-06-Carleton-University_Myanmar-Conflict-Diagnostic-2023-en.pdf. Accessed January 3 2024.
- Bujang, J.S., Zakaria, M.H. and Short, F.T. (2018). Seagrass in Malaysia: Issues and Challenges Ahead. In *The Wetland Book*. Finlayson, C., Milton, G., Prentice, R. and Davidson, N. (eds.). Dordrecht, Netherlands: Springer. https://doi.org/10.1007/978-94-007-4001-3_268.
- Bushell, J.B. (2013). *The genetic diversity and population structure of the dugongs (Dugong dugon) of Thailand*. MSc Thesis, San Jose State University, United States of America.
- Cambodia, Ministry of Information (2020). Chrouk Toeuk Remains in Cambodia's Sea, 5 July. <https://www.information.gov.kh/articles/2464>. Accessed 06 March 2024.
- Cambodian Marine Mammal Conservation Project [CMMCP] (2023). *Report of dugong presence (Dugong dugong) in Kep and Kampot*. Cambodian Marine Mammal Project unpublished report.
- Cherdsukjai, P., Buddhachat, K., Brown, J., Kaewkool, M., Poommouang, A., Kaewmong, P., Kittiwattanawong, K. and Nganvongpanit, K. (2020). Age relationships with telomere length, body weight and body length in wild dugong (*Dugong dugon*). *PeerJ* 11(8), e10319. <https://doi.org/10.7717/peerj.10319>. PMID: 33240643; PMCID: PMC7666544.
- Cox, N. (2002). Observations of the dugong *Dugong dugon* in Con Dao National Park, Vietnam, and recommendations for further research. Unentitled Report.
- Crandall, E.D., Riginos, C., Bird, C.E., Liggins, L., Trembl, E., Beger, M., Barber, P.H., Connolly, S.R., Cowman, P.F. and DiBattista, J.D. (2019). The molecular biogeography of the Indo-Pacific: Testing hypotheses with multispecies genetic patterns. *Global Ecology and Biogeography* 28, 943-960.
- Department of Marine and Coastal Resources [DMCR] (2011). *The status of Thai marine endangered animals*. Thailand: DMCR, Ministry of Natural Resources and Environment.
- DMCR. (2018). *The status of Thai marine endangered animals*. Thailand: DMCR, Ministry of Natural Resources and Environment.
- DMCR. (2019a). *The causes of dugong strandings in 2019*. Thailand: DMCR, Ministry of Natural Resources and Environment.
- DMCR. (2019b). *The marine endangered species stranding in Thailand*. Thailand: DMCR, Ministry of Natural Resources and Environment.
- DMCR (2024) Geo-information data center for marine and coastal, 2024. Available online: <https://marinemap.dmcr.go.th/>. Accessed 23 March 2024.
- Dugong and Seagrass Hub. *Thailand: Save Andaman Network Foundation (SAN)*. <https://www.dugongseagrass.org/projects/seagrass-ecosystem-services-project/thailand/>. Accessed 4 March 2024.

Ezekiel, A. (2018). Review of Marine Wildlife Protection Legislation in ASEAN. Petaling Jaya, Selangor, Malaysia: TRAFFIC.

Fabinyi, M., Belton, B., Dressler, W.H., Knudsen, M., Adhuri, D.S., Aziz, A.A., Akber M.A., Kittitornkool, J., Kongkaew, C., Marschke, M., Pido, M., Stacey, N., Steenbergen, D.J. and Vandergeest, P. (2022). Coastal transitions: Small-scale fisheries, livelihoods, and maritime zone developments in Southeast Asia. *Journal of Rural Studies* 91, 184-194.

Fauna and Flora International (FFI) (2015). *Building capacity for community-based marine conservation in Myanmar: Final technical report to Lighthouse*. FFI and Lighthouse Foundation.

Geraldine A (2019) Nicky, the friendly dugong, 18 February. <https://www.nst.com.my/news/nation/2019/02/461123/nicky-friendly-dugong>. Accessed 23 March 2024.

Gibson-Hill, C.A. (1950) The dugong. *Malayan Naturalist Journal* 5,25–29.

Hashim, M., Ito, S., Numata, S., Hosaka, T., Hossain, M.S., Misbari, S., Yahya, N.N. and Ahmad, S. (2017). Using fisher knowledge, mapping population, habitat suitability and risk for the conservation of dugongs in Johor Straits of Malaysia. *Marine Policy* 78, 18-25.

Heng, H.W., Ooi, J.L. and Ponnampalam, L. (2019). GEF DSCP Project MY4 Final Report, Attachment 3: External Report – Seagrass mapping & dugong feeding ecology surveys. In *A Multi-Pronged Approach in Overcoming Knowledge Barriers on the Ecology and Status of Dugongs in Johor – Towards Critical Habitat Protection (MY4-2114)*. Final report submitted to the Global Environment Facility (GEF) Dugong and Seagrass Conservation Project (DSCP). Ponnampalam, L.S., and Fairul Izmal, J. (eds.). GEF and DSCP.

Heng, H.W., Ooi, J.L., Affendi, Y.A., Kee Alfian, A.A. and Ponnampalam, L.S. (2022). Dugong feeding grounds and spatial feeding patterns in subtidal seagrass: A case study at Sibuluan Archipelago, Malaysia. *Estuarine, Coastal and Shelf Science* 264, 107670. <https://doi.org/10.1016/j.ecss.2021.107670>

Hines, E. (2012). Dugongs in Asia. In *Sirenian conservation: Issues and strategies in developing countries*. Hines, E.M., Reynolds III, J.E., Aragones, L.V., Mignucci-Giannoni, A.A. and Marmontel, M. (eds.). Gainesville, Florida: University Press of Florida. Chapter 7. 58-75.

Hines, E., Adulyanukosol, K., Charuchinda, M., Somany, P. and Sam Ath, L. (2004). *Conservation of dugongs (Dugong dugon) along the Eastern Gulf of Thailand in Thailand and Cambodia*. Unpublished Report. Frenchs Forest, Australia: Ocean Park Conservation Foundation, Hong Kong, China and Project Aware.

Hines, E.M., Adulyanukosol, K. and Duffus, D.A. (2005). Dugong (*Dugong dugon*) abundance along the Andaman coast of Thailand. *Marine Mammal Science* 21(3), 536-549.

Hines, E., Adulyanukosol, K., Somany, P., Ath, L.S., Cox, N., Boonyanate, P. and Hoa, N.X. (2008). Conservation needs of the dugong, *Dugong dugon* in Cambodia and Phu Quoc Island, Vietnam. *Oryx* 42(1), 113-121.

Hines, E., Ponnampalam, L.S., Junchompoo, C., Peter, C., Vu, L., Huynh, T., Caillat, M., Johnson, A.F., Minton, G., Lewison, R.L. and Verutes, G.M. (2020). Getting to the bottom of bycatch: a GIS-based toolbox to assess the risk of marine mammal bycatch. *Endangered Species Research* 42, 37-57.

Ho, N.A., Ooi, J.L., Affendi, Y.A. and Chong, V.C. (2018). Influence of habitat complexity on fish density and species richness in structurally simple forereef seagrass meadows. *Botanica Marina* 61(6), 547-557.

- Hossain, M.S., Bujang, J.S., Zakaria, M.H. and Hashim, M. (2015). Application of Landsat images to seagrass areal cover change analysis for Lawas, Terengganu and Kelantan of Malaysia. *Continental Shelf Research* 110, 124-148.
- Ichikawa, K., Akamatsu, T., Shinke, T., Arai, N., Hara, T. and Adulyanukosol, K. (2003). Acoustical analyses on the calls of dugong. *Proceedings of the 4th SEASTAR 2000 Workshop*. 72-76.
- Ichikawa, K., Tsutsumi, C., Arai, N., Akamatsu, T., Shinke, T., Hara, T. and Adulyanukosol, K. (2006). Dugong (*Dugong dugon*) vocalization patterns recorded by automatic underwater sound monitoring systems. *The Journal of the Acoustical Society of America* 119(6), 3726-3733.
- Ichikawa, K., Akamatsu, T., Shinke, T., Sasamori, K., Miyauchi, Y., Abe, Y., Adulyanukosol, K. and Arai, N. (2009). Detection probability of vocalizing dugongs during playback of conspecific calls. *The Journal of the Acoustical Society of America* 126(4), 1954-1959.
- Ichikawa, K., Akamatsu, T., Arai, N., Shinke, T. and Adulyanukosol, K. (2010). Spatial distribution of dugongs by acoustic and visual observation in Thailand. *Proceedings of the 5th International Symposium on SEASTAR2000 and Asian Bio-logging Science (The 9th SEASTAR2000 workshop)* Bangkok, Thailand. Graduate school of Informatics, Kyoto University. 39-42.
- Ichikawa, K., Akamatsu, T., Shinke, T., Arai, N. and Adulyanukosol, K. (2012). Clumped distribution of vocalising dugongs (*Dugong dugon*) monitored by passive acoustic and visual observations in Thai waters. *Proceedings of Acoustics*. 130-133.
- Ilankoon, A.D. and Tun, T. (2007). Rediscovering the dugong (*Dugong dugon*) in Myanmar and capacity building for research and conservation. *The Raffles Bulletin of Zoology* 55(1), 195-199.
- Infantes, E., Cossa, D., Stankovic, M., Panyawai, J., Tuntiprapas, P., Daochai, C. and Prathep, A. (2020). Dugong (*Dugong dugon*) reproductive behaviour in Koh Libong, Thailand: observations using drones. *Aquatic Mammals* 46(6), 603-608.
- IUCN (2021). Integrating science, traditional knowledge, tourism and education to strengthen coastal resilience in Krabi, Thailand, July 21. https://www.iucn.org/news/asia/202107/integrating-science-traditional-knowledge-tourism-and-education-strengthen-coastal-resilience-krabi-thailand?fbclid=IwAR279yMC79b563FaKAAptYPNzClSu3oXbRs_n19ubL8-77vsU6IGeqsIV8o. Accessed 4 March 2024.
- IUCN-MMPATF. IMMA Searchable Database. Marine Mammal Protected Areas Task Force (MMPATF) Website. <https://www.marinemammalhabitat.org/immas/immas-searchable-database/>. Accessed 11 March 2024.
- IUCN-MMPATF (2022a). Con Dao. IMMA Brochure. IUCN Joint SSC/WCPA Marine Mammal Protected Areas Task Force, 2022. PDF made available for download at <https://www.marinemammalhabitat.org/>. Accessed 12 March 2024.
- IUCN-MMPATF (2022b). Kien Giang and Kep Archipelago. IMMA Brochure. IUCN Joint SSC/WCPA Marine Mammal Protected Areas Task Force, 2022. PDF made available for download at <https://www.marinemammalhabitat.org/>. Accessed 12 March 2024.
- IUCN-MMPATF (2022c). Mersing Archipelago. IMMA Brochure. IUCN Joint SSC/WCPA Marine Mammal Protected Areas Task Force, 2022. PDF made available for download at <https://www.marinemammalhabitat.org/>. Accessed 12 March 2024.
- Juraj, M.E., Khaifin, M.A., Izaak, W.G., Pumpun, Y.K., Mahfud, Sailana, J., Hainun, E.A. and Relly, Y. (2018). *Survey of dugong bioecology and behavior in Sap of Pantar Strait and surroundings sea Alor Regency, East Nusa Tenggara*. GEF Dugong and Seagrass Conservation Project.

http://www.dugongconservation.org/media/2018/10/Report_Bioecology-and-Behaviour-of-Dugong-as-Recommendation-for-Responsible-Dugong-Tourism.pdf. Accessed 24 March 2024.

Khogkhaio, C., Hayashizaki, K-I., Tuntiprapas, P. and Prathep, A. (2017). Changes in seagrass communities along the runoff gradient of the Trang River, Thailand. *Science Asia* 43(6), 339-346. <https://doi.org/10.2306/scienceasia1513-1874.2017.43.339>.

Lai, S., Loke, L.H., Hilton, M.J., Bouma, T.J. and Todd, P.A. (2015). The effects of urbanisation on coastal habitats and the potential for ecological engineering: a Singapore case study. *Ocean and Coastal Management* 10, 78–8.

Leng, P., Benbow, S. and Mulligan, B. (2014). Seagrass diversity and distribution in the Koh Rong Archipelago, Preah Sihanouk Province, Cambodia. *Cambodian Journal of Natural History* 1, 37–46.

Leng, P., Benbow, S., Mulligan, B. and Ouk, V. (2015). Filling data gaps for Cambodian marine habitats: seagrass diversity and distribution in the Koh Rong Archipelago. *Cambodian Journal of Natural History* 1, 17-17.

Mangroves for the Future (2013a). *Cambodia national strategy and action plan 2014–2016*. Phnom Penh, Cambodia: Ministry of Environment and Mangroves for the Future.

Mangroves for the Future (2013b). *Community Management of Seagrass Conservation Area of Phra Thong Island*. Thailand: MFF and United Nations Development Programme (UNDP).

Mansor, M.L., Ahmad, A., Kushairi, M.R. and Marsh, H. (2000). Dugongs in Peninsular Malaysia. *FRI News* 5, 18.

Marsh, H. (2022). *Options for handling a stranded orphaned dugong calf: Advice to policy makers and managers*, CMS Technical Series No. 44. Abu Dhabi, United Arab Emirates: Coordinating Unit of the CMS Dugong MOU.

Marsh, H. and Sobtzick, S. (2019). Dugong dugon (amended version of 2015 assessment). The IUCN Red List of Threatened Species 2019: e.T6909A160756767. <https://doi.org/10.2305/IUCN.UK.2015-4.RLTS.T6909A160756767.en>. Accessed 3 January 2024.

Marsh, H., Penrose, H., Eros, C. and Hughes, J. (2002). *Dugong status report and action plans for countries and territories: Early warning and assessment report series* (UNEP/DEWA/RS.02-1). United Nations Environment Programme.

Mason, F. and Theobald, W. (1882). *Burma, Its People and Productions; or, Notes on the Fauna, Flora, and Minerals of Tenasserim, Pegu, and Burma*. *Geology, Mineralogy, and Zoology Vol. 1*. Hertford, UK: Stephen Austin & Sons.

McGowen, M.R., Vu, L., Potter, C.W., Tho, T.A., Jefferson, T.A., Kuit, S.H., Abdel-Raheem, S.T. and Hines, E. (2021). Whale temples are unique repositories for understanding marine mammal diversity in Central Vietnam. *Raffles Bulletin of Zoology* 69, 481-496.

McKenzie, L.J. and Yoshida, R.L. (2006). SOS Malaysia. In *Seagrass-Watch Magazine*. McKenzie, L.J., Yoshida, R.L. and Mellors, J.E. (eds.). Cairns, Australia: Seagrass-Watch HQ. 16.

McKenzie, L.J., Yoshida, R.L. and Langlois, L. (2023). *IKI SES Project. Report to Edith Cowen University of activities conducted by Seagrass-Watch for the “Conservation of biodiversity, seagrass ecosystems and their services – safeguarding food security and resilience in vulnerable coastal communities in a changing climate”*. Clifton Beach, Australia.

Nakanishi, Y., Hosoya, S., Arai, N., Nakanishi, Y., Katsukoshi, K. and Adulyanukosol, K. (2006). The distribution of seagrass meadows and dugong feeding trails in the dry season around Talibong

Island, Trang Province, Thailand. In *Proceedings of the 3rd International Symposium on SEASTAR2000 and Asian Bio-logging Science (The 7th SEASTAR2000 workshop)*. Bangkok, Thailand. Graduate school of Informatics, Kyoto University. 55-62.

Nakaoka, M. and Aioi, K. (1999). Growth of seagrass *Halophila ovalis* at dugong trails compared to existing within-patch variation in a Thailand intertidal flat. *Marine Ecology Progress Series* 184, 97-103.

Nakaoka, M., Mukai, H. and Chunhabundit, S. (2002), Impacts of dugong foraging on benthic animal communities in a Thailand seagrass bed. *Ecological Research* 17, 625-638.
<https://doi.org/10.1046/j.1440-1703.2002.00520.x>.

Nateekanjanalarp, S. and Sudara, S. (1994). Dugong protection awareness: An approach for coastal conservation. *Proceedings, Third ASEAN Australia Symposium on Living Coastal Resources, Vol. 2: Research Papers*. Sudara, S., Wilkinson, C.R. and Chou, L.M. (eds.). Bangkok, Thailand. Chulalongkorn University. 515-525.

Nelson, V. (1999). *The coastal zone of Cambodia – Current status and threats: Volumes I and II*. Unpublished report for the Ministry of Environment and DANIDA.

Ng, H.H., Tan, H.H., Lim, K.K.P., Ludt, W.B. and Chakrabarty, P. (2015). Fishes of the eastern Johor Strait. *Raffles Bulletin of Zoology* 31, 303–337.

Ng, S.Z., Ow, Y.X. and Jaafar, Z. (2022a). Dugongs (*Dugong dugon*) along hyper-urbanized coastlines. *Frontiers of Marine Science* 9,947700.
<https://www.frontiersin.org/articles/10.3389/fmars.2022.947700>.

Ng, S.Z., Ow, Y.X. and Jaafar, Z. (2022a). Corrigendum: Dugongs (*Dugong dugon*) along hyper-urbanized coastlines. *Frontiers of Marine Science* 9,947700.
<https://www.frontiersin.org/articles/10.3389/fmars.2022.947700>.

Nganvongpanit, K., Buddhachat, K., Piboon, P., Euppayo, T., Kaewmong, P., Cherdsookjai P., Kittiwatanawong, K. and Thitaram, C. (2017). Elemental classification of the tusks of dugong (*Dugong dugong*) by HH- XRF analysis and comparison with other species. *Scientific Reports* 7,46167.
<https://doi.org/10.1038/srep46167>.

Nganvongpanit, K., Cherdsookjai, P., Boonsri, B., Buddhachat, K., Kaewmong, P. and Kittiwatanawong, K. (2020). Pelvic bone morphometric analysis in the dugong (*Dugong dugon*). *Scientific Reports* 10.
<https://doi.org/10.1038/s41598-020-76545-w>.

Ngoc, Q.T. (2018). Impacts on the ecosystem and human well-being of the marine protected area in Cu Lao Cham, Vietnam. *Marine Policy* 90, 174-184. <https://doi.org/10.1016/j.marpol.2017.12.015>.

Nguyen, X-V., Phan, T.T., Cao, V-L., Nguyen Nhat, N-T., Nguyen, T-H., Nguyen, X-T., Lau, V-K., Hoang, C-T., Nguyen-Thi, M-N., Nguyen, H.M., Dao, V-H., Teichberg, M. and Papenbrock, J. (2022). Current advances in seagrass research: A review from Viet Nam. *Frontiers in Plant Science*, 13.

Novak, A.B., Hines, E., Kwan, D., Parr, L., Than Tun, M., Win, H. and Short, F.T. (2009). Revised ranges of seagrass species in the Myeik Archipelago, Myanmar. *Aquatic Botany* 91(3), 250-252.

Ooi, J. L., Kendrick, G.A., Van Niel, K.P. and Affendi, Y.A. (2011). Knowledge gaps in tropical Southeast Asian seagrass systems. *Estuarine, Coastal and Shelf Science* 92(1), 118-131.

Palmer, D.R. (2004). *Phylogeography and population genetic structure of the dugongs in Thailand*. MSc Thesis, San Jose State University.

Panyawai, J. and Prathep, A. (2022). A systematic review of the status, knowledge, and research gaps of dugong in Southeast Asia. *Aquatic Mammals* 48(3): 203-222.

- Panyawai, J. and Prathep, A. (2022). A systematic review of the status, knowledge, and research gaps of dugong in Southeast Asia, Supplementary Material. *Aquatic Mammals*, 48(3), 203-222.
- Perrin W.F., Reeves, R.R., Polar, M.L., Jefferson, T.A., Marsh, H., Wang, J.Y. and J. Estación, J. (2005). *Report of the Second Workshop on the Biology and Conservation of Small Cetaceans and Dugongs of South East Asia*. Perrin, W.F. and Reeves, R.R. (eds.). UNEP-CMS.
- Pham-Do, K.K. and Pham, T.T. (2020). Tourism in marine protected areas: A view from Nha Trang Bay, Vietnam. *Tourism Management Perspectives* 33, 100623. <https://doi.org/10.1016/j.tmp.2019.100623>.
- Plön, S., Thakur, V., Parr, L. and Lavery, S.D. (2019). Phylogeography of the dugong (*Dugong dugon*) based on historical samples identifies vulnerable Indian Ocean populations. *PLoS One* 14(9). <https://doi.org/10.1371/journal.pone.0219350>.
- Pomeroy, R.S. (2012). Managing overcapacity in small-scale fisheries in Southeast Asia. *Marine Policy* 36(2), 520-527.
- Poommouang A, Kriangwanich, W., Buddhachat, K., Brown, J.L., Piboon, P., Chomdej, S., Kampuansai, J., Mekchay, S., Kaewmong, P., Kittiwattanawong, K. and Nganvongpanit, K. (2021). Genetic diversity in a unique population of dugong (*Dugong dugon*) along the sea coasts of Thailand. *Scientific Reports* 11, 11624. <https://doi.org/10.1038/s41598-021-90947-4>.
- Poommouang, A.P. Piboon, K. Buddhachat, J.L. Brown, W. Kriangwanich, S. Chomdej, J. Kampuansai, S. Mekchay, P. Kaewmong and Kittiwattanawong, K. (2022). Microsatellite Polymorphism and the Population Structure of Dugongs (*Dugong dugon*) in Thailand. *Animals* 12(3), 235.
- Ponnampalam, L.S. (2017). *A Three-Pronged Approach for Overcoming Knowledge Barriers on the Ecology and Status of Dugongs in Johor, Malaysia – towards Critical Habitat Protection. Narrative Report #3: Year 3 (Final) Progress Report of PEW Fellowship in Marine Conservation (2014 – 2017)*. Report submitted to The PEW Charitable Trusts. (In prep).
- Ponnampalam, L.S., Izmal, J.F., Adulyanukosol, K., Ooi, J.L., and Reynolds III, J.E. (2015). Aligning conservation and research priorities for proactive species and habitat management: the case of dugongs *Dugong dugon* in Johor, Malaysia. *Oryx* 49(4), 743-749.
- Ponnampalam L.S, Keith-Diagne L., Marmontel M., Marshall, C., Reep, R.L., Powell, J. and Marsh, H. (2022). Historical and current interactions with humans. In *Ethology and Behavioral Ethology of Sirenia*. Marsh, H. (ed.). Cham: Springer. Chapter 7. 299-349.
- Prime Minister of Vietnam (2004). Scheme for the comprehensive development of Phu Quoc Island, Kien Giang Province to 2010 and vision to 2020. Decision No. 178/2004/QĐ-TTg. October 5. Accessed 23 March 2024.
- Quang, V.V., Ben, H.X., Vy, N.X. and Cox, N.J. (2005). *Conservation of the Dugong (Dugong dugon) in Phu Quoc Islands, Vietnam*. A report for BP conservation programme.
- Quyêt, L.V., Duy, P.T. and Toan V.P. (2022). Sustainable development of tourism economy in Phu Quoc Island, Kien Giang Province, Vietnam: Current situation and prospects. *IOP Conference Series: Earth and Environmental Science* 1028, 012005. <https://doi.org/10.1088/1755-1315/1028/1/012005>.
- Raffles, T.S. (1821). Some account of the dugong. In *The Philosophical Magazine and Journal: Comprehending the various branches of science, the liberal and fine arts, geology, agriculture, manufactures, and commerce*. Tilloch, A. (ed.). London. 341-346

- Rajamani, L. and Marsh, H. (2010). Using parallel regional- and local-scale initiatives to inform conservation management of rare wildlife: a case study of the dugong *Dugong dugon* in Sabah, Malaysia. *Endangered Species Research* 13(1), 17-23. <http://dx.doi.org/10.3354/esr00310>.
- Rattanachot, E., Stankovic, M., Aongsara, S. and Prathep, A. (2018). Ten years of conservation efforts enhance seagrass cover and carbon storage in Thailand. *Botanica Marina* 61. <https://doi.org/10.1515/bot-2017-0110>.
- Rojchanaprasart, N., Tongnunui, P. and Tinnungwattana, W. (2014). Comparison between traditional ecological knowledge of coastal villagers in Thailand and scientific ecological knowledge regarding dugong. *Kasetsart Journal - Social Sciences* 35, 368-377.
- Sakamoto, S., Ichikawa, K., Adamatsu, T., Shinke, T., Arai, N., Hara, T. and Adulyanukosol, K. (2005). Effect of ship sounds on the vocal behavior of dugongs. *Proceedings of the 3rd International Symposium on SEASTAR2000 and Asian Bio-logging Science (The 7th SEASTAR2000 workshop)*. 69-75.
- Sani, D.A. and Hashim, M. (2019). Satellite-based mapping of above-ground blue carbon storage in seagrass habitat within the shallow coastal water. *International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences XLII-4/W16*, 587-593.
- Schiavina, M., Freire, S., Carioli, A. and MacManus, K. (2023). GHS-POP R2023A - GHS population grid multitemporal (1975-2030). European Commission, Joint Research Centre (JRC).
- SG101 (2022). Dugongs, 30 November. <https://www.sg101.gov.sg/resources/connexionsg/dugongs/>. Accessed 4 March 2024.
- Shiraki, R., Ichikawa, K., Shinke, Y., Arai, N., Akamatsu, T., Hara, T. and Adulyanukosol, K. (2009). Development of detection device for dugong calls. *Proceedings of the 4th International Symposium on SEASTAR2000 and Asian Bio-logging Science (The 8th SEASTAR2000 workshop)*. 59–61.
- Short, F., Carruthers, T., Dennison, W. and Waycott, M. (2007). Global seagrass distribution and diversity: a bioregional model. *Journal of Experimental Marine Biology and Ecology* 350(1-2), 3-20.
- Sia, A. (2017). Si Tenang, the little dugong that stole our hearts, 24 June. <https://www.thestar.com.my/lifestyle/living/2017/06/24/si-tenang-little-dugong>. Accessed 23 March 2024.
- Smith, B.D., Jefferson, T.A., Dao T.H., Leatherwood, S., Chu, V.T., Andersen, M. and Chiam, E. (1995). Marine Mammal in Vietnam: A Preliminary Checklist. In *Collection of Marine Research Works*. Vol. VI. 191 – 216.
- Smith, B.D., Jefferson, T.A., Leatherwood, S., Ho, D.T., Thuoc, C.V. and Quang, L.H. (1997). Investigations of marine mammals in Vietnam. *Asian Marine Biology* 14, 145-172.
- Soe-Htun, U., Maung, A., Mon, S., Ha, S.T., Aung, S.T., Lwin, A.M. and Lunn, Z. (2015). *Seagrass Conservation and Monitoring in Myanmar: The biodiversity, distribution and coverage of seagrasses in the Tanintharyi and Rakhine*. Bay of Bengal Large Marine Ecosystem Project [BOBLMEP]. <http://hdl.handle.net/1834/34774>.
- Sudo, K., Quiros, T.E., Prathep, A., Luong, C.V., Lin, H-J., Bujang, J.S., Ooi, J.L., 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. *Frontiers in Marine Science*, 8(779). <https://doi.org/10.3389/fmars.2021.637722>.

- Supanwanid, C. (2001). Status report on seagrasses in Thailand. *Compilation of seagrass reports from participating delegates for the UNEP-WCMC Global Seagrass Workshop*. St Pete's Beach, Florida. 5-9 November 2001. Cambridge, United Kingdom: UNEP/WCMC.
- Supkong, P. and Bourne, L. (2014). *A survey of seagrass beds in Kampot, Cambodia*. Thailand: IUCN.
- Tana, T.S. (1998). *Fisheries report in Kep Ville*. Kep Municipality: Department of Fisheries.
- Tanaka, K., Ichikawa, K., Nishizawa, H., Kittiwattanawong, K., Arai, N. and Mitamura, H. (2017). Differences in vocalisation patterns of dugongs between fine-scale habitats around Talibong Island, Thailand. *Acoustics Australia* 45, 243-251.
- Tanaka, K., Ichikawa, K., Kittiwattanawong, K., Arai, N. and Mitamura, H. (2023). Spatial variation of vocalising dugongs around Talibong Island, Thailand. *Bioacoustics* 32(1), 33-47.
- Teh, L.C. and Pauly, D. (2018). Who brings in the fish? The relative contribution of small-scale and industrial fisheries to food security in Southeast Asia. *Frontiers in Marine Science* 5, 44. <https://doi.org/10.3389/fmars.2018.00044>.
- Tin, H.C., Uyen, N.T., Tu, N.H., Binh, N.H. and Ni, T.N. (2023). Dynamics of seagrass beds and land use-land cover characteristics in Vietnamese Marine protected areas. *Regional Studies in Marine Science* 59, 102794. <https://doi.org/10.1016/j.rsma.2022.102794>.
- Tsutsumi, C., Ichikawa, K., Arai, N., Akamatsu, T., Shinke, T., Hara T. and Adulyanukosol, K. (2006). Feeding behavior of wild dugongs monitored by a passive acoustical method. *Journal of the Acoustical Society of America* 120,1256–1360. <https://doi.org/10.1121/1.2221529>.
- Tubbs, S.E., Baş, A.A., Côté, G., Jones, A.L. and Notman, G. (2019). Sighting and stranding reports of Irrawaddy dolphins (*Orcaella brevirostris*) and dugongs (*Dugong dugon*) in Kep and Kampot, Cambodia. *Aquatic Mammals* 45(5), 563-568.
- Tun, T. (2012). Dugong Information from Lampi Marine National Park in Southern Myanmar. *Proceedings of the 7th International Symposium on SEASTAR2000 and Asian Bio-logging Science (The 11th SEASTAR2000 workshop)*. Bangkok, Thailand. Graduate school of Informatics, Kyoto University. 15-21.
- Tun, T. and Ilangakoon, A.D. (2007). *Assessment of dugong (Dugong dugon) occurrence and distribution in an extended area off the Rakhine coast of western Myanmar*. Unpublished Report to the Society for Marine Mammalogy.
- Tun, T., Ilangakoon, A.D. and Pe, M.T. (2010). Dugong in Man Aung Water, Myanmar. *Proceedings of the 5th International Symposium on SEASTAR2000 and Asian Bio-logging Science (The 9th SEASTAR2000 workshop)*. Bangkok, Thailand. Graduate school of Informatics, Kyoto University. 63-66.
- UNEP/CMS (2011). *Report of the UNEP/CMS Southeast Asia regional meeting on dugongs and workshop on developing standardized analysis protocols for dugong questionnaire survey project data for Southeast Asia region*. United Nations Environment Programme/Convention on Migratory Species.
- UNEP/CMS (2016). *The National Report of Viet Nam*. Abu Dhabi: UNEP/CMS.
- UNEP-WCMC and Short, F.T. (2021) *Global distribution of seagrasses (version 7.1). Seventh update to the data layer used in Green and Short (2003)*. <https://doi.org/10.34892/x6r3-d211>, 2021. Available online: <http://data.unep-wcmc.org/datasets/7>. Accessed 23 March 2024.
- United Nations (2022). World population prospects. (<https://population.un.org/wpp/>). Accessed 17 December 2023.

- United Nations Development Programme [UNDP] (2022). Human Development Index Statistical Annex. United Nations. https://hdr.undp.org/sites/default/files/2023-24_HDR/HDR23-24_Statistical_Annex_HDI_Table.xlsx. Accessed 28 March 2024.
- Van Bree, P.J. and Gallagher M.D. (1977). Catalogue de la collection des mammiferes marin du Museum de Bordeaux. *Annals Society Sciences Naturelles Char-marit* 6, 289-307. (In French).
- Voris, H.K. (2000). Maps of Pleistocene sea levels in Southeast Asia: shorelines, river systems and time durations. *Journal of Biogeography* 27, 1153-1167.
- Vu, L., McGowen, M.R., Potter, C.W., Truong, A.T., Kuit, S.H., Abdel-Raheem, S.T. and Hines E (2020). New records of Fraser's dolphin *Lagenodelphis hosei* from the whale temples and fishing communities of Vietnam. *Aquatic Mammals* 46, 395–401.
- Wipatayotin, A. (2024). 3 dugong deaths so far this year, 9 March. Bangkok Post. <https://www.bangkokpost.com/thailand/general/2755484/3-dugong-deaths-so-far-this-year>. Accessed 23 March 2024.
- The World Bank (2022). GDP (current US\$) *All Countries and Economies*. <https://data.worldbank.org/indicator/NY.GDP.MKTP.CD>. Accessed 8 March 2024.
- World Population Review (2023) *World Population Review*. Accessed 17 December 2023. <https://worldpopulationreview.com/>.
- World Shipping Council (2019). The top 50 container ports. <https://www.worldshipping.org/top-50-ports>. Accessed 2 January 2024.
- Yaakub, S.M., Lim, R.L., Lim, W.L. and Todd, P.A. (2013). The diversity and distribution of seagrass in Singapore. *Nature in Singapore* 6, 105–111.
- Zöckler, C. Delany, S. and Barber, J. (2013). *Scoping paper: Sustainable coastal zone management in Myanmar*. Cambridge, UK: ArcCona Ecological Consultants.
- Zulkifli Poh, A.N. (2009). *Dugong feeding patterns and food preferences in Sg. Pulai, Johor*. BSc thesis. Universiti Malaysia Terengganu, Terengganu, Malaysia.