Summary of Seahorse Population and Distribution

Koh Rong Samloem
Preah Sihanouk, Cambodia

Report on seahorse demographics and habitats

Marine Conservation Cambodia

3rd Quarter Report 2013 – Jul/Aug/Sept

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marine conservation
CAMBODIA

Photo 1 –*H. Spinosissimus* on the Corral, MCC 2013

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Abstract

In June 2011, MCC began an initial set of surveys to assess and monitor the changing conditions of the seahorse population and habitat in the study site, 'The Corral', located off the East coast of Koh Rong Samloem.

These surveys recommenced in August 2012 and continue in present time. This report covers the third quarter (July, August, and September) of 2013. In this quarter, there were an overall 28 seahorse sightings over 85 surveys, which comprised of 13 *Hippocampus spinosissimus*, 1 *H. trimaculatus*, and 1 *H. kuda*. The remaining 13 seahorses sighted were juveniles and as such, species was not recorded. Site information regarding habitat, holdfast selection, depth, and temperature were also collected on each survey and compiled with all previously recorded data. Data from this quarter continued to support previous hypotheses which stated that; *H. spinosissimus* seem to be more suited to the disturbed habitat than other seahorse species previously observed in the study area, the seahorse population on The Corral appears to have adapted to the use of mobile holdfasts, and there currently appear to be no strong patterns in sexual demographics ratios across the quarter.

The ongoing nature of this study means that with each quarter of data collected and analysed, comes a better understanding of this local seahorse population in terms of; their behavior, migratory patterns, breeding patterns, depth range, and the habitat they reside in.

This report also signifies the end of the first year of continuous study (September 2012 to September 2013) and thus, another report, concluding a year of study will be produced shortly.

It is hoped that through continuous research, a database of the conditions of this study area can be compiled in order to help protect and conserve this fragile and important ecosystem. By establishing relationships between species composition and diversity, depth, preferred holdfasts and holdfast densities, habitat cover, sexual demographics and reproductive activity, a more effective conservation strategy can be designed and implemented.

All of this will lead to a better understanding for the long term protection of this fragile species and sensitive habitat.

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Acknowledgements

Marine Conservation Cambodia (MCC) has been working on conservation and community livelihoods in collaboration with the Royal Government of Cambodia Fisheries Administration (RGC FiA), local authorities and local communities since 2008.

The Marine Monitoring and Marine Research programs around Koh Rong and Koh Rong Samloem are now well underway and are currently undertaking marine surveys around Koh Rong Samloem, this is to monitor the Seahorse populations and the coral reefs, so it is possible to assist the FiA in the creation of Marine Fisheries Management Areas (MFMAs), Cambodia's equivalent to Marine Protected Areas (MPAs).

Close collaboration with the FiA and international institutions such as the FAO Regional Fisheries Livelihoods Programme (RFLP), The Seahorse Trust (UK), Save Our Seahorses (Ireland) has proven that MCC is now a respected and credited leader in conservation and community work in Cambodia.

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Introduction

There are number of anthropogenic activities that continuously threaten marine habitats and biodiversity; overexploitation, habitat destruction, introduction of invasive species and climate change (Jackson *et al.* 2001). One method with which to mitigate at least the first two of these factors is the establishment of marine protected areas (MPAs). MPAs are regions with restricted anthropogenic activity, and act as harbours for marine species to breed and recruit (Gell and Roberts 2002; Leslie 2005). In 1970, there were a global total of 118 MPAs, currently there are more than 5,045 (Kelleher and Kenchington 1992; Spalding *et al.* 2008). One of the first steps to MPA establishment is the assessment of a habitat or region in order to identify areas of important ecological value in terms of species to be protected. Furthermore, adding a species or genus of concern to the Convention on International Trade in Endangered Species (CITES) Appendix can help achieve sustainable fisheries and fishing quotas (Foster and Vincent 2004). Amongst the first marine fish added to a CITES Appendix, were all known species of seahorse (*Hippocampus* spp.).

Members of the Syngnathidae family, 48 identified species of seahorses are a genus of ecological, economic, medicinal and cultural importance (Vincent *et al.* 2011). Generally for most species, seahorses occupy shallow coastal waters (<30m depth) distributed between 50° north and 50° south (Foster and Vincent 2004), however some species, such as the Zebra Seahorse, *Hippocampus zebra,* are found as deep as 70 meters (http://www.saveourseahorses.org /seahorses.php). Different *Hippocampus* species tolerate a plethora of different environmental parameters, from cool, deep, open water highly saline habitats to warmer, shallow, dense seagrass freshwater estuaries and intermediary mangroves, macroalgae and corals (Tipton and Bell 1988). As they prey on bottom-dwelling organisms, seahorses help maintain trophic balance within their occupied habitats (Bologna 2007). As such, they are a lineage of important conservative value. Characteristic of many life-history specialists, seahorses exhibit strategies which may make them particularly susceptible to overexploitation and habitat destruction (Foster and Vincent 2004).

Occupying small home ranges, poor mobility, low dispersal rates, parental care and monogamous breeding habits, seahorses have relatively low levels of fecundity and thus low population recruitment rates (Foster and Vincent 2004). Such a life-history strategy coupled with high susceptibility to unsustainable fishing techniques, a persistently high trade demand, and increasing commercial value with decreasing abundance (Courchamp *et al.* 2006), seahorse populations are internationally threatened. Their sedentary nature of attaching themselves to holdfasts using a prehensile tail makes them susceptible to habitat destruction as well as population overexploitation. Wild populations are harvested using a variety of techniques, including (but not limited to) unselective trawl fishing in American and south-east Asian waters, breath-hold diving in Brazil and the Philippines, and dip-netting in India (Meeuwig *et al.* 2006; Rosa *et al.* 2006; Vincent 1996). Up to 95% of seahorses in circulation for trade are by-catch from shrimp trawlers (McPherson and Vincent 2004), and Indian, Thai and Vietnamese fisheries have particularly high levels of annual seahorse by-catch (Vincent *et al.* 2011). As such, the Gulf of Thailand is an area of particular concern when evaluating seahorse population management and assessment.

Much of the information regarding seahorse harvest quantities and wild populations comes from relatively old trade surveys and interviews (Vincent 1996; Vincent *et al.* 2011). This assessment method is limited as it compiles out-dated figures which are often highly conservative in their estimates of seahorse catch (O'Donnell 2010). Moreover, fishery authorities can provide false harvest figures as a means to persistently exploit the growing economic demand for seahorses, particularly for use in Traditional Chinese Medicine (Doyle, n.d.). Indeed, targeted efforts by individuals and organisations such as Kealan Doyle (Save our Seahorses) and The Seahorse Trust, has shown that in China alone, over 150 million seahorses are consumed for use in Traditional Chinese Medicine yearly (Doyle, n.d.). This staggering figure is more than seven times the official number of specimens declared by the Chinese authorities (awionline.org). The fact that official numbers of harvested specimens produced by local and governmental fisheries are such an underestimate calls for a drastic re-evaluation of the ways in which seahorse harvest quantities and wild populations are determined.

One such method is to directly assess the population quality in a region by conducting population and habitat surveys. Many previous surveys of wild seahorse abundance and density have only been one-off snapshots (Rosa *et al.* 2007). Although useful for an immediate assessment of the area, such assessments provide no temporal coverage (Barrows *et al.* 2009), which is required to assess the effect of any conservative measures such as fishing quotas or MPAs on fish populations over time (Gell and Roberts 2002). The current study has been assessing seahorse populations and habitat in the same geographical area for fourteen months to date.

Primarily, seahorses are an appropriate study species for conservation and management due to their status as a 'flagship' species (Shokri *et al.* 2008). Such species are considered charismatic, and are capable of attracting public attention and sympathy, which can in turn potentially attract funding for protection (Caro and O'Doherty 1999). Also, Syngnathid density has previously been shown to be indicative of non-syngnathid species diversity in Australian estuarine seagrass beds (Shokri *et al.* 2008). As such, Syngnathids could potentially be used as indicators for areas to be protected by MPAs or fishing quotas, as these areas would encompass a diverse array of species and densities.

Our particular study area, 'The Corral', is unique and useful in the fact that it is segregated largely into two regions; protected and unprotected from unsustainable fishing techniques. In 2007, the entire region had high seahorse species diversity (six identified species; *H. comes, H. histrix, H. kelloggi, H. kuda, H. spinosissimus* and *H. trimaculatus*) (P. Ferber pers. obs.). Large scale trawling activity in March 2007 decimated the populations and habitat, so that currently *H. spinosissimus* is almost exclusively the only species in the region, occurring in low densities (MCC 2011). After the 2007 trawling event, a three hundred meter No Take Zone (NTZ) in the north-west section of the Corral was established which prevents any unsustainable fishing methods in this region (such as trawling, dynamite fishing and air supplied collection). Despite the unfortunate nature of the trawling, we are provided with an opportunity to monitor habitat and population recovery, rejuvenation and recruitment. With the establishment of a long-term successful volunteer based project (Marine Conservation Cambodia) close to The Corral survey area, seahorse population surveys can be conducted over a significant timespan of many years.

Study Area

Koh Rong Samloem Island is located 28 km south west of the port of Sihanoukville on

Cambodia's southern coast. The island's coastline is predominately shallow, mainly composed of sand flats, seagrass beds and coral reef habitats. Previous studies have identified 5 geographically separated coastal areas of seahorse habitat, designating one particular area, The Corral site, as a location for targeted seahorse research. This is due to its large breeding populations and close proximity to Marine Conservation Cambodia (MCC) facilities.

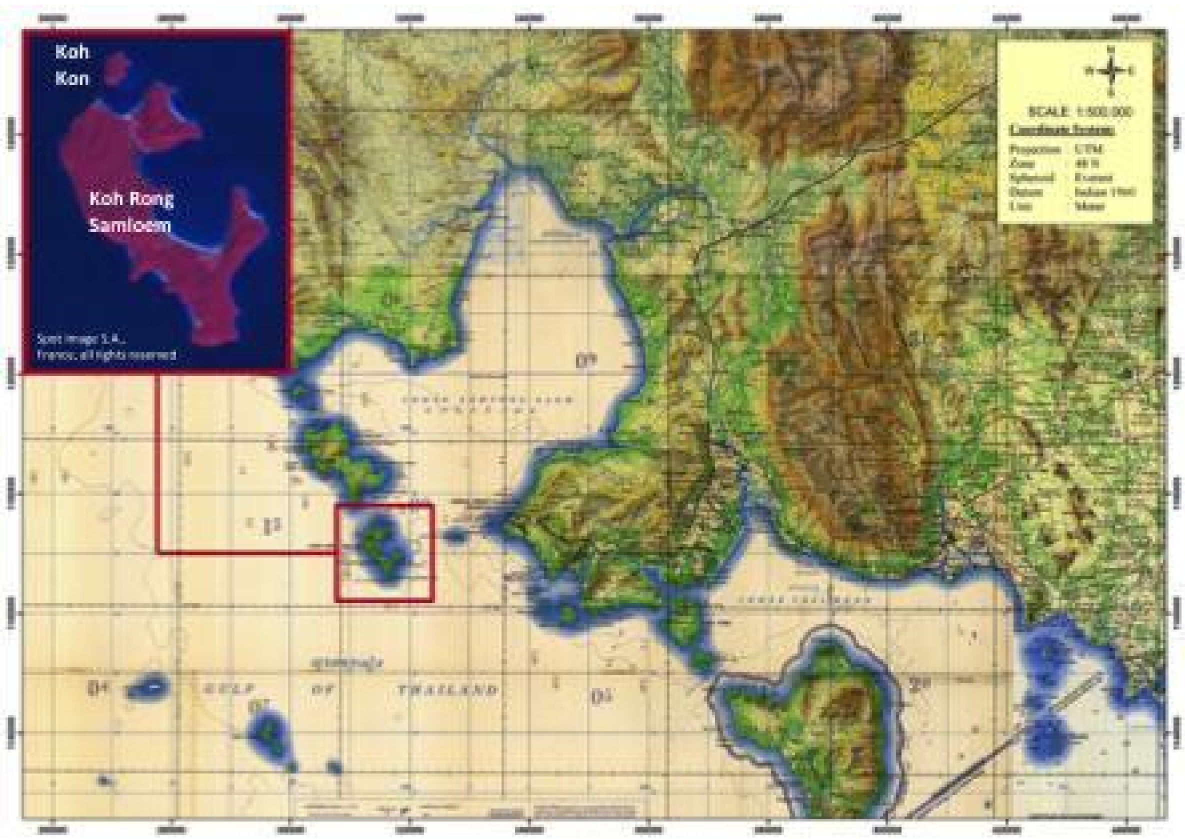

Figure 1. Map of Southern Cambodia and islands with magnification of Koh Rong Samloem

The Corral site is located to the east of Koh Koun, a small island situated to the north of Koh Rong Samloem. The area is dominated by sand flats, which slope gradually from the east coast of Koh Koun, with depths ranging between 5-20m. The area supports populations of bivalves, soft corals, hydrozoans and large numbers of pencil urchins (*Prionacidaris spp*), which provide valuable holdfasts for seahorses.

The habitat was observed to be in excellent condition in 2007, at this time species diversity of the area was observed to be unusually high, with 6 species of seahorse identified from photographic evidence taken at the Corral site. These species are *Hippocampus* *spinosissimus, Hippocampus trimaculatus, Hippocampus kuda, Hippocampus comes, Hippocampus kelloggi, Hippocampus histrix*, (*Hippocampus barbouri* and *Hippocampus comes* are suspected but have not been photographed). Previous data demonstrates that *H. spinosissimus* heavily dominates the population.

However, recent damage from illegal trawling activity has greatly impacted the habitat, reducing the biodiversity and productivity of the local ecosystem. Field observations from 2007 suggest that since this period of time seahorse species diversity has decreased to strongly favor *H. spinosissimus.*

Legal protection of the habitat has been established in the form of a 300m No Take Zone (NTZ) extending from Koh Koun Island as well as a community conservation area. The 300m NTZ only covers a small percentage of the study site; however the community conservation area covers far more of the area. Unfortunately protection measures are often ignored or circumvented; and thus, frequent monitoring and increased patrols are necessary to prevent trawling activity in the area. Regularly conducted population assessments provide the consistent data necessary to measure the recovery or decline of this area, and to make comparisons to previously observed ecosystem productivity. This data will also show the impacts, both positive and negative, of the conservation measures currently in place.

Methodology

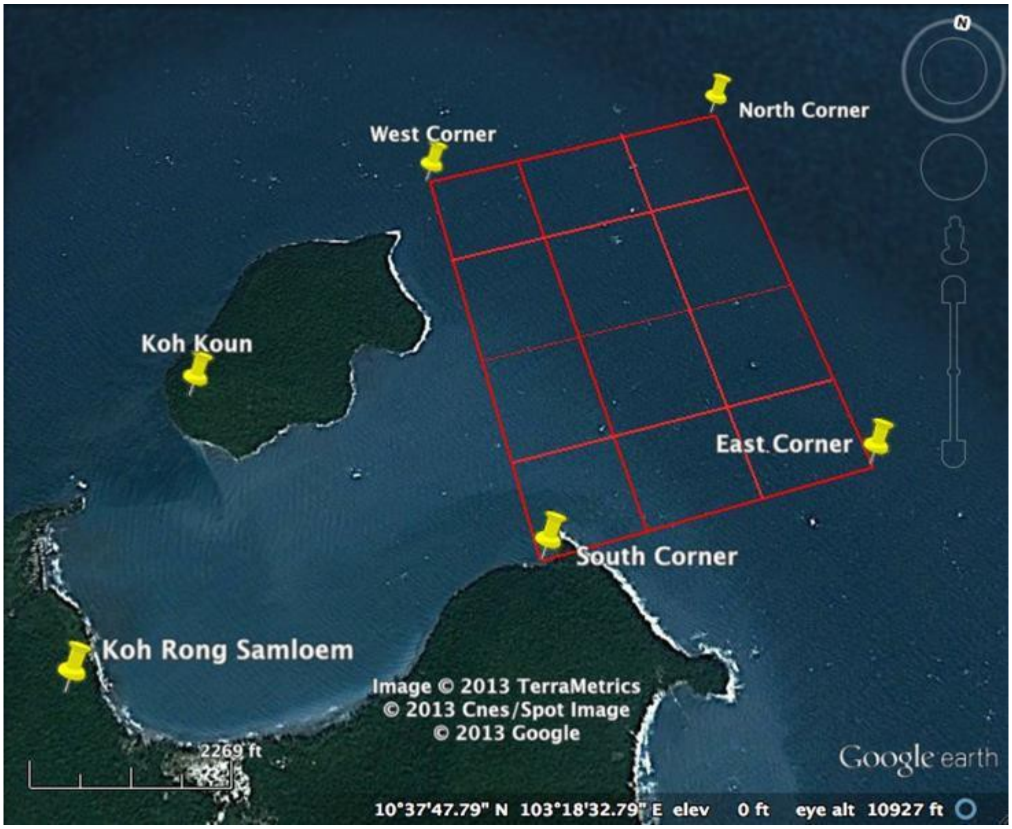

Figure 2. Map of the study area detailing the structure of the grid pattern used for surveying.

The population assessment was conducted through underwater visual transects conducted in the Corral study area. The starting point of each 500 transect is dependent upon a grid system whereby the entire seahorse area is divided evenly into 12 sections. Two GPS co-ordinates are chosen from one grid each day and surveyed. This means that each day they are randomly selected from a different grid, ensuring that each grid is selected at least once in the month before we start repeating grids. In order to have 30 sites surveyed per month inevitably some grids end up repeating more than others due to the fact there are only 12 grids. Directions are also randomised for the survey by choosing from eight options (i.e. N, NE, E, SE, S, SW, W, NW) for each survey point and making sure these are evenly distributed in any one grid. Choosing random directions from random grids ensures the same direction is not favored in any particular grid.

Each survey involves laying two parallel 50m lines, spaced 5m apart, in a previously determined direction. On each transect line, two divers swim on either side of the line surveying the area 2.5m adjacent. The total area surveyed for each transect is $500m^2$.

Seahorse species, demographic class, trunk, head and snout length, and associated habitat were recorded for each seahorse specimen within the transect area. Juveniles were defined as any seahorse with a trunk length under 2cm, and were not distinguished by sex due to difficulties in differentiating small individuals without fully developed sexual and species characteristics. Counts of pencil urchins, soft corals, anemones, sea grass, hydrozoans, sea pens and manmade structures were also recorded.

Data was recorded in Microsoft excel. SPSS PASW statistics was used to normalize seahorse sightings relative to dive effort (number of dives $month^{-1}$). Data was processed in SPSS, using ANOVA to test for significant relationships between demographic composition and sightings per month. Holdfast selection was analysed using ANOVA in SPSS.

Results

Population and demographic composition

There were no statistically significant differences found in demographic class between the months of July, August and September. Furthermore, the total number of seahorse sightings did not differ significantly between the months. July was determined to have had the most sightings at 0.055 sightings per dive^{-1} (Figure 3), which was more than twice as many as were sighted in September, at 0.025 dive^{-1}. Juveniles were the dominant demographic in July and August (0.022 and 0.025 sightings respectively), reducing significantly in September to 0.01 sightings. Non-pregnant males were not observed in any of the three months.

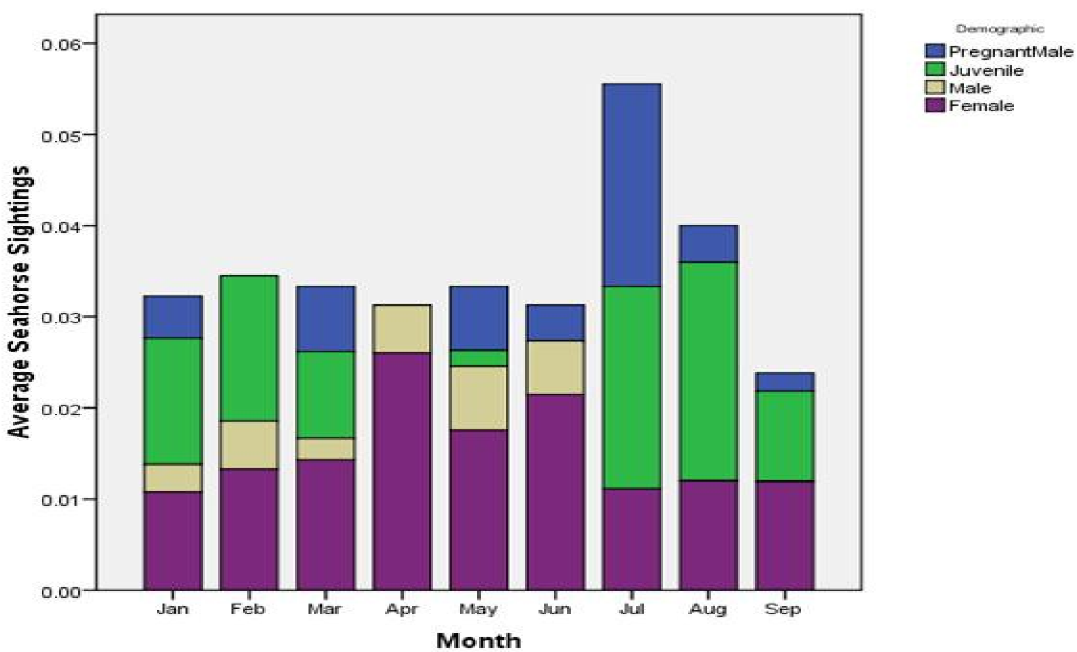

Figure 3. Average number of seahorses observed per survey month, corrected for number of dives per month (dive effort) (n=118, dives=270)

Holdfast and habitat selection

All sexual demographic categories (pregnant male, male, juvenile, female) were found on pencil urchins significantly more than any other holdfast. In particular, it was determined that females attached themselves to pencil urchins significantly more than any other holdfast. Females were the only sexual demographic to be found on all holdfasts, and were the only demographic to be found free swimming (Figure 4).

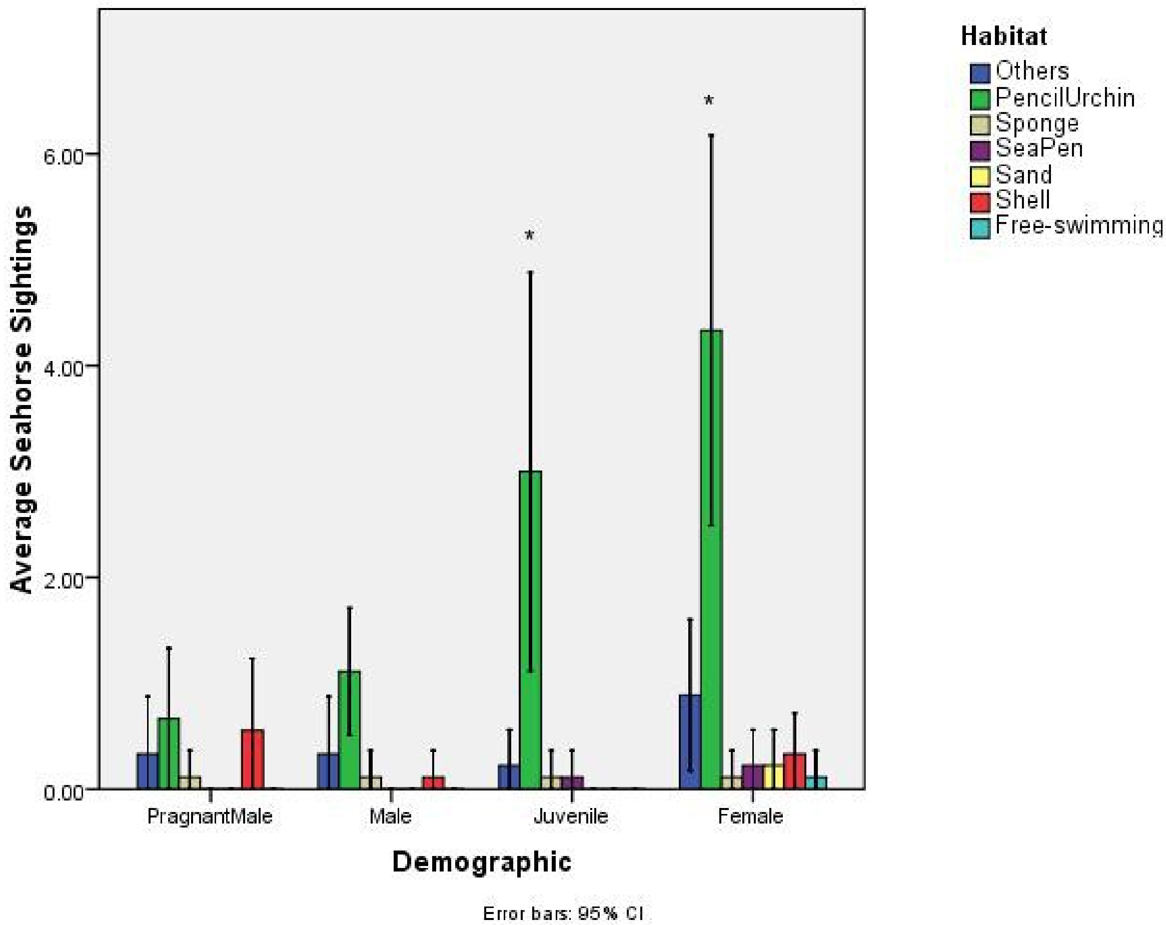

Figure 4. Holdfast preference for each seahorse demographic cohort from September 2012 to September 2013.

Figure 5 demonstrates that pencil urchins were found to be selected by seahorses as a holdfast significantly more than any other habitat. Pencil urchins were four times more common than the next habitat category (other: artificial objects) selected by seahorses sighted.

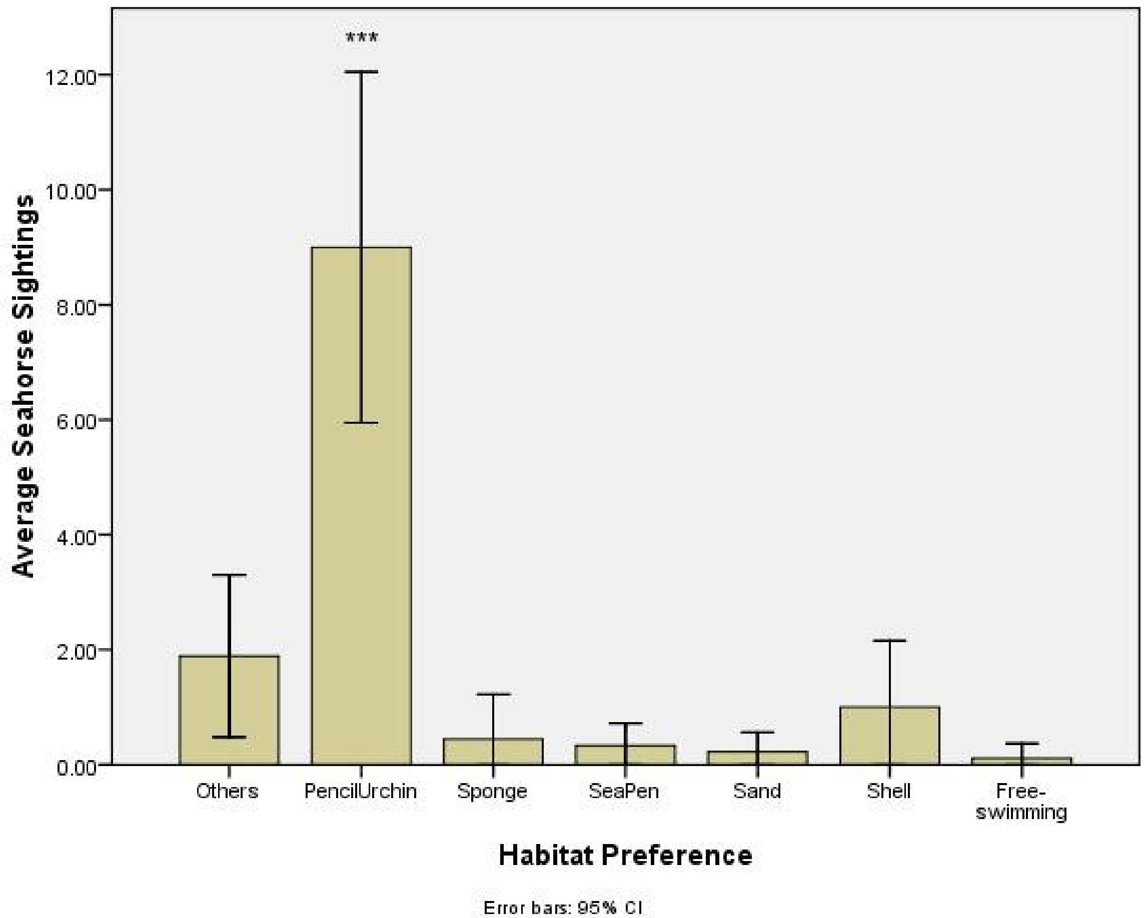

Figure 5. Average number of seahorses found on different holdfasts.

Discussion

Seahorses (*Hippocampus* spp.) are a particularly charismatic, mystical and unique genus. Similar to the tiger and giant panda for terrestrial conversation, seahorses are useful as a flagship species for the conservation of marine environments (Shokri *et al.* 2008). Over the past two decades, marked efforts by a number of organisations and grass-roots operations have focused on persistent, continuous surveys of seahorse populations (www.thesehorsetrust.org). Long-term monitoring of a specific population via unrelenting surveying provides valuable insight into temporal oscillations within that populations' abundance, demographic composition and to monitor the effectiveness of any conservative schemes that may be in place (Barrows *et al.* 2009). Marine Conservation Cambodia (MCC) has been monitoring seahorse populations in a single study area, 'The Corral' over the past fourteen months. The current study is the 2013 third quarterly assessment of the population, compiling data collected during July, August and September.

Almost exclusively, the current *Hippocampus* composition within The Corral is dominated by a single species, *Hippocampus spinosissimus.* Despite high species diversity at the Corral in 2007, extensive trawling activity destroyed the habitat and populations in the area. Various other species are beginning to return to the area, with recent positive identifications of *H. comes, H. kuda* and *H. trimiculatus,* however these have mostly been seen outside of surveys and in very low abundance (Emma Robertson, pers. obs.). As such, the current study focuses on *H. spinosissimus.* Accurate knowledge of a particular species' life-history is important for the planning and implementation of schemes to support population regeneration and long-term persistence in a region (Foster and Vincent 2004). Future papers will, however, examine fluctuations in species diversity and composition on The Corral.

Previous literature cites *H. spinosissimus* as a species inhabiting coral and soft bottom (sand) habitats, normally in depths of less than 30 meters (Foster and Vincent 2004). As the Corral is predominantly sloping sand flats with an average depth of 20 meters between 10-11° latitude, it is a predicted habitat for *H. spinosissimus.* Various life-history stages and strategies may render *H. spinosissimus* less of a specialist than other *Hippocampus* species; they have a yearly breeding season with several pregnancies, a relatively short gestation period of 12-14 days, a planktonic juvenile stage, and have been observed to utilize a relatively diverse selection of holdfasts (Truong and Nga 1995; Nguyen and Do 1996; P. Ferber pers. obs.; Cai et al. 1984; S. Morgan unpubl. data). All of these traits make *H. spinosissimus* more suited than other species to damaged and fragmented habitats, such as The Corral. Population recruitment rates are higher relative to other seahorses, with greater dispersal, rendering them better adapted to re-occupy damaged habitat.

Population and demographic composition

Due to a yearly breeding cycle and short gestation period, it is unlikely that *H. spinosissimus'* reproductive strategy would have any significant effect on the natural temporal demographic composition of the population. This is consistent with our findings for this quarter, as there was no significant difference within demographic composition between the three months (figure 3). This is one aspect of *H. spinosissimus'* life-history which renders it more suited to an exploited and damaged habitat. The constant breeding cycle, thus persistent population recruitment, leaves no single time when the population is unproductive. However, the population is still capable of dropping below a viable breeding density, whereby natural mortality (particularly coupled with anthropogenic exploitation) exceeds natural population replenishment, leading to extirpation (Beschta and Ripple 2009). Interestingly, throughout July, August and September, no non-pregnant males were observed; however the general population did not experience a significant change in abundance (figure 3). A possible explanation for the absence of non-pregnant males during this quarrter lies in intra-specific sex competition; the fitter, pregnant (thus ultimately successful) males have potentially out-competed and driven the less fit males out of the area (Garrick-Maidment, pers. Comm.), therefore leaving only pregnant males in the population. This could potentially offset a decline in the surveyed population (which is not observed), however; the short gestation period (12-14 days) and ontological period of of *H. spinosissimus* means the population could be maintained by developing juvenile individuals. However, by the same note, such a short gestation period should mean non-pregnant males are constantly observed; why, then, have no non-pregnant males been observed over a 3 month period, with no significant change in population abundance? Continued surveying and analysis is required to identify any significant population-demographical patterns.

The current study observed an apparent dip in total sightings in September; future papers will examine the final quarter of 2013 (October, November and December) and the entire 2013 dataset. This will provide insight to any yearly population oscillation and demographic trends. However, preliminary explanations for a decline in population could be attributed to individuals migrating out of the study area during the far windier months of September, October, November and December, or in response to much greater tidal fluctuations during this time of year. Such migratory behaviour has indeed been observed in *H. guttulatus* and *H. hippocampus*) in British Atlantic waters (Garrick-Maidment *et al.* 2014). Although the mechanisms triggering migratory movements are not yet fully understood, temperature, photoperiod and lunar cycling all likely play a role in seasonal habitat switching (Garrick-Maidment 2013). The on-going study on the local seahorse population at Studland Bay, UK, reveals a significant correlation between water temperature and timing of first seahorse sightings; seahorses are rarely seen close to shore in shallow depths before the water temperature reaches 9° Celsius (Garrick-Maidment 2013). Moreover, seahorse depth has been correlated with time of year, with significantly more seahorse sightings occurring at shallower depths between June-October (<20 meters), and occurring far deeper during the winter (>40 meters) (Garrick-Maidment 2014). This behaviour exhibited by this particular population occurs in response to threatening storms beginning around October; the population migrates to deeper waters to avoid the turbulent and likely fatal shallow waters of the bay during the stormy autumn-spring. It is therefore possible that the population in the current study (Cambodia) has similar adaptations to monsoon season (; continued surveying, analysis and interpretation will reveal any seasonal patterns.

Habitat and habitat selection

It must be remembered, that the study site in the current paper is a damaged and fragmented habitat. The Corral is almost exclusively non-vegetated sand flat, with bottom composition changing only in shell cover. Sponges, sea pens, hydrozoans and soft coral are observed in low densities, rendering The Corral an open water habitat, with sparse distribution of benthic invertebrates and flora. Little is known about the particulars of *H. spinosissimus* habitat preference and holdfast selection, however other *Hippocampus* species, *H. capensis* and *H. hippocampus,* have been found to select open habitats and different species select a plethora of different holdfasts (Bell *et al.* 2003; Foster and Vincent 2004; J. Curtis and A. Vincent, unpubl. data). All *Hippocampus* species possess a prehensile tail, used to grasp holdfasts (Foster and Vincent 2004); however specimens of certain species have been observed far from any object, settled in depressions within the substratum (A. Vincent, pers. obs.). Different holdfasts might be selected for a variety of reasons, from predation avoidance due to camouflaging, maximizing feeding potential via water flow to simple object availability (Bell and Westoby 1986; Bell *et al.* 2003; Choo and Liew 2003). However, the vast majority of holdfasts selected in previous literature are sedentary; seahorses in the current study have been found to significantly select mobile pencil urchins as their holdfast (figure 5).

As a genus, *Hippocampus* has generally been observed to be territorial and relatively sedentary. This has resulted in monogamous pair-bonding within a single breeding cycle in the majority of studied populations, with the male only accepting eggs from a single female in a breeding cycle (Foster and Vincent 2004). Monogamy serves to increase reproductive success of fishes found in relatively low densities, that have low mobility, and that depend on camouflage as a defence against predation (Barlow 1988; Vincent and Sadler 1995). However, a monogamous breeding strategy is associated with one sex being territorial (and therefore sedentary), establishing a breeding ground and home range in which to mate and spawn. However, the seahorse population in the current study is often found on mobile holdfasts. Interestingly, there is no relative shortage of sedentary holdfasts available on The Corral; indeed seahorse individuals are found on sponge, sea pens, shells and other holdfasts (figure 5).

Given the suspected relatively low density of the current study population, adaptation to a moving holdfast might be selected for by countering the effect of a low chance of interaction with another individual (if attached to a sedentary holdfast). In a sparsely populated area, therefore, if both sexes select a mobile holdfast, reproductive potential is maximized by increasing the chance of encountering a mate. Interestingly, the only specimens found to be 'free-swimming' (not attached to anything) were females (figure 5). It is believed that male seahorses instigate mating and attract females via pheromone production (Vincent, n.d., Garrick-Maidment 2014). As such, a free-swimming female could be searching for a male which is releasing mating pheromones in the vicinity. However, we would expect to see a far greater number of free-swimming females if this was indeed a mating mechanism; yet again, continued research will shed more light on this. One method of determining holdfast switching rate, (thus inferences on territoriality and mating strategies), would be to use a tagging scheme to pair seahorse individuals with their associated holdfast. This would show how often seahorses in our study population release their holdfast, and risk the strong currents to find a new one. Although beyond the scope of this current quarterly assessment paper, future yearly assessments will examine holdfast selection relative to demographic cohort. This will increase our understanding of mating strategies and territoriality of The Corral seahorse population.

In a genus as diverse as *Hippocampus,* it is likely that populations are capable of adapting to their local habitat, provided environmental factors such as salinity, temperature fluctuations, depth and habitat-associated pathogens remain within the tolerance levels of that particular species. Indeed, such local adaptation has been shown in UK *H. hippocampus* and *H. guttalulatus* species in response to sheltered vs. non-sheltered populations to fluctuating weather conditions (Garrrick-Maidment 2013). In these studies, populations of seahorses living in non-sheltered areas of Studland Bay have adapted a migration behaviour to avoid stormy, shallow water. The population inhabiting Poole harbour, directly next to Studland bay, have no need to migrate during the winter as they are sheltered from the storms by their habitat (the harbour).

As such, a population of a species such as *H. spinosissimus* with a relatively general life-history strategy could be expected to adapt to and persist in a disturbed habitat such as The Corral. We are unable to compare the relative health of the population in the current study with other populations due to insufficient robust data regarding the particular densities of *H. spinosissimus* in other habitats. However, previous literature indicates that seahorses in general have patchy distribution and low densities (Foster and Vincent 2004); given the fragmented habitat and continued fishing pressure on The Corral, it is likely the population in the current study is sparse and relatively scarce. Furthermore, our current inability to assess the density of our study population due to individual recognition (thus re-count) limits our behavioural assessment potential; the potential implementation of individual tagging schemes will make population density assessment possible, giving insight into the mechanisms behind mobile holdfast selection.

The current quarterly assessment only compiles data from July, August and September 2013, during which time twenty eight seahorses were observed in eighty five survey dives. Although this is an observational indicator as to how sparse and non-abundant our study population is, this sample size is far too small to provide any accurate information regarding population dynamics oscillations and holdfast preference. To date we have two-hundred and six seahorse sightings over four hundred and twenty three dives in total, and plan on completing at least sixty more surveys in 2013. An examination of our complete dataset will enable a variety of analyses, including comparisons between protected vs. unprotected GPS plots, variation between seasons, and relative holdfast preference between the different demographic cohorts (male, female, pregnant male and juvenile). Long-term studies of this nature are vital for the understanding of populations, thus for the planning of effective conservation.

Conclusion

The current paper continues the on-going research conducted by MCC at Koh Rong Samleom, Cambodia; aiming to monitor, assess and analyse the seahorse population of our single study site. In particular, the study aims to assess changes in the seahorse population over time and the way the population responds to changes in habitat conditions. With each quarter of data collected and analysed, it is hoped that the expanding dataset can explain the changes within the seahorse population in terms of abundance, species diversity, demography, and contribute to hypotheses on breeding and mating patterns.

In this third quarterly report for 2013 (July, August and September), twenty eight seahorses were observed in eighty five survey dives. Data from this quarter continued to support previous hypotheses and observations. *H. spinosissimus* significantly select the Pencil Urchin as their preferred holdfast. Mechanisms behind this behaviour remain uncertain, however this could possibly be an adaptation to a sparse population. Traditionally, seahorses have been observed to be territorial and select sedentary holdfasts; perhaps the population on The Corral can not afford to be territorial due to the highly fragmented, poor quality of the habitat, instead selecting mobile holdfasts which increase the chances of inter-individual interaction, thus increasing the chance of finding a mate.

Furthermore, the current study shows that the life-history traits of *H. spinosissimus,* such as short gestation period, yearly breeding cycle with numerous pregnancies and a diverse holdfast selection, renders it the best suited species to adapt to a fragmented habitat, such as The Corral. This explains the relative absence of other seahorse species which had once been observed in the area, however no longer are.

The fact that no non-pregnant males were observed during this quarter raises a number of interesting questions regarding inter-specific competition and breeding habits. Further study is needed in order to determine actual seasonal oscillations in population demographics before any targeted speculations can be made to attempt to explain this. Indeed, previous reports shows no significant fluctuation in population dynamics throughout the year; why, if *H. spinosissimus* has a yearly breeding cycle, do we begin to observe a change in demographic composition during this quarter?

The datasets collected over a single quarter are often quite small. Indeed, this report is based on 28 sightings over three months, making it difficult to draw definitive conclusions. This is why it is imperative to have continuous surveying of any single population. It will be the analysis of an entire year of data, and then comparison between years, that will provide solid, reliable data, allowing for temporal analyses revealing any breeding patterns, local behavioural adaptations and any yearly oscillations in population demographics. This project, Marine Conservation Cambodia, is part of a developing global co-operation between a number of different seahorse research projects. Other surveying projects are being carried out in the United Kingdom, Malta and Malaysia. By using a standardised database and persistent surveying, our knowledge of this splendidly unique creature's ecology, status and conservation methods can continue to increase. This is now more important than ever, due to increasing economic demand, particularly from the TCM trade. With knowledge, we can attempt to protect seahorses and their diverse associated habitats world-wide, and by extension, contribute towards global marine conservation efforts.

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