

ASSESSMENT OF KEP ARCHIPELAGO SEAGRASS MEADOWS



FOR THE ATTENTION OF THE ROYAL FISHERIES
ADMINISTRATION OF CAMBODIA



MARINE CONSERVATION CAMBODIA



2018

REPORT BY

Amick Haissoune, MCC Project Coordinator

Tom Collombat, MCC Cartograph

Tanguy Freneat, MCC Statistician

Neyda Radouane, MCC Graphic designer

SURVEY TEAM

Amick Haissoune

Carney Miller

Rachana Thap

Tom Collombat

Tanguy Freneat

Tim Reynolds

Rose Ellis

Becky Chambers

Romain Privat

Neyda Radouane



EXECUTIVE SUMMARY

Seagrass meadows are considered as one of the most highly productive coastal ecosystems, providing food, habitat and nursery ground for a multitude of endangered and commercial species. A substantial part of Kep's economic activities rely heavily on coastal resources, notably the blue swimmer crab. Its shallow marine ecosystem was home of one of the most extensive seagrass meadows in Southeast Asia. Today, due to Illegal, Unregulated and Unreported (IUU) destructive fishing practices, most of the seagrass ecosystem is critically damaged, threatening the livelihood of local communities. This baseline study is the first comprehensive effort to describe seagrass distribution, abundance and community structure in the Kep Archipelago, supporting the development of tailored marine management strategies. The research focused on the 3 main seagrass meadows inside the Marine Fisheries Management Area (MFMA) and its refugia, where underwater quadrat surveys were carried out in October 2018.

Mainly situated on the east side of Koh Tonsai (KT), Koh Pou (KP) and Koh Seh (KS) islands, the total combined area for the three meadows exceed 750ha (KT <261ha, KP <456ha, KS <38ha). An average of 22.7% seagrass coverage was found (KT 24.6%, KP 22.1%, KS 21.2%). There was marked differences in cover between intensively trawled areas – in which numerous fresh trawling paths were observed at multiple survey points – and the meadows submitted to less anthropogenic pressure. The seagrass community structure was composed of nine species, dominated by *Thalassia hemprichii* (present at 76% of the data points with seagrass), followed by *Enhalus acoroides* (29%) and *Halophila ovalis* (20%) with presence of *Halophila universalis* (7%), *Cymodocea serrulata* (6%), *Cymodocea rotundata* (1%), *Halodule pinifolia* (1%), *Syringodium isoetifolium* (1%) and *Halophila decipiens* (0,3%). The exception being Koh Tonsai where, when seagrass was present, *Enhalus acoroides* and *Thalassia hemprichii* occurred at 63% 62% of points, respectively. The information collected there also showed a more extensive meadow than previously assumed. Preliminary information implied a continuous meadow encompassing Koh Tonsai and Koh Tabal.

Our surveys recorded an extensive depletion of marine life, with only small invertebrates and a handful of juvenile fish present. Our data support the massive reduction in abundance of the main commercial fish stocks and the collapse of some, as stated by many fishermen interviewed by MCC. The seagrass density drastically declines and disappears on the edges of the meadows. Most of the peripheral zones, where years of repeated trawling has destroyed the habitat previously present, have been depleted of suitable substrates. Very few signs of regrowth are visible in the damaged areas, the noticeable exception being Koh Seh where continuous enforcement is implemented. With the recovery and expansion of the bivalve beds solidifying the substrates, and the return of some species of sponges and sea cucumbers in protected areas, faster recolonization could happen. But if the actual situation remains, a reduction in the size of the seagrass meadows is the more likely scenario to be expected in the next few years. This collapse could be stopped with a strong enforcement of MFMA regulations, in combination with other conservation tools, which would create the foundations so desperately needed for the recovery of marine ecosystems in the Archipelago.

ACKNOWLEDGMENT

Marine Conservation Cambodia would like to acknowledge those that have been involved with, and participated in, conserving Cambodia's marine environment and protecting the livelihoods of the people that are dependent on marine resources. Marine Conservation Cambodia's partnerships with the Fisheries Administration (FiA) of the Royal Government of Cambodia (RGC), local governments and authorities, other government bodies (national and provincial), international institutions, and other stakeholder groups have been pivotal to MCC's success. Many thanks to the following people:

H.E. Ken Satha	Governor, Kep Province
H.E. Eng Cheasan	Director General of the Fisheries Administration
H.E Som Piseth	Deputy Governor, Kep Province
H.E Tep Yuthy	Deputy Governor, Kep Province
Mr. Ouk Vibol	Director of Fisheries Conservation Division
Mr. Sar Sorin	Director of Kampot Fisheries Cantonment
Mr. Kuch Virak	Director of Kep Fisheries Cantonment
Mr. Paul Ferber	Managing Director and Project Founder, MCC

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INTRODUCTION

Globally, seagrass meadows are considered as one of the most highly productive coastal ecosystems (Duarte et al, 2004) , providing food, habitat and nursery ground for endangered species such as sea turtles, dugongs, seahorses, whale sharks and Irrawaddy dolphins, all present permanently or seasonally in the Kep Archipelago. The National Report on Seagrass of Cambodia has established that "Cambodia's marine fisheries depend significantly on seagrass ecosystem. Seagrass fishes, and especially shrimp, are highly valuable in both domestic and international markets and subject to high levels of legal and illegal fishing effort". Many commercially fished invertebrates, notably the blue swimmer crab, also depend on healthy seagrass beds for their survival at every stage of their lives. Seagrass meadows stabilize the sediment through their extensive root systems, which help mitigate the effects of wave action thus preventing coastal erosion. Seagrass also plays a major role in coastal nutrient cycling, carbon sequestration and climate change mitigation. The Kep shallow marine ecosystem was home to one of the most extensive seagrass meadows of Southeast Asia (Kampot Management Plan), but today, due to Illegal, Unregulated and Unreported (IUU) destructive fishing practices, most of the seagrass ecosystem is critically damaged.

PROJECT DESCRIPTION

Marine conservation efforts in Cambodia suffer from outdated data and a lack of recent research. Even the most recent United Nations Environmental Program (UNEP) data set showing the global distribution of seagrasses around the world has not reported any meadows for the Kep province (UNEP, 2008). To support the development of tailored management strategies for the Kep Archipelago, filling these marine ecosystem knowledge gaps is essential. Conscious of this problem and trying to improve the situation, the national fisheries department has asked Marine Conservation Cambodia (MCC) to survey and create a map of the seagrass meadows in Kep. This report aims to provide managers and stakeholders with scientific evidence and baseline data about Cambodia's (Kep province) seagrass meadows and, in particular, inside the recently proclaimed Marine Fisheries Management Area (MFMA) and its refugia.

THREE PRINCIPAL PROJECT GOALS

To use collected data to support the implementation of habitat conservation strategies locally within the MFMA such as a refugia.

Use collected data to provide tools needed for the implementation of seagrass conservation guidelines nationally, thus helping the Royal Government of Cambodia in achieving its marine conservation commitments.

To serve as baseline toward a long-term monitoring program of the seagrass meadows in order to assess seagrass recovery, expansion and recolonization, as well as carbon sequestration.

PROJECT METHODOLOGY

PHASE 1

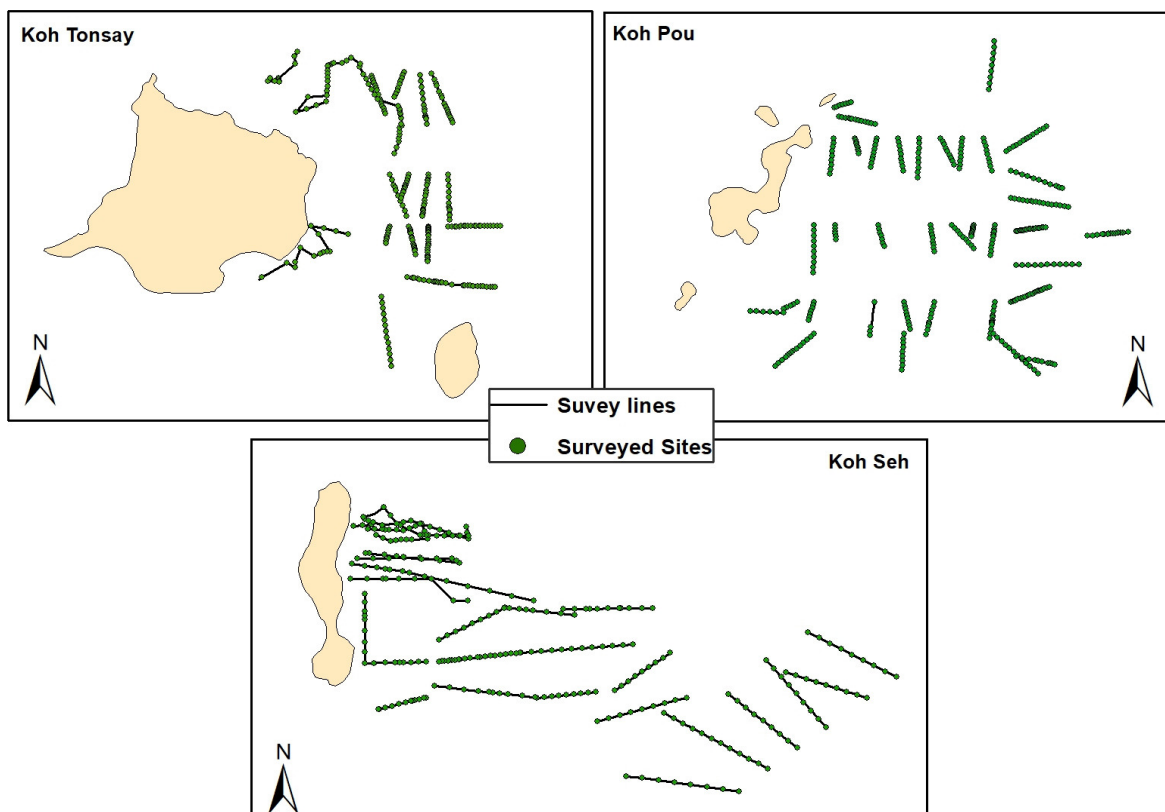
In October 2018, under-water quadrat surveys were carried out on three selected meadows. To effectively survey large subtidal meadows, many survey sites were spread across the seagrass bed in a grid arrangement to capture a representative view of the meadow (Figure 1). A total of 76 surveys were carried out and a total of 914 data points were recorded. Surveyors were dropped at every survey point and swam in a predetermined direction, recording a data point every 2 minutes of swimming or when a noticeable change (edge of the meadows, change in species, etc.) was visible. At every data point abundance (% of seagrass cover) and species composition data were measured. In addition, various physical parameters such as depth, bottom composition, distance from other habitats were entered into the data set. Used equipment was : Set of six 60*40 quadrats, a GPS, scuba diving gear, underwater slates and surface marker device.

PHASE 2

The mapping of the three seagrass beds was done using a combination of techniques involving Microsoft Excel, ArcMap 10.5.1, and QGIS 3.2.3. The collected data, centralized on Excel, was linked with GIS, to create three vectoral files corresponding to Koh Tonsay, Koh Seh, and Koh Angkrong surveyed sites. Following that process, a conditional selection was made on each layer, to create temporary features highlighting the presence or absence of seagrass. The meadows edges were drawn, linking the last points where the lowest presence of seagrass (under 10%) was recorded during the surveys. To differentiate the healthy from the recolonizing meadows, density data was used. It was recorded using a 1 to 6 scale, and **will be used in the upcoming reports to create density maps.**

SURVEY SITES

figure 1



OVERALL RESULTS

914 Points Surveyed

22.7 %

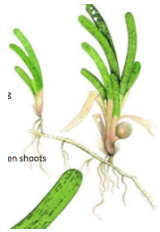
Average seagrass coverage on the surveyed areas

9 Species identified

750 ha

Of seagrass meadows estimated

SEAGRASS SPECIES DISTRIBUTION ACROSS SURVEYED MEADOWS



Thalassia hemprichii – 76 %



Halophila universalis – 7%



Enhalus acoroides – 29 %



Cymodocea serrulata – 6 %



Halophila ovalis – 20 %



Cymodocea rotundata – 1%



Syringodium isoetifolium – 1%



Halodule pinifolia – 1%



Halophila decipiens – 0,3%

RESULTS

KOH SEH

Situated on the east side of the island, the seagrass meadows start around its southern edge, expanding eastward. It is mostly composed of *Thalassia hemprichii* (present at 76% of the data points with seagrass) with a strong presence of *Halophila ovalis* (present at 38% of the data points with seagrass). An undeniably encouraging finding is a marked recovery of marine life in the most protected zone of the Archipelago (MCC research area and 300m No Take Zone on the east coast). Schools of commercial and non-commercial fishes, such as large groupers, as well as a good diversity of invertebrates, were observed in the seagrass during the surveys. This shows the augmentation in abundance and diversity of marine life, and is a strong indicator of a recovering ecosystem. With 21.2% coverage on average, it drastically declines and disappears toward the north-east (Figure 2) where years of repeated trawling has destroyed the seagrass previously present. Slow signs of regrowth are noticeable in the damaged areas. With the recovery and expansion of the bivalve beds solidifying the substrates, faster recolonization can be expected in the next few years.

KOH POU *

Situated on the east side of the island, the seagrass meadows start before the northern edge, in front of Koh Tabal, expanding eastward. It is mostly composed of *Thalassia hemprichii* (present at 88% of the data points with seagrass) with a presence of *Halophila ovalis* (present at 18% of the data points with seagrass) and *Enhalus acoroides* (present at 18% of the data points with seagrass). Our surveys recorded an extensive depletion of marine life, with only small invertebrates and a handful of juvenile fishes observed in the seagrass during the surveys. Our data support a massive reduction in abundance of the main commercial fish stocks and a collapse of some, as stated by many fishermen interviewed by MCC. With 22.1% coverage on average, it drastically declines and disappears toward the south-west (Figure 3) where years of repeated trawling has destroyed the seagrass previously present. Some sign of ecosystem recovery is visible, notably the return of some species of sea cucumbers (no commercially fished species) which will help filter the bottom sediments. Unfortunately, very few signs of regrowth are noticeable in the damaged areas, where multiple fresh trawling paths were observed at numerous survey points. A reduction of the size of the seagrass meadows is the more likely scenario to expect in the next few years unless strong, continuous, enforcement is quickly implemented in the Refugia.

KOH TONSAI *

Situated on the east and north side of the island, the seagrass meadows start around the middle of the east coast of Koh Tonsai, extending east and south. It is, overall, a mixed meadow composed of *Enhalus acoroides* (present at 63% of the data points with seagrass) and *Thalassia hemprichii* (present at 62% of the data points with seagrass), with a presence of *Halophila ovalis* and *Cymodocea serrulata* (at 14% and 12% of the data points with seagrass respectively).

The information collected at Koh Tonsai clearly illustrated that the meadow is more extensive than previously assumed. More research and surveys are necessary to map its full extent. Preliminary information implied a continuity (single meadow) encompassing Koh Tonsai and Koh Tabal. The meadow could also be more extensive westward on the north and south coast of the island. Our data clearly shows an extensive depletion of marine life, with only small invertebrates and a handful of juvenile fishes observed in the seagrass during the surveys. This data support a massive reduction in abundance of the main commercial fish stocks and a collapse of some, as stated by many fishermen interviewed by MCC. An average of 24.6% seagrass coverage was found. There was marked differences in cover between intensively trawled areas – in which numerous fresh trawling paths were observed at multiple survey points – and the ones submitted to less pressure from destructive fishing. The seagrass density drastically declines and disappears towards the north and south coast (Figure 4) where years of repeated trawling has destroyed the meadow previously present.

Very few signs of regrowth are noticeable in the damaged areas. However, with the recovery and expansion of the bivalve beds solidifying the substrates, and the return of some species of sponges and sea cucumbers (no commercially fished species) faster recolonization could happen. But if the actual situation remains, a reduction in the size of the seagrass meadow is the more likely scenario to expect in the next few years.

* It is important to note that those seagrass meadows are still under repeated incursion of illegally fishing trawlers. Multiple trawling paths inside the meadows, creating visible damage and gaps, were observed by the surveyor's team. The information compiled in this report was accurate at the time of writing but a reduction in overall area is to be considered in the near future

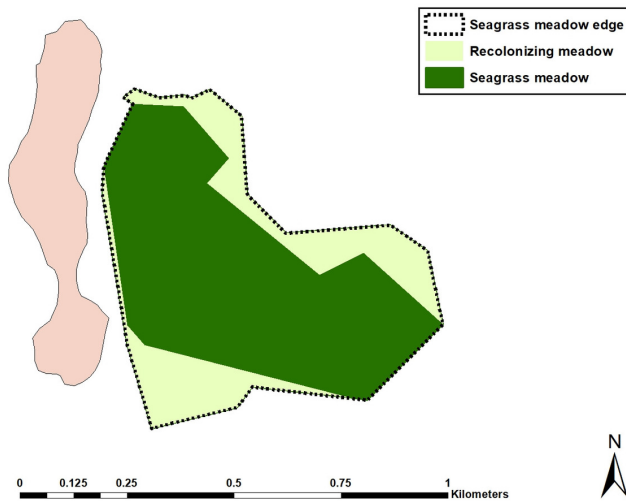
Refugia definition

Refugee areas for one or more target species in critical cycle of life period. Fishing and other activities inside fisheries refugia are strictly prohibited during the protected period. However, family fishing and other activities, which are not harmful to fisheries resources, are allowed as usual, in between periods of protection.

Kep seagrass meadow is a vital habitat for the blue-swimmer crab. The existing refugia site is strategically placed to help increase their numbers, as they will use it as their main breeding ground, and as habitat at every stage of their lives, notably during the larval stage.



KOH SEH - figure 2



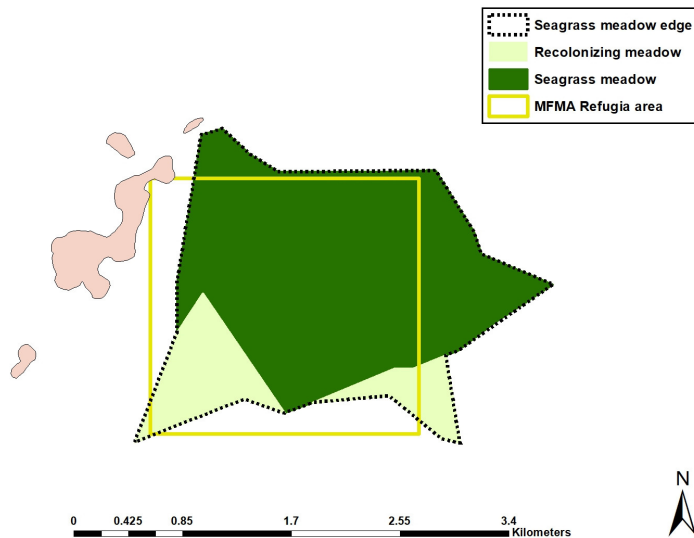
270
points surveyed

21.2 %
of seagrass coverage on
the surveyed area

7
species identified

38ha
of seagrass estimated

KOH POU - figure 3



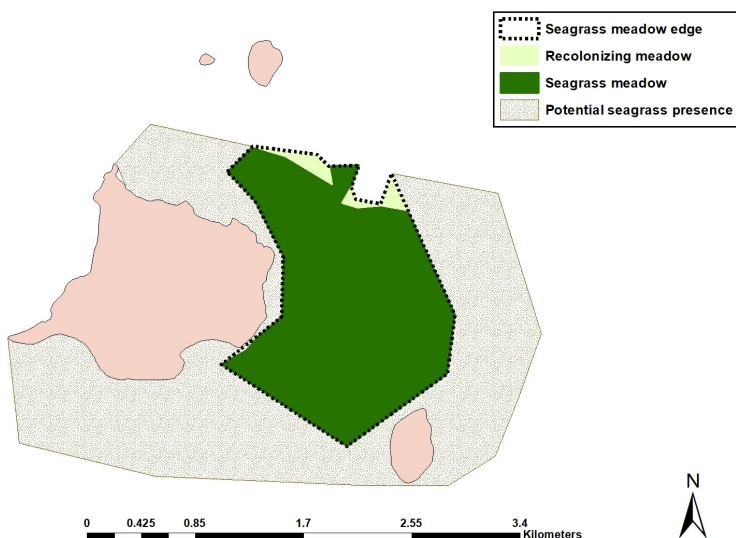
367
points surveyed

22.1 %
of seagrass coverage on
the surveyed area

7
species identified

456 ha
of seagrass estimated

KOH TONSAI - figure 4



277
points surveyed

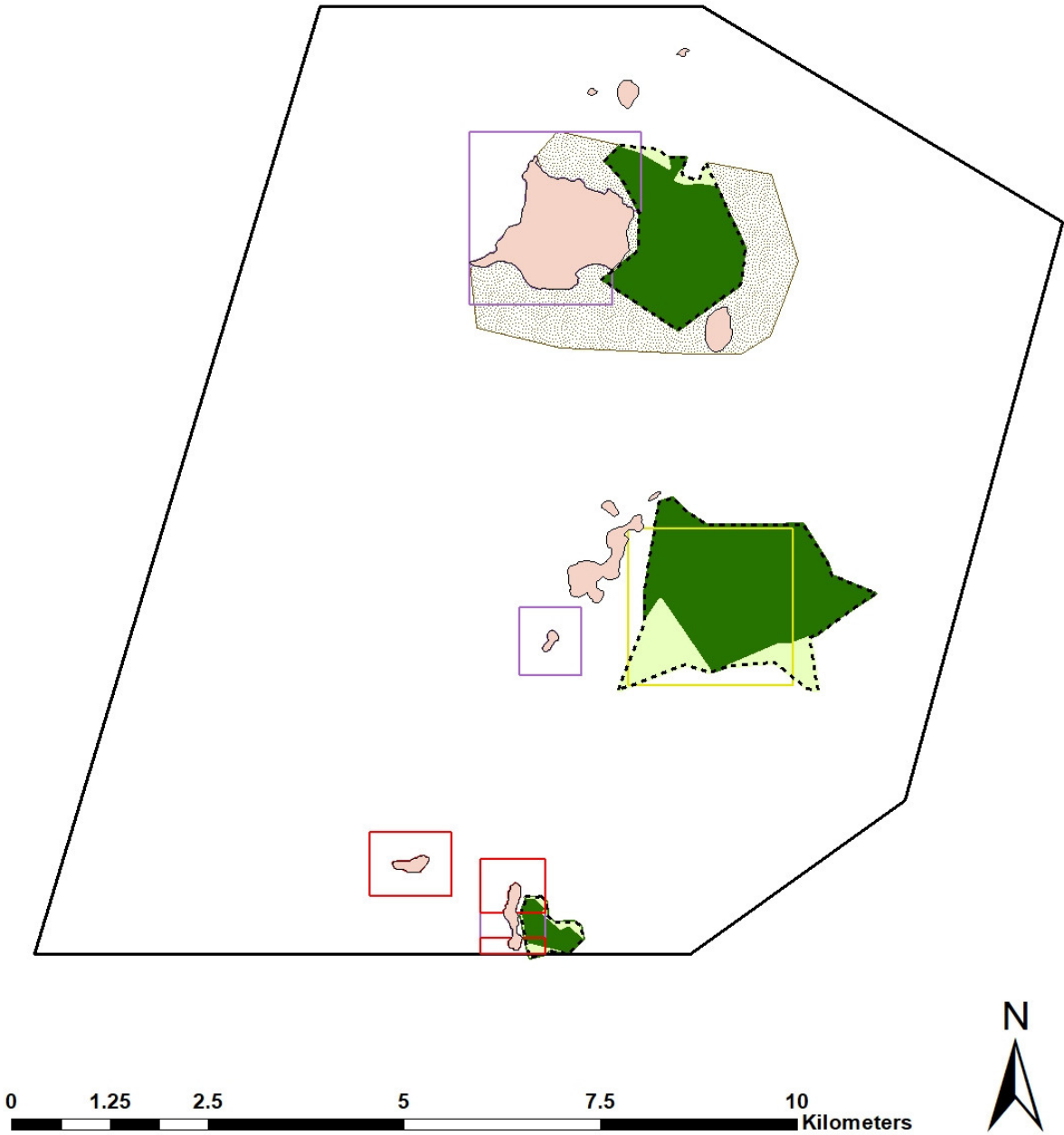
24.6 %
of seagrass coverage on
the surveyed area

7
species identified

261 ha
of seagrass estimated

KEP MFMA SEAGRASS MEADOWS

figure 5



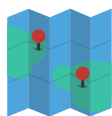
	Seagrass meadows edges		MFMA boundary
	Recolonizing meadows		MFMA Refugia area
	Seagrass meadows		MFMA Tourism Area
	Potential seagrass presence		MFMA Conservation Area

RECOMMENDATIONS

The economic value of seagrass meadows is huge and it would be incredibly beneficial for Cambodia's marine ecosystems and economy to capitalize on its potential*. In that regard, Cambodia has a strong advantage compared to its two coastal neighbours, the vastness of its meadows. Thailand has 2,583 km of coastline and 148.5 km² of seagrass, only 0.29% of its territorial sea. Vietnam has 3,200 km of coastline and 157.4 km² of seagrass, only 0.25% of its territorial sea. In comparison, Cambodia has the shortest coastline of 435 km, but 324.9 km² of seagrass, representing 6.19% of its territorial seas, 21.5 to 25 times more than its neighbours (UNEP 2008).

This project is providing valuable baseline information on the three main seagrass meadows of the Kep Archipelago. In conjunction with subsequent, more in-depth research, those data could be used toward the protection and restoration of these meadows. This would insure and increase ecosystem services, sustainable fisheries and climate change mitigation in the future, notably, by the delineation of new critical conservancy zones in need of significant protection in the Kep MFMA and the protection and monitoring of the existing one, such as the refugee. On the basis of the information analysed in this report, we strongly recommend the creation of a second refugia zone for the seagrass meadows of Koh Tonsai in order to greatly improve its resilience capabilities. Seagrass is a useful indicator of ecosystem health and, potentially, could be utilized as bio-indicator to assess the pollution status of the Kep marine ecosystem.

Potential conservation outcomes



Adaptation of the mapping of the newly created MFMA, following findings on seagrass distribution and density. It will facilitate the implementation of Cambodia's Environmental and Natural Resources Code, at a local level. For example, improving connectivity between critical habitats including mangroves, sea grasses and coral reefs.



Determination of strategic points for the deployment of additional Conservation and Anti Trawling Structures to deter illegal fishing and providing artificial substrates for reef building. It will directly protect 13 endangered species for which a healthy seagrass provides shelter or nutrition.



Help in the estimation of the carbon sequestration of Kep Archipelago seagrass meadows.



To serve as baseline toward a continuous monitoring of the recovery of damaged meadows, and the resettlement of the seagrass, in highly impacted areas of the archipelago.

* See appendix on blue credit

THREATS

Loss of habitat and biodiversity have exerted extreme pressure on the ecosystem, along with the livelihood options of those communities depending on the seagrass associated fauna. Disturbances caused by trawling uniformly uproot seagrass and disturb the associated sediment, causing siltation (Mam, 2002) . Constant disturbance to seagrass habitat greatly restricts its ability to recover. Under such circumstances, population recovery can take years (Clark & Kirkman, 1989; Preen *et al.* 1997) . Persistent trawling on a sandy bottom area (substrate suitable for seagrass growth) constantly disturbs the sea bed, up-heaving it, displacing it and eventually removing the sandy sediment layer, leaving silt and mud (Poiner *et al.* 1989). This remaining sediment is not capable of supporting seagrass growth.

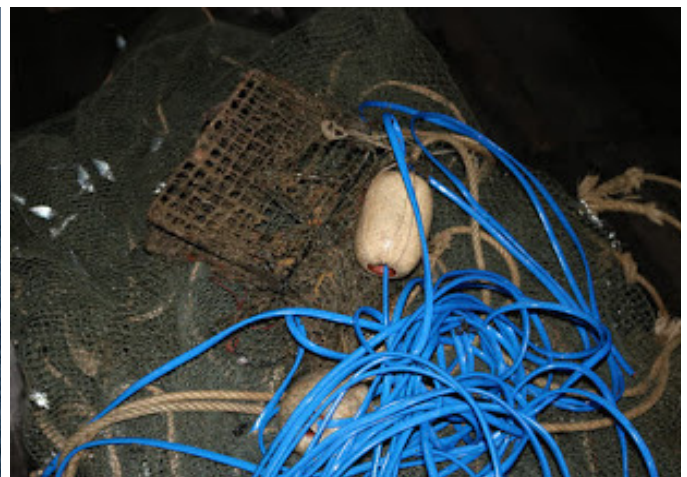
Regular incursions of big illegal foreign commercial boats (pair trawlers, deep sea seine net, mechanized push nets, etc.) in addition to the expansion of the Kep trawling fleet and the adoption of new methods (pulse trawling, tube fishing) during the past decades, has accelerated exponentially the disappearance of vast meadows.



The prevalence of IUU fishing (mostly trawling) today, causing the rapid decline of seagrass ecosystems around Kep islands, has led to collapse of various important ecosystem services, reduction of marine biodiversity and loss of sustainable local fisheries. Traditional fisheries are collapsing, and less than 2% of their catch are high value stocks (UNIDO, 2015), which severely diminishes incomes in local communities. Small-scale fishermen regularly lose fishing gear to illegal bottom trawling (MCC interviews 2015). The vast majority of the traditional fishermen in Kep are aware and suffer daily from this situation. They are experiencing a drastic reduction in the quantity and size of their catches and the destruction of their once bountiful fishing grounds. According to them, blue-swimmer crab size has decreased by nearly half, and they are more sparse than ever. The fishers actively want to reverse the situation, being now forced to send some of their children to find construction and security jobs in Phnom Penh (MCC interviews 2015).



Foreign deep sea seine net illegally present in Kep Archipelago, MCC



Class-1 offense electric trawling gear with small-scale fishing gear caught inside, MCC

This destruction has also led to the reduction of rich benthic areas (soft corals, bivalve beds, seagrass meadows) of this ecosystem, creating a destructive cycle leading to increased nutrients and sediment re-suspension, increasing the rate of seagrass decline (Burkholder *et al.* 2007) . Trawling not only destroys sensitive habitats but also threatens the whole food web. With a bycatch rate averaging 80% (UNIDO, 2015), endangered species such as seahorses, turtles, Irrawaddy dolphins, dugongs, whale sharks, and giant clams are heavily impacted. Seagrass meadows of the Kep Archipelago are home to the highest concentration of seahorses (*Hippocampus kuda*, *H. spinosissimus*, *H. monikhei*, *H. trimaculatus*) in Cambodia (MCC, 2008). Those rare animals are highly threatened due to the loss of their habitat and illegal exploitation through bycatch and tube fishing. Similarly, IUU fishing has led to a reduction of dolphin populations and the near extinction of turtle and dugong populations (MCC 2015 interviews) around these islands. However, those populations can recover with protection and restoration of seagrass habitats of the Kep Archipelago.

This situation is mostly due to the absence of enforcement and resources, compounded by a lack of data concerning the extent of the meadows and the intensity of IUU in the province. Cambodian fisheries laws were modified in 2006 to include a ban of trawling in areas shallower than 20m, encompassing the entirety of the Kep archipelago. Numerous articles of the 2007 Law on Fisheries are violated daily, by foreign and domestic vessels. Unfortunately, local authorities are not equipped to safely and efficiently tackle these problems, particularly the highly organized foreign industrial poachers. Electric trawling, for example, violates six laws but goes on unhindered; vessels moor and unload their catch openly, while Vietnamese ships cross the border illegally, taking advantage of local authorities' lack of capacities and resources.



Seagrass washed up on the shore of Koh Seh Island

In the current scenario, the few remaining seagrass meadows surveyed in this project are still seriously threatened, requiring urgent need for management actions. Without rapid, serious and proactive actions the seagrass meadows, and the Archipelago in general, might not be able to support the livelihoods of the booming coastal population in Kep province. The newly implemented MFMA with its multiple zones scheme, notably a refugia and two no-take zones, is precisely designed to decrease anthropogenic stressors and preserve the remaining habitats. One of the measures in support of this objective is the deployment of 107 concrete block structures in and around the various seagrass habitats of Kep. The deterrent effect of the units is to create high risk of snagging and entanglement of destructive fishing gear. They will be built to different heights at various depths and are designed to avoid impacts on regular and legal navigation.



Foreign pair trawler illegally present in Kep Archipelago, MCC



Destroyed seagrass from a single trawl, MCC

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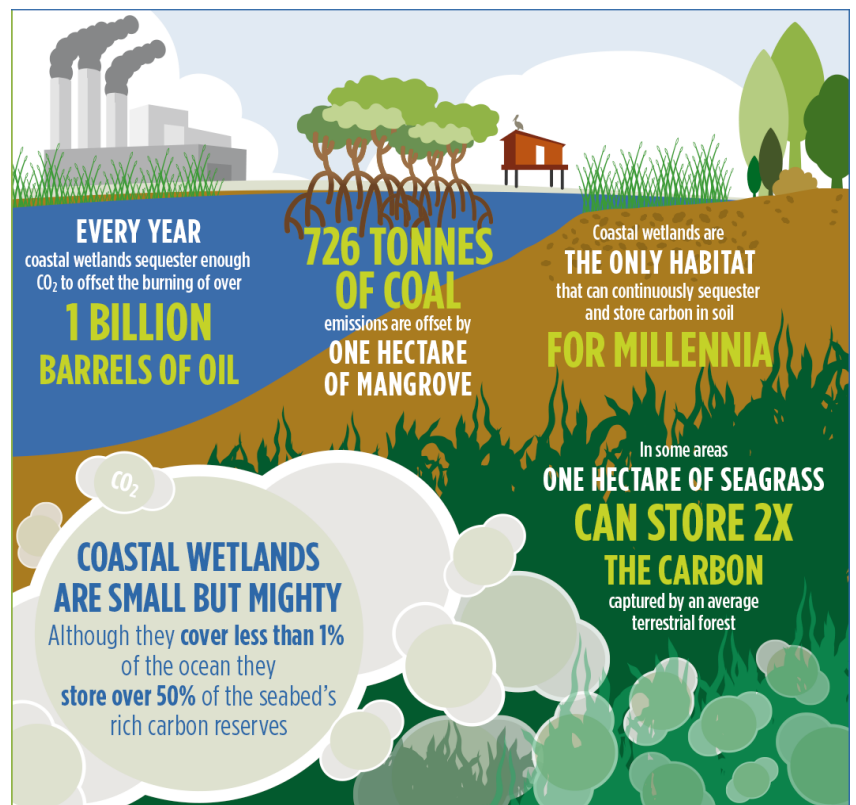
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APPENDIX 1 : BLUE CARBON

One of the key indirect services provided by the marine and coastal ecosystems is carbon sequestration, which includes both capture and long-term storage (Roger & Brent, 2012) . From all the biological carbon (Green Carbon) captured in the world, more than half (55%) is captured by marine organisms (Blue Carbon). In their study, Nellemann *et al.* affirm that approximately 93% of the Earth's carbon dioxide is stored and undergoes its cycle in the oceans. Similarly, the coastal ecosystems are recognized as the largest carbon sinks, given that they store large quantities of carbon both in their vegetation and the seabed [20]. In fact, the oceans' plant ecosystems, in particular mangroves and seagrasses—despite covering only a relatively small percentage of the surface—constitute reserves of more than 50% of the organic carbon stored in marine sediments, and are the most intense reserves on the planet (Nellemann *et al.* 2009) . Murray *et al.* present an economic model that allows an approximation of the valuation of Blue Carbon in a hypothetical global carbon market in which marine ecosystems are included. Their conclusion is that loss of marshes, mangroves and seagrasses might impose economic costs of USD \$6 – 42 billion annually (Pendleton *et al.* 2012).

Furthermore, recent study found that seagrass meadows were accumulating carbon at a rate as much as ten times faster than a typical tropical rainforest, which is often touted as the lungs of the world. In economic terms, taking Australia as an example; the carbon dioxide stored in its seagrass meadows is worth more than \$5.2 billion, according to a research from Edith Cowan University, published in the journal PLOS ONE. The research estimated Australian seagrass meadows are absorbing around 1 million tonnes of carbon each year, equivalent to \$35 million in carbon credits using the 2020 carbon price estimate (Lavery *et al.* 2013).

The future economic potential of seagrass meadows is immense, the benefits for Cambodia's economy and marine ecosystems could be enormous. As stated before, Cambodia has a strong advantage compared to his two coastal neighbours : the vastness of its meadows. A soon to be implemented blue carbon credit scheme would offer a steady stream of revenues to the countries ready to apply and capitalize on this new market.



Mapping Ocean Wealth Coastal Blue Carbon, The Nature Conservancy Organization