# Seahorse surveys and possible habitat adaptions of *H.spinosissimus* in Cambodia

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## Introduction

Seahorses (family *Syngnathidae,* genus *Hippocampus*) are a highly appropriate study species for marine conservation for a number of reasons. Firstly, they are a 'flagship' species; charismatic, cryptic creatures capable of attracting public attention and funding (**Caro and O'Doherty 1999; Garrick-Maidment *et al.* 2010; Shokri *et al.* 2008**). Furthermore, sygnathid density has been shown to be indicative of non-sygnathid species diversity in an area (**Shokri *et al.* 2008**). As such, by protecting habitat containing seahorses, many other marine species will also be protected.

Cambodian oceans house a plethora of rare, unique and endangered marine species, including dolphins, dugongs, sea turtles, sharks and a wide variety of seahorses (**Touch 1995**). This diversity is persistently threatened by unsustainable fishing techniques and increasing anthropogenic pressure.

The seahorses in Cambodia exhibit untypical behaviour for the species which could be as a result of adaptions by the species to human interference caused by overfishing and habitat destruction.

In a collaborative move Marine Conservation Cambodia (MCC), The Seahorse Trust and Save Our Seahorses has been conducting a series of long-term, continual surveys of seahorse populations in the Koh Rong archipelago in Cambodia since 2008 and Kep Province in Cambodia from 2014. These efforts attempt to understand more about and conserve the seahorses and protect their associated marine habitat, whilst also ensuring the catches of the local fishermen who depend on the marine environment for their livelihood.

Cambodia has a number of seahorse species and the full extent and numbers of the species is little understood, however the ongoing research and conservation work by the authors is contributing to the overall knowledge of habitat preference, distribution, specie types and behaviour. Ongoing study has caused quite a number of new theories to be developed about the seahorse's behaviour and ecology and how man's influence on their habitat might change their overall behaviour, change the dynamics of the populations and change how many species can survive after catastrophic activities such as over fishing and habitat destruction; only long term, continuous research will provide full and indepth answers to these theories.

To date, 48 species of seahorse have been identified worldwide (**Vincent *et al.* 2011**), however it is feasible that this number is much greater and species have gone extinct in the last 30 years as the ever-increasing demand for seahorses to be used in the Traditional Medicine Trade (TMT) and Curio Trade (CT) gathers pace. Work by Save Our Seahorses (**Kealan Doyle 2012 pers comms**) shows a conservative figure of 150 million seahorses used per annum for the TMT, as opposed to the official IUCN TRAFFIC report figure of up to 65 million (**TRAFFIC Report 1996 Amanda Vincent**) and a strong possibility that all seahorse species could be extinct in the next 20 to 30 years (**Kealan Doyle 2012 pers comms**). The Save Our Seahorse figure is probably more indicative of actual trade figures as they acquired access to areas, official surveys probably could not have gone into.

## The study site

This is the first site to be studied in this project and in 2014 a second non disturbed site was identified in Kep province and seahorse studies have been set up there. The second site is undisturbed from fishing and other activities and has seagrass and a variety of other habitats in it and the variety of seahorses is more as would be expected from this type of area. During 2015 indepth research will start in Kep province and a long term continuous study will be conducted. Due to political reasons it might not be possible to continue at the original site on the Corral, so knowledge and data gathered during the time of the project will be used to inform the new study and it is hoped to return to the Corral site in the future to continue with seahorse studies

Surveying for seahorses in Cambodia was initiated in Koh Rong and Koh Rohl Islands (**Map 1**) in 2008 by Marine Conservation Cambodia (http://marineconservationcambodia.org/); an organisation that gives volunteers an opportunity to assist in and contribute to marine surveys and record and analyse sightings into a useful database to help understand about the behaviour and ecology of seahorses.

The Seahorse Trust and Save Our Seahorses partnered with MCC and the seahorse research initially in 2010 and fully after a visit to the site in 2012, where between them all they put together an overall plan for the study using the volunteers to collect data and study the seahorses in the field.

The initial study site was off Koh Rohl Samloem Island in an area known as 'the Corral' (**Map 2**) which was in easy reach of the researchers and had been studied and observed by Paul Ferber (**MCC Founder and Director**) prior to a catastrophic, illegal fishing event that left the site destroyed and the dynamics of the seahorse population in complete disarray.

This survey site once supported an exceptional array of seahorse species, with six different species being photo identified (*H. comes, H. histrix, H. kelloggi, H. kuda, H. spinosissimus* and *H. trimaculatus* **P. Ferber pers. obs.**), however the intense illegal trawl-fishing began in 2007 which decimated the populations and associated habitat. This has now left a decimated population which is dominated by *H. spinosissimus* which as will be seen in this short communication can adapt better to this type of habitat.

Many species inhabit a diverse range of habitats (**Garrick-Maidment *et al.* 2010**) and exhibit significant variations in their life-history traits, with some specialist species, such as *H.comes* which is known to be nocturnal (**H.Koldeway pers comms 1994**) and is highly selective as to their habitat, holdfast, mating partner and as a result have infrequent breeding cycles, thus have relatively low population productivity and recruitment rates (**Foster and Vincent 2004**).

Other species, such as *H. spinosissimus,* have more general parameters concerning holdfast selection and breeding partners, and have far more and regular frequent breeding cycles; they also have higher rates of population recruitment and give the appearance of being more robust in their ecology and response to changes in environment. Indeed, *H. spinosissimus* has been shown to utilise a number of different holdfasts, and has an all year round breeding cycle with numerous pregnancies (approximately 1 a month) and a comparatively short gestation period of 12-14 days (**Nguyen and Do 1996**). As such, the relatively generalist life-history of *H. spinosissimus* renders it better adapted to persist in fragmented habitats with lower population densities; areas such as MCC's study site 'the Corral'.

Hedgehog Seahorse
*H. spinosissimus*
**Photo 1 and 2**
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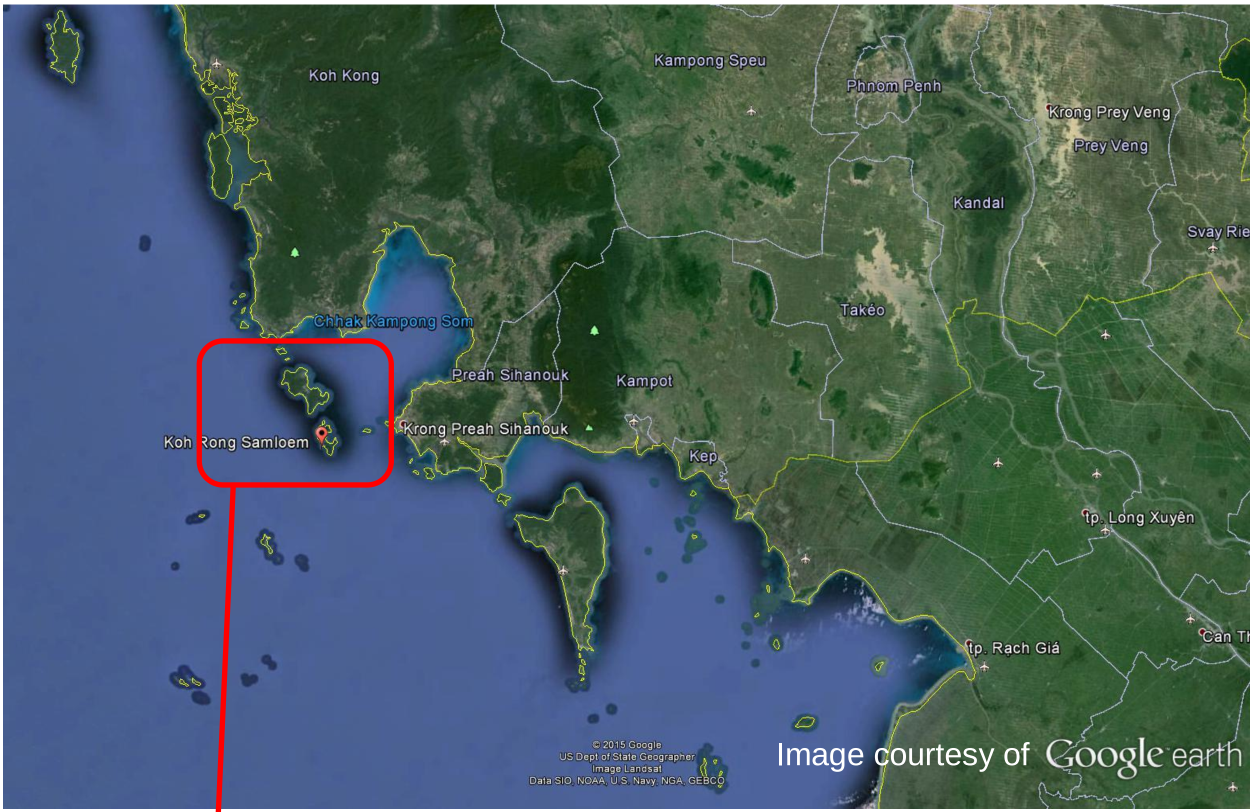
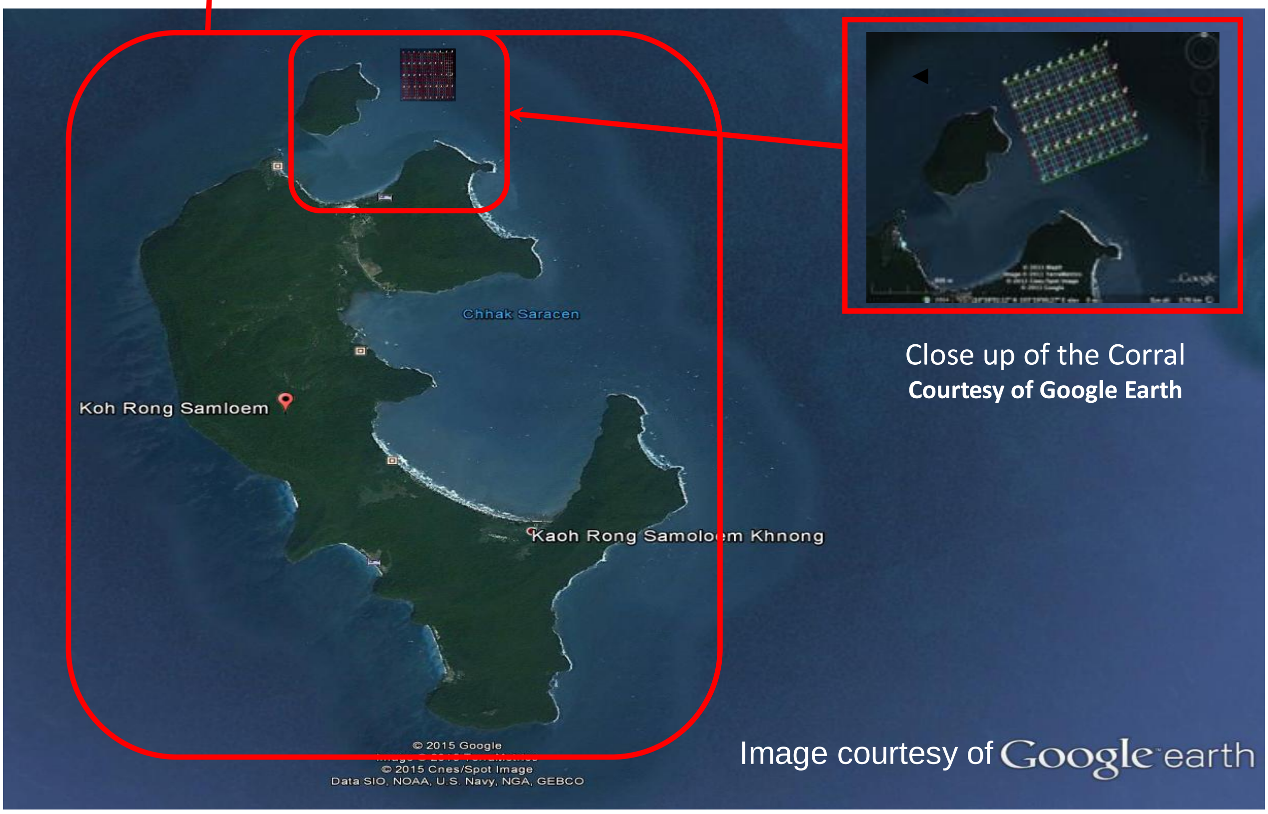
The purpose of the study is to have a greater understanding of the seahorses and their ecology in Cambodian waters and for the long term information and data collected to lend itself to setting up and monitoring conservation zones. It is also to help serve as a baseline to be built upon for long term research of the seahorse species in Cambodian waters.




Cambodia showing island location

**Map 1**

**Courtesy of Google Earth**




Koh Rong Samloem Island (inset, the Corral)

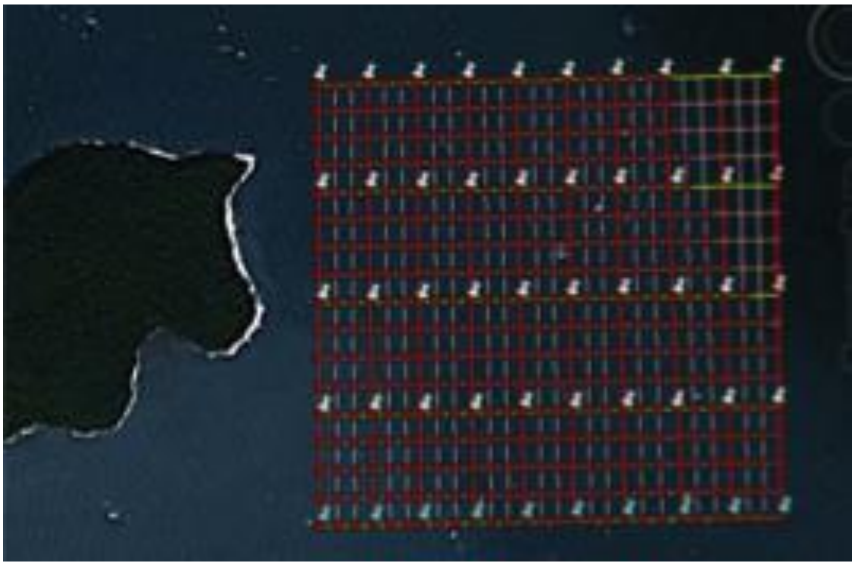
**Map 2**

**Courtesy of Google Earth**

## Method

Research of the seahorses and habitat in the Corral consists of multiple daily (weather permitting) underwater diver transect surveys (**Map 3**) conducted by MCC and its volunteers. This site lies 28 kilometres off the southern coast of Sihanoukville, Kampong Som province, near the islands of Koh Rong Samloem and Koh Koun which easily services the divers for all their diving and habitation needs during their time on the project.

The survey site covers 500m² of seabed and each team consists of five trained divers documenting benthic organisms, seabed cover, and particulars of any seahorse specimen found. Documentation is undertaken, visually, by physical morphometric measurement and photographically and all documentation is held and compiled on MCC computers by the volunteers and overseen by MCC staff. Further checks are done by Seahorse Trust and Save Our Seas staff.



Transects on the 'Corral'
**Map 3**
**Courtesy of Google Earth**

Morphometric measurements and other data is recorded on dive slates during the survey dive and dive times, depth and sea temperature is recorded in the divers own dive computers. Once back at the office this is then transferred to computer and into the database.

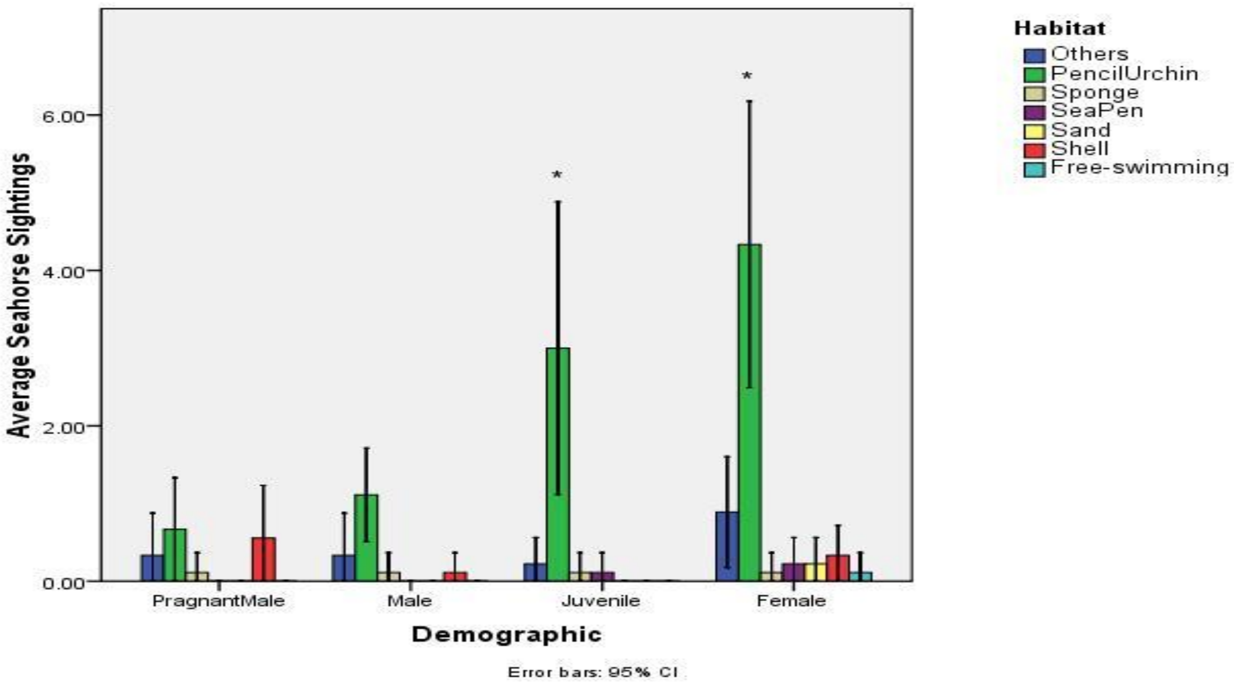
Photographic evidence is a vital tool to the research work and as such most divers are equipped with underwater cameras (at least one camera per pair of divers) and the photographs are transferred to the project computers back in the office.

Photography is a crucial tool as often during the experience of the dive when coping with the usual parameters of diving, especially in strong currents means that some detail is not recorded or observed. By analysing the photographs back in the office, very often information that was missed during the dive can then be garnered from the photographs.

## Discussion (including results)

Until recently, the low density and sparse seahorse population on 'the Corral' was almost exclusively composed by a single species, The Hedgehog Seahorse, *Hippocampus spinosissimus.* However as the effects of a no take conservation zone established in 2006 get under way, habitat is very slowly improving and other seahorse species are often seen albeit in very low numbers; Hippocampus *spinosissimus* is still the dominant species and found on almost all survey dives.

One important aspect of *H.spinosissimus'* life-history that makes it more adaptable to fragmented habitats and explains what is occurring in the Corral, is the ability of *H.spinosissimus* to use various holdfasts (objects to anchor itself to with its prehensile tail) rather than be habitat specific such as *H.guttulatus* which is predominantly a seagrass species (**Garrick-Maidment et al 2010**). Individuals in the study population of *H.spinosissimus* have been observed anchoring on sea pens, shells, sponges, man-made structures (crab traps or tangled rope), anchored in the sand, found to be free swimming and on pencil urchins (**figure 1**). These associated species are similar to those found in the Central Philippine *H. spinosissimus* populations (**Morgan ad Panes 2008**). However, seahorses of all demographic cohorts in our study population significantly select pencil urchins as their preferred and the dominant holdfast (**figure 1**) probably because this is the dominant holdfast in the study area and there is a lack of opportunity in the extent of types of holdfast.




Seahorse demographics compared with sightings on the Corral study site
**Figure 1**

Holdfast selection is generally involved with predator avoidance, feeding and territory establishment (**Nelson 1994, Garrick-Maidment et al 2010**) and many species of seahorse have typically been described as selecting sedentary holdfasts, being territorial and having high site fidelity, often returning to the same area to breed (**Foster and Vincent 2004, Garrick-Maidment et al 2010**). However *H. spinosissimus* in the Corral have adopted a different strategy for this very fragmented damaged site and that is to use the highly motile Pencil Urchins (*Eucidaris tribuloides*) as their holdfasts.

There has been a reported increase in Pencil Urchins (*Eucidaris tribuloides*) in areas that suffer from overfishing (**McClanahan, 1994: McClanahan & Mutere, 1994; McClanahan & Obura, 1997**) and this has affected the site in many ways. Firstly the Pencil Urchins have increased in numbers in response to the change in habitat; they have exploited a niche that previously was not open to them. Secondly the *H. spinosissimus* have adapted to this changing habitat and the increase in urchin numbers by utilizing them as a holdfast in the absence of other more suitable holdfasts.

The significance of selecting the motile holdfast, Pencil Urchins (*Eucidaris tribuloides*) by individuals in the current study population suggests an adaptation to the poor quality and lack of holdfasts and unlike others species such as *H.hippocampus* and H.abdominalis (**Garrick-Maidment 2007**) which when there is no other holdfast have been known to sit on the seabed, holding the flimsiest of objects or none at all, *H. spinosissimus* seem to have a preference as the data shows to being attached to an object; in this case Pencil Urchins (*Eucidaris tribuloides*).

Hedgehog Seahorse *H. spinosissimus* in a Pencil Urchin *Eucidaris tribuloides*
**Photo 3**
Copyright Paul Ferber 2012 **©**

The important and overarching question is, has *H. spinosissimus* adapted to the change in environment, if so, does this give hope for all seahorse species to be able to adapt as well or are only certain species able to cope with rapidly changing habitats and environments. Is it possible that *H. spinosissimus* was able to adapt because in non-disturbed habitats they are highly adaptable and more versatile anyway; whereas other seahorse species, such as *H.guttulatus* which is a seagrass specialist and *H.barbiganti* that is found predominantly on seafans are niche specific in their habitat needs. These niche species will most likely find it more difficult to adapt, especially when the habitat changes so rapidly as a result of the illegal fishing activities. Will the highly adaptable *H. spinosissimus* become dominant in all areas where there is disturbance?

By selecting a highly motile holdfast, individual seahorses increase the opportunity of inter-individual interaction by the coming together of their 'hosts', Pencil Urchins, deliberately or by accident: thus increasing mating potential and frequency. By 'hitching' a lift on Pencil Urchins it also reduces energy wastage when spending time swimming looking for a partner (A useful adaption in a fragmented environment which has limited food supplies); It is feasible that food items find shelter in Pencil Urchins and inadvertently end up being eaten by the seahorses.

Indeed, both pregnant and non-pregnant males within 'the Corral' are more exclusive as to their Pencil Urchin holdfasts than females (**Ferber, Garrick-Maidment, Doyle and Calef 2012**). Moreover, the only specimens found to be 'free-swimming' in the current study were females. This correlates with previous literature citing females as having larger territories which overlap that of the males (**Vincent and Sadler 1995; Garrick-Maidment *et al.* 2014**), leading to extra mating opportunities for these females as the males come in and out of their overall territory located as they are on the Pencil Urchins. These females appear to be; although more research is needed, non-monogamous and opportunistic breeders as opposed to other species such as H.guttulatus which are seasonally partnered to increase breeding opportunities which could be lost when time is spent looking for and encouraging a mate (**Garrick-Maidment, Durrant et al 2012**). It is believed that male seahorses instigate mating and attract females via pheromone production (**Vincent 1994, Garrick-Maidment 2014**). As such, a free-swimming female could be searching for a male which is producing mating pheromones in the vicinity, the release of pheromones would also allow for ease of location when the females are searching for the males, this in turn would reduce mate selection time for both male and female seahorses, which preserves energy and allows for more opportunities to mate if indeed the female is not monogamous and opportunistic in her approach to mate selection.

Many seahorse species have frequently been found to form faithful, monogamous pair bonds, at least during a single mating season and possibly for longer (**Vincent and Sadler 1995**). However, in the current study, no seahorses have been observed together or paired in the traditional sense. As *Hippocampus* species occur in low densities, have frequently been shown to be territorial, and have poor mobility, social monogamy is predicted for such species (**Whitman and Cote 2003**) and has been documented (**Vincent and Sadler 1995**). Currently, the incumbent study is limited in the fact that population density cannot be estimated due to a lack of individual recognition or marking scheme. As such, relative health of the population remains uncertain, however due to past extensive unsustainable fishing in the area, it can be assumed that the seahorse population is not in peak condition, and is at a low density, even for such a species.

The cryptic nature of seahorses, especially in an area at risk from predators, due to limited cover from the habitat would mean that exposure by visual display in courtship could put the male seahorses at risk from predation. Locating itself within the sharp spines of a Pen Urchin affords the male a great deal of protection in the same way Banggai cardinalfish (*Pterapogon kauderni*) do with their fry; using the spines of urchins as a crèche. It was noted in the study that there was limited courtship displays by the males and when these did occur, unlike other seahorse species they were limited in there extent and the males rarely come off the Pencil Urchin. It is not known if this is a deliberate adaption due to the use of Pencil urchins because of the habitat loss or whether the *H. spinosissimus* already did this as a normal part of their behaviour and ecology.

Seahorses are notoriously poor swimmers and locomotion is generated by dorsal (located low down on the back) and pectoral fins (located behind their gills, on either side of the head) which ripple at 35 to 70 beats per second, and they are completely lacking a caudal fin. As such, if females in the current study are using 'free-swimming' as a technique to increase inter-individual breeding interactions, it is likely used as a method to disperse over greater distances in order to locate a mate; advantaged by the males release of pheromones to attract her attention. The extra risk from predation and increased energy usage must be outweighed by the advantage of locating one or more mates over a much wider area and evolutionarily it has to be advantageous for increasing fecundity or it would be disposed as a mating method very quickly.

Female home ranges vary with species, however studies have shown certain species such as *H.guttulatus* can have territories up to 400 $m^2$ and as small as $2m^2$(**Garrick-Maidment *et al.* 2010**); the actions of *H. spinosissimus* probably do not exceed the largest of these ranges and so there appears to be a good proposition of this not being different in this species.

Prior to the catastrophic fishing events, the undisturbed seahorse species that were formally in the Corral study site had their own niche micro environment, with the change of habitat caused by the illegal fishing, does this mean that the environment has changed to be in favour for *H. spinosissimus* only or has *H. spinosissimus* been the only seahorse species to have adapted sufficiently to cope with the change in habitat, is there something about there atypical behaviour which favours this rapid adaption?

Without a doubt the seahorses in the Corral study area are behaving very differently to others of the same species in different more settled, undisturbed sites. The question is this an adaption to the damaged habitat or a natural adaption which occurs in others sites?

One of the authors (Paul Ferber) photographed another example of adaption to their environment in another species *H.kuda* which used to occur in numbers in the Corral site. In the pictures below (**Photos 4 and 5**) it shows *H.kuda* changing its colour to black (they can be bright orange or yellow) and lying down in amongst the detritus on the seabed. The cryptic nature of seahorses allows for a certain level of adaption but the behaviour of the *H.kuda* below and the description of the behaviour of *H. spinosissimus* makes us question our knowledge on seahorses and their adaptability; could it be they are more adaptable than has previously been accredited to them. If this is so, it bodes well for the future of seahorses as their environment is changed by man’s activities.

However as numbers are rapidly dropping (**Doyle.K., 2012**) it must be considered that most seahorse species cannot adapt fast enough to the changing environment and only a handful of species might survive due to their ability to adapt and not be one niche species.

Kuda Seahorse *H. kuda* lying on the seabed amongst detritus **Photo 4** Copyright Paul Ferber 2012 **©**

Kuda Seahorse *H. kuda* lying on the seabed  **Photo 5** Copyright Paul Ferber 2012 **©**

## Conclusion

The behaviour of *H. spinosissimus* appears to not be atypical of the species and within the Corral site it gives the appearance of a rapid adaption to a catastrophic event; illegal bottom fishing

There are many advantages and disadvantages between fixed territories and mobile territories, which include energy loss and gain, ease of finding mates, predator avoidance and feeding and mating regimes. By comparing *H.guttulatus* with *H. spinosissimus*, the first which has fixed territories in seagrass during the warmer months (**Garrick-Maidment 2004**) during the breeding seasons but migrates into deeper water in the cooler months; with the second in the Corral site that has mobile territories (**Ferber. P, et al., 2012**) all year around, it is difficult to understand which is the better survival strategy.

Having a fixed territory, where your mate comes to you, conserves energy and you can hide amongst the seagrass, thus avoiding predators, gives the advantage of the female knowing where the male is, is very efficient, however if you have to migrate seasonally due to weather conditions in the shallow areas where seagrass occurs then this reduces the time allowed for breeding and expends a great deal of energy.

However in *H. spinosissimus* on the Corral site there is little energy lost by the male because he seldom swims, food comes to him, as it shelters under the urchin (**Ferber. p pers obs**.), he is protected by the spines of the urchins from predators and females can easily find him due to pheromone release. He also has the advantage of not having to migrate seasonally which saves a great deal of energy. This adaption to a motile holdfast is not without its disadvantages due to limited suitable holdfasts which by necessity means there is a reduced amount of food availability, due to reduced areas of cover for food types (**Jones.L pers comms 2013, substrate study on the Corral**)

Both strategies appear to be positive adaptions to the environment they are in and it could be that they both are highly advantageous in the selected habitat; it is very obvious ongoing research is needed to understand this more.

It is very clear from this study that the *H. spinosissimus* in the 'Corral' study site adapted rapidly to a changing environment and appear to be the dominant species on the site after the event. It could be that this species has a more adaptable nature and that under 'normal' conditions it is more adaptable. However it asks the question: are all seahorse species able to adapt rapidly should the conditions prove favourable, or are some niche species such as *H.guttulatus*, H.barbiganti or *H.comes* restricted to the habitat and environment they find themselves in; could this be the reason why *H. spinosissimus* has become the dominant species in this fractured damaged site?

Until recently, MCC conducted surveys over a pseudo-random study area, and ensured the entire area is surveyed evenly during every month. However, future progression for this project needs to include individual identification schemes in order to provide empirical evidence for assessment to determine population density, leading to study of territoriality, home ranges, dispersal and mating strategies within the population on 'the Corral'. The more accurate and specialised the survey and assessment techniques, the more that can be derived from the collected data. And, consequently, the more effectively the data can be used for protection and conservation of species and the marine environment.

It has been estimated that in the traditional Chinese medicine trade in China alone, over 150 million seahorses are consumed per annum (**Doyle, N.D.).** This excessively high trade demand, combined with sensitive life-history traits, makes *Hippocampus* species highly susceptible to over-exploitation and extinction. As such, collaborative research and conservative efforts such as that of the current study and the new Kep Province study area are vital for enhancing public awareness, lobbying for marine protected areas and sustainable fishing quotas and methods to attempt to protect and conserve the marine environment and its associated species. Only by constant, relentless yet sound scientific surveying in a particular area over an extended period of time (such as the MCC projects) and the Seahorse Trust's work in the Studland Bay area, (UK) can the required conclusive and persuasive data be collected for effective and informed conservation.

Due to recent politics MCC has now set up a new and enlarged study site in Kep province that gives greater scope for long term sustainable research. With its partners at Save Our Seahorses and The Seahorse Trust, this project will be further developed and it is intended data gathered will lead to the long protection and enhancement of this new site; hopefully stopping it from being exploited and degraded like the original study sites; this in the long term will benefit so many more species and habitats. Partners have also been identified to work on terrestrial studies as well, which will lead to a full holistic approach to conservation of the region.

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| **The Seahorse Trust** | http://theseahorsetrust.org/ |
| **Save Our Seahorses** | http://www.saveourseahorses.org/home.php |