The Cambodian Marine Mammal Conservation Project

Annual Report

Prepared by Sarah Tubbs

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HEINRICH BÖLL STIFTUNG

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Executive Summary

In September 2017, Non-Governmental Organisation Marine Conservation Cambodia launched the Cambodian Marine Mammal Conservation Project (CMMCP), the first long-term marine mammal research program in the coastal waters of Kep province, Cambodia. CMMCP aims to support the conservation of Kep's population of Irrawaddy dolphins through collecting missing baseline data that can be used to create tailored dolphin conservation legislation in the Kep region. During the project's first twelve months, the following research and conservation outcomes have been achieved:

- Research on Kep's Irrawaddy dolphin population was conducted, with results revealing information on abundance, distribution and habitat use.
- Significant progress was made on establishing a transboundary Important Marine Mammal Area (IMMA) across the Cambodian-Vietnamese border, fostering collaboration between the two countries.
- The Kep Marine Fisheries Management Plan, including measures on dolphin research and conservation, was drafted for the Cambodian Fisheries Administration.
- Local, national and international awareness was raised through outreach, social media and news items.

Acknowledgements

The Cambodian Marine Mammal Conservation Project would like to thank the Cambodian Fisheries Administration (of the Ministry of Agriculture, Forestry and Fisheries) for their collaboration throughout the project, specifically His Excellency Eng Cheasan, Director General of the Fisheries Administration (FiA) and Vibol Ouk, Director of Conservation, as well as Phay Somany and Chheng Touch from the Dolphin Conservation and Development Division. Sincere thanks to Dr Aylin Akkaya Baş for her specialist council and Long Vu for his advice, help and transboundary cooperation from Vietnam. Much appreciation goes all Marine Conservation Cambodia volunteers, who assisted in data collection. Finally, we would like to thankfully acknowledge the International Conservation Fund of Canada and the Heinrich Boll Foundation for their economic support, as well as Chelonia Ltd. for the donation of a C-POD (Continuous Porpoise Detector) for Passive Acoustic Monitoring.

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1. Background

The Irrawaddy dolphin *Orcaella brevirostris* is a cetacean species found in rivers, lakes, estuaries and coastal waters across Southeast Asia (Perrin *et al*., 1995, 1996; Stacey and Arnold, 1999). The species once had a continuous coastal distribution across its range, however the effects of numerous threats including fisheries bycatch, habitat degradation and overfishing (Nelson, 1999; Beasley and Davidson, 2007; Jaaman *et al*., 2009; Peter *et al.*, 2016a, 2016b), have led to fragmented and declining populations, with the species recently reclassified from Vulnerable to Endangered by the International Union for the Conservation of Nature (Minton *et al.*, 2017). The species is further listed on Appendix I by both the Convention on International Trade in Endangered Species and the Convention on Migratory Species. In Cambodia specifically, the species is considered 'protected' by fisheries law (MAFF, 2006).

Irrawaddy dolphins were first confirmed in Cambodian coastal waters by Lloze (1973), with later species reports by Tana *et al*. (1995) and Nelson (1999). The species was then recorded during Cambodia's first dedicated boat–based marine mammal surveys in 2001 (Beasley and Davidson, 2007). More recently, the 18-month Transboundary Dolphin Conservation Project, across the Thai-Cambodian border, worked to enhance Irrawaddy dolphin protection in Cambodia's north-west coast (Smith *et al*., 2016). The species has also been confirmed across the Cambodian-Vietnamese border, in Vietnam's Kien Giang province (Vu *et al.,* 2015).

Between September 2017 and September 2018, The Cambodian Marine Mammal Conservation Project (CMMCP) conducted its first year of research and conservation activities. The project, launched by Non-Governmental Organisation Marine Conservation Cambodia, represents the first long-term marine mammal research project in Cambodia's Kep province. The project aims to support conservation of Kep's population of Irrawaddy dolphins through collecting missing baseline data that can be used to create tailored dolphin conservation legislation in the Kep region. A combination of observational land and boat surveys, as well as photo-identification techniques, were used to collect the long missing and much needed baseline data. This report details activities, findings and successes of CMMCP's first twelve months in the field, ending with a presentation of tailored conservation suggestions for the Kep region.

2. Research

Cambodia's 435km coastline spans from Thailand to Vietnam, bordering the Gulf of Thailand. The coastline itself is comprised of four provinces: Koh Kong; Sihanoukville; Kampot and Kep. The study area consisted predominantly of the waters of the Kep province, with some exploration into Kampot province (**Figure 1**; **Figure 2**). Kep supports 13 islands, collectively known as the Kep Archipelago, home to 46ha of fringing coral reef and ca. 2000ha of sea grass meadows. Kep's waters are shallow, ranging between 2m and 6m, with the exception of a few 9m pools. In Kampot, waters remain shallow, reaching up to 25m depth in parts. In April 2018, a Marine Fisheries Management Area (MFMA) was established around the Kep Archipelago, to support the protection and restoration of Kep's Marine Environment (**Figure 2**).

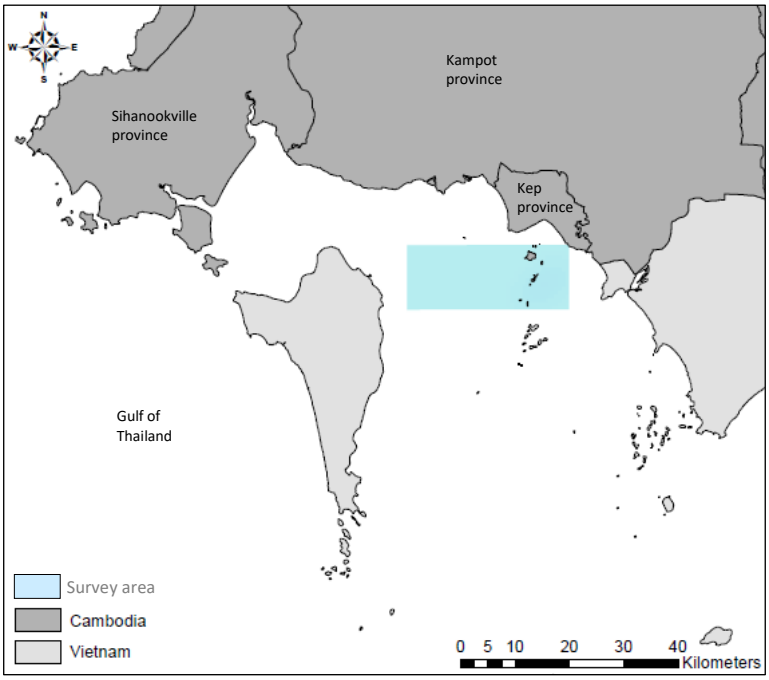

Figure 1. *South-western Cambodian and Vietnamese coastlines and project study area.*

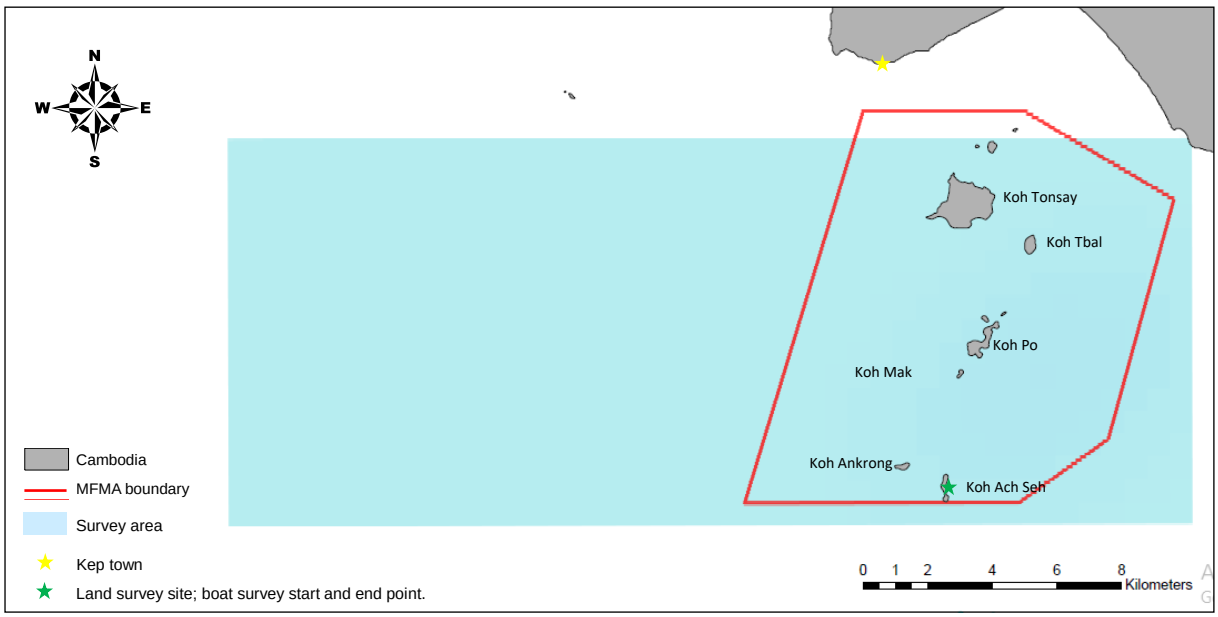

Figure 2. *Study area, displaying the islands of the Kep Archipelago, the land survey site and the start and end point for boat surveys.*

Observational land-based surveys

Observational land-based surveys were conducted from a predetermined land station on Koh Ach Seh, in the Kep Archipelago. The station was east facing and positioned 34m above sea level, selected due to its vantage point across the study area (**Figure 2**). Land surveys were conducted at sunrise or sunset, when the Beaufort sea state was <3, optimally lasting 3 hours. Opportunistic sightings from land were recorded from Koh Ach Seh's east facing beach.

Between September 2017 and June 2018, surveys were conducted with a minimum of three observers. Two observers scanned the sea with Bushnell 42x8 binoculars and one observer was on a rest shift. The observers rotated roles every 15 minutes to avoid fatigue effects. When a dolphin group was sighted, a group number was assigned, time recorded and 5-minute interval sampling was used to record the following observational data: species; group size; juvenile presence; dominant group behaviour (Surface-Feeding; Diving; Travelling; Travel-Diving; Travel-Fast; Socialising; Resting; Milling); reaction to the nearest vessel (Positive; Negative; Neutral), nearest vessel distance and nearest vessel type (Fishing Boat, i.e. longtail with an outboard engine; Fishing Vessel, i.e. Trawling Boat with onboard engine; High Speed Boat; Ferry; Cruise ship). If dolphins were sighted, but not sighted again for 20 minutes or longer, the second sighting was recorded as a separate group. If two separate groups merged together, forming a new, larger group, this group was recorded as a new group.

Between June and September 2018, a CST/Berger DGT10 theodolite was introduced to land surveys, requiring a minimum observer team of four people. During these surveys, two observers scanned the sea with binoculars, one person scanned the sea with the theodolite and one person was on a rest shift. When a dolphin group was sighted, in addition to collecting observational data, the theodolite was used in combination with Pythagoras software (version1.2) to attain GPS locations of dolphin groups. Roles were rotated every 15 minutes to reduce fatigue effects.

Observational boat-based surveys

Between September 2017 and September 2018, planned boat surveys followed one of three pre-determined routes, (1) Kep Archipelago (2) Koh Ach Seh to Kampot Channel or (3) Kampot Channel to Koh Ach Seh. Surveys were conducted on a converted Seine net vessel, with a 200HP on board engine and a viewing platform 3.8m above sea level. Planned boat surveys were conducted at sunrise or sunset, when the Beaufort sea state was <3, optimally lasting 3 hours. Opportunistic sightings were recorded when the MCC boat sighted dolphins on its supply runs between Koh Ach Seh and Kep town (**Figure 2**).

Planned boat surveys were conducted with a minimum of 5 observers. One observer scanned the starboard side, one observer scanned the port side, one observer scanned the entire 360° and two observers were on a rest shift. Observers scanned using Bushnell 8x42 binoculars and rotated roles every 10 minutes to reduce fatigue effects.

When a dolphin group was sighted, a group number was assigned and data was collected on the same parameters used during land observations, with further data collected on the distance of the dolphin group from the research vessel and the angle of the group from north. 'Research Vessel' was also added as an additional category when noting the closest marine vessel. The exact GPS position of each dolphin group was calculated using the GPS point of the research vessel, the distance of the group from the research vessel and angle of the group form north. Between June and September 2018, the depths of dolphin groups were recorded using the research vessel's depth sounder. The same group and subgroup format was applied, as used during land surveys.

Photo-identification
Between January and June 2018, when a dolphin group was sighted, either on a planned boat-based survey or an opportunistic sighting, photos were taken of the dolphins using a Canon 1300D or Canon T6i using a 75-300mm EF zoom lens (1:4-5.6 III). Photographers aimed to capture photographs of the dorsal fin, perpendicular to the camera, of each individual in the group.

Photographs were edited to provide the most detailed image possible and sorted into 'good quality' and 'bad quality' folders. Only 'good quality' photographs were used for identification. Individuals were categorised based on distinctive characteristics on their dorsal fin and/or body length. The following distinctive characteristics were used: bent fin; chopped fin; fin nicks; fin notches; fin scars; unusual fin shapes; body nicks; body notches; body scars; skin disorders. Juveniles and individuals with perfect fins were not included in the analysis due to the lack of identifying features.

Passive Acoustic Monitoring
In June 2018, a C-POD (Continuous Porpoise Detector) (Chelonia Ltd. 2014) was deployed in the near shore waters east of Koh Ach Seh (10°21'31''N, 104°19'22''E), at a water depth of 3.5m, 1m from the sea floor. The C-POD continuously monitored time, centre frequency, intensity, duration, bandwidth and frequency trends of tonal clicks with frequencies between 20 kHz and 160 kHz. Data will be collected and complied at the end of a one-year period, to reveal information on times and seasons of peak Irrawaddy dolphin activity.

Data Analysis
Data from land and boat observations were analysed separately. Encounter rates were calculated using data from planned surveys only. For the remainder of the analyses, data from planned and opportunistic sightings were combined. Descriptive statistics were used to investigate group size, juvenile presence and average depth. Dolphin sightings from land and boat surveys, as well as opportunistic boat sightings, were mapped using *Esri® ArcGIS™* software. Collected point data was transformed into a line shape file, displaying the track of each dolphin. A raster map of dolphin sightings was then created using kernel density with an output cell size of 700 and a radius of 7000.

To investigate dolphin group behaviour, observed behaviours were grouped into four categories: Foraging, comprised of Diving and Surface-Feeding; Travelling, comprised of Travelling, Travel-Diving and Travel-Fast; Socialising and Resting. Milling and Interacting With Boat were discarded from the analysis due to lack of data of this type. To investigate the effect of time of day on behaviour, sightings were organised into four categories: Early Morning; Morning; Afternoon and Evening. Each time of day category lasted for quarter of that day's daylight hours. Chi^2 tests were used to investigate the difference in frequency of occurrence of behaviours, applying Yate's correction when the degrees of frequency equalled one. When analysing the reaction of dolphin groups to the nearest marine vessel, only vessels within 400m of the dolphin group were included in the analysis. Chi^2 tests were used to investigate the difference in frequency of occurrence of the different possible dolphin-vessel reactions. Yate's correction was applied when the degrees of frequency equalled one.

Discovery software (Gailey & Karczmarski, 2012) was used to match and catalogue individuals. Photo-identified individuals were shared with neighbouring scientists in Vietnam.

3. Results

Sightings

Between September 2017 and September 2018, 226 hours and 0 minutes were spent searching for Irrawaddy dolphins from land (**Figure 3**), sighting a total of 29 groups (**Figure 4**), giving a sighting rate of 0.13 dolphin groups per hour search effort. Opportunistic sightings accounted for a further 5 groups. 77 hours and 59 minutes were spend searching for dolphins by boat (**Figure 5**), sighting a total of 42 groups (**Figure 6**), giving a sighting rate of 0.54 dolphin groups per hour search effort. Opportunistic sightings accounted for a further 10 groups. The average group size observed from land was 4 individuals (min. 1 – max. 10) and from the boat was 6 individuals (min. 1 – max. 15). From land survey data, 17.6% of groups contained juveniles, 8.8% contained no juveniles and observers could not determine if juveniles were present or not in the remaining 73.5% of cases. From boat survey data, 44.2% of groups contained juveniles, 9.6% did not and in 46.2% of cases, observers could not determine if juveniles were present or not. The average depth of sightings was 5.3m (min. 3.5m - max 7.8m).

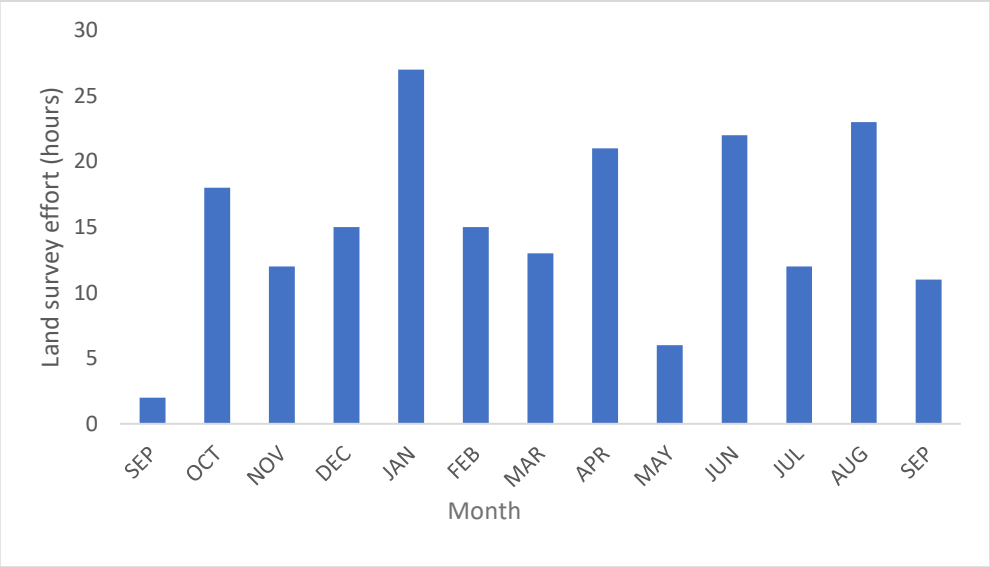

Figure 3. *Land survey effort across each month, between September 2017 and September 2018.*

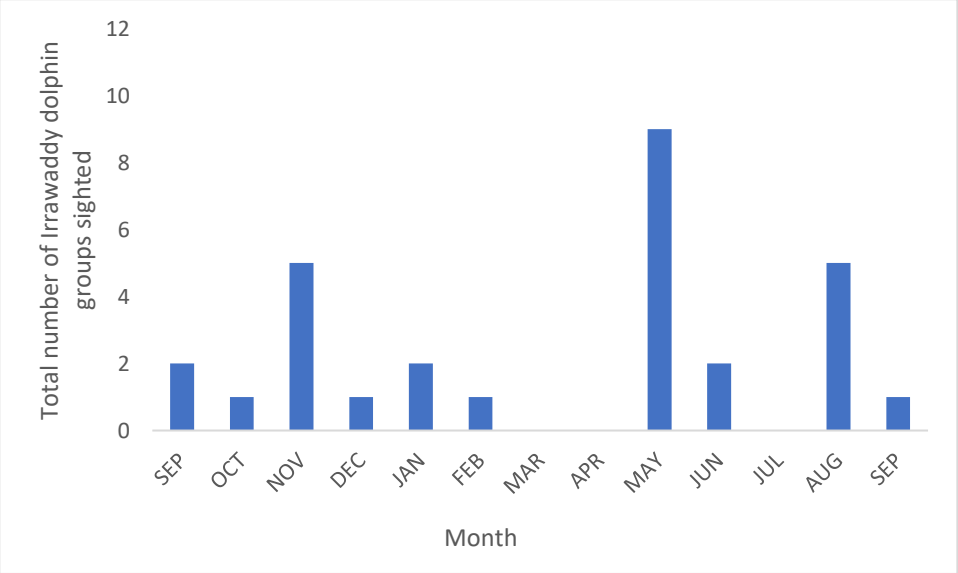

Figure 4. *Number of Irrawaddy dolphin groups sighted each month, during land surveys, between September 2017 and September 2018.*

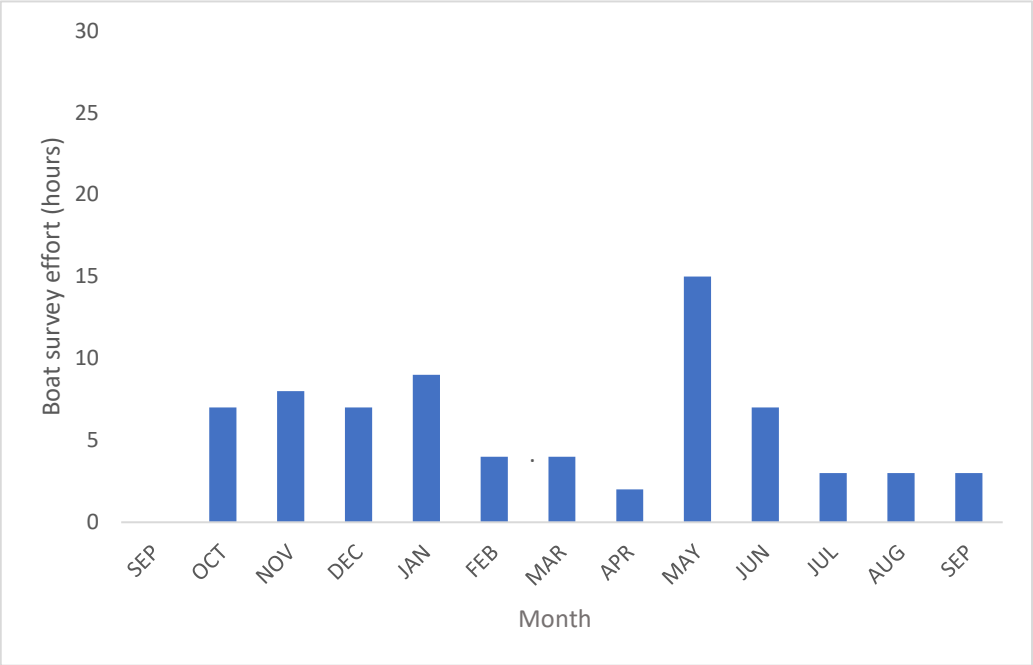

Figure 5. *Boat survey effort across each month, between September 2017 and September 2018.*

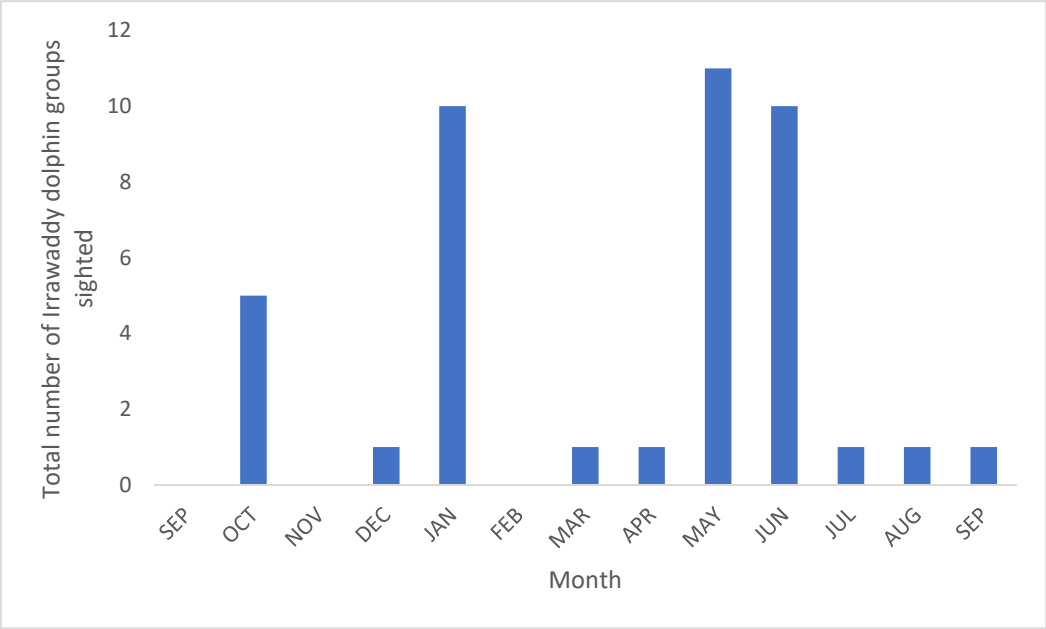

Figure 6. *Number of Irrawaddy dolphin groups sighted each month, during boat surveys, between September 2017 and September 2018.*

Within the survey area, sightings data showed Irrawaddy dolphins to be present throughout the Kep MFMA, except the area north-west of Koh Tonsay (**Figure 7**). The highest Irrawaddy dolphin density was found south-east of Koh Po and north-east of Koh Ach Seh (**Figure 7**), dissipating outwards both within and outside of the MFMA . Dolphins were also congregated ca. 3.5km west of the MFMA.

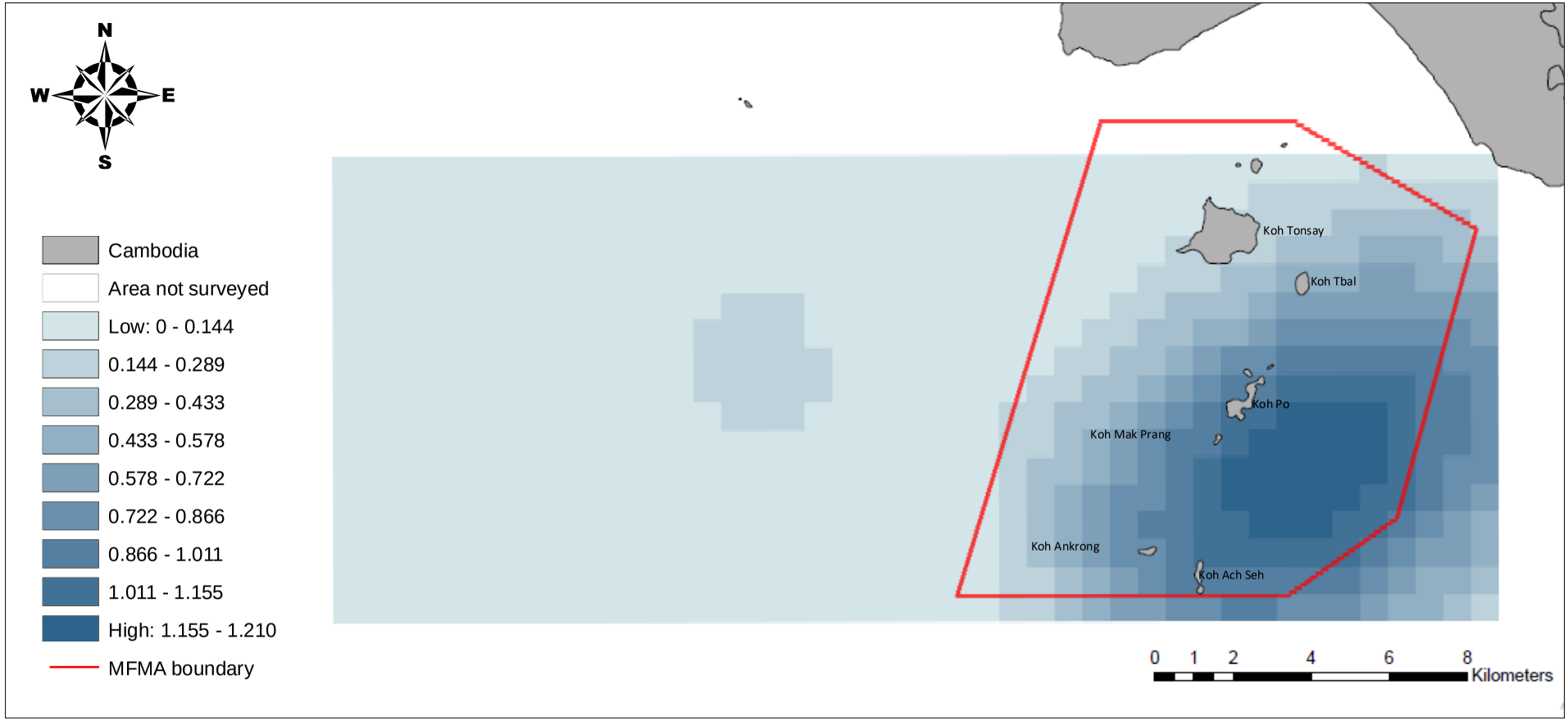

***Figure 7**. Irrawaddy dolphin density, derived from land and boat sightings data.*

Behaviour

When looking only at data collected from land-observations, over the entire study period, there was a statistically significant departure from homogeneity between the four behavioural categories observed (Chi^2 test, χ=44.12, df=3, P<0.05), with more Foraging and Travelling than expected. When the study period was divided into separate months, October and June saw more Foraging than expected (Chi^2 test, χ=12.2, df=3; chi2 test, x=9.62, df=3, P<0.05). In November, there was no departure from homogeneity between the four behaviour categories (Chi^2 test, χ=5.2, df=3, P<0.05). In May and August, there was more Foraging and Travelling than expected (Chi^2 test, χ=8.23, df=3, P<0.05; Chi^2 test, χ=13.1, df=3, P<0.05). Analysis could not be conducted for September, December and January 2017 or February, March, April, July and September 2018, due to lack of data.

When looking only at data collected from boat-observations, there was a statistically significant departure from homogeneity between the four behaviour categories (Chi^2 test, χ =86.01, df=3, P<0.05), with more Foraging and Travelling than expected. When the study period was divided into separate months, in October there was more foraging than expected (Chi^2 test, χ=17.11, df=3, P<0.05). In January and June, there was more Foraging and Travelling than expected (Chi^2 test, χ=38.33, df=3, P<0.05; Chi^2 test, χ=86.01, df=3, P<0.05). In May, there was more Travelling than expected (Chi^2 test, χ=21.24, df=3, P<0.05). Analysis could not be conducted in September, November and December 2017 or February, March, April, July, August and September 2018 due to lack of data.

When looking at data from land-observations and dividing the study period into separate times of day, the Early Morning showed a statistically significant departure from homogeneity between the four behaviours (Chi^2 test, χ=34.49, df=3, P<0.05), with more Foraging and Travelling than expected. In the Afternoon, there was no statistically significant departure from homogeneity between the four behaviour categories (Chi^2 test, χ=5.67, df=3, P<0.05). In the Evening, there was a statistically significant departure from homogeneity between the four behaviours (Chi^2 test, χ=17, df=3, P<0.05), with more Foraging behaviour than expected. There was not enough data to carry out analysis on the Morning time of day.

When looking at the effect of time of day on behaviour, using data collected from boat observations only, there was a statistically significant departure from homogeneity between the four behaviour categories in the Early Morning, Morning and Afternoon (Chi^2 test, χ=61.92, df=3, P<0.05; Chi^2 test, χ=15.52, df=3; Chi^2 test, χ=11.95, df=3, P<0.05 P<0.05), with more Foraging and Travelling than expected. There was not enough data from the Evening time of day to include it in the analysis.

Dolphin-vessel interaction

When investigating the reaction of dolphins to the nearest vessel, using data from land observations only, there was a statistically significant departure from homogeneity between dolphin reaction categories (Chi^2 test, χ=34.81, df=2, P<0.05), with more groups reacting in a Neutral way than expected. When looking only at reactions to Fishing Boats, there were more Neutral reactions than expected (Chi^2 test, χ=29.64, df=2, P<0.05). When looking only at dolphin reactions to boats ≤100m and ≤50m of the dolphins, there were more Neutral reactions than expected (Chi^2 test, χ=17, df=3, P<0.058.92, df=2, P<0.05; Chi^2 test, χ=17, df=3, P<0.056, df=2, P<0.05). Analysis could not be carried out on the effect on Fishing Vessels, High Speed Boats, Ferries, Cruise ships due to lack of data for these categories, however it should be noted that on all occasion High Speed Boats were within 400m of the dolphin group, dolphin reactions were negative.

When investigating the reaction of dolphins to the nearest vessel, using data from boat observations only, there was a statistically significant departure from homogeneity between dolphin reaction

categories (Chi^2 test, χ=64.78, df=2, P<0.05), with more Neutral and Negative reactions than expected. When looking at reactions to Fishing Boats and Research Vessels, boats ≤100 and ≤50m, there were more Neutral and Negative reactions than expected (Chi^2 test, χ=9, df=2, P<0.05; Chi^2 test, χ=55.69, df=3, P<0.05; Chi^2 test, χ=46.39, df=2, P<0.05; Chi^2 test, χ=25.73, df=2, P<0.05). Analysis could not be carried out on the effect on Fishing Vessels, High Speed Boats, Ferries or Cruise ships due to lack of data for these categories, however it should be noted that on all occasions High Speed Boats were within 400m of the dolphin group, dolphin reactions were negative.

Photo-identification

A total of 15 individuals were identified on 7 discrete sampling days between January and June 2018 (**Figure 8**), with a total of 4 resightings. The quality of photography equipment and the timid

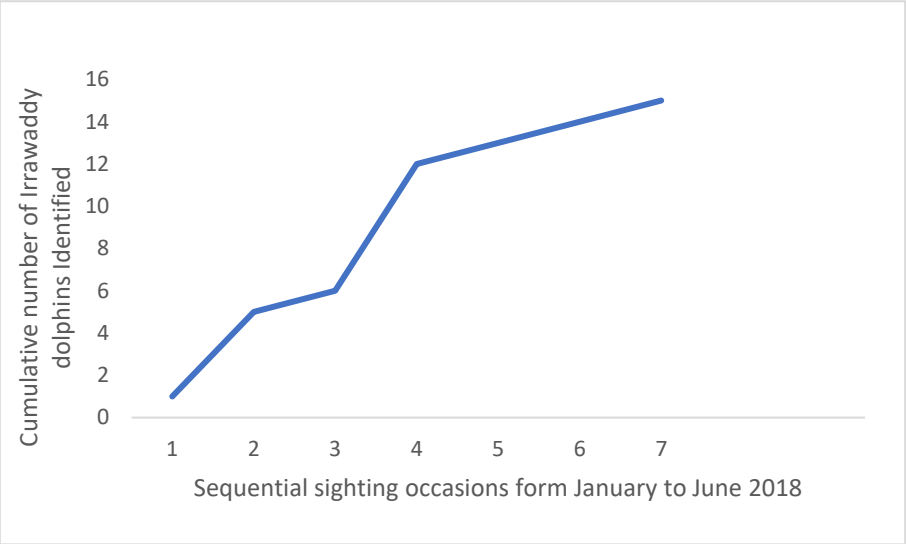

***Figure 8**. Discovery curve of newly identified Irrawaddy dolphins in the Kep Archipelago.*

***Figure 9**. Irrawaddy dolphin pictured in May 2018 in the Kep Archipelago, showing deeps scars, characteristic of bycatch.*

behaviour of the species limited photographers' ability attain 'good quality' images, suitable for identification. As a by-product, a large number of photographs were discarded from the analysis due to their potential to elicit false positives. Running mark-recapture analyses for estimating population abundance was therefore not suitable for the dataset. When cataloguing individuals, two of the 15 identified Irrawaddy dolphins, and one non-identified individual, showed wounds characteristic of

bycatch (**Figure 9, Figure 10**). When the catalogue was compared with individuals in Vietnam, no matches were made.

***Figure 10**. Irrawaddy dolphin pictured in June 2018 in the Kep Archipelago, showing a fresh dorsal fin injury, characteristic of bycatch.*

Passive Acoustic Monitoring

The C-POD has been in deployed for 97 days. No results have been analysed at this time.

Field observations

It should be noted that project scientists observed a high occurrence of illegal and destructive fishing methods in the Kep Archipelago over the study period, predominantly during non-daylight hours.

4. Dolphin Mortality

Between September 2017 and September 2018, the following dolphin mortalities were recorded:

- On 21st November 2017 an adult male Irrawaddy dolphin carcass was recovered from Koh Ach Seh Beach, Kep Archipelago, Kep province. The individual's fluke was entangled in rope however no post-mortem investigation was conducted to confirm the cause of death.
- On 21st November 2017 a juvenile Irrawaddy dolphin carcass of undetermined sex was recovered from Kep Town, Kep province. No post-mortem investigation was conducted to confirm the cause of death.
- On 14th February 2018 a juvenile female Irrawaddy dolphin carcass was recovered, 400m east of Koh Ach Seh, Kep Archipelago, Kep province (**Figure 11**). No post-mortem investigation was conducted to confirm the cause of death.
- On 12th March 2018 an Irrawaddy dolphin carcass of unknown sex was recovered on Koh Tonsay Island, Kep Archipelago, Kep province. No post-mortem investigation was conducted to confirm the cause of death.

***Figure 11**. Juvenile female Irrawaddy dolphin carcass, found 400m east of Koh Ach Seh, Kep province, in February 2018.*

5. Achievements

In terms of outreach, communication, information dissemination and attaining funds, the following achievements were made during CMMCP's first 12-months:

- Worked with researchers from Vietnam, to make significant progress on the establishment of a transboundary Important Marine Mammal Area (IMMA) across the Cambodian-Vietnamese border.
- Educated 20 'school leaders' from Kep's Don Bosco Technical High School, in marine mammal biology, the importance of marine mammal research and about the current project.
- Trained nine Cambodian students and 56 international students in cetacean survey techniques. Training for all students covered an introduction to marine mammals and their biology, as well as detailed training on data collection methods, ending with a knowledge review test.
- Published a 'News' article introducing the project in *The Cambodian Journal of Natural History*.
- Created a CMMCP Facebook Page, where updates are shared with the general public. The page has 397 likes.
- Created a CMMCP page on the Marine Conservation Cambodia website, outlining the project, providing updates and sharing the photo-identification catalogue. The page has received 2964 hits.
- Received a C-POD (Continuous Porpoise Detector) from Chelonia Ltd. for acoustically monitor Kep's population of Irrawaddy dolphins.
- Received economic support from the International Conservation Fund of Canada, supporting the fuel costs associated with boat surveys.
- Received economic support from the Heinrich Böll Foundation. The funds were dedicated to: purchasing a Theodolite for attaining GPS positions of dolphin groups during land surveys; building a second land station on Koh Ach Seh, with views in a westerly direction and producing an information book showcasing Kep's photo-identified Irrawaddy dolphins.

6. Discussion

CMMCP represents the first long-term marine mammal study in the target region. During the project's first 12-months, CMMCP was successful in attaining missing baseline that can be used to design a tailored Irrawaddy dolphin conservation strategy for the Kep region.

Sightings data revealed that Irrawaddy dolphins were present in Kep's coastal waters year-round, with the highest number of sightings in May for both land and boat surveys (**Figure 4**, **Figure 6**). The high number of sightings during boat surveys could be attributed to May having the highest search effort, however, during land surveys, May and September were the months with the least search effort. Species distribution maps showed Irrawaddy dolphins were present throughout the waters of the Kep MFMA, with a higher density congregating south-east of Koh Po and north-east of Koh Ach Seh (**Figure 7**). Dolphins were also present outside of the southern, south-eastern and eastern border of the MFMA as well as ca. 3.5km west of the MFMA (**Figure 7**). Distribution data highlights the need for further research in the waters outside of the Kep MFMA, specifically the waters south-east of the MFMA, the Kep coastline and the waters of Kampot province.

The average group size observed during land surveys was 4 individuals (min. 1 – max. 10), whereas the average during boat surveys was 6 individuals (min. 1 – max. 15). This difference could be explained by the greater distance of observes from dolphin groups during land surveys, compared to boat surveys, making group size estimates less robust. Beasley and Davidson (2007) reported an average group size of 7 individuals (min. 1 – max. 15) for Cambodia's coastal Irrawaddy dolphins, however Minton *et al.* (2011) reported an average group size of 4.3 individuals in Sarawak, Malaysia, showing a range in average group sizes across studies. In terms of group dynamics, juveniles were present in 44.2% of groups sighted by boat and only 17.6% of groups sighted from land. Observers could not determine juvenile presence in 73.5% of cases from land, with the most likely explanation being that during land surveys, observers were not in close proximity to the dolphin groups, making juvenile presence difficult to determine. Despite varying juvenile occurrence between land and boat observations, juvenile presence within the Archipelago shows that the region offers an important nursery habitat for the species.

Behavioural data attained during the 12-month study showed that Irrawaddy dolphins use the region as a foraging ground throughout the day, as well as a travelling ground in the Early Morning, Morning and Afternoon. Results suggest that the habitat provided by the Kep Archipelago is important for day-to-day activities of the population. Identifying important, or critical habitats, for cetaceans has been seen as the first step in the implementation of cetacean marine protected areas (Hoyt, 2005). Identifying the Kep Archipelago as an important habitat for Irrawaddy dolphins can therefore be seen as the first step in designing marine mammal conservation legislation in the study region.

Dolphin-vessel reaction data, collected during land observations, showed dolphins reacted with more Neutral reactions than expected (Chi^2 test, $\chi=34.81$, df=2, $P<0.05$). A Neutral reaction suggests the nearest vessel had no effect on dolphin behaviour. When looking at dolphin-vessel reaction data, collected during boat observations, more Negative and Neutral reactions occured than expected (Chi^2 test, $\chi=64.78$, df=2, $P<0.05$). The difference in reaction types between data collected from land observations and boat observations could be explained the absence of Fishing Vessels during land surveys. The difference could also be explained by the fact that the research vessel used during boat surveys was a reconditioned seine net vessel, hence it made the same engine sound a boat in the study's Fishing Vessel category. If either of these explanations were the reason for increased Negative reactions, it would suggest fishing vessels with in board engines have a more detrimental effect on Irrawaddy dolphins than long tail boats with outboard engines. While there was not enough data to perform analysis on the effect of High Speed Boats on dolphin reactions, it is important to note that all interactions between High Speed Boats and dolphin groups resulted in

Negative reactions. A Negative reaction suggests the vessel is disturbing the dolphin group. It is important to recognise the presence of marine vessel disturbance on dolphins, as such disturbances have been linked to detrimental effects on dolphin populations, including effects on reproduction and area avoidance (Nowacek, 2001; Lusseau, 2003; Ng and Leung, 2003; Lusseau, 2005; Bejder et al. 2006; Richardson, 2012; Christiansen *et al*., 2013; Christiansen & Lusseau 2014; Baş et al., 2017).

Photo-identification techniques identified a total of 15 individuals. The increasing trend in the discovery curve of the cumulative number of Irrawaddy dolphins identified (**Figure 8**) suggests the population size is larger than 15. Whilst there were no confirmed matches between the Kep Archipelago and Kien Giang identified individuals, catalogue sharing should continue to occur as both catalogues are updated. It is important to continue photo-identification techniques, in order to produce a robust abundance estimate for the population and allow population changes to be tracked over time. A multi-year photo-identification study would further allow investigations in to residency, site fidelity and population ranges.

Four Irrawaddy dolphin deaths were recorded over the study period, however all cases occurred within a four-month period between November 2017 and March 2018. It is likely that the population suffered more deaths, that went unreported. Dolphin mortality data combined with photo-identification evidence of bycatch, the high occurrence of illegal fishing activities in the study region and the globally and nationally recognised conservation status of the Irrawaddy dolphin (MAFF, 2006; Minton *et al*., 2017), provide a strong case for the need for local Irrawaddy dolphin conservation measures.

The following conservations recommendations have been made, in order to increase the health and abundance on Kep's Irrawaddy dolphin population:

1. Continue to collected robust, scientific, data on Kep's population of Irrawaddy dolphins.
2. Expand the current study area, to encompass all coastal waters of Kep and Kampot provinces.
3. Existing rules and regulations within the MFMA must be adhered to.
4. Establish a Dolphin Protection Zone within the current MFMA, where speed limits are applied. Within the Dolphin Protection Zone, there should be a more restrictive Dolphin Conservation Zone around the dolphin core habitat, where all fishing activities are prohibited.
5. A dolphin workshop should be held with Kep and Kampot FiA officers and Community Fisheries. The workshop should include training on the safe release of entangled dolphins, as well as the importance of, and methodologies for, reporting stranding and bycatch events.

12. References Cited

Bas, A., Christiansen., F, Öztürk, B., Öztürk, A., Erdog˘an and M., Watson, L., (2017) Marine vessels alter the behaviour of bottlenose dolphins *Tursiops truncatus* in the Istanbul Strait, Turkey. *Endangered Species Research*. (34), 1–14.

Beasley, I. and Davidson, P. (2007). Conservation status of marine mammals in Cambodian waters, including seven new cetacean records of occurrence. *Aquatic Mammals, 33*(3), 368-379.

Bejder L, Samuels A, Whitehead H, Gales N and others (2006) Decline in relative abundance of bottlenose dolphins exposed to long term disturbance. *Conservation Biology* (20) 1791−1798.

Chelonia Ltd. (2014a). *C-POD specification*. Retrieved from https://chelonia.co.uk/cpod_specification.htm

Christiansen F., Rasmussen M., Lusseau, D. (2013) Inferring activity budgets in wild animals to estimate the consequences of disturbances. *Behavioural Ecology*. (24) 1415−1425.

Christiansen, F. and Lusseau, D., (2014) Understanding the ecological effects of whale watching on cetaceans. In Higham J, Bejder L, Williams R, editors. Whale-watching, sustainable tourism and ecological management. Cambridge University Press, Cambridge. 177–192.

Gailey, G. and Karczmarski, L. (2012). Discovery: Photo-identification data-management system for individually recognizable animals. Retrieved from https://biosch.hku.hk/ecology/staffhp/1k/Discovery

Hoyt, E. (2005). Marine protected areas for whales dolphins and porpoises: A world handbook for cetacean habitat conservation. Earthscan, London, U.K.

Jaaman, S., Lah-Anyi, Y. and Pierce, G. (2009). The magnitude and sustainability of marine mammal by-catch in fisheries in East Malaysia. *Journal of the Marine Biological Association of the United Kingdom.* (*89*) 907-920.

Lloze (1973). Contribution a l'etude anatomique histologique et biologique de l'*Orcaella brevirosstris* (Gray 1866) (Cetacea, Delphinidae) du Mekong. P.h.D. L'Universite Paul Sabatier de Toulouse, France.

Lusseau, D. (2003). Effects of tour boats on the behaviour of bottlenose dolphins: using Markov chains to model anthropogenic impacts. *Conservation Biology*. (17) 1785−1793.

Lusseau, D. (2005). Residency pattern of bottlenose dolphins *Tursiops spp.* in Milford Sound, New Zealand, is related to boat traffic. *Marine Ecology Program Series*. (295) 265−272.

MAFF (Ministry of Agriculture, Forestry and Fisheries of Cambodia) (2006). *Draft Fisheries Law*. Phnom Penh, Cambodia. Retrieved from http://www.maff.gov.kh/pdf/DraftFisheriesLaw.pdf

Minton, G., Peter, C. and Teun, A. (2011). Distribution of small cetaceans in the nearshore waters of Sarawak, East Malaysia. *The Raffles Bulletin of Zoology*, 59(1), 91–100.

Minton, G., Smith, B., Braulik, G., Kreb, D., Sutaria, D. and Reeves, R. (2017). *Orcaella brevirostris*. In *The IUCN Red List of Threatened Species 2017.* Retrieved from http://dx.doi.org/10.2305/IUCN.UK.2017-3.RLTS.T15419A50367860.en.

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

Ng, S. and Leung, S. (2003). Behavioral response of Indo-Pacific humpback dolphin (*Sousa chinensis*) to vessel traffic. *Marine Environmental Research*. (56) 555-567.

Nowacek, S., Wells, R., Solow, A. (2001) Short term effects of boat traffic on bottlenose dolphins, *Tursiops truncatus*, in Sarasota bay, Florida. *Marine Mammal Science*. (17) 673−688.

Perrin, W., Leatherwood, S., and Dolar, M. (1995). The status of marine mammal research in Southeast Asia (UNEP/SEA95/BP6, IBI Reports No. 5), 16.

Perrin, W., Dolar, M., and Alava, M. (1996). Report of the workshop on the biology and conservation of small cetaceans and dugongs of Southeast Asia. Dumaguete: United Nations Environment Programme.

Peter, C., Poh, A., Ngeian, J., Tuen, A. and Minton, G. (2016a). Identifying habitat characteristics and critical areas for Irrawaddy Dolphin, *Orcaella brevirostris*: Implications for Conservation. In: Das, I. and Tuen, A. (eds), Naturalists, Explorers and Field Scientists in South-East Asia and Australasia, 225-238. Springer.

Peter, C., Ngeian, J., Minton, G., Zulkifli Poh, A., Grinang, J. and Tuen, A. (2016b). Artisanal fisheries and cetaceans in Kuching Bay, Sarawak, East Malaysia: Threats and potential mitigation. Report presented to the meeting of the Scientific Committee of the International Whaling Commission SC/66b/SM09.

Richardson, W.J., Greene Jr, C.R., Malme, C.I. and Thomson, D.H. (2013). Marine mammals and noise. Academic press.

Smith, B., Sonim, V., Boonchai, R., Joehl Cadena, A. and Manopawitr, P. (2016). Final Report on Dolphin Conservation along the Coastline of the Thai and Cambodian Border. https://www.iucn.org/sites/dev/files/content/documents/2016/final20report20iucn20cambodia20thailand20dolphin20project_final2028229.pdf [accessed 3 July 2018].

Stacey, P. and Arnold, P., (1999) *Orcaella brevirostris. Mammalian Species*. (616) 1-8.

Tana, T., Chea, Y., & Chamnan, C. (1995). *Review of the oceanography, natural resources and fisheries of the coastal zone of Cambodia*. Unpublished report of the project for the Management of Freshwater Capture Fisheries of Cambodia, Ministry of Agriculture, Forestry and Fisheries.

Vu, L., Tho, T., Ny, T., Tham, N., Duy, L., Hung, N. and Duc, H., (2015). Conservation of cetacean in Kien Giang Biosphere Reserve, Vietnam. Society for Marine Mammalogy 21th Biennial conference, San Francisco, US.