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Species in wildlife trade: socio-economic factors influence seahorse relative abundance in Thailand

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ABSTRACT

Unsustainable wildlife trade negatively impacts wild populations of traded species. Thus to assess these population impacts and manage trade, we need to find and characterize extant populations. Seahorses are one of the most heavily traded marine animals, with almost 6 million individuals exported worldwide annually. Thailand, the top exporter, is responsible for 88% of global export volumes of dried seahorses. Here, we sought to locate seahorse hotspots in Thailand - places where seahorses are still abundant, and elucidate predictors of these hotspots. Because seahorses have economic value, we included socio-economic parameters in addition to environmental parameters. From underwater surveys, 46 seahorses from three species were spotted at 13 of 46 sites, with *Hippocampus spinosissimus* most commonly observed. The highest seahorse densities were found off Chonburi province within the Gulf of Thailand. Seahorse density and presence were not significantly associated with habitat type, while access to market was the strongest predictor. Seahorses were less abundant in areas with a seahorse market, presumably because proximate seahorse resources in these areas are attractive commodities to extract for fishers. Intense fishing activity has already greatly impacted seahorse populations in Thailand, potentially obscuring natural habitat preferences and leading to population declines. For heavily traded species whose natural populations are already impacted, human processes may have a stronger effect on species distribution than habitat type or quality. Beyond identifying and protecting suitable habitats, the preservation of seahorse populations depends on changing human behavior in interacting with seahorses and the strict enforcement of existing fishing regulations.

1. Introduction

Unsustainable wildlife trade is one of the major challenges to conserving biodiversity in Southeast Asia (Nijman, 2009). Legal wildlife trade was valued at EUR$239.5 billion globally in 2005 alone (Engler and Parry-Jones, 2007), and though official trade volumes for wildlife exports seem large, these numbers are gross underestimates of total volume due to illegal trade and under-reporting (Rosen and Smith, 2010). Wildlife trade is incredibly difficult to track and manage because it involves large transaction volumes, movements of shipments across porous international borders and complex trade routes (Nijman, 2009). Further, as populations decline due to overexploitation, animals become rare, and thus more challenging to detect and study (Gaston and Fuller, 2007, 2008).

Studies of species distribution tend to focus on habitat type and quality in order to predict occurrence and/or relative abundance (Guisan and Zimmermann, 2000; Rosa et al., 2007; Alexiades and Fisher, 2015; Hill and Diefenbach, 2014; Landi et al., 2014). This approach serves to identify and demarcate suitable or occupied habitats for future protection (Wessels, 1999; Ferrier et al., 2004; Bailey and Thompson, 2009). Increasingly however, there is a need to consider socio-economic factors to investigate species distribution, as many threatened species are imperiled by human impacts (Pimm et al., 2014), and changing environmental conditions such as habitat loss and population declines are driven largely by human behaviors (Schultz, 2011). The population status of economically valuable species in particular, is influenced by the vagaries of market supply and demand (Burton, 1999; Bulte, 2003; Clarke et al., 2007).

Seahorses (*Hippocampus* spp.) are species of conservation concern, featuring heavily in global wildlife trade both as dried (traditional medicines or curios) and live (aquaria) specimens (Vincent et al., 2011). The seahorse trade for traditional medicine is particularly significant in Southeast Asia (Choo and Liew, 2005; Giles et al., 2006; Perry et al., 2010; Vincent et al., 2011), with more than five million dried seahorses

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exported from this region annually on average (Foster et al., 2016). The main source of dried seahorses is trawl bycatch (Baum and Vincent, 2005; Giles et al., 2006; Perry et al., 2010), while live animals are specifically targeted for capture by divers (Rosa et al., 2006; Perry et al., 2010; Laksanawimol et al., 2013). As seahorses are slow-moving, and have limited home-ranges and low fecundity relative to other fish species, they are especially prone to overfishing (Foster and Vincent, 2004), thus current harvest rates may be unsustainable (Vincent et al., 2011). In addition, seahorses are particularly sensitive to habitat degradation (Duarte, 2002; Marcus et al., 2007; Harasti, 2016), further impeding population recovery.

Official trade data indicate that Thailand is the principal source of seahorses for trade, exporting an estimated 3.0–6.5 million individuals per year from 2004 to 2011 (Foster et al., 2016). Seven seahorse species are found in Thailand (Lourie et al., 2004), including the four species, *H. trimaculatus*, *H. spinosissimus*, *H. kelloggi* and *H. kuda*, that make up more than 80% of total trade (Foster et al., 2016). These four species are categorized as vulnerable on the IUCN Red List of Threatened Species (http://www.iucnredlist.org), with their global population trends all described as decreasing (Project Seahorse, 2003; Wiswedel, 2012a, 2012b; Aylesworth, 2014). However, with a dearth of information on seahorse geographic ranges, population sizes and habitat preferences, it is difficult to assess the sustainability of current rates of exploitation in Thailand, and identify the measures needed to protect existing populations.

To address these knowledge gaps, our study focused on finding and characterizing areas of high seahorse density off the coasts of Thailand, with a view of informing future efforts to assess species distribution. Based on best available knowledge, we conducted in-water surveys to identify these seahorse "hotspots" and determine the factors that best predict the locations of other hotspots. Site data included both habitat-related, or environmental, and socio-economic parameters, such as human population density, proxies for fishing pressure and market demand for seahorses. Given the fishing pressure from Thailand's extensive trawling fleet and the high export volumes of seahorses (Perry et al., 2010; Foster et al., 2016), it is likely that several seahorse populations in the country are already impacted by human activities.

2. Materials and methods

2.1. Identifying potential seahorse sites

Few data exist for seahorse sightings in Thailand. To maximize the chances of locating significant seahorse populations, we decided to focus on sites where seahorses have been previously observed, as with other studies of rare species (Blake et al., 2016; Purcell et al., 2014). Biased sampling methods such as these can provide better initial data for rare species than systematic sampling, which tends to be constricted to small areas and have very low observation frequencies (Braunisch and Suchant, 2010). Prior to fieldwork, a concerted effort was made to collate seahorse sightings in Thailand from all available sources of information including the internet, popular media, peer-reviewed and grey publications, emails, social media, and direct contact with local divers. From the first round of inquiries we generated a shortlist of potential locations along Thailand's coastal provinces where seahorses could be found.

Additionally, we conducted informal interviews to narrow down possible survey locations and ask about seahorse population trends. From 2013 to 2014, we spoke with 37 local stakeholders including marine researchers, resource managers, conservationists, fishers, boat crew and scuba divers. When applicable, we also requested examinations of dried seahorse collections to assess the species caught in the area. Questions varied by person but usually included asking about fishing grounds (seahorse distribution) and estimations of changes to seahorse populations over the last decade (population trends). Interviews were carried out in the provinces of Phuket, Phang-nga, Trang, Satun, Nakhon Si Thammarat, Surat Thani, Chumphon, Chonburi and Trat.

Due to permit restrictions, underwater surveys were only conducted outside national parks. Over two periods, September to October 2013 and April 2014 (non-rainy seasons for survey locations), a total of 46 sites was surveyed at the following locations - Ko Tao (Surat Thani), Ban Tong Tom (Chumphon), Laem Por (Surat Thani), Khanom (Nakhon Si Thammarat), Thung Walen (Chumphon), Ao Por (Phuket), Pattaya (Chonburi), Samaesan (Chonburi), Bang Saen (Chonburi) and Ko Kood (Trat) (Fig. 1, Appendix A).

2.2. Seahorse surveys

For underwater surveys, we used methodology based on random swims, which was developed for the citizen science program iSeahorse (Project Seahorse), as part of a monitoring toolkit for wild populations of seahorses (www.iseahorse.org/trends). From preliminary surveys conducted in February 2013 in Thailand and previous studies (Bell et al., 2003; Moreau and Vincent, 2004; Curtis and Vincent, 2005; Marcus et al., 2007), we determined that seahorses were rarely observed and tended to be patchily distributed. Using random belt transects, as we did in preliminary surveys, would lead to high inter-transect variance (Caldwell and Vincent, 2012; Yasue et al., 2012) and low detection rates (Aylesworth et al., unpublished results).

Surveyors searched for seahorses during random swims while scuba diving or snorkeling and estimated distance traveled using calibrated fin-kick cycles as the effort metric. When seahorses were encountered, characteristics such as sex, reproductive state, seahorse height, and holdfast type were recorded as general information. Seahorse density was recorded as number of seahorses observed per 100 m of survey distance. Juveniles were classified based on height at 50% physical maturity from Lawson et al. (2015). One to three swims were conducted at each survey site, with mean seahorse density per site calculated for >1 swim.

2.3. Site predictors - environmental variables

The following parameters were measured for each site: concentrations of nitrate, nitrite, and phosphate, pH, salinity and water temperature. At most sites (n = 39 of 46), 250–300 ml of seawater was collected at survey depth for analysis at Shedd Aquarium (Chicago). We were unable to test water chemistry for sites surveyed in Chonburi province (n = 7 of 46) in April 2014 because of logistical difficulties with storage and transport of water samples. Instead, the API 5-in-1 Aquarium Test Strips (Mars Inc., USA), Salifert Phosphate Test Kit (Holland) and a hydrometer were used to measure water chemistry (as in Miller and Botzler, 1995; Godfrey and Sanders, 2004). Water temperature was measured at all sites with the surveyor's dive computer. As seahorse predation success depends on light availability (James and Heck, 1994), horizontal visibility was estimated underwater during surveys. Other observations recorded were habitat type (silt, rubble, sand, rock, seagrass, coral, artificial; classified according to www.reefcheck.org) and number of other syngnathids (pipefishes and pipehorses) per 100 m survey distance.

2.4. Site predictors - socio-economic data

The most recent socio-economic data publicly available from online datasets were used. To our knowledge, these were the best available sources for data at the district level. Population density per km^2 for each district was obtained from a Year 2000 census report (http://web.nso.go.th/en/census/poph/popreport_e.htm) from the National Statistical Office of Thailand. Human population density in coastal areas is negatively correlated with predatory fish abundance, indicating impacts from artisanal fisheries (Stallings, 2009). As proxies for fishing pressure, we used the number of households engaged in marine fishing per district in 2004 (http://service.nso.go.th/nso/nso_center/project/search_center/province-th.htm) and the number of fishing boats registered per district in 2011 (http://www.platalay.com/boatsurvey2554/