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marine conservation CAMBODIA

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Technical report for Marine Habitat Monitoring in Kep and Kampot provinces.

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List of abbreviations

HP – *Halodule pinifolia*

HU – *Halodule uninervis*

HO – *Halophila ovalis*

HM – *Halophila minor*

HD – *Halophila decipiens*

EA – *Enhalus acoroides*

TH – *Thalassia hemprichii*

CS - *Cymodocea serrulate*

CR - *Cymodocea rotundata*

SI - *Syringodium isoetifolium*

ha - hectares

FiA – Fisheries Administration

Cfi – Community Fishery

1. Methodology

The objective of this study is to map Kep and Kampot provinces' marine ecosystems using both drone and underwater surveys. The main habitats focused on for this study are seagrass meadows, coral reefs, seaweed, and bivalve beds. Together with the distribution, extent, and indicative species composition of these habitats, we collected data on bathymetry and bottom composition. In total, this survey effort covered more than 62 472 hectares (ha), from 100 drone mapping missions, and 5 826 points surveyed by the scientific team.

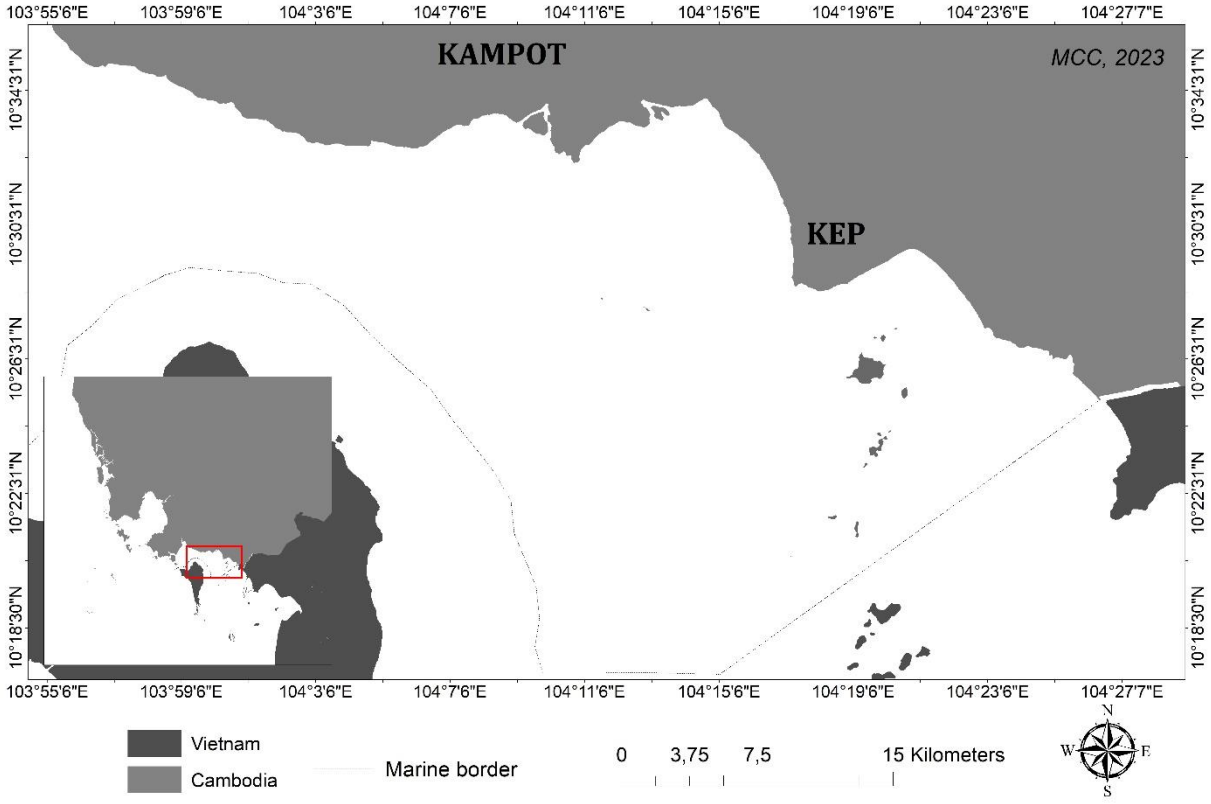

Figure 1: Study area for marine habitat monitoring study.

To produce density maps, a Raster method over a Kernel method was selected as it is more suitable to maintain the level of precision necessary to display in maps. Kernel density is useful to smooth out the transition between areas with different densities and create interpolation. However, locations with important density variation could be either replaced or would not stand out in the final map. A Raster density was selected to be able to highlight these smaller patches of seagrass scattered in the meadow.

2. Kep Province Results

2.1. General overview

To study this area, the scientific team implemented a free diving spot check methodology recording habitat composition, diversity, density, bathymetry, bottom composition, noticeable events, and traces of human activities. In Kep province, the team performed **3 659 individual spot checks** for a **total study area of 35 820 ha**.

To complete this data collection, our drone team performed **20 drone missions, for a total of 55 drone flights**. These flights collected data on marine habitats in coastal shallow waters (difficult to reach by boat) and assessed the extent of the Archipelago's fringing corals reefs for higher precision.

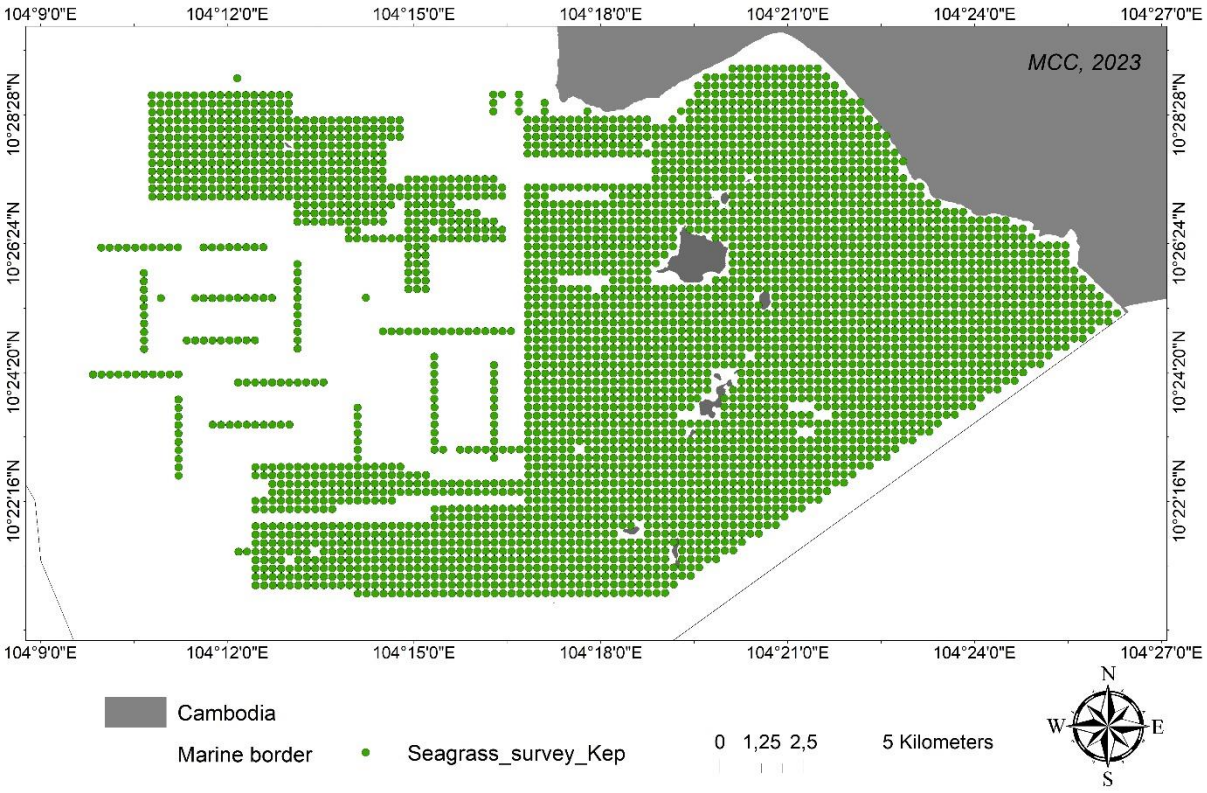

Figure 2: Survey effort, Kep Province - overview

The extent of each marine habitats was evaluated as follows:

- **Seagrass meadows**: 6 399 ha
- **Seaweed beds**: 1 202 ha
- **Bivalves beds**: 440 ha
- **Coral reefs**: 65 ha

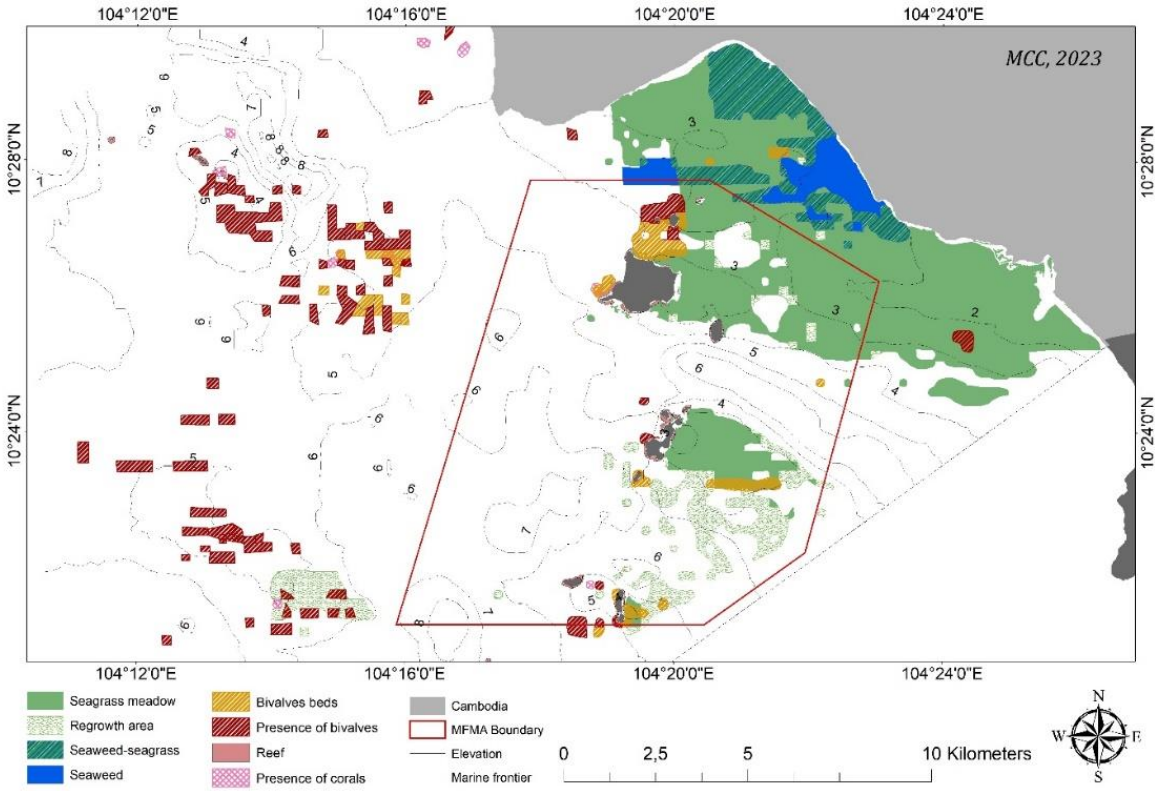

Figure 3: Marine habitats composition and distribution, Kep Province - overview

Kep Province is by far the smallest of the 4 Cambodian coastal provinces. But despite this characteristic, it hosts **the largest seagrass habitat in Cambodia**, with **6 399 ha of seagrass** recorded during this study. It is also **the most diverse**, together with Kampot meadows, since the species richness of the Kep archipelago meadows is 10 seagrass species:

- *Thalassia hemprichii (TH)*
- *Enhalus acoroides (EA)*
- *Cymodocea serrulate (CS)*
- *Cymodocea rotundata (CR)*
- *Halodule pinifolia (HP)*
- *Halodule uninervis (HU)*
- *Halophila ovalis (HO*
- *Halophila decipiens (HD)*
- *Halophila minor (HM)*
- *Syringodium isoetifolium (SI)*

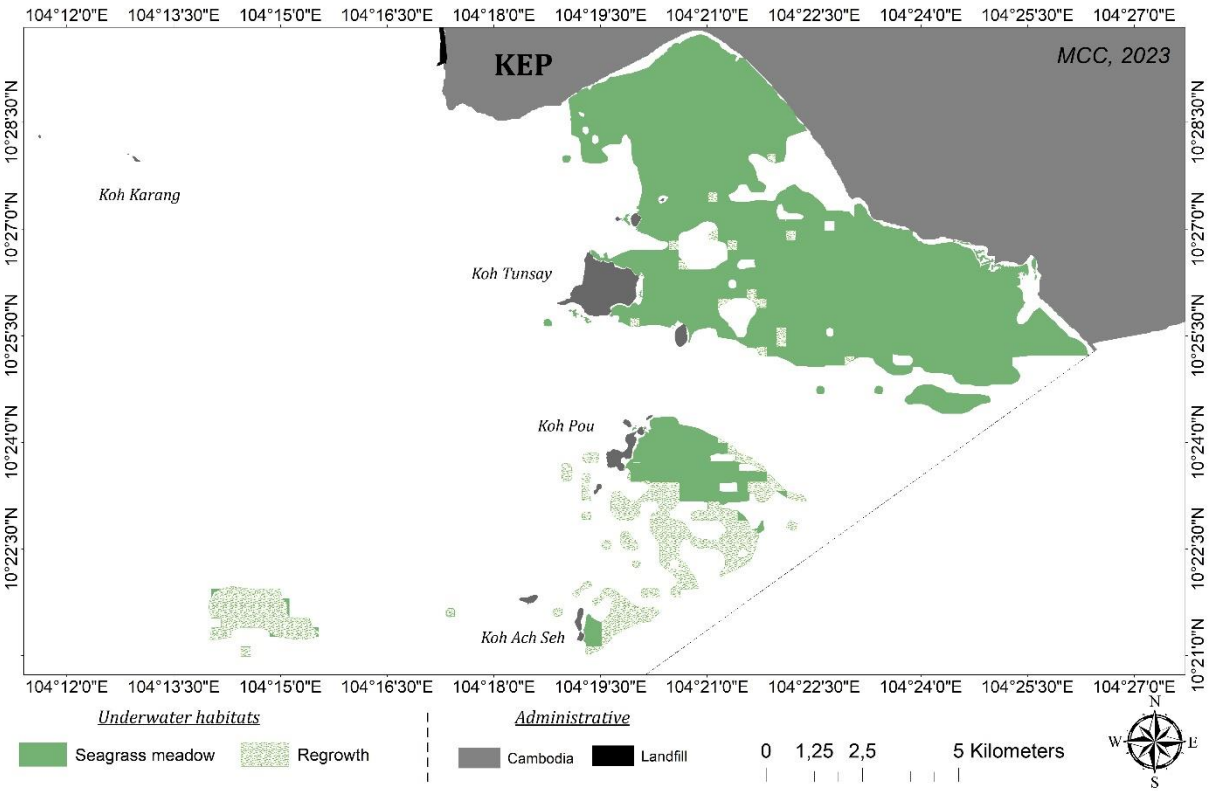

Figure 4: Seagrass meadows recovery, Kep Province

This map highlights the areas where our team recorded the presence of **pioneer seagrass species** (*Halophila spp.*) known to settle on available substrate before the establishment of other seagrass species (Razalli et al., 2011; Liu and Hsu, 2021). The research team discovered patches of these species in areas where it was previously absent due to destructive fishing activities. We documented this recovery which suggests **the positive effects of conservation efforts** implemented in Kep Archipelago. The size of this recovery area is **1 012 ha**.

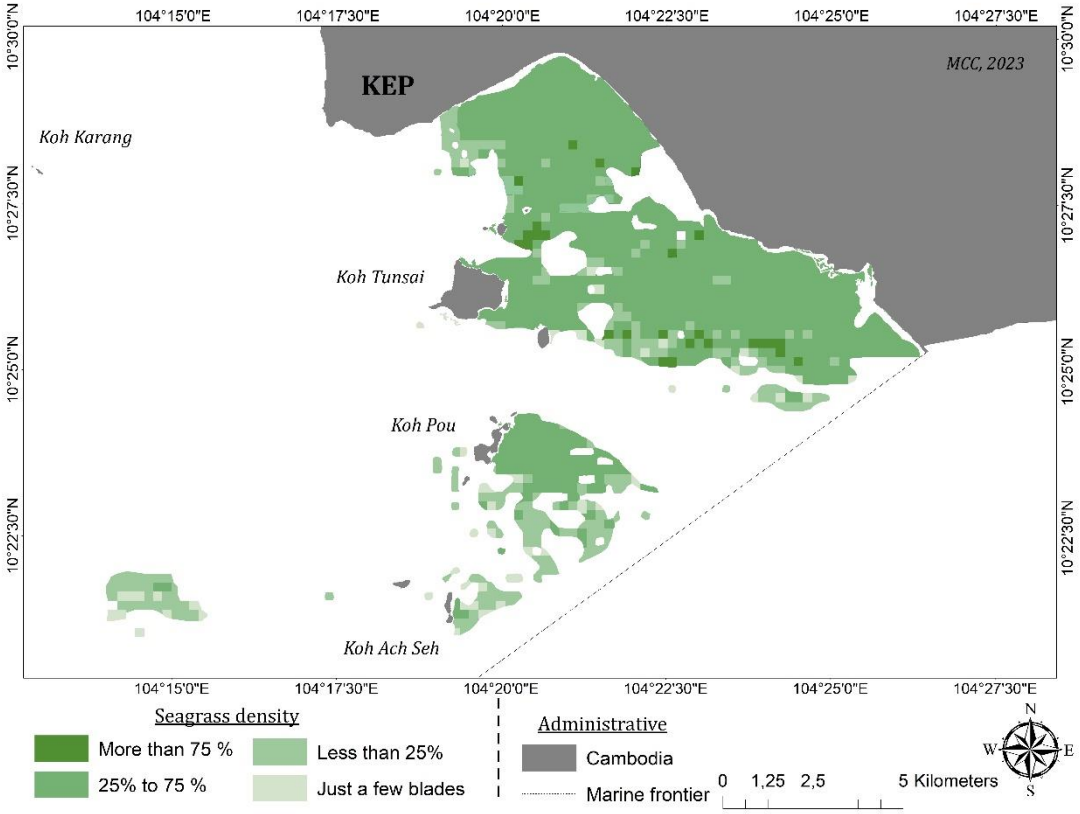

Figure 5: Seagrass density, Kep Province – overview

On this map, **the evolution of density** along the different meadows in the Archipelago can be easily distinguished. **The heterogeneity** of the three meadows provides **structural complexity** through diverse seagrass **morphological characteristics** which enable an array of **important ecological processes** (Coals, and al., 2019).

2.2. Section A

Kep province's section A encompasses the islands of Koh Ach Seh, Koh Angkrong, their conservation zones, Pirate Rock, and the corresponding marine habitats.

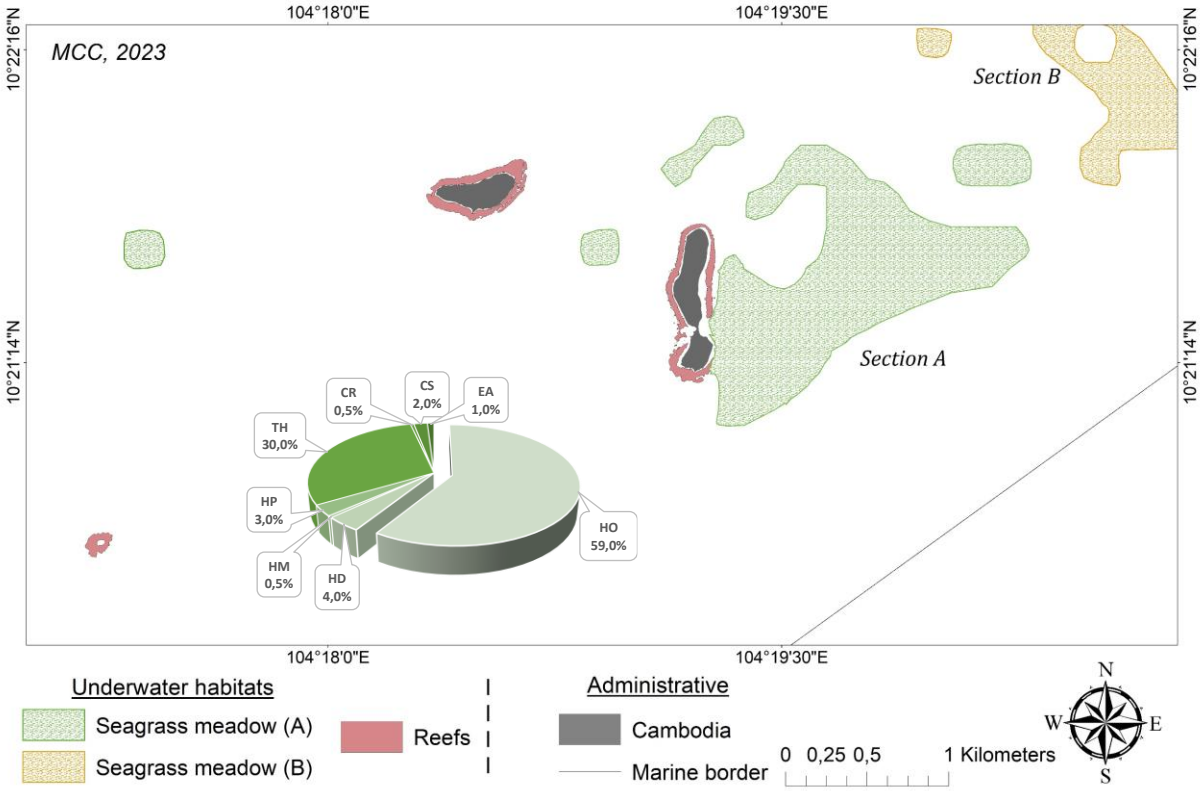

Figure 6: Seagrass diversity, Kep Province – section A

Koh Ach Seh's seagrass meadow is composed of:

- **162 ha** of seagrass.
- **8 different seagrass species** (3 species of *Halophila,* 2 species of *Cymodocea* HP*,* TH and EA).
- The **2 main species** in the meadow are HO (**59%**) and TH (**30%**).
- Its average depth is **4.9 meters**, with seagrass found between **6.9 and 1.7 meters.**
- The main sediment encountered is **SSI**.

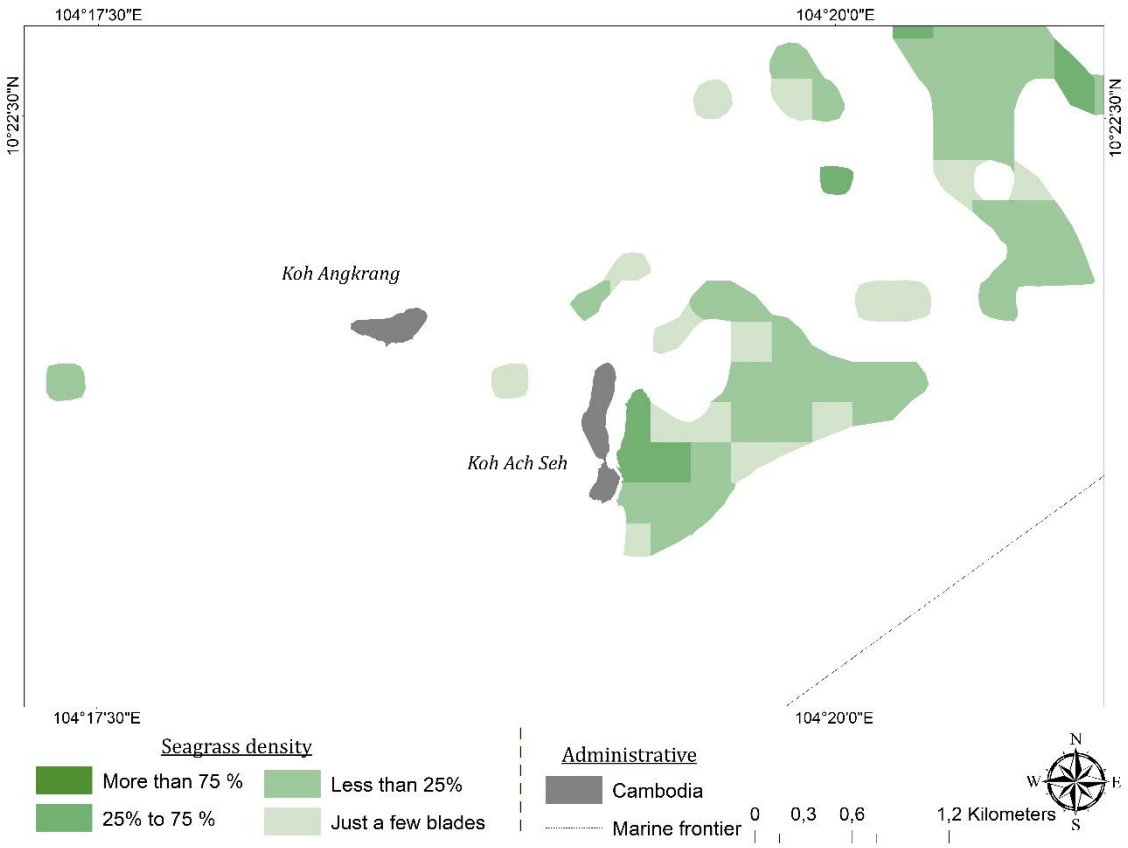

Figure 7: Seagrass density, Kep Province – section A

Despite being **the smallest seagrass bed in the province**, Koh Ach Seh's meadow is **the most diverse**, together with Koh Tunsai eastern meadow. The highest seagrass density (~95%) and diversity (6 species in one spot check) has been observed in front of **the East shore of the island**.

This meadow has been under intense anthropogenic pressure for many years but is now showing **encouraging signs of recovery**, as highlighted in Figure 4 The research team recorded the presence of pioneer seagrass species at its north-western edge. This channel separating Koh Ach Seh and Koh Pou meadows is **the deepest area where we have recorded seagrass presence** in both Kep and Kampot provinces (<6 meters).

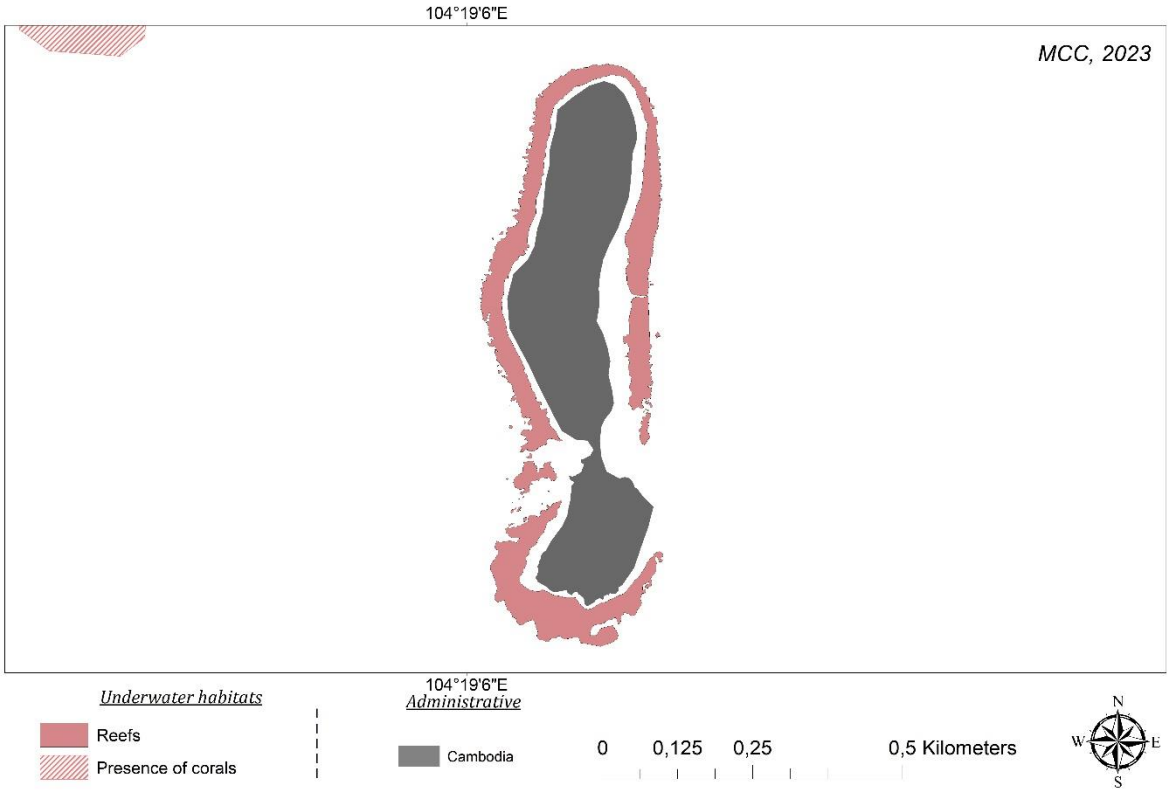

Figure 8: Coral reef, Kep Province - Koh Ach Seh

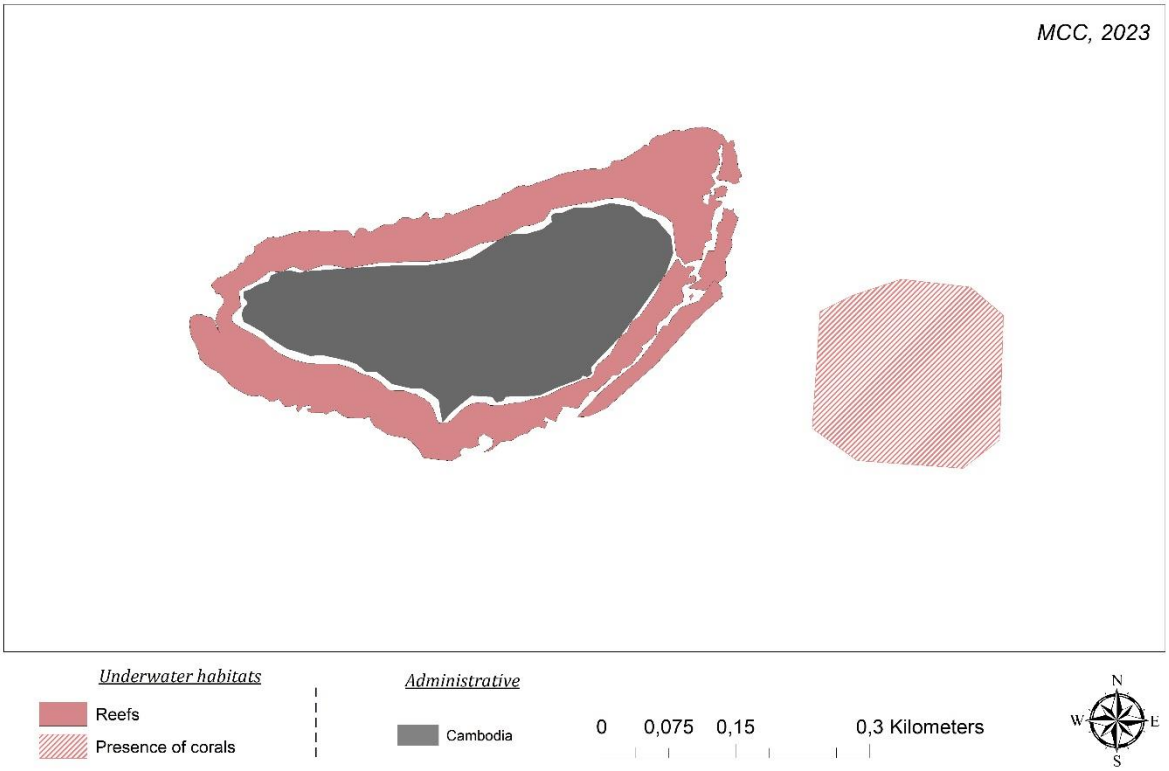

Figure 9: Coral reef, Kep Province – Koh Angkrong

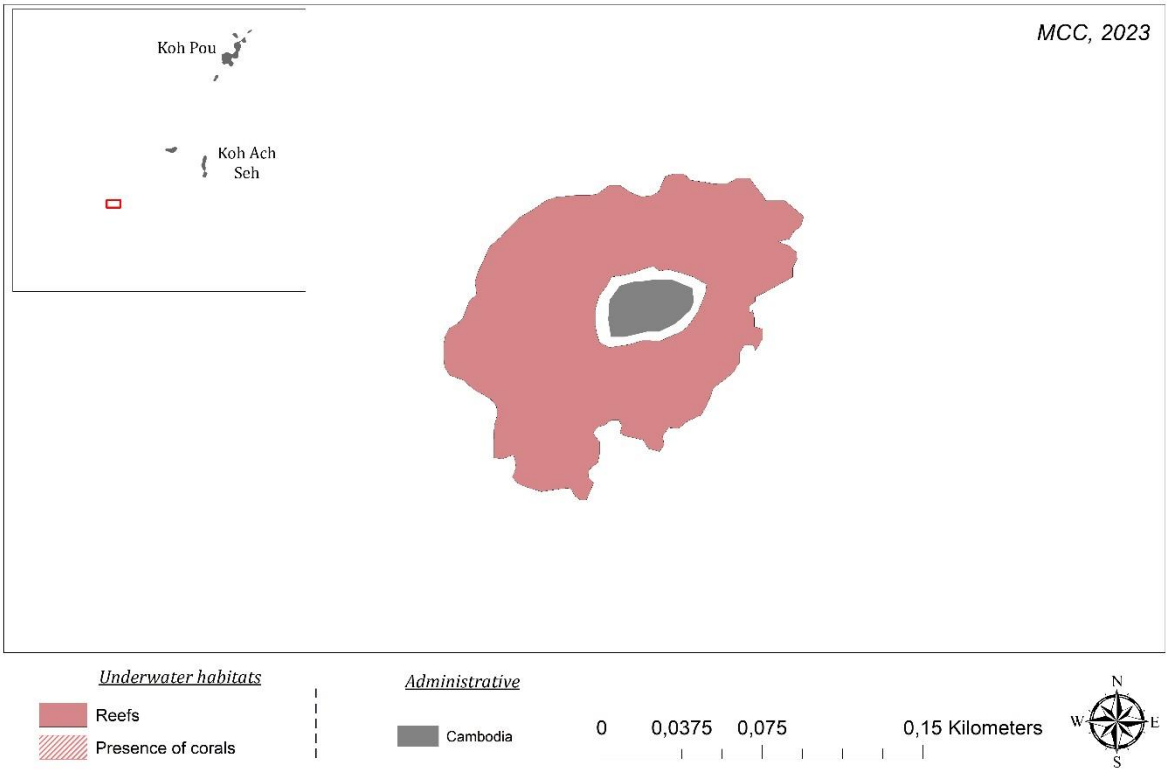

Figure 10: Coral reef, Kep Province – Pirate Rock

In this section, the coral reefs' extents are:

- Koh Ach Seh: **6 ha**.
- Koh Angkrong: **6 ha**.
- Pirate Rock: **1 ha**.

Figure 11: Drone footage, Kep Province – Pirate rock

2.3. Section B

Kep province's section B encompasses the islands of Koh Pou, Koh Makprang, and the corresponding marine habitats. The channel in between Koh Tunsai and Koh Pou marks the northern border of this section.

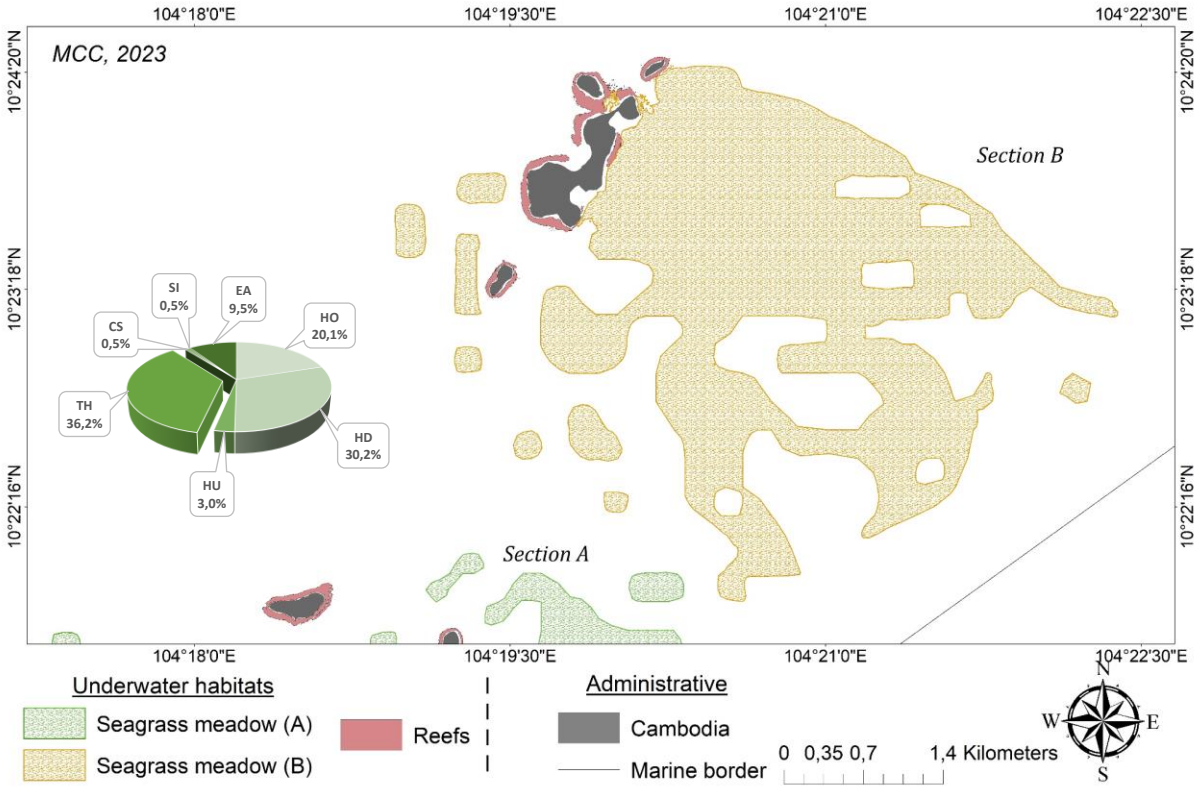

Figure 12: Seagrass diversity, Kep Province – section B

Koh Pou's seagrass meadow is composed of:

- **982 ha** of seagrass.
- **7 different seagrass species** (2 species of *Halophila,* HU, TH, EA, CS and SI).
- The 3 main species in the meadow are **TH (36%)**, **HD (30%)** and **HO (20%)**.
- Its average depth is **4.1 meters**, with seagrass found between **6.8 and 2.4 meters**.
- The main sediment encountered is **SS**.

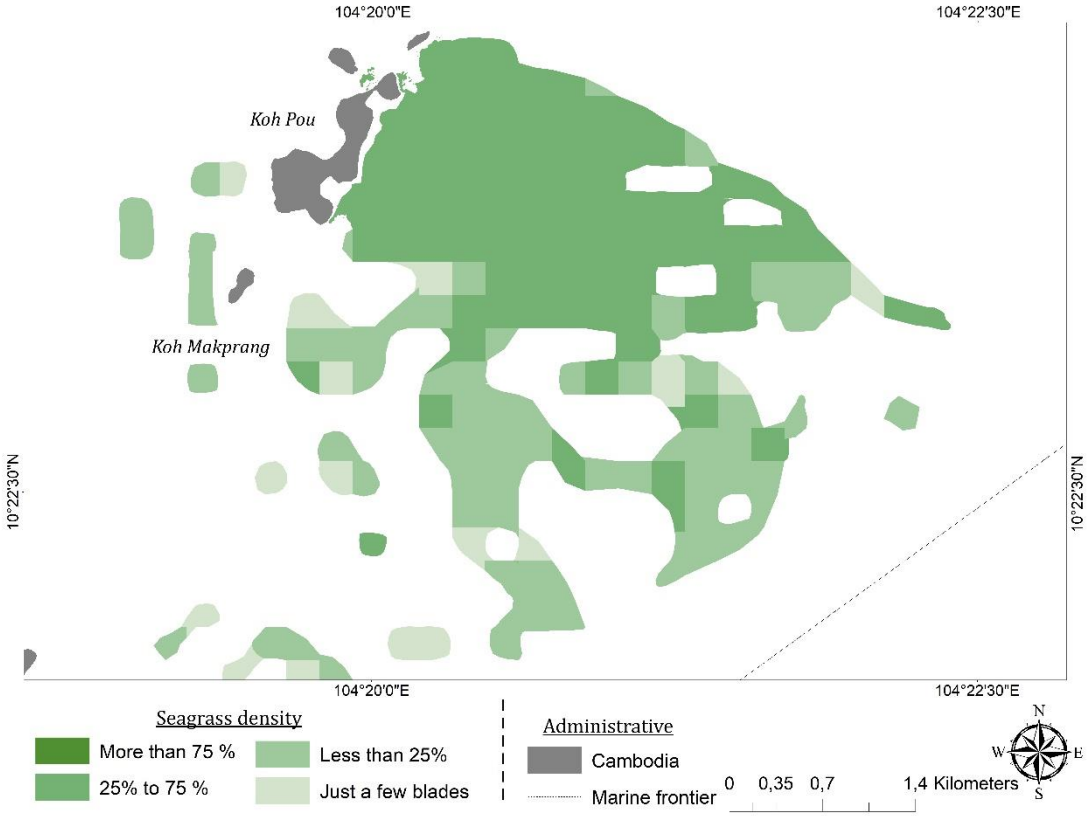

Figure 13: Seagrass density, Kep Province – section B

Koh Pou seagrass bed is **the second largest in Kep province**. Its southern edge is separated from Koh Ach Seh meadow by a channel where pioneer seagrass species below 6 meters was encountered. This discovery is particularly interesting as this zone is also the area in which MCC deployed the **highest density of conservation blocks**. These conservation efforts thus proved to be efficient to **allow a damaged ecosystem to recover**, even where the conditions did not seem ideal for seagrass regrowth (because of **depth and siltation**).

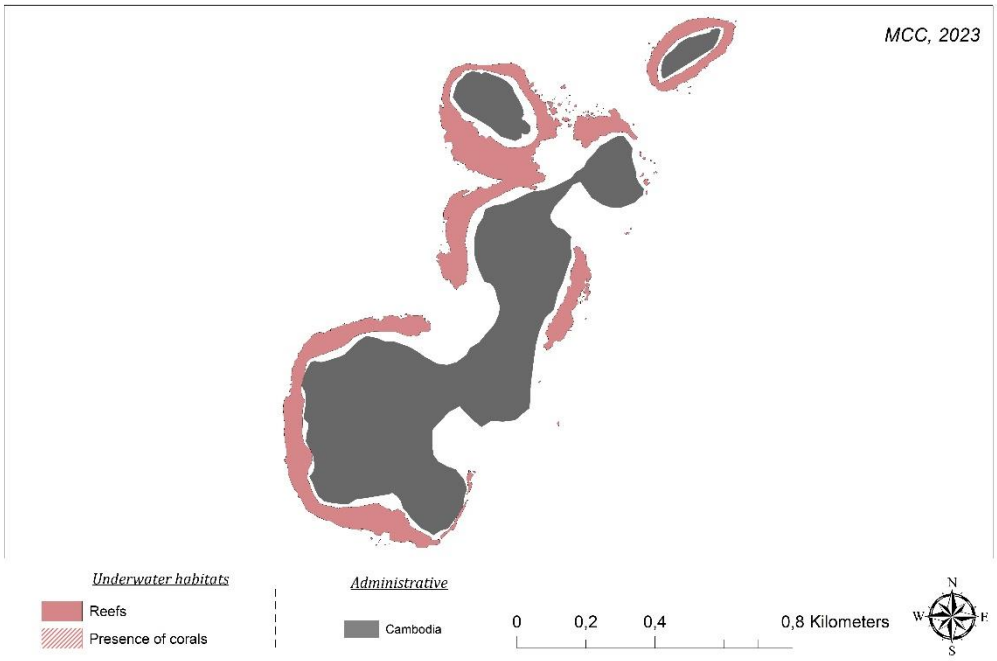

Figure 14: Coral reef, Kep Province – Koh Pou

Figure 15: Coral reef, Kep Province – Koh Pou

In this section, the coral reefs' extents are:

- Koh Pou and Northern islands: **18 ha.**
- Koh Makprang: **2 ha.**

2.4. Section C

Kep province's section C encompasses the islands of Koh Tunsai, Koh Tbal, Koh Svay, Koh Mates, Koh Kok, and the corresponding marine habitats. It is a portion of Koh Tunsai meadow, **the largest seagrass meadow in Cambodia**. This meadow has been split in 3 sections to better represent this meadow's marine habitat diversity.

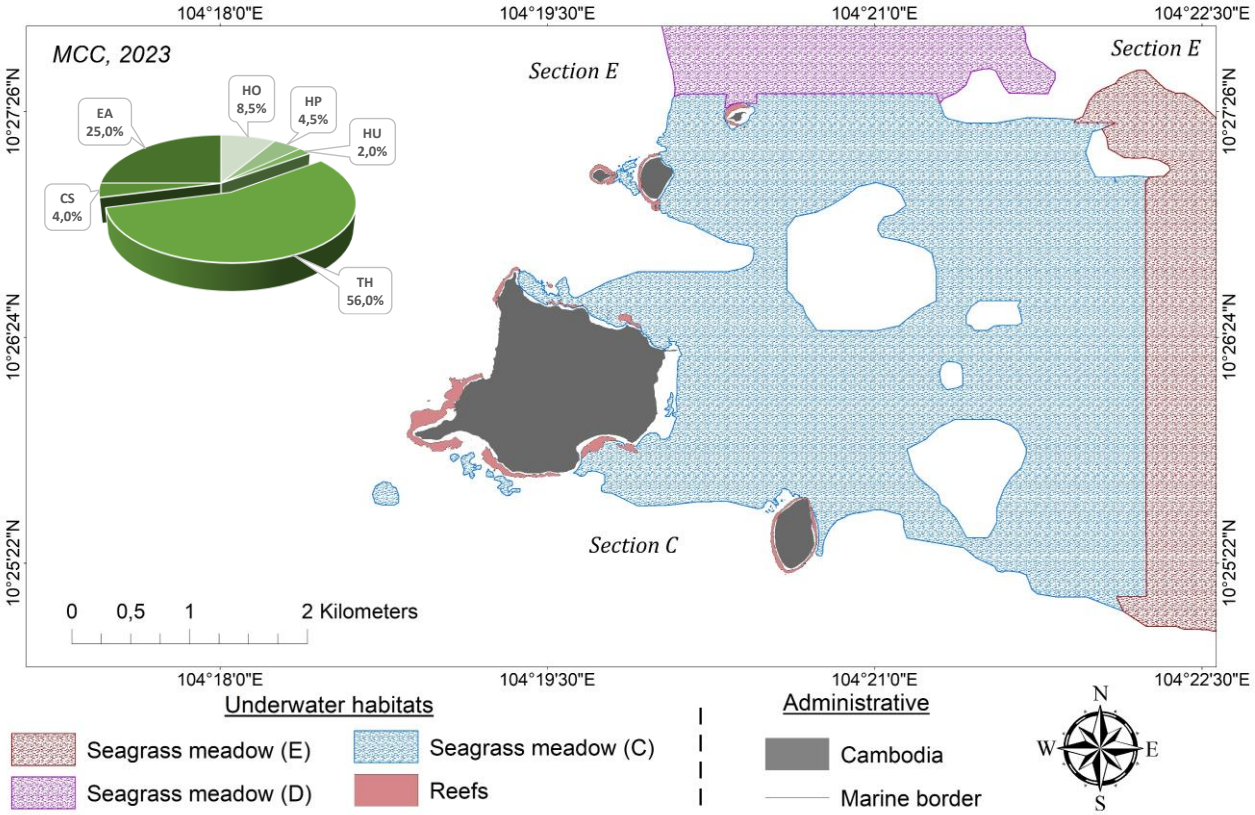

Figure 16: Seagrass diversity, Kep Province – section C

Koh Tunsai's seagrass meadow is composed of:

- **1 318 ha** of seagrass.
- **6 different seagrass species** (2 species of *Halodule,* HO*,* TH, EA, and CS).
- The 2 main species in the meadow are **TH (56%)** and **EA (25%)**.
- Its average depth is **2.9 meters**, with seagrass found between **5.4 and 1.5 meters.**
- The main sediment encountered is **SSI**.

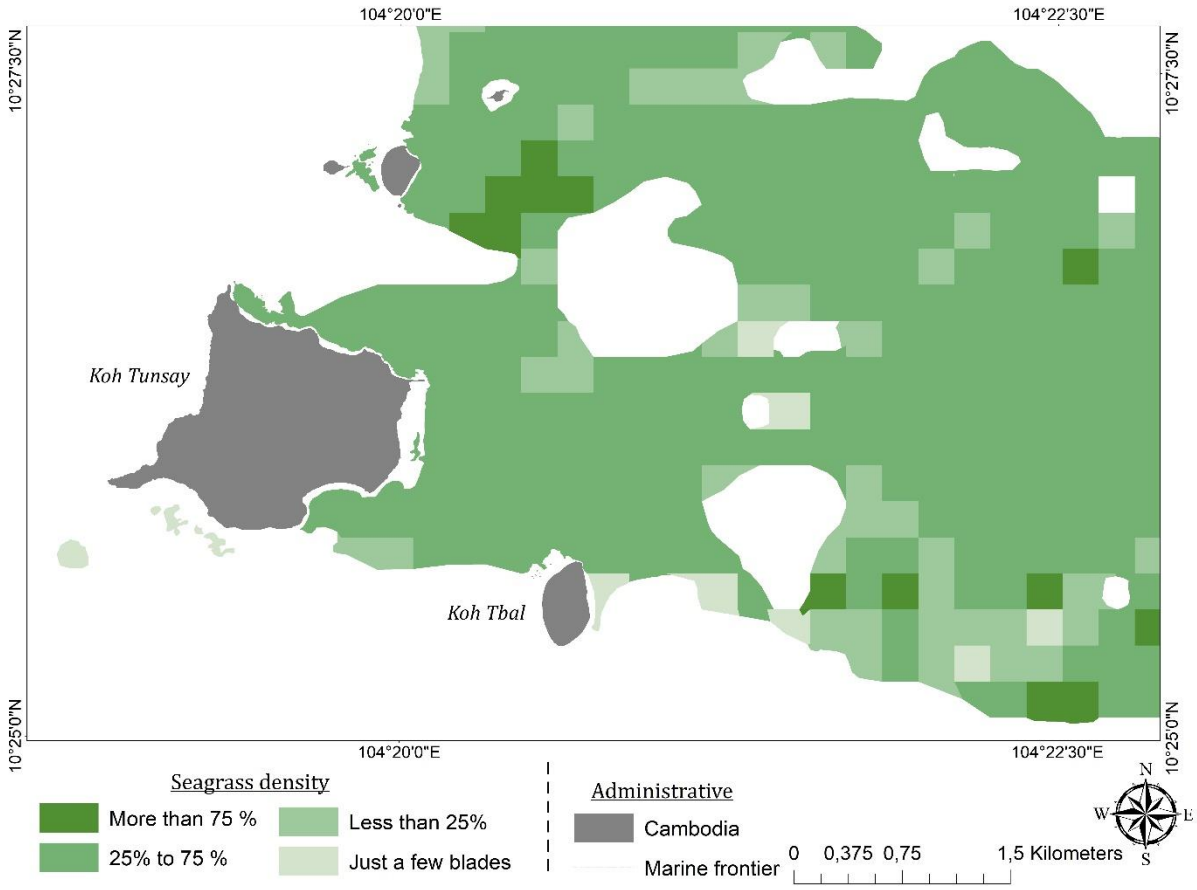

Figure 17: Seagrass density, Kep Province – section C

Koh Tunsai meadow is at **the heart of the largest meadow in Kep province**, and in Cambodia. It is located on the East of Koh Tunsai and connects with 2 larger seagrass beds on both its North and East side. It is also an area with a **high rate of marine mammal encounters**.

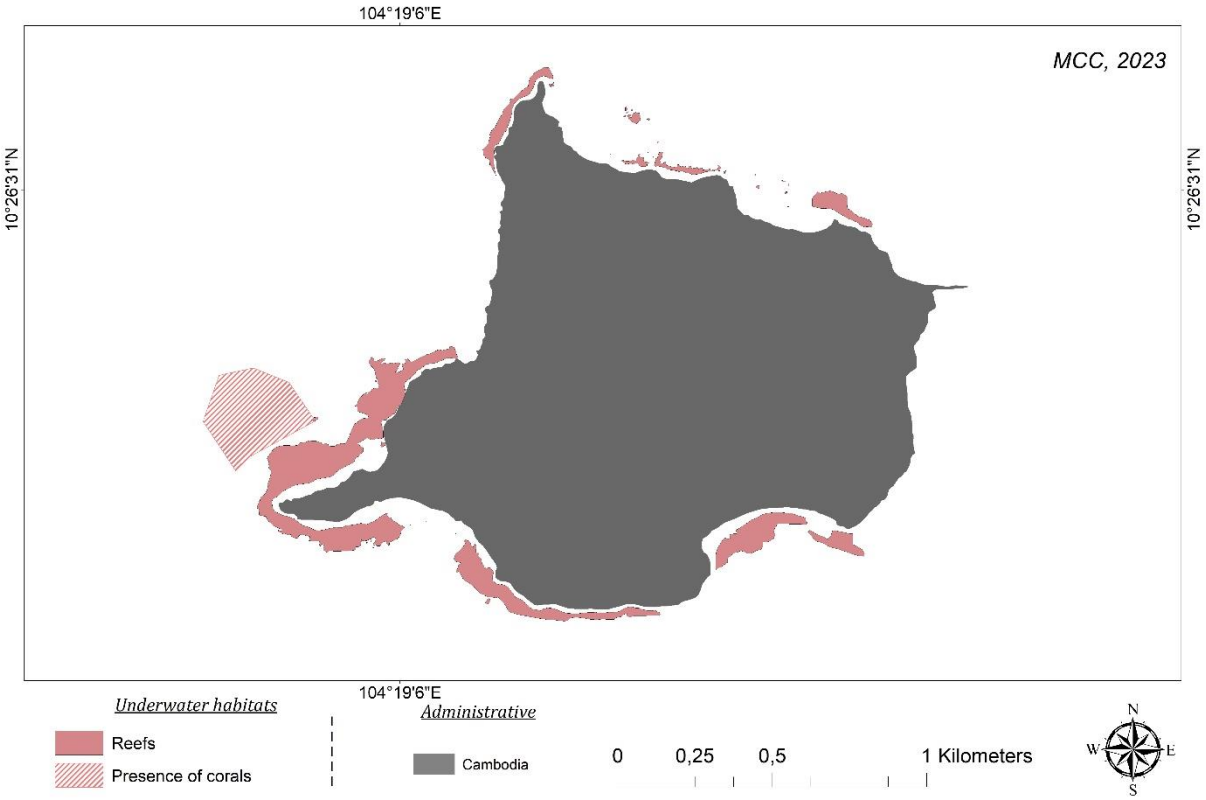

Figure 18: Coral reef, Kep Province – Koh Tunsai

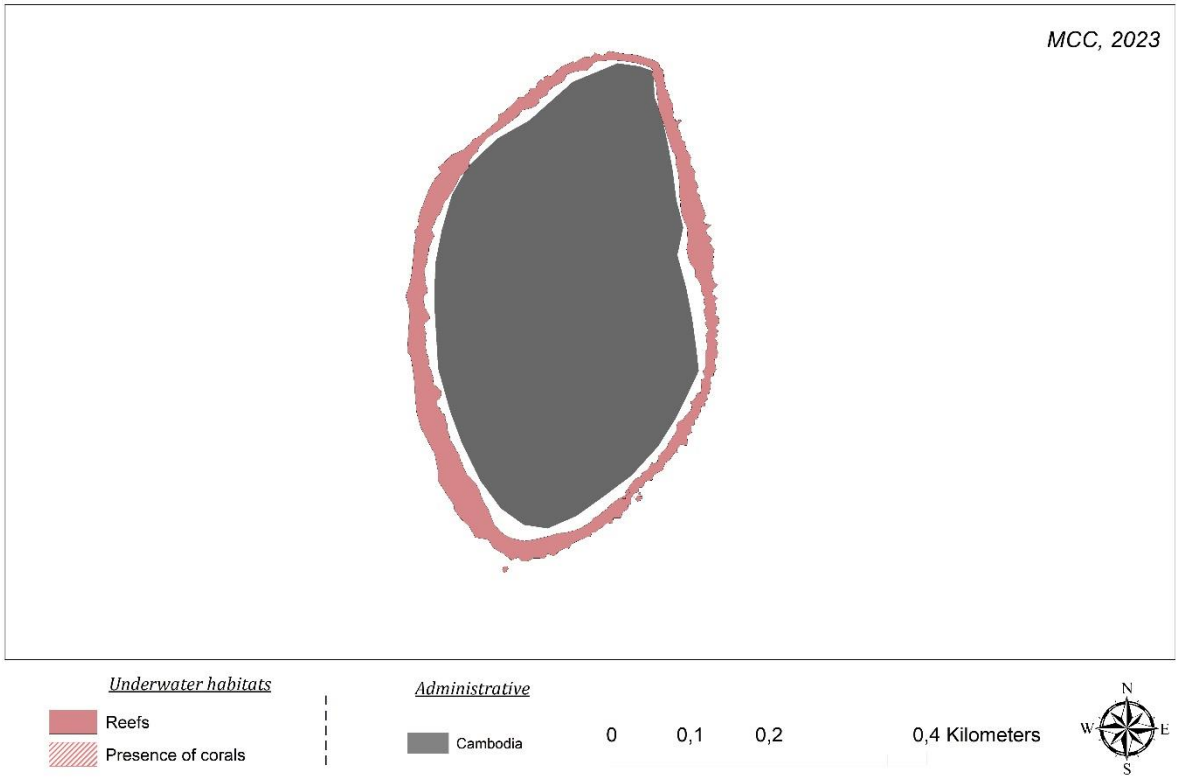

Figure 19: Coral reef, Kep Province – Koh Tbal

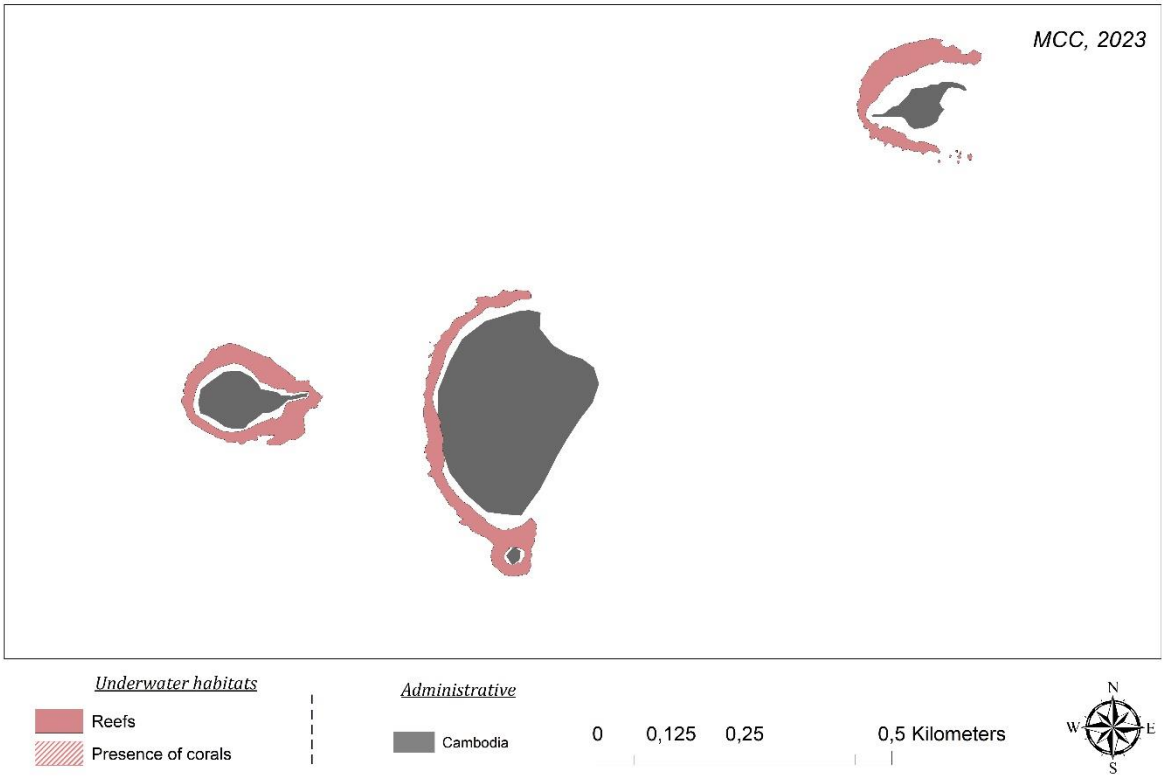

Figure 20: Coral reefs, Kep Province – Koh Mates, Koh Svay, Koh Kok

In this section, the coral reefs' extents are:

- Koh Tunsai: **17 ha.**
- Koh Tbal: **2 ha.**
- Koh Svay, Koh Mates and Koh Kok: **4 ha.**

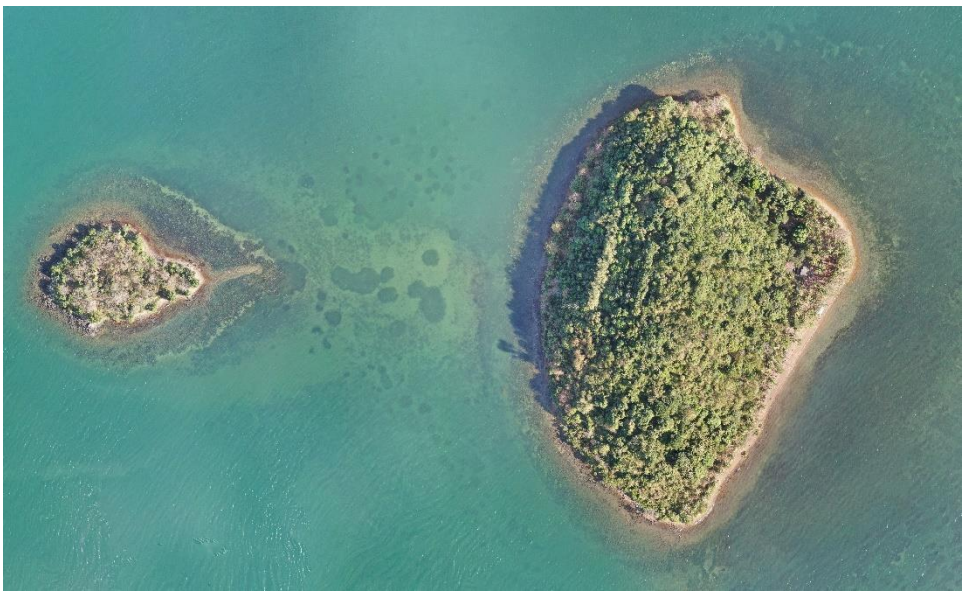

Figure 21: Drone footage – Koh Svay, Koh Mates

2.5. Section D

Kep province's section D encompasses the meadow located between the North of Koh Tunsai and Kep Coastline.

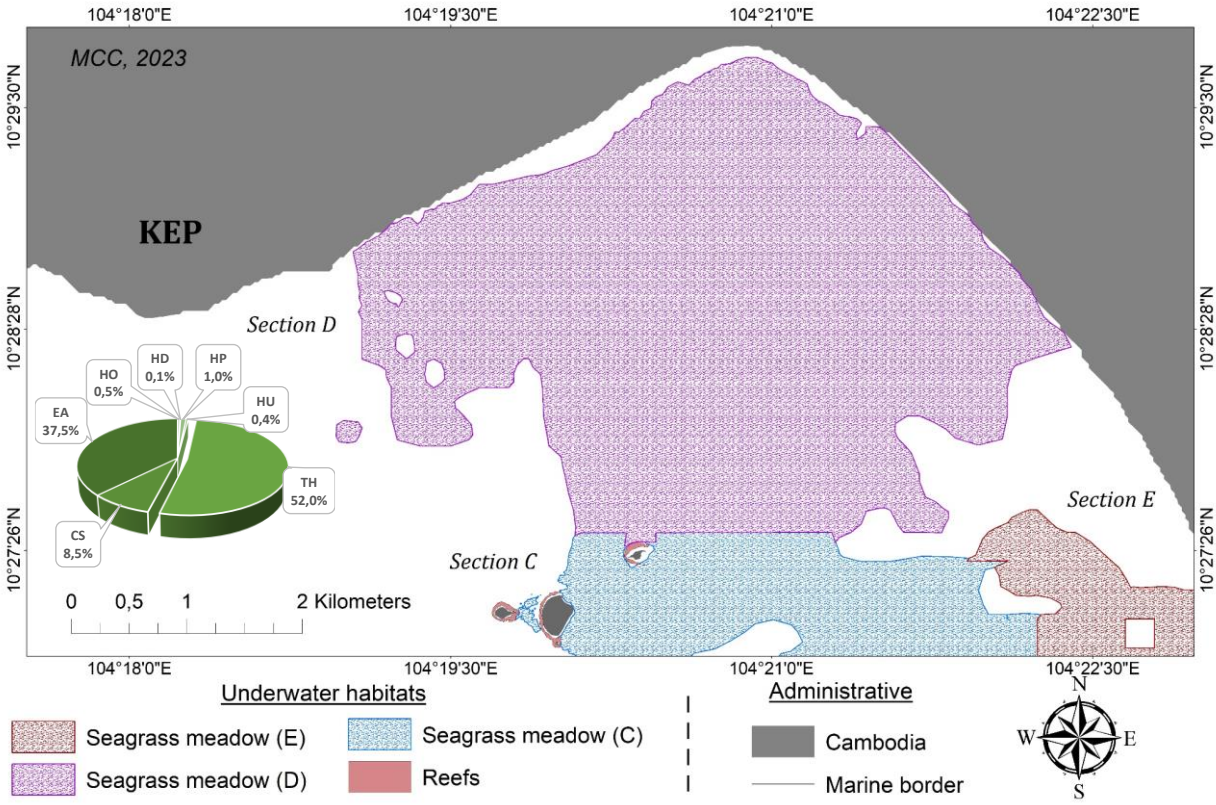

Figure 22: Seagrass diversity, Kep Province – section D

This seagrass meadow is composed of:

- **1 579 ha** of seagrass.
- **7 different seagrass species** (2 species of *Halodule,* 2 species of *Halophila,* TH, EA, and CS).
- The 2 main species in the meadow are **TH (52%)** and **EA (37.5%)**.
- Its average depth is **2.7 meters**, with seagrass found between **3.7 and 1.0 meters**.
- The main sediment encountered is **SS**.

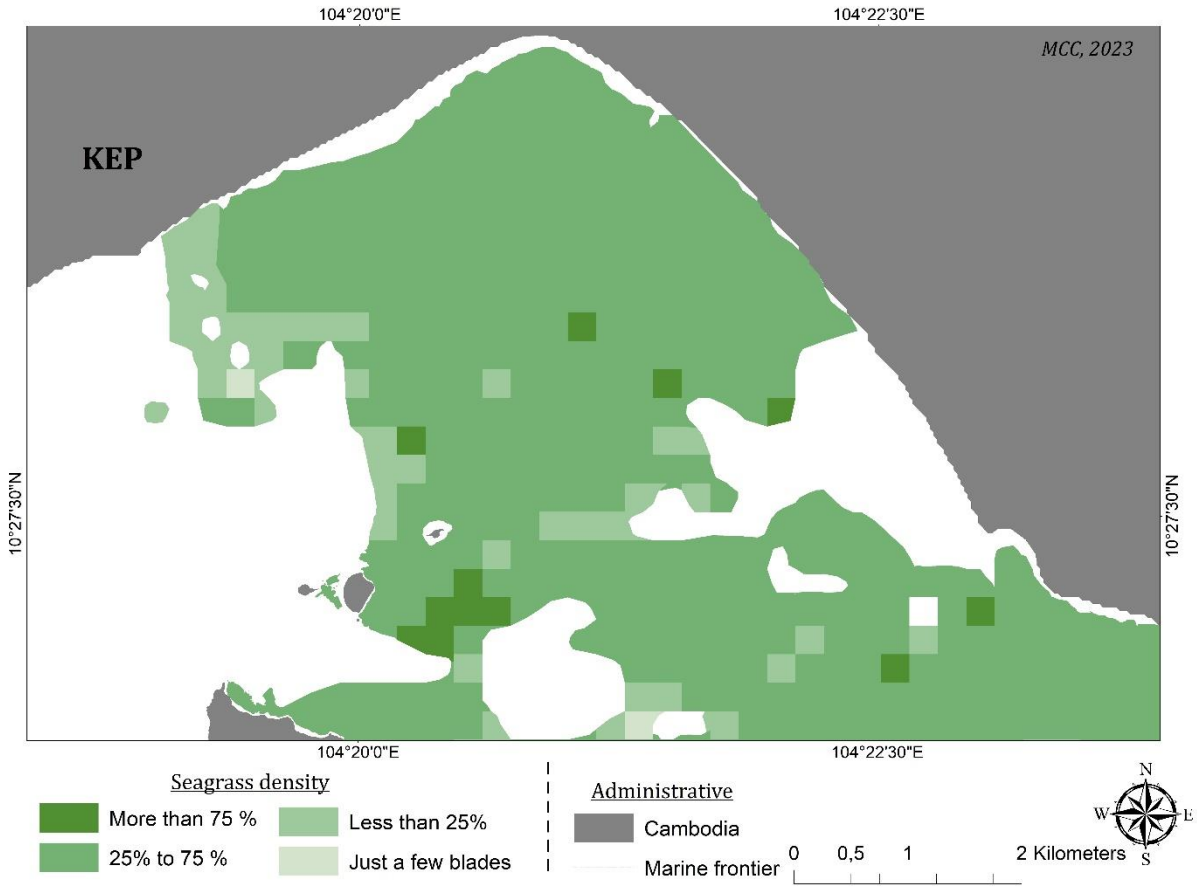

Figure 23: Seagrass density, Kep Province – section D

Aside from being a **dense and diverse** part of this meadow, this area's particularity is to present **the best marine habitat diversity**: the eastern edge of the meadow transitions to large patches of seaweed (mostly *Caulerpa sp.*) covering an area of **1 202 ha**, while **bivalve beds** cover its **South-West border**.

2.6. Section E

Kep province's section E encompasses the meadow located between the East of Koh Tunsai and Kep Coastline.

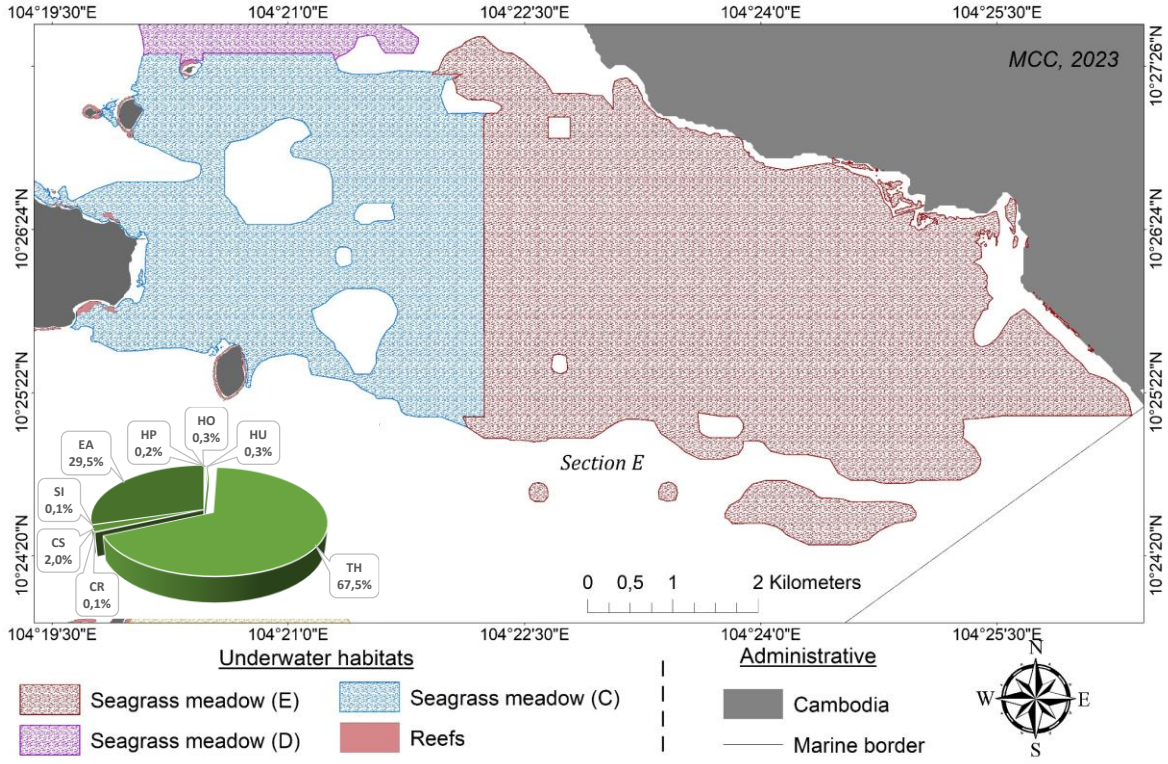

Figure 24: Seagrass diversity, Kep Province – section E

This seagrass meadow is composed of:

- **2 358 ha** of seagrass.
- **8 different seagrass species** (2 species of *Halodule,* 2 species of *Cymodocea* TH, EA, HO, and SI).
- The 2 main species in the meadow are **TH (67.5%)** and **EA (29.5%)**.
- Its average depth is **2.2 meters**, with seagrass found between **3.9 and 0.8 meters**.
- The main sediment encountered is **SS**.

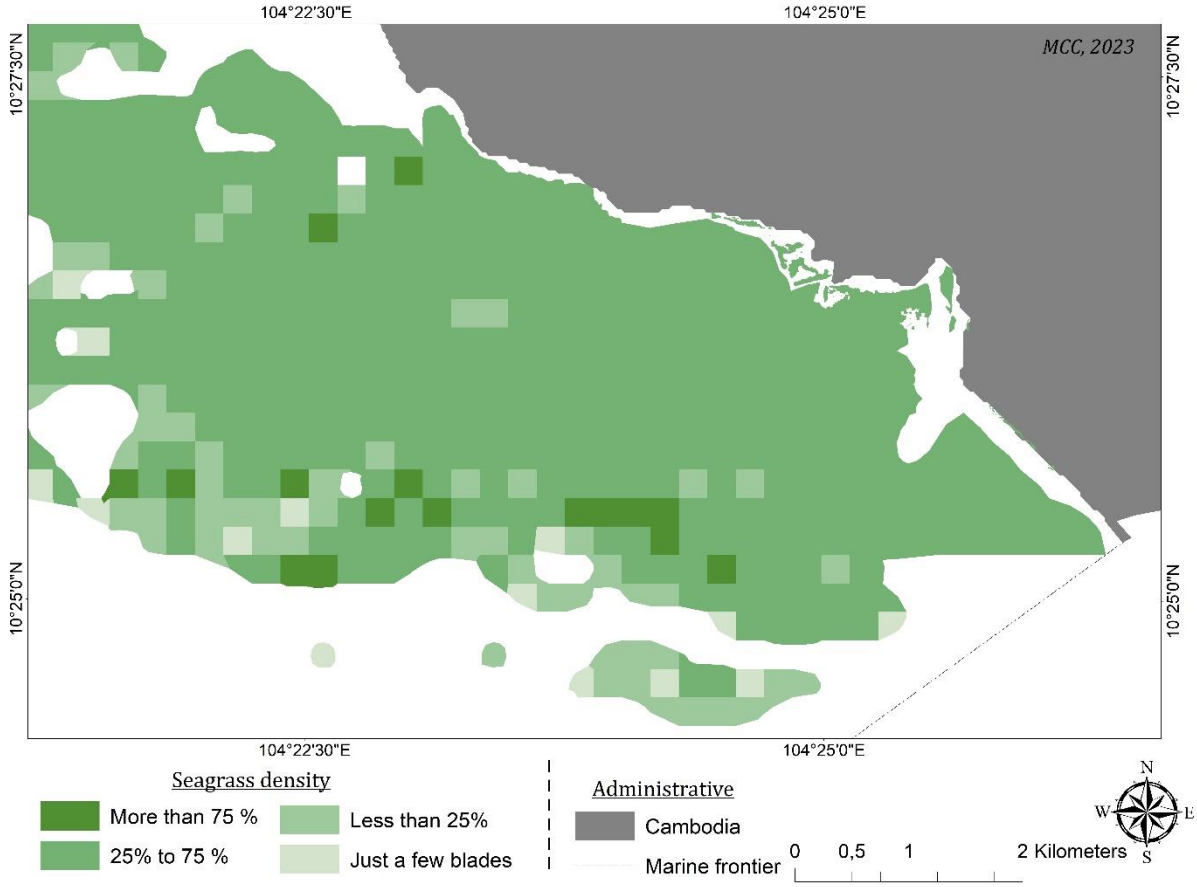

Figure 25: Seagrass density, Kep Province – section E

This section is **the core of Kep province's seagrass beds**. it is **Kep's largest (and shallowest) seagrass meadow**, which presents the **highest density** overall, and the **most important species diversity** (with Koh Ach Seh meadow).

2.7. Koh Karang and Samnang reef

This island marks the marine border between Kep and Kampot Provinces. Its reefs extent is **7 ha.**

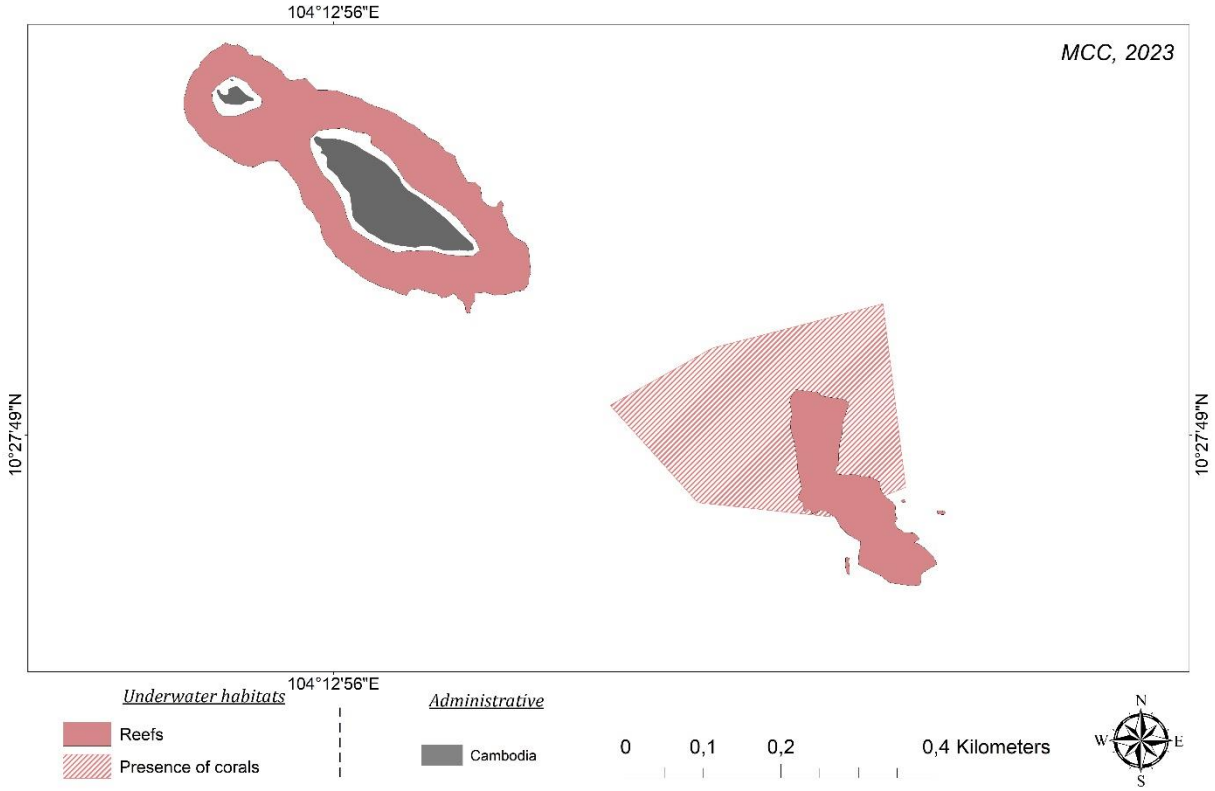

Figure 26: Coral reef, Kep Province – Koh Karang and Samnang reef

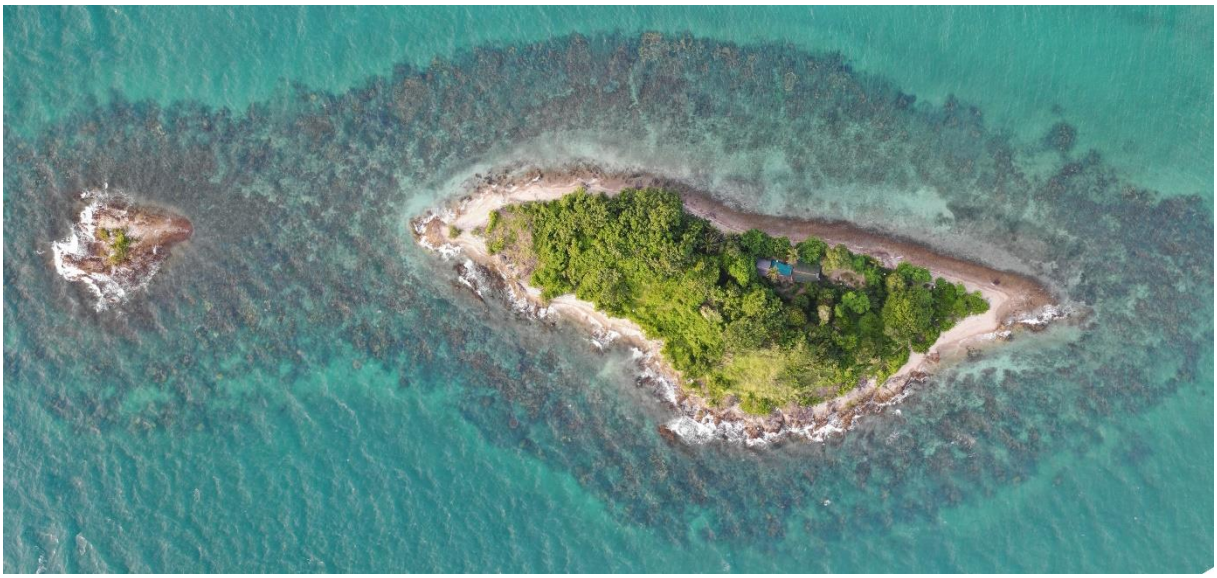

Figure 27: Drone footage, Kep Province – Koh Karang

2.8. Koh Ach Seh's reef – case study

In 2020, Sreyoun Ith, together with MCC scientific team, conducted a case study on **the diversity, community, and health of corals** around Koh Ach Seh. The study identified **four hundred coral colonies** belonging to **15 genera, and 2 orders**. Among hard corals taxa, ***Porites spp.* (56.65%)** is the most common and dominant taxon. It was found together with other corals taxa such as ***Tubinaria spp.* (13.32%), *Favites spp.* (7.54%), *Platygyra spp.* (7.05%), *Pavona spp.* (5.92 %), *Goniopora spp.* (4.83%), *Plesiastrea spp.* (2.51 %)** and ***Goniastea spp.* (2.18%)** (Ith et al. 2020). Only **two colonies of *Acropora spp.* and one soft coral patch** were found. Most of the coral colonies are in **massive forms**. The **high percentage cover and diversity** of hard coral, together with **low percentages of dead coral**, zoanthid, macro-algae and disease or bleaching signs, gives encouraging information about **the health and quality** of the reef surrounding Koh Ach Seh.

Figure 28: Coral growth form around Koh Ach Seh, Kep province

TARGET CORAL TAXA	
Coral Taxa	**Life Form**
Acropora spp	Branching
Favia spp	Massive
Favites spp	Massive
Galaxea spp	Encrusting
Goniastrea spp	Massive
Goniopora spp	Massive
Leptastrea spp	Encrusting
Montastrea spp	Massive
Pavana spp	Encrusting
Platygyra spp	Massive
Porites spp	Massive
Soft Coral spp	Unknown
Symphyllia spp	Massive
Turbinaria spp	Foliose

Table 29: Coral taxa, Koh Ach Seh

3. Kampot Province Results

3.1 General overview

WEA and MCC jointly surveyed Kampot coastline to assess the extent, diversity, and density of its marine ecosystems. The same free diving spot check methodology was implemented in both provinces. In Kampot province, the research team performed **2 167 spot checks for a total study area of 26 652 ha.**

To complete this data collection, the drone team performed **12 drone missions, for a total of 45 drone flights.** These flights collected data on marine habitats in coastal shallow waters (difficult to reach by boat) and assessed the extent of offshore corals reefs.

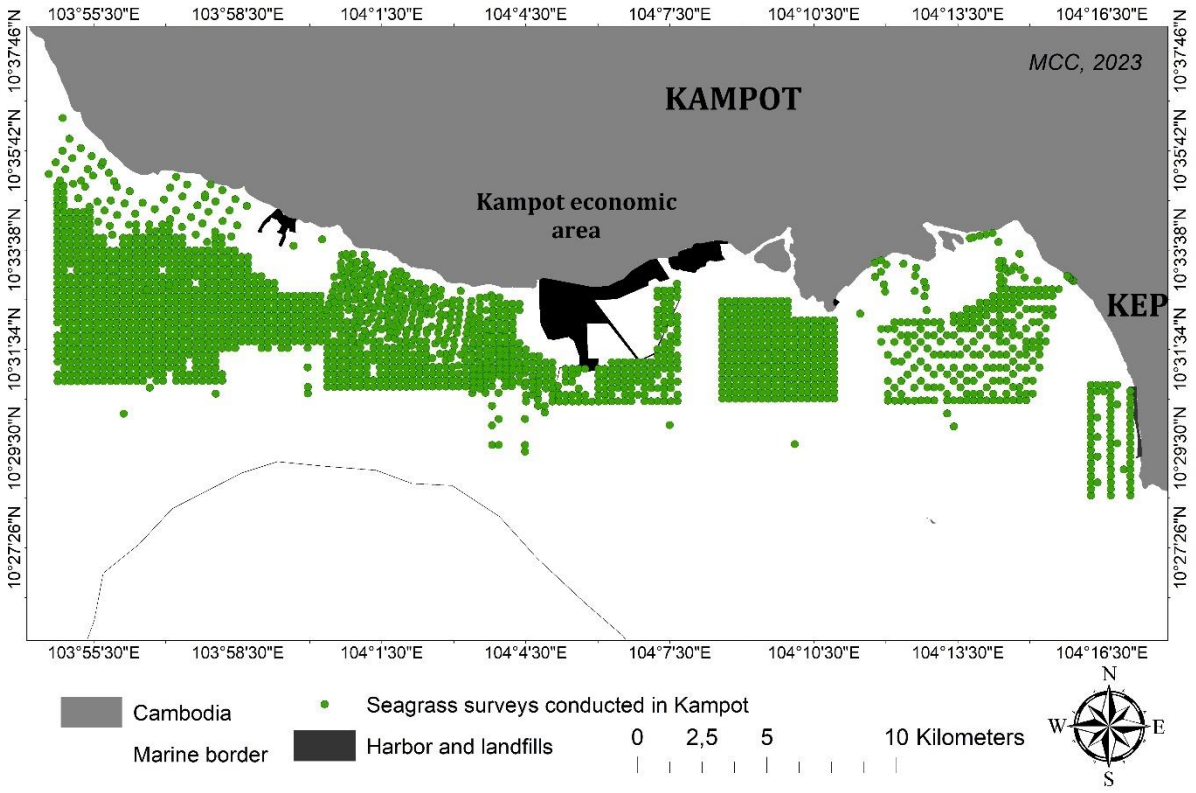

Figure 30: Survey effort, Kampot province - overview

In certain areas of Kampot Province, seagrass density has not been monitored due to difficulties on site. In section H, seagrass meadows neighboring the new harbor have been mapped **using satellite imageries** since it is **forbidden to fly drones** or for surveyors to penetrate inside this zone. In section F, the **lack of visibility** (visibility <0.05m) and **shallow water** did not allow the surveyors to completely study the area. Thus, these two locations were **classified as data deficient** for this parameter.

The extent of each marine habitats was evaluated, as follows:

- **Seagrass meadows**: 5 158 ha
- **Seaweed beds**: 133 ha
- **Bivalves beds**: 484 ha
- **Coral reefs**: 467 ha

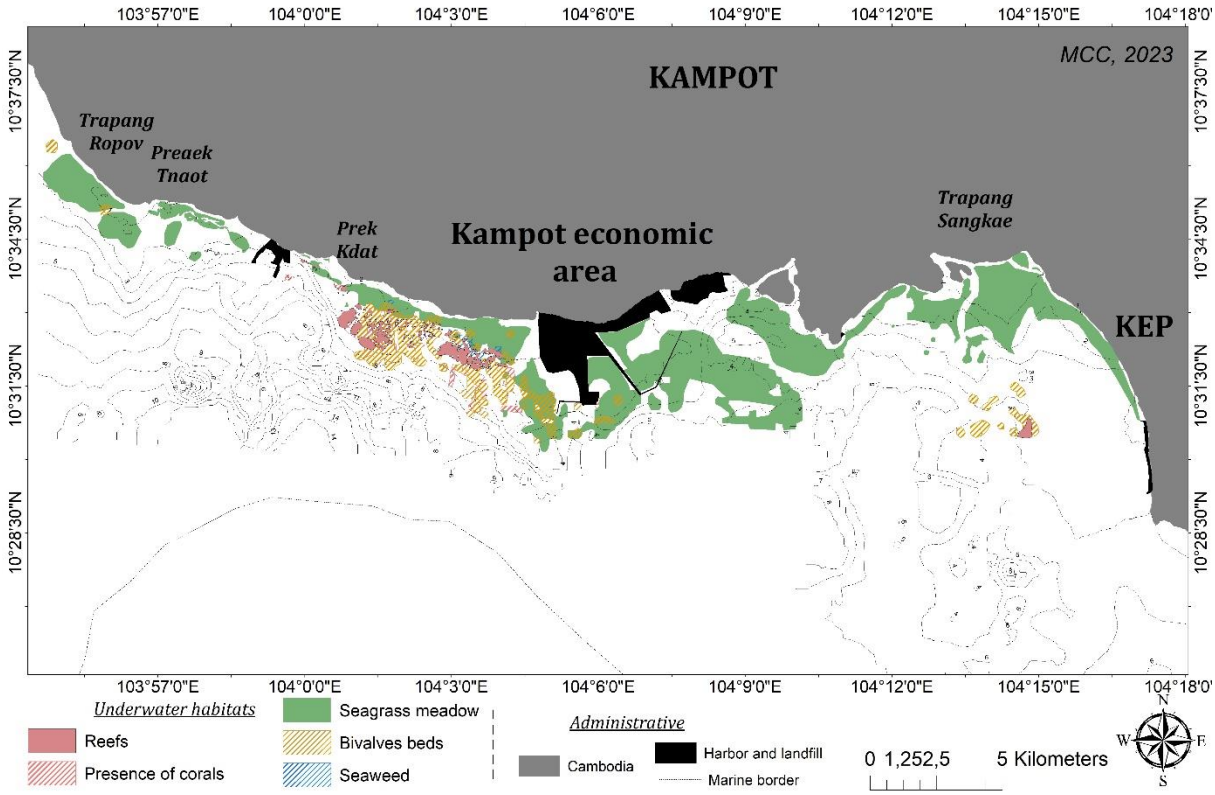

Figure 31: Marine habitats composition & distribution, Kampot Province - overview

According to previous studies, Kampot seagrass meadow **used to be the largest in Cambodia** and might have been as large as **25,000+ ha in 2005** (O Vibol et al., 2010; A.R. Rizvi and Singer, 2011; Karleep, 2014). Our study mapped **5 158 ha** of seagrass beds. If the 2005 estimate is correct; it means the seagrass area now **barely represents 20%** of what it used to be 18 years ago. Presence of seaweed was also found in an extremely diverse habitat, mixing coral reefs and bivalve beds.

Just like Kep Province, **the species richness** of Kampot Province's meadows is **10 seagrass species:**

- *Thalassia hemprichii (TH)*
- *Enhalus acoroides (EA)*
- *Cymodocea serrulate (CS)*
- *Cymodocea rotundata (CR)*
- *Halodule pinifolia (HP)*
- *Halodule uninervis (HU)*
- *Halophila ovalis (HO*
- *Halophila decipiens (HD)*
- *Halophila minor (HM)*
- *Syringodium isoetifolium (SI)*

3.2 Section F

Section F is located at the Eastern border of Kampot province, as part of Preaek Tnaot and Trapang Ropov Community Fisheries (Cfis).

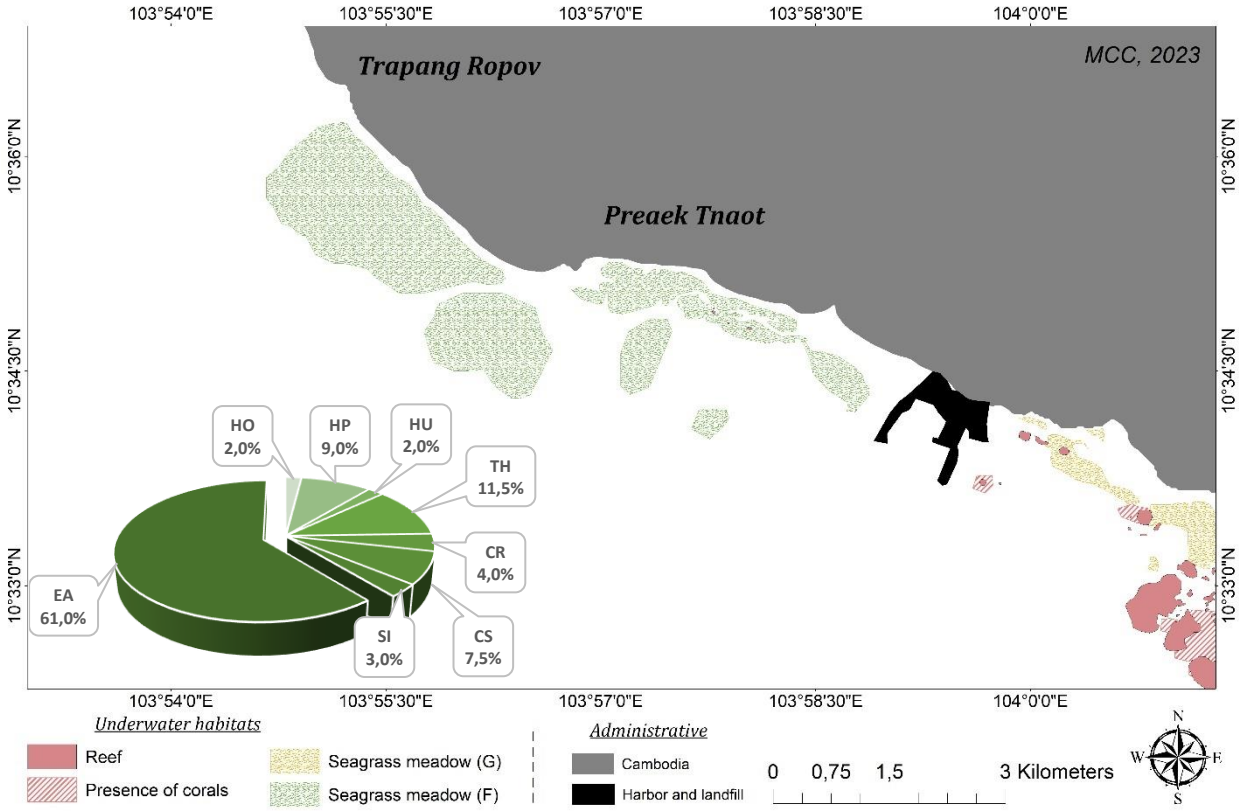

Figure 32: Seagrass diversity, Kampot province – section F

These section seagrass meadows are composed of:

- **684 ha** of seagrass.
- **8 different seagrass species** (2 species of *Halodule,* HO, TH, EA, CS, CR and SI).
- The 2 main species in the meadow are **EA (61%)** and **TH (11.5%)**.

Precise depth, density, and bottom composition could not be recorded in part of this area for reasons mentioned in Kampot province's general overview.

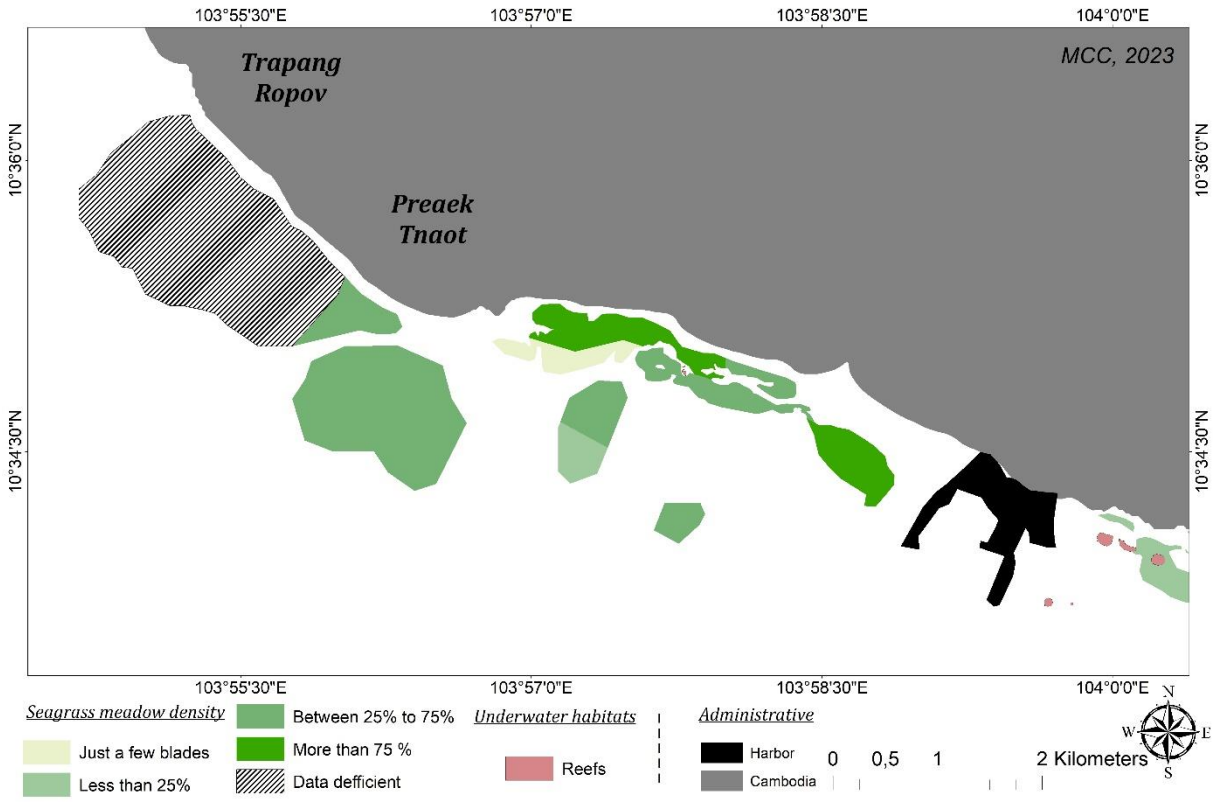

Figure 33: Seagrass density, Kampot Province – section F

This section presented **shallow murky waters,** with areas of **thick anaerobic mud.** It was noticed in other areas that these environmental conditions were **particularly suitable for seagrass growth**, for example for species like *Enhalus acoroides* (EA). However, despite this environmental potential, the meadow's size we recorded was **surprisingly small**, potentially due to anthropogenic impacts however more data would be needed to confirm this.

3.3 Section G

Section G is located in front of Nataya Resort and Prek Kdat Cfi. The eastern border of the section is marked by the beginning of Kampot new harbor.

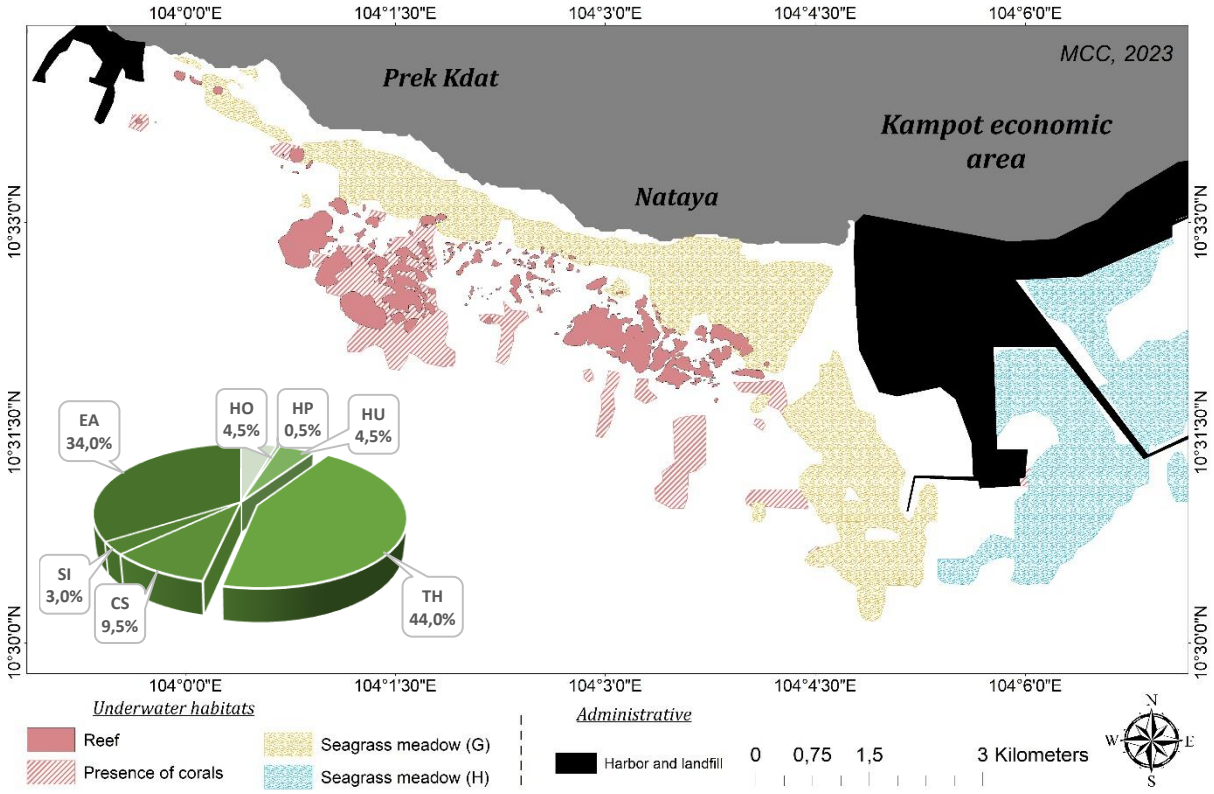

Figure 34: Seagrass diversity, Kampot province – section G

This seagrass meadow is composed of:

- **874 ha** of seagrass.
- **7 different seagrass species** (2 species of *Halodule,* HO, TH, EA, CS and SI).
- The 2 main species in the meadow are **TH (44%)** and **EA (34%)**.
- Its average depth is **2.2 meters**, with seagrass found between **3.4 and 1.2 meters.**
- The main sediment encountered is **SS**.

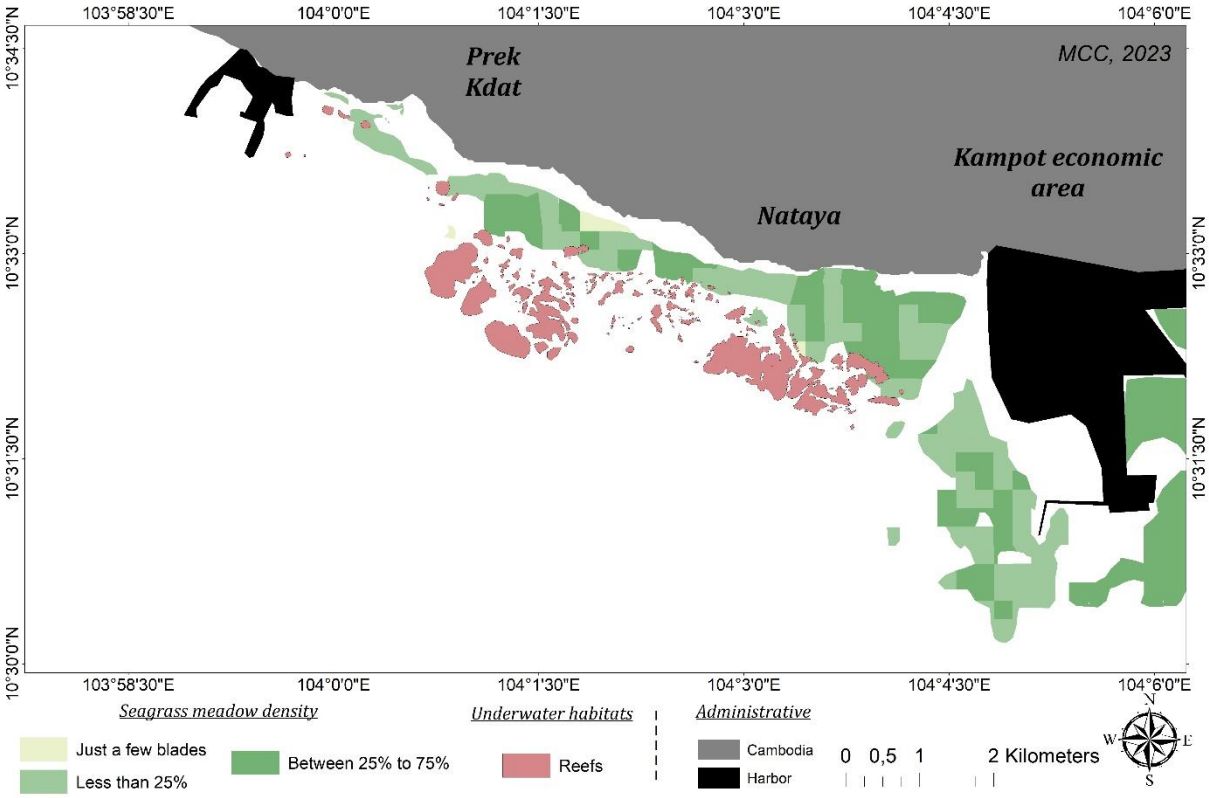

Figure 35: Seagrass density, Kampot Province – section G

A **lower density was noticed** in the seagrass bed directly neighboring the new harbor. **The current and siltation** incurred by the dredging necessary to build the harbor could potentially be at the origin of this anomaly. The other particularity of this meadow is to be placed between the shoreline and the largest coral reef in both provinces.

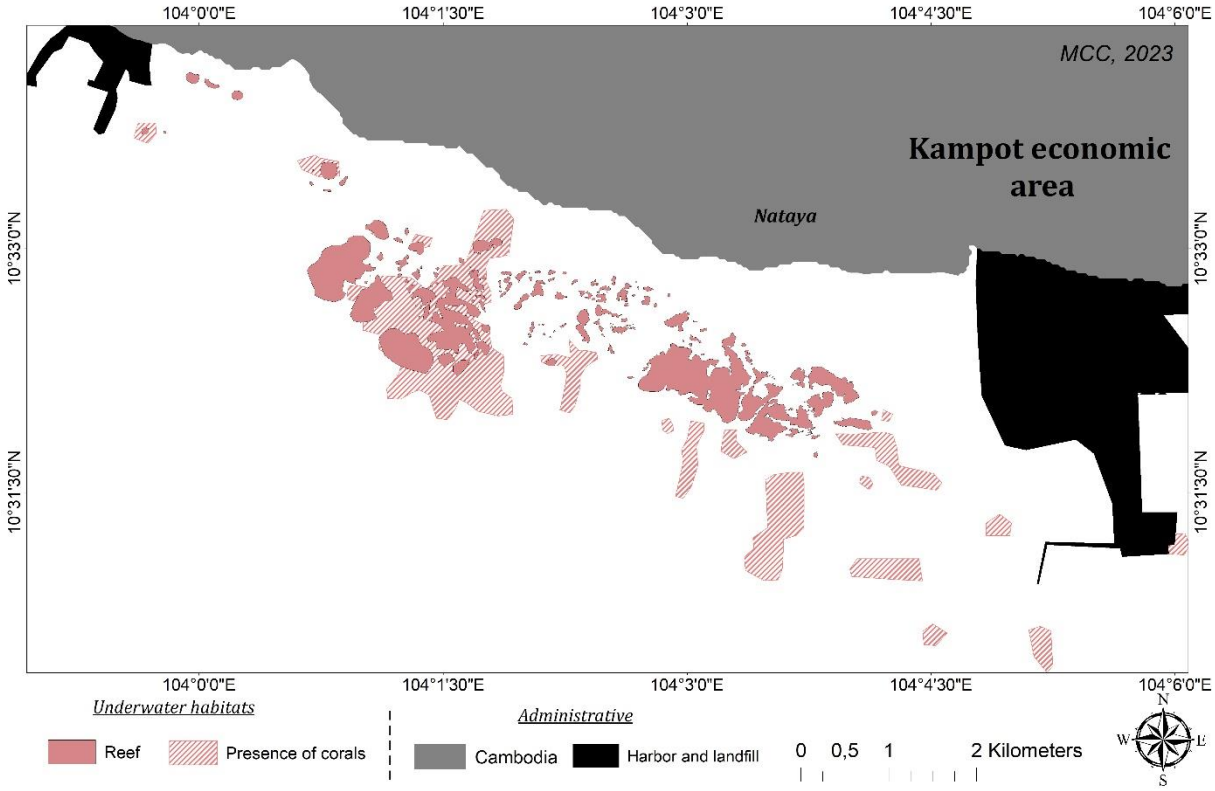

Figure 36: Coral reef, Kampot Province - Prek Kdat and Nataya

Nataya's reef is **the largest amongst both provinces with 305 ha of coral reef.** It is one of the only reefs encountered in the study which is not surrounding an island.

Figure 37: Drone footage, Kampot province – Nataya reef

3.4 Section H

Section H western border has been placed at **the East side of Kampot harbor** and finishes at the border with Trapang Sangkae Cfi.

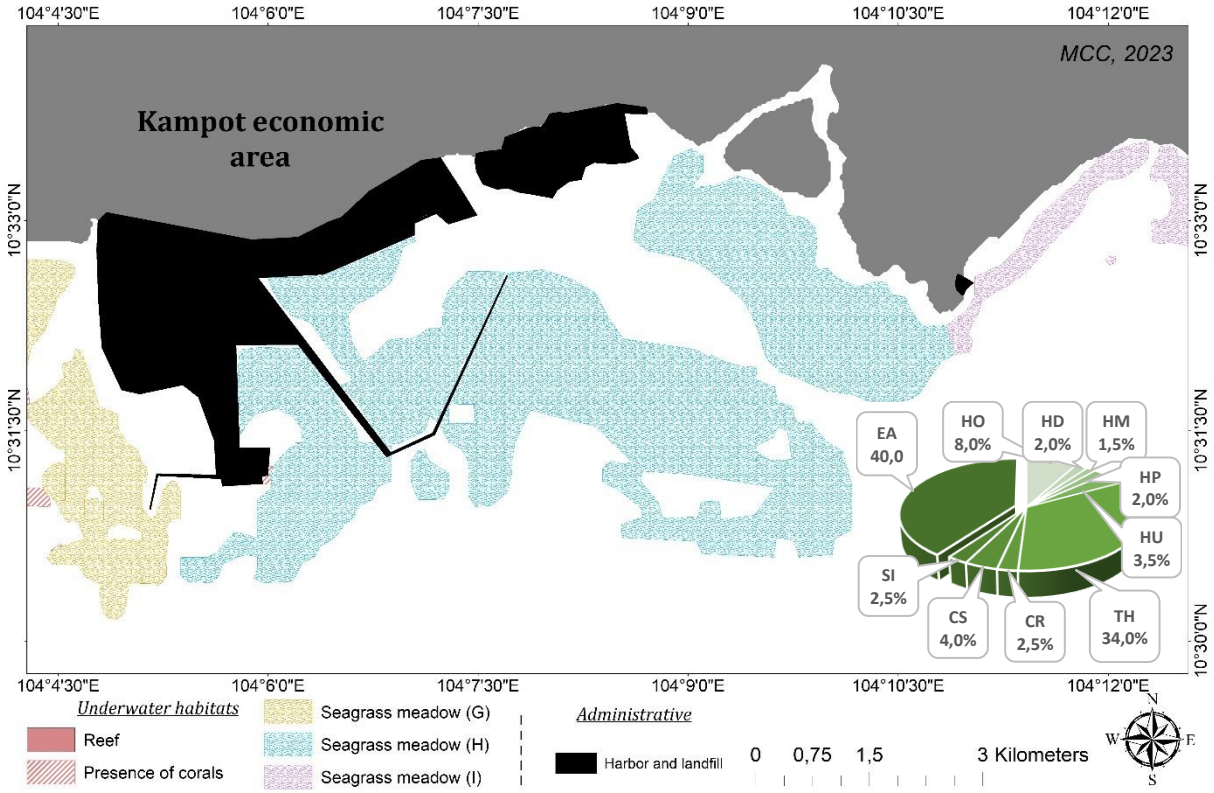

Figure 38: Seagrass diversity, Kampot Province – section H

These seagrass meadows are composed of:

- **2 296 ha** of seagrass.
- **All 10 different seagrass species of the province** (3 species of *Halophila*, 2 species of *Halodule,* 2 species of *Cymodocea,* TH, EA, and SI).
- The 2 main species in the meadow are **EA (40%)** and **TH (34%)**.
- Its average depth is **2.2 meters**, with seagrass found between **3.5 and 1.0 meters.**
- The main sediment encountered is **SS**.

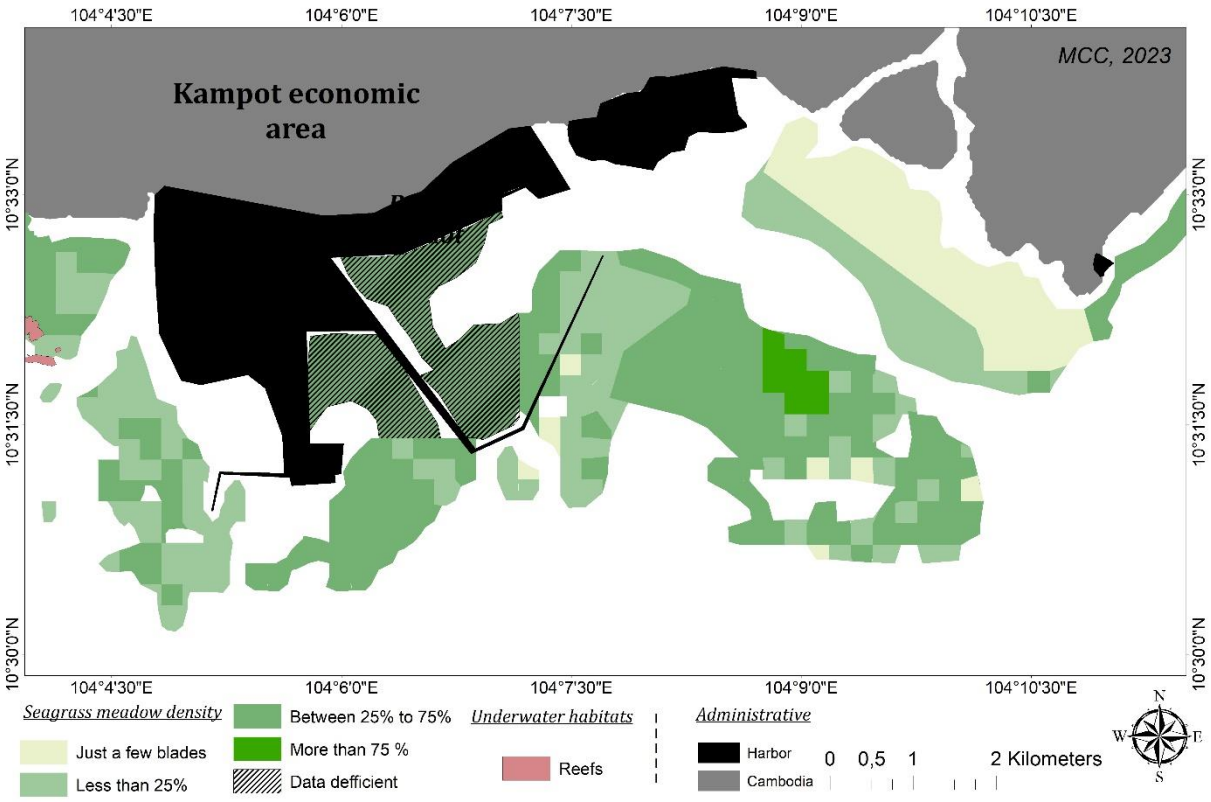

Figure 39: Seagrass density, Kampot province – section H

For this section and section G, **the impact of the harbor development** on the seagrass meadow was analyzed. Despite an obvious reduction in meadow's size due to **land filling**, the area is **surprisingly dense**, and presented **the most diverse seagrass habitat** encountered in both provinces. The research team recorded **all 10 species** of seagrass identified during our study, which is a unique finding across all study areas.

3.5 Section I

Section I begins West of Trapang Sangkae CFi and stretches until the border with Kep Province on its eastern side. Its particularity is to **surround Kampot river mouth**.

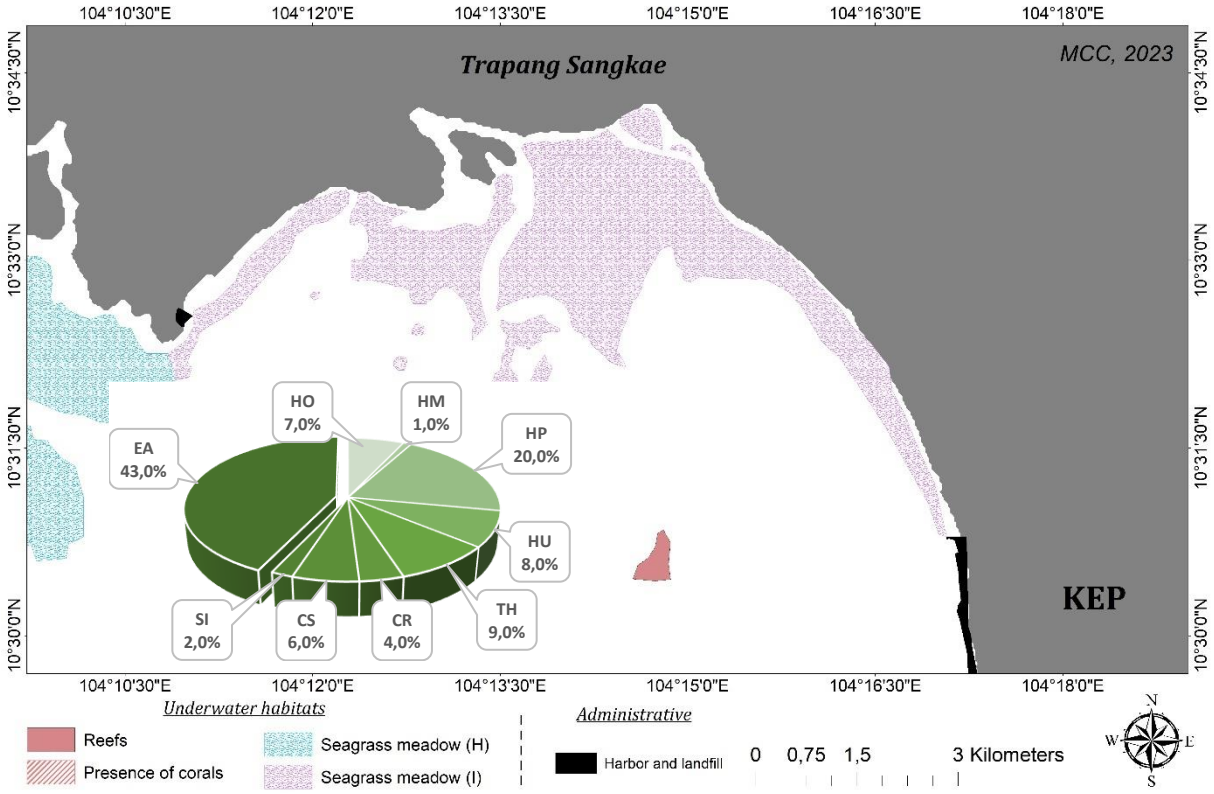

Figure 40: Seagrass diversity, Kampot Province – section I

This section's seagrass meadows are composed of:

- **1 291 ha** of seagrass.
- **9 different seagrass species** (2 species of *Halophila*, 2 species of *Halodule,* 2 species of *Cymodocea,* TH, EA, and SI).
- The 2 main species in the meadow are **EA (43%)** and **HP (20%)**.
- Its average depth is **1.2 meters**, with seagrass found between **2.9 and 0.2 meters.**
- The main sediment encountered is **SSI**.

This meadow is **the shallowest** documented during the study, with an average depth below 2 meters. It remains **narrow along the coastline** but **spread widely offshore at the river mouth** thanks to these suitable conditions for seagrass growth. Despite a low general density, it presents **an interesting diversity** with 9 species identified in the area. Finally, the presence of a **small offshore coral reef** was noticed at the Southern tip of this section.

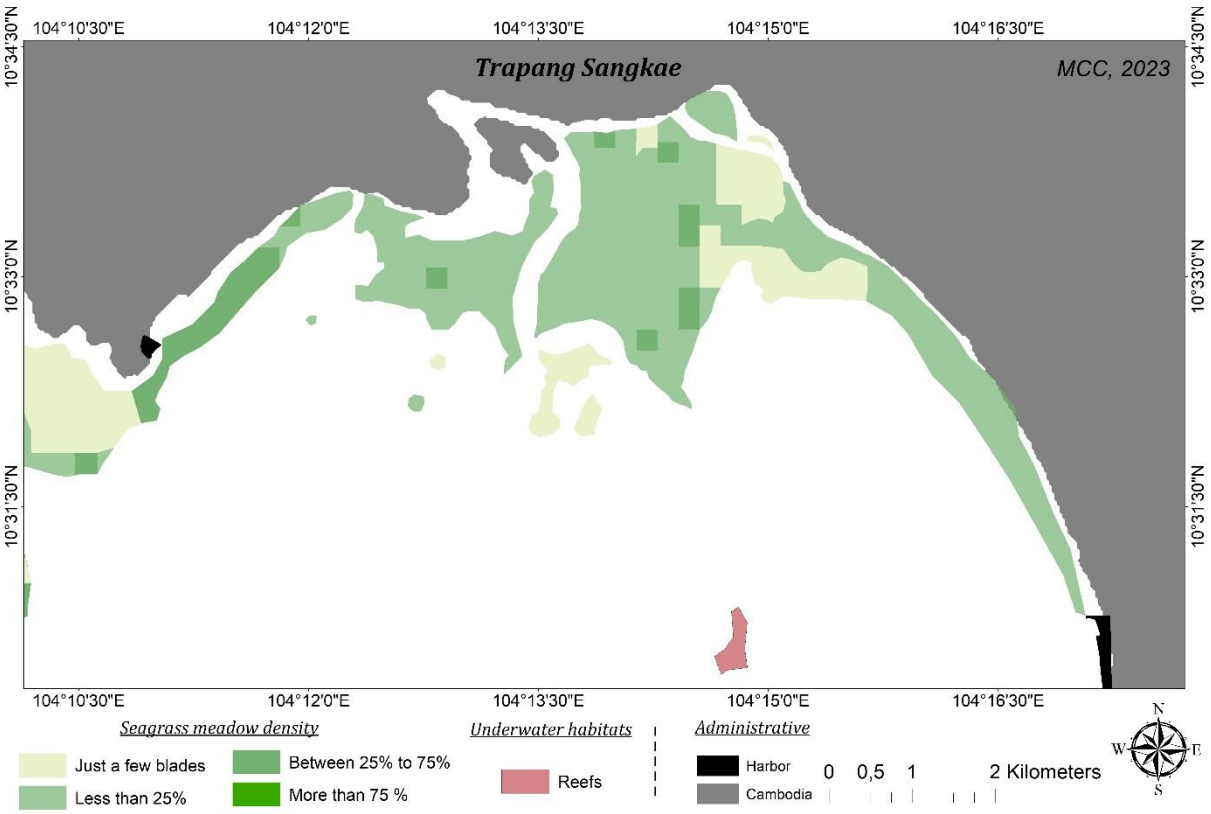

Figure 41: Seagrass density, Kampot Province – section I

Figure 42: Drone surveyor, Kampot Province – section I

3.6 Koh Trongol

The island is located at the **West of Koh Karang** and **mark the maritime border between Kep and Kampot Province**. The reef size is **2 ha**.

Figure 43: Coral reef, Kampot Province – Koh Trongol

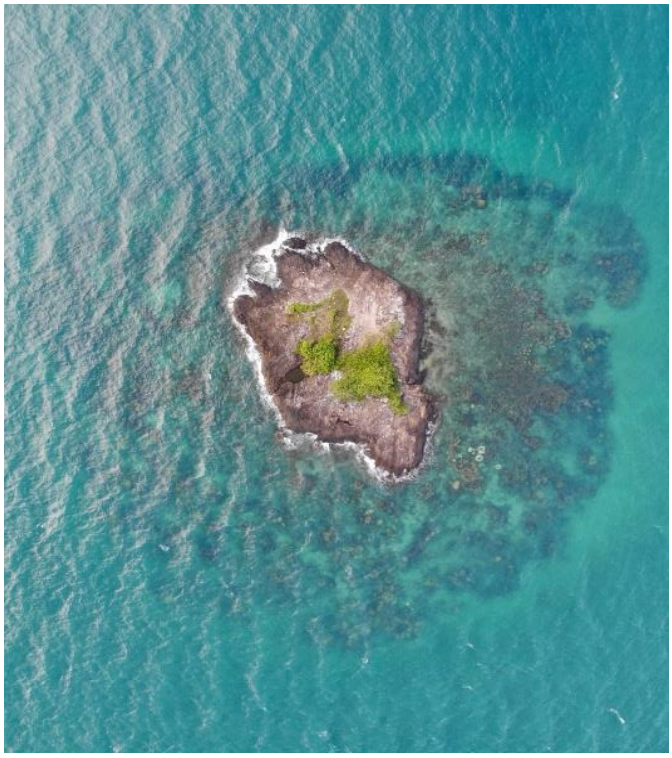

Figure 44: Drone footage, Kampot province – Koh Trongol

3.7 Koh Seh

The island is part of **Ream National Park** in Sihanoukville Province. It was nonetheless designated as part of our study area and surveyed last by the research team. **59 ha of coral reefs** and **12 ha of seagrass meadow were recorded (TH 70%, EA 25%, CS 5%).**

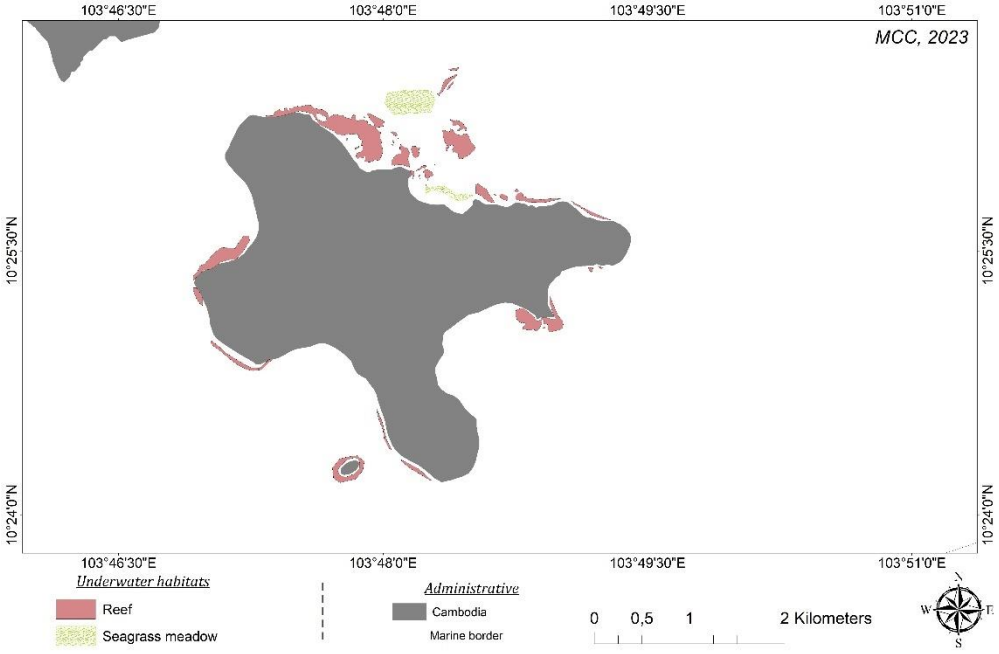

Figure 45:Marine habitats composition & distribution, Kampot Province – Koh Seh

Figure 46: MCC survey team, Kampot Province – Koh Seh

Acknowledgements

The authors of this report would like to thank the local communities for their unwavering support throughout the data collection process. To the European Union and Food and Agriculture Organization for their financial support in the progress of this project. To the Marine Police for their hospitality at remote island sites. And all of those who participated in the data collection, from WEA and MCC staff and volunteers.

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