Summary of Seahorse Population and Distribution

Koh Rong Samloem
Preah Sihanouk, Cambodia

Report of Seahorse Demographics and Habitats

Marine Conservation Cambodia
2013 Yearly Report

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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 analyses the entire 2013 observation set, which contains a total of 158 seahorse sightings over 356 survey dives. 2 of these sightings were *H. kellogi,* 39 were juveniles and the remaining 109 were adult *H. spinosissimus* (26 pregnant males, 20 males and 73 females). 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 provides the potential for temporal comparisons of data, providing a comprehensive understanding of this local seahorse population in terms of; their behaviour, demographic composition, potential migratory patterns, habitat and indications as to their breeding strategy.

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, have 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 [NUMBER] 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.

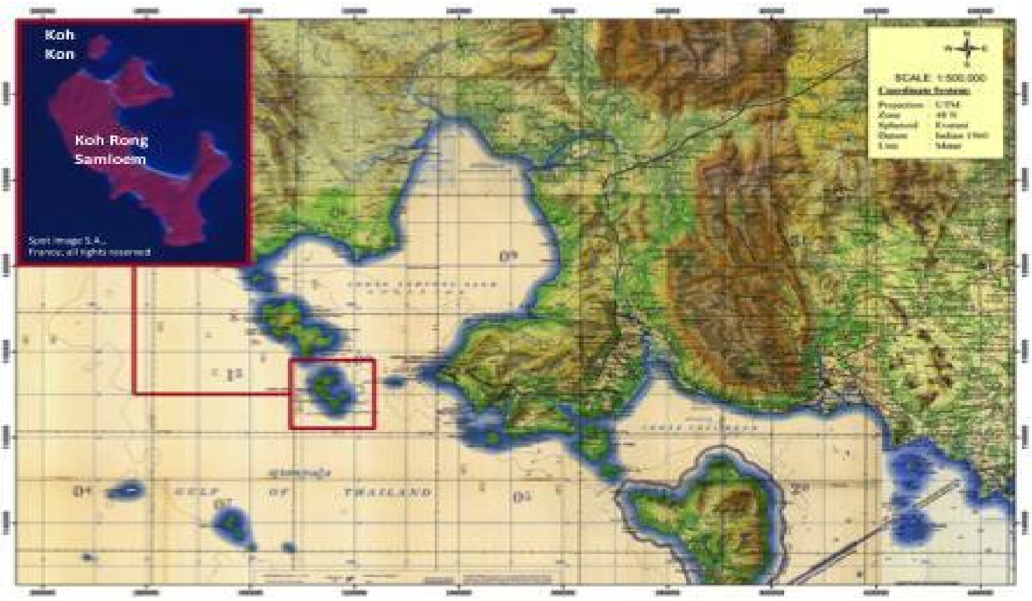

Figure 1. Map of Southern Cambodia and islands with magnification of Koh Rong Samloem

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 favour *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.

METHODS AND MATERIALS

Study area

Koh Rong Samloem is an island 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.

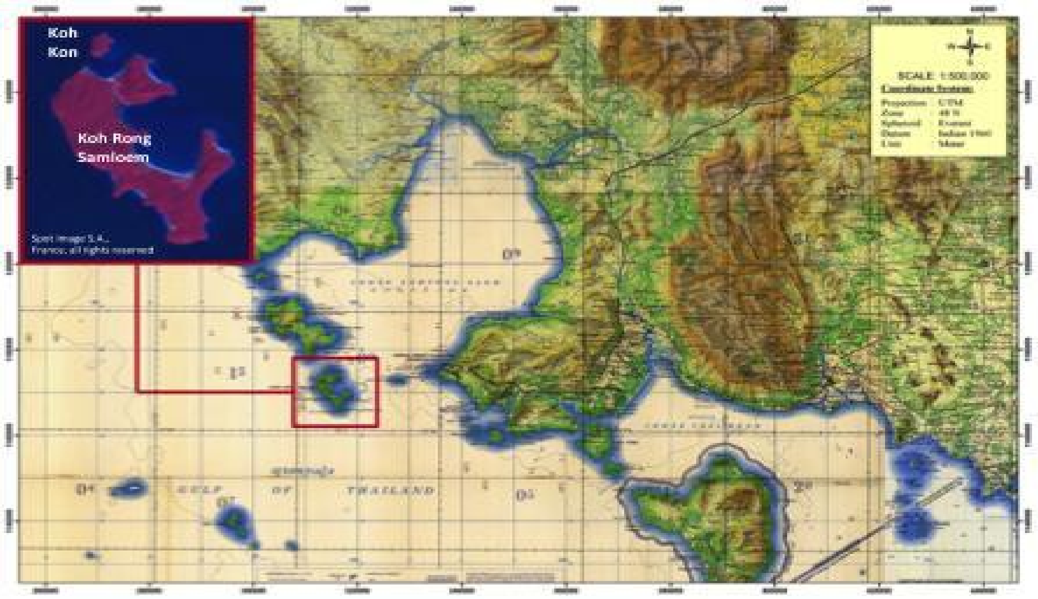

Figure 1. Map of Southern Cambodia and islands with magnification of Koh Rong Samloem

The Corral is a rectangular area, located to the east of Koh Koun (figure 1 above, figure 2 below). The co-ordinates of the north, south, east and west corners are as follows (I) North: 10°38'41.84N, 103°18'55.72E, (II) South: 10°37'51.27N, 103°19'20.31E, (III) East: 10°37'29.20N, 103°18'40.42E, (IV) West: 10°38'22.14N 103°18'14.62E.

The area is dominated by sloping sand flats, with depths ranging between 5-20m. The area supports populations of bivalves, soft corals, hydrozoans and large numbers of pencil urchins (*Prionacidaris spp)*.

The habitat was observed to be in excellent condition in 2007, at which time there were a diverse number of seahorse species recorded on The Corral (6 species photo-identified; *Hippocampus spinosissimus*, *Hippocampus trimaculatus*, *Hippocampus kuda*, *Hippocampus comes*, *Hippocampus kelloggi and Hippocampus histrix*; *Hippocampus barbouri* is suspected but has not been photographed, P. Ferber pers. comm.).

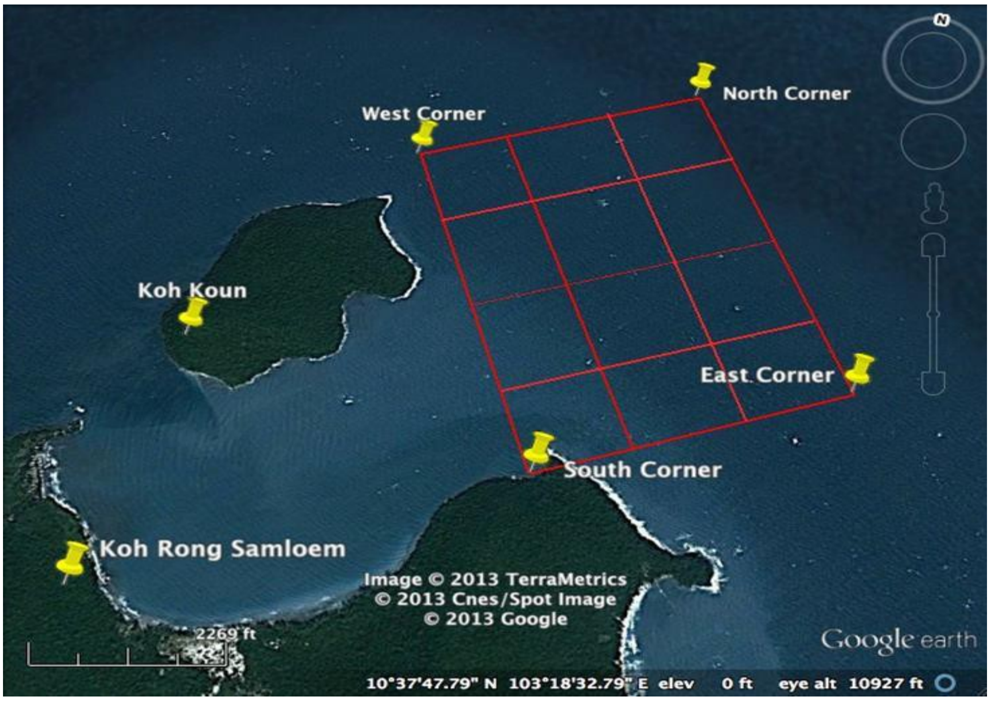

Figure 2. Map of the study area detailing the structure of the grid pattern used for surveying.

Recent damage from illegal trawling activity has greatly damaged the habitat, reducing the biodiversity and productivity of the ecosystem. Field observations from 2007 compared to results of surveys over the past three years show that seahorse species diversity has decreased to almost exclusively favour *H. spinosissimus.* Of the 251 specie-identified specimens recorded since August 2012, only 12 have not been *H. spinosissimus* (4 *H. trimaculatus*, 4 *H. kuda,* 2 *H. comes* and 2 *H. kelloggi*).

Legal protection of the habitat had 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. Protective measures are often ignored or circumvented; and thus frequent monitoring and increased patrols are necessary to prevent trawling activity in the area.

Unfortunately, MCC patrols have ceased, and anecdotal evidence suggests that trawling activity in the region has increased dramatically since 2011, with regular sightings of fishing boats trawling through the protected area. Regularly conducted population assessments provide frequent data, which is necessary for temporal comparisons to measure the recovery or decline of the seahorse population.

Population assessment

Site selection

The population assessment was achieved using underwater visual transects, which were conducted in the Corral study area. The starting point of each 500 metre^2 transect survey was dependent upon a grid system whereby the entire seahorse area is divided evenly into 12 sections. Each day, two GPS co-ordinates within the Corral were randomly selected and surveyed. This often becomes pseudo-random, as consideration is given to the experience of the survey team available, both in terms of survey experience and diving ability.
Directions are randomised for the survey by choosing from eight options (N, NE, E, SE, S, SW, W, NW) for each individual survey point, and ensuring these are evenly distributed throughout the month.

Survey methodology

Each survey team consists of five trained divers, four of whom survey and the fifth reels out and reels in one of the lines. Each survey begins with three of the divers establishing the transect area. This is achieved by planting two poles into the seabed five metres apart, from where two parallel 50 metre lines are reeled out, spaced 5 metres apart, in a previously determined direction. On each transect line, two divers swim on either side of the line surveying the area 2.5 metres adjacent. The total area surveyed for each transect is 500m^2.

Measurments

Seahorse species, trunk, head and snout length, associated habitat and demographic class (pregnant male, male, juvenile, female) were recorded for each seahorse specimen found. Measurments were taken to the nearest mm using straight lines (as per Harasti *et al.* 2012). Trunk length measured from the top of the coronet to the beginning of the tail. Head length measured from the eye to the back of the coronet, and snout size was measured from base of the snout under the eye to the snout tip.

Sex determination

Juveniles were defined as any seahorse with a trunk length under 2cm, and were not sexually distinguished due to difficulties in differentiating small individuals without fully developed morphological characteristics. Males were determined via the presence of a brood pouch or a smooth transition from body to tail. Females were identified using their characteristically sharp abdomen transition to the tail.

Counts of pencil urchins, soft corals, anemones, sea grass, hydrozoans, sea pens and man-made structures were also recorded during the surveys.

Data was recorded in Microsoft excel and Microsoft excel was used for data analyses. Datasets were tested for homogeneity of variance using standard error of the mean, and Student's t-test were undertaken to test for significance.

RESULTS

Population and demographic composition

Over the course of the year 2013, there were a total 158 seahorse sightings over 356 dives (Figure 3). Females were the most commonly seen cohort with 73 sightings. Juveniles were the second most abundant cohort with 39 sightings, followed by 26 pregnant male sightings. Non-pregnant males were seen 20 times over the entire year.

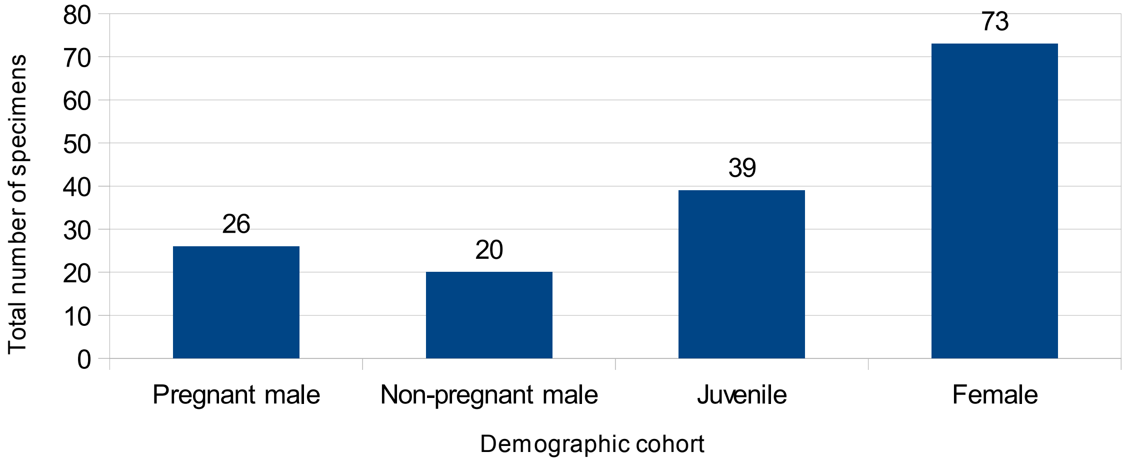

Figure 3. Graph representing the entire observation set in demographic cohorts (n=158, dives=356)

For any single dive in 2013, on average, 0.2 females were seen, 0.11 juveniles were seen, 0.07 pregnant males were seen and 0.06 non-pregnant males were observed (figure 4). Females were significantly the most abundant cohort (p=0.05, t=0.01 relative to juveniles). There were significantly more juveniles than non-pregnant males (p=0.05, t=0.03), however there was no significant difference between juvenile numbers and pregnant males (p=0.05, t=0.14). There was no significant difference between the numbers of pregnant and non-pregnant males (p=0.05, t=0.30). Even when both male cohorts were combined, there were still significantly more females than total males in the population throughout the year (p=0.05, t=0.01).

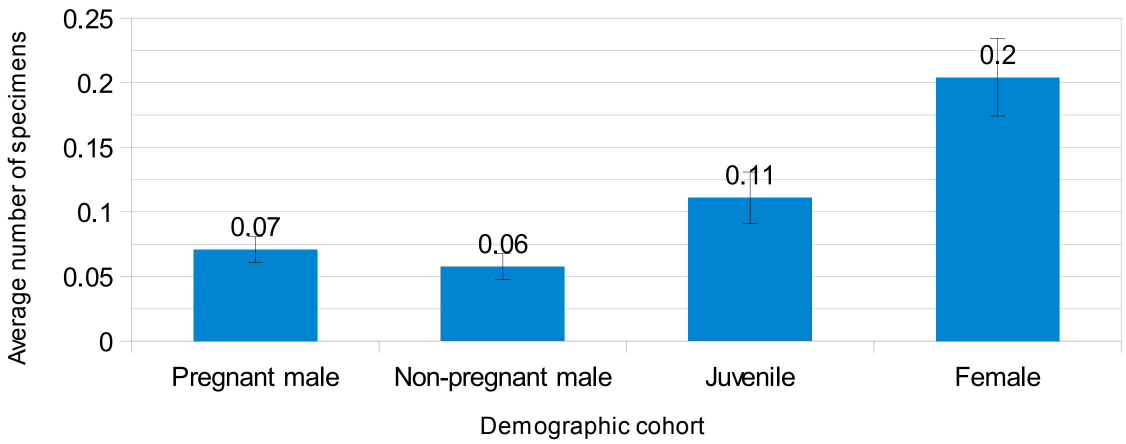

Figure 4. Graph to show the number of specimens found, on average, per dive during 2013 (n=158, dives=356).

As shown in figure 5 below, females were the most abundant cohort, comprising 46% of the oservation set. Juveniles composed 25% of the year's observations, pregnant males comprising 16% and non-pregnant males 13 %.

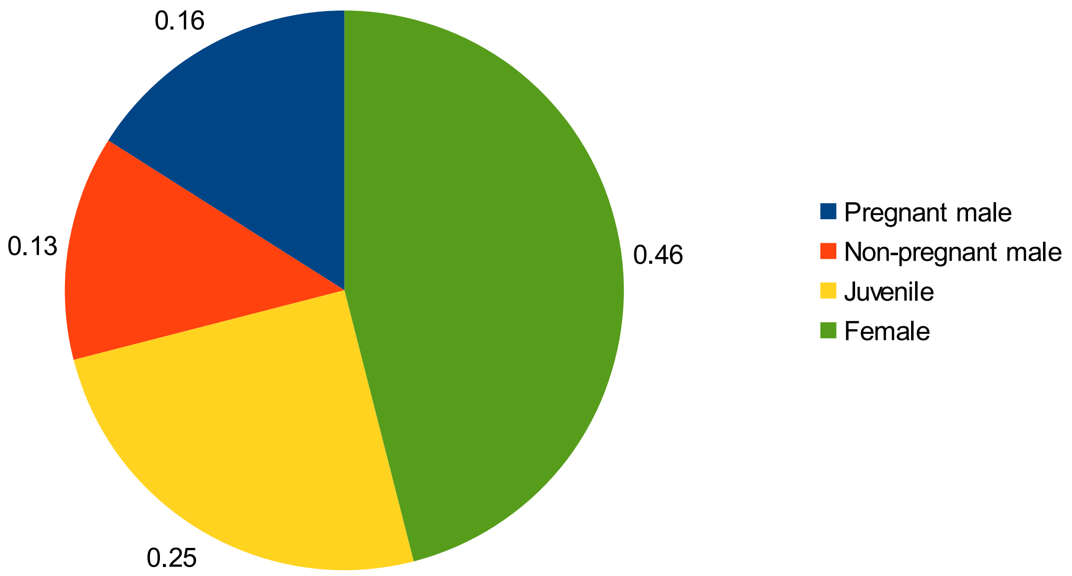

Figure 5. Demographic composition of the 2013 yearly observation set (n=158, dives=356).

Habitat and holdfast selection

Seahorses were most commonly found to be using pencil urchins as their holdfast, with an average of 0.29 seahorses found on pencil urchins per dive, which was significantly more than any other holdfast (p>0.05) (figure 6 below).

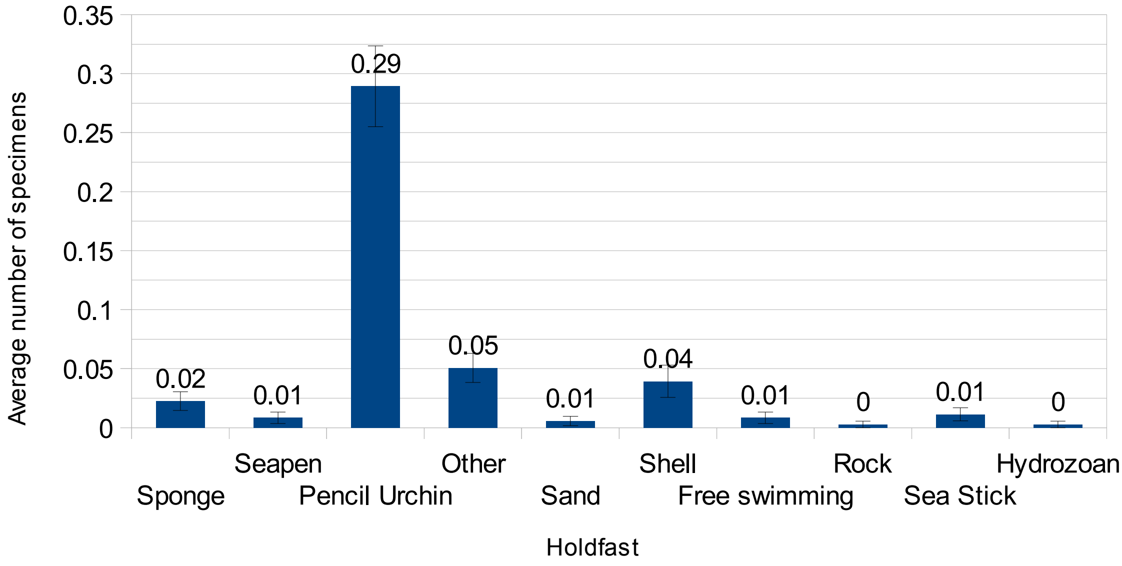

Figure 6. Average number of specimens found on various holdfasts per dive (n=158, dives=356).

Pencil urchins were the most frequently used holdfast for all demographic cohorts throughout 2013's observation set, however far more females and juveniles were found on them relative to both male cohorts. As a proportion of the entire observation set for 2013, 30% of individuals were females found on pencil urchins, followed by 23% being juveniles found on pencil urchins.

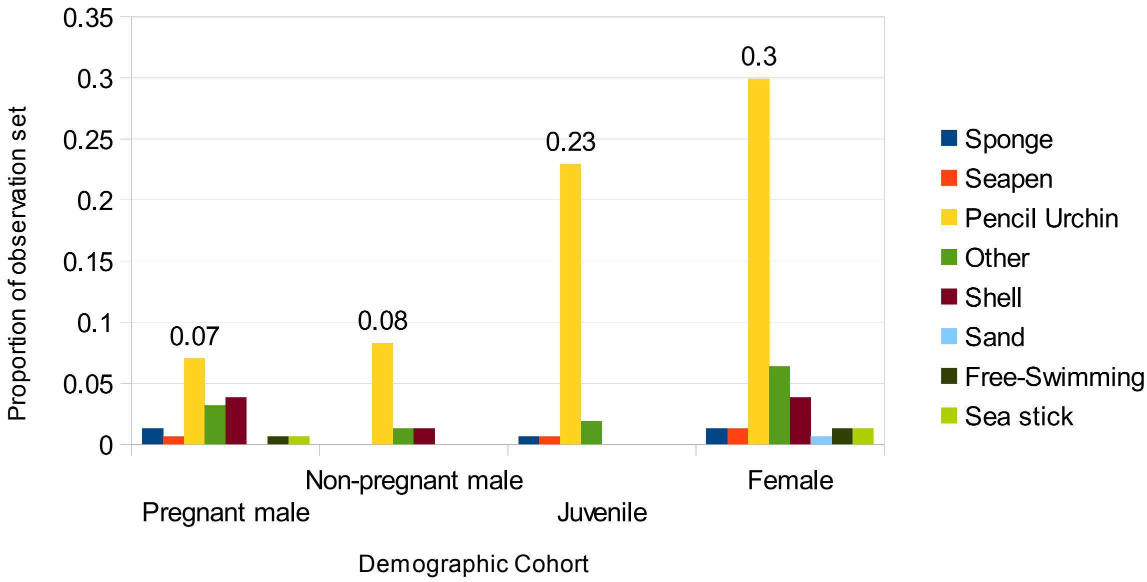

Figure 7. Proportional representation of holdfast selection by demographic cohort (n=158, dives=356).

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.theseahorsetrust.org). Long-term monitoring of a specific population via unrelenting surveying provides valuable insight into temporal oscillations within that population's 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 twenty months. The current study is the 2013 yearly assessment of the population, compiling data collected from 1st January to 31st December 2013.

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.

Species description and captive breeding

Previous literature cites *H. spinosissimus* as a species inhabiting coral and soft bottom (sand) habitats, normally in water less than 30 meters deep (Foster & Vincent 2004). As the Corral is predominantly sloping sand flats with an average depth of 20 metres 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 & Nga 1995; Nguyen & 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. With the current report's analysis of 158 specimens, it is possible to begin to understand the particular breeding strategies adopted by our local seahorse population.

Ex situ breeding trials using a single captive pair of *H. spinosissimus* by MCC showed the male pregnant every 10 days, yielding 3 broods in a single month (P. Ferber, pers. comm.). This is indicative of how rapidly the male is capable of recovering from pregnancy and giving birth - and that atleast in captivity over a single month, requires no interval between broods. Further ex situ breeding research is required to accurately identify sustainable breeding frequency of both sexes. Nonetheless, the females ability to produce and hydrate her eggs within the male's short 10 day gestation period is indicative of the high level of fecundity expressed by this species. It is likely that female *H. spinosissimus* is the sex with the shorter 'time out' period, as once the male's pregnency period had finished, her egg's were hydrated and ready to breed. Is it likely that gestation (male pregnancy period) is the phase of the breeding cycle which limits reproduction.

It is important to note, that captive conditions very rarely reflect natural conditions. It is likely that such an intense month of breeding is unnatural, as males would need to replenish energy reserves to ensure viable broods. Since seahorses in the current population have not been observed in pairs, it is likely that there is a search interval between pregnancies, during which time the male has an opportunity to recover from the previous pregnancy. The observed female egg production/hydration and male receptivity in captivity helps us understand why *H. spinosissimus* is, as a species, capable of persisting in an area as badly damaged as the Corral.

Operational Sex Ration (OSR): The ratio of females to males in a population, who are ready to mate at any given time (Emlin & Oring 1977). Any individual's breeding cycle is seperated into 'time in' and 'time out'; the time that particular individual is ready to breed, and not ready to breed. The further away from unity this ratio is, the greater the competition intensity within the more abundant sex for access to mates.

Potential Reproductive Rate (PRR): "The maximum number of independent offspring that parents can produce, per unit time" (Clutton-Brock & Vincent 1991). The shorter the 'time out' period of a sex, the higher the PRR.

Demographic composition and the Operational Sex Ratio (OSR)

According to operational sex theory, a skewed adult sex ratio (ASR) in a population will result in incresing competition within the more abundant sex for access to mating partners. Frequently in the animal kingdom, males are the competitive sex. However, there are cases of sex-role reversal in some species with a female-skewed ASR, resulting in females competining with one another for access to males (i.e. Simmons & Bailey 1990; Kvarnemo et al. 2007). OSR also predicts that the sex with the least amount of parental investment should be the most abundant sex in the population (Kvarnemo & Ahnesjo 1996).

It is difficult to empirically measure and compare parental investment. Nonethless, in seahorses, male parental care is substantial, as the brood develops in his brood pouch (Naud et al. 2008), and female parental care is minimal, as she supplies eggs for fertilization. *H. spinosissimus* does not have any post-natal parental care (Cai *et al.* 1984), and as such, male contribution to offspring development is more than that of the female seahorse. The female-biased OSR in the current study suggests that females are the sex competing for access to mating partners (Kvarnemo & Ahnesjo 1996).

The majority of studies examining *Hippocampus* mating strategy and sex-roles have concluded that conventional sex-roles exist for the majority of this genus (in that males are the sex competing for access to mates, i.e. Vincent 1994; Masonjones & Lewis 2000). Nonetheless, felame-baised populations, such as the current study, have been previously reported (Western Australian seahorse *H. subelongatus,* Kvarnemo et al. 2007). Females acting as the competitive sex in the current study could support previous hypotheses regarding holdfast selection.

Habitat and holdfast 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 have been found to select open habitats and a variety 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). 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). Whereas the vast majority of holdfasts selected in previous literature are sedentary; seahorses of all demographic cohorts in the current study have been found to preferentially select mobile pencil urchins as their holdfast (figure 6 and 7).

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. 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 various other holdfasts (figure 6).

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 7). 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. Females had the most diverse selection of holdfasts, and non-pregnant males were found only on pencil urchins, shells and 'other'. Juvenile selection on the moving holdfasts somewhat detracts from the hypothesis of mobile holdfast selection simply as mating strategy. Other mechanisms encouraging mobile holdfast selection could include dispersal, however better understanding of pencil urchin behaviour and how the seahorses interact with them is needed. In order to achieve this, a tagging scheme for individual recognition is imperative. Using this, information regarding holdfast fidelity, switching rate, and movement. could be collected.

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.

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.

The current report examines the 2013 dataset, which consists of 158 specimens found over 356 dives throughout the year. Data from this year agreed with previous hypotheses and observations. *H. spinosissimus* significantly select the Pencil Urchin as their preferred holdfast. Mechanisms behind this behaviour remain uncertain, however we see from this report that all demographic cohorts preferentially choose pencil urchins. This could possibly be related to a mating strategy to counter a sparse population, or be related to dispersal, migration or even feeding. 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 female-biased adult sex ratio implies that females are the sex competing for access to mates, which is different to what has generally been recorded for this genus. A lack of a tagging scheme prevents us from determining the abundance of the population, however with this data far better conclusions regarding behavioural mechanisms could be drawn. Nonetheless, the persistent work being carrried out by MC is beginning to show patterns and results, which is helping to explain the life-history of our particular study population.

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