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Short communication

Catch as catch can: Targeted and indiscriminate small-scale fishing of seahorses in Vietnam

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ABSTRACT

Serial depletions and the use of indiscriminate gears have led to increased fishing pressure on many previously untargeted species. A largely unregulated global extraction of seahorses (*Hippocampus* spp.) has emerged, of which Vietnam is one of the main sources. Quantifying this extraction is a major empirical and enforcement challenge. Using catch landings surveys of small-scale fishing boats, we determined the fishing pressure on seahorse populations around Phu Quoc Island – a major source of seahorses in Vietnam's trade – from April to July 2014. We focused on two fishing methods, bottom trawling and compressor diving, that either targeted seahorses or caught them incidentally along with a multitude of other species. The seahorse catch consisted of three species – *H. kuda, H. spinosissimus* and *H. trimaculatus* – with relative proportions varying by gear type and fishing ground. Fishers that targeted seahorses caught mean rates of 23 and 32 seahorses per boat per day by bottom trawling and diving, respectively. Trawls and divers that did not target seahorses caught mean rates of 1 and 3 seahorses per day respectively, and caught higher proportions of juvenile seahorses. The total catch from the island was approximately 127,000–269,000 seahorses per year from a fleet of 124 trawl boats and 46 compressor diver vessels. This is up to four times higher than the catch of similarly sized fisheries that obtain seahorses and is likely placing high pressure on local seahorse populations. Our research emphasizes the need to monitor these fisheries and develop effective management efforts for sustainable seahorse populations.

1. Introduction

Seahorses (genus *Hippocampus*) are economically valuable species that are readily extracted by fishers using many gears (Vincent et al., 2011; Lawson et al., 2017). Inhabiting mostly shallow, tropical and temperate waters, seahorses are easily accessible to inshore fisheries (Foster and Vincent, 2004). Used predominantly in traditional medicine, aquarium displays and curiosity shops, millions of seahorses are caught and traded globally each year (Vincent et al., 2011). Certain fishers target seahorses directly – mostly by hand – as in India, Malaysia, Thailand, Brazil, and the Philippines (Marichamy and Lipton, 1993; Rosa et al., 2005, 2011; Vincent et al., 2007; Perry et al., 2010). However, the majority of seahorses are caught as bycatch in non-selective gears such as trawl nets and purse seines (Lawson et al., 2017). Fishers worldwide have reported declines in seahorse populations (Vincent et al., 2011), and this global exploitation is considered unsustainable and in need of informed management. In addition to the livelihood they provide, seahorses are important predators on bottom-dwelling organisms and have an extraordinary life history wherein the male becomes pregnant (Foster and Vincent, 2004). Seahorses are particularly susceptible to overfishing, habitat loss, and other human pressures due to their extreme parental care (Foster and Vincent, 2004).

Complex and largely unmonitored multi-gear fisheries, like those for seahorses, require a suite of complementary tools to ensure their sustainability. These include typical fisheries management measures (e.g. seasonal closures, minimum size limits), the impetus for which may be enhanced by multilateral environmental agreements (Vincent et al., 2013). All seahorse species were added to Appendix II of Convention on International Trade in Endangered Species of Wild Flora and Fauna (CITES) in 2002, which requires the 182 signatory countries to ensure that their exports are legally acquired and do not damage wild populations. Such responsibilities require that member countries make non-detriment findings (NDFs), which amount to adaptive management plans for the sustainable exploitation of wild populations (Rosser and Haywood, 2002; Foster and Vincent, 2016). Suggested management options for seahorse fisheries include minimum size limits, spatial restrictions on trawling, and fully protected areas, inter alia (Foster and Vincent, 2016). Getting started with NDFs requires a basic

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understanding of wild seahorse populations or fisheries, starting with an understanding of the pressures facing seahorse populations (Foster and Vincent, 2016).

In Vietnam, seahorses are caught in vast quantities for global export and domestic consumption, but this extraction is not regulated (Giles et al., 2006). According to CITES reports, the number of seahorses exported from Vietnam per year was between 20,000 and 90,000 for the years 2004 through 2011 (UNEP-WCMC, 2012). This is likely an underestimation – historic data from pre-CITES trade surveys in Vietnam suggested 2.2 million seahorses were caught annually in trawl bycatch from just five of Vietnam's 29 coastal provinces (Giles et al., 2006), and CITES data are known to suffer from errors and/or omissions (e.g. Foster et al., 2016). Not only are seahorses exported in vast quantities, but they are also consumed within Vietnam as tonics to promote kidney health and increase sexual potency (Giles et al., 2006). Survey data of seahorse fisheries in Vietnam are out of date, and may have underestimated seahorse catch volumes by focusing on just one type of gear that caught seahorses incidentally.

There is evidence that the exploitation of seahorses is causing declines in wild populations in Vietnam (Long and Van Hoang, 1998; Giles et al., 2006), of up to 95% (Stocks, 2015). Despite these declines, Vietnam has no official management measures in place to regulate seahorse exploitation. The consequence of Vietnam's lack of data and of capacity was a decision by CITES to suspend all trade of one species (*Hippocampus kuda*) from Vietnam as of March 2013 (CITES, 2013). This is the first export ban ever imposed for any fully marine fish species under a multilateral environmental agreement. It highlights an urgent need to collect fisheries and biological data in Vietnam since *H. kuda* may still be traded domestically, and all other seahorse species in Vietnam may still be traded domestically and internationally.

A region in southern Vietnam reported as a hot spot for seahorse fisheries (Ut and Tam, 2012) was chosen for an in-depth study of different fishing strategies and how they affect seahorses. The objectives of this study were to: 1) quantify the rate of seahorse extraction by various fishing gears standardized to effort; 2) identify the seahorse species caught and their life history states; 3) determine the overall seahorse catch; 4) evaluate an indicator of fisheries sustainability; and 5) evaluate the utility of the CITES recommended 10 cm size limit as one component of an adaptive management plan for seahorse fisheries in southern Vietnam.

2. Materials and methods

2.1. Study site

The location of this study was the Phu Quoc District, Vietnam, in the Gulf of Thailand (from 9.45 −10.30° N to 103.55–104.05° E, Fig. 1). In a large study of Vietnamese seahorse bycatch and trade, Kien Giang province in South Western Vietnam was shown to have the highest seahorse catch rates in the country (Giles et al., 2006). Within this region, anecdotal fishing reports identified Phu Quoc as an area where seahorses were caught in multiple fishing gears. It is also an area of conservation concern, with fishers noting declines of up to 95% in seahorse catch between 2004 and 2014, despite reportedly consistent effort (Stocks, 2015). The area collectively known as Phu Quoc contains Vietnam's largest island, Phu Quoc Island, and 21 smaller islets known as the An Thoi Islands (land area: 593 km^2). Fishing grounds between the island and the mainland are greater than 5000 km^2. Maximum water depth to the east of Phu Quoc is approximately 10 m and the substrate is predominantly soft-bottom (sand or mud) and seagrass (Otero-Villanueva et al., 2007). The north and east coasts of Phu Quoc Island face inshore to mainland Cambodia (within 10 km) and Vietnam (40 km), while the west coast and southern An Thoi islands are more exposed to the Gulf of Thailand.

Surveys were focused on ports along the east coast of Phu Quoc, where fishers operated in shallow (mostly < 10 m deep) fishing grounds and caught seahorses. Fishing grounds were grouped into three regions: north, central, and south (Fig. 1). Each area contained one large, government-operated port, as well as many smaller fishing villages or beaches where seahorses were landed. The northern region, closest to Cambodia, was characterized by sandy, soft-bottom habitat and occasional reefs. The central region contained soft-bottom habitat and patchy seagrass beds. The southern region contained the 13 smaller An Thoi islands, surrounded by reefs and sandy bottom. The northern and southern regions contain designated marine protected areas (MPAs) (Fig. 1). Fishing activity is prohibited within the MPA core zones, and should be regulated in the buffer zones, but enforcement of the MPAs is extremely limited and unregulated fishing still occurs.

2.2. Fisheries-dependent surveys

From April to July 2014, catches were surveyed for *Hippocampus* spp. at nine landing sites along the east coast of the islands (Fig. 1): six were small fishing villages or beaches and three were large, government-operated ports. The local fishing fleet used a variety of gear types including compressor diving equipment, trawl nets, crab nets, hook and line, gill nets, and purse seines. While all gear types caught seahorses at least occasionally, we focused on compressor divers and bottom trawlers, gear types that regularly catch and land higher volumes of seahorses (Stocks, 2015). Compressor divers wear masks and weight belts and are supplied with air pumped from the ocean surface through a 300 m-long plastic hose held by the divers' teeth, collecting organisms by hand. The bottom trawlers operate 6–12 m boats with up to 60HP engines, and drag single nets along the ocean floor that are kept open either by otter boards (otter trawls) or a 5–6 m long wooden or metal beam (beam trawls). These fishing gears were then categorized by whether they targeted seahorses or caught them incidentally (referred to hereafter as: targeted divers, indiscriminate divers, target trawls, and indiscriminate trawls).

Sites were visited in the mornings and evenings on a near daily-basis in order to record catch from boats that fished at night or during the day. Landings were sampled from a total of 305 fishing trips (and about 100 different boats); 134 trips used compressor diving gear and 171 used trawl gear. The spatial distribution of sampled fishing trips across gear types was as follows (for targeted dive, indiscriminate dive, target trawl, and indiscriminate trawl, respectively): northern region: 2, 61, 9, 73; central region: 13, 54, 20, 37; southern region: 0, 4, 13, 13. Sampling was opportunistic and did not necessarily reflect actual fishing effort at each site, but this was accounted for in analyses.

For each fishing trip documented for this study, fishers were asked for information regarding fishing effort (gear type, trip length, active fishing time, distance from shore, fishing depth, and fuel use), location, and bottom habitat. When seahorses were landed the total number of individuals and/or total mass of the catch was recorded; only mass was recorded for live seahorses. Whenever fishers allowed, the species, sex, height, mass, and reproductive state of each seahorse in the landings were recorded. Seahorses were identified using standard seahorse taxonomy (Lourie et al., 2004). Seahorse height was measured as the length from the tip of the coronet to the tip of the outstretched tail (Lourie et al., 1999). Male seahorses were identified by the presence of a brood pouch or, for juvenile males, the presence of a darkened oval zone where a brood pouch was developing; females were identified by the lack of such features or by the presence of an ovipositor (Boisseau, 1967). Males were considered mature where the brood pouch was distended or recently emptied (Vincent, 1994). Females were assumed to mature at the same size as males, as female maturity state can only be determined by dissecting ovaries in freshly dead or preserved specimens (Foster and Vincent, 2004).

2.3. Data analyses: fisheries catch and effort

All catch analyses were carried out using number of individual