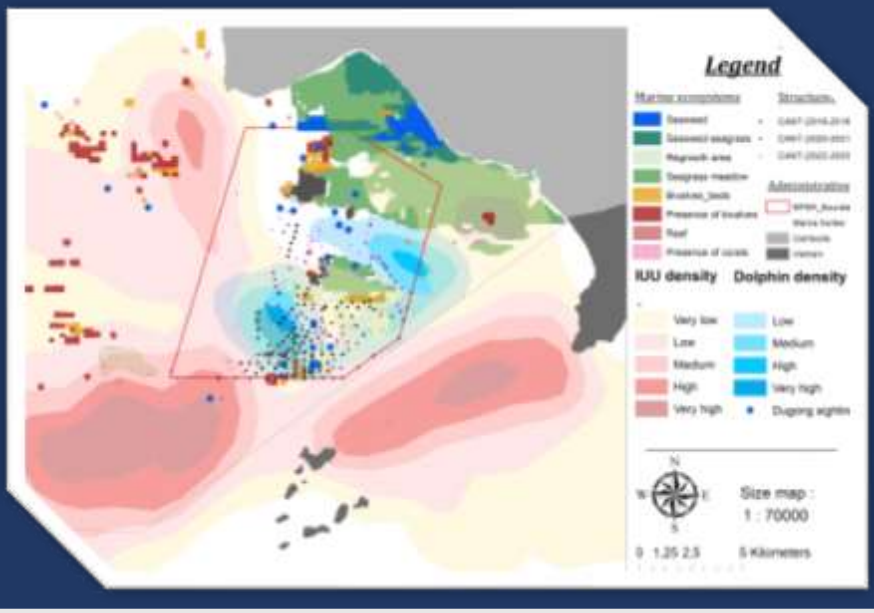
Marine Harvesting Networks in Cambodia

Technical report on the abundance and impact of bottom-trawling in 2022



09/02/2023

Marine Conservation Cambodia

Executive summary

Illegal, Unreported, Unregulated fishing (IUU) is a constant threat to wildlife and local livelihood. In Cambodia, it is the underlying cause of the current trend of marine fisheries experiencing a rapid decline in catch (UNEP, 2007) and of conflicts between different groups of users, such as traditional fishers and enforcement officers (Gillet, 2008). South-East Asia as a region and Cambodia in particular is affected by overexploitation caused by IUU fishing since approx. 10% of the country's GDP depends on fishing-related work while producing 750,000 tons of fish products annually. (FAO, 2017; Gillet, 2004).

Marine Conservation Cambodia (MCC), a local NGO in Kep, Cambodia, was founded to protect marine wildlife and sustain the livelihoods of local small-scale fishing communities that rely on the sea as their main source of food (MCC, 2019). In January 2019, MCC started the Marine Harvesting Network Project to monitor and conduct in-depth analysis of harvesting networks in and around the established Marine Fisheries Management Area (MFMA; Cambodia's equivalent of a marine protected area) in Kep, to determine the scope of illegal practices as well as whether illegal activities could be considered a regional issue. Over a 4-month data collection period (5th of April – 26th of July 2022) during daylight hours, the following insight has been gained:

- Estimation of number of bottom-trawlers at the Kep Archipelago
    - 1660 sightings of trawlers during 146 survey hours
- Fishing activities of bottom-trawlers
    - 1133 were trawling with absolute certainty in water depth < 20 meter
    - Of which 274 were trawling illegally within the MFMA area
- Illegal gear on bottom-trawlers
    - 45 trawlers were carrying illegal gear such as seine net, airtubes or electric gear
- Movement patterns between the Cambodian and Vietnamese maritime border
    - 861 foreign trawlers were entering the Cambodian EEZ

We recommend the following potential additions to identify associated offenders in the illegal marine harvesting network of Cambodia:

- Georeferencing and individualisation of vessels to investigate repeat offences
- Continous night surveys to investigate night time activities
- More precise determination of illegal activities and tracking of fishing products in a transnational context to find where they reach the market

Based on the outcome, a long-term marine surveillance system applying emerging technologies and continous data collection is recommended to be developed and implemented by 2024.

According to the data the most promising option for deterring IUU-fishing activities passively are the by MCC in 2018 developed Conservation and Anti-Trawling Structures that do not only prevent destructive bottom-trawling but also enables the creation of ecological corridors that bring marine habitats and keystone species back to former degraded ecosystems.

សង្ខេបទិដ្ឋភាពទូទៅ

ការនេសាទខុសច្បាប់គ្មានរបាយការណ៍ និងការនេសាទដែលគ្មានការគ្រប់គ្រង (IUU) គឺជាការគម្រាមកំហែងជាមឿយៗដល់អាយុជីវិតសត្វព្រៃ និងជីវភាពរបស់ប្រជាជនក្នុងតំបន់។ នៅប្រទេសកម្ពុជាការនេសាទបែបនេះគឺជាមូលហេតុចំបងនៃការថយចុះនៃចំនួនត្រីសមុទ្រដែលនេសាទបាន (ឯកសារយោង UNEP, 2007) ព្រមទាំងជាមូលហេតុនៃជម្លោះរវាងភាគីអ្នកប្រើប្រាស់ ដូចជាអ្នកនេសាទបែបប្រពៃណី និងអជ្ញាធរចាត់វិធានការ (ឯកសារយោង Gillet, 2008)។ អាស៊ីអាគ្នេយ៍ទាំងមូល និងប្រទេសកម្ពុជា រងគ្រោះជាក់ស្តែងពីភាពកេងប្រវ័ញ្ចនៃការនេសាទខុសច្បាប់ (IUU)។ ប្រមាណ១០ភាគរយនៃផលិតផលក្នុងស្រុកសរុបអាស្រ័យលើការងារទាក់ទងនឹងការនេសាទ ដែលបង្កើតបានជាផលិតផលធ្វើពីត្រី ៧៥០,០០០តោន (ឯកសារយោង FAO, 2017; Gillet, 2004)។ អង្គការក្នុងតំបន់ខេត្តកែប ប្រទេសកម្ពុជា អង្គការអភិរក្សសមុទ្រកម្ពុជា (MCC) ត្រូវបានកសាងឡើង ក្នុងគោលបំណងការពារសត្វព្រៃសមុទ្រ និងរក្សាជីវភាពរបស់ប្រជាជនសហគមន៍នេសាទខ្នាតតូចក្នុងតំបន់ ដែលពឹងពាក់ទាំងស្រុងទៅលើធនធានសមុទ្រ ដើម្បីរកអាហារ និងចិញ្ចឹមជីវិតរបស់ពួកគេ (MCC, 2019)។ កាលពីខែមករា ឆ្នាំ២០១៩ អង្គការ MCC បានចាប់ផ្តើមគម្រោងបណ្តាញប្រមូលផលសមុទ្រ ដើម្បីត្រួតពិនិត្យ និងវិភាគស៊ីជម្រៅលើបណ្តាញប្រមូលផលជុំវិញ និងក្នុងតំបន់គ្រប់គ្រងជលផលសមុទ្រ (MFMA ដែលជាតំបន់ការពារសមុទ្ររបស់ប្រទេសកម្ពុជា MPA) នៅខេត្តកែប ដើម្បីកំណត់ទំហំរបស់ការអនុវត្តខុសច្បាប់ផ្សេងៗ ក៏ដូចជាសន្ទុះម៉ត់ថាតើសកម្មភាពខុសច្បាប់អាចកំណត់បានថាជាបញ្ហាក្នុងតំបន់ដែរឬទេ។ បន្ទាប់ពីការប្រមូលទិន្នន័យជាម៉ៀងរាល់ថ្ងៃ អស់រយៈពេល៤ខែ (ចាប់ពីថ្ងៃទី៥ ខែមេសា ដល់ថ្ងៃទី២៦ ខែកក្កដាឆ្នាំ២០២២) យើងបានរកឃើញការយល់ដឹងដូចខាងក្រោម៖

- ការប៉ាន់ប្រមាណចំនួនទូកអូសបាតសមុទ្រនៅជុំវិញប្រជុំកោះកែប
    - ប្រទះឃើញ ១,៦៦០គ្រឿង ក្នុងរយៈពេល ១៤៦ម៉ោង
- សកម្មភាពនេសាទត្រីរបស់ ទូកអូសបាតសមុទ្រ
    - ប្រទះឃើញ ១,១ពាក្រឿង កំពុងអូសត្រី ក្នុងទឹកជម្រៅក្រោម២០ម៉ែត្រ
    - ក្នុងចំណោមខាងលើ មាន២៧៤គ្រឿង កំពុងអូសត្រីនៅក្នុងតំបន់គ្រប់គ្រងជលផលសមុទ្រ MFMA
- ឧបករណ៍គ្រឿងយន្តខុសច្បាប់នៅលើទូកអូសបាតសមុទ្រ
    - ទូកអូស ៤៥គ្រឿង បំពាក់ដោយឧបករណ៍ខុសច្បាប់ដូចជាសំណាញ់សែន បំពង់ទុយោខ្យល់ និងឧបករណ៍ឆក់ត្រីផងដែរ
- ក្រឡាដំណើរចេញចូលព្រំដែនសមុទ្រកម្ពុជាវៀតណាម
    - ទូកអូសបរទេស ៨៦១គ្រឿងបានចូលមកតំបន់សេដ្ឋកិច្ចផ្តាច់មុខរបស់កម្ពុជា។

យើងខ្ញុំសូមណែនាំនូវសក្តានុពលបន្ថែមដើម្បីកំណត់អត្តសញ្ញាណជនល្មើសដែលពាក់ព័ន្ធនឹងសកម្មភាពបណ្តាញប្រមូលផលសមុទ្រខុសច្បាប់ដូចខាងក្រោម៖

- បង្កើតផែនទីយោងតាមភូមិសាស្ត្រ និងធ្វើបុគ្គលភាពនៃទូកនីមួយៗ ដើម្បីធ្វើការស៊ើបអង្កេតបទល្មើសកើតឡើងដដែលជាច្រើនដង
- ការស៊ើបអង្កេត តាមរយៈការត្រួតពិនិត្យសកម្មភាពពេលយប់ជាបន្តបន្ទាប់
- ការកំណត់សកម្មភាពបទល្មើស និងការតាមដានផលិតផលនេសាទឆ្លងដែន ឲ្យកាន់តែច្បាស់លាស់ ដើម្បីរកឲ្យឃើញចំណុចដែលផលិតផលជួបជាមួយទីផ្សារ។

យោងតាមលទ្ធផល យើងខ្ញុំក៏សូមណែនាំ មុនឆ្នាំ២០២៤មកដល់ ឲ្យដាក់ឲ្យមាននូវប្រព័ន្ធឃ្លាំមើលសមុទ្រយៈពេលវែង ដែលមានដាក់ឲ្យអនុវត្តនូវបច្ចេកវិទ្យាថ្មីៗ និងការប្រមូលទិន្នន័យជាបន្តបន្ទាប់។

យោងតាមទិន្នន័យ ជម្រើសដែលមានសក្តានុពលខ្ពស់បំផុត ក្នុងការប្រឆាំងសកម្មភាពនេសាទខុសច្បាប់របស់ IUU គឺសមិទ្ធផលការព្យាយាមរបស់អង្គការ MCC កាលពីឆ្នាំ២០១៨ ដែលបានបង្កើតនូវដុំថ្មអភិរក្សបាតសមុទ្រដែលមិនត្រឹមតែអាចទប់ស្កាត់ការអូសត្រីបាតសមុទ្រតែប៉ុណ្ណោះទេ ថែមទាំងបង្កើតនូវច្រកបៀងអេកូឡូស៊ីដែលជាជម្រកសត្វសមុទ្រ និងនាំឲ្យមានបម្រែបម្រួលប្រភេទសត្វ និងរក្ខជាតិសំខាន់ៗដែលខូចគុណភាព ឲ្យក្លាយជាប្រព័ន្ធអេកូឡូស៊ីដែលមានសុខភាពល្អឡើងវិញ។

Acknowledgements

Marine Conservation Cambodia and the Marine Harvesting Network Project would like to thank those that have been involved 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 Ministry of Environment, Ministry of Agriculture, Forestry and Fisheries, the Fisheries Administration of the Royal Government of Cambodia, local governments and authorities, other government bodies, international institutions, and other stakeholder groups have been pivotal to MCC's success. Much appreciation goes to the MCC family without which this research would not have been possible as well as our funders and the teams of: Heinrich Böll Stiftung, Lighthouse Foundation, International Conservation Fund of Canada, Mission Blue, CSIRO, DJI store Frankfurt Zeil, Simrad, Orniwelt, FotoSpezialist, Mediamarkt Zeil and our godfather Mr Doug Bender for being an incredible support in the first 4 years of this project.

We would like to thank Mr Paul Ferber, Ms. Rachana Thap and all of the Khmer conservationists for their continous fight, for being an inspiration for this project and dreamers all around the world.

អង្គការអភិរក្សសមុទ្រកម្ពុជា MCC និងគម្រោងបណ្តាញប្រមូលផលសមុទ្រ សូមថ្លែងអំណរគុណដល់អ្នកដែលបានចូលរួមថែរក្សា និងចូលរួមអភិរក្សបរិស្ថានសមុទ្រកម្ពុជា ក៏ដូចជាជួយការពារនូវជីវភាពរបស់ប្រជាពលរដ្ឋដែលពឹងផ្អែកលើធនធានសមុទ្រ។ ដោយការចូលរួមភាពជាដៃគូរបស់អង្គការអភិរក្សសមុទ្រកម្ពុជា ជាមួយក្រសួងបរិស្ថាន ក្រសួងកសិកម្ម រុក្ខាប្រមាញ់ និងនេសាទ រដ្ឋបាលជលផលនៃរាជរដ្ឋាភិបាលកម្ពុជា រដ្ឋាភិបាលក្នុងតំបន់ និងអាជ្ញាធរ ស្ថាប័នរដ្ឋាភិបាលផ្សេងទៀត ស្ថាប័នអន្តរជាតិ និងក្រុមអ្នកពាក់ព័ន្ធដ៏ទៃទៀតដែលបានរួមចំណែកយ៉ាងសំខាន់ជាមួយភាពជោគជ័យរបស់អង្គការ MCC ។ សូមថ្លែងអំណរគុណយ៉ាងជ្រាលជ្រៅដល់គ្រួសារអង្គការ MCC បើគ្មានពួកគាត់ការស្រាវជ្រាវមួយនេះក៏មិនអាចទៅរួចដែរ។ ជាមួយគ្នានេះដែរ យើងខ្ញុំថ្លែងអំណរគុណដល់អ្នកផ្តល់មូលនិធិរបស់យើងដែលមានដូចជា៖ Heinrich Böll Stiftung, Lighthouse Foundation, International Conservation Fund of Canada, Mission Blue, CSIRO, DJI store Frankfurt Zeil, Simrad, Orniwelt, FotoSpezialist, Mediamarkt Zeil និងលោកឱពុកធម៌របស់ពួកយើង លោក Doug Bender សម្រាប់ការគាំទ្រ និងការលើកទឹកចិត្តក្នុងរយៈពេល៤ឆ្នាំដំបូងនៃការបង្កើតគម្រោងមួយនេះ។ អរគុណដល់លោក Paul Ferber កញ្ញា ចាប់ រចនា និងក្រុមការងារអភិរក្សខ្មែរទាំងអស់ សម្រាប់ការតស៊ូប្រឹងប្រែងឥតឈប់ឈរ ជាអ្នកដែលជំរុញឲ្យមានគម្រោងនេះកើតឡើង ក៏ជាបុគ្គលគំរូដល់មនុស្សជំវិញពិភពលោកដែលមានសេចក្តីប្រាថ្នាខ្ពស់ផងដែរ។

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1. Background

The Cambodian fisheries sector significantly contributes to its people's food security, nutrition and livelihood (PIC, 2017; MAFF, 2011). One of the biggest challenges that fisheries in South-East Asia is facing correlates with the need for significant reduction of fishing efforts to overcome overfishing (Sumaila, et al., 2012) when implementing recovery measurements that are needed to prevent underperformance with fundamental socio-economic threats (Costello, 2016; Pauly, Watson & Alder, 2005). Global overexploitation of fisheries resources has a proven negative effect on biodiversity and species abundance (Kleisner & Pauly, 2011) leading to a genetic drift towards reduced average body size and reproductive success (Pinsky & Palumbi, 2013). Only in Cambodia approximately 6 million people depend on fisheries or fisheries-related work (SEAFDEC, 2023). While conventional fishing management practice takes catch data and maximum sustainable yield into consideration (Froese *et al.*, 2012), it does not incorporate species specific uncertainties in population dynamics or environmental variation (Hélias, Langlois & Fréon, 2017). In particular, bottom-trawling has a high bycatch rate which is not taken into consideration in marine fisheries catch (Teh *et al*., 2014) and by damaging coastal ecosystems the high potential of organic carbon storage vanishes creating ocean acidification and atmospheric Carbon dioxide (Sala, et al., 2021). Substantial habitat degradation caused by the loss of seagrass beds and other coastal ecosystems that function as ecological corridors, are highly relevant for Cambodia's coastal ecosystem and climate change resilience (Rizvi & Singer, 2011) which could indefinitely harm nature-based solution to climate change in South-East Asia. Bottom-trawling in Cambodia is illegal in waters less deep than 20 meters (Fisheries law Art. 48, 49, 52.1, 52.4). Illegal, Unreported and Unregulated fishing (IUU) is a threat for both marine ecosystems and local livelihoods (Agnew *et al*., 2009) since unreported catches sold at sea, comprise 43% of the total catch, resulting in insufficient data of the fisheries statistics in Cambodia (Teh, *et al*., 2017). These practices contribute to the overexploitation of fish stocks, leaving the fisheries unsustainable and depleted (Teh & Pauly, 2018), particularly as unreported catch is not taken into consideration for fisheries management in Cambodia (Try, 2002). Additionally, IUU fishing relies on unsustainable, destructive and, for that reason, illegal fishing practices, such as bottom-trawling, which has a direct negative impact on habitat suitability (Pitcher *et al*., 2002). As well as environmental degradation, IUU directly compromises 75% of the global catch (Pauly *et al*., 2005) which leads to billions of dollars of economic damage per year globally while depleting marine resources for future generations exemplary in the development of percentage of trash fish (low-value fish) in a catch-effort comparison in Thailand between 1995 and 2015 (Table 1).

Table 1: The proportion of trash fish to total marine fishes caught in Thai coastal waters, their value, and the number of fish meal factories from 1995 to 2015 (Sampantamit et al., 2020)

Year	% Trash Fish out of Total Marine Fishes Caught	Value of Trash Fish (US$ million)	Number of Fish Meal Factories
1995	38	92	122
2000	35	58	96
2005	33	76	99
2010	32	87	87
2015	26	66	70

Cambodia and its neighbouring countries are party to several international and regional agreements, including the Convention of International Trade in Endangered Species (CITES)[1] and the Convention on Biodiversity (CBD)[2]. On 6 December 2019, Cambodia also became a party to the Agreement on Port State Measures to Prevent, Deter and Eliminate IUU Fishing (PSMA)[3]. To fulfil its international commitments, the Fisheries Administration of the Cambodian Ministry of Agriculture has received assistance in 2020 and 2021 from the Food and Agriculture Organisation of the United Nations (FAO) to draft a new Fisheries Law and subsidiary legislation[4]. Presently, Cambodia's Law on Fisheries (2006) creates offences for various activities contributing to IUU fishing (TRAFFIC, 2019).

In accordance with the FAO's International Plan of Action to Prevent, Deter and Eliminate Illegal, Unreported and Unregulated Fishing[5], Cambodia has released its National Plan of Action to prevent, deter and eliminate Illegal, Unreported and Unregulated Marine Fishing (NPOA-IUU) 2020-2024[6], laying out an action plan that includes establishing more severe sanctions and penalties to deter IUU fishing (paragraph 1.2.3) and the development of a National Plan of Inspection and Control for Marine Fisheries that outlines priority areas to enhance monitoring, control and surveillance efforts (paragraph 2.5).

The Kep Archipelago (Figure 1) further is entitled with protected status as part of the Kien Giang and Kep Archipelago Important Marine Mammal Areas (IMMA). It also sits near the maritime border area between the Vietnamese mainland and Phu Quoc, within the transition zone of the Kien Gang Biosphere Reserve (part of UNESCO's World Network of Biosphere Reserves).

Emerging technologies offer a cost-efficient way to not only monitor IUU-fishing activities but also put solutions in place such as efficient law-enforcement efforts and passive drag-net deterrents providing not only a solution but also a long-term evaluation tool for socio-economic supply and demand systems (Wich & Pin Koh, 2018). Aerial drone technology for example has been implemented as a cost-efficient conservation tool to contribute to evidence-based operating procedures (Provost, et al., 2020).

Especially for managing protected areas to counter overexploitation (Neubert, 2003), emerging technologies can be utilised to provide protection for population growth and recovery (Roberson, Kiska, Watson, 2018). Coastal ecosystems are vitally important, as high numbers of juvenile fish species rely on nursing grounds (Worm & Branch, 2012), such as seagrass beds, mangroves, bivalve beds and coral reefs, in the border area of the Kep Archipelago (Reid, et al., 2019; Huang et al., 2015). A lack of protection can also negatively impact other coastal ecosystem services, such as the prevention of coastal erosion and sediment-shifting, water filtration, as well as natural defence functions against extreme weather conditions (Barbier, 2015, Halpern et al., 2008). Thus, changes might impact infrastructure and financial resources generated from tourism, coastal development and managed fisheries resources.

[1] https://cites.org/eng/disc/parties/chronolo.php
[2] https://www.cbd.int/information/parties.shtml
[3] https://www.fao.org/port-state-measures/background/parties-psma/en/
[4] https://www.fao.org/port-state-measures/news-and-events/detail/zh/c/1415168/
[5] See document titled "IPOA-IUU"
[6] See document titled "NPOA-IUU"

Marine Conservation Cambodia (MCC) has worked towards the protection of the Kep Archipelago since 2014. In 2018, a Marine Fisheries Management Area (MFMA), the Cambodian equivalent of a Marine Protected Area (MPA) was established by the government of Cambodia simultaneously with passive IUU-fishing deterrent tools Conservation and Anti-Trawling Structures to protect Kep's rich marine biodiversity (Figure 4). The aim of the MFMA is to regulate regional fishing activities and prevent the use of destructive fishing methods in designated areas, including vulnerable marine habitats (Hill *et al*., 2017). The MFMA consists of three zones with different protective intensity (Figure 2) to balance conservation and resource use (MCC, 2016). Implemented by MCC, the management of important marine areas has already had a significant positive impact on the biodiversity and fish abundance in entire regions (Reid, Haissoune & Ferber, 2019; Pauly, Watson & Alder, 2018; Boonzaier & Pauly, 2015).

However, local, small-scale fishing communities are still impacted by IUU fishing as it threatens their livelihood in Cambodia (Teh & Pauly, 2018). MCC still observes continous violations of national and international fisheries law (Böhm, 2019; Hill *et al.,* 2017). Current IUU issues include a lack of registration of gear and vessels, trawling in shallow waters (<20m), fishing for endangered species and in protected areas (Ahmed & Chanthana, 2015), as well as insufficient Monitoring, Control and Surveillance (MCS), which has been identified by Le Gallic & Cox as a key driver for IUU fishing (Le Gallic & Cox, 2005). Implementing measures to reduce wildlife crime requires an understanding and evaluation of the harvesting networks and trade routes specific to the geographical region and species that are targeted (Ayling, 2013), hence, region-specific supply chains need to be evaluated to be able to stop illegal fishing activities and to ensure the continuity and success of the Marine Fisheries Management Area (MFMA), as well as ensuring food security in the long-term (Table 1).

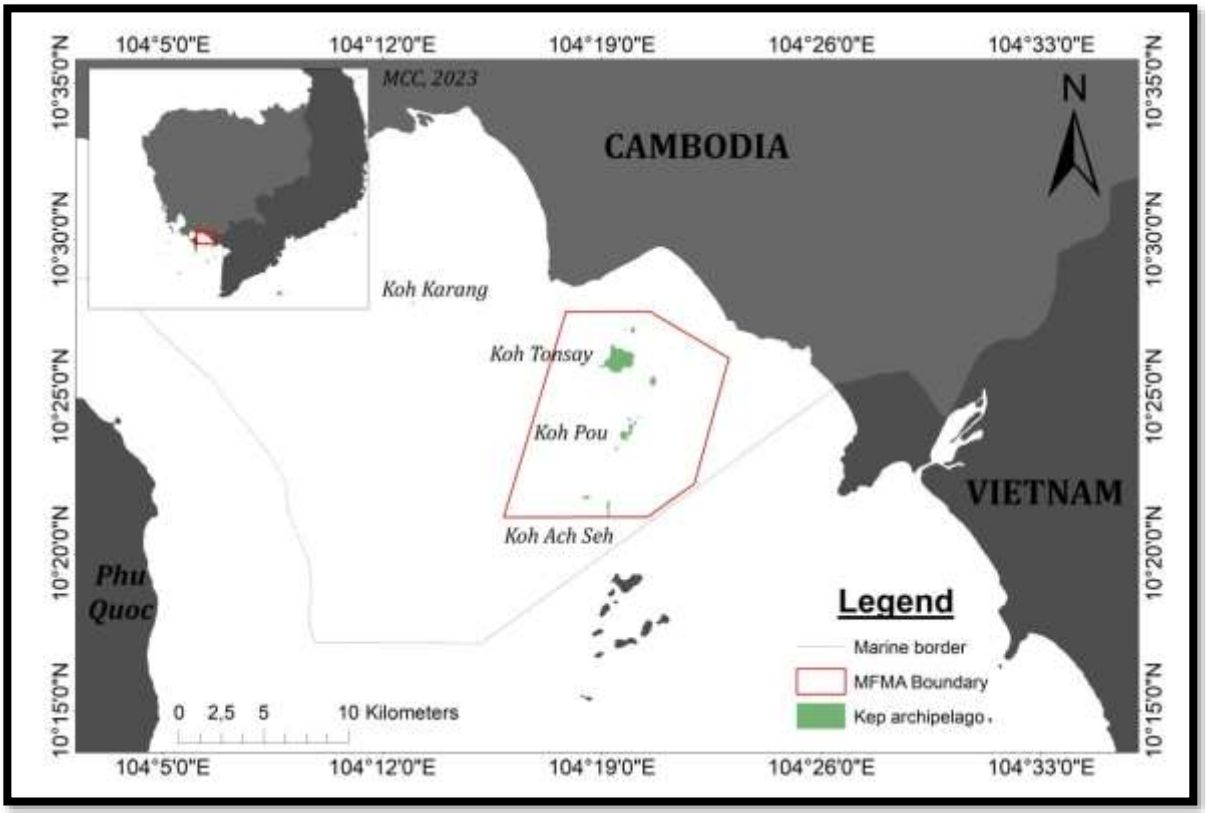

Figure 1: Overview map of Cambodia and Vietnams maritime border area

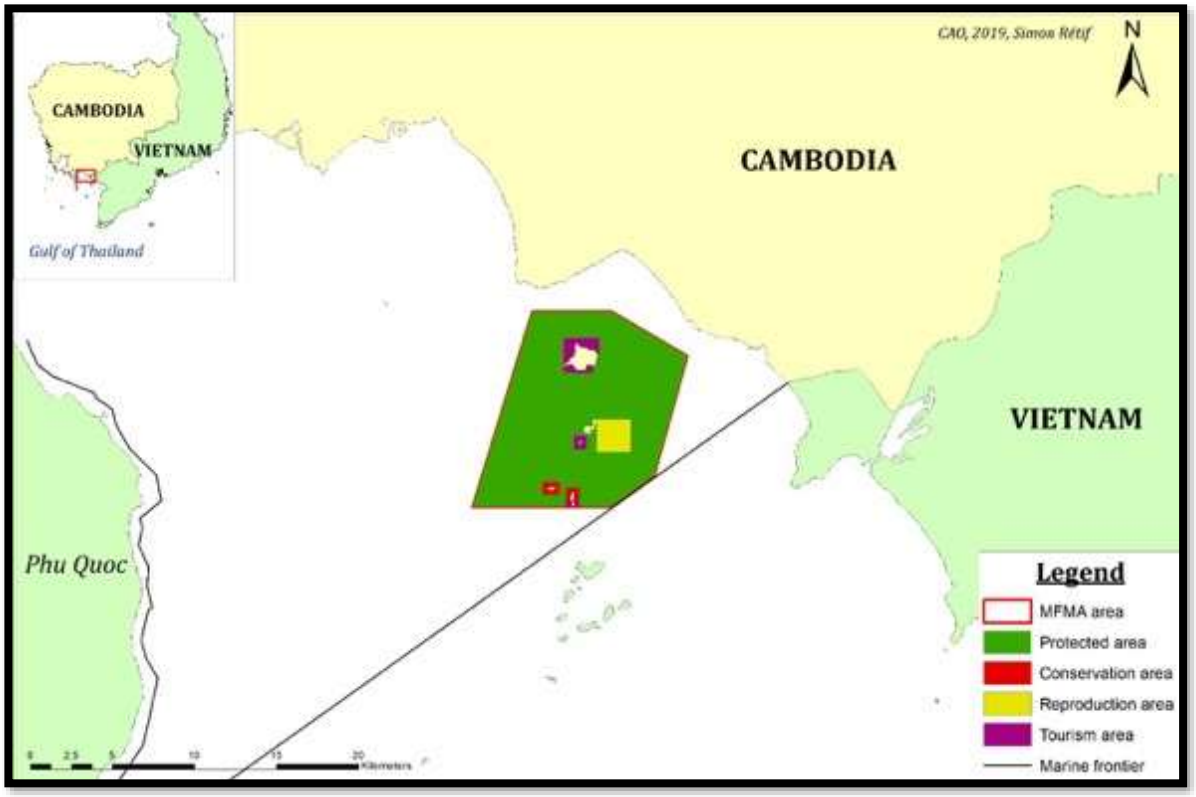

Figure 2: Map of Cambodia - Vietnam transnational area including Kep Archipelago with designated MFMA area divided in fishing zones (Map courtesy of Rétif, 2019)

1.1. Aims and objectives

The overall aim of this research is the assessment of IUU fishing activities on regional marine fisheries harvesting networks and the evaluation of the impact on the Kep MFMA in comparison to 2019. This has been achieved for 2022 by (i) assessing fishing activities in Kep Archipelago and (ii) identifying movement patterns of illegal vessels. This report focuses on the data obtained for the comparison and evaluation of the success of combating illegal fishing practices over the last five years, as well as assessing the current extent of illegal activities in the region.

The aim was achieved by answering the following research questions:

1. How many IUU fishing activities have been recorded in 2022?
2. What are the main routes of illegal vessels in the study area?
3. How are IUU-fishing activities impacting biodiversity in the Kep Archipelago?
4. Are IUU fishing activities sourced by regional demand according to the movement patterns?
5. Are current management practices effective in sustaining coastal ecosystem conservation?

2. Research

To ensure that the project can be easily expanded to other regions, fixed methods were applied further developed from the 2019 methodology. The study includes various methods, of which vessel identification method data has been applied for this report to highlight illegal fishing activity patterns. Vessel identification describes the collection of data on fishing vessels and, in particular, information on illegal activities conducted in the Kep MFMA.

2.1. Study site

To analyse IUU fishing patterns and evaluate current registration deficiencies, vessel monitoring was used as suggested by Hill *et al*. (2017). Cambodia's 435km coastline spans from Thailand to Vietnam and borders the Gulf of Thailand. There is a 200 nautical mile Exclusive Economic Zone (EEZ) covering ca. 62, 515km^2. The coastline itself is made up of four provinces, Koh Kong, Sihanoukville, Kampot and Kep (Rizvi & Singer, 2011). The research was based in Kep Province, an area of approx. 113,540 km^2 which consists of shallow waters between 2- and 10-meters depth and supports habitats of fringing coral reef, seagrass beds and mangrove forests, as well as endangered species including Irrawaddy dolphins (*Orcaella brevirostris;* Tubbs, 2019, Hill *et al*., 2017) and dugongs (*Dugong dugon)*. Sampling was conducted on Koh Ach Seh island. To cover a radius of 27km from the study base Koh Ach Seh, the survey time was divided between the two vantage points, one east facing and one west facing, splitting the survey area in two (Figure 3). These two areas were then split into 3 zones based on visibility during the surveys.

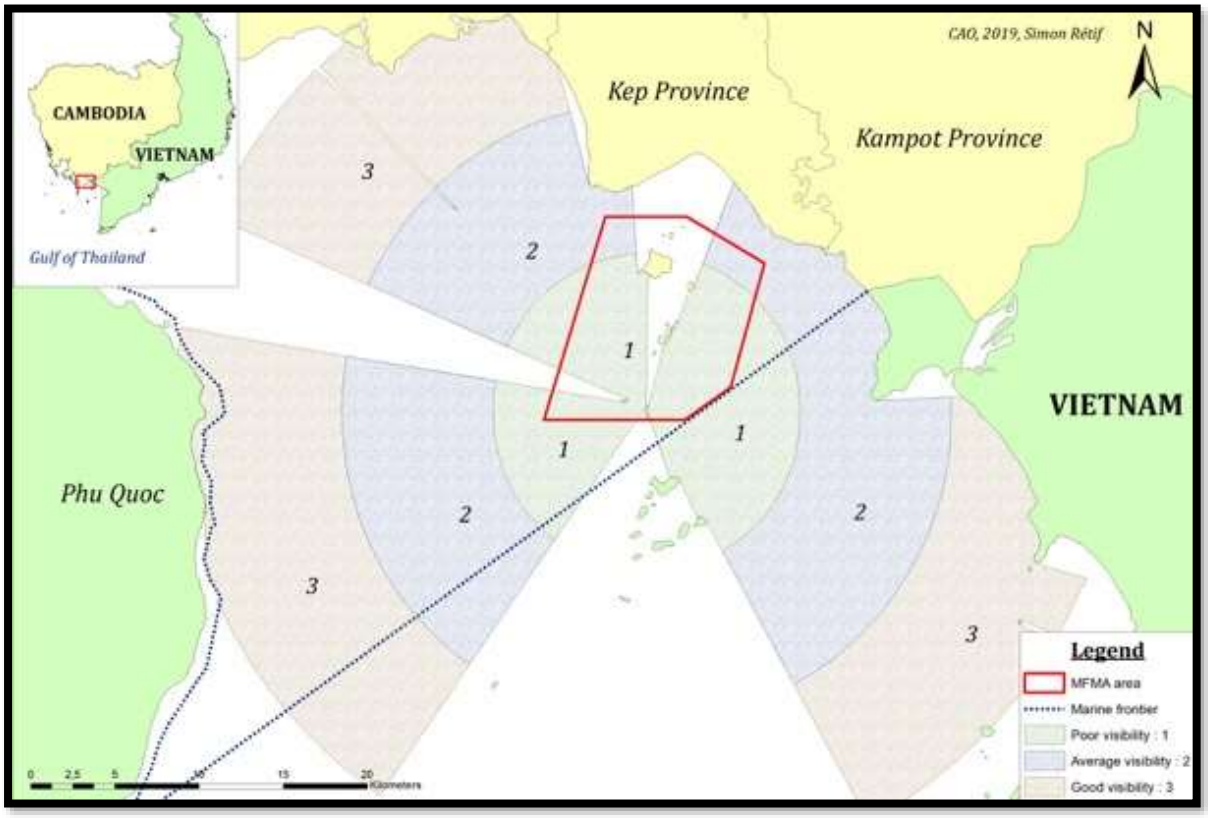

Figure 3: Study site at Kep Archipelago with maritime boundary to Vietnam (Marine frontier), protected area (MFMA area) and the visibility differentiation during surveys (Good- poor visibility) within the study range of 27km (Map courtesy of Rétif, 2019)

2.2. Vessel identification

The vessel identification survey was divided into vessel movement surveys to track and individualize IUU vessels, and vessel density surveys to investigate the ratio of IUU fishing to legal fishing. Based on the data collected in 2019 the survey time has been reduced to two shifts of 3 hours in the morning (06:00am – 09:00am) and early evening (03:00pm – 06:00pm). The 2019 data showed a clear peak in these time frames (Böhm, 2019)

The vessel movement surveys followed a contour-based approach (Scheepens, van de Wetering & van Wijk, 2014). Land-based surveys on Koh Ach Seh were conducted twice per week between 6:00 am and 6:00 pm. The surveys were divided into two 3-hour shifts (06:00 am - 09:00 am; 03:00 pm – 06:00 pm), with location alternating between the east and west sites, based on preliminary data on activity and light to collect data as efficiently and for as long as possible around the entire study site (Figure 5). Ratios of inboard to outboard engines were noted, as well as the estimated location and movement of inboard-mounted vessels by adding location changes every 30 minutes. All boat track lines were determined using a compass and maps on QGIS by adding a point with correlating information on date, time, individual vessel number, track point (1-6), trawling activity, country of origin, used gear, first sighting time, last sighting time, and additional comments such as period of trawling. However, due to restricting factors, such as weather condition and technological limitations, data on all sections could not always be obtained. National law violations have been recorded separately and reported to fishery authorities immediately.

For density analysis two 1-hour boat surveys were conducted twice per week. A line transect was followed while cruising at an average speed of 4 knots looking for vessels continuously, based on marine research conducted in the same region (Tubbs *et al*., 2019).

One way to differentiate between illegal trawlers and legal local "longtail" vessels is the engine location (SEAFDC, 2002A)—bottom-trawlers have inboard engines with a cabin that makes up almost 50% of the vessel length (Figure 6) while longtail vessels have clearly distinguishable outboard engines (Figure 7).

Figure 5: Bottom-trawler (inboard engine) while actively fishing illegally in shallow water (<20m)

Figure 4: Longtail vessel with outboard engine using fishing rod

Boat types were differentiated according to the National Plan of Control and Inspection (Appendix I Vessel types). Additionally, the country of origin of the boats was identified if possible (based on registration number, flags, or identifying gear). Vessels conducting illegal fishing activities were marked as such based on whether the booms were out to drag the net.

Figure 6: Lifted net and weights as method to identify non-trawling and trawling ratio

Figure 7: Picture proof of lifted booms (right picture.) in comparison as main identification criteria of trawling

Surveying of vessel activities was conducted using Canon all weather stabiliser binoculars (15x50, 3.2°), pictures were taken when distance was acceptable (Nikon D3000, Novagrade phone adapter), estimated GPS location and, if possible, information on gear (surrounding net, trawl net, lift net, falling gear, gill net, traps, hooks and lines, scoop nets, dredges, miscellaneous) and catch were recorded (SEAFDC, 2002A/B).

Figure 8: Bottom Otter Board Trawl with Booms (trawler) with net (SEAFDC, 2002A)

2.3. Data processing and analysis

Data entry is directly done in a mapping programe to provide geo-referencing ensuring standardised data collection method. The data has been extracted to Microsoft Excel (Appendix I) once entered in QGIS (V3.0.1.) with all correlated information (Appendix II) while collecting data (Claramunt, *et al.*, 2007). ArcGIS was then used for density illustration, to show count data (number of trawlers, number of trawlers trawling, number of trawlers with illegal gear) and to analyse vessel movement patterns such as directional information or when crossing the maritime or MFMA border (Scheepens *et al.,* 2011). Further analysis on trawler activity peak times were investigated with R Studio (Version 1.1.383). Non-parametric Exploratory Data Analysis (EDA) was used to test for normality and overlook, while Pearson's test showed the correlation between inboard mounted vessel and outboard mounted vessel density (Olin, Malinen & Ruuhijärvi, 2009). This data is only collected in 2019 and presented in Appendix II.

3. Results

Between 5th of April – 26th of July 2022, data on 1660 trawlers was collected during 45 vessel movement surveys and density surveys (Figure 9). Of these trawlers, 861 could be identified as foreign vessels (SEAFDC, 2002B) entering the Cambodian EEZ and a total of 1133 vessels were trawling with absolute certainty, of which 274 were within the Kep MFMA border (Figure 10). However, the detection rate of active trawling during land surveys was low due to the distance of the study area, leading to a low average detection rate of 14.9%. The activity (trawling/travelling) was determined for 591 trawlers of which 61,25% were trawling. 45 trawler vessels were carrying illegal gear (Appendix I).

3.1. IUU fishing vessel abundance

- Estimation of number of bottom-trawlers in the Kep Archipelago
  - 1660 sightings of trawlers during 146 survey hours
- Fishing activities of bottom-trawlers
  - 1133 were trawling with absolute certainty in water depth < 20 meter
  - Of which 274 were trawling illegally within the MFMA area
- Illegal gear on bottom-trawlers
  - 45 trawlers were carrying illegal gear such as seine net, air tubes or electric gear
- Movement patterns between the Cambodian and Vietnamese maritime border
  - 861 foreign trawlers were entering the Cambodian EEZ

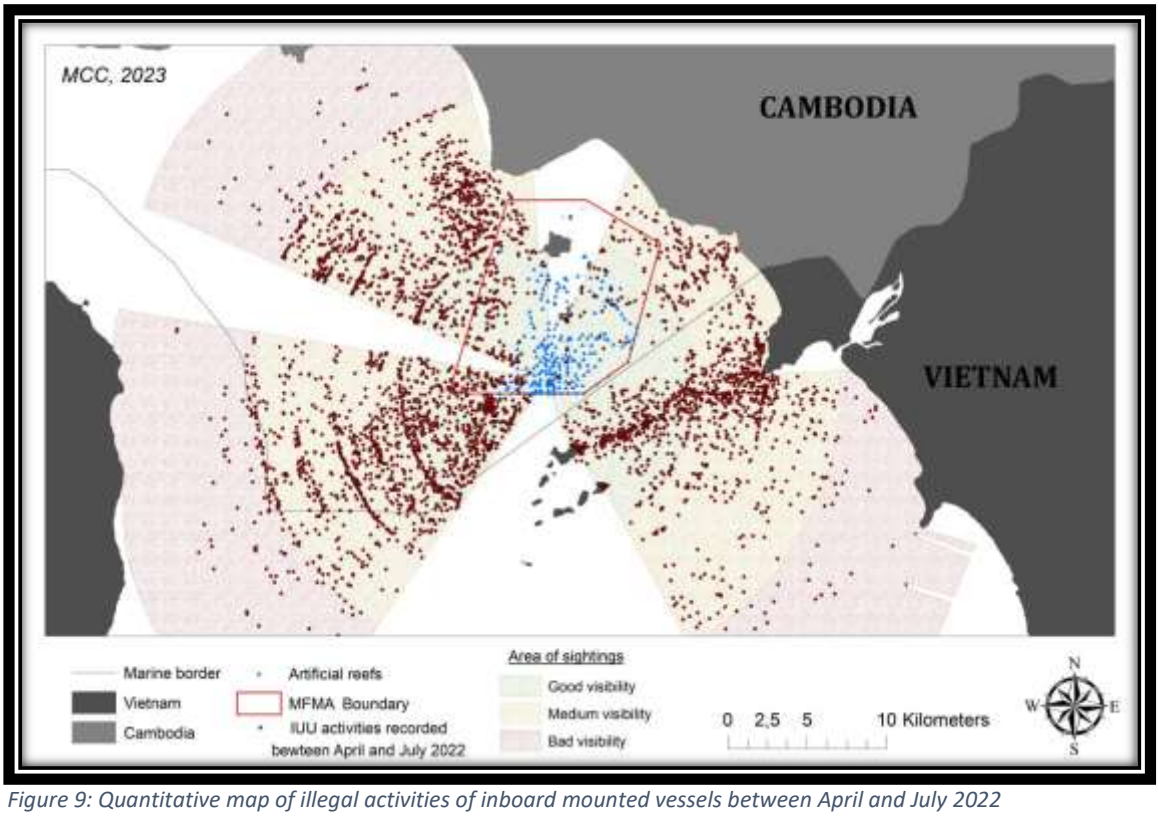

Figure 9: Quantitative map of illegal activities of inboard mounted vessels between April and July 2022

3.1. Vessel movement surveys

1323 trawlers were seen during land surveys, of which 328 trawlers were trawling with absolute certainty. The highest activity was recorded during the late shifts (n=490) during all months which varies from 2019 when high activity peak was in the morning. Based on trawlers entering the study area, activity patterns were identified throughout the day and peaked when surveys were started in the early morning and last shift during afternoons which indicates night-time activity (Figure 10). Distribution and density patterns of trawlers remained similar across all sampling months (Figure 11- overview; Figure 14-17- sampling months).

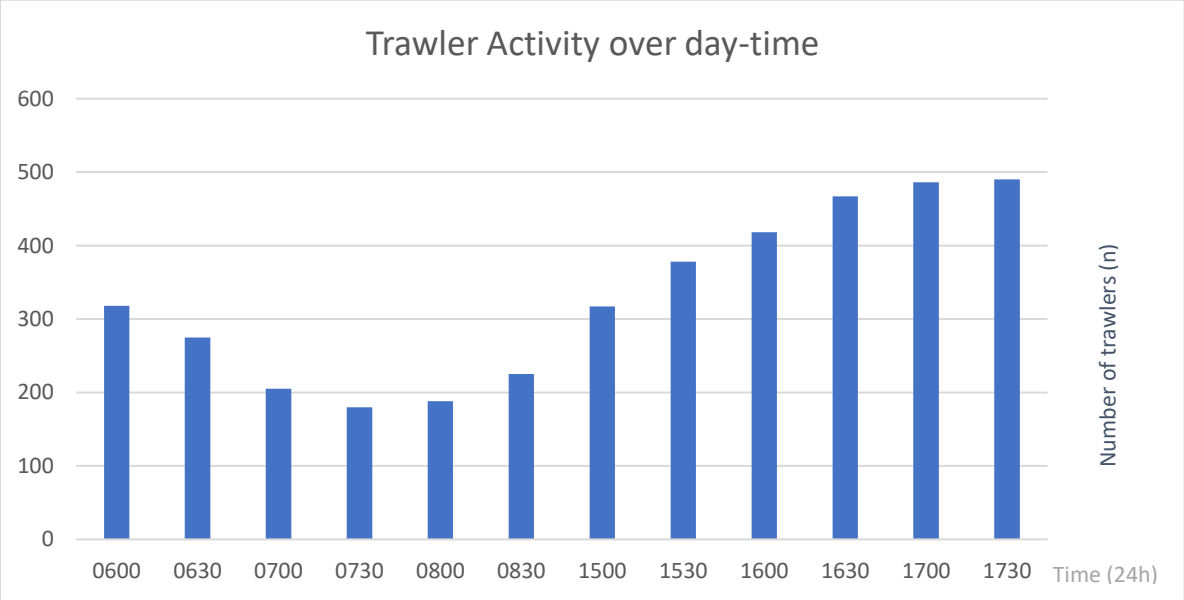

Figure 10: Number of inboard mounted vessels divided by time of day between 06:00am and 6:00pm

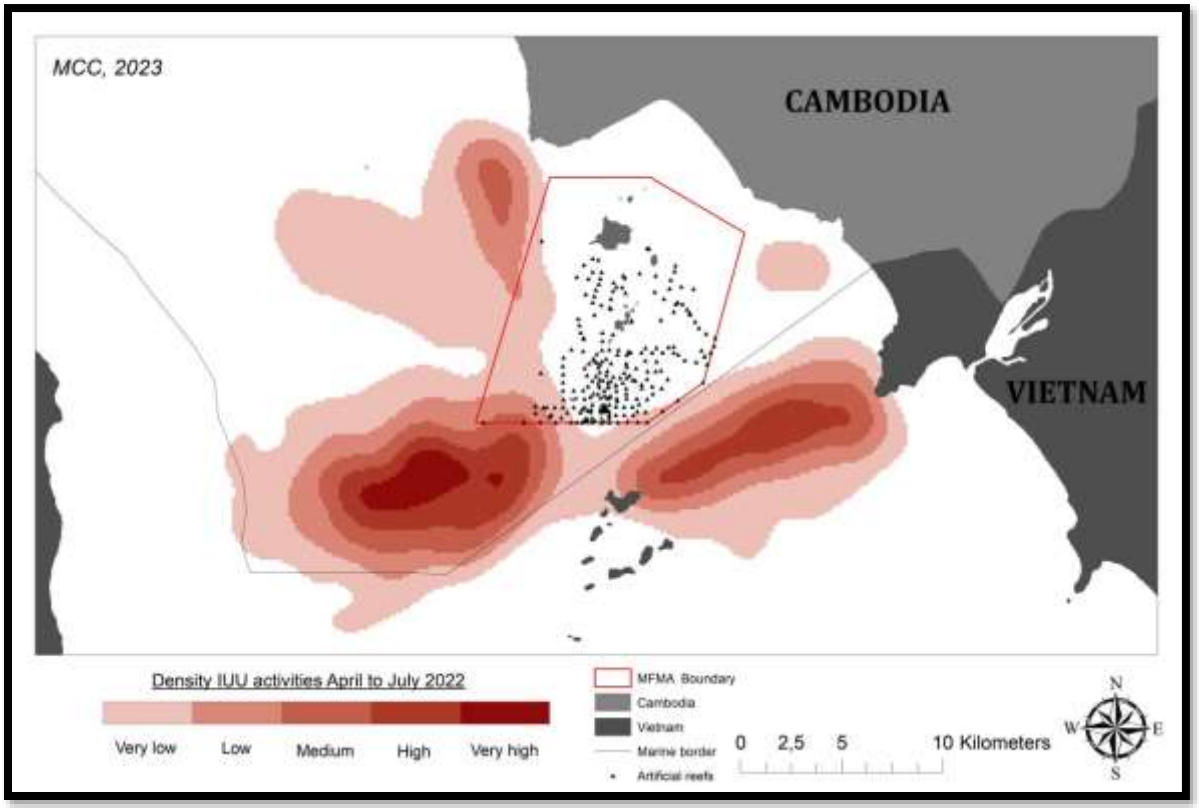

Figure 11: Inboard engine density map (trawler) of the study area for all sampling months (April-July 2022)

While the abundance of trawlers has not improved and even increased when amount of survey hours is taken into consideration (Figure 10) to the 2019 data, the density distribution did change significantly (Figure 11) for areas where blocks have been deployed. The MFMA area has been previously identified as main area of IUU activities due to its productivity but by now very low to none IUU fishing vessel presence has been detected.

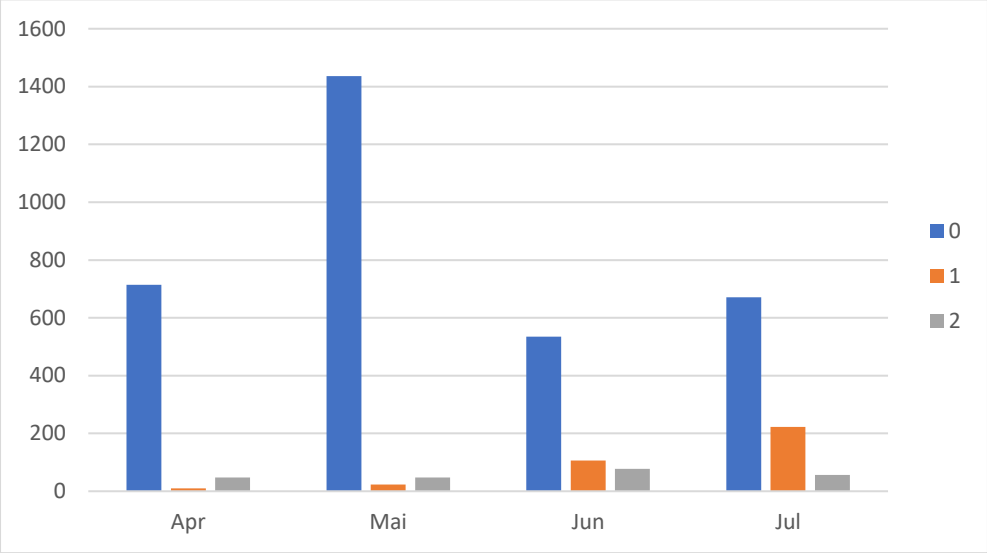

Figure 12: Monthly IUU fishing vessel activity divided by activity where unknown (0) activity is clearly the highest

Monthly overview shows a range of activity hotspots mainly distributing in high density around Vietnamese mainland, towards Phu Quoc and near Kep mainland (Figure 13) but all months show a clear avoidance behaviour in areas where Conservation and Anti-Trawling Structures have been deployed between 2018 and 2022.

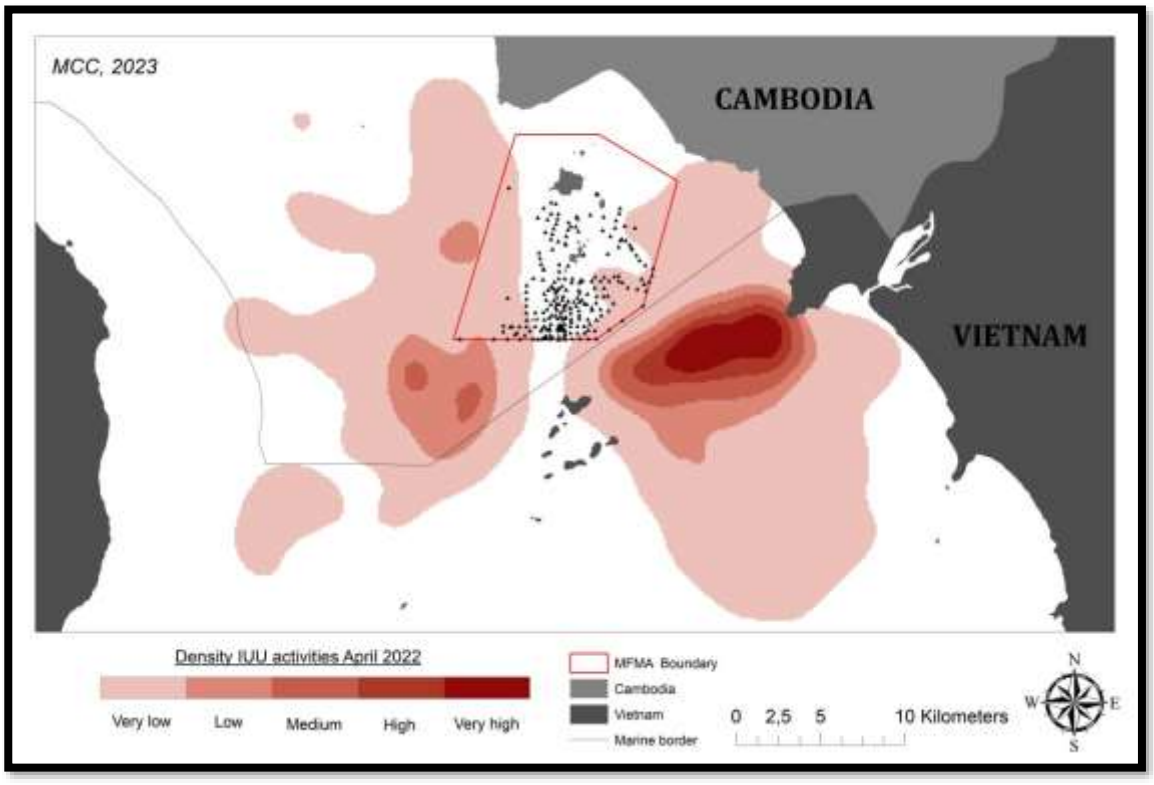

Figure 13: Inboard mounted vessel density map of the first 4 sampling weeks (05/04-21/04/2022)

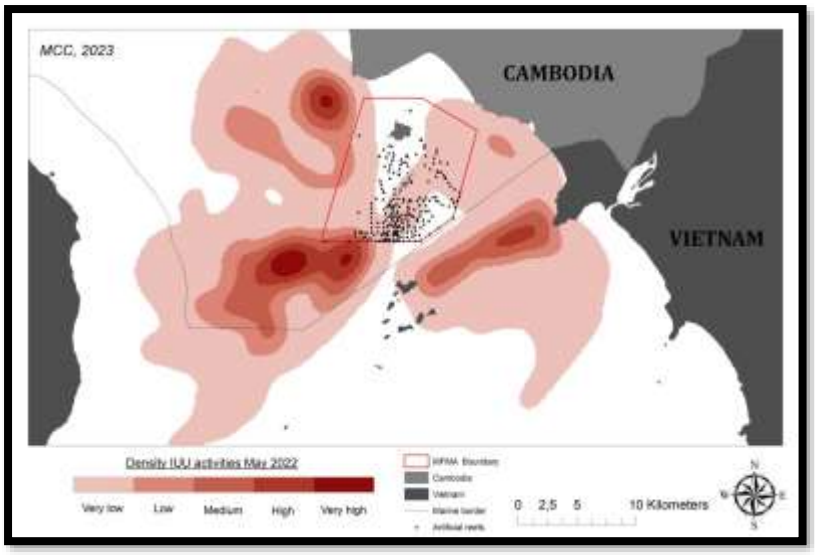

Figure 14: Inboard mounted vessel density map of the second 4-weeks (03/05-31/05)

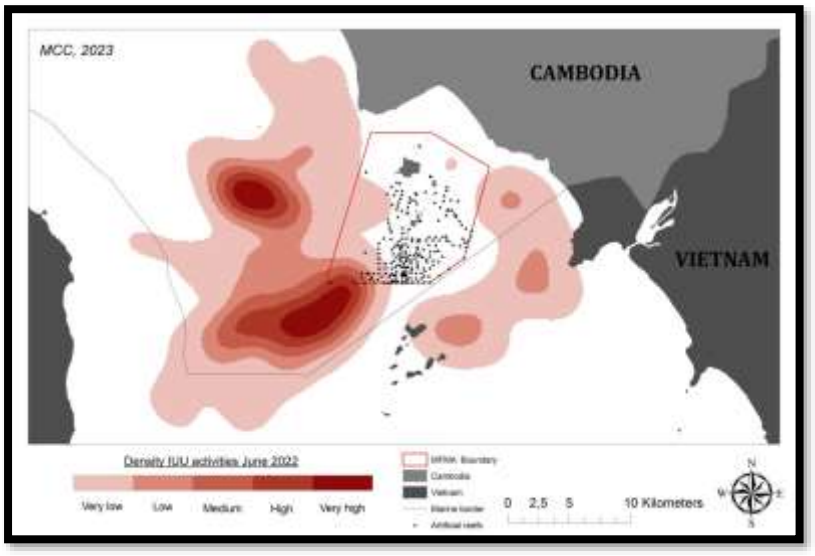

Figure 15: Inboard mounted vessel density map of the third 4-weeks sampling (06/06-23/06/2022)

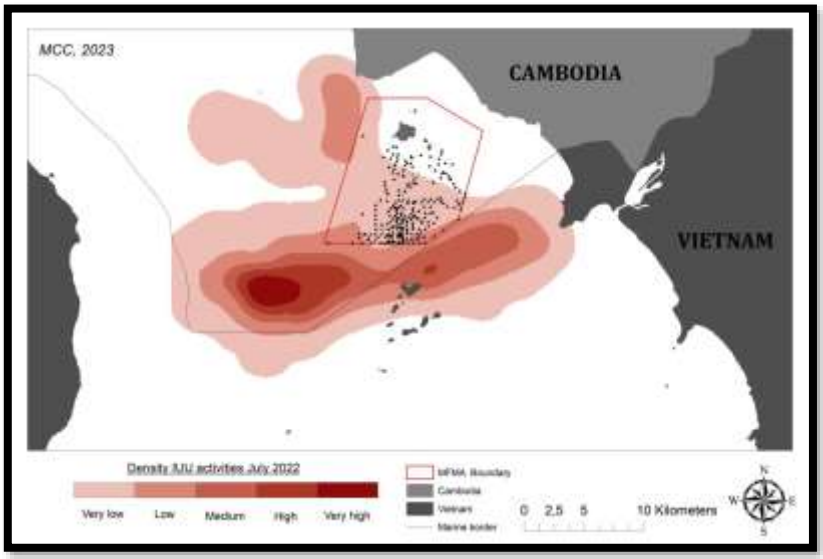

Figure 16: Inboard mounted vessel density map of the fourth 4 sampling weeks (04/07-26/07/2022)

The movement patterns (Figure 17) indicate a movement from the MFMA area towards the Vietnamese mainland in the morning (06:00 am – 09:00 am) on the east side of Koh Ach Seh, and movements from the MFMA area towards the north-east of the island in the shift between 07:00 am and 09:00 am further into the MFMA. During the afternoon shift movements from the Vietnamese mainland towards the South-West of the island were detected. This movement pattern continued until 4-5pm towards Phu Quoc. Within this shift there were also movement patterns away from Phu Quoc heading towards the MFMA towards the end of daylight hours. In comparison to our 2019 data (Figure 18), the MFMA has seen more trawling in the North-West region above Koh Angkrong. The anti-trawling structures and artificial reefs deployed by MCC, also referred to as blocks, have pushed trawlers towards these regions. The blocks predominately occupy the South to South-East regions of the MFMA.

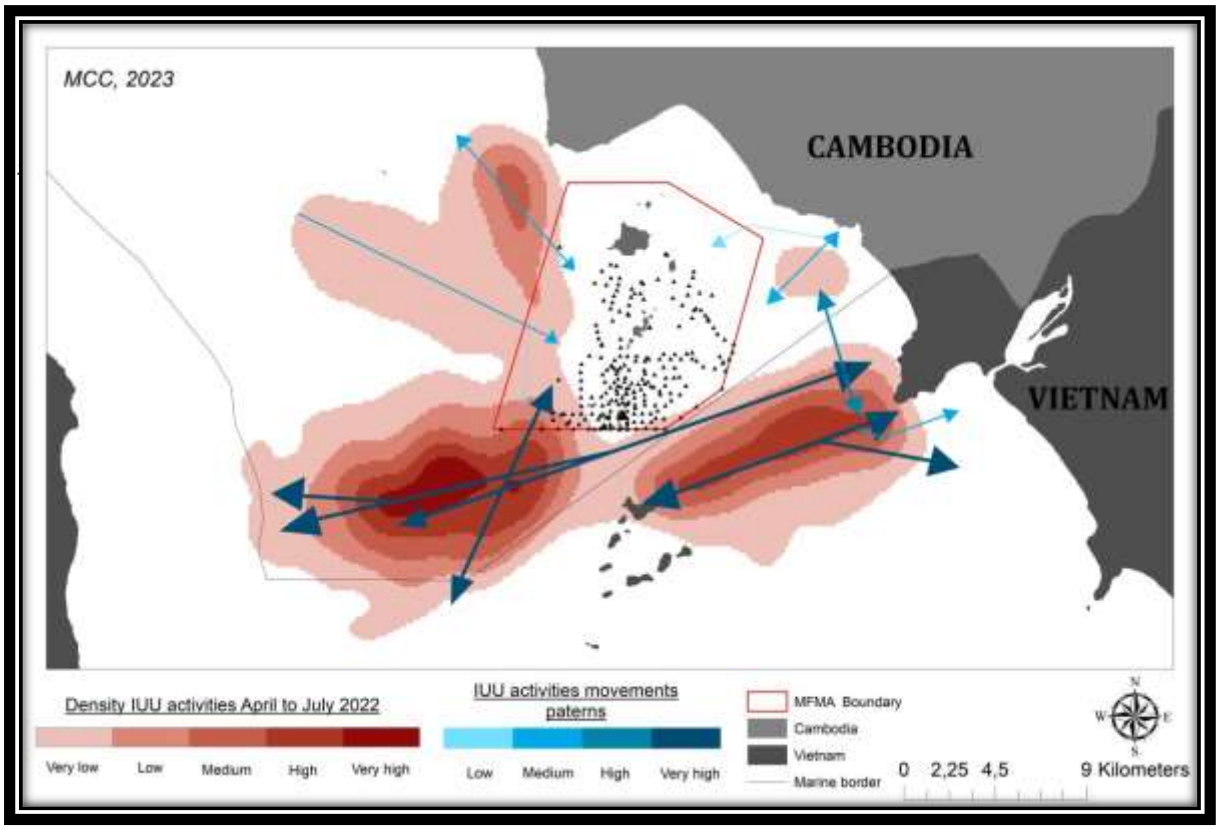

Figure 17: Movement patterns of IUU fishing vessels in the maritime border area between Vietnam and Cambodia

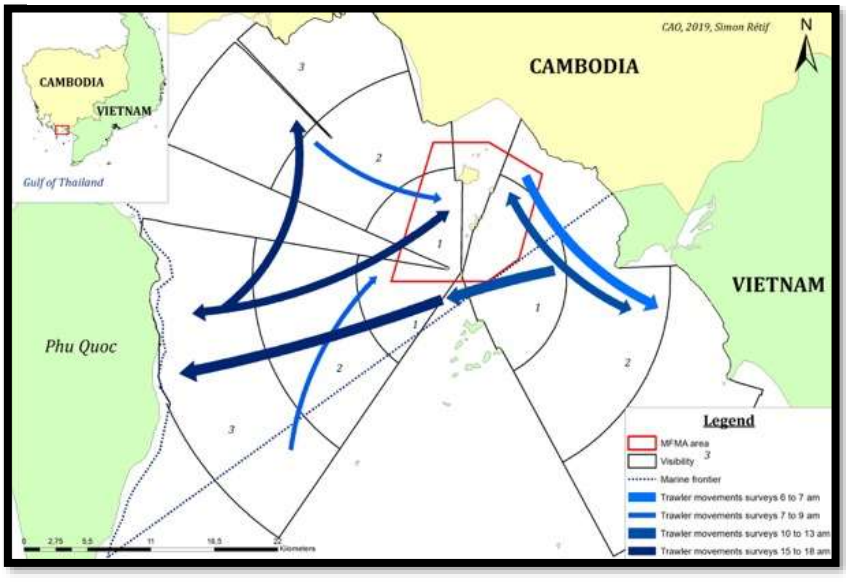

Figure 18: Comparison to movement patterns in 2019. Three years of Conservation and Anti-Trawling Structures. The movement patterns in the block area within the MFMA have been pushed outside the protected area
(Map courtesy of Simon Retif)

3.3. Legal offences

Offences against Cambodia's Law on Fisheries (2006) were recorded (Table 2). The Law on Fisheries was implemented according to the Convention of International Trade in Endangered Species (CITES) regulations for Cambodia (TRAFFIC, 2019).

Table 2: National law offences recorded during survey time

Offence	Fisheries laws violated (Article)	Amount recorded
Bottom-trawling in water <20 m	49, 52.1, 52.4	1133
Use of illegal gear	20.6, 20.8	45
Fishing in conservation area (MFMA)	11, 19, 20, 48, 49, 52	274
Foreign trawlers entering and fishing in Cambodian waters	38, 47	861

Illegal and harmful fishing practices, as well as fishing within protected areas, would also violate Cambodia's Law on Protected Areas (2008) (Art. 41). The use of harmful fishing gear is further prohibited in Cambodia's Proclamation No. 028 On Restrictions of Fishing Gear in Inland and Marine Fisheries (1984).

Vietnamese trawlers operating in the surveyed area were also in violation of Vietnamese law. Various Vietnamese legislations have confirmed Vietnam's commitment to international cooperation in marine conservation. Vietnam's National Assembly Law No. 55/2014/QH13 On Environmental Protection states that it aims to fulfil international commitments related to environmental conservation and prohibits, among other things, damaging natural resources (Arts. 5.11, 7). Vietnam's National Assembly Law No. 82/2015/QH13 on Marine and Island Natural Resources and Environment requires vessels fishing beyond Vietnamese waters to comply with international treaties, such as CITES, and comply with the laws of other coastal states (Art. 50). Vietnam's Government Decree No. 33/2010/ND-CP On the Management of Fishing Activities in Sea Areas by Vietnamese Organisations and Individuals further states that vessels fishing outside Vietnamese waters must be registered and have fishing permits from Vietnamese authorities, and must obey all international laws and laws of relevant coastal states (Arts. 6, 7, 9).
Vietnam's Law on Fisheries 18/2017/QH14 also applies to "Vietnamese individuals engaged in commercial fishing activities outside Vietnam's maritime boundary" (Article 2). This recently updated legislation specifically addresses illegal commercial fishing in Section 4, including the prescription of criminal liability for illegal commercial fishing activities in the waters of other countries or territories (Article 60).

4. Discussion

This report presents the current state of illegal fishing activities in Cambodia's Eastern maritime border area and solutions to deter these activities while strengthening law-enforcement efforts efficiently.

The data on fishing activities in the Kep Archipelago (Figure 9) indicates ongoing violation of national law as shown in the table above (Table 2). Trawler sightings in the region are very likely to violate law, as the entire coastal region is shallow (<20m) and inboard- engine fishing vessels are not equipped to fish in the open sea (Service Geographique des Fark, 1960; Teh *et al*., 2016). Since January 2023 more regular law-enforcement effort showed a promising support of deterring remaining illegal fishing activities. One of the remaining main issues remains traceability to tackle repeat-offenders due to the lack of registration and VMS-systems as well as a missing data exchange for transnational law violations (IUCN, 2019). This emphasise the benefits of the establishment of a semi-automatic marine surveillance system to support current law-enforcement efforts as time- and cost-efficient as possible (Appendix IV – Operational strategy MCS systems) while enhancing sufficient regulatory power (NEW REFERENCE).

The movement patterns in Figure 17 show a high percentage of vessels entering and trawling illegally within the Cambodian EEZ. In comparison to 2019 the identification of foreign vessels improved and supports the assumption that fishing activities are not only sourced by regional demand and supply but also include an international component (Figure 18). These findings reflect again the same conclusion of 2019 and support the general assumption that can be found in multiple reports (FAO, 2019, Hill *et al*., 2017, Try, 2002). While a clear differentiation between Cambodian and foreign vessels is not always possible with the current technical equipment, the higher ratio of identified and unidentified vessels as well as the movement patterns shows a transnational component might need to be addressed especially given the fact that the area is protected according to Cambodian (Fisheries Law of Cambodia, RGC 2006: Art. 11, 19, 20, 38, 47, 48, 49, 52, 64-69 -trade-related); Vietnamese law (Law on Environmental Protection No. 72/2020/QH14: Art. 7, 49.1, 113.1c,), as well as international regulations due to

Since 2019 this study is the first of its kind highlighting the intensity of illegal fishing in Kep. The high number of bottom-trawlers in Kep's MFMA illustrates the need for more protection of underlying habitats and associated IUCN red-listed vulnerable and endangered species, such as green sea turtles (*Chelonia mydas*), Irrawaddy dolphins (Tubbs *et al.,* 2019; Mcnamara *et al*., 2015) and since this year dugongs (*Dugong dugon*).

Finally, and perhaps most importantly, the study draws attention to the dissuasive influence of inboard mounted vessels on ecosystem services that fishing communities heavily depend on. This measured negative effect supports previous studies on the impact of industrialized fishing practices, especially in coastal areas (Teh & Pauly, 2018; Pomeroy *et al*., 2007). In the case of Cambodia not only natural resources are damaged but also cultural heritage since fishing is community-based managed (516 Cfis) and since generations represented in Cambodia's unique coastal culture (Lieng, Yagi & Ishihara, 2019) .

4.1. Implications for conservation

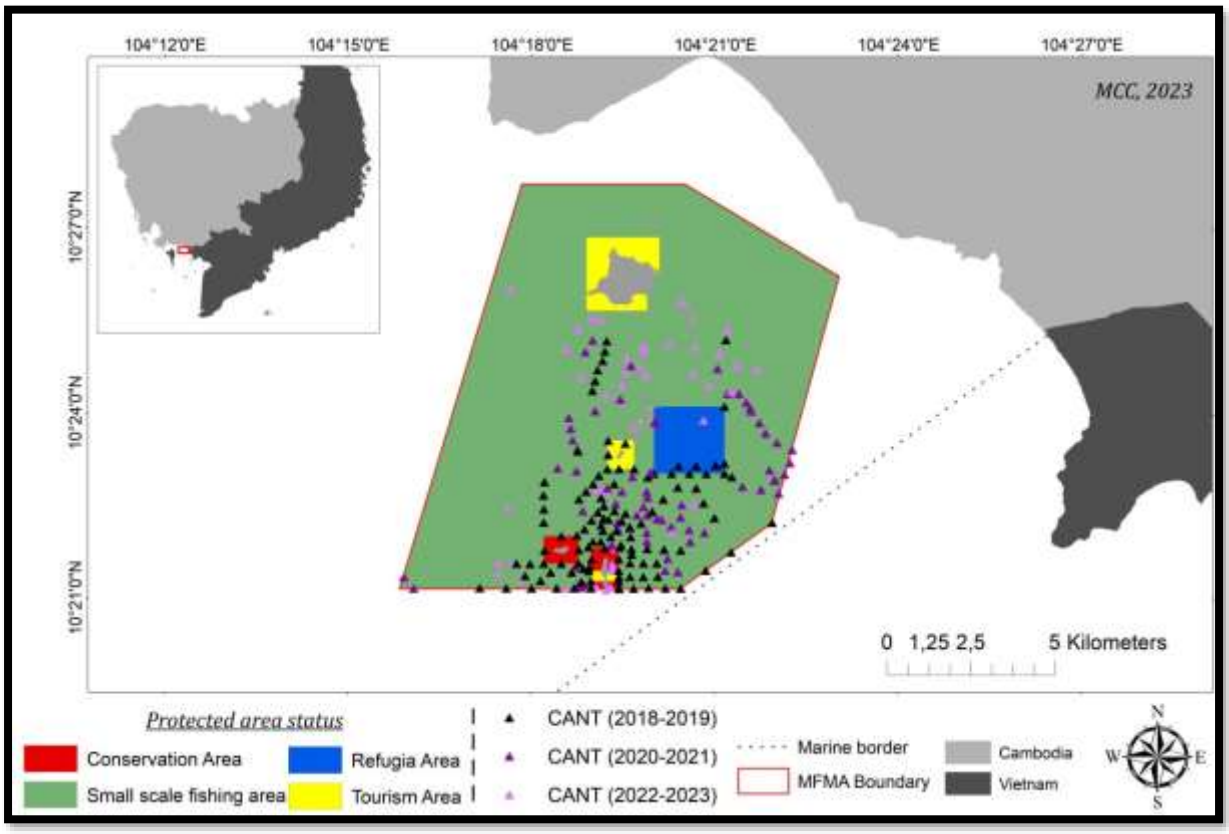

Figure 19: Cambodia's second Marine Protected Management Area including passive IUU fishing deterent method: Conservation and Anti-Trawling Structures by year of deployment

Marine protected area, especially with the variation potential of MFMAs can have a significant impact on ecosystem restoration by protecting and connecting existing habitat with areas where re-colonialisation is made possible.

This insight is supported by evaluations of the effectiveness of marine protected areas since it is enhancing how efficient law-enforcement and co-management makes compliance behaviour and ecological outcomes more significant (Warner & Pomeroy, 2012). The consequences of the recorded illegal practices are manifold but so are the impacts of a combination of active law-enforcement support and passive deterrent tools (Pomeroy, et.al., 2013)

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Figure 20: Visible impact of bottom-trawling on ecosystems

Figure 21: Passive drag-net deterrent for protected ecosystems

4.1.1. Impact on habitat and other ecosystem services:

Globally, seagrass meadows are considered one of the most highly productive coastal ecosystems, and are found in most shallow nearshore regions around the world (Knudby & Nordlund 2011; Dewsbury et al. 2016). In Cambodia, the most extensive seagrass meadows populate the waters adjacent to Kampot and Kep Provinces, with meadows distributed along the Cambodian coastline (UNEP 2008).

Destructive fishing techniques, loss of water clarity, coastal construction, and climatic changes threaten seagrass meadows but could also stabilize these issues.

Exploitation of seagrass from trawling activities directly disrupts the seafloor, and destroys seagrass beds by removing the plants entirely from the sediment, or damages their leaves and rhizomes (Short et al. 2011).

Seagrass meadows provide numerous ecosystem services, and are one of the highest value ecosystems worldwide (Hejnowicz et al. 2015). Food security, income, well-being, and livelihood options for local resources users rely on seagrass systems. In Cambodia, both domestic and international fisheries markets are reliant on seagrass ecosystems for resource provisioning, notably the trade of blue swimmer crab (*Portunus armatus*). To sustain provisioning to society, in such a social-ecological system, it is necessary to conserve these important seagrass habitats (Cullen-Unsworth et al. 2014; Berkström et al., 2013). The structural complexity of seagrass provides shelter and important habitat for juvenile fish and invertebrates to use as nursery grounds (Beck et al. 2001). Seagrass meadows provide important foraging and grazing grounds for resident and seasonal species across the Kep archipelago and Kampot coastline, including endangered megafauna such as, dugongs and Irrawaddy dolphins (Tubbs et al 2018).

Damage to seagrass from bottom trawling not only damages the rhizomes, releasing carbon stores, but removes plants available for subsequent sequestration, and reduces capacity to bind sediment (Orth et al. 2006).

By providing conservation areas for seagrass meadows to regenerate, MCC has been able to witness sediment improvement and re-growth of pioneer species (*Halophilia spp.)* in prior degraded habitat.

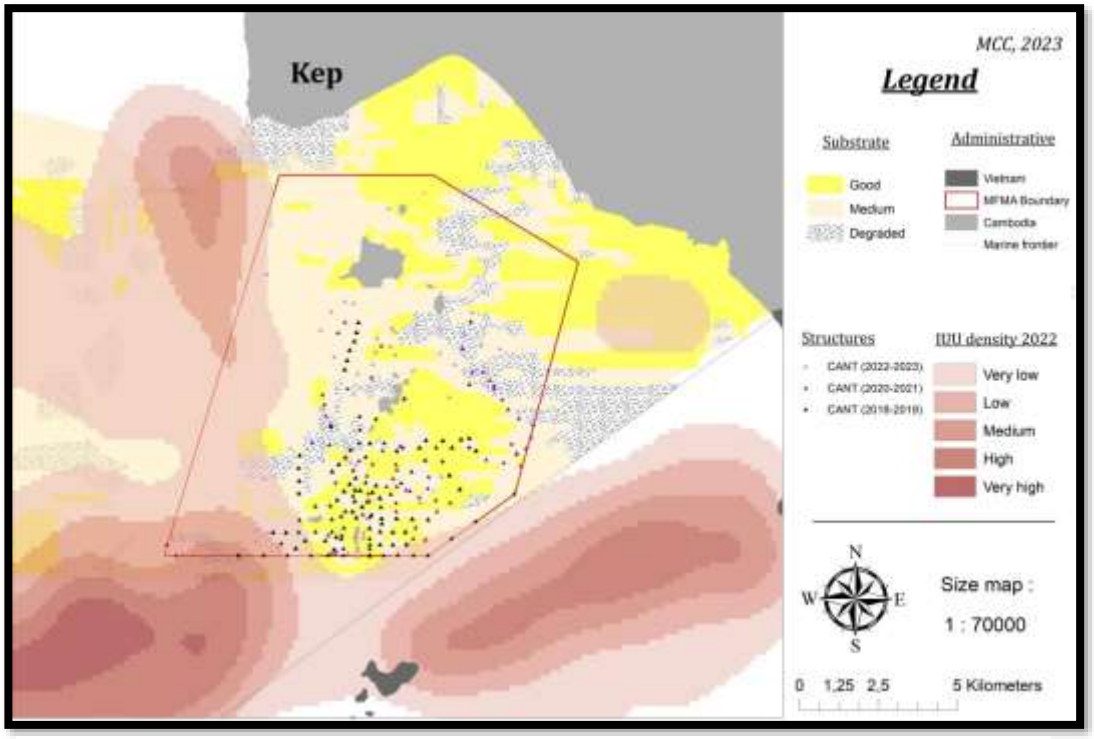


Figure 22: Geological map of substrate improvement within the protected area

4.1.1. Impact on endangered marine mammals

The Kep Archipelago has been identified as a critical habitat for the endangered Irrawaddy dolphin (Tubbs *et al.,* 2019) and is internationally recognized as an Important Marine Mammal Area (IMMA; MMPATF, 2019). This species has a discontinuous distribution along the Indo-Pacific coastline with a decreasing population trend (Minton *et al.,* 2017). IUU fishing, alongside entanglement, and bycatch, have been identified as the key threats to this specific population of Irrawaddy dolphins (Nelson, 1999; Beasley and Davidson, 2007; Tubbs *et al.,* 2019).

As identified by Tubbs *et al.* (2019), the eastern archipelago is an Irrawaddy dolphin hotspot, with dolphin presence throughout the year (Figure 22). However, the same area shows notable overlap with the trawling activity mapped above (Figure 13). This overlap in dolphin and trawler presence, highlights the necessity of IUU fishing deterrents and prevention, through effective law enforcement and penalties.

Furthermore, there is a comparative overlap in the time of activity shown by dolphins and trawlers. Through passive acoustic monitoring, Irrawaddy dolphins showed significantly more acoustic activity during non-daylight hours (Tubbs and Keen, 2019), this corresponds with the increase in observed trawling activity within the archipelago (Figure 12). This time overlap substantially increases the threat of dolphin habitat disturbance, bycatch and entanglement, threatening their already restricted distribution and abundance. Only through adequate enforcement and adherence to Cambodian Fisheries Law, will the conservation and protection of this endangered species be effective.

In addition to continued monitoring and ongoing active conservation efforts, Conservation and Anti-Trawl Structures have been found to passively protect important marine habitats such as seagrass and coral reefs (Strong et al., 2022) and may provide food supply and refuge to marine mammals such as Irrawaddy dolphins and dugongs in the process.

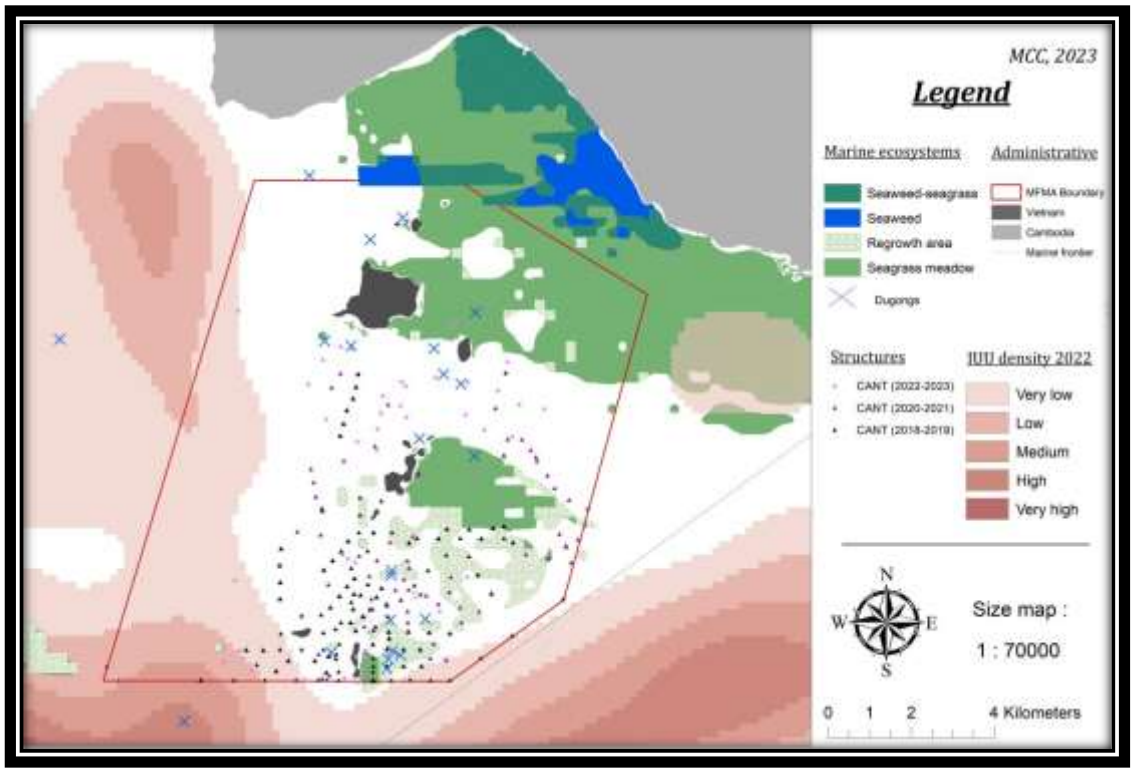
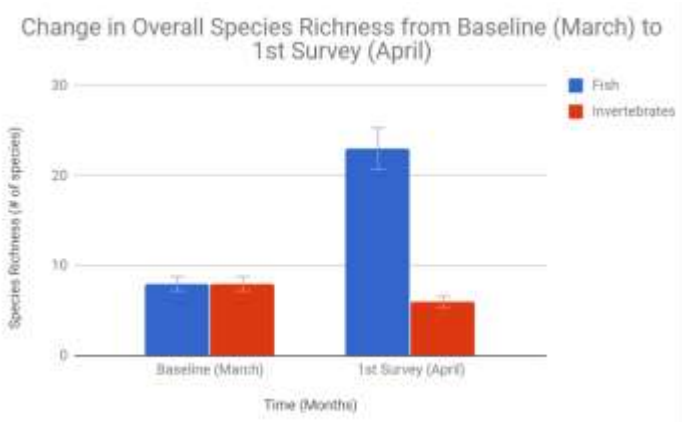


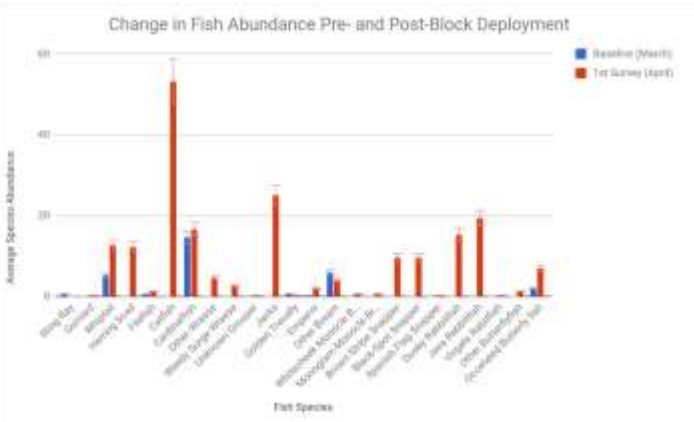
Figure 23: Overlay map of IUU fishing activities, remaining seagrass meadows, regrowth areas in relation with the location of structures and dugong sightings

4.1.3. Solutions put in place: Conservation Anti-Trawling Constructions

MCC has developed a simple interlocking design and high strength construction technique. One that can deliver effective, robust and affordable devices on an industrial scale or at community level. A full structure is made of twenty-one 1.25-meter 120-kg concrete blocks and assembled underwater. It can be built to different heights at various depths, thus avoiding impacts on regular and legal navigation, while enabling restoration of small-scale fisheries. It is designed to be easily movable without heavy machines. It provides a strong deterrent to illegal trawling, as bottom-dragged nets get caught on it. It also delineates the boundaries of the MFMA and acts as a marine life aggregation device (Figure 21).

Since March 2017, more than 100 structures have been deployed in the Kep Archipelago. In response, trawlers have exhibited significant avoidance behavior to the areas where the structures have caught nets in the past (Figure 22). This is indicative of the effectiveness of the structures, which if further employed will be met with further success.





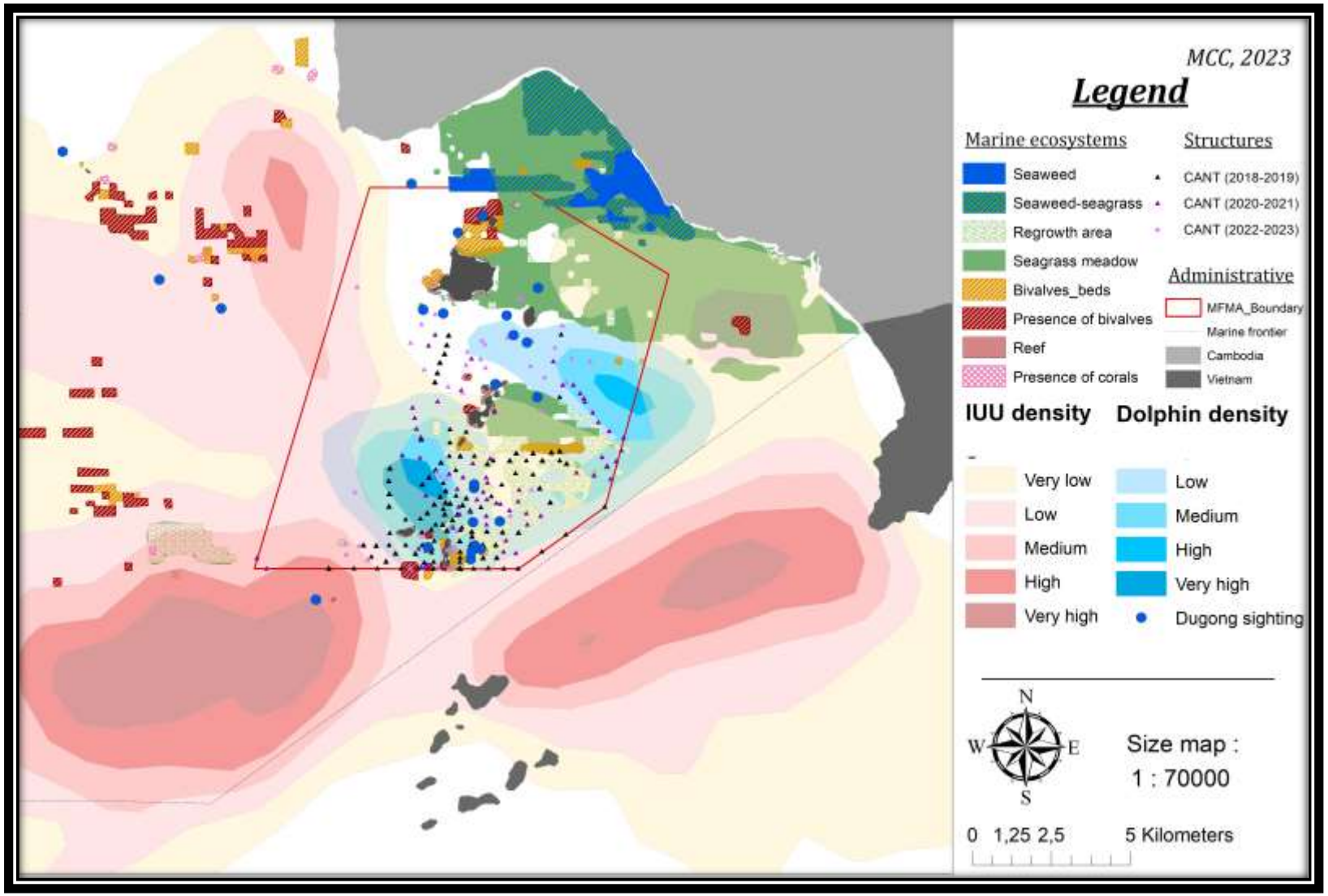


Figure 24: Overlay map of biodiversity hotspots (marine ecosystems and marine mammal presence), Conservation and Anti-Trawling Structures (deployed by year) and IUU fishing activities (Böhm, Rétif, Coales, Tubbs & Croxford, 2019)

4.1. Future perspective of this project

This report emphasizes not only violations of national law, but also violations of transnational regulations such as CITES and the Convention on Biodiversity (CBD). A standardised marine surveillance system is needed to identify the quantity and type of violations. Repeat offences would be identifiable through investigation from a closer sighting point, e.g. by boat, and therefore penalized more severely when violating intra- or international law (Law on Protected Areas, Law of Fisheries, CITES, CBD). This approach could in the long-term not only support law-enforcement efforts but also work towards systematic fisheries management for future generations.

Furthermore, compromised numbers of sea-transferred bycatch or low-value fish could be included in the harvesting network for more precise catch-effort data (Cashion *et al*., 2018). More advanced technologies such as satellite imagery or thermal drones will allow night survey and more persistent recording of IUU fishing activities.
Enhancing cooperation with fishery authorities and fishing communities in combination with international support would offer a ground-based and more efficient law-enforcement approach to tackle the situation that is not only affecting the marine environment but also jeopardizing the income and food security of the region.

4.2. Conservation recommendations

To increase marine ecosystem resilience, and sustain food and income sources of local populations, the following conservation recommendations are suggested based on these findings:

1. Implementation of a marine surveillance system for continous IUU fishing data collection within the Kep MFMA
2. Long-term research on the impacts of IUU fishing on threatened marine species and habitats
3. Continuous research on the study side to measure success of conservation and harvesting management
4. Multilateral agreements based on signed treaties and international commitments to secure ecosystem resilience, and therefore the livelihood of fishing communities
5. National and community-based capacity building of law-enforcement and research efforts to support development and consistency of law-enforcement
6. Transnational surveys to investigate transboundary circumstances in more detail

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